

CHAPTER 5

RECYCLING OF LEAD

Lead is a material which is very easy to recycle. It can be re-melted any number of times, and provided enough processes to remove impurities are performed, the final product (termed secondary lead) is indistinguishable from primary lead produced from ore.

The amount of lead recycled as a proportion of total production is already fairly high worldwide. Over 50% of lead consumed is derived from recycled or re-used material; the figure is higher in Western Europe (60%) and the USA (70%). Secondary production rates compare favourably with other metals.

The long lifetimes associated with some applications of lead coupled with steadily increasing production mean that secondary production as a proportion of total production is not a good indicator of the actual recycling rate for lead (defined as lead recycled as a proportion of end-of-life material).

Recycling rates of lead and other metals are estimated to be much higher than for other materials such as paper, plastics and glass. Disincentives to recycle these materials include: low costs of raw materials to make virgin products, relatively high collection and transportation costs for a low value product and, particularly for plastic and paper, problems with inferior product quality.

Factors influencing high collection rates of lead are:

- the biggest consumer of lead is the battery industry which has a very high rate of collection and return of scrap batteries in most EU Member States;
- many other products used in much smaller amounts are suitable for recycling, and may be returned via scrap merchants;
- in conjunction with the iron and steel industries, zinc, copper and lead are recovered within the recycling processes of these industries;
- some applications which result in its unrecoverable dispersal into the environment, in particular as petrol additives and some paint uses, are being drastically reduced.

Recycling is performed where the industry finds it economic to do so. Recovering scrap metal has the advantages that it is easier and much less energy intensive than producing primary lead from ore (the production of recycled lead

LEAD: THE FACTS

requires 35-40% of the energy needed to produce lead from ore.) Recycling also reduces dispersal of lead in the environment and conserves mineral resources for the future.

It is estimated that at least 85% of lead consumed could potentially be recycled. However, in practice the amount that is recovered is lower.

Some lead products are not recycled, either because it is not economic to do so at present, or simply because it is not practical to do so. However, recycling rates are generally increasing. Legislative and economic factors are two key incentives for this increase.

Any figures for recycling rates of lead must be treated with caution. Figures for recycling rates of lead batteries are available in a few countries, such as Italy, where collection systems involve recording this information. However, for lead recycling in general, quoted recycling rates are usually based upon estimates from lead consumption and secondary production. These figures can be distorted by:

- international trade in both scrap and refined lead;
- long time lags as a result of the long service life of some products;
- changes in lead consumption, which is generally rising world-wide, so that even a total recovery of lead would not be sufficient to meet demand for new lead products.

Improved waste management systems, such as incentives for battery recovery, guidelines for handling old building materials, old vehicles, electronic scrap, stricter quality demands for dumping materials and also progress in production techniques tend to generate higher recycling rates.

5.1 RECYCLING PROCESSES

The main stages of the recycling process are:

Collection and transportation - via one of several routes to scrap dealers, or in the case of batteries, to battery wholesalers, then to producers of secondary lead.

Material preparation/sorting - generally involves breaking or grinding the articles into small pieces, which can be separated. This can be done immediately after collection, such as at car scrap yards, or as an initial preparation stage at the smelters.

Melting and smelting - to recover metallic lead. Clean metallic scrap such as pipe and sheet is simply melted; other scrap, especially where lead compounds are involved, requires smelting.

Refining - to remove the metallic impurities from lead metal.

Alloying - to form the desired composition of the product.

Where no dedicated collection system operates, most collection and return of material is via scrap merchants, with the scrap value of the metal providing the incentive for recycling. For the special case of lead acid batteries, some countries operate formal collection systems, which are discussed later.

Smelting and refining procedures for lead scrap have already been described in section 4.1.3 Secondary Production. Smelting of metal scrap is often not necessary if the metal comes from a “clean” source such as lead sheet or piping. However, refining may be needed to remove any unwanted metals present in the scrap material.

Smelting and refining of secondary lead can often be performed in a plant designed to produce primary lead as the processes are very similar. However, secondary lead is generally produced in dedicated works, as this allows for more efficient processing.

5.2 RECYCLING OF MAJOR LEAD PRODUCTS

5.2.1 LEAD-ACID BATTERIES

Collection of batteries

The collection rate of scrap batteries is very high in most highly industrialised countries, and has been for many years. In the European Union a Batteries

Directive looks set to oblige Member States to ensure a high rate of battery collection. Some Member States already have organised collection schemes to increase collection rates, with obligations for retailers and producers to accept batteries returned to them. A levy is imposed by several countries, which is used for such purposes as: to help fund collection, transportation and return of batteries to smelters; administration of collection schemes; publicity and information; inspection of secondary smelters to ensure low emissions; and research into cleaner methods of recycling.

