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SERIES L: ENVIRONMENT AND ICTS, CLIMATE CHANGE, E-WASTE, ENERGY EFFICIENCY; CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

Guidelines and certification schemes for e-waste recyclers

Recommendation ITU-T L.1032

ITU-T L-SERIES RECOMMENDATIONS

ENVIRONMENT AND ICTS, CLIMATE CHANGE, E-WASTE, ENERGY EFFICIENCY; CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

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Recommendation ITU-T L.1032

Guidelines and certification schemes for e-waste recyclers

Summary

Recommendation ITU-T L.1032 is part of a series of ITU-T Recommendations that considers requirements for recyclers of waste information and communication technology (ICT). This Recommendation addresses, in particular, the informal sector that is involved in waste electrical and electronic equipment (WEEE) collection and dismantling.

This Recommendations must be read in conjunction with national legislation and technical requirements for WEEE recyclers at the national level. A number of standards on WEEE, related to the present series of Recommendations, are published on the ITU-T website at: https://www.itu.int/en/ITU-T/Pages/default.aspx .

Updates on the regional and international conventions and legislation presented can be found at: www.Basel.int (for the Basel Convention), also at: http://ec.europa.eu/environment/waste/shipments/legis.htm (for the EU waste shipment regulations), and at: http://ec.europa.eu/environment/waste/weee/index_en.htm (for the EU WEEE directive).

In addition, there are a number of mandatory and voluntary standards on the treatment conditions for workers and the environment that can be used as guidelines to improve national legislation and the quality of recycling where such standards are yet to be implemented.

History

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FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure, e.g., interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

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Introduction

Waste electrical and electronic equipment (WEEE), also known as e-waste, is one of the fastest growing waste streams worldwide. It includes, but is not limited to, discarded information and communication technology (ICT) equipment such as monitors, computers, printers and mobile phones and their peripherals. On the one hand, WEEE can contain highly toxic chemicals such as lead, mercury and brominated flame retardants, therefore causing pollution and adverse health effects if improperly recycled or disposed of through methods such as open burning or open landfill. On the other hand, WEEE is also a source of important secondary non-renewable materials such as copper, gold or rare earth elements. Disposal of such valuable materials without recovery means an increased pressure on primary mining worldwide to extract new materials.

From an economic perspective, WEEE includes non-renewable precious components, such as gold, silver and copper in a much higher grade than that present in mineral ores. The extraction of these materials from WEEE, if conducted properly, provides jobs and economic opportunities, reduces greenhouse gas (GHG) emissions and fosters a circular economy. If WEEE were discarded without recycling or recovery of these materials, this would certainly impose a great financial burden on nations who would consequently waste huge sums in mining for these same materials. See [b-CEDARE].

The sustainable management of WEEE will contribute to the attainment of several sustainable development goals. In particular, goal 3 (good health and well-being), goal 6 (clean water and sanitation), goal 11 (sustainable cities and communities), goal 12 (responsible consumption and production), goal 14 (life below water) and goal 8 (decent work and economic growth).

Recommendation ITU-T L.1032

Guidelines and certification schemes for e-waste recyclers

1 Scope

This Recommendation considers requirements for recyclers of waste information and communication technology (ICT) addressing in particular the informal sector that is involved in WEEE collection and dismantling. By working on the guidelines and certification schemes for WEEE recyclers, this Recommendation aims to support the WEEE informal sector with a view to developing and formalizing its working practices, while recommending interventions that may boost the sector's activities towards being environmentally friendly and protect workers in the sector as well as identifying the steps, needs and methodology required to transform this sector into a formal one.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

None.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 Recycling [b-Glossary Basel]: Recycling operations usually involve the reprocessing of waste into products, materials or substances, though not necessarily for the original purpose. Resources are saved by recovering material benefits from the waste. Recycling is to be distinguished from operations that recover energy from the waste. In some countries, where material is used once merely for its physical properties e.g., for backfilling, this does not amount to recycling. An example is used lubricating oil re-refined which could result in high grade oil which is valuable for its chemical properties and hence that would be a recycling operation. Used oil could also simply be used as a fuel so that the recovery operation would be energy recovery and not recycling. Recycling may be defined by national legislation differently in each country.

3.1.2 Waste electric and electronic equipment [b-BaselTG]: Electrical or electronic equipment that is waste, including all components, sub-assemblies and consumables that are part of the equipment at the time the equipment becomes waste.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

BFR Brominated Flame Retardant

BM	Base Metals
CB	Certifying Body
CEDARE	the Center for Environment and Development for the Arab Region and Europe
CFR	Chlorinated Flame Retardant
CRT	Cathode Ray Tube
EHSMS	Environmental, Health and Safety Management System
EPEAT	Electronic Product Environmental Assessment Tool
EPR	Extended Producer Responsibility
EPRA	Electronic Products Recycling Association
ERRS	Electronics Reuse and Refurbishing programme
ESM	Environmentally Sound Manner
GHG	Greenhouse Gas
IC	Internal Circuit
ICT	Information and Communication Technology
ISO	International Organization for Standardization
LCD	Liquid Crystal Display
OHSAS	Occupational Health and Safety Assessment Series
PBB	Polybrominated Biphenyls
PBDE	Polybrominated Diphenyl Ethers
PC	Personal Computer
PCB	Printed Circuit Board
PM	Precious Metal
POP	Persistent Organic Pollutants
PPE	Personal Protection Equipment
Ppm	parts per million
RIOS	Recycling Industry Operating Standard
RQP	Recycler Qualification Programme
SRI	Sustainable Recycling Industries
TS	Technical Specification
USEPA	United States Environment Protection Agency
WEEE	Waste Electrical and Electronic Equipment

5 Conventions

None.

6 WEEE fractions

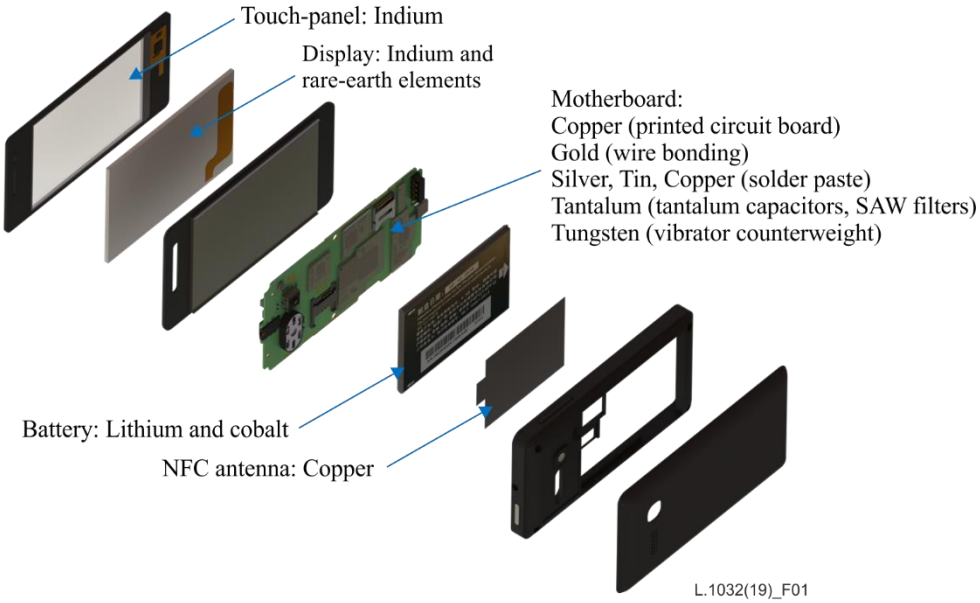
6.1 Fraction types

Electronic and electrical equipment, becoming waste, incorporates several fractions composed of different materials. These materials range from being precious, rare or basic to materials with limited value or even those that are hazardous. The bulk materials such as iron, aluminum, plastics and glass account for over 80% weight, while precious materials are found in smaller quantities but are still of high value; in addition, though hazardous elements may exist in small quantities they may have adverse effects on handlers. The material composition of different equipment is often similar, but the percentage of different materials can vary greatly.

On one hand, precious metals such as gold, platinum and silver and base metals such as copper, aluminium and iron, in addition to rare metals such as palladium are valuable substances which turn recycling of WEEE into a profitable business opportunity. On the other hand, the recycling of hazardous substances such as lead, arsenic or brominated flame retardants (BFRs) are critical and pose serious health risks and environmental dangers if not properly handled.

ICT WEEE contains various amounts of precious substances. Many precious substances are found in printed circuit boards (PCBs). Additionally, well-known precious metals such as gold, silver, platinum and palladium, as well as scarce materials like indium and gallium play an important role due to their application in new technologies such as flat screens.

More than 80% of the weight consists of silica (glass), plastics, iron and aluminium. Precious and scarce materials account for only a small percentage of the total weight. Nevertheless, the concentration of such metals, such as gold, is higher in desktop computers and mobile phones than is found in naturally occurring mineral ore [b-CEDARE, 2017a]. Figure 1 shows the location of several materials in a mobile phone.



Source: Orange

Figure 1 – Examples of materials identified in the different sub-assemblies and components of a mobile phone

6.2 Substances of concern in WEEE fractions

Table 1 lists locations of possible substances of concern in the recycling processes.

Table 1 – Location of possible substances of concern in recycling processes

Components	Lead	Brominated plastic	Mercury	Cadmium	Arsenic	PCB oil	Chlorine
Printed circuit board	•						
Cathode ray tube monitor	•			•			
Liquid crystal display (LCD) monitor			•				
Lead batteries	•				•		
External electric cables							•
Plastic frame		•					
Transducers/ capacitors						•	
Solders	•						
Sensor			•				
NOTE – This table is adapted from [b-CEDARE, 2017a].							

