

**CHROMIUM TRIOXIDE, SODIUM CHROMATE,
SODIUM DICHROMATE, AMMONIUM DICHROMATE AND
POTASSIUM DICHROMATE**

CAS No: 1333-82-0, 7775-11-3, 10588-01-9, 7789-09-5 and 7778-50-9
EINECS No: 215-607-8, 231-889-5, 234-190-3, 232-143-1 and 231-906-6

Summary Risk Assessment Report

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SUMMARY RISK ASSESSMENT REPORT

Final report, 2005

United Kingdom

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PREFACE

This report provides a summary, with conclusions, of the risk assessment report of the substances chromium trioxide, sodium chromate, sodium dichromate, ammonium dichromate and potassium dichromate that have been prepared by the United Kingdom in the context of Council Regulation (EEC) No. 793/93 on the evaluation and control of existing substances.

For detailed information on the risk assessment principles and procedures followed, the underlying data and the literature references the reader is referred to the comprehensive Final Risk Assessment Report (Final RAR) that can be obtained from the European Chemicals Bureau¹. The Final RAR should be used for citation purposes rather than this present Summary Report.

¹ European Chemicals Bureau – Existing Chemicals – <http://ecb.jrc.it>

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1 GENERAL SUBSTANCE INFORMATION

1.1 IDENTIFICATION OF THE SUBSTANCE

This information is presented in tabular form (**Table 1.1**).

Table 1.1 Identification of substances covered in the risk assessment

Substance	CAS no	EINECS no	Molecular weight (without hydration)	Formula	Synonyms
Chromium trioxide	1333-82-0	215-607-8	99.99 g/mole	CrO ₃	Chromium oxide Chrom (VI) oxide Chromium trioxide Chromic anhydride Chromic acid
Sodium chromate	7775-11-3	231-889-5	161.99 g/mole	Na ₂ CrO ₄	Sodium monochromate, Disodium chromium tetraoxide
Sodium dichromate	10588-01-9	234-190-3	261.96 g/mole	Na ₂ Cr ₂ O ₇	Disodium dichromate, Disodium dichromium heptaoxide
Ammonium dichromate	7789-09-5	232-143-1	252.06 g/mole	(NH ₄) ₂ Cr ₂ O ₇	Ammonium bichromate, Di-ammonium dichromate
Potassium dichromate	7778-50-9	231-906-6	294.22 g/mole	K ₂ Cr ₂ O ₇	Dipotassium dichromate, Potassium bichromate

1.2 PURITY/IMPURITIES, ADDITIVES

1.2.1 Purity

The information is presented in tabular form (**Table 1.2**).

Table 1.2 Purity of the substances

Substance	Purity (weight %)	Typical impurities	Impurity content (weight %)
Chromium trioxide	>99.5%	sodium hydrogen sulphate	~0.08%
Sodium chromate	99%	none stated	-
Sodium dichromate	>99.3%	water; sodium sulphate; sodium chloride.	~0.4% ~0.15% ~0.09%
Ammonium dichromate	98.5%	water; sodium sulphate.	~1.5% ~0.02-0.04%
Potassium dichromate	99.7%	water; sodium dichromate.	~0.03% ~0.28%

1.2.2 Additives

There were no stated additives used with these substances.

1.3 PHYSICO-CHEMICAL PROPERTIES

The physical state and physicochemical properties of each of the five chromium (VI) compounds are summarised in **Table 1.3** and **Table 1.4**. Information is taken from IUCLID, CRC (1995), Newth (1896) and Merck (1989)

Table 1.3 Physical state

Substance	Appearance
Chromium trioxide	Dark red deliquescent crystals, flakes or powder
Sodium chromate	Slightly deliquescent yellow crystals in hydrated form (usually tetra or deca hydrated)
Sodium dichromate	Reddish to bright orange deliquescent crystals in hydrated form usually dehydrated
Potassium dichromate	Bright orange/red crystals – not hygroscopic or deliquescent
Ammonium dichromate	Bright orange/red crystals - non hygroscopic

Table 1.4 Physico-chemical properties

Property	Chromium trioxide	Sodium chromate	Sodium dichromate	Potassium dichromate	Ammonium dichromate
Melting point	196°C	decahydrate loses H ₂ O and melts at ~20°C; anhydrous salt melts at ~762°C	becomes anhydrous at 100°C and salt melts ~357°C	~398°C	starts to decompose at ~180°C - this can become self sustaining at ~225°C
Boiling point	n/a decomposes at ~250°C to Cr ₂ O ₃ and O ₂	n/a	n/a decomposes above 400°C	n/a decomposes above 500°C	n/a decomposes above 180°C
Relative density	~2.7	~2.4 - 2.7	~2.5	~2.7	~2.15
Vapour pressure	n/a: inorganic ionic compound	n/a: inorganic ionic compound	n/a: inorganic ionic compound	n/a: inorganic ionic compound	n/a: inorganic ionic compound
Solubility (H ₂ O) at 20°C	~1,667 g/l (a 1% solution has a pH<1)	~530 g/l (the aqueous solution is alkaline (pH 9))	~2,355 g/l (a 1% solution has a pH ~4)	~115 g/l (a 10% solution has a pH ~3.5)	~360 g/l (a 1% solution has a pH ~4)
Partition coefficient (Log K _{ow})	n/a: inorganic ionic compound	n/a: inorganic ionic compound	n/a: inorganic ionic compound	n/a: inorganic ionic compound	n/a: inorganic ionic compound
Flash point	n/a: inorganic ionic compound	n/a: inorganic ionic compound	n/a: inorganic ionic compound	n/a: inorganic ionic compound	n/a: inorganic ionic compound; see auto - ignition
Autoignition and flammability	n/a: decomposes at 250°C to Cr ₂ O ₃ and O ₂	n/a	n/a: decomposes above 400°C	n/a: decomposes above 500°C	flammable - can self ignite at ~180°C and above. Reaction self sustaining and very exothermic

Table 1.4 continued overleaf

Table 1.4 continued Physico-chemical properties

Property	Chromium trioxide	Sodium chromate	Sodium dichromate	Potassium dichromate	Ammonium dichromate
Explosivity	n/a	n/a	n/a	n/a	explosive if heated in a closed container. Used in pyrotechnics. Explosivity does not meet criteria for class I explosive.
Oxidising properties	violent oxidising agent	mildly oxidising - strong oxidiser in acidic conditions	strong oxidising agent	strong oxidising agent	oxidising agent

Physico-chemical parameters such as boiling point, octanol-water partition coefficient and vapour pressure have little meaning for solid ionic inorganic compounds such as these five chromates. The melting and decomposition characteristics of these compounds are well known and can be accessed in literature dating back to the 19th century. The most pertinent parameters are the high water solubility and the strong oxidising properties in acidic solutions to organic materials, particularly in the case of chromium trioxide. Ammonium dichromate will support combustion and decomposes exothermically above its melting point and can be explosive under some conditions. All of these substances, with the exception of sodium chromate, form acidic solutions in water.

