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ENVIRONMENTAL REGULATORY ROADMAP A RECENT HISTORY AND A LOOK FORWARD

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ABSTRACT

Before the 1990s environmental laws restricting materials usages were regional in nature focusing on nuclear waste disposal, toxic material usages and emissions, workplace safety, lead elimination in paints and gasoline, and oil spill regulation. Before about 1994, IBM restricted or eliminated usage of chlorinated solvents, volatile organic compounds, certain lithium batteries, health risk chemicals, and hexavalent chromium processing. In the 1980s the proliferation of consumer electronic hardware raised concerns about product disposal practices and the related environmental impact. The United States Environmental Protection Agency focused on regulations to allow the safe usage of materials with environmental issues such as hexavalent chromium. The European Union initiated a different tactic and in 2002 adopted the Waste Electrical and Electronic Equipment (WEEE) Directive designed to promote recycling of electronic products, and the Restriction of Hazardous Substances (RoHS) Directive designed to restrict usage of six materials (cadmium, lead, hexavalent chromium, mercury, Polybrominated Biphenyls, and Polybrominated Diphenyl ethers) used in electronic hardware such as batteries, light bulbs, telecommunication switches, cell phones, and computers. WEEE Directive required that providers of electronic hardware must “take-back” and recycle their products from household consumers free of charge, including “historical” wastes, which were sold before the Directive’s implementation. Manufacturers were also required to recycle products returned from business customers free of charge, but only for products sold after the implementation of the Directive. Various local jurisdictions around the world have followed the WEEE lead and established their own product take back and recycling requirements. The future will likely bring increased regulations and material usage bans. One of the most significant challenges will be the consideration by the EU of bans on additional halogenated compounds such as PVC and the various brominated fire retardants that are currently in widespread usage. Mining operations may also come under increasing scrutiny due to social and environmental concerns associated with these operations in different parts of the world. Electronic hardware manufacturers using metals from these operations will undoubtedly see increased pressure to exert pressure on their supply chains to identify and control the sources of metals used in electronic hardware products. Increased electric car production will put demand pressure on certain commodities already critical to the electronics industry such as lithium (for batteries), and the rare earth metals (motor magnets, fiber optics, lasers). New mining operations will have to be brought on line and alternative materials will have to be developed. In the following article we explore in more detail some of the above items.

INTRODUCTION

The US EPA (Environmental Protection Agency) was formed in 1970 and over time the US banned or restricted lead usage in applications like pottery glazes, paints, gasoline, and plumbing solders. Closed loop plumbing systems, like those utilized in the high end IBM water cooled servers were exempted from this regulation because the water was isolated from the public water supply. In 1985 the Vienna Convention established mechanisms for international cooperation on the effects of ozone depleting chemicals and in that same year the Antarctic ozone hole was discovered. Two years later (1987) 24 countries plus the European Economic Community (EEC) signed the *Montreal Protocol on Substances that deplete the Ozone Layer* which established time lines for reducing chlorinated fluorocarbons usage CFCs), halons (a widely used fire suppressant), and other man made ozone depleting substances. The Montreal Protocol was amended in 1991 to require a complete phase out of these substances by 2000 in developed countries, and by 2010 in developing countries. In 1989 IBM announced that all internal product and manufacturing usages of ozone depleting chemicals (ODCs) would be terminated by 1993, and in 1993 IBM started to extend the ODC ban to its world-wide supply base.

Starting in 1992 IBM restricted hexavalent chromium usage by converting all high end system sheet metal to either nickel plated steel or painted phosphatized steel. Low end product hexavalent chromate usage was eliminated in 2006 as part of the overall RoHS initiatives. Energy efficiency and power usage were always considered byIBM to be key environmental attributes. Energy initiatives in the 1990s included a major transition from bipolar logic to FET logic in conjunction with significant reductions in space, power, and utility requirements for IBM's high end systems.

In 1986 the State of California passed Proposition 65 (OEHHA 65) which required labeling for products containing any chemical listed in the regulation if that content came into human contact. IBM responded to Proposition 65 by requiring that all IBM electronic products pass a VOC (Volatile Organic Compound) emissions test before being put on the market and to date no IBM designed products have required labeling for VOC content. One finding from the VOC testing was that the general environment is often heavily contaminated with volatile organic compounds such as benzene (from gasoline emissions) and formaldehyde (from building product emissions) that will "plate out" on metal surfaces and result in a "false positive" in VOC testing if precautions are not taken. Computer room environments are today usually far more benign (<10ppm total VOC content) than general office environments (often >100ppm total VOC content). The only IBM parts requiring labeling for Prop 65 have been some external cables which had lead content.

