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Guidelines and Standards for EoL Operations on e-Waste

Summary and Evaluation of Legislation,
Guidelines, and Standards

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Dr. Otmar Deubzer

United Nations University

Working Document

Authors

Dr. Otmar Deubzer, Rüdiger Kühn (review)

United Nations University
Zero Emissions Forum, European Focal Point
UN Campus
Hermann-Ehlers-Str. 10
53113 Bonn
Tel.: +49-228-815-0214/3
Fax: +49-228-815-0299
Website: www.unu.edu/zef

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0 Executive Summary

This report comprises the following parts:

- The description of legislation, standards and guidelines on general e-waste (section 2 on page 17)
- The description of legislation, standards and guidelines on specific types of e-waste (chapter 3 and the following ones starting on page 98)
- An analysis of specific topics addressed in legislation, standards and guidelines (chapter 10 on page 119)
- The Annex lists specific definitions used in the analyzed documents, as well as the original regulation documents and additional information on the use of lead in lead-free soldered printed wiring boards.

E-waste is among the most complex type of wastes. It contains toxic as well as scarce and valuable materials, and its amounts are growing worldwide. No or improper treatment of electrical and electronic equipment (EEE) at end-of-life (EoL) results in pollution and resource losses. Additionally, illegal exports of e-waste from industrialized countries to emerging market and developing countries cause severe health and environmental effects.

Legislation related to e-waste provides a certain framework, but does not sufficiently enforce appropriate collection, transport, treatment, and disposal of e-waste and components, fractions and materials thereof, and it cannot stop or at least curtail these illegal exports. Guidelines are hence necessary to improve the quality of EoL operations along the EoL chain of e-waste. These guidelines need to address all operators in the EoL chain, and in a globalized and ever more globalizing world, such guidelines should be as international as possible (section 1 on page 14).

Legislation related to e-waste, standards and guidelines already available are summed up and analyzed (Table 1 on page 18). The documents were analyzed and compared for e-waste in general (section 2 on page 17), broken down to these topics:

- Design (chapter 2.2, page 22)
- Collection, Transport, Handling and Storage (chapter 2.4, page 25)
- Treatment, Reuse and Recycling (chapter 2.5, page 34)
- Managerial Standards (chapter 2.6, page 62)

- Implementation and Supervision (chapter 2.7, page 96)

Some of the guidelines are elaborated and comprehensive:

- EPA Responsible Recycling (“R2”) Practices [6],
- the Oregon Electronics Recycling Management Practices [8] and,
- to a lower degree, the IAER Recycler Certification Standards [10].

None of the analyzed documents comprises detailed provisions on all of the above topics. The other documents are less detailed or represent good will rather than giving detailed and clear rules. For an overview see Table 1 on page 18.

Besides the guidelines on general e-waste, there are guidelines focusing on specific types of e-waste (section 3 and following ones, starting on page 98):

- cooling and freezing equipment (section 3, page 98)
- cathode ray tubes (section 4, page 112)
- printed wiring boards (section 5, page 115)
- waste drum and ink cartridges (section 6, page 116)
- plastics (section 7, page 117)
- wires and cables (section 8, page 118)
- liquid crystal displays (LCDs, section 9, page 119)

The analysis of these guidelines follows the same pattern as for the e-waste in general. The guidelines for the treatment of cooling and freezing equipment from the WEEE Forum et al. ([12][13]) are the most detailed and comprehensive ones. They detail stipulations on transport and specific treatment for the proper removal of CFCs and HCFCs in particular from such equipment. And these guidelines are the only ones specifying control parameters and procedures for the quality of treatment (chapter 3.2.3 on page 103, and chapter 3.2.4 on page 110).

The other specific guidelines and standards are less elaborated. Not all topics mentioned above (design, collection, transport, ...) are addressed and worked out in these specific guidelines and standards.

All the legislation and guidelines target pollution prevention as top objective, while resource recovery is in the second row of targets. The more elaborated guidelines contain detailed stipulations on

- environment, health and safety management systems (EHSMS) and other managerial issues (chapter 2.6, page 62) including stipulations on (illegal) exports (chapter 2.6.1 on page 62)

- treatment ranging from pre-treatment and disassembly, reuse, recycling, to energy recovery and disposal (chapter 2.5.7 on page 52 to 2.5.9 on page 59)
- the managerial standards specify tracking and documentation requirements for e-waste, components and materials thereof including downstream vendors (chapter 2.6.3, page 67). Further stipulations specify details for function testing on equipment for reuse in order to prevent illegal exports, as e-waste is often declared as reusable products (chapter 2.5.6, page 49)
- and further provisions like e. g. on data destruction on waste computers, closure of facilities, financial liabilities, etc.

The EPA R2 Practices [6] and the EPA Plug-in Guide [7] as well as the Oregon Electronics Recycling Management Practices [8] limit their provisions to certain components or materials from e-waste (chapter 2.2 on page 22). The EPA R2 Practices in particular exclude lead-free soldered printed wiring boards (PWBs) from several of the stipulations, including those on exports. As lead is not the only problem on PWBs, and as lead-free soldered PWBs still may contain lead (chapter 2 on page 157 in the annex), this stipulation may result in improper treatment and exports (chapter 10.4 on page 124).

Pollution prevention requires the prevention of land-filling and incineration if it is not required to adequately deal with e-waste that cannot be treated or used otherwise. Otherwise, land-filling and incineration must be excluded. Not all of the analyzed legislation and guidelines effectively may prevent even land-filling and incineration of untreated e-waste possibly containing hazardous materials (chapter 10.4 on page 124).

The European WEEE Directive and its proposed recast as well as some of the guidelines set out stipulations for transboundary shipments of e-waste or components and materials thereof. The European WEEE Directive [1] and its proposed recast [2] restrict transboundary shipments of e-waste. Both documents refer to other complex European waste regulations, which again refer to further European regulations. Exports of waste for disposal out of the EU into others than EFTA countries are prohibited. Due to the complexity of the legislative situation, it was not possible within the available time frame to clarify in detail whether and which exports of e-waste, components and materials actually are banned.

The EPA [6], the Oregon [8] and the IAER guidelines [10] allow exports as long as the legality is documented. These guidelines were set up by entities located in the USA, which have not ratified the Basel Convention [19]. Exports out of the USA thus are not subject to the provisions of the Basel Convention, but are regulated according to the legislation of the sending, the transit and the receiving countries. The BAN and ETBC Electronics Recyclers Pledge [9], although the organizations are based in the US, nevertheless declare to not allow any exports violating the Basel Convention. The Dell guidelines [11] stipulate that exports of certain environmentally sensitive materials from e-waste are not allowed. Other guidelines and standards do not contain specific export provisions. For details see chapter 10.6 on page 130. It is contentious whether and how far the provisions are sufficient to effectively prevent illegal exports of e-wastes. With view to a high level recycling, it must further on be clarified whether all exports that are allowed actually are appropriate.

The WEEE Directive and its proposed recast both recommend independent third party auditing and certification, but do not make it obligatory. Some of the guidelines require independent third party auditing and certification, while others only recommend it or completely forgo this topic (paragraph "Auditing and Certification Requirements" on page 140).

UNU recommends StEP to contribute to the improvement and development of Guidelines for EoL Operations on e-waste. This way StEP could provide scientific expertise and a global view from a neutral position. It can thus promote progress in guideline activities as a promoter and mediator between the different stakeholders in order to achieve a broad acceptance for guidelines to arrive at an international standard as the ultimate objective of the work in this project.

The work on this document summing up and analyzing legislation, guidelines and standards on e-waste will be continued. Further regulations will be integrated. The topics analyzed already in this document were chosen as they had become relevant in the work on guidelines with the WEEE Forum and in discussions with different stakeholders. The further analyzes of these regulations will be focused on aspects that become relevant in the ongoing works and discussions on guidelines, where UNU and StEP will participate.

1 Background

E-waste is one of the most complex wastes to treat. It contains almost all elements of the periodic table of elements. Some of them are well known as pollutants like lead, cadmium or mercury, others as valuable and scarce resources like gold, silver, copper and palladium. Adequate treatment at the end-of-life (EoL) of electrical and electronic equipment (EEE) is therefore crucial to avoid pollution on the one hand, and to save valuable and scarce resources on the other hand.

Adequate treatment of e-waste needs knowhow to achieve high recycling rates from this highly complex waste at low environmental impact and at reasonable cost. This needs the optimization and cooperation of all actors in the EoL chain of EEE from collection down to reuse, recycling and disposal.

In Europe, there is competition in the EoL market, although to a different degree within and between member states due to specific interpretations of the WEEE Directive in the member states. Things are working somehow, but there are serious problems along the EoL chain. Improper or no collection, consumers dumping e-waste into the household wastes, inadequate storage and transportation of e-waste, low quality treatment and recycling, dumping, and illegal exports of e-wastes into emerging market and developing countries [25]. This situation is unacceptable and contravenes the spirit of the WEEE Directive. At the same time, there are no economic or other incentives to improve the situation. [25] Guidelines or even standards at European level ensuring a proper functioning of all actors in the EoL chain are hence necessary.

The WEEE Directive does not set such standards. The WEEE Directive [1] sets requirements for WEEE treatment. It defines in Art. 3f that 'recovery' means any of the applicable operations provided for in Annex IIB to Directive 75/442/EEC. Art. 3 (e) states that "'recycling' means the reprocessing in a production process of the waste materials for the original purpose or for other purposes, but excluding energy recovery which means the use of combustible waste as a means of generating energy through direct incineration with or without other waste but with recovery of the heat".

These processes and operations may be applied in order to achieve the minimum recovery and recycling targets, which the WEEE Directive sets. Recovery and recycling in the WEEE Directive hence are operation-defined, not quality defined. This allows varying qualities of WEEE treatment operations within member states, and between member states at an increasing competition between EoL operators from different EU member states resulting in unfair competition.

“For the purposes of environmental protection, Member States may set up minimum quality standards for the treatment of collected WEEE” ([1], Art. 6). As, however, such standards may have strong impacts on conditions and cost of WEEE treatment, different standards in the member states, as well as missing quality standards, bias competition between recyclers and other actors in the EoL chain within and between member states. There is no level playing field for the different stakeholders in the EU for the proper treatment of WEEE. National standards for WEEE recycling therefore cannot be a solution in a single EU market with increasing competition across the borders between member states.

The WEEE treatment quality issue in its dimension even goes beyond the EU borders. The WEEE Directive [1] allows in Art. 6 (5) that “[...] the treatment operation [of WEEE] may also be undertaken outside the respective Member State or the Community [...]”. “The WEEE exported out of the Community [...] shall only count for the fulfilment of obligations and targets of Article 7(1) and (2) of this Directive if the exporter can prove that the recovery, reuse and/or recycling operation took place under conditions that are equivalent to the requirements of this Directive.” [1]

If WEEE may be or actually is shipped and treated outside the European Union, how can it be made sure that e-waste is properly handled and treated if this is not even properly monitored and has not been achieved within the European Union? Even if the export and treatment outside the EU is in line with all legal requirements, it may be difficult to achieve and to prove an environmentally sound treatment of e-waste.

Finally, regardless of any illegal exports of e-waste from industrialized countries, the amounts of domestic e-waste are growing in emerging market and developing countries. These countries are facing problems to adequately organize and conduct the collection and sound handling and treatment of this e-waste. Besides necessary transfer of knowledge and of technology, it might become necessary to transport and treat e-waste, components or fractions thereof from developing and emerging market countries to industrialized countries for treatment and ship back materials or fractions thereof to the countries of origin. Such exchanges, as long as possible and in line with international regulations, cannot be tolerated if the proper handling and treatment of e-waste, components and fractions thereof cannot be guaranteed.

There is, hence, great need for guidelines and standards on European level and beyond ensuring state of the art handling and treatment of e-wastes and fair competition between the different actors. These guidelines must be a base to audit and prove compliance of all operators in the EoL chain in order to achieve a trustworthy and high level operational EoL network for e-waste.

1.1 Objectives

Any standard or guideline related to e-waste should cover the whole end-of-life chain of electrical and electronic equipment.

“Guidelines for End-of-Life Operations on e-Waste” goes beyond a “Guideline for Recycling of e-waste”. The title underpins the necessity to address all actors and their activities in the EoL chain, and not only recyclers and recycling. Guidelines for the EoL Operations of EEE should comprise the whole end-of-life chain from

- collection
- storage
- all kinds of transports, e. g. to collection points, from collection points to further recycling or other treatment, from recyclers to downstream users etc.
- recycling and reuse
- disposal

It should as well address all relevant actors in the EoL chain, like:

- collectors of e-waste
- transporters of e-waste
- those responsible for treatment for reuse and remarketing
- recyclers (actors doing disassembly, shredding and mechanical separation, smelting)
- downstream vendors
- actors responsible for the disposal of materials

“Good recycling” requires the commitment of all actors in the EoL chain, and the alignment of their activities. If TVs or refrigerators are broken at the collection stage already, proper recycling is no longer possible. TVs stored unsheltered in open containers will be damaged and cannot be reused. Therefore, the EoL Operation Guidelines for EEE shall be a basis for auditing and certification of operators along the EoL chain to give all actors the certitude that they are dealing with reliable partners as long as this partner has such a certificate.

StEP’s and UNU’s understanding of “good recycling” is to

- achieve effective and efficient treatment of e-waste
- enable high level and high quality reuse of whole appliances and components
- enable high level and high quality recycling to prevent pollution and to save resources
- prevent inadequate disposal of e-waste, components, fractions and materials thereof

- prevent illegal exports to developing and emerging market countries,
- and prevent transboundary shipments of e-waste, components, fractions and materials thereof that, although being legal, contravene the objective of high quality recycling

Adequate EoL guidelines should therefore aspire achieving the above targets, and give incentives to all EoL operators to contribute to their achievement.

2 Legislation, Standards and Guidelines for EoL Operations on General E-waste

2.1 Overview

The available or discussed guidelines and standards for e-waste recycling address either e-waste in general, or specific categories of e-waste. They also address single or several stages in the EoL process chain. The guidelines and standards in this chapter are sorted into those chapters, separately for e-waste in general, and for specific e-wastes like CRTs, printed wiring boards, LCDs, etc.:

- Design
- Collection, Transport, Handling and Storage
- Treatment, Reuse and Recycling
- Managerial Standards
- Quality testing (only WEEE Forum et al. [12][13])
- Implementation and Supervision

Table 1: Overview on reviewed legislation, guidelines and standards

Guideline, Standard or Activity	Author	EEE Scope	EoL scope
WEEE Directive [1]	European Commission	Covers EEE listed in 10 categories in Annex I	Minimum requirements for collection, recovery and recycling depending on product categories; definitions (processes) for recovery operations; minimum treatment requirements; no quality standards
Proposal for a Recast of the WEEE Directive [2]	European Commission	Covers all EEE listed in 10 categories; includes medical equipment into recovery and recycling targets; new targets for collection of e-waste;	Important changes: Increased minimum requirements for collection, recovery and recycling; new definition of “remove” in fulfilment of specific treatment requirements; requirements for used EEE for transborder shipments to prevent illegal exports
Integrated Pollution Prevention and Control (IPPC), Reference Document on Best Available Techniques for the Waste Treatments Industries [3]	European Commission	All kinds of wastes; due to the focus on general waste, not all parts of the document are of relevance for e-waste recycling	Document describes best available technologies (BAT) and best emerging technologies for storage, handling and treatment of waste and the operation and management of waste treatment facilities
Integrated Pollution Prevention and Control (IPPC), Reference Document on the application of Best Available Techniques to Industrial Cooling Systems, December 2001 [17]	European Commission	Best Available Techniques for Industrial Cooling Systems	The document does not refer to end-of-life treatment of cooling equipment and thus was not taken into consideration in the following analysis
Requirements for the Collection, Transportation, Storage and Treatment of Cooling and Freezing Appliances containing Hydrocarbons (HC); [13]	WEEE-Forum, CECED and EERA, October 2006	Cooling and Freezing Equipment containing HC	Provisions for transport, treatment, management;

Requirements for the Collection, Transportation, Storage, Handling and Treatment of Household Cooling and Freezing Appliances containing CFC, HCFC or HFC; [12]	WEEE-Forum, CECEED and EERA, December 2007	Cooling and Freezing Appliances containing CFC, HCFC or HFCP	Provisions for transport, treatment, management and testing of treatment efficiency (removal of cooling agents)
Draft National Standard for Environmental Protection of the People's Republic of China, Technical Specifications of Pollution Control for Processing Waste Electrical and Electronic Product; [5]	State Environmental Protection Administration (SEPA), China; year of edition unknown	General e-waste, and consumables of EEE; some specific provisions for treatment of LCDs, printed wiring boards, ink cartridges, wires and cables	Provisions for all parts of the EoL chain of EEE
Law on Pollution Control of Electronic and Electrical Equipment (EEE), and Recycling and Reuse for Waste Electronic and Electrical Equipment (WEEE), P. R. China (Draft) [4]	China	e-waste in general	Contains some single provisions on some end-of-life stages of e-waste
IAER Certification Standard 2000, 2006 & 2007 [10]	International Association of Electronics Recyclers	e-waste in general	Guideline outlines principles for auditing (certification process, management systems, general business, operational capabilities and processes); provisions are more of general character, not very specific
Responsible Recycling ("R2") Practices for Use in Accredited Certification Programs for Electronics Recyclers; [6]	US Environmental Protection Agency (EPA)	e-waste in general	12 specific provisions setting detailed requirements for most end-of-life stages of e-waste

Plug-In to eCycling, Guidelines for Materials Management; [7]	US Environmental Protection Agency (EPA),	e-waste in general	More a guideline for owners of e-waste in order to find appropriate recyclers; contains a few more concrete provisions, but is of more general character, not intended to be a guideline for recyclers
Electronics Recycler's Pledge of True Stewardship; [9]	Basel Action Network (BAN), Electronics TakeBack Coalition (ETBC)	e-waste in general	Declaration of recyclers to stick to specific principles of treatment, business conduct; strong focus on prevention of illegal exports of e-wastes and prison labor; shall be completed by a more detailed guideline later on
Dell's Recovery and Waste Disposition Channels Environmental Guidelines December 2007 [11]	Dell	No specific scope defined, limited to Dell's EoL-activities and contractors of Dell	Stipulations for waste and pollution prevention, exports to developing countries and tracking and documentation of material flows; not very specific, more a declaration of intent than a guideline
Best Management Practices for Electronic Waste [21]	Santa Clara County Department of Environmental Health San Jose, California, 2004	Primary objective: guidance tools for local governments and others to ensure that e-waste is managed adequately	Gives background and guidance to local governments on dangers and necessities related to WEEE, how to achieve proper treatment and recycling; not appropriate for a recycler certification, but could be an example as a guide for local governments in particular in particular for countries outside the EU (via StEP)
National Center for Electronics Recycling, USA; http://www.electronicrecycling.org/Public/default.aspx	NCER	General information about different aspects of e-waste and e-waste recycling	no programs on standards or guidelines for e-waste could be identified on the organization's website; the website lists e-waste and e-waste related legislation, which, however, is dealing with the establishment of a collection and recycling infrastructure in some federal states of the US rather than aspiring guidelines or standards for the EoL of e-waste; in some states, requirements are defined for environment, health

			and safety management, e. g. in Oregon
Oregon Electronics Recycling Program Environmental Management Practices [8]	Department of Environmental Quality, US Federal State Oregon	Desktop computers, portable computers, monitors, and televisions (covered electronic devices or CEDs)	The document describes environmentally sound management practices for collection, transportation, and recycling services provided under the State (Oregon) contractor program. These practices will also serve as guidance to Oregon's Department of Environmental Quality (DEQ) staff evaluating the plans and services of manufacturer-run programs.
VDI 2343 guidelines "Recycling of electrical and electronic products", Part 1 to 4 [20]	VDI, Verein Deutscher Ingenieure, status 2008;	E-waste in general, with examples for the disassembly of specific kinds of equipment; most parts of the guideline are under revision, shall be expanded from 4 to 6 different parts	Currently 4 parts (principles, logistics, disassembly, marketing); technical papers giving an overview and explaining techniques and planning principles for different end-of-life stages; interesting information on what type of e-waste may contain hazardous materials according to be removed by disassembly before further treatment according to Annex II WEEE Directive (Part 3 Disassembly); more a detailed description of different techniques and technologies than a guideline as base for an audit; for this reason and due to strict copyright restrictions, quotations from these guidelines are not possible in this report
Recycling Industry Operational Standard (RIOS) [22]	Institute of Scrap Recycling Industries (ISRI, www.isri.org)	Not specific for e-waste	<p>RIOS is a manual showing how to set up and maintain a Quality, Environment, Health and Safety Management System (QEHSMS) based upon existing management system standards ISO 9001-2000 and ISO 14001, OSHAS 18001.</p> <p>There was no access to the document itself or to other more detailed information; RIOS seems to be an instruction on how to install and maintain a standardized QEHSMS rather than a guideline for EoL treatment. For these reasons, RIOS has not been taken into further account in this report.</p>

2.2 Limitation of Stipulations to Specific E-waste, Components and Materials

Some of the analyzed documents focus all or parts of their stipulations on materials that have specific hazardous or other properties requiring specific attention.

2.2.1 EPA R2 Focus Materials and Designated Materials

The EPA Responsible Recycling (“R2”) Practices [6] specify “Focus Materials” (FM) in end-of-life electronic equipment that warrant greater care during recycling, refurbishing, materials recovery, energy recovery, incineration, and/or disposal due to their toxicity or other potential adverse worker health and safety, public health, or environmental effects that can arise if the materials are managed without appropriate safeguards.

The following are R2 Focus Materials:

- 1) Items containing polychlorinated biphenyls (PCBs),
- 2) Items containing mercury,
- 3) CRTs and CRT glass,
- 4) Batteries
- 5) Whole and shredded circuit boards, except for whole and shredded circuit boards that do not contain lead solder, and have undergone safe and effective mechanical processing, or manual dismantling, to remove mercury and batteries.

Equipment, components, or materials (whole or shredded) that have undergone safe and effective mechanical processing or manual dismantling to remove FMs, yet still retain de minimus amounts of FMs, are not subject to the R2 requirements that are triggered by the presence of FMs.

The definition of “Designated Materials” in the EPA plug-in guide to e-cycling [7] is close to the “Focus Material” definition. “Designated Materials” mean any electronic products and components containing or consisting of circuit boards, shredded circuit boards, CRTs, batteries, and mercury- and PCB-containing lamps and devices. However, this definition does not include circuit boards that have been processed to the point where they no longer are readily identifiable as circuit boards or shredded circuit boards (such as after burning/melting), as well as CRT glass that has been adequately processed for use as an industrial feedstock material. In these cases, the economic value of the material has been enhanced significantly through processing; thus, commodities of value have been created and concern for the subsequent environmental mismanagement of this material is greatly decreased.

2.2.2 Oregon Recycling Practices' Materials of Concern [8]

Materials of concern include each of the following, and any CEDs or component, or any aggregate material(s) derived from end-of-life CEDs or components (e.g. shredded, granulated, or mixed materials) containing:

- 1) Any devices, including fluorescent tubes, containing mercury or polychlorinated biphenyls (PCBs)
- 2) Batteries
- 3) Cathode Ray Tubes (CRTs) and leaded glass
- 4) Circuit boards

These items are included because of their potential for improper handling or management that could result in risk to worker safety, public health, or the environment.

2.2.3 Dell Guideline Environmentally Sensitive Materials [11]

Substances of environmental concern, as defined by legal requirements, specific market demands, or by the following criteria:

- 1) Substances with hazardous properties that are a known threat to human health or the environment;
- 2) Substances with hazardous properties that show strong indications of significant risks to human health or the environment;
- 3) Substances with hazardous properties that are known to bio-persist and/or bioaccumulate in humans or the environment.

2.3 Design

2.3.1 WEEE Directive [1] and Proposal for a Recast of the WEEE Directive [2]

Member States shall encourage the design and production of electrical and electronic equipment which take into account and facilitate dismantling and recovery, in particular the reuse and recycling of WEEE, their components and materials. In this context, Member States shall take appropriate measures so that producers do not prevent, through specific

design features or manufacturing processes, WEEE from being reused, unless such specific design features or manufacturing processes present overriding advantages, for example, with regard to the protection of the environment and/or safety requirements. [1]

Member States shall, in line with Community product legislation including Directive 2005/32/EC on eco-design (EuP Directive), encourage measures to promote the design and production of electrical and electronic equipment notably in view of facilitating re-use, dismantling and recovery of WEEE, its components and materials. These measures shall respect the proper functioning of the internal market. In this context, Member States take appropriate measures so that producers do not prevent, through specific design features or manufacturing processes, WEEE from being re-used, unless such specific design features or manufacturing processes present overriding advantages, for example, with regard to the protection of the environment and/or safety requirements. [2]

2.3.2 Law on Pollution Control of Electronic and Electrical Equipment (EEE), and Recycling and Reuse for Waste Electronic and Electrical Equipment (WEEE), P. R. China (Draft) [4]

EEE shall be designed in line with the country standard and industry standard for control of toxic and hazardous substances or elements of EEE. Under the prerequisite of the processing requirement, EEE shall be design with non-toxic, harmless, or low toxic, less harmful option, and the option with easy degrading and easy recycling and reuse.

EEE shall be produced in line with the country standard and industry standard for control of toxic and hazardous substances or elements of EEE. Non-toxic, harmless, or low toxic, less harmful materials, technology and process with high utilization efficiency, easy recycling and treatment, option shall be chosen for EEE production.

2.3.3 BAN and ETBC Electronics Recycler's Pledge of True Stewardship [9]

We agree to support design for environment and toxics use reduction programs and/or legislation for electronic products.

2.4 Collection, Transport, Handling and Storage

2.4.1 Collection

WEEE Directive [1] and Proposal for a Recast of the WEEE Directive [2]

Minimum Targets for Separate Collection of e-Waste

Member States shall ensure that by 31 December 2006 at the latest a rate of separate collection of at least four kilograms on average per inhabitant per year of WEEE from private households is achieved. [1]

The proposed recast of the WEEE Directive sets a new target following a new approach:

Member States shall ensure that producers or third parties acting on their behalf achieve a minimum collection rate of 65%. The collection rate is calculated on the basis of the total weight of WEEE collected in accordance with Articles 5 and 6 in a given year in that Member State, expressed as a percentage of the average weight of electrical and electronic equipment placed on the market in the two preceding years in that Member State. This collection rate shall be achieved annually and starting in 2016. [2]

Stipulations on Collection

The collection and transport of separately collected WEEE shall be carried out in a way which optimises reuse and recycling of those components or whole appliances capable of being reused or recycled. [1]

In the recast proposal of the WEEE Directive [2], the European Commission proposes the following in Art. 6 instead of the above stipulations:

Member States shall ensure that the collection and transport of separately collected WEEE is carried out in a way which optimises re-use and recycling and the confinement of hazardous substances.

Draft National Standard China [5]

It is prohibited to mix waste electrical & electronic products with household garbage or industrial solid waste.

It is not allowed to pile up or disassemble collected waste electrical & electronic products at will

The collected waste electrical & electronic products should be handed over to the enterprises with qualifications for disassembly and treatment.

Waste cathode ray tubes (CRT) should be collected separately from other glass products.

In the process of collecting waste air-conditioners, refrigerators and other refrigeration equipment, leakage of vesicant in thermal insulated foaming layer and the refrigeration agent should be avoided.

Oregon Electronics Recycling Environmental Management Practices [8]

The guidelines refer to desktop computers, portable computers, monitors, and televisions (covered electronic devices or CEDs)

Legal Requirements

Collectors must:

- 1) Not dispose of whole CEDs through landfilling or incineration, beginning January 1, 2010
- 2) Comply with all applicable local, state, and federal requirements, including but not limited to environmental, health, and safety requirements;
- 3) Notify DEQ (Oregon Department of Environmental Quality) if their facility receives a fine or notice of violation that is not corrected within 30 days; and
- 4) If exporting, comply with all legal requirements that are applicable to the importation, operations, and transactions of each transit and recipient country and document its downstream vendors' adherence to such legal requirements.

Service Standards

When providing collection services for the Oregon Electronics Recycling Program (OERP), the collector must:

- 5) Staff the site during operating hours;

- 6) Provide covered storage areas so that the collected CEDs are protected from the weather;
- 7) Handle and store CEDs to minimize breakage;
- 8) Cleanup spilled and broken CEDs immediately; manage according to established solid waste management laws and regulations;
- 9) Adhere to good housekeeping standards, including keeping all storage areas clean and orderly.
- 10) Make available CED recycling information that is provided by the program(s) for which the collector is providing services or from the DEQ (Oregon Department for Environmental Quality); and,
- 11) Cooperate, when needed, with CED sampling efforts conducted by the State contractor and manufacturer recycling programs.

Reuse and Refurbishment

- 1) When screening CEDs for reuse or refurbishment, collectors must:
 - a) Post, in a readily visible location, information that informs covered entities that the CEDs are screened for reuse or refurbishment; Follow the generator's preference if the covered entities indicate they do not want their CEDs reused or refurbished;
 - b) Triage and screen appropriately for reuse or refurbishment;
 - c) Track separately the number of screened units which are sent for reuse and refurbishment;
 - d) Ensure that CEDs designated for reuse and refurbishment are packaged in a manner that minimizes damage them during transportation; and
 - e) Obtain written certification from the vendor(s) that the screened units are going for reuse and refurbishment and that the unusable units will be recycled using environmentally sound management practices as described herein.
- 2) Store whole products, components, and equipment destined for reuse or refurbishment in a manner that:
 - a) Protects them from adverse atmospheric conditions and floods;
 - b) Is secure from unauthorized entrance; and
 - c) Is in clearly labeled containers and/or storage areas.

Recordkeeping

- 1) Comply with applicable state and local recordkeeping requirements, including Oregon Material Recovery Survey reporting requirements (OAR 340-090-0100), and any CED reporting and tracking requirements for the OERP (Oregon Electronics Recycling Program).
- 2) Track CEDs, either by weight or number of units, coming from covered entities separately from non-covered entities.
Remark: The definition of “covered entity” could not be clarified; it is, however, assumed that covered entities are those entities participating in the Oregon Electronics Recycling Program as manufacturers, retailers or any other stakeholders covered by the program;
- 3) Track and maintain documentation where outgoing CEDs are sold, shipped or transferred.

Authorizing Access

A collector must allow access to DEQ (Oregon Department of Environmental Quality) or their authorized third party representative for purposes of conducting sampling/counting to determine return share or assessing compliance with these environmental management practices

Multiple Programs

A collector may provide service to more than one program. The collector must maintain records of the number or weight of CEDs collected separately for each program.

Insurance

Possess adequate comprehensive or commercial general liability insurance to cover potential risks and liability associated with the nature and size of the collector’s operations.

Site Management

Accumulating CEDs, components, or materials derived from CEDs that are in need of further off-site processing for more than 180 days without recycling at least 75% of what was accumulated at the beginning of that period may be considered speculative accumulation and operating a storage or disposal facility under OAR Chapter 340, Divisions 93 – 97 and may require a solid waste or hazardous waste permit.

