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RISK REDUCTION MONOGRAPH NO. 1

LEAD
BACKGROUND AND NATIONAL EXPERIENCE WITH REDUCING RISK

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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RISK REDUCTION MONOGRAPHS

Risk Reduction Monograph No. 1: LEAD - Background and National Experience with Reducing Risk is the first in a planned series of OECD documents on risk reduction activities for specific chemicals or groups of chemicals. These Monographs will normally include sections on: the commercial life cycle, including releases from the major point sources and categories of diffuse sources; the environmental life cycle, including qualitative and quantitative health and environmental exposure determinations and estimations; linkages between sources and targets; risk reduction and control measures and their cost/effectiveness; and conclusions that can be drawn regarding the effectiveness of risk reduction measures, the identification of major exposures that need to be addressed in order to contribute to the reduction of risk, and critical information gaps.

The Risk Reduction Monographs are part of the OECD Environment Monograph Series. This series is designed to make available to a wide readership selected technical reports on the risk reduction of chemicals prepared under the OECD Chemicals Programme. The Environment Policy Committee recommended that this report be made public under the authority of the Secretary-General, who subsequently agreed. Copies of this Monograph on a limited basis can be forwarded on request.

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FOREWORD

Background

In 1990 the Council of the OECD adopted a Decision-Recommendation on the Co-operative Investigation and Risk Reduction of Existing Chemicals (C(90) 163/Final). This Act is aimed at the reduction of risks from chemicals to the environment and/or the health of the general public or workers. It is based on the premise that international co-operation in risk reduction activities can enhance the technical and institutional aspects of risk management in Member countries through burden-sharing and a reduction of duplicative efforts. Furthermore, such activities can lead to a more effective use of the knowledge about risks that is being generated through, for example, national chemicals reviews and assessments, the OECD co-operative investigation of existing chemicals, and the work of the United Nations International Programme on Chemical Safety (IPCS) in developing an international hazard and risk evaluations.

International co-operation in risk reduction can provide a forum for the exchange of views on risk reduction strategies, thus increasing mutual understanding and facilitating the harmonization of programmes being undertaken at the national level. By means of this forum, technical barriers to trade can also be prevented.

The OECD's approach to risk reduction

The risk reduction process normally begins at the national level. However, the international character of the use and marketing of chemicals, and the mobility of certain chemicals in the environment, have given risk reduction activities an international dimension. The new work on risk reduction in OECD is a major step towards greater international co-operation, consistency and, ultimately, harmonization. It is designed to enable Member countries to use a variety of options flexibly as part of a co-ordinated international initiative to reduce risk.

The OECD's approach to risk reduction relies on the sharing and exchange of information on the management of specific chemicals. Readily available information concerning national risk reduction strategies will make comparative analyses possible. Where common interests emerge, the development and implementation of measured and consistent responses to unacceptable health and/or environmental risks can be facilitated.

In this context, risk reduction activities can take into account all stages of a chemical's commercial and environmental life cycle, beginning with the natural resources needed to produce it and extending through the chemical's uses to its eventual disposal. The chemical's health and environmental effects, and those of its possible substitutes, can be considered together with exposure via all routes and media to different populations. In addition, the relative benefits of the different elements of a risk reduction strategy at all stages of a chemical's commercial and environmental life cycles can be weighed.

OECD work on lead risk reduction

OECD Member countries chose lead as one of the five chemicals or groups of chemicals for inclusion in the initial pilot project on co-operative risk reduction. The United States prepared a summary of information on the current "state-of-the-art" with regard to national strategies for lead risk reduction. With Australia, Canada and Germany, it formed an OECD Clearing House which collected further information from Member countries, including the industries involved with the chemical. The Clearing House countries completed this Monograph, and the Member countries of OECD agreed that it should be made public.

