Environmental and Human Health Risk Reduction Strategy

Cadmium metal and Cadmium oxide

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SUMMARY / READING GUIDE

Cadmium and cadmium oxide are on the third priority list of substances (143/97/EC) drawn up under the Existing Substances Regulation (793/93/EEC). Following the outcomes of the risk assessment report for cadmium and cadmium oxide (Environment (December 2005) and and Human health (July 2005)), a risk reduction strategy is developed. The rapporteur for the risk assessment and risk reduction on cadmium metal and cadmium oxide is the Federal Public Service of Public Health, Food-Chain, Security and Environment – DG Environment (Belgium).

1 PRODUCTION AND USE

In the EU-16[1] there are 3 producers of cadmium metal and 1 producer of cadmium oxide. Metallic cadmium is used in the production of cadmium oxide powder, plating and alloying and the production of Ni-Cd batteries, next to some miscellaneous uses. Cadmium metal or cadmium oxide is used as starting material for a wide variety of other cadmium compounds (PVC heat stabilisers, pigments).

2 IDENTIFICATION OF THE RISKS TO BE LIMITED

The environmental risk assessment on cadmium oxide and cadmium metal has not yet been finalised (see chapter 2.2 scope). The overall conclusions for environment here refer to the December 2005 version. Subsequently, some of the conclusions drawn may be subject to change in the final version. Also note that an assessment for the atmosphere and the marine environment is not included in the RAR. It must also be noted that the risk characterisation in the RAR is based on emission data referring to 1996, except for the Cd manufacturing industry, for which emission data were updated to the situation in 2002.

In the environmental risk assessment (December 2005) a conclusion (iii) is reached for following compartments:

- the local surface water at 1 Cd metal production site and 4 processing (pigments production sites, plating and alloy) sites/scenarios. Both latter are generic scenarios ('Cd plating' and 'Cd alloys').
- the modelled regional PEC of surface water has a risk factor of 0.6 using a mean K_p value for EU while the risk factor is 1.7 using a K_p value that is distinctly smaller than average. This suggests potential regional risk. However, it is proposed to use measured values for the risk characterization
- the local terrestrial compartment: there are potential risks at cadmium plating and alloy production sites.
- the regional terrestrial ecosystem: the 90th percentiles of measured Cd concentrations of European soils have risk factors 0.4-1.6. Regional risk for the terrestrial ecosystem cannot be excluded in one region (UK).
- the secondary poisoning (regional level) as measured soil Cd concentrations of European soils have risk factors 0.4-1.6 for poisoning to mammals (mean: 0.86; data from 6 EU countries). Regional risk for the terrestrial ecosystem cannot be excluded in one region (UK).
- the wastewater treatment plants: risk to on-site and off-site STP cannot be excluded for Cd plating and alloy industry.

[1] Former EU-15 + Norway

In the human health risk assessment (July 2005) a conclusion (iii) is reached for:

- for cadmium oxide:
  - risk to workers
  - man indirectly exposed via the environment
- for cadmium metal:
  - risks to consumers from using Cd-containing brazing sticks an wearing (imported) jewellery

3 EXISTING RISK REDUCTION MEASURES

This chapter gives an overview of the instruments, already in place, to reduce the risks to the environment and human health from manufacturing, processing, transport and use of cadmium metal and cadmium oxide.

An overview is given of the existing European legislation. This subsection are divided in legislation for protection of workers (e.g. chemical agents at work (98/24/EC)), for protection of consumers (e.g. marketing and use restrictions (76/769/EEC)), legislation to prevent soil, water and air pollution and legislation on waste management, followed by an overview of some voluntary initiatives (EU and international).

An overview of the national legislation shows that in different Member States OEL's are ranging between 5 and 30 µg/m³ (the Netherlands and Germany respectively). A few Member States imposed occupational biological limit values (BLV) for Cd. The BLV's set for concentrations in blood range from 5.6 to 15 µg/l (Finland and Germany respectively). Limits set for Cd-concentrations in urine range from 4 to 10 µg/g creatinine (The Netherlands and France respectively) and from 5.6 to 15 µg/l (Finland and Germany respectively).

Next to the legislative measurements, some voluntary agreements (e.g. Vinyl2010) and national and international (e.g. OSPAR, HELCOM) arrangements are described.

For each measure listed in this chapter (legislative or not), an indication is given of the areas (human health, air, water, soil, secondary poisoning) on which the measure has an impact.

Based on this list a selection of the existing legislation, potentially able to effectively reduce risks by increasing its effectiveness, is performed. This selection is taken forward in the next chapter, showing a first screening of possible further risk reduction measures.

This chapter is finalised by estimating the effect of currently implemented risk reduction measures. This estimation shows that emissions of Cd to air have decreased by 63% in the year 2000 as compared to the year 1980 (EMEP, 2004). As an example for the evolution of Cd-input in soil, in Belgium a decrease of the input through the use of fertilisers from 2.27 g Cd/ha in 1980 to 1.06 g Cd/ha in 1998 was shown. A presentation of Dr. Spang (08/02/2006) shows an important decrease in the Cd-concentrations in blood (from 21 µg/l in 1967-1973 to 2 µg/l in 2001-2005) and urine (from 4.8 to 1 µg/g creatinine for 1972-'75 to 2001-'05) of exposed workers in a battery company.

4 POSSIBLE FURTHER RISK REDUCTION MEASURES

In this chapter, possible further risk reduction measures are screened to select those risk reduction measures, having potential to reduce the risks identified in the RAR. Risk reduction measures are screened for human health (workers, general population and man indirectly exposed via the environment) and for the environment (surface water, terrestrial, secondary poisoning and wastewater treatment plants. Measures screened go from regulatory controls (e.g. setting OELs within the chemical agents at work Directive) to economic instruments (e.g. levy on Cd-content in fertilisers), voluntary agreements (e.g. comprehensive occupational exposure programme), …

For each measure, a description of the possible measure is included and a decision is made whether or not these measures are viable and should be taken forward to the assessment fo further risk reduction measures (cf. chapter 5).

5 ASSESSMENT OF POSSIBLE FURTHER RISK REDUCTION MEASURES

Based on the first screening in chapter 4, expert judgement and in consultation with the rapporteur and the industry representatives (ICdA) some further possible risk reduction measures were selected to be submitted to an assessment on the basis of the criteria recommendedn in the TGD (EC, 1998): effectiveness, practicality, economic impact and monitorability. An overview of this assessment is given in table 1, table 2 and table 3.

table 1: Overview of the assessment of possible further risk reduction measures for occupational exposure

	Effectiveness	*Practicality*	*Economic impact*	*Monitoring*
Occupational exposure limit value (OEL)	Will prevent long-term exposure to high concentrations. Will never guarantee full protection, is not a "safe" concentration.	Achievable through collective reduction measures but not feasible for all scenario's due to wide range of exposure levels found.	Cost of collective reduction measures and monitoring can be significant.	Trained staff and specialised equipment not available in all companies. Simpler, more cost-effective methods would facilitate monitoring.
Combining OEL with BLV	Will prevent long-term exposure to high concentrations. These biomarkers do not reflect directly possible effects on human health.	Not feasible for all scenario's due to wide range of exposure levels found.	Costs for implementing measure to reach a certain level of BLV will be dependent of the level set. Monitoring costs will not be significant.	Possible through regular medical examination. Long term monitoring of BLVs can prevent long-time exposure to high levels.
Extended health surveillance for workers	Allows to put test results into perspective and enables to draw individual conclusions. Can prevent long-term exposure to elevated concentrations.	Implementations requires a comprehensive organisational effort for each company. All elevated cases need to be addressed, although no illness is diagnosed.	Cost specific to Cd exposure monitoring are acceptable. Cost associated with relocation of employees to other sections could be significant.	Possible through keeping health records of all employees.
Collective exposure reduction measures	Cf. setting OEL	Cf. setting OEL	Cf. setting OEL	Cf. setting OEL
Training/safety data sheets	Rising awareness on the potential effects of exposure might lead to increased use of collective measures and PPE.	Training programme can easily be set up for the entire staff.	Low	Keeping track records on the training programme. Monitoring of the number of people following the training.

	Effectiveness	Practicality	Economic impact	Monitoring
Personal protective equipment (PPE)	The use of half-masks, possibly supplied with clean air or assisted ventilation helmets are effective in cased where it is technically impossible to maintain exposure at all times below the OEL. PP also involved personal hygiene (wash hands, face, don't eat at the work premises, …)	Wearing respiratory protection is practically feasible. In practice it is difficult to ensure personal hygiene (nail biting, washing hands, …)	No excessive costs. Cost dependant on type of mask to be used.	Proper use of PPE can be checked by labour and health inspection. Hygiene aspects can be monitored through an extensive health surveillance programme.
Sector initiatives – voluntary agreement (Comprehensive occupational exposure monitoring program)	Effective due to the fact that industry can develop its own approach. A multi-dimensional approach is very effective	Transparant and credible agreements are practical (objectives, timelines, … need to be set). A guideline increases the practicality.	Costs can be shared by the whole sector and should therefore be acceptable.	Monitoring by an independent body.
Substitution	Effective to eliminate exposure of workers, although production for export may still give rise to exposure.	Alternatives having the same specific characteristics as Cd are not available for all applications. Producing alternatives would also require a complete switch of production technology.	Dependant on the application, costs are estimated from acceptable to significant.	Through Directive on restrictions on use of Cd in different applications

	Effectiveness	Practicality	Economic impact	Monitoring
Ban on NiCd batteries/ alternatives	Effective to eliminate exposure of workers, although production for export would diminish that elimination	Alternatives, reaching the same performance levels for different characteristics are not available. Producing an alternative would also require a complete switch of production technology	Involves major equipment redesigns for battery manufacturers and customers. The business loss would jeopardize the survival of the battery manufacturers.	Monitoring by an independent body.

table 2: Overview of the assessment of possible further risk reduction measures for consumers

	Effectiveness	*Practicality*	*Economic impact*	*Monitoring*
M&U restrictions for Cd-containing brazing sticks	Would prevent consumers from being exposed to Cd. Very effective.	Cd-containg alloys can be replaced by the Cd-free alloys in almost all cases.	Expected to be low.	Through Directive on restriction of Cd-containing brazing sticks.
M&U restrictions for Cd-containing jewellery	Would prevent consumers from being exposed to Cd. Very effective	Cd-free gold and silver solders are available on the market.	Assumption to have no important economic impact.	Through Directive on restriction of Cd-containing jewellery.

table 3: Overview of the assessment of possible further risk reduction measures for environment

	Effectiveness	*Practicality*	*Economic impact*	*Monitoring*
Introduce EU-wide limits on Cd content of fertilisers	Will lead to an important decrease of Cd-input in soil. Will lead to a significant decrease of Cd intake for the general population.	Lower Cd-content in phosphate fertilisers can be reached through either use of low Cd rock or decadmiations. Some doubts remain on the practicality of the selective mining route. Uncertainty exists on the availability of low Cd rock and the feasibility of decadmiation on industrial scale.	Low for the low Cd rock (in case production capacity is sufficient (and for decadmiation). Significant impact for high Cd rock producing countries. No estimation available for the selective mining option. Costs for decadmiation processes are uncertain.	Monitoring of the Cd-content upon entry of the EU market. Any load should be accompanied by the necessary analysis documents. Control through random sampling.
Charge on Cd-containing content in phosphate fertilisers	Effectiveness strongly depends on charge rate.	Administrative burden can be quite significant.	Dependant on the way it is implemented and on the charge rate.	Monitoring of Cd-content and of the correct paying of the charges is required.
Economic instruments to reduce direct emissions to soil	Effectivenesss strongly depends on charge rate, which should be high in order to stimulated end users to swith to low Cd alternatives.	Administrative burden can be quite significant. Charge levels should be uniform throughout the EU.	Might be significant if charge rates are high. Intensive measuring campaigns would be quite expensive.	Monitoring efforts could be very substantial (keeping track of transport and use of these products, monitoring correct payment).
Regulatory controls to reduce emissions from industrial plants	Lowering ELVs in WID will only have small impact. A review of BREFs in framework of IPPC Directive could have an important impact. Full implementation of the WFD would be verry effective in the future.	A profound assessment should be included in the implementation of these Directives itself and is no subject of this risk reduction strategy. Ploblems to meet these Directives are expected for different industry sectors.	Impact could be extensive but an estimation is not always available.	Procedures to monitor the compliance with these Directives are to be developed under these Directives.

6 RISK REDUCTION PROPOSAL

In section 5 of this report, possible further risk reduction measures were assessed against the four criteria: effectiveness, practicality, economic impact and monitorability. Based on this assessment a final recommendation is given here to reduce the identified risks in the Environmental and Human Health Risk Assessment.

GENERAL COMMENTS

In the Risk Assessment report, a conclusion (i) was reached for risks for the environmental compartments water and sediment because of the following reasons:

- Aquatic compartment: there is a need for better information regarding the toxic effects of cadmium to aquatic organisms under low water hardness conditions (very soft waters, hardness below about 10 mg $CaCO_3$/l). There are no data for the very soft waters and these areas may be unprotected by the proposed $PNEC_{water}$ (Predicted No Effect Concentration) for soft water (0.08 µg Cd/L)
- Sediment: there is a need for further information regarding the bioavailability of cadmium in order to possibly refine the assessment at regional and local level.

The collection of additional information should, however, not delay the implementation of appropriate control measures needed to address the concerns related to the other endpoints. All measures, proposed in the following paragraphs, aim at reducing the exposure of workers and consumers to Cd and CdO and reducing the risks for the environment, which means that these measures will also contribute to a reduction of possible above mentioned effects.

For workers and man indirectly exposed to the environment the RAR also indicates that further information is needed to better document the possible neurotoxic effects of CdO suggested in experimental animals, especially on the developing brain. The information requirements are further epidemiological and experimental information to identify more precisely the nature of the effects, the characterisation of the exposure and the mechanism of action related to neurotoxicity. These investigations should mainly focus on effects on the developing brain (prenatal and early childhood exposure). Effects on the adult nervous system should also be characterised. These risks are however taken into account in the current risk reduction strategy report.

REDUCING OCCUPATIONAL EXPOSURE

Setting up a extended health surveillance program for workers seems to be a very good measure to reduce occupational exposure of workers to cadmium. The effectiveness of a extended health surveillance program, including the monitoring of Cd-U, Cd-B and low molecular weight proteins (RBP, β2MG) lays in the fact that not only exposure, but also effects can be monitored on an individual basis. Even more effective than an extended health surveillance program is a comprehensive occupational exposure monitoring program. Such a program does not only include health surveillance, but a comprehensive predesigned program that includes air concentration measurements at the workplace, biological monitoring of exposure and effects and above that a complete description on how to act in case certain indicators exceed certain levels. Such a program could be implemented under Directive 2004/37/EC on the exposure to carcinogens or mutagens at work.

A good alternative however would be a voluntary agreement between industry and the government. Industry has already designed a comprehensive occupational exposure program (See Annex 6). The fact that this voluntary agreement would involve only about 15 companies increases its effectiveness. The effectiveness of a comprehensive occupational exposure monitoring program is already proven by putting it in practice in Sweden and the US. In all plants dealing with cadmium exposure the implementation of a health surveillance program is common practice (ICdA, personal communication, 2006). The comprehensive program, developed by industry comprises step-by-step decisions to be taken in specific situations and are triggered when certain parameters exceed certain levels, under which, good information to the workers, training, personal protective equipment, an extra health examination, transfer workers to another part of the company,…

The effectiveness of setting up a voluntary agreement between the Cd-industry and the European Commission on the implementation of a comprehensive occupational exposure monitoring program could be strenghthened by assuring a legal framework. Therefore Targets would be set in line with Resolution 97/C 321/02 [2] and Recommendation 96/733/EC [3]. Agreements should in all cases:

- take the form of a contract, enforceable either under civil or under public law;
- specify quantified objectives and indicate intermediate objectives with the corresponding deadlines;
- be published in the national Official Journal or as an official document equally accessible to the public;
- provide for the monitoring of the results achieved, for a regular reporting to the competent authorities and for appropriate information to the public;
- be open to all partners who wish to meet the conditions of the agreement.

And agreements should, where appropriate,

- establish effective arrangements for the collection, evaluation and verification of the results achieved;
- require the participating companies to make available the information regarding the implementation of the agreement to any third person under the same conditions applying to public authorities under Council Directive 90/313/EEC of 7 June 1990 on the freedom of access to information on the environment;
- establish dissuasive sanctions such as fines, penalties or the withdrawal of a permit, in case of non-compliance.

For a legal framework to strengthen the effectiveness of a voluntary agreement, we can refer to the Commissions Communication on Environmental Agreements (adopted second reading on 17 July 2002). This 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). Policy makers have shown an increasing interest in environmental agreements in recent years. Environmental Agreements are largely recognised as offering a number of potential benefits, including stimulating a pro-active approach by industry, cost-effectiveness and faster achievements of environmental objectives. The proposed procedural requirements differ according to the use of environmental agreements in the context of Self-regulation or of Co-regulation.

REDUCING RISKS FOR CONSUMERS

Risks identified for consumers are the result of the use of Cd-containing brazing sticks and wearing Cd-containing jewellery. Based on the assessment in chapter 5.2 of this report, marketing and use

[2] Council Resolution of 7 October 1997 on environmental agreements (OJ C312, 22/10/1997, p. 6-6)

[3] Commission Recommendationi of 9 December 1996 concerning Environmental Agreements implementing Community directives (OJ L333, 21/12/1996, p. 59-61)

restrictions for these applications seems to be the most effective, practical and monitorable measure with an acceptable economic impact. For the use of Cd-containing brazing sticks, a voluntary agreement between industry and the relevant national authorities might also be sufficient to reduce the risks in an appropriate way since this is a limited, well-defined industry with only a few players.

REDUCING RISKS FOR THE ENVIRONMENT

Risks were identified in the RAR for the local surface water at 1 Cd metal production site and 4 processing sites, the local terrestrial compartment at cadmium plating and alloy production sites, the regional terrestrial ecosystem in one region (UK), secondary poisoning at the regional level and for on-site and off-site sewage treatment plants.

The assessment in chapter 5.3 however shows that a reduction of emissions will automatically result from the further implementation of already existing legislation like the Water Framework Directive, IPPC Directive, the Urban Wastewater Treatment Directive, … A profound assessment of the effectiveness, practicability, economic impact and monitorability of these measures should be performed within the legal framework of each specific legislation. Based on that, the necessity to review this legislation should be evaluated. As a consequence, specific proposals to review this legislation are not covered for in this risk assessment report and no extra risk reduction measures are deemed necessary.

To reduce Cd-input to soil, according to the assessment made in chapter 5.3 of this report, setting EU-wide limits on the cadmium content of fertilisers is an effective measure (allowing phosphate fertilisers with only 20 mg Cd/kg P_2O_5 would lead to a decrease of Cd input in the soil through use of phosphate fertilisers with 37.7%). Lowering the Cd input into soil would also result in a significant decrease of Cd intake for the general population.

1 BACKGROUND

1.1 INTRODUCTION

Cadmium and cadmium oxide are on the third priority list of substances (143/97/EC) drawn up under the Existing Substances Regulation (793/93/EEC).

Rapporteur for the risk assessment and risk reduction on cadmium metal and cadmium oxide is the Federal Public Service of Public Health, Food-Chain, Security and Environment – DG Environment (Belgium). The risk assessment has been drawn up by the Laboratory of Soil and Water Management of the University of Leuven (environmental part) and by the "Faculté de Médecine- Ecole de santé publique - Unité de toxicologie industrielle et de médecine du travail" of the Catholic University of Louvain (human health part). The risk reduction strategy was assigned to the consortium Ecolas-Euras.

1.2 PRODUCTION

In the EU cadmium metal is produced mainly as a by-product of zinc production via the electrolytic processes. The companies manufacturing cadmium metal in 2005 are reported in Table 1.2.1. All companies produce the substance in massive form (e.g. plates, sticks, balls).

Table 1.2.1: Current producers of cadmium metal liable to the Regulation 793/93/EEC (RAR, draft update document July 2005)

Company (and site)	*Country*
Budel Zink (now: Zinifex Budel)	The Netherlands
Norzink (now: Boliden Odda A.S.)	Norway
Metal Europ Weser Zink (now: Xstrata Zinc GmbH)	Germany

Table 1.2.2 gives an overview of the EU-16[4] production data (RAR, draft update document July 2005). No data are available on the situation in the EU-25.

Table 1.2.2: EU production data on primary cadmium metal in metric tons (industry site specific questionnaire 2004/2005 in RAR, draft update document July 2005)

Year	*EU production (in metric tons)*
2002	1114
2003	1207

Based on the data of one producer 85% of the production volume is exported outside the EU-25. A second company mentions 100% export but it is not clear if this is meant as outside the EU or outside the country where the production is located. The amount of secondary cadmium produced in the EU-16 by recycling of batteries, production scrap and other sources, was about 974 tons for the year 2002 (of

[4] (Former EU-15 + Norway)

which 56% from batteries) and 1023 tons for the year 2003 (of which 52% from batteries). These figures are based on the information provided by 2 out of 3 recycling companies (SNAM in France, ACCUREC in Germany and SAFT-AB in Sweden) and data of the company with highest capacity are included.

The total volume of cadmium consumed within the former EU-16 (including Norway) and the actual EU-25 territory is unknown.

Table 1.2.3 gives an overview of the cadmium oxide production sites in the EU. In 2002 there was only one production site left in the EU.

Table 1.2.3: Production sites of cadmium oxide in the EU with volume > 1000 t/y (reference year 2002) (source: RAR, draft update documents, July 2005)

Company (and site)	*Country*
La Floridienne	Belgium

Information on the total production of cadmium oxide by La Floridienne was submitted for the reference year 2002. Since 1996 there has been an increase of the production volume.

1.3 USE

Metallic cadmium is used in the production of cadmium oxide powder, plating and alloying and the production of Ni-Cd batteries, next to some miscellaneous uses (deoxidising agent in nickel plating, in process engraving, …[5]). Cadmium metal or cadmium oxide is used as starting material for a wide variety of other cadmium compounds (PVC heat stabilisers, pigments). Cadmium oxide has been used as a stabiliser for the cadmium sulphide and sulpho-selenide forms in glass[6]. In nitrile rubbers the substance improves heat resistance; in plastics, it improves high temperature properties. Another field of minor applications is based on the catalytic properties of cadmium oxide. It catalyses reactions between inorganic compounds, as well as organic reactions such as oxidation-reduction, dehydrogenation, cleavage and polymerisation (use as vulcanizer). It sensitises photochemical reactions.

Figure 1.3.1 illustrates the different uses of cadmium metal and cadmium oxide in the EU (for 1996). In the updated RAR documents (RAR, draft update documents July 2005) it is indicated that this mass balance of cadmium could not be updated accurately, given the lack of information on the numerous cadmium sources and flows. However some changes compared to the data given in Figure 1.3.1 are described in the update documents:

- The number of companies producing Ni-Cd batteries has further decreased from 7 to 5 (SAFT Nersac and SAFT Bordeaux in France, Hoppecke and GAZ (Zwickau) in Germany and SAFT-AB in Sweden). The amount of cadmium used by three out of five companies is approximately 1725 metric tons for the year 2003.
- There are currently 3 recyclers of Ni-Cd batteries in the EU-16: SNAM in France, ACCUREC in Germany and SAFT-AB in Sweden
- There are currently 3 companies producing pigments in the EU-16, producing about 1216 metric tons of Cd containing pigments in 2003, of which 499 tons were consumed in the EU-16

[5] stated by Industry as no longer in use (ICdA, pers.com., 2003)

[6] This use is not known by Industry (ICdA, pers.com., 2003 in RAR (2005))

- The number of producers of cadmium containing stabilisers in the EU-16 dropped to only a few in view of the Vinyl 2010 commitment[7]. Only two companies (three sites) acknowledged to the Rapporteur that some production still took place at their sites located in Italy and Germany. The consumption of cadmium metal and cadmium oxide for this application is estimated between 50 and 120 tons in 2003.

[7] Any production of stabilisers by the companies adhering to this agreement, is destinated solely for export and cannot be sold in the EU-15

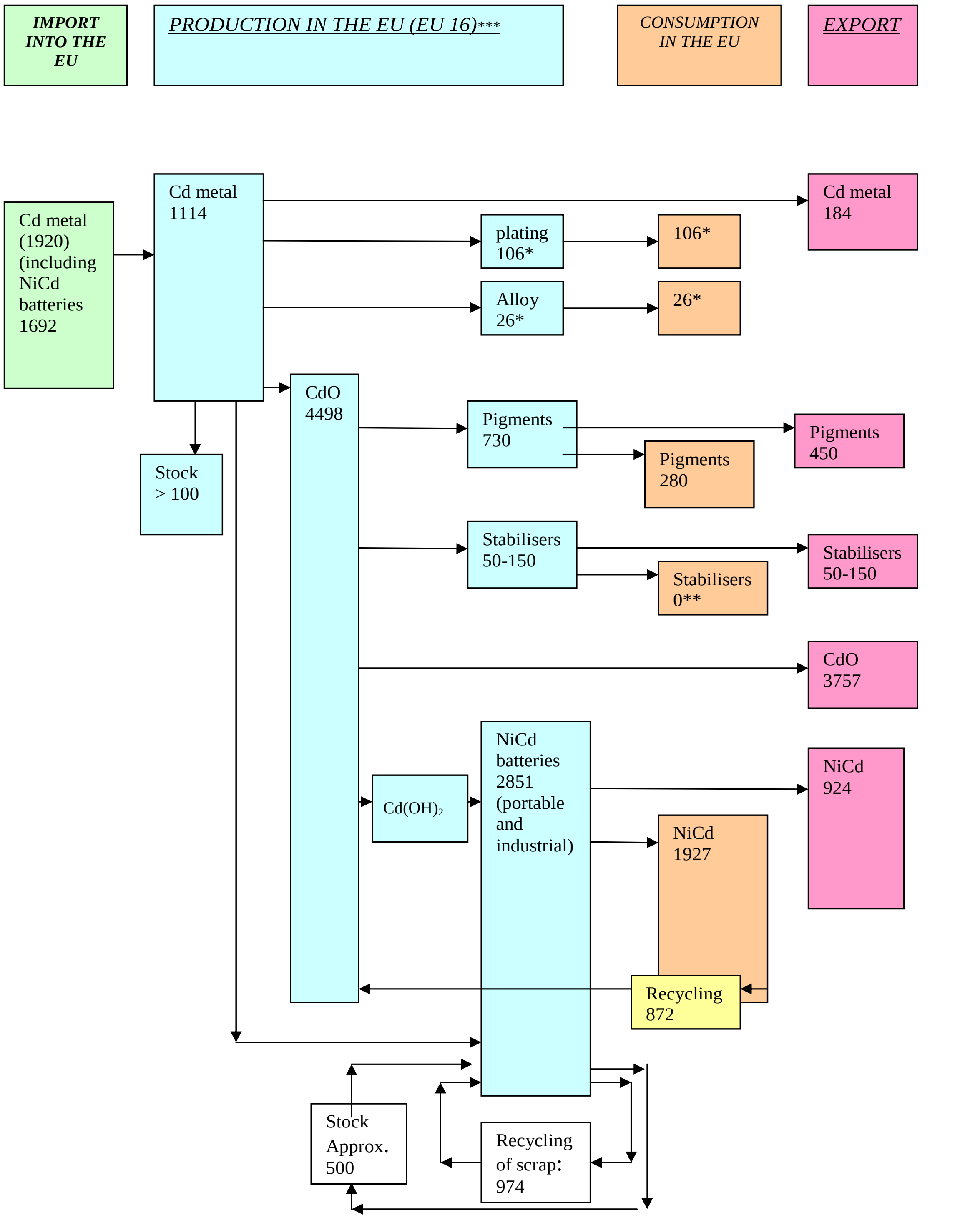


Figure 1.3.1: Cadmium mass balance flow in the EU for the reference year 2000-2002 (mass balance drawn up by ICdA, IZA-Europe and Recharge)

* Data refers to 1996. No update in figures was received

** Due to the Vinyl 2010 Commitment

*** Not included is cadmium contained in imported raw materials (zinc, copper and lead ores). For zinc ores the estimated amount of cadmium in the EU-16 is 5000 t per year. Most of this cadmium is stated to be separated in the production processes, stabilized and disposed of in authorized hazardous waste disposal sites.

Table 1.3.1 shows the industrial and use categories of cadmium and Table 1.3.2 gives an overview of the industrial and use categories of cadmium oxide. These tables were taken over from the RAR and reflect the information as reported by industry falling under the HEDSET[8] obligation and was further completed by information contained in the Product Registers.

Table 1.3.1: Industrial and use categories of cadmium in the EU (HEDSET, 1994)

Industrial category	*EC no.*	*Use category*	*EC no.*
Chemical industry: basic chemical	2		
Chemical industry: chemicals used in synthesis	3	Intermediates Laboratory chemicals	33 34
Electrical/electronic engineering industry	4	Conductive agents Batteries and cells...	12
Personal domestic	5	? (see Product Register)	
Metal extraction, refining and processing industry	8	Electroplating agents Others: Alloys	17 55
Paint, lacquers and varnishes	14	Reprographic agents	45
Others: Basic metal used in metal industry	15	Corrosion inhibitors	14

Table 1.3.2: Industrial and use categories of cadmium oxide in the EU (HEDSET, 1995; Product Registers, 1997 and 1998)

Industrial category	*EC no.*	*Use category*	*EC no.*
Chemical industry: basic chemical	2		
Chemical industry: chemicals used in synthesis	3	Intermediates Laboratory chemicals Raw material for the production of other cadmium chemicals	33 34 55
Electrical/electronic engineering industry	4	Conductive agents Electroplating agent	12 17
Polymers industry	11	Stabilisers	49
Paints, lacquers and varnishes industry	14	Colouring agents Fillers Reprographic agents	10 20 45
Others: Industrial : other = colours/frits Other : Ceramic industry Other: Glass and related industry	? 15 15	? Colouring agents Colouring agents	? 10 10

[8] HEDSET is the Harmonised Electronic Data Set software, available free of charge from the Commission, to be used by manufacturers and importers to submit the requisite information in the framework of the Council Regulation (EEC) No 793/93 of 23 March 1993 on the evaluation and control of the risks of existing substances [Official Journal L 84 of 05.04.1993]

2 IDENTIFICATION OF THE RISKS TO BE LIMITED

2.1 INTRODUCTION

In this section, it is identified which specific stages in the manufacture, storage, distribution, use or disposal of cadmium metal and cadmium oxide have been highlighted by the Risk Assessment Report (RAR, 2003) as giving rise to risks which need to be limited. EU guidelines for undertaking risk assessments require that the risks are characterised such that one of three conclusions can be reached:

(i) there is a need for further information and/or testing;

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

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

The risk reduction strategy is aimed at reducing the risks stemming from those activities identified in the risk assessment as giving rise to conclusions (iii). In addition, consideration should be given to measures that would target the possible risks for which there is a need for further information and/or testing (i).

For both the environmental and human health assessment, the Risk Assessment Report (RAR) reports conclusions (i), (ii) and (iii) depending on the compartment or use scenario.

2.2 SCOPE, APPROACH AND LIMITATIONS OF THE RAR

The study[¶] in the RAR is focused on assessing the risks of the two priority substances cadmium metal and cadmium oxide as foreseen under the Regulation 793/93/EEC, and thus especially during the production and the intentional use of these two specific substances. Under Regulation (EC) 642/2005 of 27 April 2005 [Official Journal L 107 of 28.04.2005], manufacturers and importers are required to carry out further testing and submit additional information on 12 existing priority substances, under which cadmium and cadmium oxide. Several other studies on 'cadmium' (generic) are dealing with other fields and/or compounds (e.g. the studies and reports performed in the framework of the Fertiliser Directive (76/116/EEC), Directive 91/338/EEC concerning cadmium in pigments, stabilisers and plating, Directive 2004/107/EC relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air, etc).

The RAR essentially covers the production of cadmium metal and cadmium oxide, the use of these substances in the production of stabilisers, pigments, alloys and plated products. Further down-stream uses are not or only limitedly included. However, major attention is attributed to the most important application, i.e. batteries with the whole life-cycle covered, thus including the main waste management options (recycling, incineration and landfill). Note that the scope and overall conclusions for environment and human health described here refer respectively to the December 2005

[¶] For clarification: 'the study' i.e. the RAR on Cadmium and Cadmium oxide refers to a) the so-called 'global' RAR and b) the targeted risk assessment on Cadmium (oxide) as used in batteries (the so-called 'TRAR').

(environment) and the July 2005 (human health) updates. The environmental part of the cadmium risk assessment is still under discussion at the TCNES level and hence any conclusions mentioned in this report could still be subject to changes.

For the environment, at regional level, the inventory of anthropogenic cadmium emissions has attempted to include all cadmium sources, thus including emissions from fertilisers, sludge, waste incineration, other industrial activities, etc. Sources and data were retrieved from open literature and unpublished reports available at the time this section was most importantly revised (reporting year 2000, based mainly on data from the 90-ties). Storm water and combined sewer overflows, being identified as a significant Cd-source to the surface water, have not been quantified in this assessment and may not be entirely covered.

The risk of cadmium (oxide) to the marine environment is not assessed (it is judged inappropriate to apply freshwater chemistry and ecotoxicity thresholds to the marine environment).

Cadmium in fertilisers (where cadmium is present as an impurity of the phosphate nutrient) and the potential risk linked with the use of sewage sludge on arable land, is covered to the extent needed for an appropriate assessment of the indirect exposure pathway (i.e. the use of fertilisers and sewage sludge is taken into account at the regional and continental scale). The emissions from the disposal options of the remaining sewage sludge (applications other than on arable land) could not be quantified.

As to the general assessment's approach, it was, for several reasons, preferred to adopt the 'total risk approach' in contrast with the 'added' approach in (some) other risk assessments on metals under the 'Existing Substances' Regulation. In the total risk approach, the risk characterization is performed on the 'total cadmium' concentrations in the environment, i.e. including the natural background and past anthropogenic (diffuse) input. As mentioned above, the anthropogenic sources are limited here by the context of the Regulation. Cadmium emissions of historic origin are taken into account for the soil and sediment compartment given the (very) long retention time of the substance (generic) in these compartments. The regional and continental risk characterisation for the environment is mainly based on measured data because of the limited predictive power of the exposure models at that scale.

Following points related to the environmental part are very important for the development of an adequate risk reduction strategy:

- For water, the total EU emission by the Cd(O) producing and using plants is currently estimated at 1.5 tons per year. Emissions of other sources at regional level are estimated at >39.2 tons per year. Hence, it is concluded that the cadmium emission from the cadmium(oxide) industry currently only amounts to 3.8% (1.5 tons versus a total of 1.5+39.2 tons) of the total cadmium emission to surface water. (RAR, December 2005)
- The total European emissions to air from all other sectors is currently estimated at >124 tons Cd per year while the total EU cadmium(oxide) industry emission is estimated at 4.7 tons/year (approx. 3.8% of the total 124 + 4.7 tons emitted).
- Total Cd emissions to agricultural soils are mainly related to P fertiliser application and are about 230 tons Cd year^{-1}. Additional net Cd sources are imported animal feed, sewage sludge and atmospheric deposition. The Cd deposition onto agricultural land, derived from Cd(O) production, processing and recycling is estimated to be 1.2 tons Cd year^{-1} (i.e. 4.7 tons Cd year^{-1} multiplied by 0.27, the fraction surface area that is agricultural soil).
- The actual assessment assumes good waste practices by all cadmium(oxide) producers and users.
- Note that above reported industry figures refer to the reference year 2000/2001. These values still have to be updated with more recent data. From these updates it is clear that emissions

have decreased and that some industry plants have ceased activities. The emissions to air and water from Cd(O)-industry decreased respectively from 4.7 to 0.1 ton/year and from 1.5 to 0.1 ton/year (new data of 2002). Hence the overall cadmium emission from the cadmium(oxide) industry are lower than those presented in the December 2005 version of the RAR and this may change the local and/or regional risk conclusions.

2.3 OVERALL CONCLUSIONS FOR ENVIRONMENT: CADMIUM OXIDE AND CADMIUM METAL

The environmental risk assessment on cadmium oxide and cadmium metal has not yet been finalised (see 2.2 scope). The overall conclusions for environment here refer to the December 2005 version. Subsequently, some of the conclusions drawn may be subject to change in the final version. Also note that an assessment for the atmosphere and the marine environment is not included in the RAR.

Conclusion (i)[9], "there is a need for further information and/or testing", is reached for the aquatic and sediment compartment. For the aquatic compartment, there is a need for better information regarding the toxic effects of cadmium to aquatic organisms under low water hardness conditions (very soft waters, hardness below about 10 mg $CaCO_3$/l). There are no data for the very soft waters and these areas may be unprotected by the proposed $PNEC_{water}$ (Predicted No Effect Concentration) for soft water (0.08 µg Cd/L). For sediment, there is a need for further information regarding the bioavailability of cadmium in order to possibly refine the assessment at regional and local level.

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

- the *local surface water* compartment for the CdO production site because there are no emissions to water at this site. Conclusion (ii) is also reached for the Cd metal production site, a Cd pigment producing site and all (two) Cd stabilizer production sites emitting to the aquatic environment.

- the *local sediment* compartment for the CdO production site because there are no emissions to water and no additional risk arises from its operations. The $PNEC_{sediment}$ of 2.3 mg/kg dwt is based on the NOEC of the chronic test (115 mg kg^{-1}) and divided by an assessment factor of 50. The choice of an AF of 50 instead of 100 is justified by (1) the number of acute toxicity data, showing no differences between species and (2) the fact that the PNEC would be below the background concentration.

- no risk is predicted for the *micro-organisms* in the off-site STP for Cd stabilizer production site discharging its effluents to a municipal STP.

- *modelled local soil* Cd concentrations for Cd metal production, CdO production and processing/use i.e. stabilizers and pigments production plants indicate no risks neither for the terrestrial compartment nor for secondary poisoning.

- *modelled regional soil* Cd concentrations that include natural soil, industrial soil and 8 different agricultural scenario's are all below the $PNEC_{soil}$. All modelled values are total concentrations that are expected after 60 years (agricultural soils) or far beyond that period (natural and industrial soils) with current regional emissions to soil. The starting concentrations are EU

9 Article 10.2 of regulation 2005

average values for the ambient air concentrations. If 90th percentiles of measured concentrations would have been used in such calculations, then risk cannot be excluded.

- *secondary poisoning* as field data (body burden: kidney and liver Cd data) of birds (excluding pelagic birds[10]) do not indicate Cd poisoning, even in top predators. No risk to mammals is predicted from modelled regional soil Cd concentrations.

Conclusion (iii), "there is a need for limiting the risks; risk reduction measures which are already being applied shall be taken into account", is reached for:

- the *local surface water* at 1 Cd metal production site and 4 processing (pigments production sites, plating and alloy) sites/scenarios. Both latter are generic scenarios ('Cd plating' and 'Cd alloys'). Local concentrations are based on modelling using standard default values and could possibly have been refined if substantial monitoring data would have been provided. Monitoring data are available for the Cd metal production site 1: these data indicate risk at background level but do not allow a judgment regarding potential additional risk caused by the site's operations.

  The uncertainty surrounding the PNEC for water is related to several aspects:

  1) Statistical aspects: for cadmium an effect database of 168 reliable tests on single species is available which contains 3 reliable LOECs below the derived HC_5 (0.38 µg/L) whereas the 9 multi species studies identified 1 LOEC below this hardness corrected HC_5. According to the overall RAR this suggests that NOEC and LOEC distributions overlap in the lower concentration range and that an additional assessment factor may be necessary.

  2) Species representativity

  3) Mixed pollution (etc. see section 3.2 overall RAR)

  These factors have crystallised in the AF=2 which was felt and agreed on at TCNES to cover most of the uncertainties.

  The uncertainty around the PNEC water (reflected by the assessment factor of 2) influences the risk conclusion for some sites.

- the modelled *regional* PEC of *surface water* has a risk factor of 0.6 using a mean partitioning coefficient (K_p) for EU while the risk factor is 1.7 using a K_p value that is distinctly smaller than average. This suggests potential regional risk. However, it is proposed to use measured values for the risk characterization because of the uncertainties in the choice of the natural background (which is combined with the added concentration to derive the regional PEC) and in the coverage of the surface water with small K_p values. Monitoring data were collected for 13 EU countries (of the EU-16 surveyed) but limitation in data quality (detection limit, geographical coverage etc.) reduced this information to 8 countries (as proxy for regions) for which conclusions can be derived. The regional averages of 90th percentiles of measured Cd concentrations of European rivers and lakes in these regions have a risk factor <1. The majority of regional averaged 90th percentiles have a risk factor < 1 whereas these values are >1 in the UK (based on a limited dataset of 1996) and the Walloon region of Belgium (based on data of 2000). Outliers have a large impact on the risk factors as, for example, 20 sites of the 728 investigated in the largest database of UK (data of 2003) determine risk in UK. If an

[10] no risk characterisation of marine environments was made in this report

outlier analysis is included on the UK data, there is more weight of evidence for a conclusion (ii). Since TCNES disagrees with outlier analysis on statistical basis only, conclusion (iii) is proposed in the RAR. More recent data (2002 and 2004), provided by industry, show decreased Cd concentrations in the Walloon Region of Belgium, possibly altering the risk conclusions (according to industry, a risk factor of 1 and 0.7 can be calculated for 2002 and 2004). The rapporteur agreed with most of the findings but these data were not taken on board in the RAR. The PNEC for water was derived with an assessment factor of 2 reflecting most of the uncertainties in the effects assessment. The conclusions about risk in the regions mentioned are not affected by either in- or excluding this assessment factor. During the development of the RRS, decision about (possible) reduction measures has to take into account the information on potential cadmium emission sources in these regions. In order to better characterise the regional risks to surface water in part of the EU which have not been covered in this assessment (i.e. eastern and southern Europe are underrepresented in the entire dataset, because detection limits are often too high and because fractionation is often not reported) it might be useful to obtain more information for these regions. It may be that the foreseen monitoring actions under for example the Water Framework Directive will provide this information in the future.

- the *local terrestrial compartment*: there are potential risks at cadmium plating and alloy production sites.

- the *regional terrestrial ecosystem:* the 90^{th} percentiles of *measured* Cd concentrations of European soils have risk factors 0.4-1.6 (mean: 0.86; data from 6 EU countries). Regional risk for the terrestrial ecosystem cannot be excluded in one region (UK). However, it should be noted that the 90^{th} percentile for the UK falls within the range of the proposed $PNEC_{soil}$ based on direct toxicity to soil microbial processes (21 NOEC's of microbial processes (5 different processes)). Hence risk cannot be excluded but will depend on the magnitude of the assessment factor chosen (either 1 or 2) in the derivation of the $PNEC_{soil}$.

  The uncertainty surrounding the PNEC is related to several aspects. The few field data yield NOEC's that are well above the HC_5 of 2.3 μg Cd g^{-1}. Toxicity of Cd on plants grown in pot trials is equally or more pronounced than in the field. There is currently no indication of higher toxicity of Cd salts in the field than in the laboratory. There is no single test in the database at which a toxic effect of Cd was found at or below the $PNEC_{soil}$ = 2.3 μg Cd g^{-1}. The HC_5 value of the terrestrial ecosystem is derived from 5 different microbial processes. This HC_5 almost equals the HC_5 values based on the fauna+plant data (49 different tests) and the HC_5 of the whole RI 1-3 data set (derived from 65 different tests with 20 different species and 5 different soil microbial processes). The plants belong to 9 different families and 9 different orders and the invertebrates belong to 3 different families and 3 different orders. This diversity certainly meets the recommendation of the EU workshop (17-18 January, 2001) on statistical extrapolation that the data set should contain at least 8 different taxa for applying the statistical extrapolation technique. The entire database does, however, not contain community system data and is biased towards agricultural species. These factors have crystallised in the AF ranging 1-2.

- the *secondary poisoning (regional level)* as *measured* soil Cd concentrations of European soils have risk factors 0.4-1.6 for poisoning to mammals (mean: 0.86; data from 6 EU countries). Regional risk for the terrestrial ecosystem cannot be excluded in one region (UK). The uncertainty surrounding the effects assessment, however, suggests that this is a borderline situation: the available information shows that literature data on Cd uptake in mammals dwelling in acid soils sensitively influences the effects assessment. If data on acid soils (pH <4.2) are excluded from the effects assessment, a larger PNEC is obtained and risk in the UK would be excluded. That conclusion would only remove concern provided that the P90 value in UK does not refer to acid soils, which is unknown. This analysis is, moreover, qualitatively because there is no validated model to estimate risk to mammals along the entire range of soil pH.

- *the wastewater treatment plants:* risk to on-site and off-site STP cannot be excluded for Cd plating and alloy industry. The PNECmicro-organisms (20 µg Cd/L) is derived by dividing the lowest NOEC value of a respiration inhibition by an assessment factor of 10.

2.4 OVERALL CONCLUSIONS FOR HUMAN HEALTH

2.4.1 Cadmium oxide

The characterisation of the health risks associated with cadmium oxides considers three potentially exposed human populations, i.e. workers, consumers and man exposed indirectly via the environment. The risk is estimated by comparing estimated N(L)OAEL values to exposure levels measured or estimated in the target population. For each health effect, the ratio of the N(L)OAEL to the exposure level will be assessed for each scenario, e.g. workers in a particular type of production or general population. This ratio is termed the Margin of Safety (MoS). Relevant and validated biomarkers of exposure (concentration of Cd in blood and urine) exist and were used. Since the use of biomarkers integrates all possible routes of exposure, no differentiation was made between oral, dermal or inhalation exposure.

2.4.1.1 HUMAN HEALTH: TOXICOLOGICAL EFFECTS

RISK TO WORKERS (OCCUPATIONAL EXPOSURE)

Conclusion (i) (on hold) is reached because further information is needed to better document the possible neurotoxic effects of CdO suggested in experimental animals, especially on the developing brain. The collection of this additional information should, however, not delay the implementation of appropriate control measures needed to address the concerns expressed for several other health endpoints including repeated dose toxicity and carcinogenicity.

The information requirements are further epidemiological and experimental information to identify more precisely the nature of the effects, the characterisation of the exposure and the mechanism of action related to neurotoxicity. These investigations should mainly focus on effects on the developing brain (prenatal and early childhood exposure). Effects on the adult nervous system should also be characterised.

Conclusion (iii), "there is a need for limiting the risks; risk reduction measures which are already being applied shall be taken into account", is reached because at the mentioned exposure levels, health risks (acute toxicity; respiratory irritation; kidney & bone repeated dose toxicity; genotoxicity; carcinogenicity, effects on fertility and reproductive organs) cannot be excluded upon inhalation exposure.

Table 2.4.1 provides an overview of the formal occupational health conclusions on cadmium oxide as produced/used in the scenarios relevant for the life-cycle of cadmium oxide i.e. 'CdO production', 'Ni-Cd batteries', 'Pigments', 'Stabilisers', 'Plating' and 'Others' (Table 5.4.1 from RAR).

Some important notes have to be made to put these risk conclusions more into their context.

- Risks to workers were identified based on a continuous exposure scenario.

- Concerning acute toxicity, appropriate reduction measures may already be in place to control the risk of chemical pneumonitis (e.g. by training and the use of respiratory protection). Chemical pneumonitis caused by CdO exposure has been relatively rarely reported in recent years and the few recent cases of chemical pneumonitis caused by CdO fumes were associated with non industrial circumstances.
- Concerning respiratory tract, no animal study specifically considering local irritation of the respiratory tract after exposure to CdO was located. However, as several animal studies and case reports are available on acute and chronic respiratory effects after inhalation of CdO, it was reasonable to consider in the RAR that this substance is an irritant for the respiratory tract. It is supposed that risk reduction measures are in place to prevent irritation to occur. Personal protective equipment, properly selected and worn, will also significantly reduce exposure.
- Concerning kidney and bone, it is recognized in the RAR that there are uncertainties on the accuracy of the LOAEL of 2 μg/g creatinine based on the concurrences of epidemiological studies indicating both kidney and bone effects in the general population. The clinical significance of the biochemical changes observed at these levels is still subject to a scientific debate. The LOAEL is based on the association between Cd and not only LMW proteins but also calcium excretion in urine and its possible relationship with bone effects. The LOAEL is derived from a large set of epidemiological data directly collected in the population at risk (including individuals exposed during their childhood, smokers, women with depleted iron stores, and individuals with possible predisposing conditions such as renal diseases or diabetes but also workers with previously high exposure. In addition, a MOS of 3 is assumed necessary to protect the general population: this would mainly take into account the conversion of a LOAEL to a NOAEL. It was then decided that for workers the same level of protection should be provided.

  The RAR argues that workers in an occupational environment should be offered the same level health protection than individuals from the general population because workers may also suffer from pre-existing or concurrent renal disease. On the other hand the possible mitigating effect of the "healthy workers" concept has not been taken into account (Diamond, 2005). This so-called healthy worker effect could contribute to different estimates for a given dose-response parameter (e.g. ED_{10}) derived from occupational studies, compared to general population studies because variability in the threshold within populations is expected due to interindividual variability in toxicokinetics and toxicodynamics of cadmium. This does not mean that cadmium workers and general populations have different thresholds, but rather, that these occupational and general population studies yield different estimates of a common threshold distribution for humans (Diamond, 2005).
- Concerning genotoxicity, data concerning humans exposed to CdO seem to indicate a genotoxic potential, at least in occupational settings, but it is unclear whether these effects are solely attributable to CdO. As long as the mechanism of genotoxicity is not completely elucidated, the RAR assumes that Cd compounds (and by extension CdO) is a direct acting genotoxic substance and that it is prudent to consider that there is no threshold exposure level below which effects will not be expressed.
- Concerning carcinogenicity, the RAR considers CdO at least to be a suspected inhalation non-threshold carcinogen (lung cancer) based on the data collected in long-term animal experiments and in epidemiological studies. Given the serious and irreversible nature of the effect and the fact that it is not possible to exclude the risk of this being expressed at occupational levels, there is cause of concern across all industrial uses, according to the RAR.

