

CHEMICAL SAFETY REPORT

(Section 9 and 10 non-confidential version)

Legal name of applicant: *LANXESS Elastomers B.V.*

Submitted by: *LANXESS Elastomers B.V.*

Substance: *Sodium dichromate*

CAS No. 10588-01-9 (anhydrous)

CAS No. 7789-12-0 (dihydrate)

EC No. 234-190-3

Use title: *Use of sodium dichromate as corrosion inhibitor in ammonia absorption deep cooling systems*

Use number: *1*

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LIST OF ABBREVIATIONS

µg	Microgram
a	Year
AADC	Ammonia Absorption Deep Cooling
AfA	Application for Authorization
AoA	Analysis of Authorization
APF	Assigned Protection Factor
ART	Advanced Reach Tool
BCF	Bioconcentration factor
bw	Body weight
CHESAR	Chemical Safety Assessment and Reporting Tool
Cr	Chromium
Cr(III)	Trivalent chromium
Cr(VI)	Hexavalent chromium
CrO ₄ ²⁻	Chromate
Cr ₂ O ₃	Chromium oxide
CSR	Chemical Safety Report
d	Day
DNEL	Derived No-Effect Level
EASE	Estimation and Assessment of Substance Exposure
ECETOC	European Centre for Ecotoxicology and Toxicology of Chemicals
ECS	Environmental Contributing Scenario
ELR	Extended Lifetime Risk
EPT	Ethylene-Propylene Terpolymer
ERC	Environmental Release Category
ES	Exposure Scenario
EU RAR	European Union Risk Assessment Report
EUSES	European Union System for the Evaluation of Substances
g	Gram
IC	Industry Category
ICP-MS	Inductively Coupled Plasma Mass Spectrometry
kg	Kilogram
L	Litre
LANXESS	LANXESS Elastomers B.V.
LEV	Local Exhaust Ventilation
m	Metre
m ²	Square metre
m ³	Cubic metre
MC	Main Category
MvE	Man via environment
MvE local inhalation	Man via environment, local inhalation exposure
MvE local oral	Man via environment, local oral exposure
MvE regional inhalation	Man via environment, regional inhalation exposure
MvE regional inhalation	Man via environment, regional oral exposure
min	Minute(s)
Na ₂ Cr ₂ O ₇	Sodium dichromate
NL	The Netherlands
Pa	Pascal

PPE	Personal Protective Equipment
PEC	Predicted Environmental Concentration
PROC	Process category
RAC	Committee for Risk Assessment
RCR	Risk Characterisation Ratio
REACH	Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)
RMM	Risk Management Measure
RPE	Respiratory protective equipment
TGD	Technical Guidance Document
TRA	Targeted Risk Assessment
STP	Sewage Treatment Plant
SU	Sector of Use
UC	Use category
wk	Week
w/w	Weight by weight
WCS	Worker Contributing Scenario

9 EXPOSURE ASSESSMENT (and related risk characterisation)

9.0 Introduction

9.0.1 Overview of uses and exposure scenarios

Tonnage information:

Assessed tonnage: 0.3 tonnes/year based on:

The last 3 years (2012–2014) less than 0.3 tonnes sodium dichromate/year, which is equivalent to 0.12 tonnes hexavalent chromium [Cr(VI)]/year, were purchased by the applicant LANXESS Elastomers B.V. (LANXESS) and consumed in the specific use for which the Application for Authorization (AfA) is made ('Use of sodium dichromate as corrosion inhibitor in ammonia absorption deep cooling systems').

Tonnage supplied per market sector:

Not relevant for this application. This Chemical Safety Report (CSR) has been prepared in the context of an individual AfA of one specific use of sodium dichromate. The current CSR covers only this particular use hence market sector-wide tonnages need not be considered.

The following table lists all the Exposure Scenarios (ESs) assessed in this CSR.

Table 1: Overview of exposure scenarios and contributing scenarios

Identifiers*)	Market Sector	Titles of exposure scenarios and the related contributing scenarios	Tonnage (tonnes per year)
IW-1	Not relevant	Use at industrial site - Use of sodium dichromate as corrosion inhibitor in ammonia absorption deep cooling systems: <ul style="list-style-type: none"> • Use of sodium dichromate as corrosion inhibitor in ammonia absorption deep cooling systems (ERC 7) • Use of sodium dichromate as corrosion inhibitor in ammonia absorption deep cooling systems (PROC 1) • Sampling of cooling medium (PROC 9) • Laboratory analysis of cooling medium (PROC 15) • Concentration adjustment (addition of sodium dichromate solution to the cooling circuit) (PROC 8b) • Maintenance (emptying, intermediate storage of the cooling medium and re-filling) (PROC 8b) • Waste management 	0.3 [= 0.12 as Cr(VI)]
*) Industrial end use at site: IW-#			

Properties of sodium dichromate impacting exposure

Sodium dichromate for use as corrosion inhibitor in Ammonia Absorption Deep Cooling (AADC) systems is supplied as a 60 % weight by weight (w/w) aqueous solution. Sodium dichromate is never handled in pure (solid) form hence any potential exposure occurs to liquid preparations of sodium dichromate.

9.0.2 Introduction to the assessment

9.0.2.1 Environment

Scope and type of assessment:

The current CSR and the associated ES are tailored to supporting the AfA to continue the use of sodium dichromate as corrosion inhibitor in AADC systems after the sunset date in September 2017.

Sodium dichromate has been included into Annex XIV of Regulation (EC) No 1907/2006 ('REACH') due to its intrinsic properties as being carcinogenic (Carc. 1B), mutagenic (Muta. 1B) and toxic to reproduction (Repr. 1B).

Following Regulation (EC) No 1907/2006, Article 62(4)(d) the CSR supporting an AfA needs to cover only those risks arising from the intrinsic properties specified in Annex XIV. Accordingly, only the human health risks related to the classification of sodium dichromate as a carcinogenic, mutagenic and reproductive toxicant are considered in the current CSR. The dominating health effect resulting from the intrinsic hazardous properties of sodium dichromate, being a Cr(VI) compound, is lung cancer due to inhalation of dust and/or aerosols.

Evaluation of any potential hazards to the environment is not required within the framework of this AfA. Health hazards, however may potentially also arise due to exposure of the general population via the environment.

However, in view of the Risk Management Measures (RMMs) in place at the applicant's facility (collection of all waste, be it solid or liquid, and disposal as hazardous waste by a licenced contractor, see below) emissions of sodium dichromate to the environment are effectively prevented.

Emissions to wastewater, however cannot be completely excluded in view of the fact that even a well maintained cooling circuit is not perfectly closed. Although the technical setup and the implemented engineering controls are aimed at ensuring best possible containment of the cooling medium within the circuit, perfect leak-tightness is not achievable. Pumps, valves and connecting flanges are potential weak points that provide options for diffuse leakages (albeit low quantities). In case of such a leakage, a small volume of cooling medium drips on the ground (sealed surface: concrete or asphalt), the liquid evaporates and leaves dried residues of solid chromate (primary transformation product of dichromate) on the surface. Such encrustations may be washed off by rainfall, since the cooling plants are located outdoors. The runoff from the cooling plants is collected by a dedicated drainage system that is separated from the regular wastewater stream. Runoff is directed to 'tanktainers' for hazardous waste which are disposed of by licenced contractors at regular intervals.

Nevertheless, complete segregation of the drainage system from the regular wastewater stream is not possible. Overflow upon intense rain events, or undetected leakages may result in release of Cr(VI) to the Sewage Treatment Plant (STP) and subsequently to the receiving surface water. However, since environmental risks are not within the scope of this AfA these low emissions to the environment are not assessed in detail.

Table 2: Type of risk characterisation required for the environment

Protection target	Type of risk characterisation	Hazard conclusion
Freshwater	Not relevant	–
Sediment (freshwater)	Not relevant	–
Marine water	Not relevant	–
Sediment (marine water)	Not relevant	–
Sewage treatment plant	Not relevant	–
Air	Not relevant	–
Agricultural soil	Not relevant	–
Predator	Not relevant	–

Comments on assessment approach:

In accordance with Regulation (EC) No 1907/2006, Article 62(4)(d) potential risks to the environment need not be considered.

9.0.2.2 Man via environment

Scope and type of assessment:

With reference to Section 1.0.2.1 humans may potentially be exposed to residues of sodium dichromate via the environment. Since sodium dichromate is exclusively handled in the form of aqueous solutions, and the techniques of handling liquids containing sodium dichromate do not result in generation of aerosols, aerial residues can be considered to be essentially zero. Therefore, secondary exposure of humans via the environment in the form of aerial residues need not be expected. However, since worker exposure estimates (inhalation) are calculated in the corresponding worker exposure scenarios in a worst-case approach (despite the obvious lack of aerosol generation and the negligible vapour pressure), also exposure of humans via the environment is calculated in this CSR. In an absolute worst-case approach, exposure of humans via the environment is estimated as follows, demonstrating negligibility of this exposure route.

Quantitative environmental exposure assessments were performed using the European Union System for the Evaluation of Substances (EUSES) version 2.1.2. EUSES is the software implementation of the European Commission Technical Guidance Document (TGD) on Risk Assessment (European Commission, 2003), conveniently allowing calculation of environmental concentrations of chemicals according to algorithms and default assumptions specified in the TGD. For a detailed description of the model the reader is referred to the ECHA guidance on information requirements and chemical safety assessment Chapter R.16: Environmental exposure estimation, version 2.1, October 2012 (ECHA, 2012b) and to the EUSES website (<https://ec.europa.eu/jrc/en/scientific-tool/european-union-system-evaluation-substances>).

A modified worker exposure estimate (inhalation, 90th percentile for long-term exposure) for continuous operation of the AADC systems, generated using the Advanced Reach Tool (ART), is compared with the EUSES-generated concentration of sodium dichromate at the emission source, based on TGD assumptions for release rates for industrial use of corrosion inhibitors. Since worker exposure is always related to a maximum shift duration of 8 hours, the full shift exposure estimate can be considered as the atmospheric concentration that is maximally achievable by the assessed process. Accordingly the aerial exposure concentration estimated by ART can be used for the assessment of the general population without further time correction since the concentration will not increase further. Instead, potential 24 h exposure is reflected by the dose-response relationship (see RAC/27/2013/06 Rev.1). As presented in the Environmental Contributing Scenario (ECS, see Section 0), the estimated atmospheric concentrations calculated by these two different approaches match very well. The EUSES estimate based on default TGD release rates is therefore considered as confirmed by an independent model and is therefore taken forward to the further assessment.

Oral exposure can be excluded: Since sodium dichromate is exclusively handled as aqueous solution in the assessed process steps no particles are generated. The hypothetical inhalation exposure referred to in this section would be to droplets of aqueous sodium dichromate. Therefore, there are no particles that might be transported from the bronchi to the pharynx by mucociliary clearance and subsequently be swallowed. Oral exposure via this mechanism is therefore also irrelevant and will not be assessed in this CSR.

Furthermore, oral exposure of the general population via the food chain can be considered to be insignificant: Any potential losses of sodium dichromate to the wastewater stream (which are expected to be very low, see Section 1.0.2.1) end up in the on-site STP. Being a strong oxidising agent, sodium dichromate is likely to be reduced to trivalent chromium [Cr(III)] by the overabundant organic matter present in wastewater. The potential for accumulation of Cr(VI) in the human food chain is considered to be insignificant, based on a bioconcentration factor of 1 L/kg as determined in the European Union Risk Assessment Report (EU RAR, Munn et al., 2005). Chromium (Cr) of any oxidation state may be distributed either to the solid phase (sewage sludge) or the effluent. In the Netherlands (NL), where the assessed site is located it is legally required to incinerate sewage sludge, so that exposure of humans via field crops fertilised with sludge can be excluded. Accumulation in the aquatic food chain (fish) can also be excluded due to the lack of bioaccumulation potential of Cr(VI) (Munn et al., 2005), and in view of the extremely low amounts of Cr(VI) that may end up in the receiving surface water (if any).

However, oral exposure of the general population via the food chain is nevertheless assessed quantitatively in this CSR following (i) an absolute worst-case approach and (ii) a reasonable worst-case approach in accordance with the EU RAR: Any potential losses of Cr(VI) from the AADC are assumed to be directed to wastewater (which is not the case in reality, also see Section 1.1). These hypothetical releases to wastewater are assumed to amount to the default release factor of ERC 7 (industrial use of substances in closed systems) of 5 %. The assessed site is equipped with an on-site STP. Removal of Cr(VI) in the STP is assumed to be 50 %, in accordance with the EU RAR (Munn et al., 2005). The hydraulic parameters of the on-site STP and the receiving surface water (river Maas) are adopted for calculating local concentrations (see Section 1.1.1.1).

- (i) In a clear worst-case approach, no correction for transformation of Cr(VI) to Cr(III) is taken into account, i.e. it is assumed that all released Cr(VI) maintains its oxidation state throughout its potential transfer in the food chain.

- (ii) In the reasonable worst-case approach the conclusion from the EU RAR is adopted that 97 % of the Cr(VI) released to the environment is converted to Cr(III). Accordingly, doses to humans via the food chain are corrected by a factor of 0.03.

A further remark on the worst-case character of scenario (ii): The conversion factor of 97 % is related to conversion processes in the environmental matrix (typically water and/or water-sediment systems; see Munn et al., 2005), and does not yet consider any conversion processes (reduction) during uptake by living organisms. There is a wealth of literature (summarised in Munn et al., 2005) demonstrating that organisms are capable of reducing Cr(VI) during uptake. However, quantitative figure, e.g. percentages, reduction rates, are not readily available since internal Cr concentrations were invariably presented as total Cr. Therefore the modelled concentrations in food commodities still represent a substantial overestimation of Cr(VI) levels even after correction for reduction by the aforementioned factor of 0.03.

Table 3: Type of risk characterisation required for man via the environment

Route of exposure and type of effects	Type of risk characterisation	Hazard conclusion (see RAC/27/2013/06 Rev.1* and Section 5.11)
Inhalation: Local long-term	Quantitative	Lung cancer: ELR = 2.9E-02 per µg Cr(VI)/m ³ for 70 years
Inhalation: Systemic long-term	Quantitative	Reproduction: DNEL = 3.0E+00 µg Cr(VI)/m ³
Oral: Local long-term	Qualitative	Intestinal cancer: ELR = 8.0E-04 per µg Cr(VI)/kg bw/d for 70 years
Oral: Systemic long-term	Quantitative	Reproduction: DNEL = 4.0E+00 µg Cr(VI)/kg bw/d

*) By reference to this, the applicant neither agrees nor disagrees with this dose-response relationship. However, the applicant acknowledges that the dose-response relationship is likely to be conservative and protective for human health, particularly considering the extrapolated linear relationship at low exposure concentrations.

ELR = Excess lifetime risk; DNEL = Derived no-effect level

Comments on assessment approach:

As detailed above, exposure of the general population via the environment (ambient air and the food chain) follows a worst-case approach, ignoring the conversion of Cr(VI) to Cr(III) taking place in the environment. According to the EU RAR (Munn et al., 2005) “releases of chromium (VI) from any sources are expected to be reduced to chromium (III) in most situations in the environment (see Section 3.1.1.2.1) so the impact of chromium (VI) as such is likely to be limited to the area around the source”.

For inhalation exposure, a quantitative worst-case assessment is provided.

9.0.2.3 Workers

Scope and type of assessment:**Table 4:** Type of risk characterisation required for workers

Route	Type of effect	Type of risk characterisation	Hazard conclusion (see RAC/27/2013/06 Rev.1* and Section 5.11)
Inhalation	Systemic long-term	Quantitative	Reproduction: DNEL = 1.6E+01 µg Cr(VI)/m ³
	Systemic acute	Not required	Not relevant
	Local long term	Quantitative	Lung cancer: ELR = 4.0E-03 per µg Cr(VI)/m ³ for 40 years
	Local acute	Not required	Not relevant
Dermal	Systemic long term	Quantitative	Reproduction: DNEL = 1.4E+01 µg Cr(VI)/kg bw/d
	Systemic acute	Not required	Not relevant
	Local long term	Not required	Not relevant
	Local acute	Not required	Not relevant
Eye	Local	Not required	Not relevant

*) By reference to this, the applicant neither agrees nor disagrees with this dose-response relationship. However, the applicant acknowledges that the dose-response relationship is likely to be conservative and protective for human health, particularly considering the extrapolated linear relationship at low exposure concentrations.

ELR = Excess lifetime risk; DNEL = Derived no-effect level

Comments on assessment approach related to toxicological hazard:

Sodium dichromate has been included into Annex XIV of Regulation (EC) No 1907/2006 ('REACH') due to its intrinsic properties as being carcinogenic (Carc. 1B), mutagenic (Muta. 1B) and toxic to reproduction (Repr. 1B).

Following Regulation (EC) No 1907/2006, Article 62(4)(d), the CSR supporting an AfA needs to cover only those risks arising from the intrinsic properties specified in Annex XIV. The dominating health effect resulting from the intrinsic hazardous properties of sodium dichromate is lung cancer due to inhalation of dust and/or aerosols. Intestinal cancer following ingestion is also identified as a potential risk. However, the dose-response relationship for intestinal cancer is lower than that for lung cancer, and ingestion is generally not considered an important exposure route for workers.

Since sodium dichromate is also classified for toxicity to reproduction (H360FD) an additional risk assessment needs to be performed. DNELs for the inhalation and dermal route were derived, with the aim of demonstrating adequate control of reproductive risks. Effects on fertility (spermatogenesis) were identified as the most relevant endpoint.