6.3 Valuable non-hazardous materials

Generally, metals in WEEE can be grouped into precious metals (PMs), platinum group metals (PGMs), base metals (BMs) and scarce elements (SEs). Table 2 shows some of these materials and where they may be found in equipment. The handling of these materials during the dismantling and refining processes is quite safe as long as workers are trained and equipped with the proper personal protection equipment (PPE). However, substances used to separate valuable metals from other substances may be hazardous (e.g., when leaching or melting processes are used). Table 2 lists some of the valuable and non-hazardous materials found in WEEE fractions.

Table 2 – Valuable and non-hazardous materials found in WEEE fractions

Material	Usage
Gold	Primarily in all boards as pure metal or plating of connectors
Silver	Primarily in all boards
Copper	Copper wire, printed circuit board tracks, component leads
Aluminium	Nearly all electronic goods using more than a few watts of power in electrolytic capacitors
Geranium	Bipolar junction transistors
Iron	Steel chassis, cases and fixings
Lithium	Lithium ion batteries
Silicon	Glass, transistors, internal circuits (ICs), printed circuit boards
Zinc	In galvanized steel parts as coating
NOTE – The source of this table is [b-CEDARE, 2017a]	

6.4 Hazardous materials

Some hazardous materials are also found in WEEE fractions, they are classified as follows:

– heavy metals[1]: Metals such as lead, mercury, cadmium and antimony. Despite possibly having value, these metals are hazardous and should be handled with due care and workers should wear proper PPE.

– brominated flame retardants: BFR materials exist with plastic inside some WEEE fractions. Some brominated flame retardants are listed as persistent organic pollutants (POPs) by the Stockholm Convention[2]. Like all POPs, these BFR chemicals possess properties toxic to humans and the environment, resist degradation and bioaccumulate. They are transported through air, water and migratory species, across international boundaries and deposited far from their place of release, where they accumulate in terrestrial and aquatic ecosystems.

7 WEEE processing flow

WEEE recycling consists of four main steps: sorting, dismantling, refining and end processing. Each step is critical for the recovery of metals and the recycling economy.

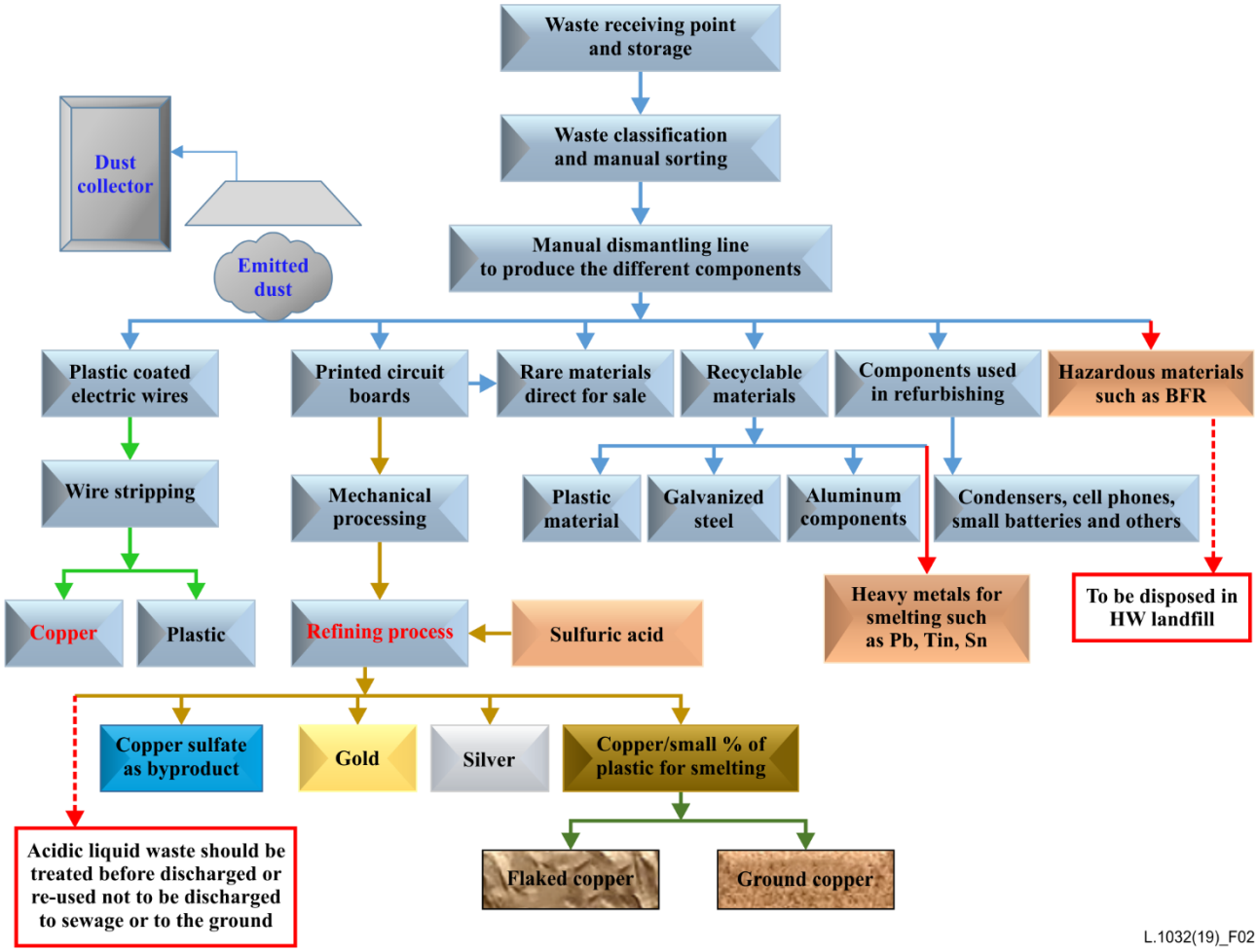
End-of-life electronic components are sorted at collection facilities where useable components are returned to the consumer supply chain. Pre-processing of the waste is one of the most important steps in the recycling chain.

After collection, the waste equipment can be dismantled and the individual components tested and reused. During the early stage, housing, wires, drives and other components are liberated. Mechanical processing is an integrated part of this stage where WEEE fractions are shredded into pieces using hammer mills and similar machines. Metal dust is emitted during these processes; accordingly, dust collection equipment should be used to render the process safe. Metals and non-metals are separated during this stage using techniques similar to those used in the mineral dressing such as screening, magnetic, eddy current and density separation techniques. Separation of PMs is performed through a

[1] Metals with density higher than 5, some are toxic e.g., mercury (Hg), cadmium (Cd), arsenic (As), chromium (Cr), thallium (Tl), and lead (Pb).

[2] Revised draft guidance for the inventory of polybrominated diphenyl ethers under the Stockholm Convention, March 2015.

hydrometallurgical process, which results in liquid waste that must be treated before discharge. One of the final stages in the recycling chain is metals smelting and non-metals treatment such as plastics recycling. Figure 2 shows a process flow diagram of WEEE fractions refining and processing.



Source: [b-CEDARE, 2017a].

Figure 2 – Process flow diagram of WEEE fractions processing

All products need to be tested before being accepted by licensed and reliable recycling companies for end-processing.

7.1 Printed circuit boards

Some devices contain PCBs constituting up to 22% of their mass, while others have a limited content of 2%; the reported average value is 3% [b-NI M], [b- sohaili]. However, the PCB is often the element of prime value in the WEEE as it contains a variety of precious, rare and base metals that are of value. PCBs are classified into several categories as per the content of PMs such as connectors, BMs such as solders (copper (Cu), lead (Pb) and tin (Sn)), construction elements such as iron, non-metals and organic materials. Research has shown that the metal content varies from 20% to 40% by weight and averages 30%. The latest research, dating from 2014, shows that the average metal content of PCBs is 27%. This variation can be explained by the wide range of board types used and the change in the composition of PCBs over the years. The content of precious metals such as silver and gold in PCBs has fallen in recent years. While gold contents above 1000 parts per million (ppm) were reported in 1993 and 1995, values reported since then are all below 1000 ppm and could soon reach as low as 100 ppm. Accordingly, the expected metal content in the PCBs shall depend on the type and age of the collected equipment and the market price of these fractions shall vary accordingly. Obviously

older equipment shall contain more precious metals; this is obvious from Annex B where the numbers in the last columns are projected from 2014 data.

8 Requested health and safety protective measures

Standards for occupational health and safety are required in the majority of recycling standards and are mentioned in clause 9 of this Recommendation. Table 3, taken from [b-CEDARE, 2017a], lists hazardous materials associated with WEEE fractions and associated hazard and protective requirements.

Table 3 – List of hazardous materials in fractions, associated hazard and protective requirements

Material	Route of entry to the body	Associated hazard and adverse health effect	Mitigation measures and protective requirements
Lead	Inhalation and ingestion	Affecting: • The central nervous system. • Cardiovascular system. • Reproductive system. • Kidneys. • Gastrointestinal system. • Gingival System.	• Provide exhaust or process ventilation to meet the required exposure limit. • Use of proper PPE (dust resistant gloves, safety goggles, etc.). • Properly dispose of the after-use contaminated cloth. • Workers should decontaminate their body contaminated organ before leaving the workplace. • Half mask and air purifying respirator equipped with efficient filter. • First aid should exist in place. • Absolutely, no child labour is allowed.

