Department of the Environment
Industry Profile

Metal manufacturing, refining and finishing works

lead works

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Contaminated Land and
Liabilities Division

Industry Profiles, together with the Contaminated Land Research Report series, are financed under the Department of the Environment's contaminated land research programme.

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The Department's Contaminated Land Research Report series deals with information needed to assess risks; procedures for categorising and assessing risks; and evaluation and selection of remedial measures.

General guidance on assessing contaminated land and developing remedial solutions which is complementary to the Department's publications is provided by the Construction Industry Research and Information Association (CIRIA).

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DOE Industry Profile

Metal manufacturing, refining and finishing works: lead works

This Profile is based on work by Environment Assessment Group Limited and was prepared for publication by the Building Research Establishment.

Preface

DOE Industry Profiles provide developers, local authorities and anyone else interested in contaminated land, with information on the processes, materials and wastes associated with individual industries. They are not definitive studies but they introduce some of the technical considerations that need to be borne in mind at the start of an investigation for possible contamination.

Every site is unique. Investigation of a site should begin with documentary research to establish past uses. Information on the site's history helps to focus a more detailed investigation. This knowledge needs to be supplemented by information on the type of contamination that may be present and where on site it may be found. Profiles give information on the contamination which might be associated with specific industries, factors that affect the likely presence of contamination, the effect of mobility of contaminants and guidance on potential contaminants.

The date when industrial practices first commenced on a site and its location are important clues in establishing the types of operations that may have taken place, so each profile provides a summary of the history of the industry and its likely geographical spread within the United Kingdom.

Profiles should be read with the following reservations in mind:

> individual sites will not necessarily have all of the characteristics described in the profile of that industry;
>
> practices can vary between sites and change over time;
>
> as practices change, problems of possible contamination may also change;
>
> the profile may refer to practices which are no longer followed, and may omit current practices which avoid contamination.

The risks presented by contaminated sites depend on the nature of the contaminants, the targets to which they are a potential threat (such as humans or groundwater) and the routes or pathways by which they reach these targets. The current or proposed use of a site and its environmental setting are crucial in deciding whether treatment is necessary and if so, the methods to be used. Some sites may not need treatment.

The information in profiles may help in carrying out Control of Substances Hazardous to Health (COSHH) assessments for work on contaminated land - see Health and Safety Guidance Note HS(G) 66 *Protection of workers and the general public during the development of contaminated land,* Health and Safety Executive, 1991, and *A guide to safe working practices for contaminated sites,* Construction Industry Research and Information Association, 1995.

Note: the chemical names given to substances in this profile are often not the modern chemical nomenclature, but the names used historically for those substances.

Metal manufacturing, refining and finishing works: lead works

1. Background

This profile covers both the primary and secondary production of lead. In the primary production process, lead ore is produced in two stages - smelting and refining - which may be carried out on the same site. In secondary production, which is a recycling process, lead is extracted from used materials, eg lead scrap and batteries. This lead may be recovered by smelting or by refining, depending on the type of scrap which forms the source material. After refining, lead is further processed to manufacture products such as alloys and lead sheet.

The most important lead ore is galena (lead sulphide) which often occurs in combination with zinc, iron pyrites and silver. Cerussite (lead carbonate) and anglesite (lead sulphate) are other commercially important ores which result from the oxidation and weathering of galena.

Lead has been used since Roman times in the United Kingdom. The industry gained momentum at the beginning of the 1800s using locally mined ores at many locations throughout the country, such as Derbyshire and Cornwall. Ores were usually smelted into pig lead near sources of ore and coal. The lead was then manufactured into finished products in small-scale refining operations.

This self-sufficiency resulted in regional specialisation of lead types and products. London produced white lead (lead carbonate) for the paint industry and for export. Lead oxides, litharge (lead monoxide) and red lead (lead tetroxide) were made in the Midlands for the glass and pottery industries. Pewter and lead shot were made from hard lead (argentiferous) in Bristol.

From the mid-19th Century, Newcastle became one of the main lead production areas, taking advantage of imports of Spanish ore and pig lead (which had already undergone primary smelting in Spain). Manufactured products included white lead, red lead, litharge, sheet, pipe and shot. Hull, Liverpool and Swansea were also ports which took advantage of imports and cheaper ore. Lead works might also be found at some explosives manufacturing sites and at dockyards.

By the early part of the 20th Century, the United Kingdom's output of lead was already in decline. As ore supplies dwindled and became increasingly expensive to mine, smaller, older plants tended to be run down in favour of plants which were located to take advantage of cheaper imports. Important sources and producers of lead are now the USA, Australia, states which were formerly part of the USSR, Mexico, Canada and Peru.

