

CHEMICAL SAFETY REPORT

Public Version

28. November 2019

Legal name of applicant(s): Tata Steel UK Ltd.
Tata Steel IJmuiden B.V.

Submitted by: Tata Steel IJmuiden B.V.

Substance: Sodium Dichromate
CAS No: 10588-01-9, 7789-12-0 (dihydrate)
EC No: 234-190-3, 616-541-6 (dihydrate)
(Annex XIV entry number: 18)

Chromium Trioxide
CAS No: 1333-82-0, EC No: 215-607-8
(Annex XIV entry number: 16)

Use title: Use of Chromium (VI) Trioxide and Sodium Dichromate
for Passivation of Electrolytic Tinplate (ETP)

Use number: 1

Note: Confidential information (CBI) is marked in [REDACTED].

Table of Contents

9. EXPOSURE ASSESSMENT (and related risk characterisation)	39
9.0 Introduction	39
9.0.1. Overview of uses and Exposure Scenarios	39
9.0.2. Introduction to the assessment	43
9.0.2.1. Environment	43
9.0.2.2. Man via environment	43
9.0.2.3. Workers	48
9.0.2.4. Consumers	62
9.0.3. Exposure-risk relationships (ERRs) for carcinogenic effects and DNEL values for reproductive toxicity used for the assessment	62
9.1. Exposure scenario 1: Use at industrial site - Use of Chromium (VI) Trioxide and Sodium Dichromate for Passivation of Electrolytic Tinplate (ETP)	64
9.1.1. Environmental contributing scenario 1	66
9.1.2. Worker contributing scenario 1: T1: Changing IBC containers (PROC 8b)	74
9.1.2.1. Conditions of use	74
9.1.2.2. Exposure assessment	74
9.1.3. Worker contributing scenario 2: T2: Sampling of passivation bath (PROC 9)	76
9.1.3.1. Conditions of use	76
9.1.3.2. Exposure assessment	77
9.1.4. Worker contributing scenario 3: T3: Sampling of wastewater (PROC 9)	78
9.1.4.1. Conditions of use	78
9.1.4.2. Exposure assessment	79
9.1.5. Worker contributing scenario 4: T4: Maintenance (PROC 28)	80
9.1.5.1. Conditions of use	80
9.1.5.2. Exposure assessment	81
9.1.6. Worker contributing scenario 5: T5: Cleaning (PROC 28)	83
9.1.6.1. Conditions of use	83
9.1.6.2. Exposure assessment	84
9.1.7. Worker contributing scenario 6: T6: Filter Press/Sludge removal from passivation tank (PROC 28)	85
9.1.7.1. Conditions of use (A)	85
T6: Filter Press/Sludge removal from passivation tank – conditions (A) Handling of “paste, slurry or clearly (soaked) wet powder”	85
9.1.7.2. Conditions of use (B)	86
T6: Filter Press/Sludge removal from passivation tank – conditions (B) handling of sludge with residual dust	86
9.1.7.2. Exposure assessment	86
9.1.8. Worker contributing scenario 7: T7: Addition of solid CT (PROC 8b)	88
9.1.8.1. Conditions of use	88
9.1.8.2. Exposure assessment	89
9.1.9. Worker contributing scenario 8: T8: Dissolution of solid CT /SD (PROC 5)	90
9.1.9.1. Conditions of use	90

9.1.9.2. Exposure assessment.....	91
9.1.10. Worker contributing scenario 9: T9: Activities close to the ETP line without handling of Cr(VI) containing solutions (PROC 4)	92
9.1.10.1. Conditions of use	92
9.1.10.2 Exposure assessment	93
9.1.11. Worker contributing scenario 10: T10: Control-Room activities (no PROC assigned).....	94
9.1.11.1. Conditions of use	94
9.1.11.2. Exposure assessment.....	94
9.1.12. Aggregated exposure estimation and risk characterisation for unit operators	95
9.1.12.1 Aggregated exposure assessment for Trostre.....	97
9.1.12.2 Aggregated exposure assessment for IJmuiden	100
9.1.12.3 Risk characterisation for Trostre.....	104
9.1.12.4 Risk characterisation for IJmuiden	105
9.2 Consideration of reproductive toxicity	106
10. RISK CHARACTERISATION RELATED TO COMBINED EXPOSURE	111
10.1. Human health.....	111
10.1.1. Workers	111
10.1.2. Consumer.....	111
10.2. Environment (combined for all emission sources)	111
10.2.1. All uses (regional scale).....	111
10.2.2. Local exposure due to all wide dispersive uses	111
10.2.3. Local exposure due to combined uses at a site	112
Annex 1 Extract of GESTIS database International limit values for chemical agents Occupational exposure limits (OELs).....	113
Annex 2 Air monitoring data provided by the companies of the APEAL consortium (anonymised)	115
Annex 3 Site specific data for this applicant – Trostre (Site [REDACTED]) and IJmuiden (Site [REDACTED]).....	124
Annex 3a Monitoring data (Trostre).....	124
Annex 3b Monitoring data (IJmuiden).....	126
Annex 3c Worker Instructions (Trostre).....	128
Annex 3d Worker Instructions (IJmuiden).....	129
Annex 4 Photo documentation.....	130
Annex 5 ART modelling input and results.....	134
Annex 6 Riskofderm modelling and results	144
Annex 7 HvE assessment.....	146
Annex 7a HvE assessment for the applicant's site in Trostre – Site [REDACTED].....	146
Annex 7b HvE assessment for the applicant's site in IJmuiden – Site [REDACTED]	151
Annex 8 EUSES protocols.....	157
Annex 8a EUSES protocol for the applicant's site in Trostre – Site [REDACTED]	157
Annex 8b EUSES protocol for the applicant's site in IJmuiden – Site [REDACTED]	187
References	217

List of Tables

Table 20. Overview on the sites of the companies of the APEAL-consortium, the substances used as source for Cr(VI) and the tonnage range of Cr(VI) used per site per year	40
Table 21. Overview of exposure scenarios and contributing scenarios	43
Table 22. Derived release factors for releases to wastewater (after reduction) and air	45
Table 23. Input data for sodium dichromate (SD) in EUSES modelling.....	46
Table 24. Input data for chromium trioxide (CT) in EUSES modelling.....	46
Table 25. Input data for chromium trioxide (CT) in EUSES modelling.....	47
Table 26. Exemplary comparison of EUSES exposure values calculated with physico-chemical and environmental fate properties of SD and CT	47
Table 27. Task definition.....	51
Table 28. Critical input parameters (bold print indicates values used in modelling).....	57
Table 29. Exposure-risk relationships for inhalation exposure of workers used for calculating risks due to CrVI exposure (from ECHA, 2013).....	62
Table 30. Exposure-risk relationships for inhalation exposure of general population used for calculating risks due to CrVI exposure (from ECHA, 2013).....	63
Table 31. Exposure-risk relationships for oral exposure of general population used for calculating risks due to CrVI exposure of humans via environment (from ECHA, 2013).....	63
Table 32. Summary of stationary air monitoring results	64
Table 33. Summary of personal air monitoring results.....	65
Table 34. Local releases to the environment	66
Table 35. Modelled exposure for humans via the environment: inhalation.....	67
Table 36. Modelled exposure for humans via the environment: oral (drinking water and fish)	68
Table 37. Risk estimates for humans via the environment (general population, local assessment).....	70
Table 38. Risk estimates for humans via the environment (general population, regional assessment)	71
Table 39. RCRs for humans via the environment.....	73
Table 40. Monitored exposure in the area of the IBC containers	75
Table 41. Modelled Exposure for Workers: task 1	75
Table 42. Overview of Cr(VI) monitoring values for WCS 2 (sampling of the passivation bath)	77
Table 43. Modelled exposure for workers: task 2	77
Table 44. Overview of Cr(VI) monitoring values for WCS 3 (sampling of the wastewater)	79
Table 45. Modelled exposure for workers: task 3.....	80
Table 46. Overview of Cr(VI) monitoring values for WCS 4 (maintenance).....	82
Table 47. Modelled exposure for workers: task 4 (maintenance)	82
Table 48. Overview of Cr(VI) monitoring values for WCS 5 (cleaning)	84
Table 49. Overview of Cr(VI) monitoring values for WCS 6 (filter press/sludge removal)	87
Table 50. Modelled exposure for workers: task 6 – conditions of use A.....	87
Table 51. Modelled exposure for workers: task 6 – conditions of use B	87
Table 52. Overview of Cr(VI) monitoring values for WCS 7 (addition of solid CT).....	89
Table 53. Modelled Exposure for workers: task 7	89
Table 54. Modelled Exposure for workers: task 8	91
Table 55. Overview of Cr(VI) monitoring values for WCS 9 (no task specific activities along the ETP line)	93
Table 56. Overview of Cr(VI) monitoring values for WCS 10 (control room)	95
Table 57. Task-specific long-term TWA inhalation exposure estimates	96
Table 58. Shift patterns for aggregated exposure estimation (Trostre).....	98
Table 59. Overview on the tasks performed by the different operators (Trostre).....	99
Table 60. Task-specific and aggregated long-term TWA inhalation exposure estimates for unit operators and contract workers (Trostre)	99
Table 61. Shift patterns for aggregated exposure estimation (IJmuiden)	100
Table 62. Overview on the tasks performed by the different operators (IJmuiden)	102
Table 63. Task-specific and aggregated long-term TWA inhalation exposure estimates for unit operators and contract workers (IJmuiden)	103
Table 64. Risk resulting from Cr(VI) exposure use of sodium dichromate and chromium trioxide for the passivation of tin-plated steel (ETP) (Trostre).....	104
Table 65. Risk resulting from Cr(VI) exposure use of sodium dichromate and chromium trioxide for the passivation of tin-plated steel (ETP) (IJmuiden)	105
Table 66. Modelled Exposure for Workers: T2 (hands), T3 (hands), and T8 (hands) based on Riskofderm	107
Table 67. Modelled Exposure for Workers for all tasks based on a default dermal load of 0.1 mg/cm ² /d (generic	

approach)	108
Table 68. Exposure concentrations for workers (dermal exposure)	109
Table 69. Exposure concentrations and risks for workers	110
Table 70. Stationary monitoring values Cr(VI), [$\mu\text{g Cr(VI)/m}^3$]	115
Table 71. Personal monitoring values Cr(VI), [$\mu\text{g Cr(VI)/m}^3$]	118
Table 72. Stationary monitoring values total chromium, [$\mu\text{g total Cr/m}^3$]	121
Table 73. Personal monitoring values total chromium, [$\mu\text{g total Cr/m}^3$]	122
Table 74:	146
Table 75:	146
Table 76:	147
Table 77:	147
Table 78:	148
Table 79:	148
Table 80:	148
Table 81:	148
Table 82:	149
Table 83:	151
Table 84:	152
Table 85:	152
Table 86:	153
Table 87:	153
Table 88:	153
Table 89:	153
Table 90:	153
Table 91:	154

List of Figures

Figure 1: Schematic structure of tin-plated steel (Courtesy of ArcelorMittal Flat Carbon Europe)	40
Figure 2: Schematic description of the passivation of tin-plated steel	41
Figure 3: Compilation of Cr(VI) personal monitoring data provided by six sites covering all tasks (median: 42.1 ng/m ³ , 90th percentile: 219.1 ng/m ³ ; and the 75th percentile 117.2 ng/m ³)	97
Figure 4:	147
Figure 5:	152

Preliminary Remark

This Chemical Safety Report has been prepared for the member companies of the Association of European Producers of steel for packaging (APEAL) to be used for the application for authorisation (AfA) for the Use of Chromium (VI) Trioxide and Sodium Dichromate for Passivation of Electrolytic Tinplate (ETP). APEAL member companies are currently running 10 sites in 8 European countries. The ETP process is performed in comparable manner (for details see section 9) which allows the preparation of a common CSR. However, due to historical developments there are slight differences with regard to the substances used for the process: Whereas some companies use only sodium dichromate, other companies use only chromium trioxide and some even use both substances, sodium dichromate and chromium trioxide, in the ETP process. Nevertheless, a common exposure and risk assessment has been performed, as the substance of toxicological relevance is chromium VI (Cr(VI)), for which the exposure calculations are provided.

This CSR is a joint CSR for Tata Steel UK Ltd. and Tata Steel IJmuiden B.V.. Currently, only sodium dichromate is used as source for Cr(VI) at the site of Tata Steel UK Ltd. whereas both substances, chromium (VI) trioxide and sodium dichromate are used at the site of Tata Steel IJmuiden B.V.. Nevertheless, both sites apply for the application of both substances, although a theoretical scenario for the site in UK at the moment. However, this would provide the flexibility to use both substances at both sites in the future.

9. EXPOSURE ASSESSMENT (and related risk characterisation)

9.0 Introduction

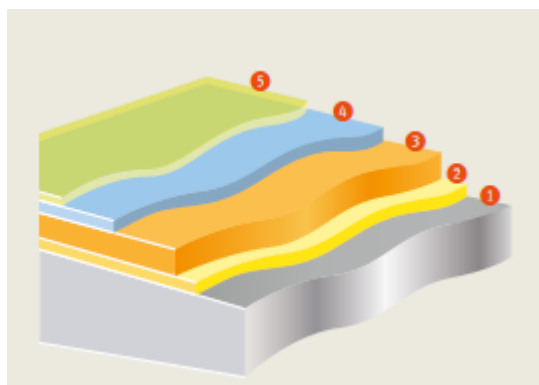
This downstream user Chemical Safety Report has been prepared for the member companies of the Association of European Producers of steel for packaging (APEAL) to be used for the application for authorisation (AfA) for the Use of Chromium (VI) Trioxide and Sodium Dichromate for Passivation of Electrolytic Tinplate (ETP).

APEAL member companies are currently running 10 sites in 8 European countries. During the ETP process the surface of tin-plated steel is passivated in a cathodic process in the presence of chromium (VI) salts by covering the tin-plated steel with an inert layer of metallic chromium and chromium (III) oxide. The ETP process is performed in a comparable manner (for details see below) at all sites which allows the preparation of a common CSR. However, due to historical developments there are slight differences with regard to the substances used for the delivery of chromium (VI) salts: Whereas some companies use only sodium dichromate, other companies use only chromium trioxide and most of them both, sodium dichromate and chromium trioxide. As a general risk management measure aqueous solutions (rather than the neat solid substance) of sodium dichromate and chromium trioxide are used as sources for chromium (VI). Only two sites use small amounts of solid chromium trioxide for pH adjustment. Therefore, this CSR relates to the Annex XIV Entries No. 16 (chromium trioxide, abbreviated in the following as CT), Entry No. 17 (acids generated from chromium trioxide and their oligomers) and Entry No. 18 (sodium dichromate, abbreviated in the following as SD). As chromium (VI) (abbreviated as Cr(VI) in the following) is the relevant constituent, both with regard to the function in the ETP process and with regard to the exposure and risk assessment, the amounts of CT and SD used are expressed as Cr(VI) equivalents. Based on the molecular weights of chromium trioxide (99.99 g/mol), sodium dichromate (261.97 g/mol for the anhydride) and chromium (51.9961 g/mol) a factor of 0.52 and 0.40 was used to calculate the amount of Cr(VI) resulting from the amount of CT or SD used, respectively. The resulting exposure estimates were used for the carcinogenic risk calculation using the dose-response-relationships provided for Cr(VI) by ECHA (2013). As sodium dichromate has also been included in Annex XIV due to its reproductive toxic effects, risk characterisation ratios have also been calculated on basis for the DNELs provided by ECHA (2015a). For details see section 9.0.3.

A joint exposure assessment has been performed for all member companies of the APEAL members considering the monitoring data provided by the individual companies. These data are used in an anonymised way (see Annex 2). Environmental exposure assessments have been performed for the individual companies. The results are presented in an anonymised way in section 9.1.1. However, CSRs are submitted by the individual companies and the legal entities for the different sites. The confidential exposure data (see Annex 3) and confidential environmental exposure and risk assessments (see Annex 7) including the corresponding EUSES calculations (see Annex 8) for the individual sites are provided in the Annexes.

9.0.1. Overview of uses and Exposure Scenarios

During the passivation of tin-plated steel (ETP) a multilayered steel product is produced. The following picture shows the schematic structure of tin-plated steel.



- Layer 1: steel substrate
 Layer 2: iron-tin alloy layer FeSn₂ (thickness 0.1 µm)
 Layer 3: tin layer Sn (thickness 0.4 µm)
 Layer 4: passivation 311: Cr + Cr₂O₃ (thickness 0.002 µm)
 Layer 5: oil film (thickness 0.005 µm).

Figure 1: Schematic structure of tin-plated steel (Courtesy of ArcelorMittal Flat Carbon Europe¹)

To achieve the passivation of tin-plated steel the tin is covered with a thin layer of metallic chromium and chromium (III) oxide (Cr₂O₃) which stabilizes the surface and prevents the growth of tin oxide. Thereby, steel is obtained that is more chemical resistant, which is more resistant against the canned products and provides a surface which could be covered by lacquer or paint.

Passivation of ETP is achieved using an electrolyte that needs to have a certain pH and a certain concentration of chromate (CrO₄²⁻) and dichromate (Cr₂O₇²⁻) ions. Two routes are possible:

1. Preparation of the electrolyte solution by a mixture of sodium dichromate and chromium trioxide, or
2. Preparation of the electrolyte solution by using a mixture of chromium trioxide and NaOH.

Independently of the starting product the resulting electrolyte contains the same ions in solution. The so-called passivation bath is simply a complex mixture with Na⁺, Cr₂O₇²⁻, CrO₄²⁻, H₂Cr₂O₇, Na₂Cr₂O₇, various hydrates of this salt, water, etc. CT and SD have the same function and are handled and used under similar processes. Therefore, as outlined above, a common exposure and risk assessment is performed for all sites of the companies of the APEAL on the basis of equivalent chromium (VI) tonnages.

The following table provides an overview of the ten manufacturing locations that use either sodium dichromate or chromium trioxide in the passivation of ETP. The overview reveals that all but one of the sites are using sodium dichromate for the passivation of ETP. Seven are also using chromium trioxide either as a source of chromate ions in the electrolyte, instead of sodium dichromate, or for pH control for the same process.

Table 20. Overview on the sites of the companies of the APEAL-consortium, the substances used as source for Cr(VI) and the tonnage range of Cr(VI) used per site per year

Site	Use of SD	Use of CT	Tonnage range (t Cr(VI)/a)
A	██████████	██████████	10-40
B	██████████	██████████	5-15
C	██████████	██████████	5-15
D	██████████	██████████	10-40
E	██████████	██████████	5-15
F	██████████	██████████	5-15
G	██████████	██████████	5-15

¹ Source: <https://packaging.arcelormittal.com/repository2/Unassigned/ArcelorMittal%20Packaging%20-%20product%20catalogue.pdf>

H			5-15
I			10-40
J			10-40

Process description

Passivation of tin-plated steel is a continuous process and the passivation itself is only one step in a series of different treatment steps which are performed consecutively. The following figure shows the principle production steps for the manufacture of passivated ETP.

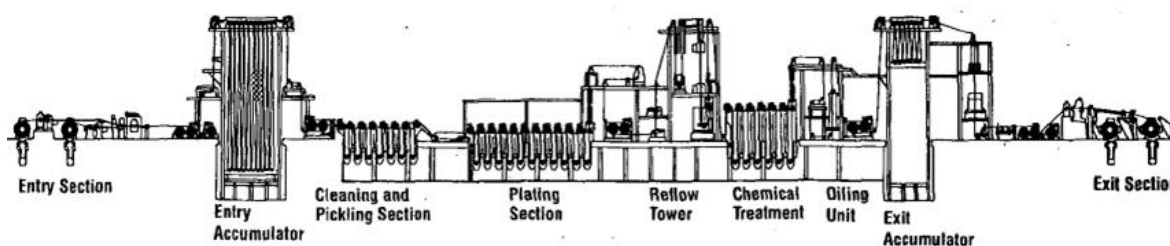


Figure 2: Schematic description of the passivation of tin-plated steel

- 1) The steel to be passivated to form ETP is delivered in big spooled steel coils which have to be unwound to pass the production line with its different baths. The steel coils are unwound at the beginning of the line in the so called entry section.
- 2) Before the tinning could be performed the steel has to be pre-treated to prepare the surface for tinning. This is performed in the so-called cleaning and pickling section.
- 3) After the pre-treatment the tinning of the steel is performed in the plating section. For this purpose, the steel is passed through several consecutive tanks to apply tin to the steel by electrochemical precipitation. Tin is delivered from the tin-anodes as tin ion (Sn^{2+}), which is finally deposited on the steel plate as metallic tin ($\text{Sn}(0)$).
- 4) After tinning the passivation in the presence of Cr(VI) takes place in the so-called chemical treatment section. The chemical treatment section consists of a passivation bath and a rinsing bath. The passivation bath contains a complex mixture with Na^+ , $\text{Cr}_2\text{O}_7^{2-}$, CrO_4^{2-} , $\text{H}_2\text{Cr}_2\text{O}_7$, $\text{Na}_2\text{Cr}_2\text{O}_7$, various hydrates of this salt, water, etc. During the passage of the steel through this passivation bath Cr(VI) is reduced in a cathodic driven process and deposited on the steel as a mixed layer of metallic chromium ($\text{Cr}(0)$) and chromium (III) oxide (Cr_2O_3) on both sides of the steel. After the passivation the steel is rinsed in the successive rinsing tank.
- 5) After the passivation the steel is further treated in the oiling unit before it is wound up again in the exit section. The steel is then ready for further treatments like lacquering, painting, etc.

The electrolytic solution used for the chromium coating is typically a mixture of SD and CT or CT and sodium hydroxide. As a principle risk management measure SD and CT are delivered as aqueous solution in 1 m^3 IBC containers (concentrations in the range of 10-80%, for details see WCS 1 below). The IBC containers are transported to the dedicated places in the production hall (or outside the hall at some sites) where they are connected with a piping system to be automatically filled in a storage tank or the passivation bath or a separate tank to prepare the passivation electrolyte (different systems are in place at different sites). Independent of the system established, once the IBC containers are connected the addition takes place in a fully automated manner in closed pipes. The mixing of chromates is achieved in a continuous closed process, using dosing equipment and controlled by pH. In the passivation bath, the solution is heated to $\text{ }^\circ\text{C}$. Where a reserve/recirculation tank is in place the passivation solution circulates from the strip plating tank to the reserve / recirculation tank. At defined intervals samples are taken at dedicated places from the passivation tanks for quality control of the passivation process.

At two sites solid CT is used beside CT dissolved in water. The solid CT is used to adjust the pH value by direct addition of solid CT to the passivation bath. The solid CT pellets are added manually directly into the

passivation tank. The total amount of solid CT used makes up only a small amount of the total CT used (for details see WCS 7 below).

During usage of the passivation solution particulate material is formed which has to be removed from the passivation solution. Depending on the technique installed at different sites, this is performed by usage of a continuously running filter press. Other sites, which have not installed a filter press, remove the sludge once a year during a general shut down by using vacuum extraction or by manually scooping. Another alternative would be a continuous filtration with regular exchange of filters which are then treated as hazardous waste. The solid waste is collected by specialized waste companies and treated and disposed as hazardous Cr(VI) waste.


The solution of the passivation tank as well as other Cr(VI) containing wastewater is collected in a dedicated drain and directed to the wastewater treatment facility. In the wastewater treatment facility the water is processed in a two-step procedure. First, Cr(VI) is reduced to Cr(III) through the addition of e.g. ferrous sulphate/ferric chloride in excess. After reduction the wastewater is neutralized so that Cr(III) is precipitated and removed through a filtering process. After controlling the Cr(VI) content of the reduced wastewater the wastewater is usually mixed with other wastewater and discharged to the receiving water (river or sea). Only one site discharges its wastewater in a municipal sewage treatment plant (STP), before the wastewater is discharged to surface water. The sludge resulting from the wastewater treatment at the sites (WWTP) is removed by different techniques (filter press or other filter systems) and disposed via a specialized waste company.

The passivation tanks are not completely contained for technical reasons and to ensure that the steel strips are able to move along the production line. However, the tanks have a coverage and local exhaust ventilation is installed above the passivation tanks. The air extracted by the LEV is usually sent over a scrubber to collect Cr(VI) before release to the environment. The water from the scrubber is automatically transferred to the wastewater treatment facility for further treatment.

A video has been included with this application showing the operational conditions used in manufacturing lines and also showing the LEV covers used above the chemical baths.

The following table lists all the exposure scenarios (ES) assessed in this CSR. The entire process can best be described by the descriptor PROC 0 – food packaging/packaging. For the individual tasks identified as potentially being associated with some exposure, additional descriptors were selected (see Table 21). These PROCs primarily serve for orientation but are not key in the exposure assessment performed here, since the monitoring data used in the exposure assessment as well as ART (Advanced Reach Tool) modelling performed in addition are completely independent of PROCs. A detailed description of the tasks performed by workers, the rationale for PROC assignment as well as details on the approach to exposure estimation is given in section 9.0.2.3.

Table 21. Overview of exposure scenarios and contributing scenarios

Identifiers	Market Sector	Titles of exposure scenarios and the related contributing scenarios	Tonnage (tonnes per year)
ES1 - IW1		Use of Sodium Dichromate for Passivation of Electrolytic Tinplate (ETP) - Industrial use resulting in inclusion into or onto a matrix (ERC 5) - T1: Changing IBC containers (PROC 8b) - T2: Sampling of passivation bath (PROC 9) - T3: Sampling of wastewater (PROC 9) - T4: Maintenance (PROC 28) - T5: Cleaning (PROC 28) - T6: Filter Press/Sludge removal (PROC28) - T7: Addition of solid CT (PROC 8b) - T8: Dissolution of solid CT or SD (PROC 5) - T9: Activities close to the ETP line without handling of Cr(VI) containing solutions (PROC 4) - T10: Control-Room activities (no PROC assigned)	 (range: 10-40 tonnes)
Manufacture: M-#, Formulation: F-#, Industrial end use at site: IW-#, Professional end use: PW-#, Consumer end use: C-#, Service life (by workers in industrial site): SL-IW-#, Service life (by professional workers): SL-PW-#, Service life (by consumers): SL-C-#.			

As the final product does not contain any relevant amount of chromium the handling of the final product does not need to be considered in this report.

9.0.2. Introduction to the assessment

9.0.2.1. Environment

Scope and type of assessment

No environmental assessment is performed because:

- 1) the effects of CT and SD on organisms in the environment did not form the basis of its identification as a substance of very high concern,
- 2) Cr(VI) from CT and SD is expected to be reduced to Cr(III) under most environmental conditions, limiting any potential impact of Cr(VI) to the immediate vicinity of the source (ECB, 2005),
- 3) passivation of tin-plated steel is characterised by a high degree of closure from an environmental perspective.

9.0.2.2. Man via environment

Scope and type of assessment

The Cr(VI) exposure of humans via the environment (HvE) due to emissions from the sites covered by this CSR to wastewater streams and air is considered in section 9.1.1. With regard to oral exposure of humans via the environment, it has to be acknowledged that Cr(VI) is rapidly reduced to Cr(III) in many environmental compartments. Exposure to Cr(VI), estimated on the basis of the release of Cr(VI) into environmental compartments, can therefore significantly overestimate human exposure via the environment. Furthermore, many of the environmental modelling parameters (in particular the partition coefficients) are based on the log Kow of a given substance. This parameter is irrelevant for inorganic substances such as Cr(VI) and the calculated partition coefficients are not applicable.

In addition, there is little data on the presence of Cr(VI) in food (EFSA, 2014). In most cases, only the total chromium was determined. A few studies reported that the fraction of Cr(VI) generally accounts for less than 10% of total chromium (range 1.31-12.9%). In addition, some studies even indicate that there is no Cr(VI) at all in food of plant origin and that measured levels of Cr(VI) are analytical artefacts. This could also be the case for food of animal origin. On the basis of these data, the EFSA-CONTAM Panel found 'that there is a lack of data on the presence of Cr(VI) in food, and decided to consider all the reported analytical results in food as Cr(III)'. The CONTAM Panel concluded that it can be assumed 'that all the chromium ingested via food is in the trivalent form, in contrast to drinking water where chromium may easily be present in the hexavalent state', mainly due to the use of strong oxidising agents in drinking water treatment (EFSA, 2014). These considerations of the CONTAM Panel reinforce the previous assessment of the EU Risk Assessment Report for chromates, which assessed the indirect oral exposure of humans via the environment based only on exposure via (drinking) water and fish (ECB, 2005). This approach is also followed here.

The assessment mainly focuses on the carcinogenicity of Cr(VI) released from CT and SD as the most relevant endpoint and compares the exposure estimates with the exposure-risk relationship derived by RAC as described in section 5.11. Additionally, risk characterisation ratios on basis of the DNEL values derived by RAC (see section 5.11) have been calculated to account for possible effects on reproduction as SD has been included in Annex XIV due to its carcinogenic, mutagenic and reprotoxic properties. In principle, effects on reproduction have only to be evaluated for Cr(VI) which originates from SD. However, in a simplified approach risk characterisation ratios have been calculated for total Cr(VI), irrespective of its origin. This approach seems to be justified, as carcinogenicity is the most sensitive endpoint and effects on reproduction are less critical.

Comments on assessment approach

This section describes the approach to estimate human exposure via the environment resulting from the industrial use of CT and SD for passivation of tin-plated steel (ETP) covered in this CSR. SD and CT are used in closed processes with a high degree of closure from an environmental point of view. Emissions to the environment are therefore considered to be low. Nonetheless, exposure via ambient air and oral exposure (through ingestion of drinking water and consumption of fish) has been assessed at both regional and local scale. Based on emission measurements to air and water, environmental concentrations and risks for HvE were calculated using EUSES software (v. 2.12).

EUSES modelling of human exposure via the environment

Site-specific release factors

Monitoring data for Cr(VI) releases to water and air are available for all sites of the member companies of the APEAL consortium using CT and/or SD for ETP as required by national legislation.

Release factors for the releases of Cr(VI) to water, air and soil were derived from the measured emission data per site and the tonnage used per site. The release factors were used as input for the EUSES modelling of human exposure via the environment, as shown in Table 22.

Wastewater

At all sites, Cr(VI) containing wastewater is collected and led to a dedicated treatment facility where Cr(VI) is reduced to Cr(III) through the addition of e.g. ferrous sulphate or ferric chloride solutions in excess of stoichiometry. After reduction, the wastewater is neutralized so that Cr(III) is precipitated. After controlling the Cr(VI) content of the reduced wastewater the wastewater is usually mixed with other wastewater (not containing Cr(VI)) and discharged to the receiving water (river or sea). Only at one site, the reduced wastewater is first led to a municipal sewage treatment plant, before it is discharged to the receiving water. The release factors calculated below relate to emissions after the reduction step.

It has to be emphasized that the **reported Cr(VI) releases to water are based mostly on very conservative assumptions**, since:

- Cr(VI) concentrations in wastewater were measured after the reduction step at all sites and were below the limit of quantification (LoQ) in the majority of cases
- for values below the quantification limit a Cr(VI) concentration of LoQ/2 was assumed in most cases, as proposed for example in the *Guidance on information requirements and Chemical Safety Assessment - Chapter R.16: Environmental exposure assessment* (ECHA, 2016a) or in *COMMISSION DIRECTIVE 2009/90/EC of 31 July 2009, laying down, pursuant to Directive 2000/60/EC of the European Parliament and of the Council, technical specifications for chemical analysis and monitoring of water status*²
- in some cases where individual Cr(VI) concentration measurements were below the LoQ, the respective site even set this value equal to LoQ and included it as such in the calculation of the average Cr(VI) concentration.

However, the actual Cr(VI) concentration for values below the LoQ can be expected to be much lower than LoQ/2 due to the reductive treatment in excess of stoichiometry to ensure a complete reduction; in these cases the actual emissions to water are likely to be negligible.

Air

Exhaust air from the ETP process is released via stacks, at most sites the air is treated in scrubbers prior to release.

Soil

Cr(VI) containing solid waste from the passivation baths and sludge from the reduction/neutralization process is removed and disposed via specialized waste companies.

The site-specific environmental contributing scenarios with the monitoring data from which the release factors are derived are presented in Annex 7. The reports from EUSES calculations are provided in Annex 8.

Table 22. Derived release factors for releases to wastewater (after reduction) and air

	Fraction of tonnage released to wastewater			Fraction of tonnage released to air			Fraction of tonnage released to soil
	Min	Max	Median	Min	Max	Median	Max
Site A-J	1.09E-05	1.37E-03	2.38E-04	6.65E-10	7.88E-04	5.00E-05	0

For the 10 different sites, the release fractions to wastewater range from 1.09×10^{-5} to 1.37×10^{-3} and the release fractions to air from 6.65×10^{-10} to 7.88×10^{-4} . The release to soil is zero for all sites, since there are no direct releases to soil.

Substance-specific input values

The input values for physico-chemical and environmental fate properties of SD (Table 23) and CT (Table 24) were taken from the EU Risk Assessment Report (ECB, 2005).

² <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32009L0090>

Table 23. Input data for sodium dichromate (SD) in EUSES modelling

Property	Description of key information	Value used for EUSES modelling	Comment
Molecular weight	262 g/mol	262 g/mol	
Melting /freezing point	Becomes anhydrous at 100 °C (ECB, 2005), salt melts at ca. 357 °C	357 °C at 101.3 kPa	
Boiling point	decomposes above 400 °C (ECB, 2005)	500 °C	
Vapour pressure		0.00001 Pa	N/A; dummy value entered
Log Kow		0	N/A; dummy value entered
Water solubility	2355 g/L	2355 g/L at 20°C	
Bioconcentration factor fish	1 L/kg	1 L/kg	Refers to Cr(VI); value used in ECB (2005)
Kp <i>suspended matter</i>	1100 L/kg	1100 L/kg	Refers to Cr(VI); mean of values in ECB (2005); see text for details
Kp <i>sediment</i>	550 L/kg	550 L/kg	Refers to Cr(VI); Mean of values in ECB (2005); see text for details
Kp <i>soil</i>	26 L/kg	26 L/kg	Refers to Cr(VI); Mean of values in ECB (2005); see text for details

Table 24. Input data for chromium trioxide (CT) in EUSES modelling

Property	Description of key information	Value used for EUSES modelling	Comment
Molecular weight	100 g/mol	100 g/mol	
Melting / freezing point		196 °C at 101.3 kPa	
Boiling point	n/a decomposes at ~250°C to Cr ₂ O ₃ and O ₂ (ECB, 2005)	250 °C	
Vapour pressure		0.00001 Pa	N/A; dummy value entered
Log Kow		0	N/A; dummy value entered
Water solubility	Completely soluble in water, 1667 g/L at 20 °C, a 1% solution has a pH <1.	1667 g/L at 20°C	
Bioconcentration factor fish	1 L/kg	1 L/kg	Refers to Cr(VI); value used in ECB (2005)
Kp <i>suspended matter</i>	1100 L/kg	1100 L/kg	Refers to Cr(VI); mean of values in ECB (2005); see text for details
Kp <i>sediment</i>	550 L/kg	550 L/kg	Refers to Cr(VI); Mean of values in ECB (2005); see text for details
Kp <i>soil</i>	26 L/kg	26 L/kg	Refers to Cr(VI); Mean of values in ECB (2005); see text for details

The partition coefficients for Cr(VI) in suspended matter, sediment and soil under acid and alkaline conditions as given in ECB (2005) are shown in Table 25. In the present evaluation, the mean value of the value under acidic and alkaline conditions was used because (a) it reflects the range of values and (b) the underlying data - in particular for Kp suspended matter and Kp sediments - are not very well founded, which prevents a more reliable estimation of these parameters.

Table 25. Input data for chromium trioxide (CT) in EUSES modelling

	Acid conditions (pH ≤ 5)	Alkaline conditions (pH ≥ 6)	Mean
Kp <i>suspended matter</i>	2 000 L/kg	200 L/kg	1100 L/kg
Kp <i>sediment</i>	1 000 L/kg	100 L/kg	550 L/kg
Kp <i>soil</i>	50 L/kg	2 L/kg	26 L/kg

Finally, the EU Risk Assessment Report (ECB, 2005) states that during biological wastewater treatment 50% of Cr(VI) are released in the effluent and 50% are adsorbed onto sewage sludge. In the present AfA, biological wastewater treatment is only conducted at one site (Site F). For this site, the default distribution of Cr(VI) in the STP used in EUSES (99.9% in water and 0.1% in sludge) was adapted to 50% in water and 50% in sludge. Application of sludge to agricultural soil (5000 kg/ha/year) and grassland (1000 kg/ha/year) was considered according to the EUSES default setting.

For EUSES modelling of Cr(VI) exposure, an example was used to assess whether the results differ when SD or CT input data are used. All parameters other than the input data given in Table 23 and Table 24 were the same for both calculations. As shown in Table 25, the modelled exposure values are mostly identical, only the regional Cr(VI) PEC in air is slightly (by factor 1.4) higher based on SD data than the one obtained for CT data. Although the difference is small, for conservatism reasons, SD data were used for EUSES modelling of Cr(VI) exposure for all sites.

Table 26. Exemplary comparison of EUSES exposure values calculated with physico-chemical and environmental fate properties of SD and CT

	Regional assessment			Local assessment		
Pathway	Regional Cr(VI) PEC in air [ng/m ³]	Drinking water [ng/kg x d]	Fish [ng/kg x d]	Local Cr(VI) PEC in air [ng/m ³]	Drinking water [ng/kg x d]	Fish [ng/kg x d]
Example site (SD)	7.55E-12	2.02E-03	6.18E-05	7.69E-01	1.41E-01	8.12E-03
Example site (CT)	5.30E-12	2.02E-03	6.18E-05	7.69E-01	1.41E-01	8.12E-03

Regional and local assessments

Human exposure via the environment from consumption of drinking water and fish and due to inhalation of air (for rationale see above) is modelled both for the regional and the local scale. Most sites are located in different countries and regions and discharge into different river basins. Two sites discharge into the same river basin, however, the intakes of these two sites in the regional assessment are so low (see Table 36) that combining the two regional intakes does not significantly increase the local intake at each site (increase by less than 2.5%; details not shown). Therefore, no second site is covered in the corresponding regional assessment using EUSES.

9.0.2.3. Workers

Scope and type of assessment

Due to the carcinogenic (SD and CT) and reproductive toxic effects (only SD) for which CT and SD have been included in Annex XIV of the REACH Regulation exposure assessment of workers mainly focuses on carcinogenic risk after inhalation exposure (for details see section 9.0.3.). Additionally, dermal exposure has to be assessed to check for possible effects on fertility due to SD exposure. As outlined above, the exposure assessment of this CSR focuses on Cr(VI) irrespective of its source of origin (CT or SD). With respect to a possible risks on fertility this is a very conservative estimate especially for sites which use only CT (in fact no assessment of a possible risk on fertility has to be performed for CT) as well as for sites which use SD and CT in parallel (again the contribution of CT does not have to be considered for effects on fertility). DNEL values and exposure-risk-relationships used for risk characterisation are based on the evaluation of RAC as presented in section 5.11 and in section 9.0.3.

Comments on assessment approach:

General approach

Use of Chromium (VI) Trioxide and Sodium Dichromate for Passivation of Electrolytic Tinplate (ETP). No professional or consumer uses are applied for in this application for authorisation and are therefore not part of this chemical safety report.

A potential for exposure may exist during the specific tasks identified below, basically reflecting sampling and loading tasks as well as maintenance tasks, and cleaning as well as addition of solid CT. Based on the process characteristics and properties of CT and SD as a non-volatile substance, all potential inhalation exposure will be towards an aerosol/dust containing Cr(VI) and all potential dermal exposure will be towards the Cr(VI) dissolved in liquids.

As outlined below carcinogenicity is the most critical endpoint for risk assessment. According to the Risk Assessment Committee (RAC) "there are no data to indicate that dermal exposure to Cr(VI) compounds presents a cancer risk to humans" (ECHA, 2013). Therefore, the main focus of the quantitative exposure estimation and risk characterisation for inhalation exposure of workers is on carcinogenic effects. A quantitative dermal exposure assessment and risk characterisation with respect to effects on reproduction is performed in section 9.2.

A qualitative risk characterisation with respect to the corrosive and skin sensitising properties of CT and SD is not part of this CSR, as CT and SD have been included into Annex XIV to Regulation (EC) No 1907/2006 (REACH) due to their carcinogenic and mutagenic properties (both substances) and the reproductive toxicity (only SD). According to REACH, Article 62(4)(d), the CSR supporting an AfA needs to cover only those potential risks arising from the intrinsic properties specified in Annex XIV. The applicants duly apply risk management measures derived by the registrants of CT and SD due to other substance properties related to human health concerns and communicated via the SDS.

In general, reliable and representative measured data are favoured in an assessment of occupational exposure to chemicals. For a carcinogen such as CT and SD, this is all the more desirable and some effort was undertaken to obtain such data. However, the following issues must be taken into account:

- Chromium exposure was previously monitored in the companies of the APEAL members which produce ETP to show compliance with national legislation, but either
 - biological monitoring was performed that does not allow a differentiation between Cr(III) and Cr(VI) (Drexler and Hartwig, 2009) and is therefore unsuitable for the assessment in this report (i.e. a comparison with the exposure-risk relationship (ERR)). In addition, total chromium levels in biomonitoring studies are also highly influenced by several other factors than occupational exposure (geographical region, smoking status, intake from food and drinking water etc.) making an interpretation of obtained values from several different countries difficult to impossible in the absence of data on the background exposure.
 - air monitoring was performed with a limit of quantification (LoQ) adequate to demonstrate compliance with national occupational exposure limit values (OELs) that generally range between 10 000-50 000 ng/m³, with more recent values at 1 000 ng/m³ (see Annex 1). As a consequence,

several monitoring results in the companies of the APEAL consortium exist that identify Cr(VI) concentrations below a certain threshold, e.g. <2 000 or <5 000 ng/m³.

- Personal monitoring was considered to be the best sampling method for inhalation exposure assessment.
- All monitoring data (personal and stationary) provided by the companies were assessed. Biomonitoring values were disregarded due to the reasons mentioned above.
- Overall, the data availability was very different for the individual site. Whereas some of the companies measured total chromium others measured chromium (VI). The limit of quantification also varied over 2-3 orders of magnitude.
- Also the number of data available from the individual sites was very different, from some single (<10) measurements up to a full set of stationary and personal monitoring values.
- The documentation in Annex 2 provides an overview of the data reported by the companies.
- Also the documentation of the data varied substantially between the companies. Whereas for some sites the monitoring data could only roughly be attributed to a specific tasks others presented a full documentation.
- Data evaluation has been performed in close contact with the companies to ascertain that the values were assigned to the correct activities.
- Due to the fact that some operators perform several tasks, their personal monitoring values were used for the assessment of these individual tasks. However, it has to be considered that the overall monitoring value represents an exposure due to different activities (see discussion below in section 9.1).
- The monitoring data submitted were collected and analysed due to different methodologies. Most of the companies had 8 h average exposure values (both for stationary and personal) whereas other companies focused on short term (1.5 hours) measurements. The latter have the advantage that the results allow a better analysis which task s might have contributed in a relevant manner to high values.
- The main focus was on data generated during the last three to four years, as these data are regarded as most representative for the current situation.
- In the end all monitoring data from all sites were assessed together and the pooled data per task were reflected in light of the results from the modelling tool.

As stated above, workers only spend a limited time at the points where monitoring was performed (i.e. at sampling outlets, in the production lab etc.). Unit operators typically spend most of the shift in the control room, visually controlling and adjusting the operation of the processes. In addition, processes and equipment in the unit are checked from time to time. Such control visits in the unit are limited in terms of the time spent since the ETP unit represents a noisy and sometimes warm environment. As a consequence, the monitoring result for a specific task is converted to a TWA under consideration of the exposure duration for that task:

$$\text{TWA} = \text{monitoring result} \times \text{exposure duration} [\text{min/shift}] / 480 \text{ min}$$

For tasks not performed on a daily basis (tasks 1 and 4; see below), the long-term TWA is calculated under consideration of the task frequency:

$$\text{Long-term TWA} = \text{TWA} [\text{ng/m}^3] \times \text{frequency} [\text{d/a}] / 240 \text{ d/a}$$

Note that such a “dilution” over the entire year for infrequent tasks is feasible for the endpoint of carcinogenicity and reproductive toxicity, but may not be adequate for other endpoints.

In principle, this CSR refers to a shift pattern of 8 h shifts on 240 workdays. At the UK site of this applicant 12 h shifts are implemented with a total of 160 workdays. With regard to long term exposure this makes no difference as the total exposure per year is 1920 hours.