To comply with the 1988/1991 Montreal Protocol IBM, in 1993, required its component and part manufacturers to eliminate usage of ozone depleting chemicals (ODCS), methylene chloride, and solvent-based paint systems. By the mid 1990s IBM was identifying plastic parts according to ISO standards. Also by the mid 1990s IBM established a US recycling capability to handle reclamation, or "demanufacturing", for IBM products. Since then, IBM has extended its product return capability world-wide and dedicated an entire business unit, Global Asset Recovery Services, to handle product returns and recycling services for customers. Internal goals were established to promote the use of recycled plastic and partnerships were formed with major plastic suppliers to develop materials with both "high" recycled material content and suitable physical properties. The recycled plastic material supply chain has been problematic in the years since 1992 with major suppliers dropping and then reinstituting their recycled materials program. Currently IBM recycled plastic material content averages 10% with some product enclosures as high as 30%. Until recently most recycled material was post industrial but current development projects are assessing more post commercial recycled materials.

Denmark, in 1992, enacted Statutory Order No. 1199 banning the importation of products with cadmium (Cd) plating and/or cadmium content above 75ppm. Three years later Denmark amended Order No. 1199 to permit the importation of products with electrical connectors that required cadmium (Cd) for reliability purposes. Cadmium is a unique alloying element that prevents "contact welding" on high voltage make-break electrical connectors and this application is the only cadmium usage permitted in current (2010) IBM products. Cadmium plating can be toxic if not handled correctly. Cadmium plating also readily "whiskers" (i.e. grows surface filaments) which have in the past caused massive reliability problems with electronic hardware.

These individual environmental initiatives were collectively implemented on IBM"s S390 (system 390) model 3672 servers in 1992 which were IBM"s first mainframe computers to utilize FET (Field Effect Transistor) as a replacement for the bipolar transistor logic used on all IBM high end server products since the late 1960s. The 9672 product family was highly modular to promote simple part replacement and upgrades in the field. Water cooling was replaced by air cooling and the system floor area per unit of computing power was reduced 7x in comparison to the bipolar, water-cooled processors of the late 1980s. Total energy consumption was reduced by 13X and the heat generated per unit of computing power was reduced by over 10X. For the high end 9672 server product line power systems were significantly upgraded to maximize overall energy efficiency. The need for expensive isolation transformers was eliminated by utilizing a high voltage (350V) internal bus distribution system with a high power correction factor (> 0.98) and a designed in ability to plug into any customer supply ranging from 115-440 volts without a need for external adapters. The 9672 S390 Server family was the first IBM product which touted environmental attributes (Designing with a Green Pen) in addition to the traditional price/performance attributes.

In the mid 1990 most IBM hardware products were brought under a single management chain (now called Systems and Technology Group) which had the added benefit of centralizing responsibility for environmental design and compliance enforcement. Product Environmental Profiles (i.e. PEPs) had long been a basic product requirement and they were now brought under centralized control and administration. An IBM Engineering Specification (46G3772) was drafted in 1993 and by 1999 it was embedded in the title block for all IBM released engineering drawings. 46G3772 lists all reportable substances, banned substances, and it specifies all labeling requirements for hardware products.

WEEE AND RoHS (1)

The European Community WEEE (Waste Electrical and Electronic Equipment) directive 2002/96/EC and the European Community RoHS (Reduction of Hazardous Substances) directive 2002/95/EC became law in 2003. WEEE set collection, recycling, and reuses targets for all types of electrical goods and RoHS bans or restricts usage of 6 substances (lead, mercury, cadmium, hexavalent chromium, polybrominated diphenyl ethers (PBDEs), and polybrominated biphenyls (PBDs). WEEE went into effect immediately (in 2003),and required member states to transpose into National Law by August 13th, 2004, and producers to utilize the WEEE label by August 13th, 2005. RoHS was scheduled to be enforced in 2006.

In 2003 IBM initiated a RoHS conversion program across all product lines to be in conformance with EU directive 2002/95/EC. The IBM environmental specification 46G3772 was updated to include a new reporting requirement for suppliers. At the time neither the RoHS nor the WEEE regulations required supplier validation reports. However, in anticipation that either RoHS or WEEE (or both) would eventually require supplier validation documents IBM required such reports in the environmental specification 46G3772. Two years later (2005) the supplier reporting requirement became mandatory for complete RoHS compliance. In 2003 IBM also released two new RoHS engineering specifications (53P6233 and 97P3864) which spelled out exactly which materials a supplier could use to meet the RoHS requirements. IBM's standard practice is to never request RoHS compliant product but rather to ask for product to meet one of two IBM RoHS engineering specifications. 53P6233 allowed suppliers to continue using leaded solder joining processes, whereas 97P3864 required suppliers to use lead-free solder processes. 53P6233 is used for most IBM server and storage products whereas 97P3864 was used for IBM printers and is still used for Retail Stores Kiosk products. The WEEE directive 2002/96/EC resulted in further design changes to facilitate dismantling. RoHS required that a new sheet metal technology be developed for the low and medium range product lines to replace any hexavalent chromated zinc finishes still in use as of 2003. Even the high end nickel plated surface finish had to be modified to remove the lead content in electroless nickel plating. IBM requested, and received, two specific but temporary exemptions. One was for leaded compliant pin connector technology (exemption #11) and the second was for a C-ring gasket (exemption #12) that was unique to IBM. These temporary exemptions have been proposed for phase out by 2010, and replacement technologies have already been implemented. There were over 3 dozen exemptions listed in the regulations and a list of the more relevant exemptions re IBM products is listed in Table 1 (below) along with the newly proposed numbering system and the newly proposed exemption wording.