Stated collection targets range from 100% in France and 99.9% in Denmark, to 75% in Portugal. (Bied-Charreton, 1997) Some Member States, including the UK, have not set up any formal system as a high (estimated at >90%) recycling rate is already achieved by existing routes using scrap dealers. However, this relies purely on the scrap value of lead providing an economic incentive, so at times of low value, there is less incentive for collection.

Preparation of lead-acid batteries

The batteries are broken open, crushed and automatically separated into their different components: case materials, metal grids and poles, and “pastes” of lead oxides and lead sulphate. The acid is collected and rendered harmless prior to disposal or reuse by other industries. The plastic material is separated into polypropylene and other plastics (hard rubber, PE etc). The latter are discarded or used as a fuel. The polypropylene is cleaned, composited with additives and molten to produce a PP-compound of desired quality for various applications (e.g. car parts, video cassette casings, plant pots etc.). The metallic components are sorted ready for smelting. The pastes, consisting of a mixture of lead oxides and sulphate, are usually treated to remove most of the sulphur (for example, with an alkaline solution). The components are then ready for smelting.

Smelting of battery pastes, grids and other materials

The battery pastes (consisting of lead oxide/hydroxide/carbonate, with a small amount of sulphate), perhaps together with oxidised lead dross obtained from other processes, are fed into the furnace together with coke or other carbon-rich reducing agent and the mixture is smelted. The lead compounds are reduced to yield a lead metal which is low in antimony. Grid metal is smelted in the same furnaces to produce an antimony containing lead. The crude metals are ready for refining.

Refining/composition control

The lead can be refined to produce soft lead suitable for any application using processes previously described. However, more commonly, recovered battery lead is used to produce new battery alloys. This has the advantage that less refining may be needed, provided the charge consists predominantly of lead

batteries. Extra refining may be needed if other scrap is included in the charge material. Some impurities can be tolerated at low levels, though quality demands for modern battery alloys require some impurities to be present in concentrations of <0.1 ppm. The tolerable limits for elements are set according to the effects of the elements upon the electrochemical or physical behaviour of the lead, i.e. how it functions in a battery. (A. Bush, LDA, personal communication)

Addition of other types of scrap

Lead used for roofing, cable sheathing etc. generally has a different composition to battery-lead. Small additions of such scrap can be tolerated in battery production; again, larger additions could necessitate more refining steps. In a modern secondary plant, lead battery alloys are produced from all types of scrap.

5.2.2 LEAD SHEET, PIPING, CABLE SHEATHING

Although there is no formal system in place, most metals are stripped from old buildings before demolition and sold on to scrap merchants. The recovery rate is not known accurately, but is estimated to be very high (Lead Sheet Association). This scrap is “clean” and is generally sold on to facilities producing similar products, so that the same alloying additions are required as are present in the scrap.

Cable sheathing is sometimes recovered after the end of the useful life of the cable. However, it is often not economic to collect old cable, as collection can be more expensive than the value of the metals. The lead sheathing has a relatively low commercial value; however, cables are recovered primarily for their more valuable copper. Cables are more likely to be recovered if they are in accessible locations (e.g. in soil, rather than on the sea bed) and have high copper contents (for example high power cables). Once a cable has been recovered, it is fairly easy to separate the different components and deliver them to scrap dealers.

5.2.3 END-OF-LIFE VEHICLES

Motor vehicles contain small amounts of lead besides the battery. Lead alloy is often used to coat the vehicles’ petrol tanks (which are made of steel) to prevent corrosion. Some of the car components are made of leaded steel, the lead being added to improve machinability as previously described. Other parts which can contain lead include balance weights on wheels and vibration dampers, some brake linings, electric and electronic solders, aluminium casting alloys, brass alloys, sliding bearings, stabilisers in plastics, ceramic coatings, glass and glass coatings, lamps, piston coatings, hot dip galvanised steel and printed circuit

boards. For the purposes of a study of the environmental impacts of these lead-containing components, it was estimated that the battery had a lead content of 10kg (the highest content known in any vehicle batteries) and all other components together contributed 2.5kg lead.