Modelling approach for inhalation exposure

Occupational exposure for the inhalation pathway was modelled with ART (Advanced REACH Tool, version 1.5, <http://www.advancedreachtool.com>) that is considered a higher tier tool in the ECHA Guidance IR & CSA, Ch. R.14 (ECHA, 2016b). It allows more adequately reflecting real conditions of use than lower tier tools such as ECETOC TRA. In addition, SD is dissolved in a liquid during all activities related to this use, a situation that is outside the applicability domain of ECETOC TRA (ECETOC, 2012). For all tasks, the following principal approach was chosen:

- Exposure was modelled as “near field exposure” within ART, i.e. the worker is assumed to be less than 1 m from the emission source for the entire exposure duration assumed.
- The upper inter-quartile confidence interval of the 75th percentile is used as the exposure estimate. This

approach follows the recommendations of the developers of the tool. This value better accounts for uncertainty and variability in the underlying data than e.g. the 90th percentile. However, both measures often result in similar values.

- Exposure was modelled in ART as a task-based concentration (assuming exposure duration = 480 min) that was then converted outside the tool to time-weighted average (TWA) on the day of exposure considering the exposure duration for the specific task:
 - $TWA = \text{task-based concentration} \times \text{exposure duration [min/shift]} / 480 \text{ min}$
 - This algorithm is identical to the one applied in ART, if the TWA is modelled rather than the task-based concentration).
- The long-term TWA was then calculated outside the tool, taking into account the frequency of each task:
Long-term TWA = TWA [ng/m³] x frequency [d/a] / 240 d/a
As discussed above, such a “dilution” over the entire year is limited to the endpoint of carcinogenicity.

The estimated long-term TWA for the different tasks were combined in aggregated exposure estimates, since a single shift operator may perform more than one task during a shift. It is, however, unlikely that a single worker will perform all tasks with the assigned frequency in a given year. This issue is addressed in more detail in the aggregated exposure assessment in section 9.1.12.

Definition of tasks

The use of CT and SD in the passivation of tin-plated steel (ETP) is a process where the nature of the design does not exclude exposure. This characterises best the ETP process, because no complete containment could be reached in a process where the large steel-plates have to be transferred through several bathes in a continuous process.

- Cr(VI) emission from the process may occur
 - from the passivation bath which has a high degree of containment but is not totally closed,
 - during sampling for process control,
 - during cleaning and maintenance activities and waste handling (sludge removal).

However, due to the use of aqueous solutions and with the Cr(VI) in the aqueous phase there is no potential for dust exposure.

Dust exposure may however occur at single sites which use (small amounts of) solid CT for pH adjustment and in the context of the theoretical scenario for the dissolution of solid CT or SD.

There is no appropriate descriptor for Process Categories available for this use. Therefore, the entire process of use of CT and SD in the passivation of tin-plated steel (ETP) is assigned to PROC 0: food packaging/packaging following the instructions of the ECHA Guidance (ECHA, 2015b).

Based on a general understanding of the processes involved, the answers in the questionnaires filled in by all companies of the APEAL consortium and a plant visits by the consultants performing the exposure assessments, the following specific tasks were identified as being potentially associated with exposure (Table 27). These tasks are described in more details below.

Table 27. Task definition

Task	Description
Task 1 (T1)	Changing IBC containers (PROC 8b)
Task 2 (T2)	Sampling of passivation bath (PROC 9)
Task 3 (T3)	Sampling of wastewater (PROC 9)
Task 4 (T4)	Maintenance (PROC 28)
Task 5 (T5)	Cleaning (PROC 28)
Task 6 (T6)	Filter Press/Sludge removal (PROC 28)
Task 7 (T7)	Addition of solid CT (PROC 8b)
Task 8 (T8)	Dissolution of solid CT or SD (PROC 5)
Task 9 (T9)	Activities close to the ETP line without handling of Cr(VI) containing solutions (PROC 4)
Task 10 (T10)	Control-Room activities (no PROC assigned)

Sampling is considered to be covered by the PROC 9 definition from ECHA (2015b) and was therefore assigned this PROC, rather than e.g. PROC 8a. However, the transfer of the concentrated CT or SD solution was considered to be better characterised by PROC 8b. Note that this transfer of the concentrated solutions is also within a closed system and exposure is only related to connection and disconnection of pumping or piping systems. Maintenance, cleaning activities and waste handling were described by PROC 28. The theoretical dissolution of solid CT or SD could be described by PROC 5 (mixing and blending in batch processes), whereas the single addition of solid CT is better described by PROC 8b.

The PROCs given in Table 27 are only a surrogate and are irrelevant in the exposure assessment presented below, since this is based on air monitoring and modelling using the ART. Both air monitoring and ART modelling are entirely independent of PROCs (see above for details on the approach to exposure estimation).

The individual tasks are described in more detail in the following sections that also describe the general modelling input for ART (e.g. activity classes, containment levels assumed). Full ART reports are attached in Annex 5. More specific input parameters (e.g. Cr(VI) concentration, exposure duration and frequency) are described below in the section on “critical input parameters”.

Whenever gloves and respiratory protective equipment (RPE) are mentioned in the task description below, these refer to:

Gloves: All gloves used for the handling of chemicals have to be tested according to DIN EN 374. A variety of material is suited for protection against CT in aqueous solutions:

breakthrough time ≥ 8 h:

- Fluoro carbon rubber (0.4 mm)

breakthrough time ≥ 2 h:

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

The following gloves are suited for protection against SD in aqueous solutions (breakthrough time ≥ 8 h for all):

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

Gloves to be used for specific tasks are laid down in work instructions for these tasks.

RPE: Half mask or full mask with P3 filter or full mask with P3 combination filter, the assigned protection factors (APF) are 20 (half mask) and 40 (full mask) according to Howie (2005). If P3 combination filters are used, the APF is lower by a factor of 2, e.g. APF is 20 for full mask with P3 combination filters. Half masks with P3 combination filters are not supported since they do not provide the APF of 20 used in exposure estimation.

Additional PPEs like goggles or face shields are not addressed in detail here, as they have no impact on inhalation exposure modelling. But, of course they are used during the handling of (corrosive) liquids.

Before working at the lines a chromate instruction is given to all working at the lines. See Annexes 3c and 3d for working instructions in place at the sites of the applicants.

The following sections describe the different tasks associated with the use applied for and also provide details on the assumptions used in ART inhalation exposure modelling. Modelling of possible dermal exposure during these tasks is described in section 9.2.

T1: Changing IBC containers

As a principal risk management measure, most sites except two (only for these two sites Task 7 becomes relevant, see below) use liquid CT or SD concentrate rather than solid CT or SD, thus preventing any exposure to neat CT or SD dust. Feeding the CT or SD concentrate from an IBC into the process or a storage tank, from which it is fed into the process, is essentially an automatic and closed process. An exposure potential exists, when connecting and disconnecting pipes/hoses or valves, but this is assumed to exist only from small amounts of liquid remaining on the transfer equipment (pipes, pumps, valves depending on the process) while connecting/disconnecting the equipment. Within ART, this situation was modelled as a “handling of contaminated objects” with small surfaces ($<0.1 \text{ m}^2$) being contaminated to a small degree ($<10\%$). These parameters were selected to reflect a surface area of up to $30 \text{ cm} \times 30 \text{ cm}$ (0.09 m^2) for connecting ends of pipes/hoses (these are much smaller, and the lowest value in ART was chosen). A low level of contamination was chosen, since special care is taken when handling the concentrated CT or SD solution that not only possesses carcinogenic properties, but is also corrosive.

Possible exposure during this activity is modelled using ART and the results of the modelling are compared to the monitoring values.

PPE: Chemical resistant gloves and respiratory protection (half mask with P3 filter or full mask with P3 filter or P3 combination filter) are worn during this task. Further, chemical resistant coveralls or at least a protective apron is worn during connection/disconnection of IBCs.

Task 1 is a regular task; frequency depends on whether the CT or SD solution is directly filled from the IBC into the process or filled in a storage tank from where it is fed into the process. In case a storage tank is in use, more IBCs are connected/disconnected during filling, but the frequency is lower compared to sites where the Cr(VI) containing solutions are filled directly into the process from the IBC storage tanks.

T2: Sampling of passivation bath

Sampling of the solution of the passivation tank is regularly performed for process control, typically once per shift. Sampling is performed at dedicated sampling points, i.e. where valves are installed for sampling. Small amounts of samples (not more than 500 ml) are collected in bottles. Sampling usually takes 5 minutes, but single sites reported even a total sampling time of 15 minutes. However, taking into account the small volumes this might overestimate the duration, so that for the calculation the median value of 5 minutes is used. Within ART, this task was modelled as a “transfer of liquid products – falling liquids”.

Further “handling that reduces contact between product and adjacent air” and “submerged loading” were selected in ART, since relatively small amounts of liquid are carefully transferred into bottles with a small opening.

No localised controls are assumed in ART modelling.

PPE: Protective clothing, chemically resistant gloves, safety goggles or face shield.

T3: Sampling of wastewater

Cr(VI) containing wastewaters e.g. from the passivation or rinse tanks or the scrubbers are collected in separate tanks which are located e.g. in the basement of the factory hall or outside. Wastewater is transported to the wastewater collection tanks through dedicated pipes. Different systems are in place at the different sites. At all sites wastewater samples are taken after the reduction step to check if the final Cr(VI) concentration in the wastewater is within the permitted limit and if the wastewater could be discharged. Only at one site () the wastewater is additionally sampled before the reduction step to control the Cr(VI) concentration in the wastewater and to dose the reducing agents on basis of the analytical results. As the Cr(VI) concentrations in the reduced wastewater are far below 0.1% (for details see the section on environmental assessment) in the exposure assessment this WCS has not to be considered in principle. However, to cover the potential worker exposure associated with this activity sampling of wastewater is included as separate WCS in this CSR. As described for Task 2 within ART, this Task 3 was modelled as a “transfer of liquid products – falling liquids”. Further “handling that reduces contact between product and adjacent air” and “submerged loading” was selected in ART, since relatively small amounts of liquid are carefully transferred into bottles with a small opening. No localised controls are assumed in ART modelling.

PPE: Protective clothing, chemically resistant gloves, safety goggles or face shield

T4: Maintenance

Maintenance activities on the ETP line could be scheduled or non-scheduled. Depending on the site scheduled maintenance is sometimes once a year for several days while other sites have scheduled maintenance activities on single days spread over the year. Additionally, spontaneous non-scheduled maintenance activities take place. Depending on the site and the number of lines duration of maintenance activities can vary considerably between the companies and sites. Additionally, it has to be considered that not all maintenance activities are related to the section of the ETP line where Cr(VI) is used. The survey indicated that maintenance activities (scheduled and unscheduled) vary between 8 to 53 days per site, including maintenance activities not related to Cr(VI) related tasks. As a worst case assumption weekly maintenance is assumed, which is even a conservative estimate for those who perform scheduled maintenance every two weeks. Task duration is often substantially longer than exposure duration, i.e. the repair of pumps takes much longer than exposure to Cr(VI) exist, since pumps are repaired after cleaning them from Cr(VI) containing solution. In addition, Cr(VI) concentration during cleaning activities will rapidly decline due to dilution with water. Therefore, a maximum of 1 h is assumed for contact with contaminated objects as an upper end or even worst case estimate for the sites covered by this CSR.

The maintenance activities could be performed partially by the line operators, in case of more complex or very specific activities external workers might also be involved in this activity.

Within ART, this situation was modelled as a “handling of contaminated objects” with small-medium surfaces (0.3-1 m²) that are contaminated to a considerable degree (10-90%). The surface area was chosen to cover areas in the range of 55 cm x 55 cm (0.303 m²) to 100 cm x 100 cm (1 m²), believed to represent connecting ends of larger pumps as well as rolls which have to be changed. The degree of contamination was selected to represent substantial contamination of this area.

PPE: Respiratory protection (half mask or full mask with P3 filter or full mask with P3 combination filter) and chemical protective gloves is stipulated for activities which are performed in the area of the Cr(VI) bathes. In case maintenance of small objects like a pump, which has been cleaned before maintenance and is transported to an area outside the Cr(VI) bathes, standard PPE (protective clothing, goggles, helmet, ear protection and safety shoes) and chemical protective gloves could be sufficient.

T5: Cleaning

Cleaning activities are mainly performed in the context of maintenance activities (both scheduled and unscheduled maintenance). In the case of (unscheduled) maintenance the equipment (e.g. valves, pumps) has to be cleaned before maintenance activities could be performed, either by external or internal maintenance workers. This cleaning is usually performed (after flushing the system with water before the equipment is dismantled) with a water hose and cleaning water is directed to the general wastewater collection system. At some sites even baths with reducing agents like sodium dithionite are in place where the equipment could be dipped to reduce remaining Cr(VI). Cleaning has also to be performed before scheduled maintenance. In the case of maintenance of the passivation bath the electrolyte is flushed out of the tank (either collected in the basement circulation tank or discharged) and afterwards the tank will be cleaned with a water hose before further maintenance is performed. Depending on the site and the number of lines per site the frequency of maintenance activities can vary considerably between the companies and sites.

Information on duration of cleaning activities vary between 5 to max. 20 minutes before maintenance activity, 4 hours per year for cleaning of the passivation tank (which would be less than 1 minute per day) or every 9 weeks

for up to 2 hours (e.g. cleaning of tanks which would correspond to ca. 2-3 minutes per day). Some sites also report regular daily cleaning activities (e.g. once per day for 10 minutes) which are performed at the shop floor or the basement. As a worst case assumption for this CSR and to cover regular and maintenance associated cleaning it is assumed that cleaning activities are performed daily for 15 minutes.

Cleaning of equipment or the passivation tank with a water hose cannot be adequately modelled with ART. Therefore, exposure assessment of this activity will be based on monitoring data.

PPE: Respiratory protection (half mask or full mask with P3 filter or full mask with P3 combination filter) in the case of aerosol formation (e.g. cleaning with a water hose); gloves are worn during this task as well as tight, long apron and boots or suitable chemical protection suit in the case of aerosol generation.

T6: Filter Press/Sludge removal from passivation tank

Solidified material has to be removed from the passivation bath as solid material impacts the quality of the product. Different routines are in place at the different sites. One site uses a constantly working filter press. I.e. the solutions from the passivation bath are continuously sent to a filter press in a fully automated way where the solid material is deposited and the solutions are recirculated to the passivation bath. In regular intervals (after 6-7 weeks, i.e. about 8 times per year) the filter has to be cleaned. Generally, the filter cake is removed from the press by gravity without any intervention by workers. In practice, however, workers have to scrape off some of the filter cake with a tool (e.g. hard brush) from time to time (typical duration 30 minutes). The filter cake is collected in IBC containers, which are closed and treated as hazardous Cr(VI) containing solid waste.

Some sites have a filter system in place which requires manual exchange of the filter with the particles once per week (duration 15 minutes), the filters are collected as hazardous waste.

At most other sites sludge from the passivation tank is removed once a year during shut down. Therefore, the tanks are emptied and flushed with water. Then the tanks are opened and the sludge deposits are removed. This activity is performed manually and the sludge is shovelled in barrels and afterwards discarded as hazardous waste. At some sites vacuum trucks are used to support the sludge removal, i.e. the sludge is dissolved by cleaning and afterwards sucked with a pipe without manual intervention. However, this is not always possible due to the consistency of the sludge. Sludge removal is often performed by industrial cleaners. This yearly removal can last between 2-4 hours.

The sludge removed, either from the filter press or manually shovelled out of the passivation tank can be modelled as “paste, slurry or clearly (soaked) wet powder”. This situation has been modelled under the conditions of use (A) for this task assuming worst case conditions for activity class, situation and handling type. However, according to ART there is no inhalation exposure (estimate of exposure concentration = 0 µg/m³) in case of handling paste, slurry or clearly (soaked) wet powder (for details see section 9.1.7.).

In a worst case estimate (conditions of use (B)) modelling was performed assuming “paste, slurry or clearly (soaked) wet powder for substance type and the activity class “handling of contaminated solid objects or paste”, as this describes best the situation. In a worst case estimate it is assumed that “handling of objects with limited residual dust (thin layer visible)” takes place under “normal handling, which involves regular work procedure”. Taking into account that the sludge is cleaned with water before removal assuming dust on the surface is unrealistic. But, to get an impression what a maximum exposure during this activity could be, this worst case conditions were modelled.

A duration of 15 minutes on 48 days a year is assumed. This covers the activity at the site with the filter press, the activity with weekly change of the filter as well as the activities once per year for up to 4 hours. In a conservative manner a Cr(VI) concentration of 5% (measured at the site with the filter press; no measurements for other sites) is assumed. As the passivation tank is cleaned with water before sludge removal this is a conservative estimate.

PPE: Full protection is worn: respiratory protection (half mask or full mask with P3 filter or full mask with P3 combination filter); chemical resistant gloves, boots, chemical protection suit.

T7: Addition of solid CT

At two production sites of the ETP producers (not including the sites of this applicant) solid CT pellets are added to the ETP process manually to adjust the pH value of the passivation bath on demand. As a principal risk management measure to reduce dust exposure, chromium trioxide pellets are used instead of powdered material. At one site this activity is performed non-regularly, as the ETP production line for which this activity applies is a mixed ETP/ECCS (Electrolytic Chromium/Chromium oxide Coated Steel) line. At this line, ETP is only produced during a few days of the year (6-12 days). At the second site this activity is performed on a regular, daily basis. Addition of solid CT pellets is performed manually at both sites. At the site with the non-regular activity CT is delivered in 25 kg clip-top steel drums which are stored in the production hall at a place close to a pipe. For the addition of CT the worker uses a beaker with which about 2 kg of the CT pellets are scooped out of the drum. The CT is carried 2 m to a pipe which connects a hole in the shop-floor boarding with the mixing tank in the cellar. The CT is carefully filled in the pipe to prevent dust formation. Afterwards the pipe opening is closed. This procedure takes a maximum of 1 minute and may take place for 1 – 3 times per shift, depending on the pH value. At the second site, where this activity is a regular one, CT is delivered in 50 kg clip-top steel drums. Filling of 1.7 kg CT, which takes about 1 minute, is performed once per shift using a small shuffle (see photo 1 in Annex 4). The required amount of CT is filled into a tundish from where the pellets fall through a metal mesh into a pipe which is connected with a mixing tank in the cellar. Afterwards the tundish is flushed with water to dissolve the CT and to flush it into the mixing tank. Within ART, this situation was modelled as 'Movement and agitation of powders, granules or pelletised material' and 'Handling that reduces contact between product and adjacent air.'

The CT drums are delivered to the place where they are needed with a barrow. As the drums are closed with a clip-top no exposure occurs during transport.

PPE: chemical resistant coverall, glasses, helmet, chemical resistant gloves according to DIN EN 374 (e.g. PVC gloves 0.8 mm) and half mask with P3 filter, e.g. moldex 9030 P3 or A1B1E1-P3 filter.

T8: Dissolution of solid CT or SD

As outlined above the companies of APEAL use liquid CT or SD concentrate as a principle risk management measure. However, in case that the supply chains might become interrupted and no liquid CT or SD concentrates will be available any longer suppliers for solid CT or SD will be contacted and it is assumed that solid CT or SD will become available to cover future substance requirements for the ETP process. The aim would be to buy solid CT or SD in form of flakes, pellets or granules instead of powder to minimise the dustiness of the substance. The substance would be bought e.g. in clip-top steel drums which could be safely stored in the warehouse from where they could be transported by forklift to dedicated places where the dissolution of solid CT or SD could take place.

For the sake of this theoretical WCS it is assumed that dissolution of the solids will be performed in a similar manner as for example described for some of the applicants of APEAL which use a similar technology already in their ECCS process. It is assumed that the dissolution of the solid substance is performed at a dedicated place where a tundish is installed which is connected to a dissolution tank which is located in subjacent floor. Beside the tundish a lifting device is installed, which grips the open drums, lifts them up and tips them to drain the flakes slowly into the tundish from where the solid is transported by gravity into the dissolution tank. Based on expected amounts used and experience from the ECCS process, this task is assumed to take place daily and to involve the transfer of 1-10 kg substance for up to 20 minutes (20-200 kg/day).

After emptying the drums the remaining solids are flushed with water into the dissolution tank. Empty drums are cleaned at dedicated places with a water hose and the wash water is collected in the wastewater drain from where it enters the wastewater treatment plant. Empty and cleaned drums are recycled or disposed as solid waste. This task is supervised by trained operators wearing chemical resistant coveralls, gloves (according to EN 374, e.g. PVC gloves 0.8 mm), and respiratory full mask with P3 filter (e.g. moldex 9030 P3 or A1B1E1-P3), but no direct manual intervention is required. Within ART, this situation was modelled as 'Movement and agitation of powders, granules or pelletised material' and 'Handling that reduces contact between product and adjacent air.' For the modelling it makes no difference if it is assumed that the worker stands close to the lifting device or handles the drums himself, since near field exposure within ART is modelled in a conservative approach. For the modelling it is assumed in a conservative manner that no dust and vapour extractors are installed. However, in case this scenario would become relevant it is intended to establish efficient technologies to protect dust exposure at the workplace. Depending on the possibilities available per site different solutions from local exhaust ventilations up to contained areas are conceivable.

PPE: chemical resistant overall, glasses, helmet, chemical resistant gloves according to EN 374 and full mask with e.g. moldex 9030 P3 or A1B1E1-P3 filter.

T9: Activities close to the ETP line without handling of Cr(VI) containing solutions

Along the ETP line several activities take place which are not directly related to the handling of Cr(VI) containing solution. For example, there are forklift drivers, which carry the steel coils to the line and from the line. Other operators are responsible for the tinning section. Other activities take place close to the places where exposure to Cr(VI) could take place e.g. during sanding of rolls or changing of rolls. These activities cannot be modelled within ART. The available monitoring values collected at several sites along the line are therefore used to describe the exposure during these activities.

PPE: standard PPE (protective clothing, goggles, helmet, ear protection and safety shoes)

T10: Control-room activities

In case the operators do not perform specific tasks along the ETP line or are inspecting the line they are in the control room. The control rooms are close to the line and not in a separate building. Most of the control rooms do not have a separate air supply from outside but receive their air from the shop floor. As the workers do not perform specific tasks with a Cr(VI) containing solution this activity cannot be modelled with ART. Existing monitoring values have been used to assess the exposure concentrations in the control room.

PPE: protective clothing, and safety shoes

Critical input parameters

The critical input parameter values described in this section are largely based on a survey conducted by the consultants performing the exposure assessment for a consortium of electro tin-plating companies (data obtained in several rounds 2018-2019, with additional e-mail surveys on specific parameter inputs). In addition, a site visit by the same consultants was performed to gain a better understanding of the processes, conditions and risk management measures in place. Note that median and maximum values are reported in the tables whenever available, but that the overall number of data points was considered insufficient to derive upper percentile values and to run a probabilistic assessment.

Table 28. Critical input parameters (bold print indicates values used in modelling)

	Unit	Range	Median	Max.	Source/comment
Task 1 Changing IBC containers					
Concentration of CT or SD solutions (% w/w)	%	10-80	50	80	Survey: concentration of CT (10-51%) and SD (46-80%) solutions used; the median value for CT solutions is 31.4 and the median for SD solutions is 61 (only for one site a higher value of 80% was mentioned); the overall median for SD and CT solutions is 50; in a conservative estimate the maximum concentration used at all sites is used for modelling
Density of solution	g/L	1.074-1.68	-	1.68	Density not considered for calculation of Cr(VI) concentration as the concentrations of the CT and SD solutions are provided as % (w/w)
Cr(VI) concentration	%	5.2-32	-	32	Calculated on basis of the provided values for concentration and the molar masses of chromium and SD; based on the maximum concentration for SD (80%) a Cr(VI) concentration of 32% results. This value also covers the maximum concentration of Cr(VI) calculated on the maximum concentration of CT used (26.52 % Cr(VI) in a 51% CT solution)
Duration	min	5-15	8	15	Survey: most of the companies: up to 5 min; single ones up to 15 minutes, maximum value is used to cover worst case
Frequency	d/a	6-124	48	124	Survey: 6 to 124 days per year; arithmetic mean: 46; the median was selected as this covers all sites which use the solutions with the relatively high Cr(VI) concentrations; those sites with solutions with clearly lower Cr(VI) concentrations are those which are not covered by the median; but selecting the maximum value for concentration and frequency would be overly conservative.
Room volume	m ³	800-60000		60000	Survey: outside for single companies, very different room sizes for the companies, therefore, no median value has been calculated; large workroom assumed in ART as a conservative estimate
Task 2 Sampling of passivation bath					
SD concentration	g/L	8-30	25	30	Survey: SD concentrations in the range of 8-30 g/L, for the calculation of the median the mean value has been considered in case a range was provided; the median very well covers the mean values of all ranges except one mean value, which was slightly higher (27.5 g/L)
Density of solution	g/L	1.03-1.1			Information on density of solution only available for 3 sites; as the value is very close to 1 no correction for density was made
SD concentration	%		2.5	3.0	Calculated from the above
Cr(VI) concentration	%		1.0	1.2	Calculated from the above
Duration	min	1-15	5	15	Survey; median value very well covers the different sites, only exceeded at one site, in a conservative estimate the maximum value for duration was selected
Frequency	d/a			240	Daily activity
Temperature	°C	45-60	50	60	Survey; in exceptional cases the temperature can reach 75°C, but this is not representative; ART : the temperature has no influence on the modelling in case of a solid dissolved in liquid
Room volume	m ³	161-60000		60000	Survey: open space for single companies, very different room sizes for the companies, therefore, no median value has been calculated; large workroom assumed in ART as a conservative estimate
Transfer rate	L/min	0.0001-0.5	0.045	0.5	Survey; calculated from sampling volume and duration reported in survey; 0.045 L/min considered

	Unit	Range	Median	Max.	Source/comment
					too low; ART input 0.1-1 L/min (for “filling of bottles”) selected, covers maximum of survey data.
Task 3 Sampling of wastewater					
Cr(VI) concentration	g/L	<1x10E-6% (< 0.01 µg/L) – 0.37% (3.7 g/L)		0.37%	Survey: most sites perform wastewater sampling after reduction of the wastewater. Only one company takes samples before the reduction step to calculate on basis of the analysis results the necessary amount or reducing agents; in a conservative manner it is assumed for this exposure assessment that the Cr(VI) concentration in the wastewater is similar to the maximum amount measured by this company.
Density of solution	g/L				No data available, in a conservative manner no corrections for density is made
Duration	min	1-180		180	Survey: this sampling is automated for many sites without intervention of operators; durations of 3 hours (180 min) refer to a single site where sampling is only performed once per quarter (unclear, if the 3 hour duration also includes the time for analysis); for the calculation of the worker exposure for this scenario a duration of 15 minutes is assumed which is the maximum value provided for sampling of the passivation tank and also covers the durations provided for wastewater sampling if a daily activity is assumed
Frequency	d/a			240	Survey: daily activity is assumed as indicated for the site where wastewater sampling is performed before the reduction step; would also cover the situation where this activity only takes place once every three month
Room volume	m ³	100- outside			Survey: the wastewater treatment is located at different places at the different sites, some are located in the cellar, some are located outside; for the calculation of the worker exposure for this scenario a room volume of 100 m³ is assumed which is a realistic estimate for the site where wastewater sampling is performed before the Cr(VI) reduction step
Transfer rate	L/min				ART input 0.1-1 L/min ; same value used as for the sampling of the passivation tank
Task 4 Maintenance					
SD concentration	g/L		25	30	See task 2
Density of solution	g/L		1	1	See task 2
Cr(VI) concentration	%		1.0	1.2	See task 2
Duration	min			60	Survey indicated different routines, some sites perform smaller scheduled maintenance for one day every nine weeks and an additional maintenance for 1 week per year, others perform smaller maintenance (e.g. pump maintenance) every 3 weeks, or some sites even every 2 weeks; not all maintenance activities are associated with contact to contaminated tools; task duration is often substantially longer than exposure duration, i.e. the repair of pumps takes much longer than exposure to Cr(VI) exist, since pumps are repaired after cleaning them from Cr(VI) containing solution; in addition, Cr(VI) concentration during cleaning activities will rapidly decline due to dilution with water; therefore, a maximum of 1 h is assumed for contact with contaminated objects
Frequency	d/a			48	As a worst case assumption weekly maintenance is assumed, which is even a conservative estimate for those who perform scheduled maintenance every two weeks.
Room volume	m ³	161-60000		60000	See task 2; large workroom assumed in ART

	Unit	Range	Median	Max.	Source/comment
Task 5 Cleaning					
Cr(VI) concentration	%	Not applicable			Cleaning is performed with pure water, using a water hose to clean equipment before maintenance or to clean the passivation tank before maintenance; this activity could not be modelled, some monitoring values could be used, but monitoring values are not available from all companies
Duration	min			15	Survey indicated very different routines, at some sites only cleaning before maintenance activities e.g. every 9 weeks for up to 2 hours (e.g. cleaning of tanks); at other sites additional regular cleaning is performed once a day for e.g. 10 min or once a week for 30 minutes. Assuming daily cleaning for 15 minutes is a worst case estimate and covers the routines at the different sites.
Frequency	d/a			240	See above
Room volume	m ³	161-60000		60000	Survey: not relevant, as exposure assessment will be based on monitoring data and not on data from modelling
Task 6 Filter Press/Sludge removal from passivation tank					
SD concentration	g/L		25	30	See task 2; information on Cr(VI) concentration in the passivation tank;
Density of solution	g/L		1	1	See task 2
Cr(VI) concentration	%		1.0	1.2	See task 2; only for one site, which uses a filter press, information on the concentration of Cr(VI) in the sludge is available: 5% Cr(VI) ; this highest value reported is used for the calculation
Duration	min			15	Survey; the combination of duration and frequency covers activities performed for 15 minutes once per week, performed for 30 minutes on 8 days per year as well as activities performed only once per year for 480 minutes
Frequency	d/a	8-48		48	Survey
Room volume	m ³	161-60000		60000	See task 2; only small work rooms selected in ART ; as the workers stand in the passivation tank which is only of limited space
Task 7 Addition of solid CT					
CT amount used per addition	kg	1.7-2	-	2	Information from both sites where this scenario applies
Cr(VI) mass	kg	-	-	1.04	Calculated from the above considering the molecular weight
Duration	min	1-3	-	3	Survey: Duration 1 min per addition, max. 3 times per shift; but at the site where this activity is performed regularly it lasts 1 min/shift
Frequency	d/a	6-240	-	240	No median value calculated; for one site this is a very seldom activity which takes place on only 6-12 days per year; for the second site this is a regular, daily activity
Activity class					ART: Falling powders, drop height: < 0.5 m
Containment level					Movement and agitation of powders, granules or pelletised material"; pelletised material will be used to reduce dust formation; Dry product (< 5 % moisture content); dust and vapour extractor in place where this activity is performed routinely (ART: other LEV systems)
Transfer rate	kg/min				ART: Transferring 1 – 10 kg/minute ; calculated from the information provided by the companies
Room volume	m ³	Shop floor	-	10000	ART: 3000 m ³ selected which is the largest room volume presented in ART and which fits best to the

	Unit	Range	Median	Max.	Source/comment
		–up to 10000			site where this task is performed regularly
Task 8 Dissolution of solid CT or SD (theoretical WCS, currently not performed)					
SD amount used per addition	kg	-	-	100	Mean value calculated on basis of the arithmetic mean of the tonnages used by all companies and assuming a daily activity; in a conservative manner to increase the amount of activities it is assumed that the necessary Cr(VI) amount is fed as SD
Cr(VI) mass	kg			40	Calculated from the above considering the molecular weight
Activity class					ART: Falling powders, drop height: < 0.5 m
Containment level					Movement and agitation of powders, granules or pelletised material”; pelletised material will be used to reduce dust formation; Dry product (< 5 % moisture content)
Duration	min			20	Assumption: two 50 kg drums will be used per event; experience from other workplaces show that it takes about 10 min to empty a 50 kg drum manually or with a lifting device under conditions which reduce contact between product and adjacent air;
Frequency	d/a			240	Assumption: daily activity
Room volume	m ³				no information available for this theoretical scenario; ART: any size workroom assumed
Transfer rate	kg/min			5	ART: Transferring 1-10 kg/minute
Task 9 Activities close to the ETP line without handling of Cr(VI) containing solutions (e.g. sanding or changing of rolls,)					
Cr(VI) concentration	µg/m ³				Not relevant as no Cr(VI) containing solutions are handled; stationary measurements and personal measurements
Duration	min	0-720		720	depending on operators duties up to the whole shift; shift duration usually 8 hours; at a single site 12 h shifts are established; but taking into account the reduced number of workdays at this site (160 vs 240) the total number of workhours is identical ; therefore 480 minutes will be assumed as maximum value
Frequency	d/a	240	-	240	Daily activity
Room volume	m ³	800-60000		60000	Survey: not relevant, as exposure assessment will be based on monitoring data and not on data from modelling
Task 10 Control-Room activities					
Cr(VI) concentration	µg/m ³				Not relevant as no Cr(VI) containing solutions are handled; none of the control rooms except one have an external (from outside the shop floor) air supply; risk of Cr(VI) contamination from the ETP process; worker exposure based on available static monitoring values for the control room
Duration	min	0-720		720	depending on operators duties up to the whole shift; shift duration usually 8 hours; at a single site 12 h shifts are established; but taking into account the reduced number of workdays at this site (160 vs 240) the total number of workhours is identical ; therefore 480 minutes will be assumed as maximum value
Frequency	d/a	240	-	240	Daily activity
Room volume	m ³	23-165		165	Survey: not relevant, as exposure assessment will be based on monitoring data and not on data from

	Unit	Range	Median	Max.	Source/comment
					modelling

9.0.2.4. Consumers

Exposure assessment is not applicable as there are no consumer-related uses for the substance.

9.0.3. Exposure-risk relationships (ERRs) for carcinogenic effects and DNEL values for reproductive toxicity used for the assessment

Chromium trioxide (CT) has been included in Annex XIV of REACH (Entry No. 16) due to its carcinogenic and mutagenic properties as it is classified as carcinogenic (Cat. 1A) and mutagenic (Cat. 1B). As chromium trioxide is mainly used as aqueous solution in the ETP process this Application for Authorisation also covers Entry No. 17 of Annex XIV of REACH, which refers to acids generated from chromium trioxide and their oligomers.

Sodium dichromate (SD) has been included in Annex XIV of REACH (Entry No. 18) due to its CMR properties as it is classified as carcinogenic (Cat. 1B), mutagenic (Cat. 1B) and reproductive toxicant (Cat. 1B).

Carcinogenicity, mutagenicity and reproductive toxicity of CT, its acids and SD is related to the chromium VI (Cr(VI)) ion liberated from these substances. Therefore, exposure assessment is performed for Cr(VI), the relevant and common substance set free from CT, its acids and SD. Whereas for CT and its acids only carcinogenic and mutagenic properties have to be considered for risk characterisation, reproductive toxicity has also to be taken into account for SD related Cr(VI) exposure. SD affects both, fertility and development. As outlined above (section 5.11) the inhalation DNEL values derived by RAC with respect to the effects on fertility are lower than the DNELs derived on basis of effects on developmental toxicity. Inhalation DNELs systemic long-term for fertility are several (5 or 6) orders of magnitude higher than the local inhalation DNELs associated with an excess risk of 1×10^{-5} or 1×10^{-6} as derived for workers or consumers, respectively. Excess cancer risk is therefore used for risk characterization for worker inhalation exposure. For comparison risk-characterisation ratios are also presented for the inhalation exposure. Worker dermal DNEL long-term systemic effects are applied for the risk characterization of dermal exposure, as no DNEL values are available for dermal exposure, because CT and SD are not carcinogenic after dermal exposure. As mutagenicity is a mode of action expected to contribute to carcinogenicity mutagenic risk can be considered to be included in the assessment of carcinogenic risk and low risks for mutagenicity are expected for exposures associated with low carcinogenic risks.

As detailed in Section 5.11, the exposure-risk relationships presented by ECHA (2013) are used for calculating risks associated with the use of Cr(VI) covered by this application. The inhalation risk characterisation for workers is solely based on inhalation exposure and the risk for lung cancer, as there is no information on the fraction of inhalable, but non-respirable particles, preventing the differentiated consideration of inhalation and oral exposure of workers. This is also the default procedure proposed by ECHA (2013). The following exposure-risk relationships are used.

Table 29. Exposure-risk relationships for inhalation exposure of workers used for calculating risks due to CrVI exposure (from ECHA, 2013)

TWA Cr(VI) exposure concentration [$\mu\text{g}/\text{m}^3$]	Excess lung cancer risk in EU workers [$\times 10^{-3}$]
25	100
12.5	50
10	40
5	20
2.5	10
1	4
0.5	2
0.25	1
0.1	0.4
0.01	0.04

Table 30. Exposure-risk relationships for inhalation exposure of general population used for calculating risks due to CrVI exposure (from ECHA, 2013)

Ambient Cr(VI) exposure concentration [$\mu\text{g}/\text{m}^3$]	Excess lung cancer risk in the general population [$\times 10^{-3}$]
10	290
5	145
2.5	72
1	29
0.5	14
0.25	7
0.1	2.9
0.01	0.29
0.001	0.029
0.0001	0.0029

Table 31. Exposure-risk relationships for oral exposure of general population used for calculating risks due to CrVI exposure of humans via environment (from ECHA, 2013)

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

To assess the possible risk on reproduction (fertility as the most sensitive endpoint) risk characterisation ratios for inhalation exposure of workers are based on the DNEL derived by RAC for effects on fertility (ECHA, 2015):

- inhalation DNEL systemic long-term: $43 \mu\text{g Cr(VI)}/\text{m}^3$

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

- dermal DNEL systemic long-term: $43 \mu\text{g Cr(VI)}/\text{kg bw}/\text{d}$

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

- inhalation DNEL systemic long-term: $11 \mu\text{g Cr(VI)}/\text{m}^3$
- oral DNEL systemic long-term: $17 \mu\text{g Cr(VI)}/\text{kg bw}/\text{d}$

9.1. Exposure scenario 1: Use at industrial site - Use of Chromium (VI) Trioxide and Sodium Dichromate for Passivation of Electrolytic Tinplate (ETP)

Sector of use:

SU 15, Manufacture of fabricated metal products, except machinery and equipment

Environment contributing scenario(s):	
Not assessed	
Worker contributing scenario(s):	
T1: Changing IBC containers	PROC 8b
T2: Sampling of passivation bath	PROC 9
T3: Sampling of wastewater	PROC 9
T4: Maintenance	PROC 28
T5: Cleaning	PROC 28
T6: Filter Press/Sludge removal	PROC 28
T7: Addition of solid CT	PROC 8b
T8: Dissolution of solid CT or SD	PROC 5
T9: Activities close to the ETP line without handling of Cr(VI) containing solutions	PROC 4
T10: Control-Room activities	no PROC assigned

Overview of air monitoring results

The next sections present the detailed exposure assessment and risk characterisation for the specific tasks relevant for the use covered by this CSR. Before addressing the task-specific values, a general overview of the air monitoring results is presented in this section. Table 32 and Table 33 show a summary of the results of the stationary and personal air monitoring values provided by the companies. As outlined above, both, personal as well as stationary monitoring values have been provided. Monitoring results comprise both, values for Cr(VI), which are regarded as relevant for this assessment, as well as values for total chromium. The results are provided in an anonymised form in Annex 2. These pooled data were used to reflect the results of the modelling of the individual tasks. Monitoring results collected by this applicant are provided in Annex 3. The table below also shows Cr(VI) concentrations based on an evaluation of the German MEGA database for comparison. The underlying data were measured by stationary sampling at German workplaces between 2000 and 2009³. These values were used here for comparison, since they were obtained with a uniform method, represent a large number of samples and sites monitored and clearly differentiate stationary sampling results from those obtained with personal sampling.

Table 32. Summary of stationary air monitoring results

Task	N (sites) Cr(VI)/tot. Cr	N Cr(VI)/ tot. Cr	Cr(VI) measure- ments <LoQ Cr(VI)/tot. Cr	Air monitoring results*: Cr(VI) [µg/m ³]			Air monitoring results*: total chromium [µg/m ³]		
				AM	Median	90 P	AM	Median	90 P
Task 1	3 / 0	27 / 0	85.2% / -	0.27	0.03	0.75			
Task 2	4 / 1	48 / 1	87.5% / 0%	0.37	0.16	0.75			
Task 3	5 / 1	22 / 1	86.4% / 0%	0.21	0.05	0.75			

³ Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung (IFA): MEGA-Auswertungen zur Erstellung von Expositionsszenarien für Chrom(VI)-Verbindungen, http://www.dguv.de/medien/ifa/de/fac/reach/mega_auswertungen/chrom-VI-Verbindungen_d.pdf, accessed: March 2015

Task 4	1 / 0	4 / 0	100% / -	0.05	0.05	0.05			
Task 5	0 / 0	0 / 0	- / -						
Task 6	2 / 0	3 / 0	100% /	0.011	0.125	0.125			
Task 7	0 / 0	0 / 0	- / -						
Task 8	0 / 0	0 / 0	- / -						
Task 9	5 / 0	56 / 0	51.8% / -	2.41	0.05	3.11			
Task 10	2 / 1	17 / 21	100% / 81%	0.02	0.01	0.05	0.69	0.50	1.0
Values for comparison									
MEGA (DE, 2000-2009)**	806	1837	65% (LoQ 100 ng/m ³)	2.933	<LoQ	3.656			

All values rounded for presentation, but unrounded values used for calculation of exposure.

AM: arithmetic mean; 90 P: 90th percentile; N (sites): Number of sites covered; N: Number of measurements

* Values below the limit of quantification were taken here as one half the LoQ.

** Values given as CrO₃ concentrations in the source were multiplied by a factor of 0.52 (based on molecular weights), resulting in the Cr(VI) concentrations given in the table.

Table 33. Summary of personal air monitoring results

Task	N (sites) Cr(VI)/total Cr	N Cr(VI)/total Cr	Cr(VI) measurements <LoQ Cr(VI)/total Cr	Air monitoring results*: Cr(VI) [µg/m ³]			Air monitoring results*: total chromium [µg/m ³]		
				AM	Median	90 P	AM	Median	90 P
Task 1	4 / 0	22 / 0	100% / -	0.032	0.03	0.05			
Task 2	6 / 0	26 / 0	84.6% / -	0.40	0.03	0.5			
Task 3	4 / 0	8 / 0	75% / -	0.13	0.05	0.26			
Task 4	5 / 1	9 / 24	66.7% / 100%	0.44	0.06	1.16	1.17	0.5	2.5
Task 5	5 / 1	17 / 6	47% / 100%	0.069	0.05	0.14	1.17	0.5	2.5
Task 6	1 / 1	2 / 3	100% / 100%				0.05	0.05	0.05
Task 7	2 / 0	5 / 0	60% / -	0.15	0.05	0.32			
Task 8	0 / 0	0 / 0	- / -						
Task 9	5 / 0	88 / 0	75% / -	0.49	0.75	0.75			
Task 10	2 / 0	19 / 0	100% / -	0.29	0.03	0.03			

All values rounded for presentation, but unrounded values used for calculation of exposure.

AM: arithmetic mean; 90 P: 90th percentile; N (sites): Number of sites covered; N: Number of measurements

* Values below the limit of quantification were taken here as one half the LoQ.

Monitoring data are available for nine of ten sites, the task related stationary monitoring values cover seven and the personal monitoring values eight sites. The data in Table 32 and Table 33 show that stationary monitoring values are not available for all tasks, neither for Cr(VI) nor for total chromium. No data are available for task 8, which is only a theoretical task in case that no liquid SD or CT solutions would be available in the future. Besides for the theoretical task 8 no stationary monitoring values are available for tasks 5 and 7 and for some tasks, like task 4, only values from one site are available. Personal monitoring data cover all tasks except the theoretical task 8, however, for some tasks only information from a single site is available. This will be further discussed in the context of the task specific analysis.

Stationary monitoring values, mean and 90th percentile, are for most of the tasks lower than Cr(VI) concentrations measured at German workplaces between 2000 and 2009, which cover several industries, including metal processing industries (which contribute about 75% of all stationary samples to the 1837 samples presented in Table 32). Mean and 90th percentile for task 9 are very well in the order of magnitude as presented in the MEGA data, indicating that the exposure concentrations reached during the ETP process are in the same range as found for other metal processing industries.

