CHEMICAL SAFETY REPORT

Public version

Name of applicant:	TCL Manufacturing Ltd (trading as Perrin & Rowe)
Submitted by:	TCL Manufacturing Ltd
Prepared by:	TCL Manufacturing Ltd Technology Sciences Group Consulting Ltd (TSG Consulting)
Date:	28th June 2022
Substance:	Chromium trioxide (EC no. 215-607-8, CAS no. 1333-82-0)
Use title:	Industrial use of chromium trioxide for functional chrome plating with decorative character for sanitary applications
Use number:	1

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Declaration

We, the Applicant (TCL Manufacturing Ltd), are aware of the fact that further evidence might be requested by the Health and Safety Executive ('the Agency') to support the information provided in this document.

Also, we request that the information blanked out in the "public version" of the Chemical Safety Report is not disclosed. We hereby declare that, to the best of our knowledge as of today (28th June 2022), the information is not publicly available, and, in accordance with the due measures of protection that we have implemented, a member of the public should not be able to obtain access to this information without our consent or that of the third party whose commercial interests are at stake.

Signature:

Date, Place: 28th June 2022
TCL Manufacturing Ltd
Wolverhampton

Andy Hampson
Director of Operations (EMEAA), FBHS WI

List of abbreviations

AfA	Application for Authorisation
AoA	Analysis of Alternatives
APF	Assigned protection factor
BS	British Standard (published by the British Standards Institution, BSI)
BS EN	British Standard, European Norm, i.e. a British Standard that implements a European Standard
BS EN ISO	British Standard which implements an identical European and International Standard
CAS	Chemical Abstracts Service
CLP	Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures (Please note that references in this report to CLP should be taken as referring to GB CLP, as retained EU law following Brexit and the end of the Implementation Period on 31 December 2020, unless otherwise specified.)
CMR	Carcinogenic, mutagenic or toxic to reproduction
COD	Chemical oxygen demand
Cr(O)	Metallic chromium
Cr(III)	Trivalent chromium
Cr(VI)	Hexavalent chromium
CrO_3	Chromium trioxide
CSR	Chemical Safety Report
CTACSub	Chromium Trioxide REACH Authorisation Consortium
EC	European Commission
ECS	Environmental contributing scenario
ECHA	European Chemicals Agency
EEA	European Economic Area, i.e. the EU plus Norway, Iceland and Liechtenstein
EN	European Norm, i.e. European Standard (published by the European Committee for Standardisation, CEN)
ELR	Excess Lifetime Risk
ERC	Environmental Release Category
ES	Exposure scenario
EU	European Union
FB	Fortune Brands
FTE	Full-time equivalent
GB	Great Britain
HSE	Health & Safety Executive
IARC	International Agency for Research on Cancer
IBC	Intermediate bulk container
ISO	International Standard (published by the International Organisation for Standardisation, ISO)

IUPAC	International Union of Pure and Applied Chemistry
LEV	Local exhaust ventilation
OC	Operational Conditions
PC	Chemical product category
PEC	Predicted environmental concentration
PFOS	Perfluorooctanesulfonic acid
PPE	Personal protective equipment
PROC	Process category
R&D	Research and development
RAC	Risk Assessment Committee
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 (Please note that references in this report to REACH should be taken as referring to UK REACH, as retained EU law following Brexit and the end of the Implementation Period on 31 December 2020, unless otherwise specified.)
RMM	Risk Management Measures
RPE	Respiratory protective equipment
SDS	Safety data sheet
SEA	Socio-economic analysis
SEAC	Committee for Socio-Economic Analysis
SOP	Standard Operating Procedure
SP	Substitution Plan
STP	Sewage treatment plant
SU	Sector of use
SVHC	Substance of very high concern
TWA	Time-weighted average
WCS	Worker Contributing Scenario
WEL	Workplace exposure limit
WI	Water Innovations (part of Fortune Brands)

9. Exposure assessment and related risk characterisation

9.1. Introduction

9.1.1. Overview of uses and exposure scenario

Functional chrome plating with decorative character involves the use of chromium trioxide in the electrochemical treatment of metal, plastic or composite surfaces. Functional chrome plating is used to deposit metallic chromium to achieve a high-quality surface with excellent corrosion protection and durability in contact with aggressive and demanding environmental conditions, as well as providing high aesthetic and decorative value to consumer.

Cr(VI) deposits a very consistent metallic layer during chrome plating. The bulk composition of the deposited layer is 90% chromium, with the balance being oxygen. The surface of the chromium naturally converts very quickly to chromium oxide. This creates a very stable coating layer and provides the sanitary products with the following properties:

- Corrosion resistance;
- Wear resistance;
- Adhesion;
- Chemical resistance;
- Temperature change / heat resistance;
- Colour consistency;
- Surface appearance;
- Longevity;
- The finish is non-toxic and safe to use.

Perrin & Rowe uses traditional manufacturing crafts to produce luxury kitchen and bathroom products. Each piece is handmade in a workshop in the UK from low lead brass of the highest quality available and then plated to a thickness with a chrome finish of typically 0.25 - 0.60 µm. All brassware is assembled by hand and individually inspected to ensure a high-quality finish. Perrin & Rowe's aim is to produce high quality, luxurious items which are not mass produced.

The electroplating process performed by Perrin & Rowe is a traditional, multi-step automated process and performed at one site in Wolverhampton in the UK. The address of this facility is TCL Manufacturing, Shaw Road, Bushbury, Wolverhampton, WV10 9LB. The facility is located approximately 3km south of Wolverhampton city centre in a densely developed area of mixed residential, commercial and industrial land use (see Figures 1 and 2 below).

The factory building is located towards the centre of the site and the ground floor of the building is largely dedicated to manufacturing. A plan of the site (Figure 3) shows the plating area. Plating Line 1 includes the chromium trioxide bath. The chemical store, laboratory and effluent line are indicated adjacent to Plating Line 1 within the building. The floor of the building is constructed from concrete, covered in acid-resistant paint and in good condition.

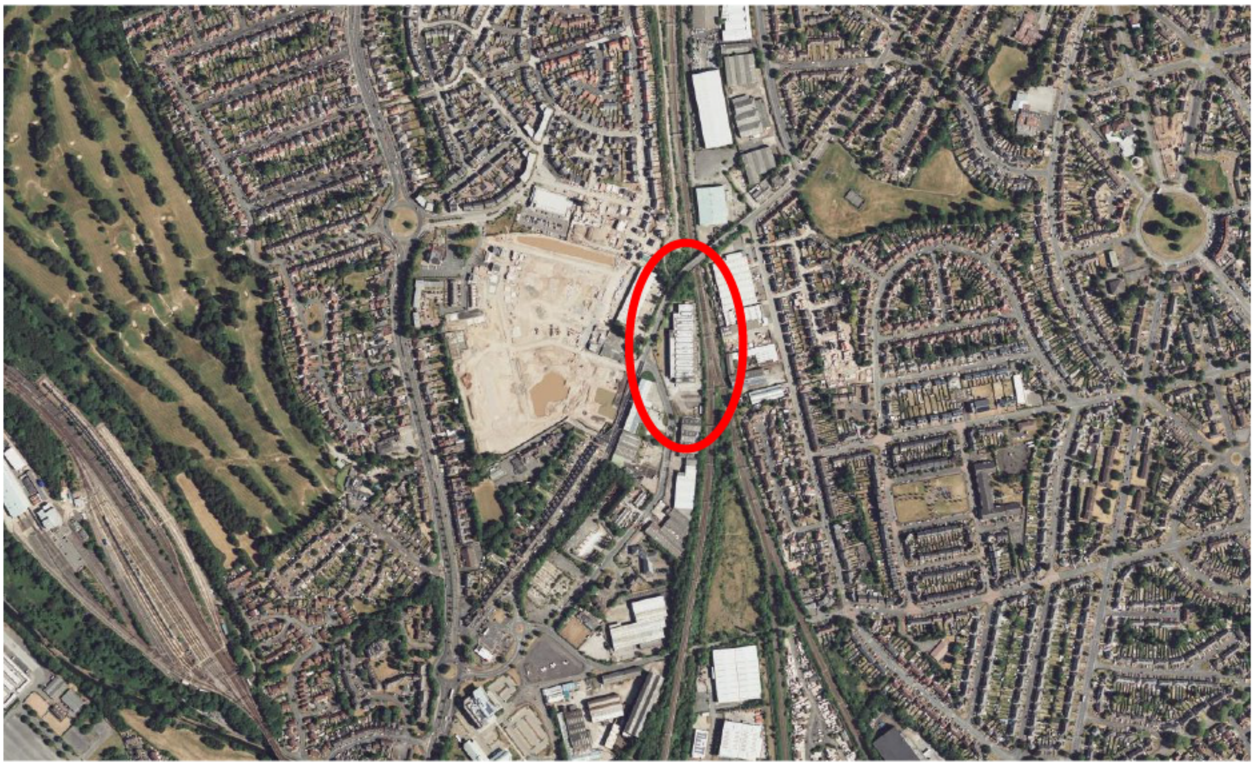

Figure 1*: Aerial view of Perrin & Rowe's Wolverhampton site (circled in red)*

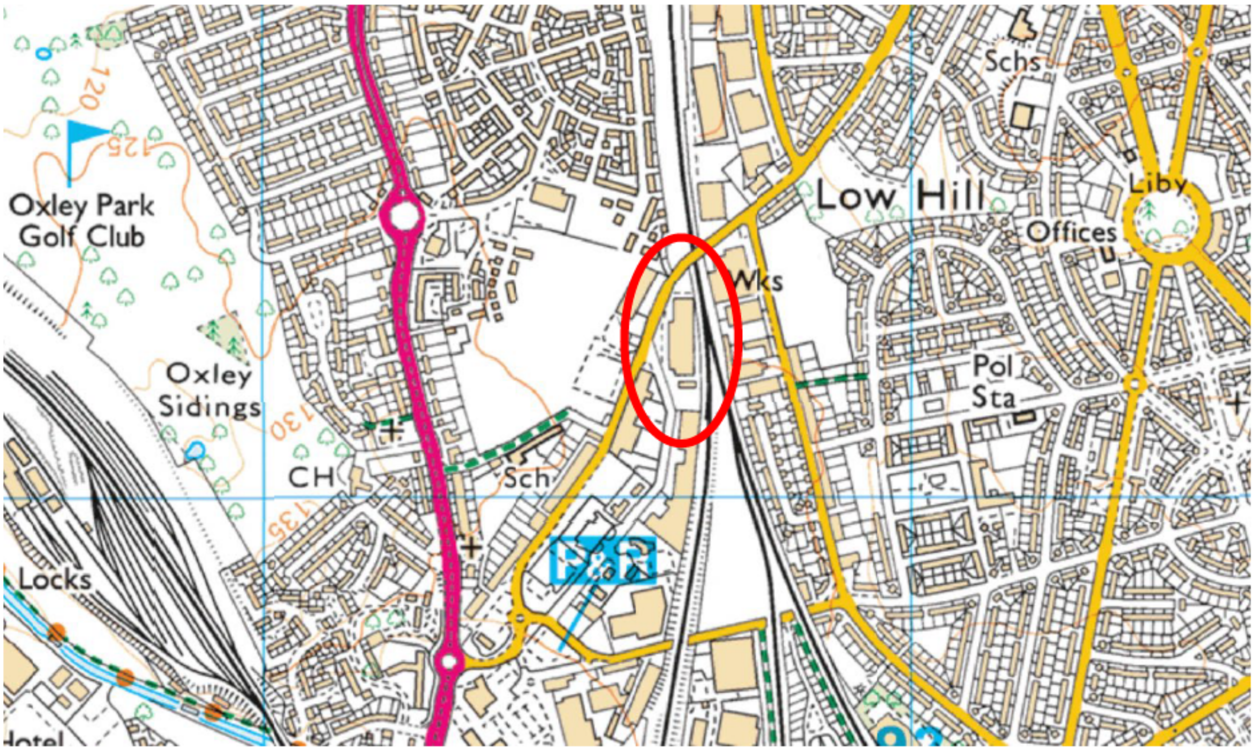

Figure 2*: Ordnance Survey map of Perrin & Rowe's Wolverhampton site (circled in red)*

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Figure 3: *Floor plan of the Wolverhampton site*

Perrin & Rowe applies a number of different surface treatment finishes on Plating Line 1, which is an automated plating line incorporating different chemical solutions in a series of tanks. The plating line is pre-programmed to deliver a particular finish by moving components on jigs attached to an overhead flight bar between tanks in a defined sequence. Chromium plating is one of three possible finishes. Plating activities that involve chromium trioxide account for approximately [redacted] (public range 50-80%) of the operations on Plating Line 1.

The plating processes in general and the chromium plating process in particular can be divided into three sub-processes, namely pre-treatment (removal of impurities, surface activation), the main surface treatment process (functional chrome plating) and post-treatment (rinsing, drying, inspection). These are summarised in Figure 4 below. Only the main surface treatment process involves the use of chromium trioxide. The pre-treatment and post-treatment steps are described here for completeness and context.

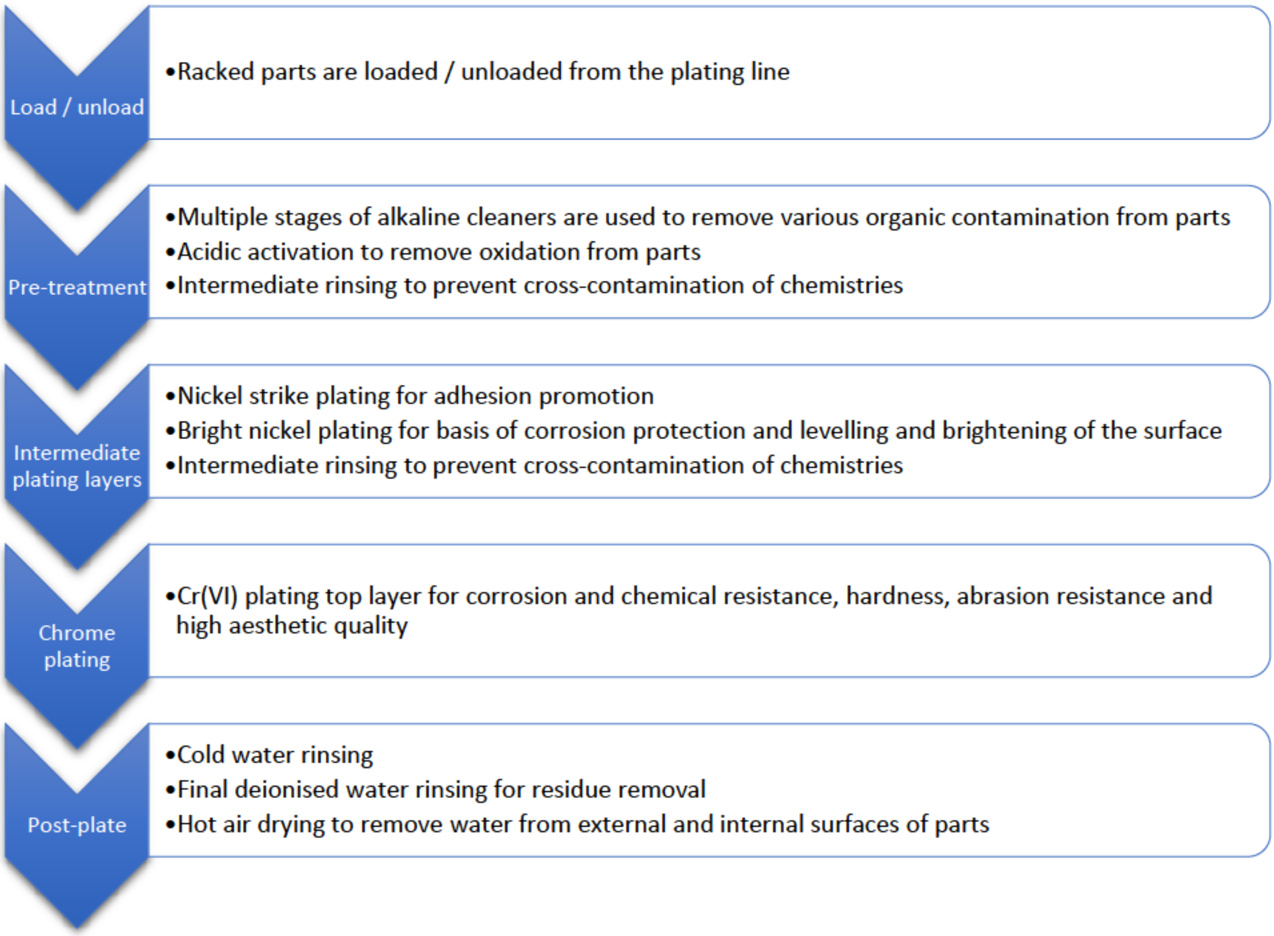


***Figure 4**: Overview of the Cr(VI) plating process*

9.1.1.1 Sub-Process 1 – Pre-treatment / cleaning of parts to be treated

Prior to plating, the parts must be cleaned of any kind of dirt, both organic and inorganic contaminants.

The parts are manually loaded onto jigs supported on trolleys by workers (jiggers) in a separate area to the chromium plating line (see blue area on Figure 3). The jigs are then manually passed through an ultrasonic tank before being placed onto the flight bar to be sent automatically to Plating Line 1 (pink area on Figure 3) where further cleaning processes are carried out.

Removal of organic material from the surface of the substrate is achieved through alkaline cleaning processes, i.e. soak cleaning and electrolytic cleaning. These processes in conjunction with intermediate rinsing effectively remove the organic material from the parts and prepare the surface.

Removal of oxidation from the surface of the parts is performed in an acidic activation process. Removal of the surface oxide film is required for appropriate adhesion of the subsequent plating layers.

The parts are then rinsed in a bath filled with clean rinsing water to prevent drag out of materials from one bath to the next. Rinsing typically occurs in several steps following the various chemical process tanks. Counter-current rinsing is normally used, where the part is rinsed in a succession of rinsing baths; the water from successive baths is used to top up preceding baths. This both reduces water consumption as well as improving the rinsing effectiveness of the parts.

9.1.1.2 Sub-Process 2 – Functional Chromium Plating

Following cleaning, multiple nickel layers are applied to the brass parts by a electrolytic chemical deposition process (typically referred to as electroplating). Multiple nickel layers are needed prior to the final chrome layer to meet the required key appearance and performance requirements of the final product. These performance requirements include corrosion and chemical resistance, hardness, adhesion and surface appearance of the final product. The nickel is applied in a two-layer system. It combines a nickel strike layer and bright nickel layer.

The chromium layer is then applied to the parts by electroplating. The metal parts are immersed in an open bath containing an aqueous solution of chromium trioxide. During the electroplating process, the hexavalent chrome (Cr(VI)) is deposited on the surface of the component and reduced to metallic chrome (Cr(0)). The chrome plate layer forms a well-adhered coating on top of the nickel plating layers. The electroplating process continues until the metallic chrome coating has reached the desired thickness level. The thickness of the metallic chrome layer is typically on average equal to 0.25 - 0.60 µm and depends on the geometry of the substrate.