Table 3 – List of hazardous materials in fractions, associated hazard and protective requirements

Material	Route of entry to the body	Associated hazard and adverse health effect	Mitigation measures and protective requirements
Mercury	Inhalation, ingestion, skin contact, eye contact, chronic exposure and aggravation of pre-existing conditions	• Harmful if absorbed through skin. Affects the kidneys and central nervous system. May cause allergic skin reaction. • Sensory impairment, dermatitis, memory loss, and muscle weakness. • Danger! Corrosive. Causes burns to skin, eyes, and respiratory tract. May be fatal if swallowed or inhaled.	• In case of accidental release ventilate area of leak or spill. Clean-up personnel require protective clothing; and • Respiratory protection from vapor. • In case of spills: Pick up and place in a suitable container for reclamation or disposal in a method that does not generate misting. Sprinkle area with sulfur or calcium polysulfide to suppress mercury. Do not flush to sewer. Handling and storage: • Keep in a tightly closed container, stored in a cool, dry, ventilated area. • Protect against physical damage. Isolate from any source of heat or ignition. • Do not use or store on porous work surfaces (wood, unsealed concrete, etc.). Follow strict hygiene practices. Containers of this material may be hazardous when empty since they retain product residues (vapors, liquid); observe all warnings and precautions listed for the product.

Table 3 – List of hazardous materials in fractions, associated hazard and protective requirements

Material	Route of entry to the body	Associated hazard and adverse health effect	Mitigation measures and protective requirements
Cadmium	Inhalation, ingestion, skin contact, eye contact, chronic exposure and aggravation of pre-existing conditions	• May cause gastrointestinal irritation with nausea, vomiting and diarrhoea. • Ingestion may produce fluid loss, acute renal failure, and cardiopulmonary depression. • Liver disease, or skin disease may be at increased risk from exposure to this substance.	• Use proper personal protective equipment. • Vacuum or sweep up material and place into a suitable disposal container. • Avoid generating dusty conditions. • Remove all sources of ignition. • Use a spark-proof tool. • Provide ventilation.
Tin	Inhalation, ingestion, skin contact, eye contact	• Tin compounds have variable toxicity. • Elemental tin and inorganic tin compounds have toxicity and are poorly absorbed when ingested. • Some inorganic tin salts are irritating or can liberate toxic fumes on decomposition.	Accidental release measures • Use proper personal protective equipment. • Clean up spills immediately, observing precautions in the protective equipment section. Sweep up; or • Absorb material, then place into a suitable clean, dry, closed container for disposal. Avoid generating dust. • Conditions: Provide ventilation.
Antimony	Inhalation, ingestion	• Carcinogenic potential.	• Use proper personal protective equipment.
Barium	Ingestion	• Brain swelling, muscle weakness. • Damage to the heart, liver and spleen.	• Use proper personal protective equipment.

Table 3 – List of hazardous materials in fractions, associated hazard and protective requirements

Material	Route of entry to the body	Associated hazard and adverse health effect	Mitigation measures and protective requirements
Polybrominated diphenyl ethers (PBDEs), Polybrominated Biphenyls (PBBs)	• Routes of potential human exposure to PBBs and PBDEs are ingestion, inhalation or dermal contact • Under thermal treatment possible formation of dioxins and furans: Inhalation, Ingestion, skin contact, eye contact, chronic exposure and aggravation of pre-existing conditions	• The U.S. Department of Health and Human Services (DHHS) states that PBBs are reasonably anticipated to be human carcinogens based on sufficient evidence of carcinogenicity from experimental animal studies. • WHO, the International Agency for research on Cancer (IARC) classified PBBs as "probably carcinogenic to humans" (IARC 2013). • Causes serious eye irritation. • Causes skin irritation. • May cause allergy or asthma symptoms or breathing difficulties if inhaled. • May cause an allergic skin reaction. • May cause respiratory irritation. • Causes damage to organs through prolonged or repeated exposure: • Respiratory system.	• Do not breathe dust/fume/mist/vapours. • Use only outdoors or in a well-ventilated area. • In case of inadequate ventilation wear respiratory protection. • Wear eye/face protection. • Wear protective gloves. • Do not eat, drink or smoke when using this product. • Wash thoroughly after handling. • Contaminated work clothing must not be allowed out of the workplace. • It is not recommended for recycling.

Table 3 – List of hazardous materials in fractions, associated hazard and protective requirements

Material	Route of entry to the body	Associated hazard and adverse health effect	Mitigation measures and protective requirements
Polychlorinated biphenyls	Inhalation, ingestion	• Cancer, effects on the immune system, reproductive system, nervous system, endocrine system.	• In case of inadequate ventilation wear respiratory protection. • Wear eye/face protection. • Wear protective gloves. • Do not eat, drink or smoke when using this product. • Wash thoroughly after handling. • Contaminated work clothing must not be allowed out of the workplace.
Chlorofluorocarbon (CFC)	Inhalation, ingestion	• Deleterious effect on the ozone layer. • Increased incidence of skin cancer / genetic damage.	• Do not breathe dust/fume/mist/vapors. • Use only outdoors or in a well-ventilated area. • In case of inadequate ventilation wear respiratory protection.
Americium (Am) occurs naturally in uranium minerals, but only in trace amounts.	Inhalation	• Radioactive element, is toxic due to its radioactivity.	• Do not breathe dust/fume/mist/vapors. • Use only outdoors or in a well-ventilated area. • In case of inadequate ventilation wear respiratory protection.

Table 3 – List of hazardous materials in fractions, associated hazard and protective requirements

Material	Route of entry to the body	Associated hazard and adverse health effect	Mitigation measures and protective requirements
Sulphur acid	Inhalation, ingestion and dermal contact	• Danger! Extremely corrosive. Causes severe burns and / or eye damage. • Mist: Causes respiratory irritation. Harmful if inhaled. • Harmful or fatal if swallowed. • Reacts violently with water. • Concentrated sulphuric acid will react with many organic materials and may cause fire due to the heat of the reaction. • Not flammable, but reacts with most metals to form explosive/flammable hydrogen gas.	Small spill: • Cover with DRY earth, sand or other non-combustible material or absorb with an inert dry material and place in a loosely covered plastic or other appropriate waste disposal container. • If necessary: Neutralize the residue with a dilute solution of sodium carbonate, lime, or another suitable neutralizing agent. Large spill: • Stop leak if possible without risk. • Dike with DRY earth, sand or other non-combustible inert material. • Prevent entry into sewers or waterways. • Consider neutralizing the residue with sodium carbonate, lime, other suitable neutralizing agent. • Ensure adequate decontamination of tools and equipment following clean up. • Comply with regulations on reporting releases dispose of waste material at an approved waste treatment/disposal facility, in accordance with applicable regulations. • Do not dispose of waste with normal garbage or to sewer systems.

9 Residue management and disposal

Whenever materials are recycled properly, there will often be residues that need to be managed in an environmentally sound manner. In a well-operated network of material recovery operations, the largest volume residue will be slag from the smelting operation and that may be further recycled or used as construction material, depending on its composition. In addition, pollution and emissions control equipment will generate hazardous residues (ash, dust and sweeps) that are removed from

filters, vacuums and other capture mechanisms. Most of the material in WEEE can be recycled, however, much is currently not recycled for economic reasons and thus needs careful final disposal in an environmentally sound manner.

9.1 Bag house dust and filter residues

Bag house filters, filter residues and dusts may have recoverable values of zinc or precious metals, provided that the material recovery facility can safely capture and transport these. If these dusts cannot be safely managed; the material recovery facility should presume them to be hazardous wastes, tested for hazardous characteristics, and managed appropriately, such as by disposal in a controlled landfill.

9.2 Sweepings

Fine particles and dusts that have fallen to the floor and other surfaces at a facility should be regularly cleaned, but should not be swept up by dry sweeping, because it will disperse these particulates into the air and into the breathing zones of workers. Fine particles and dusts should be collected by wet mopping or vacuum and then should be managed and disposed of in a similar way to bag house dusts and filter residues.

9.3 Slag

Slag, the residue of pyro-metallurgical operations, is typically a hard, dark, glassy substance. Slag from the smelting of components/fractions from WEEE can contain, among other substances, lead, cadmium and beryllium oxide, silica, alumina, iron oxide and other oxidized metals. It is often reprocessed to recover additional metals.

If slag does not contain metal concentrations of economic interest, it may be suitable for use as building or road construction aggregate, but it must have been made stable and insoluble by high-temperature processing. Smelter slag that has not been stabilized may leach hazardous metals into the ground and ground water and should not be used in such ways. As an alternative to use as a construction aggregate, however, smelter slag may be disposed in a controlled industrial landfill, with appropriate attention to the possibility of release of substances of concern.

Pyro-metallurgical operations for electronic fractions (e.g., circuit boards) require air pollution control systems that will capture particulate matter and hazardous gases, such as a Venturi, cyclone, electrostatic precipitator or fabric filter (bag house). The particulate matter collected from such devices can often be further processed for metal recovery.

Hydrometallurgical refining operations will result in residual waste effluents that may contain hazardous metal concentrations, as well as acids, cyanides and caustic solutions, all of which may require different treatment and disposal methods. These solutions may be completely reused within a refining facility but will, in any case, require attention and sound management.

9.4 WEEE incineration concerns

Incineration of WEEE or its parts and assemblies, especially the plastic in the cases and circuit boards, may be incomplete and hydrocarbon particles and other soot may be emitted. Some metals, particularly lead, have relatively low melting temperatures and may melt during such incineration and release fumes or minute metal oxide particles. Halogenated hydrocarbons, including polychlorinated dioxins and furans, may be produced. This would be particularly true if the waste incineration were essentially informal burning and completely uncontrolled. Metals that do not melt will remain in bottom ash that, if disposed of on land, may raise concerns of exposure to hazardous substances described above. In addition, leaching from ash in land disposal conditions may be substantially faster than leaching from unburned computing equipment. Therefore, while material recovery is preferable, if incineration is necessary, burnable components which cannot be recycled must be incinerated in state-of-the-art incineration plants to avoid as much as possible landfill disposal

and, if possible, to efficiently recover energy. If such environmentally sound incineration is not possible, the waste may be disposed in an engineered and controlled landfill disposal.

