

## The Disposal of Portable Batteries

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### 19.1 PORTABLE BATTERY SYSTEMS AND THEIR RELEVANCE TO THE ENVIRONMENT

Batteries are generally galvanic cells which convert chemical energy into electrical energy. As mobile sources of energy, we can no longer imagine life in the modern world without them. Every year in Germany, approximately 1 billion portable batteries are sold, an equivalent of around 30,000 tons ([Table 19.1](#)). We can state that 85% of the battery market comprises non-rechargeable primary batteries and 15% rechargeable secondary batteries.

Since production and use of portable batteries have become of little ecological relevance, the main focus has now turned to the spent product, the waste. Avoidance, recycling, and then disposal is the order prescribed by the German Waste Management and Recycling Act (law to promote life cycle management and to ensure environmentally friendly waste disposal (KrW-/AbfG) dated 27 September 1994). In principle, the battery industry is in agreement with these goals. It is even setting an example to others in many fields. In so doing, the main focus is on avoiding hazardous substances in terms of disposal and establishing recycling procedures.

#### 19.1.1 Main Systems and Their Implementation

In the following overview, you will find a selection of current electrochemical systems and their typical areas of application ([Table 19.2](#)). These varied areas of application

**Table 19.1** Batteries brought into circulation by GRS users in 1999 and 2000.

|                |             | 1999<br>in tons (app.) | 2000<br>in tons (app.) |
|----------------|-------------|------------------------|------------------------|
| Primary        |             |                        |                        |
| Round cells    | ZnC         | 9,206                  | 9,118                  |
|                | AlMn        | 12,156                 | 15,083                 |
|                | Zinc-Air    | 30                     | 32                     |
|                | Lithium     | 264                    | 351                    |
| Round cells R9 | HgO         | 6.6                    | 7.0                    |
|                | AgO         | 54                     | 51                     |
|                | AlMn        | 31                     | 34                     |
|                | Zinc-Air    | 45                     | 44                     |
|                | Lithium     | 92                     | 90                     |
| Subtotal       |             | 21,885                 | 24,810                 |
| Secondary      |             |                        |                        |
| Round cells    | Lithium-Ion | 333                    | 426                    |
|                | NiMH        | 672                    | 1,689                  |
|                | AlMn        | 6.6                    | 19                     |
|                | Pb          | 290                    | 482                    |
|                | NiCd        | 1,840                  | 1,840                  |
| Round cells R9 | Lithium-Ion | 0.5                    | 4.7                    |
|                | NiMH        | 4.5                    | 9.9                    |
|                | NiCd        | 1.5                    | 3.9                    |
| Subtotal       |             | 3,138                  | 4,475                  |
| Total          |             | <b>25,023</b>          | <b>29,284</b>          |

Source: GRS Batterien.

**Table 19.2** Areas of application.

| System                  | Area of application (example)        |
|-------------------------|--------------------------------------|
| Primary batteries       |                                      |
| AlMn                    | Tape recorders, flashlights          |
| ZnC                     | Kitchen clocks, travel alarm clocks  |
| Lithium                 | Cameras                              |
| Round cell batteries R9 | Toys, watches, hearing aids          |
| Secondary batteries     |                                      |
| NiCd                    | Drill/drivers, electric toothbrushes |
| NiMH/Li-ion             | Mobile phones, laptop computers      |
| Lead                    | Starter and drive batteries          |
| Round cell batteries R9 | Calculators, computers               |

Source: GRS Batterien.

**Table 19.3** The best-selling battery sizes.

| International designation | Conventional designation | AlMn    | ZnC    | Voltage (Volts)      |
|---------------------------|--------------------------|---------|--------|----------------------|
| AA                        | Mignon                   | LR 6    | R 6    | 1.5                  |
| AAA                       | Micro                    | LR 03   | R 03   | 1.5                  |
| C                         | Baby                     | LR 14   | R 14   | 1.5                  |
| D                         | Mono                     | LR 20   | R 20   | 1.5                  |
| 9V                        | E-block                  | 6 LR 61 | 6 F 22 | $6 \times 1.5 = 9$   |
| 4.5V                      | Normal/flat              | 3 LR 12 | 3 R 12 | $3 \times 1.5 = 4.5$ |

Source: Duracell GmbH.

necessitated the manufacture of numerous sizes (Table 19.3). The R9 round cells also come in a variety of sizes.

Depending on the electrochemical system, some portable batteries contain hazardous substances such as mercury, cadmium, and lead. Table 19.4 shows an overview of the main substances contained in portable batteries in percentages by weight. (The material composition varies significantly depending on the battery size, type, and composition. All figures are mean averages.)

Mobile applications of the future require both power and energy capacity and low weight, a combination which can no longer be provided by conventional battery types and systems. It is conceivable that in the future polymer electrolyte fuel cells (PEMs) may even be used in the field of portable applications. Prototypes of laptops and mobile phones which run on PEMs instead of conventional batteries have already been developed.

### 19.1.2 Significance of Heavy Metals for Disposal

Without going into detail regarding the toxicity and ecotoxicity of the heavy metals contained in batteries, it is clear that large quantities of mercury, cadmium, or lead must not be disposed of in domestic waste disposal facilities (normal tips) as contamination of the surrounding areas cannot definitively be prevented.

The basic principles of the European and, in particular, the German battery industry therefore call for the avoidance of environmentally harmful substances in battery systems or, where this is unavoidable, the separation and recycling of these batteries. Avoidance is not always possible.

Lead and cadmium are used as active substances in lead batteries with up to 65% lead by weight and nickel/cadmium batteries with up to 15% cadmium by weight. Mercury is used as a passive component in R9 round cells with up to 2% by weight.

#### 19.1.2.1 Mercury

In December 1998 (Directive 98/101/EU of 22.12.1998), as part of an amendment to the existing 1991 battery directive (91/157/EEC), the European Commission banned the marketing of batteries and accumulators with a mercury content of more than 5 ppm (parts per million) effective from January 1, 2000. The ban includes batteries

