RoHS Substance Thresholds: Facts and Friction

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Abstract
Meeting RoHS requirements is confusing at best. Currently, RoHS bans the presence of 6 substances,: Lead (Pb), Cadmium (Cd), Mercury (Hg), Hexavalent Chromium (Cr6+), Polybrominated biphenyl (PBB) and Polybrominated diphenylether (PBDE). As of 18 August 2005, the European Union (EU) amended the RoHS document with maximum concentration values (MCVs) of 1000 ppm for 5 of the substances; Pb, Hg, Cr6+, PBB & PBDE and 100 ppm for the 6th substance; Cd at the homogenous level. Other documents within the EU and member states have defined MCVs, but there is not total agreement between EU Directives and the member states on the maximum threshold values. With the delay of defined RoHS thresholds, other regions of the world are defining MCVs, but without universal agreement. Companies in the electrical and electronics equipment (EEE) industry are subsequently incorporating their understanding of MCVs into company specifications and requiring the suppliers to meet them.

What are the existing EU Directive requirements? How do they apply and what thresholds should be used for electrical and electronic products? This paper will discuss the RoHS 6 substances, thresholds as stated in the EU, common company defined threshold differences and the issues they cause. It is not all inclusive since laws and directives are constantly changing, evolving or being released.

Introduction
The EU document receiving the most attention and emphasis concerning banned substances is the EU's Directive 2002/525/EC (RoHS)[i] and latest amending document 2005/618/EC (RoHS MCV)[ii]. EU member states are expected to have legislation in place meeting this Directive by 1 July 2006. The RoHS document itself is still an evolving Directive only just now sorting out critical definitions like MCVs and additional exemptions. The list of proposed laws, like China's *Management Methods on the Prevention and Control of Pollution Caused by Electronic Information Products*[iii] (China RoHS), California's *Senate Bill 20 - Electronic Recycling Act of 2003*[iv] (CA SB20) or *Proposition 65*[v] (Prop 65), Japanese Green laws, and others like them are growing. None of these are truly aligned; there is no "global harmonization". Many requirements overlap in their regional application, and all of them overlap as they apply to the global marketplace. It is challenging to even begin to understand, interpret, and apply these many laws and to anticipate and align with the many proposals. What is perhaps more frustrating is the lack of any coordinated industry response aligning and harmonizing how the international supply chain should handle these challenges.

Though this paper cannot cover all EU or other regional legislation in place, under development or being updated, it can supply a groundwork for understanding MCVs, application, and exemptions. The first part of the paper covers some of the basic facts about the RoHS 6 substances as stated in several of the major EU Directives. The second part is the friction caused by inconsistent MCV requirements placed on suppliers. The paper concludes with a few suggestions and actions those within the EEE environment should work towards that may help alleviate the confusion seen today.

The Facts
The current requirement for the 6 banned substances defined in the *EU Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment* (RoHS) Article 4(1) states,

> "Member States shall ensure that, from 1 July 2006, new electrical and electronic equipment put on the market does not contain lead, mercury hexavalent chromium, cadmium, polybrominated biphenyls (PBB) or polybrominated diphenyl ethers (PDBE)."

Article 5.1(a) goes on to state,

> "Establishing, as necessary, maximum concentration values up to which the presence of the substances referred to in Article 4(1) in specific materials and components of electrical and electronic equipment shall be tolerated."

Where the previous version of the RoHS document, 2002/95/EC, was silent on maximum concentration values (MCVs), the latest RoHS Directive amendment, *2005/618/EC released 18 Aug 2005* (RoHS MCV) has included them. It specifically states in Article 1,

In the Annex to Directive 2002/95/EC the following note is added:
'For the purposes of Article 5(1)(a), a maximum concentration value of 0,1 % by weight in homogeneous materials for lead, mercury, hexavalent chromium, polybrominated biphenyls (PBB) and polybrominated diphenyl ethers (PBDE) and of 0,01 % by weight in homogeneous materials for cadmium shall be tolerated.'

The MCVs are usually stated in parts per million (ppm) or percentage where 1000 ppm = 0.1%, 100 ppm = 0.01%, 10 ppm = 0.001%, 1 ppm = 0.0001%, etc. EU directives usually have the concentration values as a percentage instead of ppm, in the form of 1 %, 0,1 %, 0,01 % etc. EU documents use the "comma" instead of a "period" in the numbering format. For the purposes of this paper, the thresholds will be stated in ppm except when quoting an EU Directive or other legislation.

Definitions for homogeneous materials are still being developed, with the latest concerning EEE products stating something along the lines of:

A material that cannot be mechanically disjointed into different materials: homogeneous materials are materials of uniform composition throughout. Ceramics, glass, metals, alloys, plating, board, resins, coatings are examples. The term "mechanically disjointed" means that the materials can be, in principle, separated by a mechanical actions such as unscrewing, cutting, crushing, grinding and abrasive processes.

Examples of Homogeneous Materials:

A plastic component is a "homogeneous material" assuming it is made with one type of resin and is not coated with, nor has any other material attached to it. Colorants added to the plastic resin would be treated as a separate homogeneous material.

An electrical component such as a resistor would consist of a variety of homogenous materials that could include ceramic, the lead frame alloy, and the plating applied to the lead frame. Each of these must be treated as a homogeneous material and evaluated for controlled substances.