EXECUTIVE SUMMARY

The main purposes of this document on lead risk reduction are:

- to provide a summary of information regarding releases of lead to the environment, the ensuing environmental and human exposures, and the way OECD Member countries and countries with observer status perceive the risks associated with exposure to lead;

- to describe the actions those countries and industry have taken, or contemplate taking, to reduce risks associated with exposure to lead; and

- to identify the benefits, in terms of protection of human health and the environment, that could result from taking such actions, to the extent that information is available.

This document reflects information provided from 1990-1992 and should be considered as a "snapshot" of the most recent thinking and activities during this time period. It may assist in evaluating the effectiveness of national risk reduction strategies for lead by identifying common trends in setting criteria, standards or national policies. It may also suggest rationales and possibilities for concerted international actions.

Risk reduction activities for lead are expected to continue to create information and technology conduits between Member countries, and to promote the development and transfer of knowledge regarding the nature and efficacy of responses to deal with unacceptable risks resulting from exposure to lead.

Chapter Summaries

1. Lead Production, Use and Disposal

Lead is a naturally occurring element within the earth's crust. It is believed to have been mined as early as 5000 B.C. Easily shaped and highly valued for its malleability and ductility, lead was used in ancient times in making pottery glazes, art objects, coins and water piping.

Today, lead is produced from the beneficiation of ores and concentrates and/or from recycling in over 50 countries. In 1990, world production of lead metal was 5.659 million tonnes, valued at over $US 4.6 billion, with slightly over 50 per cent derived from recycled materials. In that year, OECD countries accounted for 50 per cent of the world's production of lead in ores and concentrates and about 64 per cent of the world's metal production.

Primary lead from mining is often produced as a by-product or co-product with other metals such as zinc, silver, copper and cadmium. In 1989, 155 mines in 35 countries produced 2.21 million tonnes of lead in concentrate, with co-product (copper, zinc, silver) output valued at over $US 9 billion.

Lead is also among the most recycled non-ferrous metals in the world. Secondary production (from recycled materials) has risen steadily. It surpassed primary output for the first time in 1989. This growth reflects the favourable economic conditions associated with lead recycling and the fact that lead retains its physical and chemical properties when recycled. As lead applications are used worldwide, scrap lead has become a readily renewable resource to which countries without lead mines have access.

Since 1970, the world demand for lead's unique chemical, electrical and physical properties has increased by 25 per cent to a record level of 5.627 million tonnes in 1990. OECD countries accounted for 65 per cent of world demand in 1990, with the Central and Eastern European countries consuming 21 per cent. Asia is now the third largest, and fastest-growing, lead-consuming region, representing 9 per cent of world demand.

Demand for lead within OECD countries increased by 10 per cent between 1970 and 1990. The battery sector recorded the greatest growth and accounted for 63 per cent of demand in 1990. During the same period, health and environmental concerns were largely responsible for the decline in the use of lead in gasoline, soldered food cans, solder and piping for potable water systems, and pigments used in household paints. Most of the decline in other uses, such as cable sheathing, reflects changes in technology and market-driven requirements for lighter, more cost-competitive and more efficient products.

New applications are being developed for lead and lead compounds in microelectronics, superconductors, asphalt, earthquake damping materials and radon gas shielding, and for retrievable storage or permanent disposal of nuclear waste, to name a few. Industry has acknowledged that risk analyses should accompany the introduction of new products, and that recycling and reuse concepts should be developed where appropriate.

Daily prices for lead are based on international market factors, as it is traded worldwide. Regionally, Europe and Japan are the largest importers of lead concentrates and Europe is the major importer of lead bullion and refined lead. Australia, Canada and Peru are principal suppliers of both lead concentrates and lead metal. Mexico is a major exporter of refined lead.

Environmental releases of lead can occur naturally (for example, through crustal weathering, volcanism) or from anthropogenic sources relating to industrial activity, power generation (coal and oil burning), and the use and disposal of consumer products. Industrial wastes (i.e. emissions, effluent and solid waste) are often regulated within OECD countries. Post-consumer wastes containing lead may be regulated, depending on their hazard classification and/or their destination (i.e. recycling, final disposal, international trade).

