Expanding the Scope of the RoHS Directive – Prospects and Obstacles

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Expanding the Scope of the RoHS Directive – Prospects and Obstacles

Thesis for the Degree of Master in Engineering
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Möjligheter och hinder för att utöka omfattningen av RoHS-direktivet

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Sammanfattning

Abstract
The RoHS Directive was introduced in order to restrict hazardous substances in Electrical and Electronic Equipment, EEE. It currently restricts the use of six hazardous substances/compounds; cadmium, lead, mercury, hexavalent chromium, PBB, and PBDE. The RoHS Directive currently includes category 1-7 and 10 in the categories of EEE listed in Annex 1A to the WEEE-Directive (Waste of EEE). The aim with the report is to investigate and elucidate prospects and obstacles to increase the scope of RoHS. This report mainly considers the inclusion of product categories 8 (Medical Devices) and 9 (Monitoring and Control Instruments). In order to fulfil the aim eight questions were formulated, that shall be answered in the report.

In order to find the knowledge of and attitude towards RoHS of manufacturers, retailers, and importers of products falling under category 8 and 9, a questionnaire
was sent to 80 companies, of which 25 answered. The answers showed that many of the companies did not know of RoHS before the questionnaire was sent out. The majority did not consider that their product category needed a longer time period to find alternatives for the applications where any of the in RoHS restricted substances were used, compared with the other categories in annex 1A to WEEE. Of the companies that answered on the questionnaire the majority had less than 50 employees. The companies in the study had limited knowledge of the contents of their products, they bought the function rather than the contents.

One important conclusion in this report is that only a few of the companies in category 8 and 9 are likely to keep using non compliant components for a long time if they use standard electronic equipment irrespective if they intend to readjust their production according to the RoHS Directive or not. The reason is that most subcontractors will be forced by the customers, mainly the larger ones, to readjust their production. They certainly will not keep two production lines. A paradox problem that can arise for small and medium sized companies, the majority of those answering the questionnaire were, is to get access to compliant components before the RoHS Directive is put into force. These companies order such small batches that it is unrealistic to order them from the original manufacturer, who usually is located in Asia. The small and medium sized companies usually buy their components from middlemen/grossists in Europe and Sweden. These grossist in many cases have large stocks with non-compliant components that they want to sell out before RoHS Directive is put into force from the 1st July 2006.

The RoHS Directive has been criticized for restricting lead, but different studies show that the alternatives to e.g. Lead gives only slightly worse results, which by way of introduction can be expected from a new technology compared with an old, more investigated. The work with the report has also revealed a lack in communication and cooperation not only between the different stakeholders in electronic industry: retailers, importers, manufacturers and subcontractors, but also between industry, customers and authorities. The RoHS Directive may improve the communication and cooperation between these different actors.

Nyckelord
Keyword
The RoHS Directive, Category 8, Category 9, EEE, Lead, Cadmium, Mercury, Hexavalent Chromium, PBB and PBDE
Sammanfattning

RoHS-direktivet (Restriction of Hazardous Substances) antogs för att begränsa farliga ämnen i elektronisk och elektrisk utrustning, EEE. Det begränsar för närvarande användandet av sex farliga ämnen/ämnesgrupper; kamium, bly, kvicksilver, sexvärt krom, PBB och PBDE. RoHS-direktivet inkluderar för närvarande kategori 1-7 och 10 avkategorierna av EEE listade i bilaga 1A till WEEE-direktivet (Waste of EEE). Syftet med uppsatsen är att undersöka och klartägga möjligheter och hinder för att utöka omfattningen av RoHS. Uppsatsen koncentreras sig huvudsakligen på inkluderandet av produktkategori 8 (medicinteknisk utrustning) och 9 (kontroll- och övervakningsinstrument). För att uppfylla syftet formulerades åtta frågeställningar som skall besvaras i uppsatsen.

För att ta reda på kunskaper hos och attityder gentemot RoHS hos tillverkare, återförsäljare och importörer av produkter som faller under kategori 8 och 9 skickades en enkät ut till 80 företag, av vilka 25 svarade. Svaren visade att många av företagen inte kände till RoHS-direktivet innan enkäten. Majoriteten ansåg inte att deras produktkategori behövde en längre tidsperiod för att hitta alternativ för de tillämpningar där de idag använde något av de sex begränsade ämnena, jämför med övriga kategorier i bilaga 1A i WEEE. Av de företag som svarade på enkätundersökningen hade majoriteten färre än 50 anställda. Företagen i uppsatsen hade begränsad kännedom om de ingående ämnena i produkterna, de köpte funktion/-er snarare än innehåll.

En viktig slutsats i uppsatsen var att få av företagen i kategorier 8 och 9 sannolikt kommer att kunna fortsätta använda standardelektronisk utrustning som innehåller någon av RoHS ämnena under än längre tid oavsett om de kommer att omfattas av RoHS eller ej. Orsaken är att många underleverantörer kommer att bli tvingade av sina kunder, huvudsakligen de större som har produkter som faller under RoHS, att anpassa sin produktion, och de kommer inte att behålla två produktionslinjer. Ett paradoxalt problem som kan uppstå för små och medelstora företag, dvs. majoriteten av företagen som svarade på enkäten, är dock att få tillgång till komponenter fria från de sex ämnena, innan dess att RoHS direktivet skall tillämpas. Dessa företag beställer så små partier att gången att det är orealistiskt att beställa dem direkt från de ursprungliga komponenttillverkarna, som vanligtvis är lokalisera i Asien. De små och medelstora företagen köper vanligtvis sina komponenter från mellanhänder/grossister i Europa och Sverige. Grossisterna har i många fall stora lager med komponenter, som innehåller de sex ämnena som regleras i RoHS, som de vill sälja ut innan RoHS skall börja tillämpas från den 1 juli 2006. .

RoHS-direktivet har blivit kritiserat, men resultaten från olika studier visar att alternativen till t.ex. bly leder till endast mindre än 1%. Det är i linje med det inledningsvis kan förväntas av nya tekniker jämfört med gamla, beprövade tekniker och/eller ämnen. Arbetet kring uppsatsen har också visat på brister i kommunikationen och samarbetet inte bara mellan olika komponentleverantörer, utan också mellan industrin, kunderna och myndigheterna. RoHS-direktivet kan komma att öka kommunikationen och samarbetet mellan dessa olika aktörer.
Abstract

The RoHS Directive was introduced in order to restrict hazardous substances in Electrical and Electronic Equipment, EEE. It currently restricts the use of six hazardous substances/compounds; cadmium, lead, mercury, hexavalent chromium, PBB, and PBDE. The RoHS Directive currently includes category 1-7 and 10 in the categories of EEE listed in Annex 1A to the WEEE-Directive (Waste of EEE). The aim with the report is to investigate and elucidate prospects and obstacles to increase the scope of RoHS. This report mainly considers the inclusion of product categories 8 (Medical Devices) and 9 (Monitoring and Control Instruments). In order to fulfil the aim eight questions were formulated, that shall be answered in the report.

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One important conclusion in this report is that only a few of the companies in category 8 and 9 are likely to keep using non compliant components for a long time if they use standard electronic equipment irrespective if they intend to readjust their production according to the RoHS Directive or not. The reason is that most subcontractors will be forced by the customers, mainly the larger ones, to readjust their production. They certainly will not keep two production lines. A paradox problem that can arise for small and medium sized companies, the majority of those answering the questionnaire were, is to get access to compliant components before the RoHS Directive is put into force. These companies order such small batches that it is unrealistic to order them from the original manufacturer, who usually is located in Asia. The small and medium sized companies usually buy their components from middlemen/grossists in Europe and Sweden. These grossists in many cases have large stocks with non-compliant components that they want to sell out before RoHS Directive is put into force from the 1st July 2006.

The RoHS Directive has been criticized for restricting lead, but different studies show that the alternatives to e.g. Lead gives only slightly worse results, which by way of introduction can be expected from a new technology compared with an old, more investigated. The work with the report has also revealed a lack in communication and cooperation not only between the different stakeholders in electronic industry: retailers, importers, manufacturers and subcontractors, but also between industry, customers and authorities. The RoHS Directive may improve the communication and cooperation between these different actors.
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I would like to thank for all assistance supplying information, which is the very foundation for this thesis. I would also like to give my gratitude to the 25 companies who answered on my questionnaire, and to the six persons whom permitted interviews. A huge thank to Olof Hjelm at Linköping University and to IVF who gave me the opportunity to participate in their course ‘lead-free electronic production’.

Finally I would like to give special thank the staff at Swedish Chemicals Inspectorate who has assisted me throughout the development, in particular Göran Gabrielsson and Ulla Falk.
# Nomenclature

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>Deca-BDE</td>
<td>Decabromo Diphenyl Ethyl (Flame Retardant)</td>
</tr>
<tr>
<td>EEE</td>
<td>Electronic and Electrical Equipment</td>
</tr>
<tr>
<td>FET</td>
<td>Field Effect Transistor</td>
</tr>
<tr>
<td>FR</td>
<td>Flame Retardant</td>
</tr>
<tr>
<td>GMDN</td>
<td>Global Medical Device Nomenclature</td>
</tr>
<tr>
<td>IC</td>
<td>Integrated Circuit</td>
</tr>
<tr>
<td>IMC</td>
<td>Intermetallic Layer</td>
</tr>
<tr>
<td>IPC</td>
<td>Association Connecting Electronics Industry</td>
</tr>
<tr>
<td>KemI</td>
<td>Swedish Chemicals Inspectorate (Kemikalieinspektionen)</td>
</tr>
<tr>
<td>LiU</td>
<td>Linköping University</td>
</tr>
<tr>
<td>MOS</td>
<td>Metal-oxide-semiconductor</td>
</tr>
<tr>
<td>MPA</td>
<td>Medical Products Agency (Läkemedelsverket)</td>
</tr>
<tr>
<td>NVV</td>
<td>Swedish Environmental Protection Agency (Naturvårdsverket)</td>
</tr>
<tr>
<td>PBB</td>
<td>PolyBrominated Biphenyl (Flame Retardant)</td>
</tr>
<tr>
<td>PBDE</td>
<td>PolyBrominated Diphenyl Ethyl (Flame Retardant)</td>
</tr>
<tr>
<td>PPM</td>
<td>Parts Per Million</td>
</tr>
<tr>
<td>RoHS</td>
<td>Restriction of Hazardous Substances in electrical and electronic equipment</td>
</tr>
<tr>
<td>SCB</td>
<td>Statistics Sweden (Statistiska centralbyrån)</td>
</tr>
<tr>
<td>SEK</td>
<td>Swedish currency (Krona); corresponds to around 0.1 EURO</td>
</tr>
<tr>
<td>SLF</td>
<td>The Swedish Medical Suppliers Association (Sjukvårdens leverantörförening)</td>
</tr>
<tr>
<td>SOS</td>
<td>The National Board of Health and Welfare (Socialstyrelsen)</td>
</tr>
<tr>
<td>SP</td>
<td>Swedish National Testing and Research Institute</td>
</tr>
<tr>
<td>TBBPA</td>
<td>Tetrabromo Bisphenol A</td>
</tr>
<tr>
<td>U</td>
<td>University</td>
</tr>
<tr>
<td>UU</td>
<td>Uppsala University</td>
</tr>
<tr>
<td>WEEE</td>
<td>Waste from Electrical and Electronic Equipment</td>
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Introduction

Background

Electronic and Electric Equipment, EEE, are used in a wide spectrum of product. Usage areas are everything from technical products to toys. The high innovation in combination with customer demands on performance leads to that the commercial life length in many applications is shorter than the actual/technical life length. Older computers and mobile phones are replaced when new features become available, and the old, still usable, products are thrown away. One problem with EEE is that the customer majority do not separate it from the regular household waste when they decide to dispose it. This implies a risk for the hazardous substances inside the EEE to leak from landfill. Further on this problem also exists for EEE used in other places than in a household.

An effort towards dealing with these environmental problems is the two EU-directives: RoHS and WEEE Directive. The RoHS Directive (Restriction of Hazardous Substances-directive) is a legislation around the product contents of EEE, and restricts the use of six hazardous substances (Lead, Mercury, Cadmium, Hexavalent Chromium, PBB and PBDE) in eight of ten product categories in annex 1A of the current edition of WEEE. WEEE concerns the legislations of Waste of EEE. The extension of the WEEE is related to the extension of RoHS by the ten current product categories given in annex 1A of WEEE.

Problem

In order to expand the scope of the RoHS Directive to all product Categories given in annex 1A in the WEEE Directive, the main focus in this study, the knowledge about Medical Devices and Monitoring- and Control Instruments had to increase considering usage areas of, amounts of, and work carried out for substituting the six hazardous substances pointed out in RoHS.

Aim

The aim of this thesis is to investigate and elucidate prospects and obstacles for expanding the scope of the RoHS Directive. In order to fulfil the aim the following eight questions were formulated:

1. Which products can be defined as Medical Devices (Category 8 in annex 1A in WEEE) and as Monitoring- and Control instruments (Category 9 in annex 1A in WEEE)?
2. To what extent are the six hazardous substances used in these product categories? Is Deca-BDE used in products falling under Category 8 and 9? If not, which Flame Retardants are used?
3. In which amounts do these substances occur in these products?
4. In which amounts do these substances contribute to the characteristics of a material?
5. To what extent can these substances be regarded as impurities?
6. Which other hazardous substances are used in this equipment, and which hazardous substances have the industry itself identified?
7. Which work has been carried out to substitute the six hazardous substances mentioned in the RoHS Directive, or other hazardous substances, in the two product categories? Are there or will there be alternative substances and techniques available within reasonable future to substitute the six hazardous substances and others in the two product categories? Are there particular electronical components where Deca-BDE is used today, that are difficult to substitute?
8. Would a transitional period for the technical adaptation of EEE be necessary for Category 8 and 9?

With answers to all these questions one would have a good ground for deciding on the inclusion of these categories. All answers to these questions can contribute to the development according to Article 6 in RoHS. Article 6 in RoHS concerns inclusion of all product categories given in the annex of WEEE and to increase the number of hazardous substances. The two product categories of particular concern in this thesis, Category 8 and 9 are the only product categories not included for the moment.

Discussion around Sources

Considering that KemI (the Swedish Chemicals Inspectorate) is a governmental authority, it was important to find sources from all areas of concern. E.g from the industry, both companies that were positive to RoHS, and those who felt that the Directive could have negative effects on their business. The idea was to get views both for and against, in order to draw conclusions that have taken into account the opinion of ‘both sides’. The questionnaire was treated anonymously for this reason.

Delimitation

Some aspects would have been interesting to have looked into, but there was not time enough. One interesting area to look into, would have been to investigate the exact amounts of hazardous substances use in Category 8 and 9, and to weigh the environmental impact of these towards the cost of restricting the use. Another interesting area to look into would have been the example list with categories, in particular category 9, since it has no earlier overall definition. No economical aspects have been included in this study either, since the concentration has been on a non-toxic environment.

Another delimitation was the questionnaire that was sent out to 80 companies with products falling under Category 8 and 9. It could have been sent out to many more companies, either by a more extensive company search or by extending the range to Nordic companies or European companies within these two categories of interest, but the means and time was not enough. Of the companies that received the questionnaire, but did not answer despite the reminder, it probably exists more companies that are doubtful what category they fall under. The unknown fraction of which the companies that answered the questionnaire consist of is probably not a sufficient basis to draw conclusions for all EU countries.
**Method**

The thesis has been developed from the eight mentioned questions. The first four weeks period was dedicated to study literature. Three interviews was set to the sixth week, in order to get more information considering some interesting areas. One of them at the Ecotoxic Department at Uppsala University where much research has been carried out on PBDE’s, one at ELFA who is a large Swedish electronics grossist, and finally one phone interview with a company in Category 9 was carried out. The conclusion from the interview with a company in Category 9 was that it would be interesting to interview many more companies concerning both categories, in order to get a basic idea about the knowledge and attitude towards RoHS, and the use of the hazardous substances mentioned in it. A questionnaire was therefore set up with the aim to get more information from other companies.