2.4.2 Storage and Handling

IPPC BAT Document for Waste Treatment [3]

Storage of Waste

BAT is to apply the following techniques related to storage (see section 4.1.4.1 of IPPC BAT document [3]):

- 1) locating storage areas:
 - a) away from watercourses and sensitive perimeters, and
 - b) in such a way so as to eliminate or minimise the double handling of wastes within the installation
 - c) ensuring that the storage area drainage infrastructure can contain all possible contaminated run-off and that drainage from incompatible wastes cannot come into contact with each other
 - d) using a dedicated area/store which is equipped with all necessary measures related to the specific risk of the wastes for sorting and repackaging laboratory smalls or similar waste. These wastes are sorted according to their hazard classification, with due consideration for any potential incompatibility problems and then repackaged.
- 2) After that, they are removed to the appropriate storage area
 - a) handling odorous materials in fully enclosed or suitably abated vessels and storing them in enclosed buildings connected to abatement
 - b) ensuring that all connections between the vessels are capable of being closed via valves. Overflow pipes need to be directed to a contained drainage system (i.e. the relevant bunded area or another vessel)
 - c) separately bund the liquid decanting and storage areas using bunds which are impermeable and resistant to the stored materials (see section 4.1.4.4 of IPPC BAT document [3])
- 3) apply the following techniques concerning tank and process pipework labeling (see section 4.1.4.12 of IPPC BAT document [3]):
 - a) clearly labelling all vessels with regard to their contents and capacity, and applying a unique identifier. Tanks need to have an appropriately labelled system depending on their use and contents
 - b) ensuring that the label differentiates between waste water and process water, combustible liquid and combustible vapour and the direction of flow (i.e. in or outflow)

- c) keeping records for all tanks, detailing the unique identifier; capacity; its construction, including materials; maintenance schedules and inspection results; fittings; and the waste types which may be stored/treated in the vessel, including flashpoint limits
- d) take measures to avoid problems that may be generated from the storage/accumulation of waste. This may conflict with BAT number 8) on page 86 when waste is used as a reactant (see section 4.1.4.10 of IPPC BAT document [3]).

Handling of Waste

BAT is to

- 1) apply the following techniques when handling waste:
 - a) having systems and procedures in place to ensure that wastes are transferred to the appropriate storage safely
 - b) continuing the waste tracking system that began at the pre-acceptance stage, linked with acceptance, throughout the duration the waste is kept at the site (see section 4.1.2.3 of IPPC BAT document [3])
 - c) having in place a management system for the loading and unloading of waste in the installation, which also takes into consideration any risks that these activities may incur. Some options for this include ticketing systems, supervision by site staff, keys or colour-coded points/hoses or fittings of a specific size
 - d) ensuring that a qualified person attends the waste holder site to check the laboratory samples, the old original waste, waste from an unclear origin or undefined waste (especially if drummed), to classify the substances accordingly and to package into specific containers. In some cases, the individual packages may need to be protected from mechanical damage in the drum with fillers adapted to the packaged waste properties
 - e) ensuring that damaged hoses, valves and connections are not used
 - f) collecting the exhaust gas from vessels and tanks when handling liquid waste
 - g) unloading solids and sludge in closed areas which are fitted with extractive vent systems linked to abatement equipment when the handled waste can potentially generate emission to air (e.g. odours, dust, VOCs)
 - h) using a system to ensure the bulking of different batches only takes place with compatibility testing
 - i) ensure that the bulking/mixing to or from packaged waste only takes place under instruction and supervision and is carried out by trained personnel. For certain types of wastes, such a bulking/mixing needs to be carried out under local exhaust ventilation
 - j) ensure that chemical incompatibilities guide the segregation required during storage
- 1) apply the following techniques when containerised wastes are handled:

- a) storing of containerised wastes under cover. This can also be applied to any container that is held in storage pending sampling and emptying. Some exceptions on the applicability of this technique related to containers or waste not affected by ambient conditions (e.g. sunlight, temperature, water) have been identified. Covered areas need to have adequate provision for ventilation.
- b) maintaining the availability and access to storage areas for containers holding substances that are known to be sensitive to heat, light and water, under cover and protected from heat and direct sunlight.

WEEE Directive [1] and Proposal for a Recast of the WEEE Directive [2]

The WEEE Directive [1] and the proposed recast of the WEEE Directive [2] define requirements for the storage of e-waste in Annex III.

Sites for storage (including temporary storage) of WEEE prior to their treatment (without prejudice to the requirements of Council Directive 1999/31/EC):

- 1) impermeable surfaces for appropriate areas with the provision of spillage collection facilities and, where appropriate, decanters and cleanser-degreasers,
- 2) weatherproof covering for appropriate areas.

Draft National Standard China [5]

Various waste electrical & electronic products should be classified for storage, with marks in the conspicuous places.

The general storage location should be in accordance with relevant stipulations stated in GB 18599. The location for storage of waste with hazardous substances should be in accordance with relevant stipulations stated in GB 18597.

Floor of the storage location should be hardened with concrete to prevent leakage. Stream guiding facilities should be set up around the storage location.

Law on Pollution Control of EEE, and Recycling and Reuse for WEEE, China [4]

EEE and WEEE shall be stored in specific storage site with anti-seepage treatment floor and water-proof cover to avoid any leakage of EEE and WEEE to the ground water or river when raining. The storage site, container and facility for EEE and WEEE shall be kept in clean and complete condition to avoid any leakage or foul smell.

EPA R2 Guidelines [6]

An R2 electronics recycler shall store items and materials that may cause risk to worker health or safety or the environment if inappropriately stored, and equipment and components going to reuse, in an appropriate manner.

In detail, he shall store items removed pursuant to Provision 5 (R2 Focus Materials, page 5 in source [6], or see section 5) on page 81 and EPA R2 Guidelines [6] on page 54 of this document) and equipment and components destined for reuse, in a manner that:

- 1) Protects them from adverse atmospheric conditions and floods and, as warranted, includes a catchment system, and
- 2) Is secure from unauthorized entrance, and
- 3) Is in clearly labeled containers and/or storage areas.

Oregon Electronics Recycling Environmental Management Practices [8]

The guidelines refer to desktop computers, portable computers, monitors, and televisions (covered electronic devices or CEDs)

Accumulating on collection sites CEDs, components, or materials derived from CEDs that are in need of further off-site processing for more than 180 days without recycling at least 75% of what was accumulated at the beginning of that period may be considered speculative accumulation and operating a storage or disposal facility under OAR Chapter 340, Divisions 93 – 97 and may require a solid waste or hazardous waste permit.

2.4.3 Transport

WEEE Directive [1] and Proposal for a Recast of the WEEE Directive [2]

The collection and transport of separately collected WEEE shall be carried out in a way which optimises reuse and recycling of those components or whole appliances capable of being reused or recycled.

In the recast proposal of the WEEE Directive [2], the European Commission proposes the following instead of the above stipulations:

- Member States shall ensure that the collection and transport of separately collected WEEE is carried out in a way which optimises re-use and recycling and the confinement of hazardous substances.

Oregon Electronics Recycling Environmental Management Practices [8]

The guidelines refer to desktop computers, portable computers, monitors, and televisions (covered electronic devices or CEDs)

Legal Requirements

Ensure that all transportation of CEDs and CED components complies with all applicable transport laws and rules.

Dell's Recovery and Waste Disposition Channels Environmental Guidelines [11]

The entire disposition channel, including downstream intermediaries, shall meet all applicable environmental, transportation and health and safety regulations.

IAER Recycler Certification Standard [10]

The transportation of equipment, components, and materials shall have the appropriate regulatory authorizations and in a manner protective of health, safety and the environment.

There shall be physical capabilities to support the key operational elements that are consistent with the scope and mission of the company. These would typically include materials handling, processing, storage, and transportation.

Draft National Standard for Environmental Protection of the People's Republic of China [5]

- 1) Before transport, the following information should be registered:
 - a) Information on the carrier: Name of the transport organization, name and No. of the transport vehicle
 - b) Departure location and date
 - c) Arrival location and date
 - d) Name, category and/or specifications of the transported waste electrical & electronic products
 - e) Weight and/or quantity of the transported waste electrical & electronic products

- 2) The carrier should not abandon waste electrical & electronic products in the process of transportation.
- 3) The carrier is prohibited from disassembling or treating the waste electrical & electronic products by any means.
- 4) Transportation Vehicles:
 - a) Van vehicles are preferred.
 - b) The carriage and its back plane must be flat and complete, with fixed sideboard around.
- 5) WEEE is prohibited to be disassembled in the process of selling, transportation, storage and recycling.

EPA R2 Guidelines [6]

- 1) An R2 electronics recycler shall transport all equipment, components, and materials using entities that have the necessary regulatory authorizations and in a manner protective of public health and the environment:
- 2) An R2 electronics recycler ensures that all equipment, components, and materials to be transported are packaged appropriately in light of the risk they could pose during transportation to public health or the environment and the level of care warranted by their intended use.
- 3) An R2 electronics recycler obtains written documentation or a third-party certification indicating that their transporters have all the necessary regulatory authorizations and no significant violations of relevant legal requirements during the past 3 years.

2.5 Reuse, Recycling, Disposal and Incineration

2.5.1 Restriction of Stipulations to Specific e-Waste, Components and Materials

Some of the analyzed documents focus all or parts of their stipulations on specific materials. They are considered to be of specific concern, requiring specific attention in collection, treatment, disposal and export.

EPA R2 Focus Materials [6] and Designated Materials [7]

The EPA Responsible Recycling (“R2”) Practices [6] specify “Focus Materials” (FM) in end-of-life electronic equipment that warrant greater care during recycling, refurbishing, materials recovery, energy recovery, incineration, and/or disposal due to their toxicity or other potential adverse worker health and safety, public health, or environmental effects that can arise if the materials are managed without appropriate safeguards.

The following are R2 Focus Materials:

- 1) Items containing polychlorinated biphenyls (PCBs),
- 2) Items containing mercury,
- 3) CRTs and CRT glass,
- 4) Batteries
- 5) Whole and shredded circuit boards, except for whole and shredded circuit boards that do not contain lead solder, and have undergone safe and effective mechanical processing, or manual dismantling, to remove mercury and batteries.

Equipment, components, or materials (whole or shredded) that have undergone safe and effective mechanical processing or manual dismantling to remove FMs, yet still retain de minimus amounts of FMs, are not subject to the R2 requirements that are triggered by the presence of FMs.

The definition of “Designated Materials” in the EPA plug-in guide to e-cycling [7] is close to the “Focus Material” definition. “Designated Materials” mean any electronic products and components containing or consisting of circuit boards, shredded circuit boards, CRTs, batteries, and mercury- and PCB-containing lamps and devices. However, this definition does not include circuit boards that have been processed to the point where they no longer are readily identifiable as circuit boards or shredded circuit boards (such as after burning/melting), as well as CRT glass that has been adequately processed for use as an industrial feedstock material. In these cases, the economic value of the material has been enhanced significantly through processing; thus, commodities of value have been created and concern for the subsequent environmental mismanagement of this material is greatly decreased.

Oregon Recycling Practices’ Materials of Concern [8]

Materials of concern include each of the following, and any CEDs or component, or any aggregate material(s) derived from end-of-life CEDs or components (e.g. shredded, granulated, or mixed materials) containing:

- 1) Any devices, including fluorescent tubes, containing mercury or polychlorinated biphenyls (PCBs)
- 2) Batteries
- 3) Cathode Ray Tubes (CRTs) and leaded glass
- 4) Circuit boards

These items are included because of their potential for improper handling or management that could result in risk to worker safety, public health, or the environment.

BAN and ETBC Hazardous E-waste [9][10]

Hazardous e-waste means electronic equipment, parts, and materials destined for recycling or disposal but not for direct reuse, that contain, consist of, or are derived from:

- 1) Cadmium-, lead- or beryllium-containing circuit boards;
- 2) Cathode ray tubes (CRTs);
- 3) CRT glass (processed and unprocessed);
- 4) Batteries containing lead, mercury, and/or cadmium and/or are flammable;
- 5) Mercury-, beryllium- and Polychlorinated Biphenyl-containing materials, components, lamps and devices; and/or
- 6) Non-working parts and whole equipment or devices exported for repair or reuse unless assurances exist that hazardous electronic waste (such as CRTs, batteries, mercury lamps, or circuit boards) will not be disposed of in the importing country as a result.

The definition of "hazardous electronic waste" does not include:

- 1) New equipment going for use or sale (as opposed to recycling or disposal); or
- 2) Fully functional equipment and parts that are adequately tested, certified and labeled as working, packaged to protect reusability, and that are not intended for disposal or recycling, but for donation, reuse and/or resale; or
- 3) Non-hazardous waste such as copper unless it is contaminated with a Basel Convention hazardous waste such as lead, cadmium, beryllium, PCBs, mercury, etc. (constituents listed in Basel Annex I); or
- 4) Electronic equipment or materials that are to be used as a direct feedstock in manufacturing without further processing or preparation (e.g. cleaned, furnace ready, CRT cullet), and the 'competent authority' of an importing country makes a written determination that the material is not a waste, and therefore not a regulated waste under Basel. Such a determination provided in writing by the legitimate 'competent authority' and provided to BAN will be required to exercise this exemption.

The term 'hazardous electronic waste' as used in this Pledge does not pertain to, nor is synonymous with any current legal US or other national definitions of 'hazardous waste', but is meant for the purposes of this Pledge only.

IAER Materials of Concern [10]

“Materials of Concern” are including, but not limited to substances designated as “hazardous” by applicable laws and regulations.

Dell Environmentally Sensitive Materials [11]

Substances of environmental concern, as defined by legal requirements, specific market demands, or by the following criteria:

- 1) Substances with hazardous properties that are a known threat to human health or the environment;
- 2) Substances with hazardous properties that show strong indications of significant risks to human health or the environment;
- 3) Substances with hazardous properties that are known to bio-persist and/or bioaccumulate in humans or the environment.

2.5.2 Legal Compliance

Oregon Electronics Recycling Environmental Management Practices [8]

The guidelines refer to desktop computers, portable computers, monitors, and televisions (covered electronic devices or CEDs)

- 1) Comply and maintain compliance with all applicable federal, state, and local environmental, health, and safety legal requirements.
- 2) If exporting, comply with and be able to document compliance with all laws of the transit and recipient countries applicable to operations and transactions in which it engages.
- 3) The above includes, but are not limited to, applicable legal requirements relating to:
 - a) Waste and recycling processing, storage, handling, and shipping;
 - b) Air emissions and waste water discharge, including storm water discharges;
 - c) Worker health and safety; and

- d) Transboundary movement of electronic equipment, components, materials, waste, or scrap for reuse, refurbishment, recycling, or disposal.
- 4) Upon request from a customer, make available to the customer information about any fines, regulatory orders, or violations received in the previous three years related to the requirements outlined in the EMPs. For any subsequent fines or regulatory orders, make that information available within 60 days after any subsequent fines or regulatory orders are issued.

2.5.3 Requirements for Sites and Equipment for Treatment of WEEE

WEEE Directive [1] and Proposal for a Recast of the WEEE Directive [2]

The WEEE Directive [1] as well as the proposed recast [2] specify requirements and equipment, which sites for treatment of e-waste should suffice:

- 1) balances to measure the weight of the treated waste,
- 2) impermeable surfaces and waterproof covering for appropriate areas with the provision of spillage collection facilities and, where appropriate, decanters and cleanser-degreasers,
- 3) appropriate storage for disassembled spare parts,
- 4) appropriate containers for storage of batteries, PCBs/PCTs containing capacitors and other hazardous waste such as radioactive waste,
- 5) equipment for the treatment of water in compliance with health and environmental regulations.

IPPC BAT Document for Waste Treatment [3]

BAT is to:

- 1) perform crushing, shredding and sieving operations in areas fitted with extractive vent systems linked to abatement equipment (see section 4.1.6.1 in IPPC BAT document [3]) when handling materials that can generate emission to air (e.g. odours, dust, VOCs)
- 2) perform crushing/shredding operations (see section 4.1.6.1 and 4.6 in IPPC BAT document [3])) under full encapsulation and under an inert atmosphere for drums/containers containing flammable or highly volatile substances. This will avoid ignition. The inert atmosphere is to be abated

- 3) perform washing processes considering (see section 4.1.6.2 in IPPC BAT document [3]):
- 4) identifying the washed components that may be present in the items to be washed (e.g. solvents)
- 5) transferring washings to appropriate storage and then treating them in the same way as the waste from which they were derived
- 6) using treated waste water from the waste treatment plant for washing instead of fresh water. The resultant waste water can then be treated in the waste water treatment plant or re-used in the installation.

Air Emission Treatments

To prevent or control the emissions mainly of dust, odours and VOC and some inorganic compounds, BAT is to:

- 1) restrict the use of open topped tanks, vessels and pits by:
- 2) not allowing direct venting or discharges to air by linking all the vents to suitable abatement systems when storing materials that can generate emissions to the air (e.g. odours, dust, VOCs, see section see Section 4.1.4.5 of the original IPPC BAT document [3])
- 3) keeping the waste or raw materials under cover or in waterproof packaging (see Section 4.1.4.5 of the original IPPC BAT document [3])
- 4) connecting the head space above the settlement tanks (e.g. where oil treatment is a pretreatment process within a chemical treatment plant) to the overall site exhaust and scrubber units (see Section 4.1.4.1 of the original document [3])
- 5) use an enclosed system with extraction, or under depression, to a suitable abatement plant. This technique is especially relevant to processes which involve the transfer of volatile liquids, including during tanker charging/discharging (also see section 4.6.1 the original IPPC BAT document [3])
- 6) apply a suitably sized extraction system which can cover the holding tanks, pretreatment areas, storage tanks, mixing/reaction tanks and the filter press areas, or to have in place a separate system to treat the vent gases from specific tanks (for example, activated carbon filters from tanks holding waste contaminated with solvents) (also see section 4.6.1 the original IPPC BAT document [3])
- 7) correctly operate and maintain the abatement equipment, including the handling and treatment/disposal of spent scrubber media (see section 4.6.11 of the original IPPC BAT document [3])
- 8) have a scrubber system in place for the major inorganic gaseous releases from those unit operations which have a point discharge for process emissions. Install a secondary scrubber unit to certain pretreatment systems if the discharge is incompatible, or too concentrated for the main scrubbers (also see section 4.6.11 of the original IPPC BAT document [3])

- 9) have leak detection and repair procedures in place in installations
- 10) handling a large number of piping components and storage and
- 11) compounds that may leak easily and create an environmental problem (e.g. fugitive emissions, soil contamination). This may be seen as an element of the EMS
- 12) reduce air emission to the levels indicated in Table 2 by using a suitable combination of preventive and/or abatement techniques (also see section 4.6. of the original IPPC BAT document [3]) The techniques mentioned above in the this section on 'Air emission treatments' also contribute to achieve these values

Table 2: BAT emission levels into air [3]

Air parameter	Emission levels associated to the use of BAT (mg/Nm³)
VOC	7 – 20 *
PM	5 – 20

* For low VOC loads, the higher end of the range can be extended to 50

Waste Water Management

BAT is to:

- 1) reduce the water use and the contamination of water by (see Sections 4.1.3.6 and 4.7.1 of the original IPPC BAT document [3]):
- 2) applying site waterproofing and storage retention methods
- 3) carrying out regular checks of the tanks and pits especially when they are underground
- 4) applying separated water drainage according to the pollution load (roof water, road water, process water)
- 5) applying a security collection basin
- 6) performing regular water audits, with the aim of reducing water consumption and preventing water contamination
- 7) segregating process water from rainwater (also see section 4.7.2 of the original IPPC BAT document [3])
- 8) have procedures in place to ensure that the effluent specification is suitable for the on-site effluent treatment system or discharge (see section 4.7.1 of the original IPPC BAT document [3])

- 9) avoid the effluent by-passing the treatment plant systems (see section 4.7.1 of the original IPPC BAT document [3])
- 10) have in place and operate an enclosure system whereby rainwater falling on the processing areas is collected along with tanker washings, occasional spillages, drum washings, etc. and returned to the processing plant or collected in a combined interceptor (see section 4.7.1 of the original IPPC BAT document [3])
- 11) segregate the water collecting systems for potentially more contaminated waters from less contaminated water (see section 4.7.2 of the original IPPC BAT document [3])
- 12) have a full concrete base in the whole treatment area, that falls to internal site drainage systems which lead to storage tanks or to interceptors that can collect rainwater and any spillage. Interceptors with an overflow to sewer usually need automatic monitoring systems, such as pH checks, which can shut down the overflow ((see section 4.1.3.6 of the original IPPC BAT document [3])
- 13) collect the rainwater in a special basin for checking, treatment if contaminated and further use ((see section 4.7.1 of the original IPPC BAT document [3])
- 14) maximise the re-use of treated waste waters and use of rainwater in the installation (see section 4.7.1 of the original IPPC BAT document [3])
- 15) conduct daily checks on the effluent management system and to maintain a log of all checks carried out, by having a system for monitoring the effluent discharge and sludge quality in place
- 16) firstly identify waste waters that may contain hazardous compounds (e.g. adsorbable organically bound halogens (AOX); cyanides; sulphides; aromatic compounds; benzene or hydrocarbons (dissolved, emulsified or undissolved); and metals, such as mercury, cadmium, lead, copper, nickel, chromium, arsenic and zinc). Secondly, segregate the previously identified waste water streams on-site and thirdly, specifically treat waste water on-site or off-site (see section 4.7.1 of the original IPPC BAT document [3])
- 17) ultimately after the application of BAT 1) on page 40, select and carry out the appropriate treatment technique for each type of waste water (see section 4.7.1 of the original IPPC BAT document [3])
- 18) implement measures to increase the reliability with which the required control and abatement performance can be carried out (for example, optimising the precipitation of metals) (see section 4.7.1 of the original IPPC BAT document [3])
- 19) identify the main chemical constituents of the treated effluent (including the make-up of the COD) and to then make an informed assessment of the fate of these chemicals in the environment ((see section 4.7.1 of the original IPPC BAT document [3]) and their applicability restrictions identified)
- 20) only discharge the waste water from its storage after the conclusion of all the treatment measures and a subsequent final inspection (see section 4.7.1 of the original IPPC BAT document [3])
- 21) achieve the water emission values in Table 3 before discharge by applying a suitable combination of techniques mentioned in Sections 4.4.2.3 and 4.7 in the IPPC BAT

document [3]. The techniques mentioned above in this section on 'waste water management' also contribute to reach these values.

Table 3: BAT waste water emission values [3]

Water parameter	Emission values associated with the use of BAT (ppm)
COD	20 – 120
BOD	2 – 20
Heavy metals (Cr, Cu, Ni, Pb, Zn)	0.1 – 1
Highly toxic heavy metals:	
As	<0.1
Hg	0.01 – 0.05
Cd	<0.1 – 0.2
Cr(VI)	<0.1 – 0.4

Management of the process generated residues

BAT is to:

- 1) have a residue management plan (see Section 4.8.1 in original document [3]) as part of the EMS including:
 - 2) basic housekeeping techniques
 - 3) internal benchmarking techniques (see Section 4.1.2.8 in original document [3]).
 - 4) maximise the use of re-usable packaging (drums, containers, IBCs, palletes, etc.) (see section 4.8.1 in original document [3])
 - 5) re-use drums when they are in a good working state. In other cases, they are to be sent for appropriate treatment
 - 6) keep a monitoring inventory of the waste on-site by using records of the amount of wastes received on-site and records of the wastes processed (see Section 4.8.3 in original document [3])
 - 7) re-use the waste from one activity/treatment possibly as a feedstock for another (see Section 4.1.2.6 in original document [3])

Prevention of Soil Contamination

To prevent soil contamination, BAT is to:

- 1) provide and then maintain the surfaces of operational areas, including applying measures to prevent or quickly clear away leaks and spillages, and ensuring that maintenance of drainage systems and other subsurface structures is carried out (see Section 4.8.2 in original document [3])
- 2) utilise an impermeable base and internal site drainage (see Section 4.1.4.6, 4.7.1 and 4.8.2 of original document [3])
- 3) reduce the installation site and minimise the use of underground vessels and pipework (see section 4.8.2 of the original document [3])

BAN and ETBC Electronics Recycler's Pledge [9]

Every effort will be made to only make use of those facilities (e.g. smelters), which provide the most efficient and least polluting recovery services available globally.

2.5.4 Recovery Operations and Treatment Targets

WEEE Directive [1] and Proposal for a Recast of the WEEE Directive [2]

The WEEE Directive [1] requires minimum recovery and recycling targets for collected WEEE Art. 7 and Annex IA, [1]).

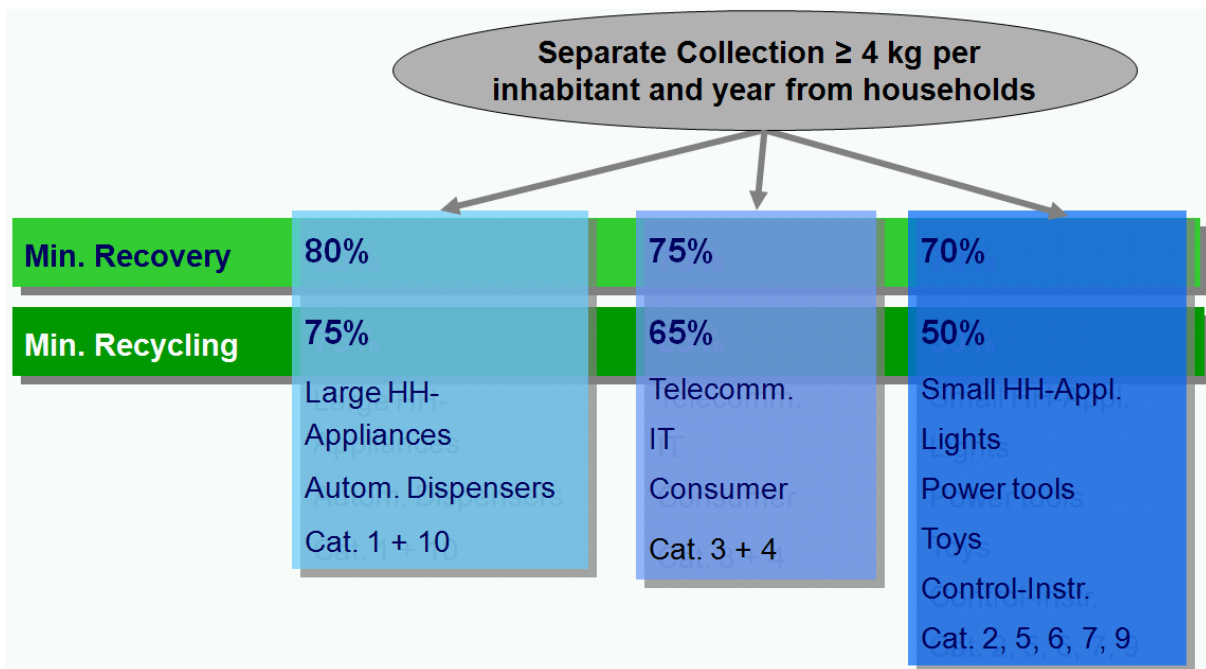


Figure 1: Minimum recovery and recycling targets in the WEEE Directive [1]

For gas discharge lamps, the rate of component, material and substance reuse and recycling shall reach a minimum of 80 % by weight of the lamps. [1]

'Recovery' means any of the applicable operations provided for in Annex IIB to Directive 75/442/EEC. [1]

'Recycling' means the reprocessing in a production process of the waste materials for the original purpose or for other purposes, but excluding energy recovery which means the use of combustible waste as a means of generating energy through direct incineration with or without other waste but with recovery of the heat. [1]

The proposed recast of the WEEE Directive [2] increases the recovery as well as the recycling targets for 5 % respectively. Medical Devices (cat. 8) are included and have to achieve the new recovery and recycling targets of cat. 2, 5, 6, 7 and 9.

The respective target for gas discharge lamps are increased for 5 % as well: 85% of collected gas discharge lamps shall be prepared for re-use and recycled. [2]

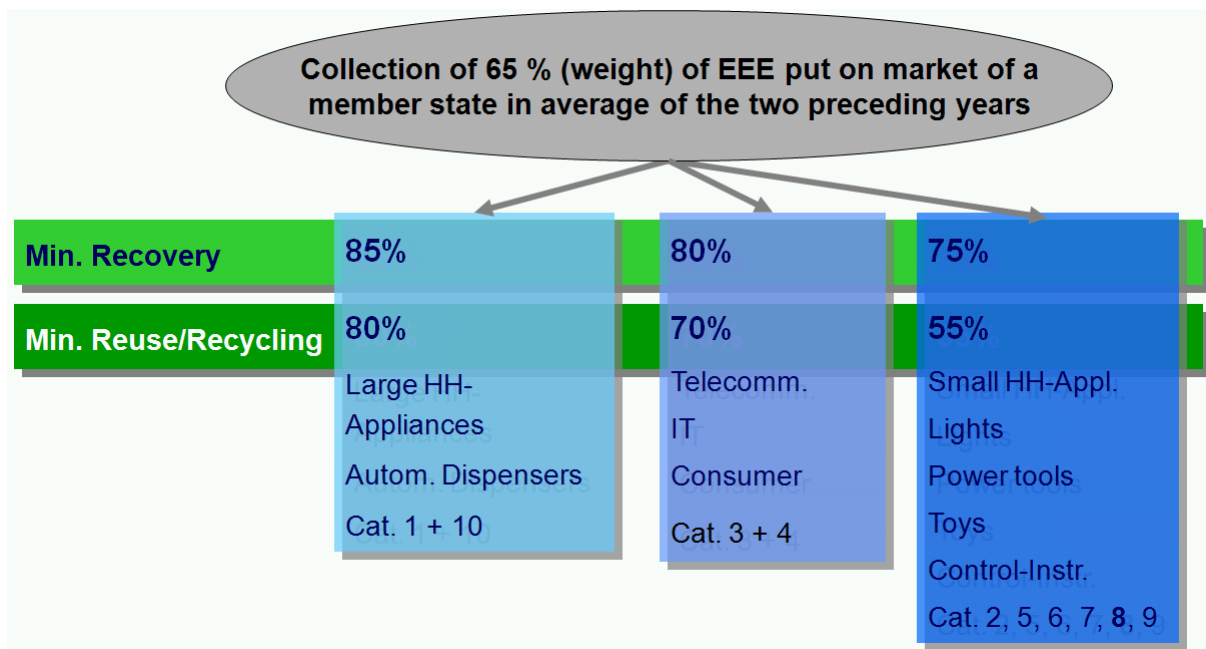


Figure 2: Minimum recovery and recycling targets in the WEEE Directive [2]

Reuse of collected waste EEE will now be allowed to be taken into account for the minimum targets set out above. The WEEE Directive explicitly had prohibited this until 31 December 2008 [1]. The collection targets have changed as well, which is explained in detail in the "Collection" chapter on page 25 f.