Quantitative worker dermal exposure assessments were performed using MEASE v1.02.01. MEASE constitutes a Tier 1 exposure assessment tool specifically developed for metals and inorganic substances. Unlike the European Centre for Ecotoxicology and Toxicology of Chemicals (ECETOC) Targeted Risk Assessment (TRA) tool, which aims at very broad applicability, MEASE reflects some specific conditions for exposure assessment of metals and inorganic substances. For estimating dermal exposure, MEASE combines the classification system of the previously used Estimation and Assessment of Substance Exposure (EASE) mode with measured data for several metal commodities. The measurement results were collated and plotted against the EASE exposure classes in the "dermal factsheet" of the HERAG project. MEASE was calibrated using data on nickel compounds. Being strong skin sensitizers, avoiding dermal exposure of nickel compounds to the greatest possible extent is a crucial target of occupational hygiene. Therefore, MEASE is applicable for estimating low exposures, as relevant for non-threshold carcinogens like Cr(VI) substances (similar to skin sensitizers). It is further noted that the current version of MEASE is nominated as a first tier assessment tool for occupational exposure for metals and inorganic substances in the ECHA guidance on information requirements and chemical safety assessment, chapter R.14: Occupational exposure estimation, version 2.1, November 2012 (ECHA, 2012a).

Quantitative worker inhalation exposure assessments were performed using the Advanced Reach Tool (ART) version 1.5. ART is a tier 2 model that was developed for higher tier exposure assessment, generating scientifically justified and realistic exposure estimates. For a detailed description of the model the reader is referred to the ECHA guidance on information requirements and chemical safety assessment, chapter R.14: Occupational exposure estimation, version 2.1, November 2012 (ECHA, 2012a) and to the ART website (<http://www.advancedreachtool.com>).

Exposure estimates generated by ART are given as the 90th percentile of the exposure distribution, in accordance with the ECHA guidance on information requirements and chemical safety assessment, chapter R.14: Occupational exposure estimation, version 2.1, November 2012 (ECHA 2012a). For the type of preparation assessed in this CSR (non-volatile liquids with low viscosity) the developers and reviewers of ART have not identified any restrictions of the applicability of the model (Fransman et al., 2013). The basic model-generated exposure estimates (ART) are calculated as sodium dichromate (Na₂Cr₂O₇). Since the reference dose-response relationship is based on Cr(VI) concentrations, i.e. a fraction of the entire substance, exposure estimates will be converted into Cr(VI) using the Cr content of sodium dichromate (39.697 %) as conversion factor.

Worker exposure events are relatively rare – see detailed description of the use profile in Section 1.0.1. The dose-response relationship (RAC/27/2013/06 Rev.1) quantifies the excess lifetime cancer mortality risk based on every day occupational exposure (5 days per week, 8 hours per day) over a whole working life of 40 years. In order to adapt the risk characterisation for the infrequent and discontinuous exposure pattern actually experienced by the cooling plant staff, the exposure estimate and hence the corresponding ELR is corrected for average yearly exposure duration, depending on the exposure patterns identified for each contributing scenario (see below).

Comments on assessment approach related to physicochemical hazard:

Not relevant. Physicochemical hazards are not subject of this CSR.

General information on risk management related to toxicological hazard:

Exposure of workers handling materials containing sodium dichromate during use as corrosion inhibitor in AADC systems is restricted to the lowest possible level:

Pure (solid) sodium dichromate is not handled at any time. Sodium dichromate is supplied as a 60 % (w/w) aqueous solution. The material is ordered from the supplier only when required and is not stored on the site, but instead is introduced into the cooling systems instantly upon arrival. The cooling circuit itself is a closed system, allowing only minimal amounts of the cooling medium to be released. The leak-tightness of the system is required to avoid release of ammonia in the first place. Leakages can be detected primarily by the pungent odour of ammonia, which is noticeable already at very low concentrations. Personnel are required to wear Personal Protective Equipment (PPE), i.e. protective clothing (work coveralls), chemical-resistant gloves, and safety goggles. During maintenance, when the cooling system needs to be opened, Respiratory Protective Equipment (RPE) is mandatory temporarily for all persons performing these operations. Access by non-involved individuals is restricted. RPE is again primarily focussed on ammonia, but is also suitable for minimising any potential exposure to Cr(VI) [supplied air full face mask, pressure demand mode, Assigned Protection Factor (APF) 2000].

Aqueous solutions of sodium dichromate are expected to entail only a low potential for generating mists, not requiring RPE. Nevertheless, protective clothing, chemical-resistant gloves, and safety goggles are mandatory for those tasks involving handling of the liquid formulation. RPE is mandatory to protect against the potential presence of ammonia during the activities described by the WCS 2, 4 and 5.

General information on risk management related to physicochemical hazard:

Not relevant. Physicochemical hazards are not subject of this CSR.

9.0.2.4 Consumers

Scope and type of assessment:

The AfA to continue the use of sodium dichromate as corrosion inhibitor in AADC systems is restricted to one specific industrial use only. Therefore, consumer uses are not subject of this CSR.

9.1 Exposure scenario 1: Use at industrial site – Use of sodium dichromate as corrosion inhibitor in ammonia absorption deep cooling systems

Sector of use:

SU 11: Manufacture of rubber products

Environment contributing scenario(s):	
Use of sodium dichromate as corrosion inhibitor in ammonia absorption deep cooling systems	ERC 7
Worker contributing scenario(s):	
Use of sodium dichromate as corrosion inhibitor in ammonia absorption deep cooling systems	PROC 1
Sampling of cooling medium	PROC 9
Laboratory analysis of cooling medium	PROC 15
Concentration adjustment (addition of sodium dichromate solution to the cooling circuit)	PROC 8b
Maintenance (emptying, intermediate storage of the cooling medium and re-filling)	PROC 8b
Waste management	PROC 8b

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

In contrast to compression cooling systems that are usually driven by electrical energy make absorption cooling systems use of thermal energy to produce cold. A simplified functional scheme of an AADC system is presented in Figure 1.

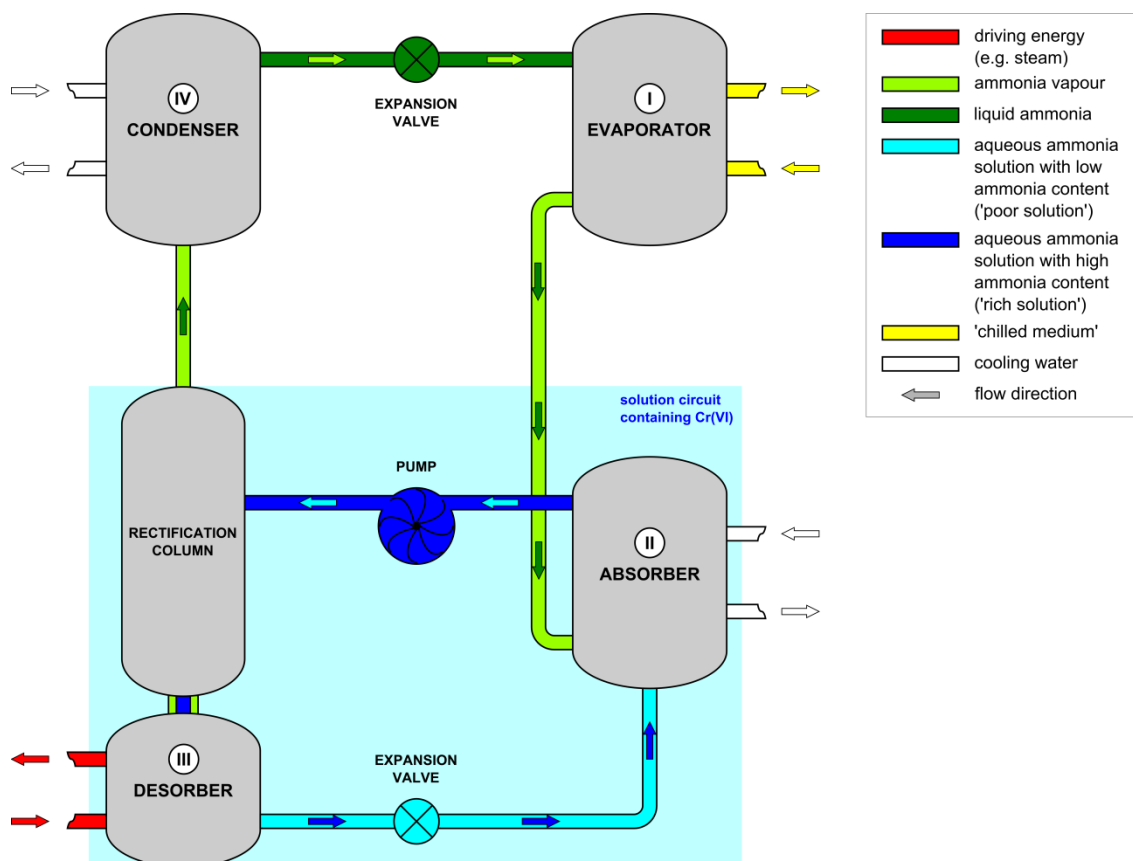


Figure 1: Simplified functional scheme of an AADC system

AADC systems allow for producing cold down to $-60\text{ }^{\circ}\text{C}$ using excess or waste heat as the main energy source ('driving energy'), e.g. steam.

The ammonia absorption refrigeration process/cycle can be subdivided into the four basic steps shown in Table 5.

Table 5: Basic steps of the ammonia absorption refrigeration process/cycle

	Description
Step 1	In an evaporator (I) liquid ammonia is evaporated at low (sub-atmospheric) pressure by taking the required energy ('heat of evaporation') from surrounding area. Upon which a liquid [e.g. reactor feed (monomers) for the LANXESS EPDM production] that is pumped through the evaporator in a separate circuit is cooled down ('chilled medium').
Step 2	The ammonia vapour generated in Step 1 is transferred to an absorber (II) , where it is taken up (absorbed) by an aqueous ammonia solution with a low ammonia content ('poor solution') leading to an ammonia enriched solution ('rich solution'), which is fed to a rectification column that is connected to a desorber (III) .
Step 3	By heating up in the desorber (III) the 'rich solution' generated in Step 2 is separated into 'poor solution', consisting mainly of water and 'vapour', consisting mainly of ammonia. The 'poor solution' is sent back to the absorber to again absorbing ("used") ammonia vapour and producing a 'rich solution'. Whereas the 'vapour' is purified in the rectification column to result in nearly pure ammonia vapour.
Step 4	The ammonia vapour generated in Step 3 is liquefied in a condenser (IV) and again fed into the evaporator.

AADC systems that rely on sodium dichromate as corrosion inhibitor are designed as closed systems since it is imperative to safely enclose the ammonia-based cooling medium within the cooling circuit.

Three Ethylene-Propylene Terpolymer (EPT) plants are located at the LANXESS site in the industrial complex of the Chemelot Industrial Park in Geleen (NL) (see Figure 2): EPT1 and EPT2 are of an older construction design. EPT3 is of a more recent design, larger and more powerful (Figure 3).

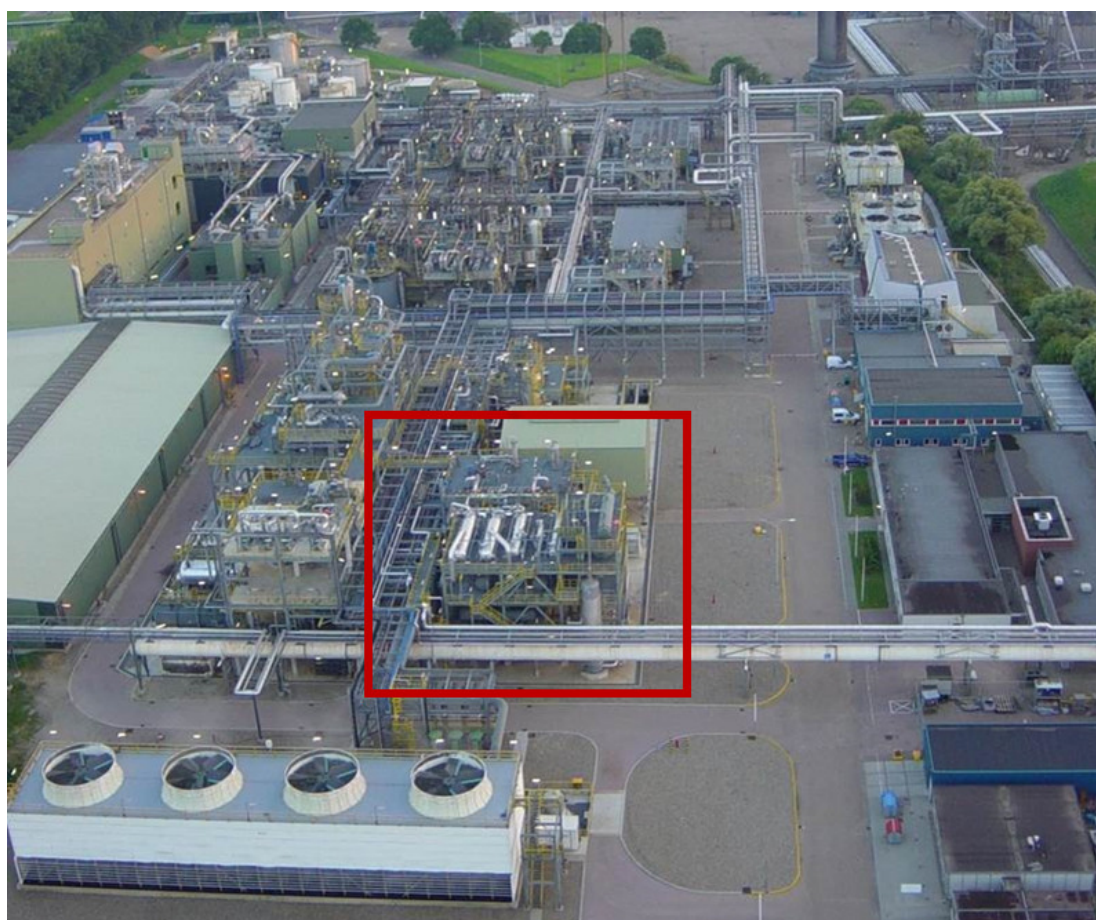


Figure 2: Overview of the LANXESS EPDM plants in Geleen (NL). The red frame highlights the AADC system for EPT3.



Figure 3: LANXESS AADC system for EPT3 in Geleen (NL).

The target concentration of sodium dichromate in order to provide effective corrosion prevention is 5 g/L. The concentration is adjusted to this target value by adding fresh aqueous sodium dichromate to the system (concentration adjustment). The actual concentration is inevitably lowered during regular operation of the cooling plant, as a result of the protective effect against corrosion. The target concentration provides a generous safety margin for maintaining the protective effect.

The following Worker Contributing Scenarios (WCSs) and related tasks and activities have been identified:

- 1. Use of sodium dichromate as corrosion inhibitor in ammonia absorption deep cooling systems:**
Exposure to sodium dichromate due to normal operation of the cooling plant is negligible. Workers are normally only present on the plant for daily inspection activities, not exceeding a few minutes per day. For exposure modelling, a worst-case duration of < 1 hour is assumed.
- 2. Sampling of cooling medium:**
Samples are taken 12 times per year (4 times per cooling plant; 3 plants are operated on the site). The duration of this activity is < 15 minutes. A visual impression of the equipment and hence of the procedure of sampling is given in Figure 4.
- 3. Laboratory analysis of cooling medium:**
Samples are analysed 12 times per year (4 times per cooling plant; 3 plants are operated on the site). The duration of this activity is < 15 minutes. The activity comprises transfer of sub-samples of cooling medium using a pipette followed by fully automated analysis (automated titration and/or ICP-MS).
- 4. Concentration adjustment (addition of sodium dichromate solution to the cooling circuit):**
On average, concentration adjustment is necessary (based on analytical results) twice a year. Not every sampling and analysis will automatically result in the need for adjusting the sodium dichromate concentration in the system. The duration of this activity is approximately 1 hour. The activity comprises opening the drum in which the aqueous sodium dichromate solution (approximately 20 kg solution per drum) is supplied, inserting the suction hose, opening the dedicated valve and waiting until the content of the drum is introduced into the cooling system (by vacuum). These steps are repeated as

required (typically 2–3 times). Approximately 30–40 kg sodium dichromate solution may need to be added per event. Therefore, two activities are described and assessed under this scenario: (a) handling of contaminated objects (opening and closing of screw caps; moving the suction hose between drums), and (b) automated transfer of aqueous sodium dichromate solution by means of vacuum. An image of the installation for introducing fresh sodium dichromate solution (suction hose) is presented in Figure 5.

5. Maintenance (emptying, intermediate storage of the cooling medium and re-filling):

For system maintenance, the respective cooling circuit needs to be completely emptied. The cooling medium is transferred into an intermediate storage tank ('tanktainer') via a flexible steel hose, which is connected prior to the maintenance activities. The cooling circuit is rinsed at least twice with clear water in order to remove any residues of ammonia and Cr(VI). This is done remotely, with no direct interference of personnel. However, the rinsing water is collected in separate tanks ('tanktainer') and disposed of as hazardous waste by a licenced contractor (waste management company). Therefore, the hose needs to be coupled and decoupled repeatedly. Maintenance itself is performed by external service technicians and consists of inspection of hardware for wear and mechanical integrity, and replacement of parts where necessary. Rinsing of the system is an RMM to protect service technicians from exposure to ammonia and Cr(VI). Therefore, there is no exposure of workers from maintenance itself. After maintenance, the cooling medium is re-introduced (vacuum) using the same flexible steel hose (see Figure 6) by remote control. Accordingly, two activities are described and assessed under this scenario: (a) handling of contaminated objects (coupling/decoupling of the flexible metal hose), and (b) monitoring the transfer of cooling medium and/or rinsing water.