Table I: Relevant exemptions re IBM products

Current #	Current Exemption Description	New #	New wording IBM Proposal thru Digital Europe @ 1/2010
3	Mercury in straight fluorescent lamps for special purposes	3a 3b 3c	Mercury in cold cathode fluorescent lamps Mercury in medium length cold cathode and external electrode fluorescent lamps not exceeding 5mg per lamp until 12/31/2012 Mercury in long length cold cathode and external electrode fluorescent lamps not exceeding 13 mg per lamp until 12/31/2012.
5	Lead in glass of cathode ray tubes; electronic components, and fluorescent tubes	5a 5b 5c	Lead in cathode ray tube glass until 7/31/2014 Lead in fluorescent tube glass tubes not to exceed 0.2% by weight until 7/31/2014 Lead in glass or ceramic other than a dielectric ceramic, or in a glass or ceramic matrix compound until 7/31/2014…and for the repair and reuse of equipment put on the market before 1/1/2015.
6	Lead as an alloying element in steel up to 0.35% by weight, aluminum up to 0.4% by weight, and copper alloys up to 4% by weight until 6/31/2013.	6a 6b 6c	Lead as an alloying element in steel for machining and in galvanized steel up to 0.35% by weight to 12/31/2013. Lead as an alloying element in aluminum up to 0.4%by weight to 12/31/2013. Lead in copper alloys up to 4% by weight to 12/31/2013. .
7a	Lead in high melting solders with lead content > 85% by weight.	7a	Lead in high melting solders with lead content >85% by weight until 6/30/2013 and lead in such solders for the repair and reuse of equipment put on the market before 7/1/2013.
7b	Lead in solders for servers, storage, network infrastructure, and telecommunications	7b	Lead in solders for servers, storage, network infrastructure equipment until 7/31/2014 and for repair and reuse of equipment put on the market before 8/1/2014.

	equipment		
7c	Lead in electronic ceramic parts	7c1 7c2 7c3	Electrical components which contain lead in a glass or ceramic other than a dielectric or in a glass or ceramic matrix compound until 7/31/2014 and for the repair and reuse of equipment put on the market before 8/1/2014. Electrical components containing lead in a dielectric ceramic rated at 125V AC/250V DC or higher until 7/31/2014 and for the repair and reuse of equipment put on the market before 1/2/2013. Electrical components containing lead in a dielectric ceramic rated at less than 125VAC/250VDC until 12/31/2012 and for the repair and reuse of equipment put on the market before 1/1/2013.
8	Cadmium and its compounds in electrical contacts and plating …with exceptions	8a 8b	Cadmium and its compounds in one shot pellet type thermal cut offs until 12/31/2011 and in thermal cut offs used for reuse and repair of equipment put on the market before 1/1/2012 Cadmium and its compounds in electrical contacts until 7/31/2014 and in electrical contacts in spare parts used for the repair and reuse of equipment put on the market before 8/1/2014.
9b	Lead in lead-bronze bearing shells and bushings	9b	Lead in bearing shells and bushings for refrigerant-containing compressors for HVACR applications with expiry date of 7/31/2014
11	Lead used in compliant pin connector systems	11a 11b	Lead used in C-press compliant pin connector systems until 6/30/2010 and for the repair and/or reuse of equipment put on the market before 7/1/2010 Lead used in “other” than C-press compliant pin connector systems until 12/31/2012 and for the repair and/or reuse of equipment put on the market before 1/1/2013.
12	Lead as a coating material for the (IBM) thermal conduction module c-ring	12	Lead as a coating material for the (IBM) thermal conduction module c-ring until 6/30/2010 and for the repair and/or reuse of equipment put on the market before 7/1/2010
14	Lead in solders consisting of more than two elements for the connections between the pins and the package of (AMD) microprocessors with a lead content of more than 80% and less than 85% by weight	14	Lead in solders consisting of more than two elements for the connections between the pins and the package of (AMD) microprocessors with a lead content of more than 80% and less than 85% by weight until 12/31/2010 and for the repair and/or reuse of products put on the market
15	Lead in solders to complete a viable electrical connection between semiconductor dies and carriers within integrated circuit Flip Chip packages	15	Lead in solders to complete a viable electrical connection between semiconductor dies and carriers within integrated circuit Flip Chip packages until 7/31/2014 and for the repair and/or reuse of equipment put on the market before 8/1/2014.

