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Survey of Heavy Metal Content of Batteries - Analysis of Representative Samples of Customary Batteries and Batteries Sold in Appliances - Preparation of a Sampling Plan, Purchase of Samples an Analysis (Hg, Pb, Cd)

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Survey of Heavy Metal Content of Batteries – Analysis of Representative Samples of Customary Batteries and Batteries Sold in Appliances – Preparation of a Sampling Plan, Purchase of Samples and Analysis (Hg, Pb, Cd)

by
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Federal Institute for Materials Research and Testing (BAM)
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Überprüfung der Schwermetallgehalte von Batterien – Analyse von repräsentativen Proben handelsüblicher Batterien und in Geräten verkaufter Batterien – Erstellung eines Probenahmeplans, Probenbeschaffung und Analytik (Hg, Pb, Cd)		
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16. Zusammenfassung

Ziel des Projekts war es, über eine gut ausgewählte Stichprobe eine qualitative Situationsbeschreibung bezüglich der Einhaltung der Schwermetallverbote der Batterieverordnung zu erhalten. Nach geltenden Vorschriften dürfen die Gehalte folgende Grenzwerte nicht überschreiten: 5 ppm Quecksilber (Hg; Knopfzellen: 20000 ppm Hg), 250 ppm Cadmium (Cd) und 4000 ppm Blei (Pb).
Dazu wurden Mignon-Zellen (Alkali-Mangan, Zink-Kohle), Monozellen (Alkali-Mangan, Zink-Kohle), Knopfzellen verschiedener chemischer Systeme (Alkali-Mangan, Zink-Luft, Lithium, Silberoxid), eingebaute Batterien (herausnehmbar und fest eingebaut) von unterschiedlichen Herstellern aus unterschiedlichen Orten sowie Bezugsquellen auf ihren Gehalt an Cadmium, Blei und Quecksilber untersucht. Von jedem Batterietyp wurden zwei Exemplare, insgesamt 294 Proben analysiert. Anhand eines Probenahmeplans wurden Batterien in vier Regionen Deutschlands im Einzelhandel, bei Straßenhändlern sowie auf Flohmärkten und im Versandhandel käuflich erworben.
Für Rundzellen (Alkali-Mangan, Zink-Kohle) sowie Knopfzellen (Zink-Luft, Lithium, Silberoxid, Alkali-Mangan) wurden unterschiedliche Analysenstrategien entwickelt. So wurden die Knopfzellen nach Möglichkeit komplett gelöst und analysiert, bei den Rundzellen kam nur eine mechanische Zerlegung mit anschließender Analyse von Teilproben in Frage. Die Knopfzellen sowie die Teilproben der Rundzellen wurden mit Hilfe eines Säureaufschlusses mit Mikrowelle gelöst, zur Bestimmung der Elemente wurden abhängig vom Gehalt ICP-MS, ICP OES sowie ein automatischer Quecksilberanalysator verwendet, einzelne unlösliche Graphitteile aus Zink-Kohle Batterien wurden mit direkter Feststoff-ICP OES analysiert.
Als Ergebnis der Studie wurde erhalten, dass nur in zwei von 147 untersuchten Batterien der Gehalt an Quecksilber leicht oberhalb des Grenzwertes von 2 % lag, für Blei und Cadmium wurden keine Grenzwertüberschreitungen festgestellt. Bei den beiden Batterien, bei denen eine Grenzwertüberschreitung vorlag, handelte es sich um Zink-Luft-Knopfzellen, die vom Hersteller als Hg-frei deklariert waren. Unterschiede nach Bezugsort von Batterien desselben Sorte eines Herstellers bzw. nach verschiedenen Größen von Batterien desselben chemischen Systems eines Herstellers konnten nicht gefunden werden.

17. Schlagwörter

Zink-Luft, Lithium, Silberoxid, Alkali-Mangan, Zink-Kohle, Knopfzellen, Rundzellen, Batterie, Schwermetallbestimmung, Cadmium, Blei, Quecksilber

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Report Cover Sheet

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16. Abstract

The aim of the project was to describe the situation concerning the compliance with the existing limits for heavy metal content in commercially available batteries in Germany on the basis of a representative sample. The allowed limits which not have to be exceeded are: 5 ppm of mercury (Hg; button cells: 20000 ppm Hg), 250 ppm of cadmium (Cd) and 4000 ppm of lead (Pb).

Several batteries of different size such as „AA“ batteries (alkaline/manganese, zinc/carbon), „D“ batteries (alkaline/manganese, zinc/carbon) and button cells of different chemical systems (zinc-air; lithium; alkaline/manganese, silver oxide) were analysed for cadmium, lead and mercury. The test batteries came from different producers and were bought on different places in Germany. From each battery type two specimen were investigated, in total 294 samples. Following a sampling plan the batteries were purchased in four regions in Germany by retail, by mail order or on flew markets.

Different strategies for the analysis of „AA“ and „D“ batteries (alkaline/manganese, zinc/carbon) and for button cells (alkaline/manganese, zinc-air, lithium, silver oxide) were developed. Button cells were dissolved completely whenever possible. From the bigger types only subspecimens were analysed after mechanical destruction. Button cells and the subspecimens of the bigger batteries were decomposed with acid in a microwave oven. For the analysis of the heavy metals ICP-MS, ICP OES and an automatic mercury analyser were used depending on the content of the interesting element. Some graphite parts from zinc/carbon batteries were analysed using solid sampling ICP OES.

The result of the study was that only two of 147 batteries had Hg-contents slightly higher than the limit of 2 %. Pb- and Cd-contents were below the limits for all batteries investigated. The two batteries with higher Hg-contents were both zinc-air button cells declared by the manufacturer to be mercury-free. Differences between batteries of the same kind and producer purchased at different places or between batteries of different size but same producer and same chemical system could not be detected.

17. Keywords

Zinc-air, lithium, silver oxide, alkaline/manganese, zinc/carbon, button cell, battery, determination of heavy metals, cadmium, lead, mercury

18. Price	19.	20.

Content

List of Abreviations, mass units and symbols

ICP OES	Optical emission spectrometry with inductively coupled plasma excitation
ICP-MS	Mass spectrometry with inductively coupled plasma excitation
ESEM	Environmental Scanning Electron Microscopy
mg/kg	milligram per kilogram
AMA	Automatic Mercury Analyser
AAS	Atomic absorption spectrometry
g	gram
kg	kilogram
ml	milliliter
AA	Symbol for Mignon dry cells
D	Symbol for Mono dry cells
ETV-ICP OES	Optical emission spectrometry with inductively coupled plasma excitation and electrothermal sample vaporisation
LR	Symbol for chemical system: Alkaline/manganese
CR	Symbol for chemical system: Lithium
SR	Symbol for chemical system: Silver oxide
ZA	Symbol for chemical system: Zinc-air
PR	Symbol for chemical system: Zinc-air
AG	Used symbol for chemical system: Alkaline/manganese
R	Symbol for chemical system: Zinc/carbon
Bxx	Battery from Berlin
Kxx	Battery from Konstanz
Gxx	Battery from Guben
Rxx	Battery from the Ruhr region
Vxx	Battery from mailorder
PFA	Perfluoralkoxy-copolymer
BG	Limit of determination (calculated as 9 x s of the blank value)
CRM	Certified Reference Material

List of chemicals used

<u>Preliminary tests:</u>

Nitric acid (HNO_3) concentrated, purity p.a. (Fa. Merck)

Hydrochloric acid (HCl) concentrated, purity p.a. (Fa. Merck)

Perchloric acid ($HClO_4$) concentrated, purity p.a. (Fa. Merck)

Hydrogen peroxide (30 %, p.a., Fa. Merck)

Sulphuric acid (H_2SO_4) concentrated, purity p.a. (Fa. Merck)

Aqua regia (HNO_3 : HCl 1 : 3)

<u>Implementation:</u>

Nitric acid (HNO_3) concentrated, purity suprapur (Fa. Merck)

Hydrochloric acid (HCl) concentrated, purity suprapur (Fa. Merck)

Perchloric acid ($HClO_4$) concentrated, purity suprapur (Fa. Merck)

Aqua regia (HNO_3 : HCl 1 : 3)

Sulphuric acid (H_2SO_4) concentrated, purity p.a. (Fa. Merck)

Pb-Stock solution, prepared of Pb-Metal (99,99 %) in HNO_3

Cd-Stock solution, prepared of Cd-Metal (99,95 %) in HNO_3

Hg-monoelemental solution (Fa. Merck)

1 Introduction

1.1 Aims and tasks of the project

Aim of the project was to investigate the situation concerning the compliance of commercially available batteries with the limitations on the heavy metal content defined in the German Battery Ordinance to get the possibility to interfere if any problems arise. The investigation was done by analysing a representative amount of batteries which allows to give a qualitative description of the present situation. The motivation for such a study was the plan of the German government formulated in 2003 to decrease the heavy metal load of domestic waste. Although there is a country-wide common collection system for batteries in Germany, heavy metal containing batteries are one of the most important sources of heavy metals in domestic waste [1].

1.2 Legal status

Following the German Battery Ordinance (BattV) and the directives of the European commission 91/157/EEC and 98/101/EC [2] there are the following limitations concerning the heavy metal content of batteries:

1) Batteries are allowed to contain max. 5 ppm of mercury (Hg).
2) Button cells are allowed to contain 20000 ppm (2 %) of Hg.
3) Batteries which contain more than 5 ppm of Hg, more than 250 ppm of cadmium (Cd) and more than 4000 ppm of lead (Pb), are defined as „harmful substance containing“, they have to be marked and must not be incorporated into any device.

1.3 State of knowledge

In a former investigation carried out in 1996 by the Federal Environment Agency (UBA) on 30 different batteries (dry cells and 9 V-blocs, zinc/carbon and alkaline/manganese) no exceeding of any limit for the heavy metal content of batteries valid in that time could be detected [3].

Another investigation was carried out in the Netherlands in 1999 testing 118 batteries (alkaline/manganese, alkaline-button cells, lithium, nickel-cadmium, nickel-metal hydride, silver oxide, zinc/carbon). Only in 3 batteries the limit of 250 mg/kg of mercury valid in that time was exceeded. The more stringent limit of 5 mg/kg of mercury valid later was exceeded in 17 batteries [4].

An investigation performed in Switzerland in 2003 when in total 42 batteries were analysed (22 alkaline/manganese and zinc/carbon dry cells, 16 batteries supplied with technical devices or toys (14 alkaline/manganese and zinc/carbon dry cells and 2 button cells) and 4 incorporated batteries (3 button cells)), showed no exceeding of limits for cadmium and lead and only three for mercury in incorporated button cells [5].

In 2005/2006, the German Stiftung Warentest tested 26 batteries (17 alkaline/manganese dry cells (AA), 3 zinc/carbon dry cells (AA), 6 alkaline/manganese dry cells (AAA) and one lithium dry cell (AA), one Oxyride-cell (Ni-oxy-hydroxide, MnO_2/graphite) (AA) [6]. Main focus of this study was the performance of batteries and not their heavy metal content. Although some of the batteries were tested for their heavy metal content. All batteries analysed contained less heavy metals Pb, Cd and Hg than permitted.

2 Sampling

Following the specifications for the present study to investigate Mignon dry cells size „AA“ (alkaline/manganese, zinc/carbon), Mono dry cells size „D“ (alkaline/manganese, zinc/carbon), button cells of different chemical systems and incorporated batteries (removable and not removable) of different producers, supplied on different places in Germany and from different sources, a rough planning for sampling and the number of batteries to be tested was developed. The following number of batteries should be analysed:

1) 15 Mignon dry cells
   a) alkaline/manganese
   b) zinc/carbon

2) 10 Mono dry cells
   a) alkaline/manganese
   b) zinc/carbon

3) 100 button cells (different types)
   The following types exist:
   a) alkaline/manganese
   b) zinc-air
   c) silver oxide
   d) lithium

4) 15 incorporated batteries (removable) from
   a) watches (maximum price EUR 15,--)
   b) calculators (maximum price EUR 5,--)

5) 15 incorporated batteries (not removable) from
   a) shoes (flashlights)
   b) toys
   c) greeting cards

Since 2 specimen of every battery should be analysed, a total amount of 310 batteries resulted from the rough planning.
As already mentioned the batteries should be supplied from different sources and from different regions of Germany:

1) Sources of supply
   a) Retail trade, discounter
   b) Mailorder
   c) Flew markets, street hawkers
   d) Export, import

2) Regions of supply:
   a) Berlin (city, urban centre, North-eastern Germany)
   b) Konstanz (medium sized town, Southern Germany, area close to the border)
   c) Guben near the Polish border (Eastern Germany, area close to the border, countryside)
   d) Duisburg/Essen (urban centre, Western Germany) (additional batteries supplied from Kleve)

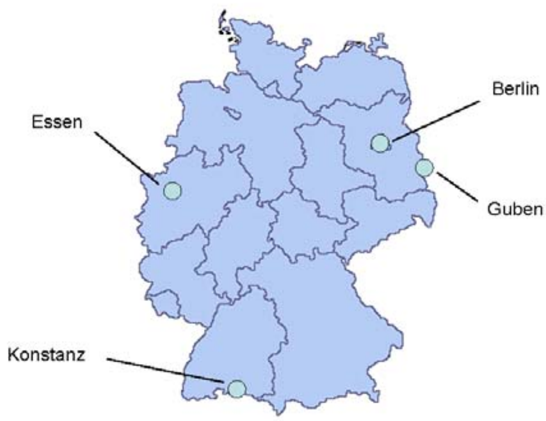

Fig. 1: regions of supply

To check for differences between batteries of same type and producer but from different regions a few batteries of same type and producer were supplied on different places.

In addition, batteries of same chemical system (e.g. alkaline/manganese) and producer but with different size (Mignon-Mono) coming from the same region should be investigated for differences in their composition.

Branded products as well as no-name products were analysed. Batteries which are sold under a trade brand are included in the group of no-name products.

The sampling plan developed considering the mentioned requirements is given in Annex 1. Since not all batteries which were planned to be analysed could be supplied, the sampling plan had to be modified during the investigation. Other batteries were tested instead of batteries not available. A detailed overview on all batteries analysed during the study is given Annex 2.

Since not all batteries which were foreseen to be tested were available a total amount of 294 instead of 310 batteries were analysed. The following tables give an overview on investigated batteries and their origin:

Batteries from	Number of batteries	Total number
Berlin	39	78
Konstanz	24	48
Guben	17	34
Essen	20	40
Mailorder	47	94
Total	**147**	**294**

Dry cells from	Total umber of batteries	Alkaline/manganese	Zinc/carbon	Total number
Berlin	6	4	2	12
Konstanz	4	3	1	8
Guben	2	1	1	4
Essen	4	2	2	8
Mailorder	9	3	6	18
Total	**25**	**13**	**12**	**50**

Batteries incorporated from	Number of batteries	Total number
Berlin	8	16
Konstanz	4	8
Guben	5	10
Essen	5	10
Mailorder	7	14
Total	**29**	**58**

Zinc-air cells	Number of batteries	Total number
Berlin	7	14
Konstanz	4	8
Guben	2	4
Essen		
Mailorder	5	10
Total	**18**	**36**

Lithium cells	Number of batteries	Total number
Berlin	7	14
Konstanz	5	10
Guben	3	6
Essen	4	8
Mailorder	9	18
Total	**28**	**56**

Alkaline/manganese cells	Number of batteries	Total number
Berlin	6	12
Konstanz	4	8
Guben	3	6
Essen	4	8
Mailorder	9	18
Total	**26**	**52**

Silver oxide cells	Number of batteries	Total number
Berlin	5	10
Konstanz	3	6
Guben	2	4
Essen	3	6
Mailorder	8	16
Total	**21**	**42**

3 Analysis

3.1 Procedures from the literature

There are only a few papers dealing with the determination of heavy metals in batteries. The authors of the Swiss study mentioned above opened the investigated batteries mechanically to separate the zinc fraction. Only this fraction was dissolved in HNO_3. Any residues were filtrated and discarded. The authors assumed that only the zinc fraction contained significant amounts of heavy metals. The determination of the heavy metals Cd, Pb and Hg was carried out using atomic absorption spectrometry [5]. Rastogi analysed Cd and Hg in different batteries after decomposition with HCl/HNO_3 (2:1 v/v). The solutions were analysed using AAS after filtration [7].

The industrial associations "European Portable Battery Association (EPBA)", "Battery Association of Japan (BAJ)" and "National Electrical Manufacturers Association (NEMA)" published a procedure for the determination of Hg, Cd and Pb in alkaline/manganese batteries. The batteries were mechanically opened and dissolved with HNO_3/H_2O_2 afterwards. The resulting solutions were filtrated, the determination of Pb and Cd was performed using flame AAS, Hg was determined using cold vapour AAS [8]. Guo and O'Hara modified this procedure to analyse Hg in Hg-free zinc-air button cells. They opened the cells mechanically and dissolved the different components with HNO_3/H_2O_2. The remaining gel coating was centrifugated and dissolved with HNO_3/H_2O_2 in a microwave oven. The determination of Hg was carried out using cold vapour AAS [9].

