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New approaches to the collection of scrap batteries

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Abstract

Lead/acid batteries are by far the largest use of lead and they continue to grow in importance, both as a proportion of total lead use and in actual tonnage terms. They are also well suited to recycling and represent the major source of recoverable lead. As such, they are collected and recycled in large numbers in most countries. Unfortunately, the economics of recycling are not always favourable and recycling rates are therefore prone to fluctuation, tending to fall at times of low lead price and rise when prices are firmer. On top of this, tightening environmental standards are imposing additional costs on those involved in battery collection and recovery and are discouraging some traditional participants from continuing involvement in the process. As a result, considerable attention is being paid to ways of ensuring consistently high rates of battery recovery. Various approaches have been considered, both voluntary and compulsory, and several have been put into practice. Two main collection routes are used: the battery distribution network and the scrap-metal trade. A range of different measures are employed including acceptance of scrap batteries by retailers, compulsory exchange of old batteries for new, prohibitions on disposal of scrap batteries with household waste, returnable deposits on battery sales, and environmental levies. In all cases, the schemes are backed by education campaigns to ensure their effectiveness. The paper examines the principles behind the various approaches and describes several of the schemes that have been piloted or introduced in different countries.

Introduction

On the world scale, batteries are by far the largest use of lead. They are also the fastest growing use which means that they account for an ever-growing proportion of total lead consumption. Importantly, both for the lead industry and for reasons of environmental protection, batteries are recycleable and, in most countries, are collected and recycled to a very significant extent.

Unfortunately, however, 100% recycling is seldom, if ever, achieved. This situation prevails despite the existence of extensive networks of scrap collectors and recycling companies. The proportion of batteries that are not recovered varies from country to country (and even from region to region within a country), but is usually dependent on both the density of population and the location of smelters. The latter, in turn, determines the costs of collection and transport of the scrap batteries. Thus, in more remote and less-densely populated regions, it is sometimes uneconomic to gather scrap batteries and move these to where the lead and other constituents can be recovered.

Whether, or not, uncollected batteries create environmental problems depends on what happens to them. In many instances, they are simply left in garden sheds or garages where they are quite harmless. Inevitably, however, a small proportion of such

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abandoned batteries are disposed of indiscriminately, in refuse or even at the sides of roads, in which situations there may be possibilities of some later environmental impact. In consequence, considerable attention has been paid to the question of how to encourage, or mandate, higher levels of recovery. A range of options has been identified and, in some cases, put into effect in various countries around the world. This paper reviews the size and nature of the problem and describes some of the schemes that have been implemented to encourage higher levels of recycling.

Production/use patterns of lead

In order to make a sensible assessment of the extent of battery recycling that is being achieved today, it is necessary first to review the overall market for lead. The latter should consider the pattern of total demand for the metal and how this is being satisfied from a mixture of primary and secondary sources. Reliable statistical data, that allow this exercise to be conducted with some degree of confidence, are collected and published by the International Lead and Zinc Study Group (ILZSG) — an intergovernmental organization based in London. The ILZSG's statistics provide total production and consumption figures for virtually every significant lead producing and using country. The data therefore enable trends to be monitored closely. Information is also collected on end-use markets for lead and cover about 90% of the lead used in market economy countries. Thus, the changing patterns of lead use can also be monitored.

Production of lead

Overall levels of lead production tend to fluctuate in response to demand, although in any one year there may be a slight surplus or shortfall. Thus, over the last twenty years there has been a gradual increase in total lead production in the market economy countries at an average rate of about 1% per year (Fig. 1). The most interesting feature of this growth in production is that it has not enjoyed equal contributions from both primary and secondary sources. For example, primary lead production has remained relatively static at a level of about 2.2 to 2.3 million tonnes per year and is even beginning to decline slightly. The overall increase in lead supplies is attributable exclusively to secondary production which has grown from a level of about 1.2 million tonnes in 1970 to 2.2 million tonnes in 1990, i.e., an annual growth rate of about 4% (see Fig. 2).