Lead materials that can be recycled vary from industrial and consumer scrap to remediation and abatement wastes. Post-consumer product scrap constitutes more than 80 per cent of the scrap supply for recycling, with batteries accounting for up to 90 per cent in a given year.

Battery recycling rates are high in many countries, sometimes exceeding 90 per cent. However, it has become apparent that the weakest link in the recycling chain is usually the consumer who retains or discards a used battery rather than returning it for recycling. In a number of countries, governments are working with industry to increase recycling by focusing on the battery life cycle and encouraging consumers to return used batteries.

If lead-containing industrial solid wastes and post-consumer products are not recycled or reused, they are generally sent to landfills for disposal or are incinerated. The composition and volume of wastes destined for final disposal, as well as management methods, vary according to country and region depending on factors such as end use patterns, recycling rates and population density.

Some countries have estimated that batteries and consumer electronic products account for most of the lead in municipal solid waste. Others have identified lead in soldered food cans as the main source of lead in household refuse. It has been observed in some countries that the volume of lead in municipal waste is declining. Studies have also found that health concerns are minimal for properly managed landfills with runoff and leachate controls, and that lead emissions from incinerators can be controlled, with proper technology, to 99 per cent or greater efficiency. While much of the atmospheric emission of lead from incineration can be eliminated, lead captured by emission control devices and the lead remaining in ashes must be disposed of properly, usually in landfills.

2. Environmental Fate, Transport and Occurrence

Human activities remove lead from the earth's crust, where it is relatively immobile, and transfer it to environmental media. The potential for human and ecosystem exposure is thus greatly increased. Industrialization has vastly accelerated the transport of lead into human and environmental exposure pathways. Substantial human and ecosystem exposure to lead can occur in all environmental media.

It has been estimated that the amount of lead emitted per year into the atmosphere from anthropogenic sources has declined to about 30 per cent of the estimated 332 350 metric tonnes in 1983. Sources of atmospheric lead emissions may be considered as belonging to one of two main categories: mobile sources (through the use of leaded fuels in automobiles) and stationary ones (refining, manufacturing and incineration). Air emissions from smelters, processing facilities and solid waste incinerators occur as point source releases from stacks and as fugitive releases from storage, processing or materials handling. Lead concentrations in the air in cities in some OECD countries have ranged from 0.5 $\mu g/m^3$ up to 10 $\mu g/m^3$ in densely travelled inner city areas. However, restrictions on lead levels in gasoline in many countries have resulted in a marked decrease in automotive emissions of lead into the atmosphere. Air concentrations near point sources often still remain high.

Lead accumulates in soils and sediments. As a result of the decline in atmospheric lead emissions, the total annual anthropogenic loading of lead to soils worldwide is considered to have been reduced, from a 1983 estimate of between 479 000 and 1 113 000 metric tonnes per year. Atmospheric deposition of lead is a major source of soil and sediment contamination. The concentration of lead in soils near highways is related to traffic density, local meteorological conditions, vegetation and topography. Lead concentrations decrease with distance from the highway and with depth in the soil column. Lead concentrations associated with stationary sources are dependent on the rate of release from source, dispersion, and deposition rate. Generally, the concentration of lead in soil decreases exponentially downwind of a point source.

House paint containing lead can significantly contribute to household dust or soil concentrations of lead. Shot and fishing weights contribute large quantities of lead to soils and

sediments. Lead tends to be immobilized by the organic component in soil and remains bound to the soil. It has been suggested that lead immobilized in soil can be released by decreases in the pH of precipitation. However, there is as yet no evidence to confirm that acid rain is influencing the chemistry and transport of lead in the soil environment.

Lead is a natural, usually very minor constituent of surface and ground waters. As with lead in soils, the total input of lead to aquatic ecosystems worldwide is considered to have declined, from an estimated 97 000-180 000 metric tonnes per year in 1983, as a result of the decrease in atmospheric lead emissions. Input of lead to aquatic ecosystems can occur from sources such as industrial wastes, effluents from mining, smelting, refining and manufacturing processes, dumping of sewage sludge, and atmospheric fall-out. Most of the lead introduced into surface waters is readily absorbed into sediments, where it complexes with organic material. Due to its relative immobility in water, lead tends to accumulate wherever delivered (for example, near point sources).

