ORGALIME

The Secretary General

Mrs. Marianne Klingbeil,
DG Environment,
Unit A.2,
European Commission,
B-1049 Brussels

Brussels, 5 July 2004

Stakeholder Consultation on Adaptation to Scientific and Technical Progress under Directive 2002/95/EC for the Purpose of a possible Amendment of the Annex

Dear Mrs. Klingbeil,

Orgalime[1] welcomes the opportunity to contribute to the stakeholder consultation for the purpose of a possible amendment of the annex of directive 2002/95/EC.

Our industry confirms the necessity of granting exemptions from the substance restrictions of Article 4 (1) to all applications currently listed in the annex to directive 2002/95/EC.

In addition, we would like to take this opportunity to address both, the very urgent cases of already announced applications for which exemptions would be necessary and our support for new exemption requests including available background information:

- **Deca-BDE**

  We welcome that the Commission would base the decision about an exemption of Deca-BDE on the risk assessment. In addition to studies, which are already available to the Commission, please find attached a German study (Fischer) on the matter. This type of flame retardant is widely used in electrical and electronic products and a substitution is in many cases impossible **(see Annex 1)**.

- **Glass containing lead and lead in light bulbs**

  Orgalime believes that lead in glass should be exempted from substance restrictions of article 4(1). The European Federations CELMA and ELC have provided their position paper and reasoning behind the issue **(see Annex 2)**. The mentioned applications are of utmost importance for the lighting industry. The requested exemptions are especially necessary for innovative environment-friendly products.

---

[1] *Orgalime speaks for 33 trade federations representing some 130,000 companies in the mechanical, electrical, electronic and metalworking industries of 23 European countries. These industries employ some 7 million people and account for 1175 billion euros of annual output, which is a quarter of the EU's output of manufactured products and a third of the manufactured exports of the European Union.*

- **Cadmium in electrical contacts**

  Our members have identified uncertainties concerning the exemption of cadmium in electrical contacts. We therefore attach the application for a general exemption for cadmium used in switch products for reliability purposes having switching contacts with less than 0.3 g contact weights per contact (**see Annex 3**).

- **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 85% in proportion to the tin-lead content (exemption until 2010)**

  We emphasize the need for this additional exemption, as it is technologically essential for our members and its denial would result in extensive problems for the semiconductor industry. Although extensive research has been and is being conducted, environmentally acceptable, technologically adequate lead-free solutions do to our knowledge currently not exist for this application (**see Annex 4**).

- **Lead in high melting temperature type solders (i.e. tin-lead solder alloys containing more than 85% lead) and any lower melting temperature solder required to be used with high melting temperature solder to complete a viable electrical connection**

  The existing RoHS exemption for high temperature melting type solder exempts the higher temperature part but not the lower temperature part. Orgalime supports ZVEI's request for an extension of the existing exemption to include the lower melting temperature solder that is necessary to create the interconnection (**see Annex 5**).

- **Lead in solders to complete a viable electrical connection internal to certain Integrated Circuit Packages (Flip Chips) (exemption until 2010)**

  Orgalime is not aware of the existence of feasible substitutes in an industrial and/or commercial scale and strongly supports this exemption request (**see Annex 6**).

Orgalime would like to ask for the support of the European Commission for the above-mentioned requests, which are of high importance for the electrical/electronic industry in Europe.

Yours sincerely,

Adrian Harris

Secretary General

Cc.: Mrs. Anna Passera; env-rohs@cec.eu.int.

Enclosures

University Lecturer Dr Kristian Fischer
c/o Chair for Public Law and Tax Law
Mannheim University

68131 Mannheim
Schloß – Westflügel
Tel.: (0621) 181-1435
Fax: (0621) 181-1437
e-mail: kfischer@jura.uni-mannheim.de

THE TREATMENT OF PLASTICS CONTAINING BROMINATED FLAME RETARDANTS IN THE EC DIRECTIVE ON WASTE ELECTRICAL AND ELECTRONIC EQUIPMENT

– EXPERT STATEMENT –

Contents

A. Legal framework and report commission

On 27 January 2003 the European Parliament and the Council passed Directive 2002/96/EC on Waste Electrical and Electronic Equipment (hereafter called Waste Electrical Equipment Directive)[1]. The Waste Electrical Equipment Directive applies to various electrical and electronic equipment, and names, for them, the relevant equipment categories (see Annex 1A) and the products belonging to those equipment categories (see Annex 1B). The waste electrical and electronic equipment covered by the Directive must be collected separately and subsequently recovered. For this purpose, manufacturers and importers must set up (individual or collective) systems for taking back, treating, recovering and disposing of electronic scrap and must assume the financial costs for doing so. Furthermore, on 27 January 2003, Directive 2002/95/EC on restricting the use of certain hazardous substances in electrical and electronic equipment (hereafter called Electrical Substance Directive) was adopted[2]. This refers to new equipment and bans the use of particularly hazardous substances for such equipment.

The EC Member States must transpose both directives into national law by 13 August 2004. The Federal Republic of Germany is planning a Decree on Waste Electrical and Electronic Equipment (Electrical End-of-Life Ordinance). In this connection, for the national regulatory body, the question also arises as to which obligations should be standardised under waste law with regard to plastics found in waste equipment and containing brominated flame retardants. To answer this question, in the following, firstly the meaning of brominated flame retardants and their impact on the environment and on human health shall be looked at (see B) and then the body of legislation of both EC Directives with regard to the question posed shall be examined (see C).

B. Brominated flame retardants and their impact on health and the environment

Various fire protection concepts are applied to prevent electrical and electronic equipment from catching fire. The aim of fire protection is to avoid endangering users of electrical equipment through the occurrence of a fire or to largely contain any such danger. For this, various measures are used in practice. Equipment is constructed to protect against fire by placing components so as to virtually rule out ignition. Adding flame retardant additives[3] then ensures that – if overheating should occur, due to incorrect use or a technical defect for instance – the effects of an ignition are kept to a minimum. In particular, plastic parts that are in direct contact with live components in electrical equipment must be protected against fire. Among other things, the brominated flame retardants discussed here are also used in the electrical sector, including for instance in plastic casings for copiers, televisions or computers.

---

[1] OJ EC 2003 L 37, p.24 seq. Sometimes the abbreviation WEEE Directive is also used, following the English term "Waste Electrical and Electronic Equipment".

[2] OJ EC 2003 L 37, p.19 seq. The title of the Directive is "Restriction of the Use of Certain Hazardous Substances". Thus, the abbreviation RoHS Directive is also sometimes used.

[3] Flame retardants are chemical compounds added to flammable materials to provide better protection against catching fire. There is a large number of various substances and combinations of them that are used for that purpose. The most important are product families of flame retardants containing halogen, phosphorus or nitrogen, or mineral ones.

Various brominated flame retardants can be used for this. PBDE (polybrominated diphenyl ether) and PBB (polybrominated biphenyl) were often used in the past. After it became apparent that potential harm could be caused by some of these substances[4], in Germany the members of the Association of the Plastics Manufacturing Industry and Chemical Industry in Germany voluntarily committed, as early as 1986, to cease manufacturing and using PBDE. PBB fell out of use as a flame retardant a few years ago. Despite this development, it should be borne in mind that no conclusive scientific research had been carried out on the impact of brominated flame retardants on the environment and human health at the time the EU Directives were passed. It is always necessary to examine each case individually. This is also evident in the EC Commission's assessment of chemicals within the framework of the Existing Substances Regulation, which assessed the risks posed by flame retardants. As a consequence of the findings of those investigations, the EC has meanwhile issued a ban on penta-BDE and octa-BDE. On the other hand, the latest risk assessment of deca-BDE (bromodiphenyl ether) comes to the conclusion that no danger to man and environment can be ascertained with respect to the use of this flame retardant. For this reason, no generalisation can be made. This concerns both the combination of various types of bromodiphenyl ethers (BDE) in poly-BDE and an even more comprehensive group of brominated flame retardants. Rather, with respect to its relevance to the environment or health, every flame retardant must be judged individually.[5] Therefore, a differentiated approach is necessary.