Table 2.4.1: Overview of the formal occupational health conclusions on cadmium oxide as produced / used in the scenarios relevant for the life-cycle of cadmium oxide i.e. 'CdO production', 'Ni-Cd batteries', 'Pigments', 'Stabilisers', 'Plating' and 'Others' (Table 5.4.1 from RAR July 2005)

End point	Conclusions proposed for the occupational scenario's																	
	CdO production				Ni-Cd batteries				Pigments		Metal plating		Stabilisers				Others	
	MOS	**Ccl**			MOS	**Ccl**			MOS	**Ccl**	MOS	**Ccl**	MOS	**Ccl**			MOS	Ccl
Acute toxicity	3	**(iii)**			-	**(ii)**			-	**(ii)**	44	**(ii)**	-	**(ii)**			220	**(ii)**
Irritation																		
eye	-	**(ii)**			-	**(ii)**			-	**(ii)**	-	**(ii)**	-	**(ii)**			-	**(ii)**
skin	-	**(ii)**			-	**(ii)**			-	**(ii)**	-	**(ii)**	-	**(ii)**			-	**(ii)**
respirat. tract	-	**(iii)**			-	**(iii)**			-	**(iii)**	-	**(iii)**	-	**(iii)**			-	**(iii)**
Corrosivity	-	**(ii)**			-	**(ii)**			-	**(ii)**	-	**(ii)**	-	**(ii)**			**-**	**(ii)**
Sensitisation	-	**(ii)**			-	**(ii)**			-	**(ii)**	-	**(ii)**	-	**(ii)**			**-**	**(ii)**
Repeated dose toxicity																		
Kidney & bone	0.20	**(iii)**			0.6	**(iii)**			0.50	**(iii)**	-	**(iii)***	-	**(iii)***			**-**	**(iii)***
Neurotoxicity	-	**(i)§**			-	**(i)§**			-	**(i)§**	-	**(i)§**	-	**(i)§**			**-**	**(i)§**
Genotoxicity	-	**(iii)**			-	**(iii)**			-	**(iii)**	-	**(iii)**	-	**(iii)**			-	**(iii)**
Carcinogenicity	-	**(iii)**			-	**(iii)**			-	**(iii)**	-	**(iii)**	-	**(iii)**			-	**(iii)**
Reprotoxicity																		
Fertility ands sex organs	0.66	**(iii)**			0.31	**(iii)**			1.25	**(iii)**	10	**(ii)**	50	**(ii)**			50	**(ii)**
Developmental	-	**(i)§**			-	**(i)§**			**-**	**(i)§**	-	**(i)§**	-	**(i)§**			-	**(i)§**

§ on hold
* by extrapolation from other scenarios

RISK TO CONSUMERS (CONSUMER EXPOSURE)

Conclusion (ii), "there is at present no need for further information and/or testing and for risk reduction measures beyond those which are being applied already", is reached because among the examined scenarios, CdO is involved for the manufacture of Ni-Cd batteries and, in this case, consumer exposure is considered to be non-existent or negligible.

MAN EXPOSED INDIRECTLY VIA THE ENVIRONMENT

Three scenarios were considered: (1) adults with sufficient body iron stores, (2) adults with depleted body iron stores, and (3) adults with sufficient body iron stores in a local condition where Cd concentrations in soil, air and diet are all elevated.

Conclusion (i) (on hold) is reached because further information is needed to better document the possible neurotoxic effects of CdO suggested in experimental animals, especially on the developing brain. The collection of this additional information should, however, not delay the implementation of appropriate control measures needed to address the concerns expressed for several other health effects including repeated dose toxicity and carcinogenicity.

The information requirements are further epidemiological and experimental information to identify more precisely the nature of the effects, the characterisation of the exposure and the mechanism of action related to neurotoxicity. These investigations should mainly focus on effects on the developing brain (prenatal and early childhood exposure). Effects on the adult nervous system should also be characterised.

Conclusion (iii) is reached because at the mentioned exposure levels, health risks (kidney & bone (all scenarios except adult non-smokers with sufficient iron stores) and lung (scenario 3) repeated dose toxicity, carcinogenicity/genotoxicity for all scenarios) cannot be excluded upon environmental exposure.

Table 2.4.2 gives an overview of the conclusions on cadmium oxide with respect to environmental exposure (Table 5.6.1 from RAR July 2005).

JECFA (Joint FAO/WHO Expert Committee on Food Additives) reaffirmed its conclusion that renal tubular dysfunction is the critical health outcome with regard to cadmium toxicity (WHO, 2004). Although some recent Japanese, European and USA studies using sensitive biomarkers indicated that changes in renal function and bone/calcium metabolism are observed at urinary cadmium levels below 2.5 μg/g creatinine, the Committee noted that appreciable uncertainty remains regarding the long-term health significance of these changes. In addition the Committee noted inconsistencies among studies in the specific biomarkers of renal function most commonly associated with urinary cadmium levels. Although recent studies suggest that increased cadmium biomarker levels are associated with health effects such as diabetes, hypertension, pancreatic cancer, fetal growth, and neurotoxicity, the Committee concluded that these data are not, at this time, sufficiently robust to serve as a basis for the evaluation. The Committee reaffirmed that its conclusion that an excess prevalence of renal tubular dysfunction will not be expected to occur if urinary cadmium levels remains below 2.5 μg/g creatinine, even under a range of plausible assumptions about the relationship between the amount of cadmium bioavailable from the diet and the urinary excretion of cadmium. The Committee maintained the current PTWI of 7 μg/kg body weight. The proposed threshold level in the RAR of 0.67 μg Cd/kg creatinine (LOAEL of 2 with a MOS of 3), is therefore significantly smaller than the proposed threshold level of JECFA of 2.5 μg Cd/kg creatinine.

Related to the scenario 3 ('near point sources'): the conclusion (iii) for kidney & bone repeated dose toxicity is based on reasonable worst-case conditions (RWC) calculated estimates derived from the highest exposure data per life-cycle step i.e. data from 1996 (three Cd metal producers) or 1999 (one NiCd battery producer). Mor recent and reliable measured data (2003/2004) have been requested and have been provided by industry in early 2005. To date, some of the plants for which these values were reported may have ceased activity or changed their production process. This risk conclusion (iii) is consequently outdated and should receive careful consideration in the risk reduction strategy.

For the same scenario, the conclusion (iii) for lung repeated dose toxicity is applicable to Cd metal producers only (RWC calculated estimate based on emission data of 1996 at three sites and in the absence of more recent emission and/or reliable measured data from Industry: to date, some of the plants for which these values were reported may have ceased activity or changed the production process).

Similar remarks can be made for kidney and bone, genotoxicity/carcinogenicity as in the occupational exposure part.

COMBINED EXPOSURE (WORKERS, CONSUMERS, MAN INDIRECTLY EXPOSED VIA THE ENVIRONMENT)

See Conclusions for Workers, for Consumers and/or for Man exposed indirectly via the environment (use of biomarkers integrates all possible routes).

Table 2.4.2: Overview of the conclusions on cadmium oxide with respect to environmental exposure (Table 5.6.1 from RAR September 2004 and July 2005 updates)

End point	Conclusions proposed for man exposed via the environment									
	1a. adults non-smokers		1b. adults smokers		2a. adults with depleted iron stores, non-smokers		2b. adults with depleted iron stores, smokers		3.near point sources	
	MOS	Ccl	MOS	Ccl	MOS	Ccl	MOS	Ccl	MOS	Ccl
Repeated dose toxicity										
Kidney and bone	12.50-3.58	**(ii)**	4.88-1.28	**(iii)**	7.72-2.00	**(iii)**	3.92-0.98	**(iii)**	0.62-4.5	**(iii)**
Lung	-	**-**	-	**-**	-	**-**	-	**-**	~2	**(iii)**[11]
Carcinogenicity /genotoxicity		**(iii)**		**(iii)**	-	**(iii)**	-	**(iii)**	-	**(iii)**
Reprotoxicity										
Effects on fertility and sex organs	>100	**(ii)**	>100	**(ii)**	>100	**(ii)**	>100	**(ii)**	>100	**(ii)**
Developmental effects	-	**(i)§**	-	**(i)§**	-	**(i)§**	-	**(i)§**	-	**(i)§**

[11] Reasonable worst-case conditions calculated estimate based on emission data of 1996 at three sites. To date, some of the plants for which these values were reported may have ceased activity or changed the production process. This alters the risk conclusion.

2.4.1.2 HUMAN HEALTH (PHYSICOCHEMICAL PROPERTIES)

Conclusion (ii) is reached because given the level of control in manufacture and use, the risks from physicochemical properties are small.

2.4.2 Cadmium metal

2.4.2.1 HUMAN HEALTH: TOXICOLOGICAL EFFECTS

The same conclusions as for Cadmium oxide are reached for Cadmium metal, except for consumers.

RISK TO CONSUMERS (CONSUMER EXPOSURE)

Conclusion (ii) is reached because among the examined scenarios, Cd metal is involved for the manufacture of Ni-Cd batteries and, in this case, consumer exposure is considered to be non-existent or negligible.

Conclusion (iii) is reached because:

- acute respiratory effect cannot be excluded when using Cd-containing brazing sticks (DIY);
- dermal exposure to Cd metal is possible when wearing (imported) jewellery and in this case, in a very conservative estimate, it cannot be excluded that consumer exposure may represent a cause of concern for the relevant endpoints associated with carcinogenicity/genotoxicity and possibly reprotoxicity.

Similar remarks can be made for kidney and bone, genotoxicity/carcinogenicity as in the occupational exposure part of CdO.

2.4.2.2 HUMAN HEALTH (PHYSICOCHEMICAL PROPERTIES)

Conclusion (ii) is reached because given the level of control in manufacture and use, the risks from physicochemical properties are small.

3 EXISTING RISK REDUCTION MEASURES

A wide range of risk reduction measures is available, allowing to develop a strategy suited to reduce the risks assessed in chapter 2 of this document. The TGD (EC, 1998) on the development of a risk reduction strategy gives a list of possible measures, categorised as follows:

- Measures related to manufacture, industrial and professional use;
- Measures related to packaging, distribution, transfer and storage;
- Measures related to domestic and consumer use;
- Measures related to waste management.

Such measures can be implemented using a range of policy instruments, including, for example, regulation, economic instruments and voluntary approaches.

In the following sections, an overview is given of the instruments, already in place, to reduce the risks to the environment and human health from manufacturing, processing, transport and use of cadmium metal and cadmium oxide. First of all, an overview is given of the existing European Community and national legislation, followed by an overview of some voluntary initiatives (EU and international).

For each measure listed here (legislative or not), an indication is given of the areas (human health, air, water, soil, secondary poisoning) on which the measure has an impact.

3.1 EUROPEAN LEGISLATION

In the following paragraphs, a brief description is given of the relevant legislation in place on a Community level.

3.1.1 Classification and labelling

3.1.1.1 Directive 67/548/EEC on the classification, packaging and labelling of dangerous substances

Relevant for: human health (workers and consumers), air, surface water and sediment, terrestrial, secondary poisoning

Cadmium metal and cadmium oxide is classified according to Annex I of the Directive 67/548/EEC (29th ATP, i.e. Dir. 2004/73/EEC, O.J. 30.04.2004).

Einecs-No for cadmium oxide and cadmium metal: 215-146-2 and 231-152-8

CAS-No for cadmium oxide and cadmium metal: 1306-19-0 and 7440-43-9

Chemical name	Classification	Labelling	Symbol	
Cadmium (non-pyrophoric) cadmium oxide (non-pyrophoric)	Carc. Cat. 2; R45 Muta. Cat. 3; R68 Repr. Cat. 3; R62-63 T; R48/23/25 T+; R26 N; R50-53 Nota E	T+; N R: 45-26-48/23/25-62-63-68-50/53 S: 53-45-60-61		T+: very toxic
				N: harmful to the environment
Cadmium (pyrophoric)	Carc. Cat. 2; R45 Muta. Cat. 3; R68 Repr. Cat. 3; R62-63 T; R48/23/25 T+; R26 R; R17 N; R50-53 Nota E	F; T+; N R: 45-17-26-48/23/25-62-63-68-50/53 S: 53-45-7/8-43-60-61		F: flammable
				T+: very toxic
				N: harmful to the environment

- R17: Spontaneously flammable in air
- R26: Very toxic by inhalation
- R45: May cause cancer
- R50: Very toxic to aquatic organisms
- R53: May cause long-term adverse effects in the aquatic environment
- R62: Possible risk of impaired fertility
- R63: Possible risk of harm to the unborn child
- R68: Possible risks of irreversible effects
- R48/23/25: Toxic: danger of serious damage to health by prolonged exposure through inhalation and if swallowed
- S43: In case of fire, use....(indicate in this space the precise type of fire fighting equipment. If water increases the risk, add "never use water")
- 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/or its container must be disposed of as hazardous waste
- S61: Avoid release to the environment. Refer to special instructions/ material safety data sheet
- S7/8: Keep container tightly closed and dry

Note E of Annex I of Directive 67/548/EEC mentions : 'Substances with specific effects on human health that are classified as carcinogenic, mutagenic and/or toxic for reproduction in categories 1 or 2 are ascribed Note E if they are also classified as very toxic (T+), toxic (T) or harmful (Xn). For these substances, the risk phrases R20, R21, R22, R23, R24, R25, R26, R27, R28, R39, R68 (harmful), R48 and R65 and all combinations of these risk phrases shall be preceded by the word "Also". (Examples: R45-23

"May cause cancer. Also toxic by inhalation"; R46-27/28 "May cause heritable genetic damage. Also very toxic in contact with skin and if swallowed".).

Cadmium pigments (cadmium sulphoselenide, cadmium zinc suphide and barium sulphate) are not classified according to Annex I of the Directive 67/548/EEC. A Health and safety data sheet for cadmium pigments is included in Annex 1 of this report.

3.1.1.2 Directive 1999/45/EC on the classification, packaging and labelling of dangerous preparations

Relevant for: human health

According to Annex V of the Directive 1999/45/EC, packaging of preparations containing cadmium (alloys) and intended to be used for brazing or soldering, must bear the following inscription printed in clearly legible and indelible characters:

Warning! Contains cadmium. Dangerous fumes are formed during use. See information supplied by the manufacturer. Comply with the safety instructions.

3.1.1.3 Classification and labelling in practice

This part will be further developed.

3.1.2 Legislation for the protection of workers

3.1.2.1 Directive 92/32/EC on safety data sheets

Relevant for: human health (workers and consumers)

Article 27 of Directive 92/32/EC (7^{th} amendment of Directive 67/548/EEC) lays down the principle that any manufacturer, importer or distributor shall communicate to the recipient a safety data sheet. The actual contents of the safety data sheet are specified in Directive 91/155/EEC (amended by 93/112/EC and 2001/58/EC), defining and laying down the detailed arrangements for the system of specific information relating to dangerous preparations in implementation of Article 10 of Directive 88/379/EEC.

In Annex 3 an SDS for cadmium metal is enclosed (Norzink (Boliden Norway), 2004). It must be noted that the classification and labelling indicated in this SDS is not in line with the classification and labelling according to Directive 67/548/EEC.

Annex 3 encloses a SDS for cadmium oxide (Floridienne Chimie, 2005). This SDS is in line with the classification and labelling according to Directive 67/548/EEC. Although it should be noted that following improvements can be suggested:

- Section 3: should say 'risks' instead of 'dangers (gevaren)';
- Section 8: the list of limit values should be completed;
- Section 8: the type of gloves to be used should be specified.

3.1.2.2 Directive 98/24/EC on chemical agents at work

Relevant for: human health (workers)

The Directive 'on the protection of the health and safety of workers from the risks related to chemical agents at work' (98/24/EC) lays down the minimum requirements for the protection of workers from risks to their safety and health arising, or likely to arise, from the effects of chemical agents that are present at the workplace or as a result of any work activity involving chemical agents. This Directive replaces and revises a number of existing directives covering exposure to chemical, physical and biological agents at work (80/1107/EEC).

Article 3 of this Directive provides a revised framework for occupational exposure limit values and biological limit values in the EU.

Article 6 of this Directive provides a hierarchy of measures that have to be taken by the employer in order to reduce the risk to safety and health of workers to a minimum :

1. substitution, whereby the employer shall avoid the use of a hazardous chemical agent by replacing it with a chemical agent or process which, under its condition of use, is not hazardous or less hazardous to workers' safety and health;
2. design of appropriate work processes and engineering controls and use of adequate equipment and materials, so as to avoid or minimise the release of hazardous chemical agents which may present a risk to workers' safety and health at the place of work;
3. application of collective protection measures at the source of the risk, such as adequate ventilation and appropriate organizational measures;
4. where exposure cannot be prevented by other means, application of individual protection measures including personal protective equipment (see 3.1.2.3.)

Article 8 of this Directive imposes the employer with the obligation to provide training and information on the appropriate precautions and on the personal and collective protection measures to be taken.

Article 10 of this Directive determines that the Member States have to introduce arrangements for carrying out appropriate health surveillance of workers.

Article 12 foresees the adaptation of the Annexes (strictly technical in nature) and determines that the Commission shall draw up practical guidelines of a non-binding nature. In the context of the application of this Directive, Member States shall take account as far as possible of these guidelines in drawing up their national policies for the protection of the health and safety of workers.

3.1.2.3 Directive 89/656/EEC on personal protective equipment

Relevant for: human health (workers)

Directive 89/656/EEC is the EU legislative framework concerning the use of personal protective equipment (PPE). This Directive lays down minimum requirements for personal protective equipment used by workers at work, saying that all personal protective equipment must (Art. 4):

- be appropriate for the risks involved, without itself leading to any increased risk;
- correspond to existing conditions at the workplace;
- take account of ergonomic requirements and the worker's state of health;
- fit the wearer correctly after any necessary adjustment.

3.1.2.4 Directive 2004/37/EC on exposure to carcinogens or mutagens at work

Directive 2004/37/EC on the protection of workers from the risks related to exposure to carcinogens or mutagens at work is a consolidation Directive that replaces Directive 90/394/EEC and its subsequent amendments (Directive 90/394/EEC, Directive 97/42/EC and Directive 1999/38/EC). It makes no substantive changes and merely consolidates the body of texts which it replaces.

This Directive implies that in the case of any activity likely to carry the risk of exposure to carcinogens or mutagens, the nature, degree and duration of workers' exposure must be determined on a regular basis in order to assess any risk to workers' health or safety and decide the steps to be taken. All routes of exposure must be taken into account, including absorption into and/or through the skin. Particular attention must be paid to workers who are especially at risk.

3.1.3 Legislation for protection of consumers

3.1.3.1 Directive 76/769/EEC on marketing and use restrictions

<u>Relevant for</u>: human health (workers and consumers), air, surface water and sediment, terrestrial, secondary poisoning

Use of cadmium products by consumers is regulated under Directive 76/769/EEC on the restrictions on the marketing and/or use of substances and especially by the relevant amendment 91/338/EEC and the Directive 1999/51/EC of 26 May 1999 adapting Annex I to Directive 76/769/EEC to technical progress for the fifth time. Substances falling under the Limitations Directive are listed in the Annex I to that Directive which also specifies the restrictions on marketing and use applying in each particular case. This Directive lays down the following restrictions on "Cadmium (CAS No 7440-43-9) and its compounds" (excerpt from Directive 76/769/EEC):

1.1. May not be used to give colour to finished products manufactured from the substances and preparations listed below:

- polyvinyl chloride (PVC) [390410] [390421] [390422]
- polyurethane (PUR) [390950]
- low-density polyethylene (ld PE), with the exception of low-density polyethylene used for the production of coloured masterbatch [390110]
- cellulose acetate (CA) [391211] [391212]
- cellulose acetate butyrate (CAB) [391211] [391212]
- epoxy resins [390730]

In any case, whatever their use or intended final purpose, finished products or components of products manufactured from the substances and preparations listed above coloured with cadmium may not be placed on the market if their cadmium content (expressed as Cd metal) exceeds 0,01 % by mass of the plastic material.

1.2. Section 1.1 also applies from 31 December 1995 for:

(a) finished products manufactured from the following substances and preparations:

- melamine — formaldehyde (MF) [390920]
- urea — formaldehyde (UF) [390910]
- unsaturated polyesters (UP) [390791]
- polyethylene terephthalate (PET) [390760]

- polybutylene terephthalate (PBT)
- transparent/general-purpose polystyrene [390311] [390319]
- acrylonitrile methylmethacrylate (AMMA)
- cross-linked polyethylene (VPE)
- high-impact polystyrene
- polypropylene (PP) [390210]

(b) Paints [3208] [3209]

However, if the paints have a high zinc content, their residual concentration of cadmium must be as low as possible and at all events not exceed 0,1 % by mass.

1.3. However, Sections 1.1 and 1.2 do not apply to products to be coloured for safety reasons.

2.1. May not be used to stabilize the finished products listed below manufactured from polymers or copolymers of vinyl chloride:

- packaging materials (bags, containers, bottles, lids) [3923 29 10] [392041] [392042]
- office or school supplies [392610]
- fittingsfor furniture, coachwork or the like [392630]
- articles of apparel and clothing accessories (including gloves) [392620]
- floor and wall coverings [391810]
- impregnated, coated, covered or laminated textile fabrics [590310]
- imitation leather [4202]
- gramophone records [852410]
- tubesand pipesand their fittings [391723]
- swing doors
- vehicles for road transport (interior, exterior, underbody)
- coating of steel sheet used in construction or in industry
- insulation for electrical wiring

In any case, whatever their use or intended final purpose, the placing on the market of the above finished products or components of products manufactured from polymers or copolymers of vinyl chloride, stabilized by substances containing cadmium is prohibited, if their cadmium content (expressed as Cd metal) exceeds 0,01 % by mass of the polymer. These provisions enter into force on 30 June 1994.

2.2. However, Section 2.1 does not apply to finished products using cadmium-based stabilizers for safety reasons.

3. Within the meaning of this Directive, 'cadmium plating' means any deposit or coating of metallic cadmium on a metallic surface.

3.1. May not be used for cadmium plating metallic products or components of the products used in the sectors/applications listed below.

(a) equipment and machinery for:

- food production: [8210] [841720] [841981] [842111] [842122] [8422] [8435] [8437] [8438] [847611]
- agriculture [841931] [842481] [8432] [8433] [8434] [8436]

- cooling and freezing [8418]
- printing and book-binding [8440] [8442] [8443]

(b) equipment and machinery for the production of:

- household goods [7321] [842112] [8450] [8509] [8516]
- furniture [8465] [8466] [9401] [9402] [9403] [9404]
- sanitary ware [7324]
- central heating and air conditioning plant [7322] [8403] [8404] [8415]

In any case, whatever their use or intended final purpose, the placing on the market of cadmium-plated products or components of such products used in the sectors/applications listed in (a) and (b) above and of products manufactured in the sectors listed in (b) above is prohibited.

3.2. The provisions referred to in Section 3.1 are also applicable from 30 June 1995 to cadmium-plated products or components of such products when used in the sectors/applications listed in (a) and (b) below and to products manufactured in the sectors listed in (b) below:

(a) equipment and machinery for the production of:

- paper and board [841932] [8439] [8441]
- textiles and clothing [8444] [8445] [8447] [8448] [8449] [8451] [8452]

(b) equipment and machinery for the production of:

- industrial handling equipment and machinery [8425] [8426] [8427] [8428] [8429] [8430] [8431]
- road and agricultural vehicles [chapter 87]
- rolling stock [chapter 86]
- vessels [chapter 89]

3.3 However, Sections 3.1 and 3.2 do not apply to:

- products and components of the products used in the aeronautical, aerospace, mining, offshore and nuclear sectors whose applications require high safety standards and in safety devices in road and agricultural vehicles, rolling stock and vessels,
- electrical contacts in any sector of use, on account of the reliability required of the apparatus on which they are installed.

4 Austria and Sweden, which already apply restrictions to cadmium going further than those prescribed in Sections 1, 2 and 3 may continue to apply these restrictions until 31 December 2002. The Commission has reviewed the provisions on cadmium in Annex I to Directive 76/769/EEC before this date in light of the results of risk assessment for cadmium and of development of knowledge and techniques in respect of substitutes for cadmium.

Directive 2005/90/EC of the European Parliament and of the Council of 18 January 2006 is an amendment (for the twenty-ninth time) of the Council Directive 76/769/EEC on the approximation of the laws, regulations and administrative provisions of the Member States relating to restrictions on the marketing and use of certain dangerous substances and preparations, in particular substances classified as carcinogen, mutagen or toxic to reproduction. In this Directive, Cd (pyrophoric) is added to the list of substances newly subject to market limitations[12]. Cd (pyrophoric) is listed as a cmr category "Carcinogen Category 2".

3.1.3.2 Directive 2001/95/EC on general product safety

Relevant for: human health (workers and consumers)

Directive 2001/95/EC on general product safety imposes a general safety requirement on any product put on the market for consumers or likely to be used by them, including all products that provide a service and excluding second-hand products that have antique value or that need to be repaired.

A safe product is one which poses no threat or only a reduced threat in accordance with the nature of its use and which is acceptable in view of maintaining a high level of protection for the health and safety of persons.

A product is deemed safe once it conforms to the specific Community provisions governing its safety. In the absence of such provisions, the product must comply with the specific national regulations of the Member State in which it is being marketed or sold, or with the voluntary national standards which transpose the European standards. In the absence of these, the product's compliance is determined according to the following:

- the voluntary national standards which transpose other relevant European standards and the Commission recommendations which set out guidelines on the assessment of product safety;
- the standards of the Member State in which the product is being marketed or sold;
- the codes of good practice as regards health and safety;
- the current state of the art;
- the consumers' safety expectations.

3.1.3.3 Directive 88/378/EEC on safety of toys

Relevant for: human health (consumers)

Directive 88/378/EEC applies to toys, i.e. any product or material designed or clearly intended for use in play by children of less than 14 years of age. They lay down the safety criteria or "essential requirements" which toys must meet during manufacture and before being placed on the market. Harmonised European standards have been drawn up on the basis of the essential requirements by the European standardisation organisations. These (non-mandatory) standards are notified to the Official Journal of the European Union. Any toy manufactured in conformity with the harmonised standards is presumed to conform with the essential requirements. The procedures for assessing the conformity of toys with the essential requirements are based on the modular approach set out in Council Decision 93/465/EEC .

The bioavailability of cadmium, resulting from the use of toys must not, as an objective, exceed 0.6 µg Cd per day.

3.1.3.4 Directive 94/62/EC on packaging and packaging waste

Relevant for: human health (workers and consumers), air, surface water and sediment, terrestrial, secondary poisoning

[12] Prohibition to being placed on the market for sale to the general public.

Directive 94/62/EC aims to harmonize national measures concerning the management of packaging and packaging waste in order, on the one hand, to prevent any impact thereof on the environment and, on the other hand, to ensure the functioning of the internal market and to avoid obstacles to trade and distortion and restriction of competition within the Community. To this end this Directive lays down measures aimed at preventing the production of packaging waste and, as additional fundamental principles, at reusing packaging, at recycling and other forms of recovering packaging waste and, hence, at reducing the final disposal of such waste.

Member States shall ensure that the sum of concentration levels of lead, cadmium, mercury and hexavalent chromium present in packaging or packaging components shall not exceed the following[13]:

- 600 ppm by weight by June 30, 1996;
- 250 ppm by weight by June 30, 1999;
- 100 ppm by weight by June 30, 2001.

3.1.3.5 Directive 84/500/EEC on food safety

Relevant for: human health (consumers)

The Council Directive 84/500/EEC of 15 October 1984 relates to ceramic articles intended to come into contact with foodstuffs. This Directive is a specific Directive coming under framework Directive 76/893/EEC, which is hereby repealed and replaced by Directive 89/109/EEC. Ceramic articles are capable of transferring lead and cadmium. These substances pose a threat to human health. In order to prevent this risk, the Directive imposes a ceiling on the quantities of lead and cadmium allowed to pass into foodstuffs. These limits must be checked by means of a test, the basic rules of which are set out in the annex to this Directive and in conjunction with a method of analysis also described in the same annex. The Directive lays down the procedures to be followed for the updating and application of the Directive.

3.1.3.6 Drinking water Directive (98/83/EC)

Relevant for: human health (consumers)

The objective of this Directive is to protect human health from the adverse effects of any contamination of water intended for human consumption.

In order to meet this objective, concentration limit values are set for a whole range of microbiological and chemical parameters. The limit value for cadmium is set at 5 µg/l.

3.1.4 Legislation to prevent soil pollution

3.1.4.1 Regulation (EC) No 2003/2003 relating to fertilisers

Relevant for: surface water and sediment, terrestrial, secondary poisoning

Regulation (EC) No 2003/2003 of the European Parliament and of the Council of 13 October 2003 relating to fertilisers is a new scheme defining, in particular, the provisions relating to the placing of fertilisers on the market, i.e. the conditions for designating "EC fertilisers", as well as the provisions regarding their

[13] The concentration levels referred to in paragraph 1 shall not apply to packaging entirely made of lead crystal glass as defined in Directive 69/493/EEC.

labelling and packaging. The European Union is thus simplifying Community legislation on the harmonisation of Member States' legislation in the field of fertilisers by bringing all the existing provisions in this field under the one instrument. The objective is to ensure the free movement of these products within the European Union. The regulation retains many of the provisions of the former Directives and introduces some new ones. The most important element is the change of legal instrument, as the move from Directives to a regulation is intended to ensure uniform application of a very technical set of provisions throughout the Community.

This Regulation consolidates 18 Directives (four basic Directives and 14 Directives amending these), which were all published between 1976 and 1998. The four basic Directives which this Regulation repeals are:

- Directive 76/116/EEC on the approximation of the laws of the Member States relating to fertilisers;
- Directive 80/876/EEC on the approximation of the laws of the Member States relating to straight ammonium nitrate fertilisers of high nitrogen content;
- Directive 87/94/EEC on the approximation of the laws of the Member States relating to procedures for the control of characteristics of, limits for and resistance to detonation of straight ammonium nitrate fertilisers of high nitrogen content;
- Directive 77/535/EEC on the approximation of the laws of the Member States relating to methods of sampling and analysis for fertilisers.

The technical specifications in the proposal have, as far as possible, been taken out of the legislative text and put into the Annexes.

The regulation only covers mineral fertilisers. All types of fertiliser which comply with this regulation are designated "EC fertilisers" and are subject to its provisions. They are listed in Annex I of the regulation with the minimum and maximum content of fertilising elements set out for each type of fertiliser (nitrogen or phosphorus content, etc.). A type of fertiliser is designated an "EC fertiliser" only if:

- under normal conditions of use it does not adversely affect human, animal, or plant health, and the environment;
- it is effective;
- appropriate sampling, analysis, and if required, test methods are available.

The recast does not apply to cadmium and does not therefore address the issue of the unintentional presence of this substance in fertilisers. However, there is an intention to take action in the field of hazardous substances that are unintentionally present in fertilisers, as stated clearly in Regulation 2003/2003: '*Fertilisers can be contaminated by substances that can potentially pose a risk to human and animal health and the environment. Further to the opinion of the Scientific Committee on Toxicity, Ecotoxicity and the Environment (SCTEE), the Commission intends to address the issue of unintentional cadmium content in mineral fertilisers and will, where appropriate, draw up a proposal for a Regulation, which it intends to present to the European Parliament and the Council. Where appropriate, a similar review will be undertaken for other contaminants*.'

Before taking measures regarding cadmium, the Commission has appointed a consultant to carry out a study based mainly on the risk assessments compiled by 9 Member States. The Commission thus gathered all available data and information on the exposure situation in the European Community from cadmium in fertilizers. As not enough data were available in all Member States, the Commission mandated two studies to elaborate a methodology and procedures with a view to assessing the risks to health and the environment from cadmium in fertilizers. Member States were subsequently invited to carry out nation-wide risk assessments by making use of the above methodology and procedures. Risk assessments have been carried out by eight Member States (plus Norway) according to the agreed common methodology. The CSTEE[14] was requested to review the Member States' risk assessments in order to establish a sound scientific basis for decision making.

Following the results of these risk assessments (ERM, 2001) and the CSTEE's opinion (2002), The European Commission wrote a draft proposal to gradually introduce upper limits for cadmium in phosphate fertilizers. This proposal suggests a stepwise decrease in the maximum cadmium content of straight or compound phosphate fertilizers aimed at allowing manufacturers and importers sufficient time to adapt their products to the requirements of the present draft proposal:

- 5 years after the entry into force of this draft proposal the limit will be 60 mg of Cd/kg P_2O_5
- 10 years after the entry into force of this draft proposal the limit will be 40 mg of Cd/kg P_2O_5
- 15 years after the entry into force of this draft proposal the limit will be 20 mg of Cd/kg P_2O_5

An 8 week internet consultation on this proposal started on 1st August 2003 and ended on 26th September 2003. Based on the received comments from industries, public authorities, distributors and agricultural co-operatives, trade unions and other miscellaneous sources, the Chemicals Unit of DG Enterprise and Industry has drafted an impact assessment on setting up regional limits of cadmium content in fertilisers depending on soil pH (26/07/2005). This option was discussed at the last fertiliser Workgroup meeting. It is by no means sure that this option will be accepted by the Member States.

3.1.4.2 Directive 86/278/EEC on protection of the soil when sewage sludge is used.

Relevant for: surface water and sediment, terrestrial, secondary poisoning

The objective of Directive 86/278/EEC is to use sewage sludge in agriculture in such a way as to prevent harmful effects on soil, vegetation, animals and man. 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.

Cadmium limit values for soil concentrations, for amounts which may be added annually to agricultural land, based on a 10-year average and for sludge are set at respectively 1-3 mg Cd/kg dry matter (DM), 0.15 kg Cd/ha.year and 20-40 mg Cd/kg dry matter.

Different, more stringent limit values apply in the different Member States (see Table 3.2.5). An overview is given of a survey of cadmium in sewage sludge in different European countries (European Commission, 2001) in Table 3.2.6.

3.1.4.3 Decision 2001/688/EC on eco-label for soil improvers

Relevant for: surface water and sediment, terrestrial, secondary poisoning

The EU eco-label is a voluntary initiative and aims to promote products with a reduced environmental impact compared with other products in the same product group. The Commission Decision of 28 August 2001 (Decision 2001/688/EC), establishing ecological criteria for the award of the Community eco-label to soil improvers and growing media sets limitations of hazardous substances in soil improvers. The Decision sets that in the final product, the cadmium content shall be lower than 1 mg/kg dry weight.

[14] Scientific Committee on Toxicity, Ecotoxicity and the Environment

The existing criteria for soil improvers and growing media expire in August 2006. Stichting Milieukeur (SMK), the Dutch Competent Body for the European Eco-label, was awarded a service contract to draft revised criteria. The first two meetings of the Ad-how Working Group (AHWG) were held in Brussels on March 15 and June 20, 2005. A third meeting was held on October 31 2005 in Amsterdam.

3.1.4.4 Regulation EEC 2092/91 on organic farming

Relevant for: surface water and sediment, terrestrial, secondary poisoning

The organic farming regulation sets limit values for metals in composted or fermented household waste, provided that it comes from source separated waste of vegetable or animal origin in a closed and monitored collection system. The limit value for Cd is set at 0.7 mg/kg DM.

3.1.4.5 EU soil strategy

As stipulated in the 6th 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. In this context the Commission services are currently finalising a proposal for this Thematic Strategy on Soil Protection. Building on the results of previous discussions with stakeholders, the Commission is now seeking to elicit relevant opinions from stakeholders on specific measures being considered for inclusion in the Thematic Strategy. The information will feed into the strategy which is scheduled for adoption in November 2005.

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
- an analysis of the environmental, economic and social impacts of the proposals

3.1.5 Legislation to prevent air pollution

3.1.5.1 Directives 96/62/EC and 2004/107/EC on management and quality of ambient air

Relevant for: human health (workers and consumers), air, surface water and sediment, terrestrial, secondary poisoning

The Council Directive 96/62/EC of 27 September 1996 on ambient air quality assessment and management in order to maintain and improve air quality within the Community defines basic principles which make it possible to:

- establish quality objectives for ambient air (outdoor air in the troposphere);
- draw up common methods and criteria for assessing air quality;
- obtain and disseminate information on air quality.

The fourth Daughter Directive (2004/107/EC) relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air sets a target value for cadmium of 5 ng/m^3 averaged over a calendar year to be reached from December 31, 2012 onwards.

Given that the substances involved in the fourth daughter Directive are listed as human carcinogens and that there is no identifiable threshold below which they do not pose a risk to human health, the proposal aims to apply the principle of lowest possible exposure to them. The proposal also determines methods and criteria for assessing concentrations and deposition of the substances in question and ensures that adequate information is obtained and made available to the public.

3.1.5.2 Heavy Metals Protocol to the 1979 Convention on Long-range Transboundary Air Pollution

Relevant for: human health (workers and consumers), air, surface water and sediment, terrestrial, secondary poisoning

On 24 June 1998 the Commission signed the Heavy Metals Protocol (Aarhus Protocol) to the 1979 Convention on Long-range Transboundary Air Pollution. This Decision approves the Protocol on behalf of the Community. The aim of the Protocol is to reduce emissions of 3 heavy metals (cadmium, mercury and lead) caused by anthropogenic activities that are subject to long-range transboundary atmospheric transport and are likely to have serious adverse effects on human health and the environment.

According to one of the basic obligations, Parties will have to reduce their emissions for these three metals below their levels in 1990 (or an alternative year between 1985 and 1995). The Protocol aims to cut emissions from industrial sources (iron and steel industry, non-ferrous metal industry), combustion processes (power generation, road transport) and waste incineration. It lays down stringent limit values for emissions from stationary sources and suggests best available techniques (BAT) for these sources, such as special filters or scrubbers for combustion sources.

3.1.5.3 Directive 96/61/EC on Integrated Pollution Prevention and Control (IPPC) Directive

Relevant for: human health (workers and consumers), air, surface water and sediment, terrestrial, secondary poisoning

The Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control [Official Journal L 257 of 10.10.1996] concerns highly polluting industrial and agricultural activities, as defined in Annex I (energy industries, production and processing of metals, mineral industry, chemical industry, waste management, livestock farming, etc.).

The Directive defines the basic obligations to be met by all the industrial installations concerned, whether new or existing. These basic obligations cover a list of measures for tackling discharges into water, air and soil and for tackling waste, wastage of water and energy, and environmental accidents. They serve as the basis for drawing up operating licences or permits for the installations concerned. Accordingly, the Directive:

- lays down a procedure for applying for, issuing and updating operating permits;
- lays down minimum requirements to be included in any such permit (compliance with the basic obligations, emission limit values for pollutants, monitoring of discharges, minimisation of long-distance or transboundary pollution).

A transitional period (30 October 1999 - 30 October 2007) is laid down during which existing installations can be brought into conformity with the requirements of the Directive. The Member States are responsible for inspecting industrial installations and ensuring they comply with the Directive. An exchange of information on best available techniques (serving as a basis for emission limit values) is organised between the Commission, the Member States and the industries concerned. Reports on the implementation of the Directive are drawn up every three years.

3.1.6 Legislation to prevent water pollution

3.1.6.1 Directive 76/464/EEC on discharge of dangerous substances

Relevant for: surface water and sediment, secondary poisoning

Directive 76/464/EEC applies to inland surface water, territorial waters, internal coastal waters and groundwater. To eliminate pollution of these waters, two lists of dangerous substances to be monitored were established:

- pollution caused by discharges of substances on list I must be ended;
- pollution caused by products on list II must be reduced.

Quality objectives and emission standards are laid down for the substances on list I, based on the best available technology. These are compulsory unless the Member States prove that the quality objectives are being met and continuously maintained. All discharges require prior authorisation by the competent authority in the Member State concerned. The authorisation is granted for a limited period and lays down the emission standards. It is up to the Member States to ensure compliance with the emission standards.

For the substances on list II, the Member States adopt and implement programmes to preserve and improve water quality. All discharges are subject to prior authorisation by the competent authority in the Member State concerned, once again laying down the emission standards.

The Member States systematically monitor water quality and may take more stringent measures than provided for by Directive 76/464/EEC.

A procedure is laid down for revising and adding to the lists or transferring specific substances from list II to list I.

Every three years Member States report on implementation of Directive 76/464/EEC, based on a questionnaire or outline drafted by the Commission in accordance with the procedure laid down in Directive 91/692/EEC.

In 1980 the protection of groundwater was taken out of 76/464/EEC and regulated under the separate Council Directive 80/68/EEC on the protection of groundwater against pollution caused by certain dangerous substances.

Cadmium and its compounds are on the List I of families and groups of substances.

On 26 September 1983 the Council adopted Directive 83/513/EEC on limit values and quality objectives for cadmium discharges (Official Journal L 291, 24.10.1983). The following monthly average limit values apply to cadmium and its compounds (Table 3.1.1).

The daily average limit values are twice the corresponding monthly average limit values given in Table 3.1.1.

The following quality objectives, relating to the arithmetic mean of the results obtained over one year and measured sufficiently close to the point of discharge, are fixed :

- 5 µg/l for total cadmium in inland surface waters affected by discharges;
- 5 µg/l for dissolved cadmium in estuary waters affected by discharges;
- 2,5 µg/l for dissolved cadmium in territorial waters and in internal coastal waters other than estuary waters affected by discharges.

For waters used for the abstraction of drinking water, the cadmium content must be conform to the requirements of Directive 75/440/EEC.

The following quality objectives, relating to the arithmetic mean of the results obtained over one year and measured by the national network referred to in Article 5, are fixed :

- 1 µg/l for total cadmium in inland surface waters;
- 1 µg/l for dissolved cadmium in estuary waters;
- 0,5 µg/l for dissolved cadmium in territorial waters and in internal coastal waters other than estuary waters.

Table 3.1.1: Monthly average limit values for cadmium and its compounds according to 83/513/EEC

Industry sector[1]	*Unit of measurement*	*Monthly average limit values which must be complied with as from*	
		1.1.1986	*1.1.1989*[2]
1. Zinc mining, lead and zinc refining, cadmium metal and non-ferrous metal industry	mg Cd/l	0,3[3]	0,2[3]
2. Manufacture of cadmium compounds	mg Cd/l	0,5[3]	0,2[3]
	g Cd/kg Cd handled	0,5[4]	[5]
3. Manufacture of pigments	mg Cd/l	0,5[3]	0,2[3]
	g Cd/kg Cd handled	0,3[4]	[5]
4. Manufacture of stabilizers	mg Cd/l	0,5[3]	0,2[3]
	g Cd/kg Cd handled	0,5[4]	[5]
5. Manufacture of primary and secondary batteries	mg Cd/l	0,5[3]	0,2[3]
	g Cd/kg Cd handled	1,5[4]	[5]
6. Electroplating[6]	mg Cd/l	0,5[3]	0,2[3]
	g Cd/kg Cd handled	0,3[4]	[5]
7. Manufacture of phosphoric acid and/or phosphatic fertilizer from phosphatic rock[7]		-	-

(1) Limit values for industrial sectors not mentioned in this table will, if necessary, be fixed by the Council at a later stage. In the meantime the Member States will fix emission standards for cadmium discharges autonomously in accordance with Directive 76/464/EEC. Such standards must take into account the best technical means available and must not be less stringent than the most nearly comparable limit values in the above table.

(2) On the basis of experience gained in implementing this Directive, the Commission will, pursuant to Article 5(3), submit in due course to the Council proposals for fixing more restrictive limit values with a view to their coming into force by 1992.

(3) Monthly flow-weighted average concentration of total cadmium.

(4) Monthly average

(5) It is impossible for the moment to fix limit values expressed as load. If need be, these values will be fixed by the Council in accordance with Article 5(3) of this Directive. If the Council does not fix any limit values, the values expressed as load given in column '1.1.1986' will be kept.

(6) Member States may suspend application of the limit values until 1 January 1989 in the case of plants which discharge less than 10 kg of cadmium a year and in which the total volume of electroplating tanks is less than 1,5 m^3, if technical or administrative considerations make such a step absolutely necessary.

(7) At present there are no economically feasible technical methods for systematically extracting cadmium from discharges arising from the production of phosphoric acid and/or phosphatic fertilizers from phosphatic rock. No limit values have therefore been fixed for such discharges. The absence of such limit values does not release the Member States from their obligation under Directive 76/464/EEC to fix emission standards for these discharges.

3.1.6.2 Directive 80/68/EC on protection of groundwater against pollution caused by certain dangerous substances

Relevant for: surface water and sediment, secondary poisoning

This Directive prohibits the direct or indirect discharge into groundwater of List I substances and limits discharges of List II substances so as to avoid pollution.

The Directive does not apply to:

- Discharges of domestic effluents from isolated dwellings not connected to a sewerage system and situated outside areas protected for the abstraction of water for human consumption;
- Discharges which are found by the competent authority of the Member State concerned to contain substances in lists I or II in a quantity and concentration so small as to obviate any present or future danger of deterioration in the quality of the receiving groundwater;
- Discharges of matter containing radioactive substances.

This Directive does not set quality objectives for ground water. Cadmium and its compounds are on the List I of substances whose direct or indirect discharge into groundwater is prohibited.

The provisions of this Directive will in the future be incorporated into a specific Daughter Directive of the Water Framework Directive (2000/60/EC).

3.1.6.3 Directive 75/440/EEC on quality required of surface water intended for the abstraction of drinking water in the Member States

Relevant for: human health (consumers), surface water and sediment, secondary poisoning

This Directive sets guide and limit values for concentrations of 46 (groups of) chemical and biological components in surface water intended for the abstraction of drinking water. Guide and limit values are depending on the type of treatment applied for the production of drinking water. Cadmium is on the list of 46 (groups of) components. The following guide and limit values apply to cadmium (Table 3.1.2).

The provisions of this Directive will in the future be incorporated into a specific Daughter Directive of the Water Framework Directive (2000/60/EC).

Table 3.1.2 : Guide and limit values for cadmium in surface water intended for the abstraction of drinking water as a function of type of treatment

Type of treatment	*Guide value (mg Cd/l)*	*Limit value (mg Cd/l)*
Simple physical treatment and disinfection, e.g. rapid filtration and disinfection.	0,001	0,005
Normal physical treatment, chemical treatment and disinfection, e.g. pre-chlorination, coagulation, flocculation, decantation, filtration, disinfection (final chlorination).	0,001	0,005
Intensive physical and chemical treatment, extended treatment and disinfection e.g. chlorination to break-point, coagulation, flocculation, decantation, filtration, adsorption (activated carbon), disinfection (ozone, final chlorination).	0,001	0,005

3.1.6.4 Bathing water Directive (76/160/EC)

Relevant for: human health (consumers), surface water and sediment, secondary poisoning

This Directive sets guide and limit values for concentrations of 19 (groups of) chemical and biological components in bathing water. Heavy metals such as arsenic, cadmium, chrome (VI), lead and mercury are on the list but no guide and limit values have been derived. The concentration of these compounds has to be checked by the competent authorities when an inspection in the bathing area shows that the substance may be present or that the quality of the water has deteriorated.

The bathing water Directive is currently under review (COM(2002) 581).

3.1.6.5 Shellfish water Directive (79/923/EC)

Relevant for: surface water and sediment, secondary poisoning

This Directive implies each Member State to set guide and limit values for the concentration of 12 (groups of) components in order to preserve the good quality of the water and the shellfish grown in them. By setting the concentration guide and limit values, the Member States should take into account the comments given for each (group of) components.

Cadmium is part of the metals group, together with silver, arsenic, chromium, copper, mercury, nickel, lead and zinc. Upon setting a guide value for metals, Member States should make sure that 'the concentration of each substance in shellfish flesh must be so limited that it contributes in accordance with Article 1, to the high quality of shellfish products'. Upon setting a limit value for metals, Member States should make sure that 'the concentration of each substance in the shellfish water or in the shellfish flesh must not exceed a level which gives rise to harmful effects on the shellfish and their larvae. The synergic effects of these metals must be taken into consideration'.

The shellfish water Directive will in the future be incorporated into (a specific Daughter Directive of ??) the Water Framework Directive (2000/60/EC).

3.1.6.6 The Urban Wastewater Treatment Directive (91/271/EEC)

The objective of the Directive is to protect the environment from the adverse effects of discharges of urban waste water and of waste water from industrial sectors of agro-food industry:

- provide prior regulation or specific authorization for all discharges of urban waste water and industrial waste water from the particular sectors mentioned in the Directive, as well as for all discharges of industrial waste water into urban waste water systems;
- provide urban waste water collecting systems (sewerage) and treatment plants for all agglomerations above 2.000 population equivalents (widely used measurement unit for the organic pollution of waste water equalling to the average pollution load of one person per day);
- ensure that by 31/12/2000 the industrial waste water from the mentioned sectors shall before discharge respect the established conditions for all discharges from plants representing 4.000 population equivalent or more;
- provide before 31/12/1998 general rules or registration or authorization for the sustainable disposal of sludge arising from waste water treatment and, by the same date, to phase out any dumping or discharge of sewage sludge into surface waters;
- ensure that the urban waste water discharges and their effects are monitored;
- publish situation reports every two years and establish implementation programmes.

