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## Procedure for recycling rare metals in information and communication technology goods

Recommendation ITU-T L.1100

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# Recommendation ITU-T L.1100

## Procedure for recycling rare metals in information and communication technology goods


### Summary

Recommendation ITU-T L.1100 provides information on the recycling procedures of rare metals in information and communication technology (ICT) goods. It also defines a communication format for providing recycling information of rare metals contained in ICT goods.


### History

| Edition | Recommendation | Approval | Study Group |
|---|---|---|---|
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### Keywords

ICT goods, rare metals, recycling.

## FOREWORD

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# Recommendation ITU-T L.1100

## Procedure for recycling rare metals in information and communication technology goods

## 1 Scope

This Recommendation explains the necessity and importance of rare metal recycling and describes the following:

– the recycling procedure for rare metals; and
– the communication method with examples of communication formats that may be used when providing recycling information of rare metals contained in ICT goods.

## 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.

[ITU-T L.1400] Recommendation ITU-T L.1400 (2011), *Overview and general principles of methodologies for assessing the environmental impact of information and communication technologies.*

## 3 Definitions

### 3.1 Terms defined elsewhere

This Recommendation uses the following term defined elsewhere:

#### 3.1.1 Terms defined in [ITU-T L.1400]

– ICT goods

### 3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

**urban mine**: Collection of scrap metal that is removed from information and communication technology (ICT) goods at the recycling and waste management stage of end of life treatment with the purpose of extracting from it valuable precious and rare elements.

## 4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

ICT Information and Communication Technology

LED Light Emitting Diode

PC Personal Computer

PCB Printed Circuit Board

RFID Radio Frequency Identification

## 5 Conventions

In this Recommendation:

The keywords "can optionally" and "may" indicate an optional requirement which is permissible, without implying any sense of being recommended. These terms are not intended to imply that the vendor's implementation must provide the option and the feature can be optionally enabled by the network operator/service provider. Rather, it means the vendor may optionally provide the feature and still claim conformance with the specification.

## 6 Introduction of rare metals in ICT industries

As global awareness of environmental problems in the ICT industry rises, the concern on recycling electrical and electronic goods is increasing. Recently, there has been a greater emphasis on the recycling of rare metals in mobile phones, PCs and other ICT goods; also, various research on recycling methods of rare metals are being promoted.

### 6.1 Rare metals in ICT goods

Rare metals have been called "vitamins of industry" and their importance in industry has been recognized for some time. Recently, ICT industries have become dependent on components that cannot be produced without using rare metals, turning them into "the lifeline of industry". Figure 1 shows the usage of rare metals related to renewable energy.

Rare metals are essential to obtain high performance and high functionality of ICT goods, especially for the goods shown in Figure 2. Examples of rare metals are indium, chromium, tungsten, cobalt, manganese, molybdenum, vanadium, etc. While they are quite rare in the earth crust and are also difficult to extract from ores, the usage scale of rare metals are greatly increasing, causing the rare metals market to more than double worldwide since 2000.

