CHEMICAL SAFETY REPORT

Non-confidential version

Legal name of applicant(s):	Boeing Distribution (UK) Inc. (CT) Henkel Ltd (CT, DtC) Indestructible Paints Ltd (CT) MacDermid Performance Solutions UK Ltd (CT) Wesco Aircraft EMEA Ltd (SD, PD)		
Submitted by:	**Wesco Aircraft EMEA Ltd**		
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
	Sodium dichromate (SD)	EC 234-190-3	CAS 10588-01-9
	Potassium dichromate (PD)	EC 231-906-6	CAS 7778-50-9
	Dichromium tris(chromate) (DtC)	EC 246-356-2	CAS 24613-89-6
Uses applied for:	Use 1: Chemical conversion coating using chromium trioxide, sodium dichromate, potassium dichromate, and/or dichromium tris(chromate) in aerospace and defence industry and its supply chains.		

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Preliminary Remark

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

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

Part A

1. SUMMARY OF RISK MANAGEMENT MEASURES

The risk management measures implemented for the use applied for are documented in detail in the exposure scenario in Chapter 9 of this CSR.
A succinct summary table of the risk management measures and operational conditions is submitted with this review report.

2. DECLARATION THAT RISK MANAGEMENT MEASURES ARE IMPLEMENTED

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

3. DECLARATION THAT RISK MANAGEMENT MEASURES ARE COMMUNICATED

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

Part B

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

9 EXPOSURE ASSESSMENT (AND RELATED RISK CHARACTERISATION)

9.1 Introduction

9.1.1 Structure of this dossier "Chemical conversion coating" and uses covered in this dossier

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

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

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

This dossier "Chemical conversion coating" contains a single use: "Chemical Conversion Coating using chromium trioxide, sodium dichromate, potassium dichromate, and/or dichromium tris(chromate) in aerospace and defence industry and its supply chains".

9.1.2 Introduction to the assessment

9.1.2.1 Grouping approach for Cr(VI) compounds

The chromates shown in Table 9-1 have been included into Annex XIV of Regulation (EC) No 1907/2006 due to their intrinsic properties (mutagenic, carcinogenic, toxic for reproduction; depending on the chromate). According to Article 62 (4)(d) of this Regulation, the chemical safety report (CSR) supporting an Application for Authorisation (AfA) needs to cover only those risks arising from the intrinsic properties specified in Annex XIV. Therefore, only the human health risks related to the classification of the respective chromate(s) as mutagenic, carcinogenic and/or reproductive toxic substance(s) are addressed in this CSR. This requires investigating the potential exposure of workers as well as exposure of humans via the environment.

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.**

Sodium dichromate (SD; Entry No. 18), and potassium dichromate (PD; Entry No. 19) have been included in Annex XIV of REACH due to their CMR properties as they are both classified as carcinogenic (Cat. 1B), mutagenic (Cat. 1B) and reproductive toxicants (Cat. 1B).

Dichromium tris(chromate) (DtC) has been included in Annex XIV of REACH (Entry No. 28) due to its carcinogenic properties as it is classified as carcinogenic (Cat. 1A).

For CT, its acids and for DtC, only carcinogenic and (for some of these substances also) mutagenic properties must be considered for risk characterisation. Reproductive toxicity has also to be taken into account for Cr(VI) exposure related to SD, and PD as these chromates affect both fertility and development.

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			
Sodium dichromate [c] (SD)	10588-01-9	234-190-3	18	Muta. 1B Carc. 1B Repr. 1B	$Na_2Cr_2O_7$	261.97	0.40
Potassium dichromate (PD)	7778-50-9	231-906-6	19	Muta. 1B Carc. 1B Repr. 1B	$K_2Cr_2O_7$	294.19	0.35
Dichromium tris(chromate) (DtC)	24613-89-6	246-356-2	28	Carc. 1B	Cr_5O_{12}	451.97	0.58

[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.

[c] This entry also covers sodium dichromate dihydrate (Formula: $Cr_2H_4Na_2O_9$ | CAS No.: 7789-12-0| EC No.: 616-541-6), which is neither registered nor does it have a harmonised classification. Should it be used, we will treat it as if it were also classified as mutagenic (Muta. 1B), carcinogenic (Carc. 1B) and reprotoxic (Repro. 1B), same as the anhydrous form. In this case, the molecular weight fraction of 0.4, as calculated for sodium dichromate, would be used, which is a conservative approach, because sodium dichromate dihydrate has a higher molecular weight (298 g/mol) with a lower Cr(VI) fraction (0.35) than sodium dichromate.

The carcinogenicity, mutagenicity and reproductive toxicities of CT, its acids, SD, PD, and DtC 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 and DNELs proposed by the Committee for Risk Assessment (RAC) express exposure as Cr(VI).

A grouping approach is used in this CSR, because

- All substances share this common toxic moiety (Cr(VI)), and are therefore expected to exert effects in an additive manner,
- At many sites various chromates are used in parallel, exposures of which are additive,
- For some uses, different chromates can be used interchangeably, as they provide the same performance properties and functionalities.

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 and DNELs.

9.1.2.2 Exposure-risk relationships (ERRs) for carcinogenic effects and DNEL values for reproductive toxicity 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.

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.

With respect to reproductive toxicity, DNELs for effects on fertility proposed by RAC are lower than DNELs derived for effects on developmental toxicity and, therefore, the RAC DNELs are used for the assessment of reproductive toxicity.

[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

Sodium dichromate, and potassium dichromate are included in Annex XIV not only due to their carcinogenic and mutagenic properties but also because of their reproductive toxicities. Although the effects on reproduction only need to be assessed for Cr(VI) derived from these two substances, for reasons of simplification risk characterization ratios were calculated for total Cr(VI), regardless of the source (i.e., total Cr(VI)). Therefore, exposures resulting from all substances mentioned in Table 9-1 will be considered for each applicable exposure scenario relevant for uses of one or more of these two chromates. With respect to a possible risk to fertility, this represents a conservative estimate for sites which use CT and/or DtC in parallel with SD, and/or PD, because the contribution of CT and/or DtC does not have to be considered for effects on fertility.

A dermal DNEL for long-term systemic effects for workers is used in the risk characterization for dermal occupational exposures, because there is no data to indicate that dermal exposure to Cr(VI) compounds presents a cancer risk in humans (ECHA, 2015).

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.

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

Chemical conversion coating	CT, SD, PD, and/or DtC

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
1	4
0.5	2
0.25	1
0.1	0.4
0.01	0.04

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

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

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

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

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

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

9.1.2.2.2 Derived no effect levels (DNELs) for the assessment of potential risks to reproduction

For the assessment of the potential risk to reproduction (fertility as the most sensitive endpoint), the risk characterisation ratios for inhalation exposure of **workers** are based on the DNEL inhalation for effects on fertility derived by RAC (ECHA, 2015):

- inhalation DNEL systemic long-term: 43 µg Cr(VI)/m^3

The risk characterisation ratios for dermal exposure of **workers** are based on the DNEL dermal for effects on fertility derived by RAC (ECHA, 2015):

- dermal DNEL systemic long-term: 43 µg Cr(VI)/kg bw/d

The risk characterisation for oral and inhalation exposure of humans via the environment is based on the DNEL inhalation and the DNEL oral for the **general population** derived by RAC for effects on fertility (ECHA, 2015):

- inhalation DNEL systemic long-term: 11 µg Cr(VI)/m^3
- oral DNEL systemic long-term: 17 µg Cr(VI)/kg bw/d

Dermal exposure of humans via the environment is considered very unlikely (ECHA, 2016a).

9.1.2.3 Environment

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

The chromates in Table 9-1 are not listed in Annex XIV for endpoints related to concerns for the environment. Therefore, no environmental assessment has been performed.

9.1.2.4 Exposure of humans via the environment

9.1.2.4.1 Scope and type of assessment

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

Apart from that, there is only limited data on the presence of Cr(VI) in food. In 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). Therefore, the same approach is followed here.

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

In addition, risk characterisation ratios (RCRs) based on the DNELs derived by RAC (see also section 9.1.2.2) are calculated to take into account possible effects on reproduction for those chromates, which have been included in Annex XIV of the REACH Regulation due to their reproductive toxicity (in addition to their carcinogenic properties). Although in principle effects on reproduction only have to be evaluated for Cr(VI) originating from SD, and PD, RCRs have been calculated for total Cr(VI) exposure, irrespective from which of the chromates covered in this CSR it was released, following a conservative approach.

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} *
	Reproductive toxicity Quantitative	RAC DNEL for the general population, derived for effects on fertility (ECHA, 2015) 11 µg Cr(VI)/m^3

Route of exposure and type of effects	Endpoint considered and type of risk characterisation	Hazard conclusion DNEL/dose – response relationship
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 $8x10^{-4}$
	Reproductive toxicity Quantitative	RAC DNEL for the general population, derived for effects on fertility (ECHA, 2015) 17 µg Cr(VI)/kg bw/d

* 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).

[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

<u>Release days</u>

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.

<u>Sewage treatment plant (STP)</u>

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.

<u>Oral uptake via drinking water and fish</u>

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

- Drinking water

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

  - The approach chosen is likely to "*overestimate the actual indirect exposure as the conversion of Cr (VI) to Cr (III) is expected to occur under the vast majority of environmental conditions* " (ECB, 2005). This reduction is not considered in the exposure values calculated in EUSES.
  - EUSES typically specifies a "purification factor" that accounts for removal processes from surface water in deriving the concentration in drinking water, e.g., by evaporation or adsorption to suspended solids. However, the latter is estimated by log Kow and not by specific distribution coefficients. This approach is not feasible for inorganic substances and therefore the estimate does not account for adsorption to suspended particles as a removal process before and during drinking water purification. Although these effects are difficult to quantify, the value of 50% (i.e., reduction by factor 2) for adsorption to sewage sludge as applied in the EU RAR (ECB, 2005) (as described above) can serve as an indicator of the degree of Cr(VI) adsorption to suspended solids in surface water.
  - The local PEC in surface water is calculated for the mixing zone, neglecting the fact that for drinking water preparation additional water sources are added and dilution takes place.

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

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

pore water of the soil (RIVM, 2004). These authors state, that "*this is a worst-case assumption, neglecting transformation and dilution in deeper soil layers*".

- Like for surface water, any additional dilution with other groundwater or surface water for drinking water preparation is not considered.

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

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

- Fish

1) In EUSES, a default consumption of 115 g fish per day is used, which overestimates the realistic human daily intake of fish on a long-term basis. According to the food consumption data for humans in Europe, as accessible in the *PRIMo – Pesticide Residue Intake Model*[4] (v.3.1) of the European Food Safety Authority (EFSA), the maximum of the mean consumption of fish (and fish- and marine-/freshwater-products) is 29.3 g per day[5]. This amount is approximately 4-fold lower (factor 3.9) than the default consumption used in EUSES, most likely due to the fact that it reflects a long-term estimate (i.e., most people do not eat fish every single day).
2) It must be noted, that "*(p)eople do not consume 100% of their food products from the immediate vicinity of a point source. Therefore, the local assessment represents a situation which does not exist in reality*" (ECHA, 2016a).

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

[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).

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 together for treatment at the treatment facility or recycled and then led 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 sent 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, brushes, used sandpaper, 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 (lisenced 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 Cr2O3 and O2 (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

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

All chromates considered in this CSR have been included in Annex XIV of the REACH Regulation for their 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. Additionally, a quantitative exposure assessment and risk characterisation with respect to effects on reproduction considers both inhalation and dermal exposures.

For chromates classified as toxic for reproduction (SD, and PD, see section 9.1.2.1), dermal exposure must be assessed for possible effects on fertility. As explained above, the exposure assessment of this CSR focuses on total Cr(VI) released from all assessed chromates combined. With respect to a possible risk on fertility this is a very conservative estimate for sites which use CT and/or DtC in parallel with SD, and/or PD (as the contribution of CT and/or DtC does not have to be considered for effects on fertility). The exposure-risk relationships and DNEL values used for risk characterisation are based on the RAC evaluation (ECHA, 2013; 2015).

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]
	Reproductive toxicity Quantitative	RAC DNEL for workers, derived for effects on fertility (ECHA, 2015) 43 µg Cr(VI)/m^3
Dermal: Systemic Long Term	Reproductive toxicity Quantitative	RAC DNEL for workers, derived for effects on fertility (ECHA, 2015) 43 µg Cr(VI)/kg bw/d [b]

[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.

[b] Only worker dermal DNEL long-term systemic fertility effects are applied for the risk characterization of dermal exposure, because there is no data to indicate that dermal exposure to Cr(VI) compounds presents a cancer risk to humans (ECHA, 2015).

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, and reproductive toxicity (see section 9.1.2.1). 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. Generally, the measured full-shift time-weighted average concentration is assigned to all uses for which tasks were performed at the day of the measurement.

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

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

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

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

- The measure of chromium in erythrocytes is the only one which is specific to Cr(VI). However, the available literature data on the general population and on workers are insufficient to determine reference values and limit values for this indicator (ANSES, 2017). The German method provides a correlation between biomonitoring in erythrocytes and inhalation exposures but only for CrO_3 concentrations above 30 µg/m^3, which is above what is expected in these exposures (Greim, 2000). Additionally, it is expected that few sites apply biomonitoring in erythrocytes, as it is an invasive method using blood sampling and is thus difficult to apply to consistently use as a method of estimating exposure.
- Urinary biomonitoring does not allow a differentiation between Cr(III) and Cr(VI) (Drexler and Hartwig, 2009). France established a BLV (biological limit value) by ANSES (French evaluation Authorities) in 2017, which can be used for workers but only under the following conditions: when the use is electroplating AND when the chrome products used are exclusively Cr(VI) compounds. Indeed, in case of mixed exposure to both Cr(VI) and Cr(III) compounds, the urine measurements need to be interpreted considering 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, considering the sensitivity of available methods.
- Infrequent activities, such as unscheduled maintenance activities, might not be included in occupational safety measurement programmes with the result that they are not covered by existing data.
- Activities using small amounts of mixtures with low concentrations of Cr(VI), such as use of touch-up pens.

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

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

Dermal exposure is considered for all activities related to a possible Cr(VI) exposure from using SD, or PD (to assess possible risks for reproductive toxicity). Minimisation of dermal exposure is required due to the corrosive and skin sensitising properties of the chromates. This is achieved by automating processes and, where manual handling cannot completely be avoided, by adequate personal protection equipment (for details on PPE see the respective exposure scenarios).

For processes for which dermal exposure cannot be excluded with certainty (e.g., sampling, cleaning, maintenance, bath preparation), the potential dermal exposure is modelled as the intensity of exposure is often difficult to accurately determine. However, modelling dermal exposure from the use of Cr(VI) substances as covered by this review report is difficult. The substances are mostly used as solids dissolved in a liquid, which is outside the applicability domain of the standard modelling tool ECETOC TRA. The Riskofderm model (v.2.1) does not contain adequate modules (DEO units) for several of the activities relevant here, e.g., handling contaminated objects, or cleaning activities. For all activities, including those outside the applicability domain of Riskofderm, we developed an Excel® spreadsheet-based model to estimate dermal exposure. This modelling approach uses dermal loads and assumption on contact areas depending on the tasks (PROCs) performed as proposed in the ECETOC TRA tool.

The following table lists the activities modelled (performed by various types of workers) and the approach used per activity.

Table 9-9: Activities with potential dermal exposure to SD and PD

Task	PROC
Surface treatment by dipping/immersion	PROC 13
Surface treatment by brush or swab application	PROC 10
Sampling of treatment baths	PROC 9
Bath make-up and addition	PROC 5, PROC 8b
Bath emptying and cleaning	PROC 28
Diverse cleaning activities – cleaning of workplace, equipment, jigs	PROC 28
Waste management – Cleaning of empty chemical containers/bags	PROC 28
Waste management – Handling of solid waste	PROC 8b
Maintenance and cleaning of equipment	PROC 28

Chemical conversion coating CT, SD, PD, and/or DtC

Task	PROC
Aliquot chemicals – Decanting of liquids	PROC 8b,
Aliquot chemicals – Measuring and weighing of solids	PROC 8b
Solution preparation for brush or swab application (Decanting of liquids)	PROC 9
Solution preparation for brush or swab application (Measuring and weighing of solids)	PROC 9

The input data and the results of the modelling for the individual activities listed in Table 9-9 as well as the detailed Riskofderm protocols are given in Annex V. The 90th percentile exposure estimate from Riskofderm modelling are used for a plausibility check and are compared with the results of the Excel® spreadsheet-based model. The aggregated exposure estimates for the various worker contributing scenarios are also presented in Annex V.

<u>Comments on assessment approach related to toxicological hazard:</u>

There are no differences in the hazard profile compared to the initial applications regarding carcinogenic risks. Dose-response relationships for carcinogenic effects as proposed by RAC are used for risk characterisation. Further, in this review report reproductive toxicity is assessed using DNELs as proposed by RAC.

<u>Comments on assessment approach related to physicochemical hazard:</u>

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

<u>General information on risk management related to toxicological hazard:</u>

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

<u>General information on risk management related to physicochemical hazard:</u>

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: "Chemical conversion coating using chromium trioxide, sodium dichromate, potassium dichromate, and/or dichromium tris(chromate) in aerospace and defence industry and its supply chains"

9.2.1 Introduction

9.2.1.1 Relationship to previous application

This review report is for "**Use 1: Chemical conversion coating using chromium trioxide, sodium dichromate, potassium dichromate, and/or dichromium tris(chromate) in aerospace and defence industry and its supply chains**". It was prepared on behalf of the applicants by the Aerospace and Defence Chromates Reauthorisation (ADCR) consortium to cover uses of Chromium VI compounds in their supply chains. The review report is based on sector-specific knowledge provided by companies at various levels of the aerospace and defence industry and its supply chains. Compared to the initial applications (see Table 9-10), we narrowed the scope of this report in terms of the use definition, addressing only *Chemical conversion coating using chromium trioxide, sodium dichromate, potassium dichromate, and/or dichromium tris(chromate) in aerospace and defence industry and its supply chains*, to provide a more meaningful and specific description of use than the initial applications, which covered a wide range of surface treatments and substrates.

This chemical safety report covers the use of the four soluble Cr(VI) compounds: chromium trioxide (CT), sodium dichromate (SD), potassium dichromate (PD) and dichromium tris(chromate) (DtC), in a grouping approach (see section 9.1.2.1 for the justification). The following table shows the initial applications to which this review report refers.

Table 9-10: Overview of initial applications

Application ID/ authorisation number	Substance	CAS #	EC #	Applicants	Use name
0032-04 REACH/20/18/14, REACH/20/18/16, REACH/20/18/18	Chromium trioxide	1333-82-0	215-607-8	Various applicants (CTAC consortium)	Surface treatment for applications in the aeronautics and aerospace industries, unrelated to functional chrome plating or functional chrome plating with decorative character

Application ID/ authorisation number	Substance	CAS #	EC #	Applicants	Use name
0032-05 REACH/20/18/21, REACH/20/18/23, REACH/20/18/25	Chromium trioxide	1333-82-0	215-607-8	Various applicants (CTAC consortium)	Surface treatment (except passivation of tin-plated steel (ETP)) for applications in various industry sectors namely architectural, automotive, metal manufacturing and finishing, and general engineering (unrelated to functional chrome plating or functional chrome plating with decorative character)
0096-01 REACH/19/29/0	Chromium trioxide	1333-82-0	215-607-8	Haas Group International SP. Z.O.O. (GCCA consortium)	Use of chromium trioxide for chemical conversion and slurry coating applications by aerospace companies and their suppliers
0043-02 REACH/20/5/3, REACH/20/5/5	Sodium dichromate	10588-01-9	234-190-3	Various applicants (CCST consortium)	Use of sodium dichromate for surface treatment of metals such as aluminium, steel, zinc, magnesium, titanium, alloys, composites and sealings of anodic films
0044-02 REACH/20/3/1	Potassium dichromate	7778-50-9	231-906-6	Brenntag UK Ltd. (CCST consortium)	Use of potassium dichromate for surface treatment of metals such as aluminium, steel, zinc, magnesium, titanium, alloys, composites, sealings of anodic films
0045-02 REACH/20/1/3	Dichromium tris (chromate)	24613-89-6	246-356-2	Various applicants (CCST consortium)	Use of dichromium tris chromate for surface treatment of metals such as aluminium, steel, zinc, magnesium, titanium, alloys, composites, sealings of anodic films

Chemical conversion coating CT, SD, PD, and/or DtC

Application ID/ authorisation number	Substance	CAS #	EC #	Applicants	Use name
0116-01 REACH/20/10/0	Dichromium tris (chromate)	24613-89-6	246-356-2	Haas Group International SP. Z.O.O. (GCCA consortium)	Use of dichromium tris(chromate) for chemical conversion coating applications by aerospace and defence companies and their associated supply chains

With the initial authorisation the European Commission issued several obligations and RAC/SEAC provided recommendations in their joint opinion on initial applications 0032-04 (REACH/20/18/14 - REACH/20/18/16 - REACH/20/18/18), 0032-05 (REACH/20/18/21 - REACH/20/18/23 - REACH/20/18/25), 0096-01 (REACH/19/29/0), 0043-02 (REACH/20/5/3 - REACH/20/5/5), 0044-02 (REACH/20/3/1), 0045-02 (REACH/20/1/3) and 0116-01 (REACH/20/10/0). 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 9-11 describes the comparison between the initial and the current applications in a concise way, while the individual exposure scenarios describe in more detail the measures already implemented.

Table 9-11: Obligations in EC Implementing decisions

Initial application	Current application
AH shall develop specific exposure scenarios for representative processes, operations, and individual tasks, describing risk management measures and operational conditions applied and containing information on the exposure levels. This obligation applies to 0032-04, 0032-05, 0096-01, 0043-02, 0044-02, 0045-02 and 0116-01.	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.
DUs shall implement best practices to reduce workplace exposure to the substances and its emissions to the environment to as low a level as technically and practically feasible, using closed systems and automation and local exhaust ventilation (LEV) systems that are appropriately designed, dimensioned, located and maintained to capture and remove the substances. This obligation applies only to 0096-01, 0043-02, 0044-02, 0045-02 and 0116-01, not to 0032-04 or 0032-05.	The exposure scenarios in section 9.2.3 describe the conditions of use including the technical and organisational measures to reduce and control workplace exposure.
Where respiratory protective equipment (RPE) is needed to control exposure, it shall be used in accordance with standard procedures for use and maintenance, including procedures for fit testing of RPE masks, applied in accordance with relevant standards. This obligation applies only to 0096-01, 0043-02, 0044-02, 0045-02 and 0116-01, not to 0032-04 or 0032-05.	Organisational measures to control and maintain adequate functioning and use of respiratory protective equipment (RPE) are described in 9.2.2.3.1.2.

Initial application	Current application
Appropriate standard operating procedures shall be developed and implemented to minimise release of dust into the air during the preparation, transfer and storage of empty bags, filters, and other process waste, in accordance with the hierarchy of control provisions set out in Article 5 of Directive 2004/37/EC. This obligation applies only to 0043-02, 0044-02, and 0045-02, not to 0032-04, 0032-05, 0096-01, or 0116-01.	The type of activities and the conditions of use relevant for handling solid waste are given in sections 9.2.3.2 and 9.2.3.4, including a description of how LEV can be used in these situations to reduce exposure.
The AHs and DUs shall implement monitoring programmes for air monitoring of occupational exposure representative for the tasks undertaken and shall implement monitoring programmes for chromium (VI) emissions to wastewater and air from local exhaust ventilation. This obligation applies to 0032-04, 0032-05, 0096-01, and 0116-01 (with the requirement for at least annual monitoring of occupational exposure and of environmental wastewater and air emissions) as well as to 0043-02, 0044-02, 0045-02 (with the requirement for annual monitoring of occupational exposure; monitoring programmes for environmental wastewater and air emissions must be implemented without an indication of frequency).	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. This obligation applies to 0032-04, 0032-05, 0096-01, 0043-02, 0044-02, 0045-02 and 0116-01.	Sites regularly review the effectiveness of risk management measures and operational conditions in place.
The AHs and the DUs ensure that there is no chromium (VI) above the detectable level present in articles for supply to the general public. This obligation applies only to 0032-05, not to 0032-04, 0096-01, 0043-02, 0044-02, 0045-02 and 0116-01.	No articles treated by chemical conversion coating are supplied to the general public.
If an authorisation holder submits a review report, it shall include a detailed guidance on how to select and apply risk management measures and a refined assessment of the exposure to chromium (VI) of humans via the environment (HvE), as well as of the resulting risks. This assessment shall be performed using a higher-tier exposure assessment model going beyond the default assumptions of the Guidance on Information Requirements and Chemical Safety Assessment and of the European Union System for the Evaluation of Substances (EUSES) model and making use of site-specific emission information. All reasonably foreseeable routes of exposure of humans via the environment, including the oral route, shall be included in the assessment. This obligation applies to 0032-04, 0032-05, 0096-01, 0043-02, 0044-02, 0045-02 and 0116-01.	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.

Initial application	Current application
Mechanical ventilation shall be used for machining activities in small work areas, except in cases where mechanical ventilation would introduce risks (e.g., local spark risk) or would otherwise not be technically and practically possible. This obligation applies only to 0096-01, and 0116-01 and not to 0032-04, 0032-05, 0043-02, 0044-02, or 0045-02.	Typically, machining activities take place where mechanical ventilation is available. The conditions of use relevant for machining activities are given in section 9.2.3.7.
Effective cleaning practices shall be implemented to prevent surface contamination around treatment baths and other equipment, in the vicinity where machining activities take place, and where solid chromates are handled. This obligation applies only to 0096-01, and 0116-01 and not to 0032-04, 0032-05, 0043-02, 0044-02, or 0045-02.	Effective cleaning practices are implemented, as described in the exposure scenarios of this use in sections 9.2.3.2 to 9.2.3.8.
AH and DU shall restrict the area in which activities involving the use of solid chromates are conducted either physically by means of barriers or by means of a strict procedure during the activity and for a specified time after the operation. This obligation applies only to 0096-01 and not to 0032-04, 0032-05, 0043-02, 0044-02, 0045-02 or 0116-01.	The treatment baths area access is controlled and only trained personnel are allowed to be in this area as described under organisational measures in section 9.2.2.3.1.2.
AH and DU shall perform decanting and mixing of liquids in a dedicated area, with controlled access, by trained workers, following procedures established based on appropriate task-based risk assessment. This obligation applies only to 00116-01 and not to 0032-04, 0032-05, 0096-01, 0043-02, 0044-02, or 0045-02.	Only trained workers are allowed to perform decanting and mixing of products in a dedicated workplace, as described in the exposure scenarios of this use.

Enforcement activities by Member State Enforcement Authorities

The authorisation holder of authorisation REACH/20/1/3 was contacted in 2021 by a national REACH enforcement authority (The Netherlands) and asked to provide additional information in the SDS, in particular regarding the key functionalities as identified in the authorisation dossier. The information was provided by the authorisation holder.

A DU site was inspected by a national REACH enforcement authority (Hungary) in 2021 to consider the compliance with a REACH authorization governing the use of Chromium Trioxide (REACH/20/18/18). Several items were considered (reviewed SDS of material, authorisation documentation, exposure scenarios and monitoring results, medical monitoring). The report issued by the national authority concluded that there were no non-conformities.

Chemical conversion coating	CT, SD, PD, and/or DtC

9.2.1.2 Overview of use and exposure scenarios

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

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

1) This review report has a much narrower scope than the initial applications to provide more meaningful use descriptions. The use covered by this review report is limited to *Chemical conversion coating using chromium trioxide, sodium dichromate, potassium dichromate, and/or dichromium tris(chromate) in aerospace and defence industry and its supply chains* while the initial applications 0032-04 (REACH/20/18/14 - REACH/20/18/16 - REACH/20/18/18), 0032-05 (REACH/20/18/21 - REACH/20/18/23 - REACH/20/18/25), 0096-01 (REACH/19/29/0), 0043-02 (REACH/20/5/3 - REACH/20/5/5), 0044-02 (REACH/20/3/1), 0045-02 (REACH/20/1/3) and 0116-01 (REACH/20/10/0) each cover a multitude of surface treatments and substrates.

2) In this review report we have identified similar exposure groups (SEGs) of workers for the uses considered here, and the SEGs are described in separate worker contributing scenarios (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 9-12). Each contributing scenario covers the relevant processes and individual tasks performed by the respective group of workers in relation to the use and describes the operating conditions (OCs) and risk management measures (RMMs) for the individual tasks involving Cr(VI) exposure. The Cr(VI) exposure from these activities is quantified by personal air measurements. In this way, Cr(VI) inhalation exposures from all relevant tasks performed by a SEG during its daily work are considered and combined for risk assessment.

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

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

Due to differences in the structure of the current and initial applications, in especially due to the assignment of tasks to SEGs, a direct comparison is not easy to perform. Table 9-12 provides an overview on major differences between the review report and the initial applications. In the first column, the PROCs assigned to different SEGs are shown. The PROCs from the initial applications corresponding to these tasks are listed in the second column. Deviations between the consideration of PROCs are described as remarks in the third column.

Table 9-12: Activities and descriptors in current and initial applications

Chemical conversion coating CT, SD, PD, and/or DtC

Current application	Initial applications [b]	Remarks
ECS 1 – Chemical conversion coating – use at industrial site leading to inclusion (of Cr(VI) or the reaction products) into/onto article ERC 5	ERC 6b - Other surface treatment ERC 6b - Use of chromium trioxide for chemical conversion ERC 6b - Surface treatment	For this use, ERC 5 is considered more appropriate, as it cannot be excluded that small amounts of Cr(VI) remain in/on the surface
WCS 1 – Line operators [a] PROC 9, PROC 13, PROC 28	PROC 2, 13 – Surface treatment by dipping/immersion PROC 13 – Filling of parts PROC 8b – Cleaning of equipment PROC 13 – Rinsing/drying PROC 15 – Laboratory analysis (sampling, laboratory analysis)	For surface treatment by dipping/immersion only PROC 13 is regarded appropriate in the current application, PROC 2 is not considered adequate For cleaning, PROC 28 is regarded more appropriate in the current application For sampling, PROC 9 is regarded more appropriate in the current application, PROC 15 is not considered adequate
WCS 2 – Brush and pen application operators [a] PROC 9, PROC 10	PROC 10 – Surface treatment by brushing or pen-stick use	For solution preparation for brush or swab application, PROC9 is regarded as appropriate
WCS 3 – Storage area workers [a] PROC 5, PROC 8b, PROC 28	PROC 5 – Mixing of solids/liquids PROC 8b – Re-filling of baths – solids/liquids PROC 8b – Decanting of liquids PROC 8b – Measuring and weighing of solids PROC 8b – Cleaning of equipment PROC 8b – Waste management	For cleaning PROC 28 is regarded more appropriate in the current application
WCS 4 – Laboratory technicians [a] PROC 15	PROC 15 – Laboratory analysis (sampling, laboratory analysis)	
WCS 5 – 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 6 – Machinists [a] PROC 21, PROC 24	PROC 21, 24 – Machining operations	

Current application	Initial applications [b]	Remarks
WCS 7 – 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 – Un-/loading and cleaning of jigs PROC 1 – Storage of articles PROC 8a – End of Life PROC 26 – Drying/curing	No exposure is expected from these processes in the current application; cleaning of jigs is covered in WCS 1 under cleaning of equipment (PROC 28)
Not considered relevant in this review report, as these activities are not part of the use described in this review report (but may be relevant for other surface treatments)	PROC 7 – Surface treatment by spraying PROC 13 – Chemical pre-/post-treatment	Not relevant for the scope of this use

[a] For descriptions of tasks assigned to the individual PROCs see worker contributing scenarios in sections 9.2.3.2 to 9.2.3.8.

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

The exposure scenarios and contributing scenarios of this review report are shown below in Table 9-13.

9.2.1.2.2 Scope of use – supply chain considerations

This CSR covers the use of CT, SD, PD, and/or DtC for chemical conversion coating in the aerospace and defence industry and its supply chains. This use is performed in the European Economic Area (EEA) and in the United Kingdom (UK) in exclusively industrial settings in the following levels of the supply chain:

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

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

The use of CT, SD, PD and/or DtC for chemical conversion coating typically involves one environmental contributing scenario for the use of these chromates at an industrial site.

Table 9-13 lists all the exposure scenarios (ES) and contributing scenarios assessed in this CSR.

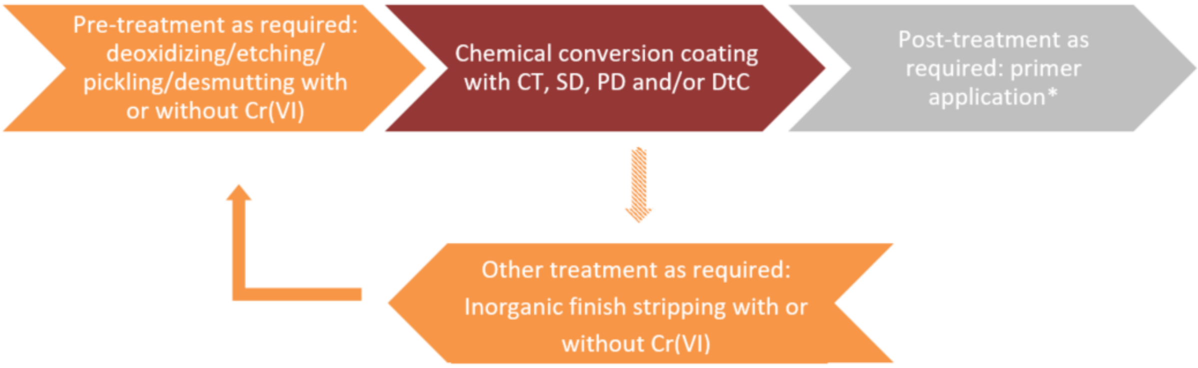
Table 9-13: Overview of exposure scenarios and their contributing scenarios

ES number	ES Title	Environmental release category (ERC)/ Process category (PROC)
ES1-IW1	Chemical conversion coating – use at industrial site	
Environmental contributing scenario(s)		
ECS 1	Chemical conversion coating - use at industrial site leading to inclusion (of Cr(VI) or the reaction products) into/onto article	ERC 5
Worker contributing scenario(s)		
WCS 1	Line operators	PROC 9, PROC 13, PROC 28
WCS 2	Brush and pen application operator	PROC 9, PROC 10
WCS 3	Storage area workers	PROC 5, PROC 8b, PROC 28
WCS 4	Laboratory technicians	PROC 15
WCS 5	Maintenance and/or cleaning workers	PROC 28
WCS 6	Machinists	PROC 21, PROC 24
WCS 7	Incidentally exposed workers	PROC 0
Exposure scenario for industrial end use at site: ES1-IW1		

9.2.1.2.3 Relationship between uses

Chemical conversion coating with CT, SD, PD, and/or DtC may be combined with Cr(VI)-containing pre-treatment(s) like deoxidizing, etching, pickling or desmutting, or other Cr(VI)-free pre-treatments like alkaline cleaning, aqueous degreasing, solvent cleaning, etc.. Usually chemical conversion coating is not combined with any specific Cr(VI) post-treatment, but can be followed by paint or primer application with or without Cr(VI). Inorganic finish stripping can also be required in case of defective finishing or as part of rework processes (see Figure 9-1), as well as mechanical stripping (e.g., blasting, sand paper stripping). For the combination with deoxidizing, etching, pickling or desmutting pre-treatments with CT or SD, or with inorganic finish stripping with CT, all details on the processes are described in the respective CSR (see ADCR dossiers “Pre-treatments: deoxidising, pickling, etching and/or desmutting” and “Inorganic finish stripping”).