[4] To be more precise: when used for thermal recovery, PBDE/PBB decomposition products are dangerous as they form dioxin and furan.

[5] Particularly since, with increasing worldwide demands for fire protection, the options for acting should not be unnecessarily restricted by dispensing with certain, tried and tested, and assessed flame retardants.

C. Provisions of the Waste Electrical Equipment Directive and of the Electrical Substance Directive for plastics containing brominated flame retardants

I. The binding nature of the objectives of EC Directives

As directives within the meaning of Art. 249 III EC, the Waste Electrical Equipment Directive and the Electrical Substance Directive are binding on the Federal Republic of Germany with respect to the targets to be met. This means that the Federal Republic must fully and precisely comply with the provisions of both directives[6] and is thus obliged, to take all necessary measures within the framework of its national system of laws to ensure the full effectiveness of the directive in accordance with its objective[7]. If, therefore, the Waste Electrical Equipment Directive and the Electrical Substance Directive contain detailed regulations on treating plastics containing brominated flame retardants, the Federal Republic of Germany must directly adopt those provisions. If, on the other hand, the directives are expressed in less concrete terms, this leaves some scope for discretion within the framework prescribed by both directives.

II. The provisions of the Electrical Substance Directive

1. The substance ban according to Art. 4 of the Electrical Substance Directive

In its Art. 4, the Electrical Substance Directive lays down a ban – which must be transposed by the Member States – on the use of certain hazardous substances in new electrical and electronic equipment. From 1 July 2006, new electrical and electronic equipment brought onto the market must not contain any lead, mercury, hexavalent chromium, polybrominated biphenyl (PBB) or polybrominated diphenyl ether (PBDE). In the preamble to the Electrical Substance Directive, the reasons for this are that there are sound scientific research findings on the environmental and health risks posed by the relevant substances. This means that, in the medium term, the use of PBB and PBDE as flame retardants in plastics is ruled out. Other brominated flame retardants, on the other hand, are not subject to the substance ban of the Electrical Substance Directive. An adaptation to the directive is needed in this regard.

Indeed the blanket ban on PBDE appears problematical if – as already explained – new scientific findings reveal evidence that the use of the flame retardants deca-BDE (bromodiphenyl ether) poses no threat to people or the environment. Then, the substance ban in Art. 4 of the Electrical Substance Directive as it relates to the blanket ban on PBDE cannot actually be justified. In this respect, it is fair to question the legality of the directive and to identify, as a central theme, an infringement of the European Fundamental Rights developed by the European Court of Justice – in particular the freedom to choose and pursue an occupation[8], the right to property[9] and the principle of equality[10] [11]. However, this question and a legal defence against the

---

[6] CoJEC ECR 1980, 1115, 1121.
[7] CoJEC ECR 1984, 1891, 1891 (Guiding principle 1).
[8] See, for example, CoJEC ECR 1974, 491 seq. – Nold.
[9] The basis for this is CoJEC ECR 1979, 3727 seq. – Hauer.
[10] See e.g. CoJEC, ECR 1983, 371 seq. – Wagner.

directive shall not be considered in any more detail here. Instead, consideration should be given to the simplest possible way in which an appropriate amendment to the Electrical Substance Directive can be brought about.

2. Easing of the substance ban

In this respect, the focus should be directed at Art. 5 of the Electrical Substance Directive. This article relates to the amendments needed to adapt the annex of the Electrical Substance Directive to scientific and technical progress. The annex sets out the exceptions to the substance ban according to Art. 4 (1) of the Electrical Substance Directive. An exemption for PBDE substances that do not pose a threat to human health or the environment could therefore be included in this. Art. 5 of the Electrical Substance Directive would, in this respect, allow a modification to be made to the annex without requiring an amendment to the Directive in a (lengthy) law-drafting procedure according to Art. 251 EC (so-called Co-decision procedure). Rather, the amendment could be carried out by the Commission within the framework of a so-called Comitology Procedure, as Art. 5 (1) in conjunction with Art. 7 (2) of the Electrical Substance Directive refers to "Articles 5 and 7 of Decision 1999/468/EC, having regard to Article 8 thereof"[12]. Decision 1999/468/EC recognises various types of procedures, and the regulatory procedure is laid down in Art. 5 of the decision. According to the 7th "whereas clause" of the decision, the regulatory procedure is intended for adapting or updating certain, non-essential provisions of a basic instrument (in this case, therefore, the Electrical Substance Directive). Art. 5 of the Decision describes the precise sequence of events involved in the regulatory procedure. At this point, however, only the following steps of the procedure are mentioned: (1) The Commission representative must submit a draft (in this case therefore amendment to the annex of the Electrical Substance Directive) to the regulatory committee, which is comprised of representatives of the Member States. (2) The Regulatory Committee issues a position statement and votes on the draft.

---

[11] A consolidation of the protection of fundamental rights in the European Union will ensue when the European Union Charter of Fundamental Rights (OJ EC No. 364 of 18.12.2000, p.1 seq.) becomes binding. This Charter also sees the aforementioned fundamental rights as protected: in Art. 15 and 16, freedom to choose and pursue an occupation and freedom to conduct a business, in Art. 17 the right to property and in Art. 20 seq. the equality rights.

[12] Council Decision on laying down the procedures for exercising the implementing powers conferred on the Commission (OJ EC 1999 L 184, p.23 seq.).

(3) If consensus is reached with the regulatory committee, the Commission issues the relevant measures (in this case therefore the amendment of the annex). This already makes it clear that, although proceeding according to Art. 5 of the Electrical Substance Directive is a practicable way of approaching the problem in question, that route is quite laborious in terms of procedure.

III. The provisions of the Waste Electrical Equipment Directive

1. Selective treatment according to Art. 6 (1) first subpara. 3rd sentence in conjunction with Annex II Waste Electrical Equipment Directive and Art. 4 Waste Framework Directive

As already mentioned in passing, the Waste Electrical Equipment Directive specifies a certain method of proceeding with the waste management of waste electrical and electronic equipment. Following the separate collection of the electronic scrap (Art. 5), it must then be treated in accordance with Art. 6 and then recovered according to the provisions of Art. 7. Plastics that contain brominated flame retardants are explicitly mentioned by the Waste Electrical Equipment Directive in the "Treatment" step of the procedure. Under Art. 6 (1) first subpara. 3rd sentence, "a selective treatment in accordance with Annex II to this directive" must take place[13]. In Annex II (Selective treatment for materials and components of waste electrical and electronic equipment in accordance with Article 6 (1)), "plastics containing brominated flame retardants" are then included under Section 1, Clause 1, 6th upstroke. For such plastics, Section 1 contains the following provision: They must first be removed from the waste equipment, then recovered or disposed of in accordance with Art. 4 of Directive 75/442/EWG. Directive 75/442/EEC is the EC Waste Framework Directive. The contents of its Art. 4 are as follows:

> "Member States shall take the necessary measures to ensure that waste is recovered or disposed of without endangering human health and without using processes or methods which could harm the environment, and in particular:
>
> - without risk to water, air, soil and plants and animals,
> - without causing a nuisance through noise or odours,
> - without adversely affecting the countryside or places of special interest.
>
> Member States shall also take the necessary measures to prohibit the abandonment, dumping or uncontrolled disposal of waste."