The definitions of reuse, recovery and recycling possibly changed. The definitions refer to other European Directives, which are, however, not yet clearly specified :

- 1) 'Re-use' means re-use within the meaning of Article 3(13) of Directive 2008/xx/EC on waste.
- 2) 'Recovery' means recovery within the meaning of Article 3(15) of Directive 2008/xx/EC on waste.
- 3) 'Recycling' means recycling within the meaning of Article 3(17) of Directive 2008/xx/EC on waste.

As the reference to the waste directive is not yet clear, it cannot yet be assessed whether and how far and with which consequences the above definition changes are of practical relevance.

The definition of "remove" is new as well:

"remove" means manual, mechanical, chemical or metallurgic handling with the result that hazardous substances, preparations and components are contained as an identifiable stream or identifiable part of a stream at the end of the treatment process. A substance, preparation or component is identifiable if it can be monitored to prove environmentally safe treatment.

This new definition does no longer necessarily require manual dismantling if components or materials have to be removed according to Annex II on selective treatment. If the flow of a

material can be tracked and safely be handled throughout the process and in the fraction where it ends up, the definition allows considering this treatment as removal of a substance.

IAER Recycler Certification Standard [10]

There shall be evidence that a high percentage of the product received by the company is reused or recycled and not landfilled as well as a commitment to continuously improve in this area. Any residual materials shall have a waste determination made prior to disposal.

2.5.5 Appropriate Recovery and Recycling Operations

WEEE Directive [1] and Proposal for a Recast of the WEEE Directive [2]

Annex IIB of Directive 75/442/EEC is intended to list recovery operations as they occur in practice. In accordance with Article 4, waste must be recovered without endangering human health and without the use of processes or methods likely to harm the environment.

- R 1 Use principally as a fuel or other means to generate energy
- R 2 Solvent reclamation/regeneration
- R 3 Recycling/reclamation of organic substances which are not used as solvents (including composting and other biological transformation processes)
- R 4 Recycling/reclamation of metals and metal compounds
- R 5 Recycling/reclamation of other inorganic materials
- R 6 Regeneration of acids or bases
- R 7 Recovery of components used for pollution abatement
- R 8 Recovery of components from catalysts
- R 9 Oil re-refining or other reuses of oil
- R 10 Land treatment resulting in benefit to agriculture or ecological improvement
- R 11 Use of wastes obtained from any of the operations numbered R 1 to R 10

- R 12 Exchange of wastes for submission to any of the operations numbered R 1 to R 11
- R 13 Storage of wastes pending any of the operations numbered R 1 to R 12 (excluding temporary storage, pending collection, on the site where it is produced)

The proposed recast of the WEEE Directive [2] does no longer refer to Annex IIB of Directive 75/442/EEC, but points to “Article 3(15) of Directive 2008/xx/EC on waste”. As this Directive is not yet clearly denominated, it could not yet be assessed whether the recast would change the above definitions of accepted recovery operations.

IPPC BAT Document for Waste Treatment [3]

Emerging techniques for treatment of waste contaminated with POPs

POPs (persistent organic pollutants) are a specific type of chemicals that require specific attention due to their highly adverse environmental and health effects. As e-waste or fractions thereof may contain polychlorinated biphenyls, a substance listed as POP, the emerging techniques for POP destruction were integrated into this document.

Wastes containing POPs is actually mostly treated by incineration. However, other types of technique are emerging as shown in Table 4.

Table 4: Emerging techniques of POPs Destruction

Technique	Comment
Base catalyzed dechlorination	Organochlorines are reacted with an alkaline polyethylene glycol, forming a glycol ether and/or a hydroxylated compound, which requires further treatment, and a salt. Dioxins have been identified in process residues. Destruction efficiencies are not high
Catalytic hydrogenation	Organochlorines are reacted with hydrogen in the presence of noble metal catalysts, yielding hydrogen chloride and light hydrocarbons.
Electrochemical oxidation	At low temperature and atmospheric pressure, electrochemically generated oxidants react with organochlorines to form carbon dioxide, water and inorganic ions with high destruction efficiencies. All emissions and residues can be captured for assay and re-processing, if needed. An electrochemical cell is used to generate oxidising species at the anode in an acid solution, typically nitric acid. These oxidisers and the acid then attack any organic compounds, converting most of them to carbon dioxide, water and inorganic ions at low temperature (<80 °C) and atmospheric pressure. Compounds that have been destroyed by this process include aliphatic and aromatic

	hydrocarbons, phenols, organophosphorous and organosulphur compounds, and chlorinated aliphatic and aromatic compounds. Data describing concentrations in gaseous, liquid and solid residues of dioxins and other POPs potentially formed by this process were not available for review. No industrial application is currently known
Electron beam oxidation	--
Mediated electro-chemical oxidation by cerium	This technique uses electrochemical cells for the generation of the active Cerium(IV) oxidant at the anode, a liquid phase reactor for primary organic destruction, a gas phase reactor to destroy any fugitive emissions from the liquid reactor and an acid gas scrubber for removal of acid gases prior to venting to the air. The process operates at low temperature (90 – 95 °C) and at atmosphere pressure
Mediated electro-chemical oxidation by silver	This process uses silver (II) to oxidise organic waste streams. Reactions take place in an electro-chemical cell similar to the type utilised in the chlor-alkali industry. The process operates at low temperature (~90 °C) and at atmospheric pressure. Molten metal Organochlorines and other materials are oxidised in a vat of molten metal, yielding hydrogen, carbon monoxide, ceramic slag and metal byproducts. There is currently designing facilities for four commercial customers in US. Molten salt Organochlorines and other materials are oxidised in a vat of molten salt, yielding carbon dioxide, water, molecular nitrogen, molecular oxygen, and neutral salts. Destruction efficiencies may be high. It is suitable for the destruction of pesticides but not for treatment of contaminated soils.
Photocatalysis	Use light to activate a catalyst that oxidise/reduce the compounds. A wide range of compounds can be destroyed. Useful for liquid and gaseous wastes
Ultraviolet oxidation	--

2.5.6 Reuse of Equipment and Components

Proposal for Recast of the WEEE Directive [2]

The recast proposal sets up minimum monitoring requirements for shipments of WEEE in Annex I. The current WEEE Directive does not have such rules.

- 1) In order to distinguish between electrical and electronic equipment and WEEE, where the holder of the object claims that he intends to ship or is shipping used electrical and electronic equipment and not WEEE, Member State authorities shall request the following to back up this claim:
 - a) a copy of the invoice and contract relating to the sale and/or transfer of ownership of the electrical and electronic equipment which states that the equipment is for direct re-use and fully functional;
 - b) evidence of evaluation or testing in the form of a copy of the records (certificate of testing, proof of functionality) on every item within the consignment and a protocol containing all record information according to point 2;
 - c) a declaration made by the holder who arranges the transport of the electrical and electronic equipment that none of the material or equipment within the consignment is waste as defined by Article 3(1) of Directive 2008/xx/EC on waste, and
 - d) sufficient packaging to protect the shipped products from damage during transportation, loading and unloading.
- 2) In order to demonstrate that the items being shipped are used electrical and electronic equipment rather than WEEE, Member States shall require the following steps for testing and record keeping for used electrical and electronic equipment to be carried out:

Step1: Testing

- a) Functionality should be tested and hazardous substances should be evaluated. The tests that should be conducted depend on the kind of electrical and electronic equipment. For most of the used electrical and electronic equipment a functionality test of the key functions is sufficient.
- b) Results of evaluation and testing should be recorded.

Step2: Record

- c) The record should be fixed securely but not permanently on either the electrical and electronic equipment itself (if not packed) or on the packaging so it can be read without unpacking the equipment.
- d) The record shall contain the following information:
 - i) Name of item (Name of the equipment according to Annex II and category according to Annex I of Directive 20xx/xx/EC (RoHS));
 - ii) Identification Number of the item (type no.);

- iii) Year of Production (if available);
 - iv) Name and address of the company responsible for evidence of functionality;
 - v) Result of tests as described in step 1;
 - vi) Kind of tests performed.
- 1) In addition to the document requested in point 1, every load (e. g. shipping container, lorry) of used electrical and electronic equipment should be accompanied by a:
- a) CMR document,
 - b) declaration of the liable person on its responsibility.
- 2) In the absence of appropriate documentation required in point 1 and 3 and packaging, Member State authorities shall presume that an item is hazardous WEEE and presume that the load comprises an illegal shipment. In these circumstances the relevant competent authorities will be informed and the load will be dealt with in accordance with Articles 24 and 25 of the Waste Shipment Regulation. In the majority of cases those responsible for the shipment will have to take back the waste to the country of dispatch at their own expense and may be liable to a criminal sanction. In those Member States where the burden is on the state authorities to prove the items are WEEE rather than electrical and electronic equipment, absence of the appropriate documentation and packaging is likely to lead to significant delays to the onward transport of the waste whilst the necessary investigations are carried out to establish the status of the items being shipped.

EPA R2 Guidelines [6]

General Principle: An R2 electronics recycler shall refurbish as needed, properly test, and adequately package equipment and components going to reuse:

- 1) An R2 electronics recycler shall not allow equipment or components to be sold or donated for reuse if contrary to commercial agreements.
- 2) An R2 electronics recycler shall, with respect to equipment and components it ships downstream:
 - a) Label and sort each shipment in a manner sufficient to track throughput in conformity with Provision 7 [6] (tracking throughput) in the original document.
 - b) Handle and package shipments in conformity with Provision 12 [6] (transport) in the original document.
- 3) An R2 electronics recycler, prior to shipping equipment and components (except equipment and components that are new and in their original packaging) that contain FMs and that will be reused as is or repaired, refurbished, or remanufactured, shall:

- c) Utilize effective testing methods to confirm that the Key Functions of the equipment or components are working properly. "Key Functions" are the originally-intended functions of a unit of equipment or component, or a subset thereof, that will satisfactorily serve the purpose(s) of someone who will reuse the unit,

or
 - d) determine that the recipient vendor is a certified R2 electronics recycler,

or
 - e) confirm through an appropriate combination of contractual agreements, detailed materials tracking and recordkeeping, and auditing that:
 - i) The equipment or components meet the specifications of the recipient vendor, and
 - ii) The recipient vendor sells the equipment or components for reuse, with their key functions functioning properly, and
 - iii) The recipient vendor manages all residual FMs resulting from refurbishing operations in a manner that conforms to the R2 Guideline Practices.
- 4) An R2 electronics recycler need not conform to Section 3) for shipments of less than 15 units that either are going to a new vendor as a sample for purposes of evaluation of whether to purchase larger quantities for refurbishment or that are being sold with a practical return policy to an end user. This section 4) does not apply to multiple sales or shipments within a proximate timeframe to the same entity.
- 5) An R2 electronics recycler need not conform to the downstream requirements of Provision 5 (Selection and Ongoing Due Diligence of Downstream Vendors for FMs, source [6], page 7, or see section 5) on page 81 and EPA R2 Guidelines [6] on page 54 of this document)) for shipments that satisfy the requirements of Section 3) or 4), or are new and in their original packaging.
- 6) An R2 electronics recycler need not conform to the exporting requirements of Provision 3 (a) (2) (source [6], page 4, or see section 1)c) on page 63) for shipments that satisfy either the functionality requirement of Section 3)c) above, or the requirements of Section 4), or are new and in their original packaging.

Oregon Electronics Recycling Environmental Management Practices [8]

When screening CEDs for reuse or refurbishment, collectors must:

- 1) Post, in a readily visible location, information that informs covered entities that the CEDs are screened for reuse or refurbishment;
- 2) Follow the generator's preference if the covered entities indicate they do not want their CEDs reused or refurbished;
- 3) Triage and screen appropriately for reuse or refurbishment;

- 4) Track separately the number of screened units which are sent for reuse and refurbishment;
- 5) Ensure that CEDs designated for reuse and refurbishment are packaged in a manner that minimizes damage them during transportation; and
- 6) Obtain written certification from the vendor(s) that the screened units are going for reuse and refurbishment and that the unusable units will be recycled using environmentally sound management practices as described herein.
- 7) Store whole products, components, and equipment destined for reuse or refurbishment in a manner that:
 - a) Protects them from adverse atmospheric conditions and floods;
 - b) Is secure from unauthorized entrance; and
 - c) Is in clearly labeled containers and/or storage areas.

IAER Recycler Certification Standard [10]

Reuse and refurbishment facilities shall ensure that electronic equipment shipped for reuse is fully functional and is shipped to a vendor who is the business of selling for reuse, and that equipment and components shipped for refurbishment are refurbishable. Reuse and refurbishment operations shall have a process to control the testing and tracking of such equipment.

Dell Guidelines [11]

Dell will endeavor to maximize re-use opportunities.

2.5.7 Disassembly and Pre-Treatment

Draft Law on Pollution Control, Recycling and Reuse of WEEE, China [4]

- 1) Enterprises for WEEE treatment shall disassemble WEEE in environmentally sound and safe condition, and safely treat the toxic and hazardous substances according to the requirement of the country.

- 2) WEEE shall be disassembled in the way of pollution prevention, and can not be disassembled directly on the ground.
- 3) The component and spare part which contains following substances shall be disassembled and collected separately:
 - a) Display screen, cathode-ray tube in TV set;
 - b) Liquid crystal display screen which is bigger than 100 cm², gas-discharge light bulb;
 - c) Printed circuit which is bigger than 10 cm² ;
 - d) Plastic cable and frame with flame retardant of PBB and PBDE;
 - e) PCB capacitor, spare part with mercury;
 - f) Nickel-cadmium rechargeable battery, lithiumion battery;
 - g) Discarded refrigerator, air conditioner and other refrigerating appliances which contain refrigerant and lubricant.
- 4) WEEE is prohibited to be disassembled in the process of selling, transportation, storage and recycling.

Draft National Standard China [5]

- 1) Various waste electrical & electronic products should be classified for disassembly.
- 2) The disassembly equipment should be placed on the concrete floor, which should be able to prevent mixture or leakage of water, rainwater or oils.
- 3) Substances, elements as well as devices stipulated in Appendix B (Substances, Elements and Devices that must be Pre-disassembled) should be pre-disassembled and taken out. In addition, wires in the waste electrical & electronic products should be pre-disassembled.
- 4) It is prohibited to discard the pre-disassembled substances, elements and devices, which should be treated and disposed in accordance with Chapter 7 (Technical Requirements for Pollution Control in the Process of Treatment) and Chapter 8 (Technical Requirements for Pollution Control in the Process of Disposal)of the Standard.
- 5) All the liquid (including lubrication oil) should be pre-disassembled and held separately.
- 6) In time of storing the pre-disassembled substances, elements and devices, they should be marked clearly. As for the hazardous substances that require special safety treatment, they must be classified and stored according to features of the hazardous waste.
- 7) The pre-disassembled capacitor containing polychlorinated biphenyl (PCB) should be placed separately in the container, with marks.
- 8) Electrolytic capacitors with both the height and diameter being over 25 mm or with similar volume should be pre-disassembled to prevent leakage of electrolytic liquid. When using

incinerating method to treat printed wire boards, it is allowed not to pre-disassemble electrolysed capacitors.

- 9) The pre-disassembled batteries should be complete and handed over to the enterprises with qualifications for treatment and disposal. Appropriate measures should be taken to avoid fire disasters caused by batteries in time of treatment and storage.
- 10) The pre-disassembled elements containing mercury should be complete, stored in exclusive containers and handed over to the enterprises with qualifications for treatment. In order to identify such kind of elements, special training is required for the workers.
- 11) As for the pre-disassembled parts containing refractory ceramic fibers (RCFs), scattering of refractory ceramic fibers (RCFs) should be prevented. In addition, they should be stored in the containers.
- 12) Scattering of the pre-disassembled parts containing asbestos and the asbestos waste should be prevented. In addition, they should be stored in the containers.

EPA R2 Guidelines [6]

- 1) Prior to shredding, materials recovery, energy recovery, incineration, or land disposal of equipment or components, Focus Materials (as well as toner and toner cartridges) shall be removed using safe and effective mechanical processing or manual dismantling, with two exceptions:
 - a) Items containing mercury if they are too small to remove safely at reasonable cost, and workers are protected from the risks posed by the mercury during and subsequent to any processing or manual dismantling of the equipment containing it, and the equipment and components containing such items are sent to materials recovery facilities that are properly licensed to receive, and that utilize technology designed to safely and effectively manage, equipment or components containing such mercury-containing items.
 - b) CRTs, batteries, and circuit boards contained in equipment or components destined for materials recovery need not be removed prior to shredding and/or materials recovery if the shredding and/or materials recovery occurs in facilities that are properly licensed to receive, and that utilize technology designed to safely and effectively manage, equipment or components containing these Focus Materials.

IAER Recycler Certification Standard [10]

- 1) Hazardous substances, electronics scrap and any associated emissions should be handled, transported and disposed of in accordance with applicable laws and regulations. All equipment used to process electronics scrap shall be equipped with the proper pollution controls and permitted in accordance with applicable laws and regulations.
- 2) Materials of Concern shall be removed from equipment and components if they are determined to potentially pose a risk to workers or downstream vendors.

2.5.8 Recovery and Recycling

IPPC BAT Document for Waste Treatment [3]

BAT is to

- 1) have and apply mixing/blending rules oriented to restrict the types of wastes that can be mixed/blended together in order to avoid increasing pollution emission of down-stream waste treatments. These rules need to consider the type of waste (e.g. hazardous, nonhazardous), waste treatment to be applied as well as the following steps that will be carried out to the waste OUT (see section 4.1.5 of IPPC BAT document [3])
- 2) have a segregation and compatibility procedure in place (see section 4.1.5 of IPPC BAT document [3]), including:
 - a) keeping records of the testing, including any reaction giving rise to safety parameters (increase in temperature, generation of gases or raising of pressure); a record of the operating parameters (viscosity change and separation or precipitation of solids) and any other relevant parameters, such as generation of odours (see section 4.1.4.13 and 4.1.4.14 of IPPC BAT document [3])
 - b) packing containers of chemicals into separate drums based on their hazard classification. Chemicals which are incompatible (e.g. oxidisers and flammable liquids) should not be stored in the same drum (see section 4.1.4.6 of IPPC BAT document [3])
- 3) have an approach for improving waste treatment efficiency. This typically includes the finding of suitable indicators to report waste treatment efficiency and a monitoring programme (see section 4.1.2.4 of IPPC BAT document [3])

WEEE Directive [1] and Proposal for a Recast of the WEEE Directive [2]

Member States shall ensure that all separately collected WEEE undergoes treatment. [2]

Article 6 (Treatment) of the WEEE Directive [1] and the proposed recast [2] in Article 8 both demand best available techniques for the treatment of e-waste without specifying which technologies this actually should be.

Both Directives require that the treatment shall, as a minimum, include the removal of all fluids and a selective treatment in accordance with Annex II. The proposed recast confines this treatment requirements to treatments which does not serve the preparation for reuse [2].

The WEEE Directive [1] as well as the proposed recast [2] define selective treatment requirements for materials and components of waste electrical and electronic equipment in Annex II.

- 1) As a minimum the following substances, preparations and components have to be removed from any separately collected WEEE:

- a) polychlorinated biphenyls (PCB) containing capacitors in accordance with Council Directive 96/59/EC of 16 September 1996 on the disposal of polychlorinated biphenyls and polychlorinated terphenyls (PCB/PCT) (1),
- b) mercury containing components, such as switches or backlighting lamps,
- c) batteries,
- d) printed circuit boards of mobile phones generally, and of other devices if the surface of the printed circuit board is greater than 10 square centimetres,
- e) toner cartridges, liquid and pasty, as well as colour toner,
- f) plastic containing brominated flame retardants,
- g) asbestos waste and components which contain asbestos,
- h) cathode ray tubes,
- i) chlorofluorocarbons (CFC), hydrochlorofluorocarbons (HCFC) or hydrofluorocarbons (HFC), hydrocarbons (HC),
- j) gas discharge lamps,
- k) liquid crystal displays (together with their casing where appropriate) of a surface greater than 100 square centimeters and all those back-lighted with gas discharge lamps,
- l) external electric cables,
- m) components containing refractory ceramic fibres as described in Commission Directive 97/69/EC of 5 December 1997 adapting to technical progress Council Directive 67/548/EEC relating to the classification, packaging and labelling of dangerous substances (2),
- n) components containing radioactive substances with the exception of components that are below the exemption thresholds set in Article 3 of and Annex I to Council Directive 96/29/Euratom of 13 May 1996 laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionising radiation (3),
- o) electrolyte capacitors containing substances of concern (height > 25 mm, diameter > 25 mm or proportionately similar volume)

These substances, preparations and components shall be disposed of or recovered in compliance with Article 4 of Council Directive 75/442/EEC.

- 2) The following components of WEEE that is separately collected have to be treated as indicated:
 - a) cathode ray tubes: The fluorescent coating has to be removed,
 - b) equipment containing gases that are ozone depleting or have a global warming potential (GWP) above 15, such as those contained in foams and refrigeration circuits: the gases must be properly extracted and properly treated. Ozone-depleting

gases must be treated in accordance with Regulation (EC) No 2037/2000 of the European Parliament and of the Council of 29 June 2000 on substances that deplete the ozone layer (4).

- c) gas discharge lamps: The mercury shall be removed.
- 3) Taking into account environmental considerations and the desirability of reuse and recycling, paragraphs 1 and 2 shall be applied in such a way that environmentally-sound reuse and recycling of components or whole appliances is not hindered.
- 4) For the purposes of environmental protection, Member States may set up minimum quality standards for the treatment of collected WEEE. Member States shall encourage establishments or undertakings which carry out treatment operations to introduce certified environmental management systems. [1], [2]

Draft Law on Pollution Control, Recycling and Reuse of WEEE, China [4]

Enterprises for WEEE treatment shall disassemble WEEE in environmentally sound and safe condition, and safely treat the toxic and hazardous substances according to the requirement of the country.

The WEEE, component, or spare part which contains toxic and hazardous substances shall be crushed and screened in sealed facilities. The emission and dust generated in this process shall be collected and filtered, and can only be emitted when they meet the requirement of emission standard.

The slug generated in the treatment and disposal of WEEE, and the sludge in the waste water treatment shall be clarified according to its characteristic in line with hazardous waste identification standard. Those, which are identified as hazardous waste, shall be treated as hazardous waste and can not be mixed with municipal waste.

Neither institution nor individual is allowed to original measures, such as baking, acid-washing, open-air burning, or direct landfill without any protection, to disassemble, treat or dispose any WEEE.

Draft National Standard China [5]

Treatment should be executed inside the factory buildings and the treatment equipment should be placed on the concrete floor that is able to prevent leakage of liquids such as water and oils. Apart from these, facilities to cut off and collect oils and liquid should be provided.

The treatment enterprise should be provided with relevant environmental protection facilities, including devices for wastewater treatment, flue gas treatment, dust treatment, noise prevention or reduction, etc. Emission of various pollutants should satisfy the requirements of the national or local pollutant emission standards.

As for the waste liquid, sillage, and solid waste from the wastewater, waste liquid and solid waste generated in the process of treatment, which cannot be treated by the enterprise, they should be handed over to the enterprises with qualifications for recycling or treatment.

EPA R2 Guidelines [6]

An R2 electronics recycler shall send removed FMs (see page 35) to processing, recovery, or treatment facilities that are properly licensed to receive, and that utilize technology designed to safely and effectively manage, the FMs. This shall include:

- 1) for items containing mercury – mercury retorting,
- 2) for circuit boards – removal of batteries and mercury and then smelting for metals recovery,
- 3) and
- 4) for items containing PCBs – technology specifically designed for PCB destruction and licensed under the Toxic Substances Control Act and/or any other applicable law.

Toner and toner cartridges, though not an FM, shall be recycled through the OEM or other qualified toner recycler unless it is not economically feasible.

Oregon Electronics Recycling Environmental Management Practices [8]

The guidelines refer to desktop computers, portable computers, monitors, and televisions (covered electronic devices or CEDs).

- 1) Dismantle, separate, or mechanically process, as appropriate, the CEDs and components from which raw materials are to be recovered into separate “streams” as appropriate to generate value, minimize waste, and enable safe management through to final disposition.
- 2) Direct materials with high BTU value to energy recovery only if the energy recovery facility is designed to safely manage any “materials of concern” and the substances they contain.
BTU: British Thermal Unit, a measure for the calorific value
- 3) If the stream being managed contains any materials of concern, ensure any by-products or wastes produced at the facility are managed safely.
- 4) Conduct due diligence, or use documented due diligence that others have performed, on each downstream vendor sent materials for recovery by obtaining a written contractual commitment, or a written certification from the vendor, or other certified documentation, such as an audit report prepared by a certified auditor, that they have verifiable records

demonstrating they meet the EHSMS practices outlined in subsection 2, and are in compliance with its environmental and worker safety legal obligations.

- 5) Accumulating CEDs, components, or materials derived from CEDs that are in need of further off-site processing for more than 180 days without recycling at least 75% of what was accumulated at the beginning of that period may be considered speculative accumulation and operating a storage or disposal facility under OAR Chapter 340, Divisions 93 – 97 and may require a solid waste or hazardous waste permit.

IAER Recycler Certification Standard [10]

Materials identified in the assessment of hazards and environmental aspects of the operations as potentially posing a risk to workers or the environment shall be treated and controlled as “Materials of Concern” – including, but not limited to substances designated as “hazardous” by applicable laws and regulations.

Each Material of Concern that presents health, safety, or environmental risks shall be handled and processed in a manner that addresses the potential risks.

Dell Guidelines [11]

Dell will endeavor to maximize re-use opportunities. Where recycling is the most viable option then Dell will endeavor to minimize the use of processes that result in landfill and incineration of end-of life electronics.

2.5.9 Energy Recovery, Incineration and Disposal

WEEE Directive [1] and Proposal for a Recast of the WEEE Directive [2]

Member States shall adopt appropriate measures in order to minimize the disposal of WEEE as unsorted municipal waste. [1] [2]

The proposed recast of the WEEE Directive additionally stipulates that Member States shall prohibit the disposal of untreated separately collected waste of electrical and electronic equipment. [2]

Draft Law on Pollution Control, Recycling and Reuse of WEEE, China [4]

Neither institution nor individual is allowed to original measures, such as baking, acid-washing, open-air burning, or direct landfill without any protection, to disassemble, treat or dispose any e-waste.

EPA R2 Guidelines [6]

An R2 electronics recycler shall not utilize energy recovery, incineration, or land disposal as a management strategy for Focus Materials (FM) or equipment and components containing FMs (unless applicable law requires the use of one of these technologies (e.g., thermal destruction of PCBs). However, if circumstances beyond the control of the R2 recycler disrupt its normal management of an FM, it may consider these technologies to the extent allowed under applicable law.

Oregon Electronics Recycling Environmental Management Practices [8]

Energy Recovery and Disposal:

Manage any residual that cannot safely or technically be reused, refurbished, or recycled by further separating for energy recovery or disposal in a safe manner in accordance with applicable laws.

Periodically evaluate management strategies to incorporate new, more effective technologies and continuously improve practices and processes where feasible within the context of the hierarchy.

Materials and residuals from processing that cannot be reused or recycled may be disposed of at solid waste landfills or incinerators, and the landfill or incinerator receiving the material is operating in compliance with all applicable permits and laws, and the materials are not determined to be a hazardous waste, requiring management at a hazardous waste facility.

BAN and ETBC Electronics Recycler's Pledge [9]

We will not allow any hazardous e-waste* we handle or control to be sent to solid waste (nonhazardous waste) landfills or incinerators for disposal or energy recovery, either directly or through intermediaries.

- 1) "Hazardous electronic waste" or "hazardous e-waste" means electronic equipment, parts, and materials destined for recycling or disposal but not for direct reuse, that contain, consist of, or are derived from:
 - a) Cadmium-, lead- or beryllium-containing circuit boards;
 - b) Cathode ray tubes (CRTs);

- c) CRT glass (processed and unprocessed);
 - d) Batteries containing lead, mercury, and/or cadmium and/or are flammable;
 - e) Mercury-, beryllium- and Polychlorinated Biphenyl-containing materials, components, lamps and devices; and/or
 - f) Non-working parts and whole equipment or devices exported for repair or reuse unless assurances exist that hazardous electronic waste (such as CRTs, batteries, mercury lamps, or circuit boards) will not be disposed of in the importing country as a result.
- 2) The definition of “hazardous electronic waste” does not include:
- a) New equipment going for use or sale (as opposed to recycling or disposal); or
 - b) Fully functional equipment and parts that are adequately tested, certified and labeled as working, packaged to protect reusability, and that are not intended for disposal or recycling, but for donation, reuse and/or resale; or
 - c) Non-hazardous waste such as copper unless it is contaminated with a Basel Convention hazardous waste such as lead, cadmium, beryllium, PCBs, mercury, etc. (constituents listed in Basel Annex I); or
 - d) Electronic equipment or materials that are to be used as a direct feedstock in manufacturing without further processing or preparation (e.g. cleaned, furnace ready, CRT cullet), and the ‘competent authority’ of an importing country makes a written determination that the material is not a waste, and therefore not a regulated waste under Basel. Such a determination provided in writing by the legitimate ‘competent authority’ and provided to BAN will be required to exercise this exemption. The term ‘hazardous electronic waste’ as used in this Pledge does not pertain to, nor is synonymous with any current legal US or other national definitions of ‘hazardous waste’, but is meant for the purposes of this Pledge only.

Dell Guideline [11]

Dell will endeavor to maximize re-use opportunities. Where recycling is the most viable option then Dell will endeavor to minimize the use of processes that result in landfill and incineration of end-of life electronics.

2.6 Managerial Standards

2.6.1 (Illegal) Exports of e-Waste or Components and Fractions Thereof

WEEE Directive [1]

- 1) The treatment operation may also be undertaken outside the respective Member State or the Community provided that the shipment of WEEE is in compliance with Council Regulation (EEC) No 259/93 of 1 February 1993 on the supervision and control of shipments of waste within, into and out of the European Community. [1]
- 2) WEEE exported out of the Community in line with [1]
 - a) Council Regulation (EEC) No 259/93,
 - b) Council Regulation (EC) No 1420/1999 (2) of 29 April 1999 establishing common rules and procedures to apply to shipments to certain non-OECD countries of certain types of waste and
 - c) Commission Regulation (EC) No 1547/1999 (3) of 12 July 1999 determining the control procedures under Council Regulation (EEC) No 259/93 to apply to shipments of certain types of waste to certain countries to which OECD Decision C(92)39 final does not apply,

shall only count for the fulfilment of obligations and targets of Article 7(1) and (2) of this Directive if the exporter can prove that the recovery, reuse and/or recycling operation took place under conditions that are equivalent to the requirements of this Directive.