Because primary and secondary production have responded differently to increased demand, their relative contributions to total production have changed with time. Thus, the share of secondary production has grown steadily to the point where, in the market economy countries as a whole, secondary production marginally exceeds primary production. The relative proportions in individual countries obviously vary considerably and depend on such factors as mining activity and availability of secondary raw materials. Nevertheless, the levels of recycling achieved in some countries are impressively high; they range up to as much as 60 or even 70%. Whilst process residues (drosses, slags, filter dusts, etc.) do contribute to the supply of secondary raw materials, by far the major source for recycling is scrap lead products.

Uses of lead

Lead has a wide range of important applications that perform vital roles in such areas as transport, communications, construction, and energy production/transmission. The present division among the uses in the market economy countries is given in

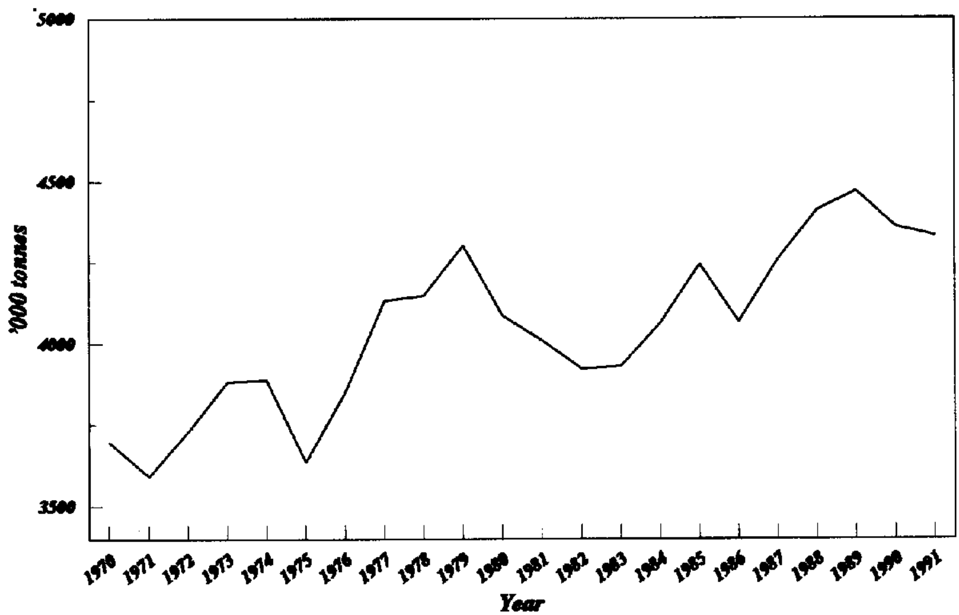

Fig. 1. Lead production in market economy countries – 1970–1991.

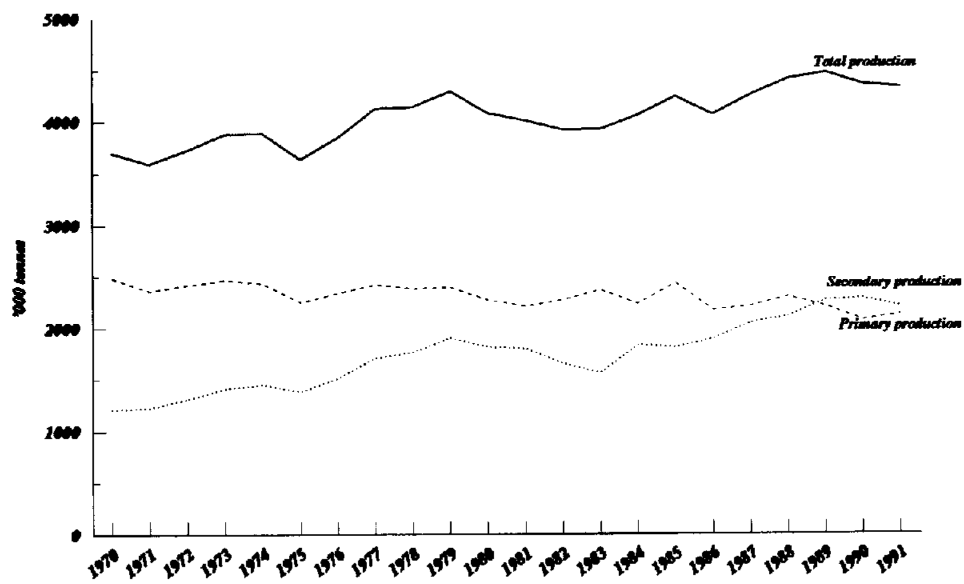

Fig. 2. Primary and secondary lead production in market economy countries – 1970–1991.

