CHEMICAL SAFETY REPORT

Legal name of applicant(s):	Indestructible Paint Ltd		
Submitted by:	**Indestructible Paint 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
Uses applied for:	Use 1: Treatment of components used in industrial gas turbines and associated components using slurry coating products containing chromium trioxide to enhance corrosion resistance, chemical resistance, high temperature oxidation resistance, adhesion to components which produce a smooth finish and enhance the technical performance of turbines		

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Preliminary Remark

Indestructible Paint Ltd's slurry coating products are also used in the aerospace and defence sector for protecting vital components. The use and application of the products is very similar for the protection of industrial gas turbine and related components as it is for the aerospace and defence sector. Indestructible Paint Ltd is part of the Aerospace and Defence Chromate Reauthorisation (ADCR) consortium. As a consortium member and as the uses of their products in both sectors is the same, Indestructible Paint Ltd made a request to the ADCR consortium to allow relevant occupational and environmental exposure data and information to be used to support the industrial turbine use application. The consortium members reviewed the request and agreed that relevant information could be accessed and used in the industrial turbine use application as part of a letter of access agreement.

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 Application for Authorisation.

2. DECLARATION THAT RISK MANAGEMENT MEASURES ARE IMPLEMENTED

Not applicable - as the applicant is not using the substance for this use

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 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.

9 EXPOSURE ASSESSMENT (AND RELATED RISK CHARACTERISATION)

9.1 Introduction to the assessment

9.1.1 Classification

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

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

Table 9-1: Substances considered for the assessment

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

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

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

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

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

9.1.2 Exposure-risk relationships (ERRs) for carcinogenic effects

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.

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

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

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

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

[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

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

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/m³]*	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/m³]*	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)

9.1.3 Environment

Scope and type of assessment

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

9.1.4 Exposure of humans via the environment

9.1.4.1 Scope and type of assessment

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

Apart from that, there is only limited data on the presence of Cr(VI) in food. In the majority of cases, only total chromium was measured. According to a few studies, Cr(VI) generally amounts to less than 10% of total chromium (range 1.31-12.9%) (EFSA, 2014). Furthermore, some studies even indicate that foods of plant origin do not contain Cr(VI) at all and that the Cr(VI) levels measured are analytical artifacts (EFSA, 2014). The same may be the case with foods of animal origin. Based on these data, the EFSA-CONTAM Panel concluded 'that there is a lack of data on the presence of Cr(VI) in food' and 'decided to consider all the reported analytical results in food as Cr(III)' (EFSA, 2014). Furthermore, the CONTAM Panel concluded that it can be assumed 'that all the chromium ingested via food is in the trivalent form (i.e., Cr(III)), in contrast to drinking water where chromium may easily be present in the hexavalent state', primarily due to the use of strong oxidizing agents in the treatment of drinking water

(EFSA, 2014). These considerations of the CONTAM Panel support the earlier evaluation of the EU Risk Assessment Report for chromates, in which the indirect oral exposure of humans via the environment was assessed only on the basis of exposure via (drinking) water and the consumption of fish (ECB, 2005). The same approach is therefore followed here.

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

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

Route of exposure and type of effects	**Endpoint considered and type of risk characterisation**	**Hazard conclusion** **DNEL/dose – response relationship**
Inhalation: Systemic Long Term	Carcinogenicity Quantitative	RAC dose-response relationship based on excess lung cancer risk (ECHA, 2013) For general population; based on 70 years of exposure; 24h/day: Exposure to 1 µg/m^3 Cr(VI) relates to an excess risk of $2.9x10^{-2}$ *****
Oral: Systemic Long Term	Carcinogenicity Quantitative	RAC dose-response relationship based on excess cancer risk for tumours of the small intestine (ECHA, 2013) For general population; based on 70 years of exposure: Exposure to 1 µg Cr(VI) /kg bw/day relates to an excess risk of $8x10^{-4}$

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

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

EUSES modelling of human exposure via the environment

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

Release days

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

- the air concentration (*annual average local "Predicted environmental concentration" (PEC) in air (total)*) and the concentration in fish (calculated from the bioconcentration factor in fish and from the *annual average local PEC in surface water (dissolved)*) are based on annual average PEC values, on which the number of release days has no impact.
- the Cr(VI) concentration in drinking water is based on the higher of the two values "*annual average local PEC in surface water (dissolved)"*, which is independent of the number of release days, as described above, and "*local PEC in pore water of agricultural soil"*, where fewer release days would lead to an intermittently higher PEC value. If the concentration in drinking water is based on the "*local PEC in pore water of agricultural soil"* and if this value is temporarily increased due to intermittent release (of sewage sludge to agricultural soil with temporarily higher Cr(VI) concentrations), the concentration in drinking water would be temporarily higher than under the assumption of 365 release days. This is a very unrealistic scenario since a spatial and temporal distance between pore water of agricultural soil and drinking water would compensate for variations in Cr(VI) drinking water concentrations due to intermittent release of Cr(VI) to wastewater. Furthermore, the use of an intermittently elevated drinking water concentration for the calculation of a lifelong cancer risk via drinking water consumption would be an overestimation of the realistic risk and therefore, by considering 365 release days, a stable concentration in drinking water is calculated.
- in this latter case, the "*local PEC in pore water of agricultural soil*" is simply equated by EUSES software with the "*local concentration in groundwater*", which is taken as the concentration in drinking water (if the concentration is higher than the one derived from surface water; see above). As noted in the EUSES background report, equating the soil porewater concentration with the groundwater concentration 'is a worst-case assumption, neglecting transformation and dilution in deeper soil layers'. This conservatism would increase the unrealistic nature of intermittent release further and the use of an annual average exposure estimate is considered more adequate in the present context.

Sewage treatment plant (STP)

For sites where wastewater is sent to a biological sewage treatment plant (STP), we have adjusted the default distribution of Cr(VI) in the sewage treatment plant (STP) used in EUSES (99.9% in water and

[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

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

Oral uptake via drinking water and fish

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

- Drinking water

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

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

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

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

that the resulting groundwater concentration only applies to the groundwater below this area.

- EUSES modelling of the concentration in groundwater is based on a simple algorithm that equates the concentration of a substance in groundwater with its concentration in the porewater 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. This is still 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

[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).

model relate to the consumption of '*fish, fish products and other marine and freshwater food product'* and therefore include food items that are unlikely to be sourced from the immediate vicinity of the site assessed.

Inhalation exposure

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

Site-specific release fractions

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

Wastewater

At many sites, no Cr(VI) emission to wastewater occurs during spray application of slurry coating as these sites either operate their paint shops without water or emerging wastewater is gathered and sent to an external waste management company (licensed contractor) for disposal as hazardous waste. These sites either operate with dry air filters or have water curtain spray booths. The Cr(VI)-containing wastewater from water curtain spray booths, wash water from wet scrubbers or rinsing/cleaning water from cleaning operations (e.g., cleaning of spray gun) is gathered in closed containers (e.g., drums, Intermediate Bulk Container (IBC) or tanks) and is directly sent to an external waste management company (licensed contractor) for disposal as liquid hazardous waste.

A few sites may convey Cr(VI)-containing wastewater from wet scrubbers or from rinsing or cleaning activities (e.g., cleaning spray booth or spray gun/brush) performed during slurry coating to a special treatment facility, which usually collects Cr(VI)-containing wastewater from various processes together for treatment at the treatment facility. The special treatment facility is in most cases located on-site.

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

Air

The exhaust air from spraying booth(s) and/or paint area is exhausted and treated through dry air filters, wet scrubbers, or wash water from water curtains prior to external release.

Soil

No direct release to soil is possible.

Solid waste containing Cr(VI) may arise in the form of sludge from water curtain spray booths or from the reduction/neutralization process (at sites where this technique is performed), empty chemical containers, cleaning materials (e.g. rags, wipes), contaminated equipment (e.g. filters, pumps), Cr(VI)-contaminated glass beads from burnishing, sand or other abrasive material from sand blasting/sanding, and disposable PPE. Waste materials containing Cr(VI) are classified and treated as hazardous wastes according to EU and national regulations. Any solid or liquid waste is collected and forwarded to an external waste management company (licensed contractor) for disposal as hazardous waste.

Substance-specific input values

We have used the properties of CT for the input of substance-specific physico-chemical properties to model the behaviour of Cr(VI) with EUSES. 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)

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	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 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 below for details
Bioconcentration factor fish	1 L/kg	1 L/kg	Refers to Cr(VI); value used in ECB (2005)

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

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

9.1.5 Workers

9.1.5.1 Scope and type of assessment

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

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

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

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

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

A qualitative risk characterisation with respect to the corrosive and skin sensitising properties of CT is outside the scope of this CSR, as CT has been included in Annex XIV to Regulation (EC) No 1907/2006

(REACH) solely due to its carcinogenic and mutagenic properties. According to REACH, Article 62(4)(d), the CSR supporting an AfA needs to cover only those potential risks arising from the intrinsic properties specified in Annex XIV. The applicants duly apply and communicate risk management measures derived by the registrants of CT due to other substance properties related to human health concerns, which they communicated via the Safety Data Sheets (SDS).

9.1.5.2 Comments on assessment approach

General approach

The potential for exposure depends on the specific tasks identified for this use, as described below in the respective sections. Based on the process characteristics and properties of CT as non-volatile substances, all potential inhalation exposure will be due to aerosols/dusts containing Cr(VI).

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 other activities with potential Cr(VI) exposure in parallel (e.g., spraying or brush/touch-up activities).

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

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

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

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

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

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

Comments on assessment approach related to toxicological hazard:

Dose-response relationships for carcinogenic effects as proposed by RAC are used for risk characterisation.

Comments on assessment approach related to physicochemical hazard:

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

General information on risk management related to toxicological hazard:

Information on risk management measures implemented are provided in chapter 9.2.3.

General information on risk management related to physicochemical hazard:

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

9.1.6 Consumers

Consumer uses are not subject of this dossier.

9.2 Use 1: "Treatment of components used in industrial gas turbines and associated components using slurry coating products containing chromium trioxide to enhance corrosion resistance, chemical resistance, high temperature oxidation resistance, adhesion to components which produce a smooth finish and enhance the technical performance of turbines"

9.2.1 Introduction

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

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

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

ES number	ES Title	Environmental release category (ERC)/ Process category (PROC)
ES1-IW1	Slurry coating **–** use at industrial site	
Environmental contributing scenario(s)		
ECS 1	Slurry 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	Spray operators	PROC 5, PROC 7, PROC 8a, PROC 8b, PROC 9, PROC 10, PROC 28
WCS 2	Maintenance and/or cleaning workers	PROC 28
WCS 3	Incidentally exposed workers	PROC 0
Exposure scenario for industrial end use at site: ES1-IW1		

9.2.2 Detailed information on use

9.2.2.1 Process description

Slurry coating is a surface treatment where steel components and nickel or cobalt-based alloys are coated with a slurry paint containing CT and afterwards are cured at high temperatures to provide corrosion resistance, high temperature oxidation resistance and other functionalities (see the Analysis of Alternatives report for more details).

Substrate(s)

Substrate materials are mainly steels (including stainless steel) and nickel or cobalt-based alloys.

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 slurry coating:

- Spray operators
- Maintenance and/or cleaning workers
- Incidentally exposed workers (without direct Cr(VI)-related activities)

9.2.2.3 Technical and organisational risk management measures

All sites that perform slurry coating are specialised industrial sites. 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.

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:

- Manual spraying is conducted in spray booths, which are connected to a local exhaust ventilation (LEV) system. Technical information on the LEV systems used is given for the respective worker contributing scenarios in sections 9.2.3.2 to 9.2.3.4.
- LEV is always used where possible and relevant, as described in the respective worker contributing scenarios in sections 9.2.3.2 to 9.2.3.4.

Efficiency of LEV

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

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

9.2.2.3.1.2 Organisational measures

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

- Annual monitoring programmes are implemented for air monitoring of occupational exposure to Cr(VI), which are representative of the range of tasks undertaken where exposure to Cr(VI) is possible, including tasks involving process and maintenance operations.
- The paint area in which slurry coating spraying is conducted in spray booths is restricted either by barriers / signage or through strict procedure during the spraying activity and for a specific time after the spray application has ceased.
- Only trained personnel are allowed to work in the paint area.
- The effectiveness of the risk management measures and operational conditions in place are regularly reviewed and, as applicable, measures are introduced to further reduce exposure and emissions.
- LEV systems are inspected and maintained according to the manufacturer´s specification.
- For tasks where respiratory protective equipment (RPE) is needed to control exposure it is used in accordance with standard procedures for use and maintenance, including procedures for fit testing of RPE masks which are applied in accordance with relevant standards.
- The provision of PPE for the workers is organised by a designated responsible person.
- The conditions of the PPE are checked regularly.
- A program of PPE management is implemented on site which includes PPE selection, training for correct wear/removal of the PPE, storage of PPE, cleaning or renewal and distribution of the PPE, communication via workplace signage or working instructions at the workplace.
- Training on chemical risks is periodically done for workers handling chemicals. Safety Data Sheets and instructions for hazardous chemicals handling are available.
- Training at the workplace is given periodically and work instructions are available on how to carry out specific tasks through standard operating procedures, e.g., how to load the spray gun safely.
- Cleaning of company supplied uniforms is organised by the site, or contaminated clothes are renewed.
- Slurry coatings are stored in a designated 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 risk assessment 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 for specific tasks)
- 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.

The specific PPE for each task is described in detail in the worker contributing scenarios in sections 9.2.3.2 to 9.2.3.4.

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 spray booths are connected to LEV systems. The local exhaust air is collected and released via exhaust stacks.
- The local exhaust air is at all sites treated by wash water (water curtain/wet scrubbers) or by dry 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 water curtains, 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. For example at one site, while spraying Cr(VI)-containing slurry coating paint was performed in spray booths, an average Cr(VI) concentration up to 0.1 mg/m³ was measured in the air volume inside the spray booth. The concentration of Cr(VI) detected in the exhaust air was below the LOQ of 0.001 mg/m³, resulting in an efficiency of >99%.

9.2.2.3.2.2 Emissions to wastewater

Most sites applying slurry coatings do not have Cr(VI) emissions to wastewater as they operate with dry air filters and/or gather the Cr(VI)-containing water (e.g., from water curtains and wash water from wet scrubbers or rinsing/cleaning water) in closed containers (e.g., drums, IBC, tanks), which are directly sent an external waste management company (licensed contractor) for disposal as liquid hazardous waste.

