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ENVIRONMENTAL LEGISLATION THAT EXPORT ORIENTED CANADIAN ELECTRONICS MANUFACTURERS SHOULD TAKE INTO CONSIDERATION

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Canadian electronics manufacturers face chemicals regulations around the world, including RoHS (EU, China, South Korean, Turkey), REACH, PFOS/PFOA, Californian legislation, CMP, and emerging conflict minerals legislation. This paper reviews some of the highlights of these different topics related to chemical restrictions.

RoHS

While it's not the earliest environmental legislation of interest to the electronics industry, the European Union's Restriction of Hazardous Substances (RoHS)[1] certainly has the current attention of electronics manufacturers in Europe and companies wishing to sell electronics into the EU.

Issued in 2003 and coming into force in 2006, while the electronics industry was essentially asleep, this directive is now proclaimed as the law of the land in the individual countries of the EU. Although by now every electronics manufacturer of note must know the basic requirements of the directive, they are presented here. At the "homogeneous materials that are mechanically separable level" products must not contain:

- lead, mercury, chromium in the plus six oxidation state (usually abbreviated as Cr(VI)),
- polybrominated biphenyls (PBB) and polybrominated diphenyl ethers (PBDE) in concentrations more than 1000 ppm,
- cadmium in concentrations higher than 100 ppm.

The primary feature that makes compliance with RoHS easier is the rather extensive set of exemptions. As of October 6, 2009 there are thirty-eight (38) active exemptions. Twenty-seven are for lead, five for mercury, four are for cadmium, one is for Cr(VI) and one is for lead and cadmium.

Exemptions 9a (decabromodiphenyl ether (decaDBE)), 10 (connectors), 28 (Cr(VI) on steel enclosures) and 35 are gone. Exemption 35 for cadmium in photoresistors for optocouplers disappeared December 31, 2009. Exemption 36 for mercury as a cathode sputtering inhibitor in DC plasma displays will be removed July 1, 2010.

The other four exemptions for mercury all have to do with lighting. The Cr(VI) exemption has nothing directly to do with manufacturing printed circuit packs. Twelve exemptions for lead plus the lead/cadmium exemption are related to lighting and/or glass. Six of the exemptions for lead are for solders.

Generally speaking, the exemptions for lead most important to the electronics manufacturing industry are those that deal with:

- metal alloy machining aids,
- lead in ceramics (e.g. lead titanate) and glasses used for manufacturing electronic components,
- high lead solders,
- lead exemptions for small components (e.g., flip chips and fine pitch leaded components).

China RoHS[2] mirrored the EU version in restricted substances and concentration limits, but initially did not allow any exemptions. That is no longer the case. The other main difference is that China RoHS requires unique labeling about the "safe use" period of the product.

Here are some updates on the implementation of China RoHS:

- Catalogue - The first batch of products in the catalogue includes mobile phones. Ministry of Industry and Information Technology's (MIIT) original plan was to publish the catalogue early in 2010, then get it implemented by the end of 2010. However, it has not yet been sent for World Trade Organization/Technical Barriers to Trade (WTO/TBT) notifications, which will take three months for comments. The new timeline for publishing the catalogue is likely to be postponed to July-August 2010. With a six month grace period, the catalogue will take effect next year.
- Certification - Products included in the catalogue will eventually be subject to mandatory China Compulsory Certification (CCC). However, MIIT and Certification and Accreditation Administration of China (CNCA) have not figured out the certification process, as this will be an inter-agency certification project involving different labs. MIIT plans to launch a pilot voluntary certification process as an interim measure before the mandatory CCC is ready.

In terms of compliance, it requires a self-declaration page in the product box and RoHS label on the product and some accessories.