The plating line operation is supervised by two technicians from a separately enclosed laboratory (located in the pink area on Figure 3). The plating line is fully visible and accessible to the technicians during this time but, due to the enclosed nature of the laboratory, exposure to Cr(VI) does not typically occur. The technicians regularly walk the plating line (once per hour) to check on the operations. This is considered further in the worker contributing scenarios in section 9.2.

9.1.1.3 Sub-process 3 – Post-treatment

For Cr(VI) plating, the post-plate operation involves various rinsing and drying steps. Multiple cold water rinses followed by a much higher purity deionized water rinse are utilized to remove residue from both the internal and external surfaces of the parts. This is then followed by a forced air drying step, where the water is then dried from the surfaces of the parts.

Once dried, the parts are unloaded from the jigs in the inspection area. All their brassware is then individually inspected to ensure a high-quality finish.

9.1.1.4 Related activities

During the processing steps (pre-treatment, functional chromium plating and post treatment) there are other activities integrally linked to the production process which are relevant for the evaluation of exposure potential. These include:

1) Receipt and storage of raw materials.
2) Weighing of solid chromium trioxide and topping up or replenishing of the chromium plating baths.
3) Sampling and analysis of the aqueous chromium solution from the plating baths to determine concentration.
4) Maintenance of the plating line when the plant is non-operational.
5) Treatment of wastewater containing chromium trioxide (batch process).
6) Sampling of wastewater from the wastewater treatment plant to check compliance with permit requirements.
7) Maintenance of the wastewater treatment plant.

The activities described are carried out by the following type of workers:

Role	Number of workers	Tasks carried out	Working hours	Length of shift
Technician	2	WCS 3, 4, 6, 10	6am – 3pm or 7am – 4 pm with 45 mins break	8 hours 15 mins
Line 1 Operator	1	WCS 1, 2, 5, 9	6am – 2.30pm or 1.30pm – 10pm with 45 mins break	7 hours 45 mins
Jiggers	2	WCS 7	6am – 3pm or 1.30pm – 10pm with 45 mins break	8 hours 15 mins
Unjiggers	1	WCS 7	6am – 2.30pm or 1.30pm – 10pm with 45 mins break	7 hours 45 mins
Maintenance (usually performed by one of the technicians)	2	WCS 8, 10	6am - 2pm (Sat) with 30 mins break	5.5 hours (Sat)
Note: - The potential for exposure to Cr(VI) does not span the whole of the shift and is dependent on the activity performed. Further details of potential exposure time are provided in each WCS.				

***Table 1**: Related activities conducted with the potential for exposure to chromium trioxide*

The following activities do not involve direct contact with chromium trioxide:

Role	Number of workers	Working hours	Length of shift
Gold Line Operator	1	6am – 2.30pm or 1.30pm – 10pm with 45 mins break	N/A
Line 2 Operator	1	6am – 2.30pm or 1.30pm – 10pm with 45 mins break	
Bronze Line Operator	1	6am – 2.30pm or 1.30pm – 10pm with 45 mins break	

Role	Number of workers	Working hours	Length of shift
Inspectors	3	6am – 3pm (Mon-Thurs) and 6am - 12.30pm (Fri) with 45 mins break 6am - 2pm (Sat) with 30 mins break	

***Table 2**: Activities conducted that do not present the potential for exposure to chromium trioxide*

9.1.1.5 Exposure scenarios and contributing scenarios

The following Tables list the exposure scenarios (ES) and contributing scenarios assessed in this CSR.

Identifiers *	Market sector	Title of exposure scenario	Tonnage (kg per year)
IW-1	Not relevant	Industrial use of chromium trioxide for functional chromium plating with decorative character for sanitary applications	[redacted] Public range 100 - 1,000
Notes: Manufacture: M-#, Formulation: F-#, Industrial end use at site: IW-#, Professional end use: PW-#, Consumer end use: C-#, Service life (by workers in industrial site): SL-IW-#, Service life (by professional workers): SL-PW-#, Service life (by consumers): SL-C-#.)			

***Table 3**: Overview of Exposure Scenarios assessed in this CSR*

Contributing scenario	PROC	Name of the contributing scenario	Size of the exposed population
ES 1: Industrial use of chromium trioxide for functional chromium plating with decorative character for sanitary applications (ERC 6b)			
WCS 1	PROC 1	Delivery of raw materials	1
WCS 2	PROC 1	Storage of raw materials	2
WCS 3	PROC 8b	Weighing and replenishing of tank	2
WCS 4	PROC 9	Sampling of plating tank	1
WCS 5	PROC 3	Operation of plating line	2
WCS 6	PROC 15	Laboratory analysis	1
WCS 7	PROC 1	Loading/unloading of parts	3
WCS 8	PROC 28	Maintenance	2
WCS 9	PROC 8b	Treatment of wastewater	2
WCS 10	PROC 8b	Maintenance: Cleaning of filter press	1

***Table 4**: Overview of Contributing Scenarios assessed in this CSR*

Figure 5 below provides a schematic overview of the electroplating process and related activities at Perrin & Rowe, with links to the relevant worker contributing scenarios (WCS).

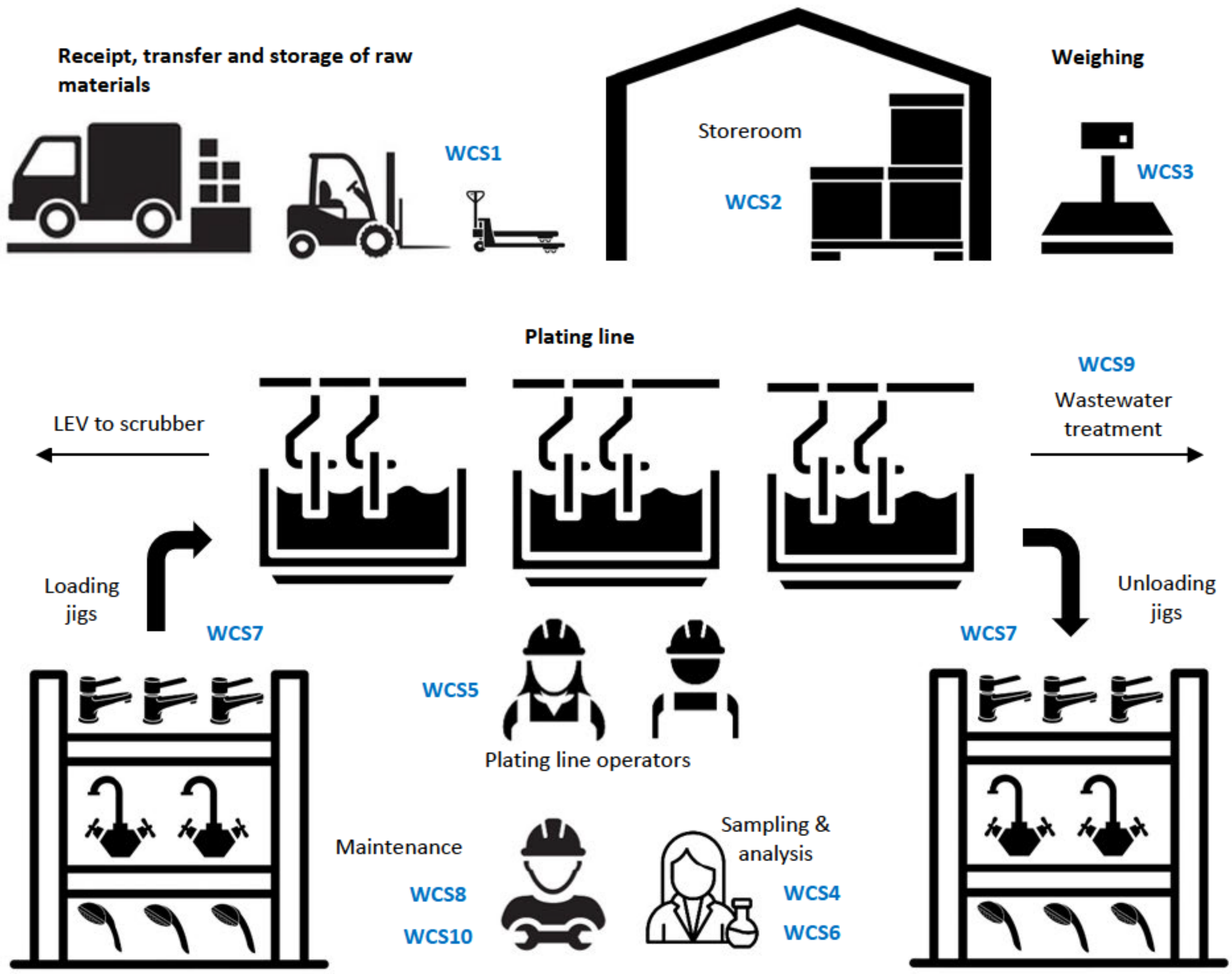


***Figure 5**: Overview of the electroplating process, with references to the relevant WCS*

9.1.1.6 Operating conditions and risk management measures

Operating conditions (OCs) and risk management measures (RMMs) are specific to each activity and are described in further detail in the worker contributing scenarios. A summary of the most significant operating conditions and risk management measures employed is provided below.

- **Mist suppressants**
  A mist suppressant is used to reduce exposure of workers to Cr(VI) during plating operations and is known to aid the reduction of Cr(VI) in the working air.

  Weekly surface retention tests are conducted by one of the two technicians. Further mist suppressant is added to the bath when the surface retention is high. Surface retention sampling is also conducted by a third party (Access Chemicals) every 2 weeks.

- **Local exhaust ventilation (LEV)**
  LEV in the form of lip extraction is installed on the Cr(VI) bath to extract Cr(VI) aerosols generated during the electrolytic process.

The air is sent through baffles before being released to atmosphere. The extraction is regularly cleaned and subject to thorough examination and testing on a yearly basis by an external contractor.

In case of failure of the LEV, a beacon above the tank is triggered and flashes to alert the inspector and a relay automatically turns off the tank current. Further information is provided in section 9.1.3.1.

- **Restricted access to specific areas**
  Management measures in place include limited access to specific areas. These include:

  - *The chemical stores*
    Access is restricted to trained personnel only using a keypad lock. Signage is also visible indicating this is an area for authorised personnel only.

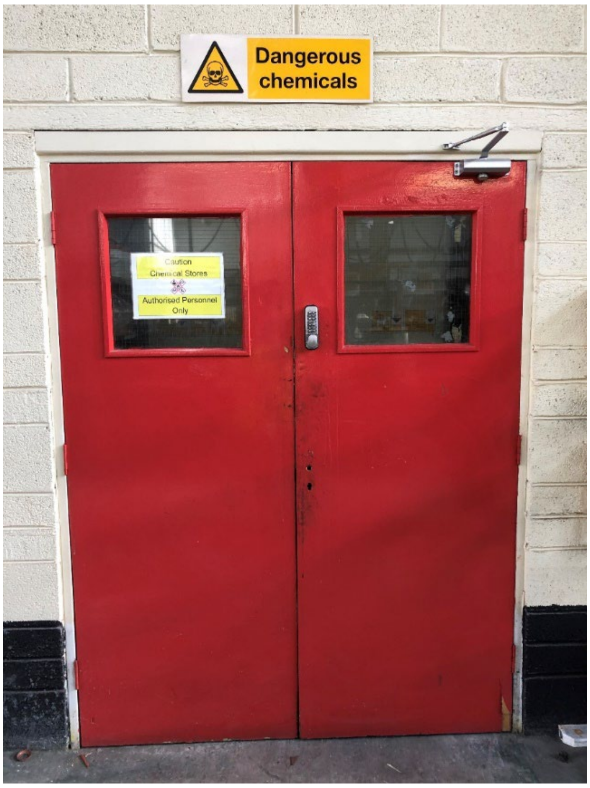


***Figure 6**: Photograph of keypad-locked door to chemical stores*

  - *The plating walkway*
    The plating area walkway is restricted to trained technicians only; access is restricted using a mechanical gate.

- **Personal protective equipment (PPE)**
  As a minimum, safety boots and protective eyewear are required to be worn for all activities on the factory floor. Where exposure to chromium trioxide is possible then the following PPE is required to be worn:

(i) A full face shield, such as the Sperian Bionic Faceshield-Clear, PC Fog-Ban/Anti-Scratch Visor.
(ii) A face mask with a APF of 20. Currently, a 3M 4279+ (FFABEK1P3 R D) half mask is used.
(iii) Protective gloves. Currently, the Ansell AlphaTec 87-900 natural rubber & neoprene gloves are used.

The specific worker contributing scenarios (WCS) provide further details of the PPE that is used during each activity. Workers are skilled operators and receive regular training as regards how to properly wear PPE.

The workers are provided with a locker in the plating area of the facility. All protective clothing is removed and stored before entering the rest rooms and/or changing rooms.

***Figure 7**: Photograph of lockers used for storage of PPE*

Regular Cr(VI) biological monitoring is in place for all operators working within the plating area. Biological monitoring is used to indicate how much Cr(VI) has entered the worker's body. It involves measuring the levels of Cr(VI) in a sample of the worker's breath, urine and blood. For workers in the plating area, urine samples, skin checks and lung function tests are conducted under supervision of medical personnel.

The last set of biological monitoring was conducted in January 2022 and the results of Cr in urine varied between 0.5 to 2.9 µmol/mol creatinine which is lower than the UK biological monitoring guidance value (BMGV) of 10 µmol/mol creatinine[1]. Workers were reminded of the importance of PPE when working onsite by the external company performing the biological testing.

[1] HSE EH40, 2020, at p43.

9.1.2. Tonnage used at site

The assessed tonnage is [redacted] (public range 100 - 1,000 kg/year CrO_3). This takes into account a realistic growth in the production of chrome plated objects. Tonnages supplied per market sector are not relevant for this application; this CSR has been prepared in the context of an individual application for authorisation (AfA) of one specific use of chromium trioxide. Market sector-wide tonnages need not be considered.

9.1.3. Introduction to the assessment

A CSR prepared for an authorisation application needs only to address the risks posed by the hazardous properties of the substance that are listed on Annex XIV. In the case of chromium trioxide, the substance was placed on Annex XIV due to its harmonised classification of Carcinogen Cat. 1A; H350 and Mutagen Cat. 1B; H340.

The molecular entity that drives the carcinogenicity of chromium trioxide is the Cr(VI) ion, which is released when chromium trioxide solubilises and dissociates. Chromium (VI) causes lung tumours in humans and animals by the inhalation route (through inhalation of dust and/or aerosols) and tumours of the gastrointestinal tract in animals by the oral route. These are both local, site-of-contact tumours – there is no evidence that Cr(VI) causes tumours elsewhere in the body.

Based on studies which show its genotoxic potential, the Risk Assessment Committee (RAC) has concluded that chromium trioxide should be considered as a non-threshold substance with respect to risk characterisation for carcinogenic effect of hexavalent chromium (reference to the studies examined are included in the RAC document RAC/27/2013/06 Rev. 1).[2]

RAC has established a reference dose response relationship for the carcinogenicity of hexavalent chromium[3] and this will be used in the risk assessment by Perrin & Rowe. It was noted that 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. The risk assessment will therefore focus on the exposure through inhalation to workers.

In addition, in this CSR, Perrin & Rowe will demonstrate minimisation of emissions through the use of suitable risk management measures (RMMs). Evaluation of any potential hazards to the environment is not required within the framework of this application. However, measures to prevent or limit release of Cr(VI) to the environment are provided as best practice at the site carrying out operations using chromium trioxide are provided. Health hazards which may potentially relate to Cr(VI) exposure of the general population via the environment are also considered accordingly.

9.1.3.1 Environment

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

Evaluation of the potential hazards to the environment are not required within the framework of this application. However, details of the measures used to limit the release of Cr(VI) to the environment at the facility are provided, to demonstrate that adequate risk management measures are in place to limit emissions to the environment.

[2] ECHA, 2013.

[3] As above.

Protection target	Type of risk characterisation	Hazard conclusion DNEL / dose-response relationship
Freshwater	Not required	Not relevant
Sediment (freshwater)	Not required	Not relevant
Marine water	Not required	Not relevant
Sediment (marine water)	Not required	Not relevant
Sewage treatment plant	Not required	Not relevant
Air	Not required	Not relevant
Agricultural soil	Not required	Not relevant
Predator	Not required	Not relevant

Table 5*: Type of risk characterisation required for the environment*

Release to water

Figure 8 below shows a schematic of the effluent flow at the Wolverhampton site. There are two areas where release of Cr(VI) to wastewater could occur: (i) via chrome rinse tanks and (ii) via the chromium neutraliser tank. These areas are considered in further detail below.

Chromium Rinse Tanks

Stations 4 and 5 are counter flowing water rinses with a weir. Both chrome rinse tanks are changed every Friday due to contaminants building up in the tank; the water in the tank is discharged and flows directly into the chromium treatment tank.

The chromium treatment tank on the wastewater system contains 4 probes, two for pH and two for chrome reduction control (redox measured in units of mV). These probes control automated dosing of sulphuric acid and sodium metabisulphite into the chromium reduction tank. Sulphuric acid is used to adjust the pH and sodium metabisulphite is then introduced to reduce all Cr(VI) present to Cr(III).

Once the reduction is complete, the wastewater is sent via a decomplexant tank to a transfer tank before being pumped into a pH correction tank. Detectors within the pH tank monitor the pH and automatically dose the correct levels of caustic and sulphuric acid to ensure that the pH of the effluent is maintained between 8 and 11, with an ideal pH being around 9.

The water then flows through to the flocculation tank where a polymer (ClearFlo L-1R) is dosed and mixed automatically. ClearFlo L-1R is a high molecular weight chelating polymer, which forms strong, insoluble chelate complexes. Due to the long-chained basic molecular structure, ClearFlo L-1R forms large strong flocs, which aid separation and settle immediately.

From the flocculation tank, the water flows into the settlement tank. The settlement tank is filled from the bottom up to allow the sludge to settle and to suspend water through the lamella pack. The sludge is then fed through a valve to a filter press where it is collected and disposed of via special waste contractors.

The top layer of the water then drops to the final outfall tank before being discharged from the site via the public sewer according to a consent with Severn Trent Water.