The contents of Art. 4 Waste Framework Directive should be seen as laying down a general principle of waste management that is environmentally-friendly and protects health and as establishing this principle as a central guideline of Community waste law.[14] The practical meaning of Art. 4 Waste Framework Directive is, admittedly, relatively sketchy as no behavioural obligations for the Member States that can really

---

[13] The contents of Art. 6 (1) first subpara. 3rd sentence Waste Electrical Equipment Directive are: "To ensure compliance with Article 4 of Directive 75/442/EEC, the treatment shall, as a minimum, include the removal of all fluids and a selective treatment in accordance with Annex II to this Directive".

[14] See Epiney in: Fluck, KrW-/Abf-/BodSchR (Stand: Nov. 2003), Kommentar zu RL 75/442/EWG Rdnr. 30.

be understood as a legal requirement can be inferred from the provision[15]. Accordingly, the European Court of Justice works on the assumption that Art. 4 Waste Framework Directive is, in principle, of an exemplary nature only and it can therefore be assumed, "that the provision at issue must be regarded as defining the framework for the action to be taken by the Member States regarding the treatment of waste and not as requiring, in itself, the adoption of specific measures or a particular method of waste disposal"[16]. If need be, in exceptional cases, the CoJEC is inclined to bring into play Art. 4 Waste Framework Directive as a litigable norm[17].

Against this background, the reference in Section 1 of Annex II of the Waste Electrical Equipment Directive to Art. 4 Waste Framework directive is only partially significant. The aim is probably to put Art. 4 Waste Framework Directive, which is treated vaguely, into concrete terms. The choice of words in Art. 6 (1) first subpara. p.3, "To ensure compliance with Article 4 of Directive 75/442/EWG…" also appears to indicate this. At the same time, it can be inferred from Art. 6 (1) first subpara. 3rd sentence in conjunction with Annex II Section 1 in conjunction with Art. 4 Waste Framework Directive that the selective treatment according to Annex II should prevent a risk to human health and environmental damage. However, no further and in particular no more concrete waste management requirements can be gathered from reference to Art. 4 Waste Framework Directive in Art. 6 (1) first subpara. 3rd sentence and in Annex II Section I.

The question then arises as to which provisions indicate detailed recovery and/or disposal requirements for the removed plastics containing brominated flame retardants. In the Waste Electrical Equipment Directive, explicit specifications regarding the recovery are to be found in Art. 7. And, in particular, Art. 7 (2) Waste Electrical Equipment Directive contains certain recovery quotas for the Waste Electrical and Electronic Equipment listed in Annex 1A. In addition, Art. 6 (1) first subpara. 1st sentence of the Waste Electrical Equipment Directive specifies that the best available treatment, recovery and recycling techniques must be used for the treatment. For the concept of recovery, in accordance with Art. 3 letter f) Waste Electrical Equipment Directive, "applicable operations according to Annex IIB of Directive 75/442/EEC" apply. Whereby, basically, a distinction can be made between material recovery (recycling) and energy recovery – and this is also expressed in the differentiating system of recovery levels set out in Art. 7 (2) and in the definitions of Art. 3 Waste Electrical Equipment Directive. With respect to recycling, a distinction can also be made between a mechanical recovery of materials and of raw materials as feedstock recycling[18]. And the fact that the Waste Electrical Equipment Directive treats both forms of material recovery the same should be taken into consideration.

---

[15] This is the translation of Epiney in: Fluck, KrW-/Abf-/BodSchR (Stand: Nov. 2003), Kommentar zu RL 75/442/EWG Rdnr. 32.

[16] CoJEC ECR 1994, I-483 Discourse no. 12-14. See also CoJEC ECR 1999, I-7773 Discourse no. 67: "Whilst that provision does not specify the actual content of the measures which must be taken in order to ensure that waste is disposed of without endangering human health and without harming the environment, it is nonetheless true that it is binding on the Member States as to the objective to be achieved, whilst leaving to the Member States a margin of discretion in assessing the need for such measures."

[17] See on this the case in CoJEC ECR 1999, I-7773.

[18] Mechanical recovery (mechanical recycling) is the mechanical process of turning used plastics into materials for grinding and recycled products that can be directly processed again. Feedstock recovery is the splitting of polymer materials into smaller fractions by means of heat or chemical reaction.

It follows from the above that, overall, the Waste Electrical Equipment Directive governs the area of recovery in a very restrained way. And that, especially with respect to the recovery of plastics containing brominated flame retardants, no specific recovery or disposal procedure is specified. In this respect, when transposing the directive, the Member States have to take into account only the following: a recovery procedure within the meaning of Annex IIB Waste Framework Directive (and/or a disposal procedure within the meaning of Annex IIA Waste Framework Directive) must be chosen, which ensures that, when plastics with flame retardants containing bromine are disposed of, environmental and health risks are ruled out and the recovery rates of Art. 7 (2) Waste Electrical Equipment Directive are achieved by the deadline of 31 December 2006.

2. Recovery methods for electronic scrap and the plastics contained therein

Consideration should now be given to which technical procedures are available for recovering waste electrical and electronic equipment, including the plastics they contain. At present, certain categories of waste equipment (such as "white goods" for example) are put into a shredder, irrespective of whether or not they contain plastics with brominated flame retardants. This circumstance is not an obstacle to recovering the raw material. Even when they contain the "hazardous" substances PBB or PBDE, it is possible, with the latest technology, to recover the raw materials harmlessly. This is particularly true of the process used for syngas production, by which chemical raw materials (such as methanol) can be produced from plastic waste products. Equally, energy recovery from electronic scrap in a waste incineration plant also constitutes an acceptable method in public welfare terms, and a constituent of plastics containing brominated flame retardants is not an obstacle to this. A mechanical recovery of the material, on the other hand, is ruled out.

From a technical point of view, it can therefore be emphasised that it is possible to recover, harmlessly, plastics containing brominated flame retardants together with the old appliance. This applies to both feedstock recycling and energy recovery. Recovering materials, on the other hand, is not possible in principle with a PBDE constituent[19]. In practice, a problem then arises, i.e. that – precisely with imported goods – it is usually impossible to discern which flame retardants have been used in the plastic parts of a piece of electrical or electronic equipment[20]. Then, to avoid risks to health and environment, both feedstock and/or energy can be recovered or disposed of by thermal means.

3. Necessity of a selective treatment in the case of plastics containing brominated flame retardants?

It follows from the above that, for waste electrical and electronic equipment, including their plastics containing brominated flame retardants, feedstock recycling or energy recovery processes can be used without posing risks to the environment or health because of brominated flame retardants. Therefore, as far as the Waste

[19] See Commission of the Lower Saxony Government on "Vermeidung und Verwertung von Abfällen", final report of Working Group 13 "Elektronikschrott" (1998), 6-8, 6-12 (Recommendation 1.3).
[20] See Commission of the Lower Saxony Government on "Vermeidung und Verwertung von Abfällen", final report of Working group 13 "Elektronikschrott" (1998), 6-9.