The fraction of Cr(VI) measurements <LoQ submitted by the companies was slightly higher than in the MEGA dataset, when task-based values are considered. This finding is probably due to the fact that most of the monitoring values were generated to serve legal requirements to show that the workplace does not exceed the legal limits, which are in the µg/m³ range (see Annex 1). A LoQ of 100 ng/m³ has been reported for the MEGA data.

In principle, it has to be noted that in the following only values for Cr(VI) are regarded and not the values for total chromium, as Cr(VI) is the chemically active substance which is relevant for exposure and risk assessment. However, in Annex 2 both values for Cr(VI) and total chromium have been documented for the sake of completeness. Information on total chromium is not regarded as relevant in the context of this CSR as the ratio of Cr(VI) on total chromium is not known and as the value for total chromium presents an overestimate of the Cr(VI) exposure.

An attempt was made to assign the monitoring data available at the companies to the different tasks covered by this CSR in order to identify tasks associated with higher exposures. Several issues have to be considered when evaluating and using these data in the context of risk assessment:

- Short-term tasks are difficult to monitor as such, since the short duration prevents any meaningful LoQ. Therefore, many of the monitoring data assigned to short-term tasks were in fact performed over longer durations (full shift or even longer in the case of stationary monitoring) and there is considerable uncertainty with respect to the contribution of the individual task to the overall monitoring result.
- It is impossible to meaningfully consider the fact that RPE is worn during a specific task, if the monitoring data cover several different tasks or exposure situations.
- For many tasks, the more than half of the monitoring results were below the LoQ and estimated exposure is therefore impacted by the LoQ, even after the exclusion of data with a very high LoQ discussed below.
- For short-term tasks (e.g. for 15-30 minutes), the monitoring data were therefore generally corrected for the duration of the task. This implies that a uniform exposure existed during the monitoring period and that the exposure resulting from the specific tasks contributes according to its duration. For some tasks, such an assumption may be more or less valid (especially if the contribution of the task is not considered to be very high, such as in T1), while the exposure from the specific task in question may have a considerably higher contribution to the exposure measured.
- Due to these uncertainties, a correction for the duration of the task was implemented on a case-by-case basis and not applied at for some tasks). Furthermore, modelled exposure estimates were preferred over the monitoring data in many of these cases and the monitoring data were only used as supportive evidence.
- Overall, the monitoring data assigned to tasks with an overall low exposure may in fact be better used to describe the general overall exposure resulting from workers performing different tasks. Interestingly, the 90th percentile exposure of all personal Cr(VI) measurements not assigned to a specific task ($0.22 \mu\text{g}/\text{m}^3$) does not change if all personal Cr(VI) measurements assigned to specific tasks are included. These measurements might indicate an upper end estimate of non-task related exposure.
- Finally, exposure estimates were also corrected for the frequency of the task, if this is performed less than daily. This correction is not subject to the uncertainty discussed to above.

9.1.1. Environmental contributing scenario 1

As SD and CT are not listed in REACH Annex XIV due to environmental effects, no environmental exposure assessment is performed here. However, human exposure via the environment is assessed and the local releases assumed in this context are shown in the following table.

Table 34. Local releases to the environment

Release	Release factor estimation method	Explanation / Justification
Water	Measured release (site-specific data)	Final release factor: $1.09 \times 10^{-5} - 1.37 \times 10^{-3}$ (Sites A - J)
Air	Measured release (site-specific data)	Final release factor: $6.65 \times 10^{-10} - 7.88 \times 10^{-4}$ (Sites A - J)
Soil	Release factor (site-specific data)	Final release factor: 0% (Sites A - J)

The release factors to water and air are based on Cr(VI) monitoring data from all sites (except Site A where all air measurements and Site B where most of (three of four) the air measurements are based on total chromium concentrations as a surrogate measurement for Cr(VI)). Details on release and derivation of release factors to water, air and soil are provided in Annex 7.

Exposure and risks for man via the environment

As Cr(VI) is not listed in REACH Annex XIV due to environmental effects, effects of the substance on the environment are not considered here.

Exposure concentrations and risks for human via the environment are calculated using EUSES software (v. 2.12).

The inhalation exposure of humans via the environment has been assessed on the basis of site-specific data on releases to air. In the following table, predicted environmental concentrations (PECs) of Cr(VI) in air at the local and regional scales are shown for all sites. The regional PEC in air ranges from 4.68×10^{-17} (Site H) to 6.48×10^{-11} (Site A) ng/m³. For the local PEC in air, values between 4.76×10^{-6} (Site H) and 6.61 (Site A) ng/m³ were predicted by EUSES modelling.

Two of the sites with the highest local PECs of Cr(VI) in air (Site A and B) are sites where all (in case of Site A) or most (three of four in case of Site B) of the air measurements are based on total chromium concentrations, which were conservatively used as surrogate measurements for Cr(VI). Moreover, at Site A, all measurements were below the LoD of the analytical method (0.01 mg/Nm³ for total chromium) and the concentration was conservatively considered to be equal to the LoD, which leads to an additional overestimation of the air release at this site since the resulting emission value strongly depends on the LoD of the monitoring data.

At site C, the site with the second highest local PEC of Cr(VI), the majority (three of four values) of the Cr(VI) measurements used for calculating the emission was below the LoQ of the analytical method (LoQ = 0.002-0.05 mg/m³), and the concentration was set equal to LoQ for calculating the emission. Accordingly, also at site C, the calculated emission value strongly depends on the LoQ of the monitoring data and is therefore likely to be overestimated.

At three of the other sites (Sites D, F and H), the majority of Cr(VI) concentrations that formed the basis to calculate air releases were below the LoQ of the analytical method. In these cases, LoQ/2 was used for calculating the emission values. Also for these sites, the calculated air emission strongly depends on the LoQ of the monitoring data.

Table 35. Modelled exposure for humans via the environment: inhalation

	Regional Cr(VI) PEC in air [ng/m ³]	Local Cr(VI) PEC in air [ng/m ³]
Site A	6.48E-11	6.61
Site B	7.97E-12	0.812
Site C	6.19E-11	6.31
Site D	1.63E-12	0.166
Site E	3.18E-12	0.324
Site F	2.09E-12	0.213
Site G	3.24E-12	0.331
Site H	4.68E-17	0.00000476
Site I	1.60E-13	0.0163
Site J	2.86E-11	2.92

For oral human exposure via the environment, only exposure via drinking water and fish is taken into account. As explained above in section 9.0.2.2 under *Scope and type of assessment*, this approach is consistent with the approach chosen in the EU Risk Assessment Report for hexavalent chromium (ECB, 2005) and is supported by the data reported by EFSA (2014). The Cr(VI) concentrations in drinking water, fish and the sum of both are shown in Table 36 for the regional and local scale. For all sites, the oral exposure is dominated by the consumption of drinking water; on the local and the regional scale the predicted oral exposure from drinking is at least one order of magnitude higher than the exposure from fish.

Table 36. Modelled exposure for humans via the environment: oral (drinking water and fish)

	Regional assessment			Local assessment		
	Drinking water [ng Cr(VI)/ kg x d]	Fish [ng Cr(VI)/ kg x d]	Sum of drinking water and fish [ng Cr(VI)/ kg x d]	Drinking water [ng Cr(VI)/ kg x d]	Fish [ng Cr(VI)/ kg x d]	Sum of drinking water and fish [ng Cr(VI)/ kg x d]
Site A	0.0174	0.000282	0.0177	1.06	0.0607	1.12
Site B	0.0021	0.0000635	0.00220	0.142	0.00815	0.150
Site C	0.0166	0.000933	0.0175	14.0	0.803	14.8
Site D	0.000437	0.0000249	0.000462	0.00839	0.000483	0.00887
Site E	0.00219	0.000126	0.00232	0.325	0.0187	0.344
Site F	0.0105	0.000303	0.0108	1.27	0.00521	1.28
Site G	0.00167	0.0000959	0.00177	11.3	0.648	11.9
Site H	0.00659	0.000379	0.00697	1.35	0.0774	1.43
Site I	0.0248	0.00142	0.0262	0.933	0.0537	0.9867
Site J	0.00767	0.000117	0.00779	0.0797	0.000160	0.0799

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

As already outlined above in section 9.0.2.2 under *EUSES modelling of human exposure via the environment*, it has to be emphasized that the **reported Cr(VI) releases to water and therewith the oral exposure estimates are based mostly on very conservative assumptions**, since (a) the release factors to wastewater are based on Cr(VI) measurements for all sites, (b) the Cr(VI) concentrations in these measurements were below the LoQ in the majority of cases and a concentration of LoQ” (or sometimes even equal to LoQ) was assumed in these cases, while (c) **the actual Cr(VI) concentration can be expected to be much lower than LoQ/2 due to the reductive treatment in excess of stoichiometry to ensure a complete reduction. In these cases, the actual emissions into the water and thus also the oral exposure risks are likely to be negligible**. More site-specific details on the respective LoQ, the treatment of values below the LoQ and exceptions from this general approach are given in Annex 7.

Table 36 shows that the overall oral exposure (sum of drinking water and fish) in the local assessment is lowest at site D with 0.00887 ng Cr(VI)/kg x d and highest at site C with 14.8 ng Cr(VI)/kg x d. Also for the regional assessment, the overall oral exposure is lowest at site D with 0.000462 ng Cr(VI)/kg x d. The regional overall oral exposure is highest at site I with 0.0262 ng Cr(VI)/kg x d.

Note that this discrepancy, that the site for which the highest concentrations in **local** fish and drinking water were predicted is different from the site for which the highest concentrations in **regional** fish and drinking water were predicted, is impacted by different dilution factors for wastewater released into the local/regional environment. While the local dilution factors of wastewater vary considerably from site to site (factors between 1.01 and 1000), depending on the size of the respective receiving water (the individual dilution factors are given in Annex 7), the dilution considered for the regional assessment is the same for all sites. Thus, no linear relationship exists between the local and regional concentration in fish and in drinking water (impact of the dilution factor on concentration in drinking water only in case the concentration in drinking water is based on the PEC in surface water, see explanation below).

Drinking water

The overall oral exposure is dominated by the drinking water pathway at all sites. For prediction of the local/regional concentration in drinking water, EUSES compares the values calculated for local/regional PEC in surface water and local PEC in groundwater under agricultural soil/regional PEC in pore water of agricultural soil and equates the higher of the two values directly with the concentration in drinking water.

At all sites (except Site F and J), the local PEC in surface water is higher than the local PEC in groundwater under agricultural soil and thus equated with the concentration in drinking water. At Sites F and J, the local PEC in groundwater under agricultural soil is the higher value and therefore the basis for the concentration in drinking water.

The regional concentration in drinking water is based on the regional PEC in surface water (since this value is higher than the regional PEC in pore water of agricultural soil) in the case of four sites (E, G, H, I) and is based on the regional PEC in pore water of agricultural soil (as this value is higher than the regional PEC in surface water) in case of the other six sites (A, B, C, D, F, J).

In this context, the estimates for concentrations in drinking water are unrealistic for the several reasons which are listed in the following.

1) Local/regional concentration in drinking water based on the local/regional PEC in surface water:

- The approach chosen is likely to "overestimate the actual indirect exposure as the conversion of Cr (VI) to Cr (III) is expected to occur under the vast majority of environmental conditions " (ECB, 2005). This reduction is not taken into account in the exposure values calculated above.
- EUSES typically specifies a "purification factor" that accounts for removal processes from surface water in deriving the concentration in drinking water, e.g. by evaporation or adsorption to suspended solids. However, the latter is estimated by log K_{ow} and not by specific distribution coefficients. This approach is not feasible for inorganic substances and therefore the estimate does not account for adsorption to suspended particles as a removal process before and during drinking water purification. Although these effects are difficult to quantify, the value of 50% (i.e. reduction by factor 2) for adsorption to sewage sludge as applied in the EU RAR (ECB, 2005) (see section 9.0.2.2) can serve as an indicator of the degree of Cr(VI) adsorption to suspended solids in surface water.
- The PEC in surface water is calculated for the mixing zone, neglecting the fact that for drinking water preparation additional water sources are added.
- Overall, the conservatism of EUSES with respect to exposure to drinking water is classified as "worst case" by the software developers (RIVM, 2004).

Against the background of these substance-specific and model-inherent considerations, the estimate for local exposure via drinking water is regarded as unrealistic. The effects of all these issues are not quantifiable, but a general reduction of the local Cr(VI) concentration in drinking water, calculated in EUSES by a factor of 5 due to the above factors, seems to be appropriate in the light of a factor of 2 due to removal by adsorption alone.

2) Local/regional concentration in drinking water based on the local PEC in groundwater under agricultural soil/ regional PEC in pore water of agricultural soil:

- The Cr(VI) concentration in groundwater is taken directly from the pore water concentration in the soil, which in turn is modelled from the Cr(VI) concentration in the soil. Cr(VI) reduction in soil is a well-known process and the EU Risk Assessment Report states that "*chromium (VI) is reduced to chromium (III) by organic matter and this process occurs reasonably readily in soils*" and assumes "*chromium present in soil following application is in the form of chromium (III)*" (ECB, 2005).
- In addition, EUSES calculates the deposition (the main relevant pathway of groundwater contamination) for a circle around the source with a radius of 1000 m (RIVM, 2004), so that the resulting groundwater concentration only applies to the groundwater below this area.

Similar to the discussion above for equating the local/regional PEC in surface water with the local/regional concentration in drinking water, any additional dilution with other groundwater or surface water for drinking water purposes is not considered. Modelled groundwater concentrations of Cr(VI) (and drinking water concentrations derived from them) are therefore also considered unrealistic. A reduction of the regional drinking water concentration by a factor of 5 is therefore used in the assessment. The reduction of local and regional exposure via drinking water by a factor of 5 is somewhat arbitrary. However, given the many factors pointing towards an overestimation in these values (also see the discussion above on measurements below the LoQ), the reduction is considered to still represent a conservative estimate.

Fish

For the intake of Cr(VI) via consumption of fish, the local scale also represents a (probably unrealistic) worst case situation. Most of the arguments presented above for the drinking water (from surface water) pathway are also valid in relation to the consumption of fish. However, the argument that other waters are added for the preparation of drinking water is specific to the drinking water pathway and is not relevant for fish. In a conservative estimate, the local contribution of fish consumption is therefore retained in the risk estimate. It must be noted, however, that "*(p)eople do not consume 100% of their food products from the immediate vicinity of a point source. Therefore, the local assessment represents a situation which does not exist in reality*" (ECHA, 2016a).

Risk estimates

For calculating the risk estimates for the individual uptake pathways, the modelled exposure estimates are compared with the exposure-risk relationships (ERR) derived by ECHA (2013) for the general population (see Section 9.0.3):

Inhalation: ambient exposure concentration of $1 \mu\text{g}/\text{m}^3$ corresponds to an excess lung cancer risk of 2.9×10^{-2} .

Oral (drinking water and fish): A constant average oral daily dose of $1 \mu\text{g Cr(VI)}/\text{kg bw}/\text{day}$ corresponds to an excess small intestine cancer risk of 8×10^{-4} .

The resulting risk estimates are shown in the following tables for the local (Table 37) and regional (Table 38) assessment.

Table 37. Risk estimates for humans via the environment (general population, local assessment)

	Inhalation	Drinking water *	Fish	Aggregated for all pathways	Contribution inhalation	Contribution drinking water	Contribution fish
Site A	1.92E-04	1.70E-07	4.86E-08	1.92E-04	99.9%	0.0884%	0.0253%
Site B	2.35E-05	2.27E-08	6.52E-09	2.36E-05	99.9%	0.096%	0.0277%
Site C	1.83E-04	2.24E-06	6.42E-07	1.86E-04	98.4%	1.21%	0.346%
Site D	4.81E-06	1.34E-09	3.86E-10	4.82E-06	100%	0.0279%	0.00802%
Site E	9.40E-06	5.20E-08	1.50E-08	9.46E-06	99.3%	0.550%	0.158%
Site F	6.18E-06	2.03E-07	4.17E-09	6.38E-06	96.8%	3.18%	0.0653%
Site G	9.60E-06	1.81E-06	5.18E-07	1.19E-05	80.5%	15.2%	4.35%
Site H	1.38E-10	2.16E-07	6.19E-08	2.78E-07	0.0496%	77.7%	22.3%
Site I	4.73E-07	1.49E-07	4.30E-08	6.65E-07	71.1%	22.5%	6.46%
Site J	8.47E-05	1.28E-08	1.28E-10	8.47E-05	100.0%	0.0151%	0.000151%

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

* Calculation performed using 1/5 of the exposure value given in Table 36; for justification see above

Inhalation**As shown in**

Table 37 for the local scale, for all sites except site H, the aggregated risk is dominated by the inhalation pathway (71.1-100%). The contribution of inhalation to the aggregated estimated risk is very similar between Sites A, B, C, D, E, F and J (96.8-100%). In case of Site G (80.5%) and Site I (71.1%), the estimated risk coming from the inhalation pathway contributes to a slightly lower extent to the aggregated estimated risk because the relative contribution of drinking water and fish is higher at these sites (for details see Annex 7 of the site-specific CSR). At site H, the aggregated risk is dominated by the contribution of drinking water (77.7%; contribution of inhalation only 0.05%) because the relative air emission fraction at this site is extremely low.

Within the context of the observation that the aggregated risk is strongly dominated by the inhalation pathway, it is noticeable that the two sites with the lowest aggregated risks (Sites H and I) have the lowest Cr(VI) PECs in air (see Table 35), although the local emissions into water are higher at these sites than at several other sites (for comparison see Table 36).

As discussed above, for two of the sites with the highest local Cr(VI) PEC air values (Table 35) and therewith the two sites with the highest inhalation risks (Site A and B), the PEC air values and risks are a worst case estimate since total chromium measurements were used as surrogate for Cr(VI) measurements at these sites. Moreover, in case of Site A, all measurements were below the LoD of the analytical method and the concentration was conservatively considered to be equal to the LoD, leading to an additional overestimation of the air release at this site.

As also discussed earlier, for Site C, which has the second highest local Cr(VI) PEC air and therewith the second highest risk from inhalation, the concentrations used for calculating the emission were mostly below the LoQ of the analytical method ($\text{LoQ} = 0.002\text{-}0.05 \text{ mg}/\text{m}^3$) and the Cr(VI) concentration was conservatively considered to be equal to the LoQ.

For most of the other sites, as described before, the majority of Cr(VI) concentrations that formed the basis to calculate the air releases were below the LoQ of the analytical method. In these cases, concentrations were assumed to be $\text{LoQ}/2$ for emission calculations, whereby the resulting emission values and inhalation risks strongly depend on the LoQ of the monitoring data.

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

Drinking water and fish

Regarding the predicted concentrations in drinking water and fish and the resulting oral risks for humans via the environment in the local assessment (Table 37), they also strongly depend on Cr(VI) concentration measurements below the LoQ of the analytical method, similar to the inhalation risks. As described above in section 9.0.2.2 under *EUSES modelling of human exposure via the environment*, at most sites, the majority of Cr(VI) concentration measurements in reduced wastewater was below the LoQ. Usually LoQ/2 was assumed for these measurements (more details and the respective LoQ are given in Annex 7), but **the actual Cr(VI) concentrations will be much lower due to addition of reducing agents in excess of stoichiometry.** Accordingly, the risks associated with the intake of drinking water and fish are overestimated, especially for sites where **all** measurements were below the LoQ, but where the LoQ was comparatively high (e.g. LoQ of 10 µg/L at Site A or LoQ of 3 µg/L at site J).

Table 38. Risk estimates for humans via the environment (general population, regional assessment)

	Inhalation	Drinking water *	Fish	Aggregated for all pathways	Contribution inhalation	Contribution drinking water	Contribution fish
Site A	1.88E-15	2.78E-09	2.26E-10	3.01E-09	0.0000624%	92.5%	7.5%
Site B	2.31E-16	3.42E-10	5.08E-11	3.93E-10	0.0000588%	87.1%	12.9%
Site C	1.80E-15	2.66E-09	7.46E-10	3.40E-09	0.0000528%	78.1%	21.9%
Site D	4.73E-17	6.99E-11	1.99E-11	8.98E-11	0.0000526%	77.8%	22.2%
Site E	9.22E-17	3.50E-10	1.01E-10	4.51E-10	0.0000204%	77.7%	22.3%
Site F	6.06E-17	1.68E-09	2.42E-10	1.92E-09	0.00000315%	87.4%	12.6%
Site G	9.40E-17	2.67E-10	7.67E-11	3.44E-10	0.0000273%	77.7%	22.3%
Site H	1.36E-21	1.05E-09	3.03E-10	1.36E-09	0.000000000100%	77.7%	22.3%
Site I	4.64E-18	3.97E-09	1.14E-09	5.10E-09	0.000000091%	77.7%	22.3%
Site J	8.29E-16	1.23E-09	9.36E-11	1.32E-09	0.0000628%	92.9%	7.1%

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

* Calculation performed using 1/5 of the exposure value given in Table 36; for justification see above

In the regional assessment (Table 38), the aggregated estimated risk (all pathways combined) of all sites is between 8.98×10^{-11} (site D) and 5.10×10^{-9} (Site I). For all sites drinking water is the dominant pathway (77.7-92.9%) with negligible exposure via inhalation ($< 0.0000628\%$ for all sites).

For both the local and the regional assessment, the exposure estimates for drinking water forming the basis of the risk estimates must be put into perspective. The following discussion is based on the Cr(VI) concentrations in drinking water originally calculated in EUSES, i.e. without the reduction by a factor of 5 used in the risk assessment. The Cr(VI) concentration calculated for **regional drinking water** ranges between 0.015 ng/L (Site D) and 0.866 ng/L (Site I). These values are very low and are three to four orders of magnitude lower than the Cr(VI) concentration in drinking water (270 ng/L) corresponding to a risk of 1×10^{-6} according to an estimate derived for the German Federal Environmental Agency (Roller, 2012). Even the **local drinking water** concentrations modelled for all sites (0.294-47.1 ng Cr(VI)/L), except for Site C (489 ng Cr(VI)/L) and Site G (395 ng Cr(VI)/L), are between one and three orders of magnitude below this level. It is noted that the estimate by Roller (2012) is almost seven-fold lower than the one derived by ECHA (2013) for the general population that is based on a draft US EPA report. These data show that even at the local scale, Cr(VI) releases from the use

covered by this CSR lead to low concentrations in the environment.

Overall, these considerations show that the risks calculated for humans exposed via the environment are low, even when conservative assumptions are used in modelling approaches. **The exposure estimates presented here are very conservative for the situation of the applicants as the applicants perform reductive treatment of wastewater, leading to quantitative reduction of Cr(VI) to Cr(III).** At most sites the majority of monitoring values for wastewater confirmed Cr(VI) concentrations below the LoQ (non-detects) and a concentration of LoQ/2 (or sometimes even equal to LoQ) was assumed in these cases. **However, the actual Cr(VI) concentration for values below the LoQ can be expected to be much lower than LoQ/2 due to the reductive treatment in excess of stoichiometry to ensure a complete reduction. In these cases the actual emissions to water are likely to be negligible and the real oral exposure estimates and risks considerably lower than the predicted values.**

For the sake of completeness, risk characterisation ratios have also been calculated for the oral and inhalation route based on the oral and inhalation DNELs for systemic effects after long-term exposure (see section 9.0.3).

The RCRs in the following table document that the exposure is far below the DNELs resulting in very low RCRs (several orders of magnitude below 1), which indicate that there is no risk for effects on fertility nor for effects on development (values not shown, as the DNELs for developmental effects are higher than the DNELs for effects on fertility; see section 5.11) under the calculated exposure of humans via the environment.

In case of several sites (details provided in Annex 7), the used exposure values (oral + inhalation) for the regional and local assessment overestimate the Cr(VI) exposure coming from SD since the total amount of Cr(VI) (from CT and SD) used for the ETP process is considered for the calculations. Thus, the calculated RCRs are conservative for the Cr(VI) exposure coming from SD. For sites where no SD is used for the ETP process the RCRs were calculated for Cr(VI) from CT. These RCRs are unnecessary and are only shown here to not reveal which sites are not using SD.

Table 39. RCRs for humans via the environment

	Regional assessment						Local assessment					
	Oral exposure [µg/kg x d]	DNEL oral systemic long-term [µg/kg x d]	RCR oral	Inhalation exposure [µg/m ³]	DNEL inhalation systemic long-term [µg/m ³]	RCR inhalation	Oral exposure [µg/kg x d]	DNEL oral systemic long-term [µg/kg x d]	RCR oral	Inhalation exposure [µg/m ³]	DNEL inhalation systemic long-term [µg/m ³]	RCR inhalation
Site A	1.77E-05	17	1.04E-06	6.48E-14	11	5.89E-15	1.12E-03	17	6.59E-05	6.61E-03	11	6.01E-04
Site B	2.20E-06		1.30E-07	7.97E-15		7.25E-16	1.50E-04		8.83E-06	8.12E-04		7.38E-05
Site C	1.75E-05		1.03E-06	6.19E-14		5.63E-15	1.48E-02		8.71E-04	6.31E-03		5.74E-04
Site D	4.62E-07		2.72E-08	1.63E-15		1.48E-16	8.87E-06		5.22E-07	1.66E-04		1.51E-05
Site E	2.32E-06		1.36E-07	3.18E-15		2.89E-16	3.44E-04		2.02E-05	3.24E-04		2.95E-05
Site F	1.08E-05		6.35E-07	2.09E-15		1.90E-16	1.28E-03		7.50E-05	2.13E-04		1.94E-05
Site G	1.77E-06		1.04E-07	3.24E-15		2.95E-16	1.19E-02		7.03E-04	3.31E-04		3.01E-05
Site H	6.97E-06		4.10E-07	4.68E-20		4.25E-21	1.43E-03		8.40E-05	4.76E-09		4.33E-10
Site I	2.62E-05		1.54E-06	1.60E-16		1.45E-17	9.87E-04		5.80E-05	1.63E-05		1.48E-06
Site J	7.79E-06		4.58E-07	2.86E-14		2.60E-15	7.99E-05		4.70E-06	2.92E-03		2.65E-04

9.1.2. Worker contributing scenario 1: T1: Changing IBC containers (PROC 8b)

9.1.2.1. Conditions of use

T1: Changing IBC containers is essentially a closed process. A potential exposure exists during coupling/de-coupling of hoses.

	Method
Product (article) characteristics	
• Concentration of substance in mixture: = 32% <i>Concentration of Cr(VI) based on highest SD concentration of 80% used.</i>	External Tool (ART 1.5)
• Product type: Powders dissolved in a liquid or incorporated in a liquid matrix	External Tool (ART 1.5)
• Viscosity: Liquids with low viscosity (like water)	External Tool (ART 1.5)
Amount used (or contained in articles), frequency and duration of use/exposure	
• Duration of activity: 20 minutes <i>Maximum duration for connection/disconnecting from survey of companies: 20 minutes/day (on days of task being performed)</i>	External Tool (ART 1.5)
• Frequency of use/task: = 41 days per year <i>Arithmetic mean value from survey of companies</i>	External Tool (ART 1.5)
Technical and organisational conditions and measures	
• Place of use: Indoors – large workrooms	External Tool (ART 1.5)
• Ventilation rate of general ventilation system: 3 ACH	External Tool (ART 1.5)
Conditions and measures related to personal protection, hygiene and health evaluation	
• Surface contamination/fugitive emission sources: The process is not fully enclosed and the integrity of that enclosure is not regularly monitored, but effective housekeeping practices are in place.	External Tool (ART 1.5)
• Protective apron or chemical resistant coverall	
• Wear chemically resistant gloves (tested to EN374) in combination with specific activity training.	
• Respiratory Protection: Yes (Respirator with APF of 20) [Effectiveness Inhal: 95%]	External Tool (ART 1.5)
Other conditions affecting workers exposure	
• Primary emission source proximity: The primary emission source is located in the breathing zone of the worker (near field, < 1 m)	External Tool (ART 1.5)
• Activity class and subclass: Handling of contaminated objects	External Tool (ART 1.5)
• Handling of contaminated objects (size of object): Activities with treated/contaminated objects (surface < 0.1 m ²)	External Tool (ART 1.5)
• Handling of contaminated objects (degree of contamination): < 10% of surface	External Tool (ART 1.5)

9.1.2.2. Exposure assessment

Air monitoring results

There are 27 stationary Cr(VI) monitoring values available from three sites (with 4, 8 and 15 values, respectively), including the site using the highest Cr(VI) concentration (individual values are provided in Annex 2). Twenty-three of these monitoring values were below the limit of quantification and LoQ/2 was used for the calculation. Fifteen of these values were measured close to the IBC, but no change of the IBC was performed during the monitoring activity. Whether the IBC was changed at the other sites during the monitoring could not be stated with certainty. The sites with 4 and 15 monitoring values provided 8 h TWA values. The site with the 8 monitoring values provided 1.5 h monitoring values. Additionally, this site has a relatively high LoQ (1.5 µg/m³). Independently, if all 27 values are regarded or only the 19 values from the sites with the 8 h TWA values a median of 30 ng/m³ resulted (median not included in the table below). The 90th percentile is very much influenced by the LoQ of the underlying methodology. If all 27 values are regarded (not shown in the table

below) a higher 90th-percentile value (750 ng/m³) results, whereas only a 90-percentile value of 120 ng/m³ results, if the monitoring values with the highest LoQ are disregarded. Taking into account the duration for the activity (15 minutes) and the frequency (48 days per year) results in the long-term TWA values presented in the table below.

Additionally, for four sites (one of them also provided stationary monitoring values) a total of twenty-two 8 h personal monitoring values are available for operators who also performed changes of the IBC during their shift (not including the site using the highest Cr(VI) concentration). The personal monitoring values were all below the LoQ, the 90th-percentile for the personal monitoring values was 50 ng/m³, indicating that this task obviously has only little impact on the 8h monitoring value. The personal monitoring value does not consider that respiratory protection is worn.

The monitoring results are shown in the following table.

Table 40. Monitored exposure in the area of the IBC containers

Type of measurement	No. of sites covered	No. of measurements	Measurements <LoQ	Range	90 th Percentile [ng/m ³]	Inhalation exposure [ng/m ³]	
						(corrected for task duration)	(frequency-corrected)
stationary	2 [#]	19	15 (79%)	< LoQ – 630 ng/m ³	124	3.88	0.78
personal	4	22	22 (100%)	< LoQ	50 **	1.56	0.31

Details are provided in Annex 2

#: excluding the site with the highest LoQ and with only 1.5 h measurements

** identical to the maximum LoQ/2 value

Modelling results

The modelled exposure estimates are shown in the following table.

Table 41. Modelled Exposure for Workers: task 1

Frequency (d/a)	Duration [min/shift]	Inhalation exposure [ng/m ³]		
		Task-based	TWA (on day of exposure)	Long-term TWA
48	15	1100 (without RPE)	34.38	6.88
48	15	55 (with RPE)*	1.72*	0.34*

All calculated values (TWA, long-term) rounded for presentation, but unrounded values used for calculation of exposure; full ART reports are attached in Annex 5; * includes reduction by 95% due to respiratory protection (half mask with P3 filter or full mask with P3 filter or P3 combination filter)

The modelled exposure estimate is based on (also see section 9.0.2.3):

- the maximum SD concentration of 80% (32% Cr(VI)), while the median across all companies is 50% of CT or SD solution (range: 10-80%) corresponding to a Cr(VI) concentration in the range of 5.2-32%
- an exposure duration of 15 minutes; this represents the maximum exposure duration given in the survey across all companies (range: 5-15 minutes), this represents the time it takes to connect/disconnect the IBC and not the time the workers might stay in the area where the IBC is located. The transfer to the system is fully automated and is in a closed system
- the median frequency reported in the survey that is ca. 2.5 times lower than the maximum frequency reported (median: 48 times/year, range: 6-124 times/year).

As a consequence, the long-term inhalation estimate represents a realistic upper end estimate, because companies using the solution with the highest CT or SD concentration are also the ones with the longest duration for this task but not the highest use frequencies. The following input for the activity emission potential within ART have been selected:

- Activities with treated/contaminated objects (surface <0.1 m²)
- Contamination < 10% surface

These were chosen to reflect handling of the concentrated CT or SD solution, which are not only carcinogenic, but also corrosive to skin and skin sensitising (see section 9.0.2.3). Special care is therefore taken to prevent contamination during the connection/disconnection of pipes/pumps, with 30 cm x 30 cm (0.09 m²) showing little contamination (<10%), the latter considered to reflect real conditions.

Discussion and conclusions

There are stationary monitoring values available measured close to the IBC container. However, there is some uncertainty, which of these monitoring values covers also a change of the IBC and to what extent the short activity of task 1 influences the resulting monitoring value. Further, these values are mainly depending on the LoQ of the methodology. Nevertheless, the resulting long-term TWA values on basis of the stationary monitoring values are in the same order of magnitude as the exposure concentration modelled with ART and therefore support the modulation. Additionally, personal monitoring values which cover Task 1 activities are available. However, all values were below the LoQ and therefore are highly depending on the LoQ instead of reflecting real exposure. Due to these uncertainties the modelled value will be used for further risk analysis.

Final exposure estimate for task 1: 0.34 ng/m³

9.1.3. Worker contributing scenario 2: T2: Sampling of passivation bath (PROC 9)

9.1.3.1. Conditions of use

T 2: Sampling of the electrolyte solution from the passivation bath

	Method
Product (article) characteristics	
• Concentration of substance in mixture: = 1.0% <i>Concentration of Cr(VI) based on median SD concentration of 25g/L in the passivation bath electrolyte (density not considered).</i>	External Tool (ART 1.5)
• Product type: Powders dissolved in a liquid or incorporated in a liquid matrix	External Tool (ART 1.5)
• Viscosity: Liquids with low viscosity (like water)	External Tool (ART 1.5)
Amount used (or contained in articles), frequency and duration of use/exposure	
• Duration of activity: 15min <i>Maximum duration for sampling from survey of companies 15 minutes/day</i>	External Tool (ART 1.5)
• Frequency of use/task: = 240 days per year	External Tool (ART 1.5)
Technical and organisational conditions and measures	
• Place of use: Indoors - large workroom	External Tool (ART 1.5)
• Ventilation rate of general ventilation system: 3 ACH	External Tool (ART 1.5)
Conditions and measures related to personal protection, hygiene and health evaluation	
• Surface contamination/fugitive emission sources: The process is not fully enclosed and the integrity of that enclosure is not regularly monitored, but effective housekeeping practices are in place.	External Tool (ART 1.5)
• Wear chemically resistant gloves (tested to EN374) in combination with specific activity training.	
Other conditions affecting workers exposure	
• Primary emission source proximity: The primary emission source is located in the breathing zone of the worker (near field, < 1 m)	External Tool (ART 1.5)
• Activity class and subclass: Transfer of liquid products - falling liquid	External Tool (ART 1.5)
• Falling liquid (transfer rate): 0.1 - 1 L/min	External Tool (ART 1.5)
• Containment of the process: Handling that reduces contact between product and adjacent air	External Tool (ART 1.5)

	Method
• Transfer Loading Type : Submerged loading, where the liquid dispenser remains below the fluid level reducing the amount of aerosol formation	External Tool (ART 1.5)

9.1.3.2. Exposure assessment

Air monitoring results

There are 48 stationary Cr(VI) monitoring values available from four sites (with 4, 20, 9 and 15 values, respectively), including the site using the highest Cr(VI) concentration. Forty-two of these monitoring values were below the limit of quantification and LoQ/2 was used for the calculation. The site with the 20 monitoring values provided 1.5 h monitoring values. Additionally, this site has a relatively high LoQ ($1.5 \mu\text{g}/\text{m}^3$). All other sites provided 8 h average values. If the twenty values with the high LoQ of $1.5 \mu\text{g}/\text{m}^3$ are not regarded a 90th percentile of $200 \text{ ng}/\text{m}^3$ results, the median is $30 \text{ ng}/\text{m}^3$. Again, the 90th percentile is very much influenced by the LoQ of the underlying methodology. If all 48 values are regarded a higher 90th-percentile value ($750 \text{ ng}/\text{m}^3$) and a median of $160 \text{ ng}/\text{m}^3$ result. Taking into account the duration for the activity (15 minutes) and the frequency (240 days per year) results in the long-term TWA values presented in the table below.

There is one 8 h stationary monitoring value ($700 \text{ ng}/\text{m}^3$) for total chromium from one site available, which is in agreement with the other stationary monitoring values. However, there is no information on the Cr(VI) content of the total chromium measurement.

Additionally, for six sites (two of them also provided stationary monitoring values) a total of twenty-six 8 h personal monitoring values are available for operators who in principle performed sampling of the passivation tank during their shift. Twenty-two of the personal monitoring values were below the LoQ, the 90th-percentile for the personal monitoring values was $570 \text{ ng}/\text{m}^3$, indicating the influence of the site with the highest LoQ. A 90th percentile of $140 \text{ ng}/\text{m}^3$ results, if the two values with this highest LoQ are disregarded.

The monitoring results are shown in the following table.

Table 42. Overview of Cr(VI) monitoring values for WCS 2 (sampling of the passivation bath)

Type of measurement	No. of sites covered	No. of measurements	Measurements <LoQ	Range	90 th Percentile [ng/m^3]	Inhalation exposure [ng/m^3]	
						(corrected for task duration)	(frequency corrected)
stationary	3 [#]	28	22 (78.6%)	< LoQ – $870 \text{ ng}/\text{m}^3$	200	6.25	6.25
personal	5 [#]	24	20 (83.3%)	< LoQ – $7550 \text{ ng}/\text{m}^3$	140	4.38	4.38

Details are provided in Annex 2.

#: excluding the site with the highest LoQ and with only 1.5 h measurements

Modelling results

The modelled exposure estimates are shown in the following table.

Table 43. Modelled exposure for workers: task 2

Frequency (d/a)	Duration [min/shift]	Inhalation exposure [ng/m^3]		
		Task-based	TWA (on day of exposure)	Long-term TWA
240	15	100	3.125	3.125

All calculated values (TWA, long-term) rounded for presentation, but unrounded values used for calculation of exposure; full ART reports are attached in Annex.

The modelled exposure estimate is based on (see also section 9.0.2.3):

- the median SD concentration of 2.5% (1.0% Cr(VI))
- a maximum exposure duration of 15 minutes; range: 5-15 minutes
- the highest frequency reported in the survey (each shift), which is realistic for sampling

As a consequence, the long-term inhalation estimate represents a realistic upper end estimate. As the Cr(VI) concentration in the passivation bath is very similar at the different sites this estimate is considered representative for all sites. However, this estimate does not consider that RPE are worn during sampling at some sites. However, as this is not established at all sites for this task RPE are not considered in this exposure estimate.

Discussion and conclusions

The estimates for long-term inhalation exposure derived from monitoring data and higher tier modelling agree very well, although the monitoring data are very much influenced by the LoQ of the underlying methodology. If the monitoring values with the highest LoQ are disregarded, the results of the stationary monitoring and the ART modelling differ only by a factor of 2. This provides high confidence for the monitoring results. As the extent of uncertainty inherent in the monitoring data due to their dependence on the LoQ remains unclear, the modelled values will be used for further risk estimates.

Final exposure estimate for task 2: 3.125 ng/m³

9.1.4. Worker contributing scenario 3: T3: Sampling of wastewater (PROC 9)

9.1.4.1. Conditions of use

T 3: Sampling of the wastewater tank

	Method
Product (article) characteristics	
• Concentration of substance in mixture: = 0.37% <i>Concentration of Cr(VI) based on maximum Cr(VI) concentration measured in the wastewater tank before reduction of Cr(VI) (density not considered).</i>	External Tool (ART 1.5)
• Product type: Powders dissolved in a liquid or incorporated in a liquid matrix	External Tool (ART 1.5)
• Viscosity: Liquids with low viscosity (like water)	External Tool (ART 1.5)
Amount used (or contained in articles), frequency and duration of use/exposure	
• Duration of activity: 15 min <i>Maximum duration for sampling from survey of companies 15 minutes/day</i>	External Tool (ART 1.5)
• Frequency of use/task: = 240 days per year	External Tool (ART 1.5)
Technical and organisational conditions and measures	
• Place of use: 100 m ³ (<i>realistic value from survey</i>)	External Tool (ART 1.5)
• Ventilation rate of general ventilation system: 3 ACH	External Tool (ART 1.5)
Conditions and measures related to personal protection, hygiene and health evaluation	
• Surface contamination/fugitive emission sources: The process is not fully enclosed and the integrity of that enclosure is not regularly monitored, but effective housekeeping practices are in place.	External Tool (ART 1.5)
• Wear chemically resistant gloves (tested to EN374) in combination with specific activity training.	
Other conditions affecting workers exposure	
• Primary emission source proximity: The primary emission source is located in the breathing zone of the worker (near field, < 1 m)	External Tool (ART 1.5)

	Method
• Activity class and subclass: Transfer of liquid products - falling liquid	External Tool (ART 1.5)
• Falling liquid (transfer rate): 0.1 - 1 L/min	External Tool (ART 1.5)
• Containment of the process: Handling that reduces contact between product and adjacent air	External Tool (ART 1.5)
• Transfer Loading Type : Submerged loading, where the liquid dispenser remains below the fluid level reducing the amount of aerosol formation	External Tool (ART 1.5)

9.1.4.2. Exposure assessment

Air monitoring results

There are 22 stationary Cr(VI) monitoring values available from five sites (with 8, 4, 4, 3 and 3 values, respectively), including the site using the highest Cr(VI) concentration (individual values are provided in Annex 2). Nineteen of these monitoring values were below the limit of quantification and LoQ/2 was used for the calculation. One site with 4 monitoring values provided 1.5 h monitoring values. Additionally, this site has a relatively high LoQ ($1.5 \mu\text{g}/\text{m}^3$). All other sites provided 8 h average values. The median for all sites is $50 \text{ ng}/\text{m}^3$. If the four values with the high LoQ of $1.5 \mu\text{g}/\text{m}^3$ are not regarded also a median of $50 \text{ ng}/\text{m}^3$ results. Like before, the 90th percentile is very much influenced by the LoQ of the underlying methodology. If all 22 values are regarded a higher 90th-percentile value ($750 \text{ ng}/\text{m}^3$) results, whereas a 90th percentile value of only $320 \text{ ng}/\text{m}^3$ results, if the monitoring values with the highest LoQ are disregarded. Taking into account the duration for the activity (15 minutes) and the frequency (240 days per year) results in the long-term TWA values presented in the table below. It has to be noted that all stationary monitoring values, which were available for monitoring in the area where wastewater sampling takes place, have been regarded for this task. But, the monitoring devices were not necessarily placed directly beside the sampling point. This adds some uncertainty on the representativeness of these data for this special task.

A single 8 h stationary monitoring value ($2200 \text{ ng}/\text{m}^3$) for total chromium from one site was provided, which seems to be in agreement with the other stationary monitoring values. However, there is no information on the Cr(VI) content of the total chromium measurement. Due to missing representativeness of this value it is not further regarded.

Additionally, for four sites (one of them also provided stationary monitoring values) a total of eight 8 h personal monitoring values are available for operators who are also involved in Task 3. Two third of the personal monitoring values were below the LoQ, the 90th-percentile for the personal monitoring values was $260 \text{ ng}/\text{m}^3$, which does not contradict the stationary monitoring values.

The monitoring results are shown in the following table.

Table 44. Overview of Cr(VI) monitoring values for WCS 3 (sampling of the wastewater)

Type of measurement	No. of sites covered	No. of measurements	Measurements <LoQ	Range	90 th Percentile [ng/m^3]	Inhalation exposure [ng/m^3]	
						(corrected for task duration)	(frequency corrected)
stationary	4 [#]	18	15 (83.3%)	< LoQ – $400 \text{ ng}/\text{m}^3$	320	10.00	10.00
personal	4	8	6 (75%)	< LoQ – 710	260	8.125	8.125

Details are provided in Annex 2

#: excluding the site with the highest LoQ and with only 1.5 h measurements

Modelling results

The modelled exposure estimates are shown in the following table.

Table 45. Modelled exposure for workers: task 3

Frequency (d/a)	Duration [min/shift]	Inhalation exposure [ng/m ³]		
		Task-based	TWA (on day of exposure)	Long-term TWA
240	15	60	1.88	1.88

All calculated values (TWA, long-term) rounded for presentation, but unrounded values used for calculation of exposure; full ART reports are attached in Annex.