Chemical conversion coating CT, SD, PD, and/or DtC



* Primer application with or without Cr(VI) not concerned by this review report

Figure 9-1: Schematic presentation of treatment steps

9.2.2 Detailed information on use

9.2.2.1 Process description

Chemical conversion coating, abbreviated CCC, also called chromate conversion coating, is used to improve corrosion resistance and/or to promote adhesion to subsequent layer as primer or paint while ensuring electrical conductivity. CCC is applied as a main treatment on plain metal substrates mainly. In a similar process, called "Passivation of (non-Al) metallic coatings", Cr(VI) is used for post-treatment of metallic coated parts. This use is described in a separate review report.

CCC is a chemical, non electrolytical process, typically carried out by immersion of a metallic part in an aqueous solution containing dissolved chromates, together usually with acid compounds such as sulphuric acid or nitric acid (Figure 9-2). A chemical reaction occurs between the metallic surface of the part and the bath solution, "converting" the natural oxide present on the substrate in a fixed and insoluble surface film. This surface layer consists in a complex of oxides and hydroxides of chromium and metal, forming an integral part of the metallic surface. There is a simultaneous oxidation of the metal and reduction of Cr(VI) to Cr(III). The result is a protective layer (active corrosion inhibition) based on chromate anions, absorbed in the metal oxide layer. The thickness of the coating is typically between 0.05 to 2 µm. CCC can be applied to repair or protect an anodized metallic part, mainly on aluminium substrate, the applied chromate oxidizes the injured part to form again chemically inert aluminium oxide.

CCC process can also be performed either by filling parts (cavities), or as a local treatment on small localised areas, or for touch-ups, in case of repair of a metallic part surface. For local treatments, the application is made by brush, swab, wipe, syringe or pen-stick (Figure 9-3).

Some Cr(VI) may remain trapped in the surface layer. Consequently, subsequent machining activities on treated parts which may generate Cr(VI) containing dust, are included in the exposure assessment of this CSR.

The key functionalities of CCC are detailed in the Analysis of alternatives (AoA) report.

Chemical conversion coating CT, SD, PD, and/or DtC

Typically, the treatment baths for CCC 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 CCC solution from the part(s).

CCC by local application can be performed in several areas, on a workbench, close to the immersion process lines or in a dedicated room. Touch-ups can also be carried in the field, e.g., in machining or mechanical workshops, or inside or outside the aircraft hangar.

Figure 9-2: Chemical conversion coating bath

Chemical conversion coating	CT, SD, PD, and/or DtC

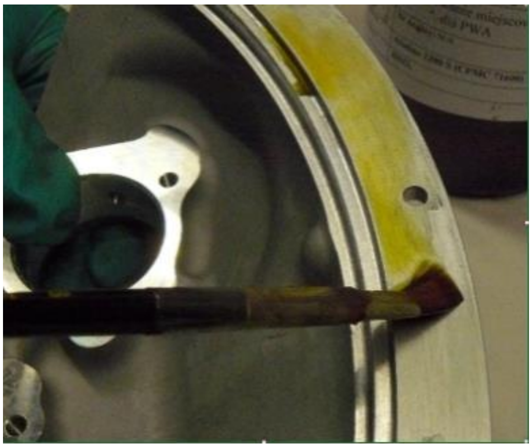


Figure 9-3: Touch-up with a paintbrush

<u>Substrate(s)</u>

CCC is usually performed on aluminium or magnesium alloys as a main treatment (> 95% of cases), and more rarely on cadmium, brass or titanium parts.

<u>Differences between chromates</u>

Either CT, SD, PD, DtC or a mixture of thereof can be used for CCC in the aerospace and defence industry and its supply chains. The four chromates do not differ in terms of functionality for this use. The reason either one or the other is used is, in most cases, due to that particular chromate being defined in the customer specifications for a particular component and/or application; such a customer specification often has a historical or empirical background.

When no specification is given by a client, the choice of the chromate is often based on practical reasons, e.g., because a site prefers to use one of the four chromates for other processes as well, and/or the handling of one of the four products is preferred.

Aluminium is usually treated by CT aqueous solutions whereas SD and/or PD aqueous solutions are mainly applied on magnesium substrates. DtC is mainly used for touch-ups, using a "ready-to-use" pen-stick for application on aluminium substrate.

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 CCC:

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

Chemical conversion coating	CT, SD, PD, and/or DtC

9.2.2.3 Technical and organisational risk management measures

All sites that perform CCC 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:

- Requirement for SD, and PD: Closed systems and automation are used for tasks involving measuring and weighing of solids, where possible.
- Requirement for DtC: decanting and mixing of liquids is performed in a dedicated area, with controlled access by trained workers, following procedures established based on appropriate task-based risk assessment.
- Requirement for CT, SD, PD and DtC: Where use of closed systems and automation is not possible, local exhaust ventilation (LEV) systems that are appropriately designed, dimensioned, located and maintained to capture and remove the substances are used. Technical information on the LEV systems used is given for the respective worker contributing scenarios in sections 9.2.3.2 to 9.2.3.8.
- Requirement for CT, SD, PD and DtC: Mechanical ventilation is used for machining activities in small work areas, except in cases where mechanical ventilation would introduce risks (e.g., local spark risk) or would otherwise not be technically and practically possible.
- Requirement for DtC: When relevant and technically and practically possible, waste management activities are conducted under a LEV. Cases where this is not technically and/or practically possible are described and justified in the respective worker contributing scenarios in sections 9.2.3.2 to 9.2.3.8.

Efficiency of LEV

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

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

9.2.2.3.1.2 Organisational measures

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

- Annual monitoring programmes are implemented for air monitoring of occupational exposure to Cr(VI), which are representative of the range of tasks undertaken where exposure to Cr(VI) is possible, including tasks involving process and maintenance operations (requirement for CT, SD, PD and DtC) as well as machining activities (requirement for SD, PD and DtC).
- 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.
- Requirement for SD, PD and DtC: Appropriate standard operating procedures are implemented to minimise release of dust into the air during the preparation, transfer and storage of empty bags, filters, and other process waste, in accordance with the hierarchy of control provisions set out in Article 5 of Directive 2004/37/EC.
- LEV systems are inspected and maintained according to the manufacturer's specification.
- Standard procedures are available for use and maintenance of respiratory protective equipment (RPE) (including procedures for fit testing of RPE masks which are applied in accordance with relevant standards).
- The provision of PPE for the workers is organised by a designated responsible person.
- The conditions of the PPE are checked regularly.
- A program of PPE management is implemented on site which includes PPE selection, training for correct wearing/removal of the PPE, storage of PPE, cleaning or renewal and distribution of the PPE, communication via workplace signage or working instructions at the workplace.
- Training on chemical risks is periodically done for workers handling chemicals. Safety Data Sheets and instructions for hazardous chemicals handling are available.
- Training at the workplace is given periodically and work instructions are available on how to carry out specific tasks through standard operating procedures.
- Cleaning of company supplied uniforms is organised by the site, or contaminated clothes are renewed.
- In the production area reducing chemicals are available, which are suitable to remove Cr(VI) from the skin (e.g., ascorbic acid, formation of Cr(III), which can be washed off easily).
- Small splashes or amounts are taken up with wipes. Wipes are disposed of as solid waste.
- Chemical products are stored in a designated area.
- Effective cleaning practices are implemented to prevent surface contamination around treatment baths and other equipment, and in the vicinity where machining activities take place, and where solid chromates are handled.
- At some sites, water in rinsing tanks is recirculated and regularly tested for conductivity. When a certain conductivity limit is exceeded, the rinse water is treated as wastewater and renewed in the

rinsing tanks. This prevents elevated Cr(VI) concentrations from being present in the rinsing tanks in the working area.

9.2.2.3.1.3 Personal Protective Equipment

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

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

Use of Assigned Protection Factors (APFs) throughout this CSR

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

The specific PPE for each task is described in detail in the worker contributing scenarios in sections 9.2.3.2 to 9.2.3.8.

9.2.2.3.2 Environment

9.2.2.3.2.1 Emissions to air

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

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

9.2.2.3.2.2 Emissions to wastewater

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

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

- Wastewater is sent to a reduction facility (typically on-site), where Cr(VI) in wastewater is reduced to Cr(III) by addition of a reducing agent (e.g., sodium bisulfite or ferrous sulfate). After the reduction process, Cr(III) is precipitated and separated from the wastewater by a filter press (the filter cake is disposed as waste), and the treated wastewater is, either evaporated, reused on site, or discharged to a wastewater treatment plant (WWTP), municipal sewage treatment plant (STP), in accordance with local regulatory requirements.
- Regular monitoring programmes for Cr(VI) releases 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, soiled brushes, syringes, and swabs, used sandpaper, empty touch-up pens, 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) or other material from touch-up activities (soiled brushes, swabs, syringes, pens, sandpaper, …) are usually disposed of as hazardous waste unless they are cleaned prior to their disposal (if they are cleaned, they are disposed as non-hazardous solid waste). The hazardous solid waste is stored in closed drums and containers and sent to an external waste management company (licensed contractor) for disposal.

9.2.2.4 Tonnages and mass balance considerations

9.2.2.4.1 Tonnages

Assessed tonnage: 0 to 332 kg Cr(VI)/year per site based on:

0 to 500 kg CT used per year per site, thereof up to 260 kg Cr(VI

0 to 250 kg SD used per year per site, thereof up to 100 kg Cr(VI)

0 to 210 kg PD used per year per site, thereof up to 73.5 kg Cr(VI)

0 to 10 kg DtC used per year per site, thereof up to 5.8 kg Cr(VI)

The upper Cr(VI) tonnage/year has been estimated based on sites using several chromates for CCC. This may be an overestimation for sites using only one chromate.

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 serves as a process aid to build the protective chromium oxide layer on the surface of the component. Cr(VI) is reduced to Cr(III) in this process. Chromate-containing baths are kept for long periods and consumed chromate is replenished. For local application, solutions are either ready-to-use or prepared, in quantity needed for the surface to be treated or in larger quantity then stored in a container to be periodically refilled. Consumed ready-to-use touch-up pens are replaced and disposed of as hazardous waste.

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 a STP or WWTP, is between 0 and 0.247 kg per year (as described in Annex III).

Amount of Cr(VI) discharged as waste

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

Amount of Cr(VI) released via fugitive emissions

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

Amount of Cr(VI) released to the atmosphere

The exhaust air from treatment baths which is released via exhaust stacks is between 7E-06 and 0.502 kg per year (as described 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: "Chemical conversion coating using chromium trioxide, sodium dichromate, potassium dichromate, and/or dichromium tris(chromate) in aerospace and defence industry and its supply chains"

Market sector: -

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

Article categories: not relevant

Environment contributing scenario(s): ERC 5

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

Subsequent service life exposure scenario(s): not relevant

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

CCC using CT, SD, PD and/or DtC by immersion and local application (see detailed use information in section 9.2.2).

Explanation on the approach taken for the ES:

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

Exposure from service life of treated articles:

CCC is performed on the surface of metallic parts of various size, which may sometime be subject to painting, dry film lubricant or primer application afterwards with or without Cr(VI).

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

9.2.3.1 Environmental contributing scenario 1

As CT, SD, PD, and DtC are 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 9-14: Conditions of use – environmental contributing scenario 1

Product (article) characteristics
Product A: Solid CT (flakes or powder), pure substance or mixture (up to 100%); **max. 52% Cr(VI)**
Product B: Solid SD (flakes or powder), pure substance (100%); **40% Cr(VI)**
Product C: Solid PD (flakes or powder), pure substance (100%); **35% Cr(VI)**
Product D: Aqueous solution of CT as purchased (0.1-50% CT (w/w)); **max. 26% (w/w) Cr(VI)**
Product E: Aqueous solution of SD as purchased (10-30% SD (w/w)); **max. 12% (w/w) Cr(VI)**
Product F: Aqueous solution of PD as purchased (0.1-0.25% PD (w/w)); **max. 0.09% (w/w) Cr(VI)**
Product G: Aqueous solution of DtC as purchased (0.1-1% DtC (w/w)); **max. 0.58% (w/w) Cr(VI)**
Product H: Aqueous solution of CT and DtC as purchased (5-10% CT; 1-5% DtC (w/w)); **max. 8.1% (w/w) Cr(VI)**
Product I: Aqueous solution of SD and PD as purchased (0.25-2.5% SD; 0.1-1% PD (w/w)); **max. 1.35% (w/w) Cr(VI)**
Amount used, frequency and duration of use (or from service life)
Product A: Solid CT (flakes or powder), used to prepare aqueous solutions for immersion baths or for local application ▪ Daily use at site: up to 0.712 g/day [as Cr(VI)] ▪ Annual use at a site: up to 260 kg/year [as Cr(VI)] ▪ Batch process ▪ 365 days/year (see section 9.1.2.4)
Product B: Solid SD (flakes or powder), used to prepare aqueous bath solutions ▪ Daily use at site: up to 280 g/day [as Cr(VI)] ▪ Annual use at a site: up to 100 kg/year [as Cr(VI)] ▪ Batch process ▪ 365 days/year (see section 9.1.2.4)
Product C: Solid PD (flakes or powder), used to prepare aqueous bath solutions ▪ Daily use at site: up to 210 g/day [as Cr(VI)] ▪ Annual use at a site: up to 73.5 kg/year [as Cr(VI)] ▪ Batch process ▪ 365 days/year (see section 9.1.2.4)
Product D: Aqueous solution of CT as purchased, used to prepare aqueous solutions for immersion baths or for local application ▪ Daily use at site: up to 570 g/day [as Cr(VI)] ▪ Annual use at a site: up to 208 kg/year [as Cr(VI)] ▪ Batch process

▪ 365 days/year (see section 9.1.2.4)
Product E: Aqueous solution of SD as purchased, used to prepare aqueous bath solutions ▪ Daily use at site: up to 23 g/day [as Cr(VI)] ▪ Annual use at a site: up to 8.4 kg/year [as Cr(VI)] ▪ Batch process ▪ 365 days/year (see section 9.1.2.4)
Product F: Aqueous solution of PD as purchased, used to prepare aqueous solutions for local application ▪ Daily use at site: up to 8.2 g/day [as Cr(VI)] ▪ Annual use at a site: up to 3 kg/year [as Cr(VI)] ▪ Batch process ▪ 365 days/year (see section 9.1.2.4)
Product G: Aqueous solution of DtC as purchased, ready-to-use pen-stick for local application ▪ Daily use at site: up to 14.2 g/day [as Cr(VI)]V ▪ Annual use at a site: up to 5.2 kg/year [as Cr(VI)] ▪ Batch process ▪ 365 days/year (see section 9.1.2.4)
Product H: Aqueous solution of CT and DtC as purchased, used to prepare aqueous solutions for local application ▪ Daily use at site: up to 45 g/day [as Cr(VI)] ▪ Annual use at a site: up to 16.2 kg/year [as Cr(VI)] ▪ Batch process ▪ 365 days/year (see section 9.1.2.4)
Product I: Aqueous solution of SD and PD as purchased, used to prepare aqueous solutions for local application ▪ Daily use at site: up to 8.2 g/day [as Cr(VI)] ▪ Annual use at a site: up to 3 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 - Exhaust air is treated in wet scrubbers or by air filters before it is released via stack(s)[6]

[6] For operations where exposure potential is low (i.e. operations are infrequent using only small quantities of Cr(VI)), air emission abatement may not be required.

- Wastewater
  - Wastewater occurs from bath solutions (depending on the site and the Cr(VI) concentration), water from drag-out tanks, rinsing water, cleaning water, liquid from secondary containment pits, water from wet scrubbers and liquid hazardous waste from the laboratory
  - Cr(VI)-containing wastewater is gathered and, either directly sent to an external company certified for disposing of liquid hazardous waste, recycled after evaporation in an on-site evaporation system (the residue is discharged as hazardous solid waste or liquid waste), and/or treated on-site in a reduction facility, where Cr(VI) in wastewater is reduced to Cr(III) by addition of a reduction agent (e.g., sodium bisulfite or ferrous sulfate), followed by neutralisation and precipitation of Cr(III)
  - Reduced wastewater is, either re-used on site, sent to a wastewater treatment plant (WWTP) or municipal sewage treatment plant (STP) (depending on local regulatory requirements)
- Soil
  - The indoor and outdoor surfaces where chemicals are handled are sealed and if chemicals and solid waste containing Cr(VI) are stored outside then it is only in closed containers
  - Tanks are surrounded by secondary containment pits, and liquids collected in the pit are sent to the wastewater collection tank

- **Organisational conditions and measures**
  - Air
    - Cr(VI) air emission measurements are regularly performed at identified exhaust stack(s) where the process emissions are released
  - Wastewater
    - Reduction of Cr(VI) in wastewater is controlled regularly by Cr(VI) measurements
    - Batches of reduced wastewater are discharged only after confirmation of Cr(VI) reduction to a concentration below the permitting limit (in accordance with the local regulatory requirements)

Conditions and measures related to sewage treatment plant

All products:

- Biological (municipal) STP: Standard STP or onsite treatment plant (removal rate: 50% to sludge assumed, see description in section 9.1.2.4)
- Sludge application to agricultural soil: in most cases not; however, as it is not ascertained in all cases, for a conservative assessment sludge application is assumed
- Discharge rate STP: 2 000 m^3/day (by model default if no site-specific data available)
- Dilution factor for receiving water body: 10 (by model default if no site-specific data available)

Conditions and measures related to treatment of waste (including article waste)
All products: ▪ Filter cake from the wastewater reduction plant only contains Cr(III) (since, even if the reduction were incomplete, residual Cr(VI) is readily soluble in water and would be found in the water phase) and is forwarded to an external waste management company (licensed contractor) for disposal as waste. ▪ Other solid hazardous waste contaminated with Cr(VI) such as contaminated wipes, rags, and PPE (e.g., gloves, overalls, aprons), contaminated equipment or empty chemical containers (canisters, bags, drums) or other material from touch-up activities (soiled brushes, swabs, syringes, pens, sandpaper, …) 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 (licenced contractor) for disposal as hazardous waste.
Other conditions affecting environmental exposure
All products: ▪ Process temperature of the treatment baths (room temperature to 105°C)
Additional good practice advice. Obligations according to Article 37(4) of REACH do not apply
▪ None

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

Air emissions

The CCC process is carried out in treatment baths at temperatures between room temperature and 105 °C and with Cr(VI) concentrations of up to 14.6% (a detailed description is given in section 9.2.3.2). At some sites, baths operating at higher temperatures are covered with lids to reduce evaporation and air emissions when the bath is not in use. Cr(VI) emissions to air generated during the treatment process are captured by LEV systems connected to the treatment baths. The exhaust air is then either treated in a wet scrubber (Figure 9-4 a + b) or by air filters. In stacks receiving exhaust air from baths with higher Cr(VI) concentrations and/or elevated temperatures Cr(VI) emissions to the environment are typically monitored in regular intervals at the sites. However, in stacks receiving only exhaust air from baths with lower Cr(VI) concentrations and/or low temperatures Cr(VI) emissions to the environment are not monitored at some sites.

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

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

Figure 9-4: 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 or brushes)
- liquid from secondary containment pits
- water from wet scrubbers
- liquid hazardous waste from samples processed in the laboratory

At some sites, the bath solutions may also be collected and sent to an external waste management company (licensed contractor) (depending on the site and the Cr(VI) concentration). At sites where wastewater is recycled 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 9-5 a). The precipitated Cr(III) is then separated from the wastewater by a filter press (Figure 9-5 b) and the filter cake is disposed by a certified waste handling company. In the reduced wastewater the Cr(VI) content is usually measured with a photometric method to confirm sufficient reduction in accordance with the permitted limit before the wastewater is sent either to a wastewater treatment plant (WWTP) or municipal sewage water treatment plant (STP). In addition to the photometric determination of Cr(VI) in wastewater on-site, the Cr(VI) concentration in reduced wastewater is at many sites also determined in regular intervals by external laboratories, whereby often more sensitive analytical methods are used, allowing the detection of very low Cr(VI) concentrations in wastewater.

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

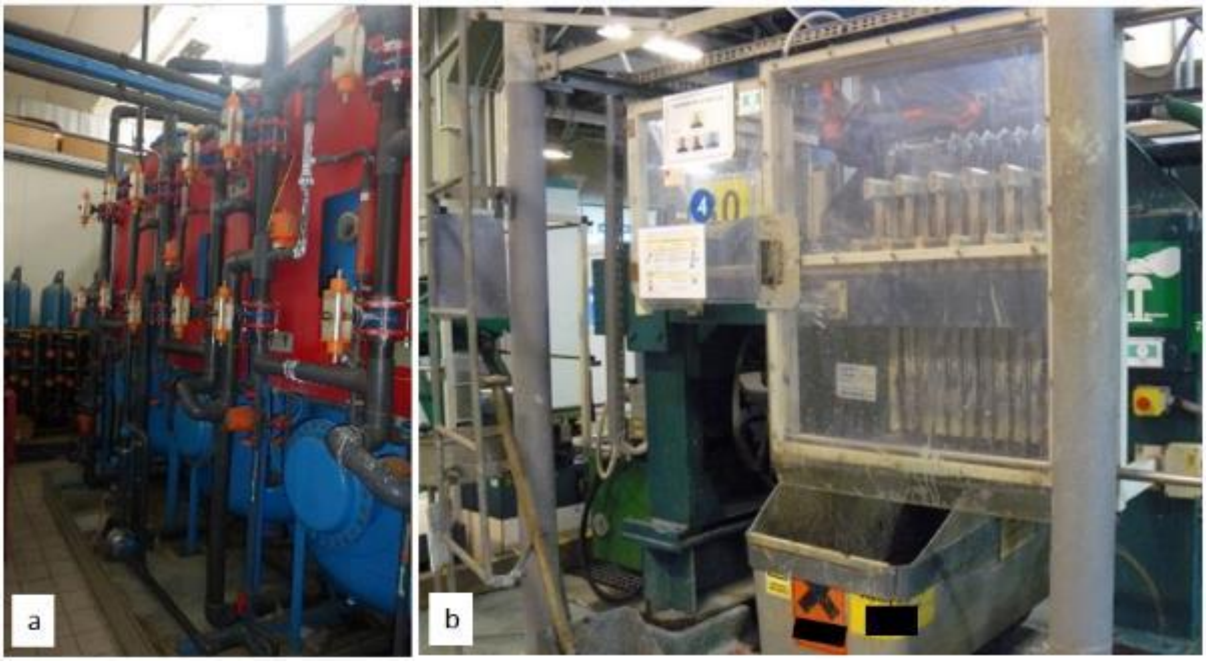


Figure 9-5: **Water deionisation tanks for wastewater treatment (a) and filter press for separation of the filter cake (b)**

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. Emissions measured at sites are usually Cr(VI) originating from all chromates used at the site and no differentiation between substances is possible. 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 CCC. This share was determined by dividing the Cr(VI) amount used for CCC by the total Cr(VI) amount contributing to the measured emission (i.e., used for all uses contributing to the measured emission).

Twenty-four sites performing CCC with CT and/or SD and/or PD provided site-specific emission data for environmental emission modelling. Among these 24 sites, 20 are in six different countries in the EEA and four sites are in the UK. Most of these sites perform additional surface treatments with Cr(VI) that contribute to air and water emissions (if any).

No data on environmental emissions related to the use of DtC only is available. Indeed, the use of this substance with the pen-stick for touch-up application does not lead to any water emissions and air emissions are expected to be very low (or even negligible) considering the very low volatility of DtC, the small quantities involved (ca 0.2 g Cr(VI) per pen) and the application process. For those sites performing CCC with touch-up pen in addition to other processes (immersion and/or brush), releases from DtC will contribute only minimally to the total environmental releases of the site.

Table 9-15 shows ranges of release fractions and total emissions from the sites. These release fractions served as input for EUSES modelling of human exposure via the environment. Note that the calculated release fractions to wastewater refer to the emissions after the on-site reduction step.

We point out that **these results represent the overall releases of the sites, among which in each case only a certain share is generated by CCC**. The calculation of the share of exposure from CCC (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 CCC in the overall emission are given in Annex III of this CSR.

Table 9-15: Local releases to the environment

Release route	Release fraction [a]	Release [kg/year] [a]	Explanation/Justification
Air [b]	4.93E-07 – 1.80E-02 90th percentile: 8.35E-03	0.00001 – 43.1 90th percentile: 6.43	Measured release (site-specific data)
Water [b]	0 – 5.60E-02 90th percentile: 3.27E-03	0 – 3.57 90th percentile: 1.14	Measured release (site-specific data)
Soil	0	0	No release to soil

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

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

One large site (Site 4) has a high air emission (43.1 kg/year) which is at least one order of magnitude higher than air emissions from other sites while the release fraction to air (9.30E-03) is comparable to that of other sites. Thus, the air emission of this site is much higher than the 90th percentile over the air releases from all sites. Nevertheless, as only a small fraction of the air emission of this site is related to CCC, the total risk from environmental emissions from this site is mitigated but still constitutes the upper range of total risks from all sites (see below).

Two sites (Site 8 and Site 20) have high water emissions (2.96 and 3.57 kg/year respectively) which are at least one order of magnitude higher than water emissions from other sites. This is explained for the first site (Site 8) by its high use tonnage (> 10t/y) and for the second site (Site 20) by its high release fraction to water (5.60E-02) which is the highest of all other sites. Thus, the water releases of these two sites are much higher than the 90th percentile calculated over the releases from all sites. However, as only a small fraction of the water emission is related to CCC for site 8 and as only a small quantity of Cr(VI) is used at site 20 (<70 kg/y), the total risk from environmental emissions for these two sites related to CCC are at the lower end of the range of total risks from all sites (see Table 9-16 below).

It has to be noted that seven out of the 24 sites have no Cr(VI) emissions to water as all contaminated water is gathered and sent to an external waste management company (licensed contractor) for disposal.

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

Releases to waste

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

Release fraction to waste from the process: 0

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

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

The calculation of the share of exposure from CCC is shown below in Table 9-16. Note that even for sites without emission to wastewater EUSES calculates oral exposure via deposition from air.

Table 9-16: Excess cancer risk estimates for humans via the environment (general population, local assessment) attributed to chemical conversion coating

	Inhalation			Oral			
Site	**Local Cr(VI) PEC in air [µg/m^3]**	**Excess lung cancer risk [1/(µg/m^3)] [a]**	**Inhalation risk**	**Oral exposure (water and fish) [µg Cr(VI)/kg x d]**	**Excess cancer risk for tumours of the small intestine [1/(µg/kg bw/day)] [b]**	**Oral risk**	**Combined risk**
Site 1	1.19E-06	2.90E-02	3.45E-08	1.32E-07	8.00E-04	1.06E-10	3.46E-08
Site 2	2.26E-06	2.90E-02	6.54E-08	5.64E-08	8.00E-04	4.51E-11	6.55E-08
Site 3	4.18E-05	2.90E-02	1.21E-06	8.13E-04	8.00E-04	6.50E-07	1.86E-06
Site 4	3.81E-04	2.90E-02	1.11E-05	9.44E-06	8.00E-04	7.55E-09	1.11E-05
Site 5	9.27E-06	2.90E-02	2.69E-07	6.09E-07	8.00E-04	4.87E-10	2.69E-07
Site 6	5.48E-07	2.90E-02	1.59E-08	1.43E-08	8.00E-04	1.15E-11	1.59E-08
Site 7	5.80E-06	2.90E-02	1.68E-07	1.44E-07	8.00E-04	1.15E-10	1.68E-07
Site 8	1.52E-05	2.90E-02	4.39E-07	7.99E-06	8.00E-04	6.39E-09	4.46E-07
Site 9	4.28E-06	2.90E-02	1.24E-07	1.06E-07	8.00E-04	8.48E-11	1.24E-07
Site 10	2.54E-07	2.90E-02	7.36E-09	6.38E-09	8.00E-04	5.10E-12	7.36E-09
Site 11	3.46E-04	2.90E-02	1.00E-05	8.93E-06	8.00E-04	7.14E-09	1.00E-05
Site 12	3.47E-05	2.90E-02	1.01E-06	8.65E-07	8.00E-04	6.92E-10	1.01E-06
Site 13	1.98E-06	2.90E-02	5.75E-08	4.91E-08	8.00E-04	3.93E-11	5.76E-08
Site 14	4.46E-05	2.90E-02	1.29E-06	1.11E-06	8.00E-04	8.86E-10	1.29E-06
Site 15	1.71E-06	2.90E-02	4.95E-08	4.23E-08	8.00E-04	3.38E-11	4.95E-08
Site 16	8.26E-09	2.90E-02	2.39E-10	7.26E-07	8.00E-04	5.80E-10	8.20E-10
Site 17	2.11E-07	2.90E-02	6.12E-09	5.49E-08	8.00E-04	4.39E-11	6.16E-09

	Inhalation			Oral			
Site	**Local Cr(VI) PEC in air [µg/m³]**	**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**
Site 18	3.82E-04	2.90E-02	1.11E-05	9.49E-06	8.00E-04	7.59E-09	1.11E-05
Site 19	5.14E-09	2.90E-02	1.49E-10	1.46E-10	8.00E-04	1.17E-13	1.49E-10
Site 20	1.10E-06	2.90E-02	3.18E-08	4.35E-05	8.00E-04	3.48E-08	6.66E-08
Site 21	9.55E-07	2.90E-02	2.77E-08	1.82E-06	8.00E-04	1.45E-09	2.91E-08
Site 22	6.61E-09	2.90E-02	1.92E-10	1.32E-07	8.00E-04	1.06E-10	2.97E-10
Site 23	1.71E-04	2.90E-02	4.97E-06	3.76E-04	8.00E-04	3.01E-07	5.27E-06
Site 24	4.27E-05	2.90E-02	1.24E-06	5.36E-04	8.00E-04	4.29E-07	1.67E-06
MIN	5.14E-09		1.49E-10	1.46E-10		1.17E-13	1.49E-10
MAX	3.82E-04		1.11E-05	8.13E-04		6.50E-07	1.11E-05
Median	3.27E-06		9.48E-08	6.67E-07		5.34E-10	9.54E-08
AM	6.20E-05		1.80E-06	7.54E-05		6.04E-08	1.86E-06
90th percentile - all processes	**2.93E-04**		**8.51E-06**	**2.77E-04**		**2.21E-07**	**8.60E-06**
90th percentile - Touch-up pen only	**5.87E-06**		**1.70E-07**	**5.53E-06**		**4.42E-09**	**1.72E-07**

[a] 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 2.9×10^{-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.

As described before, the use of DtC only through touch-up pen applications is expected to lead to very low environmental emissions. Due to the lack of specific monitoring data on this particular activity, it is not possible to estimate it independently. Therefore, based on the tonnages indicated in section 9.2.2.4.1, it has been estimated that at maximum, DtC constitutes only 2%[7] of the total Cr(VI) tonnage used for CCC. In order to assess the risk for humans via the environment for those sites performing only CCC by touch-up pen with DtC, this 2% factor is applied to the 90th percentile for the combined risk of humans via inhalation and oral exposure. This constitutes a very conservative approach considering that there is no release to water and only very low air emissions are expected due to touch-up pen specific application process.

For the use CCC (all processes), the 90th percentile for the local PEC in air is 2.93E-04 µg/m^3 and the 90th percentile for the inhalation risk is 8.51E-06. The 90th percentile for oral exposure is 2.92E-04 µg Cr(VI)/kg per day and the 90th percentile for the oral risk is 2.21E-07. **The 90th percentile for the combined risk of humans via inhalation and oral exposure is 8.60E-06.** Risks span a range of several orders of magnitude, mainly caused by differences in the size of the sites and amounts of substances used.

For sites performing **CCC exclusively by touch-up pen with DtC,** the **90th percentile for the combined risk of humans via inhalation and oral exposure is 1.72E-07** (see Table 9-16, last row)**.**

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.

In Table 9-17, the RCRs for reproductive toxicity for humans via the environment are shown, based on the PECs as given in Table 9-16.

Table 9-17: RCRs for reproductive toxicity for humans via the environment

Site	Inhalation			Oral		
	Inhalation exposure [µg/m^3]	DNEL inhalation systemic long-term [µg/m^3]	RCR inhalation	Oral exposure [µg/kg x d]	DNEL oral systemic long-term [µg/kg x d]	RCR oral
Site 1	1.19E-06	11	1.08E-07	1.32E-07	17	7.78E-09
Site 2	2.26E-06	11	2.05E-07	5.64E-08	17	3.32E-09
Site 3	4.18E-05	11	3.80E-06	8.13E-04	17	4.78E-05
Site 4	3.81E-04	11	3.46E-05	9.44E-06	17	5.55E-07
Site 5	9.27E-06	11	8.43E-07	6.09E-07	17	3.58E-08
Site 6	5.48E-07	11	4.98E-08	1.43E-08	17	8.43E-10
Site 7	5.80E-06	11	5.27E-07	1.44E-07	17	8.45E-09
Site 8	1.52E-05	11	1.38E-06	7.99E-06	17	4.70E-07
Site 9	4.28E-06	11	3.89E-07	1.06E-07	17	6.23E-09
Site 10	2.54E-07	11	2.31E-08	6.38E-09	17	3.75E-10
Site 11	3.46E-04	11	3.14E-05	8.93E-06	17	5.25E-07

[7] 5.8 kg / 332 kg = 0.017, conservatively rounded up to 2%

Site	Inhalation			Oral		
	Inhalation exposure [µg/m^3]	DNEL inhalation systemic long-term [µg/m^3]	RCR inhalation	Oral exposure [µg/kg x d]	DNEL oral systemic long-term [µg/kg x d]	RCR oral
Site 12	3.47E-05	11	3.16E-06	8.65E-07	17	5.09E-08
Site 13	1.98E-06	11	1.80E-07	4.91E-08	17	2.89E-09
Site 14	4.46E-05	11	4.05E-06	1.11E-06	17	6.51E-08
Site 15	1.71E-06	11	1.55E-07	4.23E-08	17	2.49E-09
Site 16	8.26E-09	11	7.51E-10	7.26E-07	17	4.27E-08
Site 17	2.11E-07	11	1.92E-08	5.49E-08	17	3.23E-09
Site 18	3.82E-04	11	3.48E-05	9.49E-06	17	5.58E-07
Site 19	5.14E-09	11	4.67E-10	1.46E-10	17	8.58E-12
Site 20	1.10E-06	11	9.97E-08	4.35E-05	17	2.56E-06
Site 21	9.55E-07	11	8.68E-08	1.82E-06	17	1.07E-07
Site 22	6.61E-09	11	6.01E-10	1.32E-07	17	7.76E-09
Site 23	1.71E-04	11	1.56E-05	3.76E-04	17	2.21E-05
Site 24	4.27E-05	11	3.89E-06	5.36E-04	17	3.15E-05
MIN	5.14E-09		4.67E-10	1.46E-10		8.58E-12
MAX	3.82E-04		3.48E-05	8.13E-04		4.78E-05
Median	3.27E-06		2.97E-07	6.67E-07		3.93E-08
AM	6.20E-05		5.64E-06	7.54E-05		4.44E-06
90th percentile	**2.93E-04**		**2.67E-05**	**2.77E-04**		**1.63E-05**

Conclusion on risk characterisation:

Carcinogenicity

Combined risks of cancer by inhalation and by oral route from the local assessment result in an excess cancer risk of **8.60E-06 (90th percentile; range from 1.49E-10 to 1.11E-05) for sites performing all types of CCC processes and 1.72E-07 (90th percentile) for sites performing CCC exclusively with touch-up pen**. These theoretical cancer risks are based on a conservative, linear ERR. Further, due to the overly conservative nature of the predictions of the EUSES model for the local air concentrations the risk level can be considered as overestimated.