The questionnaire was prepared and sent out by e-mail after twelve weeks and originally had a time period of two weeks assigned to reply. The period between was dedicated to find the 80 companies, and to formulate the questions to recieve the wanted information. The companies was found by random search on the internet. One week after the questionnaire was sent out, all companies that had not answered were contacted by phone. This reminder displayed that many e-mails had dissapeared as spam or never been opened. The time period for answering was therefore postponed two weeks. Week 13 was spent at a two day workshop at IVF in Gothenburg, about lead free electronic production. First the results of different research projects were presented on a theoretical basis and secondly the participants made their own RoHS compliant Printed Circuit Board and finally some of these Printed Circuit Boards were analyzed. Thereafter result of the companies in this study that had answered the questionnaire was thereafter put together statistically and analyzed. This week also included two interviews, one with Ericsson and one with IPC’s European representantive. From the next week until the final presentation at Linköping University the 14th February, all work was concentrated to writing the report.

![Flow Chart over the Report Development](image-url)

*Figure 1: Flow Chart over the Report Development*
Structure of Thesis

The structure of the thesis is based on information in ‘Lathund för rapportskrivning’ (Merkel et.al., 2004). The thesis is divided into six chapters: Directives, Legislations and Market Incentives, Hazardous Substances, Medical Devices and Monitoring- and Control Instruments, Investigative questionnaire for Category 8 and 9, International Impact, and Analysis.

The chapter about Directives, Legislations and Market Incentives describes the fundamentals of the WEEE Directive and the RoHS Directive and mentions earlier legislation on the restriction of hazardous substances. It informs about CE-marking of Products, and Market Incentives such as Environmental Management, gives basic information on the environmental objective Non-Toxic Environment and the coming chemicals legislation REACH. The end of the chapter tells a bit about the International Impact RoHS is expected to have.

The chapter about Hazardous Substances presents basic information about the six restricted substances regulated in the RoHS Directive, where they are used in EEE and which current exemptions apply to the directive for a specific substance. Further on the chapter examines the alternative techniques used in lead-free electronic production; it also presents the result of several different research papers on Flame Retardants (and for those who are interested in knowing more about PBDE’s a more extensive section about them are enclosed in the annex).

The chapter about Medical Devices and Monitoring- and Control Instruments give basic information about the two product categories 8 and 9. It informs about the current recycling of products. The chapter “Knowledge of and attitude towards RoHS at companies involved in the production of Medical Devices and Monitoring and Control Instruments” presents the results from the questionnaire sent to 80 retailers, manufacturers, subcontractors, or importers of products falling under category 8 and 9.

The Analysis chapter answers the eight given questions, based on the information given in each of the four previous chapters, and further discuss other issues that have evolved from these questions – exemptions, difficulties in demarcation between waste and products, international impact, and size issues. The conclusions presents the final conclusions, first from the questionnaire only and then from all sources used in this thesis. Finally the prospects and obstacles are presented, and last of all the outlook from this thesis is presented.

A dictionary is enclosed in the annex starting on page 44. Enclosed in the annex is also a chapter about EEE for those who have no earlier knowledge about these types of equipment, followed by a chapter about Brominated Flame Retardants. It is followed by a chapter were the articles in Elektroniktidningen with criticism from Association Connecting Electronics Industry (IPC) and the counter commentaries from another representant from the Electronic industry, Ingela Nordin, is presented. After this, the annex with all product categories from WEEE is presented, followed by the annex in RoHS with exemptions. Finally the questionnaire is enclosed. All references are mentioned according to the Harvard system (Merkel et.al, 2004).
Directives, Legislations and Market Incentives

The WEEE Directive

WEEE (Directive 2002/96/EC of the European parliament and of the council of the European Union) is short for Waste of Electrical and Electronic Equipment. Its purpose is to improve the reuse, recycling and other forms of recovery in order to reduce the amount of disposal of waste. All member states where to comply with this directive by 13th August 2004. In Sweden the Ministry of Sustainable Development is responsible for the implementation of WEEE. The Swedish Environmental Protection Agency is the designated Competent Authority.

By 13th August 2005 consumers are to be able to deliver used EEE marked as shown in figure 1 to the distributor, provided that it’s not easier to do it themselves, all free of charge. There will be free of charge collection facilities at optimized locations by this date as well. Distributors are allowed to have their own collections, provided that they match the directives purposes.

![Figure 2: Symbol for Marking EEE](image)

The figure above shows the marking of EEE, which must be printed visibly, legibly and indelibly. The table below shows the quota of recycling from the different categories, which are to be reality before 31st December 2006.

<table>
<thead>
<tr>
<th>Category</th>
<th>Percent of products average weight</th>
<th>For components, material, and substances</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 and 10</td>
<td>80%</td>
<td>75%</td>
</tr>
<tr>
<td>3 and 4</td>
<td>75%</td>
<td>65%</td>
</tr>
<tr>
<td>2,5,7, and 9</td>
<td>70%</td>
<td>50%</td>
</tr>
</tbody>
</table>

WEEE applies to the following ten categories (given that they are not used as a part in a product type that is not on the list) in Annex 1A:

1. Large household appliances
2. Small household appliances
3. IT- and telecommunications equipment
4. Consumer equipment
5. Lighting equipment
6. Electrical and electronic tools (with the exception of large-scale stationary industrial tools)
7. Toys, leisure and sports equipment
8. Medical devices (with the exception of all implanted and infected products)
9. Monitoring and control instruments
10. Automatic dispensers

Enclosed in the annex 1B of the WEEE Directive is also a list of exemplified products that fall under the different categories. Categories 8 and 9 will be considered further in this thesis.
The RoHS Directive

The RoHS Directive (Directive 2002/95/EC of the European parliament and of the council of the European Union) was adopted the 27th January 2003 and should have been transposed the 13th of August 2004. It is interconnected to WEEE by the product categories of annex 1A.

The responsibility for the implementation of RoHS Directive in Sweden is put on the Ministry of Sustainable Development. The Chemicals Inspectorate (Kemi) are the designated Competent Authority. The purpose of RoHS is to “approximate the laws of Member States on the restrictions of the use of hazardous substances in EEE and to contribute to the protection of human health and the environmentally sound recovery and disposal of WEEE.” RoHS applies to all products falling under category 1-7 and 10 of annex 1A of WEEE and to electric light bulbs, and luminaries in households. It does not apply to spare parts for the repair/reuse of EEE put on market before 1 July 2006.

These definitions also apply for WEEE Directive.

- **EEE** - Products dependent on electric current or electromagnetic fields to work properly. Equipment for generation, transfer and measurements of such currents and fields, falling under categories given in Annex 1A to WEEE Directive.
- **Producer** - Irrespective of selling technique used, a party that manufactures and sells or resells EEE under his own brand or Imports/Exports EEE on a professional basis in a Member State.

Mentioned in article 5 in RoHS is the necessity to update the RoHS Directive according to scientific and technical progress (the exemptions are listed in the Annex). The Annex is to be reviewed at least every 4th year, in order to keep it updated with the current status of the field. Before any changes are decided on the exemption list, the commission shall consult producers of EEE, recycling companies, treatment operators, environmental organisations and consumer associations. A committee assists the commission; which is set up by article 18 in 75/442/EC. Article 18 was added latter to 75/442/EEC, through the Council directive 91/156/EEC.

From the 1st of July 2006 all Member States shall ensure that new EEE put on the market do not contain Cadmium, Hexavalent Chromium, Lead, Mercury, PBB or PBDE (article 4.1). National preventive measures that restrict the usage of these substances in EEE adopted before July 2006 can be kept until this date, provided that they are in line with Community legislation. Some uses, where the current technique does not make it possible to apply to the rules, are exempted. All of these exemptions are mentioned in the annex of RoHS Directive.

**Article 6**

“The commission shall review the measures provided for in this Directive to take into account, as necessary, new scientific evidence.”

- In particular, the commission shall present proposals for including category 8 and 9 in directive 2002/96/EC.
- The need of adapting the list of substances in article 4.1 shall also be presented. Particular attention shall be paid to the environmental- and health impact.
Earlier Legislation

As mentioned in RoHS, national legislations passed before 13th February 2003 may be kept until 1st July 2006. In Sweden, the regulation on Producer Responsibility regarding EEE fits this description.

Producer responsibility

The Regulation on Producer Responsibility was decided on the 1st July 2001, and is currently being updated. Together with the Regulation on Waste (SFS 2001:1063), advice from The Swedish Environmental Protection Agency (NVV), and legislations on transport of hazardous waste it gives the scope what each producer of electronic and electric equipment has to fulfil.

The Regulation states ten categories products. All companies that produce, import or sell any of these products have Producer Responsibility.

1. Household appliances, hand tools and gardening equipment
2. IT equipment and office equipment
3. Telecom equipment
4. Televisions, video recorders etc.
5. Cameras and photographic equipment
6. Clocks
7. Games and toys
8. Light fixtures and fittings and light sources
9. Medical equipment
10. Laboratory equipment

Producer responsibility does not cover electric equipment for cars, refrigerators, electrically controlled furniture, freezers and fixed electrical installations. If a household wants to get rid of EEE without trade-in at purchase may hand it to the local authority.

CE-marking of Products

CE is a marking to prove that a product follows the EU standards who in their turn clarify the product specific demands in so called new approach Directive (these regulate direct risks on health and security from the product). It also secures that the product can be sold anywhere inside EU. Usually the control of products is launched at the company itself. Medical Devices, however, have somewhat stricter demands for CE-marking than other categories. It is often demanded for a Notified Body to issue the marking.

Apart from CE marking it is also possible to test the product security, to get it S-marked. This might be necessary in cases where the company itself has issued the CE marking, and want a Notified Body to control the Security, in order to show the customer that their product really is secure. However, there is no requirement for CE-marking or any other marking in RoHS.

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1 §24-25. All used electric products shall be sent to a pre-treatment plant, where all hazardous substances are to be removed.
2 Trade-in at purchase: A consumer returns the used product to the seller when they buy a new product.
Environmental Management

Regarding environmental management, there are several different certifications, for example ISO14001 globally and EMAS in Europe and EMAS globally. For products a particular Environmental Product Declaration has been developed. As mentioned at the homepage given in footnote 20: “The intent of an EPD is to provide the basis of a fair comparison of products by the products’ environmental performance”. (EPD, 2005)

Swan labelling, the Nordic Ecolabelling of Products, give the opportunity to label different products. One topical example is Ecolabelling of Printed Circuit Boards. The demands on a Printed Wiring Board for Swan labelling are:

- Halogen free (not more than 0.09% by weight of Cl or Br)
- Flame retardants must not be R45 (may cause cancer), R46 (may cause heritable genetic damage), R60 (may impair fertility), or R61 (may cause harm to the unborn child)
- Lead-free soldering. The Printed Wiring Board must be designed for use in lead-free soldering processes and lead must not be used in surface treatments (less than 0.1% by weight of Pb)
- A solder mask free of halogens and flame retardants falling under R45, R46, R60, or R61

So far, only one company has labelled their products according to this standard. (Svanen, 2005)

Non-Toxic Environment

The Swedish Parliament has adopted 15 environmental quality objectives, one of them is a non-toxic environment. The responsible agency for this objective is the Swedish Chemicals Inspectorate. Six different interim targets are mentioned, that indicate the scope and time perspective for concrete environmental measures: (KemI, 2005)

1. By 2010 data will be available on the properties of all deliberately manufactured or extracted chemical substances handled on the market.

   For substances handled in larger volumes and for other substances which, for example after initial general tests, are assessed as being particularly dangerous, information on their properties will be available earlier than 2010. The same information requirements will apply to both new and existing substances.

   In addition, by 2020 data will as far as possible be available on the properties of all unintentionally produced and extracted chemical substances.

2. By 2010 finished products will carry health and environmental information on any dangerous substances they contain.

3. Newly manufactured finished products will as far as possible be free from:

   - carcinogenic, mutagenic and reprotoxic substances, by 2007, if the products are intended to be used in such a way that they will enter natural cycles;
   - new organic substances that are persistent and bioaccumulating, as soon as possible, but not later than 2005;
   - other organic substances that are very persistent and very bioaccumulative, by 2010;
   - other organic substances that are persistent and bioaccumulative, by 2015;
- mercury by 2003, and cadmium and lead by 2010.

Nor will these substances be used in production processes unless the company can prove that human health and the environment will not be harmed. Already available finished products containing substances with the properties listed above, or mercury, cadmium or lead, will be handled in such a way that the substances in question are not released to the environment.

This interim target applies to substances that are man-made or extracted from the natural environment.

It also applies to substances giving rise to substances with the above properties, including those formed unintentionally.

4. Health and environmental risks associated with the manufacture and use of chemical substances will be reduced continuously up to 2010, as measured by indicators and ratios to be established by the competent authorities.

Over the same period, the occurrence and use of chemical substances which impede recycling of materials will decrease.

This target applies to substances not covered by interim target 3.

5. By 2010 guideline values will be established by the competent authorities for at least 100 selected chemical substances not covered by interim target 3.

These values will indicate the maximum concentrations to be permitted in the environment or to which humans may be exposed.

The aim is that the guideline values will in the long term be adopted as environmental quality standards.

6. By 2005 contaminated sites will have been identified and remediation will have begun at a minimum of 100 of the sites given highest priority with regard to the risks to human health and the environment. In addition, remediation will have been completed at a minimum of 50 of the sites at which such work has begun.

**REACH**

REACH, EU Registration, Evaluation and Authorisation of Chemicals legislation, will probably be put into force 2007. The aim with REACH is to increase the transparency, to promote non-animal testing, to prevent fragmentation of the internal market and to receive maintenance and enhancement of the competitiveness of the EU chemical industry. It will require from Chemical manufacturers and importers distributing Chemical substances into the EU market to have information of properties, and to give this information to the central database. It will require from companies to register all substances produced or imported in volumes over 1 tonne annually. All chemicals put on the market before 1981 is called “existing” chemicals, while the others are called “new”. “Existing” chemicals number 100,106 different substances. Earlier legislations have no demand on that “existing” chemicals are to be tested in any way before they are used. The central data base will cover both new and existing (phasen in based on volumes) compounds. A new and independent agency, placed in Finland, will receive and manage the data base. (European Commision, 02/12/2004).
International Impact

The adoption of the RoHS Directive will have global impact, particularly due to the regulation of lead, which will have the greatest consequence. Not only by the fact that many companies producing EEE act globally, but also by the fact that the price of components containing lead probably will increase globally, not only inside Europe. Some companies in the United States have already adjusted their production in order to comply with RoHS, for example Avnet and i2, where i2 will provide Avnet with data on material contents. (Spiegel, 2004)

Regulations on Lead-free soldering were initialized in 1990 in United States, where a tax on lead was used in the industry. Intense lobbying resulted in removal of these taxes. LIA (Lead Industry Association) and IPC, for example, have been active in lobbying against lead-free legislation. However, in 1999 IPC stated that they would better serve the industry by helping them with the introduction of lead-free alternatives. In Japan the first products without lead in the interconnecting system were introduced on the market 2001. (Ning-Cheng Lee)

The pressure on environmental performance is a strong force on the market in Japan, were environmental consequences have been more visible, compared with other parts of the world. In fact, the products exported to the European market are not marked if they do not contain lead, since it does not sell better with better environmental performance on the European market. (IVF, 2004)

An article in EETimes informs about a study on the RoHS Directive, performed by an operation group of Avnet Inc., Avnet Electronics Marketing, together with Technology Forecasters Inc., showing that only 69% of the electronic industry contract manufacturers in USA expect to be fully compliant by July 2006. The article also mentions the issue with marking. Their study showed that 42% were not planning to change part numbers\(^3\), meaning that they will look the same as compliant parts. Many companies in the U.S. are against the introduction of the RoHS Directive. The reason is probably that it will force them to follow the same development. (Spencer Chin, 2004)

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\(^3\) Each component has a particular part number. If lead-free components gets the same part number as the ones with the same function containing lead, it becomes impossible to separate them.
Hazardous Substances

Over 90% of the waste from EEE in Austria are disposed, burned or recycled without separate collection. This implies that a considerable share of hazardous substances in other European countries' waste come from such products (The Nordic Council of Ministers, 1995). Since the areas of use are increasing and the commercial life length is decreasing, the amount of waste has been increasing exponentially in the last decade. In order to prevent hazardous substances from leaking out into the environment, WEEE has been introduced for proper measures for taking care of waste from these applications, and RoHS has been introduced to restrict the usage of hazardous substances in EEE. The definition of a Hazardous substance is that the substance are either CMR (Carcinogenic, Mutagenic and Reprotoxic), PBT (Persistent, Bio-accumulative and Toxic), or vPvB (very persistent and very bio-accumulative).