Table I shows certain particularly relevant (to IBM) exemptions. There are over 40 exemptions under consideration as of 2/2010 and they are all enumerated in a report from the OKO- Institut titled *Adaption to Scientific and Technical Progress under Directive 2002/95/EC*. The OKO-Institut is the consultant to the European Union commission on technical matters relative regarding RoHS substance restrictions. The latest (as of 3/3/2010) official document regarding exemptions is from the European Commission to the World Trade Organization (WTO) which can be found at:

http://members.wto.org/crnattachments/2010/tbt/eec/10_0491_00_e.pdf.

Elimination of some exemptions in Table I will be particularly problematical as there are no readily apparent satisfactory solutions. A case in point is exemption 7a. Exemption 7a is for high lead content (>85% lead) solder and it is key to two very important applications. One application is for solder bump connections (called C-4 joints within IBM and Ball Grid Arrays in industry) that have to carry very high currents. Electro-migration failures are prevented by keeping the lead content above 85% in the individual solder bumps. The general industry solution for lead-free solder bumps is currently a Tin-Silver-Copper (SAC) solder with the silver content generally ranging between 3-4% by weight. These SAC solders do not have the electro-migration resistance of the high lead-content solder bumps and the solution that will most probably succeed is a copper stud technology which attaches to the chip and substrate with a relatively small amount of lead-free solder. Exemption 7a also covers the power "die attach" application where the backside of a power MOSFET is coated with high-lead solder with a melting point above 300 ^{o}C so that the subsequent SAC solder joining operation on the front side (at temperatures between 230-260 ^{o}C) does not re-melt the backside die attach joint. In addition to the temperature hierarchy there are considerations of electrical conductivity/thermal conductivity/and mechanical stress that have to be considered. Again, this author is not aware of any imminent industry solutions to this application and it appears that industry will require a continuing EU RoHS exemption for this power MOSFET die attach exemption in the 2012 time frame.

Another problematical exemption is #6 (to be renumbered as 6a, b, c) which covers lead alloying content in steel, aluminum, and copper. Lead alloying in steel, aluminum and copper is done primarily for machinability but it is also done to improve wear resistance (on bushings for example). The above mentioned OKO-Institut report states that no satisfactory substitute for lead alloying has yet been found and the report further states that the general consensus is that no satisfactory solution is likely to be found since the research to date has been extensive and without result. It is not clear how the European Union will act on this exemption x at this time. Elimination of this exemption would have a very large cost impact on industry in general. Modern machine tools can probably fabricate lead-free alloys and maintain dimensional specifications but cycle times (time to produce a final product) would be considerably lengthened. Threaded fasteners can be roll formed rather than machined with little or no impact on cost, but more complicated pieces would see very significant cost increases.

Exemption #7a (hi-lead solder) is currently due to phase out in 2013. Exemption #7b (lead solder joining for servers, storage, and telecommunication hardware) is scheduled to phase out in 2014 as is exemption #15 (lead solder joining for flip chip connections). Extensive research and development has been conducted in industry consortia and in internal research to find and qualify suitable replacement solder processes for most of these lead solder exemptions. The major problems have been with very large, multiple level processor boards with components of widely varying thermal masses. New board materials have been developed to handle the higher temperatures required for lead-free SAC (tin-silver-copper) soldering processes. Almost all the research has focused on SAC (tin-silver-copper) solders as the replacement for eutectic tin-lead solder although there has been some work on tin-bismuth solder. At this point in time it appears as if SAC solders will be successfully developed as an "adequate" replacement for eutectic tin-lead solder joining but problems still remain to be resolved with the replacement of high-lead content (>85% lead) solders in high current applications.

Pure tin platings have been widely implemented on lead-frame surface mounted devices since about 2004-2005. A major concern in this time frame was the reliability risk associated with an increased tendency to "whisker" on the part of pure tin plating relative to lead-tin plating. Since the early 1960s lead has been added to tin platings at amounts ranging from 3-10% to mitigate tin whisker formation. Tin whiskers are filamentary growths that spontaneously grow from tin film surfaces and these filaments are conductive and can cause electrical shorts if they occur in the wrong places on circuit boards. Figure 1 is a micro-graph of a tin whisker with a pronounced "kink" (i.e. change in direction). Most tin whiskers are less than 100 microns in length but some whiskers have been observed that are hundreds and even thousands of microns in length. Almost all commercial electronic components have lead-frame/pin spacings greater than 250 microns so only the longest tin whiskers could possibly cause these devices to have shorting problems. Nonetheless, the electronics industry was concerned enough about whisker shorting problems that iNEMI (the International Electrical Manufacturers Institute-an industry consortia) initiated several working committees in 2002/2003 that were concerned with one aspect or another of tin whiskers. These working committees culminated in a JEDEC standard (201-A) that defined acceptable tin whisker qualification practices that would, if implemented, significantly mitigate (i.e. reduce) the probability of whisker occurrence in "commercial" applications. It was clearly understood that these qualification practices would probably not be effective for aerospace/military applications and they might not be effective in highly corrosive environments. A joint JEDEC/IPC Guideline document (JP002) outlined mitigation practices for adding additional whisker formation resistance over and above the JEDEC 201A qualification criteria. These mitigation practices were:

a) A component anneal at 150 ^{o}C for one hour minimum within 24 hours after tin plating.
b) Use of a 1 micron (minimum) Nickel underlay.
c) Reflow (or fusing) of the tin plating.