Reproductive toxicity

Risks for reproductive toxicity are negligible as RCRs for inhalation and oral exposure are orders of magnitude below 1.

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

Comparison of outcome with initial applications

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

Total exposure of humans via the environment via inhalation (90^{th} percentile for local PEC in air = 2.93E-04 µg/m^3) and oral exposure (90^{th} percentile for oral exposure from fish and drinking water = 2.77E-04 µg/kg per day) results in an estimated excess cancer risk of 8.60E-06 (90^{th} percentile for combined risk) for CCC all types of processes and of 1.72E-07 for CCC exclusively with touch-up pen.

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

Application ID	Chromate	90^{th} percentile of PEClocal air,ann [µg/m^3]	Excess lung cancer risk
0032-04	CT	0.00325	9.43E-05
0032-05	CT	0.00325	9.43E-05
0096-01	CT	3.81E-07	1.15E-08
0043-02	SD	0.00186	5.39E-05
0044-02	PD	0.00186	5.39E-05
0045-02	DtC	0.00186	5.39E-05
0116-01	DtC	4.57E-08	1.33E-09

The excess lung cancer risks in the initial applications are 9.43E-05 and 1.15E-08 for CT and 5.39E-05 for SD, PD and 5.39E-05 and 1.33E-09 for DtC. These risks are in the same range than the combined risk of 8.60E-06 as estimated for the present assessment for CCC all type of processes, which considers emissions from all substances used at a site. For CCC performed exclusively with touch-up pen (DtC), the combined risk of 1.72E-07 as estimated risk in the present assessment is in the middle range of the risks previously estimated for DtC.

9.2.3.2 Worker contributing scenario 1 – Line operators

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

Main tasks

- Task 1: Chemical conversion coating of parts by immersion or dipping, followed by rinsing and drying of parts (PROC 13)
- Task 2: Chemical conversion coating by filling of parts (PROC 13)

- Task 3: Sampling of treatment baths (PROC 9)
- Task 4: Diverse cleaning activities – cleaning of workplace, equipment, jigs (PROC 28)

Secondary tasks

- Task 5: Bath make-up and addition, including decanting of substances and mixing them with water (PROC 5, PROC 8b)
- Task 6: Bath emptying and cleaning (PROC 28)
- Task 7: Waste management – Cleaning of empty chemical containers/bags (PROC 28)
- Task 8: Waste management – Handling of solid waste (PROC 8b)
- Task 9: Aliquot chemicals – Decanting of liquids (PROC 8b)
- Task 10: Aliquot chemicals – Measuring and weighing of solids (PROC 8b)
- Task 11: Surface treatment by brush or swab application (PROC 10)
- Task 12: Surface treatment by pen-stick application (PROC 10)
- Task 13: Solution preparation for brush or swab application (decanting of liquids) (PROC 9)
- Task 14: Solution preparation for brush or swab application (measuring and weighing of solids) (PROC 9)

As Tasks 5 to 10 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 9.2.3.4).

Depending on the site organization, line operators may be involved in touch-up applications (by brush, swab, syringes or pen-stick) and in related activities such as solution preparation (Tasks 11 to 14). At other sites, these tasks are mainly performed by dedicated brush and pen application operators, typically in MRO or machinist workshops, they are described in the dedicated worker contributing scenario (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.

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 9-18 summarises the conditions of use for the activities with direct Cr(VI) exposure related to CCC carried out by line operators.

Table 9-18: Conditions of use – worker contributing scenario 1 – Line operators

Product (article) characteristics
Product 1: Aqueous solutions of CT, SD or PD for Task 1, Task 3, and Task 4 ▪ Concentration of substance in mixture: up to 14.6% (w/w) Cr(VI) for CT bath, up to 5.6% (w/w) Cr(VI) for PD bath or 8.8% (w/w) Cr(VI) for SD bath ▪ Concentration of Cr(VI) based on ranges of CT (up to 28% (w/w)) or PD (up to 16% (w/w)) or SD (up to 22% (w/w)) in the aqueous solution in the CCC bath ▪ Product type: Solids dissolved in a liquid or incorporated in a liquid matrix ▪ Viscosity: Liquids with low viscosity (like water)

Product 2: Aqueous solutions of mixture of CT and DtC for Task 2 ▪ Concentration of substances in mixture: max. 2.8% (w/w) Cr(VI) ▪ Concentration of Cr(VI) based on ranges of CT (up to 2.5% (w/w)) and DtC (up to 2.5% (w/w)) in aqueous solution, used for filling parts ▪ Product type: Solids dissolved in a liquid or incorporated in a liquid matrix ▪ Viscosity: Liquids with low viscosity (like water)
Amount used (or contained in articles), frequency and duration of use/exposure
Task 1: Surface treatment by dipping/immersion ▪ Duration of activity: <10-150 min/shift (time spent close to the bath) ▪ Frequency of task: 48-240 days per year (1-5 days/week, 48 weeks per year)
Task 2: Surface treatment by filling of parts ▪ Duration of activity: up to 120 min/shift (time spent close to the tool used for the part treatment) ▪ Frequency of task: 48-240 days per year (1-5 days/week, 48 weeks per year)
Task 3: Sampling of treatment baths ▪ Amount: 5-300 mL sample ▪ Duration of activity: 1-20 min/shift ▪ Frequency of task: 12-240 days per year (<1-5 days/week, 48 weeks per year)
Task 4: Cleaning of workplace, equipment, jigs ▪ Duration of activity: 5-50 min/shift (with low frequency of 1 x/month up to 180 min) ▪ Frequency of task: 1-240 days per year (<1-5 day/week, 48 weeks per 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: Surface treatment by filling of parts ▪ LEV: no ▪ Ventilation rate of general ventilation system: mechanical ventilation 5-6 ACH ▪ Occupational health and safety management system: advanced (see section 9.2.2.3.1.2)
Task 3: 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 4: 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 (Tasks 1 to 4), except for Task 1 on an automatic or semi-automatic line. All gloves used for the handling of chemicals are tested according to EN 374. A variety of materials are suited for protection against CT, SD, PD and DtC. The following materials have a breakthrough time ≥8h for aqueous CT solutions (10% CT) and saturated aqueous SD or PD solutions [a]: o Natural rubber/Natural latex (0.5 mm) o Polychloroprene (0.5 mm) o Nitrile rubber/Nitrile latex (0.35 mm) o Butyl rubber (0.5 mm) o Fluorocarbon rubber (0.4 mm) o Polyvinyl chloride (0.5 mm) The following materials have a breakthrough time ≥8h for aqueous CT solutions (50% CT) [a]: o Fluorocarbon rubber (0.4 mm) The following materials have a breakthrough time ≥2h for aqueous CT solutions (50% CT) [a]: o Polychloroprene (0.5 mm) o Butyl rubber (0.5 mm) o Polyvinyl chloride (0.5 mm) Type of gloves to be used for specific tasks is laid down in work instructions for the tasks.
Respiratory protection equipment RPE is worn during all tasks not performed under a LEV for which Industrial Hygiene exposure assessment confirms RPE use is required. The following types of RPE are used according to EN 529:2005 [b]: ▪ Half mask FFP3 (APF 10), half mask with P3 filter (APF 10), half mask with P3 combination filter (APF 10) or ▪ Full mask with P3 filter (APF 20), full mask with P3 combination filter (APF 20) Type of RPE to be used for specific tasks is laid down in work instructions for the tasks.
Protective clothes Chemical protective clothing must be worn during Task 1, Task 2 and Task 4. For all cleaning activities performed with a hose the workers wear an apron and waterproof boots. Type of protective clothes to be used for specific tasks is laid down in work instructions for the tasks.

Eye protection Suitable eye protection as per relevant risk assessment must be worn during all tasks (Tasks 1 to 4). Type of eye protection to be used for specific tasks is laid down in work instructions for the tasks.
Other conditions affecting workers' exposure
Task 1: Surface treatment by dipping/immersion ▪ Place of use: indoors – any size workroom ▪ Temperature: up to 105 °C (room temperature to 105 °C) ▪ Situation: Activities with open liquid surfaces or open reservoirs ▪ Open surface: up to 8 m^2 ▪ Agitation: yes (not in every case) ▪ Primary emission source proximity: The primary emission source is in the breathing zone of the worker (near field, <1 m)
Task 2: Surface treatment by filling of parts ▪ Place of use: indoors – any size workroom ▪ Temperature: room temperature ▪ Situation: Transfer of liquid products - falling liquids ▪ Flow of liquid: 1 - 10 L/min ▪ Primary emission source proximity: The primary emission source is in the breathing zone of the worker (near field, <1 m)
Task 3: Sampling of treatment baths ▪ Place of use: indoors – any size workroom ▪ Temperature: up to 105°C (room temperature to 105°C) ▪ Activity class: Activities with relatively undisturbed surfaces (no aerosol formation) ▪ Open surface: up to 8 m^2 ▪ Primary emission source proximity: The primary emission source is in the breathing zone of the worker (near field, <1 m)
Task 4: 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 VI of this report.

9.2.3.2.2 Exposure and risks for workers

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

Usually, one to three line operators work per shift on lines where CCC is performed. It must be noted that CCC is commonly not a full-time activity of the line operators assigned to the line(s) where CCC takes place. The remaining part of their shift is spent on other activities related to the lines (e.g., pre- and/or post-treatment, which can be performed with or without Cr(VI)). However, relevant contributions from other Cr(VI)-related activities cannot be assumed for the majority of workers.

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

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

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

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

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

- manually transports the jig to the bath and hangs it in the bath, or
- moves it to the bath and immerses it by means of a crane 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 (Figure 9-6 a + b).

The degree of automation for this process is highly dependent on the frequency of this application in the respective site (high throughput applications processes are more likely to be 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 have usually a size of 1 to 8 m^3 but can raise up to 12 m^3 at some sites. The Cr(VI) concentration in the bath ranges from 0.1 to 14.6 % (w/w) for baths made up with CT and from 0.4 to 8.8% (w/w) for baths made up with PD or SD and the process temperature ranges between room temperature to 105 °C.

The immersion process is typically performed between 48 and 240 days per year. The duration of the immersion process is up to 120 min. In case of a manual or semi-automatic process, the line operator will only be close to the bath for one to 20 min (up to 10 min at the beginning and up to 10 min at the end) of the immersion process, in between he will leave the bath area. Based on durations and frequencies, the time spent close to the bath ranges between <1 and 150 min per shift. In case of an automated process, the line operator is not in the proximity of the bath during the treatment process.

In some cases, prior to the immersion process, the parts need preparatory work (e.g., machining or grit blasting in case of repair activities). These activities are described in the dedicated worker contributing scenario (see section 9.2.3.7). In other cases, after CCC, inorganic finish stripping or mechanical stripping needs to be performed in case of quality problems (non-conformity observed after the treatment process or for MRO activities). The part is then reworked and subjected to a second CCC process to restart the treatment over.

After the CCC bath, the parts are usually rinsed by immersion into one or two drag-out and/or rinsing tanks, or by using a spray, a water-air gun or a hose for parts with geometric constraints (e.g., blind holes, recesses). In case of an automatic line, the parts may also be automatically rinsed with water steam while they are lifted by crane from the CCC bath, before they are immersed into a rinsing tank. The number of rinsing steps after the treatment process is variable from site to site and can depend on the Cr(VI) concentration in the treatment tank and on the wastewater treatment system of the site. The rinsed parts are then dried at room temperature or with compressed air, or in an oven or a stove, at a temperature up to typically 60 °C. Depending on specifications requirements, some treated parts may need a paint or primer application as a further treatment involving Cr(VI) or being Cr(VI)-free.

At some sites, when the CCC baths are not in use, they are cooled down to room temperature and covered with a lid to reduce the indirect Cr(VI) exposure for the workers in the vicinity.

Whenever the line operator is close to the treatment baths during the immersion process (including rinsing), he wears eye protection (as per relevant risk assessment), chemical resistant gloves, and chemical protective clothing as specified above in Table 9-18.

Figure 9-6: Automatic line with an immersion process controlled by a crane (a) moving along the different baths (b)

Task 2: Filling of parts

At some sites, a partially closed process is implemented, for the treatment by filling of parts. The dedicated device is composed of a watertight cap to close the cavity, connected with a flexible pipe to the container that contains the treatment solution.

The operator transfers the treatment solution into the container (5L) of the treatment device. He then opens the tap of the coating solution container, and the solution is transferred by gravity through the flexible pipe, into the internal cavity of the part, where the solution remains applied for 5 minutes. After treatment, the coating solution is transferred back, by gravity, into the 5L container. The operator then disconnects the device from the part and wipes up the drips. The part is then air dried at room temperature. The wipes are collected as solid hazardous waste.

The process is repeated up to four times throughout the shift, which makes up to 120 min per shift. The concentration of the solution is up to 2.8% Cr(VI). The operation is typically performed in a specific area of the surface treatment shop, at room temperature, with a general mechanical ventilation 5-6 air changes per hour.

During this activity, the line operator wears eye protection (as per relevant risk assessment), chemical resistant gloves, and chemical protective clothing as specified above in Table 9-18.

Task 3: 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 operator takes a sample volume of 5-300 mL and performs sampling by one of the following techniques:

- Immersion of a sampling bottle or a vessel of typically 50-300 mL by hand into the treatment bath and filling it with up to 300 mL of bath solution. Then the vessel is 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 glove itself does not come into contact with the bath solution.
- The sampling bottle is attached to a metal or plastic rod and is immersed.
- A specific plastic sampling rod or a pipette is used with which a sample can be drawn up and transferred into a sample bottle (Figure 9-7).
- The sample is taken from a sampling tap installed at the bath. For this, the line operator holds a bottle under the tap and briefly opens and closes the tap to drain the required volume of solution from the bath.

The process of sampling and rinsing the sampling bottle/device takes up to 20 min (typically 1-3) min. The concentration of the CCC bath is identical to that described for the immersion process (i.e., up to 14.6% Cr(VI)), the concentrations of the rinsing baths are much lower. The sampling can be carried out at temperatures between room temperature and up to 105 °C and the LEV is running during this activity. The frequency of sampling is variable between different sites, depending on the frequency in which the immersion process is carried out and bath make-ups or additions are necessary at the respective site, ranging between 10 times/week (5 days/week, twice per day) and less than once per month.

During sampling, the line operator wears eye protection (as per relevant risk assessment) and chemical resistant gloves, and RPE (when sampling needs to be performed at a bath without a running LEV system and industrial hygiene exposure assessment confirms RPE use is required), as specified above in Table 9-18.

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 9.2.3.4) or the laboratory technician (see section 9.2.3.5) and that bath sample is taken for further brush or swab application.

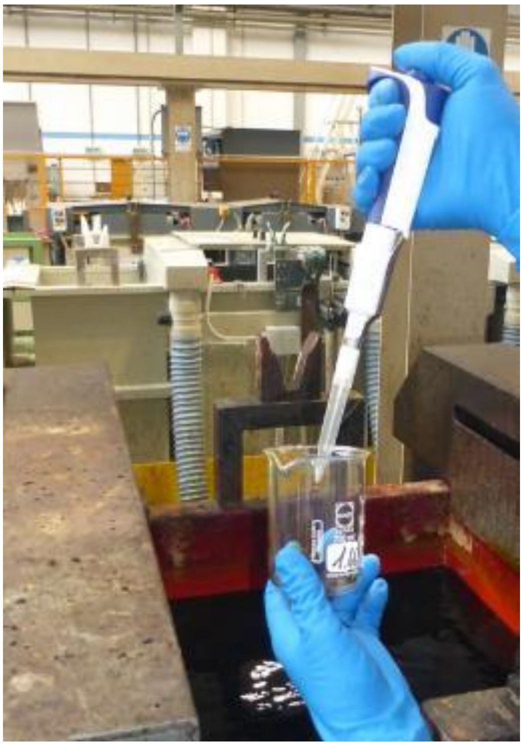


Figure 9-7: Sampling with a pipette for smaller volumes

Task 4: Cleaning of workplace, equipment, jigs

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

A typical regular cleaning activity performed at most sites is the cleaning of the floor around the bath at the end of a treatment sequence for the shift or working day. For this, the worker either rinses the floor around the baths with a hose, (the rinse water drains into the tank pits below the baths; see Figure 9-8), 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 or of equipment such as jigs, hooks or containers used for bath additions/make-ups is typically performed by rinsing the equipment in the rinsing tanks or wiping the contaminated surfaces with paper towels or rags.

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

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

For the present assessment, a regular general cleaning of the workplace, including equipment and jigs (if necessary), is considered as an integrated duty in the daily routine. Accordingly, line operators perform workplace cleaning between three times per day to at least once every two weeks, i.e., on up to 240 days per year, with a total duration of 5 to 50 min per shift where cleaning is performed. This scenario constitutes a reasonable worst-case, which also covers spontaneous cleaning whenever this may be necessary. The cleaning is carried out at room temperature and the line operators may come into contact with splashes of the treatment bath which contain a maximum of 14.6% Cr(VI) (the maximum concentration described for the immersion process above) or splashes of cleaning water from wiping solid dust (maximum Cr(VI) concentration in the cleaning water considered equal to that in the treatment baths). If cleaning is carried out with a hose the line operators may come into contact with aerosols formed from cleaning water and bath solution or cleaning water and solid chromate from bath solution dried on the floor or tanks. Cleaning with the hose results in rapid dilution of the bath solution of substance dried on the floor. Since any potential dust circulation is prevented by wet cleaning or vacuum cleaning, negligible risk of dust exposure during cleaning activities exists. Technically it is impossible to have a suitable LEV installed wherever cleaning could occur and thus, cleaning is not performed under use of a LEV. For all these general cleaning activities the line operator wears eye protection (as per relevant risk assessment), chemical protective clothing (for all cleaning activities performed with a hose he also wears an apron and waterproof boots), chemical resistant gloves, and RPE (if not performed under a LEV and industrial hygiene exposure assessment confirms RPE use is required), as specified above in Table 9-18.

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, 182 personal and 51 stationary measurements covering exposure from CCC are available for this SEG. Two personal measurements and two static measurements were excluded from further analysis because they were below an unreasonably high LOQ (i.e., <2 µg/m^3 for personal, <8.1 and <7.0 µg/m^3 for static measurements).

Of the remaining 180 personal monitoring data, 130 are long-term (≥2h)[8], shift-representative and 50 are short-term (<2h) measurements. On the 49 stationary measurements, 42 are long-term measurements and seven are short-term measurements.

The personal monitoring data come from 37 sites in nine countries in the EEA (131 measurements) and from eight sites in the UK (49 measurements). About 56% of the data (100 values, including 34 short-term measurements) are <LOQ and 44% (80 values, including 16 short-term measurements) are >LOQ.

Concerning the 49 stationary data, 33 values come from 15 sites in six countries in the EEA and 16 values come from five sites in the UK. Twenty-six stationary measurements are <LOQ and 23 values are >LOQ.

[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.

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 9-19.

Table 9-19: Overview of available inhalation exposure measurements for WCS 1 – Line operators

	n	>LOQ	<LOQ
Personal			
- Long-term (≥2h)	130	64	66
- Short-term (<2h)	50	16	34
Stationary			
- Long-term (≥2h)	42	20	22
- Short-term (<2h)	7	3	4

Personal measurements – long-term

Long-term personal measurements were taken for operators working at lines where CCC with CT, SD, and/or PD is performed. However, during many of the measurements, the line operators also had (potential) Cr(VI) exposure from other uses (e.g., deoxidising, pickling/etching, desmutting, inorganic finish stripping, anodising, passivation of (non-Al) metallic coatings) with CT or other chromates. In addition, the workers may also have carried out Cr(VI) treatments for other industrial sectors (i.e., non-aerospace and defence relevant uses). During the personal measurements, the line operators were mainly engaged in performing and controlling the immersion process for CCC (Task 1) and other dipping processes with or without Cr(VI) (e.g., the uses described before). Also, during numerous measurements, the workers were hanging parts on racks, or unhanging them, performing masking activities, cleaning the workplace or equipment (Task 4) and sometimes performing sampling of the treatment baths (Task 3). Furthermore, during 13 measurements, a bath make-up or addition was performed (secondary task of line operators), including at least in six cases also the weighing/measuring of the substance. Ten measurements also included touch-ups applications.

The arithmetic mean (AM) over the total of long-term personal measurements is **0.462 µg/m^3** and the 90th percentile is **0.602 µg/m^3** (Table 9-20).

These data cover the CCC process on manual, semi-automatic or automatic lines. Of this data, 16 measurements (12%) concern work at **automatic lines**, the other data include work on manual and/or semi-automatic lines or data for which this information is not available. The AM of long-term personal measurements on automatic lines is 0.197 µg/m^3 and the 90th percentile is 0.388 µg/m^3. Even though these results show a lower exposure, monitoring data related to all process types are considered jointly in this assessment in order to have a more robust dataset.

On 13 measurements, **bath make-up or addition** (partly in combination with measuring/weighing of the substance) was also performed: 12 have exposure values in the range of 0.0035 - 0.7 µg/m^3 showing no clear impact on exposure of handling pure substance during part of the measurement. It has to be noted that one measurement result is much higher (25.1 µg/m^3) than the others. This measurement included weighing of the solid substance and addition in the bath for concentration adjustment. The site reported that during this measurement, dust was produced when weighing the substance, which was probably the cause of this high value. This operation lasted 15 minutes of the 121 minutes sampling duration (and is usually performed around four times per year), the 8h TWA[9] value calculated from this measurement is much lower (0.633 µg/m^3) considering 359 min non-exposure time[10] (if it is theoretically assumed that the remaining shift is without exposure) and the RPE (half-mask respirator FFP3, APF of 10) that was worn during the monitoring. As indicated in the monitoring report, improvements are required and most likely the situation has been refined but as no evidence of that is available to date, this value was kept conservatively.

During ten measurements, **treatment bath sampling** was carried out, in CCC tanks only (containing CT) for three measurements, and in CCC tanks plus other uses tanks (containing CD or SD) for seven of them. The exposure values range from 0.020 to 0.500 µg/m^3, (with six values below the LOQ), which is comparable to the 90th percentile of long-term personal measurements, suggesting that no increased exposure is to be expected from sampling operations.

During ten measurements, **touch-up** operations were also carried out in addition to immersion activity (immersion in CCC baths for six of them and other Cr(VI) uses for four of them). The touch-up application was carried out by brushing next to the bath, or at a dedicated workstation. The exposure values are in the range of 0.005 to 0.15 µg/m^3, (below the LOQ for five measurements), which is below the AM and 90th percentile of the long-term personal measurements, suggesting that no increased exposure is to be expected from touch-up operations.

Among the long-term personal measurements, 48 values (37%) were taken while the workers performed activities related to **CCC only**, and not to any other Cr(VI) use (according to the information provided by the sites). The 90th percentile of these single-use personal measurements is 0.500 µg/m^3, which is slightly lower than the 90th percentile of the measurements covering activities related to CCC in combination with other Cr(VI) uses. However, it is not possible to conclude from this whether exposure from CCC is lower than exposure from other Cr(VI) uses, because it is not clear from the available information on the measured values whether workers spent as much or less time on Cr(VI) activities during these 48 measurements than during measurements that also covered other Cr(VI) uses. It should also be noted that three of these measurements involved bath additions.

During 38 of the 48 single-use measurements, the workers exclusively **handled CT** (according to the information provided by the sites). The 90th percentile for these “CT only” measurements is 0.500 µg/m^3 which is identical to the 90th percentile of the total of 48 single-use measurements. Furthermore, during seven of the single-use measurements, the line operators worked with **SD only**. The AM for these “SD only” measurements is 0.321 µg/m^3, which is 50% lower than the AM over the total of 48 single-use measurements. No information is recorded on the Cr(VI) concentration in the treatment baths and the process temperatures for the single-use measurements covering either CT or SD only, on the basis of which the differences in exposure levels could be discussed. Consequently, we do not differentiate further between these two chromates and pooled monitoring data are considered in this exposure assessment. No single-use measurements are available related to CCC where workers exclusively handled PD or DtC.

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

[10] 25.1 µg/m^3 x (121 min/480 min) = 6.33 µg/m^3

Personal measurements – short term

Fifty measurement results are from short-term exposure, 16 of them cover specifically the sampling activity (Task 3), and eight cover in addition to immersion, either activities of bath addition (task 5), or cleaning at the workplace (task 7) and waste management (task 8), or brush application (task 11). The AM of the 50 short-term exposure values is 0.781 µg/m^3 and the 90th percentile is 1.92 µg/m^3.

Among the 16 measurements covering specifically the **sampling** activity, 11 measurement results are below the LOQ. During eight measurements, only CCC treatment baths were sampled, six measurements on baths containing CT only (results range: 0.065 to 0.665 µg/m^3) and two measurements on bath containing PD or SD only (4.14 µg/m^3, duration 7 min or 3.4 µg/m^3, duration 8 min respectively). These last two high results could be linked to highly concentrated baths operated at high temperatures (respectively 160 g/L at 75°C and 145 g/L at 93°C). No information is available on RPE worn during these tasks. The 8h TWA values calculated from these two measurements would not exceed the 90th percentile of the long-term measurements (e.g., these two measurements of 4.14 µg/m^3 and 3.4 µg/m^3 would both result in an 8h TWA of 0.06 µg/m^3, considering 473- and 472-min non-exposure time[11]), if it is theoretically assumed that the remaining shift is with no exposure. Considering the eight other measurement results, samples were taken at baths for CCC plus other Cr(VI) treatment baths (e.g., bath for pre-treatment, anodising, electroplating). The results range from 0.015 to 0.968 µg/m^3. Consequently, measurement results of sampling on CCC treatments baths only or CCC treatment baths plus baths of other Cr(VI) uses give the same level of exposure. For most of sampling measurements no information is given on the use or non-use of RPE. The AM of the 14 remaining short-term exposure values drops to 0.305 µg/m^3 which is below the 90th percentile of the long-term measurements, suggesting that exposure from the sampling activity does not differ substantially from the shift-average exposure of operators working at lines where CCC is performed.

Considering the eight measurement results which cover immersion activities with also either addition to the bath, or cleaning at the workplace and waste management, or brush activities, seven results are below the LOQ with a sampling duration of 20 to 114 min. The results are in the range of 0.0125 to 0.1 µg/m^3, which is below the AM and 90th percentile of the long-term personal measurements.

Two short-term measurements are available for the exposure during the "**Filling of parts**" task (Task 2) with the results of 0.117 and 0.33 µg/m^3, which is below the AM and 90th percentile of the long-term measurements. Therefore, there is no significant difference in workers exposure for this task compared to immersion activities. Exposure from this "filling of parts" task is covered by the shift-average exposure of operators working at lines where CCC is performed.

[11] 4.14 µg/m^3 x (7 min/480 min) = 0.060 µg/m^3 / 3.4 µg/m^3 x (8 min/480 min) = 0.057 µg/m^3

Chemical conversion coating CT, SD, PD, and/or DtC

Stationary measurements

The AM of the 42 stationary long-term measurement results available for CCC is 0.243 µg/m^3 and the 90th percentile is 0.538 µg/m^3, 22 measured values are below the LOQ. Thirty-one of these results can clearly be assigned to CCC activity only. The other measurements were performed in the CCC process area, but it is unclear from the data, at which tank of the process line (including Cr(VI) chemical bath), the device was placed. The AM of the 31 static measurement results for CCC only is 0.181 µg/m^3 and the 90th percentile is 0.400 µg/m^3, which are slightly below to the AM and 90th percentile of the shift average measurements from personal monitoring of line operators working exclusively on CCC, suggesting that exposure of line operators performing CCC is close to the background exposure of CCC lines.

Seven short-term stationary measurements are available: measured values are in the range <0.0025 to 3.6 µg/m^3 and four values are below the LOQ. There are not enough details on the tasks monitored during these short-term measurements to further analyse this data.

Table 9-20 shows the summary statistics of workplace measurements for line operators. For values <LOQ, half of the LOQ (LOQ/2) was considered for statistical evaluation. All measurements are from the period 2015 through 2021.

Table 9-20: Summary statistics of inhalation exposure measurements for WCS 1 – Line operators

Personal – long-term (measurement period 2015-2021)						
	N	**% of total**	**AM [µg/m^3]**	**SD [µg/m^3]**	**Median [µg/m^3]**	**90th Perc. [µg/m^3]**
Total	130	100	0.462	2.248	0.0981	0.602
Automatic process	16	12	0.197	0.397	0.0585	0.388
Only this use covered by the measurement, with one or more chromates	48	37	0.699	3.603	0.0941	0.500
Only this use covered by the measurement, with only **CT**	38	29	0.792	4.053	0.0750	0.500
Only this use covered by the measurement, with only **SD**	7	5	0.321	n.a.	n.a.	n.a. (MAX = 1.0)
Personal – short-term (measurement period 2017-2021)						
	N	**% of total**	**AM [µg/m^3]**	**SD [µg/m^3]**	**Median [µg/m^3]**	**90th Perc. [µg/m^3]**
Total	50	100	0.781	0.919	0.500	1.92

Stationary – (measurement period 2017-2021)						
	N	**% of total**	**AM [µg/m³]**	**SD [µg/m³]**	**Median [µg/m³]**	**90th Perc. [µg/m³]**
Total	49					
Long-term	42	100	0.243	0.379	0.100	0.538
- Only this use covered by the measurement, with one or more chromates	31	74	0.181	0.325	0.0565	0.400
Short-term	7		1.042	n.a.	n.a.	n.a. (MAX = 3.6)

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.

Risk characterisation is based on the complete set of long-term personal measurements. Table 9-21 shows the resulting long-term inhalation exposure concentration for line operators used for risk assessment, based on the 90th percentile of personal sampling values.

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

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

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

Chemical conversion coating	CT, SD, PD, and/or DtC

Table 9-21: 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	130	0.602	1	0.602	0.602

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

9.2.3.2.2.2 Dermal exposure

In Table 9-22, the dermal exposure concentrations for line operators are shown, based on modelling of the activities with Cr(VI) exposure. The parameters considered for dermal exposure modelling are described in detail in Annex V of this report. For a conservative assessment of dermal exposure, we consider for modelling that only one line operator performs all tasks listed below (main and secondary tasks, including tasks typically performed by another SEG, such as aliquoting chemicals), that exposure from each activity adds up and that all tasks are performed at the maximum frequency. Considering brush activities, line operators may be involved in preparing the brushing solutions by handling chromates in solution (task 13) or solid chromates (task 14). The dermal exposure generated by these two tasks is covered by the tasks “Aliquot chemicals” (tasks 9 and 10).

Table 9-22: Dermal exposure modelling for WCS 1 – Line operators

Task	PROC(s)	Cr(VI) concentration [%]	Annual average dermal exposure value [µg Cr(VI)/kg bw/d]
Task 1: Chemical conversion coating of parts by immersion or dipping	PROC 13	8.80	3.02
Task 2: Chemical conversion coating by filling of parts	n.a.*	n.a.*	n.a.*
Task 3: Sampling of treatment baths	PROC 9	8.80	3.02
Task 4: Diverse cleaning activities – cleaning of workplace, equipment, jigs	PROC 28	0.88 **	5.24
Task 5: Bath make-up or addition	PROC 5, PROC 8b	40	2.74
Task 6: Bath emptying and cleaning	PROC 28	0.88 **	0.262

Chemical conversion coating CT, SD, PD, and/or DtC

Task	PROC(s)	Cr(VI) concentration [%]	Annual average dermal exposure value [µg Cr(VI)/kg bw/d]
Task 7: Waste management – Cleaning of empty chemical containers/bags	PROC 28	4.00 **	4.76
Task 8: Waste management – Handling of solid waste	PROC 8b	12.0	4.11
Task 9: Aliquot chemicals – Decanting of liquids	PROC 8b	12.0	0.820
Task 10: Aliquot chemicals – Measuring and weighing of solids	PROC 8b	40	2.74
Task 11: Surface treatment by brush or swab application	PROC 10	15.6	5.35
Task 12: Surface treatment by pen-stick application	n.a.*	n.a.*	n.a.*
Task 13: Solution preparation for brush or swab application (Decanting of liquids)	PROC 9	1.35	Exposure assessment covered by Task 9 assessment
Task 14: Solution preparation for brush or swab application (Measuring and weighing of solids)	PROC 9	40	Exposure assessment covered by Task 10 assessment
Combination of all tasks			**32.1**

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

* CT and DtC are not to be considered for dermal assessment (see section 9.1.2.2).

** 10-fold dilution assumed due to cleaning activity; for details see Annex V.

Despite the very conservative approach as described above, the combined dermal exposure value from all tasks of 32.1 µg Cr(VI)/kg bw/d does not exceed the DNEL of 43 µg Cr(VI)/kg bw/d.

9.2.3.2.2.3 Risk characterisation

Risk for carcinogenicity

Table 9-23 shows the risk characterisation for carcinogenicity for line operators. The risk for carcinogenicity is based on measured Cr(VI) inhalation exposure data for line operators and the RAC dose-response relationship for the excess lifetime cancer risk for lung cancer (ECHA, 2013).

Table 9-23: 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	0.602	4.00E-03	2.41E-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.

