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Evaluation of the Danish Statutory Order on Lead

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The reports are, however, published because the Danish EPA finds that the studies represent a valuable contribution to the debate on environmental policy in Denmark.

Contents

Foreword

The purpose of this project has been to evaluate the need for a revision of Statutory Order no. 1012 of 13 November 2000 (the Lead Order). This evaluation is partly based on the practical experience from implementing the Lead Order, and partly on the development of new knowledge and technology that has taken place within the area of the Order since it entered into force.

This project was commenced in spring 2005 and concluded in spring 2006 and was supervised by a steering committee comprising

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Sammenfattende artikel

Der er foretaget en vurdering af behovet for revision af Bekendtgørelse nr. 12 af 13. november 2000 om bly (blybekendtgørelsen). Denne revision viser, at det på en række punkter er relevant at justere bekendtgørelsen. De foreslåede justeringer omfatter bl.a.:

- At en række af de nuværende undtagelser fra bekendtgørelsens forbud mod anvendelse af bly ophæves, fordi der i dag er udviklet blyfri alternativer.
- At der foreslås indført undtagelser for enkelte anvendelser, som i dag ikke er undtaget reguleringen.

Hertil kommer, at der er peget på muligheden for at indføre begrænsning i anvendelsen af bly for visse anvendelser af bly som metal, som ikke er reguleret i dag samt, at det kan overvejes at ophæve en række af de nuværende undtagelser mod anvendelser af bly, som også er omfattet af EU-lovgivning.

Baggrund og formål

Siden blybekendtgørelsen blev indført er der foregået en løbende udvikling af alternativer til bly for en række anvendelser både i Danmark og internationalt. Denne udvikling er en følge af blybekendtgørelsen såvel som EU's RoHS direktiv (EU direktiv 2002/95/EC) og EU direktivet om udrangerede køretøjer (EU direktiv 2000/53/EC) samt - ikke mindst - det generelle arbejde i industrien for at udfase skadelige stoffer.

Det har siden 2003 været planlagt at blybekendtgørelsen skulle revurderes for at afklare behovet for justeringer. I denne forbindelse har der især været opmærksomhed på den generelle undtagelse for reparation, om- og tilbygning af huse.

Formålet med denne undersøgelse har derfor været at vurdere behovet for revision af blybekendtgørelsen og i denne forbindelse overveje dels de praktiske erfaringer med implementeringen af bekendtgørelsen og dels den udvikling af ny viden og teknologi, som har fundet sted indenfor bekendtgørelsens område, siden den er trådt i kraft.

Undersøgelsen

Undersøgelsen har bestået i indhentning og vurdering af oplysninger fra både virksomheder, tekniske skoler, internettet og litteraturen om status for alternativer for de forskellige anvendelsesområder.

Der er især fokuseret på de anvendelser, hvor der har været givet dispensationer i forhold til bekendtgørelsen samt den generelle undtagelse for bly til reparation, til - og ombygning af huse. Herudover er tillige lagt vægt på at undersøge udviklingen for de anvendelser af bly som kemisk forbindelse, der indtil videre har været undtaget regulering.

Endelig er for alle de anvendelser af bly som metal, der indtil nu har været undtaget regulering vurderet, om der er sket væsentlig nyudvikling således at regulering kunne være realistisk. Der er i denne forbindelse dels været kontakt med nøgle virksomheder i Danmark, dels undersøgt den internationale

udvikling herunder konsekvenserne af nye EU direktiver såsom RoHS direktivet og direktivet om udrangerede køretøjer.

For alle de anvendelser hvor der har været givet dispensation i forhold til blybekendtgørelsen er der taget kontakt til de relevante firmaer for at undersøge baggrunden for dispensationsansøgningen og status for anvendelsen og alternativer i dag.

Konklusioner

Undersøgelsen har vist, at det på en række punkter er relevant at justere bekendtgørelsen.

Bly som kemisk forbindelse

Hvad angår brugen af bly som kemisk forbindelse vurderes, at følgende undtagelser for blyforbudet kan ophæves, da der i betydeligt omfang er udviklet alternativer, der kan erstatte bly:

- Varmestabilisers i elastomere
- Bremsebelægninger
- Glasurer, emaljer og pigmenter til kunsthåndværk

Der må regnes med et behov for dispensationer, hvilket især gælder kunsthåndværk, da bly også anvendes ved fremstillingen af produkter med kulturhistorisk betydning, såsom Flora Danica.

For stabilisers i el-kabler, der indgår i produkter, samt el-kabler i øvrigt vurderes, at der alene er brug for en undtagelse for højfleksible kabler til maskindele, der bevæger sig i forhold til hinanden, herunder elevatorkabler.

Undtagelsen kan endvidere ophæves for anvendelser som bilruder og coating af planglas. Det kan tillige overvejes om undtagelsen skal ophæves for anvendelser som udladningslamper, samt blyholdigt glas til billedrør, lyskilder, optik og plader i kopimaskiner, da disse anvendelser i dag er omfattet af EU's RoHS direktiv.

Derimod er der for en række andre anvendelser, hvor der så vidt vides ikke er alternativer til bly i dag, behov for at indføre undtagelser eller anden form for langvarig dispensation. Dette gælder for anvendelser som:

- Superledere
- Tændsats til ammunition
- Blymønje til restaurering af historiske genstande

Det er dog muligt, at behovet for brug af blymønje kan løses ved at udvikle andre metoder til restaureringsarbejder.

Der er i dag dispensation for brugen af blyholdig benzin til mindre fly med stempelmotorer, da der ikke i Danmark markedsføres blyfri benzin. Blyfri benzin markedsføres imidlertid i Sverige og det vurderes at størsteparten af de pågældende fly vil kunne benytte blyfri benzin. Der er således behov for at overveje, om der kan der sikres forhandling af blyfri benzin i Danmark og hvordan dette i praksis arrangeres.

Bly som metal

Hvad angår brugen af bly som metal vurderes, at den generelle undtagelse for brug af bly ved reparation, om- og tilbygning af huse kan ophæves, hvad angår bly til inddækning omkring vinduer etc., da der i dag findes

tilfredsstillende alternativer til alle formål. Undtagelsen kan formodentlig begrænses til huse, som er fredede eller klassificeret som bevaringsværdige og hvor det af arkitektoniske årsager skønnes hensigtsmæssigt med brug af bly.

Det er tillige muligt at udvide det nuværende forbud mod brug af bly i kabelkapper til jordkabler over 24 kV til at omfatte alle jordkabler.

Det bør overvejes, om det er muligt at indføre et generelt forbud mod bly i hjulvægte. Bly vægte er i dag total forbudt i EU for biler med plads til op til 8 passagerer og varevogne med totalvægt op til 3,75 tons. Andre køretøjer er ikke omfattet af EU's direktiv, men der er i princippet intet, der teknisk forhindrer, at der udvikles blyfri hjulvægte for disse køretøjer.

Herudover kan overvejes, om bly til afbalancering af vindmøllevinger kan undværes.

Også mht. ammunition er det teknisk muligt at reducere brugen af bly. Der findes i dag blyfri riffelammunition til jagtformål i standard kalibre, og det bør overvejes, om der skal indføres et forbud mod bly til dette formål i lighed med det forbud, der vil træde i kraft i Sverige den 1. januar 2008. Anvendelsesbegrænsning kunne også overvejes for blyammunition til sportsskydning, men alternativer til bly synes at være mindre veludviklede end for jagtammunition.

Herudover er ikke foreslået ændringer hvad angår brugen af metallisk bly, på nær, at erfaringerne med substitutionsarbejdet for fiskeudstyr til erhvervsfiskeri, viser, at der på dette område er store vanskeligheder med at udvikle konkurrencedygtige alternativer til blybaseret udstyr. Der er derfor behov for forlængelse af de eksisterende dispensationer.

Sammenfattende er vurderet, at der for mange anvendelsesområder er sket en væsentlig bevægelse bort fra bly, når der sammenlignes med situationen før blybekendtgørelsen blev indført. Gevinsten, der følger af denne udvikling er en reduceret emission af bly til miljøet, både direkte gennem produktion og brug af blyholdige produkter og indirekte ved affaldsbehandling og affaldsbortskaffelse.

Summary and conclusions

An evaluation of the need for revision of the Ministry of Environment Statutory Order No. 1012 of 13 November 2000 (the Lead Order) has been undertaken. The evaluation shows that it is relevant to adjust the Statutory Order with respect to a number of issues. The suggested adjustments include the following:

- A number of the present exemptions to the statutory ban against the use of lead should be repealed, as lead-free alternatives have been developed.
- Exemptions be proposed for some applications, which at present are covered by the ban.

Furthermore, options for introducing use restrictions for certain uses of lead, such as metal, which are not presently restricted, have been identified. It may also be considered to revoke some of the existing exemptions to the ban, which are also covered by EU regulation

Background and objectives

Since the Lead Order was introduced, an ongoing development of substitutes to lead has taken place in Denmark as well as internationally. This development is a consequence of the Lead Order as well as the EU RoHS Directive (EU Directive 2002/95/EC) and the EU Directive on End-of-Life Vehicles (EU Directive 2000/53/EC) and - not least - the general efforts by industry to substitute hazardous substances.

Since 2003, there have been plans to evaluate the Lead Order in order to identify the need for adjustments. In this context, special attention has been paid to the general exemption regarding the use of lead for repairs, rebuilding of and extensions to houses.

The purpose of this investigation has, thus, been to assess the need for revision of the Lead Order and, in this context, consider the practical experience from implementation of the Lead Order as well as new knowledge and technology developed within the field covered by the Order since the Order went into force.

The investigation

The investigation has consisted of collection and evaluation of information from private companies, technical schools, the Internet, and literature on the situation regarding alternatives in the different application areas.

Special focus has been given to areas for which dispensations have been granted, and to the general exemption of lead for repairs, rebuilding of and extensions to houses. Furthermore, emphasis has been given to investigation of those uses of lead as chemical compound, which have so far been exempted from regulation.

Finally, for all uses of lead as metal, which have so far been exempted from regulation, it has been assessed whether significant new developments have

taken place that could make regulation realistic. This has been investigated partly by personal contact to key companies in Denmark, partly by studying the development in an international perspective, including the consequences of new EU directives, such as the RoHS Directive and the End-of-Life Vehicle Directive.

For all uses for which exemptions have been granted, personal contact has been made to the companies in question, in order to investigate the background of the exemption application and the actual situation regarding the use in question and the availability of alternatives etc.

Conclusions

The investigation has shown that it is relevant to amend the Statuary Order on several issues.

Lead as a chemical compound

Regarding the use of lead as a chemical compound it is assessed that the following exemptions from the ban on lead can be repealed, as substitutes have been developed that, by and large, can replace lead:

- Heat stabilisers in elastomers
- Brake linings
- Glazes, enamels and pigments for arts and crafts

A need for exemptions can be envisaged, especially for arts and crafts, as lead is also used in the manufacture of products of cultural and historic importance, as e.g. Flora Danica porcelain.

Concerning stabilisers in electrical cables integrated in products and electrical cables in general, it is assessed that exemption is needed only for high-flexible cables for machine parts moving relative to each other, including lift cables.

Furthermore, the exemption for car windows and coating of flat glass can be repealed. It may also be considered to repeal the exemption for uses such as discharge lamps, and lead glass for cathode ray tubes, lamps, optical purposes and plates in photocopy machines, as these uses are today covered by the RoHS Directive.

However, a number of uses exist for which no alternatives to lead - to the best of knowledge - seem to be available. For these uses there is a need for exemption or another form of prolonged dispensation. The uses in question include the following:

- Superconductors
- Primers for ammunition
- Lead paint for restoration of historical items

However, the need for lead paint might be met by developing other routines for restoration works.

Today, exemption is given for the use of leaded fuel for small planes propelled by piston engines, as lead-free fuel is not marketed in Denmark. Lead-free fuel is, however, marketed in Sweden, and it is expected that the majority of the planes in question could use lead-free fuel. Therefore, it is relevant to consider whether lead-free fuel can be marketed in Denmark, and how the practical arrangements can be made.

Lead as metal

Regarding the use of lead as metal, it is assessed that the general exemption for the use of lead for repairs, rebuilding of and extensions to houses can be repealed with respect to lead flashing around windows etc., as adequate alternatives are available for all applications today. The exemption may probably by limited to buildings preserved or classified as preservation-worthy and for which - for architectural reasons – it is deemed relevant to continue the use of lead.

It is also possible to expand the present ban on the use of lead in mantles for underground cables above 24 kV, to include all underground cables.

It should be considered whether it is possible to introduce a general ban on lead in wheel balancing weights. Today, lead weights are banned in the EU for cars with seats for up to eight passengers and vehicles for transport of goods with a maximum weight of up to 3.75 tonnes. Other vehicles are not covered by the EU Directive on End-of-Life Vehicles, but in principle, it should be technically possible to develop lead-free wheel balancing weights also for these vehicles.

It should, furthermore, be considered, whether the use of lead to balance wings on wind turbines could be avoided.

It is also technically possible to reduce the use of lead in ammunition. Today, lead-free rifle ammunition in standard calibres for hunting is available on the market, and it should be considered to introduce a ban on the use of lead for this purpose, corresponding to the ban that will enter into force in Sweden on 1 January 2008. Restrictions may also be considered regarding lead ammunition for sports shooting, but alternatives to lead seem to be less developed than for hunting ammunition.

Apart from this, no other changes concerning the use of metallic lead have been proposed. It is noted that experience with the substitution efforts related to equipment for commercial fishing shows that in this field it is very difficult to develop competitive alternatives to lead-based equipment. Therefore, a need exists to extend the existing exemptions.

All in all, it must be concluded that for many applications, a significant movement away from lead has taken place compared to the situation before the Lead Order was introduced. The benefits gained are reduced emissions of lead to the environment directly by the manufacture and from using products containing lead, as well as indirectly in waste handling and disposal.

