ELSEVIER

Journal of Power Sources 53 (1995) 309–314

JOURNAL OF POWER SOURCES

Environmental regulations: their impact on the battery and lead industries

John R. Ainley [1]

Britannia Recycling Limited, Thorpe Lower Lane, Thorpe, Wakefield, West Yorkshire WF3 3BS, UK

Received 22 August 1994; accepted 25 August 1994

Abstract

This paper presents a general overview of the past and current position of the lead industry in relation to environmental legislation and its impact. The lead industry has watched environmental lead levels being steadily reduced down to levels that, ten years ago, would have been considered unachievable. Nevertheless, the industry has managed to survive the effect of the ever-increasing demands of environmental controls. During the last ten to twenty years, lead producers and users have had to assess their future positions, as the cost implications of environmental laws have had a significant impact on their bottom lines. Without doubt, this consideration most definitely affected the viability of many plants. The need to be aware of the existence of new and proposed legislation is of paramount importance, as the threat from the vast array of EEC legislation is ever apparent. Lead companies have all considered environmental legislation to have no more than a nuisance value, but it is of vital importance to the future of the industry that such legislation is approached in a positive and sensible way in order to demonstrate a full commitment to protecting both employees and the general environment. Lead must receive the credit that it so richly deserves.

Keywords: Environment; Battery industry; Lead industry

1. Introduction

Lead is a naturally occurring element and nature has evolved with mechanisms to cope with its presence. A great deal is also known about lead from centuries of use and, indeed, this may largely be the reason for many present concerns.

Looking back on some of its early uses, it is now only possible to speculate as to the effects that lead might have had on the masses. It has even been suggested that the high daily intake of lead from Roman times, right through to the 18th or 19th Century, might well have had some bearing on normal life expectancies. Today, however, the lead recovery and manufacturing industries are quite familiar with criticism and adverse publicity about their activities. Unfortunately, these pressures are not likely to go away, indeed they could become more intense.

It has to be admitted that the lead industry has tended to project itself in a somewhat defensive way, particularly in the last twenty to thirty years. With hindsight this may not have helped to reassure any interested parties that the lead industry has been both environmentally aware and responsible.

In the last thirty years, there have been radical changes in environmental standards, which when taken on face value, were introduced to protect the general environment and, of course, the health and welfare of those occupationally exposed to lead. There are, however, those who believe that many of these changes were designed to affect a 'just-in-case' scenario, in keeping with the example of asbestos. As such, there is a feeling that such impositions are somewhat unreasonable or unrealistic and an unnecessary drain on financial resources.

2. History of lead controls

In considering the history of lead controls, it is necessary only to look back to the early 1970s to see the advances that have been made. Those who were involved in the industry then, will recall the general lack of controls in all aspects of workplace emission

[1] Tel: 0532-823811; Fax: 0532-829804.

Elsevier Science S.A.
SSDI 0378-7753(94)01972-X

control, where exhaust ventilation, filtration, housekeeping and personal protection were issues seldom understood or enforced. In those days, blood-lead levels over 80 μg/dl were not unusual and air lead levels were not usually measured at all. It was also accepted that chimneys were not chimneys unless they were smoking. A sudden change occurred in the mid-1970s, however, when attempts to review lead control standards were implemented. These proved to be the impetus that was so obviously required.

It is now appropriate to refer to the early work of Williams et al. [1] who pioneered the association between air and blood-lead. The outcome was a series of further attempts to understand the mechanisms by which lead is inhaled, ingested or otherwise absorbed. Williams et al. believed that a lead-in-air exposure of 0.15 mg m^{-3} correlated with a blood-lead level in the region of 60 μg/dl. Nevertheless, no real allowance could be made for particle sizing or lung retention times. Also, it was impossible to discover how much lead absorption might have been the result of ingestion.

As time passed by, more and more surveys were initiated to determine the environmental impact that lead had on a chosen environment or population. Several surveys of lead-in-blood in the general population were designed to assess the potential health effects of lead and the spread of lead from point sources, e.g., roadsides, smelters, water pipes, etc. It was gradually considered essential that exposure to lead should be minimized or, if possible, eliminated. This consideration was aimed primarily at children, where a variety of studies showed possible connections between children's IQ/learning capability and blood-lead levels. It might also be said in the defence of the lead industry that some more recent studies could have been invalidated, but nonetheless, this did not detract from the move to achieve lower environmental lead levels.