The Turkish version of RoHS, which went into effect in June of 2009, appears to mirror the EU version in terms of affected electronic and electrical devices, substances targeted and the concentration limits. The exemption list does appear to be somewhat dated, at least the English language version posted on the buyusa.gov web site.[3]

South Korea's effective date for their RoHS legislation was January 1, 2008. It states that there are restrictions on the use of hazardous substances "such as heavy metals and flame retardants". The act provides only the framework for holding producers and importers responsible for their use of resources. The specifics are still to be decided by the Ministry of Environment (MoE), which will have an advisory Eco-Assurance Review Committee. Standards concerning hazardous substances and improvements in materials and structure will be decided jointly with the Ministry of Commerce, Industry and Energy. The act's effective date of January 1, 2008 will not mean much until a number of decisions are issued by presidential decree, on the use of hazardous substances. These include the hazardous substances to restrict and the concentration limits, exemptions and the length of each exemption, and publication of *Analysis Methods of Hazardous Substances.*[4] The act also appear to have a heavy punitive aspect.

REACH

The EU's REACH[5] is somewhat different in that:

- it has a much wider scope than the electronics industry,
- tens of thousands of substances are being scrutinized,
- substances are not to be added to the list of substances of very high concern (SVHC) without solid science behind the decision, and
- the limit for SVHC is 0.1% by weight of the article, which makes testing much less onerous in terms of disjointment of the item in question and the number of tests that have to be carried out.

Table 1 contains the latest, expanded list of SVHC. They are more or less arranged in decreasing order of concern to manufacturers of electronic devices. Almost certainly one or more the listed phthalates are used as plasticizers in the polyvinyl chloride (PVC) power cords of electrical and electronic devices. Cobalt chloride has been used as a simple humidity indicator for decades, either on calendars or on indicator cards inserted into hermetically sealed component packages. Next are three flame retardants not normally used in the electronics manufacturing industry, but it cannot be definitively said that they are not used. The three arsenic compounds would not exist in the listed form in any finished electronic product, but could be used by IC manufacturers in their processes. The next three are miscellaneous materials used for quite specific purposes that could conceivably be in electronic products associated with ocean going vessels (TBTO), freezers (DNT) and frames and cabinets (MDA), respectively. All the lead and chromate containing compounds are already covered by RoHS, so for the electronics industry there is nothing new here. Certainly there is little to no concern for the rest of the substances listed.

Billions of kilograms of phthalates are produced every year. They are not added to polyvinyl chloride in the ppm range, but rather in concentrations of 20 – 55%, making them a major constituent of electrical power cord sheathings, not just a minor additive. As a result, in most cases they can be detected by infra-red spectroscopy. Definitive analysis requires stripping off the plastic sheathing, liberating the phthalates with powerful organic solvents and testing using gas chromatography/ mass spectrometry (GC/MS) or high pressure liquid chromatography (HPLC).

It is quite likely that the SVHC list will grow quickly in the next few years and may include compounds of interest to the electronics industry. In a news alert put out January 28, 2010, European Chemicals Agency (ECHA) classified and labeled indium phosphide (of interest to our industry), di-tert-butyl peroxide and trixylyl phosphate as carcinogen, mutagen and/or toxic for reproduction. They will likely be the next candidates to be added to SVHC.

Dimethyl Fumarate, PFOA, PFOS

Some parts of China are very hot and humid. This means that making products out of former living tissue like leather can be a challenge because of the possibility of mold forming on the unfinished hides and/or the completed product. Dimethyl fumarate is a very good anti-mold agent. Recently, leather furniture made in China was shipped into the EU with disastrous results. The manufacturers put small packets of silica impregnated with dimethyl fumarate inside the furniture. The affects to some consumers are as shown in Figures 1 and 2. As a result, the EU published a directive[6] on March 17 that came into effect May 1, banning the use of dimethyl fumarate in leather above 0.1 % by weight. Even this might be too high for many people. All electronic manufacturers selling leather accessories with their products (leather backing, leather cases, holders, suitcases and promotional items like purses and belts) should be aware of this potentially harmful chemical and take appropriate actions to protect their company, employees and customers.

Perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) are materials that are extremely long lived. According to the US EPA PFOS "appears to combine persistence, bioaccumulation and toxicity properties to an extraordinary degree."[7] The latter was used in 3M's Scotchguard™ products. PFOA is made by DuPont. To their credit, 3M voluntarily stopped production once the information was known. Specific to our industry, these materials have been used for extremely fine photolithography and certain connector manufacture. PFOA is durable, flame proof and slippery. It is everywhere and "every molecule that has ever been created is still around and will be around or the foreseeable future."[8] In mice it causes birth defects, developmental problems, hormone disruption and high cholesterol, and the EPA considers it a "likely carcinogen".[8] Work continues to definitively determine whether these chemicals affect humans in the same way.

Table 1 SVHC as of January 13, 2010.

Substances	Reason for Inclusion on SVHC List	Industrial Uses
Benzyl butyl phthalate (BBP)	Toxic for reproduction	Plasticizers
Bis (2-ethylhexyl)phthalate (DEHP)	Toxic for reproduction	Plasticizers
Dibutyl phthalate (DBP)	Toxic for reproduction	Plasticizers
Diisobutyl phthalate (DIBP)	Toxic for reproduction	Plasticizers
Cobalt dichloride	Carcinogenic	humidity indicator
Hexabromocyclododecane (HBCDD)	PBT	flame retardant
Short Chain Chlorinated Paraffins (C10-13)	PBT and vPvB	flame retardants, plasticizers, paints & coatings, additives in metal working fluids & in sealants
Tris(2-chloroethyl)phosphate	Toxic for reproduction	Polyester resin flame retardant
Diarsenic pentaoxide	Carcinogenic	Precursor of arsenide semiconductors and used in glasses
Diarsenic trioxide	Carcinogenic	Precursor of arsenide semiconductors and used in glasses
Triethyl arsenate	Carcinogenic	Used as a specialized intermediate in semiconductor doping. NOT in final product.
Bis(tributyltin)oxide (TBTO)	PBT	Pesticide, anti-fouling agent in paints
2,4-Dinitrotoluene (DNT)	Carcinogenic	Plasticizers & starting material for polyurethane foams
4,4'- Diaminodiphenylmethane (MDA)	Carcinogenic	Hardener in epoxy resins and adhesives
Lead chromate	Carcinogenic and toxic for reproduction	Already covered by RoHS
Lead chromate molybdate sulphate red (red pigment)	Carcinogenic and toxic for reproduction	Already covered by RoHS
Lead hydrogen arsenate	Carcinogenic and toxic for reproduction	Already covered by RoHS
Lead sulfochromate yellow (C.I. Pigment Yellow 34)	Carcinogenic and toxic for reproduction	Already covered by RoHS
Sodium dichromate	Carcinogenic, mutagenic & reproduction toxin	Already covered by RoHS
Aluminosilicate Refractory Ceramic Fibers	Carcinogenic	
Zirconia Aluminosilicate Refractory Ceramic Fibers		
Anthracene	PBT	
Anthracene oil	Carcinogenic, PBT and vPvB	
Anthracene oil, anthracene paste	Carcinogenic, mutagenic, PBT and vPvB	
Anthracene oil, anthracene paste, anthracene fraction	Carcinogenic, mutagenic, PBT and vPvB	
Anthracene oil, anthracene paste, distn. lights	Carcinogenic, mutagenic, PBT and vPvB	
Anthracene oil, anthracene-low	Carcinogenic, mutagenic, PBT and vPvB	
Pitch, coal tar, high temp.	Carcinogenic, PBT and vPvB	
5-tert-butyl-2,4,6-trinitro-m-xylene (musk xylene)	vPvB	

Figure 1 BBC NEWS Friday, 27 March 2009.

Fig 1. Patient 4 presented with a severe dermatitis.

Figure 2 Cover of British Journal of Dermatology, May 22, 2008.