Since the 1950s, the United Kingdom lead industry has become more involved with secondary processing. The very high re-use of lead is due to its corrosion resistance and the ease with which it can be separated from other materials. Only one primary lead smelter operates in the United Kingdom today. All lead bullion produced at this plant is exported for refining elsewhere. The only other primary processor refines lead imports from Australia. There are four smelting plants in the United Kingdom handling lead materials for secondary production and there are four other plants refining lead from scrap, largely for sheet lead manufacture.

2. Manufacture

The following sections describe processes occurring at typical smelting, refining and secondary metal processing plants. The main stages involved are concentration of the ore, sintering, blast furnace reduction and refining.

2.1 Primary lead production

Lead was traditionally produced by heating galena in reverberatory furnaces to oxidise it to lead oxide and lead sulphate and eventually to lead bullion. This method was superseded by the blast furnace method which is still used today. The various processes involved in primary lead production are summarised below and in Figure 1.

2.1.1 Ore concentration

Before lead ore can be smelted, the metal content of the material must be raised or concentrated. Lead ores are crushed very finely and then concentrated, either by mechanical and gravitational separation processes (eg water gravitation) or by the use of froth flotation techniques. In froth flotation the finely ground ore is mixed with water and selected reagents and agitated to produce a heavy froth. The mineral particles cling to the froth which forms on the top of the flotation tank, leaving the gangue (unwanted rock) to sink. The froth can be drawn off from the tank and easily dried. Flotation techniques can also be tailored to separate individual metals from each other and not just the metal from the gangue. Concentration by flotation procedures raises the lead concentration in the ore to 65-80% and the ore is then referred to as 'concentrate'.

The United Kingdom site which carries out primary smelting imports lead/zinc concentrates from overseas. These will have been prepared by mineral dressing/froth flotation.

2.1.2 Sintering

Before the lead concentrates can be smelted, they must be roasted to remove most of the sulphur they contain and to agglomerate the very fine flotation product which should not be introduced into the blast furnace. This process is known as 'sintering'.

The concentrates are blended with fluxes (eg limestone), recycled products (eg recycled sinter) and coke dust; they are then fed through the sintering machine where the mixture is roasted. Recycled sinter is added to control the temperature and to dilute the sulphide concentration. The sinter is agglomerated into lumps and graded to a size suitable for the blast furnace.

The waste products arising from this operation are primarily gases and dust emissions which require control. Most of the sulphur is removed from the concentrate at this stage and converted to sulphur dioxide gas (SO_2). Nowadays, the SO_2 is usually converted to sulphuric acid in a by-product plant which may be present on the same site. In the past, SO_2 may have been emitted directly to the atmosphere.

In its sintering operations, the United Kingdom primary smelting site uses lead/zinc concentrates and has gas-cleaning plant and an acid recovery plant.

Comprehensive dust collection facilities are now standard at industrial installations of this type.

2.1.3 Blast furnace reduction

The roasted concentrate or sinter, now in the form of lumps, is charged into the top of a heated blast furnace with limestone and other suitable fluxes and with coke for fuel. A blast of preheated air is admitted to the lower part of the furnace to aid combustion and to complete the formation of metallic oxides. The oxides are reduced to the metal by the coke and carbon monoxide present. The non-metallic waste, eg sulphides, silicates etc, forms a slag with the fluxing materials. The blast furnace is tapped and the lead flows off into moulds. The lead formed in this way is a semi-finished product known as 'bullion'. It contains impurities such as silver, gold, copper, zinc, antimony, tin, arsenic, bismuth and other lesser contaminants, which must be wholly or partially removed by refining to produce a commercial lead product.

The slag is tapped from the top of the molten metal and discarded. Concentrations of lead, antimony, zinc and other metallic impurities are still relatively high in the discarded slag.

The UK primary smelter operates an Imperial Smelting Furnace, which is a specially adapted blast furnace designed to deal with a mixed lead/zinc concentrate.

2.1.4 Refining

Lead bullion requires further refining to remove the metallic impurities listed in Section 2.1.3. In the past, lead was imported in bullion form rather than as ore; however, only one site in the United Kingdom currently imports lead bullion for refining.

First, copper is removed in a drossing plant. The lead bullion is melted and allowed to cool to a temperature just above the melting point of lead. The copper crystallises and rises to the surface where it is skimmed off as a copper-rich surface dross. Sulphur is stirred into the lead bullion to reduce the copper content further by forming copper sulphide, which is also skimmed off the surface of the molten lead.

After copper removal, different methods are employed to remove the remaining metallic impurities from the lead bullion. These are either pyrometallurgical or electrolytic in principle. In electrolytic processes, pure lead is deposited on lead cathodes and the metal impurities remain on the anodes. Electrolytic refining processes are not practised in the United Kingdom; pyrometallurgical processes are more widely used.