**Table 19.4** Main substances contained in batteries.

|                             |    |    |    |    |    |    |    |    |    |                                |     |                                          |                   |                  | Non-<br>metals                         |
|-----------------------------|----|----|----|----|----|----|----|----|----|--------------------------------|-----|------------------------------------------|-------------------|------------------|----------------------------------------|
| Metals                      |    |    |    |    |    |    |    |    |    | Electrolytes                   |     |                                          |                   |                  | Plastics,<br>paper,<br>carbon,<br>soot |
| System                      | Pb | Ni | Cd | Zn | Mn | Ag | Hg | Li | Fe | H <sub>2</sub> SO <sub>4</sub> | KOH | NH <sub>4</sub> Cl,<br>ZnCl <sub>2</sub> | Organ.<br>Electr. | H <sub>2</sub> O |                                        |
| Pb/PbO <sub>2</sub>         | 65 |    |    |    |    |    |    |    |    | 8                              |     |                                          |                   | 17               | 10                                     |
| NiCd<br>(steel c.)          |    | 20 | 15 |    |    |    |    |    | 45 |                                | 5   |                                          |                   | 10               | 5                                      |
| Zn/MnO <sub>2</sub><br>acid |    |    |    | 20 | 25 |    |    |    | 20 |                                |     | 5                                        |                   | 10               | 20                                     |
| alkaline                    |    |    |    | 20 | 30 |    |    |    | 20 |                                | 5   |                                          |                   | 10               | 15                                     |
| Zn/AgO <sub>2</sub>         |    |    |    | 10 |    | 30 | 1  | 40 |    | 3                              |     |                                          | 6                 | 10               |                                        |
| Zn/HgO                      |    |    |    | 10 |    |    | 30 |    | 40 |                                | 3   |                                          |                   | 6                | 11                                     |
| Zn/O <sub>2</sub>           |    |    |    | 30 |    |    | 2  |    | 45 |                                | 4   |                                          |                   | 8                | 12                                     |
| Li/MnO <sub>2</sub>         |    |    |    |    | 30 |    |    | 2  | 50 |                                |     |                                          | 10                |                  | 10                                     |

Source: Batteries Association in the ZVEI.

and accumulators built into devices. Only round cell batteries and batteries constructed from round cell batteries with a mercury content of not more than 2 percent by weight are excluded from this ban. This directive still awaits implementation as national law.

The addition of mercury has been completely and successfully eliminated from non-rechargeable portable batteries (primary batteries). The major battery suppliers in Europe (they cover approximately 95% of the market) have been offering them mercury-free since 1994. The financial expenditure for the development and the operating costs for mercury-free production were and still are considerable.

The waste stream, however, will also continue to contain a certain amount of mercury for some time after the mercury ban. This has consequences for the recycling process (see Figure 19.1).

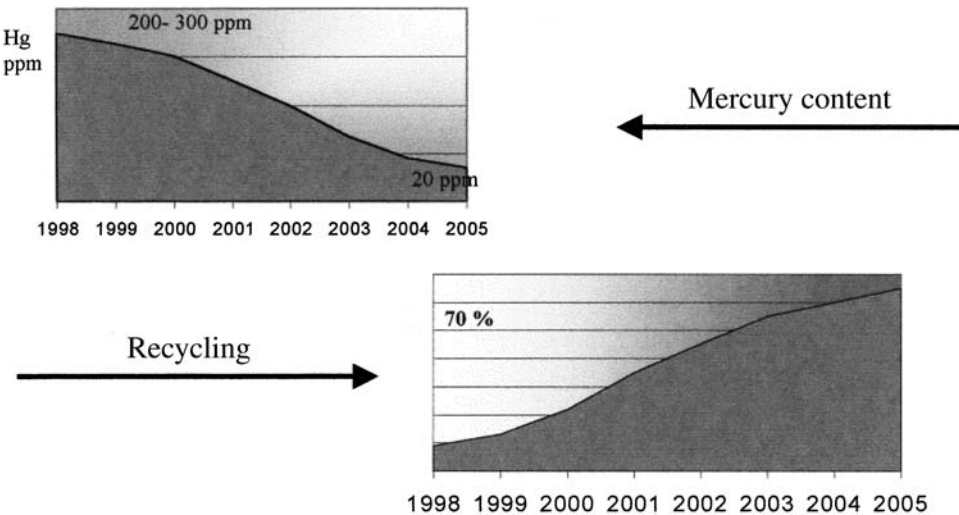
As another major contribution to the reduction of hazardous substances, the European battery manufacturers had already decided in mid-1999 to cease sales of mercury oxide round cell batteries, which are mainly used in hearing aids. As an alternative, zinc/air batteries with a low mercury content (far less than 1 percent of weight in Hg) are used. Advances made in hearing aids and battery technology now make it possible to use these batteries even in hearing aids for the extremely hard of hearing. Zinc/air batteries have been on offer for ordinary hearing aids for more than a decade now.

As part of the aforementioned implementation of the EU Directive, the marketing of mercury oxide batteries should also be banned effective from January 1, 2000. This directive still awaits implementation in national law.

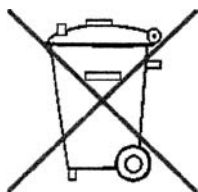
Batteries containing mercury are labelled as in [Figure 19.2](#).

19.1.2.2 Cadmium

Batteries containing nickel/cadmium are rechargeable (secondary) batteries. They are alkaline accumulators in which the positive mass consists primarily of nickel



**Figure 19.1** Mercury content-recycling interdependence. Source: GRS.



**Hg**

**Figure 19.2** Labelling of batteries containing mercury. Source: BattV.

hydroxide and the negative mass mainly of cadmium. The German Battery Decree includes nickel/cadmium accumulators in the category of batteries containing harmful substances. In certain areas of application, they are increasingly being replaced with cadmium-free nickel/metal hydride batteries. Recently, lithium-ion batteries have been offered on the market, particularly for laptop computers and mobile phones. These, too, contain no mercury, cadmium, nor lead.

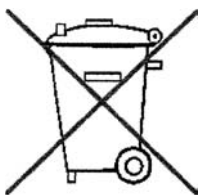
Batteries containing cadmium are labelled as in Figure 19.3.

#### 19.1.2.3 Lead

A lead battery is an accumulator in which the electrodes consist primarily of lead, while a diluted sulfuric acid is used as an electrolyte. The lead is used in the form of bivalent and quadrivalent compounds ( $\text{PbSO}_4$  and  $\text{PbO}_2$ ) and as a porous lead sponge for active masses, as well as in the form of lead-antimony or lead-calcium alloys for grids in lead batteries. The level of use of lead batteries in the portable appliance market is low. The main areas of application are starter and drive batteries as well as for uninterrupted power supply to stationary systems.

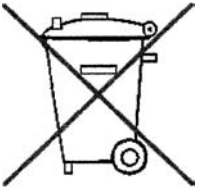
Batteries containing lead are labelled as in [Figure 19.4](#).

A variety of battery systems will still be required in the future, as there will be no such thing as a “universal battery” that is equally suitable for all applications.



**Cd**

**Figure 19.3** Labelling of batteries containing cadmium. Source: BattV.



**Pb**

**Figure 19.4** Labelling of batteries containing lead. Source: BattV.

### 19.1.3 Basic Prerequisites for Recycling

#### 19.1.3.1 Collection

Batteries must first be collected before they can be recycled. Portable batteries are normally collected as a mixture, as end users cannot perform the meticulous presorting required for recycling. Thus a comprehensive nationwide system for the collection of batteries has been developed and is in place today.

End users can either return their used portable batteries to their retailers or to the collection points set up by the communities. Commercial end users are likewise provided with collection and transport containers free of charge for the collection of their used batteries. (GRS collection containers [see Figure 19.5].)