3.2 Preliminary tests for sample preparation

Preliminary tests to decompose batteries mechanically and chemically were carried out using spent batteries taken from the collection system for spent batteries. Depending on the type of battery different procedures were performed (Note: Details on the analysis performed, i.e. quantity of acids used for dissolution etc. are given in paragraph 3.3):

3.2.1 Zinc/carbon dry cell (Example: TIP NoName Battery AA)

<u>Opening of the battery:</u> first of all the battery was weighed. Using pincers the metallic coating was removed, then the negative pole could be separated. Subsequently the plastic coating which was sticked on the zinc-coating was removed. After that all components made of plastic and bitumen were taken off from the positive pole of the battery. The zinc coating was opened on the side and on the bottom using a saw. To determine the loss of material during the mechanical treatment all components were weighed again. The zinc coating was then opened completely using pincers.

Then the separator which enclosed the manganese dioxide (MnO_2) phase was separated from the zinc coating. Adjacent the MnO_2 could be removed from the separator. Finally the electrographic pen could be removed from the MnO_2 phase. After cleaning, all parts of the dry cell were weighed separately (see Table 1, Figure 2).

<u>Dissolution of the different components:</u> Only a small part of the weighed zinc coating was taken for analysis and dissolved in nitric acid. If concentrated nitric acid was used a strong heat and gas evolution (nitrous gases) resulted. The reaction was less intense if water was added at first followed by carefully adding nitric acid.

The negative and positive pole were also weighed and than dissolved either in nitric acid or in aqua regia. Heating was not necessary. If only nitric acid was used for the dissolution less interferences occur in ICP-MS analysis compared with the use of hydrochloric acid containing aqua regia.

Table 1: Composition of battery TIP NoName Zinc/carbon AA (*italic: components which are supposed not to be relevant for the total heavy metal content of the battery)*

	mass
Metallic coating	3,07 g
Plastic coating	0,15 g
Zinc coating	3,79 g
Positive pole (metallic)	0,24 g
Negative pole (metallic)	0,26 g
Bitumen or plastic at positive pole	0,33 g
Electrographic pen	1,6 g
Separator made of paper	0,39 g
paper shims *(2)*	0,11 g
(Manganese dioxide	7,31 g)*
Total mass	**17,25 g**

*The mass of manganese dioxide was calculated by subtraction of the masses of all other components from the total mass of the battery

The battery coating was also weighed, a part of about 0,5 g was cut subsequently which was dissolved in aqua regia after exact weighing. All metallic parts could be dissolved completely. Any residue e.g. plastic parts were decomposed using microwave digestion.

About 0,5 g of the manganese dioxide fraction was weighed and dissolved hydrochloric acid using a microwave oven (selected parameters see Table 3, paragraph 3.3). After filtration the filtrate was transferred into a 100 ml volumetric flask. The residue had to be weighed subsequently and treated as described in paragraph 3.3.1).

For the analysis of zinc/carbon dry cells four different solutions had to be analysed:

- Zinc solution
- Solutions of positive and negative pole
- Solution of coating
- Manganese dioxide solution.

3.2.2 Alkaline/manganese dry cell (Example: Duracell Procell Battery AA)

Opening of the battery: first of all the battery was weighed. Then the plastic coating was removed. The cap of the negative pole could then be removed using a screwdriver. Subsequently the steel coating was opened on the side and on the bottom using a saw and pincers. Before opening, the battery and all components already removed were weighed once again to determine any loss caused by the mechanical pre-treatment. After that the zinc part which was covered by the separator was removed. All components were weighed again, the amount of manganese dioxide was calculated by subtraction (see Table 2).

Dissolution of the different components: zinc powder was dissolved in nitric acid. To avoid excessive heat development 2 ml of water were given to the zinc powder followed by adding nitric acid step by step. Nail, negative pole and negative pole could be dissolved in nitric acid completely. To dissolve the remaining plastic components the nitric acid solution was transferred into a volumetric flask, than aqua regia was added to the plastic components. Dissolution was carried out in a microwave oven. After completion of the dissolution the two solutions were pooled.

The steel coating was dissolved in aqua regia, MnO_2 in hydrochloric acid.

For the analysis of alkaline/manganese dry cells four different solutions had to be analysed:

- Zinc solution
- Solution of nail, negative pole and negative pole cover
- Solution of coating

- Manganese dioxide solution.

Table 2: Composition of battery Duracell Procell Alkaline/manganese AA (*italic: components which are supposed not to be relevant for the total heavy metal content of the battery)*

	Mass
Plastic coating	*0,23 g*
Steel coating	3,84 g
Pole cover	0,22 g
paper shim	*0,01 g*
Pole, nail	1,3 g
(Manganese dioxide	12,23 g)*
Separator	*0,65 g*
Zinc gel	5,73 g
Total mass	**24,21 g**

* The mass of manganese dioxide was calculated by subtraction of the masses of all other components from the total mass of the battery

3.2.3 Button cells

It was planed to dissolve all button cells in acid whole without any mechanical pre-treatment. Therefore different acid mixtures were tested to dissolve batteries of all chemical systems (alkaline/manganese, lithium, silver oxide, zinc-air). Some of the lithium cells were cut into four pieces since they were too big to be dissolved whole (diameter too big). Not all batteries of the same chemical system behaved identically (Fig. 2 and Fig. 3).

Depending on the used acid mixture a certain amount of residue remained undissolved. Other authors solved this problem by discarding the residues [5, 6] assuming that these residues did not contain any heavy metals. A potential risk of this procedure is that batteries with heavy metal contents above the limits can remain undetected.

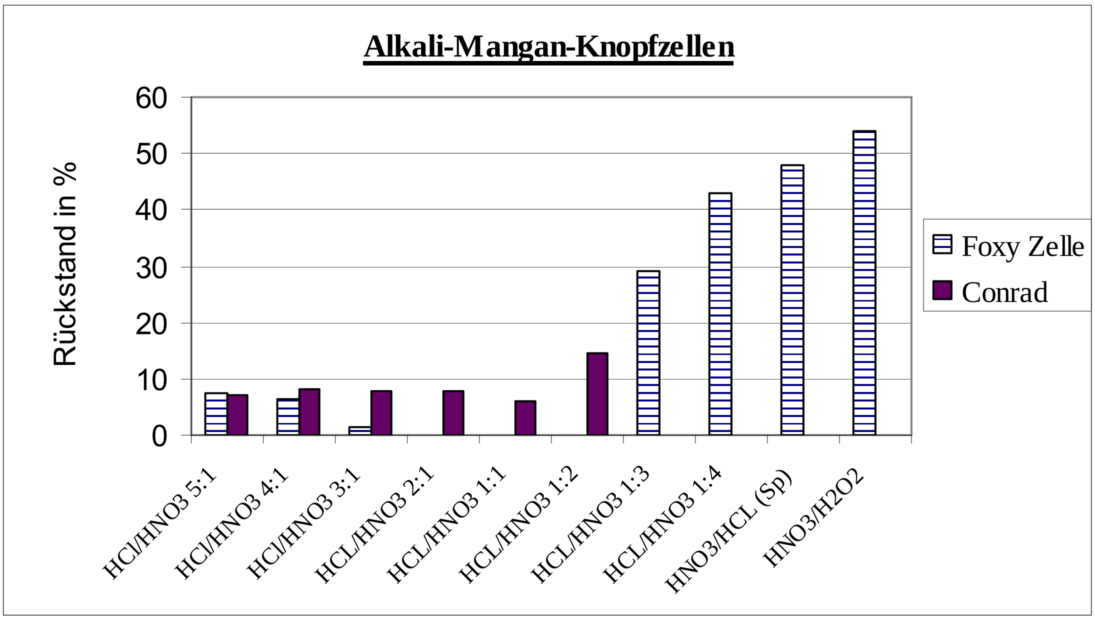

Fig. 2: Test of different acid mixtures to dissolve alkaline/manganese button cells. Two kinds of button cells from different producers were tested.

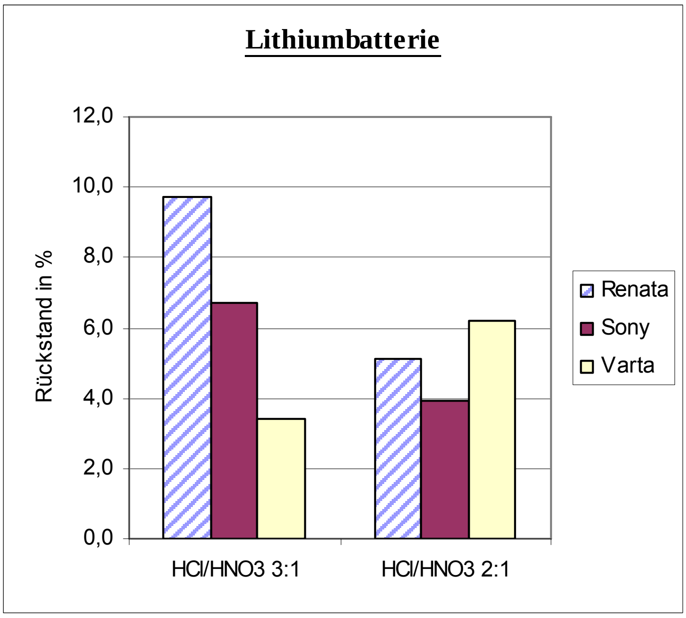

Fig. 3: Test of different acid mixtures to dissolve lithium button cells. Three kinds of button cells from different producers were tested.

The preliminary tests at button cells can be summarised as follows:

1) Zinc-air batteries can be dissolved with aqua regia in most cases without any insoluble residues. To digest alkaline/manganese button cells aqua regia and microwave heating was best suited. Depending on the composition of the hydrochloric acid/nitric acid mixture between 1 % and 10 % remained undissolved. Other acid mixtures (HNO_3/H_2O_2, H_2SO_4/HCl) were not suitable.
2) Lithium button cells could not be dissolved completely, the best results were obtained using different hydrochloric acid/nitric acid mixtures which vary between button cells of different producers (Fig. 2).
3) The steel coating of silver oxide button cells could be dissolved using aqua regia. Unfortunately the silver from the button cell then precipitated as silver chloride. To avoid this precipitation the silver/silver oxide fraction was separated from the steel coating mechanically. This fraction could then be dissolved with nitric acid.

3.3 Sample preparation and elemental analysis of dry and button cells

Button cells showed different dissolution behaviour depending on the chemical system. Therefore different acid mixtures were used.
Dry cells had to be treated in a different way than button cells because of their different configuration. After dissolution the sample solutions were analysed for lead, cadmium und mercury using ICP-MS, ICP OES and an AMA-mercury analyser.

Tab. 3: Instrumental parameters of the microwave digestion (used for all types of batteries)

Step	Power in W min	Power in W* max	Time min:s	vent
1	200	900	5:00	1 (25%)
2	900	900	25:00	1 (25%)
3	0	0	15:00	3 (100%)

*max. 75 bar/250°C

Often parts of the batteries were decomposed performing microwave digestion using a laboratory microwave oven Multiwave (Fa. PerkinElmer Life and Analytical Sciences, Inc., Wellesley, MA, USA). The instrumental parameters are given in Tab. 3.
In the case of any residue after the decomposition step the sample solutions were filtered over 8 µm cellulose acetate filter (Fa. Sartorius, Göttingen, Germany) and treated again if necessary.

3.3.1 Dry cells

Dry cells of Mignon type (AA) weighed between 11 g and 24 g, Mono type (D) dry cells between 82 g and 146 g. Therefore it was not possible to dissolve the dry cells wholly in acid. The maximum sample intake for microwave digestion was 1 g, i.e. sub samples of the dry cells had to be taken for analysis.
Thus all dry cells were opened mechanically. The different components were separated, weighed and subsequently analysed for their heavy metal content.

3.3.1.1 Zinc parts

First the zinc gel from alkaline cells as well as the zinc cups from zinc/carbon cells were weighed before analysis. About 0,5 g of these components were dissolved in concentrated nitric acid after exact weighing. To improve the decomposition the samples were treated in the microwave oven after the first reaction had subsided. The sample solutions were transferred in volumetric flasks and filled to the mark. Pb, Cd and Hg were then determined using ICP-MS. Additionally the Hg-content of some of the solid samples was determined without any digestion step using the AMA-mercury analyser.

3.3.1.2 Steel coating

About 0,5 g of the steel coatings, if existing, were cut using pincers after weighing the complete steel coating. This piece was transferred into the digestion vessel, 8 ml of aqua regia were added followed by microwave digestion after the first reaction had subsided. Since there was a residue in most cases, the solutions were filtrated afterwards, transferred in volumetric flasks and filled to the mark.
Determination of Cd, Pb and Hg-content was carried out using ICP-MS.

Fig. 4: Mechanical pretreatment of dry cells (zinc/carbon)

3.3.1.3 Manganese dioxide

To determine the heavy metal content of the MnO_2-fraction it was necessary to find out the total mass of MnO_2. Part of the MnO_2-fraction got lost while opening the batteries mechanically. Therefore the mass of MnO_2 was calculated by subtraction of the masses of all components except of MnO_2 from the total mass of the battery.

About 0,5 g of the manganese dioxide were transferred into a beaker after exact weighing. 8 ml of hydrochloric acid were added followed by heating on a hot plate and a filtration step.

The residue was transferred into a beaker together with the filter. 3 ml of sulphuric acid were added followed by heating until fuming. After cooling 1 ml of nitric acid were added again followed by heating until fuming. This procedure was repeated until the residue was completely dissolved (in most cases two to four times).

The resulting solution was transferred into a volumetric flask together with the filtrate and filled to the mark. After dilution the solution was analysed for Cd and Pb using ICP-MS.

Treating zinc/carbon cells following this procedure the residue could be dissolved nearly completely. In a few cases a small amount of a white residue, presumably silicon dioxide remained.

The alkaline cells were treated in the same way, but here a black coloured residue could not be dissolved. Therefore a second filtration step was necessary after the second decomposition step.

In contrast to all other components the digestion of MnO_2 was carried out in an open vessel. Possible losses of mercury were not relevant and could be neglected since this element was determined in the undissolved solid sample using the AMA-Mercury analyser.

3.3.1.4 Electrographic pen

The decomposition of graphite in acid is very difficult. Therefore the elements Cd, Hg and Pb were analysed using a solid sampling technique without any wet chemical treatment before the analysis.

In a first step the electrographic pens were weighed. The electrographic pens from Mignon cells were crushed mechanically to a fine powder subsequently.

Fine powder from pens coming from Mono cells was produced by drilling. Element determination was performed using ETV-ICP OES.

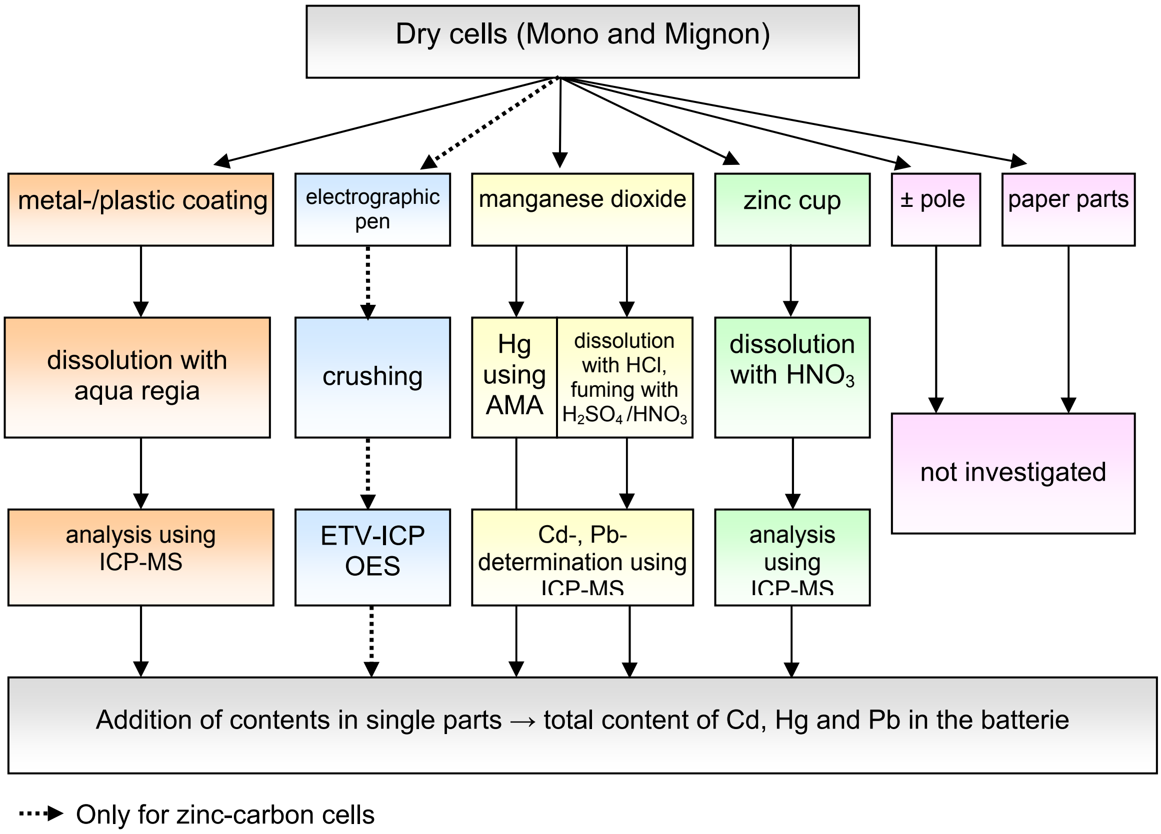

Fig. 5: Procedure for the analysis of dry cells

3.3.2 Alkaline button cells

Alkaline button cells were weighed and transferred wholly into the digestion vessel. 8 ml of aqua regia were added. After the first reaction had subsided the solution was treated in the microwave oven to minimise the amount of residue which was between 1,3 % and 7,7 %. This residue consisted of graphite which could not be dissolved by microwave digestion. Therefore the graphite was filtered, the filtrate transferred into a volumetric flask and filled to the mark.

