

Environmental Risk Reduction Strategy and Analysis of Advantages and Drawbacks for Hexavalent Chromium

Under Framework Contract: CPEC 24

Final Report

prepared for the Department for Environment,
Food and Rural Affairs

RPA

October 2005

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by

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TABLE OF CONTENTS

	<u>Page</u>
ABBREVIATIONS	<i>iii</i>
LIST OF TABLES	<i>vii</i>
LIST OF FIGURES	<i>xi</i>
EXECUTIVE SUMMARY	<i>xiii</i>
1. INTRODUCTION	
1.1 Background to the Study	1
1.2 Objectives and Approach	2
1.3 Structure of this Report	3
2. USES AND MARKETS FOR HEXAVALENT CHROMIUM	
2.1 Production of Hexavalent Chromium Substances	5
2.2 Overview of Uses and Markets for Hexavalent Chromium Substances	8
2.3 Metal Finishing	11
2.4 Leather Tanning Salts	35
2.5 Wood Preservation Products	39
2.6 Pigments and Dyes	47
2.7 Vitamin K Manufacture	50
2.8 Chromium Metal Manufacture	50
2.9 Magnetic Tapes	51
2.10 Montan Wax	52
2.11 Catalysts	53
2.12 Other Uses	53
2.13 Country-specific Data	54
3. RESULTS OF THE ESR RISK ASSESSMENT	
3.1 Overview	61
3.2 Background to the Environmental Risk Assessment	61
3.3 Lifecycle Areas Associated with Conclusion (iii)	76
3.4 Lifecycle Stages Excluded from the Environmental RRS	76
3.5 Overview of Conclusions of Human Health Risk Assessment	84
4. EXISTING CONTROLS ON EMISSIONS AND EXPOSURE TO HEXAVALENT CHROMIUM	
4.1 EU-wide Legislation Controlling Emissions and Exposure	87
4.2 Other International Initiatives	127
4.3 National Measures	133
4.4 Voluntary Action by Industry	170
4.5 Current Control Technologies and Techniques for Risk Reduction	174
4.6 Existing Controls – Consultation Findings	184
4.7 Other Emissions Data	196
4.8 Summary of Applicability and Effectiveness of Existing Controls	197

5.	POSSIBLE FURTHER RISK REDUCTION MEASURES	
5.1	Overview	207
5.2	The Range of Possible Measures	207
5.3	Identification of Possible Measures	207
5.4	Possible Means of Implementation	212
5.5	EU Strategy for a Future Chemicals Policy (REACH)	218
6.	ALTERNATIVES TO HEXAVALENT CHROMIUM COMPOUNDS	
6.1	Overview	221
6.2	Alternatives for Hexavalent Chromium in Metal Finishing	221
7.	ASSESSMENT OF POSSIBLE FURTHER RISK REDUCTION MEASURES	
7.1	Overview	233
7.2	Cessation or Phase-Out of Use	235
7.3	Legislation to Reduce Emissions and Exposure	242
7.4	Economic Instruments	250
7.5	Provision of Information	256
7.6	Negotiated Voluntary Agreements	259
7.7	Summary of Assessment of Further Risk Reduction Options	265
8.	RECOMMENDATIONS FOR A RISK REDUCTION STRATEGY	
8.1	The RAR and the Underlying Uncertainties	269
8.2	Links between the Environmental and Human Health RRSs	271
8.3	Recommendations for a Risk Reduction Strategy	271
9.	REFERENCES	277
ANNEX 1:	PROJECT SPECIFICATION	
ANNEX 2:	LIST OF CONSULTEES	
ANNEX 3:	UK CODE OF PRACTICE FOR DESIGN AND OPERATION OF TIMBER TREATMENT INSTALLATIONS	

ABBREVIATIONS

AbfKlärV	Klärschlammverordnung
AbwV	Abwasserverordnung
AWPA	American Wood Preservers' Association
BAT	Best Available Techniques
BATNEEC	Best Available Technology not Entailing Excessive Costs
BBodSchG	Bundesbodenschutzgesetz
BCSP	Polish Bureau for Chemical Substances and Preparations
BEP	Best Environmental Practice
BfR	German Federal Institute for Risk Assessment
BIME	Brussels Institute for Management of the Environment
BPD	Biocidal Products Directive
BREF	Best Available Technique Reference
BRE	Building Research Establishment
BS	British Standard
BSTSA	British Surface Treatment Suppliers Association
CASS	Copper-accelerated Salt-spray
CC	Copper Chromium
CCA	Copper Chromium Arsenate
CCB	Copper Chromium Borate
CCF	Copper Chromium Fluoride
CCL	Copper clad laminate
CCP	Copper Chromium Phosphate
CEC	Commission of the European Communities
CEN	European Committee for Standardisation
COMMPS	Combined Monitoring-Based and Modelling-Based Priority Setting
CORP	UK Control of Pesticides Regulations
COSHH	Control of Substances Hazardous to Health
CSR	Chemical Safety Report
CSTEE	Scientific Committee on Toxicity, Ecotoxicity and the Environment
CTBA	Centre Technique du Bois et de l'Ameublement (France)
Cu-HDO	Bis-(N-cyclohexyldiazoniumdioxy)-copper
Defra	UK Department for Environment Food and Rural Affairs
DG	Directorate-general
DIBt	Deutschen Instituts für Bautechnik (German Institute for Constructional Engineering)
DIY	Do-It-Yourself

Abbreviations

DWI	Drawn wall ironed
ECCS	Electro chromium coated steel
EEC	European Economic Community
EIPPCB	European Integrated Pollution Prevention and Control Bureau
ELV	End of Life Vehicles
EN	European Norm
EPA	Environmental Protection Agency
EPER	European Pollutant Emission Register
EPR	Electron Paramagnetic Resonance
EQS	Environmental Quality Standard
ESR	Existing Substances Regulation
EU	European Union
FEI	Finnish Environment Institute
GDP	Gross Domestic Product
Helcom	Baltic Marine Environment Protection Commission (Helsinki Commission)
HSE	UK Health and Safety Executive
IBC	Intermediate Bulk Container
IC	Industry Category
ICDA	International Cadmium Development Association
ICRCL	Interdepartmental Committee for the Redevelopment of Contaminated Land
IPPC	Integrated Pollution Prevention and Control
IR	Infrared
IRG	International Research Group on Wood Protection
ISO	International Organisation for Standardisation
MAPP	Major Accident Prevention Plan
NWPC	Nordic Wood Preservation Council
OECD	Organisation for Economic Co-operation and Development
OEM	Original Equipment Manufacturer
OHSAS	Occupational Health and Safety Management System
OSPAR	Oslo-Paris Convention for the Protection of the Marine Environment of the North East Atlantic
PBB	Polybrominated biphenyls
PBDE	Polybrominated diphenylether
PEC	Predicted Environmental Concentration
PNEC	Predicted No Effect Concentration
RAR	Risk Assessment Report
RBD	River Basin District
RBMP	River Basin Management Plan
REACH	Registration, Evaluation and Authorisation of Chemicals
RIVM	Rijksinstituut voor Volksgezondheid en Milieu

RIZA	Rijksinstituut voor Integraal Zoetwaterbeheer en Afvalwaterbehandeling (Institute for Inland Water Management and Waste Water Treatment)
RoHS	Reduction of Hazardous Substances
RPA	Risk & Policy Analysts Ltd.
RRS	Risk Reduction Strategy
SEA	UK Surface Engineering Association
SME	Small to Medium Enterprise
SNFPI	Lithuanian State Non Food Products Inspectorate
TGD	Technical Guidance Document
TNsG	Technical Notes for Guidance (for the Biocidal Products Directive)
TWG	Technical Working Group
UES	Uniform Emission Standard
USGS	United States Geological Survey
UV	Ultraviolet
WEEE	Waste Electrical and Electronic Equipment
WFD	Water Framework Directive
WQO	Water Quality Objective
WWTP	Wastewater treatment plant

LIST OF TABLES

Number	Title	Page
Table 1.1	Priority Chromium Substances under Council Regulation (EEC) No. 793/93	1
Table 2.1	Production of Chromite Ore in European Countries in 2003	5
Table 2.2	Production Capacities of the Four EU Past Producers of the Five Cr(VI) Compounds plus Cr(III) Oxide (pigments) and Basic Chrome Sulphate (tanning salts) (all values in kt/y)	7
Table 2.3	EU Production of Hexavalent Chromium Substances (1997 & 2004)	7
Table 2.4	Estimated EU Use of Hexavalent Chromium Substances in Downstream Industries (2004 estimates)	9
Table 2.5	Overview of Applications for the Main Hexavalent Chromium Compounds	10
Table 2.6	Key Parameters for Decorative and Hard Chromium Plating	15
Table 2.7	Key Parameters for Chromic Acid Anodising	16
Table 2.8	Key Parameters for Chromium Passivating Solutions	20
Table 2.9	Chromium-based Pre-treatment Chemicals Uses in Coil Coating	22
Table 2.10	Number of Coil Coating Lines in EU Member States	22
Table 2.11	Number of Continuous Hot Dip Coating Lines in EU-15 (1997)	30
Table 2.12	Number of Batch (General) Galvanising Plants in the EU (and other countries) in 2004	33
Table 2.13	Types of CCA Wood Preservative Formulations	41
Table 2.14	EU Consumption of Hexavalent Chromium Compounds for the Manufacture of Wood Preservatives (2004)	45
Table 2.15	EU Production and EU Sales of Chromium Containing Wood Preservatives (2004)	45
Table 2.16	Consumption of Cr and Cr(VI) Substances in Denmark (average for 1998-2000)	54
Table 2.17	Import, Export, Production and Supply of Hexavalent Chromium Substances in Denmark (1998-2000)	55
Table 2.18	Presence of Hexavalent Chromium Substances and Preparations in the Lithuanian Market	57
Table 2.19	Imports, Exports and Uses of Hexavalent Chromium Substances in Poland (2003)	58
Table 2.20	Chromium-based Wood Preservatives Approved in the UK (February 2005)	60

List of Tables

Number	Title	Page
Table 2.21	Industrial Use of Hexavalent Cr(VI) Compounds in Scandinavian Countries in 2002	60
Table 3.1	Summary of Calculated PECs in Soil (PECs, mg/kg), Groundwater (PECg, µg/l) and Surface Water (PECw, µg/l) from Wood Treated with CCA, CC and CCP for the Nordic Protection Class A (Braunschweiler 1996 Report)	72
Table 3.2	Summary of the Local PEC/PNEC Risk Ratios in a Realistic Worst-case due to the Use of Wood Treated with a CCA, CC or CCP for the Nordic Wood Preservation Classes A or AB (Braunschweiler 1996 Report)	73
Table 3.3	Maximum Concentrations and Concentrations for Chromium in Water After 28 Days for Ditch Scenario (RIVM)	74
Table 3.4	Water and Sediment Concentrations After 1 Year for Chromium for Ditch Scenario (based on different estimates)	74
Table 3.5	Summary of Emissions from Lifecycle Areas Presented in the RAR	75
Table 3.6	Predicted Chromium Concentrations for the Aquatic Compartment (water and WWTP effluent) – Values based on RAR Assumptions	75
Table 3.7	Predicted Chromium Concentrations in Sewage Sludge and Soil – Values based on RAR Assumptions	76
Table 3.8	Lifecycle Areas of Cr(VI) Substances Associated (✓) with Conclusion (iii) in the RAR	77
Table 4.1	Current Classification for the Five Hexavalent Chromium Substances	87
Table 4.2	Limit Values for Chromium in Sludge in Member States (report for years 1998-2000)	99
Table 4.3	Concentration Limit Values for Chromium in Soil (mg/kg dry weight) and Maximum Annual Average Load of Chromium to Agricultural Land (g/ha/y)	99
Table 4.4	Average Chromium Concentrations in Sludge in EU-15 in 2000 (mg/kg dry weight)	100
Table 4.5	Sludge Disposal and Re-use in EU Member States between 1999 and 2001(kt/y dry matter)	100
Table 4.6	Chromium Concentrations in Influent and Effluent of WWTP in some EU Member States	105
Table 4.7	2001 Chromium Emissions from IPPC Installations in EU-15 plus Hungary and Norway	109
Table 4.8	Helcom and Parcom (OSPAR) Recommendations of Relevance to the Five Hexavalent Chromium Substances	127

Number	Title	Page
Table 4.9	Status of Implementation of Helcom Recommendation 16/7 (Leather Treatment)	128
Table 4.10	Total Chromium Load and Specific Load or Maximum Concentrations for Discharges from the Leather Industry in Helcom Contracting Parties	128
Table 4.11	Status of Implementation of Helcom Recommendation 16/6 (Metal Surface Treatment - 2002)	129
Table 4.12	Number of Metal Surface Treatment Plants Discharging to Surface Water and Sewers	129
Table 4.13	Installations per Country Falling under Helcom Recommendation 20E/6	130
Table 4.14	Implementation of Parcom Recommendation 93/1 as of 2002 (Iron and Steel Production)	130
Table 4.15	Implementation of Parcom Recommendation 92/4 as of 1999 (Electroplating Industry)	131
Table 4.16	Austrian Wastewater Emission Limits	133
Table 4.17	Wastewater Emission Limits for Chromium in the German Wastewater Ordinance	144
Table 4.18	Provisions of 9/2002. (III.22) Joint Decree on Emission Limit Values of Discharges and Rules of their Use	148
Table 4.19	Provisions of 28/2004. (XII.25.) Decree of Ministry of Environment on the Limit values Concerning Discharges of Water Pollutant Substances and Rules of their Use (all values expressed in mg/l)	148
Table 4.20	Provisions of 204/2001. (X.26) Government Decree on Sewage Fines	148
Table 4.21	Chromium Emissions from the Metal Surface Treatment Sector in Hungary	149
Table 4.22	Dutch Integrated Environmental Quality Objectives for Chromium in the Aquatic Environment (2000)	155
Table 4.23	Market Share of Chromium-based and Chromium-free Waterborne Formulations in Sweden in 1900's	164
Table 4.24	Production of Preservative-treated Sawn Timber in Sweden (1998-2002)	165
Table 4.25	UK Environmental Quality Standards (EQS) for Dissolved Chromium	165
Table 4.26	Number and Size of Metal Plating Companies in the UK (based on data from UK HSE)	167
Table 4.27	Retention (holding) Times (in days) for Cr(VI)-treated Wood Established in Scandinavian Countries	169

List of Tables

Number	Title	Page
Table 4.28	Best Available Techniques for Conversion Coating Pre-treatment of Coil	180
Table 4.29	Best Available Techniques for Chromating in Electrolytic Continuous Coating of Steel	181
Table 4.30	Emissions Data from a Number of Finnish Metal Surface Treatment Plants (2001)	197
Table 4.31	Overview of Emission Limit Values and Water Quality Standards in EU Member States for Chromium (all values in mg/l)	202
Table 5.1	Overview of Applicability of Possible Further Risk Reduction Measures	210
Table 5.2	Possible Further Risk Reduction Measures and Means for Implementation	212
Table 6.1	Possible Alternatives to Hexavalent Chromium in Hard and Decorative Chromium Plating	222
Table 6.2	Consultation Findings on the Performance of Alternatives to Cr(VI) in Metal Finishing	231
Table 7.1	Recommended Strategy for Reduction of Risks from Hexavalent Chromium in the EU	267

LIST OF FIGURES

Number	Title	Page
Figure 2.1	Manufacture of the Five Hexavalent Chromium Substances	6
Figure 2.2	Overview of Chromium Applications(reproduced and adapted with permission from industry)	9

EXECUTIVE SUMMARY

1. Introduction

1.1 Background

Five chromium compounds are listed among the priority substances under Council Regulation (EEC) No. 793/93 (the Existing Substances Regulation, ESR). The five substances, for which the UK is rapporteur, are:

- sodium chromate (CAS No. 7775-11-3);
- sodium dichromate (CAS No. 10588-01-8);
- chromium trioxide (CAS No. 1333-82-0);
- potassium dichromate (CAS No. 7778-50-9); and
- ammonium dichromate (CAS No. 7789-09-5).

The UK prioritised chromates for assessment primarily because of concerns for human health, not the environment.

The risk assessment report (RAR) (CEC, 2002) for the five substances indicates the need to reduce risks to the aquatic and terrestrial compartments of the environment associated with a number of lifecycle stages of the five substances.

In the light of the findings and conclusions of the environmental part of the RAR, the UK Department for Environment, Food and Rural Affairs (Defra) has appointed Risk & Policy Analysts Ltd (RPA) to carry out an environmental Risk Reduction Strategy (RRS) that will effectively reduce risks to the environment, while imposing the minimum necessary burden on society as a whole, in accordance with the ESR. This report discusses the findings of the RRS which follows the provisions of the ESR and the Technical Guidance Document (TGD) on the development of RRSs.

1.2 Approach

For the purposes of this RRS, Defra set up a Steering Group comprising representatives of UK Government Departments, the ESR rapporteur and organisations from the industry sectors of relevance to this work. The objective of the Steering Group was to provide guidance and comments on the written outputs of this project and the discussions of the Steering Group would inform the development of the RRS. The Group's first meeting was held in London on 9 May 2005, following submission of the Stage 1 Report while the second meeting was held in London on 4 July 2005, following submission of the Stage 2 Report.

RPA prepared and disseminated questionnaires requesting information primarily on the use and emissions of the five Cr(VI) substances in the industry sectors of concern. A total of 222 organisations had been contacted. This includes:

- 155 private companies;
- 39 trade associations covering the EU and/or individual EU Member States; and
- 28 research organisations (including academic institutions).

A total of 59 completed questionnaires had been received. In addition, requests for information have been sent to authorities (Government agencies and departments) in all 25 Member States. Information received from a total of 35 government agencies and departments from 20 Member States plus Norway has been included in this report.

2. Results of the ESR Risk Assessment

2.1 Conclusions of the RAR

Table S.1 summarises the lifecycle stages and the associated environmental compartments for which Conclusion (iii) has been reached in the RAR.

Lifecycle area	Aquatic environment	Terrestrial environment	Wastewater treatment
Production	✓ (only for one site)	✗	✗
Pigment production	✓	✓	✓
Chromium (III) oxide production	✓	✓	✓
Tanning salts	✓	✓	✓
Wood preservative formulation	✓	✓	✓
Wood preservative application	✓	✓	✗
Treated wood in use	✓	✓	✗
Metal treatment formulation	✓	✓	✓
Metal treatment application	✓	✓	✓
- Electroplating	✓	✓	✓
- Passivating	✓	✓	✓
- Anodising	✓	✓	✗
- Brightening	✓	✓	✓

Source: CEC, 2002

2.2 Underlying Uncertainties

2.2.1 General Issues

The assessment of risks in the RAR applies to industrial activities involving the five Cr(VI) substances only. There has been no attempt to address risks from the use of

Cr(III) compounds or chromium metal. It is possible that, in some cases, the release of a chromate compound could raise the overall levels of Cr(III) in the local environment (from all sources) to such an extent that a risk would be identified, even though no risk might occur from either the Cr(III) compound releases alone or the Cr(VI) by the 'added risk' method. Ideally this should be dealt with by a thorough risk assessment for Cr(III), taking into account the input from chromates. This is in progress as a voluntary industry initiative and any relevant additional controls required on Cr(VI) would presumably be considered under that work.

2.2.2 Releases to the Aquatic Environment

1. Information from specific sites indicated that methods are generally used to remove chromium before discharge. Whilst the implication was that such measures were already in use in many locations, it was not possible for general conclusions to be drawn on the efficiency of such processes or the actual extent to which they are in use.
2. Process emissions to wastewater were, therefore, handled under two scenarios, i.e. assuming (a) no treatment (i.e. all releases to WWTP are in terms of Cr(VI)), and (b) reductive treatment (i.e. all releases to WWTP are in terms of Cr(III)). No assumptions were made about removal of the Cr(III) (e.g. by flocculation) before it is released to the WWTP. The fate of the two ions in the WWTP was taken into account.
3. Local receiving water concentrations were not adjusted for transformation or degradation processes according to the TGD on Risk Assessment; only dilution and adsorption were taken into account. This was handled in the assessment by expressing the water concentrations either as Cr(VI) or as Cr(III), with the assumption that all of the chromium in the dissolved phase is available.
4. The resulting PEC calculations, therefore, allowed the consideration of the two ends of the risk spectrum. In most real situations, the ion composition will be between these extremes, with Cr(VI) in discharges being converted into Cr(III) over time and at a rate depending on the local environmental conditions. Hence, the real picture is potentially very complex, and the information available was not sufficient to allow this to be described accurately in the RAR. The calculations were, therefore, simplified out of necessity. The rapporteur acknowledges that this approach may have resulted in the over-estimation of risk under some circumstances.
5. Under the conditions of the aquatic tests it is expected that the chromium will remain predominantly in the form in which it is added. The limited data available on conditions that influence bioavailability did not support the development of quantitative relationships between toxicity and environmental properties. As tests are usually carried out under conditions of high availability, it was recognised that there may be an over-estimate of the toxicity under other conditions. The PEC values did take some account of the environmental properties, so to some degree the issue of availability was incorporated into the PEC part of the calculations.

However, it was not possible to fully take bioavailability into account in this assessment.

2.2.3 Releases to the Terrestrial Environment

1. Similar to the case for water, information provided by specific users indicated that chromate process-related WWTP sludges were generally disposed of to landfill, although there was no overview for the whole of Europe. Any clean-up measures used before release to sewer would also reduce the amount of chromium available to absorb to sludge and so be applied to land. The rapporteur, therefore, acknowledges that the PECs are potentially unrealistic, and at the very least, are likely to be of limited applicability.
2. The $PNEC_{soil}$ for Cr(III) was derived from experiments where a highly soluble (and hence bioavailable) form of Cr(III) has been tested. In the environment, Cr(VI) is likely to be reduced to forms of Cr(III) of limited solubility and bioavailability, where it is unlikely that the concentration of “dissolved” and, hence, available Cr(III) will reach the levels where effects might be expected. This is seen in experiments with both soil and aquatic organisms when a form of Cr(III) with low water solubility has been tested.
3. Related to this last point, the available fraction of chromium in soil (available to plants and fauna) is generally low, at 0.1-1%. This could indicate that as the soils age the chromium is converted into insoluble forms which then are not available to have an effect on organisms. If a factor of 1% were applied to the risk characterisation ratios, then all but the direct release to soil from wood preservative treatment on acid soil would give a ratio less than 1. Thus the risk characterisation ratios may overestimate the effects of the chromium.
4. Finally, it was clear that there are many natural soils where the levels of total chromium are above the PNEC. However, in natural soils, the majority of chromium will be present as low solubility Cr(III) complexes, where bioavailability is again limited. The PNEC is not appropriate for such situations.

2.3 Lifecycle Areas Excluded from the Environmental RRS

2.3.1 Production of Hexavalent Chromium Compounds

At the time of writing the RAR, there were three producers of Cr(VI) substances. The conclusion of the assessment of their emissions was that one of the sites was associated with unacceptable risks to the aquatic environment.

Consultation for this RRS has revealed that only one producer of Cr(VI) substances is currently active. This plant is not the one that was identified in the RAR with unacceptable risks to the aquatic environment. The emissions from this plant to both (surface) water and air are considerably lower than the emissions for the years 1996 and 1997 that had been provided to the rapporteur for the purposes of the RAR.

Therefore, it is safe to assume that the site does not require further risk reduction measures.

It is theoretically possible that other companies may start producing Cr(VI) in the EU. Any such company will be regulated under IPPC and it can be assumed that emissions of Cr(VI) to the environment will be taken into consideration when issuing permits for any such installation.

2.3.2 Use of Wood Preservatives and Use of Treated Wood

The Biocidal Products Directive is considered to be the most suitable and appropriate framework for addressing any risks from the use of Cr(VI)-based wood preservatives and from the use of wood treated with Cr(VI)-based wood preservatives. The reasons for this were as follows:

- the scenario used in the ESR RAR for the use of treated wood was a limited one only and was simply used as a basis for identifying areas of concern;
- ‘new risk assessment methods’ developed for use under the framework of the Biocidal Products Directive were not used in the development of the ESR RAR;
- the scope of the methods used under ESR RRSs in addressing issues of alternatives is limited compared to what is required for the assessment of alternatives to a biocidal product; also, the timeframe of the RRS analysis is very limited for such a task;
- the ESR RAR has focused on CCA formulations, however, since the introduction of Directive 2003/2/EC on arsenic, the market for CCA has diminished and, in fact, CCA will not be on the market after 1 September 2006; and
- Cr(VI) substances are considered to be ‘substances of concern’ (since they are classified as carcinogens), hence, any they will be assessed for risks to human health and the environment as part of the authorisation process under the Biocidal Products Directive.

This choice is in accord with the principle that a risk that is specifically related to a biocidal use of a chemical is to be dealt with under the Biocidal Products Directive. As a result, this RRS does not address any risks from the use of Cr(VI)-based wood preservatives but refers the issue to the Biocidal Products Directive experts. It is of note that a number of formulators of wood preservatives expressed serious concerns on the capability of the Biocidal Products Directive to ensure a level playing field for all competitors at the national level.

2.3.3 Uses for which Existing Controls are Sufficient

For the following applications, detailed information received with regard to current practices, environmental emissions and existing controls demonstrates that the risks in the RAR have been significantly overestimated and no further risk reduction measures are required: (a) manufacture of wood preservatives; and (b) Electrolytic Chromium

Coating of Steel (ECCS) and tinplate passivation. The recommended risk reduction measures do not apply to these applications.

3. Existing Controls on Emissions and Exposure to Hexavalent Chromium

3.1 Community-wide Measures

There is a variety of Community-wider legislation that contributes either directly or indirectly to the control of risks from chromium to the environment. This includes:

- Council Directive 67/548/EEC on the Classification, Packaging and Labelling of Dangerous Substances;
- Council Directive 76/464/EEC (Dangerous Substances Directive) on Pollution of the Aquatic Environment;
- Council Directive 86/278/EEC on the Protection of the Environment, and in Particular of the Soil, when Sewage Sludge is used in Agriculture;
- Council Directive 89/677/EEC on Restrictions on the Marketing and Use of Certain Dangerous Substances and Preparations (arsenic in wood preservatives);
- Council Directive 91/271/EEC on Urban Wastewater Treatment;
- Council Directive 96/61/EC on Integrated Pollution Prevention and Control;
- Directive 98/8/EC of the European Parliament and of the Council concerning the Placing of Biocidal Products on the Market;
- Directive 2000/53/EC of the European Parliament and of the Council on End-of-life Vehicles;
- Directive 2000/60/EC of the European Parliament and of the Council establishing a Framework for the Community Action in the Field of Water Policy (the Water Framework Directive);
- Directive 2002/95/EC of the European Parliament and of the Council on the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment;
- Directive 2002/96/EC of the European Parliament and of the Council on Waste Electrical and Electronic Equipment (WEEE); and
- Commission Directive 2003/2/EC relating to Restrictions on the Marketing and Use of Arsenic.

3.2 International Measures

International bodies such as the Baltic Marine Environment Protection Commission (the Helsinki Commission) and the Oslo-Paris Convention (OSPAR) have issued recommendations on the control of emissions of Cr(VI) compounds. These are:

- Helcom Recommendation 16/7 on basic principles in wastewater management in the leather industry;
- Helcom Recommendation 23/7 on restriction of discharges and emissions from metal surface treatment (superseding Recommendation 16/6);
- Helcom Recommendation 23/11 on requirements for discharging of wastewater from the chemical industry (superseding Recommendation 20E/6);
- Parcom Recommendation 92/2 concerning limitation of pollution from new primary iron and steel production installations;
- Parcom Recommendation 93/1 concerning limitation of pollution from existing primary iron and steel production installations;
- Parcom Recommendation 92/4 on the reduction of emissions from the electroplating industry

EU Member States who are parties to these bodies have taken measures in accordance with the provisions of these Recommendations, however, the status of implementation for each Recommendation is variable across contracting parties.

3.3 National Measures

Member States have in place a significant volume of national legislation on chromium (either Cr(VI) or Cr(total) or both) precipitating from:

- Community legislation (for example, Directive 76/464/EEC);
- national initiatives (for example, concentration limits for chromium in sewage sludge); and
- international initiatives (for example, Helcom and Parcom Recommendations).

Although, it cannot be argued that national measures are equally stringent across the Community, in most cases, existing measures reduce risks to the aquatic and terrestrial environment considerably, if not below unacceptable levels. Table S.2 presents an overview of the ranges in the emission limits and quality standards set in EU Member States.

Table S.2: Overview of Emission Limit Values and Water Quality Standards in EU Member States for Chromium (all values in mg/l)

	All sectors		Metal finishing		Pigments		Tanning		Water quality standard	
	Cr(VI)	Cr(tot)	Cr(VI)	Cr(tot)	Cr(VI)	Cr(tot)	Cr(VI)	Cr(tot)	Cr(VI)	Cr(tot)
Range of values	0.1 to 0.2	0.2 to 2	0.05 to 0.5	0.3 to 5	0.2 to 1	0.5 to 5	0.05 to 0.5	0.1 to 3	0.01	3x10 ⁻⁴ to 1
Number of MS/regions reporting	12	10	11	10	3	2	5	6	1	11

Source: Consultation

Note: these figures include limits for releases to both surface water and sewer; the quality standards include standards for all water types. In some Member States, local authorities may impose even stricter limits in licences issued for industrial installations.

For only two Member State specific data on controls on emissions to the aquatic environment are not available at the moment. In general, it appears that the maximum emission limit for Cr(VI) to the aquatic environment is 1 mg/l; limits applicable to releases to surface waters are generally to be found at the lower end of the ranges quoted above. For total chromium, the maximum emission limit is 5 mg/l.

In general, the aforementioned existing measures and controls provide assurance that risks to the aquatic and terrestrial environment are currently significantly lower than those described in the RAR. It could be argued (and this has been the position of industry) that these measures provide sufficient protection to eliminate the unacceptable risks. Nevertheless, there is still a theoretical possibility that unacceptable risks still exist. This possibility should be considered in the context of the existing gaps in information on the use and emissions of Cr(VI) substances as well as the existing uncertainties in the RAR.

3.4 Information on Emissions from Industrial Installations

Information on actual emissions has been collected through consultation and has been identified in literature. The overall conclusion is that emissions (as reported by companies) are significantly lower than the predicted releases in the RAR; in fact, the differences may be of several orders of magnitude. In summary, the following are the key points from consultation:

- it appears that removal of Cr(VI) from wastewater is largely based on a known and established method: reduction to Cr(III) and precipitation of the hydroxide;
- treatment of wastewater prior to discharge appears to be the norm in the industry sectors of concern; and
- the majority of sites release their (treated) wastewater to sewer rather than surface water. This effectively means that in many cases limits on releases of Cr(VI) will be in place by the water companies/sewer undertakers and this wastewater is very likely to be subject to further treatment at a local municipal WWTP.

4. Assessment of Possible Further Risk Reduction Measures

4.1 Further Risk Reduction Measures Assessed

The following tools and measures for addressing the risks from releases of the five Cr(VI) substances were assessed:

- cessation or phase out of use in certain or all applications through marketing and use restrictions;
- legislation to reduce emissions and exposure;
- economic instruments, either to reduce emissions to the environment or to reduce the use of Cr(VI) substances;
- provision of information; and
- voluntary agreements to alter the processes involved in order to reduce the potential risks, to better control emissions of, or to cease the use of Cr(VI) substances in certain processes.

In accordance with the TGD on the development of RRSs (CEC, 1998), the possible further risk reduction measures were assessed against four key criteria:

- effectiveness;
- practicality;
- economic impact; and
- monitorability.

4.2 Assessment of Further Risk Reduction Measures Assessed

The assessment of the possible further risk reduction measures against the four key criteria analysis concluded the following:

- marketing and use restrictions would be an inappropriate and disproportionate measure for risk reduction. The risks have been clearly overestimated in the RAR and in the majority of Member States measures are already in place which reduce unacceptable risks, if not eliminate them. Techniques and technologies currently available are able to ensure adequate control of risks;
- the most suitable and cost-effective risk reduction measure appears to be legislation to reduce emissions and exposure. More specifically, the combination of the Water Framework Directive (incorporating the provisions of Directive 76/464/EEC) and the IPPC Directive is believed to allow for sufficient reduction of risks: the IPPC Directive will address risks from sites in all industry sectors of concern and will control emissions to the aquatic environment by taking into consideration local conditions in the issuing of permits. On the other hand, the Water Framework Directive will address the management of any potential risks from Cr(VI) substances at a wider level, taking into account the characteristics of

river basins of Member States. The identification of pressures in water bodies in Member States will serve as a confirmation of the importance (or lack of it) of chromium as a pollutant at the national level and river basin level. The choice and implementation of national measures for the control of risks from Cr(VI) (where such measures are concluded to be necessary) should (and is expected to) take into account the concerns on the effects of Cr(VI) documented in the RAR, issues of uncertainty that influence the prevailing risks (e.g. issues of bioavailability and speciation) as well as the discussion presented in this RRS; and

- with particular reference to the on-site reduction of Cr(VI) to Cr(III) tanning salts by EU tanneries, marketing and use restrictions would obviously be very effective in controlling any unacceptable risks, would probably have limited impact on tanneries and are supported by the main EU tanners' association. However, such restrictions may not be the most proportionate and appropriate measure. This is because:
 - the review of the data presented in the RAR and the information collected for this RRS have not provided concrete evidence of an unacceptable risk to the aquatic environment;
 - although there is a theoretical possibility that tanneries may still be using this practice (especially non-members of Cotance), the actual number of users is likely to be very small since the continuation of the use of Cr(VI) substances has a number of disadvantages from a practical and financial point of view; and
 - other legislative measures such as IPPC and the Water Framework Directive as well as the Sewage Sludge Directive (will) also apply to tanneries and their emissions and will be generally able to provide an environmental protection as sufficient as in the other industry sectors of concern.

Nevertheless, it is acknowledged that there is a theoretical possibility for EU tanneries to be using this practice today and this could be performed in a manner less environmentally sound than the two companies that have provided site-specific use and emissions data. To address this possibility, an amendment to the relevant BREF Document for the tanning of hides and skins to characterise this practice as non-BAT would be a suitable measure that could act as an additional safety net.

- with regard to the protection of the terrestrial environment, if measures protecting the aquatic environment are properly set out and implemented, any risks to the terrestrial environment should be eliminated. However, it may be necessary to have in place legislation protecting the terrestrial environment as an additional 'safety net'. Given that the envisaged outputs of the Soil Thematic Strategy will most likely not include a consideration of risks from the Sewage Sludge Directive, this Directive appears to be the sole appropriate instrument for regulating the chromium content of sewage sludge. The gaps in knowledge on the presence and effectiveness of national measures on the content of chromium

in sludge and soil and the uncertainties in the assessment of risks presented in the RAR do not allow for a conclusion to be reached on the need for revision of the Directive. Given that chromium in sludge is in the Cr(III) form, the results of the risk assessment of Cr(III) currently being undertaken under an industry initiative should be taken into account in assessing the need for revision and in developing the appropriate limits for chromium in sludge, if necessary.

Overall, the approach most appropriate for the risks identified in the RAR for each application appear to be the one described in Table S.3. The applications shaded in grey are those not included in the analysis.

Lifecycle area	Aquatic environment risks	Terrestrial environment risks	Wastewater treatment risks
Production	No need for measures	No need for measures	No need for measures
Pigment production	IPPC/WFD	Sewage Sludge Dir <i>IPPC/WFD</i>	IPPC/WFD
Chromium (III) oxide production *	IPPC/WFD	Sewage Sludge Dir <i>IPPC/WFD</i>	IPPC/WFD
Tanning salts production **	IPPC/WFD	Sewage Sludge Dir <i>IPPC/WFD</i>	IPPC/WFD
Wood preservative formulation	No need for measures	No need for measures	No need for measures
Wood preservative application	BPD	BPD	No need for measures
Treated wood in use	BPD	BPD	No need for measures
Metal treatment formulation	IPPC/WFD	Sewage Sludge Dir <i>IPPC/WFD</i>	IPPC/WFD
Metal treatment application ***	IPPC/WFD	Sewage Sludge Dir <i>IPPC/WFD</i>	IPPC/WFD
- Electroplating	IPPC/WFD	Sewage Sludge Dir <i>IPPC/WFD</i>	IPPC/WFD
- Passivating	IPPC/WFD	Sewage Sludge Dir <i>IPPC/WFD</i>	IPPC/WFD
- Anodising	IPPC/WFD	Sewage Sludge Dir <i>IPPC/WFD</i>	No need for measures
- Brightening	IPPC/WFD	Sewage Sludge Dir <i>IPPC/WFD</i>	IPPC/WFD
<i>Notes:</i>			
<i>For the terrestrial environment, IPPC/WFD is in italics to show that these measures may have an indirect impact on risks.</i>			
<i>* available information suggests that the majority of the production of Cr₂O₃ when Cr(VI) substance are used as feeding stock take place at the sites where Cr(VI) substances are manufactured</i>			
<i>** for the on-site reduction of Cr(VI) substances by tanneries, an amendment to the relevant BREF Document is recommended. Also note that the “production of chrome tanning salts” which attracted a Conclusion (iii) in the RAR does not include production as a by-product of montan wax manufacture for which no unacceptable risks were identified. Furthermore, the above recommended measures do not apply to the sole EU manufacturer of Cr(VI) substances whose total emissions include those from the manufacture of Cr(III) tanning salts</i>			
<i>*** this does not include ECCS and tinplate passivation</i>			

5. Recommendations for a Risk Reduction Strategy

In the light of the above and the discussion presented throughout this Report, this RRS addresses the potential risks from the following applications/lifecycle stages of the five Cr(VI) substances:

- manufacture of metal finishing formulations;
- use of metal finishing formulations (excluding ECCS and tinplate passivation);
- manufacture of Cr(III) tanning salts;
- manufacture of Cr(VI) pigments; and
- manufacture of Cr(III) oxide pigments.

This RRS makes the following recommendations for risk reduction measures for the five lifecycle areas of concern:

Recommendation 1: For **all five applications**, the main instrument for controlling local releases should be the IPPC Directive, as implemented through national IPPC licensing regulations at the Member State level. Taking into account the local characteristics for each installation and the available BAT, limits on the releases of Cr(VI) compounds to the aquatic environment should be set within the permits of each individual installation using and emitting these substances. These limits should take into consideration the discussion and conclusions of the RAR in the light of its uncertainties and assumptions made therein as well as the analysis presented in this RRS (with particular regard to the existing risk reduction measures).

Recommendation 2: With particular regard to the on-site reduction of Cr(VI) compounds to Cr(III) tanning salts by plants involved in the tanning of hides and skins, it is recommended that in the next amendment of the BREF Document for plants involved in the tanning of hides and skins, appropriate references are included to indicate that the on-site reduction of Cr(VI) substances for the production of Cr(III) tanning salts should not be considered as BAT.

Recommendation 3: Member States that have not yet assessed chromium for its relevance as a pollutant in their aquatic environment, in accordance with both Directive 76/464/EEC and Directive 2000/60/EC, should do so as soon as possible. Where chromium is proven to be a relevant pollutant but pollution reduction programmes for the control of chromium compounds are not in place, Member States should introduce appropriate programmes as soon as possible and communicate details of these programmes to the Commission. Moreover, following the analysis of pressures from industrial activities and the possible identification of chromium as a relevant pollutant (Article 5 of the Water Framework Directive), Member States should develop water quality standards for chromium for their notified river basins in accordance with the provisions of the Water Framework Directive (Annex V). These standards, be they new standards or revisions/amendments of any existing standards, should take into account the discussion and conclusions of the RAR in the context of the uncertainty issues highlighted both in the RAR and in this RRS.

Recommendation 4: It is recommended that the Commission considers the merit of including chromium in the revision of the list of priority substances under the Water Framework Directive (Annex X) taking into account:

- the information submitted by Member States as part of their obligations under the Water Framework Directive;
- the discussion and conclusions of the RAR;
- the uncertainties and key issues highlighted in the RAR (e.g. issues of bioavailability and speciation); and
- the information presented in this RRS on the industry sectors of concern and the existing risk reduction measures.

If chromium is included in the revision and if subsequently the Commission's conclusion is that existing or proposed national measures may not provide adequate protection to the aquatic environment, any Community-wide standards to be set for chromium should take into account:

- the different ecotoxicological profile of Cr(VI) and Cr(III);
- the results of the RAR for Cr(VI) and of the currently ongoing risk assessment for Cr(III); and
- the issues on fate, bioavailability and speciation highlighted in the RAR, the opinion of the CSTE of September 2003 on the RAR, and this RRS.

This RRS makes no recommendation in support of the inclusion or otherwise of chromium in the list of priority substances. Any such recommendation would require knowledge of the findings of Member States' report on pressures, of the measures to be taken to control discharges of chromium at the national level and, of the results of the ongoing risk assessment on Cr(III).

Recommendation 5: It is recommended that the Commission consider the need for a revision of the Sewage Sludge Directive to include limits on the contents of chromium in sewage sludge and in soils as well as a limit on the annual load. To decide upon such a need, information will be needed on:

- the existence of measures on the control of the chromium content of sludge in all EU Member States; and
- monitoring data on the concentration of chromium in sewage sludge and in soils in all EU Member States.

This information should be considered in the light of the findings of the RAR, the current uncertainties on the effects of chromium in the terrestrial environment and the results of the ongoing risk assessment of Cr(III) currently undertaken under an industry initiative (which will arguably address risks from Cr(III) to this environmental compartment more comprehensively).

If it is found that national measures are lacking, incomplete or allow for unacceptable risks to the terrestrial environment to be manifested, then Community-wide measures should be proposed. Any such measure will harmonise the controls on chromium in sludge across the Community and will act as 'safety net' for the protection of the terrestrial environment

Recommendation 6: It is recommended that any potential risks from Cr(VI) associated with:

- use of wood preservatives that contain Cr(VI) substances; and
- use of wood treated with wood preservatives that contain Cr(VI) substances,

be assessed as part of the assessment of Cr(VI) substances (as 'substances of concern') and of the associated biocidal products under the Biocidal Products Directive. This assessment is expected to be based on assessment methods and techniques currently under development for use within the Biocidal Products Directive framework and to take into account scientific research (e.g. publications) on the potential risks from wood preservatives and treated wood which are currently available and which were not taken into consideration in the preparation of the RAR. This assessment of environmental risks will be dependent on the recognition of Cr(VI) substances as non-active substances (to be decided upon by 1st September 2006). Consultation has highlighted the concerns of a number of leading EU formulators of wood preservatives with regard to the forthcoming implementation of the Directive in individual Member States and the possible variations in approaches at the national level, which may create a competitive disadvantage for some of the formulators. This RRS considers it important that Competent Authorities in Member States co-operate and exchange information (including the peer review of the assessment of substances and products) to ensure a uniform approach in the practical enforcement of the Biocidal Products Directive across the Community.

1. INTRODUCTION

1.1 Background to the Study

Five chromium compounds are listed among the priority substances under Council Regulation (EEC) No. 793/93 (the Existing Substances Regulation, ESR). These five substances, for which the UK is rapporteur, are presented in Table 1.1. It is of note that the UK prioritised chromates for assessment primarily because of concerns for human health, not the environment (Environment Agency, 2003).

Substance	Molecular Formula	CAS Number	EINECS Number	Priority List it Belongs to
Chromium trioxide	CrO ₃	1333-82-0	215-607-8	3*
Sodium chromate	Na ₂ CrO ₄	7775-11-3	231-889-5	3
Potassium dichromate	K ₂ Cr ₂ O ₇	7778-50-9	231-906-6	3
Ammonium dichromate	(NH ₄) ₂ Cr ₂ O ₇	7789-09-5	232-143-1	3
Sodium dichromate	Na ₂ Cr ₂ O ₇	10588-01-9	234-190-3	3

*Commission Regulation (EC) No. 143/97 of 27 January 1997

The risk assessment report (RAR) (CEC, 2002) for the five hexavalent chromium substances is complete (and was formally published on the European Chemicals Bureau Internet site in June 2005) and indicates the need to reduce risks to the aquatic and terrestrial compartments of the environment associated with a number of lifecycle stages of the five substances. The RAR has also concluded that there is a need for risk reduction with regard to risks to workers, consumers and humans exposed via the environment. A Risk Reduction Strategy (RRS) with respect to human health and the five hexavalent chromium substances is currently being undertaken by the UK Health and Safety Executive; if the human health RRS had been concluded prior to completion of the environmental RRS, measures taken under this RRS could have had an impact on the choice and implementation of proposed measures under the environmental RRS.

In the light of the findings and conclusions of the environmental part of the RAR, the UK Department for Environment, Food and Rural Affairs (Defra) appointed Risk & Policy Analysts Ltd (RPA) to carry out an environmental RRS that will effectively reduce risks to the environment, while imposing the minimum necessary burden on society as a whole, in accordance with the ESR. This RRS follows the provisions of the ESR according to which an analysis of the advantages and drawbacks of a substance should be undertaken should controls on the marketing and use of a substance be proposed. This includes an analysis of the availability and properties of replacement chemicals. All measures considered within a RRS should be assessed on the basis of their effectiveness, practicality, economic impact and monitorability.

An important aspect of this RRS is the evaluation and assessment of existing risk reduction measures and controls. These may have not been fully taken into account in the preparation of the RAR, however, the aim of this RRS has been to propose measures

that take into consideration the current (and foreseeable) situation with regard to existing measures that (will) impact upon the levels of risk to the environment from hexavalent chromium. It should be noted that, while it is imperative to consider existing controls when evaluating further controls, the objective of this RRS was not to alter or revise the RAR which is now final and has been formally published.

This RRS is focused on the use and releases of Cr(VI) compounds in the industry sectors of concern (see Section 3 of this Report). Possible risks from the use of Cr(III) compounds do not fall within the scope of this RRS and are not considered. Industry has recently commissioned a Risk Assessment of Cr(III) (see also Section 4.4.6).

1.2 Objectives and Approach

As indicated in the Project Specification (Annex 1 to this report), the objectives of the study are to:

- assess the advantages and drawbacks of different risk reduction options, primarily for the environment, on the use of the five hexavalent chromium substances;
- enable judgement as to whether the benefits of adopting the restrictions outweigh the consequences to society as a whole of imposing the controls; and
- determine the best RRS offering the greatest net benefits.

Guidelines for the development of a RRS are set out in a Technical Guidance Document (TGD) published by the European Commission (CEC, 1998). Based on the RRS TGD, the UK approach includes four key stages to the project:

- **Stage 1:** Data gathering and evaluation of all known uses of the five hexavalent chromium substances. Establishment of the range of potential risk reduction options and current control measures in place.
- **Stage 2:** A systematic qualitative assessment of the advantages and drawbacks for each option identified for the current uses of concern.
- **Stage 3:** Either a semi-quantified or a fully-quantified assessment, examining one or more options for the uses of concern. Whether such an assessment is required (or whether the assessment should move directly to Stage 4) is contingent upon the findings of Stage 2.
- **Stage 4:** Preparation of the final RRS, including a presentation of all available cost (and benefit) information for each option considered and any assumptions made in the assessment.

For the purposes of this RRS, Defra set up a Steering Group comprising representatives of UK Government Departments, the ESR rapporteur and organisations from the industry sectors of relevance to this work. The objective of the Steering Group was to provide

guidance and comments on the written outputs of this project and the discussions of the Steering Group would inform the development of the RRS. The Group's first meeting was held in London on 9 May 2005, following submission of the Stage 1 Report while the second meeting was held in London on 4 July 2005, following submission of the Stage 2 Report.

As in the previous outputs of this RRS, the data used in this Final Report are based mainly on the information presented in the RAR, information submitted by industry during consultation, and a review of relevant literature.

For the purposes of this project, RPA prepared and disseminated questionnaires requesting information primarily on the use and emissions of the five hexavalent chromium substances in the industry sectors of concern. As of 16 October 2005, a total of 222 organisations had been contacted. This includes:

- 155 private companies;
- 39 trade associations covering the EU and/or individual EU Member States; and
- 28 research organisations (including academic institutions).

As of 16 October 2005, a total of 59 completed questionnaires had been received. In addition, requests for information have been sent to authorities (Government agencies and departments) in all 25 Member States. Information received from a total of 35 government agencies and departments from 20 Member States plus Norway has been included in this report.

1.3 Structure of this Report

The remaining sections of this report provide a background to the RRS and the recommendations for the Strategy. More specifically:

- Section 2 provides background information on the uses of the five hexavalent chromium substances within the EU, in terms of their applications and markets (with an emphasis on the applications of concern as presented in the RAR);
- Section 3 provides an overview of the results and conclusions of the RAR on environmental risks for the five substances as well as a brief overview of the conclusions of the human health part of the RAR;
- Section 4 presents information on current controls on releases of and exposure to hexavalent chromium;
- Section 5 describes a range of potential risk reduction options and outlines how they could apply to the applications of concern for the five hexavalent chromium substances;
- Section 6 outlines the existing information on possible alternatives to hexavalent chromium substances in metal finishing;

- Section 7 presents the qualitative assessment of the further risk reduction options that appear to be most suitable for the control of the environmental risks from the five hexavalent chromium substances; and
- Section 8 presents a summary of conclusions and the recommendations for further risk reduction measures.

Annex 1 presents the Project Specification as set out by Defra, while Annex 2 includes the list of consultees that have been contacted for the purposes of this study. Annex 3 presents the measures for better control of environmental releases from timber treatment installations outlined in the UK Timber Treatment Installations 2003 Code of Practice for Safe Design and Operation (BWPDA, 2003).

2. EU USES AND MARKETS FOR HEXAVALENT CHROMIUM

2.1 Production of Hexavalent Chromium Substances

2.1.1 Mining of Chromite Ore

The production of the five substances begins with the mining of chromite ore. According to information from the international industry association for chromium (International Chromium Development Association, ICDA), approximately twenty countries in the world extract chromium ore today. Of these, South Africa accounts for almost half of all the chromium extracted (48%), Kazakhstan accounts for 18%, and India accounts for 15%. The total extraction carried out in Brazil, Finland, Turkey and Zimbabwe amounts to 12%, and a total of 12 other countries account for the remaining 6%. In total, approximately 15 million tonnes of marketable chromite ore were extracted in 2003 (ICDA, 2005a). Table 2.1 presents the available data on European production of chromite ore in 2003.

Country	Production (metric tonnes gross weight)
Albania	90,000
Finland	549,040
Former Yugoslav Republic of Macedonia	5,000
Russia	116,455
Turkey	229,294
Total	989,789

Source: USGS, 2004

The global reserves of chromium are estimated at 810 ktonnes with a total global reserve base of 1,800 ktonnes ('reserve base' being the part of an identified resource that meets specified minimum physical and chemical criteria related to current mining and production practices (USGS, 2005)).

According to the ICDA, chromium consumption worldwide is distributed as follows:

- 91% of all chromium is used in the metallurgical industry;
- 5% is used in the chemical industry; and
- 4% is used in refractory and foundry industries (ICDA, 2005b).

2.1.2 Production of Hexavalent Chromium Compounds

Sodium chromate is extracted from the ore and it serves as the starting material for the manufacture of sodium dichromate which, in turn, is transformed into the other three Cr(VI) substances. As shown in Figure 2.1, chromium trioxide may also be used instead of sodium dichromate for the manufacture of the remaining two substances, potassium dichromate and ammonium dichromate.

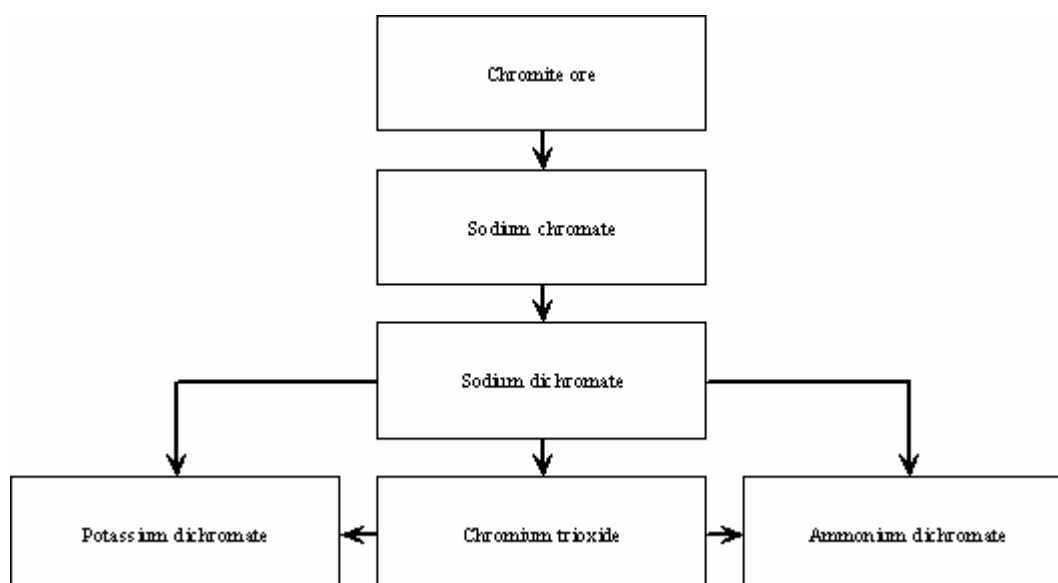


Figure 2.1: Manufacture of the Five Hexavalent Chromium Substances

Chromite ore and soda are subjected to high temperature calcination which produces sodium chromate. Acidification and evaporation of this product results in the production of sodium sulphate (a marketable product) and sodium dichromate liquor. This may then be marketed as a liquid to downstream users or is, according to the producer's Internet site:

- reacted to produce chromic acid (another name for chromium trioxide), potassium dichromate and ammonium dichromate;
- crystallised to create sodium dichromate crystals which are then sold downstream;
- subjected to calcination to produce chromic oxide (another name for chromium (III) oxide) and chrome hydrate; or
- reacted to produce chrome sulphate powder.

With regard to the volumes of chromates produced in the EU, the RAR provides information relevant to the year 1997 and the ICDA Internet site gives an overview of production capacities for the main EU producers for the years 2003-2004. These are reproduced in Table 2.2.

Company	Na ₂ CrO ₄	Na ₂ Cr ₂ O ₇	CrO ₃	K ₂ Cr ₂ O ₇	(NH ₄) ₂ Cr ₂ O ₇	Cr ₂ O ₃	Cr(OH)(SO ₄)
A		165	11			8	110
B	130	23	25	4	3	40	30
C	13	5.6	5.5	2.2		1.2	11
D		No data	No data				No data
Global capacity	910	838	184	5	5		

Source: CEC, 2002; ICDA Internet site (www.chromium-asoc.com)
 Note: The figures represent total capacities for different grades and different forms of the same chemical substance. The global capacity figures (1997) are taken from the RAR and may not correlate entirely with the ICDA capacity figures which relate to 2003 (for two companies) and 2004 (for the other two)

Up to date information on EU production of the five Cr(VI) compounds (for the year 2004) has been collected during consultation for the purposes of this RRS. This information is presented in Table 2.3 and is compared to data for the year 1997 presented in the RAR.

Year	Na ₂ CrO ₄	Na ₂ Cr ₂ O ₇	CrO ₃	(NH ₄) ₂ Cr ₂ O ₇	K ₂ Cr ₂ O ₇
	1997	103 kt	110 kt	32 kt	0.85 kt
2004	NA	↓↓	↓	↓↓	↓

Source: Personal communication with industry; CEC, 2002
 Notes:

- ↓ indicates a 2004 production volume lower than that presented in the RAR
- ↓↓ indicates a 2004 production volume significantly lower than that presented in the RAR

Sodium chromate is only used as an intermediate for production of sodium dichromate. Over 80% of sodium dichromate is converted into other chromium products including those presented in Table 2.3. Note that detailed up to date tonnages cannot be provided in this table on grounds of confidentiality.

According to the RAR, in the late 1990s, there were three producers of Cr(VI) compounds in the EU-15. Information obtained during consultation suggests that, until recently, production took place on four sites in the EU-25. During Stages 1 and 2 of this RRS, contact was established with all four potential producers. It appears that three out of four plants do not produce Cr(VI) substances any more (although such compounds may be produced at non-EU sites belonging to the relevant EU companies).

The plant which has been confirmed as still being active, apart from producing the aforementioned five substances, is also active in the production of Cr(III) substances suitable for a number of downstream uses (chromic oxide used in pigment manufacture and metallurgical applications, and basic chrome sulphate used in the tanning of leather).

Outside the EU, there have been reported a further four producers of Cr(VI) substances in the ‘wider’ European market. These are located in Turkey, Russia (two producers) and Kazakhstan.

In the EU, a reported 230 people are employed in the manufacture of the five Cr(VI) substances. The main production operations also support numerous direct and indirect contractors. The total number of employees involved in the downstream uses of these substances (as described below) is unknown but has been suggested as being significant. Information, where available, is presented later in this document for individual application areas.

The value of the European and world chromium chemicals markets, as estimated by industry, stands at around €200 million and €600 million respectively (personal communication with industry).

2.2 Overview of Uses and Markets For Hexavalent Chromium Substances

Chromium can be found in three oxidation states:

- metallic (Cr(0)) is found mainly in alloys such as stainless steel, but also in chrome-plated objects;
- trivalent (Cr(III)) occurs naturally in the environment and is the most stable, both in nature and in biological systems. It is an essential micro-nutrient in the body and combines with various enzymes in transforming sugar, protein and fat. Cr(III) is also used in a number of commercial products including dyes, pigments and salts for leather tanning; and
- hexavalent (Cr(VI)) occurs in a range of compounds that are used in industrial processes such as chrome plating.

The full range of applications for the Cr(VI) compounds is presented in Table 2.5. On the other hand, Figure 2.2 presents the changes in the oxidation state of chromium during the processing of chromite from mining to the downstream uses of Cr(VI) substances and their derivatives (the figure is adapted from information submitted by industry). The figure uses different colours for trivalent and hexavalent forms of chromium to identify and emphasise the changes in oxidation state (note the changes in wood preservatives application, metal treatment and production of chrome sulphate tanning salts; also note the difference between Cr(VI) pigments and Cr(III) oxide pigments).

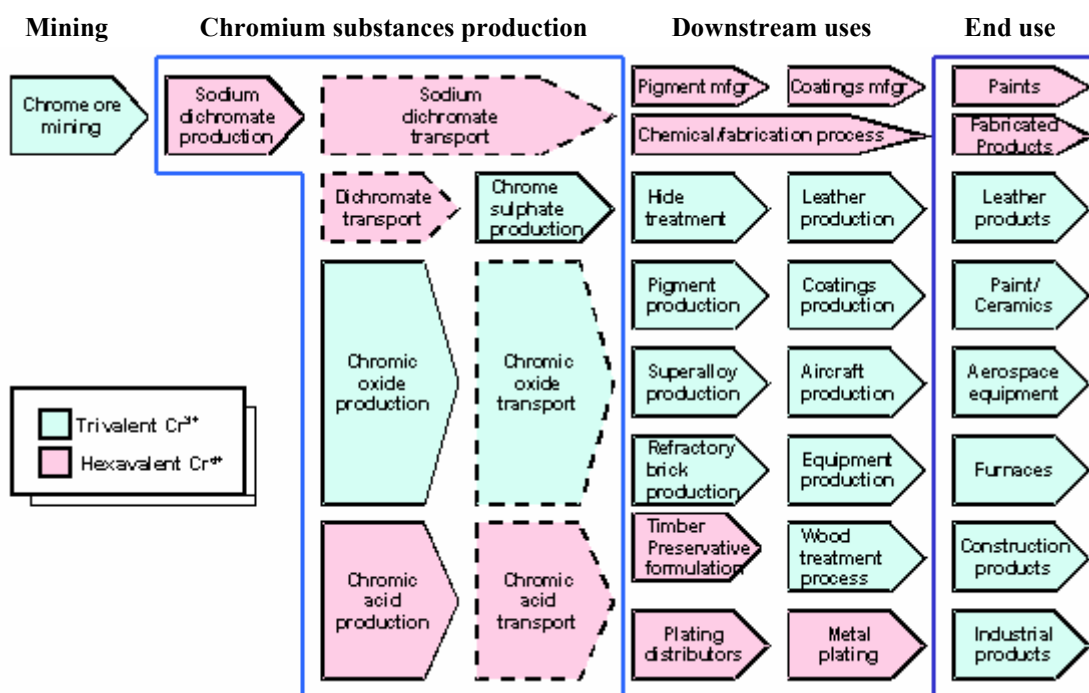


Figure 2.2: Overview of Chromium Applications
(reproduced and adapted with permission from industry)

Table 2.4 summarises the downstream industry sectors where the Cr(VI) substances find applications and the associated consumption in the form of percentages of total consumption for each substance for the year 2004.

Industry sector	Na ₂ Cr ₂ O ₇	K ₂ Cr ₂ O ₇	CrO ₃
Metal treatment formulations			75%
Wood protection formulations			15%
Tanning salts	40%		
Vitamin K production	30%		
Pigment manufacture	30%		
Chromium metal manufacture		80%	
Other		20%	10%
Tonnage used in RAR calculations	25 ktonnes (including imports/exports)		17 ktonnes
Estimated tonnage for 2004	↑		↑

Source: Personal communication with industry; CEC, 2002

Notes:

- ↑ indicates a 2004 consumption higher than that presented in the RAR
- The breakdown of the areas of use in the RAR was simplified so that it was based on only two substances (dichromates and chromium trioxide). This approach was chosen to provide a consistent set of tonnages for use in the environmental exposure assessment

No information is provided for sodium chromate in Table 2.4 (since it is used as an intermediate only) or for ammonium dichromate (the relevant tonnages are too small for reliable estimates of the breakdown of uses to be made). For each of the remaining three substances, an indication of the tonnages is provided in the form of a comparison with the figures used in the RAR. More specific information on tonnages cannot be made available here on grounds of confidentiality.

Note that ‘other’ uses for chromium trioxide and potassium dichromate indicated in Table 2.4 may not be the same for the two substances. The term is used to indicate applications not specified elsewhere (for instance, use of chromium trioxide in catalysts).

Table 2.5: Overview of Applications for the Main Hexavalent Chromium Compounds	
Substance	Applications
Sodium dichromate	Building block for virtually all other chromium compounds
	Manufacture of inorganic chromate pigments
	Metal finishing (aiding corrosion resistance)
	Oxidising agent in the production of organic products
	Preparation of coloured glass and ceramic glazes
	Mordant for acidic dyes to improve colour-fast properties
	Chrome sulphate production
Chromic acid	Production of potassium dichromate and ammonium dichromate
	Ingredient in products for industrial timber preservation
	Plating for metal and plastics
	Catalyst manufacture
	Manufacture of magnetic recording tapes
	Surface passivation for corrosion resistance
	Sealing of phosphate coatings applied to iron or steel (to improve their corrosion resistance)
	Production of chromium dioxide in production of high fidelity audio, data and video tapes
	Manufacture of other chromium chemicals
	Oxidising agent in organic syntheses and in the bleaching of oils, fats and waxes
	Analytical reagent
Potassium dichromate	Manufacture of other chromium chemicals
	Ingredient in the manufacture of engraving chemicals, pyrotechnics and safety matches
	Alternative to sodium dichromate in applications which are sensitive to moisture or where a source of potassium is required for use
	Catalyst for production of chromium metal
	Photographic engraving and lithographic chemicals
	Analytical standard
Ammonium dichromate	Precursor to the manufacture of chromium dioxide
	Magnetic media compound used in the production of data storage tapes
<i>Source: Producer Internet site</i>	

From Table 2.4 it is evident that, while for chromium trioxide and potassium dichromate there are uses that dominate their total consumption in the EU (metal treatment formulations for the former and chromium metal manufacture for the latter), the consumption of sodium dichromate is more evenly spread across its three main application areas.

It should be noted that the information provided in the Table is based on the most recent available data from industry. These data do not show a pattern of use for the substances as diverse as that described in the RAR. This is due to the fact that there are no up to date estimates for tonnages relevant to the minor applications for each of the substances (although consultation has shown that some uses not identified in the Table could be of considerable tonnage, such as the use of sodium dichromate in the metal treatment sector).

The following sub-sections provide a detailed presentation of the downstream uses of the Cr(VI) substances with an emphasis on the applications that have been identified in the RAR as being associated with Conclusion (iii) (unacceptable risks to the environment).

2.3 Metal Finishing

2.3.1 Introduction

Metal finishing encompasses a range of processes carried out by industry. These processes are varied and complex and involve chemical and physical processing, metallurgy and chemical engineering. Metal finishing may be defined as the deposition of a metallic coating onto a metallic or non-metallic substrate, or the application of an organic coating to a metallic substrate, or the treatment of a metallic substrate by the use of conversion processes, to enhance the appearance, function or performance of a product and to give added value and promote its marketability (OECD, 2004a).

The metal finishing industry can be categorised into four generic areas according to the function of the coating:

- *decorative*: decorative coatings enhance the appearance and, hence, sales value of the product;
- *decorative/protective*: decorative/protective coatings enhance the appearance of the product and protect it in the environmental conditions in which it is most likely to be used. Processes employed include: (a) electroplating; (b) anodising; (c) vitreous enamelling; (d) painting; (e) mechanical plating; (f) galvanising; and (g) vacuum deposition (physical vapour deposition and chemical vapour deposition finishes);
- *engineering*: engineering coatings are produced specifically to enhance the properties of the substrate. Technologies employed include: (a) electroless plating of copper and nickel; (b) hard chromium electroplating; and (c) vacuum

deposition (physical vapour deposition and chemical vapour deposition finishes); and

- *functional*: a functional surface coating is one which enables a product to fulfil its function more effectively. Processes employed include: (a) precious metal electroplating; (b) painting with metal bearing paints; (c) electroless plating of nickel; (d) hard anodising of aluminium; and (e) vacuum deposition (physical vapour deposition and chemical vapour deposition finishes) (OECD, 2004a).

2.3.2 Formulation of Metal Treatment Preparations

Formulations are prepared usually with mixing, however, mixing may not always be necessary (e.g. solid metal anodes are used for physical vapour deposition finishes rather than solutions). With regard to mixing, two basic mixing processes are used: dry mixes or liquid mixes. The process is essentially one of mixing components together into a product and then packaging. Chromium trioxide is the most common Cr(VI) compound used (CEC, 2002).

2.3.3 Substrate Pre-treatment

Substrates to be surface-treated must be clean from dust, swarf and moulding flash, as well as being corrosion- and grease-free to ensure uniform application and permanent adhesion of the surface treatment. There are a number of pre-treatment processes that may involve the use of Cr(VI) preparations. These, according to the relevant BREF Document (EIPPCB, 2004b), include:

- electrolytical and chemical polishing (a selective dissolution process where the high points of rough surfaces are dissolved faster than the depressions);
- electropolishing (frequently used on stainless steel, copper and its alloys and aluminium and its alloys usually for food equipment, surgical equipment, automotive and architectural applications, etc.); and
- etching or pickling of plastic (a prerequisite for good metal adhesion – usually carried out in an aqueous mixture of chromic acid (up to 380 g/l) sulphuric acid and wetting agent. It finds applications in ABS-type plastic surfaces to oxidise and dissolve the butadiene component, thus generating a micro-rough surface). The specification of this process is detailed in the standard ISO 4525:2003 (Metallic coatings – Electroplated coatings of nickel plus chromium on plastic materials). Chromium coating thicknesses are typically 0.3 to 0.5 µm and the coating is again used for its mirror-bright finish, resistance to heat and tarnish resistance, but also specifically for its ability to provide a metallic appearance to plastic components. It also protects the plastic base from possible embrittlement caused by UV-light and acts as a shield for electromagnetic radiation. Typical applications include numerous automotive applications, furniture fittings, photographic equipment and many fashion jewellery items (personal communication with industry).

2.3.4 Rinsing and Drag-out

Drag-out is the liquid from the previous process which adheres to the workpiece or substrate surfaces. Rinsing is necessary:

- between most process steps to prevent cross-contamination of process solutions; and
- to ensure there is no deterioration of the workpiece and/or substrate by residual chemicals (over-reaction or staining) (EIPPCB, 2004b).

Reduction of drag-out is a primary target for reducing losses of chemicals and releases to the environment. Rinsing is one of the largest potential sources of water-borne contamination as rinse water carries all the process chemicals from an activity and is one of the two largest water usages of water (the other being cooling) (EIPPCB, 2004b).

The paragraphs that follow describe the core activities that involve the use of Cr(VI) mixtures in the treatment of metal surfaces.

2.3.5 Chromium Plating

Background

Chromium plating has found wide use both as a decorative surface finish (bright chromium plating) and as a functional coating (hard chromium plating) because of its typical hardness and wear resistance properties (EIPPCB, 2004b).

It essentially involves the deposition of a metallic coating on a base material by an electrochemical process. The article to be electroplated is made the cathode by connecting to a negative lead and is immersed in a solution containing dissolved salts of the metal to be deposited. Many substrates can be plated: iron, nickel, steel, stainless steel, zinc castings, aluminium, some alloys, copper, brass, bronzes and plastic (including nylon).

Chromium trioxide is the usual source of Cr(VI). Cr(VI) is the preferred method for wet coating processes as it offers better performance. Instead, for powder coatings, zinc phosphate may be used instead of chromates (information submitted by industry).

Bright or Decorative Chromium Plating

The process specification is detailed in the standards ISO 1456:2003 (Metallic coatings – Electrodeposited coatings of nickel plus chromium and of copper plus nickel plus chromium) and typically gives coatings of a thickness of 0.3 to 0.5 μm in 5-8 minutes. It is of note that decorative chromium plating may be performed either with Cr(VI) mixtures or Cr(III) mixtures.

When Cr(VI) mixtures are used, usually chromic acid solutions of a concentration of 80 to 300 g/l are used in the presence of sulphate and fluoride ions. Where high corrosion protection is required, “micro-porous” chromium may be applied with techniques that result in a coating thickness of below 0.7 µm. Above this thickness the deposit becomes milky/dull and develops cracks (personal communication with industry).

Decorative chromium plating based on Cr(III), uses sulphate or chlorides alongside proprietary chemicals. A concentration of Cr(III) of up to 20 g/l only is used. The lower viscosity (compared to Cr(VI) treatments) results in better draining of coated parts and subsequently less drag-out and waste (EIPPCB, 2004b).

Typical applications for decorative plating include motorcycle components and exhaust systems, bathroom accessories, many automotive applications and many decorative housewares (information from industry).

Black Chromium Plating

Black chromium finishes can be achieved for black decorative finishes and on the same substrates as bright chromium plating. They are also plated onto a preceding nickel layer. These are based on Cr(VI) (chromic acid at 350 to 520 g/l) and catalysts (nitrates, fluorides) (EIPPCB, 2004b).

Hard Chromium Plating

With a concentration of 180 to 350 g/l and the presence of sulphate ions or sulphate/fluoride ions or proprietary fluoride-free catalysts, Cr(VI) requires long plating times and high process temperatures (50-60°C) (the presence of the catalysts is fundamental to the efficiency of the electrolyte). The specifications of this process are dictated by the standard EN ISO 6158:2004 (Metallic coatings – Electrodeposited coatings of chromium for engineering purposes). Coating thicknesses range from 2 to 500 µm and the coating is used for its superior wear, abrasion and corrosion resistance. The high process temperature may allow for sufficient evaporation to use rinse-water returned from the subsequent rinsing station (EIPPCB, 2004b).

Hard chrome markets include wear resistant surfaces in aerospace, oil and gas industries, heavy equipment and a range of general industrial applications. Hard chrome plating is also used in the restoration of dimensional tolerances, as in gas turbines where shafts require precise tolerances that may be off-target as a result of wear or manufacturing defects. Typical applications include shafts and rotors, hydraulic rams and cylinders, print rollers, motorcycle forks, gear shafts and also press and injection moulding tools (personal communication with industry).

It is of note that basic solutions are generally made up by the user, usually from the necessary salts, in crystal or powder form, which are purchased from the chemical manufacturer/supplier (OECD, 2004a). Industry suggests that basic plating solutions are only made up very occasionally in bulk; mostly they are topped up at a level of 5-10% depending on the process being operated.

Table 2.6 presents an overview of the key parameters of the methods described above. Note that the table is reproduced from the relevant OECD Emission Scenario Document and may have slight discrepancies with the information presented in the BREF Document on surface treatment of metals.

Table 2.6: Key Parameters for Decorative and Hard Chromium Plating	
Parameter	Value
<i>Decorative Chromium Plating (Hexavalent Chromium)</i>	
Chromic acid (52% chromium)	80-400 g/l
Sulphuric Acid	3.5-4.5 g/l
Temperature	40-50°C
<i>Hard Chromium Plating</i>	
Chromic acid (52% chromium)	180-350 g/l
Sulphuric acid	2.0-2.5 g/l
Temperature	50-60°C
<i>Source: OECD, 2004a; EIPCCB, 2004b</i>	

2.3.6 Chromic Acid Anodising of Aluminium

Process Description

Anodising is an electrolytic process designed to produce an oxide film integral with the surface of the metal. In theory, anodising can be applied to a number of metals such as zinc, magnesium and titanium, though its only commercial application at present is as a treatment for aluminium with alumina (Al_2O_3) formed on the surface.

The equipment and chemicals used for anodising are very similar to those used in electroplating. In the anodising process, the metal is made the anode in an electrolytic cell, while the cathodes are made of lead or aluminium. When current is applied the metal is oxidised to the metal oxide. With most metals, the formation of this oxide produces an insulating layer, and the reaction stops. With aluminium, if sufficient voltage is applied, the attack on the base metal will continue through tiny pores in the oxide film. In this way the oxide film will increase in thickness from the bottom up, forming a layer which is not really a coating, but an integral continuation of the base metal as its oxide (OECD, 2004a).

Aluminium is normally (90% of cases) anodised in sulphuric acid electrolyte. One of the special applications involves the use of chromic acid. Chromic acid anodising finds applications in the aerospace and military industry (EIPPCB, 2004b).

Table 2.7 outlines the key parameters of chromic acid anodising as described in the OECD Emission Scenario Document.

Parameter	Value
Concentration	30-100 g/l, typical 80 g/l
Sulphate	Not more than 0.5 g/l as sodium sulphate
Chloride	Not more than 0.2 g/l as sodium chloride
Total chromium as CrO ₃	100 g/l (maximum)
Cathodes	Mild steel or stainless steel
Temperature	38-42°C
Voltage	20-60 Volts (ramped)
Tank size	500-5,000 litres, typically 2,500-5,000 litres
<i>Source: OECD, 2004a</i>	

2.3.7 Brightening

This process may be part of the surface preparation (pre-treatment) before a major process such as electroplating. Chromates are used only for copper, zinc and their alloys. Brightening essentially involves dipping the substrate into a solution of chromium salts to remove scale, oxide films and tarnish. Although the RAR suggests that chromate baths are not normally made up specifically for this purpose (where a bath is already made up for plating or other use, it may also be used for brightening), industry suggests that Cr(VI) plating baths would not be used for *ad hoc* bright dipping operations. Such operations would pollute the bath and make it impossible to produce chromium deposits from them. Brightening solutions may contain chromium trioxide at a concentration of up to 350 g/l (OECD, 2004).

Brightening could have a number of different definitions depending on the company involved in it. There is bright anodising, which does not use chromates, chemical brightening, which is more correctly known as electropolishing as it also does not use chromates and, then, there is bright dipping, which is essentially a chromate passivate for (brass) articles. This process is far less common than it used to be but in the UK there is still a Ministry of Defence specification for it (personal communication with industry).

According to the UK Ministry of Defence Specification (MoD, 1998), there are three types of brass passivation:

- “Type 1”: chromic acid - sodium sulphate process;
- “Type 2”: chromic acid - sulphuric acid process; and
- “Type 3”: any other process detailed in the Process Control Schedule. This group includes processes closely related to Type 1 and 2 processes and also processes based on chromic acid and containing chloride(s) which produce visible iridescent films on the surface.

In these processes, after immersion in the chromate solution, the passivated articles may be immersed in a tank of cold water to remove excess passivating solution from the surface and then washed in two successive tanks of clean cold running water. Alternatively, articles with irregular geometry may be washed in jets of cold water.

“Type 1” has the following characteristics¹:

- chromic acid: 220 to 280 g/l;
- sodium sulphate (anhydrous): 14 to 26 g/l;
- the process solution is normally discarded when the copper content reaches 20 g/l;
- immersion time (with or without agitation): 15 to 25 seconds; and
- temperature: 15 to 25°C.

“Type 2” has the following characteristics²:

- chromic acid: 100 to 200 g/l;
- sodium sulphate: 4 to 5% (v/v);
- the process solution is normally discarded when the copper content reaches 20 g/l;
- immersion time (with or without agitation): 45 to 75 seconds; and
- temperature: 15 to 25°C.

With certain classes of work, the degree of passivation produced by the process may not meet the specification test requirement. In such circumstances, the quality of passivation may be improved to an acceptable level by immersion in chromic acid solution immediately after treatment in the process solution and washing in cold water. This process uses chromic acid at 50-100 g/l, an immersion time of 20-30 seconds and a temperature of 15 to 25°C (MoD, 1998).

The OECD Emission Scenario Document suggests that Cr(VI) may also be used in brightening of zinc and zinc alloys at a concentration of 200 to 350 g/l (OECD, 2004a).

2.3.8 Chromate Conversion Coatings

Background

Chromate conversion coatings are used to enhance corrosion protection on various metal surfaces, including electroplated zinc and cadmium, zinc die castings, tin, aluminium, magnesium and magnesium alloys, copper, brass and bronze, nickel, and silver. Often referred to as ‘chromating’ or ‘passivation’ the process is used in nearly all areas of the steel processing industry and is also used as a post-treatment in zinc

¹ This process is primarily suitable for the treatment of alpha beta brasses used for closely dimensioned machined parts, e.g. fuse components.