6. Waste management:

The rinsing water generated during maintenance (see item 5), and also Cr(III) slurry [e.g. chromium oxide, (Cr₂O₃)] formed as a result of corrosion inhibition, are directed to dedicated waste containers. All waste from rinsing/maintenance is disposed of by a licenced waste management company (external contractor). Transfer to the waste containers takes place via fixed piping (see item 5) hence exposure of personnel can be excluded beforehand. Waste disposal by the external contractor is a separate life cycle stage that is not considered in the context of this CSR. Therefore, there are no activities related to waste management that need to be assessed. This stage is only mentioned for the sake of completeness, and for illustrating the fate of Cr(VI) following use. Solid waste, i.e. empty drums from concentration adjustment are disposed as hazardous waste. Residual Cr(VI) is safely enclosed in the sealed drums, therefore no exposure from this task needs to be expected.



Figure 4: Sampling procedure (simulated realistic use conditions).
 Sampling point in regular state; sampling point with installed pipe; worker with prescribed PPE; placing of sample bottle; opening of valve; removal and sealing of sample bottle (from upper left to lower right).

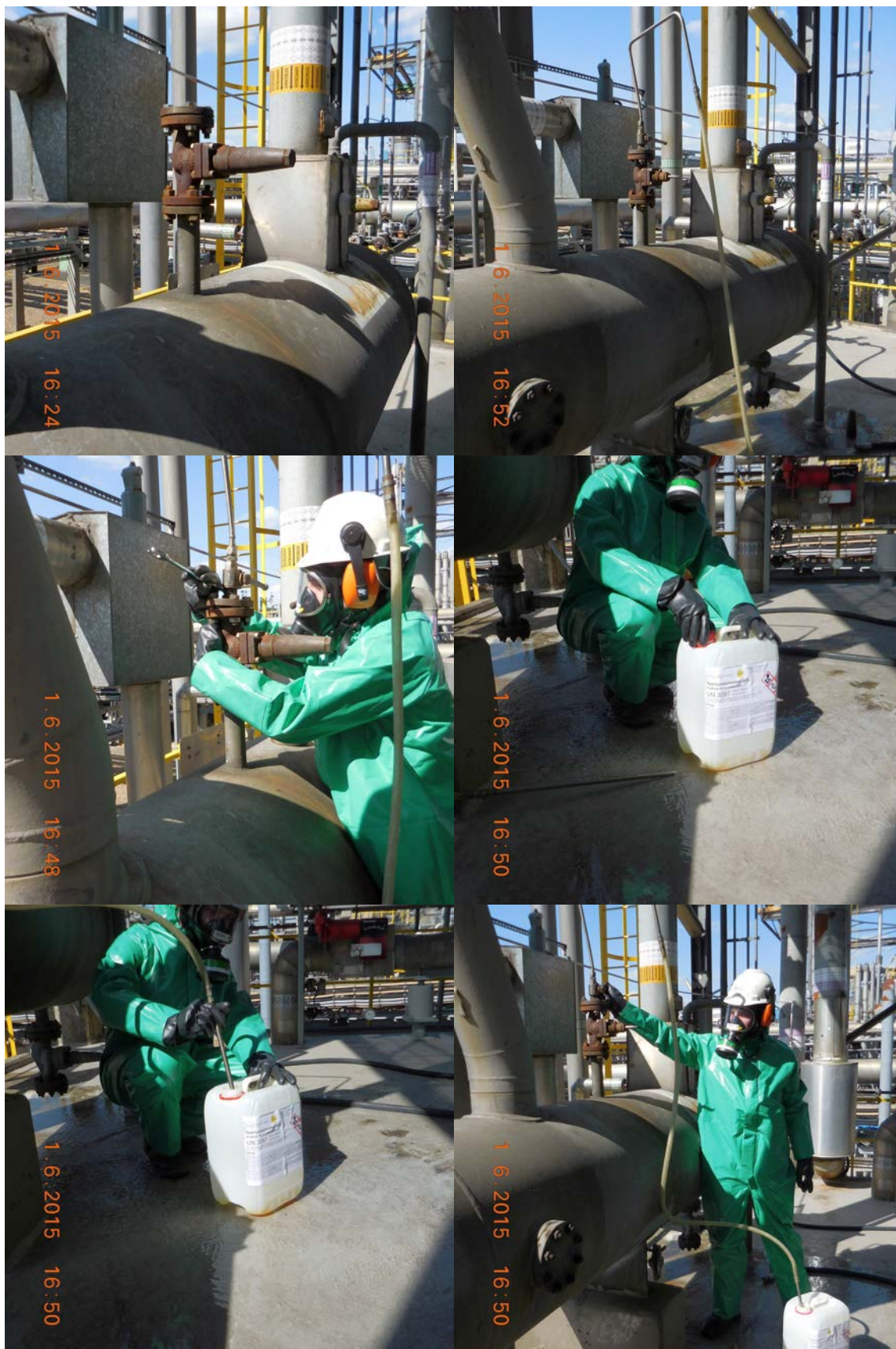


Figure 5: Concentration adjustment (simulated realistic use conditions).
 Dosing point in regular state; dosing point with installed suction hose; mounting/unmounting of suction hose; opening of the drum containing aqueous sodium dichromate solution; insertion of suction hose; opening of valve (from upper left to lower right).



Figure 6: Flexible steel hose for connecting the cooling circuit with interim storage tank during maintenance

The following safety measures and/or characteristics of the facility are relevant for the assessed site:

Occupational:

- Localised controls [Local Exhaust Ventilation (LEV): fume cupboard] for laboratory analysis (WCS 3)
- All employees wear PPE including work coveralls or lab coat, as appropriate, goggles, gloves and supplied air full face mask or ABEK P3 full face mask, where appropriate. PPE and RPE are further specified in the respective WCSs
- The cooling plants are located outdoors on impermeable sealed ground (concrete, asphalt)

Environmental:

- The facility is not connected to the wastewater stream hence no wastewater is discharged from the cooling plant. All solid waste and any liquid waste is collected (e.g. solutions and slurry generated through rinsing of the system during maintenance) and forwarded to an external waste management company (licensed contractor) for disposal as hazardous waste. Nevertheless, malfunction of the dedicated drainage system, or intense rainfall may lead to release of small amounts of Cr(VI) to the wastewater stream. However, in view of the aforementioned details on environmental fate and the non-relevance of environmental hazards in the context this authorisation application, quantitative emission estimations need not be performed.

Explanation on the approach taken for the ES:

Occupational inhalation exposure estimates are based on modelling. ART, for inhalation exposure, is generally preferred over ECETOC TRA due to greater flexibility and versatility. The figures obtained are thus considered to be reasonable worst-case estimates. Measured concentrations of aerial residues of Cr are not available. Biological monitoring of plant workers (measurement of concentrations of Cr in urine before and after performing activities on the cooling plants) is an option for future medical surveillance. Currently, however, biological monitoring data of sufficient quality are not available.

In view of the strict separation of the production facility from the wastewater stream any releases to the aquatic environment are essentially zero. Cr(VI) is rapidly reduced to Cr(III) by the organic material (both dissolved and particulate) present in wastewater. This is reflected in the ECS below.

The assessment of exposure of man via the environment is restricted to the aerial path (inhalation). As already explained in Section 1.0.2.2, oral exposure via the food chain can be considered as insignificant due to (i) extremely low releases to the aquatic environment and (ii) reductive conversion of Cr(VI) to Cr(III) in the presence of organic carbon (Munn et al., 2005). Oral exposure via the food chain is therefore assessed qualitatively, whereas inhalation exposure is estimated in a worst-case approach.

For estimating airborne concentrations of Cr(VI) the standalone version of EUSES 2.1.2 was used. EUSES is the software implementation of the TGD on Risk Assessment (European Commission, 2003), conveniently allowing calculation of environmental concentrations of chemicals according to algorithms and default assumptions specified in the TGD. Some default assumptions of the TGD, most notably environmental release fractions, deviate from those given in more recent ECHA guidance on information requirements and chemical safety assessment, chapter R.16:

Environmental exposure estimation, version 2.1, October 2012 (ECHA, 2012b). However, it is considered justified to adopt the less conservative TGD assumptions for release to air, for the following reasons:

- Sodium dichromate and any of its transformation products generated in the cooling system are not volatile
- The process is fully closed, operates continuously and does not generate any mists or aerosols
- A check for consistency and plausibility has been performed during compilation of this CSR. The aerial concentration estimated by EUSES was compared with an occupational exposure estimation by ART and found to be nearly equivalent. Details on the procedure and the results are presented in the ECS (Section 0). The model input parameters are provided in Annex A.

Accordingly, the TGD compliant release rate to air of 0.001 % is considered to be justified and to still represent a worst-case.

9.1.1 Environmental contributing scenario 1 – Use of sodium dichromate as corrosion inhibitor in ammonia absorption deep cooling systems (ERC 7)

9.1.1.1 Conditions of use

Referring to the process description in the general introduction to this ES (Section 1.1), the conditions of use and the resulting release factors are specified as follows:

- Sodium dichromate and any of its transformation products generated in the cooling system are not volatile
- The process is fully closed, operates continuously and does not generate any mists or aerosols
- The EUSES Industry Category (IC) is: IC = 15/0, others
- The EUSES Use Category (UC) is: UC = 14, corrosion inhibitors
- The EUSES Main Category (MC) industrial use is: MC = III, non-dispersive use

According to these conditions of use, TGD Table A3.16 (general table) and TGD Table B3.14 (general table) are selected for air, whereas the ERC 7 default is maintained for water, resulting in assignment of the following release factors:

- Air: 0.001 %
- Water: 5 %
- Industrial soil: 0.1 %

For this ECS, release to soil is manually set to 0 % since the cooling plants are installed on sealed ground. The release fraction to water is adopted from ERC 7 (closed systems).

Based on these assumptions and parameters EUSES calculates an aerial concentration of sodium dichromate at the emission source of $2.3E-06 \mu\text{g}/\text{m}^3$. This value can be taken forward to the exposure estimation for man via the environment if consistent with the occupational exposure estimate obtained for equivalent conditions of use. This is the case for WCS 1 (Section 1.1.2) which describes the continuous operation of the AADC system. An occupational exposure estimate for workers performing daily routine checks of the cooling plants is calculated using ART. However, that exposure estimate is normalised to an 8 h shift based on only 1 h exposure per working day. For enabling a meaningful comparison, an estimate reflecting continuous 8 h exposure is necessary. To achieve this, a separate ART calculation was performed, with equivalent input parameters as given in Section 1.1.2, except an exposure period of 8 h. The model input parameters are provided in Annex A. The resulting aerial concentration is considered to reflect the worst-case steady state concentration at the emission source, independent from exposure time since the ART 8 h estimate is considered to represent the maximally achievable aerial concentration for the assessed process. Potential 24 hour exposure is reflected by the dose-response curve for the general population (also see Section 1.0.2.2).

The result of this ART model is an aerial concentration of $4.5E-06 \mu\text{g}/\text{m}^3$. This matches very well with the EUSES estimate of $2.3E-06 \mu\text{g}/\text{m}^3$. Therefore, it is considered fully justified to use the EUSES calculation for estimating the exposure of humans via the environment (airborne residues). Given the fact that EUSES equals the concentration at the point source with that at 100 m distance, it is considered justified to adopt the slightly less conservative EUSES estimate for the risk assessment.

Amount used, frequency and duration of use (or from service life)
<ul style="list-style-type: none"> ▪ Daily use at site: ≤ 0.00082 tonnes/day (= 0.82 kg/d) <p><i>The worst-case amount used per day is derived from a worst-case annual tonnage of 300 kg sodium dichromate required for adjusting the concentration in the cooling circuits of the three plants operated at the assessed site, divided by 365 calendar days. The cooling plants are running continuously year-round.</i></p>
<ul style="list-style-type: none"> ▪ Annual use at site: ≤ 0.3 tonnes/year <p><i>The actual average tonnage consumed by the three cooling plants operated at the assessed site is 240 kg/a (years 2012–2014). Allowing some fluctuation, a worst-case tonnage of 300 kg/a is assumed. The applicant strives for further reduction of the required amount by optimisation of the process, which underpins the worst-case character of the 300 kg/a figure.</i></p>
Technical and organisational conditions and measures
<ul style="list-style-type: none"> ▪ Best possible segregation of the AADC systems from the wastewater stream ▪ Collection of liquid waste including drainage water (run-off from concrete surfaces), forwarding to an external waste management company (licenced contractor) for disposal as hazardous waste

Conditions and measures related to sewage treatment plant
<ul style="list-style-type: none"> ▪ Municipal STP: No [Effectiveness Water: 0%] <i>The cooling plant is not connected to a municipal STP.</i>
<ul style="list-style-type: none"> ▪ On-site STP: Yes [Effectiveness Water: 50 %] <i>In accordance with the EU RAR, 50 % removal by adsorption onto sewage sludge can be considered as a worst-case figure. Being a strong oxidising agent, potentially released Cr(VI) is reduced to Cr(III) by the organic material present in wastewater. Since reduction kinetics hence the degree of transformation depend on variable conditions in wastewater treatment (aeration, concentration of dissolved and particulate organic matter, etc.) chemical reduction is not considered in this assessment in a worst-case approach.</i>
<ul style="list-style-type: none"> ▪ Any liquid waste is collected and forwarded to an external waste management company (licenced contractor) for disposal as hazardous waste (see above). Nevertheless, diffuse losses to the wastewater stream including run-off from the hard surface on which the cooling plants are placed, cannot be definitively excluded. These diffuse losses can be expected to be directed to the on-site STP, where 50 % of the potentially released Cr(VI) is removed by adsorption (see above), and 50 % are released to the receiving surface water (in the current site-specific case the “Julianakanaal”, a navigable canal directly connected to the Maas river. Eventually, Cr(VI) is largely reduced to Cr(III) either in the STP and/or in the receiving surface water (see Munn et al., 2005).
Conditions and measures related to treatment of waste (including article waste)
<ul style="list-style-type: none"> ▪ Collection of all liquid waste, disposal as hazardous waste by an external waste management company (licenced contractor)
Other conditions affecting environmental exposure
<ul style="list-style-type: none"> • Discharge rate of effluent: $\geq 7.68E+04$ m³/d <i>This is the specific discharge rate of the on-site STP at Chemelot Industrial Park in Geleen (NL) that receives any wastewater from LANXESS.</i>
<ul style="list-style-type: none"> • Receiving surface water flow rate: $\geq 1.987E7$ m³/d <i>The effluent of the on-site STP is discharged to the river Maas. The average flow rate of the Maas (years 1981–1990) at the gauge Borgharen (Maastricht, NL), located approximately 15 km upstream the discharge point of the STP, is reported to be 230 m³/s (Anonymous, 1994). This value corresponds to a daily flow rate of 19872000 m³/d.</i>
Additional good practice advice. Obligations according to Article 37(4) of REACH do not apply
<ul style="list-style-type: none"> ▪ Not applicable

9.1.1.2 Releases

Table 6: Local releases to the environment

Release	Release factor estimation method	Explanation/justification
Water	ERC based	<p>Initial release factor: 5 %</p> <p>Final release factor: 2.5 %</p> <p>Local release rate: 0.02 kg/day</p> <p>Explanation/justification: Estimation based on the worst-case annual consumption of 300 kg sodium dichromate, which is equivalent to 120 kg Cr(VI), and the ERC default release factor, taking into account 50 % removal of Cr(VI) in the STP. The cooling system is in operation 365 days per year.</p>
Air	Release factor	<p>Initial release factor: 0.001 %</p> <p>Final release factor: 0.001 %</p> <p>Local release rate: 8.2E-06 kg/day</p> <p>Explanation/justification: The release factor to air was defined according to the TGD Part II, Appendix I, Tables A3.16 and B3.14 (European Commission, 2003). Sodium dichromate is a substance of negligible volatility. Corrosion inhibitors are allocated to the TGD UC 14. EUSES 2.1.2 by default allocates the above release factor.</p>

Release	Release factor estimation method	Explanation/justification
Soil	Release factor	Final release factor: 0 % Explanation/justification: The technical measures in place ensure that emissions to soil are essentially zero.

Remarks on environmental releases:

AADC systems constitute closed loops that are designed for prevention of any release of cooling medium. The cooling medium circulates within the system, without any contact to the environment. Nevertheless, any such system cannot be perfectly leak-tight. Valves, flanges, or pumps provide opportunities for leaking of minor amounts of cooling medium. It is, however, obvious from the technical description of the system that the amounts leaked from these weak spots are minute. The default release factor to water of 5 % (ERC 7) can therefore be considered to be sufficiently conservative. Moreover, for a substance lacking any significant vapour pressure like sodium dichromate which is used in a way that no aerosols whatsoever are generated (closed system), it is obvious that release to air from the process is insignificant. Therefore, the release factor to air for corrosion inhibitors of 0.001 %, based on the TGD, is considered to be sufficiently conservative. Release to soil can be considered to be negligible since the AADC systems are located in the "technosphere", i.e. an industrial site mostly covered by concrete or asphalt, and run-off from hard surfaces is drained collected as hazardous waste.