The residue was analysed for Cd and Pb qualitatively using ESEM and for Hg using the mercury analyser to ensure that no heavy metals remained undetected. Only a very low amount of heavy metals was found which was very much lower than the heavy metals contents in the sample solutions. Since these amounts did not have a significant influence on the total heavy metal content of the investigated button cells they could be ignored.

3.3.3 Lithium button cells

Lithium button cells exist in several different sizes. The biggest ones investigated in this study were lithium cells of size CR2032 weighing about 2,9 g. It was not possible to dissolve them whole since they were too heavy for the microwave digestion system and too big for the digestion vessels.

All lithium cells heavier than 2 g were cut into two or four pieces using a bolt cutter and pincers. Lithium cells lighter than 2 g were analysed whole.

Each sample was weighed and transferred into the digestion vessels. 6 ml of hydrochloric acid and 3 ml of nitric acid were added. After 30 min reaction time the cap of the vessel was rinsed with 1 ml of hydrochloric acid and 0,5 ml of nitric acid to avoid any loss of particles.

Performing microwave digestion most of the sample was dissolved. The remaining residue was filtered, the filtrate transferred into a volumetric flask and filled to the mark.

Pb, Cd and Hg were determined using ICP-MS after appropriate dissolution (matrix concentration in the solution: about 0,1 g/l). Rhodium, indium, bismuth and platinum were used as internal standards.

3.3.4 Silver oxide button cells

Decomposition of silver oxide cells was difficult compared with the button cells of other chemical systems because silver oxide cells use silver oxide as cathode material. This could not be dissolved with aqua regia because of the precipitation of silver chloride. In the case where aqua regia was used as solvent a relatively large amount of residue remained.

If only nitric acid was used it was possible to dissolve the silver oxide cathode but not the steel coating. The zinc contained as a third component in the silver oxide button cells could be dissolved in aqua regia as well as in nitric acid and therefore caused no problems.

Finally the silver oxide cells were opened mechanically and the silver oxide was separated from the battery to decompose as much material as possible. After weighing the silver oxide was transferred into a digestion vessel, 5 ml of nitric acid were added before carrying microwave digestion. Since the material was not pure silver oxide a residue remained after the decomposition step which was filtrated. The filtrate finally was transferred into a volumetric flask and filled to the mark.
The remaining parts of the battery (steel coating, seals and zinc gel) were also weighed and decomposed using 10 ml of aqua regia and microwave heating. Only small amounts of residue remained which were filtrated before transferring the solution into a volumetric flask and filling to the mark.

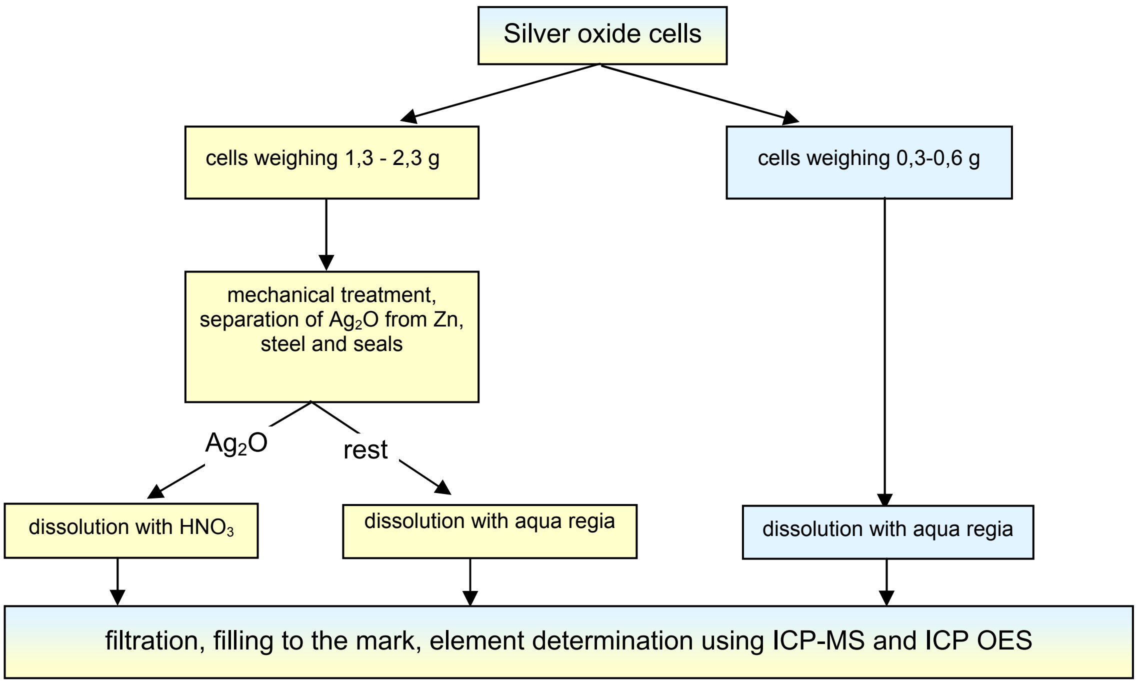

Fig. 6: Procedure for the analysis of silver oxide button cells

Following this procedure the results of the decomposition for silver oxide cells were satisfactory. Between 2 % and 9 % of the total mass remained undissolved which was acceptable. Unfortunately some of the button cells were too small to open them mechanically. These cells were weighed and dissolved with 10 ml of aqua regia in the microwave digestion unit followed by filtration. The filtrates were dissolved appropriately and analysed. About 30 % of these cells remained undissolved. The analysis of the button cells pretreated mechanically showed that the silver oxide fraction was nearly free of heavy metals. Therefore it could be concluded that most of the heavy metals were contained in the other fractions which could be decomposed completely.

3.3.5 Zinc-air button cells

Zinc-air button cells could be dissolved without any problem. These cells, composed of a steel coating, zinc gel and a small amount of seal material could be almost completely dissolved using aqua regia.

The cells were weighed and transferred into the digestion vessels. 8 ml of aqua regia were added. After waiting for 30 min to allow the first reaction to subside, the sample solutions were heated in the microwave system. Only a small sheet of teflon remained undissolved. This part was not considered because no heavy metals were expected in the teflon material.

The sample solutions were transferred into a volumetric flask and filled to the mark after addition of an internal standard. Pb and Cd were determined using ICP-MS. The mercury-content was determined using ICP OES and, in some samples using the AMA-mercury analyser.

3.4 Instrumental determination of the heavy metal content; quality assurance

3.4.1 ICP OES

An ICP OESpectrometer Jobin Yvon Ultima 2CHR (Fa. HORIBA Jobin Yvon SAS, Longjumeau France) was used to determine Hg in button cells. The intensity of the emitted light was measured using monochromator of the spectrometer and the 184,890 nm, 194,227 nm and 194,163 nm emission lines. Instrumental parameters are given in Table 4.

Table 4: ICP OES, instrumental parameters

RF-generator power	1000 W
Plasma gas, flow rate	12 l/min
Auxiliary gas, flow rate	0 l/min
Sheath gas, flow rate	0,2 l/min
Nebulizer gas, flow rate	0,02 l/min
Nebulizer gas pressure	3,4 bar
Sample uptake rate	1 ml/min
Nebulizer	V-groove
Spray chamber	cyclone
Argon humidifier	none
Injection tube diameter	3,0 mm

3.4.2 ICP-MS

A quadrupole ICP-MS instrument Agilent 7500c (Agilent Technologies, Inc. Santa Clara, CA, USA) was used for the determination of Pb and Cd in all batteries and of Hg in dry cells. All sample solutions were diluted before measurement because ICP-MS tolerates only solutions with low matrix load of about 0,1 g/l. Calibration was done using aqueous standard solutions. A comparison of the calibration curves established with matrix matched standards and aqueous standards showed that matrix matching of the standard solutions was not necessary. An advantage of aqueous standards were the lower blank values compared with matrix matched standards. All sample solutions were spiked with Rh, In, Pt and Bi as internal standards before final dilution. The following isotopes were used for the determination of the investigated heavy metals:

- ^{111}Cd, ^{113}Cd
- ^{206}Pb, ^{207}Pb, ^{208}Pb
- ^{199}Hg, ^{202}Hg.

In Table 5 the instrumental parameters used for ICP-MS analysis are given.

Table 5: ICP-MS instrumental parameters

Instrument parameter	Standard mode
RF-generator power	1500 W
Carrier gas, flow rate	0,8 l/min
Coating gas, flow rate	0,4 l/min
Nebulizer	Microconcentric, PFA
Spray chamber	Scott
Sample uptake rate	0,1 ml/min
Temperature spray chamber	2 °C
Lens voltage (Extract 1)	4,8 V
Lens voltage (Extract 2)	-95,5 V
Omega bias	-44 V
Lens voltage (Omega Lens)	7,6 V
Cell entrance voltage	-26 V
Quadrupol focus	2 V
Cell exit voltage	-38 V
Octopol bias	-6 V
Quadrupol bias	-3 V

3.4.3 Atomic absorption

A mercury analyser Leco AMA-254 (LECO Corporation, St. Joseph, MI, USA) based on atomic absorption was used for Hg-determination in liquid sample solutions in addition to ICP OES and ICP-MS and in solid samples like residues and insoluble compounds. The sample (liquid or solid) was decomposed in an oxygen-rich environment. A gold amalgamator trap collects all mercury from the evolved gases which is determined in a cold vapour atomic absorption spectrometer unit on the 253,7 nm line.

3.4.4 ETV-ICP OES

The determination of all three heavy metals (Cd, Pb and Hg) in the electrographic pens made of graphite and coming from the zinc/carbon dry cells was carried out using ETV-

ICP OES. About 2 – 4 mg of graphite taken from the electrographic pens were weighed and introduced into a graphite tube where the material was atomised by electrothermal vaporisation in a graphite furnace. An ICP OESpectrometer IRIS Advantage (Firma Thermo Electron Corporation, Waltham, MA, USA) with a graphite furnace ETV-4000 was used. During atomisation FREON R12 was added as reaction gas to ensure complete deliberation of the analytes. Calibration was performed by spiking 2,5 g of high purity graphite with aqueous standard solution followed by drying and homogenisation of the graphite in a mill. The instrumental parameters are given in Tab. 6.

Tab. 6: Instrumental parameters of ETV-ICP OES

element	wavelength	precondition temperature/time	atomisation temperature/time	calibration range in mg/kg
Cd	214,438 nm	400 °C / 20 s	2200 °C / 40 s	0 – 25
Pb	220,353 nm	400 °C / 20 s	2200 °C / 40 s	0 – 400
Hg	184,950 nm	100 °C / 20 s	1200 °C / 20 s	0 – 0,5

Only for lead contents above the limit of determination of the method (BG = 15 mg/kg) were found in some samples, for Cd (BG = 11 mg/kg) and Hg (BG = 0,6 mg/kg all contents were below the limits of determination.

3.4.5 Environmental Scanning Electron Microscopy (ESEM)

Environmental scanning electron microscopy is a special type of scanning electron microscopy which allows the analysis of sample under higher pressures than normal. This method was used to investigate qualitatively the residues of alkaline/manganese button cells remaining after microwave digestion to ensure that no heavy metals remain undetected in the residues. As mentioned in paragraph 3.3.2 this was not the case.

3.4.6 Quality control

Different approaches were embarked to ensure the accuracy of the results of the analyses. The most convenient way normally is to analyse certified reference materials (CRMs) together with the test samples. Since certified reference materials did not exist for all matrices investigated in this study and not all of the existing CRMs were certified for all interesting elements this approach was not possible to follow for all samples. In the case of analysis of zinc gel and zinc metal in zinc-air button cells and zinc/carbon dry cells using ICP-MS CRM BCR-325 pure zinc (IRMM Institute for Reference Materials and Measurements, Geel, Belgium) was used for quality control measurements. Mass fractions of Pb and Cd were certified in this material only. The following results were obtained: for Cd 93,5 ± 1,6 mg/kg (n = 9, cert. value: 94,7 ± 2,5 mg/kg) and for Pb 142 ± 3 mg/kg (n = 9, cert. value: 142 ± 9 mg/kg).

Analysis of the steel coating of dry cells and of lithium- and silver oxide button cells were controlled using a steel CRM, ECRM 090-1 (BAS Bureau of Analysed Samples, Middlesbrough, UK). Only the mass fraction of Pb was certified in this CRM. Since matrix matching of the standard solutions used for calibration of the ICP-MS the matrix of the CRM was not so important because of the high degree of dilution of the sample solutions. The following results for were obtained in ECRM 090-1: 24,3 ± 2,7 mg/kg (n = 18, cert. value: 23,9 ± 0,6 mg/kg).

Since no suitable CRMs were available to check the analysis of manganese dioxide coming from dry cells, known amounts of Pb and Cd were added to some of the samples to determine the recovery rates. Recovery rates of > 98 % were obtained.

Furthermore standard solutions used for calibration were measured as test samples to check and if necessary correct for possible drifts resulting from changes of the sensitivity of the instrument.

No reference materials with similar matrix composition were available for Hg-analysis. Therefore, some of the batteries were analysed using ICP-MS and atomic absorption. Moreover the zinc gel fraction of all alkaline/manganese dry cells were investigated using both methods. The results of both methods were not inconsistent with one another in any case but lower values for maximum Hg-contents could be given for batteries analysed with the AMA technique. With regard to the decision necessary whether the given limits for the Hg-content were met or not, it was sufficient to analyse the sample solutions with the less sensitive but less extensive method ICP-MS. The maximum contents given in Table 11 (see paragraph 4.6) were obtained using ICP-MS but it is justified to assume that the batteries investigated contained considerably less mercury than indicated.

All Hg-determinations carried out using the AMA technique were controlled analysing CRM BCR 143, a sewage sludge reference material with a certified mass fraction of Hg of 1,10 ± 0,07 mg/kg. Although the matrix was totally different the results indicated that the accuracy of the method was good.

4 Results

The results of the heavy metal determinations are given in paragraphs 4.1 to 4.5 differentiated by the chemical systems of the batteries. In Tables 7 to 12 only absolute values are given without any uncertainties. It is obvious that all results have a certain uncertainty but only a rough estimation of this uncertainty can be given. Each battery could only be analysed once although double or triple determination would be advantageous. This was not possible because too much effort would have been necessary and because most of the button cells were treated whole. In the case of dry cells only subsamples of the different fractions were analysed assuming that the heavy metal distribution was homogenous. Detailed investigations on the homogeneity of the different fractions were not performed. Systematic errors as a possible source of uncertainty could be almost completely excluded by parallel analyses of CRMs. Random deviations of about 2 % relative between certified and analysed values contributed to the total uncertainty.
The contribution of the weighing process to the total uncertainty could be neglected. Sample uptakes were between 100 mg and a few grams while the error of the balance was lower than 1 mg (i.e. maximum error: < 0,5 % relative). The uncertainty contribution from volumetric measurements e.g. for dilution steps was in the order of 1 % relative. The variation of results obtained from repeated measurements of the same sample solution was between 10 % and 2 % relative, depending on the concentration of the sample solutions.
Calculation of the combined measurement uncertainties u_c gave the following uncertainty values:

a) for higher contents:

$$u_c = \sqrt{0{,}02^2 + 0{,}005^2 + 0{,}01^2 + 0{,}02^2} = 0{,}03$$

Multiplication with a coverage factor of k = 2 gave an expanded uncertainty of approx. 6 % relative.

b) for lower contents:

$$u_c = \sqrt{0{,}02^2 + 0{,}005^2 + 0{,}01^2 + 0{,}12^2} = 0{,}103$$

Multiplication with a coverage factor of k = 2 gave an expanded uncertainty of approx. 20 % relative.

In the cases where only “less than – values” are given the measurement uncertainty is part of this value because the numbers given are then maximum contents. The real contents are lower.

4.1 Results of the analyses of zinc-air button cells

The results given in Table 7 show that the determined heavy metal contents in nearly all cases were below the limits.

All zinc-air button cells contained less than 2,5 mg/kg of Cd which was the limit of determination of the ICP-MS and which is lower than the limit by a factor of 100. Lead mass fractions were approx. 200 mg/kg for all cells (measurement uncertainty approx. 15 mg/kg), this is below the limit by a factor of 20 but above the limit of determination of the used analytical method. The situation was different for Hg were the mass fractions were between 8 mg/kg (U = 0,5 mg/kg) and 15 mg/kg (U = 1 mg/kg). In two batteries of different size of one producer (Weincell MRB400 and MRB675) Hg mass fractions were found at the limit. Because of the measurement uncertainty it could not be proved that the limit was significantly exceeded. Determination of mercury was carried out using ICP OES because of the higher mass fractions compared with Pb and Cd. In the case of the batteries mentioned above the results near the limit were checked performing an additional analysis using the AMA technique which gave similar results. It should be noted that the manufacturer of the batteries with Hg mass fractions near the limit declared his products to be free of mercury.