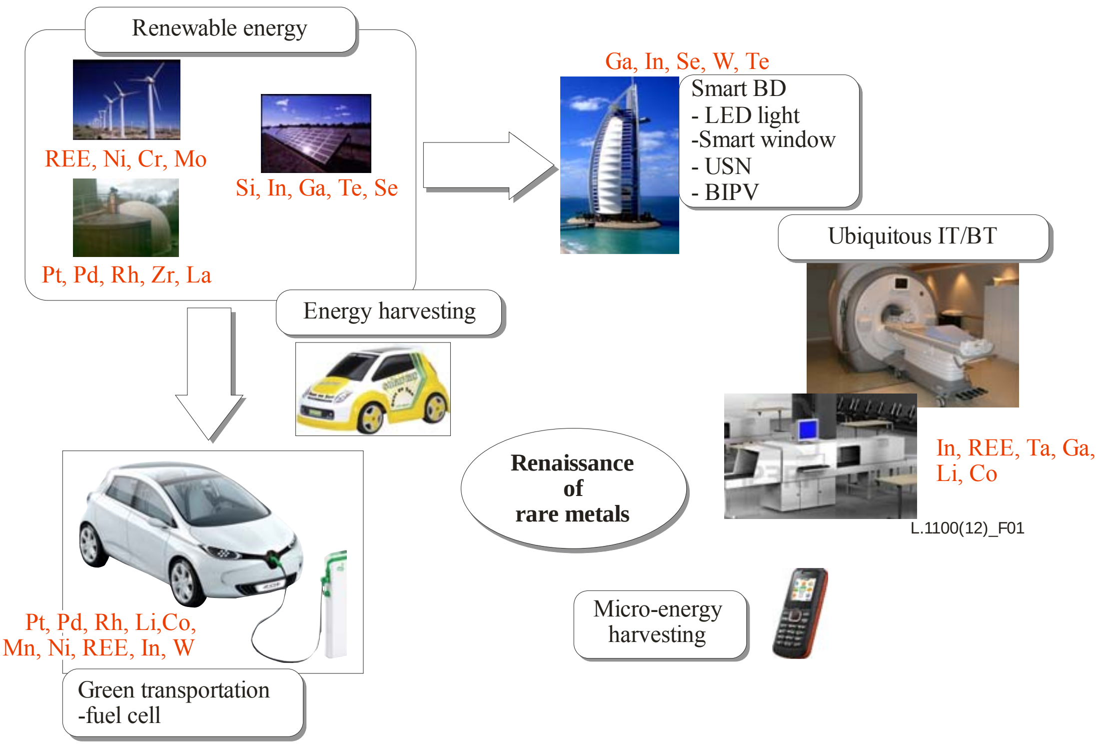


**Figure 1 – Usage and importance of rare metals in industries**

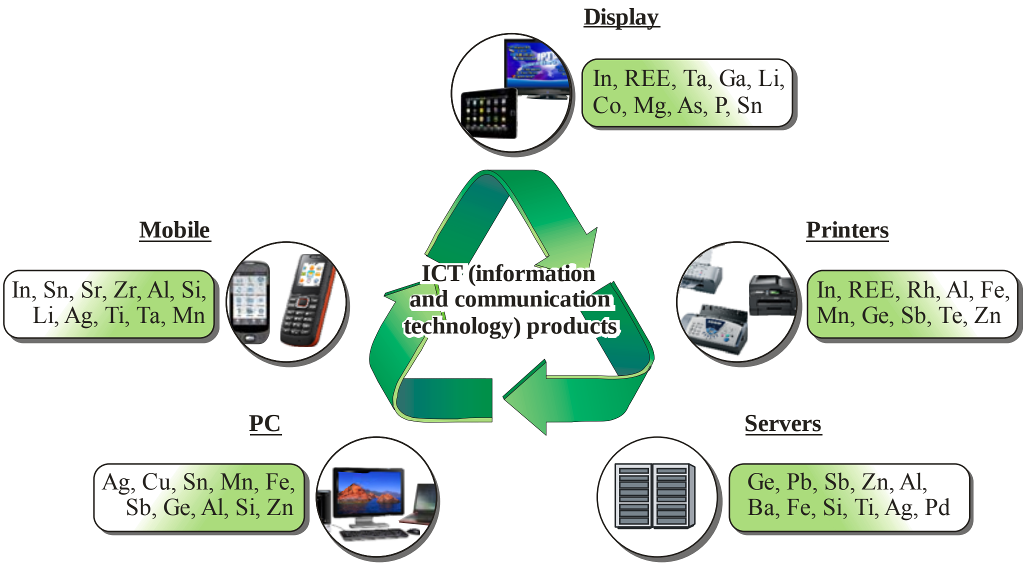


**Figure 2 – Typical rare metal application for ICT goods**

Each country has different industrial structures and security situations, and the definition of rare metals is not the same in each one. Some examples are listed in Appendix I. In order to have standardized information, ICT goods organizations should classify the common rare metals as shown in Table 1. Appendix II provides examples of communication formats for providing recycling information on the selected rare metals.