² This process is primarily suitable for the treatment of annealed and cold worked alpha brasses, e.g. cartridge cases, from which heat treatment scale has been removed.

plating (but not as widely as in the past as described in Section 2.3.13) (EIPPCB, 2004b).

The layer of the coating is between 0.1 and 2 µm and this is well suited as an adhesion mediator for subsequent treatment with paint layers or synthetic material coatings.

In general passivation of metal, two methods of application are used:

- *roll coating*: this is achieved by rolling the formulation onto the surface with a chemcoater. According to industry, in this scenario, there is no effluent; however this means of application is not always possible; and
- *dipping*: conventional dip tank systems are used and items for passivating are generally immersed in the passivating solution, which usually consists of an aqueous solution of chromium trioxide or sodium dichromate. There is a subsequent rinse stage which generates chrome-containing effluent.

For general passivation, no electric current is used, however, for tinplate passivation an electric current may be used (as described below).

Chromate Conversion Coatings on Electroplated Zinc Layers

Coatings are applied by chemical reaction in aqueous solutions. Numerous proprietary conversion coatings are available, producing decorative and protecting films (EIPPCB, 2004b).

Chromate Conversion Coatings on Copper, Brass and Bronze

Chromate solutions are used to treat copper and its alloys and are based on proprietary solutions. The treatment, apart from passivation, offers chemical surface polishing. Consequently, chromate treatments on copper and its alloys are used both as a final finish and as a whole or partial substitute for mechanical buffing prior to nickel or chromium plating (EIPCCB, 2004b).

Consultation suggests that there are three companies in the EU involved in the treatment of copper foils with chromates (two of them being subsidiaries of Japanese companies). All three companies use the copper foil in the production of printed circuit boards (PCBs).

In PCB production, chromate based conversion coatings with Cr(VI) are used as surface treatment in order to protect copper foils from corrosion and tarnishing under harsh conditions. These conversion coatings are obtained by electrolytic reduction on the cathodic non-ferrous surface.

Typically, PCBs have a so-called treated matt side and a shiny side. The treated matt side is pressed together with a resin impregnated glass cloth and forms a copper clad laminate (CCL). These CCLs are the base materials for the fabrication of PCBs, widely used for electronic, automotive and industrial equipments.

The protection of the treated matt side is imperative for avoiding any adverse chemical reactions between the treatment and the resin. Furthermore, the presence of such chromates helps to avoid any lateral corrosion effects that may happen during the etching process of the conductors. Their presence helps keep a high bond strength on thin conductors, as the integrity of the interface between the treated matt side and resin remains unaffected.

Moreover, the protection of the shiny side of the laminates is mandatory, as any oxidation or tarnishing will negatively affect most of the subsequent process steps, like photomechanical processes and etching of the structures for the PCBs. An additional benefit of these chromate treatments is that they have some kind of self-healing properties, meaning that the chromium coating continues to protect the copper surface even if scratched. The conversion coatings are extremely thin, typically below 15 nm. Therefore, the amount of Cr-VI present on these copper foils is as low as 0.02 to 0.03 mg/m² (personal communication with industry).

Chromate Conversion Coatings on Aluminium

Chromate conversion films can be produced on aluminium with a varying colour depending on immersion time, pH, solution concentration and the composition of the alloy to be coated. Coated alloys find applications in aerospace and the electronics industry. For the latter it is important that the treatment provides corrosion resistance without a corresponding loss of conductivity (EIPCCB, 2004b).

The so-called “green chromating coating” on aluminium is generally free from Cr(VI) unless the coating weight is high (>500 mg/m²). The coating contains aluminium, Cr(III) and phosphate ions. The treatment solution, however, does contain Cr(VI) (personal communication with industry).

Chromate Conversion Coatings on Magnesium and its Alloys

Chromating is the only method to treat magnesium and magnesium alloys. The treatment is applied to ensure good storage characteristics and to prepare magnesium and its alloys for subsequent plating, particularly for nickel autocatalytic plating (EIPCCB, 2004b).

Table 2.8 outlines the key parameters for chromium passivating solutions for a number of metal substrates.

2.3.9 Continuous Coil: Fundamentals

Chromate-based Pre-treatment

The presence of a conversion coating improves paint adhesion and humidity resistance, hence, it ensures enhanced corrosion performance of the final product. This coating usually contains chromates and other salts and provides an activated surface that enables the organic paint layer to adhere to the metallic surface of the strip. Good organic coating adhesion is a critical issue for the retorting of cans or jars (retorting is the sterilisation of food cans by a thermal process; other packaging

solutions are also retorted (e.g. plastic pouches)). With particular regard to coils used in the production of food containers, chromate passivation ensures that steel is protected from sulphuration by the can content (induced during retorting of foodstuffs containing thio-proteins) (information submitted by industry).

Table 2.8: Key Parameters for Chromium Passivating Solutions	
Parameter	Value
<i>Cadmium and Zinc</i>	
Sodium dichromate	135-180 g/l
Sulphuric acid	5-9 ml/l (2.5-4.5 g/l for short immersion times)
<i>Bright Gold Passivation of Zinc</i>	
Chromic acid	10 g/l
Chrome tan*	0.1 g/l
Nitric acid	3 ml/l
Sulphuric acid	0.7 ml/l
<i>Copper and Copper Alloys</i>	
Chromic acid	220-280 g/l
Sodium sulphate	14-26 g/l
Chromic acid	100-120 g/l
Sulphuric acid	40-50 g/l
<i>Source: OECD, 2004a</i>	
* it contains a high proportion of Cr(III), essential for efficient operation of chromates	

The coating can be applied via a chemical roller coater ('chemcoater') or by a spray/dip and squeegee roll arrangement. It is then oven-dried prior to entering the coating section. A re-circulating system is used to ensure minimal losses of raw material (ECCA, 2004).

Rinsing

Rinses, which require treatment, are taken to a treatment plant either on-site or off-site where they are treated to precipitate any dissolved metals, (normally by using controlled addition of lime or sodium hydroxide). The liquor is subsequently processed through a filter press to separate the solids from the liquids. Rinse waters may also be discharged directly to sewer or controlled waters under a discharge consent or sewage undertaking.

Wherever possible and where quality permits, cascade rinses are used within the process, along with squeegee rolls or air-knives to prevent carry over. Where the process permits, monitoring the discharge from the rinses using conductivity measurements can also reduce the amount of water used. This helps to control the amount of make-up required.

Recycling of water by use of closed loop systems such as cooling towers (open and closed systems) or heat exchangers reduces the amount of water used on the line. Quality of water has a very big impact on final product quality and, as such, this is closely monitored and can limit the recycling of water within the process. Use of treatment chemicals in water can affect product quality and restrict water recycling (ECCA, 2004).

Application Methods

There are two application methods for conversion coatings:

- *spray application of conversion coatings*: conventional pre-treatment refers to products that are applied by spray and dip processes for all substrates. Spray application is carried out in closed cabinets. In all cases the use of a further water-rinsing step is always necessary. Iron-phosphating products for cold rolled steel strip are used together with a chromate containing post-rinse. The alkaline conversion coatings, in combination with chromate-containing post rinses provide excellent paint adhesion and corrosion protection on zinc or zinc-alloy coated substrates. Both technologies have been used for many years in coil coating lines all over the world. Moreover, chromating of zinc coated strip and aluminium strip is a common process for conventional surface treatment; and
- *'no rinse' or 'dry in place' application of conversion coatings*: this process applies the pre-treatment products by rollcoater ('chemcoater') or squeegee rollers to the strip surface. Because it avoids aerosol formation, no chromate can be measured in the air. Without any rinsing, the wet film is dried in place, using IR-radiation or convection heat and painted directly afterwards. This kind of process does not limit the line speed in the pre-treatment section (no reaction time), needs no rinse stages after the pre-treatment section, and generates very little wastewater. Another advantage compared to the conventional rinse process products is their suitability for multi-metal pre-treatment. The application's efficiency and material usage approaches 100% (ECCA, 2004).

Table 2.9 outlines the parameters of the different Cr-based pre-treatment methods in the EU coil coating industry.

Booth application could also in theory be used when treating small parts prior to applying the coating (personal communication with industry).

In North America today, about 70% of lines are no-rinse. In Europe the change has been much slower and is probably more like 30%. Some major steel producers in Europe have almost exclusively conventional systems (personal communication with industry).

Table 2.9: Chromium-based Pre-treatment Chemicals Uses in Coil Coating

Product	Application method	Substrate	Main components	Consumption rate (kg/1,000 m ²)	Assumed % of substrate area	Total industry consumption of chemicals (kt/y)	Area treated (1,000 m ² , one-side)
Alkaline oxide (final rinse)	Spray	Zinc coated steel	Cr(VI), Cr(III), Zn, HF	0.94	35	335	1 mil
Chrome, no rinse	Chemcoater	Cold rolled steel, zinc coated steel	Cr(VI), Cr(III), phosphoric acid	0.52	28	148	1 mil
Chrome rinsed	Spray	Zinc coated steel	Cr(VI), Cr(III)	11	17	1,903	1 mil
Chrome no rise	Chemcoater	Aluminium	Cr(VI), Cr(III), phosphoric acid	0.52	37	55	0.3 mil
Chrome rinsed	Spray	Aluminium	Cr(VI), Cr(III), phosphoric acid, HF	2	27	155	0.3 mil

Source: ECCA, 2004
 Note that total industry consumption includes all chemicals (not only Cr(VI))

EU Coil Coating Market

There are about 160 coil coating lines in Europe. Table 2.10 presents the relevant figures for EU Member States.

Table 2.10: Number of Coil Coating Lines in EU Member States

Country	Number of lines	Steel production (kt/y)	Aluminium production (kt/y)	Country	Number of lines	Steel production (kt/y)	Aluminium production (kt/y)
Austria	2	375	0	Italy	34	1,225	197
Belgium	7	670	8	Luxembourg	0	0	0
Czech Republic	1	40	0	Netherlands	15	170	55
Denmark	3	20	10	Poland	4	200	10
Finland	2	270	*	Portugal	2	40	*
France	17	1,415	45	Slovak Republic	1	100	0
Germany	24	1,469	382	Spain	18	428	68
Greece	4	60	50	Sweden	13	350	*
Hungary	1	1	*	United Kingdom	9	510	10
Ireland	0	0	0				

Source: ECCA, 2004, amended on the basis of ECCA, 2005
 * Steel and aluminium data are not split so the total has been considered as steel figures

There are hundreds of applications for pre-coated steel and aluminium from the safety clip on ‘baby’ safety pins to cladding on massive buildings such as aircraft hangars

and power stations. The following is a very selective list of uses as presented on the European Coil Coating Association's (UK) Internet site³.

Building	Transport	Appliance
<ul style="list-style-type: none">• cladding;• partitioning;• doors;• roofing tiles;• ducting;• domestic/garage doors; and• suspended ceilings.	<ul style="list-style-type: none">• car body panels (primer);• car under bonnet parts;• car inner bolt-on parts;• bus exterior panels;• refrigerated lorry panels;• caravan cladding; and• road signs.	<ul style="list-style-type: none">• white kitchen goods;• heaters;• air conditioning;• climate control;• light fittings; and• bakeware (non-stick).
Audio visual	Furniture	
<ul style="list-style-type: none">• CD player cases;• video recorders;• televisions;• DVD players; and• decoder boxes.	<ul style="list-style-type: none">• office furniture;• suspended filing systems; and• filing cabinets.	

2.3.10 Continuous Coil: A. Continuous Electrolytic Zinc (Zinc/Nickel) Coating of Steel

General Information

Finished cold rolled steel (pickled, cold rolled, annealed and tempered) is a material with mechanical characteristics that make it suitable for use in industrial processes; however, it has low corrosion resistance. Enhancement of the anti-corrosion properties of cold rolled steel could be performed either by the development of metals or alloys with a certain natural resistance to corrosion or by using surface treatments involving a coating material that improves the corrosion resistance of the steel substrate. This second method is the one applied by electroplating. The coating material used could be tin, chromium, zinc, copper, lead or some of their alloys (Eurofer, 2003).

Full Chromating and Chromate Rinsing Section

This provides a clear chromate conversion coating for improving protection against white rust corrosion. Typical chromating sections involve the following steps:

1. chromating;
2. rinsing; and
3. drying.

Full chromating or chromate rinsing of the strip after zinc coating is achieved using spray banks. Chromate rinse or passivation is a spray treatment with solvents containing chromic acid. A coat of 10-35 mg/m² per side is applied. During passivation, Cr(VI) is mainly converted to Cr(III). The strip is treated with solutions of 0.5-2% and temperatures of about 40°C. The chromate solution circulates in a

³ Source: www.ecca-uk.com/contents.htm.

closed loop at a temperature below 40°C. The out of range solution is treated in the wastewater treatment section.

Rinsing can be carried out by cascade spraying in horizontal tanks. The used water is sent to wastewater treatment before release.

Finally, the chromated rinse strip is dried by means of a hot air drying device. The hot air temperature lies between 100°C and 120°C, which is necessary for a chemical reaction of excess Cr(VI) with the additives of the solution to become Cr(III).

Anti-finger Print

This provides a chromate layer for improving protection against white rust corrosion. This coating has the advantage of not showing fingerprints, which is critical to some customers. Similar to above, typical chromating sections involve two steps: coating and drying.

The anti-fingermarking chromate coating is applied via a roller coater system, similar to that used in paint lines. Subsequently, the wet coating is passed through an air oven to dry (Eurofer, 2003).

2.3.11 Continuous Coil: B. Continuous Electrolytic Tinplate (and its Passivation)

Tinplate Manufacture

According to European Standard EN 10202:2001, *electrolytic tinplate* is a term used to describe cold rolled low carbon mild steel sheet or coil coated on both surfaces with tin that is applied in continuous electrolytic operation.

The raw material for the production of tinplate is hot rolled steel strip. This is reduced to the requisite thickness by cold-rolling, then coated with tin or chromium in an electrolytic process. According to the Internet site of a leading tinplate manufacturer⁴, the steel strip is supplied in large coils weighing several tonnes which measure about 2-3 mm in thickness. The strip undergoes the following processes:

1. pickling in an acid bath (to remove the iron oxide layer formed during hot rolling);
2. cold rolling on a tandem mill (where the pre-treated hot rolled strip is rolled to the final thicknesses of between 0.12 and 0.49 mm);
3. cleaning and degreasing (when the strip is cleaned of impurities and lubricant residue);
4. continuous annealing or batch annealing (cold rolling makes the strip hard and brittle and, in this condition, it is not suitable for use as packaging material. Recrystallisation annealing of the degreased strip restores the necessary ductility);
5. temper rolling (to prevent severe kinking and irregular deformation behaviour in downstream processing);
6. tin/chromium coating;

⁴ Source: www.rasselstein.com/english/produkte/produktion.

7. slitting/cutting (to give various cut-to-size formats: straight-edged sheets for rectangular sheet metal parts such as body sections, scroll-cut sheets for round sheetmetal parts such as ends or cups, or narrow strip for semi-finished product manufacturing);
8. film laminating (for certain applications, a plastic film made of polyethylene terephthalate (PET) or polypropylene is laminated onto the tinplate);
9. printing/lacquering (to achieve desired appearance and occasionally anti-corrosion properties); and
10. storage of finished products.

Passivation Treatment

Under normal conditions of transport and storage, tinmill products are suitable for surface treatments such as established lacquering and printing operations (Electrolytic Chromium Coating of Steel, on the other hand, does not include a passivation treatment).

Passivation is obtained by a chromating treatment, in order to reduce the thickness of tin oxides formed during re-melting. The treatment produces electrolytically a chromium-containing layer, which prevents subsequent oxidation in air and also improves adhesion of the paint layer. The operation is performed in a solution of sodium dichromate (Eurofer, 2005).

In accordance to EN 10202:2001, there are two tinplate passivation processes in common use:

- Code 311, which is the most widely used and is a process of cathodic treatment in a solution of sodium dichromate;
- Code 300, which is a simple chemical dip treatment in a sodium dichromate solution.

Code 311 will normally be supplied unless otherwise specified. The EN Standard stipulates that the values per surface for total chromium shall be as follows:

- Code 311: 3.5 to 9.0 mg/m²; and
- Code 300: 1.0 to 3.0 mg/m².

The choice between both types of passivation is mainly guided by technical reasons related either to the nature of the lacquers and inks or to the nature of the canned foodstuff.

Marking of Tinplate

Tinplate can be produced either with the same tin layer thickness on both sides of the strip or, for some applications, with a differential tin layer thickness. Before the re-

flow process⁵, a CrO₃ solution (30 g/l) is applied by rolls onto the strip surface and dried while heating the strip. The roll which is in contact with the strip surface has a thin section or gutter, so that only thin lines or stripes of chromic acid solution are applied. The solutions dry during heating of the tinplate and prevent flowing and any shine formation during melting. Marking is required to indicate to the can manufacturer which side of the strip corresponds to the internal can side. This is extremely important to ensure extended shelf life to canned food (information submitted by industry). Marking is a local treatment before brightening that impeaches the brightening of the tin into the “marked” lines. So a contrast appears between the bright surface and the matt lines. The can manufacturer determines which side of the strip he wants to be marked. Generally, it corresponds to the one with the higher tin thickness (internal wall of the can) (personal communication with industry).

Applications for Tinplate

Tinplate is used in packaging applications, mainly in food & beverage segments (ca. 70% of all uses). Generally, tinplate for DWI⁶ 2-piece steel beer & beverage cans is not passivated. The same applies to tinplate for DWI 2-piece food cans. As regards the bulk of tinplate production (3-piece cans for food), there is always a passivation treatment (APEAL, 2005).

2.3.12 Continuous Coil: C. Continuous Electrolytic Chromium Coating of Steel (ECCS⁷)

General Information

Chromium plating of steel strip (known as blackplate⁸) is performed electrolytically in a chromic acid bath. The coating obtained consists of chromium metal and chromium oxides. The overall process is similar to the electrolytic tin process: the steel strip is passed through the entry section of the line, cleaned, pickled and then treated electrolytically in a solution containing chromic acid, rinsed thoroughly, dried, oiled and then recoiled (Eurofer, 2003).

According to industry, ECCS has been developed as an alternative to tinplate in order to preserve the natural reserves of this mineral. The function of chromium coating is

⁵ Flow melting is carried out in air above 232°C and leads to thin tin oxide layers. During storage, these may still grow and impair lacquer adhesion & soldering. To prevent the further oxidation of tin, the tinplate coil is passivated. Flow melting turns the matte surface into a shiny layer of tin (personal communication with industry).

⁶ Drawn wall ironed tinplate: electrolytic tinplate manufactured with a very clean steel base, maximum homogeneity and minimum planar anisotropy that makes it suitable for drawing and ironing (APEAL, 2005).

⁷ According to EN 10202:2001, this term represents cold rolled low carbon mild steel sheet or coil electrolytically treated to produce on both surfaces a duplex film of metallic chromium adjacent to the steel substrate with a top layer of hydrated chromium oxides or hydroxides.

⁸ According to European Standard EN 10205:1991, blackplate is a term used to describe cold reduced low carbon mild steel, normally oiled, used for the production of tinplate or ECCS in accordance with EN 10202:2001.

the same as for the passivation of tinfoil, i.e. it prevents the atmospheric oxidation or sulphuration of steel by foodstuffs and improves lacquer adhesion. Some foods, especially protein-rich meat and fish and, to a lesser extent, vegetables (e.g. peas, beans, corn, etc.) contain naturally occurring sulphur compounds. These can react with a plain tinfoil surface to give a purple-black stain of tin sulphide. Although the stain is harmless, it may serve to change the passivation of the tinfoil surface, which, in turn, could alter the rate of tin uptake (CCFAC, 2004).

ECCS can only be used with an additional organic coating. Furthermore, it is not suited for manufacturing 3-piece steel food cans or aerosols as it is less weldable than tinfoil. Therefore, the use of ECCS is limited to about 20% of the total amount of steel for packaging, as an attractive alternative to tinfoil for some applications (closures, 2-piece cans, etc.).

Applications for ECCS include:

- cans for human food and pet food;
- trays;
- can ends; and
- closures and crowns for containers⁹.

Chrome Plating

Before chrome plating takes place, the strip is passed through a pre-dip tank containing sulphuric acid at a concentration of 0.3-0.5 g/l to prepare the surface of the strip for electrodeposition. Lack of pre-dipping would result in stains and other surface defects forming on the surface of the strip.

During plating, the strip is passed through an electrolyte containing Cr(VI) ions, which are reduced cathodically on the strip surface to form a duplex layer of hydrated chromium oxide and metallic chromium. The treating current is determined according to strip width, line speed, current efficiency and aimed film weight and flows from the insoluble electrodes to the strip through the electrolyte, and then returns to a rectifier through the conductor rolls.

The plating solution is pumped from a circulation tank, passed through a heat exchanger, then travels up into the bottom of the coating tanks, which contain inert anodes of lead-antimony, overflowed from the top part of the tank and then returned to the circulation tank.

A typical plating electrolyte will consist of:

- chromic acid (CrO₃) at a concentration of 110 - 130 g/l;
- hydrofluoboric acid (HBF₄) at a concentration of 0.30 - 0.44 g/l; and
- sulphuric acid (H₂SO₄) at a concentration of 0.60 - 0.80 g/l.

⁹ Information from the **Corus Group** Internet site www.corusgroup.com.

The hydrofluoboric and sulphuric acids improve the efficiency of the plating process.

Temperature can have a marked effect on electrolyte efficiency: the solution is far more efficient at lower temperatures, however, because the electrolyte is heated by the electric current passing through the coating tank, the temperature has to be controlled by the heat exchanger which cools the solution to a constant temperature. In actual operation, the optimum temperature of the electrolyte is $58\pm 2^{\circ}\text{C}$ (Eurofer, 2003).

According to EN 10202:2001 (Cold reduced tinmill products – Electrolytic tinplate and electrolytic chromium/chromium oxide coated steel), for ECCS, total chromium and chromium in oxide coating masses must be $50\text{-}140\text{ mg/m}^2$ and $7\text{ to }35\text{ mg/m}^2$ respectively. These values apply to the average of three single spot measurements. Total chromium is the sum of the metallic chromium and chromium content of the oxides and hydroxides.

Drag-out Stage

After plating, the strip goes through a series of rinsing operations (drag-out), in order to:

- minimise the loss of plating electrolyte carried over from the plating section;
- recover carried over plating electrolyte for return to the plating section; and
- maintain a controlled level of dilute electrolyte on the strip surface.

At the drag-out tank, electrolyte is spray-rinsed away then returned to the electrolyte circulation tank. This is connected to an evaporator and the diluted electrolyte is condensed by the evaporating system then re-circulated back to the tank. The amount of spray rinse at the drag-out recovery tank and the capacity of the evaporator are decided from the chromic acid concentration in the drainage.

Chromic acid treated strip must be fully rinsed with water before drying, oiling and recoiling. The strip is sprayed with hot water at the entry and exit ends of the rinse tank in order to remove any carry-over of electrolyte or water-soluble constituents in the oxide film. Spraying is carried out at $50\text{-}60^{\circ}\text{C}$ at a flow typically of $5,000\text{-}10,000\text{ l/hour}$. Spraying at higher temperatures and pressures could damage the freshly formed film.

Markets for ECCS and Tinplate

Detailed information on the use of Cr(VI) has been received from APEAL, the European trade association representing the EU producers of steel for packaging (blackplate, tinplate & ECCS). APEAL represents 4 multinational companies operating in 8 countries in the EU and which altogether account for 92% of the EU production of steel for packaging. Tinplate for DWI 2-piece steel cans is produced by 3 companies in Europe, all members of APEAL (APEAL, 2005).

In 2003, the production of ECCS and tinplate in EU-15 was around 4,400 ktonnes, practically stable between 1998 and 2003. DWI tinplate represents 13% of the overall production of steel for packaging in Europe i.e. ~575 ktonnes.

The consumption of these materials was between 4,000 and 4,300 ktonnes over the same period in EU-15. Moderate growth is expected for the next five years in Western Europe whilst it is anticipated that the new Member States could catch up with the per capita levels in Western Europe (APEAL, 2005).

2.3.13 Post-treatment in Continuous Hot Dip Galvanising of Steel

Process Description

Following the coating (with zinc), steel strips are usually subjected to post-treatment in order to prevent surface damages and flaws, like 'white rust' caused by water condensation in case of insufficient air access. The resistance against white rust is considerably increased by the application of post-treatment, like oiling, passivation, phosphating, organic coating or a combination of such treatments (EIPPCB, 2001).

Although white is the most common discolouration of steel, stain can also take the form of a grey or black deposit on the surface (ILZRO, 2004). The voluminous white or grey deposit is formed by accelerated corrosion of the zinc coating when closely-packed, newly-galvanised articles are stored or shipped under damp and/or poorly ventilated conditions. It is most often found on stacked and bundled items such as galvanised sheets, plates, angles, bars and pipe. Weathered zinc surfaces which already have formed their normal protective layer of corrosion are seldom attacked. In some instances, climatic conditions can also cause wet storage staining to occur on freshly galvanised surfaces which have not been quenched in water, i.e. in autumn with condensation forming on cold nights followed by hot days.

Passivation is a treatment with solvents containing chromic acid, applied by spraying or applicator-rolls. For hot dip metal-coated strip, a coat of 10 to 35 mg/m² per side is applied. Coat thickness is, therefore, extremely thin (a few nanometers only). During passivation, Cr(VI) is mainly converted to Cr(III). Almost all of the installations have a heater after the treatment to make sure that the temperature rise over 120 °C which is necessary for a chemical reaction of excess Cr(VI) with the additives of the passivating solution to become Cr(III). The strip is treated with solutions between 0.5 to 2 % of Cr(VI) and temperatures between 70 to 120 °C (EIPPCB, 2001).

The colour of the chromate changes with coating thickness and composition of the film from blue, through yellow to olive and black. The various colours not only achieve the desired decorative effects, they also offer different corrosion protection properties. Blue passivates are generally preferred where a chromium-like gloss is required. Yellow and olive chromates are chosen for their superior corrosion protection. Black chromates used on zinc alloys achieve attractive decorative effects combined with outstanding corrosion protection (information from Atotech¹⁰).

¹⁰ Source: www.atotech.com.

EU Continuous Galvanising Lines

The European steel industry has a total annual production of over 190 million tonnes¹¹ and generates €90-100 billion in annual turnover. The industry provides direct employment for more than 250,000 EU citizens, and several times this number are employed in the steel processing, using and recycling industries. In addition, steel is a worldwide commodity (global production is more than 900 million tonnes per annum) that is both exported from, and imported into, the EU. Accordingly, the steel industry is also the origin of millions of other jobs in many other industrial activities. For example, the European constructional steelwork industry and the automotive sector represent 200,000 and 1.1 million jobs respectively (CEC, 2004c).

Data on the EU-15 continuous coating lines are presented in the relevant Best Available Techniques Reference Document for the ferrous metals processing industry and are reproduced in Table 2.11.

Country	Number of lines
Austria	4
Belgium	6
Finland	3
France	14
Germany	10
Greece	1
Italy	8
Luxembourg	3
Netherlands	2
Portugal	1
Sweden	2
Spain	6
United Kingdom	7
Total	67 <i>(inc. 4 under construction or planned)</i>
<i>Source: EIPPCB, 2001</i>	

The hot dip galvanising production for western European companies in 1997 was around 15 million tonnes (EIPPCB, 2001). More up-to-date information is not available, although consultation suggests that EU-25 production in 2004 could have been as high as 25 million tonnes (based on personal communication with industry and the Steel Sheet Quarterly Market Service by the CRU Group, London¹² which

¹¹ Source: www.eurofer.org/cgi-bin/year_crude_production.pl?YearCrude=2001.

¹² Source: www.crugroup.com

reports a total consumption of galvanised steel sheet of ca. 31 million tonnes in 2004 including continuous hot dip galvanised steel and electrolytically galvanised steel¹³).

2.3.14 Chromate Passivation in Batch Hot Dip Galvanising

Process Description

The galvanising process is typified by mounting the work pieces on to jigs by hooks, chains or wires and then progress through the successive steps are by transfer by overhead crane and dipping into the each bath (EGGA, 2005).

The quench bath is the same size as the galvanising step molten zinc bath. For example, a molten zinc bath 8m long x 1.5m wide x 3m deep would have a quench bath of the same dimensions. The items or work pieces are thus never removed from the jig until processing has been completed. The jig carrying the workpieces can be dipped without further adjustment or manual intervention. The sizes of baths or vats in the batch galvanising industry are very much larger than the electroplating industry, as a general rule. Baths of 1.5 to 2.5 metres width, 2.5 to 3m depth and length of 7-20+ m are typical (EGGA, 2005).

Aqueous Cr(VI) solutions are typically used in the quench bath for post-emergence of the workpiece from the molten zinc bath.

Quenching into the Cr(VI) solution of the freshly galvanised workpiece achieves three objectives:

- prolonged brightness;
- pre-treatment for a secondary organic coating; or
- prevention of white rust during long-term storage or transport.

Any one of these, or combination thereof, may be specified by customers (EGGA, 2005).

Passivation in the batch galvanising industry is generally undertaken with relatively dilute solutions of ~0.1 to 0.3% w/w, since the greater the concentration of the chromate then the more yellow the item becomes. Normally this is what is required to achieve the required benefits, without any discolouration of the bright silvery appearance, of the zinc surface of the galvanised item. Under certain circumstances, for example long term storage or shipping into the tropics with high humidity and ambient temperatures, higher concentrations may be used (EGGA, 2005).

Current Practices in the EU Batch (General) Galvanising Steel Industry

EGGA argues that the use of Cr(VI) passivates in the European general galvanising industry is limited. The pan-European EGGA Technical Committee suggests that it is impossible to be precise about the extent of use of Cr(VI) in the European general

¹³ We assume a 83%-17% split between the two types of galvanisation (personal communication with industry).

galvanising industry; however, the number of users and the extent of use is believed to be low and confined to a limited number of markets.

The use of chromates is not uniform in the EU: in some countries use is very limited; in some others use is still significant.

Information from German galvanisers suggests that the introduction of the ELV Directive has shifted demand to Cr(VI)-free treatments. More and more customers demand Cr(VI)-free certificates and as a result new German hot dip galvanising plants are not generally interested in using Cr(VI) formulations. In fact, the use of Cr(VI) passivates has never been particularly widespread in Germany; a small number of plants may have run in the past an electroplating plant or a powder coating plant (alongside the galvanising plant) that used Cr(VI) passivates (Marberg, 2005).

Information from France similarly suggests that French hot dip galvanisers do not use Cr(VI) passivates (EGGA, 2005).

In the Nordic countries, there is no formal restriction on the use of Cr(VI) at present, but the introduction of the ELV Directive has produced an effect similar to that in Germany (vehicle manufacturing is a very important part of the Nordic galvanising industry). For general galvanising, no plant uses Cr(VI) in post treatment, however, in continuous galvanising plants Cr(VI) passivates are still in use. Since the car industry is a major customer of theirs, it is expected that the use of Cr(VI) in these plants will be significantly reduced by 2007. The Nordic galvanising industry is reported as being in the process of developing suitable alternatives to Cr(VI) passivates (NGA, 2005).

On the other hand, use of chromates in the UK and Ireland is more widespread. The British Galvanisers Association undertook a survey among its members to collect information on current patterns of use of Cr(VI) compounds. Responses were received from 34 out of a total of 70 operating sites in the UK and Ireland. 22 out of 34 sites still use Cr(VI) with an estimated 20% of UK galvanised steel production being passivated. The use of Cr(VI) is gradually declining, however, industry claims that alternatives are not readily available. Some alternatives have been trialled but have been rejected on grounds of:

- unacceptable performance;
- incompatibility with other post-treatments such as painting;
- over-sensitivity to the high temperature of the quench liquor; and
- cost.

Overall the UK Galvanisers Association argues that their experience is that there is currently no substitute which can achieve all three objective mentioned above or combination thereof (brightness, preparation for organic coating and protection from white rust).

With particular regard to Cr(III), EGGA has suggested that Cr(VI) solutions are stable for use in batch galvanising at temperatures of up to ca. 100°C (in the quench bath); however, Cr(III) solutions cannot operate under these conditions (EGGA, 2005).

It should be noted that the main purpose of passivation (as discussed above) is the prevention of ‘white rust’. Galvanised steel produced in the UK and Ireland requires to be transported by sea more often than steel produced in continental Europe. Hence, there is a greater need for passivation in the UK and Ireland. Moreover, it has been suggested that in some markets there is customer demand for products having an appearance that only Cr(VI) passivation can offer at present (EGGA, 2005).

Where Cr(VI) is used, waste streams are not disposed of to drain, the public sewer or to the environment. They are disposed of to licensed contractors (usually by road tankers), and there is a duty of care on all those in the value chain to ensure that competent contractors are used (EGGA, 2005).

The EU Steel and Batch Galvanising Industry

Over six million tonnes of steel were batch galvanised in 2003¹⁴. The number of batch galvanising plants in operation is given on a per country basis in Table 2.12.

Table 2.12: Number of Batch (General) Galvanising Plants in the EU (and other countries) in 2004			
Country	Number of plants	Country	Number of plants
Austria	17	Latvia	3
Belgium	20	Lithuania	2
Cyprus	2	Netherlands	21
Czech Republic	23	Norway	15
Denmark	12	Poland	70
Estonia	2	Portugal	14
Finland	15	Slovak Republic	6
France	61	Spain	47
Germany	162	Sweden	31
Hungary	11	Switzerland	18
Iceland	4	UK and Ireland	79
Italy	93		

Source: EGGA, 2005
Note that EGGA's members represent the vast majority of production of batch galvanised steel in the EU. The relevant national percentages vary from 60% in the Czech Republic, Italy and Switzerland to reach 100% for the Slovak Republic, 99% in Denmark and 95% in Sweden

2.3.15 Passivation of Stainless Steel

Stainless steel is referred to in the RAR as one of the substrates that may be subject to passivation using chromate solutions. However, the chemical passivation of stainless steel is somewhat different from the passivation treatments applied to most other metals and alloys. For most other metals and alloys the passivation treatment may be

¹⁴ Source: www.egga.com/ind.htm.

described as a conversion coating, where a Cr(VI) solution is used to form a passive chromate layer on the metal or alloy surface.

In stainless steel, however, the corrosion resistance is due to a chromium-rich oxide film on the surface of the metal but this occurs naturally when a clean surface is exposed to an environment that can provide enough oxygen to form the chromium-rich oxide surface layer. In contrast to carbon or low alloy steels, stainless steels must have a minimum chromium content of 10.5% (by weight) of chromium (and a maximum of 1.2% carbon). This is the definition of stainless steels given in European Standard EN 10088-1 (Euro-Inox, 2004).

In the event of damage (e.g. by abrasion), the oxide layer self-repairs in the presence of oxygen and moisture. Thus, the protective (passive) oxide layer on stainless steel forms naturally in air. However, thickening of the oxide film follows an inverse exponential curve (i.e. the rate of thickening of the oxide decreases with time). The rate of oxide thickening may be enhanced by treatment with a 20-50% nitric acid solution or with a 20-25% nitric acid solution containing 2-2.5% sodium/potassium dichromate or with a chelating agent.

Passivation treatment restores the chromium/iron oxide film to its full thickness in approximately 30 minutes as well as removing surface discontinuities and surface contaminants (e.g. copper or iron) that may have a detrimental impact on the corrosion resistance of stainless steel. No Cr(VI) is present in the passive oxide layer on the surface of passivated stainless steels. Cr(VI) is, however, present in the passivation solution, which is rinsed off the stainless steel surface with clean water. In addition, stainless steel surfaces are often dried (with warm air or artificial maize) after passivation treatment to prevent watermarking (Newson, 2005). Companies passivate aerospace and defence components to given specifications, e.g. Defence Standard 03-2 Method M or QQP-35C; in both cases solutions containing chromate are used. Also, companies may process metal components to aerospace companies' in-house specifications. These are based generally on the USA military specification QQP-35 (personal communication with industry).

2.3.16 Other Processes Involving Hexavalent Chromium

Chemical Blacking

Immersion-type chemical oxidation coatings are used mainly for appearance, as a paint base or for their oil retention characteristics. For stainless steel, the 'Inox' process involves dipping in chromic acid and sulphate at 60-90°C (EIPPCB, 2004b).

Screen Printing

This is a process in which an ink-permeable screen is stretched on a frame, degreased, rinsed and dried. A photo-sensitive emulsion based on a silver halide and polyvinyl alcohol/acetate is applied and dried. The film is then cured with ammonium hydrogen dichromate and the image is applied and developed (EIPPCB, 2004b).

2.3.17 Overall Market Trends in Use of Chromium in Metal Finishing

The metals treatment market for Cr(VI) products is dominated by the chromium plating sector. This market tends to reflect general economic activity and GDP. A much smaller segment of the metals finishing sector is the use of Cr(VI) in passivates. Hard chrome plating comprises less than a quarter of the overall world Cr(VI) plating market (information submitted by industry based on the findings of a study undertaken by Thintri Inc. in 2003).

Information for the UK industry suggests that the market for Cr(VI) in metal treatment applications has reduced considerably. Between 1998 and 2003, the market size for Cr(VI) plating chemicals was reduced by 53%. There has been a corresponding fall of 32% in the use of Cr(VI) based passivates (personal communication with industry associations). On the other hand, the producer of Cr(VI) compounds suggests that this UK trend may not be representative of the whole of the EU according to their sales figures for recent years.

Information from individual companies involved in metal passivation is consistent in suggesting that there are signs that the metal surface treatment industry may be moving away from Cr(VI), either to Cr(III) or to chromium-free alternatives. Consultation suggests that industry is generally active in researching alternatives, both based on Cr(III) and chromium-free, however, it is not always possible to develop viable alternatives. Chromium-free alternatives are particularly relevant to coil coating. The major concern is achieving the same corrosion protection levels with the new products in order to meet customer requirements (for instance, to be able to maintain the 20 year warranties).

It has been suggested that in North America there is a clearer trend away from Cr(VI) treatments compared with Europe. For example, consultation suggests that up to 70% of coil treatment in North America is chrome-free with results in some cases possibly better than those achieved using Cr(VI) methods (see Section 6.2.2 on passivation and pre-treatment of coil with alternatives) (personal communication with industry).

The End of Life Vehicle Directive (2000/53/EC) and the Waste from Electrical and Electronic Equipment (WEEE) Directive (2002/96/EC), coupled with the Reduction of Hazardous Substances (RoHS) Directive (2002/95/EC) will considerably reduce the size of the sector even further for Cr(VI) based passivates (also see Section 4). Some preliminary information on possible alternatives is provided in Section 6.

2.4 Leather Tanning Salts

2.4.1 Production of Tanning Salts

General Information

Basic chromium sulphate refers to a family of compounds with the general formula $\text{Cr}_2(\text{OH})_{2n}(\text{SO}_4)_{3-n}$ in which part of the sulphate combined with the chromium in $\text{Cr}_2(\text{SO}_4)_3$ has been replaced by hydroxyl groups.

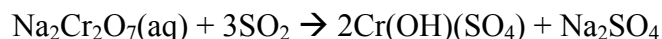
The almost exclusive use of basic chromium sulphates is in the tanning of animal, reptile or fish skins to produce leathers. However, some are also used in chromium plating. Basic chromium sulphates currently on the market fall into two broad categories according to the method of manufacture. The two methods are:

- inorganic reduction of sodium dichromate; and
- organic reduction of sodium dichromate in the presence of sulphuric acid.

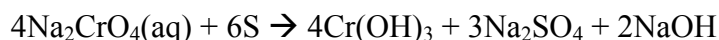
It should be noted that the processes description below is based on consultation with industry and differs from the description presented in the RAR.

Inorganic Processes

The most common variant involves reduction of sodium dichromate solution by gaseous sulphur dioxide in packed tower reactors. Burning sulphur *in situ* normally generates sulphur dioxide. This reaction generates 33% basic product and is controlled to have a slight excess of sulphur dioxide to ensure absence of residual Cr(VI).



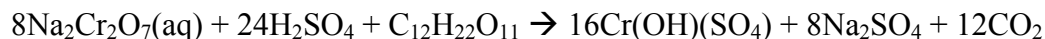
In another variant, aqueous sodium dichromate is reacted with elemental sulphur under pressure in autoclaves to produce hydrated chromium (III) oxide, which is separated and dissolved in sulphuric acid.



In both cases, a viscous dark green fluid is produced, typically containing 10-12% chromium, to which alkali, normally in the form of aqueous sodium carbonate, may be added to produce materials with higher basicity. Organic complexing agents such as formate or acetate can also be introduced, normally as the sodium salt, to provide a degree of masking of the chromium, which appears to be important in some applications (personal communication with industry).

Organic Processes

Sodium dichromate in solution is also reduced by a number of organic agents in the presence of sulphuric acid. In cases where basic chromium sulphate is the prime product, the organic reducing agents are sugar, starch or formaldehyde e.g.



Although the above reaction indicates that all of the organic material is oxidised to carbon dioxide, a range of carboxylic acids is produced which complex with the Cr(III) (personal communication with industry).

According to the RAR, chrome tanning salts are made at many sites in the EU (although consultation to date has provided little evidence on this). This, according to the RAR, is the biggest use of sodium dichromate in the EU. This assertion is supported by the information submitted by industry for the purposes of this RRS (see Table 2.4). Note that the salts are also obtained as a by-product from other processes, for example wax production and vitamin K production.

2.4.2 The Tanning Process

The tannery operations consist of transforming the raw hide, a highly putrescible material, into leather, a stable product which can be conserved indefinitely and which has a significant commercial value. Tanning of leather is a chemical process in which chemicals like chromium are fixed into the fibres in order to stabilise the hide. During this operation, collagen, the principal protein of the skin, will fix the tanning agent to its reactive sites, thus stopping the putrefaction process. In the chrome tanning process, the Cr(III) is bonded to the leather, usually by bathing the leather in a bath containing brine and Cr(III) salts for 16 hours (CEC, 2002).

Cr(III) salts are the most widely used tanning agents today. The collagen-chromium bond is the strongest known today amongst the various alternatives, including vegetable and synthetic tannins (ICDA, 1997). The RAR suggests that 90% of the world's leather is tanned with basic chromium sulphate (information from industry reduces this percentage to 80%).

2.4.3 On-site Reduction of Cr(VI) by Tanneries

Background

The RAR suggests that a small number of tanneries may be purchasing Cr(VI) compounds with the aim of reducing these on-site to Cr(III) tanning salts and then use them to tan hides. Information on emissions was also included for a single EU tannery involved in such a process. The emissions from this tannery appeared to be higher than those estimated for producers of tanning salts using default assumptions.

Consultation during Stages 1 and 2 of this RRS was aimed at determining whether this practice of on-site reduction of Cr(VI) compounds by tanneries is still of relevance to the EU industry. The Confederation of National Associations of Tanners and Dressers of the European Community (Cotance) claims that this method of manufacturing tanning salts is of no relevance to modern EU tanneries. In a statement endorsed by all national representative organisations of the European leather industry, Cotance argues that this practice is obsolete and unlikely to reappear in Europe or elsewhere (Cotance, 2005a).

The ICDA similarly states that this practice is now rare in most countries, where tanneries are supplied with ready-made chromium tanning agents that contain no detectable levels of Cr(VI) (IDCA, 2001).

Consultation Findings

Consultation identified two EU tanneries that are or have until recently been involved in on-site reduction of Cr(VI) compounds to Cr(III) tanning salts (one of them is in fact the company anonymously referred to in the RAR as using Cr(VI) substances for on-site reduction of Cr(VI) substances).

One of the two companies was purchasing potassium dichromate to reduce on-site. Since March 2004, this process has been discontinued; the tannery now purchases ready-made Cr(III) tanning salts. The company purchased Cr(VI) compounds with the intention of reducing it to Cr(III) using organic compounds in a process that resulted in chromium complexes. These complexing agents were important in order to produce high quality leather. Consultation suggests that such Cr(III) sulphate solution was not available until recently, hence the company produced its own tanning salts.

The other tannery appears to also have very recently discontinued the use of Cr(VI) compounds, mainly due to concerns on the effects of Cr(VI) to the health of the employees. As indicated by a company representative, sodium dichromate was being purchased for on-site reduction up until early 2005. Details on the emissions of chromium from these two sites are given in Section 4.6.5.

It is acknowledged that there is a theoretical possibility that tanneries (perhaps non-members of Cotance – tanners from a number of ‘new’ Member States are not members of this association) may still be using Cr(VI) substances. However, the available evidence strongly suggests that tanners would themselves probably be keen to abandon this practice, if they have not done so already, since:

- ready-made Cr(III) tanning salts are easy to obtain;
- the use of ready-made Cr(III) tanning salts simplifies the production process as it removes a production step (the reduction of Cr(VI) to Cr(III));
- the use of ready-made Cr(III) tanning salts eliminates the risks to workers from the carcinogenic properties of the Cr(VI) substances, hence there are lower costs for measures aimed at protecting occupational health; and
- the use of ready-made Cr(III) tanning salts reduces the costs associated with maintenance of the reduction equipment and the treatment of wastewater for the removal of Cr(VI).

It is concluded that while it is possible that this practice may still be relevant for a number of EU tanneries, their number is expected to be small.

2.4.4 Market Overview

In 2003, there were just over 3,000 tanneries in EU-15 plus Hungary, Slovenia, Norway, and Switzerland with a total workforce of around 55,000 employees. The

total turnover of the sector was around €9.5 billion, the majority of which was related to exports¹⁵.

With regard to the use of tanning salts, different formulators make different estimates on the future of the markets. One formulator suggested during consultation that the dominant market position for Cr(III) tanning salts is expected to be maintained and absolute sales will follow the growth in demand for leather. Consequently, a similar increase in tonnages of Cr(VI) compounds (effectively sodium dichromate) used in the manufacture of Cr(III) tanning salts will follow.

However, another leading formulator argues that the years 2000 and 2001 marked the culmination of an evolutionary phase of the EU markets, in particular in Italy and Spain. Since 2002, the tanning salts market is going through a restructuring phase of recession. The Italian market has witnessed a substantial decrease in consumption of tanning salts of around 35% with a similar or even larger decrease in other EU Member States: in Spain, for example, the market has recorded a decrease in consumption in excess of 50%. This trend seems difficult to reverse in the near future due to the upward expansion in areas such as South America and Southeast Asia.

An estimated 150 employees have been suggested to be employed in non-integrated manufacture of basic chromic sulphate for leather tanning. 'Non-integrated' means production of the substance by companies purchasing sodium dichromate as feedstock from manufacturers of Cr(VI) compounds (i.e. companies that do not manufacture the Cr(VI) compounds themselves).

Three major companies are believed to produce tanning salts from their own feedstock, although only one of them produces the feedstock (dichromates) in the EU. A number of other independent companies have been approached (some of them with questionnaires written in their native language) but no information was made available.

2.5 Wood Preservation Products

2.5.1 Historical Use of Chromium in Wood Preservatives

The first major application of chromium compounds in wood preservation occurred in the early 1900's with the development of "Wolman" salts based on sodium fluoride and dinitrophenol with sodium or potassium dichromate. This was followed in 1926 by the development of copper-chromate (CC) preservative.

Copper chrome arsenate (CCA) was introduced in the 1930's and led to the development of a range of formulations differing to a greater or lesser degree in the relative proportions of the main components and the source chemicals (see also Table 2.13). The CCA preservatives are/were applied to timber by the same methods as used for the CC systems. Since the late 1930's, several variants have evolved from the chromated copper formulations e.g. copper chrome boron (CCB), copper chrome

¹⁵ Source: www.euroleather.com/sector.htm#2003.

fluorine (CCF), copper chrome phosphorus (CCP) but the most widespread and commercially dominant systems have historically been the CCA formulations (ICDA, 1998).

2.5.2 Manufacture of Chromium Containing Wood Preservative Formulations

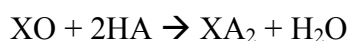
The RAR describes the formulation of arsenic-based wood preservatives (CCA), however due to the recent introduction of relevant legislation restricting the use of CCA formulations, CCA has become less relevant for the use of chromium in the EU wood preservation industry. The description of the manufacture of preservatives below is based on information received by industry and from a literature review rather than the RAR in order to reflect the recent changes in the market.

Producers of formulations may formulate a concentrated product which is then supplied to industrial timber treatment plants. These plants dilute the product with water to prepare the treatment solution used to impregnate the timber. The dilution and treatment is usually automated to reduce exposure of the operator.

Some chromium-based wood preservatives (e.g. CCP) are formulated using chromium trioxide flake while other chromium-based preservatives (e.g. CCB) are formulated using crystalline anhydrous sodium dichromate. The manufacturing process involves the transfer of the chromium compound from ‘flow bins’ (1,420 kg) and 50 kg drums to a mixing vessel via a hopper. The hopper is positioned over the manhole of the mixing vessel and slowly empties into the vessel. The hopper is fitted with an extraction system (with scrubber) to eliminate dust emissions to the environment. The product is mixed for 24 hours at a temperature of 40°C and the batch size is usually selected to use two or three complete flow bins and a few drums. A leading manufacturer suggests that there is no weighing of chromium compounds in the formulation of its wood preservatives, a fact that eliminates the risk of dust emission to the environment during weighing operations (personal communication with industry). A closed system is also used in all (four) sites that have submitted a completed questionnaire for the purposes of this environmental RRS.

Packing of the liquid concentrate product into 50 kg drums or IBCs is via a manually operated filling line. The manufacturing and filling operation is under extraction (with a scrubber), and the operator wears protective equipment.

Chromium trioxide has high water solubility and provides an acidic solution in which the water insoluble cupric oxide can be solubilised. For the production of CCB, boric acid is added, while for the production of CCF hexafluorosilicic acid is added (personal communication with industry). CCA wood preservatives are made by mixing together copper oxide, chromium trioxide, and arsenic acid. These reagents interact to produce a complex solution of copper chromates and arsenates. The RAR describes the reaction as follows:



XO is a metal oxide, HA is a mineral acid, and XA₂ is a metal salt (CEC, 2002). These complex reactions result in the wood preservative having excellent permanence

in the wood and are described as being ‘fixed’ in the wood. It is this fixation or permanence in the wood that provides the long-term effectiveness of the treated product.

There have been different types of CCA products. In the UK, these are defined by British Standard BS 4072:1999 as Type I and II, in terms of the relative amounts of hydrated salts they contain (although, as the RAR notes, other definitions have been used in the past). Both these types (I and II) are in fact CCA Type C, the only type of CCA that is permitted to be used in the EU today. “Type C” is not defined in Directive 2003/2/EC on marketing and use restrictions on arsenic, however, the formulators base their mixing analogies on the percentages for the different types of CCA as defined by the American Wood Preservers’ Association (AWPA). For the UK formulators, the percentages given by the AWPA are modified slightly to ensure adherence with the requirements of the British Standard BS 4072:1999 (personal communication with industry). Table 2.13 presents the composition for the different types of CCA wood preservatives that have been developed in the UK, the USA and Sweden (Nordic countries).

2.5.3 Wood Treatment Process

Cr(VI) based products have been used for industrial application primarily by vacuum pressure application (described below on the basis of industry submissions) across the EU.

The concentrate provided by the formulator is diluted by the treater with water to around 2-5% to prepare the treatment solution. This dilution is automated to reduce exposure and the dilute solution is stored in a tank close to the treatment plant.

Table 2.13: Types of CCA Wood Preservative Formulations				
Name	Country	Composition		
		Cu	Cr	As
BS Type I	UK	CuSO ₄ : 26.5%	Na ₂ Cr ₂ O ₇ : 45.2% Cr: 17.9%	As ₂ O ₅ : 26.3%
BS Type II	UK	CuSO ₄ : 28.2%	Na ₂ Cr ₂ O ₇ : 49.9% Cr: 19.8%	As ₂ O ₅ : 21.8%
AWPA Type A	USA	CuO: 18.1%	CrO ₃ : 65.5% Cr: 34.1%	As ₂ O ₅ : 16.4%
AWPA Type B	USA	CuO: 19.6%	CrO ₃ : 35.3% Cr: 18.4%	As ₂ O ₅ : 45.1%
AWPA Type C	USA	CuO: 18.5%	CrO ₃ : 47.5% Cr: 24.7%	As ₂ O ₅ : 34.0%
NWPC Type B	Sweden	CuO: 19.6%	CrO ₃ : 35.3% Cr: 18.4%	As ₂ O ₅ : 45.1%

Source: ICDA, 1998
NWPC stands for Nordic Wood Preservation Council
Note that the percentages of components in BS Type I and BS Type II are different to those indicated in the relevant standard because the contribution of water has been discounted in this table

Untreated timber is mechanically loaded onto bogies on a railtrack, which extends into the treatment vessel. The timber is strapped down to prevent it moving/floating

in the treatment vessel and the bogies are pushed into the vessel. A section of track is removable, usually mechanically, to allow the vessel door to be closed and locked.

An initial vacuum pulls air from the wood. Whilst under vacuum, treatment solution is transferred to the treatment vessel. Hydraulic pressure is then applied to force the solution into the wood. After the required time, pressure is released and the treatment solution is transferred back to the storage tank. A final vacuum is applied which removes some of the excess solution from the wood surface and any residual solution is drained back to the storage tank.

After releasing the vacuum, the door is opened and the bogies are pulled out of the vessel. The wood is mechanically off-loaded and placed in a drip area prior to moving into storage. According to industry, the railtrack, the surrounding area and the drip area are all within the bunded area and, therefore, any preservative solution drips are contained.

The RAR notes that during the wood treatment process in the EU, Cr(VI) is reduced to Cr(III). The rapporteur notes that the process utilised in non-EU countries is not known and, therefore, the potential for the presence of Cr(VI) in CCA treated wood imported into the EU is not known. For this reason, the RAR covered only wood that is (was) treated with CCA within the EU.

2.5.4 Current Applications for Chromium Containing Wood Preservatives

European Standard EN 335-1:1992 (Hazard classes of wood and wood-based products against biological attack) classifies the in-service environment for wood and wood-based panel products into 5 classes for the purposes of assessing the likelihood of different types of biological attack and the need for preservative treatment. The five hazard classes for wood are as follows:

- **Hazard class 1:** the wood or wood-based product is under cover, fully protected from the weather and not exposed to wetting.
- **Hazard class 2:** the wood or wood-based product is under cover and fully protected from the weather but where high environmental humidity can lead to occasional but not persistent wetting.
- **Hazard class 3:** the wood or wood-based product is not covered and not in contact with the ground. It is either continually exposed to the weather or is protected from the weather but subject to frequent wetting.
- **Hazard class 4:** the wood or wood-based product is in contact with the ground or fresh water and thus is permanently exposed to wetting.
- **Hazard class 5:** the wood or wood-based product is permanently exposed to salt water.

The market for hazard class 5 wood has been characterised by industry as a very small market segment, which has been previously partially filled by CCA-treated

timber. Under the Marketing and Use restrictions on arsenic (Directive 2003/2/EC), CCA is no longer able to be used for this end use (personal communication with industry).

The allowed uses for CCA still fall across hazard classes 1 to 4. Arsenic-free chromium-based products (i.e. not CCA) are used across hazard classes 1-4 as well, although it may be possible that they may find limited applications in hazard class 5 too (personal communication with industry).

With regard to hazard class 5 uses, according to industry submissions, copper oxide is being supported as an active substance under the Biocidal Products Directive (see Section 4) although, reportedly, its use for hazard class 5 is not being included. Copper sulphate, on the other side, is not being supported as an active substance under the Biocidal Products Directive. Consultation suggests that chromium trioxide is only ever used in conjunction with copper. Therefore, if copper is restricted to hazard classes 1 to 4, so is chromium.

Moreover, some consultees have argued that the non-chromium copper-based alternative wood preservatives are not really suitable yet for use in marine waters. If copper oxide was supported in hazard class 5 to allow use of chromium in this sector, it is such a small part of the preservative treatment business that a treater would probably not sustain a business treating only for marine uses. Given that most treaters have only one treatment plant they will probably choose a product suited to the majority of their business (personal communication with industry). A solution for hazard class 5 applications is considered to be the use of very durable tropical hardwoods (personal communication with industry).

2.5.5 Market and Trends

Historical Trends

Historically, CCA was the primary industrial wood preservative used in almost every EU country and worldwide. Chromium based products without arsenic such as CC and CCB have been used to a lesser extent. According to the RAR, over 100,000 tonnes of CCA were traded worldwide annually. Of this, 80-85% is believed to have historically been produced and consumed in the US.

Of the total annual use in Europe of around 15,000 tonnes, about half was used in the UK. There may have been up to 700 CCA treatment plants in Europe, mostly SMEs, and around half of these were in the UK before the introduction of Directive 2003/2/EC (BRE, 2002). The OECD Emission Scenario Document for Wood Preservatives suggests that both Germany and the UK had 300 vacuum pressure treatment plants each (OECD, 2002). In Spain, the number of treatment plants was 144, in Ireland 47 and in Portugal 22 (information from the public consultation on the draft of Directive 2003/2/EC).

However, things have changed primarily because, over the recent years, CCA wood preservatives have been subject to numerous regulatory reviews. The principal regulatory actions affecting the use of CCA in Europe were the following:

1. Directive 89/677/EEC (amending for the eighth time Directive 76/769/EEC on Marketing and Use restrictions) stipulated that arsenic compounds may not be used as substances and constituents of preparations intended for use in the preservation of wood unless solutions of inorganic salts of the CCA type were used in industrial installations using vacuum or pressure to impregnate wood.
2. Several years later, Directive 2003/2/EC (adapting Directive 76/769/EEC to technical progress for the tenth time) restricted the use of CCA-treated timber to a limited number of end uses where structural integrity is required for human or livestock safety and skin contact by the general public is unlikely. This had to be implemented by 30th June 2004 (more details on the provisions of the Directive are given in Section 4.1.12). These limited end uses account for a small proportion of the requirement for treated timber.
3. Another issue of importance to the evolution of the EU markets for wood treatment formulations are the introduction and the ongoing discussions on the Biocidal Products Directive (98/8/EC). Chromium trioxide and arsenic pentoxide were notified by industry as active substances following the provisions of the Directive, however, dossiers were not eventually submitted. This could have impacts on the placing of chromium containing products on the market (and will definitely have an impact on the use of arsenic in wood preservatives). The (potential) impact of the Biocidal Products Directive is discussed in more detail in Section 4.1.7.
4. Voluntary label amendments by the CCA registrants in the USA and Canada have limited the treatment of CCA in wood to be used by consumers in these countries.
5. National measures have also restricted the use of CCA (for instance, in Finland, restrictions on the dimensions of wood which can be treated with CCA effectively prevents the use of CCA treated wood in residential situations and in Norway, CCA treated wood is effectively only allowed for use in transmission poles (personal communication with industry)).

The overall result was that the use of Cr(VI)-based wood preservatives in the EU has decreased significantly over the last decade, particularly due to the significant decrease in the use of CCA which used to have a significant share of the wood preservatives market in the past.

A leading formulator suggests that their consumption of Cr(VI) compounds has reduced by over 50% in the last five years as the Nordic region was abandoning CCA. The introduction of Directive 2003/2/EC on arsenic effectively reduced CCA use to below 5% of what was the case prior to the Directive. On the other hand, some treaters that stopped using CCA have started using other chromium containing wood preservatives (CC, CCB, CCP). In short, recent changes have impacted more on those formulators who had CCA at the core of their business and less on those traditionally marketing arsenic-free products (CC, CCB, CCP and CCF).

Current Situation

With regard to the current situation, information has been collected through consultation from four major EU wood preservatives formulators. In total, the EU wood preservatives formulators manufacturing products relevant to this RRS could be as many as ten. These are:

- in the UK: three companies (possibly a fourth that has some old registrations for chromium-containing products);
- in Germany: two companies (possibly another two);
- in Finland: possibly two companies;
- in the Czech Republic: possibly one company; and
- in Slovenia: possibly one company.

There also appears to be a non-EU company with a (small) market share in the EU markets.

Available information on consumption of Cr(VI) compounds and on production and sales is summarised in Tables 2.14 and 2.15.

Table 2.14: EU Consumption of Hexavalent Chromium Compounds for the Manufacture of Wood Preservatives (2004)	
Substance	Tonnage
Chromic acid	3-4 ktonnes
Sodium dichromate	<0.5 ktonne
<i>Source: Consultation (with four formulators)</i>	

Note that Table 2.14 reflects only consumption of the four key formulators that reportedly account for around 90% of the EU market for chromium-containing wood preservatives.

Table 2.15: EU Production and EU Sales of Chromium Containing Wood Preservatives (2004)					
	CCA	CC	CCB	CCP	CCF
Production	3-4 ktonnes	<1 ktonne	4-5 ktonnes	3-4 ktonnes	<1 ktonne
Sales	3-4 ktonnes	<1 ktonne	3-4 ktonnes	3-4 ktonnes	<1 ktonne
<i>Source: Consultation (with four formulators)</i>					

Not all four companies produce all types of formulations. It is not known what products other companies may be producing although one of them has registrations for CCA, CC and CCB formulations.

The available data indicate the strong position of one of the four companies in the EU markets, if the overall sales of the four companies are considered. This company appears to account for over 50% of the market. Assuming that two identified formulators who have not returned a completed questionnaire account for 5-10% of the EU market, then the market shares of the four key players are as follows:

- Company A: 55-60% (or 45-50% for the non-UK EU markets);
- Company B: 10-15% (or 15-20% for the non-UK EU markets);
- Company C: 10-15% (or 15-20% for the non-UK EU markets); and
- Company D: 5-10% (or 10-15% for the non-UK EU markets).

With regard to patterns of use of chromium-based products across the EU, consultation thus far suggests:

- CC and CCB are being used in **France** and the **Southern European countries**, along with chromium-free alternatives;
- **Germany** continues to use CCB, CC and CCF; approximately half the market is chrome-based and half is chrome-free. The market in Germany has been dominated by arsenic-free chromium-containing products in the past. The CCB products have traditionally dominated the German market (personal communication with industry);
- the **UK** and **Ireland** still has some chrome-based products being used but the majority of plants have converted to alternatives; and
- Scandinavian countries have generally been moving away from CCA and chrome-based products for a number of years. Chromium is not approved for preservation of wood in **Denmark** (in 1998, one plant had an exemption to use chromium for pressure treatment, and preservation of poles and still had an exemption in 2000 (Danish EPA, 2001)). **Sweden** and **Finland** reportedly have a small amount of CCA and CC still being used but the majority of treatments has been with alternatives for quite some time. The arsenic- and chromium-free products are approved for the Nordic wood preservation class AB, corresponding to hazard (use) class 3 in the European Standard EN 335, and thus are intended for commodities to be used above ground. A few arsenic- and chromium-free¹⁶ preservatives are also approved for Nordic wood preservation class A, corresponding to hazard (use) class 4 of EN 335, and intended for commodities to be used in contact with the ground or fresh water.

Industry suggests that there is considerable movement of timber preserved with chromium-based preservatives between the ‘old’ EU Member States and Accession Member States (e.g. timber is treated in Sweden, Finland or Latvia and exported to the UK) so the supply chain may start in one European country and the downstream user may be in another.

It should also be noted that European suppliers of preserved wood export considerable quantities (particularly poles) to Africa and the Middle East for rural electrification and telecommunication projects.

¹⁶ “Chromium-free” is a term used to imply that there is no intentional use of chromium in the formulation of the wood preservative.

2.6 Pigments and Dyes

2.6.1 Chromates and Chromium (III) Oxide Pigments

Difference between Pigments and Dyes

A dye can generally be described as a coloured substance that has an affinity to the substrate to which it is being applied. The dye is usually used as an aqueous solution and may require a mordant to improve the fastness of the dye on the fibre. In contrast, a pigment generally has no affinity for the substrate and is insoluble (Apparel Search, not dated).

Types of Chromium Pigments

Chromium-containing pigments fall into two categories:

1. those that remain as Cr(VI); and
2. those made by reduction to Cr(III).

According to the RAR, of the Cr(VI) pigments, the main cations attached to the chromate anion for use in pigments and dyes are:

- lead;
- strontium;
- barium; and
- zinc.

Markets for Chromium Pigments

Because of their special properties various chromate pigments are often used in anti-corrosive primer paints. These include: basic zinc chromate/alkali chromate; basic potassium zinc chromate; basic zinc chromate (zinc tetroxy chromate); strontium chromate; calcium chromate; and lead chromate.

Strontium chromates are the pigments most commonly used in primer paints. However, many variants exist and may be used for special effects. Although primarily used in wet paints, chromate pigments may also be used in powder coating applications. The use of calcium chromate in paints is now rare and it may only be available as an imported material. Lead chromates are primarily used in topcoat paints, but they may also be added to primer paints to provide colouring (HSE, 1999a).

Consultation with industry suggests that, in coil coatings, chromate pigments are still used for two reasons: they are cheaper than chromate-free alternatives and the alternatives show a lower hiding powder than chromates. It has been suggested that in the near future (partly due to the introduction of the REACH Regulation) chromate pigments will be replaced by non-chromium alternatives, although other consultees

argue that chromates are not likely to be replaced in all applications for which anti-corrosive properties of the coated surface are of importance.

These pigments are made using precipitation techniques from the soluble dichromate followed by washing, filtration and drying (CEC, 2002).

With regard to the manufacture of chromium (III) oxide pigments, the two major chromium oxide producers in the EU (the present producer and a past producer of Cr(VI) substances) use a process involving reaction between ammonium sulphate and sodium dichromate followed by thermal decomposition and washing to remove sodium sulphate by-product. The RAR describes a different process for the production of these pigments. According to the RAR, these pigments are made by mixing sodium dichromate with boric acid and water and heating in a furnace at 700°C to produce green trivalent chrome oxide. After removal from the furnace, the substance is washed to remove any residual Cr(VI) before filtration and drying. Consultation with industry suggests that this process is used to produce relatively small quantities of hydrated chromium (III) oxide pigment known as Guignet's Green (personal communication with industry).

Chromium oxide pigments yield a fairly dark olive-green shade. They are largely chemically inert and, therefore, possess extremely good resistance properties. Trivalent chrome oxide pigments find applications in:

- cosmetics;
- soap;
- plastics;
- building products (for instance, cement);
- glass; and
- paints.

Consultation has identified two producers of strontium and barium chromates and two producers of chromium (III) oxide pigments. There may be at least four other chromate producers and at least one other chromium (III) oxide producer, although for the latter it is not clear whether they use Cr(VI) in the production of their pigments.

It is of note that there is a European association representing EU producers of lead chromate pigments. A total of eight producers are members of the association, however, none of them has confirmed production of chromium pigments.

2.6.2 Wood (and Cotton) Dyeing

Sodium dichromate is also used as a mordant in wool dyeing (i.e. it is used to fix the dyes to the wool). Most commonly, chromium is added to the bath after the dye has been dispersed through the fibres in a process known as 'chroming'¹⁷, however, it may be possible for chromium to be added before the dye or even simultaneously.

¹⁷ Information from the UK textiles industry suggests that 'chroming' is indeed the only process involving hexavalent chromium still in significant use in the sector.

The RAR also suggests that, in some cases, other reducing agents are added to reduce the Cr(VI) in the bath. Cr(VI) is used in variable quantities depending on the dye used.

The UK textiles industry has provided information that implies that the UK textile finishers are generally divided in two main groups:

- those who have moved completely away from using sodium dichromate or are in the process of moving away completely or, alternatively, are severely curtailing their use of sodium dichromate (from e.g. several tonnes per month at the beginning of the decade to a few kilos per month today); and
- SMEs that continue to use sodium dichromate, in quantities ranging from some tens of kilos to over a tonne per annum, to meet the specific needs of their customers.

The former have embarked on this change in their operations predominantly driven by environmental/safety concerns and business pressures (for example, large UK retailers and the UK Ministry of Defence will not accept textiles treated with chromates) (information submitted by industry).

The global annual consumption of chrome dyes is currently around 6,500 tonnes but this value is below historical levels. Based on the proportion of global wool processed in the EU (25 Member States), the proportional consumption of chrome dyes would be 22%, i.e. 1,430 tonnes (it is likely that the figure could be less than 1,430 tonnes due to the more rapid move in Europe to dyes other than chrome dyes). This level of dye use would account for approximately 430 tonnes of dichromate (Duffield, 2005a). It is difficult to estimate how many sites in the EU use Cr(VI) mordant dyes. It has been suggested that most wool dyehouses will use Cr(VI) even though some may do so only very occasionally. On this basis one could assume that this process involves around 1,000 sites (Duffield, 2005b).

The trend in Europe (and elsewhere, except for China), has been to use chrome dyes almost exclusively for black and navy shades. Alternative dyes, such as reactive and metal complex dyes have increasingly replaced chrome dyes in wool. The speed of replacement is relatively slow and it is estimated that, although the market for wool dyes will increase by 20-25% by 2008, chrome dye consumption is forecast to remain relatively static or decrease. The reason for this gradual decrease is twofold: environmental concerns and the introduction of alternative dyes that have produced quality improvements in the dye products (Duffield, 2005b).

The main environmental issues related to the application of chrome dyes are linked to the residual, non-complexed chromium that is discharged in dyehouse effluent or remains on the dyed textile. Technologies to reduce discharge levels of chromium in effluent have been known for many years, however, there remains the issue of soluble chromium (principally Cr(III)) on the dyed textile and most black or navy shades that are dyed with chrome dyes do not meet human ecology standards, for example by Ökotex.

Ökotex 100 standards require that textiles and accessories meet specific standards, according to their end-use, related to human ecology. For chromium (total extractable by the specified method), the limits are:

- general textiles: 2ppm;
- apparel textiles: 2ppm;
- textiles for baby wear: 1ppm; and
- interior textiles: 2ppm.

The level of extractable Cr(VI) must be below detection limits (Duffield, 2005b).

There are other applications of Cr(VI) compounds in textile processing, particularly for oxidation of sulphur dyes and, less commonly, for vat dyes (Duffield, 2005a).

2.7 Vitamin K Manufacture

Vitamin K is a group of chemicals containing the 2-methyl-1,4-naphthaquinone group which are produced by oxidation of 2-methylnaphthalene with a solution of sodium dichromate acidified with sulphuric acid. This process results in vitamin K3 which is 2-methyl-1,4-naphthaquinone and acts as a precursor to other K vitamins. Sodium dichromate is reduced to Cr(III) sulphate which is sold in the market (tanning salts).

Vitamins K1 and K3 are mainly used in animal feeds and as a drug to help blood coagulate (CEC, 2002).

2.8 Chromium Metal Manufacture

2.8.1 Background

Chromium metal is made from Cr(III) oxide by the aluminothermic process. Globally, a total of nine plants producing chromium by this process exist. Of them, two are located in the EU. A further three plants are producing chromium metal using other methods: the electrolytic method (two plants, none in the EU), and the silicothermic method (one plant, not in the EU). In 2002, aluminothermic chromium metal represented around 90% of the Western world supply, which was much higher than in the early 1990's when its share was around 60-65% (ICDA, 2003).

In the aluminothermic process, Cr(III) oxide is mixed with aluminium powder, alloying additions, and oxidising and conditioning reagents in a refractory vessel. The reaction is exothermic and self-sustaining (CEC, 2002).

Potassium dichromate is used as an oxidising agent in this process which requires the highest grade of Cr(III) oxide. The chromium metal produced is 97-99% pure; the main impurities are aluminium, iron and silicon (CEC, 2002). The amount of dichromates used in the aluminothermic process in the EU is of the order of several hundreds of tonnes (personal communication with industry).

2.8.2 Uses of Chromium Metal

Chromium metal has very limited uses on its own, but is primarily used in high performance alloys with nickel and cobalt (the alloying process has not been considered further in the RAR). According to industry, the potential applications (and the functionality) of the metal include:

- for Cr metal and Cr carbon:
 - superalloys (improves heat, wear and corrosion resistance – superalloys find applications in: (a) aerospace; (b) power generation; (c) process chemicals; (d) oil and gas applications, (e) pollution control; (f) electrical applications; (g) petrochemical applications; and (h) automotive applications (ICDA, 2003));
 - electrical resistance wire (enhances heat and corrosion resistance);
 - hardfacing alloys (increases hardness and wear resistance);
 - welding consumables (matches weld metal deposit composition to parent metal);
 - nickel base alloys, e.g. land-based turbines, pumps; and
 - aluminium and copper alloys (enhances heat and corrosion resistance).

- for powder products:
 - hardfacing applications;
 - thermal spraying; and
 - hardmetal.

In 2002, the consumption of chromium metal in the Western world was dominated by superalloys (60% of total consumption) and aluminium alloys (15%) (ICDA, 2003).

Market Trends

The Western world market for chromium metal is of the order of 10-20 ktonnes per year with an estimated value of €60-80 million (information submitted by industry). An estimated workforce of less than 100 employees is directly involved in the production of the metal in the aluminothermic process.

The demand for chromium metal is dominated by its consumption in super alloys for aerospace and other applications. Therefore, the demand for Cr(VI) consumed in the manufacture of chromium metal closely follows changes in activities and markets in these sectors. This market is currently particularly buoyant and long-term growth is expected by industry (personal communication with industry).

2.9 Magnetic Tapes

2.9.1 Manufacture of Chromium Dioxide

Chromium dioxide (CrO₂) is used in the manufacture of magnetic tapes (video and audio tapes). Chromium dioxide is produced by reacting chromium trioxide with Cr(III) oxide in an autoclave. This is done at 350 °C and at a pressure of 300 bar. Chromium dioxide is black/brown in colour and has a composition between CrO₃ and

Cr₂O₃. The Cr(III) oxide used in the production of magnetic chromium dioxide should be of high quality for the process to yield good results (CEC, 2002).

2.9.2 Use of Chromium Dioxide in Magnetic Tapes

The active component of magnetic tape is the first of four components:

- the magnetic material itself;
- a binder, or glue, which surrounds the magnetic material and holds it to a plastic support;
- a plastic support, usually polyethylene terephthalate. After coating, if slit into strips, it becomes tape; and
- a conductive back coating is applied if the application includes severe winding-speed requirements.

The most widely used magnetic material is iron oxide. Chromium dioxide is superior to iron oxide as it is accompanied by higher resolution and a higher frequency response (CEC, 2002). However, it is abrasive, tending to reduce head life. It is also less stable chemically than iron oxide. At extremes of temperature and humidity, it can degrade to non-magnetic compounds of chromium (Busby, not dated).

2.9.3 Market Trends

At the time of preparing the RAR, a sole EU manufacturer of magnetic tape was reported to be active. However, the market for magnetic tapes has been severely impacted by alternative recording media (compact discs). According to industry sources, manufacture of chromium dioxide in the EU for this market has now stopped (personal communication with industry).

2.10 Montan Wax

According to the RAR, until recently only one producer of montan wax was using sodium dichromate in the Gersthofen process in which Cr(VI) is reduced to Cr(III). The process is totally enclosed. The resulting Cr(III) was used on-site by the company to make leather tanning salts, dyes and pigments (CEC, 2002).

Like other plant waxes, the composition of montan wax is mainly a mixture of esters of long-chain acids with long-chain alcohols as well as free long-chain acids. After saponification and oxidation, a light yellow raffinate is produced, for the most part consisting of long-chain wax acids ranging in length from C₂₂ to C₃₄. When this is esterified, the resulting partially synthetic montan wax derivatives are extremely hard, very light in colour and produce a very good polish (Volpker, 2005a). Applications for the montan waxes include (Volpker, 2005b):

- anti-blocking agent for polymer dispersions;
- car polishes;
- wood, paper, film and textile coating;
- co-emulsifier for paraffin emulsions;

- floor and leather polishes;
- lubricants for metal work and plastics;
- water-proofing agents;
- solvent-based polishes, especially pastes;
- coating for carbon papers;
- temporary anti-graffiti coatings; and
- citrus fruit coatings.

Note that these applications may be relevant to all types of montan waxes (not only to those based on Cr(VI) chemistry).

Although there are indications that production is still active in the EU by at least one company, consultation to date has not revealed any additional information. It is understood, however, that if this use is still active, it should account for only a small percentage of total consumption of sodium dichromate.

2.11 Catalysts

Chromium/iron catalysts are mainly used in “high temperature shift” reactions (catalysts for low temperature shift reactions do not contain chromium). These catalysts are usually Cr(III) oxide and iron oxide formulations, with iron being the major component; the chromium component of the catalyst acts as a support for the catalytically active iron component. The typical content of Cr(VI) could vary from 2% to 10% (expressed as a CrO_4^{2-} salt or CrO_3). The Cr(III) content may be as high as 50% (expressed in Cr_2O_3) (personal communication with industry). This type of catalyst has been in use since the early years of the last century.

The catalysts are used for conversion of carbon monoxide and steam to carbon dioxide and hydrogen. This is a vital process step in the manufacture of ammonia and hydrogen. The former is used primarily in the manufacture of nitrogen fertilisers; the most important use of the latter is in oil refineries, e.g. for hydro-treating and hydro-cracking (information submitted by industry).

According to the RAR, catalysts based on different formulations are currently being developed to replace chromium/iron catalysts. Over the past twenty years, sulphur resistant cobalt-molybdenum-containing catalysts have in part replaced iron-chromium oxide catalysts (EIPPCB, 2004a). Industry has confirmed that there has been extensive research carried out over many years aimed at replacing the chromium component of the catalyst; however, until now, success has been limited. The length of time for which industry has been using this type of catalyst indicates the technical difficulty in achieving replacement (information submitted by industry).

2.12 Other Uses

Other minor uses of Cr(VI) substances (that have not been taken into consideration in the assessment of risks in the RAR and, hence, will not be discussed further in this report) include:

- *photography*: potassium dichromate is used as a bleach in black and white film. Since little monochromatic film is now developed, this use is considered to be insignificant;
- *drilling*: sodium dichromate has also been used in the past in drilling muds in the oil industry;
- *corrosion inhibitor*: sodium dichromate has been used in the past (perhaps 20 years ago in the UK) as a corrosion inhibitor in cooling water but its use in this area has declined almost completely;
- *manufacture of activated carbon*: chromium trioxide is impregnated into activated carbon powder in some respirators. Chromium trioxide powder is mixed with other chemicals before the activated carbon is enclosed in gauze and used in the manufacture of respirators. This use was reported as being phased out at the time of writing the RAR; and
- *other minor uses (for chromium trioxide)*: these include reprographic processes and battery production.