Many recall the adverse publicity that lead in gasoline received and the way in which unleaded fuel became 'in vogue'. At that time, advertising campaigns tarnished the image of lead and gave the metal the notoriety that no-one welcomed. Suddenly, lead was recognized for the wrong reasons, and some of the day-to-day uses for lead, that are so often taken for granted, were overlooked. Smelters and refiners were put under the microscope and many could not continue to operate as a result. Local action groups were established and liaison committees were formed to study the performances of individual plants. Gradually, a dossier on environmental lead was unfolding.

The saga continued and, as a consequence, many battery manufacturers and smelters had to take a long, close look at their operations, both in terms of internal emissions and the impact on the external environment. Employers were eventually forced to place a good deal of emphasis on informing/training their employees about the potential hazards from working with lead. This, of course, proved to be a costly exercise in itself.

In summary, the lead industry has 'set the pace' for many other metals and chemicals and, to a certain extent, the industry has grown accustomed to the reality of environmental legislative changes.

3. Current environmental monitoring and controls

In general, throughout the world, industry is well regulated to protect both the workforce and the environment from exposure to lead. The extent of these regulations may vary according to advances in knowledge and developments in environmental control technologies. There is, as a result, a general trend towards tighter standards as technical capabilities improve. Moreover, desire to implement the best and most practical methods of protection remains important.

For those occupationally exposed to lead, it is generally accepted that good hygiene practices should be adopted, along with the overall aim to limit the amount of available lead-in-air in the breathing zone. Although limit values for lead-in-air have been present for over the last 20 years, only in more recent years have these standards been tightened. Occupational limit values are typically in the range 50–150 μ/dl (Fig. 1). Much speculation has developed over the importance of lead-in-air and any correlation it may have with blood lead. As a result of this, air lead is perceived to be no more than an indicator of plant control.

Good hygiene practices are essential in reducing exposure to lead. Many countries employ strict rules with regard to eating, smoking and drinking in the workplace, and also ensure that a well designed and maintained washing and changing facility is provided. Protective clothing in the form of under- and over-garments, helmets, eye protection and respiratory protective equipment is also commonplace. The effect of these measures is difficult to quantify, but good personal hygiene practices probably have the greatest influence on personal blood-lead absorption.

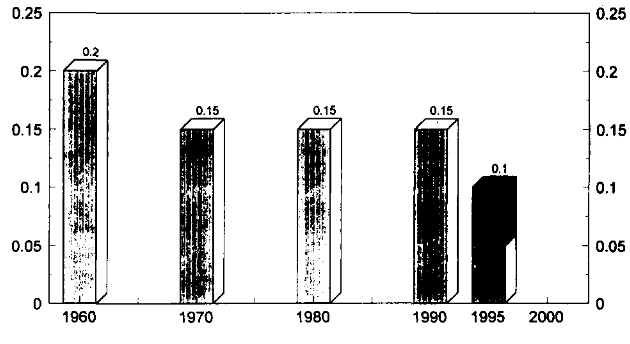

Fig. 1. Lead in air (occupational).

To measure the effectiveness of hygiene controls on workers, it is usual for a monitoring programme of blood-lead analysis to be employed. Alternatively, other indirect indicators of the degree of exposure may be used, such as aminolacvulinic acid in urine (ALAU) or zinc protoporphyrin (ZPP). The use of blood lead is more widely used, mainly because of its general reliability and accuracy.

As analytical methodologies have improved and legislation has forced down the acceptable levels of lead-in-blood, today's levels have decreased to the range 10–70 μ/dl (Fig. 2). Moreover, many operating companies have been working with lower target levels than those currently required by law.

In many of the more developed countries, large proportions of the occupationally exposed workers have blood leads that are rapidly approaching the upper limit normally to be found in a non-exposed population. Adequate training and education programmes ensure a better awareness of the possible risks from lead and how to avoid them.