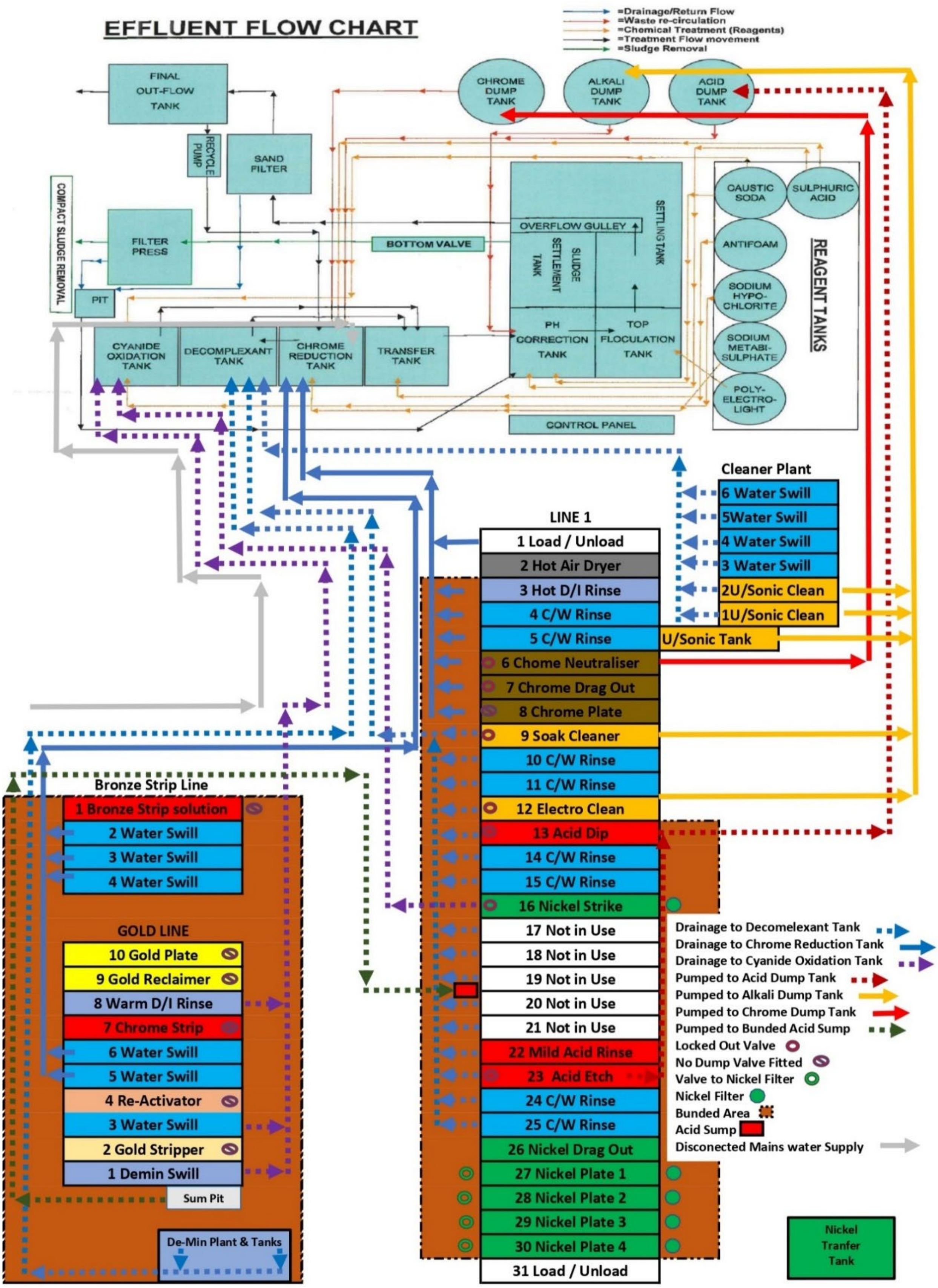


***Figure 8**: Wastewater process flow schematic*

Regular samples are taken by a trained technician from the final discharge point every 4 hours, 3 to 4 times a day and analysed in the laboratory on site for total chromium content, total Ni content, total cyanide content, effluent pH and effluent COD 1 hour settled. The results are sent via email to management on site. Perrin & Rowe's policy is not to exceed 50% of the required limit of 5 mg/L for total Cr and to maintain the pH between 8 to 11 (ideally 9). An alert will be prompted by any untoward results which are immediately investigated to find the root cause. Discharge only occurs if the results obtained are within the consent levels given below. An emergency procedure exists should the photometer (Palintest) breach the discharge consent limit (a copy is provided at Appendix 1). This essentially shuts the outflow tank valve to avoid further discharge.

Check	Severn Trent Consent Limits	Perrin & Rowe's Limits
Effluent Chromium (total)	0 to 5 mg/L	0 to 2.5 mg/L
Effluent pH	6 to 12	8 to 11 (ideally 9)

***Table 6**: Wastewater consent levels*

The local water board, Severn Trent, also takes regular samples for their analysis (on an ad hoc basis). Twin samples are taken upon collection by Severn Trent and one sample is provided to Perrin & Rowe so that they can (i) compare their result with Severn Trent and (ii) provide an immediate result.

Perrin & Rowe are currently in the process of updating their wastewater treatment plant. A schematic of the proposed update to the wastewater treatment plant is provided below.

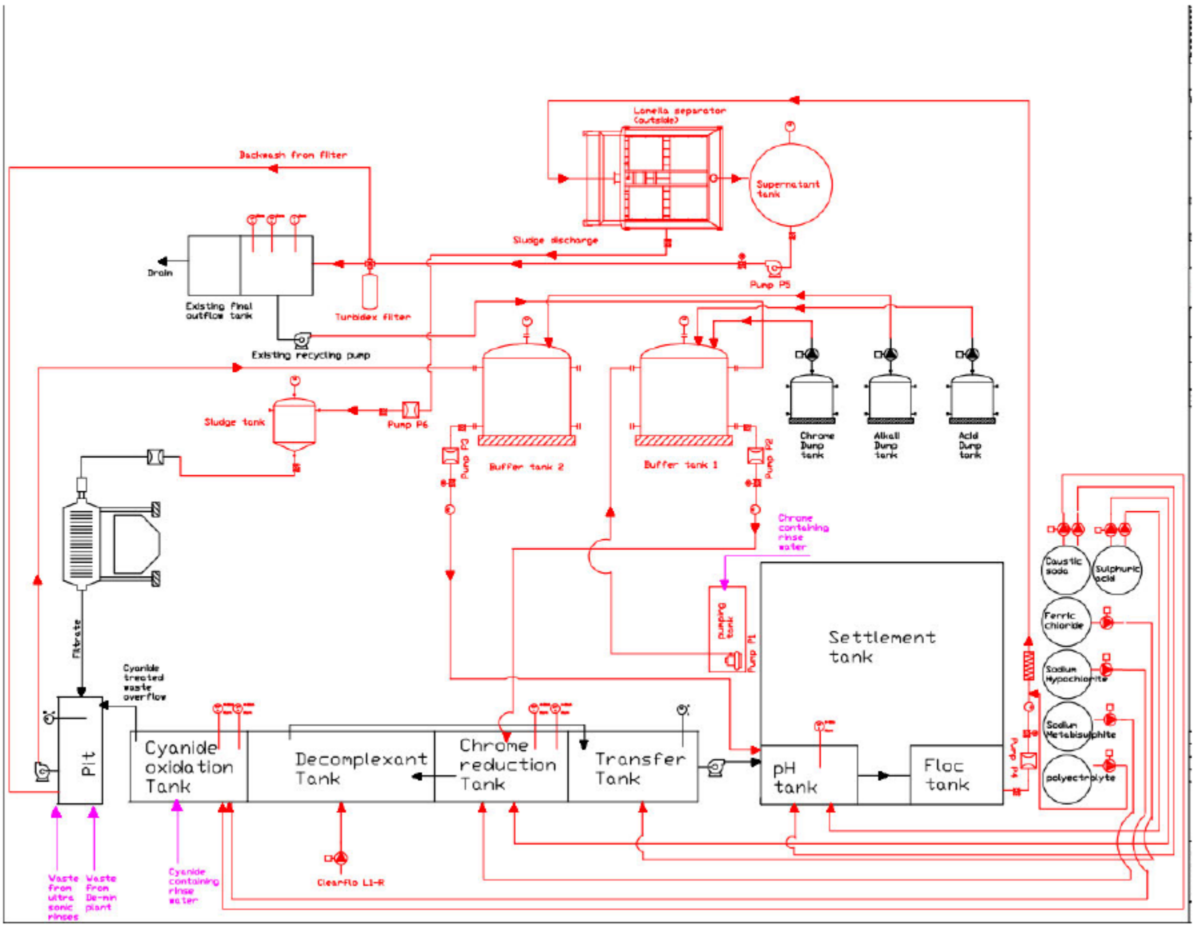


***Figure 9**: Schematic of the proposed update to the wastewater treatment plant*

Chrome neutraliser tank
The chrome neutraliser tank is discharged to the chrome dump tank on a weekly basis. Once a certain level is reached, then this wastewater flows through to the buffer tank and undergoes the same process as the chrome rinse tanks.

Chromium plating tank
The contents of the chromium plating tank are not released to wastewater. Contaminants in the chromium plating tank build up over time and the chromium plating tank is therefore emptied and refilled at a frequency of once per year. The plating tank is emptied into IBCs and sent for special waste removal by Red Industries in accordance with waste management regulations.

Releases from chrome drag out tank
The contents of the chromium drag out tank are not released to wastewater. Perrin & Rowe uses the content of the first rinse (drag out) tank to top up the chromium bath. The content of the drag out tank is transferred via container to the chrome bath (covered in WCS 3). The drag out tank may be topped up with demineralised water using a hose. After 6 months of use, the drag out tank is discharged into IBCs and sent for special waste removal in accordance with waste management regulations by Red Industries.

Sludge Removal
Once the water is treated, i.e. all Cr(VI) has been reduced to Cr(III), it is pumped into a lamella separator prior to discharge. As the water flows through the lamella separator, any solids are collected in the sludge hopper. The sludge is transferred to a sludge filter/press and the filter cake generated is removed by trained technicians into filter bags, sealed and sent to a special waste disposal company. The filtrate from the filter press is transferred to the pit. As the pit fills up it is automatically pumped to buffer tank 2 and re-circulated back into the pH tank for further treatment.

In conclusion, the graphs provided below (Figure 10) show that the wastewater released is consistently within the limits set for both pH and total chromium content. The on-site wastewater treatment facility reduces Cr(VI) to trivalent chromium (Cr(III)) via a series of reactions, such that residual concentrations of Cr(VI) in effluent can be considered negligible.

<u>Release to Air</u>
Due to its low volatility, chromium trioxide will not normally be present in air. Nevertheless, energetic processes can release chromium trioxide into air such as during the weighing of chromium trioxide and the ‘topping up’ of the chrome plating baths. Such activities are performed slowly at a rate to ensure no dust is generated or splashes occur.

A fumehood captures airborne material in the vicinity of the weighing activity and the chromium plating tank is equipped with LEV (lip extraction) to remove chromium particulates released during electrolytic process from above the tank. In case of any malfunction of the lip extraction, a beacon begins to flash and a relay turns off the tank current. There is also a lock-out, tag-out procedure for the lip extraction (see Figure 11 below).

A mist eliminator is fitted to the chrome extraction system and is positioned at the non-operator side of the plant adjacent to the chrome plating tank (see Figure 12 below). It comprises a series of eliminator blades which are designed to capture any residual Cr(VI) from entrained air before it is released to the atmosphere. A full clean of these eliminator blades is conducted at least once every four years. These blades are accessed by unbolting and removing the top cover on the unit. The blades are scraped and a hose is used to wash the blades in situ. Any solid waste is disposed of as chemical sludge using a specialist waste disposal company, while the washings are emptied into the wastewater neutralising tank.

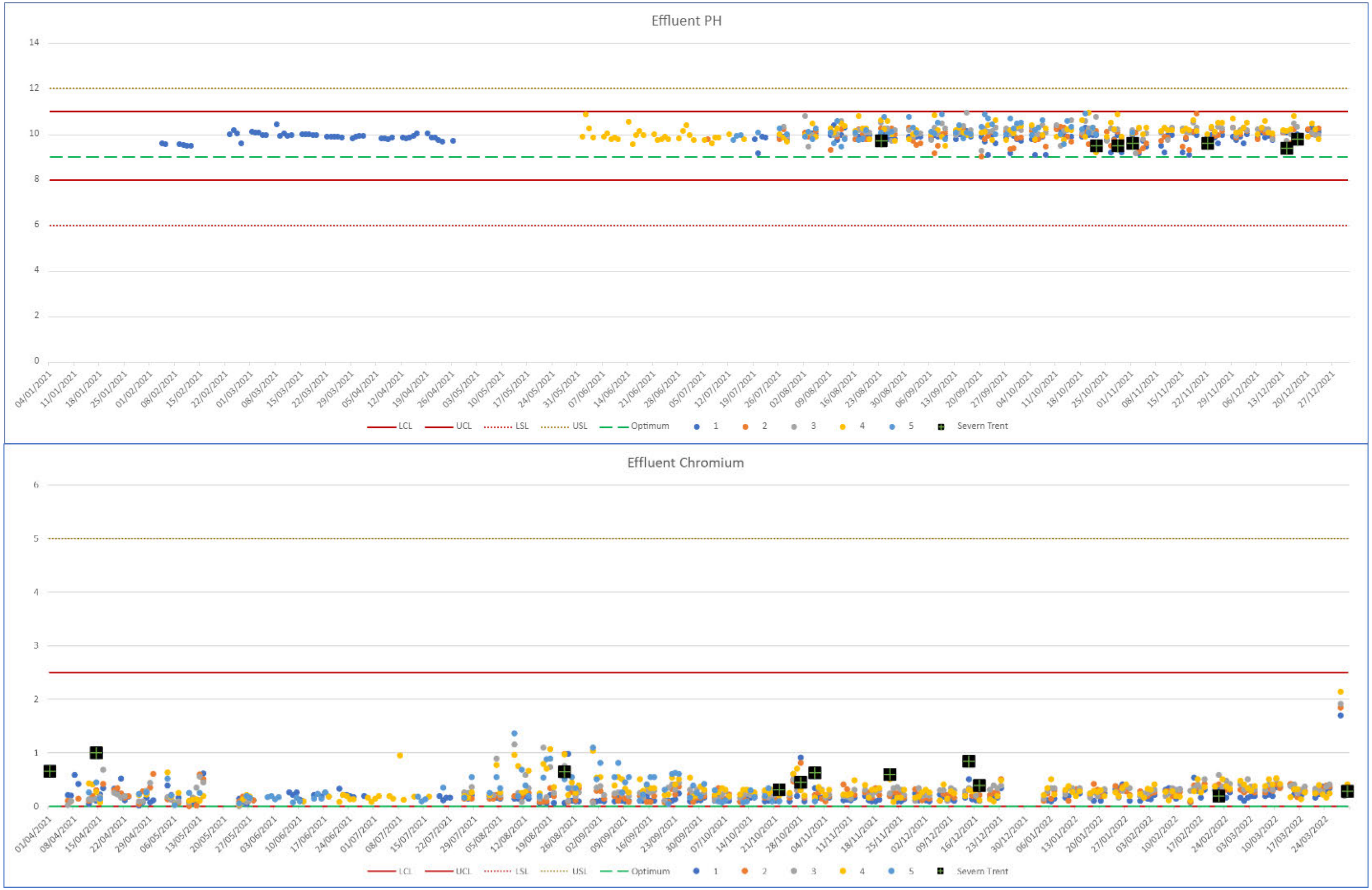


***Figure 10**: Effluent pH and effluent chromium readings*

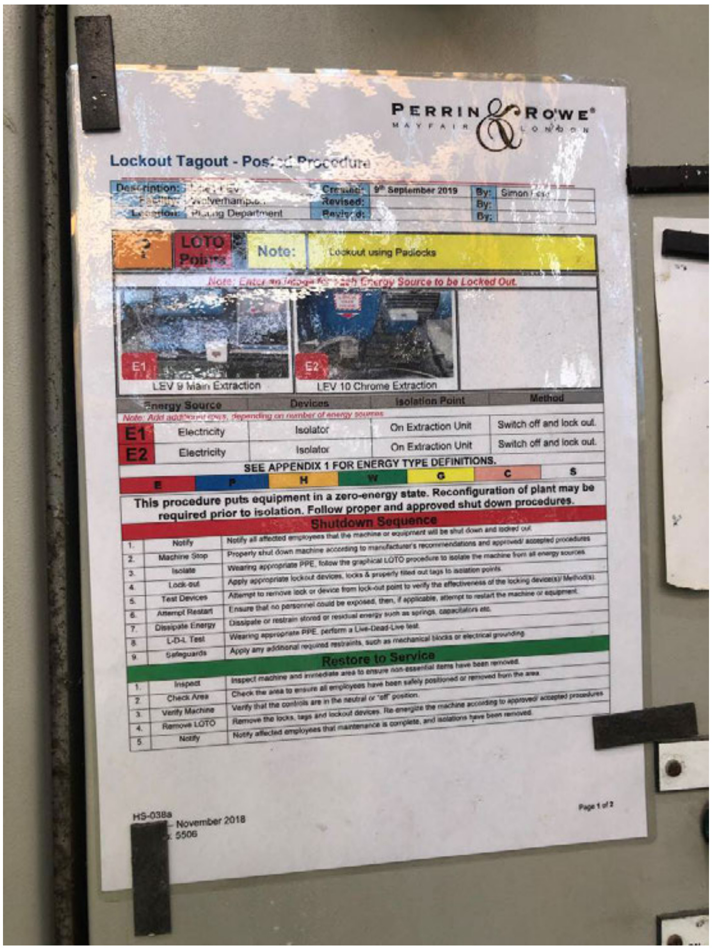


***Figure 11**: Lock-out, tag-out procedure for plating line 1 LEV*

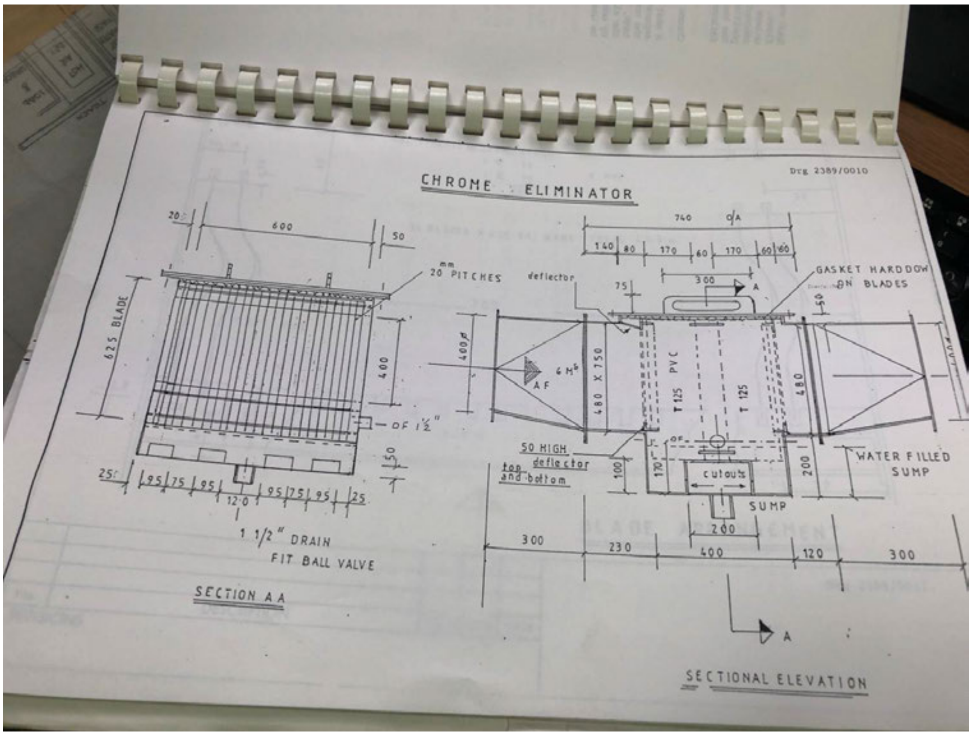


***Figure 12**: Drawing of chrome mist eliminator*

On a yearly basis, the LEV is thoroughly examined and tested by an external contractor. A recent examination and test by Zurich concluded that the LEV is adequately controlling the hazardous substance (a copy of the report is provided at Appendix 2). The capture velocity and conveyance velocity are above the minimum values stated in HSE guidance[4] (minimum capture velocity of 0.25 to 0.5 m/s at the hood and a conveyance velocity of 5 m/s for vapour).