Only a few sites produce Cr(VI)-containing wastewater from wet scrubbers and/or rinsing/cleaning activities (e.g., cleaning spray booths, cleaning of equipment/spray gun). The Cr(VI)-containing wastewater is gathered and treated on-site in a reduction facility and then recycled or discharged.

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. After the reduction process, Cr(III) is precipitated and separated from the wastewater by a filter press (the filter cake is disposed as waste), and the treated wastewater is either reused or discharged to an external wastewater treatment plant (WWTP) or municipal sewage treatment plant (STP).

- At sites, which have Cr(VI) emission to wastewater, annual monitoring programmes for Cr(VI) emissions to wastewater are implemented and the effectiveness of the risk management measures 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.
- The application of slurry coating paint is performed indoors in specially designated areas, which mostly are separated from other processes at the site, in order to minimise spreading of Cr(VI)-containing paints or particles.

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)) and Cr(VI)-contaminated waste from activities related to the surface treatment process (e.g., empty chemical containers, filters, waste from cleaning activities, contaminated 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 Cr(VI)-contaminated solid waste such as contaminated wipes and PPE (gloves, overalls, …), filters, or empty paint containers are disposed as hazardous waste. This hazardous solid waste is stored in closed drums and containers and forwarded to an external waste management company (licensed contractor) for disposal.

9.2.2.4 Tonnages and mass balance considerations

9.2.2.4.1 Tonnages

Assessed tonnage per site: up to 40 kg Cr(VI)/year per site (up to 77 kg CT/year and site).

Total UK tonnage: up to [redacted] (0.052 – 0.52) tonnes Cr(VI)/year

up to [redacted] (0.1 - 1) tonnes CT/year.

9.2.2.4.2 Mass balance considerations

Consumption during process

During the spraying process, almost all of the Cr(VI) introduced in the spray booth is consumed, as it forms the slurry coating on the component.

Amount of Cr(VI) released to wastewater

Most sites do not emit chromate via wastewater. Therefore, the loss from that route is considered negligible.

Amount of Cr(VI) discharged as waste

Cr(VI) in solid waste occurs in the form of contaminated cleaning materials, filters and PPE; the quantities are low 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) for disposal of liquid hazardous waste. 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, due to the low vapour pressure of CT and the spraying process being carried out at room temperature. During the spraying application, any air emissions occurring is extracted by the LEV.

Amount of Cr(VI) released to the atmosphere

The exhaust air from spraying booth(s) which is released via exhaust stacks is between 2.06E-04 and 9.86E-01 kg per year (as described below in Annex II).

9.2.3 Exposure scenario 1 for Use 1: "Treatment of components used in industrial gas turbines and associated components using slurry coating products containing chromium trioxide to enhance corrosion resistance, chemical resistance, high temperature oxidation resistance, adhesion to components which produce a smooth finish and enhance the technical performance of turbines"

Market sector: -
Sector of use: SU 17
Article categories: not relevant
Environment contributing scenario(s): ERC 5
Worker contributing scenario(s): PROC 0, PROC 5, PROC 7, PROC 8a, PROC 8b, PROC 9, PROC 10, PROC 28
Subsequent service life exposure scenario(s): not relevant (see below)

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

Slurry coating using CT by spray or brush 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:

Slurry coatings are applied to the surface of parts of various sizes made of steels or nickel/cobalt base alloys.

Although Cr(VI) is partly reduced during the process, it cannot be excluded that Cr(VI) remains in the coating to some extent. However, concentrations are expected to be well below 0.1%, which is the concentration above which notifications of Candidate List substances in articles according to REACH Art. 33 (ECHA, 2017) are required. Further, Cr(VI) is immobilised in the coating, and the slurry coating is often covered by paints or lacquers. Therefore, exposure from parts treated by slurry coating is negligible. In consequence, no service life scenario for use of parts treated by slurry coating is required.

9.2.3.1 Environmental contributing scenario 1

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

9.2.3.1.1 Conditions of use

Table 9-10: Conditions of use – environmental contributing scenario 1

Product (article) characteristics
Product A: Aqueous solution of CT ▪ Concentration of Cr(VI): <3.1% (w/w) ▪ Concentration of Cr(VI) based on ranges of CT (up to 6% (w/w)) in paints used for slurry coating
Amount used, frequency and duration of use (or from service life)
Product A: Aqueous solution of CT as purchased, used to apply slurry coating ▪ Daily use at site: up to 110 g Cr(VI)/day ▪ Annual use at a site: up to 40 kg Cr(VI)/year ▪ From daily to infrequent ▪ 365 days/year (see section 9.1.4.)
Technical and organisational conditions and measures
All products: ▪ **Technical measures** o Air - Exhaust air is treated by wash water from water curtains or wet scrubbers or by air filters before it is released via exhaust stack(s) o Wastewater - Most sites produce no wastewater containing Cr(VI) as they either operate with dry air filters or gather the Cr(VI)-containing water in closed containers (e.g., drums, IBC, tanks), which is directly sent to an external waste management company (licensed contractor) for disposal of liquid hazardous waste - At some sites, wastewater may occur from wet scrubbers and/or rinsing/cleaning water - Cr(VI)-containing wastewater is treated mostly on-site in a reduction facility, where Cr(VI) in wastewater is reduced to Cr(III) by addition of a reduction agent (e.g., sodium bisulfite or ferrous sulfate), followed by neutralisation and precipitation of Cr(III) - Reduced wastewater is sent to an external wastewater treatment plant (WWTP) or municipal sewage treatment plant (STP) (depending on local regulatory requirements) o Soil - The indoor and outdoor surfaces where chemicals are handled are sealed and chemicals and solid waste containing Cr(VI) are stored outside only in closed containers ▪ **Organisational conditions and measures** o Air - Cr(VI) air emission measurements are annually performed at identified 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 local regulatory and permit requirements)
Conditions and measures related to sewage treatment plant
▪ Biological (municipal) STP: Standard STP (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: 2000 m³/day (by model default) ▪ Dilution factor for receiving water body: 10 (by model default)
Conditions and measures related to treatment of waste (including article waste)
▪ 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 and PPE, Cr(VI)-contaminated glass beads from burnishing, sand or other abrasive material from sand blasting/sanding, contaminated equipment (e.g., filters), or empty chemical containers (paint tins, paint bottles) are usually also disposed as hazardous waste. This hazardous solid waste is stored in closed drums and containers and forwarded to an external waste management company (licensed contractor) for disposal as hazardous waste.
Other conditions affecting environmental exposure
▪ None
Additional good practice advice. Obligations according to Article 37(4) of REACH do not apply
▪ None

The use of CT for slurry coating is carried out at small to large sites. The sites operate between 8 and 24 h per day, on 5-7 days per week and up to 365 production days per year. However, at most sites slurry coating is not performed on a daily basis.

Air emissions

The slurry coating process is carried out in spray booths at room temperature and with Cr(VI) concentrations in the products used up to 3.1% (a detailed description is given in section 9.2.3.2). Cr(VI) emissions to air are generated during the painting process via spraying or brushing, which are captured by LEV systems connected to the spraying booths and paint area. Exhaust air from dedicated workstations where decanting and loading/unloading of spray guns is performed may also contribute to the air emissions of a site, albeit to a low extent. Depending on the installed type of spray booth filtration, either a wash water from the installed water curtain, wet scrubbers or dry filters in the dry filter system treat exhaust air.

In case a water curtain is present, exhaust air passes through metal baffles and reservoirs, which cause the air to go through several curtains of water before being emitted via the exhaust stack.

In a spray booth with dry filters, an airstream is passing through exhaust filter(s) which ensure that paint particles are held back in the filter and thus the exhaust air is treated before it is emitted via a stack. Various types of exhaust filters (e.g., single or multi-stage filters, pocket filter), which are made of a variety of material (e.g., fiberglass, cardboard, paper mesh, polyester, fleece), are used. For spraying activities with Cr(VI)-containing paints, often a combination of different types of filters or multi-layered/multi-stage filters are installed. For example, pre-filters made of paper or fleece are installed before an exhaust filter (e.g., cardboard, pocket, polyester, fiberglass or carbon filter). Additionally, metal separators may be installed in the LEV ducting in order to treat air before it is released via exhaust stack. Besides exhaust filter(s) also inlet filters, which treat the air supplied into the paint area and/or spray booth may be installed in the paint area in order to prevent defects in the paint job (e.g., contamination of particles). Regular maintenance or renewal of filters/separators are necessary to prevent clogged filters/separators, which will not work sufficiently (see section 9.2.3.3). Used filters are placed in a closed bag, disposed in a hazardous waste container, and are forwarded to an external waste management company (licensed contractor).

In stacks receiving exhaust air from spray booths, Cr(VI) concentrations emissions to the environment are regularly monitored at the sites.

The air monitoring data included in the present assessment mainly comprise air emissions from spray booths. Emissions from dedicated workstations where decanting or loading/unloading of spray guns is performed, are comparably negligible.

It must be noted that in one case, the monitored stack also received Cr(VI) emissions from other sources, i.e. from Cr(VI)-containing primer spraying activities in the same paint area where the slurry coating is taking place. For these monitoring data, in the present assessment we have calculated the contribution of slurry coating with Cr(VI) to the total Cr(VI) emission value measured in the stack via the amount of Cr(VI) used in the emission year for slurry coating. The relevant share is then considered for the assessment.

Wastewater emissions

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

- Wash water from wet scrubbers and/or
- Rinsing/cleaning water (e.g., cleaning spray booths, cleaning of spray gun)

At most sites, Cr(VI)-containing water from spray booths (wash water from water curtains; where these are installed) and cleaning waters (including cleaning of spray gun) are collected and sent to an external waste management company (licensed contractor) for disposal as hazardous waste. A few sites may gather their wastewater in 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. The precipitated Cr(III) is then separated from the wastewater by a filter press and the filter cake is disposed by an external waste management company (licensed contractor). In the reduced wastewater the Cr(VI) content is usually measured with a photometric method to confirm sufficient reduction in accordance with the permitted limit before the wastewater is released either to an external wastewater treatment plant (WWTP) or municipal sewage water treatment plant (STP). In addition to the photometric determination of Cr(VI) in wastewater on-site, the Cr(VI) concentration in reduced wastewater is at many sites also determined in regular intervals by external laboratories, whereby often more sensitive analytical methods are used, allowing the detection of very low Cr(VI) concentrations in wastewater.

Soil emissions

There is no direct release to soil.

9.2.3.1.2 Releases

Release data from several industrial sites applying slurry coating with CT were collected for the present assessment. Since release data from sites in the turbine industry are limited, we also included data from sites from the aerospace sector, where slurry coating with CT is widely used and where it can be assumed that the conditions of use are comparable to those in the turbine sector.

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. 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 a spray booth in which Cr(VI)-containing slurry coating and primer paints is released), we calculated environmental concentrations based on the share of the emission relevant for slurry coating. This share was determined by dividing the Cr(VI) amount used for slurry coating by the total Cr(VI) amount contributing to the measured emission (i.e., used for all uses contributing to the measured emission).

Thirteen sites performing slurry coating with CT provided site-specific emission data for environmental emission modelling. Thereof, two sites are from the gas turbine industry, the other eleven sites are from the aerospace sector applying slurry coating with CT. Eight sites are in UK, thereof the two gas turbine sites, and five sites are in four different EEA countries.

Table 9-11 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 water refer to emissions after the on-site reduction step.

For twelve sites the total of the reported air emission is generated by slurry coating, for one site the result represents the overall air release of the site, among which only a certain share is assigned to slurry coating and the rest is due to use of primers. The calculation of the share of exposure from slurry coating (as described above) for this site is performed after the EUSES calculation.

Of the 13 sites, only two sites have emissions to water. For these two sites, release to water is exclusively generated by slurry coating.

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 slurry coating of the overall emission are given in Annex II of this CSR.

Table 9-11: Local releases to the environment

Release route	Release fraction [a]	Release [kg/year] [a]	Explanation/Justification
Air [b]	6.76E-05 - 1.50E-01 90th percentile: 8.36E-02	2.06E-04 - 9.86E-01 90th percentile: 6.59E-01	Measured release (site-specific data of representative sites)
Water [b]	0 - 5.17E-02 90th percentile: 1.82E-05	0 - 1.55E-01 90th percentile: 1.11E-04	Measured release (site-specific data of representative sites)
Soil [b]	0	0	No release to soil is possible

[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 substance 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).

Three larger sites (Sites 5, 11, and 12) with a higher CT tonnage have air emissions (0.715, 0.433, and 0.986 kg/year) which are one order of magnitude higher than those from other sites while their release fractions to air (1.88E-02, 2.37E-02 and 9.85E-02) are comparable to those of other sites. Of the three sites, two are from the EEA, from the aerospace sector (sites 5 and 11), and one site is from UK, from the turbines sector (Site 12). The total risk from environmental emissions related to slurry coating from these sites are at the upper end of the range of risks from all sites (see below).

The 90th percentile of air releases of the total dataset (EEA + UK sites) is 0.659 kg/year. The 90th percentile of air releases from EEA sites is with 0.602 kg/year comparable to the value for the total dataset, while the 90th percentile of air releases from UK sites is with 0.356 kg/year slightly (approx. a factor of 2) lower than the value for the total dataset.

The air release from one turbine site (site 12) is with 0.986 kg/year at the upper end, while the air release from the other turbine site (site 13) is with 0.0866 kg/year well within the range of air releases from all sites.

Eleven out of the 13 sites have no Cr(VI) emissions to water as they either solely operate with dry air filters, or all contaminated water is gathered and sent to an external waste management company (licensed contractor) for disposal (see Annex III). The two remaining sites (3 and 7) have water emissions of 0.000139 and 0.155 kg/year. Although these sites have the highest oral risks (as oral exposure is strongly dominated by water emissions), total risks from environmental emissions calculated for these sites are well within the range of emissions from all sites, as their air emissions (which are dominating site-specific total risks) are not in the upper range (see below).

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 II. 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 slurry coating is shown below in Table 9-12. Note that even for sites without emission to wastewater EUSES calculates oral exposure via deposition from air.