1 Introduction

Statutory Order no. 1012 of 13 November 2000 on Lead (the Lead Order) introduced general regulation of the use of lead in Denmark. The Statutory Order and the scope of the regulation are described in more detail in Chapter 2.

In a reply to the Danish Parliament's Environment and Regional Planning Committee in March 2003, the Minister for the Environment stated that "the Statutory Order on Lead should be allowed to work for another couple of years before an evaluation is made as to whether the Statutory Order should be revised" [MPU 2003a]. It has been pointed out that the exemption applying to use of lead for repairs, rebuilding of and extensions to houses should be included in such an evaluation [MPU 2003b].

Today, exemptions are granted for the use of lead in several product categories where technical or financial reasons have complicated the substitution of lead. Moreover, there is the general exemption for repairs, rebuilding of and extensions to houses. In this report, these uses have been evaluated to determine whether there is a need to adjust the Statutory Order in these areas.

It is likely that at least some of the product categories where the use of lead is allowed until further notice will have experienced further development of lead alternatives since the Statutory Order entered into force. Some of these uses are, thus, also in focus as regards the following EU regulation:

- Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment – known as the "RoHS" Directive, which is implemented in Danish law by Statutory Order no. 1008 of 12/10/2004 on import and sale of electrical and electronic equipment containing lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB) or polybrominated diphenyl ethers (PBDE)

- Directive 2000/537/EC on End-of-Life Vehicles, limiting the use of lead, cadmium, mercury and hexavalent chromium in vehicles.

Naturally, the uses covered by these Directives will still experience a development of lead alternatives. This development will probably also have positive effects on related areas.

This study will make a status as to the extent to which new knowledge has been published as a result of EU Directives and other initiatives that make it realistic to limit further the use of lead.

Chapter 2 presents the main points of the Statutory Order on Lead. The brief presentation of the Statutory Order will serve as a basis for the evaluation of the individual uses in the subsequent chapters.

The next chapters focus on uses for which dispensation has been granted from the Statutory Order, the general exemption for repairs, rebuilding of and extensions to houses, as well as other uses of lead as a chemical compound or metal exempted from regulation.

The final chapter, "Discussion and summary", presents the conclusions and recommendations given to highlight the possibilities of adjusting the regulation.

2 Statutory Order on Lead

This chapter briefly presents the main points of Statutory Order no. 1012 of 13 November 2000 (the Lead Order). This brief presentation of the Statutory Order will serve as a basis for the evaluation of the individual uses in the subsequent chapters. The entire text of the Statutory Order is reproduced in Annex 3.

The Statutory Order prohibits import and marketing of products containing lead. Lead means the element lead, both in metallic form and in chemical compounds, while products containing lead means products in which lead represents more than 100 ppm (mg/kg) of their homogeneous components. This limit value does not apply for lead carbonates and lead sulphates in paint, however.

The Statutory Order prohibits any kind of use of lead as a chemical compound from 1 March 2001, with the exception of the product categories stated in Table 2.1. The exemptions that still apply are highlighted in the table.

The Statutory Order also prohibits the use of metallic lead for the product categories stated in table 2.2. This prohibition does not comprise products for repairing existing products, including repairs, rebuilding of and extensions to houses.

The Danish EPA may, in very special cases, waive the provisions of the Statutory Order. The Danish EPA may stipulate terms for the permit.

However, the Statutory Order does not prevent import, marketing and use of products subject to other legislation, including:

- Council Directive 93/42/EEC of 14 June 1993 concerning medical devices.
- Council Directive 84/500/EEC of 15 October 1984 on the approximation of the laws of the Member States relating to ceramic articles intended to come into contact with foodstuffs.
- European Parliament and Council Directive 94/62/EC of 20 December 1994 on packaging and packaging waste.
- Statutory Order No. 807 of 2 December 1986 on limitation of motor fuel's content of lead compounds and benzene.
- Statutory Order No. 966 of 13 December 1993 on certain batteries and accumulators containing dangerous substances.
- Statutory Order No. 41 of 21 January 1994, as amended, on firearms and ammunition permitted for hunting, etc.

- Statutory Order No. 568 of 6 December 1983 on use of slag and fly ashes.
- Statutory Order No. 823 of 16 September 1996, as subsequently amended, on Application of Waste Products for Agricultural Purposes.

Table 2.1
The Statutory Order on Lead list of product categories containing chemical compounds of lead where import and marketing are allowed until the dates stated

Product categories	Allowed until
1. Siccatives in paint, varnish and lacquer, although not siccatives containing lead carbonate and lead sulphate	1 December 2001
2. Glazes on ceramic products, except glazes for art, handicrafts, tile, vitrified brick and brick, spark plugs and products likely to be used in connection with foodstuffs	1 December 2002
3. Enamels and pigments on ceramic products, except enamels and pigments for art and handicrafts, and products likely to be used in connection with foodstuffs	1 December 2002
4. Pigments in products used for signal/warning purposes	1 December 2002
5. Special purposes in elastomers: - accelerators - heat stabilisers	 1 December 2002 until further notice
6. Stabilisers in plastic products: - door and window profiles - other products - roof gutters and down-pipes - roofing sheet - pipes and tubes - electrical cables incorporated into products	 1 December 2001 1 December 2001 1 December 2002 1 December 2003 1 December 2003 until further notice
7. Lubricants, including in bearing metal	1 December 2003
8. Brake linings	1 December 2004
9. Products for cathodic paint	1 December 2004
10. Discharge lamps	until further notice
11. Paint for special uses: - corrosion inhibiting paint containing less than 250 ppm of lead, although not in the form of lead carbonate and lead sulphate - antifouling paint containing less than 1250 ppm of lead, although not in the form of lead carbonate and lead sulphate	until further notice
12. Glass for special uses: - picture tubes - light sources - optics - radiation protection - car windows - plates in photocopy machines - coating of plane glass - crystal - silicate glass for sand blasting	until further notice

13. Glaze, enamels and pigments on art and handicrafts unlikely to be used in connection with foodstuffs	until further notice
14. Glaze on tile, vitrified brick, brick and spark plugs	until further notice
15. Electronic components	until further notice
16. Products for repairing existing products	until further notice
17. Products for research, development and laboratory use	until further notice

Table 2.2
Statutory Order on Lead List of product categories containing metallic lead where import and marketing are prohibited as from the dates stated.

Product categories	**Banned as of**
1. Products for hobby use	1 March 2001
2. Chafing dish candles and other candles	1 March 2001
3. Curtain, drapery weights	1 March 2001
4. Products for decorative use	1 March 2001
5. Security/safety seals	1 March 2001
6. Products for roofing on buildings	1 March 2001
7. Flashings and weatherings on buildings	1 December 2002
8. Fishing equipment for commercial fishing	1 December 2002
9. Fishing equipment for sports fishing	1 December 2002
10. Soldering alloys for plumbing and sanitation uses, except for soldering zinc sheets	1 December 2002
11. Mantles for underground electrical cables under 24 kV	1 December 2002

3 Applications requiring exemptions from the ban on lead

Review of Danish EPA cases shows that exemptions from the Lead Order have been granted for the product categories and the products listed in Table 3.1.

The exemptions from the Order which have been granted reflect the technical difficulties in the substitution of lead – difficulties which could not have been foreseen when the Order was issued. Therefore, information has been gathered to review all applications for which exemptions have been granted, irrespective of whether they have expired or are still in force. However, this study does not include exemptions related solely to sales from existing stocks. The normal way of contacting stakeholders was to contact by phone at least one of the enterprises that submitted the application for exemption. In cases where several exemptions were granted within one application area, contact was most often established with the enterprise that submitted the most recent application.

3.1 Special cables

Lead can be used in special cables, for instance as stabiliser in PVC insulation, and as a metal cable mantle. Lead is only used for cables for industrial applications, and lead-containing cables amount to only approx. 2 per cent of the industrial market, which, again, only represents a minor part of the entire market for cables [Pedersen, 2005].

Since 2000, a number of exemptions have been granted in this area, for instance:

- Special cables, i.e. power cables with specific properties (more flexible and resistant to heat and fire).
- High-flexible control cables for instance for robots working at high speed, and harmonised cables, co-axial cables, cables for cranes and lifts, special control cables data cables (UTP), system-specific cables, semiconductor electronics, and cables for certain types of petrochemical plants.

Major actors in the market stress that their cables may now be incorporated in products provided for under the RoHS Directive. Traditionally, cables in certain types of medical device have contained lead, both as metallic lead mantles and stabiliser in PVC insulation. Even minor changes of the composition of medical devices may require extensive test work, and therefore, producers of this type of equipment have been somewhat hesitant in efforts to introduce lead-free cables. Producers of cables now indicate that they are able to supply lead-free cables for these products.

Table 3.1 Products for which exemptions have been granted from regulation under the Statutory Order on Lead

Product category[1]	Product	Date ofexpiry[2]	Comment
K – stabilisers in PVC	Special cables	June 2006	Cf. section 3.1
M – cable with lead mantle	Special cables for aviation fuel tank facilities	Specific tasks	Cf. section 3.1
K – ceramic materials	Superconductors[3]	Dec. 2002	Cf. section 3.2
K - paint	Restoring metal items – National Museum of Denmark	Dec. 2002 Specific tasks	May also be relevant again
M – products for roofing on buildings K - paint	Restoration, incl. roofing and flashings on historical buildings, incl. churches	Specific tasks	May also be relevant later
K – brake linings	Brake linings for buses and lorries	Dec. 2006	
K - sundry	Motor bike clutch linings	2002	
K - sundry	Aviation fuel additives	March 2008	
M – commercial fishing	Equipment for commercial fishing: -Sinkers -Sinker lines	 June 2006 June 2006	
M – sports fishing	Equipment for sports fishing	Dec 2004	Cf. section 7.2
K - sundry	Primerers for bolt guns	Sep 2005	Cf. section 7.1
K - stabiliser in PVC	PVC fittings and pipes Cable conduits and sheathing	Jan. 2006 Sep 2002	
K- paint	Motor bikes	Dec. 2001	Sale of stock
M	Pianos[4]	Apr. 2002	Sale of stock
K - sundry	Fireworks (rockets)	Specific goods	Sale of stock
M - coverage	Gas boiler outlet	Specific goods	Sale of stock

1) K or M indicates whether the product category includes the use of lead as a chemical compound (K for kemisk (chemical)), or as a metal (M).

2) "Specific tasks" means a specific well-defined installation or quantity of lead. The date indicates exemption granted within the product category up to the latest date.

3) Lead is contained as a chemical compound in ceramic materials used as super conductors.

4) Exemptions apply to use of lead-containing pigments in paint for pianos.

In Denmark, one exemption is valid for the use of lead in cables for special applications. The exemption expires in June 2006. Application for the exemption was submitted and granted as a kind of safety valve for a number of cable producers who were worried that it would be difficult to substitute lead as a stabiliser in PVC, especially in data cables or high-flexible cables for engine components moving in different directions relative to each other

[Hundstrup, 2005]. Substitution is considered to be successful for most cable types, but not necessarily for all producers. For instance certain cables from the US for data networks contain lead, while corresponding European cables do not contain lead [Hundstrup, 2005].

For certain industrial applications, special cables are used in quantities so small that the producers – none of them in Denmark – do not consider it profitable to set up special lead-free production units. Such cables are high-flexible cables for engine components moving relative to each other, and cables for lifts etc.

Cables for industrial purposes are not covered by the RoHS Directive (cf. Annex 2), and production does not aim at meeting the Danish requirement of 100 ppm (the Danish market is considered too small for production aimed especially at Denmark). Such cables are estimated to represent approx. 2 per cent of the market for industrial cables – compared to industrial cables' approx. 25 per cent of the total market for cables. The remaining share (cables for private households, power plants and electric installations) does not contain lead. The special cables mentioned above will require a long-term exemption from the Danish Lead Order [Pedersen, 2005].

Sometimes foreign cables are marketed in Denmark as lead-free cables (cf. section 7.2).

A special type of cable with lead mantle (metallic lead) is underground cables at refineries and other chemical plants, where lead was used to prevent penetration of oil etc. An exemption has been granted to use lead cables at tank sites. Today, underground cables can, however, be supplied as lead-free cables, because alternative cables with mantles made of synthetic material and aluminium are available [Pedersen, 2005].

One supplier stated that they used cables with lead mantle for installation purposes to prevent rodent attacks, for instance in church towers and livestock stables [Larsen, C., 2005]. Other contacts have stated that, today, cables for such environments have been replaced by cables protected by a steel band – PAP cables [Rasmussen, 2005].

Evaluation
Apart from high-flexible cables for engine components moving relative to each other, and cables for lifts etc., available information indicates that substitutes to lead are used in all types of cable for special purposes.

As regards high-flexible cables in engine components moving relative to each other, and lift cables etc., which are only produced abroad, producers can hardly be expected to substitute lead on a voluntary basis in the short term, especially since lead-free alternatives are more expensive. For this type of cable it is assessed that longer-term exemptions from the Danish Lead Order are required.

In the longer term, it is possible that the development initiated by the RoHS Directive will also affect special cables. In a number of years, it may therefore be relevant to reassess the development

3.2 Superconductors

Together with bismuth, lead forms part of super-conduction materials, of which some are being developed in Denmark. These materials were previously produced in Denmark, but in about 2002, the production was sold to plants abroad. Today, a certain amount of lead-containing super-conductors are imported to Denmark, and used for research and development, including international testing work, for instance for medicinal equipment like MRI scanners (MRI=Magnetic Resonance Imaging)[Thiesen 2005/06]. Applications have not been submitted for exemptions from the Lead Order, because these activities are considered to be covered by the exemption granted for products intended for research and development (cf. table 2.1, point 17).

The basic materials in superconductors are oxides of the elements mentioned. In the final matrix, lead does not occur as metallic lead, but as a chemical compound. Lead amounts to approx. 7 per cent of the ceramic material. It is assessed that at this moment it is not technically possible to replace lead in these superconductors, and the producer states that there is a need for a permanent exemption from the Lead Order in this area [Thiesen 2005/06].