EPA R2 Guidelines [6]

- 1) An R2 electronics recycler shall comply with all applicable environmental, health, and safety legal requirements and shall only export equipment and components containing FMs to countries that legally accept them [6]:
 - a) In order to maintain its compliance with all applicable environmental, health, and safety legal requirements and to assure it only exports equipment and components containing FMs to countries that legally accept them, an R2 electronics recycler shall develop and implement a plan covering these matters that shall be included as a section of its EHSMS. [6]

- b) The plan shall identify and document the environmental, health, and safety legal requirements that cover the recycler's operations. The recycler shall keep the plan up to date, identify (in the plan) and implement the steps necessary to comply with each requirement, document the implementation of these steps, periodically evaluate its compliance with the requirements, and take corrective action to address any issues of non-compliance. [6]
 - c) The plan also shall identify and document the legality – under the laws of the importing countries – of all international shipments of equipment, components, or materials containing FMs that have passed through the R2 recycler's facility or control including shipments made by downstream vendors. The recycler shall identify the countries that are receiving such shipments, obtain documentation demonstrating that each non-OECD country (The R2 Document makes the assumption that these shipments are legal to import into OECD countries) legally accepts such shipments, and only make such shipments to countries for which it has such documentation (Recyclers that export used CRTs for reuse and CRT or mixed CRT glass for recycling also have export obligations under USEPA's CRT rule (FR: July 28, 2006 Volume 71, Number 145)). The documentation shall consist of one of the following [6]:
 - i) A copy of the relevant information from the United States Environmental Protection Agency, [6]
or
 - ii) Documentation from the country's Competent Authority stating that the country legally accepts such imports. The documentation must be in English, or otherwise comprehensible, to the R2 recycler's third-party R2 auditor,
or [6]
 - iii) A copy of a law or court ruling from the importing country that demonstrates the legality of the import. [6]
- 2) For shipments of removed FMs, and shipments of equipment and components containing FMs, an R2 electronics recycler shall select downstream vendors that possess and conform to
- a) the R2 recycler's FM Management Plan (developed in accordance with and including the requirements on the removal (paragraph "EPA R2 Guidelines [6]" on page 54), processing, recycling, recovery and treatment (paragraph "EPA R2 Guidelines [6]" on page 58) , and the energy recovery, incineration and land disposal of FMs ("EPA R2 Guidelines [6]" on page 60)
 - b) a documented environmental, health, and safety management system,
 - c) a list of its environmental permits and copies of each,
 - d) this Section 2), thereby establishing that each vendor in the Recycling Chain conforms to these subsections a) – g),
 - e) the provision on reuse (provision 6 in original document, paragraph "EPA R2 Guidelines [6]" on page 50 in this document)
 - f) the exporting requirements (Legal requirements, Provision 3 (a) (2) on page 4 in original document [6], or section c) on page 63 of this document)

- g) the provision on tracking throughput (provision 7 in original document; paragraph “EPA R2 Guidelines [6]”, subsection 1) on page 69 of this document)
- 3) An R2 electronics recycler confirms, through audits or other similarly effective means that each downstream vendor in the Recycling Chain to which this section 2) applies continues to conform to the requirements of this section 2) for as long as it receives FMs directly or indirectly from the R2 recycler.

Of note, the EPA has agreed to help exporters of waste electronic equipment obtain documentation from non-OECD (i.e., developing country) governments as to the legality of export of FMs, either as contained in other electronic equipment or separated as components. To request assistance, contact Frank McAllister, at mcalister.frank@epa.gov or USEPA (5304P), 1200 Pennsylvania Avenue, Washington, DC 20460.

Oregon Electronics Recycling Environmental Management Practices [8]

The guidelines refer to desktop computers, portable computers, monitors, and televisions (covered electronic devices or CEDs)

- 1) If exporting, comply with and be able to document compliance with all laws of the transit and recipient countries applicable to operations and transactions in which it engages.
- 2) The above includes, but is not limited to, applicable legal requirements relating to:
 - a) Waste and recycling processing, storage, handling, and shipping;
 - b) Air emissions and waste water discharge, including storm water discharges;
 - c) Worker health and safety; and
 - d) Transboundary movement of electronic equipment, components, materials, waste, or scrap for reuse, refurbishment, recycling, or disposal.

BAN and ETBC Electronics Recycler’s Pledge [9]

Consistent with decisions of the international Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, we will not allow the export of hazardous e-waste we handle or control to be exported from developed to developing countries, either directly or through intermediaries, throughout final disposition. [9]

Developing countries: Following the definitions of the Basel Convention and its Basel Ban Amendment, developing countries are any country not belonging to either the European Union, the Organization for Economic Cooperation and Development (OECD) or Liechtenstein. For a complete list of OECD countries see www.ban.org/country_status/country_status_chart.html and find countries shaded in gray, or go to www.oecd.org. [9]

IAER Recycler Certification Standard [10]

There shall be a process to control and document the downstream movement of electronic devices or their components until such point that they are reused or recycled in a manner that supports resource recovery and minimizes negative impacts on human health and the environment. This includes the exporting of equipment and materials for reuse and recycling, which should be conducted in accordance with all applicable laws and regulations. [10]

Dell's Guidelines [11]

Environmentally sensitive material is not exported to developing countries (Be a Responsible Neighbor). Environmentally sensitive material requiring final disposition shall not be exported from developed to developing countries either directly or through intermediaries, unless the Worldwide Dell Asset Recovery Services Council has approved the disposition channel. [11]

2.6.2 “Reuse, Recover, Dispose Hierarchy”

EPA R2 Guidelines [6]

An R2 electronics recycler shall develop and adhere to a policy for managing used and end-of-life electronic equipment that is based on a “reuse, recover, dispose” hierarchy of responsible management strategies.

- 1) An R2 electronics recycler shall develop in writing and adhere to a policy stating how it manages used and end-of-life electronics equipment, components, and materials – with respect to both onsite activities and the selection of downstream vendors – which is based on the hierarchy of reuse, recycle/recover, disposal - responsible management strategies:
 - a) Reuse – An R2 electronics recycler shall take all practical steps to direct properly functioning equipment and components to reuse unless a customer directs otherwise,
 - b) Materials Recovery – An R2 electronics recycler shall separate as appropriate, through manual dismantling and/or mechanical processing, the materials in equipment and components that are not directed to reuse and direct them to properly-equipped materials recovery facilities when technically and economically feasible.
 - c) Energy Recovery or Disposal – An R2 electronics recycler shall direct remaining material to properly-equipped energy recovery and/or disposal facilities in conformity with Provision 5 (Focus Materials, [1], page 6 in original document, or see section 5) on page 81 and EPA R2 Guidelines [6] on page 54 of this document).

- 2) This policy shall incorporate and be consistent with the Focus Material Management Plan that the R2 electronics recycler develops in accordance with Provision 5 (Focus Materials, [1], page 6, or see section 5) on page 81 and “EPA R2 Guidelines [6]” on page 54 of this document).

Oregon Electronics Recycling Environmental Management Practices [8]

The guidelines refer to desktop computers, portable computers, monitors, and televisions (covered electronic devices or CEDs)

Responsible Management Strategies

- 1) Consider and incorporate where practical the hierarchy of solid waste management for CEDs and CED components:
 - a) Reuse and refurbish – Screen for whole units at the point of collection.
 - b) Recycle –
 - i) As appropriate, dismantle, and/or mechanically process, and separate CEDs, CED components, and materials into separate streams based on principles of effective (value generating and waste minimizing) for safe recovery of materials.
 - ii) Send separated materials for recovery of raw materials at facilities that use technologies and processes that have been determined to be protective of health, safety, and the environment.
- 2) Energy Recovery and Disposal – Manage any residual that cannot safely or technically be reused, refurbished, or recycled by further separating for energy recovery or disposal in a safe manner in accordance with applicable laws.
- 3) Periodically evaluate management strategies to incorporate new, more effective technologies and continuously improve practices and processes where feasible within the context of the above reuse, recycle, disposal hierarchy

IAER Recycler Certification Standard [10]

There shall be evidence that a high percentage of the product received by the company is reused or recycled and not landfilled as well as a commitment to continuously improve in this area. Any residual materials shall have a waste determination made prior to disposal.

Reuse and refurbishment facilities shall ensure that electronic equipment shipped for reuse is fully functional and is shipped to a vendor who is the business of selling for reuse, and that equipment and components shipped for refurbishment are refurbishable. Reuse and

refurbishment operations shall have a process to control the testing and tracking of such equipment.

Dell's Guidelines [11]

End-of-life electronics are properly managed throughout the disposal channel.

Dell will endeavor to maximize re-use opportunities. Where recycling is the most viable option then Dell will endeavor to minimize the use of processes that result in landfill and incineration of end-of life electronics.

2.6.3 Tracking of Material Flows and Downstream Due Diligence

IPPC BAT Document for Waste Treatment [3]

BAT is to

- 1) have a system in place to guarantee the traceability of waste treatment. Different procedures may be needed to take into account the physico-chemical properties of the waste (e.g. liquid, solid), type of waste treatment process (e.g. continuous, batch) as well as the changes that may occur to the physico-chemical properties of the wastes when the waste treatment is carried out. A good traceability system contains the following items (see section 4.1.2.3 of IPPC BAT document [3]):
- 2) documenting the treatments by flow charts and mass balances (see section 4.1.2.4 of IPPC BAT document [3])
- 3) carrying out data traceability through several operational steps (e.g. preacceptance/acceptance/storage/treatment/dispatch). Records can be made and kept up-to-date on an ongoing basis to reflect deliveries, on-site treatment and dispatches. Records are typically held for a minimum of six months after the waste has been dispatched.
- 4) recording and referencing the information on waste characteristics and the source of the waste stream, so that it is available at all times. A reference number needs to be given to the waste and needs to be obtainable at any time in the process to enable the operator to identify where a specific waste is in the installation, the length of time it has been there and the proposed or actual treatment route
- 5) having a computer database/series of databases, which are regularly backed up. The tracking system operates as a waste inventory/stock control system and includes:
 - a) date of arrival on-site,

- b) waste producer details,
 - c) details on all previous holders,
 - d) an unique identifier,
 - e) pre-acceptance and acceptance analysis results,
 - f) package type and size,
 - g) intended treatment/disposal route,
 - h) an accurate record of the nature and quantity of wastes held on-site including all hazards details on where the waste is physically located in relation to a site plan, at which point in the designated disposal route the waste is currently positioned
- 2) only moving drums and other mobile containers between different locations (or loaded for removal off site) under instructions from the appropriate manager, ensuring that the waste tracking system is amended to record these changes (see section 4.1.4.8 of IPPC BAT document [3])

Draft National Standard China [5]

- 1) A record system should be set up in the disassembly and treatment enterprises. The record should cover the following aspects:
 - a) Name, category, weight and/or quantity of the accepted waste electrical & electronic products
 - b) Category, weight and/or quantity, treatment method and trace of various parts and materials after being disassembled or treated.
 - c) Category, weight and/or quantity, disposing method and trace of the treated residual
- 2) Records related to treatment of waste electrical & electronic products, monitoring records of pollutant emission and other relevant records of the disassembly and treatment enterprises should be kept for at least three years and inspected by the local administrations of environmental protection.
- 3) The disassembly and treatment enterprises should monitor the emitted flue gas and wastewater periodically.
- 4) The disassembly and treatment enterprises should identify the solid waste generated in the process of treatment in accordance with relevant identification standards for hazardous waste. The hazardous waste should be handed over to the organization with business license for hazardous waste for disposal. The non-hazardous waste should be disposed as industrial solid waste.
- 5) Assessment on professional safety and sanitary risks caused in the process of disassembly and treatment should be conducted in accordance with relevant state professional safety sanitary regulations. In addition, the emergency handling

procedures should be made. The employees who might be threatened by hazardous substances should be provided with full-set of safeguard devices and relevant measures should be taken.

- 6) When the operating personnel are disassembling or treating new types of waste, instructions or pre-vocational training from personnel of technical department should be given.
- 7) Pre-disassembled elements containing mercury should be complete, stored in exclusive containers and handed over to the enterprises with qualifications for treatment. In order to identify such kind of elements, special training is required for the workers.

EPA R2 Guidelines [6]

- 1) An R2 electronics recycler shall maintain business records sufficient to demonstrate the material flow of equipment, components, and materials that pass through its facility:
 - a) An R2 electronics recycler shall maintain for at least three years commercial contracts, bills of lading, or other commercially-accepted documentation for all transfers of equipment, components, and materials into and out of its facility, as well as for any brokering transactions.
- 2) An R2 electronics recycler shall maintain the documentation necessary for an auditor to assess its conformity to the requirements of this document.
- 3) An R2 electronics recycler shall maintain in a single location each piece of documentation necessary to show conformity to each requirement of this document.
- 4) For shipments of removed FMs, and shipments of equipment and components containing FMs, an R2 electronics recycler shall select downstream vendors that possess and conform to:
 - a) the R2 recycler's FM Management Plan (developed in accordance with and including the requirements set forth in section "EPA R2 Guidelines [6]" on page 54 of this document, "EPA R2 Guidelines [6] on page 58, and section "EPA R2 Guidelines [6] on page 60); (alternatively see page 6 and 7 in original document [6])
 - b) a documented environmental, health, and safety management system,
 - c) a list of its environmental permits and copies of each,
 - d) this Section d), thereby establishing that each vendor in the Recycling Chain conforms to these subsections a) to 1),
 - e) provision 6 (Reuse) on page 8 of the original document [6], or see chapter "EPA R2 Guidelines [6] on page 50 of this document
 - f) the exporting requirements of Provision 3 (a) (2) (Legal requirements, page 4 in original document [6], or see section c) on page 63 in this document

- g) provision 7 (Tracking Throughput), see page 9 in original document [6], or section 1)a) on page 69 of this document
- 1) An R2 electronics recycler shall confirm, through audits or other similarly effective means that each downstream vendor in the Recycling Chain to which section 2) on page 63 applies continues to conform to the requirements of section section 2) on page 63 for as long as it receives FMs directly or indirectly from the R2 recycler.

EPA Plug-In Guide [7]

The Plug-In partner ensures that proper business records are kept demonstrating that incineration and land disposal are minimized.

“Plug-In partner” means a manufacturer, retailer, government agency, non-profit, or other entity who

- 1) is not a recycler nor performs recycling activities (other than collection),
- 2) through contracts or other arrangements, utilizes reuse, refurbishment, recycling or disposal services, and
- 3) has a Plug-In To eCycling partnership agreement with EPA.

Oregon Electronics Recycling Environmental Management Practices [8]

The guidelines refer to desktop computers, portable computers, monitors, and televisions (covered electronic devices or CEDs).

Recyclers shall

- 1) maintain business records sufficient to demonstrate the material flow of the CEDs, components, and materials that pass through the recycler’s facility. This can be done by:
 - a) maintaining commercial contracts, bills of lading, or other commercially-accepted documentation for all transfers of CEDs, components, and materials into and out of the facility, including brokering transactions.
 - b) keeping documentation for at least three years.
- 2) conduct due diligence, or use documented due diligence that others have performed, on each downstream vendor sent materials for recovery by obtaining a written contractual commitment, or a written certification from the vendor, or other certified documentation, such as an audit report prepared by a certified auditor, that they have verifiable records demonstrating they meet the EHSMS practices outlined in chapter “Oregon Electronics Recycling Environmental Management Practices [8]” on page 81 (also see subsection 2 “Environmental, health and safety management systems” on page 4 under section 4 “Recycling” in original document [8]), and are in compliance with its environmental and worker safety legal obligations.

- 3) implement practices that establish and maintain a written record, such as shipping documents, database extracts, or other documents that identify where any CEDs, components, or materials (including materials of concern) that are recycled from the time the equipment, components, or materials leave the facility through to the point at which materials become a single material commodity suitable for final processing.
- 4) obtain from each downstream vendor where materials and materials of concern are sent, a written contractual commitment and verifiable business records or a third-party audit, or use documented due diligence that others have performed, verifying that the downstream vendor conforms to the following practices in this document:
 - a) Legal requirements (see subsection 1 of section 4 Recycling on page 4 in original document [8]; paragraph "Oregon Electronics Recycling Environmental Management Practices [8]" on page 37 of this document).
 - b) EHSMS (see subsection 2 of section 4 Recycling on page 4 in original document [8], or paragraph "Oregon Electronics Recycling Environmental Management Practices [8]" on page 81 of this document).
 - c) Recordkeeping (see subsection 3 of section 4 Recycling on page 4 in original document [8], or point no. 1) above on page 70 of this paragraph).
 - d) Operating practices (see subsection 4 of section 4 Recycling on page 4 in original document [8], or paragraph "Oregon Electronics Recycling Environmental Management Practices [8]" on page 81 of this document).
 - e) Separation and recycling of materials (see subsection 5 of section 4 Recycling on page 4 in original document [8]; paragraph "Oregon Electronics Recycling Environmental Management Practices [8]" on page 58 of this document).
 - f) Management of CED components and materials that are not reused or recovered (see subsection 6 of section 4 Recycling on page 4 in original document [8], or paragraph "Oregon Electronics Recycling Environmental Management Practices [8]" on page 58 of this document).
- 5) Obtain a written statement from immediate downstream vendors where CEDs, components, materials, or materials of concern are sent that those vendors maintain written documentation of where materials go when they leave their facility in order to assure a downstream chain of documentation is in place.
- 6) Maintain access to the downstream chain of documentation through to the point at which CEDs, components, materials, and materials of concern become a material suitable for final processing and review downstream vendors' conformity to the practices listed in section 4) above. Check conformity at least every two years and more frequently if changes in circumstances warrant.

BAN and ETBC Electronics Recycler's Pledge [9]

We agree to provide visible tracking of hazardous e-waste throughout the product recycling chain. The tracking information should show the final disposition of all hazardous e-waste

materials. If there is a concern about trade secrets, an independent auditor acceptable to parties concerned can be used to verify compliance with this pledge.

IAER Recycler Certification Standard [10]

- 1) There shall be evidence that a high percentage of the product received by the company is reused or recycled and not landfilled as well as a commitment to continuously improve in this area. Any residual materials shall have a waste determination made prior to disposal.
- 2) There shall also be management processes to support operations, such as tracking and reconciliation of customer products and materials. Tracking records shall be sufficient to demonstrate the material flow for all equipment, components, and materials that pass through the facility and to downstream vendors.
- 3) Shipments of Materials of Concern (hazardous materials) shall be tracked and documented.
- 4) For downstream due diligence and risk management, there shall be a process for the evaluation and monitoring of key contracted operations in relation to compliance with applicable regulations as well as the adequacy of their management systems.
- 5) In the case of handling customers' assets and valuable commodities (such as precious metals and electronic components), there should be a formal tracking and control process.

Dell's Guidelines [11]

Continually manage Dell Disposition Channels and communicate our performance (Continually Improve and Communicate our Performance).

Dell will track and document end-of-life electronics throughout the product disposal channels. Tracking information shall show the final disposition of all waste materials.

2.6.4 Waste Acceptance and Outlet Control

IPPC BAT Document for Waste Treatment [3]

Waste IN

To improve the knowledge of the waste IN, BAT is to:

- 1) have a concrete knowledge of the waste IN. Such knowledge needs to take into account the waste OUT, the treatment to be carried out, the type of waste, the origin of the waste, the procedure under consideration (see BAT number 7 and 8) and the risk (related to waste OUT and the treatment)
- 2) implement a pre-acceptance procedure containing at least the following items
 - a) tests for the incoming waste with respect to the planned treatment
 - b) making sure that all necessary information is received on the nature of the process(es) producing the waste, including the variability of the process. The personnel having to deal with the pre-acceptance procedure need to be able due to his profession and/or experience to deal with all necessary questions relevant for the treatment of the wastes in the waste treatment facility
 - c) a system for providing and analysing a representative sample(s) of the waste from the production process producing such waste from the current holder
 - d) a system for carefully verifying, if not dealing directly with the waste producer, the information received at the pre-acceptance stage, including the contact details for the waste producer and an appropriate description of the waste regarding its composition and hazardousness
 - e) making sure that the waste code according to the European Waste List (EWL) is provided
 - f) identifying the appropriate treatment for each waste to be received at the installation by identifying a suitable treatment method for each new waste enquiry and having a clear methodology in place to assess the treatment of waste, that considers the physico-chemical properties of the individual waste and the specifications for the treated waste.
- 3) implement an acceptance procedure containing at least the following items
 - a) a clear and specified system allowing the operator to accept wastes at the receiving plant only if a defined treatment method and disposal/recovery route for the output of the treatment is determined. Regarding the planning for the acceptance, it needs to be guaranteed that the necessary storage, treatment capacity and dispatch conditions (e.g. acceptance criteria of the output by the other installation) are also respected

- b) measures in place to fully document and deal with acceptable wastes arriving at the site, such as a pre-booking system, to ensure e.g. that sufficient capacity is available
 - c) clear and unambiguous criteria for the rejection of wastes and the reporting of all non conformances
 - d) a system for identifying the maximum capacity limit of waste that can be stored at the facility
 - e) visually inspect the waste IN to check compliance with the description received during the pre-acceptance procedure. For some liquid and hazardous waste, this BAT is not applicable
- 4) implement different sampling procedures for all different incoming waste vessels delivered in bulk and/or containers. These sample procedures may contain the following items
- a) sampling procedures based on a risk approach. Some elements to consider are the type of waste (e.g. hazardous or non-hazardous) and the knowledge of the customer (e.g. waste producer)
 - b) check on the relevant physico-chemical parameters. The relevant parameters are related to the knowledge of the waste needed in each case
 - c) registration of all waste materials
 - d) have different sampling procedures for bulk (liquid and solids), large and small containers and laboratory smalls. The number of samples taken should increase with the number of containers. In extreme situations, small containers must all be checked against the accompanying paperwork. The procedure should contain a system for recording the number of samples and degree of consolidation
 - e) details of the sampling of wastes in drums within designated storage, e.g. the timescale after receipt
 - f) sample prior to acceptance
 - g) maintenance of a record at the installation of the sampling regime for each load, together with a record of the justification for the selection of each option
 - h) a system for determining and recording:
 - i) a suitable location for the sampling points
 - ii) the capacity of the vessel sampled (for samples from drums, an additional parameter would be the total number of drums)
 - iii) the number of samples and degree of consolidation
 - iv) the operating conditions at the time of sampling.
 - i) a system to ensure that the waste samples are analysed

- j) in the case of cold ambient temperatures, a temporary storage may be needed in order to allow sampling after defrosting. This may affect the applicability of some of the above items in this BAT.
- 5) have a reception facility covering at least the following issues:
- a) have a laboratory to analyse all the samples at the speed required by BAT. Typically this requires having a robust quality assurance system, quality control methods and maintaining suitable records for storing the analyses results. Particularly for hazardous wastes, this often means that the laboratory needs to be on-site
 - b) have a dedicated quarantine waste storage area as well as written procedures to manage non-accepted waste. If the inspection or analysis indicates that the wastes fail to meet the acceptance criteria (including, e.g. damaged, corroded or unlabelled drums) then the wastes can be temporarily stored there safely. Such storage and procedures should be designed and managed to promote the rapid management (typically a matter of days or less) to find a solution for that waste
 - c) have a clear procedure dealing with wastes where inspection and/or analysis prove that they do not fulfil the acceptance criteria of the plant or do not fit with the waste description received during the pre-acceptance procedure. The procedure should include all measures as required by the permit or national/international legislation to inform competent authorities, to safely store the delivery for any transition period or to reject the waste and send it back to the waste producer or to any other authorized destination.
 - d) move waste to the storage area only after acceptance of the waste
 - e) mark the inspection, unloading and sampling areas on a site plan
 - f) have a sealed drainage system
 - g) a system to ensure that the installation personnel who are involved in the sampling, checking and analysis procedures are suitably qualified and adequately trained, and that the training is updated on a regular basis
 - h) the application of a waste tracking system unique identifier (label/code) to each container at this stage. The identifier will contain at least the date of arrival on-site and the waste code.

Waste OUT

To improve the knowledge of the waste OUT, BAT is to analyse the waste OUT according to the relevant parameters important for the receiving facility (e.g. landfill, incinerator).

2.6.5 Environmental, Health, and Safety Management System

WEEE Directive [1] and Proposal for a Recast of the WEEE Directive [2]

The WEEE Directive [1] in Art. 6 (2) requires member States to encourage establishments or undertakings which carry out treatment operations to introduce certified environmental management systems according to EMAS (Regulation (EC) No 761/2001 allowing voluntary participation by organisations in a Community eco-management and audit scheme). The proposed recast of the Directive [2] contains this recommendation as well.

IPPC BAT Document for Waste Treatment [3]

These are techniques related to the continuous improvement of environmental performance. They provide the framework for ensuring the identification, adoption and adherence to BAT options that nevertheless remain important and can play a role in improving environmental performance of the installation. Indeed, these good house housekeeping/management techniques/tools often prevent emissions. A number of environmental management techniques are determined as BAT (Best Available Technology). The scope (e.g. level of detail) and nature of the Environmental Management System (EMS) (e.g. standardized or non-standardised) will generally be related to the nature, scale and complexity of the installation, and the range of environmental impacts it may have.

An environmental management system (EMS) for an IPPC installation can contain the following components:

- 1) definition of an environmental policy
- 2) planning and establishing objectives and targets
- 3) implementation and operation of procedures
- 4) checking and corrective action
- 5) management review
- 6) preparation of a regular environmental statement
- 7) validation by certification body or external EMS verifier
- 8) design considerations for end-of-life plant decommissioning
- 9) development of cleaner technologies
- 10) benchmarking.

BAT is to implement and adhere to an EMS that incorporates, as appropriate to individual circumstances, the following features:

- 1) definition of an environmental policy for the installation by top management (commitment of the top management is regarded as a precondition for a successful application of other features of the EMS)
- 2) planning and establishing the necessary procedures
- 3) implementation of the procedures, paying particular attention to
 - a) structure and responsibility
 - b) training, awareness and competence
 - c) communication
 - d) employee involvement
 - e) documentation efficient process control
 - f) maintenance programme
 - g) emergency preparedness and response
 - h) have a noise and vibration management plan in place
 - i) safeguarding compliance with environmental legislation
- 4) checking performance and taking corrective action, paying particular attention to
 - a) monitoring and measurement (see also the Reference document on General Principles of Monitoring)
 - b) corrective and preventive action
 - c) maintenance of records
 - d) independent (where practicable) internal auditing in order to determine whether or not the environmental management system conforms to planned arrangements and has been properly implemented and maintained
- 5) review by top management

Three further features, which can complement the above stepwise, are considered as supporting measures. However, their absence is generally not inconsistent with BAT. These three additional steps are:

- 6) having the management system and audit procedure examined and validated by an accredited certification body or an external EMS verifier
- 7) preparation and publication (and possibly external validation) of a regular environmental statement describing all the significant environmental aspects of the installation, allowing

for year-by-year comparison against environmental objectives and targets as well as with sector benchmarks as appropriate

- 8) implementation and adherence to an internationally accepted voluntary system such as EMAS or EN ISO 14001:1996. This voluntary step could give higher credibility to the EMS. In particular EMAS, which embodies all the above-mentioned features, gives higher credibility. However, non-standardised systems can in principle be equally effective provided that they are properly designed and implemented.

Specifically for the waste treatment industry sector, it is also important to consider the following potential features of the EMS:

- 9) giving consideration to the environmental impact from the eventual decommissioning of the unit at the stage of designing a new plant
- 10) giving consideration to the development of cleaner technologies
- 11) where practicable, sectoral benchmarking on a regular basis, including energy efficiency and energy conservation activities, choice of input materials, emissions to air, discharges to water, consumption of water and generation of waste.

The IPPC BAT document [3] mentions further elements of an appropriate, BAT EHS management system:

- 12) produce a structured accident management plan (see section 4.1.7 of IPPC BAT document [3])
- 13) have and properly use an incident diary (see section 4.1.7 of IPPC BAT document [3])
- 14) have a noise and vibration management plan in place as part of the EMS (see Section 4.1.8 of IPPC BAT document [3]). For some waste treatment installations, noise and vibration may not be an environmental problem

EPA R2 Guidelines [6]

An R2 electronics recycler shall develop and use an Environmental, Health, and Safety Management System (EHSMS) to plan and monitor its environmental, health, and safety practices, including the activities it undertakes to conform to the R2 Practices:

An R2 electronics recycler shall develop, document, fully implement, review at least annually, and update as needed (e.g., as products and/or technologies change) a written EHSMS that:

- 1) includes written goals and procedures and requires the organization to systematically manage its environmental, health, and safety matters, and
- 2) is based on a "Plan-Do-Check-Act" model for continual improvement. Elements of this model include:

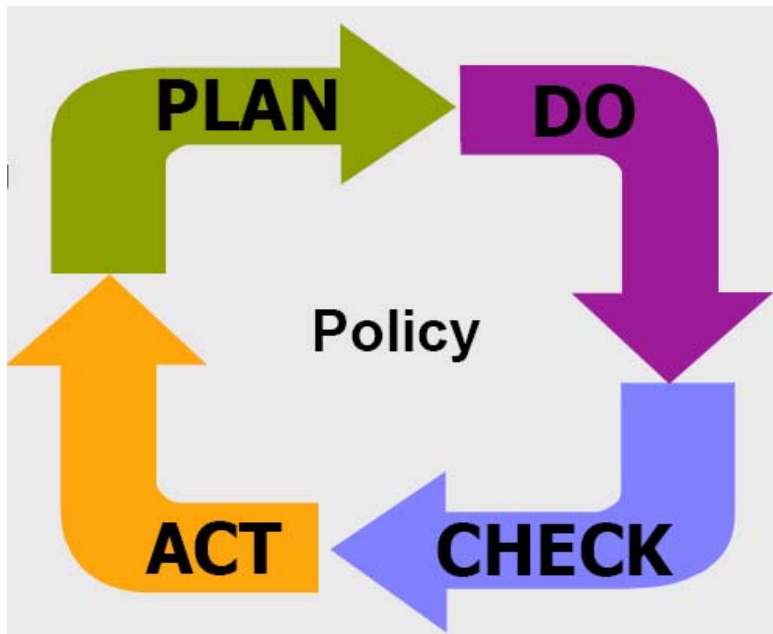


Figure 3: Plan – Do – Check – Act policy of EHSMS (source: ISRI)

a) Plan

- i) Identify environmental and worker health/safety impacts, and legal and regulatory requirements
- ii) Establish environmental goals, objectives and targets;
- iii) Plan actions that work toward achieving identified goals;
- iv) Plan for emergency preparedness and response; and
- v) Identify management support.

b) Do

- i) Establish roles and responsibilities for the EHSMS and provide adequate resources;
- ii) Ensure that staff are trained and capable of carrying out responsibilities; and
- iii) Establish a process for communicating about the EHSMS

c) Check

- i) Monitor key activities and track performance;
- ii) Identify and correct problems and prevent recurrence; and

- iii) Provide a measurement system.
- d) Act
- i) Conduct annual progress reviews;
 - ii) Act to make necessary changes to the EHSMS;
 - iii) Create and implement an action plan for continual improvement
- 3) Includes sections setting forth the following:
- a) A policy for managing used and end-of-life electronics equipment that is based on a “reuse, recover, dispose” hierarchy of responsible management strategies and covers materials management on site and throughout the Recycling Chain (as described in Provision 2 (reuse, recover, disposal hierarchy, [6], page 3, or see chapter EPA R2 Guidelines [6] on page 65 ff of this document),
 - b) A plan for complying with the environmental, health, and safety legal requirements relating to its operations, and for assuring it only exports equipment and components containing Focus Materials to countries that legally accept them (as described in Provision 3, Legal Requirements, in source [6], page 3, or see chapter “EPA R2 Guidelines [6]“ on page 62 ff of this document),
 - c) An analysis of and plan – the “FM Management Plan” – for how the R2 Focus Materials (FMs) that pass through the R2 recycler’s facility or control should be properly managed, both on site and throughout the Recycling Chain (as described in Provision 5 R2 Focus Materials, in source [6], page 6, or see section 5) on page 81 and EPA R2 Guidelines [6] on page 54 of this document – this can be a subsection of the section described in section a)) above,
 - d) An EHS hazards identification and assessment of on-site occupational and environmental risks (as described in Section (c) of Provision 4 Onsite EHS, [6], page 4, or see section 1) of page 87),
 - e) A plan for responding to and reporting exceptional releases, accidents, spills, fires, explosions, and other out-of-the-ordinary events that pose risks to worker safety, public health, or the environment – this section should be provided to local emergency responders if appropriate or required, and
 - f) A list of the activities necessary to conform to the requirements of the R2 Practices and a list of the documentation necessary to show conformity with these requirements.
- 4) An R2 electronics recycler shall manage – both on site and in the selection of downstream vendors – the R2 Focus Materials that pass through its facility or control in a manner protective of worker health and safety, public health, and the environment; and shall perform due diligence on downstream vendors (see point 4) on page 69) to which it ships these materials.