3. Linkages to Exposure

Inhalation and ingestion (of water, food, paint, soil and/or dust) are the primary routes of human exposure to lead. The relative importance of any single source of exposure is difficult to predict. It will vary with geographic location, climate and local geochemistry. Similarly, the intensity of exposure experienced by an individual can vary as a function of age, sex, occupation, socio-economic status, diet and cultural practices. In addition, the amount of lead taken up into the body is believed to vary depending on the concentration and composition (for example, particle size, chemical form) of the lead inhaled or ingested.

Some countries monitor the levels of lead in environmental media, as well as in blood, as a basis for assessing risks of exposure and the effectiveness of measures to reduce these risks. In countries that monitor trends in lead levels, data indicate that while the demand for lead products (and possibly the amount of lead destined for final disposal) has increased, the average levels of lead in air, food and blood declined to below levels of national concern. However, some countries have identified portions of the population that continue to be exposed to levels that exceed those of national concern. These elevated lead exposures often relate to point source releases, to past use of paints containing lead, or to lead piping and solder in potable water systems.

Reasons for the decline in lead levels vary according to country or region, and are in part influenced by local factors (for example, climate, socio-economic considerations, etc.). Declining lead levels in various environmental media and blood are commonly attributed to the following factors:

- restrictions on, and reductions in, dispersive uses of lead that result in its being readily bioavailable, such as:
    - lead in gasoline,
    - lead in soldered food cans,
    - lead solders and piping in drinking water systems,
    - lead in selected paints, and
    - lead-based pesticides;
- the introduction of regulatory and non-regulatory measures for management of industrial emissions and effluents (for example, from smelters);

- monitoring of water supply systems to reduce the solubility of lead from lead-bearing service lines by controlling the pH; and

- the development and implementation of regulations and technology for safe management of lead-bearing and other wastes destined for final disposal in landfills or incinerators.

4. National Positions on Current Risks from Lead

The Member country statements in this chapter essentially present the rationale for any actions the country has taken to address effects associated with environmental or human health exposures to lead. The risk assessments and risk characterizations that have led countries to take action have a national character. Countries develop positions on the need for risk reduction activities only after they have analysed the hazard and the significance of certain exposures and have factored in local social, economic and political considerations. These positions are usually arrived at after considerable debate on the numerous factors involved, and thus are not consistent across Member countries.

This chapter also contains an internationally agreed assessment of the risks of lead from the International Programme on Chemical Safety (IPCS). The IPCS assessment is taken directly from Chapters 1 and 9 of the recent Task Group-approved update of the Environmental Health Criteria Document on Lead, which will be published in late 1993 or early 1994.

5. Mechanisms for Risk Reduction

During the past few decades, most Member countries have taken steps to reduce unacceptable human and ecosystem risks from exposure to lead. Among the most successful of these measures have been restrictions on the use of lead in certain products with significant exposure potential (for example, interior paint, gasoline). Accompanying these measures have been actions to establish criteria for acceptable levels of lead in environmental media, to limit industrial emissions of lead to the environment, to control occupational exposures, and to identify biologically based indices for determining populations at risk. Despite the success of many of these measures in reducing lead exposure, some Member countries continue to consider possible steps to reduce lead exposure further, especially in light of new evidence of potential health effects at levels previously believed to be safe.

This chapter reviews risk management activities in Member countries. Included are discussions of steps taken in the past to reduce lead exposure, as well as current activities and potential future measures contemplated by certain countries. *Country-specific risk management activities* are summarized in Table 5.1. As shown in the table, the extent of these activities varies substantially among countries.

