# CHEMICAL SAFETY REPORT

Public Version

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|---|---|
| **Legal name of applicant(s)** | Maschinenfabrik Kaspar Walter GmbH & Co. KG |
| **Submitted by** | Maschinenfabrik Kaspar Walter GmbH & Co. KG |
| **Date** | 5 February 2021 |
| **Substance** | Chromium trioxide<br>EC No: 215-607-8<br>CAS No: 1333-82-0 |
| **Use title** | Use 1: Formulation of chromium trioxide-based electrolyte for electroplating process<br><br>Use 2: Chromium trioxide-based functional chrome plating of cylinders used in the rotogravure printing and embossing industry |
| **Use number** | 1 and 2 |

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## List of Abbreviations

| | |
|---|---|
| ACH | Air Changes per Hour |
| AfA | Application for Authorization |
| APF | Assigned Protection Factor |
| ART | Advanced REACH Tool |
| BG | Berufsgenossenschaft (occupational insurance association) |
| Cr(III) | Trivalent chromium |
| Cr(VI) | Hexavalent chromium |
| CSA | Chemical Safety Assessment |
| CSR | Chemical Safety Report |
| DU | Downstream User |
| DNEL | Derived No-Effect Level |
| ELR | Excess Lifetime Risk |
| ERC | Environmental Release Category |
| ES | Exposure Scenario |
| EUSES | European Union System for the Evaluation of Substances |
| F | Formulation |
| IW | Industrial End Use at Site |
| LEV | Local Exhaust Ventilation |
| LOD | Limit of Detection |
| LOQ | Limit of Quantification |
| Min | Minutes |
| NOAEL | No Observed Adverse Effect Level |
| NTP | National Toxicology Program |
| OEL | Occupational Exposure Limit |
| OSHA | Occupational Safety and Health Administration (USA) |
| PEC | Predicted Environmental Concentration |
| PNEC | Predicted No Effect Concentration |
| PPE | Personal Protective Equipment |
| PROC | Process Category |
| RAC | Committee of Risk Assessment |
| RCR | Risk Characterisation Ratio |
| REACH | Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) |
| RMM | Risk Management Measure |
| RPE | Respiratory Protective Equipment |
| SEA | Socio-Economic Analysis |
| SpERC | Specific Environmental Release Category |
| STP | Sewage Treatment Plant |
| WCS | Worker Contributing Scenario |

## Declaration

The Applicant, Maschinenfabrik Kaspar Walter GmbH & Co. KG, is aware that evidence might be requested by ECHA to support information provided in this document.

Also, we request that the information blanked out in the "public version" of the Chemical Safety Report is not disclosed. We hereby declare that, to the best of our knowledge as of today (5 February 2021) the information is not publicly available, and in accordance with the due measures of protection that we have implemented, a member of the public should not be able to obtain access to this information without our consent or that of the third party whose commercial interests are at stake.

Signature: ______________________ Date, Place: 5 February 2021, Krailling

**Christoph Gschossmann**

CEO Maschinenfabrik Kaspar Walter GmbH & Co. KG

# Part A

## 1. SUMMARY OF RISK MANAGEMENT MEASURES

The risk management measures are described in the Exposure Scenarios in **section 9** of Part B of this document.

## 2. DECLARATION THAT RISK MANAGEMENT MEASURES ARE IMPLEMENTED

We declare that the risk management measures referred to in **section 9** are implemented.

## 3. DECLARATION THAT RISK MANAGEMENT MEASURES ARE COMMUNICATED

We declare that the risk management measures referred to in **section 9** are communicated to our customers, when they are relevant for their uses.

# Part B

# 1. IDENTITY OF THE SUBSTANCE AND PHYSICAL AND CHEMICAL PROPERTIES

## 1.1. Name and other identifiers of the substance

The substance chromium trioxide is a mono constituent substance (origin: inorganic) having the following characteristics and physical–chemical properties (see the IUCLID dataset for further details).

**Table 1:** Substance identity

| | |
|---|---|
| EC number: | 215-607-8 |
| EC name: | chromium trioxide |
| CAS number (EC inventory): | 1333-82-0 |
| CAS name: | Chromium trioxide |
| IUPAC name: | Trioxochromium |
| Molecular formula: | $CrO_3$ |
| Molecular weight range: | 99.99 |

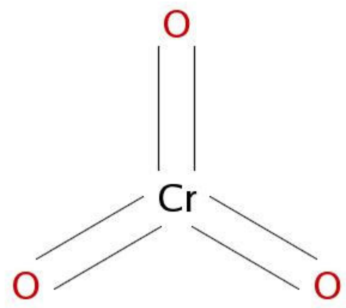

**Figure 1:** Structural formula of chromium trioxide

## 1.2. Composition of the substance

## 1.3. Physicochemical properties

The physicochemical properties of $CrO_3$ are summarized in **Table 2**.

**Table 2:** Physicochemical properties of $CrO_3$

| Property | Description of key information | Value used for CSA / Discussion |
|---|---|---|
| Physical state | | Value used for CSA: solid at 20°C and 101.3 kPa |
| Melting / freezing point | | Value used for CSA: 196 °C at 101.3 kPa |
| Relative density | | Value used for CSA: 2.7 at 20°C |
| Vapour pressure | | Value used for CSA: 0.001 Pa at 20 °C |
| Partition coefficient n-octanol/water (log value) | | Value used for CSA: Log Kow (Pow): 0.1 at 20 °C |
| Water solubility | | Value used for CSA: 1667 g/L at 20 °C |

# 2. MANUFACTURE AND USES

## 2.1. Manufacture

## 2.2. Identified uses

A summary of identifiers, use descriptors, and additional information as the tonnage and number of sites is provided in **Table 3**.

**Table 3:** Uses at industrial site

| Identifiers | Use descriptors | | Other information |
|---|---|---|---|
| F-1: Formulation of chromium trioxide-based electrolyte for electroplating process | ERC | ERC 2: Formulation of chromium trioxide-based electrolyte | Tonnage of Substance: 160 – 220 t $CrO_3$/year ([redacted] t/year [approx. [redacted] t Cr(VI)])<br>Number of sites: 1 [1]<br>Substance supplied to the Uses: As such/in a mixture |
| | PROC | PROC 1: Delivery and storage of solid $CrO_3$<br>PROC 3: Preparation of the $CrO_3$ containing formulation<br>PROC 8b: Sampling<br>PROC 28: Maintenance<br>PROC 8b: Wastewater sampling and waste management (solid and liquid) | |
| | PC | PC 0: G05000 Galvano-technical agents – for metal surface treatment | |
| | SU | SU 0: Other: rotogravure industry | |
| | Technical function of the substance | Other: Ingredient applied in the formulation of liquid mixtures | |
| IW-1: Chromium trioxide-based functional chrome plating of cylinders used in the rotogravure printing and embossing industry | ERC | ERC 5: Chromium trioxide-based functional chrome plating of cylinders | Tonnage of Substance: 160 – 220 t $CrO_3$/year ([redacted] t/year [approx. [redacted] t Cr(VI)])<br>Number of sites: 117<br>Substance supplied to the Uses: As such/in a mixture<br>Subsequent service life relevant for that use: Not relevant |
| | PROC | PROC 1: Delivery and storage of raw material<br>PROC 13: Chrome electroplating unit<br>PROC 8b: Sampling<br>PROC 8b: Concentration adjustment with liquid $CrO_3$<br>PROC 28: Maintenance<br>PROC 8b: Waste management | |
| | PC | PC 14: Metal surface treatment products, including galvanic and electroplating products | |
| | SU | SU 0: Other: rotogravure industry | |
| | Technical function of the substance | Other: Ingredient used in functional chrome plating processes to deposit metallic chromium | |

**Abbreviations:** ERC = Environmental Release Category, F = Formulation, IW = Industrial End Use at Site, PROC = Process Category, PC = Product Category; SU = Sector of end use

## 2.3. Uses advised against

No information available.

[1] Disclaimer: The formulation of chromium trioxide-based electrolyte for electroplating processes presented within this AfA is based on the information provided by one formulator's site. In general, the process of formulation of chromium trioxide-based electrolytes is well established and comparable between formulators. The presented data cover the requested amount of [redacted] t for the use applied for authorization described in this document. However, this AfA document cannot serve as a trade agreement between one formulator and the applicant and might not be restricted to the same production site.

# 3. CLASSIFICATION AND LABELLING

## 3.1. Classification and labelling according to CLP / GHS

## 3.2. Classification and labelling according to DSD / DPD

### 3.2.1. Classification and labelling according to the criteria in Directive 67/548/EEC (DSD) and Directive 1999/45/EC (DPD)

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#### 5.3.2.1. Non-human information

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There are a multitude of published studies that address the genetic toxicology of hexavalent chromium (Cr(VI)) substances. The literature is summarised in various peer reviewed publications, e. g. IRIS,1998, EU RAR, 2005 and ATSDR, 2012.

The overall body of evidence indicates that Cr(VI) is genotoxic in vivo, resulting in the formation of DNA adducts and oxidative DNA damage. However, clear evidence of mutagenicity in vivo in the target tissues for carcinogenicity (lung and intestine) by relevant routes of exposure is lacking. This supports the conclusion that Cr(VI) is only weakly mutagenic in vivo and that its mutagenicity is most likely to be only one contributory factor in the carcinogenic process, together with tissue injury/irritation/inflammation and cell proliferation.

## 5.8. Carcinogenicity

### 5.8.1. Non-human information

#### 5.8.1.1. Carcinogenicity: oral

See below

#### 5.8.1.2. Carcinogenicity: inhalation

See below

#### 5.8.1.3. Carcinogenicity: dermal

See below

#### 5.8.1.4. Carcinogenicity: other routes

### 5.8.2. Human information

### 5.8.3. Summary and discussion of carcinogenicity

There are a multitude of published studies, including both animal and epidemiological studies, that address the carcinogenicity of Cr(VI) substances. The literature is summarised in various peer reviewed publications, e. g. IRIS,1998, EU RAR 2005 and ATSDR, 2012.

Cr(VI) causes lung tumours in humans and animals by the inhalation route and tumours of the gastrointestinal tract in animals by the oral route. These are both local, site-of-contact tumours – there is no evidence that Cr(VI) causes tumours elsewhere in the body.

Reference dose response relationships for the carcinogenicity of Cr(VI) substances are documented in the ECHA publication "Application for authorisation: Establishing a reference dose response relationship for carcinogenicity of hexavalent chromium", Ref RAC/27/2013/06 Rev.1, dated 4 Dec 2013. The Committee of Risk Assessment (RAC) expects that this dose-response relationship will form the basis for the Socio-Economic Analysis (SEA).

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#### 5.9.1.1. Non-human information

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### 5.11.2. Selection of the DNEL(s) or other hazard conclusion for critical health effects

Hazard conclusions are summarized for workers in **Table 4** and for the general population in **Table 5**.

**Table 4:** Hazard conclusions for workers

| Route | Type of effect | Hazard conclusion | Most sensitive endpoint |
|---|---|---|---|
| Inhalation | Systemic effects - Long-term | Not relevant | — |
| Inhalation | Systemic effects - Acute | Not relevant | — |
| Inhalation | Local effects - Long-term | See below | Carcinogenicity |
| Inhalation | Local effects - Acute | Not relevant | — |
| Dermal | Systemic effects - Long-term | Not relevant | — |
| Dermal | Systemic effects - Acute | Not relevant | — |
| Dermal | Local effects - Long-term | Not relevant | — |
| Dermal | Local effects - Acute | Not relevant | — |
| Eyes | Local effects | Not relevant | — |

**Further explanation on hazard conclusions:**
**Inhalation Local effects – Long-term:** Based on a 40 year working life (8h/day, 5 days/week), the following risk estimates are used: An excess lifetime lung cancer mortality risk = 4.0E-3 per µg Cr(VI) /m$^3$. Ref RAC/27/2013/06 Rev.1 [2]

**Table 5:** Hazard conclusions for the general population

| Route | Type of effect | Hazard conclusion | Most sensitive endpoint |
|---|---|---|---|
| Inhalation | Systemic effects - Long-term | Not relevant | — |
| Inhalation | Systemic effects - Acute | Not relevant | — |
| Inhalation | Local effects - Long-term | See below | Carcinogenicity |
| Inhalation | Local effects - Acute | Not relevant | — |
| Dermal | Systemic effects - Long-term | Not relevant | — |
| Dermal | Systemic effects - Acute | Not relevant | — |
| Dermal | Local effects - Long-term | Not relevant | — |
| Dermal | Local effects - Acute | Not relevant | — |
| Oral | Local effects - Long-term | See below | Carcinogenicity |
| Oral | Systemic effects - Acute | Not relevant | — |
| Eyes | Local effects | Not relevant | — |

**Further explanation on hazard conclusions:**
**Inhalation Local effects - Long-term:** Based on an exposure for 70 years (24h/day, every day), the following risk estimates are used: An excess lifetime lung cancer mortality risk = 2.9E-2 per µg Cr(VI) /m$^3$ (Ref RAC/27/2013/06 Rev.1)
**Oral Local effects - Long-term:** Based on an exposure for 70 years (24h/day, every day) and an 89-year life expectancy and against a human background cumulative lifetime intestinal cancer risk of 9 – 16 per 1000 for the German population, the following risk estimates are used: An excess lifetime intestinal cancer risk = 8.0E-4 per µg Cr(VI) /kg bw/day (Ref RAC/27/2013/06 Rev.1)

[2] Application for authorisation: Establishing a reference dose response relationship for carcinogenicity of hexavalent chromium", Ref RAC/27/2013/06 Rev.1, dated 4 Dec 2013

# 6. HUMAN HEALTH HAZARD ASSESSMENT OF PHYSICOCHEMICAL PROPERTIES

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## 6.2. Flammability

## 6.3. Oxidising potential

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#### 7.1.1.1. Short-term toxicity to fish

#### 7.1.1.2. Long-term toxicity to fish

### 7.1.2. Aquatic invertebrates

#### 7.1.2.1. Short-term toxicity to aquatic invertebrates

#### 7.1.2.2. Long-term toxicity to aquatic invertebrates

### 7.1.3. Algae and aquatic plants

### 7.1.4. Sediment organisms

### 7.1.5. Other aquatic organisms

## 7.2. Terrestrial compartment

### 7.2.1. Toxicity to soil macro-organisms

### 7.2.2. Toxicity to terrestrial plants

### 7.2.3. Toxicity to soil micro-organisms

### 7.2.4. Toxicity to other terrestrial organisms

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# 8. PBT AND vPvB ASSESSMENT

## 8.1. Assessment of PBT/vPvB Properties

### 8.1.1. PBT/vPvB criteria and justification

### 8.1.2. Summary and overall conclusions on PBT or vPvB properties

# 9. EXPOSURE ASSESSMENT

## 9.1. Introduction

Occupational workplace exposure to hexavalent chromium (Cr(VI)) is regulated in most European countries. National Occupational Exposure Limits (OELs) across Europe respect a range of 8-hour Time Weighted Average (TWA) values between 1 µg/m$^3$ and 50 µg/m$^3$. In 2014, France introduced a new OEL of 1 µg/m$^3$. This is one of the most stringent OELs currently in place anywhere in the EU and compliance requires substantial research and investment. In Germany, the evaluation standard is 1 µg/m$^3$. Chromium (VI) compounds have been included in Annex I to Directive 2004/37/EC – carcinogens or mutagens at work, last amended by Directive (EU) 2017/2398 of the European Parliament and of the Council of 12 December 2017 with a transitional occupational exposure limit of 10 µg/m$^3$ until January 2025 (after that 5 µg/m$^3$).

The Carcinogens and Mutagens Directive (2004/37/EC) requires each Member State to ensure employers reduce and replace use of hexavalent chromium substances, and the introduction of a new OEL in France provides one clear example of regulation by Member States to effect a reduction in workplace exposure to Cr(VI). Industry is proactively engaged in delivering continuous reduction through the development and implementation of appropriate Risk Management Measures (RMMs).

Best practice across the industry is continually improving, driven by general awareness of workplace hygiene and increasingly stringent regulatory requirements.

This commitment to reducing exposure also reflects the widespread recognition that surface treatment including coating with Cr(VI) is critical for several industries and that alternatives are not available in the near-term.

### 9.1.1. Scope of the assessment

K.Walter is a manufacturer of plating equipment for gravure printing and embossing cylinders and supplies customer-specific complete plating systems (plating lines) for different printing segments: packaging, decorative, publication and embossing. The core part of such plating systems is the device for the application of a chromium trioxide-based functional chrome coating on the printing cylinders further called 'electroplating unit'.

The vertical supply chain in which chromium trioxide is being used originates from the applicant's assumed role as an importer of the substance in the European Economic Area. K.Walter's role in the supply chain is the sole source of supply for chromium trioxide as a raw material for the formulator and chromium trioxide-based liquid formulations as well as electroplating units to the downstream users (DU) respectively. Based on this, the affected production activity covered in this Application for Authorisation (AfA) has been segmented into two uses:

**Use 1:** Formulation of chromium trioxide-based electrolyte for electroplating process

**Use 2:** Chromium trioxide-based functional chrome plating of cylinders used in the rotogravure printing and embossing industry

In the first use (Use 1) covered in this AfA, the applicant is applying for authorisation for formulation of mixtures containing chromium trioxide to be used in galvanic units to chrome plate gravure cylinders for use in the printing and embossing industry. These formulations are prepared by a contracted party (formulator) and supplied back to the applicant within the EEA to be used by its downstream users for coating of gravure cylinders.

In the second use (Use 2), the applicant is applying for authorisation for the application of chromium trioxide-based functional chrome plating of gravure printing and embossing cylinders used in high-quality printing applications *e.g.* required in the packaging, decorative, and publication industry. For more details about the structure of the supply chain, please refer to the Socio-Economic Analysis.

In this Chemical Safety Report (CSR), an Exposure Scenario (ES) was created for either Use, consisting of an Environmental Contributing Scenario (ECS) and Worker Contributing Scenarios (WCS). The assessment provides reliable estimates and risks of current exposures of the general population via the environment as well as workplace exposure levels throughout the supply chain of K.Walter. Where available, workplace exposure measurements, respectively air emission measurements were considered. ES 1 describes the exposure assessment of Use 1 (**section 9.2**), ES 2 describes the exposure assessment of Use 2 (**section 9.3**).

### 9.1.2. Data collection and Use

For the exposure assessment related to the formulation Use (ES 1, **section 9.2**), data were collected from K.Walter's contracted formulator via detailed questionnaires. The described operational conditions (OC) were confirmed by a site visit. Exposure and risks for the environment and man via environment described in the ES are based on measurement data (measurements of residual Cr(VI) in the exhaust air and information on residual Cr(VI) concentrations in the wastewater) as well as information taken from the formulator's questionnaires. Exposure was modelled via Chesar 3 (see ECS in **section 9.2.2**). Moreover, occupational exposure measurements were available and used to assess the risk for workers during the formulation process (**section 9.2.4**). Exposure and risks for workers of further associated tasks carried out at the formulator's site were described qualitatively or were modelled using ART 1.5 considering information on operational conditions provided by the formulator (**sections 9.2.3** and **9.2.5** to **9.2.7**).

Regarding Use 2 (ES 2, **section 9.3**), Ramboll[3] conducted a downstream user survey on behalf of K.Walter. The questionnaire was designed based on the knowledge of K.Walter, who are in close contact with their clients and know most of their clients' sites (*e.g.*, from yearly maintenance work). Furthermore, five German sites from DUs operating in different industry sectors were visited by K.Walter and Ramboll prior to the finalization of the questionnaire to collect feedback on the correct understanding of the questionnaire and to confirm its applicability to the process. The DU survey is described briefly in the following.

To collect information on the supply chain covered by this AfA, questionnaires were sent to K.Walter's DUs within the EEA addressing critical points of the AoA, SEA and CSR. These questionnaires were distributed as an online survey available in five languages (Spanish, Italian, French, German and English) starting on the 25$^{th}$ of February 2020. K.Walter informed its DUs about this survey and encouraged them to participate. One CSR-related questionnaire was sent per site, while one combined AoA- and SEA-specific questionnaire was sent for each company (which might cover several sites). Hence, the number of AoA/SEA questionnaires sent is lower, considering that various companies had more than one site and therefore had to fill more than one CSR questionnaire but only one AoA/SEA questionnaire. DUs were requested to fill these questionnaires until the 30$^{th}$ of April 2020 with two reminders sent before this deadline. Additionally, explanatory videos in Spanish, Italian, French, German and English were prepared and made available to all DUs. These videos aimed to provide instructions on how the questionnaires were to be completed and to illustrate the authorisation process and its impact on K.Walter's supply chain.

A total of 117 CSR- and 105 AoA/SEA-related questionnaires were sent, covering all DUs of K.Walter in the EEA. These represent a wide range of applications in the publication, packaging and decorative industries, and include plating service providers and printing shops using gravure plating for self-use. The countries covered were Portugal, Spain, France, Belgium, Germany, Italy, Greece, Poland, Austria, Slovakia, Hungary, Croatia and Romania. Regular data assessments were carried out while the surveys were available for the DUs to evaluate response rates and the quality of the responses. DUs whose responses were unclear or incomplete were contacted individually and asked for clarification or further information, even past the response deadline.

[3] Ramboll – a global consultant – was commissioned to support K.Walter in the preparation of the AfA documents.

A response rate of 75% was obtained for CSR-related questions, for a total of 88 responses. For the AoA- and SEA-related questions, the response rates were 63% (66 responses) and 62% (65 responses), respectively.

These rates are different because not all DUs answered all sections within the surveys. Importantly, these results also include partially completed questionnaires with incomplete or missing answers. It is possible that some DUs only completed one of both questionnaires. A detailed discussion about the results of these surveys is presented in the following sections.

In brief – for the CSR part – detailed information about the conditions under which the activities connected with the use of Cr(VI) are carried out as well as the duration and frequency of each task and the number of workers involved at the different sites were collected. Because of the survey's structure, values that were entered as "0" (*e.g.*, time per task, workers necessary, etc.) were excluded from the assessment. As the DUs were not obliged to fill all fields, some of the fields were left unanswered or might have been not applicable to the specific site. Hence, following the premise to provide a worst-case approach, those values were excluded in order to ensure unbiased descriptive statistics (*e.g.*, by not lowering the mean by the inclusion of "0" values). Furthermore, information on workplace and emissions to air monitoring data were collected. Responding parties were located in 14 EU countries. The largest proportion of responses was collected from German DUs (n = 31), followed by Italy (n = 24), Spain (n = 19), France (n = 15) and Poland (n = 8). In total, these five countries made up 83 % of the sample. The distribution is presented in **Figure 2**.

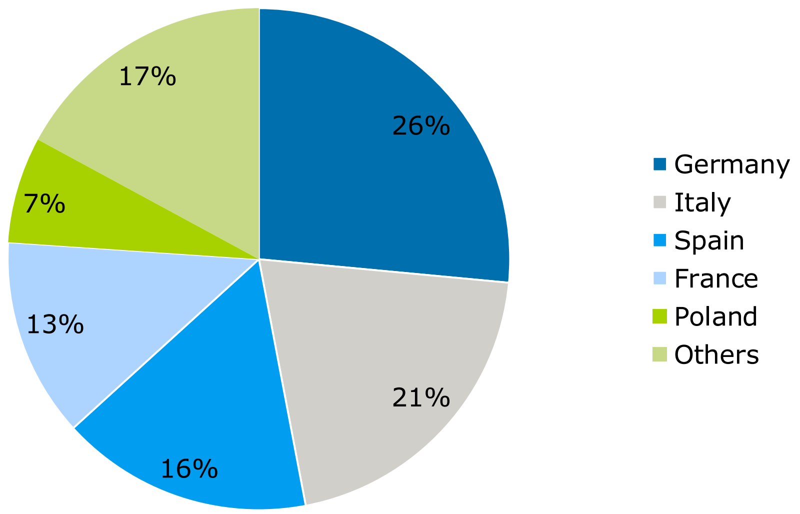


**Figure 2:** Distribution of DUs (%) by country

Exposure and risks for the environment and man via environment described in the corresponding ECS (**section 9.3.2**) is based on air emission measurements provided by the DUs. The estimation of the resulting exposure was performed with Chesar 3. Any releases to the aquatic environment are negligible as $CrO_3$ is contained within the preparation and the water used to rinse out the equipment is collected and recycled or disposed of in specialist facilities.