- 5) An R2 recycler shall develop and adhere to a Focus Material Management Plan. He shall electronics recycler shall analyze and plan how the R2 Focus Materials (FMs) that pass through its facility or control will be properly managed both on site and throughout the Recycling Chain (and include this analysis and plan as the “FM Management Plan” section of its EHSMS). The FM Management Plan shall state how the recycler and its downstream vendors shall conform to the requirements set forth in the R2 Focus Materials provision, (Provision 5, see [1], page 6 in original document), or see section 5) on page 81 and EPA R2 Guidelines [6] on page 54 of this document). 1
- 6) An R2 electronics recycler shall obtain a certification from an Accredited Certification Body stating that:
 - a) Its EHSMS conforms to the requirements of this provision, and
 - b) Its practices conform to the EHSMS and to the requirements of these R2 Practices.

Oregon Electronics Recycling Environmental Management Practices [8]

The guidelines refer to desktop computers, portable computers, monitors, and televisions (covered electronic devices or CEDs).

- 1) Develop, document, implement, and update at least annually an EHSMS. The written EHSMS includes the following:
 - a) Written goals and procedures to systematically manage environmental, health, and safety matters.
 - b) Use a “plan, do, check, act” model that identifies environmental and health risks and requirements; Elements of this model include:
 - I) Plan
 - i) Identify environmental and worker health/safety impacts and legal and regulatory requirements;
 - ii) Establish environmental goals, objectives, and targets;
 - iii) Plan actions that work toward achieving identified goals;
 - iv) Plan for emergency preparedness and response; and
 - v) Identify management support.
 - II) Do
 - i) Establish roles and responsibilities for the EHSMS and provide adequate resources;
 - ii) Ensure staff are trained and capable of carrying out responsibilities; and
 - iii) Establish a process for communicating about the EHSMS.

¹ This section on R2 Focus Materials is not the complete Provision 5 R2 Focus Material in the original EPA recycling guidelines [6]. Parts of the original provision were shifted to other chapters in this document, e. g. to “Treatment” of e-waste.

- III) Check
 - i) Monitor key activities and track performance;
 - ii) Identify and correct problems and prevent recurrence; and
 - iii) Provide a measurement system.
 - IV) Act
 - i) Conduct annual progress reviews;
 - ii) Act to make necessary changes to the EHSMS;
 - iii) Create and implement an action plan for continual improvement.
 - a) implements operational controls, and provides corrective action procedures.1
 - b) Plan for responding to and reporting exceptional releases, accidents, spills, fires, explosions, and other out-of-the-ordinary events that pose risks to worker safety, public health, or the environment. Provide plan to all appropriate emergency responders.
 - c) Procedure for identifying and evaluating the environmental, health, and safety impacts of downstream vendors and for using this information in the selection of downstream vendors.
 - d) Consistency with generally recognized standards that cover environmental and worker health/safety management such as ISO 14001, the International Association of Electronics Recyclers (IAER) certification standard, or the Recycling Industry Operating Standard (RIOS), or a similarly rigorous in-house standard.
- 2) Ensure all workers understand and follow the portions of the EHSMS relevant to the activities they perform.

BAN and ETBC Electronics Recycler's Pledge [9]

We assure that we have an "environmental management system" in place that is either certified or otherwise adequate for the nature and size of the company's operations, and that our operation meets best practices.

We commit to ensuring that the entire recycling chain, including downstream intermediaries and recovery operations such as smelters, are meeting all applicable environmental and health regulations.

IAER Recycler Certification Standard [10]

IAER Certification addresses the key elements of basic management systems, including: Environment, Health, Safety and Quality. These management systems shall be documented, maintained up to date, and have the following common elements:

- 1) Commitment and Policy
 - a) There shall be corporate commitments, in the form of policies and/or instructions that address the achievement and improvement of high standards of business practices in relation to each of the basic management systems.

- b) As an electronics recycler, there should be a commitment to reuse, recycling and materials recovery as priorities for the handling of all equipment received.

2) Planning

There shall be a planning process for each of the basic management systems that:

- a) Identifies significant environmental aspects and potential health hazards
- b) Identifies legal requirements
- c) Establishes objectives & targets
- d) Establishes programs for achieving objectives and targets

3) Implementation

The management systems shall be implemented as evidenced by the following, as applicable:

- a) Structure & responsibilities
- b) Training, awareness & competence
- c) Communications
- d) Documentation
- e) Control of Documents
- f) Operational control
- g) Emergency preparedness & response

4) Measurement and Evaluation

The management systems shall have a process for measuring and evaluating their effectiveness that includes such elements as:

- a) Monitoring & measurement
- b) Non-conformance and corrective & preventative action
- c) Records management
- d) Evaluation of Compliance
- e) Internal management system audits

5) Review and Improvement

The management systems shall have a Management Review process that includes:

- a) Objectives, targets and performance
- b) Follow-up actions from previous management reviews
- c) Internal and compliance audit findings and progress on corrective actions
- d) Communications from external interested parties
- e) Evaluation of management systems effectiveness
- f) Evaluation of corporate policy
- g) Recommendations for action, change and improvement

6) Additional Elements

In addition, the management systems shall have unique elements, as appropriate. These would typically include:

- a) Environment
 - I) The identification and assessment of Environmental Aspects and hazardous materials.
 - II) Evidence of compliance with applicable environmental regulations.
 - III) Practices for responding to and reporting exceptional releases or emergencies that could pose a risk to worker safety, public health, or the environment.
- b) Health & Safety
 - I) Processes and programs for identification of hazards and prevention of accidents and illnesses – including engineering controls, workplace practices, personal protection equipment, and exposure monitoring as applicable.
 - II) Evidence of compliance with applicable health and safety regulations
- c) Quality
 - I) Operational quality procedures and controls
 - II) Business process quality program

7) Management

IAER Certification also addresses business factors that are generally expected by customers of good suppliers. These include:

- a) Top Management of the company shall be knowledgeable, supportive and involved in the basic Management Systems.
- b) The management of the company shall be guided by a business planning process.

Dell's Guidelines [11]

Handlers of Dell end-of-life electronics shall either be refurbishing operations, or recycling or disposal operators who have or are implementing a comprehensive "environmental and safety management system(s)".

The entire disposition channel, including downstream intermediaries, shall meet all applicable environmental, transportation and health and safety regulations.

2.6.6 Facility Operation, Optimization and Workforce

IPPC BAT Document for Waste Treatment [3]

Best available technology is to

- 1) ensure the provision of full details of the activities carried out on-site. A good detail of that is contained in the following documentation
 - a) descriptions of the waste treatment methods and procedures in place in the installation
 - b) diagrams of the main plant items where they have some environmental relevance, together with process flow diagrams (schematics)
 - c) details of the chemical reactions and their reaction kinetics/energy balance
 - d) details on the control system philosophy and how the control system incorporates the environmental monitoring information
 - e) details on how protection is provided during abnormal operating conditions such as momentary stoppages, start-ups, and shutdowns
 - f) an instruction manual

- g) an operational diary
 - h) an annual survey of the activities carried out and the waste treated. The annual survey should also contain a quarterly balance sheet of the waste and residue streams, including the auxiliary materials used for each site
- 2) have a good housekeeping procedure in place, which will also cover the maintenance procedure, and an adequate training programme, covering the preventive actions that workers need to take on health and safety issues and environmental risks
 - 3) try to have a close relationship with the waste producer/holder in order that the customer's sites implement measures to produce the required quality of waste necessary for the waste treatment process to be carried out
 - 4) have sufficient staff available and on duty with the requisite qualifications at all times. All personnel should undergo specific job training and further education.
 - 5) provide a breakdown of the energy consumption and generation (including exporting) by the type of source (i.e. electricity, gas, liquid conventional fuels, solid conventional fuels and waste, see section 4.1.3.1 of IPPC BAT document [3]). This involves:
 - a) reporting the energy consumption information in terms of delivered energy
 - b) reporting the energy exported from the installation
 - c) providing energy flow information (for example, diagrams or energy balances) showing how the energy is used throughout the process.
 - 6) continuously increase the energy efficiency of the installation, by (see section 4.1.3.4 of IPPC BAT document [3]) :
 - a) developing an energy efficiency plan
 - b) using techniques that reduce energy consumption and thereby reduce both direct (heat and emissions from on-site generation) and indirect (emissions from a remote power station) emissions
 - c) defining and calculating the specific energy consumption of the activity (or activities), setting key performance indicators on an annual basis (e.g. MWh/tonne of waste processed).
 - 7) carry out an internal benchmarking (e.g. on an annual basis) of raw materials consumption. Some applicability limitations have been identified and these are mentioned in Section 4.1.3.5 of the IPPC BAT document [3]
 - 8) explore the options for the use of waste as a raw material for the treatment of other wastes (see section 4.1.3.5 of IPPC BAT document [3]). If waste is used to treat other wastes, then to have a system in place to guarantee that the waste supply is available. If this cannot be guaranteed, a secondary treatment or other raw materials should be in place in order to avoid any unnecessary waiting treatment time (see section 4.1.2.2 of IPPC BAT document [3])

EPA R2 Guidelines [6]

R2 electronics recycler shall utilize practices at their facilities that protect worker health and safety and the environment:

- 1) An R2 electronics recycler shall possess the expertise and technical capability to process each type of equipment, component, and material it accepts in a manner protective of worker safety, public health, and the environment.
- 2) An R2 electronics recycler adheres to good housekeeping standards, including keeping all work and storage areas clean and orderly. Clean up operations for all areas of the facility should be planned, regularly implemented, and monitored.

Workforce and Environmental Protection

- 1) An R2 electronics recycler shall conduct on an ongoing basis (e.g., as new types of materials are processed or new processes are utilized) a hazards identification and assessment of occupational and environmental risks that exist or could reasonably be expected to develop at the facility.
- 2) Such risks could result from any sources, including but not limited to emissions of and/or exposure to substances. Risks posed by exposure to substances may arise in a variety of situations – sometimes involving substances that do not under ordinary conditions pose a risk to worker safety or the environment. Such substances may include mercury, lead, beryllium, cadmium, PCBs, some phosphor compounds, certain brominated flame retardants (i.e., polybrominated biphenyls, pentabrominated diphenyl ether, and octabrominated diphenyl ether), silica dust, chlorinated or brominated dibenzodioxins and dibenzofurans, and hexavalent chromium. Special attention should be given to potential lead and cadmium exposures during the creation or handling of broken CRT glass, as well as where lead solder is melted during chip recovery.
- 3) Further risks may arise from noise, ergonomic factors, thermal stress, substandard machine guarding, cuts and abrasions, etc. The hazards identification and assessment shall be captured in writing and incorporated as a component of the recycler's EHSMS.
- 4) An R2 electronics recycler shall manage the hazards and minimize the releases it identifies using an appropriate combination of strategies, including but not limited to (a-c below are in order of priority, per OSHA regulations):
 - a) Engineering controls such as (I) to III) below are in order of priority, per OSHA regulations):
 - I) Substitution (e.g., replacing a toxic solvent with one less toxic),
 - II) Isolation (e.g., automating a process to avoid employee exposure), or
 - III) Ventilation and, if appropriate, capture (e.g., fume hood),
 - IV) Dust control, capture, and clean up, and
 - V) Emergency shut-off systems, and

- VI) Fire suppression systems,
- b) Administrative and work practice controls, including appropriate combinations of:
 - I) Regular, documented health and safety training that covers information from the hazards assessment, as well as safe management handling, spill prevention, engineering controls, equipment safety, and use and care of personal protection equipment; with training for new hires and refresher courses for all employees that is understandable to them given language and level-of-education considerations,
 - II) Job rotation as feasible given workforce size,
 - III) Safe work practices,
 - IV) Medical surveillance,
 - V) Safety meetings,
- c) Personal protective equipment, including respirators, protective eyewear, cut-resistant gloves, etc., as appropriate for the risks involved in the tasks being performed.
- 5) An R2 electronics recycler shall utilize monitoring and sampling protocols to provide assurances that the practices it employs are effectively and continuously managing the risks it has identified. This includes complying with all applicable Federal or State OSHA standards and PELs for sampling and/or monitoring.
- 6) An R2 electronics recycler shall treat its entire workforce, including volunteer workers, temporary workers, and anyone else performing activities under its direction, using the standard of care established pursuant to point 4) above on page 87 of this section.
- 7) An R2 electronics recycler shall designate a qualified employee or consultant to coordinate its efforts to promote worker health and safety. This individual shall be identified to all employees and two-way communication shall be encouraged between employees and this individual regarding potential hazards and how best to address them.

Exceptional Releases

- 8) An R2 electronics recycler shall be prepared at all times to implement the plan set forth in its EHSMS for responding to and reporting exceptional releases, accidents, spills, fires, explosions, and other out-of-the-ordinary events that pose risks to worker safety, public health, or the environment.

Oregon Electronics Recycling Environmental Management Practices [8]

The guidelines refer to desktop computers, portable computers, monitors, and televisions (covered electronic devices or CEDs)

1) General

- a) Possess the expertise and capability to process each type of equipment, component, and material it accepts in a manner protective of worker safety, public health, and the environment.
- b) Use safe materials handling, storage, and management practices, including good housekeeping standards and keeping all work and storage areas clean and orderly.
- c) Comply with all applicable federal and state OSHA (Operational Safety and Health Administration) standards.
- d) Designate an employee or consultant to coordinate and promote worker health and safety.
- e) Use a certified scale to weigh CEDs that are reported as recycled through the OERP.

2) Workforce and environmental protection

- a) Conduct on an ongoing basis a hazards identification and assessment of occupational and environmental risks that exist or could reasonably be expected to develop at the facility. Such risks, for example, could result from sources such as emissions of and/or exposure to substances, noise, ergonomic factors, thermal stress, substandard machine guarding, cuts and abrasions, etc.
Risks posed by exposure to substances may arise in a variety of situations – sometimes involving substances that do not under ordinary conditions pose a risk to worker safety or the environment. Substances, for example, may include mercury, lead, beryllium, cadmium, PCBs, some phosphor compounds, certain brominated flame retardants (i.e. polybrominated biphenyls, pentabrominated diphenyl ether, and octabrominated diphenyl ether), silica dust, chlorinated or brominated dibenzodioxins and dibenzofurans, and hexavalent chromium.
The hazards identification and assessment is captured in writing and incorporated as a component of the EHSMS.
- b) Manage the hazards and minimize the releases identified using an appropriate combination of strategies, including but not limited to the following:
 - I) Engineering controls such as:
 - i) Substitution (e.g. replacing a toxic solvent with one less toxic),
 - ii) Isolation (e.g. automating a process to avoid employee exposure), or

- iii) Ventilation and, if appropriate, capture (e.g. fume hood),
 - iv) Dust control, capture, and clean up, and
 - v) Emergency shut-off systems, and
 - vi) Fire suppression systems,
 - II) Administrative and work practice controls including appropriate combinations of:
 - i) Regular, documented health and safety training that covers information from the hazardous assessment, safe management handling, spill prevention, engineering controls, equipment safety, and use and care of personal protection equipment; with training for new hires and refresher courses for all employees that is understandable to them given language and level-of-education considerations,
 - ii) Job rotation as feasible given workforce size,
 - iii) Safe work practices,
 - iv) Medical surveillance,
 - v) Safety meetings
 - III) Personal protective equipment, such as respirators, protective eyewear, cut-resistant gloves, etc. as appropriate for the risks involved and the tasks being performed.
- 3) Incorporate hazard management strategies as a component of the EHSMS.
- a) Use monitoring and sampling protocols to provide assurances that the practices employed are effectively and continuously managing the risks identified. This includes complying with all applicable Federal or State OSHA standards and permissible exposure limits (PELs) for sampling and/or monitoring.
 - b) Treat the workforce, including volunteer workers, temporary workers, and anyone else performing activities in a recycling facility, using the standard of care described in section 2)b) of this provision.
 - c) Designate a qualified employee or consultant to coordinate promotion of worker health and safety. This individual is identified to all employees and two-way communication is encouraged between employees and this individual regarding potential hazards and how best to address them.
- 4) Materials separation and processing

Materials of concern include the following:

- Any mercury bearing lamps or devices or PCBs;
 - Batteries;
 - Cathode ray tubes (CRTs) and leaded glass; and
 - Circuit boards
- a) Separate CEDs and CED components that are or contain materials of concern that would pose risk to worker safety, public health, or the environment during subsequent processing; or
 - b) If processed prior to removal, store processed materials of concern in containers sufficient to prevent a release to the environment or threat to human health, and handle them in a manner consistent with the regulatory requirements that apply to the items, or any substances contained in them, in a secured, sheltered enclosure with an appropriate catchment system as warranted. Cover or otherwise effectively separate battery terminals during storage and shipment to prevent short circuiting.

5) Storage

- a) Store materials of concern as described above in a manner that:
 - I) Protects them from adverse atmospheric conditions and floods and, as warranted, includes a catchment system;
 - II) Is secure from unauthorized entrance; and
 - III) Is in clearly labeled containers and/or storage areas.
 - b) Store whole products, components, and equipment destined for reuse in a manner that:
 - I) Protects them from adverse atmospheric conditions and floods and, as warranted, includes a catchment system;
 - II) Is secure from unauthorized entrance; and
 - III) Is in clearly labeled containers and/or storage areas.
- 6) Through training and preparation be able to immediately implement response practices designated in the facility's EHSMS to report and address any releases that could pose a risk to worker safety, public health, or the environment including emergencies such as accidents, spills, fires, and explosions.
 - 7) Manage materials of concern both on-site and in the selection of downstream vendors to which materials of concern, or whole or shredded equipment or components containing materials of concern, are sent using the practices described in this chapter of this guidelines [8].

- 8) Provide a functioning security program that controls access to all or parts of the facility in a manner appropriate given the type of equipment handled and the needs of the customers served. The program, for example, may include such things as photo ID, visitor logs, video surveillance, locked doors, receptionist, security guards, perimeter fencing, securing dock and bay areas when not in use, locking gates and doors to storage and processing areas, and adequate lighting inside and outside of facility.

BAN and ETBC Electronics Recycler's Pledge [9]

We will not allow any e-waste we handle to be sent to prisons for recycling either directly or through intermediaries.

IAER Recycler Certification Standard [10]

- 1) The equipment and facilities of the operation shall be adequate to support the key elements of the operation and in accordance to all applicable environmental, safety and health laws and regulations.
- 2) There shall be physical capabilities to support the key operational elements that are consistent with the scope and mission of the company. These would typically include materials handling, processing, storage, and transportation.
- 3) The staff of the company involved in critical operations shall have adequate technical knowledge, skills and experience to perform their assigned tasks.
- 4) Training should include worker safety and health for the prevention of accidents and illnesses and the handling of hazardous materials in accordance with all applicable laws and regulations.
- 5) There should be an individual designated with the responsibility for worker safety and health programs.

2.6.7 Data Destruction

EPA R2 Guidelines [6]

An R2 electronics recycler shall employ generally-accepted data destruction procedures:

- 1) An R2 electronics recycler shall sanitize, purge, or destroy data on hard drives and other data storage devices (the National Institute of Standards and Technology's (NIST's) Guidelines for Media Sanitation – Special Publication 800-88 88 9 lists categories of devices which need sanitization consideration), unless otherwise requested in writing by the customer. The R2 electronics recycler shall adhere to the data sanitization, purging, or destruction practices described in the NIST Guidelines for Media Sanitation: Special Publication 800-88 or another current generally-accepted standard, or be certified by a generally-accepted certification program.
- 2) An R2 electronics recycler shall document their data destruction procedures.
- 3) Employees involved in data destruction shall receive appropriate training on a regular basis.
- 4) Data destruction processes shall be reviewed and validated by an independent party on a periodic basis.

Oregon Electronics Recycling Environmental Management Practices [8]

- 1) Data sanitization or destruction is not required.
- 2) If a recycler does sanitize or destroy data on hard drives and other data storage devices for its customers, adherence to the National Institute of Standards and Technology (NIST) Guidelines for Media Sanitation or certification by the National Association of Information Destruction (NAID) or other generally-accepted programs is recommended.
- 3) If a recycler does sanitize or destroy data on hard drives and other data storage devices for its customers, the recycler should document data destruction processes and procedures.

IAER Recycler Certification Standard [10]

There shall be a process to control and document the destruction of data from equipment or media capable of storing data. This process should ensure that any stored data is permanently destroyed by means of a secure data wiping process, degaussing or by physical destruction of the storage device or media.

2.6.8 Finances, Insurance and Security

EPA R2 Guidelines [6]

An R2 electronics recycler shall employ facility security measures appropriate for the equipment they handle and customers they serve:

- 1) An R2 electronics recycler shall maintain a security program that controls access to all or parts of the facility in a manner and to a degree appropriate given the type of equipment handled and the needs of the customers served.
- 2) An R2 electronics recycler shall possess insurance that is adequate to cover the potential risks and liabilities associated with the nature and size of the company's operations, and shall have adequate legal and financial assurances in place for the proper closure of its facilities:
- 3) An R2 electronics recycler shall possess adequate Comprehensive or Commercial General Liability Insurance including coverage for bodily injury, property damage, pollutant releases, accidents and other emergencies.
- 4) An R2 electronics recycler shall develop and keep current a written plan and a sufficient financial instrument that assures proper closure of the facility and assures against abandonment of any electronics recycling products, components, or materials.

Oregon Electronics Recycling Environmental Management Practices [8]

The guidelines refer to desktop computers, portable computers, monitors, and televisions (covered electronic devices or CEDs)

- 1) Possess adequate comprehensive or commercial general liability insurance to cover potential risks and liability associated with the nature and size of the recyclers' operations including coverage for:
 - a) Bodily injury,
 - b) Property damage,
 - c) Pollutant releases,
 - d) Accidents, and
 - e) Other emergencies

IAER Recycler Certification Standard [10]

- 1) The company shall have financial stability and adequate resources to meet its customer commitments.

- 2) There shall be adequate insurance coverage for potential risks and liabilities associated with the nature and magnitude of the company's operations.
- 3) There shall be a plan and program for the security of the physical facilities, products and materials assets involved in the operational processes.
- 4) In the case of handling customers' assets and valuable commodities (such as precious metals and electronic components), there should be a formal tracking and control process.

2.6.9 Provisions for the Closure of the Plant

IPPC BAT Document for Waste Treatment [3]

Specifically for the waste treatment industry sector, it is also important to consider the following potential features of the Environmental Management System:

- 1) giving consideration to the environmental impact from the eventual decommissioning of the unit at the stage of designing a new plant.
- 2) for existing installations and where decommissioning problems are identified, put a programme to minimise these problems in place (see Section 4.1.9 of IPPC BAT document [3])

Oregon Electronics Recycling Environmental Management Practices [8]

Prepare and keep current a written plan for facility closure and a sufficient financial instrument (e.g. bonds, trust fund, or letter of credit) that assures proper closure of the facility and assures against abandonment of any CEDs, components, or materials at the facility.

IAER Recycler Certification Standard [10]

Electronics recycling operations shall have a closure plan that addresses processing equipment and abandoned materials including provisions for post closure activities (as needed), and financial assurance in accordance with applicable laws and regulations.

BAN and ETBC Electronics Recycler's Pledge [9]

We agree to provide adequate assurance (e.g. bonds) to cover environmental and other costs of the closure of our facility, and additionally to provide liability insurance for accidents and incidents involving wastes under our control and ownership. Additionally we will ensure due diligence throughout the product chain.

EPA Plug-In Guide [7]

The Plug-In partner¹ ensures that reuse, refurbishment and recycling techniques are used to the full extent practicable, i.e., recognizing technical and economic feasibility, in an effort to minimize incineration and land disposal of electronic equipment and components.

- “Plug-In partner” means a manufacturer, retailer, government agency, non-profit, or other entity who
- is not a recycler nor performs recycling activities (other than collection),
- through contracts or other arrangements, utilizes reuse, refurbishment, recycling or disposal services, and
- has a Plug-In To eCycling partnership agreement with EPA.

2.7 Inspection, Supervision, Auditing and Certification

WEEE Directive [1] and Proposal for a Recast of the WEEE Directive [2]

Both versions of the WEEE Directive are almost identical in these stipulations. Just the reference to other legislation of the EU is different. No fundamental changes are expected. The following are the stipulations set out in the proposed recast of the WEEE Directive [2].

Member States shall ensure that any establishment or undertaking carrying out treatment operations obtains a permit from the competent authorities, in compliance with Article 23 of Directive 2008/xx/EC on waste. [2]

Beyond this, Member States shall ensure that inspection and monitoring enable the proper implementation of the Directive to be verified. Member States shall further ensure that any establishment or undertaking carrying out treatment operations obtains a permit from the competent authorities.

The derogation from the permit requirement referred to in Article 11(1)(b) of Directive 75/442/EEC may apply to recovery operations concerning WEEE if an inspection is carried

out by the competent authorities before the registration in order to ensure compliance with Article 4 of Directive 75/442/EEC. [1] [2]

The inspection shall verify the following [1] [2]:

- 1) the type and quantities of waste to be treated;
- 2) the general technical requirements to be complied with;
- 3) the safety precautions to be taken.

The inspection shall be carried out at least once a year and the results shall be communicated by the Member States to the Commission. [2]

Member States shall ensure that the permit or the registration includes all conditions necessary for compliance with the requirements of paragraphs 1 Article 8(2), 8(3) and 8(5) and 3 and for the achievement of the recovery targets [2] (see Figure 2 on page 45).

The WEEE Directive [1] cites the similar stipulations in Article 6 (Treatment).

Draft Law on WEEE Recycling, China [4]

The Central Government will establish a qualification mechanism for WEEE treatment. Enterprises can only do WEEE treatment business when they are approved by related authorities of the country and have received the qualification certificate. Enterprises with qualification certificate shall do WEEE treatment business according to the requirement of the qualification. Detailed management measures of the qualification for WEEE treatment shall be developed by the State Council.

The qualification for approval is handled by Local Governments. The department of resource conservation in the people's government in provincial level, autonomous region and municipalities directly under the central government is responsible for approval of WEEE treatment qualification for the enterprises in its administrative region. Enterprises under the following conditions shall apply for the WEEE treatment qualification:

- Business meets the requirement of local master plan for WEEE recycling and treatment;
- Enterprises are completed installed with WEEE testing, dissembling and treatment equipment, and designed with the technology and process in line with national and industrial policies;
- Enterprises are with professional staff for safety, quality control and environmental management;
- Technical option of toxic and hazardous substances treatment are in line with national requirement.

The department of resource conservation in the people's government in provincial level, autonomous region and municipalities directly under the central government shall report and file the list of qualified WEEE treatment enterprises to the national development and reform authority and issue this information to public.

Draft National Standard China [5]

The Standard is implemented and supervised by the administrations of environmental protection of people's government above county level.

Records related to treatment of waste electrical & electronic products, monitoring records of pollutant emission and other relevant records of the disassembly and treatment enterprises should be kept for at least three years and inspected by the local administrations of environmental protection.

3 Standards and Guidelines for EoL Operations on Equipment for Cooling and Freezing

3.1 Collection, Transport, Storage and Handling

3.1.1 Collection

Draft National Standard for Environmental Protection of the People's Republic of China [5]

- 1) It is prohibited to mix waste electrical & electronic products with household garbage or industrial solid waste.
- 2) It is not allowed to pile up or disassemble collected waste electrical & electronic products at will
- 3) The collected waste electrical & electronic products should be handed over to the enterprises with qualifications for disassembly and treatment.
- 4) In the process of collecting waste air-conditioners, refrigerators and other refrigeration equipment, leakage of vesicant in thermal insulated foaming layer and the refrigeration agent should be avoided.

3.1.2 Transport

Draft National Standard for Environmental Protection of the People's Republic of China [5]

- 1) Before transport, the following information should be registered:
 - a) Information on the carrier: Name of the transport organization, name and No. of the transport vehicle
 - b) Departure location and date
 - c) Arrival location and date
 - d) Name, category and/or specifications of the transported waste electrical & electronic products
 - e) Weight and/or quantity of the transported waste electrical & electronic products
- 2) The carrier should not abandon waste electrical & electronic products in the process of transportation.
- 3) The carrier is prohibited from disassembling or treating the waste electrical & electronic products by any means.
- 4) Transportation Vehicles
 - f) Van vehicles are preferred.
 - g) The carriage and its back plane must be flat and complete, with fixed sideboard around.
- 5) When transporting waste refrigerators or air-conditioners, emission of pollutants such as CFCs, HCFCs and HFCs, etc into the air should be avoided. Clash or drop should be avoided in the process of transporting, loading and unloading waste refrigerators which should be kept upright and prohibited from overturning or lying flat.
- 6) Steel bottle to store refrigeration agents should be in conformity with relevant stipulations stated in GB 5842.

Requirements for Household Cooling and Freezing Appliances Containing CFC, HCFC or HFC [12]

Collection, storage, transport and handling of cooling and freezing appliances shall be done carefully to avoid damage of the appliances and leakage of controlled substances. If oil

leakage is recognized, appropriate measures shall be taken to minimize environmental impacts.

As for storage, transport and handling also the treatment of cooling and freezing appliances require precautionary protective measures due to the flammability of hydrocarbons. Places where hazardous explosive atmospheres may occur shall be especially designated. Furthermore, the ban on ignition sources and the ban on entering by unauthorized persons shall be indicated (Annex III of Directive 2002/96/EC). Nonobservance should be punished.