The need to refill sodium dichromate into the AADC systems arises from the technical function of dichromate as corrosion inhibitor (also see AoA): Dichromate is hydrolysed, giving chromate (CrO_4^{2-}), which is subsequently reduced to Cr(III) as a result of protecting the steel piping of the system from corrosion:



Chromium oxide (Cr_2O_3) formed in this reaction is significantly less water soluble than sodium dichromate and will therefore precipitate in the system in the form of slurries. During maintenance, performed every 4–6 years, depending on the design of the plant, the cooling system is emptied, and Cr(III) slurries are removed. The system is rinsed at least twice with clear water in order to protect service technicians from exposure to residues of ammonia and Cr(VI). Rinsing water and slurries are disposed of as hazardous waste via a licenced contractor, whereas the removed cooling medium is safely stored and re-introduced into the system upon completion of maintenance. Handling of cooling medium and waste as described here underpins the conservative nature of the default release factors (Table 6).

Releases to waste

Release factor to waste from the process: During maintenance, all Cr(VI) converted to Cr(III) and precipitated in the form of slurry is removed and disposed of as hazardous waste. This also applied to any Cr(VI) still present in rinsing water, which is disposed of in the same way. Empty packaging units (drums) from concentration adjustment with 60 % w/w aqueous sodium dichromate solution are sealed and disposed of as hazardous waste. The release factor to waste may therefore be given as 100 % minus the sum of the default releases to water and air (Table 6), i.e. 94.999 %.

Release factor to waste from on-site treatment: Not relevant. There is no on-site treatment of waste containing chromium, since all waste is disposed of as hazardous waste by an external contractor (see above.)

9.1.1.3 Exposure and risks for the environment and man via the environment

Table 7: Exposure concentrations and risks for the environment
[Cr(VI), not yet corrected for transformation in the environment]

Protection target	Exposure concentration	Risk characterisation
Freshwater	1.3E-06 mg/L	Not required (see Section 9.0.2.1)
Sediment (freshwater)	6.1E-06 mg/kg dw	Not required (see Section 9.0.2.1)
Marine water	2.7E-06 mg/L	Not required (see Section 9.0.2.1)
Sediment (marine water)	1.3E-05 mg/kg dw	Not required (see Section 9.0.2.1)
Sewage treatment plant (on-site)	2.7E-04 mg/L	Not required (see Section 9.0.2.1)
Predator (freshwater)	7.6E-07 mg/kg ww	Not required (see Section 9.0.2.1)
Predator (marine water)	5.1E-05 mg/kg ww	Not required (see Section 9.0.2.1)
Top predator (marine water)	1.0E-05 mg/kg ww	Not required (see Section 9.0.2.1)
Air	2.3E-09 mg/m ³	Not required (see Section 9.0.2.1)
Agricultural soil	6.0E-09 mg/kg dw	Not required (see Section 9.0.2.1)
Predator (terrestrial)	7.0E-09 mg/kg ww	Not required (see Section 9.0.2.1)

Table 8: Exposure concentrations and risks for humans exposed via the environment
(annual average 100 m from point source)

Protection target	Exposure concentration	Risk characterisation
Man via environment – inhalation (MvE local inhalation)	2.3E-06 µg/m ³ as Na ₂ Cr ₂ O ₇ 9.1E-07 µg/m ³ as Cr(VI)	Based on the dose-response relationship for lung cancer mortality derived by the RAC, considering a 70 year exposure time (24 h/d, 7 d/wk), the following excess lifetime lung cancer mortality risk for the general population is derived based on the estimated exposure: ELR = 2.7E-08 2.7E-05 additional cases of lung cancer per 1000 exposed persons RCR < 0.01 (reproduction)
Man via environment – oral, local (MvE local oral)	3.7E-04 µg /kg bw/d as Na ₂ Cr ₂ O ₇ 1.5E-04 µg /kg bw/d as Cr(VI) Correction by 0.03 for environmental conversion to Cr(III): 4.4E-09 mg Cr(VI)/kg bw/d = 4.4E-06 µg Cr(VI)/kg bw/d	Based on the dose-response relationship for intestinal cancer mortality derived by the RAC, considering a 70 year exposure time (24 h/d, 7 d/wk), the following excess lifetime intestinal cancer mortality risk for the general population is derived based on the estimated exposure: ELR = 3.5E-09 3.5E-06 additional cases of intestinal cancer per 1000 exposed persons RCR < 0.01 (reproduction)

Protection target	Exposure concentration	Risk characterisation
Man via environment – combined routes		ELR*: 3.1E-08 3.1E-05 additional cases of cancer per 1000 exposed persons RCR < 0.01 (reproduction)

*) In fact, an ELR for combined routes is not applicable since both lung cancer and intestinal cancer caused by Cr(VI) are local, site-of-contact tumours; therefore, “combined” ELR actually represents an aggregated risk for different types of tumours instead of a risk arising from a systemic dose due to combined exposures.

Remarks on measured exposure:

Measured data for emissions of Cr(VI) to the environment related to the use of sodium dichromate as corrosion inhibitor in AADC systems are not available.

Table 9: Contribution to oral intake for man via the environment from local contribution [Cr(VI), not yet corrected for transformation in the environment]

Type of food	Estimated daily dose	Concentration in food
Drinking water	3.6E-08 mg/kg bw/day	1.3E-06 mg/L
Fish	2.1E-09 mg/kg bw/day	1.3E-06 mg/kg ww
Leaf crops	3.3E-07 mg/kg bw/day	1.9E-05 mg/kg ww
Root crops	8.4E-11 mg/kg bw/day	1.5E-08 mg/kg ww
Meat	4.7E-12 mg/kg bw/day	1.1E-09 mg/kg ww
Milk	8.8E-11 mg/kg bw/day	1.1E-08 mg/kg ww

Conclusion on risk characterisation:

Due to the rigorous emission control and the low amount of sodium dichromate released from the assessed use as corrosion inhibitor in AADC systems any releases to the aquatic environment are insignificant. Risks for the aquatic environment (freshwater or marine water) including sediment, for terrestrial organisms, and for predators (secondary poisoning) are therefore negligible. Furthermore, the assessment of risks to the environment is out of the scope of this CSR since only human health hazards are identified as criteria for Annex XIV inclusion.

Also humans will not be significantly exposed via the food chain. According to the EU RAR “releases of chromium (VI) from any sources are expected to be reduced to chromium (III) in most situations in the environment (see Section 3.1.1.2.1) so the impact of chromium (VI) as such is likely to be limited to the area around the source” (Munn et al., 2005). This is supported by the risk characterisation presented in Table 8, conducted under the reasonable worst-case assumption that Cr(VI) is converted to Cr(III) in the environment by 97 %.

The excess lifetime lung cancer mortality risk for the general population (Table 8) is only a hypothetical risk. In accordance with the TGD the exposure concentration is related to a 100 m radius around and idealised point source. The cooling plants at the assessed site, however, do not constitute a point source but cover themselves an area of several hectares. Furthermore, they are located in the midst of an industrial area, with a distance of several hundred metres to the boundaries of the site. Any airborne residues to which members of the general population may be exposed are more severely diluted than suggested by the current exposure assessment. Therefore the ELR of 2.7E-05 additional cases of lung cancer per 1000 exposed persons can be still considered a substantial overestimation.

9.1.2 Worker contributing scenario 1 – Use of sodium dichromate as corrosion inhibitor in ammonia absorption deep cooling systems (PROC 1)

9.1.2.1 Conditions of use

This WCS describes the continuous operation of the AADC systems using sodium dichromate as corrosion inhibitor within the cooling circuit. The cooling medium (sodium dichromate target concentration = 5 g/L) is safely enclosed in the cooling circuit, so that no opportunity for contact with sodium dichromate is given. It should be noted, however, that no cooling system is perfectly leak-tight. Therefore, small volumes (drop size) of cooling medium may occasionally leak from flanges and mufflers, leaving small (a few milligrams) spots of solid chromate contaminations (due to hydrolysis of dichromate to chromate in the enclosed cooling medium) upon evaporation. Workers' activities are restricted to regular inspections of the facilities (< 1 hour per day) and do not involve any contact to equipment surfaces. Since sodium dichromate is not volatile, and since no aerosols can be generated by the closed system, inhalation exposure can be considered to be insignificant beforehand. However, in a worst-case approach potential inhalation exposure of workers during their routine checks is estimated using ART, assuming that low levels of airborne residues of Cr(VI) may be generated by continuous operation of the AADC systems. The implementation of a continuously operated closed circuit in ART is explained and justified as follows:

Although ART normally does not provide for modelling exposure from substance use in closed systems, an adequate representation of the continuous flow (pumping) of cooling medium in the circuit (see Figure 1) is the ART activity class "transfer of liquid products", subclass "bottom loading". This can be still considered a worst-case approach since any connected hose for bottom loading is far less leak-tight than the permanently assembled cooling circuit.

As noted above, the target concentration for effective corrosion inhibition is 5 g/L (set point for concentration adjustment). The actual concentration of sodium dichromate can vary. For exposure modelling in ART, the concentration band (weight fraction) 0.5–1.0 % (corresponding to 5-10 g/L) is selected as a worst-case to allow for some technically inevitable variation.

The transfer rate corresponds to the flow rates of the pumps within the installations.

The process is not fully enclosed (the cooling plant is installed outdoors, without further enclosure).

However, the closed cooling circuit is considered to constitute a high-level containment.

The work area is located outdoors and the worker performing routine checks typically stays away from plant components, therefore a default distance of > 4 m from emission sources is reasonable.

Dermal exposure by MEASE v1.02.01

	Method
Product (article) characteristics	
<ul style="list-style-type: none"> ▪ Physical form: Aqueous solution <i>The cooling medium is an aqueous ammonia solution containing sodium dichromate as a corrosion inhibitor.</i> 	MEASE
<ul style="list-style-type: none"> ▪ Content in preparation: < 1 % <i>The target concentration of sodium dichromate for effective corrosion inhibition is 5 g/L (0.5 %). However, during concentration adjustment (WCS 4) the complete content of the drum in which fresh concentrated aqueous sodium dichromate solution is supplied is added to the cooling circuit. This may result in an interim sodium dichromate concentration slightly higher than 5 g/L.</i> 	MEASE
Amount used (or contained in articles), frequency and duration of use/exposure	
<ul style="list-style-type: none"> ▪ Duration of exposure: 15–60 minutes <i>During the daily inspection the field officer stays up to 1 hour in the cooling plant. However, touching potentially contaminated surfaces is not normally envisaged (see input parameter "contact level").</i> 	MEASE
Technical and organisational conditions and measures	
<ul style="list-style-type: none"> ▪ Pattern of use: Closed system without breaches <i>The AADC system is designed as a closed system.</i> 	MEASE
<ul style="list-style-type: none"> ▪ Pattern of exposure control: Non direct handling <i>The sodium dichromate containing cooling medium is enclosed in the cooling circuit of the AADC system.</i> 	MEASE
<ul style="list-style-type: none"> ▪ Contact level: None <i>During the daily inspection direct contact to the cooling medium containing sodium dichromate is unlikely to occur.</i> 	MEASE

	Method
Conditions and measures related to personal protection, hygiene and health evaluation	
<ul style="list-style-type: none"> Use of gloves: No gloves (0.0 % reduction) <i>For the daily inspection the field officer usually does not wear gloves.</i> 	MEASE
Other conditions affecting workers exposure	
<ul style="list-style-type: none"> Potentially exposed skin area: One hand face only (240 cm²) 	MEASE

Inhalation exposure by ART v1.5

	Method
<ul style="list-style-type: none"> Far field activity <i>During the daily inspection of the cooling plant the primary emission source (e.g. piping of the installation) is <u>not</u> located in the breathing zone of the field officer (i.e. the volume of air within 1 m in any direction of the field officer's head).</i> 	ART
<ul style="list-style-type: none"> Duration of activity: < 60 min <i>During the daily inspection the field officer stays up to 1 hour in the cooling plant.</i> 	ART
Product (article) characteristics/substance emission potential	
<ul style="list-style-type: none"> Substance product type: Powders dissolved in a liquid or incorporated in a liquid matrix <i>The cooling medium is an aqueous ammonia solution containing sodium dichromate as a corrosion inhibitor. However, pure sodium dichromate is an essentially non-volatile solid.</i> 	ART
<ul style="list-style-type: none"> Liquid weight fraction: Very small (0.5–1.0 %) <i>The target sodium dichromate concentration for effective corrosion inhibition is 5 g/L (0.5 %). However, during concentration adjustment (WCS 4) always the complete content of the drum in which fresh concentrated aqueous sodium dichromate solution is supplied is added to the cooling circuit. This may result in a final sodium dichromate concentration slightly higher than 5 g/L.</i> 	ART
<ul style="list-style-type: none"> Viscosity: Low (like water) <i>The cooling medium is an aqueous ammonia solution containing sodium dichromate as a corrosion inhibitor.</i> 	ART
Activity emission potential	
<ul style="list-style-type: none"> Activity class: Transfer of liquid products / Bottom loading <i>The process (continuous pumping of cooling medium in a circuit) can be considered as a never ending "bottom loading" of the cooling medium.</i> 	ART
<ul style="list-style-type: none"> Situation: Transfer of liquid product with flow of 100–1000 L/minute <i>The flow rates of the pumps within the installations are in the range of 26-50 tonnes/hour corresponding to 433-833 L/minute.</i> 	ART
Surface contamination	
<ul style="list-style-type: none"> Process fully enclosed? No <i>The cooling medium is safely enclosed in the cooling circuit, so that no opportunity for contact with sodium dichromate is given. However, no cooling system is perfectly leak-tight [small volumes (drop size) of cooling medium may occasionally leak from flanges and muffs]. Taking this into account for risk assessment purposes it is considered more realistic to describe the continuous operation of the AADC systems as a process with a high level containment instead of a fully enclosed process.</i> 	ART
<ul style="list-style-type: none"> Effective housekeeping practices in place? Yes <i>The implemented housekeeping regime ensures that potentially contaminated surfaces are regularly cleaned using appropriate methods.</i> 	ART
Dispersion	
<ul style="list-style-type: none"> Work area: Outdoors <i>The cooling plants and hence the inspecting field officers are located outdoors.</i> 	ART
<ul style="list-style-type: none"> Source located close to buildings? Yes <i>For daily inspection the field officer enters the cooling plant.</i> 	ART

		Method
<ul style="list-style-type: none"> Worker distance: > 4 m <p><i>During the daily inspection the field officer may occasionally approach parts of the installation to a distance of less than 4 metres. However, this is an untypical situation and the average distance to potential emission sources, if any (e.g. potential leakages), is most likely far more than 4 metres.</i></p>		ART
Risk management measures		
Localised controls		
<ul style="list-style-type: none"> Primary: High level containment (99.90 % reduction) <p><i>The cooling medium is safely enclosed in the cooling circuit, so that no opportunity for contact with sodium dichromate is given. However, no cooling system is perfectly leak-tight [small volumes (drop size) of cooling medium may occasionally leak from flanges and muff]. Taking this into account for risk assessment purposes it is considered more realistic to describe the continuous operation of the AADC systems as a process with a high level containment instead of a fully enclosed process.</i></p>		ART
<ul style="list-style-type: none"> Segregation: No segregation (0.0 % reduction) <p><i>Segregation (isolation of potential emission sources from the work environment in a separate room or work area) is not feasible for daily inspection of the cooling plant.</i></p>		ART
<ul style="list-style-type: none"> Personal enclosure: No personal enclosure (0.0 % reduction) <p><i>Personal enclosure (e.g. cabin) is not feasible for daily inspection of the cooling plant.</i></p>		ART

9.1.2.2 Exposure and risks for workers

Table 10: Exposure concentrations and risks for workers (WCS 1)

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	ART prediction, 90 th percentile: 5.7E-07 µg/m ³ as Na ₂ Cr ₂ O ₇ 2.3E-07 µg/m³ as Cr(VI) No correction for frequency of exposure	Based on the dose-response relationship for lung cancer mortality derived by the RAC, considering a 40 year working life (8 h/d, 5 d/wk), the following excess lifetime lung cancer mortality risk up to age 89 is derived based on the estimated exposure: ELR = 9.1E-10 9.1E-07 additional cases of lung cancer per 1000 exposed workers
Inhalation, systemic, long-term	ART prediction, 90 th percentile: 5.7E-7 µg/m ³ as Na ₂ Cr ₂ O ₇ 2.3E-07 µg/m³ as Cr(VI) No correction for frequency of exposure	RCR < 0.01 (reproduction)
Dermal, systemic, long-term	MEASE prediction: Dermal exposure: 1.0E-02 µg/cm ² /d Total dermal loading: 2.4E+00 µg/d as Na ₂ Cr ₂ O ₇ Body dose (70 kg bw): 3.4E-02 µg/kg bw/d as Na ₂ Cr ₂ O ₇ 1.4E-02 µg/kg bw/d as Cr(VI) No correction for frequency of exposure	RCR < 0.01 (reproduction)
Combined routes, systemic, long-term		RCR < 0.01 (reproduction)

Table 11: Correction (RPE and frequency) of the inhalation exposure concentrations and risks for workers (WCS 1)

Calculation step	Value
Modelled potential exposure per shift as Na ₂ Cr ₂ O ₇	5.7E-07 µg/m ³
Conversion factor Na ₂ Cr ₂ O ₇ → Cr(VI)	39.697 %
Potential exposure per shift as Cr(VI)	2.3E-07 µg/m ³
Reduction by RPE	not applicable
Actual estimated exposure per shift	2.3E-07 µg/m ³
Time correction: No of days exposed yearly/number of yearly working days*	260/260 = 1.0
Time corrected exposure	2.3E-07 µg/m ³
ELR (4.0E-03 per µg Cr(VI)/m ³)	9.1E-10

*) 260 annual working days assumed

Conclusion on risk characterisation:

The modelled exposure estimate (ART) of 2.3E-07 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case). An excess lifetime lung cancer mortality risk of 9.1E-07 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship for lung cancer mortality.