1.4 CLASSIFICATION

The classification and labelling of the chromates has been agreed at technical levels to be listed in Annex I to Directive 67/548/EEC following the adoption of the 29th Adaptation to Technical Progress, as follows:

Sodium chromate: Carc. Cat. 2;R45 Muta. Cat. 2;R46 Repr Cat. 2;R60-61 T+; R26 T; R25-48/23 C;R34 Xn;R21 R42 /43 N;R50-53

Labelling: T+;N R: 45-46-60-61-21-25-26-34-42/43-48/23-50/53 S: 53-45-60-61

Sodium dichromate: O;R8 Carc. Cat. 2;R45 Muta. Cat. 2;R46 Repr Cat. 2;R60-R61 T+;R26 T;R25-48/23 C;R34 Xn;R21 R42/43 N;R50-53

Labelling: T+;N;O R: 45-46-60-61-8-21-25-26-34-42/43-48/23-50/53 S: 53-45-60-61

Potassium dichromate: O;R8 Carc. Cat. 2;R45 Muta. Cat. 2;R46 Repr Cat. 2;R60-R61 T+;R26 T;R25-48/23 C;R34 Xn;R21 R42/43 N;R50-53

Labelling: T+;N;O R: 45-46-60-61-8-21-25-26-34-42/43-48/23-50/53 S: 53-45-60-61

Ammonium dichromate: E;R2 O;R8 Carc. Cat. 2;R45 Muta. Cat. 2;R46 Repr Cat. 2;R60-61 T+;R26 T;R25-48/23 C;R34 Xn;R21 R42/43 N;R50-53

Labelling: E; T+;N R: 45-46-60-61-2-8-21-25-26-34-42/43-48/23-50/53 S: 53-45-60-61

Chromium (VI) trioxide: O;R9 Carc. Cat. 1;R45 Muta. Cat. 2;R46 Repr Cat. 3;R62 T+;R26 T;R24/25-48/23 C;R35 R42/43 N;R50-53

Labelling: O;T+;N R:45-46-9-24/25-26-35-42/43-48/23-62-50/53 S:53-45-60-61

2

GENERAL INFORMATION ON EXPOSURE

This assessment is concerned with the production and use of five hexavalent chromium compounds: sodium chromate, sodium dichromate, potassium dichromate, chromium trioxide and ammonium dichromate. It does not assess risks arising from other sources of chromium, although these are mentioned where relevant.

Production

The production of the five chromium compounds starts with chromite ore, from which the chromium is extracted as sodium chromate. The vast majority of sodium chromate is converted to sodium dichromate. Chromium trioxide, potassium dichromate and ammonium dichromate are all made from sodium dichromate (potassium and ammonium dichromate can also be made from chromium trioxide as well).

Total production of the five chromium compounds in the EU in 1997 was 247,350 tonnes. However, this total is misleading, as it double or treble counts much of the chromium which is converted from one compound to another. The EU is also a net exporter of chromium compounds, so the amount used in the EU is much less. For the purpose of the assessment, the quantities of the compounds used in the EU are expressed as the two major compounds, chromium trioxide and sodium dichromate, with 17,000 and 25,000 tonnes per year respectively.

Uses

The main uses of these compounds are outlined in **Table 2.1**

Table 2.1 Uses

Chromium (VI) compound	Use
Sodium chromate	manufacture of other chromium compounds
Sodium dichromate	manufacture of other chromium compounds, manufacture of wood preservation products, vitamin K manufacture, mordant in dyeing, wax manufacture and metal finishing
Chromium trioxide	metal finishing, manufacture of wood preservation products, catalyst manufacture, chromium dioxide manufacture and pigment manufacture
Potassium dichromate	pigment manufacture, manufacture of wood preservation products, dye manufacture, catalyst manufacture, chromium metal manufacture and colouring agent in ceramics
Ammonium dichromate	magnetic tape manufacture, catalyst manufacture, mordant in dyeing and pigment manufacture

For the estimation of releases to the environment, these uses are broken down between the two main compounds as follows:

Chromium trioxide is primarily used in four applications:

- 53% in metal treatments (9,010 tonnes chromium trioxide)
- 31% in wood treatments (5,270 tonnes chromium trioxide)
- 6% in the production of magnetic media (1,020 tonnes chromium trioxide)
- 10% for other uses including the production of potassium and ammonium dichromate (1,700 tonnes chromium trioxide)

Sodium dichromate is used in the following applications:

- 54% in the production of chrome sulphate (13,500 tonnes sodium dichromate)
- 31% to produce chromium trioxide (7,750 tonnes sodium dichromate)
- 15% for other uses such as chromium (VI) pigment production, use as an oxidizing agent etc. (3,750 tonnes sodium dichromate)

Note that the percentage for chrome sulphate production includes areas such as vitamin K production where the chrome sulphate could be considered as a by-product of the actual process.

This breakdown of the areas of use has been simplified so that it is based on only two substances. A number of the use areas of chromium (VI) can involve the use of either dichromate or chromium trioxide - for example, formulations for wood treatment can be described in terms of either form - so that reference to the use of one form for a particular use does not mean that the other form cannot be used. This approach has been chosen to provide a consistent set of tonnages for use in the later environmental exposure assessment. As the emissions are based on chromium rather than on any of the substances, it is felt that this approach will not lead to any significant discrepancies.

3

ENVIRONMENT

3.1

ENVIRONMENTAL EXPOSURE

There are a large number of sources of chromium release to the environment. As well as the use of the five substances which are the subject of this assessment, these include the use of other chromium substances, cement production, processing of other ores containing chromium as an impurity, wear of metal alloys containing chromium, as well as the releases from weathering of rocks and soils. This assessment is concerned with the effects of the use of the five chromium (VI) substances. Releases of chromium (VI) from any sources are expected to be reduced to chromium (III) in most situations in the environment (see Section 3.1.1.2.1 in related EURAR 21508 EN) so the impact of chromium (VI) as such is likely to be limited to the area around the source. Therefore this risk assessment focuses on the local impact of emissions from the production and use of the five chromium (VI) compounds. The behaviour of chromium in the environment is discussed, but the wider background emissions of chromium from other sources are not considered for risk assessment. Hence the concentrations calculated in the assessment are local ones (as Clocal), and the assessment is based on the added risk which they may present. This is an application of the added risk approach, which assumes that only the anthropogenic amount of a substance, i.e. the amount added to the natural background concentration, is considered to be relevant for the effect assessment of that substance. Thus, a possible contribution of the natural background concentration to toxic effects is ignored. In this assessment the impact of chromium (VI) added to the local environment is considered, and the possible contribution of chromium from other sources is neglected. It is recognised that the wider background contributions may need to be considered when considering the effects of risk management measures.

The behaviour of chromium species in the environment can be influenced by environmental factors, such as pH and water hardness. These factors are discussed in the relevant sections of this report, but detailed relationships between properties and environmental factors are not developed. In order to take some account of the potential variation in properties across the EU, two environmental conditions are considered in the calculation of the PECs. One is intended to represent acidic environments (pH below 6) and the other to represent neutral-alkaline environments (pH greater than 6). These should not be seen as detailed alternative environments, but may be used to illustrate differences in behaviour in different areas.

Environmental releases

Releases to the environment from production sites have been estimated based on information from actual production sites. Estimates for the uses indicated in Section 2 have been estimated using a combination of industry-specific information (where available) and default assumptions from the Technical Guidance documents. The estimated releases are summarised in **Table 3.1**.