Transports optimisation is allowed as long as the initial size of the cooling and freezing appliances, including cabinets, is not reduced and good condition of the appliances is ensured.

The “controlled substances” separated shall be carefully stored, handled and transported to avoid any emissions before destruction.

Requirements for Cooling and Freezing Appliances Containing Hydrocarbons (HC) [13]

If removal of all liquids and further treatment of cabinets are being carried out at 2 different physical locations, the treatment company has to ensure that HC cabinets are not been mixed up with CFC cabinets at the time of collection and storage or during transport.

Collection, storage, transport and handling of cooling and freezing appliances shall be done carefully to avoid damage of the appliances and leakage of controlled substances. If oil leakage is recognized, appropriate measures shall be taken to minimize environmental impacts. (identical to [12])

As for storage, transport and handling also the treatment of cooling and freezing appliances require precautionary protective measures due to the flammability of hydrocarbons. Places where hazardous explosive atmospheres may occur shall be especially designated. Furthermore, the ban on ignition sources and the ban on entering by unauthorized persons shall be indicated (Annex III of Directive 2002/96/EC). Nonobservance should be punished. (identical to [12])

All sites for storage and treatment shall at least be in line with the technical requirements of Annex III of Directive 2002/96/EC. (identical to [12])

3.2 Treatment

3.2.1 Disassembly

Draft National Standard for Environmental Protection of the People's Republic of China [5]

- 1) Various waste electrical & electronic products should be classified for disassembly.
- 2) The disassembly equipment should be placed on the concrete floor, which should be able to prevent mixture or leakage of water, rainwater or oils.
- 3) Substances, elements as well as devices stipulated in Appendix B (Substances, Elements and Devices that must be Pre-disassembled) should be pre-disassembled and taken out. In addition, wires in the waste electrical & electronic products should be pre-disassembled.
- 4) It is prohibited to discard the pre-disassembled substances, elements and devices, which should be treated and disposed in accordance with Chapter 7 (Technical Requirements for Pollution Control in the Process of Treatment) and Chapter 8 (Technical Requirements for Pollution Control in the Process of Disposal) of the Standard.
- 5) All the liquid (including lubrication oil) should be pre-disassembled and held separately.
- 6) In time of storing the pre-disassembled substances, elements and devices, they should be marked clearly. As for the hazardous substances that require special safety treatment, they must be classified and stored according to features of the hazardous waste.
- 7) The pre-disassembled capacitor containing polychlorinated biphenyl (PCB) should be placed separately in the container, with marks.
- 8) Electrolytic capacitors with both the height and diameter being over 25 mm or with similar volume should be pre-disassembled to prevent leakage of electrolytic liquid. When using incinerating method to treat printed wire boards, it is allowed not to pre-disassemble electrolysed capacitors.
- 9) The pre-disassembled batteries should be complete and handed over to the enterprises with qualifications for treatment and disposal. Appropriate measures should be taken to avoid fire disasters caused by batteries in time of treatment and storage.
- 10) The pre-disassembled elements containing mercury should be complete, stored in exclusive containers and handed over to the enterprises with qualifications for

treatment. In order to identify such kind of elements, special training is required for the workers.

- 11) To disassemble the compressors and refrigeration loops, CFCs, HCFCs and HFCs from compressors of the refrigeration equipment such as refrigerators and air-conditioners, as well as the refrigeration agents HCs and lubrication oil that do not contain fluorine should be extracted first. In addition, the recovery devices should be secured not to leak and devices to recover HCs should be provided with explosion prevention measures.
- 12) As for the pre-disassembled parts containing refractory ceramic fibers (RCFs), scattering of refractory ceramic fibers (RCFs) should be prevented. In addition, they should be stored in the containers.
- 13) Scattering of the pre-disassembled parts containing asbestos and the asbestos waste should be prevented. In addition, they should be stored in the containers.

Draft National Standard China [5]

- 1) It is prohibited to disassemble thermal insulation layer containing substances such as CFCs, HCFCs and HFCs that consume the ozone layer.
- 2) To disassemble the compressors and refrigeration loops, CFCs, HCFCs and HFCs from compressors of the refrigeration equipment such as refrigerators and air-conditioners, as well as the refrigeration agents HCs and lubrication oil that do not contain fluorine should be extracted first. In addition, the recovery devices should be secured not to leak and devices to recover HCs should be provided with explosion prevention measures.
- 3) As for the pre-disassembled parts containing refractory ceramic fibers (RCFs), scattering of refractory ceramic fibers (RCFs) should be prevented. In addition, they should be stored in the containers.

3.2.2 Treatment

Draft National Standard [5]

- 1) It is prohibited to disassemble thermal insulation layer containing substances such as CFCs, HCFCs and HFCs that consume the ozone layer.
- 2) When treating the thermal insulation layer of refrigerators, the polyurethane hard foaming materials containing CFCs, HCFCs and HFCs, should be treated together with the shell. Crashing and grading operation should be conducted in the exclusive

sealed equipment with negative pressure. The equipment should be provided with collection devices and flue gas treatment devices of CFCs, HCFCs and HFCs.

- 3) When treating the polyurethane hard foaming materials containing CFCs, HCFCs, HFCs and HCs, necessary measures should be taken to prevent explosion and retard flames.

3.2.3 Requirements for Household Cooling and Freezing Appliances containing CFC, HCFC or HFC [12]

All cooling and freezing appliances and parts thereof which are not clearly identified as HC-type, either concerning refrigerant or foaming agent, must be treated as CFC, HCFC and HFC-type ones [10] [11]. Therefore treatment facilities for all types of appliances shall comply with explosion protection measures as stated in the Directive 1999/92/EC.

Separated "controlled substances" [1] shall be destroyed by a suitable thermal or chemical process. The destruction shall be proven by corresponding documents (e.g. bill, delivery sheet). The treatment process of end of life cooling and freezing appliances is usually performed in two steps:

Step 1: CFC, HCFC, HFC and Unidentified Gases , Oil and Compressor

All liquids that contribute to a contamination of separated fractions during, or after, the treatment process, shall be removed.

All refrigerants shall be separated from oil.

The amount of CFC, HCFC and HFC separated from cooling circuits shall be equal to, or higher than 90% of the expected amount of these substances.

According to the WEEE Forum, the value goes back to Swiss recyclers, who in the 1992 had brochures promising CFC recovery rates of 99.99%. They were of the opinion that it should be easy to have a rate of recovery of 90% in daily practice.

The compressor oil with less than 0.2% total halogen content may be used for material recycling or in normal incinerators, provided national regulation permit this procedure. The WEEE Forum stated that the 0.2 % residues allowed are an empirically determined value, not adjusted to legal requirements for reuse oil. According to the WEEE Forum, some countries ask for even lower values when reusing oil.

The compressor oil with more than 0.2% total halogen content shall be treated only in thermal processes for the safe destruction of "controlled substances" to prevent reuse, which in this case would be inappropriate.

Compressors shall not be re-used.

Step 2: CFC, HCFC, HFC, and unidentified gases, PU

The treatment of appliances in step 2 shall be carried out with step 1 treated appliances only (called "cabinets").

The amount of CFC, HCFC, and HFC separated from the PU-foam shall be equal or higher than 90% of the expected amount of these substances. Like the 90 % value for the removal of CFC, HCFC and HFC above, the value goes back to Swiss recyclers, who in the 1992 had brochures promising CFC recovery rates of 99.99%. They were of the opinion that it should be easy to have a rate of recovery of 90% in daily practice.

After treatment PU-fractions shall contain not more than 0.2 % CFC, HCFC, and HFC. The WEEE Forum says that the limit value was fixed at 0.5 % in 1992 in Switzerland. UBA in Germany, but was lowered down to 0.2 % by RAL (<http://www.ral-guete.de>) or the German UBA (Umweltbundesamt, environmental protection agency).

PU may contain all of the three substances as propellant, but not at the same time. Thus, there will be a mixture in the output fraction. In practice, only CFC11 is considered as it is the main propellant used. Nevertheless, the 0.2 % limit value refers to the sum of CFC, HCFC and HFCs.

It has to be guaranteed that the PU-residues (contained in the metal and plastic fractions separated for use as secondary raw material) are minimised to avoid losses of "controlled substances". Therefore, residues of PU contained in the ferrous and the nonferrous-metal fraction are to be kept below 0.3 %; residues of PU contained in the plastic fraction are to be kept below 0.5 %.

The WEEE Forum explained the background of the limits: until 2008, the 0.5 % limit, initially introduced by the German UBA (environmental protection agency), was valid for all fractions. It has been lowered by RAL since the relevance in metal fractions is bigger than in plastic fractions.

Performance Control Step 1

The determination of the degree of recovery as a percentage of the expected amount controlled substances for destruction in recycling step 1 can be achieved in two alternatives. Tests should be carried out with appliances containing CFC only, as in Switzerland, Germany, and in Austria, HCFC and HFC is not present in more than 2 %, according to the WEEE Forum. If it would be more in other countries, the composition of the collected CFC-fraction would have to be analysed concerning ratio and different specific weights, and the tests would have to be adapted accordingly. To avoid this, the test was decided to be conducted with CFC11 only containing foams.

Following input data

In a 100 unit test of appliances with intact cooling circuits and identification plates every single appliance is weighed before and after the treatment and the separated CFC and oil is compared with the total amounts filled in according to the identification plates. Those appliances which are recognized as defective should be sorted out.

Likewise during the entire test observations with visible CFC and oil losses, water and material losses which affect the mass balance must be noted.

The following recordings are available after the test:

- 1) total weight CFC (A) and oil (B) in kg (sucked off from appliances)
- 2) total weight of the CFC amount in accordance with indications on the identification plate (C)
- 3) total weight reduction (D) of all sucked off appliances in kg
- 4) amount of defective appliances or appliances with losses, which affect the mass balance. Comparison of the weight reduction of each appliance with the expected amount of weight reduction (CFC and oil) can indicate defective cooling circuits. Decisions on defective circuits have to be taken in order to get plausible figures for the mass balance

The following results with consideration of the number of defective appliances or other observations are determined:

Mass balance

The relationship between (A)+(B) and (D) is a measure for the entire plant achievement concerning mass recovery. Results more largely than 97 % are considered as tolerable values:

$$\frac{A+B}{D} > 97\%$$

Only 3 % of the sucked off oil and CFC thus are allowed to get lost.

CFC recovery

The relationship between (A) to (C) is a measure for the installation performance concerning CFC recovery. The result may not fall below 0.9 (=90 %).

$$\frac{A}{C} \geq 90\%$$

The sucked-off amount of CFC thus must be at least 90 % of the expected amount according to the identification plate on the cooling appliances.

The relationship between (A) to (D - B) (amount of CFC according to calculation) is a measure for the installation performance concerning CFC recovery. The result may not fall below 0.9 (=90 %).

$$\frac{A}{D-B} \geq 90\%$$

The sucked-off amount of CFC must be at least 90 % of the amount of CFC calculated from the weight reduction of the cooling and freezing appliances.

CFC per appliance

The relationship (A) to the number (N) of intact appliances supplies the amount of CFC per appliance. A typical result is more largely 115 g per appliance.

$$\frac{A}{N} > 115 \text{ g}$$

Oil per appliance

The relationship (B) to the number of oil containing appliances supplies the amount of oil per appliance. A typical result is more largely 240 g per appliance.

$$\frac{B}{N} > 240 \text{ g}$$

Portion of defective appliances

The number of defective appliances according to experience lies between 10 and 20 %.

Following output data

At least 1'000 appliances with intact cooling circuits [1,000 compressors] containing CFC are treated according to the used procedure and technology. Oil and CFC are separated. The cylinder for taking the CFC is weighed before operation begins and again when the operation is complete. The weighed amount in kilograms is divided by the number of compressors. The CFC recovered in grams per compressor is determined. The result shall not be lower than the 90% level of expected CFC.

Each country has to determine the expected amount according to their experience of the mix of size of compressors. In most of the European countries this value is 115 g R12 per compressor. HFC containing appliances should not be part of this performance test.

Performance Control Step 2

The determination of degree of recovery as a percentage of the expected amount of controlled substances for destruction in recycling step 2 can be achieved in two alternatives. Tests should be carried out with at least 1,000 appliances containing CFC only in their insulation foams.

- 1) The PU output fraction and the CFC fraction of the 1,000 appliances are weighed.
- 2) The containers made available to take the CFC are weighed empty before beginning of work and with filling after ending the work. The weighing result in kg CFC (without water!!!) is divided by the number of appliances. As a result, the CFC amount A in gram per appliance is determined.
- 3) During the treatment of the appliances several samples of the PU output fraction to a total weight of approximately 1 kg have to be sampled and manually divided into its PU and non-PU part (styropor, wood etc).

- 4) The PU plastic part corresponds to 91.5% (= 100 % - 8.5 % for the amount of CFC) of the corresponding PU foam input. Part of the CFC is still remaining in the PU plastic part what is called the matrix content and part of it is recovered as condensed fluid.
- 5) So the expected total amount of CFC considering also the amount analysed in the matrix can be calculated. The PU part of the fraction is sent to a laboratory to analyse the content of CFC in the matrix.
- 6) The total amount of CFC recovered (condensed and matrix part) for destruction shall be 90% of the expected and calculated amount.

Each country has to determine the expected amount according to their experience of the mix of size of appliances. In most of the European countries this value is 314.5 g CFC per appliance.

Following input data:

The procedure when determining the CFC quantities in grams per appliance is according to the category of appliance:

- 1) category 1: domestic cooling appliances (up to 180 l),
- 2) category 2: domestic combined cooling& freezing appliances (180 l to 350 l),
- 3) category 3: domestic freezing appliances (chest or cabinet, less than 500 l).

The following benchmark values, depending on the category of appliance, are to be met when separating CFC, corresponding to 90 % of the actual content:

- 1) Appliance category 1: 240 g CFC per appliance
- 2) Appliance category 2: 320 g CFC per appliance
- 3) Appliance category 3: 400 g CFC per appliance

The minimum amount of recovery for CFC for destruction has to be calculated according to the mix. In case of a 60%/25%/15 % mix it should be not be below 283 g/unit. Based on the following assumption: 3.7 kg PU per appliance, 8.5% CFC => 314.5 g → 90% = 283 g per appliance.

On the basis of the actually available mix of appliances, the expected average rate of CFC recovery per appliance (M) is calculated, with “n” as the number of appliances per category:

$$M = \frac{n_{cat1} \cdot 240 \frac{g}{appliance} + n_{cat2} \cdot 320 \frac{g}{appliance} + n_{cat3} \cdot 400 \frac{g}{appliance}}{n_{cat1} + n_{cat2} + n_{cat3}}$$

Following output data:

The amount of PU fraction (P) in kg is determined as follows:

With a suitable method of analysis the portion of foreign material in the recovered PU fraction in kg is determined (a).

The remaining amount of CFC (in kg, determined by an external laboratory) in the matrix of the PU structure is assigned with b.

The amount c of the pure PU fraction (PU fraction minus amount foreign material minus matrix content CFC in kg still in the foam is determined.

$$c = P - a - b$$

The amount c of pure PU corresponds to 91.5 % of the original PU material containing additional 8.5 % of CFC. The original content d of CFC in the original PU material thus can be calculated as

$$d = \frac{c}{0.915} - c$$

All possible losses e of PU are determined and evaluated (remaining PU adhering at Fe-metals, at non-ferrous-metals, at plastics and at other output materials).

The efficiency on the basis of the yielded PU-fractions is calculated with the following formula: Recovery rate $R_1 = \frac{\sum(Ax1000)}{\sum(d + e)}$

$$R_1 = \frac{A \cdot 1,000}{d + e} \geq 90\% \cdot 8.5\% = 7.65\%$$

As at least 90 % of the expected amount of CFC should be recovered, and the share of CFC in the PUR is 8.5%, the minimum requirement should be

$$R_1 \geq 90\% \cdot 8.5\% = 7.65\%$$

The efficiency on the basis of the brought in input-mix can be calculated with the following formula: Recovery rate $R_2 = \frac{\sum(Ax1000)}{\sum(Mx1000)}$

$$R_2 = \frac{A \cdot 1,000}{M \cdot 1,000} \geq 100\%$$

As M is defined as the minimum average recovery rate of CFC per appliance, R2 should be:

$$R_2 \geq 100\%$$

The following drawing visualizes the conditions with PU and CFC.

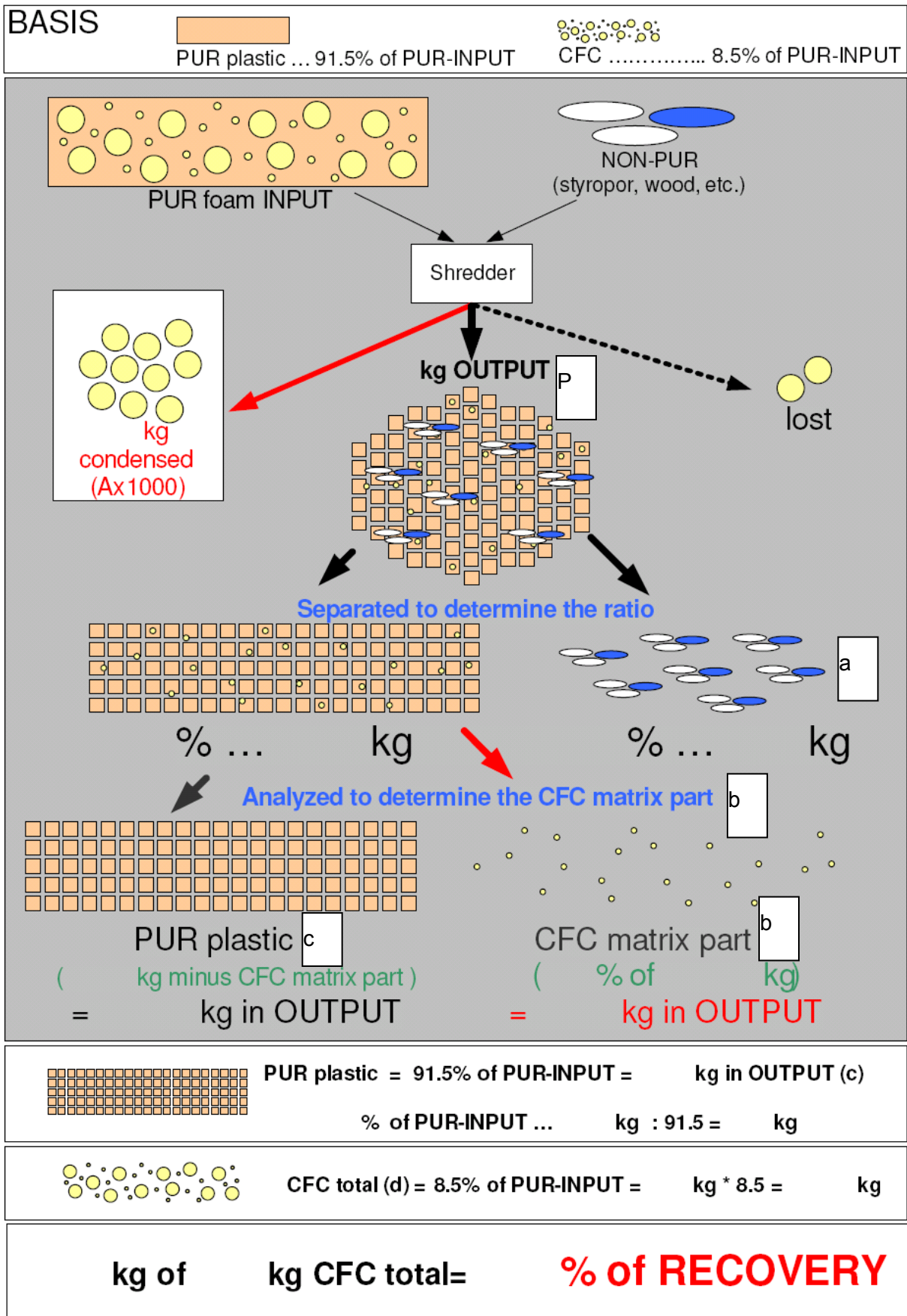


Figure 4: Conditions with PU and CFC

Recycling and Recovery Aspects

Cooling and freezing appliances and components, materials and substances that are processed as described above, are expected to fulfil the requirements of the Directive 2002/96/EC (WEEE Directive), in order to achieve a rate of recovery of at least 80% and a recycling rate of at least 75% by weight per appliance.

3.2.4 Requirements for Cooling and Freezing Appliances containing Hydrocarbons (HC) [13]

HC appliances can be treated in many different ways. The right choice of a technology is not only a question of minimising the risk of explosion, but also of getting the best separation results for the secondary raw-material market. Even though the environmental impact of HC is low (its global warming potential is below 15), the national air limiting values have to be respected.

If there is any doubt about the type of refrigerant or foaming agent, the cooling and freezing appliances must be treated as CFC-containing ones. Therefore, also treatment facilities for CFC appliances shall comply with explosion protection measures as stated in Directive 1999/92/EC.

Cooling and freezing appliances and components, materials and substances thereof have to be processed at a rate of recovery of at least 80 % and a reuse and recycling rate of at least 75% by weight per appliance according to the WEEE Directive or corresponding national regulations.

The treatment process of end of life cooling and freezing appliances is usually performed in two steps.

Step 1

Step 1 is the removal of all liquids according to Article 6.1 WEEE Directive:

- 1) All liquids that may contribute to a contamination of separated fractions during or after the treatment process shall be removed.
- 2) All HC refrigerants shall be separated from oil.
HC refrigerants used in "Commercial refrigeration equipment" mainly contain HC-290, HC-600a, HC-1270 or blends of HC-290/HC-600a, "Household refrigerators" mainly isobutane (HC-600a)
- 3) HC emissions shall comply with national legislation.
- 4) All installations shall be equipped and operated with protective measures against possible fires and explosions.

- 5) If step 1 and 2 are being carried out at 2 different physical locations, the treatment company has to ensure that HC cabinets are not been mixed up with CFC cabinets at the time of collection and storage or during transport.

Step 2

Step 2 is the further processing of HC cabinets:

- 1) It is essential for the treatment of HC cabinets that the necessary safety measures and the welfare of employees are observed.
- 2) The treatment of appliances in step 2 shall be carried out with step 1 treated appliances only (called "cabinets") from which refrigerants and oil have been removed.
- 3) HC emissions shall comply with national legislation.
- 4) In case HCs from the insulation foam are not captured, they shall be released in a controlled manner respecting the health and safety regulations. Special care to precautionary safety has to be assured as stated in Directive 1999/92/EC (Directive 1999/92/EC on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres (15th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC)).

Explosion protection measures in accordance with Directive 1999/92/EC

Plants shall comply with Directive 1999/92/EC on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres.

In practice, explosions inside the shredder can be avoided by controlling conditions.

Examples of measures to control those conditions are:

- 1) Rarefaction of the HC atmosphere by blowing air into the process or
- 2) Reduction of the oxygen content by substituting air with inert gases. There is a choice between different types of inert gases. Normally nitrogen is used (this is the usual way for treatment of HC appliances in treatment plants for CFC appliances).
- 3) Use of alternative explosion proof processing-technologies.

4 Standards and Guidelines for EoL Operations on Cathode Ray Tubes

4.1 Collection

4.1.1 Draft National Standard for Environmental Protection of the People's Republic of China [5]

- 1) It is prohibited to mix waste electrical & electronic products with household garbage or industrial solid waste.
- 2) It is not allowed to pile up or disassemble collected waste electrical & electronic products at will
- 3) The collected waste electrical & electronic products should be handed over to the enterprises with qualifications for disassembly and treatment.
- 4) Waste cathode ray tubes (CRT) should be collected separately from other glass products.

4.2 Transport and Handling of CRTs

4.2.1 Draft National Standard for Environmental Protection of the People's Republic of China [5]

- 1) Before transport, the following information should registered:
 - a) Information on the carrier: Name of the transport organization, name and No. of the transport vehicle
 - b) Departure location and date

- c) Arrival location and date
 - d) Name, category and/or specifications of the transported waste electrical & electronic products
 - e) Weight and/or quantity of the transported waste electrical & electronic products
- 2) The carrier should not abandon waste electrical & electronic products in the process of transportation.
 - 3) The carrier is prohibited from disassembling or treating the waste electrical & electronic products by any means.
 - 4) Transportation Vehicles
 - a) Van vehicles are preferred.
 - b) The carriage and its back plane must be flat and complete, with fixed sideboard around.
 - 5) Wagons with rainproof instruments should be used to transport waste cathode ray tubes (CRT) and waste printed wire boards.
 - 6) Waste televisions, monitors, cathode ray tubes (CRT) and printed wire boards (PWB), etc should be stored in the places with rainproof shelters.

4.3 Treatment of Cathode Ray Tubes (CRT)

4.3.1 Draft National Standard for Environmental Protection of the People's Republic of China [4]

- 1) Precautionary measures should be taken by the operating personnel when disassembling cathode ray tubes (CRT).
- 2) When treating cathode ray tubes (CRT), vacuum should be leaked out to prevent accidents.
- 3) When treating color cathode ray tubes (CRT), cone glass and screen glass should be separated. In the process of separation, devices that can prevent glass spattering should be provided.
- 4) When using dry methods to treat color cathode ray tubes (CRT), a dust removing system should be provided and measures should be taken to reduce noise.

- 5) The coating with fluorescent powder on the screen glass can be treated through the process of dry method or wet method.
- 6) When using the process of dry method to clean the fluorescent powder coating on the screen glass, dust extraction and filtering devices should be installed. In addition, the fluorescent powder should be well-collected.
- 7) When using the process of wet method to wash the fluorescent coating from the screen glass, a wastewater treatment system should be provided. The generated rinse wastewater should be treated to satisfy the emission standard. The sillage containing fluorescent powder should be handed over to the enterprises with qualifications for disposal.
- 8) Dry method or wet method should be adopted to rinse the cathode ray tube glass (CRT).
- 9) When rinsing with dry method, a dust collector should be provided. The collected dust should be handed over to the enterprises with qualifications for treatment.
- 10) When rinsing with wet method, a wastewater treatment system should be provided. The generated rinse wastewater should be treated to satisfy the emission standard. Sillage containing glass powder should be handed over to the enterprises with qualifications for disposal.

4.3.2 EPA R2 Guidelines [1]

Special attention should be given to potential lead and cadmium exposures during the creation or handling of broken CRT glass.

5 Standards and Guidelines for EoL Operations on Printed Wiring Boards (PWBs, PCBs)

5.1 Collection, Transport, Handling and Storage

5.1.1 Draft National Standard for Environmental Protection of the People's Republic of China [5]

Waste televisions, monitors, cathode ray tubes (CRT) and printed wire boards (PWB), etc should be stored in the places with rainproof shelters.

5.2 Treatment of Waste Printed Wire Boards

5.2.1 Draft National Standard for Environmental Protection of the People's Republic of China [5]

In the process of disassembling the elements of waste printed wire boards by heating, a treatment system should be provided for the fume generated from the heating process to control plumbum content in the fume, which should be in accordance with the stipulations stated in GB 16297.

A dust removing system should be provided when treating the facilities of waste printed wire boards by means of crashing and grading and measures should be taken to reduce noise. As for the grading method, water table is not appropriate. When water table is used, a treating system must be provided to treat the wastewater generated in the process of treatment. The flue gas and wastewater generated by means of crashing and grading must be treated.

In the process of adopting the incinerating method or the refrigerating method to treat waste printed wire boards, a flue gas treatment system must be provided. While adopting the incinerating method for treatment, air pollutant emission should be in accordance with the

stipulations stated in GB 18484. However, when using the refrigerating method for treatment, air pollutant emission should be in accordance with the stipulations stated in GB 16297.

Chemical methods are not appropriate to treat waste printed wire boards. When using chemical methods to treat waste printed wire boards, equipment with higher standard of automation, excellent seal and measures to prevent spillover of liquid chemicals should be adopted. Safety measures such as spillover prevention, leakage prevention and accident alarm devices should be provided for the equipment and storage tanks in the process of storing chemicals or other liquids with stronger corrosive features.

6 Standards and Guidelines for EoL Operations on Waste Drum and Ink Cartridges

6.1 Treatment of Waste Drum and Ink Cartridge

6.1.1 Draft National Standard for Environmental Protection of the People's Republic of China [5]

Waste drums containing arsenic selenide coating or cadmium sulfide coating should be recycled after the coating being removed. The removed substances should be collected, well-stored in the sealed containers and handed over to the enterprises with qualifications for treatment.

Flue gas collection and treatment devices should be provided in the treatment workshop of waste color-adjusting ink cartridge, liquid, paste and color ink powder. Meanwhile, the standard should be satisfied before it emits.

6.1.2 EPA R2 Guidelines [6]

Processing, Recovery, and Treatment of FMs

Toner and toner cartridges, though not a Focus Material (FM), shall be recycled through the OEM or other qualified toner recycler unless it is not economically feasible.

7 Standards and Guidelines for EoL Operations on Plastics

7.1 Collection and Transport

7.1.1 Draft National Standard for Environmental Protection of the People's Republic of China [5]

Collection, transport, treatment and recycling of waste plastics should be in accordance with the stipulations stated in HJ/T 364-2007.

7.2 Treatment of Waste Plastics

7.2.1 Draft National Standard for Environmental Protection of the People's Republic of China [5]

It is prohibited to landfill directly the disassembled waste plastics from waste electrical & electronic products.

Collection, transport, treatment and recycling of waste plastics should be in accordance with the stipulations stated in HJ/T 364-2007.

8 Standards and Guidelines for EoL Operations on Wires and Cables

8.1 Treatment of Waste Wires and Cables

8.1.1 Draft National Standard China [5]

In the process of treating waste wires and cables, metal, plastics or rubber should be separated.

It is prohibited to treat waste wires and cables with the incinerating method.

9 Recycling and Auditing Guidelines for Liquid Crystal Displays (LCDs)

9.1 Treatment of Waste LCDs

9.1.1 Draft National Standard for Environmental Protection of the People's Republic of China [5]

Before treatment and recycling of LCDs, the LCDs can be sealed up first or incinerated as hazardous waste.

The pre-disassembled back-light source on LCDs should be complete, stored separately and handed over to the enterprises with qualifications for treatment.

10 Analysis of Directives, Guidelines and Standards

10.1 Objectives of Analyzed Legislation

10.1.1 WEEE Directive [1] and Proposal for a Recast of the WEEE Directive [2]

In Europe, the WEEE Directive [1] formulates the following objectives (Art. 1, Objectives of the WEEE Directive [1], Europe):

The purpose of this Directive is, as a first priority,

- 1) the prevention of waste electrical and electronic equipment (WEEE), and in addition,
- 2) the reuse, recycling and other forms of recovery of such wastes so as to reduce the disposal of waste.
- 3) It also seeks to improve the environmental performance of all operators involved in the life cycle of electrical and electronic equipment, e.g. producers, distributors and consumers and in particular those operators directly involved in the treatment of waste electrical and electronic equipment.