The control of emissions from industrial sources is also of vital importance. This includes air, water and waste streams. Air emissions, via chimney outlets, are generally restricted on the basis of concentration, although limits on total mass emission are sometimes imposed. Although, over the years, concentration limits have been as high as 100 mg m^{-3}, the industry is currently having to comply with standards as low as 1 mg m^{-3} and usually no higher than 10 mg m^{-3} (Fig. 3). These limits are generally met by using dust extraction systems, such as cyclones, electrostatic precipitators and bag filters, all of which have to be scrupulously maintained. Other air parameters are also to be considered, i.e., boundary or ambient air levels. Typical values used globally are in the range 1.5–2.0 μg m^{-3} (Fig. 4).

Effluent plant discharges, which may contain lead or, possibly, other heavy metals such as cadmium or nickel, are usually designed to reflect Best Available Technology for the process under scrutiny. Typical levels here would be applied in the range from as low as 0.1

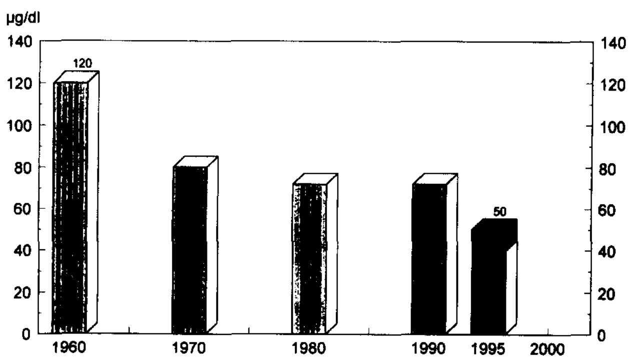

Fig. 2. Lead in blood (occupational).

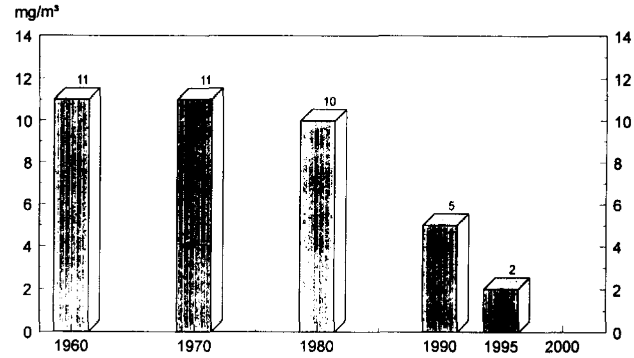

Fig. 3. Stack discharges.

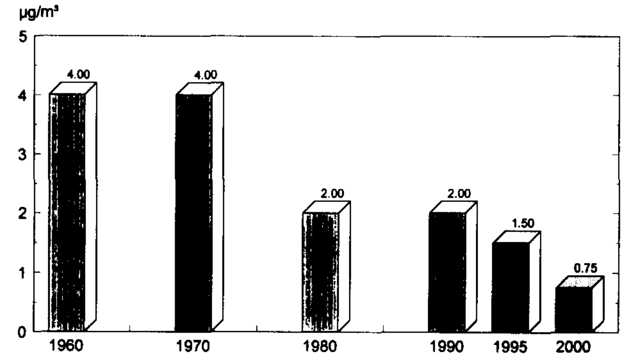

Fig. 4. Ambient air lead.

to 3 mg/l. Lower levels would be applied to some more sensitive receiving waters, while the higher values relate to sewers or main estuaries. Consents to discharge usually include restrictions on total volumes and mass discharge.

Solid wastes are unfortunately produced whenever lead recovery is no longer possible. The disposal of such wastes is carefully controlled under strict landfill conditions. The degree of hazard of this material will be determined by lead content and the general stability of the waste, i.e. the leachability of any heavy metals that it may contain. Standard leachate tests simulating landfill conditions may be applied prior to its acceptance, particularly when a non-hazardous classification is sought by the producer of this waste.

4. What the future holds

It is not necessary to be a philosopher to foresee the impact that future changes in environmental legislation may have on lead and its associated businesses. A lot of trust has to be placed in the specialists to ensure that legislation is applied reasonably consistently.