#### 19.1.3.2 Sorting

Battery sorting facilities work according to different procedures. Two of them are presented in brief in the following.

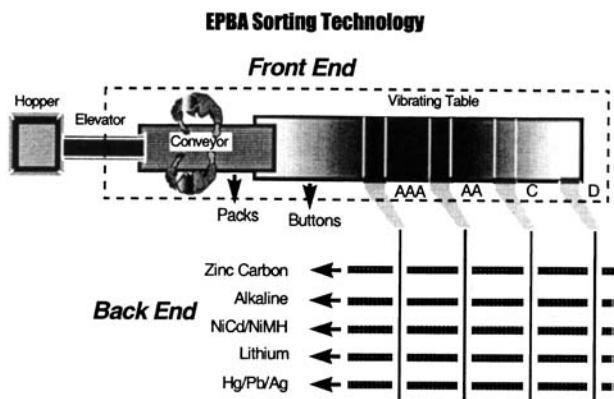
##### *Sorting by Means of Electrodynamic Sensors*

The EPBA/Sortbat and Eurobatri facilities work with electrodynamic sensors. This process has already been implemented in routine operation for sorting portable battery mixtures (see [Figures 19.6 and 19.7](#)).

The batteries are mechanically and magnetically sorted into different fractions according to their composition, i.e. after hand sorting, during which incorrectly sorted batteries and larger batteries are removed, they are sorted by size, and the R9 cells are sieved out. The round cells are run across a magnetic separator. The non-



**Figure 19.5** Pictures of the GRS collection containers. Source: GRS Batterien.



**Figure 19.6** Battery sorting facility. Source: EPBA.

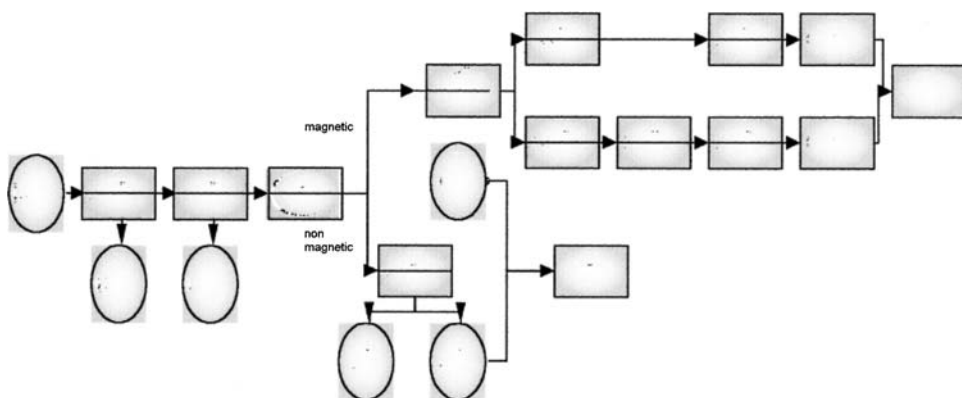
magnetic batteries (paper jacket, primarily ZnC, make up approximately 15% of the round cells) are not sorted any further automatically. The magnetic batteries are identified by an electrodynamic sensor based on their “magnetic fingerprints”.

To put it simply, the sensor consists mainly of a spool through which current flows, generating a magnetic field. Depending on which electrochemical system is passing the sensor at any given moment, the magnetic field changes. Based on this change, the respective battery system is identified. This process sorts the batteries at a speed of six batteries per second.

LSI has developed a new electrodynamic sensor which also facilitates the separation of NiCd and NiMH batteries.

#### *Sorting by Means of X-Ray Sensors*

In this process, after hand and size sorting, the batteries are separated from a stock silo via different conveyor belts and fed to the x-ray sensor. The radioscopy unit consists of an x-ray tube and a sensor installed in a radiation protection cabin. The electrochemical battery type is identified in real time. The batteries fall off the conveyor belt and are pushed out of their trajectory by compressed air blasts from



**Figure 19.7** Processing principle of the battery sorting facility. Source: GMA, Schortens.

the side or from above. In this fashion several fractions can be reliably separated. Sorting speeds of up to 10 batteries per second are achieved with battery intervals of approximately 7 mm. The analysis ensues by computer, which likewise identifies the battery types based on the gray levels of the x-ray image. A prototype of this system has been in operation since early 2000.

#### *The UV Detector*

For the further recycling of the AIMn and ZnC systems it is important to separate the batteries containing mercury from the mercury-free batteries after separation into the various electrochemical systems.

Since the mid-1990s, these batteries have been produced only in mercury-free form by the European manufacturers, but older batteries or imported batteries containing mercury still make their way into the waste disposal system. In order to separate these in the sorting facilities from the mercury-free batteries, for which recycling procedures already exist, the European battery manufacturers have coded their own AIMn brands and some of the ZnC batteries with a UV-sensitive varnish, so that in future batteries containing mercury can be separated by means of sensors from mercury-free batteries.

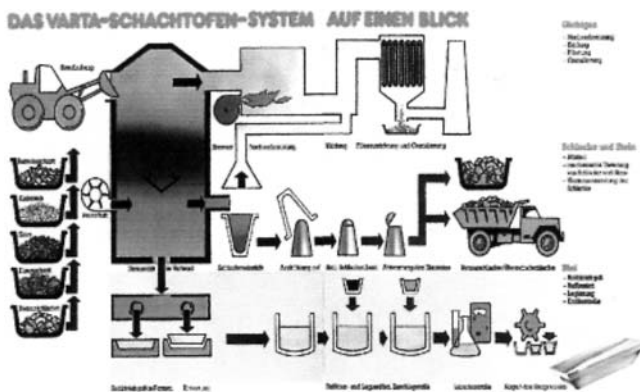
## **19.2 RECYCLING PROCEDURES AND LEVEL OF RECYCLING**

Batteries contain a range of recyclable metals and can thus be used as sources of raw materials. Below you will find a selection of the major recycling procedures for portable batteries from the various electrochemical systems. There are sufficient facilities to deal with round and button cell batteries containing lead, nickel/cadmium, nickel/metal hydride, and mercury. For the newer nickel/metal hydride and lithium systems, however, recycling is still in the early stages. For all the other aforementioned systems, such procedures have been in place for some time now.

### **19.2.1 Lead Batteries**

Lead can rightly be termed the classic recycling material. The first facilities for the recovery of lead from used lead batteries were developed about 100 years ago. In the beginning this was due exclusively to economic considerations, as lead has always been a valuable raw material. With the dramatic growth of automobile traffic, ecological aspects became increasingly important over the past few decades. What has remained the same? The trick of using lead without consuming it.