Electrical Equipment Directive is concerned, there are no objections to feedstock or energy recovery of waste equipment together with their plastics containing flame retardants. If the Waste Electrical Equipment Directive thus allows an appropriate recovery together, this raises the following question: is it necessary, in this case, to remove the substances listed in Annex II beforehand? I.e. can a situation arise in which plastics containing brominated flame retardants are first removed from the waste equipment and then recovered together with that equipment?

If one looks solely at the wording of the Waste Electrical Equipment Directive, then the answer has to be yes. Because Clause 1 of Section 1 (Annex II) contains a compelling obligation to dismantle ("must …be removed") and does not recognise any exception. According to the ultimate aim of the Waste Electrical Equipment Directive, on the other hand, the answer has to be no. Because the (perfectly legitimate) purpose of the selective treatment according to Annex II should be seen as being to ensure that substances that are more hazardous "than usual" should be separated and assigned to a separate waste management route[21]. If, however, the recovery process can be designed so that a substance that falls within Annex II can be disposed of harmlessly together with the rest of the equipment components as part of the "normal" recovery operation, and this fact can be demonstrated, removing the relevant substances is superfluous. The real aims of the Waste Electrical Equipment Directive – the preamble talks about ensuring protection of health and high levels of environmental protection – are not furthered by requiring the prior removal of substances.

Rather, this would cause financially pointless additional work. And this is also significant from a legal point of view. Not only in national law, but also in European Community law, the principle of proportionality of the means[22] applies, according to which the burden effect of a regulation must be restricted to a necessary and reasonable extent[23]. Cost-intensive measures – as is the case with dismantling equipment – are, however, disproportionate when they do not help to increase the level of protection for health and the environment. In view of the last-named aspect, even the proportionality is questionable. It is always true that proportionality can only be assumed if the desired aim can at least be furthered by the measure. Moreover, the proportionality of the removal obligation of Annex II Section 1 Clause 1, 6th upstroke can also be called into question, in so far as, in many cases, it is not visible in the plastic parts of a piece of electrical or electronic equipment whether brominated flame retardants have been used at all and – if so - which. If, however, the parts to be removed cannot even be identified or can be only partly identified, a removal obligation according to Annex II based on this must inevitably also "become void".

It is valid to emphasise, therefore, that the selective treatment according to Annex II cannot be considered in isolation but must always also be seen in connection with the subsequent waste management route. A dismantling to be carried out as part of the selective treatment makes no sense from an environmental point of view, however, if,

---

[21] Which, for instance, in the case of condensers containing PCBs appears unavoidable, and these are therefore listed in Annex II, Section 1, Clause 1, 1st upstroke.
[22] On the meaning of the proportionality principle in European Community law, see, for example, Calliess, in Calliess/Ruffert, EUReg/ECReg, 2nd ed. (2002), Art. ECReg Discourse no. 46.
[23] In addition, the Fundamental Right points already mentioned above can also be brought into play here.

subsequently, the separated substances can be recovered together with the rest of the equipment without causing greater risks to health or the environment because of that. At the same time, dismantling makes no financial sense and the burden cannot therefore be justified in the face of the principle of proportionality.

4. Proposed solutions

The question is now how this point of view, which corresponds to the ultimate aim of the Waste Electrical Equipment Directive, can be brought in line with the provisions of the Directive. A teleological reduction of Annex II presents itself first and foremost here. The interpretive principle of teleological reduction comprises that a rule contained in the law, but which is too broadly interpreted according to the meaning of the words, is reduced to the appropriate area of application according to the purpose of the regulation or contextual spirit of the law[24]. With the result that, contrary to the wording, cases not understood according to the purpose of the law are exempted from the provision[25]. Building on this general principle, Annex II could be interpreted restrictively so that the body of legislation may not be applied to materials and components of waste electrical and electronic equipment, for which a harmless and environmentally-friendly treatment and recovery together with the other equipment parts and materials is possible.

With reference to material recovery Annex II, Section 3 adds:
"Taking into account environmental considerations and the desirability of reuse and recycling, paragraphs 1 and 2 shall be applied in such a way that environmentally sound reuse and recycling of components or whole appliances is not hindered."
With this, Section 3 offers a correction in order to avoid recycling or reuse solutions which are environmentally meaningless and which could arise from a strict application of Sections 1 and 2. Sections 1 and 2 should not therefore be understood as a rigid body of legislation but as a system which is open to pragmatic and, at the same time, from an environmental point of view, convincing solutions. As already demonstrated, via the feedstock recovery route, environmentally-friendly methods of recovering whole waste electrical and electronic equipment are possible without requiring plastics containing brominated flame retardants to be removed beforehand. Removing these parts would then constitute an obstacle to the recycling process, however, so that proceeding according to Annex II Section 3 appears to be a possible practicable solution.

D. Conclusion

The two EC Directives on the waste management problem of electrical and electronic equipment – the Waste Electrical Equipment Directive and the Electrical Substance Directive – which have to be transposed by the Federal Republic of Germany by 13 August 2004, both consider the brominated flame retardants group of substances. According to the Electrical Substance Directive, new electrical and electronic equipment brought onto the market as from 1 July 2006 may not contain any PBBs or PBDEs. However, the substance ban of the Electrical Substance Directive does not appear justified when there is evidence to show that there is no danger to the

[24] Larenz, Methodenlehre der Rechtswissenschaft, 5th Ed. (1983), p.375.
[25] Wank, Die Auslegung von Gesetzen, 2nd ed. (2002) p.104.

environment or human health from a specific flame retardant – such as deca-BDE (bromodiphenyl ether) for example. In this respect – taking into account the European Fundamental Rights – the legality of the Electrical Substance Directive appears questionable. A solution to the problem would be most easily achieved by adapting the Annex to the Electrical Substance Directive accordingly via the committee procedure.

In Art. 6 (1) first subpara. 3rd sentence in conjunction with Annex II Waste Electrical Equipment Directive, the Waste Electrical Equipment Directive contains provisions for the waste management treatment of plastics containing brominated flame retardants. The relevant plastics must be treated selectively in order to avoid risks to human health and the environment. A selective treatment is not imperative, however, if a common waste managent (material or energy recovery) together with the waste equipment can occur. The prior removal of the plastic parts that contain brominated flame retardants is then superfluous, since a removal does not lead to any improvement in the level of health and environmental protection. Nor, therefore, does it further the aims of the Waste Electrical Equipment Directive. At the same time, dismantling is economically pointless and, therefore, in the face of the principle of proportionality, the burden cannot be justified. This conflict can be resolved by a teleological reduction of Annex II Waste Electrical Equipment Directive and/or by an additional application of Section 3 of Annex II Waste Electrical Equipment Directive.

Mannheim, 23 March 2004 University Lecturer Dr Kristian Fischer

EUROPEAN LAMP COMPANIES FEDERATION

CELMA

C.E.L.M.A. Federation of National Manufacturers Associations for Luminaires and Electrotechnical Components for Luminaires in the European Union

An ELC[1]/CELMA[2] Position Paper on Use of lead in luminaire glass and lamps.

A request for additional exemptions in the Annex to the RoHS Directive 2002/95/EC

1. CELMA – Requirement for exclusion of glass containing lead (which is used as 'safety glass' to cover Luminaires) from the scope of the RoHS Directive.

The use of lead in glass should generally be regarded differently to lead that forms part of other materials. Glass does not weather and corrode. Therefore the lead is durably sealed in the glass and does not harm human beings or the environment. To be able to access lead contained in glass; the glass must be melted at temperatures of approx. 1.500 °C.