Risk for reproductive toxicity

Table 9-24 shows the risk characterisation for reproductive toxicity for line operators. The risk characterisation for reproductive toxicity is based on measured Cr(VI) inhalation exposure data for line operators and modelled dermal Cr(VI) exposure values which are compared to the RAC DNEL for workers, derived for effects on fertility (ECHA, 2015).

Table 9-24: Risk characterisation for reproductive toxicity for WCS 1 – Line operators

Route of exposure and type of effects	Long-term exposure	Risk characterisation: RAC DNEL *	Risk characterisation ratio (RCR)
Inhalation: Systemic Long Term	0.602 μg/m³	43 μg Cr(VI)/m³	0.0140
Dermal: Systemic Long Term	32.1 μg/kg bw/d	43 μg Cr(VI)/kg bw/d	0.746
Combined inhalation and dermal exposure			**0.760**

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

* RAC DNEL for workers, derived for effects on fertility (ECHA, 2015).

Note that very infrequently (approximately. 2x/year) solid waste with higher Cr(VI) concentrations (e.g., empty chemical containers) of up to 40% is handled/discarded. Due to the low frequency of this activity this only increases the dermal exposure minimally to 32.2 μg/kg bw/d, leading to a dermal RCR of 0.749.

Conclusion on risk characterisation:

<u>Carcinogenicity:</u>

The Excess life-time cancer risk for line operators is 2.41E-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 **five line operators** per day and site work on the line(s) where CCC is performed.

Reproductive toxicity:

The RCR for the endpoint reproductive toxicity based on a conservative assessment is below 1 (0.760).

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

Comparison of outcome with initial applications

Inhalation exposure

In the initial applications 0032-04, 0032-05, 0043-02, 0044-02, and 0045-02, 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 tasks list is broadly comparable with the activities carried out by the SEG line operators in the present assessment. During measurements included in the present assessment, mostly immersion processes and some cleaning of workplace/equipment were performed. Accordingly, the worker monitoring data reported in the initial and in the present assessments are broadly comparable.

In the initial applications 0096-01 and 0116-01, long-term inhalation exposure from immersion process was modelled with ART 1.5 for the following activities:

- Dipping/immersion (PROC 2, PROC 13); LEV was used (0096-01 and 0116-01)
- Filling of parts (PROC 13); LEV was used (0116-01)

Chemical conversion coating CT, SD, PD, and/or DtC

Initial assessment				Present assessment	
Application ID	**Chromate**	**Inhalation, long-term exposure, 90th Perc. [µg/m³]**	**Excess lifetime lung cancer risk [1/µg/m³]**	**Inhalation, long-term exposure, 90th Perc. [µg/m³]**	**Excess lifetime lung cancer risk [1/µg/m³]**
0032-04	CT	1.25	5.00E-03	0.602	2.41E-03
0032-05	CT	1.25	5.00E-03		
0096-01	CT	0.023	0.092E-03		
0043-02	SD	1.26	5.04E-03		
0044-02	PD	1.26	5.04E-03		
0045-02	DtC	1.26	5.04E-03		
0116-01	DtC	0.036	0.144E-03		

As shown in the table above, the excess lifetime lung cancer risk for line operators in the present assessment for CCC is globally comparable to the risk calculated in the initial applications (up to 5.04E-03). The current assessment is based on a broader and more recent database and supported by additional data (short-term and stationary measurements).

Sampling

In the initial applications, inhalation exposure from sampling was modelled with ART 1.5

- as part of two sub-activities (in applications 0032-04, 0032-05, 0043-02, 0044-02, 0045-02):
  - Sub-activity 1: Drawing of sample and transfer to the laboratory (<30 min)
  - Sub-activity 2: Laboratory analysis (<60 min)
- as the activity (in applications 0096-01, 0116-01):
  - Sampling (PROC 8b)

It was assumed for modelling that sampling was performed under a capturing hood (90% efficiency), without RPE. The Cr(VI) concentrations were up to 5% (0096-01, 0116-01), or up to 50% (0032-04, 0032-05) for CT, and up to 20% for SD (0043-02), PD (0044-02) and DtC (0116-01). It was assumed that sampling is performed one time/week in the initial applications 0096-01 and 0116-01.

For the present assessment, the laboratory analysis of samples is not considered as this activity is exempted from authorisation (see explanation in section 9.2.3.5). Sampling is covered by some shift average measurements and a few short-term measurements performed on line operators, the exposure during sampling is considered to be within the 90th percentile of shift average personal measurements.

As shown in the table below, the excess lifetime lung cancer risk based on modelled inhalation exposure range from 4.56E-06 to 2.76E-03 in the initial applications. The excess lifetime lung cancer risk for the present assessment is with **2.41E-03**, comparable to the risk calculated in the initial applications when no frequency adjustment is considered. Moreover, since the measurements cover multiple Cr(VI) tasks, it can be assumed that the exposure from only the sampling activity is much lower.

Initial assessment				Present assessment	
Application ID	**Chromate**	**Inhalation exposure, 90th Perc. [µg/m³]**	**Excess lifetime lung cancer risk [1/µg/m³]**	**Inhalation exposure, 90th Perc. [µg/m³]**	**Excess lifetime lung cancer risk [1/µg/m³]**
0032-04	CT	0.69	2.76E-03	included above (0.602)	included above (2.41E-03)
0032-05	CT	0.69	2.76E-03		
0096-01	CT	2.2E-03*	8.8E-06*		
0043-02	SD	0.65	2.60E-03		
0044-02	PD	0.65	2.60E-03		
0045-02	DtC	0.65	2.60E-03		
0116-01	DtC	1.14E-03*	4.56E-06*		

*Adjusted for the frequency in the initial assessment.

Dermal exposure

No quantitative dermal exposure assessment has been performed in the initial applications.

9.2.3.3 Worker contributing scenario 2 – Brush and pen application operators

Brush and pen application operators perform local CCC by brush, cotton swab or touch-up pen application. They spend part of their working time, either at a workplace dedicated to brush application, or in the hall where the immersion processes take place, or in other areas where touch-ups are performed (e.g., machining shops).

CCC by local application is also performed at different workplaces, by trained workers, e.g., in mechanical workshops, inside or outside aircrafts hangar.

They are involved in activities either with direct or indirect Cr(VI) exposure. Typical activities with possible Cr(VI) exposure performed by brush and pen application operators are:

<u>Main tasks</u>

- Task 1: Surface treatment by brush or swab application (PROC 10)
- Task 2: Surface treatment by pen-stick application (PROC 10)
- Task 3: Solution preparation for brush or swab application (decanting of liquids) (PROC 9)
- Task 4: Solution preparation for brush or swab application (measuring and weighing of solids) (PROC 9)

<u>Secondary task</u>

- Task 5: Machining operations on small to medium sized parts (PROC 21, 24)

In addition to these tasks, brush and pen application operators usually prepare the surface with a slight sanding before brush, swab or touch-up pen application and are generally responsible for cleaning their workplace and managing the waste generated. These activities are thus included in Task 1 or Task 2 because they are conducted under the same operational conditions and risk management measures as the local application activities. At some sites, brush and pen application operators may also perform machining operations (e.g., drilling). The Task 5 machining operations, is usually performed by machinists and is described in the worker contributing scenario for machinists (see section 9.2.3.7).

Brush and pen application operators might be engaged in other activities not related to uses of Cr(VI) (e.g., masking/unmasking operations or activities on non-Cr(VI) baths), and thus not be directly exposed. However, they may still experience indirect exposure when they perform tasks in the vicinity of running baths.

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

9.2.3.3.1 Conditions of use

Table 9-25 summarises the conditions of use for the activities with direct Cr(VI) exposure related to CCC carried out by the brush and pen application operators.

Table 9-25: Conditions of use – worker contributing scenario 2 – Brush and pen application operators

Product (article) characteristics
Products used for brush or swab solutions preparation
Product 1: Solid CT or SD (flakes or powder) for Task 4 (solution preparation) ▪ Substance product type: Powders, granules, or pelletised material ▪ Dustiness: Flakes or powder ▪ Moisture content: Dry product (<5 % moisture content) ▪ Weight fraction: Pure material of CT or SD, or solid mixture of CT (max. 100%) ▪ Concentration in pure substance: 52% Cr(VI) for CT or 40% Cr(VI) for SD ▪ Concentration in solid mixture: max. 31.2% Cr(VI) for CT
Product 2: Aqueous solutions of PD for Task 3 (solution preparation) ▪ Concentration of substance in mixture: up to 0.035-0.09% (w/w) Cr(VI) ▪ Concentration of Cr(VI) based on ranges of PD (0.1-0.25% (w/w)) in aqueous solution, used for mixture preparation for brush application ▪ Product type: Solids dissolved in a liquid or incorporated in a liquid matrix ▪ Viscosity: Liquids with low viscosity (like water)
Product 3: Aqueous solutions of mixture of SD and PD for Task 1 (brush application) and Task 3 (solution preparation) ▪ Concentration of substances in mixture: 0.14-1.35% (w/w) Cr(VI)

▪ Concentration of Cr(VI) based on ranges of SD (up to 2.5% (w/w)) and PD (up to 1% (w/w)) in aqueous solution, used for mixture preparation or ready-to-use for brush application ▪ Product type: Solids dissolved in a liquid or incorporated in a liquid matrix ▪ Viscosity: Liquids with low viscosity (like water)
Product 4: Aqueous solutions of mixture of CT and DtC for Task 3 (solution preparation) ▪ Concentration of substances in mixture: 3.2-8.1% (w/w) Cr(VI) ▪ Concentration of Cr(VI) based on ranges of CT (5-10% (w/w)) and DtC (1-5% (w/w)) in aqueous solution, used diluted for brush application ▪ Product type: Solids dissolved in a liquid or incorporated in a liquid matrix ▪ Viscosity: Liquids with low viscosity (like water)
Products used for brush, swab, or touch-up pen application:
Product 5: Aqueous solutions of CT, or SD for Task 1 (brush application) ▪ Concentration of substance in mixture: 0.05-15.6% (w/w) Cr(VI) ▪ Concentration of Cr(VI) based on ranges of CT, or SD (0.1-30% (w/w)), in ready-to use aqueous solution used for brush application ▪ Product type: Solids dissolved in a liquid or incorporated in a liquid matrix ▪ Viscosity: Liquids with low viscosity (like water)
Product 6: Aqueous solutions of DtC for Task 2 (pen application) ▪ Concentration of substance in mixture: 0.06-0.58% (w/w) Cr(VI) ▪ Concentration of Cr(VI) based on ranges of DtC (0.1-1% (w/w)) in aqueous solution contained in a ready-to-use touch-up pen ▪ Product type: Solids dissolved in a liquid or incorporated in a liquid matrix ▪ Viscosity: Liquids with low viscosity (like water)
Product 7: Aqueous solutions of mixture of CT and DtC (dilution of product 4) for Task 1 (brush application) ▪ Concentration of substances in mixture: up to 2.8% (w/w) Cr(VI) ▪ Concentration of Cr(VI) based on ranges of CT (up to 2.5% (w/w)) and DtC (up to 2.5% (w/w)) in aqueous solution, used for brush application ▪ Product type: Solids dissolved in a liquid or incorporated in a liquid matrix ▪ Viscosity: Liquids with low viscosity (like water)
Product 8: Aqueous solutions of mixture of SD and PD (mixture of products 2 and 3) for Task 1 (brush application) ▪ Concentration of substances in mixture = up to 0.7% (w/w) Cr(VI) ▪ Concentration of Cr(VI) based on ranges of SD (up to 1.3% (w/w)) and PD (up to 0.6% (w/w)) in aqueous solution, used for brush application ▪ Product type: Solids dissolved in a liquid or incorporated in a liquid matrix ▪ Viscosity: Liquids with low viscosity (like water)
Product 9: Aqueous solutions of CT or SD (solution of product 1) for Task 1 (brush application) ▪ Concentration of substance in mixture = 0.25-7.2% (w/w) Cr(VI) ▪ Concentration of Cr(VI) based on ranges of CT (0.5-2.2% (w/w)), or SD (0.5-18% (w/w)) in aqueous solution, used for brush application ▪ 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 brush or swab application ▪ Amount: up to 100 mL per application ▪ Duration of activity: 1- 20 min per application, 5-60 min per shift ▪ Frequency of task: <1-240 days per year (<1 day/week up to every day, 48 weeks per year)
Task 2: Surface treatment by pen-stick application ▪ Amount: up to 20 mL per application ▪ Duration of activity: 1- 20 min per application, 5-60 min per shift (at few sites infrequent long-term activities of up to 360 min per shift on few days per year are reported) ▪ Frequency of task: <1-240 days per year (<1 day/week up to every day, 48 weeks per year)
Task 3: Solution preparation for brush or swab application (decanting of liquids) ▪ Amount: up to 1 L (of products 2, 3, and 4) ▪ Duration of activity: typically 5-10 min per shift, up to 30 min per shift ▪ Frequency of task: <1-240 days per year (<1 day/year up to every day, 48 weeks per year)
Task 4: Solution preparation for brush or swab application (measuring and weighing of solids) ▪ Amount: up to 1 kg (of product 1) ▪ Duration of activity: typically 5-10 min per shift, up to 20 min per shift ▪ Frequency of task: <1-96 days per year (<1 day/year up to twice a week, 48 weeks per year)
Technical and organisational conditions and measures
Task 1: Surface treatment by brush or swab application ▪ LEV: yes, where technically feasible (no LEV required on field, e.g., on the tarmac, or in the aircraft hangar) ▪ 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: Surface treatment by pen-stick application ▪ LEV: yes, where technically feasible (no LEV required on field, e.g., on the tarmac, or in the aircraft hangar) ▪ 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: Solution preparation for brush or swab application (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 4: Solution preparation for brush or swab application (measuring and weighing of solids) ▪ LEV: yes ▪ Ventilation rate of general ventilation system: natural ventilation ▪ Occupational health and safety management system: advanced (see section 9.2.2.3.1.2)

Conditions and measures related to personal protection, hygiene, and health evaluation
Gloves Chemical resistant gloves are worn during all tasks (Tasks 1 to 4). All gloves used for the handling of chemicals are tested according to EN 374. A variety of materials are suited for protection against CT, SD, PD and DtC. The following materials have a breakthrough time ≥8h for aqueous CT solutions (10% CT) and saturated aqueous SD or PD solutions [a]: o Natural rubber/Natural latex (0.5 mm) o Polychloroprene (0.5 mm) o Nitrile rubber/Nitrile latex (0.35 mm) o Butyl rubber (0.5 mm) o Fluorocarbon rubber (0.4 mm) o Polyvinyl chloride (0.5 mm) The following material has a breakthrough time ≥4h for solid CT, SD and PD: o Butyl rubber (0.7 mm) Type of gloves to be used for specific tasks is laid down in work instructions for the tasks.
Respiratory protection equipment RPE is worn during all tasks not performed under a LEV for which Industrial Hygiene exposure assessment confirms RPE use is required. The following types of RPE are used according to EN 529:2005 [b]: ▪ Half mask FFP3 (APF 10), half mask with P3 filter (APF 10), half mask with P3 combination filter (APF 10) or ▪ Full mask with P3 filter (APF 20), full mask with P3 combination filter (APF 20) Type of RPE to be used for specific tasks is laid down in work instructions for the tasks.
Protective clothes Chemical protective clothing must be worn during Tasks 3 and 4. Type of protective clothes to be used for specific tasks is laid down in work instructions for the tasks.
Eye protection Suitable eye protection as per relevant risk assessment must be worn during all tasks (Tasks 1 to 4). Type of eye protection to be used for specific tasks is laid down in work instructions for the tasks.
Other conditions affecting workers' exposure
Task 1: Surface treatment by brush or swab application ▪ Place of use: indoors – any size workroom, or outdoors ▪ Temperature: room temperature

▪ Primary emission source proximity: The primary emission source is in the breathing zone of the worker (near field, <1 m) ▪ Activity class: Spreading of liquid products ▪ Situation: Spreading of liquids at surfaces or work pieces < 1 m^2/hour
Task 2: Surface treatment by pen-stick application ▪ Place of use: indoors – any size workroom, or outdoors ▪ Temperature: room temperature ▪ Primary emission source proximity: The primary emission source is in the breathing zone of the worker (near field, <1 m) ▪ Activity class: Spreading of liquid products ▪ Situation: Spreading of liquids at surfaces or work pieces < 0.1 m^2/hour
Task 3: Solution preparation for brush or swab application (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: Transfer of liquid products - falling liquids ▪ Handling that reduces contact between product and adjacent air ▪ Flow of liquid: 0.1 - 1 L/min
Task 4: Solution preparation for brush or swab application (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: Transfer of powders, granules, or pelletised material ▪ Handling that reduces contact between product and adjacent air ▪ Transferring: 10 - 100 g/min (scooping)
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 VI of this report.

9.2.3.3.2 Exposure and risks for workers

Between individual sites, the number of operators working on local CCC by brush or touch-up pen application is variable from one site to another, depending on the size of the site, if the main activity is production or MRO, the throughput and distribution of work (e.g., dedicated operators or polyvalent operators). Brushing activities also can be carried out by line operators, machinists or mechanical workers who are trained to. Also, the number of work shifts varies from site to site; one to three shifts per day are run at the sites. The shift duration is usually 8h but may be up to 12h, depending on the organisation of the site and national law.

Touch-up applications can be performed either on-site (close to the treatment baths or at a dedicated workplace), or in other work areas. It can be carried out, for example, in machining or mechanical shops to rectify any surfaces that would have been machined or mechanically damaged, or, inside the aircraft hangar or outside the hangar (e.g., on the tarmac).

There are typically one to three operators per shift (could be up to 60 in few sites) working on brush or touch-up pen application. It must be noted that CCC by local application is commonly not a full-time activity for the operators (up to 30 % of their shift) and the remaining part of their shift can be spent on other activities related to the immersion lines or other Cr(VI) and Cr(VI)-free activities (e.g., (un)masking, machining). At some sites, this activity can be very infrequent and performed only during very short durations (very small surfaces treated), representing usually less than 10 % of their working time.

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

Task 1: Surface treatment by brush or swab application

Local CCC by brush or swab application may be required as localized treatment or as a repair process when damage to the surface of the coated part is caused during manipulation or other internal processes: thin stripes present on assembled parts or surface defects (scratches or dents) on small parts. It is also used for re-establishing electro-conductivity, which is lost during a previous surface treatment.

The surfaces to be treated can be small scratches or slightly larger surfaces, usually from 5 to 500 cm^2 or even larger for parts that cannot be treated by immersion, due to their shape or size.

Prior to the application, the operator prepares the surface with a light manual sanding using an abrasive cloth, sandpaper, or sanding mats and/or cleans the area with a solvent. The surface can also be prepared by a pickling/etching pre-treatment (in very small bath).

After the part preparation, the operator then immerses a small brush, paintbrush, cotton swab, cotton wool or wipe in a bucket containing the brushing solution and then apply it on the part to be treated.

After application of the solution, the surface can be flushed with water or rinsed with a wet rag. Directly after treatment or after rinsing, the surface is allowed to air dry or, drying can be accelerated (using compressed air, air dryer or an oven). The operator usually does not stay in the vicinity of the treated parts during self-drying.

The aqueous solution used for brushing applications is either ready-to use or prepared by dilution or mixing. The Cr(VI) concentration is typically from 0.05 to 15.6% Cr(VI) (w/w). The solution is applied at room temperature.

The frequency of local CCC application and the number of parts to be treated per batch is variable between different sites. Touch-up can be required from less than once a month to 30 times a week. The application operation takes typically 1- 20 min, and up to 60 min per shift.

The brushing application operator cleans the workplace and disposes of the waste generated (soiled wipes, swabs, brushes, rinsing water …) as hazardous waste.

Task 2: Surface treatment by pen-stick application

CCC by pen-stick application may be required as localized treatment on small surfaces or for touch-up after the immersion process when damage to the layer is caused during manipulation or other internal processes: thin stripes present on assembled parts or surface defects (scratches or dents).

Touch-up pen application is performed on small surfaces, typically 5 cm^2 (up to 100 cm^2). The surface to be treated is cleaned and prepared. The operator can perform a light manual sanding by using an abrasive cloth or pad.

The operator performs the touch-up using a pen-stick, ready-to-use, containing an aqueous solution of DtC, which has a Cr(VI) concentration typically from 0.06 to 0.58% Cr(VI). The local treatment is made by the application of two cross layers vertically and horizontally. The solution is applied at room temperature and then allowed to dry at room temperature or in an oven.

The frequency of pen-stick applications and the number of parts to be treated per batch is variable between different sites. Touch-up can be required from once a month to 45 times a week. The application operation takes typically 1- 20 min, and up to 60 min per shift.

The brush application operator cleans the workplace and disposes of the waste generated (empty touch-up pens, soiled paper towels or rags …) as hazardous waste.

Tasks 1 + 2:

When this local surface treatment is carried out on-site, close to the process tanks, or in a dedicated room, the operation is performed under LEV (e.g., articulated extraction arm, fixed LEV, fume hood, glove box or painting booth), where technically feasible. When touch-ups are performed on field, e.g., on the tarmac, or in the aircraft hangar, no LEV can be used (duration of application is max. 5 min).

During local CCC by brush or pen application, the operator wears eye protection (as per relevant risk assessment), chemical resistant gloves, and chemical protective clothing as specified above in Table 9-25.

Task 3 and Task 4: Solution preparation for brush or swab application – Decanting of liquids and measuring or weighing of solids

The aliquoting of chemicals needed for solution preparation for brush or swab application is usually performed by the brush and pen application operators. All measuring and weighing processes are usually carried out at a dedicated workplace (dedicated brushing area, laboratory, chemical storage area or hall of treatment baths), equipped with a LEV or under a fume hood.

Task 3: Solution preparation for brush or swab application (decanting of liquids)

When the operator aliquots liquids, he opens the lid of a container or canister with the product and carefully pours the required volume of the product into a measurement vessel, cylinder, or bottle. The measured volume per aliquot is usually up to 1 L. Then he closes the container with a lid. The measured chemical is then, either ready-to-use for brush application, or diluted with demineralized water, or transferred for blending with a second aliquot. The bottle or canister (up to 5 L) containing the brushing solution is then closed with a lid. The operator manually performs the blending by stirring the closed bottle. The empty measurement vessel is rinsed with water and the rinsing water is collected.

Task 4: Solution preparation for brush or swab application (measuring and weighing of solids)

For measuring and weighing of solids, the operator opens the lid of a container with the solid substance (flakes or powder) and carefully transfers the required quantity of the substance with a scoop into a flask or vessel placed on a scale. The amount of substance to be aliquoted is at maximum 1 kg chromate per aliquot. After this is achieved, the worker closes the container. He then adds the required quantity of demineralized water and closes the flask. At some sites, a dedicated preparation kit is used, containing one small jar of chromate powder and a second jar containing a gel. The operator carefully transfers the content of the small jar into the second jar and delicately mixes with a spatula. The operator then closes the jar with the lid.

Task 3 + 4:

The closed containers or bottles containing the aliquoted chemical are transported to the dedicated area where the activities of brush or swab application are performed.

The handling of either solids or liquids takes typically 5-10 min and up to 20 min for solids and to 30 min for liquids. Aliquoting of liquids are performed up to 240 times per year (every day) and up 96 times per year (twice a week) for solids. During these activities, the operator wears eye protection (as per relevant risk assessment), chemical protective clothing, chemical resistant gloves, and RPE (if not performed under an LEV and industrial hygiene exposure assessment confirms RPE use is required), as specified above in Table 9-25.

The tasks of solution preparation as described above are at some sites not carried out by the brush and pen application operators but by the storage area workers (see section 9.2.3.4).

9.2.3.3.2.1 Inhalation exposure

Measured inhalation exposure concentration

In total, 201 personal and 26 stationary measurements covering exposure from CCC are available for this SEG. Eight personal long-term measurement results were excluded from further analysis, seven are below an unreasonably high LOQ (from <0.75 to <2.9 µg/m^3 for personal) and the eighth (23 µg/m^3, 186 min with only 30 min of exposure) is non reliable (defective measurement considered as non-reproducible, confirmed by a short-term sampling measurement performed simultaneously, during the same exposure duration (<0.3 µg/m^3, 33 min)). Also, 18 short term measurements results were excluded because, for 17 measurements the results are below an unreasonably high LOQ, due to their short measurement duration (i.e., from <6 µg/m^3 to <650 µg/m^3) and for one measurement, only a geometric mean over six values (not detailed) is available.

On the remaining 175 personal monitoring data, 74 are long-term (≥2h)[12], shift-representative and 101 are short-term (<2h) measurements. On the 26 stationary measurements, 20 are long-term and six are short-term measurements.

The personal monitoring data come from 43 sites in 10 countries in the EEA (153 measurements) and from 16 sites in the UK (22 measurements). About 67% of the data (117 values, including 78 short-term measurements) are <LOQ and 33% (57 values, including 23 short-term measurements) are >LOQ.

[12] 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.

Among the 26 stationary data, 20 values come from seven sites in three countries in the EEA and six values come from four sites in the UK. Seventeen stationary measurements are <LOQ and nine 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 brush and pen application operators is given in Table 9-26.

Table 9-26: Overview of available inhalation exposure measurements for WCS 2 – Brush and pen application operators

	n	>LOQ	<LOQ
Personal			
- Long-term (≥2h)	74	34	40
- Short-term (<2h)	101	23	78
Stationary			
- Long-term (≥2h)	20	9	11
- Short-term (<2h)	6	0	6

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

Long-term personal measurements were taken during CCC, performed locally, by brush or by touch-up pen with solutions containing CT, SD, PD, and/or DtC. However, during some of the measurements, the workers may also have had (potential) Cr(VI) exposure to other chromates from primer application, or indirectly from CCC performed by immersion when the local application was performed in the baths area. Moreover, the workers may also have carried out Cr(VI) treatments for other industrial sectors (i.e., non-aerospace and defence relevant uses). During the personal measurements, the brush and pen application operators mainly carried out local application by brush (Task 1) or by pen application Task 2). Also, during some of the measurements, workers were preparing the brushing solutions by pouring or mixing liquids (Task 3) or by weighing and transferring solids (Task 4).

Considering the total 74 long-term personal measurements available, it has to be noted that 54% of the measurements are below the LOQ (40 values). The arithmetic mean (AM) over the total long-term personal measurements is **0.153 µg/m^3** and the 90th percentile is **0.250 µg/m^3** (Table 9-27).

On the 74 long-term personal measurements, 68 values (92%) were taken while workers performed activities related to CCC only, and not to any other Cr(VI) use (according to the information provided by the sites). The AM over these single-use personal measurements is 0.162 µg/m^3 and the 90th percentile of these measurements is 0.265 µg/m^3, which is comparable to the AM and 90th percentile of the total long-term measurements. During the other six long-term measurements, the operator performed local CCC in addition to primer application and the exposure values were between <0.037 and 0.09 µg/m^3. As this additional use does not lead to a significant difference in workers exposure, these data measurement are considered jointly in this assessment.

- Long-term personal measurement – Substances consideration

For 21 of the 68 single-use measurements, workers performed brush applications exclusively with solutions containing CT (according to the information provided by the sites). For these "**CT only**" measurements, the AM is 0.217 µg/m^3 and the 90th percentile is 0.396 µg/m^3 which is slightly above to the AM and 90th percentile of the 68 single-use measurements.

Thirty of the 68 measurement results covered touch-ups with **DtC only**. The AM is 0.132 µg/m^3 and the 90th percentile is 0.339 µg/m^3 which are slightly higher than the AM and 90th percentile of the 68 single-use measurements.

Furthermore, during 12 of these 68 single-use measurements, brush operators worked with **SD and/or PD.** For three measurements, workers used **SD only** or **PD only** and for nine measurement results, it is reported that the operator applied a solution with a mixture of **SD and PD**. For these nine results, the AM is 0.121 µg/m^3, below the AM of the 68 single-use measurements.

Only one measurement covers the application of a solution containing **CT and DtC** (value <0.0888 µg/m^3).

Considering the above data, the tendency suggests that the chromate substance contained in the brushing solution does not impact significantly the level of exposure. Consequently, there is no need to differentiate further between these four chromates in this assessment.

- Long-term personal measurement – Activities consideration

During the 74 sampling measurements, 41 measurements covered at least local application by brush, 35 covered at least pen application and three measurements covered at least brushing solutions preparation.

Considering the 36 measurement results for **brushing activities only**, 26 are below the LOQ, the AM is 0.193 µg/m^3 and the 90th percentile is 0.285 µg/m^3.

Considering the 25 measurement results for **touch-up pen activities only**, three are below the LOQ, the AM is 0.145 µg/m^3 and the 90th percentile is 0.266 µg/m^3.

Brushing and touch-up applications have similar AM and 90th percentiles with many measurement results < LOQ.

Three measurement results covering the **preparation of brushing solutions** are available, including also brushing application for two of them. The solutions were prepared under LEV (extracted booth) for one of them (no information is available for the other two). The three measured values are all below the LOQ, from <0.03 to <0.4 µg/m^3. Consequently, these values tend to suggest that the preparation of brushing solutions does not impact significantly the level of exposure of brush and pen operators.

Personal measurements – short-term

The 101 short-term measurements covered all relevant tasks performed by the brush and pen application operators:

- Task 1: Surface treatment by brush or swab application (52 values from <0.0005 to 3.31 µg/m^3, 4 - 72 min, 40 values below the LOQ)
- Task 2: Surface treatment by pen-stick application (41 values <0.0005 to 9.908 µg/m^3, 5 - 70 min, 30 values below the LOQ)
- Task 3: Solution preparation for brush or swab application (decanting of liquids) (nine values below the LOQ; <0.1 to <1.667 µg/m^3, 14 - 72 min)
- Task 4: Solution preparation for brush or swab application (measuring and weighing of solids) (three values below the LOQ; <0.16 µg/m^3, 15 min)

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

Two measured values, covering task 2 (pen application), are much higher than the other measurement values (3.9 and 9.908 µg/m^3). No details are available to explain these higher measurement results. The 8h TWA[13] values calculated from these measurements are 0.122 µg/m^3 and 0.103 µg/m^3 considering respectively 465 and 475 min of non-exposure time[14], if it is theoretically assumed that the remaining shift is without exposure. These results are well below the 90th percentile of the long-term values for pen application and the 90th percentile of all long-term measurements.

The monitoring results available for brush application (Task 1) are for most of them below the LOQ, and all below the LOQ for brush solutions preparation (Task 3 and Task 4).

Considering globally the 101 short-term measurements, 8h TWA values calculated from these measurements would be well below the 90th percentile of the long-term measurements (considering respective sampling durations, except for one of them for which the duration is unknown), if it is theoretically assumed that the remaining shift is without exposure. The highest value obtained is 0.309 µg/m^3, below the AM of long-term personal measurements. This suggests that no increased exposure is to be expected from the relevant tasks listed above.

In addition, workers wear respiratory protection for such short-term activities for which industrial hygiene exposure assessment confirms RPE use is required. Use of RPE is documented for many of the short-term measurements listed above.

Stationary measurements

Twenty stationary long-term measurements are available for CCC by brush and pen applications, 11 are <LOQ. The AM is 0.183 µg/m^3 and 90th percentile is 0.250 µg/m^3. These static measurements were performed for six of them in the brushing activities area (AM is 0.126 µg/m^3) and in the touch-up pen application area for 14 of them (AM is 0.136 µg/m^3).

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

[14] 3.9 µg/m^3 x (15 min/480 min) = 0.122 µg/m^3 and 9.908 µg/m^3 x (5 min/480 min) = 0.103 µg/m^3.

Considering pen applications, four measurements covered also drilling and/or grinding operations, but no details are available whether the parts were coated with Cr(VI) or not. One measurement covered also primers application. The nine other measurement results reported as pen application only have an AM of 0.069 µg/m^3.

The AM of the six stationary measurement results on brushing activities is lower than the AM of the shift average measurements from personal monitoring of operators performing brush application (0.198 µg/m^3). The AM of the 14 stationary measurement results on touch-up pen is lower than the AM (0.171 µg/m^3) of the shift average measurements from personal monitoring of operators performing touch-up pen. Very little information is available on the position of the monitoring device and distance from the source of exposure.

Six short-term measurements were sampled during CCC by brush and pen applications. The results were all below the LOQ.

Table 9-27 shows the summary statistics of workplace measurements for brush and pen application operators. For values <LOQ, half of the LOQ (LOQ/2) was considered for statistical evaluation. All measurements are from the period 2015 through 2021.

Table 9-27: Summary statistics of inhalation exposure measurements for WCS 2 – Brush and pen application operators

Personal – long-term (measurement period 2017-2021)						
	N	**% of total**	**AM [µg/m^3]**	**SD [µg/m^3]**	**Median [µg/m^3]**	**90th Perc. [µg/m^3]**
Total	74	100	0.153	0.356	0.075	0.250
Only this use covered by the measurements	68	92	0.162	0.370	0.085	0.265
Personal – short-term (measurement period 2015-2021)						
	N	**% of total**	**AM [µg/m^3]**	**SD [µg/m^3]**	**Median [µg/m^3]**	**90th Perc. [µg/m^3]**
Total	101	100	0.678	1.176	0.220	1.300
Stationary (measurement period 2017-2021)						
	N	**% of total**	**AM [µg/m^3]**	**SD [µg/m^3]**	**Median [µg/m^3]**	**90th Perc. [µg/m^3]**
Total	26	100				
Long-term	20	77	0.183	0.433	0.086	0.250
Short-term	6	23	0.438 [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] All values were below the LOQ ; half of the LOQ (LOQ/2) was considered for statistical evaluation.

All personal long-term measurements of workers performing tasks related to local CCC application are included in the assessment of inhalation exposure. Table 9-28 shows the resulting long-term inhalation exposure concentration for brush and pen application operators used for risk assessment, based on the 90th percentile of personal sampling values.

As stated above, partial exposure from sources and processes not related to the use of CCC may have contributed to some of the exposure values assigned to this use, (e.g., primer application, immersion) or might be engaged in other activities not related to uses of Cr(VI). However, as the 90th percentile of the single-use measurements is similar to the 90th percentile of the total long-term measurements, in a conservative way we assign 100% of the shift average exposure value (90th percentile of all long-term measurements) to this use.

Typically, one to three operators work per shift and one to three shifts are operating per site. On an average, we assume that **five brush and pen operators per day** are engaged per site. Considering that the activity is divided between these five workers, the long-term exposure concentration is then corrected by a factor of 0.2. 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 for specific short-term activities only, if industrial hygiene exposure assessment confirms RPE use is required. As these activities usually only account for short periods of the shift average measurements, no RPE is considered in the exposure assessment, which constitutes a further conservative element of the assessment.

Table 9-28: Measured inhalation exposure concentration for WCS 2 – Brushing and pen application 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	74	0.250	1	0.250	0.050

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

[a] Based on 90th percentile of measurements.