A recent campaign to monitor the stack emissions from the chrome plating line exhaust stack at Wolverhampton was commissioned by Perrin & Rowe and conducted by an external third party, Element. In this campaign, the concentration of Cr(VI) from the stack was determined to be <0.0003 mg/m^3. This result was based on three measurements taken over a 30 mins sampling time where the limit of detection was 0.0003 mg/m^3. The results are tabulated below.

Release to air of Cr(VI) through stack	Measured Cr(VI) levels from stack*	Flow rate	Release per day	Operating days	Release per annum
Yes	<0.0003 mg/m^3	6110 m^3/hour	0.04 g	250	11 g

***Table 7**: Stack emissions monitoring data*

9.1.3.2 Humans via the environment

<u>Scope and type of assessment</u>
Indirect exposure of humans via the environment may occur through the consumption of food (e.g. fish, crops, meat and milk) and drinking water (oral route), and via the inhalation of air (inhalation route).

Since strict emission control measures are implemented, releases of chromium trioxide to the aquatic environment (and also to soil), if any, are negligible. The only potential exposure path relevant is inhalation of fine dust or particulates emitted from the facilities to air and exposure following deposition from the air via food.

In relation to inhalation of particulates in air, the oral route (swallowing of the non-respirable fraction) does not need to be explicitly considered since:

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

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

(iii) the RAC document on a reference dose-response relationship for Cr(VI) compounds[5] states that "in cases where the applicant only provides data for the exposure to the inhalable particulate fraction, as a default, it will be assumed that all particles were in the respirable size range".

[4] HSE, 2017.

[5] ECHA, 2013.

Route of exposure and type of effects	Type of risk characterisation	Hazard conclusion DNEL / dose-response relationship
Inhalation: Local Long Term	Quantitative (dose-response curves)	Lung cancer ELR = 2.9 E-02 per 1 µg Cr(VI)/m3 (for general population based on 70 years of exposure, 24 h/day)
Oral: Local Long Term	Quantitative (dose-response curves)	Intestinal cancer: ELR = 8.0E-04 per 1 µg Cr(VI)/kg bw/d for 70 years (based on 70 years of exposure; 24 h/day)

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

<u>Comments on assessment approach</u>

As detailed above, exposure of the general population via the environment (ambient air and food chain) follows a worst case approach where all airborne Cr(VI) residues are in the respirable fraction. The oral route (swallowing of non-respirable fraction) does not need to be considered. However, the indirect route for oral exposure through food has been considered.

9.1.3.3 Workers

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

The scope of the exposure assessment and type of risk characterisation required for workers are described in the table below:

Route	Type of effect	Type of risk characterisation	Hazard conclusion DNEL / dose – response relationship
Inhalation	Systemic Long Term	Not required	-
	Local Long Term	Quantitative (dose-response curves)	Lung cancer ELR = 4.0 E-03 per 1 µg Cr(VI)/m³ for 40 years (for workers based on 40 years of exposure, 8 h/day; 5 days/week)
Oral	Systemic Long Term	Not required	-
	Local Long Term	Quantitative (dose-response curves)	Intestinal cancer: ELR = 2E-04 per 1 µg Cr(VI)/m³ for 40 years (for workers based on 40 years of exposure, 8 h/day; 5 days/week)
Dermal	Systemic Long Term	Not required	Dermal exposure to chromium trioxide not identified as a cancer risk to humans.
	Local Long Term	Not required	
Notes: - ELR = Excess Lifetime Risk			

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

Comments on assessment approach related to toxicological hazard
The excess risk levels in the worker risk assessment will be determined for the inhalation route only.

No data exists to indicate that dermal exposure to Cr(VI) compounds present a cancer risk to humans and as a result this route of exposure need not be considered in the worker risk assessment.

Good hygiene measures in place avoid ingestion of chromium trioxide in the workplace. Also, in relation to inhalation of particulates in air, the oral route (swallowing of the non-respirable fraction) does not need to be explicitly considered since:

(i) the exposure calculations (airborne concentrations) do not provide different particle size fractions (inhalable/thoracic/respirable);
(ii) the document on a reference dose-response relationship for Cr(VI) compounds[6] states that "in cases where the applicant only provides data for the exposure to the inhalable particulate fraction, as a default, it will be assumed that all particles were in the respirable size range";
(iii) the excess lifetime risk (ELR) for intestinal cancer is one order of magnitude lower than that for lung cancer. The assessment of health impacts is therefore dominated by the potential risk of lung cancer due to inhalation of Cr(VI).

Comments on assessment approach related to physicochemical hazard
Not relevant – physicochemical hazards are not the subject of this CSR.

General information on risk management related to toxicological hazard
This is described previously in section 9.1.1.6 above.

General information on risk management related to physicochemical hazard
Not relevant – physicochemical hazards are not the subject of this CSR.

9.1.3.4 Consumers

Exposure assessment is not applicable as there are no consumer-related uses for chromium trioxide. Cr(VI) is not present in finished parts.

Route	Type of effect	Type of risk characterisation	Hazard conclusion DNEL / dose – response relationship
Inhalation	Systemic Long Term	Not required	-
	Local Long Term	Not required	-
Dermal	Systemic Long Term	Not required	-
	Local Long Term	Not required	-
Oral	Systemic Long Term	Not required	-

***Table 10**: Type of risk characterisation required for consumers*

[6] ECHA, 2013.

9.2. Exposure scenario 1 – Use at Industrial Site: Electroplating

Sector of use:	
Industrial Use	
Environment contributing scenario(s):	
Functional chrome plating with decorative character	ERC 6B
Worker/Consumer contributing scenario(s):	
WCS1: Delivery of raw material	PROC 1
WCS2: Storage of raw material	PROC 1
WCS3: Decanting and weighing of raw material to replenish bath	PROC 8b
WCS4: Sampling of chromium solution	PROC 9
WCS5: Operation of plating line	PROC 3
WCS6: Laboratory analysis	PROC 15
WCS7: Loading/unloading of parts	PROC 4
WCS8: Maintenance	PROC 28
WCS9: Treatment of wastewater	PROC 8b
WCS10: Maintenance: Cleaning of filter press	PROC 8b
Subsequent service life exposure scenario(s):	
Not relevant	
Exposure scenario(s) of uses leading to the inclusion of the substance into article(s):	
Not relevant	

Explanation on the approach taken for the exposure scenario

Measurements of releases to air and wastewater were used to support the environmental exposure assessment. Modelling techniques were used to estimate concentrations of chromium trioxide in air 100m from the release point in accordance with ECHA Guidance[7].

Occupational exposure estimates are based on recent personal and static measurements. Personal monitoring data were collected by attaching samplers to workers while they conducted their daily tasks within the plating area. Static measurements of particulate residues of Cr(VI) in air were taken at locations where activities concerning Cr(VI) occur.

Both sets of measurements will be used to determine the excess risk levels related to each of the contributing scenarios.

If monitoring data was not able to be provided and in situations where only static data was available, then the exposure was estimated using the exposure model 'Advanced REACH Tool' (ART)[8]. The figures obtained by modelling are considered to be worst-case estimates.

[7] ECHA, 2016.

[8] See https://www.advancedreachtool.com/

9.2.1. Environmental contributing scenario 1

The physico-chemical and environmental fate properties of Cr(VI) presented in Table 11 below were used in the environmental assessment of chromium trioxide (given that chromium trioxide solubilises and dissociates into Cr(VI)). These data were used in the European Union System for the Evaluation of Substances (EUSES 2.2.0) software for the environmental fate estimation and are taken from the current chromium trioxide REACH registration dossier.

Substance property	Value
Molecular weight	99.994
Melting point	197 °C
Boiling point	–
Vapour pressure	4.74E-9 Pa at 25°C
Water solubility	1.69E+6 mg/L at 25°C
Partition coefficient (Log Kow)	0.1 (estimated default value for inorganic substances)
Adsorption/Desorption coefficient (Koc)	11.8 L/kg (calculated in EUSES 2.2.0 using the OSAR 'Non-hydrophobics (default QSAR)')
Solids-water partition coefficient in soil (Kp_{soil})	Chromium (VI) key values: 2 L/kg (alkaline conditions, worst-case for human intake via the environment); 50 L/kg (acid conditions)
Solids-water partition coefficient in sediment (Kp_{sed})	Chromium (VI) key values: 100 L/kg (alkaline conditions, worst-case for human intake via the environment); 1000 L/kg (acid conditions)
Solids-water partition coefficient in suspended matter (Kp_{susp})	Chromium (VI) key values: 200 L/kg (alkaline conditions, worst-case for human intake via the environment); 2000 L/kg (acid conditions)
Henry's law constant	2.8E-13 Pa/m³/mol at 25 °C (calculated in EUSES 2.2.0)
Bioaccumulation: BCF (aquatic species)	1 L/kg wwt *(Available data indicate that the BCF of chromium (VI) in fish is relatively low at around 1 L/kg. Once in the organism, reduction of chromium (VI) to chromium (III) appears to occur, resulting in an accumulation of total chromium in the organisms to a factor of approximately 100 times the original concentration in water. The REACH registration dossier states a dimensionless BCF of 23.11 as the key value, however EUSES 2.2.0 only allows values expressed in L/kg wwt to be input).*
Ready biodegradability	N/A for inorganic substances ('Not readily biodegradable' selected in EUSES 2.2.0 as a worst-case)
Hydrolysis	N/A for inorganic substances (default DT50 value of 1E+6-days at 12 °C used in EUSES 2.2.0)

***Table 11**: Chromium trioxide key physico-chemical and environmental fate properties*

9.2.1.1 Conditions of use

Amount used, frequency and duration of use (or from service life)
▪ Daily use amount at site: 1.4E-3 tonnes/day CrO_3; 7.3E-4 tonnes/day Cr(VI) (250 days per year operational)
▪ Annual amount used at site: 0.35 tonnes/year CrO_3; 0.182 tonnes/year Cr(VI)
Technical and organisational conditions and measures
▪ On site wastewater treatment *Perrin & Rowe treats wastewater onsite via complete reduction of Cr(VI) to Cr(III). .*
Conditions and measures related to sewage treatment plant
▪ Discharge rate of STP: >= 2E3 m3/day (Default) ▪ Application of the STP sludge on agricultural soil: No
Conditions and measures related to treatment of waste (including article waste)
▪ Collection of all solid and liquid waste, reduction of Cr(VI) in wastewater to Cr(III), disposal as hazardous waste by an external waste management company (licenced contractor)
Other conditions affecting environmental exposure
▪ Receiving surface water flow rate: >= 1.8E4 m3/day (default)

***Table 12**: Conditions of use: ECS 1*

9.2.1.2 Releases

Release route	Release factor	Release Kg or T / per year
Water	Measured data	Release factor: 0 Local release rate: 0 kg/day Explanation / Justification: On-site waste water treatment facility reduces Cr(VI) to trivalent chromium [Cr(III)] via a series of reactions, such that residual concentrations of Cr(VI) in effluent may be considered negligible.
Air	Measured data	Measured concentration in air: 3E-4 mg Cr(VI)/m3 Explanation / Justification: Monitoring data from the stack emissions of the chrome plating line exhaust stack at Wolverhampton showed that the concentration of Cr(VI) from the stack was <0.0003 mg/m^3. With a flow rate of 6110 m^3/hour for 24 hours per day this equates to 11 g per annum. This is worst case since the measurement obtained was below the limit of detection.
Soil	Measured data	Release factor: 0 Local release rate: 0 kg/day Explanation / Justification: Cr(VI) in wastewater is reduced to Cr(III), all solid and liquid waste is collected and waste is disposed as hazardous waste by an external waste management company

***Table 13**: Local releases to the environment: ECS 1*

9.2.1.3 Exposure and risks for the environment and human via the environment

As detailed above, exposure of the general population via the environment (ambient air and food chain) follows a worst case approach where all airborne Cr(VI) residues are in the respirable fraction. The oral route (swallowing of non-respirable fraction) does not need to be considered. However, the indirect route for oral exposure through food has been considered.

As the location of the site is within an industrial area then workers have been taken into consideration as far as inhalation exposure is concerned. Oral intake is not considered as it is assumed that the food/drinking water source is not locally sourced.

Emission data is provided in Table 7 above.

Protection target	Exposure concentration	Risk assessment
Freshwater	3.02E-11 mg Cr(VI)/L	Not relevant
Sediment (freshwater)	1.34E-9 mg Cr(VI)/kg wwt	Not relevant
Marine water	2.98E-12 mg Cr(VI)/L	Not relevant
Sediment (marine water)	1.32E-10 mg Cr(VI)/kg wwt	Not relevant
Sewage treatment plant	0 mg Cr(VI)/L	Not relevant
Predator (freshwater)	3.02E-11 mg Cr(VI)/kg wwt	Not relevant
Predator (marine water)	2.98E-12 mg Cr(VI)/kg wwt	Not relevant
Top predator (marine water)	2.98E-12 mg Cr(VI)/kg wwt	Not relevant
Air	1.39E-9 mg Cr(VI)/m^3	Not relevant
Agricultural soil	1.83E-7 mg Cr(VI)/kg wwt	Not relevant
Predator (terrestrial)	4.69E-8 mg Cr(VI)/kg	Not relevant
Human via Environment - Inhalation	1.39E-9 mg Cr(VI)/m^3	RAC Opinion (Lung cancer, general population) ELR = 2.9 E-02 per 1 µg Cr(VI)/m^3 RAC Opinion (Lung cancer, workers) ELR = 4.0 E-03 per 1 µg Cr(VI)/m^3 **Excess risk by inhalation to general population = 4.0 x 10^{-8}** **Excess risk by inhalation to workers = 5.6 x 10^{-9}**
Human via Environment - Oral	1.20E-8 mg Cr(VI)/kg bw/d	RAC Opinion (Intestinal cancer, general population): ELR = 8.0E-04 per 1 µg Cr(VI)/kg bw/d Not required for workers. Assume food/drinking water is not locally sourced. **Excess risk by oral (through food only) to general population = 9.7 x 10^{-9}**

Protection target	Exposure concentration	Risk assessment
Human via Environment - Combined	1.24E-8 mg Cr(VI)/kg/d	Excess risk -combined = 4.97 x 10^{-8} for the general population and 5.6 x 10^{-9} for workers.

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

Remarks on measured exposure:
Remarks on measured exposure are presented in Table 15 below.

Type of food	Estimated daily dose	Concentration in food
Drinking water	2.79E-9 mg Cr(VI)/kg/d	9.76E-8 mg Cr(VI)/L
Fish	4.97E-14 mg Cr(VI)/kg/d	3.02E-11 mg Cr(VI)/kg
Leaf crops	8.74E-9 mg Cr(VI)/kg/d	5.1E-7 mg Cr(VI)/kg
Root crops	5.07E-10 mg Cr(VI)/kg/d	9.24E-8 mg Cr(VI)/kg
Meat	1.44E-13 mg Cr(VI)/kg/d	3.35E-11 mg Cr(VI)/kg
Milk	2.68E-12 mg Cr(VI)/kg/d	3.35E-10 mg Cr(VI)/kg

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

Conclusion on risk characterisation:
The direct effects and risks to the environment resulting from environmental release are not evaluated as they are not in scope of this assessment. The indirect exposure to humans via emissions to air and water are considered.

The excess risks/cases associated with exposure of man via the environment were determined to be 4.97 x 10^{-8} for the general population and 5.6 x 10^{-9} for workers. Exposure is considered to be adequately controlled.

9.2.2. Worker contributing scenario 1: Receipt of raw materials (PROC 1)

This WCS describes the delivery of chromium trioxide to the site. Chromium trioxide is delivered as flakes in a 25kg sealed metal container on pallets at a frequency of 5-6 times per year. Perrin & Rowe uses two approved suppliers, MacDermid and Cannock Chemicals. The palletised drums are transferred from the delivery vehicle through an open roller-shutter door into the 'Goods Inward' area by a trained worker using a forklift truck. An authorised member of the plating team then transports the palletised drum to the chemical stores using a manual pump truck.

- **Potential for Exposure**: The containers are sealed and arrive on shrink wrapped pallets upon receipt. There is no handling of the containers during receipt of the raw materials therefore there is no potential for exposure to workers.

- **Engineering controls**: None.

- **Personal Protective Equipment**: Workers are required to wear safety boots, high vis jacket and protective eye wear upon delivery. All personnel performing this task are trained in the correct handling of the substance and the use of PPE.

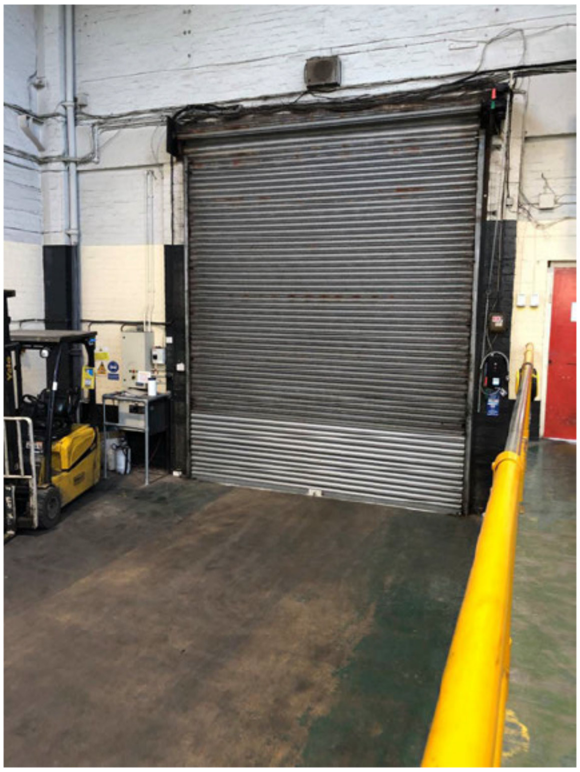


***Figure 13**: Photograph of roller shutter door and 'Goods In' area*

***Figure 14**: Photograph of closed container with no potential for exposure*

<u>Conditions of use</u>

There is no potential for exposure during this WCS. The Advanced REACH Tool (ART) estimates for occupational exposure relating to the handling of contaminated objects is provided for reference.

	Method
Product (article) characteristics	
▪ Product type: Powders, granules or pelletised material	ART
▪ Dustiness: Granules, flakes or pellets	ART
▪ Dry product (<5% moisture content)	ART
▪ Pure material (100%)	ART
Amount used (or contained in articles), frequency and duration of use/exposure	
▪ Duration of activity: 15 mins	ART
Technical and organisational conditions and measures	
▪ Activity class: Handling of contaminated solid objects or paste	ART
▪ Handling of apparently clean objects	ART
▪ General ventilation: Only good natural ventilation	ART
▪ Containment: high level, closed system	ART
▪ Local exhaust ventilation: No	ART
▪ Primary controls: Yes – containment, no extraction. Drums arrive on shrink wrapped pallets.	ART

▪ No secondary controls	ART
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory protection: No	ART
Other conditions affecting workers exposure	
▪ Place of use: Indoors, large room	ART
▪ Process Temperature: Room Temperature	ART

***Table 16**: Conditions of use: WCS 1*

Exposure and risks for workers

The exposure concentrations and excess risk levels are reported in the table below.