The EU published their directive on the materials December 27, 2006, prohibiting the sale of a finished or semi-finished product or parts and components containing PFOS in an amount of or above 0.1% (1000ppm) of total mass or concentration. The Directive is effective from the date of publication, and member countries were to implement related restrictions from June 27, 2008. This paper's author has not confirmed that each EU country has done so. Also, notice of a draft regulation for PFOS was published in the Canada Gazette, Part I on December 16, 2006.

Canadian Chemicals Management Plan

The Canadian Chemicals Management Plan (CMP)[9] is a prodigious undertaking by Environment Canada. About 23,000 industrial chemicals used in Canada were categorized using available scientific data to prioritize the substances for regulatory action. Categorization was based on environmental persistence (P), ability to bioaccumulate (B) and inherent toxicity to non-human organisms (iT).

Environment Canada made a short list of about two hundred chemicals considered "high priorities for action". These so-called "Challenge" substances were believed to be in commerce in Canada, and/or the substances were found either to meet the categorization criteria for greatest potential for exposure (GPE) or intermediate potential for exposure (IPE) as well as being identified as posing a high hazard to human health based on available evidence on carcinogenicity, mutagenicity, developmental toxicity or reproductive toxicity. The Challenge substances were divided up into a number of smaller groups of substances, and these groups (called Batches) were released to industry sequentially starting in February 2007 as Notices in the *Canada Gazette*. See Figure 3 for an Environment Canada summary[10] of the process.

The government is using the mandatory information gathering provisions of section 71 of the *Canadian Environmental Protection Act, 1999* (CEPA, 1999) to gather information required for improved decision-making. Information must be provided to the government for challenge chemicals where a company has manufactured or imported more than 100 kilograms of the chemical or used more than 1,000 kilograms "whether alone, in a mixture, in a product or in a manufactured item, at any concentration." Industry and interested stakeholders have also been invited to submit additional information that may be used to inform risk assessment and to develop and benchmark best practices for risk management and product stewardship.

A new group of substances was released every three months, and to date, all twelve batches have been released. Deadlines have passed for receiving information for most of the earlier batches and the government is closer to decisions regarding the banning or restricting substances on the older lists. The risk assessment phase of the Challenge process culminates in a decision on the handling of the substance where:

1) it will be decided that no further action is required, or
2) the substance is added to the CEPA Priority Substance List in order to assess more comprehensively the risks associated with the release of the substance, if the substance is not already on the list, or
3) it is recommended that the substance be added to the List of Toxic Substances in Schedule 1 of CEPA. Substances on Schedule 1 can be considered for regulatory control."[11]
4) The Canadian government says that it is "predisposed to treat the Challenge substances as CEPA-toxic"[12] unless stakeholders can provide new, relevant information to gain a better

understanding of the use and hazard associated with these substances. However, of the 90 substances in the first six batches for which the Challenge portion is completed, only 26 substances "meet one or more criteria in section 64 of CEPA 1999".

Batch 10 of the Challenge included a number of rosin and resin acids used to manufacture of modern soldering fluxes, raising concerns in the electronics manufacturing industry in Canada and the United States. The Toronto chapter of the Surface Mount Technology Association (SMTA) alerted its members. The IPC Solder Products Value Council, Canadian Manufacturers and Exporters (CME), flux manufacturers and others have also provided written comments to the DSL Survey Coordinator. The DSL Coordinator has subsequently sent out a survey to the Canadian electronics industry asking specific focused questions on the five rosin/resin classes in Batch 10 as well as cobalt chloride. This is a good second step. The end result of the industry response to these Challenge chemicals is keenly anticipated.

The response of the Canadian electronics industry to the restrictions/elimination of bisphenol A and epichlorohydrin would have been significant if FR-4 printed circuit boards were made from basic chemicals in this country. Bisphenol A is reacted with bromine to form tetrabromobisphenol A, which is then further reacted with epichlorohydrin to form the epoxy prepolymer that is then reacted with tetraethylenetetramine to form the final cross-linked polymer. Bisphenol A and epichlorohydrin are Batch 2 chemicals that "meet one or more criteria in section 64 of CEPA 1999", and are expected to be subject to regulatory management for their use and release to the environment.