There are basically two processes for recovering lead from used accumulators. Either the battery waste is prepared before metallurgical processing and separated according to composition (lead, plastic, acid, etc.), or the batteries are processed whole. In the shaft furnace process, the second method is used. The batteries are emptied of liquid acid and remain otherwise whole. Without further preparation they are put into the shaft furnace, where they undergo metallurgical processing in a mixture with aggregates such as coke, limestone, and iron. These aggregates enhance the combustion and conversion processes in the shaft furnace and help to recover the lead stepwise and to purify it of contaminants. The result is raw or pig lead (see [Figure 19.8](#)).



**Figure 19.8** Functional diagram of the VARTA facility. Source: VARTA.

### 19.2.2 Nickel/Cadmium Batteries

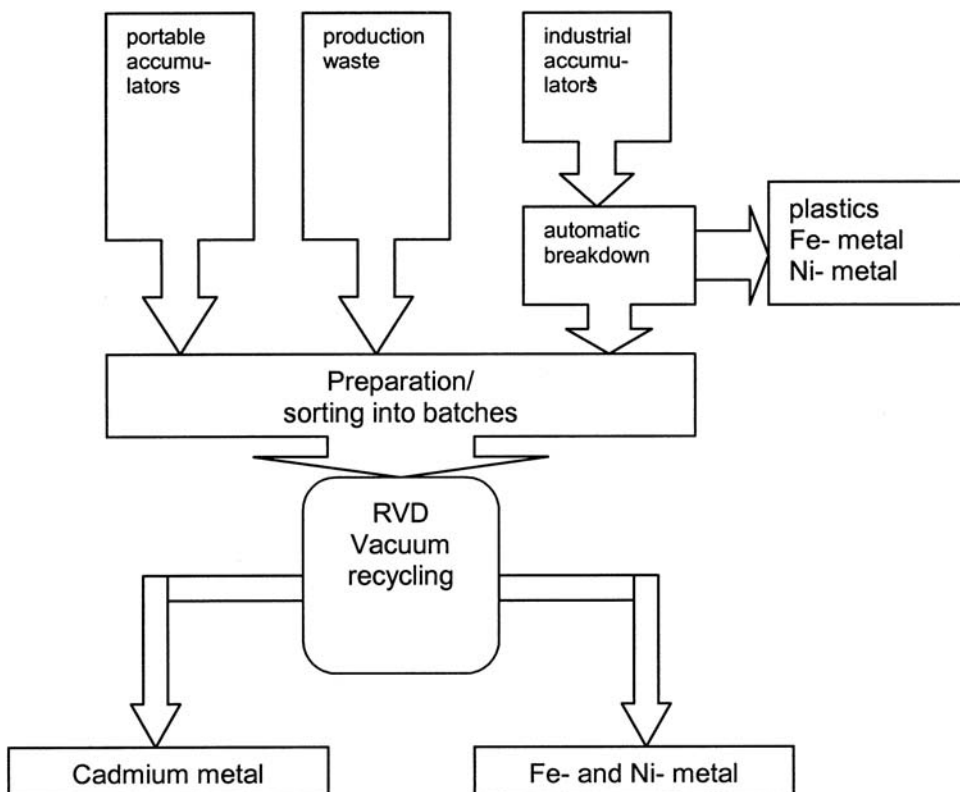
For the recycling of used Ni/Cd batteries, again only thermal procedures have hitherto gained any significance. Generally, the cadmium is precipitated in a vacuum or an inert atmosphere and the remaining steel-nickel compound is worked into iron-nickel for steel production. Due to the comparatively small quantities of nickel/cadmium batteries used (8000 tons/year), the capacities offered by the existing facilities in Germany, France, and Sweden are sufficient for the recycling of all batteries in Western Europe (see [Figure 19.9](#)).

### 19.2.3 Batteries Containing Mercury (R9 Cells)

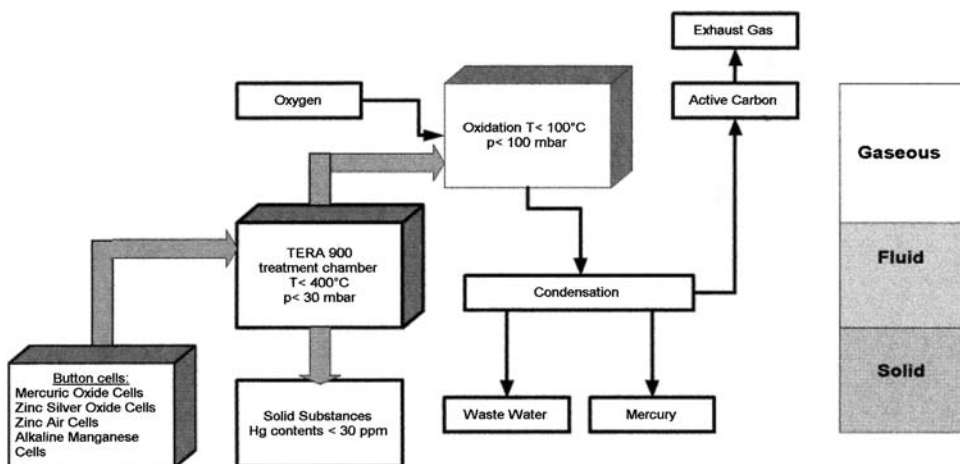
In Germany, there are currently several processing facilities for batteries containing mercury. Some of them work according to the ALD procedure. This procedure is used chiefly for the removal of mercury from mercury-containing components in natural gas production and chlorine-alkali electrolysis. It can also be used for the removal of volatile components from various materials and compounds. With the ALD procedure, the mercury-containing waste products undergo vacuo-thermal treatment. This is done in special, hermetically sealed facilities in batches. With temperatures between 350°C and 650°C, the mercury vaporizes and then condenses at lower temperatures (see [Figure 19.10](#)).

### 19.2.4 Nickel/Metal Hydride Batteries

Just after the market launch of nickel/metal hydride batteries, the German company NIREC began work on the recycling of these batteries in order to put the nickel back into the cycle of materials. The system places procedural emphasis on the separation, reclamation, and use of the high-quality nickel content and the potential risk of hydrogen. Due to the possibility of hydrogen being released as the NiMH batteries are broken down, the processing must be done in a vacuum environment. Thus, using a vacuum system, the batteries are passed through a cutting chamber which opens up the casing and releases the stored hydrogen. This is constantly drawn off by