Contributing scenario	Route of exposure	Method of assessment	Exposure value (8h TWA) *	Exposure value corrected for PPE	Exposure value corrected for PPE and frequency *	Excess risk levels (RAC opinion) 1 µg/m³ of Cr(VI) equals excess risk of 0.004
WCS 1	Inhalation	ART	0.0067 µg CrO_3/m^3 0.0035 µg $Cr(VI)/m^3$	Only safety shoes and goggles worn so no correction for PPE required.	0.0067 µg CrO_3/m^3 0.0035 µg $Cr(VI)/m^3$	1.4×10^{-5}
* obtained from ART, 90th percentile value						

***Table 17**: Exposure concentrations and risks for workers: WCS 1*

Remarks on exposure data

The containers are sealed and arrive on shrink wrapped pallets upon receipt. There is no handling of the containers by the workers during receipt of the raw materials therefore there is no potential for exposure to workers.

The modelled exposure estimate (ART) of 0.0035 µg $Cr(VI)/m^3$ provides a worst case basis for risk characterisation and assumes some unforeseen handling of contaminated materials regularly occurs in relation to this WCS. An excess lifetime lung cancer mortality risk of 1.4×10^{-5} is estimated based on the above exposure estimate and the RAC dose-response relationship for lung cancer mortality and can be considered to substantially over-estimate the risk.

Conclusion on risk characterisation

Exposure is adequately controlled. The emission and consequently the exposure related to the delivery of Cr(VI) is considered to be minimized. No further measures are considered necessary.

9.2.3. Worker contributing scenario 2: Storage of raw materials (PROC 1)

This WCS covers the transfer of the chromium trioxide from the pallet to the dedicated storage facility. The 25kg containers of chromium trioxide are stored in a dedicated bund area (maximum of 2 drums at one time) sealed with Robex paint within the storeroom.

Figure 15*: Storage of chromium trioxide in chemical stores*

Access to the storeroom is restricted to trained personnel only using a key pad lock (see Figure 6). Signage clearly indicates this is an area for authorised personnel only.

- **Potential for Exposure**: The containers are sealed so there is no potential for exposure to workers. The risk assessment considers the potential for residual chromium trioxide in the storeroom (e.g. following decanting and weighing, see WCS 3).
- **Engineering controls**: None
- **Personal Protective Equipment**: Workers are required to wear safety boots, high vis jacket and protective eye wear in the chemical stores.

<u>Conditions of use</u>

	Method
Product (article) characteristics	
▪ Product type: Powders, granules or pelletised material	Measured (static)
▪ Dustiness: Granules, flakes or pellets	Measured (static)
▪ Dry product (<5% moisture content)	Measured (static)

▪ Pure material (100%)	Measured (static)
Amount used (or contained in articles), frequency and duration of use/exposure	
▪ Duration of activity: 15 mins	Measured (static)
Technical and organisational conditions and measures	
▪ Activity class: Handling of contaminated solid objects or paste	Measured (static)
▪ Handling of apparently clean objects ▪ Careful handling, involves workers showing attention to potential danger, error or harm	Measured (static)
▪ General ventilation: Only good natural ventilation	Measured (static)
▪ Containment: high level, closed system	Measured (static)
▪ Local exhaust ventilation: No	Measured (static)
▪ Effective housekeeping practices in place	Measured (static)
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory protection: No	Measured (static)
Other conditions affecting workers exposure	
▪ Place of use: Indoors, 25 m³ (30 m³ chosen in ART)	Measured (static)
▪ Process Temperature: Room Temperature	Measured (static)

***Table 18**: Conditions of use: WCS 2*

<u>Exposure and risks for workers</u>

Static monitoring was performed in the chemical stores. Known volumes of air were drawn through sample media fixed by the eye station. The sampling was conducted according to BS ISO 16740:2005 and analysed using ion chromatography/UV-Vis. The airborne concentration (mg/m^3) was reported to be <0.000019 mg/m^3 over a 254 min sampling period. This measurement was taken before the introduction and use of an extraction booth in the storeroom, so current concentrations are expected to be lower.

The result was used to predict an exposure based on the duration and frequency of the activity in a typical working day.

Contributing scenario	Route of exposure	Method of assessment	Static Airborne concentrations, mg Cr(VI)/m^3	Exposure concentration during task, µg Cr(VI)/m^3	Exposure value (8h TWA)* µg Cr(VI) /m^3	Excess risk levels (RAC opinion) 1 µg/m^3 equals excess risk of 0.004
WCS 2	Inhalation	Static measured data	<0.000019	0.0019	0.00059	2.38 x 10^{-6}
WCS 2	Inhalation	ART			0.000045	1.79 x 10^{-10}
* taking into account the expected duration (15 mins) of the activity and the frequency (once per shift)						

***Table 19**: Exposure concentrations and risks for workers: WCS 2*

<u>Remarks on exposure data</u>
An airborne concentration of <0.000019 mg/m^3 was obtained for the chemical stores over 254 minutes. The result was converted to a 8h TWA and used to predict an exposure based on the duration and frequency of the activity in a typical working day.

An excess lifetime lung cancer mortality risk of 2.38×10^{-6} is estimated based on the above static measurement, the expected task duration and the RAC dose-response relationship for lung cancer mortality.

<u>Conclusion on risk characterisation</u>
Exposure is adequately controlled.

9.2.4. Worker contributing scenario 3: Weighing of chromium trioxide and replenishing of tank (PROC 8b)

This WCS covers the weighing of the chromium trioxide and its addition to the chromium plating tank. It also covers the topping up of the chromium tank with water and mist suppressant. The activity of topping up of water occurs daily before the start of the shift while the mist suppressant is added less frequently and depends on the surface tension measurements obtained in WCS 4.

The ‘topping up’ activity is only conducted when the plating line is not in operation, usually at the beginning of the working day, to minimise worker exposure.

The weighing out of chromium trioxide and addition to the tank is conducted once a week by a trained technician. There are two trained technicians. In the absence of a technician, this activity could be conducted by a Senior Operator. All are trained in the weighing procedure.

The weighing takes place within the chemical store. A scoop is used to collect chrome flake from the 25kg drum and decant it gently into a container (see image below) placed onto the weighing scales. The flakes are added/removed until 2kg is measured. The rate of transfer at approximately 0.5 kg/min is slow and steady to minimise the potential for dust generation.

The container is then carried by the worker a distance of approximately 7 metres from the chemical store to the chrome line where the chromium trioxide flake is transferred into the tank, accessed manually from the raised platform. The worker ensures that the transfer is performed slowly and gently to minimise disturbance to the liquid surface. After the addition, a long lance is used by the worker to mix the contents of the tank at a sufficient rate to enable dissolution of the chromium trioxide but slow enough to ensure minimal disturbance of the liquid surface and reduce the exposure to chromium trioxide.

A water hose is used to rinse out the container and lance and the washings deposited slowly into the tank at a rate to minimise splashing. All washings are deposited into the chrome tanks. The lance and container are stored on a tray adjacent to the plating line.

The task takes approximately 10 minutes to complete.

The empty chromium trioxide containers are rinsed, with washings being deposited into the chrome tanks, and sent back to the supplier for re-use/recycling.

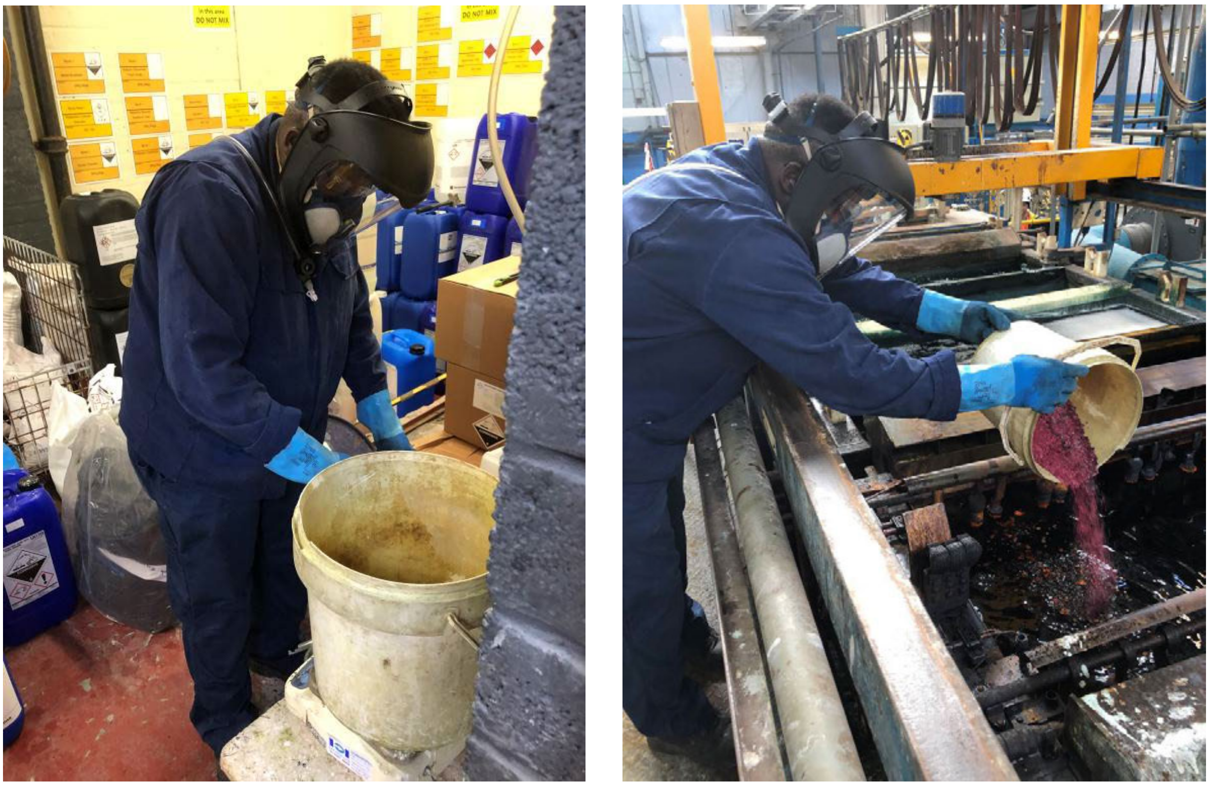


***Figure 16**: Weighing of chromium trioxide in chemical stores (L) and addition of the chromium trioxide flakes into the chromium plating tank (R)*

***Figure 17**: Container used for weighing and long lance used to ensure dissolution (L) and technician rinsing out of weighing container (R)*

- **Potential for Exposure**: Exposure to hexavalent chromium can occur during the weighing out procedure conducted in the chemical storeroom. Dust may also be generated during transfer to the bath. Appropriate personal protective equipment and engineering controls are used to minimise exposure.

- **Engineering controls**: A fume cupboard has recently been installed in the chemical storeroom and the weighing activity is carried out within this enclosed and extracted area. Lip extraction is present on the chrome plating bath.

- **Personal Protective Equipment**: The technician is required to wear RPE, such as a 3M 4279 FFA1BEK1 P3 D ori-nasal half-mask (APF=20) or similar which will provide protection against airborne particulates. The mask is required for the duration of the weighing, addition and tipping activity. The technician is also required to wear operative company-issued clothing, safety footwear, safety glasses and Master UCi L30 gloves. A face shield is also worn during additions to the bath.

A fumehood has recently been installed in the chemical stores. Transfer of chromium trioxide from the container and weighing will be completed within this enclosed and extracted area. However, new measurements of personal exposure could not be conducted in time for inclusion in the CSR.

***Figure 18**: Photograph of new fumehood installed in chemical storeroom*

Conditions of use

	Method
Product (article) characteristics	
▪ Product type: Powders, granules or pelletised material	Measured (personal monitoring)
▪ Dustiness: Granules, flakes or pellets	Measured (personal monitoring)
▪ Dry product (<5% moisture content)	Measured (personal monitoring)
▪ Pure material (100%) for chromium trioxide to up ▪ Substantial amount (10-50%) used in ART for liquid top up.	Measured (personal monitoring)
Amount used (or contained in articles), frequency and duration of use/exposure	
▪ Duration of activity: 15 mins	Measured (personal monitoring)
Technical and organisational conditions and measures	
▪ Activity class: Transfer of solid (chromium trioxide top up) ▪ Activity class: Transfer of liquid (water top up)	Measured (personal monitoring)
▪ General ventilation: Only good natural ventilation in chemical stores.	Measured (personal monitoring)
▪ Local exhaust ventilation: Yes, lip extraction positioned at the side of the tanks.	Measured (personal monitoring)
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory protection: Yes, APF = 20	Measured (personal monitoring)
Other conditions affecting workers exposure	
▪ Place of use: Indoors, 450m^3	Measured (personal monitoring)
▪ Process Temperature: Room Temperature	Measured (personal monitoring)

***Table 20**: Conditions of use: WCS 3*

Exposure and risks for workers

Personal monitoring was performed during the activity of weighing the chromium trioxide followed by the addition to the bath. The sampling method used battery powered pumps attached to individuals. A known volume of air was drawn through specific sample media positioned in the individual's breathing zone. The sampling method used was BS ISO 16740:2005 with analysis by ion chromatography/UV-Vis.

An excess risk level was obtained based on the personal measurements.

Personal monitoring data was not available for the top up of liquids such as water and mist suppressant. In this case, the Advanced REACH tool (ART) was utilised.

WCS	Route of exposure	Method of assessment	Exposure value measured Cr(VI) mg/m^3	Exposure value (8h TWA) Cr(VI) mg/m^3	Exposure value corrected for frequency Cr(VI) mg/m^3 *	Exposure value corrected for PPE Cr(VI) mg/m^3	Excess risk levels (RAC opinion) **
WCS 3a	Inhalation	Personal monitoring	0.0068	2.1×10^{-4}	2.1×10^{-5}	1.06×10^{-6}	4.25×10^{-5}
WCS 3a	Inhalation	Static	0.000019***				
WCS 3b	Inhalation	ART		0.00003224	Conducted daily	1.6×10^{-6}	6.45×10^{-5}

* Assuming that the weighing activity will only occur once per week and two workers share the task equally

** 1 $\mu g/m^3$ equals excess risk of 0.004

*** Value obtained near weighing scales only

***Table 21**: Exposure concentrations and risks for workers: WCS 3*

Using the personal monitoring data obtained for weighing and topping up of the plating bath with chromium trioxide and taking into account the frequency and PPE, an excess lifetime lung cancer mortality risk of 4.25×10^{-5} is estimated based on the RAC dose-response relationship for lung cancer mortality.

Personal monitoring data is not available for the activity of topping up the plating baths with liquids such as water and mist suppressant. The Advanced REACH tool has been used to estimate exposure. The predicted exposure is an overestimate as the model assumes that the liquid being transferred contains chromium trioxide. This is not the case for this activity as the material being transferred is mainly water. The estimate of 1.6×10^{-6} Cr(VI) mg/m^3 is therefore worst case but shows that exposure is minimal with the current operational conditions in place. It also shows good correlation with measured data. An excess lifetime lung cancer mortality risk of 6.45×10^{-5} is estimated based on the RAC dose-response relationship for lung cancer mortality.

Conclusion on risk characterisation

Exposure is adequately controlled.

9.2.5. Worker contributing scenario 4: Sampling of plating tanks (PROC 9)

Samples from the tank are taken on four separate occasions during the working week for monitoring purposes by one of the two technicians on shift. The samples are taken at the end of the plating cycle when the current is off. The laboratory analysis is for:

(i) Twice weekly monitoring of the Cr(VI) content of the tank.
(ii) Twice weekly monitoring of the surface tension of the tank.

At the end of a chromium plating cycle, a sample is removed from the plating tanks for analysis of the chromium content. A sampling vessel is immersed slowly into the plating tank in order to collect 200 mL from the plating tank. At the tank, approximately 10 mL is decanted into a 250 mL conical flask and taken to the laboratory for analysis.

Sampling of the aqueous solution in the bath to determine Cr(VI) content is carried out internally, twice a week by technicians and every 3 weeks by the external chemical supplier who supplies the data sheets for the specification that the chemistry in the plating bath needs to be maintained.

A mist suppressant is added to the plating tank to minimise emissions of hexavalent chromium. The surface tension of a chromium plating bath can be reduced to 20 dynes/cm using the non-PFOS products, but is commonly kept at an average of 30 dynes/cm. At this level, consumption of the mist suppressant is kept to a minimum and the Cr(VI) emissions are kept under control. The preferred method for ensuring the best operation of a mist suppressant in a plating bath is to monitor and control the surface tension. The permanent, non-PFOS mist suppressants can easily be monitored and controlled by either stalagmometer or tensiometer surface tension measurement in the laboratory.

Twice weekly samples of the plating bath are taken to determine the surface retention and are collected by one of the two trained technicians into a sample bottle supplied by the external contractor. Once analysed, the used sample is disposed of in the plating neutralisation tank and the excess sample is returned to the plating tank. Surface retention sampling is also conducted by a third party (Access Chemicals) every 2 weeks. In cases where the surface tension has increased, then the retention aid (Macuplex STR NPFX by MacDermid Enthone) is added to the bath to reduce the surface tension.

- **Engineering controls:** Lip extraction is used to capture the chromic acid mist over the tanks. The air is sent through a series of blades before being released to atmosphere. This LEV is thoroughly examined and tested on a yearly basis an external contractor. A closed sample container is used to transfer the sample from the tank to the laboratory.

- **Personal Protective Equipment:** The technician is required to wear RPE, such as 3M 4279 FFA1BEK1 P3 D ori-nasal half-mask (APF=20) or similar which will provide protection against airborne particulates. The mask is required for the duration of the sampling activity. The technician is also required to wear a face shield, company-issued clothing, safety footwear and AlphaTec 87-900 gloves or similar for dermal protection against the corrosive nature of chromium trioxide. All personnel performing this task are trained in the correct handling of the substance and the use of PPE.

<u>Conditions of use</u>

	Method
Product (article) characteristics	
▪ Product type: Powder dissolved in a liquid	Measured (personal monitoring)
▪ Concentration of CrO_3: 300 g/L	Measured (personal monitoring)
Amount used (or contained in articles), frequency and duration of use/exposure	
▪ Duration of activity: 15 minutes	Measured (personal monitoring)
Technical and organisational conditions and measures	
▪ Activity class: Transfer of liquid products	Measured (personal monitoring)
▪ Local exhaust ventilation: Lip extraction on tanks. LEV above plating tanks.	Measured (personal monitoring)
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory protection: Yes, half face mask with P3 filter, APF = 20	Measured (personal monitoring)

Other conditions affecting workers exposure	
▪ Place of use: Indoors, 450 m^3	Measured (personal monitoring)
▪ Process Temperature: Bath temperature ranges between 35-45 ºC	Measured (personal monitoring)

***Table 22**: Conditions of use: WCS 4*

Exposure and risks for workers

WCS	Route of exposure	Method of assessment	Exposure value (8 mins) mg Cr(VI)/m^3	Exposure value (8h TWA)* mg Cr(VI)/m^3	Exposure value corrected for frequency mg Cr(VI)/m^3	Exposure value corrected for PPE mg Cr(VI)/m^3	Excess risk levels (RAC opinion)*
WCS 4	Inhalation	Personal Monitoring	<0.0006	1.87×10^{-5}	1.5×10^{-5}	7.5×10^{-7}	3×10^{-5}
* 1 µg/m^3 equals excess risk of 0.004							

***Table 23**: Exposure concentrations and risks for workers: WCS 4*

Remarks on exposure data

Using the personal monitoring data obtained and taking into account frequency and PPE, an excess lifetime lung cancer mortality risk of 3×10^{-5} was estimated based on the RAC dose-response relationship for lung cancer mortality for each company.