Now that all 12 Batches have been issued for the Challenge, Environment Canada has sent out, under the Section 71 Update, a list of about 500 chemicals from the Domestic Substances List (DSL) that they believe to be the next most important group of chemicals. Industry was been given until the end of March to respond. When asked whether Environment Canada would provide at least the physical state of the materials on the list (gas, liquid or solid at room temperature), Susan Pecman,[13] Control and Development Scientist for the Chemicals Management Program, responded in the negative. The reasoning is due to manpower constraints and "consequences if we get it wrong". Immediately the counter question is "What if industry gets it wrong?"

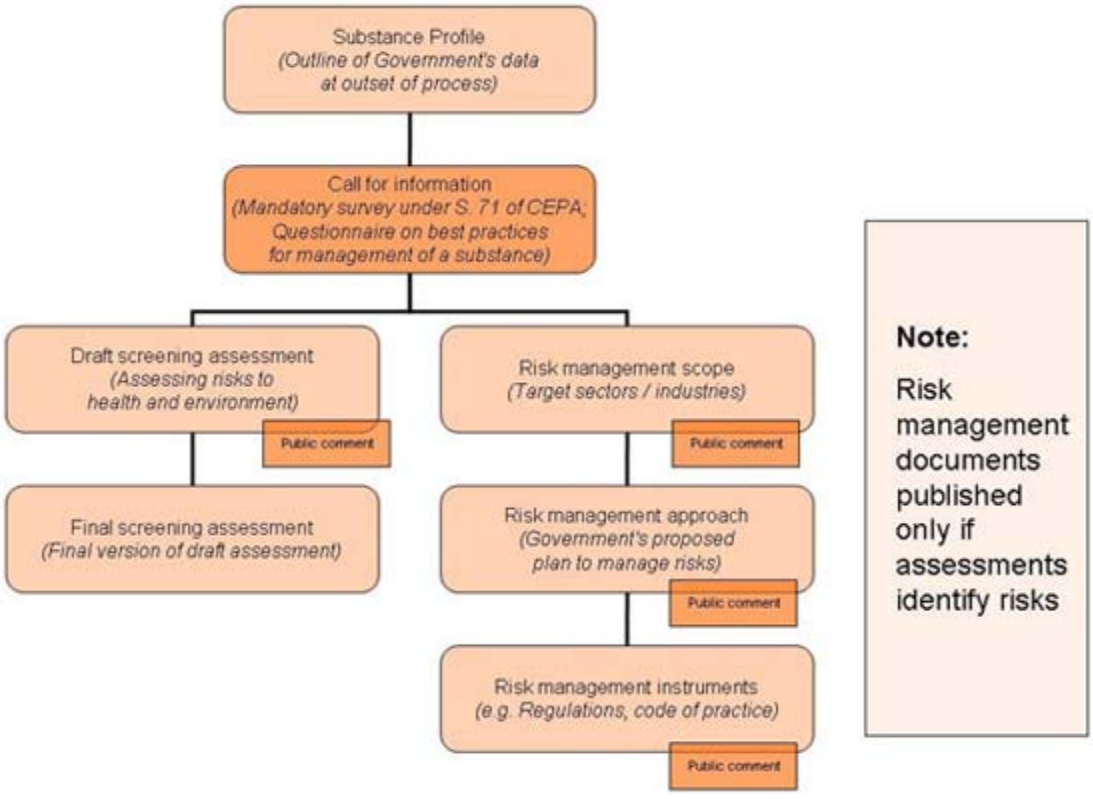

Figure 3 Overview of the Challenge Process.

On a more positive note, the DSL Coordinator has encouraged different industry sections to form working groups. The electronics manufacturing industry did that in late 2009. There are also a number of companies in the Information Technology Association of Canada (ITAC) who have banded together to work on Challenge issues and the new list of DSL chemicals. It was unlikely that any one company could effectively and accurately review all of them in the short period provided.