Fig. 3. It can be seen that by far the largest use is in the manufacture of batteries. Indeed, batteries (about 63% of total lead consumption) account for over four times as much lead as the next largest use.

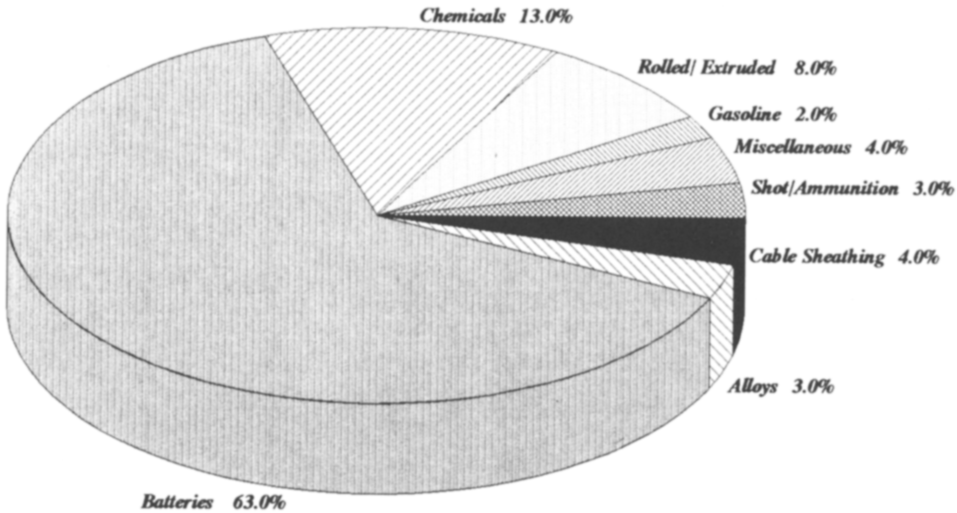

Fig. 3. Breakdown of lead uses — 1990.

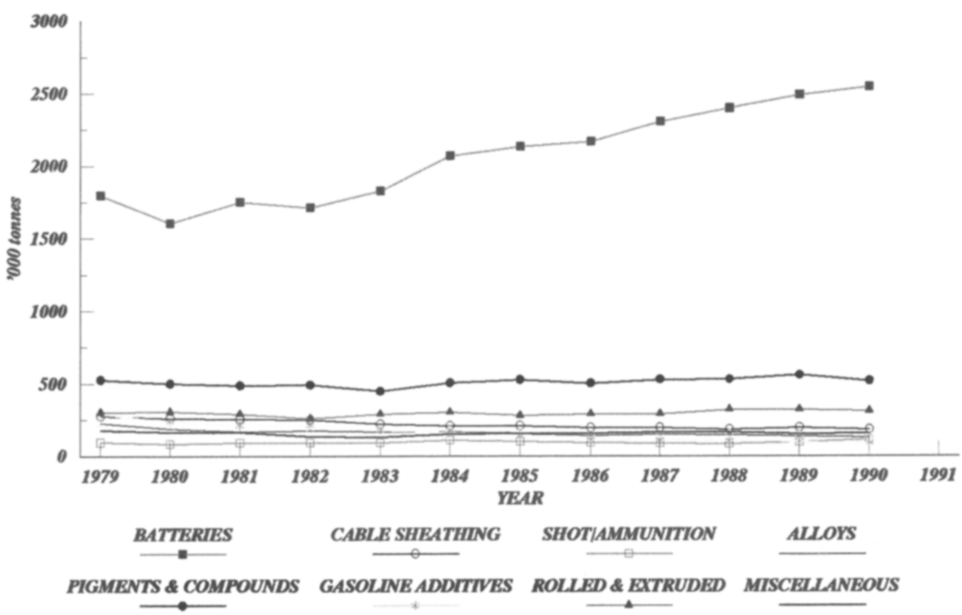

Fig. 4. Trends in lead uses — 1979–1990.