Table 3.1 Summary of emissions (all expressed as chromium)

Process	compartment	tonnes/year	kg/day	Continental (tonnes/year)
Production	air	5.6	19	6.2
	water	0.4	1.3	0.6
Pigment production	water	1.9	6.3	5.6
Chromium (III) oxide production	water	0.94	3.1	22
Chrome tanning salt production	water	4.2	14	38
Wood preservative formulation	water	2.1	6.9	8.2
Wood preservative application	water	0.054	0.18	6.2
	soil	0.054	0.18	6.2
Metal treatment formulation	air	1.1	3.1	14
	water	0.93	3.7	12
Metal treatment use	water	0.11-1.3	0.73-4.4	2342
Mordant dyeing	water	0.004	0.014	1.1

Other areas of use lead to negligible releases, and are not considered in the risk characterisation: chromium metal production; chromium dioxide production; Montan wax production. The use of chromium (VI) in the oxidation of sulphur dyes no longer occurs in Europe

Environmental fate

Once released into the environment, all of the five chromium (VI) compounds considered in this assessment will behave similarly. They give rise to the same ions in solution: CrO_4^{2-} , HCrO_4^- and $\text{Cr}_2\text{O}_7^{2-}$. The first of these is the main species at higher pHs (>7), while the other two will be present at lower pHs (the dichromate ion only at higher concentrations of chromium, >0.4 g/l chromium).

The most important degradation/transformation reactions for chromium compounds in the environment involve their oxidation/reduction behaviour. Such redox reactions can occur by both abiotic and biotic processes. These processes are summarised below under the appropriate headings. However, since the end-products of the biotic and abiotic processes are essentially the same, it is difficult to unambiguously separate the two processes, especially in experiments using natural systems.

There is a large body of evidence indicating that chromium (VI) can be reduced to chromium (III) under anaerobic conditions found in the environment by both biotic and abiotic processes, including reaction with iron (II), sulphides, organic matter and anaerobic micro-organisms. The reduction is generally favoured by increasing concentration of the reductant and lower pH. Thus, the reduction of chromium (VI) would be expected to occur most rapidly in acidic soils with high iron, sulphide or organic carbon contents. Under such conditions, reduction of chromium (VI) to chromium (III) may be complete within a few hours.

Under aerobic conditions and at higher pHs (around 7-8 and above), chromium (VI) appears to be more stable to reduction than is seen at lower pHs under anaerobic conditions. This is particularly the case where low concentrations of reductants such as iron (II) are present. Chromium (VI) in surface water appears to be relatively stable under these conditions (this will particularly be the case in seawater where the pH is generally relatively high). The same is also likely to be the case in aerobic sediments and soils, but here chromium (VI) is considered to be relatively mobile (see Section 3.1.1.2.2 in related EURAR 21508 EN) and so

would be expected to migrate to the anaerobic layers where reduction to chromium (III) could occur. Therefore, under aerobic conditions, the rate of reduction of chromium (VI) to chromium (III) may be limited by the rate of transport of the chromium ion to suitable environments for the reduction to occur.

Oxidation of chromium (III) to chromium (VI) can occur, but the process is only likely to be significant in aerobic soils and sediments where high concentrations of manganese dioxide (the only known environmental oxidant for chromium (III)) exist. Under these conditions, a few % (e.g. 2-3%) of the chromium (III) present may oxidise to chromium (VI). Again, any chromium (VI) formed in the soil or sediment may be subsequently transported to anaerobic layers where rapid reduction back to chromium (III) could occur. The oxidation reaction is thought to be limited by the low solubility of chromium (III) under neutral to alkaline conditions, and the adsorption of anions to the active sites on the manganese dioxide under more acidic conditions.

Chromium (VI) species are expected to be relatively mobile in soils and sediments, particularly under alkaline or neutral conditions (higher acidity may lead to greater sorption). Chromium (III) appears to be much more strongly adsorbed to soils and sediments, with sorption increasing with increasing pH. The partition coefficients selected for use in the assessment reflect the effects of pH (**Table 3.2**).

Table 3.2 Sorption coefficients (as m^3/m^3).

Partition coefficient	Chromium (VI)		Chromium (III)	
	Acid conditions	Alkaline conditions	Acid conditions	Alkaline conditions
Suspended sediment-water	500	50	7,500	75,000
Sediment-water	500	50	5,500	60,000
Soil-water	75	3.2	1,200	22,500

Wastewaters containing chromium (VI) are usually treated before discharge, the most common methods involving reduction of the chromium to chromium (III) under acidic conditions and then raising the pH to precipitate the chromium as chromium (III) hydroxide. In wastewater treatment plants, chromium (VI) is estimated to be distributed equally between the sludge and the effluent (50% to each). Chromium (III) is more associated with the sludge (80%) with 20% in the effluent, mainly associated with the particulate phase. Anaerobic treatment or sludge digestion is expected to reduce chromium (VI) to chromium (III).

Uptake into organisms is complicated by the conversion of chromium (VI) to chromium (III) within the organisms, which can lead to higher levels of chromium. For fish, the bioconcentration factor for chromium (VI) is 1 l/kg; the factor for levels of chromium (III) arising from the uptake of chromium (VI) is 100 l/kg (related to the concentration of chromium (VI) in water). Uptake of chromium (III) directly from water is likely to be very low due to its limited solubility and strong sorption to sediments under most conditions. BCFs for mussels are higher: 1,820 l/kg for chromium (VI) and 560 l/kg for chromium (III). The BCF for worms taking up chromium (III) from soil is 0.11 kg/kg.

Environmental concentrations

The local concentrations of chromium resulting from the releases estimated in Section 3.1 are included in **Tables 3.3 – 3.7**. For releases through a wastewater treatment plant, two calculations have been performed, one assuming that the chromium is present as chromium (VI) and the other assuming that conversion to chromium (III) has occurred. For the latter, the

suspended sediment sorption coefficients included in Section 3.2 are large enough to have an effect on the dissolved concentrations. As the sorption coefficients vary between acid and alkaline conditions, concentrations for both conditions have been estimated. The default sizes for the WWTP and dilution from the TGD have been used. The results are in **Table 3.3**.

Table 3.3 Calculated local concentrations in water from chromium use

Process	Emission to WWTP (kg/day as Cr)	Clocal as Cr (VI) (mg/l)	Clocal as Cr (III) (mg/l)	
			acid	Alkaline
Pigment production	11	0.28	0.076	0.02
Cr ₂ O ₃ production	12	0.30	0.083	0.022
Chrome tanning salts	14	0.35	0.097	0.025
Wood preservative formulation	6.9	0.17	0.048	0.013
Wood preservative application	0.18	0.0045	0.0012	0.00033
Metal treatment formulation	3.7	0.093	0.026	0.0067
Electroplating	4.3	0.11	0.030	0.0078
Passivating	3.5	0.088	0.024	0.0064
Anodising	0.73	0.018	0.005	0.0013
Brightening	4.4	0.11	0.030	0.008
Mordant dyeing	0.014	0.00032	0.0001	0.00003

In addition to the generic or default information used above, a number of sites provided specific information on releases. The concentrations calculated for these sites are in **Table 3.4**.

Table 3.4 Concentrations in water from specific sites

Process	Concentration (µg/l)	Comments
Pigment production	0	No release of Cr (VI). Cr (III) removed by precipitation
Tannery using dichromate on site	42	as Cr (III)
Chromium metal production	0.6 as Cr (VI) 0.16 or 0.04 as Cr (III)	
Chromium dioxide production	<5 as Cr (VI)	

Sediment concentrations have been calculated using the methods in the Technical Guidance. Two values for the sediment sorption coefficients were given in Section 3.2, for acid and alkaline conditions, for both chromium (VI) and chromium (III). The results are in **Table 3.5**.