A meeting was called in early February to form a strategy. Environment Canada agreed that the industry could reply as a whole. To that end, nine companies divided up the list of 500 chemicals and researched to see which ones are used in electronics manufacturing in Canada and exist in their original state (were not consumed). This has been completed and the next phase is to determine the total amounts present, based on sales. Environment Canada has given the group an extension until May 28, 2010 to complete this task.

United States

The United States has also been very active in reviewing toxic substance legislation. In light of recent activity in Europe, China and Canada, there has been interest at the federal level to expand the Toxic Substances Control Act (TSCA). When the TSCA was enacted in 1976, there were 60,000 chemicals on the inventory of existing chemicals.[14] In the last thirty years, the U.S. Environmental Protection Agency (EPA) has only successfully restricted or banned five chemicals. This may soon change. There are now over 83,000 chemicals on the TSCA inventory and the EPA is interested to use its authority to the fullest extent possible in identifying and regulating chemicals of concern.[15] The EPA announced in December of 2009 that, for the first time, the agency would establish a "Chemicals of Concern" list and begin the process of reviewing chemicals that may lead to regulation.[16] The agency is targeting chemicals that "may present an unreasonable risk of injury to health or the environment", as listed in 15 U.S.C 2604(b)(4). The first of these chemical action plans are focused on phthalates, long-chain perfluorinated chemicals (PFCs), polybrominated diphenyl ethers (PBDEs) and short-chlorinated paraffins (SCCPs). The EPA is also supporting the previously-announced DecaBDE Phase-out Initiative.

At the state level there has also been a lot of activity. Currently, over 30 states have enacted over 110 pieces of legislation regulating substances, mostly related to mercury, lead, asbestos and other heavy metals.[17] Some states such as Maine and Washington have enacted legislation that more closely regulates the use of chemicals in children's products. In addition, the states of Illinois, Maine, Minnesota, Oregon, Vermont and Washington have banned or regulated the use of brominated flame retardants. The state of California has been the most active in developing legislation related to chemicals. The Green Chemistry Initiative led by the California EPA and the state Department of Toxic Substances Control, released a report in December 2008 outlining a number of policy proposals for legislation that would help protect public health through greater regulation of chemicals.[18] Most recently, a bill was introduced in California state legislature that would require California manufacturers and wholesalers to list all substances contained in their consumer products.[19] These would need to be available publicly on company websites. The approach follows the EU directive whereby manufacturers would need to list all substances contained in a quantity greater than 0.1% of the product.

Conflict Minerals

An interesting development for manufacturers to be aware of is the issue of "conflict minerals" in electronics products. Most everyone in the western world is aware of "blood diamonds" from articles in the press and from the fictional movie Blood Diamond (2006). Blood diamonds are mined sometimes with slave labor, or sometimes the diamonds are used to finance rebel and terrorist groups, usually in sub-Saharan Africa. These groups kill, rape, subjucate and terrorize the people in the areas of their control. Rape and limb amputation are favorite techniques to keep control in their spheres of influence. The international community is trying to stop the flow of these diamonds by, among other methods, laser inscribing diamonds so they can be tracked from end customer back to the source.

It has come to the attention of NGOs like The Enough Project and Global Witness[20] that rebel groups in the eastern region of the Democratic Republic of Congo (DRC) are now doing the same things with high value metal-containing minerals. Elements like tantalum, gold, tin and tungsten are of concern. Tin, along with copper, is at the heart of the electronics industry, being the principal element in solder, whether one is speaking of eutectic tin/lead solder or the newer lead free SAC solders. Gold is used in gold bond wires inside integrated circuit components, as a surface finish on component leads, and for the ENIG (electroless nickel immersion gold) printed circuit board surface finish. Tantalum is, not surprisingly, an important element in tantalum capacitors. It is also used in small milligram quantities in other components. Tungsten is used in glasses, seals, integrated circuits, metallic films and in mobile phone vibrators.