The breakdown of uses in one particular year tells only part of the story about consumption patterns since it gives no indication of the way individual application areas are changing with time. Trends in the various end-use markets over the last ten years are therefore shown in Fig. 4 from which it is apparent that batteries are not merely the largest use of lead — they are the only use showing appreciable growth and are becoming increasingly dominant. All other uses either show more or less stable consumption or are in decline.

Battery recycling levels

The calculation of battery recycling rates is surprisingly complicated. A knowledge of the breakdown of battery use is necessary, together with an estimated mean lifetime for each type of battery. In addition, in order to calculate recovery rates in a particular country, detailed statistics are needed on imports and exports of lead, new batteries, vehicles, scrap batteries and scrap lead. Moreover, since battery movements are recorded in numbers of units, the average weight of lead in different types of batteries must also be included in the calculations.

The major categories of lead/acid batteries are, of course, automotive, motive power and stationary. Within the automotive sector there are a wide range of distinctive types (e.g., for passenger cars, lorries, tractors, motorcycles), each with its own characteristic lead content and service life; the latter is generally of the order of 3 to 4 years. Motive-power batteries tend to have longer lifetimes (about 4 to 6 years), whilst stationary batteries last longer again (up to 10 years, or so). The relative proportions of the different types of batteries vary considerably from region to region. For example, in the USA about 90% of battery lead is used in automotive batteries and only about 10% in other types, whereas in Europe a smaller proportion (about 70%) goes into automotive batteries and nearly 30% is used in the manufacture of motive-power and stationary batteries. In both regions, and indeed elsewhere, there is also a new market sector developing in the form of consumer cells for portable applications such as lap-top computers. At present, this currently represents a very small proportion of the lead/acid battery market (no more than 1%, but growing) and few, if any, of these cells are yet becoming available for recycling.

Because of the complications that are involved in determining recovery rates, relatively few attempts have been made to perform detailed calculations, although rough estimates are very widely quoted. In Europe, a 1987 study [1] estimated automotive recovery rates in most European Community countries at between 80 and 85%, although it is widely held that the rates are generally higher. One of the most thorough calculations [2, 3] has been performed for each of the years between 1987 and 1990 in the USA by the battery industry's representative organization, the Battery Council International. This study has revealed an impressive and steadily-increasing rate of recovery, from a level of 88.6% in 1987, through 91% in 1988, 95.3% in 1989, to 97.8% in 1990. In future, the calculations will be performed each year as soon as all the necessary statistical data are available. Elsewhere, rates of the order of 80 to 90% are quoted frequently as estimates for automotive batteries, but detailed calculations are rarely available. It is also often asserted that industrial batteries are usually recovered at rates closely approaching 100%, both because of the volumes (and hence value) involved and because of the nature of the supply/return system operated by manufacturers.

Despite the very high recovery rates calculated for the USA and also claimed for other countries, there have been periods when much poorer rates have been experienced, notably at times of low lead price when the economics of collection and transport simply become unviable for the scrap collectors. At such times, attention is inevitably drawn to the question of what is happening to the missing batteries and whether or not they create an environmental problem. In a number of instances, the result has been a review of collection procedures for scrap batteries and the introduction, voluntarily or otherwise, of organized schemes that are designed to ensure consistently high levels of recycling.

Collection of scrap batteries

Whilst industrial batteries are normally used and scrapped in numbers that make it economic for the supplier to recover the old batteries when they are replaced with new, the same does not always apply for automotive batteries despite the fact that the latter constitute by far the major part of the battery market. As a consequence, the collection of scrap automotive batteries tends to be a less organized exercise that is conducted at various scales by a wide variety of routes and players. This section takes a broad look at conventional collection practices and at some of the schemes that are now being introduced in an attempt to improve existing systems.