**Table 1 – World common rare metals**

| Group | Elements |
|---|---|
| Alkaline earth metal | Li, Ce, Be, Sr, Ba |
| Metalloid | Ge, Bi, Se, Te |
| VII group | Co |
| Boron group | B, Ga, In, Tl, Cd |
| High fusion point metal | Ti, Zr, Hf, V, Nb, Ta, Cr, Mo, W, Mn, Re |
| Rare earth | La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Sc, Y |
| Platinum group | Ru, Rh, Pd, Os, Ir, Pt |

As well as being rare, rare metals such as indium, yttrium, gallium and arsenic are widely used in ICT goods such as mobile phones, PCs, and display, touch-screen and LED lighting. For instance, a mobile phone includes more than 20 rare metals such as neodymium, titanium, barium, zirconium, arsenic, gallium, indium and tantalum. Figures 3 and 4 show the rare metals commonly used in a cellular phone and an LCD.

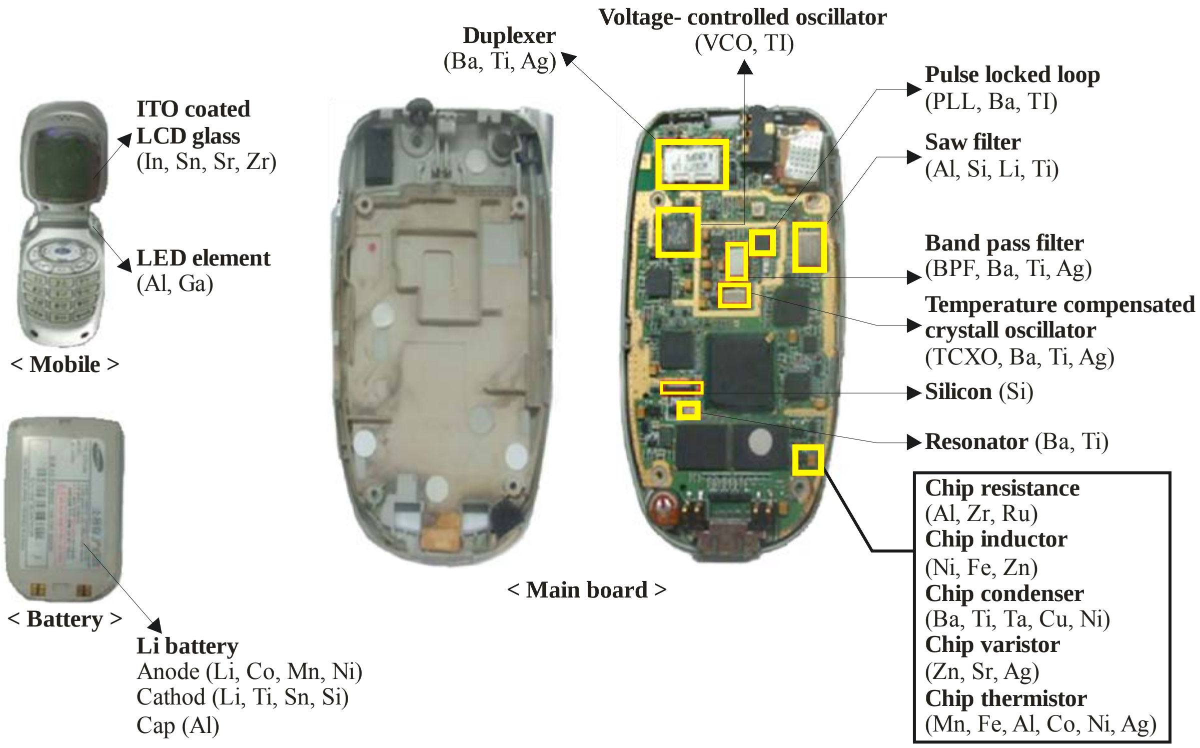


**Figure 3 – Rare metals contained in a mobile phone**

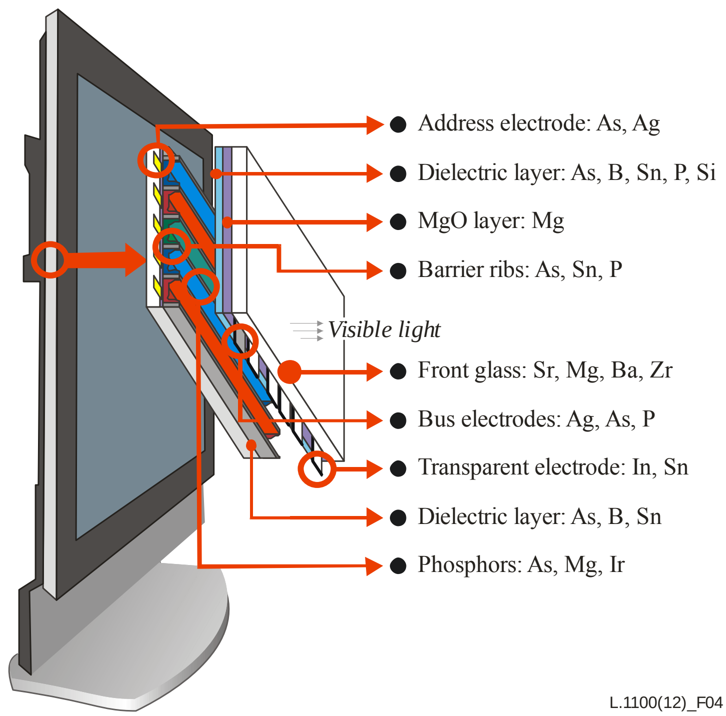


**Figure 4 – Rare metals contained in an LCD**

The issue of rare metals use is not only for existing ICT goods but they are also key for future technologies, especially for renewable energy goods such as photovoltaic panels. Figure 5 shows the general classification of solar cells determined by radiation absorbing materials. In a silicon-based