To respond to these concerns, legislation has been introduced in both the U.S. House and Senate that seeks to stem the trade of conflict minerals entering the United States. The Senate bill would require electronics manufacturers to disclose to the Securities Exchange Commission, the country of origin for these minerals, and also the mine of origin, if they originate from the DRC or a surrounding country.[21] The House bill would help to establish an approved list of third-party auditors who would declare smelters as "conflict mineral free" or as a "conflict mineral facility". The requirement on electronics manufacturers would be to disclose as part of a customs declaration whether or not the product contains minerals that come from a conflict mineral free or conflict mineral

facility smelter. This public listing would help NGOs target campaigns against electronics manufacturers who do not use conflict mineral free smelters.

In addition to this legislation, the OECD and the UN Group of Experts have begun a process to look at due diligence guidelines for companies using these minerals. The OECD process is focused specifically on tin, and there are members of the electronics manufacturing industry who are helping to shape those guidelines. The next meeting for the OECD process will take place later this spring in Paris. Resolutions have been passed in the European Parliament calling for a system that is analogous to the Kimberly Process for diamonds. It also calls on Member States to "ensure that European companies do not trade in, handle or import products derived from minerals that have been sourced in a manner that benefits armed groups in the DRC, and hold accountable any that persist in such practices."[22]

The problem with tracking metals instead of discrete diamonds (hard enough) is huge. It is true that individual bodies of ores have an isotopic "signature", but once the first mixing of ores or semi-purified metals is done that signature is lost. Tracing back through equipment manufacturer to component manufacturer, to sub-assembly manufacturer to purified metal manufacturer to perhaps a distributor to small smelters to ore amalgamators to dealers to the actual mine is difficult to contemplate. The supply chain from end user to mine-of-origin can be extremely long and difficult to trace, particularly if the minerals are extracted in Africa where there are numerous distributers, traders and comptoirs that trade in the material before it gets to the smelter for processing.

One method suggested is to ban the use of all of these elements from the Democratic Republic of the Congo (DRC), however this would deprive the country of revenue from legitimate mining operations, as well as small artisanal mining communities who seek to make their livelihood extracting minerals from hillsides and selling what they have mined to minerals dealers. The challenge is that sometimes these small artisanal groups may be illegally taxed in rebel-controlled areas, or may be forced to mine by rebel groups. At this time, there is no way to verify that material coming from the DRC has not contributed to the conflict in the region. While electronics companies would like to source responsibly from the region, there is not going to be an easy solution to this vexing problem.

The Electronics Industry Citizenship Coalition (EICC) and the Global e-Sustainability Initiative (GeSI) have partnered to form an Extractives Workgroup that examining a solution to this issue. For the most part, large electronics companies have required that their first tier of suppliers provide written assurances that their components do include minerals that have been illegally mined from DRC. However, these statements are difficult to audit back through the supply chain. The EICC-GeSI Extractives Workgroup commissioned a report through RESOLVE to look at the transparency of the supply chain for tin, tantalum and cobalt, and identify information gaps. The RESOLVE report was released in April 2010 and found significant gaps in information when they tried to trace back supplier information to the mine level on behalf of electronics manufacturers.[23] Many suppliers declined to give information citing confidentiality reasons, even though RESOLVE had signed confidentiality agreements with a number of companies. In the face of these challenges, the EICC-GeSI Extractives Workgroup has been working diligently with the tantalum supplier industry to establish a certification program that would ensure socially and environmentally responsible sourcing of tantalum. The group most recently met in Boston at the beginning of April and is hoping to announce details of a certification program later this month.

CONCLUSION

Chemical environmental compliance as an issue is not going away. In fact it is a certainty that the rate of increase is going to increase. The question is whether the increase will be linear or exponential. The overview given here in this report should be a warning that no one person can be on top of all the issues around the world. This cannot be a part time job for one employee. Companies would be advised to have advocates involved in the processes to offer suggestions and warnings where appropriate.

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