Table 9-12: Excess cancer risk estimates for humans via the environment (general population, local assessment) attributed to slurry coating (sites from the gas turbine sector: " - T")

		Inhalation			Oral			
Site	**UK/EEA**	**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 1	UK	1.57E-07	2.90E-02	4.55E-09	1.32E-07	8.00E-04	1.06E-10	4.66E-09
Site 2	EEA	9.88E-06	2.90E-02	2.87E-07	2.51E-07	8.00E-04	2.01E-10	2.87E-07
Site 3	UK	1.28E-05	2.90E-02	3.71E-07	1.11E-06	8.00E-04	8.91E-10	3.72E-07
Site 4	EEA	2.94E-05	2.90E-02	8.52E-07	7.33E-07	8.00E-04	5.87E-10	8.53E-07
Site 5	EEA	1.45E-04	2.90E-02	4.20E-06	3.59E-06	8.00E-04	2.87E-09	4.21E-06
Site 6	UK	3.17E-06	2.90E-02	9.19E-08	1.32E-07	8.00E-04	1.06E-10	9.20E-08
Site 7	EEA	1.96E-06	2.90E-02	5.68E-08	8.85E-04	8.00E-04	7.08E-07	7.65E-07
Site 8	UK	3.65E-07	2.90E-02	1.06E-08	1.32E-07	8.00E-04	1.06E-10	1.07E-08
Site 9	UK	7.67E-06	2.90E-02	2.22E-07	1.97E-07	8.00E-04	1.57E-10	2.23E-07
Site 10	UK	6.38E-07	2.90E-02	1.85E-08	1.32E-07	8.00E-04	1.06E-10	1.86E-08
Site 11	EEA	3.30E-04	2.90E-02	9.57E-06	8.19E-06	8.00E-04	6.55E-09	9.58E-06
Site 12 - T	UK	7.50E-04	2.90E-02	2.18E-05	1.86E-05	8.00E-04	1.49E-08	2.18E-05
Site 13 - T	UK	6.60E-05	2.90E-02	1.91E-06	1.63E-06	8.00E-04	1.31E-09	1.92E-06
MIN	Total (EEA + UK)	1.57E-07		4.55E-09	1.32E-07		1.06E-10	4.66E-09
MAX		7.50E-04		2.18E-05	8.85E-04		7.08E-07	2.18E-05
90th percentile		**2.93E-04**		**8.50E-06**	**1.65E-05**		**1.32E-08**	**8.50E-06**
Median		9.88E-06		2.87E-07	7.33E-07		5.87E-10	3.72E-07

		Inhalation			Oral			
Site	**UK/EEA**	**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**
AM		1.04E-04		3.03E-06	7.08E-05		5.66E-08	3.08E-06
MIN	EEA	1.96E-06		5.68E-08	2.51E-07		2.01E-10	2.87E-07
MAX		3.30E-04		9.57E-06	8.85E-04		7.08E-07	9.58E-06
90th percentile		**2.56E-04**		**7.42E-06**	**5.35E-04**		**4.28E-07**	**7.43E-06**
Median		2.94E-05		8.52E-07	3.59E-06		2.87E-09	8.53E-07
AM		1.03E-04		2.99E-06	1.80E-04		1.44E-07	3.14E-06
MIN	UK	1.57E-07		4.55E-09	1.32E-07		1.06E-10	4.66E-09
MAX		7.50E-04		2.18E-05	1.86E-05		1.49E-08	2.18E-05
90th percentile		**2.71E-04**		**7.86E-06**	**6.71E-06**		**5.37E-09**	**7.87E-06**
Median		5.42E-06		1.57E-07	1.65E-07		1.32E-10	1.57E-07
AM		1.05E-04		3.05E-06	2.75E-06		2.20E-09	3.05E-06

[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 8×10^{-4} for the general population, based on 70 years of exposure; daily exposure

Inhalation exposure and risks

Based on the releases assigned to slurry coating, the 90th percentile of local Cr(VI) PECs in air of the total dataset (EEA + UK sites) is 2.93E-04 µg/m^3 (inhalation risk: 8.50E-06). The 90th percentile of local Cr(VI) PECs in air of EEA sites with 2.56E-04 µg/m^3 (inhalation risk: 7.42E-06) and the 90th percentile of local Cr(VI) PECs in air of UK sites with 2.71E-04 µg/m^3 (inhalation risk: 7.86E-06) are comparable to the inhalation exposure and risks for the total dataset. No difference can be discerned in air exposures and inhalation risks for HvE between sites in the EEA and the UK.

The local Cr(VI) PEC in air for one turbine site (site 12) is with 7.50 µg/m^3 at the upper end, while the air release from the other turbine site (site 13) is with 6.60E-05 µg/m^3 well within the range of local Cr(VI) PECs in air for all sites. Although the small number of sites from the turbine industry does not allow a final conclusion, inhalation exposure and risks from slurry coating for HvE in the turbine industry does not seem to differ from those in the aerospace sector.

Oral exposure and risks

Based on the releases assigned to slurry coating, the 90th percentile of local oral exposure via consumption of drinking water and fish of the total dataset (EEA + UK sites) is 1.65E-05 µg Cr(VI)/kg x d (oral risk: 1.32E-08). The 90th percentile of local oral exposure of EEA sites is with 5.35E-04 µg Cr(VI)/kg x d (oral risk: 4.28E-07) one order of magnitude higher, and the 90th percentile of local oral exposure of UK sites is with 6.71E-06 µg Cr(VI)/kg x d (oral risk: 7.87E-06) one order of magnitude lower than the 90th percentile of local oral exposure of the total dataset. This is explained by the fact that oral exposure and associated risk is strongly dominated by water emissions. Since only two sites have water emissions, and the one EEA site (site 7, 0.155 kg Cr(VI)/year) has much higher (three orders of magnitude) water emission than the one UK site (site 3, 0.000139 kg Cr(VI)/year), these different values cause the divergence between the 90th percentiles for the two subgroups.

Local oral exposure for the two turbine sites (site 12 and 13) is with 1.86E-05 µg Cr(VI)/kg x d (site 12) and 1.63E-06 µg Cr(VI)/kg x d (site 13) well within the range of oral exposure from Cr(VI) emissions from all sites (EEA + UK). In comparison to oral exposure from UK sites only, local oral exposure from Cr(VI) emissions from site 12 (1.86E-05 µg Cr(VI)/kg x d) is at the upper end of the range. Both sites do not emit Cr(VI) to wastewater.

Combined risks

The combined risk per site is strongly dominated by the inhalation risk. Accordingly, the 90th percentiles for combined risks for HvE are comparable between EEA (7.43E-06) and UK (7.87E-06) sites and the total dataset (8.50E-06). The combined risk for turbine site 12 is at the upper end of the total range (2.18E-05), while the combined risk from turbine site 13 (1.92E-06) is well within the total range.

Note that the modelling of local air concentrations with EUSES is generally acknowledged as being overly conservative, as described in detail in section 9.1.4.2.

Conclusion on risk characterisation:

Carcinogenicity

Combined risks of cancer by inhalation and by the oral route from the local assessment result in an excess cancer risk of **8.50E-06** (90^{th} percentile; range from 4.66E-09 to 2.18E-05). The theoretical cancer risk is based on a conservative, linear ERR. Further, due to the overly conservative nature of the predictions of the EUSES model for the local air concentrations the risk level can be considered an overestimation.

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

9.2.3.2 Worker contributing scenario 1 – Spray operators

Spray operators for slurry coating using CT are usually involved in numerous activities related to the painting process. Most of their working time they spend in a paint area where the spray booths are located and where the painting processes, including preparatory work (e.g., sand blasting and masking) and post-treatments such as curation of parts, take place. Activities in the area comprise tasks with direct or without direct Cr(VI) exposure. Typical activities with possible Cr(VI) exposure performed by spray operators are:

Main tasks:

- Task 1: Slurry coating by manual spraying in a spray booth (PROC 7)
- Task 2: Slurry coating by brushing (PROC 10)
- Task 3: Stirring paint, mixing of components into slurry coating products, loading/unloading spray gun, and decanting of product (PROC 5, 8a, and 9)
- Task 4: Cleaning activities – cleaning of equipment and workplace (PROC 28)
- Task 5: Waste management – Handling of solid waste (PROC 8b)

Secondary tasks:

- Task 6: Maintenance of LEV system (filter change) and cleaning of spray booth (PROC 28)

As Task 6 is a main task performed by maintenance workers, it is described in detail in the worker contributing scenario for maintenance and cleaning workers (see section 9.2.3.3).

At some sites, it might be the case that preparatory or post-spraying activities are not carried out by spray operators but by incidentally exposed workers (see section 9.2.3.4), who are not directly working with slurry coating paint and are not working in the spray booths.

Depending on the organisation of the site, the spray operators may spend less than a full shift on Tasks 1 to 5. Other activities which are not related to uses of Cr(VI) may account for the remaining working time of spray operators.

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 9-13 summarises the conditions of use for the activities with direct Cr(VI) exposure related to slurry coating carried out by spray operators.

Table 9-13: Conditions of use – worker contributing scenario 1 – Spray operators

Product (article) characteristics
Product 1: Aqueous solution of CT ▪ Concentration of Cr(VI): <3.1% (w/w) ▪ Concentration of Cr(VI) based on ranges of CT (up to 6% (w/w)) in slurry coating products ▪ Product type: Liquid ▪ Viscosity: Liquids with low viscosity (like water)
Amount used (or contained in articles), frequency and duration of use/exposure
Task 1: Slurry coating by manual spraying in a spray booth ▪ Amount: up to 1000 mL per operator per shift ▪ Duration of activity: spraying with spray/airbrush gun open, up to 120 min/shift ▪ Frequency of task: 1-240 days/year (<1-5 days/week)
Task 2: Slurry coating by brushing ▪ Amount: up to 100 mL per shift ▪ Duration of activity per shift: 20-30 min ▪ Frequency of task: <1-240 days/year (<1-5 days/week)
Task 3: Stirring paint, loading/unloading spray gun, and decanting of product ▪ Amount: up to 5000 mL per shift ▪ Duration of activity: 10-45 min/shift ▪ Frequency of task: <1- 5 times/day, 1-240 days/year (<1-5 days/week)
Task 4: Cleaning activities – cleaning of equipment and workplace ▪ Duration of activity: <60 min/shift ▪ Frequency of task: Frequency of task: 1-240 days/year (<1-5 days/week)
Task 5: Waste management – Handling of solid waste ▪ Duration of activity: <15 min/shift ▪ Frequency of task: <1-240 days/year (<1-5 days/week)
Technical and organisational conditions and measures
Task 1: Slurry coating by manual spraying in a spray booth ▪ LEV: yes ▪ Ventilation rate: > 10 ACH ▪ Occupational health and safety management system: advanced (see section 9.2.2.3.1.2)
Task 2: Slurry coating by brushing ▪ LEV: yes ▪ Ventilation rate: natural ventilation ▪ Occupational health and safety management system: advanced (see section 9.2.2.3.1.2)
Task 3: Stirring paint, loading/unloading spray gun, and decanting of product ▪ LEV: yes ▪ Ventilation rate: natural ventilation

▪ Occupational health and safety management system: advanced (see section 9.2.2.3.1.2)
Task 4: Cleaning activities – cleaning of equipment and workplace ▪ LEV: yes ▪ Ventilation rate: > 10 ACH inside spray booth; natural ventilation outside spray booth ▪ Occupational health and safety management system: advanced (see section 9.2.2.3.1.2)
Task 5: Waste management – Handling of solid waste ▪ LEV: situation-dependent ▪ Ventilation rate of general ventilation system: natural ventilation ▪ Occupational health and safety management system: advanced (see section 9.2.2.3.1.2)
Conditions and measures related to personal protection, hygiene, and health evaluation
Gloves Chemical resistant gloves are worn during all tasks (Task 1 to 5). Chemical resistant gloves are worn during all activities with possible exposure to Cr(VI). All gloves used for the handling of chemicals are tested according to EN 374. A variety of materials are suited for protection against CT. The following materials have a breakthrough time ≥ 8h for aqueous CT solutions (10% CT) [a]: 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) 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. RPE is obligatory for Task 1, Task 3 (except semi-automatic filling), and Task 4 (except for cleaning equipment/spray gun in closed system). The following types of RPE are used according to EN 529:2005 [b]: ▪ Full mask with P3 filter (APF 20), full mask with P3 combination filter (APF 20) ▪ Powered filtering device incorporating a hood, helmet, or full mask (APF 40), fresh air hose breathing apparatus - full mask, hood or helmet (APF 40) Type of RPE to be used for specific tasks is laid down in work instructions for the tasks.
Protective clothes For task 1 spray operators wear a protective coverall. Chemical protective clothes or a protective coverall must be worn during tasks 2 to 5. Type of protective clothes to be used for specific tasks is laid down in work instructions for the tasks.
Eye protection

Eye protection as per relevant risk assessment must be worn during all tasks (Task 1 to 5). If an air-fed hood, helmet, or full-mask is worn during spray application, no further eye protection is needed. 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: Slurry coating by manual spraying in a spray booth ▪ Place of use: indoors – spray rooms in paint area ▪ 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: Surface spraying of liquids ▪ Application rate: low, 0.03 – 0.3 L/min ▪ Spray technique: spraying with no or low compressed air
Task 2: Slurry coating by brushing ▪ Place of use: indoors – any size workroom ▪ Temperature: room temperature ▪ Primary emission source proximity: The primary emission source is in the breathing zone of the worker (near field, <1 m) ▪ Activity class: Spreading of liquid products ▪ Spreading of liquids at surfaces or work pieces <0.1 m² / hour
Task 3: Stirring paint, loading/unloading spray gun, and decanting of product ▪ 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 ▪ Containment of the process: open process or usage of a mixer in which closed paint tin can be placed and an automated transfer of paint into reservoir of paint gun by a closed line ▪ Flow of liquid: 0.1 - 1 L/min
Task 4: Cleaning activities – cleaning of equipment and workplace ▪ 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 objects ▪ Contaminated surface: 0.1- 1 m² ▪ Level of contamination of surface: 10 - 90%
Task 5: 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 dried paint spills (worst case assumption, see details in section 9.2.3.2.2) ▪ 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. ▪ Contaminated surface: 0.3 - 1 m² ▪ Level of contamination of surface: 10 - 90%
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 IV of this report.