solar cell (Si), rare metals are used for doping elements and for typical electrode materials. The more important factor is that the market of compound photovoltaic devices in which rare metals are mainly used as the main radiation absorbing materials is increasing remarkably.

It is important to consider not only a stable supply of rare metals but also environmental issues in these industries. It is well known that some semiconductor compounds such as CIGS (copper, indium, gallium, selenide) or CdTe (cadmium, tellurium) will be depleted in the near future, putting a severe strain on the global environment in absence of the recycling process.

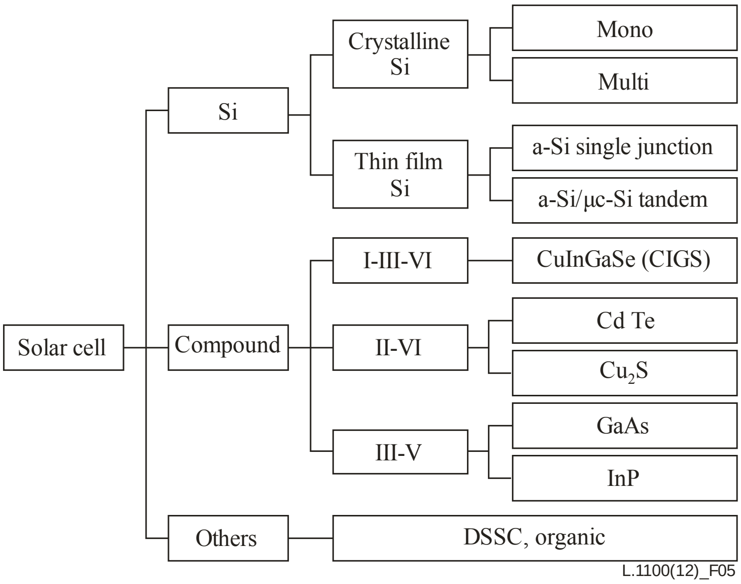


**Figure 5 – Classification of a solar cell**

## 6.2 The importance of recycling rare metals

Considering the insufficient supply on one hand and the increasing demand for rare metals on the other hand, many countries are preparing policies to ensure a stable supply of rare metals such as overseas resource development, recycling promotion, alternative material development, saving rare metals for emergencies, export control policies, etc. These countries consider that this stable supply of rare metal materials is significant for maintaining and strengthening the ICT industry's competitiveness worldwide.