The modelled exposure estimate is based on (also see section 9.0.2.3):

- the maximum Cr(VI) concentration of 0.37% measured
- a maximum exposure duration of 15 minutes; realistic estimate for the single site where sampling of wastewater before reduction is performed was 5 minutes
- the highest frequency reported in the survey (each shift), which is realistic for sampling

As a consequence, the long-term inhalation estimate represents an upper end not existing in reality, because the company reporting the maximum concentration reported a task duration for sampling of 5 minutes. Further, it has to be considered that Cr(VI) concentrations cover a range from 0-3.7 g/L. Therefore, the containment level and loading type were not set to worst case conditions (“handling that reduces contact between product and adjacent air” and “submerged loading”). Additionally, a small room size was assumed, but for many companies performing wastewater sampling after reduction this is performed automatically and/or outdoors. So, this estimate is an overestimate for most sites.

Discussion and conclusions

In summary, monitored and modelled long-term inhalation exposure to Cr(VI) was estimated to be:

- Stationary Monitoring: 10.00 ng/m³ (n=18, 90th percentile from 5 sites, excluding the values for the site with the highest LoQ)
- ART modelling: 1.88 ng/m³ (worst case estimate)

The estimates for long-term inhalation exposure derived from stationary monitoring data are ca. 5-fold higher than the higher tier modelling (excluding those monitoring values with the highest LoQ). As the monitoring data are very much influenced from the LoQ of the methodology and as it remains unclear what was the distance of the monitoring device to the operator who performs this task, there remains some uncertainty with regard to the representativeness of the monitoring data for this task. Therefore, the modelled value will be used in this CSR for risk characterisation.

Final exposure estimate for task 3: 1.88 ng/m³

9.1.5. Worker contributing scenario 4: T4: Maintenance (PROC 28)

9.1.5.1. Conditions of use

T4: Maintenance

	Method
Product (article) characteristics	
• Concentration of substance in mixture: = 1% <i>Concentration of Cr(VI) based on median SD concentration of 25g/L in the passivation bath electrolyte (density not considered).</i>	External Tool (ART 1.5)
• Product type: Powders dissolved in a liquid or incorporated in a liquid matrix	External Tool (ART 1.5)
• Viscosity: Liquids with low viscosity (like water)	External Tool (ART 1.5)
Amount used (or contained in articles), frequency and duration of use/exposure	
• Duration of activity: 60 minutes	External Tool (ART 1.5)

	Method
<ul style="list-style-type: none"> Frequency of use/task: = 48 days per year <i>Weekly maintenance assumed as worst case, but will often be less frequent.</i> 	External Tool (ART 1.5)
Technical and organisational conditions and measures	
<ul style="list-style-type: none"> Place of use: Indoors – large workroom 	External Tool (ART 1.5)
<ul style="list-style-type: none"> Ventilation rate of general ventilation system: 3 ACH 	External Tool (ART 1.5)
Conditions and measures related to personal protection, hygiene and health evaluation	
<ul style="list-style-type: none"> Surface contamination/fugitive emission sources: The process is not fully enclosed and the integrity of that enclosure is not regularly monitored, but effective housekeeping practices are in place. 	External Tool (ART 1.5)
<ul style="list-style-type: none"> Chemical protective clothing in case of possible Cr(VI) exposure 	
<ul style="list-style-type: none"> Wear chemically resistant gloves (tested to EN374) in combination with specific activity training. 	
<ul style="list-style-type: none"> Respiratory Protection: No, not basically assumed, but can be worn in case of possible aerosol exposure (Respirator with APF of 20) [Effectiveness Inhal: 95%] when aerosol formation occurs 	External Tool (ART 1.5)
Other conditions affecting workers exposure	
<ul style="list-style-type: none"> Primary emission source proximity : The primary emission source is located in the breathing zone of the worker (near field, < 1 m) 	External Tool (ART 1.5)
<ul style="list-style-type: none"> Activity class and subclass: Handling of contaminated objects 	External Tool (ART 1.5)
<ul style="list-style-type: none"> Handling of contaminated objects (size of object): Activities with treated/contaminated objects (surface 0.3-1.0 m²) <i>Covers areas on the object of 55 cm x 55 cm to 100 cm x 100 cm, believed to cover connecting ends of larger pumps up to maintenance work on rolls.</i> 	External Tool (ART 1.5)
<ul style="list-style-type: none"> Handling of contaminated objects (degree of contamination): 10-90% of surface <i>High level of contamination assumed</i> 	External Tool (ART 1.5)

9.1.5.2. Exposure assessment

Air monitoring results

Four stationary Cr(VI) monitoring values are available from one site, which were all below the limit of quantification. These single values from one site are not regarded as representative for the different monitoring activities performed at the various sites.

Sixteen personal monitoring values for Cr(VI) exposure are available from 6 sites (2, 1, 1, 4, 1, 7 values, respectively). Six of these sixteen values were below the LoQ and LoQ/2 was used for the calculation. The seven values provided from one site were monitored during maintenance of a Cr(VI) process (which uses higher Cr(VI) concentrations than the ETP process), but not on the ETP line. As the values from the non-ETP line were the highest concentrations measured their relevance for the ETP process is questionable, therefore, they were not regarded. The median for the remaining nine values from 5 sites is 60 ng/m³ and the 90th percentile 1160 ng/m³ revealing the differences observed at the different sites and possibly activities. As six values are below the LoQ the 90th percentile is mainly influenced by the maximum monitoring value of 2800 ng/m³. The personal monitoring values do not regard the influence of respiratory protection. As it is assumed that the monitoring values are mainly influenced by the exposure from maintenance no correction for task duration has been performed in a conservative manner. However, as RPE are worn during maintenance the influence of the RPE is considered in the frequency corrected monitoring values.

Additionally, twenty-four 8 h personal monitoring values for total chromium are available from one site, which were all below the LoQ (with different LoQs for different monitoring years). The median for these monitoring values is 500 ng/m³ and the 90th percentile 2500 ng/m³. As these values are only for total chromium and completely dependent on the LoQ they are not further regarded in this assessment.

The monitoring results are shown in the following table.

Table 46. Overview of Cr(VI) monitoring values for WCS 4 (maintenance)

Type of measurement	No. of sites covered	No. of measurements	Measurements <LoQ	Range	90 th Percentile [ng/m ³]	Inhalation exposure [ng/m ³]	
							(frequency corrected)
stationary	1	5	5 (100%)	< LoQ	50	50 ^{##}	10.0 (0.5 with RPE)
personal	4	9	6 (66.7%)	< LoQ – 12250 ng/m ³	1160 [#]	1160 ^{##}	232 (11.6 with RPE)

Details are provided in Annex 2.

#: a 90th percentile of 1160 results if the values from the non-ETP process are disregarded (for details see text above).

##: not corrected for task duration as it is assumed that exposure during maintenance mainly contributes to the overall exposure

Modelling results

The modelled exposure estimates are shown in the following table.

Table 47. Modelled exposure for workers: task 4 (maintenance)

Frequency (d/a)	Duration [min/shift]	Inhalation exposure [ng/m ³]		
		Task-based	TWA (on day of exposure)	Long-term TWA
48	60	100	12.5 (without RPE)	2.5 (without RPE)
48	60	100	0.63 (with RPE)*	0.125 (with RPE)*

All calculated values (TWA, long-term) rounded for presentation, but unrounded values used for calculation of exposure; full ART reports are attached in Annex 5. * includes reduction by 95% due to respiratory protection (half mask with P3 filter or full mask with P3 filter or P3 combination filter)

The modelled exposure estimates are based on (also see section 9.0.2.3):

- the median Cr(VI) concentration of 1%
- an exposure duration of 60 minutes
- a high frequency of weekly repair of a pump, which may appear over conservative

It is inherent in maintenance tasks (e.g. repair of pumps, valves etc.) that they are often unforeseeable and their frequency may be highly variable, i.e. months with 2-3 repairs and months without any repairs at all (at least in the context of relevant Cr(VI) exposure). In addition, the duration of such tasks may be quite long, but the actual exposure duration may be much shorter, e.g. exposure during dismantling of equipment and cleaning activities, but not during the actual repair.

Therefore, the approach chosen uses the median Cr(VI) concentration of the electrolyte solution (likely to be present in parts requiring repair, but most probably not all over the device) in combination with more realistic assumptions on exposure duration and frequency (also see section 9.0.2.3). This is believed to also cover exposures during less frequent activities and is possibly an overestimate with regard to the concentration, taking into account that the devices are cleaned before maintenance

As another conservative element, exposure was modelled as near-field exposure within ART, assuming that the worker remains close to the emission source (i.e. breathing zone of the worker within 1 m of the emission source) for the entire exposure duration of 60 minutes. This can be considered very conservative for this type of task. If the same task with the same input parameters is modelled in ART as far-field exposure (i.e. breathing zone of the worker more than 1 m from the emission source), the task-based concentration is reduced from 100 to 46 ng/m³. Annex 5 also presents the ART report for this scenario.

Finally, the assumptions on the surface area (0.3-1.0 m²) and the degree of contamination (10-90% of the surface) were checked for their impact on the exposure estimate, since they may also be highly variable (see section 9.0.2.3 for the rationale for these assumptions). Additional modelling exercises within ART showed that

the surface area has no additional impact, i.e. increasing it to the maximum value ($> 3 \text{ m}^2$) does not lead to an increase in the exposure estimate if the same degree of contamination is selected. This finding is due to the fact that ART models inhalation exposure from the handling of objects contaminated with powders dissolved in liquids (as in the present case) with an aerosol weighting factor that is independent of the surface area, but only dependent on the degree of contamination (Fransman et al., 2010). As a consequence, ART near-field estimates for the task addressed here range between 33 ($< 10\%$ contamination) and 333 ng/m^3 ($> 90\%$ contamination), with the task-based value derived above (100 ng/m^3) reflecting 10-90% contamination.

Overall, these considerations increase the confidence that the exposure estimates in fact represents a conservative exposure estimate for maintenance activities for this use.

Discussion and conclusions

In summary, monitored and modelled long-term inhalation exposure to Cr(VI) was estimated to be:

- Stationary Monitoring: 0.5 ng/m^3 (n=5 values from one site, all below LoQ considering RPE)
- Personal Monitoring: 11.6 ng/m^3 (n=9 values from 4 sites considering RPE)
- ART modelling (maintenance): 0.125 ng/m^3 (conservative estimate)

Stationary monitoring values for this task were all below LoQ and it remains uncertain how relevant these values are. In a conservative estimate an exposure for handling of contaminated objects has been calculated using ART. An about 100 fold higher exposure estimate results from the available personal monitoring values even if RPE is taken into account. This indicates that during maintenance additional exposure might be possible besides exposure through handling of contaminated objects. In a very conservative estimate the concentration resulting from the monitoring values will be used in this CSR for the aggregated risk characterisation.

Final exposure estimate for task 4: 11.6 ng/m^3

9.1.6. Worker contributing scenario 5: T5: Cleaning (PROC 28)

9.1.6.1. Conditions of use

T5: Cleaning with water hose

	Method
Product (article) characteristics	
• Concentration of substance in mixture: = 1% Cr(VI) <i>Concentration of Cr(VI) based on SD concentration of 25 g/L in the electrolyte of the passivation bath.</i>	
• Product type: Powders dissolved in a liquid or incorporated in a liquid matrix	
• Viscosity: Liquids with low viscosity (like water)	
Amount used (or contained in articles), frequency and duration of use/exposure	
• Duration of activity: 15 minutes	
• Frequency of use/task: = 240 days per year <i>Daily cleaning assumed as worst case, but will often be less frequent.</i>	
Technical and organisational conditions and measures	
• Place of use: Indoors – room size not regarded as this task cannot be modelled by ART	
• Ventilation rate of general ventilation system: 3 ACH	
Conditions and measures related to personal protection, hygiene and health evaluation	
• Surface contamination/fugitive emission sources: The process is not fully	

	Method
enclosed and the integrity of that enclosure is not regularly monitored, but effective housekeeping practices are in place.	
• Chemical protection clothing or protective apron as well as rubber boots when cleaning with a water hose	
• Wear chemically resistant gloves (tested to EN374) in combination with specific activity training.	
• Respiratory Protection: Yes (Respirator with APF of 20) [Effectiveness Inhal: 95%] when aerosol formation occurs (e.g. during cleaning with a hose)	
Other conditions affecting workers exposure	
• Primary emission source proximity : The primary emission source is located in the breathing zone of the worker (near field, < 1 m)	

9.1.6.2. Exposure assessment

Air monitoring results

No static monitoring results are available for this task.

Seventeen personal monitoring values for Cr(VI) exposure are available from 5 sites (2, 1, 3, 9, 2 values, respectively). Eight of these sixteen values were below the LoQ and LoQ/2 was used for the calculation. The median for all sites is 50 ng/m³ and the 90th percentile 140 ng/m³ revealing the differences observed at the different sites and possibly activities. As it is assumed that the monitoring values are mainly influenced by the exposure during cleaning, no correction for task duration has been performed. However, as RPE are worn during cleaning the influence of the RPE is considered in the frequency corrected monitoring values.

Additionally, six personal monitoring values for total chromium are available from one site, which were all below the LoQ (with different LoQs for different monitoring years). The median for these monitoring values is 500 ng/m³ and the 90th percentile 2500 ng/m³. As these values are only for total chromium and completely dependent on the LoQ they are not further regarded in this assessment.

The monitoring results are shown in the following table.

Table 48. Overview of Cr(VI) monitoring values for WCS 5 (cleaning)

Type of measurement	No. of sites covered	No. of measurements	Measurements <LoQ	Range	90 th Percentile [ng/m ³]	Inhalation exposure [ng/m ³]	
							(frequency corrected)
stationary	1	5	5 (100%)	< LoQ	50	50 ^{##}	2.5
personal	5	17	8 (47%)	< LoQ – 290 ng/m ³	140	140 ^{##}	7.0

Details are provided in Annex 2.

##: not corrected for task duration as it is assumed that exposure during maintenance mainly contributes to the overall exposure

Due to the possibility of aerosol exposure during cleaning activity, respiratory protection (half mask with P3 filter or full mask with P3 filter or P3 combination filter) is worn during cleaning.

Modelling results

No modelling results are available for cleaning with a water hose as this is outside the applicability domain of ART.

Discussion and conclusions

In summary, cleaning with a water hose cannot be modelled in Art. Stationary monitoring values are not available for this task. Therefore, the 90th percentile of personal monitoring values from five sites was used. In a conservative estimate no correction for duration was made as it was assumed that exposure during cleaning activity contributes in a relevant manner to the overall exposure.

Overall, the long-term TWA of 7 ng/m³ will be used in the aggregated exposure assessment and risk characterisation (see section 9.1.12).

Final exposure estimate for task 5: 7.0 ng/m³

9.1.7. Worker contributing scenario 6: T6: Filter Press/Sludge removal from passivation tank (PROC 28)

9.1.7.1. Conditions of use (A)

T6: Filter Press/Sludge removal from passivation tank – conditions (A) Handling of “paste, slurry or clearly (soaked) wet powder”

	Method
Product (article) characteristics	
<ul style="list-style-type: none"> Concentration of substance in mixture: = 5% Cr(VI) <i>Concentration of Cr(VI) based on single measurement for one site (no measurements from other sites)</i> 	External Tool (ART 1.5)
Amount used (or contained in articles), frequency and duration of use/exposure	
<ul style="list-style-type: none"> Duration of activity: 15 minutes <i>Maximum duration/frequency: 15 minutes on 48 days a year; this would also cover activities once per year for up to 4 hours or activities performed for 30 minutes on 8 days per year; refers to actual manual interventions</i> 	External Tool (ART 1.5)
<ul style="list-style-type: none"> Frequency of use/task: = 48 days per year <i>Maximum frequency/duration: 48 days a year for 15 minutes; this would also cover activities once per year for up to 4 hour or activities performed for 30 minutes on 8 days per year</i> 	External Tool (ART 1.5)
Substance emission potential	
<ul style="list-style-type: none"> Substance product type: Paste, slurry or clearly (soaked) wet powder 	External Tool (ART 1.5)
<ul style="list-style-type: none"> Contaminated with powder: No 	External Tool (ART 1.5)
Technical and organisational conditions and measures	
<ul style="list-style-type: none"> Place of use: Indoors – small workrooms 	External Tool (ART 1.5)
<ul style="list-style-type: none"> Ventilation rate of general ventilation system: 3 ACH 	External Tool (ART 1.5)
Conditions and measures related to personal protection, hygiene and health evaluation	
<ul style="list-style-type: none"> Surface contamination/fugitive emission sources: The process is not fully enclosed and the integrity of that enclosure is not regularly monitored, but effective housekeeping practices are in place. 	External Tool (ART 1.5)
<ul style="list-style-type: none"> Wear chemically resistant overall and gloves in combination with specific activity training. 	
Other conditions affecting workers exposure	
<ul style="list-style-type: none"> Primary emission source proximity : The primary emission source is located in the breathing zone of the worker (near field, < 1 m) 	External Tool (ART 1.5)
<ul style="list-style-type: none"> Activity class and subclass: Handling of contaminated solid objects or paste 	External Tool (ART 1.5)
<ul style="list-style-type: none"> Situation: Handling of substantially and visibly contaminated objects (layers of more than 0.5 kg) 	External Tool (ART 1.5)

	Method
• Handling type: Handling that departs from regular work procedures and involves large amounts of energy (e.g. rough handling or throwing of bags)	External Tool (ART 1.5)

9.1.7.2. Conditions of use (B)

Additionally, ART modelling was performed assuming that some limited residual dust (thin layer visible) is visible as a worst case estimate for a clearly wet sludge to get an idea about the maximum exposure possible:

T6: Filter Press/Sludge removal from passivation tank – conditions (B) handling of sludge with residual dust

	Method
Product (article) characteristics	
• Concentration of substance in mixture: = 5% Cr(VI) <i>Concentration of Cr(VI) based on single measurement for one site (no measurements from other sites)</i>	External Tool (ART 1.5)
Amount used (or contained in articles), frequency and duration of use/exposure	
• Duration of activity: 15 minutes <i>Maximum duration/frequency: 15 minutes on 48 days a year; this would also cover activities once per year for up to 4 hours or activities performed for 30 minutes on 8 days per year; refers to actual manual interventions</i>	External Tool (ART 1.5)
• Frequency of use/task: = 48 days per year <i>Maximum frequency/duration: 48 days a year for 15 minutes; this would also cover activities once per year for up to 4 hour or activities performed for 30 minutes on 8 days per year</i>	External Tool (ART 1.5)
Technical and organisational conditions and measures	
• Place of use: Indoors – small workrooms	External Tool (ART 1.5)
• Ventilation rate of general ventilation system: 3 ACH	External Tool (ART 1.5)
Conditions and measures related to personal protection, hygiene and health evaluation	
• Surface contamination/fugitive emission sources: The process is not fully enclosed and the integrity of that enclosure is not regularly monitored, but effective housekeeping practices are in place.	External Tool (ART 1.5)
• Wear chemically resistant overall and gloves in combination with specific activity training.	
Other conditions affecting workers exposure	
• Primary emission source proximity : The primary emission source is located in the breathing zone of the worker (near field, < 1 m)	External Tool (ART 1.5)
• Activity class and subclass: Handling of contaminated solid objects or paste	External Tool (ART 1.5)
• Situation: Handling of objects with limited residual dust (thin layer visible) <i>Worst case assumption for a clearly wet dust</i>	External Tool (ART 1.5)
• Handling type: Normal handling, involves regular work procedures.	External Tool (ART 1.5)

9.1.7.2. Exposure assessment

Air monitoring results

There are 3 stationary Cr(VI) monitoring values available from two sites (with 2 and 1 values, respectively. All values were below the limit of quantification and LoQ/2 was used for the calculation. Both values, the median and the 90th percentile are 125 ng/m³. Taking into account the duration for the activity (30 minutes) and the frequency (8 days per year) results in the long-term TWA value presented in the table below.

There is only one personal monitoring value for Cr(VI) exposure available from 1 site, which is below the LoQ. As this single value cannot be regarded as representative it is not regarded for the further assessment.

Additionally, three personal monitoring values for total chromium are available from one site, which were all below the LoQ. The median and the 90th percentile for these monitoring values are 50 ng/m³. As these values are only for total chromium and completely dependent on the LoQ they are not regarded further in this assessment.

The monitoring results are shown in the following table.

Table 49. Overview of Cr(VI) monitoring values for WCS 6 (filter press/sludge removal)

Type of measurement	No. of sites covered	No. of measurements	Measurements <LoQ	Range	90 th Percentile [ng/m ³]	Inhalation exposure [ng/m ³]	
						(corrected for task duration)	(frequency corrected)
stationary	2	3	3 (100%)	< LoQ	125	3.91	0.78
personal	1	1	1 (100%)	< LoQ	30 [#]	0.94	0.19

Details are provided in Annex 2.

#the table shows the monitoring value (=LoQ/2)

Modelling results

The modelled exposure estimate for manually scraping off wet solids from the filter press or shovelling the wet sludge out of the passivation tank (conditions of use A) is shown in the following table.

Table 50. Modelled exposure for workers: task 6 – conditions of use A

Frequency (d/a)	Duration [min/shift]	Inhalation exposure [ng/m ³]		
		Task-based	TWA (on day of exposure)	Long-term TWA
240*	480*	0	0	0

* Worst case assumption that is unrealistic; full ART reports are attached in Annex 5.

ART modelling performed for cake removal identified no exposure, even when unrealistic worst case assumptions were set. This finding is due to the fact that the cake to be removed from such filter presses is clearly wet (especially the sludge in the passivation tank which will be cleaned with water before removal) and is best described as “paste, slurry or clearly (soaked) wet powder” within ART. In addition, no contamination of the cake with powder was selected in ART and this combination results in a message in the ART software: “There is no potential for exposure through inhalation from this source” (Fransman et al., 2010). This outcome is independent of the concentration of a chemical. The ART report is attached in Annex 5, showing that no inhalation exposure is expected even if worst case assumptions for the other parameters are selected that do not represent real conditions.

Additionally, ART modelling was performed assuming that some limited residual dust (thin layer is visible as a worst case estimate for a clearly wet sludge to get an idea about the maximum exposure possible; conditions of use B) (see ART report in Annex 5):

Table 51. Modelled exposure for workers: task 6 – conditions of use B

Frequency (d/a)	Duration [min/shift]	Inhalation exposure [ng/m ³]		
		Task-based	TWA (on day of exposure)	Long-term TWA
48	15	7600	237.5 (without RPE)	47.50 (without RPE)
48	15	7600	11.88 (with RPE)*	2.4 (with RPE)*

All calculated values (TWA, long-term) rounded for presentation, but unrounded values used for calculation of exposure; full ART reports are attached in Annex 5; * includes reduction by 95% due to respiratory protection (half mask with P3 filter or full mask with P3 filter or P3 combination filter)

That a thin layer of dust (as flakes or particles) will be visible on the clearly wet sludge is a worst case estimate

to provide an upper range of possible exposure. Normal handling has been assumed, neither overly conservative nor overly careful.

Discussion and conclusions

In summary, there are no representative monitoring values available for this task. No exposure resulted from the ART modelling in an estimate for wet sludge (conditions of use - A). In a worst case estimate assuming that a fine layer of dust is visible on the sludge (conditions of use – B) an exposure estimate of 2.4 ng/m³ resulted.

As outlined above due to the wet character of the sludge it is assumed that no inhalation exposure occurs. This assumption is in agreement with the monitoring results, which all showed values below the LoQ.

Modelling the exposure under the conditions that a thin film of dust is on the sludge when it is removed is a very conservative estimate. To account for any sludge residues which might dry before they are removed this could be assumed as a worst case estimate. Therefore, an exposure estimate of 2.4 ng/m³ will be used for the aggregated risk estimate.

Final exposure estimate for task 6: 2.4 ng/m³

9.1.8. Worker contributing scenario 7: T7: Addition of solid CT (PROC 8b)

9.1.8.1. Conditions of use

T7: Addition of solid CT: manual decanting of chromium (VI) trioxide flakes into a pipe

	Method
Substance emission potential	
• Substance product type: Powders, granules or pelletised material	External Tool (ART 1.5)
• Dustiness: Granules, flakes or pellets	External Tool (ART 1.5)
• Moisture content: Dry product (< 5 % moisture content)	External Tool (ART 1.5)
• Powder weight fraction: Pure material	External Tool (ART 1.5)
Amount used (or contained in articles), frequency and duration of use/exposure	
• Duration of activity: 1 minute <i>Maximum duration/frequency: 1 minutes/shift; refers to actual manual interventions</i>	External Tool (ART 1.5)
• Frequency of use/task: = 240 days per year <i>Maximum frequency/duration: 1 minutes/shift</i>	External Tool (ART 1.5)
Technical and organisational conditions and measures	
• Place of use: Indoors	External Tool (ART 1.5)
• Room size: 3000 m ³	External Tool (ART 1.5)
• Ventilation rate of general ventilation system: 3 ACH	External Tool (ART 1.5)
• Primary localised controls: Other LEV (dust and vapour extractors)	External Tool (ART 1.5)
Conditions and measures related to personal protection, hygiene and health evaluation	
• Surface contamination/fugitive emission sources: The process is not fully enclosed and the integrity of that enclosure is not regularly monitored, but effective housekeeping practices are in place.	External Tool (ART 1.5)
• Localised controls: No	External Tool (ART 1.5)
• Chemical resistant overall	
• Wear chemically resistant gloves (e.g. PVC gloves, 0.8 mm) in combination with specific activity training.	
Respiratory Protection: Yes (Respirator with APF of 20) [Effectiveness Inhal: 95%]	

	Method
Other conditions affecting workers exposure	
• Primary emission source proximity : The primary emission source is located in the breathing zone of the worker (near field, < 1 m)	External Tool (ART 1.5)
• Activity class: Falling powders	External Tool (ART 1.5)
• Situation: Transferring 1 – 10 kg/minute	External Tool (ART 1.5)
• Handling type: Careful transfer involves workers showing attention to potential danger, error or harm and carrying out the activity in a very exact and thorough (or cautious) manner.	External Tool (ART 1.5)
• Drop height: < 0.5 m	External Tool (ART 1.5)
• Containment level: Handling that reduces contact between product and adjacent air	External Tool (ART 1.5)

9.1.8.2. Exposure assessment

Air monitoring results

There are no stationary monitoring values available which could be used for comparison.

Personal monitoring results are available from the two sites where this task is performed. A total of 5 measurements are available, two from one site and 3 from the other site (the latter ones were all below the LoQ). A median of 50 ng/m³ and a 90th percentile of 320 ng/m³ have been calculated. These personal monitoring values were obtained from workers who perform Task 7 in principle. However, it remains unclear, if this task has been performed on the day of the measurement. Further, the three values represent single measurements from three different years and therefore the representativeness of the data remains unclear.

The monitoring results are shown in the following table.

Table 52. Overview of Cr(VI) monitoring values for WCS 7 (addition of solid CT)

Type of measurement	No. of sites covered	No. of measurements	Measurements <LoQ	Range	90 th Percentile [ng/m ³]	Inhalation exposure [ng/m ³]	
						(corrected for task duration)	(frequency corrected)
personal	2	5	3 (60%)	< LoQ – 390	320	0.67	0.67

Details are provided in Annex 2

* includes reduction by 95% due to respiratory protection (half mask with P3 filter or full mask with P3 filter or P3 combination filter)

Modelling results

The modelled exposure estimates are shown in the following table.

Table 53. Modelled Exposure for workers: task 7

Frequency (d/a)	Duration [min/shift]	Inhalation exposure [ng/m ³]		
		Task-based	TWA (on day of exposure)	Long-term TWA
240	1	77000 (without RPE)	160.42 (without RPE)	160.42 (without RPE)
240	1	3850 (with RPE)*	8.02 (with RPE)*	8.02 (with RPE)*

All calculated values (TWA) rounded for presentation; full ART reports are attached in Annex 5; * includes reduction by 95

% due to respiratory protection (half mask with P3 filter).

This estimate presents a realistic upper end estimate for the site where this activity is performed regularly and a worst case estimate for the site where this activity is only performed on single days of the year.

Under the conditions of use as described above ART models a task-based exposure of $77 \mu\text{g}/\text{m}^3$ ($77000 \text{ ng}/\text{m}^3$), i.e. this is the exposure concentration which would result if this activity is performed for the whole workday (480 minutes). Taking into account that the whole process lasts not more than 1 minute, it results in a TWA on the day of exposure of $160.42 \text{ ng}/\text{m}^3$. This calculation does not account for the respiratory protective equipment worn by the operators. If this reduction due to RPE of 95% is considered a task based exposure of $3850 \text{ ng}/\text{m}^3$ and a TWA for the day of exposure of $8.02 \text{ ng}/\text{m}^3$ results. Taking into account the frequency (6-12 days) and duration (1-3 minutes per shift) of the other site, where this activity is only seldom performed would result in ca. 7-fold lower exposure concentrations (maximum TWA of $24.06 \text{ ng}/\text{m}^3$ without RPE and $1.20 \text{ ng}/\text{m}^3$ with RPE).

Discussion and conclusions

There are no stationary monitoring values available which could be used for comparison. Single personal monitoring values are available from the two sites where this task is relevant. However there is some uncertainty with regard to the representativeness of the monitoring values, as they represent only single measurements from different years. Modelling results represent realistic upper end estimates for the site where this task is performed regularly. Therefore, the modelled value will be used for further risk characterisation.

In summary, modelled long-term inhalation exposure to Cr(VI) was estimated to be:

- Monitoring: $0.67 \text{ ng}/\text{m}^3$ (n=5, representativeness unclear)
- ART modelling: $8.02 \text{ ng}/\text{m}^3$ (worst case)

Final exposure estimate for task 7: $8.02 \text{ ng}/\text{m}^3$

9.1.9. Worker contributing scenario 8: T8: Dissolution of solid CT /SD (PROC 5)

9.1.9.1. Conditions of use

T8: Dissolution of solid CT or SD: decanting of chromium trioxide or sodium dichromate flakes into a dissolution tank

	Method
Substance emission potential	
• Substance product type: Powders, granules or pelletised material	External Tool (ART 1.5)
• Dustiness: Granules, flakes or pellets	External Tool (ART 1.5)
• Moisture content: Dry product (< 5 % moisture content)	External Tool (ART 1.5)
• Powder weight fraction: Pure material	External Tool (ART 1.5)
Amount used (or contained in articles), frequency and duration of use/exposure	
• Duration of activity: 20 minutes <i>duration/frequency: 20 minutes/day; refers to time the drums are drained into a tundish by aid of a lifting device (or by an operator)</i>	External Tool (ART 1.5)
• Frequency of use/task: = 240 days per year <i>Maximum frequency/duration: 20 minutes/day</i>	External Tool (ART 1.5)
Technical and organisational conditions and measures	
• Place of use: Indoors	External Tool (ART 1.5)
• Room size: Any size workroom	External Tool (ART 1.5)
• Ventilation rate of general ventilation system: 3 ACH	External Tool (ART 1.5)
• Primary localised controls: No	External Tool (ART 1.5)
Conditions and measures related to personal protection, hygiene and health evaluation	

	Method
• Surface contamination/fugitive emission sources: The process is not fully enclosed and the integrity of that enclosure is not regularly monitored, but effective housekeeping practices are in place.	External Tool (ART 1.5)
• Localised controls: No	External Tool (ART 1.5)
• Chemical resistant overall	
• Wear chemically resistant gloves (e.g. PVC gloves, 0.8 mm) in combination with specific activity training.	
Respiratory Protection: Yes (Respirator with APF of 20) [Effectiveness Inhal: 95%]	
Other conditions affecting workers exposure	
• Primary emission source proximity : The primary emission source is located in the breathing zone of the worker (near field, < 1 m)	External Tool (ART 1.5)
• Activity class: Falling powders	External Tool (ART 1.5)
• Situation: Transferring 1 – 10 kg/minute	External Tool (ART 1.5)
• Handling type: Careful transfer involves workers showing attention to potential danger, error or harm and carrying out the activity in a very exact and thorough (or cautious) manner.	External Tool (ART 1.5)
• Drop height: < 0.5 m	External Tool (ART 1.5)
• Containment level: Handling that reduces contact between product and adjacent air	External Tool (ART 1.5)

9.1.9.2. Exposure assessment

Air monitoring results

There are no air monitoring results available as this is only a theoretical scenario which is currently not in place.

Modelling results

The modelled exposure estimates are shown in the following table.

Table 54. Modelled Exposure for workers: task 8

Frequency (d/a)	Duration [min/shift]	Inhalation exposure [ng/m ³]		
		Task-based	TWA (on day of exposure)	Long-term TWA
240	20	270000 (without RPE)	11250 (without RPE)	11250 (without RPE)
240	20	13500 (with RPE)*	562.5 (with RPE)*	562.5 (with RPE)*

All calculated values (TWA) rounded for presentation; full ART reports are attached in Annex 5; * includes reduction by 95% due to respiratory protection (half mask with P3 filter or full mask with P3 filter or P3 combination filter)

The modelled exposure estimates are based on (also see section 9.0.2.3):

- an exposure duration of 20 minutes
- a high frequency of daily activity with two drums, which would especially be an overestimate for sites with lower Cr(VI) consumption.

Under the conditions of use as described above ART models a task-based exposure of 270 µg/m³, i.e. this is the exposure concentration which would result if this activity is performed for the whole workday (480 minutes). Taking into account that the whole process lasts ca. 20 minutes a TWA on the day of exposure of 11.25 µg/m³ would result. This calculation does not account for the respiratory protection equipment worn by the operators. If this reduction due to RPE of 95% is considered a task based exposure of 13.50 µg/m³ and a TWA for the day

of exposure of 0.562 µg/m³ results. This is a very conservative estimate for this theoretical WCS which would also cover the situation that on short notice no liquid CT or SD will become available and that – before any technical measures could be implemented – this activity would be performed by an operator. At the same time the calculation reveals that with respect to worker protection it would be necessary to install technical measures (e.g. dust extraction, containment) to minimise worker exposure. Furthermore, it reveals that using aqueous solutions, as it is currently the situation, is a very effective risk management measure.

There are no stationary monitoring values available which could be used for comparison.

Discussion and conclusions

In summary, modelled long-term inhalation exposure to Cr(VI) was estimated to be:

- ART modelling: 562.5 ng/m³ (worst case)

This conservative estimate (assumption that no local exhaust ventilations or any containments are in place, only consideration of respiratory protection) reveals, that preparing of CT or SD solutions from pelletised material could result in relevant worker exposure and indicates the need for technical risk management measures in case this theoretical scenario would become relevant.

Final exposure estimate for task 8: 562.5 ng/m³

9.1.10. Worker contributing scenario 9: T9: Activities close to the ETP line without handling of Cr(VI) containing solutions (PROC 4)

9.1.10.1. Conditions of use

T9: Activities close to the ETP line without handling of Cr(VI) containing solutions

	Method
Product (article) characteristics	
• Concentration of substance in mixture: = 1% Cr(VI) <i>Concentration of Cr(VI) based on SD concentration of 25 g/L in the electrolyte of the passivation bath.</i>	
• Product type: Powders dissolved in a liquid or incorporated in a liquid matrix	
• Viscosity: Liquids with low viscosity (like water)	
Amount used (or contained in articles), frequency and duration of use/exposure	
• Duration of activity: 480 minutes	
• Frequency of use/task: = 240 days per year <i>Daily activities along the line.</i>	
Technical and organisational conditions and measures	
• Place of use: Indoors – large workroom	
• Ventilation rate of general ventilation system: 3 ACH	
Conditions and measures related to personal protection, hygiene and health evaluation	
• Surface contamination/fugitive emission sources: The process is not fully enclosed and the integrity of that enclosure is not regularly monitored, but effective housekeeping practices are in place.	
• Standard PPE	
• Respiratory Protection: no	
Other conditions affecting workers exposure	
• Primary emission source proximity : The primary emission source could be located in the breathing zone of the worker (near field, < 1 m) but could also be in the far field, depending on the activity along the line	

	Method

9.1.10.2 Exposure assessment

Monitoring results

There are 56 stationary monitoring values for Cr(VI) available from 5 sites (8, 4, 21, 22, 1, respectively). Twenty-nine of these values (51.8%) were below the LoQ and LoQ/2 has been used for further calculations. The resulting median and 90th percentile are 50 ng/m³ and 3110 ng/m³. These stationary monitoring values summarise all stationary monitoring results submitted by the companies which could not be attributed to a specific task. They also include measurements from places along the line which are not close to any activity points of the operators and do not necessarily provide a realistic estimate for the different operator subgroups, because the documentation of these values is often not sufficient to clearly indicate for which type of operators they might be representative.

Additionally, eighty-eight personal Cr(VI) monitoring values were provided by five sites (2, 52, 6, 19, 9, respectively). Sixty of these values were below the LoQ. Fifty-two of these values below LoQ were 1.5 h measurements with a LoQ of 1.5 µg/m³. Due to the high LoQ these 52 values were excluded from statistical evaluation. The median and 90th percentile for the remaining 36 values were 90 ng/m³ and 220 ng/m³, respectively. Due to the number of values and the number of sites covered by these thirty-six measurements they are regarded to provide a relevant estimate for the overall exposure along the line without performing any Cr(VI) related activities.

Table 55. Overview of Cr(VI) monitoring values for WCS 9 (no task specific activities along the ETP line)

Type of measurement	No. of sites covered	No. of measurements	Measurements <LoQ	Range	90 th Percentile [ng/m ³]	Inhalation exposure [ng/m ³]	
						(corrected for task duration)	(frequency corrected)
stationary	5	56	21 (51.8%)	< LoQ – 52.43	3110	3110	3110
personal	4	36	8 (22%)	< LoQ – 0.51	220	220	220

Details are provided in Annex 2

Modelling results

As the workers do not handle any Cr(VI) containing liquids or subjects in this scenario no modelling could be performed for this task.

Discussion and conclusions

In summary, modelled long-term inhalation exposure to Cr(VI) was estimated to be 220 ng/m³ (n=4 sites, 36 measurements). As discussed above personal monitoring values provide a good estimate of exposure during non-task specific activities along the ETP line. The 90th percentile covers a wide range of exposure concentrations. Exposure concentrations are probably too high for some activities (e.g. forklift drivers). But, in the absence of any descriptions of the activities performed during these measurements they are regarded as relevant for the risk characterisation. Additionally, a 90th percentile for the exposure estimate of 220 ng/m³ is supported by an analysis of all personal monitoring data available for the different tasks (excluding values with a LoQ of 1.5 µg/m³). These data indicate that performing different activities close to the line probably results in an overall exposure in this height. Therefore, a value of 220 ng/m³ is taken for the further risk characterisation.

Final exposure estimate for task 9: 220 ng/m³

9.1.11. Worker contributing scenario 10: T10: Control-Room activities (no PROC assigned)**9.1.11.1. Conditions of use**

The operators stay in the control room to watch the process when they do not have to perform task specific activities along the production line. As the control rooms at the sites are close to the production lines and are not equipped with an external air supply exposure in the control room is also addressed on basis of the available monitoring values.

T10: Control room activities

	Method
Product (article) characteristics	
• Concentration of substance in mixture: not relevant as no Cr(VI) source in near filed	
Amount used (or contained in articles), frequency and duration of use/exposure	
• Duration of activity: up to 480 minutes, depending on type of operators	
• Frequency of use/task: = 240 days per year <i>Daily activities in the control room.</i>	
Technical and organisational conditions and measures	
• Place of use: Indoors	
• Ventilation rate of general ventilation system: general ventilation system, no external air supply	
• Activity class for liquids: not relevant for this task	
Conditions and measures related to personal protection, hygiene and health evaluation	
• Effective housekeeping practices in place: yes	
• Respiratory Protection: no	
Other conditions affecting workers exposure	
• Primary emission source proximity : far field	

9.1.11.2. Exposure assessment**Monitoring results**

Stationary monitoring results for total chromium are available from one site (21 values, 17 values below the LoQ; median 500 ng/m³; 90th percentile 1000 ng/m³). As these values are mainly influenced by the LoQ and due to the fact that total chromium measurements do not provide a qualified basis for the assessment of Cr(VI) exposure, these values were not regarded for this exposure assessment.

Additionally, there are 17 stationary monitoring values for Cr(VI) from 2 sites (4 and 17 values, respectively), which were all below the LoQ. Again, No conclusion on the actual exposure could be drawn on basis of these data which are influenced by the LoQ of the underlying method. Nevertheless, these data indicate that the Cr(VI) concentration in the control room seems to be low, possibly in the lower ng/m³ range.

Personal Cr(VI) monitoring values were provided by two sites, which were all below the LoQ, which was 1.5 µg/m³ and 0.06 µg/m³ for the two sites. Due to the dependency of the result on the LoQ no relevant information on possible Cr(VI) concentration in the control room could be derived.

Table 56. Overview of Cr(VI) monitoring values for WCS 10 (control room)

Type of measurement	No. of sites covered	No. of measurements	Measurements <LoQ	Range	90 th Percentile [ng/m ³]	Inhalation exposure [ng/m ³]	
						(corrected for task duration)	(frequency corrected)
stationary	2	17	17 (100%)	< LoQ	50	50	50
personal	2	19	19 (100%)	< LoQ	750	750	750

Details are provided in Annex 2

Modelling results

As the workers do not handle any Cr(VI) containing liquids or subjects in the control room no modelling could be performed for this task.

Discussion and conclusions

In summary, modelled long-term inhalation exposure to Cr(VI) was estimated to be:

- Monitoring values: no relevant information available, mainly values < LoQ
- ART modelling: not performed for this task

Based on the available information no conclusions on the possible Cr(VI) concentration in the control room could be drawn. As all Cr(VI) concentrations measured were below LoQ it is assumed that during the stay of the operators in the control room no relevant Cr(VI) exposure happens.

Final exposure estimate for task 10: no value derived

9.1.12. Aggregated exposure estimation and risk characterisation for unit operators

Exposure estimation

Task-related exposure estimates have been derived in sections 9.1.2 to 9.1.11. For this task-related exposure assessment modelling with the higher tier tool ART have been performed except for task 5 (cleaning), task 9 (activities along the ETP line) and task 10 (activities in the control room). As far as modelling was possible a comparison of the modelling result with the available monitoring values was performed and a long-term TWA for risk characterisation was selected after weighing the uncertainties related to the modelling and monitoring data (for discussions see section 9.1.2 to 9.1.9). In case modelling was impossible (T5, T9, T10) the available monitoring values have been evaluated and a long-term TWA was calculated to be used for further risk characterisation. Table 57 summarises the long-term TWA Cr(VI) concentrations assigned to the individual tasks.

The results in Table 57 reveal that the Cr(VI) exposure related to specific tasks where Cr(VI) is handled are rather low, in the range of 0.34 to 11.6 ng/m³, except for task 8 (dissolution of solid CT or SD). As task 8 is only related to a theoretical future scenario this will not be further addressed in this context. However, the calculated long-term TWA for task 8 reveals, that operational and technical measures should be implemented beyond those assumed in section 9.1.9 to control the exposure, should this task ever become relevant.

Table 57 also reveals that, based on the available monitoring data from the different sites, a relatively high long-term TWA of 220 ng/m³ results for activities close to the ETP line without direct handling of Cr(VI), which is clearly higher than the task-related TWAs for the tasks T1-T7. This is astonishing as no direct exposure through handling of Cr(VI) was expected to take place. The long-term TWA for task 9 is based on the 90th percentile of the available personal monitoring data, which were assigned to task 9, excluding data from one site with values which were all below the LoQ, which was rather high (1.5 µg/m³; see section 9.1.10.2 for further discussion). These include inter alia data for entry and exit operators, who usually do not perform Cr(VI) related tasks. However, it turned out that this pool of data also contains all personal monitoring data of operators of the ETP line that – due to insufficient description of the activities of the operator – could not be assigned to the tasks 1-7. Therefore, this dataset also contains measurements related to direct handling of Cr(VI).

If one takes a look at all personal monitoring data for Cr(VI) which are available from six sites for the different tasks and again excludes the data from the site with the LoQ of 1.5 µg/m³, which otherwise would dominate the statistical evaluation, a total of n=99 personal monitoring data are available (versus n=36 values assigned to task 9). The median of these 99 values is 42.1 ng/m³, the 90th percentile 219 ng/m³ and the 75th percentile 117 ng/m³. So, analysing all available personal monitoring data provides the same 90th percentile value as the analysis of the personal monitoring data assigned to task 9 only. This further supports the notion that the measurements assigned to task 9 contain measurements related to direct handling of Cr(VI).