Occupational exposure estimates described in the WCS (**sections 9.3.3** to **9.3.8**) are based on measured and/or modelled data. The information used in either assessment were provided by the DUs participating in the survey. Inhalation exposure was estimated using the exposure model 'Advanced REACH Tool 1.5' (ART).

ART is a second-tier model calibrated to assess exposure to inhalable dust, vapours, and mists; the ES is within the scope of ART. The figures obtained by modelling are considered to be worst-case estimates: supportive evidence for the conservative character of the modelled estimates is provided by comparison with relevant measured exposure data (measured concentrations of particulate residues of Cr(VI) in air), where available. As indicated above, in cases where the sample size and sampling strategy was adequate, the risk characterisation relied on the measured exposure values. When no measurement results (or no sufficient/adequate measured data) were available, the exposure was modelled based on the information of the process description provided by DUs.

The methodology chosen for the exposure estimation is described in detail in each respective section.

### 9.1.3. Overview on tonnage and contributing scenarios

As mentioned above, this AfA covers two Uses with an individual ES for each Use. The total consumption of $CrO_3$ (including the tonnage formulated described by Use 1 in this AfA), was estimated from the annual quantity of $CrO_3$ delivered to DUs. The information was provided in the survey on Use 2 by the DUs. On average, DUs stated to receive [redacted] t $CrO_3$ per year, either as liquid formulation or solid flakes. Minimum and maximum consumption of $CrO_3$ reported were 1.5E-04 t/year and 6.5 t/year respectively. A tonnage band (using classes with increments of 0.5 t $CrO_3$) is presented in form of a histogram in **Figure 3**. When referred to the Cr(VI) content, an average consumption of approximately [redacted] t/year (based on a Cr(VI) content of 52 %) was derived. The summed consumption of $CrO_3$ of all 117 participating DUs based on the average value delivered was estimated as [redacted] t/year ([redacted] t Cr(VI)/year). To acknowledge yearly variation in the $CrO_3$ consumption, the tonnage applied for in this AfA was rounded up to [redacted] t/year ([redacted] t Cr(VI)/year).

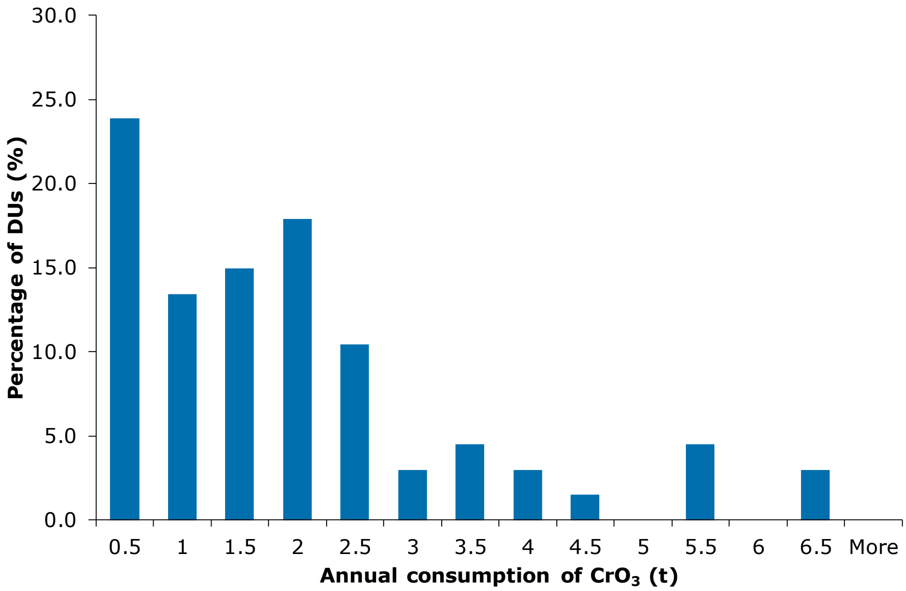


**Figure 3:** Histogram showing the percentage of DUs and their respective annual consumption of $CrO_3$ (classes with increments of 0.5 t)

A summary of the Uses and tonnage covered by this AfA is provided in **Table 6**.

**Table 6:** Overview of exposure scenarios and associated tonnage

| Route | Regional exposure | Risk characterization (RCR or Excess risk) | Route |
|---|---|---|---|
| ES 1: F-1 | Formulation | Formulation of chromium trioxide-based electrolyte for electroplating process | 160 – 220 t $CrO_3$/year ([redacted] t/year [approx. [redacted] t Cr(VI)]) |
| ES 2: IW-1 | Use at industrial site | Chromium trioxide-based functional chrome plating of cylinders used in the rotogravure printing and embossing industry | 160 – 220 t $CrO_3$/year ([redacted] t/year [approx. [redacted] t Cr(VI)]) |

The majority of the DUs reported to use $CrO_3$ in liquid (47 %) form (**Figure 4**). Also, 16 % of the DUs reported the use of both liquid and solid form, while only 12 % depended solely on solid $CrO_3$. A quarter did not indicate the form of $CrO_3$ used.

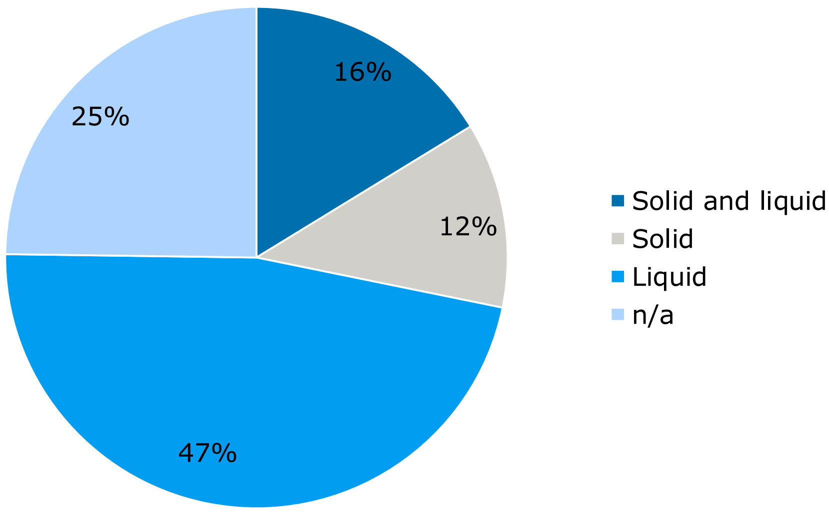


**Figure 4:** Distribution of $CrO_3$ form (liquid, solid, liquid and solid, no information provided) used for Use 2 by the 117 DUs participating in the survey to gather information

It is important to note, that K.Walter strives to entirely shift the usage of $CrO_3$ among their DUs to the liquid formulation as a risk minimization measure. Opposed to solid $CrO_3$ flakes, which have to be added manually to the bath and therefore present a higher risk for particle inhalation by the workers, the liquid formulation enables the usage of an automated dosing system (refer to WCS 4 of Use 2 in **section 9.3.6** for details). Therefore, K.Walter limits the scope of the CSR and the application, respectively, to liquid $CrO_3$. The resulting ECS and WCS covered in this CSR are listed below in **Table 7**.

**Table 7:** Overview of Contributing Scenarios

| Exposure Scenario | Contributing scenario | ERC / PROC | Name of the contributing scenario |
|---|---|---|---|
| ES 1: Formulation of chromium trioxide-based electrolyte for electroplating process | ECS 1 | ERC 2 | Formulation of chromium trioxide-based electrolyte |
| | WCS 1 | PROC 1 | Delivery and storage of solid $CrO_3$ |
| | WCS 2 | PROC 3 | Preparation of the $CrO_3$ containing formulation |
| | WCS 3 | PROC 8b | Sampling |
| | WCS 4 | PROC 28 | Maintenance |
| | WCS 5 | PROC 8b | Wastewater sampling and waste management (solid and liquid) |
| ES 2: Chromium trioxide-based functional chrome plating of cylinders used in the rotogravure printing and embossing industry | ECS1 | ERC 5 | Chromium trioxide-based functional chrome plating of cylinders |
| | WCS 1 | PROC 1 | Delivery and storage of raw material |
| | WCS 2 | PROC 13 | Chrome electroplating unit |
| | WCS 3 | PROC 8b | Sampling |
| | WCS 4 | PROC 8b | Concentration adjustment with liquid $CrO_3$ |
| | WCS 5 | PROC 28 | Maintenance |
| | WCS 6 | PROC 8b | Waste management |

### 9.1.4. Introduction to the assessment

The current CSR and the associated exposure scenarios are tailored to support the AfA to continue use of chromium trioxide for the formulation of mixtures and subsequent use in chrome plating of cylinders used in the rotogravure printing and embossing industry after the sunset date in September 2017.

Chromium trioxide has been included in Annex XIV to Regulation (EC) No 1907/2006 ('REACH') due to its intrinsic properties as being carcinogenic (Carc. 1A) and mutagenic (Mut. 1B).

Following 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. Accordingly, only the potential human health risks related to the classification of chromium trioxide as a carcinogenic and mutagenic toxicant are considered in the current CSR. The dominating health effect resulting from the intrinsic hazardous properties of chromium trioxide is lung cancer due to inhalation of dust and/or aerosols.

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

#### 9.1.4.1. Environment – Scope and type of assessment

As mentioned above and in accordance with REACH, Article 62(4)(d), potential risks to the environment do not need to be considered.

#### 9.1.4.2. Man via environment – Scope and type of assessment including comments on the assessment approach taken

As indicated in **section 9.1.4**, humans may potentially be exposed to chromium trioxide via the environment by air emissions or via the food chain following emissions to the aquatic environment. Since strict emission control measures are implemented, releases to air (and indirectly to the aquatic environment) as well as direct releases via wastewater, if any, are small. Nonetheless, an evaluation of the oral exposure via the food chain and the associated risks has been performed in both ECS (**section 9.2.2** for Use 1/ES 1, **section 9.3.2** for Use 2/ES 2). Moreover, the releases to soil and consequently the exposure and risk are considered negligible. Hence, the relevant potential exposure path is inhalation. The measures taken to prevent the above-mentioned releases to the environment are described in the following sections.

*Release to air:*

Due to its low volatility, chromium trioxide will not normally be present in air. Nevertheless, energetic processes (*e.g.*, plating) can release chromium trioxide into air. All workspaces at all sites with potential release to air are equipped with exhaust ventilation systems to remove residual particulates.

Two areas of the formulator's facility are used for the preparation/mixing of liquid $CrO_3$ formulations (Use 1). The mixing tanks are equipped with local exhaust ventilation (LEV) systems either as fixed capturing hoods at the filling area where solid $CrO_3$ is handled or as moveable exhaust systems. For a detailed description please refer to **section 9.2.4**. The captured exhaust air is led to a connected chrome scrubber (one for each room). The water of the chrome scrubber is led to the on-site wastewater treatment plant. The volume flow of the exhaust air system is monitored. The process stops immediately in any event of disturbance or malfunction and an alarm signal alerts the workers.

The electroplating units used by the DUs (Use 2) are closed loop systems with limited potential for exposure. They are equipped with fixed capturing hoods installed at the sites of the Cr(VI) containing plating unit. The exhaust air is then passed through wet scrubbers according to best available technique. The water from the chrome scrubber is redirected into the process cycle. A sensor monitors the volume flow of the exhaust air system. The process stops immediately in any event of disturbance or malfunction. An example for a chrome scrubber used is depicted in **Figure 5**. The technical principle of this procedure is similar in all assessed sites.

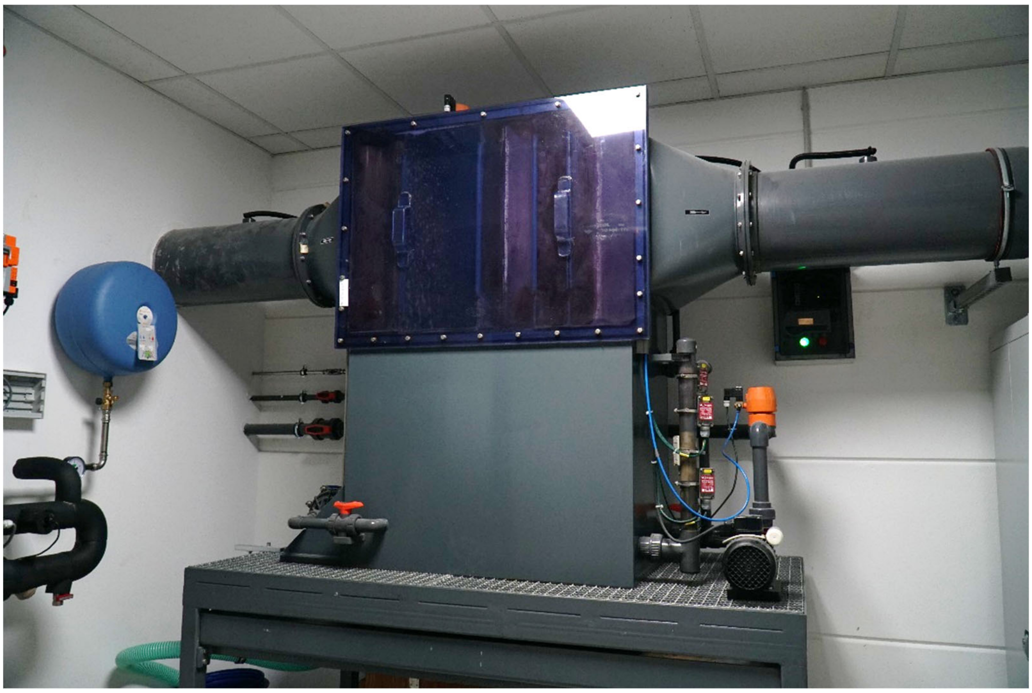

**Figure 5:** Chrome scrubber at the site of a downstream user of $CrO_3$ in rotogravure industry

*Releases to water:*

Measures to prevent or limit release of Cr(VI) to the environment are provided as best practice at facilities carrying out operations using chromium trioxide. During industrial surface treatment and formulation operations, prevention of releases of substances to the aquatic environment is a matter of good practice. In general, treatment technology (on-site or off-site) to reduce hexavalent to trivalent chromium (Cr(III)) in wastewater is generally highly effective, such that residual concentrations of Cr(VI) in the effluent are very low and often non-detectable. Solid and liquid waste containing Cr(VI) is collected and treated as hazardous waste where residual Cr(VI) can be effectively and safely treated. In view of the RMMs in place at the production facilities, emissions to the aquatic environment associated with surface treatment operations are effectively prevented.

The formulator described under Use 1 has an on-site wastewater treatment plant, where reductive treatment of Cr(VI) containing wastewater from the process takes place as described above. After reduction to Cr(III), the residual concentration of Cr(VI) is measured (Limit of Quantification; LOQ = 0.05 mg/l for internal measurements). The reduction step is repeated until Cr(VI) concentrations are below the LOQ, and Cr(III) is precipitated afterwards. Subsequently, the wastewater is additionally measured to ensure that the concentration of total chrome is below the permitted limit value for Cr(VI) in wastewater of 0.1 mg/l (German federal laws and *Land* laws apply[4]). The treated wastewater is discharged automatically and batch-wise into the sewage system. Wastewater samples are drawn daily. Additionally, measurements are performed four times per year by an external laboratory. The LOQ of the relevant Cr(VI) measurement served as basis for the exposure estimates. The resulting estimates were considered in the assessment of residual exposures to man via environment (**section 9.2.2**).

[4] *i.e.*: *Wasserhaushaltsgesetz, Abwasserverordnung, Landeswassergesetz NRW, Zuständigkeitsverordnung Umweltschutz, Selbstüberwachungsverordnung Kanal*

During the chrome plating of cylinders, using K.Walter's electroplating unit (Use 2), no wastewater is produced. Any liquids remain within the system as closed circuit. When the chromium solution needs to be replaced, it is pumped into an IBC and disposed via external service providers, who perform the reductive treatment.

The exposure and risks are referred to Cr(VI). As described in **section 5.8**, Cr(VI) causes lung tumours in humans and animals by the inhalation route and tumours of the gastrointestinal tract in animals by the oral route.

In the case of airborne Cr(VI), the oral route (swallowing of the non-respirable fraction) does not need to be explicitly considered since:

(i) the exposure calculations (airborne concentrations) do not provide different particle size fractions (inhalable/thoracic/respirable);

(ii) the excess lifetime risk (ELR) for intestinal cancer is lower than that for lung cancer. The assessment of health impacts is therefore dominated by the potential risk of lung cancer due to inhalation of Cr(VI);

(iii) the document on a reference dose-response relationship for Cr(VI) compounds (RAC/27/2013/06 Rev.1) states that "in cases where the applicant only provides data for the exposure to the inhalable particulate fraction, as a default, it will be assumed that all particles were in the respirable size range."

Therefore, in accordance with the findings above and provisions on the risk assessment for humans exposed via the environment, no exposure via the oral route due to inhalation of particles needs to be considered since it is assumed that all particles are in the respirable size range. This constitutes a worst-case approach as the potential lung cancer risk is an order of magnitude higher compared to the potential intestinal cancer risk, based on the dose-response relationships agreed by RAC.

However, the oral route of exposure is considered relevant for exposure via the food chain (drinking water and fish), and a quantitative assessment of exposure and risks is performed. For Use 1 this includes oral exposure from both, residual Cr(VI) in wastewater and initially airborne Cr(VI) deposed into waterbodies. For Use 2 – due to the absence of process wastewater – only oral exposure from initially airborne Cr(VI) deposed into waterbodies is considered.

The scope and type of assessment is also summarized in **Table 8**.

**Table 8:** Type of risk characterisation required for man via environment

| Route of exposure and type of effects | Type of risk characterisation | Hazard conclusion [1] |
|---|---|---|
| Inhalation: Lung cancer (Local effects [Long-term]) | Quantitative | ELR = 2.9E−02 per µg Cr(VI)/m³ for 70 years |
| Oral: Intestinal cancer (Local effects [Long-term]) | Quantitative (for oral exposure via the food chain only; no additional oral exposure contributing to exposure via the environment by swallowed non-respirable particles as it is assumed that all inhaled material is respirable [worst-case]) | ELR = 8.0E−04 per µg Cr(VI)/kg bw/d for 70 years |

**Abbreviations:** ELR = Excess Lifetime Risk;
[1] RAC/27/2013/06 Rev.1

### 9.1.4.3. Workers – Scope and type of assessment including comments on the approach taken

The scope of exposure assessment and type of risk characterisation required for workers are described in **Table 9** and are based on the hazard conclusions presented in **section 5.11**. The exposure estimates (ART 1.5) or measured values refer to the exposure of Cr(VI) and are expressed as an 8-hour Time Weighted Average (TWA) to represent a standard working day of an employee.

**Table 9:** Type of risk characterisation required for workers

| Route of exposure | Type of effect | Type of risk characterisation | Hazard conclusion [1)] for lung cancer |
|---|---|---|---|
| Inhalation | Systemic (Long-term) | Not necessary | — |
| | Local (Long-term) | Quantitative | ELR = 4.0E−03 per µg Cr(VI)/m³ for 40 years |

**Abbreviations:** ELR = Excess Lifetime Risk
[1)] RAC/27/2013/06 Rev.1)

The oral route (mucociliary clearance and swallowing of the non-respirable fractions) is not taken into account for the same reasons as already explained in **section 9.1.4.2**. In accordance with the RAC document on the dose-response relationship (RAC/27/2013/06 Rev.1), it is assumed, that all particles are in the respirable size range. Hence, no exposure via the oral route needs to be considered. Please note also that physicochemical hazards are not subject of this CSR.

The ES specify OC and RMM that represent good practice to minimise exposure. The sites covered under the supply chain of K.Walter must ensure that the controls which they have in place provide an equivalent or better level of protection than those set out in the ES.

The following risk management measures must be implemented accordingly:

- Access to the chrome plating unit, respectively the chrome formulation areas and the $CrO_3$ storage area is restricted to authorised personnel.
- Standard Operating Procedures (SOPs) are in place and workers receive regular training regarding chemical risk management and how to properly wear the Personal Protective Equipment (PPE).
- Potential exposure of workers handling chromium trioxide is restricted to the lowest possible level.

Solid chromium trioxide is expected to entail a certain potential for generating dust, requiring Respiratory Protective Equipment (RPE). Furthermore, protective clothing, chemical-resistant gloves, and goggles are mandatory for tasks involving handling of or potential contact with liquid formulations *e.g.*, during maintenance.

As mentioned earlier, operators need to be trained in the safe use of PPE.

(i) For determining the efficiency of RPE, the German BG rule "BGR/GUV-R190"[5] was used because it provides a robust and consistent approach. Another approach could equally have been used. In any case, such approaches rely on the assigned protection factor (APF) for RPE that may or may not be based on actual workplace measurements under relevant or non-relevant conditions.

(ii) The German BGs, especially its Institute for Occupational Safety and Health (IFA) is an internationally highly recognized institute in the field of industrial hygiene. Having this in mind, the BG rule was used as a reference. However, the advice of other member states in this regard is fully respected and highly esteemed.

(iii) As members will appreciate, the BG rule has published a comprehensive overview of respiratory protection devices and their APFs which refers to efficiencies of 96.6% (*i.e.* an APF of 30) in RPE in the workplace.

Based on national recommendations published for example by HSE[6] or DGUV[7], wearing times of RPE are determined based on results of the workplace/task specific risk assessments and limited by company specific guidelines, as appropriate. The results of the company specific risk assessments are documented, regularly reviewed and updated in accordance with Council Directive 89/391/EEC of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work and Council Directive 98/24/EC of 7 April 1998 on the protection of the health and safety of workers from the risks related to chemical agents at work (fourteenth individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC. In addition, the Council Directive 89/656/EEC on the minimum health and safety requirements for the use by workers of personal protective equipment at the workplace is followed. Workers are regularly trained accordingly. Compliance with these rules is controlled by supervisors.

An overview of the PPE used per task (respectively WCS) given in the instruction manual of K.Walter for its DUs in the rotogravure industry (ES 2) is displayed in **Table 10** together with the PPE used at the formulation site (ES 1).

[5] http://publikationen.dguv.de/dguv/pdf/10002/r-190.pdf

[6] British Control of Substances Hazardous to Health regulation (COSHH). http://www.hse.gov.uk/pUbns/priced/hsg53.pdf

[7] German BG rule "BGR/GUV-R190". http://publikationen.dguv.de/dguv/pdf/10002/r-190.pdf

**Table 10:** Personal Protective Equipment worn during the WCS of ES 1 (Use 1) and ES 2 (Use 2)

| ES (Use) | WCS | | Protective clothing: Protective clothing | Protective clothing: Chemical-resistant clothing (*e.g.*, apron) | Foot-wear: Safety footwear | Face protection: *e.g.*, safety goggles or face shield | Gloves: Protective gloves | Gloves: Chemical-resistant gloves | Gloves: Chemical- and cut-resistant gloves | RPE: Dust mask (FFP3) [1)] | RPE: Self-contained breathing apparatus |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 – Delivery and storage of solid $CrO_3$ | | X | | X | | | | | | |
| 1 | 2 – Preparation of the $CrO_3$ containing formulation | | X | | X | X | | X | | X [2)] | |
| 1 | 3 – Sampling | | X | | X | X | | X | | | |
| 1 | 4 – Maintenance | | X | | X | X | | X | | X | |
| 1 | 5 – Wastewater sampling and waste management (solid and liquid) | | X | | X | X | | X | | | |
| 2 | 1 – Delivery and storage of raw material | | X | | X | | | | | | |
| 2 | 2 – Chrome electroplating unit | | X | | X | X [3)] | | | | | |
| 2 | 3 – Sampling | | X | | X | X | | X | | | |
| 2 | 4 – Concentration adjustment with liquid $CrO_3$ | | X | | X | X | | X | | | |
| 2 | 5 – Maintenance [4)] | Cleaning of anodes (weekly) | X | X | X | X | | | X | | |
| 2 | 5 – Maintenance [4)] | Complete inspection (annually) [5)] | X | X [5)] | X | X [5)] | X | | X [5)] | | |
| 2 | 5 – Maintenance [4)] | Exchange of the electrolyte (infrequently) | X | X | X | X | | X | | | |
| 2 | 6 – Waste management | | X | | X | | | | | | |

1) One-time use; APF 30
2) Only during transfer of solid $CrO_3$
3) Only necessary when in close vicinity to the plating unit (*e.g.*, during program set-up)
4) The PPE is described for three specific maintenance scenarios which reflect tasks with the highest exposure potential. Those tasks hence require a higher level of PPE. Other maintenance tasks that are not covered in this table might need lower protection levels. Detailed information on individual tasks and the corresponding PPE worn can be found *e.g.*, in the "Maintenance instructions – Chrome plating: Minipilot SlimLine Type 81 K" and the "Electroplating manual – HelioChrome Rapid chrome plating" by K.Walter.
5) Only tasks leading to potential exposure to the electrolyte (*i.e.* mainly tasks in the upper basin of the bath) require wearing of the complete set of PPE. For instance, safety footwear, general protective clothing and gloves (where appropriate) are worn when maintaining the electronics of the unit (outside of the bath).