9.5 Landfill concerns

Land disposal of end-of-life computing equipment may create a risk of direct human contact and ingestion of contaminants and of contaminated soil and of water in landfills that are not controlled. Some landfills are often visited by scavengers, including small children, looking for valuable materials to salvage. Land disposal of WEEE may also place them in contact with acids from other sources, such as rotting food and garbage. Over an extended period of time, these acids may leach out hazardous substances, which can travel long distances into ground waters, lakes, streams, or wells, leading to much wider impacts. Only in a well-engineered, properly controlled landfill, final disposal of computing equipment is an appropriate last resort [b-PACE2].

10 Certification schemes and recycling standards

Recycling standards can be applied to the recycling process along the recycling chain or be specific to recycling facilities. Recycling standards can be promoted by governments and, in some cases can be mandatory, or can alternatively be voluntarily schemes implemented by the private sector. Appendix II presents the actors involved in the creation, accreditation, implementation and verification of the maintenance of a certification scheme, in general terms. Mandatory schemes may have the advantage of being free of charge, when applicable and a government may bear the cost of auditing and assessing the conformity to the standard. Voluntary schemes have the advantage of involving the recycling sector in quality control and assurance, bearing the cost for being certified and audited. Voluntary schemes are numerous and leave the choice of the most appropriate scheme to the recycler.

10.1 Voluntary certification schemes and standards

10.1.1 Responsible recycling (R2) certification

Figure 3 – Responsible recycling (R2)

The responsible recycling (R2) standard, as symbolized by the logo shown in Figure 3, is a leading standard for electronics repair and recycling. It has global coverage and is one of the two standards accredited in the United States. The R2 standard provides a common set of processes, safety measures and documentation requirements for businesses that repair and recycle used electronics. Six-hundred facilities are currently R2 certified in 21 countries, with more added every day [b-SERI, 2015].

R2 practices include general principles and specific practices for recyclers disassembling or reclaiming used electronics equipment including equipment exported for refurbishment and recycling [b-NSF].

R2 certification addresses:

– an in-place environmental, health and safety management system (EHSMS);

– worker health and safety and environmental protection;
– material management and recovery planning;
– traceability and accountability (downstream due diligence throughout the recycling stream, including international vendors);
– data security;
– insurance requirements;
– legal compliance.

Sustainable Electronics Recycling International (SERI) is the housing body for the R2 standard and works with a coalition of partners to raise awareness of electronics repair and recycling issues around the world. NSF International is an independent certification body for R2, emphasizing quality, safety and transparency.

10.1.2 Recycling industry operating standard certification

The recycling industry operating standard (RIOS) [b-Linkedin, 2016] is an integrated quality, environmental, health and safety management system certification. By integrating the management system, recyclers are able to more effectively manage their system, which results in stronger health and safety programmes, greater environmental responsibility and better operational efficiency.

Whether recycling paper, plastic, metals, textiles, electronics or tyres, recyclers of all commodities are able to adopt RIOS. RIOS is appropriate for both small and large firms anywhere in the world. It is also possible to become a certified electronics recycler by certifying to both RIOS and the responsible recycling (R2) standard at the same time.

R2/RIOS: Combined certification to the R2:2013 standard and to the Institute of scrap recycling industry operating standard (RIOS). RIOS defines an integrated quality, environment, health and safety management systems standard for the industry. R2/RIOS was created in 2013 to offer a certification path for electronics recyclers that combined RIOS with the R2 standard. When the R2:2013 standard emerged, Provision 1(b) mandated, "An R2:2013 electronics recycler shall be certified, throughout the duration of its R2 certification, to one or more environmental, health and safety management system standards that have been approved by SERI". It clarifies that SERI "has approved RIOS, or a combination of both ISO 14001 and OHSAS 18001, to fulfill this requirement." [b-USEPA].

10.1.3 The e-Stewards standard

The e-Stewards standard is owned by the environmental organization Basel Action Network (BAN). e-Stewards recyclers are certified through annual audits to the e-Stewards standard. The e-Stewards certification is supported by the United States Environmental Protection Agency (EPA). The e-Stewards certification is a certification that addresses the environmental, worker health and security practices of entities managing used electronics. The e-Stewards certification is available all over the world, is globally accredited and independently audited by trained auditors. The e-Stewards standard for electronics recyclers and asset managers requires, among others, that exports of toxic WEEE to developing countries are not allowed in accordance with international law, the Basel Convention and the Basel ban amendment.

10.1.4 Electronic product environmental assessment tool

Electronic product environmental assessment tool (EPEAT) is a voluntary, non-governmental eco-label for the IT sector deriving from the United States. EPEAT covers a wide range of requirements for manufacturers of EEE, including conditions for the treatment of products at their end-of-life. One of the aims of EPEAT is to provide purchasers with guidance on products based on specific attributes such as reduction of toxic materials or recycling. EPEAT covers a range of ICT goods such as computers, displays, servers and mobile phones. End-of-life requirements include the obligation for producers to provide product take-back services for the product either directly or

through a contracted third party. Additionally EPEAT requests manufacturers to ensure that primary recyclers contracted by them achieve a certification to an environmental management system such as International Standardization Organization (ISO) 14001, RIOS or a similar standard and a certification to one of R2, e-Steward, the European EN standards processing requirements or evidence of annual audits of primary recyclers.

10.2 ISO guidance principles for the sustainable management of secondary metals

The ISO guidance principles aim to provide a credible global framework for the sustainable management of secondary metals. They are in the pre-standard phase of development. They were published in 2017. The ISO guidance principles are in the first years of implementation.

They aim to improve practices of economic operators, ensure a credible traceability of recovered metals and promote the formalization of economic operators involved in subsistence activities and unofficial business activities. They can be used by the informal sector to prepare them for formalization.

The principles include criteria for enabling an equitable and safe work environment, eliminate child labour and mitigate negative impacts through the development and implementation of a management plan and continuous improvement, criteria for environmental justice and optimal recovery in metal recycling worldwide.

The ISO guidance principles were developed in the context of the sustainable recycling industry programme of the World Resources Forum and published by ISO in the International Workshop Series. The ISO guidance principles are currently undergoing initial testing and will be reviewed before April 2020, if confirmed, a decision on the conversion into an ISO standard will be made in 2023.

10.3 Mandatory schemes

10.3.1 Series of European standards on WEEE treatment

A set of standards has been developed by European standardization bodies under a mandate of the European Commission which cover the treatment of all waste from products in the scope of the EU Directive 2012/19/EU on waste electrical and electronic equipment.

The standards include general requirements applicable for all WEEE collection, transporting and recycling processes as well as special requirements for special product groups which are often treated separately such as lamps, cathode ray tube (CRT) and flat panel displays, temperature exchange equipment and photovoltaic panels as well a generic standard on general treatment requirements.

Many EU member states have already made these standards mandatory by implementing them into their national WEEE legislation.

10.3.2 Main characteristics of the standards

The standards are normative (as opposed to descriptive) requirements and concern all steps in the chain, including collection and preparation for re-use.

The standards cover all WEEE categories and address operators in the collection and logistics and the treatment of WEEE.

The technical specification (TS) TS 50625-4 covers the collection and logistics of WEEE and already starts at the point where users can drop off WEEE and continues with the collection from the drop-off point and the transport conditions to the consolidation and treatment sites. The aim is to avoid breakage at the collection site, which can lead to emissions of hazardous substances such as mercury from lamps and screens or of ozone depleting substances from cooling appliances.

EN 50614 debates the conditions for operations preparing WEEE for re-use.

EN 50625-1 and TS 50625 3-1 describe general treatment and depollution requirements which are valid for all WEEE treatment facilities, e.g., to avoid leakage of chemicals into the soil and ground water.

Other standards and specifications set further or additional requirements for specific product groups:

– EN 50625-2-1 and TS 50625-3-2 on lamps with a focus on mercury containing lamps;
– EN 50625-2-2 and TS 50625-3-3 on displays (CRT and flat-panel displays (FPDs)) with a focus on lead (CRT) and mercury (FPD);
– EN 50625-2-3 and TS 50625-3-4 on temperature exchange equipment;
– EN 50625-2-4 and TS 50625-3-5 on photovoltaic panels.

The standards define specific values for concentrations of hazardous substances that need to be achieved at the end of the treatment process. The results have to be controlled by taking samples and analysing them. A substantial part of the standards is dedicated to the procedures for specifying the concentrations of the substances of concern. The standards also provide guidance for treatment facilities on how to assess the depollution and how to meet the legal requirements.

10.3.3 Canadian stewardship programmes

In Canada, WEEE legislation has been set mainly at the provincial level and has primarily taken the form of regulations requiring extended producer responsibility (EPR) or product stewardship for designated electrical and electronic products.

The non-profit association, Electronics Product Stewardship Canada was established in 2003 with the mandate to create a national electronics stewardship programme and work with provinces and territories on the development of their programmes. In 2004, it published a "National model for WEEE stewardship" with guidance on stakeholder roles and responsibilities, programme management, and a proposed national cost model.