2.13 Country-specific Data

2.13.1 Introduction

Information on the presence of Cr(VI) substances and their preparations has been collected for a small number of EU Member States during consultation and literature review. This is presented below.

2.13.2 Denmark

Overview

Information on the presence of Cr(VI) substances in the Danish market is currently available for 1999 (more accurately, for 1998-2000 on average) on the basis of information presented in a 2003 report by the Danish Environmental Protection Agency. This information is summarised in Table 2.16.

Application	Chromium substances consumption (t/y)	Hexavalent chromium substances consumption (t/y)
Surface treatment	37.7	37.7
Pigments in paint and plastic	12.6-116.7	1-2
Impregnation	8.8	8.8
Hardeners	13-47	<<1
Laboratory chemicals	<1	<1
Other applications	208-522	0

Source: Danish EPA, 2003

It should be noted that figures for leather tanning are provided in the Danish report but are not included above. These figures are subject to dispute, since they are reportedly based on the analysis of a small sample of leather products found on the market, by an analytical method that some experts believe to be unreliable at low levels (BLC, 2005).

With regard to specific Cr(VI) substances, the imports, exports, production and supply of these substances in 1998-2000 in Denmark are outlined in Table 2.17.

Note that more up to date information for four Scandinavian countries (Denmark, Finland, Norway and Sweden) for the year 2002 is provided further below.

Table 2.17: Import, Export, Production and Supply of Hexavalent Chromium Substances in Denmark (1998-2000)				
Substance	Import (t/y)	Export (t/y)	Production (t/y)	Supply (t/y)
Chromium oxides (VI and III) and chromium hydroxide	ca. 340	<5	0	ca. 340
Sodium dichromate	6	0	0	6
Potassium dichromate	0	0	0	0
Other dichromates	3	0	0.05	3
<i>Source: Danish EPA, 2003</i>				

Sector-specific Information

The following information reflects the situation in the different sectors in the Danish market in 2003. Information is taken from the work undertaken by the Danish Environmental Protection Agency (2003).

Metal Treatment

It is estimated that a total of 75 companies in Denmark carry out decorative chromium plating (nickel plating + chromium plating), and approximately 80% of all nickel-plated surfaces will also be finished by means of chromium plating. An additional eight Danish companies carry out hard chromium plating and three of these account for approximately 70% of the total production.

Approximately five Danish companies carry out black chromium plating. Just one of these companies uses 85% of all chromium trioxide used for this process in Denmark and accounts for 91% of the total surface treated in this manner.

Approximately 10 small companies are involved in acid pickling of aluminium and the associated consumption of chromium preparations is around approximately 2 tonnes/year. Nowadays, in Denmark, a nitric acid solution is usually used instead of chromium trioxide. With regard to anodising, no more than five Danish companies carry out chromic acid anodising of aluminium and they do so on a very small scale.

The total consumption of chromium trioxide is estimated to be approximately 200 kg/year.

Chromium passivation after phosphatising is carried out at approximately 30 Danish companies, but an increasing number of these companies (approximately 40%) now use a chromium-free method of passivation which yields the same results.

Only one Danish company carries out plastic metallising, and it uses approximately 6,000 kg chromium trioxide for pickling. The total treated surface of the plastic goods is estimated to be approximately 110,000 m²/year.

Pigments

The Danish Environmental Protection Agency estimates that, in 2003, slightly more than one tonne of lead (II) chromate was sold annually to the paint and varnish industry in Denmark. Two or three years earlier, the associated quantities were reported as being ten times higher. In 2003, chromates were only available on order and customers could only order the products if they had permission to use them. Previously, chromates of zinc and, to a lesser extent, strontium and barium had been used as anticorrosive agents in paints. Today, there exist alternatives to chromates, and this means that chromates are rapidly being replaced (Danish EPA, 2003).

With regard to plastics, during the 1990s, the use of lead chromates in plastic was replaced by organic pigments which do not contain any chromium. This has been suggested by the Danish plastics industry; however, the Danish Environmental Protection Agency has not been able to confirm this.

Wood Preservatives

The use of impregnation agents containing chromium has been reduced very significantly in Denmark through voluntary agreements and, since January 1997, agents which contain chromium may only be used with the appropriate dispensations. Ever since 1997, only a few manufacturers have been allowed to use CCB and CCP agents. In 1998, a total of 17,300 tonnes of wood containing chromium was produced, and approximately 37 tonnes of chromium was used in the process. The quantities produced corresponded to approximately 12% of the total production of impregnated wood.

At the end of 1999, only a single manufacturer had a licence to use CCP agents. Some of the impregnated wood imported into Denmark may still, however, contain chromium. Information available to the Danish Environmental Protection Agency suggests that almost 60 tonnes of chromium were imported as an ingredient in impregnated wood in 2000 (Danish EPA, 2003). Both production and import of wood preserved with arsenic is now prohibited (Danish EPA, 2001).

2.13.3 Italy

Metal Finishing

With regard to the metal treatment industry sector, consultation suggests that the number of plating shops is decreasing due to stiff competition from Chinese companies. The rate of decrease in the number of plating shops may be estimated at 3-4% per year. The consumption of Cr(total) and Cr(VI) is consequently expected to decrease in line with the changes in the market. Consumption is also expected to decrease due to a voluntary programme of substitution adopted by Italian companies (Italian MoE, 2005).

Pigments Manufacture

In Italy, strontium chromate use in coil coatings was successfully abandoned in the mid 1990s and now practically all coil coating lines in the country do not use primers containing the substance (personal communication with industry).

2.13.4 Lithuania

The information available in the Chemicals Registry of the Lithuanian State Non Food Products Inspectorate on uses and applications of Cr(VI) and preparations containing Cr(VI) is presented in Table 2.18.

Products	Production	Imports	Use	Supply	Applications	No. of companies
Na ₂ CrO ₄	No data	No data	No data	No data	No data	No data
Na ₂ Cr ₂ O ₇				1-10 t/y	Metal treatment formulation, tanning salts, mordant dyeing	1
Na ₂ Cr ₂ O ₇ preparations		<1 t/y		<1 t/y	Metal treatment formulation	1
CrO ₃		<2 t/y	1-10 t/y	1-15 t/y	Metal treatment formulation	4
CrO ₃ preparations	1-15 t/y			<2 t/y	Metal treatment formulation, wood preservatives	2
K ₂ Cr ₂ O ₇		<1 t/y	<1 t/y	<1 t/y	Chemical analysis	2
(NH ₄) ₂ Cr ₂ O ₇				<1 t/y	No data	1

Source: Lithuanian State Non Food Products Inspectorate (SNFPI), 2005

2.13.5 Poland

Information has been made available on the production, imports and exports of Cr(VI) substances in Poland for the year 2003 and is presented in Table 2.19.

Substance	Import (tonnes)	Export (tonnes)	Applications
Sodium dichromate	2,766	46	<ul style="list-style-type: none"> • production of other chromium compounds • metal treatment (cleaning agent, surface treatment) • organic chemistry as a oxidiser (production of vitamin K) • mordant dyeing • fibre bleaching • colouring agent
Chromium trioxide	2,587	1,740	<ul style="list-style-type: none"> • metal treatment formulation • pigment production • catalyst in organic chemistry • wood preservative formulation • textile bleaching agent
Potassium dichromate	0	152	<ul style="list-style-type: none"> • leather tanning • production of chromium compounds • organic synthesis • wood preservative formulation

Source: Polish Bureau for Chemical Substances and Preparations (BCSP), 2005

The Polish imports in the year 2003 originated from non-EU countries; the exports were made to a variety of countries inside and outside the EU.

2.13.6 Slovenia

Current Use of Chromium in Wood Preservatives

CCA as a wood preservative has been banned in Slovenia for almost 20 years, so it cannot be produced or imported into the country. Note that there appears to be a single producer of CCB preservatives in the country.

The amount of wood treated with wood preservatives is very difficult to estimate, as there is a large amount of impregnated wood imported. It is estimated that approximately 3 million cubic metres of wood are utilised every year in Slovenia. Of this, 1.3 million cubic metres of wood are used in furniture, construction purposes, and buildings. Of this wood, approximately 15-20% is treated with biocides. It is estimated that 50 to 70,000 m³ of wood is treated with CCB. Most of this wood is used for telecommunication poles, fences, noise barriers, etc. Only 5-10 % of this wood is used in DIY applications (Humar, 2005).

There are six impregnation plants in Slovenia. Two of them still use CCB while the other uses Bis-(N-cyclohexyldiazoniumdioxy)-copper (Cu-HDO) or copper amine, or boron-based preservatives. All wood preservatives need to be approved by a committee at the Slovenian Ministry for Health. Chromium-containing wood preservatives have old registrations only (Humar, 2005).

A lot of impregnated wood or products made of impregnated wood is exported to Austria and Germany, where chromium is, reportedly, undesirable for many uses.

Therefore, Slovenian treaters need to use alternatives. It is of note that in Slovenia, until now, chromium trioxide was/is treated as an active substance (Humar, 2005).

2.13.7 Slovak Republic

Current Use of Chromium in Wood Preservatives

In the Slovak Republic, there are no companies that formulate chromium-containing wood preservatives and industrial application of chromium-containing preservatives ceased in 2000. Before that, chromium-containing preservatives were used for poles and fence posts; now use may take place only in small private impregnation sites. The products mainly used in place of chromium-containing formulations include products based on boric acid and Cu-HDO, although quaternary ammonium salts and propiconazol are also used (Reinprecht, 2005).

2.13.8 Sweden

Production and Use of Chromium Compounds

Information from the Swedish Product Register shows that none of the five chromium compounds are manufactured in Sweden. They are imported as raw material for production (160t in 2003) as well as in chemical products (370t in 2003). The five chromium compounds are also exported as raw material from Sweden (7t in 2003) and as part of chemical preparations (34t in 2003).

In 2003, about 60t of the above amounts were used for metal treatment formulations and about 150t were used for metal treatment.

The most common Swedish use for the Cr(VI) compounds is in wood preservatives. A total of 28t of sodium dichromate and 410t of chromium trioxide were sold as wood preservative products in Sweden 2003 (KemI, 2005).

Current Use of Chromium in Wood Preservatives

There are no formulators of chromium-containing wood preservatives in Sweden and it is expected that by 2006 the use of such products will cease. The main current use of chromium-containing wood preservatives is for ground contact. A total of 89 wood treatment facilities were active in 2003 (SWPA, 2005).

In the Nordic countries copper chromium salts, CCB and CCP and creosote oils are approved for Hazard Class 5 uses (personal communication with industry).

2.13.9 United Kingdom

Current Use of Chromium in Wood Preservatives

Table 2.20 presents the number of wood preservatives formulations that are currently approved in the UK (as of 2 February 2005).

Type of formulation	Number of approved products	Number of formulators	Notes
CCA (CrO ₃)	23	4	Three products (out of 23) have either been voluntarily withdrawn for commercial reasons or revoked and hold approval for storage, supply and use but not for advertisement and sale under the Control of Pesticides Regulations 1986
CCA (Na ₂ Cr ₂ O ₇)	9	4	Two products (out of 9) have either been voluntarily withdrawn for commercial reasons or revoked and hold approval for storage, supply and use but not for advertisement and sale under the Control of Pesticides Regulations 1986
CC	6	3	
CCB	7	4	

Source: HSE, 2005b

2.13.10 Scandinavian Countries

Industrial Use of Hexavalent Chromium Substances

Information on industrial use of the five Cr(VI) substances for Denmark, Finland, Norway and Sweden is available online in the SPIN 2000 database (www.spin2000.net). The most recent data available (for the year 2002) are reproduced in Table 2.21.

Country	Na ₂ CrO ₄		Na ₂ Cr ₂ O ₇		CrO ₃		K ₂ Cr ₂ O ₇		(NH ₄) ₂ Cr ₂ O ₇	
	Tonnage	Preparations	Tonnage	Preparations	Tonnage	Preparations	Tonnage	Preparations	Tonnage	Preparations
Denmark	0.0	11	1.1	11	6814.9	65	10.1	14	Conf	Conf
Finland	0.0	4	13.2	9	8188.5	69	1.4	8	Conf	Conf
Norway	No data	No data	284.4	9	119.4	24	No data	No data	No data	No data
Sweden	7.0	6	68.0	25	715.0	150	12.0	21	Conf	Conf

Source: SPIN 2000 Database available at www.spin2000.net
Note: 'Conf' indicates confidential information

Denmark and Finland appear to be the major consumers of Cr(VI) compounds, however there appears to be limited data on Norway and some of the information has been treated as confidential.

3. RESULTS OF THE ESR RISK ASSESSMENT

3.1 Overview

This Section provides an overview of the assumptions made in the environmental risk assessment calculations and the results of the risk assessment as presented in the RAR. The aim is to describe the nature of the environmental effects of Cr(VI) substances identified in the RAR that are of importance to the RRS. Towards the end of this Section, a short overview of the risks to human health identified in the RAR is also included.

Note that a summary of uncertainties in the RAR is provided in Section 8 as a backdrop to the recommendations for this environmental RRS.

3.2 Background to the Environmental Risk Assessment

3.2.1 Introduction

The RAR covers the following areas of the life cycle of the five Cr(VI) substances:

- production;
- pigment production;
- chromium oxide production;
- tanning salts;
- wood preservative formulation;
- wood preservative application;
- treated wood in use;
- metal treatment formulation;
- metal treatment - electroplating, passivating, anodising, brightening; and
- mordant dyeing.

In addition, the following processes were not considered to have significant releases to the environment and so they were believed not to present a risk:

- chromium metal production;
- chromium dioxide production; and
- montan wax production.

Use of Cr(VI) substances in the oxidation of sulphur dyes is discussed in the RAR, but not assessed as this no longer occurs in Europe (CEC, 2002).

3.2.2 General RAR Assumptions on Releases

General Assumptions Influencing Exposure

The RAR assumes that:

- the five Cr(VI) substances are of low volatility and so emissions to air are unlikely from most processes. Any releases will be in particulate form;
- there are potential releases to water as some of the processes take place in water; and
- there are no direct emissions to land, although the particulate emissions to air are likely to be deposited to land.

Transformation of Hexavalent Chromium to Trivalent Chromium

Cr(VI) released from any source is expected to be reduced to Cr(III) in most situations in the environment; therefore, the impact of Cr(VI) is likely to be limited to the area around the source. For this reason, the RAR has focused on the local impact of emissions from the production and use of the five Cr(VI) compounds.

The behaviour of chromium species in the environment can be influenced by environmental factors, such as pH and water hardness. While these factors were taken into consideration in the assessment of risks, detailed relationships between properties and environmental factors were not developed for the purposes of the RAR.

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 Predicted Environmental Concentrations (PECs). One is intended to represent acidic environments (pH below 6) and the other to represent neutral-alkaline environments (pH greater than 6). The rapporteur emphasises that these should not be seen as detailed alternative environments, but may be used to illustrate differences in behaviour in different areas.

Environmental Fate of Hexavalent Chromium

Degradation

For the assessment of risks in the RAR, it has been assumed that for acidic (or neutral, where high concentrations of reductants for Cr(VI) exist) soils, sediments and waters, Cr(VI) will be rapidly reduced to Cr(III) and that 3% of the Cr(III) formed will be oxidised back to Cr(VI). The net result of this is that of the estimated Cr(VI) release to the environment, 3% will remain as Cr(VI) and 97% will be converted to Cr(III). Note that these values resulted from the discussion presented in the RAR (see Section 3.1.0.2.1 of the RAR).

Under less favourable conditions, e.g. alkaline conditions ($\sim\text{pH}>8$) and/or neutral conditions, where low concentrations of reductants for Cr(VI) exist, it was assumed that the rate of reduction of Cr(VI) to Cr(III) is slow, with a long half-life of around 1 year.

Bioavailability and Speciation

The RAR notes that (Section 3.2.1 of the RAR), under the conditions of the aquatic tests, it is expected that the chromium will remain predominantly in the form in which it is added. The limited data available on conditions that influence bioavailability do not support the development of quantitative relationships. As tests are usually carried out under conditions of high availability, it is recognised that there may be an over-estimate of the toxicity under other conditions. The PEC values do depend on the environmental properties, so to some degree the issue of availability is incorporated into the PEC part of the calculations.

It is of interest that the then Scientific Committee on Toxicity, Ecotoxicity and the Environment (CSTEE, now SCHER) in its comments of 10 September 2003 on the environmental part of the RAR notes that, although some evidence on the importance of environmental parameters (e.g. hardness) is available in the RAR for invertebrates and fish, the issue of bioavailability should be further examined and discussed to quantitatively assess the importance of considering Cr speciation and bioavailability. The final version of the RAR included the above paragraph (in its Section 3.2.1) to address the bioavailability issue highlighted by the CSTEE and to clarify the approach taken in the preparation of the RAR.

Similarly, for the terrestrial environment, the CSTEE also commented on the importance of bioavailability of chromium and its transformation from Cr(VI) to Cr(III) for the evaluation of its effects to terrestrial organisms. The rapporteur notes that the assumption made in the RAR is that the added chromium is completely available (recognising that this is probably unrealistic when considering applications to soil over a period of 10 years). The importance of background chromium could not be determined without an extensive research programme, but the limited observations available indicated that it is largely unavailable. Further consideration of this would also have to include all sources of chromium (Environment Agency, 2003).

Adsorption

Cr(III) is more likely to partition to solids in the sediment and soil. For the water column, Cr(VI) and Cr(III) have similar adsorption partition coefficients for suspended solids, which are greater than those found for sediment and soil.

The adsorption of Cr(VI) is pH dependent. Under alkaline conditions, Cr(VI) is not readily sorbed and remains highly mobile. In acidic oxidised sediments with a high content of iron and manganese oxides or clay minerals, Cr(VI) should be adsorbed more strongly onto the sediment as the higher net positive charge present in acidic sediment should provide more or stronger sites for adsorption of the Cr(VI) anions. Cr(III) appears to be much more strongly adsorbed to soils and sediments than Cr(VI).

Behaviour in Wastewater Treatment Plants

A high percentage of Cr(III) (typically >80% in plants with secondary treatment) is removed from the water phase by adsorption onto the particulates and sludge. Most of the Cr(III) in the effluent from wastewater treatment plants appears to be associated with the particulate phase.

For Cr(VI), some reduction to Cr(III) would be expected to occur during biological wastewater treatment; however this may be limited in plants using aerobic activated sludge secondary treatment. Therefore, removal of Cr(VI) from the water phase during wastewater treatment would be due to both adsorption and reduction. Since Cr(VI) is more soluble and generally shows lower adsorption to particulate matter than Cr(III), a worst-case figure of 50% removal by adsorption onto sewage sludge was chosen.

In summary, the following worst-case values were used in the RAR for removal during wastewater treatment:

- Cr(VI): 50% adsorbed onto sewage sludge, 50% in effluent; and
- Cr(III): 80% adsorbed onto sewage sludge, 20% in effluent (associated mainly with the particulate phase).

Focus on Local Risks – The ‘Added Risk’ Approach

The wider background emissions of chromium from other sources are not considered for risk assessment. As a result, the concentrations calculated in the assessment of risks are local ones (as C_{local}), 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. This means that a possible contribution of the natural background concentration to toxic effects is effectively ignored. The rapporteur recognised that the wider background contributions may need to be considered when considering the effects of risk management measures.

Overall Approach to Environmental Releases

Local water concentrations are not adjusted in the RAR for transformation or degradation processes according to the TGD on Risk Assessment; only dilution and adsorption are taken into account. This has been addressed in this assessment by expressing the water concentrations either as Cr(VI) or as Cr(III), with the assumption that all of the chromium in the dissolved phase is available. These calculations reflect the plausible extremes and allow the consideration of the ends of the risk spectrum. In most real situations the ion composition will be between these extremes, with Cr(VI) in discharges being converted into Cr(III) over time and at a rate depending on the local environmental conditions. Hence the real picture is potentially very complex, and the information available was not sufficient to allow this to be described accurately. The calculations

have, therefore, been simplified out of necessity. It was recognised that this approach may result in the over-estimation of risk under some circumstances.

3.2.3 Compartment-specific RAR Assumptions on Releases

Releases to Water

Although companies involved in the production and use of the five Cr(VI) substances have provided information that suggests that their wastewater is treated before release, it was not possible to estimate at the time of writing the RAR how widespread the use of this or other clean-up processes were, although in view of the controls on chromium emissions in place in most countries some form of treatment would be expected. Also, it was not possible to derive any realistic figures for the efficiency of the process, although from a number of the examples provided this can be greater than 99%. Hence, the estimation of PEC values and the risk characterisation in the RAR was largely based on default release values.

The PECs were calculated in two ways: the first assumed that all chromium remains in the form of Cr(VI) when released (an extreme worst-case), while the second method assumed that all the chromium is in the form of Cr(III) before release.

For discharges to wastewater treatment plants, the fate of chromium has been estimated as described above: for Cr(VI), 50% to sludge and 50% in water; for Cr(III), 80% to sludge and 20% to water. The default sizes for a wastewater treatment plant and dilution from the TGD on Risk Assessment have been used.

It is of note that concentrations calculated for specific sites involved in some of the processes give ratios less than 1 for pigment production and chromium metal production, and above one for a tannery using dichromate on-site, and chromium dioxide production. Also, there are a few measurements of levels of chromium in sludges from wastewater treatment plants, with no indication of specific industrial activities responsible. These levels are 2-3 orders of magnitude lower than those estimated in the RAR for Cr(VI) or Cr(III). Nevertheless, the rapporteur considered that the available measured levels data are not sufficient in extent or specificity to replace the calculated values, and, hence, the assessment was based on the calculated concentrations.

Wastewater Treatment Releases

Two effluent concentrations were calculated for each use area, for Cr(VI) and Cr(III).

The rapporteur recognised that the widespread use of the Cr(VI) compounds meant that many wastewater treatment plants would receive effluent containing chromium from these processes. As the performance of wastewater treatment plants is monitored regularly this implies that they are not receiving such high concentrations of Cr(VI) as have been calculated in the RAR. This may be due to clean up of the wastewater on the processing site before release to sewer, or to possible acclimation to higher Cr(VI) levels.

Sediment

For sediment, both the C_{local} values and the Predicted No Effect Concentrations (PNECs) have been derived through use of the equilibrium partitioning method. Based on this, the risk characterisation ratios for sediment were the same as those for water.

Releases to Soil

The major route to soil included in the calculations is through sludge application. The specific information provided by users indicated that sludge is generally disposed of to landfill. Any clean-up measures used before release to sewer would also reduce the amount of chromium available to absorb to sludge and, therefore, applied to land. As with the aquatic compartment, some information on these aspects was available for individual sites, but no overview of the situation across the EU was available. Any restrictions on the application of sludge containing metals to soils that may be in place in any of the EU Member States have not been taken into account in the risk calculations in the RAR.

The values obtained from the RAR calculations are around two orders of magnitude higher than measured levels in sludge applied to agricultural soils in the UK. In Germany the chromium content in sewage sludge used in agriculture was monitored as 52, 52 and 46 mg/kg dry weight in 1995, 1996 and 1997 respectively. The calculated PEC values for the different lifecycle areas range from 10 to 9,900 mg/kg dry weight for Cr(VI) and between 16 to 12,000 mg/kg dry weight for Cr(III)¹⁸ with most values being of the g/kg dry weight order.

The RAR assumes that the removal rate for chromium from soil is zero which means that continuous input to soil would eventually bring all risk characterisation ratios to greater than unity. However, the available fraction of chromium in soil (available to plants and fauna) has been quoted in the RAR as being generally low, at 0.1-1%. This could indicate that as the soils age, the chromium is converted into insoluble forms which then are not available to have an effect on organisms. If a factor of 1% were applied to the risk characterisation ratios calculated in the RAR, then all but the direct release to soil from wood preservative treatment on acid soil would give a ratio less than 1. Thus the calculated ratios may overestimate the effects of chromium.

It should be noted that the terrestrial PNEC for Cr(III) was derived from experiments where a highly soluble (and hence bioavailable) form of Cr(III) has been tested. The rapporteur recognises that in the environment, Cr(VI) is likely to be reduced to forms of Cr(III) of limited solubility and bioavailability, where it is unlikely that the concentration of “dissolved” and hence available Cr(III) will reach the levels where effects might be expected. Data from surveys of species at locations close to a major production site suggest that the risk characterisation ratios in the RAR probably overestimate the potential for effects from chromium in soil.

¹⁸ Two ranges are given since there are two PEC values for wastewater treatment plants for Cr(VI) and Cr(III).

3.2.4 Process-specific RAR Assumptions on Releases

Releases during Production

The five substances are largely used to make other substances and so can be categorised as intermediates. Some of the substances also have direct uses in metal treatment and wood preservation and as reactants in the production of other chemicals and processes such as dyeing.

The releases used in the RAR (which are based on data provided by industry) cover all the processing of chromite ore and the production of the five Cr(VI) substances in the EU. They also include some of the subsequent processing of these substances into other products which takes place at these sites.

With regard to production Site 3 which has been associated with a Conclusion (iii), the site had a solid waste treatment plant that receives solid waste from the kiln and the sludge from the wastewater treatment plant. Cr(VI) impurities in the solid waste from this facility were present at a concentration of 8 mg/kg. The solid waste was eventually transported to a waste disposal site. Communication with representatives of the company involved suggests that production on the site has now ceased (and has been relocated to a country outside the EU).

Releases from Metal Treatment Formulation

For the purposes of the RAR, it has been assumed that all of the chromium used goes through a formulation step. Parameter assumptions include:

- tonnage of chromium trioxide used in metal treatment: 9,010 t/y;
- default emission factors for the formulation step: 0.003 to water and 0.0025 to air; and
- fraction of main source: 0.8 (this is based on the tonnage of chromium trioxide rather than that of the formulations, in the absence of information on the proportion of chromium trioxide in the formulations).

Information provided to the rapporteur by a formulator of metal treatment preparations suggested that they used ca. 350 t/y Cr(VI) compounds. The site had an effluent treatment system, which reduces Cr(VI) to Cr(III) and precipitated the chromium as sludge with other metals. The estimated emissions to water were <1 kg/year, as Cr(III). A similar release to air was also estimated. The majority of chromium waste was disposed of in the sludge sent to landfill. Due to limited information available, the risk characterisation in the RAR is based on default values.

Releases from Metal Treatment Processing

Assumptions were largely based on a Use Category Document. Processes are treated independently, although the rapporteur recognises that they can take place at the same location.

The emission estimates for the following processes do not take into account any removal of chromium from the effluents before discharge to the sewer.

Electroplating

The following have been assumed:

- typical size of treatment bath: 5,000 litres (with two 1,000 litre rinse baths and a counter-current rinse flow of 100 l/hour);
- a realistic large-scale chromium plating site processes 40 m²/hour of metal and operates for 12 hours per day, for 240 days per year (industry information);
- drag-out volume: 2 l/hour;
- concentration of chromium trioxide in solutions used for decorative plating: 350-450 g/l;
- maximum rate of removal of chromium trioxide in the drag out: 0.9 kg/hour;
- percentage of drag-out to be returned to bath: 25%; and
- contents are not usually disposed of with any regularity.

The above may not be entirely representative for hard chrome plating (it involves lower drag-out rates) but were taken forward as a worst-case scenario.

Passivating

The following have been assumed:

- drag-out rate: 2 l/hour;
- typical size of the treatment bath: 1,000 litres;
- maximum concentration of chromium trioxide used: 280 g/l for copper and copper alloys;
- operation time: 12 hours per day; and
- passivating solutions are replaced every two weeks. The solutions are assumed to contain the active components at their effective concentrations, so that the amount of chromium trioxide disposed of is 1,000 litres x 280 g/l or 280 kg.

Anodising

The following have been assumed:

- typical size for the treatment bath: 5,000 litres;
- drag out rate: 2 l/hour;
- typical concentration of chromium trioxide in treatment bath: 80 g/l;
- return rate for rinse water into bath: 25%;
- operation time: 12 hours per day; and
- rinse flow: 100 l/hour.

Brightening

The following have been assumed:

- typical size for the treatment bath: 1,000 litres;
- drag out rate: 2 l/hour;
- typical maximum concentration of chromium trioxide in treatment bath: 350 g/l;
- operation time: 12 hours per day; and
- rinse flow: 100 l/hour.

Releases from Hexavalent Chromium Pigment Production

The following have been assumed:

- amount of sodium dichromate used in pigment production: 2,000 tonnes;
- default emission factors: 0.007 to wastewater and 0 to air;
- use at a representative site: 670 t/y sodium dichromate (based on industry data); and
- production takes place for a total of 168 days a year.

Information on releases provided to the rapporteur by a company that produces pigments appears not to have been used in the risk characterisation calculations. According to this source, there were no emissions to air from the sodium dichromate solution. The whole of the production water was collected and all the soluble Cr(VI) was reduced with excess of a bivalent iron salt to insoluble Cr(III) compounds in water treatment facilities and then eliminated by precipitation. Cr(VI) was not detected in the treated wastewater.

Releases from Trivalent Chromium Oxide (Pigment) Production

This oxide of chromium was made on the production sites and releases from this process on these sites are included in the estimates for production. It was also made on-site by manufacturers of magnetic media via the decomposition of ammonium dichromate; however, information collected during consultation for this RRS suggests that this process is not used in the EU any more. This process was not considered to be associated with unacceptable risks.

The following have been assumed for Cr₂O₃ for sites other than the ones mentioned above (industry suggests that the majority of the production of Cr₂O₃ takes place at the sites on which chromates are/were manufactured):

- amount of sodium dichromate used in the production of chromium oxide: 7,750 t/y;
- default emission factors: 0.007 to wastewater and 0 to air; and
- use at a representative site: ca. 340 t/y sodium dichromate (based on industry data).

Releases from Chrome Tanning Salts Manufacture

Chromium sulphate, basic chrome sulphate and other related Cr(III) compounds are made at the production sites and at other locations. This is the major use of sodium dichromate away from the production sites (this is confirmed by consultation findings). The release estimates in the RAR also covered emissions from tanneries where sodium dichromate conversion takes place on-site as well as emissions from processes where tanning salts are produced as a by-product (e.g. vitamin K manufacture, but not wax manufacture).

The following have been assumed:

- amount of sodium dichromate used in the production of chrome sulphate: 13,500 t/y;
- default emission factors: 0.007 to wastewater and 0 to air; and
- use at a representative site: 1,490 t/y sodium dichromate.

Information provided to the rapporteur by a single tannery that purchases sodium dichromate suggested an estimated loss of total chromium of around 1%.

Releases from Wood Treatment Formulation

Wood preservative treatments other than CCA contain Cr(VI) in the form of the five substances that were the subject of this assessment. The whole amount of chromium used in this area has been treated as CCA for simplicity.

The following have been assumed:

- amount of chromium trioxide used in wood treatment: 2,740 t/y chromium;
- average chromium content of the standard formulations: 15%;
- industry category for wood treatment: IC = 0 (others);
- release fraction: 0.003; and
- CCA production at a representative plant: ca. 4,600 t/y CCA over 300 days per year.

Releases from Wood Treatment Processing

The main sources of loss of preservative solution from wood treatment processes include leaks and drips from treatment vessels and solution drippings from treated timber. These types of releases can be effectively contained by using bunded areas.

The following have been assumed:

- average application rate for CCA: 9 kg/m³ (industry information);
- use of CCA at a representative site: 162 t/y CCA (worst-case);
- estimated maximum emissions of chromium to soil and water: 0.18-0.45%;
- estimated amount of chromium in contaminated solid waste: 0.02-0.09% of chromium;

- operation time: 300 days per year; and
- releases are split equally between soil and water.

Releases from Treated Wood

According to the RAR, the majority of the chromium impregnated into the wood is converted into Cr(III) and any Cr(VI) released to soil will also be rapidly converted. Chromium levels in soil close to treated wood decrease with depth and distance from the wood. A similar pattern has also been found in sediments, so that the contamination from this source is limited. The RAR uses measured levels close to treated materials as local concentrations.

It is of note that CCA-treated timber could also be used in circumstances where it would be in contact with surface water where there was more possibility for any chromium released to move away from the source.

The main source of information on the leaching of chromium from treated wood in the RAR was the Braunschweiler *et al* (1996) report and work undertaken by the Dutch National Institute for Public Health and the Environment (RIVM).

The first, for which more information is available, assesses the risks from release of metals to the environment from treated wood over a period of 1, 5, 10 and 30 years. The report makes a number of assumptions to develop worst-case scenarios for the releases of copper, chromium and arsenic. The authors note that their PECs for metals in soil correspond well with maximum measured soil concentrations which are due to use of CCA-treated wood, except for chromium. One reason for the PECs for chromium in soil being higher than measured was the high background concentration of chromium in soil used in the estimation. The high value was due to the strong extraction technique used in the geochemical survey analysis for soil chromium. However, this was also taken into account in the established PNEC value for chromium in soil. Thus, the authors suggest that the exposure assessment for soil was at the right level. In other environmental compartments, the accuracy of the predicted exposure level could not be evaluated because no relevant measured data was available on metal contents in groundwater and fresh surface waters exposed to CCA-treated wood (Braunschweiler *et al*, 1996).

Table 3.1 presents the calculated local PEC values for CCA, CC and CCP formulations while Table 3.2 summarises the risk characterisation ratios for soil, groundwater and surface water.

The 1996 environmental risk assessment was refined in 2001 in light of:

- new data submitted by industry requesting re-approval for their products;
- other available new data and technical and scientific developments in environmental risk assessment methodology; and

- international regulations related to CCA and CC types of wood preservatives in general (such as the European Commission Decision 2001/118/EC on the list of hazardous waste and the EU Biocidal Products Directive 98/8/EC).

Overall, there was no substantial change in the conclusions to be made compared to the environmental risk assessment in 1996. The copper, chromium and arsenic compounds released from the treated wood showed a risk ratio above 1 due to the additive effects in all the environmental compartments assessed. The new data, especially the leaching rates of the CCA constituents, reduced to some extent the estimated risks for groundwater and surface water. On the other hand, the 2001 estimates of the environmental risks from the CC preservative were generally higher than estimated in 1996 (Braunschweiler, 2001). It should be noted that Cr(VI)-based products had their approvals renewed both after the 1996 report and after the 2001 revision (though with conditions attached).

Table 3.1: Summary of Calculated PECs in Soil (PECs, mg/kg), Groundwater (PECg, µg/l) and Surface Water (PECw, µg/l) from Wood Treated with CCA, CC and CCP for the Nordic Protection Class A (Braunschweiler 1996 Report)

PEC (mg/kg or µg/l)	CCA			CC		CCP		
	Cu	Cr	As	Cu	Cr	Cu	Cr	P
Realistic worst-case scenario								
PEC _s 1 year	43	105	11	44	93	54	101	
5 years	67	170	25	68	130	93	160	63
10 years	86	220	36	87	150	120	200	114
30 years	130	260	74	180	330	190	230	
Measured max. soil concentration	≤480 30 y: 48-76	160 30 y: 24-46	92 30 y: 19-183					
PEC _g (µg/l)	510	3.6	23000	520	1.9	810	3.1	2200
PEC _w (µg/l)	920	310	280	930	160	1500	260	2600
Typical case scenario								
PEC _s 1 year	28	89	6.6	34	83	30	87	22
PEC _g	14	0.32	6500	41	0.23	22	0.30	220
PEC _w	150	110	79	470	32	240	93	530

Source: Braunschweiler et al, 1996

Note: For worst case scenario in soil, PECs of the metals after 5, 10 and 30 service years are also estimated assuming the leaching of copper from wood during the first service year to be three times higher than in the subsequent years. For chromium and arsenic, the first year's leaching is assumed to be 1.5 times higher than the following year's. After 6 service years, the leaching is assumed to decrease by half. Thus with the worst-case assumptions, all metals have been leached from the wood in 30 years. For comparison, maximum measured concentrations (mg/kg) of the metals in soil adjacent to CCA treated are also given

In the 1996 report, the scenario used was of a pond with treated wood at its edge such that there was 1 m³ of wood to 100 m³ of water. The wood was assumed to have a chromium content of 1.764 kg/m³; the fraction of the chromium expected to leach to water in the first year was 0.14. The fraction of the chromium associated with particulates was taken as 0.75, and it was assumed that 50% of the water in the pond

would be changed over the year. The resulting concentration of chromium in the water was 309 µg/l (including contribution from the background). The leaching rate of 0.14 was considered to be a realistic worst case; a further calculation with a ‘typical’ rate of 0.05 was also carried out, giving a water concentration of 108 µg/l.

Table 3.2: Summary of the Local PEC/PNEC Risk Ratios in a Realistic Worst-case due to the Use of Wood Treated with a CCA, CC or CCP for the Nordic Wood Preservation Classes A or AB (Braunschweiler 1996 Report)

Metal	Protection class A			Protection class AB		
	CCA	CC	CCP	CCA	CC	CCP
Surface soil after the first service year						
Copper	1.4	1.5	1.8	1.1	1.5	1.8
Chromium	1.0	0.93	1.0	0.95	0.93	1.0
Arsenic	1.1	A	A	0.96	A	A
<i>Total</i>	3.5	2.4	2.8	3.0	2.4	2.8
Surface soil after 30 service years						
Copper	4.2	6.0	6.2	B	B	B
Chromium	2.6	3.3	2.3	B	B	B
Arsenic	7.4	A	A	B	B	B
<i>Total</i>	14	9.3	8.5	B	B	B
Groundwater of a sandy soil						
Copper	34	35	54	16	35	54
Chromium	3.6	1.9	3.1	2.2	1.9	3.1
Arsenic	2,300	A	A	1,900	A	A
<i>Total</i>	2,300	37	57	1,900	37	57
Small pond with a volume of 1000 m³						
Copper	180	190	290	C	C	C
Chromium	44	23	37	C	C	C
Arsenic	56	A	A	C	C	C
<i>Total</i>	280	210	330	C	C	C
<i>Source: Braunschweiler et al, 1996</i>						
<i>Note: ‘A’ indicates not applicable, ‘B’ indicates not calculated, ‘C’ indicates protection class not suitable.</i>						

RIVM carried out similar calculations for a situation where the treated wood is at the edge of a ditch. The dimensions of the ditch were assumed to be 5 m wide and 1.5 m deep, with a flow rate of 375 m³/day. Two scenarios were used, one with 100 m of treated wood edging the ditch and the second with 1 km of treated wood. The flow rate meant that water traversed the lengths of treated wood in 2 days and 20 days respectively. The results are presented in Tables 3.3 and 3.4.

Table 3.3: Maximum Concentrations and Concentrations for Chromium in Water After 28 Days for Ditch Scenario (RIVM)

Concentration in ditch water with 1 km long facing (µg/l)		Concentration in ditch water with 100 m long facing (µg/l)		Conditions	
20-day (max)	28-day	2-day (max)	28-day	Temperature	pH
27.4	18.3	5.4	2.4	8°C	7
41.4	25.1	9.3	3.4	20°C	7

Source: CEC, 2002 (based on confidential information from RIVM)

Table 3.4: Water and Sediment Concentrations After 1 Year for Chromium for Ditch Scenario (based on different estimates)

Water (µg/l)	Sediment (mg/kg)	Temperature	pH
3.4 - 9.5	655 – 1,810	8°C	7
5.3 – 11.6	1,010 – 2,210	20°C	7

Source: CEC, 2002 (based on confidential information from RIVM)

With regard to releases to water the concentration of 108 µg/l in pond water gives a $C_{local}/PNEC$ ratio of 23 (the aquatic PNEC is 4.7 µg/l for Cr(III)). The RIVM peak and 28-day concentrations are also higher than the PNEC values for Cr(VI) and Cr(III) for a 1 km length of fence. The maximum concentration for a 100 m fence was also above the two PNECs, but values after 28 days were below both PNEC values. Concentrations calculated for one year after application exceeded the PNECs in some cases (CEC, 2002).

Note that a PNEC for Cr(VI) for micro-organisms (in a WWTP) has been derived, as 0.21 mg/l, and a value of 10 mg/l for Cr(III).

Summary of Releases

The releases estimated following the above assumptions, expressed as chromium, are summarised in Table 3.5 which replicates Table 3.2 of the RAR. The Table also provides estimates for the total releases in the EU from these processes reached upon using the same assumptions as for the local emissions (with the exception of those from metal treatment use, where the TGD default emission of 0.5 has been used as a worst case).

Process	Compartment	Quantity emitted (t/y)	Quantity emitted (kg/day)	Continental releases (t/y)
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	2,342

Source: CEC, 2002

Tables 3.6 and 3.7 outline the predicted (calculated) concentrations of chromium in the compartments of concern, as presented in the RAR.

Process	Calculated local concentrations in water				Concentrations in effluents from WWTP	
	Emission to WWTP (kg/day as Cr)	C _{local} as Cr (VI) (mg/l)	C _{local} as Cr (III) (mg/l)		C _{eff} as Cr (VI) (mg/l)	C _{eff} as Cr (III) (mg/l)
			Acid	Alkaline		
Pigment production	11	0.28	0.076	0.02	2.75	1.1
Cr ₂ O ₃ production	12	0.30	0.083	0.022	3.0	1.2
Chrome tanning salts	14	0.35	0.097	0.025	3.5	1.4
Wood preservative formulation	6.9	0.17	0.048	0.013	1.7	0.69
Wood preservative application	0.18	0.0045	0.0012	0.00033	0.045	0.018
Metal treatment formulation	3.7	0.093	0.026	0.0067	0.93	0.37
Electroplating	4.3	0.11	0.030	0.0078	1.1	0.43
Passivating	3.5	0.088	0.024	0.0064	0.88	0.35
Anodising	0.73	0.018	0.005	0.0013	0.18	0.073
Brightening	4.4	0.11	0.030	0.008	1.1	0.44

Source: CEC, 2002

Process	Sludge (in mg/kg dw)		Soil (as Cr(III) mg/kg)	
	C _{sludge} as Cr (VI)	C _{sludge} as Cr (III)	Arable soil	Grassland
Production			2.0	3.6
Pigment production	7,700	12,000	182	73
Chromium oxide production	8,500	14,000	199	80
Tanning salts production	9,900	16,000	232	93
Wood preservative formulation	4,900	7,800	114	46
Wood preservative application	130	200	3.0	1.2*
Metal treatment formulation	2,600	4,200	61	25
Electroplating	3,000	4,800	71	29
Passivating	2,500	3,900	58	23
Anodising	510	820	12	4.8
Brightening	3,100	5,000	73	29

Source: CEC, 2002
** mainly due to sludge – aerial contribution is 5%*

3.3 Lifecycle Areas Associated with Conclusion (iii)

Table 3.8 summarises the lifecycle stages and the associated environmental compartments for which Conclusion (iii) has been reached in the RAR.

This RRS will address the risks from the lifecycle areas for which a Conclusion (iii) has been reached in the RAR with the exception of the production of Cr(VI) substances, the use of treated wood and the use of Cr(VI)-containing wood preservatives, as discussed separately below.

3.4 Lifecycle Stages Excluded from the Environmental RRS

3.4.1 Production of Hexavalent Chromium Compounds

At the time of writing the RAR, there were three producers of Cr(VI) substances. All three producers provided emissions data to the UK rapporteur. Those data were taken into account in the characterisation of risks and the conclusion was that one of the sites was associated with unacceptable risks to the aquatic environment.

Consultation for this RRS has revealed that only one producer of Cr(VI) substances is currently active. This producer has provided information on his currently employed risk reduction measures, as summarised in Section 4.6.1. This plant is not the one that was identified with unacceptable risks to the aquatic environment. The emissions from this plant to both (surface) water and air are considerably lower than the emissions data for

the years 1996 and 1997 that had been provided to the rapporteur for the purposes of the RAR. Therefore, it is safe to assume that the site does not require further risk reduction measures.

Table 3.8: Lifecycle Areas of Cr(VI) Substances Associated (✓) with Conclusion (iii) in the RAR

Lifecycle area	Aquatic environment	Terrestrial environment	Wastewater treatment
Production	✓ (only for one site)	✗	✗
Pigment production	✓	✓	✓
Chromium (III) oxide production	✓	✓	✓
Tanning salts	✓	✓	✓
Wood preservative formulation	✓	✓	✓
Wood preservative application	✓	✓	✗
Treated wood in use	✓	✓	✗
Metal treatment formulation	✓	✓	✓
Metal treatment application	✓	✓	✓
- Electroplating	✓	✓	✓
- Passivating	✓	✓	✓
- Anodising	✓	✓	✗
- Brightening	✓	✓	✓
Mordant dyeing	✗	✗	✗

Source: CEC, 2002

It is theoretically possible that other companies may start producing Cr(VI) in the EU. Any such company will be regulated under IPPC and it can be assumed that emissions of Cr(VI) to the environment will be taken into consideration when issuing permits for any such installation.

3.4.2 Use of Wood Treated with Chromium-based Wood Preservatives

Choosing an Appropriate Framework for Addressing the Potential Risks

Consultation with the HSE and DG Environment

On the first Steering Group meeting of 9 May 2005, the attendees discussed the merits of controlling the risks to the environment from Cr(VI) in wood preservatives under the Biocidal Products Directive rather than the ESR. The representative of the UK ESR rapporteur (the Environment Agency, responsible for preparing the Environment part of the ESR RAR) suggested that, at the time of writing the RAR, a scenario was developed to demonstrate any issues of concern with regard to the formulation and application of

chromium-containing wood preservatives; however, the intention was not necessarily to provide a full assessment of the issue.

It can be argued that the Competent Authorities involved in the implementation of the Biocidal Products Directive (will) have more expertise on issues relevant to this use of Cr(VI) and, therefore, any risks from Cr(VI) from this use should be addressed within the Biocidal Products Directive framework. Cr(VI) compounds are classified as carcinogens, i.e. they are ‘substances of concern’ under the Biocidal Products Directive, therefore, as such, they would be subject to more or less the same risk assessment process as those substances considered to be ‘active substances’ under the Biocidal Products Directive.

After the Steering Group meeting, the views of the HSE (responsible for the human health RRS) and the European Commission were sought.

HSE indicated that their Policy Division had considered the issue of addressing the human health risks from Cr(VI) in wood preservatives under the Biocidal Products Directive regulatory framework. However, “*given the complexity of chromates under the Biocidal Products Directive, the HSE policy line was to deal with them under the existing framework of ESR*” (HSE, 2005c).

Consequently contact was made with Directorate-General (DG) Environment at the European Commission. The representative of DG Environment agreed that “*in principle, a risk that is specifically related to a biocidal use of a chemical is to be dealt with under the Biocidal Products Directive. However, in order for risk management to be effective, we should also take into account whether the risk is then likely to be dealt with under that framework*”. Given the complexities of the case of chromium under the Biocidal Products Directive (see Section 4.1.7 on the discussion on chromium being an active substance or not), DG Environment advised that this RRS covers the issue of the possible risks from the use of treated wood under the ESR framework (van der Zandt, 2005).

Choice of the Appropriate Framework

Defra has considered the views of the members of the Steering Group (which, it should be noted, were mixed – some members considered that the Biocidal Products Directive could allow for different approaches in different EU Member States with regard to chromium in wood preservatives, i.e. a lack of market harmonisation) and those of the HSE and of DG Environment.

Following internal discussions, Defra decided that, although the points made by some Steering Group members, the HSE and DG Environment on the potential complications under the Biocidal Products Directive were valid, the best way forward would be for any risks from the use of treated wood to be assessed under the Biocidal Products Directive. The reasons for this were as follows:

1. As the representative of the rapporteur noted at the first Steering Group meeting, the scenario used in the ESR RAR was a limited one only and was simply used as a basis

for identifying areas of concern. The set of data used in the preparation of the RAR was limited since it had been considered at the time that reviewing the entirety of the relevant literature would be beyond the scope of an ESR RAR.

2. Although there are 'new risk assessment methods' developed under the framework of the Biocidal Products Directive that could be taken into account in our work on the RRS, these were not used in the development of the ESR RAR. Moreover, the timescale of this RRS does not allow any such methods to be taken fully into account for the (re-)assessment of risks from Cr(VI) substances.
3. Assessing potential alternatives for chromium in wood preservatives is not a straightforward comparison of toxicity/ecotoxicity data as usually done under other ESR RRSs. For wood preservatives, more parameters would also need to be taken into account. The scope of the methods used under ESR RRSs in addressing issues of alternatives is limited compared to what is required for the assessment of alternatives to a biocidal product; also, the timeframe of the RRS analysis is very limited for such a task. It should also be noted that, to be an alternative to Cr(VI) in a wood preservative, a substance would have to replace chromium trioxide in wood preservative formulation, which is chemically not possible. So the alternative to using Cr(VI) in a wood preservative is to formulate a completely different system where a number of active substances are combined with co-formulants to make the wood preservative. It is the registered and approved commercial product (i.e. a system) which is the alternative to a Cr(VI)-based wood preservative (system). The scope and timeframe of the RRS did not allow for these issues to be adequately addressed in a way that ensures scientific robustness.
4. The ESR RAR has focused on CCA formulations, since that was the leading type of wood preservatives at the time of preparing the RAR. Since the introduction of Directive 2003/2/EC on arsenic, the market for CCA has diminished and, in fact, CCA will not be on the market after 1 September 2006 as a result of the Biocidal Products Directive (arsenic is definitely a biocidal 'active substance' and no dossier for it has been submitted by any of the formulators). The ESR RAR contains no data specific to arsenic-free Cr(VI)-based formulations and consultation suggests that CCA and arsenic-free formulations may have different characteristics (i.e. the risks may be different).
5. Although it is currently unclear when Cr(VI) substances will be assessed for risks to human health and the environment, the Biocidal Products Directive provides the appropriate framework for this: Cr(VI) substances are considered to be 'substances of concern' (since they are classified as carcinogens), hence, any biocidal product dossier that contains Cr(VI) substances would have to contain all the necessary information regarding the toxicological and ecotoxicological properties of the chromium substances included in the product, in accordance with points 6.6 of Annex IIB and 2.1.3 of Annex IIIB to the Biocidal Products Directive. It is expected that 'substances of concern' will largely have to undergo the same risk assessment process as the 'active substances' under the Biocidal Products Directive. If the results of this risk assessment suggest that there is reason for concern, the use of

Cr(VI) substances in wood preservatives will be restricted. The restrictions tool for the Biocidal Products Directive is the Marketing and Use Directive 76/769/EEC.

In conclusion, Defra felt that there is only limited information available with which to assess adequately possible risk reduction measures for Cr(VI) in wood preservatives. In addition, the timescale of the RRS, with a completion date of September 2005, did not allow for any additional information on risks (or the lack of them) to be thoroughly assessed and taken into consideration, even if it could have been obtained in time. Moreover, the scope of a RRS is not to assess risks but rather to recommend action upon the identified risks taking into account existing risk reduction measures.

As a result, the risks from use of treated wood identified in the RAR have not been addressed in this RRS. Some information on issues to be taken into consideration when such risks are assessed under the Biocidal Products Directive is provided below.

It is of note that although there were no major objections to Defra's approach at the second Steering Group meeting, there were several attendees who expressed significant concerns on whether the Biocidal Products Directive is capable of ensuring that EU Member States have a harmonised approach to the use of Cr(VI) substances in the formulation of wood preservatives.

Discussion on the Braunschweiler and RIVM Reports

Several consultees have expressed the opinion that risks from wood treated with Cr(VI)-based wood preservatives should not be considered as unacceptable.

According to information made available by a leading EU formulator, a group of collaborating wood preservative formulators, in their application for re-approval of their CC and CCA formulations in Finland submitted information in June 2001 with the aim of revising the conclusions of the Braunschweiler *et al.* report of 1996.

This information (in the form of an appendix) has been recently made available to RPA; it suggests that the revised calculations prepared by the group of formulators used the scenarios described by Braunschweiler *et al.* (in 1996) and utilised new values for certain parameters based on measured results and more recent data. These values and data were used to calculate new PEC values for metals and subsequently new PEC/PNEC ratios were calculated. In brief, the main changes proposed in the industry's submission were (WPTF, 2001):

- a revised percentage of wood volume being sapwood from 75% in the Braunschweiler *et al.* report down to 50% on the basis of work undertaken by the European Committee for Standardisation (CEN);
- revised emission rates for metals from treated wood – for chromium instead of the 14% used in the Braunschweiler *et al.* report (based on observations of small blocks of wood in a laboratory environment), a figure of 0.9% was used on the basis of more recent research (Kennedy & Collins, 2001);

- additive effects were dismissed because the active ingredients of CC and CCA formulations have different modes of action (this was based on the need to account for the bioavailability of the metals).

Industry advised that subsequent to this submission, Cr(VI)-based wood preservatives were re-approved in Finland, including their use in soil and water contact. Moreover, even after the 2001 revision of the Braunschweiler report, the Cr(VI)-based products were again re-approved under certain conditions. The re-approval of these products and the conditions under which this was granted is discussed in Sections 2.5.5 and 4.3.8 in this report.

Hence, it could be argued that any restriction on the use of treated wood or on the use of Cr(VI) in the formulation of wood preservatives with the aim to control the potential risks from the use of treated wood on the basis of the Braunschweiler reports would appear to contradict the conclusion of the approval process in Finland, and approvals in the UK and France.

In the UK, the HSE carried out an extensive review of CCA, including environmental risk assessments, in 1999 and 2001 (HSE, 1999 and HSE, 2001). The final recommendation in both cases was that CCA products are re-approved subject to certain data requirements. The companies that have complied with the data requirements had the approvals for their products renewed until 1 September 2006. It could be argued that these studies, which resulted in the renewal of the approvals, may have examined the risks from CCA wood preservatives to the environment more comprehensively than the RAR. In France, wood preservative formulators need to submit information to the CTBA (Centre Technique du Bois et de l'Ameublement - French Wood and Furniture Technical Centre) and, on the basis of the results of an environmental risk assessment (in which the Ministry of Health is, reportedly, involved), approval is granted to the wood preservative products.

With regard to the RIVM confidential information included in the RAR, industry has suggested that the conclusions in the RIVM report are based on assumptions superseded by recent research. A wood preservatives formulator has suggested that, around 1994, there were numerous emission scenarios being proposed in Europe in which the amount of preservative used was specified and then certain parameters were used (e.g. amount of active ingredient emitted per day) to calculate a PEC value for each scenario. The RIVM report referred to a "waterway" for which specific assumptions were made. Industry provided information in the form of a study by Homan & van Oosten (1999) which suggests that "*only data and models relevant to the field situation may be used*", i.e. the RIVM study (and any similar ones) are not accurate because they deviate considerably from the field situation. These scenarios have been taken into account in the development of the Biocidal Products Directive Emission Scenario Documents; the "waterway" model therein incorporates the proposed amendments by Homan & van Oosten (personal communication with industry).

It should be noted that, in recent months, industry made available to RPA a series of studies on the leaching of chromium (and of other components) from treated wood and

on the impacts of chromium-based wood preservatives to the environment which contradict the conclusions of the RAR. The findings of these studies have not been reviewed; this falls outside the scope of this project and, moreover, it would require time beyond that provided for by the timeframe of this RRS. Some of these studies were available at the time of writing the RAR but were not made available to the rapporteur; some other studies were developed after the RAR had reached its conclusions.

Protocol for Environmental Risk Assessment

To facilitate the implementation of the Biocidal Products Directive, Technical Notes on Guidance (TNsG) and Emission Scenario Documents have been produced. TNsG give detailed and practical guidance on which studies and other data required when applying for authorisation according to the Directive.

In June 1998, in response to version 3.0 of the TNG produced by the Finnish Environment Institute, the European Wood Preservative Manufacturers' Group produced the first version of a protocol that could be used in the preparation of the environmental risk assessment part of a dossier submitted for authorisation of 'active substances' and biocidal products under the Biocidal Products Directive.

In September 1999, eight European institutes (the Environmental Focus Group) started work on the environmental risk assessment of preservative-treated wood.

The second version of the Protocol (version 2.3), incorporating comments received from experts in the field, elements of the work of the Environmental Focus Group and practical experience, was presented at an OECD Workshop in Italy in April 2000. It included proposed methods for quantifying realistic emission fluxes from preserved wood in storage at a treatment plant, or in service.

Subsequently, the OECD contracted the Technical Committee 38 of CEN to produce guidelines for measurement/estimation of emission fluxes. Work continued until October 2004 when the European Wood Preservative Manufacturers' Group produced a revised version of the Protocol under the title "Environmental Exposure Risk Assessment Protocol for Wood Preservatives and Treated Timber". This version covers the environmental exposure aspects required in the compilation of a dossier concerning a substance or preparation for wood preservation. The European Wood Preservative Manufacturers' Group intends that its members will use the Protocol in the submission of dossiers of products containing 'active substances' listed in Annex 1 to the Biocidal Products Directive and the competent authorities of Member States will use the protocol to evaluate the dossiers (Baines, 2005).

It should be noted that the Protocol is still work in progress and there are several issues that have not been resolved yet (Baines, 2005). It is of interest that consultation with the convenor of Working Group 27 of the Technical Committee 38 of CEN suggests that when emission rate estimations are to be made, these can be more or less realistic depending strongly on the kind of test method used. It has been suggested that data from monitoring of full scale treated timber installations in real exposure conditions are

preferred or, alternatively as a second best option, results from test methods specifically designed to produce environmental emissions measurements. Most data produced earlier than 1999 are reportedly based on test methods strongly maximising the emissions and are considered not to be realistic (Deroubaix, 2005).

3.4.3 Emissions of Chromium from Wood Treatment Installations

The RAR identified an unacceptable risk to the aquatic and terrestrial environment from the use of Cr(VI)-based wood preservatives in timber treatment facilities. This RRS collected information on practices and emissions during this lifecycle stage of Cr(VI) substances (although limited emissions data have been made available from individual installations) and this is presented in Section 4.6.8 of this report.

The overall picture appears to be considerably different to the assumptions made in the RAR. As discussed in Section 4.6.8, emissions from timber treatment installations involved in pressure (vacuum) treatment of wood with preservatives appear to be minimal (for instance, the Irish Environmental Protection Agency accepts that there are no process effluents generated). Information from the UK and Ireland (Member States with a long tradition in the treatment of wood with Cr(VI)-based wood preservatives) suggests that bunding of the treatment area, use of roofed facilities and measures for ensuring that the preservative has been thoroughly fixated before transport are common practice. In the UK more specifically, a Code of Practice (see Section 4.4.2 and Annex 3) makes provisions for all measures necessary to avoid releases of chromium (and of any other hazardous substance) to the aquatic and terrestrial compartments. The assertion that the RAR has overestimated the risks from these installations is also supported by the example calculations presented in Section 4.8.2 of this report.

At the same time, the information available on emissions from individual plants is limited; data from countries with a significant number of treatment facilities (for example, Germany) are lacking and this does not allow us to categorically conclude on the acceptability of potential risks from this lifecycle stage of Cr(VI) substances.

Nevertheless, any risks from the use of Cr(VI)-based wood preservatives should be considered taking into account the provisions of the Biocidal Products Directive and the discussion presented in the previous sub-section on the risks from use of treated wood.

As discussed in more detail in Section 4.1.7, the use of wood preservatives that contain Cr(VI) substances, which are ‘substances of concern’, should be authorised by the relevant authorities in Member States. The Biocidal Products Directive specifically requires that “(any) *Member State shall not authorise a biocidal product if the risk assessment confirms that the active substance, or any substance of concern, or any degradation, or reaction product presents an unacceptable risk in any of the environmental compartments, water (including sediment), soil and air*” (“Decision Making” under Annex VI: Common Principles for the Evaluation of Dossiers for Biocidal Products).

According to Annex IIB to the Directive (“Common Core Data Set for Biocidal Chemical Products”), the information to be submitted by applicants (formulators) should include measures to be adopted to protect man, animals and the environment (paragraph VIII). These include recommended methods and precautions concerning handling, use, storage, transport or fire of the biocidal product as well as procedures, if any, for cleaning application equipment. In that respect, and with particular regard to Cr(VI), the formulators applying for authorisation of their products should identify and describe the measures to be taken to prevent any risks from Cr(VI) to the environment. These could include bunding, roofed facilities, fixation requirements, etc.

In conclusion, the Biocidal Products Directive is considered to be the most suitable and appropriate framework for addressing any risks from the use of Cr(VI)-based wood preservatives. This choice is in accord with the Commissions main position that a risk that is specifically related to a biocidal use of a chemical is to be dealt with under the Biocidal Products Directive and is also in line with the approach taken within this RRS on the risks from use of treated wood. As a result, this RRS will not address any risks from the use of Cr(VI)-based wood preservatives but will rather refer the issue to the Biocidal Products Directive experts. The discussion presented in Section 4 (especially Section 4.6.8) is for completeness only.

Again, it should be noted that a number of consultees from the wider wood preservatives sector (certain formulators) expressed concerns over the capability of the Biocidal Products Directive to ensure a harmonised approach on the marketing and use of wood preservatives in the Member States. For example, the measures for the protection of the environment during the use of the wood preservatives (say, the time required for the preservative to be fixated on wood) could be different in different Member States resulting in some market players being in an advantageous or disadvantageous position. As discussed in Section 4.1.7, the aim of the Directive is to ensure harmonisation (Article 1 makes specific mention to the mutual recognition of authorisations within the Community) and companies are encouraged to take action (i.e. to complain to Member States and the Commission) if they consider that the situation is not managed in the same way in different Member States.

3.5 Overview of Conclusions of Human Health Risk Assessment

3.5.1 Introduction

The following paragraphs summarise the conclusions of the RAR with regard to risks to human health from the five Cr(VI) substances. This information is provided for illustrative purposes only with the aim to put into context any risk reduction measures that may be taken as a result of the development of the human health RRS for Cr(VI). Any such measures could influence choice and implementation of proposed measures under the environmental RRS, although the human health RRS is set to be completed after the completion of the environmental RRS.

3.5.2 Scope of Analysis and Conclusions on Risks to Human Health

The RAR notes that the assessment of risks and, therefore, the conclusions on the potential risks to human health do not address possible risks to human health as a result of exposure to Cr(VI) in cement, nor do they address the possibility of exposure to Cr(VI) in leather goods and wood imported into the EU.

In relation to cement, although this is a potential source of exposure to Cr(VI), the source of the Cr(VI) in cement is unclear and there is no direct evidence that it derives from any of the five substances covered in this risk assessment. In relation to wood and leather goods, chromium is utilised in the treatment of wood and leather. The treatment processes applied within the EU are such that any exposure is to chromium in the trivalent state, not the hexavalent state. However, the treatment processes used in wood and leather goods imported from outside the EU are not known and, therefore, an assessment of human health risks from the possible presence of Cr(VI) in such imported goods has not been made.

3.5.3 Risks to Workers

In view of the genotoxic and carcinogenic properties of the five 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, for skin and eye irritation, respiratory tract sensory irritation, skin sensitisation, occupational asthma and reproductive toxicity (fertility and developmental toxicity). Conclusion (iii) (“need for limiting the risks”) was, therefore, reached for these endpoints.

Conclusion (i) (“need for further information and/or testing”) was reached for repeated dose toxicity to the respiratory tract and to the kidney. Further information is required to clarify the NOAELs and dose-response characteristics for effects on the respiratory tract and kidney.

3.5.4 Risks to Consumers

Conclusion (iii) was 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, the RAR notes that exposure levels for consumers are very low.

Consideration was given to the possibility of consumer exposure to Cr(VI) as a result of handling wood which has been recently treated with CCA and is not fully dried. Although handling of such wood should normally be prohibited under appropriate legislation, it should be recognised that if it occurred, there would be concerns for health effects.

3.5.5 Risks to Humans Exposed Indirectly via the Environment

Conclusion (iii) was 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, the RAR notes that exposure levels are very low.

4. EXISTING CONTROLS ON EMISSIONS AND EXPOSURE TO HEXAVALENT CHROMIUM

4.1 EU-wide Legislation Controlling Emissions and Exposure

A number of EU-wide instruments control the emissions of and exposure to Cr(VI) substances. These are briefly presented in chronological order in the sub-sections below.

4.1.1 Council Directive 67/548/EEC on the Classification, Packaging and Labelling of Dangerous Substances

The current classification and labelling requirements for the five substances are presented in Table 4.1 and is based on the provisions of Directive 2004/73/EC (29th adaptation to technical progress of Directive 67/548/EEC).

Table 4.1: Current Classification for the Five Hexavalent Chromium Substances		
Substance	Classification	Labelling
Sodium chromate	Carc. Cat. 2; R49 Muta Cat. 2; R46 T+; R26 T; R25-48/23 Xn; R21 C; R43 R42/43 N;R50-53	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; R60-61 T+; R26 T; R25-48/23 Xn; R21 C; R34 R42/43 N;R50-53	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; R60-61 T+; R26 T; R25-48/23 Xn; R21 C; R34 R42/43 N;R50-53	T+; N; O R: 45-46-60-61-8-21-25-26-34-42/43-48/23-50/53 S: 53-45-60-61

Table 4.1: Current Classification for the Five Hexavalent Chromium Substances		
Substance	Classification	Labelling
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 Xn; R21 C; R34 R42/43 N;R50-53	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 trioxide	O; R9 Carc. Cat. 1; R45 Muta. Cat. 2; R46 Repr. Cat. 3; R62 T+; R26 T; R24/25-48/23 Xn; R21 C; R35 R42/43 N;R50-53	O; T+; N R: 45-46-9-24/25-26-35-42/43-48/23-62-50/53 S: 53-45-60-61

The Directive includes also the provisions for the classification of preparations of these substances on the basis of their concentration therein. The symbols used above have the following meaning:

- R2: risk of explosion by shock, friction, fire or other sources of ignition;
- R8: contact with combustible materials may cause fire;
- R9: explosive when mixed with combustible material;
- R21: harmful in contact with skin;
- R25: toxic if swallowed;
- R26: very toxic by inhalation;
- R34: causes burns;
- R35: causes severe burns;
- R41: risk of serious damage to eyes;
- R42/43: may cause sensitisation by inhalation and skin contact;
- R46: may cause heritable genetic damage;
- R48/23: toxic: danger of serious damage to health by prolonged exposure through inhalation;
- R49: may cause cancer by inhalation;
- R50/53: very toxic to aquatic organisms; may cause long-term adverse effects in the aquatic environment;
- R60: may impair fertility;
- R61: may cause harm to the unborn child;
- R62: possible risk of impaired fertility;
- S45: in case of accident or if you feel unwell, seek medical advice immediately (show the label where possible);
- S53: avoid exposure – obtain special instructions before use;

S60:	this material and its container must be disposed of as hazardous waste;
S61:	avoid release to the environment; refer to special instructions/Safety Data Sheets;
C:	corrosive;
E:	explosive;
N:	dangerous for the environment.
O:	oxidising;
T:	toxic;
T+:	very toxic; and
Xn:	harmful.

4.1.2 Council Directive 76/464/EEC (Dangerous Substances Directive) on Pollution of the Aquatic Environment

General Provisions and Applicability to Chromium

The Directive 76/464/EEC of 4 May 1976 on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community was one of the first water-related Directives to be adopted. According to the European Commission Internet site, it had the ambitious objective of regulating potential aquatic pollution by thousands of chemicals already produced in Europe at that time. The Directive covered discharges to inland surface waters, territorial waters, inland coastal waters and ground water. In 1980, the protection of groundwater was taken out of 76/464/EEC and was regulated under the separate Council Directive 80/68/EEC on the protection of groundwater against pollution caused by certain dangerous substances.

The 1976 Directive introduced the concept of list I and list II substances (also known as “the black list” and “the grey list” respectively). The purpose of the Directive is to eliminate pollution from list I substances and to reduce pollution from list II substances.

List I included a number of groups and families of pollutants from which certain individual substances were to be selected on the basis of their persistence, toxicity and bioaccumulation. In 1982, the Commission communicated a list to the Council (OJ C 176 of 14 July 1982, p. 3) that included 129 ‘candidate list I substances’. Three more substances were subsequently added to the list to bring the total up to 132.

Up to now, 18 individual substances of the ‘candidate list I’ have been regulated in five specific Directives (also known as ‘daughter’ Directives) setting emission limit values and quality objectives on a Community level. The regulation of other ‘candidate list I substances’ was suspended in the beginning of the 1990s due to the preparation of a more comprehensive and integrated permitting system for industrial installations. In 1996, the Directive on integrated pollution prevention and control, the IPPC Directive (96/61/EC) was adopted. The Directive includes the emission limit values for the 18 list I substances of the specific ‘daughter’ Directives as minimum requirements for large installations.

List I discharges must be authorised, such authorisation laying down emission standards for discharges to waters and, where necessary, to sewers. Competent authorities were required to draw up an inventory of the discharges which may contain substances within List I to which emission standards are applicable.

On the other hand, list II includes groups and families of substances that have a deleterious effect on the aquatic environment. It also consists of all individual list I substances that have not been regulated at the Community level yet. As there are only 18 ‘real’ list I substances, all the other 114 substances of the ‘candidate list I’ and the groups and families of substances listed under list I must be considered as list II substances. According to Article 7 of the Directive, all discharges into the waters referred to in Article 1 which are liable to contain any of the substances within List II require prior authorisation by the competent authority in the Member State concerned, in which emission standards shall be laid down. In order to reduce pollution of the waters referred to in Article 1 by the substances within List II, Member States are required to establish pollution reduction programmes. These programmes should include quality objectives for water and may also include specific provisions governing the composition and use of substances or groups of substances and products and shall take into account the latest economically feasible technical developments. Chromium and its compounds belong to list II.

The programmes shall provide for the identification of relevant List II substances. The approach could be based on screening monitoring and/or emission inventories and/or exposure models. Where substances are identified as irrelevant, reasons should be given for this.

With regard to the Water Quality Objectives (WQO), these should be laid down for relevant pollutants in national legal framework and guidance for the derivation of WQO is now provided by Annex V of the Water Framework Directive or the CSTEE.

Progress in the Implementation of Directive 76/464/EEC

Overall, as the European Commission Internet site suggests, progress in properly implementing list II substances that are regulated under Article 7 of the Directive proved to be very slow. In the beginning of the 1990s, the Commission decided to start infringement procedures against most of the Member States. Most of the cases are before the European Court of Justice and there have been already several rulings against Member States.

A report prepared by WRc in November 2001 on behalf of the European Commission presented the progress made on the implementation of the Directive (WRc, 2001) and it was updated in 2003 (WRc, 2003). Note that the following paragraphs provide a general overview of the implementation of the Directive at the national level; information specific to chromium in these context is not available, although the majority of national measures currently available (see Section 4.3) are assumed to be related to Directive 76/464/EEC.

Introduction of Pollution Reduction Programmes

For the 2001 report, ten Member States provided information on pollution reduction programmes in place for List II substances (WRc, 2001). The report was updated in 2003 because of the rapidly changing situation since the earlier provision of information by the Member States. In particular, additional material was received from Austria, Belgium, Denmark, Germany, Greece, Italy, Portugal and Spain, in most cases presenting recent actions taken, following Infringement Proceedings. This information was assessed and used to produce the 2003 report. Information on the Accession Countries was added for the first time in that report (WRc, 2003).

The implementation of Article 7 in the Member States was found to vary considerably, with some Member States having only recently started with the production of pollution reduction programmes. All Member States, except one, now had pollution reduction programmes in place or were preparing these, although the approaches varied substantially and might still not be in full compliance with the requirements. Some pollution reduction programmes were based on regions or river basins (not covering the whole of a Member State), the substances covered were in some cases very limited, and in some Member States a sectorial approach was taken, rather than establishing substance-specific pollution reduction programmes (WRc, 2003).

On a country-by-country basis the following have been reported (WRc, 2003):

- **Austria** was in the process of preparing pollution Reduction Programmes (it was at the time concerned mainly with monitoring and setting EQSs). The Austrian Environment Agency (Umweltbundesamt) had recently published a comprehensive document, which is to form the technical basis of pollution Reduction Programmes in Austria;
- in **Belgium**, the three Regions (Brussels, Flanders, Wallonia) had recently prepared pollution reduction programmes. These programmes focus on monitoring, preparing statutory EQSs and identification of relevant substances (on the basis of monitoring/presence above EQS) for which specific pollution reduction programmes have been prepared or are planned;
- in **Denmark**, pollution reduction programmes have been established for phosphorus and nitrogen. In addition, pollution reduction programmes are in place for 22 substances in the context of international commitments to reduce input to the sea; there was a target of 50% reduction or more in the period 1985 - 2000 for 16 of these substances, the others do not have any specified, quantitative targets.
- the **Finnish** programme 'Water Protection up to the year 2005' contains a reduction programme for seven List II substances (phosphorus, nitrogen, hydrocarbons, chromium, nickel, copper and zinc) as well as for the general parameters, biological and chemical oxygen demand (BOD and COD). The programme establishes deadlines for the reductions to be achieved through the reduction of emissions from industrial and wastewater treatment plants;

- **France** had introduced pollution reduction programmes for six metals, all of which include deadlines for the achievement of reduction targets. In addition, reduction targets for 31 List II substances had been established in a circular but no measures to achieve them appear to have been identified.
- in **Germany** the responsibility for pollution reduction programmes lies with the individual Federal States. pollution reduction programmes had recently been prepared in all 16 Federal States, following the recent introduction of legislation (during first half of 2001) requiring this. However, some of these were drafts or preliminary programmes and all were in the form of frameworks for producing substance specific reduction programmes, awaiting the results of monitoring. The programmes included monitoring programmes for the 99 substances for which statutory EQSs apply, followed by investigations and the implementation of measures, where EQSs are exceeded;
- the approach adopted in **Greece** is based on catchments, where plans, which have legal status, have been developed for the Pagasitikos Gulf and Lake Vegoritida. Furthermore, a National Framework for the establishment of pollution reduction programmes had been prepared and additional programmes will be set up as necessary, following the assessment of monitoring programmes;
- **Ireland** only had a programme in place for the reduction of phosphorus emissions;
- in **Italy** the responsibility for the preparation of pollution reduction programmes lies at Regional level. An example was provided for the Venice Lagoon and its catchment area. This involved extensive monitoring and the setting of statutory EQSs for 32 List II substances (plus other substances and sum parameters). Limited or no information is available for other Regions.
- work was ongoing to develop substance specific programmes in **Portugal** for 15 substances selected on the basis of monitoring results; some of these were selected on the basis of exceedence of the EQSs and others because of significant occurrence, although average concentrations were below the EQSs;
- in **Spain**, pollution reduction programmes were in place at regional and local level through sanitation plans. In addition, catchment based plans had been developed for some of the larger river basins including the Ebro, Suero, Tajo and Guadiana. Substance-specific reduction programmes were in preparation in the river basins, where EQSs had been exceeded in the monitoring programme in 2000 (15 substances - focusing on revising permits where point sources are identified);
- **Sweden** had introduced pollution reduction programmes for six List II metals to reduce emissions over the period 1985-1995;
- **the Netherlands** had taken a sectorial approach to the establishment of emission reduction programmes, which had been established for a number of industrial sectors, including food; wood, paper and cardboard; chemicals, refineries,

pharmaceuticals, paints, plastics; metals (iron, steel, non-ferrous metals, aluminium); and textiles; and

- the **UK** had prepared substance-specific pollution reduction programmes for 39 List II substances. Each programme has an identical structure and identifies targets for reductions, including those agreed under international agreements, national EQSs and reductions through the application of BAT to those industries falling under integrated pollution control. The programmes generally cover the whole of the UK.

Identification of Relevant Substances

Austria, Germany, Denmark, France, Italy, Portugal and the UK had identified in 2003 the largest number of List II substances. **Denmark and Portugal** consider that all tentative List II substances are of relevance, and **France** selected 120 substances. In the **UK** all the tentative List II substances, including all substances on the North Sea Action List, were selected as candidate list for the selection of substances of national relevance.

- **Austria** initially selected 112 List II (and 128 additional List II substances) but subsequently developed a model for selecting the substances most relevant to Austrian waters. Applying this model and other methods, the large list was subsequently reduced to about 70 relevant substances;
- in **Germany**, an expert group was established to identify relevant pollutants for which EQSs should be developed. Germany initially maintained that all EU List II substances were covered by its legal requirement for authorisation of all discharges and the industry specific uniform limit values laid down in legislation. However, an official list of 122 substances has been drawn up recently for which EQSs have been developed;
- **Italy** had adopted a similar approach to that initially applied by Germany. It was contended that the legal requirement for the authorisation of discharges, the quality objectives for designated water uses, the authorisation of pesticides and other marketing and use restrictions are sufficient for the control of List II substances. However, the responsibility for selection lies with the Regions in Italy; information recently received from some of the Regions (Veneto, Emilia-Romagna, and the Province of Milan) indicates that the List of 99 substances (1982) is now accepted as a starting point before selection of the most appropriate substances for control; and
- **Belgium** had not identified any relevant substances at national level, this task being the responsibility of the Regions. However, 18 substances had been identified in all three Regions, whilst a further eight have been identified in two Regions (six in Flanders and Wallonia, two in Flanders and Brussels) and another 31 in one Region (Wallonia) only (in total Brussels 20, Flanders 24, Wallonia 57 substances).

In addition to selecting relevant pollutants from the tentative List II substances, eight Member States had identified additional List II substances as relevant pollutants,

requiring the same level of control. These included Austria, Denmark, Spain, France, Germany, Greece and the UK (WRC, 2003).

Establishment of Environmental Quality Standards

Eleven Member States had established up until 2003 legally enforceable (statutory) EQSs for tentative List II substances laid down in legislation. Of these, seven Member States had also derived some non-statutory EQSs, whilst a further four Member States had established non-statutory EQSs only, though in some cases with a view to making them statutory in future.