The personal monitoring data was obtained while one of the workers was taking a sample from the plating tank which took 8 minutes to complete. The value obtained is below the limit of detection confirming that exposure is minimal. Adequate controls (mist suppressants and LEV) are in place to minimise exposure.

An excess lifetime lung cancer mortality risk of 3×10^{-5} is estimated based on the RAC dose-response relationship for lung cancer mortality.

Conclusion on risk characterisation

Exposure is adequately controlled.

9.2.6. Worker contributing scenario 5: Operation of plating line (PROC 3)

This worker contributing scenario covers the operation of the automated plating line. The plating line is operational 5 days per week, 6am to 10pm, which is split into 2 shifts. The plating line is located in a separate area of the factory and is not located on a thoroughfare to other parts of the site. The plating area will be restricted to plating staff only, with the occasional requirement for maintenance operators to enter the area. These maintenance activities are performed on a weekend when the current is switched off. A raised platform allows operators access to the plating line. The platform is gated, restricting access to this walkway.

***Figure 19**: Photograph of plating line walkway*

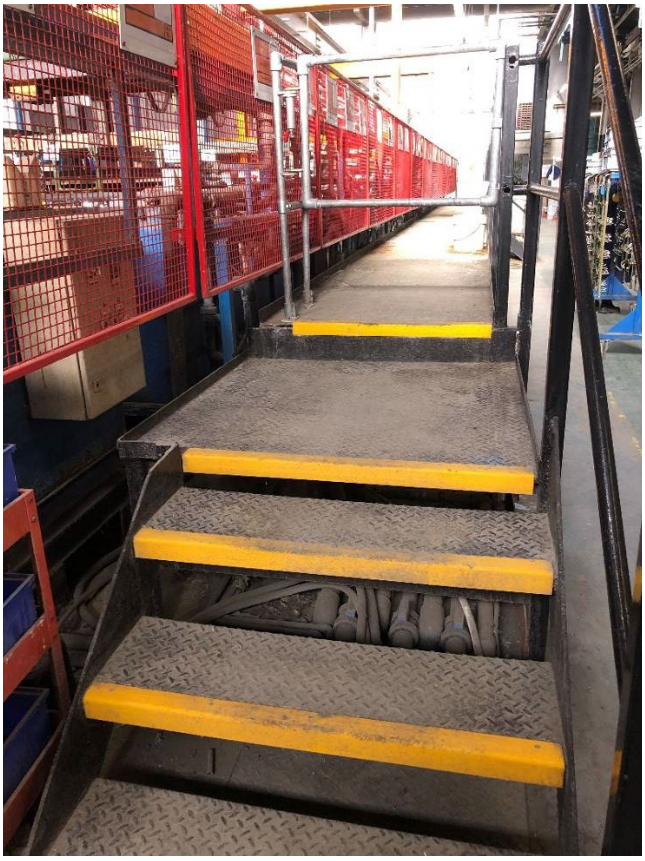


***Figure 20**: Photograph of gated walkway on plating line*

The plating line operation is supervised by two technicians from a separately enclosed laboratory (located in the pink area on the site map (see Figure 3). The plating line is fully visible and accessible to the technicians during this time. The technicians walk the plating line once per hour to check that operations are running smoothly.

- **Potential for exposure**: The plating line operation is supervised by two technicians from a separately enclosed laboratory (located in the pink area on the site map, see Figure 3). Due to its enclosed nature, there is no exposure to Cr(VI) from the laboratory. The technicians regularly walk the plating line to check that operations are running smoothly and exposure could occur during these brief checks.

- **Engineering controls**: A mist suppressant is used to reduce exposure of workers to Cr(VI) during plating operations. Macuplex STR NPFX is purchased from MacDermid Enthone and is known to aid the reduction of Cr(VI) in the working air. Lip extraction is used to capture the chromic acid mist over the tanks. The lip extraction is visible in Figure 21 below.

  In addition, there is also a dedicated extraction of air from above the chrome electroplating tank. The air is sent through baffles before being released to atmosphere. The panels within the LEV are regularly cleaned and subject to thorough examination and testing on a yearly basis by an external contractor.

***Figure 21**: Photograph of chrome plating tank showing lip extraction*

- **Personal Protective Equipment**: Technicians are required to wear operative company-issued clothing, safety footwear, safety glasses and Master UCi L30 gloves. All personnel performing this task are trained in the correct handling of the substance and the use of PPE.

- **Accidental Measures:** In case of failure of the LEV, a beacon begins to flash and a relay turns the tank current off.

Conditions of use

	Method
Product (article) characteristics	
▪ Product type: Powder dissolved in Liquid	Measured (static and personal)
▪ Concentration of CrO_3: 300 g/L	Measured (static and personal)
Amount used (or contained in articles), frequency and duration of use/exposure	
▪ Duration of activity: full shift, usually 7 h 45 mins	Measured (static and personal)
Technical and organisational conditions and measures	
▪ Activity class: Activities with open liquid surface	Measured (static and personal)
▪ Local exhaust ventilation: Yes plus lip extraction on tanks	Measured (static and personal)
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory protection: No	Measured (static and personal)
Other conditions affecting workers exposure	
▪ Place of use: Indoors, 450 m^3	Measured (static and personal)
▪ Process Temperature: Bath temperature ranges between 35-45 ºC	Measured (static and personal)

***Table 24**: Conditions of use: WCS 5*

Exposure and risks for workers

WCS	Route of exposure	Method of assessment	Sample details	Exposure value (8h TWA mg Cr (VI)/m^3) *	Exposure value corrected for PPE mg Cr(VI)/m^3)	Excess risk levels (RAC opinion) **
WCS 5	Inhalation	Personal monitoring	Line 1 operator	0.0001	Not applicable. The plating line is operational each shift and no RPE is worn.	4.0×10^{-4}
WCS 5	Inhalation	Static monitoring	End of Line 1	0.000018		7.25×10^{-5}
WCS 5	Inhalation	Static monitoring	Adjacent to Line 1	0.00018		7.25×10^{-4}
WCS 5	Inhalation	Static monitoring	Walkway adjacent to Line 1	0.000018		7.25×10^{-4}
* Based on reported shift duration of 7h 45 mins ** 1 µg/m^3 equals excess risk of 0.004						

***Table 25**: Exposure concentrations and risks for workers: WCS 5*

<u>Remarks on exposure data</u>

Using the personal monitoring data obtained, an excess lifetime lung cancer mortality risk of 4.0×10^{-4} was estimated based on the RAC dose-response relationship for lung cancer mortality for each company. The personal monitoring data was obtained during a full shift for a plating operator and is representative of the exposure to Cr(VI) during the plating activities. The value obtained is low (0.0001 mg Cr(VI)/m^3) and therefore confirms that adequate controls (mist suppressants and LEV) are in place to minimise exposure.

The static measurements taken at various locations along the plating line also confirm that exposure is minimal with all three locations reporting a value of less than the limit of detection.

<u>Conclusion on risk characterisation</u>

Exposure is adequately controlled.

9.2.7. Worker contributing scenario 6: Laboratory analysis (PROC 15)

In the on-site laboratory, a sample is taken from the flask for analysis by titration with 0.1N sodium thiosulphate. A SOP exists for this process and is provided at Appendix 3.

- **Potential for exposure**: The titration is performed on an open bench with no extraction so there is potential for exposure to the technician. Exposure is minimised by the use of full PPE. A sign is attached to the door while the sample is being prepared for analysis so that no further personnel enter without the appropriate PPE described below.

- **Engineering controls**: No engineering controls are present.

- **Personal Protective Equipment**: The technician is required to wear RPE (a half mask, APF=20) as well as a face shield, company-issued clothing, safety footwear and protective gloves. All personnel performing this task are trained in the correct handling of the substance and the use of PPE.

<u>Conditions of use</u>

	Method
Product (article) characteristics	
▪ Product type: Powders dissolved in liquid	Measured (static)
▪ Concentration of CrO_3: Substantial (10-50%) ▪ Liquids with low viscosity (like water)	Measured (static)
Amount used (or contained in articles), frequency and duration of use/exposure	
▪ Duration of activity: 15 minutes	Measured (static)
Technical and organisational conditions and measures	
▪ Activity class: Transfer of liquid products - <0.1 L/minute, open process, splash loading, good housekeeping	Measured (static)
▪ Local exhaust ventilation: No	Measured (static)
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory protection: Yes, APF = 20	Measured (static)

Other conditions affecting workers exposure	
▪ Place of use: Indoors, small workroom ▪ Only good natural ventilation	Measured (static)
▪ Process Temperature: Room temperature	Measured (static)

***Table 26**: Conditions of use: WCS 6*

<u>Exposure and risks for workers</u>

Contributing scenario	Route of exposure	Method of assessment	Exposure value (8h TWA mg Cr (VI)/m^3)	Exposure value corrected for frequency mg Cr(VI)/m^3)	Exposure value corrected for PPE mg Cr(VI)/m^3)	Excess risk levels (RAC opinion) *
WCS 7	Inhalation	Static monitoring	6.25 x 10^{-7}	5.0 x 10^{-7}	2.5 x 10^{-8}	1.0 x 10^{-7}
WCS 7	Inhalation	ART	0.0015	0.0012	0.00006	2.41 x 10^{-4}
* 1 µg/m^3 equals excess risk of 0.004						

***Table 27**: Exposure concentrations and risks for workers: WCS 6*

<u>Remarks on exposure data</u>
An airborne concentration of <0.00002 mg/m^3 was obtained in the laboratory over 236 minutes. The measurement obtained was lower than the limit of detection and confirms that exposure is minimal in the laboratory.

The predicted exposure obtained using the ART model, which is usually a conservative figure, is higher than the static measurements. This can be attributed to using a conservative approach that the concentration of chromium trioxide in the plating solution will be 10-50% as a worst case. In reality, this concentration will only be possible at the beginning of the titration before dilution with distilled water occurs.

Using the static monitoring data obtained, an excess lifetime lung cancer mortality risk of 1.0 x 10^{-7} was estimated based on the RAC dose-response relationship for lung cancer mortality for each company.

<u>Conclusion on risk characterisation</u>
Exposure is adequately controlled.

9.2.8. Worker contributing scenario 7: Loading/unloading of brass parts (PROC 4)

This worker contributing scenario covers the manual loading of parts onto jigs supported by trolleys by workers ('stacking operators' or 'jiggers') in a separate area to the chromium plating line). The parts are then manually passed through an ultrasonic tank before being placed onto the flight bar which moves the parts automatically to and through plating line 1.

The parts are returned automatically on the flight bars back to the loading/unloading area where they are placed on trolleys. The 'unjigger' then collects the trolleys and takes them through to the unjigging / inspection area. The jiggers and unjiggers perform this activity for the duration of their shift.

- **Potential for exposure**: There is no potential for direct exposure to Cr(VI). The brass parts are loaded onto the jigs prior to any contact with the Cr(VI) plating solution. At the end of the plating process when the parts are unloaded the likelihood of exposure is also minimal as all parts have been through an extensive post treatment process which involves various washing steps and a drying step.

- **Engineering controls**: None

- **Personal Protective Equipment**: Technicians are required to wear company-issued clothing, safety footwear, safety glasses and gloves. All personnel performing this task are trained in the correct handling of the substance and the use of PPE.

<u>Conditions of use</u>

	Method
Product (article) characteristics	
▪ Product type: Liquid	Measured (personal)
Amount used (or contained in articles), frequency and duration of use/exposure	
▪ Duration of activity: - Jig loader – 9 hour shift, 8 hours 15 min exposure time - Jig unloader – 8.5 hour shift, 7 hours 45 mins exposure time	Measured (personal)
Technical and organisational conditions and measures	
▪ Activity class: Loading/unloading of parts	Measured (personal)
▪ General ventilation only	Measured (personal)
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory protection: None ▪ Standard site PPE worn – eye protection, gloves, coveralls and safety shoes ▪ All personnel are trained in the use of PPE.	Measured (personal)
Other conditions affecting workers exposure	
▪ Place of use: Indoors, 450 m^3	Measured (personal)
▪ Process Temperature: Room temperature	Measured (personal)

***Table 28**: Conditions of use: WCS 7*

<u>Exposure and risks for workers</u>

Contributing scenario	Route of exposure	Method of assessment	Exposure value (8h TWA) mg Cr(VI)/m³	Exposure value corrected for PPE and frequency	Excess risk levels (RAC opinion) *
WCS 8	Inhalation	Personal Monitoring Jig Unloader	0.00086 mg/m³	No RPE worn. Performed for duration of shift, every shift.	0.00343
		Personal Monitoring Jig Loader	0.00002 mg/m³		0.0000729
* 1 µg/m³ equals excess risk of 0.004					

***Table 29**: Exposure concentrations and risks for workers: WCS 7*

<u>Remarks on exposure data:</u>
Using the personal monitoring data obtained, an excess lifetime lung cancer mortality risk of 0.0000729 for a jig loader and 0.00343 for a jig unloader is estimated based on the RAC dose-response relationship for lung cancer mortality.

The higher value for the jig unloader has been noted and investigated. Changes to the design of the jig are being implemented to ensure plating solution drains completely from the equipment so there is no residual material. Plating technicians wearing PPE will check the jigs before unjigging until this change is implemented.

<u>Conclusion on risk characterisation</u>
Exposure is adequately controlled.

9.2.9. Worker contributing scenario 8: Maintenance (PROC 28)

This worker contributing scenario considers all activities performed at the site to maintain the chromium bath and related equipment such as LEV systems, pumps etc. Chromium trioxide is corrosive and all equipment has to be constructed of corrosion-resistant materials and checked regularly for corrosion damage. A maintenance schedule is displayed onsite showing the maintenance activities performed and the frequency required (see Figure 22 below).

For the purposes of this CSR, the maintenance activities where potential to Cr(VI) could occur are provided in the table below.

Maintenance task	Frequency	Description of maintenance task
Ultrasonic cleaner	6 weeks	Emptying and top of tank
Water rinse tanks	3 weeks	Emptying and top of tank
Hot swill	Weekly	The chrome rinse tanks are discharged as effluent and flows directly into the treatment tank at present.
Water swill	Weekly	
Chrome neutraliser tank	Weekly	The chrome neutraliser tank is discharged to the chrome dump tank and then is treated using the onsite WWTP.

Chrome drag out tank	6 months	The drag out tank is discharged into IBC and sent for special waste removal by Red Industries.
Anodes in chrome plating tank	Weekly	Check anodes in chrome plating tank
Clean anodes	Weekly	Clean contacts
Cleaning of chromium plating tank	Yearly	The plating tank is emptied into IBCs and sent for special waste removal by Red Industries.

***Table 30**: Maintenance activities undertaken involving the potential for Cr(VI) exposure*

- **Potential for Exposure:** These maintenance activities are performed on a Saturday when the plating baths are turned off and are at ambient temperature (non-activity of plating line). There is no possibility of aerosol formation from the tanks. There is potential for exposure to Cr(VI) when emptying and cleaning the various tanks although the contact is minimal as the majority of tasks are automated and the tanks emptied and rinsed via sealed pipes, with the wastewater being sent for treatment at the onsite wastewater treatment plant. Once cleaned, the various tanks are refilled with fresh water.

  Other maintenance activities which occur are:

  (i) Checking of the sensors on a monthly basis. Before the sensors are checked, the tanks are switched off and drained so the potential for exposure of workers to Cr(VI) is reduced to residual solution only.
  (ii) A cleaning schedule is also in place to ensure all surfaces are regularly wiped and free from contamination by Cr(VI) residues.

  Cleaning of the LEV takes place approximately every four years or as needed. This cleaning activity is performed by a specialist external waste contractor.

  The LEV is checked on a 12 monthly basis by Zurich and was last performed in January 2022 with satisfactory results. These checks meet the requirements of health and safety law which states that LEV must be thoroughly examined and tested by a competent LEV examiner at least once every 14 months and a record kept for at least five years.

- **Personal Protective Equipment:** Maintenance personnel are trained in the hazards associated with the use of Cr(VI) and receive instruction in the correct use of PPE. Standard site PPE is worn which includes eye protection, coveralls and safety boots.