The national model was endorsed by the Canadian Council of Ministers of the Environment (CCME) with the objective of promoting product stewardship as the main approach to WEEE management within Canada, and harmonizing WEEE management strategies between provinces. In 2009, the Council adopted a Canada-wide action plan for extended producer responsibility. Implementation of standards and oversight of provincial programmes is now the responsibility of the Electronic Products Recycling Association (EPRA), a national industry-led non-profit organization established in 2011. EPRA developed minimum requirements for recyclers and reuse and refurbishment operators. These are not certified standards but audited in the context of two dedicated registration and auditing programmes to ensure quality assurance of operators participating in the stewardship programmes. Two standards are developed and audited by EPRA: the electronics recycling standard which is audited within the recyclers qualification programme and the electronics reuse and refurbishing standard audited within the electronics reuse and refurbishing programme.

10.3.4 The AS/NZS 5377 standard

The AS/NZS 5377 (also mentioned as AS 5377) standard was prepared by the Joint Standards Australia/Standards New Zealand Committee EV-019, WEEE and published in February 2013. This standard outlines the minimum requirements for the safe and environmentally sound collection, storage, transport and treatment of end-of-life electrical and electronic equipment, known as WEEE, in order to maximize re-use and material recovery, reduce or eliminate the amount of waste from this equipment going to final point of disposal operations such as landfill, safeguard worker health, and minimize harm to the environment. From 1 July 2016, the Australian Government required from 2016 to conclude contracts only with recycling service providers that are certified to AS 5377.

10.3.5 The Rwanda standards RS 276 – 1:2016 and RS 276 – 2:2016

In April 2016 the Rwanda Standards Board (RSB) published two standards on WEEE treatment:

RS 276-1:2016: Electrical and electronic waste – Handling, collection, transportation and storage – Code of practice.

RS 276-2:2016: Electrical and electronic waste – Treatment and disposal – Code of practice.

The standards prescribe handling, collection, transportation and storage of various categories of electrical and electronic waste. They also prescribe the treatment and disposal of WEEE including consumer and industrial electrical and electronic wastes in order to ensure the environment and human health is protected against the potential adverse impacts.

11 Legal requirements for international trade of products and transboundary movements of WEEE

Because material recovery operations may involve further operations by other downstream facilities, including transboundary movement of wastes and intermediate products, a recycling or material recovery facility should also take care to ensure both its own compliance and the compliance of downstream material recovery operations with applicable laws of concerned countries, including multinational and bilateral agreements on movements of waste. A facility should comply with all necessary waste transport regulations, including those related to packaging manifests, bills of lading and chain of custody documentation.

The Basel Convention transboundary movement controls should be implemented for end-of-life electrical and electronic equipment destined for material recovery and recycling where the end-of-life electrical and electronic equipment contains Annex I constituents, unless it can be demonstrated that the end-of-life electrical and electronic equipment is not hazardous using Annex III characteristics of the Basel Convention [b-Basel]. For information on transboundary movement of WEEE it is important to consult the Basel technical guidelines on transboundary movements of WEEEs in particular regarding the distinction between waste and non-waste [b-BaselTG]. According to these Basel technical guidelines, depending on national legislation, used equipment destined for direct reuse and equipment destined for repair refurbishment and failure analysis may not fall within the scope of the Basel Convention and should travel with accompanying documents which are different from the documents accompanying the shipment subject to the Basel Convention. In the European Union the Basel Convention is transposed into the Union legislation by the Waste Electrical and Electronic Equipment Directive (WEEE Directive).

The Basel Convention competent authority (or authorities) of the country can provide information on the requirements related to the Basel Convention or to national legislation in line with the Basel technical guidelines on transboundary movements of WEEEs, if applicable. The Basel Convention competent authority is responsible for the prior informed consent procedure under the Convention within a state party to the Convention.

Annex A

Identified standards and WEEE management schemes

(This annex forms an integral part of this Recommendation.)

Table A.1 presents a comparison of key elements of Canadian stewardship programmes, EN 50625, R2, e-Stewards and AS NZ 5377 [b-PACE5.1].

Table A.1 – Comparison of WEEE standards and management schemes

	Canadian stewardship programmes	**EN 50625**	**R2**	**e-Stewards**	**AS NZ 5377**
Standards	– Recycler qualification programme (RQP) – Electronics reuse and refurbishing programme (ERRP)	– Collection – Logistics – Treatment	The Responsible Recycling (R2) Standard for Electronics Recyclers-2013	e-Stewards standard for Responsible Recycling and Reuse of Electronic Equipment-2013	– Collection, storage, transport and treatment of end-of-life electrical and electronic equipment

Table A.1 – Comparison of WEEE standards and management schemes

	Canadian stewardship programmes	EN 50625	R2	e-Stewards	AS NZ 5377
Intent	– Minimum requirements for use in the provincial electronics recycling stewardship programme RQP for end-of-life electronics processors and recyclers electronics reuse and refurbishing programme (ERRS)	– To protect the environment using European standards – Based on the precautionary principle	Help prospective purchasers make informed decisions and have increased confidence that used and EOLE are managed in an environmentally responsible manner, protective of the health and safety of workers and the public, and all data on all media devices is secure until destroyed	To provide a verifiable system with specific performance requirements: – Protect customer data and privacy – Protect occupational health and safety (OH&S), and communities surrounding facilities – Prevent pollution, reduce environmental impacts and efficient resources use – Fair labor practices – Excluding forced and child labor, and prison operations – Restrictions on disposal of hazardous WEEE to final disposition – Conformity with international laws, treaties, and agreements – Application of the above throughout the recycling chain	– Guidance and requirements – Safe and environmentally sound collection, storage, transport, and treatment of EOLE – Maximize reuse and recovery – Reduce or eliminate WEEE going to final disposal operations – Safeguard worker health – Minimize harm to the environment

Table A.1 – Comparison of WEEE standards and management schemes

	Canadian stewardship programmes	EN 50625	R2	e-Stewards	AS NZ 5377
Governance	– Created by electronics industry – Operated by the EPRA-non-profit-implementation guidance provided	– WEEE forum (producers) – Provide basis for 39 EU WEEE producer compliance schemes web-based tool developed by The WEEE forum to report recycling and recovery rates – Contractual relationship for 2/3 of reported WEEE collection in EU	– R2:2013 developed by a multi-stakeholder group–R2 Technical Advisory Committee (TAC) – Accredited certified EHSMS – Flexible rather than prescriptive approach	– Created by the Basel Action Network with leaders in the recycling industry – Sanctioned interpretations – Guidance – Oversight	– Prepared by the joint standards Australia/standards New Zealand Committee on WEEE

Table A.1 – Comparison of WEEE standards and management schemes

	Canadian stewardship programmes	EN 50625	R2	e-Stewards	AS NZ 5377
Scope	– RQP-EOLE processors and recyclers – ERRS – reuse/refurbishing organizations	– Europe – Covers all kinds of WEEE	– Global – Electronics recyclers (brokers, refurbishers, collectors, resellers, etc.) – Facility-not corporate	– Global with some external limitations – Corporate not site specific – EE, property and assets under ownership or control – Applies to all workers, including contract, volunteer, and interns	– Australia and New Zealand – Currently mandatory – To be used by all parties involved in the collection, storage, transport and treatment of end-of-life electrical and electronic equipment – Covers all electrical and electronic equipment designed for a supply voltage not exceeding 1000 volts for ac and 1500 for dc – Facilities including collection, transport, storage, recovery, reuse, treatment and disposal

Table A.1 – Comparison of WEEE standards and management schemes

	Canadian stewardship programmes	EN 50625	R2	e-Stewards	AS NZ 5377
Conformity verification	Assurance process-not an accredited programme – Application to EPRA and application verification Audit/submission of The Audit Report – Stewardship programme approval	– Rules to decide Whether an undertaking's processes deserve to be WEEELABEX approved – Trained auditors conducting audits using the same documents – Plan for this to become a certified EU/CENELEC Standard-2015	Accredited certified R2 system with applicants required to also be certified to an EHSMS	Accredited certified EMS	– Accredited certified assurance process in development – Expect to be completed by mid-2015 – Being developed by JAS-ANZ

Annex B

Typical variation of PCBs composition over the years

(This annex forms an integral part of this Recommendation.)

Intensive efforts have been exerted since 1993 to identify the metals contents in PCBs. Table B.1 provides a brief summary of this effort and shows the typical variation of PCBs composition over the years [b-CEDARE, 2017a]. Note that in Table B.1 the header row lists the study periods, labelled as "a" to "n", and the corresponding years to these study periods are listed below the table.