In pyrometallurgical processes, the metallic mixture obtained after copper removal is sequentially heated and cooled under different conditions and at different temperatures. These processes preferentially oxidise or otherwise remove the metal impurities from refined lead. Some of the main processes used are shown in Figure 1 and described below.

Softening
The presence of arsenic, tin and antimony causes lead to be hard; the furnace used for their removal is therefore called a softening furnace. The lead bullion is melted and agitated with an air blast.

Harris process
In this process a flux of molten sodium hydroxide and sodium nitrate is added to the bullion. After thorough mixing, arsenic, tin and antimony impurities are removed in an alkaline flux as sodium arsenate, stannate and antimonate.

Parke's process/desilverising
This process removes silver and gold by the addition of zinc in a desilverising kettle. Silver and gold are preferentially dissolved in the zinc which, being lighter than lead, rises to the surface of the bullion. The temperature of the molten metal is lowered and the silver and zinc-rich crust or dross solidifies and is skimmed off. The components of the silver-zinc dross are separated by distillation. The zinc is recycled to be used in the desilverising process again while the silver-rich dross is further refined, usually in cupellation furnaces. In the cupellation process, the lead present is oxidised to litharge (which is used in other industries, see Section 2.3.2) and the silver-rich dross is fluxed with sodium nitrate which reduces other impurities such as copper, bismuth and iron to a minimum.

Zinc removal
Zinc is removed from the primary lead bullion using vacuum distillation. A vacuum is created over the surface of the molten metal and the zinc vapour condenses on the dome of the vacuum vessel. The zinc metal is collected and re-used in the desilverising process.

Kroll-Betterton process
This process removes bismuth by the addition of a calcium-magnesium alloy to the molten lead. Bismuth forms a more complex alloy which rises to the top of the metal and is skimmed off.

Final caustic refining
The addition of caustic soda to the bullion at high temperatures leads to the formation of a dross of sodium antimonate and zincate which is removed from the surface of the metal.

The above processes are combined as necessary to refine the lead bullion. The resulting pure lead is cast into ingots or 'pigs' and used as required.

The drosses obtained from the refining processes are usually re-smelted to obtain the impurity as a by-product and to recover the lead contained in them. Copper drosses are treated and the copper removed as a 'matte' which can be sold on for recovery of the copper. Antimony and tin are usually recovered as more concentrated alloys with lead and can be used directly for the preparation of other lead alloys, as in the case of tin-lead alloy used for the preparation of solder. Fluxes and other slag-forming materials are used in these smelting processes and inevitably some metals are retained in the resultant slag. The recovered lead bullion is fed back to the refinery.

2.2 Secondary lead production

The primary sources of secondary lead are:

Scrap lead, eg vehicle battery scrap, discarded lead pipe and sheet
Vehicle battery scrap has constituted a significant proportion of raw materials for the United Kingdom secondary lead industry. Some scrap may have been pre-melted into ingots by the supplier.

Lead drosses containing between 35% and 90% lead
They arise in several ways and are bought in as residues from other metallurgical processes.

Lead sheathing
This has been used in the past for power and telephone cables; it occurs in combination with a copper core which requires removal.

Reject lead products
Off-cuts and wastes from manufacturing processes.

Pre-preparation of scrap lead may involve some physical separation of materials before processing. This is particularly so with scrap lead batteries. In the past, many sites bought in used batteries whole; sulphuric acid was drained from them and the ebonite cases had to be broken manually. However, all modern smelters have mechanical breaking and separating plants, as well as effluent treatment facilities to deal with the acid. Batteries now have polypropylene cases which must be removed.

The individual operations involved in the refining process are essentially the same as those used in primary production although companies tend to make their own adaptations. The extent of removal of metallic impurities depends on the raw materials undergoing processing, eg scrap lead sheet needs only refining, whereas lead drosses require smelting prior to refining.

The scrap lead material is generally charged into a melting kettle. During melting a considerable quantity of dross is formed (containing free copper, iron, oxides, dirt etc). This dross is skimmed off from the molten lead for subsequent treatment in smelting furnaces. The remaining lead is then refined using processes similar to those used in primary lead production. For example, copper is removed as the sulphide after sulphur has been added, and tin and antimony are removed as sodium stannate and sodium antimonate following fluxing with sodium hydroxide and sodium nitrate. The molten lead is then run off and cast into moulds before further processing.

The drosses arising from the melting and refining of the scrap lead and materials such as battery scrap are smelted in rotary furnaces. In the past, blast furnaces or reverberatory furnaces were used. Fluxes such as sodium carbonate, silica and millscale remove the impurities from the lead and other metals and form slags. In the recovery of lead from batteries, the flux absorbs the sulphides, silicates and non-metallic impurities, and is discarded as waste material. The metals are fed back to the refining process. A recent development in the United Kingdom is the use of the Isasmelt process for secondary lead recovery.