Table 7: Mass fractions of Cd, Pb and Hg in zinc-air button cells, relating to 1 kg of battery

				Cadmium		Blei		Quecksilber	
Int.Nr.	Marke	Größe	Gewicht Batterie in g	Massen-anteil in mg/kg	Grenzwert in mg/kg	Massen-anteil in mg/kg	Grenzwert in mg/kg	Massen-anteil in g/kg	Grenzwert in g/kg
B17a	Duracell	10	0,273	<BG	250	197,24	4000	12,10	20
B17b	Duracell	10	0,275	<BG	250	200,02	4000	12,10	20
B18a	Horning	10	0,294	<BG	250	192,02	4000	11,33	20
B18a	Horning	10	0,296	<BG	250	193,68	4000	12,11	20
B19a	**Rayovac**	10	0,298	<BG	250	195,19	4000	8,75	20
B19b	**Rayovac**	10	0,301	<BG	250	202,53	4000	9,61	20
B20a	Conrad Energy	ZA675	1,617	<BG	250	225,08	4000	10,92	20
B20b	Conrad Energy	ZA675	1,599	<BG	250	221,10	4000	10,96	20
B21a	Renata	ZA675	1,957	<BG	250	192,60	4000	11,53	20
B21b	Renata	ZA675	1,969	<BG	250	158,27	4000	9,68	20
B24a	WeinCell	MRB675	1,825	<BG	250	253,83	4000	**19,81**	**20**
B24b	WeinCell	MRB675	1,838	<BG	250	188,21	4000	**22,04**	**20**
B25a	WeinCell	MRB400	0,510	<BG	250	170,49	4000	**21,96/20,24**	**20**
B25b	WeinCell	MRB400	0,515	<BG	250	173,57	4000	**21,75/19,96**	**20**
G9a	Dr. Hähle	312	0,520	<BG	250	200,44	4000	12,28	20
G9a	Dr. Hähle	312	0,516	<BG	250	199,46	4000	12,55	20
G11a	**Rayovac**	13	0,788	<BG	250	254,35	4000	11,17	20
G11b	**Rayovac**	13	0,790	<BG	250	253,85	4000	11,15	20
K10a	**Rayovac**	10	0,297	<BG	250	198,11	4000	8,73	20
K10b	**Rayovac**	10	0,306	<BG	250	208,54	4000	7,79	20
K11a	Das Ohr	10	0,300	<BG	250	200,81	4000	14,74	20
K11b	Das Ohr	10	0,293	<BG	250	195,56	4000	15,70	20
K12a	**Rayovac**	13	0,786	<BG	250	235,50	4000	9,99	20
K12b	**Rayovac**	13	0,792	<BG	250	246,48	4000	10,32	20
K13a	Dynamic Ener.	312	0,513	<BG	250	185,72	4000	10,94	20
K13b	Dynamic Ener.	312	0,522	<BG	250	179,94	4000	11,04	20
V16a	Varta	312	0,520	<BG	250	206,03	4000	13,02	20
V16b	Varta	312	0,518	<BG	250	193,71	4000	12,90	20
V17a	Rayovac	312	0,507	<BG	250	198,70	4000	10,12	20
V17b	Rayovac	312	0,515	<BG	250	206,61	4000	10,15	20
V19a	Energizer	312	0,516	<BG	250	203,53	4000	< 1,9	20
V19b	Energizer	312	0,517	<BG	250	193,93	4000	< 1,9	20
V23a	"Panasonic"	PR2330	1,967	<BG	250	184,79	4000	7,99	20
V23b	"Panasonic"	PR2330	1,980	<BG	250	184,34	4000	7,67	20
V18a	Duracell	312	0,465	<BG	250	216,36	4000	13,05	20
V18b	Duracell	312	0,467	<BG	250	215,46	4000	13,15	20

BG: 2,5 mg/kg

Differences in heavy metal content between batteries of the same size and producers but supplied at different places could not be detected, see B19 and K10 (2. column of Table 7 dark grey coloured) as well as G11 and K12 (2. column of Table 7 reversed print). There are also no differences between batteries from the same producer and place of supply but of different size – see B24 und B25 – (1. column of Table 7 light grey coloured), the difference between the Pb-content of two batteries B24 is higher.

4.2 Results of the analyses of Alkaline/manganese button cells

Table 8 shows the results of the heavy metal determination of the investigated alkaline/manganese button cells.

Some batteries had mass fractions of cadmium below the limit of determination of ICP-MS (0,2 mg/kg), which is lower than the limit by a factor of 1000. All other cells contained not more than 9,5 ± 2 mg/kg of Cd which is lower than the limit by a factor of 25.

Lead was found in all alkaline/manganese button cells with contents below the limit by a factor of 80. The battery with the highest mass fraction of lead contained 95 ± 10 mg/kg.

In contrast to the zinc-air button cells the alkaline/manganese button cells contained mercury well below the limit. In no case were Hg-contents found near the limit.

The determination of Cd und Pb was performed using ICP-MS, Hg was determined using atomic absorption (Leco AMA).

Battery B27a could not be analysed because an error occurred during the digestion procedure. Therefore only battery B27b was analysed.

Differences in heavy metal content between batteries of the same size and producer but supplied at different places could not be detected, see B26 and K15 (2. column of Table 8 dark grey coloured) as well as G14 and K14 (2. column of Table 8 reversed print). There were only slight differences in mercury content between batteries from the same producer and same place of supply but of different size – see B39 and B40 – (1. column of Table 8 light grey coloured).

Table 8: Mass fractions of Cd, Pb and Hg in alkaline/manganese button cells, relating to 1 kg of battery

				Cadmium		Blei		Quecksilber	
Int.Nr.	Marke	Größe	Gew. Batterie [g]	Massen-anteil in mg/kg	Grenzwert in mg/kg	Massen-anteil in mg/kg	Grenzwert in mg/kg	Massen-anteil in g/kg	Grenzwert in g/kg
B11a	Musikkarte	L1131	1,1534	<BG	250	62,74	4000	5,07	20
B11b	Musikkarte	L1131	1,1610	<BG	250	65,69	4000	5,20	20
B13a	LCD Game	LR44	2,0082	0,680	250	52,44	4000	5,16	20
B13b	LCD Game	LR44	2,0156	0,555	250	54,36	4000	5,86	20
B14a	Spieltel.	LR44	1,9581	<BG	250	51,31	4000	5,74	20
B14b	Spieltel.	LR44	1,9520	<BG	250	49,93	4000	5,31	20
B26a	**Duracell**	LR44	1,8264	<BG	250	56,84	4000	2,66	20
B26b	**Duracell**	LR44	1,8379	<BG	250	55,17	4000	2,86	20
B27b	Panasonic	LR44	1,9203	<BG	250	37,15	4000	3,22	20
B28a	No Name	LR44	1,9386	0,763	250	57,49	4000	6,41	20
B28b	No Name	LR44	1,9802	0,663	250	54,49	4000	5,26	20
B29a	Camelion	LR54	1,1258	0,513	250	49,07	4000	5,51	20
B29b	Camelion	LR54	1,1162	<BG	250	49,98	4000	6,10	20
B7a	Otany Rechn.	L1131	1,0720	<BG	250	49,82	4000	2,99	20
B7b	Otany Rechn.	L1131	1,0697	0,308	250	51,47	4000	3,01	20
B39a	Renata	LR43	1,3297	<BG	250	36,47	4000	2,15	20
B39b	Renata	LR43	1,3307	0,580	250	37,90	4000	2,14	20
B40a	Renata	LR44	1,9108	0,230	250	42,52	4000	2,75	20
B40b	Renata	LR44	1,9160	<BG	250	37,74	4000	2,64	20
G14a	**Varta**	LR44	1,9513	0,671	250	42,07	4000	5,61	20
G14b	**Varta**	LR44	1,9319	0,623	250	39,34	4000	4,57	20
G15a	**Energizer**	LR44	1,8984	1,263	250	75,84	4000	3,81	20
G15b	**Energizer**	LR44	1,9018	1,084	250	71,62	4000	4,02	20
G16a	No Name	LR44	1,9659	<BG	250	52,55	4000	3,58	20
G16b	No Name	LR44	1,9522	<BG	250	52,73	4000	5,82	20
G3a	Scientific Rechner	L1131	1,0860	0,249	250	52,19	4000	3,44	20
G3b	Scientific Rechner	L1131	1,0830	0,598	250	50,11	4000	3,38	20
G5a	Grußkarte	LR41	0,6395	<BG	250	45,86	4000	4,50	20
G5b	Grußkarte	LR41	0,6461	<BG	250	43,81	4000	4,31	20
G6a	Smile Kamera	LR41	0,5966	5,031	250	63,92	4000	3,54	20
G6b	Smile Kamera	LR41	0,6000	5,503	250	62,91	4000	3,19	20
G8a	LED-Lampe	LR41	0,6129	0,490	250	54,55	4000	7,25	20
G8b	LED-Lampe	LR41	0,6088	0,592	250	51,22	4000	6,38	20
K14a	**Varta**	LR44	1,9403	0,613	250	40,71	4000	5,13	20
K14b	**Varta**	LR44	1,9438	0,553	250	39,14	4000	5,33	20
K15a	**Duracell**	LR44	1,8627	<BG	250	55,39	4000	3,07	20
K15b	**Duracell**	LR44	1,8325	<BG	250	53,76	4000	2,70	20
K16a	**Energizer**	LR44	1,8885	1,037	250	67,66	4000	3,98	20
K16b	**Energizer**	LR44	1,8716	0,616	250	68,80	4000	3,90	20
K17a	Panasonic	LR44	1,9283	<BG	250	40,43	4000	4,47	20
K17b	Panasonic	LR44	1,9247	<BG	250	39,37	4000	4,18	20
K5a	Grußkarte	LR41	0,6376	<BG	250	45,62	4000	3,58	20
K5b	Grußkarte	LR41	0,6371	<BG	250	45,39	4000	3,45	20
R13a	NoName	LR41	0,6319	<BG	250	41,28	4000	4,55	20
R13b	NoName	LR41	0,6387	<BG	250	41,37	4000	4,48	20
R14a	NoName	LR44	1,8733	<BG	250	52,05	4000	6,49	20
R14b	NoName	LR44	1,9233	0,52	250	57,04	4000	6,20	20
R15a	NoName	LR754	0,9367	8,007	250	54,94	4000	5,69	20
R15b	NoName	LR754	0,9427	9,547	250	56,73	4000	5,77	20
R16a	NoName	LR754	0,9015	0,610	250	46,85	4000	5,07	20
R16b	NoName	LR754	0,9034	0,498	250	50,82	4000	5,75	20
R5a	network rechner	AG10	1,0295	2,817	250	36,55	4000	1,95	20
R5b	network rechner	AG10	1,0212	0,588	250	34,68	4000	1,89	20
R7a	Grußkarte	LR41	0,6092	0,443	250	56,93	4000	6,41	20
R7b	Grußkarte	LR41	0,6165	0,584	250	52,40	4000	5,97	20
R9a	Weihnachtsmütze	LR44	1,9619	0,510	250	52,63	4000	6,51	20
R9b	Weihnachtsmütze	LR44	1,9507	0,308	250	55,44	4000	6,86	20
V10a	Eurorechner	AG10	1,1275	0,355	250	41,96	4000	4,87	20
V10b	Eurorechner	AG10	1,1139	0,628	250	38,90	4000	4,66	20
V13a	Fußballbär	LR44	1,9267	5,190	250	57,55	4000	4,29	20
V13b	Fußballbär	LR44	1,9052	7,348	250	58,40	4000	4,41	20
V14a	Lambada Modul	LR41	0,6312	0,666	250	40,94	4000	4,68	20
V14b	Lambada Modul	LR41	0,6297	<BG	250	42,97	4000	4,94	20

Table 8: Mass fractions of Cd, Pb and Hg in alkaline/manganese button cells, relating to 1 kg of battery (continued)

				Cadmium		Blei		Quecksilber	
Int.Nr.	Marke	Größe	Gew. Batterie [g]	Massen-anteil in mg/kg	Grenzwert in mg/kg	Massen-anteil in mg/kg	Grenzwert in mg/kg	Massen-anteil in g/kg	Grenzwert in g/kg
V15a	Voice Modul	LR1130	1,1871	<BG	250	94,47	4000	0,05	20
V15b	Voice Modul	LR1130	1,1990	0,751	250	93,91	4000	0,02	20
V24a	Varta	LR43	1,3598	0,552	250	40,06	4000	2,20	20
V24b	Varta	LR43	1,3697	0,515	250	39,67	4000	2,12	20
V25a	Energizer	LR43	1,4985	0,200	250	65,21	4000	3,54	20
V25b	Energizer	LR43	1,4958	5,019	250	70,42	4000	3,90	20
V26a	Panasonic	LR43	1,4863	0,202	250	42,19	4000	5,12	20
V26b	Panasonic	LR43	1,4861	0,303	250	41,81	4000	5,23	20
V27a	Duracell	LR43	1,3650	3,300	250	41,27	4000	2,27	20
V27b	Duracell	LR43	1,3608	1,103	250	40,01	4000	2,15	20
V28a	Vinnic	LR43	1,5010	0,900	250	78,36	4000	4,05	20
V28b	Vinnic	LR43	1,5039	0,255	250	76,95	4000	3,91	20
V29a	Vinnic	LR43	1,4991	<BG	250	69,07	4000	3,80	20
V29b	Vinnic	LR43	1,4998	0,300	250	66,81	4000	3,53	20
V30a	Ansmann	LR43	1,5006	0,600	250	38,26	4000	2,14	20
V30b	Ansmann	LR43	1,4936	2,011	250	41,03	4000	2,04	20
V31a	Chromex	LR44	2,0511	0,293	250	64,80	4000	7,25	20
V31b	Chromex	LR44	2,0232	0,297	250	68,82	4000	8,68	20
V32a	Camelion	LR44	1,9188	0,521	250	50,31	4000	5,76	20
V32b	Camelion	LR44	1,9068	0,734	250	53,30	4000	6,03	20

BG 0,2 mg/kg

4.3 Results of the analyses of silver oxide button cells

Table 9 shows the results of the heavy metal determination of the investigated silver oxide button cells.

All silver oxide button cells contained mass fractions of Cd below 1/10 of the limit. Lead could be determined in all silver oxide button cells, the contents were in all cases below the limit by a factor of 50. Mercury contents for all silver oxide button cells were below half the limit.

As already mentioned in paragraph 3.3.4, the digestion of very small button cells, where the mechanical separation of the Ag_2O fraction from the other parts of the cell was not possible, was not complete. In some cases considerable amounts of insoluble residue remained. But the results for button cells which could be digested almost completely showed that the silver oxide fraction contained much less heavy metals than the other components which could be dissolved.

Considering the high percentage of insoluble residue in the case of button cells which could not be pretreated mechanically the uncertainty in these cases was estimated to 50 %. Even in these cases it was possible to say that mass fractions of Pb, Cd and Hg were well below the limits.

Table 9: Mass fractions of Cd, Pb and Hg in silver oxide button cells, relating to
1 kg of battery

					Cadmium		Blei		Quecksilber	
Int.Nr.	Marke	Größe	Gew. Zink+Stahl [g]	Gew. Ag_2O [g]	Massen-anteil in mg/kg	Grenzwert in mg/kg	Massen-anteil in mg/kg	Grenzwert in mg/kg	Massen-anteil in g/kg	Grenzwert in g/kg
V49a	noname (Vinnic)	SR43	0,9343	0,5483	19,98	250	81,81	4000	3,44	20
V49b	noname (Vinnic)	SR43	0,9003	0,5874	18,37	250	79,14	4000	4,20	20
V48a	noname (Vinnic)	SR44	1,1681	0,6304	15,91	250	52,48	4000	4,15	20
V48b	noname (Vinnic)	SR44	1,1469	0,6684	18,83	250	59,14	4000	4,05	20
B31a	Duracell	SR43	1,3530	0,5659	12,66	250	35,29	4000	7,94	20
B31b	Duracell	SR43	1,4710	0,6924	12,80	250	37,41	4000	7,18	20
B32a	Energizer	SR44	1,1087	0,7898	5,79	250	56,68	4000	2,28	20
B32b	Energizer	SR44	0,9590	0,6728	6,97	250	74,90	4000	2,78	20
V50a	maxell	SR43	1,0937	0,5233	11,06	250	47,29	4000	2,53	20
V50b	maxell	SR43	1,0750	0,5445	14,25	250	38,57	4000	2,49	20
R17a	Varta	SR44	1,4918	0,6218	2,31	250	43,57	4000	2,62	20
R17b	Varta	SR44	1,4672	0,6322	6,89	250	55,33	4000	2,68	20
B30a	Varta	SR54	0,8201	0,4121	0,50	250	41,12	4000	2,53	20
B30b	Varta	SR54	0,8317	0,4058	0,92	250	39,78	4000	2,49	20
K18a	**Duracell**	SR44	1,2753	0,7800	21,57	250	49,53	4000	3,32	20
K18b	**Duracell**	SR44	1,1986	0,7780	22,85	250	55,04	4000	3,29	20
R20a	Panasonic	SR44	1,2872	0,8399	15,82	250	60,31	4000	2,90	20
R20b	Panasonic	SR44	1,3147	0,7763	16,04	250	62,07	4000	2,86	20
R21a	**Duracell**	SR44	1,2994	0,7246	17,45	250	51,88	4000	3,38	20
R21b	**Duracell**	SR44	1,2040	0,8678	16,45	250	48,66	4000	3,14	20
K19a	Panasonic	SR1130	0,8634	0,4586	11,38	250	62,96	4000	2,46	20
K19b	Panasonic	SR1130	0,8671	0,4506	12,07	250	54,17	4000	2,42	20
K20a	noname	SR626	0,3352		10,25	250	13,48	4000	2,71	20
K20b	noname	SR626	0,3308		10,40	250	7,45	4000	2,80	20
G22a	maxell	SR626	0,3848		8,80	250	22,26	4000	2,67	20
G22b	maxell	SR626	0,3860		17,27	250	17,36	4000	1,51	20
G21a	maxell	SR621	0,3008		7,60	250	7,63	4000	1,88	20
G21b	maxell	SR621	0,2971		7,81	250	13,92	4000	1,96	20
V34a	Duracell	SR66	0,3967		12,23	250	49,16	4000	2,60	20
V34b	Duracell	SR66	0,3963		13,65	250	43,75	4000	2,72	20
V42a	Varta	SR66	0,3779		0,26	250	42,38	4000	2,47	20
V42b	Varta	SR66	0,3772		1,12	250	43,54	4000	2,47	20
V46a	maxell	SR66	0,3896		12,40	250	35,07	4000	2,77	20
V46b	maxell	SR66	0,3817		10,49	250	34,19	4000	2,60	20
V45a	Panasonic	SR626	0,3853		15,53	250	55,63	4000	2,66	20
V45b	Panasonic	SR626	0,3829		18,47	250	65,46	4000	2,76	20
B42a	renata	SR721	0,4154		13,38	250	36,22	4000	2,18	20
B42b	renata	SR721	0,4132		14,15	250	38,56	4000	2,15	20
V47a	Energizer	SR66	0,3841		1,89	250	32,35	4000	5,05	20
V47b	Energizer	SR66	0,3841		1,99	250	33,15	4000	4,58	20
V11a	Uhrenbatt.		0,3845		9,92	250	31,73	4000	2,49	20
V11b	Uhrenbatt.		0,3863		10,91	250	30,56	4000	2,46	20
B10a	Uhrenbatt. REZ		0,3357		17,56	250	55,34	4000	5,28	20
B10b	Uhrenbatt. REZ		0,3189		14,22	250	44,18	4000	4,59	20
R6a	Uhr SH		0,3395		17,47	250	55,33	4000	5,14	20
R6b	Uhr SH		0,3348		16,38	250	57,95	4000	5,34	20
B41a	renata	SR41	0,6539		14,00	250	36,50	4000	2,39	20
B41b	renata	SR41	0,6573		17,14	250	37,53	4000	2,32	20