When glass is used as a cover for luminaires, it must be produced according the European standards guiding luminaires - EN 60598-1, sub clause 4.13 (mechanical strength) and EN 60598-2-5. Glass in this application must fulfill several functions including the protection of human life in the form of:

- Avoidance of the risk of injury in the case of breakage
- Avoidance of the risk of injury from exposure to heated parts within the luminaire.

In addition to these factors, the glass in this application must guarantee the *even distribution of light.*

The composition of silicate glass used for this application contains max. 2% lead by weight. This is necessary to ensure that the physical properties (*impact resistance, rigidity*) during the treatment of the finished glass can be safeguarded. Lead oxide cannot be replaced by another material composition. The substitution of lead and other components in this complex system require intensive research and development, which cannot be realized within a five-year period. Furthermore the existing safety standards for luminaires must be regarded. It is the CELMA position that lead-containing glass with ≤ 2% lead by weight should therefore be excluded from the scope of the RoHS Directive.

---

[1] ELC Federation - Created in 1985, the European Lamp Companies Federation (ELC) is both the forum and the voice of the lamp industry in Europe. We represent the leading European lamp manufacturers, which collectively directly employ 50,000 people, and account for 95 percent of total European production, with an annual turnover in Europe of €5 billion. From the outset, our objectives have been to promote efficient lighting practice for a sustainable environment and the advancement of human comfort, health and safety. To this end, we monitor, advise and co-operate with legislative bodies in developing European Directives and Regulations relevant to the European lamp industry.

[2] CELMA is a Federation established for an unlimited period, representing 20 National Manufacturers Associations for Luminaires and Electrotechnical Components for Luminaires. CELMA Associations are representing some 1200 companies in the Luminaires and Electrotechnical Components for Luminaires industries in 12 European countries. These producers, which include many small and medium-sized companies, directly employ some 100.000 people and generate 8 billion Euro annually. CELMA acts as a Body of contact, co-ordination, representation and assistance for the European and National Associations, Federations and Organisations in the EU manufacturing of luminaires and electrotechnical components for the Luminaires Industry.

• Diamant Building • 6th Floor • Bde A. Reyers 80 • B-1030 Brussels • Belgium •
• T. +32 2 706 86 08 • F. +32 2 706 86 09 • info@elcfed.org • www.elcfed.org •

2. ELC Federation - Requirement for the necessary use of lead in lamps in certain specific applications.

A few essential applications of lead in lamps are not yet covered by the exemptions listed in the ANNEX of the RoHS directive, for example, the compounds and alloys present in some specific lamps listed below.

These lamps and lamp components contain only very minor quantities of lead, typically 50 mg or less, which is essential for the lamps proper operation. Alternatively, the presence of lead in materials, e.g. alloys, might also be due to impurity levels typical to their production methods.

Please find below therefore, a list of lamps, which necessitate the presence of minor amounts of lead that are as yet not covered by the exemptions listed in the ANNEX of the RoHS directive.

- High Intensity Discharge (HID) lamps for professional U.V. applications, containing lead halide as radiant agent.
    - Lead is essential for creating the proper lamp emission spectrum and lamp efficacy.

- Discharge lamps for special purposes containing lead as activator in the fluorescent powder (1% lead by weight or less).
    - Lead is essential for creating the proper lamp emission spectrum and lamp efficacy.

- Discharge lamps for special purposes containing lead in the glass envelope.
    - This type of glass is required for transmission of appropriate radiation.

- Discharge lamps containing lead in the form of an amalgam.
    - Amalgam in some lamps is necessary to create smaller lamps used as substitute of the less energy efficient incandescent lamps, mainly in high power applications.

- Mercury free flat-panel discharge lamps require the use of lead solder and lead oxide containing glass solder.
    - Solder with a concentration of 70% lead is necessary to create a safe electrical contact on the plane glass surface. Lead oxide containing glass solder is necessary to seal the flat-panel glass envelope. Lead free glass solder is not able to guaranty a safe assembly for more than 100.000 hours lifetime.

It is the ELC & CELMA position that these applications (*since there are no alternatives*) should be added to the list of accepted exemptions.

Electronic Components and Systems
Division

Zentralverband
Elektrotechnik- und
Elektronikindustrie e.V.

MEZ/ERB
24.06.2004

Joint application of members of the ZVEI Association to the EU Commission regarding the addition of an exemption for cadmium contacts to the appendix of the EU Directive 2002/95/EC (RoHS)

Despite intensive efforts to fully meet the requirements of RoHS and following intensive, internal examinations our member companies have ascertained, that they are unable to do without cadmium in the switch contacts in every case for safety reasons, especially regarding compliance with the international safety standards EN 61058 and UL 1054.

The majority of the concerned switches is used in the whole range of appliances affected by 'RoHS/WEEE'. The range of performance of the AC voltage (up to 400 V) fulfils a qualitatively unique feature for silver-cadmium-oxide contacts (AgCdO) at rated currents from 8 A and brief current peaks up to the range around 180 A.

This means ultimately, that contacts made of AgCdO offer an ideal working environment for the mentioned area of application of the AC voltage regarding the permissible heating in use and the low tendency to "weld". This result cannot generally be achieved by an alternative material composition such as silver-nickel (AgNi) or silver-stannic-oxide (AgSnO2).

The tendency to "weld" describes the safety risk, which implicates, that the switch contacts are subjected to very high thermal stressing during closing and at high currents. Thereby these switch contacts are bonding irresolvable, so that opening of the switch is prevented. This should be avoided at all cost when using switches with safety functions to protect the user.

Heating during use means in accordance with EN 61058 that, at rated current and at a specified number of switching cycles, the maximum permissible heating may not exceed 55°K. Since our switches are sold worldwide and are installed in appliances in world-wide use, additional approvals by the Underwriters Laboratories Inc. (UL1054) are essential. In this case, the maximum permissible heating is 30°K only.

Unlike applications with narrowly defined operating conditions (e.g. contactors), the functioning of the appliance switches and snap action switches must be guaranteed for general use in miniature sizes. Smaller switch sizes lead to smaller contact forces and reduced contact weights. According to the latest state-of-the-art, it is in many cases impossible to do without AgCdO in contacts due to its tolerant behaviour in order to satisfy the functional safety requirements specified in EN 61058 and UL 1054. This problem is aggravated additionally by a very wide range of applications of inductive, resistive and capacitive loads which occur in the different electrical and electronic appliances concerned.