The lead risk reduction activities of thirteen individual countries (Australia, Canada, Denmark, Finland, France, Germany, Japan, Mexico, New Zealand, Sweden, Switzerland, the United Kingdom and the United States), the Nordic countries and the European Community are described in this chapter, followed by a summary of industry risk reduction activities. *At the end of the chapter is a series of tables that summarize available data on lead risk reduction activities in all*

Member countries and Mexico. Repeated requests for information on lead risk reduction activities were made to all Member countries in 1991 and 1992. Lack of information in this report on a particular country means either that no risk reduction activities have taken place in that Member country, or that the Member country has declined to respond to the requests for information.

The following is a brief summary of the information given in this chapter, apart from that presented in the tables:

Australia: The Australian Government supports the production and uses of lead, consistent with the principles of ecologically sustainable development. Australia restricts the manufacture and use of lead-based household paint with a 0.25 per cent non-volatile content, and the lead content of gasoline is limited to levels ranging from 0.3 g/l to 0.84 g/l, depending on location. Since 1 January 1986, all imported and domestic new cars have been required to operate on unleaded petrol (i.e. less than 0.013 g/l). This policy has resulted in unleaded petrol sales now approaching 50 per cent of total sales. A penetration level of about 80 per cent is forecast for the end of the decade. Australia also limits the emission concentration from stationary point sources to 1.5 $\mu g/m^3$ over a three-month average. The concentration of lead in drinking water should not exceed 0.05 mg/l and the permissible levels for lead in specific foods are between 0.2 and 2.5 mg/kg, depending on the foodstuff. The lead content of ceramic glazes is restricted, as is the lead content of pencils, toys, crayons and artists' paints (to 0.01 per cent). Although there are no recycling regulations governing lead batteries, the industry reports that over 90 per cent of the lead used in batteries is recycled.

Canada: The advertisement, importation and sale of paints containing lead are restricted. Lead is permitted in products (paints) for exterior use only and must be properly labelled. The Canadian paint industry voluntarily stopped using lead in household (interior and exterior) paint in 1991. In 1990 Canada prohibited the use of leaded gasoline (not to exceed 5 mg/l), except for use in critical equipment (not to exceed 26 mg/l). Canada currently allows a maximum of 10 µg/l of lead in drinking water and the plumbing code permits a maximum concentration of 0.2 per cent lead for solder and fluxes in contact with potable water.

Lead concentrations allowed in food vary between 0.08 mg/kg for infant formula and 1.5 mg/kg for tomato products. National standards exist for ambient water quality (0.001 to 0.007 mg/l freshwater aquatic life), soil and air (emissions of particulates from secondary lead smelters from 0.023 to 0.046 g/m^3). Lead is limited to 0.5 per cent in coating materials applied to children's products. Canada recycles an estimated 93 per cent of lead-acid batteries. Lead batteries that are filled with acid are classified as hazardous and, as a result, their transportation and storage are regulated by federal and provincial requirements. Regulation of the handling of lead-bearing scrap is divided between federal and provincial authorities. Canada has undertaken extensive education and labelling programmes designed to increase community awareness of the hazards associated with lead exposure.

Denmark: Danish lead risk reduction activities are aimed at phasing out the use of lead totally. Possible actions are regulation and voluntary agreements. The means could be substitution and, where this is not possible, improved recycling. International action is seen as a necessary means of eliminating lead use.

Finland: The use of white lead and lead sulphate has been prohibited in interior paints since 1929. Lead carbonates and lead sulphates may not be used in paints after 1 January 1993, except in paint intended for restoration and maintenance of works of art and historic buildings. The lead content of gasoline is limited to 0.013 g/l (unleaded) and 0.15 g/l (leaded). Maximum values for emissions from facilities into air and water are set on a case-by-case basis during environmental permitting procedures. The maximum allowable concentration of lead in workplace air is 0.10 mg/m^3 (time-weighted average over eight hours). The maximum allowable lead concentration in the blood of exposed workers is 50 µg/dl. Food safety standard: the maximum lead content in fruits and vegetables is 0.3 mg/kg, in drinks 0.3 mg/kg, and in canned food 1.0 mg/kg. Maximum lead leaching from ceramic ware that will come into contact with foodstuffs has been defined. The maximum lead level for drinking water is 0.05 mg/l.