Table B.1 – Variation of PCBs composition over the years

Metal %	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**	**m**	**n**
Cu (%)	19	20	22	12.5	26.8	15.6	19.66	28.7	27.6	14.6	12.58	19.19	28	14.2
Al (%)	4.1	2	–	2.04	4.7	–	2.88	1.7	–	–	2.38	7.06	2.6	–
Pb (%)	1.9	2	1.55	2.7	–	1.35	3.93	1.3	–	2.96	2.44	1.01	–	2.50
Zn (%)	0.8	1	–	0.08	1.5	0.16	2.10	–	2.7	–	–	0.73	–	0.18
Ni (%)	0.8	2	0.32	0.7	0.47	0.28	0.38	–	0.3	1.65	0.39	5.35	0.26	0.41
Fe (%)	3.6	8	3.6	0.6	5.3	1.4	11.47	0.6	2.9	4.79	3.24	3.56	0.08	3.08
Sn (%)	1.1	4	2.6	4.0	1.0	3.24	3.68	3.8	–	5.62	1.41	2.03	–	4.79
Sb (%)	–	–	–	–	0.06	–	–	–	–	–	–	–	–	0.05
Cr (%)	–	–	–	–	–	–	0.005	–	–	0.356	–	–	–	–
Na (%)	–	–	–	–	–	–	–	–	–	–	–	–	–	0.48
Ca (%)	–	–	–	–	–	–	1.13	–	1.4	–	–	–	–	1.69
Ag (ppm)	5210	2000	–	300	3300	1240	500	79	–	450	–	100	135	317

Table B.1 – Variation of PCBs composition over the years

Metal %	a	b	c	d	e	f	g	h	i	j	k	l	m	n
Au (ppm)	1120	1000	350	–	80	420	300	68	–	205	–	70	29	142
Cd (ppm)	–	–	–	–	–	–	–	–	–	–	–	–	–	1183
K (ppm)	–	–	–	–	–	–	–	–	–	–	–	–	–	180
In (ppm)	–	–	–	–	–	–	500	–	–	–	–	–	–	–
Mn (ppm)	–	–	–	–	–	–	9700	–	4000	–	–	–	–	81
Se (ppm)	–	–	–	–	–	–	–	–	–	–	–	–	–	21
As (ppm)	–	–	–	–	–	–	–	–	–	–	–	–	–	11
Mg (ppm)	–	–	–	500	–	–	1000	–	–	–	–	–	–	–
Pd (ppm)	–	50	–	–	–	–	–	33	–	220	–	–	–	–

NOTE – Key to study periods in Table B.1

(a) Feldman (1993)
(b) Menetti et al. (1995)
(c) Iji et al. (1997)
(d) Veit et al. (2002)
(e) Zhao et al. (2004)
(f) Kim et al. (2004)
(g) Wang et al. (2005)
(h) Creamer et al. (2006)
(i) Marco et al. (2008)
(j) Hino et al. (2009)
(k) Das et al. (2009)
(l) Yoo et al. (2009)
(m) Oliveira et al. (2010)
(n) Projection base on 2014 data

Annex C

International, regional and national legal frameworks on the transboundary movements of WEEE and on standards for their recycling

(This annex forms an integral part of this Recommendation.)

Source: [b-CEDARE, 2017b]

C.1 International legislation and conventions

C.1.1 European directives

Table C.1 presents European directives on WEEE.

Table C.1 – European directives on WEEE

Directive	Details
DIRECTIVE 2012/19/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 4 July 2012 on WEEE	The purpose of this directive is to contribute to sustainable production and consumption by, as a first priority, the prevention of WEEE and, in addition, by the re-use, recycling and other forms of recovery of such wastes so as to reduce the disposal of waste and to contribute to the efficient use of resources and the retrieval of valuable secondary raw materials. It also seeks to improve the environmental performance of all operators involved in the life cycle of EEE, e.g., producers, distributors and consumers and, in particular, those operators directly involved in the collection and treatment of WEEE. In particular, different national applications of the 'producer responsibility' principle may lead to substantial disparities in the financial burden on economic operators. Having different national policies on the management of WEEE hampers the effectiveness of recycling policies. For that reason, the essential criteria should be laid down at the level of the Union and minimum standards for the treatment of WEEE should be developed.
DIRECTIVE 2011/65/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 8 June 2011	This directive is related to the restriction of the use of certain hazardous substances in electrical and electronic equipment

C.1.2 Basel Convention on the control of transboundary movement of hazardous wastes and their disposal

Table C.2 presents a summary of the Basel Convention and associated guidelines and initiatives.

Table C.2 – Basel Convention

Legislation and conventions	Description
Scope of the Convention	1) The Basel Convention requires its parties to control transboundary movements of hazardous and other wastes, included its scope, through a control procedure that requires a prior informed consent for each shipment of hazardous and other wastes from the states of export, transit and import. 2) The Basel Convention requires that hazardous and other wastes are managed in an environmentally sound manner (ESM) nationally and during their transboundary movements. This includes preventing and minimizing their generation and treating them as close as possible to the location where these are generated. 3) The Basel Convention provides codes for WEEE to be moved transboundary in Annexes I (Y codes), Annex III (H codes) VII (A codes) and IX (B codes). Annex IX (B codes) include waste that are not supposed to be hazardous and are not in the scope of the Basel Convention, unless it is otherwise demonstrated.
Technical guidelines on transboundary movements of e-waste in particular on the distinction between waste and non-waste under the Basel Convention	The technical guidelines are non- binding and set principles that need to be transposed into national legislation to become applicable at national level. The guidelines identify two categories of equipment that may be considered as non-waste under the Basel Convention and therefore are not covered by its provisions: equipment for direct reuse and equipment to be exported for repair, failure analysis and refurbishment. The guidelines set criteria for their transport and the distinction between these two categories of e-equipment and WEEE. www.basel.int/technical guidelines
Mobile Phone Partnership Initiative (MPPI)	The Mobile Phone Partnership Initiative developed guidance documents on the ESM of mobile phones. These are available at www.basel.int/partnerships/mppi – Guideline on the refurbishment of used mobile phones; – Guideline on the collection of used mobile phones; – Guideline on material recovery and recycling of end-of-life mobile phones; – Guideline on the awareness raising-design considerations; – Guideline for the transboundary movement of collected mobile phones; – Guidance document on the environmentally sound management of used and end-of-life mobile phones.

Table C.2 – Basel Convention

Legislation and conventions	Description
Partnership for Action on Computing Equipment (PACE)	The Partnership for Action on Computing Equipment developed a series of guidance documents on the ESM of computing equipment, available at www.basel.int/partnerhips/pace – Guideline on environmentally sound testing, refurbishment, and repair of used computing equipment; – Guideline on environmentally sound material recovery and recycling of end-of-life computing equipment; – Overall guidance document; – Glossary of terms; – Report with ESM criteria recommendations; – Report on strategies, actions and incentives to promote environmentally sound management of end-of-life-computing equipment; – Manual on steps to establish and implement environmentally sound management for used and waste computing equipment.

C.1.3 E-waste codes under the Basel Convention

Table C.3 presents examples of e-waste and corresponding e-waste codes employed under the Basel Convention [b-BaselTG].

Table C.3 – Classification of e-waste

Examples of e-waste	Y-code, Annex I of Basel Convention	H-code, Annex III of Basel Convention	A-code, Annex VIII or B-code Annex XI of Basel Convention	United Nations shipping name, number and hazard class or division
E-waste unsorted (i)	Various (e.g.,Y31, Y20, Y27, Y45)	H6.1, H11, H12, H13	A1180	Environmentally Hazardous Substances, Solid, N.O.S., UN3077, Class 9
Lead-containing glass from cathode ray tubes (CRTs) and imaging lenses	Y31	H6.1, H11, H12, H13	A1180, A2010	Environmentally Hazardous Substances, Solid, N.O.S., UN3077, Class 9
Nickel-cadmium batteries and batteries containing mercury	Y26, Y29	H6.1, H11, H12, H13	A1170	Environmentally Hazardous Substances, Solid, N.O.S., UN3077, Class 9
Selenium drums	Y25	H6.1, H11, H12, H13	A1020	Environmentally Hazardous Substances, Solid, N.O.S., UN3077, Class 9
Printed circuit boards	Various (e.g.,Y31, Y20, Y27, Y45)	H6.1, H11, H12, H13	A1020 A1180	Environmentally Hazardous Substances, Solid, N.O.S., UN3077, Class 9
PCB- or PCT-containing equipment	Y10	H11, H12	A1180 A3180	Waste Polychlorinated Biphenyls, Liquid, UN2315, Class 9 (5)

Table C.3 – Classification of e-waste

Examples of e-waste	Y-code, Annex I of Basel Convention	H-code, Annex III of Basel Convention	A-code, Annex VIII or B-code Annex XI of Basel Convention	United Nations shipping name, number and hazard class or division
Plastic components containing brominated flame retardants, if applicable	Y45, Y27	H6.1, H11, H12, H13	A3180	Environmentally Hazardous Substances, Solid, N.O.S., UN3077, Class 9
Mercury-containing fluorescent tubes and backlight lamps from liquid crystal displays (LCD)	Y29	H6.1, H11, H12, H13	A1030	Environmentally Hazardous Substances, Solid, N.O.S., UN3077, Class 9
Other mercury-containing components, such as mercury switches, contacts and thermometers	Y29	H6.1, H11, H12, H13	A1010 A1030 A1180	Environmentally Hazardous Substances, Solid, N.O.S., UN3077, Class 9
Components containing asbestos, such as cooking stoves and heaters	Y36	H11	A2050	Waste Asbestos, UN 2590, Class 9
Non-hazardous waste electrical and electronic assemblies	Not applicable	Not applicable	B1110	Not applicable
H6.1=Poisonous (acute); H11=Toxic (delated or chronic); H12=Ecotoxic; H13=Capable, by any means, after disposal of yielding another material that possesses any of the characteristics listed in Annex III of [b-BaselTG].				

Appendix I

Comparison between the EN 50625 series of standards and Egyptian legislation

(This appendix does not form an integral part of this Recommendation.)

Table I.1 presents a comparison between the EN 50625 series of standards and Egyptian e-waste legislation [b-CEDARE, 2017b].

Table I.1 – Comparison between the EN 50625 series of standards and Egyptian legislation

	EN 50625	**Egyptian legislation**
Energy Information Agency (EIA) requirements	*Administrative and Organizational Requirements (EN 50625-1 general treatment requirements)*: The operator shall establish and maintain a procedure to identify legal requirements that are applicable to the environmental, health and safety aspects of all activities, services and processes undertaken at the facility. Records of the operator's activities and related legal provisions shall be controlled and valid permits required by all relevant authorities shall be maintained.	*EIA Requirements: Article 19,20, 21 and 23 of law 9/2009 (Law 4/1994 and 9/2009 and its amendments and executive regulations)*: Every natural or legal person, public or private shall submit a study evaluating the environmental impact of the facility or project to the competent administrative authority or the donor's license before the start of implementation of the project. This study is conducting in accordance with the elements of the designs and specifications and the foundations of quality and loads issued by the Egyptian Environmental Affairs Agency (EEAA) in coordination with the administrative competent authorities committed and competent administrative authorities to provide industrial zones maps showing types of industries permitted by environmental loads.