9.2.3.2.2 Exposure and risks for workers

Between individual sites, the number of spray operators working on slurry coating is variable, depending on the size of the site, the organisation of the paint process, the throughput, and distribution of work.

The total number of spray operators ranges between two and 20 per site (depending on the size of the paint area, the number of booths, and number of shifts; large paint shops are less frequent than small ones). Only one spray operator is always working in one spray booth. Typically, the spray operators work in one to three shifts. On average it is assumed that five operators perform spraying of slurry coating on one day at a specific site. The shift duration is usually 8 h but may also be up to 12 h, depending on the organisation of the site and national law.

The relevant activities with Cr(VI) exposure for spray operators and the working conditions are described below in detail.

Task 1: Slurry coating by manual spraying in a spray booth

Manual spraying of slurry coating is conducted in a paint area, which is separated from the site's other processes and is access controlled (either physically (barrier/signage) or through strict procedures). A single or several spray booths are located in this designated paint area. The spray booths can be either stand-alone or next to each other. The spray booths are always connected to a locally installed extraction system. Various types of spray booths are possible:

- closed at three sides and open in the front with a dry extraction system (LEV),
- closed at three sides and open in the front with a running water curtain on the three walls and LEV,
- fully closed spray booth with running water curtain on one wall and LEV or
- fully closed spray booth with a dry extraction system (LEV) (see Figure 9-1).

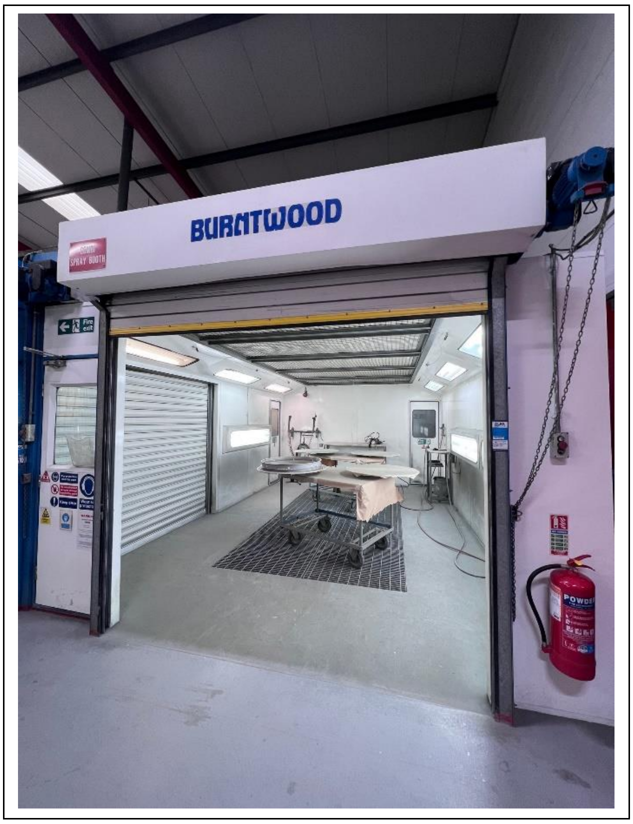


Figure 9-1: Closed spray booth

Prior to the spray-painting process, the parts are cleaned and may be pre-modified (e.g., abrasive treatment, sandblasting, masking, plugging). For the slurry coating spraying, parts are typically placed in the spray booth on a mounting table. Spray operators specially trained for this task conduct the spray application of slurry coating (see Figure 9-2). Spray and airbrush guns are used for the spraying application at low pressure typically between 2 to 6 bars. Due to the low pressure, bounce back from the sprayed part is minimised. During spraying, the spray operator usually sprays level downwards and only in special circumstances in upward direction if specifications require it.

Depending on the geometry of the part and specification, one or more layer(s) of slurry coating are sprayed. Thereby one or more slurry coating products (e.g., base and seal coat) may be used. Typically, the spraying application is performed at room temperature with a Cr(VI) concentration below 3.1%. During a typical shift, the spraying activity performed by the spray operator in the spray booth is often interrupted by e.g., drying, handling (turning or mounting the part onto/from mounting table), and inspecting the part. Thus, reporting the total duration of spraying activity in the spray booth as the exposure time of the spray operator would lead to an overestimation as the spray operator is mainly exposed to Cr(VI) while the spray/airbrush gun is open (its trigger pulled/pressed). Therefore, the duration of spray/airbrush gun open, which represents aggregated time periods of spraying when the spray operator is pulling/pressing the trigger of the spray/airbrush gun during a shift is reported. For a typical shift, the spray operator performs manual slurry coating by spraying with spray/airbrush gun open for up to 120 minutes. The frequency ranges between one and 240 days per year.

After a layer of coating is applied, the part is left for drying at room temperature for approximately 10-40 minutes before applying the next layer, handling (e.g., turning) or transporting the part to the oven for curing. The curing process is performed at temperatures up to 550 °C and for a duration up to 300 min. During the drying and/or curing process the spray operator is not in close vicinity to the part or oven and no direct Cr(VI) exposure is expected. After curing, the surface of the sprayed part may be mechanically treated in a closed system by burnishing or blasting if the specifications require it. In the end, inspection of treated parts is performed (e.g., visual inspection, resistance measured manually with Ohmmeter) and if necessary, correction painting by brushing is carried out (for further details see Task 2).

Per spray booth one spray operator is performing manual spraying of slurry coating (see Figure 9-2). Thus, the number of workers directly exposed to Cr(VI) is reduced to a minimum. In a typical shift the spray operators spends most of their working time on preparation, pre-treatment of the part(s), and cleaning. Typically, the spray operators work in one to three shifts with up to five spray operators per 8-hour shift.

While working in the spray booth, the spray operator is wearing a coverall, chemical resistant gloves, and respiratory protection as specified above in Table 9-13.

At some sites, due to organisational workflow conditions it is necessary that preparatory or post-spraying activities are not carried out by spray operators but by other workers (see section 9.2.3.4).

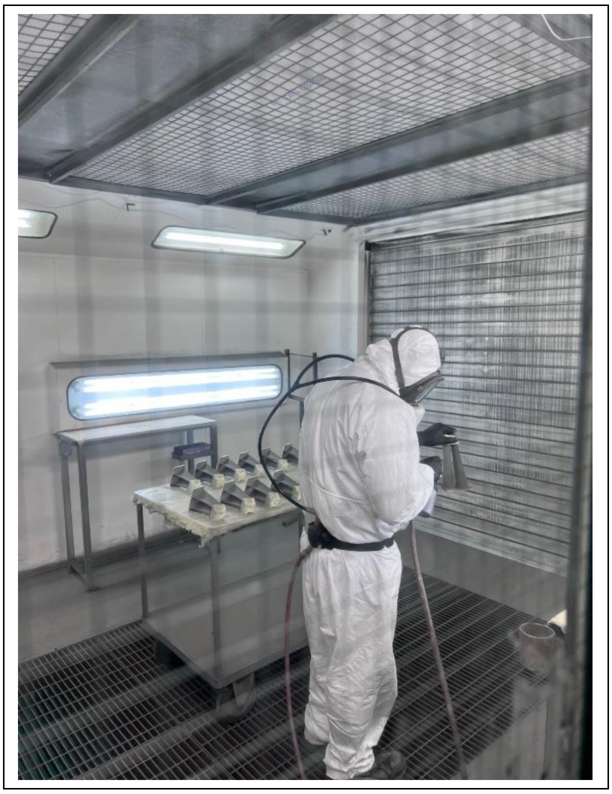


Figure 9-2: Manual spraying with slurry coating paint in a spray booth

Task 2: Brushing

Brushing of slurry coating is performed on small areas of parts. Typically, it is carried out in areas that need to be reworked/corrected or areas where the spray/airbrush gun did not reach during spraying.

Spray operators conduct this task in spray booths or at workbenches, which are connected to a LEV. If necessary, the component is cleaned, masked or its surface roughed by sandpaper prior to brushing. For the application of slurry coating brushes or wipes are used. Afterwards, the brushed parts are dried at room temperature.

Usually, two to three operators per shift and in rare occasions up to five operators per shift perform this task. The duration of brush slurry coating is highly depending on the geometry of the part, but in general less than 100 mL of paint are applied and it takes less than 30 minutes per shift with a frequency ranging between less than one and 240 days per year. At few sites, operators, who are involved in MRO activities and are also exposed to other Cr(VI)-containing products (e.g., primers) may perform this task as well.

For the task, operators wear nitrile gloves, coveralls/chemical protective clothes, and respiratory protection (if industrial hygiene exposure assessment confirms RPE use is required), as specified in Table 9-13.

Task 3: Stirring paint, loading/unloading spray gun, and decanting of product

Prior to slurry coating application, paint needs to be stirred or shaken in order to form a homogenous suspension as it may have separated while it has been stored in its respective container or tin in a chemical cupboard. For stirring, decanting slurry coating paint and loading/unloading spray guns, spray operators can follow various procedures depending on the organisation or available equipment at the site.

One option is that the spray operator opens the paint container (1 L container) and places a mixer/stirrer in the container. Afterwards the paint is decanted either directly or via a funnel into the reservoir or the spray/airbrush gun itself. In case filtering is necessary a filter (paper or mesh filter) is placed upon the reservoir of the spray gun before decanting the slurry coating paint into the reservoir. Afterwards, the filter is either disposed of as hazardous waste or cleaned by rinsing with water and the rinsing water is either collected and disposed of as hazardous waste or treated in an on-site reduction facility.

For another procedure, the original, closed paint container (1 L or 5 L container) is placed in a mixer or on a roller and thoroughly stirred by the movement of the device. Then the spray operator opens the container and either decants the slurry coating paint directly into the reservoir of the spray/airbrush gun or pours the paint in a small tank that serves as a feeder and via a hose the spray gun is loaded. In case filtering is necessary a filter is placed upon the reservoir of the spray gun before decanting the slurry coating paint into the reservoir (for disposal of filters see above).

The third option is a semi-automatic process. The closed paint container (1 L or 5 L container) is mixed by rotating movement, afterwards the lid is opened, and the paint is pumped via a hose into the reservoir of the spray gun/airbrush gun. During this stirring and loading procedure direct Cr(VI) exposure is limited to a minimum amount.

If specifications demand the addition of supplements (e.g., hardener) to slurry coating paint, the stirred slurry coating paint is decanted into a container (up to 250 mL) under a fume hood. Then the hardener is added, and the mixture is homogenised. A conical filter element (similar to a coffee filter; 5 µm pore diameter) is placed upon the reservoir of the spray gun. The prepared paint is then filled into the filter and poured into the reservoir of the spray gun. This step is done under a fume hood. The contaminated filter is sealed in a bag and placed in the hazardous waste container.

For manual spraying, the stirred volume of paint can be up to 1000 mL, whereas the volume for loading/unloading the spraying gun is typically up to 250 mL. In case of brushing application of slurry coating, the stirred paint is decanted into a small container or cup with a loading capacity up to 100 mL. Usually, the volume handled ranges between approximately 20 to 100 mL.

At the end of the surface treatment, left over slurry coating paint may be unloaded of the spraying gun, container, or cup by decanting either back into the original paint container or disposal as hazardous waste.

The task of stirring, loading/unloading, and decanting is performed by spray operators at a dedicated workstation with local LEV or in the spray booth. During the rotating/shaking of closed containers no exposure to Cr(VI) is occurring. Altogether, the duration of activity where the spray operator is in a close vicinity to Cr(VI) is less than 60 minutes per shift and the frequency ranges from one to five times per day and between one and 240 days per year. Per shift up to five spray operators perform this task.

The PPE of the spray operator during this task includes coverall/chemical protective clothes, eye protection (as per relevant risk assessment), and chemical resistant gloves. During the short-time period while handling the liquid paint and not the closed container, spray operators additionally wear respiratory protection as specified above in Table 9-13.

Task 4: Cleaning activities - cleaning of equipment and workplace

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

A typical activity is the cleaning of the spray/airbrush gun after finishing slurry coating spraying. For this activity various cleaning options exist. One option is that the spray operator takes the contaminated spray/airbrush gun to a spray gun washer (closed system), which is located near by the spray booth. In this closed system the operator takes apart the spray/airbrush gun and places the parts of the gun in the washer and closes the gun washer. Then the cleaning process is started by the spray operator, in which the spray gun parts are cleaned with water. Afterwards, the spray gun is reassembled by the operator. Therefore, the direct Cr(VI) exposure is reduced to a minimum. The spray gun washer operates by an extraction duct which feeds into the room extract duct to the rear. The Cr(VI)-contaminated water is tanked (e.g., steel drums or IBC) and disposed of by an external company as hazardous waste. For this task spray operators wear coverall, chemical resistant gloves, and respiratory protection, as specified above in Table 9-13.

As a second option of cleaning the spray gun, spray operators may clean the gun manually with a solvent (thinner and/or water) and collect the cleaning water in a closed container, which is sent to an external company for disposal as hazardous waste or empty the spray gun by spraying in the spray booth, which is connected to a LEV.

Thirdly, in case the spray booth has a water curtain, spray operators clean the spray/airbrush gun by manually washing the gun with the water from the water curtain.

Additionally, spray operators perform minor cleaning activities at the working area of the paint area. For instance, this becomes necessary when spills occur in the booth or at the place where the spray gun is loaded/unloaded. The spray operators wipe it up with paper towels and dispose them of as hazardous solid waste. If areas of the spray booth or equipment (e.g., spray robot) were covered with paper during the spraying process, these will be removed and disposed of as hazardous waste. In case a defect of equipment occurs, spray operators clean the slurry coated part/equipment prior to handing the part over to maintenance workers who perform the maintenance activity (for details see section 9.2.3.3).

Cleaning of spray booths is usually not performed by spray operators but carried out by external cleaning workers (see section 9.2.3.3.2). However, depending on the organisation of the site, this task may also be done by spray operators.

The tasks of cleaning spray gun and workbenches in the paint/spray area are completed by up to five spray operators per shift (one per booth), in typically less than 45 minutes per shift and in rare cases less than 60 minutes per shift with a frequency ranging from 1 and 240 days per year. For cleaning the workplace except the spray booth, the spray operator wears coverall/chemical protective clothes, chemical resistant gloves, eye protection (as per relevant risk assessment) and respiratory protection. For cleaning equipment/spray gun in a closed system, the spray operators wear coverall/chemical protective clothes, chemical resistant gloves, and eye protection (as per relevant risk assessment). During manual cleaning of the spray gun or cleaning of the spraying booth, spray operators wear coveralls/chemical protective clothes, chemical resistant gloves, and respiratory protection, as specified above in Table 9-13.