Protective clothing comprises close-fitting working clothes with low tear resistance, close-fitting sleeves, and no protruding parts. The chemical-resistant clothing (*e.g.*, an apron) protects the body from splashes of aggressive chemicals. Safety footwear protects feet from being crushed, falling parts, and slipping on slippery surfaces. Face protection as *e.g.*, safety goggles protect the eyes from flying parts and liquid spray or as *e.g.*, face masks serve to protect the eyes and face from parts flying about, splashing liquid, flames, hot gases, heat, and sparks as well as hot particles and exhaust fumes. Protective gloves are used to protect hands from friction, abrasive burns, puncture wounds or deeper injuries and against contact with hot surfaces. Chemical-resistant gloves protect the hands from aggressive chemicals. Chemical- and cut resistant gloves additionally protect against cuts while handling sharp objects. The self-contained breathing apparatus (full face mask with respirator filter in accordance with safety data sheet) protects from harmful gasses, vapours, dust and similar materials and media that can occur when handling chemical substances. The respirator filter must be designed in accordance with the safety data sheet for the respective application (hazardous substance).

No further information is provided on RMM regarding physicochemical hazards as these are not subject of this CSR.

In **Figure 6**, exemplary pictures of workers from the formulators site wearing PPE are shown.

**Figure 6:** Worker wearing PPE for the performance of, e.g. WCS 3 of ES 1 (left) and worker wearing PPE for the addition of solid $CrO_3$ within WCS 2 of ES 1 (right).

## 9.2. Exposure scenario 1

### 9.2.1. Description of the activities and technical processes covered in this ES

In this ES, the exposure of man via environment and of workers by manufacturing liquid formulations of $CrO_3$ for application in functional chrome plating of cylinders used in the rotogravure printing and embossing industry is covered. A summary of the described tasks is given in **Table 11**.

**Table 11:** Descriptors of ES 1

| | |
|---|---|
| **Market sector** | Formulation |
| **Article categories** | Liquid formulations for application in functional chrome plating of rotogravure cylinders |
| **Environment Contributing Scenario(s)** | ECS 1: Formulation of chromium trioxide-based electrolyte (ERC 2) |
| **Worker Contributing Scenario(s)** | WCS 1: Delivery and storage of solid $CrO_3$ (PROC 1) |
| | WCS 2: Preparation of the $CrO_3$ containing formulation (PROC 3) |
| | WCS 3: Sampling (PROC 8b) |
| | WCS 4: Maintenance (PROC 28) |
| | WCS 5: Wastewater sampling and waste management (solid and liquid) (PROC 8b) |
| **Subsequent service life exposure scenario(s)** | Not Relevant |

The basic process of the formulation of mixtures can be summarized as follows: Water, solid $CrO_3$ and further additives (if required) are mixed in a designated tank and the solution is afterwards filled in 1000 litre IBCs, or smaller vessels.

The liquid formulations are distributed to the DUs of K.Walter performing functional chrome plating of cylinders used in the rotogravure printing and embossing industry.

A general explanation on the approach taken is provided in **section 9.1**. Specific information is given in each sub-section of the respective ECS/WCS.

## 9.2.2. Environmental contributing scenario 1: Formulation of chromium trioxide-based electrolyte (ERC 2)

### 9.2.2.1. Conditions of use

At the formulators site, formulations are produced on 230 working days per year in an 8-hour shift. Over the last three years, an average tonnage of [redacted] t was used per year. In 2018, a maximum tonnage of [redacted] t (*i.e.* [redacted] t Cr(VI)) was consumed. For the calculations of release rates (air emissions and wastewater), the latter value was used. However, for the exposure estimates performed with Chesar 3, an annual tonnage of [redacted] t (160 to 220 tons) (*i.e.* [redacted] t Cr(VI)/a) was used in reference to the tonnage covered in this AfA. As described in **section 9.1.2**, measured data on air and wastewater emissions were provided by the formulator.

Air emission measurements were performed in 2012. Reported Cr(VI) exhaust concentrations were < [redacted] mg/m³. In combination with a flow rate of [redacted] m³/h, hourly releases of [redacted] mg/h were calculated. In consideration of the reported annual operation time of [redacted] h/a, the annual air emission releases of Cr(VI) corresponded to [redacted] kg/a. A release fraction of 1.85E-08 corresponding to a release rate of 1.85E-06 % was calculated from the annual releases (kg/a) in referral to the annual tonnage of [redacted] t Cr(VI) (see above).

As described in **section 9.1.4.2**, the LOQ of the internal Cr(VI) measurements is 0.05 mg/l, and reduction is repeated prior to precipitation until Cr(VI) concentrations fall below the LOQ. Hence, as a worst-case, the LOQ was considered as the maximum Cr(VI) concentration in the wastewater. In the years 2017, 2018 and 2019, wastewater volumes of [redacted] m³, [redacted] m³ and [redacted] m³ were discharged. Because a maximum tonnage of [redacted] t $CrO_3$ ([redacted] t Cr(VI)) was reported for the year 2018, the corresponding wastewater volume of 2018 was used for the calculations. In consideration of the worst-case concentration of 0.05 mg Cr(VI)/l, an annual release of [redacted] kg Cr(VI) was calculated. When referred to the annual tonnage of [redacted] t Cr(VI), a release rate of 4.72E-05 % resulted.

The conditions of use are summarized **Table 12**. Further details on the measurement is provided in the **Annex**, **section 2.1**.

**Table 12:** Conditions of use for ES 1 – ECS 1

| Conditions | | | Method |
|---|---|---|---|
| **Product (article) characteristics** | Substance as such/in a mixture | Concentration of Cr(VI): minute | Default assumption |
| **Amount used, frequency and duration of use (or from service life)** | Daily use at site | [redacted] t | Formulator data |
| | Annual use at a site | [redacted] t (230 working days) | |
| | Percentage of EU tonnage used at regional scale | 100% | Default assumption |
| **Conditions and measures related to sewage treatment plant** | Biological STP | Standard [Effectiveness Water: 0.147%] | Default assumption |
| | Discharge rate of STP | ≥ 2E03 $m^3/d$ | |
| | Application of STP sludge on agricultural soil | Yes | |
| **Conditions and measures related to treatment of waste (including article waste)** | Particular considerations on the waste treatment operations | No (low risk) (ERC based assessment demonstrating control of risk with default conditions. Low risk assumed for waste life stage. Waste disposal according to national/local legislation is sufficient.) | Default assumption |
| **Other conditions affecting environmental exposure** | Receiving surface water flow rate | ≥ 1.8E04 $m^3/d$ | Default assumption |

## 9.2.2.2. Releases

The release rates based on the conditions of use and measurement values are described below in **Table 13**.

**Table 13:** Local releases to the environment

| Release route | Release factor | | Total Release Rate | Release estimation justification, method and details |
|---|---|---|---|---|
| Water | Final release factor | 4.72E-05 % | [redacted] kg/y | Based on measured data |
| Air | Final release factor | 1.85E-6 % | [redacted] kg/y (1.00E-3 – 5.00E-3 kg/y) | Based on measured data |
| | Local release rate | [redacted] kg/d | | |
| Soil | Final release factor | 0 % | 0 kg/y | Not relevant |
| Waste | Final release factor | 0 % | 0 kg/y | Not relevant |

### 9.2.2.3. Exposure and risks for man via environment

Based on the information provided by the formulator and the assumptions described in **Table 13**, an exposure estimate of 1.54E-9 mg/m³ was calculated for the annual local air concentration ($c_{local\ air\ annual}$) of Cr(VI) using Chesar 3. In addition to the $c_{local\ air\ annual}$ originating from the air emissions of the site, the annual regional predicted environmental concentration of Cr(VI) ($PEC_{regional\ air\ annual}$) was estimated to be negligible and was reported as 0 mg/m³.

Both values, $c_{local\ air\ annual}$ and $PEC_{regional\ air\ annual}$, were summed to estimate the annual local PEC for the compartment air ($PEC_{local\ air\ annual}$). The $PEC_{local\ air\ annual}$ was calculated as 1.54E-9 mg/m$^3$. The same value was derived for the estimate of environmental exposure of man (see **Table 14**).

**Table 14:** Exposure concentrations and risks for the environment – on local scale

| Protection target | Exposure concentration |
|---|---|
| Air | Local PEC: 1.54E-9 mg/m³ |
| Man via Environment – Inhalation | Local PEC: 1.54E-9 mg/m³ |

The excess lifetime lung cancer risk was estimated using the information provided by ECHA in the RAC document "Establishing a reference dose response relationship for carcinogenicity of hexavalent chromium" (RAC/27/2012/06 Rev.1). The estimated $PEC_{local\ air\ annual}$ of 1.54E-9 mg/m³ = 1.54E-6 µg/m³ was hence multiplied with a factor of 29. This corresponds to the value established by RAC for the excess lifetime lung cancer risk estimates for the general population exposed at different ambient concentrations of Cr(VI) for 70 years.

From the data an excess lifetime lung cancer risk of **4.47E-05 per 1000 exposed** is estimated.

As described in **section 9.1.4.2**, the oral exposure route is also taken into account for the exposure of man via the food chain. This is to address the risk of intestinal cancer. Because no exposure to soil is assumed, only oral exposure via water (from transfer of Cr(VI) into drinking water and fish via both wastewater and deposition from air emissions) is considered relevant. The exposure estimates derived with Chesar 3 are summarized in **Table 15**.

**Table 15:** Contribution to oral intake for mans via environment from local contribution

| Type of food | Estimated daily dose | Concentration in food |
|---|---|---|
| Drinking water | 2.01E-07 mg/kg bw/day | 7.05E-6 mg/L |
| Fish | 1.64E-08 mg/kg bw/day | 9.96E-6 mg/kg ww |
| Leaf crops | 3.83E-07 mg/kg bw/day | 2.23E-5 mg/kg ww |
| Root crops | 9.06E-09 mg/kg bw/day | 1.65E-6 mg/kg ww |
| Meat | 4.95E-12 mg/kg bw/day | 1.15E-9 mg/kg ww |
| Milk | 9.22E-11 mg/kg bw/day | 1.15E-8 mg/kg ww |

The summed estimated daily dose from the consumption of drinking water and fish was calculated as 2.17E-07 mg/kg bw/day.

Subsequently, the estimated daily exposure was accounted for the transformation of Cr(VI) to Cr(III) with a reduction factor of 97% (see EU RAR 2005):

$$2.17\text{E-}07\ \frac{mg}{kg\ bw \times day} \times 0.03 = 6.52\text{E-}09\frac{mg}{kg\ bw \times day} = 6.52\text{E-}06\frac{\mu g}{kg\ bw \times day}$$

The excess lifetime small intestinal cancer risk was estimated using the information provided by ECHA in the RAC document "Establishing a reference dose response relationship for carcinogenicity of hexavalent chromium" (RAC/27/2012/06 Rev.1). The estimated exposure concentration was hence multiplied with a factor of 0.8. This corresponds to the value established by RAC for the excess lifetime small intestinal cancer risk estimates for the general population exposed at different oral concentrations of Cr(VI) for 70 years.

From the data, an excess lifetime small intestinal cancer risk of **5.22E-06 per 1000 exposed** is estimated.

## 9.2.3. Worker contributing scenario 1: Delivery and storage of solid $CrO_3$ (PROC 1)

### 9.2.3.1. Conditions of use

Solid $CrO_3$ is delivered to the production site in steel drums by truck. Each delivery contains [redacted] t (20 – 30 t) of $CrO_3$. The truck is unloaded open-air with a forklift.

The $CrO_3$-containers are transported to a dedicated storage area for oxidizing materials according to "Technical Rules for Hazardous Substances (TRGS) 510 – Storage of hazardous substances in non-stationary containers"[8]. The room is dry, freeze-proof (≥ 15°C) and is supplied with mechanical ventilation. As the formulator is a producer of a range of chemicals the storage area is accessible for the employees of the site. However, the site is secured against unauthorized access following the *Störfallverordnung* of the German Federal Immission Control Act (BImSchG)[9]. Moreover, the storage room is locked during work-free time.

General PPE (safety shoes and clothing) is worn during the described tasks. A description of the number of workers involved as well as the duration and frequency of the task is given in **Table 16**.

**Table 16:** Description of workers, frequency and duration of the tasks of WCS 1

| | Workers involved (n) | Time to complete the task (h) | Raw material deliveries per year (n) |
|---|---|---|---|
| Maximum | 6.0 | 2.0 | [redacted] (1 – 2 times per week) |

As containers are not opened during delivery and storage, there is no potential for exposure to $CrO_3$. The conditions of use are summarized in **Table 17**.

**Table 17:** Conditions of use for ES 1 – WCS 1

| Conditions | | | Method |
|---|---|---|---|
| **Product (article) characteristics** | Substance product type | Powders, granules or pelletised material | Qualitative |
| | Dustiness | Granules, flakes or pellets | |
| | Moisture content | Dry product (< 5 % moisture content) | |
| | Power weight fraction | 52 % | |
| **Amount used (or contained in articles), frequency and duration of use/exposure** | Amount used | Not applicable | |
| | Frequency | 1 - 2 times per week | |
| | Duration of activity | 2.0 hours | |
| **Technical and organisational conditions and measures** | Containment | Closed system (minimal contact during routine operations) | |
| | Local exhaust ventilation | No | |
| | Occupational Health and Safety Management System | ISO14001 / ISO45001 (formerly OHSAS18001) / ISO9001 | |
| **Conditions and measures related to personal protection, hygiene and health evaluation** | Respiratory Protection | No | |
| **Other conditions affecting workers exposure** | Place of use | Outdoor (Delivery) & Indoor (Storage) | |
| | Process temperature | Ambient | |

[8] *Technische Regeln für Gefahrstoffe 510 – Lagerung von Gefahrstoffen in ortsbeweglichen Behältern*
[9] *Bundes-Immissionsschutzgesetz*

## 9.2.3.2. Exposure and risks for workers

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

**Table 18:** Exposure concentrations for ES 1 – WCS 1

| Contributing scenario | Route of exposure | Method of assessment | Exposure value (8h TWA) | Exposure value corrected for PPE | Exposure value corrected for PPE and frequency |
|---|---|---|---|---|---|
| WCS 1 | Inhalation | Qualitative | 0 μg/m$^3$ | 0 μg/m$^3$ | 0 μg/m$^3$ |

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

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

## 9.2.4. Worker contributing scenario 2: Preparation of the $CrO_3$ containing formulation (PROC 3)

### 9.2.4.1. Conditions of use

The task of formulation preparation includes the transportation of $CrO_3$ from the storage to the mixing tank, manual filling of solid $CrO_3$ into the mixing tank and (manual) filling of the formulation into distribution/shipping vessels using a pump. After the formulation has been transferred to the distribution/shipping vessel, the installation is cleaned. The empty drums that contained the solid $CrO_3$ were also cleaned and subsequently disposed (for waste management and disposal see WCS 5, **section 9.2.7**). The number of workers, the frequency and duration of the task is summarized in **Table 19**.

**Table 19:** Description of workers, frequency and duration of the tasks of WCS 2

| | Workers involved (n) | Time to complete the task (h) | Frequency of task |
|---|---|---|---|
| Maximum | 3.0 | 3.0 – 4.0 | daily |

Solid $CrO_3$ is transferred in closed vessels with a forklift from storage to the processing area. There is no potential of exposure. Standard PPE (safety shoes and clothes) is worn during the transport.

For the preparation of $CrO_3$-containing formulations for the use in electroplating processes two production rooms are available at the formulators site. In the first room (department A) formulations with $CrO_3$ concentrations [redacted] % are prepared, in the second room (department B) formulations with $CrO_3$ concentrations [redacted] % are prepared. Each room contains one mixing tank with a lid (department A: [redacted] m³ (0.5 – 2 m³) with a liquid surface area of [redacted] m² (0.25 to 1.5 m²), department B: [redacted] m³ (1.5 – 5 m³) with a liquid surface of [redacted] m² (2 – 5 m²). The room temperature is ambient. Exemplary figures of the mixing tanks are presented in **Figure 7**.

1. Department A is built over two levels. The mixing tank is situated at ground level and the filling unit is situated at the upper level. Closed vessels of solid $CrO_3$ are transferred to the upper level via a forklift. The solid $CrO_3$ is subsequently filled into a funnel. A fixed LEV system, which is connected to an air wet scrubber, is installed at the edges of the system. The maximum flow rate of the scrubber is [redacted] m³/h. The upper level is additionally equipped with water pipes in order to rinse remaining solid $CrO_3$ of the funnel, fill the mixing tank ([redacted] l) in the lower level, and clean the empty $CrO_3$ containers. The emptied and cleaned solid $CrO_3$ containers are disposed by an external contractor. After mixing (with closed lid), the formulation is transferred to distribution/shipping vessels using a pump. Normally, 1000 litre-IBCs are filled with the formulation but the transfer to smaller vessels is also possible. Subsequently, the surrounding area is cleaned of any residual $CrO_3$ formulation with water. The water is directly discharged to the wastewater treatment system via a drainage system in the floor.

2. The mixing in department B is performed in mobile [redacted] litre-mixing tanks. Mixing is only performed in one tank at a time. Each tank is supplied with two mixing units and with two moveable LEV hoses that are connected to the tank.

   A third moveable LEV hose is used during filling of the solid $CrO_3$ into the tank to minimize potential exposure to Cr(VI)-containing dust. The LEV hoses are connected to a chrome scrubber with a maximum flow rate of [redacted] m³/h.

Water is transferred to the tank via a pellet truck with a built-in scale. To reduce dust formation and to facilitate dissolving of the solid $CrO_3$, water is submitted to the tank primarily. The solid $CrO_3$ are added manually via an opening in the upper site of the mixing tank. Potential additives are also added via this opening. During the mixing process, the lid of the tank opening is closed. After mixing, the formulation is transferred to a distribution/shipping vessel via a pump. The installation is cleaned with water. The empty vessels that contained the solid $CrO_3$ are also cleaned and disposed by an external contractor. Subsequently, the surrounding area is cleaned of any residual $CrO_3$ formulation with water. The water is directly discharged to the wastewater treatment system via a drainage system in the floor.

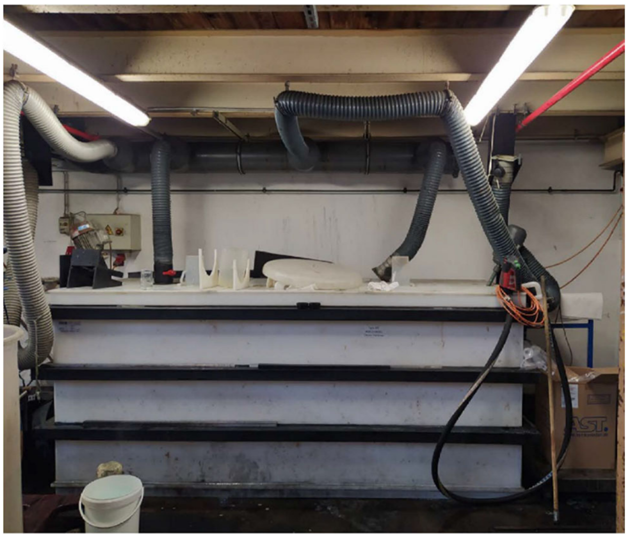

**Figure 7:** Mixing tanks in department A (left) and the department B (right)

Full PPE (safety shoes and clothes, chemically resistant gloves [exchanged every two days], face protection, dust safety RPE [FFP3 with APF 30; one-time use]) is worn during the described tasks in both production rooms. A summary of the room conditions is given in **Table 20**. The conditions of use are summarized in **Table 21**.

**Table 20:** Conditions in rooms used for the preparation of $CrO_3$-containing formulations (WCS 2)

| Condition | Department A | Department B |
|---|---|---|
| $CrO_3$ concentration of formulations | [redacted] % | [redacted] % |
| Room temperature | Ambient | Ambient |
| Mixing tank with a lid | 1 | 1 |
| Mixing tank size | [redacted] m³ (0.5 – 2 m³) | [redacted] m³ (1.5 – 5 m³) |
| Mixing tank surface area (liquid) | [redacted] m² (0.25 – 1.5 m²) | [redacted] m² (2 – 5 m²) |
| LEV | yes | yes |
| Air wet scrubber connected to LEV | yes | yes |
| Nominal flow rate of scrubber | [redacted] m³/h | [redacted] m³/h |

**Table 21:** Conditions of use for ES 1 – WCS 2

| Conditions | | | Method |
|---|---|---|---|
| **Product (article) characteristics** | Substance product type | Solid (transfer of solid $CrO_3$ into the mixing tank) and Liquid (in the formulation) | Measured data |
| | Substance as such/in a mixture. Concentration of Cr(VI) in the electrolyte: | Solid: ≤ 52 %<br>Liquid: Substantial (10 – 50 %) | |
| | Process temperature | Room temperature | |
| | Vapor pressure of substance | < 0.01 Pa | |
| | Viscosity | Low | |
| **Activity emission potential** | Frequency | Daily | |
| | Duration of activity | 3.0 – 4.0 h | |
| **Surface contamination** | Process fully enclosed? | No | |
| | Effective housekeeping practices in place? | Yes | |
| **Dispersion** | Work area | Indoors | |
| | Room size | ≥ 300 m³ | |
| **Technical and organisational conditions and measures** | Primary | Fixed capturing hoods and/or moveable LEV hoses | |
| | Secondary | No localized controls (0.0% reduction) | |
| | Ventilation rate | Mechanical ventilation giving at least 1 ACH | |
| **Conditions and measures related to personal protection, hygiene and health evaluation** | Respiratory Protection | Yes (FFP3 with APF 30 during transfer of solid $CrO_3$) | |

### 9.2.4.2. Exposure and risks for workers

Workplace exposure measurements were conducted by the formulator in 2020 covering the tasks described in the previous section. The results of three personal measurements (one worker of department B and two workers of department A) were pooled for exposure assessment. Two of the measurements were below the respective limit of detection (LOD) of 0.14 and 0.16 µg/m³. For those measurements, half of the LOD was used for further calculation. The average value was 0.120 µg/m³, the 90th percentile sat at 0.184 µg/m³. Details about the measurements (*i.e.*, tasks performed by the employees) are summarized in the **Annex**, **section 1.1**.

The exposure estimate based on the 90th percentile of the measured data from air sampling of 1.84E-01 µg Cr(VI)/m³ is used as basis for risk characterization for ES 1 – WCS 2. The resulting exposure concentration is presented in **Table 22**.

**Table 22**: Exposure concentration for ES 1 – WCS 2

| Contributing scenario | Route of exposure | Method of assessment | Exposure value (8h TWA) | Exposure value corrected for PPE | Exposure value corrected for PPE and frequency |
|---|---|---|---|---|---|
| WCS 2 | Inhalation | Measured data | 1.84E-01 µg/m³ | 1.84E-01 µg/m³ | 1.84E-01 µg/m³ |

The excess lifetime lung cancer risk was estimated using the information provided by ECHA in the RAC document "Establishing a reference dose response relationship for carcinogenicity of hexavalent chromium" (RAC/27/2012/06 Rev.1). The estimated exposure value corrected for PPE and frequency (1.84E-01 µg/m³) was hence multiplied with a factor of 4. This corresponds to the value established by RAC for the excess lifetime (up to age 89) lung cancer risk estimates for workers exposed at different 8h-TWA concentrations of Cr(VI) for 40 years.