It is important to decide a maximum concentration of hazardous substances in products. In low levels a hazardous substance can be regarded as an impurity, which might be impossible to avoid during production. Especially when a material is not used for the first time.

The following substances are the six hazardous mentioned in article 4.1 in RoHS Directive: Cadmium, Hexavalent-chromium, Lead, Mercury, PBB, and PBDE. The first four of them are heavy metals, which then are persistent substances. The last two groups are Flame Retardants. All six substances are banned in products placed on the market from the 1st July 2006, apart from the exemptions specially mentioned in the Annex of RoHS.

Cadmium

Cadmium is a silver-white-blue metal that has the chemical symbol Cd. Inhalation is toxic and may lead to cancer. It is extremely hazardous for water living organisms. It exists in low amounts in food as a result of small amounts of cadmium as pollution in fertilizers; this is the largest exposure source apart from smoking. In products it is most common, jointly with nickel, in accumulators. Inside the body cadmium is bio accumulated in the kidneys, which also is the most affected part in the body. It is classified as ecologically harmful and toxic. (KemI and NVV, 2004)

Usage in EEE

Cadmium is used in EEE as power supply jointly with nickel (Ni-Cd batteries), stabilizer in plastic components, colour pigment, phosphorescent coating, and in plating applications. (Five Winds International, 2003)

Exemptions in annex of RoHS Directive

Cadmium will still be used in plating, unless banned under directive 76/769/EEC.

Hexavalent-Chromium

Hexavalent-Chromium is a metal with the chemical symbol CrVI. It is mainly used in wooden impregnation, paints, and plastics, or as pigments in photography. It has been proven that workers at industries involving these chemicals suffer from a greater risk to develop lung cancer (Occupational Safety & Health Administration, 2005). Hexavalent-chromium is classified as carcinogenic, ecologically harmful, poisonous and allergenic.
Usage in EEE
There is little information on the use of Hexavalent chromium in EEE, but typical use is as hardener or stabilizer for plastic housings, as anti-corrosion, and as colorant in pigments. (Five Winds International, 2003)

Exemptions in annex of RoHS Directive
Hexavalent-chromium will continually be used as an anti-corrosion of the carbon steel cooling system in absorption refrigerators.

Mercury
Mercury is a liquid metal with the chemical symbol Hg, mainly used in thermometers, since it expands proportionally with the temperature. It is also used in amalgam and in accumulators and lamps. Inhalation is toxic. Mercury can accumulate in humans and lead to different forms of injuries. In humans it usually leads to injuries of the nervous system, like mental changes or trembling. The mercury levels in fish are an issue; in Swedish lakes, half of the fish populations exceed the limits given by WHO/FAO. Hence pregnant women are recommended not to eat fish from any of these lakes, since mercury has shown to give foetus injuries. It is also recommended for the whole population not to eat fish more than once a week. Mercury is classified as toxic, allergenic and ecologically harmful. (KemI, Report 4/2004)

Usage in EEE
Mercury is used in different light applications such as backlights for LCD’s, and in batteries in EEE (Five Winds International, 2003). Most producers heard in the survey recognise mercury as a Hazardous Substance. The current use is severely restricted to areas of use where no alternative technique is available and the recycling is secured. The current use is restricted mainly to two products: light sources and amalgam. For amalgam there are alternatives and, according to a survey carried out by Statistics Sweden for the Dental Material Investigation, 64% of the Dentist say that they do not use amalgam. (KemI, Report 4/2004)

Exemptions in annex of RoHS Directive
- In compact fluorescent lamps up to 5 mg/lamp
- In straight fluorescent lamps for general purpose up to 10 mg of halo phosphate, 5 mg of tri phosphate with normal lifetime, 8 mg of tri phosphate with long lifetime
- In straight fluorescent lamps for special purposes
- In other lamps not specifically mentioned in the Annex of the RoHS Directive.

Lead
Lead is a metal and has the chemical symbol Pb. Historically, it has been used in many different applications. The main use today is in accumulators, where the rate of recycling is circa 98%, but lead is still used in numerous other product. It is for example also used in bullets for hunting and shooting. Lead in paint has also caused emissions, but most applications are prohibited today. Minute amounts of lead are used in electronical applications compared with the amounts used in accumulators, but considering the relatively moderate reuse and recycling the consequences are still significant. Lead may damage the nervous system, which affects the cognitive and intellectual development. It also causes high blood pressure and hence increases the risk of cardiovascular disease. It is classified as toxic and ecologically harmful. (Segerkvist, 2003)
Usage in EEE

Considering electronic equipment and the RoHS Directive, lead regulation is of the greatest consequence for the industry. The decision to restrict lead has been much criticised and many companies lobbied against it. The reason being that lead is supposed to have important advantages compared to the current lead-free alternatives for electronical applications; lead has:
- Lower reflow soldering temperature than the lead-free alloys
- Lower wave soldering temperature than the lead-free alloys
- High mechanical strength
- Good thermal coefficient
- Less active flux (compared with less hazardous alternatives)

The need of higher process temperatures when using lead free alternatives will cause changes in the production of four materials:

1. Solder
   In the solder, lead-free alternatives have shown worse results in wettability. This is caused by higher surface tension when different alloys are used. A high surface tension increases the risk of voids. However, voids can be both good and bad, depending on the placement. They can prevent a crack, but they can also cause a short circuit. Currently the best alternative solder, according to IVF, is an alloy of tin, copper and silver. Lead-free solders depict somewhat higher surface tensions.

2. Printed Circuit Board
   Lead is currently used in the material used as surface metallization finish in Printed Circuit Boards. The most common alternative is matte tin, with excellent solderability; corrosion resistance and good solder joint strength. The standard material used in Printed Circuit Boards is the glass/epoxy composite FR-4 (FR is short for flame-retardant), with a thermal coefficient between 130-140°C. FR-5 is being developed, since the higher process temperature may be exceeded for FR-4. FR-5 will probably have a thermal coefficient around 180°C, but it will cost 1.5 times as much as FR-4. Non-halogen alternatives has thermal coefficient around 140°C.

3. Components
   The surface metallization finish of component is the same as for Printed Circuit Boards. Hence the same alternatives are presented for this application. The placing of components on lead-free pads need to be marginally more accurate compared with lead, since the self-alignment is not as effective as for lead. The higher process temperatures involve requirements on better storing of components, due to the risk of popcorn-effect of components. This problem arises when components absorb moisture and therefore expand at high temperatures. If the components are stored in vacuum, the risk is decreased.

4. Flux
   In order to remove rest products from lead-free PCB’s, more aggressive flux is needed, since the process temperature makes rest products more attached to the board compared with lead applications. They also need to have a higher area of activity, since the temperature is higher. It is recommended to perform these processes in nitrogen, since it shows slightly better results than air.

Other factors to consider in lead-free production:

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4 This section is based on information given at a two-day workshop at Industrial Research and Development Corporation (IVF, 2004), if no other information is given.
• The process window (margin between minimum temperature for reliable reflow and the maximum temperature for materials’ safety) will be decreased, causing higher demands on manufacturing processes.
• During repair and rework the right instrument and right temperature is very important. It is also highly important to remember using the same solder as in the original process, in order not to compromise the reliability.
• Reprogramming and education of inspection staff is necessary when readjusting the processes, since other issues rise with the new solders.

One issue that has been much discussed concerning lead-free alternatives are the reliability. The fact that higher processes temperatures are used might lead to thicker intermetallic layers (IMC) and this is where the Circuit Assemblies usually cracks. A thicker IMC further increase the possibility of cracking, meaning that this process step also needs to be optimized. Another issue is the coefficient of thermal expansion (CTE), which will vary more with different materials, meaning that the different parts might expand differently, causing stress on the materials that can lead to delamination and cracking in vias. Finally there is a problem with lead contamination. When readjusting to lead-free production, it is of high importance to be sure that the different parts do not contain any lead, since lead contamination up to a few percent causes a severe decrease in fatigue for lead-free applications.

There is much information to be found on lead-free alternatives, including several homepages. A homepage with many articles on the subject is: http://www.pb-free.com/. Further, there is an inter-Nordic cooperation researching around lead-free alternatives, No Lead in Nordic Electronics (NoNE). More information can be found at the homepage: http://www.ittf.no/prosjekter/none/site/

**Exemptions in annex of RoHS Directive**

- Lead in glass of cathode ray tubes, electronic components and straight fluorescent lamps
- Lead as alloying element in steel containing up to 0.35 % by weight, aluminium up to 0.4% by weight, and copper up to 4% by weight
- Lead in solder with high melting point
- Lead in solder for servers, computer storing (including “array” storing)
- Lead in solder to net communication for connecting, signalling, transferring and handling telecommunication
- Lead in ceramic parts in electronics

**Flame Retardants**

PBB is short for PolyBrominated Biphenyls, which is a group of substances used as Flame Retardants. They are not produced anymore, but are still found in the blood of some humans. It is extremely hazardous to water living organisms. PBB is classified as very ecologically harmful and carcinogenic. (KemI, 2003)

PBDE is a chemical group consisting of several different substances. PBDE compounds are persistent and hard to decompose, but the toxicity and bioaccumulation differs a little between the PBDEs (even more if you regard all Flame Retardants). All compounds included in the group except for Deca-BDE (Decabromo Diphenyl Ethyl) are classified as ecologically harmful and dangerous to health, and suspected for giving fetus damage. Penta- and Octaphenyl Ethyl falls under earlier regulations of restriction, February 2003 the Commission introduced regulation on Penta- and Octaphenyl Ethyl in directive 2003/11/EG, amending Directive 76/769/EEC. Deca-BDE is not included in any Swedish, or international legislation so far.
Deca-BDE is not produced inside EU, but is resold by three different importers. The annual world production of Deca-BDE is estimated to be 40,000 tonnes/year. The leading producers are located in Japan and USA. The European import 2003 was estimated to be ca. 1300 tonnes, mainly inside electronic equipment. It has been approximated that 80% of the world production of Deca-BDE is used in plastics. (KemI, report 5/2004)

A recent study has shown amounts of PBDE in food of animal origin. The level of PBDEs has shown to be highest in fish (where up to 70% where contributed by congener 47), followed by meat and diary products. Different food was examined for constituting different PBDEs. Deca-BDE was found at highest levels in wild animals as ground turkey and duck. The levels measured in this study were higher than in two other studies, performed in Spain and Japan. The study also revealed record high amounts of PBDE in human breast milk in USA in the world to date. In Sweden the levels have peaked and are currently decreasing. (Schecter et.al, 2004)

This is of particular concern due to the effects that has been shown by studies around the world (one mentioned later on): endocrine disruption, reproductive/developmental toxicity including neurotoxicity, and cancer. It is anticipated in this study that PBDE with ten bromide atoms, Deca-BDE, will be the only commercial PBDE manufactured in USA at the beginning of 2005, and a change in future patterns is expected (University of Texas Health Science Centre, 2004).

Usage in EEE

PBDE’s are used as Flame Retardants in different applications, among them in microchip production and as coating for EEE. Microchips are used in several different products, among them medical devices, computers, cellular phones, and control instruments. The use of PBDE, however, is limited to three variations of subjects: Penta- (10%), Octa- (15%) and Decabromodiphenyl Ethyl (75%). They have different amount of bromide atoms in their structure (illustrated earlier), hence the names. (KemI, 2003).

Exemptions in annex of RoHS Directive

As mentioned Deca-BDE is the substance with highest priority to evaluate, since it is not concerned in any earlier legislation. This need is particularly mentioned in point 10 in RoHS Directives annex. Deca-BDE has been suggested to become prohibited in Sweden, and has recently been evaluated by KemI. (KemI, Report 5/2004)
Medical Devices and Monitoring- and Control Instruments

Medical Devices

15000 people are employed in companies producing medical devices in Sweden, and the industry produce around 1.5 billion EURO worth of products annually (of which 1.3 billion worth is exported). Of these, only a few falls under the WEEE Directive, since by definition it is the ones which are EEE. In the register of business given by SCB (Statistics Sweden), it is given that 509 companies are producing medical devices in Sweden (515 as primary activity, 73 as secondary, 16 as third). The balance in Sweden between import (1 billion EURO) and export of medical devices was about 0.5 billions EURO in 2001. Hence, it is of great importance for the national economy. The largest international producer is USA (79 billion EURO), followed by Japan (20 billion EURO), and Germany (19 billion EURO). The EU market accounts for 25.6% of the worldwide sales of all Medical Devices. (SLF, 2004)

The example list of products that fall under “medical devices” in Annex 1A of the WEEE Directive is shown in Annex 1B, they are:

- Radiotherapy equipment
- Cardiology
- Dialysis
- Pulmonary ventilators
- Nuclear medicine
- Laboratory equipment for *in-vitro* diagnosis
- Analysers
- Freezers
- Fertilization tests
- Other appliances for detecting, preventing, monitoring, treating, alleviating illness, injury or disability

Definition

The definition of “Medical Devices” in WEEE is mentioned above, given by examples of different applications. But there are different definitions, differing more in scope than in meaning, given in different legislations. The most extensive definition is given by MPA, who together with SOS controls and regulates and is responsible for all medical devices produced and imported into Sweden (see next heading). Another definition is the one given in the Commissions Directive 93/42/EEC (shorter version is to be found in the Swedish governmental legislation 1993:584), where “Medical Devices” is defined as:

“Any instrument, apparatus, appliance, material or other article, whether used alone or in combination, including the software necessary for its application intended by the manufacturer to be used for human beings for the purpose of:

- Diagnosis, prevention, monitoring, treatment or alleviation of disease,
- Diagnosis, monitoring, treatment, alleviation of or compensation for an injury or handicap,
- Investigation, replacement or modification of the anatomy or of a physiological process, or
- Control of conception,

And which does not achieve its principal intended action in or on the human body by pharmacological, immunological or metabolic means, but which may be assisted in its function by such means;”
Control of medical devices

In the 1st of September 2001 the Medical Devices Act and Ordinance was changed. It settled new, increased fees for registration and clinical trial, but the change mainly concerned the distribution of responsibility. MPA (Medical Products Agency) and SOS (The National Board of Health and Welfare) share the responsibility for medical devices. MPA owns the responsibility for supervision over manufacturers and products, while SOS owns the responsibility for supervision of professional use (and the supervision of own production of medical devices). Accidents and incidents in the medical service shall be reported to SOS regional units for supervision according to lex Maria.5 (MPA, 2004)

Regulations were also changed when the Medical Devices Act and Ordinance was changed, since much of the responsibility was transferred to MPA. SOSFS 1994:2 turned into LVFS 2001:5, SOSFS 1994:20 turned into LVFS 2001:6 etc. Altogether there exist six MPA regulations around medical devices.

Three European Directives regulate the marketing and putting into service of medical devices:

- Active Implantable Medical Devices (AIMDD)
- Medical Devices Directive (MDD)
- In Vitro Diagnostic Directive (IVDD)
(European Commission, 2004)

Hazardous substances

All medical instruments and medicinal products used in Sweden are controlled by MPA. They test each new product using the rule “patient benefit weighed against negative consequences”. The six hazardous substances mentioned in RoHS can therefore be applied under circumstances where it results in tremendous patient recovery.

However it is mentioned in Directive 93/42/EEC, the Medical Devices Directive, that particular attention must be paid to the choice of materials, particularly as regards toxicity and, flammability. This means that if there are alternative techniques available for preventing flammability, the least toxic method will be applied.

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5 Law on duty for the attendant to report SOS if a patient has been exposed to or suffered from the risk of being seriously injured in connection with care, treatment or examination within health- and medical care. Legislation put into force 1997. Restriction was introduced 1938 due to two deaths caused by poisoning at Maria hospital in Stockholm, hence the name.
Monitoring and Control Instruments
It is given in the Statistics Sweden’s register of business that 522 companies (247 as primary activity, 63 as secondary, and 4 as third) are producing monitoring and control instruments in Sweden.