Allthough no emission limit values for Cd in the treated wastewater are specified it this Directive, its implementation will have a beneficiary effect on Cd discharges from urban areas:

- the emission limit value on suspended solids will lead to a decrease of the discharge of metals bound to the suspended solid phase;
- biological treatment of wastewater also removes part of the dissolved metals by adsorption to and incorporation in the biosolids. Removal efficiency depends on the treatment level (primary (mechanical), secondary (mechanical + activated sludge) and tertiary (mechanical + activated sludge + N or P removal), see Table 3.1.3.

Table 3.1.3: Removal efficiencies of metals from urban wastewater depending on the treatment level (Fuchs et al, 2002)

Reference	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Mechanical treatment							
Mean	55	46	44	59	21	65	48
Firk (1986)	50	36	39	57	26	57	41
Oliver/Cosgrove (1974)	60	55	33	60	15	66	54
Schäfer/Hoffmann (1999)	-	-	61	-	-	73	-
Mechanical treatment + activated sludge treatment							
Mean	60	67	72	75	43	84	73
Switzerland (1983)[5]	30-50	50-90	50-90	-	30-50	50-90	50-90
Firk (1986)	81	59	65	70	42	78	66
Oliver/Cosgrove (1974)	80	79	73	> 85	16	93	77
Jenkins/Russel (1994)	67	91	93	76	59	84	88
Klopp (1987)	-	83	80	-	61	90	83
Bode/Klopp (1997)	50	56	66	-	51	-	78
Koppe/Stozek (1998)	-	50	-	90	40	90	-
Zessner(1999)	42	53	58	55	38	84	47
Mechanical treatment + activated sludge treatment including P-elimination							
Mean	73	85	88	79[1]	63	88	79
Umlandverband Frankfurt[2]	-	81	88	-	57	-	79
Zessner (1999)	54	82	81	(> 48)	70	84	54
Schäfer/Hoffmann (1999)	-	-	94	-	-	91	-
Schleswig-Holstein[3]	89	94	91	97	64	92	95
Baden-Württemberg[4]	76	82	85	61	60	83	89

[1] Values in brackets were not used to calculate mean heavy metal removal; [2] mean heavy metal removal of 23 MWWTPs (Umlandverband Frankfurt. 1996); [3] mean heavy metal removal determined from MWWTP data of Schleswig-Holstein 1999/2000; [4] mean heavy metal removal determined from MWWTP data of Baden-Wuerttemberg; [5] Federal office for environment protection of Switzerland (1983) cited in ATV (1984).

3.1.6.7 The Water Framework Directive (2000/60/EC)

Relevant for: surface water and sediment, secondary poisoning

The Water Framework Directive (Directive 2000/60/EC) is a legislative framework to protect and improve the quality of all water resources such as rivers, lakes, groundwater, transitional and coastal water within the European Union. The WFD was published and entered into force in December 2000 (Official Journal of the European Communities, L327, 22 December 2000, pages 1-72). Member States must incorporate the WFD into national law by the end of 2003. Thereafter, many more steps must be taken to achieve "good status" of all European waters by 2015. Good surface water chemical status means the chemical status required to meet the environmental objectives for surface waters established in Article 4(1)(a), that is the chemical status achieved by a body of surface water in which concentrations of pollutants do not exceed the environmental quality standards established in Annex IX and under Article 16(7), and under other relevant Community legislation setting environmental quality standards at Community level. In the WFD, the limit values and quality objectives established under Directive 76/464/EEC shall be considered. Emission limit values for cadmium are established in the "Cadmium Discharges Directive (83/513/EEC)".

The European Commission is currently preparing a Groundwater Daughter Directive under the Water Framework Directive (COM(2003) 550 final), replacing the existing Directive 80/68/EC and aiming at at least the same level of protection. In the proposed Groundwater Daughter Directive cadmium is identified as 'a substance, which may both occur naturally and as a result of human activities, for which member states are required to establish threshold values in accordance with Article 4.2'.

Cadmium has been identified as a priority hazardous substance under Article 16 of the Water Framework Directive and appears as such in Annex 10 to the Directive.

3.1.6.8 Major accidents (Seveso)

Relevant for: air, surface water and sediment, terrestrial, secondary poisoning

Directive 82/501/EEC is aimed at the prevention of major accidents which involve dangerous substances, and the limitation of their consequences for man and the environment, with a view to ensuring high levels of protection throughout the Community in a consistent and effective manner. Member States shall ensure that the operator is obliged to take all measures necessary to prevent major accidents and to limit their consequences for man and the environment.

3.1.6.9 Decision 85/613/EEC on prevention of marine pollution from land-based sources

Relevant for: surface water and sediment, secondary poisoning

Council Decision (85/613/EEC) of 20 December 1985 concerning the adoption, on behalf of the Community, of programmes and measures relating to mercury and cadmium discharges under the convention for the prevention of marine pollution from land-based sources (OJ L 375 , 31/12/1985 p.20-44 (cf. PARCOM decision 85/2, see chapter 3.4.2).

3.1.7 Waste management

3.1.7.1 Directive 91/157/EEC on batteries

Relevant for: air, surface water and sediment, terrestrial, secondary poisoning

Council Directive 91/157/EEC on batteries and accumulators containing certain dangerous substances. Directive 91/157/EEC covers batteries and accumulators put on the market as from 18 September 1992 and containing more than 0.025 % of cadmium by weight. Member States must draw up programmes aimed primarily at reducing the heavy-metal content of batteries and accumulators. Under these programmes, Member States must encourage the separate collection of batteries and accumulators with a view to their recovery or ultimate disposal. The batteries and accumulators, or the appliances in which they are incorporated, must be marked in such a way as to indicate separate collection and recycling requirements and heavy-metal content. Directive 91/157/EEC is adapted by the Directives 93/86 and 98/101. The provisions indicated in Directive 91/157/EEC are inserted in Annex I to Council Directive 76/769/EEC of 27 July 1976 on the approximation of the laws, regulations and administrative provisions of the Member States relating to restrictions on the marketing and use of certain dangerous substances and preparations (1).

The implementation of Directive 91/157 has lead to the development of collection schemes for NiCd batteries (and other battery technologies) in EU countries. Figure 3.1.1 describes the different types of collection schemes developed in different countries, be it national, regional, or based on private initiatives (Recharge, 2005).

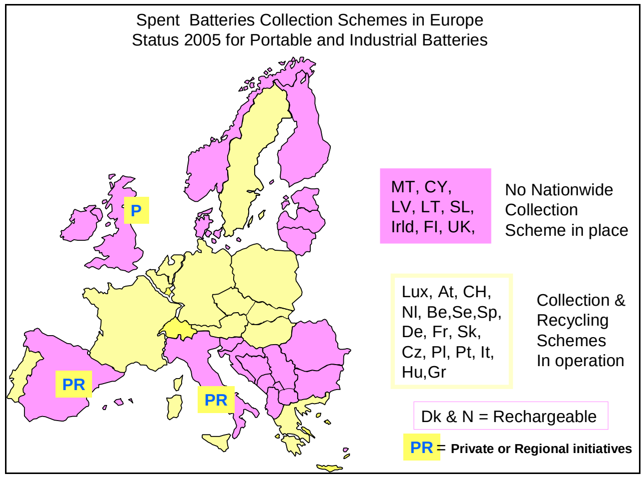


Figure 3.1.1: Overview of the different types of collection schemes for NiCd-batteries, developed in different countries

Furthermore, Figure 3.1.2 demonstrates a ten-year trend in amount of NiCd batteries (industrial and portable) collected (Recharge, 2005).

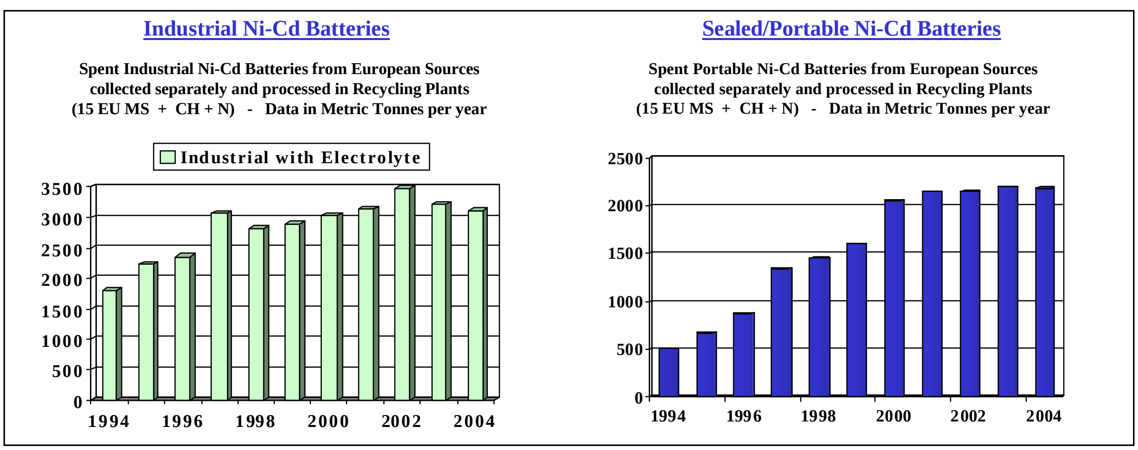


Figure 3.1.2: The ten-year development in amount of NiCd-batteries collected (Recharge, 2005)

On 24 November 2003, the Commission has adopted a Proposal for a new Battery Directive on Batteries and Accumulators and Spent Batteries and Accumulators (COM (2003) 723). The new Directive applies to all batteries and accumulators placed on the Community market. In line with Article 2(3) of the WEEE Directive, batteries and accumulators which are used in equipment connected with the protection of the essential security interests of the Member States are excluded from the scope.

The proposal (COM (2003) 723) is currently in the final stages of the co-decision procedure. The European Parliament second reading confirmed on 13/12/2005 the main decisions adopted by the Council in its Common Position of 18/07/2005. These main decisions are:

- Implementation of the extended producer responsibility : Producers will have to set up collection and recycling schemes throughout the EU. Increasing mandatory collection targets are set for all portable batteries to be reached within strict time limits. All industrial batteries will have to be collected and recycled at their end of life. For this latter category, producers and end-users will have the freedom to enter into commercial agreements in order to share the costs of collection and recycling.
- Definitions of categories of batteries : In order to be portable, a battery must meet three criteria ; it must be sealed, it must be able to be carried by hand, and it must not be industrial. To be industrial, a battery must have been designed for exclusively industrial or professional use or used in an electric vehicle. Automotives batteries are those used for automobile starting,lighting or ignition.
- Marketing restrictions : No marketing restrictions on industrial Ni-Cd batteries are introduced as no substitution is available. Regarding portable Ni-Cd batteries (see definitions above), these can no longer be placed on the market, but exemptions for batteries used in emergency and alarm systems (including emergency lighting batteries), medical equipment and cordless power tools are granted, the latter being subject to review in mid- 2010, based on the possible future development of alternatives.
- Legal base : The double legal base of the EU treaty that has been retained will not allow individual Member States to set up stricter marketing restrictions to the ones described above. This will guarantee the proper functioning of the European single market for batteries.

As this document is being written, remaining differences on other issues are being debated in "informal trialogue meetings", before possible formal Conciliation. The main outstanding differences are :

- Should small battery producers undergo mandatory registration ?
- Should batteries be required to be easily removeable from equipment by end-users ?
- Should distributors be obliged to participate in the collection schemes ?
- Should producers be required to participate in information campaigns to the public ?
- Should capacity marking be required on batteries and accumulators ?

The new battery directive is expected to be approved in mid-2006.

Lastly, it is anticipated that the implementation of the new battery directive (in preparation, (COM (2003) 723)), requesting to collect all batteries, will increase significantly the quantities collected due to two effects:

- the extension of the collection from rechargeable (1991/157) to all types of battery technologies;
- the implementation of collection schemes in all member states (EU 25).

3.1.7.2 Directive 91/689/EEC on hazardous waste

<u>Relevant for</u>: air, surface water and sediment, terrestrial, secondary poisoning

All waste (hazardous or not) is subject to Directive 75/442/EEC. Hazardous waste is also subject to Directive 91/689/EEC. A list of the hazardous wastes covered by the Directive is to be drawn up on the basis of the categories, constituents and properties set out in the Annexes to the Directive by 12 June 1993. Domestic waste is not covered by the Directive. Member States ensure that hazardous waste is recorded and identified; they also ensure that different categories of hazardous waste are not mixed and that hazardous waste is not mixed with non-hazardous waste, save where the necessary measures have been taken to safeguard human health and the environment. Any establishment or undertaking which carries out disposal operations must obtain a permit. This applies also in the case of operations which may lead to recovery. However, the permit requirement may be waived in the latter case if the method of recovery is such that there is no danger to human health or the environment, or if the Member State has adopted general measures laying down conditions for various methods of recovery, provided the conditions have been communicated to the Commission.

3.1.7.3 Commission Decision 2000/532/EC on The European Waste List (EWL)

A Community list of waste was established by Commission Decision 2000/532/EC of 3 May 2000 replacing Decision 94/3/EC establishing a list of wastes pursuant to Article 1(a)of Council Directive 75/442/EEC on waste and Council Decision 94/904/EC establishing a list of hazardous waste pursuant to Article 1(4)of Council Directive 91/689/EEC on hazardous waste. Ni-Cd batteries are in this list identified with the following code "16 06 02":

16	Wastes not otherwise specified in the list
16 06	Batteries and accumulators
16 06 02	Ni-Cd batteries

Category "16 06 02" is considered as a hazardous waste pursuant to the Hazardous Waste Directive (91/689/EEC), and subject to the provisions of that Directive. This means that a tracking document for each shipment is required as well as a registry for outbound and inbound shipments.

3.1.7.4 Directive 2000/76/EC on incineration of waste

<u>Relevant for</u>: air, water

Directive 2000/76/EC aims at preventing or reducing, as far as possible, air, water and soil pollution caused by the incineration or co-incineration of waste, as well as the resulting risk to human health.

When the proposal for this Directive was introduced the Community's waste incineration system was covered by Directives 89/369/EEC and 89/429/EEC (new and existing municipal waste-incineration plants) and 94/67/EC (incineration of hazardous waste). This Directive is intended to fill the gaps existing in that legislation. Apart from the incineration of non-toxic municipal waste its scope extends to the incineration of non-toxic non-municipal waste (such as sewage sludge, tyres and hospital waste) and toxic wastes not covered by Directive 94/67/EC (such as waste oils and solvents). At the same time it is intended to incorporate the technical progress made on monitoring incineration-process emissions into the existing legislation, and to ensure that the international commitments entered into by the Community are met in terms of pollution reduction, and more particularly those laying down limit values for the emissions of dioxins, mercury and dusts arising from waste incineration (protocols signed in 1998 under the aegis of the United Nations' Economic Commission Convention on long-distance cross-border atmospheric pollution). The proposal is based on an integrated approach: limits for discharges into water are added to the updated limits for emissions to atmosphere. Unlike Directives 89/369/EEC and 89/429/EEC referred to above, this Directive applies not only to facilities intended for waste incineration ("dedicated incineration plants") but also to "co-incineration" plants (facilities whose main purpose is to produce energy or material products and which use waste as a regular or additional fuel, this waste being thermally treated for the purpose of disposal).

All incineration or co-incineration plants must be authorised. Permits will be issued by the competent authority and will list the categories and quantities of hazardous and non-hazardous waste which may be treated, the plant's incineration or co-incineration capacity and the sampling and measurement procedures which are to be used.

In Annex 4 of this Directive, emission limit values[15] for cadmium and it compounds for discharges of waste water from the cleaning of exhaust gases of 0.05 mg Cd/l are set. The ELV for air is set at 0.05 mg/m³ for Cd and Tl. For existing plants for which a permit to operate was granted before 31/12/1996 and which incinerate hazardous waste only, an ELV of 0.1 mg/m³ to air is applicable until 1/1/2007.

3.1.7.5 Directive 99/31/EC on landfilling

Relevant for: air, surface water and sediment, terrestrial, secondary poisoning

Council Directive 99/31/EC is intended to prevent or reduce the adverse effects of the landfill of waste on the environment, in particular on surface water, groundwater, soil, air and human health. It defines the different categories of waste (municipal waste, hazardous waste, non-hazardous waste and inert waste) and applies to all landfills, defined as waste disposal sites for the deposit of waste onto or into land. Landfills are divided into three classes:

- landfills for hazardous waste;
- landfills for non-hazardous waste;
- landfills for inert waste.

Leachate composition and groundwater composition need to be monitored in the operation and after care phase. Parameters that need to be monitored have to be listed in the permit. It is very likely that heavy metals, including Cd, are on that list for most landfills.

Decision 2003/33/EC establishes the criteria and procedures for the acceptance of waste at landfills in accordance with the principles set out in Directive 1999/31/EC and in particular Annex II thereto.

3.1.7.6 Directive 2000/53/EC on materials and components in vehicles

Relevant for: air, surface water and sediment, terrestrial, secondary poisoning

Directive 2000/53/EC 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 life cycle of vehicles and especially the operators directly involved in the treatment of end-of life vehicles.

Member States shall ensure that materials and components of vehicles put on the market after 1 July 2003 do not contain cadmium other than in following specific cases:

- Thick film pastes (expiry data for this exemption is July 2006);
- Batteries for electrical vehicles (After 31 December 2005, the placing on the market of NiCd batteries shall only be allowed as replacement parts for vehicles put on the market before this date).

3.1.7.7 Directive 2002/95/EC on restriction of the use of certain hazardous substances in electrical and electronic equipment

Relevant for: air, surface water and sediment, terrestrial, secondary poisoning

[15] Emission limit values expressed in mass concentrations for unfiltered samples

The purpose of Directive 2002/95/EC (amended by Directive 2003/108/EC) is to approximate the laws of the Member States on the restrictions of the use of hazardous substances in electrical and electronic equipment (RoHS) and to contribute to the protection of human health and the environmentally sound recovery and disposal of waste electrical and electronic equipment. The Resolution stresses that the use of cadmium should be limited to cases where suitable and safer alternatives do not exist. Member States shall ensure that, from 1 July 2006, new electrical and electronic equipment put on the market does not contain lead, mercury, cadmium, hexavalent chromium, 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.

Cadmium plating, except for applications banned under Directive 91/338/EEC amending Directive 76/769/EEC relating to restrictions on the marketing and use of certain dangerous substances and preparations, is an application of cadmium which is exempted from the requirements of Article 4(1) of this Directive.

Commission Decision 2005/618/EC of 18 August 2005 is an amendment of Directive 2002/95/EC of the European Parliament and of the Council for the purpose of establishing the maximum concentration values for certain hazardous substances in electrical and electronic equipment (notified under document number C(2005) 3143). This Decision says that a maximum concentration value of 0,01 % by weight in homogeneous materials for cadmium shall be tolerated.

3.1.7.8 Directive 2002/96/EC on Waste of Electric and Electronic Equipment (WEEE)

The WEEE Directive 2002/96 requests the collection of electronic and electrical equipment (EEE) at end-of-life, which will also increase the collection rates of spent batteries. Indeed +/- 90% of rechargeable batteries are sold incorporated in equipment. The WEEE Directive requests the removal of these batteries from the equipment with the purpose of sending the collected batteries to dedicated treatment as specified under the batteries Directive.

Commission Decision 2004/249/EC of 11 March 2004 concerning a questionnaire for Member States reports on the implementation of Directive 2002/96/EC of the European Parliament and of the Council on WEEE.

Commission Decision 2005/369/EC of 3 May 2005 lays down rules for monitoring compliance of Member States and establishing data formats for the purposes of Directive 2002/96/EC of the European Parliament and of the Council on WEEE (notified under document number C(2005) 1355).

3.1.8 Other legislation

3.1.8.1 Directive 96/77/EC on food additives other than colours and sweeteners

Directive 96/77/EC lays down specific purity criteria on food additives other than colours and sweeteners. This Directive was amended by the Directives 98/86/EC, 2000/63/EC, 2001/30/EC, 2002/82/EC and 2003/95/EC and includes purity criteria for cadmium ranging from 1 to 5 mg/kg.

3.1.8.2 Reporting of emissions (EPER)

Relevant for: air, surface water and sediment, terrestrial, secondary poisoning

EPER is the European Pollutant Emission Register, which was established by a Commission Decision of 17 July 2000. The EPER Decision is based on Article 15(3) of Council Directive 96/61/EC concerning integrated pollution prevention and control.

According to the EPER Decision, Member States have to produce a triennial report on the emissions of industrial facilities into the air and waters. The report covers 50 pollutants which must be included if the threshold values indicated in Annex A1 of the EPER Decision are exceeded. The threshold value for cadmium is 10 kg to air and 5 kg to water. The threshold values have been chosen in order to include about 90% of the emissions of the industrial facilities looked at, so as to prevent an unnecessarily high burden on all industrial facilities. Given these thresholds, it must be stressed that not all sources of cadmium emissions are included in the EPER database and that this information cannot be used to determine concrete actions. The first reporting year was 2001. This information had to be reported June 2003 at the latest. The second reporting year will be 2004.

An overview of the reported emissions for 2001 to EPER from different Member States is given in Table 3.1.4.

Table 3.1.4: Reported emissions (2001) to EPER from different Member States (EPER, 2005)

Member State	*Reported emissions (2001)* [(1)]		
	Air (tons Cd)	*Direct to water (tons Cd)*	*Indirect to water (tons Cd)*
Austria	0.0569	0.0730	0.0159
Belgium	0.8363	0.5548	0.0430
Denmark	0.0150		
Finland	0.7952	0.0723	
France	8.3600	4.0800	0.0987
Germany	2.0700	0.3262	0.0508
Greece	0.0192	0.0432	
Italy	1.4100	4.3200	1.1200
Portugal	1.56000	0.3505	
Spain	4.6600	0.9141	0.3222
Sweden	0.2232	0.5680	
The Netherlands	1.2600	0.2127	
United Kingdom	2.2800	0.8347	0.0262
TOTAL	23.5458	12.3495	1.6768

[(1)] It must be noted that since 2001 some facilities, having an important share in total emissions, closed down (personal communication, L. Regoli, September 2005). Therefore the data in Table 3.1.4 have to be interpreted with caution.

3.2 NATIONAL LEGISLATION

3.2.1 National Occupational Exposure Limit values

<u>Relevant for</u>: human health (workers)

Current occupational limit values for cadmium and (inorganic) cadmium compounds are reported in Table 3.2.1 and Table 3.2.2 (cf. RAR, 2005).

Several agencies and countries have proposed biological limit values for Cd. As with occupational exposure levels (OEL, TLV) biological limit values are defined on the assumption that occupational exposure occurs for 8 hours daily and 5 days per week. Table 3.2.3 shows an overview of the occupational biological limit values for cadmium (Cd-B and Cd-U) introduced in several Member States.

Table 3.2.1 Occupational exposure limit values for cadmium and inorganic cadmium compounds (Cd-air)

Country	*8-hr TWA (mg/m³)*	*15-min STEL (mg/m³)*	*References*
Belgium	0.01 (inhal.) 0.002 (resp.)	-	Min. Emploi et Travail, 1998
Finland	0.02	-	FIOH, 2000
Germany	0.03 (inhal.) (1) 0.015 (resp.)	-	DFG, 2001
The Netherlands	0.005 (inhal.)	-	SZW, 2000
Sweden	0.02 (resp.)	-	Swedish National Board of Occupational Safety and Health, 1993
United Kingdom	0.025	0.05	HSE, 2000
France	0.05	-	INRS, 1999

(1) THe German OEL and BLV are under revision and presently out of force (TRGS (Technische Regeln für Gefahrstoffe) 900, edition 1/2006 and TRGS 903 edition 5/2004)

Table 3.2.2 Occupational exposure limit values for cadmium oxide fumes (Cd-air)

Country	*8-hr TWA (mg/m³)*	*15-min STEL (mg/m³)*	*References*
Finland	0.01	-	FIOH, 2000
United Kingdom	-	0.05	HSE, 2000
France	-	0.05	INRS, 1999

Table 3.2.3 Occupational biological limit values for cadmium (Cd-B and Cd-U) (RAR, draft update documents 2005)

Country	*Cd-B (Cd in blood)*	*Cd-U (Cd in urine)*
Finland	5,6 µg/l	5,6 µg/l
Germany (1)	15 µg/l	15 µg/l
The Netherlands (2)	10 µg/l	4 µg/g creatinine
Sweden	11 µg/l	
France	5 µg/l	5 µg/g creatinine

(1) THe German OEL and BLV are under revision and presently out of force (TRGS 900, edition 1/2006 and TRGS 903 edition 5/2004)

(2) these values were provided by ICdA (personal communication, Lidia Regoli)

The OSHA (2005) proposes a Permissible Exposure Limit (PEL) The employer shall assure that no employee is exposed to an airborne concentration of cadmium in excess of five micrograms per cubic meter of air (5 ug/m(3)), calculated as an eight-hour time-weighted average exposure (TWA). In industries where a separate engineering control air limit (SECAL) has been specified for particular processes (See **Error! Reference source not found.**), the employer shall implement engineering and work practice controls to reduce and maintain employee exposure at or below the SECAL, except to the extent that the employer can demonstrate that such controls are not feasible.

Table 3.2.4: Separate Engineering Control Airborne Limits (SECALs) for processes In Selected Industries

Industry	*Process*	*SECAL (µg Cd/m³)*
Nickel Cadmium Battery	Plate making, plate preparation	50
	All other processes	15
Zinc/Cadmium Refining *	Cadmium refining, casting, melting, oxide production, sinter plant	50
Pigment Manufacture	Calcine, crushing, milling, blending	50
	All other processes	15
Stabilizers *	Cadmium oxide charging, crushing, drying, blending	50
Lead Smelting *	Sinter plant, blast furnace, baghouse, yard area	50
Plating *	Mechanical plating	15

(*) Processes in these industries that are not specified in this table must achieve the PEL using engineering controls and work practices

AUSTRIA

The Austrian OEL list is based on international and national sources such as the American Conference of Governmental Industrial Hygienists (ACGIH) and the German MAK-Commission. The Bundesministerium für Wirtschaft und Arbeit, or BMWA (Ministry of the Economy and Labour) fixes these limit values. The Austrian list is published in the Austrian Governmental Journal (cf. Verordnung des Bundesministers für Wirtschaft und Arbeit über Grenzwerte und über krebserzeugende Arbeitsstoffe, Grenzwerteverordnung 2001, published in the Austrian Governmental Journal (Bundesgesetzblatt) from July 27, 2001.)).

BELGIUM

In Belgium, OELs are known as "Valeurs Limites d'Exposition Professionnelle" (VLEP) or "Grenswaarden voor Beroepsmatige Blootstelling (GWBB)".

Following the Royal decree of 10 August 1998 (Statute Paper of 12 September 1998), some of the Belgian OELs were changed to adapt to the European Union Guidelines, but the source of many OELs in Belgium is still the ACGIH (USA) TLV list. These OELs were fixed by the Ministry of Employment and Work.

GERMANY

In Germany, there are two kinds of OELs for air in the workplace:

- TRKs (Technische Richtkonzentrationen), which are technical guidance concentrations, and

- MAKs (Maximale Arbeitsplatzkonzentrationen), which give the maximum concentration of a chemical substance in the workplace.

The MAK-values are daily 8-hour time-weighed average values and apply to healthy adults. Substance-specific acceptable peak concentrations, including the highest possible duration of such peaks, are defined. If the substance can be taken up through the skin, this is indicated.

The TRK is the concentration of a chemical substance in the air within a working area, which may be reached in accordance with the best available technology (state of the art). This type of limit value is usually applied to substances that are in carcinogenic category 1 or 2. In some cases, the Committee on Hazardous Substances proposes technical-based MAK-Values which base on the TRK-concept (TRGS 102). This type of limit value usually applies to substances which are carcinogenic or mutagenic category 3 (substances suspected of having a carcinogenic or mutagenic potential) and to important industrial substances for which no harmless minimum concentration can be determined (e.g. Cobalt, metal working fluids). In the new "Gefahrstoffverordnung 2005", MAK and TRK values are not used anymore. Instead AGW (risikobezogene Arbeitsplatzgrenzwerte – risk related workplace limit values) are used now. In most cases these AGW-values will be identical to the MAK values.

DENMARK

In the Danish OSH system, the "Grænseværdier for stoffer og materialer" (limit values for substances and materials), are administrative instructions that are enforced under the Working Environment Act. The Ministry of Labour sets up the regulation on these limit values and the "Arbejdstilsynet" (Labour Inspectorate) publish the OEL list and supervise their execution. In the sphere of the Act, employers are obliged to keep the exposure as low as reasonably possible and the limit values should never be exceeded.

The "Arbejdstilsynet" decides on the OELs after consulting with employer and employee representatives on the technical and economical feasibility of the proposed limit value level. The scientific background is studied by the OEL setting committee acting under the "Arbejdsmiljørådet" (Council on Working Environment). This committee refers to the OEL criteria documentation provided by:

- The SCOEL (EU),
- ACGIH, OSHA, and NIOSH (USA),
- MAK (Germany),
- DECOS (The Netherlands),
- the Nordic Expert Group (NEG), and
- the experience of the Inspectorate within the Danish workplaces.

Usually, the committee gives a proposal for a limit value and a preferred safety factor (1, 2, 5, 10, 20...) for the substance.

In Denmark, most of the OEL values are TWA - 8h. An "H" ("Huden") in the tables annotates substances that can be taken into body via the skin. The allergic potential is not marked, but it is tentatively taken into account when setting the limit value level. For acute toxic substances, like strong irritants, there is annotation L ("Loftværdi") on the limit value tables. The limit value for this substance must not be exceeded even for a short (less than 15 minutes) time. For acutely neurotoxic substances, the limit value should not be exceeded even for 5 minutes.

For specific hazardous substances, the Limit Values for Substances and Materials list the substances that are considered human carcinogens by the International Agency for Research on Cancer (IARC) or by the EU Commission. These substances are regulated by a specific order set by the Ministry of Labour. These substances are also annotated by "K" (kræftfremdkaldende, carcinogenic) on the OEL value tales.

SPAIN

The legal framework for limit values for hazardous substances (in Spanish: VLA = Valore Límite Ambientales) is under reconstruction. Beside the European Directive-based legislation, based for example on EC Directive 98/24/CE - the Chemical Agents Directive, two Spanish regulations exist. Since 1961, a national ordinance about health impairing and dangerous activities at work places is in force entitled Reglamento de Actividades Molestas, Insalubres, Nocivas y Peligrosas. This ordinance did not include single OELs. When OELs were needed in practice the ACGIH's (USA) limit values were used. Since 1998 the Instituto Nacional de Seguridad e Higiene en el Trabajo, or INSHT (National Institute for Occupational Safety and Health) has published a guide including a list of more than 500 OELs and instructions for the use and application of these values.

The "Límites de exposición profesional para agentes químicos en España" (Current OELs) are published in Spanish on the Internet and on paper and are renewed yearly by the INSHT.

The INSHT defines three different types of TLVs:

- VLA-ED (Valor Límite Ambiental Exposición Diaria), the limit for the daily average concentration. For 30 minutes period, an employee's exposure can be three times the VLA-ED. The exposure should never exceed the level of five times the VLA-ED.
- VLA-EC (Valor Límite Ambiental Exposición de Corta Duración) is the limit for short-term exposure concentration. The VLA-EC should not be exceeded during any part of the working exposure. It may be used as an OEL for highest 15 minutes per day.
- VLB (Valor Límite Biológico) is a limit value for the content of the substance in biological media (i.e. blood, urine). VLBs have been defined for dozens of substances.

FRANCE

In France, the Occupational (Air) Exposure Limits (OELs) are called "Valeurs limites d'exposition professionnelle aux agents chimiques en France" (VLEP). These VL are defined as the concentration of an agent in the air of the working area that a person can inhale for a defined duration without a risk of changes to his or her health. Furthermore, the VLEP should be seen as a minimum requirement. The VLs are fixed by the Ministère de l'Emploi et de la Solidarité (Ministry of Employment and Solidarity). Some values are also recommended by the National Illness Insurance Fund (CRAM). There are currently two types of OELs:

- Statutory and compulsory OELs for certain extremely hazardous substances; and
- recommended OELs for the remaining substances.

Two types of OEL values exist in France:

- Short-term exposure limit values (valeurs limites d'exposition à court terme) are ceiling values for measured over one duration of maximum 15 minutes; and
- average exposure limit values (valeurs limites de moyenne d'exposition) are measured or estimated over the duration of 8 hours.

After endorsement the OELs are published in the French Official Journal, Official Bulletin and in the publications of the Institut National de Recherche et de Sécurité, INRS (National Institute of Safety Research). The INRS publishes parts of the VL on the Internet.

FINLAND

The Finnish OEL system can be divided into legally enforcing binding limit values (sitovat raja-arvot) and more orientating concentrations known to be harmful (haitalliseksi tunnetut pitoisuudet, HTP -arvot).

Both of these are connected to the Labour Protection Act, which oblige the employer to provide the employee healthy and safe working conditions.

All air limit values define two basic influence factors:

- The concentration - in mg/m^3 or ppm, and
- the average exposure time in minutes or hours.

The exposure times are averaged for 15 minutes and eight hours, and some substances have momentary limit values, which should never be exceeded. The possibility of skin penetration is remarked by "Skin" (Iho). This annotation does not take into account the possibly corrosion or irritation potential of the substance. The potency to cause allergy may be considered when setting the OEL, but it is not annotated on the OEL list.

GREECE

The general law on 'health and safety for workers' and several ensuing presidential decrees have achieved harmonisation to European Union legislation. Among the topics addressed in this legislation (e.g. occupational factors, working conditions) are provisions on enforceable occupational exposure limits for nearly 600 chemicals. Most of the OELs reported are equivalent to the threshold limit values (TLV-TWA) published by the ACGIH (USA) (Bazas, 2001)

ITALY

The Italian exposure limits are identical with the TLVs established by the ACGIH (USA).

IRELAND

In Ireland, the Occupational (Air) Exposure Limits (OELs) are defined as the maximum permissible concentration of a chemical agent in the air at the workplace to which workers may be exposed in relation to an 8-hour or a 15-minute reference period. These limits are set out in Schedule 1 to 1999 Code of Practice for the Safety, Health and Welfare at Work (Chemicals Agents) Regulations, 1994 (S.I. No. 445 of 1994). The establishment of OELs in Ireland is based on the Safety, Health and Welfare at Work (Chemical Agents) Regulations, 1994 (S.I. No. 445 Of 1994).

LUXEMBOURG

The exposure limits in Luxembourg are adopted from various international health and safety agencies. The exposure limits in Luxembourg are based on the regulation of 19 July 1991. OELs used in Luxembourg are the same as used in Germany, unless specific OELs are provided.

THE NETHERLANDS

In the Netherlands, there are two types of OELs with differing bases and status:

- Legally binding OELs, and
- administrative OELs.

They both have a different basis and a different status. Occupational Exposure Limits (OELs) are called MAC-values (Maximaal Aanvaarde Concentraties). The MAC is defined as the maximum allowed concentration of a gas, vapour, mist or dusty agent in the air of the working area. In the Netherlands, the OEL values are set for 8-hours time-weighted maximum allowed concentration (8-hour TWA) and for 15-minutes average concentration (15-minutes TWA). Additionally, there is also MAC-C, a ceiling value, which should not be exceeded at any time. The legally binding OELs are based upon the health-based recommended occupational exposure level provided by the Dutch Expert Committee on Occupational

Standards (DECOS) of the Health Council, but also taking into account the socio-economic feasibility of that value. The legal status is based on the Dutch Occupational Law and the Labour Inspectorate controls the implementation.

Administrative OELs are not legally binding. They are regulated in a policy rule based on the working condition regulations. The Labour Inspectorate considers these values as levels that should in any case not be exceeded to protect workers. Mostly these originate from other Member States of the European Union or are TLVs from ACGIH (USA).

PORTUGAL

In Portugal, the occupational exposure limits for dangerous substances are published in the Portuguese Standard 1796 of 1988. The publisher is the Portuguese Institute of Quality. The Standard 1796 is currently being reviewed. The VLEs (OELs) reported in this Standard as well as in the new Standard are equivalent to the limit values published by ACGIH (USA). In the future Portuguese Standard should contain time-weighted average for 8hrs (TLV-TWA), ceiling values (TLV-C) and the short-term exposure limits (STEL).

SWEDEN

The "Hygienic limit values and measures for air pollutants" (Hygieniska gränsvärden och åtgärder mot luftföronreningar, Arbetarskyddsstyrelsens författningssamling; AFS 2000: 3) is an instruction given by the Swedish Work Environment Authority (Arbetsmiljöverket) with the empowerment of the Work Environment Ordinance (Arbetsmiljöförordningen; SFS 1977: 1166). These regulations are based on the Work Environment Act (Arbetsmiljölagen; SFS 1977: 1160) and the limit values are a starting point of the chemical risk management. According to the national regulations, the employer is obliged to keep the exposure level as far below the limit value as possible.

Most of the OELs are maximal values of air concentrations in workplace air. The concentration limits are averaged over certain time periods, which are generally eight hours ("maximal limit value", or nivågränsvärde) and 15 minutes ("short-term limit", kortidsvärde). The ceiling values (takgränsvärde) are momentary limit values and the reference time can be as short as 5 minutes. In the OEL lists, "K" (Cancerframkallande, Grupp C), annotates carcinogenic substances, "S" (Sensibiliserande, Grupp D), annotates sensitisers and "R" (Reproduktionsstörande, Grupp E), indicates substances toxic to reproduction. In addition, the "Hygienic limit values and measures for air pollutants" includes lists of substances, which are banned (Grupp A) or subject to license (Grupp B).

UNITED KINGDOM

Occupational exposure limits in the UK function under the Control of Substances Hazardous to Health Regulations (COSHH) and its mirror legislation in Northern Ireland. The COSHH regulations require the employer to ensure that the employee's exposure to substances hazardous to health is either prevented or if not practically possible, adequately controlled. OELs in the UK can be divided in Maximum Exposure Limits (MELs) and Occupational Exposure Standards (OESs). Exposure should be reduced as far below an MEL as possible, while reduction to the substance specific level OES is considered adequate. The list of exposure limits is known as EH40.

All legally enforceable OELs in UK are air limit values. The exposure times are averaged for eight hours (8-hour TWA) and 15 minutes (short-term exposure limit STEL). For some substances, a brief exposure is considered so critical that they are set only a STEL, which should not be exceeded even for a shorter time. The potency to penetrate through skin is annotated in the OEL list by remark "Skin". Carcinogenicity, reproduction toxicity, and irritation and sensitation potential are considered when preparing a proposal for an OEL according to the present scientific knowledge.

The COSHH Amendment Regulations 2004 have introduced a number of changes concerning the packaging and use of hazardous substances in the workplace. The withdrawal of both OES's (Occupational Exposure Standards) and MEL's (Maximum Exposure Limits) are introduced on the 6th April 2005. The OES's and MEL's have been replaced by a single new standard known as a WEL (Workplace Exposure Limit) A revised and updated copy of the HSE publication EH40 is due to be published shortly and this will contain details of all new WEL's.

3.2.2 Implementation of Directive 86/278/EEC (Sewage sludge directive)

The requirements of Directive 86/278/EEC regarding maximum Cd content in the soil and the sewage sludge and the maximum yearly allowable load of Cd are implemented differently in the various Member States (Table 3.2.5).

Table 3.2.6 provides an overview of Cd levels in sewage sludge in the various Member States.

Table 3.2.5: Implementation of the requirements of Directive 86/278/EEC regarding Cd in some Member States

		Maximum Cd content in the soil *mg/kg DM*	*Maximum Cd content in the sludge* *mg/kg DM*	*Maximum allowable yearly Cd load* *g/ha/year*
86/278/EEC		1 - 3	20 - 40	150
Belgium	Flanders	1,2	6	12
	Walloon Region	2	10	60 (pasture) 120 (agricultural land)
The Netherlands		0,4 + 0,007(L+3H)*	1,25	2,5 (pasture) 1,25 (agricultural land)
Germany	Soil pH > 6	1,5	10	2,5
	5 < soil pH < 6 or clay content < 5%	5	1	1,7
France		2	20	30
Denmark		0,5	0,4	2,8
Sweden		0,4	2	0,75
Austria		1 - 3	2 – 10	
Italy	pH < 6 and CEC < 15*	1,5	20	50
	6 < pH < 7,5 and CEC > 15	1,5	20	100
	pH > 7,5	1,5	20	150
UK		3		150
Luxemburg		3	40	120
Ireland		1	20	40

		Maximum Cd content in the soil *mg/kg DM*	*Maximum Cd content in the sludge* *mg/kg DM*	*Maximum allowable yearly Cd load* *g/ha/year*
Finland	Unmixed	0,5	1,5	1,5
	Mixed**	0,5	3	1,5
Spain	Soil pH < 7	1	20	
	Soil pH > 7	3	40-	
Slovak Republic			13	

* L : lutum ; H: humus; CEC: cation exchange capacity

** Mixing with lime, bark, sand or soil is allowed.

Table 3.2.6: Overview of a survey of Cd in sewage sludge in different EU Member States (European Commission, 2001); values in mg Cd / kg DS

Country	*Mean*	*Median*	*Minimum*	*Maximum*	*Survey years*
Austria	1.5	1.2	0.4	3.4	1994-95
Denmark	1.4				1995-97
Finland	1.0				1995-97
France	4.1				1995-97
Germany	1.5				1995-97
Greece	1.6 / 1.4				1996 / 1997
Ireland	2.8				1997
Italy			0.8	23	1998-99
Luxembourg	3.8				1997
Poland	9.93	13.5	0.8	15.3	1999
Sweden	1.5				1995-96
The Netherlands	3				1990
United Kingdom	3.5				1995-96
EU	4.0 / 2.2				1992 /1994-98

3.2.3 Limit values for cadmium in fertilisers

Table 3.2.7 gives an overview of limit values for cadmium in fertilisers and soils in EU Member States.

Since the 1990s mineral fertilisers containing more than 100 mg of cadmium per kilogram phosphorous (100 mg Cd/kg P; 43 mg Cd/kg P_2O_5) may not be marketed or supplied in Sweden (Section 3 of the Ordinance 1998:944). In addition, a tax is imposed of 30 SEK (± 3 EUR) per g Cd exceeding 5 grams of Cd per tonne of P in the mineral fertiliser.

In the accession treaty 1998, Sweden, Finland and Austria were allowed to maintain national legislation concerning cadmium content in fertilisers and there was a commitment to review the directive on fertilisers (76/116). As this review has not been finalised as regards cadmium, the national derogation has been prolonged and is currently valid until the end of 2005. Sweden has recently applied for a prolongation until a harmonised limit for cadmium content in mineral fertilisers can be established on the EU level.

Table 3.2.7: Limit values for cadmium in fertilisers and soils in EU Member States (Oosterhuis *et al.*, 2000)

Table3.1 Limit values for cadmium in fertilisers and soils in EU Member States.

Country	Max. concentration of Cd in fertiliser (mg per kg P_2O_5)	Max. amount of Cd input to agricultural soils (grammes per ha per year)	Max. conc. of Cd in agr. soils (mg/kg dry soil; guidance level)
Austria	75 (since 1994)	10 (1) / 5 (2)	1.0
Belgium/Lux.	90 (10)	150	1.0 – 3.0
Denmark	47 (since 1995)		0.5
Finland	21.5	3	0.5
France			
Germany	40 – 90 (7)	16.7 (3)	1.0
Greece			
Ireland			
Italy			
Netherlands	(8)		0.5 – 1.0
Portugal	40 – 70 (10)		
Spain			
Sweden	43 (9)	1.75 (4)	
UK		0.15 (5)	3.0 (6)

(1) arable land (20 g over a period of 2 years)
(2) grassland and vegetables (10 g over a period of 2 years)
(3) average over a period of 3 years
(4) average for 7 years; will be lowered to 0.75 g/ha/year as from 2000
(5) with sewage sludge only (average over a period of ten years)
(6) soils with a pH of 5.0 and above, treated with sewage sludge
(7) based on a voluntary agreement between government and industry: all fertilisers should comply with the 90 mg/kg level; 89% of the products with the 70 mg/kg level and 63% with the 40 mg/kg level.
(8) OECD (1994) mentions a limit of 40 mg per kg phosphorous, which would equal 17 mg per kg P_2O_5. However, according to a spokesman of the Dutch Fertiliser Producers' Association VKP, there is no legal limit to the Cd content in phosphate fertiliser in the Netherlands. Instead, a voluntary agreement is in preparation (see below).
(9) a voluntary limit of 21.5 mg/kg P_2O_5 (50 mg/kg P) has been introduced by the Swedish Farmers' Regional Selling and Purchasing Association SLR (Drake and Hellstrand, 1998).
(10) Mentioned in OECD (1994); probably not a legal limit.
Sources: OECD (1994); ERM (1997); Ehrenberg (1999); Swedish Government (1985)

3.2.4 Implementation and review of the batteries Directive (91/157/EEC)

3.2.4.1 Swedish restrictions on the use of Cd in batteries

Sweden (COM (2003) 423) is aiming for a phase-out of cadmium in batteries. In the ongoing review of the batteries Directive, Swedish holds the position that feasible alternatives are available in most cases:

"*As a complement to restrictions, specific fees and collection systems for disposed batteries have been introduced. Since the 1990s there is a specific fee on NiCd batteries to encourage the use of alternatives (section 16 of the Ordinance (1997:645) on Batteries). Anyone who professionally manufactures or imports hazardous batteries or products containing/accompanied by hazardous batteries, is obliged to* *pay a fee and provide information to the Swedish Environmental Protection Agency regarding the quantity of batteries. The fee is intended to cover costs for e.g. the disposal or recycling of hazardous batteries. For a typical 12 Volt battery with the weight of 0,6 kg the fee, 300 SEK (± 33 EUR) per kg NiCd battery, would amount to around 20 EUR. The fee has had an impact on NiCd battery sales, which have decreased from over 300 000 kg in 1997 to less than 100 000 kg in 2004*."

"*To further prevent cadmium contamination of the environment, all batteries are to be collected, as it is difficult for consumers to differentiate hazardous batteries from others. The goal is that no batteries or products with built-in batteries should be disposed of in household waste. According to the Swedish Battery Ordinance (Ordinance (1997:645) on Batteries), the municipalities are obliged to organize systems for collection and reprocessing or final disposal of discarded small batteries. Consumers are to turn in all spent batteries to the municipality's collection system, or to retail outlets that receive batteries. Discarded products with built-in hazardous batteries must be turned in to the place of purchase or to the collection station designated by the municipality*."

Presently, the most common use of NiCd batteries in Sweden is for cordless power tools. In 2004, the alternative NiMH batteries were used in 90% of professional power tools in Sweden (Nordic Council of Ministers, 2005). This high figure of 90% is only stated for Sweden and contrasts sharply with the penetration of NiMH batteries in the professional market for other Scandinavian countries. EPTA commented on the Nordic Council Paper (2004) that NiCd batteries still are the overwhelming technology of choice for cordless power tool users and hat 90% of worldwide cordless power tools use NiCd batteries (EPTA, 2005). SAFT (de Metz, personal communication, 2006) draws the attention on the fact that the position presented here, that feasible alternatives are available for power tools, is grounded in the very unique market situation of Sweden, where a tax of 33€/kg is levied against every NiCd battery. Faced with such a tax which can represent a price increase of 30%, it must be recognized that consumers are faced with other considerations than the pure comparative merits of the battery when making a purchasing decisions.

It should be noted that the proposal for the new Batteries Directive (2003/0282 COD) does not mention a phase-out of cadmium in batteries. This position has been rejected by a majority of Member States in the Council, and was subsequently rejected as well as by the Commission and the European Parliament. However, this proposal sets out provisions on the collection of spent batteries and accumulators designed to avoid the final disposal thereof. The Proposal also provides a framework to use economic instruments. This means that the use of economic instruments remains a valid option for Member States to achieve the objectives of this Proposal.

It must be kept in mind that the Swedish position was taken prior to extensive data compilation and review assessing contribution of Cd from NiCd batteries to environment (TRAR on Cd from NiCad Batteries – several draft reports since 2003 and final report of December 2005). The TRAR concluded that there is no risk from Cd from NiCd batteries and that contribution is generally negligible.

3.2.4.2 German implementation of Directive 91/157/EEC on batteries

The Ordinance on the return and disposal of used batteries and accumulators (2 July 2001, Federal Law Gazette BGB1) includes following general provisions:

- a collection scheme for all batteries, free of charge, must be set up by manufacturers (or manufacturers must participate);
- distributors must accept, free of charge, the return of batteries by end users;
- end users are obliged to return waste batteries to a distributor or collection point;
- following marketing of appliances are prohibited:
  - of house batteries containing harmful substances (including batteries containing more than 0.025% by weight of cadmium);

- which are not designed in such a ways as to ensure effortless removal of the battery by the user at the end of the battery's useful life.

This national approach goes beyond the requirements of the 1991 batteries Directive but has now been the selected approach in the proposal of the revised batteries Directive.

Figure 3.2.1 shows that the implementation in Germany of a requirement to collect separately all batteries, irrespective of their chemistry, did substantially raise the collection efficiency of NiCd batteries (de Metz, personal communication, 2006). In addition 100 and 200 tons (years 2002 and 2004) of collected spent NiCd batteries were sent to mines storage facilities.