From the data an excess lifetime lung cancer risk of **7.36E-01 per 1000 exposed workers** is estimated.[10] Please note that during the transfer of solid $CrO_3$ employees also wear RPE with an APF of 30, further reducing exposure and risk. The reduction was however not considered in the risk calculation as RPE is not worn during all tasks covered by the personal measurements.

[10] As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks interfered in the low exposure range (*i.e.* below an exposure concentration of 1 µg Cr(VI)/m³ might be an over-estimate.

### 9.2.5. Worker contributing scenario 3: Sampling (PROC 8b)

#### 9.2.5.1. Conditions of use

The concentration of the $CrO_3$ containing formulation is analysed in a QC laboratory on-site. Samples are taken manually with a 0.25 l plastic vessel twice per week by one employee. The task takes ≤ 15 minutes. During sampling, the employee wears safety footwear and clothing, face protection and long, chemical resistant gloves that reach above the elbows. Exemplary pictures of the sampling are presented below in **Figure 8**. The number of workers, the frequency and duration of the task are summarized in **Table 23**. The conditions of use are displayed in **Table 24**.


**Figure 8:** Sampling of $CrO_3$ containing solution using a plastic measuring vessel. The employee is protected against exposure via long, chemically protective gloves and the use of face protection.

**Table 23**: Description of workers, frequency, and duration of the tasks of WCS 3

| | **Workers involved (n)** | **Time to complete the task (min)** | **Frequency of task (per week)** |
|---|---|---|---|
| Maximum | 1.0 | 15.0 | 2.0 |

**Table 24**: Conditions of use for ES 1 – WCS 3

| Conditions | | | Method |
|---|---|---|---|
| **Product (article) characteristics** | Substance product type | Liquid | ART 1.5 |
| | Substance as such/in a mixture. Concentration of Cr(VI) in the electrolyte: | ≤ 34 % | |
| | Process temperature | Room temperature | |
| | Vapor pressure of substance | < 0.01 Pa | |
| | Viscosity | Low | |
| **Activity emission potential** | Frequency | 2 times per week | |
| | Duration of activity | ≤ 15.0 minutes | |
| | Primary emission source located in the breathing zone of the worker | Yes | |
| | Activity class | Activities with relatively undisturbed surfaces (no aerosol formation) | |
| | Situation | Open surface 0.3 – 1 m² | |
| **Surface contamination** | Process fully enclosed? | No | |
| | Effective housekeeping practices in place? | Yes | |
| **Dispersion** | Work area | Indoors | |
| | Room size | 300 m³ | |
| **Technical and organisational conditions and measures** | Primary | No localized controls (0.00 % reduction) | |
| | Secondary | No localized controls (0.00 % reduction) | |
| | Ventilation rate | Mechanical ventilation giving at least 1 ACH | |
| **Conditions and measures related to personal protection, hygiene and health evaluation** | Respiratory Protection | No | |

### 9.2.5.2. Exposure and risks for workers

The modelled exposure estimate (see ART printouts in the **Annex**, **section 3.1**) of 3.90 E-01 µg Cr(VI)/$m^3$ was used as the basis for risk characterization of ES 1 – WCS 3 (**Table 25**).

As supportive evidence, one of the three personal measurements performed at the formulators site in 2020 covered among others sampling of the formulation by a worker at the department B. The measurement result was below the LOD of 0.14 µg/$m^3$ (see **Annex**, **section 1.1**). Since the modelled and measured exposure level are on comparable levels, the more conservative modelled value was used for the risk characterization as a worst-case approach.

**Table 25:** Exposure concentrations for ES 1 – WCS 3

| Contributing scenario | Route of exposure | Method of assessment | Exposure value (8h TWA) | Exposure value corrected for PPE | Exposure value corrected for PPE and frequency |
|---|---|---|---|---|---|
| WCS 3 | Inhalation | ART 1.5 | 3.90E-01 µg/m³ | 3.90E-01 µg/m³ | 1.56E-01 µg/m³ [1)] |

[1)] The estimate was based on the time taken for the task per month. In order to adjust for daily exposure, the exposure value was multiplied with a factor of 0.40 (2 working days a week).
Equation used to calculate the adjusted exposure value: 3.90E-01 µg/m³ × 0.40

The excess lifetime lung cancer risk was estimated using the information provided by ECHA in the RAC document "Establishing a reference dose response relationship for carcinogenicity of hexavalent chromium" (RAC/27/2012/06 Rev.1). The estimated exposure value corrected for PPE and frequency (1.56E-01 µg/m³) was hence multiplied with a factor of 4. This corresponds to the value established by RAC for the excess lifetime (up to age 89) lung cancer risk estimates for workers exposed at different 8h-TWA concentrations of Cr(VI) for 40 years.

From the data an excess lifetime lung cancer risk of **6.24E-01 per 1000 exposed workers** is estimated.

## 9.2.6. Worker contributing scenario 4: Maintenance (PROC 28)

### 9.2.6.1. Conditions of use

As described by the formulator, tanks and equipment is checked visually before each use (2 days per week for 5 minutes by 2 workers). Moreover, the tanks, pumps and stirrers are checked by internal industrial engineers/maintenance personnel once to twice yearly. Every seven years (approximately) the funnel for filling solid $CrO_3$ is exchanged in department A. However, maintenance is only performed on the cleaned equipment and hence exposure is highly improbable.

The worst-case scenario of potential exposure is presented by the maintenance of the chrome scrubbers during which the filters of the scrubber are rinsed out. The task is performed on 2 days per week by 2 workers. As a worst-case assumption, a duration of 15 minutes is assumed. The maximum concentration of $CrO_3$ in the chrome scrubbers is [redacted] g/l (≈ [redacted] %). The exposure for this maintenance task was modelled with ART 1.5 to estimate the risk for workers. Full PPE (safety footwear and clothing, chemically resistant gloves, face protection and dust-filters [disposable FFP3 masks]) are worn.

The number of workers, the frequency and duration of the task is summarized in **Table 26**. The conditions of use are displayed in **Table 27**.

**Table 26**: Description of workers, frequency and duration of the tasks of WCS 4

| | Workers involved (n) | Time to complete the task (min) | Frequency of task (per week) |
|---|---|---|---|
| Maximum | 2.0 | 15.0 | 2.0 |

**Table 27:** Conditions of use for ES 1 – WCS 4

| Conditions | | | Method |
|---|---|---|---|
| **Product (article) characteristics** | Substance product type | Liquid | ART 1.5 |
| | Substance as such/in a mixture. Concentration of Cr(VI) in the electrolyte: | Small (1 to 5 %) | |
| | Process temperature | Room temperature | |
| | Vapor pressure of substance | < 0.01 Pa | |
| | Viscosity | Low | |
| **Activity emission potential** | Frequency | 2.0 –times per week | |
| | Duration of activity | ≤ 15.0 minutes | |
| | Primary emission source located in the breathing zone of the worker | Yes | |
| | Activity class | Handling of contaminated objects | |
| | Situation | Activities with treated/contaminated objects (surface 1 – 3 m²) | |
| | Contamination level | Contamination > 90 % of surface | |
| **Surface contamination** | Process fully enclosed? | No | |
| | Effective housekeeping practices in place? | Yes | |
| **Dispersion** | Work area | Indoors | |
| | Room size | 300 m³ | |
| **Technical and organisational conditions and measures** | Primary | No localized controls (0.00 % reduction) | |
| | Secondary | No localized controls (0.00 % reduction) | |
| | Ventilation rate | Mechanical ventilation giving at least 1 ACH | |
| **Conditions and measures related to personal protection, hygiene and health evaluation** | Respiratory Protection | Yes (disposable FFP3 masks [APF 30]) | |

### 9.2.6.2. Exposure and risks for workers

The modelled exposure estimate (see ART printouts in the **Annex**, **section 3.1**) of 3.40E-02 µg Cr(VI)/m³ was used as the basis for risk characterization for ES 1 – WCS 4 (**Table 28**).

**Table 28:** Exposure concentrations for ES 1 – WCS 4

| Contributing scenario | Route of exposure | Method of assessment | Exposure value (8h TWA) | Exposure value corrected for PPE [1)] | Exposure value corrected for PPE and frequency [2)] |
|---|---|---|---|---|---|
| WCS 4 | Inhalation | ART 1.5 | 3.40E-02 µg/m³ | 1.13E-03 µg/m³ | 4.53E-04 µg/m³ |

1) During the task a disposable FFP3 mask with APF 30 is worn
Equation used to calculate the adjusted exposure value: 3.40E-02 µg/m³ × (1/30)
2) The estimate was calculated for daily exposure. However, the task is only performed at a maximum of three times per working week of five days. In order to adjust for actual daily exposure, the exposure value was multiplied with a factor of 0.40 (2 working days a week).
Equation used to calculate the adjusted exposure value: 1.13E-03 µg/m³ × 0.40

The excess lifetime lung cancer risk was estimated using the information provided by ECHA in the RAC document "Establishing a reference dose response relationship for carcinogenicity of hexavalent chromium" (RAC/27/2012/06 Rev.1). The estimated exposure value corrected for PPE and frequency (4.53E-04 µg/m³) was hence multiplied with a factor of 4. This corresponds to the value established by RAC for the excess lifetime (up to age 89) lung cancer risk estimates for workers exposed at different 8h-TWA concentrations of Cr(VI) for 40 years.

From the data an excess lifetime lung cancer risk of **1.81E-03 per 1000 exposed workers** is estimated.[11]

[11] As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks interfered in the low exposure range (*i.e.* below an exposure concentration of 1 µg Cr(VI)/m³ might be an over-estimate.

## 9.2.7. Worker contributing scenario 5: Wastewater sampling and waste management (solid and liquid) (PROC 8b)

### 9.2.7.1. Conditions of use

Cleaning of the empty $CrO_3$ containers is covered under WCS 2 (**section 9.2.4**) as it is performed in the same area and is considered as one of the work steps of this scenario. The cleaned $CrO_3$ containers are disposed by an external contractor. Used and potentially contaminated PPE (solid waste) is collected in specified containers and disposed of as hazardous waste by an external contractor.

Wastewater is treated in an on-site wastewater treatment plant. Samples are drawn daily by 1 worker in the wastewater treatment area. The task takes ≤ 15 minutes. Two possible procedures are available for wastewater sampling:

1. The sample is drawn directly from the tank and filtered into a small (0.25 l) vessel with the help of a sampler.
2. The sample is drawn and filtered into a small (0.25 l) vessel from a drain valve at the tank.

As a worst-case it is assumed that all sampling is conducted directly from the open surface of the tank. The permitted limit value of Cr(VI) in wastewater is 0.1 mg/l (German federal laws and *Land* laws apply[12]). As the measurements show that the level is not exceeded, a minute concentration (0.01 to 0.1 %) of Cr(VI) is assumed for the modelling with ART 1.5. During the sampling, the employee wears safety footwear and clothing, face protection and chemical resistant gloves.

The number of workers, the frequency and duration of the task is summarized in **Table 29**. The conditions of use are displayed in **Table 30**.

**Table 29**: Description of workers, frequency and duration of the tasks of WCS 5

| | Workers involved (n) | Time to complete the task (min) | Frequency of task |
|---|---|---|---|
| Maximum | 1.0 | 15.0 | Daily |

[12] *i.e.*: *Wasserhaushaltsgesetz, Abwasserverordnung, Landeswassergesetz NRW, Zuständigkeitsverordnung Umweltschutz, Selbstüberwachungsverordnung Kanal*

**Table 30:** Conditions of use for ES 1 – WCS 5

| Conditions | | | Method |
|---|---|---|---|
| **Product (article) characteristics** | Substance product type | Liquid | ART 1.5 |
| | Substance as such/in a mixture. Concentration of Cr(VI) in the electrolyte: | Minute (0.01 to 0.1 %) | |
| | Process temperature | Room temperature | |
| | Vapor pressure of substance | < 0.01 Pa | |
| | Viscosity | Low | |
| **Activity emission potential** | Frequency | Daily | |
| | Duration of activity | ≤ 15.0 minutes | |
| | Primary emission source located in the breathing zone of the worker | Yes | |
| | Activity class | Activities with relatively undisturbed surfaces (no aerosol formation) | |
| | Situation | Open surface 0.3 – 1 $m^2$ | |
| **Surface contamination** | Process fully enclosed? | No | |
| | Effective housekeeping practices in place? | Yes | |
| **Dispersion** | Work area | Indoors | |
| | Room size | 300 $m^3$ | |
| **Technical and organisational conditions and measures** | Primary | No localized controls (0.00 % reduction) | |
| | Secondary | No localized controls (0.00 % reduction) | |
| | Ventilation rate | Mechanical ventilation giving at least 1 ACH | |
| **Conditions and measures related to personal protection, hygiene and health evaluation** | Respiratory Protection | No | |

### 9.2.7.2. Exposure and risks for workers

The modelled exposure estimate (see ART printouts in the **Annex**, **section 3.1**) of 6.80E-04 µg Cr(VI)/m$^3$ was used as the basis for risk characterization of ES 1 – WCS 5 (**Table 31**).

**Table 31:** Exposure concentrations for ES 1 – WCS 5

| Contributing scenario | Route of exposure | Method of assessment | Exposure value (8h TWA) | Exposure value corrected for PPE | Exposure value corrected for PPE and frequency |
|---|---|---|---|---|---|
| WCS 5 | Inhalation | ART 1.5 | 6.80E-04 µg/m³ | 6.80E-04 µg/m³ | 6.80E-04 µg/m³ |

The excess lifetime lung cancer risk was estimated using the information provided by ECHA in the RAC document "Establishing a reference dose response relationship for carcinogenicity of hexavalent chromium" (RAC/27/2012/06 Rev.1). The estimated exposure value corrected for PPE and frequency (6.80E-04 µg/m³) was hence multiplied with a factor of 4. This corresponds to the value established by RAC for the excess lifetime (up to age 89) lung cancer risk estimates for workers exposed at different 8h-TWA concentrations of Cr(VI) for 40 years.

From the data an excess lifetime lung cancer risk of **2.72E-03 per 1000 exposed workers** is estimated.[13]

[13] As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks interfered in the low exposure range (*i.e.* below an exposure concentration of 1 µg Cr(VI)/m$^3$ might be an over-estimate.

## 9.3. Exposure Scenario 2

### 9.3.1. Description of the activities and technical processes covered in this ES

In this ES, the exposure of man via environment and of workers by functional chrome plating of cylinders used in the rotogravure printing and embossing industry based on $CrO_3$ is covered. A summary of the described tasks is given in **Table 32**.

**Table 32:** Descriptors of ES 2

| | |
|---|---|
| **Market sector** | Use at industrial site |
| **Sector of use** | SU 0: Other – Rotogravure industry |
| **Article categories** | Rotogravure and embossing cylinders for the printing of *e.g.* packaging, magazines, or floorings |
| **Environment Contributing Scenario(s)** | ECS 1: Chromium trioxide-based functional chrome plating of cylinders (ERC 5) |
| **Worker Contributing Scenario(s)** | WCS 1: Delivery and storage of raw material (PROC 1)<br>WCS 2: Chrome electroplating unit (PROC 13)<br>WCS 3: Sampling (PROC 8b)<br>WCS 4: Concentration adjustment with liquid $CrO_3$ (PROC 8b)<br>WCS 5: Maintenance (PROC 28)<br>WCS 6: Waste management (PROC 8b) |
| **Subsequent service life exposure scenario(s)** | Not Relevant |
| **Exposure scenario(s) of the uses leading to the inclusion of the substance into the article(s)** | None |

K.Walter provides electroplating units for the functional chrome plating of cylinders applied for rotogravure printing or embossing.

Rotogravure printing is a printing technique based on the transfer of fluid ink from engravings on a printing cylinder to the surface of a substrate, or the material to be printed. Rotogravure is used primarily for long printing runs in applications such as magazines, catalogues, inserts, flyers, gift-wrap, and labels, among many others, achieving fine and clear images. Embossing is a process by which a relief is created on a substrate, usually paper, by means of a gravure cylinder. This technique is used for giving a 3D texture to the embossed surface for both decorative and functional purposes, *e.g.* chocolate packaging where printed sections are raised to match printed or drawings on the package or specific surface pattern that provides anti slip properties to the surface.

Even though these processes and their end products are different, the process of Cr(VI) plating of the cylinders is the same:

The production of gravure cylinders starts with the degreasing of steel cylinders, followed by copper plating and finishing. The printing pattern is then embedded into the copper coating through either engraving or laser imaging. Regardless of the method applied, the cylinders are then degreased and finally plated with chromium in a 20-minute step carried out in the closed electroplating unit. Following a finishing step, the cylinders are ready for printing.

The entire cylinder preparation process takes approximately 210 minutes if the cylinders are engraved and approximately 230 minutes if direct laser imaging is used instead. In **Figure 9** a finished chrome plated printing cylinder is shown.

**Figure 9:** Chrome plated gravure cylinder.

A general explanation on the approach taken is provided in **section 9.1**. Specific information is given in each sub-section of the respective ECS/WCS.

## 9.3.2. Environmental contributing scenario 1: Chromium trioxide-based functional chrome plating of cylinders (ERC 5)

### 9.3.2.1. Conditions of use

As described in **section 9.1.2**, measured data were used for the assessment of man via environment. The provided data were included in the estimation when relevant information to estimate the yearly emissions were available (*e.g.*, $CrO_3$ tonnage, flow rate of the exhaust ventilation, emission days). Sufficient information on air emissions allowing an exposure assessment for man via environment were available from 28 companies in 8 EU-States (Austria, Croatia, France, Germany, Italy, Poland, Portugal, and Spain) covering the time period 2007-2020. All details on measurements and calculations are listed in the **Annex**, **section 2.2**. $CrO_3$ and Cr(VI) concentrations in the wastewater were not considered as described in **section 9.1.4.2**.

To derive air emission values to be used for the risk assessment, the DUs data were used to individually calculate the $c_{local\ air\ annual}$. In order to do so, daily releases of Cr(VI) were calculated for each DU in a first step. Subsequently, daily release values were multiplied with the concentration in air at a source strength of 1 kg/d, *i.e.* 2.78E-4 mg/m³ to calculate the local concentration in air during release episode $c_{local\ air}$ [14]:

$$\text{Daily release of Cr(VI)} \times 2.78\text{E-4}\ \frac{mg}{m^3} = c_{local\ air}\ \text{in}\ \frac{mg}{m^3}$$

The resulting values ranged from 1.23E-08 mg/m³ to 2.14E-06 mg/m³ with a mean value of 4.94E-07 mg/m³ and a 90th percentile of 1.42E-06 mg/m³.

The maximum value was used in the risk assessment of man via environment and the pathway inhalation. To consider the exposure of man via environment by oral exposure (food), the highest reported annual tonnage of 6.5 t $CrO_3$ (*i.e.* 3.38 t Cr(VI)) was related to the maximum calculated exposure estimate of 2.14E-06 mg/m³ in Chesar 3. The related release fraction was determined as 0.083 %.

[14] ECHA (2016). Guidance on information requirements and Chemical Safety Assessment – Chapter R.16: Environmental exposure assessment (Version 3.0)

**Table 33:** Conditions of use for ES 2 – ECS 1

| Conditions | | | Method |
|---|---|---|---|
| **Product (article) characteristics** | Substance as such/in a mixture | Concentration of Cr(VI): minute | Default assumption |
| **Amount used, frequency and duration of use (or from service life)** | Daily use at site | ≤ 0.0169 t/day | DU data |
| | Annual use at a site | ≤ 3.38 t/year | |
| | Percentage of EU tonnage used at regional scale | 100% | Default assumption |
| **Conditions and measures related to sewage treatment plant** | Biological STP | Standard [Effectiveness Water: 0.147%] | Default assumption |
| | Discharge rate of STP | ≥ 2E03 $m^3$/d | |
| | Application of STP sludge on agricultural soil | Yes | |
| **Conditions and measures related to treatment of waste (including article waste)** | Particular considerations on the waste treatment operations | No (low risk) (ERC based assessment demonstrating control of risk with default conditions. Low risk assumed for waste life stage. Waste disposal according to national/local legislation is sufficient.) | Default assumption |
| **Other conditions affecting environmental exposure** | Receiving surface water flow rate | ≥ 1.8E04 $m^3$/d | Default assumption |

## 9.3.2.2. Releases

The release rates based on the conditions of use and measurement values are described below in **Table 34**.

**Table 34:** Local releases to the environment

| Release route | Release factor | | Release | Release estimation justification, method and details |
|---|---|---|---|---|
| Water | Final release factor | 0 % | 0 kg/year | Not relevant |
| Air | Final release factor | 0.083 % | 2.805 kg/year | Based on measured data |
| | Local release rate | 0.014 kg/day | | |
| Soil | Final release factor | 0 % | 0 kg/year | Not relevant |
| Waste | Final release factor | 0 % | 0 kg/year | Not relevant |

## 9.3.2.3. Exposure and risks for man via environment

Based on the information provided by DUs, a worst-case estimate of 2.14E-06 mg/$m^3$ was calculated for the annual local air concentration ($c_{local\ air\ annual}$) of Cr(VI). The annual regional predicted environmental concentration of Cr(VI) ($PEC_{regional\ air\ annual}$) was estimated to be 1.59E-15 mg/$m^3$.

Both values, $c_{local\ air\ annual}$ and $PEC_{regional\ air\ annual}$, were summed to estimate the annual local PEC for the compartment air ($PEC_{local\ air\ annual}$). The $PEC_{local\ air\ annual}$ was calculated as 2.14E-06 mg/$m^3$.

**Table 35:** Exposure concentrations and risks for the environment – on local scale

| Protection target | Exposure concentration |
|---|---|
| Air | Local PEC: 2.14 E-06 mg/m³ |
| Man via Environment - Inhalation | Local PEC: 2.14 E-06 mg/m³ |

The excess lifetime lung cancer risk was estimated using the information provided by ECHA in the RAC document "Establishing a reference dose response relationship for carcinogenicity of hexavalent chromium" (RAC/27/2012/06 Rev.1). The estimated $PEC_{local\ air\ annual}$ of 2.14E-06 mg/m³ = 2.14E-3 µg/m³ was hence multiplied with a factor of 29. This corresponds to the value established by RAC for the excess lifetime lung cancer risk estimates for the general population exposed at different ambient concentrations of Cr(VI) for 70 years.

From the data an excess lifetime lung cancer risk of **6.21E-02 per 1000 exposed** is estimated.

As described in **section 9.1.4.2**, the oral exposure route is also taken into account for the exposure of man via the food chain. This is to address the risk of intestinal cancer. Because no exposure to soil is assumed, only oral exposure via water (as described earlier: from deposition of airborne Cr(VI) to waterbodies, not from Cr(VI) in wastewater) is considered relevant. This covers drinking water and fish. The exposure estimates derived with Chesar 3 are summarized in **Table 36**.

**Table 36:** Contribution to oral intake for humans via the environment from local contribution

| Type of food | Estimated daily dose | Concentration in food |
|---|---|---|
| Drinking water | 2.44E-07 mg/kg bw/day | 8.55E-6 mg/L |
| Fish | 1.09E-10 mg/kg bw/day | 6.66E-8 mg/kg ww |
| Leaf crops | 3.23E-04 mg/kg bw/day | 0.019 mg/kg ww |
| Root crops | 4.44E-08 mg/kg bw/day | 8.09E-6 mg/kg ww |
| Meat | 4.35E-09 mg/kg bw/day | 1.01E-6 mg/kg ww |
| Milk | 8.11E-08 mg/kg bw/day | 1.01E-5 mg/kg ww |

The summed estimated daily dose from the consumption of drinking water and fish was calculated as **2.44E-07 mg/kg bw/day**.

Subsequently, the estimated daily exposure was accounted for the transformation of Cr(VI) to Cr(III) with a reduction factor of 97% (see EU RAR 2005):

$$2.44\text{E-}07\ \frac{\text{mg}}{\text{kg bw} \times \text{day}} \times 0.03 = 7.32\text{E-}09\frac{\text{mg}}{\text{kg bw} \times \text{day}} = 7.32\text{E-}06\frac{\mu\text{g}}{\text{kg bw} \times \text{day}}$$

The excess lifetime small intestinal cancer risk was estimated using the information provided by ECHA in the RAC document "Establishing a reference dose response relationship for carcinogenicity of hexavalent chromium" (RAC/27/2012/06 Rev.1). The estimated exposure concentration was hence multiplied with a factor of **0.8.** This corresponds to the value established by RAC for the excess lifetime small intestinal cancer risk estimates for the general population exposed at different oral concentrations of Cr(VI) for 70 years.