Lead sheathing on copper cables is generally melted off the underlying metal and removed for refining.

2.3 Further processing

The manufacture of lead products from refined lead may involve several processes, some of which are undertaken on the smelting and refining sites. The simplest processes are the physical casting and shaping of the metal into the desired product. These activities do not involve the use of chemicals and are therefore relatively clean. Other processes are highly specialised and may take place on separate manufacturing sites which buy in refined lead as a raw material.

2.3.1 Physical processes

These processes include casting, rolling and extrusion.

Casting (pouring molten metal into moulds) is the oldest process employed in the industry. Casting into sheet and pipe was undertaken from the beginning of the 18th Century. Sheet lead was produced by casting into a shallow trough, although rolling is the method now used for sheet. Shot and bearings are also made by casting.

By the mid-19th Century, conventional casting had been almost completely replaced by strip rolling or milling. Conventional cold rolling involves casting the lead into large rectangular blocks and passing them through pairs of rollers to produce thin sheets. Continuous rolling involves the pick-up of molten lead on a rotating drum. It is then cut automatically to size.

Pipes were originally made by casting in moulds and then drawing (extruding) them cold through a series of dies. This method was replaced from the end of the 1820s by the use of hydraulic pistons. The extrusion of lead by pistons was adapted and extended to the production of wire and cables.

2.3.2 Special processes and chemical treatments

These processes involve the production of lead alloys and other forms of lead for defined markets:

Alloys

Lead alloys are manufactured by the addition of other metals at concentrations of between 0.1% and 70%. Antimony and tin are often used to give protection from corrosion, improved fluidity when melted or hardness when cooled. Cadmium is also a constituent of easily fusible alloys and some soft solders, though it is not in widespread use. Lead alloys are most common in batteries, solders, printing metals and protective coatings.

White lead (lead carbonate)

Production was common throughout the 18th, 19th and early 20th Centuries. Various production processes have been used, eg Old Dutch process and the Carter, Euston, Sperry and Thompson-Stewart processes, which all used the same basic chemical reaction. Lead, either as a solid or as a powder, was converted to lead acetate by reaction with acetic acid and the acetate was then converted to lead carbonate by reaction with carbon dioxide. White lead was used widely as a pigment in the paint industry and in pottery glazes, although it has been largely replaced in paint by the use of titanium dioxide.

Litharge (lead monoxide, PbO) and red lead (lead oxide, Pb_3O_4)
Litharge is formed by melting pig lead in reverberatory or cupellation furnaces in the presence of air. Some production processes involved burning lead to a fume in oxygen. Litharge, which has been used in a wide variety of industries in flake or powdered form may be known as glassmaker's litharge (used to make a toughened form of glass), potter's litharge (used as a constituent of glazes for pottery and enamel), colourmaker's litharge (used in pigment manufacture) or rubbermaker's litharge (used as an accelerator or toughener in rubber manufacture). Red lead, which is used as a pigment, is a more highly oxidised form of lead than litharge. It is formed by heating powdered litharge at a carefully controlled temperature. The litharge takes up additional oxygen and is converted to red lead.

2.4 Wastes from primary and secondary lead processing

2.4.1 Slag

Slag arising from blast furnace operations contains minerals and many metallic impurities, including 2-4% lead. Lead slag has always been recycled within the process to enable maximum recovery of metallic impurities which remain after smelting. In some cases the slag is further volatilised in a furnace to collect any recoverable zinc. In the same way, further refining operations produce small quantities of metallic slag and dross. If these substances were not recycled in a smelting furnace they would have been disposed of either off site or on site (if space was available) or used for making up ground. Nowadays, there are strict controls for the disposal of these materials if they are not recycled.

2.4.2 Dross

Dross arising from refining operations contains lead, tin, copper, arsenic, antimony, silver and bismuth. The concentrations of these metals depends on the amount originally contained within the raw material. The recovery of metals from dross only occurs if the concentration warrants it.

2.4.3 Dusts and fume

In the sintering, smelting and refining stages, fume and metal-laden dusts can be emitted during processing and during charging and discharging operations. These dusts may contain 10-20% lead as well as a wide range of metals and metalloids, especially copper, zinc, arsenic, antimony, tin, cadmium, silver, gold and bismuth. Plant is normally designed with hygiene hoods and the flue dusts are usually extracted in cyclones and filters. The concentrated dust is either re-smelted or, in the past, it may have been disposed of on site. Metal-rich dusts are commonly present in furnaces, stack ductwork, stacks and throughout the works structure. In the early days, building floors were unsurfaced and direct contamination of soils occurred as a result of the fumes, spillage of slags and ores and poor housekeeping.

2.4.4 Wastewaters

Contaminated waters can arise from several sources, including battery treatment plants, washing-down operations and run-off on the site.