No differences in heavy metal content could be detected between silver oxide button cells of the same size and producers but supplied at different places, see K18 and R21 (2. column of Table 9 dark grey coloured). Batteries from the same producer and same place of supply but of different size – see G22 and G21 – (1. column of Table 9 light grey coloured) did not differ more than the two batteries from each other (G21a and G21b resp. G22a and G22b).

4.4 Results of the analyses of lithium button cells

Table 10 shows the results of the heavy metal determination of the investigated lithium button cells.

Mass fractions of Cd (highest content found: 2,8 ± 0,6 mg/kg), of Pb (highest content found: 12,1 ± 2,4 mg/kg) and of Hg (highest content found: 2,3 ± 0,5 mg/kg) were all well below the limits. The "less than values" given for some of the batteries, which were calculated using the limit of determination of the used method, differ between different cells because of the different sample uptake.

Differences in heavy metal content between batteries of the same size and producers but supplied at different places could not be detected for the lithium button cells, see G25 from Guben and V41, supplied from mailorder (2. column of Table 10 grey coloured). Batteries from the same producer and same place of supply but of different size – see B38 and B43 (1. column of Table 10 light grey coloured) as well as G25 and G26 (column of Table 10 reversed print) differ not more than batteries a and b (B38a, B38b as well as B43a and B43b resp. G25a, G25b as well as G26a and G26b).

In contrast to all other lithium button cells samples B44a and B44b were analysed for Hg using ICP OES instead of ICP-MS. Since the limit of determination of ICP OES is higher than the one of ICP-MS a higher maximum Hg-content is given for those batteries. This content was still below the limit.

Table 10: Mass fractions of Cd, Pb and Hg in lithium button cells, relating to 1 kg of battery

				Cadmium		Blei		Quecksilber	
Int.Nr.	Marke	Größe	Gew. Batterie [g]	Massen-anteil in mg/kg	Grenzwert in mg/kg	Massen-anteil in mg/kg	Grenzwert in mg/kg	Massen-anteil in mg/kg	Grenzwert in g/kg
B15a	Blinklichtschuh	CR2025	2,8597	1,47	250	< 5,56	4000	< 1,35	20
B15b	Blinklichtschuh	CR2025	2,8351	1,35	250	< 5,54	4000	< 1,35	20
B34a	Varta	CR2025	2,2987	1,70	250	6,11	4000	< 1,39	20
B34b	Varta	CR2025	2,2776	1,00	250	< 5,86	4000	< 1,43	20
B35a	Duracell	CR2025	2,2603	0,76	250	< 1,34	4000	1,43	20
B35b	Duracell	CR2025	2,2838	1,05	250	1,92	4000	1,45	20
B36a	Energizer	CR2025	2,5386	0,83	250	< 5,62	4000	0,48	20
B36b	Energizer	CR2025	2,5551	0,69	250	< 5,77	4000	< 1,40	20
B37a	Panasonic	CR2025	2,2900	0,71	250	< 5,47	4000	< 1,33	20
B37b	Panasonic	CR2025	2,2899	1,33	250	< 5,63	4000	< 1,37	20
B38a	renata	CR1025	0,5829	0,42	250	< 3,33	4000	< 1,42	20
B38b	renata	CR1025	0,5772	1,68	250	< 3,36	4000	< 1,44	20
B43a	renata	CR2016	1,7788	1,16	250	< 1,84	4000	1,20	20
B43b	renata	CR2016	1,7761	0,95	250	0,26	4000	1,20	20
B44a	Blinklichtschuh	CR2032	2,8339	1,86	250	2,57	4000	< 350	20
B44b	Blinklichtschuh	CR2032	2,8339	0,11	250	4,46	4000	< 300	20
G24a	panasonic	CR2032	2,8302	0,57	250	< 1,86	4000	< 1,62	20
G24b	panasonic	CR2032	2,8067	0,38	250	< 1,95	4000	< 1,70	20
G25a	**Camelion**	CR2032	2,9461	1,23	250	9,54	4000	0,61	20
G25b	**Camelion**	CR2032	2,9877	1,04	250	9,48	4000	0,55	20
G26a	Camelion	CR2016	1,4896	1,54	250	< 4,70	4000	1,35	20
G26b	Camelion	CR2016	1,5219	1,11	250	< 6,33	4000	1,58	20
K22a	noname	CR1216	0,6800	1,51	250	12,15	4000	1,42	20
K22b	noname	CR1216	0,6740	1,76	250	2,53	4000	1,44	20
K23a	Kodak	CR2032	2,8656	0,88	250	< 1,43	4000	< 1,66	20
K23b	Kodak	CR2032	2,8208	0,35	250	7,59	4000	< 1,60	20
K24a	noname	CR2032	3,0650	1,33	250	5,76	4000	1,22	20
K24b	noname	CR2032	3,0297	0,41	250	6,09	4000	1,62	20
K25a	Camelion	CR2025	2,4237	1,10	250	3,98	4000	1,23	20
K25b	Camelion	CR2025	2,4764	0,82	250	2,45	4000	1,12	20
K26a	noname	CR2016	1,6583	1,83	250	5,91	4000	0,79	20
K26b	noname	CR2016	1,6641	2,79	250	11,77	4000	0,53	20
R22a	Varta	CR2032	3,1136	0,43	250	4,93	4000	< 1,62	20
R22b	Varta	CR2032	3,1204	0,34	250	3,39	4000	< 1,63	20
R24a	noname	CR1220	0,7748	1,36	250	< 5,88	4000	0,53	20
R24b	noname	CR1220	0,7817	1,39	250	< 5,82	4000	0,92	20
R25a	panasonic	CR1025	0,6521	0,47	250	< 6,11	4000	< 1,49	20
R25b	panasonic	CR1025	0,6534	0,69	250	< 6,10	4000	< 1,48	20
R26a	Duracell	CR1616	1,1133	0,70	250	< 5,62	4000	0,12	20
R26b	Duracell	CR1616	1,0840	1,72	250	< 5,78	4000	0,34	20
V16a	noname	CR927	0,5217	0,72	250	3,63	4000	1,40	20
V16b	noname	CR927	0,5380	1,05	250	6,23	4000	2,27	20
V33a	Energizer	CR1620	1,3185	0,80	250	< 5,61	4000	< 1,36	20
V33b	Energizer	CR1620	1,3197	0,97	250	< 5,61	4000	< 1,36	20
V35a	Varta	CR1620	1,3259	0,25	250	< 5,58	4000	< 1,36	20
V35b	Varta	CR1620	1,3249	0,30	250	< 5,59	4000	< 1,36	20
V36a	panasonic	CR1620	1,3283	0,87	250	< 5,57	4000	< 1,35	20
V36b	panasonic	CR1620	1,3317	0,54	250	< 5,56	4000	< 1,35	20
V37a	Camelion	CR1620	1,2456	1,21	250	< 5,48	4000	0,35	20
V37b	Camelion	CR1620	1,2400	0,03	250	0,10	4000	0,12	20
V38a	Conrad	CR2032	2,9580	0,15	250	0,92	4000	0,83	20
V38b	Conrad	CR2032	2,9619	0,43	250	1,49	4000	1,04	20
V39a	Ansmann	CR1620	1,2651	1,56	250	2,65	4000	< 1,42	20
V39b	Ansmann	CR1620	1,2482	1,74	250	0,74	4000	0,68	20
V40a	Conrad	CR1620	1,2406	1,36	250	1,94	4000	0,26	20
V40b	Conrad	CR1620	1,2299	1,14	250	3,15	4000	< 1,35	20
V41a	**Camelion**	CR2032	2,8826	0,87	250	1,30	4000	1,97	20
V41b	**Camelion**	CR2032	2,9050	0,62	250	1,90	4000	0,68	20
V43a	Duracell	CR1620	1,2687	0,97	250	< 5,83	4000	0,61	20
V43b	Duracell	CR1620	1,2552	1,30	250	< 5,90	4000	0,51	20

4.5 Results of the analyses of alkaline/manganese- and zinc/carbon dry cells

Table 11 shows the results of the heavy metal determination of the investigated alkaline/manganese dry cells, Table 12 the results of the heavy metal determination of the investigated zinc/carbon dry cells. The total mass fractions of the heavy metals investigated were calculated by summation of the absolute quantities of heavy metals in the subsamples of the dry cells taking into account their total masses. In the cases where only „less than values“ were determined calculation was done with these maximum values, i.e. a „worst case estimation“ was performed.

Table 11: Mass fractions of Cd, Pb and Hg in Alkaline/manganese dry cells, relating to 1 kg of battery

				Cadmium		Blei		Quecksilber	
Int.Nr.	Marke	Größe	Gew. Batterie [g]	Massen-anteil in mg/kg	Grenzwert in mg/kg	Massen-anteil in mg/kg	Grenzwert in mg/kg	Massen-anteil in mg/kg	Grenzwert in mg/kg
B1a	NoName (Top Craft)	AA	12,95	< 0,96	250	8,55	4000	< 3,00	5
B1b	NoName (Top Craft)	AA	12,82	< 1,07	250	6,05	4000	< 3,07	5
B2a	NoName (TopCraft)	D	81,37	< 0,58	250	10,90	4000	< 3,07	5
B2b	NoName (TopCraft)	D	81,55	< 0,56	250	8,07	4000	< 3,01	5
B5a	**Varta**	AA	12,14	1,17	250	5,81	4000	< 3,53	5
B5b	**Varta**	AA	11,97	< 1,20	250	13,65	4000	< 3,51	5
B6a	**Varta**	D	77,42	0,10	250	43,36	4000	< 3,11	5
B6b	**Varta**	D	77,58	0,22	250	42,77	4000	< 3,09	5
G1a	Duracell	D	78,45	< 0,87	250	41,79	4000	< 3,30	5
G1b	Duracell	D	78,73	< 0,49	250	33,63	4000	< 3,19	5
K1a	**Varta**	AA	12,03	< 0,53	250	14,43	4000	< 3,52	5
K1b	**Varta**	AA	11,80	< 1,34	250	12,05	4000	< 3,87	5
K2a	**Varta**	D	77,27	0,48	250	43,09	4000	< 3,33	5
K2b	**Varta**	D	76,75	0,24	250	42,17	4000	< 3,41	5
K3a	NoName	AA	11,70	1,11	250	3,05	4000	< 3,28	5
K3b	NoName	AA	11,70	1,40	250	10,52	4000	< 3,17	5
K8a	Spielzeug	AA	11,62	1,11	250	73,39	4000	< 3,25	5
K8b	Spielzeug	AA	11,75	1,01	250	15,19	4000	< 3,36	5
R1a	Panasonic	AA	11,72	0,72	250	8,84	4000	< 3,33	5
R1b	Panasonic	AA	11,81	0,59	250	8,48	4000	< 3,21	5
R4a	NoName	D	67,38	1,64	250	14,17	4000	< 3,77	5
R4b	NoName	D	67,56	1,82	250	11,01	4000	< 3,51	5
V12a	Abschleppwagen	AA	11,74	0,49	250	92,82	4000	< 3,29	5
V12b	Abschleppwagen	AA	11,45	1,65	250	97,65	4000	< 3,28	5
V1a	Duracell	AA	12,24	< 1,05	250	10,99	4000	< 3,49	5
V1b	Duracell	AA	12,27	< 1,14	250	10,85	4000	< 3,57	5
V3a	NoName (Camelion)	AA	11,95	1,50	250	5,81	4000	< 3,20	5
V3b	NoName (Camelion)	AA	12,20	2,34	250	7,92	4000	< 3,09	5
V6a	Panasonic	D	75,38	0,58	250	6,53	4000	< 3,34	5
V6b	Panasonic	D	74,16	1,17	250	13,66	4000	< 3,38	5

Mass fractions of Cd and Pb of some dry cells and Hg of all dry cells were below the limits of determination of the applied analytical methods. Mercury in parts (zinc gel,

Table 12: Mass fractions of Cd, Pb and Hg in zinc/carbon dry cells, relating to 1 kg of battery

				Cadmium		Blei		Quecksilber	
Int.Nr.	Marke	Größe	Gew. Batterie [g]	Massen-anteil in mg/kg	Grenzwert in mg/kg	Massen-anteil in mg/kg	Grenzwert in mg/kg	Massen-anteil in mg/kg	Grenzwert in mg/kg
B3a	TIP Allzweckbatterie	D	91,917	< 14,6	250	896	4000	< 1,87	5
B3b	TIP Allzweckbatterie	D	92,497	< 13,5	250	907	4000	< 1,96	5
B4a	TIP Allzweckbatterie	AA	17,456	< 12,4	250	226	4000	< 3,75	5
B4b	TIP Allzweckbatterie	AA	17,391	< 12,0	250	271	4000	< 3,51	5
G2a	Panasonic	D	100,118	< 12,5	250	418	4000	< 2,21	5
G2b	Panasonic	D	100,007	< 12,4	250	401	4000	< 2,19	5
K4a	NoName (Dynamic Energy)	D	82,264	62,4	250	655	4000	< 1,83	5
K4b	NoName (Dynamic Energy)	D	82,196	56,9	250	842	4000	< 1,84	5
K7a	Auto	AA	12,242	81,9	250	1310	4000	< 3,43	5
K7b	Auto	AA	11,904	80,7	250	1277	4000	< 3,43	5
K9a	Lampe mit Batterien	D	100,887	< 15,5	250	1044	4000	< 2,98	5
K9b	Lampe mit Batterien	D	101,984	< 16,3	250	1021	4000	< 3,16	5
R2a	Panasonic	AA	17,445	< 12,1	250	403	4000	< 3,64	5
R2b	Panasonic	AA	17,401	< 12,5	250	611	4000	< 3,59	5
R3a	NoName	AA	14,714	117,6	250	1490	4000	< 3,58	5
R3b	NoName	AA	14,682	137,6	250	1563	4000	< 3,50	5
R8a	Spielzeugauto	AA	19,066	< 12,2	250	943	4000	< 4,60	5
R8b	Spielzeugauto	AA	19,153	< 11,2	250	1032	4000	< 4,24	5
V2a	NoName (Conrad Energy)	AA	15,826	135,1	250	1072	4000	< 3,72	5
V2b	NoName (Conrad Energy)	AA	15,491	134,7	250	1338	4000	< 3,65	5
V4a	NoName (MGZ Premium)	AA	14,910	113,4	250	1715	4000	< 3,62	5
V4b	NoName (MGZ Premium)	AA	14,972	122,4	250	1819	4000	< 3,61	5
V5a	Panasonic	AA	17,845	< 9,3	250	403	4000	< 3,48	5
V5b	Panasonic	AA	17,861	< 12,1	250	472	4000	< 3,70	5
V7a	NoName (Camelion)	D	89,751	116,9	250	1473	4000	< 2,52	5
V7b	NoName (Camelion)	D	89,707	108,3	250	1733	4000	< 2,50	5
V8a	NoName (MNZ Premium)	D	90,168	94,6	250	1906	4000	< 2,41	5
V8b	NoName (MNZ Premium)	D	89,310	88,2	250	1827	4000	< 2,67	5
V9a	NoName (Conrad Energy)	D	90,554	106,2	250	1736	4000	< 2,47	5
V9b	NoName (Conrad Energy)	D	90,705	105,6	250	1808	4000	< 2,62	5

steel coating) of all alkaline/manganese dry cells and in some of the zinc/carbon dry cells (B3, R3, R8, V5, V7 and V9) was determined not only by using ICP-MS but

additionally using the more sensitive AMA technique (see section 3.4). Since the use of the less sensitive ICP-MS normally was sufficient to decide whether the Hg-contents were below the limits the use of the more sensitive but more extensive AMA technique was not necessary.
Therefore the maximum contents given in Tables 11 and 12 are determined using ICP-MS, the real Hg-contents were likely to be lower.
No heavy metal contents above the limits were detected in the dry cells investigated. Although the limit for Hg in dry cells was much lower than for button cells all dry cells contained Hg mass fractions below the limit. In most of the batteries Hg-contents were higher than half the limit.
It should be noted that zinc/carbon dry cells contained significantly more lead (up to 1900 ± 200 mg/kg) than all button and all alkaline/manganese dry cells. All contents were below the limit anyhow.