Risks for toxicity to reproduction are adequately controlled.

9.1.3 Worker contributing scenario 2 – Sampling of cooling medium (PROC 9)

9.1.3.1 Conditions of use

This WCS describes the activities related to the sampling of cooling medium samples containing sodium dichromate:

Withdrawal of a sample of the cooling medium from the closed system via a dedicated valve, with little opportunity for exposure. Although this task does not take place at an automated filling line, it may be most appropriately described by PROC 9. A volume of maximally 0.5 L cooling medium is withdrawn via a dedicated valve and piping and directly filled into a sample bottle (see Figure 4). The duration of this activity is < 15 minutes, and the frequency 12 times per year (4 times per cooling plant; 3 plants are operated on the site). Since this task may be performed by different persons, depending on the shift plan, the figure of 12 exposures per year can be considered a worst-case assumption.

As with WCS 1 (Section 1.1.2) the concentration range (weight fraction) 0.5–1.0 % (corresponding to 5–10 g/L) is selected as a worst-case to allow for some technically inevitable variation.

Dermal exposure by MEASE v1.02.01

	Method
Product (article) characteristics	
<ul style="list-style-type: none"> Physical form: Aqueous solution <i>The cooling medium is an aqueous ammonia solution containing sodium dichromate as a corrosion inhibitor.</i> 	MEASE
<ul style="list-style-type: none"> Content in preparation: < 1 % <i>The target sodium dichromate concentration for effective corrosion inhibition is 5 g/L (0.5 %). However, during concentration adjustment (WCS 4) always the complete content of the drum in which fresh concentrated aqueous sodium dichromate solution is supplied is added to the cooling circuit. This may result in a final sodium dichromate concentration slightly higher than 5 g/L.</i> 	MEASE
Amount used (or contained in articles), frequency and duration of use/exposure	
<ul style="list-style-type: none"> Duration of exposure: < 15 minutes <i>A trained worker needs less than 15 minutes to take a sample of the cooling medium.</i> 	MEASE

	Method
Technical and organisational conditions and measures	
<ul style="list-style-type: none"> Pattern of use: Non-dispersive use <i>Workers are specifically trained for taking a samples of the cooling medium.</i> 	MEASE
<ul style="list-style-type: none"> Pattern of exposure control: Direct handling <i>After sampling the worker needs to manually seal the screw-cap sample bottle. In accordance with the MEASE glossary, the activity is classified as "direct handling" since the worker is not separated from the cooling medium by means of space or time. However, since exposure is controlled by using a dedicated sampling pipe (see Section 1.1, Figure 4), the assumption of direct handling represents a clear worst-case.</i> 	MEASE
<ul style="list-style-type: none"> Contact level: Incidental <i>Samples of cooling medium are only taken with a frequency of 12 times per year, once a given day (4 times per cooling plant; 3 plants are operated on the site). This corresponds to incidental contact level according to the MEASE glossary.</i> 	MEASE
Conditions and measures related to personal protection, hygiene and health evaluation	
<ul style="list-style-type: none"> Use of gloves: Properly designed/selected gloves (90.0 % reduction) <i>Workers are specifically trained for the use of the prescribed protective gloves hence a reduction of dermal exposure of 90 % is justified.</i> <i>According to the GESTIS Substance Database of the 'Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung (IFA)' the following materials are suitable for protective gloves:</i> <ul style="list-style-type: none"> Natural rubber (NR), thickness: 0.5 mm, permeation time: ≥ 2 hours Polychloroprene (CR), thickness: 0.5 mm, permeation time: ≥ 4 hours Nitrile rubber (NBR), thickness: 0.35 mm, permeation time: ≥ 8 hours Butyl rubber (Butyl), thickness: 0.5 mm, permeation time: ≥ 8 hours Fluoro carbon rubber (FKM), thickness: 0.4 mm, permeation time: ≥ 8 hours Polyvinyl chloride (PVC), thickness: 0.5 mm, permeation time: ≥ 2 hours <i>Please note that with respect to sodium dichromate the permeation time for the above protective glove materials is ≥ 8 hours (saturated aqueous solution) (GESTIS, 2015b). However, the described task involves also aqueous solution of ammonia for which the permeation time is shorter. Therefore, the above permeation times, which indicate for how long the protective gloves should maximally be worn, relate to aqueous solutions of ammonia (≤ 10 %) (GESTIS, 2015a).</i> 	MEASE
<ul style="list-style-type: none"> Use of gloves: Properly designed/selected gloves (90.0 % reduction) <i>Workers are specifically trained for the use of the prescribed protective gloves hence a reduction of dermal exposure of 90 % is justified.</i> 	MEASE
Other conditions affecting workers exposure	
<ul style="list-style-type: none"> Potentially exposed skin area: Two hands face (480 cm²) 	MEASE

Inhalation exposure by ART v1.5

	Method
<ul style="list-style-type: none"> Far field activity <i>During sampling of cooling medium the primary emission source (e.g. sample bottle) is <u>not</u> located in the breathing zone of the worker (i.e. the volume of air within 1 m in any direction of the worker's head).</i> 	ART
<ul style="list-style-type: none"> Duration of activity: < 15 min <i>A trained worker needs less than 15 minutes to take a sample of the cooling medium.</i> 	ART
Product (article) characteristics/substance emission potential	
<ul style="list-style-type: none"> Substance product type: Powders dissolved in a liquid or incorporated in a liquid matrix <i>The cooling medium is an aqueous ammonia solution containing sodium dichromate as a corrosion inhibitor. However, pure sodium dichromate is an essentially non-volatile solid.</i> 	ART
<ul style="list-style-type: none"> Liquid matrix weight fraction: Very small (0.5–1.0 %) <i>The target sodium dichromate concentration for effective corrosion inhibition is 5 g/L (0.5 %). However, during concentration adjustment (WCS 4) always the complete content of the drum in which fresh concentrated aqueous sodium dichromate solution is supplied is added to the cooling circuit. This may result in a final sodium dichromate concentration slightly higher than 5 g/L.</i> 	ART

	Method
<ul style="list-style-type: none"> Viscosity: Low (like water) <i>The cooling medium is an aqueous ammonia solution containing sodium dichromate as a corrosion inhibitor.</i> 	ART
Activity emission potential	
<ul style="list-style-type: none"> Activity class: Transfer of liquid products / Falling liquids <i>The sample is withdrawn via a dedicated valve and piping and directly filled into a sample bottle.</i> 	ART
<ul style="list-style-type: none"> Situation: Transfer of liquid product with flow of 0.1–1 L/minute <i>The sample bottle is carefully filled with a flow rate typical for filling bottles.</i> 	ART
<ul style="list-style-type: none"> Containment level: Handling that reduces contact between product and adjacent air. <i>The inside diameter of the sample bottle matches the outside diameter of the steel filling pipe at the sample point. Additionally the end of filling pipe is equipped with a cap preventing splashes outside the bottle during filling.</i> 	ART
<ul style="list-style-type: none"> Loading type: Splash loading, where the liquid dispenser remains at the top of the reservoir and the liquid splashes freely <i>The design of the steel filling pipe (cap preventing splashes outside the bottle during filling) does not allow for the filling pipe to reach the bottom of the sample bottle.</i> 	ART
Surface contamination	
<ul style="list-style-type: none"> Process fully enclosed? No <i>Full process enclosure is not feasible for sampling.</i> 	ART
<ul style="list-style-type: none"> Effective housekeeping practices in place? Yes <i>The implemented housekeeping regime ensures that potentially contaminated surfaces are regularly cleaned using appropriate methods.</i> 	ART
Dispersion	
<ul style="list-style-type: none"> Work area: Outdoors <i>The cooling plant and hence the sample point and the worker taking samples are located outdoors.</i> 	ART
<ul style="list-style-type: none"> Source located close to buildings? Yes <i>The sample point is located inside of the cooling plant.</i> 	ART
<ul style="list-style-type: none"> Worker distance: < 4 m <i>For sampling the worker is located in proximity of the sample point.</i> 	ART
Risk management measures	
Localised controls	
<ul style="list-style-type: none"> Primary: No localized controls (0.0 % reduction) <i>There are no localized controls implemented for the sampling of cooling medium.</i> 	ART
<ul style="list-style-type: none"> Segregation: No segregation (0.0 % reduction) <i>Segregation (isolation of potential emission sources from the work environment in a separate room or work area) is not feasible for sampling.</i> 	ART
<ul style="list-style-type: none"> Personal enclosure: No personal enclosure (0.0 % reduction) <i>Personal enclosure (e.g. cabin) is not feasible for sampling.</i> 	ART
Conditions and measures related to personal protection, hygiene and health evaluation	
<ul style="list-style-type: none"> Respiratory protection: ABEK P3 full mask (95.0 % reduction) <i>Workers are specifically trained for the use of the prescribed ABEK P3 full mask hence a reduction of inhalation exposure of 95 % is justified.</i> 	ART (extended)

9.1.3.2 Exposure and risks for workers

Table 12: Exposure concentrations and risks for workers (WCS 2)

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	ART prediction, 90 th percentile: 3.5E-04 µg/m ³ as Na ₂ Cr ₂ O ₇ 1.4E-04 µg/m ³ as Cr(VI) Corrected for RPE and frequency of activity (12 times yearly): 3.2E-07 µg Cr(VI)/m³	Based on the dose-response relationship for lung cancer mortality derived by the RAC, considering a 40 year working life (8 h/d, 5 d/wk), the following excess lifetime lung cancer mortality risk up to age 89 is derived based on the estimated exposure: ELR = 1.3E-09 1.3E-06 additional cases of lung cancer per 1000 exposed workers
Inhalation, systemic, long-term	ART prediction, 90 th percentile: 3.5E-04 µg/m ³ as Na ₂ Cr ₂ O ₇ 1.4E-04 µg/m ³ as Cr(VI) Corrected for RPE and frequency of activity (12 times yearly): 3.2E-07 µg Cr(VI)/m³	RCR < 0.01 (reproduction)
Dermal, systemic, long-term	MEASE prediction: Dermal exposure: 5.0E-03 µg/cm ² /d Total dermal loading: 2.4E+00 µg/d as Na ₂ Cr ₂ O ₇ Body dose (70 kg bw): 3.4E-02 µg/kg bw/d as Na ₂ Cr ₂ O ₇ 1.4E-02 µg/kg bw/d as Cr(VI) Corrected for frequency of activity (12 times yearly): 6.5E-04 µg Cr(VI)/kg bw/d	RCR < 0.01 (reproduction)
Combined routes, systemic, long-term		RCR < 0.01 (reproduction)

Table 13: Correction (RPE and frequency) of the inhalation exposure concentrations and risks for workers (WCS 2)

Calculation step	Value
Modelled potential exposure per shift as Na ₂ Cr ₂ O ₇	3.5E-04 µg/m ³
Conversion factor Na ₂ Cr ₂ O ₇ → Cr(VI)	39.697 %
Potential exposure per shift as Cr(VI)	1.4E-04 µg/m ³
Reduction by RPE	95 %
Actual estimated exposure per shift	6.9E-06 µg/m ³
Time correction: Number of days exposed yearly/number of yearly working days*	12/260 = 0.046
Time corrected exposure	3.2E-07 µg/m ³
ELR (4.0E-03 per µg Cr(VI)/m ³)	1.3E-09

*) 260 annual working days assumed

Remarks on exposure data:

Measured exposure data or biological monitoring data suitable for exposure estimation are not available.

Conclusion on risk characterisation:

The modelled RPE- and frequency-corrected exposure estimate (ART) of 3.2E-07 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case). An excess lifetime lung cancer mortality risk of 1.3E-06 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship for lung cancer mortality.

Risks for toxicity to reproduction are adequately controlled.

9.1.4 Worker contributing scenario 3 – Laboratory analysis of cooling medium (PROC 15)

9.1.4.1 Conditions of use

This WCS describes the activities related to the laboratory analysis of cooling medium samples containing sodium dichromate:

The analyses are carried out in a fume hood, laboratory technicians wear PPE (e.g. lab coat, protective gloves and safety goggles).

The maximum work time per analysis is 5 minutes with a diluted sample in glassware. Repetition of a single analysis can result in an exposure period of 15 minutes at maximum. There is no contact to the liquid sample which is securely enclosed in the laboratory glassware.

Handling of the cooling medium samples is done using pipettes hence any direct contact is strictly avoided. The analysis itself is done as automated titration, not requiring personal handling of the samples.

As with WCS 1 (Section 1.1.2) the concentration range (weight fraction) 0.5–1.0 % (corresponding to 5–10 g/L) is selected as a worst-case to allow for some technically inevitable variation.

Dermal exposure by MEASE v1.02.01

	Method
Product (article) characteristics	
<ul style="list-style-type: none"> Physical form: Aqueous solution <i>The cooling medium is an aqueous ammonia solution containing sodium dichromate as a corrosion inhibitor.</i> 	MEASE
<ul style="list-style-type: none"> Content in preparation: <1% <i>The target sodium dichromate concentration for effective corrosion inhibition is 5 g/L (0.5 %). However, during concentration adjustment (WCS 4) always the complete content of the drum in which fresh concentrated aqueous sodium dichromate solution is supplied is added to the cooling circuit. This may result in a final sodium dichromate concentration slightly higher than 5 g/L.</i> 	MEASE

	Method
Amount used (or contained in articles), frequency and duration of use/exposure	
<ul style="list-style-type: none"> Duration of exposure: < 15 minutes <i>Preparation of the cooling medium samples for analysis takes 15 minutes at maximum.</i> 	MEASE
Technical and organisational conditions and measures	
<ul style="list-style-type: none"> Pattern of use: Non-dispersive use <i>Standard operating procedures implemented at contract testing facilities ensure careful handling of cooling medium samples.</i> 	MEASE
<ul style="list-style-type: none"> Pattern of exposure control: Direct handling <i>For sample preparation aliquots of the cooling medium samples are transferred using a pipette.</i> 	MEASE
<ul style="list-style-type: none"> Contact level: Incidental <i>Samples of cooling medium are only analysed with a frequency of 12 times per year, once a given day (4 times per cooling plant; 3 plants are operated on the site). This corresponds to incidental contact level according to the MEASE glossary.</i> 	MEASE
Conditions and measures related to personal protection, hygiene and health evaluation	
<ul style="list-style-type: none"> Use of gloves: Properly designed/selected gloves (90.0 % reduction) <i>Standard operation procedures implemented at contract testing facilities ensure the proper use of the prescribed protective gloves hence a reduction of dermal exposure of 90 % is justified. According to the GESTIS Substance Database of the 'Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung (IFA)' the following materials are suitable for protective gloves:</i> <ul style="list-style-type: none"> Natural rubber (NR), thickness: 0.5 mm, permeation time: ≥ 2 hours Polychloroprene (CR), thickness: 0.5 mm, permeation time: ≥ 4 hours Nitrile rubber (NBR), thickness: 0.35 mm, permeation time: ≥ 8 hours Butyl rubber (Butyl), thickness: 0.5 mm, permeation time: ≥ 8 hours Fluoro carbon rubber (FKM), thickness: 0.4 mm, permeation time: ≥ 8 hours Polyvinyl chloride (PVC), thickness: 0.5 mm, permeation time: ≥ 2 hours <i>Please note that with respect to sodium dichromate the permeation time for the above protective glove materials is ≥ 8 hours (saturated aqueous solution) (GESTIS, 2015b). However, the described task involves also aqueous solution of ammonia for which the permeation time is shorter. Therefore, the above permeation times, which indicate for how long the protective gloves should maximally be worn, relate to aqueous solutions of ammonia (≤ 10 %) (GESTIS, 2015a).</i> 	MEASE
Other conditions affecting workers exposure	
<ul style="list-style-type: none"> Potentially exposed skin area: Two hands face (240 cm²) 	MEASE

Inhalation exposure by ART v1.5

	Method
<ul style="list-style-type: none"> Near field activity <i>During sample preparation for analysis the primary emission source (e.g. sample in glassware) is located in the breathing zone of the laboratory technician (i.e. the volume of air within 1 m in any direction of the laboratory technician's head).</i> 	ART
<ul style="list-style-type: none"> Duration of activity: < 15 min <i>Preparation of the cooling medium samples for analysis takes 15 minutes at maximum.</i> 	ART
Product (article) characteristics/substance emission potential	
<ul style="list-style-type: none"> Substance product type: Powders dissolved in a liquid or incorporated in a liquid matrix <i>The cooling medium is an aqueous ammonia solution containing sodium dichromate as a corrosion inhibitor. However, pure sodium dichromate is an essentially non-volatile solid.</i> 	ART
<ul style="list-style-type: none"> Liquid weight fraction: Very small (0.5–1.0 %) <i>The target sodium dichromate concentration for effective corrosion inhibition is 5 g/L (0.5 %). However, during concentration adjustment (WCS 4) always the complete content of the drum in which fresh concentrated aqueous sodium dichromate solution is supplied is added to the cooling circuit. This may result in a final sodium dichromate concentration slightly higher than 5 g/L.</i> 	ART