Exhaust gases are sometimes scrubbed producing wastewaters contaminated with metals. These waters then require treatment to neutralise and precipitate out the metals (in the form of a sludge) prior to discharge. The sludge is then disposed of in a lagoon or landfill, possibly on site, or may possibly be smelted.

3. Contamination

The contaminants on a site will largely depend on the history of the site and on the range of materials produced there. Potential contaminants are listed in the Annex and the probable locations on site of the main groups of contaminants are shown in Table 1. It is most unlikely that any one site will contain all of the contaminants listed. It is recommended that an appropriate site investigation be carried out to determine the exact nature of the contamination associated with individual sites.

3.1 Factors affecting contamination

3.1.1 Handling of raw materials and fuels

The raw materials, lead ore, flux, coal and coke were stockpiled prior to use. The storage and movement of these raw materials around the site may have left residues in surface soils. Wind dispersion of dusts may have resulted in a general distribution of contaminants over surface soils.

Coke may have been manufactured on site from coal. Information about this process is given in the Industry Profile on gas works, coke works and other coal carbonisation plants (see Section 4). The storage of coal could have produced coal dust carpets. Coke and coal dust are combustible. Coke production could have caused specific contamination eg coal tar, phenols.

Oil for firing furnaces and other equipment is stored in bulk tanks (sometimes underground). Charging and leakage from these tanks and connecting pipework might have caused contamination of soils and groundwater, for example by diesel and oil.

3.1.2 Primary lead production

Contaminants would mainly have arisen from these operations by the spillage of metallic process materials, from the charging of furnaces and from the movement of materials around the site from one process area to another. Contamination would generally be concentrated in the main areas of activity, ie around the bases and discharge points of furnaces and kettles. Because of the long history of many sites, the process areas may have been relocated from time to time. Furnaces periodically collapsed causing the spillage of slag and molten lead onto the ground. New furnaces would then have to be constructed. Contamination often occurred over the whole site owing to the complex nature of the refining operation. Brickwork and other structural elements of the plant may have become highly contaminated with dusts and fumes.

3.1.3 Waste disposal

After it is recycled to recover metals, the slag still contains significant concentrations of metals. Slags and metal-rich materials were often used to fill parts of the site as foundation material for new buildings or hard surfacing, for periodic repair of such areas, or as general ash surfacing of vehicle parks, loading areas or railheads. Metal contamination of fill material remaining on sites is likely and may occur to significant depths if voids were used for waste disposal.

Although much flue dust was recycled to the production process, some was disposed of on site, possibly in conjunction with slag disposal. Charging activities would also have caused dust to be distributed generally about the site. Such dust may be located some distance from the works as a result of atmospheric transport of emissions. Soils in the surrounding environment may contain elevated levels of lead and other contaminants.

Liquid effluents may have originated from smelting operations, air pollution control units, sintering plants and acid recovery plants. These wastewaters may have undergone primary settlement in lagoons or been recycled in reservoirs after sedimentation and precipitation of solids. The primary contaminants would have been the range of metals given in the Annex. The presence of reservoirs or lagoons on sites would indicate the possible occurrence of contaminated sediments containing both metallic and organic substances (for example from the spillage of lubricating oils from machinery maintenance).

It is possible that plant buildings and infrastructure were insulated with asbestos lagging, or that asbestos cement sheeting was used in roofing or cladding. Waste asbestos material may be found in discrete dumps on the site where plant has been dismantled or asbestos may still be associated with existing buildings and plant.

Some sites may have had transformers or an electrical substation which, in the past may have contained polychlorinated biphenyls (PCBs) oils. Soil contamination may have occurred as a result of spillages and leaks of oil.

3.1.4 Secondary metal processing

Secondary metal processing is similar to primary processing, except that the potential sources of contamination are broader owing to the nature of materials brought on to sites. Lead scrap may have contained other materials likely to contribute to the localised contamination of soils. These contaminants might include metal-based paints or finishes (eg with chromium or cadmium) on the lead articles, as well as oils and greases. Unwanted material may also have been disposed of on site.

Where vehicle batteries have been dealt with, fragmentising units and acid disposal or neutralisation facilities were usually situated on site. Early on, the emptying of battery acid would probably have been uncontrolled, with acid being poured directly onto bare ground where it could drain away. Secondary metal processing sites may therefore have extensive and severe sulphate contamination and elevated pH.

Secondary metal slags and dusts are more variable in composition than those from primary lead production and are generally contaminated with lead, copper and iron. On-site disposal of slags and dust from secondary metal operations was commonplace. The use of iron, limestone and quartz sand fluxes also produced a slag similar to that from iron blast furnaces. These slags tend to break down upon weathering, forming expansive compounds which can cause upward movement of slag in disposal areas.