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

[c] The correction factor of 0.2 was applied for brushing and pen application operators (see text above).

9.2.3.3.2.2 Dermal exposure

In Table 9-29, the dermal exposure concentrations for brushing and pen application operators are shown, based on modelling of the activities with Cr(VI) exposure. The parameters considered for dermal exposure modelling are described in detail in Annex V of this report. For a conservative assessment of dermal exposure, we consider for modelling that only one brush and pen application operator performs all tasks described above, that exposure from each activity adds up and that all tasks are performed at the maximum frequency.

Table 9-29: Dermal exposure modelling for WCS 2 – Brush and pen application operators

Task	PROC(s)	Cr(VI) concentration [%]	Annual average dermal exposure value [µg Cr(VI)/kg bw/d]
Task 1: Surface treatment by brush or swab application	PROC 10	15.6	5.35
Task 2: Surface treatment by pen-stick application	n.a.*	n.a.*	n.a.*
Task 3: Solution preparation for brush or swab application (Decanting of liquids)	PROC 9	1.35	0.46
Task 4: Solution preparation for brush or swab application (measuring and weighing of solids)	PROC 9	40	5.49
Combination of all tasks			**11.3**

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

* CT and DtC are not to be considered for dermal assessment (see section 9.1.2.2)

Despite the very conservative approach as described above, the combined dermal exposure value from all tasks of 11.3 µg Cr(VI)/kg bw/day does not exceed the DNEL of 43 µg Cr(VI)/kg bw/day.

9.2.3.3.2.3 Risk characterisation

Risk for carcinogenicity

Table 9-23 shows the risk characterisation for carcinogenicity for brush and pen application operators. The risk for carcinogenicity is based on measured Cr(VI) inhalation exposure data for brush and pen application operators 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 2 – Brush and pen application 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	0.050	4.00E-03	2.00E-04

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.

Risk for reproductive toxicity

Table 9-31 shows the risk characterisation for reproductive toxicity for brush and pen application operators. The risk characterisation for reproductive toxicity is based on measured Cr(VI) inhalation exposure data for brush and pen application operators and modelled dermal Cr(VI) exposure values which are compared to the RAC DNEL for workers, derived for effects on fertility (ECHA, 2015).

Table 9-31: Risk characterisation for reproductive toxicity for WCS 2 – Brush and pen application operators

Route of exposure and type of effects	Long-term exposure [µg/m³]	Risk characterisation: RAC DNEL *	Risk characterisation ratio (RCR)
Inhalation: Systemic Long Term	0.050	43 µg Cr(VI)/m³	1.16E-03
Dermal: Systemic Long Term	11.3	43 µg Cr(VI)/kg bw/d	0.263
Combined inhalation and dermal exposure			0.264

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

* RAC DNEL for workers, derived for effects on fertility (ECHA, 2015).

Conclusion on risk characterisation:

Carcinogenicity:

The Excess life-time cancer risk for line operators is 2.00E-04 µg/m^3.

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 **five brush and pen operators** per day and site perform all tasks assigned to this SEG related to CCC. It should be noted that at some sites (e.g., where MRO activities are performed), CCC may only be performed by brush and/or pen applications.

Reproductive toxicity:

The RCR for the endpoint reproductive toxicity based on a conservative assessment is well below 1 (0.264).

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

Comparison of outcome with initial applications

Inhalation exposure

The tasks considered in the present assessment typically performed by the brush and pen application operators were described in the initial applications as separate tasks that were not assigned to a specific SEG and were not aggregated in their exposure. These separate tasks were modelled with ART 1.5 in the initial applications. Consequently, we can only compare the modelling results for individual tasks with the shift-average inhalation exposure values measured for the storage area workers in the current assessment.

As shown in the table below, the excess lifetime lung cancer risks based on inhalation exposure modelling in the initial applications were between 1.4E-05 and 6.00E-03 for the individual activities performed by brush and pen application operators. RPE with an assigned protection factor (APF) of 30 was considered for activities where solid chromates are handled (dossiers 0032-04, 0032-05, 0043-02, 0044-02) and for brush activities with CT solutions (dossier 0032-04 and 0032-05). It was assumed that decanting of liquids is performed one time/week in the initial applications 0096-01 and 0116-01.

In the present assessment, the excess lifetime lung cancer risk based on shift-average inhalation exposure value is **2.00E-04**, which is slightly lower to the estimated risk of the previous applications. In contrast to the modelling approach in the initial applications, **use of RPE is not considered in the present assessment** based on shift-average values, although it is used during some exposure-relevant tasks. This constitutes a very conservative approach.

<table>
<tr><th colspan="4">Initial assessment</th><th colspan="2">Present assessment</th></tr>
<tr><th>Application ID</th><th>Chromate</th><th>Inhalation exposure, 90th Perc. [µg/m³]</th><th>Excess lifetime lung cancer risk [1/µg/m³]</th><th>Inhalation, long-term exposure, 90th Perc. [µg/m³]</th><th>Excess lifetime lung cancer risk [1/µg/m³]</th></tr>
<tr><td colspan="4">Surface treatment by brushing/rolling (PROC 10)
<180 min, up to 10% Cr(VI), LEV and RPE (APF30) (0032-04, 0032-05)
<60 min, up to 5% Cr(VI), no LEV, no RPE (0096-01, 0043-02, 0044-02, 0045-02)
<30 min, up to 1% Cr(VI), no LEV, no RPE (0116-01)</td><td rowspan="24">0.070</td><td rowspan="24">2.00E-04</td></tr>
<tr><td>0032-04</td><td>CT</td><td>0.57</td><td>2.28E-03</td></tr>
<tr><td>0032-05</td><td>CT</td><td>0.57</td><td>2.28E-03</td></tr>
<tr><td>0096-01</td><td>CT</td><td>0.23</td><td>0.92E-03</td></tr>
<tr><td>0043-02</td><td>SD</td><td>0.23</td><td>0.92E-03</td></tr>
<tr><td>0044-02</td><td>PD</td><td>0.23</td><td>0.92E-03</td></tr>
<tr><td>0045-02</td><td>DtC</td><td>0.23</td><td>0.92E-03</td></tr>
<tr><td>0116-01</td><td>DtC</td><td>0.29</td><td>1.16E-03</td></tr>
<tr><td colspan="4">Surface treatment by brushing or pen stick (PROC 10)
<60 min, up to 1% Cr(VI), no LEV, no RPE (0045-02)
<30 min, up to 0.5% Cr(VI), no LEV, no RPE (0116-01)</td></tr>
<tr><td>0045-02</td><td>DtC</td><td>0.017</td><td>0.07E-03</td></tr>
<tr><td>0116-01</td><td>DtC</td><td>3.5E-03</td><td>1.4E-05</td></tr>
<tr><td colspan="4">Decanting of liquids (PROC 8b)
<60 min, up to 50% Cr(VI), contain.99% (0032-04, 0032-05)
<15 min, up to 25% Cr(VI), no LEV, no RPE (0096-01)
<60 min, up to 20% Cr(VI), contain.99% (0043-02, 0044-02, 0045-02)
<15 min, up to 5% Cr(VI), no LEV, no RPE (0116-01)</td></tr>
<tr><td>0032-04</td><td>CT</td><td>0.69</td><td>2.76E-03</td></tr>
<tr><td>0032-05</td><td>CT</td><td>0.69</td><td>2.76E-03</td></tr>
<tr><td>0096-01</td><td>CT</td><td>0.26*</td><td>1.04E-03*</td></tr>
<tr><td>0043-02</td><td>SD</td><td>0.42</td><td>1.68E-03</td></tr>
<tr><td>0044-02</td><td>PD</td><td>0.42</td><td>1.68E-03</td></tr>
<tr><td>0045-02</td><td>DtC</td><td>0.42</td><td>1.68E-03</td></tr>
<tr><td>0116-01</td><td>DtC</td><td>0.015*</td><td>6.00E-05*</td></tr>
<tr><td colspan="4">Decanting and weighing of solids (PROC 8b)
<60 min, up to 50% Cr(VI), no LEV, RPE (APF30) (0032-04, 0032-05)
<15 min, up to 40% Cr(VI), no LEV, RPE (APF30) (0043-02, 0044-02)</td></tr>
<tr><td>0032-04</td><td>CT</td><td>1.5</td><td>6.00E-03</td></tr>
<tr><td>0032-05</td><td>CT</td><td>1.5</td><td>6.00E-03</td></tr>
<tr><td>0043-02</td><td>SD</td><td>0.5</td><td>2.0E-03</td></tr>
<tr><td>0044-02</td><td>PD</td><td>0.5</td><td>2.0E-03</td></tr>
</table>

* Adjusted for the frequency in the initial assessment.

Dermal exposure

No quantitative dermal exposure assessment has been performed in the initial applications.

9.2.3.4 Worker contributing scenario 3 – Storage area workers

The SEG defined as "storage area workers" comprises workers who perform several relevant activities related to CCC 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 CCC with potential for Cr(VI)-exposure, but these tasks account only for a small fraction of their working time and mostly, they are occupied with activities not related to CCC and without Cr(VI) exposure.

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

Main tasks

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

Secondary task

- Task 7: Sampling of treatment baths (PROC 9)
- Task 8: Solution preparation for brush or swab application (decanting of liquids) (PROC 9)
- Task 9: Solution preparation for brush or swab application (measuring and weighing of solids) (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). At some sites, storage area workers may also prepare solutions for local CCC application. These tasks (task 8 and task 9) are main tasks carried out by brush and pen application operators, they are described in the dedicated worker contributing scenario (see section 9.2.3.3).

In addition to the tasks listed above, the storage area workers may also perform and control the wastewater and sludge treatment at sites where wastewater is treated on-site, but at some sites, this can also be the responsibility of the laboratory technicians. The treatment of wastewater and sludge typically includes refilling of reducing agents, sampling of reduced wastewater, analysis of the Cr(VI) content in the wastewater samples (e.g., by means of a photometric quick test; for verification that the Cr(VI) content in the wastewater is below a threshold value under which release to the external WWTP or STP is permitted), dewatering and removal of the sewage sludge (containing only Cr(III)) and cleaning of the sludge press. However, as the duration that 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 as 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.

9.2.3.4.1 Conditions of use

Table 9-32 summarises the conditions of use for the activities with Cr(VI) exposure related to CCC 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 9-18.

Table 9-32: Conditions of use – worker contributing scenario 3 – Storage area workers

Product (article) characteristics
Product 1: Solid CT, SD, or PD (flakes or powder) for Task 2, Task 3, and Task 5 ▪ Substance product type: Powders, granules, or pelletised material ▪ Dustiness: Flakes or powder ▪ Moisture content: Dry product (<5 % moisture content) ▪ Weight fraction: Pure material of CT, SD or PD, or solid mixture of CT (max. 100%) ▪ Concentration in pure substance: 52% Cr(VI) for CT, 40% Cr(VI) for SD, 35% Cr(VI) for PD ▪ Concentration in solid mixture: max. 31.5% 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: up to 26% (w/w) Cr(VI) ▪ Concentration of Cr(VI) based on ranges of CT (up to 50% (w/w)) in supplied aqueous solution used for bath make-up or addition ▪ Product type: Solids dissolved in a liquid or incorporated in a liquid matrix ▪ Viscosity: Liquids with low viscosity (like water)
Product 3: Aqueous solution of SD for Task 1, Task 4, Task 5 ▪ Concentration of substance in mixture: max. 12% (w/w) Cr(VI) • Concentration of Cr(VI) based on range of 25-30% (w/w) SD 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 4: Aqueous solutions of CT, SD or PD for Task 4 and Task 6 ▪ Concentration of substance in mixture: 0.09-14.6% (w/w) Cr(VI) ▪ Concentration of Cr(VI) based on ranges of CT (up to 28% (w/w)) or PD (up to 16% (w/w)) or SD (up to 22% (w/w)) in the aqueous solution of the CCC bath ▪ Product type: Solids dissolved in a liquid or incorporated in a liquid matrix ▪ Viscosity: Liquids with low viscosity (like water)

Amount used (or contained in articles), frequency and duration of use/exposure
Task 1: Aliquot chemicals – Decanting of liquids ▪ Amount per aliquot: up to 9 kg Cr(VI); corresponding to up to 20 L of product 2 (density = 1.725 g/cm3) or 5L of product 3 for bath addition ▪ Duration of activity: 5-10 min ▪ Frequency of task: <1-48 days per year (<1 days/year up to 1 day/week, 48 weeks per year)
Task 2: Aliquot chemicals – Measuring and weighing of solids ▪ Amount per aliquot: up to 13 kg Cr(VI) (bath addition) and up to 260 kg Cr(VI) (bath make-up), corresponding to up to 25 kg (bath addition) and up to 500 kg (bath make-up) of product 1 ▪ Duration of activity: 5-10 min (for large quantities aliquoting may take up to 60 min) ▪ Frequency of task: <1-48 days per year (<1 days/year up to 1 day/week, 48 weeks per year)
Task 3: Waste management – Cleaning of empty chemical containers/bags ▪ Duration of activity: <1-10 min ▪ Frequency of task: <1-48 days per year (<1 days/year up to 1 day/week, 48 weeks per year)
Task 4: Waste management – Handling of solid waste ▪ Duration of activity: 2-10 min ▪ Frequency of task: 2-240 days per year (2 days/year up to 5 days/week, 48 weeks per year)
Task 5: Bath make-up or addition ▪ Amount: up to 260 kg Cr(VI) (bath make up); up to 13 kg Cr(VI) (bath addition) ▪ Duration of activity: 5-60 min ▪ Frequency of task: <1-12 days per year (bath make-up) or <1-48 days per year (bath addition)
Task 6: Bath cleaning ▪ Duration of activity: 30-45 min ▪ Frequency of task: <1-12 days per year
Technical and organisational conditions and measures
Task 1: Aliquot chemicals – Decanting of liquids ▪ LEV: yes/no; depending on the site ▪ Ventilation rate of general ventilation system: natural ventilation ▪ Occupational health and safety management system: advanced (see section 9.2.2.3.1.2)
Task 2: Aliquot chemicals – Measuring and weighing of solids ▪ LEV: yes/no; depending on the site ▪ Ventilation rate of general ventilation system: natural ventilation ▪ Occupational health and safety management system: advanced (see section 9.2.2.3.1.2)
Task 3: Waste management – Cleaning of empty chemical containers/bags ▪ LEV: no ▪ Ventilation rate of general ventilation system: natural ventilation

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

Task 4: Waste management – Handling of solid waste
- LEV: no; use of LEV during handling of solid waste is technically impossible
- Ventilation rate of general ventilation system: natural ventilation
- Occupational health and safety management system: advanced (see section 9.2.2.3.1.2)

Task 5: Bath make-up or addition
- LEV: yes
- Ventilation rate of general ventilation system: natural ventilation
- Occupational health and safety management system: advanced (see section 9.2.2.3.1.2)

Task 6: Bath cleaning
- LEV: yes/no; depending on the site
- Ventilation rate of general ventilation system: natural ventilation
- Occupational health and safety management system: advanced (see section 9.2.2.3.1.2)

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

Gloves

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

The following materials have a breakthrough time ≥8h for aqueous CT solutions (10% CT) and saturated aqueous SD, and PD solutions [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, SD, and PD:

- Butyl rubber (0.7 mm)

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

Respiratory protection equipment

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

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

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

Protective clothes

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

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

Eye protection

Suitable eye protection as per relevant risk assessment must be worn during all tasks (Tasks 1 to 6).

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

Other conditions affecting workers' exposure

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

Task 2: Aliquot chemicals – Measuring and weighing of solids
- Place of use: indoors – any size workroom
- Temperature: room temperature
- Primary emission source proximity: The primary emission source is in the breathing zone of the worker (near field, < 1 m)
- Activity class: Movement and agitation of powders, granules, or pelletised material
- Situation: Transferring 1-10 kg/min
- Containment of the process: Handling that reduces contact between product and adjacent air

Task 3: Waste management – Cleaning of empty chemical containers/bags
- Place of use: indoors – any size workroom
- Temperature: room temperature

▪ Primary emission source proximity: The primary emission source is in the breathing zone of the worker (near field, <1 m) ▪ Activity class: Handling of contaminated solid objects or paste
Task 4: Waste management – Handling of solid waste ▪ Place of use: indoors – any size workroom ▪ Temperature: room temperature ▪ Primary emission source proximity: The primary emission source is in the breathing zone of the worker (near field, <1 m) ▪ Activity class: Handling of contaminated solid objects or paste (worst case assumption, see section details in 9.2.3.4.2.2) ▪ Handling type: Careful handling, involves workers showing attention to potential danger, error or harm and carrying out the activity in a very exact and thorough (or cautious) manner.
Task 5: Bath make-up or addition ▪ Place of use: indoors – any size workroom ▪ Temperature: room temperature ▪ Primary emission source proximity: The primary emission source is in the breathing zone of the worker (near field, <1 m) ▪ Situation: Activities with open liquid surfaces or open reservoirs ▪ Open surface: up to 8 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)
Task 6: Bath cleaning ▪ Place of use: indoors – any size workroom ▪ Temperature: room temperature to 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 VI of this report.

9.2.3.4.2 Exposure and risks for workers

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

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

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

The aliquoting of chemicals needed for bath make-ups and additions is performed by the storage area workers either in the storage area (Figure 9-9 a), in the laboratory or close to the treatment bath. Measuring and weighing processes are carried out at a dedicated place, either under a fume hood, or at a station equipped with an LEV, when technically feasible.

Task 1: To aliquot liquids, the storage area worker either carefully pours the required volume of the product into a graduated container or transfers it via a small hand pump (Figure 9-9 b). The measured volume per aliquot is at maximum 20 L chromate solution, depending on the required Cr(VI) concentration in the bath and the tank volume. Then the storage area worker closes the container or canister and the measurement vessel with lids. In case the chemical is measured in a measurement canister that cannot be closed, he transfers the measured liquid into a bottle which he then closes with a lid. The empty measurement vessel is rinsed with water and the rinse water is gathered in the wastewater collection tank.

Task 2: For measuring or weighing solids, the worker opens the lid of a container with the solid substance (flakes or powder) and transfers the required quantity of the substance with a shovel into a measuring container or bag (Figure 9-9 c + d). The amount of substance to be aliquoted is at maximum 25 kg chromate per aliquot, 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 or bags are used for bath additions and bath make-ups (up to 500 kg of solid chromate) then aliquoting is not required.

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

Task 1+ 2: The closed containers, bags or bottles containing the aliquoted chemical are transported to the treatment bath where they are used for a bath make-up or addition (Figure 9-10). In cases where large quantities of chromates are required, the measuring of the solution or solid product is typically carried out at the bath.

The aliquoting procedure of either solids or liquids takes each approximately 5-10 min. Typically, aliquoting of solids or liquids are performed 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 eye protection (as per relevant risk assessment), chemical protective clothing, and chemical resistant gloves. At least in cases where it is technically impossible to aliquot within a fume hood or at a station equipped with an LEV, they also wear RPE (if industrial hygiene exposure assessment confirms RPE use is required), as described above. All relevant PPE is specified in Table 9-32.

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

The tasks of aliquoting chemicals as described above are at some sites not carried out by the storage area workers but by the line operators (secondary task of line operators; see section 9.2.3.2). At some sites, storage area workers may also prepare the chromate solutions required for brushing applications (main task of brush and pen application operators; see section 9.2.3.3).

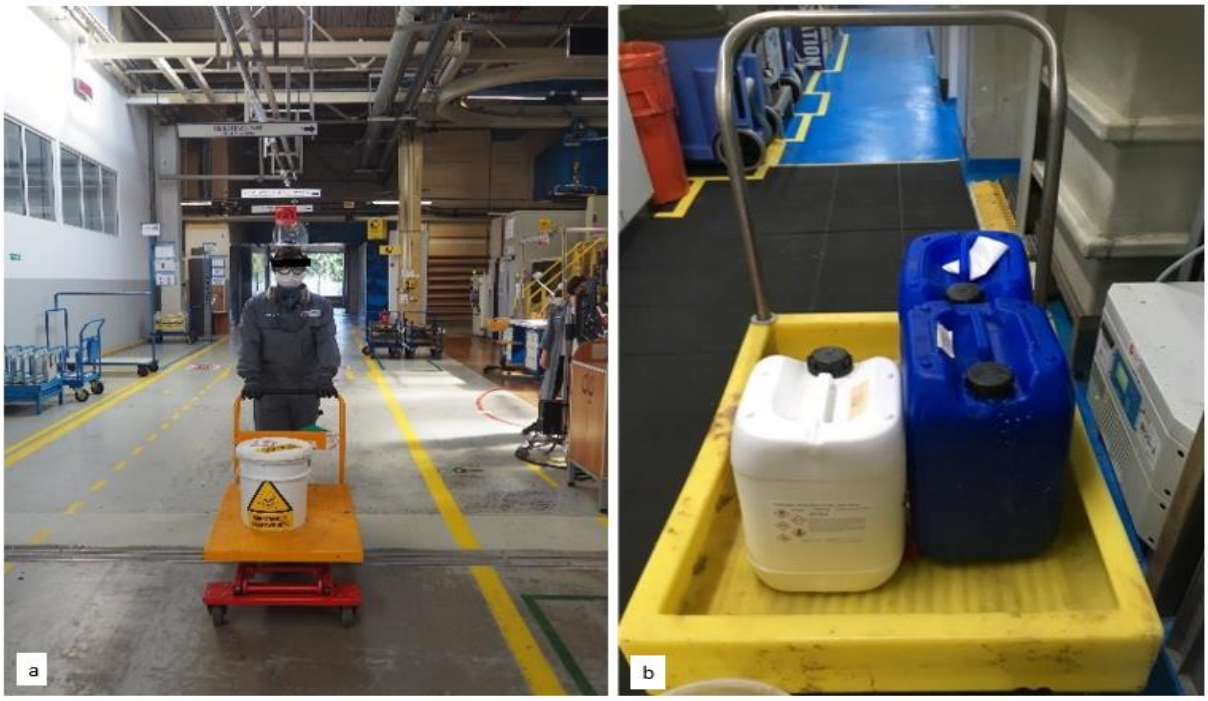


Figure 9-10: Transport of solid (a) and liquid (b) chemicals to the treatment bath(s)

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

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

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

During cleaning of empty chemical containers/bags, the worker wears eye protection (as per relevant risk assessment), chemical protective clothing (for cleaning with a hose he also wears an apron and waterproof boots), chemical resistant gloves and RPE (if industrial hygiene exposure assessment confirms RPE use is required), as specified above in Table 9-32.

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 CCC and cleaning activities (empty uncleaned bags and containers, contaminated wipes, rags, and PPE, sorbents, contaminated equipment, filter cartridges) is disposed of in a waste container, typically by the worker who generates the waste (Figure 9-11 a). In cases where there is a considerable amount of moisture in the waste, the worker may add a special sorbent to the waste to absorb the moisture. During the handling of empty bags, filters, and other process waste, the operator proceeds in accordance with appropriate standard operating procedures to reduce as low as possible the release of dust in the air during these operations.

At most sites, the waste container holds a waste bag in which the waste is collected. The waste container is placed e.g., near the CCC baths, in the storage area and/or in the laboratory, and is closed when it is not in use (see Figure 9-11 b).

When the waste bag is full, the storage area worker will seal the waste bag and either remove it from the waste container and transport it to the storage area or leave the sealed waste bag in the storage container and transport both to the storage area. The waste remains in the storage area until it is sent to an external waste management company (licensed contractor) for disposal as hazardous waste. The frequency of this activity (which 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) is assumed to take place up to one time per day at the end of a shift. The duration of the transport can be variable depending on the organization of the site, but the exposure duration (sealing of waste container/ bag and transport to storage area/container) is maximum 10 min per day.

When handling solid waste, the worker wears eye protection (as per relevant risk assessment), chemical protective clothing, chemical resistant gloves and RPE (if industrial hygiene exposure assessment confirms RPE use is required), as specified above in Table 9-32.

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 9.2.3.6).

Figure 9-11: Operator discarding solid waste contaminated with Cr(VI) into a drum for hazardous waste (a); closed hazardous waste drum (b)

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

For bath make-up or addition, the storage area worker uses the appropriate amount of chemical (either pure solid substance or a solid or liquid mixture containing CT, PD or SD) which he already aliquoted into a closed container, bottle, or bag (see description for Task 1 and 2 above; see Figure 9-12 a). Then he either mixes the aliquoted amount of chemical in a bucket with water and stirs it with a metal rod to prepare a homogenised pre-mixture (in case of solid chemical) or he fills it as it is (solid or liquid) in the treatment bath. In rare cases of make-ups where high amounts of chromates are required, the storage area worker transfers the product directly from the original chemical container into the bath (Figure 9-12 b - c).

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

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 260 kg Cr(VI) for bath make-up and up to 13 kg Cr(VI) for bath addition. Both tasks are carried out at room temperature. For bath make-up the whole process of mixing, transfer to the bath, pouring it into the bath and then filling the bath up with water can take up to several hours. However, the operator may leave the bath in between (e.g., during filling of the bath), so that the exposure duration is at maximum 60 min per make-up. Bath make-up is typically carried out up to 12 times per year. Bath addition only takes up to 10 min and is necessary at a maximum of 48 times per year (once per week).

For both, bath make-up and addition, the storage area worker wears eye protection (as per relevant risk assessment), chemical protective clothing, chemical resistant gloves and RPE (if industrial hygiene exposure assessment confirms RPE use is required), as specified above in Table 9-32.

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).

Figure 9-12: Operator transfers a bucket with solid chromate to the tank (a); operator carefully pours the chromate into the bath for bath make-up or addition (b + c)

Task 6: Bath cleaning

The cleaning of the baths is carried out during a bath renewal. For this purpose, the storage area worker drains the old bath solution by gravity or by means of a pump and, depending on the site's wastewater management system and the concentration of the bath solution, either pumps it into an Intermediate Bulk Container (IBC) (see Figure 9-13 a), in which case it is later disposed of externally as a liquid hazardous waste[15], or it is pumped to the on-site wastewater treatment plant, where it is reduced and neutralized (see a detailed description of the wastewater treatment process in section 9.2.2.3.2.2).

When the bath is drained, at some sites the storage area worker rinses it thoroughly with a hose and removes potential solid deposits in the bath with the water jet or wet and dry vacuum cleaner (Figure 9-13 b-d). 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 operator usually spends up to 45 min at the bath, but during the draining process the worker may temporarily be away from the bath. Depending on the size of the plant and the number of CCC baths, bath cleaning is necessary up to 12 times per year. During the cleaning process, the treatment solutions and the rinsing water are in most events at room temperature, but sometimes they may be at elevated temperature (up to 45°C). The LEV is usually running when the treatment bath is cleaned. For the bath cleaning the storage area worker wears eye protection (as per relevant risk assessment), chemical protective clothing (for cleaning with a hose he also wears an apron and waterproof boots; in case he enters the treatment bath he wears a chemical protective coverall), chemical resistant gloves and RPE (at least at sites where the LEV is not running during bath cleaning and if industrial hygiene exposure assessment confirms RPE use is required), as specified above in Table 9-32.

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

[15] 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 per month), the short duration in which the worker connects and disconnects the tank nozzle (approximately 5 min per event) and as the transfer is exclusively performed via closed lines this activity is not considered for a separate group of workers. It is expected that the exposure coming from this activity is covered by the number of workers, duration and frequency considered for the bath cleaning performed by the storage area workers.

Figure 9-13: Bath emptying by transfer of old bath solution into an IBC (a) and bath cleaning with a hose and wet and dry vacuum cleaner (b, c, d)

9.2.3.4.2.1 Inhalation exposure

Measured inhalation exposure concentration

In total, 71 personal measurements covering exposure from CCC are available for this SEG. One personal long-term value was excluded from further analysis because it is below an unreasonably high LOQ (i.e., <2 µg/m³).

Of the remaining 70 personal monitoring data, 27 are long-term (≥2h)[16], shift-representative and 43 are short-term (<2h) measurements. Five stationary measurement results are available for storage area workers (three long-term and two short-term).

The personal monitoring data come from 17 sites of nine countries in the EEA (61 measurements) and from five sites in the UK (nine measurements). 41% of the data (29 values, including 19 short-term measurements) are <LOQ and 59% (41 values, including 24 short-term measurements) are >LOQ.

A summary on the analytical methods for inhalation exposure monitoring and information on their LOQs is given in Annex IV of this report. The individual measurements can be provided upon request. An overview of the available data for storage area workers is given in Table 9-33.

Table 9-33: Overview of available inhalation exposure measurements for WCS 2 – Storage area workers

	n	>LOQ	<LOQ
Personal			
- Long-term (≥2h)	27	17	10
- Short-term (<2h)	43	24	19
Stationary			
- Long term (≥2h)	3	2	1
- Short-term (<2h)	2	1	1

Personal measurements – long-term

Long-term personal measurements were taken for storage area workers performing tasks related to CCC. However, during most of the measurements the storage area workers also had potential Cr(VI) exposure from other uses (e.g., deoxidising, pickling/etching, inorganic finish stripping, passivation of (non-Al) metallic coatings, anodising, anodise sealing) with CT and/or other chromates, as storage area workers are typically responsible for providing chemicals for all baths operating at a site. During the personal measurements, storage area workers mainly performed decanting of liquids (Task 1), measuring/weighing of solids (Task 2), bath make-ups or additions (Task 5), bath cleaning (Task 6), logistic activities related to chemical storage (transport, ordering) and activities related to wastewater

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

or sludge treatment. Cleaning of chemical containers (Task 3) and handling of solid waste (Task 4) are not explicitly recorded for the long-term measurements data, but it can be assumed that exposure from these activities is covered by the available shift average exposure values as these are typical activities performed on a regular basis by storage area workers.

The AM of all long-term personal measurements is **0.381 µg/m³**, the 90th percentile is **0.940 µg/m³**. For long-term exposure values of measurements covering activities involving the handling of **solids** (from which exposure to dust may arise) such as weighing/measuring of solids and bath make-ups/additions (among other activities; in total 12 long-term measurements), five results are below the LOQ. The AM is 0.462 µg/m³, slightly above the AM of all long-term personal measurements, which indicates that these activities are well represented by the worker exposure measurements. For eight of these 12 measurements, it is reported that the workers wore RPE (at least reusable half mask – particle filter) during parts of the measurement period, during which they performed specific activities (such as weighing of solid substance), but for the other measurements no information is available on the use of RPE.

Seven measurements covered measuring of **liquids** and pouring into the baths for concentration adjustment, (some of them covering also weighing of solids), with four values below the LOQ. The AM is 0.406 µg/m3, comparable to the AM of the measurements covering handling of solids. It is reported for three of these seven measurements that a RPE was worn (half-mask or full face respirator). No information is available for the other four measurements.

Nine of the long-term measurements covered 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. These measurement values are within a range of 0.01 – 0.9 µg/m³.

Only four of the long-term measurements were taken while the worker performed activities **only related to CCC**, but not to any other Cr(VI) use (according to the information provided by the sites). These four measurements were carried out during handling of solid CT (during 120 and 420 min), solid SD (during 420 min) and solid PD (during 420 min). These four single-use values range between <0.02 and 0.18 µg/m³, which is well below the AM of the long-term measurement results. It is reported for all these measurements that the workers wore a RPE (half-mask). These measurements would suggest that the activity of weighing and bath make-up/addition for CCC only contributes to a low extent to the shift-average exposure of storage area workers performing activities on several processes involving Cr(VI). Nevertheless, no conclusions can be drawn from these four values alone.

<u>Personal measurements – short term</u>

The 43 short-term measurements cover all relevant tasks performed by storage area workers except Task 3 (Cleaning of empty chemical containers/bags):

- Task 1: Decanting of liquids (two values; 0.052 µg/m³, 9 min, covered also addition into the bath, and 0.564 µg/m³, 82 min covered also bath addition and weighing of solid)
- Task 2: Measuring and weighing of solids (18 values; 0.04-109.95 µg/m³, 3-115 min; nine of these measurements covered also bath make-up/addition with for one of them decanting of liquids, and one measurement covered bath emptying, cleaning and refilling)
- Task 4: Handling of solid waste (nine values; <0.085 - <0.97 µg/m³, 10-118 min)
- Task 5: Bath make-up or addition, including decanting of substances and mixing them with water (21 values, <0.04 - 14.268 µg/m³, 4-105 min; 11 of these values covered also measuring/weighing of solids and two values covered also bath cleaning)

- Task 6: Bath emptying and cleaning (two values, <2 and 11 µg/m³, 61 and 44 min, both covering also bath addition and the first one covered in addition weighing of solids)
- Wastewater treatment (three values, <0.18 - 4.57 µg/m³, 10-45 min)

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

Thirty-seven of the 43 short-term measurements are within a range of 0.04 – 7.71 µg/m³. The other six measurements, all covering measuring/weighing of solids and/or bath make-up/additions, differ from the other results by their high value: 11, 14.13, 14.27, 23.8, 39.1 and 109.9 µg/m³ (with a measurement duration between 3 and 44 min). The 8h TWA[17] values calculated from these measurements ranges from 0.088 and 1.01 µg/m³, if it is theoretically assumed that the remaining shift is without exposure[18]. It was clearly stated that RPE was worn during five of these measurements (at least a half-mask with particle filter P3 with an APF factor of 10), no information is recorded for the sixth measurement (the one with the 8h TWA of 0.208 µg/m³). The six exposure values calculated on a 480 min shift and corrected for five of them with the RPE ranges from 0.009 to 0.208 µg/m³, which is well below the 90th percentile of the long-term measurements, suggesting that exposure from these individual activities of measuring/weighing of solids and bath make-up or addition are covered by the shift-average exposure of operators.

Stationary measurements

Three long-term stationary measurements available for CCC were taken in two different locations: two in the chemical storage area and one in front of open wastewater collection containers (employees are only present in this area irregularly and for short periods of time). The measurement results are respectively 0.18, 0.23 and <0.008 µg/m³, suggesting a background exposure concentration lower than the AM (0.381 µg/m³) of the shift-average exposure concentration for storage area workers.

Two short-term measurements were performed next to the collection container of solid waste (0.14 µg/m³; 30 min) and in the wastewater treatment area (< 0.12 µg/m³; 111 min).

Table 9-34 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 2016 through 2021.