Evaluation
Over time, many alternatives to superconductors have been tested, and development work is still going on at international level. Although, at the moment, alternatives to lead are not considered available for production in Denmark, it is expected that alternatives or other solutions will be developed in the future.

It is recommended to introduce an exemption for superconductors, and to reassess it after some years.

3.3 Restoration of metal objects

The National Museum of Denmark uses lead for restoration work in connection with gilding [Sørensen 2005].

Before gilding a metal object, pre-treatment of the object is required, for instance based on paints containing lead or zinc. For restoration of objects which seem to be painted with paint containing lead or zinc, a new type of lead-containing paint is used, for instance red lead. However, lead-containing paint is always used when the objects are considered to contain iron, since treatment with zinc may cause galvanising reactions between iron and zinc, resulting in the formation of voluminous corrosion products – and, thus, poor gilding. With this in mind, exemptions have been granted to use red lead to restore gilded parts of the Christiansborg tower.

Lead is used, because we know from experience that these methods work as intended. Studies and tests of alternatives to lead have not been made [Sørensen 2005].

Evaluation
It is assessed that certain alternatives to the use of lead are available for such purposes. However, it is not immediately possible to assess the quality of these alternatives, compared to lead.

These applications of lead paint will take place on a continuous basis, and reliable alternatives therefore have to be developed and accepted by the National Museum, or else there will have to be a permanent exemption from the Lead Order.

3.4 Roofing/Flashings and weatherings on historical buildings, including churches

Exemptions have been granted for roofing/flashings and weatherings on churches or extensions and additional buildings, such as porches or bell towers. Work typically consists of renewing roofing felt.

On many churches and historical buildings, the roofing material is lead plates. If there is a need to renew the material, the preferred material will typically be new lead plates. This is also the case with renewal of extensions and annexes, since there is a wish to safeguard the architectural entirety of existing and new buildings.

Evaluation
In terms of substitution, roofs of historical buildings are difficult to regulate, since preservation rules and the wish to safeguard the overall architectural impression of lead roofing must be weighed against the significant pollution from lead in the local area, caused by corrosion of the lead plates over a long period of time.

Previous studies point to lead-coated steel plates as alternatives to lead roofing [Hansen & Brønnum 1990]. However, there is no Danish experience with this and other alternatives in practical tests.

Renewal work of this type will have to be made regularly, and there is, thus, a need to develop reliable alternatives which can be accepted by the competent authority in Denmark. An alternative solution is a permanent exemption from the Lead Order.

3.5 Brake linings

Lead can and has been used for brake linings as a friction-regulating lubricant. Traditionally, the substances used were lead sulphides. In the design of the linings, it is always necessary to carefully consider how much friction is required, and how much lead is required to regulate the friction [Pedersen, C 2005].

For expanding brakes it is also important that lead in linings prevents brake noise of a frequency which is very unpleasant to the human ear [Mose 2005].

In accordance with EU Directive 2000/53/EC on end-of life-vehicles, lead in brake linings of passenger cars, minibuses, vans and certain three-wheeled motor vehicles is prohibited from 1 July 2003 (cf. Annex 2 and [EU 2005a]). However, lead in copper in friction materials in brake linings with a lead content not exceeding 0.4 per cent by weight is allowed until 1 July 2007.

Brake linings in large buses and trucks are not covered by the EU Directive on End-of-Life Vehicles. However, the use of lead in brake linings in these

vehicles is regulated in the Lead Order. In this connection, an exemption has been granted for such uses under the Lead Order.

According to information provided by a major producer of trucks in Sweden, some suppliers are able to deliver brake linings which meet the requirements of the EU end-of-life Directive (cf. Annex 2) [Brodin, 2005].

For disc brakes, the problem of brake noise is less important. A motivating factor in work to phase-out Pb in brake linings may therefore be the use of disc brakes, instead of expanding brakes [Mose 2005].

According to information given by a Danish producer of brake linings [Pedersen, C 2005], we are today able to regulate friction without lead additives. Therefore, lead compounds are no longer deliberately added to brake linings. The extent lead is found in brake linings today is due to lead as a contaminant or filling material in other materials used, and not to deliberate addition of lead compounds. Lead-free materials can be used, although they are five times as expensive as lead-containing materials, and, thus, not competitive. The content of lead in the materials used does not exceed 0.1 per cent.

A Japanese producer of motorbikes states that brake linings will be lead-free as from 2005 [Kløcker 2005].

Evaluation
The information available indicates that lead in brake linings is still used by a number of producers of large buses and trucks, while, for smaller vehicles, there is no doubt that lead can be avoided.

However, the development of alternatives to lead in brake linings, including other types of brakes for large buses and trucks, is considered to have reached a stage where there is no need to renew exemptions or derogations for such vehicles, when the current exemption expires.

On the other hand, for large buses and trucks, it will be natural to allow the use of lead in brake linings in the form of contaminants in copper used as friction material in brake linings, corresponding to the regulation of passenger cars.

3.6 Motorbike clutch linings

An exemption has been granted for this application of lead. However, the market actors indicate that the exemption is no longer required, since lead has already been phased out [Kløcker, 2005].

3.7 Aviation fuel

Lead compounds are used as additives in fuel for piston engines in small aircraft. Lead is added in order to increase octane rating, and as a lubricant in the fuel [Jensen, M.M. 2005]. An exemption has been granted to the use of lead for such applications, which is valid up to March 2008.

In Denmark, aviation fuel is marketed only with octane rating 100, known as "avgas 100 LL". According to the Danish oil sector, there are no technical

problems producing lead-free aviation fuel with a lower rating. According to the oil sector [Jensen, M.M. 2005]: ”The Danish oil sector has no special interest in maintaining a market for leaded aviation fuel, since handling is difficult and costly. However, since the Danish market for avgas is modest (approx. 3.5 mill. litres), large costs would be involved in setting up two separate systems of distribution. Therefore only 100 octane gas is marketed, since it can be used by all aircraft.

Today, it is not possible to produce 100 octane fuel without lead. Aircraft manufacturers are carrying out research to develop engines based on diesel – which means that lead can be avoided. Avgas producers expect that the fuel of the future is diesel and not gasoline, and therefore they are in general not encouraged to invest systematically in the development of lead-free avgas with 100 rating [Jensen, M.M. 2005].

Lead-free aviation fuel is marketed in Sweden, but there is no information on marketing in other countries. The Swedish producer and supplier Hjelmco Oil [Hjelmberg 2005] supplies lead-free fuel type 91/96, which consists of pure hydrocarbons without additives. According to [Hjelmberg 2005] lead-free fuel without additives requires hardened valve seats, which are used in all aircraft piston engines produced or overhauled after 1978.

In practice, piston engines for leaded petrol can also use lead-free petrol. Moreover, the valve seats can be replaced fairly easily. Lead-free petrol can, thus, be used in all engines which meet the specifications of the engine suppliers. However, it may be necessary to change to another type of motor oil.

However, lead-free petrol cannot be used in piston engines requiring 100-octane rating or which are modified with non-original parts [Hjelmberg 2005].

The major barrier to import of lead-free petrol in Denmark is considered to be related to the market. In Sweden lead-free petrol can be supplied at the same price as leaded petrol.

In Denmark, it is a decisive factor whether lead-free petrol can compete with leaded petrol, and whether investments in new tank installations are required. Hjelmco states that the company can hardly compete on a market where they have to depreciate and pay interest on new tank installations, while competitors use old installations which have been fully written down. If, on the other hand, Hjelmco can supply petrol to existing plants, they expect to be able to compete on the Danish market. According to Hjelmco, it is no problem to use old tank installations - leaded petrol is removed, and lead-free petrol is filled into the tanks instead [Hjelmberg 2005].

The conclusion to be drawn from the discussion with the Danish oil sector is that there is a need to evaluate a number of practical and financial issues, before we can decide whether it would be appropriate in practice to import lead-free fuel for small piston-engined aircraft in Denmark. What should be considered is the number and location of aircraft that need lead-free petrol versus leaded petrol, the number of tank installations in existing airfields, safety and quality routines etc.

Evaluation
It is estimated that a significant part of the fleet of small piston-engine aircraft could use lead-free fuel, if it was available at airfields in Denmark. It is recommended to study more closely whether and how lead-free fuel can be made available in Denmark and used by the aircraft able to use this type of fuel.

It is expected that a small part of the small piston-engine aircraft will need leaded petrol in the future. Therefore, a number of practical problems will have to be solved, for instance the need for extra tank installations at airfields.

3.8 Fishing equipment

A number of exemptions have been granted, both for equipment for commercial fishing, and for sports fishing. All exemptions granted for sports fishing have now expired, but for commercial fishing a number of exemptions are still valid. Based on available information (cf. [Hansen et al 2004]) substitutes for all major applications of lead in equipment for sports fishing in Denmark have been developed (cf. section 7.2). The following sections only address commercial fishing.

A project on lead-free fishing equipment for commercial fishing carried out at Randers Reb and other suppliers under the Cleaner Technology Programme was initiated in 2000, but has still not resulted in useful and useable alternatives. Therefore, in 2002 an exemption, valid for two years, was granted. On the basis of [Abrahamsen 2004] short-term additional exemptions were granted in 2004. At the moment, it is not permitted to import lead sinkers, while sale of sinkers and import and sale of lead-containing sinker lines and cables for seine fishing are allowed until 1 June 2006.

Equipment for commercial fishing can be divided into simple sinkers, barrel sinkers, cables for seine fishing, and sinker lines [Abrahamsen 2005].

For simple sinkers, including sinkers for ground nets, alternatives are considered to include iron or zinc weights. Today, 1-kg iron weights are marketed at a price below lead weights. Other sizes of simple iron sinkers are still not available [Abrahamsen 2005]. [Bue 2005] has confirmed that practical iron alternatives are available, imported from China.

In principle, for other types of equipment – barrel sinkers, seine fishing ropes, and sinker lines – possible alternatives based on zinc are available, but still not marketed, since they are more expensive than equipment with lead weights. The fishing trade is of the opinion that alternatives to lead are not available on the market at the moment [Jensen, J. 2005; Bue, 2005], and that identification of substitutes for lead tackle is very slow – to the extent that alternatives to lead are not very likely to be marketed before the exemption expires [Larsen, O.L. 2005].

However, in the longer term, key producers of cables for seine fishing expect that alternatives to lead will be available in the form of zinc compounds [Schulin 2005]. Generally, key actors believe that experience gained with substitution in one product area can be used in another area. Therefore, producers of seine ropes think they will be able to use the zinc ropes developed for producers of sinker lines [Schulin 2005].

For sinkers, lead-free fishing tackle is expected to be ready for marketing in December 2007, while for seine ropes and sinker lines, alternatives will not be marketed until at least December 2009 [Abrahamsen 2005].

Evaluation
This study concludes that financial and market-related aspects are the most important factors inhibiting the development of alternatives to lead-containing equipment, rather than purely technical aspects. It seems evident that so far efforts to develop alternatives to barrel sinkers, sinker lines and seine ropes which are able to compete with well-established lead equipment, have not been successful. At the moment, zinc is more expensive than lead, and solutions based on zinc will therefore not be financially competitive until the price of zinc falls, or until the development reaches a stage where the technological solution compensates for the additional costs of using zinc.

In view of the lack of alternatives on the market, there seems to be a need for extending the temporary exemptions that have been granted for sinkers, seine ropes and sinker lines.

3.9 PVC fittings and pipes

Exemptions have been granted to use lead-containing PVC for discharge pipes – in all cases three-layer pipes consisting of 80 per cent regenerated PVC and 20 per cent virgin PVC. Regenerated PVC is extracted from leaded PVC, which is collected in Denmark and regenerated in Sweden.

This procedure has now stopped, because the exemption from the Lead Order granted to companies using leaded PVC is given for periods of one year only. This time horizon is too short for rational operation, and the companies have therefore decided not to produce pipes made with leaded regenerate. Pipes collected in Denmark are now regenerated in Sweden and the lead-containing regenerate is sold outside Denmark. In the years following the entry into force of the Lead Order, leaded fittings could be found on the Danish market. However, the PVC industry is of the opinion that illegal fittings and pipes are no longer found [Grøndahl 2005].

For PVC windows, the situation is, however, more serious. Many lead-containing windows and profiles are marketed in Denmark. The products are primarily produced in Germany, where the production of windows containing leaded PVC has still not been stopped (cf. section 7.2) [Grøndahl 2005].

4 Exemption for repairs, rebuilding of and extensions to houses

4.1 Flashings and weatherings on buildings

Flashing and weathering products are used for sealing joints between roof and chimney, between roof and skylights, or similar points.

Since 2002, there has been a ban on such uses of lead for new buildings. The ban does not cover repair of existing buildings, and rebuilding and extensions (cf. section 2). On the basis of information from technical schools etc. [Larsen, C. 2005; Skipper 2005; Wolf 2005; Hansen and Hansen 2005; Rosholm 2005], it is assessed that this distinction between new buildings and repair work has not necessarily been widely known. This situation is changing, because building constructors and plumbers are now being trained to use the State Building and Urban Research guidelines "Blyfri taginddækninger" (lead-free roofing) [By og Byg 2002]. Since the Lead Order was introduced, training at technical schools has been based on repair work without lead and use of lead-free roofing such as extruded aluminium cast in polymer rubber. The students are therefore assumed to know the difference between repair work and building of new houses.

Generally, consulting engineers are considered to know and meet the rules, but the situation may be different for building workers. The building trade is rather conservative, and in Denmark, there is a long tradition for using lead roofing products, and long-term experience with alternative products is still not sufficient.

The study of the use of lead for flashings and weatherings was also based on contact to a number of craftsmen and building companies. The answers they gave vary.