As a European business, the battery manufacturing and smelting plants have observed some inconsistencies in the way European environmental legislation has been adopted in member states. This can sometimes be viewed as a means by which possible commercial advantages might be gained. Lead Regulations, Control of Chemical Agents, Pollution Control and Product Liability have all been introduced, but at different times. Thus, there has been a noticeable absence of harmonization within Europe.

As it becomes more accustomed to the reality of environmental changes, the industry is facing the prospect of a blood-lead reduction from 60–70 μg/dl down to 40–50 μg/dl. There is strong medical evidence to suggest some adverse health effects above a blood-lead level of 50 μg/dl. The lead industry has found itself unable to offer any defence against this. These health effects include an alleged effect on male fertility, which surely will create some concern for employers. Lead compounds are also being classified as having possible reproductive effects and it will become necessary to label these compounds appropriately.

If life is now thought to be intolerable in the lead industry, there is yet more to come. In brief, there are at least ten different environmental initiatives in the pipeline, outlined as follows.

4.1. Integrated pollution prevention and control

This is a Directive proposed by the Commission that will provide for measures and procedures to adopt an integrated approach to protect public health and the environment by preventing, or minimizing, emissions from industrial installations. This proposal will have a major impact on both new and existing plants, where Best Available Technique policies will be sought. It is hoped that there will be a sensible balance here between true environmental benefit and cost effectiveness.

4.2. Waste management and packaging wastes, landfill of wastes

In 1990, the Council adopted a resolution on the waste policy which states that recycling, prevention and reuse be given the highest priority, and that the 'polluter pays' principle be implemented. This may restrict certain wastes from being accepted and could place an unnecessary constraint on some trade activities.

4.3. Restrictions on marketing certain dangerous substances; Seveso directive; Risk assessment; Classification, packaging and labelling

It was simpler to put all of the above headings together, for although they have individual status, they do have some relatively close connections. The four headings are designed to identify potential dangers of substances and, thus, to avoid major incidents. They will also identify any lack of appropriate information on each material before it is dispatched or marketed. Clearly, this could have a major impact on marketing. If, for example, lead compound or indeed lead was classified as carcinogenic, the effect could be quite catastrophic.

The movement of hazardous wastes within Europe is a subject that has been highlighted within the last twelve months and has attracted much attention. The presence of classifications on waste and the description of some wastes is quite unclear and again inconsistent.

Lead recyclers have some concerns over the movement of wastes within Europe, i.e., secondary residues and, of courses, batteries. Although these materials do have a commercial value, they must be labelled as hazardous waste. Spent batteries can be moved more easily, apparently when they have been drained of their acid. There must, however, be a question mark against the whereabouts of the acid, that they once contained.

There are now strict controls on the movements of wastes within member states and the level of consciousness is increasing rapidly. The introduction of suitable documentation that accompanies waste movements gives a high level of accountability and, although this is something of a burden to the industry, the lack of a formal system of control in the past has been the motivation behind this development.

5. Battery collection

The European Battery Directive has called for more formal methods of battery collection to be introduced in member states. Although there have been collection schemes introduced in Italy and Sweden, each country is being asked to design its own system. This may force a shift away from the more traditional routes of collection (i.e., through scrap merchants or traders) and place more emphasis on the battery manufacturer to take in, and be responsible for, battery scrap (Table 1).

Table 1
Battery recovery rates in various OECD countries

	1986	1987	1988	1989	1990	1991	1992	1993
Australia						90		
Belgium	77							
Canada						93		
France	80			90				
Germany	83					>95		
Italy	83							
Japan	92.3	92.5	95.2	93.8	92.2			
Spain	83							
Sweden						>100		
UK	84					93	92	80
USA		88.6	91.0	95.3	97.7			

In the UK, there have been suggestions that a levy scheme is required to underpin the cost of collection, particularly when lead prices are low. This matter has still to be resolved with the UK Government, and it will be some time before it can be introduced.