From the data, an excess lifetime small intestinal cancer risk of **5.86E-06 per 1000 exposed** is estimated.

### 9.3.2.4. Addendum to ECS 1 to be applied in SEA

The exposure values and corresponding risk assessment presented in **sections 9.3.2.1** to **9.3.2.3** are worst-case estimations as those are based on the maximum tonnage consumed as well as the highest exposure $C_{local\ air}$ calculated. However, in order to consider the impact of the described use of $CrO_3$ in the Socio-Economic Analysis it is mathematically inadequate to use the maximum value as a surrogate for all 117 sites. Therefore, a second assessment was performed based on the derived release fraction of 0.083 % and the mean annual tonnage of [redacted] t $CrO_3$ (*i.e.* [redacted] t Cr(VI)/a; [redacted] t Cr(VI) per day based on the tonnage applied for of [redacted] t Cr(VI)/a). Apart from those deviations, the same conditions as described in **Table 33** apply.

The local releases calculated with the described input values are listed in **Table 37**. It is noteworthy that the annual release of [redacted] kg/year calculated with this approach is in close range to the mean annual release of 0.649 kg/year calculated with DU data; in this regard, the presented value can be considered as realistic, slightly over-estimating the measured values.

**Table 37:** Local releases to the environment (Mean tonnage, SEA-specific)

| Release route | Release factor | | Release | Release estimation justification, method and details |
|---|---|---|---|---|
| Water | Final release factor | 0 % | 0 kg/year | Not relevant |
| Air | Final release factor<br>Local release rate | 0.083 %<br>[redacted] kg/day | [redacted] kg/year<br>(0.6 – 0.8 kg/year) | Based on measured data |
| Soil | Final release factor | 0 % | 0 kg/year | Not relevant |
| Waste | Final release factor | 0 % | 0 kg/year | Not relevant |

The corresponding $C_{local\ air\ annual}$ was calculated as 5.88E-7 mg/m³. The $PEC_{regional\ air\ annual}$ was reported as 0 mg/m³ by Chesar. However, the $PEC_{regional\ air\ annual}$ of 1.59E-15 mg/m³ which is based on the maximum tonnage of 3.38 t Cr(VI)/year (**section 9.3.2.3**) can be used to estimate a $PEC_{regional\ air\ annual}$ of 4.37E-16 mg/m³ for the mean tonnage of [redacted] tons Cr(VI)/year, [redacted]. In any case, the $PEC_{local\ air\ annual}$ (*i.e.* the sum of both values) was reported as 5.88E-7 mg/m³ by Chesar (**Table 38**).

**Table 38:** Exposure concentrations and risks for the environment – on local scale (Mean tonnage, SEA-specific)

| Protection target | Exposure concentration |
|---|---|
| Air | Local PEC: 5.88E-7 mg/m³ |
| Man via Environment - Inhalation | Local PEC: 5.88E-7 mg/m³ |

According to the process described in **section 9.3.2.3**, the local PEC was used to determine a risk of **1.71E-02 per 1000 exposed**.

Consistent with the approach described above, the exposure and risks of man via environment via oral exposure was based on the consumption of drinking water and fish. All calculated values are listed below (**Table 39**). The risk was calculated as **1.61E-06 per 1000 exposed**, following the same approach as described above (**section 9.3.2.3**).

**Table 39:** Contribution to oral intake for humans via the environment from local contribution (Mean tonnage, SEA-specific)

| Type of food | Estimated daily dose | Concentration in food |
|---|---|---|
| Drinking water | 6.72E-08 mg/kg bw/day | 2.35E-6 mg/l |
| Fish | 3.01E-11 mg/kg bw/day | 1.83E-8 mg/kg ww |
| Leaf crops | 8.88E-05 mg/kg bw/day | 5.18E-3 mg/kg ww |
| Root crops | 1.22E-08 mg/kg bw/day | 2.23E-6 mg/kg ww |
| Meat | 1.20E-09 mg/kg bw/day | 2.78E-7 mg/kg ww |
| Milk | 2.23E-08 mg/kg bw/day | 2.78E-6 mg/kg ww |

Finally, a risk value may be calculated for the estimated regional exposure ($PEC_{regional\ air\ annual}$ of 4.37E-16 mg/m³) by itself. In accordance with the above described procedure (**section 9.3.2.3**), a risk of **1.27E-11 per 1000 exposed** would result for the pathway inhalation to regional exposure on the basis of the mean tonnage.

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

### 9.3.3.1. Conditions of use

$CrO_3$ is delivered as a solution in an IBC, unloaded and stored in a chemical storage or is directly attached to the automated dosing system (WCS 4).

On average, 2 workers (90$^{th}$ percentile = 3 workers) per site are usually engaged in this activity. The task takes on average 1.3 h (90$^{th}$ percentile = 1.4 h) to complete. Raw material is delivered about 5 times per year. The data provided by the DUs are summarized below (**Table 40**). Furthermore, the total number of workers was estimated by multiplying the mean number of workers times the number of DU sites and added to the table. This procedure was performed for all following WCS described for ES 2. Please note that these data also contain information provided by DUs using both, solid and liquid or only solid $CrO_3$.

**Table 40:** Information provided by DUs on WCS 1

| | Workers involved (n) | Time to complete the task (h) | Raw material deliveries per year (n) |
|---|---|---|---|
| Minimum | 1.0 | 0.1 | 1.0 |
| Maximum | 17.0 | 48.0 | 15.0 |
| Median | 2.0 | 0.5 | 4.0 |
| Mean | 2.3 | 1.3 | 4.8 |
| 90$^{th}$ percentile | 3.0 | 1.4 | 10.0 |
| DU responses (n) | 83 | 83 | 81 |
| Total number of workers estimate = 2.3 x 117 = 269 | | | |

General PPE (protective clothing and safety footwear) is worn during delivery and storage. Access to the storage cabinet is restricted to authorised, trained personnel only. There is no potential for exposure. The conditions of use are summarized in below **Table 41**.

**Table 41:** Conditions of use for ES 2 – WCS 1

| Conditions | | | Method |
|---|---|---|---|
| **Product (article) characteristics** | Substance as such/in a mixture. Concentration of Cr(VI) | ≤ 35 % | Qualitative |
| **Amount used (or contained in articles), frequency and duration of use/exposure** | Amount used | Not applicable | |
| | Frequency | 10.0 times per year (90th percentile) | |
| | Duration of activity | 1.4 h (90th percentile) | |
| **Technical and organisational conditions and measures** | Containment | Closed system (minimal contact during routine operations) | |
| | Local exhaust ventilation | No | |
| | Occupational Health and Safety Management System | Advanced *) | |
| **Conditions and measures related to personal protection, hygiene and health evaluation** | Respiratory Protection | No | |
| **Other conditions affecting workers exposure** | Place of use | Indoor | |
| | Process temperature | Room temperature | |

*) Advanced Health and Safety management systems is terminology referred to within exposure assessment models such as ECETOC TRA. Such models assume that a significant reduction in exposure can be achieved through use of Health and Safety management systems and assume this to be the default for industrial operations. This can be seen to reflect the fact that companies have a duty of care to their employees through general Health and Safety at Work legislation, as well as via more specific legislation, such as the Carcinogens Directive (2004/37/EC) and the Chemical Agents at Work Directive (98/24/EC).
There is no standard definition of this term but, based on regulatory requirements, it can be considered to include:

- Requirement to ensure only workers essential for repairs shall be permitted to work in the affected area, and only with appropriate protection. The exposure may not be permanent and shall be minimised.
- Requirement to ensure if a temporary, planned higher exposure is unavoidable (*e.g.* maintenance), the employer shall consult workers/representatives on the measures to minimise exposure, and provide appropriate prevention, together with access control.
- Provision of appropriate hygienic circumstances for workers free of charge
    - Prohibition of eating/drinking/smoking in contamination risk areas
    - Appropriate protective clothing
    - Separate storage places for working/protective clothing and for street clothes
    - Appropriate and adequate washing and toilet facilities
    - Cleaned, checked and maintained protective equipment, stored in a well-defined place.
- Provision of appropriate training on potential risks to health, precautions to prevent exposure, hygiene requirements, protective equipment, clothing and incidents.
- Requirement to inform on objects containing carcinogens or mutagens, and label them clearly and legibly, together with warning and hazard signs.
- Requirement to inform workers and/or representatives on abnormal exposures as quickly as possible.

## 9.3.3.2. Exposure and risks for workers

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

**Table 42:** Exposure concentrations for ES 2 – WCS 1

| Contributing scenario | Route of exposure | Method of assessment | Exposure value (8h TWA) | Exposure value corrected for PPE | Exposure value corrected for PPE and frequency |
|---|---|---|---|---|---|
| WCS 1 | Inhalation | Qualitative | 0 µg/m³ | 0 µg/m³ | 0 µg/m³ |

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

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

## 9.3.4. Worker contributing scenario 2: Chrome electroplating unit (PROC 13)

### 9.3.4.1. Conditions of use

The chrome plating process in a K.Walter electroplating unit (**Figure 10**) is designed for automatic and unstaffed chrome plating of rotogravure cylinders. Although the plating process is conducted with a closed hood, the electroplating unit is not enclosed air-tight (*i.e.* because the plating tank takes in air from the outside to balance the exhaust airflow; this is necessary to prevent the creation of an explosive atmosphere within the tank caused by the generation of $H_2$). The $CrO_3$ solution is situated in an enclosed basin below the main tank and is only pumped up to the main tank when the plating process is started and the unit is closed. After the plating process is finished, the solution flows back into the basin and the cylinder is rinsed with water before the unit is opened again for unloading. Therefore, any potential for exposure is low.

Additionally, the loading and unloading of the electroplating unit is performed via an automated or manual crane, which minimizes the exposure potential. The crane is controlled either fully automatically according to a pre-defined programme or manually via a remote control.

During automatic loading and unloading, no employee is involved in the process or is positioned in the immediate vicinity (within a distance of ~ 1 m) of the electroplating unit. The process is exemplarily depicted in **Figure 11**. In the automatic loading process using a cylinder crane (1) the cylinder is picked up (2) and transported to the electroplating unit (3). The cylinder crane lowers the cylinder (4) and the electroplating unit opens. The cylinder is automatically clamped (5). Before the plating process begins, the opening of the electroplating unit is closed (6). After the chrome plating process, the cylinder is rinsed with water inside the closed chrome plating unit, before the lid opens and the cylinder is picked up again by the cylinder crane.


**Figure 10:** K.Walter electroplating unit SlimLine

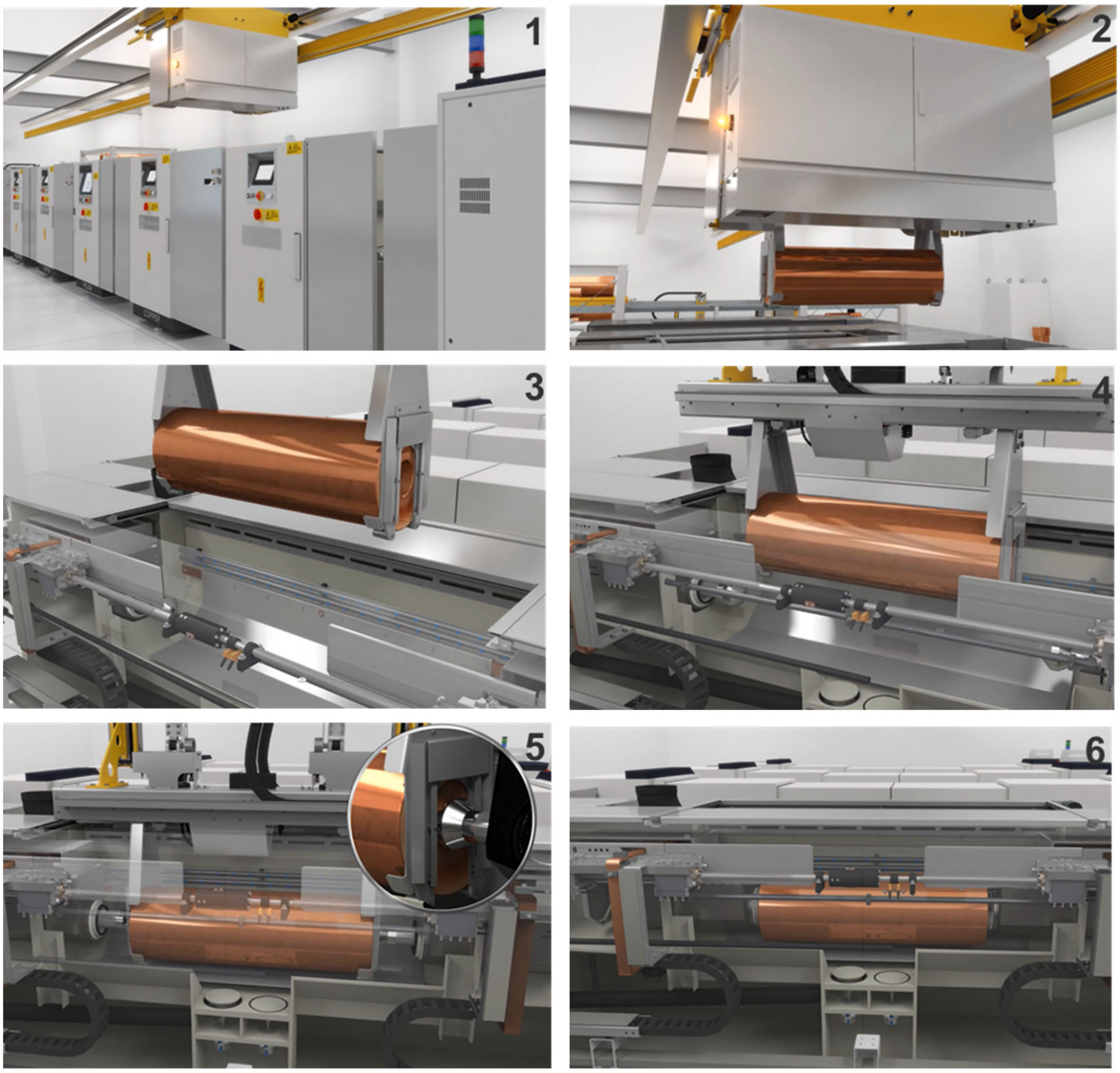


**Figure 11:** Computer rendered example of the automatic loading process with a cylinder crane, following six consecutive steps

In **Figure 12**, the loading and unloading processes using either an automatic or a manual (remote-controlled) crane are exemplarily presented as installed at DU sites.


**Figure 12:** Exemplary pictures from DU sites of the automatic (left) and manual (right) loading and unloading process of the electroplating unit

For the electrochemical chrome plating process, the cylinder (cathode) needs direct contact with an external voltage source. To achieve this, the cylinder is placed on holding clamps within an anode-basket in the electroplating unit, avoiding direct contact of the basket and the cylinder (**Figure 13**). The holding clamps also facilitate a rotation of the cylinder during the electroplating process. As described previously, the $CrO_3$ solution (260 to 310 g/l) is pumped to the main tank from an enclosed basin below the main tank at the beginning of the plating process. To depose an even chrome layer on the rotating cylinder, an electric potential is permanently applied on the cylinder and the anode via an external rectifier.

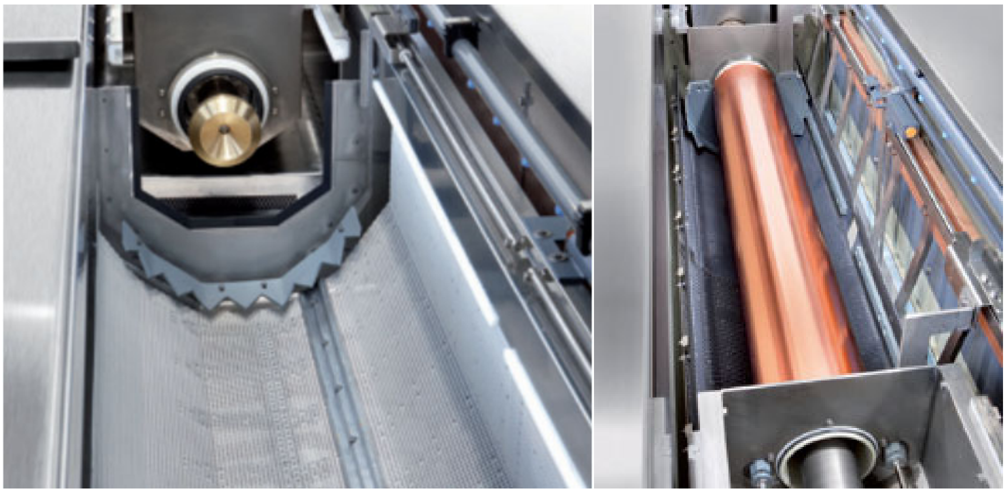

**Figure 13:** Anode basket with clamps within the titanium trough of the plating unit (left) and anode basket after loading with a cylinder in working position

Large chrome plating units are additionally equipped with a mixer in the lower tank to keep the temperature and the $CrO_3$ concentration stable. In smaller machines the activation of a circulation pump is sufficient.

After extensive use of the printing cylinder, the affected chromium surface can be renewed, enabling further usage of the cylinder. The dechroming of gravure printing and embossing cylinders takes place both electrolytically and chemically. For dechroming, the cylinder is submerged into an acidic electrolyte within a closed-loop dechroming galvanic unit. The process is initially started electrolytically in order to remove the outer passivated chromium layer. For this purpose, an anodic voltage is applied to the cylinder. To prevent an accumulation of Cr(VI) during electrolytical dissolution, a reducing agent (HelioDeChrome Salt, based on sodium hypophosphite) is used in the dechroming unit. This additive reduces the electrolytically produced Cr(VI) in-situ to Cr(III). After a short time, the anodic polarisation can be switched off and the remaining chromium layer is subsequently chemically dissolved by using sulphuric acid. In total, the entire chromium layer of the cylinder is removed as dissolved Cr(III) salt. Similar to the chrome electroplating unit, the dechroming unit is equipped with a local exhaust ventilation system and no wastewater is generated. Since the dechroming unit is usually part of the plating line, the exposure assessment presented below which is partly based on measurements at the plating lines of the DU's also covers potential exposures from the dechroming step.

As mentioned above, the chrome plating and dechroming processes runs fully automatically in the respective closed units and are monitored by the software system of

K.Walter. With help of the software, the exact position of the cylinders as well as process parameters can be observed and controlled during the electroplating or dechroming processes. During the processes, no employee is in the immediate vicinity (within a distance of ~ 1 m) of units.

The exposure assessment is based on worker exposure data from static and personal measurements received from the DUs participating in the CSR survey. Measurements were included, if the provided information *e.g.* on measurement type, sample duration, limit of detection (LOD) etc. were complete and the following criteria were met: (1) LOD ≤ 1 µg Cr(VI)/m³ and (2) measurement duration ≥ 2 h. In total, 69 measurements from 31 DUs were included in the assessment, which represent ~26 % of all DUs of K.Walter. Of those measurements, 40 were based on personal sampling and 29 on static sampling. The samples were taken during routine works at and around the electroplating unit or galvanic line. 45 of the measurements (16 static and 29 personal measurements) were below the respective LOD, which sat between 0.004 to 1.000 µg Cr(VI)/m³. For further calculations, half of the detection limit was considered for those measurements. Detailed information on each measurement is summarized in the **Annex**, **section 1.2**. Please note that the company names were anonymised.

Additional information provided by DUs in the survey were also integrated in the assessment. In the questionnaire, DUs could differentiate between the use of automatic or manual loading and unloading but could also choose both processes. Regarding the number of workers, the data are presented jointly for all procedures (manual/automatic or both) (**Table 43**). On average, 4 workers (90$^{th}$ percentile = 9 workers) were employed with the loading and unloading of the electroplating unit. The time necessary to perform the task is presented individually for automatic and manual loading and unloading to acknowledge the large range and high maximum values of collected data for either process. Those data characteristics might be attributed to the variation between the actual working time needed for automatic or manual loading but also hint towards a differing comprehension of the question (*e.g.*, regarding the shift length or the total time needed per all workers vs. the total time needed per individual worker). A realistic estimate on the time needed might be derived by the mean value but a worst-case exposure of 8 hours (as the duration of a standard working day) might be considered from the DU responses. However, as the exposure concentration was based on measured values, and those values were representative of an 8-hour TWA, such a worst-case scenario can be considered as fulfilled.

Also, of the 117 participating DUs, 77 responded on the use of wetting agents to prevent mist formation, and 68 (88 %) of those reported to use wetting agents. On average, the DUs (n = 80) reported to chrome-plate 1011 cylinders per month (**Table 43**).

General protective clothing as well as safety footwear is worn during the task. Additionally, when in close vicinity to the electroplating unit (*e.g.*, during program set-up), face protection is worn.

**Table 43:** Information provided by DUs on the number of workers and the time needed (hours, in total per day) for loading/unloading, and on the number of cylinders plated

| | Workers (n) | Time taken for automatic loading/unloading per day (h) | Time taken for manual loading/unloading per day (h) | Cylinders plated (n per month) |
|---|---|---|---|---|
| Minimum | 1.0 | 0.02 | 0.1 | 10 |
| Maximum | 25.0 | 24.0 | 24.0 | 4000 |
| Median | 3.0 | 1.0 | 2.0 | 800 |
| Mean | 4.4 | 3.2 | 4.2 | 1011 |
| 90$^{th}$ percentile | 11.4 | 8.0 | 9.3 | 2000 |
| DU responses (n) | 79 | 79 | | 80 |
| Total number of workers estimate = 4.4 x 117 = 515 | | | | |

The general conditions of use are summarized in **Table 44**.

**Table 44:** Conditions of use for ES 2 – WCS 2

| Conditions | | | Method |
|---|---|---|---|
| **Product (article) characteristics** | Substance product type | Liquid | Measured data |
| | Substance as such/in a mixture. Concentration of Cr(VI) in the electrolyte: | ≤ 20 % | |
| | Process temperature | Above room temperature | |
| | Vapor pressure of substance | < 0.01 Pa | |
| | Viscosity | Low | |
| **Activity emission potential** | Frequency | Daily | |
| | Duration of activity | ≤ 8.0 h | |
| **Surface contamination** | Process fully enclosed? | No | |
| | Effective housekeeping practices in place? | Yes | |
| **Dispersion** | Work area | Indoors | |
| | Room size | Any sized workroom | |
| **Technical and organisational conditions and measures** | Primary | Fixed capturing hood (90.00% reduction) | |
| | Secondary | No localized controls (0.0% reduction) | |
| | Ventilation rate | Only good natural ventilation [1)] | |
| **Conditions and measures related to personal protection, hygiene and health evaluation** | Respiratory Protection | No | |

[1)] Please note that production areas often have additional workplace exhaust systems and the presence of such systems may be viewed as industry standard. However, good natural ventilation was considered as a worst-case.

### 9.3.4.2. Exposure and risks for workers

To weight the measurements of the different companies equally and avoid to overrepresent the results of single companies who provided more data than others, mean values were calculated for each company. Therefore, the results from static and personal sampling were partly pooled. Following this approach, an arithmetic mean of 0.29 µg Cr(VI)/$m^3$ and a 90$^{th}$ percentile value of 0.50 µg Cr(VI)/$m^3$ could be derived.

The exposure estimate based on the 90$^{th}$ percentile of the measured data from air sampling of 0.50 µg Cr(VI)/$m^3$ is used as basis for risk characterization for ES 2 – WCS 2. The resulting exposure concentration is presented in **Table 45**.

**Table 45:** Exposure concentration for ES 2 – WCS 2

| Contributing scenario | Route of exposure | Method of assessment | Exposure value (8h TWA) | Exposure value corrected for PPE | Exposure value corrected for PPE and frequency |
|---|---|---|---|---|---|
| WCS 3 | Inhalation | Measured data | 5.00E-01 µg/m³ | 5.00E-01 µg/m³ | 5.00E-01 µg/m³ |

The excess lifetime lung cancer risk was estimated using the information provided by ECHA in the RAC document "Establishing a reference dose response relationship for carcinogenicity of hexavalent chromium" (RAC/27/2012/06 Rev.1). The estimated exposure value corrected for PPE and frequency (5.00E-01 µg/m³) was hence multiplied with a factor of **4.** This corresponds to the value established by RAC for the excess lifetime (up to age 89) lung cancer risk estimates for workers exposed at different 8h-TWA concentrations of Cr(VI) for 40 years.