The personal monitoring data for Cr(VI) are illustrated in Figure 3. These data, which were provided from six different sites reveal different exposure concentrations which could be site- or task-specific. Some of the higher exposure concentrations could clearly be assigned to tasks for which one would expect a higher task-related exposure, e.g. maintenance. For other values no such clear assignment to certain activities is possible due to insufficient documentation of the activities performed by the operators during the monitoring. Therefore, mistakes in the assignment of personal monitoring data to certain tasks cannot be excluded which contributes to the uncertainty of the exposure assessment in this joint CSR for all sites of the APEAL member companies. The total number of values provided from the individual sites is insufficient to further analyse this issue. However, in total these data indicate that – at least at some sites – elevated exposure concentrations could occur also in the context of activities that are not directly related to the handling of Cr(VI).

Table 57. Task-specific long-term TWA inhalation exposure estimates

Task	Long-term TWA Cr(VI) concentration [ng/m³]	Comments
T1 - Changing IBC containers	0.34	Based on modelling
T2 - Sampling of passivation bath	3.125	Based on modelling
T3 - Sampling of wastewater	1.88	Based on modelling
T4 – Maintenance	11.6	Based on 90 th percentile of monitoring
T5 – Cleaning	7.0	Based on 90 th percentile of monitoring
T6 - Filter Press/Sludge removal	2.4	Based on modelling
T7 - Addition of solid CT	8.02	Based on modelling
T8 - Dissolution of solid CT or SD	562.5	Based on modelling
T9 - Activities close to the ETP line without handling of Cr(VI) containing solutions	220.0	Based on 90 th percentile of monitoring
T10 - Control-Room activities	-	Time spend in control room does not contribute to Cr(VI) exposure

All calculated values (TWA, long-term) rounded for presentation, but unrounded values used for calculation of aggregated exposure (see below)

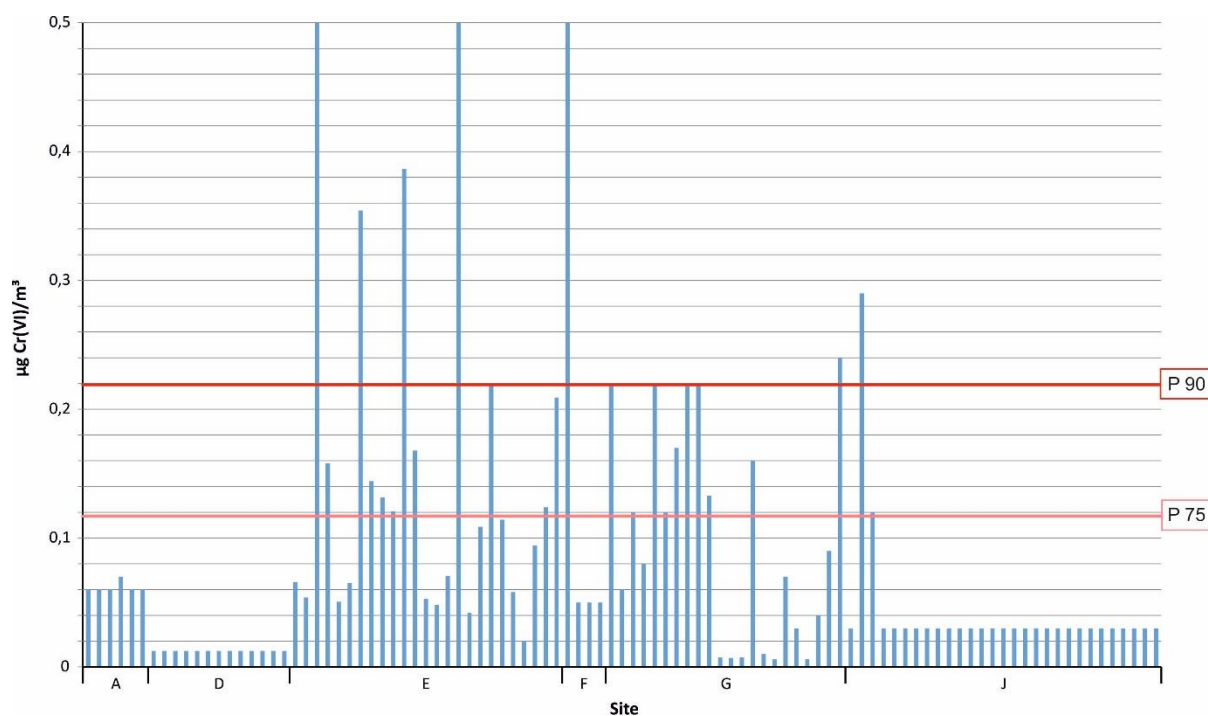


Figure 3: Compilation of Cr(VI) personal monitoring data provided by six sites covering all tasks (median: 42.1 ng/m³, 90th percentile: 219.1 ng/m³; and the 75th percentile 117.2 ng/m³)

Aggregated inhalation exposure assessment

This section aggregates the exposure estimates of unit operators engaged in the tasks described in section 9.1.2-9.1.11. For such an aggregation, addition of all long-term TWA would be the simplest option. However, one and the same worker does not perform all tasks with the indicated frequencies over the entire year. In particular, tasks that are not performed daily (e.g. T4 maintenance) are (partially) carried out by other staff members than those involving the regular running of the unit with the daily tasks of sampling (T2) that are indeed regularly performed by the same workers (although these take turns during their shift, see below).

9.1.12.1 Aggregated exposure assessment for Trostre

The following table reveals the number of workers engaged in the ETP process at the applicant's site in Trostre. Table 59 provides an overview on the tasks performed by the different operators. Based on the tasks performed by the operators (see Table 59) and the long-term TWA Cr(VI) concentration assigned to the different tasks (see Table 57) aggregated long-term TWA inhalation exposure estimates have been calculated (see Table 60).

Table 58. Shift patterns for aggregated exposure estimation (Trostre)

Worker	Number of workers [#]	Assumptions for aggregation
Team leader	██████ team leader per shift, 4 shifts -> ██████ team leaders	The team leader is engaged in Task 4 and Task
Team leader deputy	██████ team leader deputy per shift, 4 shifts -> ██████ team leader deputies	The team leader deputy is engaged in Task 4
Entry operator	██████ entry operator per shift, 4 shifts -> ██████ entry operators	Entry operators are engaged in Task 4
Exit operator	██████ exit operator per shift, 4 shifts -> ██████ exit operators	Exit operators are engaged in Task 4
Anode operator Type 1	██████ anode operator 1 per shift, 4 shifts -> ██████ anode operators 1	Anode operators 1 are engaged in Task 1 and Task 4
Anode operator Type 2	██████ anode operator 2 per shift, 4 shifts -> ██████ anode operators 2	Anode operators 2 are engaged in Task 2
Inspector	██████ inspector per shift, 4 shifts -> ██████ inspectors operators	Inspectors are not engaged in any specific Cr(VI) related tasks
Expeditor	██████ expeditor per shift, 4 shifts -> ██████ expeditors	Expeditors are not engaged in any specific Cr(VI) related tasks
Forklift driver	██████ forklift driver per shift, 4 shifts -> ██████ forklift driver	Forklift drivers are not engaged in any specific Cr(VI) related tasks
External maintenance worker	Maximum ██████ external maintenance workers	External maintenance workers are engaged in Task 4
Contract worker (cleaning)	██████ contract cleaning workers	Contract cleaning workers are engaged in Task 5 and Task 6
External contractor for WWTP	██████ external contractor for WWTP	The external contractor for WWTP is engaged in Task 3

[#] the applicant is running ██████ ETP lines in total in Trostre

Table 59. Overview on the tasks performed by the different operators (Trostre)

Operator type	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Task 7*	Task 8*	Task 9	Task 10**
Team leader				X	X					
Team leader deputy				X						
Entry operator				X						
Exit operator				X						
Anode operator Type 1	X			X						
Anode operator Type 2		X								
Inspector										
Expeditor										
Forklift driver										
External maintenance worker				X						
Contract worker (cleaning)					X	X				
External contractor for WWTP			X							

* not relevant for this site **time spent in control room not indicated for operators, taken into account in the context of the upper end estimate

Table 60. Task-specific and aggregated long-term TWA inhalation exposure estimates for unit operators and contract workers (Trostre)

Aggregated exposure estimate	Long-term TWA Cr(VI) concentration [ng/m ³]	Consideration of Cr(VI) related tasks
Team leader	18.6	T4 + T5
Team leader deputy	11.6	T4
Entry operator	11.6	T4
Exit operator	11.6	T4
Anode operator Type 1	11.9	T1 + T4
Anode operator Type 2	3.13	T2
Inspector		Does not perform specific Cr(VI) related task
Expeditor		Does not perform specific Cr(VI) related task
Forklift driver		Does not perform specific Cr(VI) related task
External maintenance worker	11.6	T4
Contract worker (cleaning)	9.4	T5 + T6
External contractor for WWTP	1.88	T3

All calculated values (TWA, long-term) rounded to two or three significant figures for presentation, but unrounded values used for calculation of aggregated exposure; aggregated exposure given with three significant figures.

The calculation in reveals long-term TWA Cr(VI) concentrations for the different operators which are in the range of 1.88 to 18.6 ng/m³. This assessment is based on the task related long-term TWAs and the knowledge of the tasks performed by the operators.

Based on the considerations on possible Cr(VI) exposure concentrations along the line as revealed by personal monitoring data (see above) it becomes obvious, that a task related exposure estimate as shown in Table 60, might underestimate the real exposure if it is taken into consideration that the operators also stay for different times in the area along the ETP line performing also other non-Cr(VI) related tasks. The duration of these stays along the line is different for the different operator types and might also differ for a certain type of operators from day to day. The assumption for the duration of the time spent along the line has a major impact on the overall exposure assessment. To take possible exposure during non-Cr(VI) related activities into account for shift operators an upper end **task-independent exposure estimate of 220 ng Cr(VI)/m³** would result **for all shift operators** on basis of the personal monitoring data. Such an upper end exposure assumption could be made for all shift operators. However, for external contract workers which come to the line only for their specific duties a task related exposure has been assumed.

This upper end exposure estimate is probably also an upper end exposure estimate for the shift operators at the applicant's site in Trostre. Most recent stationary monitoring values (for details see Annex 3) revealed that the exposure is usually below the limit of quantification, which is <100 ng Cr(VI)/m³. No conclusions could be drawn on basis of the available personal monitoring data, as they provide only information on total chromium exposure.

9.1.12.2 Aggregated exposure assessment for IJmuiden

The following table reveals the number of workers engaged in the ETP process at the applicant's site in IJmuiden. Table 62 provides an overview on the tasks performed by the different operators. Based on the tasks performed by the operators (see Table 62) and the long-term TWA Cr(VI) concentration assigned to the different tasks (see Table 57) aggregated long-term TWA inhalation exposure estimates have been calculated (see Table 63).

Table 61. Shift patterns for aggregated exposure estimation (IJmuiden)

Worker	Number of workers [#]	Assumptions for aggregation
Team leader	██████ team leaders per shift, 5 shifts plus ██████ team leaders as reserve -> ██████ team leaders in total	The team leader is not involved in Cr(VI) related exposures, no assignment of specific tasks 1-8; exposure due to activities near the line (Task 9) are assumed
Process operator	██████ process operators per shift, i.e. 2 process operators per line which share the activity, 5 shifts plus ██████ process operators as reserve-> ██████ process operators in total	Process operators are engaged in Task 1, task 2, task 4 and task 5
Entry operator	██████ entry operators per shift, 5 shifts plus ██████ entry operators as reserve -> ██████ entry operators in total	Entry operators are engaged in Task 4
Exit operator	██████ exit operators per shift, 5 shifts plus ██████ exit operators as reserve -> ██████ exit operators in total	Exit operators are not engaged in any specific tasks
Anode operator	██████ anode operators per shift, 5 shifts	Anode operators are not engaged in any specific tasks

	plus [REDACTED] anode operators as reserve -> [REDACTED] anode operators in total	
Inspector	[REDACTED] inspectors per shift, 5 shifts plus [REDACTED] inspectors as reserve-> [REDACTED] inspectors operators in total	Inspectors are not engaged in any specific tasks
Process operator wastewater stream	[REDACTED] process operators waste water stream per shift, 5 shifts plus [REDACTED] as reserve -> [REDACTED] process operators waste water stream in total	Process operators waste water stream are engaged in Task 3 and Task 9
Shift maintenance operators	[REDACTED] shift maintenance operators per shift, 5 shifts plus [REDACTED] deputy maintenance operators as reserve -> [REDACTED] shift maintenance operators in total	Shift maintenance operators are engaged in Task 4
Maintenance day shift	[REDACTED] maintenance day shift workers in total	Maintenance day shift workers are engaged in Task 4
Contract maintenance workers	[REDACTED] contract maintenance workers in total	Contract maintenance workers are engaged in Task 4 and Task 5
Contract worker	[REDACTED] contract worker, only once per year	The contract worker is engaged in WCS 6
Technologists, laboratory staff and managers (production, maintenance)	[REDACTED] technologists, laboratory staff and ,managers in total	The technologists, laboratory staff and managers are not involved in Cr(VI) related exposures, no assignment of specific tasks 1-8

the applicant is running [REDACTED] ETP lines in total in IJmuiden

Table 62. Overview on the tasks performed by the different operators (IJmuiden)

Operator type	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Task 7*	Task 8*	Task 9	Task 10
Team leader										
Process operator	X	X		X	X				X	
Entry operator				X						
Exit operator										
Anode operator										
Inspector										
Process operator wastewater stream			X						X	
Shift maintenance operators				X						
Maintenance day shift				X						
Contract maintenance worker				X	X					
Contract workers						X				
Technologists, laboratory staff and managers										

* not relevant for this site

Table 63. Task-specific and aggregated long-term TWA inhalation exposure estimates for unit operators and contract workers_(IJmuiden)

Aggregated exposure estimate	Long-term TWA Cr(VI) concentration [ng/m ³]	Consideration of Cr(VI) related tasks
Team leader		Does not perform specific Cr(VI) related task
Process operator	31.66	(T1 + T2 + T4 + T5)/2* + 45 minutes T9
Entry operator	11.60	T4
Exit operator		Does not perform specific Cr(VI) related task
Anode operator		Does not perform specific Cr(VI) related task
Inspector		Does not perform specific Cr(VI) related task
Process operator wastewater stream	50.0	T3 + 105 minutes T9
Shift maintenance operators	11.60	T4
Maintenance day shift	11.60	T4
Contract maintenance worker	18.60	T4 + T5
Contract worker	2.4	T6
Technologists, laboratory staff and ,managers		Do not perform specific Cr(VI) related task

All calculated values (TWA, long-term) rounded to two or three significant figures for presentation, but unrounded values used for calculation of aggregated exposure; aggregated exposure given with three significant figures.

*two operators per shift which take turn of the activities so that it could reasonably be assumed that every operator only is exposed to half of the Cr(VI) resulting from these activities

The calculation in Table 63 reveals long-term TWA Cr(VI) concentrations for the different operators which are in the range of 0.79 to 29.38 ng/m³. This assessment is based on the task related long-term TWAs and the knowledge of the tasks performed by the operators. Additionally, for the team leader and the process operator wastewater stream, for whom an average estimate for the time spend along the line is available, a contribution of the overall Cr(VI) concentration along the line (Task 9) was taken into account.

Based on the considerations on possible Cr(VI) exposure concentrations along the line as revealed by personal monitoring data (see above) it becomes obvious, that a task related exposure estimate as shown in Table 63, might underestimate the real exposure if it is taken into consideration that the operators also stay for different times in the area along the ETP line performing also other non-Cr(VI) related tasks. The duration of these stays along the line is different for the different operator types and might also differ for a certain type of operators from day to day. The assumption for the duration of the time spent along the line has a major impact on the overall exposure assessment. To take possible exposure during non-Cr(VI) related activities into account for shift operators an upper end **task-independent exposure estimate of 220 ng Cr(VI)/m³** would result for **all shift operators** on basis of the personal monitoring data. Such an upper end exposure assumption could be made for all shift operators. However, for external contract workers which come to the line only for their specific duties a task related exposure has been assumed. No exposure is assumed for technologists, laboratory staff and managers, who usually do not perform any activities along the ETP line.

This upper end exposure estimate would also be an upper end exposure estimate for the shift operators at the applicant's site in IJmuiden. Stationary monitoring values (for details see Annex 3) revealed that the exposure is usually below the limit of quantification, which is <100 ng Cr(VI)/m³. Also the personal monitoring data available for the applicant's site in IJmuiden indicate that the upper end exposure estimate is an overestimate for the shift operators of this applicant, as the personal monitoring data were all below the LoQ of 60 or 70 ng/m³.

9.1.12.3 Risk characterisation for Trostre

The exposure estimate derived in section 9.1.12.1 was compared with the exposure-risk relationship (ERR) derived by ECHA (2013), according to which occupational exposure to 10 ng/m³ is associated with an excess lung cancer risk of 4×10^{-5} (see section 9.0.3). The risk resulting from the application of this ERR to the inhalation exposure estimate presented above is shown in the table.

Table 64. Risk resulting from Cr(VI) exposure use of sodium dichromate and chromium trioxide for the passivation of tin-plated steel (ETP) (Trostre)

Workers	Task aggregation	Inhalation exposure [ng/m ³]	Risk –task related	Upper end-estimate*
Team leader	T4 + T5	18.6	7.4×10^{-5}	8.8×10^{-4}
Team leader deputy	T4	11.6	4.6×10^{-5}	8.8×10^{-4}
Entry operator	T4	11.6	4.6×10^{-5}	8.8×10^{-4}
Exit operator	T4	11.6	4.6×10^{-5}	8.8×10^{-4}
Anode operator Type 1	T1 + T4	11.9	4.8×10^{-5}	8.8×10^{-4}
Anode operator type 2	T2	3.13	1.3×10^{-5}	8.8×10^{-4}
Inspector				8.8×10^{-4}
Expeditor				8.8×10^{-4}
Forklift driver				8.8×10^{-4}
External maintenance worker	T4	11.6	4.6×10^{-5}	Not applicable

Contract worker (cleaning)	T5 + T6	9.4	3.8×10^{-5}	Not applicable
External contractor for WWTP	T3	1.88	7.5×10^{-6}	Not applicable

* based on task-independent upper end exposure estimate of $220 \text{ ng Cr(VI)/m}^3$ for shift operators (see text for details)

Conclusion on risk characterisation

The task based risk estimates are in the range of 7.5×10^{-6} to 7.4×10^{-5} . If a task-independent upper end exposure estimate of 220 ng/m^3 for shift operators is assumed an upper end risk estimate of 8.8×10^{-4} would result for shift operators. Available stationary monitoring data from the UK site of this applicant indicate that the upper end exposure estimate is probably a conservative estimate for the UK site of this applicant. No firm conclusions could be drawn on basis of the UK personal monitoring data for the Trostre operators of this applicant, as only total chromium was measured with a LoQ in the range of $1\text{--}5 \text{ }\mu\text{g/m}^3$.

9.1.12.4 Risk characterisation for IJmuiden

The exposure estimate derived in section 9.1.12.2 was compared with the exposure-risk relationship (ERR) derived by ECHA (2013), according to which occupational exposure to 10 ng/m^3 is associated with an excess lung cancer risk of 4×10^{-5} (see section 9.0.3). The risk resulting from the application of this ERR to the inhalation exposure estimate presented above is shown in the table.

Table 65. Risk resulting from Cr(VI) exposure use of sodium dichromate and chromium trioxide for the passivation of tin-plated steel (ETP) (IJmuiden)

Workers	Task aggregation	Inhalation exposure [ng/m^3]	Risk – Task-related	Upper end risk-estimate*
Team leader				8.8×10^{-4}
Process operator	(T1 + T2 + T4 + T5)/2 + 45 minutes T9	31.66	1.3×10^{-4}	8.8×10^{-4}
Entry operator	T4	11.60	4.6×10^{-5}	8.8×10^{-4}
Exit operator				8.8×10^{-4}
Anode operator				8.8×10^{-4}
Inspector				8.8×10^{-4}
Process operator waste water stream	T3 + 105 minutes T9	50.0	2.0×10^{-4}	8.8×10^{-4}
Shift maintenance operators	T4	11.60	4.6×10^{-5}	8.8×10^{-4}
Maintenance day shift	T4	11.60	4.6×10^{-5}	8.8×10^{-4}
Contract maintenance worker	T4 + T5	18.6	7.4×10^{-5}	Not applicable [#]
Contract	T6	2.4	1.0×10^{-5}	Not applicable [#]

worker				
Technologists, laboratory staff and ,managers				Not applicable [#]

* based on task-independent upper end exposure estimate of 220 ng Cr(VI)/m³ for shift operators (see text for details); #: see text for explanation

Conclusion on risk characterisation

The task based risk estimates for shift operators, maintenance day workers and contract workers are in the range of 1.0×10^{-5} to 2.0×10^{-4} . If a task-independent upper end exposure estimate of 220 ng/m³ for shift operators is assumed an upper end risk estimate of 8.8×10^{-4} would result for shift operators. However, available personal monitoring data from the applicant's site in IJmuiden are in good agreement with the task related exposure assessment indicating that the upper end estimate is probably too conservative.

9.2 Consideration of reproductive toxicity

Dermal exposure should be regarded for all activities which are related to a possible Cr(VI) exposure due to SD exposure to check for possible risks related to reproductive toxicity (see section 9.0.3.). Dermal exposure may in principle occur through splashes during sampling of the passivation solution or the wastewater (T2 and T3), during changing of IBC containers (T1) during cleaning and maintenance activities (T4 and T5), filter press or sludge removal (T6) or during dissolution of solid SD (T8, currently not performed by any site). For further details see section 9.0.2.3 (Table 27)

Table 27). In a conservative manner total Cr(VI) exposure is regarded also for the dermal assessment without distinguishing the origin of Cr(VI) from CT or SD, although in principle only Cr(VI) exposure from SD would be relevant. This results in an overestimate of the dermal Cr(VI) exposure resulting from SD exposure alone.

Modelling dermal exposure during the use of Cr(VI) containing solutions covered by this AfA is difficult. The substance is a solid dissolved in a liquid and is therefore outside the applicability domain of the standard modelling tool ECETOC TRA. The Riskofderm model (v.2.1) does not contain adequate modules (DEO units) for T1 (handling contaminated objects), and T4, T5 and T6 (cleaning tasks such as cleaning with a water hose). Tasks covered by T2, T3 and T8 may be modelled as filling tasks (DEO unit 1 in Riskofderm). The conditions of use applied for the Riskofderm model are described in the following table. A density of 1 g/mL was assumed in line with the information reported in Table 28.

9.2.1 Conditions of use (Riskofderm modelling, realistic input, for details see Annex 6)

	Method
Product (article) characteristics	
• Physical form of the used product: Liquid (T2, T3) and solid (T8)	Riskofderm 2.1
Amount used (or contained in articles), frequency and duration of use/exposure	
• Duration of dermal exposure: = 15 min (liquid), 20 min (solid)	Riskofderm 2.1
• Frequency of skin contact: Rare contact	Riskofderm 2.1
• Use rate of the product : <= 0.5 L/min (liquid), 5 kg/min (solid)	Riskofderm 2.1
Technical and organisational conditions and measures	
• Level of automation of the task: Manual task	Riskofderm 2.1
Conditions and measures related to personal protection, hygiene and health evaluation	
• Dermal protection: Yes (Chemically resistant gloves conforming to EN374 with specific activity training) and (other) appropriate dermal protection [Effectiveness Dermal: 95%]	Riskofderm 2.1
Other conditions affecting workers exposure	
• Generation of aerosols or splashes during task: No	Riskofderm 2.1
• Type of skin contact: Light skin contact	Riskofderm 2.1

The 90th percentile exposure estimate from Riskofderm modelling was used for an estimate of potential dermal exposure.

A second (generic) modelling approach using a default dermal load of 0.1 mg/cm²/d (EU RAR for SD for non-dispersive uses) was also followed. This approach allowed estimating dermal exposure during all tasks, including body exposure during cleaning with a water hose and provides estimates of possible dermal exposure.

Modelling results

The modelled exposure estimates for T2, T3 and T8 are shown in the following table. Annex 6 provides details for an additional, unrealistic exposure scenario with liquid preparations.

Table 67 shows the actual dermal exposure to Cr(VI) based on input data from the EU RAR (generic approach) .

Table 66. Modelled Exposure for Workers: T2 (hands), T3 (hands), and T8 (hands) based on Riskofderm

Parameter	Unit	T2 (hands)	T3 (hands)	T8 (hands)	Rationale (Reference)
Potential dermal exposure to product per event	mg	68.5	68.5	26.7	Riskofderm result
Body weight	kg	70	70	70	Body weight for workers

					(Guidance IR & CSA, R.8 (ECHA, 2012a))
Potential dermal exposure to product	mg/kg bw/d	0.979	0.979	0.381	Calculated
PPE efficiency (gloves, protective clothing or apron)	%	95	95	95	See section 9.0.2.3.
Actual dermal exposure to product	mg/kg bw/d	0.0489	0.0489	0.0191	Calculated
Cr(VI) concentration in product	%	1	0.37	40	See Table 28 (critical input parameters)
Actual dermal exposure to Cr(VI)	µg/kg bw/d	0.489	0.181	7.63	Calculated

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

Using realistic inputs for tasks 2 and 3 (liquid), dermal exposure to Cr(VI) is estimated to 0.489 µg/kg bw/d (task 2) and 0.181 µg/kg bw/d (task 3). Several input parameters involve a subjective element (e.g. in the judgement, whether contact is rare or light). For a sensitivity analysis, these input values were set to worst case values (more than rare contact, more than light contact, significant amounts of aerosols or splashes), although these do not represent the situation in reality and are unrealistic, all the more if combined. Using these unrealistic input parameters, the exposure during task 2 (in mg product) is estimated to be 2050 mg, corresponding to an actual Cr(VI) exposure of 14.6 µg/kg bw/d (all input values and calculations for the realistic and the unrealistic input are shown in Annex 6). This estimate is about 30-times higher than the one obtained with realistic input parameters and is considered unrealistic not only due to the input values chosen, but also considering the fact that dermal exposure will be prevented due to the corrosive nature of SD and CT (see next paragraph).

With realistic input parameters for task 8 (solid) a dermal exposure of 7.63 µg Cr(VI)/kg bw/d is estimated. The higher estimated exposure in T8 results from the higher Cr(VI) concentration (i.e. pure SD/CT; the concentration applied reflects the fraction of Cr(VI) in SD). It must be noted that both SD and CT are classified for skin corrosion. As a consequence dermal exposure to any neat substance has to be prevented. The assumption of permeation of gloves by 5 % of the potential dermal dose is a purely hypothetical assumption, since dermal exposure has to be prevented due to local effects alone. The same is essentially true for other tasks, since SD concentrations ≥ 0.2 % require labelling as Skin Sens. 1 (H317) according to the CLP Regulation, implying that such low concentrations may be corrosive to the skin.

The following table shows a generic exposure assessment based on the upper end of range for dermal load as provided in the EU RAR, which was based on EASE for non-dispersive use with direct handling with incidental contact, which is similar to the ones relevant here.

Table 67. Modelled Exposure for Workers for all tasks based on a default dermal load of 0.1 mg/cm²/d (generic approach)

Parameter	Unit	T1 (hands)	T2 (hands)	T3 (hands)	T4 / T5 (hands)	T5 (body)	T6 (hands)	T8 (hands)	Rationale (Reference)
EU RAR modelling assumption (0-0.1 mg/cm ² /d)	mg/cm ² /d	0.1	0.1	0.1	0.1	0.1	0.1	0.1	Upper end of range (EU RAR (ECB, 2005)) from EASE for non-dispersive use with direct handling with incidental contact -> similar to the ones relevant here
Skin contact area	cm ²	480	480	480	480	8750	480	480	One side of both hands used as a conservative assumption; for T5 (body) one half of the body surface is assumed as a worst case, contact area from ECETOC TRA consumer module (ECETOC, 2009; 2012)

Parameter	Unit	T1 (hands)	T2 (hands)	T3 (hands)	T4 / T5 (hands)	T5 (body)	T6 (hands)	T8 (hands)	Rationale (Reference)
Dermal load	mg/d	48	48	48	48	875	48	48	Calculated
Body weight	kg	70	70	70	70	70	70	70	Body weight for workers (Guidance IR & CSA, R.8 (ECHA, 2012))
Potential dermal exposure to product	mg/kg bw/d	0.686	0.686	0.686	0.686	12.5	0.686	0.686	Calculated; identical to PROC 3 estimate (Batch manufacture of a chemical or formulation where the predominant handling is in a contained manner, e.g. through enclosed transfers, <u>but where some opportunity for contact with chemicals occurs, e.g. through sampling</u>); one hand face only assumed in ECETOC TRA
PPE efficiency (gloves, protective clothing or apron)	%	95	95	95	95	80	95	95	For hand exposure, see CSR; for T5 (body) a lower efficiency of 80% is assumed (HEEG Opinion 9)
Actual dermal exposure to product	mg/kg bw/d	0.0343	0.0343	0.0343	0.0343	2.50	0.0343	0.0343	Calculated
Cr(VI) concentration in product	%	32	1	0.37	1	1	1	40	See Table 28 (critical input parameters)
Actual dermal exposure to Cr(VI)	µg/kg bw/d	11.0	0.343	0.127	0.343	25.0	0.343	13.7	Calculated

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

With this generic approach the highest actual dermal Cr(VI) exposure was calculated for T5, which involves exposure of the body (25.0 µg/kg bw/d), followed by T1 (11.0 µg/kg bw/d) and T8 (13.7 µg/kg bw/d) due to higher Cr(VI) concentrations. As discussed above, such an exposure is unlikely to occur due to the corrosive effects of the substance (especially at higher concentrations in T1 and T8).

For T2, T3 and T8 the exposure estimated by the two different approaches agree well (within a factor of 2). Riskofderm modelling results in somewhat higher values for T2 and T3 (factor 1.4), while the generic approach results in somewhat higher values for T8 (factor 1.8).

In all cases, these values presented above are uncorrected for the lower frequency of these tasks. Therefore, the exposure estimates derived above were corrected with the frequency information given in Table 28. For this purpose, modelling results using both approaches (where possible) are given and frequency-corrected. Furthermore, hand and body exposure were combined for T5. The data in the following table indicate that body exposure is almost exclusively responsible for the high dermal exposure in T5.

Table 68. Exposure concentrations for workers (dermal exposure)

Task	Exposure (uncorrected)	Frequency (d/y)	Exposure (corrected)
T1 (generic modelling)	11.0 µg/kg bw/d	48	2.19 µg/kg bw/d
T2 (Riskofderm)	0.489 µg/kg bw/d	240	0.489 µg/kg bw/d
T2 (generic modelling)	0.343 µg/kg bw/d	240	0.343 µg/kg bw/d
T3 (Riskofderm)	0.181 µg/kg bw/d	240	0.181 µg/kg bw/d

Task	Exposure (uncorrected)	Frequency (d/y)	Exposure (corrected)
T3 (generic modelling)	0.127 µg/kg bw/d	240	0.127 µg/kg bw/d
T4 (generic modelling)	0.343 µg/kg bw/d	48	0.0686 µg/kg bw/d
T5 (generic modelling, hands)	0.343 µg/kg bw/d	240	0.343 µg/kg bw/d
T5 (generic modelling, body)	25.0 µg/kg bw/d	240	25.0 µg/kg bw/d
T5 (generic modelling, hand & body)	25.3 µg/kg bw/d	240	25.3 µg/kg bw/d
T6 (generic modelling)	0.343 µg/kg bw/d	48	0.0686 µg/kg bw/d
T8 (Riskofderm)	7.63 µg/kg bw/d	240	7.63 µg/kg bw/d
T8 (generic modelling)	13.7 µg/kg bw/d	240	13.7 µg/kg bw/d

Conclusion on risk characterisation:

Discussion and conclusions

In summary, modelled long-term dermal exposure to Cr(VI) was in good agreement when two different estimation approaches could be used. This increases the confidence obtained for the tasks where only one approach could be used due to applicability domain considerations. As discussed above, dermal exposure to neat SD (and even to solutions containing SD at relatively low concentrations) will need to be prevented due to the corrosive nature of the substance. Therefore, the dermal exposure estimates should be considered theoretical rather than reflecting true exposure levels.

9.2.2 Exposure and risks for workers

While the dermal exposure assessment presented above was performed to address reproductive toxicity, the risk assessment for reproductive toxicity should assess both dermal and inhalation exposure. The following table shows the frequency-corrected dermal exposure estimates (from Table 68; highest values per task chosen if two modelling results were available) and the inhalation exposure estimates (derived in detail in section 9.1), the RCR for both pathways of exposure separately as well as the combined RCR with respect to reproductive toxicity.

Table 69. Exposure concentrations and risks for workers

	Unit	T1	T2	T3	T4	T5	T6	T8
Dermal exposure	µg/kg bw/d	2.19	0.489	0.181	0.0686	25.3	0.0686	13.7
RCR, dermal		0.051	0.008	0.008	0.002	0.589	0.002	0.319
Inhalation exposure	ng/m ³	0.34	3.125	1.88	11.6	7	2.4	563
RCR, inhalation		0.00001	0.00007	0.00004	0.0003	0.00016	0.00006	0.01309
RCR, combined		0.0509	0.0114	0.00425	0.00187	0.589	0.00165	0.332
Contribution dermal		99.98%	99.10%	99.45%	85.84%	99.97%	96.69%	96.06%

The data demonstrate that dermal exposure is almost exclusively responsible for the combined RCR, i.e. more than 95 % (except task 4) of the combined RCR results from the dermal RCR. This finding is related to (a) the low inhalation exposure and (b) the conservative nature of dermal exposure modelling.

Conclusion on risk characterisation:

In summary, all combined RCRs are below 1 for all tasks and the two modelling options and the risk is therefore adequately controlled.

Aggregated exposure

In a conservative approach all tasks that could be performed over a working shift by the same worker have to be combined and the aggregated RCR calculated. Since at different sites different tasks may be performed by the

same operator, an aggregated RCR coming from all tasks was calculated (T1 –T6) as a worst case estimate for illustrative purposes. The aggregated RCR from tasks T1 to T6 is 0.66. Task 8 was excluded from the calculation of the aggregated RCR since it is not yet performed at any site. With the inclusion of T8, the aggregated RCR would be 0.99. This value is considered to be entirely hypothetical, since it is unrealistic that any worker will perform all tasks on a single day.. In case that this task should become relevant in the future, technical measures (e.g. automated systems, containment) will be considered to take care that even then a combined $RCR < 1$ will result for dermal exposure.

In summary, even the aggregated RCR is below 1 and the risk is therefore adequately controlled even under the assumed worst case conditions. It needs to be stressed again that the dermal exposure estimate is a theoretical figure since dermal exposure has to be prevented due to the corrosive properties of SD.

10. RISK CHARACTERISATION RELATED TO COMBINED EXPOSURE

10.1. Human health

10.1.1. Workers

Combined exposure of workers involved in different tasks at the site is covered by the aggregated exposure assessment and risk characterisation presented above in sections 9.1.12 (inhalation exposure) and 9.2 (dermal exposure).

10.1.2. Consumer

Exposure assessment and risk characterisation is not applicable as there are no consumer-related uses for the substance addressed in this CSR.

10.2. Environment (combined for all emission sources)

As sodium dichromate is not listed in REACH Annex XIV due to environmental effects, no environmental exposure assessment is performed here.

Man via environment

Exposure of humans via the environment and associated risks are discussed and presented in Section 9.1.1. above (local and regional scale).

10.2.1. All uses (regional scale)

Not relevant as no environmental assessment is performed.

10.2.2. Local exposure due to all wide dispersive uses

Not relevant as no environmental assessment is performed and there are no wide dispersive uses covered in this CSR.

10.2.3. Local exposure due to combined uses at a site

Not relevant as no environmental assessment is performed and there is only one use covered in this CSR.

Annex 1 Extract of GESTIS database

International limit values for chemical agents Occupational exposure limits (OELs)

Substance	Chromium(VI) compounds			
CAS No.	18540-29-9			
Remarks	as Cr			
	Limit value - Eight hours		Limit value - Short term	
	ppm	mg/m ³	ppm	mg/m ³
Australia		0,05		
Austria		0,05 inhalable aerosol		0,2 inhalable aerosol
Belgium		0,05		
Canada - Ontario		0,05		
Denmark		0,005		0,01
European Union		0,005 (1)		
		0,01 (1)(2)		
		0,025 (1)(3)		
Finland		0,05		
France		0,05		0,005
		0,001		
Germany (AGS)		0,001 (1)(2)		0,008 (1)(2)(3)
Hungary				0,05
Ireland		0,05 (1)		
Japan (MHLW)		0,05		
Japan (JSOH)		0,05		
		0,01 (1)		
New Zealand		0,01		
Romania		0,05		
Singapore		0,05 (water soluble)		
		0,01 (insoluble)		
South Korea		0,05 (water soluble)		
		0,01 (insoluble)		
Spain		0,05 (as Cr) insoluble compounds		
		0,01 (as Cr) soluble compounds		
Sweden		0,005 total aerosol		0,015 total aerosol (1)
Switzerland		0,005 (1)		
The Netherlands		0,025		0,05
USA - NIOSH		0,001 (1)		
USA - OSHA		0,005		
United Kingdom		0,05		
	Remarks			
Austria	TRK value (based on technical feasibility)			
Belgium	Soluble chromium VI compounds			
European Union	(1) Carcinogens defined as a substance which meets the criteria for classification as a category 1 or 2 carcinogen set out in Annex VI to Directive 67/548/EEC (2) Limit value until 17.01.25 (3) Limit value for welding or plasma cutting work or similar smoke-producing work procedures until 17.01.25 Bold-type: Binding Occupational Exposure Limit Value (BOELV) ~ (for references see bibliography)			
France	Bold type: Restrictive statutory limit values Restrictive statutory limit values will come into force on 1 July 2014			
Germany (AGS)	(1) Assessment scale, risk-based (see background document: Germany AGS) (2) Inhalable fraction (3) 15 minutes average value			
Ireland	(1) Water soluble			
Japan (JSOH)	(1) certain chromium(VI) compounds			
Sweden	(1) Short-term value, 15 minutes average value			
Switzerland	(1) Inhalable fraction			
The Netherlands	Applies for soluble compounds			
USA - NIOSH	(1) 10 hr TWA see also chromic acid			

Source: https://limitvalue.ifa.dguv.de/WebForm_ueliste2.aspx
(accessed: 19 September 2019)

Annex 2 Air monitoring data provided by the companies of the APEAL consortium (anonymised)

Note: Most sites provided 8 h time weighted average values whereas the monitoring data provided by Site C are based on air collections during 1.5 h.