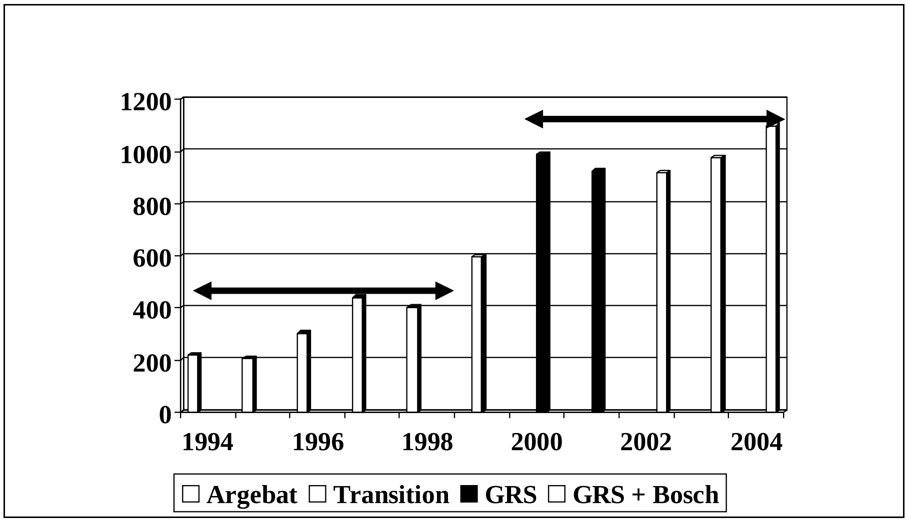


Figure 3.2.1: Spent portable Ni-Cd batteries collection in Germany

3.2.4.3 French implementation of Directive 91/157/EEC on batteries

The French Decree No. 99-374 of 12 May 1999 relates to the marketing of batteries and accumulators and to their disposal. This Decree includes the following general provisions:

- batteries and accumulators containing more than 0.025% in weight of cadmium may only be used in equipment on the condition that they can be easily removed by the user after use (there are some exemptions e.g. for medical equipment, mobile equipment, professional equipment in specific situations);
- the disposal of all batteries and accumulators or their components, must be made in installations authorised for this purpose;
- distributors, manufacturers, importers of batteries and accumulators are obliged to take back free of charge all used batteries or accumulators from consumers;
- users of batteries and accumulators other than for domestic use, must collect, reprocess, dispose of their used batteries or accumulators, whether or not incorporated in equipment.

This national approach goes beyond the requirements of the 1991 batteries Directive but has now been the selected approach in the proposal of the revised batteries Directive.

3.2.5 National implementation of marketing and use restrictions

The Swedish restrictions on marketing and use of cadmium and its compounds are more general and extensive than the current restrictions in directive 76/769/EEC. The use of cadmium and cadmium compounds for surface treatment, as stabiliser and as colouring agent has been prohibited in Sweden since 1982 (Section 3 of the Ordinance 1998:944). Professional marketing and supply of goods which have been surface-treated with a cadmium substance or contain a cadmium substance as stabiliser or colouring agent is also prohibited, as well as import of such goods from countries outside of the European Union.

The Swedish Chemicals Inspectorate can decide on derogations from this prohibition. Current derogations are:

- Pigments in artists' colours;
- Table articles and fancy goods made of ceramic material when the pigment is in or under glaze;
- Glassware for table, kitchen and fancy goods; for signalling purposes and for mosaic work when the pigment is in the glass mass;
- Nuclear reactors, steam-engines, machines and apparatus, mechanic equipment when the pigment or stabiliser is not included in casings and covers or in lacquer and paints;
- Electro-mechanic household apparatus, electric water heaters, immersion heaters, hairdryers, … when the pigment or stabiliser is not included in casings and covers;
- Electric machines and apparatus and other electric material when the pigment or stabiliser is not included in the casings and covers;
- Pigment, stabiliser and surface treatment of armoured tanks;
- Pigment and stabiliser, when not used in interior and exterior application, and surface treatment for aircraft;
- Surface treatment of cruise liners, excursion ships, ferries, cargo ships, fishing vessels, lightships, warships, …
- Pigments and stabiliser, when not used in casings and covers, and surface treatment for binoculars and astronomic instruments, cameras, projectors, copying machines, microscopes, measuring instruments, …
- Pigments and stabiliser, when not used in casings and covers, and surface treatment for watches and time switches;
- Pigment, stabiliser and surface treatement of weapons and ammunition;
- Light fiitings and other light articles of glass when pigment is in the glass mass;
- Pigment in paintings and artistic graphical original sheets;
- Goods for which the use of cadmium substance is of vital importance from the viewpoint of warning or perception or the use of cadmium for surface treatment is of vital importance from the viewpoint of safety in electrical contacts or in goods and components used within the aviation, space, mining, offshore and nuclear power sectors;
- Samples or models which, with regard to material, design, number or value, are clearly intended only to show the nature or use of the product;
- Parts, materials and raw material intended for manufacture, repair or maintenance of products covered by the exemption from the prohibition or for which exemption has been granted;
- Parts and materials intended for maintenance and repair of goods which are not covered by the exemption from the cadmium prohibition but which were manufactured or imported into Sweden before the prohibition of the product came into force.

Campaigns have been performed to inform about appropriate handling of colours containing cadmium and to encourage use of alternative pigments.

Austria also has a more stringent approach towards marketing and use restrictions but no information has been provided on the nature of these measures.

Sweden and Austria have negotiated to be able to maintain their more stringent approach towards marketing and use restrictions upon accession to the EU until December 2002. Annex I 24. 4. of Directive

76/769/EEC explicitly states: '*Austria and Sweden, which already apply restrictions to cadmium going further than those prescribed in Sections 1, 2 and 3 may continue to apply these restrictions until 31 December 2002. The Commission will review the provisions on cadmium in Annex I to Directive 76/769/EEC before this date in light of the results of risk assessment for cadmium and of development of knowledge and techniques in respect of substitutes for cadmium.*'

This clause has, however, been overruled by the European Court of Justice in its judgement of 18 June 2002, based on the following arguments:

- there is no evidence to suggest that the risks from cadmium were any greater in Austria and Sweden than in the rest of the EU;
- the more stringent marketing and use restrictions were not based on advances in knowledge and techniques regarding substitutes for cadmium.

3.3 VOLUNTARY INITIATIVES

3.3.1 Vinyl 2010

In March 2000, the PVC industry, represented by the European associations ECVM, EuPC, ESPA and ECPI, signed a voluntary agreement in which it committed itself to improve its environmental performance. Vinyl 2010 puts the PVC industry's Voluntary Commitment into practice. Signed in 2000, this is a 10-year plan to deliver continuous improvement in product stewardship across the PVC lifecycle. Principal elements are to cut raw material and energy consumption in manufacturing; minimise the environmental impact of resin production; develop a comprehensive waste management strategy; ensure that all plasticizers can be safely used and assess potential risks linked to lead as a stabiliser while working toward replacement by 2015 (Euractiv, 2005). The industry also committed to cease using cadmium stabilisers for products put on the EU market by 2001.

The use of cadmium in stabilisers is being phased out. ESPA members phased out the sale of all cadmium stabilisers in the EU, Norway and Switzerland in 2001 (Vinyl 2010, 2004).

3.3.2 SAFT

As the European leader of the high technology industrial battery segment, Saft, has implemented since the early 1990's a take back policy for industrial batteries. The main elements of this policy are :

- Saft has identified collection points in most EU countries as well as spent Ni-Cd battery recyclers in France, Germany and Sweden,
- when Saft sells a new battery to a customer, Saft takes back the battery that is replaced, be it a Lead/acid or a NiCd battery, whether or not this replaced battery was manufactured by Saft or not,
- the agreement specifies that the customer must organise for the spent battery to be delivered at the collection points of its country. From there on, the battery is forwarded to the recycling plants and recycled there at Saft's cost, hence at no charge to the customer, it should be noted that transboundary waste shipment notifications (per the Basel Convention) are always obtained prior to shipping the waste,
- this commitment is formally implemented in Saft's Companies Terms and Conditions,
- ;this programme ensures that all waste industrial batteries are collected,
- with such a programme, Saft has already implemented the producer responsibility principle, which is introduced in the new battery directive,

- the provisions that are spelled out in the new (almost) finalised directive regarding industrial battery producer responsibility are modelled on the voluntary programme that Saft has developed.
- a similar programme has since been developed and implemented by the second largest player in the industry: Hoppeke from Germany.

3.4 INTERNATIONAL AGREEMENTS

3.4.1 JECFA (Joint Expert Committee on Food Additives)

The Joint FAO/WHO Expert Committee on Food Additives (JECFA) is an international expert scientific committee that is administered jointly by the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO). It has been meeting since 1956, initially to evaluate the safety of food additives. Its work now also includes the evaluation of contaminants, naturally occurring toxicants and residues of veterinary drugs in food.

Cadmium was evaluated at the sixty-first meeting of JECFA in Rome in June 2003. A Permissible Tolerable Weekly Intake (PTWI) of 7 µg Cd/ kg body wt has been determined and that no adverse effects are expected to occur if the urinary cadmium level remains below 2,5 µg/g creatinine.

As mentioned in section 3.1.8.1, legislation on food additives also exists in the EU.

3.4.2 The OSPAR Convention

Relevant for: surface water and sediment, secondary poisoning

The 1992 OSPAR Convention for the protection of the marine environment of the North-East Atlantic is the current instrument guiding international cooperation on the protection of the marine environment of the North-East Atlantic. It combined and up-dated the 1972 Oslo Convention (OSCOM) on dumping waste at sea and the 1974 Paris Convention (PARCOM) on land-based sources of marine pollution. The work under the convention is managed by the OSPAR Commission, made up of representatives of the Governments of 15 Contracting Parties and the European Commission, representing the European Community .

The work under the Convention is guided by the Ministerial Declarations and Statements made at the adoption of the Convention and at the Ministerial Meetings of the OSPAR Commission. The work applies the ecosystem approach to the management of human activities.

The OSPAR hazardous substances strategy sets the objective of preventing pollution of the maritime area by continuously reducing discharges, emissions and losses of hazardous substances, with the ultimate aim of achieving concentrations in the marine environment near background values for naturally occurring substances and close to zero for man-made synthetic substances. As its timeframe, the Hazardous Substances Strategy further declares that the Commission will implement this Strategy progressively by making every endeavour to move towards the target of the cessation of discharges, emissions and losses of hazardous substances by the year 2020.

The Oslo and Paris Commission (OSPAR) has adopted the following Recommendations and Decisions with relevance for cadmium and cadmium-relevant industries (OSPAR 2001):

- PARCOM Recommendation 84/2 for reducing cadmium pollution (Source: PARCOM 6/13/1, paras 4.20-4.23) (calls for substitution of cadmium in electroplating, pigments and stabilisers, and for labelling, collecting and recycling cadmium batteries)

- PARCOM Decision 85/2: Programmes and Measures on Limit values and Quality Objectives for cadmium Discharges (establishes same discharge limit criteria as HELCOM 6/6)
- PARCOM Recommendation 90/1 of 14 June 1990 on the definition of the best available technology for Secondary iron and steel plants (lists acceptable emissions control technologies)
- PARCOM Decision 90/2 on programmes and measures for mercury- and cadmium containing batteries (requires separate collection and recycling of batteries containing more than 0.025% cadmium by weight, such batteries must be removable without aid of special tools and should be labelled)
- PARCOM Recommendation 91/2 of 20 June 1991 on the definition of best available technology in the primary iron and steel industry (favours dry methods of dust removal rather than wet scrubbing, recommends general techniques for dust prevention and removal)
- PARCOM Recommendation 91/3 of 20 june 1991 on measures to be taken and investigations to be carried out in order to reduce pollution from secondary iron and steel production (as HELCOM 13/4)
- PARCOM Recommendation 92/2 concerning limitation of pollution from new primary iron and steel Production installations (sets limits for dust emissions (50 mg/m^3, but lower if cadmium or other heavy metals are present))
- PARCOM Recommendation 92/3 concerning limitation of pollution from new secondary steel production and rolling mills (sets limits for dust emissions (20 mg/m^3, but lower if heavy metals are present) and discharge limit criteria for waste water from pickling plants, including 0,2 mg/l for Cadmium)
- PARCOM Recommendation 92/4 on reduction of emissions from the electroplating industry (sets wastewater discharge limit criteria, including 0,2 mg/l for Cadmium)
- PARCOM recommendation 93/1 concerning limitation of pollution from existing primary iron and steel production installations (applies limits as in Recommendation 92/2 to existing plant, after a phase-in period).

3.4.3 HELCOM Convention

<u>Relevant for</u>: surface water and sediment, secondary poisoning

The Helsinki Commission, or HELCOM, works to protect the marine environment of the Baltic Sea from all sources of pollution through intergovernmental co-operation between Denmark, Estonia, the European Community, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden. HELCOM is the governing body of the "Convention on the Protection of the Marine Environment of the Baltic Sea Area" - more usually known as the Helsinki Convention.

The following HELCOM recommendations with relevance to Cd are currently valid (HELCOM website November 2001):

- Recommendation 6/6 (1985) on Limitation of discharge of Cadmium from land based sources: set limits for wastewater emissions from industrial activities:
  - electroplating: 0,2 mg/l from 1989 (0,5 mg/l in 1986), max. 0,3 g per kg Cd used
  - pigments: 0,2 mg/l from 1989 (0,5 mg/l in 1986), max. 0,3 g per kg Cd used
  - stabilizers: 0,2 mg/l from 1989 (0,5 mg/l in 1986), max. 0,5 g per kg Cd used
  - battery manufacture: 0,2 mg/l from 1989 (0,5 mg/l in 1986), max. 1,5 g per kg Cd used
  - manufacture of Cadmium compounds: 0,2 mg/l from 1989 (0,5 mg/l in 1986), max. 0,5 g per kg Cd used
  - zinc mining: 0,2 mg/l from 1989 (0,3 mg/l in 1986)

  this Recommendation has been proposed for deletion on the grounds that its provisions are covered by other Recommendations and by the HELCOM Convention of 1992 (HELCOM 2001F).

- Recommendation 11/7 (1990) on reduction of emissions to the atmosphere from Iron and Steel industry: 54 general requirement to reduce dust emissions. If Cadmium emission is greater than 5 g/hr then continuous monitoring is required.
- Recommendation 13/4 (1992) on Atmospheric pollution related to use of scrap materials in the iron and steel industry: presence of mercury and cadmium should be avoided in all products that can end up as scrap.
- Recommendation 14/5 (1993) on reduction of diffuse emissions from used batteries containing heavy metals (mercury, cadmium, lead) (supersedes an earlier recommendation on this subject, no. 6/5 (1985)): batteries containing these heavy metals should preferably be substituted with less harmful products, they should be collected for safe disposal and should be clearly marked.
- Recommendation 16/6 (1995) on restriction of discharges and emissions from metal surface treatment: harmful substances including cadmium should be substituted. Discharge limit criteria include maximum 0.2 mg/l for cadmium in wastewater. Cadmium containing waste streams to be monitored and treated separately from other streams.
- Recommendation 16/8 (1995) on limitation of emissions to the atmosphere and discharges to water from the incineration of household waste: aqueous discharges from flue gas scrubbers may not contain more than 15 mg Cadmium per t incinerated waste.
- Recommendation 17/6 (1996) on reduction of pollution from discharge into water, emission into the atmosphere and phosphogypsum out of the production of fertilizers: sets limits on the cadmium contents of fertilizer products and a ban on phosphogypsum discharge to water.
- Recommendation 20/6 (1999) on requirements for the discharge of wastewater from the chemical industry: sets a discharge limit value of 0,2 mg Cd per litre wastewater.

3.4.4 ICPR (International Commission for the Protection of the Rhine)

<u>Relevant for</u>: surface water and sediment, secondary poisoning

As Rhine bordering countries Switzerland, France, Germany and the Netherlands as well as Luxemburg and the European Union co-operate within the ICPR on the basis of a treaty under international law. The targets of the ICPR are:

- Sustainable development of the Rhine ecosystem
- Secure the use of Rhine water for drinking water production
- Improve sediment quality in order to be able to dispose of dredged material without causing any harm
- Comprehensive flood prevention and protection taking into account ecological requirements
- Depollution of the North Sea

The Rhine 2020 "Programme on the sustainable development of the Rhine" continues the extremely successful Rhine Action Programme of 1987 to 2000 and fixes the general objectives of Rhine protection policy as well as the required measures for its implementation during the next 20 years.

3.5 NATIONAL AGREEMENTS

3.5.1 Swedish Seal of Quality for food

The Swedish Seal of Quality (Svenskt Sigill) is a voluntary quality label for food. The label guarantees that the food item has been produced on farms that follow strict criteria concerning safe food, animal welfare, responsibility for the environment and a vivid landscape. The fundamentals of Swedish Seal are a set of rules, different for different kinds of food production. An independent audit company reviews the farm's compliance with the Swedish Seal criteria. The logo "Svenskt Sigill" (Swedish Seal) is owned and administrated by a wholly owned subsidiary of the Federation of Swedish Farmers (LRF).

Examples of criteria:

- Control and analysis of cadmium in soil, fertilisers and grain.
- Safe use of pesticides and fertilisers.
- No use of sewage sludge.

Many of the products labelled with the Swedish Seal of Quality are based on cereals. Before the cereals can be used a cadmium-analysis is performed. The soil in the field is analysed (maximum 0,3 mg Cd/kg dry substance) and, if needed, the cereal (maximum 0,08 mg Cd/kg). According to the Swedish Seal of Quality all fertilisers used must have a low cadmium-content. Approximately 25 % of Swedish cereals used for human food are cultivated in compliance with the Swedish Seal of Quality.

The Swedish Environmental Protection Agency's Criteria for Environmental Quality Assessments constitute a system of classification, which facilitates the interpretation of environmental data. The system can be used to determine whether measured values are low or high in relation to either a national average or baseline readings. For cadmium in crops three levels exist. Low < 0,05 mg Cd/kg, Moderate 0,05-0,1 mg Cd/kg and High > 0,1 mg Cd/kg.

3.6 EFFECT OF CURRENT RISK REDUCTION MEASURES

One has to take into account that the effects of any legislation only starts to show only a few years after its adoption. In case of EU legislation for instance, a first hurdle is the transposition into national legislation. After that, one should account for at least a number of years before the legislation is really implemented in the field and starts to show its effect.

In the case of Cd, there is a broad range of legislation that has been recently adopted and has not yet been fully implemented in the various Member States and has not shown any effect so far:

- IPPC Directive: should come into effect for existing plants from October 30, 2007 onward
- Large Combustion Plants Directive: adopted November 27, 2001 and transposition on a Member State level required before November 27, 2002
- Waste Incineration Directive: applies for new plants from December 28, 2002 onward and for exisiting plants from December 28, 2005 onward.
- Chemical Agents at Work Directive: adopted April 7, 1998 and transposition on a Member State level required before May 5, 2001
- Water Framework Directive
- ...

As data used in the updated assessment generally refer to 2002 as the reference year, none of the above mentioned pieces of legislation, expected to have a significant influence on Cd emissions and exposure, are likely to have had any effect on the emission and exposure levels used in the risk assessment.

On the other hand, legislation in place did show its effect on the emissions of Cd to the environment, on the observed Cd concentrations for water and air and on the occupational exposure.

3.6.1 Water

Fuchs et al (2002) studied the emissions of metals and lindane to the various river basins in Germany over the period 1985 – 2000. The following sources were quantified in this study:

- Point sources:
  - Industry sources (emissions likely to be affected by the requirements of Directive 76/464/EEC on discharge of dangerous substances) and by national legislation;
  - Municipal wastewater treatment plants (emissions likely to be affected by the requirements of Directive 91/271/EEC on Urban Waste Water Treatment);
  - Historic mining activities
- Diffuse sources:
  - Atmospheric Deposition (emissions to air likely to be affected by Directives 88/609/EEC (large combustion plants) and 89/369/EEC (waste incineration plants));
  - Seepage and spraydrift (direct input into waterbodies from manure and mineral fertiliser spreading);
  - Surface runoff (emissions likely to be affected by the requirements of Directive 91/271/EEC on Urban Waste Water Treatment (sewer overflows), of Directive 86/278/EEC on the protection of soil when sewage sludge is used and by all Directives relating to the lowering of emissions to air (lower deposition));
  - Erosion (emissions likely to be affected by the requirements of Directive 86/278/EEC on the protection of soil when sewage sludge is used and by all Directives relating to the lowering of emissions to air (lower deposition));
  - Drainage (emissions likely to be affected by the requirements of Directive 86/278/EEC on the protection of soil when sewage sludge is used);
  - Separate sewers (emissions likely to be affected by the requirements of Directive 91/271/EEC on Urban Waste Water Treatment);
  - Combined sewer overflows (emissions likely to be affected by the requirements of Directive 91/271/EEC on Urban Waste Water Treatment);
  - Sewers not connected to municipal wastewater treatment plant (emissions likely to be affected by the requirements of Directive 91/271/EEC on Urban Waste Water Treatment);
  - Households not connected to sewer (emissions likely to be affected by the requirements of Directive 91/271/EEC on Urban Waste Water Treatment);
  - Groundwater.

The effect of all above mentioned legislation in combination with national legislation (e.g. on industrial point sources to water not regulated by 76/464/EEC and on agricultural practises) has led to the following decreases in input to the various river basins in Germany over the period 1985-2000 (Table 3.6.1).

3.6.2 Air

Data from EMEP indicate that the emissions of Cd to air have decreased by 63% in the year 2000 as compared to the year 1980. Countries relying heavily on coal, such as Germany, have seen their emissions reduced by 92% in the year 2000 as compared to the year 1980. Figure 3.6.1 gives an overview of the spatial pattern of Cd emissions in Europe (g/km²/year) for 1980, 1990 and 2000. Decrease in emissions are most obvious in the former EU15, although most of the hot spots have also disappeared from the new Member States. This reduction in emissions can be ascribed to the implementation of national and Community legislation as well as international Protocols relating to air quality.

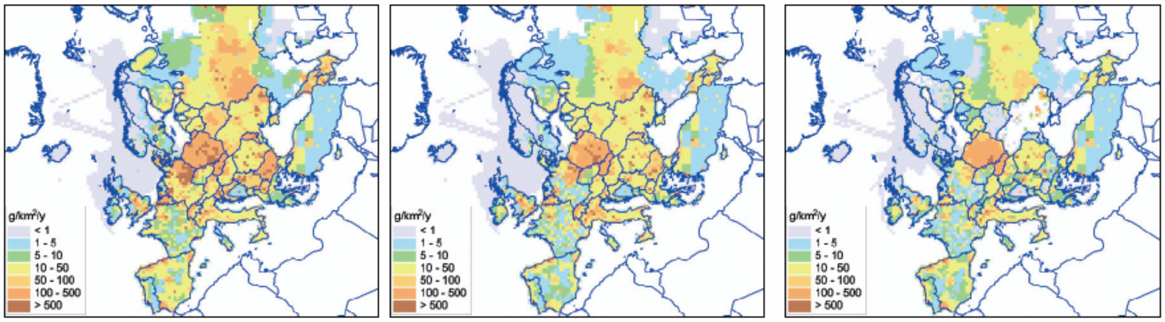


Figure 3.6.1: Spatial distribution of Cd emissions (g/km²/year) in Europe for 1980 (left), 1990 (middle) and 2000 (right) (EMEP, 2004)

This decrease in emissions has lead to a significant improvement of the ambient air quality for Cd as well as a significant reduction in Cd deposition. While in 1980 ambient air concentrations for Cd were still in the range of 0,1 – 0,7 ng/m³, the 2000 values are in the range 0,07 – 0,25 ng/m³; a decrease by 30 – 64%. Cd deposition fluxes in 1980 varied from 30 – 150 g/km²/year, with significantly higher deposition fluxes in Poland, Bulgaria and the Länder of former East-Germany (Figure 3.6.2), while Cd deposition fluxes in 2000 reach levels of 20 – 50 g/km²/year. Cd deposition is still largely influenced by transboundary transport of pollution. On average, the transboundary contribution to total deposition of Cd in Europe amounted to 30% in 2000.

Table 3.6.1: Evolution of the input of Cd into German river basins from various sources over the period 1985 – 2000 (Fuchs *et al.*, 2002)

River basin	Year	Industry [kg/a]	MWWTPs [kg/a]	Historic mining activities [kg/a]	Atmospheric deposition [kg/a]	Seepage and spraydrift [kg/a]	Surface runoff [kg/a]	Erosion [kg/a]	Tile drainage [kg/a]	Separate sewers [kg/a]	Combined sewer overflows [kg/a]	Sewers without MWWTP [kg/a]	Households without connection [kg/a]	Ground-water [kg/a]	Point sources total [kg/a]	Nonpoint sources total [kg/a]	Total [kg/a]
	1985		476		258.7	4.6	1143	418	90	211	450	66	9	356	476	3007	3463
Danube	1995	44.2	218		30.0	3.6	627	461	94	183	225	17	4	340	262	1984	2247
	2000	7.8	140		22.0	3.5	321	467	94	144	179	15	3	340	148	1588	1735
Difference	1985-2000		-71%		-91%	-25%	-72%	12%	4%	-32%	-60%	-78%	-68%	-5%	-69%	-47%	-50%
	1985	1775.0	4117	71	423.6	6.7	1335	547	148	582	2086	258	10	658	5963	6054	12017
Rhine	1995	365.0	1635	71	80.0	5.3	687	567	151	413	1033	55	4	632	2071	3627	5698
	2000	324.5	1053	71	59.0	5.1	354	577	151	326	825	47	3	632	1449	2980	4429
Difference	1985-2000	-82%	-74%	0%	-86%	-25%	-73%	5%	2%	-44%	-60%	-82%	-66%	-4%	-76%	-51%	-63%
	1985	15.0	145		59.1	1.2	38	21	32	188	36	0	4	80	160	459	619
Ems	1995	3.5	61		10.0	1.0	30	21	34	131	16	0	2	79	65	324	389
	2000	6.4	67		9.0	1.0	17	23	34	104	13	0	1	79	73	281	354
Difference	1985-2000	-57%	-54%		-85%	-18%	-55%	12%	7%	-45%	-64%	0%	-64%	-1%	-54%	-39%	-43%
	1985	1150.0	516		302.8	3.7	145	203	91	677	343	253	6	244	1666	2270	3936
Weser	1995	60.2	219		35.0	3.0	103	198	100	455	109	42	3	222	279	1269	1548
	2000	36.8	183		25.0	2.9	58	207	100	359	87	36	2	222	220	1099	1319
Difference	1985-2000	-97%	-65%		-92%	-20%	-60%	2%	10%	-47%	-75%	-86%	-74%	-9%	-87%	-52%	-67%
	1985	18577.7	3591	478	7567.1	6.6	100	426	245	2547	2267	1339	117	301	22647	14915	37562
Elbe	1995	91.2	692	478	279.0	3.7	95	423	273	623	310	212	17	306	1261	2541	3802
	2000	68.1	273	478	142.0	3.7	59	440	273	492	247	183	14	306	819	2160	2979
Difference	1985-2000	-100%	-92%	0%	-98%	-43%	-40%	3%	12%	-81%	-89%	-86%	-88%	2%	-96%	-86%	-92%
	1985		222		460.5	0.4	2.3	9	9	233	44	12	6	14	222	792	1014
Odra	1995	15.9	24		5.0	0.2	1.9	10	9	36	6	2	1	14	40	85	124
	2000	23.7	7		3.0	0.2	1.9	11	9	28	4	1	1	14	30	73	104
Difference	1985-2000		-97%		-99%	-47%	-15%	26%	3%	-88%	-91%	-89%	-90%	-1%	-86%	-91%	-90%
North Sea	1985	2.0	103		64.8	1.1	39	6	90	136	50	10	3	57	105	458	563
Coast	1995	2.1	24		8.0	0.9	23	5	90	90	25	1	1	53	26	297	323
	2000	1.8	24		7.0	0.9	13	7	90	71	20	1	1	53	26	264	289
Difference	1985-2000	-10%	-77%		-89%	-21%	-67%	9%	0%	-48%	-60%	-92%	-65%	-7%	-76%	-42%	-49%
Baltic Sea	1985		302		2653.3	1.9	21	28	93	555	166	22	22	69	302	3832	4134
Coast	1995	0.3	63		58.0	1.1	18	29	104	156	20	11	3	67	63	466	550
	2000	0.3	9		35.0	1.1	13	32	104	123	16	9	2	67	10	402	412
Difference	1985-2000		-97%		-99%	-42%	-39%	14%	11%	-78%	-90%	-58%	-90%	-2%	-97%	-89%	-90%
Black	1985		476		258.7	4.6	1143	418	90	211	450	66	9	356	476	3007	3483
Sea	1995	44	218		30.0	3.6	627	461	94	183	225	17	4	340	262	1984	2247
total	2000	8	140		22.0	3.5	321	467	94	144	179	15	3	340	148	1588	1735
Difference	1985-2000		-71%		-91%	-25%	-72%	12%	4%	-32%	-60%	-78%	-68%	-5%	-69%	-47%	-50%
North Sea	1985	21520	8472	549	8417.4	19.2	1657	1203	607	4130	4782	1860	141	1339	30541	24156	54697
total	1995	522	2631	549	412.0	13.9	937	1214	648	1712	1493	309	26	1292	3702	8057	11760
	2000	436	1600	549	242.0	13.5	502	1254	648	1352	1192	267	22	1292	2587	6784	9370
Difference	1985-2000	-98%	-81%	0%	-97%	-30%	-70%	4%	7%	-67%	-75%	-86%	-85%	-4%	-92%	-72%	-83%
Baltic Sea	1985		524		3313.8	2.2	23	37	102	788	210	35	30	83	524	4623	5147
total	1995	16	107		63.0	1.3	20	39	113	192	26	13	4	81	123	551	674
	2000	24	16		38.0	1.3	15	43	113	151	20	11	3	81	40	476	516
Difference	1985-2000		-97%		-99%	-43%	-37%	17%	11%	-81%	-90%	-69%	-90%	-2%	-92%	-90%	-90%
Germany	1985	21520	9472	549	11989.9	26.1	2824	1657	799	5129	5442	1961	180	1778	31541	31786	63327
total	1995	582	2956	549	505.0	18.7	1584	1714	855	2087	1744	339	33	1713	4088	10593	14680
	2000	469	1756	549	302.0	18.3	837	1764	855	1647	1391	293	27	1713	2774	8847	11622
Difference	1985-2000	-98%	-81%	0%	-97%	-30%	-70%	6%	7%	-68%	-74%	-85%	-85%	-4%	-91%	-72%	-82%

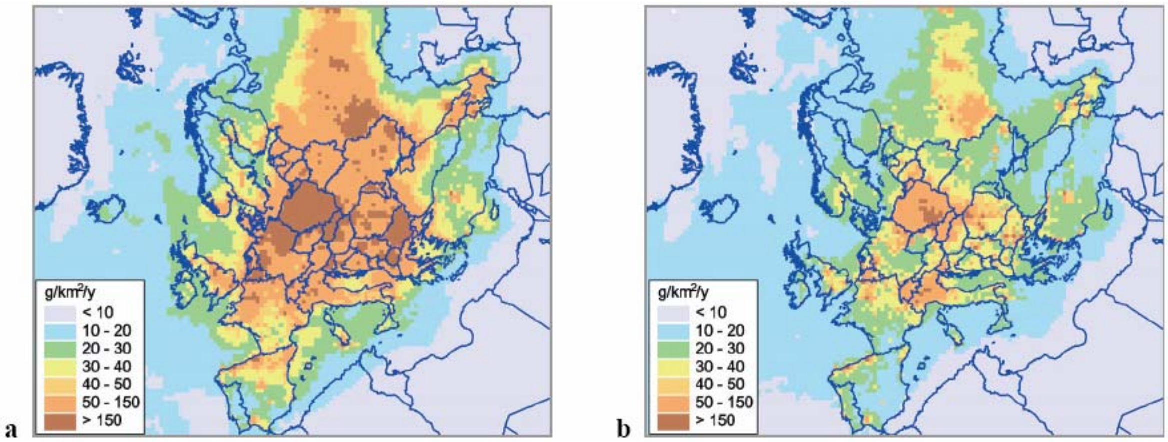


Figure 3.6.2: Spatial distribution of Cd deposition fluxes (g/km²/year) in Europe for 1980 (a) and 2000 (b) (EMEP, 2004)

In an economic evaluation of air quality targets for heavy metals (Entec, 2001), the authors conclude that 'several adopted or proposed policies at a EU and international level are expected to secure significant further reduction in heavy metals emissions to air from certain sectors'. Full implementation of the IPPC Directive (96/61/EC) is expected to have a major impact on emissions from metals, including Cd, from existing processes in the iron & steel, non ferrous metals, petroleum, cement and glass sectors. Implementation of the Large Combustion Plants Directive (2001/80/EC) is found likely to have significant implications on the metal emissions from existing coal and oil fired large combustion plants. Implementation of the Waste Incineration Directive (2000/76/EC) will potentially have significant implications on metals emissions from existing incineration and co-incineration plants. These include municipal waste incinerators, clinical waste incinerators, hazardous waste incinerators, sewage sludge incinerators, other thermal processes for waste treatment and co-incineration in the power and cement industry. Other Directives that also might indirectly affect air quality for metals are the first air quality daughter Directive (1999/30/EC), because of the limit values for particulate matter, the national emissions ceilings Directive (2001/81/EC). International protocols like the UNECE Protocol to the 1979 Convention on Long Range Transboundary Air Pollution on Heavy Metals and the Kyoto Protocol are also likely to have a beneficial effect on air quality for heavy metals.

The implementation of the fourth air quality daughter Directive (2004/107/EC) will in itself lead to a lowering of Cd concentrations in ambient air because of the measures to be taken in these zones or agglomerations where air quality target values are exceeded. It is most likely that air quality in areas in the vicinity of point sources will be most affected by the implementation of this Directive.

Entec (2005) made a study within the framework of the review of the large combustion plants Directive (2001/80/EC). There were insufficient data available to assess the effects of this Directive on the emissions of metals, including cadmium, from the large combustion plants. However, a decrease of PM10 emissions from 2,445 ktonnes in 2000 to 1,495 ktonnes in 2020 and of PM2.5 emissions from 1,749 ktonnes in 2000 to 971 ktonnes in 2020 was expected as a result of the implementation of the Large Combustion Plants Directive (figures based on RAINS modelling data). As emissions of metals, except for mercury, are largely particle bound, an decrease of the metal emissions, including Cd, in line with the decrease of the PM10 and PM2.5 emissions can be expected. EPER data for 8 Member States show an emission of 4 tonnes of Cd to the air from large combustion plants in 2001.

3.6.3 Soil

Cadmium is a natural occurring element in soils. Increased cadmium in soil (concentrations higher than natural background) is the result of deposition and for agricultural soils, input through agricultural activities (mineral fertilisers, manure, sewage sludge, …). The influence of already implemented legislation on the evolution of Cd-concentration in the soil during the past years is difficult to assess. The availability of Cd-concentration data in soil is very scarce. Nevertheless, it can be assumed that Cd-concentrations in soils will not have decreased over the past years if no soil remediation took place. The only influence current legislation could have is that the input to the soil has decreased. The decrease of deposition was already shown in Figure 3.6.2. As an example for Europe, a Belgian report (Guns M. and Pussemier L., 2000) on the risk assessment to health and the environment from cadmium in fertilisers shows the evolution of cadmium input in Belgian soils through phosphate fertilisers (cf. Table 3.6.2).

Table 3.6.2: Evolution of cadmium input through phosphate fertilisers in Belgium (Guns M. and Pussemier L., 2000)

Agricultural region	Cd ($g.ha^{-1}$)				
	1980 [4]	1995	1996	1997	1998
Polders	2.98	0.78	0.82	0.65	0.59
Sandy region	1.67	0.98	0.98	0.85	0.78
Campine	1.27	0.82	0.91	0.91	0.68
Sandy-loam	3.16	1.26	1.29	1.08	0.98
Loamy region	5.09	1.42	1.37	1.32	1.22
Grassy region	1.38	0.88	0.95	0.91	0.65
Campine Hennuyère	1.27	1.37	1.37	1.34	1.27
Condroz	3.64	1.40	1.37	1.34	1.40
Haute Ardenne	1.13	1.08	0.91	1.04	0.88
Fagnes	1.35	1.37	1.37	1.40	1.27
Famenne	2.18	1.37	1.37	1.40	1.27
Ardenne	2.22	1.50	1.40	1.50	1.37
Jurassic region	2.11	1.50	1.40	1.50	1.37
Average	2.27	1.21	1.19	1.17	1.06

Table 3.6.2 shows that cadmium input through phosphate fertilisers has in Belgium decreased in average from 2.27 g/ha in 1980 to 1.06 g/ha in 1998. Lowering the input should lower the increase of Cd-concentration in the soil.

3.6.4 Occupational exposure

During the years, a lot of effort has been done to reduce Cd exposure levels in the workplace for some scenario's (RAR, update 2005). This is illustrated by Table 5.1.1 and Table 5.1.2, giving an overview of typical Cd exposure level values and the typical biomonitoring data, used in the RAR (2005), which are data from 1994-1996 and typical values in the update RAR (2005), which are data from 2002.

The decrease of occupational exposure in the cadmium industry, for example the batteries industry, over the years can be shown based on the evolution of Cd-concentrations in blood and in urine of workers of a battery company (Figure 3.6.3 and Figure 3.6.4),

Figure 3.6.3 shows that the average Cd-B concentrations of the exposed workers of a battery company decreased from about 193 nmol/liter (or ~21 µg/l) in 1957-1973 to 17 nmol/liter (or ~ 2µg/l) in 2001-2005.

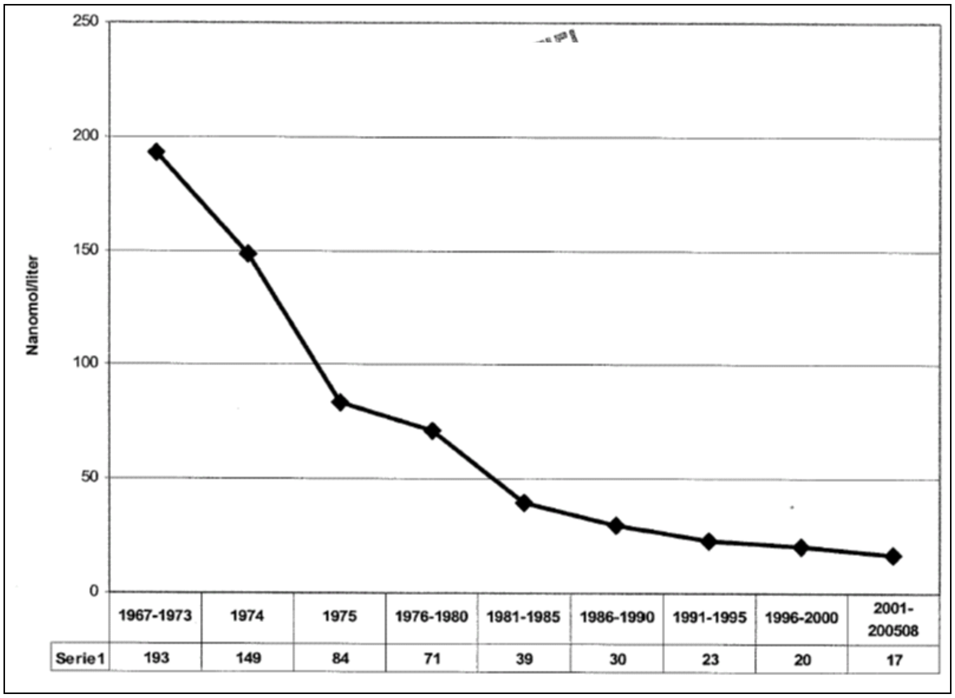


Figure 3.6.3: Evolution of the concentrations of cadmium found in blood samples of the exposed workers of a battery company (1976-2005) (Dr Spång, presentation given on 8/02/2006)

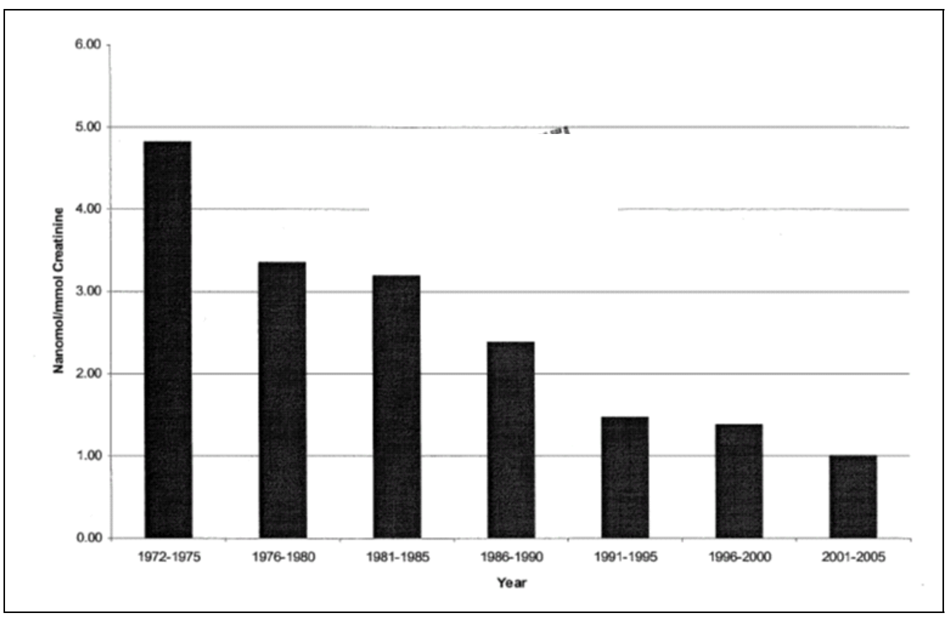


Figure 3.6.4: Evolution of the concentrations of cadmium found in urine samples of the exposed workers of a battery company (1972-2005) (Dr Spång, presentation given on 8/02/2006)

Figure 3.6.4 shows that the average Cd-U concentrations of the exposed workers of a battery decreased from about 4.8 nmol/mmol creatinine (4.8 µg/g creatinine) in 1972-1975 to 1 nmol/mmol creatinine (1 µg/g creatinine) in 2001-2005.

These data clearly show that the efforts done so far have been very effective to reduce occupational exposure.

4 POSSIBLE FURTHER RISK REDUCTION MEASURES

4.1 INTRODUCTION

Potential risks have been assessed for the environment, both on the local and the regional level (surface water, sediment, terrestrial and secondary poisoning). For human health risks have been assessed for workers; for consumers and for man indirectly exposed via the environment. For a more detailed discussion on the risks assessed, the reader is referred to chapter 2 of this report.

As already indicated in chapter 3, the TGD (EC, 1998) publishes a list of possible risk reduction measures, which can be used to reduce the risks assessed. In a first step this list is screened to select those measures applicable for reducing the environmental and human health risks identified for Cd/CdO.

Once the possible measures, which will be further assessed, are chosen, a tool to implement these measure needs to be selected also.

A list of tools (administrative, legal and others) to implement risk reduction measures is considered in the TGD (EC, 1998) and is cited here:

- Information programmes and other EC/Government Initiatives;
- Unilateral action by industry;
- Voluntary agreements;
- Technical standards and authoritative guidance;
- Economic instruments;
- Regulatory controls

For each scenario (workers, consumers, surface water, …) first an overview is given of all possible further risk reduction measures and tools in Table format. Secondly, a more detailed description is given per measure indicated in the overview table.

4.2 POSSIBLE FURTHER RISK REDUCTION MEASURES FOR HUMAN HEALTH

4.2.1 Workers

Table 4.2.1 shows an overview of the possible legislative initiatives to reduce risks for workers.

Table 4.2.1: Overview of possible measures to reduce risks assessed for workers and tools to implement those measures

Risk assessed	*Possible measures to reduce risk*	*Possible tools*	*Description in chapter:*
Inhalation occupational exposure	- restriction on marketing and use; - safe systems of work - application of good manufacturing practice - classification and labelling - monitoring and maintenance of equipment - dust suppression methods; - occupational exposure limits; - accurate hazard information;	1) Regulatory controls: - Chemical agents at work Directive (98/24/EC) - substitution of Cd - ban of NiCd batteries 2) Action by industry	4.2.1.1 4.2.1.2 4.2.1.3 4.2.1.4

Risk assessed	*Possible measures to reduce risk*	*Possible tools*	*Description in chapter:*
	- biological exposure indices; - medical survey of workers; - training; - use of personal protective equipment		

4.2.1.1 Chemical agents at work Directive (98/24/EC)

The RAR concludes that health risks cannot be excluded for workers upon inhalation exposure. Therefore, in industry further risk reduction measures, reducing the possible inhalation of Cd at the workplace need to be taken. The **'Chemical agents at work' Directive (98/24/EC)** lays down the minimum requirements for the protection of workers from risk to their safety and health (cf. 3.1.2.2). In the framework of this Directive, some further risk reduction measures can be evaluated:

- Occupational exposure limit values
- Collective exposure reduction measures
- Training
- Health surveillance of workers
- Personal protective equipment
- Safety data sheets
- Classification and labelling

This shows that, nearly all possible measures, listed in Table 4.2.1 are covered by the Chemicals at work Directive.

OCCUPATIONAL EXPOSURE LIMIT VALUES

For some EU countries, OEL values for Cd in air were found as given in chapter 3.1.2.2 of this document. These OEL's are ranging between 5 and 30 µg/m³ (the Netherlands and Germany respectively). A few Member States imposed occupational biological limit values (BLV) for Cd. The BLV's set for concentrations in blood range from 5.6 to 15 µg/l (Finland and Germany respectively). Limits set for Cd-concentrations in urine range from 4 to 10 µg/g creatinine (The Netherlands and France respectively) and from 5.6 to 15 µg/l (Finland and Germany respectively).

The setting of a community wide OEL value for Cd would lead to a harmonised level of control in the workplace for all sectors.

In accordance with Article 3(6) of Directive 98/24/EC on chemical agents the Commission may establish biological limit values (BLV's) based on independent scientific assessment of the latest available scientific data.

For the general population, following endpoints were identified based on scientific literature:

- Acute toxicity: LOAEL (as Cd) of 437.5 µg/m³ (Cd-A)
- Repeated toxicity (lung and bone): LOAEL (as Cd) of 3 µg/g creatinine (Cd-U);
- Kindney and bone: LOAEL (as Cd) of 2 µg/g creatinine (Cd-U);
- Reprotoxicity – effects on fertility and sex organs: LOAEL (as Cd) of 1 mg/kg/day (Cd uptake).

It is important to mention that there is some scientific debate about the health significance of the changes observed at Cd-U levels < 5µg/g creatinine (for kidney) and this was reflected in the contrasting views expressed by experts during the TMs of the RAR. Nevertheless a LOAEL of 2 µg/g creatinine was taken forward in the risk characterisation.

The MOS for workers, taking into account a LOAEL of 5 µg/g creatinine, ranges from 1.65 for Cd-metal production to 1.25 for pigments industry, which should be sufficient.

It is important to pay attention on the fact that risks for workers were identified in the RAR (2005), based on:

- studies indicating both kidney and bone effects in the general population and not in workers specifically;
- a LOAEL of 2 µg/g creatinine, based on the occurrence of effects at body burden below 5 µg/g creatinine

The RAR (2005) states however that there is consensus in the literature concerning the health significance of the threshold of 5 µg/g creatinine because of the frequent observation of irreversible tubular changes above this threshold and in view of its association with further renal alteration. On the other hand, the RAR also indicates that the biochemical changes observed at these levels is also subject to a scientific debate.

In the RAR (update July 2005), it was argued that a LOAEL of 2 µg/g creatinine is too low for identifying risks for workers. However a LOAEL of 5 µg/g creatinine results in MOS between 1.7 (for pigments) and 2.5 (for Cd metal production and batteries), except for the manufacture of Cd stabilisers[16]. A MOS of 3 is needed to protect the workers (RAR, updated 2005). Using a LOAEL of 2 µg/g creatinine and taking into account in a MOS of 3 results in a safety level of 0.67 µg/g creatinine. This approach is based on a one-dimensional view that refers to Cd-U as not only the parameter for exposure, but also the parameter for effects.

These are however other important factors in developing an OEL/BLV which are not considered in the risk assessment (multi-dimensional approach):

- the healthy worker's effect;
- the exposure is during working hours only;
- workers are normally closely monitored for cadmium exposure;
- workers are not only monitored for cadmium exposure but also for cadmium effects (through well known bio-indicators of chronic effects to cadmium).

A combined approach, monitoring biological indicators for exposure (Cd-B and Cd-U) and effects (RBP, β2MG) is an option to monitor, prevent and control risks to each individual worker. The safety level of 0.67 µg Cd/g creatinine (taking into account a MOS of 3), as mentioned in the RAR (update July 2005), would probably not be necessary for workers who are monitored for exposure and effect (based on a multi-dimensional approach).

COLLECTIVE EXPOSURE REDUCTION MEASURES

An overview of possible collective measures to guarantee sufficiently limited exposure on the work premises, is based on a document from ICdA/Eurometaux (2006) on the management of the risk related to chronic occupational exposure to cadmium and its compounds.

Ventilation

A proper ventilation of the workplace can be used to remove harmful fumes and gases. Local exhaust ventilation removes the fumes and gases at their source. General ventilation uses roof vents, open doors

[16] confidential data (RAR, draft updated documents July 2005)

and windows, roof fans or floor fans to move air through the entire work area. Ventilated air has to be cleaned in order to reduce emissions to the environment.