From the data an excess lifetime lung cancer risk of **2.00 per 1000 exposed workers** is estimated.[15]

[15] As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks interfered in the low exposure range (*i.e.* below an exposure concentration of 1 µg Cr(VI)/$m^3$ might be an over-estimate.

### 9.3.5. Worker contributing scenario 3: Sampling (PROC 8b)

#### 9.3.5.1. Conditions of use

To check the composition of the electrolyte, a sample is taken manually using a measuring cup or a ladle and is analysed in an inhouse laboratory and/or sent to a K.Walter-operated facility for analysis. Sampling takes place at the side or in case of older/larger models at the back of the plating unit. An exemplary picture provided by one DU is presented in **Figure 14**. On average, a sample is taken 3 times per month (90$^{th}$ percentile = 8 times per month) and 2 workers (90$^{th}$ percentile = 4 workers) are employed with the task (**Table 46**). The procedure is short and takes about 9 minutes (90$^{th}$ percentile = 15 minutes).

**Figure 14:** Exemplary picture of the sampling process provided by DU

**Table 46:** Information provided by DUs on WCS 4

| | Workers involved (n) | Time to complete the task (min) | Count of samples taken (per month) |
|---|---|---|---|
| Minimum | 1.0 | 0.1 | 0.3 |
| Maximum | 17.0 | 60.0 | 22.0 |
| Median | 1.0 | 5.0 | 1.0 |
| Mean | 2.2 | 8.7 | 3.0 |
| 90$^{th}$ percentile | 4.0 | 15.0 | 8.0 |
| DU responses (n) | 81 | 81 | 80 |
| Total number of workers estimate = 2.2 x 117 = 257 | | | |

The exposure of workers was modelled with ART 1.5. As a considerable worst-case assumption for the exposure modelling, the 90$^{th}$ percentile of the data provided was used. The input parameter for the time of exposure was set to 120 minutes as the product of the 90$^{th}$ percentiles of time to complete the task (15 minutes) and the count of samples taken (8 times per month). ART 1.5 is optimized for the exposure modelling over a standard working day (*i.e.* 480 minutes). Therefore, the exposure estimate was back-calculated subsequently to describe the actual daily exposure. General protective clothing, safety footwear as well as chemical resistant gloves and face protection is worn during the task to protect the worker against splashes.

**Table 47:** Conditions of use for ES 2 – WCS 3

| | Conditions | | Method |
|---|---|---|---|
| **Product (article) characteristics** | Substance product type | Liquid | ART 1.5 |
| | Substance as such/in a mixture. Concentration of Cr(VI) in the electrolyte: | ≤ 20 % | |
| | Process temperature | Above room temperature | |
| | Vapor pressure of substance | < 0.01 Pa | |
| | Viscosity | Low | |
| **Activity emission potential** | Frequency | 8 times per month ($90^{th}$ percentile) | |
| | Duration of activity | 15 minutes per sampling ($90^{th}$ percentile) | |
| | Primary emission source located in the breathing zone of the worker | Yes | |
| | Activity class | Activities with relatively undisturbed surfaces (no aerosol formation) | |
| | Situation | Open surface 0.1 – 0.3 m² | |
| **Surface contamination** | Process fully enclosed? | No | |
| | Effective housekeeping practices in place? | Yes | |
| **Dispersion** | Work area | Indoors | |
| | Room size | Any sized workroom | |
| **Technical and organisational conditions and measures** | Primary | Fixed capturing hood (90.00% reduction) | |
| | Secondary | No localized controls (0.0% reduction) | |
| | Ventilation rate | Only good natural ventilation [1)] | |
| **Conditions and measures related to personal protection, hygiene and health evaluation** | Respiratory Protection | No | |

[1)] Please note that production areas often have additional workplace exhaust systems and the presence of such systems may be viewed as industry standard. However, good natural ventilation was considered as a worst-case.

### 9.3.5.2. Exposure and risks for workers

The modelled exposure estimate (see ART printouts in the **Annex**, **section 3.2**) of 3.10E-01 µg Cr(VI)/$m^3$ was used as the basis for risk characterization of ES 2 – WCS 3 (**Table 48**).

As supporting evidence, a personal workplace exposure measurement was available from one Spanish DU. The measurement referred to both sampling (WCS 3) and bath adjustment (WCS 4) and represented an 8-hour TWA. The measured value was below the LOD of the measurement of 2.5E-02 µg/m³.

**Table 48:** Exposure concentrations for ES 2 – WCS 3

| Contributing scenario | Route of exposure | Method of assessment | Exposure value (8h TWA) | Exposure value corrected for PPE | Exposure value corrected for PPE and frequency |
|---|---|---|---|---|---|
| WCS 3 | Inhalation | ART 1.5 | 3.10E-01 µg/m³ | 3.10E-01 µg/m³ | 1.55E-02 µg/m³ [1)] |

[1)] The estimate was based on the time taken for the task per month (= 120 minutes). In order to adjust for daily exposure, the exposure value was multiplied with a factor of 0.25 (4 weeks of a month) and 0.20 (5 working days a week).
Equation used to calculate the adjusted exposure value: 3.10E-01 µg/m³ × 0.25× 0.20

The excess lifetime lung cancer risk was estimated using the information provided by ECHA in the RAC document "Establishing a reference dose response relationship for carcinogenicity of hexavalent chromium" (RAC/27/2012/06 Rev.1). The estimated exposure value corrected for PPE and frequency (1.55E-02 µg/m³) was hence multiplied with a factor of 4. This corresponds to the value established by RAC for the excess lifetime (up to age 89) lung cancer risk estimates for workers exposed at different 8h-TWA concentrations of Cr(VI) for 40 years.

From the data an excess lifetime lung cancer risk of **6.20E-02 per 1000 exposed workers** is estimated.[16]

[16] As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks interfered in the low exposure range (*i.e.* below an exposure concentration of 1 µg Cr(VI)/$m^3$ might be an over-estimate.

## 9.3.6. Worker contributing scenario 4: Concentration adjustment with liquid $CrO_3$ (PROC 8b)

### 9.3.6.1. Conditions of use

To maintain the concentration of $CrO_3$ in the electrolyte, adjustment with either liquid or solid $CrO_3$ is necessary. Please note that the scope of this AfA is limited to the concentration adjustment process using liquid $CrO_3$, as K.Walter seeks to establish the use of automated dosing systems.

As indicated in **section 9.1.3**, the survey data revealed that the majority of DUs used liquid formulations of $CrO_3$ in their processes. Answers were received from 88 DUs regarding the used form of $CrO_3$; the largest proportion indicated that they primarily use either liquid (n = 55, 63 %) or both liquid and solid (n = 19, 16 %) $CrO_3$ for refilling. Approximately a fifth of those DUs (n = 14, 22 %) reported the sole use of solid $CrO_3$, mainly if the volume in the plating tank is at maximum or if the switch to automation has not yet taken place.

Liquid $CrO_3$ is refilled automatically via a container (*e.g.*, an IBC) connected to the electroplating unit and hence no worker is needed to perform the actual concentration adjustment process. The task described in this WCS therefore refers to the exchange of containers with liquid $CrO_3$ solution, which presents the only potential for exposure in this scenario. Containers are either reusable and can be refilled by K.Walter as required or are disposable. During the adjustment process, no employee is located in the immediate vicinity (within a distance of approximately 1 m) of the plating unit.

The highest potential for exposure therefore exists during the replacement process by the handling of contaminated objects (*e.g.*, a suction lance). This challenge was identified by K.Walter. Consequently, K.Walter developed the "Quick Connect"-system to further reduce the potential for exposure when exchanging the $CrO_3$ container. The main part of the system is a newly developed removal head connected to a pump via a hose. The removal head facilitates the connection/disconnection of $CrO_3$-containers without contact to $CrO_3$. The associated containers offered by K.Walter feature an integrated and fixed immersion tube, thus prohibiting unintentional dripping when reconnecting the removal head. Additionally, a sensor connected to the system issues a message when the container is running low or empty. Exemplary pictures on the automatic dosing via liquid $CrO_3$ (standard system and "Quick connect" removal head) were provided by DUs and are presented below (**Figure 15**).

**Figure 15:** Exemplary pictures provided by DUs displaying the concentration adjustment with liquid $CrO_3$ using a standard connection (left) and K.Walter's Quick Connect system (right; only removal head and hose shown)

On average, 2 workers (90th percentile = 3 workers) need half an hour (90th percentile = 1 hour) to exchange the container with liquid $CrO_3$ at the automatic dosing system. Information on the number of workers, the time taken and the number of IBC replacements per months are listed **Table 49**. To describe a worst-case scenario, it was not differentiated if the workers were adjusting the concentration only remotely – without being exposed to the formulation – or replace the $CrO_3$-containing container. Furthermore, for the same reasons, it was not differentiated if the DUs used a standard connection or K.Walter's Quick Connect system. During the exchange of the $CrO_3$-containing container, the workers wear general protective clothing, safety footwear, face protection and chemical-resistant gloves.

**Table 49:** Information provided by DUs on WCS 4

| | **Workers (n)** | **Time to complete the task (h)** | **Replacement of IBC per month (n)** |
|---|---|---|---|
| Minimum | 1.0 | 0.1 | 0.1 |
| Maximum | 17.0 | 1.5 | 16.5 |
| Median | 1.0 | 0.5 | 0.5 |
| Mean | 2.1 | 0.5 | 1.4 |
| 90th percentile | 3.0 | 1.0 | 4.0 |
| DU responses (n) | 59 | 55 | 58 |
| Total number of workers estimate = 2.1 x 117 = 246 | | | |

The conditions of use applied to the exposure modelling are summarized in **Table 50**. The exposure estimates were based on the 90th percentile of the time taken to complete the task (1.0 hour) and frequency of IBC replacement per month (4.0 times). The product of those values (4 hours = 240 minutes) was used in ART 1.5 as the program is optimized for the calculation of exposure estimates over a standard working day (8 hours = 480 minutes). The exposure estimate was back-calculated subsequently to describe the actual daily exposure.

Please note that according to the manufacturer's point of view, which is based on their industry expertise, the considered exchange rate of 4 times per month is considerably high. It is very likely that this value is a significant overestimation in turn potentially leading to a higher than actual risk.

**Table 50:** Conditions of use for ES 2 – WCS 4

| Conditions | | | Method |
|---|---|---|---|
| **Product (article) characteristics** | Substance product type | Liquid | ART 1.5 |
| | Substance as such/in a mixture. Concentration of Cr(VI) in the electrolyte | Substantial (10 – 50 %) | |
| | Process temperature | Room temperature | |
| | Vapor pressure of substance | < 0.01 Pa | |
| | Viscosity | Low | |
| **Activity emission potential** | Frequency | 4 times per month (90th percentile) | |
| | Duration of activity | 60 minutes per task (90th percentile) | |
| | Primary emission source located in the breathing zone of the worker | Yes | |
| | Activity class | Handling of contaminated objects | |
| | Situation | Activities with treated/contaminated objects (surface < 0.1 m²) | |
| | Contamination level | Contamination < 10 % of surface | |
| **Surface contamination** | Process fully enclosed? | No | |
| | Effective housekeeping practices in place? | Yes | |
| **Dispersion** | Work area | Indoors | |
| | Room size | Any sized workroom | |
| **Technical and organisational conditions and measures** | Primary | No localized controls (0.0% reduction) | |
| | Secondary | No localized controls (0.0% reduction) | |
| | Ventilation rate | Only good natural ventilation [1)] | |
| **Conditions and measures related to personal protection, hygiene and health evaluation** | Respiratory Protection | No | |

[1)] Please note that production areas often have additional workplace exhaust systems and the presence of such systems may be viewed as industry standard. However, good natural ventilation was considered as a worst-case.

### 9.3.6.2. Exposure and risks for workers

The modelled exposure estimate (see ART printouts in the **Annex**, **section 3.2**) of 9.10E-01 µg Cr(VI)/$m^3$ was used as the basis for risk characterization for ES 2 – WCS 4 (**Table 51**).

As supporting evidence, a personal workplace exposure measurement was available from one Spanish DU. The measurement referred to both sampling (WCS 3) and bath adjustment (WCS 4) and represented an 8-hour TWA. The measured value was below the LOD of the measurement of 2.5E-02 µg/m³.

**Table 51:** Exposure concentrations for ES 2 – WCS 4

| Contributing scenario | Route of exposure | Method of assessment | Exposure value (8h TWA) | Exposure value corrected for PPE | Exposure value corrected for PPE and frequency [1)] |
|---|---|---|---|---|---|
| WCS 4 | Inhalation | ART 1.5 | 9.10E-01 µg/m³ | 9.10E-01 µg/m³ | 4.55E-02 µg/m³ |

[1)] The estimate was based on the time taken for the task per month (= 240 minutes). In order to adjust for daily exposure, the exposure value was multiplied with a factor of 0.25 (4 weeks of a month) and 0.20 (5 working days a week). Equation used to calculate the adjusted exposure value: 9.10E-01 µg/m³ × 0.25× 0.20

The excess lifetime lung cancer risk was estimated using the information provided by ECHA in the RAC document "Establishing a reference dose response relationship for carcinogenicity of hexavalent chromium" (RAC/27/2012/06 Rev.1). The estimated exposure value corrected for PPE and frequency (4.55E-02 µg/m³) was hence multiplied with a factor of 4. This corresponds to the value established by RAC for the excess lifetime (up to age 89) lung cancer risk estimates for workers exposed at different 8h-TWA concentrations of Cr(VI) for 40 years.

From the data an excess lifetime lung cancer risk of **1.82E-01 per 1000 exposed workers** is estimated.[17]

[17] As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks interfered in the low exposure range (*i.e.* below an exposure concentration of 1 µg Cr(VI)/$m^3$ might be an over-estimate.

## 9.3.7. Worker contributing scenario 5: Maintenance (PROC 28)

At the DU sites, regular maintenance of the plating lines is conducted by responsible authorized workers and is strictly controlled and documented with the help of maintenance instructions of the provided manual. To gather further information the DUs were asked to provide data on the number of workers involved and the time necessary for maintenance tasks which are performed with a varying frequency (daily/weekly/quarterly/half-yearly/yearly). The regular maintenance of the plating lines includes daily checks of the extractor systems, check of the level in supply tanks, cleaning of the spindle seal and clamping cones of bearing brackets. Anodes and the protective shell of the electroplating unit are cleaned weekly and the moving parts are checked weekly for wear. The spindles of the bearing bracket and guide rails of the lid are lubricated monthly. The carbon brushes are checked monthly, too. Quarterly, the tightening of screw connections, cleaning of screen elements in the water installation and lubrication of various parts take place. The screw connections of the power supply system are checked half-yearly. Once a year, the basic maintenance is carried out by the manufacturer and/or the DU.

The data on frequency and time were combined with information provided by K.Walter to identify tasks of the highest exposure potential. Additionally, K.Walter provided worst-case estimates on the time and number of workers for the infrequent task "Exchange of the electrolyte" which was not part of the DU survey. From the available information, three tasks that mark overall worst-case scenarios were considered in this AfA. The required PPE for each of the tasks is listed in **Table 10**. The scenarios are termed:

1. Cleaning of anodes (weekly):

   The cleaning of the anodes (sub-scenario 1) is performed with a high frequency (weekly). Simultaneously, it requires a considerable time and poses an increased risk of exposure to $CrO_3$ by direct contact to contaminated surfaces. As described by the DUs, the weekly maintenance takes on average 1.2 hours by 2 workers and with $90^{th}$ percentiles of 3 workers and 2.3 hours.

2. Complete inspection (annually):

   In the second maintenance sub-scenario – the yearly maintenance – a range of tasks is covered. Those include tasks with a low exposure potential *e.g.*, checking on the electronics but also works in the electrolyte basin of the bath. On average, 3 workers need 12 hours to complete the tasks. As a worst-case ($90^{th}$ percentile), 4 workers need 35.2 hours (*i.e.* 4.4 working days).

3. Exchange of the electrolyte (infrequently):

   For the third scenario (exchange of the electrolyte solution of the bath), estimates were provided by K.Walter. The exchange of the electrolyte also poses the risk of direct exposure to the $CrO_3$ formulation. It was estimated that the task is performed every third year and takes one working day and includes 2 workers.

As described for the other tasks, the $90^{th}$ percentile was used to calculate worst-case exposure estimates for maintenance scenario 1 and 2. For maintenance scenario 3, worst-case estimates by K.Walter were available. All data are summarized below in **Table 52**.

**Table 52:** Overview on workers involved and time needed to perform the three identified maintenance scenarios

| | Maintenance scenario | | | | | |
|---|---|---|---|---|---|---|
| | 1 (weekly) | | 2 (annually) | | 3 (infrequently) | |
| | Workers (n) | Time (hours) | Workers (n) | Time (hours) | Workers (n) | Time (hours) |
| Minimum | 1.0 | 0.2 | 1.0 | 0.3 | — | — |
| Maximum | 17.0 | 6.0 | 17.0 | 72.0 | 2.0 *) | 8.0 *) |
| Median | 1.0 | 1.0 | 2.0 | 8.0 | — | — |
| Mean | 1.8 | 1.2 | 2.6 | 12.0 | — | — |
| 90th percentile | 3.0 | 2.3 | 4.0 | 35.2 | — | — |
| DU responses | 71.0 | 68.0 | 44.0 | 43.0 | — | — |

Total number of workers estimate (scenario 1) = 1.8 x 117 = 211
Total number of workers estimate (scenario 2) = 2.6 x 117 = 304
Total number of workers estimate (scenario 3) = 2.0 x 117 = 234

*) The typical duration and number of workers were estimated by K.Walter.

### 9.3.7.1. Maintenance scenario 1 – Cleaning of anodes (weekly)

#### 9.3.7.1.1. Conditions of use

The DUs reported that weekly maintenance tasks took 2.3 hours = 138 minutes (90th percentile). As ART 1.5 is optimized for the exposure modelling over a standard working day (*i.e.* 480 minutes), the estimation was subsequently back-calculated from weekly to daily exposure. To cover a reasonable worst-case, it was assumed that during this time only the cleaning of the anodes was performed (*i.e.* the task with the highest exposure potential). Safety footwear, protective clothing, chemical-resistant clothing as well as face protection and chemical- and cut-resistant gloves are worn during this task. No RPE is required. The conditions of use are listed below (**Table 53**).

**Table 53:** Conditions of use for ES 2 – WCS 5 (Maintenance scenario 1 – Cleaning of anodes (weekly))

| Conditions | | | Method |
|---|---|---|---|
| **Product (article) characteristics** | Substance product type | Liquids | ART 1.5 |
| | Substance as such/in a mixture. Concentration of Cr(VI) in the electrolyte | ≤ 20 % | |
| | Process temperature | Room temperature | |
| | Vapor pressure of substance | < 0.01 Pa | |
| | Viscosity | Low | |
| **Activity emission potential** | Frequency | Weekly | |
| | Duration of activity | 138 minutes (90th percentile) | |
| | Primary emission source located in the breathing zone of the worker | Yes | |
| | Activity class | Handling of contaminated objects | |
| | Situation | Activities with treated/contaminated objects (surface 0.1 – 0.3 m²) | |
| | Contamination level | Contamination 10 – 90 % of surface | |
| **Surface contamination** | Process fully enclosed? | No | |
| | Effective housekeeping practices in place? | Yes | |
| **Dispersion** | Work area | Indoors | |
| | Room size | Any sized workroom | |
| **Technical and organisational conditions and measures** | Primary | No localized controls (0.00 % reduction) | |
| | Secondary | No localized controls (0.00 % reduction) | |
| | Ventilation rate | Only good natural ventilation [1)] | |
| **Conditions and measures related to personal protection, hygiene and health evaluation** | Respiratory Protection | No | |

[1)] Please note that production areas often have additional workplace exhaust systems and the presence of such systems may be viewed as industry standard. However, good natural ventilation was considered as a worst-case.

### 9.3.7.1.2. Exposure and risks for workers

The modelled exposure estimate (see ART printouts in the **Annex**, **section 3.2**) of 1.10 μg Cr(VI)/m³ was used as the basis for risk characterization for ES 2 – WCS 5 (Maintenance scenario 1 – Cleaning of anodes (weekly)) (**Table 54**).

As supporting evidence, three (two personal and one static) workplace exposure measurements were available for maintenance tasks. The data originated from three different sites, two in Italy and one in Germany. One DU reported a value of < 1.4E-01 μg/m³ for maintenance tasks that were performed with a daily frequency. For two further unspecified tasks, values of < 1.9 μg/m³ and < 1.3E-01 μg/m³ were measured. As indicated, all values were below the LOD of the respective measurement.

**Table 54:** Exposure concentrations for ES 2 – WCS 5 (Maintenance scenario 1 – Cleaning of anodes (weekly))

| Contributing scenario | Route of exposure | Method of assessment | Exposure value (8h TWA) | Exposure value corrected for PPE | Exposure value corrected for PPE and frequency 1) |
|---|---|---|---|---|---|
| WCS 5 (1) | Inhalation | ART 1.5 | 1.10 μg/m³ | 1.10 μg/m³ | 2.20E-01 μg/m³ |

1) The estimate was based on the time taken for the task per week. In order to adjust for daily exposure, the exposure value was multiplied with a factor of 0.20 (5 working days a week). Equation used to calculate the adjusted exposure value: 1.10 μg/m³ × 0.20

The excess lifetime lung cancer risk was estimated using the information provided by ECHA in the RAC document "Establishing a reference dose response relationship for carcinogenicity of hexavalent chromium" (RAC/27/2012/06 Rev.1). The estimated exposure value corrected for PPE and frequency (2.20E-01 μg/m³) was hence multiplied with a factor of 4. This corresponds to the value established by RAC for the excess lifetime (up to age 89) lung cancer risk estimates for workers exposed at different 8h-TWA concentrations of Cr(VI) for 40 years.

From the data an excess lifetime lung cancer risk of **8.80E-01 per 1000 exposed workers** is estimated.[18]

[18] As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks interfered in the low exposure range (*i.e.* below an exposure concentration of 1 μg Cr(VI)/m³ might be an over-estimate.

### 9.3.7.2. Maintenance scenario 2 – Complete maintenance (annually)

#### 9.3.7.2.1. Conditions of use

For completion of the annual maintenance, a duration of 35.2 hours was indicated by the DUs as a worst-case (90$^{th}$ percentile). This corresponds to a period of 4.4 days during one year (of 220 working days). As ART 1.5 is optimized for the exposure modelling over a standard working day (*i.e.* 480 minutes), the exposure during maintenance scenario 2 was firstly estimated for a period of 480 minutes. The resulting value was then multiplied with a factor of 4.4 to attribute for the complete duration. Finally, this annual exposure estimate was back-calculated to reflect the daily exposure.

Even though the task consists of working steps that do not pose the threat of direct contact to $CrO_3$, it was assumed that contact to contaminated surfaces was given to derive a worst-case scenario. When contact to $CrO_3$ is possible (*e.g.*, during working steps in the upper basin of the bath), safety footwear, protective clothing, chemical-resistant clothing as well as face protection and chemical- and cut-resistant gloves are worn. For working steps without exposure to $CrO_3$, general protective clothes and gloves as well as safety footwear is worn. No RPE is required. The conditions of use are summarized below (**Table 55**).

**Table 55:** Conditions of use for ES 2 – WCS 5 (Maintenance scenario 2 – Complete maintenance (annually))

| Conditions | | | Method |
|---|---|---|---|
| **Product (article) characteristics** | Substance product type | Liquids | ART 1.5 |
| | Substance as such/in a mixture. Concentration of Cr(VI) in the electrolyte | ≤ 20 % | |
| | Process temperature | Room temperature | |
| | Vapor pressure of substance | < 0.01 Pa | |
| | Viscosity | Low | |
| **Activity emission potential** | Frequency | 4.4 days per year (220 working days) (90$^{th}$ percentile) | |
| | Duration of activity | 480 minutes | |
| | Primary emission source located in the breathing zone of the worker | Yes | |
| | Activity class | Handling of contaminated objects | |
| | Situation | Activities with treated/contaminated objects (surface > 3 m²) | |
| | Contamination level | Contamination 10 – 90 % of surface | |
| **Surface contamination** | Process fully enclosed? | No | |
| | Effective housekeeping practices in place? | Yes | |
| **Dispersion** | Work area | Indoors | |
| | Room size | Any sized workroom | |
| **Technical and organisational conditions and measures** | Primary | No localized controls (0.00 % reduction) | |
| | Secondary | No localized controls (0.00 % reduction) | |
| | Ventilation rate | Only good natural ventilation [1)] | |
| **Conditions and measures related to personal protection, hygiene and health evaluation** | Respiratory Protection | No | |

[1)] Please note that production areas often have additional workplace exhaust systems and the presence of such systems may be viewed as industry standard. However, good natural ventilation was considered as a worst-case.