Table I.1 – Comparison between the EN 50625 series of standards and Egyptian legislation

	EN 50625	Egyptian legislation
Environmental register	*Administrative and organizational requirements (EN 50625-1 general treatment requirements)*: The operator shall comply with European Community legislation and its corresponding transposition. The operator shall maintain a record documenting compliance with legal and regulatory obligations applying to all activities undertaken on site.	*Environmental register requirements: Article 22 (Law 4/1994 and 9/2009 and its amendments and executive regulations)*: On management of the facility, in accordance with the provisions of this law, to keep a record indicating the impact established activity on the environment (environmental record). EEAA shall follow-up record data to make sure they conform to reality and take the necessary samples and conduct appropriate tests to demonstrate the impact of activity on the environment. If records show that the establishment does not meet the requirements of the applicable laws or violates of the provisions of this Article, the competent administrative authority shall notify the owner of the facility to correct the violation quickly; if he does not do so within 60 days of the date of the notification, the competent administrative authority should take any of the following actions: • Granting of additional specific deadline for the facility to correct the violations at the expense of the facility. • Stop offending activity while removing the effects of the offense and without prejudice to the remuneration of its employees. • In the case of a serious environmental hazard the facility must stop until the cause of this hazard is eradicated.

Table I.1 – Comparison between the EN 50625 series of standards and Egyptian legislation

	EN 50625	Egyptian legislation
Workplace quality	*Technical requirements*: (EN50625-1 General treatment requirements) • WEEE shall be handled and stored with due care in order to avoid release of hazardous substances into air, water, or soil, as a result of damage and/or leakage. • During handling and storage special attention shall be given to: • Temperature exchange equipment, to avoid damage to the temperature exchange system, • CRT display appliances to avoid implosion and/or emissions of fluorescent coatings, • Lamps and appliances containing lamps to prevent breakage resulting in the release of mercury, • Lamps when handling and separating into linear and non-linear categories to prevent breakage of lamps, • Smoke detectors as they may contain radioactive components, • Appliances containing oil and other liquids within an internal circuit as part of the appliance or capacitors containing mineral or synthetic oil to avoid spillages and other emissions, and • Appliances containing asbestos or ceramic fibres to avoid release of asbestos or ceramic fibre.	*Workplace requirements: Article 43 (Law 4/1994 and 9/2009 and its amendments and executive regulations)*: The owner of an establishment is held to take all precautions and procedures necessary to prevent the leakage or emission of air pollutants inside the work premises except within the permissible limits as defined by the executive regulations of this Law, whether they result from the nature of the establishment activities or from malfunctioning equipment. He has to provide the necessary protective measures for workers in accordance with the conditions of occupational safety and health, including choosing the appropriate machinery, equipment, material and fuel, taking into account the period of exposure to these pollutants. He must also ensure adequate ventilation and install chimneys and other air purification devices.

Table I.1 – Comparison between the EN 50625 series of standards and Egyptian legislation

	EN 50625	Egyptian legislation
WEEE storage	*Storage requirements*: • Storage areas of the collection facilities require: • Impermeable surfaces for all WEEE storage areas. • Spillage collection facilities for all uncovered storage areas. • Weather proof covering where temperature exchange equipment, CRT display appliances, flat panel displays, and lamps are stored. • Storage areas designated for the storage of WEEE intended for preparation for re-use shall have weatherproof covering. • When storing CRT display appliances, flat panel displays, temperature control equipment, and lamps they shall be placed in containers or stacked in a stable manner to prevent damage or breakage.	*WEEE Storage requirements: Article 28/1(executive regulation of Law 4/1994 & 9/2009 and its amendments and executive regulations)*: • Storage in specific areas specially designed. • Safety conditions shall be in place. • Emergency plan shall be implemented. • Hazardous materials register shall be prepared.

Table I.1 – Comparison between the EN 50625 series of standards and Egyptian legislation

	EN 50625	Egyptian legislation
WEEE transport and handling	*WEEE transport and handling requirements*: • All handling of WEEE including the loading, unloading and transport shall be carried out with appropriate tools, containers and fixing to avoid damage to WEEE. • Uncontrolled tipping of containers of CRT display appliances, flat panel displays, temperature control equipment, and lamps shall not be permitted. • WEEE shall not be handled in such a way that subsequent preparation for re-use, de-pollution, or recovery according to this normative document is adversely affected or even inhibited. • CRT display appliances and flat panel displays shall be prepared and loaded for transport in such a way that they are not damaged during loading and transport. • Appropriate methods shall be used to prevent the breakage of flat-panel displays during transport.	*Article 28/3 (executive regulation): the article regulates the waste transport*: • The transport should be through a certified company that possess a special permit for HW transport. • Specifications of the transport vehicles. • Trained drivers should conduct the vehicles. • The transport route should be identified. • Health and safety measures should be maintained. • Personal protection equipment of suitable level should be used. • An emergency plan should be prepared and ready for implementation. • A chain of custody form should be prepared and filled as it accompanies the transported shipment. *Article (29, 30, 31 of the law 4/1994 and 9/2009 and its amendments and executive regulations and 25,26 and 27 of the executive regulations*: • The ministry of Industry and Foreign Trade shall issue the permit for handling the WEEE waste through: Description of the waste, the quantity, the storage, transport, emergency plan, consents, etc. • The permit shall be valid for 5 years.

Table I.1 – Comparison between the EN 50625 series of standards and Egyptian legislation

	EN 50625	Egyptian legislation
Technical and infrastructural preconditions	*Technical and infrastructural preconditions requirements*: • The operator shall possess infrastructure in terms of size, technologies installed and characteristics of the operations, which are suitable for the activities performed on site. Suitability of site shall be assessed by a risk assessment for all tasks performed on site and include the identification of hazards, the assessment of risk and, where appropriate, the elimination or reduction of the risk, and documentation of the process. • Employees handling lamp waste shall properly use required personal protective equipment as identified by a risk assessment. • Collection facilities, including storage areas, shall be designed, organized, and maintained to provide safe access to and egress from the site, and to avoid access by unauthorized persons. • Collection facilities shall be secured to prevent damage to and theft of WEEE and components thereof.	*EIA requirements*:

Table I.1 – Comparison between the EN 50625 series of standards and Egyptian legislation

	EN 50625	Egyptian legislation
Training	*Training requirements*: • All employees at the collection facility shall be familiar with the environmental, and health and safety risks of the facility, especially when working with CRT display appliances, flat panel displays, temperature exchange equipment, and lamps which are broken or damaged. Employees and contractors involved in operations shall be instructed and trained to perform the tasks assigned to them. • Employee training materials and information shall be available at the work place or be easily accessible to employees at all times. Materials and information shall document specific risks inherent to CRT display appliances, flat panel displays, temperature exchange equipment and lamps.	None
Downstream monitoring	*Downstream monitoring requirements*: • The operator shall trace and document the downstream logistic chain of WEEE. Documentation shall record proper processing according to clause 5 of this normative document. • Responsibility of downstream monitoring remains in cases where handing over of WEEE to dealers or brokers, or when shipped across borders.	Environmental register

Table I.1 – Comparison between the EN 50625 series of standards and Egyptian legislation

	EN 50625	Egyptian legislation
Preparing for re-use	*Preparing for re-use requirements*: • The operator is only entitled to contract with a third party authorized to perform preparing for re-use activities, if it can ensure that WEEE and fractions thereof not used for re-use are returned to the collection facility. • If the operator is involved in preparing for re-use activities, it shall conform with clause 4.6 of the Treatment normative document.	None
Documentation	*Documentation requirements*: • Operators of collection facilities shall record the quantity of WEEE collected and forwarded by means of weight notes, piece count or documentation of number, size, and filling level of receptacles. Agreements regarding the location where weighing and data provision is foreseen shall be possible. • Electronic or hard copies of documents and records shall be available for at least three years, unless authorities, WEEE take-back organizations or other customers stipulate a longer period.	Environmental register

Table I.1 – Comparison between the EN 50625 series of standards and Egyptian legislation

	EN 50625	Egyptian legislation
Penalization	None	*Penalization requirements: Article 84 (Law 4/1994 &9/2009 and its amendments and executive regulations)*: Shall be fined not less than fifty thousand pounds and not exceeding one million pounds, anyone who violates the provisions of Article 19,23 of this law. In case of repetition minimum and maximum limits shall be doubled as well as the maximum penalty of imprisonment. In addition to the previous original sanctions the establishment may be closed and the abolition of the license may be imposed. Whoever, violates provisions of Article 43, shall be fined a sum not less than L.E. one thousand and not more than L.E. twenty thousand. In case of recidivism, the fines provided shall be doubled. *Article 88: the article regulates the penalties applicable in case of importing or the handling without permit*: Any person who violates the provisions of articles 29, 32 of the present Law shall be punished by imprisonment for a term of not less than five years and a fine of twenty thousand Egyptian Pounds to forty thousand Egyptian Pounds. Whoever violates the provisions of Article 32 shall be held to re-export the hazardous wastes subject of the crime at his own expense.