d) Bismuth as an alloy in tin plating at concentrations of 3 to 7 or 8% by weight.

For most active/passive electronic components the most common mitigation practice is (a) the 150 ^oC anneal. The connector industry does utilize (b) the Nickel underlay which is both a whisker mitigator and a means of improving the wear properties of the connector. This author knows of no major electronic suppliers utilizing either (c) or (d) (reflow or bismuth additions).

The 150 ^oC anneal is troubling to some because it is thought that there is no way to check after the fact whether or not annealing was actually performed on the device. In fact, there is a way to determine after the fact whether annealing has been performed. Annealing results in a more complex inter-metallic formation at the tin film/copper substrate interface than would otherwise be the case. With annealing, a Cu_3Sn inter-metallic forms between the copper substrate and the Cu_6Sn_5 inter-metallic. Cu_3Sn is morphologically different (i.e. clearly evident) and clearly distinguishable under the microscope. If you don't "see" the Cu_3Sn inter-metallic it is clear evidence that there was no annealing done on the part in question. Diffraction analysis can also be used to definitively identify the different inter-metallics.

The above mitigation practices have been very successful for the commercial electronics industry to date. However, with the advent of component spacing as small as 75 microns these mitigation practices may no longer be "good enough". There is some evidence that SAC solders grow whiskers on the order of 10-50 microns under conditions of normal processing and ambient storage. So these JEDEC mitigation practices which were very effective for devices with lead spacing >250 microns will in all likelihood need to be revised to deal with component spacing that go below 100 microns. The aerospace industry continues to have concern with tin whiskers and they do not depend upon the JEDEC mitigation practices for their most severe applications. Aerospace firms routinely either coat their componentry with a hard, polyurethane conformal coating or they strip the pure tin plating and re-plate with a tin-lead solder. The iNEMI whisker fundamentals consortia disbanded in 2006 after the JEDEC standards were adopted. There remains an iNEMI whisker test method committee under the chairmanship of Richard Parker from Delco Corp. which has continued to develop whisker acceleration test methodology. The aerospace industry still maintains an active consortia (CALCE) dealing with whisker reliability issues. CALCE is under the direction of the University of Maryland, College Park, Maryland. Some funding for post-graduate whisker research has been available from the National Science Foundation and government research laboratories. Hitachi has a very active research activity on tin whiskers and the Max Planck Institute in Germany has done some recent work on characterizing the state of stress in whisker forming tin films. In the U.S. the National Institute of Science and Technology (NIST) at Gaithersburg, Md. maintains a continuing research interest on whisker topics. There has been a considerable body of published research about tin whiskers and iNEMI (the International Electrical Manufacturer's Institute maintains a comprehensive soft copy library. iNEMI is at 2214 Rock Hill Road-Suite 110, Herndon, VA (20170-4214).

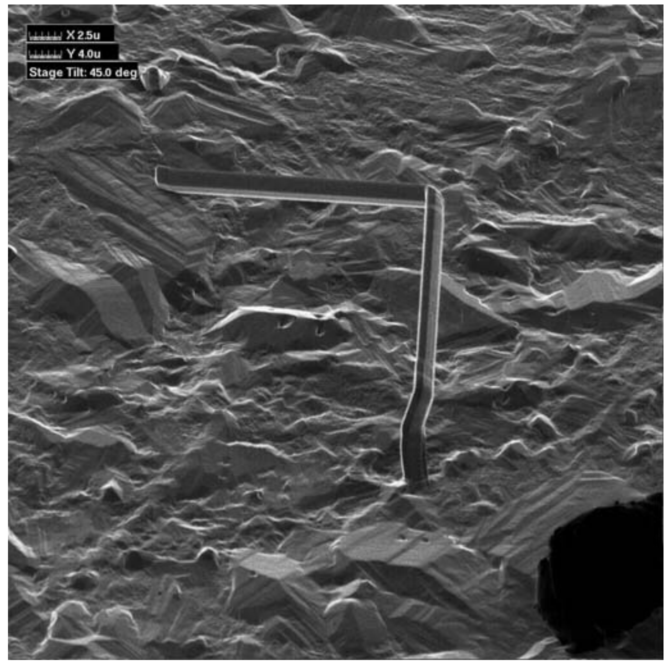

Figure 1 – a Filamentary Tin Whisker with a kink

CHINA RoHS (3)