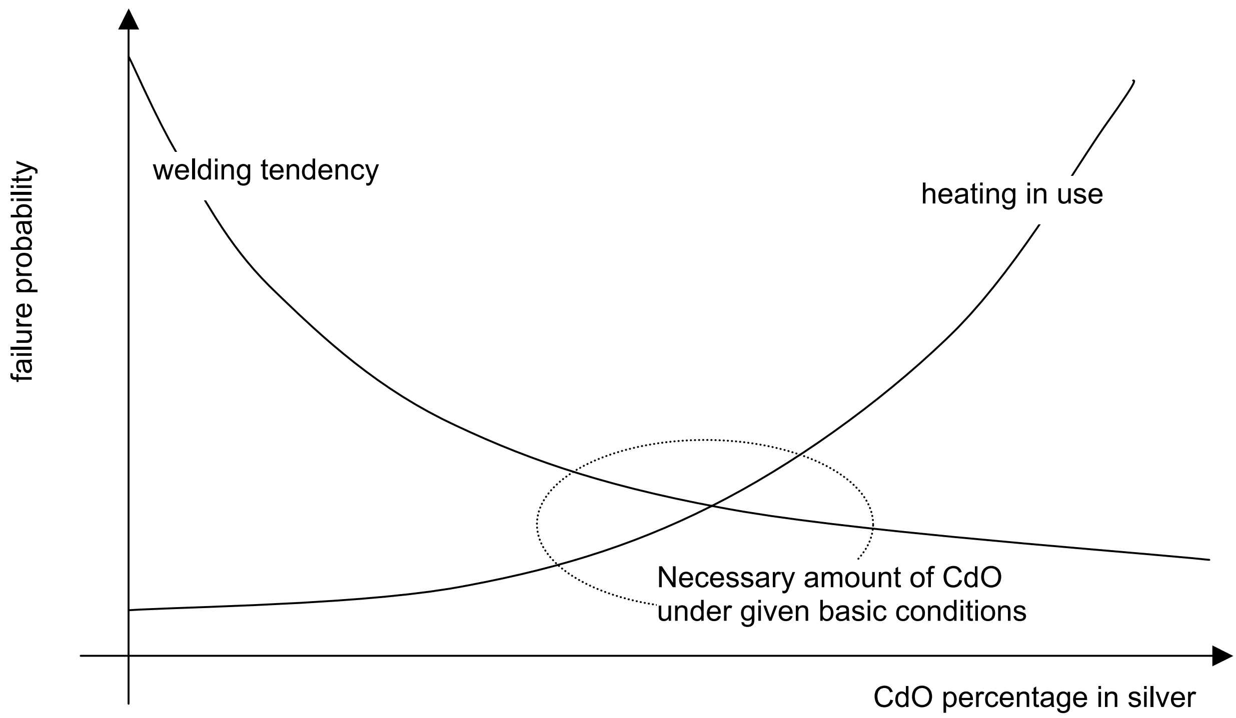
With a general prohibition of cadmium even in switching contacts the failure probability will increase and therewith the risk for the end consumer of switch applications (see figure 1). In addition to that, the manufacturers are facing challenges to even further miniaturise their products in the relevant application field. Therefore the total weight of the switches generally needs to be less than 10 grams. The weights used per contact are less than 0.3 g and the cadmium-oxide percentage is typically 10 % and at maximum 20 %.

For the reasons mentioned above, we therefore apply for general exemption from the requirements of article 4 paragraph 1 of the EU directive 2002/95/EC regarding cadmium used in switch products having switching contacts with less than 0.3 g contact weights per contact.

Basic technical conditions:

Voltage range:	AC (up to 400 V)
Rated currents:	≥ 8 A
Peak currents:	≤180 A
Implemented weights/contact:	< 0.3 g
Cadmium-oxide percentage/contact:	typical 10 %

Fig.1:

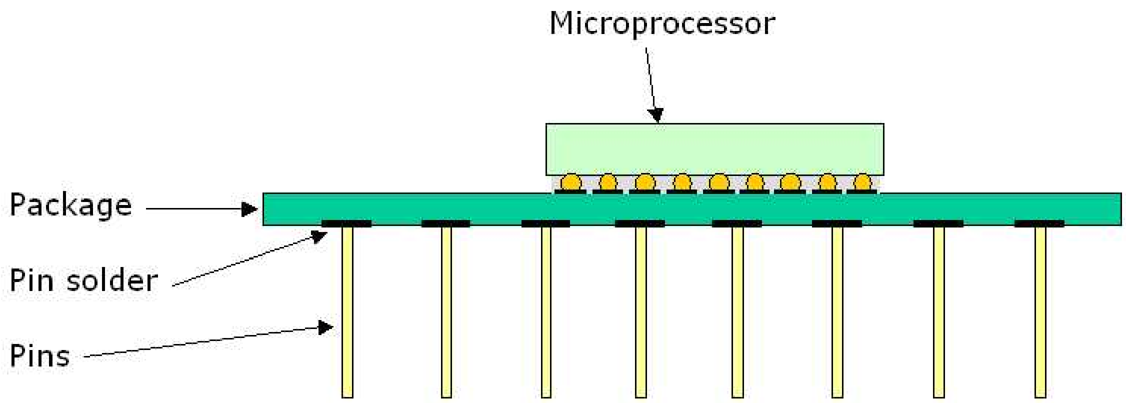


Symbolic representation of the failure probability depending on the percentage of cadmium-oxide in contacts of switches

Guide to proposals for exemptions to substance bans by the RoHS –
*New Request "**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 85% in proportion to the tin-lead content (exemption until 2010).**"*

Outline of the problem and substantiation of the necessity for the exemption
Simple, concise, technical explanation of the problem
List of examples (equipment, categories…)

The exemption relates to connection technology for the production of technologically advanced microprocessors in "organic" packages (consisting of epoxy resins as opposed to ceramic materials). These microprocessors are used in notebooks and desktop PCs.
Pins are attached to the organic package of the microprocessor (the latest generation of microprocessor requires over 900 pins) with solder that contains lead (high lead content and a high melting point). These pins make the electrical connection between the organic packages of the microprocessor and the socket, which is on the motherboard of a PC (see diagram).
According to today's knowledge the connection between pins and organic package of the microprocessor cannot occur with a reliable lead-free solder. The exemptions of the ROHS Annex (lead in high melting temperature solder, lead in solders for servers, storage systems, etc.) does not exempt the application of the interconnection technology described here.



Very high reliability requirements apply to the connection between the organic package of the microprocessor and the pins, as the connections also have a long life after the test cycles have been run through, for which every microprocessor is inserted in various test sockets several times.
There is no reliable lead-free connection technology, which fulfils the necessary reliability requirements. In tests, the known lead-free connection alternatives show an unacceptably higher probability of failure per pin. For technologically advanced microprocessors, which have a lot of pins, the large number of connections between the pin and organic packages requires high reliability per individual connection. The lead-free alternatives tested show a statistical certainty of severed connections between the pin and the package under normal circumstances.

A theoretically possible solution would be to raise the lead content of the solder to over 85%, to be exempted under the currently existing exemption. The solder in question would, however, lose some of its special properties.

Formulation of the proposed exemption to the RoHS Directive
Formulation in line with the appendix to the RoHS Directive
"**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 85% in proportion to the tin-lead content (exemption until 2010).**"

Explanation of the delay in information after the adoption of the RoHS Directive

"Zero" (i.e. not intentionally added, <0.1%) lead content is strived for for all products and applications, the greater part of which has been achieved. In 2002, tests were carried out to identify a reliable lead-free alternative for pin connection technology now in production and the subject of this proposed exemption.

The connection technology for which the proposed exemption is being requested is very new and developed especially for reliability.

Range of producers

The exemption requested does not play a role for other components than microprocessors. With regard to the number of items, microprocessors form a small share (~ < 1%) of the semiconductor elements sold worldwide.

Significance of the subject for the sector

The proposed exemption relates to technologically advanced microprocessors. The number of pins on a microprocessor package is directly linked to the technology generation of a microprocessor and thus also to the functionalities available.

The necessity of reliable connection technology for the connection between the pins and an organic package will thus increase for future generations of microprocessors and thus is directly relevant to technological innovations in the field of microprocessors.

Relevance for the environment

Material balance accounting: How much heavy metal is used for the application in question?

0.26 g lead per microprocessor – that also means 0.26 g lead per PC.