Some of this lead can be returned to lead smelters via the vehicle recycling chain. Scrap vehicles are shredded and separated into ferrous (iron and steel), non-ferrous metallic and the non-metallic fluff fractions. It is estimated that, of the 2.5kg lead in the car (after battery removal), 1.0kg is contained in the ferrous fraction, 1.0kg in the non-ferrous fraction, and 0.5kg in the fluff (though less than 0.5g derives from leaded machining steels). The ferrous fraction is returned to the steelworks. When charged to the furnace, almost all the lead present is evolved as fume. The vapour, which condenses to a dust, is collected in pollution control equipment together with all the other dust components, particularly zinc. Where this dust is rich in lead (and also zinc) it is recycled by the Waelz-kiln process and Imperial Smelting Process to recover both zinc and lead. It is also possible to recover lead from the non-ferrous fraction and some companies routinely do this.

The lead contained in the fluff may be passed to an incinerator, and potentially contributes to lead emissions to the environment, though pollution control equipment should reduce such emissions to very low levels. (See Chapter 6.)

5.2.4 ELECTRICAL AND ELECTRONIC PRODUCTS

Lead-tin solder is the most widely used material for electrical connections in electrical and electronic goods. If such end-of-life articles are collected and recycled because of their copper value, then lead (and tin) can be recovered simultaneously. At present, some recycling of smaller electrical and electronic parts is done in Europe (examples of such facilities are in Boliden, Sweden, and the UM-Hoboken plant in Belgium). Although the practice is not widespread at present, and they generally enter the waste stream at the end of their lives, recovery rates are expected to increase in the future. The main driving force for this in Europe is the EU directive on waste electrical and electronic equipment, which is currently in preparation. This is expected to set targets for the recycling of such material.

Scrap electrical and electronic equipment can be treated in a broadly similar way to vehicles: ground up into fine particles and separated into different fractions. In this case, most of the lead would be collected in the non-ferrous metallic fraction. This fraction would then be processed to separate the different metals.

The main monetary value of this recycling lies in any precious metals present. However, lead is also routinely recovered in the process.

5.2.5 CATHODE RAY TUBES

The main source of cathode ray tubes is TV sets and computer monitors. Again, very little recycling is done in Europe at present, though considerable amounts are recycled in North America. However, European practice looks set to change in the future as recycling rates for electrical and electronic equipment are predicted to increase. The practice of recovering these items in the USA may be regarded as an example to aim for.

Because of lead's intrinsic properties there is no substitute available for its use for radiation protection in the cone-glass in cathode ray tubes. The draft EU Directive on electric and electronic waste takes these facts into account by making an exemption from a ban.

Leaded glass could be returned to glass manufacturers for recycling. At present, the glass industry is not doing this because there is no economic incentive to do so. If economic conditions were to change in favour of recycling, it is believed that an operational scheme could be set up within 3-5 years. (M. Marshall, British Glass, personal communication.) The glass industry is also concerned about impurities present in old glass, such as metals, enamel and porcelain, which can damage furnace linings.

In some countries television screens from different manufacturers have significant differences in compositions, which could cause some difficulties for manufacturers, though the difficulties are not insurmountable. Television screens sold in some other countries have very similar compositions, so recycling would be easier.

Alternatively, lead can be recovered by returning the tubes to lead smelters for lead recovery. The glass can be ground up and added to the furnace. This glass consists largely of silica, which is necessary to produce the slag, (the non-metallic material which floats on top of the metal during smelting, and is essential for removing some impurities from the metal, as mentioned in section 4.1.2.1 Primary Smelting) and is usually added anyway for this purpose. Most of the lead from the glass ends up in the metal fraction. The economic margin is less than for recycling into new glass as the lead content of cathode ray tubes is typically around only 8% (average of all parts of the tube - M. Marshall, British Glass, personal communication). However, separation of the front panel (screen) would result in a higher average lead content.

5.3 NATIONAL POLICIES AND COLLECTING STRATEGIES

This section is based on a summary paper by B. Bied-Charreton, METALEUROP, published in the Proceedings of the 12th International Lead Conference, 22-25 September 1997.

EC Directive on Batteries and Accumulators

Council Directive no. 91/157 of March 1991 on batteries and accumulators containing certain dangerous substances covers batteries and accumulators containing more than 0.4% lead by weight (and also more than 0.025% cadmium by weight, alkaline batteries containing more than 0.025% mercury by weight, and other batteries containing more than 25mg mercury per cell).

The Directive offers the opportunity for a legal framework for battery recycling, for batteries to be considered as “clean” products because of their recyclability, and for their acceptance by Member States even though they do contain heavy metals. Member States may set up disposal or collection systems and use measures such as economic instruments to encourage collection (after appropriate consultation, provided such instruments could be justified on ecological and economic criteria, and that they avoid distortion of competition).