**Figure 19.9** Recycling process of Accurec. Source: Accurec.

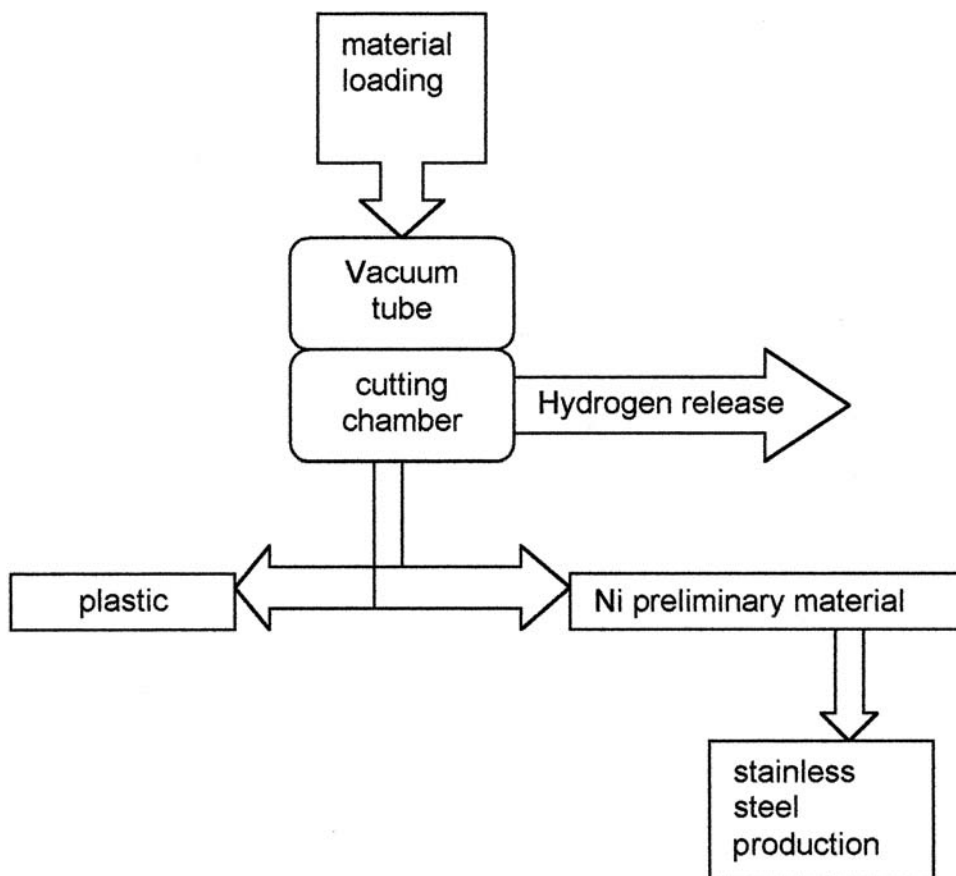


**Figure 19.10** Recycling of R9 batteries containing mercury. Source: EPBA.

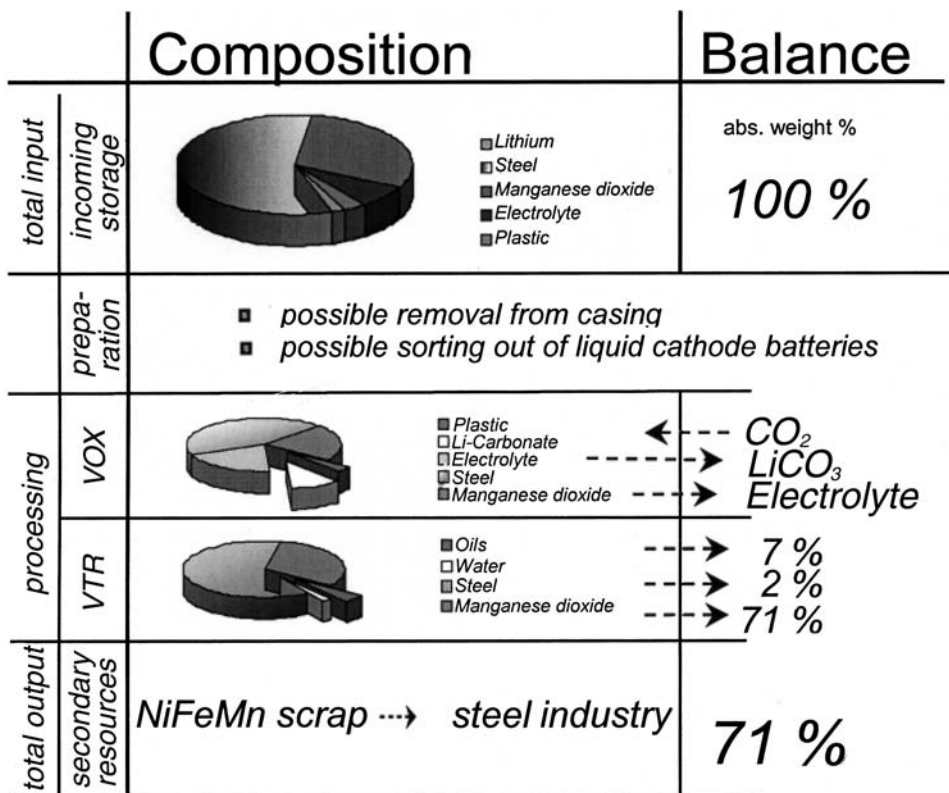
the difference in pressure. The batteries then go into a collecting tank. After expiry of a stabilization period monitored by sensors and then aeration to render it inert, the material can then be taken out. After separation of the plastic content, a usable product is obtained with a high nickel content, which can then be reused as a significant alloy component in stainless steel production (see Figure 19.11).

### 19.2.5 Lithium Batteries

Recycling procedures have also been developed fairly recently for the newer lithium primary and secondary systems. They are currently in the pilot phase but the early stages look promising. Thus, for example, the Mülheim-based company Accurec has developed the RVD (recycling through vacuum distillation) procedure for lithium manganese oxide ( $\text{Li-MnO}_2$ ) batteries (see [Figure 19.12](#)).



**Figure 19.11** Process diagram for the NiMH battery recycling facility. Source: NIREC.



\*Rest: CO<sub>2</sub> from graphite, water from the electrolyte

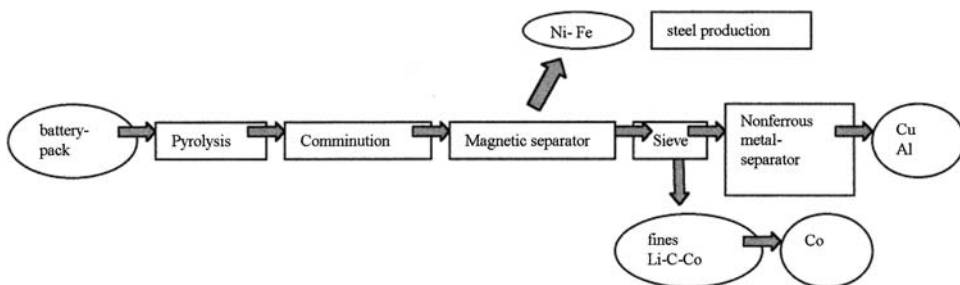
**Figure 19.12** Recycling balance for lithium batteries. Source: ACCUREC.

S.N.A.M. in St. Quentin Fallavier (France) also offers a reprocessing procedure for lithium secondary systems, which is currently in the pilot stage. Here, after deactivation the metals are separated and returned to the production cycle (Figure 19.13).