The example list of products that fall under “monitoring and control instruments” in Annex 1A of the WEEE Directive is shown in Annex 1B, they are:

- Smoke detectors
- Heating regulators
- Thermostats
- Measuring, weighing or adjusting appliances for households or as laboratory equipment
- Other monitoring or control instruments used in industrial installations (e.g. control panels)

Definition
Monitoring and Control instrument are more difficult to regard as a group, compared with medical devices. Monitoring and Control instruments do not consist of one line of business, but many varying. Hence, it is much more difficult to find out exactly how many they are, and which other directives they act under. There is no organisation representing all the companies of this category.

Since companies producing and/or importing Monitoring and Control Instruments do not have any common organisation it does not exist any general view on how these companies should take hazardous substances into account, as for Medical Devices.

Recycling of Products
This chapter is based on the activity report of El-Kretsens AB 2003-2004 (El-Kretsen AB, 2004).

El-Kretsen AB is a non-profit service company for the collection and recycling of electrical and electronic products that began operating on 1st July 2001. 20 trade associations own El-Kretsen AB, and the fees are paid by the producers. The turnover is 300 million SEK. It consists of over 500 affiliated companies that account for 90% of the market.

The amount of WEEE from Medical Devices (together with Laboratory equipment) collected and recycled at El-Kretsen AB was 300 kg in 2003. It was an increase with 200% from 2002. Since El-Kretsens AB has the same categories as given in annex 1A of the WEEE Directive (or the one used in Regulation on Producer Responsibility, which is another version), it has no particular category that correspond to category 9 in the WEEE Directive.

El-Kretsen points out in their activity report that the quantities of hazardous materials in used electrical and electronic products are small compared with other usage areas, but that historically these electrical and electronic products have not been properly taken care of, and that it therefore is of importance that they are handled in the right way.
Knowledge of and attitude towards RoHS at companies involved in the production of Medical Devices and Monitoring and Control Instruments

In order to get an general idea of the knowledge of and attitude towards RoHS at retailers, producers, and producer of subsystems to products falling under Category 8 or 9, a questionnaire was sent out to 80 companies. The idea behind the questionnaire was partly to find out the knowledge of and attitude towards RoHS, and partly to get information from the industry that could contribute to answering the eight questions. The companies in this study was found and chosen by internet search.

Large extents of the questions were about different substances and their use in products, particularly the once restricted in RoHS. The survey was divided into seven sections, alike this chapter:
1. The RoHS Directive
2. Product information
3. Hexavalent chromium, Cadmium and Mercury
4. Lead
5. Flame retardants
6. Alternative techniques and substitution
7. Other comments

The answer frequency of the questionnaire was as shown in the table above. Around 50% of the companies in this study that were contacted responded in some way. Of these (circa 40) companies 31% responded by sending a filled out question sheet. 40% of these 25 companies were producing products falling under category 8 and the other 60% under category 9. It is their answers to the question sheet that are presented in the following chapters.

Table 3: Number of Employees

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<tr>
<td>Category 9</td>
<td>9 (35%)</td>
<td>3 (12%)</td>
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</tbody>
</table>

As illustrated in the table above the majority of the companies selected in this study that answered on the questionnaire had 1-19 employees in both categories, thus small sized companies.
• 50% of all companies in this study regarded themselves being retailers or importers of complete products,
• 35% as producers of complete products and
• 15% as subcontractors or producers of subsystems.

The market concentration of the companies in this study was equally distributed between Global, European and National. Regarded location it was a 50/50 relation between companies based in larger cities (by Swedish standards), and companies in smaller cities or villages. Only one of the 25 companies in this study was located in the north of Sweden, so the geographical dispersion was not very good, but according to the inhabitants it is somewhat justly dispersed.

The RoHS Directive

The first section concentrated on the RoHS Directive. The first question was about how the companies in this study gained knowledge about the Directive. It is shown in the figure below that the most common way that the companies gained knowledge about RoHS was through the questionnaire, for both categories. Other reasons mentioned, apart from the given, is through subcontractors, head offices, El-Kretsen AB, and magazines like “elektroniktidningen”.

Table 4: How the Companies in this Study have received information about the RoHS Directive

<table>
<thead>
<tr>
<th>Number of Companies</th>
<th>Customer demands</th>
<th>Authority demands</th>
<th>Business organisations</th>
<th>Through the questionnaire</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category 8</td>
<td>0</td>
<td>2 (6%)</td>
<td>2 (6%)</td>
<td>5 (13%)</td>
<td>4 (11%)</td>
</tr>
<tr>
<td>Category 9</td>
<td>2 (6%)</td>
<td>5 (13%)</td>
<td>3 (8%)</td>
<td>7 (18%)</td>
<td>4 (11%)</td>
</tr>
</tbody>
</table>

Of the 25 companies that answered, only one had the view that their product did not belong to the given category (plus that another one was doubtful). Around 50% of the companies in this study in both categories considered the categories were cloudy, and some gave suggestions on more categories that would be good to include. Finally there was a question whether the companies in this study felt that they already fulfilled the demands in RoHS Directive or not, 20% in category 9 and 33% in category 8 answered yes.

Product Information

Only one of the companies falling under category 8, in this study, had received any demands from customers to stop using the hazardous substances in RoHS, while 31% of the companies in category 9 had. 60% of the producers in category 8 had received demands on information about the contents of hazardous substances, while only 29% of the companies in category 9 had experienced it.

Table 5: Information from Producers to Customers on Hazardous Substances

<table>
<thead>
<tr>
<th>Question 6: Do your customers ask for information on hazardous product contents?</th>
<th>Category 8</th>
<th>Category 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>6 (24%)</td>
<td>4 (16%)</td>
</tr>
<tr>
<td>No</td>
<td>4 (16%)</td>
<td>9, 2 some cases (44%)</td>
</tr>
</tbody>
</table>
The information that the companies in this study requested from their subcontractors varied from no information at all to extensive information. Some mentioned that the information was product technical information, information according to company norms, CE-marking, only information on demands, specification on chemicals (lead contents, information on RoHS substances, information on flame retardants), and environmental declarations. Some of the companies in this study pointed out that they had no information since they only were subsidiaries to larger companies, and that the information was gathered at other departments.

**Flame Retardants**

More than 50% of the companies in this study did not know whether their products contained any Flame Retardants or not. Of the 25 companies answering, only two in category 8 answered that they used PBB or PBDE.

<table>
<thead>
<tr>
<th>Question 18: Do your products contain of PBB and/or PBDE?</th>
<th>Yes</th>
<th>No</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category 8</td>
<td>2 (8%)</td>
<td>2 (8%)</td>
<td>6 (23%)</td>
</tr>
<tr>
<td>Category 9</td>
<td></td>
<td>5 (19%)</td>
<td>11 (42%)</td>
</tr>
</tbody>
</table>

16% of the companies answering the questionnaire used alternative Flame Retardants, such as TBBPA. 24% of the companies in this study had fire protection as a demand in the current product standard.

**Hexavalent Chromium, Cadmium and Mercury**

<table>
<thead>
<tr>
<th>Number of Companies</th>
<th>Hexavalent Chromium</th>
<th>Cadmium</th>
<th>Mercury</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>Don’t know</td>
</tr>
<tr>
<td>Category 8</td>
<td>1</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Category 9</td>
<td>4</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

24% of the companies knew they were using Hexavalent chromium, Cadmium, and/or Mercury. 32% of them did not know whether their products contained any Cadmium or Mercury or not, and 52% did not know if the products contain Hexavalent chromium. 16% of the companies in the study mentioned they had substituted one or more of these substances in all applications. 12% mentioned more specific that the substitution meant replacement of batteries from those using hazardous substances, towards environmentally adapted alternatives. 24% of them were aware of alternative techniques, but did not use these due to costs or decrease in performance. One company mentioned that they would change to alternative techniques after the end of the current batch run.
Lead

24% of the companies did not know whether they used lead or not. 60% of the companies in this study in both categories knew that they used lead in their products. In all these cases, apart from 16% of the companies, lead was used in the Printed Circuit Board. The other four applications mentioned was in seals, alloys, batteries, radiotherapy sources, and radiation protection. Some of these uses are exemptions listed in the annex of the RoHS Directive or not within the scope of RoHS (e.g. batteries). Most of the companies in this study that used lead exclusively in the Printed Circuit Board included in their final product were aware of the lead-free alternatives. The majority of them had chosen not to use these lead-free alternatives due to the fact that they did not trust the reliability of these.

Alternative Technique and Substitution

67% of all companies in this study did not know of any alternative techniques that could be used in the future in order to replace hazardous substances. Only 24% of the companies had ongoing research to develop products to decrease the risk of health- or environmental damage, and few of them had replaced substances they had found out, or suspected, to be dangerous for the health, security or environment.

12% of the companies in this study believed that their product category would need a later last date than other categories to adapt the production if the category they fell under would become within the scope of the RoHS Directive. The reason was that they did not trust the performance of alternatives, that the number one factor always was the recovery of the patient (category 8), and that there did not exist any alternatives (for radiation protection).

More than 75% of the companies in this study felt that it was an advantage in competition with other companies to develop ‘environmental’ products, and all of them felt that this factor would increase in the future. Driving forces mentioned was:

- Commercial, goodwill, market/Customer, customer demands, public opinion, “people get more aware”
- Environmental reasons, resources
- Working environment, health, risks of illness or diseases
- Authority demands, legislations, forced demands

Only one company felt that they had suffered from unequal international environmental legislation. This company felt that many cheap products from Asia were a consequence of unequal legislation. One company felt that there was a higher demand for information and knowledge of products in Europe compared with USA, which was considered positive.

Finally it was interesting to find out how the companies thought that their business would be affected by the RoHS Directive. Eight different consequence alternatives where suggested, and the companies also had an opportunity to name other consequences they thought RoHS would bring their activity.
Table 8: Opportunities that RoHS may bring, according to the 25 Companies in this study

<table>
<thead>
<tr>
<th>Category</th>
<th>Number of Companies</th>
</tr>
</thead>
<tbody>
<tr>
<td>More just market inside EU</td>
<td>Category 8</td>
</tr>
<tr>
<td>Opportunity to increase market share</td>
<td>5</td>
</tr>
<tr>
<td>Subcontractor issue</td>
<td>0</td>
</tr>
<tr>
<td>Want to be environmentally profiled</td>
<td>1</td>
</tr>
<tr>
<td>No direct difference</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 9: Obstacles that RoHS may bring, according to the 25 companies in this study

<table>
<thead>
<tr>
<th>Category</th>
<th>Number of Companies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threat by competitor companies gaining market shares</td>
<td>0</td>
</tr>
<tr>
<td>Re-adaption of production when changing to lead-free production</td>
<td>2</td>
</tr>
<tr>
<td>Difficulties to separate lead from lead-free components, if the marking does not differ</td>
<td>3</td>
</tr>
<tr>
<td>Change of subcontractors, if they switch to lead-free production and we still want components containing lead</td>
<td>2</td>
</tr>
<tr>
<td>A risk of 'digital' judgement, small usage with no direct environmental impact may suffer</td>
<td>1</td>
</tr>
<tr>
<td>Risk of lower quality</td>
<td>0</td>
</tr>
</tbody>
</table>

The result is, as shown in the two figures above, that the major opportunity that these companies saw was that RoHS will result in a more just market inside EU. The major obstacle was that it might lead to difficulties to separate RoHS compliant components from non-compliant. Many large component buyers such as ELFA and Ericsson demand from their subcontractors to adapt their production according to the restrictions in RoHS, and to properly mark the compliant components (Susanne Lundberg, 2004; Marianne Lindberg, 2004). Most subcontractors probably will adapt to the RoHS Directive, but the question is how many that will mark their components properly. But a recent research partly concerning marking of compliant component from USA showed that 42% did not plan to change the marking of their compliant components (Spencer Chin, 2004).
24% of the companies in this study claimed that they would need to re-adapt their production to lead-free. According to IVF most of the equipment used today can still be used after adaption. When the production is looked over it is more usual with an increase in productivity and quality of the output, which might make up for the negative qualities of the alternatives. (IVF, 2004). 8% of the companies regarded RoHS to be a threat by competitor companies gaining market shares and equally many regarded RoHS to be an opportunity to increase market shares. 32% of the companies in this study also thought that RoHS Directive will make no direct difference for their business. 16% of the companies in this study mentioned other aspects. One mentioned the risk of decrease in quality, one regarded RoHS to be an issue for their subcontractors, and one saw the opportunity to be environmentally profiled. Another company that mentioned other aspects were afraid that the effect of RoHS would be ‘digital’, meaning that its either all companies or none. They mentioned that small series with negligible impact on the environment become restricted and that this might involve greater costs than profit for the companies.

**Other comments**

The last section in the questionnaire gave the companies the opportunity to add further comments. About 40% of the companies answering added some comments.

About 33% of the 25 companies pointed out the fact that as they were retailers or producers of a final product, they had no information on the content of their products. Some of them were retailers to a large, international company, and some were retailers of products bought from other companies. Many companies in the study also mentioned that they bought EEE from other companies. Hence many of the 25 companies answering the questionnaire felt that RoHS did not directly affect them, since the change mainly will take place earlier in the production line.

A small number of companies in this study were negative to the introduction of RoHS. One company said that the introduction of RoHS was a step in the line of introducing unreasonable demands on the already clean Swedish industries, when the real problems are to be found outside Sweden. The contact person at the company thought that the work on environmental issues that was performed in Sweden currently made no difference, and that it would be better to concentrate on areas with real environmental problems. Mentioned, as examples, were Russia and the Baltic States.
Analysis

Answering the 8 questions

Obstacles for answering the questions

The fact that all EEE have a long line of producers makes it difficult for the final producer to know the contents of their products. Retailers usually buy a function in a product rather than the actual content, which is of little concern, as long as it follows the current legislation. For example, of the companies that answered the questionnaire, only a third knew if their products contained any Flame Retardants. The substance that most companies in this study had information on was lead, where only a little over 20% did not know whether their products contained any lead or not, closely followed by mercury and cadmium, where a little over 25% did not know if their products contained these substances. There appears, generally speaking, to be more knowledge about elemental substances than more complex groups of chemicals, e.g. hexavalent chromium and Flame Retardants. Regarding levels, most applications where these substances are used in Category 8 and 9 (standard electronic equipment) are also used in other categories, hence the same levels.

1. Which products can be defined as Medical Devices (Category 8 in annex 1A in WEEE Directive) and as Monitoring- and Control instruments (Category 9 in annex 1A in WEEE Directive)?

Medical devices as a group are well defined in three different directives, as mentioned in “Control of medical devices” on page 17. They have most likely been excluded from RoHS since the reliability is of outmost importance, and since many Medical Devices are complex and used during their entire technical life length. Not all Medical Devices uses electro-technology, but, since the definition exists, it should not be difficult for companies to know if they produce Medical Devices. All retailers, producers of subsystems, and producers of complete products falling under Medical Devices are hopefully also aware if they use electro-technology in their products. If a product uses electro technology and fall under a category that is within the scope of RoHS, which probably both these Categories will be within reasonable future, they cannot use any of the six restricted substances in their applications. Despite that Medical Devices as a group is well defined in earlier Directives, half of the companies in Category 8 answering the questionnair felt that it was necessary to further define the Categories. One company stated that no further definition was necessary, but suggested that a reference to the definition in Directive 93/42/EEC6 could make the definition for Medical Devices more plain. Since this Directive is already known by most of these companies, it probably could clarify the definition. It is of course important to bear in mind that the questionnaire was answered only by ten companies in Category 8, a small fragment of the Swedish market, and a even smaller fragment of the European market, and therefore the relevance can be discussed.

Monitoring and control instruments are not as well defined as the Medical devices. They are most likely excluded since their commercial life length is the same as the actual life length, since they often are huge and expensive. Demands on reliability are high, and the reliability of alternative methods is not well known. Apart from expanding the example list on monitoring and control instruments, one idea could be to have a detailed description in the final example who works as a “funnel” for products that does not fit under any other example. Seven of fifteen companies under category 9 that answered the questionnaire believed that the categories needed to be

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6 MDD: Medical Devices Directive
expanded and/or further defined, hence a smaller fraction of companies compared with Medical Devices. It is easier to understand why retailers, producers of subsystems, and producers of complete products falling under Monitoring and control instruments experience difficulties with the definition. The difference that could be noticed in the questionnaire compared with Category 8 was that six of seven companies in Category 9 suggested extensions to the example list in annex 1B in the WEEE Directive. The suggestions were from three of these companies to elucidate the example list further. Since these products have no earlier definition as a group, it would be a good idea to elucidate the example list for Monitoring and Control Instruments, so that it becomes clear what products fall under the category. Altogether, it is not obvious in all cases which category a product should fall under. Of the companies that answered the questionnaire, one regarded their products not to fall under any of the two categories.