Closed circuits

To reduce occupational exposure, certain installations or parts of installations can be placed in a closed circuit, especially intermediate packaging and storing of materials. Closed circuits enable central removal of contaminated air. Any purge from such closed circuit should be cleaned before release into the environment.

Cleaning of the workplace

A proper cleaning of floors, surfaces, superstructures and equipments should be done in a normal working situation, in order to minimize the presence of particles to a sufficient low degree (e.g. respect of an OEL -Occupational Exposure Limit - in the air of the work premises). Specific cleaning techniques can be imposed to ensure a clean workplace. Especially during intervention for preventive maintenance or in case of damage extra cleaning should be done.

Automation

Working positions or stations with excessive exposure levels should be automized as much as possible.

Control

A control of the products resulting from the purification systems and the waste can reduce the risks for the employees on the work premises as well as for the environment.

The efficiency of all measures taken should be checked by measurements of the air quality (Cd content in the air at the workplace = Cd A), and should be confirmed by the biological exposure indicators (Cd-B /Cd-U/ protein content in urine).

Measurement of the air quality can be done by sampling the aerosol particles in the air or by measurements by means of sampler worn in operator breathing zone.

Protected premises (clean)

Special measures should be taken at premises where it is possible to drink, eat or smoke to prevent exposure to contaminated air or through ingestion by eating with contaminated hands and face (obligation to wash at least hands and face or to take a full shower). Removal of contaminated clothes before entering clean premises is also a possible measure.

Individual hygiene at the workplace

A proper individual hygiene can be of major importance to reduce occupational exposure. Some of the options are to forbid drinking, oblige eating outside protected premises, discourage nail biting or other habits, oblige showering after each working day, frequently washing of working clothes, ….

TRAINING (ICdA/Eurometaux, 2006)

Whatever the collective decontamination quality may be, and even if the measurements of the air inhaled give correct results, there is still a risk of excessive absorption via other routes; this risk has to be controlled extremely well by means of precautions taken individually. All workers should be well trained on

- the good operation of the installations,
- the good application of the procedures,
- efficient cleaning of the premises,
- efficient personal hygiene,
- proper acceptance of medical supervision.

Workers can be made aware of these topics or can be trained through :

- Brochures, leaflets, videos.
- Information and discussion sessions, with transparencies.
- Many more posters, notices, pictograms,...
- Dialogue between the participants in a "progress group" spirit.
- Video recording in the industrial workshop;
- Need for well-supported and long-term action, mobilizing all levels of the hierarchy.

PERSONAL PROTECTIVE EQUIPMENT (ICDA/EUROMETAUX, 2006)

In some cases it is technically impossible to maintain exposure at all times below the occupational exposure limit (OEL) which is recognized as sufficient to ensure full protection against the inhalation risk. Such situations may be :

- either in a normal working situation in certain installations or at certain working posts (operations with a limited length of time, where collective technical measures are not appropriate),
- or during intervention or particular maintenance work (e.g. : dismantling or cleaning inside a device, demolition of furnace brickwork, intervention inside a bag filter).

In such cases, personal protection equipment (PPE) can protect workers against occupational exposure. Examples of PPE are respiratory protection devices, gloves, overalls,… Respiratory protection and other personal protective equipment are also often used as an additional protection measure by industry to further reduce exposure even when OEL are met.

HEALTH SURVEILLANCE OF WORKERS

Occupational exposure of workers to cadmium can be assessed by periodical monitoring of biological indicators for exposure (Cd-U and Cd-B) and effects (RBP, β2MG). Enforcing a strict monitoring program can assess the effectiveness of implemented risk reduction measures.

SAFETY DATA SHEETS

The available safety data sheets at industrial plants should be in line with all legal requirements.

CLASSIFICATION AND LABELLING

Products containing Cd or Cd compounds should be labelled according to the 'classification and labelling' requirements described in Directive 67/548/EEC. How Cd and Cd compounds are classified is given in chapter 3.1.1 of this report.

4.2.1.2 SUBSTITUTION

Substitution of a hazardous chemical by a less hazardous or non hazardous is in theory, the first measure to reduce a risk. The use of cadmium in several applications has already been decreased because of the marketing and use restrictions for cadmium laid down in Directive 91/338/EEC. Nevertheless further substitution can be considered as an option for certain applications. Literature describes several alternatives for cadmium, going from substitution of cadmium by zinc nickel alloys or ion vapor deposited aluminium in plating, substitution of Cd in Ag-CdO electrical contact alloys, substitution from cadmium to zinc/barium or calcium/barium stabilisers and substitution from Cd to bismuth/vanadate, Ni and Pb-based or organic pigments. The viability of these mentioned alternatives are assessed in chapter 5.1.1.8.

It must be noted that substitution is always based on hazardous and precautionary principles and is not always supported by a complete Risk Assessment Study of the substitute.

Substitution is in theory a relevant measure for scenarios where Cd containing materials are used in a production process but not for the production of the Cd containing materials themselves (e.g. Cd and CdO metal production, NiCd battery production, production of Cd-based stabilisers and pigments). Substitution for the relevant scenarios will be further discussed in the next chapter.

4.2.1.3 Ban on NiCd batteries

Substituting Cd in a NiCd battery is not an option. If Cd cannot be used, no NiCd battery can be produced and a complete alteration of the production process is necessary to produce e.g. NiMH, Li-ion batteries or other existing batteries. A ban of NiCd batteries and as a result a complete stop of production would reduce the exposure to Cd of workers in the battery industry. A ban of NiCd batteries would also require viable alternatives. The issue of a ban of NiCd batteries is being assessed in detail in the framework of the adaptation of the New Batteries Directive and is in the current status of the document (described in chapter 3.1.7.1 of the underlying report) not included. Since this Directive is in the final stage of the co-decision procedure it can be concluded that a limited ban will be decided for portable NiCd batteries in the New Batteries Directive (for more details see section 3.1.7.1). Due to the importance of this measure, it is taken forward in the assessment of further risk reduction measures (cf. chapter 5).

4.2.1.4 Sector initiatives

ICdA/Eurometaux (2006) has drawn up a document on how to manage the risks related to chronic occupational exposure to cadmium and its compounds, as a guideline for the sector. This industry initiative could contribute to a large extent to the reduction of risks related to occupational exposure.

4.2.2 Consumers

Table 4.2.2 shows an overview of the possible measures to reduce risks for consumers and the possible tools to implement those measures.

Table 4.2.2: Overview of possible measures suitable to reduce the risks assessed for consumers and the possible tools to implement them

Risk assessed	*Possible measures to reduce risk*	*Possible tools*	*Description in chapter:*
Acute respiratory effect upon use of Cd containing brazing sticks	- restrictions on use - classification and labelling; - hazard warnings and/or use instructions on packaging	Regulatory controls: - Marketing and use restrictions (76/769/EEC) - Product safety Directive (2001/95/EC): handling and use instructions	4.2.2.1 4.2.2.2
Dermal exposure when wearing Cd containing	- restrictions on use - classification and labelling	Regulatory controls: - Marketing and use restrictions (76/769/EEC)	4.2.2.3

Risk assessed	*Possible measures to reduce risk*	*Possible tools*	*Description in chapter:*
jewellery			

4.2.2.1 Marketing and use restrictions for Cd containing brazing sticks

On the consumer market brazing sticks, involving a Cd-containing filler material, are available. Using these brazing sticks, Cd-containing welding fume is produced. A ban of Cd containing brazing sticks for the consumer market would prevent consumers from being exposed to elevated Cd-concentrations, which can be inhaled. As the WEEE Directive explicitly prohibits the use of Cd in electric and electronic applications (except for some special applications) Cd brazing sticks are prone to be no longer used on the industrial market.

4.2.2.2 General Product Safety Directive: Handling and use instructions / safety prescriptions / PPE for Cd containing brazing sticks

Even though the Council Directive on general product safety (2001/95/EC) prescribes that "producers shall within the limits of their respective activities, provide consumers with the relevant information to enable them to assess the risks inherent to a product throughout the normal or reasonably foreseeable period of its use, where such risks are not immediately obvious without adequate warnings, and to take precautions against those risks". "Producers shall adopt measures commensurate with the characteristics of the products which they supply, enabling them to: (a) be informed of risks which these products might pose; (b) choose to take appropriate action including, if necessary to avoid these risks, withdrawal from the market, adequately and effectively warning consumer or recall from consumers. Measures shall include:

(a) an indication, by means of the product or its packaging, of the identity and details of the producer and the product reference or, where applicable, the batch of products to which it belongs, except where not to give such indication is justified and

(b) in all cases where appropriate, the carrying out of sample testing of marketed products, investigating and, if necessary, keeping a register of complaints and keeping distributors informed of such monitoring."

Handling and use instructions and safety prescriptions available in or on the packages of Cd-containing brazing sticks should be checked. Nevertheless, the presence of sufficient safety prescriptions does not ensure that they will be read and followed by consumers.

4.2.2.3 Marketing and use restrictions for Cd containing jewellery

The RAR concludes that dermal exposure to cadmium metal is possible when wearing (imported) silver jewellery. Cadmium has traditionally been used in jewellery solders as it confers good melt fluidity as well as lowering the melting range. It has a low melting point of 321°C, boils at 767°C and has a high vapour pressure. This means that, on melting the solder, it readily boils off and forms a vapour that reacts with air to form cadmium oxide fume.

Many jewellers now use 'cadmium-free' solders. These may require a small adjustment to the soldering technique as they will 'feel' different.

The cadmium content in jewellery is thus the result of the solders. A M&U restriction for Cd containing jewellery would prevent dermal exposure.

4.2.3 Man indirectly exposed via the environment

The decision on the prioritisation of cadmium sources which should be subject to emission reduction measures to reduce the risks for the general population is dependent on the relative contribution of the different sources of cadmium in the total cadmium exposure. To understand this relative contribution, Figure 4.2.1 and Figure 4.2.2 give an overview of the relative contribution of different Cd-sources for respectively the non-smoking and smoking general population. These figures show that for the non-smoking population the use of P-fertilisers (53%) and the fossil fuel combustion (16%) have the largest relative contribution in the total Cd exposure. The use of Cd-containing products only accounts for 0.7% of the total contribution to Cd-exposure. For the smoking population, the smoking habit itself accounts for 64% of the total exposure to Cd. Next to this source, also the use of P-fertilisers (18%) and the fossil fuel combustion (5%) have the largest relative contribution in the total Cd exposure. For the smoking population, the use of Cd-containing products only accounts for 0.2% of the total contribution to Cd-exposure.

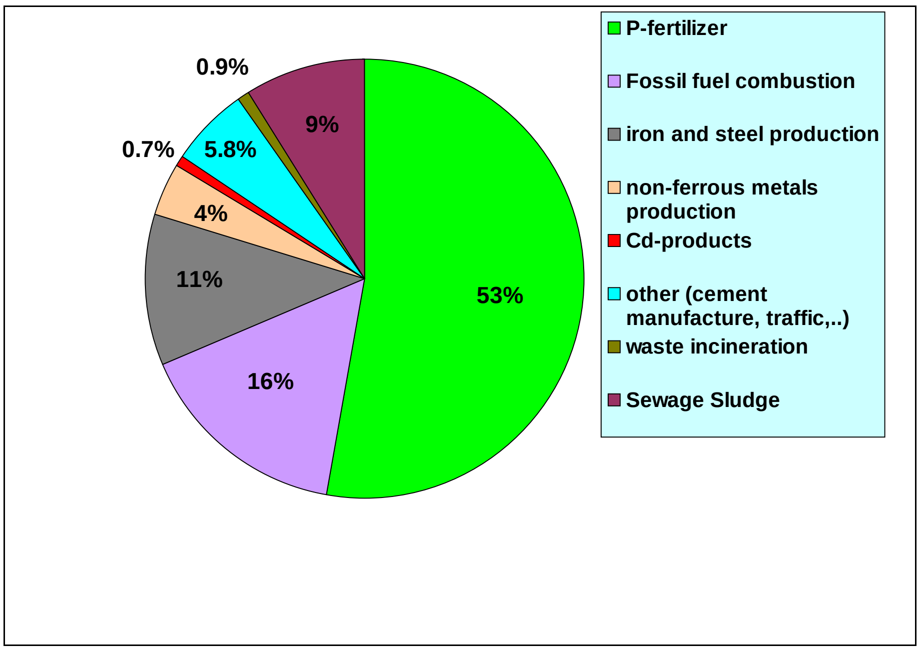


Figure 4.2.1: The relative contribution of different sources of cadmium to exposure of the non-smoking general population (update '05)

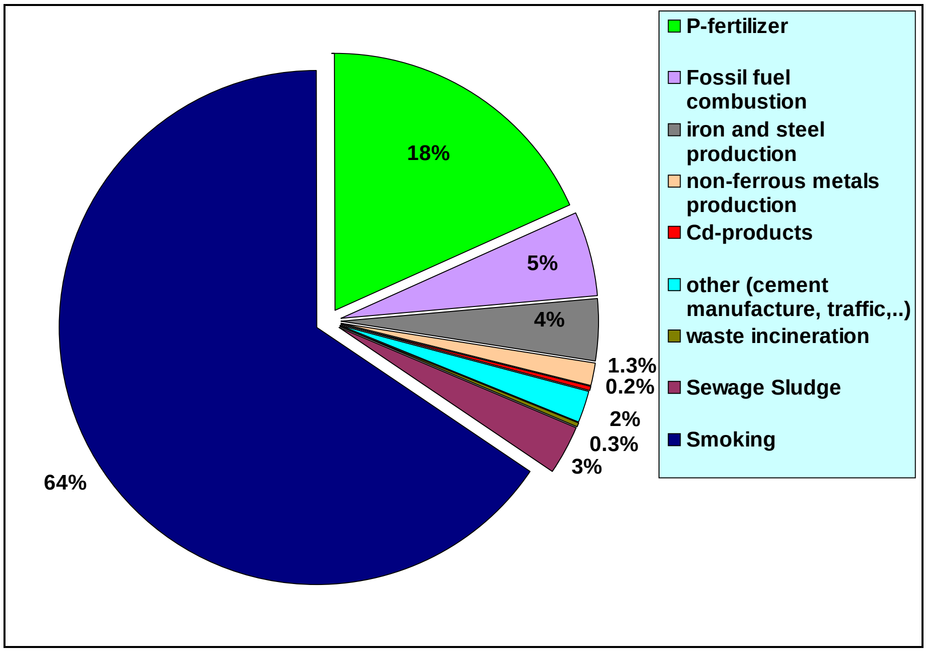


Figure 4.2.2: The relative contribution of different sources of cadmium to exposure of the smoking general population (update '05)

In order to reduce the risks for man indirectly exposed via the environment, risk reduction measures should aim at the most significant uptake routes.

Risk in the RAR (not taking into account carcinogenicity/genotoxicity) are identified especially for smokers (MOS of 1.28 - 4.88), adults with depleted iron-stores (MOS of 0.98 – 3.92) and the general population living near point sources (MOS of 0.62 - 4.5). Therefore, risk reduction measures should focus especially on these target groups.

Table 4.2.3 shows the contribution of the various uptake routes to overall cadmium uptake for various scenarios: general population with sufficient iron body stores (scenario 1), general population with depleted iron body stores (scenario 2), general population near local sources (scenario 3) and workers (scenario RRS). For all categories both smoking and non-smoking individuals have been considered. For scenarios 1-3 data from the draft RAR have been used (see Table 4.1.3.2 of the draft RAR).

It can be concluded that for non-smokers in the general population over 90% of the total Cd-uptake results from dietary uptake (drinking water + food), irregardless of the fact whether the person suffers from depleted body iron stores or not. For smokers in the general population, the main uptake route is their smoking habit but dietary uptake also delivers a significant contribution of 30 – 50%. For non-smokers living in the vicinity of point sources, main exposure route continuous to be dietary intake but inhalation exposure still accounts for some 24% of the total Cd uptake. Note that except for the manufacturing industry, where data from 2002 were used in the updated RAR (December 2005), all other emission data in the updated RAR date from 1996.

Table 4.2.3: Contribution of various exposure routes to Cd uptake for different scenarios

Exposure route	*Non-smokers*			*Smokers*		
	Uptake (µg/day)		*Contri-bution*	*Uptake (µg/day)*		*Contri-bution*
	Range	*Average*		*Range*	*Average*	
Scenario 1: General population with sufficient body iron stores						
Inhalation	0.025 – 0.075	0.050	6.98%	0.025 – 0.075	0.050	2.54%
Soil & dust	0.021	0.021	2.93%	0.021	0.021	1.07%
Drinking water	0.06	0.060	8.38%	0.06	0.060	3.05%
Dietary intake	0.21 – 0.96	0.585	81.70%	0.21 – 0.96	0.585	29.76%
Smoking	non smoker	0.000	0.00%	0.5 – 2.0	1.250	63.58%
Scenario 2: General population with depleted body iron stores						
Inhalation	0.025 - 0.075	0.050	3.62%	0.025 - 0.075	0.050	1.90%
Soil & dust	0.042	0.042	3.04%	0.042	0.042	1.60%
Drinking water	0.12	0.120	8.68%	0.12	0.120	4.56%
Dietary intake	0.42 - 1.92	1.170	84.66%	0.42 - 1.92	1.170	44.45%
Smoking	non smoker	0.000	0.00%	0.5 - 2.0	1.250	47.49%
Scenario 3: General population near point sources with sufficient body iron stores						
Inhalation	0.02 – 0.63	0.325	24.44%	0.02 – 0.63	0.325	12.50%
Soil & dust	0.21	0.210	15.79%	0.21	0.210	8.14%
Drinking water	0.06	0.060	4.51%	0.06	0.060	2.33%
Dietary intake	0.51 - 0.96	0.735	55.26%	0.51 - 0.96	0.735	28.49%
Smoking	non smoker	0.000	0.00%	0.5 - 2.0	1.250	48.45%
Scenario RRS: Workers with sufficient body iron stores						
Inhalation	?*	?*	?	?*	?*	?
Soil & dust	0.21	0.210	?	0.21	0.210	?
Drinking water	0.06	0.060	?	0.06	0.060	?
Dietary intake	0.51 - 0.96	0.735	?	0.51 - 0.96	0.735	?
Smoking	non smoker	0.000	?	0.5 - 2.0	1.250	?

* Uptake can not be calculated directly for concentration in workplace atmosphere because the effect of PPE is not known. Only total exposure of workers by all routes can be monitored through Cd levels in blood or urine.

The most relevant measures to reduce dietary uptake is to reduce Cd input into the soil and/or to reduce the bio-availability of cadmium already present in the soil[17] (either from natural origin or as a result of anthropogenic emissions). Based on the available data (Table 4.2.4) deposition (and thus indirectly all Cd emissions to air) accounts on average for 41.43% of total input to soil (range 9.66 – 67,71%), use of phosphate fertilisers on average for 32.73% (range 10.44 – 70.53%) and other sources (use of manure, sewage sludge, lime, compost) on average for 25,84% (range 0 – 68.82%). Ranges are broad because some input routes to soil were not considered by some countries. Reduction in atmospheric deposition will not only lower input to the soil but will also lower direct deposition onto fruits, vegetables and animal food.

Reduction of indirect exposure via the environment should thus aim at reduction of Cd input into the soil and at reduction of atmospheric discharges from all potential sources. The latter measure will not only lead to reduced deposition of Cd to soil but will also lower inhalation exposure in the vicinity of local sources. On the other hand, it needs to be kept in mind that an important portion of our food is not produced locally (in Europe) but is imported from other continents. Reducing Cd-input in European soils will not reduce the Cd-uptake through food proportionally.

A better land management and land occupation can also be brought forward as an efficient risk reduction measure. This because of the fact that experience shows that the threat for food production resides in historically contaminated soils.

Table 4.2.4: Input of Cd to the soil from various sources in different countries (Risk assessment documents for Cd in fertilisers)[18]

	Input into soil (g Cd/ha/year)					
	Deposition	*Phosphate fertilisers(1)*	*Livestock manure*	*Sewage sludge*	*Compost*	*Lime*
Austria	2.1	0.787(2) 0.350(3)	0.463(2) 0.823(3)	0.04	0.04	
Belgium	3.65(4) 1.50(5)	1.06 (0.59 - 1.40)	1.32 (0.74 - 2.88)			
Denmark	0.41	0.696 - 1.392	0.488	1.45		0.503
Germany	1.7	5.6	0.64			
Ireland	1.5	1.67	0.9	0.0047		
Sweden	0.65 (0.35 - 0.85)	0.26 - 0.77	0.05			
UK	1.8	2.18				
Norway	0.37(6) 0.62(7)	0.3	0.04	0.2		0.02

[17] Certain agricultural practices may lead to an increase of bio-availability of Cd, potentially leading to increased Cd-levels in crops even when total soil concentration is within the normal range for EU soils. Factors that influence Cd-uptake by plants are Cd-speciation (metal, metal oxide or salt; in the latter case the type of counter ion is also important) and soil properties (pH, presence of complexing agents, total ion strength, organic matter content (sorbent)). Most of these factors are influenced by agricultural practices. Finally, the uptake of Cd (and other metals) is also crop dependent.

[18] Available on http://europa.eu.int/comm/enterprise/chemicals/legislation/fertilizers/cadmium/reports_en.htm - Accessed on 7/11/2005

(1) Ranges given reflect crop dependency of Cd input in soil through use of phosphate fertilisers

(2) Arable land

(3) Grassland

(4) Flanders – more updated data were submitted to the Rapporteur for the updated version of the RAR

(5) Walloon

(6) Deposition measurements

(7) Moss data

Table 4.2.5 provides an overview of the possible measures to reduce risks for man indirectly exposed to the environment and possible tool to implement those measures.

Table 4.2.5: Overview of possible measures suitable to reduce the risks assessed for man indirectly exposed to the environment and possible tools to implement those

Risk assessed	*Possible measures to reduce risk*	*Possible tools*	*Description given in chapter:*
Man exposed indirectly via the environment	Reduce intake through the food chain by reducing emissions to air from all possible sources (indirect route via deposition): - end-of-pipe controls; - limit values for emission; - environmental quality standards	Regulatory controls: - Review of Large Combustion Plants Directive - Review of Waste Incineration Directive - IPPC Directive – review of BREF's for specific sectors - Chemical agents at work directive (substitution)	4.2.3.1 4.2.3.2 4.2.3.3 4.2.1.1
	Reduce direct input into soil (fertilisers. sewage sludge. compost. …)	Regulatory controls: - Review of fertilizer Directive -Review of Directive on use of sewage sludge in agriculture - Review of the organic farming regulation - EU soil strategy Economic instruments: - levy on Cd-content in fertilisers, sewage sludge, compost	4.2.3.5 4.2.3.7 4.2.3.11 4.2.3.12 4.2.3.6, 4.2.3.8 and 4.2.3.10
Man exposed indirectly via the environment near point sources	Reduce direct emissions to air of facilities under consideration: - end-of-pipe controls; - limit values for emission; - environmental quality standards	Regulatory controls: - Review of Large Combustion Plants Directive - Review of Waste Incineration Directive - IPPC Directive – review of BREF's for specific sectors - Chemical agents at work directive (substitution)	4.2.3.1 4.2.3.2 4.2.3.3 4.2.1.1
	Reduce direct emissions to air of facilities under consideration (indirect route via deposition) : - end-of-pipe controls; - limit values for emission; - environmental quality standards	Regulatory controls: - Review of Large Combustion Plants Directive - Review of Waste Incineration Directive - IPPC Directive – review of BREF's for specific sectors - Chemical agents at work directive (substitution)	4.2.3.1 4.2.3.2 4.2.3.3 4.2.1.1
	Reduce emissions to air from all possible sources (indirect route via deposition) : - end-of-pipe controls; - limit values for emission; - environmental quality standards	Regulatory controls: - Review of Large Combustion Plants Directive - Review of Waste Incineration Directive - IPPC Directive – review of BREF's for specific sectors - Chemical agents at work directive (substitution)	4.2.3.1 4.2.3.2 4.2.3.3 4.2.1.1

	Reduce direct input into soil (fertilisers. sewage sludge. compost. …)	Regulatory controls: - Review of fertilizer Directive - Review of Directive on use of sewage sludge in agriculture - Review of the organic farming regulation - EU soil strategy Economic instruments - levy on Cd-content in fertilisers, sewage sludge, compost	 4.2.3.5 4.2.3.7 4.2.3.11 4.2.3.12 4.2.3.6, 4.2.3.8 and 4.2.3.10

4.2.3.1 Review of Large combustion plants Directive (2001/80/EC)

According to the RAR (December 2005), oil and coal combustion were responsible for 43% of the total emission of Cd to air in the EU in 1996. According to EPER data, combustion installations >50 MW and mineral oil and gas refineries (mainly combustion emissions) were responsible for 20,5% of the reported Cd emissions to air in 2001.

The large combustion plants Directive (2001/80/EC) currently does not specify emission limit values for Cd to air for solid and liquid fuelled combustion plants. Setting emission limit values for Cd specifically will reduce the overall input of Cd into the air and will lead to lower deposition of Cd on the soil.

The effects of the full implementation of the current requirements of the LCP Directive on Cd discharge to the air (through stringent limit values for dust) have not been assessed so far.

4.2.3.2 Review of Waste incineration Directive (2000/76/EC)

According to the RAR (December 2005), municipal waste incineration was responsible for 2,6% of the total emission of Cd to air in the EU in 1996. According to EPER data, waste treatment is responsible for 3,9% of the reported Cd emissions to air and for 5,2% of the reported Cd emissions to water.

A review of the emission limit values for Cd to air and for Cd in the waste water from cleaning of exhaust gasses in the waste incineration directive might reduce the overall input of Cd in the air and surface water and will lead to lower deposition of Cd on the soil.

4.2.3.3 Review of the BREF documents with specific attention to Cd

The BREF documents list a selection of Best Available Techniques (BAT) for different industrial sectors to reduce emissions of relevant substances to the environment. The documents want to provide reference information for the permitting authority to take into account when determining permit conditions. Following BREF documents can be of importance for reducing Cd emissions to the environment:

- Non ferrous metals;
- Iron and steel;
- Large combustion plants;
- Waste incineration;
- Cement;
- Refineries;
- Surface treatment (electroplating).

Table 4.2.6 gives an overview of the share of previously mentioned sectors in total cadmium emissions to air and water according to the RAR (2005) and EPER.

A revision of these BREF documents can possibly lead to new/additional risk reduction techniques, reducing the emissions to air, water, soil from industrial plants influencing also the overall Cd concentrations in air, water and soil on the local scale.

Table 4.2.6: Share of different industrial sectors in total anthropogenic emissions to air and water

Sector	*Share in total emissions according to the RAR (2005) (%)*		*Share in total emissions according to EPER (%)*	
	Air	*Water*	*Air*	*Water*
Non ferrous metals	10.8	27.8	58.5 [c]	65.8 [c]
Iron and steel	24.7	39.8		
Large combustion plants	43.0	0.03	14.0	5.2
Waste incineration	2.6 [a]	0.01 [a]	3.9 [d]	4.4 [d]
Cement	15.1 [b]	0.03 [b]	12.0 [e]	2.0 [e]
Refineries	NA	NA	6.0	1.4
Surface treatment (electroplating)	NA	NA	0.06 [f]	0.3 [f]

NA: Not available

[a] municipal incineration

[b] total share for ‘other sectors, including cement, glass production, traffic, …)

[c] total share for metal industry and metal ore roasting or sintering installations, installations for the production of ferrous and non-ferrous metals

[d] installations for the disposal or recovery of hazardous waste (>10 t/d) or municipal waste (>3t/h), installations fro the disposal of nonhazardous waste (>50t/d) and landfills (>10t/d)

[e] installations for the production of cement klinker (>500t/d), lime (>50t/d), glass (>20t/d), mineral substances (>20t/d) or ceramic products (>75t/d)

[f] installations for surface treatment or products using organic solvents (>200t/y)

4.2.3.4 Substitution / Ban on NiCd-batteries

The possibility to substitute cadmium in some applications was already tackled in 4.2.1.2.

For the general population however, exposure to cadmium from the use of Cd-containing products (including NiCd batteries), only contributes for 0.7% and 0.2% of total exposure for non-smokers and smokers respectively. Substitution would therefore not be an effective option to reduce cadmium exposure of the general population. This option will therefore not be further assessed in this report.

One has to take also into account that the risks assessed are mostly based on the highest emissions/ concentrations measured at all Cd producing and consuming companies, including NiCd recycling and producing companies. Very often, emissions/concentrations measured at the latter are substantially lower than the maximum values, rendering a number of the risks assessed not valid for those plants:

- For Scenario 3 (general population near point sources) an ambient air concentration of 1 µg/m³ has been used in the uptake scenario. First of all, the three plants that had emissions leading to calculated ambient air concentrations of 1 µg/m³ have since been closed. Secondly, worst case ambient air concentrations in the vicinity of battery production and recycling plants and waste management plants are in the range 22 – 28 ng/m³, leading to an inhalation uptake of 0,11 – 0,15 µg/day, which is low compared to dietary intake.
- Based on the same arguments as above, lung repeated dose toxicity is not an issue in the vicinity of NiCd producing and recycling plants.

- Risks to kidney and bone have also been assessed in Scenario 3, based on a calculated MOS in the range 0.62 – 4.5; while a MOS of 3 has been regarded as safe. Based on exposure in the vicinity of battery production and recycling plants and waste management plants only, the calculated MOS increases to 2.9 – 4.5 and only at one plant the MOS is below the save level of 3.

The question can also be raised in how far the risks assessed in Scenario 3 are not better tackled by actions at the local level (more stringent emission limit values in the environmental permit) than by amending existing legislation or setting up new legislation at the EU level. This does not only hold for battery recycling and production plants but for all local sources of Cd, as the number of local sources in the EU is rather limited.

4.2.3.5 Regulation (EC) No 2003/2003 on Cd content of mineral fertilisers

Regulation 2003/003 does not set any limit on the Cd content of mineral fertilisers, although an intention of the Commission to address the issue of unintentional Cd content in mineral fertilisers is announced in the Regulation . An EU wide standard for the maximum allowable cadmium concentration in fertilisers could be proposed. Another option is to limit the yearly amount of cadmium input on agricultural land, and/or inhibit the use of Cd containing fertilisers when a certain limit value for Cd concentration in agricultural soils is reached. The cadmium content in fertilisers can be reduced by using phosphate rock with a lower cadmium content to produce fertilisers or by cadmium removal in the fertiliser production process.

4.2.3.6 Introducing a levy on cadmium content in phosphate fertilisers

To improve the competitive position of a more expensive 'low-Cd' product versus the 'high-Cd' one, an EU-wide charge on cadmium in fertilisers can be introduced. Designing a charge on Cd in P fertilisers implies a number of choices concerning issues such as the charge base and rate, the earmarking of revenues, degree of harmonisation and various implementation issues.

4.2.3.7 Review of Directive 86/278/EEC on use of sewage sludge on agricultural land

Reviewing the limit values for concentrations of heavy metals in the soil, in sludge and for the maximum annual quantities of heavy metals which may be introduced into the soil, laid down in Directive 82/278/EEC can reduce the cadmium input into the soil. An even more stringent measure would be to ban all use of sewage sludge on agricultural soil.

4.2.3.8 Introducing a levy on cadmium content in sewage sludge used on agricultural land

This measure could promote the use of low-Cd sewage sludge or even discourage the use of sewage sludge on agricultural land.

4.2.3.9 Ban on the use of sewage sludge on agricultural soil

A ban on the use of sewage sludge on agricultural land can be introduced in different ways: either a total ban or a ban on sewage sludge exceeding a certain limit value for cadmium concentrations could be introduced.

4.2.3.10 Introducing a levy on cadmium content in compost

This measure could promote the use of low-Cd compost or even discourage the use of compost on agricultural land.

4.2.3.11 Review of the organic farming regulation

Lowering the limit value for the Cd-content in composted or fermented household waste could reduce the Cd input into soil.

4.2.3.12 Review of the EU soil strategy

Since the Commission services are currently finalising a proposal for the Thematic Strategy on Soil Protection, specific measures, reducing the Cd-input into the soil could be considered.

4.3 POSSIBLE FURTHER RISK REDUCTION MEASURES FOR THE ENVIRONMENT

Certain measures are suitable to reduce risks for more than one scenario where risk has been assessed, both for the environment and for human health. To keep a complete picture of possible measures for each particular scenario (surface water, air, soil) an overview table will be given at the beginning of each scenario. To avoid repetition however, only those tools to implement measures, not described in a earlier scenario, will be described in detail. For all other tools, reference is made in the accompanying table.

4.3.1 Surface water/sediment

Table 4.3.1 shows an overview of the possible measures to reduce risks for surface water and sediment and possible tools to implement those measures. For each tool, also reference is made to the chapter in this document, where this tool is described.

Table 4.3.1: Overview of possible measures to reduce risks for surface water and sediment and possible tools to implement those measures.

Risk assessed	*Possible measures to reduce risk*	*Possible tools*	*Description given in chapter:*
Local surface water/sediment	Reduce direct discharge to surface water of facilities under consideration: - end-of-pipe controls; - limit values for emission; - environmental quality standards	Regulatory controls: - Art. 16 of the Water Framework Directive - IPPC Directive – review of BREF's for specific sectors - Chemical agents at work directive (substitution)	4.3.1.1 4.2.3.3 4.2.1.1
	Reduce emissions to air of facilities under consideration (indirect route via deposition): - end-of-pipe controls; - limit values for emission; - environmental quality standards	Regulatory controls: - Review of Large Combustion Plants Directive - Review of Waste Incineration Directive - IPPC Directive – review of BREF's for specific sectors - Chemical agents at work directive (substitution)	4.2.3.1 4.2.3.2 4.2.3.3 4.2.1.1
	Reduce direct discharge to	Regulatory controls:	

	surface water from all sources (reduction of $PEC_{regional}$ and $PEC_{continental}$): - end-of-pipe controls; - limit values for emission; - environmental quality standards	- Art. 16 of the Water Framework Directive - IPPC Directive – review of BREF's for specific sectors - Review of landfill Directive - Review of urban wastewater treatment Directive - Chemical agents at work directive (substitution)	4.3.1.1 4.2.3.3 4.2.1.1
	Reduce emissions to air from all possible sources (indirect route via deposition): - end-of-pipe controls; - limit values for emission; - environmental quality standards	Regulatory controls: - Review of Large Combustion Plants Directive - Review of Waste Incineration Directive - IPPC Directive – review of BREF's for specific sectors - Chemical agents at work directive (substitution)	4.2.3.1 4.2.3.2 4.2.3.3 4.2.1.1
Regional surface water/sediment	Reduce direct discharge to surface water from all sources (reduction of $PEC_{regional}$ and $PEC_{continental}$): - end-of-pipe controls; - limit values for emission; - environmental quality standards	Regulatory controls: - Art. 16 of the Water Framework Directive - IPPC Directive – review of BREF's for specific sectors - Review of landfill Directive - Review of urban wastewater treatment Directive - Chemical agents at work directive (substitution)	4.3.1.1 4.2.3.3 4.3.1.2 4.3.1.3 4.2.1.1
	Reduce emissions to air from all possible sources (indirect route via deposition): - end-of-pipe controls; - limit values for emission; - environmental quality standards	Regulatory controls: - Review of Large Combustion Plants Directive - Review of Waste Incineration Directive - IPPC Directive – review of BREF's for specific sectors - Chemical agents at work directive (substitution)	4.2.3.1 4.2.3.2 4.2.3.3 4.2.1.1

4.3.1.1 Water Framework Directive (2000/60/EC)

As already indicated in chapter 3.1.6.6, cadmium has been identified as a priority hazardous substance (PHS) under Article 16 of the Water Framework Directive. The ultimate aim of this Directive is to achieve cessation of emissions, discharges and losses of priority hazardous substances and contribute to achieving concentrations in the aqueous and marine environment near background values for naturally occurring substances. Pollution through the discharge, emission or loss of priority hazardous substances must cease or be phased out. The European Parliament and the Council should agree on specific measures to be taken against pollution of water by those substances, taking into account all significant sources and identifying the cost-effective and proportionate level and combination of controls.

Since cadmium is identified as a PHS, the implementation of the WFD shall in theory result in a cessation of all emissions or losses into the water. The environmental objectives ('good quality status'), set out in the WFD, should be met by 2015. This means that, if all Member States meet these objectives, no extra measures need to be taken to reduce Cd emissions to the water compartment. If emissions to water no longer occur, the identified risks to surface water from cadmium emissions will be eliminated in the future.

4.3.1.2 Landfill Directive

Decision 2003/33/EC, establishing the criteria and procedures for the acceptance of waste at landfills in accordance with the principles set out in Directive 1999/31/EC lays down limit values for cadmium in landfill leachate, as well as in the waste itself. Cadmium emissions from landfills could be reduced by lowering the limit values for cadmium in the accepted waste and in the landfill leachate. The current leaching limit values are given in Table 4.3.1.

A revision of these limit values could reduce Cd emissions to surface water from leaching of landfills.

Tabel 4.3.1: Leaching limit values set for cadmium in Decision 2003/33/EC on landfilling of waste

	mg Cd/kg dry substance		*mg Cd/l*
	L/S= 2 l/kg	*L/S= 10 l/kg*	*C (percolate test)*
Inert waste	0.03	0.04	0.02
Non-hazardous waste	0.6	1	0.3
Hazardous waste	3	5	1.7

4.3.1.3 Review of urban wastewater treatment Directive

This Directive concerns the collection, treatment and discharge of urban waste water and the treatment and discharge of waste water from certain industrial sectors. Its aim is to protect the environment from any adverse effects due to discharge of such waters. The Directive establishes a time-table, which Member States must adhere to, for the provision of collecting and treatment systems for urban waste water in agglomerations which meet the criteria laid down in the Directive. The Directive lays down specific requirements for discharges of biodegradable industrial waste water from certain industrial sectors not entering urban waste water treatment plants before discharge to receiving waters.

Any wastewater treatment plant, being primary, secondary or tertiary, will result in a decrease of Cd concentration in the treated wastewater, the level of decrease being dependent on the level of treatment (tertiary > secondary > primary). Moreover, the Directive also requires pre-treatment of industrial discharges to an urban wastewater treatment plant. This pre-treatment will lead to a lowering of the Cd content in the influent to the UWWTP.

4.3.2 Terrestrial

Table 4.3.2 shows an overview of the possible measures to reduce risks for the terrestrial compartment and possible tools to implement those measures.

Table 4.3.2: Overview of possible measures to reduce risks for the terrestrial compartment and possible tools to implement those measures.

Risk assessed	*Possible measures to reduce risk*	*Possible tools*	*Description given in chapter*
Local terrestrial	Reduce direct emissions to air of facilities under consideration (indirect route via deposition) : - end-of-pipe controls; - limit values for emission; - environmental quality	Regulatory controls: - Review of Large Combustion Plants Directive - Review of Waste Incineration Directive - IPPC Directive – review of BREF's for specific sectors - Chemical agents at work directive	4.2.3.1 4.2.3.2 4.2.3.3

	standards	(substitution)	4.2.1.1
	Reduce emissions to air from all possible sources (indirect route via deposition) : - end-of-pipe controls; - limit values for emission; - environmental quality standards	Regulatory controls: - Review of Large Combustion Plants Directive - Review of Waste Incineration Directive - IPPC Directive – review of BREF's for specific sectors - Chemical agents at work directive (substitution)	4.2.3.1 4.2.3.2 4.2.3.3 4.2.1.1
Regional terrestrial	Reduce emissions to air from all possible sources (indirect route via deposition) : - end-of-pipe controls; - limit values for emission; - environmental quality standards	Regulatory controls: - Review of Large Combustion Plants Directive - Review of Waste Incineration Directive - IPPC Directive – review of BREF's for specific sectors - Chemical agents at work directive (substitution)	4.2.3.1 4.2.3.2 4.2.3.3 4.2.1.1

4.3.3 Secondary poisoning

Table 4.3.3 shows an overview of the possible measures to reduce risks for secondary poisoning and possible tools to implement those measures.

Table 4.3.3: Overview of possible measures to reduce risks for secondary poisoning and possible tools to implement those measures.

Risk assessed	*Possible measures to reduce risk*	*Possible tools*	*Description given in chapter*
Local secondary poisoning	Reduce direct emissions to water of facilities under consideration: - end-of-pipe controls; - limit values for emission; - environmental quality standards	Regulatory controls: - Review of Large Combustion Plants Directive - Review of Waste Incineration Directive - IPPC Directive – review of BREF's for specific sectors - Chemical agents at work directive (substitution)	4.2.3.1 4.2.3.2 4.2.3.3 4.2.1.1
	Reduce direct emissions to air of facilities under consideration (indirect route via deposition) : - end-of-pipe controls; - limit values for emission; - environmental quality standards	Regulatory controls: - Review of Large Combustion Plants Directive - Review of Waste Incineration Directive - IPPC Directive – review of BREF's for specific sectors - Chemical agents at work directive (substitution)	4.2.3.1 4.2.3.2 4.2.3.3 4.2.1.1
	Reduce direct discharge to surface water from all sources (reduction of $PEC_{regional}$ and $PEC_{continental}$) : - end-of-pipe controls; - limit values for emission; - environmental quality standards	Regulatory controls: - Art. 16 of the Water Framework Directive - IPPC Directive – review of BREF's for specific sectors - Review of landfill Directive - Review of urban wastewater treatment Directive	4.3.1.1 4.2.3.3 4.3.1.2 4.3.1.3

		- Chemical agents at work directive (substitution)	4.2.1.1
	Reduce emissions to air from all possible sources (indirect route via deposition) : - end-of-pipe controls; - limit values for emission; - environmental quality standards	Regulatory controls: - Review of Large Combustion Plants Directive - Review of Waste Incineration Directive - IPPC Directive – review of BREF's for specific sectors - Chemical agents at work directive (substitution)	 4.2.3.1 4.2.3.2 4.2.3.3 4.2.1.1
Regional secondary poisoning	Reduce direct discharge to surface water from all sources (reduction of $PEC_{regional}$ and $PEC_{continental}$) : - end-of-pipe controls; - limit values for emission; - environmental quality standards	Regulatory controls: - Art. 16 of the Water Framework Directive - IPPC Directive – review of BREF's for specific sectors - Review of landfill Directive - Review of urban wastewater treatment Directive - Chemical agents at work directive (substitution)	 4.3.1.1 4.2.3.3 4.3.1.2 4.3.1.3 4.2.1.1
	Reduce emissions to air from all possible sources (indirect route via deposition) : - end-of-pipe controls; - limit values for emission; - environmental quality standards	Regulatory controls: - Review of Large Combustion Plants Directive - Review of Waste Incineration Directive - IPPC Directive – review of BREF's for specific sectors - Chemical agents at work directive (substitution)	 4.2.3.1 4.2.3.2 4.2.3.3 4.2.1.1

4.3.4 Wastewater treatment plants

Table 4.3.4 shows an overview of the possible measures to reduce risks for wastewater treatment plants and possible tools to implement those measures.

Table 4.3.4: Overview of possible measures to reduce risks for wastewater treatment plants and possible tools to implement those measures.

Risk assessed	*Possible measures to reduce risk*	*Possible tools*	*Description given in chapter*
Wastewater treatment plants (Cd pigments. plating and alloying industry)	Reduce direct discharge to surface water of facilities under consideration: - end-of-pipe controls; - limit values for emission; - environmental quality standards	Regulatory controls: - Art. 16 of the Water Framework Directive - IPPC Directive – review of BREF's for specific sectors	 4.3.1.1 4.2.3.3

4.3.5 Batteries

Possible measures for the risk reduction relevant to batteries has its effect on different scenario's and is therefore described here in a separate section. It was already indicated that risks may occur in the production phase due to occupational exposure and that risks to consumers and the general population (in the use phase) are negligible. Risks to the environment and to man indirectly exposed via the environment may occur in the waste management phase (incineration or landfilling). The assessment of possible futher risk reduction measures is performed in section 5.4 of this report.

5 ASSESSMENT OF POSSIBLE FURTHER RISK REDUCTION MEASURES.

In consultation with the Directorate-General for Environment Risk Management of the Federal Public Service of Public Health, Food-Chain Security and Environment and the industry (ICdA), some further possible risk reduction measure were selected to be submitted to an assessment on the basis of the criteria recommended in the TGD (EC, 1998): effectiveness, practicability, economic impact, and monitorability.

Effectiveness: The measure (or measures) must be targeted at those significant hazardous effects and routes of exposure where risks that need to be limited have been identified by the risk assessment and must be capable of reducing the risks that need to be limited within and over a reasonable period of time,

Practicality: The measure (or measures) should be implementable, enforceable and as simple as possible to manage (such that smaller enterprises are able to comply). Priority should therefore be given to consideration of commonly used measures that could be properly carried out within existing infrastructure (though not to the exclusion of novel measures);

Economic impact: The task force can make a rough qualitative estimate of the impact of the measure on producers, processors, users and other parties on the basis of experience and judgement. However, regarding restrictions on marketing and use, the task force should provide a more detailed analysis of the advantages and drawbacks of the measures;

Monitorability: Monitoring possibilities should be available to allow the success of the risk reduction to be assessed

5.1 ASSESSMENT OF POSSIBLE FURTHER RISK REDUCTION MEASURES FOR OCCUPATIONAL EXPOSURE

Since for the smoking population, 64% of the Cd-exposure is related to their smoking habit, for this part of the population, a "stop smoking campaign" would be most effective to reduce Cd-exposure. The development of this route is however not a subject of this risk assessment study, but must be kept in mind, looking at other measures.

Following measures were taken forward to be subjected to a further assessment:

- OEL and BLV;
- Collective exposure reduction measures;
- Training/safety data sheets;
- Personal protective equipment;
- Health surveillance of workers;
- Substitution
- Sector initiatives;

5.1.1 Chemical agents at work Directive (98/24/EC)

Under de "Chemicals agents at work Directive" it is possible for the European Commission to set indicative or binding Occupational Exposure Limits (OEL). If so, according to the Directive, normalised methods should be drawn up to measure and evaluate air concentrations at the workplace. The Commission can also impose Biological Limit values (BLV) on Community level. In that case, according to the Directive, a health surveillance of the workers to evaluate whether the limit values are exceeded, is obligatory. Two scenario's will be evaluated:

- Imposing a community wide OEL for cadmium, accompanied by air concentration measurements;
- Imposing a community wide OEL and BLV for cadmium, accompanied by air concentration measurements and Cd-B and Cd-U surveillance.

In general, the Directive imposes that "the employer shall ensure that the risk from a hazardous chemical agent to the safety and health of workers at work is eliminated or reduced to a minimum". Therefore the employer can take following measurements:

- the substitution of the hazardous chemical agent in the production process;
- design of appropriate work processes and engineering controls and use of adequate equipment and materials, application of collective protection measures
- application of individual protection measures including personal protective equipment.

The employer shall also ensure that workers and/or their representatives are provided with:

- information on the hazardous chemical agents occurring in the workplace, such as the identity of those agents, the risks to safety and health, relevant occupational exposure limit values and other legislative provisions;
- training and information on appropriate precautions and actions to be taken in order to safeguard themselves and other workers at the workplace,
- access to any safety data sheet provided by the supplier

All mentioned measures will be explained in detail below.

5.1.1.1 Occupational exposure limit values (OEL)

The OEL's imposed for cadmium metal by different Member States range from:

- 5 – 10 µg/m³ (8-hr TWA) for the inhalable fraction
- 2 – 15 µg/m³ (8-hr TWA) for the respirable fraction
- 20 - 50 µg/m³ (8-hr TWA) (fraction unspecified)
- 50 µg/m³ (15-min STEL) - UK

The OEL's imposed for cadmium oxide by different Member States are:

- 10 µg/m³ (8-hr TWA) – Finland
- 50 µg/m³ (15-min STEL) – France and UK

It is unclear whether all Member States impose OEL's for cadmium metal/cadmium oxide.

Different Member States have imposed OEL's for Cd metal and CdO. An OEL of 50 µg/m³ for short term exposure (Cd metal and CdO) has been imposed by the UK and France. For time-weighted average exposure for Cd metal, OEL's range between 5-50 µg/m³. For CdO, only for Finland a time-weighted average exposure OEL of 10 µg/m³ is given. According to the risk assessment, taking into account a MOS of 10, these OEL's do not offer sufficient protection against acute toxicity (LOAEL (as Cd) = 437.5 µg/m³), repeated toxicity (NOAEL (as Cd) = 10 µg/m³) and reprotoxicity (NOAEL (as Cd) = 100 µg/m³).

EFFECTIVENESS

The setting of Community wide OEL would lead to a harmonised level of control in the workplace. Taking into account that the risk characterisation in the RAR (2005) is based upon a MOS of 10, in order to guarantee protection against acute toxicity, repeated toxicity and reprotoxicity, the Community wide OEL would have to be set at a lower level than the current most stringent Member States OEL's.

Some disadvantages of OEL's can be given:

- OEL's only influence exposure through inhalation and will never guarantee full protection against health risks. Although inhalation is the most important exposure route for workers, additional uptake can also occur as a consequence of contamination of food and tobacco (mainly workers who eat or smoke at the workplace).
- OEL's cannot be interpreted as "safe" concentrations for all workers. OEL's are not levels above which harm will definitely arise and they are certainly not levels which are definitely safe i.e. below which harm will not arise. A rough rule of thumb is that they are levels below which most of the working population could be exposed on a regular basis with a low risk to health (but risk might still be there and could result in severe effects) (COEH, 2005).
- OEL values refer to the majority rather than to all the workers because, due to the enormous differences that exist between individual responses, based as much on genetic factors as on living habits, a small percentage of workers may suffer effects at lower concentrations than the OEL and may even be very seriously affected, whether through the worsening of a previous condition or by developing an occupational pathology (INSHT, 2005).