Over tens of millions of ICT goods are annually withdrawn from the market as waste, and recycling rare metals from this ICT goods waste by urban mining gives huge opportunities for collecting expensive rare metals (Figure 6).

In the case of gold, 5 g of gold may be extracted from 1 ton of gold ore. On the other hand, 400 g of gold may be extracted from 1 ton of wasted mobile phones. Also, 200 g of silver, 20 g of palladium and some copper, tin, nickel, aluminium, zinc, etc. are contained in 1 ton of printed circuit boards (PCBs) of wasted PCs.

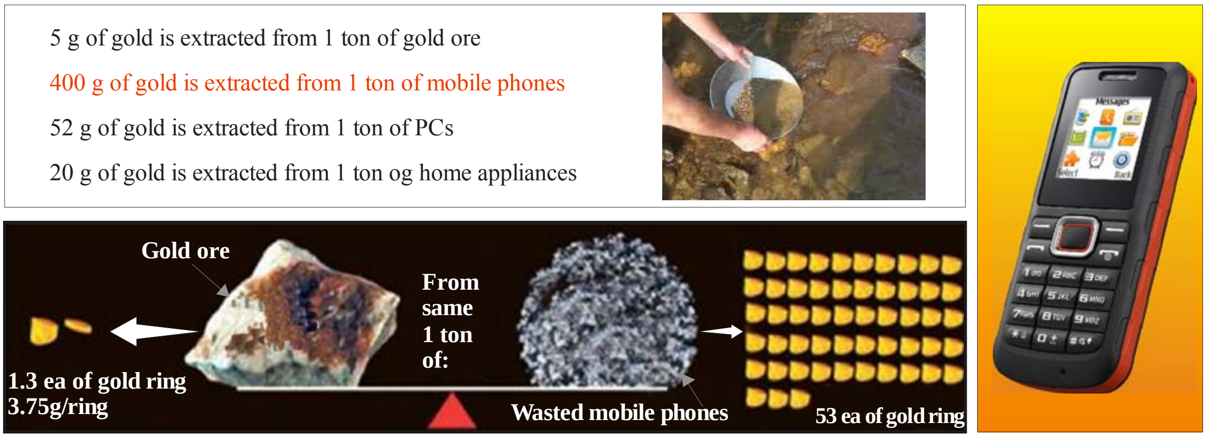


**Figure 6 – Example of the impact of urban mining of rare metals**

## 7 Recycling procedure of rare metals

In the past, recycling only referred to reuse, but the concept has now been expanded to include collection, separation and extraction. Figure 7 shows a typical example of a recycling sequence of urban mining of ICT goods using standardized rare metal information. In order to obtain the final metals, each step should be clearly organized.