Conventional collection routes

Traditionally, the collection of spent automotive batteries has not been a particularly well-organized exercise. By and large, however, despite fluctuations in the price of lead and in the costs of transport, a spent battery has enjoyed a positive value and this has provided sufficient motivation and incentive for the scrap trade to collect and deliver to secondary lead smelters a very high proportion of available scrap batteries. Increasingly severe environmental requirements in recent years have affected the economics of recovery in some areas and have resulted in a greater degree of involvement by battery manufacturers when the scrap trade alone has not been able to maintain the very high recovery rates previously achieved. As a result, there are today two main routes for recovery of spent lead/acid batteries: (i) the battery manufacturers who take responsibility for their own products and organize collection through their retail outlets, and (ii) the scrap dealers who seek out scrap batteries from all available sources for profit.

When an automotive battery fails, a replacement is available from a variety of sources such as garages, specialist motor accessory suppliers, or more general retail outlets. In many cases, these suppliers of new batteries will accept old batteries in exchange for the new and will return them to secondary lead smelters either via battery manufacturers or via the scrap-metal trade. Nevertheless, few countries make it compulsory for the retailer to accept scrap batteries and it is not always convenient for the owners to return them at the time of purchase, with the result that substantial numbers of batteries remain for collection and return through other routes.

Many of the batteries that are not returned to retailers remain with the owners, or find their way to waste disposal sites, or accumulate at car junkyards when old cars are themselves scrapped. These batteries are generally collected by scrap-metal dealers who accumulate them until there are sufficient quantities to make it economic either to sell them on to larger dealers or to deliver them directly to secondary lead smelters. Furthermore, scrap dealers are often involved in the chain of movements from retailers to smelters, although there is now an increasing trend towards the battery manufacturers themselves collecting scrap batteries from their retail outlets and delivering them direct to the smelters without the involvement of the scrap trade.

Overall, the somewhat disjointed collection systems that are conventionally employed work remarkably well and exceptionally high collection rates are generally achieved. However, because price fluctuations can adversely affect the value of scrap batteries and because transport costs to smelters can be excessive, particularly for more remote communities, collection rates can vary both with time and from region to region. As a consequence, a number of schemes have been devised and/or introduced to encourage, or require, consistently high levels of collection.

Methods for enhancing collection rates

Many of the ideas for improving collection efficiencies that have actually been put into practice are essentially voluntary in nature; they rely on encouragement of the consumer to return old batteries to an appropriate collection point. This encouragement can take the form of either education about the benefits of recycling or some financial advantage to the owner of the battery.

Education about the benefits of recycling — economic, environmental, resource conservation — can encourage the right attitude in owners of dead batteries but, on its own, may be insufficient to enhance return rates if attention is not also paid to where the owner can return the old battery. Thus, it is becoming increasingly common for retailers of new batteries to accept spent batteries at the time of sale and indeed this is now a legal requirement in some countries. A further means of encouragement that has also found its way into legislation is to prohibit the dumping of spent batteries with household waste. This restriction gives the owner little option but to find an authorized outlet for the battery or, alternatively, to retain it indefinitely.

Reliance on the goodwill of a battery owner and the creation of obstacles to dumping still represent somewhat limited encouragement, and so another and more powerful (financial) means of encouragement is sometimes employed in the form of a returnable cash deposit on a battery. In effect, this makes a new battery cheaper if an old one is handed in since a refund is given for the old battery. Because the real value of the recoverable materials in a battery is usually quite small, the value of a deposit is normally set artificially high in order to make it genuinely attractive to the owner to hand in the old battery.

An alternative means of encouraging higher levels of collection is the imposition of levies, or taxes, on the sale of new batteries. In this case, however, the encouragement is aimed not so much at the battery owner but rather at those involved in the collection and recycling of the old batteries. This is because the money raised from the levies/taxes can be used to help subsidize otherwise uneconomic stages of the collection and recycling chain; for example, by paying collectors a rate for the scrap batteries that is greater than the prevailing market price. A proportion of the money raised from the levies/taxes can also be used to fund education campaigns that encourage the return of dead batteries.

One other approach that has been practised and that virtually guarantees 100% recovery of dead batteries is the compulsory return of an old battery in order to obtain a new one. Unfortunately, this tends to be an unduly bureaucratic process that involves detailed monitoring of battery ownership, so it is not commonly employed.