Some small carpenters and plumbers state they no longer use lead flashings for new buildings. The companies contacted know the rules and are happy with the alternatives. For some uses, alternatives are sometimes considered to be better than leaded products – for instance lead felt may crack during work if the temperature is too low and sufficient care is not taken when putting the felt into place. Leaded products may also cause problems in relation to the working environment.

However, other companies (for instance one-man businesses) only use lead, because they are familiar with leaded products, and do not trust the alternatives. In addition, some local construction products wholesalers only sell leaded products and not the alternatives. Other statements made are:

- Customers want to buy leaded flashings and weatherings.
- Some suppliers of new houses stress that they do not question their clients' choice of products [Korsbæk, 2005].

Generally, the alternative flashing products for new buildings are considered to be good, and in practice, all repair work can be made without lead. Useful alternatives are in fact available for all types of flashings and weatherings, and there are not practical examples of building projects that could only be completed using lead.

The standard recommendation for flashings etc. is polymer rubber aluminium (may, where required, be glued to the roofing material). This product is recommended for instance for eternite roofs [Brøndum 2005]. The product is covered by a 10-year guarantee, and is expected to last for an average of 20-25 years [Quist & Meier 2006]. For minor repair work aluminium repair tape of rubber bitumen (self-adhesive) may be used, and is supplied in a gloss and a lead-coloured version. Skylights are supplied with aluminium edge around bitumen. Also various types of sealing products are marketed.

The only real argument for continued use of lead is, thus, considerations of architecture. This argument may also be questioned, since repair and flashing products are marketed in colours looking like lead.

So far, the standard alternative polymer rubber aluminium alternatives are primarily marketed through suppliers of products for the plumbing and sanitation sector. Typically, the product cannot be bought at DIY centres, one of the reasons is that the price is approx. 50 per cent higher than lead. DIY centres therefore expect the customer base to be modest [Quist & Meier 2006]. On the other hand, DIY centres supply ordinary lead felt for roofing applications. This may be important for the customers (for instance carpenters and do-it-yourself customers), who buy most of their products at DIY centres.

Evaluation
Even if documentation proper has not been provided for uses of lead for flashings and weatherings beyond what is strictly necessary, substantial quantities are likely to be used. In view of the satisfactory alternatives for repair, rebuilding and extension work, only architectural considerations warrant the use of lead.

It seems technically justified to consider whether the general exemption for repair, rebuilding and extensions to houses can be limited, for instance by including only buildings that are listed or otherwise classified as worthy of preservation.

4.2 Lead soldering of new zinc roof gutters etc.

Lead soldering of zinc roof gutters and down-pipes is still allowed, both for new gutters and existing gutters.

Technical schools offer courses in lead-free soldering. However, for the purpose of repair of historical buildings, like churches and manor houses, lead soldering courses are also offered.

In practice, teaching at technical schools is based on the soldering agents available from the suppliers, and which, at the moment, contain lead.

One supplier offers a PU (polyurethane) adhesive which can be used for joining zinc gutters. PU technology has been developed mainly in Germany,

and according to information, today the technology is widely used in Germany. In Denmark, PU adhesives used to be primarily known for the earlier negative experience (limited durability, tightness). Knowledge of positive experience gained later is not common in Denmark, and, therefore, available information indicates that technical schools in Denmark do not offer courses in the use of the products [Hansen & Hansen 2005].

[Carlsen 2005] confirms that some actors on the market do not believe that glue can replace lead soldering of zinc gutters, and therefore they only use lead for soldering projects. However, technical schools are preparing courses in lead-free processes for all types of plumbing and sanitation work [Hansen and Hansen 2005].

Evaluation
Statements obtained during this study indicate that lead could be avoided, also for soldering zinc gutters, if experience gained in Germany with the use of adhesives could be gathered and disseminated to technical schools and the plumbing and sanitation sector in Denmark.

It is recommended that the exemption granted be extended for a couple of years, and that work to collect and assess German experience with the use of adhesives for sealing zinc gutters be initiated. It might also be relevant to test and collect experience with adhesives other than the PU type. If results of such studies are positive, they should be disseminated to the technical schools and the sanitation sector in Denmark.

5 Applications of lead as a chemical compound - exemptions from regulation

5.1 Heat stabilisers in elastomers

Elastomers are defined as polymers which, when cross-linked, form a three-dimensional network which makes the material stable to many different impacts, for instance heat. The formation of cross-linking is initiated/catalysed by zinc oxide. The zinc oxide used contains 0.2 to 0.6 per cent lead, and the final rubber product will therefore contain up to 0.006 per cent [Wendsjö 2005].

Some actors on the market have used lead oxide to activate cross-linking. One of them has for several years been working to phase out lead oxide for such applications, without being able to find anything with the same heat-stabilising effect as lead oxide. In practice, a lower level of heat stability has been accepted, and this minimises the use of lead oxide as heat stabilisers in products regulated under the Lead Order [Thisgård 2005].

In the past, lead was used for vulcanising rubber, mainly for cables, but this process is probably no longer used in Western Europe [Nielsson, 2005]. Lead contents could have amounted to approx. 5 per cent PbO [Wendsjö 2005].

In the EU End-of-Life Vehicles Directive (cf. Annex 2 and [EU 2005a]), an exemption is granted for lead in elastomers for the following applications:

- Vulcanisers and stabilisers for elastomers used for liquids and in propelling devices with up to 0.5 per cent by weight of lead - until 1 July 2006.
- Binders in elastomers used in propelling devices with up to 0.5 per cent by weight of lead.

Evaluation
Exemptions from lead regulation in the EU end-of-Life Vehicles Directive also apply in Denmark. For the purpose of this study, the fact that exemptions can be defined as precisely as they are (only elastomers in propelling devices), indicates that there is no need for a general exemption for lead in elastomers.

This harmonises well with the fact that major Danish producers are of the opinion that the current exemption from the Lead Order is no longer required as regards heat stabilisers in polymers. However, it is possible that lead is being used in imported rubber products, including vehicles above 3.5 tonnes, which are not regulated in the EU End-of-Life Vehicles Directive.

It is recommended to cancel the present exemption for elastomers.

For some products there may still be a need to use lead. In such cases the possibility of applying for an exemption can always be used.

5.2 Stabilisers incorporated in electrical cables in products

Stabilisers incorporated in electrical cables in electrical and electronic equipment are to a large extent covered by the RoHS Directive. The RoHS Directive (cf. Annex 2) and amendments and the Annex (cf. [EU 2005]) do not provide for exemptions for lead stabilisers in power cables. See also section 3.1 on special cables.

NKT [Thiesen 2005/06] points out the special problem that the RoHS Directive sets out a limit value for the content of lead of 1000 ppm, while in the Lead Order, the limit value is 100 ppm. Lead stabilisers in concentrations of 900 mg/kg may in principle be applied deliberately in PVC with the purpose of reducing quantities of the more expensive lead-free stabilisers. Certain producers are therefore likely to do so for economic reasons. According to NKT [Thiesen 2005/06] it should therefore be considered to increase the limit value to 1000 ppm for lead in PVC in power cables incorporated in products.

Evaluation:
The fact that the RoHS Directive does not provide for exemptions for lead stabilisers in electrical cables may be considered as documentation that the EU is of the opinion that satisfactory alternatives to lead as stabilisers are available (probably Ca/Zn stabilisers) which are considered suitable for power cables in the types of electrical and electronic equipment covered by the Directive. These alternatives should actually be suitable in most other types of equipment. In accordance with section 3.1, it is probable that lead-free stabilisers are used for the majority of all cables.

It is therefore recommended that the exemption for electrical cables incorporated in products be repealed.

It is, however, possible that some products that are not identified in this study contain cables for which alternatives to lead are difficult to find (cf. section 3.1). In such cases it should be possible to apply for an exemption from the Lead Order.

At international level, there is probably no doubt that - as stated by NKT – the producers will pay more attention to the limit value for lead in the RoHS Directive than in the Lead Order. Therefore, lead in PVC insulation of electrical cables incorporated in products may very well occur in quantities that do not violate the RoHS Directive, but which exceed the limits set in the Lead Order. This scenario – if it became general practice – might very well cause difficulties in relation to imports of important equipment into Denmark.

However, the general impression is that producers have introduced lead-free stabilisers (cf. section 3.1). Besides, the problem can be minimised by effective inspection. It is true that the NKT proposal to raise the limit value for lead in power cables incorporated in products to 1000 ppm will reduce the need for inspection, but it would also be in conflict with the intentions behind the Lead Order.

It is therefore recommended to maintain the limit value of 100 ppm for lead stabilisers in electrical cables incorporated in products.

5.3 High-intensity discharge lamps

When consulted regarding the RoHS Directive, industry and other stakeholders stated that high-intensity discharge lamps (HID) contain lead iodide in order to have the proper light spectrum, and, further, that the lamps are used for conservation, reprography, and printing of labels [FIA 2004]. Each lamp contains 0.5-5 mg lead iodide, depending on the type and size of the lamp [FIA 2004]. Lead consumption in Europe for such purposes is estimated at a total of 10 kg/year [ELC 2005]. There is no information on alternatives [ELC 2005]. The EU Technical Advisory Committee has decided to recommend that lead in HID lamps for graphic applications and in HID lamps for specific purposes (see Annex 2) be exempt from the ban set out in the RoHS Directive.

High-intensity discharge lamps are not produced in Denmark. According to information received, high-pressure sodium lamps, in the group of HID lamps, can be supplied with and without lead, and that, for lead-containing lamps, power consumption is lower than for lead-free lamps [Jensen 2005].

Evaluation
Information is not available in Denmark to decide whether lead can be avoided in high-intensity discharge lamps. At European level, this issue is being evaluated in connection with the RoHS Directive, and it is therefore considered natural to follow the decisions and evaluations made at European level. It should be noted that in the Directive it has been proposed to exempt high-intensity discharge lamps for a number of specific applications (see Annex 2) from the ban, and this can be considered as documentation for the fact that at EU level suitable alternatives for such applications are not considered available. Since the RoHS Directive applies in Denmark, it should be considered whether there is a need to maintain the exemption granted for HID lamps. If it is decided to uphold the exemption, it should be defined in more detail in order to correspond to the exemption set out in the RoHS Directive.

5.4 Paint for special uses

According to Hempel [Makholm 2005] substitutions have not been developed for lead in corrosion protection and anti-fouling agents. The current limits to the content of lead - below 250 ppm – in paint for corrosion protection, and less than 1250 ppm in anti-fouling agents (cf. section 2), are based on the content of lead as a natural impurity in the zinc and copper compounds in the paints.

It is possible to use zinc compounds that have been treated in order to remove lead. However, the price will be substantially higher, and given the modest amount of lead, this solution does not pay off. The problem complex is the same for copper [Makholm & Spove 2005]. The major part of production is exported [Makholm & Spove 2005].

In corrosion inhibitor used to protect iron and steel, the active pigment is zinc phosphate. This type of paint is used for objects that are difficult to clean

properly, or that are to be painted in bad weather conditions (cold weather etc.) [Makholm & Spove 2005]. An alternative to zinc phosphate is zinc dust paint containing lead impurities, but exempt from the Lead Order because lead for such purposes is considered as a metal, and not as a chemical compound. In addition, epoxy paint or water-based thick-coat acrylic paint [Makholm & Spove 2005, Meyer and Brix 2005], which require better preparation treatment to clean the objects to be painted, or more favourable weather conditions.

Anti-fouling paints contain zinc oxide and copper oxide, which help regulate solubility. Alternatives include other techniques, for instance manual or mechanical cleaning, which are generally more expensive. New silicone-based anti-fouling agents are being developed, but are only efficient on fast-moving vessels, because algae cannot stick to the surface when the vessel is moving at a certain speed. Therefore, silicone-based paints do not work on leisure boats which are in harbour for much of the time [Makholm & Spove 2005].

Evaluation
Alternatives are not available for all applications of paints containing too much lead, neither for corrosion inhibition, nor for anti-fouling purposes.

Given the lack of such products on the market, it is expected that some users are buying the paints outside Denmark.

It is recommended that the current exemption be upheld. The exemption should be reassessed within a few years.

It should be noted that the problem complex indicates that problems with zinc compounds might occur in relation to the Lead Order in other contexts.

5.5 Glass for special uses

Special uses of glass include the following:

- picture tubes
- light sources
- optics
- radiation protection
- car windows
- plates in photocopy machines
- coating of plane glass
- crystal
- silicate glass for sand blasting

Current applications of lead for such purposes are described below.

Picture tubes
Picture tubes for TV sets, computers etc., are covered by the RoHS Directive, but this application is among those exempt from regulation under the Directive (Annex 2). One picture tube contains approx. 0.5-1 kg lead in the form of lead oxide, and the application is one of the most important applications of lead in electrical and electronic equipment. Substitution of lead in picture tubes is not considered technically feasible [Lavendt 2005]. Therefore, lead for such applications is exempt from the ban under the RoHS Directive (cf. Annex 2). Since the RoHS Directive also applies in Denmark, it

should be considered whether there is a need to uphold the exemption for lead in picture tubes provided for in the Lead Order.

However, developments are moving towards phasing out picture tubes, and introducing flat-screen panels. It is impossible to predict the speed of this development, but in the next decade, sales of new picture tubes are likely to fall substantially.

Light sources
Lead glass with lead oxide is used to seal the sockets of power conductors in fluorescent tubes. Lead glass is also used in the tube of compact fluorescent lamps and in certain neon advertisement signs. These applications are covered by the RoHS Directive. The EU Technical Advisory Committee has decided to recommend that lead oxide in glass for flat tubes in LCD screens should also be exempt from the ban provided for in the RoHS Directive (cf. Annex 2).

Information is not available in Denmark to decide whether lead can be avoided for such applications. Since the issue will be evaluated at European level in connection with the RoHS Directive, it is natural to postpone decisions until these evaluations and decisions have been made. Lead glass is exempt from regulation under the RoHS Directive (cf. Annex 2). Since the RoHS Directive also applies in Denmark, it should be considered whether there is a need to uphold the Lead Order's exemption applying to light sources. If it is decided to uphold the exemption, it should be defined in more detail in order to correspond to the exemption set out in the RoHS Directive.