Past documents have recommended these newly adopted MCVs for RoHS like the one from the *Commission of the European Communities which met in Brussels on 9 Sep 2004*[vi]. It states, "Since it is evident that a total avoidance of heavy metals and brominated flame retardants is in some instances impossible to achieve, certain concentration values for lead, mercury, cadmium, hexavalent chromium, PBBs or PBDEs in materials should be tolerated." It recommends within the Annex to the RoHS document an amended statement to include MCVs:

> "For the purposes of Article 5(1)(a), a maximum concentration value of 0.1% by weight in homogeneous materials for lead, mercury, hexavalent chromium, polybrominated biphenyls (PBB) and polybrominated diphenyl ethers (PBDE) and a 0.01% by weight in homogeneous materials for Cadmium shall be tolerated."

These newly adopted RoHS MCVs are now in alignment with other existing EU Directives. For the 4 heavy metals, the *End of Life Vehicle 2002/525/EC*[vii] (EoLV) has had 100 ppm for Cd and 1000ppm for Pb, Hg & Cr6+ limits in its document since its latest release, 27 June 2002. Each of the 6 substances, the associated EU specifications with MCVs are listed in Table 1 below. It also includes a specific case for the 4 heavy metals in shipping materials (package and packaging).

Table 1- RoHS 6 Substances and Associated EU Legislation

Substance	Threshold (ppm)	EU Legislation
Lead	1000	EoLV 2002/525/EC RoHS MCV 2005/618/EC
Mercury	1000	EoLV 2002/525/EC RoHS MCV 2005/618/EC
Hexavalent Chromium	1000	EoLV 2002/525/EC RoHS MCV 2005/618/EC
Cadmium	100	EoLV 2002/525/EC, 91/338/EEC RoHS MCV 2005/618/EC
Polybrominated biphenyl	1000	83/264/EEC RoHS MCV 2005/618/EC
Polybrominated diphenylether	1000	2003/11/EC RoHS 2005/618/EC
Packaging: sum of Cd, Hg, Cr6+ & Pb	100	2004/12/EC

Tables 2 - 7 give detailed reviews of current EU specifications for each of the RoHS 6 substances. They consist of the EU Directives and any associated MCVs, application specific requirements and/or exemptions that may apply. Also included are references and thresholds to the JEDEC JIG-101, California SB20 and China RoHS requirements.

Table - RoHS 6 Substances; Lead Detailed Information
Lead (Pb)

Legislation	Thresholds and Exemptions
2002/95/EC - Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (**RoHS**) - 18 Aug 2005 amendment **2005/618/EC (RoHS MCV)** - 21 Oct 2005 amendment **2005/747/EC (Pb and Cd exemptions)**	MCV = 1000 ppm of homogenous material officially released 18 Aug 2005, 2005/618/EC **Exemptions:** - In glass of cathode ray tubes, electronic components and fluorescent tubes - <= 3500 ppm in steel - <= 4000 ppm in aluminum - <= 40,000 ppm in copper alloys - Lead in high melting temperature type solders (i.e. lead-based alloys containing 85 % by weight or more lead) - Lead in solders for servers, storage and storage array systems, network infrastructure equipment for switching signaling, 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 **Additional proposed exemptions waiting approval:** - In optical transceivers for industrial applications - In lead-bronze bearing shells and bushes
2002/525/EC – Commission Decision of 27 June 2002 amending	MCV = 1000 ppm by weight per homogeneous material - MCV = 3500 ppm as an steel alloy for machining purposes

ANNEX II of Directive 2000/53/EC of the European Parliament and of the Council on end-of-life vehicles (**EoLV**)	and galvanized steel, - MCV = 10,000ppm as alloy in aluminum for machining purposes, expired 1 July 2008 - MCV = 40,000 ppm by weight in copper alloy - No MCV for lead-bronze bearing shells and bushes - No MCV for Lead-acid batteries, must be labeled - No MCV for vibration dampeners, must be labeled - No MCV for Solder in electronic circuit boards and other electric applications - MCV = 5,000 ppm in copper used in brake linings - No MCV for Valve seats, expires 1 July 2006 - No MCV for electrical components which contain lead in a glass or ceramic matrix compound except glass in bulbs and glaze of spark plugs - No MCV Pyrotechnic initiators, expires 1 July 2007 The EoLV Directive is being reviewed for updating the current exemptions
Denmark : Statutory Order No. 1012 of November 13, 2000, on Prohibition of Import and Marketing of Products Containing Lead	MCV = 100 ppm in homogeneous material **Annex I Exemption no. 15:** - Electronic components
Law put in place with reference to **California Prop 65**	MCV = 300 ppm in cabling
JEDEC JIG-101[viii]	MCV = 1000 ppm
China RoHS	No MCV stated
CA SB20	MCV should match RoHS requirements

Table 3 - RoHS 6 Substances; Cadmium Detailed Information
Cadmium (Cd)

Legislation	**Thresholds and Exemptions**
2002/95/EC – Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (**RoHS**) - 18 Aug 2005 amendment **2005/618/EC (RoHS MCV)** - 21 Oct 2005 amendment **2005/747/EC (Pb and Cd exemptions)**	MCV = 100 ppm in homogeneous material officially released 18 Aug 2005, 2005/618/EC **Exemptions:** - Cadmium and its compounds in electrical contacts and cadmium plating except for applications banned under Directive 91/338/EEC (*) amending Directive 76/769/EEC (**) relating to restrictions on the marketing and use of certain dangerous substances and preparations. - Lead and cadmium in optical and filter glass
2002/525/EC - Commission Decision of 27 June 2002 amending ANNEX II of Directive 2000/53/EC of the European Parliament and of the Council on end-of-life vehicles (**EoLV**)	MCV = 100 ppm by weight per homogeneous material for Cd shall be tolerated. **Exemptions:** - No MCV for thick film pastes, expires 1 July 2006 - No MCV in batteries for electrical vehicles. After 31 December 2005, the placing on the market of NiCd batteries shall only be allowed as replacement parts for vehicles put on the market before this date.
91/338/EEC[ix] - Council Directive 91/338/EEC of 18 June 1991 amending for the 10th time Directive 76/769/EEC on the approximation of the laws, regulations and administrative provisions of the Member States relating to restrictions on the marketing and use	MCV = 100 ppm Cd may not be placed on the market if the Cd content exceeds threshold by mass - Of concern are plastics like PVC, paints, inks, plating, etc. MCV = 1000 ppm for Paints with high zinc content by mass. **Exemption:** - Items of high color for safety reasons are exempted