Finally, a new idea that has recently emerged is for the encouragement of recycling by requiring that a specified (and growing) proportion of secondary lead be used in the manufacture of new batteries. This puts the onus on battery manufacturers to ensure that a sufficient number of batteries are being recycled since otherwise they may not be able to purchase the requisite amount of secondary lead. This approach has not yet been tried in practice, but is the subject of serious consideration.

Practical examples of collection schemes

A number of the methods outlined above for enhancing collection rates have been built into schemes and put into effect by certain countries or regions. As a result, experience is now starting to be acquired that concerns the practicalities and effectiveness of the various approaches. Brief descriptions of schemes now in effect in the European Community, the USA, Sweden and Italy are given below.

The European Community

In March 1991, the Council of the European Communities approved a Directive (91/157/EEC) on batteries and accumulators that contain dangerous substances [4]. This is designed to ensure that all EC Member States organize efficient collection and disposal of certain types of batteries, including lead/acid. 'Disposal' in this context also involves the possibility of recycling which, for lead/acid batteries, is clearly the appropriate disposal route.

The EC Directive does not lay down many specific requirements for the achievement of its objectives, beyond requirements for standardized marking of batteries and education of consumers about what to do with a used battery. The choice of precise mechanisms of collection schemes is left to the individual Member States.

Thus, lead/acid batteries must be marked to indicate that they can be recycled and that they must be disposed of separately, i.e., not with household waste. The marking must include an internationally-recognized recycling symbol that comprises three arrows in a ring. Consumers must be informed about the meaning of the markings and about the dangers of uncontrolled disposal of spent batteries. The appropriate authorities in each country are required to ensure the efficient organization of disposal (i.e., recycling). In this respect, the concept of deposit systems is specifically identified as a possible mechanism, although it is not mandated. The authorities are also required to draw up their own collection and recycling programmes; the first one will take effect in March 1993. Because the Directive is so recent, little progress has yet been made with its implementation. It is therefore still too early to judge how successful the process will prove to be.

The United States of America

In the USA, there is no Federal legislation designed to ensure a uniform approach to battery collection and recycling throughout the country. Nevertheless, when it became apparent that recycling rates were declining as a consequence of increasingly severe environmental legislation that forced collectors to stop handling scrap batteries, the initiative was taken voluntarily by the battery industry. The latter, through its trade organization, the Battery Council International (BCI), has drawn up, and is actively promoting to the individual States, a proposed model for battery recycling legislation [5].

The main elements of the BCI model comprise the prohibition of land disposal of batteries and the acceptance of scrap batteries by battery retailers. Specifically, the model proposes that no one may place a used lead/acid battery in municipal solid waste, or otherwise dispose of it except by delivering it to an authorized battery collector such as a battery retailer or wholesaler, a scrap dealer or a secondary lead smelter. In order to make disposal easy for the owner of a spent battery, the model requires all retailers of new batteries to accept old ones in whatever numbers are offered (i.e., the customer is allowed to return all old batteries that may have accumulated over the years). Retailers are also required under the model to display notices advising customers that the dumping of batteries is illegal and that they accept old batteries for recycling.

The BCI model was first translated into State legislation by two US States with effect from 1 January 1989; since then, many others have followed suit. At the latest count (April 1991), 30 States had enacted legislation based on the BCI model and a further four had prohibited battery disposal in municipal solid waste. Some States, but not all, had also introduced deposits on new batteries to encourage more returns.

Following a period during the mid-1980s, when recovery rates apparently declined significantly (particularly in areas with sparse populations and far from secondary smelters), a marked recovery has evidently taken place, even before the BCI legislation became widely adopted. Calculated recovery rates indicate an increase in battery lead recovery from 88.6% in 1987, through 91.0% in 1988, 95.3% in 1989, to 97.8% in 1990.

Sweden

Despite a reputation for a high degree of environmental awareness, Sweden experienced a significant decline in the battery recycling rate during the mid-1980s when lead prices fell to relatively low levels. The problem was largely a result of the long distances over which scrap batteries had to be transported to the single secondary lead smelter in the south of the country, and the accompanying high transport costs.