Table 70. Stationary monitoring values Cr(VI), [$\mu\text{g Cr(VI)}/\text{m}^3$]

	WCS1	WCS2	WCS3	WCS4	WCS5	WCS6	WCS7	WCS8	WCS9	WCS10
Total number of values	27	48	22	4	0	3	0	0	56	17
Number of values below LoQ	23 (85.2%)	42 (87.5%)	19 (86.4%)	4 (100%)	-	3 (100%)	-	-	29 (51.8%)	17 (100%)
Sites	C, D, J	B, C, D, J	A, B, C, D, J	B	-	D, J	-	-	A, B, D, E, J	A, J
No per site										
1	0.75*	0.75*	0.05*	0.05*		0.0125*			31.1 [#]	0.05*
2	0.75*	0.75*	0.05*	0.05*		0.0125*			0.05*	0.05*
3	0.75*	0.75*	0.05*	0.05*		0.01*			0.05*	0.05*
4	0.75*	0.75*	0.05*	0.05*					0.05*	0.05*
5	0.75*	0.75*	0.05*						0.05*	0.03*
6	0.75*	0.75*	0.36						0.05*	0.01*
7	0.75*	0.75*	0.05*						0.05*	0.01*
8	0.75*	0.75*	0.05*						0.05*	0.01*
9	0.0125*	0.75*	0.40						1.50	0.01*
10	0.0125*	0.75*	0.30						11.80	0.01*
11	0.0125*	0.75*	0.05*						2.8	0.01*
12	0.0125*	0.75*	0.05*						0.05	0.01*
13	0.09	0.75*	0.75*						0.0125*	0.01*
14	0.26	0.75*	0.75*						0.0125*	0.01*
15	0.08	0.75*	0.75*						0.0125*	0.01*
16	0.03*	0.75*	0.75*						0.0125*	0.01*
17	0.03*	0.75*	0.0125*						0.0125*	0.01*
18	0.63	0.75*	0.0125*						0.0125*	

	WCS1	WCS2	WCS3	WCS4	WCS5	WCS6	WCS7	WCS8	WCS9	WCS10
19	0.01*	0.75*	0.0125*						0.0125*	
20	0.03*	0.75*	0.03*						0.0125*	
21	0.01*	0.05*	0.03*						0.0125*	
22	0.01*	0.05*	0.06*						0.0125*	
23	0.03*	0.05*							0.0125*	
24	0.03*	0.05*							0.0125*	
25	0.03*	0.0125*							0.0125*	
26	0.03*	0.0125*							0.0125*	
27	0.03*	0.0125*							0.0125*	
28		0.0125*							0.0125*	
29		0.0125*							0.0125*	
30		0.0125*							0.0125*	
31		0.0125*							0.0125*	
32		0.0125*							0.0125*	
33		0.0125*							0.0125*	
34		0.03*							0.04	
35		0.03*							0.02	
36		0.26							0.022	
37		0.14							3.42	
38		0.03*							52.43	
39		0.07							1.27	
40		0.03*							19.64	
41		0.87							0.49	
42		0.74							0.02	
43		0.18							2.52	
44		0.03*							0.042	
45		0.03*							0.79	
46		0.03*							0.007	
47		0.03*							0.06	
48		0.03*							0.83	
49									0.11	
50									3.53	
51									0.12	
52									0.35	
53									1.18	
54									0.09	

	WCS1	WCS2	WCS3	WCS4	WCS5	WCS6	WCS7	WCS8	WCS9	WCS10
55									0.12	
56									0.01*	
Range	<LoQ - 0.63	<LoQ - 0.87	<LoQ - 0.40	<LoQ	-	<LoQ	-	-	<LoQ – 52.43	<LoQ
Arithmetic mean	0.27	0.37	0.21	0.05	-	0.011	-	-	2.41	0.02
Median (all values)	0.03	0.16	0.05	0.05	-	0.125	-	-	0.05	0.01
90th P (all values)	0.75	0.75	0.75	0.05	-	0.125	-	-	3.11 (75th Percentile: 0.38)	0.05
Median (not regarding values with highest LoQ of 1.5 µg/m ³)	0.03	0.03	0.05							
90th P (not regarding values with highest LoQ of 1.5 µg/m ³)	0.12	0.20	0.32							
Arithmetic mean P (not regarding values with highest LoQ of 1.5 µg/m ³)	0.07	0.10	0.09							

*value below LoQ, numerical value provided = LoQ/2

#: outlier, due to accidental strip break and non-correct placement of sealing hatches

Table 71. Personal monitoring values Cr(VI), [$\mu\text{g Cr(VI)/m}^3$]

	WCS1	WCS2	WCS3	WCS4**	WCS5	WCS6	WCS7	WCS8	WCS9	WCS10
Total number of values	22	26	8	9	17	2	5	0	88	19
Number of values below LoQ	22 (100%)	22 (84.6%)	6 (75%)	6 (66.7%)	8 (47%)	2 (100%)	3 (60%)	.	60 (75%)	19 (100%)
Sites	A, D, F, J	A, C, D, E, F, J	A, E, F, J	A, C, E, F, G	A, E, F, G, J	J	E, F	.	A, C, D, E, G	C, J
No per site										
1	0.06*	0.06*	0.06*	0.06*	0.06*	0.03*	0.39		0.06*	0.75*
2	0.06*	0.06*	0.07*	0.06*	0.06*	0.03*	0.21		0.06*	0.75*
3	0.0125*	0.75*	0.054	0.75*	0.17		0.05*		0.75*	0.75*
4	0.0125*	0.75*	0.71	0.17	0.05*		0.05*		0.75*	0.75*
5	0.0125*	0.0125*	0.05*	2.8	0.05*		0.05*		0.75*	0.75*
6	0.0125*	0.0125*	0.05*	0.05*	0.05*				0.75*	0.75*
7	0.05*	0.0125*	0.05*	0.05*	0.0075*				0.75*	0.75*
8	0.05*	0.066	0.03*	0.05*	0.0070*				0.75*	0.03*
9	0.05*	0.39		0.006	0.0075*				0.75*	0.03*
10	0.03*	0.17			0.06				0.75*	0.03*
11	0.03*	7.55			0.12				0.75*	0.03*
12	0.03*	0.05*			0.01				0.75*	0.03*
13	0.03*	0.05*			0.006				0.75*	0.03*
14	0.03*	0.05*			0.03				0.75*	0.03*
15	0.03*	0.03*			0.07				0.75*	0.03*
16	0.03*	0.03*			0.29				0.75*	0.03*
17	0.03*	0.03*			0.12				0.75*	0.03*
18	0.03*	0.03*							0.75*	0.03*
19	0.03*	0.03*							0.75*	0.03*
20	0.03*	0.03*							0.75*	
21	0.03*	0.03*							0.75*	
22	0.03*	0.03*							0.75*	
23		0.03*							0.75*	
24		0.03*							0.75*	
25		0.03*							0.75*	
26		0.03*							0.75*	

	WCS1	WCS2	WCS3	WCS4**	WCS5	WCS6	WCS7	WCS8	WCS9	WCS10
27									0.75*	
28									0.75*	
29									0.75*	
30									0.75*	
31									0.75*	
32									0.75*	
33									0.75*	
34									0.75*	
35									0.75*	
36									0.75*	
37									0.75*	
38									0.75*	
39									0.75*	
40									0.75*	
41									0.75*	
42									0.75*	
43									0.75*	
44									0.75*	
45									0.75*	
46									0.75*	
47									0.75*	
48									0.75*	
49									0.75*	
50									0.75*	
51									0.75*	
52									0.75*	
53									0.75*	
54									0.75*	
55									0.0125*	
56									0.0125*	
57									0.0125*	
58									0.0125*	
59									0.0125*	
60									0.0125*	
61									0.16	
62									0.05	

	WCS1	WCS2	WCS3	WCS4**	WCS5	WCS6	WCS7	WCS8	WCS9	WCS10
63									0.07	
64									0.35	
65									0.14	
66									0.13	
67									0.12	
68									0.05	
69									0.05	
70									0.07	
71									0.51	
72									0.04	
73									0.11	
74									0.22	
75									0.11	
76									0.06	
77									0.02	
78									0.09	
79									0.12	
80									0.218	
81									0.219	
82									0.133	
83									0.22	
84									0.12	
85									0.17	
86									0.040	
87									0.090	
88									0.240	
Range	< LoQ	<LoQ – 7.55	<LoQ – 0.71	<LoQ – 2. 8	<LoQ – 0.29	-	<LoQ – 0.39	-	<LoQ – 0.51	<LoQ
Arithmetic mean	0.032	0.40	0.13	0.44	0.069	-	0.15	-	0.49	0.29
Median (all values)	0.03	0.03	0.05	0.06	0.05	-	0.05	-	0.75	0.03
90th P (all values)	0.05	0.57	0.26	1.16	0.14	-	0.32	-	0.75	0.75
Median (not regarding values with		0.03							0.09 [#]	0.03

	WCS1	WCS2	WCS3	WCS4**	WCS5	WCS6	WCS7	WCS8	WCS9	WCS10
highest LoQ of 1.5 µg/m ³)										
90 th P (not regarding values with highest LoQ of 1.5 µg/m ³)		0.14							0.22	0.03

*value below LoQ, numerical value provided = LoQ/2

** values submitted by one site which were obtained during monitoring activities of a non-ETP process, which uses higher Cr(VI) concentrations, were not regarded

#AM if values with highest LoQ of 1.5 µg/m³ are not regarded: 0.11

Table 72. Stationary monitoring values total chromium, [µg total Cr/m³]

	WCS1	WCS2	WCS3	WCS4	WCS5	WCS6	WCS7	WCS8	WCS9	WCS10
Total number of values	0	1	1	0	0	0	0	0	0	21
Number of values below LoQ	-	0	0	-	-	-	-	-	-	17 (81%)
Sites	-	I	I	-	-	-	-	-	-	B
No per site										
1		0.7	2.2							0.50*
2										0.50*
3										0.50*
4										0.50*
5										0.50*
6										0.50*
7										0.50*
8										0.50*
9										0.50*
10										0.50*
11										0.50*
12										0.50*
13										0.50*
14										0.50*
15										0.50*

	WCS1	WCS2	WCS3	WCS4	WCS5	WCS6	WCS7	WCS8	WCS9	WCS10
16										0.50*
17										0.50*
18										2.0
19										2.0
20										1.0
21										1.0
Range	-	-	-	-	-	-	-	-	-	<LoQ-2.0
Arithmetic mean	-	-	-	-	-	-	-	-	-	0.69
Median (all values)	-	-	-	-	-	-	-	-	-	0.50
90th P (all values)	-	-	-	-	-	-	-	-	-	1.0

Table 73. Personal monitoring values total chromium, [$\mu\text{g total Cr/m}^3$]

	WCS1	WCS2	WCS3	WCS4	WCS5	WCS6	WCS7	WCS8	WCS9	WCS10
Total number of values	0	0	0	24	6	3	0	0	0	0
Number of values below LoQ	-	-	-	24 (100%)	6 (100%)	3 (100%)	-	-	-	-
Sites	-	-	-	B [#]	B [#]	F	-	-	-	-
No per site										
1				2.5*	2.5*	0.05*				
2				2.5*	2.5*	0.05*				
3				2.5*	0.5*	0.05*				
4				2.5*	0.5*					
5				2.5*	0.5*					
6				2.5*	0.5*					
7				2.5*						
8				2.5*						
9				0.5*						
10				0.5*						
11				0.5*						

	WCS1	WCS2	WCS3	WCS4	WCS5	WCS6	WCS7	WCS8	WCS9	WCS10
12				0.5*						
13				0.5*						
14				0.5*						
15				0.5*						
16				0.5*						
17				0.5*						
18				0.5*						
19				0.5*						
20				0.5*						
21				0.5*						
22				0.5*						
23				0.5*						
24				0.5*						
Range	-	-	-	<LoQ	<LoQ	<LoQ	-	-	-	-
Arithmetic mean	-	-	-	1.17	1.17	0.05	-	-	-	-
Median (all values)	-	-	-	0.5	0.5	0.05	-	-	-	-
90th P (all values)	-	-	-	2.5	2.5	0.05	-	-	-	-

monitoring values from differnt years with different LoQ

*value below LoQ, numerical value provided = LoQ/2

Annex 3 Site specific data for this applicant – Trostre (Site [REDACTED]) and IJmuiden (Site [REDACTED])

Annex 3a Monitoring data (Trostre)

Personal monitoring values

The following table shows an overview of **personal monitoring values** measured during two monitoring campaigns in 2014 and one campaign in 2017. Total chromium was measured for the operators on 2 consecutive days. Sampling time was in the range of 350-385 minutes. All personal monitoring values were below the limit of quantification (LoQ), with different LoQs feasible in 2014 (LoQ = 1 µg total chromium/m³) and 2016 (LoQ = 5 µg total chromium/m³). No information on the share of Cr(VI) on total chromium is available.

Operator	Total chromium [µg/m ³]					
	2014		2014		2016	
Team leader						
Team leader						
Exit end inspector						
Exit end inspector						
Annode attendant						
Annode attendant						
Entry end operator						
Entry end operator						

*all values were below the limit of quantification of 1 or 5 µg/m³.

Stationary monitoring values

Annual **stationary monitoring** for Cr(VI) exposure was performed to check if the workplace exposures are in concordance with the legal requirements for workplace exposure limits. Pumps were located at four different places close to the passivation section of the ETP line:

- Above the passivation section,
- At the front of the passivation section,
- At the rear of the passivation section,
- In the cellar of the passivation section

Air sampling was performed for at least 6 hours (420 min). But, even longer sampling durations up to 11.7 hours (644 min) are available which cover nearly a whole shift, which lasts 12 h at this site. Monitoring values are available from the years 2014 (measurements on two different days during a monitoring campaign in May, measurements from single days in March and April), 2016, 2017 and 2018 with measurements on two different days. In former years (2014 and 2016) measurements with a higher limit of quantification (1 µg/m³) were performed. In 2017 and 2018 a lower LoQ of 0.1 µg/m³ was realisable. These monitoring values from 2017 and 2018, which represent the most recent data and which are regarded as representative for the current situation were used for the common data pool of all sites of the APEAL member companies.

Monitoring place	Cr(VI) [µg/m ³]					
	2014		2014		2016	2017**
Above passivation section						
Above passivation section						
Front of passivation section						
Front of passivation section						
Rear of passivation section						
Rear of passivation section						
Cellar of passivation section						

Cellar of passivation section

*below LoQ; ** used for the common data pool of all sites

Stationary monitoring values (time weighted 24 hour values) have been recorded on a nearly daily basis in 2017 and 2018 for total chromium concentrations with pumps located beside the plating tanks. A total of 638 monitoring values is available (n=137 below LoD of $1 \mu\text{g}/\text{m}^3$) with a median of $\mu\text{g}/\text{m}^3$ and a 90th percentile of $\mu\text{g}/\text{m}^3$. No information on Cr(VI) content for these measurements is available.

Additionally, twenty-one stationary monitoring data for total chromium concentrations in the control room (air sampling for 24 hours, ICP analysis) measured in April and May 2018 are available and are documented in the table below. However, no information on the share of Cr(VI) on total chromium is available.

Monitoring place: Control room Date of measurement	Total chromium [$\mu\text{g}/\text{m}^3$]
15 April 2019	
16 April 2019	
17 April 2019	
18 April 2019	
19 April 2019	
20 April 2019	
21 April 2019	
22 April 2019	
23 April 2019	
24 April 2019	
25 April 2019	
26 April 2019	
27 April 2019	
28 April 2019	
29 April 2019	
30 April 2019	
1 May 2019	
2 May 2019	
3 May 2019	
4 May 2019	
5 May 2019	

*below LoQ of $1 \mu\text{g}/\text{m}^3$

Overall, the personal monitoring data lack information on Cr(VI) exposure, as no information on the share of Cr(VI) on total chromium is available and as only relatively high LoQs were achieved in these measurements which were performed to check if the workplace exposure limits in the $\mu\text{g}/\text{m}^3$ range were exceeded. Future measurements will focus on personal monitoring of Cr(VI) with a lower LoQ to analyse the real exposure during electro-tin plating. Stationary monitoring data from 2017 and 2018 indicate that exposure is mainly below $0.1 \mu\text{g Cr(VI)}/\text{m}^3$ with occasional exceedances of this value, especially directly above the passivation section. However, these values measured above the passivation section do not represent worker exposure as respiratory protection is used in case of any activities at this place. Overall, specific working instructions are in place to guarantee a safe handling for activities related to the handling of Cr(VI) containing solutions (see below).

Methodology

Stationary monitoring was performed according to the HSE Methods for the Determination of Hazardous Substances MSDS 52/4 – Hexavalent chromium in chromium plating mists. A measured volume of air is drawn through a membrane filter mounted in an inhalable sampler. The filter (sodium-hydroxide-treated polyvinylidene fluoride membrane filters) is then desorbed with dilute sulphuric acid and the soluble Cr(VI) compounds are derivatised by the addition of 1,5-diphenylcarbazide solution. After colour development, quantification is carried out using a spectrophotometer at 540 nm or semi-quantitatively using a colour comparator.

Total chromium analysis in the stationary monitoring samples collected in the control room was performed by Inductively Coupled Plasma (ICP) technique.

For personal monitoring in principle the same method was applied as for stationary monitoring, however analysis of total chromium was performed by Inductively Coupled Plasma (ICP) technique.

Annex 3b Monitoring data (IJmuiden)

Personal monitoring values

The following table shows an overview of **personal monitoring values** measured during a monitoring campaign in 2017. Total chromium was measured for the operators on 4 consecutive days. Additionally, chromium (VI) was analysed in parallel on 6 days of the campaign for individual operators (marked in yellow in the table below). All monitoring values for Cr(VI) were below the limit of quantification (0.1 µg) and LoQ/2 was used for the calculation of the air concentration. The amount of Cr(VI) is about 10% (mean value; range: ca. 6-16%) of total chromium. The monitoring results for total chromium are in very good agreement with measurements from monitoring campaigns performed in previous years. However, as in previous years no Cr(VI) was measured, the older values for total chromium were not used for the statistical evaluation of the monitoring data from all sites.

Operator	Total chromium [µg/m ³]				chromium (VI) [µg/m ³]*
	30 Oct 2017	31 Oct 2017	1 Nov 2017	2 Nov 2017	
Operator A / B EV 11					
Operator A / B EV 12					
Operator A / B EV 13					
EV11 / 12 anode controller					
EV13 anode controller					
Regenerant EV 11/12/13					
Operator EV 14					
Regenerant EV 14					

*all values were below the limit of quantification of 0.1 µg/m³ and LoQ/2 was used for the calculation of the air concentration; measurements for Cr(VI) were included in the statistical evaluation of the monitoring data from all sites.

Stationary monitoring values

The following table shows an overview of **stationary monitoring values** measured during monitoring campaigns in 2017, 2018 and 2019 performed at different places along the ETP line and the control rooms. The 2017 monitoring campaign covered all 4 lines of the site (EV11, EV12, EV13 and EV14). In 2017 nineteen measurements for total chromium covering different places along the lines or the control rooms of the lines were performed. For four of measurements additionally Cr(VI) was analysed. Four measurements revealed unexpected high values of >1 µg/m³ in 2017, especially high values were observed in the after treatment sections (circulation tank, basement) of lines EV11 and EV12 (35.28 µg/m³ and 4.63 µg/m³, respectively). After implementing technical improvements (installation of a ventilation system at these two after treatment sections) new measurements for total chromium and Cr(VI) were performed in 2018 for the places with the high values in the 2017 campaign and an additional measurement in an office was performed. Total chromium measurements were performed due to the legal requirements for workplace monitoring. To reveal more information on Cr(VI) exposure which is relevant in the context of this AfA in 2019 new measurements were performed covering the places along the line already included in the 2017 monitoring campaign. In 2019 all except two values were below the LoQ (0.1 µg Cr(VI)/m³). Only for two measurements higher values were reported. Especially, the high value of 31.1 µg/m³ measured in the post treatment section of line EV11 is not regarded to be representative for routine at this place and should be regarded as an outlier, as a strip break was experienced in this place on the day before the measurement and the sealing hatches were obviously not closed appropriately after the repair. However, this value also indicates that during unscheduled maintenance activities higher Cr(VI) exposure concentrations might occur which underpins the necessity of wearing respiratory protection equipment during maintenance in the Cr(VI) sections. Chromium (VI) monitoring values obtained in 2019 were included in the statistical evaluation of the monitoring data from all sites.

Overall, the personal and stationary monitoring values for IJmuiden reveal that during a normal workday Cr(VI) exposure is rather low (in the range of 0.05-0.06 µg/m³). This exposure height is obviously determined by the limit of quantification of the analytical method so that it remains speculative how low the real exposure is. However, higher exposure concentrations could be reached in case of e.g. disturbances of the routine workflow. But these exposure concentrations are accidental and in no way representative for normal exposure. Effective operational instructions are in place to guarantee a safe handling also for such emergency cases.

Monitoring place	2017		2018		2019
	Total chromium	Cr(VI)	Total chromium	Cr(VI)	Cr(VI)
	$\mu\text{g}/\text{m}^3$		$\mu\text{g}/\text{m}^3$		$\mu\text{g}/\text{m}^3$
EV11, after-treatment section 1st stage					
EV11, after-treatment section, circulation tank, basement					
EV12, after-treatment section 1st stage					
EV12, after-treatment section, circulation tank, basement					
Management office					
EV12, control room					
EV13, after-treatment section ground floor roll position 2835					
EV13, after-treatment section, circulation tank, basement					
EV13, control room					
EV14, work floor 2nd floor					
EV14, after-treatment section, 1st floor					
EV14, circulation tank pump cellar					
EV14, ETP neutralization coarse					
EV14, ETP chrome reduction tank					
EV14, control room					
AWZ, Phase 1 raw water container					
AWZ, Phase 2 chrome reduction tank					
AWZ, Q cellar next to container 28					
AWZ, Q-basement room with 300 cubic meters					
AWZ, Phase 1A					

*below LoQ

Methodology

The personal and stationary air measurements were performed with pre-calibrated, portable personal air sampling (PAS) pumps, coupled to IOM sampling heads. During the working day, the pumps suck air at a flow rate of 2.0 liters per minute through the sampling heads with filter. The sampling heads were placed in the breathing zone of the employees during the 8-hour working day (one shift). In addition, pumps with sampling heads have been placed at the predetermined stationary measuring points.

Two different types of filters were used in the IOM sampling head. A 25 mm MCE filter for the analysis of total chromium and a 25 mm PVC filter for the analysis of chromium VI.

The analysis on total chromium was carried out by the ANA Laboratory of Tata Steel with the accredited analysis method ICP-AES (Inductively Coupled Plasma-Atomic Emission Spectrometry with a detection limit of 0.1 μg / filter.

The accredited analysis of chromium VI (spectrometry, equivalent to NIOSH 7600) was carried out by RPS Analyze BV (accredited in accordance with NEN-EN-ISO / IEC 17025). A detection limit of 0.1 μg / filter also applies to this analysis.

Annex 3c Worker Instructions (Trostre)

A number of working instructions are in place related to operational conditions and the use of PPE to ensure a safe handling of Cr(VI)

AFAR-8CYFW2	Changing HDR with overhead crane ETL 5
AJBN-6BSGM6	Changing a Marker Wick Board ETL5
GDIN-8M3FSP	Starting Chem. Treat rinses and final sprays
GDIN-8MCEDS	Cleaning strip marker circ. tank feed pump filters
GDIN-8MKDNZ	CHEM. TREAT KT09 - Circulating Chem. treat solution
GDIN-8MKELY	CHEM. TREAT KT03 - Selecting marker units (Top + Bottom)
AJBN-6BTA45	Changing Marker Rings
AJBN-6BTA9P	Cleaning Top And Bottom Marker Units Filters
GDIN-8HKDB3	De-sludging Q/Tank Line Tank
GDIN-8MBABH	CHEM TREAT KT06 - Dumping Chemical Treatment Solution from Circ. tank
GDIN-8MCH27	CHEM TREAT KT04 - Changing marker rolls
GDIN-8PGAS8	Changing Chem Treat or Dragout wringer rolls
GWAS-7M6J73	Removing Guarding - top level of Chem. Treat
GWAS-7M7JGC	Cleaning Chem. Treat final sprays plenty filters
GWAS-7M8F4W	Removal of Chem. treat fume exhaust hoods
GWAS-7M8GDZ	Removing Chem. Treat by pass roll
GWAS-7MEJLE	CHEM. TREAT KT07 Cleaning Quench tank spray nozzles ETL5
GWAS-7MKCHM	CHEM TREAT KT16 Removing dents - Chemical treatment squeegee rolls
GWAS-7MKERX	CHEM TREAT KT05 Roll surface Inspection or Removing dent / scrap from Chem.
treat Rinse sink roll	
GWAS-7MUAWF	Threading Chem. Treat sprays
AJBN-6BSDVG	Automatic Hold-Down Roll Control
AJBN-6BSDWG	Manual Control Of Hold-Down-Rolls
GWAS-7M7KD3	Make up and Transfer Chrome Free Marker Solution
GDIN-8LEHF8	Changing a Conductor/carrier roll
GWAS-7P8BWG	Housekeeping - Area 3 (Coating department)
AJBN-6PUBY6	Threading the Pre-Plating & Plating section of the line
PGDS-6W6LDL	Comah Safety Related Equipment -Coatings
AFAN-7SPK38	Transferring Chromic Acid and Sodium Dichromate to Effluent Treatment Plant
BOLN-6BMEAL	Sodium Dichromate Delivery
AEML-4AEJF7	Chemical Storage Tanks, Bunds and Pipework Inspections
JBAT-3RTLTLU	Environmental Training and Awareness
AFAN-6SGC8Q	Procedure for the Use and Collection of Barreled Waste
AFAN-7JJFB6	Waste Disposal, Duty of Care
JBAT-4B4BGU	Waste Disposal Contractor Audit Procedure
EWRS-46VJZZ	Process Team Member Duties
MEDS-8LAK73	ETL 5 Process Parameters
GLAN-8W2JB3	Layered Process Audit Roles and Responsibilities
MMAG-4UZHRM	Standard Solution Control and Traceability

Annex 3d Worker Instructions (IJmuiden)

A number of working instructions are in place related to operational conditions and the use of PPE to ensure a safe handling of Cr(VI)

EV11 SWI	Rinse bichromate conductivity measurement
EV11-EV12	Change wringer roll treatment section
SWI Wg4 & 5	Use of chromium cleaner
SWI Wg4 & 5	Repair of pumps contaminated with chromates
SWI Wg4 & 5	Clearance of rolls contaminated with chromates
SWI Wg4 & 5	How to work with sodium dichromate and chromium trioxide
SWI Wg4 & 5	Use of portable douche cabin
SWI Wg4 & 5	Use of shoecover dispenser
Control plan	Overview of all chromate related process parameter

Annex 4 Photo documentation

A video has been submitted with this AfA to illustrate the routine work at an ETP line. This Annex contains photos to illustrate specific tasks.

The photos are CONFIDENTIAL (CBI).

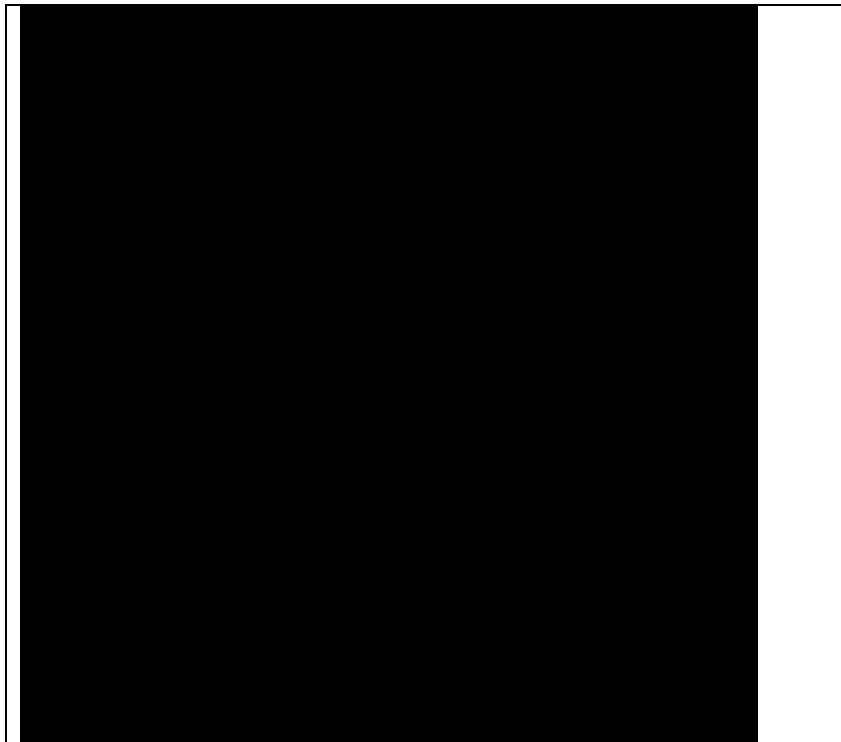


Figure A4-1: T1-Changing IBC containers: connecting-disconnecting container



Figure A4-2: T4-Maintenance: cleaning rolls during shut down

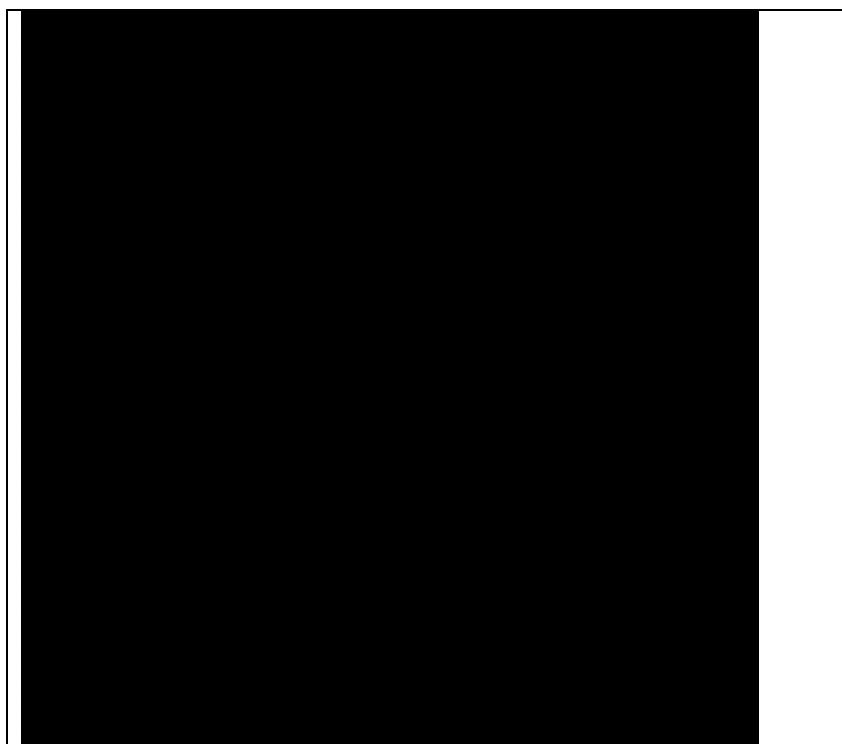


Figure A4-3: T5-Cleaning with a water hose



Figure A4-4: T6- Filter Press/Sludge removal from passivation tank: manual exchange of filters



Figure A4-5: T7 - Drums with solid CT – not used at this site



Figure A4-6: **T7-Addition of solid CT – not used at this site**

Annex 5 ART modelling input and results

Note: “Cr” in the following ART reports refers to Cr(VI)

ART REPORT – APEAL_CrVI_Task1_Connecting IBC

Connecting IBC

Chemical details

Chemical chromium(VI)oxide
CAS No. 1333-82-0

Scenario details

Number of activities 1
Total duration (mins) 480
Nonexposure period (mins) 0

Metadata

ART version 1.5

Details for Activity Changing IBC

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

Near-field exposure

Operational Conditions

Substance emission potential

Substance product type Powders dissolved in a liquid or incorporated in a liquid matrix
Liquid matrix weight fraction 0.32
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 Large workrooms only

Risk Management Measures

Localised controls

Primary No localized controls (0.00 % reduction)
Secondary No localized controls (0.00 % reduction)

Dispersion

Ventilation rate 3 air changes per hour (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 75th percentile full-shift exposure is 0.0005 mg/m³.

The inter-quartile confidence interval is 0.00023 mg/m³ to 0.0011 mg/m³.

ART REPORT – T2: APEAL Sampling passivation bath

Sampling (0.25 %SD; 0.1%Cr)

Chemical details	
Chemical	Sodium dichromate
CAS No.	10588-01-9
Scenario details	
Number of activities	1
Total duration (mins)	480
Nonexposure period (mins)	0
Metadata	
ART version	1.5

Details for Activity (Tank Sampling)

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

Near-field exposure

Operational Conditions

Substance emission potential	
Substance product type	Powders dissolved in a liquid or incorporated in a liquid matrix
Liquid matrix weight fraction	0.01
Viscosity	Low
Activity emission potential	
Activity class	Falling liquids
Situation	Transfer of liquid product with flow of 0.1 - 1 l/minute
Containment level	Handling that reduces contact between product and adjacent air. Note: This does not include processes that are fully contained by localised controls (see next questions).
Loading type	Submerged loading, where the liquid dispenser remains below the fluid level reducing the amount of aerosol formation
Surface contamination	
Process fully enclosed?	No
Effective housekeeping practices in place?	Yes
Dispersion	
Work area	Indoors
Room size	Large workrooms only
Risk Management Measures	
Localised controls	
Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)
Dispersion	
Ventilation rate	3 air changes per hour (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 75th percentile full-shift exposure is 0.000047 mg/m³.

The inter-quartile confidence interval is 0.000022 mg/m³ to 0.0001 mg/m³.

ART REPORT – T3: APEAL Sampling waste water

Sampling (0.0037%Cr(VI))

Chemical details

Chemical	Sodium dichromate
CAS No.	10588-01-9

Scenario details

Number of activities	1
Total duration (mins)	480
Nonexposure period (mins)	0

Metadata

ART version	1.5
-------------	-----

Details for Activity (Tank Sampling)

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

Near-field exposure

Operational Conditions

Substance emission potential

Substance product type	Powders dissolved in a liquid or incorporated in a liquid matrix
Liquid matrix weight fraction	0.0037
Viscosity	Low

Activity emission potential

Activity class	Falling liquids
Situation	Transfer of liquid product with flow of 0.1 - 1 l/minute
Containment level	Handling that reduces contact between product and adjacent air. Note: This does not include processes that are fully contained by localised controls (see next questions).
Loading type	Submerged loading, where the liquid dispenser remains below the fluid level reducing the amount of aerosol formation

Surface contamination

Process fully enclosed?	No
Effective housekeeping practices in place?	Yes

Dispersion

Work area	Indoors
Room size	100 m ³

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)

Dispersion

Ventilation rate	3 air changes per hour (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 75th percentile full-shift exposure is 0.000028 mg/m³.

The inter-quartile confidence interval is 0.000013 mg/m³ to 0.00006 mg/m³.

ART REPORT – T4: APEAL maintenance – Near field

Chemical details

Chemical	Sodium dichromate
CAS No.	10588-01-9

Scenario details

Number of activities	1
Total duration (mins)	480
Nonexposure period (mins)	0

Metadata

ART version	1.5
-------------	-----

Details for Activity (Maintenance)

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

Near-field exposure

Operational Conditions

Substance emission potential

Substance product type	Powders dissolved in a liquid or incorporated in a liquid matrix
Liquid matrix weight fraction	0.01
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	Large workrooms only

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)

Dispersion

Ventilation rate	3 air changes per hour (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 75th percentile full-shift exposure is 0.000047 mg/m³.

The inter-quartile confidence interval is 0.000022 mg/m³ to 0.0001 mg/m³.

ART REPORT – T4: APEAL maintenance – Far field

Maintenance (2.5% SD; 1%Cr(VI))

Chemical details

Chemical	Sodium dichromate
CAS No.	10588-01-9

Scenario details

Number of activities	1
Total duration (mins)	480
Nonexposure period (mins)	0

Metadata

ART version	1.5
-------------	-----

Details for Activity (Maintenance)

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

Far-field exposure**Operational Conditions****Substance emission potential**

Substance product type	Powders dissolved in a liquid or incorporated in a liquid matrix
Liquid matrix weight fraction	0.01
Viscosity	Low

Activity emission potential

Activity class	Handling of contaminated objects
Situation	Activities with treated/contaminated objects (surface 0.3-1 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	Large workrooms only

Risk Management Measures**Localised controls**

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)
Segregation	No segregation (0.00 % reduction)
Personal enclosure	No personal enclosure (0.00 % reduction)

Dispersion

Ventilation rate	0.3 air changes per hour (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 75th percentile full-shift exposure is 0.000021 mg/m³.

The inter-quartile confidence interval is 0.00001 mg/m³ to 0.000046 mg/m³.

Use conditions A:

ART REPORT – T6: APEAL Filter Press/sludge removal

Filter press/sludge removal (5%Cr(VI))

Chemical details

Chemical	Sodium dichromate
CAS No.	10588-01-9

Scenario details

Number of activities	1
Total duration (mins)	480
Nonexposure period (mins)	0

Metadata

ART version	1.5
-------------	-----

Details for Activity (Filter Press/Sludge removal)

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

Near-field exposure

Operational Conditions

Substance emission potential

Substance product type	Paste, slurry or clearly (soaked) wet powder
Contaminated with powder	No

Activity emission potential

Activity class	Handling of contaminated solid objects or paste
Situation	Handling of substantially and visibly contaminated objects (layers of more than 0.5 kg).
Handling type	Handling that departs from regular work procedures and involves large amounts of energy (e.g. rough handling or throwing of bags)

Surface contamination

Process fully enclosed?	No
Effective housekeeping practices in place?	Yes

Dispersion

Work area	Indoors
Room size	100 m ³

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)

Dispersion

Ventilation rate	3 air changes per hour (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 75th percentile full-shift exposure is 0 mg/m³.

The inter-quartile confidence interval is 0 mg/m³ to 0 mg/m³.

Use conditions B:

ART REPORT – T6: APEAL Filter Press/sludge removal

Filter press/sludge removal (5%Cr(VI))

Chemical details	
Chemical	Sodium dichromate
CAS No.	10588-01-9
Scenario details	
Number of activities	1
Total duration (mins)	480
Nonexposure period (mins)	0
Metadata	
ART version	1.5
Details for Activity (Filter Press/Sludge removal)	
Emission sources:	Near field  Far field
Duration (mins):	480
Near-field exposure	
Operational Conditions	
Substance emission potential	
Substance product type	Paste, slurry or clearly (soaked) wet powder
Contaminated with powder	Yes
Dustiness	
Powder weight fraction	0.05
Activity emission potential	
Activity class	Handling of contaminated solid objects or paste
Situation	Handling of objects with limited residual dust (thin layer visible)
Handling type	Normal handling, involves regular work procedures.
Surface contamination	
Process fully enclosed?	No
Effective housekeeping practices in place?	Yes
Dispersion	
Work area	Indoors
Room size	Small workrooms only
Risk Management Measures	
Localised controls	
Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)
Dispersion	
Ventilation rate	3 air changes per hour (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 75th percentile full-shift exposure is 0.004 mg/m ³ .	
The inter-quartile confidence interval is 0.0021 mg/m ³ to 0.0076 mg/m ³ .	

ART REPORT – T7:APEAL Addition of solid CTDecanting of a solid (2000 g CrO₃; 1040 g Cr)**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

Details for Activity (Decanting of a solid)

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

Near-field exposure**Operational Conditions****Substance emission potential**

Substance product type	Powders, granules or pelletised material
Dustiness	Granules, flakes or pellets
Moisture content	Dry product (< 5 % moisture content)
Powder weight fraction	Pure material

Activity emission potential

Activity class	Falling powders
Situation	Transferring 1 – 10 kg/minute
Handling type	Careful transfer involves workers showing attention to potential danger, error or harm and carrying out the activity in a very exact and thorough (or cautious) manner.
Drop height	Drop height < 0.5 m
Containment level	Handling that reduces contact between product and adjacent air. Note: This does not include processes that are fully contained by localised controls (see next questions).

Surface contamination

Process fully enclosed?	No
Effective housekeeping practices in place?	Yes

Dispersion

Work area	Indoors
Room size	3000 m ³

Risk Management Measures**Localised controls**

Primary	Other LEV systems (50.00 % reduction)
Secondary	No localized controls (0.00 % reduction)

Dispersion

Ventilation rate	3 air changes per hour (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 75th percentile full-shift exposure is 0.04 mg/m³.

The inter-quartile confidence interval is 0.021 mg/m³ to 0.077 mg/m³.

ART REPORT – T8: APEAL Dissolution of solid CT /SDDecanting of a solid (100000 g Na₂Cr₂O₇; 40000 g Cr)**Chemical details**

Chemical	Sodium dichromate
CAS No.	10588-01-9

Scenario details

Number of activities	1
Total duration (mins)	480
Nonexposure period (mins)	0

Metadata

ART version	1.5
-------------	-----

Details for Activity (Decanting of a solid)

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

Near-field exposure**Operational Conditions****Substance emission potential**

Substance product type	Powders, granules or pelletised material
Dustiness	Granules, flakes or pellets
Moisture content	Dry product (< 5 % moisture content)
Powder weight fraction	Pure material

Activity emission potential

Activity class	Falling powders
Situation	Transferring 1 – 10 kg/minute
Handling type	Careful transfer involves workers showing attention to potential danger, error or harm and carrying out the activity in a very exact and thorough (or cautious) manner.
Drop height	Drop height < 0.5 m
Containment level	Handling that reduces contact between product and adjacent air. Note: This does not include processes that are fully contained by localised controls (see next questions).

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	3 air changes per hour (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 75th percentile full-shift exposure is 0.14 mg/m³.

The inter-quartile confidence interval is 0.075 mg/m³ to 0.27 mg/m³.

Annex 6 Riskofderm modelling and results

Dermal exposure estimate – Riskofderm model

1) Realistic Input (liquid)

Filling, mixing or loading (DEO unit 1)		cream	
You can move the input messages with the input fields by dragging and dropping			Scroll down to see the remainder!
Question	Answer	Additional explanation	Measured range as basis for model
What is the quality of the ventilation related to the task done?	Normal or good ventilation	Good (mechanical) ventilation and/or proper local exhaust ventilation	
What is the frequency of (skin) contact with the contaminant?	Rare contact	It happens sometimes, but on average less than once per scenario	
What kind of (skin) contact with the contaminant occurs?	Light contact	Touching of contaminated surfaces and/or limited deposition of dust or aerosols	
What type of product is handled?	Liquid	The product handled is a liquid	
Are significant amounts of aerosols or splashes generated in the task?	No	Task does not lead to substantial interaction between product and air, nor to dropping of	
What is the level of automation of the task done by the worker?	Manual task	The task is largely done manually with substantial interaction between worker and package, contaminated installation or product	
What is the use rate of the product?	0.5	L/min	<div>Overview results</div> <div>Back</div> <p>0,56-225 kg/min for powders; 0,008-257 L/min for liquids</p>
Percentile for the exposure rate distribution to be assessed	90	percentile	<p>Scroll up or down</p> <p>The sheet "Fillmixload_results" provides an overview of the results of this assessment</p>
Resulting exposure rate hands		median .526 percentile distribution 4.57	µL/min or mg/min
Resulting exposure rate body		only hand exposure is estimated with this model µL/min or mg/min	
What is the cumulative duration of the scenario during a shift?	15	minutes	1-20 min for powders; 0,33-125 for liquids
Exposure loading per shift hands		median 7.890 percentile distribution 68.500	µL or mg
Exposure loading per shift body		only hand exposure is estimated with this model µL or mg	

See the guidance for some remarks on different criteria for the performance of the model.

2) Conservative Input (liquid)

Filling, mixing or loading (DEO unit 1)		cream	
You can move the input messages with the input fields by dragging and dropping			Scroll down to see the remainder!
Question	Answer	Additional explanation	Measured range as basis for model
What is the quality of the ventilation related to the task done?	Normal or good ventilation	Good (mechanical) ventilation and/or proper local exhaust ventilation	
What is the frequency of (skin) contact with the contaminant?	More than rare contact	It happens on average once or more per scenario	
What kind of (skin) contact with the contaminant occurs?	More than light contact	Splashes or drops fall onto the worker, part of the worker is in direct contact with the (stream of) product, or heavy deposition of dusts or aerosols	
What type of product is handled?	Liquid	The product handled is a liquid	
Are significant amounts of aerosols or splashes generated in the task?	Yes	The product interacts with the air, is stirred vigorously, or is dropped onto a hard surface	
What is the level of automation of the task done by the worker?	Manual task	The task is largely done manually with substantial interaction between worker and package, contaminated installation or product	
What is the use rate of the product?	0.5	L/min	
Percentile for the exposure rate distribution to be assessed	90	percentile	Scroll up or down The sheet "Fillmixload_results" provides an overview of the results of this assessment
		median 15.7 percentile distribution 137.	µL/min or mg/min µL/min or mg/min
Resulting exposure rate hands		only hand exposure is estimated with this model	
Resulting exposure rate body		only hand exposure is estimated with this model	
What is the cumulative duration of the scenario during a shift?	15	minutes	1-20 min for powders; 0,33-125 for liquids
		median 236.000 percentile distribution 2050.000	µL or mg µL or mg
Exposure loading per shift hands		only hand exposure is estimated with this model	
Exposure loading per shift body		only hand exposure is estimated with this model	
See the guidance for some remarks on different criteria for the performance of the model.			

3) Realistic Input (solid)

Filling, mixing or loading (DEO unit 1)		cream	
You can move the input messages with the input fields by dragging and dropping			Scroll down to see the remainder!
Question	Answer	Additional explanation	Measured range as basis for model
What is the quality of the ventilation related to the task done?	Normal or good ventilation	Good (mechanical) ventilation and/or proper local exhaust ventilation	
What is the frequency of (skin) contact with the contaminant?	Rare contact	It happens sometimes, but on average less than once per scenario	
What kind of (skin) contact with the contaminant occurs?	Light contact	Touching of contaminated surfaces and/or limited deposition of dust or aerosols	
What type of product is handled?	Low or moderately dusty solid	A low or moderately dusty solid either does not	
Are significant amounts of aerosols or splashes generated in the task?	No	Task does not lead to substantial interaction between product and air, nor to dropping of product on a hard surface	
What is the level of automation of the task done by the worker?	Manual task	The task is largely done manually with substantial interaction between worker and package, contaminated installation or product	
What is the use rate of the product?	5	kg/min	
Percentile for the exposure rate distribution to be assessed	90	percentile	Scroll up or down The sheet "Fillmixload_results" provides an overview of the results of this assessment
		median .154 percentile distribution 1.34	µL/min or mg/min µL/min or mg/min
Resulting exposure rate hands		only hand exposure is estimated with this model	
Resulting exposure rate body		only hand exposure is estimated with this model	
What is the cumulative duration of the scenario during a shift?	20	minutes	1-20 min for powders; 0,33-125 for liquids
		median 3.080 percentile distribution 26.700	µL or mg µL or mg
Exposure loading per shift hands		only hand exposure is estimated with this model	
Exposure loading per shift body		only hand exposure is estimated with this model	
See the guidance for some remarks on different criteria for the performance of the model.			
No model for potential body exposure is available for this scenario due to lack of data			
Scroll up or down			

Annex 7 HvE assessment

Annex 7a HvE assessment for the applicant's site in Trostre – Site [REDACTED]

This entire section is confidential.

Environmental contributing scenario

Process and tonnage information

Table 74: [REDACTED]

Table 74: [REDACTED]

	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

[REDACTED]

Wastewater

Table 75: [REDACTED]

	[REDACTED]
[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]

[REDACTED]

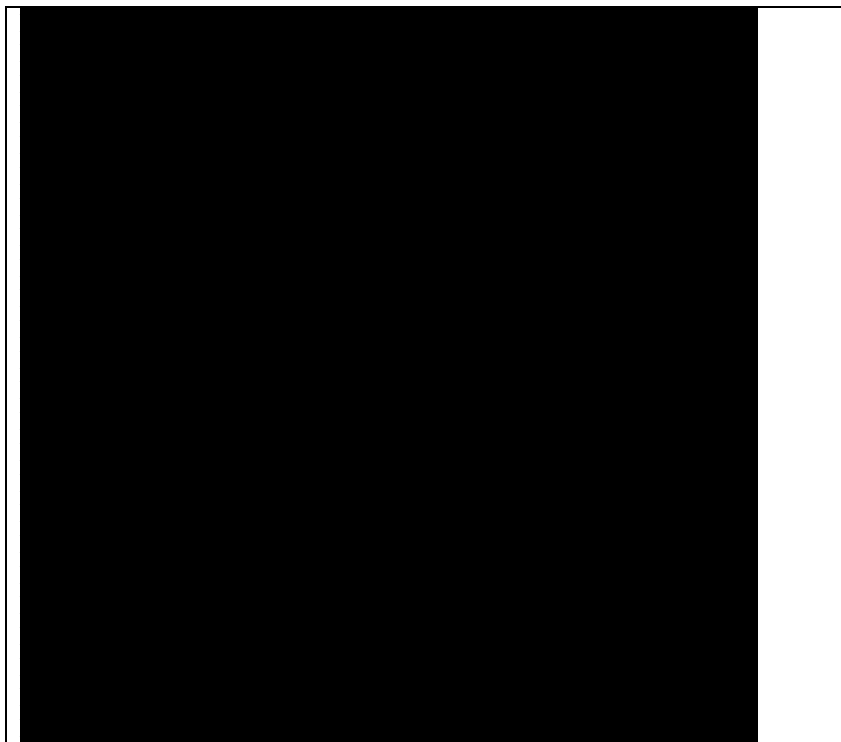


Figure 4: [REDACTED]

Air

[REDACTED]

Table 76: [REDACTED]

[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

[REDACTED]

[REDACTED]

Solid waste

[REDACTED]

Exposure and risks for H_vE

[REDACTED]

Table 77: [REDACTED]

[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

Table 78: [REDACTED]

[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]

Table 79: [REDACTED]

[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

Table 80: [REDACTED]

[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

Table 81: [REDACTED]

[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

Table 82: [REDACTED]

[REDACTED]							[REDACTED]					
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

Annex 7b H_vE assessment for the applicant's site in IJmuiden – Site

This entire section is confidential.