3.2 Migration and persistence of contaminants

3.2.1 Metals

Contaminants found on lead works are mostly metals, metalloids or metal alloys (see Annex), located in surface soils and landfills. The movement of metals through the soil is significantly retarded by clay minerals and organic matter in the soil; in this case, metals may accumulate near the soil surface. The greatest degree of migration occurs in coarse-grained sands and gravels.

These contaminants may be in an insoluble form and relatively stable. However, the soil may be acid eg in secondary lead works where battery acids have been handled, or where sulphuric acid was produced on site at a by-product plant. The solubility of some metals may increase under acidic conditions (eg. cadmium, copper, zinc and lead). In other cases the relationship is more complex. For example, trivalent chromium is more soluble under acidic conditions, whereas the solubility of hexavalent chromium is increased under both acidic and alkaline conditions. Therefore, significant contamination of groundwater and aquifers by metals may have occurred. It should be noted that metals may migrate more readily if they are present in their anionic form, eg sodium arsenate and sodium stannate are very soluble in water, and therefore very mobile. Metals are not generally biodegradable. Heavy metals may inhibit micro-organisms, thereby reducing the biodegradation of other pollutants such as oils.

3.2.2 Fuel oils

Liquid hydrocarbons are highly mobile. Although they are only slightly soluble in water, their soluble components present a significant threat to water resources. They are moderately biodegradable.

3.2.3 Asbestos

Contamination may occur by wind-blown dispersion of surface deposits containing loose asbestos fibres. Asbestos is not soluble or biodegradable and will persist in the soil.

3.2.4 PCBs

PCBs wich may occur in some electrical equipment do not degrade. They are fat-soluble and can accumulate in food chains.

4. Sources of further information

4.1 Organisations

For further information concerning the operational aspects of lead processing and associated hazards, the following organisations should be consulted:

Lead Development Association
42 Weymouth Street
London
W1N 3LQ

Lead Smelters and Refiners Association
St John's Road
Tunbridge Wells
Kent
TN4 9XA

4.2 Sources of further information concerning the activities described in this profile

Burt R. *British lead mining industry.* Dyllansow Truran, 1984.

Duckworth D V. *An assessment of the environmental impact of the demolition of a lead works.* Pollution Monitoring Group, Scientific Services Branch, Greater London Council. London Environmental Supplement No 5. Spring 1984. London, GLC, 1984.

Rowe D J. *Lead manufacture in Britain.* Croom Helm, 1983.

Ryan W. *Non-ferrous extractive metallurgy in the United Kingdom.* Institution of Mining and Metallurgy, Warren Spring Laboratory. London, IMM, 1968.

United Nations Environment Programme. *Environmental aspects of selected non-ferrous metals industries.* Industry and Environment, 1984.

Wilson, D. *Supply and demand for lead in the United Kingdom, the role of the secondary sector.* Conference Proceedings, International Lead and Zinc Study Group, 1988.

Case study including information relevant to this Industry Profile:

Paul V. *Bibliography of case studies on contaminated land: investigation, remediation and redevelopment.* Garston, Building Research Establishment, 1995.

Information on researching the history of sites may be found in:

Department of the Environment. *Documentary research on industrial sites.* DOE, 1994.

4.3 Related DOE Industry Profile

Gas works, coke works and other coal carbonisation plants

4.4 Health, safety and environmental risks

The Notes issued by the Chief Inspector of Her Majesty's Inspectorate of Pollution (HMIP) provide guidance for the processes prescribed for integrated pollution control in Regulations made under the Environmental Protection Act 1990. Of particular relevance are:

Her Majesty's Inspectorate of Pollution. *Processes for the manufacture of lead.* Chief Inspector's Guidance to Inspectors. Process Guidance Note IPR 2/5. London, HMSO, 1992.

Her Majesty's Inspectorate of Pollution. *Processes for the manufacture and use of antimony, arsenic, beryllium, gallium, indium, lead, palladium, platinum, selenium, tellurium, thallium and their compounds.* Chief Inspector's Guidance to Inspectors. Process Guidance Note IPR 4/22, London, HMSO, 1992.

The Control of Substances Hazardous to Health (COSHH) Regulations 1994 and the Management of Health and Safety at Work Regulations 1992 are available from HMSO. Information on relevant health and safety legislation and approved codes of practice published by HSE publications are available from Health and Safety Executive Books, PO Box 1999, Sudbury, Suffolk, CO10 6FS (telephone 01787 881165), as well as HMSO and other retailers.

Information on the health, safety and environmental hazards associated with individual contaminants mentioned in this profile may be obtained from the following sources:

Sax N and Lewis R. *Hazardous chemicals desk reference.* New York, Van Nostrand Reinhold Company, 1987.

Verschueren K. *Handbook of environmental data on organic chemicals.* 2nd Edition. New York, Van Nostrand Reinhold Company, 1983.