	Method
<ul style="list-style-type: none"> Viscosity: Low (like water) <i>The cooling medium is an aqueous ammonia solution containing sodium dichromate as a corrosion inhibitor.</i> 	ART
Activity emission potential	
<ul style="list-style-type: none"> Activity class: Transfer of liquid products / Falling liquids <i>For sample preparation aliquots of the cooling medium samples are transferred using a pipette.</i> 	ART
<ul style="list-style-type: none"> Situation: Transfer of liquid product with flow of < 0.1 L/minute <i>Small aliquots of the cooling medium samples are transferred using a pipette.</i> 	ART
<ul style="list-style-type: none"> Containment level: Handling that reduces contact between product and adjacent air <i>Standard operating procedures implemented at contract testing facilities ensure careful handling of cooling medium samples.</i> 	ART
<ul style="list-style-type: none"> Loading type: Submerged loading, where the liquid dispenser remains below the fluid level reducing the amount of aerosol formation <i>When transferring aliquots of the cooling medium samples with a pipette aerosol formation, if any, can be considered to be negligible.</i> 	ART
Surface contamination	
<ul style="list-style-type: none"> Process fully enclosed? No <i>Full process enclosure is not feasible for the sample preparation for analysis.</i> 	ART
<ul style="list-style-type: none"> Effective housekeeping practices in place? Yes <i>Standard operation procedures implemented at contract testing facilities ensure that demonstrable and effective housekeeping practices (e.g. daily cleaning using appropriate methods) are in place.</i> 	ART
Dispersion	
<ul style="list-style-type: none"> Work area: Indoors <i>The laboratory and hence the laboratory technician are located indoors.</i> 	ART
<ul style="list-style-type: none"> Room size: 100 m³ <i>A laboratory has a typical room size of 100 m³.</i> 	ART
<ul style="list-style-type: none"> Ventilation rate: Only good natural ventilation <i>At contract testing facilities at least good natural ventilation is available.</i> 	ART
Risk management measures	
Localised controls	
<ul style="list-style-type: none"> Primary: Fume cupboard (99.00 % reduction) <i>The cooling medium samples are handled in a fume cupboard.</i> 	ART
Conditions and measures related to personal protection, hygiene and health evaluation	
<ul style="list-style-type: none"> Respiratory protection: No (0.0 % reduction) <i>Laboratory technicians do not wear RPE when preparing cooling medium samples for analysis.</i> 	ART (extended)

9.1.4.2 Exposure and risks for workers

Table 14: Exposure concentrations and risks for workers (WCS 3)

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	ART prediction, 90 th percentile: 4.6E-05 µg/m ³ as Na ₂ Cr ₂ O ₇ 1.8E-05 µg/m ³ as Cr(VI) Corrected for frequency of activity (12 times yearly): 8.4E-07 µg Cr(VI)/m³	Based on the dose-response relationship for lung cancer mortality derived by the RAC, considering a 40 year working life (8 h/d, 5 d/wk), the following excess lifetime lung cancer mortality risk up to age 89 is derived based on the estimated exposure: ELR = 3.4E-09 3.4E-06 additional cases of lung cancer per 1000 exposed workers
Inhalation, systemic, long-term	ART prediction, 90 th percentile: 4.6E-05 µg/m ³ as Na ₂ Cr ₂ O ₇ 1.8E-05 µg/m ³ as Cr(VI) Corrected for frequency of activity (12 times yearly): 8.4E-07 µg Cr(VI)/m³	RCR < 0.01 (reproduction)
Dermal, systemic, long-term	MEASE prediction: Dermal exposure: 5.0E-03 µg/cm ² /d Total dermal loading: 1.2E+00 µg/d as Na ₂ Cr ₂ O ₇ Body dose (70 kg bw): 1.7E-02 µg/kg bw/d as Na ₂ Cr ₂ O ₇ 6.8E-03 µg/kg bw/d as Cr(VI) Corrected for frequency of activity (12 times yearly): 3.1E-04 µg Cr(VI)/kg bw/d	RCR < 0.01 (reproduction)
Combined routes, systemic, long-term		RCR < 0.01 (reproduction)

Table 15: Correction (RPE and frequency) of the inhalation exposure concentrations and risks for workers (WCS 3)

Calculation step	Value
Modelled potential exposure per shift as Na ₂ Cr ₂ O ₇	4.6E-05 µg/m ³
Conversion factor Na ₂ Cr ₂ O ₇ → Cr(VI)	39.697 %
Potential exposure per shift as Cr(VI)	1.8E-05 µg/m ³
Reduction by RPE	not applicable
Actual estimated exposure per shift	1.8E-05 µg/m ³
Time correction: Number of days exposed yearly/number of yearly working days*	12/260 = 0.046
Time corrected exposure	8.4E-07 µg/m ³
ELR (4.0E-03 per µg Cr(VI)/m ³)	3.4E-09

*) 260 annual working days assumed

Remarks on exposure data:

Exposure data on laboratory staff are not available.

Conclusion on risk characterisation:

The modelled and frequency-corrected exposure estimate (ART) of 8.4E-07 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case). An excess lifetime lung cancer mortality risk of 3.4E-06 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship for lung cancer mortality.

Risks for toxicity to reproduction are adequately controlled.

9.1.5 Worker contributing scenario 4 – Concentration adjustment (addition of sodium dichromate solution to the cooling circuit) (PROC 8b)

9.1.5.1 Conditions of use

This WCS describes the activities related to the adjustment of the sodium dichromate concentration in the cooling medium:

For concentration adjustment a 60 % w/w aqueous sodium dichromate solution is added to the cooling circuit. Transfer of the aqueous sodium dichromate solution directly from shipping containers by means of vacuum is done via suction hose at a dedicated facility. There are two types of activities that are modelled in two ART sub-scenarios, resulting in one combined exposure estimate:

- a) Handling of potentially contaminated screw caps and suction hose:
Manipulations of material and equipment during concentration adjustment comprise opening and closing the transport packaging of aqueous sodium dichromate (removing and re-sealing the screw cap), and moving the suction hose from one drum to the next. Typically the content of 2 or 3 drums is introduced into the cooling system. The total duration of handling these potentially contaminated objects is 5 minutes at maximum (sum of all opening/closing steps, and hose moves). The surface area of these objects is obviously small. A surface area in the range of 0.1–0.3 m² can be considered as a worst-case. A fraction of 10–90 % of the surface area (ART category) may be contaminated with sodium dichromate solution.
- b) Transfer of aqueous sodium dichromate solution:
In the second sub-scenario the vacuum transfer process itself is described, without manual handling of drums and suction hose. The estimated exposure is therefore related to waiting periods and supervision of the transfer. The duration of this activity is approximately 55 minutes, giving a total duration for both activities (a and b) of 60 minutes at maximum.

As shown in Figure 5 for both activities workers wear coveralls, safety goggles, protective gloves and RPE (ABEK P3 full face mask). Workers are specifically trained for the activities and the use of the required PPE hence reduction of dermal exposure by 90 % for the use of protective gloves and a reduction of inhalation exposure of 95 % for the use of RPE is justified.

The maximum frequency of concentration adjustment is 6 times per year (2 times per cooling plant; 3 plants are operated on the site). Since this activity is likely to alternate between several workers, the figure of 6 exposures per year is a worst-case assumption.

Dermal exposure by MEASE v1.02.01

	Method
Product (article) characteristics	
<ul style="list-style-type: none"> ▪ Physical form: Aqueous solution <i>The sodium dichromate concentration of the cooling medium is adjusted using a 60 % (w/w) aqueous sodium dichromate solution.</i> 	MEASE
<ul style="list-style-type: none"> ▪ Content in preparation: > 25 % <i>The sodium dichromate concentration of the cooling medium is adjusted using a 60 % (w/w) aqueous sodium dichromate solution.</i> 	MEASE
Amount used (or contained in articles), frequency and duration of use/exposure	
<ul style="list-style-type: none"> ▪ Duration of exposure: 15–60 minutes <i>Concentration adjustment with 60 % (w/w) aqueous sodium dichromate solution takes up to 60 minutes.</i> 	MEASE
Technical and organisational conditions and measures	
<ul style="list-style-type: none"> ▪ Pattern of use: Non-dispersive use <i>Workers are specifically trained for concentration adjustment with 60 % w/w aqueous sodium dichromate solution.</i> 	MEASE
<ul style="list-style-type: none"> ▪ Pattern of exposure control: Direct handling <i>For concentration adjustment the worker needs to manually unscrew the drums containing the 60 % (w/w) aqueous sodium dichromate solution.</i> 	MEASE
<ul style="list-style-type: none"> ▪ Contact level: Incidental <i>The maximum frequency of concentration adjustment is 6 times per year, once a given day (2 times per cooling plant; 3 plants are operated on the site).</i> 	MEASE

	Method
Conditions and measures related to personal protection, hygiene and health evaluation	
<ul style="list-style-type: none"> ▪ Use of gloves: Properly designed/selected gloves (90.0 % reduction) <i>Workers are specifically trained for the use of the prescribed protective gloves hence a reduction of dermal exposure of 90 % is justified.</i> <i>According to the GESTIS Substance Database of the 'Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung (IFA)' the following materials are suitable for protective gloves (GESTIS, 2015b):</i> <ul style="list-style-type: none"> - Natural rubber (NR), thickness: 0.5 mm, permeation time: ≥ 8 hours - Polychloroprene (CR), thickness: 0.5 mm, permeation time: ≥ 8 hours - Nitrile rubber (NBR), thickness: 0.35 mm, permeation time: ≥ 8 hours - Butyl rubber (Butyl), thickness: 0.5 mm, permeation time: ≥ 8 hours - Fluoro carbon rubber (FKM), thickness: 0.4 mm, permeation time: ≥ 8 hours - Polyvinyl chloride (PVC), thickness: 0.5 mm, permeation time: ≥ 8 hours 	MEASE
Other conditions affecting workers exposure	
<ul style="list-style-type: none"> ▪ Potentially exposed skin area: Two hands (960 cm²) <i>MEASE calculates with an exposed skin area of 480 cm², which is not in line with the ECETOC TRA default (960 cm²). In a worst-case approach, the MEASE exposure estimate is thus multiplied by a factor 2, to compensate for this difference.</i> 	MEASE (extended)

Inhalation exposure by ART v1.5

a) Handling of potentially contaminated screw caps and suction hose

	Method
<ul style="list-style-type: none"> ▪ Near field activity <i>When handling potentially contaminated screw caps and suction hose the primary emission source (e.g. sample in glassware with screw cap) is located in the breathing zone of the worker (i.e. the volume of air within 1 m in any direction of the worker's head).</i> 	ART
<ul style="list-style-type: none"> ▪ Duration of activity: < 5 min <i>The total duration of handling potentially contaminated screw caps and suction hose is 5 minutes at maximum.</i> 	ART
Product (article) characteristics/substance emission potential	
<ul style="list-style-type: none"> ▪ Substance product type: Powders dissolved in a liquid or incorporated in a liquid matrix <i>The sodium dichromate concentration of the cooling medium is adjusted using a 60 % w/w aqueous sodium dichromate solution. However, pure sodium dichromate is an essentially non-volatile solid.</i> 	ART
<ul style="list-style-type: none"> ▪ Liquid weight fraction: 0.6 <i>The handled screw caps and suction hose are potentially contaminated with 60 % w/w aqueous sodium dichromate solution.</i> 	ART
<ul style="list-style-type: none"> ▪ Viscosity: Low (like water) <i>The sodium dichromate concentration of the cooling medium is adjusted using a 60 % w/w aqueous sodium dichromate solution.</i> 	ART
Activity emission potential	
<ul style="list-style-type: none"> ▪ Activity class: Handling of contaminated objects <i>Handling of potentially contaminated screw caps and suction hose.</i> 	ART
<ul style="list-style-type: none"> ▪ Situation: Activities with treated/contaminated objects (surface 0.1–0.3 m²) <i>The surface area of the handled potentially contaminated screw caps and suction hose is obviously small. A surface area in the range of 0.1–0.3 m² can be considered as a worst-case.</i> 	ART
<ul style="list-style-type: none"> ▪ Contamination level: Contamination 10–90 % of surface <i>A relevant part of the surface (10–90 %) of the handled screw caps and suction hose may be potentially contaminated with aqueous sodium dichromate solution.</i> 	ART
Surface contamination	
<ul style="list-style-type: none"> ▪ Process fully enclosed? No <i>Full process enclosure is not feasible for the handling of potentially contaminated screw caps and suction hose.</i> 	ART

	Method
<ul style="list-style-type: none"> Effective housekeeping practices in place? Yes <i>The implemented housekeeping regime ensures that potentially contaminated surfaces are regularly cleaned using appropriate methods.</i> 	ART
Dispersion	
<ul style="list-style-type: none"> Work area: Outdoors <i>The cooling plant and hence the worker handling potentially contaminated screw caps and suction hose are located outdoors.</i> 	ART
<ul style="list-style-type: none"> Source located close to buildings? Yes <i>Concentration adjustment takes place inside of the cooling plant.</i> 	ART
Risk management measures	
Localised controls	
<ul style="list-style-type: none"> Primary: No localized controls (0.0 % reduction) <i>There are no localized controls implemented for the handling of potentially contaminated screw caps and suction hose.</i> 	ART
Conditions and measures related to personal protection, hygiene and health evaluation	
<ul style="list-style-type: none"> Respiratory protection: ABEK P3 full mask (95.0 % reduction) <i>Workers are specifically trained for the use of the prescribed ABEK P3 full mask hence a reduction of inhalation exposure of 95 % is justified.</i> 	ART (extended)

b) Transfer of aqueous sodium dichromate solution

	Method
<ul style="list-style-type: none"> Far field activity <i>When transferring the 60 % w/w aqueous sodium dichromate solution for concentration adjustment the primary emission source (e.g. opening of the drum) is <u>not</u> located in the breathing zone of the worker (i.e. the volume of air within 1 m in any direction of the worker's head).</i> 	ART
<ul style="list-style-type: none"> Duration of activity: < 55 min <i>The transfer of the 60 % w/w aqueous sodium dichromate solution for concentration adjustment takes up to 55 minutes.</i> 	ART
Product (article) characteristics/substance emission potential	
<ul style="list-style-type: none"> Substance product type: Powders dissolved in a liquid or incorporated in a liquid matrix <i>An aqueous sodium dichromate solution is used for concentration adjustment. However, pure sodium dichromate is an essentially non-volatile solid.</i> 	ART
<ul style="list-style-type: none"> Liquid weight fraction: 0.6 <i>The sodium dichromate concentration of the cooling medium is adjusted using a 60 % w/w aqueous sodium dichromate solution.</i> 	ART
<ul style="list-style-type: none"> Viscosity: Low (like water) <i>An aqueous sodium dichromate solution is used for concentration adjustment.</i> 	ART
Activity emission potential	
<ul style="list-style-type: none"> Activity class: Transfer of liquid products / Bottom loading <i>The 60 % w/w aqueous sodium dichromate solution is transferred to the cooling circuit by means of vacuum via suction hose that is inserted into the shipping container (drum).</i> 	ART
<ul style="list-style-type: none"> Situation: Transfer of liquid product with flow of 1–10 L/minute <i>Typically the content of 2 or 3 drums (approx. 40–60 kg) is introduced into the cooling system. Giving the duration of the transfer the worst-case flow rate is set to 1–10 L/minute.</i> 	ART
Surface contamination	
<ul style="list-style-type: none"> Process fully enclosed? No <i>Full process enclosure is not feasible for the transfer of aqueous sodium dichromate solution for concentration adjustment.</i> 	ART

		Method
<ul style="list-style-type: none"> Effective housekeeping practices in place? Yes <i>The implemented housekeeping regime ensures that potentially contaminated surfaces are regularly cleaned using appropriate methods.</i> 		ART
Dispersion		
<ul style="list-style-type: none"> Work area: Outdoors <i>The cooling plant and hence the worker monitoring the transfer of aqueous sodium dichromate solution for concentration adjustment is located outdoors.</i> 		ART
<ul style="list-style-type: none"> Source located close to buildings? Yes <i>Concentration adjustment takes place inside of the cooling plant.</i> 		ART
<ul style="list-style-type: none"> Worker distance: < 4 m <i>The worker monitoring the transfer of aqueous sodium dichromate solution for concentration adjustment is located in vicinity of the sample point.</i> 		ART
Risk management measures		
Localised controls		
<ul style="list-style-type: none"> Primary: No localized controls (0.0 % reduction) <i>There are no localized controls implemented for transfer of aqueous sodium dichromate solution for concentration adjustment.</i> 		ART
<ul style="list-style-type: none"> Segregation: No segregation (0.0 % reduction) <i>Segregation (isolation of potential emission sources from the work environment in a separate room or work area) is not feasible for monitoring the transfer of aqueous sodium dichromate solution for concentration adjustment.</i> 		ART
<ul style="list-style-type: none"> Personal enclosure: No personal enclosure (0.0 % reduction) <i>Personal enclosure (e.g. cabin) is not feasible for monitoring the transfer of aqueous sodium dichromate solution for concentration adjustment.</i> 		ART
Conditions and measures related to personal protection, hygiene and health evaluation		
<ul style="list-style-type: none"> Respiratory protection: ABEK P3 full mask (95.0 % reduction) <i>Workers are specifically trained for the use of the prescribed ABEK P3 full mask hence a reduction of inhalation exposure of 95 % is justified.</i> 		ART (extended)

9.1.5.2 Exposure and risks for workers

Table 16: Exposure concentrations and risks for workers (WCS 4)

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	ART prediction, 90 th percentile: 2.6E-01 µg/m ³ as Na ₂ Cr ₂ O ₇ 1.0E-01 µg/m ³ as Cr(VI) Corrected for RPE and frequency of activity (6 times yearly): 1.2E-04 µg Cr(VI)/m³	Based on the dose-response relationship for lung cancer mortality derived by the RAC, considering a 40 year working life (8 h/d, 5 d/wk), the following excess lifetime lung cancer mortality risk up to age 89 is derived based on the estimated exposure: ELR = 4.8E-07 4.8E-04 additional cases of lung cancer per 1000 exposed workers

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, systemic, long-term	ART prediction, 90 th percentile: 2.6E-01 µg/m ³ as Na ₂ Cr ₂ O ₇ 1.0E-01 µg/m ³ as Cr(VI) Corrected for RPE and frequency of activity (6 times yearly): 1.2E-04 µg Cr(VI)/m³	RCR < 0.01 (reproduction)
Dermal, systemic, long-term	MEASE prediction: Dermal exposure: 1.0E-01 µg/cm ² /d Total dermal loading: 4.8E+01 µg/d as Na ₂ Cr ₂ O ₇ Body dose (70 kg bw): 6.9E-01 µg/kg bw/d as Na ₂ Cr ₂ O ₇ 2.7E-01 µg/kg bw/d as Cr(VI) Corrected for frequency of activity (6 times yearly): 6.3E-03 µg Cr(VI)/kg bw/d	RCR < 0.01 (reproduction)
Combined routes, systemic, long-term		RCR < 0.01 (reproduction)

Table 17: Correction (RPE and frequency) of the inhalation exposure concentrations and risks for workers (WCS 4)

Calculation step	Value
Modelled potential exposure per shift as Na ₂ Cr ₂ O ₇	2.6E-01 µg/m ³
Conversion factor Na ₂ Cr ₂ O ₇ → Cr(VI)	39.697 %
Potential exposure per shift as Cr(VI)	1.0E-01 µg/m ³
Reduction by RPE	95 %
Actual estimated exposure per shift	5.2E-03 µg/m ³
Time correction: Number of days exposed yearly/number of yearly working days*	6/260 = 0.023
Time corrected exposure	1.2E-04 µg/m ³
ELR (4.0E-03 per µg Cr(VI)/m ³)	4.8E-07

*) 260 annual working days assumed

Remarks on exposure data:

Measured exposure data or biological monitoring data suitable for exposure estimation are not available.