Setting an OEL for workplaces will enhance that air concentration levels are kept below a limit value and will therefore prevent long-term exposure to high concentrations.

An Eurométaux document (2006) on management of the risk related to chronic occupational exposure to cadmium and its compounds also highlights the disadvantage of implementation of OEL's without combining with other risk reduction measures. In practice, when exposed to pulverulent materials (dusts and fumes) containing cadmium compounds, the cadmium concentration in air can rarely be related to internal impregnation levels, for at least two reasons :

- According to the nature of the work and individual behaviour, the ratio between exposure through inhalation and exposure through ingestion varies on a very large scale. For this reason, checking the cadmium contents in the air of the work premises cannot be a sufficient preventive measure.
- According to the chemical nature and the physical characteristics (particularly the size) of the inhaled or ingested particles, the assimilation rates can be considerably different.

In a study of workplaces with high total air Cd-concentrations, it was noticed that generally less than 25% of the total Cd in air was in the respirable range and that this value decreased as the total concentration increased (Lauwerys et al, 1974). Cd-containing dust particles that are too large to get into the lungs can enter the gastrointestinal tract by mucociliary transfer. Different Cd-related processes result in exposure to different chemical forms of Cd: in thermal processes Cd-fumes, quickly transformed into CdO, are predominant; in other industrial processes, CdS, $CdSO_4$, etc. are involved. These various Cd-species have quite different solubilities that will strongly influence their uptake and absorption by the human body. These factors are not taken into account in usual workplace air sampling.

Moreover, if in the past a correlation did actually exist between exposure through inhalation and Cd-air content, industrial experience shows that this relationship is no longer evident at the present, with much lower Cd levels in air at the workplace. Under present-day conditions, other Cd transfer pathways have become relevant for the workers' exposure, depending very much on workers' individual hygiene and habits.

It can be concluded that setting an OEL as an isolated measure to reduce risks is not effective and a combination of measures needs to be considered. Although it must be noted that the "Chemical Agents at work Directive" already indicates that other measures like, personal protection of workers, distribution of information, … need to be taken by the employers to protect there workers from health and safety risks.

PRACTICALITY

The setting of more stringent Community wide OEL's is in practice feasible because collective reduction techniques can be implemented in theory at the Cd/CdO producing and using companies.

Over the years, a lot of effort has been done to reduce Cd exposure levels in the workplace for some scenario's (RAR, update 2005). Table 5.1.1 and Table 5.1.2 give an overview of typical Cd exposure level values and the typical biomonitoring data, used in the RAR (2005), which are data from 1994-1996 and typical values in the update RAR (2005), which are data from 2002. Also the evolution of measurements of Cd-concentrations in the air (Cd-A), in blood (Cd-B) and in urine (Cd-U) of workers of a battery company (see Figure 3.6.3 and Figure 3.6.4) illustrate this effort.

For the setting of a Community wide OEL and/or BLV, the data in Table 5.1.1 and Table 5.1.2 should be kept in mind. These show that one OEL and/or BLV for all scenario's does not seem feasible due to the wide range of exposure levels found for different scenario's.

To develop OEL's one needs to go through a specific procedure. The key stages leading to the establishment of OEL's are the (European Commission, 2005):

- establishment by DG Employment of a list of priority substances for which OEL's should be developed;
- submission of the priority list to the Scientific Committee on Occupational Exposure Limits (SCOEL) (see Committees section for information on SCOEL);
- evaluation by SCOEL of the published scientific data on the toxicology of the chemical;
- preparation by SCOEL of a draft recommendation summary document (SCOEL/SUM);
- six month consultation period during which the contact points may provide comments on the SCOEL/SUM document;
- consideration by SCOEL of comments and new data followed by amendment, if necessary, of the recommendation;
- publication by the Commission of the final recommendation of SCOEL;
- development by the Commission of a proposal for a directive based on the SCOEL recommendation;
- consultation of the Advisory Committee on Safety and Health at Work on the Commission's proposal; and
- adoption of the Commission's final proposal either through the adaptation to technical progress procedure (IOELVs) or by the Council and European Parliament route (BOELVs).

Table 5.1.1: Reduction in typical Cd exposure levels for different scenarios from 1994-1996 (RAR, 2005) to 2002 (RAR update, 2005)

Scenario	*Inhalation exposure (Cd-air (µg Cd/m³))*	
	1994-1996 (RAR, 2005)	*2002 (RAR update, 2005)*
1. Production of CdO	15	nu

Scenario	*Inhalation exposure (Cd-air (µg Cd/m³))*	
	1994-1996 (RAR, 2005)	*2002 (RAR update, 2005)*
2. Production of Cd metal	12	9
3. Production and recycling of Ni-Cd batteries: - manufacture - recycling	 50 35	 13 1.2 (1)
4. Production of Cd alloys	50 (2)	nu
5. Cd pigments production	22	10
6. Cd plating	5	nu
7. Manufacture of Cd stabilisers	2 (2)	C
8. Brazing, soldering and welding	280 (2)	nu
9. Other uses	2 (2)	nu

(1) update only for one company and not judged representative for the whole sector/scenario

(2) Reasonable worst case is given here in absence of a typical value

C: confidential data (p.m. to check with individual companies if more precise values can be reported)

nu: no update

ECONOMIC IMPACT

Taking additional central engineering measures to lower the concentration in the workplace atmosphere might incur significant investment and operating costs for the industry. Monitoring costs can become significant in case of more stringent OEL since more specialized equipment is needed. It must be noted that, the lower the limits, the more sophisticated the measurement methods need to be.

MONITORING

Regular measurements of the concentration of Cd/CdO in the workplace will have to be organised in all companies. The monitoring at very low levels requires specialized equipment and trained staff, which is not always available at all companies (especially not the SME's). This includes that, due to the need for sophisticated measurement methods, monitoring results will be available after a high exposure has occurred and immediate intervention is not possible. Nevertheless monitoring of air concentration levels can contribute to an overall monitoring of workplace levels and can prevent a long-time exposure to high concentrations.

Simpler, more cost-effective monitoring methods would facilitate monitoring for all companies.

5.1.1.2 Combining Occupational Exposure Limits (OEL) with Biological limit values (BLV)

This measure refers to setting BLV's for Cd-U (Cd-concentrations in urine) and Cd-B (Cd-concentrations in blood). Only a few Member States also imposed occupational biological limit values (BLV) for Cd. The BLV's set for concentrations in blood range from 5.6 to 15 µg/l (Finland and Germany respectively). Limits set for Cd-concentrations in urine range from 4 to 10 µg/g creatinine (The Netherlands and France respectively) and from 5.6 to 15 µg/l (Finland and Germany respectively).

EFFECTIVENESS

Additional biological monitoring of exposure offers several advantages over environmental monitoring (e.g. air quality monitoring) to evaluate internal dose and hence to estimate overall integrated health risk (RAR, 2005):

- A biological parameter of exposure is more directly related to the adverse health effects that one attempts to prevent than any environmental measurement.
- Biological monitoring takes into consideration all exposure routes (lung, skin, gastrointestinal tract) and not only the inhalation route (cf. OEL)
- Biological monitoring can be used to test the efficiency of various reduction measures
- Also non-occupational background exposure is expressed at a biological level as the organism integrates this total external exposure into one internal load.

As indicated, two types of BLV's can be set: Cd-B and Cd-U. Cadmium in blood may be considered as a biomarker for recent exposure, while cadmium in urine (a biomarker of the body burden) allows to integrate the long-term exposure. In the absence of renal damage, Cd-concentration in urine usually reflects the amount of cadmium stored in the body.

A disadvantage of setting BLV's as Cd-B and Cd-U is that these are biomarkers of exposure and do not reflect directly possible effects on human health (e.g. kidney dysfunction). Biomarkers of effects caused by cadmium include measurements of β_2-microglobulin (β_2-M), N-acetyl-β-D-glucosaminidase (NAG) and metallothionein in urine.

Another important disadvantage of setting BLV's, comparable with setting OEL's, is the fact that by the time an exceedance of the limit is observed, the excessive exposure of workers already took place and adverse health effects can already occur. A BLV does also not permit consideration of the inter-individual variability in response to exposures. The BLV is instead limited to making reference to statistical correlations between exposure and effect, and therefore will be required to be set at very low levels (which may not be workable) in order to 'statistically' ensure the safety of workers. Since the monitoring of bio-indicators of effects of cadmium exposure is also well established, and therefore the individual's own sensitivity to cadmium can be evaluated, the "statistical' safety is not the most effective approach to managing risk to workers. As for OEL, it must be stressed that also BLV's refer to the majority rather than to all workers and that a BLV cannot be seen as a "safe" concentration as such. Nevertheless, as for OEL's, it can be said that setting BLV's can contribute to an overall lowering of exposure and can prevent a long-time exposure to high concentrations.

PRACTICALITY

As already indicated, a lot of effort has been done over the years to reduce Cd exposure levels in the workplace for some scenario's (RAR, update 2005). Table 5.1.2 gives an overview of typical biomonitoring data, used in the RAR (2005), which are data from 1994-1996 and typical values in the update RAR (2005), which are data from 2002.

For the setting of a Community wide BLV (Cd-B or/and Cd-U), the data in Table 5.1.2 should be kept in mind. These show that one BLV for all scenario's seems not feasible due to the wide range of exposure levels found for different scenario's.

Table 5.1.2: Reduction in typical biological monitoring data for different scenarios from 1994-1996 (RAR, 2005) to 2002 (RAR update, 2005)

Scenario	*Cd-U (µg/g creatinine)*		*Cd-B (µg/l)*	
	1994-1996	*2002*	*1994-1996*	*2002*
1. Production of CdO	10	nu	1	nu
2. Production of Cd metal	3	2	3	2

3. Production and recycling of Ni-Cd batteries: - manufacture - recycling	 3.5 8	 2 1 (1)	 2.3 2	 2 -
4. Production of Cd alloys	-	nu	-	nu
5. Cd pigments production	4	3	5	4
6. Cd plating	-	nu	-	nu
7. Manufacture of Cd stabilisers	-	C	-	C
8. Brazing, soldering and welding	-	nu	-	nu
9. Other uses	-	nu	-	nu

(1) update only for one company and not judged representative for the whole sector/scenario

nu: no update

ECONOMIC IMPACT

Possible additional costs for implementing this measure would be related to the fact that a regular health surveillance of the workers is necessary to monitor their Cd-B and Cd-U levels. According to industry, a health surveillance program for workers is already in place in all plants, dealing with potential Cd-exposure. Monitoring of the BLV's is in this case restricted to blood and urine sampling of the workers. A health surveillance program, taken into account a monitoring system for BLV's would in this case not impose significant costs for the industry.

Looking at the levels itself however, additional costs for the industry as a result of setting BLV's will depend of the imposed level. The setting of a very low BLV will cause important costs.

MONITORING

Monitoring of compliance with the imposed BLV's, can be done through a regular medical examination of the workers, especially by taking blood and urine samples. Since in the cadmium industry, a health surveillance of the workers is already in place, monitoring BLV's would only induce (if not already performed) an extension of the medical examination, already in place. Monitoring of Cd-B and Cd-U gives an indication of exceeded exposure. Although monitoring of Cd-U and Cd-B show exceedances that already took place in the past, a long-term monitoring of these biomarkers can prevent a long-time exposure to high concentrations.

5.1.1.3 Extended health surveillance of workers

This measure takes into account the implementation of a profound health surveillance program for all workers. Additionally to monitoring of biomarkers for exposure (Cd-U and Cd-B), this program also includes examination of the general health of the employee, as well as monitoring biomarkers for effects of Cd exposure (e.g. β_2-M, NAG,…). The medical monitoring program of OSHA (2004) for workers potentially exposed to cadmium gives an example of what a profound health surveillance can include:

- An initial examination for each employee within 30 days of employment in a position that involves exposure to cadmium. This examination must include:
  - Medical and work history:
    - ~ Any past, present, or anticipated future exposure to cadmium;
    - ~ History of renal, cardiovascular, respiratory, hematopoietic, reproductive or musculoskeletal system dysfunction;

    - ~ Current use of medication with potential nephrotoxic side effects;
    - ~ Smoking history and current status;
  - Biological monitoring:
    - ~ Cd-U, standardised to grams of creatinin;
    - ~ β_2-M, standardised to grams of creatinin, with pH specified;
    - ~ Cd-B, standardised to liters of whole blood

  For each of these parameters, trigger levels are to be set. These levels will determine which level of periodic medical surveillance is required for each employee.

- Based on the results of periodical examinations, three groups of employees can be identified:
  - Those who exceed one of the preset levels. For those employees, a reassessment of the employee's occupational exposure to cadmium needs to be performed within two weeks of receiving the results of the tests
  - Those who show biological test results elevated relative to the trigger levels. A full medical examination within 90 days after receiving the results from the initial testing must be performed. At this point the examining physician should make a decision whether to medically remove the employee from cadmium exposure. If decided not to, biological monitoring must continue on a semiannual basis along with an annual medical exam.
  - Those who do not test above trigger levels for which an exam within one year after the initial exam and thereafter an exam at least every two years should be performed.
- The two-yearly exam mentioned above should include:
  - Detailed medical and work history;
  - Complete physical examination, emphasizing blood pressure, the respiratory system, and the urinary system;
  - A chest x-ray;
  - Pulmonary function tests;
  - Blood analysis;
  - Urine analysis;
  - Prostate exam for males over 40 years old;
  - Other tests deemed appropriate by the physician.

EFFECTIVENESS

A regular check-up of workers potentially exposed to Cd by a medical staff that is aware of the potential effects of Cd exposure can lead to the early detection of the effects of Cd exposure, avoiding the evolution to the development of irreversible effects. In case a number of workers show the same symptoms, this might be a signal that occupational exposure is not properly controlled (although this should already have become clear by monitoring of the workplace atmosphere) or working procedures, collective exposure reduction measures and/or PPE are not adequately followed or used.

Risk reduction through health surveillance can only be effective if a detailed health monitoring plan is set up, combining monitoring for both exposure and effects. For Cd, the most effective biological indicators for exposure are:

- Cd-B: Cd concentrations in blood, reflecting recent exposure and absorption;
- Cd-U: Cd concentrations in urine, the main indicator for overall exposure.

For Cd, the most effective biological indicators for effects are:

- Low molecular weight proteins (RBP, β2MG);

Both of these (bio-indicators of exposure and effect) are important data to monitor, prevent and control risks to each individual worker. A more extended medical examination allows to put test results into perspective and enables to draw individual conclusions, taking into account that different persons can show different effects to cadmium exposure.

The health monitoring plan also needs to include an indication of the actions to be taken when health indicators are above certain thresholds. An example of how to set up such monitoring plan was given above (OSHA, 2004).

A extended health surveillance program will be most effective if the program is multidimensional, meaning that it is not solely based on Cd-U or Cd-B or microprotein excretion, but decisions must be made taking into account all information, interpreting the specific message delivered by each bio-indicator. The decision tree should also not be based on an over simplistic yes/no decision but:

- A first set or "alert thresholds" should be set whereby, if exceeded, a review of an individual workers personal situation (current work position, prior exposure, personal hygiene habits, age and years left to retirement…) should be analysed and the medical doctor should be able to exercise his best judgement regarding possible removal from exposure, with flexibility. Guidelines should be given to assist the doctor in this task;
- A second set or thresholds should be strong upper limits where removal from exposure should be (quasi)-mandatory.

An over simplistic programme based on a single threshold and a simple yes/no decision would lead to a high pressure for not hiring smokers when at the pre-hire medical examination BLV's are determined to be close or around alert threshold BLV's. This could:

- be lawful in some countries while unlawful in others, but in both cases would obviously lead to problems,
- create false "positives", forcing people into non-exposed positions (whose number is not unlimited) and possibly out of work, leading to high costs to workers and employers alike as well as to society, with little if any benefit to employees;
- raise problems for SME's where the number of available fall-back positions is limited. In such a situation, the only route for exposure removal would be employment termination, leading to immediate legal costs on the basis of "termination without cause".

One needs to take into account that, the moment increased concentrations are measured, exposure already took place and effects already occurred. A periodic extended medical examination however enable the employer to identify cases of exceeded exposure and can react in due time to prevent a long-term elevated exposure. This scenario is what has been codified into Law in Sweden, the US, is common practice in all plants dealing with cadmium exposure, and yields excellent results (ICdA, personal communication, 2006).

PRACTICALITY

Regular health inspection is a requirement in the entire industry. The health inspectors have to be informed, however, of the use of Cd in the workplace and the potential effects of Cd on health in order to be able to pay attention to these aspects. The use of questionnaires that have to be filled out on a regular basis by the employees themselves may provide additional input for the health inspectors. The organisation of health examinations on a regular basis, asks for a quite extended organisational effort for each company, especially when blood and urine samples need to be taken.

The implementation of a extended health surveillance program (e.g. OSHA) involves however that the situation of workers whose bio-indicators exceed thresholds (due to historical exposure at higher -but legal- values) and in which no illness is diagnosed, must be addressed (de Metz, personal communication, 2006).

ECONOMIC IMPACT

As health surveillance of workers in industry is obligatory already, paying extra attention to potential effects of Cd exposure (by measuring RBP, β2MG, …) during health surveillance will not incur significant additional costs. One must take into account that the cost will depend on the frequency of the examinations, the number of parameters and the complexity of the sample analysis.

Industry assesses economic impact to be low to medium based on following data:

- Costs that are specific to Cd exposure monitoring, which includes [Cd-Air] monitoring as well as BI's monitoring, costs between 170€ to 240€ per exposed employee per year. This does not include the additional Cd specific medical visits and the additional time spent in regular visits to address Cd risk management. All inclusive, cost seems to be capped at 300€ per exposed worker per year;
- Additional costs will be required if stricter limits than current were deemed necessary and imposed.

Looking at the levels itself however, additional costs for the industry as a result of setting BLV's will depend of the imposed level. The setting of a very low BLV will cause important costs.

MONITORING

A health record of all employees has to be kept available for labour and health inspection up to 40 years after the last entry. This health record can be checked upon inspections to verify whether attention has been paid to the specific potential effects of exposure to Cd.

5.1.1.4 Collective exposure reduction measures

The use of collective exposure reduction measures is closely linked with the setting of the OEL. Effectiveness, practicality, economic impact and monitoring is similar/equal.

5.1.1.5 Training / safety data sheets

EFFECTIVENESS

Increasing the awareness of workers to the potential dangers of exposure to Cd/CdO and to the available means to lower this exposure (working procedures, collective exposure reduction measures, PPE, …) will lead to an increased use of these available means and to an early reporting of symptoms of Cd exposure. In order to be effective, training programmes have to be repeated on a regular basis and the proper use of the available means to lower exposure has to be checked on the work floor. The use of warning signs at 'critical' locations on the work floor and the availability of safety data sheets can even increase the effect of training.

PRACTICALITY

A regular training programme can easily be set up to reach all employees. Safety data sheets can easily be made available at the work place.

ECONOMIC IMPACT

The cost of providing regular training to all workers that can be potentially exposed can be estimated to be low.

MONITORABILITY

Companies can keep track records on the training programme of employees which can be checked by work and health inspection.

In case of the installation of a system of accreditation, the monitoring of the number of people actually following the training is even more simple, while the attainment of the accreditation should provide a guarantee of the awareness of the worker to the potential dangers of exposure to Cd and to the proper use of the available means to lower exposure.

5.1.1.6 Personal protective equipment

EFFECTIVENESS (ICDA/EUROMETAUX, 2006)

The use of respiratory protection is effective in cases where it is technically impossible to maintain exposure at all times below the OEL, e.g.:

- A normal working situation in certain installations or at certain working posts (operations with a limiting length of time where the use of collective measures is not appropriate);
- During intervention or particular maintenance work (e.g. dismantling or cleaning inside a device, demolition of furnace brickwork, intervention inside a bag filter)

Respiratory protection and other personal protective equipment are also often used as an additional protection measure by industry to further reduce exposure even when OEL are met.

Different types of respiratory protection could be necessary for different cases:

- For a dust level slightly higher than an OEL, a half-masked fitted with a filter cartridge with a P2 or P3 efficiency level is generally enough;
- For increased efficiency it is necessary to use panoramic masks or half-masks, supplied with clean air from outside the work premises and ensure a permanent over-pressure of this clean air inside the mask. This category is recommended particularly for works with heating: soldering, grinding, blowlamp cuttings, etc … or for exposure to very fine fumes.
- A third category is being tested in some industries; it comprises assisted ventilation helmets supplied with filtrated ambient air (level P2 or P3 according to the models). These are also very expensive and opinion is divided as to their efficiency.

The efficiency of PPE however will depend on the cleanness of the protection and the good general condition (mechanical, electrical,…).

Personal protection also involves individual hygiene and the presence of protected premises where it is possible to drink, eat or smoke. Individual hygiene measures include:

- prohibit to eat, drink , smoke, … on work premises which are exposed to certain metals;
- avoid habits like nail biting, licking of lips, wiping its face with hands or forearm;
- increase awareness of the risks of facial hair;
- oblige the workers to take a complete shower at the end of the day;
- oblige workers to wash hands and face before eating or drinking (during brakes).

PRACTICALITY

Wearing respiratory protection, when necessary is a measure which is practically feasible. Panoramic masks or half-masks, supplied with clean air however are less easily tolerated by the persons wearing them. In theory, it is also feasible to lay down some rules for personal hygiene and to assure the presence of protected premises. In practice however it is difficult to prohibit people from nail biting, wiping their face, licking their lips, … The latter issues can be discussed with individual workers within the framework of a extended health surveillance programme (see section 5.1.1.3), based on long-term monitoring data of exposure and effect indicators.

ECONOMIC IMPACT

The provision of proper PPE by the employer might incur some costs that are, however, not excessive. Panoramic masks or half-masks, supplied with clean air are however far more expensive than the half masks fitted with a filter cartridge with a P2 or P3 efficiency.

MONITORABILITY

The proper use of PPE can be checked upon by labour en health inspection during site visits. Some individual hygiene aspects (e.g. nail biting, wiping face, …) are less easily to monitor, but may become clear when comparing individuals with similar occupational exposure within the framework of a extended health surveillance programme (see section 5.1.1.3).

5.1.1.7 Sector initiatives – Voluntary agreement

As an alternative for enforcing OEL's or BLV's or a extended health surveillance program by law, a voluntary agreement can be set between industry and relevant national authorities. The measure assessed here is setting up a voluntary agreement that all industries, dealing with cadmium occupational exposure should implement a comprehensive occupational exposure monitoring program, developed by ICdA/Eurométaux. Annex 6 gives a full description of the proposed occupational exposure monitoring program as subject to a voluntary agreement (ICdA/Eurométaux, 2006). Next to taking air samples at the workplace, this guideline describes a parallel health surveillance of the workers for both exposure and effects but also a description of measures to be taken, like personal protection equipment, hygiene at the workplace, … in case indicators exceed certain levels. In fact this guideline is a comprehension of all measures mentioned and assessed before.

EFFECTIVENESS

The fact that the industry can develop its own approach to the risk reduction strategy through a voluntary agreement can be very effective. Sector organisations (e.g. ICdA/Eurometaux, 2006) developing a guidance document to manage the risks related to chronic occupational exposure to Cd and its compounds will be more efficient than letting each individual plant or industry develop its own strategy. Combined know-how will result in a better underpinned guideline and a better description of possible risk reduction measures. The availability of a guidance document is an incentive for the industry to take action and the more plants follow these guidelines, the more the risks can be reduced. Sector initiatives can be very effective, since they allow industry to develop its own approach to reduce the risks. To make this initiative fully effective, it must be assured that all players on the market are covered by this initiative. This is necessary to avoid that companies, not covered by this initiative, take advantage of non-compliance. To optimise the effectiveness of a voluntary agreement, guidelines for the development, implementations and monitoring of such agreements are set out in the EC Council Resolution of 1997 (97/C 321/02 [2]), the Communication from the Commission of the European Communities to the Council and European Parliament of 1996 COM(96), and in the Commission Recommendation of December 1996

(96/733/EC [3]). In many agreements, the legalisation remains on the background as a deterrent, only being fully developed and enforced if the agreement does not seem to be working satisfactorily. This approach incorporates the possibility of enforcing the agreement which is vital to its success.

The proposed comprehensive monitoring system or guidance to reduce exposure includes which actions to be taken in which situation. Actions can go from raising the awareness of workers that hygiene is important, giving information to workers on the toxicity of cadmium, to performing a medical examination for specific workers or move workers to an other department in the factory, where cadmium exposure is much lower or not existent. Agreeing on using this guideline is very effective to reduce risks since it defines a case-specific solution or measurement.

PRACTICALITY

To make sure a sector initiative will be effective, in practice, some effort is required to bring companies and authorities together. Voluntary initiatives need to be transparent and credible by:

- Quantifying objectives;
- Defining a timetable;
- Appropriate monitoring;
- Reporting to public bodies.

To optimise the practicality of the agreement, the guidance document for a occupational exposure monitoring program should be easy to read and to use. This guidance document should also be flexible and compatible with national and international legislation already in place.

ECONOMIC IMPACT

If actions are undertaken by a whole sector, costs can be shared, while the cost for designing an individual strategy per company will be much higher. The economic impact will only be a result of the implementation of the introduced measures in the guideline but the costs for developing a guideline will be minimal. Since industry is directly involved in developing the guideline, and thus have the opportunity to adapt the agreement to their economic possibilities, the economic impact of implementation will normally be acceptable.

MONITORABILITY

An independent body can be asked to control the results of the initiative.

5.1.1.8 Substitution

Substitution is a measure that would have an impact on the exposure of workers, the general population and the environment as a result of the use of Cd-containing materials in production processes. Therefore the assessment of this measure is performed for all scenarios jointly.

EFFECTIVENESS

Substitution of Cd in different applications, will eliminate occupational exposure and associated risks from the manufacture and use of the above mentioned products. Also human and environmental exposure from the use of some products and the final disposal will decrease gradually until these products are no longer in use (pigments, stabilisers, …). However, looking at the relative contribution of anthropogenic sources of cadmium to exposure of the smoking and non-smoking general population respectively, the use of Cd-products only accounts for 0.7% and 0.2% in the overall contribution. P-fertilisers (53%) and fossil fuel combustion(16%) are the main contributors to total cadmium exposure for the non-smoking population, while smoking is the main contributor for the smoking population (64%) (Figure 4.2.1 and Figure 4.2.2). Therefore, replacing Cd-products by substitutes not containing Cd will not be effective to reduce Cd exposure of the general population as well as releases to the environment from the use of these products. The exposure to cadmium of workers in those specific product branches will however be reduced.

Instead the general population, workers and environment will be exposed to other substances (Cu, Al, Li, Zn, etc)) and the question is whether these substances are less harmful than Cd. Only a profound risk assessment study for all substitutes could provide an answer to this question, which is not feasible in the framework of this study.

An important issue is that cadmium will continue to be produced even if it is substituted in above mentioned applications. Cadmium is not produced independently, but is an inevitable by-product of zinc primary production (CollectNiCad, 2001). As a consequence, Cd not used in some products, will be landfilled as a waste by-product. An elimination of cadmium metal production in the EU would have a negligible influence on the emission situation of the respective plants, because cadmium is a natural component of zinc ores, and has to be separated in any case not to contaminate the main product (Zn) of these plants. As already mentioned, substitution has no influence on Cd exposure of workers in Cd/CdO producing industries. Even if Cd is banned from above mentioned products, Cd will still be present in our daily environment from its major sources of human exposure: background environmental concentration and other anthropogenic sources such as fertilisers, non-ferrous and ferrous metals processing. It also needs to be mentioned that the lifetime of Cd plated metal is between 10 and 25 years (WS Atkins, 1998) so if Cd is substituted in metal plating activities now, Cd plated metal in use will keep emitting for the following 10-25 years. The same applies for pigments. In general, colouration of plastics with cadmium pigments afford very long product lifetimes (often 30 years) (ICdA, personal communication). This type of substitution will thus not show an important effects as from 10-25 years. Some conclusions on environmental performance of substitutes found in literature are given below for the differnt applications.

PRACTICALITY

As mentioned in 4.2.1.2 a few substitutes for CdO and Cd metal in different use sectors are theoretically possible. Only the most promising substitutes are listed. Each of these options will be discussed further in this chapter. Substitution in:

- plating applications;
- alloys;
- PVC stabilisers;
- Pigments.

Cd plating

The WS Atkins report (1998) analyses the effect of substitution of Cd by other metals. In the report a list of the exceptional properties of cadmium that explain its continued use as a plating agent in these applications is given. These qualities are:

- good corrosion resistance;
- controlled slippage characteristics;
- low coefficient of friction;
- low electrical resistivity;
- good soldering characteristics;

- good plating characteristics on a wide variety of substrates;
- bright appearance for decorative applications;
- good formability;
- galvanic compatibility with aluminium.

Morrow H. (1995) points out the same major advantages. He indicates that it is not so much that cadmium coatings exhibit any of these attributes, but that they exhibit all of them together which makes them such unique coatings. It is the combination rather than the specific value of any one of these properties alone which make cadmium coatings hard to replace.

Alternatives for cadmium coatings have been sought since the mid-1970s and have replaced cadmium in a number of non-safety applications. Alternatives to cadmium plating include (WS Atkins, 1998):

- zinc, the most common metal for plating;
- zinc alloys (including alloys with iron, tin, nickel, cobalt, silicon, and magnesium), particularly used in automotive applications; and
- aluminium, which has proved very useful in IVD (Ion Vapour Deposition) plating (ivadized aluminium).

Cadmium coatings behave very much like zinc in corrosion behaviour and are often compared to zinc in this respect. This corrosion behaviour can however differ in different environments. In general, cadmium coatings are superior to zinc in marine or concentrated salt atmospheres, whereas zinc coating may behave better than cadmium in industrial atmospheres containing sulphur dioxide. Cadmium coatings are characterised by thin, flexible oxide corrosion products whereas the corrosion products from zinc and zinc alloy coatings are more voluminous and unsightly. These characteristics make cadmium coatings ideal for threaded fasteners, valves and other moving parts, and delicate mechanisms where minimal corrosion products assures proper functioning of the component. The attempts to develop corrosion resistant coatings with low coefficients of friction to replace cadmium coatings have not been succeeded on a cost-effective basis (Morrow H., 1995).The industry (ICdA, personal communication) states that zinc itself is not a suitable substitute for cadmium coatings. Zinc alloys such as Zn-Ni, Zn-Fe, Zn-Co, Zn-Mn, Zn-Si and Zn-C have been evaluated and some of them do possess good corrosion resistance, but not low coefficients of friction nor high electrical and thermal conductivity.

The WS Atkins report (1998) gives following conclusions on substitution of Cd in metal plating:

- "Despite research and development programmes, suitable alternatives have not yet been found for most of the remaining applications. This is because cadmium is used in applications which require a combination of good alkaline corrosion resistance plus either low friction coefficient, low electrical resistance, good soldering characteristics, galvanic compatibility or plating characteristics for cast irons and other difficult to plate materials.
- For example, according to industry sources the available alternatives exhibit varying degrees of corrosion resistance, some of them very similar to that of cadmium. However, none of them has a low coefficient of friction except zinc-silicon alloys, low electrical resistivity, plateability on many different surfaces or galvanic compatibility.
- As far as corrosion performance of plating agents in marine environments is concerned, cadmium seems to perform a lot better than zinc or zinc alloys while aluminium seems to be more efficient than all other agents.

When an application requires several/all properties to be present, cadmium is the only technical choice possible for the moment. Substitution is therefore deemed not feasible from a technical point of view by industry (both plating and end-user industry), i.e. to date no other plating agent presents the characteristics required by some applications. A partial or complete ban on cadmium would create unquantified technical problems to end-user industries."

In industry, some studies are performed to try to look for potential cadmium alternatives. The National Defence Center for Environmental Excellence (NDCEE) prepared a study for the Joint Group on Pollution Prevention (JGPP, 2002) on the validation of alternatives to electrodeposited cadmium for corrosion protection, specifically for the aerospace industry. The scope of this project was limited to applications on substrates of low strength steel alloy and stainless steels, aluminum alloys, aluminum/nickel/bronze alloy, and copper. Qualification testing of coatings on common National Aerospace Standard (NAS) threaded fasteners and component testing for qualification of fatigue-sensitive or flight-critical components was beyond the scope of this project.

For the NDCEE study the technical representatives selected four potential cadmium alternatives for evaluation.

- Electrodeposited Tin Zinc
- Electrodeposited Alkaline Zinc Nickel
- Electrodeposited Boeing Zinc Nickel
- Ion Vapor Deposited Aluminum

This study concluded that none of the candidate coatings matched the performance of cadmium in all the tests. In many cases, however, several of the candidates matched the performance of the cadmium controls and may be acceptable for use on selected applications. IVD aluminum and Boeing zinc-nickel were the best performing of the alternate technologies. IVD aluminum was tightly adhered to the substrate materials although it tended to fracture in the middle of the coating in bend tests. Paint adhesion was perfect on this coating. The resistance of IVD aluminum to attack by all of the fluids tested was exceptional. In no case did the coating lose weight as a result of exposure. It is a nonembrittling process and has no significant impact on fatigue resistance. In galvanic coupling, IVD aluminum maintained the lowest contact resistance of all of the coatings tested, including cadmium. The one test where IVD aluminum did not perform as well as cadmium is the scribed corrosion test. Several of the coupons exhibited significant widening of the scribe line and developed red rust at one test site. The performance was not consistent however, as several of the coupons also showed little attack at the scribe line. Also, components used in corrosive environments often are finished with cadmium plating with a primer and topcoat. The corrosion performance of IVD aluminum with primer may better represent actual use configuration than testing the bare coating. IVD aluminum should be acceptable for many of the component applications that now use cadmium. In particular, it is a leading candidate to replace cadmium on electrical connectors. It has acceptable performance on threads, when applied at an appropriate thickness and dry film lubricated. It is a candidate for use on high-strength steel as a replacement for low-embrittlement cadmium.

Boeing zinc-nickel also performed well, matching the performance of cadmium in all tests except for the scribed salt fog test where it developed small amounts of red rust at the end of a relatively long exposure period. Like IVD aluminum, the performance of Boeing zinc-nickel when coated with a primer could be much like that of a cadmium-based finish system. Adhesion to most substrates and paint adhesion to the plating was excellent. Adhesion of the Boeing zinc-nickel plating to aluminum showed some localized failures that are likely attributable to contamination or inadequate zincate treatment of the aluminum substrate. Boeing zinc-nickel passed hydrogen embrittlement testing and had little effect on fatigue resistance. The coating maintained a fairly low contact resistance in the galvanic corrosion test. The coating showed sensitivity to an alkaline paint stripper but otherwise was comparable to cadmium controls. Testing of run-on and breakaway torque as well as torque-tension shows that Boeing zinc-nickel meets requirements. Boeing zinc-nickel is a viable candidate to replace cadmium on components and threaded parts. It is a candidate for use on high-strength steel to replace low-embrittlement cadmium or titanium-cadmium plating.

Alkaline zinc-nickel was the only candidate coating to show an effect on fatigue life. Use of this coating on fatigue sensitive components, even when using a nickel strike to control hydrogen embrittlement, should be carefully reviewed.

Tin-zinc passed unscribed corrosion but failed scribed corrosion with red rust occurring after about 350 hours of exposure to salt spray. Testing tin-zinc plating in combination with a primer might improve the overall performance. Tin-zinc was the only candidate to show greater contact resistance than cadmium control. Use of tin-zinc on components should be reviewed carefully. If the coating can be protected from damage and/or is coated with a protective paint coating then it should perform well. The automotive industry uses tin-zinc-coated fasteners in many vehicles and this coating is also allowed by the Army for fasteners. Except for the question regarding scribed corrosion resistance, tin-zinc is a potential candidate for use on high-strength steel applications.

Cushnie (1994) reports that three companies successfully implemented a low-cyanide, low-cadmium substitute. No single cadmium substitute stands out as the most favourable. Successfully implemented alternatives for cadmium are:

- Tin and tin alloys;
- Aluminum coatings applied by ion vapour deposition (IVD);
- Zinc-alloy plate.

No details were given however in this report on the results of the performance tests.

According to P2IRIS (Pollution prevention Information Resource for Industry sectors), to date, the primary problems with cadmium substitutes have been:

- Customer acceptance;
- Finish quality;
- Higher cost.

Some advantages of IVD coatings compared to cadmium coatings are listed by P2IRIS (2006):

- The process significantly reduces the generation of hazardous wastes, and potentially eliminates the need for special pollution control systems. Some waste is produced in alkaline cleaning and stripping although these wastes can be neutralized and disposed of as special (i.e. non-hazardous) wastes.
- Outperforms cadmium coatings in preventing corrosion in acidic environments.
- Can be used at temperatures up to 925 °F, as compared to 350 °F for cadmium coatings.
- Can be used to coat high-strength steels without danger of hydrogen embrittlement. Unlike cadmium electroplating, the aluminum IVD process does not expose the substrate to hydrogen gas.
- Superior to the vacuum-applied cadmium process in resisting particle impact (e.g., can withstand burnishing pressures up to 90 psi as compared to 40 psi for vacuum-applied cadmium coatings).
- Permits coatings of several mils (10^{-3} inch, 1 inch = 2.54 cm) compared to about 1 mil for electroplated and vacuum-applied cadmium coatings, increasing corrosion resistance.
- Provides better uniformity of coatings on the edges of parts than does electroplating.

The industry (ICdA, personal communication) states that most of the advantages mentioned here are in fact in circumstances where cadmium is never used. Cadmium coatings are never used in acidic environments. They corrode much too fast. In an acidic environment, zinc alloy coating would perform better than cadmium and IVD coatings are ten times more expensive than zinc alloy coatings. Cadmium is also never used above 925 °F. Vacuum applied cadmium coatings are not widely used and generally do not have the same superior characteristics as electrochemically applied coatings. Cadmium coatings of more than 1 mil have been applied to many components over the years, for example on landing gear for aircraft.

It is not known how the IVD aluminium burnishing pressures compare to electrochemically applied cadmium, a more widely used technique compared to vacuum applied cadmium coating.

Some of the disadvantages of IVD coatings are:

- It is difficult to coat the interiors of blind holes or cavities that have a depth greater than their diameter.
- Compared to cadmium, aluminum IVD coatings have a higher electrodeposit coefficient of friction as well as inadequate lubricity. Application of a lubricant is sometimes required for proper torque-tension of fasteners. When lubricants cannot be used, inadequate lubrication might be a significant limitation.
- Unlike cadmium, aluminum IVD cannot be combined with nickel to provide an erosion-resistant surface.
- Unlike electroplating, there is no simple way to repair damaged aluminum IVD coatings.
- Aluminum IVD is slower than cadmium electroplating (above a certain level of plating throughput) due to capacity limits of the IVD system. For high-strength parts, however, reduced speed is not an issue because these parts would have to undergo hydrogen embrittlement relief after cadmium electroplating.
- Parts coated by aluminum IVD do not require time-consuming heat treatment for hydrogen embrittlement (hydrogen stress cracking) relieve, thus compensating for the slower application speed.
- Because IVD aluminum coatings have a columnar structure and tend to be porous, parts might need to be peened with glass beads to improve fatigue and corrosion resistance. Peening can add to production costs and slow productivity. Cadmium electroplating has neither of these disadvantages.

Another disadvantage is that the IVD process to coat high-strength steels results in lower production rates because this process occurs in vacuum on a piece-by-piece basis (ICdA, personal communication).

Legg (2002) gives an overview of cadmium alternative technologies. This overview discussed Cd alternatives, especially for applications such as aircraft, where the requirements are particularly demanding. Legg selected following alternatives:

- Zn-Ni and Sn-Zn aqueous electroplates;
- Al organic bath electroplates
- Al-Mn molten salt bath electroplates;
- IVD Aluminum;
- Al or Zn metal-filled composites;
- Stainless alloys

For each of the alternatives, advantages as well as disadvantages are identified by Legg (2002). Legg identifies Zn-Ni and Sn-Zn aqueous electroplates, Al organic bath electroplates, Al-Mn molten salt bath electroplates and stainless alloys as techniques which are still under development.

For aqueous electroplates hydrogen embrittlement of high strength steels during plating will be an issue.

Testing has shown that in general Al can be used in place of Cd for almost every Cd application. Al cannot be electroplated from simple aqueous baths. Oxygen-free organic plating or IVD can be used. Another Al alloy electroplate currently under development and evaluation is Al-Mn. This alloy must be deposited from a molten salt bath (i.e. Al and Mn chlorides), which operates at a temperature of 170 °C. This temperature is too high for use in some electrical connectors, but is low enough for most aircraft steels. The corrosion protection provided by Al-Mn appears to be comparable to Cd. This technique is still under development and is not commercially available.

ICdA (personal communication) contradicts the statement made by Legg (2002) that "in general Al can be used in place of Cd for almost every Cd application". The coefficient of friction of the aluminum oxide corrosion products is much too high and the thermal and electrical characteristics of aluminum oxide very poor compared to those of the cadmium oxide corrosion products. Aluminum can only replace cadmium where corrosion alone is the consideration.

A polymer filled with metal flakes (Zn or Al) is a coating that has been tested by the Army Tank Automotive Command (TACOM) and found to be as good as Cd plating in this type of application.

Coating can be completely avoided by the use of stainless steels in place of Cd-plated steels. This method seems to work for engines. A new stainless landing gear steel has been designed and is currently under test. If this approach proves to be successful it will demonstrate a new ability to create new alloys to meet very specific technical requirements. ICdA (personal communication) wants to draw attention to the fact that still years of testing would be required to guarantee the safety of a stainless steel landing gear, especially looking at the coefficient of friction needed.

The Legg study (2002) concludes that because hard Cd is so widely used, in so many disparate applications, that no single replacement will work. There are however a number of viable alternatives for cadmium. Zn-Ni electroplate and IVD Aluminum are both gaining wide acceptance for Cd replacements, while materials replacements are gaining ground as a means of avoiding the problem all together.

It must be noted that most of the end users do not like to have many different coatings requirements for many different materials and applications, especially in view of cost effectiveness (ICdA, personal communication, cf economic impact).

Based on these different studies, it can be concluded that it is very difficult to find an alternative, performing as good as cadmium for all plating applications. None of the mentioned alternatives includes all specific characteristics of cadmium. Most of the mentioned studies, identify Zinc-nickel alloys and IVD Aluminum as being the most accepted alternatives for cadmium. Industry (ICdA, personal communication, 2006) states however that in those applications where Cd plating could be substituted by zinc alloys or Ivadized aluminium, it was substituted long time ago. The applications remaining today for cadmium coatings cannot, according to industry, be substituted by zinc alloy coatings or Ivadized aluminium.

Cd alloys

Cd containing alloys are used in several applications (based on Hansen *et al.*, 2002):

- Cd-containing solders for the making of jewellery;
- Ag-Cd oxide electrical contact alloys;
- Cd in Cu-alloys for critical thermal and electrical conductivity applications;
- Cd in cathodic protection anodes;
- Pb-Cd alloys used in cable sheaths.

The ICdA (2005, personal communication) states that Cd is rarely used today for cathodic protection anodes, although it may remain as an alloying element in some zinc anode alloys. ICdA also never even heard of Pb-Cd alloys being used as cable sheaths, and cannot imagine that it is a significant application any longer. As a general observation, it should be noted that the use of cadmium in most alloys has decreased significantly since 1980 as cadmium-free substitutes has been developed for a whole series of brazing, soldering, low-melting and other special application alloys. The only significant cadmium use remaining in the alloys markets are in the Cu-Cd electrical and thermal conductivity alloys and in the Ag-CdO electrical contact alloys. All others are disappearing or non-existent today.

Only the practicality of substitution of Cu-Cd electrical and thermal conductivity alloys and the Ag-CdO electrical contact alloys should be assessed since all other applications seem to be disappearing or non-existent already. The substitution of Cd in solders for jewellery is assessed in chapter 5.2.2 of this document.

Cadmium and titanium are added to Cu alloys to impart strength and formability without impairing thermal and electrical conductivity for certain critical thermal and electrical conductivity applications. Other strengtheners cannot be used without reducing the thermal and electrical conductivity (ICdA, 2005, personal communication).

Cd is added to Ag-CdO electrical contact alloys to strengthen silver which is notoriously weak and ductile. The cadmium addition does not diminish the alloy's electrical conductivity which is essential for the proper functioning of an electrical contact alloy (ICdA, 2005, personal communication). Silver cadmium oxide has become very popular as a general-purpose contact material in medium to high current switching applications because of its excellent resistance to erosion and welding and its very high electrical and thermal conductivity. AgCdO is produced by mixing silver and cadmium oxide using powder metallurgy techniques. The result is a material with a conductivity and contact resistance (using somewhat higher contact pressures) that is close to that of silver but with superior erosion and welding resistance due to the inherent welding resistance and arc-quenching characteristics of cadmium oxide. Usual AgCdO contact materials contain 10-15% cadmium oxide. Resistance to sticking or welding improves as the cadmium oxide content increases; however, electrical conductivity decreases and cold working characteristics degrade due to decreases ductility (Leach International, 2005).

HSE UK (1999) indicates that the use of cadmium in silver soldering or brazing has particular advantages in reducing the working temperature required and providing good flow properties for making the joint. Typically, between 16-25% cadmium may be present in a cadmium-containing silver solder. A cadmium-containing alloy of 42% silver has a melting range of 608-617°C whereas the 'cadmium-free' near cost equivalent alloy of 40% silver has a melting rang of 650-710 °C. According to this publication, a full range of practical and safer 'cadmium-free' silver solders are now available. Details however are not given in this publication. Users of cadmium containing alloys have the option of changing the new range but need to consider price and temperature equivalents.

To conclude:

- Practically speaking, substitutes exist for cadmium in silver soldering and brazing;
- None of the studies referred to mention a viable alternative for Cu-Cd electrical and thermal conductivity alloys.

Cd stabilisers

Stabilisers are used in the manufacure of PVC, a thermally unstable material, to allow it to be formed and shaped into products. The type of stabiliser used largely depends on the end-product (Atkins, 1998). Cadmium containing PVC stabilisers (Ba-Cd-Zn and Pb-Ba-Zn systems) have been or are being replaced by calcium-zinc, barium-zinc, and the organo-tin stabilisers. This substitution leads a complete cessation of occupational exposure to cadmium from the manufacturing of these stabilisers and of the release to the environment as a result of the use and disposal phase of the Cd-based stabilised products.

In Europe, cadmium is restricted to applications where good weathering qualities are required (Atkins, 1998). Hence, it is still used in the manufacture of window profiles (in combination with barium and lead). However, they are progressively being replaced by:

- lead-based systems, and
- to a lesser extent calcium-zinc systems.

Currently, the use of Cd-stabilisers in profiles rests in only a few very small producers of profiles (FOD, personal communication, 2006).

Lead-based systems currently account for about 60% of all stabilisers in the EU (see Figure 5.1 above). Lead-based products have a very positive cost/performance ratio with excellent heat and light stability and good electrical resistance and low water absorption. Lead systems have a successful track record in the construction industry. However, lead-based stabilisers have also come under environmental scrutiny and legislative pressure because of potential hazards to man and the environment.

Calcium-zinc systems currently represent about 15% of all stabilisers used in the EU. In order to develop potential replacement for the threatened cadmium and lead systems, stabiliser manufacturers have carried out extensive Research and Development. However, the life performance of these systems remains unknown for the moment.

A Dutch publication (1996) on "some aspects for cadmium risk reduction" reports that there is evidence that the use of cadmium in stabilisers and pigments has been virtually eliminated in some countries. In Austria, cadmium stabilisers in plastics have been 100% replaced, in The Netherlands, the only permitted use of cadmium as a stabiliser is in PVC frames on flat roofs and in Sweden, cadmium additives have been virtually eliminated (a usage of less than 0.1 ton/year).

Koot J.T. (1996) concluded that a higher amount of lead or zinc-based stabilizers was in most cases sufficient as a substitute for cadmium. However, in the case of thin wall profiles, substitution remained too critical because of the risk of what is called "burners" due to insufficient thermal stability. Koot (1996) also indicates that new formulations with lead and zinc-based stabilizer proved able to meet the high standards. Koot (1996) concludes that cadmium stabilizers for plastic products are replaceable. Product lifetime is however shorter because of discolouration of substitutes.

The European PVC industry organisations (ECVM, EuPC, ESPA and ECPI, 2001) state that the stabilisers industry has put a lot of effort in the development of new stabiliser systems. Liquid stabilisers used to be entirely based on barium/cadmium (Ba/Cd)-systems. Currently, barium/zinc (Ba/Zn) or calcium/zinc (Ca/Zn) systems are used. Systems based on cadmium already were reduced to 230 tons in 1998 compared to more than 16.000 tons fifteen years ago.

Baker P. (2004) found that replacement of a stabilizer composed of specific levels of barium/cadmium salts in flexible vinyl with another containing the same levels of barium/zinc has been found to give dramatically reduced performance in heat stability tests. However, results of this study has shown that satisfactory replacement of barium/cadmium/zinc or barium/cadmium systems in flexible vinyl is possible with barium/zinc stabilizers. This replacement appears to depend on higher barium-to-zinc ratios than those utilized in barium/cadmium analogs, use of special ligands that compensate for the smaller sized zinc cation; and prevention of their destruction by inadvertent addition of competitors.