Optics
Lead glass is used as optical glass in many different types of equipment, for instance professional cameras, projection apparatus etc. (see [POI 2005]). Information is not available in Denmark to decide whether lead can be avoided in such applications.

Lead in optical and filter glass is covered by the RoHS Directive, but exempt from the ban on the use of lead (cf. Annex 2). This should be considered sufficient documentation that the EU finds that acceptable alternatives to lead do not exist for such applications. Since the RoHS Directive also applies in Denmark, it should be considered whether there is a need to uphold the Lead Order's exemption applying to optical glass.

Radiation protection
Lead glass is used to protect against radiation at dentists, hospitals etc. In principle, lead glass might be replaced by other types of glass containing other heavy metals, but in practice, lead glass is dominant. Information is not available on real alternatives on the market, and it is assessed that there is no incentive to develop such alternatives.

Car windows
The basis for the current exemption for car windows is not quite certain. However, the edges of car windows are known to contain a black ceramic material based on lead glass. The purpose of the black material is to protect the glue retaining the window pane from being degraded by solar UV radiation [Lassen et al 2003]. The fact that the EU End-of-Life Vehicles Directive (cf. Annex 2) prohibits the use of lead in car windows should be considered sufficient documentation that the use of lead for this purpose is

not based on technical requirements. Thus, there is no need to uphold the exemption from the ban on lead for such applications.

Plates in photocopy machines
See section above on optical glass.

Coating of plane glass
The use of lead for coating plane glass should be considered as historical. Major market players indicate that for coloured coating it was necessary to use dyes containing heavy metals, including lead. Today, dyes for coatings are available without lead, and the major suppliers of coated glass for the Danish market are now supplying lead-free coated glass [Brauer 2005]. It is recommended that the exemption for plane glass be repealed. For suppliers who can document a continued need for lead, it should be possible to apply for an exemption.

Crystal
The Danish glassworks Holmegård Glasværk substituted lead in crystal glass several years ago. However, lead is commonly used for the production of crystal glass in Europe, because the designation crystal is only allowed for glass containing a minimum of 24 per cent lead oxide [EU 1969].

Silicate glass for sand blasting
The primary purpose of the current exemption is to take account of products based on ash from sewage sludge etc. The content of lead in these waste products is a result of the use and flow of lead in society in general. Lead does not serve any technical purpose in the silicate glass, and should therefore be considered an impurity, and not a deliberately added substance [Nytofte 2005].

Evaluation
In line with the above, it is recommended that the exemption be repealed for car windows and coating of plane glass. It is also recommended to consider whether the exemption applying to picture tubes, light sources, optical glass and plates in photocopy machines should be repealed.

For the remaining applications it is recommended to uphold the exemptions and to re-evaluate them within a couple of years.

The reason for recommending whether the exemption for picture tubes, light sources, optical glass and plates for photocopy machines should be cancelled is that these applications are covered by the RoHS Directive and, until further notice, exempt from the ban on the use of lead under the Directive. Since the RoHS Directive also applies in Denmark, the applications are regulated twice. As is the case with the Lead Order, the RoHS Directive aims at minimising lead in the products involved, and under the Directive, the exemptions are being re-evaluated on a continuous basis. It is considered unlikely that Denmark will support less strict regulation of lead in electrical and electronic equipment. Thus, it serves no practical purpose to uphold separate Danish exemptions.

5.6 Glaze, enamels and pigments on art and handicrafts that are not likely to be used in connection with foodstuffs

Both Royal Copenhagen and Georg Jensen have used, and to a certain extent still use, lead in colouring, enamels and glazing on art and handicrafts. The following properties of lead compounds make them difficult to replace in some ceramic products [Eskildsen & Christoffersen 2005/06; Poulsen & Nielsen 2005]:

- Lead is contained in the glass smelt which retains and smelts the colouring pigments.
- The lead content means smelting, reaction and firing can be at a temperature low enough to maintain the correct colouring.

In Denmark, lead has been used especially in faience products, but this production has now ceased. Small amounts of lead silicate are used in the manufacture of items decorated over the glaze such as those made by Flora Danica and similar. It has not been possible to identify practicable alternatives. Otherwise, porcelain is manufactured traditionally without using lead compounds. Colouring containing lead silicate is only used to decorate fired porcelain.

The enamels used today in modest quantities in, for example jewellery and silverware, still contain lead. It has not been possible to identify practicable alternatives here either, because of the melting point of the enamel and correct colour tones [Eskildsen & Christoffersen 2005/06].

Lead-free colouring for porcelain does exist and it is marketed in the hobby sector etc. According to the manufacturer it can be regarded as a perfect substitute, but users are conservative and prefer the products containing lead [Schjerning 2005].

Regarding ceramics, the market is dominated by private artists and any real industrial production in Denmark has ceased. A dominant supplier for this market in Denmark believes that previously lead was used to reduce melting points, but today for all intents and purposes it is not used in ceramic dyes, but only for special glass dyes [Markusen 2005]. Ceramics is therefore one of the uses where substitution of lead has actually been introduced.

Another factor regarding use of porcelain and ceramics etc. colouring containing lead at hobby classes is that the colouring is a powder labelled toxic and it can only be purchased provided the Danish Working Environment Authority has been notified. However, it is possible to buy toxic ready-to-use porcelain colouring without submitting a signed notification or requisition to the police [Petersen 2005].

There have been no attempts to obtain information about the use of lead pigments and alternatives for other types of art such as paintings etc.

Evaluation
Art and handicrafts are traditionally an area granted exemptions in regulation on the use of hazardous substances, partly because there are significant cultural assets and partly because consumption is often relatively modest compared with most other uses.

As described above, there are alternatives to lead on their market, at least with regard to handicrafts. It is not known whether these alternatives can cover all existing needs. Ultimately, however, the choice of pigments and other chemicals is always a question of the colours and textures that can be obtained. Therefore, excluding lead means that there may be certain nuances and textures that must also be excluded, but this does not otherwise prevent the production of porcelain, ceramics and enamel. Moreover it will always be possible to allow exemption for products of cultural-historical significance such as Flora Danica.

In view of the fact that the continuing general exemption for these products is not motivating development of alternatives, it is recommended that the exemption for handicrafts be repealed.

It is likely that there will be many applications for exemptions.

It should be noted that ceramic articles intended to come into contact with foodstuffs are exempt from the ban, as these articles are covered by EU Directive 84/500/EEC.

5.7 Glaze on tiles, vitrified brick, brick and spark plugs

Glazing containing lead is still used to glaze tiles, bricks and vitrified brick made in Denmark, as well as in imports of glazed products, especially from Germany and the Netherlands. Danish production includes in particular specialist products [Bisgård 2005; Kalmer 2005].

Use of glazing containing lead still dominates in Europe, because, as yet, alternatives have not been developed which give the same water-proofing in the long term. This is important as tiles, brick etc. are usually made to have a long lifetime outdoors and exposed to rain and frost [Bisgård 2005].

No development and tests of glazing have been carried out in Denmark. Developments in this area are primarily taking place in Germany, and in practice German initiatives and experience are directing development in the field [Bisgård 2005].

Spark plugs were removed from the list of exemptions from the EU End-of-Life Vehicles Directive with the amendment of 20 September 2005 to the Directive [EU 2005a]. This should be regarded as a definite indication that lead can be substituted in glaze on spark plugs. It is known that at least one dominant manufacturer has been working on substituting lead in spark plugs for a long time [Kløcker 2005].

Evaluation
As there are currently no technically acceptable alternatives to lead glaze on tiles, bricks and vitrified bricks, it is necessary to maintain the exemption for these materials. This exemption should be reassessed after a certain number of years.

The fact that it is now possible to substitute lead in the glaze on spark plugs, and that to a large extent it is possible to exclude lead from the glaze on porcelain and ceramics (cf. section 5.6) should be regarded as a sign that the technical problems involved in such substitution can be solved, at least for products for indoor use. Products for use indoors will usually not be exposed

to frost, and in practice they will have a somewhat shorter lifetime than products for outdoor use.

Therefore, possibilities should be considered to accelerate development and, for example, exploit the expertise existing in the porcelain and ceramics field in Denmark to develop acceptable alternatives for tiles, bricks and vitrified bricks.

5.8 Electronic components

Lead is used in electronic components, in solder, as a colouring, and in ceramic components. Electronic components are extensively covered by the RoHS Directive (cf. Annex 2). In fact, the RoHS Directive and the ongoing efforts to assess applications for exemptions are setting the pace and direction for substitution work in this field. Although the RoHS Directive focuses on ordinary electronic appliances used in households and the retail trade, primarily the same components are used in all other types of equipment, including industrial, military and other equipment which is today exempt from the RoHS Directive.

Annex 2 lists the uses of lead in electronic components which today are exempt from the ban in the RoHS Directive. This list has been updated and it includes the final corrections adopted by the European Commission (cf. [EU 2005]) or recommended by the EU Technical Advisory Committee for the RoHS Directive [Nørlem 2006].

Evaluation
It cannot be expected that products exempted from the RoHS Directive will immediately become lead-free, even though development will probably move in this direction. Therefore it is recommended that the exemption for electronic components be maintained and re-evaluated after some years.

5.9 Other applications

Chemical compounds of lead in products to repair existing products and in products for research, development and laboratory use are exempt from the ban in the Lead Order (cf. section 2). The extent to which restrictions on the use of lead in this context have developed has not been examined. However, it is clear that it will not be possible to stop using lead in chemicals for chemical analysis, for example.

Since December 2003 no applications for exemption of lead in lubricating oil have been submitted, and this may be because Danish users and manufacturers do not know the full composition of their raw materials (especially metal additives) and therefore the composition of their own products at substance level. Danish users and manufacturers therefore rely on their foreign suppliers knowing all details of Danish legislation, and experience shows that this is not always the case.

However, in general the Danish mineral oils sector considers that lead is no longer intentionally added to lubricating agents, but metal additives can contain lead impurities and thus the final product may also contain small concentrations – probably much less than 100 ppm. The lubricating properties of lead are exploited in a number of alloys, e.g. red brass in taps,

and this represents a larger quantity than in lubricants themselves [Olsen, 2005].

On 15 February 2006, the EU Technical Advisory Committee for the RoHS Directive decided to recommend introduction of an exemption for lead in incandescent lamps (defined as: "Lead in linear incandescent lamps with silicate coated tubes") - cf. Annex 2. This exemption covers all uses of lead as a chemical compound and as a metal in the relevant types of incandescent lamp. It is not immediately clear what uses of lead as a chemical compound could be covered by the ban.

Evaluation
It is recommended that the existing exemptions for products to repair existing products and lead in products for research, development and laboratory use be maintained.

With regard to leads as a chemical compound in the types of incandescent lamp mentioned above, consideration is recommended on whether there is a need to introduce an exemption in the Lead Order, given that the use is already covered by the RoHS Directive. If it is decided to introduce an exemption, this should be worded so that it corresponds to the exemption in the RoHS Directive.

6 Other uses of lead as a metal

The list of other uses of lead as a metal is extremely long and, with only few exceptions, no significant progress has been made in finding substitutes to lead, except in areas subject to international regulation.

The most important international regulation in this connection is EU Directive 2002/95/EC (the RoHS Directive) and EU Directive 2000/537EC on End-of-Life Vehicles. The RoHS Directive restricts the use of lead etc. in electrical and electronic equipment, while the EU Directive on end-of-Life Vehicles only limits the use of lead etc. in vehicles. See Annex 2.

Table 6.1 presents an overview of the relevant uses of lead. Where necessary, this overview is described in more detail below.

With regard to the use of lead as a metal, the Lead Order does not introduce a general ban, but only a ban on selected uses. Therefore, the following focuses on whether alternatives have been developed enough to make a ban possible. On the other hand, recommendations have not generally been given.

6.1 Soldering alloys for electronics

In recent years there have been considerable developments in alloys for soldering electronics, both in Denmark and abroad. Developments have been accelerated in particular by the RoHS Directive. There are acceptable alternatives for most purposes, but there remains a need to adapt the manufacturing processes to the new soldering materials [DTI 2003].

The alternative soldering alloys on the market include SnAgCu (tin-silver-copper), which currently seems to be the most popular substitute. In addition SnCu (tin-copper), SnAgBi (tin-silver-bismuth), SnZn (tin-zinc), SnAg (tin-silver) and SnAgIn (tin-silver-indium) [NoNE 2004] are also being tested and used. The choice of substitute depends on both price and technical properties, and it varies according to the method of soldering - "reflow" soldering versus "wave" soldering or manual fitting [Elfnet 2005].

Today there are no acceptable alternatives for solder with a high melting point (i.e. tin-lead soldering alloys with more than 85 % lead), and this use has been exempted from the ban in the RoHS Directive (cf. Annex 2). Sn-80Au (tin-80gold) could be a practical alternative, but it is very expensive [JBCE 2004].

Other uses of solder containing lead currently exempt from the ban in the RoHS Directive include (cf. Annex 2):

Lead in solders for servers, storage and storage array systems, network infrastructure equipment for switching, signalling, transmission as well as network management for telecommunications.

- Lead in solders consisting of more than two elements for the connection between the pins and the package of microprocessors with a lead content of more than 80 % and less than 85 % by weight.

- Lead in solders to complete a viable electrical connection between semiconductor die and carrier within integrated circuit Flip Chip packages.