Task 5: Waste management - Handling of solid waste

The hazardous solid waste generated from this use (e.g., disposable PPE, wipes, gloves, (masking) tape, paper, plugs, (paper) filters, dried paint debris, used paint containers)) is collected by the spray operator. During the handling of empty bags, filters, and other process waste, the operator proceeds in accordance with appropriate standard procedures to reduce as low as possible the release of solid waste containing Cr(VI) particles in the air during these operations. The workers collect the waste in a closable waste container located near the spraying booth, masking area, and/or at a dedicated station. At most sites the waste container holds a waste bag in which the waste is collected. The waste container is closed when it is not in use.

When the waste container or the waste bag is full, the spray operator seals the waste bag and takes it out of the waste container, or they close and take the waste container and then transport the waste bag or container to the closed larger container for collection of solid hazardous waste, where the waste container is emptied, and the waste bag is disposed. The waste is then kept there until it is forwarded 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 be up to once per day at the end of a shift. Also, the duration of the transport can be variable depending on the organization of the site, but the exposure duration (closing waste container/sealing waste bag, emptying waste container/throwing waste bag into the larger hazardous waste container) is less than 15 min per day.

Additionally, solid waste containing Cr(VI) particles may be generated by pre- and/or post-treatments (e.g., burnishing or sandblasting), which are carried out in closed systems. The solid waste is the Cr(VI)-contaminated glass beads, sand or other abrasive material. Spray operators empty the reservoir, where the contaminated material is stored, by placing a waste bag over the outlet. Then the outlet is opened and waited for a short time, so that whirled-up dust can settle. Afterwards the waste bag is sealed with a cable tie and labelled (waste managed as hazardous solid waste). The area also is vacuumed cleaned (waste disposed of as hazardous solid waste). This task typically is performed once per month by one spray operator.

When handling solid waste, the worker wears coverall/chemical protective clothes, eye protection (as per relevant risk assessment), chemical resistant gloves, and respiratory protection if industrial hygiene exposure assessment confirms RPE use is required, e.g., when there is risk for exposure to dust (e.g., emptying Cr(VI)-containing material from closed systems), as specified above in Table 9-13.

9.2.3.2.2.1 Inhalation exposure

Measured inhalation exposure concentrations

For the present assessment, monitoring data for spray operators performing slurry coating with CT was collected. For the gas turbine industry few monitoring data were available. In the aerospace sector, slurry coating with CT is in widespread use. As the conditions of use for slurry coating in the aerospace and gas turbine sector are assumed to be comparable, the monitoring data of spray operators from the aerospace sector are included in this assessment.

In total, 194 personal and 46 stationary measurements covering exposure from slurry coating are available for this SEG, originating from the aerospace and turbines sector in the EEA and UK. Eight personal measurements were excluded from further analysis for various reasons: three measured values were below an unreasonably high LOQ (i.e., <10.0 µg/m³), two values are not representing a regular spraying activity, one measurement was below an unreasonably high LOQ (i.e., <9.0 µg/m³) and the measurement duration was not reported, and two values were measured inside a helmet.

Of the remaining 186 personal monitoring data, 73 are long-term ((≥2h)[6], shift-representative and 113 are short-term (<2h) measurements. The personal monitoring data come from nine sites in six countries in the EEA (87 measurements) and from nine sites in the UK (99 measurements). About 57% of the data are <LOQ and 43% are >LOQ. For the turbines sector in the UK, five long-term values from three sites are reported. From one site of the turbines sector in the EEA are two short-term values available. For the aerospace sector in the EEA, 38 personal long-term measurements from 4 sites in 4 countries and 47 personal short-term measurements from eight sites in five countries are available. From the aerospace sector in UK 30 personal long-term measurements from 4 sites and 64 personal short-term measurements from six sites are reported.

From the 46 stationary measurements, two values from an anonymous Art. 66 submission are identical to values reported by a company and thus are excluded from further assessment. Of the remaining 44 stationary measurements, 30 are long-term and 14 are short-term measurements. 11 stationary measurements come from five sites in four EEA countries and 33 values come from seven sites in the UK. About 80% of the data are <LOQ and 20% are >LOQ.

For some companies their industrial gas turbine business is a smaller or only an occasionally part of their business. Sometimes these companies may be contacted at short notice for urgent coating work. Due to the short-term urgent nature of some of the coating work (to reduce the downtime of turbines as much as possible), there is often not enough time to align occupational and environmental testing with the time demands of the costs. Any delays requested by the applicator to align this timing with occupational and environmental testing would like result in the loss of the business to another applicator/MRO competitor.

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

A summary on the analytical methods for inhalation exposure monitoring and information on their LOQs is given in Annex III of this report. The individual measurements can be provided upon request. An overview of the available data for spray operators is given in Table 9-14.

Table 9-14: Overview of available inhalation exposure measurements for WCS 1 – Spray operators

	n	>LOQ	<LOQ
Personal long-term (≥2h)			
Total	73	48	25
- Aerospace sector EEA	38	27	11
- Aerospace sector UK	30	17	13
- Turbines sector EEA	0	-	-
- Turbines sector UK	5	4	1
Personal short-term (≤ 2h)			
Total	113	32	81
- Aerospace sector EEA	47	20	27
- Aerospace sector UK	64	10	54
- Turbines sector EEA	2	-	2
- Turbines sector UK	0	-	-
Stationary long-term (≥2h)			
Total	30	3	27
- Aerospace sector EEA	2	-	2
- Aerospace sector UK	23	3	20
- Turbines sector EEA	0	-	-
- Turbines sector UK	5	-	5
Stationary short-term (≤2h)			
Total	14	6	8
- Aerospace sector EEA	3	3	-
- Aerospace sector UK	5	-	5
- Turbines sector EEA	6	3	3
- Turbines sector UK	0	-	-

Personal long-term measurements were taken at spray operators working in the paint area where slurry coating with CT is performed for the aerospace sector in the EEA and UK and the turbines sector in the UK. For the turbines sector in the EEA, no personal long-term monitoring data are obtained. For the larger part of the values (62 values, 85%) slurry coating was the only Cr(VI)-related activity reported. For the remainder it is reported that primer applications (nine values, 12%) and in two cases primer and chemical conversion coating applications (3%) were carried out in addition. The monitoring data were spray operators experienced co-exposure to Cr(VI) from handling also other Cr(VI)-containing products were reported from the aerospace sector in UK (10 measurements) and EEA (one measurement).

During the personal measurements, the spray operators were mainly engaged in performing and controlling the spraying process (Task 1). Also, during several measurements, the workers were performing preparatory measures (e.g., stirring paint, loading/unloading spray gun, decanting product) (Task 3), performing brushing activities (Task 2), sometimes cleaning the workplace or equipment (Task 4), and rarely handling of solid waste (Task 5). In addition, during one long-term measurement changing of filters was also performed (secondary task of spray operators).

Most of the personal long-term measurements from the aerospace sector in the EEA and UK are from 2017 through 2021 (only four measurements from 2015 and three measurements from 2016 are included). From the turbines sector in the UK, the obtained monitoring data are from 2021 through 2023.

Long-term measurements included mainly manual spraying of slurry coating. For the aerospace sector, three values were taken at spray operators performing manual and automatic spray application (4.3, 7.6, and <0.7 µg/m³) and only one long-term measurement is from automatic spray application (<0.16 µg/m³) when the spray operator was handling/turning sprayed parts.

Table 9-15 shows the summary statistics of workplace measurements for spray operators from the aerospace and turbines sector in the EEA and UK. For values <LOQ, half of the LOQ (LOQ/2) was considered for statistical evaluation. The arithmetic mean (AM) over the total of personal long-term measurements is 4.01 µg/m³ and the 90th percentile is 9.98 µg/m³ (Table 9-15). Monitoring data from the aerospace sector in the EEA represent half of the total data base and have comparable statistics as the total data base; AM is 3.99 µg/m³ and the 90th percentile is 10.0 µg/m³. For personal long-term measurements from the aerospace sector in the UK the calculated AM is 2.42 µg/m³ and the 90th percentile is 6.01 µg/m³. Approximately 43% of the data from the aerospace sector in the UK is below the LOQ (see Table 9-14).

Of the five long-term values from the turbines sector in the UK, four values were below the LOQ. Due to one measured value of 50 µg/m³ the statistic parameters are approximately a factor 3 higher than compared to the total data base (AM: 13.7 mg/m³; 90th percentile: 33.4 µg/m³). The reason for this higher long-term value is unknown. In the monitoring report from the monitoring campaign, it was recommended to redesign the spray booth and to modify several process conditions to achieve a lower exposure.

Personal long-term measurements are shift representative values, which typically include time periods when spray operators are not exposed to slurry coating paints containing Cr(VI) (e.g., during masking/demasking, preparatory work, drying of paint before applying next coat). Spray operators are expected to be exposed to higher Cr(VI) concentrations during the shorter spraying intervals in the spray booths, which in a typical shift may add up to 120 min. The statistical evaluation includes nine personal long-term measurements from the aerospace sector in the EEA and one measurement from the aerospace sector in the UK while spray operators are not engaged in spraying slurry coating and instead performed preparatory work, brushing slurry coating, or cleaning equipment. All the nine measurements from the EEA were below 1 µg/m³ and the one value from UK was 1.0 µg/m³.

During manual spraying application (Task 1), stirring paint, loading/unloading spray gun, and decanting of product (Task 3), brush application (Task 2), and cleaning of equipment and workplace (Task 4), spray operators wore RPE (e.g., full-face mask, powered filtering device incorporating a hood or a helmet, or fresh air hose breathing apparatus – full-face mask, or hood or helmet). However, during an 8-hour shift there are time periods when no direct exposure to Cr(VI) occurs, and spray operators do not wear RPE.

Personal measurements – short term

Personal short-term measurements were taken at spray operators working in the paint area where slurry coating with CT is performed for the aerospace sector in the EEA and UK as well as the turbines sector in the EEA. No personal short-term monitoring data are obtained for the turbines sector in the UK. In total 113 personal short-term values are available. More than 96% of the 113 measurements report slurry coating as the only Cr(VI)-related activity performed by the spray operator. Of the remaining four measured values two measurement values (2%) were taken while slurry coating and primers were applied and in two cases primer and chemical conversion coating applications (2%) were carried out in addition. The monitoring data with co-exposure to primers are from the aerospace sector in the UK and data on co-exposure to primers and chemical conversion coating are from the aerospace sector in the EEA.

Most of the personal short-term measurements from the aerospace sector in the EEA and UK are from 2017 and 2019 through 2021. From the turbines sector in the EEA, the monitoring data are from 2021.

The short-term measurements in the aerospace and turbines sector cover spraying of slurry coating (Task 1, 71 values). Additionally, operators were performing preparatory measures (e.g., stirring paint, loading/unloading spray gun, decanting product) (Task 3), and during several measurements performing brushing activities (Task 2), cleaning the workplace or equipment (Task 4), and sometimes handling of solid waste (Task 5).

For the aerospace sector, two short-term values were taken while spray operators performing manual and automatic slurry coating in the UK (2x 6.00 µg/m³) and one value was taken during automatic spraying in the EEA (3.30 µg/m³).

For the total data base of personal short-term measurements, the AM is 7.71 µg/m³, the median 2.50 µg/m³ and the 90th percentile 23.3 µg/m³ (Table 9-15). Of the 113 short-term measurements, 47 measured values are for the aerospace sector in the EEA. The calculated AM is 13.3, the median is 0.800 µg/m³ and the 90th percentile is 52.0 µg/m³. Compared to the total data base and data from aerospace sector in the UK, more than half of the measurements from the aerospace sector in the EEA (57%) are above the LOQ and seven values are equal or above 50 µg/m³ (50, 51.4, 53, 54, 55.8, 75, and 96.1 µg/m³) which result in a higher AM and 90th percentile and a lower median. For the aerospace sector in the UK the calculated AM is 3.66 mg/m³, the median is 2.50 mg/m³ and the 90th percentile is 4.75 µg/m³. The median is the same as for the total data base. The lower values for AM and 90th percentile compared to the total data base are due to the large number of measured values below the LOQ (84 %). For the turbines sector in the EEA, two personal short-term values are reported (2.6 and 6.8 µg/m³). No short-term values are available for the turbines sector in the UK.

Approximately half of the personal short-term measurements (57) of the 113 values included in the statistical analysis are taken while spray operators were not engaged in spraying slurry coating but performed preparatory work, brushing slurry coating, cleaning equipment, or handling solid waste only. 31 of these measurements are from the aerospace sector in the UK and 26 from the EEA. Of the 57 measurements 26 measurements were below 1 µg/m³, which were all except one from the aerospace sector in the EEA.

Stationary measurements

For the aerospace and turbines sector in the EEA and UK are 30 long-term stationary measurements available. No stationary measurements are reported for the turbines sector in the EEA (Table 9-14).

The AM of the 30 long-term stationary measurements available is 0.510 µg/m^3, the median is 0.173 µg/m³ and the 90th percentile is 0.992 µg/m^3 (Table 9-15). The values are noticeably lower than the respective long-term values from personal monitoring (AM: 4.01 µg/m³). However, a larger part of the long-term stationary measurements was taken outside the spray booth and are therefore not reflecting exposure during spraying (see below) but rather ancillary activities of spray operators (e.g. masking, brush application).

All measurements are from the period 2017 through 2023. During 24 of the 30 stationary measurements solely slurry coating with CT was performed (80%). For the remaining six measurements application of slurry coating and primers (13%, four values) or slurry coating, primers, and chemical conversion coating (7%, two values) are reported. For the aerospace sector in the EEA the two long-term stationary measurements are 0.029 and 0.04 µg/m³. The five values for the turbines sector in the UK are all below the LOQ (2x 0.500 µg/m³ and 3x 0.300 µg/m³) resulting in an AM of 0.380 µg/m³. Of the remaining 23 values for the aerospace sector in the UK, three values are above the LOQ (0.98, 2.06 and 6.0 µg/m³) resulting in an AM of 0.580 µg/m³, which is slighter higher that the AM of the total data base.