Table 3.5 Calculated local concentrations in sediment

Process	Clocal as Cr (VI) (mg/kg)		Clocal as Cr (III) (mg/kg)	
	acid	alkaline	acid	alkaline
Pigment production	120	12	495	1,304
Cr ₂ O ₃ production	130	13	540	1,423
Chrome tanning salts	152	15	630	1,660
Wood preservative formulation	75	7.5	310	818
Wood preservative application	2.0	0.2	8.1	21
Metal treatment formulation	40	4.0	166	439
Electroplating	47	4.7	193	510
Passivating	38	3.8	157	415
Anodising	7.9	0.79	33	87
Brightening	48	4.8	198	522
Mordant dyeing	0.15	0.015	0.63	1.7

Emissions to air are considered to be low. Estimates of releases for two processes were included in **Table 3.1**, and the air concentrations calculated from these are in **Table 3.6**. Chromium in air is expected to be associated with the particulate or aerosol phases.

Table 3.6 Predicted local concentrations in air

Process	Emission rate as chromium	Concentration in episode	Annual average concentration	Comment
Production	19 kg/day	5.2 µg/m ³	4.3 µg/m ³	Based on largest release from actual sites
Metal treatment formulation	3.1 kg/day	0.86 µg/m ³	0.71 µg/m ³	

Soil concentrations have been calculated assuming the application of sludge from waste water treatment plants to land and where appropriate deposition from air. In many countries there are restrictions on the application of sludge containing metals to soils; no account of these restrictions is taken in the calculations. Chromium (VI) is readily reduced to chromium (III) by organic matter in sludge and soil, so the calculations assume that the chromium is present in soil in the form of chromium (III). The resulting soil concentrations are in **Table 3.7**.

Table 3.7 Predicted local concentrations in soil

Process	Chromium concentration (as Cr (III), mg/kg)	
	Arable soil	Grassland
Production ^a	2.0	3.6
Pigment production	182	73
Chromium oxide production	199	80
Tanning salts	232	93
Wood preservative formulation	114	46
Wood preservative application	3.0	1.2
Metal treatment formulation ^b	61	25
Electroplating	71	29
Passivating	58	23
Anodising	12	4.8
Brightening	73	29
Mordant dyeing	0.23	0.093

a from aerial deposition

b from combined aerial deposition and sludge application (air contribution <5%)

For the assessment of indirect exposure through the food chain, concentrations in fish and mussels were calculated from the water concentrations above to represent the aquatic food chain, and concentrations in earthworms estimated from those in soil for the terrestrial food chain. The methods in the Technical Guidance Document were used.

A comparison of the predicted levels with measurements from the environment is not generally meaningful, as the calculated values do not include any contribution from other sources (either natural or anthropogenic) and the measured values in most cases only present the total chromium concentrations. The calculated values are used in the risk assessment.

Chromium is the 21st most common element in the earth's crust. As a result, chromium is a natural constituent of many rocks, soils, sediments and waters, and the atmosphere (as a result of wind blown dust). The ranges of levels associated with various phases are indicated below. The levels given usually refer to the concentration of total chromium and give no indication of the form or (bio) availability of the chromium found.

The chromium content of rocks varies from an average of around 20 mg/kg for granitic rocks up to 1,800 mg/kg in ultra basic and serpentine rocks. The chromium concentration of soils varies greatly from traces up to 250 mg/kg or more. In most soils, chromium occurs at concentrations between 2 and 60 mg/kg. In soils and sediments, the highest concentrations of chromium tend to be associated with the finest grain size. Only a fraction of the total chromium present in soil is available for plants. Although chromium is not thought to be an essential element for plants, all plants appear to contain chromium at levels up to 0.19 mg/kg wet weight.

The concentrations of chromium in rivers and freshwaters are usually between 1 and 10 µg/l (although levels in lakes in Scandinavia tend to be lower than this). In oceans, the chromium concentrations are typically reported to be in the range 0.1-5 µg/l and generally <1 µg/l.

Chromium concentrations in air are generally in the range 10-50 ng/m³ in urban areas, with lower levels (annual means <10 ng/m³) found in rural areas. Most of the chromium in air is associated with the particulate phase (Bencko, 1985).

Environmental effects

The discussions on the fate and behaviour of chromium compounds in the environment concluded that the same species are produced in water from all five substances. Therefore the ecotoxicity data have been interpreted on the assumption that the observed toxicity will be due to the amount of dissolved chromium in the water, irrespective of the original chromium compound. All toxicity results are expressed in terms of mg chromium, converted as necessary from the original data.

For aquatic organisms, short-term and long-term ecotoxicological data on the effects of hexavalent chromium compounds are available for a wide variety of organisms (freshwater and marine fish, invertebrates, algae, plants, amphibians), life stages (juveniles, adults, fry, larvae, tadpoles, eggs, etc.), endpoints (LC₅₀s, EC₅₀s, NOECs, LOECs based on mortality, reproduction, hatching, etc.), and test conditions. In general, the majority of ecotoxicological information is available for potassium dichromate, as it is a reference toxicant. Few results are available for chromic acid and ammonium dichromate.

The acute toxicity of chromium appears to be dependent on a number of factors, including pH, water hardness, salinity and temperature. Long term studies seem to show less dependence of toxicity on water properties; as no relationships between toxicity and properties could be established, all chronic toxicity data were treated together. The selected chronic toxicity values used in the assessment are in **Table 3.8**.

To make use of the large data base available for chromium (VI), a statistical extrapolation method has been used to derive the PNEC. The approach assumes that the no-effect levels for the various species come from a log-normal distribution, and calculates the 95% value for the distribution. The resulting value for the chromium data set is 10.2 µg/l. The data set covers a wide range of species and a range of chronic endpoints; the organisms which are the most sensitive in acute tests (results not shown in this summary) are crustaceans, and these are represented in the chronic data set. Against this, there are a limited number of insects and molluscs included, compared to a large number of fish species. There are also no results from field or mesocosm tests to compare with the derived values. Based on these considerations, an assessment factor of 3 is applied to give a PNEC of 3.4 µg/l.

For chromium (III) the data set is more limited. An assessment factor of 10 is used on the lowest NOEC value for aquatic organisms, giving a PNEC of 4.7 µg/l.