- Austria initially had proposed EQSs for 129 List II substances with a view to adopting these as legally binding. On further assessment, the number was reduced to 39 substances out of a total of about 70 identified relevant pollutants. However, four of these were not now considered relevant to Austrian waters;
- in **Belgium**, the derivation of EQSs is carried out at the Regional level. All three Regions had derived statutory EQSs for the same 18 List II substances. In total, EQSs had been derived for 57 substances in one or more of the Regions;
- **Denmark** had set EQSs for 92 List II substances; of these, five (List II metals) were proposed EQSs only (assessment still to be completed); a further 27 substances were under consideration, but there was insufficient information to set EQSs for these;
- **Finland** had established EQSs for six substances only; two of these were statutory (phosphorus compounds and total nitrogen) and four are non-statutory (chromium, copper, nickel and zinc);
- **France** had derived non-statutory EQSs for 43 List II substances. However, for selenium, barium and mecoprop, statutory EQSs were in place for the protection of water abstracted for drinking water supply. In addition, EQSs for phosphorus compounds, ammonia and nitrate have been incorporated into the river basin management plan of the Agence de l'Eau Loire-Bretagne. EQSs have not been derived for the remaining List II substances because the French authorities considered that doing so would not lead to significant reductions in pollution. Instead, the emphasis has been placed on the authorisation of discharges;
- **Germany** had recently established statutory EQSs for 99 List II substances at Federal level. Two of the EQSs were set for suspended solids, rather than water (arsenic and PCBs) and another two for water and suspended solids (dibutyltin and tetrabutyltin). In addition, non-statutory EQSs had been established at Federal level for the 15 Candidate List I (1990) substances and another eight List II substances;
- in **Greece**, 33 statutory EQSs had been derived (of 55 relevant List II substances); another six non-statutory EQSs had been used in specific reduction programmes. Due to inadequate data, EQSs had not been derived for 12 List II substances identified as being relevant pollutants in Greece;

- in **Ireland**, statutory EQSs had been derived only for some List II metals and nutrients;
- in **Italy**, EQSs for 32 List II substances had been derived for the Venice Lagoon and its catchment (set down in National legislation). Nine of these substances also have EQSs set at national level, but based on the objectives laid down in Directives 75/440/EEC and 78/659/EEC;
- **Luxembourg** had established non-statutory EQSs for eight List II substances; these included ammonia, nitrite, phosphorus compounds, one pesticide and four other organic substances;
- in **the Netherlands**, non-statutory EQSs had been derived for 23 List II substances, and a further six substances were being considered;
- **Portugal** had derived statutory EQSs for 90 of the 139 substances identified as relevant pollutants. Another 14 EQSs had recently been established; these did not appear to be statutory. No EQSs have been derived for those substances that do not occur in Portuguese waters;
- in **Spain**, statutory EQSs had been derived for 20 of the 28 relevant pollutants, and non-statutory EQSs for the other eight pollutants;
- **Sweden** had established statutory EQSs for ten substances, i.e. ammonia and nitrite, six metal/metalloids, one pesticide and PCB/PCTs; and
- **the UK** had statutory EQSs for 46 List II substances and non-statutory (or proposed) EQSs for another 14 List II substances.

Eight Member States either provided no information or insufficient information to allow a comparison between the methods used to derive EQSs and Annex V of the Water Framework Directive (see Discussion in Section 4.1.9). Information was available for Belgium, Denmark, Germany, Greece, Luxembourg, Portugal and the UK. From the available information it appeared that the methodologies used were similar to that laid down in Annex V of the WFD or to that applied by the Scientific Committee on Toxicity and Ecotoxicity (CSTEE) (WRc, 2003).

Legislation on Authorisation of Discharges

In all Member States legislation had been passed requiring the authorisation of discharges containing List II substances to surface waters and (WRc, 2003).

Implementation of the Directive in the New EU Member States

The Accession Countries were considered to be in a good position to co-ordinate the implementation of Article 7 of the Directive with the implementation of the WFD (WRc, 2003).

Most countries already had existing legislation and procedures for the authorisation of discharges and are adapting these to bring them in line with the requirements of the Directive (and the Water Framework Directive). Some have established emission limit values or industry sector specific permissible concentration or load of a List II substance in the discharge of that industry (known as Uniform Emission Standards, UESs), but these are also often limited to a very small number of substances. Moreover, the UESs or emission limit values were often unrealistically stringent and, therefore, not enforceable.

Whilst **Estonia** had UESs for 33 substances (may include List I), there were UESs for 21 List II substances in Slovenia and 34 sector specific Regulations to control discharges. **The Czech Republic** had recently introduced legislation (to come into force in 2003) which includes EQSs and industry specific UESs for many of the same substances. Similarly, **Hungary** had introduced new legislation, which included emission limit values and would come into force in 2003, but no details of the number of emission limit values had been provided.

EQSs had generally not been established at this stage, except in **the Czech Republic, Slovenia** and **the Slovak Republic**. In the **Czech Republic**, there were statutory EQSs for 78 substances (18 List I, 47 List II and 13 additional substances). **Slovenia** had statutory EQSs for 14 List II substances, two additional List II substances and five group parameters. **The Slovak Republic** had established statutory EQSs for List I and some List II substances, but no details had been made available.

The status of transposition of the Directive in the then accession countries was in early 2003 as follows (WRc, 2003):

- **Cyprus:** Directive transposition planned for January 2002; adoption of EQSs planned by end of 2002; no information on pollution reduction programmes;
- **Czech Republic:** Directive transposed through new Water Act 2002 and Government Order 2002 (to enter into force January 2003); Statutory EQSs for 78 substances (18 List I, 47 List II, 13 additional substances); PRP first drafts expected to be completed by end of 2002;
- **Estonia:** Directive transposed in 2001, includes 57 relevant List II substances; research in progress to establish EQSs by end of 2003; pollution reduction programmes should be ready by 2003, the implementation period is envisaged to be five years;
- **Hungary:** legislation to transpose DSD adopted and would enter into force in January 2003; guidelines for the preparation of pollution reduction programmes were being elaborated;
- **Latvia:** Directive apparently not transposed; preliminary selection of 117 relevant List II substances, based on discharge inventory and usage data;

- **Lithuania:** project started in 2001 to implement Directive by 2003 (existing legislation amended, some new legislation, others planned); PRP preparation planned to start in 2003;
- **Malta:** Directive transposed in 2001 and expected to be implemented over a period of six years; some relevant List II substances identified; no information on pollution reduction programmes;
- **Poland:** implementation of Directive seems to be taking place under existing legislation; statutory emission limit values planned for 24 List II substances and 5 group parameters; pollution reduction programmes planned, covering 30 substances (may include List I), but pollution reduction programmes would be prepared for groups of substances (industry-specific);
- **Slovak Republic:** Directive transposed through new Water Act and Decree in 2002, incl. UESs and EQSs; selection of substances and planning of PRP preparation in progress; and
- **Slovenia:** Directive deemed covered by Decree 1996 and associated legislation; statutory EQSs (14 List II, 2 additional, 5 group), emission limit values and industry specific UESs.

Transition to the Water Framework Directive

The Council Directive 76/464/EEC will be integrated in the Water Framework Directive. Article 22 together with Article 16 of the Water Framework Directive (2000/60/EC) set out the transitional provisions for the existing Directive on discharges of certain dangerous substances (76/464/EEC). In summary, the provisions are as following:

- Article 6 (list I substances) was repealed with the entry into force of Directive 2000/60/EC;
- the list of priority substances of the Water Framework Directive (Annex X) has replaced the ‘candidate list I’ of 1982;
- the rest of Directive 76/464/EEC including the emission reduction programmes will be still in place until 2013 (transition period); and
- the review of specific ‘daughter’ Directives would take place within 2 years after entry into force of Directive 2000/60/EC.

4.1.3 Council Directive 86/278/EEC on the Protection of the Environment, and in Particular of the Soil, when Sewage Sludge is used in Agriculture

Current Framework

The purpose of this Directive is to regulate the use of sewage sludge in agriculture in such a way as to prevent harmful effects on soil, vegetation, animals and man, thereby encouraging the correct use of such sewage sludge. The Directive applies to residual sludge from:

- sewage plants treating domestic or urban wastewater and from other sewage plants treating wastewater of a composition similar to domestic and urban wastewater;
- septic tanks and other similar installations for the treatment of sewage; and
- sewage plants other than those referred to above.

The Directive lays down limit values for concentrations of heavy metals in the soil (Annex IA), in sludge (Annex IB) and for the maximum annual quantities of heavy metals which may be introduced into the soil (Annex IC).

The use of sewage sludge is prohibited if the concentration of one or more heavy metals in the soil exceeds the limit values laid down in accordance with Annex IA. The Member States must take the measures necessary to ensure that these limit values are not exceeded through the use of sludge.

Sludge must be treated before being used in agriculture but the Member States may authorise the use of untreated sludge if it is injected or worked into the soil.

Although chromium is included in Annexes IA (limit values for concentrations of heavy metals in soil) and IB to the Directive (limit values for heavy-metal concentrations in sludge for use in agriculture), no limits for chromium are set in the Directive.

Nevertheless, a report from the Commission to the Council and the European Parliament on the implementation of a number of Directives in Member States, including Directive 86/278/EEC, presented limits established in Member States for chromium. These are presented in Table 4.2.

Table 4.3 outlines the concentration limit values for chromium in soil and the maximum annual average load of chromium to agricultural land. It is of note that not all Member States (in EU-15) appear to have established limits and the maximum annual load varies considerably across the EU.

Table 4.2: Limit Values for Chromium in Sludge in Member States (report for years 1998-2000)

Country	AT	BE		DE	DK	ES		GR	FI
		Fla	Wal			pH>7	pH<7		
Cr in mg/kg dry matter	50-500	250	500	900	100	1,000	1,500	VI: 10 III: 500	300
Country	FR	IT	IE	LU	NL	PT	SE	UK	
Cr in mg/kg dry matter	1,000	-	-	1,000-1,750	75	1,000	100	-	

Source: CEC, 2003

Table 4.3: Concentration Limit Values for Chromium in Soil (mg/kg dry weight) and Maximum Annual Average Load of Chromium to Agricultural Land (g/ha/y)

Country	Limit	Maximum load	Country	Limit	Maximum load
Austria	50-100	350 – 1,250	Italy	1 µM Cr(VI)	-
Belgium - Flanders	46	500	Luxembourg	100-200	4,500
Belgium - Wallonia	100	-	Netherlands	100	150
Denmark	30	-	Portugal	50 (pH<5.5)	4,500
Finland	200	300		200 (5.5<pH>7)	
France	150	1,200 (5<pH<6)		300 (pH>7)	
		1,500 (6<pH<7)	Spain	100 (pH<7)	3,000
Germany	100	-		150 (pH>7)	
Greece	-	5	Sweden	60	40
Ireland	-	3,500	United Kingdom	-	-

Source: CEC, 2003

Table 4.4 presents the average heavy metal concentrations in sludge in different Member States for the year 2000.

For the period 1998-2000 in Member States, the weighted average chromium concentration in sewage sludge in 1999 was 73 mg/kg dry weight (CEC, 2004d). This is considerably lower than the estimated concentration of Cr(VI) (130 - 9,900 mg/kg dw) and Cr(III) (200 – 16,000 mg/kg dw) estimated in the RAR (see Table 3.7 of this Report). Even the highest of these concentration levels does not result into soil concentrations exceeding the PNEC_{soil} value for Cr(III) of 2.8 mg/kg wet weight (following the TGD assumptions used in the RAR), although some of the limit values referred to in Table 4.2 could theoretically result in unacceptable risks.

Country	Cr concentration	Country	Cr concentration
Austria	39 - 67	Ireland	165 (1999)
Belgium – Flanders	77	Italy	104
Belgium – Wallonia	86	Luxembourg	57
Denmark	24.6 (1999)	Netherlands	20
Finland	104 (estimate)	Portugal	110
France	44 (estimate)	Spain	146
Germany	41 (estimate)	Sweden	24
Greece	-	United Kingdom	113

Source: CEC, 2003

Table 4.5 outlines the pathways for sludge disposal and re-use in EU Member States between 1999 and 2001.

Pathway	Member State															
	AT	BE	DK	DE	FI	FR	GR	IRL	LU	NL	PT	ES	SE	UK	Total	%
Re-use	37	15	84	920	90	507	6	9	6	77	106	578	116	588	3,139	45
Landfill	41	32	36	230	60	0	90	17	0	64	71	360	76	192	1,270	18
Incineration	151	25	10	460	0	0	0	0	0	195	0	74	0	237	1,153	17
Surface water	0	0	0	0	0	0	0	12	0	0	0	57	0	0	69	1
Not specified	86	19	25	690	0	398	0	0	1	0	0	0	30	113	1,343	19
Total	315	91	156	2,300	150	904	96	38	7	336	177	1,069	222	1,130	6,992	100

Source: CEC, 2004a
Notes: Member States did not provide data for one and the same year but rather for one or more years between 1999 and 2001. Italy did not provide any information. For Greece, France, Portugal and Spain, the implementation programmes according to Article 17 were used as a data source

Some additional information is available for two of the new EU Member States, Cyprus and Malta. Information for Cyprus suggests that the production of sludge in 2000 was just over 1,900 t/y and was expected to increase 5-fold in the following years. Under Law 69/1991 on Water Pollution Control, and the existing Code of Practice for the Use of Sewage Sludge in Agriculture, part of the generated sludge was applied on agricultural soil. These practices take into account the following limits:

- maximum allowable concentration of Cr(III) in sludge: 1,000 mg/kg dry weight;
- maximum allowable concentration of Cr(III) in soils: 150 mg/kg dry weight; and
- maximum allowable quantity of Cr(III) to be spread on land every year: no limit set.

It should be noted that these values appear to derive from the Code of Practice rather than legislation (existing legislation on use of sludge in agriculture appears not to include limits on Cr(III)).

Data for 2000 for the two Cypriot regions producing sludge suggest that the concentration of Cr(III) in the sludge from a wastewater treatment plant processing domestic sewage and industrial wastewater was 133 mg/l. The other plant that was processing only domestic sewage showed a concentration of Cr(III) of 22 mg/l (COST, 2000).

On the other hand, the use of sewage sludge in Malta is regulated by the Sludge (Use in Agriculture) Regulations 2001 (Legal Notice 212 of 2001). In accordance to these Regulations, sludge supplied for the purpose of use in agriculture should be tested for a number of parameters including chromium. The use of chromium should not exceed 2,400 g Cr per hectare per year with a limit of detection of 800 mg/kg dry matter. For sludge to be used on agricultural soil, the soil should be tested and the concentrations of chromium should not exceed:

- 30 mg/kg dry matter for $5 < \text{pH} < 6$;
- 60 mg/kg dry matter for $6 < \text{pH} < 7$; and
- 100 mg/kg dry matter for $\text{pH} > 7$.

Revision of the Sludge Directive

The experience gained so far in the EU has shown three main weaknesses of this Directive, which:

- basically only covers urban sludge (i.e. sludge from the treatment of domestic or urban wastewater or wastewater of a composition similar to domestic and urban wastewater), but does not consider other non-hazardous sludges (e.g. paper sludges or textile sludges) that may have similar negative and positive implications as urban sludge if they are spread on land;
- regulates the spreading of sewage sludge to agricultural land only and does not provide for any measure as regards other types of land use; and
- it is not conservative enough in taking into account the effects of long term accumulation of heavy metals to the topsoil. Although reaching the upper threshold limits for heavy metal concentrations in agricultural soil provided for by Annex I A of Directive 86/278/EEC does not pose any immediate risk to human and animal health, these upper limits do not seem to be protective enough for soil quality in the long term (CEC, 2004d).

A revision of Directive 86/278/EEC to address these points is, therefore, an option to consider. Indeed, there have been efforts to revise the Directive twice; in both cases, limits on chromium in sludge were proposed for inclusion in the revised Directive. The

Commission proposed, back in 1988, the introduction of the following limit values for chromium in Annex I to Directive 86/278/EEC:

- 100-200 mg/kg in soil;
- 1,000-1,750 mg/kg in sludge; and
- 4.5 kg/ha/y maximum loading rate (COM(88) 624, 10 November 1988)¹⁹.

The introduction to COM(88) 624 explains that “[i]nsufficient scientific and technical data were available to the Council during its discussions [leading to the adoption of Directive 86/278/EEC] to enable it to fix limit values for Chromium. Accordingly, it was decided that the Council would fix those values at a later date, on the basis of proposals to be submitted by the Commission” (Marmo, 2005).

However, the Council could not agree on what proposed by the Commission in 1988. Indeed, at that time the Council needed unanimity to adopt a legislative measure based on an environmental legal basis. The Commission finally decided to withdraw its proposal in 1993 (Marmo, 2005).

Later on, new proposals were developed for an amendment of the Directive. The proposals included limits on chromium (along with other changes to the current legislation). According to the 3rd Draft of the Working Document on Sludge (CEC, 2000), the amended Directive would include a limit on the concentration of Cr in sludge which will be 1,000 mg/kg dry weight (Annex III of the envisaged Directive). The maximum limit value for the amount of chromium that could be added annually to soil, based on a ten year average was proposed to be 3,000 g/ha/y.

Annex II to the envisaged Directive would include limit values for chromium in soil. The limits would be:

- for $5 \leq \text{pH} < 6$: 30 mg/kg dry weight;
- for $6 \leq \text{pH} < 7$: 60 mg/kg dry weight; and
- for $\text{pH} \geq 7$: 100 mg/kg dry weight (CEC, 2000).

The aim of the amended Directive would be to achieve (among other things for other pollutants) the following concentrations of chromium in sewage sludge:

- 800 mg/kg dry weight for the medium term (about 2015); and
- 600 mg/kg dry weight for the long term (about 2025).

However, the European Commission has, again, decided to halt the work towards a possible revision of the Directive (Fras, 2005). Therefore, the Working Document of 2000 will not be followed by a formal proposal for a revised Directive in the near future.

¹⁹ Official Journal C 114, 08/05/1990 p.9.

The Soil Thematic Strategy

Consultation suggests that no other initiative currently exists in the field of sewage sludge management at the Community level. Soil protection, however, will be addressed by the European Commission later in 2005 in the context of one of the seven thematic strategies foreseen by the Sixth Environment Action Programme, namely the Soil Protection Strategy (known as the ‘Soil Thematic Strategy’) (Fras, 2005).

As stipulated in the Sixth Environment Action Programme, the European Union has decided to adopt a Thematic Strategy on Soil Protection as part of its aim of protection and preservation of natural resources. According to the European Commission, DG Environment Internet site²⁰, the Strategy will comprise three elements:

- a Communication laying down the principles of Community Soil Protection Policy;
- a legislative proposal for the protection of soil - a Soil Framework Directive that would aim to strike the right balance between EU action and subsidiarity; and
- an analysis of the environmental, economic and social impacts of the proposals.

At present, the Commission is seeking to elicit relevant opinions from stakeholders on specific measures being considered for inclusion in the Soil Thematic Strategy. The information will feed into the strategy which was scheduled for adoption in November 2005. It should be noted that although the revision of the Sewage Sludge Directive was an element of the Soil Protection Strategy when it was announced on 19 April 2002, recent communication with DG Environment suggests that there are no specific plans for a revision of the Sewage Sludge Directive within the Soil Thematic Strategy. Moreover, the Soil Framework Directive is not intended to address issues specifically relating to sewage sludge (Marmo, 2005).

Eco-label for Soil Improvers and Growing Media

Commission Decision 2001/688/EC of 28 August 2001 established ecological criteria for the award of the Community eco-label to soil improvers and growing media.

For a product to be considered for the eco-label, it should not contain sewage sludge. Moreover, with regard to chromium, its concentration should be below 100 mg/kg dry weight (total chromium).

4.1.4 Council Directive 89/677/EEC amending for the Eighth Time Directive 76/769/EEC on Restrictions on the Marketing and Use of Certain Dangerous Substances and Preparations

In accordance with Article 1 of this Directive, Annex I to Directive 76/769/EEC was amended to include restrictions on the marketing and use of arsenic compounds. As a

²⁰ ‘EUROPA – Environment – Soil Protection Policy’ available at europa.eu.int/comm/environment/soil/.

result arsenic compounds could not be used as substances and constituents of preparations intended for use:

- in the prevention of fouling by micro-organisms, plants or animals of:
 - the hulls of boats;
 - cages, floats, nets and any other appliances or equipment used for fish or shellfish farming; and
 - any totally or partly submerged appliances or equipment.
- in the preservation of wood: in this case, the ban did not apply to solutions of inorganic salts of the CCA (copper - chromium - arsenic) type employed in industrial installations using vacuum or pressure to impregnate wood.

4.1.5 Council Directive 91/271/EEC on Urban Wastewater Treatment

General Provisions

The Directive is aimed at protecting the environment from the adverse effects of wastewater discharges. It sets minimum sewage treatment standards to be achieved in stages by the end of 2005, and provides for advanced wastewater treatment for the removal of nitrogen and phosphorus from sensitive areas.

The Directive 91/271/EEC supports the use of sewage sludge in Article 14: “*Sludge arising from wastewater treatment shall be re-used whenever appropriate. Disposal routes shall minimise the adverse effects on the environment.*” The same article also prohibits the disposal of sludge to surface waters since 31 December 1998, and specifies that from that date onwards, the disposal of sludge from urban wastewater treatment plants is subject to general rules, registration or authorisation.

Information on Levels of Chromium in Sewage Sludge and Wastewater

The latest report from the Commission on the implementation of Directive 91/271/EEC in Member States includes some interesting statistics on the use of sewage sludge produced in urban wastewater treatment plants across the EU. The information reported below on sewage sludge generation and disposal is based partly on Member States’ situation reports according to Article 16 of the Directive, and partly on the implementation programmes according to Article 17 of the Directive. The report notes that (CEC, 2004a):

- the total amount of sludge generated in urban wastewater treatment plants increased from 5.5 million tonnes dry matter in 1992 to 7.0 million tonnes in 2000;
- since 1992, the amount of sewage sludge re-used in agriculture and landscape architecture (including coverage of landfills) represented about 50% of the total sludge produced (45% in the 1999-2001 period);

- the quantity of sludge that was disposed of in landfills has decreased slightly;
- sludge incineration almost doubled from 1992 to 2000; while
- as the data supplied by Member States was not complete and 20% of the sludge could not be accounted for, the data do not allow any trend analysis for the sludge being re-used, disposed of or incinerated.

With regard to chromium, in a study commissioned by DG Environment, the following breakdown of courses of chromium entering the urban wastewater treatment plants was shown (Rautiu, 2001):

- domestic wastewater: 2-20%;
- commercial wastewater: 35-60%; and
- urban runoff: 2-20%.

Another study commissioned by DG Environment presents details on the presence of chromium and other pollutants in urban wastewater (ICON, 2001). Table 4.6 outlines the data presented in the report on the concentrations of chromium in influents and effluents of WWTP in a number of EU Member States.

Country	Influent (mg/l)	Effluent (mg/l)
Austria	7.1 (6.2 – 7.9)	3.9 (<0.9 – 5.6)
Italy	Central: < 0.02 Northern: 5×10^{-4} – 0.032	
Sweden		3

Source: ICON, 2001

These values (with the exception of Italy) appear to be higher than the values quoted in Table 3.6 on the predicted concentrations of chromium as presented in the RAR (however, the values in the RAR assume that each single lifecycle stage of the Cr(VI) substances is the source of chromium into the WWTP influent and effluent). More generally, these values appear to be considerably high. With particular reference to Austria, it is important to note that the treatment of wastewater seems to remove only 45% of chromium; in addition, the levels of chromium in the effluent are well above existing national limits on Cr(VI) released from STPs (see Table 4.16 – limits on Cr(total) are not in place). Similarly, the levels of chromium in effluent in Sweden appear to be unusually high.; It should be noted that the variability of influent concentrations within a WWTP can be very high due to season, precipitation and levels of industrial and domestic activities. This means that comparisons based on small numbers of samples must be made with caution.

4.1.6 Council Directive 96/61/EC on Integrated Pollution Prevention and Control

Overview of the IPPC Directive

The IPPC Directive lays down measures designed to prevent or, where that is not practicable, to reduce emissions to air, water and land from the activities mentioned in Annex 1 of the Directive, including measures concerning waste. All installations covered by Annex I of the Directive are required to obtain an authorisation (permit) from the authorities in the various EU countries. Installations/sites should be operated (and permits granted) according to the ‘best available techniques’ (BAT) which are set out for the various process types covered in BAT Reference (BREF) Documents. The BREF Documents are only intended to assist the licensing authorities²¹ as the final decision on emission limits and process conditions for individual sites is established by the Member States’ authorities.

The Directive covers mainly medium-sized and large scale industrial installations but also waste management installations. New installations listed in Annex I require a permit from the competent authority before being put into operation. Existing installations will have to operate in accordance with the Directive by 30th October 2007 at the latest.

Metals and their compounds (therefore, Cr(VI) substances) are included in Annex III to the Directive which presents an indicative list of the main polluting substances to be taken into account, **if they are relevant**, for fixing emission limit values. Total chromium is also included in the list of pollutants to be reported if a threshold value is exceeded (this can be found in Annex 1A to Commission Decision 2000/479/EC on the implementation of a European pollutant emission register (EPER)). The threshold values for reporting are 100kg/y to air and 50 kg/y to water.

With regard to Cr(VI), the IPPC Directive applies among others to the following types of installations (listed in Annex 1 of the Directive):

- **production and processing of metals:** covering the production of non-ferrous crude metals from ore, concentrates or secondary raw materials by metallurgical, chemical or electrolytic processes;
- installations for **surface treatment of metals and plastic materials** using an electrolytic or chemical process where the volume of the treatment vats exceeds 30 m³. Due to the existence of this threshold limit, consultation has been undertaken to identify the extent to which the IPPC Directive covers the metal finishing sector in the EU Member States. Information, where available, for individual countries is provided later in Section 4;
- chemical installations for the **production of basic inorganic chemicals**, such as acids (chromic acid) and salts;

²¹ Article 9 of the Directive states that authorities must take into account (a) the technical characteristics of the installation, (b) its geographical location and (c) the local environmental conditions.

- chemical installations for the **production of basic plant health products** and of **biocides**; and
- plants for the **tanning of hides and skins** where the treatment capacity exceeds 12 tonnes of finished products per day (although consultation suggests that all tanneries are normally subject to licensing irrespective of their capacity).

Wood treatment plants do not fall under IPPC; Annex 1 to the Directive does not include installations involved in the treatment of timber. However, given that the IPPC Directive and its implementation at the national level have been adjusted to pre-existing national licensing systems for industrial installations, approaches in member States vary. According to discussions at the second Steering Group meeting, wood treatment facilities do fall under the UK IPPC Regulations, however, in the UK, treatment plants using water-based products can claim exemption from authorisation requirements on the grounds that any emissions to air, water or land are trivial. Operators may be asked to demonstrate this to be the case to the Local Authority. In Ireland, the national IPPC Regulations apply to “*the treatment or protection of wood, involving the use of preservatives, with a capacity exceeding 10 tonnes of wood pre day*”. There are currently 50 licensed timber preserving facilities in Ireland. In Greece, all industrial facilities are required to have a licence, although the authority evaluating the submission of an application for a licence could be different on a case-by-case basis. A similar system is in place in Sweden (see Section 4.3.26). Therefore, although no explicit reference to wood preservation is made in Annex 1 to the Directive, national IPPC regulations may well apply to timber treatment plants.

There is a number of BREF Documents that have been or are being created to assist the licensing authorities in the allocation of permits and the establishment of limit values for releases. The ones relevant to this RRS are:

- reference document on Best Available Techniques for the **production of speciality inorganic chemicals** (chromium (III) pigments) – second draft of June 2005;
- reference document on Best Available Techniques in the **ferrous metal processing industry** (post-treatment of metals, such as chromate passivation in aluminisation of steel sheets and lead-tin coating of steel sheets) – December 2001;
- reference document on Best Available Techniques in the **large volume inorganic chemicals – solid and others industry** (production of chromate pigments and chrome tanning salts) – second draft of June 2005 in which information on chromium is still lacking. The latest (and final) draft of the BREF Document does not include information on the chromium compounds industry because the information available was not sufficient to be used for the determination of BAT. As a result there is no specific discussion on the processes involved, consumption and emission levels or techniques to be taken into account for the determination of BAT;

- reference document on Best Available Techniques for the **surface treatment of metals and plastics** (electroplating, anodising, dip treatments, direct chromating, plating of plastics) – final draft of May 2005; and
- reference document on Best Available Techniques for the **tanning of hides and skins** (on-site reduction of Cr(VI) to Cr(III) tanning salts and associated emissions) – February 2003.

Reference documents that are of relevance to Cr(VI) but apply to lifecycle areas that are not subject to this RRS include:

- reference document on Best Available Techniques in the **non-ferrous metals industries** (manufacture of metal chromium via the aluminothermic process) – December 2001; and
- reference document on Best Available Techniques for the **textiles industry** (use of chromium in wool and cotton dyeing) – July 2003.

It appears that no BREF Document is currently available (in draft or other form) for the production of basic plant health products and of biocides.

The term ‘best available techniques’ as described in Article 2(11) of the Directive means the most effective and advanced stage in the development of activities and their methods of operation which indicate the practical suitability of particular techniques for providing in principle the basis for emission limit values designed to prevent and, where that is not practicable, generally to reduce emissions and the impact on the environment as a whole.

‘Techniques’ includes both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned. ‘Available’ techniques means those developed on a scale which allows implementation in the relevant industrial sector, under economically and technically viable conditions, taking into consideration the costs and advantages, and whether or not the techniques are used or produced inside the Member State in question, as long as they are reasonably accessible to the operator. ‘Best’ means most effective in achieving a high general level of protection of the environment as a whole.

Availability of Data in the European Pollutant Emission Register

This section presents an overview of the emissions of chromium in the EU-15. It is based on publicly available data from the European Pollutant Emission Register (EPER). As indicated in the EPER Internet page (EPER, 2005)²², EPER contains data on the main pollutant emissions to air and water reported by around 10,000 large and medium-sized industrial facilities in the 15 EU Member States plus Hungary and Norway. These sites are listed in Annex I of the IPPC Directive and exceed specified emission thresholds set in Annex A1 to Commission Decision 2000/479/EC. Annex A1 indicates that emissions

²² Source: www.eper.cec.eu.int.

of chromium and its compounds are to be reported when these exceed 100 kg/y when the receiving compartment is air and 50 kg/y for water. These threshold values have been fixed at a level that aims to cover about 90% of the emissions from facilities covered by IPPC.

The share of total emissions covered by EPER varies for each Member State, industrial activity and pollutant. As the EPER web site states, “for most air pollutants the EPER share can be assessed, whereas for direct and indirect emissions to water it is more difficult due to a lack of pan-European data sets.” The website also gives examples of the thoroughness of the data within the database. For instance, EPER covers around (EPER, 2005):

- 42% of EU-15 carbon dioxide (CO₂) emissions;
- 15% of methane (CH₄) emissions;
- 26% of nitrogen oxides (NO_x) emissions; and
- 70% of sulphur oxides (SO_x) emissions.

The above suggest that EPER is yet to cover the entirety of EU emissions of pollutants which are required by IPPC to be reported. It is of note that IPPC requires the monitoring of emissions of “chromium and its compounds”; this general term may include emissions of chromium compounds other than those relevant to this RRS work. Nevertheless, the value of the EPER database should not be underestimated; EPER is a collection of comparable emission data based on actual monitoring across EU Member States rather than estimates and can serve as a useful starting point for the evaluation of industrial emissions of pollutants. Table 4.7 only presents emissions data for chromium (all chromium compounds) in the industry sectors of relevance to this RRS.

Table 4.7: 2001 Chromium Emissions from IPPC Installations in EU-15 plus Hungary and Norway

Activity/Description	Air (tonnes)	Direct to water (tonnes)	Indirect to water (tonnes)
Basic inorganic chemicals or fertilisers	9.38	60.93	0.1972
Installations for surface treatment or products using organic solvents (>200t/y)	1.72	2.41	1.12
Installations for the disposal of non-hazardous waste (>50t/d) and landfills (>10t/d)	0.112	12.59	0.9911
Installations for the disposal or recovery of hazardous waste (>10t/d) or municipal waste (>3t/h)	5.20	0.804	6.46
Metal industry and metal ore roasting or sintering installations, installations for the production of ferrous and non-ferrous metals	92.12	864.25	13.80
Plants for tanning of hides and skins (>12t/d)	-	2.13	182.58

Source: EPER, 2005
Note that the above emissions relate to all chromium compounds (not only Cr(VI))

It is of interest that the metal industry, which includes not only the surface treatment of metals, is associated with continental emissions of ca. 864 t/y to water (directly). This is

considerably lower than then estimated emissions of over 2,300 t/y presented in the RAR and reproduced in Table 3.5 of this Report.

4.1.7 Directive 98/8/EC of the European Parliament and of the Council concerning the Placing of Biocidal Products on the Market

Background Information

This Directive concerns the authorisation and placing on the market for use of biocidal products within the Member States, the mutual recognition of authorisations within the Community and the establishment at Community level of a positive list of active substances which may be used in biocidal products. The Directive does not apply to certain product types already covered by other Community legislation, such as plant protection products, medicines or cosmetics.

An exhaustive list of 23 product types with an indicative set of descriptions within each type is given in Annex V to the Directive. Wood preservatives are product type category 8 in this Annex.

The basic principles of the Directive are (CEC, 2004b):

- active substances²³ have to be assessed and the decision on their inclusion into Annex I²⁴ of the Directive shall be taken at Community level;
- a comparative assessment will be made at the Community level when an active substance, although in principle acceptable, still causes concern. Inclusion in Annex I may be denied if there are less harmful, suitable substitutes available for the same purpose;
- Member States shall authorise the biocidal products in accordance with the rules and procedures set in Annex VI of the Directive. They can only authorise products which contain active substances included in Annex I;
- the producers and formulators responsible for the placing on the market of the biocidal products and their active substances must apply for authorisation and submit all necessary studies (dossier) and other information needed for the assessments and the decision making; and
- a biocidal product authorised in one Member State shall be authorised upon application also in other Member States unless there are specific grounds to derogate from this principle of mutual recognition.

²³ Active substance is a substance or micro-organism including a virus or a fungus having general or specific action on or against harmful organisms.

²⁴ List of active substances with requirements agreed at community level for inclusion in biocidal products.

Information Required for Authorisation of Biocidal Products

According to Annex IIB to the Directive (Common Core Data Set for Biocidal Chemical Products), the information to be submitted by applicants (formulators) should include measures to be adopted to protect man, animals and the environment (paragraph VIII). These includes recommended methods and precautions concerning handling, use, storage, transport or fire of the biocidal product as well as procedures, if any, for cleaning application equipment.

On the other hand, Annex VI to the Directive lays down the requirements for risk assessment of active substances and substances of concern (“...if there are (...) any substances of concern present in the biocidal product then a risk assessment shall be carried out for each of these”). The risk assessment shall cover the proposed normal use of the biocidal product together with a realistic worst-case scenario including any relevant production and disposal issue either of the biocidal product itself or any material treated with it.

The risk assessment shall determine:

- the risk to humans and animals;
- the risk to the environment; and
- the measures necessary to protect humans, animals and the general environment during both the proposed normal use of the biocidal product and in a realistic worst-case situation.

As discussed further below, Cr(VI) substance may only be used in biocidal products if the formulators prove to the Competent Authorities that it is not an active substance. If formulators prove that, then chromium trioxide will be a substance of concern and the above requirements will apply in order for Cr(VI)-based wood preservatives to be authorised for marketing and use in the EU.

Actions of the Wood Preservatives Industry under the Biocidal Products Directive

Chromium trioxide, sodium dichromate, arsenic pentoxide and copper oxide were notified as active substances following the provisions of the Directive. The notification for chromium (trioxide) was accepted by the Commission in accordance with Article 4(2) of Regulation (EC) No 1896/2000 in relation to product type 8 (wood preservatives). The UK competent authorities were designated for the evaluation of chromium trioxide (Berend, 2005b). However, the formulators who originally notified chromium trioxide, did not eventually submit a dossier for the substance.

Further to the decision of the participants to discontinue their participation in the review programme for chromium trioxide and in the absence of any other producer, formulator, association or person to take over the role of participant, a decision shall now be taken, in

accordance with Article 8 (5) of Regulation 2032/2003, not to include chromium trioxide in Annex I, IA or IB to Directive 98/8/EC (Berend, 2005a).

This decision has already been adopted and shall be published very soon so that chromium trioxide will be included in Annex III to Directive 98/8/EC and that all biocidal products containing chromium trioxide (and arsenic trioxide for that matter) as an active substance will have to be removed from the market on 1 September 2006. This means that all Member States have to withdraw authorisations for biocidal products containing chromium as an active substance.

The Role of Hexavalent Chromium in Wood Preservatives – How this Affects the Market for Cr(VI)-based Wood Preservatives

There has been an ongoing debate on whether chromium trioxide is an active substance within the meaning of Directive 98/8/EC. The following paragraphs outline the current assumptions on this issue. Notably, according to the RAR, chromium, in wood preservatives, acts as a mordant or fixative whereby it permanently fixes toxic elements such as copper and arsenic, which prevent the growth of wood-destroying organisms, onto the wood lignins.

From a legal point of view, if a substance, even though it is listed in Annex III of Regulation 2032/2003/EC²⁵ (Annex III: Existing Active Substances that have been Identified but in respect of which no Notification has been Accepted or no Member State has Indicated an Interest), is considered as not active, the product – in which it is contained – could remain on the market provided that its active substance(s) is(are) included in Annex II of Regulation 2032/2003/EC for the product-type concerned (Annex II: Existing Active Substances and Product Types included in the Review Programme). Chromium trioxide is listed in Annex III (as are sodium dichromate and potassium dichromate which may also be used in wood preservative formulations).

Therefore, in simple terms, for Cr(VI)-based wood preservatives to remain on the market, the only option is that the formulator of a product containing chromium trioxide furnishes proof that it is not an active substance in his/her products (i.e. it shows no biocidal activity under the “normal conditions” for which this product is to be used – see Box 4.1 for more details on “normal conditions of use”).

If it is intended to demonstrate that chromium trioxide is not an active substance – within the meaning of Article 2(1)(d) of Directive 98/8/EC, the Competent Authorities of the Member States, where products containing Cr(VI) are authorised/licensed, should be contacted as early as possible by the formulators to clarify which and when information should be submitted.

²⁵ Commission Regulation (EC) No 2032/2003 of 4 November 2003 on the second phase of the 10-year work programme referred to in Article 16(2) of Directive 98/8/EC of the European Parliament and of the Council concerning the placing of biocidal products on the market, and amending Regulation (EC) No 1896/2000.

Box 4.1: The Issue of “Normal Conditions of Use”

As discussed above, Cr(VI) compounds were notified as active substances by a consortium of wood preservative formulators, however, a dossier for these was never submitted, therefore it cannot be included in Annex I or IA to the Directive. Active substances for which the notification was not accepted or withdrawn are still considered as identified existing active substances and products containing them cannot be placed on the market beyond 1 September 2006.

Article 5(1) (a) of the Directive makes it clear that biocidal products can only contain active substances that are listed in Annex I or IA. Whereas, if a substance is not considered to be an active substance, it does not have to be listed in Annex I or IA and can be used in formulated biocidal products (provided of course that it fulfils all other requirements e.g. regarding acceptability of risks or other requirements) (CEC, 2005).

The main issue is under which conditions a substance is ‘sufficiently effective’ for a claimed effect. This does not apply only to chromium trioxide but to other substances too (similar questions have been raised with regard to synergists used with insecticides, or products containing 2 ‘active’ substances (i.e. 2 substances identified or notified), but one not being active under the conditions of use) (CEC, 2005).

Article 10 of Directive 98/8/EC, setting out the inclusion criteria for Annex I, contains, among others, a reference to Article 5, in particular 5(1) (b), (c) and (d). Most relevant for this debate is 5(1)(b), which contains an efficacy requirement in (i) and the requirement for a positive outcome of the risk assessment regarding toxicological and ecotoxicological effects in (iii). According to the wording of Article 5(1) (b), these criteria have to be examined for biocidal products containing an active substance under “*all normal conditions under which the biocidal product may be used, how the material is treated with it may be used, the consequences from use and disposal*”.

It is of note that the Technical Notes for Guidance on the Directive indicate that efficacy is not defined specifically in the Directive, but it may be defined as ‘the power to produce an effect’. Efficacy is described in the Directive (Annex IIB [5.10], and Annex VI, paragraph 51) as the ability of a biocidal product to fulfil the label claims made for it on the proposed label. Section 7.2 of this document outlines that evaluation is based upon substantiation of efficacy claims and sets out the information that makes up an efficacy claim.

The Technical Notes for Guidance on Annex I inclusion indicates that full assessment of efficacy is conducted on applications for product authorisations at a national level (that is, within individual Member States) and will be conducted according to the detailed principles set out in the Technical Notes for Guidance for product evaluation. For the purposes of inclusion onto Annex I, some assessment of the inherent activity of both the candidate active substance and an accompanying product is required (CEC, 2005).

In conclusion, although chromium trioxide could possibly be sufficiently effective at high concentrations, it may not be sufficiently effective on its own under normal conditions of use (i.e. in a product containing only chromium trioxide in typical concentrations and with typical application rates) or when used in combination with other active substances under normal conditions of use (i.e. in typical concentrations and with typical application rates) and, therefore, would not have to be considered as an active substance in the sense of the Directive under such conditions. However, it must be up to the applicant for authorisation to demonstrate that chromium trioxide contained in a product for which authorisation is requested, is not acting as an active substance under the conditions of use. It is of note that, at concentrations/application rates where chromium trioxide by itself would be sufficiently effective, it will most likely not pass the other important criteria for inclusion into Annex I or IA, i.e. not to have ‘unacceptable toxicological or ecotoxicological effects’. In fact, there are probably very many substances that could be considered active substances at high concentrations, but are never used in such concentrations and, hence, are not added to formulated products to achieve biocidal effects (CEC, 2005).

It should be pointed out that chromium trioxide is to be regarded as a ‘substance of concern’ as defined under Article 2(1)(e) of Directive 98/8/EC. As such, upon review of any biocidal product containing chromium trioxide – as a non-active substance – toxicological data on chromium trioxide would have to be submitted in accordance with Annex IIB of Directive 98/8. Where necessary, the tests described in Annex IIA (applicable to active substances) may also be requested for chromium trioxide (Berend, 2005b).

In conclusion, the following apply:

1. Until 1 September 2006, only national legislation applies.
2. On 1 September 2006, authorisations for all products where chromium trioxide is an active substance (and is recognised as such in an existing authorisation) will have to be withdrawn.
3. If formulators want to demonstrate that chromium trioxide is not active in their products, they should start convincing the Member States concerned as soon as possible and ask them to submit any decision for review by the other Member States and the Commission to ensure a harmonised approach.
4. By 1 September 2006 at the latest, formulators need to have provided proof (and for this proof to have been accepted) that chromium trioxide is not an active substance. Note that for arsenic, despite its notification, no dossier has been submitted and arsenic pentoxide is most definitely an active biocidal substance. Therefore, the use of arsenic pentoxide in wood preservatives in the EU will be prohibited on 1 September 2006 (this effectively means a ban on CCA formulations).
5. Member States (such as Austria, France, Germany and Luxembourg) which have not had any formal approval system for wood preservatives will have to ensure otherwise that products with active substances that can no longer be used after 1 September 2006 are withdrawn from the market (irrespective of workload or other similar considerations).
6. If any company is unhappy that the situation is not properly managed, and in the same way in different Member States, they can complain to the Member States concerned and to the Commission; there are mechanisms to deal with this in the Treaty.

It should be noted that the Directive does not provide for any Community-wide evaluation of substances in biocidal products other than the active substances. Ingredients of formulated products, such as fixatives, are to be evaluated as components of biocidal products when companies request authorisations. Obviously, the authorities in other Member States should recognise the evaluations made by the first Member State granting authorisation for a product (Berend, 2005a).

Notably, the wood preservative formulators do not appear to have a common position on the issue of chromium trioxide (and the other Cr(VI) substances) being an active substance or not.

Different Approaches of Member States with Regard to the use of Chromium in Wood Preservatives

As suggested by industry, in Germany, there is an agreement between authorities, industry and the scientific community that chromium in wood preservatives has to be seen as a fixative. At the beginning of the 1990s, the introduction of alternatives not based on Cr(VI) led to a broad discussion concerning restrictions of the use of Cr(VI)-based wood preservatives.

In 1997, the German Committee for Hazardous Materials (AGS) issued the TRGS 618 (technical rules for hazardous materials) in which the use of Cr(VI)-based wood preservatives is described in detail. In this paper, the function of chromium is described as a fixative for the active ingredients (p7 8.1). Furthermore, the German Institute for Constructional engineering (DIBt) publishes yearly a list of authorised wood preservatives in which chromium trioxide is declared a fixative for all Cr(VI)-based wood preservatives (personal communication with industry).

German formulators are reportedly in an ongoing discussion about an efficacy study that will prove that chromium trioxide is not an active substance (personal communication with industry).

On the other hand, in the UK, chromium is authorised for use under the Control of Pesticides Regulations as an active substance.

Finally, as discussed in Section 2.13.6, in Slovenia, chromium trioxide has also been considered to be an active substance in wood preservative formulations (Humar, 2005).

4.1.8 Directive 2000/53/EC of the European Parliament and of the Council on End-of-life Vehicles

This Directive lays down measures which aim, as a first priority, at the prevention of waste from vehicles and, in addition, at the reuse, recycling and other forms of recovery of end-of-life vehicles and their components so as to reduce the disposal of waste, as well as at the improvement in the environmental performance of all of the economic operators involved in the lifecycle of vehicles and especially the operators directly involved in the treatment of end-of-life vehicles.

In accordance with the Directive, the use of Cr(VI) should be prohibited. This should only be used in certain applications. This will help to ensure that certain materials and components do not become shredder residues and are not incinerated or disposed of in landfills.

Hence, Article 4 (2.a) requires that Member States shall ensure that materials and components of vehicles put on the market after 1 July 2003 do not contain Cr(VI) other than in cases listed in Annex II under the conditions specified therein. According to Annex II, Cr(VI) may be used in corrosion preventive coating of numerous key vehicle components (with a maximum weight of 2 grams per vehicle). The Annex was amended by Commission Decision 2002/535/EC according to which the exemption for corrosion preventive coatings will expire on 1 July 2007²⁶. A maximum concentration value up to 0.1% by weight and per homogeneous material, for lead, Cr(VI) and mercury and up to 0.01% by weight per homogeneous material for cadmium shall be tolerated, provided these substances are not intentionally introduced.

4.1.9 Directive 2000/60/EC of the European Parliament and of the Council establishing a Framework for the Community Action in the Field of Water Policy (the Water Framework Directive)

General Objective and Approach

The objective of the Water Framework Directive is to achieve ‘good quality status’ for waters in the Community within a set deadline. To achieve this, the Directive introduced the notion of ‘river basin management’. This was based on the idea that the best model for a single system of water management is management by river basin - the natural geographical and hydrological unit - instead of according to administrative or political boundaries. For each river basin district (RBD), which may include several river basins and may traverse national frontiers, a ‘river basin management plan’ (RBMP) will need to be established and updated every six years.

Each RBMP is a detailed account of how the objectives set for the river basin (ecological status, quantitative status, chemical status and protected area objectives) are to be reached within the timescale required. The plan will include all the results of the above analysis:

- the river basin's characteristics;
- a review of the impact of human activity on the status of waters in the basin including an estimation of the effect of existing legislation and the remaining ‘gap’ to meeting these objectives; and
- a set of measures designed to fill the gap.

One additional component is that an economic analysis of water use within the river basin must be carried out. This is to enable there to be a rational discussion on the cost-effectiveness of the various possible measures.

²⁶ A new exemption for absorption refrigerators in motorcaravans was also introduced for which labelling is required.

Member States' Key Actions

The key actions that Member States need to take include:

- identifying the individual river basins lying within their national territory and assigning them to individual RBDs and identifying competent authorities by 2003 (Article 3, Article 24);
- characterising RBDs in terms of pressures, impacts and economics of water uses, including a register of protected areas lying within the RBD, by 2004 (Article 5, Article 6, Annex II, Annex III);
- carrying out, jointly and together with the European Commission, the intercalibration of the ecological status classification systems by 2006 (Article 2(22), Annex V);
- making operational the monitoring networks by 2006 (Article 8);
- based on sound monitoring and the analysis of the characteristics of the river basin, identifying by 2009 a programme of measures for achieving the environmental objectives of the WFD cost-effectively (Article 11, Annex III);
- producing and publishing RBMPs for each RBD including the designation of heavily modified water bodies, by 2009 (Article 13, Article 4.3);
- implementing water pricing policies that enhance the sustainability of water resources by 2010 (Article 9);
- making the measures of the programme operational by 2012 (Article 11); and
- implementing the programmes of measures and achieve the environmental objectives by 2015 (Article 4).

Requirements for Surface Waters

With regard to surface water, a general requirement for ecological protection, and a general minimum chemical standard, was introduced to cover all surface waters. These are the two elements 'good ecological status' and 'good chemical status'. Good ecological status is defined in Annex V of the Water Framework Directive, in terms of the quality of the biological community, the hydrological characteristics and the chemical characteristics.

Good chemical status is defined in terms of compliance with all the quality standards established for chemical substances at European level. The Directive also provides a mechanism for renewing these standards and establishing new ones by means of a prioritisation mechanism for hazardous chemicals. This will ensure at least a minimum

chemical quality, particularly in relation to very toxic substances, everywhere in the Community.

The Water Framework Directive addresses the dichotomy in approach to pollution control at European level, with some controls concentrating on what is achievable at source, through the application of technology, and some dealing with the needs of the receiving environment in the form of quality objectives. The Water Framework Directive requires that as part of the basic measures to be taken in the river basin, all existing technology-driven source-based controls must be implemented as a first step. But over and above this, it also sets out a framework for developing further such controls. The framework comprises the development of a list of priority substances for action at EU level, prioritised on the basis of risk, and then the design of the most cost-effective set of measures to achieve load reduction of those substances, taking into account both product and process sources.

Substance Prioritisation

Article 16 of the Directive sets out a ‘Strategy against pollution of water’. Article 16 outlines the steps to be taken. The first step of the strategy was the establishment of a list of priority substances to become Annex X of the Directive. With Decision (2455/2001/EC) of 20 November 2001 the (first) list of priority substances was introduced. The list identifies 33 substances or group of substances, which have been shown to be of major concern for European waters. Within this list, 11 substances were identified as priority hazardous substances which are of particular concern for the inland, transitional, coastal and territorial waters. These substances will be subject to cessation or phasing out of discharges, emissions and losses within an appropriate timetable that shall not exceed 20 years. A further 14 substances were identified as being subject for review for identification as possible ‘priority hazardous substances’.

The identification of priority hazardous substances among the priority substances was based on a combined monitoring-based and modelling-based priority setting (COMMPS) procedure. In the application of the COMMPS procedure about 820,000 monitoring data from waters and sediments from all Member States were evaluated and data for more than 310 substances on production, use and distribution in the environment were used for modelling if the available monitoring information was insufficient. The procedure considered, among others, the finalised risk assessments made under ESR and the information under the regulations of pollution by certain dangerous substances discharged into the aquatic environment under Council Directive 76/464/EEC and its five ‘daughter’ directives. This information was used to group the priority substances into clusters with increasing ‘levels of concern’.

For the final assignment of a priority substance, ‘additional considerations’ were considered to confirm or reject the status of the substance. The ‘additional considerations’ included other relevant Community legislation or relevant international agreements, the production and use of the substance, the socio-economic impacts of a cessation or phase-out and the suspected endocrine disrupting potential of the substance.

Relevance to Chromium and Future Actions

Measures taken under Directive 76/464/EEC

As discussed in Section 4.1.2, Directive 76/464/EEC, which includes chromium and its substance in its list II, now falls under the Water Framework Directive and will be incorporated in it by 2013. This means that measures already taken by Member States are still valid.

Further Action to be taken by Member States under the Water Framework Directive

Chromium does not belong to the list of priority substances. As a result there are no Community-wide quality standards or emission limit values for chromium or chromium substances. In accordance to the provisions of the Water Framework Directive, it is up to each Member State to decide whether it impacts upon water quality and whether they need to set an EQS and develop relevant measures.

The decision on whether a (new) EQS and further measures are required is to be based on whether chromium (or any other pollutant for that matter) is of relevance to the river basins. This will be decided through the review and analysis of the impact of human activity on the status of surface waters (and on groundwater), what is known as 'pressures'.

Identification of Pressures

According to Annex II to the Directive, Member States were required to collect and maintain information on the type and magnitude of the significant anthropogenic pressures to which the surface water bodies in each river basin district are liable to be subject, in particular the following:

- estimation and identification of significant point source pollution, in particular by substances listed in Annex VIII, from urban, industrial, agricultural and other installations and activities;
- estimation and identification of significant diffuse source pollution, in particular by substances listed in Annex VIII, from urban, industrial, agricultural and other installations and activities;
- estimation and identification of significant water abstraction for urban, industrial, agricultural and other uses, including seasonal variations and total annual demand, and of loss of water in distribution systems;
- estimation and identification of the impact of significant water flow regulation, including water transfer and diversion, on overall flow characteristics and water balances;
- identification of significant morphological alterations to water bodies;

- estimation and identification of other significant anthropogenic impacts on the status of surface waters; and
- estimation of land use patterns, including identification of the main urban, industrial and agricultural areas and, where relevant, fisheries and forests.

Member States were required to use the information collected above, and any other relevant information including existing environmental monitoring data, to carry out an assessment of the likelihood that surface waters bodies within the river basin district will fail to meet the environmental quality objectives set for the bodies under Article 4. Member States may utilise modelling techniques to assist in such an assessment.

Identification of Relevant Pollutants

Guidance on identifying relevant pollutants is provided in Guidance Document No. 3 of the Common Implementation Strategy for the Water Framework Directive (IMPRESS, 2003).

The generic approach to the identification of specific pollutants includes the following five steps:

1. *Starting point*: the starting point is the indicative list of the main pollutants set out in Annex VIII of the Directive. Only those pollutants under points 1 to 9 need further consideration as potential specific pollutants. The pollutants under points 10, 11 and 12 of the Annex are the general physico-chemical quality elements and are considered separately.
2. *Screening*: a screening of all available information on pollution sources, impacts of pollutants and production and usage of pollutants in order to identify those pollutants that are being discharged into water bodies in the river basin district. In the screening step, two sub-steps can be distinguished: a) collation of information, and b) deriving a list of pollutants. Sources of information to be consider include among others source/sectoral analyses, monitoring data, information on intrinsic properties of the pollutants affecting their likely pathways into the water environment, information from existing obligations and programmes (priority substances, Directive 76/464/EEC, EPER, results of 793/93, etc.)

Assessment of the collated information will result in a working list of those pollutants identified as being discharged into water bodies. Most of these pollutants will be selected by the combination of a top-down and bottom-up approach. Pollutants for which there is adequate confidence that they are not being discharged into water bodies may be excluded from further consideration.

3. *Testing for relevance*: step 3 selects from the pollutants identified under Step 2 those likely to cause, or already causing, harm to the environment. This will depend on the intrinsic properties of the pollutants, their fate and behaviour in the environment and the magnitude of their discharges. The selection should ideally be

based on an assessment of the environmental significance of the concentrations (and trends in concentrations) estimated for the pollutants or their breakdown products in the water bodies. However, effects data or an assessment of the significance of predicted loads may also be relevant in the selection process.

Two sub-steps are envisaged in the test for relevance: a) estimating concentrations in water bodies; and b) comparing the estimated concentrations with suitable 'benchmarks'. The former will be based on monitoring: i.e. measured data and/or modelling: i.e. estimated data. With regard to the latter, pollutants identified under Step 2 may be excluded where their concentrations are estimated to be lower than the most relevant critical value such as estimated LC₅₀, NOEC, PNEC, EQS or critical load.

4. *Safety net*: a safety net is needed to ensure that pollutants that may be environmentally significant are not incorrectly excluded from the list of specific pollutants during Step 3 above. For example, the safety net should consider:
 - whether a number of small (individually minor) pollution sources may be expected to have a significant combined effect;
 - trends that may indicate an increasing importance of a pollutant, even though the EQS is not currently exceeded;
 - the presence of pollutants with similar modes of toxic action and hence potentially additive effects.

For some pollutants the assessments made in Steps 2 and 3 may not provide adequate confidence that a pollutant is either not being discharged or not presenting a significant environmental risk. For example, confidence may be low if the tests for environmental significance under Step 3 are based on EQSs that were derived using insufficient or inadequate ecotoxicological data. In such cases, the uncertainty should be taken into account in deciding whether to identify the pollutant as a specific pollutant, and appropriate further investigations should be made to improve confidence in the selection procedure.

5. *Final outcome*: the final outcome must be a list of specific pollutants relevant to a river basin district or to particular water bodies within a river basin district.

Consultation with a Commission representative suggests that, if a statutory EQS for chromium already exists, this should be used for the testing of relevance of chromium under the Water Framework Directive. At the same time, at this stage, it is unlikely that new information out of the RAR can be considered. Where no EQS exists, most member State methodologies will use some kind of ecotoxicology data to determine the relevance of chromium. For chromium, some Member States may or may not consult and use the information in the RAR.

The IMPRESS Guidance suggests that existing EQSs do not always reflect the actual effects concentrations. In addition, EQSs have not been derived for all potential specific pollutants. The best estimate for the EQS should be used based on the most recent

ecotoxicological data. Effects data from monitoring programmes should be taken into account where available (IMPRESS, 2003).

It should be noted that the Member States have very recently submitted reports to the Commission on the identification of pressures. Information in these reports (not made available to RPA) will be crucial in determining the relevance of chromium under the Water Framework Directive. The Commission intends to complete the assessment of these reports by the end of 2006

Procedure for Setting of Chemical Quality Standards by Member States

If chromium is identified as a relevant national pollutant, a statutory EQS must be established by the end of 2006 to achieve ‘good chemical status’ and prepare measures, in particular those required under Article 11.3 (g) and (h) of the Directive. In deriving EQSs, Member States shall act in accordance with the following provisions outlined in Annex V to the Directive:

- standards may be set for water, sediment or biota;
- where possible, both acute and chronic data shall be obtained for the taxa set out below which are relevant for the water body type concerned as well as any other aquatic taxa for which data are available. The ‘base set’ of taxa are: (a) algae and/or macrophytes; (b) daphnia or representative organisms for saline waters; and (c) fish.

For setting a maximum annual average concentration Member States must set appropriate safety factors in each case consistent with the nature and quality of the available data and the guidance given in section 3.3.1 of Part II of TGD in support of Commission Directive 93/67/EEC on risk assessment for new notified substances and Commission Regulation (EC) No 1488/94 on risk assessment for existing substances and the safety factors set out in below:

- at least one acute L(E)C₅₀ from each of three trophic levels of the base set: 1000
- one chronic NOEC (either fish or daphnia or a representative organism for saline waters): 100
- two chronic NOECs from species representing two trophic levels (fish and/or daphnia or a representative organism for saline waters and/or algae): 50
- chronic NOECs from at least three species (normally fish, daphnia or a representative organism for saline waters and algae) representing three trophic levels: 10
- other cases, including field data or model ecosystems, which allow more precise safety factors to be calculated and applied: case-by-case assessment

This approach is similar to the analysis undertaken in the Risk Assessment Reports for the development of $PNEC_{\text{water}}$ values of priority substances. It is reasonable to assume that Member States will take into account the analysis presented in the RAR in the light of the existing uncertainties (see Section 8.1.2) as well as the discussions in this RRS.

Scope for Inclusion of Chromium in the Water Framework Directive List of Priority Substances

It is understood that the Commission is already working on the review of the list of priority substances under the Water Framework Directive. This work is still at an early stage and the completion of the revision of the list is not expected until 2007-2008.

Under this work, the Commission **may** look at other metals including chromium, although at present it is too early to assess whether this will eventually be the case. If chromium is given consideration, it would be reasonable to expect that the discussion and results of the RAR will be taken into account as will probably be this RRS and the results of the ongoing RAR on Cr(III) (see Section 4.4.6). Naturally, consideration is also expected to be given to the results of the assessment of the pressures reports recently submitted by Member States.

It is important to note that Article 16(2) of the Directive stipulates that substances will be prioritised for action on the basis of risk to or via the aquatic environment, identified by:

- a) risk assessment carried out under Council Regulation (EEC) No 793/93, Council Directive 91/414/EEC, and Directive 98/8/EC of the European Parliament and of the Council; or
- b) targeted risk-based assessment (following the methodology of Regulation (EEC) No 793/93) focusing solely on aquatic ecotoxicity and on human toxicity via the aquatic environment.

If chromium is considered in the revision of the list of priority substance and **if** it is included in the list, it is not clear at present whether it could be classified as a priority hazardous substance (i.e. a cessation or phase-out of emissions would be required). The information available at present does not allow for any conclusion to be reached and any recommendation to be made within this RRS on the appropriateness of any such classification. Information on pressures at the national level will be an important source of data for future decision-making. In the event that chromium is included in the list of priority substances, it will be important to take into account the different toxicological and ecotoxicological profile of Cr(VI) and Cr(III) (with the latter being the prevailing form of chromium in the aquatic environment). This issue could be addressed by specifying Cr(VI) as the relevant species for which any Community-wide EQS should be developed.

It is of interest that the findings of the ESR RAR are already being taken into account by Member States. As discussed in Section 4.3.8, the Finnish Environment Institute is currently considering the introduction of Maximum Permissible Additions for Cr(VI) and

Cr(III) in waters. The proposed values are identical to the $PNEC_{\text{water}}$ values for the two forms of chromium that were used in the RAR.

Transposition and Reporting

The Water Framework Directive provides for a number of deadlines by which Member States have to fulfil particular obligations and report the achievement to the European Commission. The key reporting obligations in the Directive are summarised below:

- 22 December 2003: legal transposition into national legislation (for the 10 new Member States, the date was 1 May 2004);
- 22 June 2004: reporting of river basin districts and competent authorities;
- 22 March 2005: reporting of characterization and analysis on pressure, impacts and water uses;
- 22 March 2007: reporting of monitoring programmes; and
- 22 March 2010: reporting of RBMP including programme of measures.

4.1.10 Directive 2002/95/EC of the European Parliament and of the Council on the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment

The purpose of this Directive, known as the RoHS Directive, is to approximate the laws of the Member States on the restrictions of the use of hazardous substances in electrical and electronic equipment and to contribute to the protection of human health and the environmentally sound recovery and disposal of waste electrical and electronic equipment (WEEE).

The Directive applies to electrical and electronic equipment falling under the categories 1, 2, 3, 4, 5, 6, 7 and 10 set out in Annex IA to Directive No 2002/96/EC (WEEE) and to electric light bulbs, and luminaires in households, although it does not apply to spare parts for the repair, or to the re-use, of electrical and electronic equipment put on the market before 1 July 2006.

Article 4(1) requires that Member States ensure that, from 1 July 2006, new electrical and electronic equipment put on the market does not contain lead, mercury, cadmium, Cr(VI), polybrominated biphenyls (PBB) or polybrominated diphenyl ethers (PBDE). National measures restricting or prohibiting the use of these substances in electrical and electronic equipment which were adopted in line with Community legislation before the adoption of this Directive may be maintained until 1 July 2006.

The Annex to the Directive introduced a single derogation for Cr(VI): its use as an anti-corrosion of the carbon steel cooling system in absorption refrigerators.

4.1.11 Directive 2002/96/EC of the European Parliament and of the Council on Waste Electrical and Electronic Equipment (WEEE)

The purpose of this Directive is, as a first priority, the prevention of WEEE, and in addition, the re-use, recycling and other forms of recovery of such wastes so as to reduce the disposal of waste. It also seeks to improve the environmental performance of all operators involved in the life cycle of electrical and electronic equipment, e.g. producers, distributors and consumers and in particular those operators directly involved in the treatment of WEEE.

According to Article 2(1), the Directive applies to electrical and electronic equipment falling under the categories set out in Annex IA provided that the equipment concerned is not part of another type of equipment that does not fall within the scope of this Directive. Categories of electrical and electronic equipment covered by this Directive include:

- large household appliances;
- small household appliances;
- IT and telecommunications equipment;
- consumer equipment;
- lighting equipment;
- electrical and electronic tools (with the exception of large-scale stationary industrial tools);
- toys, leisure and sports equipment;
- medical devices (with the exception of all implanted and infected products);
- monitoring and control instruments; and
- automatic dispensers.

4.1.12 Commission Directive 2003/2/EC relating to Restrictions on the Marketing and Use of Arsenic

According to Article 1 of this Directive, Annex I to Directive 76/769/EEC was amended to include restrictions on the marketing and use of arsenic compounds. This Directive does not apply to CCA-treated wood already in place.

Arsenic compounds may not be used as substances and constituents of preparations intended for use:

- to prevent the fouling by micro-organisms, plants or animals of:
 - the hulls of boats;
 - cages, floats, nets and any other appliances or equipment used for fish or shellfish farming;
 - any totally or partly submerged appliances or equipment; or
- in the preservation of wood. Furthermore, wood so treated may not be placed on the market.

However, by way of derogation:

- *relating to the substances and preparations in the preservation of wood*: these may only be used in industrial installations using vacuum or pressure to impregnate wood, if they are solutions of inorganic compounds of the copper, chromium, arsenic (CCA) type C. Wood so treated may not be placed on the market before fixation of the preservative is completed;
- *relating to wood treated with CCA solutions in industrial installations*: this may be placed on the market for professional and industrial use provided that the structural integrity of the wood is required for human or livestock safety and skin contact by the general public during its service life is unlikely:
 - as structural timber in public and agricultural buildings, office buildings, and industrial premises;
 - in bridges and bridgework;
 - as constructional timber in freshwater areas and brackish waters e.g. jetties and bridges;
 - as noise barriers;
 - in avalanche control;
 - in highway safety fencing and barriers;
 - as debarked round conifer livestock fence posts;
 - in earth retaining structures;
 - as electric power transmission and telecommunications poles; and
 - as underground railway sleepers.

All treated wood placed on the market shall be individually labelled “*For professional and industrial installation and use only, contains arsenic*”. In addition, all wood placed on the market in packs shall also bear a label stating “*Wear gloves when handling this wood. Wear a dust mask and eye protection when cutting or otherwise crafting this wood. Waste from this wood shall be treated as hazardous by an authorised undertaking*”.

- treated wood referred to above may not be used:
 - in residential or domestic constructions, whatever the purpose;
 - in any application where there is a risk of repeated skin contact;
 - in marine waters;
 - for agricultural purposes other than for livestock fence posts and structural uses in accordance with the above; and
 - in any application where the treated wood may come into contact with intermediate or finished products intended for human and/or animal consumption.

Arsenic compounds may not be used as substances and constituents of preparations intended for use in the treatment of industrial waters, irrespective of their use.

The public consultation that preceded the introduction of this Directive suggested that the derogated uses would account for around 15% (maximum 30%) of the use of pressure-impregnated wood at the time (2002).

4.2 Other International Initiatives

4.2.1 Recommendations of the Helsinki Commission and the Oslo-Paris Convention

International bodies such as the Baltic Marine Environment Protection Commission (the Helsinki Commission) and the Oslo-Paris Convention (OSPAR) have issued recommendations on the control of emissions of Cr(VI) compounds. These are briefly described in Table 4.8.

Table 4.8: Helcom and Parcom (OSPAR) Recommendations of Relevance to the Five Hexavalent Chromium Substances	
Instrument	Description
Helcom Recommendation 16/7 on basic principles in wastewater management in the leather industry	Wastewater discharges from leather industry into water bodies or municipal sewerage systems should not exceed the limit values of 0.075 kg Cr (total)/tonne leather as annual mean and 1.5 mg Cr (total)/l as 24h-value or shorter sampling period
Helcom Recommendation 23/7 on restriction of discharges and emissions from metal surface treatment (superseding Recommendation 16/6)	Before discharging into sewers or surface waters the treatment should be provided so that the concentrations of Cr(total) should not exceed 0.7 mg/l and Cr(VI) should not exceed 0.2 mg/l. Plants discharging small loads of metals (defined as sum of total chromium, copper, lead, nickel and zinc less than 200 g/day prior to end-of-pipe treatment) may be subject to limit values up to maximum four times higher for total chromium. This Recommendation should apply primarily to plants in which surfaces are plated with metals electrolytically or chemically
Helcom Recommendation 23/11 on requirements for discharging of wastewater from the chemical industry (superseding Recommendation 20E/6)	For plants discharging into water bodies or connected to the municipal sewerage system, the concentration of Cr(total) should not exceed 0.5 mg/l while the concentration of Cr(VI) should not exceed 0.1 mg/l. These requirements should neither be exceeded in the effluent after final treatment for plants discharging into water bodies nor in the effluent connected to municipal sewerage system
Parcom Recommendation 92/2 concerning limitation of pollution from new primary iron and steel production installations	Waste gases containing dust should be collected and be subjected to dedusting. After dedusting, the gases should not contain more than 50 mg dust/m ³ . If the dust contains hazardous substances (e.g. heavy metals such as cadmium, lead and/or chromium) lower standards should be achieved (Spain lifted its reservation in 2003)
Parcom Recommendation 93/1 concerning limitation of pollution from existing primary iron and steel production installations	Waste gases containing dust should be collected and be subjected to dedusting. After dedusting, the gases should not contain more than 50 mg dust/m ³ . If the dust contains hazardous substances (e.g. heavy metals such as cadmium, lead and/or chromium) lower standards should be achieved (Spain lifted its reservation in 2003)
Parcom Recommendation 92/4 on the reduction of emissions from the electroplating industry	Before discharging into sewers or surface waters, treatment should be provided on- or off-site, so that the concentrations of chromium (VI) does not exceed 0.1 mg/l while the concentration of total chromium should not exceed 0.5 mg/l. For new plants, the Recommendation entered into force on 1 January 1994. Existing plants were to be retrofitted by 31 December 1998

4.2.2 Status of Implementation of Helcom Recommendations

It should be noted that the Recommendations apply only to installations that fall within the Baltic Sea catchment area of the contracting parties, not the entire countries.

Helcom Recommendation 16/7 on Basic Principles in Wastewater Management in the Leather Industry

Table 4.9 provides an overview of the status of implementation of Recommendation 16/7 as of 2002.

Country	Status of implementation
Denmark	Fully implemented
Estonia	Only one plant reporting. Fully implemented
Finland	Partly implemented. Limit value for Cr exceeded
Germany	No tanneries located in the Baltic Sea catchment area
Latvia	Data incomplete
Lithuania	Fully implemented
Poland	Recommendation was observed except one very small tannery (20 t/y of input hide)
Sweden	Fully implemented

Source: Helcom, 2002a

Table 4.10 presents the available data on releases of total chromium from the leather industry in the Helcom members.

Country	Wastewater discharged to municipal sewer				Wastewater discharged surface water			
	Load (t/y)		Specific load (kg/t) or concentration (mg/l)		Load (t/y)		Specific load (kg/t) or concentration (mg/l)	
	1998	2001	1998	2001	1998	2001	1998	2001
Denmark	1.252	0.07	0.3	0.005-0.012	-	-	-	-
Estonia	0.375	0.0006	0-75 mg/l	0.02 mg/l	-	n.d.	-	n.d.
Finland	5.046	5.482	0.085-2.07 18-43 mg/l	0.17-1.14 6.3-46.8 mg/l	0.26	0.035	0.053-0.329	0.012-0.044
Germany	No tanneries in the Baltic Sea catchment area							
Latvia	N.d	N.d.	N.d.	N.d.	-	-	-	-
Lithuania	0.327	0.200	0.012-0.177 kg/t 1.5-2.0 mg/l	0.014-0.048 1.3-2.0 mg/l	-	-	-	-
Poland	5.252	0.543	0.0017-2.57 kg/t	0.0-0.075 0.0-7.6 mg/l	0.19	0.16	0.00013- 0.048	0.00-0.32
Sweden	5.118	2.310	0.009-0.43	0.00-0.19	-	-	-	-

Source: Helcom, 2002a
N.d. = no data

Helcom Recommendation 16/6 on Restriction of Discharges and Emissions from Metal Surface Treatment

Table 4.11 provides an overview of the status of implementation of Recommendation 16/6 (superseded by Recommendation 23/7) as of 2002.

Country	Status of implementation
Denmark	Partly implemented. The recommendation is implemented in the national regulation of the industry and chemicals. This means both permission and other instruments are used
Estonia	Partly implemented. Adopted national legislation not sufficient. A new act concerning integrated permits was adopted in 2002. After the full implementation of the integrated permitting system it would be possible to determine exactly the technologies used in those plants and check the compliance to the references of BAT and BEP
Finland	Partly implemented. Limit value for Cr exceeded. Around 80% of installations discharging to municipal wastewater treatment plants comply with requirements. The average size of the plants is small and small plants do not have many resources to make improvements to their processes
Germany	Fully implemented. The requirements of the Recommendation are mandatory and subject to regular surveillance by the local authorities
Latvia	Partly implemented
Lithuania	Data incomplete
Poland	Partly implemented. The plants discharging wastewater into surface waters, except one, where the Cr(VI) concentration recommended was not met, were in full compliance with the limit values of the Recommendation. Discharges are regulated under the Environmental Protection Law and the Water Law
Sweden	Partly implemented. Around 90% of installations discharging to municipal wastewater treatment plants comply with requirements
<i>Source: Helcom, 2002</i>	

Table 4.12 presents the number of metal surface treatment installations that discharge directly to surface water and those discharging to municipal sewers in Helcom contracting parties.

Country	Total number of plants	Discharge to surface water	Discharge to sewer
Denmark	95	3	92
Estonia	3	0	3
Finland	~300	~30	~270
Germany	~5,000	No data	No data
Latvia	51	6	45
Lithuania	26	0	26
Poland	97	17	80
Sweden	~700	~400	~300
<i>Source: Helcom, 2002</i>			

Helcom Recommendation 20E/6 on Requirements for Discharging of Wastewater from the Chemical Industry (now superseded by Recommendation 23/11)

Table 4.13 shows the number of plants falling under the Recommendation.

Country	Cr/ Cr(VI)	Number of plants regulated by 20E/6	Insufficient data or parameter not relevant	Complying with recommendations	Not complying with recommendation
Estonia	Cr	6	0	6	0
	Cr(VI)	6	6	0	0
Finland	Cr	16	14	2	0
	Cr(VI)	16	15	1	0
Latvia	Cr	6	6	0	0
	Cr(VI)	6	6	0	0
Lithuania	Cr	1	0	1	0
	Cr(VI)	1	No data	0	0
Poland	Cr	30	21	9	0
	Cr(VI)	30	26	4	0
Sweden	Cr	13	10	3	0
	Cr(VI)	13	10	3	0

Source: Helcom, 2003

According to the Danish and German national reports of 1999, there is no chemical plant regulated by HELCOM recommendation 20E/6 within the Baltic Sea catchments areas of these two countries.

4.2.3 Status of Implementation of Parcom (OSPAR) Recommendations

Parcom Recommendation 93/1 Concerning the Limitation of Pollution from Existing Primary Iron and Steel Production Installations

Table 4.14 outlines the status of implementation of Parcom Recommendation 93/1 as of 2002.

Contracting party	Reservation	Report sent	Measure not applicable	Action by legislation	Administrative action
Belgium	✓	✓			
Denmark		✓	✓		
Finland		✓			✓
France		✓ (late)		✓	
Germany		✓		✓	✓
Iceland		✓	✓		

Contracting party	Reservation	Report sent	Measure not applicable	Action by legislation	Administrative action
Ireland		✓	✓		
Luxembourg				No evidence of implementation	
Netherlands		✓			✓
Norway		✓	✓		
Portugal				No evidence of implementation	
Spain	✓				
Sweden		✓		✓	✓
United Kingdom		✓		✓	✓
Switzerland		✓	✓		
<i>Source: OSPAR, 2002</i>					

Parcom Recommendation 92/4 on the Reduction of Emissions from the Electroplating Industry

Table 4.15 outlines the status of implementation of Parcom Recommendation 92/4 as of 2002.