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

[18] 11.0 µg/m³ x (44 min/480 min) = 1.01 µg/m3, 14.13 µg/m³ x (3 min/480 min) = 0.088 µg/m3, 14.27 µg/m³ x (7 min/480 min) = 0.208 µg/m3, 23.8 µg/m³ x (6 min/480 min) = 0.297 µg/m³, 39.14 µg/m³ x (3 min/480 min) = 0.245 µg/m³ and 109.9 µg/m³ x (3 min/480 min) = 0.687 µg/m³

Table 9-34: Summary statistics of inhalation exposure measurements for WCS 2 – Storage area workers

Personal – long-term (measurement period 2016-2021)						
	N	**% of total**	**AM [µg/m³]**	**SD [µg/m³]**	**Median [µg/m³]**	**90th Perc. [µg/m³]**
Total	27	100	0.381	0.631	0.130	0.940
- Only this use covered by the measurement	4	15	0.225	n.a.	n.a.	n.a.
Personal – short-term (measurement period 2017-2021)						
	N	**% of total**	**AM [µg/m³]**	**SD [µg/m³]**	**Median [µg/m³]**	**90th Perc. [µg/m³]**
Total	43	100	6.33	17.77	0.800	13.50
Stationary – (measurement period 2019-2021)						
	N	**% of total**	**AM [µg/m³]**	**SD [µg/m³]**	**Median [µg/m³]**	**90th Perc. [µg/m³]**
Total	5	100				
- Long-term	3	50	0.138	n.a.	n.a.	n.a. (MAX = 0.230)
- Short-term	2	50	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 measurement values are < 0.12 and 0.14 µg/m³.

All personal long-term measurements of storage area workers performing tasks related to CCC are included in the assessment of inhalation exposure. Table 9-35 shows the resulting long-term inhalation exposure concentration for storage area workers used for risk assessment, based on the 90th percentile of personal sampling values.

As stated above, partial exposure from sources and processes not related to the use of CCC may have contributed to most of the exposure values assigned to this use. Considering that, storage area workers typically spend only a minor part of their working time on activities related to CCC (rounded up to 2.0%[19]), we assign 2.0% of the shift average exposure value (90th percentile of all long-term measurements) to this use.

[19] Considering the maximum durations (exposure time) and frequencies of all main tasks performed by storage area workers as described in section 9.2.3.4.2 and considering 1920h working time per year for one worker (8h per day, 240 days per year),

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

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

Table 9-35: Measured inhalation exposure concentration for WCS 3 – Storage area workers

Type of measurement	Number of measurements	Exposure value (8h TWA) [a] [µg/m³]	Assigned protection factor (APF) for RPE [b]	Exposure value corrected for RPE [µg/m³]	Long-term exposure [c] [µg/m³]
Personal	27	0.940	1	0.940	0.0188

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

[a] Based on 90th percentile of measurements.

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

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

9.2.3.4.2.2 Dermal exposure

In Table 9-36, the dermal exposure concentrations for storage area workers are shown, based on modelling of the activities with Cr(VI) exposure. The parameters considered for dermal exposure modelling are described in detail in Annex V of this report. For a conservative assessment of dermal exposure, we consider for modelling that only one storage area worker performs all tasks described above (also the tasks typically performed by a different SEG, such as sampling of treatment baths), that exposure from each activity adds up and that all tasks are performed at the maximum frequency.

Considering brush activities, storage area workers may be involved in preparing the brushing solutions by handling chromates in solution (task 8) or solid chromates (task 9). The dermal exposure generated by these two tasks is covered by the tasks "Aliquot chemicals" (tasks 1 and 2).

the exposure time related to CCC accounts for 6.5% of his shift ((10 min 48x/year (Task 1) + 60 min 48x/year (Task 2) + 10 min 48x/year (Task 3) + 10 min 240x/year (Task 4) + 60 min 12x/year (Task 5) + 45 min 12x/year (Task 6)) = 7500 min/y = 125h/y; 125h/1920h = 6.5%) assuming that one worker performs all activities; if the activities are divided between four workers the percentage is 1.628% per worker, conservatively rounded up to 2%.

Table 9-36: Dermal exposure modelling for WCS 3 – Storage area workers

Task	PROC(s)	Cr(VI) concentration [%]	Annual average dermal exposure value [µg Cr(VI)/kg bw/d] [b]
Task 1: Aliquot chemicals – Decanting of liquids	PROC 8b	12	0.82
Task 2: Aliquot chemicals – Measuring and weighing of solids	PROC 8b	40.0	2.74
Task 3: Waste management – Cleaning of empty chemical containers/bags	PROC 28	4.00*	4.76
Task 4: Waste management – Handling of solid waste	PROC 8b	12.0	4.11
Task 5: Bath make-up or addition	PROC 5 PROC 8b	40.0	2.74
Task 6: Bath emptying and cleaning	PROC 28	0.880*	0.262
Task 7: Sampling of treatment baths	PROC 9	8.80	3.02
Task 8: Solution preparation for brush or swab application (Decanting of liquids)	PROC 9	1.35	Exposure assessment covered by Task 1 assessment
Task 9: Solution preparation for brush or swab application (measuring and weighing of solids)	PROC 9	40	Exposure assessment covered by Task 2 assessment
Combination of all tasks			**18.5**

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

* 10-fold dilution assumed due to cleaning activity; for details see Annex V.

Despite the very conservative approach as described above, the combined dermal exposure value from all tasks of 18.5 µg Cr(VI)/kg bw/d does not exceed the DNEL of 43 µg Cr(VI)/kg bw/d.

9.2.3.4.2.3 Risk characterisation

Risk for carcinogenicity

Table 9-37 shows the risk characterisation for carcinogenicity for storage area workers. The risk for carcinogenicity is based on measured Cr(VI) inhalation exposure data for storage area workers and the RAC dose-response relationship for the excess lifetime cancer risk for lung cancer (ECHA, 2013).

Table 9-37: Risk characterisation for carcinogenicity for WCS 3 – 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	0.0188 µg/m^3	4.00E-03	7.52E-05

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

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

Risk for reproductive toxicity

Table 9-38 shows the risk characterisation for reproductive toxicity for storage area workers. The risk characterisation for reproductive toxicity is based on measured Cr(VI) inhalation exposure data for storage area workers and modelled dermal Cr(VI) exposure values which are compared to the RAC DNEL for workers, derived for effects on fertility (ECHA, 2015).

Table 9-38: Risk characterisation for reproductive toxicity for WCS 3 – Storage area workers

Route of exposure and type of effects	Long-term exposure	Risk characterisation: RAC DNEL *	Risk characterisation ratio (RCR)
Inhalation: Systemic Long Term	0.0188 µg/m^3	43 µg Cr(VI)/m3	4.37E-04
Dermal: Systemic Long Term	18.5 µg/kg bw/d	43 µg Cr(VI)/kg bw/d	0.429
Combination of inhalation and dermal exposure			0.430

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

* RAC DNEL for workers, derived for effects on fertility (ECHA, 2015).

Note that very infrequently (approx. 2x/year) solid waste with higher Cr(VI) concentrations (e.g., empty chemical containers) of up to 40% is handled/discarded. Due to the low frequency of this activity this only increases the dermal exposure minimally to 18.6 µg/kg bw/d, leading to a dermal RCR of 0.432.

Conclusion on risk characterisation:

Carcinogenicity:

The Excess life-time cancer risk for storage area workers is 7.52E-05.

This risk estimate can be considered as conservative, because:

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

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

Reproductive toxicity:

The RCR for the endpoint reproductive toxicity based on a conservative assessment is well below 1 (0.430).

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

Comparison of outcome with initial applications

Inhalation exposure

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

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

In the present assessment, the excess lifetime lung cancer risk based on shift-average inhalation exposure value is **7.52E-05**, covering all individual tasks and considering durations and frequencies in which these tasks are performed in relation to CCC. In contrast to the modelling approach in the initial applications, **use of RPE is not considered in the present assessment** based on shift-average values, although it is used during exposure-relevant tasks. This constitutes a very conservative approach.

Initial assessment				Present assessment	
Application ID	**Chromate**	**Inhalation exposure, 90th Perc. [µg/m³]**	**Excess lifetime lung cancer risk [1/µg/m³]**	**Inhalation, long-term exposure, 90th Perc. [µg/m³]**	**Excess lifetime lung cancer risk [1/µg/m³]**
Decanting of liquids (PROC 8b) <60 min, up to 50% Cr(VI), contain.99% (0032-04, 0032-05) <15 min, up to 25% Cr(VI), no LEV, no RPE (0096-01) <60 min, up to 20% Cr(VI), contain.99% (0043-02, 0044-02)					
0032-04	CT	0.69	2.76E-03		
0032-05	CT	0.69	2.76E-03		
0096-01	CT	0.26*	1.04E-03*		
0043-02	SD	0.42	1.68E-03		
0044-02	PD	0.42	1.68E-03		
Decanting and weighing of solids (PROC 8b) <60 min, up to 50% Cr(VI), no LEV, RPE (APF30) (0032-04, 0032-05) <15 min, up to 40% Cr(VI), no LEV, RPE (APF30) (0043-02, 0044-02)					
0032-04	CT	1.5	6.00E-03		
0032-05	CT	1.5	6.00E-03		
0096-01	CT	-	-		
0043-02	SD	0.5	2.00E-03		
0044-02	PD	0.5	2.00E-03		
Mixing of liquids (PROC 5) <60 min, up to 50% Cr(VI), contain.90% (0032-04, 0032-05) <30 min, up to 25% Cr(VI), no LEV, no RPE (0096-01) <15 min, up to 20% Cr(VI), contain.90% (0043-02, 0044-02)				0.0188 µg/m³	7.52E-05
0032-04	CT	0.69	2.76E-03		
0032-05	CT	0.69	2.76E-03		
0096-01	CT	0.13*	5.10E-04*		
0043-02	SD	0.11	4.40E-04		
0044-02	PD	0.11	4.40E-04		
Mixing of solids (PROC 5) <60 min, up to 50% Cr(VI), contain.90%, RPE (APF30) (0032-04, 0032-05) <15 min, up to 40% Cr(VI), no LEV, RPE (APF30) (0043-02, 0044-02)					
0032-04	CT	0.5	2.00E-03		
0032-05	CT	0.5	2.00E-03		
0096-01	CT	-	-		
0043-02	SD	0.17	6.80E-04		
0044-02	PD	0.17	6.80E-04		
Re-filling of baths – liquids (PROC 8b) <10 min, up to 50% Cr(VI), LEV eff.90%, no RPE (0032-04, 0032-05) <10 min, up to 25% Cr(VI), LEV eff.90%, no RPE (0096-01) <10 min, up to 20% Cr(VI), LEV eff.90% (0043-02, 0044-02)					
0032-04	CT	1.1	4.40E-03		
0032-05	CT	1.1	4.40E-03		

0096-01	CT	0.19*	7.6E-04*		
0043-02	SD	0.76	3.04E-03		
0044-02	PD	0.76	3.04E-03		
Re-filling of baths – solids (PROC 8b) < 10 min, up to 50% Cr(VI), LEV eff.90%, RPE (APF 30) (0032-04, 0032-05) < 10 min, up to 40% Cr(VI), LEV eff.90%, RPE (APF 30) (0043-02, 0044-02)					
0032-04	CT	0.025	1.00E-04		
0032-05	CT	0.025	1.00E-04		
0096-01	CT	-	-		
0043-02	SD	0.066	2.64E-04		
0044-02	PD	0.066	2.64E-04		
Waste management (PROC 8b) 30 min, up to 50% Cr(VI), contain.90%, RPE (APF 30) (0032-04, 0032-05) <15 min, up to 5% Cr(VI), no LEV, no RPE (0096-01) < 30 min, up to 40% Cr(VI), contain.90%, RPE (APF 30) (0042-02, 0043-02)					
0032-04	CT	0.22	8.80E-04		
0032-05	CT	0.22	8.80E-04		
0096-01	CT	0.037	1.5E-04		
0043-02	SD	0.22	8.80E-04		
0044-02	PD	0.22	8.80E-04		

* Adjusted for the frequency in the initial assessment.

Note that applications ID 0045-02, 00116-01 are not reported in the table above as they are specific to DtC only, which is not a substance handled by storage area workers.

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 applications and the current assessment is possible.

Dermal exposure

No quantitative dermal exposure assessment has been performed in the initial applications.

9.2.3.5 Worker contributing scenario 4 – Laboratory technicians

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

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[20] 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).

9.2.3.6 Worker contributing scenario 5 – Maintenance and/or cleaning workers

Maintenance and/or cleaning workers may be involved in activities related to CCC 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 chemical CCC.

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 9.2.3.4).

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

9.2.3.6.1 Conditions of use

Table 9-39 summarises the conditions of use for maintenance and cleaning activities with Cr(VI) exposure related to CCC carried out by maintenance workers.

Table 9-39: Conditions of use – worker contributing scenario 5 – Maintenance and/or cleaning workers

Product (article) characteristics
Product: Aqueous solution of CT, SD, or PD, or mixture of CT and DtC ▪ Concentration of substance in mixture: 0.09-14.6% (w/w) Cr(VI) ▪ Concentration of Cr(VI) based on ranges of CT (max. 28% (w/w)) or PD (up to 16% (w/w)) or SD (up to 22% (w/w) in the aqueous solution in the CCC bath, or mixture of CT (max. 2.5% (w/w)) and DtC (max. 2.5% (w/w)) in the aqueous solution for filling of parts ▪ Product type: Solids dissolved in a liquid or incorporated in a liquid matrix ▪ Viscosity: Liquids with low viscosity (like water)
Amount used (or contained in articles), frequency and duration of use/exposure
Task 1: Maintenance and cleaning of equipment ▪ Duration of activity: up to 240 min (at some sites, specific maintenance activities are performed for 480 min once per year) ▪ Frequency of task: 48 days/year (once per week, 48 weeks/ 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, SD, PD, and DtC. The following materials have a breakthrough time ≥8h for aqueous CT solutions (10% CT) and saturated aqueous SD and PD solutions [a]: o Natural rubber/Natural latex (0.5 mm) o Polychloroprene (0.5 mm) o Nitrile rubber/Nitrile latex (0.35 mm) o Butyl rubber (0.5 mm) o Fluorocarbon rubber (0.4 mm) o 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 activities is laid down in work instructions for the activities.

Respiratory protection equipment

RPE is worn during all tasks not performed under a 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 activities.

Eye protection

Suitable eye protection as per relevant risk assessment must be worn during task 1.

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

Other conditions affecting workers' exposure

Task 1: Maintenance and cleaning of equipment

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

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

- *None*

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

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

9.2.3.6.2 Exposure and risks for workers

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

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

<u>Task 1: Maintenance and cleaning of equipment</u>

Typical maintenance tasks comprise for example maintenance or replacement of pipes, pumps, sensors, filters, rectifiers, and scrubbers, machining equipment, repair of electrical installations such as heating and mixing equipment installed in the treatment baths, pumps and valves, joints of baths/hydraulic installations and LEV systems (exemplarily, the replacement of a filter is shown in Figure 9-14). 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 CCC 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 9.2.3.4) in preparation for the maintenance work. Then the maintenance worker enters the empty bath and either repairs the heater in situ, if this is possible, or he removes the heater and transports it to the workshop for repair (exemplarily, cleaning and repair of equipment in a cleaned treatment bath is shown in Figure 9-15 a + b). In the workshop, when the heater is being repaired, additional cleaning may be necessary, either by wiping the heater with e.g., a cloth or by rinsing it with water over a collection vessel (the liquid waste is fed to the on-site reduction unit). After repair, the maintenance worker brings the heater back to the treatment bath and reinstalls it. In total, including dismantling, repair, and re-installation, such a maintenance case takes about 240 min.

The duration and frequency of maintenance activities can be highly variable between different sites, with frequencies between 1 and 48 times per year and durations typically between 10 and 240 min per maintenance case. At some sites, specific maintenance activities are performed for 480 min once per year. For the present exposure assessment, we consider a frequency of 48 times per year and a duration of 240 min per maintenance/cleaning event as a worst-case estimate.

Maintenance activities are performed at room temperature whenever possible, but sometimes it may be necessary that maintenance is performed directly near a heated treatment bath. The maximum Cr(VI) concentration in the treatment bath at which maintenance may be necessary is 14.6% Cr(VI). During maintenance in and at the treatment bath, the LEV of the bath is running and when contaminated parts are handled in the workshop a mobile LEV is used wherever this is technically and practically possible. For maintenance activities performed in the workshop the maintenance worker wears eye protection (as per relevant risk assessment), and chemical resistant gloves; for activities with potential Cr(VI) exposure (e.g., during cleaning and when entering the treatment bath) he additionally wears chemical protective clothing and RPE (if industrial hygiene exposure assessment confirms RPE use is required) , as specified above in Table 9-39.

Figure 9-14: Maintenance of equipment - Filter change

Figure 9-15: Cleaning of equipment (a + b)

9.2.3.6.2.1 Inhalation exposure

Measured inhalation exposure concentration

For maintenance and/or cleaning workers, 24 personal measurements covering exposure from CCC are available. One personal long-term measurement value was excluded from further analysis as it was below an unreasonably high LOQ (i.e., <2 µg/m³). The remaining 23 values are 11 long-term (≥2h)[21] and 12 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

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

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

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

The pooled personal monitoring data come from 13 sites in four countries in the EEA (27 measurements) and from three sites in the UK (five measurements). About 44% of the data (14 values, including seven short-term measurements) are <LOQ and 56% (18 values, including eight short-term measurements) are >LOQ. A summary on the analytical methods for inhalation exposure monitoring and information on their LOQs is given in Annex IV of this report. The individual measurements can be provided upon request. An overview of the available data for maintenance and/or cleaning workers is given in Table 9-40.

Table 9-40: Overview of available inhalation exposure measurements for WCS 5 – Maintenance and/or cleaning workers

	n	>LOQ	<LOQ
Personal – related to CCC			
- Long-term (≥2h)	11	6	5
- Short-term (<2h)	12	5	7
Personal – related to any Cr(VI) use			
- Long-term (≥2h)	17	10	7
- Short-term (<2h)	15	8	7

Personal measurements – related to CCC

The 11 long-term personal measurements were taken for workers performing maintenance activities related to CCC. The arithmetic mean (AM) for these measurements is 0.301 µg/m^3 and the maximum value is 1.00 µg/m^3). None of these measurements is exclusively related to this use, they all cover activities related to multiple Cr(VI) uses (e.g., deoxidising, pickling/etching, inorganic finish stripping, anodising, passivation of (non-Al) metallic coatings, anodise sealing). Activities performed during the measurements include general inspections, maintenance and cleaning throughout the site and specific tasks such as replacement of heaters, repair of pipes or dampers in the baths, cleaning and repair of wet scrubbers, removal of anodes from treatment baths or refilling of chemicals for the wastewater treatment plant. For two measurements (covering the removal of anodes from a treatment bath for the first one and infrequent maintenance activities without further details for the second one), it was reported that RPE was used. No information on the use of RPE is documented for the other measurements.

Also, 12 short-term personal measurements were performed on operators working on maintenance activities related to CCC. The AM for these measurements is 0.191 µg/m^3 and the 90th percentile is 0.516 µg/m^3). During these measurements the workers performed regular maintenance of the baths and related equipment. RPE was worn in all cases (e.g., reusable half mask – particle filter or full face mask in case of splashes). Only two short-term personal measurements were taken while the workers performed activities related to CCC, but not to any other Cr(VI) use (according to the information provided by the sites). The exposure values of these single-use measurements are <0.16 and 0.17 µg/m^3, which is below the AM of the total personal long-term measurements. However, it is not possible to conclude from these values whether exposure from CCC is lower than exposure from other Cr(VI) uses due to the low number of single-use measurements.

As described above, both, the long-term and short-term 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.

<u>Personal measurements – related to any Cr(VI) use (long-term measurements)</u>

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

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

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

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

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

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

Table 9-41 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 9-41: Summary statistics of inhalation exposure measurements for WCS 5 – Maintenance and/or cleaning workers

Personal – related to any Cr(VI) use (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	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 CCC (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	11	34	0.301	0.387	0.0400	1.00
Short-term	12	37	0.191	0.219	0.0613	0.516

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

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 9-42 shows the resulting long-term inhalation exposure concentration for maintenance workers used for risk assessment, based on the 90th percentile of personal sampling values.

As stated above, exposure from sources and processes not related to the use of CCC contributed to most of the exposure values. Considering that maintenance workers typically spend only a minor part of their working time on activities related to CCC (at maximum 5%[22]), we assign 5% of the shift average exposure value (90th percentile of all long-term measurements) to this use. We further assume that

[22] Considering the durations of all main tasks performed by maintenance and/or cleaning workers as described in section 9.2.3.6.2 and assuming conservatively 48 maintenance activities per year, with a duration of 4h each, the exposure time related to CCC 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%).

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 CCC**). Consequently, the long-term exposure concentration is corrected by a factor of 0.05. For sites where the work is distributed among a higher number of workers, a higher number of people would have to be considered, but their long-term average individual exposure concentration would be lower.

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

Table 9-42: Measured inhalation exposure concentration for WCS 5 – Maintenance and/or cleaning workers

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

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

[a] Based on 90th percentile of measurements.

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

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

9.2.3.6.2.2 Dermal exposure

In Table 9-43, the dermal exposure concentrations for maintenance and/or cleaning workers are shown, based on modelling of the activities with Cr(VI) exposure. The parameters considered for dermal exposure modelling are described in detail in Annex V of this report. For a conservative assessment of dermal exposure, we consider for modelling that only one maintenance and/or cleaning worker performs all tasks potentially carried out by maintenance and/or cleaning workers (also the tasks typically performed by a different SEG such as waste management – handling of solid waste), that exposure from each activity adds up and that all tasks are performed at the maximum frequency.

Table 9-43: Dermal exposure modelling for WCS 5 – Maintenance and/or cleaning workers

Task	PROC(s)	Cr(VI) concentration [%]	Annual average dermal exposure value [µg Cr(VI)/kg bw/d]
Task 1: Maintenance and cleaning of equipment	PROC 28	8.80	0.603
Task 2: Waste management – Handling of solid waste	PROC 8b	12.0	4.11
Combination of all tasks			**4.72**

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

Despite the very conservative approach as described above, the combined dermal exposure value from all tasks of 4.72 µg Cr(VI)/kg bw/d does not exceed the DNEL of 43 µg Cr(VI)/kg bw/d.

9.2.3.6.2.3 Risk characterisation

Risk for carcinogenicity

Table 9-44 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 9-44: Risk characterisation for carcinogenicity for WCS 5 – 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 4x10^{-3} for workers, based on 40 years of exposure; 8h/day; 5 days/week.

Risk for reproductive toxicity

Table 9-45 shows the risk characterisation for reproductive toxicity for maintenance and/or cleaning workers. The risk characterisation for reproductive toxicity is based on measured Cr(VI) inhalation exposure data for maintenance and/or cleaning workers and modelled dermal Cr(VI) exposure values which are compared to the RAC DNEL for workers, derived for effects on fertility (ECHA, 2015).

Table 9-45: Risk characterisation for reproductive toxicity for WCS 5 – Maintenance and/or cleaning workers

Route of exposure and type of effects	Long-term exposure	Risk characterisation: RAC DNEL *	Risk characterisation ratio (RCR)
Inhalation: Systemic Long Term	0.0960 µg/m^3	43 µg Cr(VI)/m^3	0.00223
Dermal: Systemic Long Term	4.72 µg/kg bw/d	43 µg Cr(VI)/kg bw/d	0.110
Combination of inhalation and dermal exposure			**0.112**

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

* RAC DNEL for workers, derived for effects on fertility (ECHA, 2015).

Note that very infrequently (approx. 2x/year) solid waste with higher Cr(VI) concentrations (e.g., empty chemical containers) of up to 40% is handled/discarded. Due to the low frequency of this activity this only increases the dermal exposure minimally to 4.83 µg/kg bw/d, leading to a dermal RCR of 0.112.

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 CCC.

Reproductive toxicity

The RCR for the endpoint reproductive toxicity based on a conservative assessment is well below 1 (0.112).

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

Comparison of outcome with initial applications

Inhalation exposure

Maintenance of equipment (PROC 8a)

In the initial applications, regular maintenance of equipment at the baths (e.g., change of LEV or pump) are considered as a separate task in applications 0096-01 and 0116-01. For such activities inhalation exposure was estimated by modelling with ART 1.5. It was assumed for modelling that regular maintenance of the baths and related equipment was performed once every two weeks for up to 60 min. For this activity exposure with a Cr(VI) weight fraction of up to 5% was considered without use of LEV, without RPE.

In all other initial applications, maintenance of equipment is covered by personal monitoring of workers who also perform the surface treatment by dipping/immersion. As these measured values also cover such treatment activities and other tasks that are usually carried out by line operators (see the comparison with initial applications in section 9.2.3.2.2.3), these values are not suitable for a direct comparison.

Infrequent maintenance activities (PROC 8a)

In addition to such regular maintenance and cleaning activities, infrequent maintenance activities are considered as a separate task in the applications 0032-04, 0032-05 and 0096-01 but not in 0043-02, 0044-02, 0045-02 or 0116-01. For such activities inhalation exposure was estimated by modelling with ART 1.5. It was assumed for modelling that filter changes were performed 1x per month for 240 min. For this activity handling of solids/powders with a Cr(VI) weight fraction of up to 10% was considered in 0032-04, 0032-05 initial applications and up to 5% in 0096-01, without use of LEV but with RPE (APF 30).

As shown in the table below, the excess lifetime lung cancer risk based on inhalation exposure modelling ranges from 9.20E-06 to 1.00E-03 in the initial applications. In the present assessment, inhalation exposure from maintenance and cleaning of equipment is evaluated by personal monitoring of maintenance and/or cleaning workers performing typical maintenance tasks.

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

Initial assessment				**Present assessment**	
Application ID	**Chromate**	**Inhalation, long-term exposure, 90th Perc. [µg/m³]**	**Excess lifetime lung cancer risk [1/µg/m³]**	**Inhalation, long-term exposure, 90th Perc. [µg/m³]**	**Excess lifetime lung cancer risk [1/µg/m³]**
0032-04	CT	0.25 [b]	1.00E-03 [b]	0.0960	3.84E-04
0032-05	CT	0.25 [b]	1.00E-03 [b]		
0096-01	CT	0.0023 [a]	9.20E-06 [a]		

		0.088 [b]	3.52E-04 [b]		
0043-02	SD	not assessed as separate task	n.a.		
0044-02	PD	not assessed as separate task	n.a.		
0045-02	DtC	not assessed as separate task	n.a.		
0116-01	DtC	0.0023 [a]	9.20E-06 [a]		

[a] Maintenance of equipment
[b] Infrequent maintenance activities

Dermal exposure

No quantitative dermal exposure assessment has been performed in the initial applications.

9.2.3.7 Worker contributing scenario 6 – Machinists

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

Moreover, at sites where machining is carried out on parts that have been treated by CCC, the machinists are responsible for operations of all types of industrial machinery. Machining may be required for both production and repair activities. With the help of manual or numerical controls, they carry out the operations needed to make machined parts that meet precise specifications. They may spend the most part of their working time in a dedicated room where machining tools are located.

Typical tasks with potential Cr(VI) exposure are:

<u>Main task</u>

- Task 1: Machining operations on metallic parts treated by CCC, including cleaning (PROC 21, 24)

In addition to this task, the machinists are generally responsible for cleaning their machines and managing the waste generated. These activities are included in this task because they are conducted under the same operational conditions and risk management measures as the machining activities.

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

9.2.3.7.1 Conditions of use

Table 9-46 summarises the conditions of use for activities with potential direct Cr(VI) exposure related to machining activities carried out by machinists on parts which were treated by CCC.

Table 9-46: Conditions of use – worker contributing scenario 6 – Machinists

Product (article) characteristics
Product 1: Treated part by CCC with CT, SD, PD or DtC ▪ Product type: solid object ▪ Solid material: Metal ▪ Moisture content: Dry product (<5 % moisture content)
Amount used (or contained in articles), frequency and duration of use/exposure
Task 1: Machining operations metallic parts treated by CCC, including cleaning ▪ Duration of activity: up to 180 min (at few sites infrequent long-term activities of up to 600 min per shift on 2 days per year are reported) ▪ Frequency of task: <1-240 days per year (<1-5 days/week, 48 weeks per year)
Technical and organisational conditions and measures
Task 1: Machining operations on metallic parts treated by CCC, including cleaning ▪ LEV: yes, where technically feasible ▪ Ventilation rate of general ventilation system: mechanical ventilation, where technically feasible ▪ Occupational health and safety management system: advanced (see section 9.2.2.3.1.2) ▪ Effective cleaning practices shall be implemented to prevent surface contamination around treatment baths and other equipment, in the vicinity where machining activities take place
Conditions and measures related to personal protection, hygiene, and health evaluation
Gloves As it is expected that any residual Cr(VI) contained in coating particles released by machining cannot be absorbed through the skin, no gloves are required for protection against Cr(VI). However, although gloves are not required to protect against Cr(VI), the PPE for each machining activity is determined by each site with an overall EH&S risk assessment for potential mechanical injury.
Respiratory protection equipment RPE is worn during all tasks not performed under a 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 Protective suit must be worn during Task 1. Type of protective clothes to be used for specific activities is laid down in work instructions for the activities.
Eye protection Suitable eye protection (as per relevant risk assessment) must be worn during all activities related to Task 1. Type of eye protection to be used for specific tasks is laid down in work instructions for the tasks.
Other conditions affecting workers' exposure
Task 1: Machining operations on metallic parts treated by conversion coating ▪ Place of use: indoors – any size workroom ▪ Temperature: room temperature ▪ Activity Class: Fracturing and abrasion of solid objects ▪ Situation: Mechanical treatment / abrasion of small to large sized surfaces ▪ Containment level: Open or partially enclosed processes ▪ Primary emission source proximity: The primary emission source is in the breathing zone of the worker (near field, <1 m)
Additional good practice advice. Obligations according to Article 37(4) of REACH do not apply
▪ *None*

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

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

9.2.3.7.2 Exposure and risks for workers

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

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

<u>Task 1: Machining operations on metallic parts treated by CCC, including cleaning</u>

After the CCC process, some parts may need to be reworked or resized to fulfil dimensional accuracy, special surface characteristics or textures defined in the customer specifications.

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

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

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

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

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

Machining activities are performed at room temperature. The duration and frequency of machining activities can be highly variable between different sites, with frequencies up to 240 times per year and durations up to 600 min per machining activity (with low frequency, up to two times a year). For the present exposure assessment, we consider a frequency of 240 times per year and a duration of 180 min per machining event as a reasonable worst-case estimate.

During machining activities, a fixed or mobile LEV is used wherever this is technically and practically possible. Machinists wear eye protection (as per relevant risk assessment), and protective suit, and RPE (if not performed under an LEV and industrial hygiene exposure assessment confirms RPE use is required), as specified above in Table 9-46.

9.2.3.7.2.1 Inhalation exposure

Measured inhalation exposure concentration

In total, 80 personal and 16 stationary measurements covering exposure from machining activities on parts treated by CCC are available for this SEG.

Among the 80 personal monitoring data, 58 are long-term (≥2h) [23], shift-representative and 22 are short-term (<2h) measurements. Among the 16 stationary measurements, 12 are long-term (≥2h), shift-representative and four are short-term (<2h) measurements.

The personal monitoring data come from ten sites of six countries in the EEA (76 measurements) and from three sites in the UK (four measurements). 49% of the data (39 values, including 18 short-term measurements) are <LOQ and 51% (41 values, including four short-term measurements) are >LOQ. Regarding stationary data, they all come from two sites located in two EEA countries, and are >LOQ for 13 of them and three are <LOQ.

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

A summary on the analytical methods for inhalation exposure monitoring and information on their LOQs is given in Annex IV of this report. The individual measurements can be provided upon request. An overview of the available data for machinists is given in Table 9-47.

Table 9-47: Overview of available inhalation exposure measurements for WCS 5 – Machinists

	n	>LOQ	<LOQ
Personal			
- Long-term (≥2h)	58	37	21
- Short-term (<2h)	22	6	16
Stationary			
- Long-term (≥2h)	12	11	1
- Short-term (<2h)	4	2	2

Personal measurements – long-term

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

The AM of the 58 long-term personal measurements is 0.238 µg/m^3 and the 90th percentile is 0.532 µg/m^3, with 21 measured results below the LOQ. During the long-term personal measurements, the workers performed diverse machining activities such as deburring, milling, drilling, polishing or boring.

[23] 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.

Some tasks are performed with machines (such as milling, drilling, or boring), other tasks are carried out manually (e.g., manual grinding).

Twenty-four long-term measurements were performed while the machinist worked on parts treated by CCC only, and not with any other Cr(VI) use (according to the information provided by the site). The AM of these measurements is 0.143 µg/m^3 and the 90th percentile is 0.274 µg/m^3 which are respectively lower than the AM and 90th percentile of all values combined.

Personal measurements – short term

Eighteen of the 22 short-term measurements are within a range of <0.0031 to 0.163 µg/m^3, with 15 values below the LOQ (up to <0.3 µg/m^3). Four measurements differ from the other results by their high values, with one being below a higher LOQ (< 2 µg/m^3). Concerning the three other measurements, one was taken on a worker who performed machining operations with a manual grinder (9.98 µg/m^3, 50 min sampling duration). Another measurement was performed the same year at the same site, under apparently identical conditions but it is unclear why the exposure concentration differs considerably between these two values (measurement 1: 0.065 µg/m^3, 60 min; measurement 2: 9.98 µg/m^3, 50 min). During these two measurements, RPE was worn (half mask with filters P3). Concerning the remaining two short-term measurements out of the 4, work was performed in a grinding cabin in the same conditions, during grinding off corrosion spots with an impulse driver and grinding wheels inside the component (12.9 and 14 µg/m^3, 112 min for both). The 8h TWA values calculated from these two measurements are 3.01 µg/m^3 and 3.27 µg/m^3, considering 368 min non-exposure time[24], if it is theoretically assumed that the remaining shift is with no exposure. It was clearly stated that RPE was worn during these two measurements (FFP3 mask with an APF factor of ten leading to exposure values of 0.30 and 0.33 respectively). These two exposure values corrected for RPE are well below the 90th percentile of the long-term measurements.

Fifteen of these 22 short-term measurements were taken while the worker performed activities only related to CCC, but not to any other Cr(VI) use (according to the information provided by the sites). One measurement result is <2 µg/m^3 (same data as above) and the 14 other measurements are in the same range as all short term measurement results.

Stationary measurements

Twelve long-term stationary measurements are available for workplaces where machining of CCC parts was performed in addition to many other tasks (e.g., immersion, primer application, touch-up). All these values were taken at two different sites. The AM is 0.511 µg/m^3 and the 90th percentile is 0.744 µg/m^3, which are above the personal long-term measurements AM and 90th percentile.

It is reported that for seven measurements, sampling was performed at one meter from the source of exposure and that machining was performed on parts treated by CCC with a solution containing DtC only. The AM of these seven measurements is 0.0796 µg/m^3, well below the AM of long-term personal measurement.