2. To what extent are the six hazardous substances mentioned in the RoHS Directive used in these product categories? Is Deca-BDE used in products falling under Category 8 and 9? If not, which Flame Retardants are used?

An obstacle for answering this question has been, as mentioned, that the production of electronic products usually involves a long production line, where the communication so far has been concentrated on technical data and not on contents of a product. The information is lacking – 25 companies answering the questionnaire revealed to have little knowledge on the contents of their products; ¼ of the companies in this study stated that they did not know if they used lead or not, and that was the substance that most companies knew about, while the worst result was 69% of these 25 companies who did not know if their product contained PBB or PBDE. If the concentration would be on the companies who stated that they either used it or not, the numbers would be as following:

Table 10: Percent of companies in this study, apart from the companies that did not know if they used the substance or not, that used the six hazardous substances

<table>
<thead>
<tr>
<th>Substance</th>
<th>Lead</th>
<th>Cadmium</th>
<th>Mercury</th>
<th>Hexavalent Chromium</th>
<th>PBB &amp; PBDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent of companies, of the companies that knew if they used the substances or not, that use any of the six hazardous substances</td>
<td>79%</td>
<td>28%</td>
<td>6%</td>
<td>8%</td>
<td>22%</td>
</tr>
</tbody>
</table>

The overall information on the products contents were as mentioned poor at the companies in this study. Regarding Flame Retardants, it was even more lacking. Regarding Deca-BDE, a congen of PBDE, the information was absent. Once again, it appears as if the question should be asked earlier in the line of production where the Flame Retardants are added, since Deca-BDE is used as a flame-retardant. It should not be too difficult for a component manufacturer to know which flame-retardant that is used in their products, since it logically are the component manufacturer who adds it to the component. The fact that more than half of all companies that participated in the survey did not know if they used PBDE is severe, regarding the environmental and health impact of the substance. PBB is not of any large industrial use anymore; it was replaced during the 90s. PBDE on the other hand is still used to some extent, but it is often replaced in the current applications by TBBPA, as mentioned. 3 of the 25 companies in this study stated that they used TBBPA.

Demanding information on product contents in all production lines could solve the problem that the company that finally puts a product on the market do not know the exact content of it. Obviously, according to the result in this study, the lack on content information is great between
part manufacturer and the producer of a final product, and the retailer or importer of a final product. The companies, generally speaking, orders a function from the subcontractor and gets a function with technical description. The reason is partly that there is no current legislation demanding for companies to know the exact contents of a product, they only have to know that they do not use certain hazardous substances that are regulated. Also, there is little demands from the customer and market in Europe for products to have good environmental performance, compared with, for example, the Asian market.

Table 11: Usage of hazardous substance in Category 8 and 9, given in this study

<table>
<thead>
<tr>
<th>Application Examples</th>
<th>Questionnaire</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cadmium</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Batteries</td>
<td>10% say they use 70% say they do not use 20% do not know if they use it or not</td>
<td>25% say they use 37% say they do not use 37% do not know if they use it or not</td>
</tr>
<tr>
<td>Pigments</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stabilisers</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Lead</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solder &amp; Flux</td>
<td>60% say they use 20% say they do not use 20% do not know if they use it or not</td>
<td>60% say they use 13% say they do not use 26% do not know if they use it or not</td>
</tr>
<tr>
<td>Surface finish</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mercury</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Batteries</td>
<td>80% say they do not use 20% do not know if they use it or not</td>
<td>6% say they use 56% say they do not use 37% do not know if they use it or not</td>
</tr>
<tr>
<td>Measuring and control equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light Sources</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Hexavalent Chromium</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardener</td>
<td>60% say they do not use 40% do not know if they use it or not</td>
<td>6% say they use 37% say they do not use 56% do not know if they use it or not</td>
</tr>
<tr>
<td>Stabiliser</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Colorant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anti-corrosion</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PBB and PBDE (DecaBDE)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flame Retardants</td>
<td>20% say they use 20% say they do not use 60% do not know if they use it or not</td>
<td>31% say they do not use 69% do not know if they use it or not</td>
</tr>
</tbody>
</table>

It might be difficult to know the exact contents of a product since a component is put together from several different materials, it might be virgin material but also recycled, and recycled material suffers the risk of containing some level of impurities (from earlier uses). It is however possible to know the main content though it can be difficult to know the exact content, and to ask for information on the main contents from the subcontractors ought to be interesting later in the production as well. Another good thing that improved communication between the subcontractors, retailers and producer of subsystems could lead to is that the readaption of processes would become less strenuous.
3. In which amounts do these substances occur in these products?

Since most of the companies that answered the questionnaire did not even know the contents of their products, they obviously do not know in which amounts they occur. The approach appears to be to follow the current legislations, rather than having a more long-term point of view, concerning hazardous substances. For example, when the RoHS Directive is put into force, a list of the six hazardous substances will probably be sent from the larger buyers to the subcontractors, saying “the following substances are banned”. There is a demand from the large buyers (since the smaller have no saying in the matter) on the subcontractors, who adapt their production accordingly.

An issue concerning amounts is how to measure the contents, both companies that want to make sure that they are not exceeding the current limits given in legislations, and also authorities that test if companies do live up to the current legislation. There are different ways of measuring the content of a substance in a product. Lead in solders, for example, can be measured:

- % By volume
- % By weight
- % Of printed circuit board
- % Of bonding

The RoHS Directive will regard % by weight amounts, in a homogenous material. The definition of “homogenous material” might be difficult to interpret. It can be described as concentration of a substance in the smallest parts of a product. The maximum concentrations in the RoHS Directive is 0.1% by weight in a homogenous material for Lead, Mercury, PBB, PBDE, and Hexavalent Chromium, and 0.01% by weight for Cadmium. SP, Swedish National Testing and Research Institute, has stated that the cost of analysing a product by the formulation: through every smallest part, will increase the price dramatically. They compare with the methods used for Ecolabelling, where the larger parts are removed and analysed, while all smaller parts are being crushed and analyzed all together with the Printed Circuit Board (SP, 2004).

The current lead-free alternative (SnCuAg) in lead-free electronic production will demand larger temperature differences between large and small components. The smaller component risk to suffer from the popcorn-effect if the temperature is adjusted for the larger components. The larger components risk to not get properly attached if the temperature is adjusted for the smaller components. Higher temperature also may cause delamination on the Printed Circuit Board. This is, as mentioned, one of the large problems with this alternative technique. This problem imply that the placing of components on the Printed Circuit Board will become more important, and that the heating processes will be forced to become more optimized. Larger components probably will be placed together, in order to be able to heat selectively (IVF, 2004). A positive factor following is that this probably would simplify the testing of substance contents marginally, since the smaller components will be placed together and the larger as well, and as mentioned earlier the larger parts are analyzed one by one while the smaller are crushed and analyzed with the Printed Circuit Board.
4. In which amounts do these substances contribute to the characteristics of a material?

As mentioned most companies in this study did not even know which substances their product contain and, consequently, not in which amounts or in which amounts they are needed for the characteristics. As mentioned earlier, the application in which these categories use the hazardous substances is often used in other categories as well. For example, the amount of lead in solder is well known, with a typical amount of ca 63% Lead and 37% Tin. Lead has, as mentioned both in question one and in the chapter about Hazardous Substances, also been used as flux and surface finish on components and Printed Circuit Board.

Brominated Flame Retardants on the other hand, are difficult to measure since they are physically attached to the material. Flame Retardants are usually much cheaper to buy compared with the plastic components they are added to, which might be the reason why some products contain more Flame Retardants than necessary. This statement is based on the fact that higher amounts of Flame Retardants both secure the flammability of a product, and also results in a lower cost. Also, the fact that the demands on flame protection is higher in some countries might lead to that global or international companies use the higher amount, in order to be on the safe side.

5. To what extent can these substances be regarded as impurities?

Trace amounts of different substances are often found in materials after production. Virgin organic material, e.g. plastics, do not contain any organic impurities, e.g. Flame Retardants. They can on the other hand contain some non-organic impurities, e.g. metals such as Lead or Cadmium. The amounts of impurities differ between batches, which makes it difficult to know the exact content of each product. To clarify this it would demand a test on each batch, which is economically impossible, particularly regarding that the price will increase according to SP (SP, 2004). The maximum levels given in RoHS are quite high though, and some disparity is possible within the frame.

The maximum levels of hazardous substances given in the RoHS Directive are 0.1% by weight for all substances apart from Cadmium, where the maximum level is 0.01% by weight. Regarding lead it will be of concern for the producers to avoid lead impurities, in order to avoid the decrease in reliability caused by contaminations within the lead-free production.

6. Which other hazardous substances are used in this equipment, and which hazardous substances have the industry itself identified?

None of the companies that answered the questionnaire mentioned any hazardous substance (apart for the ones mentioned in RoHS). The overall attitude of the industry appears to be to keep up with current legislation. Environmental performance is not regarded as a competition mean of importance at the moment. This probably also is caused by the market, that has not pushed the industry to such extent that they have become forced to change attitude.

The alternative alloy that credibly will replace lead, SnAgCu, will result in a better environmental performance, regarding toxicity. (O. Deubzer e.al, 2001). This alternative has, however, some downsides, such as negative downstream environmental impact, but it is currently the best alternative.

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7 Hazardous Substances, meaning that are either CMR (Carcinogenic, Mutagenic and Reprotoxic), PBT (Persistent, Bio-accumulative and Toxic), or vPvB (very persistent and very bio-accumulative)

8 In order to get one unit Sn, Ag or Cu, many more units of bedrock has to be extracted
7. Which work has been carried out to substitute the six hazardous substances mentioned in the RoHS Directive, or other hazardous substances, in products falling under the two product categories? Are there or will there be alternative substances and techniques available within a reasonable future to substitute the six hazardous substances and others in the two product categories? Are there particular electronical components where Deca-BDE is used today that are difficult to substitute?

The survey showed that most companies had no information on the EEE component contents in these two categories, or that they did not want to give that information to a questionnaire sent from the Chemicals Inspectorate. Since they order EEE subsystems from other companies, there probably is more know-how on the function and substance contents of the EEE at these companies. The majority of all companies answering the questionnaire where small sized companies, with less than 50 employees. However, about one third of all companies in this study knew about alternative techniques. A fifth of them had continuing research on alternative techniques, and two companies participated in overriding research. Six of the companies in this study mentioned that they had substituted some of the six hazardous substances mentioned in RoHS, or other hazardous substances. In most of these cases, it was a replacement of one kind of batteries to another, with better environmental performance. The effect of RoHS Directive on production can probably be found further down the line of production, where the know-how is, at component suppliers, Printed Circuit Board Manufacturers, and Printed Circuit Assembly Manufacturers and at larger companies, rather than small sized. They are the ones that are going to adapt their processes according to the current legislation, pressured by the buyers and the authorities.

Instead of PBDE and PBB other substances are used as Flame Retardants in new EEE products. One rather common replacement in EEE is Tetrabromo Bisphenol A (TBBPA). TBBPA is chemically attached to the material, instead of physically, and does therefore not involve the same risks of diffusion as PBDE. The information on risks to the environment and humans from TBBPA are somewhat scanty and there is a risk that the test methods used today are not developed enough to be able to see the toxicity of the substance. There is currently an EU risk assessment ongoing concerning TBBPA and it was expected to be finalized during 2004 (EBFRIIP, 2004). TBBPA was also tested in the research published in “Brominated Flame Retardants: developmental Neurotoxicants”, where mouse exposed to different Flame Retardants locomotion where measured during a finite time limit. It resulted in pathological behaviour in the mouse that had been exposed to PBDEs, while the mouse exposed to TBBPA did not differ much from the normal (Eriksson and Viberg, 2004).

Considering lead, there exist several alternatives in electronic production. Several different actors have research on the substitution processes, among them IVF, financed by some of the larger producers. They have found an investment in having the know-how of these new techniques, and IVF currently give courses to companies that are to readjust their processes. The result of the studies at IVF shows that the best alternative to lead is an alloy of tin, silver and copper. An issue to regard is the environmental behaviour of the alloys. Compared with lead, it might be a better alternative, however tin is hazardous for water living organisms and copper is ecologically harmful. The alloy can be regarded as a temporary solution, which is far from ideal. It is a difficult balance to neither risk the function nor the environmental performance of the EEE.

Hexavalent Chromium, Cadmium, and Mercury are hardly used in category 8 and 9 according to the results of this study. Only 12% of the companies found it necessary for their products to have a long time limit before substitution. Since 60% of the companies in this study used lead in their products, it appears as if a regulation of this substance would have little consequence for
Regarding all information on EEE, lead regulation is the one most discussed concerning the RoHS Directive. To conclude according to this questionnaire, the substitution of Deca-BDE in components is not going to bring any larger complications. Björn Albinson mentions in the article in Råd&Rön, that flame-retardant are not the most important factor to avoid fire; it is the knowledge of the risks that is more important. KemI points out in their report on Flame Retardants that it is possible to use alternative materials that do not need flame protection, instead of changing to another flame-retardant or worse alternatives. It is also possible to change the overall design so that Flame Retardants become superfluous. Altogether it is of high importance to think on fire safety rather than Flame Retardants. (Råd&Rön, 2004)

8. Would a longer transitional period, compared with the other 8 categories, for the technical adaption of EEE be necessary for Category 8 and 9?

Only three of the companies answering considered it necessary with a longer time limit for these two categories, but these answers are too few to make any conclusions. One of these three companies suggested an extra year, and another five years. These companies did not operate in the same line of business. The one suggesting five years operated in radiation protection, where no current alternatives are available, and felt that it was necessary to find reliable alternatives. In this case, an exemption probably is the best alternative, since they do not use the same technology as other categories. The other company suggesting one year said that it was fair to give an extra year to the companies producing products under the two categories, since they had not had the chance to prepare as good as the other categories. It might of course be regarded as a downside at first, but on the other hand it might also be easier for a company to get prepared when other companies have years of experience. But the approach not to research on alternatives due to the fact that a company currently is not covered by RoHS is a very short-term approach, and not recommended, since the goal is not to have any exemptions and that all applications will be included as soon as alternatives are found.

In the applications where these categories use the same electro-technology as other Categories they probably have to readapt their production simultaneously, since the subcontractors readapt their systems to be compliant with RoHS. The price of non-compliant component will increase, since they will become more rare, and eventually be phased out.
Issues concerning the RoHS Directive

The reason these particular issues around the RoHS Directive is discussed is that they have been frequently discussed. It is issues that the companies answering the questionnaire have wondered about, it is questions asked by the different persons that have been interviewed and it is issues that has been discussed in articles concerning the RoHS Directive. They are important to elucidate and analyze proportionately to the 8 questions this study aim to answer.

- Are the alternatives to lead better alternatives, regarding the environment

The alternatives are of great importance. It is of importance to make consequence analysis for the alternative substances and techniques that are going to be used, in order to be sure that the alternatives are better. Otherwise the industry might just end up with equally hazardous substances. The goal is to reach such a non-toxic environment as possible, and in order to reach that goal it is of high importance to go from one alternative to a better. Regarding lead, the environmental performance of the current alternatives are better (O. Deubzer, H. Hamano, T. Suga, 2001). Still, there are some issues around these alternatives as well, and better alternatives will probably be found with the technical development.

- Difficulties to separate lead-free components from non-compliant components

In order for this new legislation to work, it is of high importance for component suppliers, Printed Circuit Board Manufacturers, and Printed Board Assembly Manufacturers to properly mark their lead-free products. The effect of lead contamination on lead-free applications is fatal for the reliability. It is of high importance for buyers to separate the components, and to use the ones containing lead in time before the RoHS Directive is put into force.

- Higher process temperature will increase energy consumption

The conclusion of a increased energy consumption is negligible, since the actual effect of the alternatives will be (according to the research at IVF) that the process window will decrease. This will demand higher performance of the production processes and possibly also of the equipment, and this will require a overhaul of the processes and equipment. In many cases this overhaul may decrease the energy consumption, in the cases where the equipment and production processes have not been looked over for several years.