France: The lead content of gasoline was reduced to 0.15 g/l in 1991, and unleaded (less than 0.013 g/l) gasoline has been granted a tax reduction which makes its retail price lower than that of leaded gas. France has adopted the EC limit of 0.05 mg/l lead content of surface water to be used as a source for potable water. The average annual limit value for ambient air concentration of lead is 2 µg/m^3. Standards exist for limiting lead emissions from industrial and other facilities. Sewage sludge used in land application must not have a lead concentration greater than 800 ppm. France limits the migration of lead from ceramic kitchen utensils into food, allows only external soldering of cans, and adheres to the January 1993 prohibition of lead capsules for overcorking wine bottles imposed by the EC. Import and sale of paint containing white lead compounds is prohibited from 1 February 1993. Battery recycling is accomplished through voluntary agreements designed to facilitate recovery and transport of spent batteries.

Germany: Regarding paint, white lead compounds are banned from sale and lead-based anti-corrosive paint is being phased out. Containers for paint with more than 0.15 per cent lead content must be labelled. The maximum content of leaded gasoline has been restricted to 0.15 g/l since 1976, and unleaded (less than 0.013 g/l) gas has been on the market since 1982. In 1992, the market share of unleaded gas was greater than 80 per cent.

Municipalities responsible for drinking water supply systems have to maintain a lead level of less than 40 µg/l at the mains connection. Lead service lines are no longer used, and old lead systems are gradually being replaced. Copper pipes have to be soldered with lead-free alloys. Many German states have limited the lead concentration in the soil. For example, Northrhine-Westphalia has a limit of 20 mg/kg lead in the sand of children's playgrounds. The maximum tolerable lead concentration in air is limited to 2.0 µg/m^3 (annual mean); the maximum deposition on soil to 0.25 mg/m^2/day. Total metal emissions (including lead) from lead smelters are limited to 5 mg/m^3. For direct discharges to water, limits vary from 0.3 to 2.0 mg/l, according to the type of facility. The use of sewage sludge for agricultural purposes is legally prohibited if its lead content exceeds 900 mg/kg.
In Germany, guide values (*Richtwerte für Schadstoffe in Lebensmitteln*, ZEBS) have been established for most foodstuffs in a range of 0.03-2.0 mg/kg. In addition, a limit value for wine has been introduced through the "wine regulation". For other foodstuffs, guidelines for lead have been established. There is no use of soldered cans for food packaging. Lead capsules for overcorking wine bottles are prohibited from 1993, in accordance with

an EC regulation. The recycling rate for lead-acid batteries is reported to be above 95 per cent. In the workplace, the maximum allowable air lead concentration is 0.10 mg/m^3 (eight-hour time-weighted average). The maximum allowable blood lead concentration for workers is 70 µg/dl for men and for women over 45, and 30 µg/dl for women under 45. Some physiologists and toxicologists recommend that the blood lead levels of adults should not exceed the concentration of 15 µg/dl, and that those of children and of women of childbearing age should not exceed 10 µg/dl.

Japan: Japan does not prohibit the use of lead-based paints but does, through voluntary agreements, limit the extent to which lead-based paint is used (prohibited for toys, households). Lead-based paints are used primarily in construction, automobiles and electronic products. Lead gasoline is not manufactured, imported or used in Japan. The maximum permissible lead concentration in drinking water is 0.1 mg/l. Japan has set emission standards for smelters and other lead processing facilities at 10-30 mg/m^3 depending on the facility. Waste water effluent must have a lead concentration of less than 1 mg/l. The administrative level for lead in the workplace is set at 0.1 mg/m^3.