China RoHS was enacted in March of 2007 and required that a "Hazardous Substances Table" (HST) be included with all electronic information product shipments to China. The HST lists the same materials banned by the EU RoHS and checks off the ones that apply to the product being shipped into China. The "banned materials" are not currently proscribed by China RoHS. China just wants to be informed via the HST which of the banned materials is contained in the product being shipped into China. At some future time the China RoHS regulations will likely restrict the use of certain hazardous substances in certain product types, and require that products be certified at a qualified (qualified by the Chinese government) testing laboratory with respect to banned material content.

RoHS AND OTHER GEOGRAPHIES

Japan, South Korea, Croatia, Iceland, Turkey, New York City, the State of California, Liechtenstein, Monaco, Norway, San Marino, Switzerland, Vatican City, French Guiana, and French Polynesia have all adopted RoHS like regulations in recent years and several other jurisdictions (e.g., Australia, Brazil,) are considering similar legislation. Some Corporations have requested RoHS compliance for their electronic hardware purchases even if those Corporations are in jurisdictions that do not currently require RoHS compliance. Japan's RoHS regulations apply to personal computers, copier machines, washing machines, etc. Table II lists the product categories (column 1) affected by Japan's RoHS regulations along with the applicable METI regulation/s (columns 2 and 3).

FUTURE RoHS AND WEEE REVISIONS

In 2008 the European Commission posted some proposed changes to the RoHS directive on their web site: http://ec.europa.eu/environment/waste/weee/index_en.htm. No new "banned materials were proposed but there were some proposed additions to "Annex III" which is a list of substances under "consideration" for a future ban. The European Parliament (EP) subsequently amended both Annex III (Banned) and Annex IV (Reportable) as proposed by the commission. Table III (banned substances-see below) shows a comparison between the Annex III substances as recommended by the European Commission (EC) and the amendments proposed by the European Parliament (EP). Table IV shows a similar comparison for Annex IV substances:

Table II - Japan RoHS

Personal computers	METI No. 62	METI No. 77
Unit air conditioners	METI No. 63	METI No. 78
Copy machines		METI No. 81
Televisions	METI No. 66	METI No. 82
Microwave ovens	METI No. 67	METI No. 83
Dryers	METI No. 68	METI No. 84
Refrigerators	METI No. 69	METI No. 85
Washers	METI No. 70	METI No. 86

Table III – Banned Substances

Annex III substances as proposed by the EC	**Annex III substance amendments from the EP**
Hexabromocyclododecane	Arsenic compounds
Bis (2-ethylhexyl) Phthalate	Beryllium and its compounds
Butyl Benzyl Phthalate (BBP)	Antimony trioxide
Dibutylphtalate (DBP)	Denickeltrioxide
	Bisphenol A
	Organobromines other than brominated flame retardants
	Organochlorines other than chlorinated flame retardants or plasticisers

Table IV- Similar Comparison

Annex IV substances as proposed by the EC	**Annex IV substance amendments from the EP**
Lead (0,1%)	Brominated flame retardants (0,1%)
Mercury (0,1%)	Chlorinated flame retardants (0,1%)
Cadmium (0,01%)	Polyvinylchloride (PVC) (0,1%)
Hexavalent Chromium (0,1%)	Chlorinated plasticisers (0,1%)
Polybrominated biphenyls (PBB) (0,1%)	Bis (2-ethylhexyl) Phthalate (DEHP) (0,1%)
Polybrominated diphenyl ethers (PBDE) (0,1%)	Butyl Benzyl Phthalate (BBP) (0,1%)
	Dibutylphtalate (DBP) (0,1%)

The above proposed changes in Tables III and IV can be found in the report from the Environmental Committee of the European Parliament as released on December 14th, 2009 and can be found on the web at: http://members.wto.org/crnattachments/2010/tbt/eec/10_0491_00_e.pdf. In addition to the proposed changes in Annexes III and IV the Commission recommended a RoHS conformance label requirement and they also recommended expanding the RoHS scope of to include medical devices and regulation/control equipment. The earliest anticipated date for implementation of these proposed changes would be mid 2012.

The proposed WEEE changes include a clarification on some of the more ambiguous criteria such as “put on the market”, “making available on the market”, and “remove from the market”. Harmonization of requirements across national boundaries will be improved with the objective of allowing a WEEE registration in one country also to be acceptable for registration in any other EU jurisdiction. There is a proposed increase in the collection target (currently set at 4Kg/capita per year) to 65% of the weight of products put “on the market” in the two preceding years. This new collection target is proposed to go into effect in Y2016.