Table I.1 – Comparison between the EN 50625 series of standards and Egyptian legislation

	EN 50625	Egyptian legislation
Import legislation	None	*Import requirements: Article 32 Law 4/1994 and 9/2009 and its amendments and executive regulations*: It is forbidden to import hazardous waste or to allow its introduction into or its passage through Egyptian territories. It is forbidden without a permit from the competent authority to allow the passage of ships carrying hazardous waste in territorial seas or in the exclusive maritime economic zone of the ARE.
List of hazardous waste	None	*Decree 165/2002*: The Decree includes a list of hazardous waste that is prohibited to import or traded within Egypt without a license issued by the Ministry of Industry; the list included: Waste from electrical assemblies or electronic or scrap containing components such as accumulators, batteries banned mercury-switches, glass pipeline from cathode, other activated glass, PCB capacitors rays chlorination or PCB contaminated with any of the dangerous elements in concentrations sufficient to exhibit one of the hazardous characteristics.

Table I.1 – Comparison between the EN 50625 series of standards and Egyptian legislation

	EN 50625	Egyptian legislation
Import		*Import requirements: Decision of the Minister of Trade and Supply No. 194 for the year 1997 and the decision of the Minister of Trade and Industry No. 770 of 2005*: Regulation of import special rules implementing the provisions of the Import Act and export); the regulation required that the imported used computers should be not older than 10 years. (This part replaced by decision No. 603 of 2007 of the Minister of trade and industry).
Import		*Decree No. 603 of 2007 of the Minister of Trade and Industry*: The decision prohibits the importation of used computers older than five years.
Decision in favour of the Ministry of Environment		*The Decision of the Government Services Authority*: This decision implied the compilation of all waste generated shall be in favour of the Ministry of Environment.

Appendix II

Roles and responsibilities of standards' owners, accreditation bodies, certification bodies of standards

(This appendix does not form an integral part of this Recommendation.)

Figure II.1 outlines roles and responsibilities of standards' owners, accreditation bodies and certification bodies of standards.

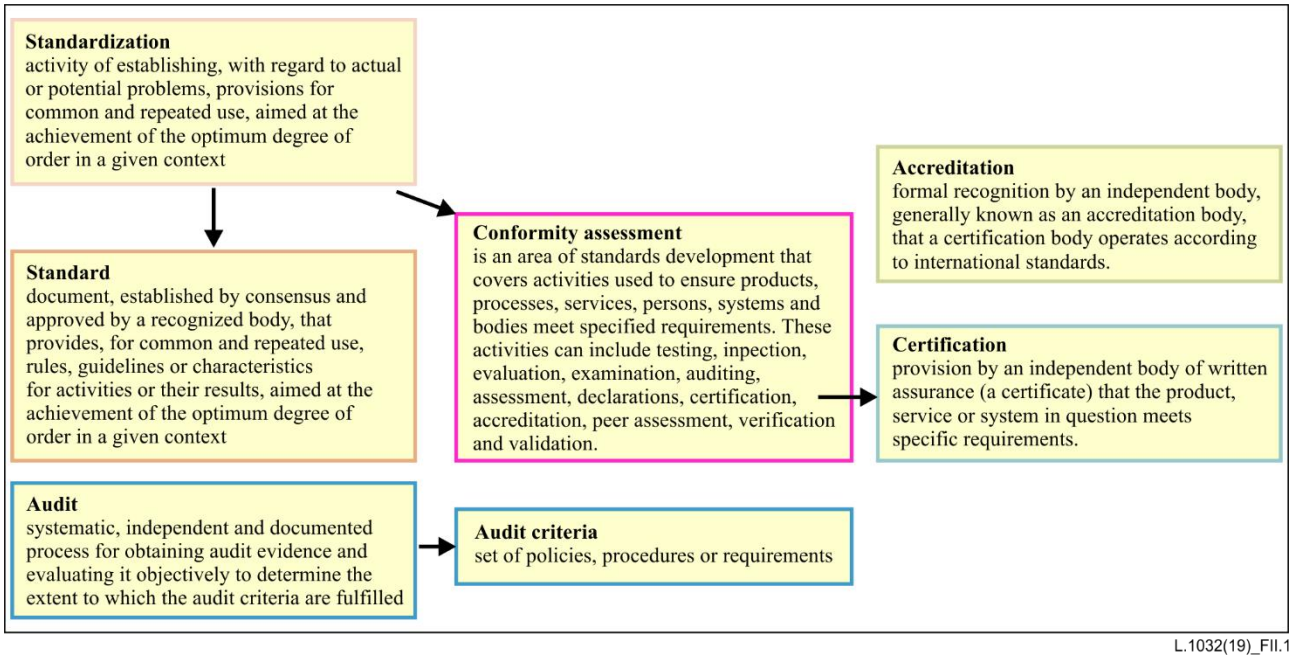


Figure II.1 – Roles and responsibilities of standards' owners, accreditation bodies and certification bodies of standards

Standard owners

Standard owners are the parties that developed and own the standards.

They play a critical management and support role throughout the certification process. Their activities can include:

– working with the accreditation body on oversight of the standards;

– developing training and guidance materials (e.g., interpretations) to support implementation of the standards;

– training the certifying bodies (CBs) on the standards;

– witnessing audits performed by the CBs, and, at times, directly conducting audits (or "spot checks") of recycling facilities as part of a quality assurance plan;

– planning for and carrying out updates to their standards with public comment processes;

– having advisory boards; and

– managing fiscal matters for their standards.

Accreditation bodies

Accreditation bodies are governmental and non-governmental organizations that provide accreditation services to public- and private-sector organizations. They carry out conformity assessment accreditation of standards ensuring that the CBs are operating in conformity with standards and practices set forth for certifying bodies in international standards, such as [b-ISO 17021-1].

Certifying bodies

CBs are the organizations responsible for certifying facilities, e.g., electronics recycling facilities. CBs hire and train auditors to certify facilities as meeting (or not meeting) the criteria in standards, and ensure their auditors are properly trained on the requirements associated with the standards. Most CBs utilize training programmes offered by third parties for their initial auditor training, complemented by additional in-house training.

Auditors

Hired by CBs, auditors perform the audits of facilities, e.g., the electronics recycling facilities seeking to obtain or maintain a certification. Auditors are the 'front line' of certification, going on-site and examining all aspects of the management system set up by a facility.

Electronics recycling facilities implement certified management systems to improve quality and to protect environmental and human health and safety.

Figure II.2 illustrates the roles and the relationship between accreditation bodies, standards owners, CBs, auditors and recycling facilities for the R2 and e-stewards standards in the United States. See [b-USEPA].

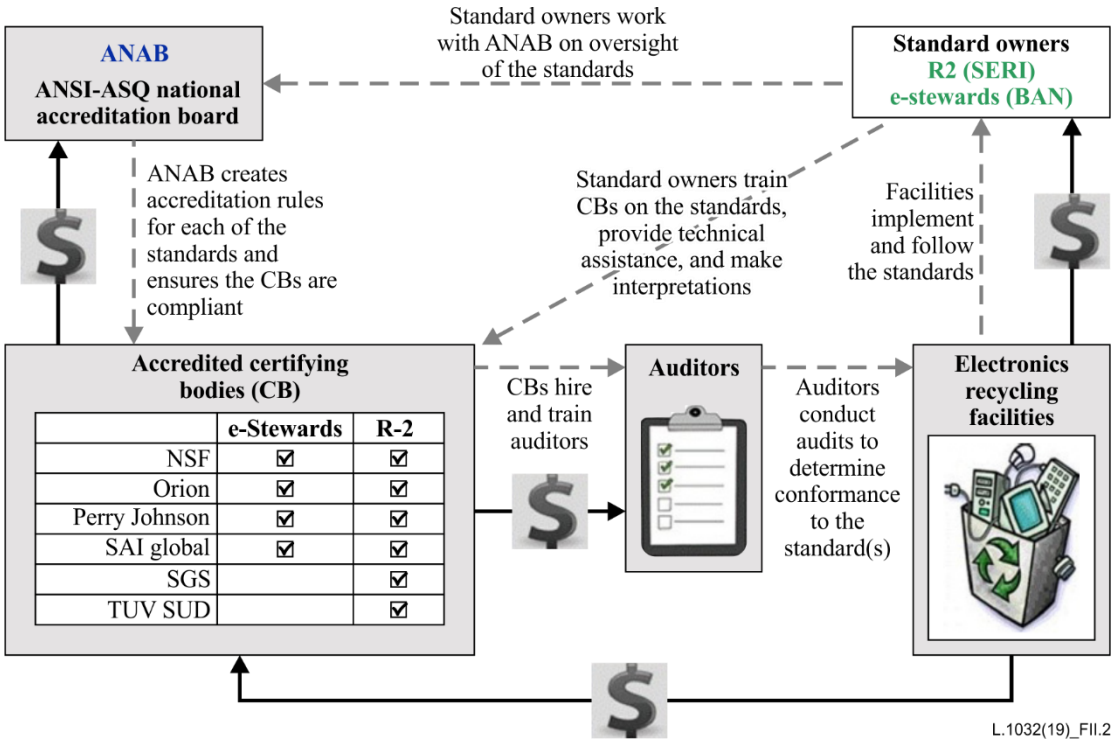


Figure II.2 – Relationships between accreditation bodies, standards owners, certifying bodies, auditors and recycling facilities for the R2 and e-stewards standards

Appendix III

Types of materials resulting from WEEE processing

(This appendix does not form an integral part of this Recommendation.)

Figures III.1 to III.4 show typical materials fractions collected from the visited companies during the site visits**.**

Figure III.1– Processed metals obtained (different types of copper fractions)

Figure III.2 – Bulk fractions

Figure III.3 – Processed plastic

Liquid copper sulfate produced from copper extraction process

Copper sulfate
(By product)

NOTE – Figures from [b-CEDARE, 2017a]

Figure III.4 – Produced by-product

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