Table 3.8 Data used for PNEC derivation

	Species	NOEC (mg Cr/l)	Notes
Blue-green algae	<i>Microcystis aeruginosa</i>	0.35	
Algae	<i>Chlorella pyrenoidosa</i>	0.1	
	<i>Chlorella</i> sp (wild)	0.1	
	<i>Scenedesmus pannonicus</i>	0.11	
	<i>Selenastrum capricornutum</i>	0.033	Geometric mean of EC ₁₀ (g)
Macrophytes	<i>Lemna gibba</i>	0.1	
	<i>Lemna minor</i>	0.11	
	<i>Spirodela polyrhiza</i>	0.1	
	<i>Spirodela punctata</i>	0.5	
Crustaceans	<i>Ceriodaphnia dubia</i>	0.0047	Reproduction value
	<i>Daphnia carinata</i>	0.05	
	<i>Daphnia magna</i>	0.019	Geometric mean of reproduction values
Coelenterates	<i>Hydra littoralis</i>	0.035	
	<i>Hydra oligactis</i>	1.1	
Insect	<i>Culex pipiens</i>	1.1	Survival/growth NOEC
Mollusc	<i>Lymnaea stagnalis</i>	0.11	Reproduction value
Fish	<i>Catastomus commersoni</i>	0.29	Longer growth value
	<i>Esox lucius</i>	0.538	
	<i>Ictalurus punctatus</i>	0.15	30-day growth NOEC
	<i>Oncorhynchus mykiss</i>	0.07	Geometric mean of growth NOECs
	<i>Oryzias latipes</i>	3.5	Survival NOEC
	<i>Pimephales promelas</i>	0.68	Geometric mean of growth NOECs
	<i>Poecilia reticulata</i>	3.5	Growth/mortality NOEC
	<i>Salvelinus fontinalis</i>	0.01	Growth NOEC
	<i>Salvelinus namaycush</i>	0.105	Growth NOEC
Amphibian	<i>Xenopus laevis</i>	0.35	Mortality NOEC

The PNECs for sediment are derived using the equilibrium partitioning approach. It is recognised that this approach is very tentative for metals, even though the relevant partition coefficients are based on measurements. It is likely that there will be conversion of chromium (VI) to chromium (III) in sediment, and the chromium (III) formed is likely to be of much lower solubility than chromium (VI). Different results are obtained for acidic and alkaline environments, as the partitioning behaviour varies with pH. The resulting PNECs for chromium (VI) are 1.5 mg/kg in acidic conditions, 0.15 mg/kg in alkaline; for chromium (III) they are 31 mg/kg for acid conditions and 307 mg/kg for alkaline. All values are on a wet weight basis.

The PNEC for micro-organisms in waste water treatment plants is 0.21 mg/l.

For the terrestrial compartment the PNEC is derived for chromium (III) as the concentrations in soil have been calculated on this basis. The value is 2.8 mg/kg wet weight. It should be

noted that there are many natural soils where the levels of total chromium are above this value; this PNEC is for added chromium and should not be used to compare with natural levels.

A PNEC for secondary poisoning of 17 mg Cr(VI)/kg food has been derived from mammalian toxicity data.

3.2 RISK CHARACTERISATION

The results of the risk characterisation are in **Table 3.9**, presented as conclusions rather than as risk characterisation ratios. As the risk characterisation for sediment is based on the equilibrium partitioning method the ratios and conclusions are the same as those for water, and are not repeated in the table. In addition to those included in the table, risks are identified for water and for sediment for chromium leaching from preservative-treated wood in direct contact with water.

It should be emphasised that the risk characterisation is based only on the effects of the releases of chromium on the local environments.

For the aquatic environment, the risk characterisation concludes that risk management measures are needed for water for all scenarios, with the exception of two production sites and use in mordant dyeing. Risk reduction measures may already be in use at individual locations, but there is not sufficient general information on the extent of their use to be able to take them into account in the assessment. For sediment, the risk characterisation ratios are the same as for water. The PNEC for sediment is based on that for water, and so could be improved through testing on sediment-dwelling organisms. However, measures to reduce the risk to organisms in water will also have an impact on levels in sediment. Therefore at present no further testing is proposed.

Risks are identified to waste water treatment plants for most uses of chromium (VI) compounds. For the terrestrial compartment, risk is identified for all scenarios except for production and mordant dyeing.

The assessment of secondary poisoning based on accumulation in fish shows no risks. That based on uptake in mussels does show some ratios above one. It is concluded that there is a need for further information or testing, as the current assessment uses uptake values from saltwater organisms to estimate levels from concentrations in freshwater. However, measures to reduce the risk to the aquatic compartment will also reduce the risk from secondary poisoning through the aquatic food chain, so at present it is not proposed to carry out any further work.

Table 3.9 Risk characterisation conclusions for chromium (VI) compounds

Process	Water		Wastewater treatment		Terrestrial		Secondary poisoning		
	Chromium (VI)	Chromium (III)		Chromium (VI)	Chromium (III)	Arable soil	Grassland	Fish-based food chain	Mussel-based food chain
		Acid	Alkaline						
Production ^a	ii	iii	iii				ii	ii	ii
Pigment production	iii	iii	iii	iii	ii	i	i	ii	i
Chromium oxide production	iii	iii	iii	iii	ii	i	i	ii	i
Tanning salts	iii	iii	iii	iii	ii	i	i	ii	i
Wood preservative formulation	iii	iii	iii	iii	ii	i	i	ii	i
Wood preservative application	iii	iii	ii	ii	ii	i	ii	ii	ii
Metal treatment formulation ^b	iii	iii	iii	iii	ii	i	i	ii	i
Electroplating	iii	iii	iii	iii	ii	i	i	ii	i
Passivating	iii	iii	iii	iii	ii	i	i	ii	i
Anodising	iii	iii	ii	ii	ii	i	i	ii	i
Brightening	iii	iii	iii	iii	ii	i	i	ii	i
Mordant dyeing	ii	ii	ii	ii	ii	ii	ii	ii	ii

a from aerial deposition

b from combined aerial deposition and sludge application (air contribution <5%)

4 HUMAN HEALTH

4.1 HUMAN HEALTH (TOXICITY)

4.1.1 Exposure assessment

Occupational exposure

The figures for exposure are summarised in **Table 4.1**. Inhalation exposures are based on the 90th percentile of available measured data with professional judgement used where limited data were available. Dermal exposures were calculated using EASE unless otherwise stated.

Table 4.1 Estimates of inhalation and dermal exposure

Industry	Inhalation (mg/m ³)	Dermal (mg/cm ² /day)	Comment
Chromate manufacture	0.02	0.0 – 0.1	Value is for production of all five chromates.
Dyestuff production	0.5 1.5 (short term)	0.1 – 1.0	
Tanning salts production	0.007	0.0 – 0.1	
CCA production	0.01	0.0 – 0.1	Professional judgement.
Cr metal production	0.01	Very low	
Metal treatment products formulation	0.02	0.1 – 1.0	Dermal range is for the higher process activity.
CCA use	0.006	16.5	Daily dermal exposure based on measured data (90 th percentile) is 16.5 mg.
Metal treatment -electrolytic -passivation	0.02 0.001	1.0 – 5.0	Range given for dermal exposure is for dragout. Ranges for other processes are lower.
Manufacture of magnetic tapes	0.005	0.1 – 1.0	
Manufacture of montan wax	0.004	0.1 – 1.0	Inhalation exposure calculated using EASE
Manufacture of vitamin K	0.0025	0.0 – 0.1	Inhalation exposure calculated using EASE
Use as a mordant in wool dyeing	0.5	0.0 – 0.1	
Catalyst manufacture	0.005	0.1 – 1.0	Dermal exposure value is for direct handling during sampling.

The manufacturing process for the five chromates is largely enclosed with breaching for bagging of product and some maintenance activities. PPE is worn during all manufacturing stages.

In relation to dyestuff production, there are two types of chromium pigments: those that remain as chromium (VI) and those that are reduced to chromium (III). For both types, inhalation exposures usually occur during weighing and mixing of ingredients. Dermal exposures most often occur during weighing and charging of reactants to vessels.