REACH (Regulation, Evaluation, Authorization-Chemicals)

In 2006 the EU adopted a set of chemical usage restrictions (REACH) that required electronic hardware manufacturers to analyze all substances and substances in “articles” to determine, and report, whether there was any content on the REACH list of “substances of very high concern.”

Reporting requirements were established if the total weight of listed substances exceeded1 ton per year. The initial input on substances of very high concern ran to thousands of chemicals. The initial REACH legislation listed15 SVHC but it was understood that this list would grow over time. Table V list the original 15 SVHC substances. Table VI shows the amendments to the list as of January 2010. Table VII shows the proposed amendments under discussion as of January 2010.

Table V - list the original 15 SVHC substances

Candidate List Substance	Found In Hardware / EEE (yes/no)
3 phthalate plasticizers: DEHP, DBP and BBP	Yes – PVC, Rubber
HBCDD	Yes – High impact polystyrene
SCCP	Possible – rubber, sealants, etc
Bis(tributylin)oxide	Possible – polyurethane foam
Cobalt dichloride	Possible – blue silica gel (desiccant)
Diarsenic pentoxide	Very unlikely – specialist glass
Diarsenic trioxide	Very unlikely – specialist glass
4,4’-Diaminodiphenylmethane	No
Anthracene	No
Sodium dichromate (dehydrate form)	No
Musk xylene	No
Lead hydrogen arsenate	No
Triethyl arsenate	No

Table VI - amendments to the list as of January 2010

Candidate List Substance	Found In Hardware / EEE
Plasticizer: Disobutyl phthalate	Yes – cellulose resin, vinyl resin, acrylonitrile-butadiene rubber, chlorinated rubber, PVC
Flame retardant: Tris (2-chloroethly) phosphate	Yes – polyurethane foam, polyisocyanurate foam, PVC, acetyl cellulose, polystyrole

Lead chromate, lead chromate molybdate sulfate red, lead sulfochromate yellow	Lead compound already restricted under RoHS
2,4-Dinitrotoluene	No
Five variants of anthracene oils and pastes	No
Aluminosilicate and Zirconia Aluminosilicate refractory ceramic fibres	No
Acrylamide	No
Coal tar pitch	No

Table VII - Proposed amendments under discussion as of January 2010.

Found In Hardware / EEE* Still to be reviewed by IBM REACH team	**Candidate List Substance – CAS #**
Yes - Cleaning and degreasing of metal parts Solvent in adhesives Intermediate in the manufacture of chlorinated and fluorinated organic compounds	Trichloroethylene 79-01-6
Yes – Uses include a multitude of applications, e.g., in biocides and preservatives, personal care products, food additives, glass, ceramics, rubber, flame retardants, paints, industrial fluids, soldering products, film developers.	Boric acid 10043-35-3 / 11113-50-1
Yes -Uses include a multitude of applications, e.g.; in glass and glass fibers, ceramics, detergents and cleaners, industrial fluids, metallurgy, adhesives, flame retardants,	Disodium tetraborate, anhydrous 1330-43-4 12179-04-3 1303-96-4
Yes -Uses include a multitude of applications, e.g. in glass and glass fibers, ceramics, detergents and cleaners, industrial fluids, metallurgy, adhesives, flame retardants.	Tetraboron disodium heptaoxide, hydrate12267-73-1
Yes -Laboratory (analytical agent) Manufacture of other chromium compounds	Sodium chromate 7775-11-3
Yes - Oxidizing agent Laboratory (analytical agent) Tanning of leather Manufacture of textiles Manufacture of photosensitive screens (cathode ray tubes) Metal treatment	Ammonium dichromate 7789-09-5
Yes -Chrome metal manufacturing Treatment and coating of metals Manufacture of reagents and chemicals Laboratory (analytical agent) Cleaning of laboratory glassware Photolithography Wood treatment Corrosion inhibitor in cooling systems	Potassium dichromate 7778-50-9
Yes -Treatment and coating of metals Manufacture of reagents and chemicals Coloring agent in ceramics Manufacture of pigments/inks Laboratory (analytical reagent) · Pyrotechnics	Potassium chromate 7789-00-6

Article 33 of the REACH regulations requires that product importers with content >0.1 weight percent of the substances listed in Tables V and VI (and eventually VII):

a) declare such content with the REACH authorities
b) notify commercial users immediately upon their receipt of such substances
c) notify household users within 45 days of their receipt of such substances

Reach Article XVII proscribes usage of 59 substances most of which do not apply to electronic hardware. Two substances, cadmium (Cd) and nickel (Ni), are proscribed in certain applications. E.g., cadmium is proscribed as a paint or coloring agent. This proscription required cable manufacturers to phase out cadmium based marking inks. Cadmium plating was (voluntarily) eliminated as finish plating for electronic components in the early 1950s due to cadmium's propensity to form metallic whiskers. Nickel is also proscribed by REACH for applications where the article comes in contact with skin. Skin contact is uncommon for most electronic hardware and nickel is still widely used as finish plating for electrical connectors and sheet metal.