Considering the five other measurements, four values range from <0.018 to 0.767 µg/m^3 and one measured value is 4.09 µg/m^3. No specific information is available to explain such a difference for this highest value. It is reported that during the measurements, primers application and sanding may also

[24] 12.9 µg/m^3 x (112 min/480 min) = 3.01 µg/m^3 and 14.0 µg/m^3 x (112 min/480 min) = 3.27 µg/m^3

have been performed (the details of the tasks performed during the measurement are not available). Therefore, we assume that either the activities carried out during the measurement involved more Cr(VI) activities than only machining would include or that a problem occurred during this measurement, as two other measurements performed the same year at the same site, covering the same tasks (still without details), are available and showed much lower exposure (0.173 and 0.767 µg/m^3). Without further information, this value is considered in this assessment and presented in the following tables.

Four short-term measurements were performed at the same site, during grinding work (measured values <0.024 µg/m^3, <0.33 µg/m^3, and 9.89 µg/m^3) and next to the control panel of the milling machine (0.14 µg/m^3). No details are available to understand the highest measured value sampled in the grinding cabin.

Table 9-48 shows the summary statistics of workplace measurements for machinists. For values <LOQ, half of the LOQ (LOQ/2) was considered for statistical evaluation. All measurements are from the period 2017-2021.

Table 9-48: Summary statistics of inhalation exposure measurements for WCS 5 – Machinists

Personal – long-term (measurement period 2017-2021)						
	N	**% of total**	**AM [µg/m^3]**	**SD [µg/m^3]**	**Median [µg/m^3]**	**90th Perc. [µg/m^3]**
Total	58	100	0.238	0.458	0.100	0.532
Personal – short-term (measurements performed in 2021)						
	N	**% of total**	**AM [µg/m^3]**	**SD [µg/m^3]**	**Median [µg/m^3]**	**90th Perc. [µg/m^3]**
Total	22	100	1.753	4.340	0.033	9.082
Stationary – (measurement period 2019-2021)						
	N	**% of total**	**AM [µg/m^3]**	**SD [µg/m^3]**	**Median [µg/m^3]**	**90th Perc. [µg/m^3]**
Total	16	100				
- Long-term	12	75	0.511	1.150	0.086	0.744
- Short-term	4	25	2.552	n.a.	n.a.	n.a. (MAX = 9.89)

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

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

All personal long-term measurements of machinists performing tasks related to CCC are included in the assessment of inhalation exposure. Table 9-49 shows the resulting long-term inhalation exposure concentration for machinists used for this risk assessment, based on the 90th percentile of personal sampling values.

As stated above, partial exposure from sources and processes not related to the CCC use may have contributed to all exposure values assigned to this use. Considering that machinists typically spend only a minor part of their working time on activities related to CCC (at maximum 40%[25]), we assign 40% of the shift average exposure value (90th percentile of all long-term measurements) to this use.

Typically, two or three machinists per shift are engaged, with one to two shifts per site. They usually spend only a minor part of their time on this use, often limited to a few days per week. On average, we assume that **four machinists per day** are engaged per site and that **each worker spends a maximum of 40% of his working time on activities related to CCC**. Consequently, the long-term exposure concentration is corrected by a factor of 0.4. It should be noted that machining activities are not performed at all sites but less than 25 % are actually performing them.

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

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

Table 9-49: Measured inhalation exposure concentration for WCS 6 – Machinists

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	58	0.532	1	0.532	0.213

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

[a] Based on 90th percentile of measurements.

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

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

9.2.3.7.2.2 Dermal exposure

No dermal exposure assessment is performed as it is to be expected that any residual Cr(VI) contained in coating particles released by machining cannot be absorbed through the skin.

[25] Considering the durations of all main tasks performed by machinists as described in section 9.2.3.7.2 and assuming conservatively relevant machining activities daily for 180 min per shift, the exposure time related to CCC accounts for 37.5% (180 min/480 min = 37.5%), conservatively rounded up to 40%.

9.2.3.7.2.3 Risk characterisation

Risk for carcinogenicity

Table 9-50 shows the risk characterisation for carcinogenicity for machinists. The risk for carcinogenicity is based on measured Cr(VI) inhalation exposure data for machinists and the RAC dose-response relationship for the excess lifetime cancer risk for lung cancer (ECHA, 2013).

Table 9-50: Risk characterisation for carcinogenicity for WCS 6 – Machinists

Route of exposure and type of effects	Long-term exposure [µg/m^3]	Risk characterisation: Excess lifetime lung cancer risk * [1/µg/m^3]	Excess lifetime cancer risk (ELCR)
Inhalation: Systemic Long Term	0.213	4.00E-03	8.51E-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.

Risk for reproductive toxicity

Table 9-51 shows the risk characterisation for reproductive toxicity for machinists. The risk characterisation for reproductive toxicity is based on measured Cr(VI) inhalation exposure data only, as no dermal exposure is considered for these workers. The exposure value is compared to the RAC DNEL for workers, derived for effects on fertility (ECHA, 2015).

Table 9-51: Risk characterisation for reproductive toxicity for WCS 6 – Machinists

Route of exposure and type of effects	Long-term exposure	Risk characterisation: RAC DNEL *	Risk characterisation ratio (RCR)
Inhalation: Systemic Long Term	0.213 µg/m^3	43 µg Cr(VI)/m^3	0.00495

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

* RAC DNEL for workers, derived for effects on fertility (ECHA, 2015).

Conclusion on risk characterisation:

Carcinogenicity:

The Excess life-time cancer risk for machining workers is 8.51E-04.

This risk estimate can be considered as conservative, because:

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

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

Reproductive toxicity:

The RCR for the endpoint reproductive toxicity based on a conservative assessment is well below 1 (0.00495).

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

Comparison of outcome with initial applications

Inhalation exposure

The tasks considered in the present assessment to be typically performed by the machinists were described in the initial applications as separate tasks. These separate tasks were modelled with ART 1.5 in the initial applications and no typical frequencies were specified. Consequently, we can only compare the modelling results for individual tasks with the shift-average inhalation exposure values measured for the 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 applications was from and 5.00E-05 to 8.12E-03 for machining.

In the present assessment, the excess lifetime lung cancer risk based on shift-average inhalation exposure value is with **8.51E-04** in the range of the initial applications.

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

<table>
<tr><th colspan="4">Initial assessment</th><th colspan="2">Present assessment</th></tr>
<tr><th>Application ID</th><th>Chromate</th><th>Inhalation exposure, 90^{th} Perc. [$\mu g/m^3$]</th><th>Excess lifetime lung cancer risk [$1/\mu g/m^3$]</th><th>Inhalation, long-term exposure, 90^{th} Perc. [$\mu g/m^3$]</th><th>Excess lifetime lung cancer risk [$1/\mu g/m^3$]</th></tr>
<tr><td colspan="4">Machining operations on small to medium sized parts containing Cr(VI) on an extracted bench/extraction booth including cleaning (PROC 21, 24)
<180 min, <0.1% Cr(VI), LEV (99%), RPE (APF10) (0032-04, 0032-05)
<60 min, <0.1% Cr(VI), LEV (99%), RPE (APF30) (0096-01)
<180 min, <0.1% Cr(VI), LEV (99%), RPE (APF10) (0043-02, 0044-02, 0045-02)
<60 min, < 0.1% Cr(VI), LEV (99%), RPE (APF30) (0116-01)</td><td rowspan="19">0.213</td><td rowspan="19">8.51E-04</td></tr>
<tr><td>0032-04</td><td>CT</td><td>0.11</td><td>4.40E-04</td></tr>
<tr><td>0032-05</td><td>CT</td><td>0.11</td><td>4.40E-04</td></tr>
<tr><td>0096-01</td><td>CT</td><td>0.013</td><td>5.00E-05</td></tr>
<tr><td>0043-02</td><td>SD</td><td>0.11</td><td>4.40E-04</td></tr>
<tr><td>0044-02</td><td>PD</td><td>0.11</td><td>4.40E-04</td></tr>
<tr><td>0045-02</td><td>DtC</td><td>0.11</td><td>4.40E-04</td></tr>
<tr><td>0116-01</td><td>DtC</td><td>0.013</td><td>5.00E-05</td></tr>
<tr><td colspan="4">Machining operations on small to medium sized surfaces containing Cr(VI) on an extracted bench/extraction booth including cleaning (PROC 21, 24)
<180 min, <3% Cr(VI), LEV (99%), RPE (APF30) (0032-04, 0032-05, 0043-02, 0044-02, 0045-02)</td></tr>
<tr><td>0032-04</td><td>CT</td><td>1.13</td><td>4.52E-03</td></tr>
<tr><td>0032-05</td><td>CT</td><td>1.13</td><td>4.52E-03</td></tr>
<tr><td>0096-01</td><td>CT</td><td>not assessed as separate task</td><td>n.a.</td></tr>
<tr><td>0043-02</td><td>SD</td><td>1.13</td><td>4.52E-03</td></tr>
<tr><td>0044-02</td><td>PD</td><td>1.13</td><td>4.52E-03</td></tr>
<tr><td>0045-02</td><td>DtC</td><td>1.13</td><td>4.52E-03</td></tr>
<tr><td>0116-01</td><td>DtC</td><td>not assessed as separate task</td><td>n.a.</td></tr>
<tr><td colspan="4">Machining operations in large work areas on parts containing Cr(VI) including cleaning (PROC 21, 24)
<60 min, <0.1% Cr(VI), LEV (90%), RPE (APF 10) (0032-04, 0032-05)
<30 min, <0.1% Cr(VI), LEV (90%), RPE (APF30) (0096-01)
<60 min, <0.1% Cr(VI), LEV (90%), RPE (APF10) (0043-02, 0044-02, 0045-02)
<30 min, < 0.1% Cr(VI), LEV (90%), RPE (APF30) (0116-01)</td></tr>
<tr><td>0032-04</td><td>CT</td><td>0.20</td><td>8.00E-04</td></tr>
<tr><td>0032-05</td><td>CT</td><td>0.20</td><td>8.00E-04</td></tr>
</table>

0096-01	CT	0.028	1.10E-04		
0043-02	SD	0.20	8.00E-04		
0044-02	PD	0.20	8.00E-04		
0045-05	DtC	0.20	8.00E-04		
0116-01	DtC	0.028	1.10E-04		
Machining operations in large work areas on surfaces containing Cr(VI) including cleaning (PROC 21, 24) <60 min, <3% Cr(VI), LEV (90%), RPE (APF30) (0032-04, 0032-05, 0043-02, 0044-02, 0045-02)					
0032-04	CT	2.03	8.12E-03		
0032-05	CT	2.03	8.12E-03		
0096-01	DtC	not assessed as separate task	n.a.		
0043-02	SD	2.03	8.12E-03		
0044-02	PD	2.03	8.12E-03		
0045-02	DtC	2.03	8.12E-03		
0116-01	DtC	not assessed as separate task	n.a.		
Machining operations on parts containing Cr(VI) in small work areas including cleaning (PROC 21, 24) <60 min, <0.1% Cr(VI), no LEV, RPE (APF400) (0032-04, 0032-05) <30 min, <0.1% Cr(VI), no LEV, RPE (APF400) (0096-01) <60 min, <0.1% Cr(VI), no LEV, RPE (APF400) (0043-02, 0044-02, 0045-02) <30 min, <0.1%, no LEV, RPE (APF400) (0116-01)					
0032-04	CT	0.16	6.40E-04		
0032-05	CT	0.16	6.40E-04		
0096-01	CT	0.08	3.20E-04		
0043-02	SD	0.16	6.40E-04		
0044-02	PD	0.16	6.40E-04		
0045-02	DtC	0.16	6.40E-04		
0116-01	DtC	0.08	3.20E-04		
Machining operations on surfaces containing Cr(VI) in small work areas including cleaning (PROC 21, 24) <60 min, <3% Cr(VI), no LEV, RPE (APF1000) (0032-04, 0032-05, 0043-02, 0044-02, 0045-02)					
0032-04	CT	1.90	7.60E-03		
0032-05	CT	1.90	7.60E-03		
0096-01	CT	not assessed as separate task	n.a.		
0043-02	SD	1.90	7.60E-03		
0044-02	PD	1.90	7.60E-03		
0045-02	DtC	1.90	7.60E-03		

0116-01	DtC	not assessed as separate task	n.a.		

Dermal exposure

No quantitative dermal exposure assessment has been performed in the initial applications.

9.2.3.8 Worker contributing scenario 7 – 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 CCC 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 CCC 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.

9.2.3.8.1 Conditions of use

Table 9-52 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 CCC is carried out, from which the workers are incidentally exposed.

Table 9-52: Conditions of use – worker contributing scenario 7 – Incidentally exposed workers

Product (article) characteristics
Product 1: Aqueous solutions of CT, SD, PD, or DtC or mixtures of them ▪ Concentration of substance in mixture: 0.09-14.6% (w/w) Cr(VI) ▪ Concentration of Cr(VI) based on ranges of CT (up to 28% (w/w)) or PD (up to 16% (w/w)) or SD (up to 22% (w/w)) or DtC (up to 2.5% (w/w)), in the aqueous solution of CCC baths or used for local applications ▪ 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*

9.2.3.8.2 Exposure and risks for workers

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

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

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

Considering:

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

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

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

<u>Task 1: Activities without direct Cr(VI) exposure</u>

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

- line operations at other process baths (not using Cr(VI))
- supervision of processes
- quality assessment of parts
- un-/jigging of parts and cleaning of jigs (Figure 9-16)
- un-/masking of parts
- transportation of closed chemical containers
- machining activities (on parts, where no Cr(VI) exposure is possible)

Figure 9-16: Workers responsible for un-/jigging

During all tasks performed by incidentally exposed workers at the same location as the treatment bath(s) for CCC, the workers wear standard PPE, as specified above in Table 9-52.

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

9.2.3.8.2.1 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) [26], 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 9-53.

Table 9-53: Overview of available inhalation exposure measurements for WCS 7 – 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

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

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. Ten of these measurements cover exposure from CCC in combination with exposure from other Cr(VI) uses, but none of them relates exclusively to exposure from CCC. As we expect incidental exposure to be comparable between diverse Cr(VI) uses, the monitoring data for all Cr(VI) immersion uses were pooled regardless of whether they also cover incidental exposure from CCC or

[26] 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.

only from other Cr(VI) uses. The AM over the total of long-term personal measurements is **0.316 µg/m³**, the median is 0.290 µg/m³ and the 90th percentile is **0.500 µg/m³**.

Personal measurements – short term

The short-term measurement has an exposure value of 1.0 µg/m³ and was taken in a hall where passivation of stainless steel and electroplating (both with Cr(VI)) were performed.

Stationary measurements

The eight stationary monitoring data are long-term measurements. The AM over of these measurements is 0.0564 µg/m³. The measurements were taken in halls where in most cases multiple immersion uses were performed (e.g., anodising, CCC 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). Four of the static measurements cover incidental exposure from CCC in combination with other Cr(VI) uses. And two of the measurements exclusively covers incidental exposure from CCC. During these two measurements machining activities and touch-ups with brush or pen stick were carried out in approximately 2m distance to where the static sampling device was positioned (both results were < LOQ).

Table 9-54 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 2015 through 2021.

Table 9-54: Summary statistics of inhalation exposure measurements for WCS 7 – Incidentally exposed workers

Personal (measurement period 2015-2021)						
	N	**% of total**	**AM [µg/m³]**	**SD [µg/m³]**	**Median [µg/m³]**	**90th Perc. [µg/m³]**
Long-term	15	94	0.316	0.254	0.290	0.500
Short-term	1	6	n.a. [a]			
Stationary – (measurement period 2018-2021)						
	N	**% of total**	**AM [µg/m³]**	**SD [µg/m³]**	**Median [µg/m³]**	**90th Perc. [µg/m³]**
Long-term - total	8	100	0.0564	n.a.	n.a.	n.a.

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

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

[a] The value is 1.0 µg/m³

All personal long-term measurements of incidentally exposed workers operating in halls where Cr(VI) uses were performed are included in the assessment of inhalation exposure. Table 9-55 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 CCC 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 9-55: Measured inhalation exposure concentration for WCS 7 – 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.

9.2.3.8.2.2 Dermal exposure

No dermal exposure is considered for incidentally exposed workers, as they are not in direct contact with Cr(VI).

9.2.3.8.2.3 Risk characterisation

Risk for carcinogenicity

Table 9-56 shows the risk characterisation for carcinogenicity for incidentally exposed workers. The risk for carcinogenicity is based on measured Cr(VI) inhalation exposure data for incidentally exposed workers and the RAC dose-response relationship for the excess lifetime cancer risk for lung cancer (ECHA, 2013).

Table 9-56: Risk characterisation for carcinogenicity for WCS 7 – 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 $4x10^{-3}$ for workers, based on 40 years of exposure; 8h/day; 5 days/week.

Risk for reproductive toxicity

Table 9-57 shows the risk characterisation for reproductive toxicity for incidentally exposed workers. The risk characterisation for reproductive toxicity is based on measured Cr(VI) inhalation exposure data only, as no dermal exposure is considered for these workers. The exposure value is compared to the RAC DNEL for workers, derived for effects on fertility (ECHA, 2015).

Table 9-57: Risk characterisation for reproductive toxicity for WCS 7 – Incidentally exposed workers

Route of exposure and type of effects	Long-term exposure	Risk characterisation: RAC DNEL *	Risk characterisation ratio (RCR)
Inhalation: Systemic Long Term	0.250 µg/m³	43 µg /m³	0.00581

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

* RAC DNEL for workers, derived for effects on fertility (ECHA, 2015)

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.

Reproductive toxicity

The RCR for the endpoint reproductive toxicity based on the assessment of inhalation exposure is well below 1 (0.00581).

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

Comparison of outcome with initial application
Exposure of incidentally exposed workers was not considered in previous applications.

10 RISK CHARACTERISATION RELATED TO COMBINED EXPOSURE

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

10.1.1 Workers

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

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

10.1.2 Consumers

No consumer uses are addressed in this CSR.

10.2 Environment (combined for all emission sources)

10.2.1 All uses (regional scale) – regional assessment

In accordance with RAC's conclusions (see e.g., the RAC/SEAC "Opinion on an Application for Authorisation for Use of Sodium dichromate for surface treatment of metals such as aluminium, steel, zinc, magnesium, titanium, alloys, composites and sealings of anodic films"[27]), 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.

[27] 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 0.00001 and 43.1 kg/year to air (compared to 0.000007-0.502 kg/year for CCC only) and between 0 and 3.57 kg/year to water (compared to 0-0.25 kg/year for CCC only), as summarised in Table 9-15 and as shown in detail in Annex III (Table Annex III-1) of this CSR.

11 ANNEXES

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

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

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

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

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

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

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

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

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

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

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

Physico-chemical properties of dichromium tris(chromate) (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 CCC of the overall emission. The Cr(VI) amounts used by the sites shown in Annex III-1 for CCC range from <1 to 332 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 sewage sludge to agricultural soil/grassland	Dilution factor receiving water
Site 1	2.08E-03	0.002	no water emission	0.000	1.000	1.000	-	-	-
Site 2	6.17E-04	0.039	1.45E-06	0.000	0.075	0.075	2000 [a]	assume yes [d]	48.52 [e]
Site 3	2.04E-04	0.547	5.31E-04	1.420	0.100	0.100	2000 [a]	assume yes [d]	1000 [b]
Site 4	9.30E-03	43.100	no water emission	0.000	0.012	0.012	-	-	-
Site 5	4.41E-04	0.299	8.36E-06	0.006	0.041	0.041	2077	no	4.33 [f]
Site 6	2.54E-03	8.230	1.19E-04	0.386	0.000	0.000	2000 [a]	no	10 [c]
Site 7	4.88E-03	7.270	6.72E-06	0.010	0.001	0.001	2000 [a]	no	10 [c]
Site 8	2.99E-04	3.012	2.94E-04	2.960	0.007	0.007	2000 [a]	no	10 [c]
Site 9	1.20E-03	0.001	0.00E+00	0.000	0.018	0.018	-	-	-
Site 10	1.76E-04	0.374	8.89E-05	0.188	0.001	0.001	275000	no	2.73 [g]
Site 11	1.80E-02	0.475	2.56E-06	0.000	0.955	0.955	2000 [a]	assume yes [d]	10 [c]
Site 12	2.31E-04	0.046	0.00E+00	0.000	0.995	0.995	-	-	-

Site 13	5.21E-03	1.008	no water emission	0.000	0.003	0.003	-	-	-
Site 14	3.15E-03	0.399	1.73E-09	0.000	0.147	0.147	2000 [a]	assume yes [d]	10 [c]
Site 15	7.47E-03	0.934	no water emission	0.000	0.002	0.002	-	-	-
Site 16	4.93E-07	0.000	5.77E-06	0.001	0.124	0.124	2000 [a]	assume yes [d]	10 [c]
Site 17	5.33E-06	0.019	1.67E-07	0.001	0.014	0.014	2000 [a]	assume yes [d]	10 [c]
Site 18	2.00E-03	4.480	1.79E-08	0.000	0.112	0.112	2000 [a]	assume yes [d]	10 [c]
Site 19	2.25E-05	0.013	8.70E-09	0.000	0.001	0.001	2000 [a]	assume yes [d]	10 [c]
Site 20	3.26E-04	0.021	5.60E-02	3.565	0.069	0.069	65000	assume yes [d]	10 [c]
Site 21	2.16E-04	0.127	5.41E-05	0.032	0.010	0.010	2000 [a]	assume yes [d]	10 [c]
Site 22	1.39E-06	0.000	0.00E+00	0.000	1.000	1.000	-	-	-
Site 23	8.73E-03	1.571	2.61E-03	0.470	0.143	0.139	2000 [a]	assume yes [d]	10 [c]
Site 24	5.49E-03	0.259	9.15E-03	0.432	0.217	0.217	2000 [a]	assume yes [d]	10 [c]
MIN	4.93E-07	0.00001	0.00E+00	0.00	0.000088	0.000088			
MAX	**1.80E-02**	**43.10**	**5.60E-02**	**3.57**	**1.000**	**1.000**			
90th percentile	8.35E-03	6.43	3.27E-03	1.14	0.983	0.983			
Median	9.06E-04	0.336	6.25E-06	0.0003	0.05503	0.05503			
AM	3.02E-03	3.01	3.44E-03	0.395	0.210	0.210			

[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] 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.

[c] 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.

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

[e] According to site-specific data, a minimum flow rate of the receiving water of 10 000 – 100 000 [redacted] m^3/day and a treatment plant discharge of 2000 m^3/day results in a dilution factor of 48.5

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

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

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 CCC**.

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

	Inhalation	**Oral (drinking water and fish)**		
Site	**Local Cr(VI) PEC in air [µg/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]**
Site 1	1.19E-06	1.25E-07	7.18E-09	1.32E-07
Site 2	2.99E-05	7.40E-07	7.38E-09	7.47E-07
Site 3	4.16E-04	8.10E-03	3.24E-07	8.10E-03
Site 4	3.28E-02	8.12E-04	2.28E-07	8.12E-04
Site 5	2.28E-04	1.42E-05	8.14E-07	1.50E-05
Site 6	6.26E-03	1.55E-04	8.58E-06	1.64E-04
Site 7	5.53E-03	1.37E-04	2.66E-07	1.37E-04
Site 8	2.29E-03	1.14E-03	6.56E-05	1.21E-03
Site 9	2.37E-04	5.86E-06	8.78E-09	5.87E-06
Site 10	2.84E-04	7.02E-06	1.20E-07	7.14E-06
Site 11	3.62E-04	9.34E-06	1.11E-08	9.35E-06
Site 12	3.49E-05	8.62E-07	7.42E-09	8.69E-07
Site 13	7.67E-04	1.90E-05	1.24E-08	1.90E-05
Site 14	3.04E-04	7.54E-06	9.24E-09	7.55E-06
Site 15	7.11E-04	1.76E-05	1.20E-08	1.76E-05
Site 16	6.68E-08	5.84E-06	3.00E-08	5.87E-06
Site 17	1.46E-05	3.78E-06	2.06E-08	3.80E-06
Site 18	3.41E-03	8.46E-05	3.10E-08	8.46E-05
Site 19	9.85E-06	2.72E-07	7.36E-09	2.79E-07
Site 20	1.58E-05	6.24E-04	2.44E-06	6.26E-04
Site 21	9.69E-05	1.84E-04	7.14E-07	1.84E-04
Site 22	6.61E-09	1.25E-07	7.18E-09	1.32E-07
Site 23	1.20E-03	2.70E-03	1.04E-05	2.71E-03
Site 24	1.97E-04	2.46E-03	9.56E-06	2.47E-03
MIN	6.61E-09	1.25E-07	7.18E-09	1.32E-07
MAX	3.28E-02	8.10E-03	6.56E-05	8.10E-03

90th percentile	**4.89E-03**	**2.06E-03**	**9.27E-06**	**2.09E-03**
Median	2.61E-04	1.59E-05	3.05E-08	1.63E-05
AM	2.30E-03	6.87E-04	4.13E-06	6.91E-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 4.89E-03 µg/m^3 for the PEC in air and 2.09E-03 µg Cr(VI)/kg per day for oral exposure via drinking water and fish. Note that for the exposure via drinking water and fish a reduction factor of 5 was applied, as described in section 9.1.2.4.2 of the CSR.

11.4 Annex IV – Inhalation exposure measurements for workers

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

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

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

11.5 Annex V – Dermal exposure modelling

11.5.1 EXCEL-based exposure assessment

Table Annex V-1 shows a generic, Excel-based exposure assessment developed for the purpose of this review report. It is based on the upper end of the range for the dermal load (0.1 mg/cm^2/d) as provided in the EU RAR (ECB, 2005), which was based on EASE for non-dispersive use with direct handling with incidental contact, which is similar to the situation relevant here. The rational for the selection of the parameters used is provided in the table below.

As a conservative assumption exposure of one side of both hands is assumed for most activities except cleaning related activities. For those activities with possible exposure to splash water exposure of larger parts of the body is assumed. The consumer module of ECETOC TRA (ECETOC, 2009; 2012) assumes exposure of half of the surface of the body (corresponding to 8750 cm^2). However, this approach seems overly conservative taking into consideration that mostly impermeable personal protection equipment including boots, apron, gloves, and face shield are worn during the cleaning activities. Further, in case of bath cleaning the workers stand outside next to the approximately waist-high bath, which covers the lower half of the body. Therefore, for cleaning activities a skin contact area of 2083 cm^2 has been assumed, which corresponds to the surface of both hands and forearms, i.e., ca. ¼ of the front of the body. As described in section 9.2.3.2.2 cleaning of the workplace is usually performed with wiper mops or rags. Incidental hand exposure can reasonably be assumed for this scenario. However, at some sites the workplace is also cleaned with a water hose. In a conservative manner Cr(VI) exposure to hands and forearms of the body is used for the aggregated assessment of the WCS.

The actual dermal exposure to the product is calculated under consideration of body weight (ECHA, 2012) and PPE efficiency (EC, 2010). For the calculation of the dermal exposure to Cr(VI) the concentration of Cr(VI) in the solid or liquid product or bath solution is considered. In general, in case more than one substance is used only the molecular weight fraction of Cr(VI) for the substance with the highest molecular weight fraction is considered to calculate the Cr(VI) exposure concentration in a conservative manner (molecular weight fraction of Cr(VI) for SD, PD and SC: 0.40, 0.35, and 0.32, respectively). When cleaning with a hose is performed a rapid dilution (at least 10-fold) of the Cr(VI) containing product or bath solution is assumed. This assumption seems to be justified taking into consideration the large water volumes used for cleaning, that only small splashes are usually on the floor surrounding the bathes, that chemical containers are partially cleaned by immersion in the rinsing tanks, and that the chemical containers are thoroughly rinsed with enough water so that the containers could be discharged with normal waste.

It should be noted that both SD and PD are classified for skin corrosion. Consequently, dermal exposure to any neat substance must be prevented. The assumption of permeation of gloves by 5 % of the potential dermal dose is a purely hypothetical assumption since dermal exposure must be prevented due to local effects alone. The same is essentially true for other tasks, since SD and PD concentrations ≥0.1 % require labelling as Skin Sens. 1 (H317) according to the CLP Regulation, implying that such low concentrations may be sensitising to the skin.

For the sake of comparison, the results of the Riskofderm model are also included in Table Annex V-1 below. Annual average exposure estimates with the Riskofderm model resulted in estimates in the same order of magnitude or lower than the estimates with the generic model. Therefore, the results of the generic model are used for the calculation of the aggregated exposure and risk assessment of the different worker contributing scenarios. In a conservative manner all tasks possibly performed by one SEG are considered in the aggregated dermal exposure assessment. There are slight organisational differences between the sites, for example at one site line operators and at another site storage area workers perform sampling of treatment baths. To cover the situation of all sites, dermal exposure from any activity possibly related to a certain SEG is considered for all SEGs that could perform this activity. Modelling with Riskofderm is explained in section 11.5.2.

Table Annex V-1: Modelled Exposure for Workers for all tasks (main tasks and secondary tasks; Excel-based approach)

Parameter	Unit	Surface treat-ment by dipping/ immer-sion	Sampling of treat-ment baths	Bath make-up and addition	Bath emp-tying and cleaning	Diverse cleaning activities - Cleaning of work-place, equip-ment, jigs	Waste manage-ment – Cleaning of empty chemical contain-ers / bags	Surface treatment by brush or swab application	Solution preparation for brush or swab application (decanting of liquids)	Solution preparation for brush or swab application (Measuring and weighing of solids)	Waste manage-ment – Handling of solid waste	Main-tenance and cleaning of equip-ment	Aliquot chemicals – Decanting of liquids	Aliquot chemicals – Measuring and weighing of solids	Rationale (Reference)
Exposed part of the body		(hand)	(hand)	(hand)	(hands and forearms)	(hands and forearms)	(hands and forearms)	(hand)	(hand)	(hand)	(hand)	(hand)	(hand)	(hand)	
PROCs		PROC 13	PROC 9	PROC 5 PROC 8b	PROC 28	PROC 28	PROC 28	PROC 10	PROC 9	PROC 9	PROC 8b	PROC 28	PROC 8b	PROC 8b	
EU RAR modelling assumption (0-0.1 mg/cm^2)	mg/cm^2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	Upper end of range (EU RAR (ECB, 2005) from EASE for non-dispersive use with direct handling with incidental contact which is similar to the scenarios relevant here

Parameter	Unit	Surface treat-ment by dipping/ immer-sion	Sampling of treat-ment baths	Bath make-up and addition	Bath emp-tying and cleaning	Diverse cleaning activities - Cleaning of work-place, equip-ment, jigs	Waste manage-ment – Cleaning of empty chemical contain-ers / bags	Surface treatment by brush or swab application	Solution preparation for brush or swab application (decanting of liquids)	Solution preparation for brush or swab application (Measuring and weighing of solids)	Waste manage-ment – Handling of solid waste	Main-tenance and cleaning of equip-ment	Aliquot chemicals – Decanting of liquids	Aliquot chemicals – Measuring and weighing of solids	Rationale (Reference)
Exposed part of the body		(hand)	(hand)	(hand)	(hands and forearms)	(hands and forearms)	(hands and forearms)	(hand)	(hand)	(hand)	(hand)	(hand)	(hand)	(hand)	
Skin contact area	cm^2	480	480	480	2083	2083	2083	480	480	480	480	480	480	480	One side of both hands used as a conservative assumption; for cleaning activities hands and forearms assumed as a worst case, contact area from ECETOC TRA consumer module (ECETOC, 2009; 2012)
Dermal load	mg	48	48	48	208.3	208.3	208.3	48	48	48	48	48	48	48	Calculated
Body weight	kg	70	70	70	70	70	70	70	70	70	70	70	70	70	Body weight for workers

Parameter	Unit	Surface treat-ment by dipping/ immer-sion	Sampling of treat-ment baths	Bath make-up and addition	Bath emp-tying and cleaning	Diverse cleaning activities - Cleaning of work-place, equip-ment, jigs	Waste manage-ment – Cleaning of empty chemical contain-ers / bags	Surface treatment by brush or swab application	Solution preparation for brush or swab application (decanting of liquids)	Solution preparation for brush or swab application (Measuring and weighing of solids)	Waste manage-ment – Handling of solid waste	Main-tenance and cleaning of equip-ment	Aliquot chemicals – Decanting of liquids	Aliquot chemicals – Measuring and weighing of solids	Rationale (Reference)
Exposed part of the body		(hand)	(hand)	(hand)	(hands and forearms)	(hands and forearms)	(hands and forearms)	(hand)	(hand)	(hand)	(hand)	(hand)	(hand)	(hand)	
															(Guidance IR & CSA, R.8 (ECHA, 2012)
Potential dermal exposure to product	mg/kg bw	0.686	0.686	0.686	2.98	2.98	2.98	0.686	0.686	0.686	0.686	0.686	0.686	0.686	Calculated
PPE efficiency (gloves, protective clothing or apron)	%	95	95	95	80	80	80	95	95	95	95	95	95	95	For efficiency of gloves and protective clothing 95% and 80%, respectively, are assumed; see (EC, 2010)

Parameter	Unit	Surface treat-ment by dipping/ immer-sion	Sampling of treat-ment baths	Bath make-up and addition	Bath emp-tying and cleaning	Diverse cleaning activities - Cleaning of work-place, equip-ment, jigs	Waste manage-ment – Cleaning of empty chemical contain-ers / bags	Surface treatment by brush or swab application	Solution preparation for brush or swab application (decanting of liquids)	Solution preparation for brush or swab application (Measuring and weighing of solids)	Waste manage-ment – Handling of solid waste	Main-tenance and cleaning of equip-ment	Aliquot chemicals – Decanting of liquids	Aliquot chemicals – Measuring and weighing of solids	Rationale (Reference)
Exposed part of the body		(hand)	(hand)	(hand)	(hands and forearms)	(hands and forearms)	(hands and forearms)	(hand)	(hand)	(hand)	(hand)	(hand)	(hand)	(hand)	
Actual dermal exposure to product	mg/kg bw	0.0343	0.0343	0.0343	0.595	0.595	0.595	0.0343	0.0343	0.0343	0.0343	0.0343	0.0343	0.0343	Calculated
Cr(VI) concen-tration in product	%	8.80	8.80	40.0*	0.880	0.880	4.00	15.6	1.35	40.0*	12	8.80	12	40.0*	See WCS specific conditions of use as described in sections 9.2.3.2 to 9.2.3.8; for cleaning with a water hose a 10-fold dilution is assumed
Task specific dermal	**µg/kg bw**	3.02	3.02	13.7	5.24	5.24	23.8	5.35	0.5	13.7	4.11	3.02	4.1	13.7	Calculated