Table 6.1 Other uses of lead as a metal

Use	Remarks
1. Soldering alloys for soldering zinc sheets	Cf. section 4.2
2. Soldering alloys for soldering - electronics - electric light bulbs and fluorescent tubes etc.	Cf. section 6.1
3. Bearings in cars	Bearing bushes and bearing liners are exempt from the ban in the EU Directive on End-of-Life Vehicles
4. Low-melting alloys, fuses in cars, overheating protection in electric motors etc.	Cf. section 6.2
5. Lead batteries for - starting purposes (cars and others) - emergency supply - traction batteries - UPS - small batteries - miscellaneous (actuators) 6. Organ pipes	Special regulation in Statutory Order No. 966 of 13 December 1993 on certain batteries and accumulators containing dangerous substances. Lead still dominates the market, despite ongoing developments in other types of battery, including lithium batteries Organ pipes made traditionally of lead-tin alloy. New developments have not been investigated, but these have probably not taken place.
7. Lead windows	Lead still used - cf. [Bl-glas 2005]
8. Ship keels	Lead still used - cf. [Ørkild 2005]
9. Lead as additive or alloy in - brass - red metal (naval brass) - zinc for hot galvanising - aluminium and steel for machining	See section 6.3
10. Balancing - car wheels - ventilators - wings on wind turbines - machine parts, technical equipment - pianos	See section 6.4
11. Radiation screening - plates in walls, ceilings, floors, doors and windows at dentists, hospitals (X-ray rooms) - packaging for X-ray film - personal protective equipment (aprons etc.) - transport containers	See section 6.5

Table 6.1 Other uses of lead as a metal – cont.

Use	Remarks
12. Coating on petrol tanks	Banned in EU Directive on end-of-Life Vehicles (cf. Annex 2)
13. Sound and vibration suppression	See section 6.6
14. Lead belts for divers	New developments have not been investigated, but these have probably not taken place.
15. Lead hammers	New developments have not been investigated, but these have probably not taken place.
16. Police truncheons	New developments have not been investigated, but these have probably not taken place.
17. Counter weights	New developments have not been investigated, but these have probably not taken place - alternatives are other materials.
18. Gear and brake cables	New developments have not been investigated, but these have probably not taken place.
19. Anchor cables	New developments have not been investigated, but these have probably not taken place – the situation is regarded as parallel to cables for seine fishing and similar used in commercial fishing.
20. Anti-corrosion in the chemicals industry - pipes, baths and plates	New developments have not been investigated, but these have probably not taken place – the alternative is still stainless steel.
21. Mantles for underground electrical cables over 24 kV	See section 6.7
22. Ammunition	See section 6.8
23. Lead casting – National Museum	Lead is used to secure pillars and fencing in historical buildings. No developments have taken place for alternatives [Sørensen 2005].

Evaluation

Work to introduce the RoHS Directive has shown clearly that lead soldering is a field covering many uses, each with its own special requirements. The work has also shown that, in by far the majority of cases, it seems to be possible to replace lead-tin solder with other types of solder.

With regard to lead solder in electronic and electrical equipment which is not covered by the RoHS Directive, it seems that only limited immediate drip-down effects from the RoHS Directive can be expected. The fact that lead solder is both cheap and well-tested means that many and perhaps the majority of manufacturers will continue using this type of solder.

Although in practice it would clearly be possible to substitute with unleaded solder for many purposes, it is unlikely that manufacturers of the relevant equipment are ready to do so. Furthermore, it is not known how willing manufacturers are to adapt their products to the Danish market. This means that a ban on lead in soldering alloys for all types of electronic and electrical equipment could cause difficulties for imports of important equipment to Denmark.

6.2 Low-melting alloys

Alloys which melt at a relatively low temperature are used for protection against fire and overheating in electronic equipment. Alloys based on lead and cadmium dominate the market. Alternatives are InSn (indium-tin) or BiSn (bismuth-tin) alloys, but indium is very expensive. Fuses to protect against overheating in electronic equipment can be made redundant by better cooling [Goodman and Stuckwick 2002].

At the moment, the RoHS Directive has introduced a ban on the use of lead for this purpose in electronic equipment (cf. Annex 2). According to [Goodman and Stuckwick 2002] it is unlikely that the existing alternatives are practical for all purposes.

Evaluation
There are probably alternatives for most purposes, but these alternatives can be considerably more expensive. However only small amounts of metal (less than 1 g) are usually used in each fuse. The RoHS Directive also applies in Denmark and it must be assumed that the types of electronic and electrical equipment not covered by the RoHS Directive will only represent a small amount of lead. Furthermore, there will clearly be a number of uses where replacing lead will pose technical problems and it is not known how willing manufacturers will be to adapt their products to the Danish market. Marginal Danish consumption means that efforts in this area may well not pay off.

6.3 Other alloys

Lead is used as an alloying element in small concentrations in several metals to improve their manageability, e.g. machining the material. Lead is used for this purpose in steel, aluminium, and copper alloys. According to [Petersen 2005] ordinary recycled steel (also known as "black steel") contains large amounts of lead as an impurity.

In order to examine the possibilities of reducing lead impacts on employees, a committee for health and safety in the casting and foundry sector completed an assessment of possible substitutes for lead. The group of experts behind the report deem that the following five alloys are less harmful to health than traditional bronze containing lead [Tiedje et al, 2003]:

- Tin-bronze composed of copper, tin and 0.8 % lead
- Aluminium bronze, an alloy of aluminium, nickel, iron and possibly manganese
- Cu-Se-Bi alloys composed of copper, selenium, bismuth
- Stainless steel, containing 18 % chromium and 8 % nickel
- Copper alloys with graphite particles - a tin-bronze alloy 8 % tin and 4 % zinc, with graphite particles added during smelting.

In summary it seems that there are substitution possibilities for the most important product uses. The alternatives are typically more expensive, but they have the advantage of fewer environmental and health and safety problems [Tiedje et al, 2003]

However, it should be noted that both the RoHS Directive and the Directive on End-of-Life Vehicles allow for exemptions for 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 copper alloy containing up to 4 % lead by weight. (cf. Annex 2).

For aluminium in vehicles it is also permitted to have up to 1.5 % lead by weight up to 1 July 2008. Furthermore there are exemptions for lead in lead/bronze bearing bushes and bearing liners (cf. Annex 2).

Evaluation
The exemptions from the lead ban in the RoHS Directive and in the Directive on End-of-Life Vehicles can be regarded as evidence that there are currently no commonly accepted European alternatives to lead as an alloying element in aluminium, steel and copper alloys.

It is worth considering the possibilities to promote the use of lead-free alloys in Danish industry.

6.4 Balancing

Lead is used to balance wheels on vehicles and in numerous other applications such as ventilators, wind turbine wings, machine components and pianos.

Wheel weights
Today, lead weights are completely banned in the EU on cars with seats for up to 8 passengers and vans with a total weight of up to 3.75 tonnes (cf. EU Directive on End-of-Life Vehicles [EU 2005a]). In connection with the introduction of this Directive, the need to use lead to balance wheels on vehicles was assessed. Today, wheel weights are covered by the ban on lead. According to [Buergel 2004] alternative materials (zinc, tin, steel etc.) have been used on vehicles with type approval after 1 July 2003. According to an important manufacturer of wheel weights, today alternatives are supplied made of zinc, steel, tin and copper. Which substitute is best is determined from case to case. Wheel weights made of lead are still available for vehicles of more than 3.75 tonnes, which are not covered by the EU Directive [Trax 2005].

The existing ban in Denmark against using lead as a wheel weight applies to vehicles with type approval after 1 July 2003 as well as spare parts for these vehicles. According to [Grau 2006], this means that it is illegal to fit lead weights when changing tyres on cars placed on the market after 1 July 2003. Moreover the EU Directive was later amended so that today it is also illegal to use lead in wheel weights on vehicles approved before July 2003. This amendment is expected to be implemented in Danish legislation during 2006 [Grau 2006].

There is nothing to prevent fitting wheels with lead weights when changing tyres in Denmark. As it is considerably easier and cheaper for Danish workshops to use lead weights, it is probable that today Danish cars are extensively fitted with lead weights following a tyre change.

The vehicles not covered by EU Directive 2000/53/EC on End-of-Life Vehicles are primarily vehicles with a total weight of more than 3.75 tonnes. In principle there is no great technical difference between balancing wheels on vehicles of more than 3.75 tonnes and balancing wheels on lighter vehicles such as cars. The most important difference is that the wheels are typically larger and that for harder substitutes it is necessary to manufacture weights

which fit the individual types of rim. In connection with this project, information has not been obtained from Danish importers of vehicles weighing more than 3.75 tonnes on whether it is practicable for importers to initiate substitution of wheel weights on imported vehicles.

Pianos
No pianos are manufactured in Denmark, and about 80 % of Danish pianos are manufactured in Germany. Production has followed the same principles for the past 400 years, including using lead to balance the keys. Lead is still used to balance the keys [Danielsen 2005].

Most Danish pianos are repaired in Denmark. Many of these repairs involve balancing the keys with lead, in the same way as when the piano was made. This lead is imported by wholesalers and sold on Danish piano repairers. An important Danish wholesaler would like to use something other than lead, but the long tradition for using lead means there is general reluctance to avoid lead [Danielsen 2005].

Other uses
No information has been obtained on developments in the use of lead for balancing in other contexts. It is known that in addition to balancing wheels, lead is also used extensively to balance wind turbine wings and ventilators. It is also used to balance machine components such as flywheels, clutches, drive shafts, electric rotors, fans, pulleys, rollers etc. [Lassen et al 2003].

It is known that in practice wind turbine wings and ventilators are balanced with lead and with other materials such as cast iron, polyurethane etc. [Lassen et al 2003]. No information has been obtained on the technical arguments for choosing specific materials in specific situations.

It is likely that lead remains the preferred material for balancing many machine components. Arguments for using lead are based on cost (lead is cheap), that lead is easy to work with (lead can be soldered on and ground into shape), weight and tradition. The weight of lead can be very important in situations where balancing is to be carried out in places with restricted space. Otherwise there are no other properties which give rise to technical barriers to substituting lead. In many cases, tin will have comparable properties, except that tin is more expensive and not quite as heavy as lead.

Evaluation
In principle, it is also possible to do without lead to balance wheels on vehicles of more than 3.75 tonnes. Therefore, practical possibilities should be examined to substitute lead in wheel weights for vehicles of more than 3.75 tonnes imported into Denmark.

In addition, balancing wind turbine wings is significant in terms of amount. It seems that it is possible to substitute the use of lead to balance wind turbine wings. Therefore stopping or restricting the use of lead for this purpose should be examined.

With regard to other uses, it is deemed that in many situations lead could be replaced by other materials. Quantities of lead consumed for these purposes are of limited importance, however.

6.5 Protection against radiation

Historically, because of its high density, lead has been used as protection against radiation, including X-rays, and, as far as we know, the use of lead for this purpose has not undergone dramatic change [Lauritsen 2005]. It is possible to protect from X-rays using other materials than lead. These must be heavy materials (high atomic number). Concrete is a possibility, but it is impractical where flexibility is required, for example in aprons etc. [Lauritsen 2005]. Metallic lead powder is still used in production of rubber aprons to protect against X-rays [Thisgård 2005].

Evaluation
It is deemed possible to substitute lead for protection against radiation in many situations. Compared with the alternatives (concrete, other heavy metals), in most cases lead will have significant advantages because it requires little space and it is cheap.

6.6 Sound and vibration suppression

The use of lead to suppress vibration in vehicles is still permitted according to the EU Directive on End-of-Life Vehicles (cf. Annex 2). According to [Buergel 2005] steel is often used in cars, but in some circumstances lack of space means that lead is the only practicable solution.

There have been no attempts to obtain further information about the use of lead for noise and vibration suppression. According to the mass-flow analysis of 2000, the consumption of lead for this purpose by industry can be regarded as marginal [Lassen et al 2003].

Evaluation
It is likely that it will be possible to substitute lead with other materials in many circumstances. However, there may be uses where it would be very difficult to find alternatives. Marginal consumption means that there would only be a minimal effect from efforts in this area.

6.7 Mantles for cables

According to NKT [Thiesen 2005], today lead has been substituted in all new cables > 24 kV, laid underground. Lead has been replaced with aluminium combined with the use of more copper. This compensates for the earlier problems with eddy currents in the aluminium foil and the resistance associated with these. Repairs to existing lead-mantled underground cables still require the use of small quantities of metallic lead.

Lead is still used in underwater cables, but this is also being substituted.

Evaluation
It is deemed that it is possible to ban the use of lead in all cables, except undersea cables.

6.8 Ammunition

Today, use of lead shot is banned in Denmark, both for hunting and for sports shooting, except in selected sports shooting facilities. On the other hand, the use of lead slugs for hunting and sports shooting is unrestricted. The status of lead-free ammunition is described in [Hansen et al 2004], and this report forms the basis of the following.

Internationally there is currently great development in lead-free ammunition. The most important driving forces behind this development include:

- That Sweden will introduce a ban on lead in rifle ammunition from 1 January 2008 for both hunting and sports shooting unless the spent ammunition is gathered up and disposed of in a manner appropriate for the environment and health.
- That it is very expensive to clean up military ranges for lead pollution.

Today, a Nordic ammunition firm supplies the Swedish, Norwegian and Finnish armed forces with lead-free ammunition, and in 2004 an agreement on production under licence was made between this firm and the Danish Ammunitionsarsenalet. The lead-free ammunition meets NATO requirements and costs about 20 % more than lead ammunition. There is no information on what materials have substituted the lead. A possible substitute may be tungsten alloys. New information indicates that there are possibly undesirable environment and health effects from tungsten [Hansen et al 2004].

All calibres of lead-free ammunition for hunting are also available on the market. These are usually copper slugs, see [Lapua 2006]. However, hunters are not happy with the ban on lead-containing ammunition [Hunters Magazine 2004].

Whether there are alternatives for all ordinary weapons for hunting or sports shooting has not as yet been investigated. As copper is lighter than lead, the cartridges will usually be longer and it is possible that these cartridges will not suit all rifles. There are also problems with rifles which do not use a standard calibre. As far as is known, lead-containing ammunition is by far the most popular for sports shooting.

It is known that the International Sports Shooting Association is working to organise environmentally friendly ranges rather than to substitute lead. It is unclear whether building environmentally friendly ranges is cheaper or more expensive in the long term than substituting lead [Hansen et al 2004].