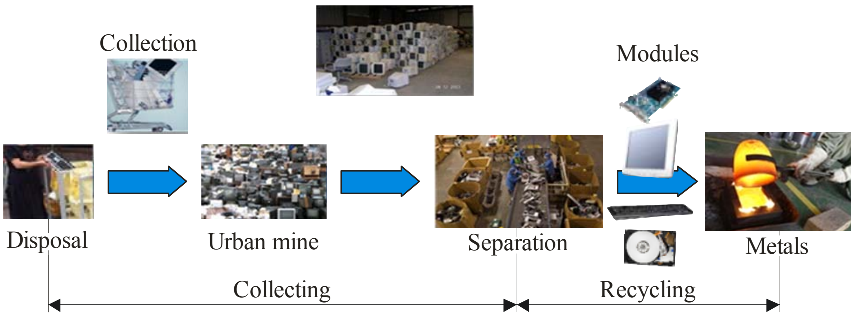


**Figure 7 – A typical example of urban mining**

In a traditional recycling procedure, the recycling industries have to obtain rare metal information from ICT goods manufacturers. However, as the responsibility of managing ICT goods recycling information lies with the manufacturers, risks exist that they may change line of business or disappear during the lifetime of an ICT good, which could cause losses of information on the rare metal. Therefore, a more efficient and secured means of collecting this information and supplying it to the recycling industry should be created. To realize this management method, ICT goods manufacturers could submit "rare metal information" to an authentication organization (not defined in this Recommendation) for each one of their ICT goods.

The rare metals recycling system may follow the recycling process given below. In this case, the recycling industry could be able to obtain more reliable information.

NOTE – In the future this information might be certified and secured.

## 7.1 Production stage

In the production stage, the following steps should be performed:

a. Analyse the current recycling technology on the elements in the ICT good.

b. Input the data of rare metal (type and quantity) and of the extracting order of each element (e.g., A→ B→ C→ D→ E or A→B→D→C→E). The extracting order may differ based on the fabricating order.

c. Rare metals in urban mines are extracted by following a set of rules in urban mines. As an example, elements A, B, C, D and E in an ICT good can be extracted by the steps of the production stage, collection stage and recycling stage. Details of each step are found in the following clauses.

Figure 8 shows a flowchart of a recycling process for an ICT good. These ICT goods are separated by mechanical treatment processes such as "shredding". Plastic materials can be removed by a general "combustion" procedure, and then only materials containing rare metals may remain. The remaining materials are distinguished by their particle sizes after the "milling" step. Some materials can be separated out with magnetism during the "milling/sizing" step. The "refining" process such as a pyrometallurgical treatment is applied after the "smelting" step. Then, depending on the composition and their purity, metal recovery processes such as a hydrometallurgical process and/or electrolytic refining process are performed. It must be noted that each recycling process is strongly dependent on the types of rare metals.

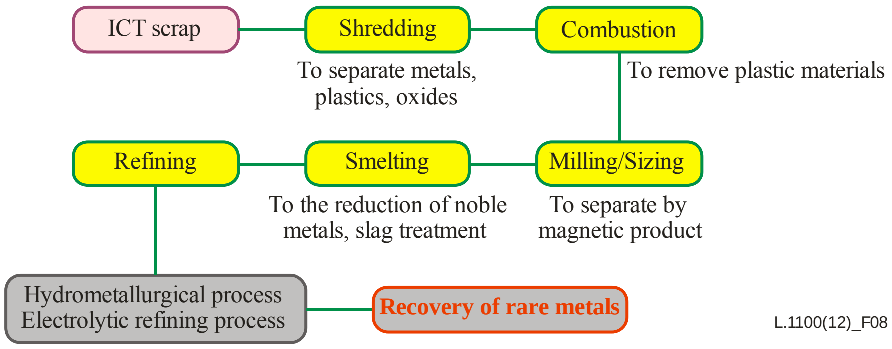


**Figure 8 – A flowchart of recycling process**

## 7.2 Collecting stage

This Recommendation does not include a detailed collecting method of ICT goods.

## 7.3 Recycling stage

In the recycling stage, the following steps should be performed:

a. According to the rare metals present in each device, the ICT good is separated into modules.

b. Each module is sent to the corresponding recycling processes in accordance with the input data from the production stage, step by step.

c. In case the ICT good contains an element which cannot be extracted in the given order, it is returned and stored in a urban mine.

d. Depending on the developed recycling technology, the un-extracted metals which are still stored in the urban mine will go through the next extraction stage.

## 8 Communication of recycling information

Rare metals may have a key role in the development of ICT goods' further functionalities; however the amount of available rare metals is not sufficient to satisfy the industrial demand. In order to ensure the appropriate provision of rare metals to the ICT industry, recycling of rare metals becomes a crucial objective. Therefore, it is important to estimate which quantity of rare metals is used in each ICT good to the extent that this investigation is legally, technically and economically feasible, and provided that this is meaningful to recyclers.