Chrome tanning salts are made in an enclosed process using liquid chromates. Exposures are low as there is little potential for exposure except when liquid chromate is discharged from a road tanker into a storage vessel.

Copper chrome arsenate (CCA) compounds are wood preservation products manufactured using chromium trioxide flake. Exposure can occur during weighing and mixing of reactants and during packing of the finished product. Remote working and automatic filling lines reduces exposures. Inhalation exposures during use of CCA for the preservation of wood are likely to be highest when the treatment vessel doors are opened at the end of the cycle and the treated wood is pulled out and removed to the drip area. Dermal exposure can occur at a number of stages in the wood treatment process, particularly when the bogie containing the treated wood is unloaded, during maintenance of the treatment vessel and from contact with contaminated surfaces.

Potassium dichromate is used as an oxidising agent in the manufacture of chromium metal. Exposure to chromium (VI) is only likely at the start of the process, particularly during weighing.

Production of dry and liquid metal treatment formulations can give rise to exposures during weighing and mixing of ingredients and during packing of the final product. Occupational exposure to chromium (VI) during use of these formulations for metal treatment can occur during either electrolytic or passive processes. When electric current is used airborne chromium (VI) in the form of mist is generated leading to higher exposures. Exposure will also occur in both types of process when chromate solutions are made up and added to the treatment bath. Dermal exposures are likely to be similar for both electrolytic and passive processes. They can occur during making up of treatment solutions, adding the solution to the treatment bath, from drag out and splashing and when re-threading treated steel strips.

The operations likely to lead to exposure in the production of magnetic tapes are charging of reagents and packing. Dermal exposure is only likely to occur during sampling of a closed system.

Exposures during manufacture of both montan wax and vitamin K are likely to be very low as they are mostly enclosed processes. In the production of montan wax, dermal exposure is only likely to occur during sampling of a closed system. Dermal exposure in vitamin K production would be to liquid sodium dichromate and is only likely to occur during road tanker unloading.

Sodium dichromate used as a mordant in wool dyeing, gives rise to exposures during weighing and mixing with water. Once in solution inhalation exposure is negligible. Dermal exposure can occur during weighing, making up of solutions and during addition of the solution to the dyeing vat.

In catalyst manufacture, both inhalation and dermal exposure can occur when sodium dichromate solution is unloaded into storage tanks and during sampling of the reaction process.

Consumer exposure

Chromium (VI) compounds are not known to be included in greater than residual concentrations in products available directly to the consumer. They are present at residual concentrations in copper chrome arsenate (CCA) treated wood, which can be handled by consumers. The residual concentration may vary depending on a number of factors. There is no other consumer exposure.

Estimates of exposure have been made for handling CCA treated wood and for children playing on treated wooden equipment. A body burden of 1.63 µg/kg has been calculated based on the inhalation and dermal exposure values for a typical consumer handling and sawing dry CCA treated timber. For a child playing on CCA treated timber, a body burden of 0.1 µg/kg has been estimated for oral ingestion and dermal exposure.

It is assumed that a consumer will not come into contact with timber that is still wet after CCA treatment. This is a condition of the approval of the preservative under the UK Control of Pesticides regulations, 1986 and in other EU member state legislation.

Humans exposed via the environment

Chromium (VI) released into the environment from any source is expected to be reduced to chromium (III) in most situations in the environment so the impact of chromium (VI) as such is likely to be limited to the area around the source. Therefore the assessment focuses on the local impact of emissions from the production and use of the five chromium (VI) compounds.

Only those compartments where Cr(VI) concentrations were estimated have been included. These are water and fish, and for two process steps air (**Table 4.2**). It is likely that these will over-estimate the actual indirect exposure to Cr (VI) via the environment, as it has been stated that conversion of Cr(VI) to Cr(III) is expected to occur under the vast majority of environmental conditions.

Table 4.2 Uptake of chromium (VI) from environmental media

Process	Water	Air	Fish	Total	
	(mg/day)	(mg/day)	(mg/day)	(mg/day)	(µg/kg bw/day)
Production	0.004	0.086	0.0002	0.090	1.3
Pigment production	0.19		0.032	0.22	3.1
Cr ₂ O ₃ production	0.60		0.035	0.64	9.1
Chrome tanning salts	0.70		0.04	0.74	11
Wood preservative formulation	0.34		0.02	0.36	5.1
Wood preservative use	0.009		0.005	0.01	0.14
Metal treatment formulation	0.19	0.014	0.011	0.20	2.9
Electroplating	0.22		0.013	0.23	3.3
Passivating	0.18		0.01	0.19	2.7
Anodising	0.036		0.002	0.04	0.57
Brightening	0.22		0.013	0.23	3.3
Mordant dyeing	0.0006		0.00003	0.000063	0.009

Combined exposure

For a combined exposure, consideration is given to a consumer who is also exposed indirectly via the environment. The worst-case scenario would be that of someone living in the vicinity of a plant producing chrome-tanning salts (0.011 mg/kg), and who installs a fence using CCA treated wood (1.63 µg/kg). This would lead to a total exposure of 0.013 mg/kg.

4.1.2 Exposure assessment: hazard identification and dose (concentration) – response (effect) assessment

Following inhalation exposure, animal studies have shown that 20-30% of the administered Cr(VI) is absorbed via the respiratory tract. Highly water-soluble Cr(VI) is poorly absorbed via the gastrointestinal tract (only 2-9% of the dose was absorbed in human studies) due to reduction to the relatively poorly absorbed Cr(III). Only limited dermal absorption takes place through intact skin, with 1-4% Cr(VI) from an aqueous solution crossing the skin in guinea pig studies.

According to results of animal testing, chromium derived from these compounds can remain in the lungs for several weeks after inhalation exposure and also becomes bound to haemoglobin in erythrocytes for the lifespan of the cells. Cr(VI) becomes reduced to Cr(III) after entering the body due to the influence of reducing agents, for example glutathione. Distribution is widespread even after a single dose and includes transfer of absorbed Cr(VI) across the placenta. Excretion occurs in urine and faeces. Repeated exposure leads to accumulation of chromium in several tissues, particularly the spleen because of uptake of senescent erythrocytes.

Highly water-soluble Cr(VI) compounds are very toxic by inhalation and toxic by ingestion. Following inhalation and oral exposure, these compounds damage the respiratory tract and the kidney respectively. Although acutely harmful or toxic by the dermal route, more severe responses may be observed due to greater uptake via the skin if there is any prior or simultaneous damage to the skin

The five chromium (VI) compounds under review are considered to be corrosive. Severe and persistent eye and skin effects, including ulcers, have been observed in humans following single or repeated exposures. Data in humans and standard animal tests clearly show that Cr(VI) compounds are skin sensitizers. The available case reports and evidence from well-conducted bronchial challenge tests indicate that inhalation of Cr(VI) compounds can cause occupational asthma. As with skin, Cr(VI) sensitized subjects may react to Cr(III). It is not possible to determine a no-effect level or exposure-response relationship for induction or elicitation of occupational asthma.