Evaluation
It is possible to substitute extensively the use of lead in rifle ammunition for hunting purposes. Implementation of a ban on lead would give rise to a number of practical problems, which must be solved in cooperation with the relevant users and their organisations. It is likely that a ban against lead-containing ammunition for hunting will give rise to debate to the same extent as the introduction of the ban on lead shot.

It is probably also possible to substitute lead in sports shooting. Just as for hunting there will be a number of practical problems related to a ban, and these will have to be solved in cooperation with the relevant users and their organisations.

6.9 Other uses

New developments have not been examined for a number of the other uses listed in Table 6.1. In practice this will probably not be the case. Alternatives are available on the market for most of these uses. These alternatives will usually contain other metals or other materials. It is deemed unlikely that further substitution will take place for these uses without influencing the market, for example through restrictions on the use of lead.

7 Uses in conflict with the Statutory Order on Lead

As part of work to assess the need to revise the Statutory Order on Lead, certain existing or possible uses of lead have been recorded which in fact contravene the Lead Order. These uses are listed below.

7.1 Primers for bolt guns etc.

There was an exemption for lead in primers for bolt guns used, for example, to secure bolts and nails in concrete. This exemption applied until September 2005.

In this use, lead is a component in the primer for the cartridges. The primer is composed of several different chemical compounds, listed in the safety data sheet for the cartridges [Hovang, 2005]. According to the safety data sheet from the manufacturer Hilti, dated 30 May 2002, the cartridges contain lead 2,4,6-trinitroresorcinolate (CAS No. 15245-44-0), or lead styphnate as it is also called.

Lead is used to achieve the greatest degree of safety and to contain the explosion. Not using lead styphnate would just mean an explosion could be caused and the cartridge would be lost [Hovang, 2005].

Lead styphnate and possibly other lead compounds in the primer or detonator cap are general in ammunition. Detonator caps for ordinary ammunition are not produced in Denmark, and they are imported from Germany. Therefore, Danish ammunition manufacturers do not always know the complete composition of caps and may use lead unintentionally [Hansen, 2005].

The supplier for most Danish manufacturers states that, with regard to lead, a detonator cap contains 24 mg "Zenoxid", which contains 37-48 % lead styphnate and possibly lead oxide [Hansen, 2005].

The weapons industry in the US is working to find substitutes for lead, but so far it has not been able to find anything as stable as lead. It is therefore difficult to identify substitution possibilities [Hansen, 2005].

As far as is known, lead is also contained in detonators for explosives. There may typically be 0.02 – 0.37 g lead azide in each detonator [Schneider 2005].

Evaluation
It is likely that the use of lead compounds in primers in ammunition is widespread and therefore there are lead compounds in most types of ammunition, and possibly all. However, only few users are aware of this. Therefore exemption has only been applied for with regard to bolt guns. In fact all importers of ammunition and detonators should have applied for exemption.

There do not seem to be any practical substitutes under development. Therefore an exemption is required for the area. Such an exemption should be reassessed after a certain number of years.

7.2 Equipment which could be imported illegally

The study has become aware of the following examples of illegal imports or risks of illegal imports of lead-containing products.

Electrical cables
NKT has stated that foreign cables are sometimes marketed in Denmark as being lead-free. However, studies show that some of these cables do contain lead, and this may be because the foreign manufacturer has chosen cheap lead stabilisers for the PVC component instead of the more expensive lead-free alternatives such as calcium/zinc –stabilisers [Thiesen, 2005/06].

PVC products
As regenerated PVC with lead stabilisers is used in Germany and possibly other countries to manufacture PVC pipes and fittings, imports of lead cannot be ruled out in these products made of lead-containing regenerated PVC-granulate. However, the PVC industry considers that this illegal practice has stopped with regard to fittings and pipes [Grøndahl 2005].

The situation is more serious on this point for PVC windows. Many lead-containing windows and window profiles do appear on the Danish market. They primarily come from Germany, where production of windows with lead-containing PVC has not yet ceased. This is a great nuisance to Danish manufacturers of windows as they have invested tens of millions of DKK in substituting lead in their windows. They are now facing competition from illegally imported and cheaper windows and window profiles. Production of lead-containing windows in Germany and other countries will cease in 2015 according to the PVC industry's voluntary environmental programme, Vinyl 2010. However, there is no indication that the use of lead-containing regenerate in Europe will be regarded as undesirable in the future [Grøndahl 2005].

Evaluation
As Denmark has introduced tighter regulation on the use of lead than neighbouring countries, there will always be a risk of illegal imports of products containing lead. The risk is present for most product groups where lead-free alternatives are more expensive than products containing lead and it can only be contained through control.

8 Discussion and summary

Possible amendments to the Lead Order are summarised in Tables 8.1 and 8.2. Table 8.1 concentrates on lead in chemical compounds, while Table 8.2 concentrates on lead as a metal.

The tables list the amendments to the Lead Order which are deemed technically possible and practicable. In order for substitution to be practicable, there must be alternatives and these must cover the largest part of the current consumption within the relevant area of use. However, it is rarely possible to identify alternatives which cover current consumption 100 %, as in many situations special conditions such as specific product properties must be provided for; so, in practice 100 % cover often requires tests to adjust other parameters.

Therefore, it is always likely that individual manufacturers will have special problems finding practical alternatives, and thus will need to seek exemption.

The current Lead Order has been designed as a general ban (with exemptions) on lead as a chemical compound, while bans on lead as a metal have been introduced for selected uses. Accordingly, this report provides specific recommendations regarding lead as a compound, while for uses of lead as a metal, which are currently not regulated, the report concentrates on alternatives sufficiently well-developed to make a ban possible.

In general, compared with the use of lead and the status of alternatives before the Lead Order was introduced in the late 1990s, there has been a considerable movement away from lead for many areas of use (cf. [Hansen & Brønnum 1998]).

For example, use of lead as a pigment in plastic and as a stabiliser in PVC. Both these uses have been important, but today they have either ended altogether (pigment) or they have almost ended (stabilisers). Another example is the use of lead to balance wheels on cars, which has now been banned for new cars.

The general benefits arising from this development are lower emissions of lead into the environment, either directly through use or production of products containing lead, or indirectly in waste treatment and disposal.

There have been several forces behind this development, including that Danish enterprises have continued to make significant efforts to develop lead-free alternatives, even though the Statutory Order provides exemptions for these uses. For example cable mantles on underground electrical cables, where it is now possible to eliminate lead in all underground cables. Brake linings and porcelain are other examples.

Table 8.1 Uses of lead as a chemical compound where amendments to the Statutory Order on Lead could be considered

Use	Possible amendment	Remarks
Special purposes in elastomers	There is no need for a general exemption for heat stabilisers.	It is possible there may be applications for exemptions.
Stabilisers in electrical cables incorporated in products	There is no need for a general exemption for electrical cables incorporated in products. The exemption could be limited to an exemption for high-flexible cables in machine components which move relative to each other. This exemption is also relevant for cables which are not incorporated in products.	Electrical cables incorporated in products are subject to the RoHS Directive. It is possible there may be applications for exemptions.
Brake linings	There is no real reason to continue the exemption for brake linings. The exemption could be replaced with an exemption for increased content of lead in raw materials for brake linings as in the EU End-of-Life Vehicles directive.	Brake linings in cars of up to 3.5 tonnes are subject to the EU End-of-Life Vehicles Directive. It is clear that applications for exemption will be submitted.
Electrical discharge lamps	The exemption should possibly be repealed. If the exemption is retained it should be made more specific so that it corresponds with the exemption in the RoHS Directive.	Electrical discharge lamps are subject to the RoHS Directive
Paint for special purposes	No change – the exemption should be re-evaluated after some years.	
Glass for special purposes	There is no need for exemptions for car window screens and coating of plane glass. It is possible that the exemption should be repealed for picture tubes, light sources, optics and plates in photocopiers. With regard to glass for protection against radiation, crystal and silicate glass for sand blasting, the exemption should be re-evaluated after some years.	Picture tubes, light sources, optics and filter glass, and plates in photocopiers are covered by the RoHS Directive. Car window screens are covered by the EU End-of-Life Vehicles Directive.
Glaze, enamels and pigments on art and handicrafts	It should be possible to repeal the exemption for works of art.	There will be a need to exempt Flora Danica porcelain and other art of cultural-historic significance. Clearly exemption applications will be submitted.
Glaze on tile, vitrified brick, brick and spark plugs	The exemption for glaze on tile, vitrified brick, and brick should be continued and re-evaluated after some years. The exemption can be repealed for spark plugs for cars of up to 3.5 tonnes.	Spark plugs are covered by the EU End-of-Life Vehicles Directive. How to promote development of alternatives for glaze on tile, vitrified brick, and brick should be considered.
Electronic components	No change – the exemption should be re-evaluated after some years.	Electronic components are subject to the RoHS Directive.
Superconductors	An exemption for superconductors should be introduced - the exemption should be re-evaluated after some years.	
Red lead	The exemption for red lead to restore historical objects should be considered.	Alternatively other methods of restoration should be developed.
Aviation fuel	No change	There should be consideration on how trading in unleaded aviation fuel can be ensured in Denmark. Certain aircraft or piston engines for aircraft can require permanent exemption to be able to use leaded fuel.
Primers for ammunition	There is a need for a general exemption for lead compounds in primers for ammunition and detonators. This exemption should be reassessed after some of years.	
Lead in incandescent lamps	The need to introduce exemptions for lead as a chemical compound in special incandescent lamps should be considered.	Lead in incandescent lamps is covered by the RoHS Directive.

Table 8.2 Uses of lead as a metal where amendments to the Statutory Order on Lead could be considered

Use	Possible amendment	Remarks
Flashing on roofs	There is no need for a general exemption for repairs, rebuilding and extensions on houses. The exemption can probably be limited to listed buildings or those classified as worthy of preservation, and where, for architectural reasons, it is deemed appropriate to use lead.	There is clearly a need to retrain "older" tradesmen who have not been trained in the new materials and techniques.
Lead solder on zinc gutters	No change - should be reassessed after some of years.	There is a need to gather, evaluate and if necessary report German experience with using glue on zinc gutters.
Roof covering	Exemption for lead roof covering on historical or listed buildings should be considered	Alternatively other roofing materials should be developed which can replace lead roofing on these buildings.
Fishing tackle	No change	The exemptions should be extended.
Soldering alloys for electronics	No change	Soldering alloys for most types of electronics are subject to the RoHS Directive. A general ban in Denmark could make it hard to import important products.
Low-melting-point alloys	No change	Fuses in many types of electrical and electronic equipment are covered by the RoHS Directive. Only modest amounts of lead are used for this purpose.
Other alloys	No change - should be reassessed after some of years.	Corresponding alloys are covered by both the RoHS Directive and the EU End-of-Life Vehicles Directive.
Balancing	It should be possible to ban lead wheel weights on all vehicles. It could be considered whether it is relevant to ban balancing wind-turbine wings with lead.	Lead wheel weights for cars with up to 8 seats and vans with a total weight of up to 3.75 tonnes are banned under the EU End-of-Life Vehicles Directive.
Protection against radiation	No change	
Sound and vibration suppression	No change	Vibration suppression in cars is covered by the EU End-of-Life Vehicles Directive.
Cable mantles	It is possible to extend the ban on lead cable mantles to all underground cables.	
Ammunition	It should be possible to stop the use of metallic lead in rifle ammunition for hunting and possibly also for sports shooting.	Use of lead in rifle cartridges will be banned in Sweden from 1 January 2008 both for hunting and sports shooting, unless the spent ammunition is gathered up and disposed of appropriately.
Other purposes	Restrictions on the use of lead for certain of the uses involved could be considered.	

Introduction of the EU RoHS Directive and the End-of-Life Vehicles Directive has in many ways accelerated developments, especially because “at one blow” the regulation covers such a large market, that manufacturers globally must adapt their production to meet the requirements. In this way it has been possible in practice to introduce substitutes for lead in solder, lead as a stabiliser in electrical cables, lead in weights on car wheels, lead in brake linings, and lead for many more purposes.

The introduction of these directives also means that removal of a number of exemptions from the Lead Order could be considered, as regulation of these uses has been taken over by the Directives.

Finally, technological developments mean, for example, that the use of lead in picture tubes in televisions and computer screens is coming to an end without regulation because the traditional picture-tube screens are disappearing from the market as flat screens take over.

Examples of areas where no significant progress is being made towards substitution are equipment for commercial fishing and glazing on tiles, vitrified brick and bricks.

Considerable efforts have been invested in equipment for commercial fishing, including by the suppliers of equipment. However, the fisheries sector is currently under financial pressure and it has so far not been possible to develop alternatives, except for simple sinkers, which are financially competitive with traditional lead solutions, there has been no motivation to market alternatives. For the moment it is suggested that the exemptions be extended for this area.

With regard to glazing for tiles, vitrified bricks and bricks, it seems that the lack of efforts could be due to a lack of motivation to develop alternatives, and therefore a special effort is recommended for this area.

A particularly important area for Denmark is flashing around windows etc. on roofs. Large quantities of lead have traditionally been used for this purpose. Developments in this area, however, have been successful and alternatives have been developed which could replace traditional lead flashing for all uses. Consideration for listed buildings and other buildings classified as worthy of preservation, and where for architectural reasons it is considered appropriate to use lead, today seem the only real arguments for continuing to use lead.

The Lead Order includes a general exemption for repairs, rebuilding and extensions for houses. This exemption means that lead felt for flashing is still sold at do-it-yourself centres and can thus be used by both tradesmen and do-it-yourself enthusiasts, even though alternatives are available. In order to prevent this abuse, it is suggested that the exemption for repairs, rebuilding and extensions to houses be repealed for lead flashings.