***Figure 22**: Line 1 Maintenance Schedule displayed on site*

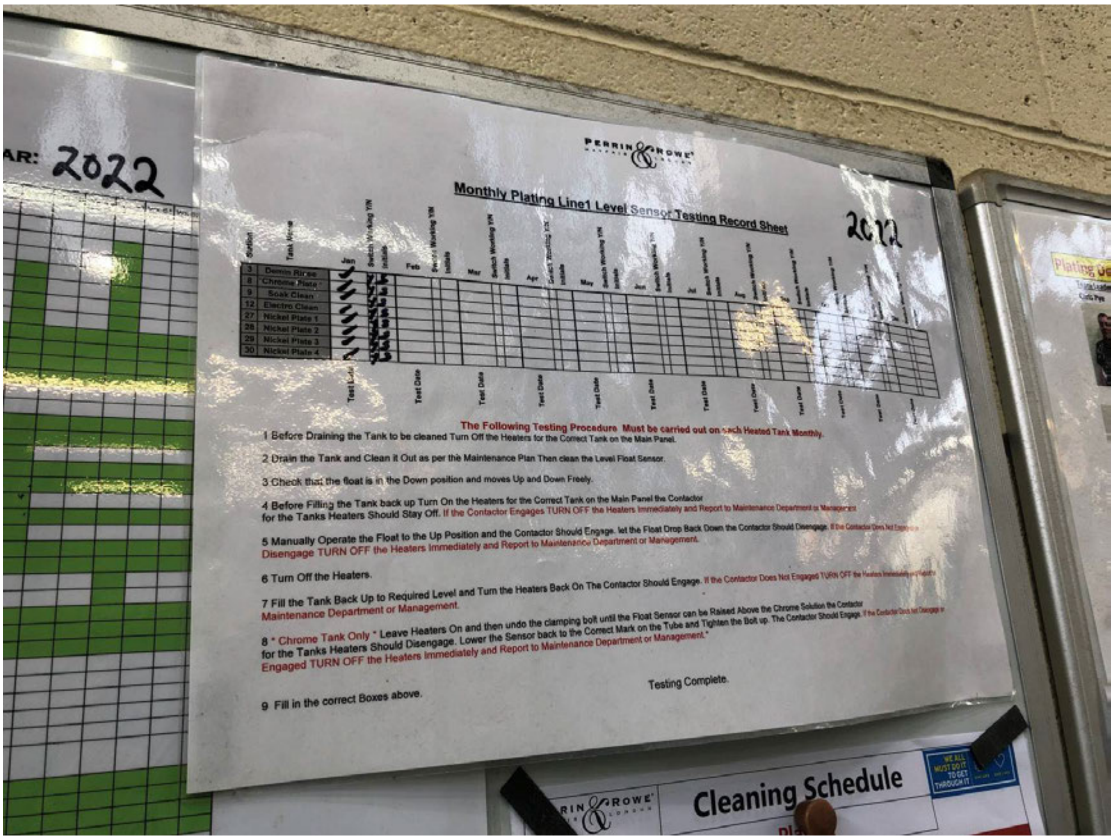


***Figure 23**: Photograph of sensor testing record*

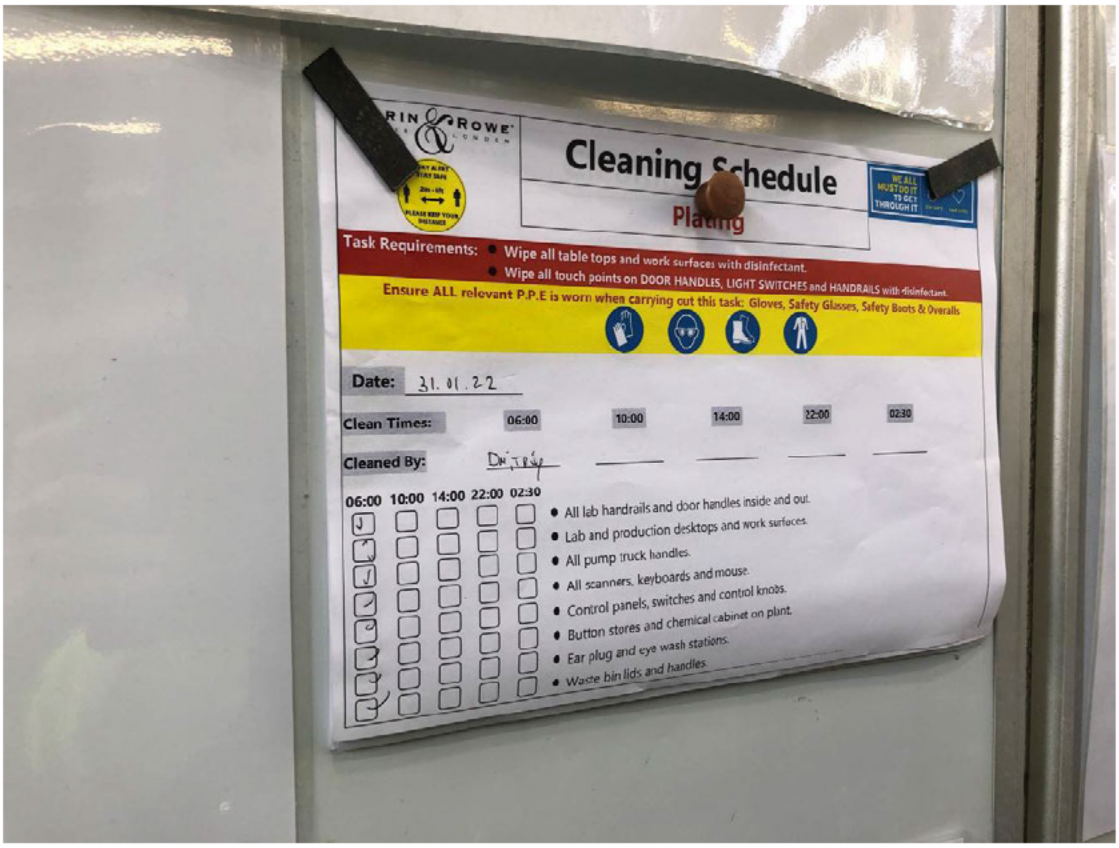


***Figure 24**: Photograph of cleaning schedule used to minimise surface contamination*

<u>Conditions of use</u>

Neither personal monitoring data for this task nor static monitoring data when the current to the plating bath is switched off is available. Instead, static measurements obtained around the plating line during the operation of the plating tank have been used to estimate exposure. These measurements are worst case and show that exposure to workers around the plating area is minimal. The WCS was also modelled using ART.

	Method
Product (article) characteristics	
▪ Product type: Liquid	Measured (static)
▪ Concentration of CrO_3: 300 g/L (residual solution only) (For the purposes of ART, substantial (10-50%) selected)	Measured (static)
Amount used (or contained in articles), frequency and duration of use/exposure	
▪ Duration of activity: 6 hours	Measured (static)
Technical and organisational conditions and measures	
▪ Activity class: Handling of contaminated objects ▪ Activities with treated/contaminated objects (surface >3m^2) ▪ Contamination <10% of the surface	Measured (static)
▪ Local exhaust ventilation: Yes, LEV available in plating area	Measured (static)

Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory protection: No	Measured (static)
Other conditions affecting workers exposure	
▪ Place of use: Indoors, large, good natural ventilation	Measured (static)
▪ Process Temperature: Room Temperature	Measured (static)

***Table 31**: Conditions of use: WCS 8*

<u>Exposure and risks for workers</u>

WCS	Route of exposure	Method of assessment	Sample details	Exposure value (airborne conc. mg Cr(VI)/m^3)	Exposure value (8h TWA airborne conc. mg Cr(VI) m^3) *	Exposure value corrected for frequency mg Cr(VI) m3	Excess risk levels (RAC opinion) **
WCS 8	Inhalation	Static monitoring	End of Line 1	<0.00002	0.000015	0.0000015	6×10^{-6}
WCS 8	Inhalation	Static monitoring	Adjacent to Line 1	<0.0002	0.00015	0.000015	6×10^{-5}
WCS 8	Inhalation	Static monitoring	Walkway adjacent to Line 1	<0.0002	0.000015	0.0000015	6×10^{-6}
WCS 8	Inhalation	ART	-	-	0.003848	0.0003848	1.54×10^{-5}
* based on 6 hours performing maintenance tasks ** 1 µg/m^3 equals excess risk of 0.004							

***Table 32**: Exposure concentrations and risks for workers: WCS 8*

<u>Remarks on exposure data</u>

The static monitoring value of <0.0002 mg Cr(VI)/m³ obtained near the plating line while in operation was used to determine an 8h TWA of 0.00015 mg Cr(VI)/m³ for maintenance activities based on a 320 minutes of exposure during an 8 hour shift. This is assumed worst case since maintenance activities are usually performed on a Saturday when the plating baths are turned off and are at ambient temperature (non-activity of plating line) so there is no possibility of aerosol formation from the tanks.

Using the static measurements and taking into account the frequency of maintenance activities, an excess lifetime lung cancer mortality risk of 6×10^{-5} is estimated based on the above exposure estimate and the RAC dose-response relationship for lung cancer mortality.

The predicted exposure obtained using the ART model, which is usually a conservative figure, is comparable with the static measurements obtained adjacent to plating line 1 and confirms that exposure is minimal during maintenance activities, as suitable operational conditions and risk management measures are in place.

<u>Conclusion on risk characterisation</u>

Exposure is adequately controlled.

9.2.10. Worker contributing scenario 9: Treatment of wastewater (PROC 8b)

This worker contributing scenario covers the treatment of wastewater in the onsite facility. The treatment of the wastewater is automated and a control panel controls the amount of sulphuric acid and sodium metabisulphite to the chrome reduction tank to effectively reduce all remaining Cr (VI) to Cr(III).

Regular samples are taken by a trained technician from the final discharge point every 4 hours, 3 to 4 times a day and analysed in the laboratory on site for total chromium content, total Ni content, total cyanide content, effluent pH and effluent COD 1-hour settled. Full details on the wastewater treatment are provided in section 9.1.3.1.

***Figure 25**: Photograph of a technician collecting a water sample from the final discharge point*

- **Potential for Exposure**: The wastewater treatment process is an enclosed system and the only opportunity for exposure of workers to Cr(VI) is during the sampling of the wastewater. The collection of the solid waste from the wastewater treatment is considered in the next exposure scenario.

- **Personal Protective Equipment**: All staff are trained in the hazards associated with the use of Cr(VI) and receive instruction in the correct use of PPE. Standard site PPE is worn which includes eye protection, coveralls, gloves and safety boots.

Conditions of use

	Method
Product (article) characteristics	
▪ Product Type: Cr(VI) powders dissolved in liquid	ART
▪ Concentration of Cr(VI): 2.5 mg/L (maximum level reached at site in wastewater). Minute chosen in ART	ART
▪ Liquids with low viscosity	ART
Amount used (or contained in articles), frequency and duration of use/exposure	
▪ Duration: 15 minutes	ART
Technical and organisational conditions and measures	
▪ Activity class: Transfer, <0.1 L/minute, open process	ART
▪ Type of transfer: Splash loading	ART
▪ No primary localised controls	ART
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ No respiratory protection	ART
▪ Gloves, coveralls and eye protection	ART
Other conditions affecting workers exposure	
▪ Outside, located close to buildings	ART

***Table 33**: Conditions of use: WCS 9*

Exposure and risks for workers

Contributing scenario	Route of exposure	Method of assessment	Predicted Exposure value (8h TWA airborne conc. mg/m^3)	Excess risk levels (RAC opinion) *
WCS 9 – Wastewater treatment process	Inhalation	ART	1.56×10^{-7}	6.24×10^{-7}
WCS 9 – sampling of wastewater	Inhalation	ART	2.34×10^{-6}	3.24×10^{-5}
* 1 µg/m^3 equals excess risk of 0.004				

***Table 34**: Exposure concentrations and risks for workers: WCS 9*

Remarks on exposure data

No personal monitoring data exists for this activity. Exposure is likely to be minimal as the wastewater treatment process is fully automated and ensures that all Cr(VI) is reduced to Cr(III). The only opportunity for exposure of workers to Cr(VI) is during the sampling of the wastewater but again the concentration of Cr(VI) should be negligible if the wastewater treatment process is running effectively.

As no personal monitoring data is available, the modelled exposure estimate (ART) of 2.34×10^{-6} mg Cr(VI)/m^3 is used as the basis for risk characterisation (worst case) for the sampling of wastewater.

An excess lifetime lung cancer mortality risk of 3.24×10^{-5} is estimated based on the above exposure estimate and the RAC dose-response relationship for lung cancer mortality.

Conclusion on risk characterisation
Exposure is adequately controlled.

9.2.11. Worker contributing scenario 10: Maintenance (cleaning of filter press) (PROC 8b)

This worker contributing scenario considers the maintenance activities performed at the site on a regular basis. This includes the cleaning of the filter press in the onsite wastewater treatment facility. The filter press is a final stage in managing solids associated with the wastewater treatment process. Reduction of hexavalent chromium to trivalent chromium by overdosing with sodium metabisulfite under acidic conditions has been carried out. Residual concentrations of hexavalent chromium in the sludge, if any, are negligible.

Prior to release of the water to the environment, the wastewater is sent through a filter press which separates the liquids and solids using pressure filtration across a filter media. Afterward, the slurry is pumped into the filter press and then dewaters under pressure.

The compacted sludge remaining (see Figure 26 below) is removed by operators and sealed into filter bags ready to be collected by a waste carrier (World Resources). A dedicated area, external to the building, is used to store the filter bags. The filter bags are sealed, limiting exposure to the slurry. The collection occurs every 4 months.

***Figure 26**: Photograph of sludge on filter press*

***Figure 27**: Photograph of sealed bag containing filter cake – signs are visible to show access is restricted*

- **Potential for Exposure**: There is potential for worker exposure during the removal of the sludge, however, this is minimised by the use of PPE. Workers are trained to work with the sludge in a careful manner to ensure exposure is minimal. All operators will perform this task.

- **Personal Protective Equipment**: Operators must wear RPE (half-mask with APF of 20), a face shield and heavy duty gloves.

<u>Conditions of use</u>

	Method
Product (article) characteristics	
▪ Product type: Paste, slurry or clearly soaked wet powder	Measured (static)
▪ Very small (0.5-1%)	Measured (static)
Amount used (or contained in articles), frequency and duration of use/exposure	
▪ Duration: 15 minutes	Measured (static)
Technical and organisational conditions and measures	
▪ Activity class: Handling of contaminated solid objects or paste	Measured (static)
▪ Handling of substantially and visibly contaminated objects (eg. maintenance of heavily contaminated equipment)	Measured (static)
▪ Careful handling, involves workers showing attention to potential danger, error or harm and carrying out the activity in a very exact and thorough (or cautious)	Measured (static)

manner	
▪ Local exhaust ventilation: No	Measured (static)
Conditions and measures related to personal protection, hygiene and health evaluation	
▪ Respiratory protection: Yes, APF=20	Measured (static)
Other conditions affecting workers exposure	
▪ Place of use: Indoors, large room, only good natural ventilation	Measured (static)
▪ Process Temperature: Room Temperature	Measured (static)

***Table 35**: Conditions of use: WCS 10*

Exposure and risks for workers

Contributing scenario	Route of exposure	Method of assessment	Exposure value (250 mins)	Exposure value (8h TWA) mg Cr(VI)/m³	Exposure value corrected for frequency and PPE mg Cr(VI)/m³ *	Excess risk levels (RAC opinion) **
WCS 10	Inhalation	Static monitoring	<0.00002 mg/m³ Cr(VI)	1.25 x 10^{-5}	2.5 x10^{-8}	1 x 10^{-7}
WCS 10	Inhalation	ART	-	0.000156	3.12 x 10^{-6}	1.25 x 10^{-5}
* sludge removed twice weekly ** 1 µg/m³ equals excess risk of 0.004						

***Table 36**: Exposure concentrations and risks for workers: WCS 10*

Remarks on exposure data

There is potential for worker exposure during the removal of the sludge, however, this is minimised by the use of PPE. Workers are trained to work with the sludge in a careful manner to ensure exposure is minimal.

A static measurement of <0.00002 mg/m³ Cr(VI) was obtained during a 250 minutes sampling period and is used as the basis for risk characterisation (worst case).

An excess lifetime lung cancer mortality risk of 1.0 x 10^{-7} is estimated based on the above exposure estimate and the RAC dose-response relationship for lung cancer mortality.

As only a static monitoring result is available, the ART model was ran for this activity and provided a exposure of 0.000156 mg/m³ Cr(VI). Taking into account the frequency of the task and the PPE worn, the estimate can be reduced to 3.12 x 10-6 mg/m³. Although higher than the result obtained using the static measurement, this still shows that exposure is minimal and that the operational conditions and risk management measures in place are suitable.

Conclusion on risk characterisation

Exposure is adequately controlled.

10. Risk characterisation related to combined exposure

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

Workers are clearly assigned to specific tasks. In Chapter 9, the various tasks performed by each of the different workers and the exposure levels were described. In this section, the various tasks performed during a typical shift for each type of worker will be described in order to determine the total exposure to Cr(VI) for a worker during one shift.

The combined exposure for each worker position and the tasks which are performed in their role are summarised in the table below. It should be noted that workers can also perform activities not directly related to the production process involving Cr(VI). In other words, they perform tasks in other parts of the plant, which are non-Cr(VI) areas. These activities will be regarded as non-exposure activities.

Roles	Number of workers per shift	Total number of workers	WCS covered in role	Combined exposure, mg/m^3 per worker	Excess risk per worker
Technicians	1 (+Sat mornings)	3	WCS 3, 4, 6, 10	3.4E-06	3.78E-04
Plating line operators	1	6	WCS 1, 2, 5, 9	3.0E-05	4.40E-04
Jiggers	2 in morning and 1 in afternoon	3	WCS 7	1.8E-05	7.29E-05
Unjiggers	1 in morning and 1 in afternoon	2	WCS 7	8.6E-04	3.43E-03

***Table 37**: Combined exposure and risk characterisation for workers*

Information on combined consumer exposure is not relevant to this CSR.

10.2. Environment (combined for all emission sources)

10.2.1. Total releases

The table below shows total releases to the environment per year from all life cycle stages.

Release route	Total releases per year
Water	0 kg/year
Air	11.4 g/year
Soil	Not relevant

***Table 38**: Total releases to the environment per year from all life cycle stages*

10.2.2. Regional exposure

The regional predicted environmental concentration (PEC regional) and the related risk characterisation ratios when a PNEC is available are presented in Table 39 below. The exposure to humans via the environment from regional exposure and the related risk characterisation ratios are provided (when relevant) in Table 40 below. The exposure concentration for human via inhalation is equal to the PEC air.

Environment

Protection target	Regional PEC	Risk characterisation (RCR or Excess risk)
Freshwater	3.03×10^{-11} mg/L	Not relevant
Sediment (freshwater)	2.13×10^{-9} mg/kg wwt	Not relevant
Marine water	2.99×10^{-12} mg/L	Not relevant
Sediment (marine water)	1.76×10^{-10} mg/L	Not relevant
Air	2.36×10^{-21} mg/m3	Not relevant
Agricultural soil	2.42×10^{-10} mg/kg wwt	Not relevant

***Table 39**: Predicted regional environmental concentrations (Regional PEC)*

Humans via the environment

Route	Regional exposure	Risk characterisation (RCR or Excess risk)
Inhalation	2.36×10^{-21} mg/kg/d	See SEA
Oral	3.81×10^{-7} mg/kg/d	Not required. Assume all inhaled material is respirable.

***Table 40**: Regional exposure and risk to human via the environment*

Appendices

Appendix 1: Copy of effluent plant emergency shut-down procedure

EFFLUENT PLANT EMERGENCY SHUT-DOWN PROCEDURE

This procedure should be initiated in the following situations:

- **Confirmed Photometer (Palintest) reading of breach of discharge consent limit.**
- **PH Alarm on final Outflow tank – PH at 8.5 or Less.**
- **More than simultaneous 3 alarms on the Alarm panel – This indicates a significant chemistry failure.**

SHUT DOWN PROCEDURE

STEP 1

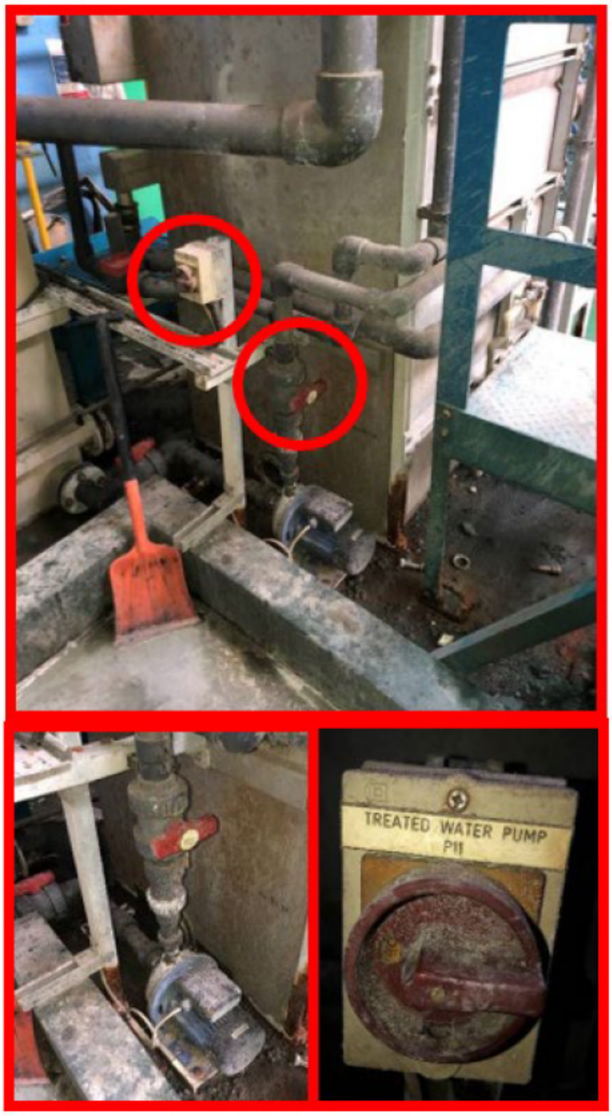
Immediately shut off final outflow tank vale to stop any further discharge. Turn level to horizontal position.