In order to correct the situation and establish a consistently higher rate of battery recovery, the Swedish government instituted a trial scheme in 1988 that involved a levy (or environmental charge) on all battery sales in the country. The purpose was to subsidize uneconomic stages of the collection chain and to educate the public about the desirability of returning old batteries for recycling. The possibility of imposing deposits on batteries was considered but rejected, at least for the trial period of the scheme, reliance being placed instead on the consumer's environmental consciousness and the desire to act appropriately in the interests of environmental protection. The deposit option still exits, but will only be adopted if voluntary returns of scrap batteries prove inadequate.

To administer the system, a nonprofit management company (Returbatt) was created. The latter comprised representatives of the battery manufacturers, scrap trade and secondary lead industry. This company collected the levies on battery sales, coordinated collection activities and distributed financial contributions to the collectors. It also conducted the necessary education programme to ensure that the public understood and participated in the scheme. As with the BCI model in the USA, a critical factor in the scheme was that all battery retailers were obliged to accept spent batteries.

During the trial years of 1989–1990, considerable success was achieved with the apparent collection rate rising to about 130 to 140%. This suggested that a considerable stock of spent batteries that had previously been stored was brought in for recovery. Given the success of the trial years, definitive legislation was introduced with effect from January 1991 with the battery levy set at 35 Swedish kroner. So far, the apparent collection rate has remained well over 100%. This means that the stated aim of establishing a consistent collection rate of at least 95% appears to have been achieved.

Italy

A system with distinct similarities to the Swedish collection approach has recently been introduced in Italy. The main elements of the system are a Consortium to coordinate collection and recycling of batteries, a tax on new battery sales and education of the public about the need for ecologically-sound disposal of spent batteries. The main difference from the Swedish scheme is that there is no obligation on battery retailers to accept spent batteries.

The creation of the Italian Consortium for lead/acid batteries and lead-containing waste was approved by Statute in May 1990. Its tasks are the collection and storage of dead batteries and lead wastes and their transfer to recycling plants, or their ecological disposal in the case of wastes that are not suitable for recycling. The Consortium has a broad base; it comprises all sectors involved in the battery life cycle, namely, producers and importers of batteries, national associations of battery fitters and car wreckers, and industrial recycling plants. Representatives of Italian government departments are also involved in the Consortium's governing body.

The main objectives of the Consortium are to ensure a maximum degree of collection of scrap and a minimum amount of disposal. The existing collection network is used as a basis and is being upgraded to ensure that all aspects of collection, transport and storage are performed to high environmental standards. Extensive educational activities will ensure a thorough understanding and appreciation of the need for recycling. To this end, the Consortium will also promote research into improved disposal/recycling of battery components other than lead, e.g., plastics, sulfuric acid, wastes and sludges.

To finance its activities, the Consortium has two sources of income, viz., the receipts from sales of scrap batteries to the recycling plants, and a levy on the sales of new batteries. The price of scrap will be determined by the Consortium and will be essentially constant across the country, with minor differences allowed only in relation to distance of transport. The levy on battery sales will be set by the government and reviewed periodically to ensure an adequate level of funding for the proper functioning of the Consortium.

Other countries

Battery collection schemes are under close scrutiny in a number of other countries — especially in the European Community where the battery directive referred to earlier is due to take effect in 1993. Whilst details have not yet been decided in most cases, it appears that schemes based on the Swedish/Italian models are receiving particularly close attention, with the emphasis on voluntary approaches and the maximum possible use of existing collection routes. A single pan-European scheme would have obvious advantages but is unlikely to materialize, at least in the short-term.

Conclusions

As environmental concerns continue to grow and as patterns of lead use change with batteries accounting for an ever-increasing proportion of the metal's markets, it will become even more important to ensure the maximum possible rates of scrap-battery collection and recycling. Although traditionally high, rates are susceptible to fluctuating market prices, a factor outside the industry's control. As a consequence, recent years have seen experiments with new collection schemes or with adaptations to existing ones.

So far the experiments have shown encouraging results and indications are that they will enable consistently high rates of recovery to be achieved, irrespective of prevailing economic circumstances. Collection routes based on both the battery distribution network and the scrap-metal trade are proving equally effective and it is clear that schemes can be tailored to suit local circumstances with the minimum adverse impact on existing participants. As time goes on and the schemes become more established, it is reasonable to expect near 100% recycling of all major applications of lead/acid batteries.

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