The proposal for the recast of the WEEE Directive [2] states in Art. 1 (Subject Matter):

This Directive lays down measures to protect the environment and human health

- 1) by preventing or reducing the adverse impacts of the generation and management of waste from electrical and electronic equipments and
- 2) by reducing overall impacts of resource use and improving the efficiency of such use.

Next to the above objectives, the conditions for exports of WEEE out of the European Community are formulated in Art. 5 (5) of the WEEE Directive [1] (or see section “WEEE Directive [1]” on page 62 of this document, and section “WEEE Directive [1]”, page 130 for more detailed explanations).

10.1.2 Chinese Legislation

Chinese legislation also points out objectives of legislation on e-waste (Art. 1, Objectives, Law on Pollution Control of Electronic and Electrical Equipment (EEE), and Recycling and Reuse for Waste Electronic and Electrical Equipment (WEEE), P. R. China (Draft) [4], China):

The purpose of this Legislation is, as a first priority,

- the pollution prevention and control of electrical and electronic equipment (EEE) to
 - environment,
 - water and
 - land resource,
 - air and
 - human health, and in addition,
- the recycling and reuse of such wastes, and finally,
- the improvement of sustainable development of social economy.

The cited pieces of legislation thus target the prevention of pollution to protect human health and the environment as a main target. Reuse and recycling are considered as a mean to achieve this target.

The proposed recast of the WEEE Directive [2] explicitly formulates the increase of the resource efficiency, although under the overall objective of protecting the environment and human health. This objective also is addressed indirectly in the Chinese legislation [4], as it wants to promote recycling and reuse not only for the prevention of pollution, and improve sustainable development.

10.2 Objectives of Analyzed Guidelines and Standards

Recycling guidelines and standards for e-waste should support these targets, and therefore should warrant the following issues:

- 1) proper collection, transport, handling and storage of e-waste in order to prevent damages to environment, health and safety
- 2) safe operation of all sites involved in the end-of-life chain of e-waste
- 3) promote reuse over recycling over disposal and incineration
- 4) aspire high recovery and recycling rates
- 5) prevent illegal exports of e-waste or fractions thereof

The focus of the different documents is on pollution prevention and the protection of environment, health and safety.

None of the analyzed documents addresses the quality of the secondary materials obtained in the recycling process.

10.3 Topics Addressed in Guidelines and Standards

The degree of elaboration between the different guidelines and standards is highly different. The most elaborated stipulations can be found in the following guidelines, in the order of decreasing degree of elaboration:

- 1) EPA Guidelines [6]
- 2) Oregon Guidelines [8]
- 3) IAER Guidelines [10]

Working Document

Table 5: Topics addressed in guidelines and standards (v: addressed; x: not addressed)

Topics	EPA Guidelines [6]	Oregon Guidelines [8]	IAER Guidelines [10]
Stipulations for collection, handling, storage and transport between collection point and recycling plant	x	v	x
Requirements for environmental, health, and safety management system	v	v	v
Obligation for (consistency with) standard management system (ISO 14001, EMAS, etc.)	x	(v)	x
Requirement for third party certification	v	v	v
Management strategy to implement “reuse, recover, disposal” hierarchy	v	v	v
Obligations and procedures for compliance with (environmental) legislation	v	v	v
Specific stipulations on exports	v	v	yes, but not elaborated
Environment, health, and safety requirements for facility operation	v	v	v
Definition of materials of concern requiring specific attention and treatment	v	v	v
Specific stipulations for removal of materials of concern, specific treatment, recycling, disposal/incineration	v	v	v
Stipulations on testing and conditions for reusable equipment and components	v	v	No documentation required
Tracking and documentation of throughput	v	v	v
Downstream due diligence and documentation	v	v	v
Obligations for data destruction	v	x	v

Recycling facility storage and transport of e-waste, components and materials, internal and downstream transports	v	v	v
Insurance, closure plan, and financial responsibility	v	v	v
Recordkeeping (for auditing) to prove compliance with guideline	v	v	x

10.4 Prevention of Disposal and Incineration of e-Waste

For the provisions of the different guidelines on landfilling and incineration see chapter 2.5.9 on page 59.

10.4.1 Comparison of Stipulations in Guidelines

The proposed recast of the WEEE Directive [2] does not generally ban the disposal of separately collected e-waste, but targets reducing the disposal of untreated e-waste. The disposal of treated e-waste thus is not generally banned, as long as producers achieve the recovery and recycling targets in the WEEE Directive and the disposal is in line with other legislation.

The Chinese Draft Law on WEEE [4] does not allow the disposal and incineration of e-waste. The wording, however, does not allow detailing whether this restriction is general or limited to certain conditions.

The EPA R2 Practices [2] ban energy recovery, incineration, or land disposal as a regular management strategy unless applicable law requires the use of one of these technologies (e.g., thermal destruction of Polychlorinated Biphenyls (PCBs)). This stipulation is limited to e-waste, components and materials containing Focus Materials (FM) and thus does not necessarily result in a complete disposal and incineration ban of e-waste due to the FM definition (chapter . The provision opens a gate to disposal and incineration of e-waste “[...] if circumstances beyond the control of the R2 recycler disrupt its normal management of an FM [...]” (paragraph 2.2.1 on page 22).

The R2 Practices do not further elaborate on what kind of circumstances this might be. The wording of this stipulation further on does not clearly exclude the landfilling or incineration of untreated e-waste containing FMs under these circumstances. Although the guideline in another of its provisions requires the removal of FMs from e-waste (paragraph “EPA R2 Guidelines [6]” on page 54), it is not clear whether and how far the “circumstances beyond

the control of the R2 recycler” allow landfilling and incineration of untreated e-waste. There is no crosslink to the section that requires the removal of FMs from e-waste before landfilling or incineration. If regulations are unclear, it cannot be excluded that this ambiguity is exploited. The R2 Practices thus do not ultimately exclude the direct landfilling of untreated e-waste containing hazardous materials.

The Oregon Guideline [8] allows safe landfilling and incineration in line with applicable laws as the final stage for materials that cannot be reused or recycled otherwise. The underlying requirement is that the waste is not a hazardous waste, needing management at a hazardous waste facility. Landfilling and incineration of untreated e-waste thus is excluded as long as it contains hazardous materials requiring a pre-treatment.

The BAN and ETBC Electronics Recycler’s Pledge [9] does not allow any hazardous e-waste to be sent to solid waste (nonhazardous waste) landfills or incinerators for disposal or energy recovery, either directly or through intermediaries.

The Dell guideline allows landfilling and incineration if recycling is not the most viable option, and it promises endeavoring to minimize the use of processes that result in landfill and incineration of end-of life electronics. The stipulation does not give details or specify concrete conditions for landfilling and incineration. It is thus a declaration of intent, which cannot effectively prevent landfilling and incineration of e-waste of all kind.

10.4.2 Summary and Conclusions

Landfilling and incineration are required for e-waste, components and materials that cannot be reused or recycled. They are even indispensable for specific hazardous materials like or example polychlorinated biphenyls (PCB). Consequently, the legislation and guidelines analyzed allow landfilling and incineration of e-waste in these cases.

Differences exist in the detailing and the strictness of provisions, which shall prevent landfilling and incineration beyond the necessities described above. The Dell guideline is just a declaration of intent without further specifications and cannot effectively prevent such landfilling and incineration. The EPA R2 Practices, although being stringent with stipulations to prevent inadequate landfilling and incineration on the one hand, weaken the rules on the other hand and thus cannot effectively prevent landfilling and incineration of e-waste.

The proposed recast of the WEEE Directive, the Oregon Guidelines and the Chinese Draft WEEE Law are stringent and strict with prohibiting at least landfilling and incineration of untreated e-waste (WEEE Directive) or e-waste in general, whereas the details of the Chinese Law are not clear.

10.5 Exclusion of Lead-free Soldered PWBs from FM Material Definitions in EPA R2 Practices

In the EPA R2 guidelines [6], whole or shredded lead-free soldered printed circuit boards (printed wiring boards, PWBs), after removal of mercury and battery, are not considered as FMs. The EPA R2 Guidelines thus do not classify them as needing greater care during recycling, refurbishing, materials recovery, energy recovery, incineration, and/or disposal due to their toxicity or other potential adverse worker health and safety, public health, or environmental effects that can arise if the materials are managed without appropriate safeguards. As the EPA R2 guideline's export stipulations only refer to devices, components or materials containing Focus Materials, lead-free soldered printed wiring boards could be exported without any restrictions from the R2 guidelines.

Printed wiring boards (PWBs) are highly complex mixtures of organic and inorganic materials.

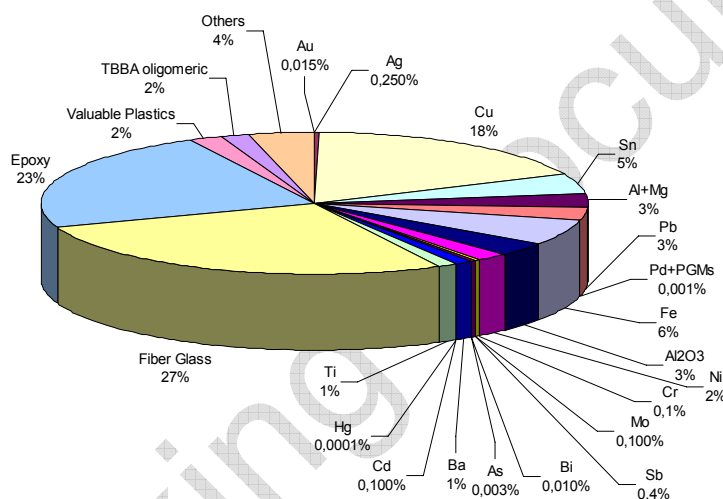


Figure 5: Example for a composition of a printed wiring board (in mass-%) [1]

The inorganic materials contained range almost across the whole periodic system of elements. Some of the materials are toxic or of high economical value. The concentration ranges from trace elements up to concentrations where recycling is economically viable, and which may cause damages to health and environment in case of improper treatment. For recycling, PWBs are classified into (very) low grade, medium grade and high grade PWBs, depending on their content of gold and silver, and platinum group metals.

The principle in end-of-life treatment of PWBs is to concentrate the different metals and the organic compounds in different fractions through a shredding and mechanical separation process. The metals can then be recycled in respective smelters, partially after further pre-treatment. High grade PWBs may be treated directly in copper smelters. Mechanical separation causes a certain loss of noble metals to fractions, from which they cannot be recycled. As high grade PWBs have high concentrations of noble metals, this loss becomes

economically and ecologically adverse and a direct processing in primary or secondary copper smelters, or in integrated smelters, may be preferred.

In any case, the proper treatment and recycling of PWBs or fractions thereof is a highly complex task. It requires sophisticated technology and process knowhow to avoid pollution and to achieve adequate recycling of the metal contents.

Lead on Lead-free Soldered PWBs

Lead is considered as a hazardous material. The European RoHS Directive and Japanese industry efforts have resulted in the use of lead-free solders and thus in a considerable reduction of lead use on printed wiring boards. Nevertheless, printed wiring boards remain a difficult material with hazardous properties if improperly treated in recycling processes. They also contain economically and ecologically valuable metals that require sophisticated recycling processes in order to recycle them from PWBs.

Lead-free soldered PWBs, due to different technical reasons, still contain lead.

Lead-free soldering reduces the amount of lead on PWBs. Nevertheless, lead-free soldered PWBs still contain lead. Lead cannot yet be substituted in all solder applications. One of the main lead sources are the high melting point (HMP) solders that do not yet – and for the foreseeable future will not have - viable lead-free substitutes. The same applies to other uses of lead in solders, where it cannot yet be replaced. A look into the Annex of the RoHS Directive banning lead – among other substances - shows that there are several exemptions in place where lead cannot be replaced and will therefore continue to be found in solders on lead-free soldered PWBs. Lead in high melting point solders should be the biggest remaining source of lead.

A simple calculation allows a rough estimate of the amount of lead remaining on lead-free soldered PWBs. Lead-free soldering globally may replace around 70,000 t of lead-containing solders [15]. These solders contain around 28,000 t of lead [15]. The annual use of high melting point solders amounts to around 10,000 t, with a lead content of around 80 % to 90 %. These HMP solders thus contain around 8,000 t to around 9,000 t of lead [15]. The lead on PWBs thus in average may be reduced to around 30 % (rounded) of the original lead content. There may be lead from other exemptions on PWBs so that the 70 % reduction may be smaller. Most of the other persisting uses of lead in solders on PWBs, however, should only account for minor amounts of lead compared to the HMP solders.

Strictly speaking, due to the described irreplaceable usages of lead-containing solders in some applications and technologies, there are no or hardly any PWBs that do not contain lead solders, even if they are officially declared as lead-free soldered.

Another question is whether and how far lead-free soldered PWBs can actually be differentiated from those that were soldered with lead-containing solders at least where lead-free solders can replace the lead-containing ones.

Differentiation of lead-free soldered from non-lead-free soldered PWBs

At end-of-life, it may be difficult to clearly differentiate between PWBs that are soldered with and without lead solders. In the EU, although lead is banned in solders in electrical and electronic equipment, a marking of lead-free soldered equipment is not obligatory. Nevertheless, newer equipment on the European market from July 2006 on must be lead-free soldered as far as lead-free solders can replace the lead-containing ones. In the US, this situation might not be as clear, as there is no US national regulation banning the use of lead in such solders, unless there are marking regulations or agreements with producers in the US to clearly mark lead-free soldered equipment. Even if the use of lead-free solders will become standard technology worldwide, for a certain period of time e-waste will consist of both lead-free soldered and other equipment.

If the equipment is not marked as lead-free, it would be necessary to open it in order to access the PWBs for inspection. It will be difficult, given the large variety of different products from different manufacturers, to know from experience or from individual producer information, which products are produced using lead-free solders. Normally, only equipment containing high grade PWBs with high contents of noble metals will be disassembled for separate treatment of the PWBs. For other equipment, the standard treatment is the removal of components containing hazardous substances followed by shredding and mechanical separation.

Assuming the equipment is disassembled, in principle, it is possible to optically identify lead-free soldered PWBs, as the solder joint appearance is different. However, this needs specific training, and might not always be possible unequivocally. Rapid testing using, e. g. mobile x-ray diffractometers, is possible, but will not be viable due to time and cost constraints. Thus, a clear identification of lead-free soldered PWBs is probably not viable and may, in particular in the transition period where equipment with both types of PWBs appears in the e-waste, pose a major challenge.

Recyclers normally know the type of waste quite well, which they process. It could be argued that they thus know what equipment is lead-free soldered. This would, however, require the sorting of e-waste to obtain a fraction with only lead-free soldered PWBs. Financially, this additional labour does not pay to just sort lead-free soldered from other PWBs. Some lead-free solders and finishes contain noble metals like silver, gold and platinum. The amounts, however, are too small to achieve an additional recycling profit that could pay for the sorting labour if it is not yet already done for other reasons.

Brominated flame retardants, hazardous materials and valuable resources

PWBs contain lead and other materials that require specific attention in the EoL treatment. In Germany, smelters processing metal fractions from e-waste or entire PWBs for metal recycling must have a special license, which is limited to a certain amount of such waste. Within the EU, there are similar regulations.

One reason for this is that e-waste and fractions thereof contain brominated flame retardants which may generate toxic dioxins and furans. To prevent this, the processor needs adequate processing knowhow and the respective technology for flue gas cleaning. PWBs contain brominated flame retardants, e. g. TBBA, in the substrate materials, but also in plastics of components. It cannot be excluded that PWBs contain other brominated flame retardants as well with a higher dioxin and furane generation potential, although some of them are banned, e. g. polybrominated biphenyls (PBB) or polybrominated diphenyl ethers (PBDE) in the European RoHS-Directive. Copper is a catalyst for the generation of dioxins and furanes from such substances and an indispensable constituent in PWBs. Improper treatment, e. g.

incineration of PWBs over open fire or processing in smelters with insufficient filters and process knowhow thus may generate high amounts of dioxins and furanes.

Further on, PWBs can contain most elements of the periodic table, in different amounts, e. g.

- 1) Lead, which is used in different types of solders, in finishes on components and on the PWBs lands. The use of lead-free solders is becoming more wide-spread, at least in Europe, where the use of lead in solders is banned. Nevertheless, lead is also present on lead-free soldered PWBs (see
- 2) Antimony, which is used as antimony trioxide, an accessory substance to the brominated flame retardants
- 3) Beryllium, which is part of some components or substrate materials, although the concentration in most of electrical and electronic equipment is low
- 4) Cadmium, which is banned in the European RoHS Directive, but also exempted in some applications
- 5) Noble metals and platinum group metals, which are economically and ecologically valuable
- 6) Other metals like tin, copper and bismuth as part of solders, finishes and of the conductive paths and inner layers of PWBs.

Besides possible hazardous effects, PWBs thus also contain valuable resources which can be recycled. As PWBs are one of the most complex materials, it requires sophisticated recycling technology to treat them without harm to health and environment, and in order to achieve reasonably high recycling rates.

Summary

Excluding PWBs that do not contain lead-solders from the focus materials has several implications. First of all, in practice there are no or hardly any purely lead-free soldered PWBs, even if lead-free solders are used on PWBs. Lead-solders cannot yet be replaced in all applications and technologies. Secondly, differentiating lead-free soldered from other PWBs in practice is not viable. Additionally, PWBs contain other hazardous materials besides lead that require proper processing to prevent pollution. Finally, from the resource point of view PWBs contain economically and ecologically valuable materials, which, due to the highly complex construction of PWBs, needs sophisticated technology and process knowhow to achieve high recycling rates saving valuable resources.

10.6 Stipulations on Exports

Exports of e-waste that are either illegal or result in inadequate, inefficient and ineffective treatment of e-waste are a main concern. A major touchstone for legislation, guidelines and standards related to end-of-life of electrical and electronic equipment is whether they can effectively prevent such exports.

WEEE Directive [1]

The European WEEE Directive allows the treatment of e-waste outside the respective Member State or the Community provided that the shipment of WEEE is in compliance with Council Regulation (EEC) No 259/93 of 1 February 1993 on the supervision and control of shipments of waste within, into and out of the European Community (1). [1]

WEEE exported out of the Community in line with [1]

- 1) Council Regulation (EEC) No 259/93,
- 2) Council Regulation (EC) No 1420/1999 (2) of 29 April 1999 establishing common rules and procedures to apply to shipments to certain non-OECD countries of certain types of waste and
- 3) Commission Regulation (EC) No 1547/1999 (3) of 12 July 1999 determining the control procedures under Council Regulation (EEC) No 259/93 to apply to shipments of certain types of waste to certain countries to which OECD Decision C(92)39 final does not apply,

shall only count for the fulfilment of obligations and targets of Article 7(1) and (2) of this Directive if the exporter can prove that the recovery, reuse and/or recycling operation took place under conditions that are equivalent to the requirements of this Directive.

The WEEE Directive refers to regulation (EEC) No 259/93 on the supervision and control of shipments of waste within, into and out of the European Community [16]. The next section shall clarify whether and under which conditions this directive allows the export of e-waste.

Wastes for Disposal

Directive (EEC) No 259/93 [16] states in Article 14 (1) that “All exports of waste for disposal thus are prohibited, except those to EFTA countries which are also parties to the Basel Convention.”

EFTA is the European Free Trade Association. The member countries are Iceland, Norway, Liechtenstein and Switzerland, which at the same time signed the Basel Convention and thus

in principle may receive waste for disposal from the European Community. Directive (EEC) No 259/93 specifies further conditions for such exports. Exports to EFTA states can be banned as well under certain conditions, which shall not be further detailed here.

Wastes for Recovery

Art. 16 of Directive (EEC) No 259/93 [16], prohibits all exports for recovery of waste listed in Annex V for recovery, except those to countries to which the OECD Decision applies. Exports to non-OECD countries were allowed under certain conditions until 31 December 1997 only.

Directive (EEC) No 259/93 explains in Art. 16 (2) that these agreements and arrangements concerning exports of waste for recovery into non-OECD countries shall guarantee an environmentally sound management of the waste in accordance with Article 11 of the Basel Convention and shall, in particular:

- 1) guarantee that the recovery operation is carried out in an authorized centre which complies with the requirements for environmentally sound management;
- 2) fix the conditions for the treatment of the non-recoverable components of the waste and, if appropriate, oblige the notifier to take them back;
- 3) enable, if appropriate, the examination of the compliance of the agreements on the spot in agreement with the countries concerned;

As a result, the WEEE Directive bans exports of waste for recovery into non-OECD countries, as long as this waste or fractions thereof are listed under the respective sections of Annex V in Directive (EEC) No 259/93. Part I of Annex V corresponds to Annexes VIII and XI of the Basel Convention [19]. Directive (EEC) No 259/93 specifies further conditions and limitations of exports even to OECD countries.

A more detailed explanation of which types of e-waste or fractions thereof actually can be exported in accordance with the WEEE Directive and under which conditions requires an in-depth and detailed investigation of several other European and international regulations and of the Basel Convention. This would go beyond the task of summarizing and analyzing guidelines and standards for e-waste recycling.

Treatment Requirements for Exported Wastes

The WEEE Directive [1] obliges producers to set up systems for recovery of WEEE collected separately, and to achieve the recovery and recycling targets for the different categories of e-waste (see Figure 1 on page 44. E-waste, which is exported legally out of the European Community, only counts for the fulfilment of these producers' obligations under one specific condition: The exporter has to prove that the recovery, reuse and/or recycling operations took place under conditions that are equivalent to the requirements of the WEEE Directive (see chapter WEEE Directive [1]" on page 62).

The WEEE Directive thus does not make the fulfilment of its treatment requirements a condition for exports of e-waste. As long as the export does not conflict with other legal regulations, the Directive does not require treatment of e-waste under the conditions, which it sets for the European Community.

EPA R2 Guidelines [6]

The USA have not ratified the Basel Convention. The US EPA guidelines allow exports to OECD as well as to non-OECD countries. For non-OECD countries, there are restrictions, which, however, only apply to equipment, components and materials containing “Focus Materials” (see section “EPA R2 Focus Materials [6] and Designated Materials [7]” on page 35 and chapter 2.2.1 on page 22).

The legality and the compliance with the regulations of the importing countries of all international shipments of equipment, components and materials containing FMs must be documented. The receiving countries must be identified. These requirements include international shipments made by downstream vendors.

The underlying assumption is that such exports are legal to OECD countries. For non-OECD countries receiving FM containing equipment, components and materials, the guidelines require recyclers to have documentation that they legally accept them. This documentation, which shall prove the legality of such international shipments, can be

- 1) a document from the US EPA [6], or
- 2) from the importing country’s Competent Authority, or [6]
- 3) a copy of a law or court ruling from the importing country that demonstrates the legality of the import. [6]

The above provisions on international shipments apply to all equipment, components, or materials containing FMs that have passed through the R2 recycler’s facility or control, including downstream vendors’ international shipment. For other e-waste containing no FMs, there are no limitations from the EPA R2 provisions.

The provisions on reuse of equipment and components (provision 6, Reusable Equipment and Components [6]), open the gate for the export for reuseable equipment and components. The provisions on exports do not apply to such equipment and components as long as it has been tested that their key functions work properly (also see section EPA R2 Guidelines [6] on page 50 of this document). The recycler himself can confirm that he has conducted all necessary tests and found the key functions working properly.

Exports of “FM-free” e-Waste

The export stipulations only apply to equipment, components and materials containing FMs. For other equipment, components and materials, the guidelines do not set any restrictions.

Mercury is found in switches, backlights of LCDs and in energy saving lamps. Older capacitors may contain PCBs, modern electrical and electronic equipment (EEE) should not use capacitors containing PCB any more.

Lead-free soldered PWBs will become the standard in most e-waste, as lead-free soldering is widely used even in countries that do not have respective legal bans of lead in solders for electrical and electronic equipment.

This means that equipment and components from e-waste can be exported freely

- 1) if it is not a CRT or equipment containing one or more CRTs,
- 2) if it does not comprise switches using mercury or capacitors containing polychlorinated biphenyls, which were only used in older equipment
- 3) if it is not a LCD using mercury containing backlights, or a energy saving lamp
- 4) if the equipment does not have batteries, or if they are removed from the equipment, which should be possible for most EEE unless the batteries are built-in
- 5) if the printed wiring boards (PWBs) are produced using lead-free solders and the batteries and mercury containing switches are removed.

There should be a number of electrical and electronic equipment (EEE) that is “FM-free” and thus free for exports without restrictions from the EPA R2 guidelines.

Nevertheless, recyclers shall record all equipment, components and materials passing through their facility, regardless of whether they contain FMs (see provision 7 in original document [6], or the chapter “EPA R2 Guidelines [6]” on page 69 of this document). For FM-containing materials, downstream vendors have to comply with the tracking and documenting requirements as well. There is not tracking requirement for downstream vendors for FM-free equipment, components and materials in the EPA R2 Guidelines [6].

10.7 Management Systems in Legislation, Guidelines and Standards

10.7.1 Management System Requirements in e-Waste-related Legislation

The WEEE Directive [1] in Art. 6 (2) requires member States to encourage end-of-life operators to introduce certified environmental management systems in accordance with EMAS. The proposed recast of the Directive [2] as well asks member states to encourage such measures (see chapter WEEE Directive [1] and Proposal for a Recast of the WEEE

Directive [2] on page 76). It is, however, not mandatory for end-of-life operators to have such a management system.

According to the Chinese WEEE legislation [4], China's central government establishes the standardized management mechanism for toxic and hazardous substances or elements of EEE. Ministry of Information Industry, together with state authorities responsible for environmental protection and standardization, develops country standard and industry standard for control of toxic and hazardous substances or elements of EEE. There is no further specification whether this actually means setting up EHSMS, or only requires these governmental bodies to establish certain rules or more specific legislation.

10.7.2 Management System Requirements in Guidelines and Standards

Obligation to have a (Standardized) EHSMS

Most guidelines and standards require recyclers or other end-of-life operators for e-waste to have an environment, health and safety management systems (EHSMS). None of the guidelines, however, makes an ISO-standard management system obligatory.

The Chinese SEPA draft standard [5] recommends that an information management system should be set up to treat waste electrical & electronic products and provide relevant information for the administrations, related enterprises and organizations. There is no further specification on the scope and the elements of such an information management system. An EHSMS is not explicitly mentioned.

According to the Oregon Electronics Recyclers Management Practices [8], the management system must, however, be consistent with generally recognized standards covering environmental and worker health/safety management. As examples, the Oregon Guidelines specify ISO 14001, the International Association of Electronics Recyclers (IAER) certification standard, or the Recycling Industry Operating Standard (RIOS, see Table 118 and reference [22]), or a similarly rigorous in-house standard. [8]

The IAER recycler certification standard [10] audits whether recyclers have a management system addressing environment, health, safety and quality. An international standard management program like ISO 14001 is not required, as the IAER program certifies its own standards. The IAER certification standard does not mention any other standard or guideline as a base for its own standard.

The Dell guidelines [11] demand EoL operators to have a comprehensive EHSMS, but without defining specific elements or requirements of such an EHSMS. Recyclers promise in the BAN/ETBC "Electronics Recycler's Pledge of True Stewardship" [9] to have an "environmental management system" in place that is either certified or otherwise adequate for the nature and size of the company's operations, and that the operation meets best practices.

Core Elements of an EHSMS

The EPA R2 Guidelines [6] and the Oregon Electronics Recyclers Management Practices [8] explicitly list elements of the EHSMS. The IPPC BAT for Waste Treatment [3] defines elements of an EHSMS (see Table 6), to which the elaborated EHSMS can be compared. Some guidelines do not categorize specific issues as part of the EHSMS, but as single stipulation or as part of other provisions. Only the guidelines mentioned in Table 6 have elaborated stipulations on EHS management systems, the EPA guideline being the most comprehensive one.

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Table 6: Elements of EHSMS (v: addressed; x: not addressed)

BAT Elements of EHSMS for Waste Treatment Operators [3]		EPA Guidelines [6]	Oregon Guidelines [8]	IAER Guidelines [10]
For details see chapter 2.6.5 on page 76				
1	Definition of an environmental policy for installation by top management	v	v	v
2	Planning and establishing the necessary procedures paying particular attention to	v	v	v
3	structure and responsibility	v	v	v
4	training, awareness and competence	v	v	v
5	communication	v	v	v
6	employee involvement	v	v	v
7	documentation efficient process control	v	x	v
8	maintenance program	x	x	x
9	emergency preparedness and response	v	v	v

10	have a noise and vibration management plan in place	x	x	x
11	safeguarding compliance with environmental legislation	v	v	v
12	checking performance and taking corrective action, paying particular attention to	v	v	v
13	monitoring and measurement	v	v	v
14	corrective and preventive action	v	v	v
15	maintenance of records	v	v	v
16	independent (where practicable) internal auditing to determine implementation, performance and maintenance of EHSMS as planned	conduct annual (internal) reviews	conduct annual (internal) reviews	Included, but no intervals mentioned
17	review by top management	x	x	x
18	produce a structured accident management plan	v	v	v
19	have and properly use an incident diary	x	x	x

20	Consideration to environmental impact from decommissioning of the unit at the stage of designing a new plant	Plan for closure of plant and its financial backing, no focus on plant design	Plan for plant closure and its financial backing required, no focus on plant design	x
21	Consideration to the development of cleaner technologies	x	x	x
22	where practicable, sectoral benchmarking on a regular basis, including energy efficiency and energy conservation activities, choice of input materials, emissions to air, discharges to water, consumption of water and generation of waste.	x	x	x
23	Three further features, which can complement the above stepwise, are considered as supporting measures. However, their absence is generally not inconsistent with BAT. These three additional steps are:			
24	Examination and validation of management system and audit procedure by accredited certification body or external EMS verifier	v	x	v
25	publication (and possibly external validation) of regular environmental statement allowing for year-by-year comparison against environmental objectives and targets as well as with sector benchmarks as	x	x	x

appropriate				
26	implementation of internationally accepted voluntary system such as EMAS or EN ISO 14001:1996.	x	obligatory, but not limited to EMAs or ISO 14001	x
27	not mentioned explicitly	Procedures to allow continuous improvement	v	Explicitly mentioned only for increase of reuse/recycling and reduction of landfilling
28	x	Operational implementation of "Reuse, recycling, disposal" hierarchy	v	v

Auditing and Certification Requirements

In the following, it is assumed that “certified auditor”, “accredited certification body” and “certified” as used in standards and guidelines means independent, third party auditing.

European WEEE Directive [1] [2]

The European WEEE Directive [1] does not require EoL operators to be certified. The Directive just asks member states to encourage establishments or undertakings carrying out treatment operations to introduce certified environmental management systems in accordance with Regulation (EC) No 761/2001 (EMAS). The recommendation hence is limited to the EMS and does not comprise other stipulations, which can as well be part of guidelines (see Table 5 on page 123).

Operators in the EoL chain need a permit after they prove to comply with certain requirements (see chapter 2.7 on page 96).

The proposed recast of the WEEE Directive [2] follows the same line.

Draft Law on WEEE Recycling, China [4]

The Chinese draft WEEE recycling law requires operators to have approval and a qualification certificate, which the local governments issue. The approved and certified operators are published. The draft regulation does not outline any further detailed requirements for control and monitoring.