5 Summary

The aim of the project „Survey of Heavy Metal Content of Batteries – Analysis of Representative Samples of Customary Batteries and Batteries Sold in Appliances – Preparation of a Sampling Plan, Purchase of Samples and Analysis (Hg, Pb, Cd)“ was to describe the situation concerning the compliance of the existing limits for heavy metal content in commercially available batteries in Germany on the basis of a representative sample. The limits for the maximum content of heavy metals in batteries are: 5 ppm of mercury (button cells: 20000 ppm), 250 ppm of cadmium and 4000 ppm of lead.
Several batteries of different size such as „AA“-batteries (alkaline/manganese, zinc/carbon), „D“-batteries (alkaline/manganese, zinc/carbon) and button cells of different chemical systems (zinc-air; lithium; alkaline/manganese, silver oxide) were analysed for cadmium, lead and mercury. The test batteries came from different producers and were bought on different places in Germany. From each battery type two specimen were investigated, in total 294 samples. Following a sampling plan the batteries were purchased in four regions in Germany by retail, by mail order or on flew markets.
Different strategies for the analysis of „AA“- and „D“-batteries (alkaline/manganese, zinc/carbon) and for button cells (alkaline/manganese, zinc-air, lithium, silver oxide)

were developed. Button cells were dissolved whole whenever possible. From the bigger types only subspecimens after mechanical destruction were analysed. Button cells and the subspecimens of the bigger batteries were digested with acid in a microwave oven. For the analysis of the heavy metals ICP-MS, ICP OES and an automatic mercury analyser were used depending on the content of the interesting element. Some graphite parts from zinc/carbon batteries were analysed using solid sampling ICP OES.

The result of the study was that only two of 147 batteries had Hg-contents slightly higher than the limit of 2 %. Pb- and Cd-contents were below the limits for all batteries investigated. The two batteries with higher Hg-contents were both zinc-air button cells declared by the manufacturer to be mercury-free. Differences between batteries of the same kind and producer purchased at different places or between batteries of different size but same producer and same chemical system could not be detected.

6 Literature

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[3] Internal UBA-Study 1996

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[7] S. C. Rastogi, Determination of Cadmium and Mercury in Dry Batteries, Atomic Spectroscopy, 1989, 10, 144

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[9] J. Guo, T.J. O’Hara, Zero Mercury Air Cells, United States patent US 6,602,629 B1, Aug. 5, 2003

Annex 1: Sampling plan

Ort	Typ	Chem. System	Hersteller	Anzahl
A	AA	1	Marke 1	2
A	D	1	Marke 1	2
B	AA	1	Marke 1	2
B	D	1	Marke 1	2
C	D	1	Marke 2	2
C	D	2	Marke 2	2
D	AA	1	Marke 3	2
D	AA	2	Marke 3	2
Versand	AA	1	Marke 2	2
Versand	D	2	Marke 2	2
Versand	AA	2	Marke 3	2
Versand	D	1	Marke 3	2
Versand	AA	2	NoName 1	2
Versand	D	2	NoName 1	2
Versand	AA	1	NoName 1	2
Versand	AA	2	NoName 2	2
Versand	D	2	NoName 2	2
A	AA	1	NoName 3	2
	D	1	NoName 3	2
	AA	2	NoName 3	2
	D	2	NoName 3	2
B	AA	1	NoName 4	2
	D	2	NoName 4	2
D	AA	2	NoName 5	2
	D	1	NoName 5	2
			Summe:	50

Legende:

Ort:		Chem. System:		Typen	
A	Berlin	1	Alkali-Mangan	AA	Mignon
B	Konstanz	2	Zink-Kohle	D	Mono
C	Guben				
D	Ruhrgebiet				

Hersteller:

Marke 1	Varta
Marke 2	Duracell
Marke 3	Panasonic

Overview on dry cells

Ort	Typ	Chem. System	Hersteller	Anzahl
A	a (Größe 1)	2	2	2
A	a (Größe 1)	2	4	2
B	a (Größe 1)	2	2	2
B	a (Größe 1)	2	4	2
B	a (Größe 2)	2	2	2
B	a (Größe 2)	2	4	2
C	a (Größe 1)	2	1	2
C	a (Größe 1)	2	3	2
Versand	a (Größe 3)	2	1	2
Versand	a (Größe 3)	2	2	2
Versand	a (Größe 3)	2	3	2
Versand	a (Größe 3)	2	4	2
A	b (Größe 1)	2	2	2
A	b (Größe 1)	2	4	2
D	b (Größe 1)	2	NoName 1	2
D	b (Größe 1)	2	NoName 2	2
D	b (Größe 2)	2	NoName 1	2
A	b (Größe 1)	2	NoName 3	2
A	b (Größe 2)	2	NoName 3	2
C	b (Größe 1)	2	1	2
C	b (Größe 1)	2	3	2
Versand	b (Größe 3)	2	1	2
Versand	b (Größe 3)	2	2	2
Versand	b (Größe 3)	2	3	2
Versand	b (Größe 3)	2	4	2
A	b (Größe 1)	1	2	2
A	b (Größe 1)	1	4	2
D	b (Größe 1)	1	NoName 1	2
D	b (Größe 1)	1	NoName 2	2
D	b (Größe 2)	1	NoName 1	2
D	b (Größe 2)	1	NoName 2	2
A	b (Größe 1)	1	NoName 3	2
A	b (Größe 2)	1	NoName 3	2
C	b (Größe 1)	1	1	2
C	b (Größe 1)	1	3	2
C	b (Größe 1)	1	NoName4	2
C	b (Größe 2)	1	2	2
C	b (Größe 2)	1	4	2
B	b (Größe 3)	1	1	2
B	b (Größe 3)	1	2	2
B	b (Größe 3)	1	3	2
B	b (Größe 3)	1	4	2
Versand	b (Größe 4)	1	1	2
Versand	b (Größe 4)	1	2	2
Versand	b (Größe 4)	1	3	2
Versand	b (Größe 4)	1	4	2
Versand	b (Größe 4)	1	NoName 1	2
Versand	b (Größe 4)	1	NoName 2	2
Versand	b (Größe 1)	1	NoName 1	2
Versand	b (Größe 1)	1	NoName 2	2

Overview on button cells

B	b (Größe 1)	3	2	2
B	b (Größe 1)	3	4	2
C	b (Größe 1)	3	NoName 1	2
C	b (Größe 1)	3	NoName 2	2
C	b (Größe 2)	3	NoName 1	2
C	b (Größe 2)	3	NoName 2	2
B	b (Größe 1)	3	NoName 3	2
B	b (Größe 2)	3	NoName 3	2
D	b (Größe 1)	3	1	2
D	b (Größe 1)	3	3	2
D	b (Größe 1)	3	NoName4	2
D	b (Größe 2)	3	2	2
D	b (Größe 2)	3	4	2
A	b (Größe 3)	3	1	2
A	b (Größe 3)	3	2	2
A	b (Größe 3)	3	3	2
A	b (Größe 3)	3	4	2
Versand	b (Größe 4)	3	1	2
Versand	b (Größe 4)	3	2	2
Versand	b (Größe 4)	3	3	2
Versand	b (Größe 4)	3	4	2
Versand	b (Größe 4)	3	NoName 1	2
Versand	b (Größe 4)	3	NoName 2	2
Versand	b (Größe 1)	3	NoName 1	2
Versand	b (Größe 1)	3	NoName 2	2
C	b (Größe 1)	4	2	2
C	b (Größe 1)	4	4	2
B	b (Größe 1)	4	NoName 1	2
B	b (Größe 1)	4	NoName 2	2
B	b (Größe 2)	4	NoName 1	2
B	b (Größe 2)	4	NoName 2	2
C	b (Größe 1)	4	NoName 3	2
C	b (Größe 2)	4	NoName 3	2
D	b (Größe 1)	4	1	2
D	b (Größe 1)	4	3	2
D	b (Größe 1)	4	NoName4	2
D	b (Größe 2)	4	2	2
D	b (Größe 2)	4	4	2
A	b (Größe 3)	4	1	2
A	b (Größe 3)	4	2	2
A	b (Größe 3)	4	3	2
A	b (Größe 3)	4	4	2
Versand	b (Größe 4)	4	1	2
Versand	b (Größe 4)	4	2	2
Versand	b (Größe 4)	4	3	2
Versand	b (Größe 4)	4	4	2
Versand	b (Größe 4)	4	NoName 1	2
Versand	b (Größe 4)	4	NoName 2	2
Versand	b (Größe 1)	4	NoName 1	2
Versand	b (Größe 1)	4	NoName 2	2
			Summe:	200

Legende:	Ort:		Chem. System:		Typen	
	A	Berlin	1	Alkali-Mangan (LR)	a	Hörgerätebatterie
	B	Konstanz	2	Zink-Luft (PR)	b	andere
	C	Guben	3	Silberoxid (SR)		

Overview on button cells (continued)

Ort	Entnahme möglich	Produkt	Bezugsquelle	Anzahl
A	ja	1	Einzelhandel	2
A	ja	2	Einzelhandel	2
A	ja	1	Flohmarkt, Straßenhändler	2
A	ja	2	Flohmarkt, Straßenhändler	2
C	ja	1	Flohmarkt, Straßenhändler	2
C	ja	2	Flohmarkt, Straßenhändler	2
D	ja	1	Einzelhandel	2
D	ja	2	Einzelhandel	2
Versand	ja	1	Webshop	2
Versand	ja	2	Webshop	2
A	nein	3	Einzelhandel	2
A	nein	3	Flohmarkt, Straßenhändler	2
B	nein	3	Einzelhandel	2
B	nein	3	Flohmarkt, Straßenhändler	2
C	nein	3	Einzelhandel	2
D	nein	3	Einzelhandel	2
A	nein	4	Einzelhandel	2
A	nein	4	Flohmarkt, Straßenhändler	2
B	nein	4	Einzelhandel	2
B	nein	4	Flohmarkt, Straßenhändler	2
C	nein	4	Einzelhandel	2
C	nein	4	Flohmarkt, Straßenhändler	2
D	nein	4	Einzelhandel	2
D	nein	4	Flohmarkt, Straßenhändler	2
A	nein	5	Einzelhandel	2
A	nein	5	Flohmarkt, Straßenhändler	2
Versand	nein	3		2
Versand	nein	4		2
Versand	nein	3		2
Versand	nein	4		2
			Summe:	60

Legende:	Ort:		Produkt	
	A	Berlin	1	Taschenrechner
	B	Konstanz	2	Uhr
	C	Guben	3	Grußkarte
	D	Ruhrgebiet	4	Spielzeug
			5	Blinklichtschuh

Overview on incorporated batteries

Annex 2: Overview on all analysed batteries

Tab. A2-1: Dry cells from Berlin

No.	Size	Chem. system	Producer/ distributor	Date of supply	supplied from	Lot-No.	Pack content/ number of packs supplied	Price in €	Name	Expiry date
B1	AA	Alkaline/manganese	NoName1	30.11.2005	**ALDI** Sundgauer Str. 83-85 14169 Berlin	k.A.	8/1	1,75	TOP Craft Ultra Alkaline 1,5 V Mignon LR 6	09/2010
B2	D	Alkaline/manganese	NoName1	30.11.2005	**ALDI** Sundgauer Str. 83-85 14169 Berlin	k.A.	3/1	1,75	TOP Craft Ultra Alkaline 1,5 V Mono LR 20	09/2010
B3	D	Zinc/carbon	NoName2	05.12.2005	**real** Senftenberger Ring 15-18 13439 Berlin	k.A.	4/1	1,49	TIP Allzweck-Battery R20-1,5 V Mono Torcia AD UM1, Made in E.U.	12/2007
B4	AA	Zinc/carbon	NoName2	05.12.2005	**real** Senftenberger Ring 15-18 13439 Berlin	k.A.	8/1	1,49	TIP Allzweck-Battery R6-1,5 V Mignon Stilo AA UM3, Made in E.U.	2/2007
B5	AA	Alkaline/manganese	Varta	03.12.2005	**Woolworth** Müllerstraße 153a-154 13353 Berlin	PD0705 ED0611	4/1	4,49	Varta High Energy Made in Germany	6/2011
B6	D	Alkaline/manganese	Varta	03.12.2005	**Woolworth** Müllerstraße 153a-154 13353 Berlin	PD0805 ED0611	2/1	4,49	Varta High Energy Made in Germany	2011

Tab. A2-2: Dry cells from Konstanz

No.	Size	Chem. system	Producer/ distributor	Date of supply	supplied from	Lot-No.	Pack content/ number of packs supplied	Price in €	Name	Expiry date
K1	AA	Alkaline/manganese	Varta	20.01.2006	**Karstadt** Hussenstraße 23 78462 Konstanz	PD1105ED0811	4/1	5,29	Varta High Energy New Formula Made in Germany	06/2011
K2	D	Alkaline/manganese	Varta	20.01.2006	**Karstadt** Hussenstraße 23 78462 Konstanz	PD1205ED0611	2/1	5,29	Varta High Energy New Formula Made in Germany	2011
K3	AA	Alkaline/manganese	NoName3	20.01.2006	**Karstadt** Hussenstraße 23 78462 Konstanz	k.A.	8/1	2,79	Alkaline Batteries 1,5 V 4006 Mignon Anabasis Handelgesellschaft mbH, Germany	06/2009
K4	D	Zinc/carbon	NoName4	21.01.2006	**1 EuroShop** Hussenstr. 22 , Konstanz	k.A.	2	1,00	Dynamic Energy D-R20-Mono 1,5V Ultra Item No. 12860 NL	12/2007

Tab. A2-3: Dry cells from Guben

No.	Size	Chem. system	Producer/ distributor	Date of supply	supplied from	Lot-No.	Pack content/ number of packs supplied	Price in €	Name	Expiry date
G1	D	Alkaline/manganese	Duracell	19.12.2005	**real** Karl-Marx-Str. 112 03172 Guben	k.A.	2/1	5,99	Duracell Plus Long Lasting Duracell Power MN 1300-LR 20	03/2009
G2	D	Zinc/carbon	Panasonic	19.12.2005	**real** Karl-Marx-Str. 112 03172 Guben	k.A.	4/1	4,99	Panasonic Special Power Size XL R20R/4P 1,5 V Made in Poland	11/2006

Tab. A2-4: Dry cells from the Ruhr region (Essen, Duisburg, Kleve)

No.	Size	Chem. system	Producer/ distributor	Date of supply	supplied from	Lot-No.	Pack content/ number of packs supplied	Price in €	Name	Expiry date
R1	AA	Alkaline/manganese	Panasonic	09.12.2005	**Galeria Kaufhof** Kettwiger Str. 1a 45127 Essen	322264151031	4/1	6,99	Panasonic Xtreme Power Improved Capacity Made in EU	04/2012
R2	AA	Zinc/carbon	Panasonic	09.12.2005	**AK Tele-komunikation** 47051 Duisburg Hbf	M1-AA06-001-0000	4/1	2,50	Panasonic Plus Power AA/R6/UM3 Made in Poland	08/2008
R3	AA	Zinc/carbon	NoName5	09.12.2005	**Saturn** Porscheplatz 2a 45127 Essen	4500419	16/1	2,99	OCSM GmbH & Co. KG16 Zinc/carbon-Batteries 1,5 V Mignon	08/2008
R4	D	Alkaline/manganese	NoName6	06.02.2006	**Kaufland** Olmerstraße 1-14, Kleve	k.A.	2/1	0,99	K Classic Alkaline Power Battery	06/2010