To conclude, the use of cadmium in stabilisers had already been reduced to a very significant extend in the past years. The substitution to barium/zinc stabilisers seems to be a viable option for flexible PVC.

Cd pigments

Cd-pigments are predominately used for colouration of polymers (80%) but also for ceramics and glasses (10%) and artists paints (5%). The remainder are used in miscellaneous uses such as high performance paints (Cook and Atherton, 1996).

For Cd-pigments some alternatives are available (WS Atkins (1998):

- inorganic pigments like lead chromates, nickel titanates, bismuth vanadates, cerium sulphide pigments and
- organic pigments like quinacridones, pPerylenes, dyestuffs, napthols, perinones, diarylides, classical azos, azo-condensation pigments, isoindolinones, etc.

Cadmium pigments have exceptional properties, which explain their continued use. The pigments are based on fired hexagonal inter-crystalline compounds of cadmium sulphide, which itself produces a golden yellow pigment, but other colours are obtained by addition of zinc, selenium or mercury.

ICdA (2001a) carried out an evaluation of pigments as potential alternatives to cadmium pigments in a range of polymers. Both inorganic and organic pigments in the colour range yellow, through orange to red, were assessed in four widely used polymer types. The purpose was to identify if problems still exist in substituting for cadmium pigments in any applications. The performance of commercially available yellow, orange and red pigments was compared with that of cadmium pigments in low density polyethylene (LDPE), general purpose polystyrene (GPPS), acrylonitrile-butadiene-styrene (ABS), and polycarbonate (PC). Selection of the alternative pigments for each polymer system was carried out by consultation with the respective manufacturers. Following conclusions were drawn in that report:

- None of the individual alternative pigments tested proved to be a satisfactory replacement across all four of the polymer systems evaluated.
- No satisfactory alternative pigments were identified for use in polycarbonate.
- The majority of alternatives gave dispersibility and opacity problems in ABS.
- All of the inorganic alternative pigments are much lower in chroma (colour saturation) and in tinting strength.
- All but four of the organic alternatives displayed lower chroma (colour saturation) than that of cadmium pigments.
- Many organic pigments also showed lower tinting strength in ABS.
- Most of the organic pigments possessed inferior thermal stability and weatherfastness.
- Only four (one orange, one mid red and two maroons), out of a total of 42 alternative pigments tested, have comparable levels of colour saturation (chroma) to that of cadmium pigments. However, all four represent a compromise in terms either of processing or stability properties.
- This study clearly shows that very significant problems still remain in use of alternative pigments to replace cadmium pigments in all the polymer systems investigated. The problems are most acute for polymers requiring higher processing temperatures (typified by polycarbonate in this study), but also extend to polymer systems processed at lower temperatures. The problems remain despite many years research and development of pigments, most especially since the Directive of 1988.
- This study confirms the findings of previous surveys in 1995-1997 of industrial users that reported problems[19] and of a much more recent survey of users carried out by the International Cadmium Association.

Two questionnaires were prepared by the ICdA (2001b) to survey manufacturers who use pigments for the colouration of polymers in order to seek information about the use of alternatives to replace cadmium pigments. The surveys encompassed the different processing techniques, the wide range of polymers and a large number of potential alternatives. They found that technical problems exist that are most acute for polyamide (nylon), but that also extend to almost all of the polymers in current use, including polymers that require lower processing temperatures. Overwhelmingly, users do not believe that cadmium pigments can be replaced without technical compromises, relating to both pigment performance and environmental and Health and Safety factors. Almost all users stated that they would revert to greater use of cadmium pigments if legislation allowed.

[19] KEMI PM nr 4/97. Mona Olsson Öberg & Gunhild Granath. "Experiences of the Swedish regulation concerning cadmium in stabilisers and pigments in plastics". 1997 and Issue paper on "Substitution of Cadmium in Plastics - Selected Examples from Danish and Swedish Companies". Prepared by RAMBOLL for the Danish Environmental Protection Agency. September 1995.

In the revised RPA report (2002) no significant risk was identified to man or to the environment in the full life cycle assessment of cadmium pigments. Furthermore, the results of the RPA report and the questionnaire (ICdA, 2001b) have lead the Commission to decide on no further restrictions on marketing and use of cadmium (as detailed in Directive 91/338) (ICdA, personal communication). The imposition of restrictions on cadmium pigments has forced pigment users to move to other pigments which have not been assessed for risk to the extent that cadmium pigments have. It is clear that in some applications, the Directives have forced substitution of cadmium pigments by other pigments (e.g. lead chromate pigments) that almost certainly pose greater risk to both man and the environment (RPA, 2002).

Cook and Atherton (1996) indicate that the poor heat transfer characteristics of organic pigments compared to Cd-based pigments lead to an increase in moulding time and so to a decrease in productivity.

Cadmium-based pigments have been used extensively in the plastics industry due to their relatively low kilo price coupled with their good fastness properties and reasonable processability (CIBA, 2006). Ciba Specialty Chemicals is leading the search for organic colouring alternatives to heavy metal-based pigments. Not only does this mean high-performance solutions but also more cost-effective general-performance formulations where cost is the major constraint.

CIBA (2006) has carried out extensive comparative work matching heavy metal-based standards with selected products from the Ciba range based on the following criteria:

- migration;
- weather fastness;
- light fastness

From the above, they have produced heavy metal alternative formulations which target either cost-effective or high-performance requirements.

Golden Artist Colors inc., a supplier of professional art material (USA), has undertaken years of research in an effort to identify and market suitable alternatives for cadmium based pigments. They list some important characteristics like, hue or color position, chroma or color saturation, opacity, indoor lightfastness, and tinting strength. According to Golden Artist Colors inc. the finding of alternatives, satisfying this list of objectives is a difficult task, particularly in the yellow range. They found that the pyrrole family can offer a good alternative for the orange to medium red range. These are strong tinting, high chroma colors with excellent lightfastness. Suitable alternatives for the cadmium yellows has been a more difficult task. The bismuth vanadate family offers many of the attributes being sought, but concerns over the toxicity of the constituent heavy metals (Bi and V), seem to indicate they may offer little benefit over cadmium pigments. Another alternative found, arylide pigments, seem to offer the best choice for the artist eschewing cadmium pigment. The arylide yellow pigments are entirely organic, containing no metals. However this alternative does not provide a range of choice equal to that available in the current range of cadmium yellow. Although the properties of these new organic pigments are in many ways similar to cadmium colors, they are not identical in every aspect. The biggest variation is how the colors mix to create new colors.

Koot (1996) states that alternative pigments can be used in place of cadmium pigments but acknowledges that technical problems still exist. The replacement pigments cannot achieve some of the required technical properties equal to those of cadmium pigments (for colour, freedom from warpage, and for heat stability during polymer processing at temperatures greater than 300 °C). Koot also states that extra additives are required in order to achieve some other technical properties (polymer stability, and colour stability) or that the required technical performance can only be met over shorter product lifetimes (bleaching and discolouration) which increases the rate of product wastage.

According to these very tight criteria, there are no alternatives to cadmium pigments. However some pigments have been developed by a number of major international chemical companies such as BASF, Bayer, Sandoz, Ciba-Geigy and Rhone-Poulenc which are suitable to replace cadmium for some applications. At present, no alternative covers a substantial fraction of the colour range of cadmium pigments, and many provide merely single colours. Consequently, a wide range of alternatives would have to be used in place of cadmium pigments to cover the range of colours, and stabilities (to heat, light, weather and migration). Current manufacturers of cadmium pigments do not supply any alternative pigments. Developing new pigments requires research and development programmes, which can only be sustained by very large concerns.

The efficacy of alternative pigments varies greatly. Inorganic pigments have the lightfastness, weatherability and high temperature performance required but they lack the colour intensity of cadmium-based pigments. Most cerium sulphide pigments are still under development, therefore commercial availability is low. The efficacy of organic pigments varies depending on the type of polymer used. No alternative pigment offers the same qualities as cadmium pigments for such a large number of processes and end-uses.

In some specific cases (beer crates) colourfastness of organic pigments (as an alternative for Cd) appeared to be a problem due to cleaning chemicals.

Streatfield G. (1996) concludes that Cd-pigments are stable to light, weather and chemical attack during the lifetime of the product and they have no effect on the physical properties of the polymer. They maximise productivity and energy efficiency, giving acceptable colouring costs to the industrial user. According to Streatfield G. (1996), further legislation is unnecessary with respect to cadmium pigments

For Cd-containing pigments for colouration of plastics we can conclude, based on above mentioned literature that no substitutes but some alternatives are available. Some disadvantages can not be overlooked and are mentioned in most of the studies. It is difficult to find a substitute for the yellow colour range and problems with colourfastness of alternative pigments is mentioned several times. There are virtually no alternatives to cadmium pigments for orange to red decoration of ceramics or glasses, and only very poor alternatives for yellow decoration. For artists' colours, it is very unlikely that any alternatives to cadmium pigments will meet the required technical performance adequately in order to gain acceptance.

ECONOMIC IMPACT

Cd plating

Interviews with cadmium platers show (WS Atkins, 1998) that most companies operate on fairly narrow profit margins (around 5%). Their fixed asset base is relatively new indicating that in order to comply with recent legislation companies have had to invest. The economic impact is described by WS Atkins (1998) as follows:

- most medium-sized platers would be affected by any measure that would modify their income. They would also be negatively affected if measures required them to increase investment levels in order to comply with new abatement measures.
- However, in the event of a total or partial ban (that would involve some applications only) on the use of cadmium plating (irrespective of technical feasibility) platers would recover the loss by plating an equivalent amount of the suitable alternative.
- Metal cost is not really an issue, as small amounts are needed. Any additional cost would be passed down to the customers. Provided the legislation is enforced, i.e. platers operate on a level-playing field, there will be no loss of competitiveness.

- Extra-EU competition is unlikely to occur, as a short turnaround is an essential element of competitiveness.
- If substitution of cadmium plating were technically feasible, substitution could and would take place without negative effects for the plating or the end-user industry.
- The effects of a total or partial ban would therefore be:
  - very little impact, positive or negative, on the plating industry;
  - negative effects on the end-user industry because of the unsuitability of alternatives (technical feasibility); but
  - a probable boost to research and development efforts to find suitable alternatives.

ICdA (personal communication, 2005) comments on the second bullet point. It is arguable whether or not platers could recover their business by plating an equivalent amount of a suitable alternative. The point is that there is not a suitable alternative for all of the applications, and most shops could not afford to develop plating lines for each one of those applications. Electroplating shops are generally set up to do several different types of plating operations. They will not make a substantial investment in new equipment to produce a new type of coating unless there is considerable incentive to do so. The experience in the United States has been that some electroplaters simply elect to eliminate cadmium plating from their product line with the result that more and more of the cadmium plating is done by fewer and fewer shops. So a few shops might benefit but the majority would just choose to discontinue plating for that application. What should be noted is that research and development for alternatives for cadmium plating have been going on for thirty years without success. Cadmium plating has been reduced because it is used now only in those applications where it is absolutely necessary. However, where it is necessary, there are no substitutes.

ICdA (personal communication) draws the attention on the fact that substitution in the plating industry would mean the establishment of a new plating system with all of its own particular set of process parameters, environmental regulation and necessary controls.

Capital costs and operating costs for aluminum IVD equipment ($500,000 for a typical IVD system) are significantly higher than electroplating, but are partially offset by reduced waste treatment and disposal costs. Electroplating equipment and wastewater treatment for producing the same amount of plated work would be approximately 1/4 to 1/6 of that amount (P2IRIS, 2006).

As already tackled in the section of applicability, most end users do not like to have many different coatings requirements for many different materials and applications. It is far less cost effective to have to develop multiple coatings systems that not have a few basic systems which cover their requirements.

A conclusion on the economic impact of substitution in the Cd plating is difficult to draw. Much more detailed studies would have to be performed to assess the real economic impact.

Cd alloys

More information needs to be gathered here to perform an assessment of the economic impact of substituting Cd containing alloys. According to HSE UK (1999), the cost of some 'cadmium-free' alternatives may be greater, and further costs can result fromm extended heating cycles and lower output rates, These can however soon be recovered by savings made in the protective measures required. This statement is not supported with quantitative data.

Since the cadmium alloy industry has largely disappeared and there are only a few manufacturers left who produce the electrical contact, thermal conductivity, and electrical conductivity alloys (ICdA, personal communication, 2005), overall economic impact seems to be low.

To conclude, economic impact seems acceptable.

Cd stabilisers

Sale and use in the EU of all cadmium stabilisers has ceased since March 2001. This means that no members of ESPA (European Stabiliser Producers Association) sell such products in the European Union, Norway and Switzerland . EuPC also communicates to its members not to use cadmium-based stabilisers (Vinlyl2010, 2006). In case of a ban on cadmium stabilisers, extra-EU exports are likely to remain stable. The main export markets are Asia and the Far East where awareness of environmental issues is limited. In the case of a ban, increased trade of alternative stabiliser systems would offset the drop in intra-EU trade for cadmium stabilisers. Trade flows between EU Member States are unlikely to be significantly altered, as manufacturers of cadmium stabilisers are also the producers of alternative systems (WS Atkins, 1998).

Stabiliser manufacturers believe they would not be significantly affected by a European ban as:

- alternatives (lead-based or calcium/zinc-based systems) are available and have gradually been replacing cadmium stabilisers;
- most of the remaining production of cadmium stabilisers is sold outside the EU (to Asia and the US); and
- industry announced in 1995 its intention to phase out cadmium stabiliser systems for PVC.

The commercial impact of banning cadmium stabilisers would therefore be very limited, particularly as much of the process equipment used in the production of cadmium-based stabilisers can be readily converted to the manufacture of lead-based stabilisers. The small costs involved in the switch would be recovered relatively quickly due to the lower production costs of lead-based stabilisers.

Most EU manufacturers of PVC window profiles have already changed to lead-based stabilisers and to a much lesser extent to calcium/zinc systems. In the UK, the last manufacturer of PVC products to be using cadmium stabilisers ceased to do so at the end of 1997. In Germany, three manufacturers are still using cadmium stabilisers but industry is planning on introducing a voluntary agreement to ban the use of cadmium by mid-1998.

A few manufacturers have been reluctant to change to lead-based stabilisers because they feel more testing is needed before they can safely guarantee the same product life to their customers as with cadmium stabilisers. In Europe, window profiles are normally guaranteed 20 years.

Of major concern to the industry is the environmental and legislative pressure directed at lead-based stabilisers. Contrary to a ban on cadmium, any restriction on the use of lead stabilisers (which represent 60% of the market for stabilisers) would have a major impact on stabiliser manufacturers, the PVC industry in general and ultimately the European consumer.

VROM (1996) drew some conclusions in relation to costs due to the regulations restricting the use of cadmium (implementation of 91/338/EEC). There conclusions are based on the publications of ERM (1995), MARCH consulting (1993) and Fraunhofer Institut (1992):

- generally there are no major compliance cost issues for industrial users of pigments, stabilisers and metal coatings;
- the major impact will be on pigment producers who do not change to non-cadmium substitutes: their turnover could fall by an average 45% within five years of the Directive being implemented;
- the most problematic substitutions are for pigments, particularly for red and yellow high performance engineering plastics and for glazes. It is difficult to match the brilliance of the colours and the heat and light stability of cadmium
- organic compounds as alternatives for Cd-pigments are generally more expensive;
- mixed metal oxides containing titanium, antimony, nickel and chromium, and cerium sulphides may be cheaper;

- Alternatives to cadmium stabilisers include lead-based, barium/zinc-based, calcium/zinc-based and organo-tin based systems. The additional costs of the substitutes vary from approximately 0% (lead-based) to 50-100% (calcium-zinc-based);
- In the UK the Directive had little impact on plating activities, since only an estimated 17% of cadmium plating was affected by the Directorate, and cadmium plating only accounts for some 12% of plating activities in the UK.

Koot (1996) reports that the costs of alternatives are 150 to 300 per cent higher than cadmium stabilizers. Being cadmium-free did not result in any sales advantage but did result in sales disadvantages in that the biggest problem of all was to get the higher costs repaid by the market.

Cd pigments (WS Atkins, 1998)

A ban on the marketing and use of cadmium pigments would affect trade flows as manufacturing facilities would be forced to close down. Overall trade would probably remain unchanged as the decline in the trade of cadmium pigments would be offset by an increased trade in replacement products (see section on alternatives).

Trade flows and trade balances would change as the main producer countries for alternatives to cadmium pigments are Germany and Switzerland. The UK would probably become a net importer of products and Germany would see its exports increase significantly. The EU's trade balance for pigments would probably still be positive but imports from non-EU countries and particularly Switzerland would increase sharply.

According to the study on "the impact of the internal market of Community legislation limiting the marketing and use of cadmium" (ERM, 1996), the main impacts on economic operators were decreased revenues from EU markets and increased reliance on non-EU markets. The possibility of production facilities closing down and downstream effects on users of cadmium pigments were also identified as common impacts on the industry as a result of the Directive. These effects would be intensified by any further restriction on the use of cadmium.

In case of a total ban on cadmium, it is believed that the main economic impacts on industry would be:

- discontinuity of EU production capability;
- heavy costs for processors and users of pigments;
- beneficial effect on R&D levels; and
- beneficial effect on manufacturers of alternatives.

Koot (1996) reports that the costs of alternatives are 150 to 300 percent higher than cadmium pigments, and in addition there are considerable costs involved in identification of suitable alternatives and for associated process development. Being cadmium-free did not result in any sales advantage, but did result in sales disadvantages, and the biggest of all of these was to get the higher costs repaid by the market. ICdA (personal communication, 2005) comments that it is incorrectly to assume that cadmium pigments will readily be substituted for by German and Swiss alternatives. In reality, cadmium pigment producers outside of Europe will increase their production, and the only effect will be the shutdown of cadmium pigment production facilities in the UK and France.

In the event of cadmium pigments being restricted further by an increase in the list of polymers (under Directive 76/769/EEC on marketing and use restrictions), production in the EU would be reduced but would almost certainly remain in order to service the technically more-difficult end-applications within the EU (artists' colours and decoration of ceramics) and for extra-EU export of cadmium pigments. I estimate that about 50% of current production is for extra-EU exports (increased proportion since the data reported in section 1.3; my page 2). Thus in terms of Practicality, the reduced cadmium pigment production within the EU would probably not result in any significant reduction in exposure of workers or in local emissions to the environment from manufacturing sites. The colouring of plastics for use within the EU would most likely require use of organic pigments in place of cadmium pigments with consequently reduced technical performance. Because organic pigments are increasingly being produced outside the EU, in locations where employment costs are lower (e.g. India, China and the Far East), very probably this would cause a shift of production outside the EU.

The costs will be heavy for the processors and users of pigments, but it is doubtful that there will be significant benefits for R&D levels of the manufacturers of alternatives simply because the industry has been searching for suitable alternatives for the past 35 years and found none up until now.

Based on the above mentioned references, it can be concluded that economic impact will be significant for processors and users of pigments.

MONITORABILITY

Control can be carried out through the Directive on restriction of the use of Cd in several applications.

5.2 ASSESSMENT OF POSSIBLE FURTHER RISK REDUCTION MEASURES FOR CONSUMERS

Since for the smoking population, 64% of the Cd-exposure is related to their smoking habit, for this part of the population, a "stop smoking campaign" would be most effective to reduce Cd-exposure. The development of this route is however not a subject of this risk assessment study, but must be kept in mind, looking at other measures.

Following measures were taken forward to be subjected to a further assessment:

- Marketing and use restrictions for Cd containing brazing sticks;
- Marketing and use restrictions for Cd containing jewellery

5.2.1 Marketing and use restrictions for Cd containing brazing sticks

EFFECTIVENESS

A ban of Cd-containing brazing stiks for the consumer market would prevent consumers from being exposed to elevated Cd-concentrations when using brazing sticks would therefore be very effective.

PRACTICALITY

Only scarce information could be found on the production and use of Cd-containing brazing sticks. The following findings are communicated to us by the ICdA and are based on the information of one company in Europe (confidential information).

Cd is from the technical point of view an element that improves the brazing properties of brazing alloys. Cd is a melting point depressant and improves the wetting behaviour of a brazing alloy to several kinds of base materials. The most used Cd-containing brazing alloys have either 40 or 30% (weight%) Ag and around 20 % (weight%) Cd, balance Zn and Cu. Their melting range is between 600 and 690 °C

If customers would like to have a Cd-free brazing alloy in the same melting range they have to buy alloys with higher Ag-contents (up to 56 weight%) and this means they have to pay a higher price. If they would like to buy a Cd-free brazing alloy with the same Ag-content the brazing temperature will be higher and by this either the people have to change their way of brazing or the machine set ups have to be changed.

Nevertheless there exist a lot of Cd-free brazing alloys those could replace the Cd-containing alloys. They do not have the same Ag-content or melting temperature and if now someone would like to have the same technical properties of his Cd-containing alloy with the same Ag-content but Cd-free then there is no alloy that can fulfill these demands.

Brazing alloy companies have, due to their long technical experience with brazing alloys, informed its customers about the risk of using Cd-brazing alloys and has helped to replace them by Cd-free alloys. Cd-free alloy with almost the same melting temperature than the commonly used Cd-containing alloy with 40% Ag has been developed. This new alloy however contains 56 % Ag and 3 % Ga and by this it is more expensive.

From the technical point of view, Cd-containing alloys can be replaced by the Cd-free alloys in almost all cases.

ECONOMIC IMPACT

Based on information in Europe the following companies produce Cd-containing brazing alloys (ICdA, personal communication, 2005):

- BrazeTec (Germany)
- Italbras (Italy)
- Galliani (Italy)
- Metalli Preciosi (Italy)
- Dentalini (Italy)
- Reboud Roche (France)
- Sempsa (Spain)
- Thessco (Great Britain)
- Sentes (Turkey)
- Inmet (Poland)

There are no exact data on the amount of Cd-containing brazing alloys produced in Europe. ICdA (personal communication, 2005) estimates the amount to be 300-400 t maximum. A lot of these alloys are sold outside of Europe, so the economic impact of a ban on Cd-containing brazing sticks for the consumer market is expected to be low. Replacing brazing sticks with higher Ag content is more expensive to consumers.

Because the EEE Directive (2002/95/EC) prohibits the use of Cd in electric and electronic equipment (except for some critical applications), the professional market for Cd-containing brazing sticks will largely disappear. It is highly unlikely that companies are able to create a sustainable business on just the consumer market. As a result of the implementation of the EEE Directive, alternatives for Cd-containing brazing sticks will be developed for the professional market, that can also be introduced on the consumer market.

MONITORABILITY

Control can be carried out through the Directive on restriction of the use of Cd-containing brazing sticks.

5.2.2 Marketing and use restrictions for Cd containing jewellery

To reduce the risk of dermal exposure to cadmium for costumers, a M&U restriction on the use of Cd containing solder for jewellery, could be suggested.

EFFECTIVENESS

A ban on using Cd containing solder in jewellery is the most effective measure to reduce risks of dermal exposure for costumers. If Cd-containing jewellery is not sold anymore, dermal exposure to cadmium by wearing jewellery will cease in the future. Of course, jewellery, made with Cd-containing solder, still in use, will keep causing a risk for the consumer during the life-time of the jewellery. Consequently, a ban will not stop dermal exposure of consumers immediately after introducing a ban.

A ban involves the use of substitute products like indium, gallium, zinc, … and only a complete assessment of the risks introduced by using these alternatives can show the health safety of these products.

PRACTICALITY

Restrictions on the marketing and/or use could be enforced under EC Directive 76/769/EEC. In the Annex of this Directive, preparations can be listed that may only be placed on the market or used subject to the conditions specified herein. Due to the flexibility of this Directive it is possible to restrict use of specified applications.

A ban does also imply the need for a substitute. Cadmium is used in the solder of jewellery to decrease the melting range and to impart desirable wetting and flow characteristics. Substitution of Cd in jewellery brazing alloys can be done by use of other low melting point metals. The most applicable are tin (Sn), indium (In) and gallium (Ga) as well as zinc (Zn). A study from Dabala M. *et al.* (1998) shows that Cd in gold jewellery can be completely substituted in brazing alloys by indium and gallium, with little detrimental affect on any of the important material characteristics. In comparison with Cd they have:

- Better thermal characteristics;
- Good bonding between the alloys;
- Absence of any erosion or porosity but the presence of localized fractures in some instances;
- Satisfying mechanical behaviour of brazed joints is satisfactory;
- A lower yield strength and a greater ductility.

It seems that cadmium-free gold and silver solders are available on the market (Allgemeine, 2005 and Ögussa, 2005).

ECONOMIC IMPACT

It is not clear whether substituting Cd by other metals for jewellery solders implicates a major economic impact. Taking into account that:

- Cd-containing as well as Cd-free solders for jewellery are put on the market by the same companies;
- The industry estimates that in 2004 only about 250 kg Cd was used in costume jewellery in Europe (ICdA, personal communication, 2005);

One might assume that a ban of Cd-containing jewellery would not impose an important economic impact.

MONITORABILITY

Control can be carried out through the Directive on restriction of the use of cadmium containing jewellery

5.3 ASSESSMENT OF POSSIBLE FURTHER RISK REDUCTION MEASURES FOR THE ENVIRONMENT

In this chapter, tools for reducing risks for:

- man indirectly exposed via the environment;
- surface water/sediment;
- terrestrial
- secondary poisoning;
- wastewater treatment plants,

are assessed because tools affecting these risks often have an affect on more than one scenario (e.g. tools reducing emissions to surface water also reduce risk to soil). As already indicated, risks for man indirectly exposed via the environment are in the RAR identified especially (not taken into account carcinogenicity/genotoxicity) for smokers (MOS of 1.28 - 4.88), adults with depleted iron-stores (MOS of 0.98 – 3.92) and the general population living near point sources (MOS of 0.62 - 4.5). Therefore, risk reduction measures should focus especially on these target groups.

Following measures were taken forward to be subjected to a further assessment:

- Regulatory controls to reduce direct emissions to soil (Regulation on Cd content in mineral fertilisers; Directive on use of sewage sludge in agriculture, the organic farming regulation and the EU soil strategy)
- Economic instruments to reduce direct emissions to soil (levy on Cd-content in fertilisers, sewage sludge, compost);
- Regulatory controls to reduce emissions to the environment from industrial plants.

Since for the smoking population, 64% of the Cd-exposure is related to their smoking habit, for this part of the population, a "stop smoking campaign" would be most effective to reduce Cd-exposure. The development of this route is however not a subject of this risk assessment study, but must be kept in mind, looking at other measures.

5.3.1 Regulatory controls to reduce direct emissions to soil

In a study (ERM, 2001) with the objective of producing an evaluation of the risks posed by cadmium in fertilisers to health and the environment, also options for risk management were developed. This study assessed different options to reduce Cd concentrations in fertilisers, being:

- introduce EU-wide limits on the cadmium content of fertilisers;
- a product charge to tax the high cadmium fertilisers and promote the use of low-Cd fertilisers;
- establishing restriction of the Cd content of agricultural soils

One has to take into account, however, that uptake of Cd is not only influenced by soil Cd-content but also by bio-availability which in its turn is influenced by agricultural practices (soil pH, ion strength, organic matter content) and crop type.

5.3.1.1 Introduce EU-wide limits on the cadmium content of fertilisers

EFFECTIVENESS

In Table 5.3.1 the decrease of Cd input into soil through the use of phosphate fertilisers with a lower Cd content (20 and 10 mg Cd/kg P_2O_5 respectively) is calculated for 11 countries. Allowing phosphate fertilisers with only 20 mg Cd/kg P_2O_5 would lead to a decrease of Cd input in the soil through use of phosphate fertilisers with 37.7%, resulting in an overall decrease of Cd in the soil with 12.3% if one accounts for the fact that on average 32.73% of total Cd input into the soil results from the use of phosphate fertilisers (see 4.2.3). Allowing phosphate fertilisers with only 10 mg Cd/kg P_2O_5 would lead to a decrease of Cd input in the soil through use of phosphate fertilisers with 65%, resulting in an overall decrease of Cd in the soil with 21.3% if one accounts for the fact that on average 32.73% of total Cd input into the soil results from the use of phosphate fertilisers.

If one accounts for the fact that dietary intake accounts for over 80% of total uptake of the general non-smoking population and for some 35% of total uptake of the general smoking population (see 4.2.3), reducing the input into soil by limiting the Cd content of phosphate fertilisers may result in a decrease of total uptake with 8 – 16% for the general non-smoking population and with 3.5 – 7% for the general smoking population.

As a secondary effect, lowering Cd input into the soil through use of phosphate fertilisers with a lower Cd content will also result in reduced Cd content in animal feed and as a result in manure, which will lead to an even further decrease of Cd input into soil.

The proposed measure will lead to a significant decrease of Cd intake for the general population and can be regarded as being a very effective measure.

Table 5.3.1: Impact of a limit value on Cd content in phosphate fertiliser on total Cd input into the soil

	*Cd content of fertiliser**	*Fertiliser consumption***	*Cd input through use of fertiliser*	*Effect of limit value on Cd content in phosphate fertiliser*			
				Limit value	*Cd input through use of fertiliser*	*Limit value*	*Cd input through use of fertiliser*
	mg Cd/kg P_2O_5	*ton P_2O_5/year*	*kg Cd/year*	*mg Cd/kg P_2O_5*	*kg Cd/year*	*mg Cd/kg P_2O_5*	*kg Cd/year*
Austria	25	56000	1400	20	1120	10	560
Belgium	32	51000	1632	20	1020	10	510
Denmark	15	48000	720	20	720	10	480
Finland	1	58000	58	20	58	10	58
Germany	40	415000	16600	20	8300	10	4150
Greece	18	132000	2376	20	2376	10	1320
Ireland	58	129000	7482	20	2580	10	1290
The Netherlands	25	61000	1525	20	1220	10	610
Norway	2.3	30000	69	20	69	10	69
Sweden	7	45000	315	20	315	10	315
UK	15	402000	6030	20	6030	10	4020
			38207		23808		13382

* ERM (2001)

** Oosterhuis et al (2000)

PRACTICALITY

Lower Cd contents in phosphate fertilisers may be reached either through the use of low Cd phosphate rock, through the application of decadmiation technology or through selective mining.

Low Cd phosphate rock is only available from limited sources (ingneous rock) found mainly in the former Soviet Union, South Africa and Jordan. Current European supply of phosphate rock is currently only covered for 26,7% by low Cd rock while current European supply of processed phosphate is currently only covered for 29,2% by sources from low Cd rock (Oosterhuis et al., 2000). It is not clear for the moment whether countries with low Cd rock would be able to significantly increase their production in order to be able to fully supply the European market. It is also not clear whether low Cd rock is suitable for use in all fertiliser production processes currently in operation.

Decadmiation can be either applied to the rock (calcination) or to the intermediate phosphoric acid (cocrystalisation, precipitation, solvent extraction or ion exchange). Decadmiation of the intermediate phosphoric acid seems the most promising for the moment, with cocrystalisation being by far the preferred methodology. Decadmiation technologies allows to reduce Cd levels below 2 mg Cd/kg P_2O_5. However, most technologies only made it up to the pilot scale and a full industrial unit for producing fertiliser phosphate has never been built. An industrial plant for Cd removal by calcination of phosphate rock has been operated by Nauru Phosphate Corp. but has been closed down recently. Decadmiation of phosphoric acid by means of precipitation and solvent extraction is in use on an industrial scale by only for food grade phosphate. Disposal of the waste with high Cd content is a limiting factor for some of these decadmiation technologies, while others produce metallic Cd as a side product that can be sold on the market.

Selective mining is a third possibility that would allow to lower the Cd content of high Cd rock. High Cd phosphate rock comes mainly from sedimentary rock and Cd content is not uniform over the entire deposit. By separating low Cd from high Cd layers during the extraction of the phosphate rock, average Cd content in a partial stream could be lowered in order to meet the limit values in phosphate fertiliser after processing. This approach has, however, never been tested in practise. Main drawback of this selective mining approach is the fact that the high Cd part (with higher Cd contents than the current average Cd content) might be directed to other parts of the world outside Europe. According to industry (ICdA, personal communication, 2006) selective mining is not a realistic option in the case of horizontal layers. Moreover, phosphate rock should be too soft to allow selective mining.

In conclusion it can be stated that lower Cd contents in phosphate fertilisers can be certainly reached through either use of low Cd rock or decadmiation. Some doubts remain on the practicality of the selective mining route. Uncertainty exists on the availability of low Cd rock and on the feasibility of decadmiation on an industrial scale.

ECONOMIC IMPACT

Price of phosphate rock is influenced mainly by other factors (purity, processability, transport, …) and not by Cd content. This can be illustrated by rock prices in the Netherlands where prices of low Cd rock from Jordan and South Africa are 3.50 € above average rock price while prices of low Cd rock from the former Soviet Union is 2.50 € beneath average rock price. In case of sufficient production capacity of low Cd rock from existing sources, a significant increase of rock price is highly unlikely and economic impact can be estimated to be low. However, in case production capacity for low Cd rock is not sufficient, a sharp rise of low Cd rock price is to be expected. Taking into account a price elasticity of -0.2 for phosphate fertilisers, the impact on farmer income is expected to be low while producers are likely to pass on cost changes to end users (ERM, 2001). Economic impact might be very significant in those countries for which the trade of high Cd rock contributes significantly to their export earnings and who export major parts of the mined rock to the EU (e.g. Morocco, Togo, …).

As costs of decadmiation processes are not available for industrial processes, except for decadmiation of food grade phosphoric acid which costs about 30 US$/ton P_2O_5, impact of decadmiation on fertiliser cost remains highly uncertain. Different sources cite increases in production costs ranging from 10 up to 30% (ERM, 2001). Taking into account the low price elasticity of phosphate fertiliser, the impact on farmer income is however expected to be low.

There is no cost estimation available for the selective mining option.

Economic impact within the EU can be estimated low for the use of low Cd rock (in case production capacity is sufficient) and for decadmiation, both due to the low price elasticity of phosphate fertilisers. When switching to low Cd rock, very significant economic impacts can be expected for high Cd rock producing countries that significantly rely of phosphate rock for their income and export mainly to the EU.

MONITORABILITY

Monitoring of Cd content in phosphate fertilisers upon entry in the EU market, either by fertiliser producers in the EU or imported fertilisers from third countries, does not seem to pose major problems. Any load should be accompanied by the necessary analysis documents and control through random sampling can be easily performed at low cost.

5.3.1.2 Charge on cadmium content in phosphate fertilisers

Rather than putting a limit value on the Cd content of phosphate fertilisers a charge or levy can be raised. There are two possibilities for this charge or levy. First of all a charge on total cadmium content can be raised, meaning that importers or producers pay a charge or levy per kg of cadmium put on the EU market. In this way low Cd fertilisers would have to pay a lower charge than high Cd fertilisers, resulting in a price differential between both products and a financial incentive for end users to use the low Cd product. Secondly, a charge or levy could be raised on products for which the Cd content exceeds a certain limit value, again offering a financial incentive in favour of the low Cd product. Revenues from this charge or levy can be used to finance R&D on the production of low Cd phosphate fertilisers.

EFFECTIVENESS

The effectiveness of this measure strongly depends on the charge rate. Due to the low price elasticity of phosphate fertilisers, the price difference between low and high Cd fertilisers should be significant before an end user would be stimulated to switch to the low Cd product. If one takes into account that production costs low Cd fertilisers are higher (cost of decadmiation), charge rate should more than compensate this higher production cost. Raising a charge on total quantity of Cd put on the market would increase price of all phosphate fertilisers while raising a charge on fertilisers with Cd contents above a certain limit value would only create a more pronounced price differential between low and high Cd fertilisers.

Issues regarding availability of low Cd rock and decadmiation technologies are identical to the ones discussed under 5.3.1.1.

PRACTICALITY

Administrative burden can be quite significant for this option. If charge raising is made the responsibility of the Member States, care should be taken that charge levels are uniform throughout the EU in order not to distort th common market.

ECONOMIC IMPACT

Economic impact of this measure is solely dependent on the way it is implemented (charge on Cd put on the market or on fertilisers with Cd content exceeding a certain limit value) and on the charge rate. According to ERM (2001) a charge of 1000 € per kg of Cd put on the market would result in a decrease in demand for phosphate fertilisers between 7.8 and 23.4% (depending on the price elasticity used in the calculation) and a cost increase for farmers between 2.1 and 2.5% on a yearly basis, which is significant. Because of these significant impacts, this option is the less preferred one. Impacts of a charge on fertilisers with a Cd content exceeding a certain limit value is expected to have similar economic impacts as putting in place a limit value on Cd in fertilisers. It would, however, offer more flexibility to the producers who can choose between putting only low Cd fertilisers on the market (with associated costs) or paying the charge.

MONITORABILITY

Besides monitoring of Cd content an additional monitoring of the correct paying of the charges is required.

5.3.2 Economic instruments to reduce direct emissions to soil

This measure would consist of putting a charge or levy on all cadmium that is intentionally brought on agricultural land and pastures (e.g. through the use of manure, mineral fertiliser, compost, soil improvers, lime, …).

EFFECTIVENESS

The effectiveness of this measure strongly depends on the charge rate, which should be high in order to stimulate end users to switch to low Cd alternatives.

An overall lowering of the Cd input into agricultural land and pastures would have a beneficial effect on the Cd content of crops being grown or animals grazing on them. As dietary intake accounts for over 80% of total intake for the general non-smoking population and some 35% of total intake for the general smoking population, this measure has a potential to significantly lower the exposure to Cd from EU produced food. On should take into account, however, that a lot of food is imported from third countries into the EU where such measures would not apply.

A side effect of this measure might be that the products with higher Cd content will not be used for agricultural purposes anymore while other use or disposal options are not available. Care should also be taken that these higher Cd content streams are not exported for use in third countries which might lead to an increase of the Cd content in imported food.

PRACTICALITY

The administrative burden can be quite high for this option. If charge raising is made the responsibility of the Member States, care should be taken that charge levels are uniform throughout the EU in order not to distort the common market or to avoid export of high Cd materials to Member States where charge levels are lower.

ECONOMIC IMPACT

The economic impact of this measure is mainly determined on the charge rate and impact on farmers income might be significant if charge rates are high (verwijzen naar 6.3.1.2). This measure would also require intensive measuring campaigns to determine Cd contents in a broad range of products, the cost of which might also be significant.

MONITORABILITY

This measure would require the monitoring of Cd contents in a broad range of products, keeping track of the transport and use of these products and monitoring the correct payment of the applicable charges. Monitoring efforts can be assessed to be very substantial for this measure.

5.3.3 Regulatory controls to reduce emissions to the environment from industrial plants.

Regulatory controls to reduce industrial emissions to the environment are e.g.:

- Waste incineration Directive (WID);
- IPPC Directive;
- Water Framework Directive (WFD)

As already indicated, reviewing the above mentioned directives could reduce emissions from industrial plants to the environment.

EFFECTIVENESS

The WID, setting an ELV of 0.05 mg Cd/l for water and 0.05 mg/m³ for air only covers waste incineration plants (incineration and co-incineration). The share of this sector in total cadmium emissions is only 2.6% to air and 0.01% to water (RAR, 2005). It can be assumed that lowering ELVs in this Directive will only have a small impact on total cadmium emissions.

The IPPC Directive only covers large plants and implies that the installations in various sectors need to reach BAT levels. As important cadmium emitters like the non ferrous metals sector, the iron and steel industry and the large combustion plants fall under this Directive, a review of BREFs, could have an important effect on total cadmium emissions and resulting risks.

The full implementation of the WFD will lead to a zero emission of cadmium in the future and is thus very effective in view of this risk reduction strategy. The timeframe however for implementation is 20 years so it must be noted that the implementation of the WFD will only be effective in the future and not in short-term.

PRACTICALITY

How industries should comply to the above mentioned Directives is something that should be included in the implementation of these Directives itself and should not be a subject of this risk reduction strategy.

Industry comments (ICdA, personal communication, 2006) that a great part of the non-ferrous metals industry, or at least the zinc industry, would not be able to meet the intended emission limits (for example, a "zero emission" of cadmium in water as expected as a result of the Water Framework Directive is technically impossible). A much larger number of industries than the few European cadmium producers will be affected (others are the mining operations in Sweden and Ireland, smelting operations in Finland, Netherlands, Belgium, Germany, Poland, Italy, and Spain, and the recycling operations in some EU member states).

ECONOMIC IMPACT

RPA (2000) assessed the socio-economic impact of identifying cadmium as PHS under the WFD as being:

- negligible for stabilisers
- extensive but probably decreasing for pigments, plating and batteries (costs for batteries may be reduced, depending upon future legislation) and,
- extensive for unintentional sources

UK Defra (2002) assesses the impact very significant for the metals, fertilisers, batteries and surface treatment industry. Since this WFD already needs to be implemented, without the existence of the risk reduction strategy, no additional costs are to be expected.

The economic impact of reviewing BREFs and of course implementing the measures, given in these BREFs is not yet available at this time.

MONITORABILITY

Procedures to monitor the compliance with these Directives are to be developed under these Directives also.

5.4 NICKEL CADMIUM BATTERIES

Possible measures referring to NiCd batteries are discussed here in a separate chapter, since all possible measures have their influence on different scenario's and are difficult to allocate to one of the previous chapters.

5.4.1 Alternatives to NiCd batteries

Pb-acid, NiMH and Li-ion batteries can be mentioned as potentially viable alternatives for NiCd-batteries and will therefore be taken up here in this assessment.

Various parameters and technical characteristics have to be satisfied when a battery system is chosen to meet the requirements of a specific application. An important issue in the practicability of alternatives for NiCd-batteries is the fact that NiCd batteries have specific/unique characteristics.

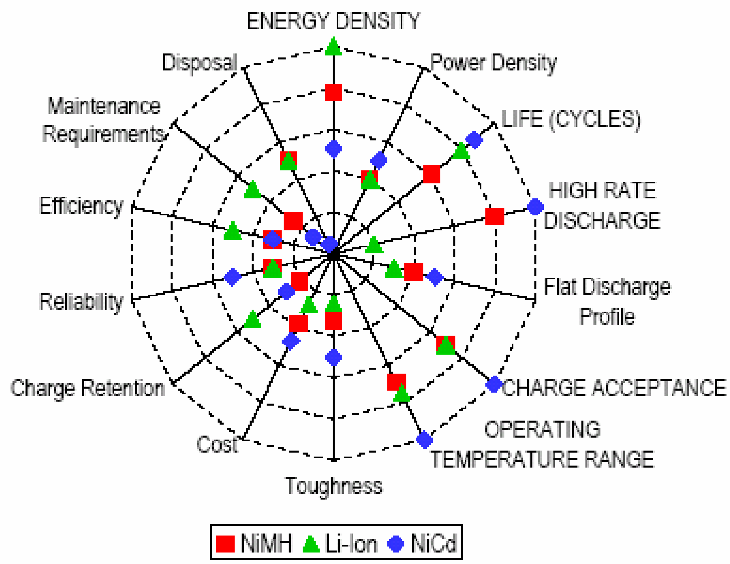
Due to their high level of safety and reliability for people and equipment, often in extreme conditions, NiCd-batteries are selected over and over by corporate customers for uses where reliability is the key decision factor. For example, NiCd-batteries are the only technology approved to supply emergency power to commercial airplanes in a situation where the normal power supply is unable to reach the cockpit. NiCd batteries are often selected to provide power to various personal protection equipments such as forced air respirators for workers exposed to hazardous atmospheres, personal lighting equipment in the mining industry, emergency lighting systems in public buildings and tunnels, infusion pumps and defibrillators for therapeutic uses. Finally, their very low maintenance requirements and long life and reliability give them an edge in many distributed networks: the infrastructure of the gas, oil, electrical and telecommunications industries typically use industrial NiCd-batteries for their networks (SAFT, 2005).

The practicality of a substitution of NiCd batteries by alternative rechargeable batteries is well described by ERM (2004). They state that the key alternative battery technologies that might replace NiCd are NiMH and Li-ion. Based on other studies (NATIBO, 1999; EPTA, xxx; Linden *et al.*, 2002 and Aalborg University, xxx) in which these three batteries were scored against different performance criteria, ERM produced a spider diagram, showing the average scores of previously mentioned studies. To produce the final scores, ERM gave a bigger weight to five criteria:

- Energy Density (Discharge <1°C): How big/heavy a battery must be for a given amount of stored energy
- Life (Cycles): How many charge/discharge cycles before battery failure
- High Rate Discharge (>10 amps): Translates to how much torque the power tool can deliver
- Fast Charge: How quickly a drained battery can be recharged
- Operating Temperature Range: In particular, how cold before the battery performance drops noticeably

Summing the ratings for each criterion gives NiCd-batteries a rating of 7.6 versus 7.0 for Li-ion and 6.6 for NiMH. This is a difference of 8.7% between NiCd and Li-Ion. The results are visualised in a spider diagram in Figure 5.4.1. Scored against these criteria, NiCd batteries seem to have the best performance characteristics.

Figure 5.4.1: Spider diagram of rechargeable battery performance (ERM, 2004)



It should be noted that the rating presented above does not take into account the fact that every battery selection is made in response to a unique set of needs, reflected in a unique set of weights given to each characteristic (the above spider diagramme ignores the relative weight attached to the different characteristics when selecting a solution). Industrial NiCd batteries are selected when reliability, robustness, cycling ability, performance at high and/or low temperatures are needed. The adequacy of the NiCd solution relative to other technologies when these are the requirements put forth by the end-users is much greater than what is reflected by the 8.7% described above.

Nilsson A.O. (unknown) also mentions that the major disadvantages with NiMH cells are their narrow operating temperature range, relatively short cycle life, high heat dissipation during charging, and very limited tolerance to overdischarge. All of these cell deficiencies can result in significant risk of individual cell imbalance in multicell batteries.

CollectNiCad (2001) also states that NiCd batteries are performing in conditions where other batteries cannot be used, like at temperatures above 40°C. Even in the medium temperature range (0-25°C) NiCd batteries remain the best choice. A substitution to lead-acid would impose a need for increased maintenance and an overall lower performance.

One of the gaps, identified in the ERM (2004) study is the fact that environmental performance was not included in the assessment. To fill in this gap, a report on the "Contribution of Spent Batteries to the Metal Flows of Municipal Solid Waste" was written (EURAS, 2005). In this report, emissions to the environment have been based on emission data, quantified in several EU-Risk Assessment Reports (RAR) for metals such as lead, zinc, cadmium and nickel. From these individual RAR, it was possible to consolidate information in order to evaluate the respective contribution of different types of spent batteries systems to the overall metallic emissions.

The study (EURAS, 2005) takes into consideration measured data on the overall metallic content of Municipal Solid Waste (MSW) and also on the content of spent batteries in MSW. These data have been obtained in countries where collection schemes for spent batteries have been in operation for several years: Austria, Belgium, Sweden, The Netherlands, France and Germany. In those countries, it is also possible to quantify the specific and relative contribution of batteries to metals emissions from MSW. The study takes also into consideration the fact that in a majority of Member States there is yet no collection programme in place.

The main waste strategies considered for MSW in this report are landfilling and incineration. Based on measured emissions data and on estimated scenarios, the environmental contribution of different battery types (both primary and rechargeable batteries) to the overall emissions of nickel, cadmium, zinc and lead is evaluated.

Considering cadmium emissions to the air compartment (total of 124 Tonnes), the incineration of MSW only contributes 2.6 % to the overall cadmium emissions to air. With regard to water emissions (total of 39.1 Tonnes), the contribution of landfilling and incinerating MSW to water emissions are minor (2.3 %).

It was concluded that the relative contribution of the Municipal Solid Waste phase is limited to a few percent to the overall cadmium emissions from all anthropogenic sources. The same conclustion was drawn for metals used in other batteries (Pb, Zn, Ni). When the contribution of spent batteries is considered it is clear that the environmental contribution of the metals present in batteries to the overall metal load is limited. The following contributions were evaluated according to the results obtained in this report. In the case of cadmium, Ni-Cd batteries would account for 17 % of the observed Cd content of MSW or approximately 0.5 % of overall cadmium emissions to air and to water.

Indeed, during the post-consumer phase, the environmental contribution of the different battery systems (Zn-C, Alk-Mn, Ni-Cd, Ni-MH and Pb-Acid) to the overall anthropogenic metal emissions towards the environment is small to negligible in comparison with the nickel, zinc, lead and cadmium emissions from other anthropogenic sources. Ni-Cd batteries contributes 0.4 % to total air emissions (equal to 0.5 tonnes Cd) and 0.4 % to total water emissions (i.e. 0.15 tonnes Cd). Ni-based batteries contribute 0.021 % (i.e. 0.1 tonnes Ni) and 0.4 % (i.e 2.5 tonnes Ni) to the nickel air and nickel water emissions of all sources. An estimated 0.05 % (1 tonnes Zn) of all anthropogenic zinc emissions to the air can be allocated to the end-of-life stage of primary EURAS Final Report 6 batteries (Zn-C; Zn-alk). The emissions to water are very small (0.006 % or 0.5 tonnes Zn) in comparison with other sources. In a similar way the contribution of Pb-acid batteries to the overall lead load is negligible (0.007 % (i.e. 0.1 tonnes Pb) to air, 0.01 % (i.e. 0.1 tonnes Pb) to water).