### 9.3.7.2.2. Exposure and risk for workers

The modelled exposure estimate (see ART printouts in the **Annex**, **section 3.2**) of 3.70 µg Cr(VI)/m³ was used as the basis for risk characterization for ES 2 – WCS 5 (Maintenance scenario 2 – Complete maintenance (annually)) (**Table 56**).

**Table 56:** Exposure concentrations for ES 2 – WCS 5 (Maintenance scenario 2 – Complete maintenance (annually))

| Contributing scenario | Route of exposure | Method of assessment | Exposure value (8h TWA) | Exposure value corrected for PPE | Exposure value corrected for PPE and frequency 1) |
|---|---|---|---|---|---|
| WCS 5 (2) | Inhalation | ART 1.5 | 3.70 µg/m³ | 3.70 µg/m³ | 7.40E-02 µg/m³ |

1) The calculated exposure value was estimated for a duration of 480 minutes as ART 1.5 is optimized for the calculation of exposure over a standard working day of 8 hours (= 1 working day). However, the total task takes 35.2 hours (=4.4 working days). In order to adjust for daily exposure, the exposure value was multiplied with a factor of 4.4. Subsequently, as the task takes place only once per year (of 220 working days), the estimate was multiplied with a factor of 0.00455 (= 1/220). Equation used to calculate the adjusted exposure value: 3.70 µg/m³ × 4.4 × (1/220)

The excess lifetime lung cancer risk was estimated using the information provided by ECHA in the RAC document "Establishing a reference dose response relationship for carcinogenicity of hexavalent chromium" (RAC/27/2012/06 Rev.1). The estimated exposure value corrected for PPE and frequency (7.40E-02 µg/m³) was hence multiplied with a factor of 4. This corresponds to the value established by RAC for the excess lifetime (up to age 89) lung cancer risk estimates for workers exposed at different 8h-TWA concentrations of Cr(VI) for 40 years.

From the data an excess lifetime lung cancer risk of **2.96E-01 per 1000 exposed workers** is estimated.[19]

[19] As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks interfered in the low exposure range (*i.e.* below an exposure concentration of 1 µg Cr(VI)/m³ might be an over-estimate.

### 9.3.7.3. Maintenance scenario 3 – Exchange of the electrolyte (infrequently)

#### 9.3.7.3.1. Conditions of use

Information on the infrequently performed exchange of the electrolyte was provided by K.Walter. They estimated that the electrolyte was exchanged every third year as a worst-case. It was furthermore assumed that the task would take one working day (8 hours = 480 minutes). In ART 1.5, the exposure during maintenance scenario 3 was hence estimated for a period of 480 minutes and back-calculated afterwards to adequately reflect the exposure for one day.

As PPE, safety footwear, protective clothing, chemical-resistant clothing, face protection and chemical-resistant gloves are worn. No RPE is required. The conditions of use are summarized below (**Table 57**).

**Table 57:** Conditions of use for ES 2 – WCS 5 (Maintenance scenario 3 – Exchange of the electrolyte (infrequently))

| Conditions | | | Method |
|---|---|---|---|
| **Product (article) characteristics** | Substance product type | Liquids | ART 1.5 |
| | Substance as such/in a mixture. Concentration of Cr(VI) in the electrolyte | ≤ 20 % | |
| | Process temperature | Room temperature | |
| | Vapor pressure of substance | < 0.01 Pa | |
| | Viscosity | Low | |
| **Activity emission potential** | Frequency | Every third year (220 working days each) | |
| | Duration of activity | 480 minutes | |
| | Primary emission source located in the breathing zone of the worker | Yes | |
| | Activity class | Handling of contaminated objects | |
| | Situation | Activities with treated/contaminated objects (surface > 3 m²) | |
| | Contamination level | Contamination > 90 % of surface | |
| **Surface contamination** | Process fully enclosed? | No | |
| | Effective housekeeping practices in place? | Yes | |
| **Dispersion** | Work area | Indoors | |
| | Room size | Any sized workroom | |
| **Technical and organisational conditions and measures** | Primary | No localized controls (0.00 % reduction) | |
| | Secondary | No localized controls (0.00 % reduction) | |
| | Ventilation rate | Only good natural ventilation [1)] | |
| **Conditions and measures related to personal protection, hygiene and health evaluation** | Respiratory Protection | No | |

[1)] Please note that production areas often have additional workplace exhaust systems and the presence of such systems may be viewed as industry standard. However, good natural ventilation was considered as a worst-case.

### 9.3.7.3.2. Exposure and risk for workers

The modelled exposure estimate (see ART printouts in the **Annex**, **section 3.2**) of 1.20E+01 µg Cr(VI)/$m^3$ was used as the basis for risk characterization for ES 2 – WCS 5 (Maintenance scenario 3 – Exchange of the electrolyte (infrequently)) (**Table 58**).

**Table 58:** Exposure concentrations for ES 2 – WCS 5 (Maintenance scenario 3 – Exchange of the electrolyte (infrequently))

| Contributing scenario | Route of exposure | Method of assessment | Exposure value (8h TWA) | Exposure value corrected for PPE | Exposure value corrected for PPE and frequency [1)] |
|---|---|---|---|---|---|
| WCS 5 (3) | Inhalation | ART 1.5 | 1.20E+01 µg/m³ | 1.20E+01 µg/m³ | 1.82E-02 µg/m³ |

[1)] The calculated exposure value was estimated for a duration of 480 minutes as ART 1.5 is optimized for the calculation of exposure over a standard working day of 8 hours (= 1 working day). However, the task is only performed every third year. In order to adjust for daily exposure, the exposure value was multiplied with a factor of 0.33333 (=1/3). Subsequently the estimate was multiplied with a factor of 0.00455 (= 1/220) to adjust for yearly exposure (of 220 working days). Equation used to calculate the adjusted exposure value: 1.2E+01 µg/m³ × (1/3) × (1/220)

The excess lifetime lung cancer risk was estimated using the information provided by ECHA in the RAC document "Establishing a reference dose response relationship for carcinogenicity of hexavalent chromium" (RAC/27/2012/06 Rev.1). The estimated exposure value corrected for PPE and frequency (1.82E-02 µg/m³) was hence multiplied with a factor of 4. This corresponds to the value established by RAC for the excess lifetime (up to age 89) lung cancer risk estimates for workers exposed at different 8h-TWA concentrations of Cr(VI) for 40 years.

From the data an excess lifetime lung cancer risk of **7.27E-02 per 1000 exposed workers** is estimated.[20]

[20] As the mechanistic evidence is suggestive of non-linearity, it is acknowledged by RAC that excess risks interfered in the low exposure range (*i.e.* below an exposure concentration of 1 µg Cr(VI)/$m^3$ might be an over-estimate.

## 9.3.8. Worker contributing scenario 6: Waste management (PROC 8b)

### 9.3.8.1. Conditions of use

The collected water is redirected in the process cycle. The electroplating unit is a closed process circle without wastewater production.

Process waste with potential Cr(VI) loads (*e.g.*, waste from repair work or PPE) are stored in closed containers which are collected by licensed waste management companies for treatment, incineration, and disposal of incineration residues at licensed landfills.

The exposure potential during disposal of the process waste into collection containers or waste bins is considered negligible. The qualitative conditions of use are summarized in **Table 59**. It can be assumed that one worker is responsible for waste management at each site, which equals a total number of workers of 117 over all sites. General protective clothing and safety footwear is worn during this task.

**Table 59:** Conditions of use for ES 2 – WCS 6

| Conditions | | | Method |
|---|---|---|---|
| **Product (article) characteristics** | Substance in a mixture.<br>Concentration of Cr(VI) | ≤ 20 % | Qualitative |
| | Process temperature | Room temperature | |
| **Activity emission potential** | Duration of activity | < 1 min | |
| **Dispersion** | Work area | Indoors | |
| | Room size | Any sized workroom | |
| **Technical and organisational conditions and measures** | Containment | Closed system (minimal contact during routine operations) | |
| | Local exhaust ventilation | No | |
| | Occupational Health and Safety Management System | Advanced *) | |
| **Conditions and measures related to personal protection, hygiene and health evaluation** | Respiratory Protection | No | |

*) Advanced Health and Safety management systems is terminology referred to within exposure assessment models such as ECETOC TRA. Such models assume that a significant reduction in exposure can be achieved through use of Health and Safety management systems and assume this to be the default for industrial operations. This can be seen to reflect the fact that companies have a duty of care to their employees through general Health and Safety at Work legislation, as well as via more specific legislation, such as the Carcinogens Directive (2004/37/EC) and the Chemical Agents at Work Directive (98/24/EC).
There is no standard definition of this term but, based on regulatory requirements, it can be considered to include:

- Requirement to ensure only workers essential for repairs shall be permitted to work in the affected area, and only with appropriate protection. The exposure may not be permanent and shall be minimised.
- Requirement to ensure if a temporary, planned higher exposure is unavoidable (*e.g.* maintenance), the employer shall consult workers/representatives on the measures to minimise exposure, and provide appropriate prevention, together with access control.
- Provision of appropriate hygienic circumstances for workers free of charge
  - o Prohibition of eating/drinking/smoking in contamination risk areas
  - o Appropriate protective clothing
  - o Separate storage places for working/protective clothing and for street clothes
  - o Appropriate and adequate washing and toilet facilities
  - o Cleaned, checked and maintained protective equipment, stored in a well-defined place.
- Provision of appropriate training on potential risks to health, precautions to prevent exposure, hygiene requirements, protective equipment, clothing and incidents.
- Requirement to inform on objects containing carcinogens or mutagens, and label them clearly and legibly, together with warning and hazard signs.
- Requirement to inform workers and/or representatives on abnormal exposures as quickly as possible.

## 9.3.8.2. Exposure and risks for workers

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

**Table 60:** Exposure concentrations for ES 2 – WCS 6

| Contributing scenario | Route of exposure | Method of assessment | Exposure value (8h TWA) | Exposure value corrected for PPE | Exposure value corrected for PPE and frequency |
|---|---|---|---|---|---|
| WCS 6 | Inhalation | Qualitative | 0 µg/m$^3$ | 0 µg/m$^3$ | 0 µg/m$^3$ |

There is no potential for exposure. The qualitatively determined exposure estimate of 0 µg/m$^3$ is used as the basis for risk characterization.

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

# 10. RISK CHARACTERISATION RELATED TO COMBINED EXPOSURE

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

### 10.1.1. Workers

In this section, the combined risk for workers employed either within ES 1 (**Table 61**) or ES 2 (**Table 62**) is presented.

**Table 61:** Combined exposure and risk characterisation – ES 1

| Contributing scenario | Route of exposure | 8h TWA exposure values, corrected for PPE and frequency (µg/m³) | Excess risk (per 1000 exposed) |
|---|---|---|---|
| WCS 1 | Inhalation | 0.00E+00 | 0.00E+00 |
| WCS 2 | | 1.84E-01 | 7.36E-01 |
| WCS 3 | | 1.56E-01 | 6.24E-01 |
| WCS 4 | | 4.53E-04 | 1.81E-03 |
| WCS 5 | | 6.80E-04 | 2.72E-03 |
| Maximum exposure for 8 hours | Inhalation | 3.41E-01 | 1.36E+00 |

**Table 62:** Combined exposure and risk characterisation – ES 2

| Contributing scenario | | Route of exposure | 8h TWA exposure values, corrected for PPE and frequency (µg/m³) | Excess risk (per 1000 exposed) |
|---|---|---|---|---|
| WCS 1 | | Inhalation | 0.00E+00 | 0.00E+00 |
| WCS 2 | | | 5.00E-01 | 2.00E+00 |
| WCS 3 | | | 1.55E-02 | 6.20E-02 |
| WCS 4 | | | 4.55E-02 | 1.82E-01 |
| WCS 5 | 1 | | 2.20E-01 | 8.80E-01 |
| | 2 | | 7.40E-02 | 2.96E-01 |
| | 3 | | 1.82E-02 | 7.27E-02 |
| WCS 6 | | | 0.00E+00 | 0.00E+00 |
| Maximum exposure for 8 hours | | Inhalation | 8.73E-01 | 3.49E+00 |

## 10.2. Environment (combined for all emission sources)

### 10.2.1. All uses (regional scale)

#### 10.2.1.1. Regional exposure

The exposure estimates and corresponding risk characterization for ES 1 – ECS 1 is listed in **Table 63**, for ES 2 – ECS 1 in **Table 64**.

**Table 63:** Regional exposure and risk to man via environment for ES 1 – ECS 1

| Route | Exposure concentration | Risk characterisation (Excess risk per 1000 exposed) |
|---|---|---|
| Inhalation | 0 mg/m³ | negligible |
| Oral | negligible | negligible |

**Table 64:** Regional exposure and risk to man via environment for ES 2 – ECS 1

| Route | Exposure concentration | Risk characterisation (Excess risk per 1000 exposed) |
|---|---|---|
| Inhalation | 1.59E-15 mg/m³ | negligible |
| Oral | negligible | negligible |

# Annex

## 1. Worker exposure measurements

### 1.1. Measurements related to ES 1

**Table 65:** Overview of the worker exposure measurements provided by the formulator.

| Use 1 - Results of workplace exposure monitoring | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Date** | **Measurement result Cr(VI)** | **LEV** | **Position/sampling location** | **RPE** | **Sampling duration** | **Sampling type** | **Measured results (8h TWA)** | **Method** | **Reference to WCS** |
| *yyyy-mm-dd* | *µg/m³* | | | | *min* | | | | |
| 2020-05-10 | < 0.140 | Yes | Department B: Filling of the mixing tank; sampling; filling of product into IBC; transport of IBC | Yes, FFP3 mask (APF 30) during addition of solid $CrO_3$ | 165 | Personal | Yes | IFA 7284/ 6665 | WCS 2 + WCS 3 |
| 2020-05-10 | 0.210 | Yes | Department A: Addition of solid $CrO_3$ to mixing tank; transport of IBC | Yes, FFP3 mask (APF 30) during addition of solid $CrO_3$ | 168 | Personal | Yes | IFA 7284/ 6665 | WCS 2 |
| 2020-05-10 | < 0.160 | Yes | Department A: Preparation of products | Yes, FFP3 mask (APF 30) | 154 | Personal | Yes | IFA 7284/ 6665 | WCS 2 |

## 1.2. Measurements related to ES 2

**Table 66:** Overview of the worker exposure measurements provided by the DUs of K.Walter.

| **Use 2 - Downstream User in rotogravure printing and embossing industry - Results of workplace exposure monitoring** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **DU ID** | **Date** | **Measure-ment result Cr(VI)** | **LEV** | **Position/sampling location** | **RPE** | **Sampling duration** | **Sampling type** | **Measured results (8h TWA)** | **Reference to WCS** |
| | *yyyy-mm-dd* | *µg/m³* | | | | *min* | | | |
| 705872546 | 2019-01-09 | 0.400 | Yes | galvanic operator | No | 480 | Personal | Yes | WCS 2 |
| 705872547 | 2019-05-07 | 0.031 | Yes | galvanic operator | No | 480 | Personal | Yes | WCS 2 |
| 705922036 | 2014-06-04 | 0.880 | Yes | at the plating line/ plating unit | No | 130 | Static | Yes | WCS 2 |
| 705922036 | 2014-06-04 | 0.790 | Yes | galvanic operator | No | 120 | Personal | Yes | WCS 2 |
| 705922038 | 2018-07-17 | < 1.000 | Yes | galvanic operator | No | 450 | Personal | Yes | WCS 2 |
| 705922038 | 2017-02-03 | < 1.000 | Yes | galvanic operator | No | 450 | Personal | Yes | WCS 2 |
| 705922038 | 2015-11-24 | < 1.000 | Yes | galvanic operator | No | 450 | Personal | Yes | WCS 2 |
| 705922038 | 2017-05-27 | < 1.000 | Yes | galvanic operator | No | 120 | Personal | Yes | WCS 2 |
| 705922041 | 2019-03-12 | < 1.000 | Yes | galvanic operator | No | 225 | Personal | Yes | WCS 2 |
| 705922043 | 2016-01-13 | 0.240 | Yes | at the plating line/ plating unit | No | 240 | Static | Yes | WCS 2 |
| 705922043 | 2016-01-13 | < 0.130 | Yes | at the plating line/ plating unit | No | 240 | Static | Yes | WCS 2 |
| 705922043 | 2016-01-13 | < 0.140 | Yes | galvanic operator | No | 240 | Personal | Yes | WCS 2 |
| 705922043 | 2016-01-13 | < 0.140 | Yes | at the plating line/ plating unit | No | 240 | Static | Yes | WCS 2 |
| 705922044 | 2020-02-27 | 0.940 | Yes | galvanic operator | No | 193 | Personal | Yes | WCS 2 |
| 705922044 | 2020-02-27 | 0.160 | Yes | galvanic operator | No | 205 | Personal | Yes | WCS 2 |
| 705922044 | 2020-02-27 | 0.057 | Yes | at the plating line/ plating unit | No | 210 | Static | Yes | WCS 2 |
| 705922044 | 2020-02-27 | 0.048 | Yes | at the plating line/ plating unit | No | 212 | Static | Yes | WCS 2 |
| 705922045 | 2012-08-27 | 0.630 | Yes | at the plating line/ plating unit | No | 240 | Static | Yes | WCS 2 |
| 705922045 | 2012-08-28 | 0.095 | Yes | at the plating line/ plating unit | No | 240 | Static | Yes | WCS 2 |
| 705922045 | 2012-08-29 | 0.058 | Yes | at the plating line/ plating unit | No | 180 | Static | Yes | WCS 2 |
| 705922045 | 2021-08-30 | < 0.140 | Yes | galvanic operator | No | 240 | Personal | Yes | WCS 2 |
| 705922047 | 2018-01-15 | < 0.170 | Yes | at the plating line/ plating unit | No | 120 | Static | Yes | WCS 2 |
| 705922056 | 2015-09-24 | < 0.004 | Yes | at the plating line/ plating unit | No | 240 | Static | Yes | WCS 2 |
| 705922056 | 2015-09-24 | < 0.140 | Yes | Daily maintenance | No | 240 | Personal | Yes | WCS 5 |
| 705922068 | 2019-07-23 | < 1.000 | Yes | galvanic operator | No | 480 | Personal | Yes | WCS 2 |
| 705922072 | 2012-02-09 | 1.700 | Yes | at the plating line/ plating unit | No | 120 | Static | Yes | WCS 2 |
| 705922072 | 2012-02-09 | 1.700 | Yes | at the plating line/ plating unit | No | 120 | Static | Yes | WCS 2 |
| 705922072 | 2012-09-21 | 0.130 | Yes | galvanic operator | No | 240 | Personal | Yes | WCS 2 |
| 705922072 | 2012-09-21 | 0.050 | Yes | at the plating line/ plating unit | No | 240 | Static | Yes | WCS 2 |
| 705922074 | 2016-03-18 | < 1.000 | Yes | at the plating line/ plating unit | No | 300 | Static | Yes | WCS 2 |
| 705922074 | 2015-05-13 | < 1.000 | Yes | at the plating line/ plating unit | No | 240 | Static | Yes | WCS 2 |
| 705922074 | 2014-07-24 | < 1.000 | Yes | at the plating line/ plating unit | No | 120 | Static | Yes | WCS 2 |
| 705922081 | - | < 0.200 | Yes | at the plating line/ plating unit | No | 240 | Static | Yes | WCS 2 |
| 705922081 | - | < 0.200 | Yes | at the plating line/ plating unit | No | 241 | Static | Yes | WCS 2 |
| 705922105 | 2019-06-04 | < 0.070 | Yes | galvanic operator | No | 240 | Personal | Yes | WCS 2 |
| 705922105 | 2019-06-04 | < 0.070 | Yes | at the plating line/ plating unit | No | 240 | Static | Yes | WCS 2 |

**Use 2 - Downstream User in rotogravure printing and embossing industry - Results of workplace exposure monitoring**

| DU ID | Date | | Measure-ment result Cr(VI) | LEV | Tasks performed/sampling location | RPE | Sampling duration | Sampling type | Measured results (8h TWA) | Reference to WCS |
|---|---|---|---|---|---|---|---|---|---|---|
| | *yyyy-mm-dd* | | *µg/m³* | | | | *min* | | | |
| 705922107 | 2019-10-31 | < | 0.120 | Yes | at the plating line/ plating unit | No | 120 | Static | Yes | WCS 2 |
| 705922110 | 2017-11-09 | | 0.150 | Yes | at the plating line/ plating unit | No | 480 | Static | Yes | WCS 2 |
| 705922110 | 2017-11-09 | < | 0.130 | Yes | at the plating line/ plating unit | No | 480 | Static | Yes | WCS 2 |
| 705922118 | 2017-09-19 | < | 0.387 | Yes | at the plating line/ plating unit | No | 180 | Static | Yes | WCS 2 |
| 705922118 | 2017-09-19 | < | 0.515 | Yes | galvanic operator | No | 180 | Personal | Yes | WCS 2 |
| 705922120 | 2015-08-18 | | 0.500 | Yes | at the plating line/ plating unit | No | 267 | Static | Yes | WCS 2 |
| 705922120 | 2015-08-18 | | 1.000 | Yes | galvanic operator | No | 267 | Personal | Yes | WCS 2 |
| 705922126 | 2012-11-08 | < | 0.391 | Yes | galvanic operator | No | 127 | Personal | Yes | WCS 2 |
| 705922127 | 2018-03-27 | < | 0.210 | Yes | at the plating line/ plating unit | No | 240 | Static | Yes | WCS 2 |
| 705922130 | 2019-06-25 | < | 0.380 | Yes | galvanic operator | No | 135 | Personal | Yes | WCS 2 |
| 705922130 | 2017-08-27 | | 0.800 | Yes | at the plating line/ plating unit | No | 122 | Static | Yes | WCS 2 |
| 705922131 | 2018-01-10 | < | 0.280 | Yes | galvanic operator | No | 120 | Personal | Yes | WCS 2 |
| 705922131 | 2018-01-10 | < | 0.480 | Yes | at the plating line/ plating unit | No | 120 | Static | Yes | WCS 2 |
| 705922135 | 2016-12-19 | | 0.090 | Yes | galvanic operator | No | 146 | Personal | Yes | WCS 2 |
| 705922135 | 2016-05-02 | < | 0.025 | Yes | Sampling and bath adjustment | No | 150 | Personal | Yes | WCS 3 + WCS 4 |
| 705922137 | 2019-03-21 | < | 0.130 | Yes | galvanic operator | No | 240 | Personal | Yes | WCS 2 |
| 705922137 | 2019-03-21 | < | 0.130 | Yes | galvanic operator | No | 240 | Personal | Yes | WCS 2 |
| 705922137 | 2019-03-21 | < | 0.130 | Yes | galvanic operator | No | 240 | Personal | Yes | WCS 2 |
| 705922137 | 2019-03-28 | < | 0.130 | Yes | galvanic operator | No | 240 | Personal | Yes | WCS 2 |
| 705922137 | 2019-03-28 | < | 0.130 | Yes | at bath control unit | No | 240 | Static | Yes | WCS 2 |
| 705922137 | 2019-03-28 | < | 0.130 | Yes | worker at bath control unit | No | 240 | Personal | Yes | WCS 2 |
| 705922137 | 2019-03-28 | < | 0.130 | Yes | Maintenance staff | No | 240 | Personal | Yes | WCS 5 |
| 705922138 | 2019-11-26 | < | 0.100 | Yes | galvanic operator | No | 120 | Personal | Yes | WCS 2 |
| 705922138 | 2019-11-26 | < | 0.100 | Yes | galvanic operator | No | 120 | Personal | Yes | WCS 2 |
| 705922146 | 2019-09-16 | < | 1.000 | Yes | galvanic operator | No | 360 | Personal | Yes | WCS 2 |
| 705922146 | 2019-04-25 | < | 1.000 | Yes | galvanic operator | No | 360 | Personal | Yes | WCS 2 |
| 705922146 | 2018-10-18 | < | 1.000 | Yes | galvanic operator | No | 360 | Personal | Yes | WCS 2 |
| 705922146 | 2017-09-11 | < | 1.000 | Yes | galvanic operator | No | 360 | Personal | Yes | WCS 2 |
| 705922146 | 2016-04-18 | < | 1.000 | Yes | galvanic operator | No | 360 | Personal | Yes | WCS 2 |
| 705922148 | 2016-09-28 | < | 0.750 | Yes | galvanic operator | No | 120 | Personal | Yes | WCS 2 |
| 705922150 | 2019-12-10 | < | 1.000 | Yes | galvanic operator | No | 480 | Personal | Yes | WCS 2 |
| 705922150 | 2019-05-07 | < | 1.000 | Yes | galvanic operator | No | 480 | Personal | Yes | WCS 2 |
| 714584448 | 2019-08-05 | | 0.054 | Yes | galvanic operator | No | 453 | Personal | Yes | WCS 2 |
| 714584448 | 2019-08-05 | | 0.055 | Yes | galvanic operator | No | 448 | Personal | Yes | WCS 2 |
| 714584448 | 2019-08-06 | | 0.051 | Yes | galvanic operator | No | 473 | Personal | Yes | WCS 2 |
| 717770732 | 2016-11-28 | < | 0.400 | Yes | galvanic operator | No | 120 | Personal | Yes | WCS 2 |