Tab. A2-5: Dry cells from mailorder

No.	Size	Chem. system	Producer/ distributor	Date of supply	supplied from	Lot-No.	Pack content/ number of packs supplied	Price in €	Name	Expiry date
V1	AA	Alkaline/manganese	Duracell	09.12.2005	www.westfalia.de	GPC 15070555	10/1	6,99	Duracell Procell Professional Alkaline Battery MN1500LR61,5V Made in EC	03/2012
V2	AA	Zinc/carbon	NoName7	25.01.2006	www.conrad.de	k.A.	4/1	1,50	Conrad Energy Zinc/carbon Battery Standard Nr 650046	06/2008
V3	AA	Alkaline/manganese	NoName8 (Camelion)	09.12.2005	www.westfalia.de	k.A.	4/1	1,99	Camelion Alcaline Plus Puissance Longue Durée	08/2012
V4	AA	Zinc/carbon	MGZ Premium	16.12.2005	www.conrad.de	k.A.	8/1	1,95	MGZ Premium Qualität (MGZ8) Hartig und Hellig	12/2007
V5	AA	Zinc/carbon	Panasonic	16.12.2005	www.akkutheke.de/	k.A.	1/2	0,90	Panasonic Special Power Size Made in EU	05/2008
V6	D	Alkaline/manganese	Panasonic	09.12.2005	www.westfalia.de	k.A.	2/1	4,49	Panasonic Xtreme PowerSize XL 1,5 V 539B Made in EU	01/2013
V7	D	Zinc/carbon	NoName8 (Camelion)	09.12.2005	www.westfalia.de	k.A.	2/1	1,49	Camelion Super Heavy Duty Camelion Betterien GmbH Berlin R20P-SP2K	06/2008
V8	D	Zinc/carbon	MNZ Premium	16.12.2005	www.conrad.de	k.A.	4/1	1,95	MNZ Premium Qualität (MNZ 4) Hartig und Hellig	12/2007
V9	D	Zinc/carbon	NoName7	25.01.2006	www.conrad.de	k.A.	4/2	3,00	Conrad energy Standard Nr 650070	06/2008

Tab. A2-6: Button cells from Berlin

No.	Appli-cation	Chem. system	Dimension	Producer/ distributor	Date of supply	supplied from	Lot-No.	Pack content/ number of packs supplied	Price in €	Name	Expiry date
B17	hearing aid battery	Zinc-air	1	Duracell	08.12.2005	**Horning** Karolinenstr. 1d 13507 Berlin	4G0710 341105-12-00	6/1	6,90	Activair by Duracell 1,4 V Zinc Air Made in U.K.	03/2007
B18	hearing aid battery	Zinc-air	1	Panasonic	08.12.2005	**Horning** Karolinenstr. 1d 13507 Berlin	k.A.	6/1	6,00	-	05/2007
B19	hearing aid battery	Zinc-air	1	Rayovac	08.12.2005	**Batterie-Shop** Gorkistr. 24 13509 Berlin	k.A.	6/1	4,95	Rayovac Acoustic Special Made in USA	03/2007
B20	hearing aid battery	Zinc-air	2	NoName7	10.02.2006	**Conrad Electronic** Hasenheide 14-15 10967 Berlin	k.A.	6/1	4,95	Conrad energy Hörgerätebattery Zinc-air ZA 675 Made in USA 1,4 V	08/2008
B21	hearing aid battery	Zinc-air	2	renata	10.02.2006	**Conrad Electronic** Hasenheide 14-15 10967 Berlin	k.A.	6/1	6,95	renata zinc air Hearing aid batteries ZA675 1,4V Swiss made	10/2007
B24	others	Zinc-air	1 (MRB675)	NoName9	24.01.2006	**Wüstefeld** Schloßstraße 96 12163 Berlin	k.A.	1/2	18,00	Wein Cell 1,35 V Made in China	bis zu 10 Jahre lagerfähig
B25	others	Zinc-air	2 (MRB400)	NoName9	25.01.2006	**Wüstefeld** Schloßstraße 96 12163 Berlin	k.A.	1/2	19,90	Wein Cell 1,35 V Made in China	bis zu 10 Jahre lagerfähig
B26	others	Alkaline/manganese	1 (LR44)	Duracell	08.12.2005	**Media Markt** Am Borsigturm 2 13507 Berlin	42073181	2/1	5,49	Duracell Electronics Made in China	2010
B27	others	Alkaline/manganese	1 (LR44)	Panasonic	08.12.2005	**Media Markt** Am Borsigturm 2 13507 Berlin	3222 641 52171	1/2	6,98	Panasonic Cell Power Made in Japan	07/2007
B28	others	Alkaline/manganese	1 (LR44)	NoName10	08.12.2005	**street hawker** Wilhelmsruher Damm/Senftenberger Ring	k.A.	2/1	1,20	AG 13 Alkaline Battery	k.A.

Tab. A2-6: Button cells from Berlin (continued)

No.	Appli-cation	Chem. system	Dimension	Producer/ distributor	Date of supply	supplied from	Lot-No.	Pack content/ number of packs supplied	Price in €	Name	Expiry date
B29	others	Alkaline/manganese	2 (LR54)	NoName8	08.12.2005	**Street hawker** Wilhelmsruher Damm/Senftenberger Ring	k.A.	2/1	1,20	Camelion Alakline Battery AG 10 LR1130	02/2008
B30	others	Silver oxide	3	Varta	05.08.2006	**Fotopoint** Am Borsigturm 2 13507 Berlin	k.A.	2/1	9,98	Varta Electronics V390 SR54	05/2010
B31	others	Silver oxide	3 (SR43sw)	Duracell	21.04.2006	**MediaMarkt** Pankstraße 32-39 13357 Berlin	42034347	1/2	1,50	Duracell 386/301 Silver Oxide 1,5V Made in Switzerland	k.A.
B32	others	Silver oxide	3 (SR44)	Ucar/Energizer	24.01.2006	**Wüstefeld** Schloßstraße 96 12163 Berlin	k.A.	2/1	10,10	Energizer EPX 76 1,55 V	07/2009
B34	others	Lithium	3 (CR2025)	Varta	08.12.2005	**Fotopoint** Am Borsigturm 2 13507 Berlin	k.A.	1/2	9,98	Varta Elektronics Made in Indonesia	05/2010
B35	others	Lithium	3 (CR2025)	Duracell	08.12.2005	**Saturn** Senftenberger Ring 15-17 13439 Berlin	42039614	1/2	10,98	Duracell Electronics Made in Switzerland	2015
B36	others	Lithium	3 (CR2025)	Ucar/Energizer	24.01.2006	**Wüstefeld** Schloßstraße 96 12163 Berlin	k.A.	1/2	9,96	Made in Japan	07/2012
B37	others	Lithium	3 (CR2025)	Panasonic	05.12.2005	**real** Senftenberger Ring 15-18 13439 Berlin	3222 641 52281	1/2	9,58	Panasonic Cell Power Made in Indonesia	07/2015
B38	others	Lithium	CR1025	renata	29.04.2006	**Conrad Electronic** Kleiststrasse 30-31 10787 Berlin	k.A.	1/2	3,75	renata Lithium Battery 3V Made in Switzerland	08/09

Tab. A2-6: Button cells from Berlin (continued)

No.	Appli-cation	Chem. system	Dimension	Producer/ distributor	Date of supply	supplied from	Lot-No.	Pack content/ number of packs supplied	Price in €	Name	Expiry date
B39	others	Alkaline/manganese	LR43	renata	29.04.2006	**Conrad Electronic** Kleiststrasse 30-31 10787 Berlin	k.A.	2/1	2,45	Renata Calculator LR 43 Alkaline 1,5V Made in Switzerland	k.A.
B40	others	Alkaline/manganese	LR44	renata	29.04.2006	**Conrad Electronic** Kleiststrasse 30-31 10787 Berlin	k.A.	2/1	2,45	renata Alkaline 1,5 V ;Made in Switzerland	04/09
B41	others	Silver oxide	SR41W	renata	29.04.2006	**Conrad Electronic** Kleiststrasse 30-31 10787 Berlin	k.A.	1/2	1,95	renata Watch Battery Silver 1,55 V Made in Switzerland	06/08
B42	others	Silver oxide	SR721SW	renata	29.04.2006	**Conrad Electronic** Kleiststrasse 30-31 10787 Berlin	k.A.	1/2	1,95	renata Watch Battery Silver 1,55 V Made in Switzerland	05/08
B43	others	Lithium	CR2016	renata	28.07.2006	**Conrad Electronic** Kleiststrasse 30-31 10787 Berlin	k.A.	1/2	3,75	renata Lithium Battery 3V Made in Switzerland	02/13

Tab. A2-7: Button cells from Konstanz

No.	Appli-cation	Chem. system	Dimension	Producer/ distributor	Date of supply	supplied from	Lot-No.	Pack content/ number of packs supplied	Price in €	Name	Expiry date
K10	hearing aid battery	Zinc-air	1 (ZA10)	Rayovac	20.01.2006	**Müller** Hussenstr. 34 78462 Konstanz	k.A.	6/1	7,49	Rayovac Acoustic Special Gr. 10 1,4 V SSLPD Made in USA	09/2009
K11	hearing aid battery	Zinc-air	1 (ZA10)	NoName11	20.01.2006	**Das Ohr** Münzgasse 29 78462 Konstanz	k.A.	6/1	7,50	pro akustik PR 70 1,4 V Gr. 10	08/2008
K12	hearing aid battery	Zinc-air	2 (ZA13)	Rayovac	20.01.2006	**Müller** Hussenstr. 34 78462 Konstanz	k.A.	6/1	7,49	Rayovac Acoustic Special Gr. 13 Made in U.K: 1,4 V USJEC	11/2009
K13	hearing aid battery	Zinc-air	2 (ZA13)	NoName12	20.01.2006	**Woolworth** Kanzleistr. 2-4	k.A.	6/1	1,99	Dynamic Energy Hearing Aid A312-1,4V item No. 12882 Eindhoven, NL	k.A.
K14	others	Alkaline/ man-ganese	LR44	Varta	20.01.2006	**Karstadt** Hussenstraße 23 78462 Konstanz	k.A.	1/2	5,98	Varta Electronics V13GA.LR44 Made in China	06/2008
K15	others	Alkaline/ man-ganese	3 (LR44 bzw. LR42)	Duracell	20.01.2006	**Media Markt** Schneckenburgstr. 2 78467 Konstanz	42073181	2/1	3,99	Duracell Electro-nics LR44 1,5 V Made in China	2010
K16	others	Alkaline/ man-ganese	3 (LR44 bzw. LR42)	Ucar/-Energizer	20.01.2006	**Kaufland** Zähringer Platz 7 78464 Konstanz	k.A.	2/1	3,99	Energizer LR44/A76	07/2010
K17	others	Alkaline/ man-ganese	3 (LR44 bzw. LR42)	Panasonic	20.01.2006	**Praktiker** Reichenaustr. 208 78467 Kostanz	322264152171	1/2	3,98	Panasonic Cell Power 1,5 V Made in Japan	08/2007
K18	others	Silver oxide	1(SR44W, 303/357)	Duracell	20.01.2006	**Media Markt** Schneckenburgstr. 2 78467 Konstanz	42039602	2/1	5,99	Duracell Electronics 1,5 V 357/303/Sr44W Made in Switzerland	5/2009
K19	others	Silver oxide	SR1130W/ 389	Panasonic	20.01.2006	**Elektronikladen** Bahnhofstr. 5 78462 Konstanz	k.A.	1/2	6,00	Panasonic Silver 1,55 V Made in Japan	k.A.

Tab. A2-7: Button cells from Konstanz (continued)

No.	Appli-cation	Chem. system	Dimension	Producer/ distributor	Date of supply	supplied from	Lot-No.	Pack content/ number of packs supplied	Price in €	Name	Expiry date
K20	others	Silver oxide	1 (SR626)	NoName13	20.01.2006	**Elektrobasar** Kreuzlinger Str. 8 78462 Konstanz	k.A.	10/1	3,50	Hi-Power SR626SW SG 41,55V	k.A.
K22	others	Lithium	1(CR1216)	NoName14	20.01.2006	**Elektrobasar** Kreuzlinger Str. 8 78462 Konstanz	k.A.	2/1	2,00	Lithium Battery CR1216 3V www.walma-frankfurt.de	10/2008
K23	others	Lithium	1(CR2032)	Kodak	20.01.2006	**Foto am Münster** Wessenbergstr. 41 78462 Konstanz	5278866	1/2	5,00	Kodak Max CR 2032 I-Pack 3V Lithium Battery Made in Indonesia	2014
K24	others	Lithium	1 (Cr2032)	NoName15	20.01.2006	**Elektronikladen** Bahnhofstr. 5 78462 Konstanz	k.A.	2/1	8,00	Lithium Battery CR2032 3V	k.A.
K25	others	Lithium	2(CR2016)	NoName8 (Camelion)	20.01.2006	**Elektrobasar** Kreuzlinger Str. 8 78462 Konstanz	k.A.	2/1	1,50	Camelion Premium Lithium CR 2025 3V	k.A.
K26	others	Lithium	2(CR2016)	NoName15	20.01.2006	**Elektronikladen** Bahnhofstr. 5 78462 Konstanz	k.A.	2/1	8,00	Lithium Battery CR2016 3V	k.A.

Tab. A2-8: Button cells from Guben

No.	Appli-cation	Chem. system	Dimension	Producer/ distributor	Date of supply	supplied from	Lot-No.	Pack content/ number of packs supplied	Price in €	Name	Expiry date
G9	hearing aid battery	Zinc-air	1 (312)	Varta	19.12.2005	**Hörgeräte Dr. Hähle** Frankfurter Str. 14 03172 Guben	k.A.	6/1	7,50	Hörgeräte Dr. Hähle Made in Germany by Varta Microbattery GmbH	09/1008
G11	hearing aid battery	Zinc-air	(ZA13)	Rayovac	19.12.2005	**Ringfoto Hentzschels** Schiller Str. Guben	k.A.	6/1	8,99	Rayovac Acoustic Special Precise Energy for High Tech Made in U.K.	02/2008
G14	others	Alkaline/ man-ganese	1(LR44)	Varta	19.12.2005	**Ringfoto Hentzschels** Schiller Str. Guben	k.A.	1/2	9,20	Varta Electronics V13GA. LR44 Made in China	04/2008
G15	others	Alkaline/ man-ganese	1(LR44)	Energizer	19.12.2005	**Kaufland** Guben Fr. Schiller-Str. 5b 03172 Guben	k.A.	2/1	3,99	Energizer LR 44/A76 Alkaline	07/2010
G16	others	Alkaline/ man-ganese	1(LR44)	NoName16	19.12.2005	**Büro- & Kopierservice Hausmann** 03172 Guben	k.A.	40/1	4,50	Foxy 40 Stück Button cells-Sortiment	12/2006
G21	others	Silver oxide	2 (SR621SW)	NoName17	19.12.2005	street hawker im Kauflandvorraum	k.A.	1/2	4,00	Maxell Silver Oxide Battery 1,55 V Sr621SW (364) Made in Japan	12/2007
G22	others	Silver oxide	2 (SR626SW)	NoName17	19.12.2005	street hawker im Kauflandvorraum	k.A.	1/2	4,00	Maxell Silver Oxide Battery 1,55 V Sr626SW (377) Made in Japan	12/2007
G24	others	Lithium	1 (CR2032)	Panasonic	19.12.2005	**Real** Karl-Marx-Str. 112 03172 Guben	k.A.	1/2	9,58	Panasonic Power Cells CR2032 3V Lithium, Made in Indonesia	07/2014

Tab. A2-8: Button cells from Guben (continued)

No.	Appli-cation	Chem. system	Dimension	Producer/ distributor	Date of supply	supplied from	Lot-No.	Pack content/ number of packs supplied	Price in €	Name	Expiry date
G25	others	Lithium	1 (CR2032)	NoName8 (Camelion)	19.12.2005	street hawker im Kauflandvorraum	k.A.	2/1	4,00	Camelion CR 2032 3V Lithium Camelion Batteries GmbH Berlin	06/2013
G26	others	Lithium	2 (CR2016)	NoName8 (Camelion)	19.12.2005	street hawker im Kauflandvorraum	k.A.	2/1	4,00	Camelion CR 2016 3V Lithium	12/2011

Tab. A2-9: Button cells from the Ruhr region (Essen, Duisburg, Kleve)

No.	Appli-cation	Chem. system	Dimension	Producer/ distributor	Date of supply	supplied from	Lot-No.	Pack content/ number of packs supplied	Price in €	Name	Expiry date
R13	others	Alkaline/ man-ganese	1 (LR41)	NoName19	09.12.2005	**AK Telekomunikation** 47051 Duisburg Hbf	k.A.	2/1	1,25	Alkaline Battery Button Cell LR 41 AG3	09/1008
R14	others	Alkaline/ man-ganese	1 (LR44)	NoName18	09.02.2006	**Woolworth** Herzogstr. 25-27 47533 Kleve	k.A.	36/1	3,99	Dynamic Energy Eindhofen NL Button Assortment	02/2008
R15	others	Alkaline/ man-ganese	2 (LR754)	NoName19	09.12.2005	**AK Tele-komunikation** 47051 Duisburg Hbf	k.A.	2/1	1,25	Alkaline Battery Button Cell AG5	04/2008
R16	others	Alkaline/ man-ganese	2 (LR754)	NoName18	09.02.2006	**Woolworth** Herzogstr. 25-27 47533 Kleve	k.A.	36/1	3,99	Dynamic Energy Eindhofen NL Button Assortment	07/2010

Tab. A2-9: Button cells from the Ruhr region (Essen, Duisburg, Kleve) (continued)

No.	Appli-cation	Chem. system	Dimension	Producer/ distributor	Date of supply	supplied from	Lot-No.	Pack content/ number of packs supplied	Price in €	Name	Expiry date
R17	others	Silver oxide	1 (SR44)	Varta	09.12.2005	**Foto Frankenberg** Flachsmarkt 1 45127 Essen	k.A.	1/2	7,90	Varta Electronics V76PX.SR44 Made in Germany	12/2006
R20	others	Silver oxide	2 (SR44)	Panasonic	09.12.2005	**Galeria Kaufhof** Kettwiger Str. 1a 45127 Essen	3222641 52341	1/2	15,98	Panasonic Cell Power SR44-1,55 V Made in Japan	04/2008
R21	others	Silver oxide	2 (SR44W)	Duracell	09.12.2005	**Galeria Kaufhof** Kettwiger Str. 1a 45127 Essen	42039602	2/1	7,99	Duracell Electronics 357/303 Sr44W 1,5 V Silver Oxide, Made in Switzerland	5/07
R22	others	Lithium	1 (CR2032)	Varta	09.12.2005	**Wal-Mart** Porscheplatz 2 45127 Essen	k.A.	1/2	8,96	Varta Electronics CR2032 Made in Japan	12/09
R24	others	Lithium	1 (CR1220)	NoName19	09.12.2005	**AK Tele-komunikation** 47051 Duisburg Hbf	k.A.	2/1	5,00	Lithium Battery CR1220 3V	k.A.
R25	others	Lithium	2 (CR1025)	Panasonic	09.12.2005	**Galeria Kaufhof** Kettwiger Str. 1a 45127 Essen	3222641 44683	1/2	10,18	Panasonic Power Cells CR1025 3V Lithium Made in Japan	07/20014
R26	others	Lithium	2 (DL 1616)	Duracell	09.12.2005	**Galeria Kaufhof** Kettwiger Str. 1a 45127 Essen	31746	1/2	11,98	Duracell Long Life Lithium DL 1616 3V Made in Switzerland	k.A.