With respect to repeated exposure, a large number of studies are available relating to exposure of workers to highly water-soluble Cr(VI), specifically sodium or potassium chromate/dichromate and chromium (VI) trioxide. The main effects reported are irritant and corrosive responses in relation to inhalation and dermal exposure. These include inflammation in the lower respiratory tract, and nasal septum perforation in the upper respiratory tract. It is not possible to relate these effects to reliable measures of Cr(VI) exposure. Although in principle a threshold dose should be identifiable, in practice the location of such a threshold is not possible from the data available. Some evidence of kidney damage has also been found among chromate production and chromium plating workers. No exposure-response data or no-effect levels are available. However, it appears that the exposure levels at which kidney toxicity occurs overlap with the airborne concentrations at which respiratory tract effects have been reported. Only limited animal repeated dose toxicity testing is available, and, in general, the effects seen are consistent with those found in humans.

Few studies of genotoxic potential in humans are available. No evidence of genotoxic activity has been found in adequately-conducted studies in circulating lymphocytes from chromium-exposed workers. In contrast, there is a vast array of genotoxicity data *in vitro* and less extensive testing in animals which clearly indicate that highly water-soluble Cr(VI) compounds can produce significant mutagenic activity *in vitro* and *in vivo*. The Cr(VI)

compounds under consideration are therefore regarded as *in vivo* somatic cell mutagens. In addition, toxicokinetic and dominant lethal data suggest that water-soluble Cr(VI) has the potential to be an *in vivo* germ cell mutagen.

Chromium (VI) trioxide is regarded as a human carcinogen. Evidence from epidemiological studies has shown an excess in lung cancer in workers exposed to chromium (VI) trioxide. However, this excess in lung cancer cannot be related to particular airborne Cr(VI) levels in any reliable manner. The evidence for the other four chromium (VI) compounds is less clear, but on balance, taking into account all the human and animal evidence, together with the genotoxicity profile of these compounds, it is likely they also have carcinogenic potential, at least at the initial site of contact.

Adverse effects on fertility have been found in studies in mice following repeated oral exposure. In addition, adverse effects on the testes have been seen following repeated oral exposure in the rat. Highly water-soluble chromium (VI) compounds are considered to be developmental toxicants in the mouse. These findings can be regarded as relevant to humans.

4.1.3 Risk characterisation

4.1.3.1 Human health (toxicological properties)

Workers

The health effects of concern for the five chromium (VI) compounds in this risk characterisation for workers are: acute toxicity, skin, eye and respiratory tract irritation, skin sensitisation, occupational asthma, repeat dose toxicity to the respiratory tract and the kidney, genotoxicity, carcinogenicity and reproductive toxicity.

The main route of occupational exposure is inhalation. Although dermal exposure can occur, given the corrosive nature of Cr (VI), it is considered that measures taken to preclude substantial skin contact mean that there would be no prospect of systemic effects arising via dermal exposure. Significant oral exposure is not expected to occur in the workplace.

There is no cause for concern with respect to acute toxicity in relation to full shift exposures. However, there may be concerns associated with short-term peak exposures and such exposures should be avoided.

The five chromium (VI) compounds under review are considered to be corrosive. Severe and persistent eye and skin effects, including ulcers, have been observed in humans following single or repeated exposures. Furthermore, there is clear evidence that the chromium (VI) compounds are skin sensitisers. Given the type and severity of effects, uninhibited contact with these compounds is of concern. In addition, there are concerns for respiratory tract irritation for all industrial uses, particularly the tasks of weighing, manual tipping or transfer of solid, in maintenance work, manufacture of pigments and dyes, formulation of metal treatment products and wool dyeing.

Inhalation of chromium (VI) compounds can cause occupational asthma. Given the severe nature of this effect, and that once the hypersensitive state is induced in an individual then even low levels of exposure might induce an asthmatic response, there is cause for concern across all industrial uses.

For repeated exposure toxicity (local and systemic) it is not possible to formally calculate an MOS for the respiratory tract or kidney effects because no NOAELs can be identified. Hence it is not possible to assess risk under contemporary working conditions. To be able to do this, further exposure-response information for respiratory tract and kidney effects is required.

The consequences of mutagenicity in both somatic and germ cells can be serious and it is not possible to exclude the risk of such effects being expressed at occupational levels of exposure, and therefore there is cause for concern across all industrial uses.

Chromium (VI) trioxide is regarded as a human carcinogen. The other forms of Cr(VI) compounds are also likely to have carcinogenic potential, at least at the initial site of contact. In the workplace this is of concern particularly for inhalation exposure. From the available information and taking into account the mutagenic properties of these compounds, it is not possible to identify any dose-response relationship or thresholds for this effect. Given the serious and irreversible nature of the effect and the fact that it is not possible to exclude the risk of this being expressed at occupational levels of exposure, there is cause for concern across all industrial uses.

For fertility and developmental effects, the MOS values are insufficient to provide reassurance that adverse effects would not occur, taking into account toxicokinetic and toxicodynamic differences between species. Therefore there is a cause for concern for all industrial uses.

Consumers

Consumer exposure to Cr(VI) from the five chromates under review is considered to be relevant only in the case of copper chrome arsenate (CCA) treated wood.

CCA treatment of wood involves solutions that contain either sodium dichromate or chromium trioxide as the Cr(VI) source. The exposure to consumers handling treated wood will be infrequent, maybe no more than once a year, although it might be of several days' duration.

Consideration was given in the consumer exposure assessment to the possibility of exposure to Cr(VI) from handling wood that was still wet following CCA treatment. As indicated in the exposure assessment, such a possibility should be prevented by legislative controls (in the UK, a condition of the approval of the use of the preservative under the Control of Pesticides Regulations, 1986 is that only dry treated wood may be sold to consumers). In view of this, no exposure assessment has been derived for this scenario and thus no risk characterisation will be performed. However, although no formal risk characterisation is appropriate, it should be recognised that if consumer exposure to Cr(VI) from wet treated wood did occur, there would be concerns for human health, for all relevant endpoints.

Single exposure of children as a result of contact with CCA treated wooden playing structures and single exposure of adults handling CCA treated wood for use outdoors e.g. building fences are estimated to be extremely low and the resultant MOSs lead to low concern for acute toxicity. There are also no concerns for skin, eye and respiratory tract irritation and for skin sensitisation as exposures are low and infrequent.

In relation to repeated dose toxicity, the handling of CCA treated wood by adults is not considered of concern as it is not likely to be repeated very often and each activity is not likely to last more than a couple of days. For exposure of children playing on wooden structures, although the exposure may be repeated frequently, the estimated body burdens are very low. In addition, it is expected that as the wood is exposed to weathering, levels of Cr(VI) will continually decrease. Hence, there is also no concern for this scenario.

Given that there is no known threshold below which there is no risk from the carcinogenic or genotoxic potential of these chromate compounds there is statistically a concern for any exposure. However, modelling of consumer exposure indicates extremely low daily intakes. Therefore, the concern for human health for these endpoints is low.

For fertility and developmental effects, the resultant MOS values are considered to be sufficient, and so there are no concerns.

Humans exposed via the environment

The endpoints of relevance for risk characterisation of indirect exposure via the environment, which is mainly low level, repeated exposure via the oral route are repeated dose toxicity, reproductive toxicity, genotoxicity and carcinogenicity. Where estimates of MOSs are possible, these have been calculated for the highest environmental exposure scenario, manufacture of chrome tanning salts.

Large MOSs for repeated dose toxicity and reproductive toxicity have been obtained. Consequently concern for both endpoints is low for all scenarios.