of certain hazardous substances and preparations	
98/101/EC[x] – Commission Directive 98/101/EC of 22 December 1998, adapting to technical progress Council Directive **91/157/EEC**[xi] on batteries and accumulators containing certain dangerous substances	MCV = 250 ppm by weight
Related EU Member State Legislation, other Laws, Specifications and papers on Cadmium	
Cadmium Decree 1999[xii] - Netherlands, Cadmium Decree 1999 (Chemical Substance Act) Rules for the Manufacture and Sale of Products Containing Cadmium)	MCV = 100 ppm, Changed threshold from 50 ppm to 100ppm matching EU Cadmium Directive 91/338/EEC
Statutory Order No. 11299[xiii] - Danish Environmental Protection Agency Statutory Order No. 11299 of December 23, 1992 on the Prohibition, of Sale, Import, and Manufacture of Cadmium-Containing Products	MCV = 75 ppm for cadmium-containing products in which cadmium is used either as surface treatment agent (cadmium plating), colour pigment or plastic stabilizer with more than 75 ppm in the homogeneous components of the product.
JEDEC JIG-101	MCV = 75 ppm to match Danish EPA limit, will change to 100 ppm if Denmark changes to match the RoHS MCV
China RoHS	No MCV stated
CA SB20	MCV should match RoHS requirements
OECD paper, "**LIMITS ON CADMIUM IN PLASTICS AND PVC**"[xiv]	Paper on Cadmium concerns and thresholds reflecting 100ppm for most EU states and 1000ppm for US.

Table 4 - RoHS 6 Substances; Mercury Detailed Information
Mercury (Hg)

Legislation	Short Description, threshold specific
2002/95/EC – Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (**RoHS**) - 18 Aug 2005 amendment **2005/618/EC (RoHS MCV)**	MCV = 1000 ppm of homogeneous material officially released 18 Aug 2005, 2005/618/EC **Exemptions:** - <= 5mg in compact fluorescent lamps - <= 10mg halophoshpate fluorescent lamps - <= 5mg triphosphate fluorescent lamps, normal lifetime - <= 8mg triphosphate fluorescent lamps, long lifetime - In fluorescent lamps for special purposes - In lamps not specifically mentioned in Annex
2002/525/EC - Commission Decision of 27 June 2002 amending ANNEX II of Directive 2000/53/EC of the European Parliament and of the Council on end-of-life vehicles (**EoLV**)	MCV = 1000 ppm by weight and per homogeneous material for Hg **Exemption:** - No MCV for discharge lamps and instrument panel displays
98/101/EC – Commission Directive 98/101/EC of 22 December 1998, adapting to technical progress Council Directive 91/157/EEC on batteries and accumulators containing certain dangerous substances	MCV = 5 ppm by weight **Exemption:** - >25 mg per cell, except alkaline manganese batteries MCV = 20,000 ppm by weight in button cells
91/157/EEC – Council Directive 91/157/EEC of 18 March 1991 on batteries and accumulators containing dangerous substances	MCV = 500 ppm by weight for prolonged use in extreme conditions alkaline manganese batteries MCV = 250 ppm by weight for all other alkaline manganese **Exemptions**: - Button cell batteries exempted - >25 mg per cell for other batteries
2002/96/EC[xv] – Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment (WEEE)	Must report the use of - Hg in components such as switches or backlighting lamps - Hg in batteries
JEDEC JIG-101	MCV = 1000 ppm
China RoHS	No MCV stated
CA SB20	MCV should match RoHS requirements

Table - RoHS 6 Substances; Hexavalent Chromium Detailed Information
Hexavalent Chromium (Cr6+)

Legislation	Short Description, threshold specific
2002/95/EC – Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (**RoHS**) - 18 Aug 2005 amendment **2005/618/EC (RoHS MCV)**	MCV = 1000 ppm of homogeneous material officially released 18 Aug 2005, 2005/618/EC **Exemptions**: - Cr6+ as an anti-corrosion of the carbon steel cooling system in absorption refrigerators
2002/525/EC - Commission Decision of 27 June 2002 amending ANNEX II of Directive 2000/53/EC of the European Parliament and of the Council on end-of-life vehicles (**EoLV**)	MCV = 1000 ppm by weight and per homogeneous material for Cr6+ **Exemptions:** - No MCV for corrosion preventative coatings, expires 1 July 2007 - No MCVs for absorption refrigerators in motor caravans
JEDEC JIG-101	MCV = 1000 ppm
China RoHS	No MCV stated
CA SB20	MCV should match RoHS requirements

Table 6 - RoHS 6 Substances; Polybrominated Biphenyl Detailed Information

Polybrominated biphenyl (PBB)