Contracting party	Report sent	Measures taken	Comments
Belgium	✓	✓	Most of the recommendations found to be applicable for the Flemish industry (in 1997) and largely coincide with those of a Flemish BAT study which was recently performed
Denmark	No		
Finland	✓	✓	Guidelines for limit values for wastewater discharges for industries connected to municipal wastewater treatment plants have been in use since 1992. These guidelines include limit values similar (or partly stricter) than those stipulated in Parcom Recommendation 92/4. Individual stricter limit values can be negotiated between the industry and the wastewater treatment plants
France	✓	✓	French regulations reach the same goals as those stipulated in Parcom Recommendation 92/4, although using a different approach. French regulations are limiting loads of contaminants by setting limits for water consumption (8 litres per m ² treated metal surface) and contaminant concentrations. However, according to the list in the French technical instructions for limiting the emissions of the surface treatment industry, the limit values stipulated for heavy metal concentrations are higher (by a factor 4 - 10) than those in Parcom Recommendation 92/4
Germany	✓	✓	Concentration limits for contaminants in wastewater as stipulated in Parcom Recommendation 92/4 are covered by the relevant German ordinance
Iceland	✓		No new plants have been set up since 1 st January 1994. Existing plants are mostly very small with permits issued by local authorities. They have been addressed to take up the measure when renewing operating licences. Information on effectiveness is not available
Ireland			No data

Table 4.15: Implementation of Parcom Recommendation 92/4 as of 1999 (Electroplating Industry)			
Contracting party	Report sent	Measures taken	Comments
Luxembourg	✓	✓	Limit values for discharges from electroplating industries have been prescribed by administrative action. New discharge permits generally meet the requirements of Parcom Recommendation 92/4
Netherlands	✓	✓	In 1997, the Committee for the Implementation of the Pollution of Surface Water Act (CUWVO) published a guideline for the electroplating industry. This guideline prescribes the wide use of BAT and the compliance with discharge limit values in the same manner as stipulated in Parcom Recommendation 92/4 with the exception of ranges for cadmium (0.2 - 0.3 mg/l) and zinc (0.5 - 2 mg/l). The implementation is largely supported by means of negotiated agreements
Norway	✓	✓	New discharge permits to meet the requirements of Parcom Recommendation 92/4 were expected to enter into force by 1 st January 1999. In April 1995, existing plants had been informed about the requirements stipulated in Parcom Recommendation 92/4
Portugal	✓	✓	This industrial sector is included in a set of legal provisions ruling liquid waste and exhaust emissions. Difficulties result from the large number of enterprises operating in the sector. In particular, small and medium size enterprises need to be assisted and supported in specific implementation actions. Funds by the government have been granted for carrying out specific (environmental) plans
Spain			Lifted reservation in 2003
Sweden	✓	✓	General guidelines for the metal-surface treatment based on BAT as described in Parcom Recommendation 92/4 were established in 1997. Further descriptions of general norms and minimum requirements to be fulfilled by industry in certain sectors were in preparation (expected for Jan. 1999)
United Kingdom	✓	✓	Most of the requirements of Parcom Recommendation 92/4 are covered in national guidance documents. Discharges from this sector are covered by discharge consents. The Environment Agency controls discharges from electroplating plants by implementing EC Directive 76/464 and daughter Directives for the control of List I and List II substances. The water companies control discharges to sewer and the Environment Agency controls discharges from the relevant sewage treatment works. The large plants in this sector are regulated by the Environment Agency under the Integrated Pollution Control regime
Switzerland	✓	✓	National legislation for implementing measures in accordance with Recommendation 92/4 entered into force at the beginning of 1999 (Federal Ordinance on Water Protection of 28 October 1998)
<i>Source: OSPAR, 1999</i>			

Where implementation reports are available, they show that national regulations of Contracting Parties have been adjusted, where necessary, substantially to meet the requirements stipulated in Parcom Recommendation 92/4.

Although in 1999 it was not possible to provide a complete assessment of the implementation the Recommendation and of the measures and limit values stipulated therein by OSPAR Contracting Parties, some conclusions were drawn:

- the measures stipulated in Recommendation 92/4 were consistent with acknowledged ‘state of the art’ technologies and were appropriate for achieving demanding reductions of hazardous emissions in the electroplating industry; and
- even though a number of national programmes had been adjusted to correspond with the requirements of Recommendation 92/4, the full implementation of the stipulated measures would take some more time due to exemptions granted especially for smaller enterprises (OSPAR, 1999).

4.3 National Measures

4.3.1 Introduction

National legislation on chromium also exists. Information on such measures is available in the RAR and additional input from competent authorities has been sought during of the development of this RRS. This information is summarised by country below. Note that legislation introduced in Member States in many cases was the result of implementation of Community legislation (see Section 4.1) and of other initiatives (for example, compliance with Helcom and Parcom Recommendations).

The focus in the discussion that follows is on emission limit values or water quality standards although, where available, information is presented on the applicability of national IPPC regulations to surface treatment facilities (with particular emphasis on the implications of the 30m³ vat size threshold limit provided for the IPPC Directive).

4.3.2 Austria

Controls on Emissions to the Aquatic Environment

Table 4.16 outlines the Austrian national wastewater emission limits.

Industry sector	Limits for Cr(VI) (mg/l)		Limits for Cr(total) (mg/l)	
	Direct	Indirect	Direct	Indirect
Tanneries	0.1	0.1	1.0	3.0
Textile and leather treatment			0.5	0.5
Production of inorganic acids, bases and salts	0.1	0.1	0.5	0.5
Ferrous metal industry	0.1	0.1	0.5	0.5
Surface treatment	0.1	0.1	0.5	0.5
Inorganic pigments	0.1	0.1		
Sewage treatment (general)	0.1	0.1		
Drainage water			0.5	0.5

Source: Austrian UBA, 2005 (based on several legal instruments)

Applicability of IPPC Directive to Metal Finishing Installations

Austria has implemented the IPPC Directive by amending different existing laws, of which most relevant are the Austrian Trade Act, the Water Act, the Waste Management Act, the Emission Control Act and the Clean Air Act. Within these laws not only IPPC installations, but other installations are regulated as well. Depending on the environmental medium and the type of installation, the aforementioned regulations will apply: the Trade Act applies to most (industrial) installations; the Clean Air Act applies to steam boilers, turbines and hot water boilers and in the case of wastes, the Waste Management Act applies (Austrian UBA, 2005).

In the Austrian Trade Act, the whole of Annex I to the IPPC Directive has been included, and, therefore, the threshold limit for the vat size of EU surface treatment installations of 30m³ has been accordingly included. Similarly, the limit has also been included in the Waste Management Act but is not included in the Water Act (which only refers to the IPPC Directive and its Annexes for the assessment of the state of engineering) or the Emission Control Act.

Of relevance to the metal finishing sector are two regulations: AEU Surface Treatment and AEU Iron & Steel industry which make reference to the IPPC Directive concerning the possibility of introducing emission limits according to Article 18 of the IPPC Directive (Austrian UBA, 2005).

With regard to the structure of the metal finishing sector in Austria, the sector has been quoted as being “widespread”. Although statistics for metal finishing installations are not available, Statistics Austria suggests the following numbers for the wider metals industry:

- production and processing of metals:
 - total number of companies: 168;
 - number of SMEs (<250): 130;
 - number of small companies (<50): 91,

- manufacture of metal products:
 - total number of companies: 3,950;
 - number of SMEs (<250): 3,922;
 - number of small companies (<50): 3,706.

It should be noted that the above number generally represent companies which may own more than one installation. Also, “production and processing of metals” includes the major steelworks and non-ferrous metal production companies; these companies very often have metal finishing lines. Finally, the term “manufacture of metal products” is wider than the term “metal finishing sector” (Austrian UBA, 2005).

Implementation of the IPPC Directive and Controls on the Use and Emissions of Wood Preservatives

With regard to the treatment of wood in vacuum chambers, the (most) relevant regulations would be the Austrian Trade Act (with regard to air emissions) and the Austrian Water Act (with regard to wastewater emissions). As regards the Trade Act, an ordinance with emission limit values does not exist for this sector; therefore, emission limits in the permits are set on a site-by-site basis by the competent authority according to BAT. As regards the Water Act, a specific ordinance on this sector does not exist either; therefore, the Allgemeine Abwasserordnung (General Ministerial Ordinance on Wastewater Discharge; cf. BGBl. 1996/186) is relevant. Within this ordinance emission limits for chromium are defined, however definition of the emission limit values in the permit are on a site-by-site basis (the authority has to decide on pollutants and monitoring depending on the origin and composition of the waste water; also the authority might set more stringent emission limit values depending on local conditions) (Austrian UBA, 2005).

4.3.3 Belgium

Brussels Region – Controls on Emissions to the Aquatic Environment

The emissions of chromium are regulated in the region of the Belgian capital by the following legal instruments:

- Royal Decree of 11 July 1989 determining the sectoral conditions of discharge, to surface water and the public sewers, of wastewater from the sector of mechanics, cold transformation and surface treatment of metals:
 - dissolved chromium: 2 mg/l (in surface water);
 - total chromium: 5 mg/l (in surface water and sewer); and
 - chromium (VI): 0.5 mg/l (in surface water and sewer).

- Royal Decree of 3 February 1998 determining the sectoral conditions of discharge, to surface water and the public sewers, of wastewater from the sector of the tanneries and furriery:
 - total chromium: 3 mg/l (in surface water and sewer); and
 - chromium (VI): 0.5 mg/l (in surface water and sewer).

- Royal Decree of 4 August 1986 determining the sectoral conditions of discharge, to surface water and the public sewers, of wastewater companies which produce varnishes, paints, printing inks and pigments:
 - total chromium: 2 mg/l (in surface water);
 - chromium (VI): 0.2 mg/l (in surface water);
 - total chromium: 5 mg/l (in sewer); and
 - chromium (VI): 1 mg/l (in sewer).

There is additional legislation setting emission limits for sectors not directly relevant to this RRS such as oil refineries, textiles, non-ferrous metals and cleaning of vessels as well as legislation on taxation on industrial activities (BIME, 2005).

Flemish Region - Controls on Surface Treatment of Metals

According to the Flemish Institute for Technological Research (VITO, 2005), the following limits apply for mechanical construction, cold working and surface treatment of metals (VLAREM II, appendix 5.3.2, 55°, specific installations referred to in category 4 and subheading 29.5 of the classification list):

- discharges to surface water:
 - chromium (VI): 0.5 mg Cr/l;
 - dissolved chromium: 2.0 mg Cr/l; and
 - total chromium: 5.0 mg Cr/l,
- discharges to sewer systems:
 - chromium (VI): 0.5 mg Cr/l
 - total chromium: 5.0 mg Cr/l.

For installations for the surface treatment of metals by means of an electrolytic or chemical process and installations involved in degreasing of metals or metal objects by means of halogenated solvents or solvents with an ignition point up to 55°C or other organic solvents, prior to discharge to the public sewerage system or to surface water, the wastewater must be treated in such a way that the concentrations of chromium do not exceed the following levels (these levels must be obtained without any form of dilution):

- total chromium (VI): 0.1 mg Cr/l; and
- total chromium: 0.5 mg Cr/l.

Installations with a small metal turnover (this corresponding with a load whereby the effluent of the wastewater treatment plant contains a sum of total chromium, total copper, total lead, total nickel and total zinc of less than 200 gram per day) may, subject to permission from the licensing authority, discharge maximum concentrations of total chromium of 2.0 mg Cr/l.

It should be noted that these limits were introduced under VLAREM II in 1995, before the IPPC Directive was introduced. With regard to emission registers, for the Flemish part of Belgium, companies need to report their releases in a yearly environmental report to the authorities (Flemish Environmental Agency - VMM).

For the Flemish region, the transportation of this sludge to licensed waste treatment plants needs to be carried out by specialist transporters of waste. This is all co-ordinated through Vlarea (Vlaams Reglement voor Afvalvoorkoming en –beheer) and the specific authority on this matter is the Public Waste Agency for Flanders (OVAM) (VITO, 2005).

Flemish Region - Controls on Pigment Manufacture

For the lacquer, paint, printing inks and pigments (production) industries, the following emission limits apply in the Flemish region of Belgium:

- discharges to surface water:
 - chromium (VI): 0.2 mg Cr/l; and
 - total chromium: 2.0 mg Cr/l,
- discharges to sewer systems:
 - chromium (VI): 1.0 mg Cr/l
 - total chromium: 5.0 mg Cr/l.

Flemish Region - Controls on Use of Chrome Tanning Salts

For the tanneries industry, the following emission limits apply in the Flemish region of Belgium:

- discharges to surface water:
 - chromium (VI): 0.5 mg Cr/l; and
 - total chromium: 1.5 mg Cr/l,
- discharges to sewer systems:
 - chromium (VI): 0.5 mg Cr/l
 - total chromium: 1.5 mg Cr/l.

Flemish Region - Applicability of IPPC Directive to Metal Finishing Installations

The IPPC Directive has been transposed into law in the Flemish Part of Belgium with VLAREM II, art. 4.1.2.1 of 1 June 1995. With regard to the threshold limit of 30m³ indicated in the text of the Directive, the Flemish regulations include a series of thresholds ranging from 0.01 m³ to 30m³. These thresholds apply to the total collective content of the treatment baths and rinsing baths. Therefore, it is expected that most of the Flemish installations are covered by the regional regulations implementing the IPPC Directive²⁷ (VITO, 2005).

Walloon Region - Controls on Emissions to the Aquatic Environment

In the Walloon region, the following limit values for Cr(VI) apply (MRW, 2005):

- for metal finishing:
 - surface water: 0.5 mg/l; and
 - sewer: 0.5 mg/l;

²⁷ Note that in Wallonia, the range of threshold values is 0.01 to 500 m³

- for pigment production:
 - surface water: 0.2 mg/l; and
 - sewer: 1.0 mg/l;

4.3.4 Cyprus

Controls on Emissions of Chromium to the Aquatic Environment

Consultation with the Cypriot Ministry of Agriculture, Natural Resources and Environment (MoANRE, 2005), there exist no legally binding national emission limits for chromium (total or hexavalent) for the aquatic environment. Discharge limits for industrial installations are set on a case-by-case basis. Within this context, consultation suggests that typical discharge limits recently imposed on a Cypriot tannery were:

- total chromium: 0.5 mg/l; and
- chromium (VI): 0.1 mg/l.

Applicability of IPPC Directive to Metal Finishing Installations

The requirements of the IPPC Directive have been implemented with Law 106(I)/2002 of 12 July 2002. The vat size threshold referred to in this law is identical to that in the Directive (30m³). Cypriot regulations require that all metal finishing installations, pigment production installations and tanneries have an operating licence irrespective of size but not within the context of BAT as for installations falling under IPPC (MoANRE, 2005).

4.3.5 Czech Republic

Applicability of IPPC Directive to Metal Finishing Installations

According to Act No. 76/ 2002 of 1st March 2002 on integrated pollution prevention and control, on the integrated pollution register and on amendment to some laws, the national regulations implementing the IPPC Directive include a threshold vat size limit of 30m³.

4.3.6 Denmark

Controls on Emissions of Chromium to the Aquatic Environment

Statutory Order No. 921 (8/10/1996) on quality standards for water bodies and emission standards for discharges of certain hazardous substances to watercourses, lakes or the sea provides quality standards for chromium (among other substances). These are:

- for saltwater: 1.0 µg/l; and
- for fresh water: 10.0 µg/l.

It is of note that these were proposed quality standards, where final assessment of the quality of the data had not been completed. The above values were based on the Commission proposal for a Council Directive on water quality objectives concerning chromium (COM(88) 29 final) which was eventually withdrawn by the Commission on 4th August 1993.

Applicability of IPPC Directive to Metal Finishing Installations

Limited information is available at present on the practicalities of the implementation of the IPPC Directive in the metal finishing sector in Denmark. Preliminary consultation with the Danish Environmental Protection Agency suggests that the Danish IPPC Regulations are enforced by the local authorities. The guidance value for total chromium in wastewater discharged to a municipal wastewater treatment plant has been quoted as 0.3 mg/l. The 30m³ vat size threshold limit has also been reported as having been transposed to Danish regulations implementing the IPPC Directive (Danish EPA, 2005).

Controls on the Use of Wood Preservatives

The use of impregnation agents containing chromium has been reduced very significantly in Denmark through voluntary agreements and, since January 1997, agents which contain chromium may only be used with the appropriate dispensations. Since 1997, only a few manufacturers have been allowed to use CCB and CCP agents. At the end of 1999, only a single manufacturer had a licence to use CCP agents (Danish EPA, 2003).

Some of the impregnated wood imported into Denmark may still, however, contain chromium. The Danish EPA (2003) quotes a study that reported that almost 60 tonnes of chromium were imported in Denmark as an ingredient in impregnated wood.

4.3.7 Estonia

Controls on Emissions of Chromium to the Aquatic Environment

According to the Water Act of 11 May 1994 (RT I 196, 40, 655; consolidated text RT I 1998, 13, 241) that came into force on 16 June 1994, and Regulation No. 75 of 16 October 2003 of the Minister of Environment "Establishment of the Requirements for discharging Dangerous Substances into Public Sewage System", effluent may be discharged into a water body only if the concentration of total chromium in the effluent is below 0.5 mg/l and the concentration of Cr(VI) is below 0.1 mg/l. These limits apply to all industrial applications.

Local authorities may impose stricter requirements for wastewater discharged to STP. For example, in Tallinn the limit on Cr(VI) in effluent discharged from industrial installations to municipal STPs is as low as 0.04 mg/l (Estonian CNC, 2005).

Applicability of IPPC Directive to Metal Finishing Installations

The IPPC Directive has been transposed to national law with the Integrated Pollution Prevention and Control Act of 17th October 2001 (RT1 I 2001, 85, 512) which entered into force on 1st May 2002 (and has been amended by Act RT I 2002, 61, 375 of 1st August 2002 and Act RT I 2003, 73, 486 of 5th November 2003). The Act indicates that threshold capacities would be subsequently set but, at present, it is not known if this is the same with the limit set out in the Directive.

4.3.8 Finland

Controls on Emissions of Chromium to the Aquatic Environment

The Finnish Environmental Protection Decree (169/2000) lists substances requiring an environmental permit for discharges into waters or a public sewer. Within Annex 2 to the Environmental Protection Decree, chromium is one of the pollutants for which the setting of limit values for emissions and discharges is required. However, in Finland there are no national emission limit values for discharges from industrial installations. Therefore, discharges are regulated in environmental permits on case-by-case basis.

For example, the emission limit for Cr(VI) set by Helsinki Water Works is 0.1 mg/l and this emission limit is quite widely used in environmental permits. If there are aquatic releases of Cr(VI) in any industrial sector of concern, an emission limit value (mg/l) and usually also the load limit (g/d) is defined in the environmental permit. But since there is no national legislation imposing emission limits for Cr(VI), the emission limit values and load limits in permits could vary somewhat (Uusimaa Regional Environment Centre, 2005).

The total industrial discharges of total chromium in Finland are estimated at 1,800 kg/y. The national objectives of water protection up to 2005 (Government Decision) required to curb the total chromium discharges into water bodies by 90% in 1995-2005 - this objective has reportedly been achieved. So far, no statutory Environmental Quality Standards exist in Finland for chromium, but there has been a proposal by the Finnish Environment Institute for new Standards in the form of Maximum Permissible Addition limits of 3.4 µg/l Cr(VI) and 4.7 µg/l Cr(III) as dissolved concentration in freshwaters. These are to be taken into account in determining the good ecological status according to the Water Framework Directive (Silvo, 2005). The methodology used for the derivation of these Standards is based on the analysis presented in the RAR.

Applicability of IPPC Directive to Metal Finishing Installations

The IPPC Directive has been transposed into national law with the Environmental Protection Act (86/2000) and Decree (169/2000) and was implemented on 1 March 2000. With regard to surface treatment installations and their vat sizes, all surface treatment installations need an environmental permit according to the Environmental Protection Act (86/2000) and Decree (169/2000), irrespective of vat size. The threshold 30m³ only determines which authority grants the permit. The environmental requirements set by the

environmental permit are not significantly different for 'small' or IPPC installations (Uusimaa Regional Environment Centre, 2005).

As discussed above, statutory emission limit values do not exist in Finnish national legislation. In setting emission limit values, the Helcom recommendation (23/7) for reduction of discharges and emissions from metal surface treatment is widely used. According to the Helcom Recommendation (23/7) emission, the limit value for Cr-total is 0.7 mg/l and Cr(VI) 0.2 mg/l. In addition to a concentration (mg/l) limit, a load (g/d) limit is often set within permits. Emission limit values set in environmental permits are usually the same whether the surface treatment plant discharges its treated wastewater directly into surface water or into the public sewer.

In many cases, wastewater from surface treatment plants are discharged to the public sewer and also waterworks can also set their own limit values for industrial wastewaters. If the emission limit values set by a waterworks or by the environmental authority (in the environmental permit) are different, the operator must comply with the stricter values.

Surface treatment plants usually treat their wastewaters on-site; the level of treatment is usually both primary and secondary and increasingly also tertiary (for example sand filter or ion exchange). Waste (sludge) from the wastewater treatment is classified as hazardous waste and can, therefore, only be disposed of by those who have a permit to receive and handle hazardous waste (Uusimaa Regional Environment Centre, 2005).

There are approximately 300 metal finishing installations in Finland, all of which are believed to be SMEs Uusimaa Regional Environment Centre, 2005).

Controls on the Use of Wood Preservatives

The CCA and CC wood preservatives were evaluated thoroughly for the first time in Finland in 1996 (Braunschweiler *et al*, 1996) according to the provisions of the Chemicals Act. In 2001, these products were reviewed in the light of new data on environmental and health effects, exposure and waste handling methods (Braunschweiler, 2001).

After evaluation and consultation with industry, the Finnish Environment Institute (FEI) (Finnish Competent Authority for the Biocidal Products Directive 98/8/EC) decided on the following risk reduction measures:

- CCA products should only be used in industrial wood impregnation plants which have a quality assurance and classification scheme for the impregnated wood;
- the chemicals may only be used for treatment of wood which is intended for use either in continuous contact with soil or water or in constructions where special protection against wood destroying organisms is essential for safety reasons (e.g. wooden bridges, stairs, docks);

- from July 2002, CCA products may only be used for the treatment of sawn lumber with a cross-section of at least 38 mm or poles with diameter of at least 80 mm. The wood treated with these products may not be used indoors, on playgrounds or in constructions which come into contact with food or edible plants. The treated wood may be cut but not otherwise worked on;
- in the impregnation plant, the preservatives have to be fixed properly to the wood, either by artificial drying or by some other reliable method; and
- from July 2002, every piece of wood impregnated wood with CCA products has to be labelled. The label has to contain information on: (a) the chemicals used in impregnation; (b) the manufacturer of the treated wood and time of the treatment; and (c) the use or wood protection class of the treated wood. Every bundle of treated wood has to be accompanied with a leaflet, which in addition to the information above contains the following:
 - allowed uses of the treated wood;
 - restrictions for use and working;
 - instructions for prevention of adverse health and environmental effects; and
 - instructions for proper waste management.

In addition, the leaflet should contain the phrase: “*Wood preservative used in the impregnation contains arsenic and chromium compounds, which are dangerous to human health and the environment*”. This information also has to be given to the customer buying treated wood (FEI, 2002).

Note that according to the Environmental Protection Decree 169/2000, an environmental permit is required for wood impregnation plants or other plants using wood preservatives (as well as for those formulating the preservatives). The municipal authorities are responsible for these permits and discharges of carcinogens and wood preservatives must be authorised by a permit.

4.3.9 France

Controls on Emissions of Chromium to the Aquatic Environment

Emissions of Cr(VI) to water are limited to 0.1 mg/l if the emissions exceed 1 g/day, and emissions of total chromium are limited to 0.5 mg/l if the emissions exceed 5 g/day (CEC, 2002).

Applicability of IPPC Directive to Metal Finishing Installations

The IPPC Directive has been implemented by an earlier decree (1977) and a ministerial order (2000, revised in 2004). With regard to a vat size threshold, the threshold of 30m³ is used to identify the installations that need an authorisation permit and fall under IPPC. A threshold of 1.5 m³ is used to identify installations that need an authorisation permit.

Irrespective to whether an installation falls under IPPC or not, if it exceeds the 1.5 m³ threshold, then emissions of Cr(VI) to water are limited to 0.1 mg/l if the emissions exceed 1 g/day²⁸. For Cr(III) a 3 mg/l limit applies (EIPPCB, 2004b). Under the same legislative framework, the spreading of waste and sludge from these installations is prohibited (paragraph 5.8) (MEDD, 2005). Under decree No. 97-517 of 15 May 1997, sludges from surface treatment of metals are considered hazardous wastes (EIPPCB, 2004b).

In France, there exist approximately 2,900 metal finishing installations of which around 1,160 (40%) are believed to be SMEs. There is a considerable number of installations that do not meet either the 1.5m³ or the 30m³ threshold (exceeding 1,5 m³: 2,400 installations - exceeding 30 m³: 870 installations) and, therefore, are not subject to the above requirements (MEDD, 2005).

However, for installations with a vat size between 0.2 and 1.5 m³, a more simple procedure applies: the operator has to send a declaration file specifying the nature of their activity to the Prefect (local authority). The Prefect returns to the operator a receipt of the declaration file and a copy of the general prescriptions applicable to the installation. In the case of surface treatment, the prescriptions are outlined in *Arrêté du 30 juin 1997 relatif aux prescriptions générales applicables aux installations classées pour la protection de l'environnement soumises à déclaration sous la rubrique n° 2565: Métaux et matières plastiques (traitement des) pour le dégraissage, le décapage, la conversion, le polissage, la métallisation..., par voie électrolytique, chimique, ou par emploi de liquides halogènes*. This prescribes a limit of 0.1 mg/l for Cr(VI), if the release exceeds 1 g/day (MEDD, 2005).

Controls on the Use of Wood Preservatives

With regard to wood preservatives, most EU countries have authorisation schemes for wood preservative products. There are two notable exceptions: France and Germany. In France there are no national requirements and, in theory, treaters could use their preferred formulations. However there has been a very strong private quality scheme, under the name 'CTBA P+' (Centre Technique du Bois et de l'Ameublement - French Wood and Furniture Technical Centre) which has been in place for many years and most users of treated wood insist on 'approval' by this scheme. It includes strict provisions and involves health, safety, environment and efficacy evaluations. The Safety, Health and Environment assessment involves a panel that includes various government departments (personal communication with industry). There is also a quality scheme for the treatment companies, known as 'CTBA B+' which requires use of CTBA P+ approved products (personal communication with industry).

In the French market, there appear to be 14 different products available that contain chromium. Four formulators are active of which two of them market only one product

²⁸ Arrêté du 30 juin 1997 relatif aux prescriptions générales applicables aux installations classées pour la protection de l'environnement soumises à déclaration sous la rubrique n° 2565 : Métaux et matières plastiques (traitement des) pour le dégraissage, le décapage, la conversion, le polissage, la métallisation..., par voie électrolytique, chimique, ou par emploi de liquides halogènes.

each. There appears to be no production of such preservatives in France. In France no product has an approval for use in Hazard Class 5 applications (personal communication with industry).

4.3.10 Germany

Legislation on Emissions and Releases

The German Wastewater Ordinance (Abwasserverordnung AbwV, 2004) includes the limits presented in Table 4.17.

The following national measures have also been identified in the RAR (CEC, 2002):

- **Water quality:** the German water quality criterion for aquatic communities ('Zielvorgabe') uses the fourfold of the background concentration, which is 10 µg/l Cr-total. For suspended matter, a quality criterion of 320 mg Cr/kg is given.
- **Soil protection:** the German soil protection Directive (Bundesbodenschutzgesetz BBodSchG, 1999) includes precautionary limits ('Vorsorgewerte') which are levels which should guarantee a long-term protection of the soil (including all possible uses in future). For chromium the values are 100 mg/kg for clay soil, 60 mg/kg for loam/silt and 30 mg/kg for sandy soil.
- **Sewage sludge:** the limit threshold of chromium in sewage sludge is 900 mg/kg dw according to the German national Directive (Klärschlammverordnung AbfKlärV, 1992). The maximal tolerable input via sludge on agricultural soils is 1,500 g/ha/y.

Relevant appendix	Industry sector	Limit value
Appendix 22	Manufacturing, further processing or application of chromium	Cr(VI): 0.5 mg/l (prior to blending with other wastewater)
	For wastewater flows not originating from the manufacturing, further processing or application of chromium but which are nevertheless contaminated with chromium below 0.5 mg/l	Cr(VI): 0.05 mg/l (prior to blending with other wastewater)
	Cr(VI) content in wastewater at the site of occurrence	Cr(VI): 0.1 mg/l (random sample)
Appendix 23	Facilities for biological treatment of waste	Cr(VI): 0.1 mg/l (prior to blending with other wastewater) Cr(total): 0.5 mg/l (prior to blending with other wastewater)
Appendix 25	Leather production, fur processing, leather fibre board manufacturing	Cr(total): 0.1 mg/l (prior to blending with other wastewater)
Appendix 29	Production of iron and steel (Continuous surface treatment of semi-finished steel and steel products)	Cr(VI): 0.1 mg/l (prior to blending with other wastewater) Cr(total): 0.5 mg/l (prior to blending with other wastewater)

Relevant appendix	Industry sector	Limit value
Appendix 37	Production lead and zinc pigments	Cr(total) 0.03 kg/t
	For mixed phase pigments, pigment and colouring body mixtures	Cr(total) 0.5 mg/l
	For production of chromium oxide pigments	Cr(total) 0.02 kg/t
Appendix 40	Metal finishing and metal processing	Cr(VI) 0.1 mg/l Cr(total) 0.5 mg/l

Source: German UBA, 2005

Controls on the Use of Wood Preservatives

In Germany, until now there has been no statutory authorisation procedure for wood preservatives (BfR, not dated). At present, there are three methods for evaluating wood preservatives:

1. The procedure for agents with a general building inspection authorisation pursuant to the provisions of the Deutschen Instituts für Bautechnik (German Institute for Constructional Engineering - DIBt). These wood preservatives are stipulated for bearing and bracing building components (no approval is required for other uses). The testing of the agents includes a health assessment by German Federal Institute for Risk Assessment (BfR).
2. The voluntary inspection procedure of the Gütegemeinschaft Holzschutzmittel e.V. (quality circle wood preservatives) (RAL quality mark for wood preservatives). This applies to wood preservative formulators and industrial users. Wood preservatives which carry the quality stamp “RAL Wood Preservative” have been tested by BfR in order that a health risk can be ruled out with sufficient probability.
3. The voluntary registration procedure for ‘blue-stain preservatives’ as part of a coating system with the Federal Environmental Agency (UBA registration procedure). The UBA registration procedure for blue-stain preservatives is a simplified assessment procedure because the biocide-containing, blue-stain priming colour has several coating layers and, therefore, a health risk from exposure can be ruled out with a sufficient degree of probability. BfR is responsible for the health assessment of blue-stain preservatives in the registration procedure (BfR, not dated).

TRGS 618 (Technical Guidance for Hazardous Substances No. 618) relates to substitutes and restrictions on the application of Cr(VI)-containing wood preservatives mainly for occupational health reasons. The products shall be used only in vacuum vessel application (no dipping, spraying, etc.) and they should be only for wood in ground contact (Hazard Class 4). The TRGS is not legally binding; it is a recommendation of the German Committee for Hazardous Materials. In Germany no registration process exists for Hazard Class 5 (personal communication with industry).

In Germany, special regulations for emissions from impregnation facilities do not exist, but emissions of these installations are regulated by different general national and/or regional state level acts, ordinances and rules. Some examples include (Reisser, 2005):

- Wasserhaushaltsgesetz (WHG): legislation on water supply and consumption (Federal Water Management Act);
- Abwasserverordnung (AbwV): Ordinance concerning the requirements for releasing wastewater to the aquatic environment;
- Anlagenverordnungen (VAwS): regional state level ordinances for facilities dealing with water pollutants/substances hazardous to water;
- Bundesimmissionsschutzgesetz (BImSchG): Federal Ambient Pollution Control Act and its underlying regulations; and
- Störfallverordnung (12. BImSchV): the German transposition of the European Seveso-II-Directive.

Additionally, guides, called DGfH-Merkblätter, edited by the German Association for Wood Research (Deutsche Gesellschaft für Holzforschung e.V.) are available. These represent the state-of-the-art situation and are the basis for the approval of a new treatment plant:

- Verfahren zur Behandlung von Holz mit Holzschutzmitteln - Teil 1 Druckverfahren; Teil 2 Nichtdruckverfahren (Oct. 1991) – Processes for treating wood with wood preservatives; Part 1: Pressure processes, Part 2: Non pressure processes;
- Merkblatt für den sicheren Betrieb von Nichtdruckanlagen mit wasserlöslichen Holzschutzmitteln – Guide for the safe operation of non pressure plants with waterborne wood preservatives; and
- Merkblatt für den sicheren Betrieb von Kesseldruckanlagen mit aromatischen Imprägnierölen - Guide for the safe operation of pressure plants with aromatic solvent-borne preservatives (OECD, 2002).

4.3.11 Greece

Controls on Emissions of Chromium to the Aquatic Environment

According to the Environmental Planning Division of the Hellenic Ministry for the Environment, Physical Planning and Public Works (HMEPPPW, 2005), national legislation (Act of Ministerial Council 2/1-2-2001 (Official Journal 15A/2001) requires that the mean annual concentration of Cr in the aquatic environment must not exceed the limit value of 50 µg/l.

In accordance with Joint Ministerial Decree 4859/726/9-3-2001, the emission limits for Cr (total) released from industrial installations for the different surface water categories are (HMEPPPW, 2005):

- for lakes: 0.6 mg/l monthly and 1.2 mg/l daily;
- for rivers: 1.0 mg/l monthly and 2.0 mg/l daily; and
- for coastal waters: 1.5 mg/l monthly and 3.0 mg/l daily.

Applicability of IPPC Directive to Metal Finishing Installations

Directive 96/61/EC has been transposed to Greek law by Law 3010 of 2002 (OJ 91A), the Joint Ministerial Decision (JMD) 15393/2332/2002 (OJ 1022B) which describes the classification of public and private projects and JMD 11014/703/2004 (OJ 332B) which describes the procedures for preliminary assessment of the effects of certain public and private projects on the environment (transposing Directive 97/11/EC).

IPPC activities fall within Annex II to Article 5 of JMD 15393/2332/2002 and belong to categories 7 and 9 and sub-categories 1 and 2 of category A. For these activities, an environmental impact assessment is required and it should include among others, information on relevant preventive measures against pollution in accordance with BAT, information on the choice of BAT to be used, the materials and substances used, the nature and levels of emissions, the measures to control emissions and to manage any waste as well as the relevant monitoring arrangements.

With regard to the metal finishing sector and the vat size threshold limit of 30m³, although this threshold limit exist in the Greek legislation, all Greek industrial installations need to be licensed irrespective of relevance to IPPC or not (in reality all installation exceeding a 15hp power limit which is reduced to 1 hp for the Prefecture of Attica in which the capital Athens is located). The difference is in the authorities that issue the licence/permit (Ministry, regional authorities or prefectures). Moreover, due to the combination of the two Directives (IPPC and Environmental Impact Assessment), each application for a permit is a substantial document in which IPPC-related issues form only part of (HMEPPPW, 2005).

In this context, out of a total ~380 installations involved in metal finishing activities, only six IPPC licences have been issued until now by the Ministry for the Environment, Physical Planning and Public Works. The smaller installations are regulated by the local authorities (prefectures) (HMEPPPW, 2005).

4.3.12 Hungary

Controls on Emissions of Chromium to the Aquatic Environment

There is varied national legislation controlling emissions of chromium in Hungary. This is legislation that preceded the implementation of the IPPC Directive in Hungary (in

2001) and has been amended since it was first introduced. A summary of the provisions relevant to chromium is given in Tables 4.18 through to 4.20.

Table 4.18: Provisions of 9/2002. (III.22) Joint Decree on Emission Limit Values of Discharges and Rules of their Use			
Substance	Lake Balaton and its catchment area (mg/l)	Other protected areas (mg/l)	General (mg/l)
Chromium total	0.2	0.2	1
Chromium (VI)	0.1	0.1	0.5

Source: Schönweitz & Nyári, 2005
Note: this regulates directly discharged wastewater into the surface water environment

Table 4.19: Provisions of 28/2004. (XII.25.) Decree of Ministry of Environment on the Limit values Concerning Discharges of Water Pollutant Substances and Rules of their Use (all values expressed in mg/l)												
Substance	Activity											
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
Chromium total	0.5	0.5	0.5	0.5	-	-	0.5	-	0.5	0.5	0.5	0.5
Chromium (VI)	0.1	0.1	0.1	0.1	-	-	0.1	-	0.1	0.1	-	0.1

Source: Schönweitz & Nyári, 2005
Note: These are requirements of the Decree for limits on chromium in discharges before mixing with other discharges in ranked point samples or 2-hour average samples. Chapter 33 on metal work and surface treatment deals with discharges, which contain pollutants from the following activities (including pre-treatment, interim treatment and after-treatment): 1) electroplating, 2) pickling, 3) anodic oxidation of aluminium, 4) blackening, 5) galvanising and tinning, 6) heat-setting treatment and tempering, 7) production of printed circuits, 8) dry battery production, 9) enamelling, 10) metal-work, 11) burnishing processes, 12) painting, lacquering, varnishing

Table 4.20: Provisions of 204/2001. (X.26) Government Decree on Sewage Fines		
Substance	Threshold value (g/m³ or 10⁻³ m³/m³)	Fine (Ft/kg)
Chromium total	1	3,000
Chromium (VI)	0.5	10,000

Source: Schönweitz & Nyári, 2005
Note: this Decree includes threshold value and fine units of poisonous materials

Applicability of IPPC Directive to Metal Finishing Installations

The IPPC Directive has been transposed into national law with Government Decree 193/2001. No. (X.19) on the detailed rules of the integrated permitting procedure for the use of the environment. The Directive was implemented in the same year. The national legislation implementing the IPPC Directive makes provisions for a threshold limit of 30m³ for vats used in surface treatment processes. A total of approximately 300 metal finishing operate in Hungary; 265 of them (88%) are considered to be SMEs. Only 40 exceed the 30 m³ vat size threshold (Schönweitz & Nyári, 2005). For sites falling outside the scope of the Directive, the legal instruments described above apply.

Consultation suggests that, in the Hungarian metal surface treatment industry, the rinse waters containing chromium are treated on-site. Only a small number of enterprises have their concentrate treated by special companies. The wastewater is treated with potassium hydrogensulphite or potassium dithionite. After reduction, the solution is neutralised and the precipitate is filtered out (Schönweitz & Nyári, 2005).

Emissions of Chromium from the Metal Surface Treatment Sector

The Statistics Division of the National Directorate for Environment, Nature and Water holds information on emissions of chromium from surface metal treatment operations in Hungary. This is outlined in Table 4.21.

Year	Emissions of Cr(VI) in kg/y	Emissions of Cr(total) in kg/y
2003	20.03	23.08
2002	22.34	60.96
2001	8.43	46.91

Source: Schönweitz & Nyári, 2005

4.3.13 Ireland

Controls on Emissions of Chromium to the Aquatic Environment

The Water Quality (Dangerous Substances) Regulations 2001 (Statutory Instrument No.12 of 2001) prescribes the following quality standards for chromium:

- standard for freshwater for hardness ≤ 100 mg/l CaCO₃: 5 µg/l;
- standard for freshwater for hardness > 100 mg/l CaCO₃: 20 µg/l; and
- standard for tidal waters: 15 µg/l.

Ireland introduced the Integrated Pollution Control (IPC) licensing regime before the introduction of the IPPC Directive. IPC since been amended to accommodate the provisions of the IPPC Directive.

Under IPC, the licensing authorities were using guidance documents on BATNEEC (BAT not entailing excessive costs) when setting up and issuing permits. BATNEEC Guidance Notes of relevance to this RRS (which have been superseded by the relevant BREF Notes) included the following emission limit values for discharges to water:

- chemical sector in general:
 - chromium (total): 0.5 mg/l;
 - chromium (VI): 0.1 mg/l,

- production, recovery or processing of non-ferrous metals:
 - chromium (total): 0.5 mg/l;
 - chromium (VI): 0.1 mg/l,
- wood treatment and preservation:
 - chromium (total): 0.5 mg/l;
 - chromium (VI): 0.1 mg/l,

All values refer to daily averages and apply to effluent prior to dilution by uncontaminated streams e.g. stormwater, cooling waters, etc.

Applicability of IPPC Directive to Metal Finishing Installations

The IPPC Directive has been transposed into national law with the Protection of the Environment Act Number 27 of 2003 and was implemented on 12 July 2004. The 30m³ vat size threshold introduced with the Directive also applies. A total of 13 installations undertake surface metal treatment operations, all of which are licensed under IPPC (i.e. they exceed the 30m³ threshold). For sites that might not fall under IPPC, a local authority would grant a discharge licence under the Water Pollution Act 1977 (Irish EPA, 2005).

Controls on the Use of Wood Preservatives

Wood treatment installations in Ireland are subject to licensing under the IPC regime. Although, the relevant BATNEEC Guidance Note includes the emission limit values for chromium presented above, in IPC licences for wood treatment installations there are generally no emission limit values since, according to the Irish Environmental Protection Agency (Irish EPA, 2005), there are no process effluents generated.

There are currently 50 IP(P)C licences for wood treatment facilities issued by the Environmental Protection Agency of which 22 are involved in pressure treatment of wood of which some are using Cr(VI)-based wood preservatives. Most up to date information suggests that the use of CCA gradually diminishes (and obviously will cease in September 2006) and for those plants that still use CCA, CCA products generally find applications to only part of their operations. It should be noted that IPC (IPPC) licences are issued for installations involved in “*the treatment of protection of wood, involving the use of preservatives, with a capacity exceeding 10 tonnes of wood per day*”. Installations falling below this threshold are regulated by the local authorities.

4.3.14 Italy

Controls on Emissions of Chromium to the Aquatic Environment

Under legislative Decree No. 152/99, the general Italian limits on chromium are:

- Cr(VI): 0.2 mg/l for both surface water and sewerage; and
- Cr(III): 2 mg/l for surface water and 4 mg/l for sewerage (Italian MoE, 2005).

Under Decree No.367-6/11/2003 of the Ministry of Environment concerning the quality of the water, chromium is listed therein with the following target limit values for 2008:

- for marine waters and lakes: 0.7 µg/l;
- for internal surface waters (rivers): 4 µg/l.

The target limits for the year 2016 are more stringent:

- for marine waters and lakes: 0.5 µg/l;
- for internal surface waters (rivers): 0.7 µg/l.

For sediments, the limit on Cr(VI) currently stands at 5 mg/kg (Italian MoE, 2005).

The two aforementioned decrees are national and, for chromium substances, do not allow local authorities to exceed the limits (which stem from EU legislation). Therefore, no Region, Province or sewerage undertaker may allow for higher limits for chromium (as well as for all metals and substances included in the relevant priority list). Stricter limits may be required by the local authorities depending on the category of the area and on the PTA (that is the plan for the protection of the water that each region has to adopt). If an installation exceeds any of these, a penal procedure is initiated and, pending on a court judgment, a fine or even imprisonment of the manager of the installation is possible (Italian MoE, 2005).

Applicability of IPPC Directive to Metal Finishing Installations

The IPPC Directive has been transposed into national law with Legislative Decree 372/99, substituted by Legislative Decree 59 of 18 February 2005. The national legislation implementing the IPPC Directive in Italy makes provisions for the threshold limit of 30m³ for vats used in surface treatment processes (Italian MoE, 2005)

Almost all surface treatment installations in Italy are SMEs (6,060 out of a total of 6,062 installations). Information from the Italian Ministry of Environment suggests that the total number of employees in the sector is approximately 56,000, therefore, the average workforce per installation is around 9 employees. The percentage of sites covered by the IPPC Directive is around 30% on the basis of the vat size (1,844 out of 6,062 sites).

For sites falling outside the scope of the IPPC Directive, the existing Italian national legislation described above provides the framework for controlling emissions of chromium from the metal surface treatment industry sector. The limits therein have to be respected by all, irrespective to whether their activities fall under or outside IPPC.

Estimates from the Italian Ministry of Environment suggest that 90% of all Italian surface treatment installations perform on-site wastewater treatment. The treatment general involves:

- a. reduction of the process losses to water:
 - recovery of the material from the counter-rinsing vats after the chrome plating vats;

- recovery of the material with evaporation in atmospheric pressure equipment; and
 - recovery of the material under vacuum equipment,
- b. reduction of emissions to environmental compartments by physicochemical treatment of the effluent:
- chemical treatment: reduction of Cr(VI) to Cr(III);
 - physical treatment: precipitation as hydrates or dynamic flotation or electro-flocculation; and
 - filtering and/or filter-pressing of the produced sludge (Italian MoE, 2005).

The removal efficiency is very high (to allow for the set emissions limits to be met by Italian installations). The Italian Ministry of Environment believes that it is difficult to detect Cr(VI) in the effluents because the chemical reaction of reduction is relatively easy to perform. However, given the targets for the years 2008 and 2016 mentioned above, sites may have in the future greater difficulty in meeting the requirements set by authorities (Italian MoE, 2005).

Controls on the Use of Wood Preservatives

Consultation suggests that in Italy there are no national restrictions on the use of Cr(VI)-based wood preservatives, beyond those imposed on arsenic by Directive 2003/2/EC.

Although, in theory, it is possible to use CCA in industrial applications such as structural timber in public and industrial buildings, bridges, constructional timber in water, noise barriers, avalanche control, etc., CCA has not been used for several years. At the most important Italian impregnation plant (in total no more than two plants exist), CCA has not been used for almost 10 years in electric power poles, telephone transmission poles and railways sleepers. Therefore, the introduction of Directive 2003/2/EC has not impacted significantly on Italian timber impregnation market. It has been suggested that Italian public opinion has long been opposed to the use of arsenic-based wood preservatives especially on playground equipment (Palanti, 2005).

4.3.15 Latvia

Controls on Emissions of Chromium to the Aquatic Environment

There are no limits on Cr(VI) in Latvian national legislation for its monitoring in the environment. However, there exist quality standards for chromium which are as follows (LVA, 2005):

- for saltwater: 50 µg/l; and
- for freshwater: 11 µg/l.

Applicability of IPPC Directive to Metal Finishing Installations

The IPPC Directive was transposed to national law with the Law on Pollution of 20 June 2002 (as amended on 18 December 2003). Within the Law, a threshold vat size limit of 30m³ is included. The Regulations came into force on 1st July 2001.

4.3.16 Lithuania

Controls on Emissions of Chromium to the Aquatic Environment

The use and emissions of chromium are regulated by the following measures in Lithuanian national legislation (based on unofficial translation of titles provided by the Lithuanian State Non Food Products Inspectorate (Lithuanian SNFPI, 2005a)):

- Hygienic Regulation of Lithuania HN 36:2002 “Prohibited and restricted substances”
- Rules on the control of water pollution from hazardous substances, confirmed by the Order of the Minister of Environment of the Republic of Lithuania No. 624 of 21 December 2001 (Žin. [– Lithuanian State Official Bulletin], 2002 Nr.14-523). The limits set on Cr(VI) are (Lithuanian SNFPI, 2005b):
 - maximum allowable concentration for release to sewer: 0.2 mg/l;
 - maximum allowable concentration for releases to surface waters: 0.1 mg/l; and
 - maximum allowable concentration in receiving water body: 1 mg/l.
- Order of the Minister of Environment of the Republic of Lithuania on partial changing of orders regulating the handling of discharges No. 267 of 22 May 2002 (Žin., 2002 Nr. 62-2533). The limits set on Cr(VI) are (Lithuanian SNFPI, 2005b):
 - maximum allowable concentration for release to sewer: 0.2 mg/l;
 - maximum allowable concentration for releases to surface waters: 0.1 mg/l; and
 - maximum allowable concentration in receiving water body: 1 mg/l.
- Recommendations on the arrangement of programmes on diminishing of water pollution with hazardous substances, confirmed by the Order of the Minister of Environment of the Republic of Lithuania No. 643 of 22 December 2001 (Žin., 2002 Nr.14-524).
- Order of the Minister of Environment of the Republic of Lithuania on confirmation of the programme on control of water pollution from hazardous substances No. D1-71 of 13 February 2004 (Žin., 2004 Nr. 46-1539).
- Letter of the Minister of Environment of the Republic of Lithuania on the recommendations of application of the legal acts regulating the discharges No. 10-6-7124 of 13 October 2003.

- Order of the Minister of Environment of the Republic of Lithuania on the confirmation of method of primary records and monitoring of the water resources use and on pollutants in discharges No. 171 of 30 March 2001 (Žin., 2001 Nr.29-94). Cr(VI) is among the pollutants that should be controlled and recorded in the following industries (Lithuanian SNFPI, 2005b):
 - pesticide factories (if more than 5 tonnes of active ingredients per year are produced and if the possibility of Cr(VI) presence exists;
 - chemical factories;
 - electroplating factories; and
 - textile factories.
- Order of the Minister of Environment of the Republic of Lithuania on the rules on collection of data and reporting on the priority and routine hazardous substances No. 696 of 31 December 2002 (Žin., 2003, Nr. 9-314).

4.3.17 Luxembourg

Controls on Industrial Releases to the Aquatic Environment

Information submitted by a single company using Cr(VI) conversion coatings suggests that national emission limits exist for releases of total chromium and Cr(VI) to water. For total chromium the emission limit value is 0.5 mg/l while for Cr(VI) the limit is 0.1 mg/l.

4.3.18 Malta

Controls on Industrial Releases to the Aquatic Environment

The Maltese National Programme for the Adoption of the Acquis (NPAA), pointed out in 2000 that there were no Maltese industries which discharge directly into the marine environment most the substances relevant to the Dangerous Substances Directive (76/464/EEC) and its daughter Directives (Axiak & Delia, 2000)

In 2001, the Pollution Caused by Certain Dangerous Substances Discharged into the Aquatic Environment Regulations 2001 (Legal Notice 213 of 2001) were introduced. These transposed Directive 76/464/EEC into Maltese law.

In 2003, the proposed National Marine Pollution Strategy proposed the following for chromium:

- Environmental Quality Standard for water: 0.05 mg/l Cr(VI) dissolved (for non-industrial areas);
- Environmental Quality Standard for sediment: 15 mg/kg dry weight (for non-industrial areas); and

- Emission Limit Values for releases to marine environment: 0.1 mg/l for Cr(VI) and 0.5 mg/k for Cr(total).

It is uncertain whether these or other standards and limit values were eventually adopted.

Applicability of IPPC Directive to Metal Finishing Installations

The IPPC Directive was transposed to national law with Integrated Pollution Prevention and Control Regulations 2002 (Legal Notice 234 of 2002) in accordance with the Environment Protection Act 2001. Within the Regulations, a threshold vat size limit of 30m³ is included. The Regulations came into force on 1st May 2004.

4.3.19 Netherlands

Controls on Industrial Releases to the Aquatic Environment

According to the OECD Emission Scenario Document for Metal Finishing, the Netherlands has established a discharge limit of 0.5 mg/l for total chromium in wastewater (OECD, 2004a). With regard to Cr(VI), the limits set in site licences are those stipulated in Parcom Recommendation 92/4 (Kerkhof-Damen, 2005).

Information from a publication of Rijksinstituut voor Integraal Zoetwaterbeheer en Afvalwaterbehandeling (Institute for Inland Water Management and Waste Water Treatment - RIZA), indicates that Dutch legislation on water pollution control in the Netherlands provides for environmental quality objectives for chromium (among other substances). These are summarised in Table 4.22.

Table 4.22: Dutch Integrated Environmental Quality Objectives for Chromium in the Aquatic Environment (2000)					
Surface water (total)		Surface water (dissolved)		Sediment	
Target value	MPC	Target value	MPC	Target value	MPC
2.4 µg/l	84 µg/l	0.3 µg/l	8.7 µg/l	84 mg/kg dry matter	100 mg/kg dry matter
<i>Source: RIZA, 2002</i>					
<i>Notes: MPC stands for maximum permissible concentration; both target values and MPCs include the national background concentrations</i>					

According to RIZA, for the metal finishing sector, Dutch regulations require that, if Cr(VI) is used, there must be a closed-loop system for water containing Cr(VI). The rinse water must be brought back in the process bath (RIZA, 2005).

With regard to pigments, it may be of relevance that a 1979 report by RIZA recommended guidelines with regard to the maximum permissible concentrations of metal pollutants present in discharges from paint and printing ink plants. The recommended limit for chromium was 2 mg/l (RIZA, 2005).

Applicability of IPPC Directive to Metal Finishing Installations

The Netherlands has transposed the IPPC Directive into national environmental law (WM) and the Surface Water Protection Act (WVO). Implementation will be final in November this year. In the meantime, the IPPC regime is currently active and valid for industrial installations (Kerkhof-Damen, 2005).

The transposition of the IPPC Directive incorporates the 30m³ threshold limit provided for in the Directive. Out of an approximate total of 700 installations involved in metal finishing activities, around 140 installations exceed the vat size threshold limit set by the Directive (Kerkhof-Damen, 2005).

As indicated above, for metal finishing installations the limits of Parcom Recommendation 92/4 apply.

Controls on Industrial Releases to the Terrestrial Environment

The Netherlands appears to have established target and intervention values for a number of soil contaminants. The target values represent the value below which any contaminant is considered to pose no risk to the environment, whereas the intervention values are those where some form of remediation is required. If the average of these two values is exceeded, then further investigation and some remediation is required. Regarding chromium, the target value for soil is 100 mg/kg dry weight with an intervention value of 380 mg/kg dry weight. For groundwater, the target value is 50 µg/l and the intervention value is 625 µg/l (UKQAA, 2003).

Controls on the Use of Wood Preservatives

National Evaluation Guidelines, called BRLs (Nationale Beoordelingsrichtlijnen) are in place. Plants that comply with the BRLs can get a certificate for their processes and/or products. Certificates are assigned by the Stichting Keuringsbureau Hout (Foundation for Testing of Wood). The relevant BRLs are:

- 2901: Wood preservation with capsules;
- 2906: Wood preservation by means of dipping;
- 2903: Wood preservation by means of dipping followed by diffusion; and
- 0601: Wood preservation by means of vacuum pressure, salt and creosote (OECD, 2002).

According to RIZA, in 2003, it was reported that the use of chemically preserved wood in surface water would not be permitted. The details of any potential replacement of wood that has been already been treated chemically are still unclear (RIZA, 2005).

4.3.20 Norway

Controls on Industrial Releases to the Aquatic Environment

Norwegian discharge permits for the electroplating industry set limits on Cr(VI) of 0.05 mg/l which is half of the concentration limits set in Parcom Recommendation 92/4. According to the Norwegian Pollution Control Authority, this discrepancy is because of specific concern for high values of Cr(VI) in sludge from wastewater treatment plants. Most of the electroplating companies discharge water to municipal wastewater treatment plants and, in Norway, this sludge is generally used as a fertiliser on agricultural soil (SFT, 2005a).

A Norwegian regulation regulates the content of various heavy metals in sludge for agricultural use. For chromium there is a limit of 100 mg/kg dry weight (SFT, 2005b).

Controls on the Use of Wood Preservatives

Regarding the use of Cr(VI) in wood preservatives, Norway introduced a national restriction on the use of wood treated with arsenic and chromium in 2002. The national restriction on arsenic is now replaced by the implementation of Directive 2003/2/EC but Norway has included the same restrictions on chromium as well (SFT, 2005a).

The national restriction included a general ban on the application of arsenic and chromium as wood preservatives, including similar derogations with those now included in Directive 2003/2/EC. The restriction also contained obligations regarding drying of treated wood and provision of information. Any importer or manufacturer was required to ensure that all wood treated with chromium or arsenic (that was permitted under section 2 of the restriction) should be dried so that its moisture content was below 30% before it was delivered to distributors or users, so as to prevent the wood preservative from being released into the environment through leaching. Moreover, wood treated with copper, chromium or arsenic should contain a label with information about the content of metals in the wood preservative formulation.

This restriction entered into force on 1 October 2002, but was revised along with the text of Directive 2003/2/EC in January 2005, in such a way that the restriction now covers both arsenic and chromium (STF, 2005a).

4.3.21 Poland

Controls on Industrial Releases to the Aquatic Environment

In accordance with the Regulation of the Minister of the Environment of 8th July 2004 on conditions which have to be fulfilled while discharging wastewater into water or soil and on substances harmful to the aquatic environment (Dz.U. No. 168, Item 1763) issued on the basis of Article 45 of the Water Law of 18th July 2001 (Dz.U. No. 115, Item 1229 as amended), Polish national limits of Cr(VI) in industrial wastewater emitted to the aquatic environment are as follows:

- for tanneries: 0.05 mg/l;
- for combustion facilities: 0.5 mg/l; and
- for all other industries: 0.1 mg/l.

These provisions do not apply to biodegradable sewage from (BCSP, 2005):

- milk processing;
- fruit and vegetable manufacturing and processing (including mushrooms);
- grain and potatoes processing;
- breeding, raising and processing of animals;
- breweries;
- production of alcohol and alcoholic drinks;
- production of animal fodder from plants;
- production of gelatine and adhesives from hide and bones of animals;
- malt-house and yeast factories;
- fish processing;
- production of animals and vegetables fat; and
- sugar industry.

4.3.22 Portugal

Controls on Industrial Releases to the Aquatic Environment

Portuguese national legislation on wastewater emissions includes the following limits under the relevant instruments (C3P, 2003):

- Regulation DL No. 236/98, 1 August 1998 on industry discharges to surface water:
 - Cr(VI): 0.1 mg/l
 - Cr(total): 2.0 mg/l,
- Ordinance No. 1030/93, 14 October 1993 on metal finishing industry:
 - Cr(VI): 0.1 mg/l;
 - Cr (III): 3.0 mg/l,
- Ordinance No. 512/92, 22 June 1992 on leather tanning industry:
 - Cr(total): 2.0 mg/l.

Applicability of IPPC Directive to Metal Finishing Installations

The IPPC Directive has been transposed into national law with Decree Law No. 194/2000 of 21 August 2000. The date of implementation was 1 September 2000. The national legislation implementing the IPPC Directive makes provisions for the threshold limit of 30m³ for vats used in surface treatment processes (IdA, 2005).

In the case of surface treatment installations that are not IPPC installations or for the existing IPPC installations that do not yet have an IPPC permit, the chromium emissions are regulated by Regulation DL No. 1030/93 of 14 October 1993. This Regulation is taken into account during the licensing of these installations.

Also, installations that discharge wastewater to sewer need to have an authorisation for that discharge issued by the sewage undertaker, which will set out the discharge conditions.

Sewage sludge generated during on-site treatment of wastewater needs to be sent to an authorised waste operator, for further operations of disposal or elimination, according to the sludge type (IdA, 2005).

The emission limits/provisions indicated above have already been introduced through a different legislative framework, before the implementation of the IPPC. As these emission limits/provisions are items from the general national legislative framework, they are the minimum requirements for the IPPC installations. Under the scope of IPPC, and taking into account a case-by-case analysis, more strict conditions than those stated in the general national legislation could be imposed for a certain installation, accounting for the local conditions and BAT.

Until now, 72 surface treatment installations have been registered with the Instituto do Ambiente, the national IPPC Competent Authority. Taking into account the number of IPPC permits issued until now for the surface treatment installations, the Instituto do Ambiente suggests that all these installations have on-site wastewater treatment facilities. Some of those installations directly discharge the treated wastewater to surface water and some of them discharge to a sewer, for further treatment. According to this, the type of on-site wastewater treatment is variable. Some of the installations have primary and secondary (namely metal precipitation) treatments and some other installations have, in addition, tertiary treatment (e.g. ion exchange processes, activated carbon filtration, etc.) (IdA, 2005).

4.3.23 Slovak Republic

Controls on Industrial Releases to the Aquatic Environment

Main legislative tool of the Slovak Republic focused on hazardous substances and priority hazardous substances is Act No.364/2005 Coll. on Waters and Amending Some Others Laws (Water Act). Based on this law, chromium is listed on List II which contains hazardous substances with harmful effects to the water environment.

Important executive regulation concerning wastewater discharges containing hazardous substances and priority hazardous substances is the Governmental Order No. 296/2005 Coll. which sets up requirements on water quality and surface water qualitative objectives and limit values of parameters of pollution in wastewater and special waters.

The environmental quality standard in this Governmental Order for total chromium is 100 µg/l, while the standard for Cr(VI) is 10 µg/l. The same Governmental Order includes emission limit values of pollution for Cr(VI) discharges for individual sources of pollution in Annex 3, Part B. These are:

- for metallurgical installations (non-ferrous metals):
 - for Cr(total): 0.8 mg/l; and
 - for Cr(VI): 0.1 mg/l;
- for surface finishing of metals and plastics:
 - for Cr(total): 0.5 mg/l; and
 - for Cr(VI): 0.1 mg/l;
- for paint shops (coating of metal surfaces):
 - for Cr(total): 0.5 mg/l; and
 - for Cr(VI): 0.1 mg/l;
- for the leather industry:
 - for Cr(total): 1.0 mg/l; and
 - for Cr(VI): 0.1 mg/l.

For drinking water, the relevant limit value for total chromium is 50 µg/l.

Based on paragraph 21 of the Water Act, each wastewater discharge into surface water and into groundwater must be allowed by the state water administration authority. This means that each site which discharges wastewater containing Cr(VI) must have permission for such a discharge, in which an emission limit value for the pollutant is set.

Based on the Water Act, the state water administration authority in the permission process is obliged to take into consideration limit values for parameters of pollution, requirements for surface water quality and qualitative objectives for surface waters with regard to their use, which are set up in the aforementioned Governmental Order. Based on paragraph 36 of the Water Act, the state water administration authority may set up more stringent limit values of pollution for discharged wastewater and special waters or set up further limit values of pollution in addition to those listed in the Governmental Order (MESR, 2005).

Applicability of IPPC Directive to Metal Finishing Installations

The IPPC Directive has been transposed to Slovakian law by Act No. 245/2003. The Act includes in Annex 1, paragraph 2.6 the 30 m³ vat size threshold limit. At present, a total of 24 installations exceeding this threshold limit have been registered in the Slovak Republic. Installations not meeting this limit are not registered by the Slovakian IPPC Department (Nitschneiderova, 2005).

4.3.24 Slovenia

Controls on Industrial Releases to the Aquatic Environment

Consultation suggests that there is a general decree on wastewater emission limit values (Decree on emission of substances and heat with wastewater to waterways and public sewage). The total permissible emission limit values for sewage and waterways are:

- for Cr(VI): 0.1 mg/l; and
- for Cr(total): 0.5 mg/l.

According to the Chamber of Commerce and Industry of Slovenia, this general decree was very recently published in the Official Journal (13 May 2005) (GZS, 2005b).

With regard to the use of chromium in installations involved in the treatment of metal surfaces, the emission limit values are those referred to above. Sludge is considered dangerous and requires special treatment if run-off water (effluent from the sludge) contains more than 50 mg Cr(total) per litre or 2 mg Cr(VI) per litre (GZS, 2005a)

The general decree mentioned above is generally valid for all activities unless there is a specific decree for a certain activity. Consultation suggests that, usually, the specific decrees are stricter than the general one or some special parameter may be added to the sector decrees, which is specific for a certain activity and is not relevant in general for all other activities. There are currently around thirty sectoral decrees some of which are relevant to this RRS and include emission limit values for chromium. These decrees have not been renewed yet so to come in-line with the recently published general decree. For the iron and steel making industry as well as the leather and tanning industry the emission limit for Cr(VI) is 0.1 mg/l, while the limit on Cr(total) is 1.0 mg/l (GZS, 2005b).

Applicability of IPPC Directive to Metal Finishing Installations

Information from the Chamber of Commerce and Industry of Slovenia suggests that IPPC permits are compulsory for vat sizes of 30m³ and above, but smaller plants will also have to obtain a permit (by the same date as IPPC installations, end of October 2007) for their wastewater emissions only (in accordance with the new decree discussed above). Only a few of the Slovenian metal finishing facilities do not exceed the 30m³ vat size threshold (GZS, 2005b).

Slovenian companies had until the end of April 2005 to register as IPPC sites. Currently, there are 187 IPPC sites of which 15 are registered as metal finishing installations. The Chamber of Commerce and Industry has suggested that very few of them are expected to release chromium to the aquatic environment (GZS, 2005b).

About half of the Slovenian IPPC metal finishing installations are SMEs; two companies have 250-300 employees and the remaining have a workforce greater than 300 employees. The sites with a workforce of over 250 employees are usually companies

that make certain products which subsequently require some surface treatment, while the smaller companies usually perform surface treatment operations under contract to the larger companies and surface treatment is their main, if not the only, activity (GZS, 2005b).

For these companies, the emission limit for chromium, if it occurs, will have to be within the recommended BAT reference values which are 0.1 - 0.2 mg/l for Cr(VI) (with 0,1 mg/l being already compulsory as discussed above) and 0,1 – 2.0 for Cr(total) (with 0.5 mg/l being already compulsory by the recent decree) (GZS, 2005b).

4.3.25 Spain

Controls on Industrial Releases to the Aquatic Environment

Royal Decree 995/2000 of 2nd June 2000 in the framework of Royal Decree 849/1986 of 11th April 1986 (implementing Directive 76/464/EEC) set a quality objective for total dissolved chromium (among other polluting substances) at 50 µg/l (MMA, 2005b).

Applicability of IPPC Directive to Metal Finishing Installations

The IPPC Directive has been transposed into national law with Law 16/2002, 1 July 2002, de Prevención y Control Integrado de la Contaminación (BOE n° 157 de 2 de Julio). National legislation implementing the IPPC Directive makes provisions for the threshold limit of 30m³ for vats used in surface treatment processes.

Only 27% (450 out of a total of 1,558) of Spanish installations in the surface treatment sector appear to exceed the limit of 30m³. However, under Spanish Water Law (*Real Decreto Legislativo 1/2001 of 20 July 2001, por el que se aprueba el texto refundido de la Ley de Aguas*) and under the legislation that transposes the Water Framework Directive 2000/60/EC (*Ley 62/2003 of 30 December 2003, de Medidas Fiscales, Administrativas y del Orden Social*), emissions from non-IPPC plants will be regulated. Moreover, the Autonomous Communities of Spain can be more restrictive (but never less restrictive), in drawing up their own legislation, for example Cataluña has its own IPPC law (*Ley 3/98*) that regulates all kind of installations, including the smallest ones (MMA, 2005a).

The percentage of installations treating their wastewater on-site is variable: some examples are 14% in Andalucía, 75.5% in Cataluña and 85% in Madrid. The level of treatment is usually physical and chemical (primary and secondary) (MMA, 2005a).

4.3.26 Sweden

Controls on Industrial Releases to the Aquatic Environment

According to information from the Swedish Chemicals Inspectorate (KemI, 2005), since the 1980s, Swedish legislation requests industrial sites to control their environmental emissions. Larger installations in most industrial sectors need to have a licence before

starting operations. These legislative provisions were updated upon the introduction of the IPPC Directive.

The Swedish environmental legislation, when it comes to emission limit values, is traditionally not based on specification of individual values, as opposed to national legislations in other Member States, but rather on the principle that these limit values are specified in each individual plant permit and that they then must be based on what is BAT at that moment (Borinder, 2005).

That means that there are very few specific emission limit values in the legislation, and if they occur, they are, with few exceptions, the result of national implementation of EU directives where limit values occur. This also means that, for a given sector, e.g. iron and steel, the emission limit values in the permits for plants in that sector are not necessarily the same all over Sweden. This is the consequence of the fact that BAT develops over time and that individual permits are granted not at the same time for all plants. Plus the fact that the situation at the specific plants or sites often varies, for example the sensitivity of the recipient water bodies (Borinder, 2005).

Although emission limit values for a specific pollutant may thus vary from plant to plant, there is naturally a tendency that the permit granting authorities specify similar values as in other “contemporary” permits, at least if BAT has not made a recent “leap ahead”.

Conditions of a permit are normally renewed frequently, as any major change in operation requires a new permit (although not necessarily the whole permit/conditions, if the operation is only changed in limited parts of the whole plant). Even if no change in operation is foreseen at a plant, the conditions may be renewed on the initiative of the regional supervisory authority or by the Swedish Environmental Protection Agency, under certain circumstances such as if new technology makes it possible to reduce emissions. In any case, if the permit is older than ten years it is always possible to initiate a revision of the permit conditions (Borinder, 2005).

Permits are either issued by the national environmental courts, of which there are five in Sweden, for the major polluting industries, or by the regional administrative boards (20 of them), for less harmful activities. The Swedish Environmental Protection Agency does not issue permits, but act as an expert and provides guidance on BAT etc. to the permit issuing courts or county administrative boards. It also has the ability to initiate revision of permit conditions at the court and to appeal against a decision of a permit and make its own suggestions.

For Cr (VI) in particular (and for many other heavy metals) in effluents, the emission limit values in permit conditions of surface treatment industry plants are normally equal to, or lower than, the limit values specified in the corresponding Parcom Recommendations (Borinder, 2005).

Controls on the Use of Wood Preservatives

In Sweden, severe restrictions against arsenic and chromium containing preservatives were introduced in the period 1992-1993. With the aim of reducing the use and distribution of potentially environmentally dangerous substances, the Swedish Chemicals Inspectorate (KemI) introduced in 1992 restrictions on the use of wood treated with arsenic- and chromium-containing wood preservatives. In the KemI Code of Statutes KIFS 1990:10, it was stated that such treated wood was restricted for use accordingly:

- where the wood is buried in, or otherwise in permanent contact with damp soil or water;
- where the wood is used for the construction of jetties or other marine applications;
- where the wood is permanently installed as a safety device to protect against accidents; and
- where the wood is used for the interior of constructions where it is difficult to replace and where there is a risk of accidental wetting, e.g. ground plates on plinths and concrete slabs, ground-floor joists, etc.

All other uses of such treated wood were prohibited (Jermer, 2004), although use of such preservatives on timber for export was permitted (ICDA, 1998).

During a transition period 1992-1993, wood treated with chromium-based preservatives was allowed for other end-uses than the ones mentioned above. Following the KemI restrictions, the use of CCA-treated sawn wood decreased from approximately 85 % in 1991 to below 40 % in 1994, whereas the arsenic and chromium free preservatives increased their market share from about 10% to nearly 60% during the same period (with CCP products showing a remarkable rise in 1992-1993). Since 1994, the percentage of CCA-treated sawn timber on the domestic market was fairly constant around or just below 40% (Jermer, 2004).

Table 4.23 outlines the changes in the percentage of the chromium (and non-chromium) waterborne wood preservatives in the Swedish market in the period 1991-1997. The data display a clear pattern in the move away from Cr(VI)-based wood preservatives as a result of the restrictions imposed by KemI.

Products	1991	1992	1993	1994	1995	1996	1997
CCA	86%	55%	23%	35%	38%	40%	42%
CCB	1%	9%	5%	0%	0%	0%	0%
CCP	35	29%	50%	10%	6%	5%	3%
CC	1%	1%	2%	0%	0%	0%	0%
Others	10%	6%	19%	55%	56%	55%	55%

Source: Jermer, 2004
Note: "Others" may in theory include chromium-based formulations not specified elsewhere, however, the contribution of such formulations to the total market share, if any, is taken as insignificant. Therefore, "others" essentially represents chromium-free formulations in this context.

A different source provides information on developments in the Swedish treated timber market for the years 1998-2002. These are shown below.

Products	1998	1999	2000	2001	2002
CCA	40%	33%	38%	38%	37%
CCP	2%	~1%	~1%	~1%	~1%
CCB/CC	~0%	~0%	~0%	~0%	~0%
Others	58%	66%	61%	61%	62%

Source: Jermer et al, 2004

4.3.27 United Kingdom

Controls on Industrial Releases to the Aquatic Environment

As discussed earlier in this Report, under Directive 76/464/EEC, EU Member States are required to regulate List I substances not yet regulated at European level (candidate substances), and relevant List II substances. In the UK this has generally been achieved through the Surface Waters (Dangerous Substances) (Classification) Regulations 1997 (SI 2560) and the Surface Waters (Dangerous Substances) (Classification) Regulations 1998 (SI 389). With particular regard to chromium, Environmental Quality Standards were introduced with the UK Department of Environment Circular 7/89. These are non-statutory Standards (Defra, 2005).

The national Environmental Quality Standards for the protection of sensitive aquatic life (e.g. salmonid fish) are dependent on the total water hardness, and range from 5 µg Cr/l for waters with less than 50 mg/l hardness (as CaCO₃) to 50 µg Cr/l in waters above 250 mg/l hardness. More stringent values may be appropriate locally for particularly sensitive organisms. Levels for the protection of other aquatic life also vary with hardness and range from 150 to 250 µg Cr/l. The quality standard for the protection of saltwater life is 15 µg Cr/l. All EQS values relate to annual average concentrations of the dissolved form and are presented in Table 4.25.

Compartment	EQS type	EQS (µg/l) for hardness bands (mg/l CaCO ₃)					
		0-50	50-100	100-150	150-200	200-250	>250
Freshwaters, suitable for Salmonid (game) fish	Annual average	5	10	20	20	50	50
Freshwaters, suitable for Cyprinid (coarse) fish	Annual average	150	175	200	200	250	250
Coastal and estuarine waters	Annual average	15 µg/l					

Source: Environment Agency Internet site (www.environment-agency.gov.uk)

In the UK, surface water which is to be abstracted for drinking water must contain less than 0.05 mg/l of total chromium (95% of samples).

Controls on Industrial Releases to the Terrestrial Environment

With regard to soil, the current threshold trigger for Cr(VI) is 25 mg/kg. The most recent provisional guideline concentrations are 150 mg/kg for gardens and allotments, 1,000 mg/kg for residential areas without gardens, parks, playing fields and open spaces, and 3,800 mg/kg for commercial and industrial sites (ICDA, 2001).

Controls on the Use of Wood Preservatives

In the UK, CCA wood preservatives are authorised under the Control of Pesticides Regulations (COPR) 1986 (SI 1986/1510) and the authorisations for the industrial treatment of timber are renewed by the HSE (Arch, 2002).

As discussed in Section 3.4.2, the UK HSE carried out an extensive review of CCA, including environmental risk assessments, in 1999 and 2001 (HSE, 1999 and HSE, 2001). The final recommendation in both cases was that CCA products are re-approved subject to certain data requirements. The companies that have complied with the data requirements had the approvals for their products renewed until 1 September 2006.

Applicability of IPPC Directive to Metal Finishing Installations

The UK already had in place a system similar to IPPC before the introduction of the relevant Directive (the IPC authorisation system). This existing system has been adapted to the requirements of the IPPC Directive.

Under the UK IPPC Regulations, the Environment Agency for England and Wales (and the relevant authorities in Scotland and Northern Ireland) develops sector guidance notes that are used by the regulators when issuing permits to industrial installations. The UK sector guidance notes contain benchmark values for emissions of pollutants which are indeed used as guides, but the Environment Agency includes threshold values in all IPPC permits and includes an improvement notice for those companies that do not currently meet the limits.

With regard to the applicability of the IPPC Regulations to metal finishing installations in the UK, data presented in Table 4.26 would suggest that at least around 60% of companies (180) in the UK metal treatment sector are unlikely to be covered by IPPC (on the basis of their size).

Actual estimates are that as the IPPC Directive has a 30m³ vat capacity limit for this sector, even if all the process tanks in an installation are added together, IPPC will only affect about 10-20% of the installations in the sector (RPA & BRE, 2004). The information collected for this RRS, however, suggest that more than half the identified UK users of Cr(VI) in the metal finishing sector have an IPPC permit.

At the same time, for companies without IPPC permits, emissions to wastewater are controlled on the basis of discharge consents set by companies/sewage undertakers to the emitting installations (personal communication with industry).

Company size (number of employees)	Number of companies	Percentage
>250	6	2%
10-249	114	38%
<10	180	60%
Total	300	100%
<i>Source: RPA & BRE, 2004</i>		

Pursuant to the 1991 Water Industry Act, the water companies may impose conditions on the consents of individual sites including setting limits for releases of pollutants. The holder of the discharge consent is required to provide with details of the pollutants and the associated quantities/concentrations in his/her discharges when applying for the consent (Wiltshire, 2005).

The water companies set limits on the releases of total chromium; these limits vary and depend on local conditions. The general approach is that where a large WWTP receives relatively low loads of chromium, the water companies may allow for higher emission limits to be set in the discharge consents. Instead, where the treatment plant receives significant quantities of chromium, the limits set in the consents tend to be stricter. Since chromium will generally partition to the sludge during wastewater treatment and the sludge may be used for land spreading, the water companies are very keen to control the releases of chromium upstream, so that good quality sludge may be produced. Information has been provided on the chromium limits set by the water companies operating in England and Wales. The limits range from 2 mg/l for total chromium up to 10 mg/l. These values are flexible: limits as low as 0.5 mg/l may be set in discharge consents depending on local conditions. On the other hand the 10 mg/l reported for a single water company applies to an individual metal or the total concentration of Cr, Cu, Pb, Sb, Be, Ni, Se, Ag, Sn, V and Zn. This limit may also be set at a lower level depending on local conditions (Wiltshire, 2005).

Invariably, the emission limits set in discharge consents may be breached by the clients. The water companies periodically monitor emissions by conducting sampling on the sites of their clients. If the analysis of samples reveals elevated levels of a certain pollutant (say, chromium), the water company will discuss this with the site involved in order to reduce emissions to an acceptable level. At the same time, water companies are involved into strategic sampling within the catchment area of their responsibility to identify any problems along the sewerage system. In addition, through a variety of sources (literature, Internet, etc.) the water companies keep updated records of industrial installations in the area of their responsibility and have a good idea of the processes and likely emissions from these installations. In the event of a site releasing wastewater that does not comply with the requirements of its discharge consent or even in the unlikely event that a site

without a discharge consent releases such wastewater to the sewer (or surface waters), the water companies are confident that by sampling along the water courses they will be able to identify the polluter and take legal action against him. It should be noted that the WWTPs run by the water companies are monitored and controlled by the Environment Agency for England and Wales (Wiltshire, 2005).

The water companies are also involved in the issuing of IPPC permits; although this is the responsibility of the Environment Agency for England and Wales, the water companies are statutory consultees and advise the Agency on the discharges from individual industrial installations (Wiltshire, 2005).

4.3.28 National Measures for Control of Emissions at Wood Treatment Sites – Retention and Fixation of Wood Preservatives

Fixation of Wood Preservatives and Emissions of Hexavalent Chromium

Treated timber following the holding period is generally stored on the yard area until transported off site. Depending on the state of fixation, residual Cr(VI) may wash from the surface of the wood during rainfall, which could potentially reach soil.

The rate of fixation is temperature-dependent so the state of fixation may vary following a holding period with potential for some residual Cr(VI) to be released on the storage yard.

One option is to introduce longer holding times to ensure fixation is complete as is done in Scandinavia or introduce criteria on residual Cr(VI) that have to be met before wood can be released from the treatment site, as is done in the Netherlands.

Examples of this temperature time dependence on the rate of fixation and differences in chromium based products can be seen from the holding times developed by some of the Scandinavian countries (see Table 4.27). Various EU countries impose holding times at the treatment plant for timber treated with chromium-based products. In the UK it is time-related, whilst in some, such as the Netherlands, it is linked to fixation requirements (personal communication with industry).