Tab. A2-10: Button cells from mailorder

No.	Appli-cation	Chem. system	Dimension	Producer/ distributor	Date of supply	supplied from	Lot-No.	Pack content/ number of packs supplied	Price in €	Name	Expiry date
V16	hearing aid battery	Zinc-air	312	Varta	07.12.2005	www.batterie-3000.de Best.-No. 10310	k.A.	6/1	3,40	Zinc Air Cardio Cell Hörgeräte-Batterien AE312 Made in Germany by Varta Microbattery GmbH	08/2008
V17	hearing aid battery	Zinc-air	312	Rayovac	07.12.2005	www.batterie-3000.de Best.-No. 10623	k.A.	6/1	3,30	Acoustic Spacial Precise Energy for High-Tech 1,4 V 160mAh Made in UK	04/2008
V18	hearing aid battery	Zinc-air	Easy Tab 312	Duracell	15.12.2005	www.office-netshop.de Best.-No. 3040117	k.A.	6/1	7,06	Duracell Hearing Aid Easy Tab 6 Batteries 1,4 V Zinc Air Made in U.K.	01/2007
V19	hearing aid battery	Zinc-air	312	Energizer	07.02.2006	www.shop-apotheke.com Best.-No. 566316	k.A.	6/1	6,69	Energizer 312 Ultra+ Zinc Air Made in USA 0% Mercury	07/2008
V23	others	Zinc-air	PR2330	Panasonic	26.01.2006	www. hottmeyer.de Best.-No. 8298	k.A.	1/2	7,00	Button cell Zinc-air PR-2330 1,4 V	k.A.
V24	others	Alkaline/ man-ganese	LR43	Varta	07.12.2005	www.batterie-3000.de Best.-No. 10310	k.A.	1/2	2,80	Varta Electronics V12GA.LR43 Made in China	12/2007
V25	others	Alkaline/ man-ganese	LR43 / 186	Energizer	13.12.2005	www. batterie24.com Best.-No. 14030581	k.A.	2/1	3,49	Energizer LR43/189 Alkaline 1,5 V Made in China	07/2009
V26	others	Alkaline/ man-ganese	LR43	Panasonic	02.01.2006	www.computer-universe.net Best.-No. 90116060	k.A.	1/2	2,58	Panasonic Cell Power Alkaline LR43 1,5V Made in Japan	05/2007

Tab. A2-10: Button cells from mailorder (continued)

No.	Appli-cation	Chem. system	Dimension	Producer/ distributor	Date of supply	supplied from	Lot-No.	Pack content/ number of packs supplied	Price in €	Name	Expiry date
V27	others	Alkaline/ man-ganese	LR43	Duracell	15.12.2005	www.office-netshop.de Best:-No. 3040098	k.A.	2/1	3,02	Duracell LR43 eElectronics Alkaline 1,5 V Made in China	2009
V28	others	Alkaline/ man-ganese	LR43	NoName20	15.12.2005	www.office-netshop.de Best:-No. 3010850	k.A.	10/1	2,15	Vinnic L1142 Alkaline Cell AG12/LR 43	k.A.
V29	others	Alkaline/ man-ganese	LR43	NoName20	16.12.2005	www. akkutheke.de Best.-No. 1076010086	k.A.	1/2	0,98	Vinnic L1142 Alkaline Cell AG12/LR 43	k.A.
V30	others	Alkaline/ man-ganese	LR43	NoName21	02.01.2006	www.computer-universe.net Best.-No.	k.A.	1/2	1,58	Ansmann energy Alkaline Battery LR43 1,5V Heavy Duty	03/2007
V31	others	Alkaline/ man-ganese	LR44	NoName22	16.12.2005	www. akkutheke.de Best.-No. 1076010096	k.A.	1/2	0,98	Chromex Battery AG 13	k.A.
V32	others	Alkaline/ man-ganese	LR44/A76	NoName8 (Camelion)	09.12.2005	www.westfalia.de Best.-No. 472050	k.A.	5/1	1,89	Camelion Alkaline Battery 1,5 V	k.A.
V33	others	Lithium	CR1620	Energizer	13.12.2005	www.batterie24.c om	k.A.	1/2	6,98	Energizer 1620 Lithium 3 V	07/2012
V35	others	Lithium	CR1620	Varta	07.12.2005	www.batterie-3000.de Best.-No. 10321	k.A.	1/2	3,80	Varta Electronics V12GA.LR43 Made in China	04/2010
V36	others	Lithium	CR1620	Panasonic	02.01.2006	www.computer-universe.net Best.-No. 90116071	k.A.	1/2	3,58	Panasonic Cell Power Lithium CR1620 3V Made in Japan	07/2015
V37	others	Lithium	CR1620	NoName8 (Camelion)	09.12.2005	www.westfalia.de Best.-No. 873497	k.A.	1/2	3,38	Camelion Premium Lithium 3V Camelion Batteries GmbH Berlin	08/2013

Tab. A2-10: Button cells from mailorder (continued)

No.	Appli-cation	Chem. system	Dimension	Producer/ distributor	Date of supply	supplied from	Lot-No.	Pack content/ number of packs supplied	Price in €	Name	Expiry date
V38	others	Lithium	CR2032	NoName7	16.12.2005	www.conrad.de Best.-No. 650183 - 62	k.A.	1/2	3,90	Conrad energy Lithium Battery Cr2032 3V Nr 650183	03/2008
V39	others	Lithium	CR1621	NoName21	02.01.2006	www.computer-universe.net Best.-No.	k.A.	1/2	1,98	Ansmann energy Buttoncell CR1620 3V	k.A.
V40	others	Lithium	CR1620	NoName7	16.12.2005	www.conrad.de Best.-No. 650147 - 62	k.A.	1/2	3,90	Conrad energy Lithium Battery Cr1620 3V Nr 650147	k.A.
V41	others	Lithium	Cr2032	NoName8 (Camelion)	07.12.2005	www.batterie-3000.de Best.-No. 10363	k.A.	1/2	2,20	Camelion Premium Lithium 3V CR 2032	k.A.
V42	others	Silver oxide	SR66	Varta	15.12.2005	www.office-netshop.de Best:-No. 3060260	k.A.	1/2	1,59	Varta Watch V377	k.A.
V43	others	Lithium	CR1620	Duracell	15.12.2005	www.office-netshop.de Best:-No. 3040092	k.A.	1/2	2,21	Duracell Elektronics Lithium 3 V 1620, Made in Switzerland	2015
V45	others	Silver oxide	SR626	Panasonic	02.01.2006	www.computer-universe.net Best.-No. 90135604	k.A.	1/2	2,78	Panasonic Silver 1,55V SR626SW 377, Made in Japan	k.A.
V46	others	Silver oxide	SR66	NoName17	16.12.2005	www. akkutheke.de Best.-No. 1136010146	k.A.	1/2	0,98	maxell Micro Silver Oxide Battery Watch Battery 1,55 V SR626 SW Made in Japan	k.A.
V47	others	Silver oxide	SR66	Energizer		http://watch-out.prag.web-space24.de/ Best.-No.	k.A.	2/1	5,00	Energizer Silver 1,55 V 377 LD Made in USA	k.A.

Tab. A2-10: Button cells from mailorder (continued)

No.	Appli-cation	Chem. system	Dimension	Producer/ distributor	Date of supply	supplied from	Lot-No.	Pack content/ number of packs supplied	Price in €	Name	Expiry date
V48	others	Silver oxide	SR44	NoName20	15.12.2005	www.office-netshop.de Best:-No. 3010854	k.A.	10/1	5,60	Vinnic Silver Oxide 3357 Button Cell	k.A.
V49	others	Silver oxide	SR43	NoName20	15.12.2005	www.office-netshop.de Best:-No. 3010853	k.A.	10/1	5,03	Vinnic Silver Oxide 386 Button Cell	k.A.
V50	others	Silver oxide	SR43	NoName17	16.12.2005	www. akkutheke.de Best.-No. 1186010136	k.A.	1/2	0,98	maxell Micro Silver Oxide Battery Watch Battery 1,55 V SR43SW Made in Japan	k.A.

Tab. A2-11: Incorporated batteries from Berlin

No.	Product	to be supplied from	Producer/distributor/ BatterieType	Date of supply	supplied from	Lot-No.	Pack content/ number of packs supplied	Price in €	Name	Expiry date
B7	calculator	retail trade	Otany/ L1131 Alkali Mangan	03.12.2005	**Woolworth** Wilhelmsruher Damm 134 13439 Berlin	k.A.	2/1	4,99	OtanyKc-153 Wissenschaftlicher Rechner Made in China	k.A.
B9	watch	retail trade	IMAGE -	05.12.2005	**Woolworth** Wilhelmsruher Damm 134 13439 Berlin	k.A.	1/2	10,00	IMAGE Quarts SG5208080	k.A.
B10	watch	flew market/ street hawker	REZ -	08.12.2005	**street hawker** Wilhelmsruher Damm/Senftenberger Ring (Sukhjeet Singh Alt-Friedrichsfelde 123, 10315 Berlin)	k.A.	1/2	20,00	REZ Quartzuhr	k.A.
B11	greeting card	retail trade	Paperclip/ LR1130	03.12.2005	**McPaper AG** Filiale 9057 Senftenberger Ring 15-17	k.A.	1/2	5,90	mixedemotions EM219b-GB Paperclip international	k.A.
B13	toy	retail trade	Simba 357 A Alkaline	08.12.2005	**Woolworth** Scharnweberstr. 21-22 13405 Berlin	k.A.	2/1	3,19	LCD Games Football von Simba	k.A.
B14	toy	flew market/ street hawker	-/ LR44	08.12.2005	**street hawker** Wilhelmsruher Damm/Senftenberger Ring	626-600	3/1	1,00	Benign Girl Super Telephone Made in China	k.A.
B15	shoes (flashlights)	retail trade	Spellbound/ Lithium	08.12.2005	**Deichman** Am Borsigturm 13507 Tegel	k.A.	2/1	19,90	Spellbound The Koala Brothers Made for Leomil Europe	k.A.
B44	shoes (flashlights)	retail trade	Blinklicht-schuh/ Panasonic 3V CR2032 Lithium	07.08.2006	**Lidl** Roedernallee 45-50 13407 Berlin	k.A.	2/1	5,99	-	k.A.

Tab. A2-12: Incorporated batteries from Konstanz

No.	Product	to be supplied from	Producer/distributor/ BatterieType	Date of supply	supplied from	Lot-No.	Pack content/ number of packs supplied	Price in €	Name	Expiry date
K5	greeting card	retail trade	Horn/ LR41	20.01.2006	**Karstadt** Hussenstraße 23 78462 Konstanz	k.A.	2/2	9,90	Musik Karte BP Studio Horn Die gute Karte 51-H1198	k.A.
K7	toy	retail trade	Dickie/ R6 Dry cell	20.01.2006	**Karstadt** Hussenstraße 23 78462 Konstanz	k.A.	2/1	5,99	S.O.S. City van von Dickie Spielzeug 1,5 V R6	12/2006
K8	toy	flew market/ street hawker	Dicheng/ Photo Alkaline von Varta Made in Germany	21.01.2006	**Steinhauser & Schellhammer** Schnetztor-Unterführung 78462 Konstanz	k.A.	1/2	5,00	High Quality Quartz Clock 3041	06/2007
K9	pocket lamp with batteries	-	-/ D Zinc/carbon	20.01.2006	**OBI** Carl Benz Str. 13 78467 Konstanz	k.A.	6/1	5,49	CMI Made for OBI Batterie: Dorcy Mastercell Heavy Duty Battery	12/2007

Tab. A2-13: Incorporated batteries from Guben

No.	Product	to be supplied from	Producer/distributor/ BatterieType	Date of supply	supplied from	Lot-No.	Pack content/ number of packs supplied	Price in €	Name	Expiry date
G3	calculator	flew market/ street hawker	Scientific/ L1131 3V	19.12.2005	**Kaufland** Guben II Fr. Schiller-Str. 5b 03172 Guben	k.A.	2/1	3,99	Scientific Calculator Genie 52SC	k.A.
G4	watch	flew market/ street hawker	-/ Alkaline Button cell	19.12.2005	street hawker im Kauflandvorraum	k.A.	1/2	7,98	D-Cong Made in China	k.A.
G5	greeting card	retail trade	Taunus/ LR41	19.12.2005	Heidi´s Geschenkidee Berliner Straße 12 03172 Guben	51-5000/2	1/2	5,90	Taunus Verlag 65232 Taunusstein	k.A.
G6	toy	retail trade	Chicco/ LR41 Button cells	19.12.2005	**Real** Karl-Marx-Str. 112 03172 Guben	k.A.	2/1	9,99	chicco Smile Kamera Flash	k.A.
G8	LED-lamp	retail trade	Stellar/ LR41 (AG3)	19.12.2005	**Hellweg** Gewerbestr. 32 03172 Guben	k.A.	4 AG3 4/1	1,99	Stellar LED Taschenlampe Art.-Nr 4011	k.A.

Tab. A2-14: Incorporated batteries from the Ruhr region (Essen, Duisburg, Kleve)

No.	Product	to be supplied from	Producer/distributor/ BatterieType	Date of supply	supplied from	Lot-No.	Pack content/ number of packs supplied	Price in €	Name	Expiry date
R5	calculator	retail trade	Network/ AG10	09.12.2005	**Saturn** Porscheplatz 2a 45127 Essen	9917D014880C	1/2	2,00	network einfach rechnen PC 1248P Pocket Calculator	k.A.
R6	watch	retail trade	SH	09.12.2005	**WICKY** Kettwiger Str.40 45127 Essen	k.A.	1/2	9,90	SH Quartz	k.A.
R7	greeting card	retail trade	-/ AG3 LR41	09.12.2005	**WICKY** Kettwiger Str.40 45127 Essen	k.A.	1/2	1,90	DBS-0028	k.A.
R8	toy	retail trade	Dickie Spielzeug/ R6 1,5 V AA	09.12.2005	**Galeria Kaufhof** Kettwiger Str. 1a 45127 Essen	k.A.	2/1	5,00	Flip Top von DICKIE Spielzeug Auto mit Kabelfernsteuerung Batteries enth. Made in China	k.A.
R9	christmas cap	flew market/ street hawker	-/ AG 13 (LR44)	09.12.2005	**street hawker**	k.A.	2/1	1,00		k.A.

Tab. A2-15: Incorporated batteries from mailorder

No.	Product	Chem. system	Producer/ distributor	Date of supply	supplied from	Lot-No.	Pack content/ number of packs supplied	Price in €	Name	Expiry date
V10	calculator	Alkaline (AG10)	-	09.12.2005	www.westfalia.de Best:-No. 835330	k.A.	1/2	6,58	Euro Commercial Desktop Euro-Converter 2X AG10 (alkaline Batteries)	k.A.
V11	watches	Silver oxide	W Chrono	09.12.2005	www.westfalia.de Best:-No. 358614	k.A.	1/2	14,99	watches	k.A.
V12	toy	Alkaline Dry cells (AA)	goodplay	13.12.2005	www.quelle.de Best:-No. 039388H	k.A.	2/1	14,99	goodplay Mega-Mammoth Made in China Batteries: 4x Artin AA 1,5V roduced by GPI Made in China	07/2008
V13	toy	Alkaline (LR44)	heunec	13.12.2005	www.quelle.de	k.A.	3/1	8,99	---	k.A.
V14	music card 1	Alkaline/manganese (LR41)	-	01.02.2006	www.pearl.de Best:-No. PE8854	k.A.	10 Module 1/10	2,90	Lambada Melodie-Moul	k.A.
V15	music card 2	LR1130	-	01.02.2006	www.pearl.de	k.A.	3 Module 1/3	12,90	Voice Record/Playback Module LR1130	k.A.
V16	Blue Bubble LED	Lithium CR927	Henlimax	01.02.2006	www.pearl.de Best:-No. SD2000	k.A.	2/1	2,90	Blue Buubble LED-Lichtspiel	k.A.