Legislation	Short Description, threshold specific
2002/95/EC – Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (**RoHS**) - 18 Aug 2005 amendment **2005/618/EC (RoHS MCV)** - 13 Oct 2005 amendment **2005/717/EC (DecaBDE exemption)**	MCV = 1000 ppm of homogeneous material officially released 18 Aug 2005, 2005/618/EC **Exemption:** - DecaBDE
2003/11/EC[xvi] – Directive 2003/11/EC of the European Parliament and the Council of 6 February 2003 amending for the 24th time Council Directive 76/769/EC relating to restrictions on the marketing and use of certain dangerous substances and preparations (pentabromodiphenyl ether, octabromodiphenyl ether)	No MCV directly stated, but in the testing section, "The presence of PentaBDE and OctaBDE in concentrations higher than 0,1% can be identified using standard analytical techniques such as GC-MS (gas chromatography-mass spectrometry)." The analysis report specifically calls out PBB and PBDE and to what level they can be tested
2002/96/EC – Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment (WEEE)	Must report the use of Brominated flame retardants (PBB & PBDE) in plastics
JEDEC JIG-101	MCV = 1000 ppm
China RoHS	No MCV stated
CA SB20	MCV should match RoHS requirements

Table 7 - RoHS 6 Substances; Polybrominated Diphenyl Ether Eetailed Information

Polybrominated diphenyl ether (PBDE)

Legislation	Short Description, threshold specific
2002/95/EC – Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (**RoHS**) - 18 Aug 2005 amendment **2005/618/EC (RoHS MCV)** - 13 Oct 2005 amendment **2005/717/EC (DecaBDE exemption)**	MCV = 1000 ppm of homogeneous material officially released 18 Aug 2005, 2005/618/EC **Exemption:** - DecaBDE
2003/11/EC - Directive 2003/11/EC of the European Parliament and the Council of 6 February 2003 amending for the 24th time Council Directive 76/769/EC relating to restrictions on the marketing and use of certain dangerous substances and preparations (pentabromodiphenyl ether, octabromodiphenyl ether)	The presence of PentaBDE and OctaBDE in concentrations higher than 0,1% can be identified using standard analytical techniques such as GC-MS (gas chromatography-mass spectrometry). Analysis report specifically calls out PBB and PBDE
2002/96/EC – Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment (WEEE)	Must report the use of Brominated flame retardants (PBB & PBDE) in plastics
JEDEC JIG-101	MCV = 1000 ppm
China RoHS	No MCV stated
CA SB20	MCV should match RoHS requirements

As can be seen from each of the 6 tables above, there are many existing EU documents describing the RoHS 6 substances, with varying exemptions and MCVs already in place. There may be more. Without understanding the surrounding requirements within the EU, being aware of developments and changes, EEE companies have a very difficult task assessing required MCVs for their products. Silence within the RoHS Directive until the latest release, has only made it more difficult.

The Friction

Why should unified MCVs be an important goal for industry to encourage regulators to embrace?

Companies in the electronics industry have placed wide and varying threshold requirements within their individual company specifications. They can range from 0 ppm up to the RoHS MCVs. Some do not mention concentration values, and others state zero tolerance or "will not be tolerated". As seen in Tables 2-7, there are other EU documents already in affect with the same RoHS MCV values. Companies that establish content requirements without an understanding the complex and non-uniform requirements of existing and proposed laws will only add to the confusion. This lack of consistency has brought much misunderstanding to suppliers within the electronics industry trying to meet their customers' specifications. It is difficult to track and these customer specifications continue to change.

Companies requiring their suppliers to meet MCVs more strict than the 1000 ppm for Pb, Hg, Cr6+, PBB & PBDE and 100 ppm for Cd have created a catch 22 situation. Suppliers are working towards and/or meeting current regulated requirements within the EU. They are also receiving customer requirements more restrictive than applicable regulations. Do suppliers once again qualify towards these customer specs which are subject to change without notice? Do they continue to qualify and meet industry regulated limits? Will they continue to be subjected to ever changing and evolving customer requirements that are difficult to track and may be impossible to meet? Make it stop!

For now, the EU is the leader concerning banned substance reduction with Directives already in place. With the RoHS deadline of 1 Jul 2006 quickly approaching, efforts within the Electronics Industry are focused on meeting the RoHS 6

requirements. Because RoHS is the document driving the requirement, expected thresholds and requirements from customers should align with the latest RoHS MCVs. These values, as indicated by other EU Directives, papers and the proposed RoHS MCVs voting process which started in June of 2004 have not changed, as of August 2005 they are now official.

Currently most customer specifications and EU Directive MCVs are not the same. After reviewing and providing official feedback to over 85 major electronics companies around the world and answering RoHS types of questionnaires from an additional 160+ companies, there are similarities between these companies and common problems created by lack of clarity.

The greatest similarity is the RoHS Directive being referenced by all major companies. Many companies include some or all of the surrounding Directives as well. This does not mean they align with the thresholds as stated by the Directives, just that they are referenced. The other similarity is requiring a minimum of the RoHS 6 substance declaration from their suppliers.

The greatest problem is the varying threshold levels required by customer specifications. If responses sent back from the supplier state the supplier will only meet the maximum thresholds as defined by the EU Directives, this may or may not be accepted by the customer. In some cases it is "unacceptable because the customer's customer threshold limits must be met". Gaining acceptance further up the customer base can be a difficult task. Others have stated, "This is our threshold, you must meet it". Again, without understanding the regulations driving the requirements, the threshold levels set by customers and their demands to meet them can prove to be difficult if not impossible to meet. An example of these different spec requirements is shown in Table 8.