Parameter	**Unit**	**Surface treat-ment by dipping/ immer-sion**	**Sampling of treat-ment baths**	**Bath make-up and addition**	**Bath emp-tying and cleaning**	**Diverse cleaning activities - Cleaning of work-place, equip-ment, jigs**	**Waste manage-ment – Cleaning of empty chemical contain-ers / bags**	**Surface treatment by brush or swab application**	**Solution preparatio n for brush or swab application (decanting of liquids)**	**Solution preparatio n for brush or swab application (Measurin g and weighing of solids)**	**Waste manage-ment – Handling of solid waste**	**Main-tenance and cleaning of equip-ment**	**Aliquot chemicals – Decanting of liquids**	**Aliquot chemical s – Measuri ng and weighing of solids**	**Rationale (Reference)**
Exposed part of the body		(hand)	(hand)	(hand)	(hands and forearms)	(hands and forearms)	(hands and forearms)	(hand)	(hand)	(hand)	(hand)	(hand)	(hand)	(hand)	
exposure to Cr(VI)															
Frequency	**d/year**	240	240	48	12	240	48	240	240	96	240	48	48	48	See WCS specific conditions of use as described in sections 9.2.3.2 to 9.2.3.89.2.3.3
Annual average dermal exposure to Cr(VI)	µg/kg bw/d	3.02	3.02	2.74	0.262	5.24	4.76	5.35	0.46	5.49	4.11	0.603	0.82	2.74	Calculated
Annual average dermal	µg/kg bw/d		0.672	0.397-3.76					0.355	0.040			0.626-0.657	0.397-0.487	Results of Riskofderm

Parameter	**Unit**	**Surface treat-ment by dipping/ immer-sion**	**Sampling of treat-ment baths**	**Bath make-up and addition**	**Bath emp-tying and cleaning**	**Diverse cleaning activities - Cleaning of work-place, equip-ment, jigs**	**Waste manage-ment – Cleaning of empty chemical contain-ers / bags**	**Surface treatment by brush or swab application**	**Solution preparatio n for brush or swab application (decanting of liquids)**	**Solution preparatio n for brush or swab application (Measurin g and weighing of solids)**	**Waste manage-ment – Handling of solid waste**	**Main-tenance and cleaning of equip-ment**	**Aliquot chemicals – Decanting of liquids**	**Aliquot chemical s – Measuri ng and weighing of solids**	**Rationale (Reference)**
Exposed part of the body		(hand)	(hand)	(hand)	(hands and forearms)	(hands and forearms)	(hands and forearms)	(hand)	(hand)	(hand)	(hand)	(hand)	(hand)	(hand)	
exposure to Cr(VI)															model, see Table Annex V-2
Tasks to be considered for WCS 1 – Line operators		**X**	**X**	**X**	**X**	**X**	**X**	**X**			**X**		**X**	**X**	Resulting aggregated dermal exposure per WCS: **32.1 µg/kg bw/d**
Tasks to be considered for WCS 2 – Brush application operators								**X**	**X**	**X**					Resulting aggregated dermal exposure per WCS: **11.3 µg/kg bw/d**

Parameter	**Unit**	**Surface treat-ment by dipping/ immer-sion**	**Sampling of treat-ment baths**	**Bath make-up and addition**	**Bath emp-tying and cleaning**	**Diverse cleaning activities - Cleaning of work-place, equip-ment, jigs**	**Waste manage-ment – Cleaning of empty chemical contain-ers / bags**	**Surface treatment by brush or swab application**	**Solution preparatio n for brush or swab application (decanting of liquids)**	**Solution preparatio n for brush or swab application (Measurin g and weighing of solids)**	**Waste manage-ment – Handling of solid waste**	**Main-tenance and cleaning of equip-ment**	**Aliquot chemicals – Decanting of liquids**	**Aliquot chemical s – Measuri ng and weighing of solids**	**Rationale (Reference)**
Exposed part of the body		(hand)	(hand)	(hand)	(hands and forearms)	(hands and forearms)	(hands and forearms)	(hand)	(hand)	(hand)	(hand)	(hand)	(hand)	(hand)	
Tasks to be considered for WCS 3 – Storage area workers			**X**	**X**	**X**		**X**				**X**		**X**	**X**	Resulting aggregated dermal exposure per WCS: **18.5 µg/kg bw/d**
Tasks to be considered for WCS 4 – Laboratory technicians			**X**												Resulting aggregated dermal exposure per WCS: **3.02 µg/kg bw/d**

Parameter	Unit	Surface treat-ment by dipping/ immer-sion	Sampling of treat-ment baths	Bath make-up and addition	Bath emp-tying and cleaning	Diverse cleaning activities - Cleaning of work-place, equip-ment, jigs	Waste manage-ment – Cleaning of empty chemical contain-ers / bags	Surface treatment by brush or swab application	Solution preparation for brush or swab application (decanting of liquids)	Solution preparation for brush or swab application (Measuring and weighing of solids)	Waste manage-ment – Handling of solid waste	Main-tenance and cleaning of equip-ment	Aliquot chemicals – Decanting of liquids	Aliquot chemicals – Measuring and weighing of solids	Rationale (Reference)
Exposed part of the body		(hand)	(hand)	(hand)	(hands and forearms)	(hands and forearms)	(hands and forearms)	(hand)	(hand)	(hand)	(hand)	(hand)	(hand)	(hand)	
Tasks to be considered for WCS 5 – Maintenance and/or cleaning workers											**X**	**X**			Resulting aggregated dermal exposure per WCS: **4.72 µg/kg bw/d**
Tasks to be considered for WCS 6 – Machinists															No dermal exposure
Tasks to be considered for WCS 7 – Incidentally															No dermal exposure

Parameter	Unit	Surface treat-ment by dipping/ immer-sion	Sampling of treat-ment baths	Bath make-up and addition	Bath emp-tying and cleaning	Diverse cleaning activities - Cleaning of work-place, equip-ment, jigs	Waste manage-ment – Cleaning of empty chemical contain-ers / bags	Surface treatment by brush or swab application	Solution preparation for brush or swab application (decanting of liquids)	Solution preparation for brush or swab application (Measuring and weighing of solids)	Waste manage-ment – Handling of solid waste	Main-tenance and cleaning of equip-ment	Aliquot chemicals – Decanting of liquids	Aliquot chemicals – Measuring and weighing of solids	Rationale (Reference)
Exposed part of the body		(hand)	(hand)	(hand)	(hands and forearms)	(hands and forearms)	(hands and forearms)	(hand)	(hand)	(hand)	(hand)	(hand)	(hand)	(hand)	
exposed workers															

All values rounded to three significant figures, but unrounded values used in calculation.

* In case both substances, sodium and potassium dichromate, are used in parallel only the conversion factor for sodium dichromate is considered in a conservative manner (conversion factor for Cr(VI) fraction of SD and PD: 0.40 and 0.35, respectively)

Discussion and conclusions

In summary, modelled long-term dermal exposure to Cr(VI) as calculated with Riskofderm is in the same order of magnitude or about 10-fold lower than the Cr(VI) exposure calculated with the Excel based model, which shows that the Excel based model is a rather conservative approach. As discussed above, dermal exposure to neat SD and PD (and even to solutions containing SD, or PD at relatively low concentrations) will need to be prevented due to the corrosive nature of the substance. Therefore, the dermal exposure estimates should be considered theoretical rather than reflecting true exposure levels.

11.5.2 Riskofderm modelling

The Riskofderm model (v.2.1) only contains a limited number of modules (DEO units), which are applicable to the worker activities described in sections 9.2.3.2 to 9.2.3.8. Exposure can only reasonably be estimated for activities relating to DEO 1 (filling, mixing, loading; only hand, not body exposure covered by the model), like aliquot chemicals, bath addition/make-up and sampling. We have refrained from modelling of surface treatment by dipping/immersion (DEO 5: immersion) as the data underlying the model for this DEO largely relate to "*mechanical immersing of objects into baths*", which describes activities where hands are immersed or are in contact with contaminated surfaces and does not cover automated or semi-automated (by means of a manual controlled crane) immersion processes which are typical for this use. Further, the developer of the Riskofderm model stated that "*the immersion model is the least satisfactory of the developed models … having large residual errors for both the hand and the body…and includes just 13 measurements … all relating to degreasing of machine parts*" (Warren et al., 2006).

The conditions of use applied for the Riskofderm model are described in the following table (for details see in sections 9.2.3.2 to 9.2.3.8).

Table Annex V-2: Conditions of use (Riskofderm modelling, DEO 1, realistic input parameters)

	Method
Product (article) characteristics	
• Physical form of the used product: • Aliquot chemical, bath addition/make-up: liquid • Aliquot chemical, bath addition/make-up: solid (low or moderately dusty solid) • Sampling: liquid • Solution preparation: liquid • Solution preparation: solid (low or moderately dusty solid)	Riskofderm 2.1

	Method
Amount used (or contained in articles), frequency and duration of use/exposure	
• Duration of dermal exposure: • Liquid: Aliquot chemical (5-10 min), bath addition/make-up (5-60 min), solution preparation for brush or swab application (5-10 min) • Solid: Aliquot chemical (5-60* min), bath addition/make-up (5-60* min), solution preparation for brush or swab application (5-10 min) • Sampling (1-20 min) * value for upper limit not covered by the measurement data used for the model; therefore the calculation was performed assuming a typical duration of 10 min	Riskofderm 2.1
• Frequency of skin contact: Rare contact	Riskofderm 2.1
• Use rate of the product: • Liquid: Aliquot chemical (0.5-1 L/min), bath addition/make-up (0.5-1 L/min), solution preparation for brush or swab application (0.1-0.2 L/min) • Solid: Aliquot chemical (6.5-11 kg/min), bath addition/make-up (6.5-11 kg/min), solution preparation for brush or swab application (0.1-0.2 kg/min) • Sampling (0.05 L/min)	Riskofderm 2.1
Technical and organisational conditions and measures	
• Level of automation of the task: Manual task	Riskofderm 2.1
Conditions and measures related to personal protection, hygiene, and health evaluation	
• Dermal protection: Yes (Chemically resistant gloves conforming to EN374 with specific activity training) and (other) appropriate dermal protection [Effectiveness Dermal: 95%]	Riskofderm 2.1
Other conditions affecting workers exposure	
• Generation of aerosols or splashes during task: No	Riskofderm 2.1
• Ventilation: Light contact (normal or good ventilation)	Riskofderm 2.1
• Type of skin contact: Light contact	Riskofderm 2.1

The 90th percentile exposure estimate from Riskofderm modelling was used for an estimate of potential dermal exposure. The results of the Riskofderm model are documented in section 11.5.2.1 of this Annex.

Modelling results

The exposure estimates modelled with Riskofderm are shown in the following table.

Table Annex V-3: Modelled Exposure for workers based on Riskofderm results

Parameter	Unit	Aliquot liquid chemical		Bath addition – liquid	Bath make-up – liquid	Aliquot solid chemical		Bath addition – solid	Bath make-up solid	Solution preparation for brush or swab application - liquid	Solution preparation for brush or swab application - solid	Sampling	Rationale (Reference)
		Small amount	Large amount	Small amount	Large amount	Small amount	Large amount [a]	Small amount	Large amount [a]				
		(hands)	(hands)	(hands)	(hands)	(hands)	(hands)	(hands)	(hands)	(hands)	(hands)	(hands)	
Potential dermal exposure to product per event	µl	22.8	87	22.8	522					10.2		10.7	Riskofderm result, 90th percentile
Density	g/cm^3	1.68	1.68	1.68	1.68					1.68		1	Information from SDS
Potential dermal exposure to product per event	mg	38.3	146	38.3	877	8.53	27.8	8.53	27.8	17.14	0.351	10.7	Riskofderm result for solid; calculated under consideration of Riskofderm

													result and density
Body weight	kg	70	70	70	70	70	70	70	70	70	70	70	Body weight for workers (Guidance IR & CSA, R.8 (ECHA, 2012))
Potential dermal exposure to product	mg/kg bw	0.547	2.09	0.547	12.5	0.122	0.397	0.122	0.397	0.245	0.005	0.153	Calculated
PPE efficiency (gloves, protective clothing, or apron)	%	95	95	95	95	95	95	95	95	95	95	95	see (EC, 2010)
Actual dermal exposure to product	mg/kg bw	0.0274	0.104	0.0274	0.626	0.00609	0.020	0.00609	0.020	0.012	0.000251	0.00764	Calculated
Cr(VI) concentration in product	%	12	12	12	12	40	40	40	40	2.9	40	8.8	See WCS specific conditions of use as described in sections 9.2.3.2 to 9.2.3.89.2.3.3
Actual dermal exposure to Cr(VI)	**µg/kg bw**	**3.28**	**12.5**	**3.28**	**75.2**	**2.44**	**7.94**	**2.44**	**7.94**	**0.355**	**0.100**	**0.673**	**Calculated**

Frequency	d/year	48	12	48	12	48	12	48	12	240	96	240	
Annual average dermal exposure to Cr(VI)	**µg/kg bw/d**	**0.657**	**0.626**	**0.657**	**3.76**	**0.487**	**0.397**	**0.487**	**0.397**	**0.355**	**0.040**	**0.673**	**Calculated**

All values rounded to three significant figures, but unrounded values used in calculation.

[a] Duration for aliquot solid large amounts and bath make-up solids not covered by data base for model (duration up to 60 min, model was based on values up to 20 min for powders, see section 11.5.2.1; for the calculation a duration of 10 min was assumed.

With realistic input parameters task-related dermal exposure estimates ranged from 0.100 to 75.2 µg/kg bw/d, with all estimates being ≤ 7.94 µg/kg bw/d except those for bath make-up with liquids, activity only performed on rare occasions (12d/year). However, taking into consideration the low frequency of these activities an annual average dermal exposure to Cr(VI) of < 3.76 µg/kg bw/d results for all tasks.

11.5.2.1 Riskofderm modelling results

Aliquot liquid – small amount

Filling, mixing or loading (DEO unit 1)

You can move the input messages with the input fields by dragging and dropping — *Scroll down to see the remainder!*

Question	Answer	Additional explanation	Measured range as basis for model
What is the quality of the ventilation related to the task done?	Normal or good ventilation	Good (mechanical) ventilation and/or proper local exhaust ventilation	
What is the frequency of (skin) contact with the contaminant?	Rare contact	It happens sometimes, but on average less than once per scenario	
What kind of (skin) contact with the contaminant occurs?	Light contact	Touching of contaminated surfaces and/or limited deposition of dust or aerosols	
What type of product is handled?	Liquid	The product handled is a liquid	
Are significant amounts of aerosols or splashes generated in the task?	No	Task does not lead to substantial interaction between product and air, nor to dropping of product on a hard surface	
What is the level of automation of the task done by the worker?	Manual task	The task is largely done manually with substantial interaction between worker and package, contaminated installation or product	
What is the use rate of the product?	0.5	L/min (Overview results) (Back)	0,56-225 kg/min for powders; 0,008-257 L/min for liquids
Percentile for the exposure rate distribution to be assessed	90	percentile	*Scroll up or down* *The sheet "Fillmixload_results" provides an overview of the results of this assessment*

	median	percentile distribution	
Resulting exposure rate hands	.526	4.57	µL/min or mg/min
Resulting exposure rate body	only hand exposure is estimated with this model		µL/min or mg/min

Question	Answer	Additional explanation	Measured range as basis for model
What is the cumulative duration of the scenario during a shift?	5	minutes	1-20 min for powders; 0,33-125 for liquids

	median	percentile distribution	
Exposure loading per shift hands	2.630	22.800	µL or mg
Exposure loading per shift body	only hand exposure is estimated with this model		µL or mg

See the guidance for some remarks on different criteria for the performance of the model.

No model for potential body exposure is available for this scenario due to lack of data — *Scroll up or down*

Aliquot liquid – large amount

Filling, mixing or loading (DEO unit 1)

You can move the input messages with the input fields by dragging and dropping — *Scroll down to see the remainder!*

Question	Answer	Additional explanation	Measured range as basis for model
What is the quality of the ventilation related to the task done?	Normal or good ventilation	Good (mechanical) ventilation and/or proper local exhaust ventilation	
What is the frequency of (skin) contact with the contaminant?	Rare contact	It happens sometimes, but on average less than once per scenario	
What kind of (skin) contact with the contaminant occurs?	Light contact	Touching of contaminated surfaces and/or limited deposition of dust or aerosols	
What type of product is handled?	Liquid	The product handled is a liquid	
Are significant amounts of aerosols or splashes generated in the task?	No	Task does not lead to substantial interaction between product and air, nor to dropping of product on a hard surface	
What is the level of automation of the task done by the worker?	Manual task	The task is largely done manually with substantial interaction between worker and package, contaminated installation or product	
What is the use rate of the product?	1	L/min (Overview results / Back)	0,56-225 kg/min for powders; 0,008-257 L/min for liquids
Percentile for the exposure rate distribution to be assessed	90	percentile	*Scroll up or down* *The sheet "Fillmixload_results" provides an overview of the results of this assessment*
	median	percentile distribution	
Resulting exposure rate hands	1.	8.7	µL/min or mg/min
Resulting exposure rate body	only hand exposure is estimated with this model		µL/min or mg/min
What is the cumulative duration of the scenario during a shift?	10	minutes	1-20 min for powders; 0,33-125 for liquids
	median	percentile distribution	
Exposure loading per shift hands	10.000	87.000	µL or mg
Exposure loading per shift body	only hand exposure is estimated with this model		µL or mg

See the guidance for some remarks on different criteria for the performance of the model.

No model for potential body exposure is available for this scenario due to lack of data — *Scroll up or down*

Aliquot solid – small amount

Filling, mixing or loading (DEO unit 1)

You can move the input messages with the input fields by dragging and dropping

Scroll down to see the remainder!

Question	Answer	Additional explanation	Measured range as basis for model
What is the quality of the ventilation related to the task done?	Normal or good ventilation	Good (mechanical) ventilation and/or proper local exhaust ventilation	
What is the frequency of (skin) contact with the contaminant?	Rare contact	It happens sometimes, but on average less than once per scenario	
What kind of (skin) contact with the contaminant occurs?	Light contact	Touching of contaminated surfaces and/or limited deposition of dust or aerosols	
What type of product is handled?	Low or moderately dusty solid	A low or moderately dusty solid either does not produce clearly visible dust in the air, or the dust can be seen only briefly	
Are significant amounts of aerosols or splashes generated in the task?	No	Task does not lead to substantial interaction between product and air, nor to dropping of product on a hard surface	
What is the level of automation of the task done by the worker?	Manual task	The task is largely done manually with substantial interaction between worker and package, contaminated installation or product	for powders: always Manual task
		Overview results	
What is the use rate of the product?	6.5	kg/min Back	0,56-225 kg/min for powders; 0,008-257 L/min for liquids
Percentile for the exposure rate distribution to be assessed	90	percentile	*Scroll up or down* *The sheet "Fillmixload_results" provides an overview of the results of this assessment*

	median	percentile distribution	
Resulting exposure rate hands	.196	1.71	µL/min or mg/min
Resulting exposure rate body	only hand exposure is estimated with this model		µL/min or mg/min

Question	Answer	Additional explanation	Measured range as basis for model
What is the cumulative duration of the scenario during a shift?	5	minutes	1-20 min for powders; 0,33-125 for liquids

	median	percentile distribution	
Exposure loading per shift hands	0.982	8.530	µL or mg
Exposure loading per shift body	only hand exposure is estimated with this model		µL or mg

See the guidance for some remarks on different criteria for the performance of the model.

No model for potential body exposure is available for this scenario due to lack of data

Scroll up or down

Aliquot solid – large amount

Filling, mixing or loading (DEO unit 1)

You can move the input messages with the input fields by dragging and dropping *Scroll down to see the remainder!*

Question	Answer	Additional explanation	Measured range as basis for model
What is the quality of the ventilation related to the task done?	Normal or good ventilation	Good (mechanical) ventilation and/or proper local exhaust ventilation	
What is the frequency of (skin) contact with the contaminant?	Rare contact	It happens sometimes, but on average less than once per scenario	
What kind of (skin) contact with the contaminant occurs?	Light contact	Touching of contaminated surfaces and/or limited deposition of dust or aerosols	
What type of product is handled?	Low or moderately dusty solid	A low or moderately dusty solid either does not produce clearly visible dust in the air, or the dust can be seen only briefly	
Are significant amounts of aerosols or splashes generated in the task?	No	Task does not lead to substantial interaction between product and air, nor to dropping of product on a hard surface	
What is the level of automation of the task done by the worker?	Manual task	The task is largely done manually with substantial interaction between worker and package, contaminated installation or product	for powders: always Manual task
What is the use rate of the product?	11	kg/min	0,56-225 kg/min for powders; 0,008-257 L/min for liquids
Percentile for the exposure rate distribution to be assessed	90	percentile	*Scroll up or down* *The sheet "Fillmixload_results" provides an overview of the results of this assessment*

Overview results

Back

	median	percentile distribution	
Resulting exposure rate hands	.32	2.78	**µL/min or mg/min**
Resulting exposure rate body	**only hand exposure is estimated with this model**		**µL/min or mg/min**

What is the cumulative duration of the scenario during a shift?	10	minutes	1-20 min for powders; 0,33-125 for liquids

	median	percentile distribution	
Exposure loading per shift hands	3.200	27.800	**µL or mg**
Exposure loading per shift body	**only hand exposure is estimated with this model**		**µL or mg**

See the guidance for some remarks on different criteria for the performance of the model.

No model for potential body exposure is available for this scenario due to lack of data *Scroll up or down*

Bath addition – liquid

Filling, mixing or loading (DEO unit 1)

You can move the input messages with the input fields by dragging and dropping

Scroll down to see the remainder!

Question	Answer	Additional explanation	Measured range as basis for model
What is the quality of the ventilation related to the task done?	Normal or good ventilation	Good (mechanical) ventilation and/or proper local exhaust ventilation	
What is the frequency of (skin) contact with the contaminant?	Rare contact	It happens sometimes, but on average less than once per scenario	
What kind of (skin) contact with the contaminant occurs?	Light contact	Touching of contaminated surfaces and/or limited deposition of dust or aerosols	
What type of product is handled?	Liquid	The product handled is a liquid	
Are significant amounts of aerosols or splashes generated in the task?	No	Task does not lead to substantial interaction between product and air, nor to dropping of product on a hard surface	
What is the level of automation of the task done by the worker?	Manual task	The task is largely done manually with substantial interaction between worker and package, contaminated installation or product	
What is the use rate of the product?	0.5	L/min (Overview results) (Back)	0,56-225 kg/min for powders; 0,008-257 L/min for liquids
Percentile for the exposure rate distribution to be assessed	90	percentile	*Scroll up or down* *The sheet "Fillmixload_results" provides an overview of the results of this assessment*
	median	percentile distribution	
Resulting exposure rate hands	.526	4.57	µL/min or mg/min
Resulting exposure rate body	only hand exposure is estimated with this model		µL/min or mg/min
What is the cumulative duration of the scenario during a shift?	5	minutes	1-20 min for powders; 0,33-125 for liquids
	median	percentile distribution	
Exposure loading per shift hands	2.630	22.800	µL or mg
Exposure loading per shift body	only hand exposure is estimated with this model		µL or mg

See the guidance for some remarks on different criteria for the performance of the model.

No model for potential body exposure is available for this scenario due to lack of data

Scroll up or down

Bath make-up – liquid

Filling, mixing or loading (DEO unit 1)

You can move the input messages with the input fields by dragging and dropping

Scroll down to see the remainder!

Question	Answer	Additional explanation	Measured range as basis for model
What is the quality of the ventilation related to the task done?	Normal or good ventilation	Good (mechanical) ventilation and/or proper local exhaust ventilation	
What is the frequency of (skin) contact with the contaminant?	Rare contact	It happens sometimes, but on average less than once per scenario	
What kind of (skin) contact with the contaminant occurs?	Light contact	Touching of contaminated surfaces and/or limited deposition of dust or aerosols	
What type of product is handled?	Liquid	The product handled is a liquid	
Are significant amounts of aerosols or splashes generated in the task?	No	Task does not lead to substantial interaction between product and air, nor to dropping of product on a hard surface	
What is the level of automation of the task done by the worker?	Manual task	The task is largely done manually with substantial interaction between worker and package, contaminated installation or product	
		Overview results	
What is the use rate of the product?	1	L/min	0,56-225 kg/min for powders; 0,008-257 L/min for liquids
		Back	
Percentile for the exposure rate distribution to be assessed	90	percentile	*Scroll up or down* *The sheet "Fillmixload_results" provides an overview of the results of this assessment*
	median	percentile distribution	
Resulting exposure rate hands	1.	8.7	µL/min or mg/min
Resulting exposure rate body	only hand exposure is estimated with this model		µL/min or mg/min
What is the cumulative duration of the scenario during a shift?	60	minutes	1-20 min for powders; 0,33-125 for liquids
	median	percentile distribution	
Exposure loading per shift hands	60.200	522.000	µL or mg
Exposure loading per shift body	only hand exposure is estimated with this model		µL or mg

See the guidance for some remarks on different criteria for the performance of the model.

No model for potential body exposure is available for this scenario due to lack of data

Scroll up or down

Bath addition – solid

Filling, mixing or loading (DEO unit 1)

You can move the input messages with the input fields by dragging and dropping *Scroll down to see the remainder!*

Question	Answer	Additional explanation	Measured range as basis for model
What is the quality of the ventilation related to the task done?	Normal or good ventilation	Good (mechanical) ventilation and/or proper local exhaust ventilation	
What is the frequency of (skin) contact with the contaminant?	Rare contact	It happens sometimes, but on average less than once per scenario	
What kind of (skin) contact with the contaminant occurs?	Light contact	Touching of contaminated surfaces and/or limited deposition of dust or aerosols	
What type of product is handled?	Low or moderately dusty solid	A low or moderately dusty solid either does not produce clearly visible dust in the air, or the dust can be seen only briefly	
Are significant amounts of aerosols or splashes generated in the task?	No	Task does not lead to substantial interaction between product and air, nor to dropping of product on a hard surface	
What is the level of automation of the task done by the worker?	Manual task	The task is largely done manually with substantial interaction between worker and package, contaminated installation or product	for powders: always Manual task
What is the use rate of the product?	6.5	kg/min Overview results Back	0,56-225 kg/min for powders; 0,008-257 L/min for liquids
Percentile for the exposure rate distribution to be assessed	90	percentile	*Scroll up or down* *The sheet "Fillmixload_results" provides an overview of the results of this assessment*
	median	**percentile distribution**	
Resulting exposure rate hands	**.196**	**1.71**	**µL/min or mg/min**
Resulting exposure rate body	**only hand exposure is estimated with this model**		**µL/min or mg/min**
What is the cumulative duration of the scenario during a shift?	5	minutes	1-20 min for powders; 0,33-125 for liquids
	median	**percentile distribution**	
Exposure loading per shift hands	**0.982**	**8.530**	**µL or mg**
Exposure loading per shift body	**only hand exposure is estimated with this model**		**µL or mg**

See the guidance for some remarks on different criteria for the performance of the model.

No model for potential body exposure is available for this scenario due to lack of data *Scroll up or down*

Bath make-up - solid

Filling, mixing or loading (DEO unit 1)

You can move the input messages with the input fields by dragging and dropping

Scroll down to see the remainder!

Question	Answer	Additional explanation	Measured range as basis for model
What is the quality of the ventilation related to the task done?	Normal or good ventilation	Good (mechanical) ventilation and/or proper local ...aust ventilation	
What is the frequency of (skin) contact with the contaminant?	Rare contact	It happens sometimes, but on average less than once per scenario	
What kind of (skin) contact with the contaminant occurs?	Light contact	Touching of contaminated surfaces and/or limited deposition of dust or aerosols	
What type of product is handled?	Low or moderately dusty solid	A low or moderately dusty solid either does not produce clearly visible dust in the air, or the dust can be seen only briefly	
Are significant amounts of aerosols or splashes generated in the task?	No	Task does not lead to substantial interaction between product and air, nor to dropping of product on a hard surface	
What is the level of automation of the task done by the worker?	Manual task	The task is largely done manually with substantial interaction between worker and package, contaminated installation or product	for powders: always Manual task
What is the use rate of the product?	11	kg/min	0,56-225 kg/min for powders; 0,008-257 L/min for liquids
Percentile for the exposure rate distribution to be assessed	90	percentile	*Scroll up or down* *The sheet "Fillmixload_results" provides an overview of the results of this assessment*

Overview results

Back

	median	percentile distribution	
Resulting exposure rate hands	.32	2.78	µL/min or mg/min
Resulting exposure rate body	only hand exposure is estimated with this model		µL/min or mg/min

Question	Answer		Measured range as basis for model
What is the cumulative duration of the scenario during a shift?	10	minutes	1-20 min for powders; 0,33-125 for liquids

	median	percentile distribution	
Exposure loading per shift hands	3.200	27.800	µL or mg
Exposure loading per shift body	only hand exposure is estimated with this model		µL or mg

See the guidance for some remarks on different criteria for the performance of the model.

No model for potential body exposure is available for this scenario due to lack of data

Scroll up or down

Solution preparation for brush or swab application - liquid

Filling, mixing or loading (DEO unit 1)

You can move the input messages with the input fields by dragging and dropping *Scroll down to see the remainder!*

Question	Answer	Additional explanation	Measured range as basis for model
What is the quality of the ventilation related to the task done?	Normal or good ventilation	Good (mechanical) ventilation and/or proper local exhaust ventilation	
What is the frequency of (skin) contact with the contaminant?	Rare contact	It happens sometimes, but on average less than once per scenario	
What kind of (skin) contact with the contaminant occurs?	Light contact	Touching of contaminated surfaces and/or limited deposition of dust or aerosols	
What type of product is handled?	Liquid	The product handled is a liquid	
Are significant amounts of aerosols or splashes generated in the task?	No	Task does not lead to substantial interaction between product and air, nor to dropping of product on a hard surface	
What is the level of automation of the task done by the worker?	Manual task	The task is largely done manually with substantial interaction between worker and package, contaminated installation or product	
What is the use rate of the product?	0.1	L/min Overview results Back	0,56-225 kg/min for powders; 0,008-257 L/min for liquids *Scroll up or down*
Percentile for the exposure rate distribution to be assessed	90	percentile	*The sheet "Fillmixload_results" provides an overview of the results of this assessment*
	median	percentile distribution	
Resulting exposure rate hands	.118	1.02	µL/min or mg/min
Resulting exposure rate body	only hand exposure is estimated with this model		µL/min or mg/min
What is the cumulative duration of the scenario during a shift?	10	minutes	1-20 min for powders; 0,33-125 for liquids
	median	percentile distribution	
Exposure loading per shift hands	1.180	10.200	µL or mg
Exposure loading per shift body	only hand exposure is estimated with this model		µL or mg

See the guidance for some remarks on different criteria for the performance of the model.

No model for potential body exposure is available for this scenario due to lack of data *Scroll up or down*

Solution preparation for brush or swab application - solid

Filling, mixing or loading (DEO unit 1)

You can move the input messages with the input fields by dragging and dropping *Scroll down to see the remainder!*

Question	Answer	Additional explanation		Measured range as basis for model
What is the quality of the ventilation related to the task done?	Normal or good ventilation	Good (mechanical) ventilation and/or proper local exhaust ventilation		
What is the frequency of (skin) contact with the contaminant?	Rare contact	It happens sometimes, but on average less than once per scenario		
What kind of (skin) contact with the contaminant occurs?	Light contact	Touching of contaminated surfaces and/or limited deposition of dust or aerosols		
What type of product is handled?	Low or moderately dusty solid	A low or moderately dusty solid either does not		
Are significant amounts of aerosols or splashes generated in the task?	No	Task does not lead to substantial interaction between product and air, nor to dropping of product on a hard surface		
What is the level of automation of the task done by the worker?	Manual task	The task is largely done manually with substantial interaction between worker and package, contaminated installation or product		for powders: always Manual task
What is the use rate of the product?	0.1	kg/min	Overview results Back	0,56-225 kg/min for powders; 0,008-257 L/min for liquids
Percentile for the exposure rate distribution to be assessed	90	percentile		*Scroll up or down* *The sheet "Fillmixload_results" provides an overview of the results of this assessment*
	median	percentile distribution		
Resulting exposure rate hands	.004048	.03514		µL/min or mg/min
Resulting exposure rate body	only hand exposure is estimated with this model			µL/min or mg/min
What is the cumulative duration of the scenario during a shift?	10	minutes		1-20 min for powders; 0,33-125 for liquids
	median	percentile distribution		
Exposure loading per shift hands	0.040	0.351		µL or mg
Exposure loading per shift body	only hand exposure is estimated with this model			µL or mg

See the guidance for some remarks on different criteria for the performance of the model.

No model for potential body exposure is available for this scenario due to lack of data *Scroll up or down*

Sampling

Filling, mixing or loading (DEO unit 1)

You can move the input messages with the input fields by dragging and dropping *Scroll down to see the remainder!*

Question	Answer	Additional explanation	Measured range as basis for model
What is the quality of the ventilation related to the task done?	Normal or good ventilation	Good (mechanical) ventilation and/or proper local exhaust ventilation	
What is the frequency of (skin) contact with the contaminant?	Rare contact	It happens sometimes, but on average less than once per scenario	
What kind of (skin) contact with the contaminant occurs?	Light contact	Touching of contaminated surfaces and/or limited deposition of dust or aerosols	
What type of product is handled?	Liquid	The product handled is a liquid	
Are significant amounts of aerosols or splashes generated in the task?	No	Task does not lead to substantial interaction between product and air, nor to dropping of product on a hard surface	
What is the level of automation of the task done by the worker?	Manual task	The task is largely done manually with substantial interaction between worker and package, contaminated installation or product	
What is the use rate of the product?	0.05	L/min Overview results Back	0,56-225 kg/min for powders; 0,008-257 L/min for liquids
Percentile for the exposure rate distribution to be assessed	90	percentile	*Scroll up or down* *The sheet "Fillmixload_results" provides an overview of the results of this assessment*
	median	percentile distribution	
Resulting exposure rate hands	.06182	.537	µL/min or mg/min
Resulting exposure rate body		only hand exposure is estimated with this model	µL/min or mg/min
What is the cumulative duration of the scenario during a shift?	20	minutes	1-20 min for powders; 0,33-125 for liquids
	median	percentile distribution	
Exposure loading per shift hands	1.240	10.700	µL or mg
Exposure loading per shift body		only hand exposure is estimated with this model	µL or mg

See the guidance for some remarks on different criteria for the performance of the model.

No model for potential body exposure is available for this scenario due to lack of data *Scroll up or down*

11.6 Annex VI – Respiratory protection –Assigned protection factors (APF)

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

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

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

Full mask (all types) with combined gas-particle filter Gas X P3	EN 136 (mask) EN 143 (filter)		-	400	-	-	20	-	**20**
Powered filtering device incorporating a hood or a helmet (PAPR, 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		100 0	500	400	100 0	40	60 (120 l/min) 100 (160 l/min)	**40**
fresh air hose breathing apparatus - full mask or hood or helmet	EN 138		500	100 0	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		100 0	100 0	400	100 0	40	-	**40**

[1] Source: INRS guidance ED6106

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