Although the contribution of batteries to the metal emissions from Municipal Solid Waste have been estimated based on data that have been obtained in countries where collection schemes for spent batteries are in operation for several years, the conclusions reached can be extended to those countries which have not yet a dedicated collection system in place. Indeed, when no dedicated collection system is in place emissions for zinc can be calculated with a factor of 3.7 higher than emissions obtained when collection systems are in operation. It would result in an emission to air of 3.7 tonnes Zn (0.2 % overall Zn air emissions) and 1.9 tonnes Zn to the water (0.02 % overall Zn water emissions) which are still representing a minor fraction of overall emissions.

For rechargeable batteries the case of a 10 % collection rate was calculated in the frame of the Targeted Risk Assessment Report on the use of cadmium in batteries (TRAR). It was calculated that the difference in potential emissions due to batteries between a country with a collection system in place and one with no collection system in place is a factor of 3.6. If this factor is applied, it leads to an emission to air of 1.8 tonnes Cd (1.4 % overall Cd air emissions) and 0.5 tonnes Cd to the water (1.4 % overall Cd water emissions) which are still minor fractions of total emissions from anthropogenic sources.

Based on the above-mentioned studies, we can conclude that other technologies are available for rechargeable batteries, but in those industrial applications were NiCd batteries are selected, no other technology is able to deliver the expected level of performance on the required criteria.

5.4.2 Evaluation of various policy options regarding NiCd batteries

From the targeted risk assessment on NiCd batteries it became clear that exposure may arise during the production and recycling phase and during the disposal phase (waste incineration or landfill) of these batteries. No exposure arises during the use phase if these batteries are used in a way they are supposed to be.

In the production and recycling phase occupational exposure may take place as well as release to the environment (mainly air and water) which contribute to the exposure of man indirectly through the environment. Reduction of occupational exposure is addressed in 5.1.1 and the measures presented there are applicable to the production and recycling industry for NiCd batteries as well. Release to the environment during production and recycling may present an important local source but the overall emission to the environment from these activities are low compared to other sources (fertilisers, fossil fuels, iron and steel, non ferrous metal plants, …), meaning that the contribution of these emissions to the regional and continental level are low.

Releases to the environment during the disposal phase can be addressed in three ways:

- Ban on NiCd batteries, which would also reduce occupational exposure during production and recycling of these batteries;
- Increased collection and recycling targets for NiCd batteries so that the amount for disposal decreases;
- More stringent limit values for waste incineration (air + water) and landfiil (water), which would also reduce the quantity of Cd released from other sources in the waste fraction.

In the extended impact assessment on selected policy options for revision of the batteries Directive, the option of a ban on NiCd batteries was compared to the option of increased collection and recycling targets for NiCd batteries (Bio Intelligence Service, 2003):

- A ban on NiCd batteries will not lead to an immediate 'no exposure' situation because batteries which will become waste after the ban and batteries discarded after being hoarded will still have to be treated, meaning that collection and recycling infrastructure will have to remain in place for years after the ban while collected quantities will slowly decrease over the years. Increased collection and recycling will have a beneficial effect on a number of environmental indicators like emission of Cd, NO_x and SO_2 and primary energy consumption. The higher the collection and recycling rate, the higher the environmental benefits will be.
- The most suitable alternative for NiCd batteries would be NiMH batteries whose life expectancy in terms of number of charging cycles is between 1/3 and ½ of that of NiCd batteries, meaning that the quantity of portable batteries for recycling or disposal might double or triple. For domestic tools, it is often necessary to replace the entire tool because the battery is in a sealed unit and can not be removed/replaced.
- A ban was only estimated to be feasible for the market segment of household applications with the exception of cordless power tools. The market segment for which replacing of NiCd batteries is deemed possible only represents about 30% of the portable NiCd batteries. For cordless power tools, high power delivery is the most critical parameter and therefore only NiCd seem to be appropriate. On the other hand, in a study from the Nordic Council of Ministers it has been shown that in the Scandinavian market NiMH batteries is 60-90% for professional tools and 30-50% for tools on the DIY market (Norden, 2005). The high figure of 90% for professional tools is only stated for Sweden and contrasts sharply with the penetration of NiMH batteries in the professional market for other Scandinavian countries.
- Additional costs to consumers of a ban on NiCd batteries in household applications was estimated in between 825 and 1,995 million Euro, although prices of alternatives are likely to lower when demand increases. When domestic tools would have to be entirely replaced because of a sealed battery compartment, costs to households would even be significantly larger. Depending on whether or not sufficient recycling capacity is available for the alternatives, additional costs for disposal would range between 0 and 1.3 million Euro. Depending on the targets set for collection and recycling, additional costs may amount to 140-225 million Euro (50-60% target), 345-420 million Euro (60-70% target) and 475-570 million Euro (70-80% target). The significant increase

in additional costs once the target exceeds 50% is mainly due to the need for intensive awareness raising campaigns (lower levels of hoarding).

As mentioned in section 3.3.2 of this report, SAFT has implemented since the early 1990's a take back policy for its industrial batteries. This voluntary collection programme has been recognized as an efficient approach to ensure that industrial NiCd batteries do not end up in uncontrolled waste streams.

In conclusion it can be stated that the current approach of setting more stringent goals for collection and recycling taken in the revision of the battery Directive (COM(2003) 723 final)[20] is the one that will lead to the highest level of environmental protection for the lowest socio-economic cost. When the current proposal for the revision of the battery Directive is implemented, there is no need for additional measures to be taken for the NiCd batteries.

For the option of ban of NiCd batteries, the four criteria were assessed.

EFFECTIVENESS

Prohibiting NiCd batteries would be effective in removing workers from potential occupational Cd exposure. It would have a negligible impact in reducing the Cd uptake for the general population, since the uptake coming from other sources such as smoking or dietary intake is much more important.

One should also take into account that such a ban would have no effects on Scenario 3 (general population in the vicinity of point sources) and on the overall release of Cd to the environment, as the contribution of NiCd battery recycling and production is really low (cfr. supra).

On the other hand is should be noted that EU manufacturing for export to non-EU countries (batteries from all segments : oil industry, power plants, aerospace back-up systems, emergency lighting…are exported) would still be allowed, and potential occupational exposure would still be possible.

The reduction in use of Cd compounds (Carc. C2) would have to be balanced with the effects of the weight increase in use of other hazardous substances such as Pb (Reprotox. R1) or Ni compounds (classification to be issued in the near future).

PRACTICALITY

As long as other battery technologies with comparable performance levels in the criteria where NiCd batteries deliver excellent results are not available, forced replacement of these batteries would lead to major deterioration of the performance levels of industrial systems. This is generally considered to be unacceptable by industry.

If the hypothesis whereby the reduction in the quality of service could be ignored, the very electrical system that the battery is supposed to power would have to undergo major redesign, since the electrical characteristics of different battery technologies are rather different from one another (not interchangeable 'plug and play').

Furthermore, under the same hypothesis, it should also be noted that the battery management systems (for the purpose of charging, monitoring and optimizing battery use) and all physical housings would have to be redesigned to allow for other technologies to be implemented.

[20] The proposed Directive sets a target of 80% for collection of NiCd batteries. All cadmium and 75% by average weight of the materials in the collected NiCd batteries need to be recycled.

Finally, the impact of the additional maintenance operations (due to shorter life and reduced reliability) which would have to be implemented should be assessed in the areas of increased transportation costs, additional waste generated, direct and indirect costs induced.

ECONOMIC IMPACT

The redesign of these industrial systems is likely to involve major equipment redesigns (train rolling stocks, railway fixed assest for safety, aircraft back-up systems, safety lighting in public buildings, oil/electrical power-plant stand-by power systems…). The costs to retrofit these fixtures designed to last for more than 30 years is hard to estimate but will be large (de Metz, personal communication).

Futhermore, the business loss to companies specializing in these battery technologies would jeopardize their very survival (European headcount : > 2000)

MONITORABILITY

An independant body could be entrusted with the role to supervise such a measure.

5.5 SUMMARY

An overview of the assessment of possible further risk reduction measures for occupational and consumer exposure and for the environment is presented in Table 5.5.1 to Table 5.5.3.

Table 5.5.1: Overview of the assessment of possible further risk reduction measures for occupational exposure

	Effectiveness	*Practicality*	*Economic impact*	*Monitoring*
Occupational exposure limit values				
OEL	-/+	+	-/?	-/?
OEL + BLV	+	+/- (1)	-/?	-/?
Extended health surveillance of workers	+	+/-	-/ ?	-/ ?
Industry initiative	+	+	+/-	-
Substitution				
Plating	+	-/+	+	+
Alloys	+	-/+	+	+
Stabilisers	+	+	-	+
Pigments	+	-/+	-	+
Collective exposure reduction measures	-/+	+	-/?	-/?
Training / Safety data sheets	+	+	+	+
PPE	+	+	+	+
NiCd batteries	-/+	-	-	+

(1) dependant of industry sector

Table 5.5.2: Overview of the assessment of possible further risk reduction measures for consumers

Risk reduction measure	*Effectiveness*	*Practicality*	*Economic impact*	*Monitorability*
M&U for Cd containing brazing sticks	+	+	?	+
M&U for Cd-containing jewellery	+	+	+	+

Table 5.5.3: Overview of the assessment of possible further risk reduction measures for the environment

Risk reduction measure	*Effectiveness*	*Practicality*	*Economic impact*	*Monitorability*
Eu-wide limits on Cd in fertilisers	+	+	-/+	+
Charge on Cd-content in fertilisers	Dependant of charge rate	-	+	+
Regulatory controls to reduce emissions from industrial plants	+ (in future)	-	+/?	+

6 RISK REDUCTION PROPOSAL

In section 5 of this report, possible further risk reduction measures were assessed against the four criteria: effectiveness, practicality, economic impact and monitorability. Based on this assessment a final recommendation is given here to reduce the identified risks in the Environmental and Human Health Risk Assessment.

GENERAL COMMENTS

In the Risk Assessment report, a conclusion (i) was reached for risks for the environmental compartments water and sediment because of the following reasons:

- Aquatic compartment: there is a need for better information regarding the toxic effects of cadmium to aquatic organisms under low water hardness conditions (very soft waters, hardness below about 10 mg $CaCO_3$/l). There are no data for the very soft waters and these areas may be unprotected by the proposed $PNEC_{water}$ (Predicted No Effect Concentration) for soft water (0.08 µg Cd/L)
- Sediment: there is a need for further information regarding the bioavailability of cadmium in order to possibly refine the assessment at regional and local level.

For workers and man indirectly exposed via the environment the RAR also indicates that further information is needed to better document the possible neurotoxic effects of CdO suggested in experimental animals, especially on the developing brain. The information requirements are further epidemiological and experimental information to identify more precisely the nature of the effects, the characterisation of the exposure and the mechanism of action related to neurotoxicity. These investigations should mainly focus on effects on the developing brain (prenatal and early childhood exposure). Effects on the adult nervous system should also be characterised. This is however taken into account in the current risk reduction strategy report.

The collection of additional information should, however, not delay the implementation of appropriate control measures needed to address the concerns related to the other endpoints. All measures, proposed in the following paragraphs, aim at reducing the exposure of workers and consumers to Cd and CdO and reducing the risks for the environment, which means that these measures will also contribute to a reduction of possible above mentioned effects.

REDUCING OCCUPATIONAL EXPOSURE

Setting up an extended health surveillance program for workers seems to be a very good measure to reduce occupational exposure of workers to cadmium. The effectiveness of a extended health surveillance program, including the monitoring of Cd-U, Cd-B and low molecular weight proteins (RBP, β2MG) lays in the fact that not only exposure, but also effects can be monitored on an individual basis. Even more effective than an extended health surveillance program is a comprehensive occupational exposure monitoring program. Such a program does not only include health surveillance, but a comprehensive predesigned program that includes air concentration measurements at the workplace, biological monitoring of exposure and effects and above that a complete description on how to act in case certain indicators exceed certain levels. Such a program could be implemented under Directive 2004/37/EC on the exposure to carcinogens or mutagens at work.

As good alternative however would be a voluntary agreement between industry and the government offers an excellent alternative here. Industry already designed a comprehensive occupational exposure program (See Annex 6). The fact that this voluntary agreement would involve only about 15 companies increases its effectiveness. The effectiveness of a comprehensive occupational exposure monitoring program is already proven by putting it in practice in Sweden and the US. In all plants dealing with cadmium exposure the implementation of a health surveillance program is common practice (ICdA, personal communication, 2006). The comprehensive program, developed by industry comprises step-by-step decisions to be taken in specific situations and are triggered when certain parameters exceed certain levels, under which, good information to the workers, training, personal protective equipment, an extra health examination, transfer workers to another part of the company,…

The effectiveness of setting up a voluntary agreement between de Cd-industry and the European Commission on the implementation of a comprehensive occupational exposure monitoring program could be strenghthened by assuring a legal framework. Therefore Targets would be set in line with Resolution 97/C 321/02 [2] and Recommendation 96/733/EC [3]. Agreements should in all cases:

- take the form of a contract, enforceable either under civil or under public law;
- specify quantified objectives and indicate intermediary objectives with the corresponding deadlines;
- be published in the national Official Journal or as an official document equally accessible to the public;
- provide for the monitoring of the results achieved, for a regular reporting to the competent authorities and for appropriate information to the public;
- be open to all partners who wish to meet the conditions of the agreement.

And agreements should, where appropriate,

- establish effective arrangements for the collection, evaluation and verification of the results achieved;
- require the participating companies to make available the information regarding the implementation of the agreement to any third person under the same conditions applying to public authorities under Council Directive 90/313/EEC of 7 June 1990 on the freedom of access to information on the environment;
- establish dissuasive sanctions such as fines, penalties or the withdrawal of a permit, in case of non-compliance.

For a legal framework to strengthen the effectiveness of a voluntary agreement, we can refer to the Commissions Communication on Environmental Agreements (adopted second reading on 17 July 2002). This 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). Policy makers have shown an increasing interest in environmental agreements in recent years. Environmental Agreements are largely recognised as offering a number of potential benefits, including stimulating a pro-active approach by industry, cost-effectiveness and faster achievements of environmental objectives. The proposed procedural requirements differ according to the use of environmental agreements in the context of Self-regulation or of Co-regulation.

REDUCING RISKS FOR CONSUMERS

Risks identified for consumers are the result of the use of Cd-containing brazing sticks and wearing Cd-containing jewellery. Based on the assessment in chapter 5.2 of this report, marketing and use restrictions for these applications seems to be the most effective, practical and monitorable measure with an acceptable economic impact. For the use of Cd-containing brazing sticks, a voluntary agreement between industry and the relevant national authorities might also be sufficient to reduce the risks in an appropriate way since this is a limited, well-defined industry with only a few players.

REDUCING RISKS FOR THE ENVIRONMENT

Risks were identified in the RAR for the local surface water at 1 Cd metal production site and 4 processing sites, the local terrestrial compartment at cadmium plating and alloy production sites, the regional terrestrial ecosystem in one region (UK), secondary poisoning at the regional level and for on-site and off-site sewage treatment plants.

The assessment in chapter 5.3 however shows that a reduction of emissions will automatically result from the further implementation of already existing legislation like the Water Framework Directive, IPPC Directive, the Urban Wastewater Treatment Directive, …. A profound assessment of the effectiveness, practicability, economic impact and monitorability of these measures should be performed within the legal framework of each specific legislation. Based on that, the necessity to review this legislation should be evaluated. As a consequence, specific proposals to review this legislation is not covered for in this risk assessment report and no extra risk reduction measures are deemed necessary.

To reduce Cd-input to soil, according to the assessment made in chapter 5.3 of this report, setting EU-wide limits on the cadmium content of fertilisers is an effective measure (allowing phosphate fertilisers with only 20 mg Cd/kg P_2O_5 would lead to a decrease of Cd input in the soil through us e of phosphate fertilisers with 37.7%). Lowering the Cd input into soil would also result in a significant decrease of Cd intake for the general population.

CONSULTEES

ICdA	Regoli Lidia, general manager
JMB	Dean Christopher R.S., pigments division manager
Oskarshamm	Dr. Spång, occupational doctor
RGE Consulting Environment/ Recystem-Pro	Eloy Robert, environmental consultant
Saft	de Metz Patrick, Corporate environmental affairs director
Zinifex - Budel Zinc	Schuurmans Erik L., Arbeidshygiënist Veiligheidskunde (Inudstiral hygiëne expert safety matters)

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ANNEXES

Annex 1: Health and safety data sheet for Cadmium pigments (all shades) (James M. Brown Limited, 1995)

James M. Brown Limited

Napier Street, Fenton, Stoke - on - Trent, Staffs ST4 4NX, UK
Telephone (01782) 744171 Fax (01782) 744473

Health & safety data sheet

CADMIUM PIGMENTS (ALL SHADES)

January 1995 : Edition 1 (ORIGINAL)
File name : "CAD_PIGS"

General description of product :-

This data sheet covers the entire range of JMB cadmium pigments from primrose through to maroon.

Uses :- Cadmium pigments are used for the colouration of plastics, in surface coatings and in enamelling. They are also used in the manufacture of ceramic colours and artist's colours.

COMPOSITION/INFORMATION ON INGREDIENTS

Constituent	Formula	CAS No	Comments
CADMIUM SULPHOSELENIDE	$CdS_{1-x}Se_x$	-	in cadmium oranges and reds
CADMIUM ZINC SULPHIDE	$Cd_{1-x}Zn_xS$	-	in cadmium yellows
BARIUM SULPHATE	$BaSO_4$	7727-43-7	in extended pigments only

HAZARDS INFORMATION

Over-exposure to cadmium compounds for long periods can result in reduction of lung and kidney function. HSE has produced a detailed Guidance Note EH1 "Cadmium : health & safety precautions" : this reviews the monitoring precautions which need to be taken in the case of workers exposed to significant levels of cadmium. It is suggested that this Guidance Note should be consulted.

FIRST-AID MEASURES

Remove from exposure
If in eyes, wash out with plenty of clean water. If redness or soreness develops, seek medical advice - taking this data sheet.

Remove material from skin with soap and water.
If inhaled in quantity, seek medical advice - taking this data sheet.
In ingested in quantity, seek medical advice, taking this data sheet.

FIRE-FIGHTING MEASURES

Extinguishing media: water ✓ CO2 ✓ dry powder ✓ BCF ✓
Water is the preferred medium
At very high temperatures, may evolve toxic cadmium (and in the case of reds, selenium) fumes, together with sulphur dioxide. Fire fighters should therefore wear totally-enclosed breathing apparatus.

ACCIDENTAL RELEASE MEASURES

Wear full protective equipment as in section on 'PERSONAL PROTECTION'
DAMP down spilled material to minimise dust levels.
Shovel up spilled material and seal in plastic bags.
Do not allow spilled material to enter drains or water courses. If this happens, alert the local water authority and/or NRA. Advise them of the material involved. It should be pointed out that the material is of very low water solubility.
Any SMALL remaining spillage may be safely hosed away.
Dispose of collected material as in section on 'DISPOSAL'

HANDLING AND STORAGE

Store away from concentrated acids
Store away from food, drink and animal feeding stuffs
Do not eat, drink or smoke when using this material
Keep container sealed when not in use
If possible, use under local exhaust ventilation to minimise dust levels. A face velocity of 0.5 - 1 m/s is suggested. HSE publication HS(G)37 "Introduction to local exhaust ventilation" (1993 revision) gives much useful guidance on LEV and should be consulted. HSE also publishes document EH 44 "Dust : general principles of protection" which should also be consulted.

EXPOSURE CONTROLS/PERSONAL PROTECTION

HSE has produced a guidance document "EH 1 Cadmium health & safety precautions". At present, this is the 1986 edition. This is being revised by HSE, largely at the insistence of industry, to bring it up to date.

HSE document EH 40/93 lays down an MEL for cadmium pigments of 0.04 mg/m3 (as Cd) for an 8-hour TWA. This is based on the RESPIRABLE fraction of the dust. HSE has announced that whereas the dust-in-air limits for other camium compounds are being halved from March 1994, that for cadmium pigments will remain unchanged.

In the case of JMB cadmium pigments, it is known that the ratio of respirable : total dust is typically 1:5. Therefore, the above limit may generally be interpreted as a limit for TOTAL Cd of 0.2 mg/m3. It should be emphasised, however, that the respirable limit laid down in EH 40 is legally binding.

As regards the use of these materials overseas, all relevant national legislation must be complied with.

Wear overalls, goggles and gloves when using this material to reduce exposure.
If local exhaust ventilation is not available, then use of a dust mask conforming to the requirements of BS EN 149 is suggested

PHYSICAL AND CHEMICAL PROPERTIES

Appearance: yellow/orange/red powders
Odour: none
Melting point: > 1000°C
Boiling point: NOT APPLICABLE
Water solubility: insoluble
pH of solution/extract: approx 7
Density: 3 - 5
Bulk density: approx 1

Flammable ?: NO
Flash point: NOT APPLICABLE
Autoignition point: NOT APPLICABLE

Reducing agent: NO
Oxidising agent: NO
Customs code: 320630 00 0 00
EINECS number: listed
EEC number:

STABILITY AND REACTIVITY

Produces toxic hydrogen sulphide with concentrated acids

TOXICOLOGICAL INFORMATION

Reported acute toxicity for this material (LD50 oral rat) is > 5000 mg/kg

ECOLOGICAL INFORMATION

No specific information available

DISPOSAL CONSIDERATIONS

Contact supplier regarding possible return of unwanted material.
Do not burn or re-use contaminated containers.
Dispose of contaminated material following the requirements of the Environmental Protection Act 1990 and observing the requirements of the "Duty of Care".

Outside UK, dispose of this material in accordance with all relevant national and local legislation.

Further information on the chemical composition of particular materials can be provided in order to ensure that they are disposed of using a safe method.

TRANSPORT INFORMATION

UN number: NONE
Packing group: NONE
Hazard class: NONE
Tremcard number: NONE
Hazchem number: NONE

This material is NOT classed as hazardous for transport by any route.

REGULATORY INFORMATION

Statutory hazard description :- NOT APPLICABLE

No statutary safety phrases are required under the UK Chemicals (Hazard Information and Packaging) Regulations.
No statutary risk phrases are required under the UK Chemicals (Hazard Information and Packaging) Regulations.

OTHER INFORMATION

All JMB products covered by this health & safety data sheet have a 'CADMIUM PIGMENT' label attached to every drum.

JMB cadmium pigments conform to the Council of Europe limits for acid-soluble cadmium laid down for food-contact use. The maximum allowable result is 0.01 % Cd and a typical result on a JMB cadmium pigment would be < 0.0005 % Cd. A position paper on this subject is available on request.

Tests carried out by JMB have demonstrated that polymers pigmented with up to 1 % of JMB cadmium pigments give levels of extractable cadmium (and, for reds, selenium) well within the limits laid down in EN 71 part 3. This does not, of course, remove the responsibility to carry out the required tests on any finished toy. A position paper on this subject is available on request.

Apart from a few pigments manufactured to meet specific customer requirements, all JMB cadmium pigments give levels of extractable cadmium well below the limits set by the US "TCLP" requirements.

EC Directive 91/338/EEC restricts the use of cadmium pigments in certain plastic systems : this has been implemented in the UK by the Environmental Protection (Controls on Injurious Substances)(No.2) Regulations 1993 (SI 1993 No. 1643)

IMPORTANT NOTE

This data-sheet gives information on the HAZARDS involved in the use of this material : it cannot, however, cover the RISKS associated with such use. This assessment, required by the UK Control of Substances Hazardous to Health (COSHH) Regulations, can only be carried out by the end-user in the light of the actual conditions of use.

DISCLAIMER

Although the data given on this sheet is believed to be both complete and up-to-date, due to the many factors outside our control when the product is used, we cannot accept liability for any accident, injury or damage caused through its use.

---------------------------- END OF DATA-SHEET ----------------------------

Annex 2: Annex I from the Directive 83/513/EEC.

ANNEX I

Limit values, time limits fixed for compliance with these values and monitoring procedures to be applied to discharges

1. *Limit values and time limits*

Industrial sector (1)	Unit of measurement	Limit values which must be complied with as from	
		1. 1. 1986	1. 1. 1989 (2)
1. Zinc mining, lead and zinc refining, cadmium metal and non-ferrous metal industry	Milligrams of cadmium per litre of discharge	0,3 (3)	0,2 (3)
2. Manufacture of cadmium compounds	Milligrams of cadmium per litre of discharge	0,5 (3)	0,2 (3)
	Grams of cadmium discharged per kilogram of cadmium handled	0,5 (4)	(5)
3. Manufacture of pigments	Milligrams of cadmium per litre of discharge	0,5 (3)	0,2 (3)
	Grams of cadmium discharged per kilogram of cadmium handled	0,3 (4)	(5)
4. Manufacture of stabilizers	Milligrams of cadmium per litre of discharge	0,5 (3)	0,2 (3)
	Grams of cadmium discharged per kilogram of cadmium handled	0,5 (4)	(5)
5. Manufacture of primary and secondary batteries	Milligrams of cadmium per litre of discharge	0,5 (3)	0,2 (3)
	Grams of cadmium discharged per kilogram of cadmium handled	1,5 (4)	(5)
6. Electroplating (6)	Milligrams of cadmium per litre of discharge	0,5 (3)	0,2 (3)
	Grams of cadmium discharged per kilogram of cadmium handled	0,3 (4)	(5)
7. Manufacture of phosphoric acid and/or phosphatic fertilizer from phosphatic rock (7)		—	—

(1) Limit values for industrial sectors not mentioned in this table will, if necessary, be fixed by the Council at a later stage. In the meantime the Member States will fix emission standards for cadmium discharges autonomously in accordance with Directive 76/464/EEC. Such standards must take into account the best technical means available and must not be less stringent than the most nearly comparable limit value in this Annex.

(2) On the basis of experience gained in implementing this Directive, the Commission will, pursuant to Article 5 (3), submit in due course to the Council proposals for fixing more restrictive limit values with a view to their coming into force by 1992.

(3) Monthly flow-weighted average concentration of total cadmium.

(4) Monthly average.

(5) It is impossible for the moment to fix limit values expressed as load. If need be, these values will be fixed by the Council in accordance with Article 5 (3) of this Directive. If the Council does not fix any limit values, the values expressed as load given in column '1. 1. 1986' will be kept.

(6) Member States may suspend application of the limit values until 1 January 1989 in the case of plants which discharge less than 10 kg of cadmium a year and in which the total volume of the electroplating tanks is less than 1,5 m^3, if technical or administrative considerations make such a step absolutely necessary.

(7) At present there are no economically feasible technical methods for systematically extracting cadmium from discharges arising from the production of phosphoric acid and/or phosphatic fertilizers from phosphatic rock. No limit values have therefore been fixed for such discharges. The absence of such limit values does not

release the Member States from their obligation under Directive 76/464/EEC to fix emission standards these discharges.

2. Limit values expressed as concentrations which in principle must not be exceeded are given in the above table for the industrial sectors in sections 2, 3, 4, 5 and 6. In no instance may limit values expressed as maximum concentrations be greater than those expressed as maximum quantities divided by water requirements per kilogram of cadmium handled. However, because the concentration of cadmium in effluents depends on the volume of water involved, which differs for different processes and plants, the limit values, expressed in terms of the quantity of cadmium discharged in relation to the quantity of cadmium handled, given in the above table must be complied with in all cases.
3. The daily average limit values are twice the corresponding monthly average limit values given in the above table.
4. A monitoring procedure must be instituted to check whether the discharges comply with the emission standards which have been fixed in accordance with the limit values laid down in this Annex.

   This procedure must provide for the taking and analysis of samples and for measurement of the flow of the discharge and the quantity of cadmium handled.

   Should the quantity of cadmium handled be impossible to determine, the monitoring procedure may be based on the quantity of cadmium that may be used in the light of the production capacity on which the authorization was based.
5. A sample representative of the discharge over a period of 24 hours will be taken. The quantity of cadmium discharged over a month must be calculated on the basis of the daily quantities of cadmium discharged.

   However, a simplified monitoring procedure may be instituted in the case of industrial plants which do not discharge more than 10 kg of cadmium per annum. In the case of industrial electroplating plants, a simplified monitoring procedure may only be instituted if the total volume of the electroplating tanks is less than 1,5 m^3.

Annex 3: MSDS of Cadmium metal (Xstrata zinc, 2005)

xstrata zinc	**Refined Cadmium**	
	Safety data sheet as per dir. 91/155/EC	Page 1 of 8

1. Product and Company Identification:

1.1 Product identity:

1.1.1	Trade name:	Refined Cadmium with at least 99.99% Cd in solid form (e.g. balls or sticks)
1.1.2	Chemical Name:	Cadmium
1.2.	Use:	Manufacture of Ni/Cd batteries etc.
1.3	Manufacturer / supplier:	Xstrata Zink GmbH Johannastr. 1 26954 Nordenham Germany Telephone +49 (0) 4731 368 2 Telefax +49 (0) 4731 368 603
1.4	Emergency hotline:	Telephone +49 (0) 4731 368 2

2. Composition / Component Details:

2.1 Chemical characterisation (individual substance):

2.1.1 CAS-No.: 7440-43-9 2.1.2 EINECS-No.: 231-152-8

2.1.3 Classification: T+, N

2.1.4 Add. information: -

2.2 Chemical characterisation (preparation): -

No.	Components	CAS-No.:	Content	Unit	Designation code

2.2.7 Add. information: -

3. Hazards Identification:

Very toxic by inhalation. (R26)
May cause cancer. (R45)
Possible risks of irreversible effects. (R68)
Possible risk of impaired fertility. (R62)
Possible risk of harm to the unborn child. (R63)
Toxic: danger of serious damage to health by prolonged exposure through inhalation and if swallowed. (R48/23/25)
Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment. (R50/53)
There is no danger from the solid metal in the supplied state.

	Refined Cadmium	
xstrata zinc	Safety data sheet as per dir. 91/155/EC	Page 2 of 8

4. First Aid Measures:

4.1	General information:	In the supplied state, cadmium does not represent any risk. First Aid measures are only required if dust, fumes and aerosols are produced when working with Cd and its compounds.
4.2	After inhaling:	After inhalation of fumes and dust, take affected person out of the danger area into the fresh air, taking care to protect yourself. Keep person immobilised and take measures to prevent hypothermia. Ensure medical treatment is obtained.
4.3	After skin contact:	Skin resorption not serious. Rinse affected skin areas with running water for 10 minutes. Remove wet clothing.
4.4	After eye contact:	Rinse affected eye with generous quantities of water; call an eye specialist.
4.5	After swallowing:	If patient is not unconscious, apply activated carbon with a large quantity of water. Immediate medical treatment necessary.
4.6	Instructions for the doctor:	As soon as possible, administer a metered glucocorticoid aerosol for repeated deep inhalation. See also Item 11.

5. Fire-Fighting Measures:

5.1	Suitable extinguishers:	No restrictions in the case of local fire. For burning and molten metal: dry sand and Class D fire extinguisher (powder extinguisher).
5.2	For safety reasons unsuitable extinguishers:	water for burning and molten metal.
5.3	Particular danger from the substance, its combustion products or resulting gases:	CdO fumes and dust can result in acute poisoning, if inhaled.
5.4	Special protective equipment for fire-fighting:	Always use breathing protection and helmet with visor for molten metal and flame resistant protective clothing, safety footwear with gaiters and safety gloves.

6. Accidental Release Measures:

6.1	General information:	For the product in delivery form: collect with safety gloves and place in lockable metal or plastic containers.
6.2	Person-related precautionary measures:	For dust, fumes and aerosols, use breathing, face and body protection and also safety gloves. Remove from the danger area employees who are not required for remedying the fault.
6.3	Environmental measures:	Do not permit Cd-bearing dust, salts and solutions to enter water bodies and soil. Put dust into sealed containers, immediately, if possible. Otherwise cover and block off.
6.4	Process to clean/absorb:	Pick up dust only with type-tested vacuum cleaners or sweeping machines.

7. Handling and Storage:

7.1 Handling:

7.1.1	Information on safe handling:	When working with Cd (dissolving or melting) use closed equipment or extractors, at least. Ventilate premises well. Protective procedure 4 must be applied in accordance with German Dangerous Substances Directive.
7.1.2	Information on fire and explosion protection:	Good ventilation is essential for dissolving processes where hydrogen is formed. No open flames and no sparks are permitted.

7.2 Storage:

7.2.1	Requirements for storage rooms and containers:	Keep in sealed storage and inside packaging, if at all possible.
7.2.2	Information for storage with other materials:	Observe ban on storage with other hazardeous materials. Also, do not store with acids.
7.2.3	Further details on storage conditions:	None.

8. Exposure Controls / Personal Protection:

8.1	Components with workplace-related limit values:	Observe national legislation on Cadmium and cadmium compounds.

8.2 Personal protective equipment:

8.2.1	General protective and hygienic measures:	Do not eat drink or smoke when working with it. Also, do not let it touch packaged foods. Wash thoroughly before meals. Change clothes completely after work and keep them separate. Wash the body after work.
8.2.2	Respiratory protection:	May be necessary in the case of fumes and dust.
8.2.3	Hand protection:	Necessary - but should vary with work task.
8.2.4	Eye protection:	Protective glasses or extensive eye protection may be necessary, depending on type of work.
8.2.5	Body protection:	No particular measures necessary in the case of product in supplied state. When working with molten metal, wear highly flame-resistant protective clothing.

xstrata zinc	Refined Cadmium	
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9. Physical and chemical properties:

9.1 General information:

9.1.1	Form:	Solid
9.1.2	Colour:	Fresh, slivery white and metallic lustre; Becomes matt and grey during longer storage.
9.1.3	Odour:	No odour.

9.2 Safety-relevant data:

9.2.1	pH-value:	n.a.		
9.2.2	Melting point / melting range:	321	°C	
9.2.3	Boiling point / boiling range:	767	°C	
9.2.4	Flash point:	n.a.	°C	not applicable to metallic powder!
9.2.5	Flammability solid / gaseous:	n.a.		
9.2.6	Ignition temperature:	n.a.	°C	close to boiling point
9.2.7	Spontaneous combustibility:	n.a.		
9.2.8	Fire promoting properties:	n.a.		not applicable to metallic powder!
9.2.9	Explosion risk:	n.a.		not applicable to metallic powder!
9.2.10	Lower explosion limit:	n.a.	Vol-%	
9.2.11	Upper explosion limit:	n.a.	Vol-%	
9.2.12	Vapour pressure at 50C: Vapour pressure at 394:	1 133	hpa	
9.2.13	Density at 20 °C:	8,64	g/cm^3	
9.2.14	Solubility in water at ... °C:	not so-luble	mg/l	
9.2.15	Distribution coefficient n-octanol / water:	n.d.		
9.2.16	Viscosity:	n.d.	poise	for the metal
9.2.17	Further information:			

9.3 Other Information: -

10. Stability and Reactivity:

10.1	Conditions to be avoided:	unmonitored heating
10.2	Substances to be avoided:	acids - because of corrosion and hydrogen formation (7.1.3) water with molten metal.
10.3	Dangerous decomposition products:	none for metal.
10.4	Additional information:	above melting point, increased oxidation into highly toxic reddish-brown cadmium oxide.

11. Toxicological Information:

11.1 Acute toxicity:

11.1.1 Relevant LD/LC50 – values for Cadmium:

type		value	species	source
LD50	oral	225 mg/kg	rat	GDL
LD50	oral	2330 mg/kg	rat	RAR Cadmium
LD50	oral	890 mg/kg	mouse	GDL
LC50	inhalativ	25 mg/m³	rat	GDL

11.1.2	Specific symptoms in animal tests:	The tendency of certain cadmium compounds, in inhalable form, to produce lung cancer in rats was proved in animal tests.
11.1.3	Primary irritation effect	
	skin:	Metallic cadmium has no skin irritant effect (GDL).
	eye:	No information available
11.1.4	Sensitisation:	Metallic cadmium has no sensitising effect (RAR cadmium).
11.1.5	other information:	-
11.2	Sub-acute to chronic toxicity:	With a dose of 546 mg/kg, changes in serum composition, loss of body weight and enzyme inhibitions were observed in rats (GDL).
11.3	Experience with humans:	Inhaling cadmium aerosols leads to a metallic taste in the mouth, loss of sense of smell, shortness of breath, irritation to the upper airways with coryza, retrostemal burning pain, feeling weak and cold, shivering and headaches. After a latency period of between 24 and 36 hours, pulmonary oedema may develop, with shortage of breath, thoracic pains, sputum containing blood and mucus, culminating in shock and death in serious cases. Serious pathological changes also occur in the alveoli. Fibrous bronchiolitides may be the cause of death at a later stage. Lung diseases may persist for years. 5 mg/m3 is fatal over a period of exposure of 8h; 1 mg/m3 may cause suffocation fits. After it has been taken orally, diarrhoea and vomiting and colic-type pains result. In serious cases, the following occur within minutes: sickness, vomiting, stomach pains, cramps and diarrhoea which may lead to shock and death. (GDL)
11.4	Additional information:	-

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12. Ecological Information:

12.1 Ecotoxicity:

12.1.1	Aquatic toxicity	Cadmium in solid form is not aquatically toxic. This does not apply to small particles.
12.1.2	Behaviour in sewage works:	Cadmium ions may damage the limnology of sewage works. There are threshold values for cadmium in the particular management regulations for sewage works. The Sludge Directive contains a threshold value for cadmium in sewerage sludge.
12.1.3	Contains the following substances in the list I of the EC directive 76/464/EEC:	Cadmium
12.1.4	Other information:	-
12.2	Mobility:	Mobility and bioavailability of Cd ions decreases as the pH value of the soil increases.
12.3	Persistency and biodegradability:	not applicable
12.4	Bioaccumulation potential:	High bioaccumulation potential in certain animals and plants
12.5	Other harmful effects:	-
12.6	General information:	Contamination of soil and water bodies by cadmium and its compounds must be avoided.

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13. Disposal Considerations:

13.1	Product:	
13.1.1	Recommendation:	manufacturing residue and remnants must be properly disposed of, e.g. in the scrap metal trade.
13.1.2	Waste code:	Waste name:
	06 04 05	waste containing other heavy metals
13.2	Packing:	
13.2.1	Recommendation:	packagings do not usually contain any detectable traces of cadmium. We do, however, recommend that the big bags and the film lining of the cartons be disposed of as special waste. The cartons may be recycled as recovered paper.
13.2.2	Waste code:	Waste name:
	15 01 01	paper and board packagings
	15 01 10	packagings containing hazardous residue
13.2.5	Recommended cleaner:	-

14. Transport Information:

14.1	Road / Rail:	not regulated
14.2	Inland waterway transport:	not regulated
14.3	Sea transport:	not regulated
	Marine pollutant:	no

	Refined Cadmium	
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15. Regulatory Information:

15.1 Classification as per EC directives:

15.1.1	Designation code and description of danger:		T+; highly toxic if inhaled. T; toxic if inhaled and swallowed Cancer Category 2 Mutation Category 3 Reproduction Category 3 N; environmentally hazardous
15.1.2	Danger-determining component(s) to be labelled:		Cadmium
15.1.3	R-sets:	R 26	Very toxic by inhalation.
		R 45	May cause cancer.
		R 68	Possible risks of irreversible effects.
		R 62	Possible risk of impaired fertility.
		R 63	Possible risk of harm to the unborn child.
		R 48/23/25	Toxic: danger of serious damage to health by prolonged exposure through inhalation and if swallowed.
		R 50/53	Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.
15.1.4	S-sets:	S 53	Avoid exposure - obtain special instructions before use.
		S 45	In case of accident or if you feel unwell, seek medical advice immediately. (Show the label where possible.)
		S 60	This material and its container must be disposed of as hazardous waste.
		S 61	Avoid release to the environment. Refer to special instructions / Safety data sheets.
15.1.5	Special designation of preparations acc. to directive 1999/45/EC:		Preparations for soldering or welding which contain cadmium must be specially labelled in accordance with Annex V Item B No. 6.
15.1.6	Other regulations:		Bans and restrictions acc. to directives 76/769/EEC, 2000/53/EC, 2002/95/EC, 2002/769/EC.

15.2 National regulations: Observe national legislation.

16. Other Information:

This data sheet gives our current knowledge on the environmental relevance and on the work protection of our product in its delivery state. It describes the safety requirements when using our unaltered product.

All details going beyond this have merely an indicative character, as the methods and conditions for storage, use and disposal after change of possession lie outside of our responsibility. This is why we assume no responsibility for damage and/or costs that are connected in any way whatsoever with the storage and the use of our product as well as the disposal of the resulting production residue.

Information sources:

- Dangerous substances database of German federal states (Gefahrstoffdatenbank der Länder, GDL)
- Risk Assessment Report Cadmium and Cadmium Oxide, final draft, (RAR Cadmium), European Chemicals Bureau
- WEKA- dangerous substances legislation database
- Legislation

Contact: Dr. Rodermund, Tel +49 (0)4731 368 615
Issued by: Xstrata Zink GmbH

Annex 4: SDS for cadmium oxide (Floridienne Chimie S.A., 2005)

VEILIGHEIDSINFORMATIEBLAD

1. Identificatie van de stof of het preparaat en het bedrijf

Identificatie van de stof/het preparaat

Handelsnaam : **Cadmium Oxide**

Leverancier - Fabrikant

Bedrijf: **FLORIDIENNE CHIMIE S.A.**
Quai des Usines, 12 – 7800 ATH
BELGIË

Voor informatie/noodoproepnr. Telefoonnr. : 32.68.28.19.12
Contactafdeling : Onderzoek en ontwikkeling Faxnr : 32.68.28.68.11
E-mail : reception@floridiennechimie.com

- ~~Invoerder~~
- ~~Verkoper~~

Antigifcentrum (België) 32.70.245.245

Gebruik :

2. Samenstelling en informatie over de bestanddelen

2.1 Chemische naam : /

2.2 Gevaarlijke bestanddelen :

Stof	Index (2001/59/CE)	CAS	EINECS	Class.	%
Cadmium Oxide	048-002-00-0	1306-19-0	215-146-2	Carc. Cat 2 : R 45 Muta. Cat 3 : R 68 Repr. Cat 3 : R 62 ; R 63 T : R 48/23/25 T+ : R 26 N : R 50/53	> 99

2.3 Gevaarlijke onzuiverheden : /
2.4 Andere gegevens : /

3. Risico's

Voor de risico's zie punt 2.2.
Zie ook punt 15, R & S zinnen.

4. Eerste hulpmaatregelen

Voor aanvullende informatie, zich tot een antigifcentrum richten

Een arts raadplegen en handelen als volgt :

4.1.	Inademen	:	Persoon uit de besmette zone verwijderen en in de frisse lucht brengen.
4.2	Inslikken	:	De mond met fris water spoelen. De persoon niet braken. Bewusteloze personen niet laten drinken. Een arts raadplegen.
4.3	Oogcontact	:	Onmiddellijk en langdurig (15 min.) met water spoelen. Niet in de ogen wrijven.
4.4	Huidcontact	:	Bevuilde kledij verwijderen. Huid met zeepwater grondig reinigen.

5. Brandbestrijdingsmaatregelen

5.1 Blusstoffen :

- Geschikt	:	Water / CO_2 / poeder / schuim
- Niet gebruiken	:	/

5.2	Speciale risico's	:	/
5.3	Speciale methodes van tussenkomst	:	/
5.4	Persoonlijke veiligheidsuitrusting	:	ademhalingsapparaat met onafhankelijke lucht.

6. Maatregelen bij ongewild vrijkomen

6.1	Persoonlijke maatregelen	:	Stofdeeltjes niet inademen.
6.2	Maatregelen ter bescherming van het milieu	:	het product niet in de waterkanalen of grondwater laten komen.
6.3	Reiniging	:	het product mechanisch verzamelen door opzuigen en dispersie in de atmosfeer vermijden.

7 Hantering en opslag

7.1	Hantering	:	Stofvorming vermijden.
7.2	Opslag	:	Opslaan in een droge plaats.

8. Blootstellingsbeheersing / persoonlijke bescherming

8.1.	Technische beschermingsmiddelen	:	/
8.2.	Controle parameters	:	TLV (ACGIH 1977) : 0,01 mg /m^3.
8.3.	Persoonlijke beschermingsmiddelen :		
	- Bescherming van de ademhalingswegen:		noodzakelijk bij vorming van stofdeeltjes : stofmasker met P2 filter.
	- Bescherming van de handen	:	handschoenen

- Bescherming van de ogen	:	veiligheidsbril
- Bescherming van de huid	:	werkkledij

9. Fysische en chemische eigenschappen

9.1	Fysische eigenschappen :		
	- Voorkomen	:	poeder
	- Fysisch toestand	:	vast
	- Kleur	:	bruin/rood
	- Geur	:	/
9.2	Waarde van de PH (50 g/L H_2O)	:	/
9.3.	Ontbindingstemperatuur	:	900°C
9.4.	Vlampunt	:	niet bepaald
9.5.	Zelfontbrandingstemperatuur	:	brandbaar
9.6.	Ontploffingskenmerken	:	niet bepaald
9.7.	Dampdruk	:	/
9.8.	Dampdensiteit	:	/
9.9	Massa volume	:	8.15 gr/cm³
9.10	Oplosbaarheid in	:	praktisch onoplosbaar in water - oplosbaar in zuren.
9.11	Deelcoëfficient n-octanol/water	:	/

10. Stabiliteit en reactiviteit

10.1	Stabiliteit	:	stabiel
10.2	Te vermijden omstandigheden	:	/
10.3	Te vermijden stoffen	:	Magnesium
10.4	Gevaarlijke ontledingsproducten	:	/

11. Toxicologische informatie

11.1.	Acute toxiciteit	:	LD ORAL (Rat) : 72 mg/kg
11.2.	Lokale uitwerking	:	geen gegevens voorradig
11.3.	Gevoeligheid	:	geen gegevens voorradig
11.4.	Chronische toxiciteit	:	TLV : 0.01 mg/m³ (Inademing) – Arbeidsministerie 1998 – Belgie TLV : 0.05 mg/m³ (Inademing) – INRS 1999 - Frankrijk
11.5.	Toxiciteit op lange termijn	:	/
11.6.	Typische kenmerken	:	/

12. Ecologische informatie

12.1.	Mobiliteit	:	/
12.2.	Weerstand / afbreekbaarheid	:	/
12.3.	Bio accumulatie	:	/
12.4.	Ecotoxiciteit	:	/
12.5.	Anderen	:	/

13. Instructies voor verwijdering

Lokale administratieve regels volgen.

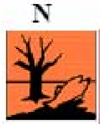
14. Informatie met betrekking tot het vervoer

ADR/GGVS en RID/GGVE	: 2570, Cadmiumverbinding, N.E.G., 6.1, III, ADR, Cadmium Oxide
IMDG/GGVSee	: Kl 6.1, verpakkingsgroep III
ICAO/IATA	: Kl 6.1, verpakkingsgroep III
Nummer EEN	: 2570
Andere inlichtingen	: Zeevervuiler "P"

15. Informatie met betrekking tot regularisatie

T+

N



"T" : Giftig
"N" : Vergiftig voor het milieu

R en S zinnen :

R26	Zeer vergiftig bij inademing.
R 45	Kan kanker veroorzaken.
R 48/23/25	Vergiftig : gevaar voor ernstige schade aan de gezondheid bij langdurige blootstelling bij inademing en opname door de mond.
R 62	Mogelijk gevaar voor verminderde vruchtbaarheid.
R 63	Mogelijk gevaar voor beschadiging van het ongeboren kind.
R 68	Onherstelbare effecten zijn niet uitgesloten.
R 50/53	Zeer vergiftig voor in het water levende organismen; kan in het aquatisch milieu op lange termijn schadelijke effecten veroorzaken.
S 45	Bij een ongeval of indien men zich onwel voel, onmiddellijk een arts raadplegen (indien mogelijk hem dit etiket tonen).
S 53	Blootstelling vermijden. Vóór gebruik speciale aanwijzingen raadplegen.
S 60	Deze stof en de verpakking als gevaarlijk afval afvoeren.
S 61	Voorkom lozing in het milieu. Vraag om speciale instructies/veiligheidskaart.

15. Overige informatie

Stand van 31.03.2005.

De informatie is gebaseerd op de huidige beschikbare gegevens. Het beschrijft het product met betrekking tot de geschikte veiligheidsvoorzorg maatregelen. Het kan niet de eigenschappen van het product garanderen.

Annex 5: Survey of cadmium in sewage sludge in mg Cd / kg DS (European Commission, 2001)

CADMIUM	Country	Mean	Median	Min.	Max.	Survey Year/s
	Austria	1.5	1.2	0.4	3.4	1994/95 (11)
	Germany	1.5				1995-97 (4)
	Denmark	1.4				1995-97 (4)
	France	4.1				1995/97 (4)
	Finland	1.0				1995-97 (4)
	Greece (a) (b)	1.6 1.4				1996 (6) 1997 (1)
	Italy			0.8	23	1998/99 (10)
	Ireland	2.8				1997 (4)
	Luxembourg	3.8				1997 (4)
	Netherlands	3				1990 (16)
	Sweden	1.5				1995/96 (4)
	UK	3.5				1995/96 (4)
	Norway	0.97				1998 (12)
	Poland	9.93	13.5	0.8	15.3	1999 (3)
	EU	4.0 2.2				1992 (9) 1994-98
	USA	38.1 25	8.95			1988 (13) 1992 (2)

	Limits	Agricultural Soils	Sewage Sludge	
	EU	1-3	10 1*	(4)
	WHO	7		(5)
	USEPA		39	(14)

Annex 6: Report on management of the risk related to chronic occupational exposure to cadmium and its compounds (ICdA/Eurométaux, 2006)