Table 8 - Example of Different Types of Customer Defined Threshold Requirements

		Varying Customer Defined Thresholds					
Substance	**RoHS MCVs**	**No tolerance**	**Power of 10 less than MCVs**	**20% less than MCVs**	**50% less than MCVs**	**Variable MCVs**	**MCVs or Intentionally added**
Cd	100 ppm	No tolerance	10 ppm	80 ppm	50 ppm	5 ppm	75 ppm
Hg	1000 ppm	No tolerance	100 ppm	800 ppm	500 ppm	None stated	Intentionally added
Cr6+	1000 ppm	None stated	100 ppm	800 ppm	500 ppm	1000 ppm	1000 ppm
Pb	1000 ppm	No tolerance	100 ppm	800 ppm	500 ppm	100 ppm	1000 ppm
PBB	1000 ppm	None stated	100 ppm	800 ppm	500 ppm	Not stated	1000 ppm
PBDE	1000 ppm	None stated	100 ppm	800 ppm	500 ppm	Not stated	Intentionally added

A note concerning "intentionally added" needs to be included. This term, "intentionally added" was introduced in the 76/769/EEC[xvii] document, but not as applied to any of the RoHS 6 substances. RoHS documents do not contain this statement, but the EoLV for the 4 heavy metals does. It has created a legal issue on its very inclusion within reporting requirements. How should the term "intentionally added" be interpreted and applied when it appears outside any regulatory contest, such as in a customer's specification? Below are 4 scenarios and the potential issues of each.

Example 1: MCV for Pb = 1000 ppm. Actual content is 100 ppm and it is not intentionally added.
- No issues from a RoHS reporting standpoint. It passes both the MCV and intentionally added clause.

Example 2: MCV for Pb = 1000 ppm. Actual content is 100 ppm, but it was intentionally added
- According to the MCV, it is in compliance
- Using the intentionally added clause, is it still in compliance because it was used on purpose?

Example 3: MCV for Pb = 1000 ppm. Actual content is 1100 ppm and is intentionally added
- No issues, this component is not compliant. It fails both the MCV and intentionally added clause

Example 4: MCV for Pb = 1000 ppm, Actual content is 1100 ppm, but is not intentionally added
- Per the MCV, this would be out of compliance.
- If a company only states "intentionally added" within their thresholds and excludes the appropriate MCV, does this mean it is in compliance?

Only stating "intentionally added" as a threshold for a given substance can be very confusing. From Example 2, the reported value is below the MCV yet the product may be declared as non-compliant because the substance was intentionally added. Is this the right interpretation? In Example 4, using "intentionally added" without the appropriate MCV may result in not reporting the correct information concerning RoHS compliance. "Intentionally added" requires reporting the substance, MCVs should be used for reporting whether the substance is in compliance wherever possible.

Substance hot buttons
Of the 6 RoHS substances, Pb and Cd seem to be the biggest hot buttons concerning the varying thresholds required by customers. These 2 substances will be discussed in greater detail with comments concerning where these differences may have been derived.

Lead
Several documents and even interpretation of documents have caused issues with declaring different levels of lead. Some have come directly from larger company requirements being used by their suppliers. Others may have been based on two European driven documents. One is the Danish *Statutory Order No. 1012 of November 13, 2000, on Prohibition of Import and Marketing of Products Containing Lead*[xviii] and the other is the EU *Directive 2004/12/EC on Packaging and Packaging Waste*[xix]. Order No. 1012 states in paragraph (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.

This Order is a broad based restriction on Lead covering many products like construction, candles, drapery, etc. In *Annex I: 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* it clearly states the exemption of electronic components in item 15 "until further notice". Inquiries made of the Danish officials clarified as of July 1, 2006 the higher lead content limit of RoHS will supersede the Danish limit.

Another 100ppm threshold that contains Lead as one of the banned substances is the *EU Directive 2004/12/EC amending Directive 94/62/EC, on package and packaging waste*[xx] which states:

> Member States shall ensure that the sum of concentration levels of lead, cadmium, mercury and hexavalent chromium present in packaging or packaging components shall not exceed 100ppm by weight five years after the date referred to in Article 22.

This 100 ppm threshold may have been applied generically for Lead as an MCV for any application, not just for shipping materials.

Both of these documents clearly state a 100ppm threshold. Reading and understanding the documentation is key to know where they apply and to what extent. There are other documents like the Battery Directive, California Prop 65 law of 300ppm for electrical cabling that may also form the basis for a customer content requirement. The base threshold for Lead is 1000ppm as stated by RoHS. RoHS has several existing exemptions for Lead and even some proposed. Further details of application specific exemptions and restrictions must be understood and applied accordingly. Use of a single MCV would logistically be the easiest to monitor, but it is not the correct application of the EU Directives.

Cadmium
The most stringent company requirement being seen for cadmium is 5 ppm, especially in applications centered on plastics. Reading through customer specs, EU Directives, industry papers and requirements, 3 areas appear to have influenced these tighter limits.

Defining product use and thresholds of Cadmium:
The basic cadmium threshold is 100ppm as stated by the RoHS, EoLV and the 91/338/EEC on plastics. Application specific directives like the Battery Directive 98/101/EC threshold states 250 ppm and the sum of the 4 heavy metals not to exceed 100 ppm per the Packaging and Packaging waste Directive 2004/12/EC amending 94/62/EC. Article 11 of the Packaging Directive states:

> "Concentration levels of heavy metals present in packaging 1. Member States shall ensure that the sum of concentration levels of lead, cadmium, mercury and hexavalent chromium present in packaging or packaging components shall not exceed the following

– 100 ppm by weight five years after the date referred in Article 22 (i)."

The initial date in Article 22 (i) is 30 June 1996. The subsequent 5 year date for the 100 ppm Cd threshold was June 30, 2001 for packaging per the 94/62/EC document. Two points of confusion seem to have arisen. The first is the definition of package and packaging. Package and packaging are the materials used to ship product from point A to B. The shipping material may be used to move raw material to suppliers, supplier products to EMS, EMS to OEM, OEMs to the consumer, etc. in a safe, protected, and practical manner. For instance, a plastic enclosure for a PC monitor is made of plastic. It does not fall under the package and packaging requirements but does need to meet the 1000 ppm threshold for Pb, Hg, Cr6+, PBB & PBDE and 100 ppm for Cd. The materials (box, labels, plastic protectors, etc.) used to keep the monitor safe during shipping are required to meet the 100ppm MCV sum for the 4 heavy metals.