Which amounts can be expected within the scope of the RoHS Directive? (rough estimate)

Every year, less than 3000 kg lead is expected in the EU (and in Eastern Europe), based on market data from 2002.

Are there any other impacts relevant for the environment?

Modern microprocessors make more efficient use of resources possible – because systems on the basis of these processors make both server and PC applications possible – it is no longer necessary to buy two PCs instead of one for the same purpose.

Tests of lead-free alternatives are being carried out at the moment to include all the consequences of the economic life. The exemption requested here does not have any additional impact on the environment, as it concerns a small amount of lead per machine and the microprocessors (which already contain lead in solder with a high melting point inside the microprocessor package) are built into large machines, which are offered for recycling.

Tin – antimony solder, which is used in other applications, have an impact on the environment, due to contamination, which cannot be caught in the recycling process.

Measures taken until now by the industry to prepare for the conversion of the substance ban of the RoHS Directive

For the connection technology, for which the exemption is being requested, reliability tests have been carried out with approximately 15 materials, with the result, that none of the alternatives tested are suitable.

Lead-free alternatives exist for the majority of the other applications and products or they are in the development and qualification of production.

Time frame

Which measures are planned with which deadlines, to substitute the substances in question in the future?

During the next 10 years, the connection technology of microprocessors will change into "socket-free" technology (that is to say a microprocessor will not need any pins any more for attachment to the

socket). This “socket-free” technology is currently in a very early phase and technically not yet sufficiently ripe to be applied. The time frame for the exemption requested will accordingly be set to 2010.

As explained above, the development of lead-free solutions will continue at high speed.

Request for clarification or an additional exemption

MEZ/ERB
24.06.2004

Lead in high melting temperature type solders (i.e. tin-lead solder alloys containing more than 85% lead) and any lower melting temperature solder required to be used with high melting temperature solder to complete a viable electrical connection

When attaching a semiconductor chip onto a substrate (package), two separate solders with different physical properties are necessary. A high temperature melting point solder is required for the chip. However, the same solder type cannot be used for the substrate because the substrate cannot withstand the high temperature. In other words, in order to guarantee full electrical connectivity, the lead solder attaching the chip to the substrate has to include a high temperature component and a lower temperature component. The existing RoHS exemption for high temperature melting type solder exempts the higher temperature part but not the lower temperature part. ZVEI is requesting the extension of the existing exemption to include the lower melting temperature solder that is necessary to create the interconnection.

Thus, ZVEI proposes to clarify the wording concerning the exemption for lead in high melting temperature type solders as follows:

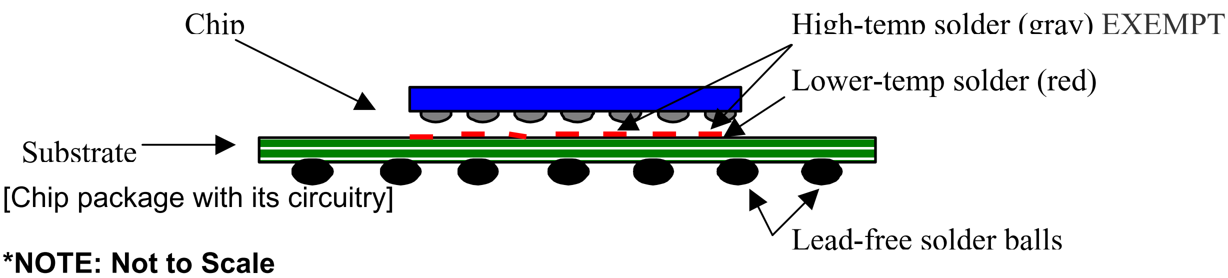
"Lead in high melting temperature type solders (i.e. tin-lead solder alloys containing more than 85% lead) ***and any lower melting temperature solder required to be used with high melting temperature solder to complete a viable electrical connection"***

The chip (silicon circuitry forming the "brain" of the semiconductor device) with the high melting point lead solder bumps must then be attached to a substrate (semiconductor package) before it can be used as a semiconductor device. The substrate, however, cannot withstand elevated temperatures. Therefore, the chip with high melting point lead solder bumps is attached to the substrate circuitry by using a very small amount of lower temperature tin-lead solder alloy. The resulting solder joint is a mixture of the high and lower melting point -lead solders, consisting of approximately 65-80% lead.

One common application of using high melting temperature solders is found in the internal solder joints of certain components. During the component manufacturing process, lead solder bumps (>85% lead) are connected to the circuitry of the chip. The chip is the silicon circuitry that makes up the "brain" of the semiconductor. The high melting point tin-lead alloy has high electrical conductivity and has unique mechanical properties that make the material malleable and better able to withstand both temperature and physical stress. Such properties ensure fewer defects during manufacturing and high reliability throughout the life of the component.

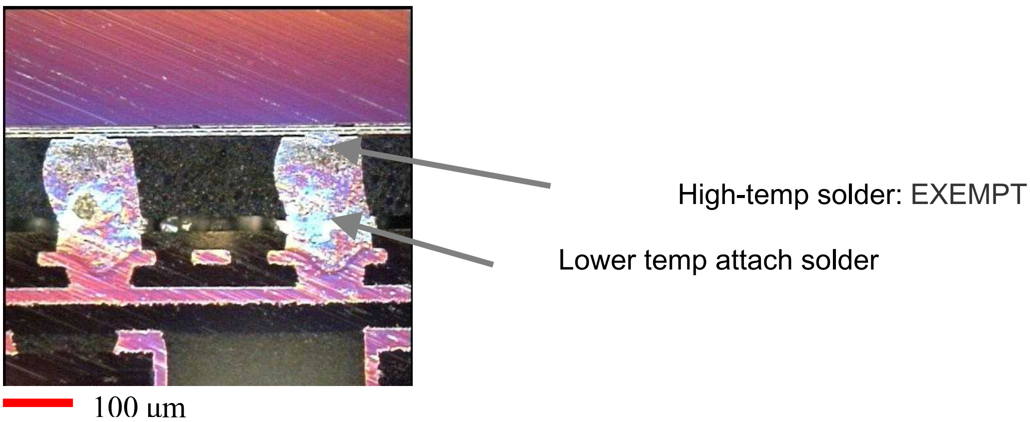
A graphic description of the chip, substrate (package) and resulting solder joint is shown below.

Figure 1 – Diagram of a Component Using High and Low Temperature Solders for an Internal Solder Joint*



***NOTE: Not to Scale**

Figure 2 – SEM Image of Internal Solder Joint (high and lower temperature solders)



As the diagrams above illustrate, the solder joint in the applications at issue is composed of a small amount of high melting point solder (< 0.1 mg) with an even smaller amount of lower melting point solder (< 0.03 mg). Lead-free solutions are currently not available to attach the chip with high temperature solder bumps to the package substrate. This is due to the technical properties of the lead-free solders, which are stiff and cause stress on the chip circuitry. These stresses cause failures to the circuitry of the chip, creating a non-functioning semiconductor. Research continues in this area, but for the foreseeable future lead-free solutions are not available and may never be available.

New Exemption Request:

Lead-bearing solder to complete a viable electrical connection internal to certain integrated circuit packages (Flip Chips) (exemption until 2010).