Two of the 30 long-term measurements were taken inside the spray booth (2x 0.250 µg/m³), while spraying of slurry coating was performed. Of all long-term stationary measurements, 28 values (93%) were taken outside the spray booth (e.g., paint kitchen and masking area). The AM of these values is slightly higher (0.529 µg/m³) than the respective measurements inside the spray booth. However, the main reason for this higher AM of measurements outside the spray booths are three measurements from the UK aerospace sector above LOQ with values of 0.98, 2.06 and 6.00 µg/m³, which were all monitored during application of slurry coating, primers and in two cases additionally chemical conversion coating in 2017. After 2017, all measurements outside the spray booth were performed when solely slurry coating was used, and all values were below LOQ.

In total 14 short-term stationary measurements are available, which were all taken while solely slurry coating was used and from the period 2019 through 2021. For the total data base of 30 measurements AM is 2.70 µg/m³, the median is 1.25 µg/m³ and the 90th percentile is 4.35 µg/m³. Three short-term measurements are from the aerospace sector in the EEA (0.026, 4.80 and 16.0 µg/m³) with a calculated AM of 6.94 µg/m³. Two of the three measurements were taken inside the spray booth and thus explain the higher Am than the total data base. From the aerospace sector in the UK are five short-term values available (2x 0.200 and 3x 1.2 µg/m³) with a calculated AM of 0.800 µg/m³. For the turbines sector in the EEA, six values (1.10, 2x 1.30, 2.60, and 2x 3.30) with an AM of 2.15 µg/m³ are reported. Of these measurements three are below the LOQ and two of three below the LOQ were measured inside the spray booth.

Of the 14 short-term stationary measurements were seven performed outside the spray booth (0.026, 0.200, 1.20, 1.30, 2.60, and 2x 3.30 µg/m³) and seven inside the spray booth (0.200, 1.10, 2x 1.20, 1.30, 4.80, and 16.0 µg/m³). The calculated AM for stationary measurements inside the spray booth is 3.69 µg/m³ and for outside the spray booth is 1.70 µg/m³.

Table 9-15 shows the summary statistics of workplace measurements for spray operators from the aerospace and turbines sector in the EEA and UK. For values <LOQ, half of the LOQ (LOQ/2) was considered for statistical evaluation. The measured values shown in Table 9-15 are without taking RPE into consideration. As indicated in the conditions of use in the CSR (see section 9.2.3.2.1) it is required to wear (at least) a full mask with P3 filter during exposure relevant activities (e.g., manual spraying).

Table 9-15: Summary statistics of inhalation exposure measurements for WCS 1 – Spray operators

Personal – long-term (measurement period 2015-2023)						
	N	**% of total**	**AM [µg/m³]**	**SD [µg/m³]**	**Median [µg/m³]**	**90th Perc. [µg/m³]**
Total	73	100	4.01	6.69	1.90	9.98
- Aerospace sector EEA	38	52	3.99	4.44	2.02	10.0
- Aerospace sector UK	30	41	2.42	3.03	1.00	6.01
- Turbines sector EEA	0	0	n.a.	n.a.	n.a.	n.a.
- Turbines sector UK	5	7	13.7	20.5	5.00	33.4
Personal – short-term (measurement period 2017, 2019-2021)						
	N	**% of total**	**AM [µg/m³]**	**SD [µg/m³]**	**Median [µg/m³]**	**90th Perc. [µg/m³]**
Total	113	100	7.71	16.7	2.50	23.2
- Aerospace sector EEA	47	41	13.3	23.7	0.800	52.0
- Aerospace sector UK	64	57	3.66	6.81	2.50	4.75
- Turbines sector EEA	2	2	n.a. [a]	n.a.	n.a.	n.a.
- Turbines sector UK	0	0	n.a.	n.a.	n.a.	n.a.
Stationary – long-term (measurement period 2017-2021)						
	N	**% of total**	**AM [µg/m³]**	**SD [µg/m³]**	**Median [µg/m³]**	**90th Perc. [µg/m³]**
Total	30	100	0.510	1.12	0.173	0.982
Outside spray booth	28	93	0.529	1.16	0.095	0.986

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

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

[a] The individual values are 2.6 and 6.8 µg/m³.

All personal long-term measurements of spray operators performing slurry coating for the aerospace and turbines sector in the EEA and UK are included in the assessment of inhalation exposure. Although the 90th percentile for the UK turbine sector is higher, this result is based on one single high value (the other 4 values were below LOQ. Table 9-16 shows the resulting long-term inhalation exposure concentration for spray operators used for risk assessment, based on the 90th percentile of personal sampling values.

As stated above, partial exposure from spraying of primers may have contributed to some of the exposure values assigned to this use. However, the majority of values come from workplaces without other sources of Cr(VI) exposure. Therefore, we assign 100% of the shift average exposure value (90th percentile of long-term measurements) to this use.

As explained above, we assume on average that **five spray 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 obligatory for Task 1 (spraying), Task 3 (stirring paint, loading/unloading spray gun, and decanting of product, except semi-automatic filling), and Task 4 (cleaning of equipment and workplace, except for cleaning equipment/spray gun in closed system). Most of the long-term measurements were performed while spraying slurry coating and wearing RPE. Therefore, RPE is considered in the exposure assessment and an APF of 20 is applied to the long-term measurements.

Table 9-16: Measured inhalation exposure concentrations for WCS 1 – Spray 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	73	9.98	20	0.499	0.499

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

[a] Based on 90th percentile of measurements.

[b] According to EN 529:2005 (BSI), see Annex IV of this report.

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

9.2.3.2.2.2 Risk characterisation

Risk for carcinogenicity

Table 9-17 shows the risk characterisation for carcinogenicity for spray operators working in the aerospace and turbines sector in the EEA and UK. The risk for carcinogenicity is based on measured Cr(VI) inhalation exposure data for spray operators and the RAC dose-response relationship for the excess lifetime cancer risk for lung cancer (ECHA, 2013).

Table 9-17: Risk characterisation for carcinogenicity for WCS 1 – Spray 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	0.499	4.00E-03	2.00E-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.

Conclusion on risk characterisation:

Carcinogenicity:

The excess lifetime cancer risk for spray operators is 2.00E-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.

As described above, it is considered for the assessment that on average **five spray operators** per day and site work in the paint area where slurry coating is performed.

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

9.2.3.3 Worker contributing scenario 2 – Maintenance and/or cleaning workers

All maintenance and/or cleaning workers may be involved in activities related to slurry coating 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 slurry coating.

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 tasks

- Task 1: Infrequent repairs of equipment (PROC 28)
- Task 2: Maintenance of LEV system (filter change) and cleaning of spray booth (PROC 28)

Secondary task

- Task 3: Waste management – Handling of solid waste (PROC 8b)

Typical activities of infrequent repairs of equipment as well as maintenance of LEV system (filter change) and cleaning of spray booth related to the use with potential direct exposure to Cr(VI) are described below in detail together with the working conditions. They are supported by worker air monitoring data covering maintenance activities, if available.

In summary, internal maintenance workers perform infrequent repair activities in the paint area when defects occur. External maintenance/cleaning workers usually clean the spray booths and maintain the installed LEV systems which also includes filter changing.

Since Task 3 is a typical main task performed by spray operators, it is described in detail in the worker contributing scenario for spray operators (see section 9.2.3.2).

9.2.3.3.1 Conditions of use

Table 9-18 summarises the conditions of use for maintenance and cleaning activities with Cr(VI) exposure related to slurry coating carried out by maintenance workers.

Table 9-18: Conditions of use – worker contributing scenario 2 – Maintenance and/or cleaning workers

Product (article) characteristics
Product 1: Aqueous solution of CT ▪ Concentration of Cr(VI): <3.1% (w/w) ▪ Concentration of Cr(VI) based on ranges of CT (<1 - ≤6% (w/w)) in paints used for slurry coating ▪ Product type: Liquid ▪ Viscosity: Liquids with low viscosity (like water)
Amount used (or contained in articles), frequency and duration of use/exposure
Task 1: Infrequent repairs of equipment ▪ Duration of activity per shift: up to 120 min ▪ Frequency of task: approx. 4 times/year
Task 2: Maintenance of LEV system (filter change) and cleaning of spray booth ▪ Duration and frequency of task: variable (480 min/up to 4 times/year or 160 min/up to 12 times/year or 30 min/up to 52 times/year)
Technical and organisational conditions and measures
Task 1: Infrequent repairs of equipment ▪ LEV: yes/no (depends on the place 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)
Task 2: Maintenance of LEV system (filter change) and cleaning of spray booth ▪ LEV: no for filter change; yes for cleaning of spray booth ▪ Ventilation rate: natural ventilation for filter change; >10 ACH for cleaning of spray booth ▪ Occupational health and safety management system: advanced (see section 9.2.2.3.1.2)

Conditions and measures related to personal protection, hygiene, and health evaluation
Gloves Chemical resistant gloves are worn during all tasks (Task 1 and 2) with possible exposure to Cr(VI). All gloves used for the handling of chemicals are tested according to EN 374. A variety of materials are suited for protection against CT. The following materials have a breakthrough time ≥ 8h for aqueous CT solutions (10% CT) [a]: 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) 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 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 clothes or if needed protective suits are worn during all tasks (Task 1 and 2) with possible Cr(VI) exposure. Type of protective clothes to be used for specific activities is laid down in work instructions for the tasks.
Eye protection Eye protection as per relevant risk assessment is worn during Task 1 and 2. Type of eye protection to be used for specific activities is laid down in work instructions for the tasks.
Other conditions affecting workers' exposure
Task 1: Infrequent repairs of equipment ▪ Place of use: indoors – paint area ▪ 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 objects ▪ Contaminated surface: 0.3 - 1 m²

▪ Level of contamination of surface: 10 - 90%
Task 2: Maintenance of LEV system (filter change) and cleaning of spray booth ▪ Place of use: indoors – spray booths and ancillary area ▪ 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 objects ▪ Contaminated surface: >3 m² ▪ Level of contamination of surface: 10 - 90%
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 IV of this report.

9.2.3.3.2 Exposure and risks for workers

For slurry coating, the maintenance and/or cleaning activities at the paint area are performed by internal and external maintenance and/or cleaning workers, who come in contact with the slurry coating product in liquid form or dried on solids.

Internal maintenance workers are a group of workers, who are responsible for infrequent repairs in the paint area as well as at the site. Typically, one or two workers per shift perform this activity. The work system at a site can be divided in one to three shifts per day. The shift duration is usually 8 h but may also be up to 12 h, depending on the organisation of the site and national law. At some sites, the maintenance workers are subcontracted service providers.

At some sites, external maintenance/cleaning workers are responsible for cleaning the spray booths and for maintenance of the installed LEV systems (e.g., change of filters). A small group of workers perform this activity on a few days per year.

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

<u>Task 1: Infrequent repairs of equipment</u>

Typical infrequent repair tasks performed by internal maintenance workers comprise the repair of LEV systems or pumps, drainage, and plumbing in the spray booths with water curtains. Also, some other defects, which might occur in the spray booth or paint area (e.g., difficulties with electricity or compressed air) are repaired by internal maintenance workers. 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 at a specialized external company. Usually, the spray operators clean the defect part before the internal maintenance workers begin with their tasks, but additional cleaning by the maintenance worker in situ and/or in the workshop may be necessary. In case of a repair/maintenance task in a spray booth, no spraying is performed.

Infrequent repair activities are conducted at room temperature. The frequency of this task is very low in case of a defect. Thus, conservatively estimated this task is performed for a duration of up to 120 minutes four times a year. For repair activities, the internal maintenance workers wear chemical protective clothes, chemical resistant gloves, for activities with potential Cr(VI) exposure (e.g., entering the spray booth), and eye protection (as per relevant risk assessment), and for activities with potential Cr(VI) exposure (e.g., during work in spray booth) they additionally wear RPE (at least where no LEV is used), as specified above in Table 9-18.

Task 2: Maintenance of LEV system (filter change) and cleaning of spray booth

This task is typically performed by external maintenance or cleaning workers. During maintenance or cleaning in the spray booths, no spraying activities in the spray booths are taking place.

Maintenance/cleaning workers conduct checks on the LEV systems and change the installed filters in the spray booth(s). This activity is carried out without the LEV running due to technical reasons. Depending on the installed LEV system, maintenance workers change inlet and exhaust filters. The exhaust filters may comprise pre-filters made from paper/fleece and/or multi-layered or multi-staged filters, which are made of a variety of material (e.g., fiberglass, cardboard, paper mesh, polyester, and fleece). The maintenance workers check, maintain, and if necessary, change filters in the rear of the spraying booths and LEV systems. Also moving parts (e.g., valves, seals, gear wheels, separators) or parts which can deteriorate or become contaminated (e.g., separators, filters, flexible ducting) are checked and maintained, cleaned, repaired, or changed if necessary. The duration of this activity depends on the construction of the LEV system and may take up to 240 minutes.

Also cleaning of the spray booth(s) is typically performed by maintenance/cleaning workers from an external service provider at room temperature.

In spraying booths with a dry extraction system, the walls of the spray booths are covered with foils, whereby no cleaning of the walls is necessary. The floor is cleaned by the maintenance/cleaning worker with a cleaning machine. The machine sprays water in front of it on the floor, cleans the floor and in the rear of the machine the water is collected. Afterwards, the maintenance/cleaning worker collects the Cr(VI)-contaminated cleaning water in an IBC. The foils/paper protecting the walls of the spray booth(s) are replaced at least once per year and used foils/paper are collected in a solid waste bag/container. Cr(VI)-contaminated cleaning water and used foils/paper are both disposed of by an external waste management company (licensed contractor). At sites where it is technically not possible to run the LEV system during spray booth cleaning, the LEV system runs throughout the night prior to booth cleaning.

In case spray booths with installed water curtains are cleaned, the walls and floor are cleaned by using water and scrubbing paint residues off. The resulting Cr(VI)-containing cleaning water and sludge is transferred in IBCs or tanks by maintenance/cleaning workers and then disposed of by an external waste management company (licensed contractor).

The duration and frequency of maintenance and/or cleaning activities can be highly variable between different sites: Either infrequent intensive (thorough booth cleaning a few times per year) or more frequent short-term cleaning activities (e.g., cleaning of floors every two weeks) are performed. Scenarios reported by companies are 480 min/up to 4 times/year or 160 min/up to 12 times/year or 30 min/up to 52 times/year.