Howard P H. *Handbook of environmental fate and exposure data for organic chemicals.* Vols I and II. USA, Lewis Publishers, 1990.

4.5 Waste disposal and remediation options

Useful information may be obtained from the Department of the Environment series of Waste Management Papers, which contain details of the nature of industrial waste arisings, their treatment and disposal. A current list of titles in this series is available from HMSO Publications Centre, PO Box 276, London, SW8 5DT.

Publications containing information on the treatment options available for the remediation of contaminated land sites, prepared with the support of the Department of the Environment's Research Programme, can be obtained from National Environmental Technology Centre Library, F6, Culham, Abingdon, Oxfordshire, OX14 3DB.

A full list of current titles of Government publications on all aspects of contaminated land can be obtained from CLL Division, Room A323, Department of the Environment, Romney House, 43 Marsham Street, London, SW1P 3PY.

Advice on the assessment and remediation of contaminated land is contained in guidance published by the Construction Industry Research and Information Association (CIRIA), 6 Storey's Gate, Westminster, London, SWIP 3AU.

Annex Potential contaminants

The chemical compounds and other materials listed below generally reflect those associated with the industry and which have the potential to contaminate the ground. The list is not exhaustive; neither does it imply that all these chemicals might be present nor that they have caused contamination.

Metals, metalloids and metal alloys	lead arsenic tin antimony cadmium chromium bismuth magnesium manganese copper zinc silver iron
Inorganic compounds	sulphides sulphates chlorides carbonates eg lead carbonate, sodium carbonate oxides eg lead oxide, lead tetroxide sodium salts eg sodium nitrate sodium arsenate sodium stannate sodium antimonate sodium zincate
Acids	sulphuric
Alkalis	sodium hydroxide
Coal products	see Industry Profile on Gas works, coke works and other coal carbonisation plants (Section 4)
Oils	fuel oils, including diesel lubricating oils
Asbestos	
PCBs	

Table 1 Main groups of contaminants and their probable locations

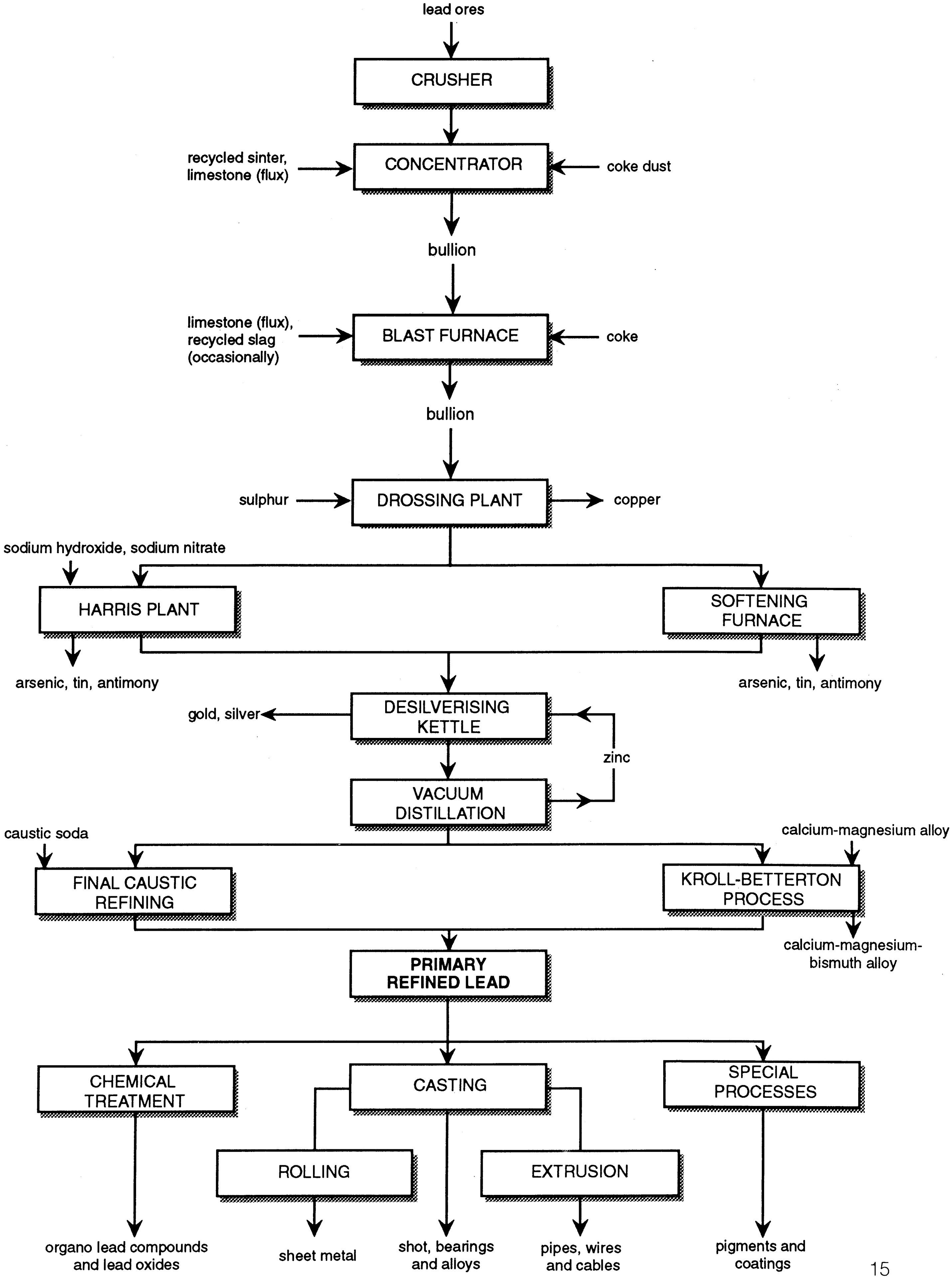
Metal manufacturing, refining and finishing works: lead works