Environmental contributing scenario

Process and tonnage information

Table 83:

				1.3

Wastewater



Figure 5: [REDACTED]

[REDACTED]

Table 84: [REDACTED]

[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]

[REDACTED]

Air

[REDACTED]

Table 85: [REDACTED]

[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]

[REDACTED]

Solid waste

[REDACTED]

Exposure and risks for H_vE

[REDACTED]

Table 86: [REDACTED]

[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	0

[REDACTED]

Table 87: [REDACTED]

[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]

[REDACTED]

Table 88: [REDACTED]

[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

[REDACTED]

Table 89: [REDACTED]

[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

[REDACTED]

Table 90: [REDACTED]

[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

[REDACTED]

[REDACTED]

Table 91: [REDACTED]

	[REDACTED]						[REDACTED]					
	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

Annex 8 EUSES protocols

Annex 8a EUSES protocol for the applicant's site in Trostre – Site

Section/parameter	Actual value	Unit	Stat
STUDY			
STUDY IDENTIFICATION			
Study name			S
Study description			S
Author			D
Institute			D
Address			D
Zip code			D
City			D
Country			D
Telephone			D
Telefax			D
Email			D
Calculations checksum			S
DEFAULTS			
DEFAULT IDENTIFICATION			
General name			D
Description			D
CHARACTERISTICS OF COMPARTMENTS			
GENERAL			
Density of solid phase			D
Density of water phase			D
Density of air phase			D
Environmental temperature			D
Standard temperature for Vp and Sol			D
Temperature correction method			D
Constant of Junge equation			D
Surface area of aerosol particles			D
Gas constant (8.314)			D
SUSPENDED MATTER			

Volume fraction solids in suspended matter			D
Volume fraction water in suspended matter			D
Weight fraction of organic carbon in suspended matter		[kg.kg-1]	D
Bulk density of suspended matter			O
Conversion factor wet-dry suspended matter			O
SEDIMENT			
Volume fraction solids in sediment			D
Volume fraction water in sediment			D
Weight fraction of organic carbon in sediment			D
SOIL			
Volume fraction solids in soil			D
Volume fraction water in soil			D
Volume fraction air in soil			D
Weight fraction of organic carbon in soil			D
Weight fraction of organic matter in soil			O
Bulk density of soil			O
Conversion factor wet-dry soil			O
STP SLUDGE			
Fraction of organic carbon in raw sewage sludge			D
Fraction of organic carbon in settled sewage sludge			D
Fraction of organic carbon in activated sewage sludge			D
Fraction of organic carbon in effluent sewage sludge			D
DEGRADATION AND TRANSFORMATION RATES			
Rate constant for abiotic degradation in STP			D
Rate constant for abiotic degradation in bulk sediment			D
Rate constant for anaerobic biodegradation in sediment			D
Fraction of sediment compartment that is aerated			D
Concentration of OH-radicals in atmosphere			D
Rate constant for abiotic degradation in bulk soil			D
RELEASE ESTIMATION			
Fraction of EU production volume for region			D
Fraction of EU tonnage for region (private use)			D
Fraction connected to sewer systems			D
SEWAGE TREATMENT			
GENERAL			
Number of inhabitants feeding one STP			D
Sewage flow			D
Effluent discharge rate of local STP			O

Temperature correction for STP degradation			D
Temperature of air above aeration tank			D
Temperature of water in aeration tank			D
Height of air column above STP			D
Number of inhabitants of region			D
Number of inhabitants of continental system			O
Windspeed in the system			D
RAW SEWAGE			
Mass of O ₂ binding material per person per day			D
Dry weight solids produced per person per day			D
Density solids in raw sewage			D
Fraction of organic carbon in raw sewage sludge			D
PRIMARY SETTLER			
Depth of primary settler			D
Hydraulic retention time of primary settler			D
Density suspended and settled solids in primary settler			D
Fraction of organic carbon in settled sewage sludge			D
ACTIVATED SLUDGE TANK			
Depth of aeration tank			D
Density solids of activated sludge			D
Concentration solids of activated sludge			D
Steady state O ₂ concentration in activated sludge			D
Mode of aeration			D
Aeration rate of bubble aeration			D
Fraction of organic carbon in activated sewage sludge			D
Sludge loading rate			D
Hydraulic retention time in aerator (9-box STP)			O
Hydraulic retention time in aerator (6-box STP)			O
Sludge retention time of aeration tank			O
SOLIDS-LIQUIDS SEPARATOR			
Depth of solids-liquid separator			D
Density suspended and settled solids in solids-liquid separator			D
Concentration solids in effluent			D
Hydraulic retention time of solids-liquid separator			D
Fraction of organic carbon in effluent sewage sludge			D
LOCAL DISTRIBUTION			
AIR AND SURFACE WATER			
Concentration in air at source strength 1 [kg.d ⁻¹]			D
Standard deposition flux of aerosol-bound compounds			D

Standard deposition flux of gaseous compounds			O
Suspended solids concentration in STP effluent water			D
Dilution factor (rivers)			D
Flow rate of the river			D
Calculate dilution from river flow rate			D
Dilution factor (coastal areas)			D
SOIL			
Mixing depth of grassland soil			D
Dry sludge application rate on agricultural soil			S
Dry sludge application rate on grassland			S
Averaging time soil (for terrestrial ecosystem)			D
Averaging time agricultural soil			D
Averaging time grassland			D
PMTC, air side of air-soil interface			O
Soil-air PMTC (air-soil interface)			D
Soil-water film PMTC (air-soil interface)			D
Mixing depth agricultural soil			D
Fraction of rain water infiltrating soil			D
Average annual precipitation			D
REGIONAL AND CONTINENTAL DISTRIBUTION			
CONFIGURATION			
Fraction of direct regional emissions to seawater			D
Fraction of direct continental emissions to seawater			D
Fraction of regional STP effluent to seawater			D
Fraction of continental STP effluent to seawater			D
Fraction of flow from continental rivers to regional rivers			D
Fraction of flow from continental rivers to regional sea			D
Fraction of flow from continental rivers to continental sea			O
Number of inhabitants of region			D
Number of inhabitants in the EU			D
Number of inhabitants of continental system			O
AREAS			
REGIONAL			
Area (land+rivers) of regional system			D
Area fraction of freshwater, region (excl. sea)			D
Area fraction of natural soil, region (excl. sea)			D
Area fraction of agricultural soil, region (excl. sea)			D
Area fraction of industrial/urban soil, region (excl. sea)			D
Length of regional seawater			D
Width of regional seawater			D
Area of regional seawater			O

Area (land+rivers+sea) of regional system			O
Area fraction of freshwater, region (total)			O
Area fraction of seawater, region (total)			O
Area fraction of natural soil, region (total)			O
Area fraction of agricultural soil, region (total)			O
Area fraction of industrial/urban soil, region (total)			O
CONTINENTAL			
Total area of EU (continent+region, incl. sea)			D
Area (land+rivers+sea) of continental system			O
Area (land+rivers) of continental system			O
Area fraction of freshwater, continent (excl. sea)			D
Area fraction of natural soil, continent (excl. sea)			D
Area fraction of agricultural soil, continent (excl. sea)			D
Area fraction of industrial/urban soil, continent (excl. sea)			D
Area fraction of freshwater, continent (total)			O
Area fraction of seawater, continent (total)			D
Area fraction of natural soil, continent (total)			O
Area fraction of agricultural soil, continent (total)			O
Area fraction of industrial/urban soil, continent (total)			O
MODERATE			
Area of moderate system (incl.continent,region)			D
Area of moderate system (excl.continent, region)			O
Area fraction of water, moderate system			D
ARCTIC			
Area of arctic system			D
Area fraction of water, arctic system			D
TROPIC			
Area of tropic system			D
Area fraction of water, tropic system			D
TEMPERATURE			
Environmental temperature, regional scale			D
Environmental temperature, continental scale			D
Environmental temperature, moderate scale			D
Environmental temperature, arctic scale			D
Environmental temperature, tropic scale			D
Enthalpy of vaporisation			D
Enthalpy of solution			D
MASS TRANSFER			

Air-film PMTC (air-water interface)			O
Water-film PMTC (air-water interface)			O
PMTC, air side of air-soil interface			O
PMTC, soil side of air-soil interface			O
Soil-air PMTC (air-soil interface)			D
Soil-water film PMTC (air-soil interface)			D
Water-film PMTC (sediment-water interface)			D
Pore water PMTC (sediment-water interface)			D
AIR			
GENERAL			
Atmospheric mixing height			D
Windspeed in the system			D
Aerosol deposition velocity			D
Aerosol collection efficiency			D
RAIN			
Average precipitation, regional system			D
Average precipitation, continental system			D
Average precipitation, moderate system			D
Average precipitation, arctic system			D
Average precipitation, tropic system			D
RESIDENCE TIMES			
Residence time of air, regional			O
Residence time of air, continental			O
Residence time of air, moderate			O
Residence time of air, arctic			O
Residence time of air, tropic			O
WATER			
DEPTH			
Water depth of freshwater, regional system			D
Water depth of seawater, regional system			D
Water depth of freshwater, continental system			D
Water depth of seawater, continental system			D
Water depth, moderate system			D
Water depth, arctic system			D
Water depth, tropic system			D
SUSPENDED SOLIDS			
Suspended solids conc. freshwater, regional			D
Suspended solids conc. seawater, regional			D
Suspended solids conc. freshwater, continental			D

Suspended solids conc. seawater, continental			D
Suspended solids conc. seawater, moderate			D
Suspended solids conc. seawater, arctic			D
Suspended solids conc. seawater, tropic			D
Concentration solids in effluent, regional			D
Concentration solids in effluent, continental			D
Concentration biota			D
RESIDENCE TIMES			
Residence time of freshwater, regional			O
Residence time of seawater, regional			O
Residence time of freshwater, continental			O
Residence time of seawater, continental			O
Residence time of water, moderate			O
Residence time of water, arctic			O
Residence time of water, tropic			O
SEDIMENT			
DEPTH			
Sediment mixing depth			D
SUSPENDED SOLIDS			
(Biogenic) prod. susp. solids in freshwater, reg			D
(Biogenic) prod. susp. solids in seawater, reg			D
(Biogenic) prod. susp. solids in freshwater, cont			D
(Biogenic) prod. susp. solids in seawater, cont			D
(Biogenic) prod. susp. solids in water, moderate			D
(Biogenic) prod. susp. solids in water, arctic			D
(Biogenic) prod. susp. solids in water, tropic			D
SEDIMENTATION RATES			
Settling velocity of suspended solids			D
Net sedimentation rate, freshwater, regional			O
Net sedimentation rate, seawater, regional			O
Net sedimentation rate, freshwater, continental			O
Net sedimentation rate, seawater, continental			O
Net sedimentation rate, moderate			O
Net sedimentation rate, arctic			O
Net sedimentation rate, tropic			O
SOIL			
GENERAL			
Fraction of rain water infiltrating soil			D
Fraction of rain water running off soil			D

DEPTH			
Chemical-dependent soil depth			D
Mixing depth natural soil			D
Mixing depth agricultural soil			D
Mixing depth industrial/urban soil			D
Mixing depth of soil, moderate system			D
Mixing depth of soil, arctic system			D
Mixing depth of soil, tropic system			D
EROSION			
Soil erosion rate, regional system			D
Soil erosion rate, continental system			D
Soil erosion rate, moderate system			D
Soil erosion rate, arctic system			D
Soil erosion rate, tropic system			D
CHARACTERISTICS OF HUMANS			
Daily intake of drinking water			D
Daily intake of fish			D
Daily intake of leaf crops (incl. fruit and cereals)			D
Daily intake of root crops			D
Daily intake of meat			D
Daily intake of dairy products			D
Inhalation rate for humans (consumers, environment)			D
Inhalation rate for humans (worker exposure)			D
Bodyweight of the human considered			D
Correction factor for duration and frequency of exposure			D
SUBSTANCE			
SUBSTANCE IDENTIFICATION			
General name			S
Description			D
CAS-No			S
EC-notification no.			D
EINECS no.			S
PHYSICO-CHEMICAL PROPERTIES			
Molecular weight			S
Melting point			S
Boiling point			S
Vapour pressure at test temperature			S
Temperature at which vapour pressure was measured			D
Vapour pressure at 25 [oC]			O

Octanol-water partition coefficient			S
Water solubility at test temperature			S
Temperature at which solubility was measured			S
Water solubility at 25 [oC]			O
PARTITION COEFFICIENTS AND BIOCONCENTRATION FACTORS			
SOLIDS-WATER			
Chemical class for Koc-QSAR			D
Organic carbon-water partition coefficient			O
Solids-water partition coefficient in soil			S
Solids-water partition coefficient in sediment			S
Solids-water partition coefficient suspended matter			S
Solids-water partition coefficient in raw sewage sludge			O
Solids-water partition coefficient in settled sewage sludge			O
Solids-water partition coefficient in activated sewage sludge			O
Solids-water partition coefficient in effluent sewage sludge			O
Soil-water partition coefficient			O
Suspended matter-water partition coefficient			O
Sediment-water partition coefficient			O
AIR-WATER			
Environmental temperature			D
Water solubility at environmental temperature			O
Vapour pressure at environmental temperature			O
Sub-cooled liquid vapour pressure			O
Fraction of chemical associated with aerosol particles			O
Henry's law constant at test temperature			D
Temperature at which Henry's law constant was measured			D
Henry's law constant at 25 [oC]			O
Henry's law constant at environmental temperature			O
Air-water partitioning coefficient			O
BIOCONCENTRATION FACTORS			
PREDATOR EXPOSURE			
Bioconcentration factor for earthworms			O
HUMAN AND PREDATOR EXPOSURE			
Bioconcentration factor for fish			S
QSAR valid for calculation of BCF-Fish			O
Biomagnification factor in fish			O
Biomagnification factor in predator			O
HUMAN EXPOSURE			

Partition coefficient between leaves and air			O
Partition coefficient between plant tissue and water			O
Transpiration-stream concentration factor			O
Bioaccumulation factor for meat			O
Bioaccumulation factor for milk			O
Purification factor for surface water			O
BIOTA-WATER			
FOR REGIONAL/CONTINENTAL DISTRIBUTION			
Bioconcentration factor for aquatic biota			O
DEGRADATION AND TRANSFORMATION RATES			
CHARACTERIZATION			
Characterization of biodegradability			D
STP			
Degradation calculation method in STP			D
Rate constant for biodegradation in STP			O
Total rate constant for degradation in STP			O
Maximum growth rate of specific microorganisms			D
Half saturation concentration			D
WATER/SEDIMENT			
WATER			
Rate constant for hydrolysis in surface water			O
Rate constant for photolysis in surface water			O
Rate constant for biodegradation in surface water			O
Total rate constant for degradation in bulk surface water			O
Rate constant for biodegradation in saltwater			O
Total rate constant for degradation in bulk saltwater			O
SEDIMENT			
Rate constant for biodegradation in aerated sediment			O
Total rate constant for degradation in bulk sediment			O
AIR			
Specific degradation rate constant with OH-radicals			D
Rate constant for degradation in air			O
SOIL			
Rate constant for biodegradation in bulk soil			O
Total rate constant for degradation in bulk soil			O
REMOVAL RATE CONSTANTS SOIL			

Total rate constant for degradation in bulk soil			O
Rate constant for volatilisation from agricultural soil			O
Rate constant for leaching from agricultural soil			O
Total rate constant for removal from agricultural top soil			O
Rate constant for volatilisation from grassland soil			O
Rate constant for leaching from grassland soil			O
Total rate constant for removal from grassland top soil			O
Rate constant for volatilisation from industrial soil			O
Rate constant for leaching from industrial soil			O
Total rate constant for removal from industrial soil			O
RELEASE ESTIMATION			
CHARACTERIZATION AND TONNAGE			
High Production Volume Chemical			S
Production volume of chemical in EU			S
Fraction of EU production volume for region			D
Regional production volume of substance			O
Continental production volume of substance			O
Volume of chemical imported to EU			D
Volume of chemical exported from EU			D
Tonnage of substance in Europe			O
USE PATTERNS			
PRODUCTION STEPS			
EMISSION INPUT DATA [1 "PRODUCTION OF SD"]			
Usage/production title			S
Industry category			S
Use category			S
Extra details on use category			D
Extra details on use category			D
Main category production			S
Use specific emission scenario			D
Emission scenario			S
Fraction of tonnage for application			O
Total of fractions for all production steps			O
Relevant production volume for usage			O
Regional production volume of substance			O
Regional production volume for usage			O
OTHER LIFE CYCLE STEPS			
EMISSION INPUT DATA [2 "USE OF SD AS A PROCESS CHEMICAL IN SODIUM CHLORATE"]			
Usage/production title			S

USE PATTERN			
Industry category			S
Use category			S
Extra details on use category			D
Extra details on use category			D
INDUSTRIAL USE			
Use specific emission scenario			D
Emission scenario			S
TONNAGE			
Fraction of tonnage for application			O
Fraction of chemical in formulation			D
Tonnage of formulated product			O
Relevant tonnage for application			O
Regional tonnage of substance			O
Tonnage of formulated product			O
Regional tonnage of substance (private use step)			O
Continental tonnage of substance (private use step)			O
Total of fractions for all applications			O
INTERMEDIATE RESULTS			
INTERMEDIATE [1 "PRODUCTION OF SD"]			
RELEASE FRACTIONS AND EMISSION DAYS [1 "PRODUCTION OF SD"]			
PRODUCTION			
Emission tables			S
RELEASE FRACTIONS			
Fraction of tonnage released to air			S
Fraction of tonnage released to wastewater			S
Fraction of tonnage released to surface water			O
Fraction of tonnage released to industrial soil			S
Fraction of tonnage released to agricultural soil			O
Emission fractions determined by special scenario			O
EMISSION DAYS			
Fraction of the main local source			S
Number of emission days per year			S
Release to wastewater only			D
Emission days determined by special scenario			O
REGIONAL AND CONTINENTAL RELEASES [1 "PRODUCTION OF SD"]			
PRODUCTION			

REGIONAL			
Regional release to air			O
Regional release to wastewater			O
Regional release to surface water			O
Regional release to industrial soil			O
Regional release to agricultural soil			O
CONTINENTAL			
Continental release to air			O
Continental release to wastewater			O
Continental release to surface water			O
Continental release to industrial soil			O
Continental release to agricultural soil			O
INTERMEDIATE [2 "USE OF SD AS A PROCESS CHEMICAL IN SODIUM CHLORATE"]			
RELEASE FRACTIONS AND EMISSION DAYS [2 "USE OF SD AS A PROCESS CHEMICAL IN SODIUM CHLORATE"]			
INDUSTRIAL USE			
Emission tables			S
RELEASE FRACTIONS			
Fraction of tonnage released to air			S
Fraction of tonnage released to wastewater			S
Fraction of tonnage released to surface water			O
Fraction of tonnage released to industrial soil			S
Fraction of tonnage released to agricultural soil			O
Emission fractions determined by special scenario			O
EMISSION DAYS			
Fraction of the main local source			S
Number of emission days per year			S
Release to wastewater only			D
Emission days determined by special scenario			O
REGIONAL AND CONTINENTAL RELEASES [2 "USE OF SD AS A PROCESS CHEMICAL IN SODIUM CHLORATE"]			
INDUSTRIAL USE			
REGIONAL			
Regional release to air			O
Regional release to wastewater			O
Regional release to surface water			O
Regional release to industrial soil			O
Regional release to agricultural soil			O

CONTINENTAL			
Continental release to air			O
Continental release to wastewater			O
Continental release to surface water			O
Continental release to industrial soil			O
Continental release to agricultural soil			O
REGIONAL AND CONTINENTAL TOTAL EMISSIONS			
Total regional emission to air			O
Total regional emission to wastewater			S
Total regional emission to surface water			S
Total regional emission to industrial soil			O
Total regional emission to agricultural soil			O
Total continental emission to air			O
Total continental emission to wastewater			O
Total continental emission to surface water			O
Total continental emission to industrial soil			O
Total continental emission to agricultural soil			O
LOCAL			
[1 "PRODUCTION OF SD"] [PRODUCTION]			
Local emission to air during episode			O
Emission to air calculated by special scenario			O
Local emission to wastewater during episode			O
Emission to water calculated by special scenario			O
Show this step in further calculations			O
Intermittent release			D
[2 "USE OF SD AS A PROCESS CHEMICAL IN SODIUM CHLORATE"] [INDUSTRIAL USE]			
Local emission to air during episode			O
Emission to air calculated by special scenario			O
Local emission to wastewater during episode			O
Emission to water calculated by special scenario			O
Show this step in further calculations			O
Intermittent release			D
DISTRIBUTION			
SEWAGE TREATMENT			
CONTINENTAL			
Fraction of emission directed to air			O
Fraction of emission directed to water			O
Fraction of emission directed to sludge			O

Fraction of the emission degraded			O
Total of fractions			O
Indirect emission to air			O
Indirect emission to surface water			O
Indirect emission to agricultural soil			O
REGIONAL			
Fraction of emission directed to air			O
Fraction of emission directed to water			O
Fraction of emission directed to sludge			O
Fraction of the emission degraded			O
Total of fractions			O
Indirect emission to air			O
Indirect emission to surface water			O
Indirect emission to agricultural soil			O
[2 "USE OF SD AS A PROCESS CHEMICAL IN SODIUM CHLORATE"] [INDUSTRIAL USE]			
INPUT AND CONFIGURATION [2 "USE OF SD AS A PROCESS CHEMICAL IN SODIUM CHLORATE"] [INDUSTRIAL USE]			
INPUT			
Use or bypass STP (local freshwater assessment)			S
Use or bypass STP (local marine assessment)			S
Local emission to wastewater during episode			O
Concentration in untreated wastewater			O
Local emission entering the STP			O
CONFIGURATION			
Type of local STP			D
Number of inhabitants feeding this STP			O
Effluent discharge rate of this STP			S
Calculate dilution from river flow rate			S
Flow rate of the river			S
Dilution factor (rivers)			S
Dilution factor (coastal areas)			O
OUTPUT [2 "USE OF SD AS A PROCESS CHEMICAL IN SODIUM CHLORATE"] [INDUSTRIAL USE]			
Fraction of emission directed to air by STP			O
Fraction of emission directed to water by STP			O
Fraction of emission directed to sludge by STP			O
Fraction of the emission degraded in STP			O
Total of fractions			O
Local indirect emission to air from STP during episode			O

Concentration in untreated wastewater			O
Concentration of chemical (total) in the STP-effluent			O
Concentration in effluent exceeds solubility			O
Concentration in dry sewage sludge			O
PEC for micro-organisms in the STP			O
REGIONAL, CONTINENTAL AND GLOBAL DISTRIBUTION			
PECS			
REGIONAL			
Regional PEC in surface water (total)			O
Regional PEC in seawater (total)			O
Regional PEC in surface water (dissolved)			O
Qualitative assessment might be needed (TGD Part II, 5.6)			O
Regional PEC in seawater (dissolved)			O
Qualitative assessment might be needed (TGD Part II, 5.6)			O
Regional PEC in air (total)			O
Regional PEC in agricultural soil (total)			O
Regional PEC in pore water of agricultural soils			O
Regional PEC in natural soil (total)			O
Regional PEC in industrial soil (total)			O
Regional PEC in sediment (total)			O
Regional PEC in seawater sediment (total)			O
CONTINENTAL			
Continental PEC in surface water (total)			O
Continental PEC in seawater (total)			O
Continental PEC in surface water (dissolved)			O
Continental PEC in seawater (dissolved)			O
Continental PEC in air (total)			O
Continental PEC in agricultural soil (total)			O
Continental PEC in pore water of agricultural soils			O
Continental PEC in natural soil (total)			O
Continental PEC in industrial soil (total)			O
Continental PEC in sediment (total)			O
Continental PEC in seawater sediment (total)			O
GLOBAL: MODERATE			
Moderate PEC in water (total)			O
Moderate PEC in water (dissolved)			O
Moderate PEC in air (total)			O
Moderate PEC in soil (total)			O
Moderate PEC in sediment (total)			O
GLOBAL: ARCTIC			

Arctic PEC in water (total)			O
Arctic PEC in water (dissolved)			O
Arctic PEC in air (total)			O
Arctic PEC in soil (total)			O
Arctic PEC in sediment (total)			O
GLOBAL: TROPIC			
Tropic PEC in water (total)			O
Tropic PEC in water (dissolved)			O
Tropic PEC in air (total)			O
Tropic PEC in soil (total)			O
Tropic PEC in sediment (total)			O
STEADY-STATE FRACTIONS			
REGIONAL			
Steady-state mass fraction in regional freshwater			O
Steady-state mass fraction in regional seawater			O
Steady-state mass fraction in regional air			O
Steady-state mass fraction in regional agricultural soil			O
Steady-state mass fraction in regional natural soil			O
Steady-state mass fraction in regional industrial soil			O
Steady-state mass fraction in regional freshwater sediment			O
Steady-state mass fraction in regional seawater sediment			O
CONTINENTAL			
Steady-state mass fraction in continental freshwater			O
Steady-state mass fraction in continental seawater			O
Steady-state mass fraction in continental air			O
Steady-state mass fraction in continental agricultural soil			O
Steady-state mass fraction in continental natural soil			O
Steady-state mass fraction in continental industrial soil			O
Steady-state mass fraction in continental freshwater sediment			O
Steady-state mass fraction in continental seawater sediment			O
GLOBAL: MODERATE			
Steady-state mass fraction in moderate water			O
Steady-state mass fraction in moderate air			O
Steady-state mass fraction in moderate soil			O
Steady-state mass fraction in moderate sediment			O
GLOBAL: ARCTIC			
Steady-state mass fraction in arctic water			O
Steady-state mass fraction in arctic air			O
Steady-state mass fraction in arctic soil			O

Steady-state mass fraction in arctic sediment			O
GLOBAL: TROPIC			
Steady-state mass fraction in tropic water			O
Steady-state mass fraction in tropic air			O
Steady-state mass fraction in tropic soil			O
Steady-state mass fraction in tropic sediment			O
STEADY-STATE MASSES			
REGIONAL			
Steady-state mass in regional freshwater			O
Steady-state mass in regional seawater			O
Steady-state mass in regional air			O
Steady-state mass in regional agricultural soil			O
Steady-state mass in regional natural soil			O
Steady-state mass in regional industrial soil			O
Steady-state mass in regional freshwater sediment			O
Steady-state mass in regional seawater sediment			O
CONTINENTAL			
Steady-state mass in continental freshwater			O
Steady-state mass in continental seawater			O
Steady-state mass in continental air			O
Steady-state mass in continental agricultural soil			O
Steady-state mass in continental natural soil			O
Steady-state mass in continental industrial soil			O
Steady-state mass in continental freshwater sediment			O
Steady-state mass in continental seawater sediment			O
GLOBAL: MODERATE			
Steady-state mass in moderate water			O
Steady-state mass in moderate air			O
Steady-state mass in moderate soil			O
Steady-state mass in moderate sediment			O
GLOBAL: ARCTIC			
Steady-state mass in arctic water			O
Steady-state mass in arctic air			O
Steady-state mass in arctic soil			O
Steady-state mass in arctic sediment			O
GLOBAL: TROPIC			
Steady-state mass in tropic water			O
Steady-state mass in tropic air			O

Steady-state mass in tropic soil			O
Steady-state mass in tropic sediment			O
[2 "USE OF SD AS A PROCESS CHEMICAL IN SODIUM CHLORATE"] [INDUSTRIAL USE]			
LOCAL CONCENTRATIONS AND DEPOSITIONS [INDUSTRIAL USE]			
AIR			
Concentration in air during emission episode			O
Annual average concentration in air, 100 m from point source			O
Total deposition flux during emission episode			O
Annual average total deposition flux			O
WATER, SEDIMENT			
Concentration in surface water during emission episode (dissolved)			O
Concentration in surface water exceeds solubility			O
Annual average concentration in surface water (dissolved)			O
Concentration in seawater during emission episode (dissolved)			O
Annual average concentration in seawater (dissolved)			O
SOIL, GROUNDWATER			
Concentration in agric. soil averaged over 30 days			O
Concentration in agric. soil averaged over 180 days			O
Concentration in grassland averaged over 180 days			O
Fraction of steady-state (agricultural soil)			O
Fraction of steady-state (grassland soil)			O
LOCAL PECS [INDUSTRIAL USE]			
AIR			
Annual average local PEC in air (total)			O
WATER, SEDIMENT			
Local PEC in surface water during emission episode (dissolved)			O
Qualitative assessment might be needed (TGD Part II, 5.6)			O
Annual average local PEC in surface water (dissolved)			O
Local PEC in fresh-water sediment during emission episode			O
Local PEC in seawater during emission episode (dissolved)			O
Qualitative assessment might be needed (TGD Part II, 5.6)			O
Annual average local PEC in seawater (dissolved)			O
Local PEC in marine sediment during emission episode			O
SOIL, GROUNDWATER			
Local PEC in agric. soil (total) averaged over 30 days			O

Local PEC in agric. soil (total) averaged over 180 days			O
Local PEC in grassland (total) averaged over 180 days			O
Local PEC in pore water of agricultural soil			O
Local PEC in pore water of grassland			O
Local PEC in groundwater under agricultural soil			O
EXPOSURE			
HUMANS EXPOSED TO OR VIA THE ENVIRONMENT			
REGIONAL			
CONCENTRATIONS IN FISH, PLANTS AND DRINKING WATER			
Regional concentration in wet fish			O
Regional concentration in root tissue of plant			O
Regional concentration in leaves of plant			O
Regional concentration in grass (wet weight)			O
Fraction of total uptake by crops from pore water			O
Fraction of total uptake by crops from air			O
Fraction of total uptake by grass from pore water			O
Fraction of total uptake by grass from air			O
Regional concentration in drinking water			O
CONCENTRATIONS IN MEAT AND MILK			
Regional concentration in meat (wet weight)			O
Regional concentration in milk (wet weight)			O
Fraction of total intake by cattle through grass			O
Fraction of total intake by cattle through drinking water			O
Fraction of total intake by cattle through air			O
Fraction of total intake by cattle through soil			O
DAILY HUMAN DOSES			
Daily dose through intake of drinking water			O
Fraction of total dose through intake of drinking water			O
Daily dose through intake of fish			O
Fraction of total dose through intake of fish			O
Daily dose through intake of leaf crops			O
Fraction of total dose through intake of leaf crops			O
Daily dose through intake of root crops			O
Fraction of total dose through intake of root crops			O
Daily dose through intake of meat			O
Fraction of total dose through intake of meat			O
Daily dose through intake of milk			O
Fraction of total dose through intake of milk			O
Daily dose through intake of air			O
Fraction of total dose through intake of air			O

Regional total daily intake for humans			O
[2 "USE OF SD AS A PROCESS CHEMICAL IN SODIUM CHLORATE"] [INDUSTRIAL USE]			
CONCENTRATIONS IN FISH, PLANTS AND DRINKING WATER [2 "USE OF SD AS A PROCESS CHEMICAL IN SODIUM CHLORATE"] [INDUSTRIAL USE]			
Local concentration in wet fish			O
Local concentration in root tissue of plant			O
Local concentration in leaves of plant			O
Local concentration in grass (wet weight)			O
Fraction of total uptake by crops from pore water			O
Fraction of total uptake by crops from air			O
Fraction of total uptake by grass from pore water			O
Fraction of total uptake by grass from air			O
Local concentration in drinking water			O
Annual average local PEC in air (total)			O
CONCENTRATIONS IN MEAT AND MILK [2 "USE OF SD AS A PROCESS CHEMICAL IN SODIUM CHLORATE"] [INDUSTRIAL USE]			
Local concentration in meat (wet weight)			O
Local concentration in milk (wet weight)			O
Fraction of total intake by cattle through grass			O
Fraction of total intake by cattle through drinking water			O
Fraction of total intake by cattle through air			O
Fraction of total intake by cattle through soil			O
DAILY HUMAN DOSES [2 "USE OF SD AS A PROCESS CHEMICAL IN SODIUM CHLORATE"] [INDUSTRIAL USE]			
Daily dose through intake of drinking water			O
Fraction of total dose through intake of drinking water			O
Daily dose through intake of fish			O
Fraction of total dose through intake of fish			O
Daily dose through intake of leaf crops			O
Fraction of total dose through intake of leaf crops			O
Daily dose through intake of root crops			O
Fraction of total dose through intake of root crops			O
Daily dose through intake of meat			O
Fraction of total dose through intake of meat			O
Daily dose through intake of milk			O
Fraction of total dose through intake of milk			O
Daily dose through intake of air			O
Fraction of total dose through intake of air			O
Local total daily intake for humans			O

EFFECTS			
INPUT OF EFFECTS DATA			
MAMMALS			
REPEATED DOSE			
ORAL			
Oral NOAEL (repdose)			D
Oral LOAEL (repdose)			D
Oral CED (repdose)			D
Species for conversion of NOAEL to NOEC			D
Conversion factor NOAEL to NOEC			O
NOEC via food (repdose)			D
LOEC via food (repdose)			D
CED via food (repdose)			D
INHALATORY			
Inhalatory NOAEL (repdose)			D
Inhalatory LOAEL (repdose)			D
Inhalatory CED (repdose)			D
Correction factor for allometric scaling			D
DERMAL			
Dermal NOAEL (repdose)			D
Dermal LOAEL (repdose)			D
Dermal CED (repdose)			D
FERTILITY			
ORAL			
Oral NOAEL (fert)			D
Oral LOAEL (fert)			D
Oral CED (fert)			D
Species for conversion of NOAEL to NOEC			D
Conversion factor NOAEL to NOEC			O
NOEC via food (fert)			D
LOEC via food (fert)			D
CED via food (fert)			D
INHALATORY			
Inhalatory NOAEL (fert)			D
Inhalatory LOAEL (fert)			D
Inhalatory CED (fert)			D
Correction factor for allometric scaling			D
DERMAL			

Dermal NOAEL (fert)			D
Dermal LOAEL (fert)			D
Dermal CED (fert)			D
MATERNAL-TOX			
ORAL			
Oral NOAEL (mattox)			D
Oral LOAEL (mattox)			D
Oral CED (mattox)			D
Species for conversion of NOAEL to NOEC			D
Conversion factor NOAEL to NOEC			O
NOEC via food (mattox)			D
LOEC via food (mattox)			D
CED via food (mattox)			D
INHALATORY			
Inhalatory NOAEL (mattox)			D
Inhalatory LOAEL (mattox)			D
Inhalatory CED (mattox)			D
Correction factor for allometric scaling			D
DERMAL			
Dermal NOAEL (mattox)			D
Dermal LOAEL (mattox)			D
Dermal CED (mattox)			D
DEVELOPMENT-TOX			
ORAL			
Oral NOAEL (devtox)			D
Oral LOAEL (devtox)			D
Oral CED (devtox)			D
Species for conversion of NOAEL to NOEC			D
Conversion factor NOAEL to NOEC			O
NOEC via food (devtox)			D
LOEC via food (devtox)			D
CED via food (devtox)			D
INHALATORY			
Inhalatory NOAEL (devtox)			D
Inhalatory LOAEL (devtox)			D
Inhalatory CED (devtox)			D
Correction factor for allometric scaling			D
DERMAL			

Dermal NOAEL (devtox)			D
Dermal LOAEL (devtox)			D
Dermal CED (devtox)			D
CARC (THRESHOLD)			
ORAL			
Oral NOAEL (carc)			D
Oral LOAEL (carc)			D
Oral CED (carc)			D
Species for conversion of NOAEL to NOEC			D
Conversion factor NOAEL to NOEC			O
NOEC via food (carc)			D
LOEC via food (carc)			D
CED via food (carc)			D
INHALATORY			
Inhalatory NOAEL (carc)			D
Inhalatory LOAEL (carc)			D
Inhalatory CED (carc)			D
Correction factor for allometric scaling			D
DERMAL			
Dermal NOAEL (carc)			D
Dermal LOAEL (carc)			D
Dermal CED (carc)			D
CARC (NON-THRESHOLD)			
ORAL			
Oral T25 for non-threshold effects			D
Oral CED for non-threshold effects			D
Species for conversion of NOAEL to NOEC			D
Conversion factor NOAEL to NOEC			O
T25 via food for non-threshold effects			D
CED via food for non-threshold effects			D
INHALATORY			
Inhalatory T25 for non-threshold effects			D
Inhalatory CED for non-threshold effects			D
Correction factor for allometric scaling			D
DERMAL			
Dermal T25 for non-threshold effects			D
Dermal CED for non-threshold effects			D

ACUTE			
Oral LD50			D
Oral Discriminatory Dose			D
Inhalatory LC50			D
Dermal LD50			D
BIO-AVAILABILITY			
Bioavailability for oral uptake (oral to inhalation)			D
Bioavailability for oral uptake (oral to dermal)			D
Bioavailability for oral uptake (route to oral)			D
Bioavailability for inhalation (route from inhalation)			D
Bioavailability for inhalation (route to inhalation)			D
Bioavailability for dermal uptake (route from dermal)			O
Bioavailability for dermal uptake (route to dermal)			O
HUMANS			
REPEATED DOSE			
ORAL			
Oral NOAEL (repdose)			D
Oral LOAEL (repdose)			D
INHALATORY			
Inhalatory NOAEL (repdose)			D
Inhalatory LOAEL (repdose)			D
DERMAL			
Dermal NOAEL (repdose)			D
Dermal LOAEL (repdose)			D
Dermal NOEC in a medium (repdose)			D
Dermal LOEC in a medium (repdose)			D
FERTILITY			
ORAL			
Oral NOAEL (fert)			D
Oral LOAEL (fert)			D
INHALATORY			
Inhalatory NOAEL (fert)			D
Inhalatory LOAEL (fert)			D
DERMAL			
Dermal NOAEL (fert)			D
Dermal LOAEL (fert)			D
Dermal NOEC in a medium (fert)			D

Dermal LOEC in a medium (fert)			D
MATERNAL-TOX			
ORAL			
Oral NOAEL (mattox)			D
Oral LOAEL (mattox)			D
INHALATORY			
Inhalatory NOAEL (mattox)			D
Inhalatory LOAEL (mattox)			D
DERMAL			
Dermal NOAEL (mattox)			D
Dermal LOAEL (mattox)			D
Dermal NOEC in a medium (mattox)			D
Dermal LOEC in a medium (mattox)			D
DEVELOPMENT-TOX			
ORAL			
Oral NOAEL (devtox)			D
Oral LOAEL (devtox)			D
INHALATORY			
Inhalatory NOAEL (devtox)			D
Inhalatory LOAEL (devtox)			D
DERMAL			
Dermal NOAEL (devtox)			D
Dermal LOAEL (devtox)			D
Dermal NOEC in a medium (devtox)			D
Dermal LOEC in a medium (devtox)			D
CARC (THRESHOLD)			
ORAL			
Oral NOAEL (carc)			D
Oral LOAEL (carc)			D
INHALATORY			
Inhalatory NOAEL (carc)			D
Inhalatory LOAEL (carc)			D
DERMAL			
Dermal NOAEL (carc)			D
Dermal LOAEL (carc)			D

Dermal NOEC in a medium (carc)			D
Dermal LOEC in a medium (carc)			D
CURRENT CLASSIFICATION			
Corrosive (C, R34 or R35)			D
Irritating to skin (Xi, R38)			D
Irritating to eyes (Xi, R36)			D
Risk of serious damage to eyes (Xi, R41)			D
Irritating to respiratory system (Xi, R37)			D
May cause sensitisation by inhalation (Xn, R42)			D
May cause sensitisation by skin contact (Xi, R43)			D
May cause cancer (T, R45)			D
May cause cancer by inhalation (T, R49)			D
Possible risk of irreversible effects (Xn, R40)			D
RISK CHARACTERIZATION			
REFERENCE MOS			
HUMANS EXPOSED TO OR VIA THE ENVIRONMENT			
REPEATED DOSE			
ORAL			
Assessment factor for allometric scaling			D
Assessment factor for remaining interspecies differences			D
Assessment factor for intraspecies differences			D
Assessment factor for differences in exposure duration			D
Assessment factor for differences in exposure route			D
Assessment factor for dose-response relationship			D
Reference-MOS, human environmental, oral (repdose)			O
INHALATORY			
Assessment factor for allometric scaling			D
Assessment factor for remaining interspecies differences			D
Assessment factor for intraspecies differences			D
Assessment factor for differences in exposure duration			D
Assessment factor for differences in exposure route			D
Assessment factor for dose-response relationship			D
Reference-MOS, human environmental, inhalatory (repdose)			O
FERTILITY			
ORAL			
Assessment factor for allometric scaling			D
Assessment factor for remaining interspecies differences			D
Assessment factor for intraspecies differences			D
Assessment factor for differences in exposure duration			D

Assessment factor for differences in exposure route			D
Assessment factor for dose-response relationship			D
Reference-MOS, human environmental, oral (fert)			O
INHALATORY			
Assessment factor for allometric scaling			D
Assessment factor for remaining interspecies differences			D
Assessment factor for intraspecies differences			D
Assessment factor for differences in exposure duration			D
Assessment factor for differences in exposure route			D
Assessment factor for dose-response relationship			D
Reference-MOS, human environmental, inhalatory (fert)			O
MATERNAL-TOX			
ORAL			
Assessment factor for allometric scaling			D
Assessment factor for remaining interspecies differences			D
Assessment factor for intraspecies differences			D
Assessment factor for differences in exposure duration			D
Assessment factor for differences in exposure route			D
Assessment factor for dose-response relationship			D
Reference-MOS, human environmental, oral (mattox)			O
INHALATORY			
Assessment factor for allometric scaling			D
Assessment factor for remaining interspecies differences			D
Assessment factor for intraspecies differences			D
Assessment factor for differences in exposure duration			D
Assessment factor for differences in exposure route			D
Assessment factor for dose-response relationship			D
Reference-MOS, human environmental, inhalatory (mattox)			O
DEVELOPMENT-TOX			
ORAL			
Assessment factor for allometric scaling			D
Assessment factor for remaining interspecies differences			D
Assessment factor for intraspecies differences			D
Assessment factor for differences in exposure duration			D
Assessment factor for differences in exposure route			D
Assessment factor for dose-response relationship			D
Reference-MOS, human environmental, oral (devtox)			O
INHALATORY			
Assessment factor for allometric scaling			D

Assessment factor for remaining interspecies differences			D
Assessment factor for intraspecies differences			D
Assessment factor for differences in exposure duration			D
Assessment factor for differences in exposure route			D
Assessment factor for dose-response relationship			D
Reference-MOS, human environmental, inhalatory (devtox)			O
CARC (THRESHOLD)			
ORAL			
Assessment factor for allometric scaling			D
Assessment factor for remaining interspecies differences			D
Assessment factor for intraspecies differences			D
Assessment factor for differences in exposure duration			D
Assessment factor for differences in exposure route			D
Assessment factor for dose-response relationship			D
Reference-MOS, human environmental, oral (carc)			O
INHALATORY			
Assessment factor for allometric scaling			D
Assessment factor for remaining interspecies differences			D
Assessment factor for intraspecies differences			D
Assessment factor for differences in exposure duration			D
Assessment factor for differences in exposure route			D
Assessment factor for dose-response relationship			D
Reference-MOS, human environmental, inhalatory (carc)			O
CARC (NON-THRESHOLD)			
ORAL			
Assessment factor for allometric scaling			D
Assessment factor for remaining interspecies differences			D
Assessment factor for differences in exposure route			D
Assessment factor for dose-response relationship			D
Assessment factor for extrapolation to a low-risk level			D
Reference-MOE, human environmental, oral (non-threshold)			O
INHALATORY			
Assessment factor for allometric scaling			D
Assessment factor for remaining interspecies differences			D
Assessment factor for differences in exposure route			D
Assessment factor for dose-response relationship			D
Assessment factor for extrapolation to a low-risk level			D
Reference-MOE, human environmental, inhalatory (non-threshold)			O

HUMAN EQUIV. DOSE			
INHALATORY			
Assessment factor for allometric scaling	██████	██████	D
Assessment factor for differences in exposure route	██████	██████	D
Assessment factor humans via environment, inhalatory, non-threshold	██████	██████	O
Human equivalent dose humans via environment, inhalatory, non-threshold	██████	██████	O
TOTAL EXPOSURE			
Assessment factor for allometric scaling	██████	██████	D
Assessment factor for differences in exposure route	██████	██████	D
Assessment factor humans via environment, total, non-threshold	██████	██████	O
Human equivalent dose humans via environment, total, non-threshold	██████	██████	O