Conclusion on risk characterisation:

The modelled RPE- and frequency-corrected exposure estimate (ART) of 1.2E-04 µg Cr(VI)/m³ is used as the basis for risk characterisation (worst case). An excess lifetime lung cancer mortality risk of 4.8E-04 per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship for lung cancer mortality.

Risks for toxicity to reproduction are adequately controlled.

9.1.6 Worker contributing scenario 5 – Maintenance (emptying, intermediate storage of the cooling liquid, and re-filling) (PROC 8b)

9.1.6.1 Conditions of use

This WCS describes the preparatory activities for system maintenance:

Emptying includes connecting the transfer hoses (flexible metal hose), whereupon the cooling medium contained in the AADC system is transferred to a storage tank ('tanktainer'). The worker stays in the vicinity of the connected hose to monitor the process. Accordingly, there are two types of activities that are modelled in two ART sub-scenarios, resulting in one combined exposure estimate:

- a) Coupling/decoupling of the transfer hose:
The flexible metal hose is connected to the AADC system and the 'tanktainer'. After discharging the cooling medium to the 'tanktainer', the system is repeatedly rinsed with clear water, and the first two volumes of rinsing water are transferred to separate 'tanktainers' and disposed of as hazardous waste by a licenced contractor. Directing the different solutions/rinsing waters to different 'tanktainers' requires manual coupling/decoupling of the metal hose. This activity is described by the by the ART activity class "handling of contaminated objects". The total duration of repeat connecting and disconnecting the metal hose is 30 minutes at maximum. No further manipulation of the sodium dichromate or potentially contaminated objects takes place.
- b) Monitoring the transfer processes:
The transfer of the cooling medium (emptying) in itself takes place within the securely connected system "cooling plant – metal hose – tanktainer" and does not require manual interference. It can thus be described by the ART activity class "Transfer of liquid product / Bottom loading" and as a medium level containment process in accordance with the ART manual. This is equivalently the case for the subsequent repeat rinsing. The rinsing water will contain significantly less sodium dichromate than the cooling medium. Therefore, using the ART liquid weight fraction range of 0.5–1.0 % (corresponding to 5–10 g/L sodium dichromate concentration) for exposure estimation constitutes an absolute worst-case scenario. The transfer is monitored by two workers who stay in the vicinity of the connected hose. However, the primary emission source (e.g. couplings) is not located in the breathing zone of the workers (i.e. the volume of air within 1 m in any direction of the workers' heads). Accordingly, emptying and rinsing of the cooling plant can be described as a process with potential far-field exposure. Assuming that workers remain within < 4 m distance from the emission source represents a worst-case, because for safety reasons the worker monitoring the transfer is supervised by the second worker who is located more than 4 m away from the connected hose. The repeat emptying and rinsing operations can be assumed to last for the remainder of a full shift, i.e. 7.5 hours at maximum.

Maintenance itself consists of inspection of the AADC system by external service providers. There is no potential for exposure to Cr(VI) of these workers since any residues were removed by prior rinsing.

The facilities EPT1 and EPT2 undergo maintenance every 4 years, EPT3 every 6 years. Re-filling of the ammonia absorption is equivalent to emptying (reverse process) and takes place on a separate working day (after completion of maintenance). Therefore, there are two days of exposure per maintenance period. For reasons of simplicity, an overall maintenance frequency of once per year (two working days) is assumed as a worst-case. i.e. two working days per year on average.

For both activities workers wear coveralls, safety goggles, protective gloves and RPE (supplied air full face mask, pressure demand mode; APF 2000).

Dermal exposure by MEASE v1.02.01

	Method
Product (article) characteristics	
<ul style="list-style-type: none"> ▪ Physical form: Aqueous solution <i>The cooling medium is an aqueous ammonia solution containing sodium dichromate as a corrosion inhibitor.</i>	MEASE

	Method
<ul style="list-style-type: none"> Content in preparation: < 1 % The target concentration of sodium dichromate for effective corrosion inhibition is 5 g/L (0.5 %). Possible increases in sodium dichromate concentration to above the target as a result of concentration adjustment (WCS 4) are not relevant for maintenance activities: At the end of a service period, when maintenance is necessary, actual sodium dichromate concentrations are lower than the target, for obvious reasons. Therefore, assuming a concentration of 5 g/L (0.5 %) for risk assessment constitutes a clear worst-case approach. Upon removal of the cooling medium the system is repeatedly rinsed with clear water and the rinsing water is collected in 'tanktainers' for disposal as hazardous waste by a licenced contractor. Since there is no manual interference leading to dermal contact with contaminated objects during rinsing, this phase is not considered in the exposure estimation. 	MEASE
Amount used (or contained in articles), frequency and duration of use/exposure	
<ul style="list-style-type: none"> Duration of exposure: 15–60 minutes There is only potential for dermal exposure during coupling/decoupling the potentially contaminated transfer hose, which takes 30 minutes at maximum. 	MEASE
Technical and organisational conditions and measures	
<ul style="list-style-type: none"> Pattern of use: Non-dispersive use Workers are specifically trained for emptying and rinsing of the cooling plant. 	MEASE
<ul style="list-style-type: none"> Pattern of exposure control: Direct handling The worker needs to manually couple/decouple the transfer hose, which represents a potentially contaminated object. 	MEASE
<ul style="list-style-type: none"> Contact level: Intermittent The facilities EPT1 and EPT2 undergo maintenance requiring emptying and rinsing of the cooling plant every 4 years, EPT3 every 6 years. Transfer hoses are coupled/uncoupled once or a few times per day, in any case less than 10 times. This corresponds to intermittent contact level according to the MEASE glossary (2–10 events per day). 	MEASE
Conditions and measures related to personal protection, hygiene and health evaluation	
<ul style="list-style-type: none"> Use of gloves: Properly designed/selected gloves (90.0 % reduction) Workers are specifically trained for the use of the prescribed protective gloves hence a reduction of dermal exposure of 90 % is justified. According to the GESTIS Substance Database of the 'Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung (IFA)' the following materials are suitable for protective gloves: <ul style="list-style-type: none"> - Polychloroprene (CR), thickness: 0.5 mm, permeation time: ≥ 1 hours - Butyl rubber (Butyl), thickness: 0.5 mm, permeation time: ≥ 8 hours - Fluoro carbon rubber (FKM), thickness: 0.4 mm, permeation time: ≥ 2 hours Please note that with respect to sodium dichromate the permeation time for the above protective glove materials is ≥ 8 hours (saturated aqueous solution) (GESTIS, 2015b). However, the described task involves also aqueous solution of ammonia for which the permeation time is shorter. Therefore, the above permeation times, which indicate for how long the protective gloves should maximally be worn, relate to aqueous solutions of ammonia (≤ 32 %) (GESTIS, 2015a). 	MEASE
Other conditions affecting workers exposure	
<ul style="list-style-type: none"> Potentially exposed skin area: Two hands (960 cm²) MEASE calculates with an exposed skin area of 480 cm², which is not in line with the ECETOC TRA default (960 cm²). In a worst-case approach, the MEASE exposure estimate is thus multiplied by a factor 2, to compensate for this difference. 	MEASE (extended)

Inhalation exposure by ART v1.5

a) Coupling/decoupling of the transfer hose

	Method
<ul style="list-style-type: none"> Near field activity When coupling/decoupling the transfer hose for emptying and rinsing of the cooling plant the primary emission source (e.g. coupling of the hose) is located in the breathing zone of the worker (i.e. the volume of air within 1 m in any direction of the worker's head). 	ART

	Method
<ul style="list-style-type: none"> Duration of activity: < 30 min <i>The total duration of coupling/decoupling the potentially contaminated transfer hose is 30 minutes at maximum.</i> 	ART
Product (article) characteristics/substance emission potential	
<ul style="list-style-type: none"> Substance product type: Powders dissolved in a liquid or incorporated in a liquid matrix <i>The cooling medium is an aqueous ammonia solution containing sodium dichromate as a corrosion inhibitor. However, pure sodium dichromate is an essentially non-volatile solid.</i> 	ART
<ul style="list-style-type: none"> Liquid weight fraction: Very small (0.5–1.0 %) <i>The target sodium dichromate concentration for effective corrosion inhibition is 5 g/L (0.5 %). However, during concentration adjustment (WCS 4) always the complete content of the drum in which fresh concentrated aqueous sodium dichromate solution is supplied is added to the cooling circuit. This may result in a final sodium dichromate concentration slightly higher than 5 g/L. Upon removal of the cooling medium the system is repeatedly rinsed with clear water and the rinsing water is collected in 'tanktainers' for disposal of as hazardous waste by a licenced contractor. The rinsing water will contain significantly less sodium dichromate than the cooling medium. However, in order to describe the worst-case this drop in concentration is not taken into account for the risk assessment.</i> 	ART
<ul style="list-style-type: none"> Viscosity: Low (like water) <i>The cooling medium is an aqueous ammonia solution containing sodium dichromate as a corrosion inhibitor.</i> 	ART
Activity emission potential	
<ul style="list-style-type: none"> Activity class Handling of contaminated objects <i>Handling (coupling/decoupling) of the potentially contaminated transfer hose.</i> 	ART
<ul style="list-style-type: none"> Situation: Activities with treated/contaminated objects (surface 1–3 m²) <i>A surface area range of 1–3 m² is proposed by ART for coupling and decoupling of hoses, which can be considered as a worst-case.</i> 	ART
<ul style="list-style-type: none"> Contamination level: Contamination < 10 % of surface <i>Only the inner surface of the flanges of the transfer hose is potentially contaminated with an aqueous sodium dichromate solution.</i> 	ART
Surface contamination	
<ul style="list-style-type: none"> Process fully enclosed? No <i>Full process enclosure is not feasible for the handling (coupling/decoupling) of the potentially contaminated transfer hose.</i> 	ART
<ul style="list-style-type: none"> Effective housekeeping practices in place? Yes <i>The implemented housekeeping regime ensures that potentially contaminated surfaces are regularly cleaned using appropriate methods.</i> 	ART
Dispersion	
<ul style="list-style-type: none"> Work area: Outdoors <i>The cooling plant and hence the worker handling (coupling/decoupling) of the potentially contaminated transfer hose are located outdoors.</i> 	ART
<ul style="list-style-type: none"> Source located close to buildings? Yes <i>Handling (coupling/decoupling) the potentially contaminated transfer hose takes place inside and/or in the vicinity of the cooling plant.</i> 	ART
Risk management measures	
Localised controls	
<ul style="list-style-type: none"> Primary: No localized controls (0.0 % reduction) <i>There are no localized controls implemented for the handling (coupling/decoupling) of the potentially contaminated transfer hose.</i> 	ART

	Method
Conditions and measures related to personal protection, hygiene and health evaluation	
<ul style="list-style-type: none"> ▪ Respiratory protection: Supplied air full face mask, pressure demand mode (APF 2000) (99.95 % reduction) <i>Workers are specifically trained for the use of the prescribed 'Supplied air full face mask, pressure demand mode' hence a reduction of inhalation exposure of 99.95 % (APF 2000) is justified.</i> 	ART (extended)
b) Monitoring the transfer processes	
Method	
<ul style="list-style-type: none"> ▪ Far field activity <i>When monitoring the transfer of cooling medium and rinsing water to the 'tanktainer' the primary emission source (e.g. coupling of the hose) is <u>not</u> located in the breathing zone of the worker (i.e. the volume of air within 1 m in any direction of the worker's head).</i> 	ART
<ul style="list-style-type: none"> ▪ Duration of activity: < 450 min <i>Emptying and rinsing of the cooling plant usually last for the remainder of a full shift, i.e. 7.5 hours (=450 minutes) at maximum.</i> 	ART
Product (article) characteristics/substance emission potential	
<ul style="list-style-type: none"> ▪ Substance product type: Powders dissolved in a liquid or incorporated in a liquid matrix <i>The cooling medium is an aqueous ammonia solution containing sodium dichromate as a corrosion inhibitor. However, pure sodium dichromate is an essentially non-volatile solid.</i> 	ART
<ul style="list-style-type: none"> ▪ Liquid weight fraction: Very small (0.5–1.0 %) <i>The target sodium dichromate concentration for effective corrosion inhibition is 5 g/L (0.5 %). However, during concentration adjustment (WCS 4) always the complete content of the drum in which fresh concentrated aqueous sodium dichromate solution is supplied is added to the cooling circuit. This may result in a final sodium dichromate concentration slightly higher than 5 g/L. Upon removal of the cooling medium the system is repeatedly rinsed with clear water and the rinsing water is collected in 'tanktainers' for disposal of as hazardous waste by a licenced contractor. The rinsing water will contain significantly less sodium dichromate than the cooling medium. However, in order to describe the worst-case this drop in concentration is not taken into account for the risk assessment.</i> 	ART
<ul style="list-style-type: none"> ▪ Viscosity: Low (like water) <i>The cooling medium is an aqueous ammonia solution containing sodium dichromate as a corrosion inhibitor.</i> 	ART
Activity emission potential	
<ul style="list-style-type: none"> ▪ Activity class: Transfer of liquid products / Bottom loading <i>Cooling medium and rinsing water are pumped via a steel transfer hose to the 'tanktainer'.</i> 	ART
<ul style="list-style-type: none"> ▪ Situation: Transfer of liquid product with flow of 100–1000 L/minute <i>Cooling medium and rinsing water are transferred to the 'tanktainer' by means of the pumps within the installations. The flow rates of these pumps are in the range of 26-50 tonnes/hour corresponding to 433-833 L/minute.</i> 	ART
Surface contamination	
<ul style="list-style-type: none"> ▪ Process fully enclosed? No <i>Full process enclosure is not feasible for the transfer of cooling medium and rinsing water to the 'tanktainer'.</i> 	ART
<ul style="list-style-type: none"> ▪ Effective housekeeping practices in place? Yes <i>The implemented housekeeping regime ensures that potentially contaminated surfaces are regularly cleaned using appropriate methods.</i> 	ART
Dispersion	
<ul style="list-style-type: none"> ▪ Work area: Outdoors <i>The cooling plant and hence the worker monitoring the transfer of cooling medium and rinsing water to the 'tanktainer' are located outdoors.</i> 	ART
<ul style="list-style-type: none"> ▪ Source located close to buildings? Yes <i>The transfer of cooling medium and rinsing water to the 'tanktainer' takes place inside and/or in the vicinity of the cooling plant.</i> 	ART

		Method
<ul style="list-style-type: none"> Worker distance: < 4 m <p><i>The worker monitoring the transfer of cooling medium and rinsing water to the 'tanktainer' is located in the vicinity of the connected hose.</i></p>		ART
Risk management measures		
Localised controls		
<ul style="list-style-type: none"> Primary: Medium level containment (99.00 % reduction) <p><i>When coupling the steel transfer hose to the AADC system and the 'tanktainer' almost the same level of containment is reached as for the rest of the cooling system.</i></p>		ART
<ul style="list-style-type: none"> Segregation: No segregation (0.0 % reduction) <p><i>Segregation (isolation of potential emission sources from the work environment in a separate room or work area) is not feasible for the transfer of cooling medium and rinsing water to the 'tanktainer'.</i></p>		ART
<ul style="list-style-type: none"> Personal enclosure: No personal enclosure (0.0 % reduction) <p><i>Personal enclosure (e.g. cabin) is not feasible for the transfer of cooling medium and rinsing water to the 'tanktainer'.</i></p>		ART
Conditions and measures related to personal protection, hygiene and health evaluation		
<ul style="list-style-type: none"> Respiratory protection: Supplied air full face mask, pressure demand mode (APF 2000, 99.95 % reduction) <p><i>Workers are specifically trained for the use of the prescribed 'supplied air full face mask, pressure demand mode' hence a reduction of inhalation exposure of 99.95 % (APF 2000) is justified.</i></p>		ART (extended)