For maintenance/cleaning activities, the maintenance/cleaning workers wear chemical protective clothes, chemical resistant gloves, and eye protection (as per relevant risk assessment). For activities with potential Cr(VI) exposure (e.g., removing contaminated filters) they additionally wear chemical protective clothing (if needed disposable coverall) and RPE (if industrial hygiene exposure assessment confirms RPE use is required), as specified above in Table 9-18.

Depending on the organisation of the site, task 2 of the maintenance/cleaning activities may also be performed by spray operators (see section 9.2.3.2) or internal maintenance or cleaning personnel.

9.2.3.3.2.1 Inhalation exposure

Measured inhalation exposure concentrations

For maintenance and/or cleaning workers, 21 personal measurements covering exposure of workers from slurry coating from the aerospace sector are available. Five personal short-term measurement values were excluded from further analysis as they were below an unreasonably high LOQ (i.e., <4 µg/m³). Additionally, two short-term values (322 µg/m³, duration: 3 min and 68.4 µg/m³, duration: 5 min) are excluded as they are two orders of magnitude higher than all other short-term values. The remaining 14 values are three long-term (≥2h)[7] measurements, and eleven short-term (<2h) measurement values. No stationary measurements are available for maintenance and/or cleaning workers. For the turbines sector, no monitoring data for maintenance and/or cleaning workers were available.

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 to be planned months in advance and as, per definition, repair activities are difficult to predict). Due to this, monitoring data on maintenance tasks were rather difficult to collect, which is reflected in the comparably low number of measurements. Considering these restrictions all measurement data for maintenance and/or cleaning workers available for diverse Cr(VI) uses performed in painting and galvanic areas (comprising uses of chromates for surface coating as well as galvanic surface treatments such as chemical conversion coating) are pooled for the exposure assessment of maintenance and/or cleaning workers. More than one chromate is used at many of the sites providing these measurements and measurements are often not assignable to a single chromate. However, in most cases CT was used.

In total, 48 personal monitoring values are available, but nine values were excluded from the analysis: the seven values described above plus one value which was below an unreasonably high LOQ (i.e., <2 µg/m³) and another value as the worker did not follow the hygiene rules, resulting in an increased exposure value (6.94 µg/m³). Of the remaining 39 personal measurements, 19 long-term, shift-representative and 20 personal short-term measurements are available.

The pooled personal monitoring data come from 13 sites in four countries in the EEA (31 measurements) and from four sites in the UK (eight measurements). About 44% of the data (17 values, including nine short-term measurements) are <LOQ and 56% (22 values, including eleven short-term measurements) are >LOQ. A summary on the analytical methods for inhalation exposure monitoring and information on their LOQs is given in Annex III 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 9-19.

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

Table 9-19: Overview of available inhalation exposure measurements for WCS 2 – Maintenance and/or cleaning workers

	n	>LOQ	<LOQ
Personal – related to slurry coating from the aerospace sector			
- Long-term (≥2h) EEA	3	2	1
- Long-term (≥2h) UK	0	-	-
- Short-term (<2h) EEA	9	2	7
- Short-term (<2h) UK	2	-	2
Personal – related to any Cr(VI) use from the aerospace sector			
- Long-term (≥2h) EEA + UK	19	11	8
- Short-term (<2h) EEA + UK	20	10	10

Personal measurements – related to slurry coating from the aerospace sector (long-term measurements)

The three personal long-term measurements were taken at workers performing maintenance activities related to slurry coating from the aerospace sector in the EEA. The arithmetic mean (AM) for these measurements is 1.20 µg/m^3. Two of these measurements are exclusively related to this use (0.02 and 3.00 µg/m^3) and were taken while performing manual cleaning of the spray booth or changing of filters and maintenance of the LEV.

The remaining one value (0.583 µg/m^3) covers activities related to multiple Cr(VI) uses (e.g., deoxidising, pickling/etching, inorganic finish stripping, anodising, chemical conversion coating, and anodise sealing). Infrequent maintenance activities were performed during this measurement without providing further details on the activities. For all these measurements use of RPE was reported (full mask and particle filter).

Personal long-term measurements for maintenance and/or cleaning workers from the aerospace sector in the UK are not available.

Personal measurements – related to slurry coating from the aerospace sector (short-term measurements)

For slurry coating, eleven personal short-term measurements were taken at workers performing maintenance activities related to slurry coating from the aerospace sector in the EEA and UK. The calculated AM is 0.618 µg/m^3 and 90th percentile is 0.363 µg/m^3. Of these measurements, two are exclusively for slurry coating, two values cover slurry coating and primer applications, and the remaining seven values cover activities related to multiple Cr(VI) uses (e.g., deoxidising, pickling/etching, inorganic finish stripping, anodising, chemical conversion coating, and anodise sealing). Maintenance activities related to spraying use consisted of changing filters in the spray booth (0.289 and 0.290 µg/m^3) as well as checking doors, meters, and valves of the spray booth (0.7 µg/m^3). For the remaining measurements infrequent maintenance activities without further details are reported (0.0145, 3x 0.0213, 2x 0.0425, 0.363). Additionally, one value (0.0425 µg/m³) is available for cleaning of the spray booth. During all measurements maintenance and/or cleaning workers used RPE.

For the nine personal short-term measurements from the aerospace sector in the EEA the calculated AM is 0.141 µg/m³, the mean is 0.043 µg/m³ and the 90th percentile is 0.430 µg/m³. The two values above the LOQ were 0.363 and 0.7 µg/m³. During these measurements maintenance workers wore RPE and were either checking installations of the spray booths (e.g., doors, valves) or performing irregular maintenance activities (no further details provided).

The two personal short-term measurements from the aerospace sector in the UK were both below the LOQ (0.289 and 0.290 µg/m³).

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

The AM of the total long-term measurements is 0.800 µg/m³ and the 90th percentile is 3.06 µg/m³ for the pooled personal monitoring data (Table 9-20). 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 or filters, cleaning of spray booths, 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 slurry coating, which further supports the total long-term measurements to be considered for the assessment.

The AM of the pooled personal monitoring data is by a factor 1.5 lower than the AM of the monitoring data related to slurry coating. As explained above, this is due to two high values, for which it is documented that respiratory protection was worn by the workers. Use of RPE (half mask and particle filter) is also documented for several of the measurements related to non-slurry coating uses. Therefore, there are no reasons for not pooling long-term measurements of slurry coating and other Cr(VI) uses together.

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

For the total of 20 short-term measurements the AM is 7.2 µg/m³ and the 90th percentile is 1.08 µg/m³ (Table 9-20). During these measurements the workers performed regular maintenance of spraying booths, galvanic 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/full mask - particle filter) is used, e.g., during line breakdowns, during maintenance of equipment, or changing of filters.

The AM of the short-term monitoring data related to slurry coating is more than ten times lower than the AM of the pooled personal monitoring data. Thus, pooling monitoring data of slurry coating and other Cr(VI) uses together can be performed.

Table 9-20 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 2017-2021.

Table 9-20: Summary statistics of inhalation exposure measurements for WCS 2 – Maintenance and/or cleaning workers

Personal – related to any Cr(VI) use from aerospace sector (measurement period 2017-2021)						
	N	**% of total**	**AM [µg/m³]**	**SD [µg/m³]**	**Median [µg/m³]**	**90th Perc. [µg/m³]**
Long-term	19	100	0.800	1.32	0.240	3.06
Short-term	20	100	7.2	30.7	0.260	1.08
Personal – related to slurry coating from aerospace sector (measurement period 2017, 2020-2021)						
	N	**% of total**	**AM [µg/m³]**	**SD [µg/m³]**	**Median [µg/m³]**	**90th Perc. [µg/m³]**
Long-term EEA	3	16	1.20	n.a. [a]	n.a.	n.a. (MAX = 3.00)
Short-term EEA + UK	11	55	0.168	0.220	0.043	0.363
Short-term EEA	9	45	0.141	0.237	0.043	0.430
Short-term UK	2	10	n.a. [b]	n.a.	n.a.	n.a.

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

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

[a] The individual values are 0.020, 0.583 and 3.00 µg/m³.

[b] The individual values are 0.289 and 0.290 µg/m³.

All personal long-term measurements of maintenance and/or cleaning workers performing tasks related to any galvanic Cr(VI) use are included in the assessment of inhalation exposure. Table 9-21 shows the resulting long-term inhalation exposure concentration for maintenance workers used for risk assessment, based on the 90th percentile of personal sampling values.

Considering that maintenance workers typically spend only a minor part of their working time on activities related to Cr(VI) exposure in relation to slurry coating (at maximum 1%[8]), we assign 1% of the shift average exposure value (90th percentile of all long-term measurements) to this use. We further assume that one worker per shift (**three maintenance and/or cleaning workers per day**) is engaged with activities potentially leading to Cr(VI) exposure (**each worker spending a maximum of 1% of his working time on activities related to slurry coating**). Consequently, the long-term exposure concentration is corrected by a factor of 0.01. For sites where the work is distributed among a higher

[8] Considering the durations of all main tasks performed by maintenance and/or cleaning workers as described in section 9.2.3.5.2 and assuming conservatively 4 maintenance activities per year, with a duration of 8h each, the exposure time related to slurry coating accounts for (4 x 8h = 32h plus 4 x 2h = 8h; 40h/(1920h working time per year) = 2.1%. If tasks are divided between three workers, this would consume 0.7% of their working time, which is conservatively rounded to 1%).

number of workers, a higher number of people would have to be considered, but their long-term average individual exposure concentration would be lower.

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

Table 9-21: Measured inhalation exposure concentrations for WCS 2 – 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	19	3.06	1	3.06	0.0306

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

[a] Based on 90th percentile of measurements.

[b] No RPE is considered, see text above.

[c] The frequency/duration correction factor of 0.01 was applied for maintenance and/or cleaning activities related to slurry coating: see text.

9.2.3.3.2.2 Risk characterisation

Risk for carcinogenicity

Table 9-22 shows the risk characterisation for carcinogenicity for maintenance and/or cleaning workers working in the aerospace and turbines sector in the EEA and UK. 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 9-22: Risk characterisation for carcinogenicity for WCS 2 – Maintenance and/or cleaning 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	0.0306	4.00E-03	1.22E-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 4×10^{-3} for workers, based on 40 years of exposure; 8h/day; 5 days/week.

Conclusion on risk characterisation:

Carcinogenicity

The excess life-time cancer risk for maintenance and/or cleaning workers is 1.22E-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 changing of filter).

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 slurry coating.

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

9.2.3.4 Worker contributing scenario 3 – Incidentally exposed workers

This group is defined as workers who spend a relevant part of their working time in the work area where the spray booth(s) for slurry coating are located. These workers do not carry out tasks with direct Cr(VI) exposure potential themselves but may incidentally be exposed from such activities due to inhalation background exposure in the work area. Due to the organisation of sites and achieving an efficient work process, incidentally exposed workers must perform their tasks in the paint area, as these are necessary activities related to either slurry coating or to other processes carried out in the paint area and cannot be located to other areas at the sites. 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 of incidentally exposed workers can occur, and we describe typical activities carried out by these workers while they are indirectly exposed.

9.2.3.4.1 Conditions of use

Table 9-23 summarises the conditions of use for various tasks performed by incidentally exposed workers working in the hall and in the vicinity of the spray booths where slurry coating is carried out, from which the workers are incidentally exposed.

Table 9-23: Conditions of use – worker contributing scenario 3 – Incidentally exposed workers

Product (article) characteristics
Product 1: Aqueous solution of CT ▪ Concentration of Cr(VI): <3.1% (w/w) ▪ Concentration of Cr(VI) based on ranges of CT (<1 - ≤6% (w/w)) in paints used for slurry coating ▪ Product type: Liquid ▪ 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 ▪ LEV: Local LEV arms (for quality control) ▪ 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 chromium trioxide) 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 – paint area ▪ 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*

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

9.2.3.4.2 Exposure and risks for workers

The number of incidentally exposed workers and the share of working time that they spend in the relevant area can be highly variable, depending on the size of the site, the organisation of processes in the paint area (e.g., working close to spraying booth so distance is short) and the organisation of work. Therefore, at some sites, the task of incidentally exposed workers is performed by spray operators (see section 9.2.3.2).

Based on information provided by representative sites, normally between zero and one incidentally exposed workers per shift may work in the larger surroundings of the spray booths in one to three shifts per day. The shift duration is usually 8 h but may also be up to 12 h, depending on the organisation of the site and national law. However, the time incidentally exposed workers are actually close to the spray area is typically only a small part of their working time. In a conservative way, it is assumed that potential exposure time is up to 50%. Therefore, it is estimated that on average two incidentally exposed workers (working 480 min per day in the hall, 240 days per year), being indirectly exposed during 50% of their working time to Cr(VI) from slurry coating are to be considered per site. For these workers, the inhalation exposure data shown in section 9.2.3.4.2.1 are considered representative.

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 spray booth(s).

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 slurry coating may occur.

Task 1: Activities without direct Cr(VI) exposure

The tasks of these workers can be very diverse, but at many sites, they may regularly carry out activities in the paint area, including, but not limited to the following:

- de-/masking of parts
- supervision of processes
- quality assessment of sprayed parts
- machining activities (on parts, where no Cr(VI) exposure is possible (closed system))

During all tasks performed by incidentally exposed workers in the same area as the spray booth(s) for slurry coating, the workers wear standard PPE, as specified above in Table 9-23.

Depending on the organisation of the site, some of the above-mentioned activities may also be performed by spray operators (see section 9.2.3.2).

9.2.3.4.2.1 Inhalation exposure

Measured inhalation exposure concentrations

For the present assessment, monitoring data for incidentally exposed workers was collected at sites, where slurry coating with CT is performed. For the gas turbine industry few monitoring were available. In the aerospace sector, slurry coating with CT is in widespread use. As the conditions of use for slurry coating in the aerospace and gas turbine sector are assumed to be comparable, the monitoring data of incidentally exposed workers from the aerospace sector are included in this assessment.