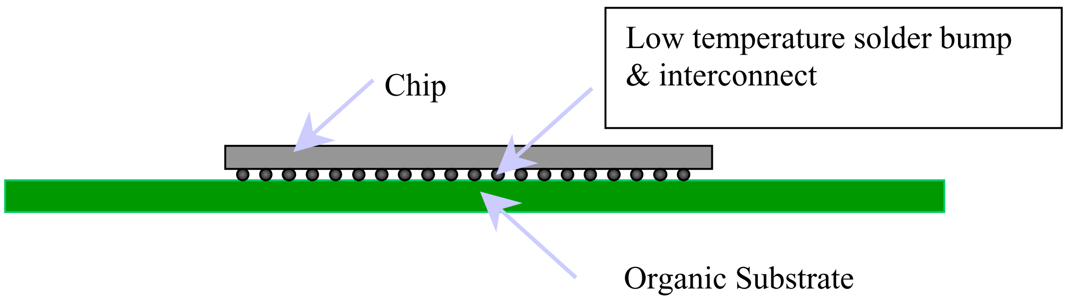
Outline of the problem and substantiation of the necessity for the exemption:

Certain integrated circuit (IC) packages are currently manufactured with low temperature solder for the internal electrical connection. These IC packages are commonly referred to as "flip chip". Organic substrates require low melting temperature solder to connect the chip to the substrate. Low temperature (eutectic, lead content less than 40%) solder has been used for many years and provides a product which is suitable for many mainstream electronics applications. The amount of lead in the solder joint is less than a half compared to the high temperature lead solders which are currently exempted from the requirements of Article (4) of the RoHS directive. This exemption was granted because there are no known lead-free technical alternatives to its use in high performance/high reliability packages.

This new exemption request is for a even narrower application – lead-bearing solder required to complete a viable electrical connection internal to the integrated circuit package.

Today flip packages are used ubiquitously in computing applications, in hard disc drives, handsets and portable electronic devices (e.g. cameras, radios, personnel digital assistants (PDA's), in cars (ABS systems and engine control unit (ECU) microcontrollers.

Figure 1 Diagram of a Flip Chip Package with Internal Connection Technology



In flip chip packages, tiny amounts of tin lead solder are used to connect the chip to the substrate. These bumps (internal to the package) for state of the art flip chips are about the same size as the diameter of a human hair and may contain less than 0.002 mg lead per bump. Replacing the tin-lead solder balls (outside the package) with lead-free solder balls eliminates more than 97-99% of the lead from the finished package.

The connection between the chip and the substrate forms the heart of the integrated circuit package. After the flip chip connection is formed, the gap between the die and the substrate is filled for mechanical and environmental protection. At this point, the die can be encased in a plastic mold compound or covered with a lid, or the package can be installed directly into an electronic assembly with no further processing.

Explanation of the delay in information after the adoption of the RoHS Directive:

The industry began in the nineties to consider alternatives to tin lead solders and today entire product lines are available lead-free.

In the case of flip chips lead - free test units using several different alloys passed reliability testing at lab level but just recently field experience with these circuits has identified reliability issues not apparent during the development phase.

Flip chip interconnect is advantageous to wire bond packages because its efficient use of real estate, because the entire chip area can be used for I/O interconnection. In contrast traditional wire bond chips are limited to interconnection only at the edges. Result is smaller, lighter and faster products with improved electrical performance.

Range of producers:

Manufacturer spectrum for flip chips, divided by regions:

Region	*Market share flip chip*
Germany	<3.3%
EU	6.9%
Non-EU	>89.9%

All numbers based on list of top 30 worldwide semiconductor companies.

Market segment of flip chips in relation to other chips worldwide:

2002	about 2.8% of total packages are/may be FC
2004	about 4.6% of total packages may be FC
2006	about 6.5% of total packages may be FC

Relevance for the environment

Material balance accounting: How much heavy metal is used for the application in question? Which amounts can be expected within the scope of the RoHS Directive? (rough estimate)
3 – 5 mg lead per flip chip results in an imported lead volume to the EU:

Year	*2004*	*2005*	*2006*	*2007*
Worldwide lead in internal package bumps in kg	1086	1175	1379	1376
Lead imported to EU in package bumps in kg	**326**	**352**	**414**	**413**

Environmental Relevance of low temperature Flip Chip Bumps:

The amount of lead in the solder joint is less than a half compared to the high temperature lead solders which are currently exempted from the requirements of Article (4) of the RoHS directive. Due to the lack of lead-free alternatives for this application, the current RoHS Directive would require manufacturers to switch to a higher lead alternative for all flip chip applications.

This request for a new exemption would allow the continued use of low lead concentration solder until lead-free alternatives are found and evaluated. It would be counterproductive for the environment to change to high-lead solders within flip chip packages in order to get coverage by the existing exemptions and the clarification to this existing exemption.

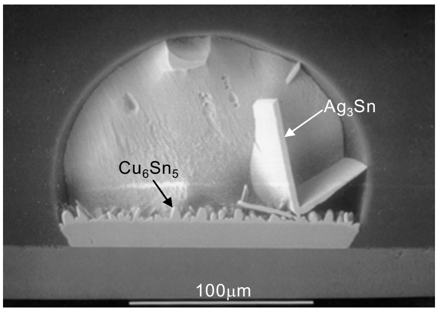
Flip chips are used in applications that serve the environment. They reduce the fuel consumption of cars by effective motor control and contribute to road safety by supporting ABS systems.

Measures taken until now by the industry to prepare for the conversion of the substance ban of the RoHS Directive

Lead-free solder research is widespread across industry, universities, institutes and national laboratories in all regions of the world. We will work with interested parties, if desired. Lead-free solder flip chip interconnections are successfully used today in many applications.
Industry believes lead-free solders can eventually be used for most flip chip applications. Our

research shows that lead-free alternatives to low temperature tin lead bumps are currently not universally available because:

1. In lead-free solutions, the formation of intermetallic alloys in this tiny bump constitute a high percentage of the joint volume and greatly reduces the resistance to impact (e.g. drop) and thermo-mechanical stresses normally found in the use environment, especially in flexible circuit applications; failure of the joint renders the integrated circuit useless;
2. Lead-free solders with a melting point sufficiently high for mainstream products are much stiffer than eutectic lead-tin solders. This stiffness increases stress on the chip, and can cause premature failure of the chip circuitry.
3. The equipments and materials required for fabricating lead-free bumps are still in the development stage. For example, fluxes for lead-free solder flip chip connections are just now being developed.
4. The industry is still learning the full impact of lead-free solder flip chip interconnect on manufacturability and reliability. For example, it is well known that lead-free solders do not wet (coat) metal terminals as well as lead-tin solders. In order to obtain adequate wetting, new fluxes are being developed. However, the nature of these fluxes impacts other assembly steps and product reliability, and the full extent of the impacts are still being determined.
5. In high temperature(high lead) flip chip solutions, attachment to the organic substrate still requires a low temperature lead-containing solder interface;



Undesirable intermetallic alloys make up a significant portion of the experimental lead-free solder bump. Current technology for the connection between the package and the PWB will not work for interconnect bumps with small dimensions.

A variety of reliability problems have surfaced and no broadly applicable reliable alternative has been identified. To ensure no disruptions in flipchip applications, it is critical to provide a new narrow exemption for low temperature lead solder for these tiny internal connections.

Time frame for finding potential substitutes:
During the next years, ITRS (International Technology Roadmap for Semiconductors) provides an industry identification/assessment of future technical challenges. Alternatives to flip chip connection may be optical interconnects or bump less area areas (direct copper to copper bonding). International chipmakers are in active development and are seeking lead-free alternatives at high speed. These solutions may find their way into products by the end of the decade, but their use will be limited to certain niche applications until the cost is reduced.