The Council Directive 91/338/EEC directive for plastics threshold value of Cadmium is 100ppm for all applications as stated in the Annex.

"Cd may not be placed on the market if the Cd content exceeds 0,01 % threshold by mass…"

- Of concern are plastics like PVC, paints, inks, plating, etc.

None of the aforementioned Directives defines MCVs at the 5 ppm level as specified by some customers.

Substance analysis reports
Testing requirements have been written requiring 5 ppm as a minimum test equipment detection level. This type of accuracy, even if it is off by +/- 100% will report accurate enough information well below the 100ppm MCV threshold. This minimum test equipment detection limit of 5ppm seems to have become confused with the maximum concentration value of 100 ppm for cadmium as a substance. The OECD paper, "*Limits on Cadmium in Plastics and PVC*[xxi]" states in Section 5,

"… the Council set a limit of 100ppm. This limit is *not* a zero-tolerance level, as the limit of detection for cadmium is much lower, in the neighbourhood of 5 ppm."

The minimum detection limit to test for Cadmium in products is much different than the maximum concentration value of Cd. The MCV for Cd is 100 ppm per RoHS & EoLV and 75 ppm per Danish law and the JEDEC JIG-101. Once again, the threshold requirements may get confused with the actual test equipment detection capabilities.

Loss of Income
Fear of product rejection within the EU ending in loss of sales is a major concern. Unfortunately, an example was made during the 2001 Christmas season with the Sony PlayStation 1 game machines being held by Dutch customs agents. Cables in the consoles were tested and discovered to contain cadmium levels exceeding the threshold as defined by the Dutch law. The estimated costs incurred while replacement parts were identified, received and placed on these units start around $100 million with other claims stating the cost was much higher. It has become a case study for companies needing to understand the importance of meeting banned substance requirements.

For many customers this may be THE reason customer specifications require tighter MCVs than what are required by the EU Directives.

In any of these 3 scenarios, the base threshold for Cadmium must be used as stated by RoHS or other applicable regulations. Randomly choosing a threshold and requiring suppliers to meet them is not practical and may not be feasible. There are hopes now that RoHS contains 100ppm in the EU Directive, the remaining EU member states will contain comparable legislation. Until then, companies may continue to require 75ppm as per Danish Law since it is the tighter limit. Requiring an MCV less than 75 ppm or 100 ppm, out side of application specific exemptions and restrictions, is not found in any EU Directive requirement. This is another point of friction.

Work outside of the EU
Material declarations and MCV requirements are receiving more and more attention in all regions of the world. China seems to be leading the pack with their Management Methods on the Prevention and Control of Pollution Caused by Electronic Information Products, commonly referred to as "China RoHS". China RoHS does not state MCVs for the banned 6 substances and contains many similarities to the EU Directive 2002/96/EC on waste electrical and electronic equipment (WEEE) concerning recycling and reuse. It also contains a different list of electronic equipment the ban applies to. It is

hoped to relate close enough to the EU RoHS document that the MCVs recently adopted in the RoHS MCV will also be adopted within China RoHS.

Japan, through efforts in organizations like the JGPSSI and JEITA associations are working with the Japanese Green laws. These seem to have accepted thresholds as defined in the joint effort by JGPSSI, EIA and JEDEC resulting in the JEDEC JIG-101 Joint Industry Guide (JIG-101) document for material declaration. Thresholds that match RoHS are reflected in this document except for Cd which is at 75 ppm due to the threshold defined by Danish Law.

Within the US, national legislation dealing with RoHS specific legislation does not exist. California has released the SB20 law that reflect the RoHS requirements, basically stating products that can not be used or shipped in Europe because of RoHS substances can not be used or shipped in California. California has also released Prop 65 concerning the maximum allowable dose levels for hazardous substances. An ensuing lawsuit resulted in a settlement creating the Pb MCV limit of 300 ppm in electronic cabling.

There are on-going efforts in Korea, Australia, Canada and many other countries to work the issues the RoHS types of Directives have initiated. The IEC/TC111 met in late June, 2005 to begin formation of a task group working towards more WW involvement addressing the specific needs of the electronics industry. The WGs defined to date are:

WG 1 – Material Declaration
WG 2 – Environmental Conscious Design
WG 3 – Test Methods for Hazardous Substances
WG 4 – Product Declaration

Though RoHS is an EU Directive requiring EU member companies to adopt substance bans, it has become a WW requirement due to the global marketplace we live in today. For large suppliers, they may not know what application their components will be used in nor where in the world the end consumer will be located. Because of this, all their products must be compliant. As regulations are developed around the world, there must be alignment between different regions especially for companies providing products across regions to meet them in a timely, economical and realistic manner.

Establishing a clear and understandable baseline for MCVs through legislation that companies can reference within their internal specifications is critical. Much like latest *IPC/JEDEC J-STD-020C Joint Industry standard on Moisture/Reflow Sensitivity Classification*[xxii] is used to set the reflow temperature and rating for Pb-free soldering of components, a standard for MCVs must be created and gain acceptance by all affected countries for use in the electronics industry.