Some Member States had their own regulations in place prior to the Directive. National regulations in Member States include:

Sweden - to address transportation problems, a number of measures have been introduced. The producer or importer pays a fee, which is used to fund collection, transportation and information/PR, to keep the recycling rate above 95%. Batteries can be returned to retail outlets where they were purchased, to municipality recycling yards or to scrap collectors.

Italy - the customer pays a fee on each battery, which is used to fund a consortium which buys, collects and delivers old batteries to smelters. The consortium also carries out research into cleaner methods of battery treatment and ensures that recycling is performed under clean conditions. The recycling rate is reported to be above 95%.

Austria - there is an obligation on all retailers of batteries and accumulators to take back used batteries returned by the customer.

Denmark - a fee is imposed on all producers and importers of lead accumulators, and all retailers are obliged to accept used accumulators free of charge. This fee is given as a bonus to collectors who deliver used accumulators. The authorities aim to reach a collection and recovery rate of 99.9%.

Germany - an obligation is placed on retailers of batteries to accept old ones from consumers, and on battery producers to accept them from retailers. A deposit of DM 15 per lead battery is levied on the buyer of a new battery if an old battery is not returned. This is a special regulation for starter-type lead batteries.

Netherlands - collection of end-of-life vehicles is organised and financed by Auto Recycling Netherlands BV, with a fee on every new car.

United Kingdom - high rates of collection and return of lead-acid batteries are already achieved (estimated at greater than 90%). Old batteries are usually returned to garages or suppliers of new batteries, or they are separated from waste at municipal dumps and from there returned to scrap merchants who sell them to lead smelters. It was deemed unnecessary to implement a formal system of battery collection: the only change in law was to require labelling. The effectiveness of this scheme is discussed below.

France - a network exists which allows the return of lead-acid batteries from the public to smelters; a minimum acceptable recycling rate of 85% has been set, with a commitment to reach 100% “as soon as possible”. A committee exists to organise publicity and information, to secure commitments from all parties, to calculate recycling yields and to set economic instruments if goals are not reached.

Belgium - collection and recycling rates are estimated to be around 50%.

5.4 FUTURE OPPORTUNITIES

Improvements in battery collection

Though some countries have implemented formal collection systems, with resulting excellent collection rates, this is not yet universal. Even in the EU, most countries are still relying on existing informal collection routes.

Example: UK system

The system already in place achieves collection rates estimated at over 90%. This has been described as “a working but fragmented collection system, which can and does have weaknesses, particularly when the market value of lead is low” as in 1993, when the collection rate fell below an estimated 80% - an opinion from within the recycling industry itself (Ainley, 1996). There was then support from the lead industry to introduce a more formal collection system to ensure high collection rates even when the market price of lead is low.

A further difficulty now faced in Britain is that UK Waste Regulations now require documentation and a fee to be paid for battery movement (£10 for 5 or more batteries): some small scrap dealers have stopped collecting batteries. The effect of this on overall recycling rates is not known.

Even when the collection rate is over 90%, considered high by most, with an annual consumption of 100,000t of lead in batteries in the UK, this would mean

that up to 10,000t of lead from this source is unaccounted for per annum. However, rather than being disposed of, most of this shortfall is believed to be stored in private garages etc., and should eventually enter the recycling system.

There is clearly room for improvement. An organised collection scheme could improve return rates, though such a scheme would entail administration costs. Economic instruments, such as a levy on batteries produced, could ensure a reasonable price can be paid for scrap lead, even at times of low lead price on the world market; these would also be expected to improve collection rates. The lead industry would eagerly welcome any such development, because at times of low lead price, secondary production is not profitable (can even operate at a loss) and there can be shortages of batteries available for smelting.

Collection of other items

For products containing smaller amounts of lead, any economic incentive to recycle will depend on the economic value and recyclability of other materials. The economic value of the lead content alone will never be enough to ensure increasing collection rates.

Cathode ray tubes are an example of a product for which the technology to recycle is available (or would be after a small amount of development), but at present there is insufficient incentive to recycle. This situation is expected to change in the future when new legislation comes into force: however, this could still be a number of years away.

Dispersed applications of lead

A significant proportion, about 10%, of lead is still used in compounds (this does not include the large amount of lead oxide used in batteries, as this is included in the totals for batteries). Much of this is used in cathode ray tubes, already described, but other uses include crystal glass, ceramics and PVC stabilisers. Much smaller amounts are used in paint for specialised applications, and for other leaded glasses. Recovery of lead from some of these products does not appear likely, although closed loop recycling of PVC includes recovery of stabilisers.

Complete recovery of metallic lead from applications such as sea-bed cable sheaths, shot and minor uses appears unrealistic.