REACH also restricts usage of polymeric materials but this aspect of REACH is quite complicated. If the polymeric material is part of an article it is not restricted by REACH. However, if the polymeric substance is imported as a substance REACH regulations do apply. Specifically, the importer is required to register the substance and provide REACH authorities the complete monomer make up for any imported polymeric substance. This is a very problematic aspect of REACH and especially so for top end importers like IBM. Almost all polymer substance manufacturers consider monomer makeup to be proprietary information and they do not wish to make such information available to REACH or anyone else for that matter. Fortunately, REACH regulations do not apply to polymeric substances procured within the European Union. So all polymeric substances shipped by IBM in support of electronic hardware purchases within the European Union are procured within the European Union thereby circumventing the REACH reporting requirement.

FUTURE MATERIAL RESTRICTIONS

Individual countries, cities, and other political subdivisions have enacted legislation concerning product take-backs, battery labeling, mercury usage, the use of specific brominated fire retardants, etc. . As we look forward we see these regional restrictions proliferating world wide. We also anticipate regulatory enactments regarding the use of phthalates (a plasticizer), some halogenated flame retardants, and polyvinyl chloride (PVC).

ENERGY EFFICIENCY

Energy efficiency standards are moving from the voluntary to the mandatory. At the present time the energy standards (both voluntary and the proposed mandatory) are focused on 115/230 volt multi and single output, single phase, power supplies used on low to mid level server systems. Discussions have begun under ENERGY STAR® for Storage power systems and requirements are expected to mimic those for server power supplies. High end, 3-phase power systems have been unaddressed to date with respect to both testing methodology and energy efficiency metrics.

There will need to be some industry work on addressing a common position on idle power metrics which realistically assess the way that power is actually used in the customer applications. The current approach is to set specific idle power limits for servers. To date this has been done for 1 and 2 processor socket servers in ENERGY STAR® with various national requirements being discussed. ENERGY STAR, and some jurisdictions, is pursuing workload based server metrics either in addition to or in lieu of idle power metrics. The industry position is to integrate idle measurements into a workload based performance/power analysis. A similar discussion is underway under the auspices of ENERGY STAR for storage systems, though it is in the early stages.

Similarly, there will need to be an industry agreement on a 3-phase power measurement methodology similar to the current agreements on single phase power testing methodology.

MINING AND THE ENVIRONMENTAL

Another environmental area of concern is responsible mining of raw materials.. To date most electronic hardware environmental regulations have focused on landfill usage and related issues like recycling. The ODC (ozone depleting chemicals) regulation of the early 1990s focused on processes used to manufacture hardware. IBM's 1992 Hexavalent –chromium elimination program was based on manufacturing process concerns as was the elimination of methylene chloride and solvent paints. The electronic industry will probably be under increasing governmental pressure to "certify" that their material supply chain conform to certain "standards" for responsible and sustainable" mining operations.

E.G. TIN MINING IN INDONESIA

For residents of the resource-rich Bangka-Belitung Islands province in Indonesia, unlicensed undersea tin mining is a way of life. "You say illegal, we say legal," said Jahoi, a 25-year-old illicit miner, who has spent the past eight years diving for tin sands in the waters off Permis, on the island of Bangka, east of Sumatra In 2009 the Indonesian Department of Energy and Mineral Resources outlined plans to limit tin exports. Indonesia, the world's biggest exporter of tin and second largest producer after China, confirmed plans to limit tin production in a bid to support prices and extend the life of the local industry. It is believed that production problems at PT Timah are one cause behind the government's decision to limit production. The company is expanding its offshore dredging capacity, but in the short-term this may be offset by falling onshore production. The declining supply from its onshore mining areas was partly due to a policy allowing “small” miners to operate on PT Timah properties and (illegally) sell to third parties rather than Timah.

CONCLUDING REMARKS

It seems clear that environmental attributes are becoming an increasingly greater consideration for the electronic hardware industry requiring continual attention and diligence. The penalties for “not conforming” are serious and include fines, jail time, exclusion from markets, bad publicity, etc. All engineering disciplines and all technical societies should expand their scope to become at least aware of, if not skilled in, environmental engineering, alternative technologies in chemistry and bio-industrial and or bio-medical technologies with respect to electronics. We are glad to see the SMTA leading the way with respect to environmental awareness.

REFERENCES

1] EU RoHS EU RoHS: “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”, Official Journal of the European Union L 37/19

[2] EU REACH: “Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 Concerning the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH), Establishing a European Chemicals Agency, Amending Directive 1999/45/EC and Repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC”; Official Journal of the European Union L 396/1

[3] China RoHS (Restriction of Hazardous Substances), officially known as Administrative Measure on the Control of Pollution Caused by Electronic Information Product http://www.chinarohs.com/

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