# 2. Air emission measurements

## 2.1. Measurements related to ES 1

**Table 67:** Overview of the air emission measurements provided by the formulator.

| Use 1 - Results of exhaust air measurement | | | | |
|---|---|---|---|---|
| **Formulator** | **Date** | **Measurement result Cr(VI) emission per hour** | **Annual operating time** | **Total annual release** |
| | *yyyy-mm-dd* | *g/h* | *h* | *kg/a* |
| | | | | *Cr(VI) emission per hour x Annual operating time / 1000* |
| 1 | 2012-10-09 | [redacted] | [redacted] | [redacted] |

## 2.2. Measurements related to ES 2

**Table 68:** Overview of the air emission measurements provided by the DUs of K.Walter.

| Use 2 - Downstream User in rotogravure printing and embossing industry - Results of exhaust air measurement | | | | | | |
|---|---|---|---|---|---|---|
| **DU ID** | **Date** | **Measurement result Cr(VI) emission per hour** | **Annual operating time** | **Total annual release** | **Average daily release** | **Cr(VI) exposure in 100 m from emission source** |
| | *yyyy-mm-dd* | *g/h* | *h* | *kg/a* | *kg/d* | mg/m³ |
| | | | | *Cr(VI) emission per hour x Annual operating time / 1000* | *Total annual release / 365* | *Average daily release x* $Cstd_{air}$ [a)] |
| 705872542 | 2019-04-16 | 0.258 | 6860 | 1.769 | 4.85E-03 | 1.35E-06 |
| 705872543 | 2018-11-06 | 0.089 | 1300 | 0.116 | 3.17E-04 | 8.81E-08 |
| 705872544 | - | 0.003 | 5460 | 0.019 | 5.09E-05 | 1.41E-08 |
| 705872546 | 2019-10-14 | 0.003 | 6000 | 0.016 | 4.44E-05 | 1.23E-08 |
| 705872547 | 2019-04-07 | 0.016 | 6000 | 0.093 | 2.55E-04 | 7.09E-08 |
| 705872548 | 2013-04-25 | 0.831 | 3000 | 2.493 | 6.83E-03 | 1.90E-06 |
| 705872554 | 2019-06-25 | 0.175 | 6000 | 1.051 | 2.88E-03 | 8.01E-07 |
| 705922037 | 2019-09-24 | 0.052 | 1000 | 0.052 | 1.43E-04 | 3.97E-08 |
| 705922041 | 2017-04-17 | 0.041 | 4800 | 0.197 | 5.39E-04 | 1.50E-07 |
| 705922051 | 2007-03-21 | 0.389 | 5328 | 2.072 | 5.68E-03 | 1.58E-06 |
| 705922056 | 2017-07-04 | 0.003 | 8760 | 0.026 | 7.20E-05 | 2.00E-08 |
| 705922070 | 2018-04-10 | 0.009 | 4000 | 0.036 | 9.93E-05 | 2.76E-08 |
| 705922072 | 2016-12-15 | 0.335 | 8400 | 2.814 | 7.71E-03 | 2.14E-06 |
| 705922073 | 2019-04-19 | 0.127 | 4000 | 0.509 | 1.40E-03 | 3.88E-07 |
| 705922078 | 2017-10-05 | 0.376 | 2500 | 0.940 | 2.58E-03 | 7.16E-07 |
| 705922082 | 2019-07-16 | 0.096 | 4160 | 0.399 | 1.09E-03 | 3.04E-07 |
| 705922096 | 2020-02-28 | 0.036 | 4000 | 0.143 | 3.92E-04 | 1.09E-07 |
| 705922100 | 2019-04-10 | 0.090 | 6000 | 0.540 | 1.48E-03 | 4.11E-07 |
| 705922105 | 2020-03-11 | 0.042 | 5000 | 0.209 | 5.72E-04 | 1.59E-07 |
| 705922107 | 2019-04-12 | 0.266 | 4000 | 1.064 | 2.92E-03 | 8.10E-07 |
| 705922110 | 2018-10-18 | 0.004 | 4000 | 0.016 | 4.50E-05 | 1.25E-08 |
| 705922111 | 2015-03-09 | 0.370 | 4000 | 1.480 | 4.05E-03 | 1.13E-06 |
| 705922118 | 2019-02-27 | 0.004 | 8760 | 0.034 | 9.31E-05 | 2.59E-08 |
| 705922121 | 2020-04-24 | 0.017 | 4000 | 0.068 | 1.86E-04 | 5.18E-08 |
| 705922137 | 2019-11-21 | 0.023 | 8760 | 0.200 | 5.47E-04 | 1.52E-07 |
| 705922148 | 2018-06-20 | 0.008 | 3000 | 0.024 | 6.58E-05 | 1.83E-08 |
| 714584448 | 2019-12-18 | 0.202 | 7080 | 1.432 | 3.92E-03 | 1.09E-06 |
| 717770732 | 2018-09-14 | 0.080 | 4440 | 0.355 | 9.73E-04 | 2.71E-07 |

[a)] $Cstd_{air}$ (concentration in air at the source strength of 1 kg/d) = *2.78E-04 mg/m³*
*ECHA Guidance R.16 (2016). Guidance on information requirements and Chemical Safety Assessment. Chapter R.16: Environmental Exposure Assessment. Version 3.0, p. 113.*

# 3. ART 1.5 printouts

## 3.1. Printouts related to ES 1

# ART REPORT – WCS 3 - Sampling (PROC 8b) – 04-Feb-21

K.Walter AfA (Use 1)

| Chemical details | |
|---|---|
| Chemical | Chromium Trioxide |
| CAS No. | 1333-82-0 |

| Scenario details | |
|---|---|
| Number of activities | 1 |
| Total duration (mins) | 480 |
| Nonexposure period (mins) | 465 |

| Metadata | |
|---|---|
| ART version | 1.5 |
| Creator | sven.kroesen@ramboll.com |
| Date created | 14-Oct-20 |
| Date last edited | 04-Feb-21 |

Details for Activity WCS 3 - Sampling (PROC 8b)

| | | | |
|---|---|---|---|
| Emission sources: | Near field ✓ | Duration (mins): | 15 |
| | Far field | | |

Near-field exposure

*Operational Conditions*

| *Substance emission potential* | |
|---|---|
| Substance product type | Liquids |
| Process temperature | Room temperature |
| Vapour pressure | 0.001 Pa |
| Liquid weight fraction | 0.34 |
| Viscosity | Low |

| *Activity emission potential* | |
|---|---|
| Activity class | Activities with relatively undisturbed surfaces (no aerosol formation) |
| Situation | Open surface 0.3 - 1 $m^2$ |

| *Surface contamination* | |
|---|---|
| Process fully enclosed? | No |
| Effective housekeeping practices in place? | Yes |

| *Dispersion* | |
|---|---|
| Work area | Indoors |
| Room size | 300 $m^3$ |

*Risk Management Measures*

| *Localised controls* | |
|---|---|
| Primary | No localized controls (0.00 % reduction) |
| Secondary | No localized controls (0.00 % reduction) |

| *Dispersion* | |
|---|---|
| Ventilation rate | Mechanical ventilation giving at least 1 ACH |

## Predicted exposure levels

ART predicts air concentrations in a worker's personal breathing zone outside of any Respiratory Protection Equipment (RPE). The use of RPE must be considered separately.

### Mechanistic model results

The predicted 90th percentile full-shift exposure is 0.00039 $mg/m^3$.

The inter-quartile confidence interval is 0.00017 $mg/m^3$ to 0.00089 $mg/m^3$.

# ART REPORT – WCS 4 Maintenance (PROC 28) – 04-Feb-21

K.Walter AfA (Use 1)

| Chemical details | |
|---|---|
| Chemical | Chromium Trioxide |
| CAS No. | 1333-82-0 |

| Scenario details | |
|---|---|
| Number of activities | 1 |
| Total duration (mins) | 480 |
| Nonexposure period (mins) | 465 |

| Metadata | |
|---|---|
| ART version | 1.5 |
| Creator | sven.kroesen@ramboll.com |
| Date created | 14-Oct-20 |
| Date last edited | 04-Feb-21 |

Details for Activity WCS 4 Maintenance (PROC 28)

| | | | |
|---|---|---|---|
| Emission sources: | Near field ✓ | Duration (mins): | 15 |
| | Far field | | |

Near-field exposure

*Operational Conditions*

| *Substance emission potential* | |
|---|---|
| Substance product type | Liquids |
| Process temperature | Room temperature |
| Vapour pressure | 0.001 Pa |
| Liquid weight fraction | Small |
| Viscosity | Low |

| *Activity emission potential* | |
|---|---|
| Activity class | Handling of contaminated objects |
| Situation | Activities with treated/contaminated objects (surface 1-3 $m^2$) |
| Contamination level | Contamination > 90 % of surface |

| *Surface contamination* | |
|---|---|
| Process fully enclosed? | No |
| Effective housekeeping practices in place? | Yes |

| *Dispersion* | |
|---|---|
| Work area | Indoors |
| Room size | 300 $m^3$ |

*Risk Management Measures*

| *Localised controls* | |
|---|---|
| Primary | No localized controls (0.00 % reduction) |
| Secondary | No localized controls (0.00 % reduction) |

| *Dispersion* | |
|---|---|
| Ventilation rate | Mechanical ventilation giving at least 1 ACH |

# Predicted exposure levels

ART predicts air concentrations in a worker's personal breathing zone outside of any Respiratory Protection Equipment (RPE). The use of RPE must be considered separately.

## Mechanistic model results

The predicted 90th percentile full-shift exposure is 0.000034 $mg/m^3$.

The inter-quartile confidence interval is 0.000015 $mg/m^3$ to 0.000079 $mg/m^3$.

# ART REPORT – WCS 5 - Wastewater sampling (liquid) (PROC 8b) – 04-Feb-21

K.Walter AfA (Use 1)

| Chemical details | |
|---|---|
| Chemical | Chromium Trioxide |
| CAS No. | 1333-82-0 |

| Scenario details | |
|---|---|
| Number of activities | 1 |
| Total duration (mins) | 480 |
| Nonexposure period (mins) | 465 |

| Metadata | |
|---|---|
| ART version | 1.5 |
| Creator | sven.kroesen@ramboll.com |
| Date created | 14-Oct-20 |
| Date last edited | 04-Feb-21 |

Details for Activity WCS 5 - Wastewater sampling (liquid) (PROC 8b)

Emission sources: Near field ✓ Far field

Duration (mins): 15

Near-field exposure

*Operational Conditions*

| *Substance emission potential* | |
|---|---|
| Substance product type | Liquids |
| Process temperature | Room temperature |
| Vapour pressure | 0.001 Pa |
| Liquid weight fraction | Minute |
| Viscosity | Low |

| *Activity emission potential* | |
|---|---|
| Activity class | Activities with relatively undisturbed surfaces (no aerosol formation) |
| Situation | Open surface 0.3 - 1 $m^2$ |

| *Surface contamination* | |
|---|---|
| Process fully enclosed? | No |
| Effective housekeeping practices in place? | Yes |

| *Dispersion* | |
|---|---|
| Work area | Indoors |
| Room size | 300 $m^3$ |

*Risk Management Measures*

| *Localised controls* | |
|---|---|
| Primary | No localized controls (0.00 % reduction) |
| Secondary | No localized controls (0.00 % reduction) |

| *Dispersion* | |
|---|---|
| Ventilation rate | Mechanical ventilation giving at least 1 ACH |

## Predicted exposure levels

ART predicts air concentrations in a worker's personal breathing zone outside of any Respiratory Protection Equipment (RPE). The use of RPE must be considered separately.

### Mechanistic model results

The predicted 90th percentile full-shift exposure is 0.00000068 $mg/m^3$.

The inter-quartile confidence interval is 0.00000031 $mg/m^3$ to 0.0000016 $mg/m^3$.

## 3.2. Printouts related to ES 2

# ART REPORT – WCS 3 - Sampling (PROC 8b) – 04-Feb-21

K.Walter AfA (Use 2)

| Chemical details | |
|---|---|
| Chemical | Chromium Trioxide |
| CAS No. | 1333-82-0 |

| Scenario details | |
|---|---|
| Number of activities | 1 |
| Total duration (mins) | 480 |
| Nonexposure period (mins) | 360 |

| Metadata | |
|---|---|
| ART version | 1.5 |
| Creator | sven.kroesen@ramboll.com |
| Date created | 06-Aug-20 |
| Date last edited | 04-Feb-21 |

Details for Activity WCS 3 - Sampling (PROC 8b)

Emission sources: Near field ✓ Duration (mins): 120

Far field

Near-field exposure

*Operational Conditions*

| *Substance emission potential* | |
|---|---|
| Substance product type | Liquids |
| Process temperature | Above room temperature |
| Vapour pressure | 0.001 Pa |
| Liquid weight fraction | 0.2 |
| Viscosity | Low |

| *Activity emission potential* | |
|---|---|
| Activity class | Activities with relatively undisturbed surfaces (no aerosol formation) |
| Situation | Open surface 0.1 – 0.3 m² |

| *Surface contamination* | |
|---|---|
| Process fully enclosed? | No |
| Effective housekeeping practices in place? | Yes |

| *Dispersion* | |
|---|---|
| Work area | Indoors |
| Room size | Any size workroom |

*Risk Management Measures*

| *Localised controls* | |
|---|---|
| Primary | Fixed capturing hood (90.00 % reduction) |
| Secondary | No localized controls (0.00 % reduction) |

| *Dispersion* | |
|---|---|
| Ventilation rate | Only good natural ventilation |

# Predicted exposure levels

ART predicts air concentrations in a worker's personal breathing zone outside of any Respiratory Protection Equipment (RPE). The use of RPE must be considered separately.

## Mechanistic model results

The predicted 90th percentile full-shift exposure is 0.00031 $mg/m^3$.

The inter-quartile confidence interval is 0.00014 $mg/m^3$ to 0.00071 $mg/m^3$.

# ART REPORT – WCS 4 - Concentration adjustment with liquid CrO3 (PROC 8b) – 04-Feb-21

K. Walter AfA (Use 2)

| Chemical details | |
|---|---|
| Chemical | Chromium Trioxide |
| CAS No. | 1333-82-0 |

| Scenario details | |
|---|---|
| Number of activities | 1 |
| Total duration (mins) | 480 |
| Nonexposure period (mins) | 240 |

| Metadata | |
|---|---|
| ART version | 1.5 |
| Creator | sven.kroesen@ramboll.com |
| Date created | 06-Aug-20 |
| Date last edited | 04-Feb-21 |

Details for Activity WCS 4 - Concentration adjustment with liquid $CrO_3$ (PROC 8b)

| | | | |
|---|---|---|---|
| Emission sources: | Near field ✓ | Duration (mins): | 240 |
| | Far field | | |

Near-field exposure

*Operational Conditions*

| *Substance emission potential* | |
|---|---|
| Substance product type | Liquids |
| Process temperature | Room temperature |
| Vapour pressure | 0.001 Pa |
| Liquid weight fraction | Substantial |
| Viscosity | Low |

| *Activity emission potential* | |
|---|---|
| Activity class | Handling of contaminated objects |
| Situation | Activities with treated/contaminated objects (surface <0.1 m²) |
| Contamination level | Contamination < 10 % surface |

| *Surface contamination* | |
|---|---|
| Process fully enclosed? | No |
| Effective housekeeping practices in place? | Yes |

| *Dispersion* | |
|---|---|
| Work area | Indoors |
| Room size | Any size workroom |

*Risk Management Measures*

| *Localised controls* | |
|---|---|
| Primary | No localized controls (0.00 % reduction) |
| Secondary | No localized controls (0.00 % reduction) |

| *Dispersion* | |
|---|---|
| Ventilation rate | Only good natural ventilation |

# Predicted exposure levels

ART predicts air concentrations in a worker's personal breathing zone outside of any Respiratory Protection Equipment (RPE). The use of RPE must be considered separately.

## Mechanistic model results

The predicted 90th percentile full-shift exposure is 0.00091 $mg/m^3$.

The inter-quartile confidence interval is 0.00041 $mg/m^3$ to 0.0021 $mg/m^3$.

# ART REPORT – WCS 5.1 - Maintenance (PROC 28): Cleaning of anodes (Weekly) – 04-Feb-21

K.Walter AfA (Use 2)

| Chemical details | |
|---|---|
| Chemical | Chromium Trioxide |
| CAS No. | 1333-82-0 |

| Scenario details | |
|---|---|
| Number of activities | 1 |
| Total duration (mins) | 480 |
| Nonexposure period (mins) | 342 |

| Metadata | |
|---|---|
| ART version | 1.5 |
| Creator | sven.kroesen@ramboll.com |
| Date created | 04-Sep-20 |
| Date last edited | 04-Feb-21 |

Details for Activity WCS 5.1 - Maintenance (PROC 28): Cleaning of anodes (Weekly)

Emission sources: Near field ✓ Duration (mins): 138

Far field

Near-field exposure

*Operational Conditions*

| *Substance emission potential* | |
|---|---|
| Substance product type | Liquids |
| Process temperature | Room temperature |
| Vapour pressure | 0.001 Pa |
| Liquid weight fraction | 0.2 |
| Viscosity | Low |

| *Activity emission potential* | |
|---|---|
| Activity class | Handling of contaminated objects |
| Situation | Activities with treated/contaminated objects (surface 0.1-0.3 $m^2$) |
| Contamination level | Contamination 10-90 % of surface |

| *Surface contamination* | |
|---|---|
| Process fully enclosed? | No |
| Effective housekeeping practices in place? | Yes |

| *Dispersion* | |
|---|---|
| Work area | Indoors |
| Room size | Any size workroom |

*Risk Management Measures*

| *Localised controls* | |
|---|---|
| Primary | No localized controls (0.00 % reduction) |
| Secondary | No localized controls (0.00 % reduction) |

| *Dispersion* | |
|---|---|
| Ventilation rate | Only good natural ventilation |

# Predicted exposure levels

ART predicts air concentrations in a worker's personal breathing zone outside of any Respiratory Protection Equipment (RPE). The use of RPE must be considered separately.

## Mechanistic model results

The predicted 90th percentile full-shift exposure is 0.0011 $mg/m^3$.

The inter-quartile confidence interval is 0.00048 $mg/m^3$ to 0.0025 $mg/m^3$.

# ART REPORT – WCS 5.2 - Maintenance (PROC 28) - Complete maintenance (Annually) – 04-Feb-21

K.Walter AfA (Use 2)

| Chemical details | |
|---|---|
| Chemical | Chromium Trioxide |
| CAS No. | 1333-82-0 |

| Scenario details | |
|---|---|
| Number of activities | 1 |
| Total duration (mins) | 480 |
| Nonexposure period (mins) | 0 |

| Metadata | |
|---|---|
| ART version | 1.5 |
| Creator | sven.kroesen@ramboll.com |
| Date created | 16-Sep-20 |
| Date last edited | 04-Feb-21 |

Details for Activity WCS 5.2 - Maintenance (PROC 28) - Complete maintenance (Annually)

| | | | |
|---|---|---|---|
| Emission sources: | Near field ✓ | Duration (mins): | 480 |
| | Far field | | |

Near-field exposure

*Operational Conditions*

| *Substance emission potential* | |
|---|---|
| Substance product type | Liquids |
| Process temperature | Room temperature |
| Vapour pressure | 0.001 Pa |
| Liquid weight fraction | 0.2 |
| Viscosity | Low |

| *Activity emission potential* | |
|---|---|
| Activity class | Handling of contaminated objects |
| Situation | Activities with treated/contaminated objects (surface > 3 $m^2$) |
| Contamination level | Contamination 10-90 % of surface |

| *Surface contamination* | |
|---|---|
| Process fully enclosed? | No |
| Effective housekeeping practices in place? | Yes |

| *Dispersion* | |
|---|---|
| Work area | Indoors |
| Room size | Any size workroom |

*Risk Management Measures*

| *Localised controls* | |
|---|---|
| Primary | No localized controls (0.00 % reduction) |
| Secondary | No localized controls (0.00 % reduction) |

| *Dispersion* | |
|---|---|
| Ventilation rate | Only good natural ventilation |

# Predicted exposure levels

ART predicts air concentrations in a worker's personal breathing zone outside of any Respiratory Protection Equipment (RPE). The use of RPE must be considered separately.

## Mechanistic model results

The predicted 90th percentile full-shift exposure is 0.0037 $mg/m^3$.

The inter-quartile confidence interval is 0.0016 $mg/m^3$ to 0.0085 $mg/m^3$.

# ART REPORT – WCS 5.3 - Maintenance (PROC 28) - Exchange of the electrolyte (Infrequently) – 04-Feb-21

K.Walter AfA (Use 2)

| Chemical details | |
|---|---|
| Chemical | Chromium Trioxide |
| CAS No. | 1333-82-0 |

| Scenario details | |
|---|---|
| Number of activities | 1 |
| Total duration (mins) | 480 |
| Nonexposure period (mins) | 0 |

| Metadata | |
|---|---|
| ART version | 1.5 |
| Creator | sven.kroesen@ramboll.com |
| Date created | 16-Sep-20 |
| Date last edited | 04-Feb-21 |

Details for Activity WCS 5.3 - Maintenance (PROC 28) - Exchange of the electrolyte (Infrequently)

Emission sources: Near field ✓ Duration (mins): 480

Far field

Near-field exposure

*Operational Conditions*

| *Substance emission potential* | |
|---|---|
| Substance product type | Liquids |
| Process temperature | Room temperature |
| Vapour pressure | 0.001 Pa |
| Liquid weight fraction | 0.2 |
| Viscosity | Low |

| *Activity emission potential* | |
|---|---|
| Activity class | Handling of contaminated objects |
| Situation | Activities with treated/contaminated objects (surface > 3 $m^2$) |
| Contamination level | Contamination > 90 % of surface |

| *Surface contamination* | |
|---|---|
| Process fully enclosed? | No |
| Effective housekeeping practices in place? | Yes |

| *Dispersion* | |
|---|---|
| Work area | Indoors |
| Room size | Any size workroom |

*Risk Management Measures*

| *Localised controls* | |
|---|---|
| Primary | No localized controls (0.00 % reduction) |
| Secondary | No localized controls (0.00 % reduction) |

| *Dispersion* | |
|---|---|
| Ventilation rate | Only good natural ventilation |

# Predicted exposure levels

ART predicts air concentrations in a worker's personal breathing zone outside of any Respiratory Protection Equipment (RPE). The use of RPE must be considered separately.

## Mechanistic model results

The predicted 90th percentile full-shift exposure is 0.012 $mg/m^3$.

The inter-quartile confidence interval is 0.0055 $mg/m^3$ to 0.028 $mg/m^3$.

## 4. Justification for confidentiality claims [21]

[21] This annex will not be made publicly available as part of the broad information on uses package