9.1.6.2 Exposure and risks for workers

Table 18: Exposure concentrations and risks for workers (WCS 5)

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Inhalation, local, long-term	ART prediction, 90 th percentile: 3.8E-03 µg/m ³ as Na ₂ Cr ₂ O ₇ 1.5E-03 µg/m ³ as Cr(VI) Corrected for RPE and frequency of activity (2 times yearly): 5.8E-09 µg Cr(VI)/m ³	Based on the dose-response relationship for lung cancer mortality derived by the RAC, considering a 40 year working life (8 h/d, 5 d/wk), the following excess lifetime lung cancer mortality risk up to age 89 is derived based on the estimated exposure: ELR = 2.3E-11 2.3E-08 additional cases of lung cancer per 1000 exposed workers
Inhalation, systemic, long-term	ART prediction, 90 th percentile: 3.8E-03 µg/m ³ as Na ₂ Cr ₂ O ₇ 1.5E-03 µg/m ³ as Cr(VI) Corrected for RPE and frequency of activity (2 times yearly): 5.8E-09 µg Cr(VI)/m ³	RCR < 0.01 (reproduction)

Route of exposure and type of effects	Exposure concentration	Risk characterisation
Dermal, systemic, long-term	MEASE prediction: Dermal exposure: $1.0E-02 \mu\text{g}/\text{cm}^2/\text{d}$ Total dermal loading: $9.6E+00 \mu\text{g}/\text{d}$ as $\text{Na}_2\text{Cr}_2\text{O}_7$ Body dose (70 kg bw): $1.4E-01 \mu\text{g}/\text{kg bw}/\text{d}$ as $\text{Na}_2\text{Cr}_2\text{O}_7$ $5.4E-02 \mu\text{g}/\text{kg bw}/\text{d}$ as Cr(VI) Corrected for frequency of activity (2 times yearly): $4.1E-04 \mu\text{g Cr(VI)}/\text{kg bw}/\text{d}$	RCR < 0.01 (reproduction)
Combined routes, systemic, long-term		RCR < 0.01 (reproduction)

Table 19: Correction (RPE and frequency) of the inhalation exposure concentrations and risks for workers (WCS 5)

Calculation step	Value
Modelled potential exposure per shift as $\text{Na}_2\text{Cr}_2\text{O}_7$	$3.8E-03 \mu\text{g}/\text{m}^3$
Conversion factor $\text{Na}_2\text{Cr}_2\text{O}_7 \rightarrow \text{Cr(VI)}$	39.697 %
Potential exposure per shift as Cr(VI)	$1.5E-03 \mu\text{g}/\text{m}^3$
Reduction by RPE	99.95 %
Actual estimated exposure per shift	$7.5E-07 \mu\text{g}/\text{m}^3$
Time correction: Number of days exposed yearly/number of yearly working days*	$2/260 = 0.0077$
Time corrected exposure	$5.8E-09 \mu\text{g}/\text{m}^3$
ELR ($4.0E-03$ per $\mu\text{g Cr(VI)}/\text{m}^3$)	$2.3E-11$

*) 260 annual working days assumed

Remarks on exposure data:

Measured exposure data or biological monitoring data suitable for exposure estimation are not available.

Conclusion on risk characterisation:

The modelled RPE- and frequency-corrected exposure estimate (ART) of $5.8E-09 \mu\text{g Cr(VI)}/\text{m}^3$ is used as the basis for risk characterisation (worst case). An excess lifetime lung cancer mortality risk of $2.3E-08$ per 1000 exposed workers is estimated based on the above exposure estimate and the RAC dose-response relationship for lung cancer mortality.

Risks for toxicity to reproduction are adequately controlled.

9.1.7 Worker contributing scenario 6 – waste management

9.1.7.1 Conditions of use

As already elaborated in the general use description (see Section 1.1), waste management consists of transfer of rinsing water (including any slurry) to dedicated waste containers, performed remotely via fixed piping. This process step does not require separate interference by plant personnel. Workers are therefore not exposed to sodium dichromate from this process step, which is described as a WCS only for the sake of completeness.

9.1.7.2 Exposure and risks for workers

In line with the conditions of use (see Section 1.1.7.1), exposure of workers and associated risks can be considered to be negligible.

10 RISK CHARACTERISATION RELATED TO COMBINED EXPOSURE

10.1 Human health (related to combined exposure)

10.1.1 Workers

The use that is applied for, sodium dichromate used as corrosion inhibitor in AADC systems, has been divided into 6 WCSs, whereas potential for exposure to Cr(VI) is identified in only five of those: Waste management is not expected to result in any exposure due to lack of interference by workers (see Section 0).

Combined worker exposure may potentially occur from the activities described in WCSs 1, 2, 4 and 5: These WCSs describe activities performed by a common pool of plant personnel of 15 workers among whom all activities are distributed more or less randomly. Combination of exposures from WCSs 1, 2, 4 and 5 would mean that any worker is involved in all events. However, since in reality each operator is involved in only a fraction of the activities performed, combining WCSs 1, 2, 4 and 5 represents a hypothetical extreme worst case.

Analytical work in the laboratory (WCS 3) is performed by laboratory staff. Combination with other activities is not relevant hence this scenario is assessed independently. In conclusion, combined exposures, adjusted as average daily exposure values as presented in Table 20, are considered.

Table 20: Overview of combined and independent worker inhalation exposure to Cr(VI)

Scenario	Exposure estimate	Risk characterisation (reproduction)
WCS 1 Use of sodium dichromate as corrosion inhibitor in ammonia absorption deep cooling systems, PROC 1	2.3E-07 µg Cr(VI)/m ³	RCR < 0.01
WCS 2 Sampling of cooling medium, PROC 9	3.2E-07 µg Cr(VI)/m ³	RCR < 0.01
WCS 4 Concentration adjustment (addition of sodium dichromate solution to the cooling circuit), PROC 8b	1.2E-04 µg Cr(VI)/m ³	RCR < 0.01
WCS 5 Maintenance(emptying, intermediate storage of the cooling medium and re-filling), PROC 8b	5.8E-09 µg Cr(VI)/m ³	RCR < 0.01
Combined (WCSs 1, 2, 4 and 5)	1.2E-04 µg Cr(VI)/m³	RCR < 0.01
Independent exposure:		
WCS 3 Laboratory analysis of cooling medium, PROC 15	8.4E-07 µg Cr(VI)/m ³	RCR < 0.01

For combined exposure from WCSs 1, 2, 4 and 5, an **excess lifetime lung cancer mortality risk of 4.8E-07** (i.e., 4.8E-04 additional cancer cases per 1000 exposed workers) is estimated based on the exposure estimates presented in Table 20 and the RAC dose-response relationship for lung cancer mortality.

The independent excess lifetime lung cancer mortality risk for workers performing **laboratory analysis** of cooling medium is calculated to be **2.3E-09** (i.e., 2.3E-06 additional cancer cases per 1000 exposed workers) is estimated based on the exposure estimate presented in Table 20 and the RAC dose-response relationship for lung cancer mortality.

Table 21: Overview of combined and independent worker dermal exposure to Cr(VI)

Scenario	Exposure estimate	Risk characterisation (reproduction)
WCS 1 Use of sodium dichromate as corrosion inhibitor in ammonia absorption deep cooling systems, PROC 1	1.4E-02 µg Cr(VI)/kg bw/d	RCR < 0.01
WCS 2 Sampling of cooling medium, PROC 9	6.5E-04 µg Cr(VI)/kg bw/d	RCR < 0.01
WCS 4 Concentration adjustment (addition of sodium dichromate solution to the cooling circuit), PROC 8b	6.3E-03 µg Cr(VI)/kg bw/d	RCR < 0.01
WCS 5 Maintenance(emptying, intermediate storage of the cooling medium and re-filling), PROC 8b	4.1E-04 µg Cr(VI)/kg bw/d	RCR < 0.01
Combined (WCSs 1, 2, 4 and 5)	2.1E-02 µg Cr(VI)/kg bw/d	RCR < 0.01
Independent exposure:		
WCS 3 Laboratory analysis of cooling medium, PROC 15	3.1E-04 µg Cr(VI)/kg bw/d	RCR < 0.01

For reproductive effects, the risk assessment is dominated by modelled dermal exposure values, the contribution of the inhalation route for this effect is insignificant (RCR < 0.01). Therefore, the dermal RCR can also be considered as representative for the combined routes. With combined RCRs of < 0.01 for both the inhalation and the dermal route the risk for toxicity to reproduction from combined exposure is adequately controlled.

Remarks on exposure data:

Measured exposure data or biological monitoring data suitable for exposure estimation are not available.

10.1.2 Consumers

The AfA to continue the use of sodium dichromate as corrosion inhibitor in AADC systems is restricted to one specific industrial use only. Therefore, consumer uses are not subject of this CSR.

10.2 Environment (combined for all emission sources)

10.2.1 All uses (regional scale)

10.2.1.1 Total releases

Table 22: Total releases to the environment per year from all life cycle stages (only one life cycle step is relevant for the current application)

Release route	Total releases per year
Water	0 kg/a
Air	0.01 kg/a
Soil	0 kg/a

Remarks:

The AfA to continue the use of sodium dichromate as corrosion inhibitor in AADC systems is restricted to one specific industrial use only. Therefore, only one use and life cycle stage hence only one emission source is relevant for this CSR.

10.2.1.2 Regional exposure**Environment**

Risk characterisation is not required for environment.

Remarks on measured regional concentrations:

No use-related measurements of regional environmental concentrations are available. It is noted that Cr is a ubiquitous element in all environmental media. For background concentrations of both natural and anthropogenic origin reference is made to the EU RAR on Cr(VI) compounds (Munn, et al., 2005).

Remarks on risk characterisation for regional concentrations:

In accordance with Regulation (EC) No 1907/2006, Article 62(4)(d) potential risks to the environment need not be considered.

Man via environment**Table 23:** Regional exposure and risk to man via the environment

Route	Regional exposure	Risk characterisation
Man via environment – inhalation (MvE regional inhalation)	2.6E-15 µg/m ³ as Na ₂ Cr ₂ O ₇ 1.0E-15 µg/m ³ as Cr(VI)	Based on the dose-response relationship for lung cancer mortality derived by the RAC, considering a 70 year exposure time (24 h/d, 7 d/wk), the following excess lifetime lung cancer mortality risk for the general population is derived based on the estimated exposure: ELR = 3.0E-17 3.0E-14 additional cases of lung cancer per 1000 exposed persons RCR < 0.01 (reproduction)
Man via environment – oral, regional (MvE regional oral)	7.6E-06 µg/kg bw/day as Na ₂ Cr ₂ O ₇ 3.0E-06 µg/kg bw/day as Cr(VI) Correction by 0.03 for environmental conversion to Cr(III): 9.1E-08 µg Cr(VI)/kg bw/d	Based on the dose-response relationship for intestinal cancer mortality derived by the RAC, considering a 70 year exposure time (24 h/d, 7 d/wk), the following excess lifetime intestinal cancer mortality risk for the general population is derived based on the estimated exposure: ELR: 7.2E-11 2.4E-06 additional cases of intestinal cancer per 1000 exposed persons RCR < 0.01 (reproduction)
Man via environment – combined routes		ELR*: 7.2E-11 7.2E-08 additional cases of cancer per 1000 exposed persons RCR < 0.01 (reproduction)

*) In fact, an ELR for combined routes is not applicable since both lung cancer and intestinal cancer caused by Cr(VI) are local, site-of-contact tumours; therefore, this cancer risk actually represents an aggregated risk for different types of tumours instead of a risk arising from a systemic dose due to combined exposures.

Remarks:

Humans will not be significantly exposed via the food chain. According to the EU RAR (Munn et al., 2005) “releases of chromium (VI) from any sources are expected to be reduced to chromium (III) in most situations in the environment (see Section 3.1.1.2.1) so the impact of chromium (VI) as such is likely to be limited to the area around the source”.

This is supported by the risk characterisation presented in Table 23, conducted under the worst-case assumption that no conversion of Cr(VI) to Cr(III) takes place.

10.2.2 Local exposure due to all wide dispersive uses

Environment

Remarks:

The AfA to continue the use of sodium dichromate as corrosion inhibitor in AADC systems is restricted to one specific industrial use only. Therefore, there are no wide dispersive uses that need to be considered.

Man via environment

Remarks:

The AfA to continue the use of sodium dichromate as corrosion inhibitor in AADC systems is restricted to one specific industrial use only. Therefore, there are no wide dispersive uses that need to be considered.

10.2.3 Local exposure due to combined uses at a site

There are no combined uses at the assessed site. The AfA to continue use of sodium dichromate as corrosion inhibitor in AADC systems is restricted to one specific industrial use only.

11 REFERENCES

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12 Annex A

ART input parameters and additional explanations for the exposure model used as plausibility check for EUSES calculations of aerial concentrations in the environment (ECS 1).

	Method
<ul style="list-style-type: none"> Far field activity <i>During the continuous operation of the AADC systems the primary emission source (e.g. piping of the installation) is <u>not</u> located in the breathing zone of the member of the general population (i.e. the volume of air within 1 m in any direction of the head).</i> 	ART
<ul style="list-style-type: none"> Duration of activity: < 480 min <i>The AADC systems are operated continuously. The ART 8 h exposure estimate represents the maximally achievable aerial concentration hence is also applicable to potential 24 h exposure of the general public.</i> 	ART
Product (article) characteristics/substance emission potential	
<ul style="list-style-type: none"> Substance product type: Powders dissolved in a liquid or incorporated in a liquid matrix <i>The cooling medium is an aqueous ammonia solution containing sodium dichromate as a corrosion inhibitor. However, pure sodium dichromate is an essentially non-volatile solid.</i> 	ART
<ul style="list-style-type: none"> Weight fraction: Very small (0.5–1.0 %) <i>The target sodium dichromate concentration for effective corrosion inhibition is 5 g/L (0.5 %). However, during concentration adjustment (WCS 4) always the complete content of the drum in which fresh concentrated aqueous sodium dichromate solution is supplied is added to the cooling circuit. This may result in a final sodium dichromate concentration slightly higher than 5 g/L.</i> 	ART
<ul style="list-style-type: none"> Viscosity: Low (like water) <i>The cooling medium is an aqueous ammonia solution containing sodium dichromate as a corrosion inhibitor.</i> 	ART
Activity emission potential	
<ul style="list-style-type: none"> Activity class: Transfer of liquid products / Bottom loading <i>The process (continuous pumping of cooling medium in a circuit) can be considered as a never ending “bottom loading” of the cooling medium.</i> 	ART
<ul style="list-style-type: none"> Situation: Transfer of liquid product with flow of 100–1000 L/minute <i>The flow rates of the pumps within the installations are in the range of 26–50 tonnes/hour corresponding to 433–833 L/minute.</i> 	ART
Surface contamination	
<ul style="list-style-type: none"> Process fully enclosed? No <i>The cooling medium is safely enclosed in the cooling circuit, so that no opportunity for contact with sodium dichromate is given. However, no cooling system is perfectly leak-tight [small volumes (drop size) of cooling medium may occasionally leak from flanges and mufflers]. Taking this into account for risk assessment purposes it is considered more realistic to describe the continuous operation of the AADC systems as a process with a high level containment instead of a fully enclosed process.</i> 	ART
<ul style="list-style-type: none"> Effective housekeeping practices in place? Yes <i>The implemented housekeeping regime ensures that potentially contaminated surfaces are regularly cleaned using appropriate methods.</i> 	ART
Dispersion	
<ul style="list-style-type: none"> Work area: Outdoors <i>The cooling plants are located outdoors.</i> 	ART
<ul style="list-style-type: none"> Source located close to buildings? Yes <i>The AADC unit is an industrial plant located outdoors. However, the plant itself constitutes a structure similar to a building. Therefore, setting this parameter to 'yes' is considered to be justified.</i> 	ART
<ul style="list-style-type: none"> Worker distance: > 4 m <i>In view of the actual distance of any members of the general population from the emission source setting this ART parameter to '> 4 m' is considered to be justified.</i> 	ART

	Method
Risk management measures	
Localised controls	
<ul style="list-style-type: none"> ▪ Primary: High level containment (99.90 % reduction) <i>The cooling medium is safely enclosed in the cooling circuit, so that no opportunity for contact with sodium dichromate is given. However, no cooling system is perfectly leak-tight [small volumes (drop size) of cooling medium may occasionally leak from flanges and muffers]. Taking this into account for risk assessment purposes it is considered more realistic to describe the continuous operation of the AADC systems as a process with a high level containment instead of a fully enclosed process.</i> 	ART
<ul style="list-style-type: none"> ▪ Segregation: No segregation (0.0 % reduction) <i>Segregation (isolation of potential emission sources from the work environment in a separate room or work area) is not feasible for the continuous operation of the AADC systems.</i> 	ART
<ul style="list-style-type: none"> ▪ Personal enclosure: No personal enclosure (0.0 % reduction) <i>Personal enclosure (e.g. cabin) is not feasible for the continuous operation of the AADC systems.</i> 	ART

The predicted 90th percentile for long-term exposure is 0.0000000045 mg/m³ (4.5E-06 µg/m³).