In the case of genotoxicity and carcinogenicity, there is no known threshold below which there is no risk from exposure to these compounds. However, modelling of exposure via the environment indicates low daily intakes. Therefore, the concern for human health for these endpoints is low for all scenarios.

Combined exposure

The combination of consumer exposure with indirect exposure via the environment does not produce significantly higher total exposures and therefore concern for all endpoints is low.

4.2 HUMAN HEALTH (PHYSICO-CHEMICAL PROPERTIES)

The physico-chemical properties of the five Cr (VI) compounds under review are well known. Overall, the risks from physico-chemical properties, given the level of control in manufacture and use, are small.

5 RESULTS

5.1 ENVIRONMENT

The environmental risk characterisation considers the production of the five chromium (VI) substances and their use in the following areas: pigment production; chromium oxide production; tanning salt production; wood preservation (formulation and use); metal treatment (formulation and use in electroplating, passivating, anodising and brightening); and mordant dyeing. The leaching of chromium from preservative-treated wood in direct contact with water is also included. A number of other uses were also considered and found to have negligible releases: chromium metal production; chromium dioxide production; Montan wax production. The use of chromium (VI) in the oxidation of sulphur dyes no longer occurs in Europe.

There are other sources of chromium release to the environment, both anthropogenic and natural, but these are not considered in this assessment. The assessment is based on the added local risk from the activities included. It is recognised that the wider background contribution may need to be considered when evaluating possible risk reduction measures.

For the aquatic compartment, including sediment, all the PEC/PNEC ratios are above one with the exception of two production sites and the use in mordant dyeing. Risk reduction measures are needed for surface water. The PNEC for sediment could be refined, but no work is proposed at present as the risk reduction measures for water will also reduce the risk to sediment organisms.

Risks are identified to micro-organisms in waste water treatment plants for all scenarios except production, wood preservative application and mordant dyeing.

For the terrestrial environment, risks are identified for all scenarios except production and mordant dyeing.

For indirect exposure through the food chain, the risk characterisation based on calculated concentrations in fish shows no risk from any of the scenarios. In contrast, the risk characterisation based on calculated concentrations in mussels shows a risk to all but three scenarios – production, wood preservative application and mordant dyeing. Further work could be carried out to refine this risk characterisation, but risk reduction measures for surface water will also lead to reduced risk for this endpoint and therefore no specific work is proposed. The terrestrial food chain risk characterisation shows no risk for any scenario.

Conclusion (i) There is a need for further information and/or testing.

This conclusion applies to sediment for all areas except for mordant dyeing. The effect concentration used in the risk characterisation is derived from data for aquatic organisms, and could be refined with data for sediment dwelling organisms. Although there may be value in trying to establish the relative sensitivity of sediment and aquatic organisms, measures to reduce water concentrations as a result of the assessment will also lead to reduced sediment levels. No further testing is proposed at the present.

This conclusion also applies to indirect exposure through the food chain for the mussel based food chain, for all areas except production, wood preservative application and mordant dyeing. Further work could be done to test whether the mussel-based food chain is of concern, for example through further investigation of the uptake of chromium into organisms other than fish, characterisation of the nature of the chromium in organisms and consideration of the toxicity of chromium in other forms to organisms consuming prey containing chromium.

However it should be noted that reductions in the emissions of chromium (VI) to water will reduce the estimated levels in biota as well. At present it is not proposed to carry out any further work, but to await the development of risk reduction measures.

Conclusion (ii): There is at present no need for further information and/or testing and for risk reduction measures beyond those which are being applied already.

For the aquatic compartment this conclusion applies to the use in mordant dyeing and to production (two sites only).

For sediment this conclusion applies to use in mordant dyeing.

For waste water treatment plants, this conclusion applies to production, wood preservative application, anodising and mordant dyeing.

For the terrestrial compartment, this conclusion applies to production and to mordant dyeing.

This conclusion also applies to all areas for the air compartment and for indirect exposure through the fish-based food chain.

Conclusion (iii) There is a need for limiting the risks; risk reduction measures which are already being applied shall be taken into account.

This conclusion applies to all areas for the aquatic, and terrestrial compartments, with the exception of mordant dyeing (both compartments) and production (terrestrial only, although the conclusion only applies to one production site for the aquatic). It also applies to waste water treatment plants for all areas, with the exception of production, wood preservative application, anodising and mordant dyeing.

5.2 HUMAN HEALTH

5.2.1 Human health (toxicity)

Occupational exposure

Conclusion (i) There is a need for further information and/or testing.

Conclusion (i) is reached for repeated dose toxicity to the respiratory tract and the kidney. It is not possible to formally calculate an MOS for these effects since no NOAELs have been identified. Hence it is not possible to assess risk under contemporary working conditions. Further exposure-response information for respiratory tract and kidney effects is required.

Conclusion (ii) There is at present no need for further information and/or testing and no need for risk reduction measures beyond those which are being applied already.

Conclusion (ii) is reached for acute toxicity for full shift exposures since MOS values indicate there is no cause for concern.

Conclusion (iii) There is a need for limiting the risks; risk reduction measures which are already being applied shall be taken into account.

In view of the genotoxic and carcinogenic properties of these Cr(VI) compounds, there are concerns for all exposure scenarios. In addition, there are concerns for acute toxicity as a result of short-term peak exposures, skin and eye irritation, respiratory tract sensory irritation,

skin sensitisation, occupational asthma and reproductive toxicity (fertility and developmental toxicity). Conclusion (iii) is reached for these endpoints.

Consumer assessment

Conclusion (ii) There is at present no need for further information and/or testing and no need for risk reduction measures beyond those which are being applied already.

Conclusion (ii) is reached for all endpoints other than mutagenicity and carcinogenicity for the handling of CCA treated wood, both for adults and for children exposed via wooden playing structures.

Conclusion (iii) There is a need for limiting the risks; risk reduction measures which are already being applied shall be taken into account.

Conclusion (iii) is reached for mutagenicity and carcinogenicity because no threshold below which there would be no risk to human health can be identified for these endpoints. However, it is noted that exposure levels are very low.

No formal risk characterisation has been conducted for consumer exposure to wet CCA treated wood. In the UK, the supply of wood not fully dried following CCA treatment is prohibited as a condition of approval under the Control of Pesticides Regulations (1986). Similar controls may already exist in all other Member States. However, if specific controls were not available in each Member State, then there would be concerns for all relevant human health endpoints

Indirect exposure via the environment

Conclusions are presented for both local and regional scenarios together.

Conclusion (ii) There is at present no need for further information and/or testing and no need for risk reduction measures beyond those which are being applied already.

Conclusion (ii) is reached for all endpoints other than mutagenicity and carcinogenicity.

Conclusion (iii) There is a need for limiting the risks; risk reduction measures which are already being applied shall be taken into account.

Conclusion (iii) is reached for mutagenicity and carcinogenicity because no threshold below which there would be no risk to human health can be identified for these endpoints. However, it is noted that exposure levels are very low.

Combined exposure

The combination of consumer exposure with indirect exposure via the environment does not produce significantly higher total exposures than those calculated for the separate individual contributions and therefore conclusion (ii) or, where appropriate, conclusion (iii) also applies to combined exposure.

5.2.2 Human Health (physico-chemical properties)

Given the level of control in manufacture and use the risks from physico-chemical properties are small.

Conclusion (ii) There is at present no need for further information and/or testing and no need for risk reduction measures beyond those which are being applied already.