- Companies will outsource their production due to the costs of adapting to RoHS

The readaption of processes might be an overwhelming cost for companies with little capital, hence mostly small sized companies. But on the other hand higher demands on the production processes might also consequence in that the processes have to be placed in the countries with high know-how and experience, both considering design, and production. This is an opportunity for countries with top competence concerning production processes.
- Exemptions are not going to be exemptions in reality
(See the current Exemptions in “Annex in RoHS Directive” on page 55)

Exemptions will probably be approached differently at companies, partly depending on their environmental profile, but also depending on their size. Large companies, like Ericsson, do not readjust only parts of their production; they will readjust the entire line of production, despite some applications might have product specific exemptions listed in RoHS at the moment. Susanne Lundberg, Director of Product Regulations and Environmental Issues at Ericsson, says that she thinks it would have been better to include the whole industry in one sweep, somewhat later than the current date for entry into force. The exemptions will not be exempted in the production, according to her experience (Lundberg, 2004). Ericsson have worked on phasing out lead in their applications since some years back, and informed in May 2000 that lead-free solder would be used in 80% of their products by the end of 2001 (Five Winds International, 2001). The same document also mentions an 80% elimination of the use of halogenated flame retardants in new Printed Boards. The fact that exemptions will have problems being exemptions in reality, due to both costs and supply, is probably true for the applications where the same electro-technology is used inside the products as for other companies that is within the scope of the RoHS Directive.

It is also important to separate the different kind of exemptions. The current exemptions can be regarded in three cases:

1) Exemptions where no alternatives are available at the moment
The first case to regard is some special applications where there currently exist no alternative. These applications should, when alternatives are found (all exemptions will be analyzed at least every 4th year) be analyzed separately, and exempted on the basis of a weigh of the environmental impact.

2) Products falling under categories 8 and 9, that are outside the scope of RoHS
Placing a whole product category outside the scope of the RoHS Directive is probably not going to have much effect in reality, in the cases where the electro-technology used are the same as in other categories. This is one case, where a retailer, producer of subsystem, or a producer of a whole product in Category 8 or 9 buys the same electro-technology as other categories, but is exempted just because their product falls under one of these two categories. It will also cause problems for these companies when their subcontractors change over to become compliant.

3) Exemptions due to special applications.
Finally a third alternative is possible, where the alternatives are not reliable enough, due to the outstanding importance of reliability. Instead of excluding the two categories one suggestion can be to expand the list of exemptions in essential in the annex of RoHS. The exemptions can apply to applications within this categories with products working under extreme environments. Extreme environments can be:
- Long lifetime requirements
- Vibrations
- Extreme physical environments:
  - High or low temperatures
  - Wet or dry environments

To sum up: all of the cases where the reliability is of outstanding importance, for example devices monitoring the heartbeat of persons with a heart disease, since the alternative technology available cannot guarantee the same reliability, and since it has not been used and explored in the same way as EEE containing lead. However, as mentioned earlier, it will be difficult to keep an
exemption for many years, since the price of these components will increase after the readjustment to RoHS Directive, and the leaded components will not work properly in lead-free environments. The suggestion is for these applications to have a time limit of 2-3 extra years, in order to have the same time as other categories had to prepare for the readjustment, and to be sure about the reliability of the alternative techniques. The reliability will most certainly have increased by then.

Numerous companies in this study did not know that their product category was excluded from RoHS. With RoHS the subcontractors will adjust their mass production of components so that they do not contain the restricted substances, hence the price of components still containing these substances will increase. The fact that all products using electro-technology order components from the same subcontractors most certainly will make it difficult, and expensive, to continue using components containing the hazardous substances in RoHS. For many exemptions there will probably be a need to find alternative techniques as soon as possible, not only due to the fact that they have to follow the legislation, but also by economical reasons. The majority of companies producing electro-technology equipment and EEE in Europe will have to readjust their production. Since the same subcontractors are used, they will readapt their processes to lead-free as well, and the price of parts containing lead will increase dramatically. Since lead-free becomes standard, it will become cheaper.

- **Reliability issues**

The reliability of the alternative substances is not as well known as the once that have been used for decades, obviously. The research at IVF has shown that lead-free electronic production is better in some aspects, as well as worse in some. With this new technology, as with all new technologies, comes new Obstacles and new Prospects. It is of high importance not to risk the safety of EEE users, and consequently some exemptions, where the reliability is of outstanding importance, have to be exempted until the reliability is well known.

The risk of EEE not functioning well are in these two categories of particular concern. It is especially important for Medical Devices to be reliable (due to the fact that they are used directly on humans). Monitoring- and Control Instruments are of concern if they do not work well, due to the fact that it may have fatal consequences, not only economical (since usually these machines are quite expensive and therefore have a long actual as well as technical life length). For example, if an instrument that measures the amount of hazardous substances in air malfunctions, it can be a risk for the worker. If it is an instrument controlling a process with vessels containing corrosive substances, it can cause unexpected tipping of the vessels, which can endanger the safety for the worker.
Conclusions

The study of literature has shown that much research on the restrictions in RoHS is concentrated to lead-free electronic production. The criticism from IPC is entirely focused on the phasing out of lead, none of the other substances is mentioned at all. This imply that lead is the substance with most consequences on the electronic industry.

Conclusions from the Questionnaire

- Half of the 25 companies that answered the questionnaire regarded themselves as retailers or importers of complete products, 35% as producers of complete products and 15% as subcontractors or producers of subsystems.
- 60% of the companies in Category 8 and 75% of Category 9 had less than 49 employees, implying that most companies in Sweden can be regarded as small companies.
- Most of the companies in this study got knowledge about RoHS through this questionnaire.
- Little demands from customers to stop using the hazardous substances in RoHS; 10% in Category 8 and 31% in Category 9.
- The companies questioned in the survey, which sell medical devices and monitoring- and control instruments, often had little knowledge of the electronic parts in their products. The reason is that most final products consist of many different components produced at many different companies.
- Little or no knowledge on product contents:
  - More than half of the 25 companies answering the survey did not know whether or not their products consisted of any flame-retardant.
  - 13 companies did not know if they used Hexavalent Chromium.
  - 8 companies did not know whether they used Cadmium and Mercury.
  - 6 companies did not know if they used Lead.
  - Four companies used alternative Flame Retardants, such as TBBPA.
  - Four companies had substituted Cadmium batteries with alternative batteries.
- 75% felt that the development of environmental products was not a competition advantage now but they believed that it would grow further in the future.
- Majority feels that RoHS will result in a more just EU market.

25 companies did actively participate in the questionnaire, ten from category 8 and fifteen from category 9. This is a little more than 30% of all companies that received the questionnaire. The reason that so many did not answer may be many, for example:
  - Many companies mentioned that they probably would not have time to answer the questionnaire when they were reminded to answer.
  - Some companies might have been afraid that they would have been examined by KemI if they claimed to use different hazardous substances, despite that it was given in the information that the survey was confidential.

Together, these companies consist of a small part of all companies that produce products falling under category 8 and 9 in the WEEE Directive. Hence, the relevance of the survey is difficult to estimate. No exact information is available on how many companies there exist in these two categories, since there is no particular categorisation of products using electro-technology in that lines of business. The relevance can be further discussed since all referred companies are located in Sweden and give a basic idea of the Swedish industries concerns and attitude.
Conclusions from Questionnaire, Interviews and Literature together

1. Subcontractors readjustment force companies to become compliant

Since many products in these categories use electro-technology, that most certainly contain lead, they will be directly affected by the readjustment of the other categories. The reason is that when a substance becomes restricted in law the affected industries push their subcontractors into using other substances. The majority of all companies in this study claimed that they (or their middlemen) had no influence on their subcontractors, since they more or less only took whatever there was left after the larger importers had bought what they needed, such as telecom companies. If this is the case, the readjustment for the European market will be total since the majority of companies using Electro-technology is within the scope of the RoHS Directive and will force their subcontractors to change to lead-free production. Hence the exempted categories and some of the particular exemption cases might be superfluous. The readjustment at subcontractors can also cause lead-free components to be introduced in non compliant applications. As mentioned, lead contamination causes severe decreases in fatigue, and it is important for these companies to realize the need of readjusting all processes to these new techniques, in order not to risk decreases in reliability.

Products in categories 8 and 9 falling under the definition of EEE often have the same subcontractors as all the other categories. The line of subcontractors regarding EEE is often very long and the subcontracting work is nearly without exception located in Asia, since they have the cheapest labour. According to the results of the statistical survey, half of all companies are retailers and importers of complete systems, meaning that they have no direct clear grasp of the production processes.

Most of the companies answering the questionnaire were small sized companies that bought electro-technology from subcontractors. The impression they gave in the questionnaire was that these companies ordered only small amounts of electro-technology, and that it often was leftover from larger buyers. Large buyers might order a batch of say 5000 components from a subcontractor, and then the subcontractor produces a little more than 5000 to be on the safe side, and the leftovers is bought by small companies. If this is the case, the small sized companies will be forced to readapt according to the demands from the majority of larger buyers, meaning that the exemption might be misleading and cause these small sized companies never to have a realistic chance to adapt their processes, given that they have a short-term approach and have not researched on alternatives earlier.

2. Matter of Size

The size of a company tends to matter for the impact of the RoHS Directive. The result from the survey confirms that (generally):

Larger industries

- often falls under several categories, and adjust their production after the strictest legislation
- have access to information on coming legislations
- often regard exemptions as temporary, and adjust their production in an early stage
- often have sent lists over the restricted substances given in RoHS to their subcontractors, forcing them to stop using them
Smaller industries

- cannot really affect the subcontractors, since their financial means are restricted
- buy EEE that is left from the larger buyers
- when the price of components containing hazardous substances increase, and those without decrease, they are forced to buy the cheapest
- have difficulties getting hold of lead-free components in time, since European middlemen want to get rid of their stock before RoHS is put into force

It is important to understand the complexity of speculating around the future of small sized companies. Many different factors will impact the outcome. It is a risk that small sized companies will suffer if they neither have the economical means, nor the technical know-how to become compliant. The environmental issues have become more important for both small and medium sized companies lately, and some models of cooperation have been developed, in order to survive the increased competition. A suggestion could be to work like in ‘Hackeforsmodellen’, (Altea, 2004), where several small and medium sized companies worked together to get certificated according to ISO 14001.

3. International Impact

The effects of a European legislation will affect the entire world, since the market in Europe is too large to be ignored by worldwide producers. Since most of the subcontracting work is located in Asia, where the cheapest labour is to be found, it would certainly have a direct impact on their production. Most companies will eventually be forced to adapt. All of the exemptions mentioned in the annex cannot keep their production of parts containing lead. The reason is that:

- all component suppliers will switch to lead-free,
- all Printed Circuit Board manufacturers surpass to lead-free finish,
- all Printed Circuit Assembly manufacturers will change to lead-free processes,
- finally the economic factor – lead-free will become cheaper.

4. Hazardous Substances

For category 8 it is described in the Medical Devices Directive that particular attention must be paid to the choice of materials, particularly as regards toxicity and, flammability. This should logically result in that none of these substances are used in any products where alternative methods are available.

A historical pattern around hazardous substances is traceable. Deca-BDE was not classified as hazardous earlier. With improved research methods it was later discovered to be hazardous. It showed that Deca also had the ability to break down in nature, and dissolve to other Brominated Diphenyl Ethyls inside living organisms (like Penta- or Octa-BDE). Formation of other hazardous substances has also been discovered during burning and recycling of materials consisting of PBDEs. The amount is not known.

PCB, was found to be potentially hazardous during the 60s. It was not prohibited in some industrial applications until late in the 80s. Both Deca and PCB have been used due to their good properties in certain applications. It was later found out that they have some severe consequences. Freon was used for cleaning away the flux in the electronic industries earlier. It was later found to be hazardous. The examples are many.
To generalize, the process for substances (brominated flame retardants, and heavy metals) follows a pattern, as mentioned:

1. **Substance with right properties:** A substance with right properties for the functioning is found by the industry.
2. **Testing, stage one:** For the over 100,000 different substances that was put on the market before 1981, so-called “existing” chemicals, there is no demands on that the substance have to be tested in any way by the industry before it is put on the market – see REACH. Tests on “new” chemicals with current methods does not show any severe consequences. Single or few independent studies or research papers from other instances proves the toxicity of the substance.
3. **Costs overwhelming:** Costs for readaption is too big for the industry to change substance. The cost is currently unproportional against the environmental gain, especially since the toxicity is only proved according to a single or few research.
4. **Testing, stage two:** Methods for testing are improved, toxicity is proven by a larger number of studies and research papers.
5. **Substance defined as hazardous:** The product is tested further, and finally defined as hazardous. Authorities starts decision process for phasing it out.
6. **Find alternatives:** Industry is forced to find other substances (and process starts over again).

It is important to remember that (based on historical evidence) consequences are often found after the introduction of a substance. If the substance is persistent and is spread by air it will have global consequences. It is very important for companies to change this pattern to having a more long-term point of view when choosing materials during the design of a product, and it is also important for customers to put pressure on the companies to do so. Finally, for the customers to become aware of the issues with hazardous substances, the authorities have a role of informing them. Susanne Lundberg at Ericsson said in the interview that she had a fear that the responsibility of chemicals would be transferred from the chemical suppliers to the product manufacturers. She feared that the cost of this would increase the price of the final products. She wanted to point out that legislation should target the manufacturer, in other words, that the material should be phased out at the chemical plants. (Lundberg, 2004). This fear will hopefully and probably not become reality when REACH is put into force.
Prospects and obstacles

Prospects:

• Much of the EEE used in Category 8 and 9 are the same as in other categories, in these cases it is better for the companies not to be exempted, in order to have time to prepare the design and production processes accordingly
• Non-compliant components will become rare and expensive, hence it is an opportunity for some small and medium companies to survive by not exempting them and forcing them to adapt, despite that they might protest
• If the companies readapt their production, they will probably look over their production processes. This may increase the productivity
• Considering Category 8: The Directive 93/42/EEC⁹ states that particular attention must be paid to the choice of materials, particularly regarding toxicity and flammability
• The conclusions that can be drawn from the survey and the information from the different interviews show that the RoHS Directive will have effect on all users of EEE, whether or not the companies are willing to change and readjust their products. It will affect the entire world, since the products falling under the categories that are included in RoHS Directive are so many that they will affect the entire line of business
• Exemptions might be superfluous in reality, since the price of non-compliant parts will increase and eventually be phased out. Large companies, such as Ericsson, will adjust their entire production when RoHS is put into force
• Opportunity for small sized companies to start cooperation for mutual support
• As mentioned in the WEEE Directive there is no demand on increased quota of recycling before 31st December 2006 for Category 8, and 50% for Category 9. Hence it is of high importance that these products do not contain Hazardous Substances.

Obstacles:

• If subcontractors do not change part numbers, it will be impossible to separate compliant parts from others. The consequences of lead contamination is, as mentioned, fatal for the fatigue
• The long line of production makes it difficult for the end of the line to know the contents of their products
• Costs for some small sized companies may be overwhelming. Still, if their uses are exempted and they use the same electro-technology as other categories, they will not be able to keep on using non-compliant equipment for a long time, since the price will increase for such equipment when the availability decreases
• Uncertainty concerning the reliability and little know-how on the new materials. As time goes and knowledge increases this obstacle will disappear

⁹ MDD: Medical Devices Directive
Outlook

The result of this study suggests that Category 8 and 9 should be included, for two reasons.

1) Areas where these categories do not use EEE that is used in other categories is rare, according to the result of the questionnaire, and these areas are better to exempt, instead of the whole category.

2) Non-compliant components will become more rare and more expensive, and to include the categories is to help them find alternatives in time.

Since these categories have been outside the scope of RoHS it would be fair to give them the same period as for the other categories to adapt their production. Meaning that they would be exempted 2-3 years after RoHS is put into force. For these, often small sized, companies in Category 8 and 9 it is necessary to adapt the production in time, so that they do not end up with production processes that cannot be used, since the non-compliant components have increased in price and availability. It might be easy, due to the exemption, to push the production adaption to far away in the future and get problems when only RoHS compliant components are available for a resonable price.

Regarding including more substances this study have not found other substances that could be replaced with better alternatives. The reason is partly that the concentration was to elucidate prospects and obstacles for expanding the scope of the RoHS Directive. An issue that is of high importance to consider further is the alternatives to the current uses of the six different hazardous substances – are the industry going to use substances that are better alternatives compared with the restricted? It is necessary to make consequence analysis for the alternatives.