There are many issues still needing attention. Consistent MCVs must become established within the EU, alignment achieved with the EU member states; organization & participation from all regions of the world to gain WW agreement on MCVs, development of RoHS-like material restrictions, and appropriate legislation created at the local, state, country & regions outside of the EU, etc. The challenges to the EEE industry will only get bigger. Time is running out to meet the 1 Jul 2006 RoHS deadline requirements; what time remains must be used wisely.

Summary
From a practical standpoint, companies should work towards alignment with existing regulations and requirements. If they need to tighten their internal specs to create watch levels for decision points which would require further information from their suppliers, this would make good business sense. Requiring suppliers to meet customer internal specs that are tighter than Industry requirements (which should themselves align with, not exceed, regulatory requirements) does not.

For instance: require their suppliers to meet the 1000 ppm MCV for Lead as stated by RoHS. The customer's internal documents may have a 900 ppm Lead trigger point for data being received from their suppliers. If the documentation sent back to the customer is above this threshold and still meets the RoHS requirements, further information may be needed to verify maintaining a RoHS compliant component. If it is below this threshold, no further information would be required.

Understanding the RoHS and surrounding Directives, appropriate exemptions, product specific applications and thresholds is critical for meeting MCVs and promoting these requirements up and down the supply chain. It is a worldwide issue. From within the ZVEI *White Paper on Good Declaration Practice of Substances in Electronic Components and Assemblies*[xxiii], Section 5, paragraph 1 on page 13 is the following statement concerning material declaration.

This process involves typically characterisation of the specific material / substance, taking clear rules and criteria into account, which are globally harmonized and accepted, such as reference to the relevant regulation, threshold limits for declaration etc…

These requirements have moved beyond an individual person, single company, state, province, even country or region. At this point in time, the place to look is the European Union since they have Directives in place. But even these must find alignment with China RoHS, efforts within Japan, Asia Pacific region, the Americas and the rest of the world. It is not Europe vs. China, vs. Japan, vs. APR vs. Americas vs. the World. It requires worldwide efforts, alignment, and cooperation from all business partners to address this world need for our future. The EU RoHS, with MCVs appropriately addressed, is a start down this path… a little confusing, but we will get there.

Abbreviations

Abbreviation	Description
CA SB20	California Senate Bill 20—Electronic Recycling Act of 2003
Cd	Cadmium
CEFIC	European Chemical Industry Council
Cr6+	Hexavalent Chromium
DTI	Department of Trade and Industry, Eco-design and Product Policy Unit, Sustainable Development Directorate, www.dti.gov.uk/sustainability
Ecma	Ecma International is an industry association founded in 1961 and dedicated to the standardization of Information and Communication Technology (ICT) and Consumer Electronics (CE). http://www.ecma-international.org/default.htm
EECA	European Electronic Component Manufacturers Association
EEE	Electrical and electronic equipment
EICTA	European Information, Communications and Consumer Electronics Industry Technology Association
EMS	Electronics Manufacturing Services
EoLV	EU Directive on the use of hazardous substances in the End-of-Life vehicles
EU	European Union, currently consisting of 25 member states
EUROMETAUX	European Association of Metals
Hg	Mercury
Homogeneous material	A material that cannot be mechanically disjointed into different materials: homogeneous materials are materials of uniform composition throughout. Ceramics, glass, metals, alloys, plating, board, resins, coatings are examples. the term "mechanically disjointed" means that the materials can be, in principle, separated by a mechanical actions such as unscrewing, cutting, crushing, grinding and abrasive processes. Examples of Homogeneous Materials: A plastic component is a "homogeneous material" assuming it is made with one type of resin and is not coated with, nor has any other material attached to it. Colorants added to the plastic resin would be treated as a separate homogeneous material. An electrical component such as a resistor would consist of a variety of homogenous materials that could include ceramic, the lead frame alloy, and the plating applied to the lead frame. Each of these must be treated as a homogeneous material and evaluated for controlled substances.
IEC	International Electrotechnical Commission, http://www.iec.ch/
JIG-101	JEDEC Joint Industry Guide, release April 2005
MCV	Maximum Concentration Value as referenced to a banned substance
Mechanically disjointed	The materials can be separated by mechanical actions such as unscrewing, cutting, crushing, grinding and abrasive processes.

OECD	Organisation for Economic Co-operation and Development, www.oecd.org, The OECD groups 30 member countries sharing a commitment to democratic government and the market economy. With active relationships with some 70 other countries, NGOs and civil society, it has a global reach. Best known for its publications and its statistics, its work covers economic and social issues from macroeconomics, to trade, education, development and science and innovation.
OEM	Original equipment manufacturer
Pb	Lead
PBB	Polybrominated biphenyl
PBDE	Polybrominated diphenylether
ppm	Parts per million, calculated by (weight of substance) / (total weight of homogenous material) * 1,000,000
RoHS	EU Directive on the Restriction of the use of certain hazardous substances in electrical and electronic equipment
RoHS MCV	Latest RoHS update that contains Maximum Concentration Values for the 6 banned substances
WW	World wide

[i] **2002/95/EC** – Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (**RoHS**) http://europa.eu.int/eur-lex/pri/en/oj/dat/2003/l_037/l_03720030213en00190023.pdf

[ii] **2005/618/EC –** Commission Decision of 18 August 2005 amending Directive 2002/95/EC of the European Parliament and of the Council for the purpose of establishing the maximum concentration values for certain hazardous substances in electrical and electronic equipment 2005/618/EC **(RoHS MCV),** http://europa.eu.int/eur-lex/lex/LexUriServ/site/en/oj/2005/l_214/l_21420050819en00650065.pdf

[iii] **China RoHS** – Management Methods on the Prevention and Control of Pollution Caused by Electronic Information Products http://www.aeanet.org/GovernmentAffairs/YOdMXqHGI.pdf