The UK imposed a 48-hour minimum holding period for CCA-treated wood and this is applied to other chromium-based products as well. In any case, timber has to be held until dry in a banded area. The 48-hour period was based on the time taken to achieve a drip-free product that could be further handled. In the Netherlands, they use a shower test instead. Packs of wood are showered with a set amount of water and the runoff is collected. The level of components in the runoff have to be below set levels (there are values for chromium and copper in different formulations) and each site has to have such tests conducted periodically to demonstrate compliance. This test is still being used but can have variable results and an alternative is reportedly being sought (personal communication with industry).

Table 4.27: Retention (holding) Times (in days) for Cr(VI)-treated Wood Established in Scandinavian Countries

Preparation	Denmark ¹		Sweden				Norway			
	Summer	Winter	20°C	15°C	10°C	5°C	20°C	10°C	0 - 10°C	<0°C
CCA, Class AB ²	3	8					3-5	6-14	>14	Days don't count ³
CCA, Class A ²	6	>30								
CCB, Class AB ²	12	>30								
CCB, Class A ²	14	>30	15	>30	>30	>30				
CC, Class AB ²			8	20	>30	>30				
CC, Class A ²										

Source: Personal communication with industry

Notes:

¹ adopted to meet a 15 ppm residual Cr(VI) limit.

² the Nordic wood preservation classes A, AB & B, correspond to Hazard Classes 4 and 3 (class B is intended for external joinery) respectively according to standard EN 335-1 (Hazard classes of wood and wood-based products against biological attack)

³ for Norway, if the temperature is below zero then the treater does not count that day as being relevant in the holding period. So if the temperature is zero to 10°C, treated wood is held for 14 days as a minimum. If during that 14 days the temperature goes below zero, the treater misses those days when it does so and, therefore, holding may be much longer. In winter this forces holding to take place in heated storage areas

Methods of Accelerating Fixation

As the fixation is temperature-dependent, it is possible to speed the reaction up by heating the wood. There are various ways of doing this. Timber can be stored in a warm room but it takes considerable energy to heat the wood sufficiently and it is difficult to get heat to pieces within a pack of timber. As the wood also has a high moisture content, care is required not to over-dry the surface.

Another method is the use of UV radiation, although industry suggests that the most efficient process is to steam the wood immediately after treatment.

Some steam condenses on the wood during the early stages and this has a benefit in washing some residual solution from the wood surface. The steaming process heats the wood to 40-80°C, depending on the species, so once it is brought out of the vessel the surface rapidly dries due to evaporation.

Timber following steaming is drip-free immediately, is fixed to a comparatively high degree and can be stored outside with minimal potential for runoff during rainfall. In many cases, the process allows timber to be moved off site without the requisite holding period thereby speeding up the post treatment process.

The process can be conducted in the existing treatment vessel or in a dedicated separate vessel. The technology is not new and has been in use in some countries for many years to meet their post treatment requirements for Cr(VI). The costs vary depending on the

approach taken and on the capacity of the treatment facility. Also the existing layout may require modification.

Utilising the existing vessel: The capital costs will be lower utilising the existing treatment vessel but it does reduce the treatment capacity as it effectively doubles the time taken to treat the wood. Major changes to the treatment plant area are not required.

Utilising a dedicated vessel: This has a higher capital cost as a new vessel, railtrack transfer system etc. are required. It may be that the existing building has to be modified. The advantage of this option is that it maintains the treatment capacity of the facility and is more efficient in that residual heat in the vessel is not lost during treatment (personal communication with industry).

The investment cost of the fixation and mixing equipment is around €100,000 for a standard treatment operation. Reducing the need for special storage areas under roof will save a greater part of the investment. The operational costs have been reported as negligible (BRE, 2002).

4.4 Voluntary Action by Industry

4.4.1 Metal Treatment – Initiatives of the UK Surface Engineering Association

Provision of Guidance

The UK Surface Engineering Association (SEA, an umbrella association that incorporates a number of associations representing companies involved in the treatment of metal surfaces) issued in 2001 a Health and Safety Training Document for chromium electroplating operators and supervisors. The document includes guidance on existing (at the time) legislation in the UK as well as instructions and information on chromium trioxide with regard to (SEA, 2001a):

- product labelling;
- health effects;
- protective measures;
- storage;
- emergency action;
- disposal; and
- housekeeping.

The UK SEA has also published in the past a number of relevant guidance publications: “Safer Chromium Finishing” in 1995 and the “Chromium Code of Approved Practice” in late 1998 (information submitted by industry).

More recently, the British Surface Treatment Suppliers Association (BSTSA, a member of the UK SEA) published guidance on the health and safety of surface treatment tank

side personnel (BSTSA, 2004). The Guide contains advice and assistance on how to carry out surface treatment work in a safe and health conscious manner.

Substitution of Hexavalent Chromium by Trivalent Chromium

The substitution of Cr(VI) with the less hazardous Cr(III) in decorative plating applications is a risk reduction measure which is of relevance to this RRS. This recommendation has been advocated in the past by industry (suppliers of Cr(VI)), UK industry associations (UK SEA and BSTSA) and government departments (for example HSE, who started an initiative in 2004).

The need for Cr(VI) in ‘bright’ decorative-chrome plating could be eliminated by substitution with the less hazardous trivalent form where anti-corrosion properties of the plated surface are not essential. Early attempts to encourage substitution were not successful, mainly because Cr(III) deposited a different colour to Cr(VI) which was unacceptable to customers, particularly those purchasing chrome bathroom and kitchen fittings in the domestic market. However, most of these barriers to substitution have now been overcome and, in most cases, in ‘bright’ decorative-chrome plating it is now reasonably practicable to substitute hexavalent with Cr(III) (RPA & BRE, 2004 based on information from UK SEA).

It has been suggested that there are approximately 100 metal plating installations using Cr(III) worldwide (compared to a total of 3,000 decorative plating installations) with 20 such installations located in the UK. France and Spain are also suggested to have Cr(III) users (RPA & BRE, 2004).

For hard chromium platers, while substitution with Cr(III) may not be an option, employers are still required under the Control of Substances Hazardous to Health (COSHH) Regulations in the UK to ensure that their employees are handling Cr(VI) safely. Similar legislation should be in place in the other EU Member States at least due to the classification of the Cr(VI) substances as carcinogens. The UK SEA advises that workplace inspectors should ensure that employers have adequately assessed and controlled inhalation exposure and dermal exposure (RPA & BRE, 2004).

To date, these initiatives have only had limited success owing to a number of factors including platers having to respond to customers’ specifications. This has been reported as constituting a significant obstacle to a voluntary approach and to setting BAT in the BREF Document under IPPC, as customers’ specifications need to be brought within the process.

4.4.2 Wood Preservatives – Current Initiatives in the UK

A Code of Practice for wood treatment installations was recently developed in the UK. This Code was developed in 2003 by the British Wood Preserving and Damp-proofing Association (BWPDA) in consultation with the Environment Agency, the Scottish Environment Protection Agency, the Environment and Heritage Service Northern Ireland, the Health and Safety Executive and the Chief and Assistant Chief Fire Officers Association.

It is intended to give practical guidance on environmental, safety and health issues relevant to all companies engaged in the activity of industrial wood preservation. There is no statutory obligation to adopt this Code, but, in doing so, participants confirm their commitment to ensure full compliance with current legislation and to adopt progressive practices by continuous improvement. Compliance with the Code would be taken into consideration by the regulatory authorities in determining whether to take enforcement action and may be taken into account by the courts in the event of prosecution (BWPDA, 2003).

With regard to environmental protection, the Code advances the following principles:

- elimination, or where this is not possible, minimisation and treatment to render harmless any releases to air, water (surface and groundwater) or land;
- total containment to be followed during site design and applied to the processing plant, preservative storage area and the holding area for treated timber;
- use of wood preservative products only in sealed, properly labelled and approved containers, conveyed in suitable and designated vehicles;
- safe disposal of any waste produced or handled by following the legal requirements of the Duty of Care;
- proper labelling and adequate secondary containment for permanent tanks used for the storage of products (i.e. a bund);
- diversion of clean uncontaminated rain or surface water away from the plant area;
- use of processes and products that present lower risks to the environment and the workplace, where possible;
- periodic reviews of the products used;
- periodic reviews of the processes used (including enquiries to the suppliers about less polluting alternatives or alternatives that create less waste);
- drawing up of emergency plans; and
- periodic environmental and safety audits (BWPDA, 2003).

The Code of Practice goes on to outline measures to be taken to prevent and minimise environmental releases. Measures are relevant to:

- bunding of the timber treatment plant and wood-preservative storage tanks;
- design and operation of post-treatment containment and conditioning areas;
- storage of conditioned timber;
- waste management and bulk deliveries.

There is a detailed description of steps that can be taken to improve environmental performance and these are reproduced in Annex 3 to this Report.

4.4.3 Voluntary Elimination of Use of Hexavalent Chromium in EU Tanneries

Over the years, EU tanneries appear to have gradually abandoned the use of Cr(VI) compounds in the on-site production of chrome tanning salts. As discussed in Section 2.4.3, Cotance and the national tannery associations under the umbrella of Cotance indicate that their members have voluntarily eliminated the use of Cr(VI) in EU tanning installations.

Consultation suggests that Cotance's generally appears to be correct. Only two sites have been identified as having used Cr(VI) compounds in the recent past (note that one of them purchased Cr(VI) feedstock as recently as January 2005). Given the large number of tanneries in EU Member States and the fact that Cotance does not represent the entirety of EU tanneries, it is theoretically possible that the on-site reduction of Cr(VI) to Cr(III) may not have been completely abandoned, however, as discussed in Section 2.4.3, non-members of Cotance would have very good reasons to abandon this process, if they have not done so already.

4.4.4 Voluntary Actions of the European Aerospace Industry

The European aerospace industry has been working in collaboration with the automotive industry and the pigment manufacturers to address the issues surrounding the possible effects of Cr(VI) to the environment and human health. Cr(VI) compounds are used in all applications in these sectors where protection against corrosion is important (on aluminium alloys, surface treatments, paints, sealants and adhesives (personal communication with industry)).

With regard to the long term toxicity of Cr(VI), several actions have been launched by a leading manufacturer in the aerospace industry. These include:

- a comprehensive evaluation of environmental, health and safety risk for each situation of exposure/emission, and the implementation of all appropriate and efficient protection/control measures; and
- the launch of a formal project to eliminate all chromate-relevant applications within the shortest possible timeframe (expected 2009) including paints and surface treatments (personal communication with industry).

4.4.5 Voluntary Action of Wood Preservative Formulators in the United States and Canada

On 12th February 2002, the US Environmental Protection Agency announced a voluntary decision by pesticide registrants to move consumer use of treated lumber products away from a variety of uses of pressure-treated wood that contains arsenic, in favour of new

alternative wood preservatives, effective 31st December 2003. This transition affects virtually all residential uses of wood treated with CCA, including wood used in play-structures, decks, picnic tables, landscaping timbers, residential fencing, patios and walkways/boardwalks. This action was expected to result in a reduction of virtually all residential uses of CCA-treated wood within less than two years. This voluntary approach was believed to be capable of accelerating the transition to new alternatives, while responding to marketplace demands for wood products that do not contain CCA.

Industry notes that, the US and Canadian CCA formulators voluntarily amended their CCA labels to limit the use of CCA treated wood to certain commodities and dimensions of timber for industrial applications. It should be noted that existing CCA structures were not affected nor were there any recommendations that they be removed.

According to the US EPA, the 22-month transition period was intended to provide consumers with increasingly more non-CCA treated wood alternatives as the industry underwent conversion and retooling of their industrial equipment and practices, while also allowing adequate time to convert treatment plants with minimal economic disruption for the industry's employees.

Further to this voluntary action, it has been noted by industry that there are still issues to be resolved by the US EPA concerning the treatment of the US categories of 'industrial and commercial timbers' with CCA.

4.4.6 Current Work on the Risk Assessment for Trivalent Chromium

The chromium industry recognised that the ESR RAR has not covered the full range of chromium-containing materials and has commissioned RARs for chromium in its trivalent and metallic states (including alloys) designed to meet part of the Registration requirements under REACH. Consultation suggests that the human health RAR is nearing completion and the environmental equivalent is underway; this latter document is expected to enable a full assessment of the impact of chromium on the environment. The project will consider the impact of releases of both Cr(III) and Cr(VI) (personal communication with industry).

4.5 Current Control Technologies and Techniques for Risk Reduction

4.5.1 Introduction

The following paragraphs include information collected from literature on current technologies and methods used in the prevention and minimisation of emissions of chromium and the treatment of wastewater and sludge containing chromium in the industry sectors of concern. Section 4.6 provides information on emissions controls collected from individual companies during consultation for the purposes of this RRS.

4.5.2 Background to Best Available Techniques for Surface Treatment of Metals and Plastics

The following information is taken mainly from the relevant BREF Document (draft of April 2004 – note that a final draft was issued in May 2005) on surface treatment of metals and plastics.

Abatement of Releases: Fundamentals

With regard to releases of chromates to water, operators need to:

- treat chromates to change them to more readily managed chemical species; and
- separate the resulting chromium compounds from the water to pre-determined levels (EIPPCB, 2004b).

This essentially means dilution of concentrated Cr(VI) effluents and then primary treatment i.e. reduction to Cr(III) and subsequent neutralisation and precipitation. In secondary treatment, flocculation and separation of liquids/solids take place. The solids are treated as waste and the liquids are subject to tertiary treatment (polishing), where available, before final discharge (EIPPCB, 2004b).

Solids removed from the effluent via precipitation or filtering may be further concentrated using a filter press, belt press or centrifuge to produce a cake manageable as a solid. Filter cake may be further dried to lower water content. Liquid wastes may be stored and disposed of as liquid waste, sent for special recycling or recovery, or disposed of as hazardous waste (EIPPCB, 2004b).

Benchmark Material Efficiencies

The losses of metals from during the deposition process in chromium plating have been estimated at 40% for hard chromium plating and 52% for decorative chromium plating (EIPPCB, 2004b). These losses do not represent the percentage emitted from the facility since the losses are subject to recycling and/or treatment. The overall efficiency of surface treatment operations is quoted in the BREF Document to be 90% or higher.

Information on Actual Emissions and Benchmark Values

Releases to Water

The draft BREF Document on surface treatment of metals and plastics provides some relevant information on practices in this sector in the EU. According to Section 3.3 of the Document (EIPPCB, 2004b), in Germany 94% of the surface treatment sector discharges wastewater to local sewerage systems and pre-treatment is undertaken prior to discharging. In the case of physicochemical pre-treatment, the toxic anions in the sewage are destroyed and heavy metals are removed to the required standards. Further treatment in the local biological municipal wastewater treatment plant follows.

In France, wastewater from surface treatment installations is quoted as being discharged to surface water after complete treatment on-site. Discharge to municipal wastewater treatment plants is only considered after a detailed analysis including biodegradation studies and must achieve an additional reduction in pollution.

In Norway, an investigation of installations using good practice derived a benchmark figure of a treated effluent discharge of 50 l/m² of treated surface area with an effluent containing less than 0.1% of the metal used (EIPPCB, 2004).

With regard to ECCS and timplating, the BREF Document suggests that common site effluent treatment facilities (shared with other steel processing activities) are often used. Limited data are available for final effluent discharges from individual coating lines; these show typical emission values of 0.0001-0.01 mg Cr(VI)/l. On the other hand, for continuous zinc electroplating, no emissions of Cr to water are expected following wastewater treatment (EIPPCB, 2004b).

Typical emission values for anodising installations are below 0.5 mg/l for total chromium and below 0.05 mg/l for Cr(VI) following typical wastewater treatment (EIPPCB, 2004b).

The BREF benchmark values for wastewater discharges to public sewer or surface water are 0.5 mg/l for total chromium and 0.1 mg/l for Cr(VI) after using both waste minimisation and effluent treatment.

In the UK, the Sector Guidance Note IPPC S2.07 produced by the Environment Agency (2004) lists benchmark emissions limits of 0.1 mg/l for Cr(VI) and 1.0 mg/l for total chromium for releases to sewer (trade effluent), based on chemical precipitation and permanent media filtration.

The Sector Guidance Note requires that drag-out reduction, drag-out recovery and other appropriate techniques should enable the following process efficiencies with respect to input materials:

- chromium plating (closed loop): 95%;
- anodising: 90%.

In practice, UK SEA claims that many companies have a zero limit discharge for Cr(VI) compounds. A typical plating company with a yearly outflow of 35,000 m³, continuously discharging at 0.1 mg/l will give a yearly discharge of just 3.5 kg, as a worst-case scenario (SEA, 2005). This is considerably lower than the predicted release from metal treatment use in the RAR where a range of 0.73-4.4 kg/day is given.

Waste Arisings

For waste, the draft BREF Document indicates that the most significant waste stream for most plants involved in surface treatment is sludge or filter cake from a batch process filter concentrating the solids produced in the wastewater treatment plant. The sludge

contains 60-80% water. Dissolved metals are usually precipitated as hydroxides. The sludge is usually considered to be hazardous waste and is managed in accordance to existing legislation on hazardous waste. It is of note that the BREF Document suggests that, in Germany, approximately 30% of the amount of electroplating sludge (estimated at 70-80 kt/y) is used as a secondary raw material in the non-ferrous metal industry. The remainder is disposed of in hazardous waste landfills (EIPPCB, 2004b).

4.5.3 Best Available Techniques for the Surface Treatment of Metals and Plastics

The following information is taken from the BREF Document (draft of April 2004) on surface treatment of metals and plastics.

Best Available Techniques for Drag-out Reduction

In accordance to the relevant BREF Document, BAT for drag-out reduction include (EIPPCB, 2004b):

- reduction of viscosity by: (a) lowering concentration of chemicals; (b) adding wetting agents; (c) ensuring the process chemicals do not exceed recommended values; (d) ensuring the temperature is optimised; and
- use of jigs and barrels in a manner that minimises drag-out (more details are given in Chapter 5 of the draft BREF Document).

Best Available Techniques for Closed-loop or Zero-discharge Processes

Closed-loop systems can be achieved for controlling releases of Cr(VI) by combining rinse minimisation and drag-out recovery techniques with metal recovery techniques such as membrane ion exchange (EIPPCB, 2004b).

Best Available Techniques for Hexavalent Chromium Substitution

In accordance to the BREF Document, BAT for Cr(VI) substitution include (EIPPCB, 2004b):

- replacement of Cr(VI) in decorative plating by Cr(III) where Cr(VI) is not specified or corrosion resistance requirements are low (e.g. where the CASS²⁹ requirement is less than 16h). Where increased corrosion resistance is required, use of Cr(III) solution with increased nickel layer underneath and/or organic passivation OR replacement of Cr(VI) with a Cr-free technique, such as tin-cobalt alloy where specifications allow, such as decorative finishes;

²⁹ Copper-accelerated salt-spray (CASS) test: an accelerated corrosion test for some electrodeposits for anodic coatings on aluminium.

- replacement of high concentrations of Cr(VI) plating solutions with low concentration solutions and/or a ‘cold chrome’ technique (more details on this are given in Chapter 4 of the BREF Document);
- operation of Cr(VI) solutions on a closed-loop basis; and
- replacement of Cr(VI) conversion (passivation) coatings with Cr(III) or Cr-free coatings using additional coatings if necessary (e.g. composite organic-zirconium fluoride solution, treatment with titanium fluoride or treatment with organic silicon derivatives).

Best Available Techniques for Wastewater Treatment

In accordance to the BREF Document, BAT for wastewater treatment include (EIPPCB, 2004b):

- minimisation of water usage;
- elimination of ‘priority substances’ and use of closed-loop systems where feasible;
- identification, separation and treatment of flows that contain chromates;
- treatment of chromates by: (a) reduction to Cr(III) at pH values below 2.5 usually with hydrogen bisulphite or at pH<3.5 using hydrogen peroxide or with sodium dithionite or Fe(II) at alkaline pH if Cr(VI) is present in small amounts; (b) precipitation of Cr(III) hydroxide; and
- observance of benchmark values of 0.1 mg/l for Cr(VI) and 0.5 mg/l for Cr(total) for effluent without any kind of dilution before discharge and on samples being representative and unfiltered prior to analysis.

With regard to current practices, the OECD Emissions Scenario Document on metal finishing agrees in that waste solutions containing heavy metals, such as acidic, alkaline and hydrolysable liquids, are treated by physico-chemical processes to precipitate the metals as hydroxides. Following settlement the solutions are filtered, the liquid is discharged to sewer and the solid filter cake disposed of to landfill (OECD, 2004a).

Best Available Techniques for Treatment of Wastes

In accordance to the draft BREF Document, BAT for wastewater treatment include (EIPPCB, 2004b):

- minimisation of waste generation by controlling use and loss of raw materials from the processes;

- identification and separation of waste streams with the intention of re-using or recovering off-site; and
- for closed-loop systems, the material efficiency for chromium plating should be 95%.

Best Available Techniques for Coil Coating

ECCA's contribution to the development of the BREF Document on surface treatment of metals and plastics outlines the Best Available Techniques for the coating of coils (steel and aluminium). The BAT relevant to the use of Cr(VI) solutions are described below.

With regard to 'no rinse' systems, this technology does not use chromating rinsing baths, however, contaminated wastewater still accumulates, albeit in relatively small quantities, in the cleaning of rolls, tanks and baths. Various types of equipment for applying 'no-rinse' treatment solutions are available. In the most common types, a pick-up roll takes the solution and transfers it to an applicator roll which then rolls it onto the coil. After application of the solution by the chemcoater, the coil should pass through a 3 to 5 m free section which, even at coil speeds of 200 m/min, guarantees more than enough time for reaction with the metal surface. Subsequently, the coil goes through the dryer. In the chemcoater techniques, no treatment solution which has been in contact with the metal coil passes back into the storage tank, no reaction products are able to accumulate in the treatment bath, and therefore, no special replenishment of the bath is required. The consumption of chemicals in 'no-rinse' processes is between 0.1 and 1 g/m² per process stage as opposed to 2-10 g/m² in conventional processes (Mady & Seidel, 1996).

Other measures suggested for better control of emissions include (ECCA, 2004):

- discharge of spent conversion coating solutions should only take place when they no longer give the specified coating requirements required for the product;
- any possible accidental releases from the application of the chromate conversion coating operations should be directed to a low-level emergency tank, to prevent its release;
- suitable means should be available to isolate the plant sewage system from the main sewer, to prevent possible discharge that may damage the main sewer and subsequent treatment plant;
- where effluent is treated off-site at a sewage treatment plant, it should be demonstrated that all appropriate measures have been taken to reduce effluent volume and pollutant concentration, and that the treatment provided at the STP is as good as would be achieved if the emission was treated on-site, based on reduction of load (not concentration) of each substance to the receiving water; and
- a suitable monitoring programme should be in place for emissions to sewer, taking into consideration the potential inhibition of any downstream biological processes.

Description	Applicability	Economics
Application of conversion coating: use of the ‘no rinse’ method. This technique generally produces waste in very small volumes, whereas the ‘spray and squeeze’ technique produces larger volumes of waste. Also the chemical consumption is much lower in comparison to ‘spray and squeeze’ application because application efficiency and material usage approaches 100%. This makes overflow to wastewater superfluous as also any waste gas abatement technique	Widely used in some parts of EU	Investment for application unit. Low consumption of surface treatment chemicals. Much less wastewater.
Rinsing: reverse cascade rinsing. This combined with conductivity measurement and related flow meters in the last water rinse step guarantees minimum water consumption and lowest waste generation. Usually the cascade consists of three rinsing steps; the more steps are used, the lower the amount of fresh water added to the last step in order to maintain conductivity borders	Options and combinations are suitable for all installations	Considerable costs (additional tanks, workpiece transport equipment and control). This is compensated by decrease in water consumption, recovery of process chemicals and smaller effluent discharge
Rinsing: closed loop rinsing water. Recycling of water by use of closed loop systems such as cooling towers (open and closed systems) or heat exchanger reduces the amount of water used on the line	Widely used for heat exchangers and cooling processes	Lower water consumption
Treatment of rinse water before discharge: Process waters are usually treated in a wastewater treatment plant with a sequence of process steps. Dissolved metals in rinse water are precipitated, e.g. by using lime or sodium hydroxide. The liquor is subsequently processed through a filter press to separate the solids from the liquids	No data	Capital and treatment costs may be significantly reduced by treating individual wastewater streams separately
Water treatment – chromate-containing waste: Cr(VI) compounds (chromates or dichromate) are normally reduced to Cr(III), which is subsequently precipitated as Cr(III) hydroxide on neutralisation. The reduction is made at pH values under 2.5. The most common reducing agent is sodium hydrogen sulphite (bisulphite)	Widely used	No data
Monitoring of rinse water before discharge by conductivity: this can reduce the amount of water used, because it helps to control the amount of make-up required	Widely used	No data

Source: ECCA, 2004

Best Available Techniques for Electrolytic Continuous Coating of Steel

Eurofer’s contribution to the development of the BREF Document for surface treatment of metals and plastics outlines the Best Available Techniques for the electrolytic continuous coating of steel. The BAT relevant to the use of Cr(VI) solutions are described below.

Description	Applicability	For new or existing plants	Type	Installation cost	Operational cost	Assumed environmental benefit
Control and management of electrolyte consumption: Following the plating section, the strip passes through a rinse section drag-out to minimise the loss of electrolyte. The electrolyte is spray rinsed with a dilute solution of phenolsulphonic acid and tin, it is then returned to an electrolyte recirculation tank. An evaporator system is then used to condense the dilute electrolyte solution through evaporation, which is then sent back to the process for reuse	1,2	N+E	PI	M	M	H
Wastewater treatment process: Treatment of wastewaters from the process via a wastewater treatment plant. Solids are removed via a precipitation process. A resultant filter cake is produced. Oily wastewaters are dewatered and then treated, for example, through a dissolved air flotation system and centrifuge to remove the oil. Treated effluent can then be discharged into the environment via pH control	1,2,3	N+E	EoP	H	H	H
Chromic wastewater treatment process: The function is to remove the chrome ions in the chromating rinse water. In the treatment plant the Cr(VI) is reduced to Cr(III) with sodium bisulphite or ferric chloride; in the following stage the Cr(III) precipitates as hydroxide due to a pH increase obtained by addition of hydrated lime or sodium hydroxide. The slurry obtained is treated in a decanter, with milk of lime and subsequently passed through a press filter	1,2	N+E	EoP	H	H	H
Cleaning and regeneration of chromate bath: Spent chromate bath is filtered; the concentrations in metallic ions and the pH are adjusted. The regenerated chromate solution is reused	3	N+E	PI	M	L	H
<p>Source: Eurofer, 2003</p> <p>Notes: 'Applicability' indicates which chromating processes this could be implemented for. The numbers indicate: 1. Continuous Electrolytic Tin Coating of Steel; 2. Continuous Electrolytic Chromium Coating of Steel (ECCS); and 3. Continuous Electrolytic Zinc(Zinc/Nickel) Coating of Steel. 'Type' indicates process integrated (PI) measures or end-of-pipe (EoP) measures. L, M, H stand for Low, Medium, High.</p>						

4.5.4 Best Available Techniques for Post-treatment of Hot Dip Galvanised Steel

The following information is taken from the BREF Document on processing of ferrous metals.

Typical Outputs

The BREF Document for the Ferrous Metal Processing Industry suggests that typical outputs for chromium from the whole of the coating line are in the range of <0.08 - 1.7 mg/m³. After treatment of wastewater, the reported concentrations for chromium are:

- chromium(total): <0.01-0.43 mg/l; and
- chromium(VI): 0-0.02 mg/l.

The quantity of the generated sludge is 0.12 kg/t processed steel and is reported as having high concentrations of Cr and Cr(VI). For a plant involved in lead-tin coating of steel, a concentration of 5 ml/l for chromium in wastewater is also reported (EIPPCB, 2001).

Techniques to Consider when Determining Best Available Techniques

The BREF Document describes the following techniques as possible options for better control of chromium releases:

- *cleaning and reuse of chromating solution*: the chromium solution is filtered through filters while re-circulated. Exhausted solution is discharged from time to time and treated externally in the water treatment plant. This treatment may also be carried out off-site. This results in the reduction of chromium chemical consumption and reduction of water outlets and volume of sludge in the water treatment plant;
- *using squeeze rolls*: the remaining solution on the steel strip is removed from the strip by squeeze rolls before leaving each treating section. This ensures that drag-out of solution into next section is minimised and loss of chemicals is reduced;
- *wastewater treatment with a chromic water line*: the function of this circuit is to remove the chrome ions existing in the water, mainly the Cr(VI), due to its higher toxicity, and the Cr(III). In the treatment plant, Cr(VI) is reduced to Cr(III) with sodium bisulphite or ferric chloride. In the following stage Cr(III) precipitates due to a pH increase obtained by addition of hydrated lime. The ferric hydroxide precipitates simultaneously with the chromic hydroxide. The slurry obtained is treated in a decanter, inerted with milk of lime and subsequently passed through a press filter. Treatment with a polymer to achieve flocculation is also possible; and
- *wastewater treatment with a general wastewater circuit*: the processing of the wastewater consists of flocculation with subsequent filtering and cooling. In order to improve the removal of oil and solid particles, a small amount of coagulating agent and polyelectrolyte is added to produce a microfloculation. The water and the flocculi are sent to a battery of two-layer sand and anthracite filters that retain the particles formed. The filtrated water is transferred to cooling towers and the slurries retained in the filters are removed and passed through a press filter for subsequent recycling. Data from a plant employing this technique show a concentration of Cr in the effluent discharge lower than 0.006 mg/l (EIPPCB, 2001).

Best Available Techniques for Continuous Hot Dip Galvanising of Steel

The environmental impact from phosphating and passivation/chromating can be reduced by the following BAT (EIPPCB, 2001):

- covered process baths;
- cleaning and reuse of phosphating solution;
- cleaning and reuse of passivation solution;
- use of squeeze rolls; and
- collection of skinpass/temper solution and treatment in wastewater treatment plant.

The techniques described above on wastewater treatment or equally efficient combinations of individual treatment measures are considered to be BAT. The associated concentration of Cr(total) in the effluent is reported to be below 0.2 mg/l. In lead-tin coating of steel, for passivation, BAT is a 'no-rinse' system and, hence, no rinse waters from the system require treatment. If a drier is required, this should be a gas-fired oven. No effluent is thus produced.

With regard to emerging techniques, the BREF Document suggests that rollers can be used for applying organic coatings or paintings that are nowadays replacing chromating surface treatment. If compatible with the high speed of galvanising, this application improves notably the environmental performance in the finish stage, because there are no effluents with chromic products (EIPPCB, 2001).

4.5.5 Best Available Techniques for the Production of Inorganic Pigments

A draft BREF Document has been developed for the production of speciality inorganic chemicals; this term encompasses inorganic pigments.

For production of chromium (III) oxide pigments, the BREF Document suggests a typical volume of wastewater of 60 m³/t of pigment produced with a release of chromium of 0.02 kg/t. With regard to chromium, the treatment of wastewater follows the typical pattern described above: reduction of Cr(VI) to Cr(III) with excess sodium dioxide or sodium hydrogen sulphite (to ensure completes of the reaction) and precipitation of chromium hydroxide with a sodium base accompanied by flocculation agents. The sediment is mechanically dehydrated and recycled back into the process.

Together with other effluent streams, the total wastewater from Cr(III) oxide pigment production is purified again in a precipitation step and then discharged into the receiving water body (EIPPCB, 2005).

4.5.6 Currently Used Techniques in the Leather Processing Sector

Wastewater Treatment at EU Tanneries

According to the relevant OECD Emission Scenario Document (OECD, 2004b), the tanning process results in releases of Cr(III). For this reason on-site pre-treatment of wastewater is common practice. This leads also to a partial removal of substances (e.g. dyes) from the aqueous phase by co-precipitation.

The wastewater treatment strategies employed by tanneries are so varied that it is difficult to generalise, but the traditional process is:

- *mechanical pre-treatment*: skimming of fats, oil, and grease, and sedimentation;
- *physico-chemical treatment*: includes equalising flows, neutralisation, oxidation of sulphide from the beamhouse, precipitation of chrome from tanning and post-tanning

processes, sedimentation or flotation. It is mainly performed to remove organic matter, sulphide and chrome;

- *biological treatment*: reduction of the high organic content. It may include nitrification/denitrification steps gradually introduced in countries with strict nitrogen discharge limits; and
- *sedimentation*: separation of activated sludge from the purified overflow.

With regard to sewage sludge, the surplus sludge is collected and treated together with the primary sludge from mixing and equalising. To reduce the sludge volume a de-watering step is often followed (OECD, 2004b).

The OECD document goes on to suggest that, in most countries, tanneries have to carry out a pre-treatment of their wastewater for sulphide and chrome. Strict discharge limits must be met before effluents are discharged to a municipal water treatment plant where the biological treatment is done. Tanneries discharging directly to surface water have to meet additionally the requirements for COD, BOD (chemical and biological oxygen demand) and nitrogen so they have to treat the wastewater biologically, too. A German study referred to in the Emission Scenario Document shows that out of a total of 30 German tanneries, 5 plants (17%) discharge their wastewater after pre-treatment and biological treatment directly into surface waters and 25 plants (83%) after mechanical and physico-chemical treatment into municipal sewage treatment plants (Böhm *et al*, 1997; Böhm *et al*, 2000; Hillenbrand, 1999).

4.6 Existing Controls – Consultation Findings

4.6.1 Controls Relevant to the Production of Hexavalent Chromium Substances

Information on current emission controls has been made available from the sole confirmed producer of Cr(VI) substances in the EU. This is summarised below and includes:

- *for emissions to air*: emissions are controlled by effective process design and a comprehensive range of abatement systems. These include: bag filters, electrostatic precipitators, packed wetted scrubbers, venturi scrubbers and demister. This array of control technology ensures that emissions are kept below consent limits;
- *for emissions to water*: the site is equipped with an effluent treatment plant which discharges to surface water. Chromium removed from the effluent is recycled back into the manufacturing process. Effluent discharge quality is monitored continuously against internal trigger values set well within permitted consents. The site does not discharge to sewer; and
- *for waste*: manufacture of chromium chemicals from chromium ore produces a mineral residue (other metallic oxides in the ore other than chromium, principally

iron, aluminium and magnesium). This mineral residue as well as waste contaminated with Cr(VI) are treated prior to disposal to a licensed, non-hazardous landfill facility owned by the producer. There is the possibility for generation of Cr(VI)-contaminated waste that would then need to be disposed of through a licensed waste contractor.

Other existing control measures include:

- enclosure of manufacturing processes (enclosure is breached for sampling, packing and maintenance activities);
- certification in accordance to environmental, health and safety and quality management systems ISO 14001, OHSAS 18001 and ISO 9001:2000 respectively;
- compliance with the requirements of the site permit issued by the relevant Competent Authority. The site had been granted in the past a number of authorisations for a number of different processes. Recently, the site applied for an IPPC authorisation which is currently being considered by the Competent Authority; and
- the facility also has to comply with the provisions of Council Directive 96/82/EC on the control of major accident hazards involving dangerous substances (Seveso II Directive). This applies to establishments that have the potential to cause major accidents because they use or store significant quantities of dangerous substances, such as oil products, natural gas, chemicals or explosives. In accordance with national legislation implementing the Seveso II Directive, this site has to prepare a Major Accident Prevention Plan (MAPP), provide a Safety Report and have an on-site emergency plan. The local authorities must also prepare an off-site emergency plan for this site.

4.6.2 Emissions Data from Manufacture of Metal Treatment Formulations

Only three companies have provided information in the form of a completed questionnaire. No emissions data were made available for any of the sites: two of them are not production sites.

The two of the companies that provided consumption data consume several tens of tonnes of chromates (mainly chromic acid) in the production of their formulations. The larger of the two companies (on the basis of chromate consumption) appears to use a significant proportion of chromates in the preparation of formulations of proprietary composition. For the remaining company, its role is essentially that of a re-seller (i.e. it purchases chromates which are solubilised and then sold to downstream users).

One of the first two companies is a provider of Cr(VI) solutions to sites that passivate metal surfaces (coils). The company notes that there has recently been a strong interest by their clients in chromium-free passivates as a result of the ELV and RoHS Directives.

On the other hand, there has also been an increase in their sales of Cr(VI) passivates as a result of increased demand and output. It is expected that the company's consumption of Cr(VI) compounds will increase in the short term but will eventually subside as alternative methods will capture an increasing portion of the coil coating market.

The other company (one of the major EU formulators) distributes its products in more metal finishing sub-sectors such as:

- decorative chrome plating;
- hard chrome plating;
- passivation; and
- etching of plastics.

According to this company's analysis, as regards their national decorative chrome plating sector, the overall metal finishing market has declined dramatically over the past five years due to many Original Equipment Manufacturers (OEMs), second tier manufacturers and, finally, third and fourth tier suppliers closing down or leaving the country for lower operating cost countries in Asia, Eastern Europe, and elsewhere.

Most the company's sales in the decorative plating sector have been predominantly based on Cr(III) systems. Recent legislation and increased concerns about the environmental and health effects of Cr(VI) are expected to continue to drive users in this direction. However, the trivalent technology currently available has yet to show that it is suitable for some applications (e.g. some automotive applications). The company believes, however, that these challenges are achievable within the foreseeable future.

With regard to hard chrome plating, the company believes that any market trends will be influenced by the availability of commercially viable alternatives to Cr(VI) formulations but it will not be easy to achieve within the foreseeable future, although significant research and development resource is being channelled in this direction.

Similarly, for etching of plastics, the company suggests that commercially viable alternatives to Cr(VI)-based etches are not currently available for a large proportion of the types of plastics currently plated, although significant research and development resources are being channelled in this direction. Some plastics are suitable for non-chromium etches, but their physical properties do not lend themselves to the application environment they will be used in.

Finally, with regard to passivates, a large proportion of the market is driven by automotive requirements, and the only future here is for Cr(VI)-free technology. The company has witnessed a steady decline in sales of Cr(VI) products over the last couple of years and the rate of decline has been increasing as more specifications in the market call for Cr(VI)-free finishes which are now readily available in most required finishes. There are still some significant finishes where the technology has yet to provide satisfactory Cr(VI)-free finishes, such as black on zinc. Non-automotive industries, while not directly affected by the ELV Directive, are now following suit, and the

company predicts that Cr(VI) passivation of zinc and zinc alloys will be replaced by alternatives in the not too distant future.

The third company, for which no consumption data are available, supplies to the coil coating industry, chemicals for the pre-treatment (conversion coating) of metal coil surfaces. The chemicals are prepared as aqueous formulations that are used, after appropriate dissolution, by the coil coaters in spray, dip or rollcoater application on to the moving strip. The company produces and distributes several hundreds of tonnes per year of pre-treatment chemicals for coil coating that involve chromates in either conversion or post-rinse stages. This includes alkaline passivation, iron phosphating, chrome chromate and phosphochromate processes.

4.6.3 Emissions Data from Metal Finishing Installations

Information on Electroplating, Passivation, Anodising, Brightening

Information has been received in the form of completed questionnaires from 45 companies. Of these, 35 are SMEs (with a workforce smaller than 250 employees) with 21 having less than 50 employees. It should be noted that all responses came from UK companies. Although the number of questionnaires received may be considered to be small compared to the total number of metal finishing installations in the EU, it is estimated that around 100 sites use Cr(VI) formulations in the UK which means that the available information represents around half of the total UK market.

With regard to turnover, only nine companies out of 45 have a turnover of more than €50 million. Of these nine companies, eight are large companies and only one is a medium-sized company in terms of workforce. A total of 23 companies have a turnover smaller than €10 million.

The companies are involved in the following processes (note that many companies are involved in more than one process):

- 16 companies are involved in hard chrome plating;
- 11 companies are involved in decorative chrome plating;
- 11 companies are involved in anodising;
- 22 companies are involved in passivation;
- 2 are involved in etching;
- 1 is involved in brightening; and
- 4 are involved in other pre-treatments.

In chrome plating (both hard and decorative), the only Cr(VI) compound to be used is chromic acid (CrO₃). In anodising, etching and conversion coatings, the majority utilises solutions of chromic acid, although sodium and potassium dichromates also find some use. The concentration of chromic acid in solutions ranges between:

- 15% and 52% for chrome plating; and
- 0.3% to 52% in anodising, etching and conversion coatings (although it tends to be towards the lower end of this range).

Consumption of Cr(VI) compounds varies widely: it may be as low as 40 kg per year up to 150 tonnes per year per site.

A total of 35 sites provided emissions data on their Cr(VI) emissions (to sewer, surface water, soil and waste – data on air emissions were also provided but are of little relevance to this RRS). The data were a mixture of measured values and estimates. The figures provided were consistently low compared to the estimates presented in the RAR. More specifically, only one company appears to release Cr(VI) to surface water and this takes place after on-site surface treatment of wastewater so that the total annual release to surface water is below 50 kg/y (compared to the much higher values given in Table 3.6).

The vast majority of operators release Cr(VI) to sewer. Emissions of this type are reported to be close to zero with a maximum identified release of 120 kg/y (another site has reported 400 kg/y, however the accuracy of this number is unclear). The percentage of losses to sewer can be as high as 50% of the chromic acid used (but this figure is associated with a site emitting only 50 kg/y) but usually is below 5%. For emissions to sewer, limits set by the water companies need to be met.

Soil emissions are minimal, however, waste containing chromium may be produced in high volumes: up to 100 tonnes may be produced each year at on-site treatments plants. This contains Cr in the form of Cr(III) hydroxide following reduction of Cr(VI) and precipitation.

A total of 34 companies provided details of their existing risk reduction measures. Of them, 23 indicated that they have an on-site wastewater treatment plant. The common method used for controlling Cr(VI) emissions is the reduction of Cr(VI) to Cr(III) and the precipitation of Cr(III) in the form of a hydroxide which is then filtered and disposed of. A further six sites do not treat their effluent on-site either because their system does not require them to do so (for instance, they have a ‘no-rinse’ production line or a closed loop system that recycles wastewater) or they simply have their wastewater collected by specialist contractors that treat it off-site (possibly after initial evaporation to reduce the associated volumes). This latter method applies to two sites.

For five sites, it is not clear whether they employ on-site treatment or not. For two sites, the emissions are considerably low and it appears that most probably they treat their wastewater on-site. For two other sites no emissions are available, hence a conclusion cannot be reached. Several sites have also noted that their installations are bunded to prevent run-off containing chromium (and other pollutants) to enter the water courses or to be released to soil.

With regard to the treatment of sludge, specific information on its fate is available from six companies. All these indicate that the sludge (essentially filter cake) is handled as hazardous waste and is removed by specialised contractors. Subsequently, this material

will either be disposed of in a landfill or will be recycled (two sites suggested this option).

Finally, with regard to trends in the consumption of chromates in the metal finishing sector, a mixed picture has arisen. It appears that most consultees that provided information on trends (21 companies) believe that their consumption is relatively stable and a similar pattern for the EU should be expected for the near future. Only four companies suggested that consumption may be on the increase mainly due to the positive outlook and currently increased demand in a number of downstream markets such as building, aerospace, and oil and gas. Nine companies suggests a downward trend in consumption which is expected to continue. The main drives for this are:

- fierce competition from companies in the Far East;
- introduction of relevant legislation (for instance, the ELV Directive); and
- attempts to replace Cr(VI) in their production lines (due to environmental and, primarily, occupational health considerations) with either Cr(III) or Cr-free alternatives.

Information on ECCS and Tinplate Passivation

The most complete data set was made available from the ECCS/tinplate manufacturers through their EU trade association APEAL which submitted a completed joint questionnaire for the purposes of this RRS. Emissions data provided by APEAL cover a representative sample of APEAL members' tinplate and/or ECCS manufacturing sites in EU-25 (9 sites out of 11). The sites which were omitted are either running pilot lines or are about to discontinue their production (APEAL, 2005).

Data provided by APEAL indicate that for the production of ECCS, chromium trioxide is mainly used in aqueous/solution form but also in powder. As far as tinplate production is concerned, sodium dichromate is the most used compound, followed by chromium trioxide (as trioxide CrO₃ and as the acid H₂CrO₄). In some tinplate manufacturing sites, more than one Cr(VI) compounds are used (APEAL, 2005).

With regard to wastewater treatment, all sites precipitate Cr(VI) as a Cr(III) hydroxide by using either sodium bisulphite or iron sulphate. Releases of chromium in wastewater are regulated by national legislation and governed by limits to be found in the permits issued by the competent and local authorities of the countries the sites are located in.

Emission limits for the aquatic compartment are expressed either as Cr(VI) and/or Cr(total). Where emission limits for Cr(VI) releases to surface water are in place (four sites provided information), the typical limits are 0.1-0.5 mg/l. For total chromium the limits range from 0.5 mg/l to 1 mg/l (information from six sites). Actual data on emissions of Cr(VI) show the following ranges:

- to air: from nil to 6.2 kg/y;
- to sewer: from nil (5 sites) to 92 kg/y (one site) (two sites have emissions below their detection limits, for one of them the detection limit is quoted as 0.02 mg/l);
- to surface water: from nil to 0.5 kg/y (a site emits 42 kg/y Cr(total) while four sites have Cr(VI) emissions below the detection limit; this ranges from 0.0005 mg/l to 0.05 mg/l);
- to soil: nil; and
- to waste: only in one site sludge and water containing chromium compounds are taken off-site and processed by a specialist contractor (APEAL, 2005).

4.6.4 Emissions Data from Formulators of Leather Tanning Salts

Attempts have been made to establish contact with a number of EU manufacturers of leather tanning salts and some of these companies were sent a questionnaire in their native language. Only a single questionnaire has been received by a major EU formulator which contains no information on emissions of chromium to the environment. The sole EU producer of Cr(VI) compounds is also a manufacturer of leather tanning salts, however, any emissions from this process are included in the overall emissions from the production site.

4.6.5 Emissions Data from On-site Reduction of Cr(VI) in EU Tanneries

As discussed in Section 2, (past) emissions data have been made available for two tanneries involved in the past in on-site reduction of Cr(VI) for the reduction of tanning salts.

The first tannery used dichromates in a 1 tonne lead reactor to reduce them to Cr(III) salt by using glucose and sulphuric acid. The reaction was kept under control to ensure that no Cr(VI) remained unreacted.

In a similar fashion, the process used by the second tannery essentially involved the reduction of sodium dichromate in a lead tank. The feedstock was mixed with water and sulphuric acid and subsequently a solution of dextrose was poured into the tank at a low flow rate. To complete the reduction, a 3% solution of sodium sulphide was added.

The first company treats its wastewater on-site in a physicochemical process that precipitates Cr as a hydroxide. The effluent is then sent off-site to a biological treatment plant. The effluent sent to biological treatment contained just over 1% of the total tonnage of Cr (as Cr(VI)) used in 2003. It is unclear what the impact of biological treatment to the Cr load of wastewater was. Sludges produced during treatment of wastewater were treated as hazardous waste and were disposed of at a landfill for such waste. Sludge effluent in 2003 contained just over 20% of the chromium used (in the form of dichromates). For these calculations it has been assumed that dichromates were the only source of Cr in the operations of the site. With a total of 230 days of operation

per year, it appears that this site had releases higher than the site-specific releases of Cr(III) reported in the RAR although it is important to note that the releases described above are into the sewer as opposed to the releases to a river mentioned in the RAR. Another issue of importance is that emissions of Cr(III) are most likely associated with tanning operations rather than on-site reduction of Cr(VI) to Cr(III).

Consumption and emissions data were also made available for the second company. The company treats the wastewater on-site where Cr(VI) is reduced to Cr(III). With a reported 220 days of operation per year, it appears that 0.8% of chromium used each day is released from the site in the form of treated wastewater with an effluent concentration of Cr(III) below 0.5 mg/l. The site disposes of treated wastewater to the sewer and this, after being mixed with wastewater from other facilities in the region, is treated at a municipal WWTP and the produced effluent is subsequently released to a river. The site is not permitted to release more than 200 g of (total) chromium per day.

A considerable amount of chromium is removed from the site in sludge: almost one third of the annual consumption of chromium can be found in this waste stream (as Cr(III)). The sludge is treated as hazardous waste. It appears that the releases from this tannery do not pose unacceptable risks to the aquatic and terrestrial compartments and, in fact, are considerably lower than those quoted in the RAR.

Overall, emissions data for two tanneries show that the combination of on-site treatment and subsequent treatment at a municipal WWTP, should remove any risk to the aquatic (and terrestrial) environment. Hence, the site-specific data do not corroborate the discussion in the RAR. However, it is acknowledged that there is a possibility of other tanneries still using this obsolete process (perhaps non-members of Cotance). It is also of note that the two companies for which use and emissions data are available, are, reportedly, medium-sized enterprises with a good track record in environmental protection (this is supported by data on their emissions) and may not represent 'worst-case scenarios'.

4.6.6 Emissions Data from Production of Chromium Pigments

A number of potential manufacturers have been identified in the course of Stages 1 and 2 of this RRS. Their production of chromium pigments has been confirmed through consultation or literature review (for example, some are advertising their chromium pigments on their Internet sites). To date, three companies have provided information on production and emissions:

- two are involved in the production of chromium (III) oxide; and
- one is a producer of Cr(VI) pigments.

One of the producers of chromium (III) oxide is the EU producer of Cr(VI) compounds; the other is a past producer of Cr(VI) compounds. This second company uses sodium dichromate to manufacture chromium (III) oxide pigments. The production is automated and results in the following emissions of Cr(VI):

- air: 0.001 t/y;
- sewer: consistently below the detection limit of 0.025 mg/l;
- surface water: nil;
- soil: nil; and
- waste: 0.001 t/y.

On the other hand, the producer of Cr(VI) pigments reacts sodium dichromate with inorganic salts to form strontium chromate, zinc potassium chromate, basic zinc chromate or barium chromate. The main product in terms of volume is strontium chromate. The emissions to the different environmental compartments are:

- air: 0.0055 Cr t/y (all as Cr(VI));
- sewer: nil;
- surface water: 0.034 Cr(total) t/y (of which 0.00024 t/y as Cr(VI));
- soil: nil; and
- waste: 0.002 t/y (all as Cr(III)).

The site needs to adhere to emission limits set by the local authority and its emissions referred to above are reportedly well below these limits. The site has an on-site wastewater treatment plant and for emissions to surface water all measurements from the effluent station are below the detection limits of the measuring equipment.

4.6.7 Emissions Data from Manufacture of Chromium Containing Wood Preservatives

Information has been received from four key EU formulators of chromium containing wood preservatives.

As described in Section 2.5.2, liquid concentrates of the Cr(VI) compounds are delivered in IBCs or by road tankers and their contents are delivered via a manifold into a tank where dilution with water takes place. The resulting solution is stored in a storage tank, typically of 20,000 litres. Industry suggests that the system is sealed and there is no risk of exposure to the plant operator during dilution. In normal operation, there is no emission to the environment during mixing via the air, soil or water. The IBC, concentrate storage tank, main storage tank and treatment vessel are in a bunded area, which would retain the concentrate and treating solution in case of accidental spillage, with no release to the environment.

Site A (reportedly compliant with ISO 9001:2000) indicates that the process of manufacturing the liquid concentrate of the chromium-based wood preservative is operated to be a 'nil emission' process. All of the chromium compound which is purchased as the raw material is mixed into the concentrate. The process has been refined over the last 25 years to ensure that there are no emissions of chromium to sewer, surface water, soil or as waste. The 'nil emission' process is confirmed by ongoing compliance with the emission limits set by the national authorities. Chromium emission values are measured and submitted to the authorities responsible for issuing the permit for the site under the IPPC regime. As part of IPPC compliance, an Operator and Pollution Risk Appraisal is carried out.

Due to its use of arsenic trioxide/arsenic acid in quantities exceeding 100 kg/y, the site needs to comply with additional regulations that stipulate the development of a safety case, a major accident prevention policy and on-site and off-site emergency plans. All these measures are critically evaluated by the competent authority and improvements are mandatory.

All emissions are closely monitored and reported to the competent authority or local authority, under discharge consents. Isokinetic emission sampling of the scrubber vents, and sampling of the drainage water are carried out routinely. Emissions from the site are below approved levels. Exposure data, e.g. airborne chromium levels during product formulation, are available, although they have been monitored for over twenty years and in the absence of any cause for concern, the frequency of sampling has reduced. Currently they are measured annually.

Site B also notes that the production process is managed in a closed system. The resulting wastewater (e.g. rinsing water after production) is collected and re-used in production. The water that is used to clean the floor of the production site is also re-used in production.

The company argues that during the production process, neither solid nor liquid waste is produced. Empty containers (e.g. drums for chromic acid and containers for wood preservatives) are re-used.

The site is required to comply with national legislation on hazardous substances and air emissions.

Site C is also working on a closed system principle. The system is not connected to the sewer. Water used to rinse the facilities and used product containers are collected and recycled into the production process.

Site D similarly notes that emissions to air, sewer etc. are all covered by the permits and discharge consents set by the relevant national authorities responsible for the implementation of the IPPC Directive.

In light of the above, emissions to all compartments are reported as nil by the operators. Only one of them notes that 0.02% of their annual consumption of chromium trioxide may be found in waste. This waste is essentially slurry from the collection pan for waters from cleaning of used containers (before re-use or scrapping) and of the production facilities. This slurry is concentrated and disposed of in an underground landfill. It is of note that during the concentration process, Cr(VI) is partly reduced to Cr(III).

With regard to the possible introduction of further risk reduction measures, the formulators maintain that the existing risk reduction measures in wood preservative formulation have eliminated risk to the aquatic and terrestrial compartments, and to wastewater treatment plants. With particular regard to the UK, industry believes that the BWPDA Code of Practice provides the necessary framework for sufficient environmental protection should the formulators adhere to its provisions.

4.6.8 Emissions Data from Wood Treatment Installations

Site-specific Information

A total of six companies sent completed questionnaires. Of these, only one company actually uses chromium containing wood preservatives and it is in fact a formulator of Cr(VI)-based wood preservatives who also owns a timber treatment plant. The remaining five companies (all of them based in the UK) have used chromium containing formulations in the past but, following the introduction of Directive 2003/2/EC on arsenic, they have opted for alternative non-Cr wood preservative formulations.

The site for which data are available uses CCA and CC products (manufactured in-house) to impregnate wood for:

- uses allowed by Directive 2003/2/EC (for CCA); and
- uses involving external exposure above and in ground/water contact (for CC).

The treatment is carried out only in industrial vacuum pressure impregnation plants. No other use of such products is approved. The plant is sited in fully bunded areas and is within a covered building; there are no drains in the plant. The RAR indicates *“the main sources of loss of preservative solution from wood treatment processes include leaks and drips from treatment vessels and solution drippings from treated timber. These types of releases can be effectively contained by using bunded areas”*.

The emissions of CrO₃ to the various environmental compartments are reported to be:

- air: negligible;
- sewer: nil;
- surface water: nil;
- soil: unknown; and
- waste: <0.05 t/y (estimated).

The treatment plants in normal operation produce no waste solution for disposal. Over a period of time there may be sawdust and accumulated dirt in the treatment vessel or in the bund under the front of the vessel, which require disposal. The quantities are small and much of the chromium is in trivalent form.

Timber is placed on a slight incline when loaded onto the bogies. During the final vacuum this allows excess treatment solution to run off in the treatment vessel and be recovered. This usually assists to minimise dripping as the packs are moved from the bogies. Freshly treated timber is held in a bunded area under cover for the required holding period. Information on the holding period requirements in different EU Member States was presented in Section 4.3.28.

Treated timber (following the holding period) is stored on the yard area until transported off-site. If the fixation process is incomplete or not properly performed in accordance with conditions of approval and the relevant regulations in each Member State,

depending on the state of fixation, residual Cr(VI) may wash from the surface of the wood during rainfall, which could potentially reach soil.

A UK formulator has suggested that the UK HSE (Biocides and Pesticide Unit) has cooperated with industry in preparing a study to quantify the leaks, drips and solution drippings from a CCA treatment plant. The report has not been published nor has it been made available to RPA; however, the formulator alleges that the emission values therein suggest that the assumptions in the RAR greatly overestimate emissions from timber treatment plants.

Other Information

A wood preservatives formulator has provided some general background information on the existing risk reduction measures in treatment facilities. This suggests that the process of dilution of the liquid concentrate and the use of the treatment solution in an industrial vacuum pressure impregnation process to preserve wood is operated to be a 'nil emission process'.

The formulator suggests that emissions of chromium are adequately controlled primarily due to measures that have been taken with the aim to reduce occupational exposure to airborne chromium. Treatment plants have no drains in the treatment area. The formulator suggests that a risk assessment for a scenario where the treatment area was connected to a sewage treatment plant was submitted to the UK HSE to satisfy the data requirements following the review of CCA by the UK HSE. The conclusion reportedly was that there was an acceptable risk to the STP, even in the unlikely scenario of the connection of the treatment area to a sewer. With regard to direct emissions to soil, the treatment area is usually concrete, therefore emissions to soil from the area are nil.

Finally, the treatment process is operated to have no waste solution because it is all used in the treatment of wood. Periodically, approximately yearly for most plants, sawdust builds up in the treatment vessel and has to be disposed of as hazardous waste because it contains preservative. A typical plant could dispose of 50 kg of sawdust per year, containing chromium, which will be present as Cr(III) compounds³⁰.

This information is corroborated by the findings of consultation with the Irish Environmental Protection Agency (Irish EPA, 2005). Irish wood treatment plants fall under the Irish IP(P)C Regulations and their emissions are regulated by the Agency and local authorities. According to the Agency, the existing licences for wood treatment plants, in general, do not include emission limit values as there are no process effluents generated.

It is of note that a timber treatment installation in Ireland is currently subject to prosecution by the Agency due to contamination of groundwater with chromium.

³⁰ The Cr(VI) ion reacts with the other active ingredients and the wood, to minimise the rate of leaching of the active ingredients, from the wood, when wet, in service. It should be noted that the rate and extent of Cr(VI) reduction to Cr(III), and the nature, rate and extent of the fixation reactions, may not be the same in all chromium-based preservatives.

Contamination was caused by runoff from the drag-out area and from the storage of treated timber on permeable ground. The use of CCA was discontinued at this site in September 2003. A ‘pump and treat’ remediation system is in place on one groundwater borehole and in two downgradient surface water drains. These systems use granulated activated carbon to remove chromium prior to discharge to surface waters. In 2004, the groundwater concentration of chromium was 2.9 mg/l while now it stands at around 1 mg/l.

The site has a concrete drag-out area and this is sloped towards the treatment plant bunds to collect preservative runoff from unloading and dripping of freshly treated timber. While the treatment vessels are covered, the drag-out area is not. The plant now has an application planning permission to allow them to cover parts of the site and other works for added protection on-site. Moreover, its licence requires that “*treated timber be held under a roofed area for a minimum of 24 hours after treatment. Any preservative dripping off the timber is collected in an under ground tank from which it is pumped to a holding tank for reuse. Waste wood from the processing is sent off site for reuse by a specific specialist company*”. These measures can adequately protect the environment from releases of chromium during timber treatment operations. The Agency believes that the elevated chromium levels in groundwater were the result of poor management practices (Irish EPA, 2005).

As discussed in Section 3.4.3, this RRS will refer the issue of potential risks from the use of Cr(VI)-based wood preservatives to the Biocidal Products Directive experts; the information above is provided for completeness and with the aim to highlight issues that may be considered under that Directive.

4.7 Other Emissions Data

Emissions data for the year 2001 are available for a number of Finnish metal surface treatment plants in a report on the implementation of Helcom Recommendations and EU water legislation in Finland. The relevant Helcom Recommendation was 16/6. Table 4.30 summarises the data for emissions of total chromium and Cr(VI).

The report suggests that there are nearly 300 metal surface treatment plants in Finland (this agrees with information received during consultation for this RRS). About 150 plants use classic plating processes, nearly 100 plants have phosphating or phosphate cleaning process, around 20 plants produce printed circuits, 10 plants anodise aluminium and 15 plants are hot dip galvanisers. Most plants are connected to municipal treatment plants and only about 30 plants discharge to surface waters.

The values for daily emissions have been calculated on the assumption of 300 days of operation per year and they appear to be much lower than the values presented in the RAR and reproduced in Table 3.2 in this Report. It is of note that the wastewater described above will also be treated at municipal wastewater treatment plants in most of the cases.

Table 4.30: Emissions Data from a Number of Finnish Metal Surface Treatment Plants (2001)

Site Code	Wastewater emission (m ³ /y)	Cr(total) in effluent (mg/l)	Cr(VI) in effluent (mg/l)	Annual emission of Cr(total) (kg/day)	Annual emission of Cr(VI) (kg/day)
A	2,067	1.11	0.66	0.007	0.005
B	3,127,415	0.1	0.06	1.04	0.63
C	70,626	0.18	0.037	0.04	0.009
D	45,517	0.037		0.006	
E	70,000	3.8	0.4	0.89	0.09
F	11,550	0.277	0.032	0.01	0.001
G	1,100	0		0	
H	24	7.2	0.014	5.76x10 ⁻⁵	1.12x10 ⁻⁶
I	2,614	0.010		8.71x10 ⁻⁵	
J	20,700	0.159	0.01	0.011	0.001
K	5,220	0.36	0.1	0.006	0.002
L	28,700	0.1	0.1	0.01	0.01
M	1,650	1.39		0.008	
N	5,865	2.57		0.05	
O	42,313	<0.05	<0.01	<0.007	<0.001

Source: FEI, 2003

4.8 Summary of Applicability and Effectiveness of Existing Controls

4.8.1 Existing Control Framework

The discussion provided in this Section demonstrates that there is a significant amount of legislation regulating the uses and primarily the emissions of Cr(VI) (and chromium more generally) in the EU and in individual Member States. This is the result of:

- a long-established knowledge of the hazards posed by the substances which are reflected in their existing classification under Directive 67/548/EEC; and
- the classification of chromium substances as a substances that have a deleterious effect on the aquatic environment under Directive 76/464/EEC.

Information on existing controls has been collected from the vast majority of Member States; for those Member States for which information is lacking, it is likely that similar controls are in place but relevant information has simply not been made available in the timeframe of this RRS.

With regard to the possible effect of the existing risk reduction measures the following can be deduced:

- **Classification and Labelling Directive:** Directive 2004/73/EC describes the classification and labelling requirements for the Cr(VI) substances. The most important aspect of their classification is that these are carcinogenic and mutagenic chemicals which are very toxic to aquatic organisms and may cause long-term adverse effects to the aquatic environment. As a result, those using the substances need to take measures to prevent exposure of humans and releases to the (aquatic) environment. Consultation suggests that companies using these substances already take measures with priority given to the control of workers' exposure. Such measures may contribute indirectly to the control of potential risks to the environment. In that respect, further risk measures that may be taken under the human health RRS may further reduce the potential risks to the environment.
- **Dangerous Substances Directive 76/EEC and Water Framework Directive:** chromium and its compounds belong to list II of Directive 76/464/EEC and as a result Member States were required to establish pollution reduction programmes including water quality objectives targeting emissions of chromium to the aquatic environment. Although there exists information that pollution reduction programmes have been developed in the 'old' EU Member States and are planned/being developed in the 'new' Member States (according to the WRc 2003 report), it is not clear whether all Member States have indeed identified the relevance (or otherwise) of chromium for their aquatic environment. Moreover, it is not known whether the established pollution reduction programmes are specifically aimed at chromium, where appropriate. However, it is a fact that in the vast majority of Member States there exist either water quality objectives (usually referred to as Environmental Quality Standards) or emission limit values for all industrial installations or for installations within specific industry sectors (as shown in Section 4.3). Measures taken under this Directive are still valid under the Water Framework Directive which will replace Directive 76/464/EEC by 2013.
- **Sewage Sludge Directive and Urban Wastewater Treatment Directive:** the combination of the two Directives provides protection to the aquatic and terrestrial environment from emissions of pollutants to wastewater that is blended with domestic waste prior to treatment at a municipal WWTP. It should be noted that the Urban Wastewater Treatment Directive does not apply to all urban settlements.

With regard to the Sewage Sludge Directive, in its current form, it does not include a limit on the concentration of chromium in sludge to be used for agricultural purposes. Although a revision to the Directive was planned twice (in the 1980s and also a few years ago) to include a limit on the concentration of chromium in sewage sludge, this has not materialised in either case. Consultation suggests that the plans for such a revision have been abandoned; there is currently no plan for any measures with regard to the use of sewage sludge in agriculture to be put forward as part of a future Soil Framework Directive under the Thematic Soil Strategy of the Sixth Environment Action Programme.

Nevertheless, despite the lack of a specific EU limit on the chromium load of sludge, data from EU-15 plus some new Member States suggest that many States have in

place limits on the concentration of chromium in sludge and on the maximum permissible annual average load of chromium to soil (see Tables 4.2 and 4.3). In 1998-2000, the average content of chromium in sludge produced in the EU was 73 mg/kg dry weight, well below the values estimated in the RAR. Real data presented for EU-15 in Table 4.4 indicate that there is currently no unacceptable risk from the presence of chromium in sludge destined for agricultural applications. However, some of the limits on chromium concentration in sludge, currently in place in Member States (Table 4.2) could, in theory, allow the manifestation of unacceptable risks to the terrestrial environment (based on the assumptions of the RAR and the relevant TGD). It should be noted that the RAR provides estimates of concentrations of Cr(III) in sludge originating from individual applications; the data available from Member States reflect chromium concentrations in sludge from the treatment of all types of wastewater ending up at a municipal WWTP.

- **IPPC Directive:** the IPPC Directive covers most lifecycle areas of concern (apparently not the treatment of timber with Cr(VI)-based wood preservatives, although national IPPC regulations may cover this activity, for example in Ireland and the UK) and (will) target(s) emissions to both aquatic (directly) and terrestrial (indirectly) environment. BREF Documents are available (most of them in draft form) which show that techniques are available for the control of emissions of chromium to the environment. It is important to note that the lack of information on the chromium compounds industry, the BREF Document on Large Volume Inorganic Chemicals – Solid and Others does not contain any description of the industry, the processes involved, the consumption of materials, the associated emissions or BAT.

Some of the techniques described in the BREF Documents are relatively simple and already find wide application in the industry sectors of concern. For instance, the reduction of Cr(VI) to Cr(III) and precipitation of the latter as an insoluble hydroxide is a method that evidence shows to be popular across the board. The use of excess reducing agent ensures complete reduction of Cr(VI) to Cr(III).

On the other hand, there are some other techniques and technologies which although available, only a limited number of companies currently employ, such as closed-loop systems in surface treatment of metals, ‘no-rinse’ chemcoaters in coil coating, etc. This is partly due to the cost of these techniques and technologies.

Obviously, IPPC could in theory also lead to the replacement of Cr(VI) with alternatives if the required reductions in emissions are difficult to achieve (although, as mentioned above, there are relatively simple techniques for the removal of Cr(VI) from wastewater).

The use of the IPPC Directive as the main instrument for controlling emissions of Cr(VI) has found wide support among industry during consultation and discussions within the Steering Group. However, the main uncertainty of IPPC is that it is a system primarily targeting large installations, at least as implemented at present. For instance, surface treatment facilities fall under IPPC in most countries only if the

size of their vats exceeds 30 m³. However, sites that do not fall under the provisions of the IPPC Directive are invariably:

- covered by national IPPC regulations, especially in Member States where a licensing system pre-existed and has been amended to incorporate the provisions of the Directive (for example, Austria, France, Ireland, Portugal, the UK and possible elsewhere); or
 - regulated under other national regulatory frameworks imposing emission limits on the concentration of chromium (VI and total) in discharges from industry in general and/or specific industry sectors (for example, the discharge consent system operated by water companies in Finland and the UK).
- **Biocidal Products Directive:** the Directive provides for a framework for control of risks from Cr(VI) in wood preservative formulations. The immediate effect of the Directive is that it will prohibit the use of arsenic in wood preservatives, i.e. it will prohibit the marketing and use of CCA formulations after 1 September 2006. With regard to other types of Cr(VI)-based formulations, their fate will rely upon the formulators providing evidence that chromium is not an active substance. Only if such proof is provided, will chromium trioxide (the main form of Cr(VI) used in wood preservatives) be allowed to be used in biocidal products beyond 1 September 2006. Even so, due to the classification of the Cr(VI) substances as carcinogens, chromium trioxide will be considered to be a ‘substance of concern’. This practically means that chromium trioxide will be subject to risk assessment i.e. the formulators will be required to provide information on physical and chemical properties, toxicological and metabolic data and ecotoxicological data. The risk assessment shall cover the proposed normal use of the relevant biocidal product together with a realistic worst-case scenario including any relevant production and disposal issue either of the biocidal product itself or any material treated with it.

The Biocidal Products Directive is the most appropriate framework for addressing and managing potential environmental risks from Cr(VI) during use of wood preservatives in wood treatment installations, and during use of wood treated with preservatives containing Cr(VI). The assessment of the dossiers submitted for wood preservatives containing chromium trioxide will include recommended methods and precautions concerning handling, use, storage, transport or fire as well as procedures, if any, for cleaning the application equipment.

- **Water Framework Directive:** the Water Framework Directive will change the national approaches to the control of pollution in the aquatic environment by focusing on river basins and their specific characteristics. For chromium, Member States will have to identify whether it is a relevant pollutant for each river basin (as for Directive 76/464/EEC); given the uncertainty on whether unacceptable risks to the aquatic environment actually exist (the RAR has overestimated the potential risks), the analysis of pressures on river basins and the identification of the relevant pollutants will be very useful in putting any such risks into context. If chromium is identified as a relevant pollutant, Member States will be required to develop

Environmental Quality Standards by the end of 2006 following the methodology of the TGD on risk assessment. EU-wide Environmental Quality Standard values may be developed only for substances belonging to the list of Priority Substances (Annex X). On the basis of the available information, this RRS cannot make a recommendation on the inclusion or non-inclusion of chromium to Annex X. It is possible that its inclusion may be considered in the revision of the list of Priority Substances which has recently been initiated and is expected to be completed in 2007.

- **Directives on use of arsenic in wood preservatives:** two Directives on the use of arsenic in wood preservatives have reduced the EU market for CCA formulations by an estimated 97% in the last few years. The use of chromium in these products is decreasing and, as discussed above, the marketing of CCA products will cease in September 2006.
- **End of Life Vehicles Directive:** the Directive has had a significant impact on the surface treatment sector. There is now a very clear trend away from Cr(VI) systems, although there may still be some applications for which the available alternatives still perform worse than Cr(VI) systems. It is expected that this trend will continue; more importantly, this trend has stimulated similar action in other segments of the market not directly relevant to the Directive (see Section 2.3.14).
- **National legislation:** Member States have in place a significant volume of national legislation on chromium (either Cr(VI) or Cr(total) or both) precipitating from:
 - Community legislation (for example, Directive 76/464/EEC);
 - national initiatives (for example, concentration limits for chromium in sewage sludge); and
 - international initiatives (for example, Helcom and Parcom Recommendations).

Although, it cannot be argued that national measures are equally stringent across the Community, in most cases, existing measures reduce risks to the aquatic and terrestrial environment considerably, if not below unacceptable levels. Table 4.31 presents an overview of the ranges in the emission limits and quality standards set in EU Member States.

For only two Member State specific data on controls on emissions to the aquatic environment are not available at the moment. In general, it appears that the maximum emission limit for Cr(VI) to the aquatic environment is 1 mg/l; limits applicable to releases to surface waters are generally to be found at the lower end of the ranges quoted in Table 4.31. For total chromium, the maximum emission limit is 5 mg/l.

Table 4.31: Overview of Emission Limit Values and Water Quality Standards in EU Member States for Chromium (all values in mg/l)

	All sectors		Metal finishing		Pigments		Tanning		Water quality standard	
	Cr(VI)	Cr(tot)	Cr(VI)	Cr(tot)	Cr(VI)	Cr(tot)	Cr(VI)	Cr(tot)	Cr(VI)	Cr(tot)
Range of values	0.1 to 0.2	0.2 to 2	0.05 to 0.5	0.3 to 5	0.2 to 1	0.5 to 5	0.05 to 0.5	0.1 to 3	0.01	3x10 ⁻⁴ to 1
Number of MS/regions reporting	12	10	11	10	3	2	5	6	1	11

Source: Consultation

Note: these figures include limits for releases to both surface water and sewer; the quality standards include standards for all water types. In some Member States, local authorities may impose even stricter limits in licences issued for industrial installations.

In general, the aforementioned existing measures and controls provide assurance that risks to the aquatic and terrestrial environment are significantly lower than those described in the RAR. It could be argued (and this has been the position of industry) that these measures provide sufficient protection to eliminate the unacceptable risks. Nevertheless, there is still a theoretical possibility that unacceptable risks still exist. This possibility should be considered in the context of the existing gaps in information on the use and emissions of Cr(VI) substances as well as the existing uncertainties in the RAR.

Assuming default dilution ratios in surface water (taken from the relevant TGD) and taking into account the RAR assumptions on the fate of Cr(VI) in the aquatic environment, these limit values may theoretically result in PEC values still exceeding the PNEC_{water} values used in the RAR (see Box 4.1). It should be noted, however, that consultation strongly suggests that wastewater from the industry sectors of concern is normally released to sewer rather than surface water.

It appears that, in acidic environments, while local Cr(VI) concentrations in water will be lower than the PNEC value used in the RAR, the concentrations for Cr(III) exceed the PNEC value used in the RAR. It has to be noted that the RAR acknowledges this PNEC value for Cr(III) as “tentative”. On the other hand, in alkaline environments, the calculated local concentration of Cr(VI) would exceed the PNEC value. These calculations are evidently a simplistic and rather conservative approach; for a thorough evaluation and assessment of the risks to the aquatic environment the speciation of chromium would require further investigation as well as information on the ecotoxicity of Cr(III) (the ongoing industry-sponsored risk assessment of Cr(III) would be a suitable source of such information).

Box 4.1: Possibility for Unacceptable Risks to the Aquatic Environment under the Existing National Emission Limit Values

The local concentration in surface water if calculated in accordance to Equation 45 in Environmental Exposure Assessment Part of the TGD for risk assessments. The equation is:

$$C_{localwater} = C_{localeff} / (1 + K_{psusp} \times SUSP_{water} \times 10^{-6}) \times DILUTION$$

where:

- C_{localeff}: concentration of the substance in the STP effluent
- K_{psusp}: solids-water partitioning coefficient of suspended matter
- SUSP_{water}: concentration of suspended matter in the river (15 mg/l)
- DILUTION: dilution factor (10)
- C_{localwater}: local concentration in surface water during emission episode

The K_{psusp} values for Cr(VI) and Cr(III) are taken from the RAR:

- Cr(VI) – acid conditions : 2,000 l/kg
- Cr(VI) – alkaline conditions: 200 l/kg
- Cr(III) – acid conditions: 30,000 l/kg
- Cr(III) – alkaline conditions: 300,000 l/kg

We assume a maximum concentration of Cr(VI) in the effluent of 1 mg/l. Since the RAR assumes that 97% of Cr(VI) is reduced to Cr(III) in acidic conditions, we take the following effluent concentrations for Cr(VI) and Cr(III):

- C_{localeff} Cr(VI): 0.03 mg/l; and
- C_{localeff} Cr(III): 0.97 mg/l.

Therefore, for Cr(VI), the following local concentrations in surface water are calculated:

$$C_{localwater} = 0.03 / (1 + 2000 \times 15 \times 10^{-6}) \times 10 = \mathbf{2.9 \mu g/l}$$

For Cr(III), the following local concentrations in surface water are calculated:

$$C_{localwater} = 0.97 / (1 + 30000 \times 15 \times 10^{-6}) \times 10 = \mathbf{67 \mu g/l}$$

In alkaline conditions, the RAR assumes that the rate of reduction of Cr(VI) to Cr(III) is slow, with a long half-life of around 1 year. Therefore, if no reduction is assumed, the local concentration of Cr(VI) in surface water after the release of the effluent would be:

$$C_{localwater} = 1 / (1 + 200 \times 15 \times 10^{-6}) \times 10 = \mathbf{100 \mu g/l}$$

4.8.2 Actual Emissions Data

Information on actual emissions has been collected through consultation and has been identified in literature. The overall conclusion is that emissions (as reported by companies) are significantly lower than the predicted releases in the RAR; in fact, the differences may be of several orders of magnitude (see discussion on consultation above as well as data from literature, e.g. Table 4.30).

Some consultees have noted that the concentrations in wastewater estimated in the RAR are unrealistically high. For example, if a large wood treatment plant, treating 18 m³ of wood per day and using 9,000 litres of CCA treating solution, had an emission of 0.18 to 0.45% as assumed in the RAR, then it would be releasing to soil or water between 16 and 40 litres of treating solution per day. Considering that the treating solution is bright yellow, it would be immediately obvious to the plant operator, the plant management and the authorities, that there was a significant and unacceptable emission from the plant. The same argument has been made by consultees from the metal finishing sector. Box 4.2 presents a more detailed analysis of the discrepancies between the assumptions in the RAR and the current situation across EU Member States as identified through consultation. It should be noted that the RAR recognises that controls may be in place to prevent Cr(VI) being released to the different environmental compartments.

Box 4.2: RAR Assumptions and Existing Risk Reduction Measures

For electroplating, the RAR assumes that a realistic large-scale chromium plating site operates for 12 hours per day and the emissions to WWTP are 4.3 kg/day as Cr (as presented in Table 3.6). The resulting concentrations in the receiving water C_{local} are:

- 110 µg/l as Cr(VI) or
- 7.8 to 30 µg/l as Cr(III).