It would also be interesting to find out in more exact amounts that the six substances restricted in RoHS are used in the two product Categories. This would be interesting in order to weigh the environmental performance against the costs for the industry and society. Another interesting area to look into would have been the example list over categories, in particular for category 9, since it has no earlier overall definition.

Finally, it is necessary for both authorities and consumers to continually put pressure on companies to use substances with environmental performance, not hazardous substances. Another important factor is to improve the communication and cooperation between the different stakeholders, which may bring solutions to many difficulties. The communication has to improve between retailers, producers, subcontractors, and other stakeholders involved in the manufacturing and placing of products. The communication also needs to improve between authorities, consumers and industry. The communication has to improve between EU member states also, and globally.
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http://www.kemi.se/
The Swedish National Encyclopaedia
http://www.ne.se/
## Dictionary

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<th>English</th>
<th>Swedish</th>
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<tbody>
<tr>
<td>Alleviation</td>
<td>Lindring, lättnad</td>
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<td>Allergenic</td>
<td>Allergiframkallande</td>
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<tr>
<td>Alloying element</td>
<td>Legering; 2 eller flera grundämnen som tillsammans bildar ett material med metalliska egenskaper</td>
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<td>Amber</td>
<td>Bärnsten</td>
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<td>Amplifier</td>
<td>Förstärkare</td>
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<td>Automatic dispensers</td>
<td>Automater</td>
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<td>Bioaccumulation</td>
<td>Bioackumulerbarhet; biologisk nedbrytbarhet</td>
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<td>Carbon</td>
<td>Kol</td>
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<td>Carcinogenic</td>
<td>Cancerframkallande</td>
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<td>Cardiology</td>
<td>Kardiologi; läran Om hjärtat</td>
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<td>Cardiovascular diseases</td>
<td>Hjärt- och kärlsjukdomar</td>
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<td>Cathode ray tubes</td>
<td>Katodstrålerör; används som bildrör i olika applikationer. Vanligaste skärmtkteniken i t.ex. Data, tv, oscilloskop</td>
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<tr>
<td>Channel</td>
<td>Kanal</td>
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<td>Coating</td>
<td>Höljen</td>
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<td>Coil</td>
<td>Spole</td>
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<td>Compact fluorescent lamp</td>
<td>Lågenergilampa</td>
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<td>Comply</td>
<td>Följa</td>
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<tr>
<td>Conception</td>
<td>Begrepp, uppfattning</td>
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<td>Congener</td>
<td>Kongent</td>
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<tr>
<td>Deca</td>
<td>Tio (grekiska)</td>
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<td>Decompose</td>
<td>Upplösa</td>
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<tr>
<td>Dialysis</td>
<td>Dialys; teknik för att separera små molekyler från stora</td>
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<td>Diffusion</td>
<td>Utbredning, spridning</td>
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<td>Dismantling</td>
<td>Demontering</td>
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<td>Disparity</td>
<td>Skillnad</td>
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<td>Avfall</td>
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<td>Ecologically harmful</td>
<td>Miljöfarlig</td>
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<td>Electronic tube</td>
<td>Elektronrör; en förstärkare bestående av en tub (oftast i glas) och två eller flera elektroder</td>
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<td>Elucidation</td>
<td>Förtydligande</td>
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<tr>
<td>Endocrine disruption</td>
<td>Endokrin störning; Endokrina organ är körtlar som bildar hormoner och utsöndrar dessa i blodet</td>
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<td>Etched</td>
<td>Etsad</td>
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<tr>
<td>Flame Retardant</td>
<td>Flamskyddsmedel</td>
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<td>Flussmedel</td>
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<td>Fosterskador</td>
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<td>Funnel</td>
<td>Tratt</td>
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<td>Halofosfat</td>
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<td>Farlig</td>
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<td>Sexvärt krom</td>
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<td>In-vivo</td>
<td>Verkligheten</td>
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<td>In-vitro</td>
<td>Konstgjord</td>
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<td>Legislation</td>
<td>Lagstiftning</td>
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<td>Lipo</td>
<td>Fett</td>
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<td>Luminaries</td>
<td>Belysningsarmatur</td>
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<tr>
<td>Mercury</td>
<td>Kvicksilver</td>
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<tr>
<td>Term</td>
<td>Translation</td>
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<tr>
<td>Minute</td>
<td>Minimal</td>
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<tr>
<td>Molding compound</td>
<td>Gjutande ämne</td>
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<tr>
<td>Neurotoxicity</td>
<td>Neurotoxicitet; skadligt för nervsystemet</td>
</tr>
<tr>
<td>Octa</td>
<td>Åtta (grekiska)</td>
</tr>
<tr>
<td>Ophthalmic</td>
<td>Oftalmologisk; Medicinska frågor kring människans synorgan</td>
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<tr>
<td>Overhaul</td>
<td>Översyn</td>
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<tr>
<td>Pathological</td>
<td>Patologiskt beteende</td>
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<tr>
<td>Penta</td>
<td>Fem (grekiska)</td>
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<tr>
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<td>Ihärdig, envis</td>
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<td>Plating</td>
<td>Överdrag (av metall)</td>
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<td>Poisonous</td>
<td>Giftig</td>
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<td>Printed Circuit Board</td>
<td>Mönsterkort</td>
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<td>Printed Circuit Assembly</td>
<td>Kretskort</td>
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<td>Pulmonary ventilators</td>
<td>Lungrespirator</td>
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<td>Radiotherapy equipment</td>
<td>Strålbehandlingsutrustning</td>
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<tr>
<td>Rectifier</td>
<td>Likriktare (diod)</td>
</tr>
<tr>
<td>Refute</td>
<td>Motbevis</td>
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<tr>
<td>Restriction</td>
<td>Begränsning</td>
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<td>Silicon</td>
<td>Kisel</td>
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<tr>
<td>Solder</td>
<td>Lod</td>
</tr>
<tr>
<td>Sound</td>
<td>Frisk, sund</td>
</tr>
<tr>
<td>Straight fluorescent lamp</td>
<td>Lysrör</td>
</tr>
<tr>
<td>Strain</td>
<td>Familj, art</td>
</tr>
<tr>
<td>Strenuous</td>
<td>Ansträngande</td>
</tr>
<tr>
<td>Subcontracting work</td>
<td>Legotillverkning</td>
</tr>
<tr>
<td>Tri phosphate</td>
<td>Trifosfat</td>
</tr>
<tr>
<td>% By weight</td>
<td>Viktprocent</td>
</tr>
</tbody>
</table>
Annex

Brominated Flame Retardants

Article on flame retardants

The Swedish Consumer Agency (konsumentverket) magazine “Råd&Rön” had an article on Flame Retardants in October 2004. It mentioned that products from England, or products intended for the English market, usually contain more Flame Retardants than others, since they have other demands on fire protection. The same applies for products put on market in USA, where Flame Retardants are used in everything from Santa masks to children pyjamas and mattresses. (Råd&Rön, 2004)

In the article Mikael Karlsson, chairman of Swedish Society for Nature Conservation (Svenska Naturskyddsföreningen) criticise that flame-retardant, as a group, are not investigated several in one sweep. The Swedish Minister for the Environment, Lena Sommestad, agreed that some Flame Retardants are hazardous, but pointed out that KemI at their last evaluation found out that Flame Retardants are so different that it is not possible to consider them all at the same time. The chairman of SNF criticised the statement for being a contradiction towards the concept of the Government. He claimed that it was against the fundamental concept of considering whole chemical groups, which The Government stands for.

He continued that it is unreasonable not to restrict chemicals referring to the fact that no alternatives are available, since there are no demands for this in the law. He mentioned further that there are alternatives, shown by Swedish Rescue Services Agency (räddningsverket), by both alternative design and alternative materials. “They are dangerous and generally unnecessary. Chemicals that can be stored in lipo tissue and that can travel long distance shall be phased out, hence we don’t want flame protection with characteristics like this”, Mikael Karlsson said.

Per Thureson, test engineer at Swedish National Testing and Research Institute (SP), said in the article that he never had seen any written standards on those Flame Retardants. How the standard is fulfilled is up to the producer. He mentioned that furniture do not have to contain flame-retardant to fulfil the standards. Parallel with the evaluation at KemI the Swedish Rescue Services Agency is working to decrease the use of Flame Retardants further, and increase the power of penetration for environmentally developed fire protection.

Björn Albinson, fire engineer at the Swedish Rescue Services Agency tells about the work: “Fire alarms, caution with candlelight and smoking, and knowledge is more important for the fire protection than the flame-retardant. More nature material is what we want to affirm. A cover of tree on a television burns much slower, but costs extra. Another example is stuffed furniture. We have compared an armchair from the 50s with a newer stuffed with foam rubber, and the last burned faster.”

Research on PBDEs

Per Eriksson at Uppsala University has published several research papers on PBDEs and other Brominated Flame Retardants together with scientists and students. Henrik Viberg is a student who took his PhD on PBDEs before Christmas 2004.

They have, in cooperation with others, proven in the study “Neurobehavioral Derangements in Mice Receiving PBDE 209 during a Defined Period” that PBDE can cause fetus damage. This
paper has, however, been criticised for not following the guidelines and hence not been approved as scientific evidence. Per Eriksson claims that the result from their study should be correct, since the result would not differ from the method they use and the method given by the guidelines in the directive. He also points out the fact that they are guidelines, not rules. The criticism has been that they did not use enough many strain of mice, and that there might be gender differences. (Eriksson & Viberg, 2004)

This criticism was refuted by a publication in July 2004, “Investigations of Strain and/or Gender Differences in Developmental Neurotoxic Effects of Polybrominated Diphenyl Ethers in Mice”, written by Henrik Viberg, Anders Fredriksson, and Per Eriksson. It shows that a study with three strains of mice gives same results as the nine given in the Guidelines. It also proves that the gender differences can be ignored. (Eriksson & Viberg, 2004)

In the article “Brominated Flame Retardants: developmental Neurotoxicants”, mice locomotion behaviour was investigated. The comparison was between Control mice, and mice exposed to PBDE and TBBPA, at different levels. The result was that PBDE gave disastrous locomotion, and made the mice incapable to know their surroundings. TBBPA did not give any results implying that it was hazardous, in this test. (Eriksson & Viberg, 2004)

There exist differences between mice and human development. However, all animals and humans are most sensitive for the introduction of toxic subjects during the development of the brain. PBDE (as PCB and PBB) is lipo soluble and therefore easy for the brain to absorb. Mice are pregnant during 20 days, where the offspring development is divided 80% as embryo and 20% as foetus. Humans are pregnant during 9 months and the percentage is just the opposite. (Eriksson & Viberg, 2004)

A study published by Swedish Society for Nature Conservation from 2001 showed that wild living peregrine falcons had up to 400% higher amounts of Flame Retardants compared with a captive breeding population. Deca-BDE was found in 18 of 21 analyzed eggs. The industry has used as argument that Deca-BDE is such a large molecule that it is not bioavailable, and therefore cannot accumulate in living organisms. Yet the study showed that the captive breeding population had little or no amount of the Flame Retardants, meaning that it had to be bioavailable. The authors mention PBDEs to be the “new PCB problem”. (U. Sellström and more, 2001)
Electricity and magnetism was great discoveries of the 18th century. But one form of electricity had been known for a long time. Friction electricity was discovered as early as 600 B.C., when Thales from Miletos learned about amber properties. William Gilbert in England first introduced the word ”electricity” in a book published 1600.

Electronics on the other hand, is a rather young technology. It started with the discovery of electronic tubes in 1900, which came into use in radio application in the 20s. But the real discovery was 1947 in the Bell Laboratories, where John Bardeen, Walter Brattain, and William Shockley produced the first transistor. Three years later the first MOS-transistor was introduced.

The first transistor
(Picture from http://cm.bell-labs.com/world-of-science)

The basic idea of the transistor is that the relation between an external and an internal resistance decides the amplification. It resulted in a Noble Prize in Physics and in the information revolution. Many new electronic products have arisen since then, and they are still expanding exponentially in capacity.

Definition
All electrical and electronic equipment is based on five fundamental components. All other products have arisen from combinations of these.

1. **Resistor**: a passive component used as resistance in a circuit.
2. **Capacitor**: stores electrical energy between two conducting surfaces. The material between and the area of the conducting surfaces decide the capacitance.
3. **Diode**: used as a rectifier, to lead current in only one direction. Transforms alternating voltage to direct voltage.
4. **Transistor**: it exist two different types of transistors: Uni- or Bipolar. If you say only transistor, it is implicated that it is a bipolar transistor. The bipolar transistors have three legs – emitter, base and collector. They work by different polarisations; one at the emitter, collector, and the leading channel, one at the base. In unipolar transistors it is always just one polarisation in emitter, collector, and the leading channel. Unipolar transistors are usually called field effect transistors, or short, FET-transistors. Transistors are used as current or voltage amplifier. It is the most important building block of modern electronics.
5. **Coil**: isolated copper foil twisted around a plastic- or iron frame. It is used together with capacitors or resistors in order to generate or filter voltage. Works like a low pass filter. A fuse is a form of coil. It consists of a cylinder of glass with metal caps on each end. Between these two caps there is a thread that will burn if the current becomes too high.
Integrated Circuit

An integrated circuit (IC) consists of combinations of one or more of the components mentioned, connected electrically on the surface. It is a small, rectangular, black box, and has 4-14 legs to connect to the Multichip Module.

Historically Kilby (Texas Instruments) developed the first IC in 1958. Two years later Noyce developed another type at Fairchild. A fight over the patent for the invention followed, where Fairchild won. But it did not really matter, since they both agreed on a cross licence earlier. Noyce is one of the three founders of Intel.

IC’s are nearly exclusively produced in silicon, hence “silicon valley”. The silicon is produced from purification of Silicon dioxide. It is thereafter divided into microscopic thin wafer slices by a diamond saw. One wafer can be the basis for hundreds of chips. The next step in the production is to create data and component pathways in the silicon. Different masks are used to describe the pattern for different layers. The masks are made of metal and etched into the silicon surface. This process is called photolithography.

Chip design before Lithography

(Picture from http://www.just2good.co.uk/cpuSilicon.htm)

Photolithography, repeated for each mask. Different chemicals and dopants are used at different layers:

1. The wafer is exposed to light through the mask and a lens (used to focus). This causes the areas where light is exposed to harden.
2. Stripping: removes the non-exposed areas. Usually use of negative resist. Positive resist also exist, where the light causes the exposed material to soften, and removes the exposed areas in the chemical stage instead.
3. The patterns are transferred to the silicon dioxide and the resist is thereafter removed completely.
4. Doping step: Dopant substances (e.g. boron or arsenic) forced areas containing no silicon dioxide. This doping alters electrical properties, and forms features such as transistors.

Dies: The multilayered wafer is diced to chips. They are packed and metallic pins are added for electrical contact. They become an IC, and tested. At this stage they become tested, since many chips turn out to be useless. The quality also varies much between the different IC’s.
IC’s are divided into bipolar- and MOS-circuits (MOSFET - unipolar), dependent on the type of transistor that is used. The division can also be digital or analogue, depending on the electrical function of the circuit. Digital MOS-circuits are dominant, since it has the largest area of use.

**Printed Circuit Board**

The Printed Circuit Board with components becomes a Printed Circuit Assembly. It can be used itself or together with others on a Motherboard in a computer or in other applications. Historically Printed Circuit Board has been changing technology each decade. During the 50s all where single sided, during the 60s double sided. During the 70s multilayer techniques where discovered and used, during the 80s fine line and smaller holes. During the 90s buried and blind vias was used. Photolithography is used to produce Printed Circuit Boards as with IC’s, but the materials vary.

**Reliability**

The reliability of electronic circuits is said to follow a curve looking like a bathtub, meaning that the probability of failure is largest in the very beginning of use, or in the end of lifetime. It is not usually problems during the time in between. This fact is the reason for all circuits being tested before used in any application. As mentioned earlier a lot of IC’s fails these tests, and the quality of the once that pass the test often vary.