In total, 36 personal measurements are available for incidentally exposed workers in paint areas of the aerospace and turbines sector in the EEA and UK, where spray applications of slurry coating or primer products, which contain Cr(VI), is performed. Four personal measurements from a UK site of the turbines sector with an unreasonably high LOQ (above 9 µg/m³) and unspecified measurement durations were excluded from further analysis. Also, two personal long-term measurements from a UK site of the aerospace sector were excluded from further analysis due to unreasonably high LOQs (i.e., above 2 µg/m³). From the same site, four personal long-term measurements were excluded as these values were unreasonably high (2x 2.0, 7.0, and 14.0 µg/m³) and measurements, which were performed at this site six months later were all below LOQ. The reason for these higher values is unknown.

All the remaining 26 monitoring data are personal long-term measurements (≥2h) [9]. The number of personal long-term measurements for the aerospace and turbines sector in the EEA and UK are

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

provided in Table 9-24. For the EEA, the personal monitoring data come from one site of the aerospace sector (one measurement). No personal monitoring data for the turbines sector in the EEA were reported. In total, 25 personal long-term measurement values were available from the UK. Thereof, two personal long-term measurements are from two sites of the turbines sector and 23 from one site of the aerospace sector.

Approximately 92% of the data (26 values) are <LOQ and 8% (two values) are >LOQ. A summary on the analytical methods for inhalation exposure monitoring and information on their LOQs is given in Annex III of this report. The individual measurements can be provided upon request.

Table 9-24: Overview of available inhalation exposure measurements for WCS 3 – Incidentally exposed workers

	n	>LOQ	<LOQ
Personal long-term (≥2h)			
- Aerospace sector EEA	1	0	1
- Aerospace sector UK	23	1	22
- Turbines sector EEA	0	-	-
- Turbines sector UK	2	1	1

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

Personal long-term measurements were taken in the paint department where spraying applications of paints containing Cr(VI) were performed without the incidentally exposed worker working directly with slurry coating product, e.g., in the area where masking, or blasting are carried out or in the control area.

Table 9-25 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. Personal long-term measurements are from 2017, 2019 through 2021, and 2023.

Of the 26 long-term measurements from the aerospace and turbines sector in EEA and UK, 25 values relate exclusively to exposure from slurry coating. One measurement covers exposure from slurry coating in combination with exposure from primer application. The arithmetic mean (AM) over the 26 personal long-term measurements is 0.435 µg/m^3, the median is 0.069 µg/m^3 and the 90th percentile is 0.425 µg/m^3. Statistical analysis of the 23 long-term measurements from the aerospace sector in UK results in an AM of 0.163 µg/m^3, the median is 0.067 µg/m^3 and the 90th percentile is 0.081 µg/m^3.

The higher AM of the total data base compared to the AM of measurements from the aerospace sector in UK is due to one measurement (7.0 µg/m^3) from the turbines sector in UK. The reason for this higher measurement value is unknown. In the respective monitoring report it is recommended to redesign the spray booth and to modify further conditions to achieve a lower exposure. The value is included in the statistical analysis.

Stationary measurements performed outside the spray booth as shown in section 9.2.3.2.2.1 indicate the background exposure of incidentally exposed workers. For the 30 long-term stationary measurements available the AM is 0.510 µg/m^3, the median is 0.173 µg/m^3 and the 90th percentile is 0.992 µg/m^3, which is higher than the AM (0.435 µg/m^3) for incidentally exposed workers.

Table 9-25: Summary statistics of inhalation exposure measurements for WCS 3 – Incidentally exposed workers

Personal (measurement period 2017, 2019-2021, 2023)						
	N	**% of total**	**AM [µg/m³]**	**SD [µg/m³]**	**Median [µg/m³]**	**90th Perc. [µg/m³]**
Total	26	100	0.435	1.389	0.069	0.425
- Aerospace sector EEA	1	4	n.a. [a]	n.a.	n.a.	n.a.
- Aerospace sector UK	23	88	0.163	0.390	0.067	0.081
- Turbines sector EEA	0	0	n.a.	n.a.	n.a.	n.a.
- Turbines sector UK	2	8	n.a. [b]	n.a.	n.a.	n.a.

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

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

[a] The individual value is 0.2 µg/m³.

[b] The individual values are 0.35 and 7.0 µg/m³.

All personal long-term measurements of incidentally exposed workers operating in paint areas where also Cr(VI)-containing slurry coating products were used are included in the assessment of inhalation exposure. Table 9-26 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.

It was estimated above that for risk characterisation, an average of **two incidentally exposed workers** needs to be considered per site. The working time of incidentally exposed workers is typically split between activities related to spraying of slurry coating and primers. Therefore, the potential contribution from slurry coating to their indirect Cr(VI) exposure is assumed to be 50%.

Table 9-26: Measured inhalation exposure concentrations for WCS 3 – 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	26	0.425	1	0.425	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.

[c] The frequency/duration correction factor of 0.5 was applied for incidentally exposed workers related to slurry coating: see text above.

9.2.3.4.2.2 Risk characterisation

Risk for carcinogenicity

Table 9-27 shows the risk characterisation for carcinogenicity for incidentally exposed workers working in the aerospace and turbines sector in the EEA and UK. 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 9-27: Risk characterisation for carcinogenicity for WCS 3 – Incidentally exposed workers

Route of exposure and type of effects	Long-term exposure [µg/m^3]	Risk characterisation: Excess lifetime lung cancer risk * [1/µg/m^3]	Excess lifetime cancer risk (ELCR)
Inhalation: Systemic Long Term	0.213	4.00E-03	8.52E-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/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.

As explained above, the number of incidentally exposed workers can vary but according to the calculation on average 2 workers are considered for a site where this use is performed.

Conclusion on risk characterisation:

<u>Carcinogenicity</u>

The excess life-time cancer risk for incidentally exposed workers is 8.52E-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.

As described above, it is considered for the assessment that **two incidentally exposed workers** work per site and day in the paint area.

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

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 chromium trioxide. 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"[10]), 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.

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 chromium trioxide used for this use. For all but one site reported release data are

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

specific for the slurry coating use. Only in one case, air emissions (no water releases from this site) are partly from the use of primer products containing Cr(VI). Therefore, the total air release at this specific site (site 5) comprises emissions from both slurry coating and primer use (total: 0.715 kg/year; release assigned to slurry coating: 0.190 kg/year). However, the total air release of this site is within the range of air releases of the other sites, which is between 0.000206 and 0.986 kg/year to air and between zero and 0.155 kg/year to water for all sites (EEA and UK), as shown in Table 9-11 and in detail in Annex III (Table Annex II-1) of this CSR.

11 Annexes

11.1 Annex I – 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.

Table Annex I-1 – 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%

11.2 Annex II – 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 slurry coating of the overall emission. The Cr(VI) amounts used by sites shown in Annex II-1 for slurry coating range from 0.0671 to 18.3 kg/year.

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

Site	UK/EEA	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 [m3/day]	Application of sewage sludge to agricultural soil/grassland	Dilution factor receiving water
Site 1	UK	6.76E-05	0.000206	0, no water emission	0.00	1.00	1.00	-	-	-
Site 2	EEA	2.10E-02	0.0130	0, no water emission	0.00	1.00	0.00	-	-	-
Site 3	UK	2.75E-03	0.0168	2.27E-05	0.000139	1.00	0.00	2000 [a]	assume yes [b]	10 [c]
Site 4	EEA	7.76E-03	0.0386	0, no water emission	0.00	1.00	1.00	-	-	-
Site 5	EEA	1.88E-02	0.715	0, no water emission	0.00	0.265	0.265	-	-	-
Site 6	UK	1.98E-02	0.00413	0, no water emission	0.00	1.00	1.00	-	-	-
Site 7	EEA	8.56E-04	0.00257	5.17E-02	0.155	1.00	1.00	2000 [a]	assume yes [b]	10 [c]
Site 8	UK	2.17E-04	0.000480	0, no water emission	0.00	1.00	1.00	-	-	-
Site 9	UK	1.50E-01	0.0101	0, no water emission	0.00	1.00	1.00	-	-	-
Site 10	UK	2.50E-03	0.000838	0, no water emission	0.00	1.00	1.00	-	-	-
Site 11	EEA	2.37E-02	0.433	0, no water emission	0.00	1.00	1.00	-	-	-
Site 12 - T	UK	9.85E-02	0.986	0, no water emission	0.00	1.00	1.00	-	-	-
Site 13 - T	UK	1.01E-02	0.0866	0, no water emission	0.00	1.00	1.00	-	-	-
MIN		6.76E-05	2.06E-04	0.00E+00	0.00E+00	0.265	0.27			

Site	UK/EEA	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 [m3/day]	Application of sewage sludge to agricultural soil/grassland	Dilution factor receiving water
MAX	Total (EEA + UK)	1.50E-01	9.86E-01	5.17E-02	1.55E-01	1.00	1.00			
90th percentile		**8.36E-02**	**6.59E-01**	**1.82E-05**	**1.11E-04**	**1.00**	**1.00**			
Median		1.01E-02	1.30E-02	0.00E+00	0.00E+00	1.00	1.00			
AM		2.74E-02	1.78E-01	3.98E-03	1.19E-02	0.943	0.943			
MIN	EEA	8.56E-04	2.57E-03	0.00E+00	0.00E+00	0.265	0.27			
MAX		2.37E-02	7.15E-01	5.17E-02	1.55E-01	1.00	1.00			
90th percentile		**2.26E-02**	**6.02E-01**	**3.10E-02**	**9.31E-02**	**1.00**	**1.00**			
Median		1.88E-02	3.86E-02	0.00E+00	0.00E+00	1.00	1.00			
AM		1.44E-02	2.40E-01	1.03E-02	3.10E-02	0.853	0.853			
MIN	UK	6.76E-05	2.06E-04	0.00E+00	0.00E+00	1.000	1.00			
MAX		1.50E-01	9.86E-01	2.27E-05	1.39E-04	1.00	1.00			
90th percentile		**1.14E-01**	**3.56E-01**	**6.81E-06**	**4.16E-05**	**1.00**	**1.00**			
Median		6.42E-03	7.10E-03	0.00E+00	0.00E+00	1.00	1.00			
AM		3.55E-02	1.38E-01	2.84E-06	1.73E-05	1.000	1.000			

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

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

[c] 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.

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.

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

		Inhalation	Oral (drinking water and fish)		
Site	**UK/EEA**	**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	UK	1.57E-07	1.25E-07	7.18E-09	1.32E-07
Site 2	EEA	9.88E-06	2.44E-07	7.24E-09	2.51E-07
Site 3	UK	1.28E-05	1.10E-06	1.03E-08	1.11E-06
Site 4	EEA	2.94E-05	7.26E-07	7.38E-09	7.33E-07
Site 5	EEA	5.46E-04	1.35E-05	1.09E-08	1.35E-05
Site 6	UK	3.17E-06	1.25E-07	7.20E-09	1.32E-07
Site 7	EEA	1.96E-06	8.82E-04	3.44E-06	8.85E-04
Site 8	UK	3.65E-07	1.25E-07	7.18E-09	1.32E-07
Site 9	UK	7.67E-06	1.90E-07	7.24E-09	1.97E-07
Site 10	UK	6.38E-07	1.25E-07	7.18E-09	1.32E-07
Site 11	EEA	3.30E-04	8.18E-06	9.40E-09	8.19E-06
Site 12 - T	UK	7.50E-04	1.86E-05	5.06E-09	1.86E-05
Site 13 - T	UK	6.60E-05	1.63E-06	4.46E-10	1.63E-06
MIN	Total (EEA + UK)	1.57E-07	1.25E-07	4.46E-10	1.32E-07
MAX		7.50E-04	8.82E-04	3.44E-06	8.85E-04
90th percentile		**5.03E-04**	**1.75E-05**	**1.08E-08**	**1.76E-05**
Median		9.88E-06	7.26E-07	7.24E-09	7.33E-07
AM		1.35E-04	7.13E-05	2.71E-07	7.16E-05
MIN	EEA	1.96E-06	2.44E-07	7.24E-09	2.51E-07
MAX		5.46E-04	8.82E-04	3.44E-06	8.85E-04
90th percentile		**4.60E-04**	**5.35E-04**	**2.07E-06**	**5.37E-04**
Median		2.94E-05	8.18E-06	9.40E-09	8.19E-06
AM		1.83E-04	1.81E-04	6.95E-07	1.82E-04
MIN	UK	1.57E-07	1.25E-07	4.46E-10	1.32E-07
MAX		7.50E-04	1.86E-05	1.03E-08	1.86E-05
90th percentile		**2.71E-04**	**6.71E-06**	**8.17E-09**	**6.71E-06**
Median		5.42E-06	1.57E-07	7.18E-09	1.65E-07
AM		1.05E-04	2.75E-06	6.48E-09	2.75E-06

* See explanations on oral uptake via drinking water and fish in CSR section 9.1.4.2.

Remarks on measured exposure:

Based on **overall releases of the sites** the 90th percentile of local Cr(VI) PECs in air of the total dataset (EEA + UK sites) is 5.03E-04 µg/m^3 and the 90th percentile of local oral exposure via consumption of drinking water and fish of the total dataset is 1.76E-05 µg Cr(VI)/kg x d. Note that for the exposure via drinking water and fish a reduction factor of 5 was applied, as described in section 9.1.4.2 of the CSR.

11.3 Annex III – Inhalation exposure workers

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

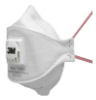
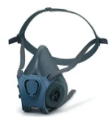
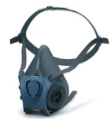
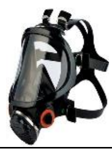
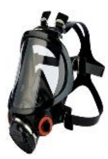
According to the diversity of analytical methods used, the reported LOQs are heterogeneous, ranging from 0.01 µg/m^3 to 10 µg/m^3. Values with even higher LOQs (above 10 µg/m^3) were not considered in the assessment.

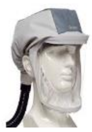
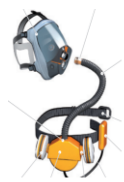
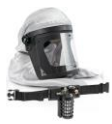
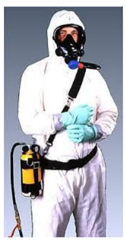
Available Information on methods and LOQs for individual measurements are documented in a separate excel file.

11.4 Annex IV – 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 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	
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-	EN 136 (mask) EN 143 (filter)		-	400	-	-	20	-	**20**

particle filter Gas X P3									
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**

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