### 19.2.6 Zinc-Carbon and Alkali-Manganese Batteries

Previously, zinc-carbon and alkali-manganese batteries still contained mercury. There were no recycling facilities and removal of the small quantities of mercury using the existing recycling technologies was extremely costly. This resulted in two major developments for the recycling of these batteries:

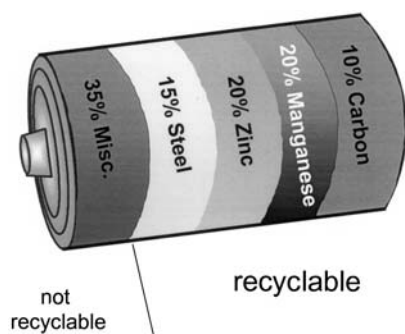
1. Development of technologies for the avoidance of mercury in these primary batteries.
2. Development and promotion of battery-specific recycling processes to extract mercury and other metals.



**Figure 19.13** Lithium-ion processing. Source: S.N.A.M.

In the early 1980s, the battery industry agreed to reduce the mercury content from the then 1% by weight to ultimately reach 0% by weight in AlMn and ZnC batteries. For some years now, European manufacturers have been producing these batteries without mercury. As soon as the battery waste flow is nearly free of mercury, and batteries containing mercury can be separated from mercury-free batteries in sorting facilities, recycling makes economic and ecological sense (see Figure 19.14).

Below is a description of several recycling procedures for alkali-manganese, zinc-carbon and zinc/air batteries.



**Figure 19.14** Average composition of a primary battery. Source: EPBA.

### 19.2.6.1 Rotary Furnace

The rolling process is a metallurgical process carried out in an inclined furnace which rotates around its own axis, known as the rotary furnace or drum furnace. The zinc-containing waste is loaded into the rotary furnace together with aggregates (sands) and reducing agents (coke). These flow through the rotary furnace, which is tilted 2.5°, in a reverse flow to the hot process gases. The loaded material is thereby gradually heated to the operating temperature. Within the material bulk, the zinc, lead, and iron compounds are reduced at temperatures of up to 1300 °C. Zinc and lead evaporate due to their low vapor pressure. Fresh air is supplied in a counterflow to the fixed bed flowing through the rotary furnace. Under these oxidizing conditions, zinc oxide and lead oxide are formed again. These oxides leave the furnace with the process gases. The waste gas first flows through the dust chamber, where a part of the entrained dust as well as the material backflow caused by a material jam in the furnace build up. This material is fed directly back into the furnace. The waste gas is then cooled. In these downstream coolers and filters, the metal oxides are emitted as high-quality rolled oxide. The process gas, which has been purified of the rolled oxide, is then sucked through an adsorption filter to remove gaseous pollutants. The material in the furnace, now largely free of zinc and lead, together with the coke ash, forms the so-called rolled slag, which undergoes a partial reoxidation of the iron near the furnace discharge area due to the prevailing oxidizing conditions there. At the furnace discharge, this slag falls through a slag chute into a water jet and is conveyed to a water basin in granulated form. The rolled slag is used in, among other things, road construction. The rolled oxide is forwarded to primary zinc foundries (smelting furnaces or electrolyses) and thus returned to the zinc metal cycle.

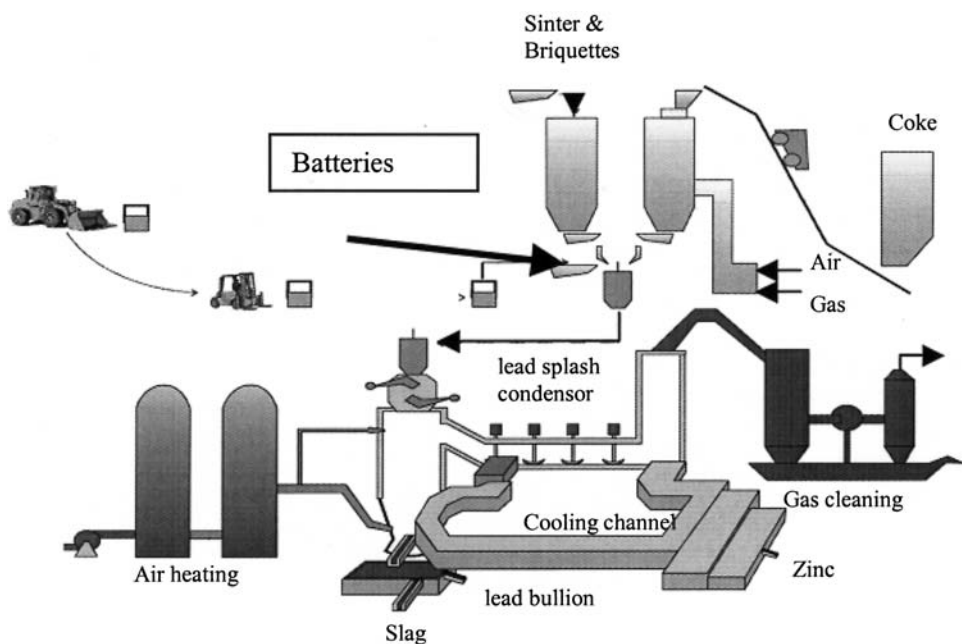
### 19.2.6.2 The Imperial Smelting Process

Alkali-manganese and zinc-carbon batteries (up to a maximum of 100 ppm Hg) are melted together with other preliminary materials. The zinc is reclaimed during the gaseous phase and thus permanently separated from most of the accompanying elements ([Figure 19.15](#)).

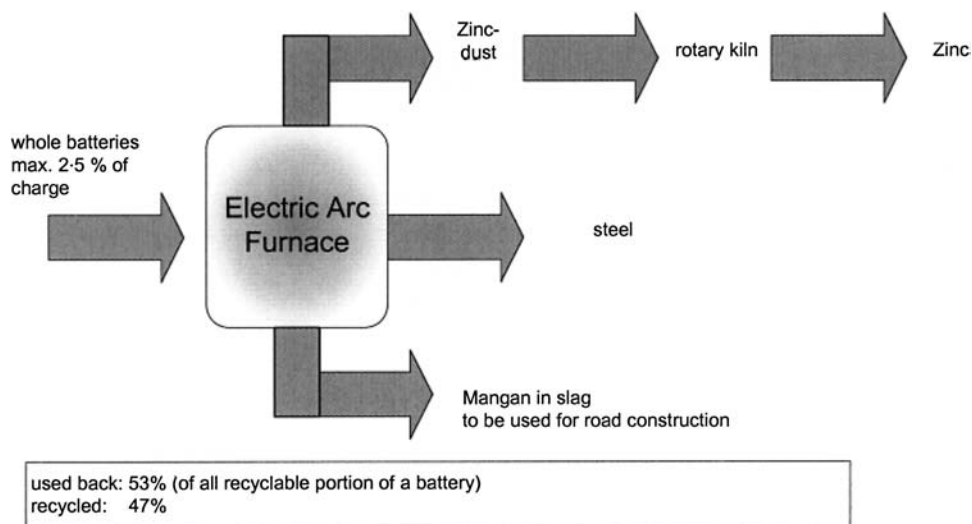
### 19.2.6.3 Electric Arc Furnace/Steel

Electric arc furnaces use a variety of processes to manufacture either steel or ferromanganese. In both cases the zinc is reclaimed as zinc dust and then converted to pure zinc in the rotary furnace. Any slag that develops is used in road construction. Electric furnaces are heated with electricity, either by means of an electric arc formed between two carbon electrodes or in an induction furnace by means of resistance heating. Because contamination by fuel and firing gases cannot occur, the soft electric steel is distinguished by its high degree of purity (see [Figure 19.16](#)).