Valve Open

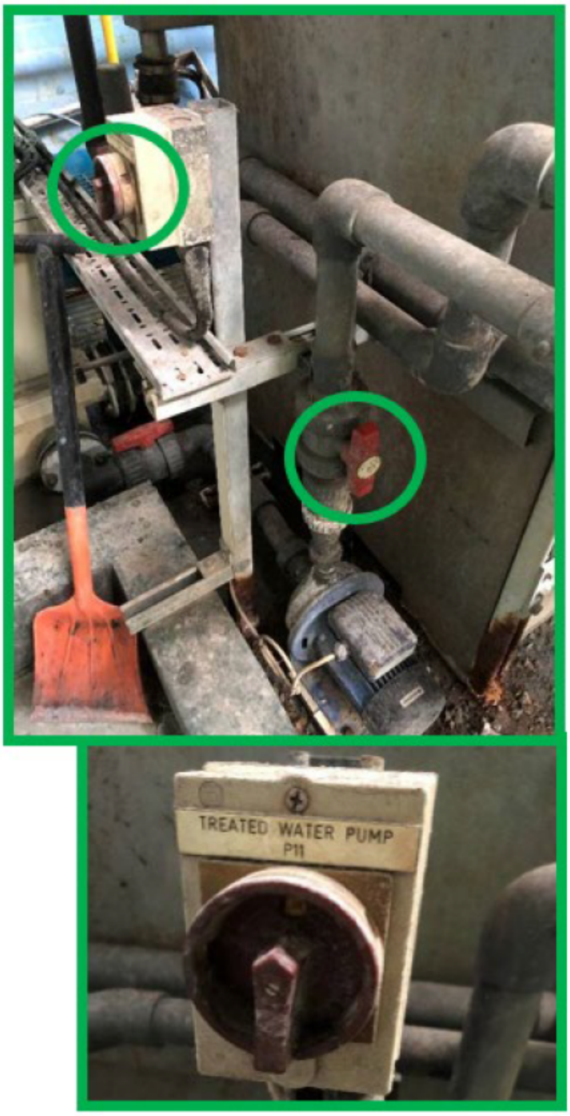
Valve Closed

STEP 2

Turn recycle pump valve on (vertical) and turn recycle pump power on (isolation switch).



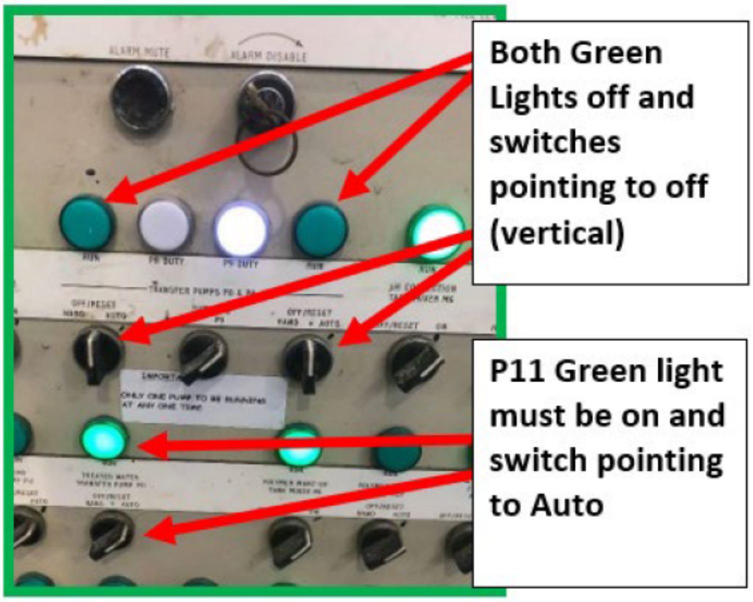
Valve closed & Pump Off



Valve Open & Pump On

STEP 3

Ensure pumps from transfer tank are both switched off (Pumps 8 and 9 on Control Panel). Transfer pump to be switched to Auto (pump 11)



STEP 4

Turn off water to ultrasonic cleaner.

Valve Open **Valve Closed**

STEP 5

TURN OFF WATER TO LINE 1

Turn off valve behind station 21 – Line 1

Valve Open

Valve closed

Turn off Valve for cooler water addition (water from header tank)

Valve Open

Valve Closed

STEP 6

TURN OFF WATER TO GOLD LINE (above Caustic Tank)

Valve Open

Valve Closed

STEP 6

TURN OFF WATER SUPPLY TO LINE 2 AND BRONZE STRIP LINE

Turn off water supply behind bronze strip line

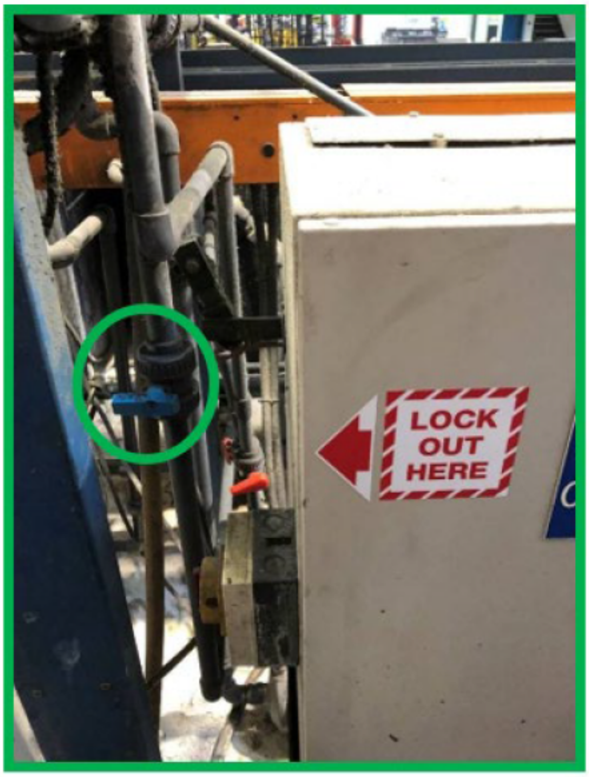
Valve Open

Valve Closed

STEP 7

TURN OFF WATER SUPPLY TO BRONZE LINE (behind bronze line)

Valve Open



Valve Closed

IMPORTANT! When tank is fully drained ensure Recycle Pump is turned to off position

FINAL CHECK!

CHECK FINAL OUTFLOW TANK IS EMPTY AND NOT DISCHARGING TO SEWER

Appendix 2: Example report of thorough examination and test of LEV

Routine, rep no. 57870446/5

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ZURICH

THE CONTROL OF SUBSTANCES HAZARDOUS TO HEALTH REGULATIONS 2002 (AS AMENDED) (DL2.9)

REPORT OF PERIODIC THOROUGH EXAMINATION AND TEST

Report No: 57870446/5
Policy / Contract No: NYB26913 Schedule: LEV2 ES Item No: LEV10
Freq: 12 Mths

Policy / Contract Name: TCL MANUFACTURING LTD
Occupier (or Owner) of Premises: TCL MANUFACTURING LTD
Address: SHAW ROAD BUSHBURY WEST MIDLANDS WV10 9LB

	Initial Examination Details
a. Distinguishing No. and description of plant	P & R 000435 Not determined. Local Exhaust Ventilation Unit
b. Situation within premises	Plating Shop Chrome Plating
c. Hazardous Substance(s)	Chromic Acid Fume
d. Air Monitoring	Evidence of a satisfactory Assessment is required in order to demonstrate that this LEV system is adequately controlling the hazardous substance. This report of LEV system independent of this Assessment will not provide proof of compliance with the Regulations.

e. Details of Fan/Air Mover	Make	Type	Identity No	Motor HP/KW	Fan Size
	Industrial fans Ltd.	Centrifugal	Not determined.	5.5 kW	500 mm diameter
	Other Details	Speed (r.p.m) Stated Motor	Direction of Rotation	Static Inlet Pressure EM (Pa)	Volume Flow (m³/s)
	Exhausted to atmosphere	1440	Clockwise	-770	1.89
f. Details of Filter/Collector	**Make**	**Type**	**Identity No**	**Filter Medium**	**Automatic Monitor**
	Not determined.	Wet Fume Scrubber	Not determined.	Water mist	None fitted.
	Other Details	Static Inlet Pressure EM (Pa)	Static Outlet Pressure EM (Pa)	Differential (Pa)	Volume Flow (m³/s)
	Exhausted to atmosphere	-440	-750	310	1.89

g. Details of System Velocities & Volume Flow	Point Number	VP A			
	Section	0.12 m²			
	Avg. Duct Velocity (m/s)	15.8			
	Volume Flow (m³/s)	1.89			
h. Date of Initial Examination and Test	05/04/2016				

	Initial and Periodic Examination Results [Initial Examination Results shown in brackets]
1. Is arrangement and method of use or system unchanged from the initial Examination and Test	Yes.
2. Status of plant at time of examination and test.	Normal working conditions
3. Are all elements of the system in good working condition.	Yes.

4. Static Pressure Readings immediately behind Hoods EM	SP 1 -810 [-920]	SP 2 -360 [-410]	SP 3 -300 [-310]							

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(State Identification Number) Units: Pa	EM	EM	EM								
5. Face Velocities (State Identification Number) Units: m/s	FV 1 Ave 2.1 [3.30] HWA	FV 2 Ave 7.3 [9.80] HWA	FV 3 Ave 4.6 [7.60] HWA								
6. Average Duct Velocity (State Identification Number) Units: m/s	VP A 12.9 [15.8] EM										

7. Filter/Collector Static Pressures Units: Pa	Inlet 1: -350 [-440] EM Outlet 1: -1090 [-750] EM Across Filter 1: 1055 [310]
8. Air Mover / Fan Inlet units: Pa	Static Pressure Fan 1 Inlet: -980 [-770] EM Speed (r.p.m) Fan 1: 1440 stated motor
9. Are all pressures and velocities acceptable when compared with Initial Examination and Test	Yes.
10. Is the substance being adequately controlled (specify test).	Refer to section "d" of this report. Tests Applied: Visual and Audible techniques. Face Velocity Tests. Static Pressure Tests. Duct Velocity Tests. Smoke Tests. The following abbreviations refer to the results recorded above and to the test points shown in the schematic drawing. FV = Face Velocity Reading. SP = Static Pressure Reading. VP = Velocity Pressure Reading. NM = Not measured / No suitable test points. Ave = Average Face Velocity Reading. [5 x Readings] List of Instruments used at this examination. EM = Electronic Pressure Meter, Manufacturer Digitron Model APM140 Serial Number 4607115166, ZE reference PM94 HWA = Hot Wire Anemometer, Manufacturer Extech Model 407123 Serial Number Q622981, ZE reference HWA/146Cert Number: U292781, Serial Number: Z163824, ZE Reference: HWA/125.
11. Particulars of defect(s) found and repairs required. The defects in this section should be remedied as soon as reasonably practicable unless otherwise stated.	None
12. Observations	The benchmark examination results are shown in brackets in this report and originate from a benchmark examination performed by Zurich Engineering in the absence of Intended Operating Performance or Commissioning data. There is no evidence that a user manual or logbook exists for this extraction system. Your attention is drawn to Health and Safety Guidance note 258 and section 9 therein. It is recommended that a user manual and logbook are created as per the guidance. In the absence of Intended Operating Performance (IOP) and or commissioning details HSE Guidance note HSG258 states a minimum capture velocity of 0.25 to 0.50 m/s at the hood and a

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	conveyance velocity of 5 m/s for vapour. The performance of this system is satisfactory.
	Repairs Carried Out
13. Name and designation of person carrying out repairs and date carried out.	

Date of previous Examination and Test: 24/10/2019
Date of this Examination and Test: 08/01/2021

Authenticated by: Mark Sliwka
Designation: Team Manager

Contact: mark.sliwka@uk.zurich.com
Telephone: 07764 149016

Date: 11/01/2021

Client's Additional Comments

Submit Comment

Comments History		
Date/Time	User	Comment

.. more comments

Save Changes | Quit | Print

Report Status ☐ Read ☐ Needs Actioning ☐ Completed Action

Report forwarding History				
Date Requested	Date emailed	Sender	Recipients	Comments

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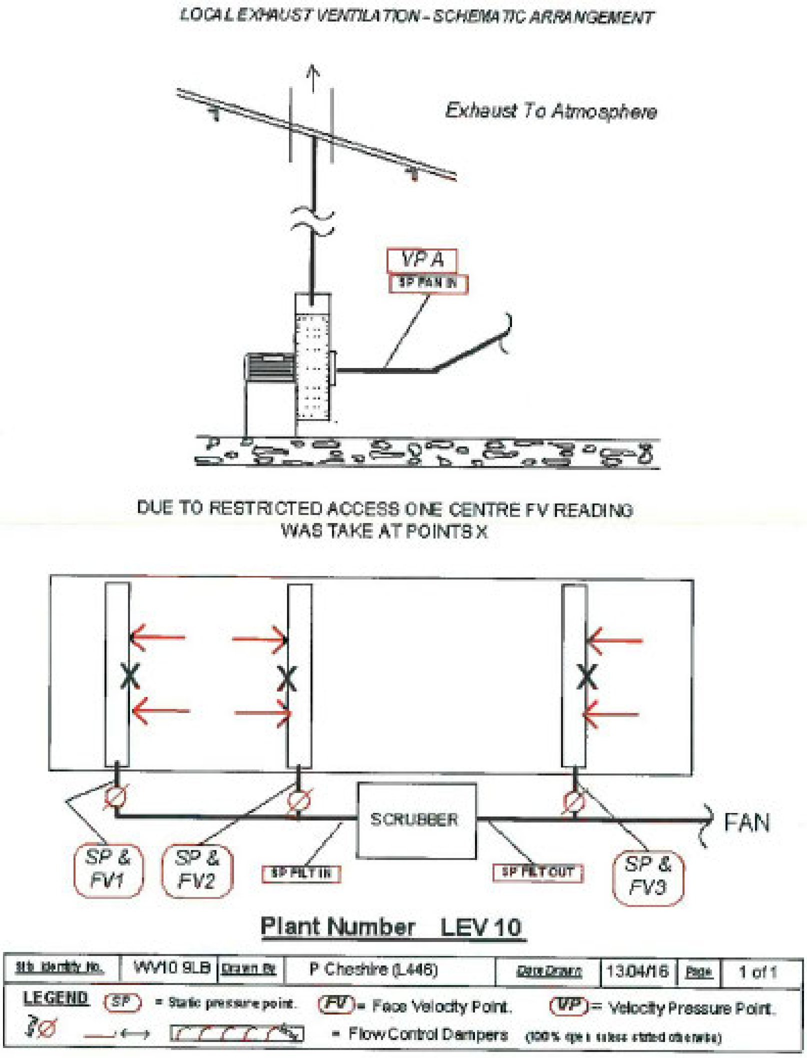

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Appendix 3: Laboratory analysis SOP

	Page:	1 of 3
	Date:	
ANALYSIS FOR (Hexavalent Chromium)	File:	

Reagents:

1. 0.1M (0.1N) Sodium Hydroxide Solution
2. 50% by volume Sulphuric Acid Solution
3. Potassium Iodide
4. Thyodene Indicator
5. 0.1M (0.1N) Sodium Thiosulphate Solution

Procedure:

First, into a clean 500ml Volumetric flask pipette 5.0ml of sample solution. Top up to mark with de-ionised water, mix thoroughly. This is dilution 'A'.

For Chromium (VI) Oxide Content

1) Pipette 20ml of dilution 'A' into a clean 250 ml Conical flask. Add 100ml of deionised water

2) Now add 1g of Potassium Iodide and 20 ml of 50% Sulphuric acid and mix thoroughly. Cover the flask with a black cap.

3) Allow the flask to stand in the dark for exactly 5 minutes.

4) After the 5 minutes, titrate immediately with 0.1N Sodium Thiosulphate until a colour change to light brown. Add 1gml of Thyodene indicator and continue to titre until light green/blue endpoint is reached.

Record titre (as X)

(X) titre x 16.67 = Chromium (VI) Oxide

Authorised by:	Signed:	Issue:

Trivalent Chromium (III) Content

Determination by UV / Visible Spectroscopy
Instrument Jenway Spectrophotometer (UV / Visible)

Procedure

1) Pipette 10.0 ml of the plating solution into a 100 ml volumetric flask and dilute to the mark with deionised water and mix thoroughly.

2) Set the Spectrophotometer to 580nm and Zero using De-Ionised water

3) Measure the absorbance of the diluted sample in a plastic Cuvette on the Spectrophotometer

Calculation

[(Absorbance Value - (Chromic Acid content x 0.00013)] x 25.78 = g/l Trivalent Chromium.

Title: **ANALYSIS FOR BRIGHT CHROME (Sulphuric Acid)**	File:	**LP 15**

Reagents: Solution A 50% by vol. Hydrochloric Acid

Solution B 20% by wt Barium Chloride solution

Preparation of Solution B
Accurately weigh 100gms Barium Chloride and mix with 400ml de-ionised water. When fully dissolved pour the solution into a 500ml volumetric flask and top up to the mark with de-ionised water. Allow the solution to stand overnight , decant off the clear solution into a labelled container

1) If the chrome solution to be analysed appears cloudy or has a precipitate it should be filtered through a 540 filter paper.

Signed:	Issue: 1C

2) Pipette 20ml of the chrome solution into the centrifuge tube. **3)** Pipette 5ml of each solution A and B into the centrifuge tube. **4)** Securely fit the cover on top of the centrifuge tube invert the tube and shake for 30seconds. **5)** Repeat steps 1 to 4 with a second centrifuge tube. **6)** Place the centrifuge tubes into the aluminium holder of the KOCOUR centrifuge opposite each other (to ensure an even balance when running the centrifuge). **7)** Close the lid and run the centrifuge for 3 minutes. Remove both the tubes and tap lightly to settle and level the precipitate. **8)** Replace the tubes into the centrifuge as in **step 6** and run the centrifuge for 1 minute. **9)** Remove the centrifuge tubes and tap lightly to level the precipitate. Read the number of small divisions occupied by the precipitate in the stem of the centrifuge tube. **10)** Take the average reading from both tubes **Average reading in small divisions x 0.15 = gm/lt Sulphuric acid**		

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