Annex 8b EUSES protocol for the applicant's site in IJmuiden – Site

Section/parameter			Stat
STUDY			
STUDY IDENTIFICATION			
Study name			S
Study description			S
Author			D
Institute			D
Address			D
Zip code			D
City			D
Country			D
Telephone			D
Telefax			D
Email			D
Calculations checksum			S
DEFAULTS			
DEFAULT IDENTIFICATION			
General name			D
Description			D
CHARACTERISTICS OF COMPARTMENTS			
GENERAL			
Density of solid phase			D
Density of water phase			D
Density of air phase			D
Environmental temperature			D
Standard temperature for Vp and Sol			D
Temperature correction method			D
Constant of Junge equation			D
Surface area of aerosol particles			D
Gas constant (8.314)			D
SUSPENDED MATTER			
Volume fraction solids in suspended matter			D
Volume fraction water in suspended matter			D

Weight fraction of organic carbon in suspended matter			D
Bulk density of suspended matter			O
Conversion factor wet-dry suspended matter			O
SEDIMENT			
Volume fraction solids in sediment			D
Volume fraction water in sediment			D
Weight fraction of organic carbon in sediment			D
SOIL			
Volume fraction solids in soil			D
Volume fraction water in soil			D
Volume fraction air in soil			D
Weight fraction of organic carbon in soil			D
Weight fraction of organic matter in soil			O
Bulk density of soil			O
Conversion factor wet-dry soil			O
STP SLUDGE			
Fraction of organic carbon in raw sewage sludge			D
Fraction of organic carbon in settled sewage sludge			D
Fraction of organic carbon in activated sewage sludge			D
Fraction of organic carbon in effluent sewage sludge			D
DEGRADATION AND TRANSFORMATION RATES			
Rate constant for abiotic degradation in STP			D
Rate constant for abiotic degradation in bulk sediment			D
Rate constant for anaerobic biodegradation in sediment			D
Fraction of sediment compartment that is aerated			D
Concentration of OH-radicals in atmosphere			D
Rate constant for abiotic degradation in bulk soil			D
RELEASE ESTIMATION			
Fraction of EU production volume for region			D
Fraction of EU tonnage for region (private use)			D
Fraction connected to sewer systems			D
SEWAGE TREATMENT			
GENERAL			
Number of inhabitants feeding one STP			D
Sewage flow			D
Effluent discharge rate of local STP			O
Temperature correction for STP degradation			D

Temperature of air above aeration tank			D
Temperature of water in aeration tank			D
Height of air column above STP			D
Number of inhabitants of region			D
Number of inhabitants of continental system			O
Windspeed in the system			D
RAW SEWAGE			
Mass of O2 binding material per person per day			D
Dry weight solids produced per person per day			D
Density solids in raw sewage			D
Fraction of organic carbon in raw sewage sludge			D
PRIMARY SETTLER			
Depth of primary settler			D
Hydraulic retention time of primary settler			D
Density suspended and settled solids in primary settler			D
Fraction of organic carbon in settled sewage sludge			D
ACTIVATED SLUDGE TANK			
Depth of aeration tank			D
Density solids of activated sludge			D
Concentration solids of activated sludge			D
Steady state O2 concentration in activated sludge			D
Mode of aeration			D
Aeration rate of bubble aeration			D
Fraction of organic carbon in activated sewage sludge			D
Sludge loading rate			D
Hydraulic retention time in aerator (9-box STP)			O
Hydraulic retention time in aerator (6-box STP)			O
Sludge retention time of aeration tank			O
SOLIDS-LIQUIDS SEPARATOR			
Depth of solids-liquid separator			D
Density suspended and settled solids in solids-liquid separator			D
Concentration solids in effluent			D
Hydraulic retention time of solids-liquid separator			D
Fraction of organic carbon in effluent sewage sludge			D
LOCAL DISTRIBUTION			
AIR AND SURFACE WATER			
Concentration in air at source strength 1 [kg.d-1]			D
Standard deposition flux of aerosol-bound compounds			D
Standard deposition flux of gaseous compounds			O

Suspended solids concentration in STP effluent water			D
Dilution factor (rivers)			D
Flow rate of the river			D
Calculate dilution from river flow rate			D
Dilution factor (coastal areas)			D
SOIL			
Mixing depth of grassland soil			D
Dry sludge application rate on agricultural soil			S
Dry sludge application rate on grassland			S
Averaging time soil (for terrestrial ecosystem)			D
Averaging time agricultural soil			D
Averaging time grassland			D
PMTC, air side of air-soil interface			O
Soil-air PMTC (air-soil interface)			D
Soil-water film PMTC (air-soil interface)			D
Mixing depth agricultural soil			D
Fraction of rain water infiltrating soil			D
Average annual precipitation			D
REGIONAL AND CONTINENTAL DISTRIBUTION			
CONFIGURATION			
Fraction of direct regional emissions to seawater			D
Fraction of direct continental emissions to seawater			D
Fraction of regional STP effluent to seawater			D
Fraction of continental STP effluent to seawater			D
Fraction of flow from continental rivers to regional rivers			D
Fraction of flow from continental rivers to regional sea			D
Fraction of flow from continental rivers to continental sea			O
Number of inhabitants of region			D
Number of inhabitants in the EU			D
Number of inhabitants of continental system			O
AREAS			
REGIONAL			
Area (land+rivers) of regional system			D
Area fraction of freshwater, region (excl. sea)			D
Area fraction of natural soil, region (excl. sea)			D
Area fraction of agricultural soil, region (excl. sea)			D
Area fraction of industrial/urban soil, region (excl. sea)			D
Length of regional seawater			D
Width of regional seawater			D

Area of regional seawater			O
Area (land+rivers+sea) of regional system			O
Area fraction of freshwater, region (total)			O
Area fraction of seawater, region (total)			O
Area fraction of natural soil, region (total)			O
Area fraction of agricultural soil, region (total)			O
Area fraction of industrial/urban soil, region (total)			O
CONTINENTAL			
Total area of EU (continent+region, incl. sea)			D
Area (land+rivers+sea) of continental system			O
Area (land+rivers) of continental system			O
Area fraction of freshwater, continent (excl. sea)			D
Area fraction of natural soil, continent (excl. sea)			D
Area fraction of agricultural soil, continent (excl. sea)			D
Area fraction of industrial/urban soil, continent (excl. sea)			D
Area fraction of freshwater, continent (total)			O
Area fraction of seawater, continent (total)			D
Area fraction of natural soil, continent (total)			O
Area fraction of agricultural soil, continent (total)			O
Area fraction of industrial/urban soil, continent (total)			O
MODERATE			
Area of moderate system (incl.continent,region)			D
Area of moderate system (excl.continent, region)			O
Area fraction of water, moderate system			D
ARCTIC			
Area of arctic system			D
Area fraction of water, arctic system			D
TROPIC			
Area of tropic system			D
Area fraction of water, tropic system			D
TEMPERATURE			
Environmental temperature, regional scale			D
Environmental temperature, continental scale			D
Environmental temperature, moderate scale			D
Environmental temperature, arctic scale			D
Environmental temperature, tropic scale			D
Enthalpy of vaporisation			D
Enthalpy of solution			D

MASS TRANSFER			
Air-film PMTC (air-water interface)			O
Water-film PMTC (air-water interface)			O
PMTC, air side of air-soil interface			O
PMTC, soil side of air-soil interface			O
Soil-air PMTC (air-soil interface)			D
Soil-water film PMTC (air-soil interface)			D
Water-film PMTC (sediment-water interface)			D
Pore water PMTC (sediment-water interface)			D
AIR			
GENERAL			
Atmospheric mixing height			D
Windspeed in the system			D
Aerosol deposition velocity			D
Aerosol collection efficiency			D
RAIN			
Average precipitation, regional system			D
Average precipitation, continental system			D
Average precipitation, moderate system			D
Average precipitation, arctic system			D
Average precipitation, tropic system			D
RESIDENCE TIMES			
Residence time of air, regional			O
Residence time of air, continental			O
Residence time of air, moderate			O
Residence time of air, arctic			O
Residence time of air, tropic			O
WATER			
DEPTH			
Water depth of freshwater, regional system			D
Water depth of seawater, regional system			D
Water depth of freshwater, continental system			D
Water depth of seawater, continental system			D
Water depth, moderate system			D
Water depth, arctic system			D
Water depth, tropic system			D
SUSPENDED SOLIDS			
Suspended solids conc. freshwater, regional			D
Suspended solids conc. seawater, regional			D

Suspended solids conc. freshwater, continental			D
Suspended solids conc. seawater, continental			D
Suspended solids conc. seawater, moderate			D
Suspended solids conc. seawater, arctic			D
Suspended solids conc. seawater, tropic			D
Concentration solids in effluent, regional			D
Concentration solids in effluent, continental			D
Concentration biota			D
RESIDENCE TIMES			
Residence time of freshwater, regional			O
Residence time of seawater, regional			O
Residence time of freshwater, continental			O
Residence time of seawater, continental			O
Residence time of water, moderate			O
Residence time of water, arctic			O
Residence time of water, tropic			O
SEDIMENT			
DEPTH			
Sediment mixing depth			D
SUSPENDED SOLIDS			
(Biogenic) prod. susp. solids in freshwater, reg			D
(Biogenic) prod. susp. solids in seawater, reg			D
(Biogenic) prod. susp. solids in freshwater, cont			D
(Biogenic) prod. susp. solids in seawater, cont			D
(Biogenic) prod. susp. solids in water, moderate			D
(Biogenic) prod. susp. solids in water, arctic			D
(Biogenic) prod. susp. solids in water, tropic			D
SEDIMENTATION RATES			
Settling velocity of suspended solids			D
Net sedimentation rate, freshwater, regional			O
Net sedimentation rate, seawater, regional			O
Net sedimentation rate, freshwater, continental			O
Net sedimentation rate, seawater, continental			O
Net sedimentation rate, moderate			O
Net sedimentation rate, arctic			O
Net sedimentation rate, tropic			O
SOIL			
GENERAL			
Fraction of rain water infiltrating soil			D

Fraction of rain water running off soil			D
DEPTH			
Chemical-dependent soil depth			D
Mixing depth natural soil			D
Mixing depth agricultural soil			D
Mixing depth industrial/urban soil			D
Mixing depth of soil, moderate system			D
Mixing depth of soil, arctic system			D
Mixing depth of soil, tropic system			D
EROSION			
Soil erosion rate, regional system			D
Soil erosion rate, continental system			D
Soil erosion rate, moderate system			D
Soil erosion rate, arctic system			D
Soil erosion rate, tropic system			D
CHARACTERISTICS OF HUMANS			
Daily intake of drinking water			D
Daily intake of fish			D
Daily intake of leaf crops (incl. fruit and cereals)			D
Daily intake of root crops			D
Daily intake of meat			D
Daily intake of dairy products			D
Inhalation rate for humans (consumers, environment)			D
Inhalation rate for humans (worker exposure)			D
Bodyweight of the human considered			D
Correction factor for duration and frequency of exposure			D
SUBSTANCE			
SUBSTANCE IDENTIFICATION			
General name			S
Description			D
CAS-No			S
EC-notification no.			D
EINECS no.			S
PHYSICO-CHEMICAL PROPERTIES			
Molecular weight			S
Melting point			S
Boiling point			S
Vapour pressure at test temperature			S
Temperature at which vapour pressure was measured			D

Vapour pressure at 25 [oC]			O
Octanol-water partition coefficient			S
Water solubility at test temperature			S
Temperature at which solubility was measured			S
Water solubility at 25 [oC]			O
PARTITION COEFFICIENTS AND BIOCONCENTRATION FACTORS			
SOLIDS-WATER			
Chemical class for Koc-QSAR			D
Organic carbon-water partition coefficient			O
Solids-water partition coefficient in soil			S
Solids-water partition coefficient in sediment			S
Solids-water partition coefficient suspended matter			S
Solids-water partition coefficient in raw sewage sludge			O
Solids-water partition coefficient in settled sewage sludge			O
Solids-water partition coefficient in activated sewage sludge			O
Solids-water partition coefficient in effluent sewage sludge			O
Soil-water partition coefficient			O
Suspended matter-water partition coefficient			O
Sediment-water partition coefficient			O
AIR-WATER			
Environmental temperature			D
Water solubility at environmental temperature			O
Vapour pressure at environmental temperature			O
Sub-cooled liquid vapour pressure			O
Fraction of chemical associated with aerosol particles			O
Henry's law constant at test temperature			D
Temperature at which Henry's law constant was measured			D
Henry's law constant at 25 [oC]			O
Henry's law constant at environmental temperature			O
Air-water partitioning coefficient			O
BIOCONCENTRATION FACTORS			
PREDATOR EXPOSURE			
Bioconcentration factor for earthworms			O
HUMAN AND PREDATOR EXPOSURE			
Bioconcentration factor for fish			S
QSAR valid for calculation of BCF-Fish			O
Biomagnification factor in fish			O

Biomagnification factor in predator			O
HUMAN EXPOSURE			
Partition coefficient between leaves and air			O
Partition coefficient between plant tissue and water			O
Transpiration-stream concentration factor			O
Bioaccumulation factor for meat			O
Bioaccumulation factor for milk			O
Purification factor for surface water			O
BIOTA-WATER			
FOR REGIONAL/CONTINENTAL DISTRIBUTION			
Bioconcentration factor for aquatic biota			O
DEGRADATION AND TRANSFORMATION RATES			
CHARACTARIZATION			
Characterization of biodegradability			D
STP			
Degradation calculation method in STP			D
Rate constant for biodegradation in STP			O
Total rate constant for degradation in STP			O
Maximum growth rate of specific microorganisms			D
Half saturation concentration			D
WATER/SEDIMENT			
WATER			
Rate constant for hydrolysis in surface water			O
Rate constant for photolysis in surface water			O
Rate constant for biodegradation in surface water			O
Total rate constant for degradation in bulk surface water			O
Rate constant for biodegradation in saltwater			O
Total rate constant for degradation in bulk saltwater			O
SEDIMENT			
Rate constant for biodegradation in aerated sediment			O
Total rate constant for degradation in bulk sediment			O
AIR			
Specific degradation rate constant with OH-radicals			D
Rate constant for degradation in air			O
SOIL			

Rate constant for biodegradation in bulk soil			O
Total rate constant for degradation in bulk soil			O
REMOVAL RATE CONSTANTS SOIL			
Total rate constant for degradation in bulk soil			O
Rate constant for volatilisation from agricultural soil			O
Rate constant for leaching from agricultural soil			O
Total rate constant for removal from agricultural top soil			O
Rate constant for volatilisation from grassland soil			O
Rate constant for leaching from grassland soil			O
Total rate constant for removal from grassland top soil			O
Rate constant for volatilisation from industrial soil			O
Rate constant for leaching from industrial soil			O
Total rate constant for removal from industrial soil			O
RELEASE ESTIMATION			
CHARACTERIZATION AND TONNAGE			
High Production Volume Chemical			S
Production volume of chemical in EU			S
Fraction of EU production volume for region			D
Regional production volume of substance			O
Continental production volume of substance			O
Volume of chemical imported to EU			D
Volume of chemical exported from EU			D
Tonnage of substance in Europe			O
USE PATTERNS			
PRODUCTION STEPS			
EMISSION INPUT DATA [1 "PRODUCTION OF SD"]			
Usage/production title			S
Industry category			S
Use category			S
Extra details on use category			D
Extra details on use category			D
Main category production			S
Use specific emission scenario			D
Emission scenario			S
Fraction of tonnage for application			O
Total of fractions for all production steps			O
Relevant production volume for usage			O
Regional production volume of substance			O
Regional production volume for usage			O

OTHER LIFE CYCLE STEPS			
EMISSION INPUT DATA [2 "USE OF SD AS A PROCESS CHEMICAL IN SODIUM CHLORATE"]			
Usage/production title			S
USE PATTERN			
Industry category			S
Use category			S
Extra details on use category			D
Extra details on use category			D
INDUSTRIAL USE			
Use specific emission scenario			D
Emission scenario			S
TONNAGE			
Fraction of tonnage for application			O
Fraction of chemical in formulation			D
Tonnage of formulated product			O
Relevant tonnage for application			O
Regional tonnage of substance			O
Tonnage of formulated product			O
Regional tonnage of substance (private use step)			O
Continental tonnage of substance (private use step)			O
Total of fractions for all applications			O
INTERMEDIATE RESULTS			
INTERMEDIATE [1 "PRODUCTION OF SD"]			
RELEASE FRACTIONS AND EMISSION DAYS [1 "PRODUCTION OF SD"]			
PRODUCTION			
Emission tables			S
RELEASE FRACTIONS			
Fraction of tonnage released to air			S
Fraction of tonnage released to wastewater			S
Fraction of tonnage released to surface water			O
Fraction of tonnage released to industrial soil			S
Fraction of tonnage released to agricultural soil			O
Emission fractions determined by special scenario			O
EMISSION DAYS			
Fraction of the main local source			S
Number of emission days per year			S
Release to wastewater only			D

Emission days determined by special scenario			O
REGIONAL AND CONTINENTAL RELEASES [1 "PRODUCTION OF SD"]			
PRODUCTION			
REGIONAL			
Regional release to air			O
Regional release to wastewater			O
Regional release to surface water			O
Regional release to industrial soil			O
Regional release to agricultural soil			O
CONTINENTAL			
Continental release to air			O
Continental release to wastewater			O
Continental release to surface water			O
Continental release to industrial soil			O
Continental release to agricultural soil			O
INTERMEDIATE [2 "USE OF SD AS A PROCESS CHEMICAL IN SODIUM CHLORATE"]			
RELEASE FRACTIONS AND EMISSION DAYS [2 "USE OF SD AS A PROCESS CHEMICAL IN SODIUM CHLORATE"]			
INDUSTRIAL USE			
Emission tables			S
RELEASE FRACTIONS			
Fraction of tonnage released to air			S
Fraction of tonnage released to wastewater			S
Fraction of tonnage released to surface water			O
Fraction of tonnage released to industrial soil			S
Fraction of tonnage released to agricultural soil			O
Emission fractions determined by special scenario			O
EMISSION DAYS			
Fraction of the main local source			S
Number of emission days per year			S
Release to wastewater only			D
Emission days determined by special scenario			O
REGIONAL AND CONTINENTAL RELEASES [2 "USE OF SD AS A PROCESS CHEMICAL IN SODIUM CHLORATE"]			
INDUSTRIAL USE			
REGIONAL			

Regional release to air			O
Regional release to wastewater			O
Regional release to surface water			O
Regional release to industrial soil			O
Regional release to agricultural soil			O
CONTINENTAL			
Continental release to air			O
Continental release to wastewater			O
Continental release to surface water			O
Continental release to industrial soil			O
Continental release to agricultural soil			O
REGIONAL AND CONTINENTAL TOTAL EMISSIONS			
Total regional emission to air			O
Total regional emission to wastewater			S
Total regional emission to surface water			S
Total regional emission to industrial soil			O
Total regional emission to agricultural soil			O
Total continental emission to air			O
Total continental emission to wastewater			O
Total continental emission to surface water			O
Total continental emission to industrial soil			O
Total continental emission to agricultural soil			O
LOCAL			
[1 "PRODUCTION OF SD"] [PRODUCTION]			
Local emission to air during episode			O
Emission to air calculated by special scenario			O
Local emission to wastewater during episode			O
Emission to water calculated by special scenario			O
Show this step in further calculations			O
Intermittent release			D
[2 "USE OF SD AS A PROCESS CHEMICAL IN SODIUM CHLORATE"] [INDUSTRIAL USE]			
Local emission to air during episode			O
Emission to air calculated by special scenario			O
Local emission to wastewater during episode			O
Emission to water calculated by special scenario			O
Show this step in further calculations			O
Intermittent release			D
DISTRIBUTION			

SEWAGE TREATMENT			
CONTINENTAL			
Fraction of emission directed to air			O
Fraction of emission directed to water			O
Fraction of emission directed to sludge			O
Fraction of the emission degraded			O
Total of fractions			O
Indirect emission to air			O
Indirect emission to surface water			O
Indirect emission to agricultural soil			O
REGIONAL			
Fraction of emission directed to air			O
Fraction of emission directed to water			O
Fraction of emission directed to sludge			O
Fraction of the emission degraded			O
Total of fractions			O
Indirect emission to air			O
Indirect emission to surface water			O
Indirect emission to agricultural soil			O
[2 "USE OF SD AS A PROCESS CHEMICAL IN SODIUM CHLORATE"] [INDUSTRIAL USE]			
INPUT AND CONFIGURATION [2 "USE OF SD AS A PROCESS CHEMICAL IN SODIUM CHLORATE"] [INDUSTRIAL USE]			
INPUT			
Use or bypass STP (local freshwater assessment)			S
Use or bypass STP (local marine assessment)			S
Local emission to wastewater during episode			O
Concentration in untreated wastewater			O
Local emission entering the STP			O
CONFIGURATION			
Type of local STP			D
Number of inhabitants feeding this STP			O
Effluent discharge rate of this STP			S
Calculate dilution from river flow rate			S
Flow rate of the river			S
Dilution factor (rivers)			O
Dilution factor (coastal areas)			O
OUTPUT [2 "USE OF SD AS A PROCESS CHEMICAL IN SODIUM CHLORATE"] [INDUSTRIAL USE]			
Fraction of emission directed to air by STP			O

Fraction of emission directed to water by STP			O
Fraction of emission directed to sludge by STP			O
Fraction of the emission degraded in STP			O
Total of fractions			O
Local indirect emission to air from STP during episode			O
Concentration in untreated wastewater			O
Concentration of chemical (total) in the STP-effluent			O
Concentration in effluent exceeds solubility			O
Concentration in dry sewage sludge			O
PEC for micro-organisms in the STP			O
REGIONAL, CONTINENTAL AND GLOBAL DISTRIBUTION			
PECS			
REGIONAL			
Regional PEC in surface water (total)			O
Regional PEC in seawater (total)			O
Regional PEC in surface water (dissolved)			O
Qualitative assessment might be needed (TGD Part II, 5.6)			O
Regional PEC in seawater (dissolved)			O
Qualitative assessment might be needed (TGD Part II, 5.6)			O
Regional PEC in air (total)			O
Regional PEC in agricultural soil (total)			O
Regional PEC in pore water of agricultural soils			O
Regional PEC in natural soil (total)			O
Regional PEC in industrial soil (total)			O
Regional PEC in sediment (total)			O
Regional PEC in seawater sediment (total)			O
CONTINENTAL			
Continental PEC in surface water (total)			O
Continental PEC in seawater (total)			O
Continental PEC in surface water (dissolved)			O
Continental PEC in seawater (dissolved)			O
Continental PEC in air (total)			O
Continental PEC in agricultural soil (total)			O
Continental PEC in pore water of agricultural soils			O
Continental PEC in natural soil (total)			O
Continental PEC in industrial soil (total)			O
Continental PEC in sediment (total)			O
Continental PEC in seawater sediment (total)			O
GLOBAL: MODERATE			

Moderate PEC in water (total)			O
Moderate PEC in water (dissolved)			O
Moderate PEC in air (total)			O
Moderate PEC in soil (total)			O
Moderate PEC in sediment (total)			O
GLOBAL: ARCTIC			
Arctic PEC in water (total)			O
Arctic PEC in water (dissolved)			O
Arctic PEC in air (total)			O
Arctic PEC in soil (total)			O
Arctic PEC in sediment (total)			O
GLOBAL: TROPIC			
Tropic PEC in water (total)			O
Tropic PEC in water (dissolved)			O
Tropic PEC in air (total)			O
Tropic PEC in soil (total)			O
Tropic PEC in sediment (total)			O
STEADY-STATE FRACTIONS			
REGIONAL			
Steady-state mass fraction in regional freshwater			O
Steady-state mass fraction in regional seawater			O
Steady-state mass fraction in regional air			O
Steady-state mass fraction in regional agricultural soil			O
Steady-state mass fraction in regional natural soil			O
Steady-state mass fraction in regional industrial soil			O
Steady-state mass fraction in regional freshwater sediment			O
Steady-state mass fraction in regional seawater sediment			O
CONTINENTAL			
Steady-state mass fraction in continental freshwater			O
Steady-state mass fraction in continental seawater			O
Steady-state mass fraction in continental air			O
Steady-state mass fraction in continental agricultural soil			O
Steady-state mass fraction in continental natural soil			O
Steady-state mass fraction in continental industrial soil			O
Steady-state mass fraction in continental freshwater sediment			O
Steady-state mass fraction in continental seawater sediment			O

GLOBAL: MODERATE			
Steady-state mass fraction in moderate water			O
Steady-state mass fraction in moderate air			O
Steady-state mass fraction in moderate soil			O
Steady-state mass fraction in moderate sediment			O
GLOBAL: ARCTIC			
Steady-state mass fraction in arctic water			O
Steady-state mass fraction in arctic air			O
Steady-state mass fraction in arctic soil			O
Steady-state mass fraction in arctic sediment			O
GLOBAL: TROPIC			
Steady-state mass fraction in tropic water			O
Steady-state mass fraction in tropic air			O
Steady-state mass fraction in tropic soil			O
Steady-state mass fraction in tropic sediment			O
STEADY-STATE MASSES			
REGIONAL			
Steady-state mass in regional freshwater			O
Steady-state mass in regional seawater			O
Steady-state mass in regional air			O
Steady-state mass in regional agricultural soil			O
Steady-state mass in regional natural soil			O
Steady-state mass in regional industrial soil			O
Steady-state mass in regional freshwater sediment			O
Steady-state mass in regional seawater sediment			O
CONTINENTAL			
Steady-state mass in continental freshwater			O
Steady-state mass in continental seawater			O
Steady-state mass in continental air			O
Steady-state mass in continental agricultural soil			O
Steady-state mass in continental natural soil			O
Steady-state mass in continental industrial soil			O
Steady-state mass in continental freshwater sediment			O
Steady-state mass in continental seawater sediment			O
GLOBAL: MODERATE			
Steady-state mass in moderate water			O
Steady-state mass in moderate air			O
Steady-state mass in moderate soil			O
Steady-state mass in moderate sediment			O

GLOBAL: ARCTIC			
Steady-state mass in arctic water			O
Steady-state mass in arctic air			O
Steady-state mass in arctic soil			O
Steady-state mass in arctic sediment			O
GLOBAL: TROPIC			
Steady-state mass in tropic water			O
Steady-state mass in tropic air			O
Steady-state mass in tropic soil			O
Steady-state mass in tropic sediment			O
[2 "USE OF SD AS A PROCESS CHEMICAL IN SODIUM CHLORATE"] [INDUSTRIAL USE]			
LOCAL CONCENTRATIONS AND DEPOSITIONS [INDUSTRIAL USE]			
AIR			
Concentration in air during emission episode			O
Annual average concentration in air, 100 m from point source			O
Total deposition flux during emission episode			O
Annual average total deposition flux			O
WATER, SEDIMENT			
Concentration in surface water during emission episode (dissolved)			O
Concentration in surface water exceeds solubility			O
Annual average concentration in surface water (dissolved)			O
Concentration in seawater during emission episode (dissolved)			O
Annual average concentration in seawater (dissolved)			O
SOIL, GROUNDWATER			
Concentration in agric. soil averaged over 30 days			O
Concentration in agric. soil averaged over 180 days			O
Concentration in grassland averaged over 180 days			O
Fraction of steady-state (agricultural soil)			O
Fraction of steady-state (grassland soil)			O
LOCAL PECS [INDUSTRIAL USE]			
AIR			
Annual average local PEC in air (total)			O
WATER, SEDIMENT			
Local PEC in surface water during emission episode (dissolved)			O

Qualitative assessment might be needed (TGD Part II, 5.6)			O
Annual average local PEC in surface water (dissolved)			O
Local PEC in fresh-water sediment during emission episode			O
Local PEC in seawater during emission episode (dissolved)			O
Qualitative assessment might be needed (TGD Part II, 5.6)			O
Annual average local PEC in seawater (dissolved)			O
Local PEC in marine sediment during emission episode			O
SOIL, GROUNDWATER			
Local PEC in agric. soil (total) averaged over 30 days			O
Local PEC in agric. soil (total) averaged over 180 days			O
Local PEC in grassland (total) averaged over 180 days			O
Local PEC in pore water of agricultural soil			O
Local PEC in pore water of grassland			O
Local PEC in groundwater under agricultural soil			O
EXPOSURE			
HUMANS EXPOSED TO OR VIA THE ENVIRONMENT			
REGIONAL			
CONCENTRATIONS IN FISH, PLANTS AND DRINKING WATER			
Regional concentration in wet fish			O
Regional concentration in root tissue of plant			O
Regional concentration in leaves of plant			O
Regional concentration in grass (wet weight)			O
Fraction of total uptake by crops from pore water			O
Fraction of total uptake by crops from air			O
Fraction of total uptake by grass from pore water			O
Fraction of total uptake by grass from air			O
Regional concentration in drinking water			O
CONCENTRATIONS IN MEAT AND MILK			
Regional concentration in meat (wet weight)			O
Regional concentration in milk (wet weight)			O
Fraction of total intake by cattle through grass			O
Fraction of total intake by cattle through drinking water			O
Fraction of total intake by cattle through air			O
Fraction of total intake by cattle through soil			O
DAILY HUMAN DOSES			
Daily dose through intake of drinking water			O

Fraction of total dose through intake of drinking water			O
Daily dose through intake of fish			O
Fraction of total dose through intake of fish			O
Daily dose through intake of leaf crops			O
Fraction of total dose through intake of leaf crops			O
Daily dose through intake of root crops			O
Fraction of total dose through intake of root crops			O
Daily dose through intake of meat			O
Fraction of total dose through intake of meat			O
Daily dose through intake of milk			O
Fraction of total dose through intake of milk			O
Daily dose through intake of air			O
Fraction of total dose through intake of air			O
Regional total daily intake for humans			O
[2 "USE OF SD AS A PROCESS CHEMICAL IN SODIUM CHLORATE"] [INDUSTRIAL USE]			
CONCENTRATIONS IN FISH, PLANTS AND DRINKING WATER [2 "USE OF SD AS A PROCESS CHEMICAL IN SODIUM CHLORATE"] [INDUSTRIAL USE]			
Local concentration in wet fish			O
Local concentration in root tissue of plant			O
Local concentration in leaves of plant			O
Local concentration in grass (wet weight)			O
Fraction of total uptake by crops from pore water			O
Fraction of total uptake by crops from air			O
Fraction of total uptake by grass from pore water			O
Fraction of total uptake by grass from air			O
Local concentration in drinking water			O
Annual average local PEC in air (total)			O
CONCENTRATIONS IN MEAT AND MILK [2 "USE OF SD AS A PROCESS CHEMICAL IN SODIUM CHLORATE"] [INDUSTRIAL USE]			
Local concentration in meat (wet weight)			O
Local concentration in milk (wet weight)			O
Fraction of total intake by cattle through grass			O
Fraction of total intake by cattle through drinking water			O
Fraction of total intake by cattle through air			O
Fraction of total intake by cattle through soil			O
DAILY HUMAN DOSES [2 "USE OF SD AS A PROCESS CHEMICAL IN SODIUM CHLORATE"] [INDUSTRIAL USE]			
Daily dose through intake of drinking water			O
Fraction of total dose through intake of drinking water			O

Daily dose through intake of fish			O
Fraction of total dose through intake of fish			O
Daily dose through intake of leaf crops			O
Fraction of total dose through intake of leaf crops			O
Daily dose through intake of root crops			O
Fraction of total dose through intake of root crops			O
Daily dose through intake of meat			O
Fraction of total dose through intake of meat			O
Daily dose through intake of milk			O
Fraction of total dose through intake of milk			O
Daily dose through intake of air			O
Fraction of total dose through intake of air			O
Local total daily intake for humans			O
EFFECTS			
INPUT OF EFFECTS DATA			
MAMMALS			
REPEATED DOSE			
ORAL			
Oral NOAEL (repdose)			D
Oral LOAEL (repdose)			D
Oral CED (repdose)			D
Species for conversion of NOAEL to NOEC			D
Conversion factor NOAEL to NOEC			O
NOEC via food (repdose)			D
LOEC via food (repdose)			D
CED via food (repdose)			D
INHALATORY			
Inhalatory NOAEL (repdose)			D
Inhalatory LOAEL (repdose)			D
Inhalatory CED (repdose)			D
Correction factor for allometric scaling			D
DERMAL			
Dermal NOAEL (repdose)			D
Dermal LOAEL (repdose)			D
Dermal CED (repdose)			D
FERTILITY			
ORAL			
Oral NOAEL (fert)			D
Oral LOAEL (fert)			D
Oral CED (fert)			D

Species for conversion of NOAEL to NOEC			D
Conversion factor NOAEL to NOEC			O
NOEC via food (fert)			D
LOEC via food (fert)			D
CED via food (fert)			D
INHALATORY			
Inhalatory NOAEL (fert)			D
Inhalatory LOAEL (fert)			D
Inhalatory CED (fert)			D
Correction factor for allometric scaling			D
DERMAL			
Dermal NOAEL (fert)			D
Dermal LOAEL (fert)			D
Dermal CED (fert)			D
MATERNAL-TOX			
ORAL			
Oral NOAEL (mattox)			D
Oral LOAEL (mattox)			D
Oral CED (mattox)			D
Species for conversion of NOAEL to NOEC			D
Conversion factor NOAEL to NOEC			O
NOEC via food (mattox)			D
LOEC via food (mattox)			D
CED via food (mattox)			D
INHALATORY			
Inhalatory NOAEL (mattox)			D
Inhalatory LOAEL (mattox)			D
Inhalatory CED (mattox)			D
Correction factor for allometric scaling			D
DERMAL			
Dermal NOAEL (mattox)			D
Dermal LOAEL (mattox)			D
Dermal CED (mattox)			D
DEVELOPMENT-TOX			
ORAL			
Oral NOAEL (devtox)			D
Oral LOAEL (devtox)			D
Oral CED (devtox)			D

Species for conversion of NOAEL to NOEC			D
Conversion factor NOAEL to NOEC			O
NOEC via food (devtox)			D
LOEC via food (devtox)			D
CED via food (devtox)			D
INHALATORY			
Inhalatory NOAEL (devtox)			D
Inhalatory LOAEL (devtox)			D
Inhalatory CED (devtox)			D
Correction factor for allometric scaling			D
DERMAL			
Dermal NOAEL (devtox)			D
Dermal LOAEL (devtox)			D
Dermal CED (devtox)			D
CARC (THRESHOLD)			
ORAL			
Oral NOAEL (carc)			D
Oral LOAEL (carc)			D
Oral CED (carc)			D
Species for conversion of NOAEL to NOEC			D
Conversion factor NOAEL to NOEC			O
NOEC via food (carc)			D
LOEC via food (carc)			D
CED via food (carc)			D
INHALATORY			
Inhalatory NOAEL (carc)			D
Inhalatory LOAEL (carc)			D
Inhalatory CED (carc)			D
Correction factor for allometric scaling			D
DERMAL			
Dermal NOAEL (carc)			D
Dermal LOAEL (carc)			D
Dermal CED (carc)			D
CARC (NON-THRESHOLD)			
ORAL			
Oral T25 for non-threshold effects			D
Oral CED for non-threshold effects			D
Species for conversion of NOAEL to NOEC			D

Conversion factor NOAEL to NOEC			O
T25 via food for non-threshold effects			D
CED via food for non-threshold effects			D
INHALATORY			
Inhalatory T25 for non-threshold effects			D
Inhalatory CED for non-threshold effects			D
Correction factor for allometric scaling			D
DERMAL			
Dermal T25 for non-threshold effects			D
Dermal CED for non-threshold effects			D
ACUTE			
Oral LD50			D
Oral Discriminatory Dose			D
Inhalatory LC50			D
Dermal LD50			D
BIO-AVAILABILITY			
Bioavailability for oral uptake (oral to inhalation)			D
Bioavailability for oral uptake (oral to dermal)			D
Bioavailability for oral uptake (route to oral)			D
Bioavailability for inhalation (route from inhalation)			D
Bioavailability for inhalation (route to inhalation)			D
Bioavailability for dermal uptake (route from dermal)			O
Bioavailability for dermal uptake (route to dermal)			O
HUMANS			
REPEATED DOSE			
ORAL			
Oral NOAEL (repdose)			D
Oral LOAEL (repdose)			D
INHALATORY			
Inhalatory NOAEL (repdose)			D
Inhalatory LOAEL (repdose)			D
DERMAL			
Dermal NOAEL (repdose)			D
Dermal LOAEL (repdose)			D
Dermal NOEC in a medium (repdose)			D
Dermal LOEC in a medium (repdose)			D

FERTILITY			
ORAL			
Oral NOAEL (fert)	████████	████████	D
Oral LOAEL (fert)	████████	████████	D
INHALATORY			
Inhalatory NOAEL (fert)	████████	████████	D
Inhalatory LOAEL (fert)	████████	████████	D
DERMAL			
Dermal NOAEL (fert)	████████	████████	D
Dermal LOAEL (fert)	████████	████████	D
Dermal NOEC in a medium (fert)	████████	████████	D
Dermal LOEC in a medium (fert)	████████	████████	D
MATERNAL-TOX			
ORAL			
Oral NOAEL (mattox)	████████	████████	D
Oral LOAEL (mattox)	████████	████████	D
INHALATORY			
Inhalatory NOAEL (mattox)	████████	████████	D
Inhalatory LOAEL (mattox)	████████	████████	D
DERMAL			
Dermal NOAEL (mattox)	████████	████████	D
Dermal LOAEL (mattox)	████████	████████	D
Dermal NOEC in a medium (mattox)	████████	████████	D
Dermal LOEC in a medium (mattox)	████████	████████	D
DEVELOPMENT-TOX			
ORAL			
Oral NOAEL (devtox)	████████	████████	D
Oral LOAEL (devtox)	████████	████████	D
INHALATORY			
Inhalatory NOAEL (devtox)	████████	████████	D
Inhalatory LOAEL (devtox)	████████	████████	D
DERMAL			
Dermal NOAEL (devtox)	████████	████████	D
Dermal LOAEL (devtox)	████████	████████	D
Dermal NOEC in a medium (devtox)	████████	████████	D
Dermal LOEC in a medium (devtox)	████████	████████	D

CARC (THRESHOLD)			
ORAL			
Oral NOAEL (carc)	████████	████████	D
Oral LOAEL (carc)	████████	████████	D
INHALATORY			
Inhalatory NOAEL (carc)	████████	████████	D
Inhalatory LOAEL (carc)	████████	████████	D
DERMAL			
Dermal NOAEL (carc)	████████	████████	D
Dermal LOAEL (carc)	████████	████████	D
Dermal NOEC in a medium (carc)	████████	████████	D
Dermal LOEC in a medium (carc)	████████	████████	D
CURRENT CLASSIFICATION			
Corrosive (C, R34 or R35)	████████		D
Irritating to skin (Xi, R38)	████████		D
Irritating to eyes (Xi, R36)	████████		D
Risk of serious damage to eyes (Xi, R41)	████████		D
Irritating to respiratory system (Xi, R37)	████████		D
May cause sensitisation by inhalation (Xn, R42)	████████		D
May cause sensitisation by skin contact (Xi, R43)	████████		D
May cause cancer (T, R45)	████████		D
May cause cancer by inhalation (T, R49)	████████		D
Possible risk of irreversible effects (Xn, R40)	████████		D
RISK CHARACTERIZATION			
REFERENCE MOS			
HUMANS EXPOSED TO OR VIA THE ENVIRONMENT			
REPEATED DOSE			
ORAL			
Assessment factor for allometric scaling	████████	████████	D
Assessment factor for remaining interspecies differences	████████	████████	D
Assessment factor for intraspecies differences	████████	████████	D
Assessment factor for differences in exposure duration	████████	████████	D
Assessment factor for differences in exposure route	████████	████████	D
Assessment factor for dose-response relationship	████████	████████	D
Reference-MOS, human environmental, oral (repdose)	████████	████████	O
INHALATORY			
Assessment factor for allometric scaling	████████	████████	D

Assessment factor for remaining interspecies differences			D
Assessment factor for intraspecies differences			D
Assessment factor for differences in exposure duration			D
Assessment factor for differences in exposure route			D
Assessment factor for dose-response relationship			D
Reference-MOS, human environmental, inhalatory (repdose)			O
FERTILITY			
ORAL			
Assessment factor for allometric scaling			D
Assessment factor for remaining interspecies differences			D
Assessment factor for intraspecies differences			D
Assessment factor for differences in exposure duration			D
Assessment factor for differences in exposure route			D
Assessment factor for dose-response relationship			D
Reference-MOS, human environmental, oral (fert)			O
INHALATORY			
Assessment factor for allometric scaling			D
Assessment factor for remaining interspecies differences			D
Assessment factor for intraspecies differences			D
Assessment factor for differences in exposure duration			D
Assessment factor for differences in exposure route			D
Assessment factor for dose-response relationship			D
Reference-MOS, human environmental, inhalatory (fert)			O
MATERNAL-TOX			
ORAL			
Assessment factor for allometric scaling			D
Assessment factor for remaining interspecies differences			D
Assessment factor for intraspecies differences			D
Assessment factor for differences in exposure duration			D
Assessment factor for differences in exposure route			D
Assessment factor for dose-response relationship			D
Reference-MOS, human environmental, oral (mattox)			O
INHALATORY			
Assessment factor for allometric scaling			D
Assessment factor for remaining interspecies differences			D
Assessment factor for intraspecies differences			D
Assessment factor for differences in exposure duration			D

Assessment factor for differences in exposure route			D
Assessment factor for dose-response relationship			D
Reference-MOS, human environmental, inhalatory (mattox)			O
DEVELOPMENT-TOX			
ORAL			
Assessment factor for allometric scaling			D
Assessment factor for remaining interspecies differences			D
Assessment factor for intraspecies differences			D
Assessment factor for differences in exposure duration			D
Assessment factor for differences in exposure route			D
Assessment factor for dose-response relationship			D
Reference-MOS, human environmental, oral (devtox)			O
INHALATORY			
Assessment factor for allometric scaling			D
Assessment factor for remaining interspecies differences			D
Assessment factor for intraspecies differences			D
Assessment factor for differences in exposure duration			D
Assessment factor for differences in exposure route			D
Assessment factor for dose-response relationship			D
Reference-MOS, human environmental, inhalatory (devtox)			O
CARC (THRESHOLD)			
ORAL			
Assessment factor for allometric scaling			D
Assessment factor for remaining interspecies differences			D
Assessment factor for intraspecies differences			D
Assessment factor for differences in exposure duration			D
Assessment factor for differences in exposure route			D
Assessment factor for dose-response relationship			D
Reference-MOS, human environmental, oral (carc)			O
INHALATORY			
Assessment factor for allometric scaling			D
Assessment factor for remaining interspecies differences			D
Assessment factor for intraspecies differences			D
Assessment factor for differences in exposure duration			D
Assessment factor for differences in exposure route			D
Assessment factor for dose-response relationship			D
Reference-MOS, human environmental, inhalatory (carc)			O

CARC (NON-THRESHOLD)			
ORAL			
Assessment factor for allometric scaling	██████	██████	D
Assessment factor for remaining interspecies differences	██████	██████	D
Assessment factor for differences in exposure route	██████	██████	D
Assessment factor for dose-response relationship	██████	██████	D
Assessment factor for extrapolation to a low-risk level	██████	██████	D
Reference-MOE, human environmental, oral (non-threshold)	██████	██████	O
INHALATORY			
Assessment factor for allometric scaling	██████	██████	D
Assessment factor for remaining interspecies differences	██████	██████	D
Assessment factor for differences in exposure route	██████	██████	D
Assessment factor for dose-response relationship	██████	██████	D
Assessment factor for extrapolation to a low-risk level	██████	██████	D
Reference-MOE, human environmental, inhalatory (non-threshold)	██████	██████	O
HUMAN EQUIV. DOSE			
INHALATORY			
Assessment factor for allometric scaling	██████	██████	D
Assessment factor for differences in exposure route	██████	██████	D
Assessment factor humans via environment, inhalatory, non-threshold	██████	██████	O
Human equivalent dose humans via environment, inhalatory, non-threshold	██████	██████	O
TOTAL EXPOSURE			
Assessment factor for allometric scaling	██████	██████	D
Assessment factor for differences in exposure route	██████	██████	D
Assessment factor humans via environment, total, non-threshold	██████	██████	O
Human equivalent dose humans via environment, total, non-threshold	██████	██████	O

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