Therefore, for the risk characterisation for Cr(VI) to become unity (i.e. unacceptable risks are eliminated), emissions of chromium as Cr(VI) should be reduced by a factor $110 \div 3.4 = 32$. In terms of daily releases, this means that the assumed release should be reduced to $4.3 \div 32 = 0.134$ kg over 12 hours. To meet the highest reported discharge limit of 0.5 mg Cr(VI)/l (see Table 4.31), the site would need to release $0.134 \times 10^6 \div 0.5 = 268,000$ litres of effluent over a 12 hour period or ~23,300 litres per hour. This is evidently a very high volume of effluent.

If we take the risk characterisation ratios for WWTP, these are 5.2 for Cr(VI) and 0.04 for Cr(III). Therefore, for the risk characterisation for Cr(VI) to become unity (i.e. unacceptable risks are eliminated), emissions of chromium as Cr(VI) should be reduced by a factor of 5.2. In terms of daily releases from WWTP associated with electroplating sites, this means that the assumed release should be reduced to $4.3 \div 5.2 = 0.827$ kg over 12 hours. To meet the highest reported discharge limit of 0.5 mg Cr(VI)/l (see Table 4.31), the site would need to release $0.827 \times 10^6 \div 0.5 = 1,654,000$ litres of effluent over a 12 hour period or ~137,800 litres per hour. This is evidently a very high volume of effluent.

These calculations suggest that indeed the assumptions in the RAR have not taken into account the existing national measures controlling the emissions of Cr(VI) to the aquatic environment and lead to a significant overestimation of the risks to the aquatic (and terrestrial) environment.

In summary, the following are the key points from consultation:

- it appears that removal of Cr(VI) from wastewater is largely based on a known and established method: reduction to Cr(III) and precipitation of the hydroxide;
- treatment of wastewater prior to discharge appears to be the norm in the industry sectors of concern; and

- the majority of sites release their (treated) wastewater to sewer rather than surface water (see, for example, Table 4.12). This effectively means that in many cases limits on releases of Cr(VI) will be in place by the water companies/sewer undertakers and this wastewater is very likely to be subject to further treatment at a local municipal WWTP.

Moreover, there are industry sectors for which consultation suggests that emissions are substantially low and do not result in unacceptable risks for the aquatic environment. These include:

- wood preservatives formulation: the four main EU formulators appear to operate 'nil emission' systems. It appears that the measures taken by these companies apply to the entirety of the sector; and
- ECCS and tinplate passivation: data provided for almost all EU plants suggest very low emissions of Cr(VI) and Cr(total).

The wood preservative formulators argue that timber treatment facilities also have minimal emissions; the analysis of the available information appears to corroborate this, however, in the absence of substantial emissions data and other detailed information on practices from treatment facilities, no categorical conclusion may be reached on this. In any case, risks from wood preservative formulations during their use at timber treatment facilities will be appropriately addressed within the Biocidal Products Directive.

However, this analysis has its limitations: there are sectors for which information is very limited, such as the formulation of tanning salts, the manufacture of pigments and the application of wood preservatives.

4.8.3 Conclusions

The information at hand varies in depth and detail across the industry sectors of concern. However, this information provides ample evidence that the risks from Cr(VI), as presented in the RAR, are overestimated and controls are already in place to reduce releases to the environment and the associated risks.

At the regulatory level, there appears to be a range of EU-wide legislation that has resulted in national measures targeting releases of Cr(VI) to the environment. These measures although predominantly focused on aquatic releases, they indirectly target the risks to the terrestrial environment as well. These measures appear to generally provide a significant reduction of unacceptable risks.

Overall, any measures to be proposed within this RRS will have to take into account the considerable amount of effort by both regulatory authorities and industry to control and reduce releases of Cr(VI) compounds to the environment. Any further measures will address any shortcomings of the existing framework while recognising and building upon the controls provided for by existing measures, both at the national and the EU level.

5. POSSIBLE FURTHER RISK REDUCTION MEASURES

5.1 Overview

The risks and risk endpoints for Cr(VI) substances identified in the RAR have been described in Section 3. Section 4 has further introduced the existing controls on Cr(VI) substances that are operating at present. The discussion on these existing controls in Section 4 puts the findings of the RAR into perspective with regard to actual levels of risk from Cr(VI) substances.

The following paragraphs discuss the types of further controls that may be most appropriate for further reduction of the risks.

Types of risk reduction measures that can be applied to chemical risks are outlined in the RRS TGD (CEC, 1998). This Section discusses these, providing a screening of appropriate measures in order to identify those that are relevant to addressing the environmental risks of concern identified in the RAR taking into account the existing risk reduction measures.

5.2 The Range of Possible Measures

The types of risk reduction measures outlined in the RRS TGD relate to manufacture, industrial and professional use of substances and waste management and are outlined in Box 5.1. The TGD also includes a range of possible risk reduction measures for domestic and consumer use; however these are not relevant to the environmental risks identified in the RAR. The potential measures relating to waste management have been included to address the risks to terrestrial environment which largely result from application of sludge to soil.

5.3 Identification of Possible Measures

5.3.1 Initial Screening of Possible Measures

In order to identify measures that are suitable for further consideration in this strategy, the measures identified in Box 5.1 have been screened in order to eliminate from consideration those that are not relevant to the Cr(VI) substances and their potential risks as identified in the RAR.

Box 5.1: Possible Further Risk Reduction Measures

Measures for Manufacture and Industrial/Professional Use

- controls on manufacture;
- restrictions on the marketing and/or use of the substance under Directive 76/769/EEC;
- re-designing the process itself, or changing the substances or materials used in it;
- safe systems of work, such as specified standards of physical containment or extraction ventilation;
- application of good manufacturing practice, for example, under ISO standards;
- classification and labelling;
- separation of personnel;
- monitoring and maintenance of equipment;
- dust suppression methods, such as the use of substances in tablet or pellet form;
- occupational exposure limits and/or air monitoring in the workplace;
- accurate hazard information (for example, safety data sheets), and/or better delivery of safety information, such as clearer labelling or the provision of warning signs in the workplace;
- biological exposure indices and/or biological monitoring of workers;
- medical surveys of workers;
- training;
- use of personal protective equipment;
- licensing of operators of certain operations;
- ‘end-of-pipe’ controls to minimise, neutralise or render less harmful any emissions that cannot practicably be avoided otherwise;
- limit values for emission and effluent monitoring; and
- environmental quality standards and/or environmental monitoring.

Measures for Waste Management

- classification as hazardous waste;
- labelling which encourages responsible disposal;
- producer responsibility schemes;
- use of recycling banks;
- duty of care systems;
- compulsory acceptance of returned products; and
- specified disposal methods and/or conditions, for example, incineration (temperature and time).

Source: CEC, 1998

In terms of the measures that are applicable to manufacture and professional/industrial use, the following can be removed from the list of measures (Box 5.1):

- *controls on manufacture*: as discussed in Section 3.4.1, this RRS will not consider further risk reduction measures for the sole remaining EU production site (note that the site is subject to IPPC authorisation);
- *application of good manufacturing practice, for example, under ISO standards*: this measure is of uncertain effectiveness and it seems to be of limited feasibility in sectors where large numbers of SMEs operate (the metal finishing sector, for instance);
- *classification and labelling*: classification and labelling proposals are not the responsibility of the developers of the RRS but rather of the ESR RAR rapporteur.

Note that classification and labelling for the five substances is provided for under Directive 2004/74/EC (see Section 4.1.1). It should be noted, however, that the classification of the five Cr(VI) substances as Category 2 carcinogen requires that the uses of these substances are authorised under the forthcoming REACH legislative framework (see Section 5.5);

- *monitoring and maintenance of equipment*: risks associated with exposure to Cr(VI) substances are related to emissions from normal operational procedures, not as a result of lack of maintenance;
- *use of dust suppression methods*: the RAR does not consider releases of dust to water or soil as major pathways of exposure;
- *occupational exposure limits and/or air monitoring in the workplace*: such measures are primarily aimed at controlling the risks to human health and their suitability is expected to be assessed during the development of the human health RRS by the UK HSE;
- *use of personal protective equipment*: as above for occupational exposure limits;
- *licensing of operators of certain operations*: in the context of the known uses and applications of Cr(VI) and their formulations, this measure appears to be of limited relevance;
- *separation of personnel*: not relevant to Cr(VI) substances;
- *biological exposure indices and/or biological monitoring of workers*: in the context of the known uses and applications of Cr(VI) and their formulations, this measure appears to be of limited relevance; and
- *medical surveys of workers*: as above for biological monitoring.

Therefore, the following potential measures for manufacture and professional/industrial use will be considered:

1. Restrictions on the marketing and/or use of the substance under Directive 76/769/EEC.
2. Re-designing the process itself, or changing the substances or materials used in it.
3. Safe systems of work, such as specified standards of physical containment.
4. Accurate hazard information (for example, safety data sheets), and/or better delivery of safety information, such as clearer labelling or the provision of warning signs in the workplace.
5. Training.
6. 'End-of-pipe' controls to minimise, neutralise or render less harmful any emissions than cannot practicably be avoided otherwise.
7. Limit values for emission and effluent monitoring.
8. Environmental quality standards and/or environmental monitoring.

In terms of the measures that are applicable to waste management, the following can be removed from the list of measures (Box 5.1):

- *labelling which encourages responsible disposal*: not of relevance based on the types of identified risks;
- *producer responsibility schemes*: not of relevance for risks from sewage sludge application;
- *use of recycling banks*: not of relevance based on the types of identified risks;
- *duty of care systems*: not of direct relevance to the production and handling of sewage sludge; and
- *compulsory acceptance of returned products*: not of relevance based on the types of identified risks.

Therefore, the following potential measures for waste management will be considered:

1. Classification as hazardous waste.
2. Specified disposal methods and/or conditions, for example, incineration (temperature and time).

Note that, with regard to sewage sludge, the measures taken within this environmental RRS will aim at ensuring that sewage sludge contains levels of Cr (essentially in the form of Cr(III)) that would not result in the PNEC_{soil} value to be exceeded. In that respect, the two possible identified potential measures could be considered in combination (i.e. sludge with high concentration of Cr should be considered hazardous and, therefore, should be appropriately disposed of instead of used for land spreading).

Table 5.1 presents the applicability (in principle) of the remaining possible further risk reduction measures to the lifecycle areas of concern. The table does not include the lifecycle areas not addressed in this RRS (see Section 3.4).

Possible measures	Metal formul.	Metal applic.	Tanning salts	Pigments manuf.
Directive 76/769/EEC	✓	✓	✓	✓
Re-designing	✓	✓	✓	✓
Safe systems of work	✓	✓	✓	✓
Accurate hazard information	✓	✓	✓	✓
Training	✓	✓	✓	✓
'End-of-pipe' controls	✓	✓	✓	✓
Limit values	✓	✓	✓	✓
EQSs	✓	✓	✓	✓
Classification as hazardous waste	Not application-specific			
Specified disposal	Not application-specific			

5.3.3 Consolidation of Types of Measures

For the remaining potential measures, there are certain similarities in terms of the changes that they imply and their prospective means of implementation.

We have divided the remaining measures into three categories of measures. It is likely that measures taken forward will probably fall into one of these three categories. These are examined below. Possible means of implementing these measures vary and these are considered in Section 5.4.

Controls on Supply, Marketing and Use

The relevant measure under this category, involves placing restrictions on the marketing and use of Cr(VI) substances (including a limit on the concentration of the substances in their preparations). These could apply to all or some of the uses of these substances and may require an immediate cessation of use(s) or a phase out over a certain period of time.

Provision of Information

Under this category, the relevant measures would include:

- accurate hazard information (for example, safety data sheets), and/or better delivery of safety information, such as clearer labelling or the provision of warning signs in the workplace; and
- training.

Policy Measures for Emissions and Exposure Control

Finally, the remaining possible further measures can be categorised as measures for control of emissions that require policy-level implementation, potentially allowing individual industries or companies to choose the means of implementation. These include:

- ‘end-of-pipe’ controls to minimise, neutralise or render less harmful any emissions than cannot practicably be avoided otherwise;
- limit values for emission and effluent monitoring;
- environmental quality standards and/or environmental monitoring;
- classification (of sludge) as hazardous waste;
- specified disposal methods and/or conditions; and
- process changes.

Process changes is a general heading under which we have grouped any modifications in the manufacture of formulations based on them or in processes these products are used in. The following relate to potential changes to the processes involved that could impact upon the risks from Cr(VI):

- re-designing the process itself, or changing the substances or materials used in it; and
- safe systems of work, such as specified standards of physical containment or extraction ventilation.

5.4 Possible Means of Implementation

5.4.1 Summary of Possible Means of Implementation

The RRS TGD (CEC, 1998) identifies a range of possible administrative, legal and/or other tools that could be used to take forward proposed risk reduction measures. These are as follows:

- information programmes and other EC/government initiatives;
- unilateral action by industry;
- voluntary agreements (such as negotiated agreements between industry and governments/the Commission);
- technical standards and authoritative guidance (statutory, advisory or voluntary);
- regulatory controls, including more effective enforcement of existing controls, amendments to existing legislation or new legislation (such as uniform EU controls, target based controls - e.g. on the amount emitted to water - or restrictions on marketing and use); and
- economic instruments including taxes (such as emission taxes or product taxes), subsidies or tradeable permits.

Table 5.2 provides a summary of the key types of possible measures and the means by which they could be implemented.

Possible Risk Reduction Measures	Possible Tools for Implementation
Controls on supply, marketing and use	<ul style="list-style-type: none"> • Unilateral action by industry • Voluntary agreements • Economic instruments • Community-level regulatory controls
Provision of information	<ul style="list-style-type: none"> • Unilateral action by industry • Technical standards/guidance • Community-level regulatory controls
Policy measures for emissions control (including process changes)	<ul style="list-style-type: none"> • Unilateral action by industry • Voluntary agreements • Technical standards/guidance • Economic instruments • Community-level regulatory controls

These potential tools and measures for addressing the risks from releases of the five Cr(VI) substances are thus, considered in more detail:

- **unilateral action** to alter the processes involved in order to reduce the potential risks, or to cease the use of Cr(VI) substances in certain processes;
- **voluntary agreements** to alter the processes involved in order to reduce the potential risks, to better control emissions of, or to cease the use of Cr(VI) substances in certain processes;
- **legislation to reduce emissions and exposure**, including control under the Integrated Pollution Prevention and Control (IPPC) Directive, the Sewage Sludge Directive, the Water Framework Directive etc.;
- **provision of information** in the form of the dissemination of hazard information to workers on Cr(VI) substances by industry or government departments/agencies;
- **cessation or phase out of use** in certain or all applications through marketing and use restrictions; and
- **economic instruments**, either to reduce emissions to the environment or to reduce the use of Cr(VI) substances.

5.4.2 Unilateral Action by Industry

The analysis of the applicability of this possible type of risk reduction measure for the sectors in question shows the following:

- **Metal treatment formulation:** despite efforts to establish contact with formulators, both directly and through their trade associations, very limited information is available at present on the number of sites involved and on their views on possible unilateral action. On the basis of these uncertainties, this potential measure cannot be considered further.
- **Metal treatment application:** only six respondents (out of 35) have indicated that they would be willing to assume unilateral action with regard to chromium. Moreover, the questionnaires received only apply to a portion of the UK metal finishing market. On the other hand, efforts made by the relevant UK associations (SEA and BSTSA) to voluntarily improve controls on Cr(VI) releases should be recognised. Given that on an EU-wide basis the number of installations is large with the majority being SMEs, it is concluded that this potential measure should not be considered further.
- **Leather tanning salts:** very little information is available from non-integrated manufacturers of tanning salts. At the same time, the main EU tanners' trade association has indicated that they are not prepared to be involved in any further

unilateral action. No information is available from non-members. In summary, this potential measure will not be considered further.

- **Pigment manufacture:** it is unclear how many companies produce Cr pigments in the EU (especially Cr(VI) ones). The only company producing Cr(VI) pigments that has submitted a completed questionnaire has indicated that they are not prepared to voluntarily take measures that would restrict their use of Cr(VI). Therefore, it is unlikely that this measure could be relied upon to deliver a sufficient reduction in risks.

Overall, this measure will not be considered further in this RRS since its uptake by the industry sectors involved and its effectiveness cannot be guaranteed.

5.4.3 Negotiated Voluntary Agreements

Negotiated agreements between industry and governments can allow for a proactive approach to be taken by industry and can potentially allow for tailor-made solutions to environmental emissions to be adopted in a more timely and cost-effective manner than through traditional legislation.

In the case of Cr(VI) substances, such an agreement could take the form of one of the following:

- an agreement to modify the process technologies used, such that risks from Cr(VI) substances are below a certain level; or
- an agreement to phase-out the use of Cr(VI) substances or to reduce and limit use to a certain level

It should be noted that not all businesses would start from the same point if voluntary action to discontinue the use of Cr(VI) substances were chosen as the way forward. For instance, while some companies have invested in research and development on alternatives to Cr(VI), others have not done so, perhaps because they do not have the means or resources for this. Similarly, while the cost of transition to another substance or to a different process may be easily absorbed by large companies, this may not hold true for smaller companies. For them, the associated cost could be significantly high to make them avoid implementing any changes until such times as the change is legally enforceable.

Hence, any such voluntary agreement should ideally be supplemented by legislation. This will ensure that: (a) all companies are trading on an equal basis (or else companies opting for non-compliance will avoid costs incurred by those who opt to comply with the provisions of a voluntary agreement); and (b) an incentive for compliance (i.e. success of the voluntary agreement) is given. Requirements for the effective functioning of such agreements include:

- a sufficient coverage in order to cover the bulk of emissions;
- involvement of the majority of relevant companies and sites (which means that the impact of voluntary agreements promoted by industry associations will be limited if the associations do not represent or cannot mobilise and involve the majority of the companies and sites involved);
- clearly defined goals;
- public awareness of the agreement in order to provide an incentive for compliance;
- an effective means of monitoring compliance with the agreement; and
- legislative action to allow for the effects of non-compliance.

The possibility for voluntary agreements and the likely success of any such initiatives for the sectors involved are discussed in more detail in Section 7, where information from consultation is presented.

5.4.4 Legislation to Control Emissions of Hexavalent Chromium Substances

Legislation Applicable to the Protection of the Environment

The following legal instruments are relevant to the introduction of further controls on Cr(VI):

- the IPPC Directive (sector-specific measure, applicable to most industry sectors of concern, possibly not wood treatment);
- the Water Framework Directive incorporating the Dangerous Substances Directive 76/464/EEC (not sector-specific measure, applicable to risks from all industry sectors of concern); and
- the Sewage Sludge Directive.

IPPC Directive

As discussed in Section 4, under the IPPC Directive, a framework is provided for controlling emissions from certain industrial facilities. Sites should be operated according to BAT which are, or will be, set out for the various process types covered in BREF Documents. Emissions limits and process conditions for individual sites are then established by the Competent Authorities of Member States. The Directive includes chromium in the indicative list of the main polluting substances to be taken into account if they are relevant for fixing emission limit values (Annex III to the Directive). Moreover, all of the industry sectors of concern to this project appear to be generally covered by the provisions of the Directive (it does not apply to installations involved in the treatment of wood with preservatives, however, the potential risks from this application will be referred to the Biocidal Products Directive experts).

Water Framework Directive

The Water Framework Directive introduced a new framework for controls on certain ‘priority substances’ that present a significant risk to or via the aquatic environment. At the same time, the Directive incorporates the provisions of the pre-existing Community legislative framework on the protection of the aquatic environment (e.g. Directive 76/464/EEC).

Measures adopted under the Water Framework Directive are likely to predominantly focus upon industrial sources of substances. However, it does provide for product and process controls on both point and diffuse sources, although its effectiveness on controlling the latter remains to be seen.

Chromium is already regulated under Directive 76/464/EEC; this Directive provides the framework for Member States to take national measures for the prevention of pollution by chromium and its compounds. On the other hand, chromium is not on the list of priority substances of the Directive but could, theoretically, be added to the list of priority substances, following the forthcoming revision of the list of priority substances (which may or may not include chromium). This would provide a means of introducing a harmonised Community-wide framework for limiting emissions from the industry sectors of concern to acceptable levels, although it is not clear at present whether such a harmonised approach is necessary for the control of risks from Cr(VI) substances, given the presence of a significant volume of relevant legislation at the national level.

The Water Framework Directive also provides a basis for the recovery from industry of environmental and resource costs associated with damage to the aquatic environment, based on an economic analysis of water services. Thus, if water companies were, for example, required to limit emissions of chromium to the aquatic environment, there exists a basis for the recovery of the costs of doing so from the industries concerned.

Note that reference is made to ‘chromium’ being included in the list of priority substances rather than to ‘Cr(VI)’. It is possible that the future list of priority substances may include chromium and could specify Cr(VI) as the relevant species for which an EU EQS should be developed. This option will be considered if and when chromium is included in the revision of the list of priority substances (D’Eugenio, 2005).

Sewage Sludge Directive

As discussed in Section 4.1.3, the plans to revise the Sewage Sludge Directive (and include limits on the levels of Cr in sludge) have been abandoned in the past, partly because at the time the Council needed unanimity to adopt a legislative measure based on an environmental legal basis. For this Directive to be a suitable instrument for the introduction of further risk reduction measures, an amendment to the Directive would be necessary. The Commission is currently working on the development of the Soil Thematic Strategy. It is unclear what form the strategy will take and what legislative and/or other action may precipitate from it and a revision of the Sewage Sludge Directive in the framework of the Soil Thematic Strategy appears to be unlikely.

Legislation Requiring a Cessation or Phase Out of Use

The main established route for introducing restrictions on the marketing and use of substances is Directive 76/769/EEC concerning the marketing and use of certain dangerous substances and preparations. With particular regard to wood preservation products, which is not relevant to the discussion of further risk reduction measures, the Biocidal Products Directive 98/8/EC will also play a vital role in the control of risks from chromium in wood preservatives.

Regarding Directive 76/769/EEC, a number of substances have already been restricted under this Directive and the procedures for implementing such restrictions are well established. A variety of different types of restrictions have been introduced for other substances, with derogations proposed in some applications. Marketing and use restrictions do not simply constitute a ban on use and can be very flexible in their approach to use and associated risk issues. It is important to note that conditions can be attached to any derogations, including time factors and process technologies (for example the compulsory use of vacuum pressure treatment of wood when using CCA).

5.4.5 Provision of Information (Technical Standards or Guidance) and Training

The provision of information on the risks from Cr(VI) substances could be targeted primarily at workers handling and being exposed to these substances.

Information could be provided in the form of 'safe handling and disposal guidelines', such as those prepared by SEA in the UK (see Section 4.4.1) or in the form of a Code of Practice such as the one prepared for the UK timber treatment installations and is presented in Annex 3. These should ideally target any losses/releases of Cr(VI) substances into the environment during manufacturing and formulation, as well as describe what preventative and corrective action should be taken to minimise exposure to the substance (for example, best practice to reduce drag-out in metal finishing installations). These guidelines could be circulated by producers and distributors of the substances and their preparations and could be taken into account when upgrading facilities and plant design.

Any such guidance could be accompanied by training of employees aimed at the accurate and effective implementation of the guidance's provisions. Such training could be organised and delivered by the relevant industry trade associations in collaboration with the relevant Competent Authorities (for example, the HSE in the UK).

5.4.6 Economic Instruments

Economic instruments could be used to provide a financial incentive to achieve reductions in emissions from the various uses of Cr(VI) substances or, alternatively, to reduce (and possibly eliminate) the use of Cr(VI) substances in the relevant industry sectors. They could also be used to limit the quantities of Cr(VI) substances that are used within those industry sectors. The following types of economic instrument may be relevant to the risk management of Cr(VI) substances:

- **emissions charge:** this type of scheme could be used to levy a per unit charge on emissions of Cr(VI) substances to the environment;
- **product charge:** this could be developed by levying a charge on the use of Cr(VI) substances in all or certain applications of concern;
- **tradeable permits:** a permit trading scheme could be developed to place a ceiling on the quantity of Cr(VI) substances consumed in the EU, or on emission levels, within the various industry sectors, with users then able to trade permit quantities; and
- **liability based regimes:** instruments such as a performance bond could be used to reinforce voluntary commitments to reduce the use of Cr(VI) substances to levels where associated risks are deemed to be acceptable or to employ technologies at sites that limit environmental emissions.

It is currently unclear how economic instruments could be given legal force through EU legislation. Directive 76/769/EEC may provide the most appropriate legal framework.

5.5 EU Strategy for a Future Chemicals Policy (REACH)

On 29 October 2003, the Commission adopted a proposal for a new EU regulatory framework for chemicals. The proposed new system is called REACH (Registration, Evaluation and Authorisation of CHemicals).

Registration will involve providing information on:

- the intrinsic properties and hazards of each substance (such as physicochemical, toxicological and eco toxicological properties). This information - if not already available - can be found through a variety of means such as computer modelling and epidemiological studies, or through testing. Where testing is necessary and involves animals, it will be kept to a minimum by requiring companies to share existing data; and
- the use(s) of the substance identified by the importer or manufacturer or by their customers. A report of an assessment of risks for human health and the environment, and how those risks are adequately controlled, for the identified uses for substances produced or imported in volumes of 10 tonnes or more per year per manufacturer or importer (known as chemical safety reports). For lower volumes, safety information produced for the safety data sheets will be submitted as part of the technical dossiers.

Moreover, all substances of very high concern will be subject to authorisation. Authorisations apply to particular uses of the substance in question and will be granted only if the manufacturer or importer can show that risks from the use in question can be adequately controlled, or that the socio-economic benefits of the use of the substance outweigh the risks. In the latter case, the possibility of substitution should be considered. Among the substances to be subject to authorisation are Category 2 carcinogens (all five

Cr(VI) compounds are classified as such under Directive 2004/73/EC (see Section 4.1.1)). Authorisation covers all substances of very high concern regardless of volume. This means that also use of small volumes will need to be authorised.

The five Cr(VI) will have to be both registered and authorised for use in the various uses/applications under the new chemicals policy.

Overall, in the new REACH era, responsibility for the management of the risks of substances will lie with the enterprises that manufacture, import, place on the market or use these substances. In short, the registration provisions require manufacturers and importers to generate data on the substances they manufacture or import, use these data to assess the risks related to these substances and to develop and recommend appropriate risk management measures. However, where such risk management measures are considered to be insufficient and where Community-wide action is justified, appropriate restrictions should be laid down.

It is yet unclear when the new chemicals policy will come into force. The proposals are currently under examination and negotiation at the European Parliament and Council level.

6. ALTERNATIVES TO HEXAVALENT CHROMIUM COMPOUNDS

6.1 Overview

This Section presents information collected to date with regard to potential alternatives to Cr(VI) compounds. Information is provided only on metal (and plastic) treatment applications; the discussion below is provided in support of the analysis of possible risk reduction measures such as marketing and use restrictions in Section 7. Although previous versions of this RRS report produced upon completion of Stages 1 and 2 of the project included a brief overview of the availability and technical suitability of alternatives for Cr(VI) in wood preservatives, this has been removed since the use of wood preservatives and of treated wood have been excluded from the scope of this RRS.

A discussion is not provided for pigments (no information was made available) or for tanning salts (the consideration of alternatives was not necessary).

This discussion is not purported to be complete or capable of indicating specific substances or systems that could replace the five Cr(VI) compounds. Moreover, the following paragraphs are intended to highlight key issues but do not analyse the availability and suitability of alternatives in great depth since the introduction of marketing and use restrictions is not the preferred option for the metal finishing sector in this RRS.

6.2 Alternatives for Hexavalent Chromium in Metal Finishing

6.2.1 Alternatives for Chromium Plating

Information on alternatives has been identified through consultation and literature review. The possible alternatives are summarised in Table 6.1 which is reproduced from Northeast Waste Management Officials Association (NEMWOA, 2003) and are discussed further below. Note that reference to any commercial proprietary system should not be assumed as endorsement of technical suitability or environmental/human health performance of these systems.

Trivalent Chromium Systems in Hard Chrome Plating

Industry agrees that part of the chrome plating sector can substitute its use of Cr(VI). Cr(III) solutions for decorative electroplating have been available for a number of years now and UK SEA has published a specific case study on this topic. However, there is currently no commercially available alternative to Cr(VI) for functional (hard) chromium electroplating.

Possible alternative		Notes
Chromium	Trivalent chromium	A number of proprietary systems are available on the market such as Trichrome Plus, Geomet, Trimac-Envirochrome
Electroplated nickel	Nickel-tungsten-boron	Uses conventional plating equipment and operates similar to a conventional nickel plating bath; may be more costly than Cr(VI)
	Nickel-tungsten-silicon-carbide	May provide higher plating rates and higher cathode current efficiencies; may provide better throwing power and better wear resistance; may be more costly than Cr(VI)
	Tin-nickel	Good corrosion resistance in strong acids; breaks down above 320°C; less wear resistance than Cr(VI)
	Nickel-iron-cobalt	Vendor claims twice the wear resistance and 2.6 times the corrosion resistance of Cr(VI); same colour can be obtained
	Nickel-tungsten-cobalt	Contains no chloride or strong chelators; can be used in rack and barrel plating; good corrosion resistance except in marine environments; may tarnish; contains ammonia
Non-nickel electroplate	Tin-cobalt	Plate on nickel; decorative only
		Plate on decorative nickel and nickel alloy; may be used in racking; mildly alkaline
		Good colour, light blue cast; no ammonia; no fluorides; no chlorides
	Cobalt phosphorous	Nano-crystalline deposit produces extreme hardness; plating current waveform modification (electrically mediated deposition) used to produce nano-crystalline deposit.
Electroless	Electroless nickel - nickel-tungsten - nickel-boron - nickel-diamond composite - nickel-phosphorous - nickel-polytetrafluorethylene	Possibly less hardness and abrasion resistance than Cr(VI); no build up on corners
Other Methods	HVOF (high velocity oxygenated fuel) thermal sprays	Hardness and wear resistance similar to Cr(VI); limited to line-of-sight applications.
	Physical vapour deposition (PVD) -titanium nitride	Greater hardness than Cr(VI) with a thinner coating; less corrosion resistance
	Ion beam-assisted PVD	Line-of-sight; thinner coatings give same properties as other thicker coatings
	Plasma spray -titanium carbide	Aluminium, steel, carbon steel, titanium substrates
	Chemical vapour deposition (CVD)	Vacuum deposition; not limited to line-of-sight; resistant to acids; high deposition rate
	Ion implantation	Ions are implanted – no thickness; non-line-of-sight
	Powder coating	Vacuum metallisation (PVD)
	Laser cladding	Non-line-of-sight; nickel carbide coating

Source: NEMWOA, 2003

According to industry, with the current state of development of Cr(III) processes, platers cannot produce the thicker deposits required for the hard chrome market. Although Cr(III) electrodeposits may be visually acceptable to consumers, currently the corrosion resistance of a nickel + chromium or copper + nickel + chromium coating systems is lower when a Cr(III) process is used than when a hexavalent deposit is used (SEA, 2005).

Some substitution by hard deposits other than chromium (e.g. by electroless nickel, which has its own hazards) is possible but for many engineering applications currently using hard chromium deposits, no substitution is possible.

Therefore, industry believes it is not reasonably practicable in many applications to substitute the Cr(VI) process with a less hazardous one. To produce coatings with the functionality required, applicators will need to continue to use Cr(VI) electroplating processes and conform to all of the relevant legislation (for example, in the UK this would be the PPC Regulations and the Control of Substances Hazardous to Health Regulations 2002) (SEA, 2005).

Trivalent Chromium Systems in Decorative Chromium Plating

Substitution of Cr(VI) with Cr(III) in decorative chromium plating, where technically possible has a number of advantages (SEA, 2001b):

- it helps companies comply with occupational health regulations (Cr(VI) is a carcinogen);
- it is less harmful compared to Cr(VI) (in terms of carcinogenicity, sensitisation, corrosivity and oxidising properties);
- it drains off plated parts better than Cr(VI), hence the likelihood of human contact is reduced;
- the chromium content of a Cr(III) bath is lower (~20g/l rather than ~200g/l) which results in lower viscosity and hence less drag-out and staining of the work;
- the amount of sludge produced is reduced (by as much as 80%);
- the waste requires less extensive chemical treatment;
- the process is more energy-efficient since Cr(III) requires less power to deposit the same amount of metal;
- Cr(III) results in less rejects produced due to insensitivity to current interruption and due to better metal distribution, good throwing power and good covering power which give better corrosion protection;
- operational costs are reduced due to lower requirements for air scrubbers, rinse water treatment and occupational health surveillance, and greater system efficiency.

Cr(III) plating is not free of problems. These show that the method is evidently less established than Cr(VI) plating, however, these problems can be addressed. Such problem areas include:

- colour: Cr(III) deposits a different colour to Cr(VI) deposits;
- deposition rate: Cr(III) solutions vary in deposition rate with age, analysis, and levels of contamination;
- measurement of the deposit thickness: this is currently performed on machines calibrated using Cr(VI) deposits;
- corrosion resistance: Cr(VI) plating baths adequately passivate the parts processed. This ensures that the integrity of the plated parts are maintained through the post plating rinses, and subsequent drying operations;
- solution maintenance: maintenance practices for good Cr(VI) tanks are well understood and easy to carry out. Cr(III) tanks require daily maintenance and attention;
- service corrosion resistance of Cr(III) deposits: this relates to effects of contamination within the Cr(III) bath; and
- training: training in the use of the Cr(III) solutions and how they are kept in optimum conditions is required (SEA, 2001b).

Table B1 in the British Standard BS EN 12540:2000 (Corrosion protection of metals – Electrodeposited coatings of nickel, nickel plus chromium, copper plus nickel and copper plus nickel plus chromium) specifies four service condition numbers. These are:

- Service Condition 1: service indoors in warm dry atmospheres.
- Service Condition 2: service indoors in places where condensation may occur.
- Service Condition 3: service outdoors in temperate conditions.
- Service Condition 4: service outdoors in severe corrosion conditions e.g. marine or industrial.

The UK SEA suggests that the decorative electroplating market could be considered as incorporating two markets:

1. applications where there are no corrosion resistance requirements or a requirement to meet Service Condition 1 or 2; and
2. applications with a requirement to meet Service Condition 3 or 4.

With regard to the first segment of the decorative chromium coatings market, although it can be anticipated that there would be some market or consumer resistance to a colour that may be slightly different or less attractive, the use of a Cr(III) electroplating process

(or of non-chromium processes) is a reasonably practicable alternative. It is likely that all parameters, including corrosion resistance, of the standard for coatings to Service Condition 1 can be met by Cr(III) processes. Work will be completed this year to show how well the deposits perform for Service Condition 2 (SEA, 2005).

In contrast, SEA believes that for the second segment of the decorative chromium coatings market, with the current state of development of Cr(III) plating processes, currently no applicator in the UK (and elsewhere) is able to meet these requirements using Cr(III) processes. It is anticipated that in the future, after further technical development, Cr(III) deposits will be able to meet the corrosion requirements of Service Conditions 3 and 4 (SEA, 2005).

UK consultees suggest that the UK HSE is prepared to accept that for Service Condition 4 (external use, corrosion resistant) products, Cr(III) coatings are not sufficiently robust. Therefore, total replacement of Cr(VI) in the decorative plating market is currently not advisable (personal communication with industry).

Nickel-based Systems

Two types of nickel-based systems have been identified: electroplated nickel and electroless nickel.

Electroplated nickel: electroplated nickel coatings have good corrosion resistance but often tarnish easily in sulphur-containing environments. Corrosion resistance is also not good in marine environments. A number of proprietary systems exist (Graves, not dated-1).

Electroless nickel: higher phosphorus electroless nickel coatings have better aqueous corrosion resistance, whereas lower phosphorus deposits have good corrosion resistance in alkaline environments. Several proprietary electroless nickel coatings have been tested as alternatives to chromium plating. One proprietary electroless nickel coating process, using operating conditions comparable to standard electroless nickel plating, uses 5g/l nickel and operates at a pH of 7. Hardness and wear are improved compared to standard electroless deposits. Another proprietary electroless nickel bath contains boron and thallium. In the salt fog test, this coating withstood 200-hr exposure, and withstood exposure in an oxidising atmosphere at 98°C. The main drawback to these coatings is that they are not easily reproduced on a plating line (Graves, not dated-1).

Nickel coatings have excellent wear and corrosion resistance, and may be used in a wide range of applications. However, risks from hazardous vapour and corrosive chemicals still exist in this process (US EPA, 2000).

Cobalt-based Systems

Nickel-iron-cobalt (Ni-Fe-Co) alloy substitutes for chromium plating are said to have a wear resistance twice that of chromium and corrosion resistance that is 2.6 times greater.

With the appropriate nickel and iron content, a colour similar to that of chromium can be obtained. The iron and cobalt in solution increase hardness and stability.

In tests on other cobalt-based coatings, it was found that the coatings adhere well to carbon and mild-steel substrates, however, cracks are evident in the coating at temperatures of 500°C and higher. Cobalt-tungsten coatings are said to peel at 600°C and are softer than Cr(VI) plated coatings. Therefore, these are not seen as good alternatives to Cr(VI) plating (Graves, not dated-1).

Tin can be electroplated as an extremely bright, white and lustrous deposit. Tin-cobalt deposits are both durable and attractive. These may be considered to be alternatives to decorative chromium, especially where barrel plating is used. With good corrosion resistance, such alloys can be used as both a decorative and an industrial finish, in industries such as brewing (BSTSA, not dated). It has been suggested that tin-cobalt systems are now substituted by the Cr(III) ones as the latter have a better quality of finish and colour modifications, and due to the re-classification of cobalt sulphate at EU level which is quite similar to that of Cr(VI). Tin-cobalt systems are a good solution for high throwing power for items that cannot be chrome-plated in other ways. An advantage of this method compared to Cr(VI) plating is that the concentration of cobalt sulphate in the bath is considerably lower to that of Cr(VI) in chrome plating baths (personal communication with industry).

Inorganic Alternatives

High-velocity oxygenated fuel (HVOF) flame spraying allows chromium replacement coatings to be produced with comparable surfaces to Cr(VI). Different powder materials are used to substitute for hard chromium depending on the mechanical loading of the component (Graves, not dated-1). Different types of coatings include:

- tungsten-carbide-cobalt-chromium (WCCoCr): provides protection against extreme abrasive wear;
- chromium-carbide-nickel (CrCNi): provides protection against wear with superimposed corrosion;
- tungsten-carbide-cobalt-nickel-chromium-molybdenum (WCCoNiCrMo): protection against abrasion with superimposed adhesion;
- tungsten-carbide-cobalt (WCCo): hard with high bond strength and high wear resistance;
- nickel-chromium-boron-silicon (NiCrBSi): have a medium abrasion resistance; and
- iron-chromium-molybdenum (FeCrMo): the primary component provides wear protection, and the secondary one provides toughness and ductility.

Thermal spraying offers corrosion and wear resistance, but cannot effectively coat complex substrates. This process also generates dust and fumes that may pose health hazards (US EPA, 2000).

Chemical Vapour Deposition

Chemical vapour deposition, or CVD, is a process in which a coating is deposited onto a substrate by a reactive vapour that is typically a metal halide, metal carbonyl, hydride, or organometallic compound. CVD provides a thick, dense, high-purity film on substrates. Parts are placed in a reaction chamber. During the process, a gas reacts chemically at low temperatures with the parts' surface to form a smooth, dense, conformal coating. CVD has mainly been used with electronic and optical parts; however, it can be tailored for finishing high-strength steels. But the coatings are thin and deposition rate is slow (Graves, not dated-2). Due to the high temperatures necessary to complete this process, temperature-sensitive substrates cannot be coated with CVD (US EPA, 2000).

Physical Vapour Deposition/Vacuum Coating

Physical vapour deposition (PVD) or magnetron sputtering uses a vacuum in which atoms are dislodged from the target, which is made of the coating material (e.g. aluminium) and accelerated toward the substrate where they are deposited. Magnetron sputtering is a similar, yet more efficient process. The PVD process, as with CVD, produces a smooth, dense, conformal coating. Various targets can be used to produce multi-layer coatings that can be applied to a variety of substrates; however, it is a line-of-sight process with limited applications (Graves, not dated-2). This technology is environmentally benign, very versatile, and offers improved adhesion and film structure. The downside of vacuum coating is its high capital cost, high voltage requirements, and use of toxic chemicals (US EPA, 2000).

Titanium nitride is a prime candidate for replacing chromium coatings using PVD. Titanium nitride is much harder than chromium but it can be cost-effectively applied in much thinner coatings. Because of the thin, hard nature of the coating, titanium nitride is inferior to chromium as a coating in highpoint or line-load applications. Titanium nitride coatings also do not provide as much corrosion protection as do thicker, crack-free chromium coatings. PVD results in a thin, uniform coating that is much less likely to require machining after application. However, PVD is a line-of-sight coating process, and parts with complex shapes are difficult to coat (US EPA, 1994).

6.2.2 Alternatives for Chromium Conversion Coatings

Overview

Consultation and literature suggests that the following may be used as replacements for Cr(VI) systems:

- Cr(III) systems (most of them proprietary systems such as Geomet, Magna, Delta, etc.);

- systems based on H₂TiF₆;
- titanium/zirconium systems;
- systems based on poly(4-vinylphenol-N-methylglucamin) Mn-Salt (organic coatings used with a chemcoater);
- cerate systems (for aluminium pre-treatment, for both architectural profiles and other applications);
- Self-Assembling-Molecule systems (for aluminium pre-treatment, well established in the aluminium wheel industry); and
- silane systems (for aluminium pre-treatment (Schmidt-Hansberg & Schubach, 2003)).

Chrome-free Passivation

With regard to treatment of coil, the treatment may involve temporary or permanent passivation. Chromates have not found significant application in temporary passivation operations. Chrome passivation provides a non-reactive surface that may be unacceptable for coil coating applications. The processing of this material through a normal alkaline cleaner bath would give rise to partial stripping of the chromate layer. This would lead to contamination of the bath and to the creation of a chromate effluent problem (GE, 2004).

Where material is intended for further processing on a coil line, oil is often used to give shorter term protection against white rust in storage and in transit. Oil does not impede the normal surface reactivity of the metal and is, therefore, acceptable to the coil coater as it can be readily removed with an alkaline cleaner bath. It will, of course, add to waste water treatment plant loading and raise the COD. This will require the use of chemicals to help remove the oil (GE, 2004).

In Europe, the most commonly encountered short-term protection will be rust preventative oils. Chrome-free temporary passivation for transit protection can be encountered by the coil coater occasionally. The main reason that they have not been adopted in Europe to any great extent is the fact that performance in natural salt spray (NSS) testing is not as good as chrome. This is often a requirement of the end user, although it is not especially relevant in many cases (GE, 2004).

Performance of chrome-free temporary passivations is good in both condensing humidity and wet stack testing, but NSS performance shows a gap with regard to chrome passivation. It is not, therefore, a direct substitute. The typical results obtained show that for short to medium term protection of the metal it is an acceptable choice, but where conditions can be very aggressive, a more permanent passivation may be necessary. Examples include storage outside in coastal areas and transport by sea, where there is increased risk of chloride attack on the metal surface (GE, 2004).

With regard to permanent passivation of coil there are two main types of permanent chrome-free passivations: those which are a direct replacement for typical chrome passivation and those which include an organic polymer in the formulation, and which are often known as thin film organics.

For the former, testing shows performance to be equal to, or in some cases better than chrome in humidity and wet stack testing. The technology has been tested on a wide variety of substrates and qualities. The results obtained are reportedly good in all cases, but a general observation is that the best results are usually seen with smaller spangle sizes for hot dip galvanised steel where it can often outperform Cr(VI). In field tests carried out in a direct comparison with chrome, results in NSS were reportedly shown to be identical with no statistically significant difference, while results in wet stack and condensing humidity were both better than chrome (GE, 2004).

The other area of permanent passivations is the thin film organics. These contain passivating chemicals along with an organic polymer which forms a thin film on the surface. Typical film build is only about 1 micron, much less than for true paint systems, but the layer provides added corrosion protection as well as providing anti-fingerprint properties and lubricity to aid forming processes. Acrylic polymers have been most commonly used, but polyurethanes have also found a place especially in Asia, although other polymer systems can also be used. Most systems in use today are chrome-based, although a small number of chrome-free alternatives exist. Some of these chrome-free systems are capable of providing results which are equal to, or even better than chrome in NSS, humidity and wet stack tests (GE, 2004).

Chrome-free Pre-treatments

For chrome-free pre-treatments, product selection is more substrate-dependent than for chrome. When selecting a product, it is much more critical to carry out thorough testing with the paint system to be used. Most chrome-free usage so far has tended to be on aluminium, where performance is very close to chrome. Here, there is more than a decade of experience with very good results (GE, 2004).

Chrome-free pre-treatments are generally not visible on the surface like chrome. While the visibility of chrome clearly does not give any accurate indication of coating weight, it does give the coil coater confidence that the coating is being applied and that the film is reasonably uniform. The control of non-chromes often requires the use of a Portaspec to control typical ingredients such as titanium. Zirconium and silanes are other typical ingredients that are used in these products (GE, 2004).

Work over a period of many years has yet to come up with chrome-free products which have the full versatility of performance of chrome. To achieve further improvements has required the development of new technology involving the use of robotics and development of rapid screening methodologies which could screen many thousands of formulations in a fraction of the time it would have taken previously (GE, 2004).

6.2.3 Environmental and Human Health Risks

Little information is available on the possible impacts of alternatives on human health and the environment. As discussed above, replacing Cr(VI) systems will essentially involve the use of a combination of alternative systems. Therefore, the possible risks introduced by these new systems could possibly be very complex. Information from

consultation suggests that generally the risks from alternatives appear to be lower (notably this is the case with the main possible alternative, Cr(III)), however, there are cases, such as systems based on nickel, for which the risks may be similar, if not higher than Cr(VI) (note that nickel is currently undergoing assessment of risks under ESR with Denmark as the rapporteur, and is a priority substance under the Water Framework Directive). It is important to note the following two points:

- metal finishing formulations are often proprietary preparations, therefore, obtaining information on their components (and assessing their possible risks) is difficult; and
- while for Cr(VI) a RAR is available, the information on effects of the alternatives is not as comprehensively (although, it is of note that industry is preparing a RAR for Cr(III)).

6.2.4 Performance and Cost Issues

It is of importance that Cr(VI) cannot be replaced by a single system. Depending on the substrate, the end-use of the products and the processes used the systems referred to above may be suitable or unsuitable alternatives to Cr(VI). The discussion on alternative conversion coating systems testify to that.

Recently, substitution has been achieved in a number of applications. For example:

- Cr(III) systems find increasing uptake in the decorative plating sector; and
- the ELV Directive resulted in the use of Cr(VI)-free passivates and, in general, passivation of hot dip galvanised steel is now to a significant extent Cr(VI)-free, although this varies from one EU Member State to another.

On the other hand, currently available alternatives seem to incur problems in replacing Cr(VI) in the following areas:

- hard chrome plating;
- etching of plastics;
- passivation of copper foils (for production of PCBs);
- passivation in the aviation industry;
- in-line passivation treatment of hot-dip galvanised steel strip; and
- ECCS and tinline passivation (when tinline passivation is necessary, there currently appear to be no other alternative post treatment processes available in technical grade, which give the same technical performance to tinline as the Cr(VI)-based passivation treatment).

Table 6.2 presents the views of users of Cr(VI) metal plating systems with regard to the performance characteristics and the comparative costs of alternatives.

Table 6.2: Consultation Findings on the Performance of Alternatives to Cr(VI) in Metal Finishing

Alternative system	Number of companies expressing an opinion	Application area	Performance compared to Cr(VI)	Cost compared to Cr(VI) systems
Cr(III) systems	6	Decorative plating	From 'poor' to 'same'	From 1x to 10x (including capital cost)
Cr(III) systems	4	Passivation	From 'same' to 'superior' (noted reduced lifetime)	From 1.2x to 8x
Cr(III) systems	1	Copper foil passivation	'Very poor'	5x
Geomet	1	Passivation	'Inferior'	1.2x
Magna/Delta	1	Passivation	'Similar'	2x
Electroless Ni plating	1	Hard chrome plating	'Poor'	2x
Thermal metal spray	1	Hard chrome plating	'Difficult to assess'	
H ₂ TiF ₆ systems	1	Pre-treatment	'Acceptable'	1.5x
H ₂ TiF ₆ systems	1	Copper foil passivation	'Very poor'	10x
Ti/Zi systems	1	Pre-treatment	'Acceptable'	
Polyvinylphenol systems	1	Pre-treatment	'Acceptable'	

Source: Consultation

All consultees who provided information on the envisaged costs of possible substitution of Cr(VI) in metal finishing suggest that Cr(VI)-free materials are, in general, more expensive than Cr(VI)-based products. However, apart from the cost of purchasing the chemical formulations, there are other types of costs that may increase or decrease the overall cost of substitution. These include:

- disposal of old solutions;
- change of equipment (for example, it has been suggested that the installation of a tank to be used with Cr(III) system may cost approximately €45,000 if fitted with an ion exchange and solution make-up system);
- training of staff;

but also:

- possibly reduced need for treatment of wastewater;
- reduced need for rinsing;
- reduced need for replenishment of chemicals (if using a system that requires a chemcoater, for instance); and
- reduced need for investment in meeting regulatory requirements for protection of occupational health and the environment.

The estimates of companies of the overall cost to their business from substituting Cr(VI) vary greatly due to the variety of operations involved, the availability and cost of alternatives and the implied changes in their processes and operations that would have to be introduced.

Hence, there are companies that suggest an overall cost of substitution of:

- €120,000 for conversion of a large company (more than 250 employees with a turnover over €50 million per year) from Cr(VI) to Cr(III) including costs for changes to the plant, equipment, disposal of old solutions and general changes to operating practices;
- 5% increase on production costs for a large company (more than 250 employees with a turnover over €50 million per year) that is now using Cr(VI) in the passivation of aluminium strips (the company notes that it has not identified a suitable alternative yet);
- €1.5 million for a large company (more than 250 employees with a turnover over €50 million per year) that uses Cr(VI) passivates as primers in coating a variety of substrates (the company suggests that this would be the cost for introducing new primers);
- €23,000 for a medium sized company involved in hard chrome plating, anodising and passivation for replacing solutions and equipment; and
- €5,000 for a small company to dispose of existing solutions (€750) and purchase new equipment and new Cr(III) solutions.

An issue of concern for those involved in metal finishing using Cr(VI) systems is that substitution of all products may be subject to approval by customers. This is particularly relevant where performance of the coated material is of paramount importance. For example, the aerospace industry or the building sector require guarantees of a minimum service life (for example, 20 years for the latter - also note that, in the UK at least, the use of chromates is specified in Ministry of Defence process specifications). Consultees suggest that if substitutes cannot meet the specifications set by some clients, the clients will simply move their business elsewhere.

With particular regard to the aerospace industry, consultation with a leading company suggests that the replacement of Cr(VI) anticorrosion systems is not feasible at present. Efforts are made to achieve substitution in this sector but it is expected that this process cannot be completed before 2009-2010 due to the significant R&D requirements involved.

7. ASSESSMENT OF POSSIBLE FURTHER RISK REDUCTION MEASURES

7.1 Background

According to the TGD on the development of risk reduction strategies (CEC, 1998), there are four key criteria against which possible risk reduction measures should be assessed:

- ***Effectiveness*** - the measure should target the significant hazardous effects and routes of exposure identified in the risk assessment. It should be capable of reducing the risks that need to be limited within and over a reasonable period of time.
- ***Practicality*** - the measure should be implementable, enforceable and as simple as possible to manage. Priority should be given to commonly used measures that could be carried out within the existing infrastructure (but not to the exclusion of novel measures).
- ***Economic impact*** - the impact of the measure on producers, processors, users and other parties should be estimated.
- ***Monitorability*** - monitoring should be possible in order to allow the success of the risk reduction measure to be assessed.

Although for the various industry sectors of concern, the implications of the possible further risk reduction measures outlined in Section 5 will differ due to the different nature of the industries concerned), for reasons of consistency, clarity and presentation, the discussion on the different further controls will be grouped across the industry sectors where possible and appropriate.

In the following sections, each of the possible measures referred to in Section 5 is considered in turn, with information presented on the performance of the measures against the four key criteria. The possible further measures are discussed in the following order:

- cessation or phase-out of use;
- legislation to reduce emissions;
- economic instruments;
- provision of information; and
- negotiated voluntary agreements.

The industry sectors/lifecycle areas of concern are:

- manufacture of Cr(VI) metal finishing formulations;
- use of Cr(VI) metal finishing formulations;
- manufacture of tanning salts;

- manufacture of Cr(VI) pigments; and
- manufacture of chromium (III) oxide pigments.

In comparison with the conclusions of the RAR, four lifecycle areas have been omitted from the analysis. These are:

- the production of Cr(VI) substances: recent changes in the market and existing risk reduction measures suggest that there is no need for further risk reduction measures and the use of treated wood;
- the formulation of wood preservatives: information on current practices and existing risk management measures from the main four EU formulators (accounting for 90% or more of the EU market) may adequately control any risks to the environment. It is of note that the Biocidal Products Directive requires that “...*the risk assessment (for substances of concern) shall cover the proposed normal use of the biocidal product together with a realistic worst-case scenario including any relevant production and disposal issue either of the biocidal product itself or any material treated with it*” (Annex VI – Evaluation). Hence, risks from Cr(VI) substances during formulation of wood preservatives will be addressed within the Biocidal Products Directive;
- the use of wood preservatives: the Biocidal Products Directive is again considered the most appropriate framework for the control of potential risks to the environment. At the same time, indications exist that emissions from these sites are minimal due to the lack of process effluents generated as well as the control measures that are in place at least in some Member States; and
- the use of wood treated with chromium-based wood preservatives: the Biocidal Products Directive is considered to be the most appropriate framework for addressing any potential risks from releases of chromium.

Note that ‘metal finishing’ in the discussion on further risk reduction measures below does not include ECCS or tinsplate passivation. Comprehensive evidence from almost all EU plants suggests that emissions of Cr(VI) are too low to pose a risk to the aquatic or terrestrial environment. The remaining metal finishing processes, possibly associated with unacceptable risks, are grouped and considered as a whole for reasons of simplicity and ease of assessment of the further risk reduction measures. Finally, with regard to the manufacture of tanning salts, the use of Cr(VI) substances has been confirmed for the current EU producer of Cr(VI) substances and one of the past producers. For the former, any emissions from this process are included in the overall emissions from the production site (for which no further risk reduction measures are required).

7.2 Cessation or Phase-Out of Use

7.2.1 Overview

The main means for introducing measures aiming at the cessation of use of Cr(VI) compounds is Directive 76/769/EEC. Measures could be introduced under this Directive to require industry sectors to cease use of Cr(VI) compounds by a certain deadline or to place phased requirements on reductions in use. Use restrictions could also be designed so as to only apply to particular applications or processes. For example, those applications that may have significant socio-economic importance and for which suitable alternatives to Cr(VI) are not currently available may be either exempted from any marketing and use measures or be granted a derogation which could be conditional (for instance, time-limited) or unconditional.

7.2.2 Effectiveness

A total ban upon the marketing and use of the Cr(VI) substances would eliminate any environmental and human health risks from the substances (this would inevitably cancel out the need for any measures recommended in the forthcoming human health RRS).

On the other hand, the reduction of risks needs to take into account the possible risks that would be introduced by alternatives. A preliminary analysis of the potential alternatives has been undertaken (see Section 6) for the metal finishing sector. In general, the evidence suggests that there appear, in principle, to be suitable substitutes available for a number of the applications of concern, including:

- decorative chromium plating (when corrosion resistance is not imperative); and
- passivation (but perhaps not for all substrates or all types of processes).

However, the information currently available does not allow for conclusions to be drawn with regard to the suitability of these alternatives. It appears that in industry sectors such as metal finishing, it is not generally possible to simply replace Cr(VI) substances with an alternative chemical. Even where some alternatives appear to exist, combinations of them (especially in metal finishing) may be necessary to be used.

Industry stakeholders challenged the suitability and performance of the alternatives for applications other than the above; in particular, they challenged the suitability of alternatives for hard chrome plating and conversion coatings in the aerospace industry.

At the same time, there is only limited information on pigments and, therefore, the criticality of the application in pigments is unclear, although there have been suggestions that some applications are important for the protection of substrates against corrosion.

More importantly, our knowledge of the possible effects of the alternatives on human health and the environment is limited. For alternatives to metal finishing operations, little specific information is available. Cr(III) has been suggested by several

consultees as a suitable alternative, particularly in decorative chrome plating. This is generally less hazardous than Cr(VI), however, many of the Cr(III)-based products on the market are of proprietary composition, therefore, the assessment of their effects to the environment and human health is not straightforward. At the same time, some of the other potential alternatives (based on nickel, for example) may be equally or more hazardous than Cr(VI) systems.

In summary, we do not have a clear picture of the overall changes in risks that would be introduced with the replacement of Cr(VI) in some sectors..

A separate mention needs to be made at this point to the manufacture of chrome tanning salts by tanners. This method of production has been characterised by industry as obsolete and consultation has identified only two companies that have been using this practice until recently. It is possible that there may still be a small number of tanners who use Cr(VI) and the associated risks to the environment could in theory be unacceptable although site-specific data available from two companies do not indicate unacceptable risks. The European trade association for the tanning industry (Cotance) recognises the importance of controlling emissions of Cr(VI) and where possible substituting dangerous substances with substitutes that pose lower risks to the environment. Therefore, Cotance would not object to restrictions on this particular use of Cr(VI); this would demonstrate the commitment of the sector to continuous improvement of the environmental performance of tanneries and, perhaps, set an example for tanneries outside the EU which may still reduce Cr(VI) on-site.

7.2.3 Practicality

Applicability

Marketing and use restrictions are, in principle, compatible with all applications and industry sectors of concern to this RRS. It should be noted that any such restriction would not target the manufacture of these substances; these could, for example, be manufactured and marketed in the EU for the uses not relevant to the scope of this RRS. Marketing and use restrictions would also not target sodium chromate since this is only used in production of other Cr(VI) substances (which it is assumed is not associated with unacceptable risks) as an intermediate.

It is recognised that an important aspect of any recommendation for marketing and use restrictions is the scope of such restrictions. For example, under the heading “metal treatment formulation”, several different processes are grouped. Moreover, the availability of substances may not be identical across the board. An example of this is the difference between hard (functional) chrome plating and decorative chrome plating. All signs from industry indicate that replacement of Cr(VI) in hard chrome plating is difficult to achieve with the currently available technologies. Similarly, Cr(VI) pigments (mainly strontium chromate) are indispensable in applications that require high corrosion resistance (for instance, in the aerospace industry).

On the other hand, applicability touches upon the extent and magnitude of risks in the context of the existing risk reduction measures. Industry argues that, for all sectors

involved, the risks are not those presented in the RAR but considerably lower. Information that has been collected through consultation and literature review provide ample supporting evidence for industry's claims. Actual emissions data suggest considerably lower risks than those depicted in the RAR. Naturally, a six-month project such as this cannot possibly collect information from the entirety of the sectors of concern. Therefore, there is a degree of uncertainty to the actual emissions patterns from all industry sectors of concern, although it may confidently be suggested that the prevailing risks to the environment, if any, are considerably lower than those presented in the RAR.

From a procedural point of view, the procedure for restricting the marketing and use of substances at the EU level under Directive 76/769/EEC is well established, with various substances already subject to restrictions. Furthermore, Member States are considered to have suitable procedures in place for implementing the requirements of the EU legislation.

Flexibility

Any restrictions under Directive 76/769/EEC would not necessarily be an outright ban. Derogations and exemptions could be granted where industry could make a valid case on technical and/or socio-economic grounds. The differences between decorative and functional coatings in the metal finishing sector, for example, could provide the basis of a variable approach to restrictions. However, more information would be needed on alternatives before any such recommendation would be formally made.

Simplicity

Amendments to Directive 76/769/EEC have been introduced several times and in this respect it is a simple measure to introduce and implement. Should any derogations be included, the wording would need to be made clear so that formulators and downstream users know exactly which applications/products Cr(VI) can or cannot be used.

Timing

It is unclear how long it would take for any restrictions to be introduced in the form of an amendment to Directive 76/769/EEC. By the end of 2005, the UK Government shall present its recommendations to the Member States and discussions will follow before the Commission formulates the text of any restrictions. On the basis of previous experience (for example, for pentabromodiphenyl ether or short-chain chlorinated paraffins), the time elapsed between completion of the RRS and the introduction of restrictions was two to three years. Member States would then need to introduce national legislation transposing the amending Directive to national law. The timing of such actions across all 25 Member States cannot be foreseen at this point.

7.2.4 Economic Impact

Costs to Industry

Marketing and use restrictions will inevitably result in costs to industry. First, any such measure will impact upon the sales of the sole EU producer of the Cr(VI) substances. As discussed in Section 2.1.2, the European market for chromium substances has an approximate value of €200 million. Not all of this can be attributed to the uses/applications under consideration. Moreover, any cost to the producer will depend on the scope of the restrictions. From Table 2.4, it seems that sales/consumption of CrO₃ in the metal finishing sector may be impacted upon more seriously than chromate salts. On the other hand, while for applications such as wood preservatives the alternatives are combinations of substances irrelevant to chromium, for other uses such as in metal finishing, one of the main identified alternatives is Cr(III). In this case, the producer of Cr(VI) would compensate some of his losses through his new sales of Cr(III) compounds.

Section 6.2.4 presents an initial review of the performance parameters and estimated cost of substitution for the metal finishing sector. As discussed therein, the costs include not simply the losses to business due to the increased cost of the replacement chemicals but also due to downtime, changes in equipment, training of personnel etc.

The estimates of the costs from restrictions vary depending on the size of company, the variety of operations/processes at each site, the existing level of knowledge of the alternative systems (what R&D each company has undertaken) and the type of alternative chosen. Estimates for the envisaged cost vary from a few thousand Euros to more than a million Euros for each business. But this may not reflect the indirect costs that could precipitate from substitution. For the metal finishing industry (and most probably for the pigments industry), customer specification requirements are of paramount importance in application where performance and functionality is of the essence. If an installation that has switched to a Cr(VI)-free alternative cannot meet the requirements of the customer, then it is very likely that the customer will opt for another operator. Hence, the loss of this business will add to the cost of switching.

It is important to consider that estimates provided by industry during consultation for the purposes of this RRS reflect the current state of the market. If new technologies are introduced more widely (for instance, Cr(III) systems), their cost will gradually reduce as they find increasing uptake. Restrictions have the inherent advantage of spurring innovation; such innovation can make more environmentally friendly technologies less costly and more accessible to downstream users.

With particular regard to the on-site reduction of Cr(VI) by EU tanneries, information submitted by one of the companies that until recently was employing this process suggests that abandoning this process has resulted in financial gain:

- an entire production step (i.e. the reduction of Cr(VI)) is now avoided;
- the costs for implementing measures for the protection of employees from carcinogenic Cr(VI) compounds are eliminated;

- the costs for maintaining vessels and pipes have been reduced; and
- the costs for wastewater treatment are lower.

It is unclear what the costs to Cr(VI) suppliers could be from a restriction on this application, although, it is likely to be limited; it is of note that, according to consultation, the sole EU producer of Cr(VI) substances does not supply any Cr(VI) substances to any EU tannery for on-site reduction.

Costs to Consumers

Inevitably, any increase in the costs of operation or part thereof will be passed on to consumers. The potential costs to consumers from the replacement of Cr(VI) the other industry sectors of concern are not known. With particular regard to on-site reduction of Cr(VI) by EU tanneries, no (adverse) cost implication to the consumer is expected.

Costs to Regulators

The costs to regulators are not known. However, in comparison to the costs from controlling the risks from Cr(VI) with legislation on emissions, the costs to regulators from restrictions could be lower.

Number of Affected Organisations

The numbers of organisations affected by possible restrictions on the marketing and use of the substance are:

- one producer of Cr(VI) compounds;
- unknown number of suppliers of Cr(VI) compounds (this includes companies that manufacture the compounds outside the EU and import them to be sold to downstream users, and suppliers that purchase Cr(VI) compounds from the producers and then sell simple formulations or neat products to downstream users);
- an estimated <100 formulators of metal finishing mixtures;
- an unknown number of metal finishing installations using Cr(VI) substances (there is an estimated 20-25,000 metal finishing shops³¹, however, not all of them may be using Cr(VI) substances – for the UK out of a total of ~300 shops, industry has suggested that around only 100 use Cr(VI) substances and their formulations);
- an estimated 5-10 producers of leather tanning salts;
- an unknown but most likely small number of tanneries producing their own tanning salts;
- an estimated 5-10 manufacturers of Cr(VI) pigments;
- an estimated <5 manufacturers of Cr(III) oxide pigments; and
- an unknown number of downstream users of pigments.

³¹ There were about 9,000 in-house shops and over 10,000 subcontract companies (job or jobbing shops) in EU-15) (EIPPCB, 2002)

Obviously the grand total of the number of organisations affected will depend on the scope of any restrictions.

Types of Businesses Affected

Some of the sectors of concern include a significant proportion of SMEs, such as the metal finishing sector and the tanneries sector in which the vast majority of installations are SMEs. In that respect, the impacts of restrictions on the marketing and use would be significant. With regard to pigments, the main Cr(II) oxide pigment producers are medium to large companies, while the only Cr(VI) pigment producer who has provided information is a small enterprise.

Proportionality

Proportionality is an important issue for the introduction of marketing and use restrictions (beyond that of the availability, suitability and effects of alternatives) especially when the level of risk is under dispute. Although an ESR RAR cannot provide and assess all possible scenarios for all possible applications of the substances of concern, in the case of Cr(VI) compounds, it seems that very little information on emissions was made available to the rapporteur.

The proportionality of a risk reduction measure relates to the scope of the measure and how able the measure is to take into account the different levels of risk for the different applications as well as socio-economic implications of the introduction of marketing and use restrictions. In other words, a measure should ideally target the areas associated with unacceptable risk only and should not impose unnecessary burdens on any of the parties affected by the measure (although the primary consideration should be impact on society as a whole) and should also take into account the criticality of each application.

The available information demonstrates that the RAR has overestimated the risks from the industry sectors of concern. Risks appear to be lower than those assumed in the RAR since existing EU and national legislation does target emissions of Cr(VI) and Cr(total) both across the board and for individual industry sectors. At the same time, international fora such as Helcom and Ospar, to which a number of EU Member States are contracting parties, have taken initiatives with regard to emissions of Cr(VI) from the industry sectors of concern and this has resulted in action at the national level.

Information on actual emissions from a number of individual sites suggests that emissions of Cr(VI) (especially to the aquatic environment) could be in the order of kilograms per year as opposed to the estimated emissions of kilograms per day in the RAR. The removal of Cr(VI) from wastewater (which subsequently reduces the risks to WWTP and the terrestrial environment) is based on simple techniques that reportedly find wide application. Moreover, due to the hazard profile of Cr(VI), which is well known and documented, installations using Cr(VI) compounds have to comply with occupational health legislation that indirectly limits the emissions of Cr(VI) substances to the environment.

In short, the available legislative framework provides the means for reducing the risks from Cr(VI) to the environment (although it is not possible to reach a final judgment whether this reduction is sufficient to eliminate the risks identified in the RAR) and currently available techniques allow for sufficient reduction of the risk, if properly implemented. These facts provide a clear indication that restrictions on the marketing and use of Cr(VI) substances would most likely place on the affected parties a burden disproportionate to the actual levels of risks.

With particular reference to the on-site reduction of Cr(VI) by EU tanneries, a restriction on the marketing and use of Cr(VI) for this process, would most probably have little impact to tanneries, however such a measure might not be entirely proportional to the identified risks: the information in the RAR applies to a single site and the conclusion that an unacceptable risk may arise was based on releases of total chromium which is very likely to predominantly be released as a result of the use of baths of Cr(III) tanning salts rather than the on-site reduction of Cr(VI). Moreover, information on releases from two companies (one of which is the site referred to in the RAR) that recently discontinued the purchase of Cr(VI) substances suggests no unacceptable risk to the aquatic environment. Overall, the process appears to have been abandoned and there is no concrete evidence that there is an unacceptable risk to the aquatic environment.

It is acknowledged that there is a theoretical possibility that tanneries (perhaps non-members of Cotance) may still be using Cr(VI) substances, although the available evidence strongly suggests that tanneries themselves would probably be keen to abandon this practice (see discussion in Section 2.4.3).

Legislation controlling emission (IPPC and Water Framework Directive) will also apply to EU tanneries and will be able to provide an environmental protection as sufficient as in the other industry sectors of concern. Therefore, imposing additional regulations in the form of marketing and use restrictions does not appear to be an entirely proportional option.

7.2.5 Monitorability

Available Networks

It should be relatively simple to monitor whether a ban on the use of Cr(VI) is being implemented by formulators given that in all chemical sectors involved, only a limited number of players exist. On the other hand, monitoring the enforcement of restrictions among downstream users may be more complicated, especially for industry sectors such as the metal finishing sector that include a large number of companies (the majority of which are SMEs). It has to be noted, however, that in the majority if not all of the sectors discussed in the report installation are generally subject to monitoring under EU and national regulations, in many cases irrespective of their size.

Further Monitoring Arrangements Needed

No particular further monitoring arrangements would be necessary for Customs authorities and enforcement authorities in the Member States. The five Cr(VI) would be added to the list of other restricted substances currently monitored for and controlled.

7.3 Legislation to Reduce Emissions and Exposure

7.3.1 Overview

Legislation to reduce emissions and exposure would be based on existing regulatory frameworks. The different measures that could be used include:

- the IPPC Directive 96/61/EC;
- the Water Framework Directive 2000/60/EC (incorporating the provisions of Directive 76/464/EEC);
- the Sewage Sludge Directive 86/278/EEC.

The last of the three Directives may only address risks to the terrestrial environment by controlling the quantity of chromium in sewage sludge applied to agricultural land.

The other two Directives will directly address the potential risks to the aquatic environment (by using emission limits or setting quality objectives) and will also affect the potential risks to the terrestrial environment indirectly (for example, precipitation of Cr(VI) as Cr(OH)₃ with the aim of meeting a limit on emissions to water will reduce the amount of Cr(VI) reaching the municipal WWTP and subsequently the amount of Cr(VI) in the sewage sludge produced and applied to land).

Consultation suggests that sludges from the industry sectors of concern (i.e. waste generated during on-site treatment of wastewater, which is essentially a filter cake most of the times) are normally treated as hazardous and when they are not, they do not find applications in spreading on agricultural land. In any case, it should be noted that chromium in sludges will be predominantly (if not exclusively) in the form of Cr(III).

Strictly speaking, the aforementioned two of the three legislative measures are not “further” risk reduction measures since are pieces of Community legislation that have been introduced some years ago. However, these have been chosen because they appear to provide the most suitable framework; the discussion below focuses on how these could address the potential risks from Cr(VI) and whether they will need to be amended or expanded to ensure sufficient reduction of risks.

7.3.2 Effectiveness

IPPC Directive: in theory, the IPPC Directive should be able to control risks to the aquatic environment to the required level. The issuing of permits under IPPC takes

account the specific characteristics of each individual site and tailors the requirements of the permit to accommodate these characteristics. The regulatory authorities are obliged to ensure protection of the environment (all compartments) when deciding upon the specifics of each permit.

One of the advantages of this approach is that sites are allowed to choose their means of meeting the requirements of their permit. In most cases, this means that companies will invest in technology (if they cannot meet these requirements already) rather than replace the chemicals of concern.

It is of note that consultation and the BREF Document on metal finishing demonstrate that there is a variety of techniques that may be employed to reduce releases of chromium to the aquatic environment. These could range from total elimination of releases by using the appropriate application systems (e.g. 'no-rinse' chemcoaters for coil coating) to treatment of wastewater to precipitate Cr(VI) as Cr(OH)₃. These technologies already find application in this sector. On the other hand, the BREF Document on Speciality Inorganic chemicals describe the treatment of wastewater which essentially entail the reduction of Cr(VI) to Cr(III) by the addition of excess sulphur dioxide or sodium hydrogen sulphite and the precipitation of Cr(III) hydroxide. There is no information of wastewater treatment techniques in the BREF Document for Large Volume Inorganic Chemicals – Solid and Others (which applies to the manufacture of chromate pigments and leather tanning salts).

As discussed above, measures taken by individual sites under the IPPC Directive will also impact upon the levels of chromium in sewage sludge at the local WWTP.

Water Framework Directive: the Water Framework Directive incorporates the provisions of Directive 76/464/EEC (which will be embodied to the Water Framework Directive in 2013). In that respect, the Directive already provides a framework for controls on emissions of Cr(VI) to the aquatic environment. These controls are taken at the national level and may be emission limits and/or environmental quality standards.

The Water Framework Directive requires that Member States identify any pressure from human activities on the quality of waters at the river basin level. If such pressures for specific chemicals are identified, then national environmental quality standards for each relevant chemical substance need to be introduced. The development of the standards will follow a similar process as in the RAR (i.e. use of data on ecotoxicological effects and suitable safety factor – see Section 4.1.9). The PNEC_{water} value in the RAR is the result of extensive analysis and it is expected to be a starting point for setting the national quality standards in RBMPs, although the limitations and uncertainties underlying the RAR should also be taken into account. There is already evidence that Member States are considering the RAR as a starting point for their approach on the development of national quality standards (see Section 4.3.8 on proposed national measures in Finland).

This approach allows for the identification and targeting of only those chemicals that are of relevance and by thus it ensures the effectiveness and efficiency of Member States' actions for the protection of the aquatic environment.

It is believed that the approach to be taken under the Water Framework Directive will deal with any shortcomings of the 'old' system under Directive 76/464/EEC and address the delays experienced to date in the implementation of the older Directive. However, the Water Framework Directive could be even more far fetching. **If** the Commission decides to include chromium in the list of priority substances (Annex X), then any measures would be taken at the Community level. **If** chromium is included in the group of priority hazardous substances, then the aim of the measures will be the cessation or phase-out of releases and losses of chromium to the aquatic environment. It is not clear at this point in time what the likelihood of this happening is; this RRS does include a recommendation for inclusion (or non inclusion) of chromium in the list of priority substances (this will depend on the results of the analysis of pressures at the national level and will be decided by the Commission and the Member States in due course, if chromium is included in the revision of the list of priority substances).

In short, the Directive has the potential of reducing the risks to the aquatic environment either with or without the inclusion on chromium in the list of priority substances, although inclusion would harmonise the risk reduction approaches across the Community (but could also result in considerable implications to the industry sectors of concern should chromium be added to the group of priority hazardous substances).

Sewage Sludge Directive: at present, the Sewage Sludge Directive does not include any requirements on the chromium content of sewage sludge or of the receiving soil. Therefore, for this Directive to be an effective risk reduction measure, an amendment would be required to introduce the relevant provisions. As discussed in Section 4.1.3, although an amendment to the Directive has been discussed and partially acted upon twice in the past (in both cases, limits on chromium were being considered), there appears to be no intention at the Commission level for such an amendment to the Directive. However, in the light of the conclusions of the RAR (and taking into account the uncertainties in the RAR and the gaps in information on existing controls in Member States), this RRS considers the amendment of the Directive as a possible means for introducing further risk reduction measures.

If a limit value for chromium in sewage sludge and soil is set at an appropriate level, any risks to the terrestrial environment from the application of sewage sludge will be effectively controlled. It is important to emphasise again the fact that despite the lack of specific limit values for chromium in the 1986 Directive, several EU Member States (most likely most, if not all of them, although specific data for a number of countries is lacking) already have in place national measures controlling the chromium content of sewage sludge. The weighted average concentration of chromium in the sludge in the EU for 1999 was 73 mg/kg dry weight. Under the assumptions made in the RAR (TGD), this would lead to chromium levels in soil lower than the PNEC_{soil} value for Cr(III) (2.8 mg/kg wet weight). On the other hand, some of the existing national limits

on the chromium contents of sludge could, in theory, provide insufficient protection to the terrestrial environment (again on the basis of the assumptions in the RAR).

Note that measures taken (either existing measures or new ones as a result of this RRS) to control emissions to water (will) also result in the reduction of the quantities of chromium ending up in sewage sludge.

7.3.3 Practicality

Applicability

IPPC Directive: The IPPC Directive applies to all industry sectors of concern, however, very limited information on the chromium compounds industry sector has been made available and as a result there is no specific discussion on BAT for the sector

For the metal finishing sector there is a vat size threshold limit of 30m³ over which the provisions of the IPPC Directive apply. Consultation has been undertaken to identify what proportion of EU metal finishing shops fall under IPPC. It appears that the majority of installations are SMEs and only a fraction of the total number of sites may fall under IPPC. This of course depends on the approach of each Member State. In countries like Belgium and France (and reportedly in Germany too), the interpretation/implementation of the Directive is such that all sites are covered by IPPC. In other countries, the 30m³ threshold limit may simply be used to identify which authority will issue a permit, although all sites will need a permit.

It is of note that within the Technical Working Group (TGW) at the EIPPCB responsible for developing the relevant BREF Document, there have been long discussions on the threshold value (which could change when the Directive is revised). The conclusion of these discussions was that 30 m³ is the total volume of all the vats within an installation used for process steps involving alteration of the surface as a result of an electrolytic or chemical process. Many installations operate a mix of small and larger production lines, each involving a selection of electrolytic and/or chemical processes. Clause 2 of Annex 1 to the Directive applies the 30m³ threshold to the sum of all the capacities of vats for all the relevant processes. The TGW agreed that this means that all relevant (electrolytic or chemical) processes regardless of size must be considered in the information exchange for the development of the BREF Document; however, the volume threshold is relevant to permitting authorities and operators deciding which installations are controlled by IPPC (EIPPCB, 2002).

With particular regard to the on-site reduction of Cr(VI) to Cr(III) by EU tanneries, the relevant BREF Document could be amended to include a reference that the on-site reduction of Cr(VI) substances to Cr(III) tanning salts does not represent BAT. The aim would effectively be to prevent tanneries from employing this practice.