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Annex 1 Organisations and companies contributing to the study

Interest organisations
Danish Association of Motor Vehicle Importers, DK
Fisheries Service Sector, DK
Danish Petroleum Industry's Association (OFR), DK

Institutions
Aalborg Technical School
Haslev Technical School
Danish Army Material Command, Ammunition Arsenal
Painters Occupational Health Service (BST)
Danish Environmental Protection Agency
National Museum of Denmark
Academy of Professional Higher Education NOEA
Danish Petroleum Industry's Association
PVC Information Council Denmark - plastics industry
Vitus Bering
Risø National Laboratory

Companies
Bach Klaver & Flygler, DK
Bue-Net, DK
Castrol, DK'
Codan Gummi, DK
Coterro, DK
Cerama, DK
Dansk Eternit Holding A/S, DK
Dansk Lysteknisk Co. A/S
Danish Toxicology Centre, DK
Fatoca Tagdækning ApS, DK
Grundfos, DK
KETEC, Teleinstrument A/S
Knud Danielsen A/S, Piano-, Flygel- og Orgeldele, DK
Locksmith and carpenter Kristian Kristensen
Miltronic, DK
NKT Cables, DK
Old Way Logging
Poul-E Meier ApS, DK
Randers Reb, DK
Randers Tegl, DK
RGS 90, DK
Roulunds Braking, DK
Roulunds Rubber, DK
Royal Copenhagen, DK
Scandia DK og S,
Scanglas, DK
Schjerning Farver, DK
Solar, DK

Danish Technological Institute, DK
Ulkebøl Byggeservice, DK
Yamaha Motor, DK

Annex 2 EU Directives

EU Directive 2002/95/EC (RoHS Directive)

In Denmark, the RoHS Directive is implemented in Danish law by Statutory Order no. 1008 of 12/10/2004 on import and sale of electrical and electronic equipment containing lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB) or polybrominated diphenyl ethers (PBDE).

According to the Directive and the Statutory Order, import and sale of electrical and electronic equipment containing lead etc. are prohibited as from 1 July 2006. This ban also applies to spare parts for the repair of such equipment. For lead, a limit value of 0.1 per cent by weight has been fixed for the homogeneous components of the products.

However, the Directive and the Statutory Order only apply to the following categories of electrical and electronic equipment:

1. Large household appliances
2. Small household appliances
3. IT and telecommunications equipment
4. Consumer products
5. Lighting equipment
6. Electrical and electronic tools (excluding large-scale stationary industrial tools)
7. Toys and sport and leisure equipment
8. Medical equipment (excluding all implanted and infected products).

Moreover, equipment for specifically military purposes, medical devices and monitoring and regulation instruments are not covered by the provisions.

In addition, the following specific applications of lead are so far exempt from the prohibition:

- Lead in glass of cathode ray tubes, electronic components and fluorescent tubes.
- 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.
- 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, network infrastructure equipment for switching, signalling, transmission as well as network management for telecommunications.
- Lead in electronic ceramic parts (e.g. piezoelectronic devices).
- Lead used in compliant pin connector systems.
- Lead as a coating material for the thermal conduction module c-ring.
- Lead and cadmium in optical and filter glass.

- Lead in solders consisting of more than two elements for the connection between the pins and the package of microprocessors with a lead content of more than 80 % and less than 85 % by weight.
- Lead in solders to complete a viable electrical connection between semiconductor die and carrier within integrated circuit Flip Chip packages.
- Lead in lead/bronze bearing bushes and bearing liners.

At a meeting on 15 February 2006 of the EU Technical Advisory Committee for the RoHS Directive, it was decided to introduce the following exemptions for lead [Nørlem 2006]. With this decision, it is considered certain that the exemptions will be formally adopted by the European Commission within a very short time [Nørlem 2006].

- Lead in linear incandescent lamps with silicate coated tubes.
- Lead halide as radiant agent in High Intensity Discharge (HID) lamps used for professional reprography applications.
- Lead as activator in the fluorescent powder (1 % lead by weight or less) of discharge lamps when used as sun tanning lamps containing phosphors such as BSP ($BaSi_2O_5$:Pb) as well as when used as speciality lamps for diazo-printing reprography, lithography, insect traps, photochemical and curing processes containing phosphorus such as SMS ($(Sr,Ba)_2MgSI_2O_{7:}$:Pb).
- Lead with PbBiSn-Hg and PbInSn-Hg in specific compositions as main amalgam and with PbSn-Hg as auxiliary amalgam in very compact Energy Saving Lamps (ESL).
- Lead oxide in glass used for bonding front and rear substrates of flat fluorescent lamps used for Liquid Crystal Displays (LCD).

European Parliament and Council Directive 2000/53/EC of 18th September, 2000, on scrapped motor vehicles,

In accordance with the Directive materials and components of vehicles put on the market after 1 July 2003 shall not contain for instance lead.

However, the Directive applies only to the following categories of vehicles:

- Motor vehicles for private transport with a maximum of eight seats, plus driver's seat.
- Motor vehicles for goods transport with a maximum weight not exceeding 3.75 tonnes.
- Three-wheel motor vehicles, as defined in Directive 92/61/EEC, but excluding three-wheeled motor bikes.

Besides, the following specific applications are so far exempt form the prohibition (in accordance with Council Decision of 20 September 2005):

- Lead as an alloying element (incl. galvanised steel up to 0.35 per cent by weight
  - Steel for machining and galvanised steel with a lead content of up to 0.35 per cent by weight until 1 July 2008, and after this date up to 0.4 per cent by weight.
  - copper up to 4 per cent by weight
  - lead/bronze bearing bushes and bearing liners until 1 July 2008
- Batteries

- Vibration suppression
- Vulcanisers and stabilisers for elastomers used for liquids and in propelling devices with up to 0.5 per cent by weight of lead - until 1 July 2006.
- Binders in elastomers used in propelling devices with up to 0.5 per cent by weight of lead
- Lead in copper in friction materials in brake linings with a lead content not exceeding 0.4 per cent by weight - until 1 July 2007.
- Lead in valve seats for motor types developed before 1 July 2003 – until 1 July 2007
- Electrical components containing lead bound in a glass or ceramic matrix, except for glass in lamps and glazing on spark plugs.
- Pyrotechnic starters in vehicles which are type-approved before 1 July 2006, and spare parts for such equipment.

Annex 3 Statutory Order on Lead

Statutory Order no. 1012 of 13 November 2000 on prohibition of import and marketing of products containing lead

Part 1

1.-(1) This Order comprises import and marketing of products containing lead.

2.-(1) For the purpose of this Order lead shall mean the element lead, both in metallic form and in chemical compounds.

(2) For the purpose of this Order, products containing lead shall mean products in which lead represents more than 100 ppm (mg/kg) of their homogeneous components. (3) The limit in subsection (2) above does not, however, apply to lead carbonates and lead sulphates in paint.

3.-(1) The rules of this Order do not affect import, marketing and use of products that, at the time of the entry into force of this Order, are regulated under other legislation implementing EU Council Directives[1] and other legislation, including, Statutory Order No. 807 of 2 December 1986 on limitation of motor fuel's content of lead compounds and benzene, Statutory Order No. 966 of 13 December 1993 on certain batteries and accumulators containing dangerous substances, Statutory Order No. 41 of 21 January 1994, as amended, on firearms and ammunition permitted for hunting, etc., Statutory Order No. 568 of 6 December 1983 on use of slag and fly ashes, Statutory Order No. 823 of 16 September 1996, as subsequently amended, on Application of Waste Products for Agricultural Purposes.

4.-(1) This Order does not apply to import and marketing of products exclusively for export.

5.-(1) This Order does not apply to:

1) raw materials and semi-finished goods

2) second-hand products that complied with Danish requirements when first sold.

Part 2

Restrictions of use

Chemical compounds of lead

6.-(1) Import and marketing of products containing chemical compounds of lead shall be prohibited as of 1 March 2001.

(2) Notwithstanding the prohibition in subsection (1) above, import and marketing of products containing chemical compounds of lead shall be permitted for the product categories specified in Annex 1 to this Order, until the dates stated in the Annex.

Metallic lead

7.-(1) Import and marketing of products containing metallic lead shall be prohibited for the product categories stated in Annex 2 to this Order as of the dates stated in the Annex.

(2) The prohibition in subsection (1) above shall not comprise products for repairing existing products, including repairs, rebuilding of and extensions to houses.

Part 3

Supervision, derogations and complaints

8.-(1) The Danish Environmental Protection Agency may in very special cases permit derogations from the rules of this Order. The Danish Environmental Protection Agency may stipulate terms for the permit.

9.-(1) Supervision and control of compliance with the rules of this Order shall be carried out by the Danish Environmental Protection Agency, cf. Part 10 of Act on Chemical Substances and Products.

(2) Complaints against decisions made by the Danish Environmental Protection Agency under section 8 may not be made to any other administrative authority.

Part 4

Penalty and entry into force

10.-(1) Unless more severe penalty is due pursuant to other legislation, the penalty for the following infringements shall be a fine:

1) violation of sections 6 and 7 above,

2) disregard of terms attached to a permit according to section 8 above.

(2) The penalty may increase to detention or imprisonment for a maximum term of two years if the offender acted deliberately or by gross negligence, and if the infringement resulted in:

1) harm to the life or welfare of humans or domestic animals or risk of harm, or

2) damage to the environment or risk of damage, or

3) achieved or intended economic advantages, including savings, for the offender or for others.

(3) Criminal liability may be imposed on companies (legal persons) according to the rules of Part 5 of the Danish Criminal Code.

11.-(1) This Order enters into force on December 1, 2000. (2) The rules concerning lead in sections 2 and 13 of Statutory Order No. 1042 of December 17, 1997 are repealed on March 1 2001.

Ministry of Environment and Energy, 13 November 2000

Svend Auken

/Helge Andreasen

Official notes

[1)] This Order was in a draft version notified in accordance with Directive 98/34/EC from the European Parliament and the Council (Information Procedure), as last amended by Directive 98/48/EC. The Statutory Order contains provisions implementing Council Directive 89/677/EEC (OJ L 398, p. 19).

[2)] Including Council Directive 93/42/EEC concerning medical devices, which was implemented through various statutory orders including: Statutory Order No. 734 of 10 August 1994, Statutory Order No. 41 of 17 January 1995 and Statutory Order No. 139 of 1 March 1995. Council Directive 84/500/EEC on ceramic articles intended to come into contact with foodstuffs, which was implemented i.a. through Statutory Order No. 1064 of 4 December 1996. Council Directive 94/62/EEC on packaging and packaging waste, which was implemented i.a. through Consolidated Act No. 698 of 22 September 1998 as subsequently amended, Consolidated Act No. 21 of 16 January 1996 as subsequently amended, Statutory Order No. 350 of 9 May 1994, Act No. 376 of 18 May 1994, Consolidated Act No. 637 of 21 August 1998, Statutory Order No. 731 of 9 October 1998, Statutory Order No. 124 of 27 February 1989, Statutory Order No. 600 of 18 September 1987, Statutory Order No. 299 of 30 April 1997, Statutory Order No. 298 of 30 April 1997, Statutory Order No. 583 of 24 June 1996, Statutory Order No. 1199 of 23 December 1992, Statutory Order No. 692 of 22 September 1998, and Statutory Order No. 300 of 30 April 1997.

Annex 3.1

List of product categories containing chemical compounds of lead where - notwithstanding the prohibition in section 6(1) – import and marketing shall be allowed until the dates stated in this Annex

Product categories	Allowed until
1. Siccatives in paint, varnish and lacquer, although not siccatives containing lead carbonate and lead sulphate	1. December 2001
2. Glazes on ceramic products, except glazes for art, handicrafts, tile, vitrified brick and brick, spark plugs and products that must be assumed to be used in connection with foodstuffs	1. December 2002
3. Enamels and pigments on ceramic products, except enamels and pigments for art and handicrafts, and products that must be assumed to be used in connection with foodstuffs	1. December 2002
4. Pigments in products used for signal/warning purposes	1. December 2002
5. Special purposes in elastomers	
– accelerators	1. December 2002
– heat stabilisers	until further notice
6. Stabilisers in plastic products:	
– door and window profiles	1. December 2001
– other products	1. December 2001
– roof gutters and down-pipes	1. December 2002
– roofing sheet	1. December 2003
– pipes and tubes	1. December 2003
– electrical cables incorporated into products	until further notice
7. Lubricants, including in bearing metal	1. December 2003
8. Brake linings	1. December 2004
9. Products for cathodic paint	1. December 2004

10. Discharge lamps	until further notice
11. Paint for special uses: – corrosion prevention paint containing less than 250 ppm of lead, although not in the form of lead carbonate and lead sulphate – antifouling paint containing less than 1250 ppm of lead, although not in the form of lead carbonate and lead sulphate	until further notice
12. Glass for special uses: – picture tubes – light sources – optics – radiation protection – car windows – plates in photocopy machines – coating of plane glass – crystal – silicate glass for sand blowing	until further notice
13. Glaze, enamels and pigments on art and handicrafts that must be assumed not to be used in connection with foodstuffs	until further notice
14. Glaze on tile, vitrified brick, brick and spark plugs	until further notice
15. Electronic components	until further notice
16. Products for repairing existing products	until further notice
17. Products for research, development and laboratory use	until further notice

Annex 3.2

List of product categories containing metallic lead where - pursuant to section 7 – import and marketing shall be prohibited as from the dates stated in this Annex

Product categories	Banned as of
1. Products for hobby use	1. March 2001
2. Chafing dish candles and other candles	1. March 2001
3. Curtain, drapery weights	1. March 2001
4. Products for decorative use	1. March 2001
5. Security/safety seals	1. March 2001
6. Products for roofing buildings	1. March 2001
7. Flashings and weatherings on buildings	1. December 2002
8. Fishing equipment for commercial fishing	1. December 2002
9. Fishing equipment for sports fishing	1. December 2002
10. Soldering alloys for plumbing and sanitation uses, except for soldering zinc sheets	1. December 2002
11. Mantles for electrical underground cables under 24 kV	1. December 2002