### 8.1 Method to provide recycling information

When relevant (e.g., a non-negligible amount), it is recommended that the amount of rare metals used in ICT goods be clearly provided to ensure an efficient recycling process. It is important to take into account all components and modules constituting ICT goods to facilitate the recycling process. Suppliers of components and modules are encouraged to provide the assembling company of the final ICT goods or intermediate modules with relevant information on the type and the amount of rare metal elements and their quantity embedded in these components and modules. For efficient recycling, it is beneficial that all ICT goods contain such rare metal information which is then finally provided to recycling industries.

Collecting rare metal information can be done directly or indirectly. It is possible for example to store the information on rare metal on barcodes, vericodes, or by radio frequency identification (RFID) tags in the ICT good for example, so that this information is available. In this case, rare metal recycling industries can acquire rare metal information directly from the ICT goods. In an indirect way, rare metal information may be collected and managed by a designated authority from which recycling industries can acquire rare metal information. The ICT goods are easily dismantled by using acquired rare metal information and the dismantled parts are put into recycling processes to extract each rare metal element.

Example formats for collecting rare metal information are shown in Appendix II and may be defined by designated authorities, national policies, international standards or industry agreements.

# Appendix I

## Rare metal examples of some countries

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

In order to select world common rare metals, it is important to understand that the definitions of rare metals are not exactly the same in each country. The following tables show rare metals tracked in different countries: United States (Table I.1), Japan (Table I.2) and Korea (Table I.3). Typically, some metals are defined as a rare metal in one country but not in another. However, there are common metals which are defined as rare metals in all countries listed below. This Recommendation only focuses on the rare metals listed in Table 1 of this Recommendation.

**Table I.1 – Rare metals in the United States**

| Group | Elements |
|---|---|
| Alkaline earth metal | Li, Ce, Be, Sr, Ba |
| Metalloid | Ge, Bi, Se, Te, Si |
| Iron group | Co |
| Boron group | B, Ga, In, Tl, Cd |
| High fusion point metal | Ti, Zr, Hf, V, Nb, Ta, Cr, Mo, W, Mn, Re |
| Rare earth | La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Sc, Y |
| Platinum group | Ru, Rh, Pd, Os, Ir, Pt |
| Other group | Ca, Rb, Th, U, Pu |

**Table I.2 – Rare metals in Japan**

| Group | Elements |
|---|---|
| Alkaline earth metal | Li, Ce, Be, Sr, Ba |
| Metalloid | Ge, As, Sb, Bi, Se, Te, Sn |
| Iron Group | Co, Ni |
| Boron Group | B, Ga, In, Tl |
| High fusion point metal | Ti, Zr, Hf, V, Nb, Ta, Cr, Mo, W, Mn, Re |
| Rare Earth | La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Sc, Y |
| Platinum Group | Ru, Rh, Pd, Os, Ir, Pt |

**Table I.3 – Rare metals in Korea**

| Group | Elements |
|---|---|
| Alkaline earth metal | Li, Mg, Ce, Be, Sr, Ba |
| Metalloid | Ge, P, As, Sb, Bi, Se, Te, Sn, Si |
| Iron group | Co, Ni |
| Boron group | B, Ga, In, Tl, Cd |
| High fusion point metal | Ti, Zr, Hf, V, Nb, Ta, Cr, Mo, W, Mn, Re |
| Rare earth | La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Sc, Y |
| Platinum group | Ru, Rh, Pd, Os, Ir, Pt |

# Appendix II

## Example communication formats for providing recycling information

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

The following communication formats provide examples on how information on rare metals contained in ICT goods could be exchanged. The following information may be presented for any ICT good:

a. Manufacturer

b. Model name

c. Model number

d. Certification authority

e. Certification number

f. Issue date

Detailed rare metal information depends on rare metal groups. The following tables contain examples for typical rare metal groups. Countries may have different rare metal groups according to their geographic location and industries (see Appendix I).