Water Framework Directive: the Directive directly applies to chromium. Chromium and its substances are included in the indicative list of the main pollutants (Annex VIII to the Directive). Moreover, the Directive does not make any distinction

between industrial sectors because it is not focused on sectors but rather on RBDs and their management. Naturally, measures at the national level may be taken only if chromium is identified as a relevant pollutant for any given river basin, while measures at the Community level may be taken only if chromium is included in the list of priority substances.

Sewage Sludge Directive: prior work on the revision of the Directive has been undertaken in the past, therefore, the issues are well known to the Commission services. Moreover, impediments such as the need for unanimity at the Council which hindered the adoption of a revised Directive in the late 1980's-early 1990's have reportedly been alleviated (Marmo, 2005). On the other hand, the fact that a revision of the Directive has been planned and carried forward to a point twice in the past without any result, shows that any such revision may not be as straightforward. At the same time, the uncertainties in the RAR coupled with the documented real measurements of chromium in sludge from Member States which do not cause concern do not support the case for the revision of the Directive (i.e. the harmonisation of approaches in Member States).

Flexibility

IPPC Directive: perhaps the most significant advantage of the IPPC approach is the flexibility that it allows in the level of effort required by each company to meet the requirements set by legislation. Permits are to include measures to ensure a high level of protection for the environment as a whole (Article 9). These include emission limit values or equivalent measures based on the best available techniques (Article 9 (3, 4)) without prescribing the use of any technique or specific technology. The permit must take into account BAT, the installation's technical characteristics, its location and the local environmental conditions. Each site will decide upon the most cost-effective approach in meeting the requirements of the permit as well as choose the most cost-effective means of disposing the hazardous waste it produces.

Water Framework Directive: as it stands, the Directive requires Member States to take into account local characteristics of river basins when setting controls on relevant pollutants. If chromium was included in the list of priority substances, then Community-wide measures would apply. In any case, the installations that release chromium to the aquatic environment would have to choose their preferred means for controlling their emissions. However, if chromium was made a priority hazardous substance, industry would have far less room for manoeuvring since the aim would then be the cessation or phase-out of releases and losses of chromium to the aquatic environment.

Sewage Sludge Directive: any limit set on the concentration of chromium in sewage sludge would not allow for great flexibility in handling the sludge: if the limit was exceeded, the sludge would not be used for land spreading. At the same time, the operators of WWTPs could be flexible in choosing between reducing the chromium levels in the wastewater on-site or setting more stringent requirements on chromium levels within the discharge consents of their customers (in Member States where such a discharge consent system exists).

Simplicity

IPPC Directive: This measure may not be as simple as marketing and use restrictions. However, chromium is a known pollutant and the framework under which IPPC-related measures will be introduced has existed for some time and installations should be familiar with negotiating their actions within these framework. For sites covered by IPPC, the authorities issuing permits should be in position to provide guidance (especially to smaller companies) on meeting the requirements of legislation.

Water Framework Directive: the development of RBMPs may be quite complicated for Member States as this is a new approach in water management. More generally, the way the Directive is to be implemented in practice is something Member States do not have experience in. Similarly, the development of Environmental Quality Standards for chromium could be relatively complicated: many Member States may not have previous experience in setting quality standards. Moreover, the effects of chromium in the aquatic environment depend on a number of factors such as water hardness, speciation, etc., therefore, choosing the appropriate Environmental Quality Standard may be particularly complicated (and possibly controversial).

Sewage Sludge Directive: the introduction of a limit on the contents of chromium in sewage sludge within the Sewage Sludge Directive could be a complicated issue taking into account past failures for a revision to be seen through and the fact that although the RAR provides an extensive discussion on the potential risks to the terrestrial environment, uncertainties on the extent of these risks are still present. It would require consultation and consideration of practices at the national levels at different Member States before any limits for chromium could be decided upon. If the limits were decided, chromium would be added to the list of parameters to be assessed when deciding on the suitability of sludge to be spread on land. It is unknown what practical implications for WWTP operators would the inclusion of chromium in the assessment parameters have.

Timing

IPPC Directive: the IPPC Directive applies already to new plants falling under its provisions. For existing plants, compliance should be achieved by the end of October 2007.

Water Framework Directive: the programme of measures taken under the first RBMPs is to be made operational by 2012 and the environmental objectives of the first RBMPs are to be achieved by 2015. The environmental objectives should be set by 2009.

Sewage Sludge Directive: it is unclear what the timeframe for revision could be given the recent abandonment of the revision of the Directive and the priority given by the Commission to the development of the Thematic Soil Strategy. If the revision was included in the development of the Strategy, the time required for any revision to be completed could be made shorter.

7.3.4 Economic Impact

Costs to Industry

IPPC Directive: it is unclear what the costs to industry will be since it is not known what proportion of the sites within the industry sectors of concern will need to take measures and invest in new technology and systems to allow them to achieve the required reduction in emissions. It is of note that all companies that have returned a completed questionnaire appear to be controlling their Cr(VI) emissions at levels that do not pose a risk to the environment. Several of those have pointed out that they believe they already apply BAT to their operations.

In any case, changes to be introduced and investments to be made in installations affected by any proposed risk reduction measures will not be introduced merely for the control of Cr(VI) emissions. Most likely they will take place as part of each installation's effort to meet the overall requirements of its permit. Therefore, any such costs should be attributed to the implementation of IPPC rather than to this RRS.

Water Framework Directive: Similar to above for IPPC, it is not known what proportion of the sites involved will need to take additional measures to reduce their emissions to acceptable levels to achieve any quality objectives for the aquatic environment. If chromium is included in the list of priority substances the costs may be higher, especially if the substance is included in the group of priority hazardous substances. In that case, the need for cessation of emissions may require additional measures and could effectively result in the substitution of the substance if cessation of emissions cannot be met by other means (although the currently used methods for the treatment of wastewater could, in theory, result in 'nil emissions').

Sewage Sludge Directive: the cost to industry from a revision of the Directive is unknown. In any case, the operators of the WWTPs would have to test the sludge for an additional metal (chromium) and, where necessary, take action to reduce concentrations to acceptable levels. The cost of these measures would probably be passed on to their customers i.e. the holders of discharge consents.

Costs to Consumers

All measures: costs to consumers cannot be foreseen at present but they are expected to be lower compared to those resulting from restrictions on the marketing and use of the Cr(VI) substances. An exception could arise from inclusion of chromium in the group of priority hazardous substances of the Water Framework Directive which may effectively require the replacement of chromium. Then, the costs could be equivalent to those of marketing and use restrictions.

Costs to Regulators

IPPC Directive: any measures relating to Cr(VI) emissions are not expected to result in significant additional costs to the authorities beyond the general costs associated with the implementation of the IPPC Directive.

Water Framework Directive: the cost to the regulators is not known. This will depend on the identification of chromium as a relevant pollutant at the national level, its possible inclusion to the list of priority substances (Annex X) and its potential characterisation as a priority hazardous substance.

Sewage Sludge Directive: the addition of chromium to the pollutants monitored for in sewage sludge prior to its use for spreading on land should not entail significant cost to the regulator compared to the current regime under the Sewage Sludge Directive.

Number of Affected Organisations

All measures: as discussed above with regard to costs to industry, the number of installations to be affected by this combination of legislation will depend on the number of installations that currently achieve the required level of control on Cr(VI) emissions. This will most likely be much smaller than the number of organisations affected by a possible introduction of marketing and use restrictions.

Types of Businesses Affected

All measures: some of the sectors involved include a considerable number of SMEs. It is not necessary that all SMEs may need to modify their processes and enhance their emission controls. For example, a significant proportion of metal finishing companies that have submitted information for the purposes of this RRS are SMEs and their current controls on emissions are sufficient.

Proportionality

All measures: these measures are inherently more proportional than marketing and use restrictions, as they target the outputs (emissions) rather than the processes. Those sites that are found to pollute will have to introduce changes (process changes, changes in chemicals used, changes in emission controls, etc.) to ensure that they do not breach the relevant national and Community legislation. Those who already control their emissions adequately will not have to bear an additional cost for emission reduction. It is possible, however, that the need to achieve BAT may pose an excessive burden on smaller companies that have limited resources and flexibility in meeting legislative requirements.

7.3.5 Monitorability

Available Networks

All measures: these measures will employ the existing monitoring networks that have been established as a result of Community-wide (IPPC) and national legislation on emissions control and environmental protection. The Water Framework Directive may be considered to be an exception since monitoring networks required by it may not be in place already but will be set up during the implementation of the Directive by Member States. It should be noted that under Directive 76/464/EEC, Member States should have already developed pollution reduction programmes for list II substances

(such as chromium and its compounds). Information available suggests that most Member States have either developed such programmes or are in the process of doing so, although it is unclear whether these programmes specifically target chromium.

Further Monitoring Arrangements Needed

All measures: as mentioned above, the Water Framework Directive may require additional monitoring networks to be installed. However, it is expected that any such network will be introduced as part of the implementation of the Directive rather than as a result of this RRS.

7.4 Economic Instruments

7.4.1 Overview

Potential use of economic instruments in limiting the identified risks was discussed in Section 5. In relation to the sectors of concern, a number of instruments could, in theory, be effectively used in addressing the risks. These are:

- an emission charge to be levied on the industry sectors using Cr(VI) substances and their formulations;
- a product charge applicable to the products produced by the industry sectors using Cr(VI) substances and their formulations;
- a tradeable permits system to reduce Cr(VI) consumption or to limit its emissions; and
- liability regimes: instruments such as a performance bond that could be used to reinforce voluntary commitments to reduce the use of Cr(VI) substances to levels where associated risks are deemed to be acceptable or to employ technologies at sites that limit environmental emissions

Whilst the use of economic instruments would certainly provide an incentive to companies to reduce their emissions of Cr(VI), it would not guarantee that local risks associated with any one site are reduced to a 'protective' level. For example, the financial incentive to reduce emissions provided by an emissions charge may not be sufficient to induce any one company to introduce additional emissions controls. However, in terms of the overall quantity of Cr(VI) emitted to the environment, these types of measures could be relatively effective in reducing the level of risk posed to the environment.

7.4.2 Effectiveness

Emissions charge: Under an emissions charging regime, a charge (or tax) would be levied on each unit of emissions of Cr(VI) from sites that use Cr(VI) substances and/or their preparations. The emissions charge would have to be set at a level high enough

to ensure adequate control of the risks from companies whose emissions are associated with unacceptable levels of risk. The advantage of this approach is that it provides an incentive to all dischargers to reduce emissions but penalises most those with higher emission rates.

Owing to a lack of specific information on the costs of adopting controls at individual sites, it is not possible to calculate a minimum charge rate at present. The rate would be calculated using detailed information on emissions and the costs to different facilities in adopting emissions control; as noted above, it is uncertain what level of emission controls is in place at each site, their efficiency and what further controls would be required.

In terms of the effectiveness of emissions charges in reducing the environmental risks to acceptable levels, it is important to note that emissions charges provide no certainty in terms of the final outcome. They would act to provide an incentive to sites to reduce emissions, but the companies may prefer to pay the charge rather than to respond by introducing further emission controls. As a result, they cannot guarantee the desired reduction of emissions to acceptable levels.

Product charge: In order to create a sufficient price differential to stimulate changes in the use of Cr(VI) in industrial production, a charge on products containing Cr(VI) would need to be high enough to make it a market differentiating factor. This means that the increase in price for products containing Cr(VI) would have to outweigh other factors, such as the costs of switching to an alternative substance.

Other issues to be taken into consideration when setting the level of charge include:

- the availability of alternatives; and
- the environmental and health effects of the potential substitutes; at present, limited information on the effects of potential substitutes is available, therefore, the overall environmental benefits (or otherwise) of substitution cannot be assessed.

On the basis of information provided in Section 6, possible alternatives to Cr(VI) may be up to ten times more expensive for metal finishing applications (the only of the sectors of concern for which some cost information is currently available). Therefore, the charge rate could be as much as ten times the price of Cr(VI) substances.

A product charge would, however, provide no certainty that risks would be reduced to an acceptable level. Companies may be willing to pay the higher cost if there are significant technical benefits or if clients demand the use of Cr(VI). Assuming a price is set sufficiently high, an incentive to move to substitutes should be provided and most companies would be likely to shift once substitutes were developed that provided the appropriate level of performance, given the competitiveness of the market.

Tradeable permits: Tradeable permit systems are generally thought of in terms of trading in emissions of Cr(VI) to the environment or setting a ceiling on the quantity

of the commercial product that could be consumed within the EU. Permits would then be auctioned to prospective users and acquired by the highest bidders. The proceeds from the auction could be used to fund the administration of the system, including monitoring activities. An alternative way is to allocate permits for the use of Cr(VI) to the sites involved, for example on the basis of current usage (in a procedure known as ‘grandfathering’).

The benefit of this measure is that it fixes the amount of Cr(VI) that can be emitted or consumed in the EU in the sectors of concern and would not allow for the levels emitted or consumed to be increased in the future. Furthermore, restrictions could be placed on those potential buyers entering the auction market, such as requirements on emissions controls or on the life of a permit (to allow for a review of the system in the future).

However, the performance of the measure will depend on market interactions among the permit holders and, in any case, cannot guarantee that emissions at the local level would be reduced to an acceptable level.

Liability-based schemes: Introduction of a voluntary agreement in conjunction with a performance bond could increase the effectiveness of such an agreement by providing an additional financial incentive for compliance amongst participating companies. The effectiveness of this measure depends considerably on the level of the bond. A rate that is too high may impact upon the companies’ ability to invest in new technologies or products, while if set too low it may prove a weak incentive for companies to either invest in emission control measures or alternative technologies or products.

7.4.3 Practicality

Applicability

Emissions charge: The practicality of the measure relies heavily on the structure of the sectors involved and also the differences across the sectors. The companies involved would have to register their use and emissions of Cr(VI) on an annual basis. This could be a complex procedure if a large number of companies are subject to the measure (for example, the metal finishing sector).

Product charge: The introduction of a product charge would entail the setting of the charge, which as described above, is not always a straightforward task for the regulators. From an administrative point of view, following the setting of the charge there would be the need to trace the supplying of Cr(VI) from the producer/suppliers of Cr(VI) to the sectors of concern. At present there is only one producer of Cr(VI) in the EU and the amounts of Cr(VI) imported are considerable. Information obtained during consultation suggests that for some applications, the vast majority of the Cr(VI) substances used is not produced in the EU (this applies to three sectors of concern: manufacture of metal finishing formulation, manufacture of pigments and manufacture of tanning salts). Both producers and importers would have to declare and register the quantities that they supply to their downstream users for the charges to be levied upon

the users of Cr(VI). It is believed that these companies are able to accurately trace the industries to which their product is supplied, although the number and identities of suppliers is currently unknown.

Tradeable permits: The setting of permits is a complex procedure that needs to take into consideration the following:

- the initial quantity of permits;
- the distribution of the permits among the companies involved;
- the rate of reduction of the total number of permits;
- whether to allow banking and borrowing; and
- whether to create a single market for all sectors of concern or create separate markets.

Additionally, in some respects, a tradeable permits scheme would have similar requirements to an emissions or products charge. Again, information would be needed on the amounts of Cr(VI) being sold to companies in the sectors of concern (same as a product charge) or information on emissions from each site (same as an emissions charge). The latter would have practical complications for sectors that involve a considerable number of sites. In general, this option appears less practical than the charges discussed above.

Liability-based schemes (performance bonds): With regard to performance bonds, it is generally difficult to achieve full participation of the companies concerned especially when the number of companies is large and when such an approach needs to expand beyond the limits of a single country. In addition, it is not certain that all companies would be willing to enter such a voluntary scheme.

Flexibility

The flexibility of any such system is difficult to predict and would rely upon the functional parameters of the system.

Simplicity

Economic instruments are not simple either in setting them up or in managing them. Especially for sectors that involve a significant number of SMEs, it would be difficult to involve and explain the practicalities of any such regime to participants.

Available Frameworks

It is currently unclear how economic instruments could be given legal force through EU legislation. Directive 76/769/EEC may provide the most appropriate legal framework.

Timing

The timing of the above measures cannot be foreseen. Implementation of these measures would require negotiations among the interested parties before their details are agreed upon.

7.4.4 Economic Impact

Emissions charge: The impact of an emissions charge will depend on the level of charge and the reaction of each company to the introduction of the charge. Companies may choose to pay the charge and carry on their processes as usual; alternatively, they could opt for reducing their emissions by upgrading their facilities. A third option would be to improve the wastewater treatment facilities to the extent that the cost of the emission charge is lower than the cost of installing and operating more sophisticated equipment. The choice will depend on the current levels of emissions at each site and the financial capabilities and calculations each company would make. It should be assumed, though, that companies will adopt the least costly option for action.

When assessing the economic impacts of this option, the costs of administering the measure should be included. The costs for the regulator would depend on two factors:

- *the number of sectors and of companies involved:* the smaller the number, the easier to administer and monitor the emissions charge; and
- *the requirements for registration of emissions:* emissions would need to be registered on an annual basis. If such registers can be made available through the existing legislative framework (for instance, IPPC or other similar monitoring systems), the administrative costs would be lower.

Product charges: The charge rate should be set at a rate higher than the cost of substitutes with companies then having two options: either pay the tax and continue to use Cr(VI) or abandon Cr(VI) in favour of alternative substances. Under the first option, companies could choose to merely pay the tax without any changes in the use of Cr(VI) (without any alterations to the equipment used in their processes, for example). This would produce revenue but no real environmental benefit.

The second option would involve reformulation or re-design of processes to adapt production to the new chemicals used in place of Cr(VI). Section 6 provides some information on the costs associated with replacing Cr(VI) with alternatives ones.

With regard to administrative costs, resources would need to be devoted to identifying the potential substitutes and the price differentials (if dealing with more than one application of Cr(VI)).

Another issue to be addressed within a product charge scheme is the availability and use of the funds collected through this form of taxation. While they could be used to fund research activities that would help to better protect the environment and lower the costs of production, they could also be used to improve emissions controls.

Tradeable permits: As with the charging-based systems, users of Cr(VI) would be free to determine whether they should respond to the instrument by ceasing use or by remaining in the market. If they choose the latter, they would have to establish their willingness to pay for the use of the substance in order to determine their maximum auction price.

For the regulator, the costs would depend on the resources allocated for deciding the nature of the permit on the basis of the factors described above. If the initial allocation is made by an auction, then the administrative costs will be lower than grandfathering as this would involve establishing the basis for allocation and verification of the permits on a site-by-site basis. If emissions monitoring is performed under an existing framework, such as IPPC, this could result in a lower cost to the regulator, although it may not be entirely safe to rely on IPPC for the monitoring of all relevant sites (due to threshold limits set in Annex I to the IPPC Directive).

Liability-based schemes: The cost of setting a performance bond obviously entails a bond being deposited by the participating companies and a cost for the overseeing authorities that need to assess the characteristics of the sectors involved and decide upon the level of the bond. Administration issues that need to be addressed are how and by whom the bonds are held and who would be the beneficiary of any interest earned from a centrally deposited and held bond. Any such revenue could be used to offset part of the costs incurred by the regulators that administer the bond, although this is to be decided upon in advance.

Proportionality

In comparison to restrictions on marketing and use, economic instruments could offer a more proportional approach to the reduction of risks: in theory, those who pollute the most would also have to pay the most. However, some economic instruments could prove ‘undemocratic’: only those with funds available would be able to bid for tradeable permits leaving the smaller player in the market in an even more disadvantageous position.

7.4.5 Monitorability

Available Networks

Emissions charges: The monitoring of an emissions charge scheme may be facilitated by the presence of established monitoring networks, such as those that currently monitor emissions under existing legislation (i.e. IPPC).

Further Monitoring Arrangements Needed

Emission charges: As discussed earlier in this Report, the IPPC framework may not cover all installations of concern (due to the presence of threshold limits), although it has been confirmed that in several Member States non-IPPC installations are regulated and monitored alongside IPPC ones. Therefore, additional monitoring networks could be needed.

Product charges: For a product charge scheme to be functional, systems would need to be put in place at the point of import for recording quantities and/or their composition. However, this type of approach would rely on declarations by importers, as it could be difficult for Customs authorities to monitor imports otherwise. The potential for charge evasion will exist unless the producers were also willing to provide records of sales for cross-validation purposes.

Monitoring of the submission of charge duties from companies using Cr(VI) in their production lines would also be necessary, although the regulators in Member States are expected to have the necessary infrastructure for such monitoring.

Tradeable permits: If trading of permits was allowed, systems would be required to register and monitor any trade to ensure that there were adequate environmental controls in place in the facilities buying up permits. In general, it is expected that the implications of undertaking this monitoring could make these instruments relatively less favourable compared to some of the other potential risk reduction measures being considered, although no quantified information is available for a more robust conclusion to be drawn.

Liability-based schemes: The monitorability of a voluntary agreement will depend on the targeted companies. If only a small number of companies are involved, monitoring would not be difficult. However, there may be companies that do not belong to a EU trade association (which could organise the inception and implementation of such a scheme) and this could complicate the development of an agreement.

7.5 Provision of Information

7.5.1 Overview

At this stage, the following measures would appear to be relevant:

- accurate hazard information (for example, safety data sheets), and/or better delivery of safety information, such as clearer labelling or the provision of warning signs in the workplace; and
- training.

There are three general types of standards/guidance:

- statutory (failure to comply is an offence unless it can be demonstrated that other means of compliance are equally effective);
- advisory (no obligation to follow, but degree to which they have been followed could be used as evidence in prosecution); and
- voluntary (no direct or legal consequences).

An example of such a measure is the Code of Practice that has been developed by the BWPDA with regard to the operation of wood treatment facilities (see Annex 3). This is intended to give practical guidance on environmental, safety and health issues relevant to all companies engaged in the activity of industrial wood preservation. There is no statutory obligation to adopt this Code, but in doing so participants confirm their commitment to ensure full compliance with current legislation and to adopt progressive practices by continuous improvement. Compliance with the Code would be taken into consideration by the regulatory authorities in determining whether to take enforcement action and may be taken into account by the courts in the event of prosecution (BWPDA, 2003).

Consultation suggests that several companies, apart from complying with the Safety Data Sheets, the Classification, Packaging and Labelling Directives, they offer guidance and training to their customers/downstream users. This applies to the producer of Cr(VI) substances and the formulators of Cr(VI) preparations for use in metal finishing. Representatives of these organisations visit the downstream users on a regular basis to discuss with and advise them on the appropriate use of their products.

7.5.2 Effectiveness

Any guidance cannot guarantee the required level of reduction because its success relies on the willingness of the polluters to comply with the guidance. In general, the provision of more information on hazards and relevant training of personnel are measures that complement the adoption of any further process controls to limit emissions within the industry sectors of concern. Although this linkage is not necessary, any such guidance may be used as documentation of the aims and targets of other more binding measures, such as legislation, or as a walk-through for individual companies in choosing and implementing new technologies that will allow them to comply with new legislation.

Any form of guidance will ideally be disseminated to all members of the relevant association and (hopefully), even beyond, to ensure that its contents may influence the practices in the entire industry sector in question. As a risk reduction measure, guidance can only appeal for voluntary action unless it is statutory.

In theory, guidance may also be used to document the aims and objectives of a voluntary agreement.

7.5.3 Practicality

Applicability

Guidance may be provided to all sectors of concern (as happens already to an extent). It would require trade associations to take a pro-active approach in environmental issues, invest time and money in consulting and developing the guidance, and would ideally be wide enough to encompass the majority if not the entirety of the industry sector they represent. In most cases, trade associations only represent part of their

sector. Therefore, it may be necessary to rely on the actions of individual companies (for instance, formulators).

Flexibility

The contents and dissemination of the guidance may be agreed upon by the members of the trade associations and the regulators. In this respect, there are few limits to be imposed on the development of the guidance.

Simplicity

The guidance may be as simple or as complicated as the trade association (or formulators in collaboration with their downstream users) finds necessary to accommodate the needs and competence of their members. In terms of the development of the guidance, it is expected that all trade associations have experts or may ask for expertise from their members for developing it.

Available Frameworks

There is no automatic framework for development of such guidance, although examples may be found in other such initiatives (for example, the Code of Practice by BWPDA or the guidance prepared by UK SEA, see Section 4.4.1).

Timing

It is unclear how long it would take for such guidance to be developed; nevertheless, it could probably require a shorter timeframe compared to marketing and use restrictions, legislation on emissions or economic instruments.

7.5.4 Economic Impact

Cost of Developing the Guidance

The cost of developing the guidance itself is expected to be small and, in comparison to other risk reduction measures such as marketing and use restrictions, would be negligible. Regarding the costs of measures that may be taken as a result of the guidance, these could vary greatly: they could range from very low (for example, the cost of simply disseminating to employees to raise awareness with regard to control of emissions of Cr(VI)) to costs equivalent to those of legislation on emissions control (for example, when statutory guidance requires emissions to be reduced below specific levels).

Proportionality

No specific issues of proportionality would arise under this measure, however, it should be considered whether reliance on this measure for the reduction of risks is proportional to the level and complexity of the risks.

7.5.5 Monitorability

With most forms of non-statutory industry guidance and standards, monitorability and enforcement is likely to be less robust than statutory conditions of use, as the agreements are, in part, based on trust.

Monitoring success will depend upon the number of sites involved, the quality of the relationship between individual sites and the trade association, and on the type of guidance (if statutory, regulatory authorities may be involved in the monitoring process which, while providing some additional guarantee of 'compliance', will entail an additional cost to the authorities).

7.6 Negotiated Voluntary Agreements

7.6.1 Overview

As discussed in Section 5, in the case of Cr(VI) substances, a negotiated voluntary agreement could take the form of one of the following:

- an agreement to modify the process technologies used, such that risks from Cr(VI) substances are below a certain level; or
- an agreement to phase-out the use of Cr(VI) substances or to reduce and limit use to a certain level.

To ensure success, the agreement could be accompanied by relevant legislation.

Formal environmental agreements can stem from a variety of drivers. Firstly, they can be purely spontaneous decisions initiated by stakeholders on issues which the European Commission has neither proposed legislation nor expressed an intention of doing so. Secondly, they can represent a response by stakeholders to an expressed intention of the Commission to legislate. Thirdly, they can be initiated by the Commission itself.

The Commission adopted on 17 July 2002 a second Communication on Environmental Agreements. A first Communication on Environmental Agreements was adopted in 1996 (COM(1996)561 final 27/11/1996) followed in 1997 by Council Conclusions (OJ C 286 of 22/09/1997 p. 254) and a Resolution from the European Parliament (OJ C 321 of 22/10/1997 p. 6).

In the 1996 Communication, the Commission recognised that environmental agreements held a number of potential benefits, including:

- a pro-active approach by industry;
- cost-effectiveness and tailor-made solutions; and
- faster achievement of environmental objectives.

The most recent Communication presents how the provisions of the recently adopted Action Plan "Simplifying and improving the regulatory environment" with regard to co-regulation, self-regulation and voluntary sectoral agreements can be applied in the context of environmental agreements (COM(2002)278 final of 05/06/2002).

According to the proposals in the Action Plan, the Commission may also encourage or acknowledge them (under self-regulation) or propose to the legislator to use them when appropriate (co-regulation).

Self-Regulation: Once the Commission has completed its analysis of a proposed environmental agreement, it may inform the European Parliament and the Council of its evaluation and conclusion, indicating whether it considers that an agreement can be acknowledged. Such an intention to acknowledge an environmental agreement could be included in the Commission work programme or a broader paper, for example a sufficiently detailed White Paper or a Thematic Strategy under the Sixth Environment Action Programme.

In the environmental field, the modalities used so far at Community level to acknowledge self-regulation include Commission Recommendations and, in some instances, a simple exchange of letters. In other words, the Commission may stimulate an environmental agreement by means of a Recommendation or recognise it by means of an exchange of letters with the relevant industry's representatives.

A recent example is the unilateral industry self-commitment negotiated among chemical companies using renewable as well as fossil raw materials as feedstock for their production. The European Commission through its informal working group of DG Enterprise and Industry on "Renewable Raw Materials for Industry" played a facilitating role in the development of that agreement.

In certain cases, the Commission and the legislator may have an interest in the results of an environmental agreement and may, therefore, wish to monitor it closely, for example by combining a Commission Recommendation with a Parliament and Council Decision on monitoring.

Co-regulation: Under co-regulation arrangements, the European Parliament and the Council would adopt, upon a Proposal from the Commission, a Directive. This legal act would stipulate that a precise, well-defined environmental objective must be reached on a given target date. It would also set the conditions for monitoring compliance.

Under co-regulation, key elements (notably the environmental objective and monitoring requirements), and potentially also a follow-up mechanism in case of failure of an environmental agreement to deliver, are integrated into the legal act itself. The latter is subject to stakeholder consultation during its preparation, in line with the Commission Communication on minimum standards for consultation, and is adopted under a normal co-decision procedure. Given the aforementioned content of the legal act itself, procedural requirements for individual environmental agreements submitted in the framework of the legal act can be reduced.

Where the Commission decides that co-regulation is the best means of achieving an environmental objective and where key elements of its proposal are based on an existing or proposed voluntary agreement, which is satisfactory from the Commission's point of view, the Commission will include these elements in its proposal and pursue them in discussions with the other institutions, making full use of the possibilities available to it in accordance with its Communication on the Action Plan "Simplifying and improving the regulatory environment"³².

7.6.2 Effectiveness

An agreement to ensure that emissions from the processes of concern are below a specified level could, in theory, provide the same level of environmental protection as emission limits or quality standards established through the legislative route. As with most such 'voluntary' agreements, there exists the possibility that some companies will not participate in the agreement or will not comply with its requirements. This could reduce the level of environmental protection afforded by such a mechanism and could also competitively disadvantage those companies that do comply.

Similarly, a voluntary cessation or phase-out in the use of Cr(VI) substances for the applications of concern could essentially have the same effect as legal restrictions on marketing and use, in terms of reducing risks to the environment. There would also, however, be the same issues regarding the potential risks associated with substitutes.

However, the nature of voluntary agreements cannot guarantee the absolute success of the measure and the reduction of risks to an acceptable level. It may be the case that individual companies are not members of a wider organisation (a trade association) which can co-ordinate the actions of individual companies. The introduction of relevant legislation may provide some assurance that the individual companies adhere to the provisions of the agreement.

Environmental agreements will neither replace all legislation and regulation, nor be a panacea for solving present and future environmental problems. Complementary legislation may be necessary to set clear, achievable objectives and targets.

The most comprehensive survey so far on the use of environmental agreements was undertaken by the OECD (OECD, 1999). It concludes that environmental agreements are most efficiently used as part of a policy mix alongside legislative and economic instruments. For the EU alone, the OECD Report lists a total of 312 environmental agreements concluded in the Member States (based on a 1997 survey conducted by the European Environment Agency).

³² The information on formal environmental agreements is reproduced from the DG Enterprise Internet site europa.eu.int/comm/enterprise/index_en.htm

7.6.3 Practicality

Applicability

The starting point for any voluntary agreement is the willingness of industry to recognise the need for risk reduction measures and the need for introducing changes to current practices.

Consultation with companies suggests that the majority of companies involved in metal finishing would welcome a voluntary agreement to reduce emissions of Cr(VI) to acceptable levels. Thirty-two of them gave a positive answer and only four gave a negative or no answer. Similarly, the majority of the companies were in principle positive to the idea of a voluntary agreement co-ordinated by their trade association. It has to be noted that these companies are in their majority based in the UK.

On the other hand, very few companies would welcome a voluntary agreement to discontinue their use of Cr(VI) substances and formulations.

It is important to note that the majority of the companies that would agree to a voluntary agreement to reduce emissions believe that the measures they have in place are already sufficient for the targets of any such voluntary agreement to succeed. Therefore, they believe that such a voluntary agreement would not entail any significant additional cost.

With regard to the tanning sector, Cotance has indicated that it is not prepared to engage in any voluntary action, especially given that its members appear to have abandoned the on-site reduction of Cr(VI); Cotance would not object to the introduction of marketing and use restrictions on the use of Cr(VI) by tanneries.

Generally, the number of installations involved in metal finishing activities in the EU makes the prospect of a successfully organised and implemented voluntary agreement uncertain. Reaching an agreement in sectors with large numbers of SMEs or with limited awareness of the need for risk reduction could be problematic.

Achievability of targets also relies on the negotiated targets and objectives of the agreement. If the agreement requires substitution of Cr(VI) in applications where alternatives are limited, more costly, or do not meet certain performance requirements, then the agreement may have limited success. Section 6 provides some preliminary discussion on these issues. Similarly, if the agreement requires reduction of emissions to specified levels, it is important that the techniques and technologies available can deliver the required reductions. This may not be true for all alternative substances and technologies (for instance, in the metal finishing sector).

Flexibility

The flexibility of a voluntary agreement would be subject to negotiation between interested parties. It is important, however, to acknowledge the fact that the options companies make with regard to chemicals or techniques to be used may be influenced

by factors outside their control; for example, passivation of aircraft components is strictly specified by their aerospace industry customers with no concessions allowed.

Simplicity

Again, the simplicity of the agreement will depend on the negotiations between interested parties.

Available Frameworks

There is no pattern for creating voluntary agreements, although past agreements could be used as a source of ideas and experience. Every agreement is unique because it relates to a unique industry sector, using specific chemicals and having unique objectives. With regard to formal voluntary agreements, the Commission's Communications would provide a framework for such a measure.

Timing

A large sector with many players would require a longer period of organising, negotiating and implementing a voluntary agreement. However, it is possible that an agreement can be implemented more quickly than marketing and use restrictions unless there is a need to back the agreement up with legislation. This would involve consultation with the Commission and would require additional time.

7.6.4 Economic Impact

Costs to Industry

Costs to industry will vary depending on the objectives and targets of the agreements. They could be as high as those resulting from marketing and use restrictions or as low as those for preparing and disseminating guidance to interested parties. One of the perceived advantages of voluntary agreements is the ability of the contracting parties to choose the most cost-effective option in meeting their obligations under the agreement.

On the other hand, it could be costly to 'police' compliance with the agreement, especially when dealing with a large number of installations (SMEs).

Compliance costs might also be increased, at least for some parties involved, under certain conditions. This would result if a small number of firms were able to negotiate an agreement favourable to themselves, through negotiating objectives with which only a few firms could comply at reasonable cost (EEA, 1997).

Costs to Consumers

The costs to consumers will depend upon the provisions of the agreement.

Costs to Regulators

Regulatory administrative costs could be reduced by an environmental agreement approach because the pursuit of information on which policy instruments are designed is reduced. Indeed, most voluntary agreements involve the volunteering of information to the regulator by regulated parties. At the same time, the running and management of the agreement should be the responsibility of the industry and not the regulators. For instance, the identification of ‘free-riders’ and the allocation of fines or other penalties should be tasks to be performed by industry.

Number of Affected Organisations

The number of affected organisations will depend on the scope, aim and objectives of the agreement (if, for example, the agreement sets emission targets and many sites already have emissions lower than the target levels, then only a limited number of sites will actually be impacted upon by the agreement).

Types of Businesses Affected

This will depend on the industry sectors developing agreements. As discussed elsewhere in this Report, some of the sectors of concern (e.g. metal finishing) involve significant numbers of SMEs.

Proportionality

Proportionality of a voluntary agreement should be assumed to be assured for the parties involved (or else the agreement could not be agreed upon).

7.6.5 Monitorability

Available Networks

Compliance with the agreement targets should be monitored and the results of the monitoring should be (a) published to show any progress made, and (b) used in reviewing the shortcomings of the agreement and possibly recommending corrective action.

Monitoring entails a cost. This cost will depend again on the structure of the market, the frequency of monitoring and whether individual sites are capable of performing it on their own. General monitoring of emissions may already be taking place due to companies’ obligations under other existing frameworks (for instance, IPPC).

Further Monitoring Arrangements Needed

Any further needs for monitoring of compliance should be discussed at the negotiation stage and will vary in accordance with the number of sites involved and the specific targets of the agreement.

7.7 Summary of Assessment of Further Risk Reduction Options

The analysis provided above allows us to reach the following conclusions:

- marketing and use restrictions would be an inappropriate and disproportionate measure for risk reduction. The risks have been clearly overestimated in the RAR and in the majority of Member States measures are already in place which reduce unacceptable risks, if not eliminate them. Techniques and technologies currently available are able to ensure adequate control of risks;
- the most suitable and cost-effective risk reduction measure appears to be legislation to reduce emissions and exposure. More specifically, the combination of the Water Framework Directive (incorporating the provisions of Directive 76/464/EEC) and the IPPC Directive is believed to allow for sufficient reduction of risks: the IPPC Directive will address risks from sites in all industry sectors of concern and will control emissions to the aquatic environment by taking into consideration local conditions in the issuing of permits. On the other hand, the Water Framework Directive will address the management of any potential risks from Cr(VI) substances at a wider level, taking into account the characteristics of river basins of Member States. The identification of pressures in water bodies in Member States will serve as a confirmation of the importance (or lack of it) of chromium as a pollutant at the national level and river basin level. The choice and implementation of national measures for the control of risks from Cr(VI) (where such measures are concluded to be necessary) should (and is expected to) take into account the concerns on the effects of Cr(VI) documented in the RAR, issues of uncertainty that influence the prevailing risks (e.g. issues of bioavailability and speciation) as well as the discussion presented in this RRS; and
- with particular reference to the on-site reduction of Cr(VI) to Cr(III) tanning salts by EU tanneries, marketing and use restrictions would obviously be very effective in controlling any unacceptable risks, would probably have limited impact on tanneries and are supported by the main EU tanners' association. However, such restrictions may not be the most proportionate and appropriate measure. This is because:
 - the review of the data presented in the RAR and the information collected for this RRS have not provided concrete evidence of an unacceptable risk to the aquatic environment;
 - although there is a theoretical possibility that tanneries may still be using this practice (especially non-members of Cotance), the actual number of users is likely to be very small since the continuation of the use of Cr(VI) substances has a number of disadvantages from a practical and financial point of view; and
 - other legislative measures such as IPPC and the Water Framework Directive as well as the Sewage Sludge Directive (will) also apply to tanneries and their

emissions and will be generally able to provide an environmental protection as sufficient as in the other industry sectors of concern.

Nevertheless, it is acknowledged that there is a theoretical possibility for EU tanneries to be using this practice today and this could be performed in a manner less environmentally sound than the two companies that have provided site-specific use and emissions data. To address this possibility, an amendment to the relevant BREF Document for the tanning of hides and skins to characterise this practice as non-BAT would be a suitable measure that could act as an additional safety net.

- with regard to the protection of the terrestrial environment, if measures protecting the aquatic environment are properly set out and implemented, any risks to the terrestrial environment should be eliminated. However, it may be necessary to have in place legislation protecting the terrestrial environment as an additional ‘safety net’. Given that the envisaged outputs of the Soil Thematic Strategy will most likely not include a consideration of risks from the Sewage Sludge Directive, this Directive appears to be the sole appropriate instrument for regulating the chromium content of sewage sludge. The gaps in knowledge on the presence and effectiveness of national measures on the content of chromium in sludge and soil and the uncertainties in the assessment of risks presented in the RAR do not allow for a conclusion to be reached on the need for revision of the Directive. Given that chromium in sludge is in the Cr(III) form, the results of the risk assessment of Cr(III) currently being undertaken under an industry initiative should be taken into account in assessing the need for revision and in developing the appropriate limits for chromium in sludge, if necessary.

Overall, the most appropriate approach for reducing the risks identified in the RAR is largely based on existing measures and is described in Table 7.1. The applications shaded in grey are those not included in the analysis as per the discussions in Sections 3 and 4 of this Report.

Table 7.1: Recommended Strategy for Reduction of Risks from Hexavalent Chromium in the EU			
Lifecycle area	Aquatic environment risks	Terrestrial environment risks	Wastewater treatment risks
Production	No need for measures	No need for measures	No need for measures
Pigment production	IPPC/WFD	Sewage Sludge Dir <i>IPPC/WFD</i>	IPPC/WFD
Chromium (III) oxide production *	IPPC/WFD	Sewage Sludge Dir <i>IPPC/WFD</i>	IPPC/WFD
Tanning salts production **	IPPC/WFD	Sewage Sludge Dir <i>IPPC/WFD</i>	IPPC/WFD
Wood preservative formulation	No need for measures	No need for measures	No need for measures
Wood preservative application	BPD	BPD	No need for measures
Treated wood in use	BPD	BPD	No need for measures
Metal treatment formulation	IPPC/WFD	Sewage Sludge Dir <i>IPPC/WFD</i>	IPPC/WFD
Metal treatment application ***	IPPC/WFD	Sewage Sludge Dir <i>IPPC/WFD</i>	IPPC/WFD
- Electroplating	IPPC/WFD	Sewage Sludge Dir <i>IPPC/WFD</i>	IPPC/WFD
- Passivating	IPPC/WFD	Sewage Sludge Dir <i>IPPC/WFD</i>	IPPC/WFD
- Anodising	IPPC/WFD	Sewage Sludge Dir <i>IPPC/WFD</i>	No need for measures
- Brightening	IPPC/WFD	Sewage Sludge Dir <i>IPPC/WFD</i>	IPPC/WFD
<p><i>Notes:</i> For the terrestrial environment, <i>IPPC/WFD</i> is in italics to show that these measures may have an indirect impact on risks. * available information suggests that the majority of the production of Cr₂O₃ when Cr(VI) substances are used as feeding stock take place at the sites where Cr(VI) substances are manufactured ** for the on-site reduction of Cr(VI) substances by tanneries, an amendment to the relevant BREF Document is recommended. Also note that the “production of chrome tanning salts” which attracted a Conclusion (iii) in the RAR does not include production as a by-product of montan wax manufacture for which no unacceptable risks were identified. Furthermore, the above recommended measures do not apply to the sole EU manufacturer of Cr(VI) substances whose total emissions include those from the manufacture of Cr(III) tanning salts *** this does not include ECCS and tinplate passivation</p>			

8. RECOMMENDATIONS FOR A RISK REDUCTION STRATEGY

8.1 The RAR and the Underlying Uncertainties

8.1.1 Introduction

The following paragraphs present an overview of the uncertainties underpinning the RAR prepared by the rapporteur (Environment Agency, 2005). These have been referred to in Section 3 of this Report and have been taken into consideration when making recommendations for further risk reduction measures.

8.1.2 RAR Uncertainties: General Issues

The assessment of risks in the RAR applies to industrial activities involving the five Cr(VI) substances only. There has been no attempt to address risks from the use of Cr(III) compounds or chromium metal. It is possible that, in some cases, the release of a chromate compound could raise the overall levels of Cr(III) in the local environment (from all sources) to such an extent that a risk would be identified, even though no risk might occur from either the Cr(III) compound releases alone or the Cr(VI) by the 'added risk' method. Ideally this should be dealt with by a thorough risk assessment for Cr(III), taking into account the input from chromates. As discussed earlier in this Report, this is in progress as a voluntary industry initiative. Presumably, any additional controls required on Cr(VI) would be considered under that work.

8.1.3 RAR Uncertainties: Releases to the Aquatic Environment

1. Information from specific sites indicated that methods are generally used to remove chromium before discharge. Whilst the implication was that such measures were already in use in many locations, it was not possible for general conclusions to be drawn on the efficiency of such processes or the actual extent to which they are in use.
2. Process emissions to wastewater were, therefore, handled under two scenarios, i.e. assuming (a) no treatment (i.e. all releases to WWTP are in terms of Cr(VI)), and (b) reductive treatment (i.e. all releases to WWTP are in terms of Cr(III)). No assumptions were made about removal of the Cr(III) (e.g. by flocculation) before it is released to the WWTP. The fate of the two ions in the WWTP was taken into account.
3. Local receiving water concentrations were not adjusted for transformation or degradation processes according to the TGD; only dilution and adsorption were taken into account. This was handled in the assessment by expressing the water concentrations either as Cr(VI) or as Cr(III), with the assumption that all of the chromium in the dissolved phase is available.
4. The resulting PEC calculations, therefore, allowed the consideration of the two ends of the risk spectrum. In most real situations, the ion composition will be between

these extremes, with Cr(VI) in discharges being converted into Cr(III) over time and at a rate depending on the local environmental conditions. Hence, the real picture is potentially very complex, and the information available was not sufficient to allow this to be described accurately in the RAR. The calculations were, therefore, simplified out of necessity. The rapporteur acknowledges that this approach may have resulted in the over-estimation of risk under some circumstances.

5. Under the conditions of the aquatic tests it is expected that the chromium will remain predominantly in the form in which it is added. The limited data available on conditions that influence bioavailability did not support the development of quantitative relationships between toxicity and environmental properties. As tests are usually carried out under conditions of high availability, it was recognised that there may be an over-estimate of the toxicity under other conditions. The PEC values did take some account of the environmental properties, so to some degree the issue of availability was incorporated into the PEC part of the calculations. However, it was not possible to fully take bioavailability into account in this assessment.

8.1.4 RAR Uncertainties: Releases to the Terrestrial Environment

1. Similar to the case for water, information provided by specific users indicated that chromate process-related WWTP sludges were generally disposed of to landfill, although there was no overview for the whole of Europe. Any clean-up measures used before release to sewer would also reduce the amount of chromium available to absorb to sludge and so be applied to land. The rapporteur, therefore, acknowledges that the PECs are potentially unrealistic, and at the very least, are likely to be of limited applicability.
2. The $PNEC_{soil}$ for Cr(III) was derived from experiments where a highly soluble (and hence bioavailable) form of Cr(III) has been tested. In the environment, Cr(VI) is likely to be reduced to forms of Cr(III) of limited solubility and bioavailability, where it is unlikely that the concentration of “dissolved” and, hence, available Cr(III) will reach the levels where effects might be expected. This is seen in experiments with both soil and aquatic organisms when a form of Cr(III) with low water solubility has been tested.
3. Related to this last point, the available fraction of chromium in soil (available to plants and fauna) is generally low, at 0.1-1%. This could indicate that as the soils age the chromium is converted into insoluble forms which then are not available to have an effect on organisms. If a factor of 1% were applied to the risk characterisation ratios, then all but the direct release to soil from wood preservative treatment on acid soil would give a ratio less than 1. Thus the risk characterisation ratios may overestimate the effects of the chromium.
4. Finally, it was clear that there are many natural soils where the levels of total chromium are above the PNEC. However, in natural soils, the majority of chromium

will be present as low solubility Cr(III) complexes, where bioavailability is again limited. The PNEC is not appropriate for such situations.

8.2 Links between the Environmental and Human Health RARs

The five hexavalent chromium compounds were prioritised by the UK under the 793/93/EEC Regulation predominantly on grounds of their effects to human health. The ESR RAR has indeed identified unacceptable risks to human health for workers, consumers and human health via the environment. As discussed in Sections 3.5.4 and 3.5.5 of this RRS, regarding consumers and human health via the environment, Conclusion (iii) was 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, the RAR notes that exposure levels for consumers are very low. The result of these conclusions was that a human health RRS has been initiated by the UK HSE.

It is possible that the human health RRS will result in risk reduction measures. These risk reduction measures may have an impact to the extent and level of risks from the five Cr(VI) compounds to the environment and, consequently, to any environmental risk reduction measures required. At the time of writing this Report, the human health RRS had not been concluded and it was unclear what the timeline for completion would be.

8.3 Recommendations for a Risk Reduction Strategy

All stages of this project for the development of the RRS involved extensive consultation with industry in the form of questionnaires disseminated to trade associations and companies as well as with Competent Authorities from the overwhelming majority of Member States. Information was collected on the existing risk reduction measures and current practices in the industry sectors of concern. The key points of consultation and analysis are summarised as follows:

- out of three EU production plants involved in the manufacture of the five Cr(VI) substances at the time of writing the RAR, only one is still active today. This particular plant is not associated with unacceptable risks to any environmental compartment. Moreover, the emissions of Cr(VI) from the plant are lower than those quoted in the RAR and the plant is regulated both under IPPC and Council Directive 96/82/EC on the control of major accident hazards involving dangerous substances (Seveso II Directive). As a result, the RRS considers that further risk reduction measures on the manufacture of the five Cr(VI) substances are not required;
- the use of methods aiming at the minimisation of releases of Cr(VI) to the aquatic environment appears to be much more widespread than assumed in the RAR. Information from consultation for particular application areas (such as ECCS, tinplate passivation and wood preservatives formulation), shows that the emissions

of Cr(VI) may be confidently considered as posing no unacceptable risks to the environment;

- emissions of chromium and its compounds to the aquatic environment have been regulated at the Member State level since the introduction of Directive 76/464/EEC. Implementation of the Directive may have been generally slow, however, it appears at present that (at least) the majority of EU Member States have in place national legislation imposing emission limits or setting out water quality standards for chromium;
- Community legislation currently ‘in the pipeline’ or partially implemented, such as the IPPC Directive and the Water Framework Directive, are/will also target emissions of chromium to the aquatic environment;
- although the existing Community legislation on the use of sewage sludge in agriculture (Sewage Sludge Directive) does not contain any provision specifically relevant to chromium and although its amendment/revision has been abandoned twice, several Member States have in place concentration limits values for chromium in sludge and in agricultural soil. Moreover, statistics on the concentration of chromium in sewage sludge used on agricultural soil in the EU in the late 1990’s-early 2000’s show national and Community-wide average concentrations which are several orders of magnitude lower than the sludge concentrations estimated in the RAR. All average figures reported in Table 4.4 of this RRS would not result in unacceptable risks for the terrestrial environment (either arable soil or grassland). Nevertheless, some of the identified national limits on the concentration of chromium in sludge could, in theory, result in unacceptable risks to the terrestrial environment, if we accept the assumptions made in the RAR;
- the Biocidal Products Directive is the most appropriate framework for addressing (and managing, where necessary) the risks associated with the use of Cr(VI) substances in wood preservatives. Therefore, this RRS which is developed under the ESR framework will not address potential risks from the use of Cr(VI)-based wood preservatives or from the use of wood treated with such formulations. Nevertheless, Sections 3 and 4 discuss the information available today as well as issues that may need to be taken into account in the assessment of risks under the Biocidal Products Directive.

In the light of the above and the discussion presented throughout this Report, this RRS addresses the potential risks from the following applications/lifecycle stages of the five Cr(VI) substances:

- manufacture of metal finishing formulations;
- use of metal finishing formulations (excluding ECCS and tinplate passivation);
- manufacture of Cr(III) tanning salts;
- manufacture of Cr(VI) pigments; and
- manufacture of Cr(III) oxide pigments.

This RRS makes the following recommendations for an environmental RRS:

Recommendation 1: For all five applications, the main instrument for controlling local releases should be the IPPC Directive, as implemented through national IPPC licensing regulations at the Member State level. Taking into account the local characteristics for each installation and the available BAT, limits on the releases of Cr(VI) compounds to the aquatic environment should be set within the permits of each individual installation using and emitting these substances. These limits should take into consideration the discussion and conclusions of the RAR in the light of its uncertainties and assumptions made therein as well as the analysis presented in this RRS (with particular regard to the existing risk reduction measures).

Recommendation 2: With particular regard to the on-site reduction of Cr(VI) compounds to Cr(III) tanning salts by plants involved in the tanning of hides and skins, it is recommended that in the next amendment of the BREF Document for plants involved in the tanning of hides and skins, appropriate references are included to indicate that the on-site reduction of Cr(VI) substances for the production of Cr(III) tanning salts should not be considered as BAT.

Recommendation 3: Member States that have not yet assessed chromium for its relevance as a pollutant in their aquatic environment, in accordance with both Directive 76/464/EEC and Directive 2000/60/EC, should do so as soon as possible. Where chromium is proven to be a relevant pollutant but pollution reduction programmes for the control of chromium compounds are not in place, Member States should introduce appropriate programmes as soon as possible and communicate details of these programmes to the Commission. Moreover, following the analysis of pressures from industrial activities and the possible identification of chromium as a relevant pollutant (Article 5 of the Water Framework Directive), Member States should develop water quality standards for chromium for their notified river basins in accordance with the provisions of the Water Framework Directive (Annex V). These standards, be they new standards or revisions/amendments of any existing standards, should take into account the discussion and conclusions of the RAR in the context of the uncertainty issues highlighted both in the RAR and in this RRS.

Recommendation 4: It is recommended that the Commission considers the merit of including chromium in the revision of the list of priority substances under the Water Framework Directive (Annex X) taking into account:

- the information submitted by Member States as part of their obligations under the Water Framework Directive;
- the discussion and conclusions of the RAR;
- the uncertainties and key issues highlighted in the RAR (e.g. issues of bioavailability and speciation); and

- the information presented in this RRS on the industry sectors of concern and the existing risk reduction measures.

If chromium is included in the revision and if subsequently the Commission's conclusion is that existing or proposed national measures may not provide adequate protection to the aquatic environment, any Community-wide standards to be set for chromium should take into account:

- the different ecotoxicological profile of Cr(VI) and Cr(III);
- the results of the RAR for Cr(VI) and of the currently ongoing risk assessment for Cr(III); and
- the issues on fate, bioavailability and speciation highlighted in the RAR, the opinion of the CSTEE of September 2003 on the RAR, and this RRS.

This RRS makes no recommendation in support of the inclusion or otherwise of chromium in the list of priority substances. Any such recommendation would require knowledge of the findings of Member States' report on pressures, of the measures to be taken to control discharges of chromium at the national level and, of the results of the ongoing risk assessment on Cr(III).

Recommendation 5: It is recommended that the Commission consider the need for a revision of the Sewage Sludge Directive to include limits on the contents of chromium in sewage sludge and in soils as well as a limit on the annual load. To decide upon such a need, information will be needed on:

- the existence of measures on the control of the chromium content of sludge in all EU Member States; and
- monitoring data on the concentration of chromium in sewage sludge and in soils in all EU Member States.

This information should be considered in the light of the findings of the RAR, the current uncertainties on the effects of chromium in the terrestrial environment and the results of the ongoing risk assessment of Cr(III) currently undertaken under an industry initiative (which will arguably address risks from Cr(III) to this environmental compartment more comprehensively).

If it is found that national measures are lacking, incomplete or allow for unacceptable risks to the terrestrial environment to be manifested, then Community-wide measures should be proposed. Any such measure will harmonise the controls on chromium in sludge across the Community and will act as 'safety net' for the protection of the terrestrial environment

Recommendation 6: It is recommended that any potential risks from Cr(VI) associated with:

- use of wood preservatives that contain Cr(VI) substances; and
- use of wood treated with wood preservatives that contain Cr(VI) substances,

be assessed as part of the assessment of Cr(VI) substances (as ‘substances of concern’) and of the associated biocidal products under the Biocidal Products Directive. This assessment is expected to be based on assessment methods and techniques currently under development for use within the Biocidal Products Directive framework and to take into account scientific research (e.g. publications) on the potential risks from wood preservatives and treated wood which are currently available and which were not taken into consideration in the preparation of the RAR. This assessment of environmental risks will be dependent on the recognition of Cr(VI) substances as non-active substances (to be decided upon by 1st September 2006). Consultation has highlighted the concerns of a number of leading EU formulators of wood preservatives with regard to the forthcoming implementation of the Directive in individual Member States and the possible variations in approaches at the national level, which may create a competitive disadvantage for some of the formulators. This RRS considers it important that Competent Authorities in Member States co-operate and exchange information (including the peer review of the assessment of substances and products) to ensure a uniform approach in the practical enforcement of the Biocidal Products Directive across the Community.

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ANNEX 1

PROJECT SPECIFICATION

PROJECT SPECIFICATION

RISK REDUCTION STRATEGY AND ANALYSIS OF ADVANTAGES AND DRAWBACKS FOR HEXAVALENT CHROMIUM

This specification should be read as a request for a bids in line with the CGMPs Framework agreement. In line with this agreement we require the production of a risk reduction strategy that would meet the following specification.

If you have any initial queries, these should be directed to Mike Roberts Department for Environment, Food and Rural Affairs, Chemicals and GM Policy Division, Zone 3/E7, Ashdown House, 123 Victoria Street, London SW1E 6DE. Tel 020 7082 8099 who is the Nominated Officer for the piece of work.

Please provide a short response with an estimation of cost and timescales that you would be able to complete this piece of work by **(NOTE: the Strategy will need to be completed by September 2005)**.

1. Objective

1.1 To assess the advantages and drawbacks of different risk reduction options, primarily for the environment, on the use of the hexavalent chromium (or chromium (VI)) substances chromium trioxide, sodium chromate, sodium dichromate, ammonium dichromate, potassium dichromate:

- i. enable judgement as to whether the benefits of adopting the restrictions, outweigh the consequences to society as a whole of imposing the controls;
- ii. determine the best risk reduction strategy offering the greatest net benefits.

5. Outline Work Plan and Programme – Hexavalent Chromium Risk Reduction Strategy

5.1 The scope of this contract is to produce a risk reduction strategy as laid out in the Framework Agreement for the uses specified below of;

- chromium trioxide,
- sodium chromate,
- sodium dichromate,
- ammonium dichromate and
- potassium dichromate.

A Regulatory Impact Assessment (RIA) may also be needed.

The strategy should separately address both the environment risks and the implications of control measures that would be necessary to deal with the man via the environment concerns identified in the human health risk assessment. The need for any precautionary action to address the human health concerns would be a policy decision informed by the results of the strategy.

2. Background

2.1 The environmental risk assessment for the five hexavalent chromium substances, conducted under the Existing Substances Regulation (793/93/EEC), is complete and indicates the need to reduce the risks to the aquatic and terrestrial compartments of the environment.

2.2 Where any proposed control measures include recommendations for restrictions on the marketing and use of substances, the rapporteur (Member State with the lead on the risk assessment) is required to submit an analysis of the advantages and drawbacks of the substance, and of the availability of replacement substances. The implication is that benefits as well as risks should be taken into account in developing controls on hazardous substances in current use, while examining the likely effectiveness, practicability, economic impact, and monitor ability of the risk reduction measure(s).

2.3 Tenders are therefore invited to produce a risk reduction strategy for the uses specified below of the five hexavalent chromium substances and, if necessary, a Regulatory Impact Assessment (RIA).

3. Risk assessment

3.1 The specific substances to be addressed by this contract are the hexavalent chromium (chromium (VI)) substances chromium trioxide, sodium chromate, sodium dichromate, ammonium dichromate, potassium dichromate. The UK is rapporteur for the risk assessment, which has been completed. Copies can be provided upon request.

3.2 The environmental risk assessment for the hexavalent chromium (chromium (VI)) substances indicates the need to reduce the risks to the aquatic and terrestrial compartments of the environment associated with the following:

- Production (but only to one production site for the aquatic compartment)
- Pigment production
- Chromium oxide production
- Tanning salts
- Wood preservative formulation
- Wood preservative application
- Treated wood in use
- Metal treatment formulation
- Metal treatment – electroplating, passivating, anodising, brightening
- Wastewater treatment for all areas, except production, wood preservative application, anodising and use in mordant dyeing.

3.3 A risk reduction strategy with respect to human health and the five hexavalent chromium substances has already been produced, which may or may not have a bearing on the risk reduction strategy for the environment.

Reports and Presentations

4. These will be required as laid out in the Framework Agreement and in discussion with the Nominated Officer.

5. Nominated Officer

5.1 The Nominated Officer for the contract is Mike Roberts, Department for Environment, Food and Rural Affairs, Chemicals & GM Policy Division, Zone 3/E6, Ashdown House, 123 Victoria Street, London SW1E 6DE, Tel 020 7082 8099.

Chemicals and GM Policy Division

ANNEX 2

LIST OF CONSULTEES

ANNEX 2: LIST OF CONSULTEES

Trade Associations

Name	Remit
APEAL	EU
Association of Mechanical Engineering and Metalworking Industries of Latvia	LV
British Coatings Federation	UK
British Colour Makers Association	UK
British Galvanisers Association	UK
British Leather Confederation	UK
British Stainless Steel Federation	UK
British Surface Treatment Suppliers Association	UK
British Wood Preserving & Damp Proofing Association	UK
Confederation of British Wool and Textiles	UK
CEPE	EU
European Committee for Surface Treatment - CETS	EU
Chamber of Commerce and Industry of Slovenia	SI
Confemadera	ES
Cotance	EU
Danish Wood Preserving Association	DK
Deutsche Bauchemie	DE
ECCA	EU
EGGA	EU
Enterprise Ireland	IE
Euratex	EU
Eurofer	EU
Euro-Inox	EU
European Aluminium Association	EU
European Manufacturers of Lead Chromate and Lead Molybdate Pigments Association	EU
Federchimica	IT
Feique	ES
Finnish Energy Industry	FI
Finnish Wood Preservation Association	FI
Galvanoprofi-Sassler	DE
German Wood Preserving Association	DE

Trade Associations

Name	Remit
International Cadmium Development Association	INT
Latvian Association of Wood Processing Entrepreneurs	LV
Lithuanian Wood Preservation Association	LT
Metal Packaging Manufacturers Association	UK
Surface Engineering Association	UK
Swedish Wood Preservation Association	SE
UK Steel	UK

Note that not all associations above have provided information

Companies

Name	Location
Abbey Metal Finishing Co. Ltd	UK
AEM Ltd	UK
AEP Ltd	UK
Airbus	FR
Alcoa	FR
Alran	FR
Alric	FR
Alwernia	PL
Annonay	FR
Anochrome Group	UK
Abbey Metal Finishing Co. Ltd	UK
Arcelor	FR
Arch Chemicals	UK
Arichemie	DE
Ashton & Moore Ltd	UK
Atotech	UK
Avenarius	AT
Averpeaux	FR
BASF	DE
BASF	UK
Birmingham Plating Co. Ltd	UK
Boliden	FI
Borough Ltd	UK
Bowmill Metal Treatment	UK
British Metal Treatments	UK
Brockhues Gamble & Co KG	DE
Bruchsaler Farbenfabrik GmbH & Co. KG	DE
Cabot Carbon	UK
Carmo SA	PT
Ciba	CH
Ciba	UK
Chemetall	DE
Chemipal	IT
Circuit Foil	LU

Companies

Name	Location
Clariant	DE
Clariant	UK
Cookson Electronics	UK
Corus	UK
Costil SAS	FR
Cromital	IT
CSI Wood Protection Ltd.	UK
Dalton Group	IT
Degermann	FR
Degussa	DE
Delachaux	FR
Deutsche Borax	DE
Desowag GmbH	DE
Diesel Marine International	UK
DMS Chromium Plating Ltd	UK
Dowding & Mills	UK
Dr Wolman	DE
Dupire Tanneries	FR
DyStar	DE
Eberhard Faber	DE
Eckart	DE
EC Pigments	UK
Elementis	UK
Euramax	UK
Ferro (GB) Ltd.	UK
Firma-Chrome Ltd	UK
G.B. Hard Chrome	UK
GE Infrastructure	UK
Habich	AT
Haldor Topsoe	DK
Hervy Mercier	FR
Heubach Color	DE
Highland Electroplaters	UK
Hiriar	FR

Companies

Name	Location
Holland Colours	HU
Hoppings Softwood Products plc	UK
Howarth Timber (Importers) Ltd	UK
H Reis Ltd	UK
Hunter Douglas Europe BV	NL
Huntsman-Tioxide	UK
Impregna SA	ES
Intorsa	ES
James M Brown	UK
Jebron Plating	UK
Johnson Matthey	UK
Jullien	FR
Katres	CZ
Kehra Wood Ltd	EE
Kulba Bauchemie GmbH	DE
Lancashire Chemicals	UK
Lanxess	DE
Laporte	IT
Lauret	FR
A. Liebetruh & Co. KG	DE
The London and Brighton Plating Co Ltd	UK
London & Scandinavian Metallurgical	UK
Lukas	DE
Magellan Aerospace (Bournemouth)	UK
Manox	UK
Marabu	DE
Menadiona	ES
Merck	DE
Michrome Electro-Plating Ltd	UK
Mira Showers	UK
Nerchau Mal- und Künstlerfarben	DE
Nubiola	ES
NuevaTanex	ES
Outokumpu	FI

Companies

Name	Location
Oxkem	UK
Pigments Ltd	UK
Poeton (Cardiff) Ltd	UK
Poeton (Gloucester) Ltd	UK
Polish Institute of Wood Technology	PL
Protek Products	UK
PTG Treatments	UK
Ransfords	UK
Remmers	DE
Remy Carriat	FR
Repico	IT
Rockwood Italia SpA	IT
Rockwood Pigments	UK
Ruetgers	DE
Schlenk	DE
Schminke	DE
SCRD	FR
SE Plate	UK
SGA Technologies Ltd	UK
SilvaProduckt	SI
Smit & Zoon	NL
SNCZ	FR
Solvay Solexis	USA
Southwest Metal Finishing Ltd	UK
SSAB Tunnplat	SE
Stoppani	IT
Stotfold Plating Co Ltd	UK
Tannerie Fortier Beaulieu	FR
Tanneries Haas	FR
Taylormade Timber Products Ltd	UK
TCIM Roggwiler	FR
Tennants Inks & Coatings	UK
TFL	ES
Thames Water	UK

Companies

Name	Location
Vivechrom	GR
Vanetta Spa	IT
VHN	NL
Volpker	DE
The Woolmark Company	UK

Note that not all of the above companies have provided information. A total of thirteen companies have requested not to be included in this list.

Government Agencies and Departments

Name	Country
Austrian Federal Environment Agency	AT
Belgian Federal Public Service Health, Food Chain Safety and Environment	BE
The Brussels Institute for Management of the Environment	BE
Flemish Institute for Technological Research (VITO)	BE
Cypriot Ministry of Agriculture, Natural Resources and Environment	CY
Cypriot Ministry of Labour and Social Insurance	CY
Danish Environmental Protection Agency	DK
Federal Environmental Agency of Germany	DE
German Federal Institute for Occupational Safety and Health	DE
Estonian Chemicals Notification Centre	EE
Finnish Environment Institute	FI
Uusima Regional Environment Centre	FI
Ministry of Ecology and Sustainable Development	FR
Irish Environmental Protection Agency	IE
Irish Health and Safety Authority	IE
Italian Ministry for the Environment	IT
Italian Ministry of Health	IT
Latvian Environment, Geology and Meteorology Agency	LV
Lithuanian State Non Food Products Inspectorate	LT
Infomil	NL
Dutch Ministry of Housing, Spatial Planning and the Environment (VROM)	NL
Norwegian Pollution Control Authority	NO
Polish Bureau for Chemical Substances and Preparations	PL
Regional Management of Water Economics at Gdansk, Poland	PL
Portuguese Environment Institute	PT
Ministry of Economy of the Slovak Republic	SK
Ministry of the Environment of the Slovak Republic	SK
Centre for Chemical Substances and Preparations of the Slovak Republic	SK
Slovak Inspectorate of the Environment	SK
Spanish Ministry of Environment	ES
Swedish Chemicals Inspectorate	SE
Swedish Environmental Protection Agency	SE
Environment Agency for England and Wales	UK
Health and Safety Executive	UK

European Commission - DG Environment

EU

European IPPC Bureau

EU

Competent authorities in all EU Member States have been contacted. The list above includes only those that have submitted information during this project.

Research Organisations

Name	Country
Aristotelian University of Thessaloniki	GR
The August Cieszkowski Agricultural University of Poznań	PL
Austrian Wood Research Society	AT
CATAS	IT
CNR-IVaLSA	IT
CTBA	FR
CTIB	BE
Danish Technological Institute	DK
Federal Institute for Materials Research and Testing	DE
Flemish Institute for Technological Research (VITO)	BE
Ghent University	BE
Greek National Agricultural Research Foundation	GR
Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria	ES
International Research Group on Wood Protection (IRG)	INT
Latvian State Institute of Wood Chemistry	LV
Lithuanian Forest Research Institute	LT
LNEC	PT
Norwegian Institute of Wood Technology	NO
SHR Timber Research	NL
Swedish National Testing and Research Institute (SP)	SE
Technical University of Zvolen	SK
Timber-Wood Research and Development Institute	CZ
TNO-Building Systems	NL
University of Hamburg-BFH	DE
University of Ljubljana	SI
University of Westhungary	HU
VTT Technical Research Centre	FI
Western European Institute for Wood Preservation	EU

Note that not all of the above organisations have provided information.

ANNEX 3

**UK CODE OF PRACTICE FOR DESIGN AND OPERATION OF TIMBER
TREATMENT INSTALLATIONS**

ANNEX 3: UK CODE OF PRACTICE FOR DESIGN AND OPERATION OF TIMBER TREATMENT INSTALLATIONS

The information presented below is taken by the UK Timber Treatment Installations 2003 Code of Practice for Safe Design and Operation (BWPDA, 2003) and is focused on design and operation measures for better control of environmental releases from timber treatment installations. This information is provided with the aim of describing possible measures to be taken for better control of risks from the use of Cr(VI) formulations in the treatment of wood and to providing an insight to current practices in this industry sector (although no claim can be made that all EU timber treatment installations or even UK ones adhere to the provisions of this Code of Practice).

A3.1 Bunding of the Timber Treatment Plant and Wood-Preservative Storage Tanks

The plant, associated loading and/or unloading area and preservative storage tanks should be located within secondary containment – generally provided by bunding. This bunding should be impervious and made of, or sealed with, a substance resistant to the chemicals that it might contain. It must also be strong enough to withstand the hydrostatic pressure when the bund is full of liquid.

In most situations, a cast-concrete construction is preferable to block or brick for a long service life. Non-reinforced block or brick is not suitable. Services should not pass through bund walls or bund floors. Sumps should be included to facilitate the collection and removal of any fluids from the bund. Gravity drains or automatic pumps must not be incorporated in the sump design. The bund should be in a covered and enclosed area to avoid the collection of rainwater and the possible contamination with wood-preservative treatment fluid. The disposal of contaminated rainwater can be very expensive.

Provision should also be made for the secure and contained storage of packaging that contains wood preservatives such as 200 litre drums or intermediate bulk containers (IBCs). Empty containers should be stored in a secure compound, sent back to the supplier for re-use where possible or disposed of safely via a registered waste carrier to a licensed waste-management site. PPG 26, Storage and Handling of Drums and Intermediate Bulk Containers, provides further useful guidance.

Bunds should be designed to withstand:

- static and dynamic loads that would be exerted by the escape of liquid through a failure of primary containment;
- the weight of the primary containment when filled with liquid and any other forces that arise from activities carried out within the bunded area and act on the base of the bund, including timber loading on the bogies and rail track;

- stresses induced by ground conditions, for example differential settlement and aggressive ground materials; and
- thermal and shrinkage stresses (for example, fire and climate weathering).

Bunds may also be fabricated from metal, but these are not recommended where wood preservatives based on organic solvents are to be used. Proprietary prefabricated tanks may be used as bunds or they may be made on a one-off basis. A prefabricated bund must not rely on structural linkage with the storage tank for its stability and the storage tank must not be supported on the bund walls. It is recommended that new bunds be tested (by filling with water) before acceptance.

The bunding should have a large enough capacity to contain a spillage that would arise from the worst credible failure in the storage system, plus 10% to take account of the possibility of fire-fighting water or foam being added (i.e., at least 110% of the total quantity of treatment solution in each bunded area). Bunded areas should not be allowed to accumulate rainwater and should be maintained in a dry, clean condition. The bund should be constructed so as to catch spillage from the vessel door in the event of a door-seal failure (door baffles may be required to achieve this, unless the building walls and roof can serve this purpose).

Adequate space should be provided between the plant and the bund wall to enable a person to inspect the walls of the bund. It may be necessary to create a walkway to allow safe access. This should be taken into account when assessing bund capacity. The bund should be examined regularly for cracks, faults or signs of decay. A record of routine inspections and remedial action should be kept on site. In addition, there should be a full annual inspection by a competent person such as an engineering surveyor or an insurance company representative. A bund specification should be obtained from a competent person at an early stage in the development of the project proposal.

A3.2 Post-Treatment Containment and Conditioning Areas

Post-treatment dripping may be eliminated or minimised by sloping loads during treatment and/or by modifying the process. Where possible, flat metal areas should be eliminated from the bogie by good design. Loads should be stacked with appropriate spacers to preclude capillary retention between surfaces, and shaped profiles should be positioned so as not to provide traps that collect free solution.

Where possible, it is recommended that the strapping around packs of smooth sawn timber be released after the dripping period, followed by an extended dripping period with the packs of timber chocked to promote the treating solution to run out of any shaped profiles in the timber and be recovered.

It is a statutory condition for all industrial wood preservatives in the UK that treated wood must be held until the surfaces are dry. It must be held within a bunded area on a site that is maintained to prevent loss of treatment product to the environment.

A contained and impermeable dripping area for freshly treated timber should be provided and be situated adjacent to the plant and storage tank bund. Timber should be transferred from the plant to the post-treatment dripping area within the total containment zone. Drips should be collected for reuse or safe disposal, as appropriate.

The dripping area must not discharge into surface water drains, the foul sewer or groundwater, and provision should be made to divert away all uncontaminated water. This area should be large enough to hold the amount of treated timber in accordance with the conditions of approval stated on the wood-preservative product label.

Minimum holding times and other requirements may be required to be met before the treated timber can be removed from the treatment area. Operational practices to eliminate the spread of contamination, via vehicle wheels or footwear, are necessary (e.g. dedicated forklift for the treatment area).

A3.3 Storage of Conditioned Timber

Once the treated timber surface is dry, it may be moved away to the post-treatment holding area.

It is recommended that bulk, dry treated timber be stored under cover on an impermeable surface to help prevent possible contamination of surface water and or groundwater. In addition, this ensures the timber stock is maintained in a dry condition prior to use.

After the treated timber has left the treatment site, it may be stocked at builders' merchants and retail outlets before being used. Suppliers of treated timber to these outlets need to consider whether they advise their customers as to any special precautions that need to be taken while the timber is being stocked prior to sale and use.

A3.4 Waste Management

A statutory Duty of Care (Environmental Protection Act 1990, Section 34) applies to anyone who produces or imports, keeps, carries, treats or disposes of controlled waste. It is likely that most, if not all, waste produced on site will be controlled waste and must be disposed of at sites authorised to accept such material. Separate legislation applies in Northern Ireland through the Waste and Contaminated Land (Northern Ireland) Order 1997.

The Duty of Care requires all reasonable steps to be taken to ensure that no unauthorised handling or disposal of controlled waste occurs and that controlled wastes are transferred only to an authorised person, together with a written description of the waste (i.e. a waste-transfer note). The waste-transfer note must also include an accurate six-figure waste classification code by reference to the European Waste Catalogue, which will identify if the material is hazardous or non-hazardous waste.

Wastes associated with wood-preservation processes are usually classed as hazardous waste, but may also be deemed ‘special waste’. Special wastes are the most dangerous and difficult to handle. In addition to the Duty of Care requirements, special wastes have additional consignment procedures as laid down in the Special Waste Regulations 1996 (as amended) or Special Waste Regulations (Northern Ireland) 1998 (S.R.289).

Special wastes are likely to be:

- redundant preservative solution;
- sludge and debris from tanks;
- sawdust or other materials used to soak up spills;
- redundant containers that still contain residues of the product;
- redundant plant and equipment (prior to decontamination);
- contaminated rainwater (within bunds, etc.); or
- contaminated soil.

Redundant treated wood, off cuts and sawdust produced while cutting treated materials should not be mixed with untreated wood waste if there is any possibility of the resultant mixture being used for fuel or as animal bedding or litter.

To determine if redundant treated timber is classified as special or hazardous waste requires separate consideration. Producers of such waste are recommended to contact the supplier of the wood preservative used or the Environmental Agencies.

All efforts should be made to introduce management procedures and waste minimisation techniques and technologies that correspond with the guides and publications listed in the reference bibliography. The less waste produced, the smaller the handling and disposal costs.

A3.5 Bulk Deliveries

The risk of chemical spillage is greatest at the delivery and handling stages. If tanker deliveries are necessary, they should be made according to a written procedure that includes a checklist covering all the safety-critical steps in the delivery process:

- provision should be made to contain any potential spillage from the tanker, delivery and/or handling vehicle, taking the discharge system into account. For example, siting the tanker in a containment area during discharge or incorporating a suitable emergency sump with shut-off valves, which are closed during deliveries, prevents drainage leaving the site;
- tankers that deliver chemicals in bulk should discharge to storage via a lockable fixed coupling within the containment area, and not at a point remote from the bund;
- receiving points should be marked with the appropriate product identity;

- tanker access to the plant should be unobstructed to minimise the length of discharge hose necessary;
- bulk storage tanks should be fitted with a content indicator to warn of over fill. A high level alarm provides an additional safeguard. Such alarms should ideally be powered independently from the plant itself;
- a trained representative of the receiving company should authorise and attend the receipt of the product. The operation should not be left unattended by either the tanker driver or the company representative, and there should be a written contingency plan, tested periodically, for use in the event of an accident. Refillable bulk containers should be stored and emptied in a secure bunded area; and
- the person in charge of the delivery should sign the checklist to ensure each step is correctly carried out.

The risk of spillage during the loading and handling of smaller containers or packages, such as IBCs or drums, is significant; similar measures should be taken for these deliveries to those detailed above for tankers. PPG 26 Storage and Handling of Drums and Intermediate Bulk Containers provides further useful guidance.

A3.6 Other Releases to the Environment

In certain situations, in addition to potential releases to controlled waters (including surface-water sewers or via foul-water sewers) or land, process emissions to air may need to be managed or controlled in accordance with authorisations issued under the provisions of the Environmental Protection Act 1990 or the Pollution Prevention and Control Act 1999 (PPC Act) and its associated regulations SI 2000 no. 1973 (Control of Pollution Act 1974) or the Pollution Prevention and Control (Scotland) Regulations 2000, SSI 2000 No.323 in Scotland.

The discharge to ground of certain listed substances is subject to the Groundwater Regulations 1998 SI 2746. The discharge of most timber-treatment compounds to groundwater is not permitted under these regulations. Further guidance and advice is available from regulatory authorities and product suppliers.