Nedstahl in Amsterdam now processes ZnC batteries in this way for the Common Battery Recycling and Collection System run by battery manufacturers in The Netherlands (STIBAT).



**Figure 19.15** System diagram. Source: MHD M.I.M.



**Figure 19.16** Steel production in an electric arc furnace. Source: EPBA.

19.2.6.4 Electric Arc Furnace/Ferromanganese

Valdi in Feurs (France) also offers this procedure for alkali-manganese and zinc-carbon batteries containing mercury (Figure 19.17).

19.2.6.5 Converter Steel Furnace/Ferromanganese

Instead of the electric arc furnace, ZnC and AIMn mercury-free batteries can also be processed in conventional converter steel furnaces. Tests have already been carried out at the Duisburg copper foundry. Work is still in progress for the commercial use of this process.

In the blast furnace, under the influence of the coke, the iron oxide is reduced to raw iron and the material is separated into recyclable products. Zinc is vaporized in the blast furnace and reclaimed in the gas purification process in the form of zinc concentrate, which is forwarded to zinc foundries. The raw iron is run off from the blast furnace in elementary form and the slag recycled.

19.2.6.6 Oxy Reducer

Citron, in Le Havre, France, offers this process, which emphasizes the recycling of alkali-manganese and zinc-carbon batteries containing mercury (Figure 19.18). The quality of the sorting is allegedly not so important in this process.

During the oxy reducer process,

- The waste is heated.
- Metals (e.g. Zn, Cd, Pb, etc.) are vaporized and oxidized.
- The mercury is condensed in metallic form.
- Organic components are completely burned off.
- The metal oxides are reduced.

Table 19.5 provides an overview of the procedures described above.

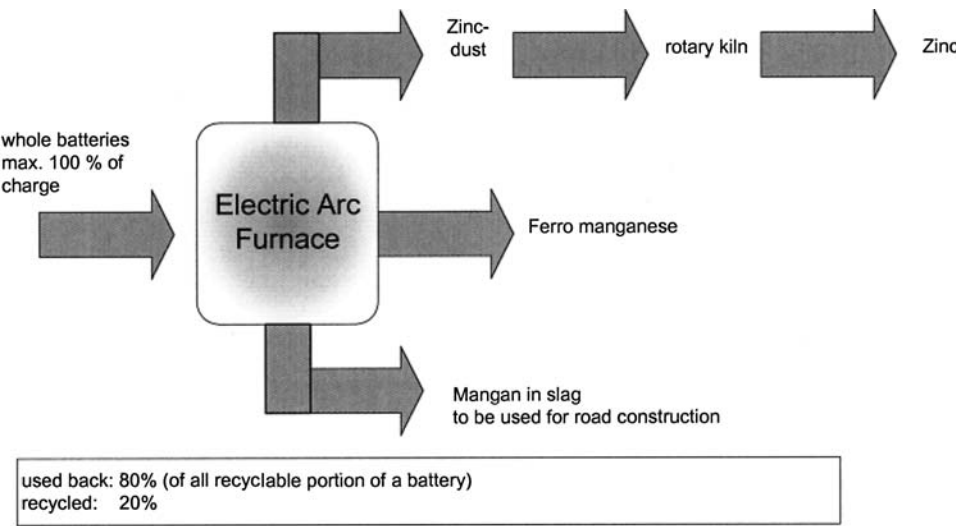
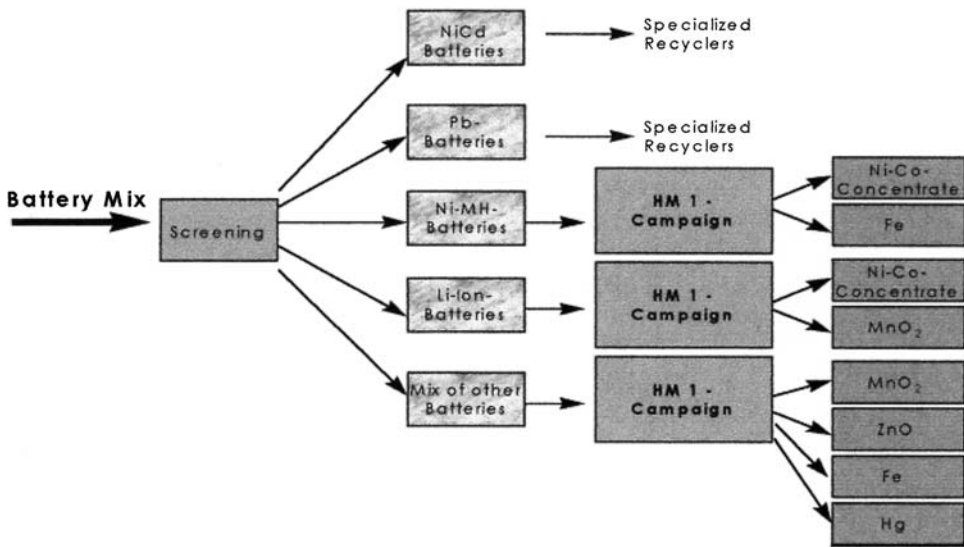


Figure 19.17 Ferromanganese production in electric arc furnaces. Source: EPBA.

**Table 19.5** Overview of recycling processes.

| Process              | Rotary furnace             | Imperial smelting<br>furnace/ISF | Electric arc furnace/<br>EAF/steel     | Electric arc furnace/<br>EAF/ferromanganese | Converter steel<br>furnace/<br>ferromanganese | Oxy reducer                                                              |
|----------------------|----------------------------|----------------------------------|----------------------------------------|---------------------------------------------|-----------------------------------------------|--------------------------------------------------------------------------|
| System<br>(examples) | BUS, Freiberg              | MHD, M.I.M.,<br>Duisburg,        | Nedstahl, Ablasserdam<br>(Netherlands) | Valdi, Feurs (France)                       | DK, Duisburg                                  | Citron, Le Havre<br>(France)                                             |
| Battery input        | 10–20%                     | 2–3%                             | 2–3%                                   | 100%                                        | 2–3%                                          | 100%                                                                     |
| Product              | Zinc oxide, slag<br>(alk.) | Zing, slag                       | Zinc dust, slag, steel                 | Zinc dust, slag,<br>manganese steel         | Zinc dust, lead, slag,<br>raw iron            | Zinc oxide, nickel-<br>cobalt alloy, iron<br>manganese oxide,<br>mercury |

Source: GRS Batterien.