[iv] **California Senate Bill 20 - Electronic Recycling Act of 2003 (CA SB20)** - Match EU RoHS legislation thresholds (when stated). Implementation on limited electronic products starting Jan 1, 2007, http://www.ciwmb.ca.gov/electronics/act2003/

[v] **California Prop 65 –** Safe Drinking Water and Toxic Enforcement Act of 1986, http://www.oehha.ca.gov/prop65.html, does not state 300 MCV for lead in cabling, but resulting lawsuit defines this requirement

[vi] **Commissions of the European Communities Brussels 23.9.2004 COM(2004) 606 final, Proposal for COUNCIL DECISION amending Directive 2002/95/EC** of the European Parliament and of the Council for the purposes of establishing the maximum concentration values for certain hazardous substances in electrical and electronic equipment - Reasons for needing MCVs added to RoHS http://europa.eu.int/eur-lex/lex/LexUriServ/site/en/com/2004/com2004_0606en01.pdf

[vii] **2002/525/EC** - Commission Decision of 27 June 2002 amending ANNEX II of Directive 2000/53/EC of the European Parliament and of the Council on end-of-life vehicles (**EoLV**) http://europa.eu.int/eur-lex/lex/LexUriServ/site/en/com/2005/com2005_0291en01.pdf

[viii] **JEDEC JIG-101** – Joint Industry Guide, Material Composition Declaration for Electronic Products http://www.jedec.org/download/search/ACF276.pdf

[ix] **91/338/EEC** – Council Directive 91/338/EEC of 18 June 1991 amending for the 10th time Directive 76/769/EEC on the approximation of the laws, regulations and administrative provisions of the Member States relating to restrictions on the marketing and use of certain hazardous substances and preparations (Cadmium Directive) http://www.dantes.info/Strategies/Docs/91-338-EEC.pdf#search='91%2F338%2FEEC'

[x] **98/101/EC** – Commission Directive 98/101/EC of 22 December 1998, adapting to technical progress Council Directive 91/157/EEC on batteries and accumulators containing certain dangerous substances

[xi] **91/157/EEC** – Council Directive 91/157/EEC of 18 March 1991 on batteries and accumulators containing dangerous substances http://europa.eu.int/eur-lex/en/consleg/pdf/1991/en_1991L0157_do_001.pdf#search='91%2F157%2FEEC'

[xii] **Cadmium Decree 1999** - Netherlands, Cadmium Decree 1999 (Chemical Substance Act) Rules for the Manufacture and Sale of Products Containing Cadmium) reference summary, http://www.sharedspaces.nl/Docs/internationaal/CADMIUM_DECREE_1999.pdf

[xiii] **Statutory Order No. 11299** - Danish Environmental Protection Agency Statutory Order No. 11299 of December 23, 1992 on the Prohibition, of Sale, Import, and Manufacture of Cadmium-Containing Products

[xiv] OECD paper, "***LIMITS ON CADMIUM IN PLASTICS AND PVC***", http://webdomino1.oecd.org/comnet/ech/tradeandenv.nsf/viewHtml/index/$FILE/cadmium.pdf

[xv] **2002/96/EC** – Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment (WEEE) http://www.ce-mark.com/weee.pdf#search='98%2F101%2FEC'

[xvi] **2003/11/EC** - Directive 2003/11/EC of the European Parliament and the Council of 6 February 2003 amending for the 24th time Council Directive 76/769/EC relating to restrictions on the marketing and use of certain dangerous substances and preparations (pentabromodiphenyl ether, octabromodiphenyl ether) http://europa.eu.int/eur-lex/pri/en/oj/dat/2003/l_170/l_17020030709en00310031.pdf

[xvii] **76/769/EEC –** Council Directive of 27 July 1976 on the approximation of the laws, regulations and administrative provisions of the Member States relating to restrictions on the marketing and use of certain dangerous substances and preparations http://www.gdsc.net.cn/StdLiterature/WTO/76-769-EEC.pdf

[xviii] **Denmark** : Prohibition on Import and Marketing of Products Containing Lead, **STATUTORY ORDER NO. 1012** OF NOVEMBER 13, 2000, ON PROHIBITION OF IMPORT AND MARKETING OF PRODUCTS CONTAINING LEAD, http://www.tid.gov.hk/english/aboutus/tradecircular/cic/eu/2001/ci0701a.html

[xix] **Denmark** : Prohibition on Import and Marketing of Products Containing Lead, **STATUTORY ORDER NO. 1012** OF NOVEMBER 13, 2000, ON PROHIBITION OF IMPORT AND MARKETING OF PRODUCTS CONTAINING LEAD **http://www.tid.gov.hk/english/aboutus/tradecircular/cic/eu/2001/ci0701a.html**

[xx] **2004/12/EC** - Directive 2004/12/EC of the European Parliament and of the council of 11 February 2004 amending Directive 94/62/EC on packaging and packaging waste http://europa.eu.int/eur-lex/pri/en/oj/dat/2004/l_047/l_04720040218en00260031.pdf

[xxi] OECD paper, "***LIMITS ON CADMIUM IN PLASTICS AND PVC***", http://webdomino1.oecd.org/comnet/ech/tradeandenv.nsf/viewHtml/index/$FILE/cadmium.pdf

[xxii] **IPC/JEDEC J-STD-020C -** Joint Industry standard on Moisture/Reflow Sensitivity Classification http://www.jedec.org/download/search/jstd020c.pdf

[xxiii] **ZVEI** *White Paper on Good Declaration Practice of Substances in Electronic Components and Assemblies***, http://www.zvei.org/uploads/tx_ZVEIpubFachverbaende/wp_oct_2004.pdf**