When an IC is produced, its reliability is demonstrated by Yield. Yield is measured by the following formula:

\[ P(Y, \text{nr.of } transistors) = Y^{\text{nr.of } transistors} \]

**Example**:

\[ P(50\%,1) = 0.5^1 = 50\% \]
\[ P(50\%,4) = 0.5^4 = 6.25\% \]
\[ P(95\%,8) = 0.95^8 = 66\% \]
\[ P(99.9\%,10000) = 0.999^{10000} = 36.8\% \]

In the current industry applications it is as standard to express the yield in PPM. It cannot be more defects, and then the IC is tossed away (hopefully in the right place). The price is decreasing
and the performance increasing, as it has been historically in all electronic applications since the introduction.

**Development**

The capacity of electronic products has been growing in a very rapid pace since the introduction. The chip-capacity increases annually by 60%, the power of computers by 25%, while the cost per function decreases 30%.

The question is for how long time this development can continue. Limits of the development is both economical, physical, and in complexity. Also, an application end is expected. Meaning that you have too much space in your personal computer, it might be impossible to fill it up during a lifetime. That is the application end.

The electronical products have created numerous new producers, leading to numerous of employment opportunities. It has resulted in the everyday life (in industrialized countries) to become much more convenient. It has also resulted in the storing of information to become much easier.

But the exponential development of this new technology has not all been well. It has caused some unnatural changes in nature. The need of having material with right properties has often caused upstream material consumption or excessive production of “unnatural” substances. Another issue is the waste of used products. It have become an issue do to the high innovation, causing products lifetime on the market far shorter than the actual product life. One source of this being a real problem is that it has been no proper marking on most EEE; it has been thrown in the regular household garbage and along with other kinds of garbage at industries. This fact explains the need of WEEE. The need of RoHS is considering a more “upstream” part of the problem. It is going to prevent hazardous substances from ever being content in applications other than where it is absolutely necessary.

*If your are interested in reading more about different techniques around electronic production, a recommendation is to look at:*

*http://extra.ivf.se/ngle/*
Criticism from Lars Wallin

IPC, the Association Connecting Electronics Industries, was founded 1957 as the Institute for Printed Circuits. It is a global trade organisation, based in the United States, with over 2200 member companies worldwide, including designers, board manufactures, assembly companies, suppliers, and original equipment manufacturers. Lars Wallin, the European representative, has written three articles with strong criticism towards RoHS in Elektroniktidningen. The criticism is directed foremost to the restriction of lead, but also the restriction of Flame Retardants.

The first article\(^\text{10}\) focuses on the exemptions and lobbyism. Here Lars claims that all exemptions will become unimportant; hence the production will be readjusted to lead-free at subcontractors. Further on he says that subcontractors will not keep two different production lines, and the price of electronics containing lead will increase. As a consequence these production lines will be phased out, since the competition prevents retailers from increasing the price of the final product. In order to prevent this the exemptions is a second issue. The Swedish industry has to become active lobbyists and pressure the authorities on information. Lars mentions that many homepages with know-how banks have been introduced globally, in purpose to consider the industries interests. He therefore questions the competence of the authorities, and offers himself by being the European representative of IPC, to be a counterpoint for the companies of concern.

In the second article\(^\text{11}\) Wallin presents the consequences he think the RoHS Directive will bring. First of all he criticises the fact that the electronic industries use only a small amount of all lead that is put on the market, 0.5-0.6% of the 2.5 billion tons that is extracted annually. Wallin suggests that it would be better to try finding alternatives to the accumulators, and thereby simplify the development of electric cars, that most certainly will decrease greenhouse gases. Secondly he points out the raise of temperature in the manufacturing by 40-50\(^\circ\)C will increase the amount of electricity used, which in turn will increase greenhouse gases, since many countries still uses doubtful energy sources, such as coal. Thirdly he points out that the large number of alternatives has to be tested in electronical products, both separately and together, leading to around 1800 credible parameters that are to be tested. This in turn will decrease the quality and life length of the product, and an increase the cost of production. This will lead to an increase in garbage, which contradicts the original purpose of RoHS Directive.

In the third article\(^\text{12}\) Lars Wallin tells about a company that will be forced to outsource their production to countries with lower salary, because of the RoHS Directive. They have made a consequence analysis and found out that it is impossible for their activity to continue in Sweden. In order to follow the demands they will need the following expands:

- Three more buyers that can guarantee their components to be RoHS-compatible; 950000/annually.
- Fees to customers and the State for not fulfilling the directive; 550000 the first year.
- Increased spoilage due to introduction of lead-free processes; 1.2 million.
- Two extra production technicians to readjust to lead-free; 790000
- Write-off on obsolete non-compatible trading stock; 2.3 million.
- Education on scanning lead-free correctly for the staff; 350000
- Increased energy consumption due to higher process temperatures; 480000

\(^{10}\) ‘Production Perspective’ published in Elektroniktidningen, 2004
\(^{11}\) ‘Lead free creates chaos’ published in Elektroniktidningen, okt. 2004
\(^{12}\) ‘RoHS creates unemployment’ published in Elektroniktidningen, nov. 2004
- Purchase of new machines and equipment suitable for lead-free processes; 45000/annually.

It is also impossible to increase the price of the products, since the competition is too hard. The company will be forced to fire 47 of the 55 employees, who most certainly will have problems finding other jobs in the same line of business.

The introduction of RoHS Directive is expected to imply a 20 million decrease for this company. With the same calculations for whole Sweden the fee becomes 15 billions.

Wallin also criticises the restriction on Flame Retardants, since there is standard demands on some markets, like United States and United Kingdom. In Japan they have demands on all electronics to be free of halogens, but Wallin is very doubtful to the alternative of use, currently white phosphor. He fears that a restriction in Europe by RoHS Directive could lead to equivalent poor alternatives.

Finally he regards the fact that it will be very difficult to control the maximum levels. It is unrealistic to know the contents of each component, since all materials naturally contain in some ppm of other materials. He also questions the responsibility around the fees for companies that go bankrupt before their products are used.

**Counter comments from Ingela Nordin**

The articles from Lars Wallin was not left uncommented. Ingela Nordin, employee at Strandow & Paalo, commented the last article from Lars Wallin in a letter to the editor of Elektroniktidningen. She pointed out that both the WEEE Directive and the RoHS Directive have been official since February 2003. Hence the Electronic industry all over the world have known for quite a while that the Directives soon should be put into force.

Further on she claims that the lead-free electronic production have been developed during a long time, since the end of the 90s, but that this development has suffered from the depression in telecom. Still, many subcontractors have come a long way, she says. Another reason for slow development of lead-free production is that the market pressure is not as apparent as in other parts of the world, such as Japan. But one demand from the customer is for the products to follow the current legislations.

She mentions some important issues to consider, e.g.

- Parallel processes, both lead-free and leaded production?
- Involve subcontractors, in order to find out what is put into the products and cooperate to phase out the hazardous substances
- Marking of products, demand in WEEE
- Marking of components and moduls, to know which ones are lead-free and which ones manage lead-free processes
- Planning logistics
- Market costs, share the costs of producer responsibility

She finally states that Swedish electronic industry should work on finding good and efficient solutions on these and other questions concerning RoHS instead of trying to prevent it from being put into force, which is only a waste of time.
Annex 1A in WEEE Directive

ANNEX 1A

Categories of electrical and electronic equipment covered by this Directive

1. Large household appliances
2. Small household appliances
3. IT and telecommunications equipment
4. Consumer equipment
5. Lighting equipment
6. Electrical and electronic tools (with the exception of large-scale stationary industrial tools)
7. Toys, leisure and sports equipment
8. Medical devices (with the exception of all implanted and infused products)
9. Monitoring and control instruments
10. Automatic dispensers
ANNEX

Applications of lead, mercury, cadmium and hexavalent chromium, which are exempted from the requirements of Article 4(1):

1. Mercury in compact fluorescent lamps not exceeding 5 mg per lamp.
2. Mercury in straight fluorescent lamps for general purposes not exceeding:
   - halophosphate 10 mg
   - molybdate with normal lifetime 5 mg
   - molybdate with long lifetime 8 mg.
3. Mercury in straight fluorescent lamps for special purposes.
4. Mercury in other lamps not specifically mentioned in this Annex.
5. Lead in glass of cathode ray tubes, electronic components and fluorescent tubes.
6. Lead as an alloying element in steel containing up to 0.35 % lead by weight, aluminium containing up to 0.4 % lead by weight and as a copper alloy containing up to 4 % lead by weight.
7. — Lead in high melting temperature type solders (i.e. tin-lead solder alloys containing more than 85 % lead):
   — lead in solders for servers, storage and storage array systems (exemption granted until 2010);
   — lead in solders for network infrastructure equipment for switching, signalling, transmission as well as network management for telecommunication;
   — lead in electronic ceramic parts (e.g. piezoelectronic devices).

9. Hexavalent chromium as an anti-corrosion of the carbon steel cooling system in absorption refrigerators.

10. Within the procedure referred to in Article 7(2), the Commission shall evaluate the applications for:
    — Deca BDE,
    — mercury in straight fluorescent lamps for special purposes,
    — lead in solders for servers, storage and storage array systems, network infrastructure equipment for switching, signalling, transmission as well as network management for telecommunication (with a view to setting a specific time limit for this exemption), and
    — light bulbs,
    as a matter of priority in order to establish as soon as possible whether these items are to be amended accordingly.

**Questionnaire**

Since the statistical survey was restricted to Sweden, the questionnaire is written in Swedish.

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<thead>
<tr>
<th>Företag:</th>
<th>Antal anställda:</th>
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<td>E-postadress:</td>
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<thead>
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<th>Vårt företag kan beskrivas som:</th>
<th>Vår marknad kan anses:</th>
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<td>☐ Underleverantör/tillverkare av delsystem</td>
<td>☐ Nationell</td>
</tr>
<tr>
<td>☐ Tillverkare av färdiga produkter</td>
<td>☐ Europeisk</td>
</tr>
<tr>
<td>☐ Importör av färdiga produkter/återförsäljare</td>
<td>☐ Global</td>
</tr>
</tbody>
</table>

**RoHS-direktivet**

1. **Hur har ni fått kännedom om RoHS-direktivet?**
   - ☐ Kundkrav
   - ☐ Myndighetskrav
   - ☐ Branschorganisation
   - ☐ Genom den här enkäten
   - ☐ Annat alternativ:

2. **Anser ni att de produkter ert företag tillverkar/importerar eller återförsäljer hör till den angivna produktkategorin – medicinteknisk utrustning?**
   - ☐ Ja ☐ Nej

3. **Anser ni att kategorierna i bilaga 1A i WEEE-direktivet skulle behöva definieras ytterligare?**
   - ☐ Ja ☐ Nej

   a. **Skulle ni vilja lägga till fler underkategorier (vilka?) eller förtydliga de som redan finns, eller skulle ni vilja lösa uppdelningen på annat sätt?**
4. Anser ni att era produkter redan idag uppfyller kraven i RoHS-direktivet?  
Ja ☐ Nej ☐

<table>
<thead>
<tr>
<th>Produktinformation</th>
</tr>
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<tbody>
<tr>
<td>5. Har ni fått krav från kunder att sluta använda de ämnen som regleras i RoHS-direktivet i era produkter?</td>
</tr>
<tr>
<td>☐ Ja ☐ Nej</td>
</tr>
<tr>
<td>a. Har ni ställt krav på era underleverantörer att sluta använda dessa farliga ämnen?</td>
</tr>
<tr>
<td>☐ Ja ☐ Nej</td>
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<tr>
<td>b. Hur har era underleverantörer reagerat på dessa krav?</td>
</tr>
<tr>
<td>Har dem efterlevt kraven utan protester, har dem inte efterlevt kraven?</td>
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<tr>
<td>☐ Ja ☐ Nej</td>
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<tr>
<td>6. Begär era kunder uppgifter om vilka farliga ämnen som komponenter eller produkter innehåller?</td>
</tr>
<tr>
<td>☐ Ja ☐ Nej</td>
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<tr>
<td>7. Vilken information om produkterna begär ni från era underleverantörer?</td>
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<tr>
<td>Innehåll av ämnen?</td>
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<td>☐ Ja ☐ Nej</td>
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<tr>
<td><strong>Sexvärt krom, Kadmium och Kvicksilver</strong></td>
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<td>8. Innehåller era produkter Sexvärt krom?</td>
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<td>9. Innehåller era produkter Kadmium?</td>
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<tr>
<td>10. Innehåller era produkter Kvicksilver?</td>
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<tr>
<td>11. Har ni substituerat någon av dessa tre av RoHS begränsade ämnena?</td>
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<tr>
<td>12. Finns det alternativa tekniska eller kemiska lösningar till de tillämpningar där dessa metaller används, d.v.s. känner ni till metoder att ersätta någon av ämnena i dess aktuella användningsområde?</td>
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<tr>
<td>a. Varför använder ni er inte av någon av dessa lösningar (kostnader/vinster) (fördelar/nackdelar)?</td>
</tr>
<tr>
<td>13. Innehåller era produkter Bly?</td>
</tr>
<tr>
<td>a. Får/har ni vetskap om i vilken halt ämnet förekommer?</td>
</tr>
<tr>
<td>År det information ni fått från underleverantörer eller genom egna test?</td>
</tr>
<tr>
<td>14. Använder ni bly i andra delar av era produkter än i kretskorten?</td>
</tr>
<tr>
<td>a. I vilka delar/material?</td>
</tr>
<tr>
<td>b. Varför?</td>
</tr>
<tr>
<td>15. Använder ni/era underleverantörer högtemperaturlod under tillverkningen av era produkter?</td>
</tr>
<tr>
<td>16. Har ni substituerat bly i någon tillämpning?</td>
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<tr>
<td>Om möjligt, svara på hur?</td>
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<tr>
<td>17. Finns det alternativa tekniska eller kemiska lösningar till tillämpningarna där bly används, d.v.s. känner ni till metoder att ersätta någon av ämnen i dess aktuella användningsområde?</td>
</tr>
</tbody>
</table>
a. Varför använder ni er inte av någon av dessa lösningar (kostnader/vinster) (fördelar/nackdelar)?

<table>
<thead>
<tr>
<th>Flamskyddsmedel</th>
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<tbody>
<tr>
<td>18. Innehåller era produkter PBB och/eller PBDE?</td>
</tr>
<tr>
<td>a. Får/har ni vetskap om i vilken halt ämnet förekommer?</td>
</tr>
<tr>
<td>Är det information ni fått från underleverantörer eller genom egna test?</td>
</tr>
<tr>
<td>19. Innehåller era produkter andra kemiska flamskyddsmedel?</td>
</tr>
<tr>
<td>Om möjligt, kan ni ange vilka?</td>
</tr>
<tr>
<td>20. Omfattas era produkter av krav på flamsäkerhet i tillämplig produktstandard?</td>
</tr>
<tr>
<td>21. Har ni substituerat kemiska flamskyddsmedel i någon tillämpning?</td>
</tr>
<tr>
<td>Om möjligt, svara på hur?</td>
</tr>
<tr>
<td>22. Finns det alternativa tekniska eller kemiska lösningar, d.v.s. känner ni till metoder att ersätta någon av ämnena i dess aktuella användningsområde?</td>
</tr>
<tr>
<td>Alternativa tekniker och substitutionsinsatser</td>
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<tr>
<td>-----------------------------------------------</td>
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<tr>
<td>23. Känner ni till alternativa tekniker som</td>
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<tr>
<td>ert företag kan komma att använda i</td>
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<tr>
<td>framtiden för att ersätta farliga ämnen?</td>
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<tr>
<td>a. Bedriver ert företag egen</td>
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<tr>
<td>forskning för att kunna</td>
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<tr>
<td>utveckla era produkter för att</td>
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<td>minska risker för skador på</td>
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<tr>
<td>hälsa och miljö?</td>
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<tr>
<td>b. Deltar ert företag i</td>
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<tr>
<td>branschövergripande forskning</td>
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<tr>
<td>på detta område?</td>
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<tr>
<td>veta är farliga för säkerheten,</td>
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<tr>
<td>människors hälsa eller miljön?</td>
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<tr>
<td>25. Anser ni det vara nödvändigt för er</td>
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<tr>
<td>produktkategori med en längre tidsram</td>
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<tr>
<td>för att övergå till alternativ teknik än</td>
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<tr>
<td>för övriga produkter som använder</td>
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<tr>
<td>elektrisk och elektronisk utrustning?</td>
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<tr>
<td>b.</td>
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Plats för eventuella tillägg