Contaminant	Location										
	Process buildings and building fabric	**Raw material storage**	**Process areas**	**Coke manufacture**	**Effluent drains etc from air pollution control units, sintering, acid recovery etc**	**Fuel tanks and pipework**	**On-site waste storage/disposal (inc fill and foundations)**	**Reservoirs and lagoons**	**Battery recycling**	**Surrounding surface soils**	**Electrical transformers capacitors**
Metals, metalloids and their compounds	▨	▨	▨		▨		▨	▨	▨	▨	
Inorganic compounds		▨	▨				▨				
Acids					▨		▨		▨		
Alkalis					▨				▨		
Asbestos	▨						▨				
Coal products		▨	▨	See profile[1]							
Oils						▨		▨			
PCBs											▨

[1] See profile on Gas works, Section 4.3

Shaded boxes indicate areas where contamination is most likely to occur

Figure 1: Primary lead production and processing



DOE Industry Profiles

Airports
Animal and animal products processing works
Asbestos manufacturing works
Ceramics, cement and asphalt manufacturing works
Chemical works: coatings (paints and printing inks) manufacturing works
Chemical works: cosmetics and toiletries manufacturing works
Chemical works: disinfectants manufacturing works
Chemical works: explosives, propellants and pyrotechnics manufacturing works
Chemical works: fertiliser manufacturing works
Chemical works: fine chemicals manufacturing works
Chemical works: inorganic chemicals manufacturing works
Chemical works: linoleum, vinyl and bitumen-based floor covering manufacturing works
Chemical works: mastics, sealants, adhesives and roofing felt manufacturing works
Chemical works: organic chemicals manufacturing works
Chemical works: pesticides manufacturing works
Chemical works: pharmaceuticals manufacturing works
Chemical works: rubber processing works (including works manufacturing tyres or other rubber products)
Chemical works: soap and detergent manufacturing works
Dockyards and dockland
Engineering works: aircraft manufacturing works
Engineering works: electrical and electronic equipment manufacturing works (including works manufacturing equipment containing PCBs)
Engineering works: mechanical engineering and ordnance works
Engineering works: railway engineering works
Engineering works: shipbuilding, repair and shipbreaking (including naval shipyards)
Engineering works: vehicle manufacturing works
Gas works, coke works and other coal carbonisation plants
Metal manufacturing, refining and finishing works: electroplating and other metal finishing works
Metal manufacturing, refining and finishing works: iron and steelworks
Metal manufacturing, refining and finishing works: lead works
Metal manufacturing, refining and finishing works: non-ferrous metal works (excluding lead works)
Metal manufacturing, refining and finishing works: precious metal recovery works
Oil refineries and bulk storage of crude oil and petroleum products
Power stations (excluding nuclear power stations)
Pulp and paper manufacturing works
Railway land
Road vehicle fuelling, service and repair: garages and filling stations
Road vehicle fuelling, service and repair: transport and haulage centres
Sewage works and sewage farms
Textile works and dye works
Timber products manufacturing works
Timber treatment works
Waste recycling, treatment and disposal sites: drum and tank cleaning and recycling plants
Waste recycling, treatment and disposal sites: hazardous waste treatment plants
Waste recycling, treatment and disposal sites: landfills and other waste treatment or waste disposal sites
Waste recycling, treatment and disposal sites: metal recycling sites
Waste recycling, treatment and disposal sites: solvent recovery works
Profile of miscellaneous industries incorporating:
  Charcoal works
  Dry-cleaners
  Fibreglass and fibreglass resins manufacturing works
  Glass manufacturing works
  Photographic processing industry
  Printing and bookbinding works

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