5.1. *An example of 'negative' legislation in the UK*

When lead metal prices are low, the smelter can only pay an appropriate amount for spent batteries, based upon their metal content. Consequently, the prices paid can be very low indeed.

Low scrap prices are, and always will be, less attractive to those collecting batteries, particularly when legislative requirements place a higher financial burden on collection and storage facilities. For example, to achieve compliance with the Environmental Protection Act and with the associated 'Duty of Care' requirements, scrap merchants have to provide a storage area. This may have to have a surface that is impervious to battery acid, and that may need to have a suitable storage or collection container for spillages and/or rainwater. Effluent treatment costs may then be incurred. Added to this, the merchant may have to apply for a waste disposal license, or what is more commonly known today as a waste management license.

Having collected the lead/acid batteries, the merchant must transport batters in a responsible way. This might commence with the pre-notification of a consignment of batteries to the Waste Regulatory Authority using appropriate documentation. Such a procedure can be quite burdensome and extremely time-consuming. Added to this, the merchant should also ensure the following:

- drivers are adequately trained to carry special wastes
- vehicles carry appropriate plating
- vehicles and containers are sound- and leak-proof
- documentation is completed and returned
- documentation is retained for up to 2 years

The general outcome here, is a real and considerable cost imposition on the collector of batteries.

Over the last seven years, the actual recovery rates in the UK have been over 84% [2]. It is believed, however, that in more recent years this level has increased to well over 90% (estimated to have been 93% in 1991) [3]. The recovery rates in the UK are amongst some of the best in the world. The effects of a low market price for lead and the aforementioned increasing pressures on the traditional collection routes, have caused these high rates to be seriously jeopardized. Some examples of the reasons for this are as follows:

- merchants avoiding collecting or storing batteries due to the potential costs/ inconveniences involved
- a reluctance to remove batteries from scrap cars

As a consequence, the forecasted lead/acid battery recovery rate fell to about 80% in 1993 [4]. There is, without a shadow of doubt, an unfortunate, but clear, impact on the environment as a result of this. The impact also features strongly at steel-making plants where significant and worsening lead emissions have become a reality.

6. Conclusions

There has to be an admission, that this paper only skims over the subject of environmental legislative impact. Nevertheless, the message is still abundantly clear. The lead industry must prepare for the inevitable.

Lead will always attract a large amount of attention due to its presence in the general environment and for its obvious popularity among environmentalists. The lead industry must decide its own fate in either accepting these changes in environmental law or risk its future. Similarly, individual companies must consider their own policies and ask themselves if they intend to stay in business by investing in their plants and their employees. Most plants have not remained inactive and have invested wisely for the future by developing methods of reducing the exposure of their employees to lead. This will go a long way towards securing their futures. Those who decide to wait until change is forced upon them, will face a very uncomfortable period that will put them under necessary pressure.

Environmental legislation is often considered to be something of a nuisance. It is of vital importance, however, that the lead industry is perceived to respond positively to the requirements of legislation. It must project itself as being a nucleus for any development in environmental legislation and, where possible, it must be involved in discussions at the earliest stages. This will enable the industry to raise its concerns before it is too late.

No longer is the lead business the 'dirty' end of industry, in that it produces harmful pollution and waste problems. The global lead industry produces and consumes 4.5 million tonnes of lead per annum [5]. This is a measure of the metal's importance to daily life. While this activity continues, lead must receive the credit that it deserves.

The lead industry must project itself as being fully committed to protecting the environment in general, by reducing the environmental impact of our factories. This should help achieve the high profile that the lead business demands. Lead is here to stay and workers in the industry need to believe in themselves and what the industry stands for in global society.

References

[1] M.K. Williams, E. King and J. Walford, *Br. J. Ind. Med., 26* (1969) 202–216.

[2] J.R. Ainley and H. Rimmington, *Wasteman Seminar, Birmingham, UK, 1994.*

[3] D.N. Wilson, *J. Power Sources, 42* (1993) 319–329.

[4] J.R. Ainley, Electrochemical processing; innovations and progress, Glasgow, UK, 1993; unpublished.

[5] International Lead and Zinc Study Group, *Monthly Bulletin,* July 1994.