The qualification certificate thus is comparable to the permit EoL operators have to obtain according to the WEEE Directive (see chapter 2.7 on page 96).

Guidelines on Cooling and Freezing Equipment [12], [13]

The two treatment guidelines for cooling equipment from WEEE Forum et al. ([12], [13]) recommend independent third party auditing of three aspects:

- the publication of annual reports of treated HC appliances and removed liquids and/or HC cabinets
- compliance with environmental legal and other requirements (permits, storage area etc.)

- the capability of the treatment company to comply with requirements put forward in this document

It seems that the auditor does not certify whether the EoL operator actually complies with the requirements put forward in the guidelines, but just checks whether he has the capability to do so. On request, the WEEE Forum explained this passage referred to the initial audit of the recycler, before any contracts are signed with a recycler for the treatment of cooling equipment. The recycler can thus not yet have or currently comply with the guidelines before he is obliged to do so. So the first time, the auditor can only check whether the capabilities for compliance are available.

For audits after the initial check, hence for operators that are under contract and have obligations to comply with the guideline, the audit should check not only the capability, but also whether the operator actually has complied with the guidelines. The guidelines currently do not yet reflect this.

Oregon EMS Practices [8]

The Oregon recycling guideline [8] does not directly ask for an independent third party audit and certification. It does, however, require recyclers to have an EHSMS, which is consistent with generally acknowledged standards like ISO 14001, the IAER guidelines, etc. ISO 14001 as well as the IAER document require independent external auditing. Implicitly, the Oregon guidelines thus make an independent, external auditing indispensable, but restrict it to the EHSMS, with additional stipulations on quality in some of the standards.

Further on, the Oregon recycling guidelines [8] oblige recyclers to apply downstream due diligence. Downstream vendors have to prove to the recycler that they comply with the guidelines' EHSMS. The downstream vendor can use an audit report from a certified auditor. This is, however, not mandatory and just one of several possibilities to prove compliance.

The Oregon EMS Practices guideline requires recyclers to obtain documentation that the downstream vendors comply to the Oregon EMS Practices. The recycler is obliged to check conformity at least every two years and more frequently if changes in circumstances warrant. Other actors in the EoL chain do not have such control obligations.

EPA "Responsible Recycling ("R2") Practices [6] and the EPA Plug-in Guide [7]

The EPA "Responsible Recycling ("R2") Practices For Use In Accredited Certification Programs For Electronics Recyclers" demand electronics recyclers to obtain a certification from an Accredited Certification Body stating that:

- 1) Its EHSMS conforms to the requirements of this provision, and
- 2) Its practices conform to the EHSMS and to the requirements of these R2 Practices. The certificate includes that the own transports or contracted transporters have all necessary regulatory authorizations and no significant violations of relevant legal requirements during the past 3 years.

Further on, the R2 Practices require recyclers to destroy data stored on data storage equipment. The electronics recycler has to show its compliance to the data sanitization, purging, or destruction practices described in the NIST Guidelines for Media Sanitation:

Special Publication 800-88 or another current generally-accepted standard, or be certified by a generally-accepted certification program.

Additionally, the EPA R2 Guideline [6] obliges end-of-life operators to make sure any downstream vendor of reusable equipment and components is certified to comply with the EPA recycling guidelines, if he receives e-waste containing specific materials (focus materials, see 10.4 on page 124 ff).

The EPA Plug-in Guide [7] asks for the “Completion of an EH&S audit, preferably by a recognized independent auditor, on an annual basis. However, for small businesses, greater flexibility may be needed, and an audit every three years may be appropriate.” [7] The EPA Plug-in Guide thus is the only one of the analyzed guidelines specifying an auditing time frame for recyclers. The EPA R2 Guideline does not mention such an obligation.

BAN and ETBC Electronics Recyclers Pledge [9]

The Electronics Recyclers Pledge [9] recommends, if there is concern about trade secrets, to use an independent auditor acceptable to parties concerned to verify proper visible tracking of hazardous e-waste throughout the product recycling chain until final disposition. The electronics recyclers further on “assure that we have an “environmental management system” in place that is either certified or otherwise adequate for the nature and size of the company’s operations, and that our operation meets best practices.” [9] There is no general obligation for independent third party auditing and certification.

IAER Certification Standard [10]

The IAER certification standard itself is a base for “a leading third party registrar with expert auditors to evaluate the management systems and capabilities of electronics recycling companies in relation to the IAER Certification standards and the company's scope of business.” [10] Recyclers complying with this standard hence must undergo an independent third party certification process.

Other Guidelines and Standards

The Dell guidelines [11] do not mention any obligations for an audit, but just require recyclers to have an extensive EHSMS.

The Chinese SEPA draft standard relies on control by government. “The Standard is implemented and supervised by the administrations of environmental protection of people’s government above county level.” [5]

Self Assessment as Alternatives to Independent Third Party Auditing

The Chinese Draft Law on WEEE Recycling [4] and the Chinese SEPA Treatment Standard [5] rely on governmental control at local level to ensure compliance with e-waste legislation and standards. Otherwise, all analyzed guidelines and standards either rely on independent third party auditing or do not contain detailed stipulations on control and monitoring of compliance.

As auditing and certification rise questions of confidentiality and are related to cost, possible alternatives should be discussed as well. What could be such alternatives?

Self Assessment in the RoHS and the EuP Directive

The operators in the EoL chain could declare their compliance based on a self assessment. This compliance would then have to be assumed as long as any control does not prove the opposite.

This self assessment system is well established in the implementation of some European Guidelines, namely in the RoHS Directive (Restriction of Use of Certain Hazardous Substances, Directive 2002/95/EG) [26] and the EuP Directive (Energy Using Products, Directive 2005/32/EC) [28]. These Directives are product/related. The producer has to ensure that his products comply with the stipulations in these Directives:

- **Material bans**
The RoHS Directive bans lead, cadmium, mercury, hexavalent chromium, and two brominated flame retardants in electrical and electronic equipment (EEE).
- **Product specific requirements**
The EuP Directive allows setting specific requirements e. g. for energy consumption of specific EEE, e. g. for TVs or external power supplies.

The producer conducts a self assessment and declares the compliance of his products. Products brought into the market are assumed to be compliant. The competent authorities in the EU member states, however, have to conduct random checks of products in the market. In case products are found to be non-compliant, the authorities may impose a sanction on the producer. This may range from a penalty up to the withdrawal and the ban of the product from the market.

The constellation here is that on the one hand member states monitor and control compliance with clear and product-related requirements, and on the other hand there is a legal base for imposing sanctions.

Control and Monitoring of Compliance with Guidelines and Standards

In Europe, the WEEE Directive leaves it to the member states which sanctions they impose for non-compliance. The transposition of the WEEE Directive into German National Law (ElektrG) [27] sets penalties of up to 50,000 Euro for non-compliance. A recycler not removing a liquid, for example, may be subject to a fine of 10,000 Euro.

As long as a recycler clearly offends legal regulations, he can be fined. The point with guidelines, however, is that they are of cause based on the legal regulations, but they make them more concrete and specific and they may well go beyond the level of the legal regulations. A guideline or a standard just repeating the legal requirements is useless.

Problems arise with the control and monitoring of compliance. Do governmental authorities have the capacity, the competence and above all the authority to impose sanctions on any

operator in the EoL chain if he does not comply with a specific guideline or standard he has declared to comply with, as long as he complies with the legal requirements?

A guideline or a standard is not a piece of legislation. In many countries and regions including Europe, private companies, industrial associations or other non-governmental bodies set up and enact guidelines and standards. How far can a guideline or standard then be a base for governmental control and for action against an EoL operator that complies with legislation, but does not comply with a guideline or standard he had declared to comply with? In the opinion of the author in most countries this is not possible.

Actors in the economy would be free to agree on controls and fines in case of non-compliance with guidelines or standards, if compliance with a guideline would be part of a contract, e. g. between a producer of EEE and a collector or a recycler. Who, however, controls the collector's or the recycler's compliance?

If the producer or his representative control the compliance of the collector or recycler, it may require access to records and contracts, e. g. with downstream vendors, or the control of material flows. Confidentiality issues and conflicts of business interests may arise if the producer as the contractor controls the contracted collector or recycler. This basic conflict would aggravate a proper compliance control, and it might hamper the acceptance of guidelines or standards among EoL operators.

China relies on governmental controls. This may not be possible everywhere. A self assessment and a self declaration of compliance with a EoL operation guideline or standard, however, needs proper control and sanction in case of non-compliance. As neither governmental authorities (not in all countries) nor the producers can viably control compliance, independent third party auditing is the only remaining possibility.

Summary and Conclusions

The EPA R2 Practices define comprehensive third party auditing and certification obligations. The auditing and the certificate comprise not only the EHSMS part, but all stipulations set out in the R2 guidelines, and they include transporters and downstream vendors of reusable equipment and components. The R2 Practices do not specify time frames for regular audits. The EPA Plug-in guide is the only document asking for annual auditing, or at least every three years for smaller companies. Third party auditing is only recommended, but not obligatory.

In the IAER Certification Standard [10], independent third party auditing is mandatory. The Oregon recycling guideline [8] indirectly makes independent third party auditing obligatory. It requires recyclers to have an EHSMS system based on standards or guidelines requiring independent third party certification.

The following standards, guidelines and legislation just recommend but do not require third party certification:

- the WEEE Directive as well as the proposed recast [1] [2]
- the WEEE Forum Guidelines on cooling and freezing equipment [12][13]
- the Electronics Recyclers Pledge [9]

The Dell Guideline do not contain stipulations on auditing and certification.

The Chinese SEPA standard fully relies on governmental control of the actors involved in the EoL chain of electrical and electronic equipment.

General alternatives to independent third party auditing could not be identified. Strict and continuous government control may be a way in case it is viable. Otherwise guidelines and standards for e-waste EoL operations may fail to be of value in the EoL chain without independent third party auditing, as there is no adequate checking and monitoring of compliance.

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Annex

Contents

- 1 Definitions Used in Legislation, Standards and Guidelines (page 149)**
- 2 Uses of Lead on Lead-free Soldered PWBs (page157)**
- 3 Copies of legislation, standards and guidelines (in additional document)**

1 Definitions Used in Legislation, Standards and Guidelines

1.1 Draft National Standard for Environmental Protection of the People's Republic of China [5]

The following terms and definitions are applicable to the Standard.

Waste Electrical & Electronic Product

It refers to the discarded or abandoned electrical & electronic products (inclusive of all the elements (members), spare parts (components) as well as the consumables of these products) that the owner does not use, the non-conforming products, written-off products and overdue products in the process of production, transport and sales. In addition, it also includes all the elements (members), spare parts (components) as well as the consumables of these products (Refer to Appendix A).

Hazardous Substance

It refers to the substances or elements contained in or from the waste electrical & electronic products but jeopardizing people, animals & plants and environment, including Pb, Hg, Cd, Cr6+, PBB, PBDE (exclusive of decabromodiphenyl ether), PCB, substances consuming the ozone layer and other hazardous substances stipulated by the government.

Collection

It refers to the activities to obtain, classify and sort waste electrical & electronic products.

Collector

It refers to the dealer who engages in collection of waste electrical & electronic products.

Storage

It refers to the activities to temporarily store waste electrical & electronic products in the designated location that satisfies relevant requirements in an attempt to collect, transport, disassemble, treat or dispose them.

Reuse

It refers to the action to continue to use waste electrical & electronic products or their elements (members) or spare parts (components) or use them for original purposes after being cleaned or repaired.

Recycling

It refers to the process in which waste electrical & electronic products are treated to reuse as raw materials, exclusive of recovery of energy.

Recovery

It refers to the process in which waste electrical & electronic products are treated to satisfy the requirements for the previous functions or other functions, including recovery of energy.

Disassembly

It refers to the activities to disassemble or disintegrate waste electrical & electronic products for the purpose of better treatment in manual or mechanical ways.

Treatment

It refers to the activities to remove stains of, disassemble, crush and recycle waste electrical & electronic products.

Disposal

It refers to the activities to reduce or eliminate the hazards of waste electrical & electronic products by incinerating, land filling or in other ways that can change the physical, chemical and biological features of solid waste, or the activities to finally place solid waste in the permanent concentrated disposal location in accordance with the standard for environmental protection.

1.2 EPA R2 Recycling Guidelines [6]

Accredited Certification Body

An “accredited certification body” is accredited under ISO Guide 66 or ISO/IEC Standard 17021:2006 to certify electronics recyclers to the R2 Practices.

Downstream Vendors

“Downstream vendors” include any entity to which a recycler transfers used or end-of-life electronic

equipment, components, or materials including reuse, refurbishing, demanufacturing, processing,

materials recovery, energy recovery, incineration, and disposal facilities.

Electronic Equipment

“Electronic equipment”, also referred to as “equipment and components”, includes computers and peripheral equipment – central processing units (CPU’s), monitors, printers, keyboards, scanners, storage devices, servers, networking systems; copiers; fax machines; imaging systems; printing systems; telephones; televisions; video cassette recorders; camcorders; digital cameras; control boxes; stereo systems; compact disc players, radios, cell phones; pagers; personal digital assistants (PDAs); calculators; organizers; and game systems and their accessories. It furthermore includes any other or new (future) types of equipment that are designed primarily to store or convey information electronically, and any new accessories to such equipment.

Key Functions

“Key Functions” are the originally-intended functions of a unit of equipment or component, or a subset thereof, that will satisfactorily serve the purpose(s) of someone who will reuse the unit.

R2 Focus Materials

“R2 Focus Materials”, also referred to as “FMs”, are materials in end-of-life electronic equipment that warrant greater care during recycling, refurbishing, materials recovery, energy recovery, incineration, and/or disposal due to their toxicity or other potential adverse worker health and safety, public health, or environmental effects that can arise if the materials are managed without appropriate safeguards.

The following are R2 Focus Materials:

- Items containing polychlorinated biphenyls (PCBs),
- Items containing mercury,
- CRTs and CRT glass,
- Batteries
- Whole and shredded circuit boards, except for whole and shredded circuit boards that do not contain lead solder, and have undergone safe and effective mechanical processing, or manual dismantling, to remove mercury and batteries.
- Equipment, components, or materials (whole or shredded) that have undergone safe and effective mechanical processing or manual dismantling to remove FMs, yet still retain de minimus amounts of FMs, are not subject to the R2 requirements that are triggered by the presence of FMs.

Recycling Chain

“Recycling Chain” refers to all the downstream vendors that handle end-of-life equipment, components, or materials that pass through an R2 electronics recycler’s facility or control. It includes, but does not extend beyond materials recovery facilities such as smelters. For equipment and components that are sold or donated for reuse, it does not extend beyond the entity that conforms with Provision 6 (c) or (d). [6]

Recyclers

“Recyclers” includes but need not be limited to electronics resellers, refurbishers, recyclers, demanufacturers, asset recoverers, brokers, as well as leasing companies that engage in these activities.

1.3 EPA Plug-In Guide [7]

Plug-In partner

means a manufacturer, retailer, government agency, non-profit, or other entity who

is not a recycler nor performs recycling activities (other than collection),

through contracts or other arrangements, utilizes reuse, refurbishment, recycling or disposal services, and

has a Plug-In To eCycling partnership agreement with EPA.

Designated materials

means any electronic products and components containing or consisting of circuit boards, shredded circuit boards, CRTs, batteries, and mercury- and PCB-containing lamps and devices. However, this definition does not include circuit boards that have been processed to the point where they no longer are readily identifiable as circuit boards or shredded circuit boards (such as after burning/melting), as well as CRT glass that has been adequately processed for use as an industrial feedstock material. In these cases, the economic value of the material has been enhanced significantly through processing; thus, commodities of value have been created and concern for the subsequent environmental mismanagement of this material is greatly decreased.

Refurbishment

means the repair, reconditioning or upgrading of an end-of-life product or component for the purpose of equipment reuse. Refurbishment of end-of-life electronics includes replacement of components or parts that are part of a larger piece of electronic equipment, aesthetic improvements, such as polishing and removal of scratches, and upgrading of the equipment by installation of new operating systems, memory, or software.

Recycling facilities

include any non-disposal facilities that receive designated materials under conditions that do not conform with guideline 5 (see document [7]) for legitimate reuse or refurbishment.

1.4 Oregon Electronics Recycling Environmental Management Practices [8]

Collection

Means receiving, sorting, screening and preparing for transportation CEDs from covered entities. Collection does not include recycling, reuse, or refurbishment activities.

Collector

Means an entity that conducts and is responsible for collection activities.

Covered Electronic Device (CED)

Includes:

- a) Computer monitor of any type with a viewing area greater than four inches measured diagonally;
- b) Desktop or portable, including a notebook, computer; and
- c) Television of any type with a viewing area greater than four inches measured diagonally.

Does not include:

- a) Any part of a motor vehicle;
- b) Any part of a larger piece of equipment designed and intended for use in an industrial, commercial, or medical setting, such as diagnostic, monitoring, or control equipment;
- c) Telephones or personal digital assistants *unless* they contain a viewing area greater than 4 inches measured diagonally; and
- d) Any part of a clothes washer, clothes dryer, refrigerator, freezer, microwave oven, conventional oven or range, dishwasher, room air conditioner, dehumidifier, or air purifier.

Downstream Vendor

Any entity to which a collector or recycler transfers used or end-of-life CEDs, components, or materials for demanufacturing, processing, materials recycling, energy recovery, and disposal.

Materials of Concern

include each of the following, and any CEDs or component, or any aggregate material(s) derived from end-of-life CEDs or components (e.g. shredded, granulated, or mixed materials) containing:

- a) Any devices, including fluorescent tubes, containing mercury or polychlorinated biphenyls (PCBs)
- b) Batteries
- c) Cathode Ray Tubes (CRTs) and leaded glass
- d) Circuit boards

These items are included because of their potential for improper handling or management that could result in risk to worker safety, public health, or the environment.

Recycler

Means someone who is conducting recycling activities for the OERP (Oregon Electronics Recycling Program).

Recycling

Means processing through disassembling, dismantling, shredding, transforming, or remanufacturing CEDs, components, and by-products into usable or marketable raw materials or products in a manner such that the original products may lose their identity. Recycling does not include collection, direct reuse of CEDs, refurbishing, energy recovery, or disposal.

Refurbish

Means to repair a used CED in order to restore or improve it so that it may be used for the same purpose for which it was originally designed.

Reuse

Means any operation by which a CED or component of a CED changes ownership and is used, as is, for the same purpose for which it was originally purchased.

1.5 Dell's Recovery and Waste Disposition Channels Environmental Guidelines December 2007 [11]

Disposition Channel

The route of End-of-Life Electronics that begins with Dell and ends at the End-of-Life Electronics' final disposition.

End-of-Life Electronics

Any electronic product or part that can no longer be used as intended, or that contains material that will be recycled or processed in order to reclaim a substance for further use.

Environmentally Sensitive Material

Substances of environmental concern, as defined by legal requirements, specific market demands, or by the following criteria:

- Substances with hazardous properties that are a known threat to human health or the environment;
- Substances with hazardous properties that show strong indications of significant risks to human health or the environment;
- Substances with hazardous properties that are known to bio-persist and/or bioaccumulate in humans or the environment.

2 Uses of Lead on Lead-free Soldered PWBs

2.1.1 Exemptions for the Use of Lead on PWBs in EEE According to the European RoHS Directive

The numbers refer to the exemption numbering in the current version of the Annex of the European RoHS Directive [24].

- 5. Lead in glass of [...], electronic components.
- 6. Lead as an alloying element in steel containing up to 0,35 % lead by weight, aluminium containing up to 0,4 % lead by weight and as a copper alloy containing up to 4 % lead by weight.
- 7. a Lead in high melting temperature type solders (i.e. lead-based alloys containing 85 % by weight or more lead),**
 - b) lead in solders for servers, storage and storage array systems, network infrastructure equipment for switching, signalling, transmission as well as network management for telecommunications,
 - c) Lead in electronic ceramic parts (e.g. piezoelectronic devices).
- 11. Lead used in compliant pin connector systems
- 14. 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.
- 15. Lead in solders to complete a viable electrical connection between semiconductor die and carrier within integrated circuit Flip Chip packages.
- 24. Lead in solders for the soldering to machined through hole discoidal and planar array ceramic multilayer capacitors.

The above exemptions for the use of lead on PWBs are in place as technically and scientifically the substitution of lead in these applications is not yet practical. Lead therefore has to be used in these applications, even on lead-free soldered PWBs.

2.1.2 Uses of High Melting Point Solders with High Contents of Lead

High melting point solders with high contents of lead (85 % of weight and more) are the main remaining source of lead on printed wiring boards. They are used in several applications where they cannot be replaced. Examples are [23]:

HMP solders are used to form high reliability electrical connections. Examples of applications include large BGA or solder column packages, as well as some discrete devices in high reliability electronics. The lead content facilitates solder joints with a high resistance to thermal fatigue and to electromigration failure.

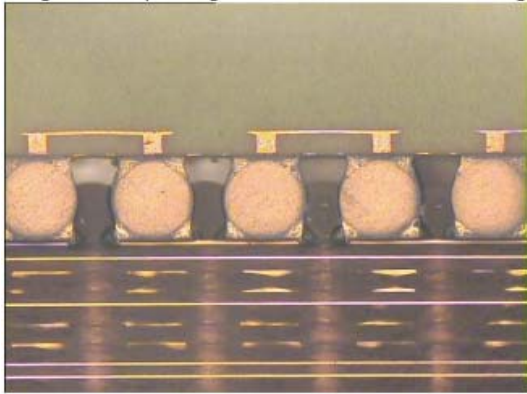


Figure 6: Ball Grid Array component with HMP balls [23]

HMP solders are also used to form a high conductivity thermal interface to the back of a semiconductor device, also known as die attach. The use of high melting temperature solders is required in power devices and discrete semiconductors. These typically are used in high reliability applications, such as server applications. The HMP solders enable high conductivity interfaces between the die and the leadframe/heat spreader. These are capable of meeting hierarchical reflow temperature requirements for components to be soldered to the board, while also having sufficient mechanical compliance required to prevent device damage during manufacture and operation.

The melting point of these solders should be higher than the reflow temperature that is used for board assembly. The latter temperature has gone up to 260 °C due to Pb-free assembly.

HMP solders are used as a sealing substance between tubular plugs and metal cases, e. g. in crystal resonators and crystal oscillators. These applications can be found in many products, including PCs, cellular phones, and other home appliances.

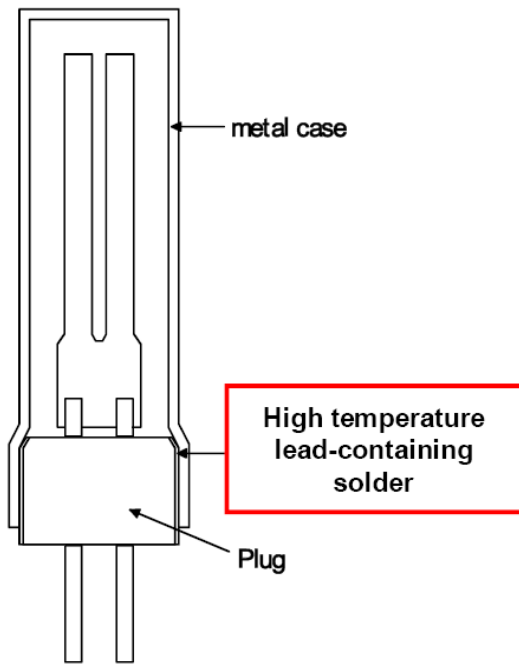


Figure 7: Schematic view of a crystal unit [23]

HMP solders are used for a reliable internal connection in passive components, to withstand soldering processes, especially those using lead-free solder. The varying lead content allows adjusting the melting point of the solder to the requirements of the manufacturing processes.

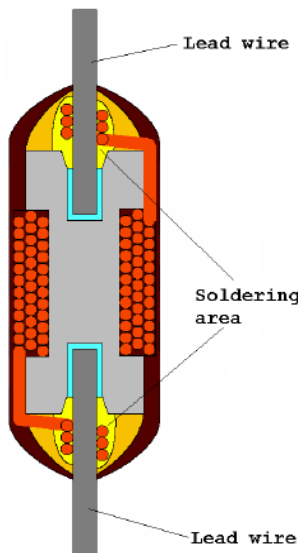


Figure 8: Passive component using HMP solders for internal solder joints [23]

High melting point solders containing lead are used in the following types of components that are commercially available and used by most electrical and electronics sectors [23]:

- Rectifiers
- Power semiconductor devices such as MOSFETs, power transistors, etc.
- Voltage regulators
- Solder joints in equipment which operates at $> 100^{\circ}\text{C}$

- Some types of fuses
- RF modules, attenuation modules and high frequency switches in telemetry medical devices
- Quartz crystal oscillators – some types
- Position sensor coils
- Inductor coils (some types)
- Surface mount transformers

Other sources further complement the information on applications and technologies, in which they consider the use of HMP solders to be without alternative [23]:

Intended Use	Reasons for Necessity	Related Products
<p>Solders used for internally combining a functional element and a functional element, and a functional element with wire/terminal/heat sink/substrate, etc. within an electronic component.</p>	<ol style="list-style-type: none"> 1. It is needed to achieve electrical characteristic and thermal characteristic during operation, due to electric conductivity, heat conductivity, etc. 2. It is needed to gain high reliability for temperature cycles, power cycles, etc. 3. When it is incorporated in products, it needs heatproof characteristics to temperatures higher than melting temperatures (250 to 260°C) of lead-free solders 4. Stress relaxation characteristic with materials and metal materials at the time of assembly is needed. 	<p>Resistors, capacitors, chip coil, resistor networks, capacitor networks, power semiconductors, discrete semiconductors, microcomputers, ICs, LSIs, FCBGA, chip EMI, chip beads, chip inductors, chip transformers, etc.</p> <p>(see Figure 9)</p>

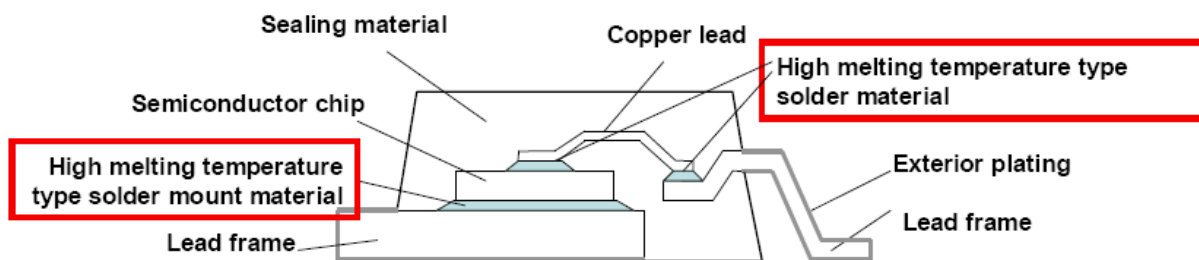


Figure 9: Schematic cross sectional view of internal semiconductor connection [23]

Intended Use	Reasons for Necessity	Related Products
<p>Solders for mounting electronic components onto sub-assembled module or sub-circuit boards.</p>	<ol style="list-style-type: none"> 1. It is needed to achieve electrical characteristic and thermal characteristic during operation, due to electric conductivity, heat conductivity, etc. 2. It is needed to gain high reliability for temperature cycles, power cycles, etc. 3. When it is incorporated in products, it needs heatproof characteristics to temperatures higher than melting temperatures (250 to 260°C) of lead-free solders 4. Stress relaxation characteristic with materials and metal materials at the time of assembly is needed. 5. It is needed to prevent copper leaching that occurs when connecting it in the product using the copper wire. 	<p>Hybrid IC, modules, optical modules, etc.</p> <p>(see Figure 10)</p>

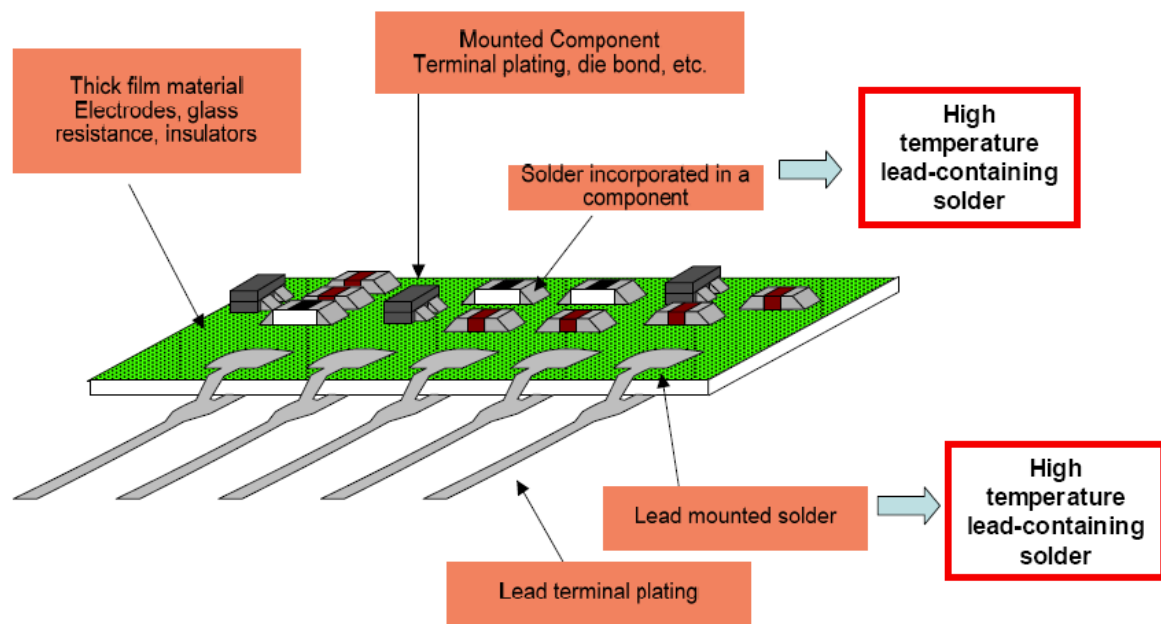


Figure 10: Schematic view of a circuit module component [23]

Intended Use	Reasons for Necessity	Related Products
Solders used as a sealing material between a ceramic package or plug and a metal case	<ol style="list-style-type: none"> 1. Stress relaxation characteristic with materials and metal materials at the time of assembly is needed. 2. When it is incorporated in products, it needs heatproof characteristics to temperatures higher than melting temperatures (250 to 260°C) of lead-free solders. 3. It is needed to gain high reliability for temperature cycles, power cycles, etc. 	SAW (Surface Acoustic Wave) filter, crystal unit, crystal oscillators, crystal filters, etc. (see Figure 7)

Even though there is some overlap of the different sources describing the inevitable uses of leaded high melting point solders, the examples show that they are used in a wide range of applications. Even lead-free soldered printed wiring boards thus still contain lead, although the lead content is reduced compared to PWBs that are soldered with tin-lead solders. [23]

Working Document