**Table II.1 – Alkaline earth metal**

| Module and part name | Maker | Model number | Alkaline earth metal (ppm) | | | | |
|---|---|---|---|---|---|---|---|
| | | | Li | Ce | Be | Sr | Ba |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

**Table II.2 – Metalloid**

| Module and part name | Maker | Model number | Metalloid (ppm) | | | |
|---|---|---|---|---|---|---|
| | | | Ge | Bi | Se | Te |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

**Table II.3 – Iron group**

| Module and part name | Maker | Model number | Metalloid (ppm) |
|---|---|---|---|
| | | | Co |
| | | | |
| | | | |
| | | | |

**Table II.4 – High fusion point metal**

| Module and part name | Maker | Model number | High fusion point metal (ppm) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Ti | Zr | Hf | V | Nb | Ta | Cr | Mo | W | Mn | Re |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

**Table II.5 – Platinum group**

| Module and part name | Maker | Model number | Platinum group (ppm) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Ru | Rh | Pd | Os | Ir | Pt |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

**Table II.6 – Rare earth**

| Module and part name | Maker | Model number | Rare earth (ppm) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | La | Ce | Pr | Nd | Pm | Sm | Eu | Gd | Tb | Dy | Ho | Er | Tm | Yb | Lu | Sc | Y |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |

When the recycling industries obtain rare metal information on a given ICT good, they can easily describe which rare metals are used in the ICT good. Table II.7 shows a summarized rare metal composition of a printed circuit board (PCB) as an example. Not only are complex PCBs assembled with various chips, but the simplest PCBs are still composed of complicated assemblies of electronic components, which embody numerous rare metals.

This example shows that it becomes easy to obtain recycling information of rare metals from an ICT good using such a data format. This leads to an environmental benefit, as it is well-known that the energy used for recycling rare metals is smaller than the one needed for mining them through traditional means.

**Table II.7 – Example of the average chemical composition of a PCB**

| Element | Composition(ppm) | Group ICT goods | Elements distribution in ICT goods (% by weight) | |
|---|---|---|---|---|
| Br | 29,500 | Group1= Gas | | |
| Cl | 1,490 | | | |
| | 30,990 | 3% of PCBs | | |
| Ge | < 290,000 | Group 2= Oxides | $GeO_2$ | 62.1 |
| K | < 90,000 | (Flue Dust) | $K_2O$ | 32.2 |
| Pb | 10,000 | | PbO | 1.6 |
| Sb | 4,150 | | $Sb_2O$ | 31.5 |
| Zn | 14,160 | | ZnO | 2.6 |
| | 408,310 | 41% of PCBs | (Oxide) | 100.0 |
| Al | 47,400 | Group 3 = Slag | $Al_2O_3$ | 33.9 |
| Ba | 6,140 | | BaO | 1.3 |
| Cr | 1,075 | | $Cr_2O_3$ | 0.6 |
| Fe | 76,800 | | FeO | 18.7 |
| Mn | 17,800 | | MnO | 4.4 |
| Na | 1,580 | | $Na_2O$ | 0.8 |
| Si | 91,400 | | $SiO_2$ | 37.1 |
| Ti | <10,300 | | $TiO_2$ | 3.2 |
| | 252,495 | 25% of PCBs | (Slag) | 100.0 |
| Ag | 1,053 | Group 4 = Alloy | Ag | 2.0 |
| Au | 70 | | Au | 0.1 |
| Cu | 29,800 | | Cu | 56.9 |
| Ni | 2,040 | | Ni | 3.9 |
| Pd | <1,500 | | Pd | 2.9 |
| Rh | <1,600 | | Ph | 3.1 |
| Sn | 16,300 | | Sn | 31.1 |
| | 52,360 | 5% of PCBs | (Alloy) | 100.0 |
| Total | 744,155 | 74% | | |
| Remainder | 255,845 | 26% | | |

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