**Figure 19.18** Citron Process for the Recycling of Batteries. Source: Citron.

### 19.3 THE GERMAN BATTERY DECREE

The German Battery Decree (decree concerning the collection and disposal of used batteries and accumulators (BattV) of March 27, 1998) came into force in two phases: the first phase concerned labeling provisions and a ban on marketing and has been in place since April 1, 1998. This is a direct implementation of the EU Directive. The second phase concerned the obligations of the manufacturers, importers, distributors, municipalities, and end consumers and had to be implemented by these parties after October 1, 1998: Manufacturers and importers are obliged to provide distributors and municipalities with suitable collecting tanks and must take away the collected portable batteries free of charge.

Manufacturers/importers can join a common collection system or carry out the collection individually. Individual collection by single manufacturers and via third parties commissioned to do so is permitted in accordance with §4(3) in combination with §16 of the German Battery Decree. This makes sense primarily for batteries used for special purposes, in which batteries of one brand or type (e.g. construction site batteries, lithium batteries for heat meters, etc.) occur in isolated instances.

The distributors and municipalities have a duty to collect the batteries free of charge and regardless of the brand or system.

Wherever batteries are sold, these must be taken back free of charge. However, the public waste disposal services (districts and independent municipal entities) will take back batteries free of charge from private end users and small businesses

within the framework of the mobile and stationary collection of hazardous substances.

It is not just a question of the manufacturers' duty to *collect*, however; it is also the end consumers' duty to *return* the batteries. Regardless of their electrochemical system and hazardous substance content, used batteries may no longer be disposed of in domestic waste. The end user is the first in the collection chain: he must return used batteries to the distributors or the municipalities.

## 19.4 THE MANUFACTURERS' COMMON COLLECTION SYSTEM

The new German Battery Decree obliged manufacturers and importers to take charge of the sorting, recycling, and disposal of used portable batteries. Under §4(2), the German Battery Decree provides for a common collection system among manufacturers. As a result of this, Duracell, Panasonic, Philips, Energizer, Saft, Sanyo, Sony, Varta, and the German Electrical and Electronic Manufacturers' Association established a foundation: the Common Battery Collection and Recycling System (GRS Batterien) as a non-profit organization. The Senate of the City of Hamburg approved the foundation in May 1998.

The service provided by GRS is equally available to all manufacturers and importers. The users of GRS pay a contribution towards waste disposal costs for the batteries marketed by them in Germany, according to weight and system. The foundation provides distributors and municipalities as well as commercial users with appropriate collection and transportation containers free of charge and organizes sorting and disposal in accordance with the German Battery Decree.

In the meantime, more than 400 manufacturers and importers of portable batteries have joined GRS. These users put approximately 30,000 tons of portable batteries into circulation in 2000.

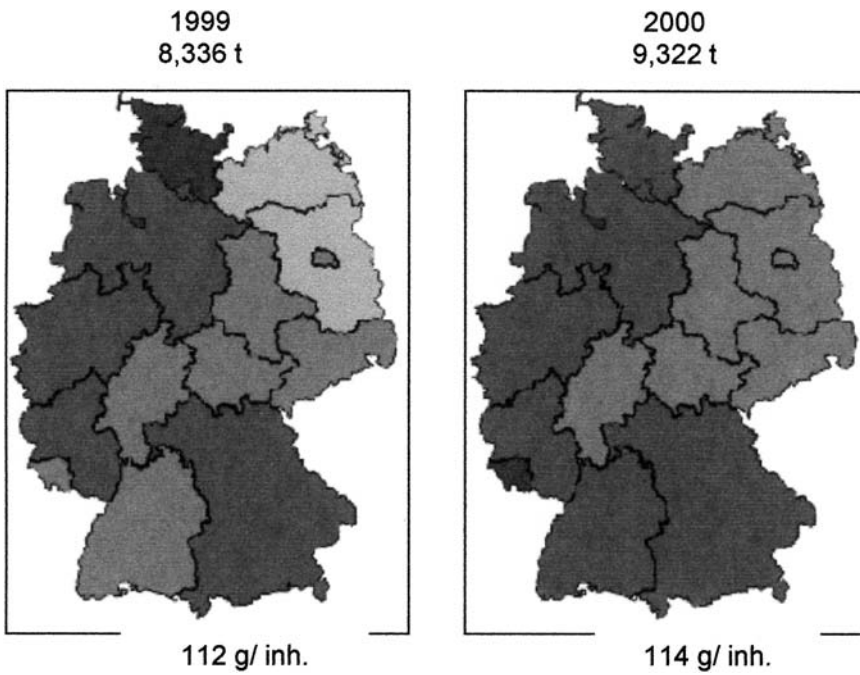
There are now approximately 130,000 retail outlets equipped with an initial 240,000 collection boxes and 400,000 transportation containers in a closely meshed network covering Germany nationwide. Numerous commercial users and nearly all public waste disposal services likewise use the GRS collection system and have been equipped with roughly 65,000 plastic containers for collection and pick-up.

Since 1998 the quantity collected has risen continuously. In 2000 9266 Mg were collected, an increase of approximately 11% over 1999 (8336 Mg). In 2000, an average of 112 g per head of the population was collected (see [Figure 19.19](#)).

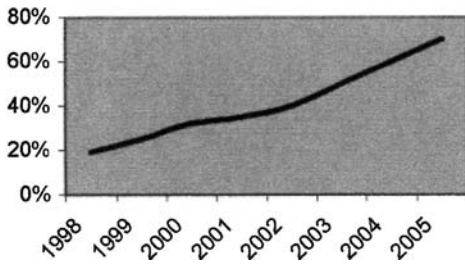
Due to the increased circulation of UV-coded batteries, their sorting via UV detectors, and the general reduction of the mercury content in the battery waste stream thanks to the prohibition against bringing ZnC and AIMn batteries containing mercury into circulation, the proportion of recycled batteries will rise successively to over 70% in the year 2005 (see [Figure 19.20](#)).

End users have been made aware of the free battery disposal through numerous public relations measures. Battery return has never before been so easy for end consumers.

After the batteries have been collected, GRS Batterien organizes the sorting of the batteries into the various electrochemical fractions and the subsequent disposal. Between 6000 and 7000 orders per month reflect the resounding acceptance of the system (see [Figure 19.21](#)).



**Figure 19.19** Collection by land. Source: GRS Batterien.



**Figure 19.20** Increase of share of recycling.



**Figure 19.21** Batt-Man. Source: GRS.

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