Mexico: Mexico has an aggressive programme underway to reduce tetraethyl lead concentration in regular gasoline. In 1990, unleaded gasoline (less than 0.01 g/l) was introduced. From 1988 to 1992, an 88 per cent reduction in the lead content of gas took place. For drinking water the government established a lead level of 0.05 mg/l. Mexico has also set standards for lead in foodstuffs, drugs and cosmetics. The maximum permissible level of lead in tomato sauce is 0.36 mg/kg and the maximum permissible level of lead in synthetic organic dyes added to food, beverages, drugs and cosmetics is 10 ppm.

Mexico has eliminated the use of lead solder in welding of tin cans and has established a maximum permissible level of lead in surface paint of 90 mg/kg. Industries have agreed to eliminate the use of lead red oxide and lead-based carbonate from pigments, lacquer, enamel, paint and varnish on toys, pencils, school articles, printing inks, cosmetics, furniture and paints for interiors. Labelling on products containing lead is now required. In addition, a coalition of industry and artisans has agreed with government on maximum solubility levels for kiln-fired glazed pottery. Mexico has established a maximum permissible level of lead in the workplace of 150 µg/m^3. A further reduction to 50 µg/m^3 is being considered.

New Zealand: White lead compounds cannot be manufactured, imported or used in paint, distemper, powder coatings, pigments, or antifoulant. The maximum permissible amount of lead in paint is 5000 mg/kg; however, it is anticipated that this level will be reduced to 2500 mg/kg during 1993. The maximum permissible level of lead in petrol is 0.013 g/l (unleaded) and 0.46 g/l (leaded). A target date for elimination of lead in petrol has been set as January 1996. Material used for writing, drawing, marking or painting that contains more than 100 mg/kg of lead is prohibited. The maximum permissible amount of lead in coating materials for toys is 5000 mg/kg. This level will be reduced to 2500 mg/kg in the Fourth Amendment of the Toxic Substances Regulations 1983. Accessible plastic material on toys is restricted to a maximum permissible amount of 250 mg lead/kg.

New Zealand's drinking water guideline of 0.05 mg/l was established based on the WHO Guidelines for Drinking Water Quality, 1984. There is a proposal to review the standard in 1993 to align with the new WHO Guidelines. The maximum permissible amounts of lead

in food range from 0.2 to 10 parts per million, depending on the food product. Limits for lead in sewage sludge intended for application to arable land were established in 1992. The maximum acceptable concentration of lead in dry sewage sludge is 600 mg/kg, the limit value allowable in soil is 300 mg/kg, and the maximum cumulative loading is 125 kg/ha. New Zealand has proposed a national ambient air quality guideline of 1.0 µg/m^3 for an average time of three-month moving average. The workplace exposure standard for lead in air is 0.15 mg/m^3.

Sweden: In 1991, the Swedish Government decided that measures should be carried out in order to phase out the use of lead on a voluntary basis, and in the long run to ensure its cessation. White lead compounds are not used in paints; however, some lead is used in paint as pigments, drying agents and rust-proofing agents. Sweden limits the lead content in gasoline at 0.15 g/l for leaded and 0.013 g/l for unleaded products and recently a ban has been proposed on the manufacture and import of leaded gasoline from 1 July 1994. Water with lead concentrations of less than 0.01 mg/l is deemed suitable for use as drinking water. Air and water standards are set on a case-by-case basis during the facility licensing process. Food tolerance levels have recently been lowered to 0.3-0.5 mg/kg for most canned food, and to between 0.02-0.5 mg/kg for various foodstuffs (higher values for spices, etc.). Ceramic ware, intended for handling food and beverages, is prohibited for sale if more than 3 mg/l lead is leached out during a standardized acetic acid leaching test. Sweden has instituted an aggressive recycling programme for batteries, supported in large part by taxes on batteries. The maximum allowable air lead concentration in the workplace is 0.10 mg/m^3 (total) and 0.05 mg/m^3 (respirable).

Switzerland: The use of lead and its compounds is prohibited in water paints and non-washable distempers used for interior paintwork. The lead content of gasoline is limited to 0.15 g/l (leaded), 0.013 g/l (unleaded), and 0.56 g/l in aircraft petrol. The permissible lead concentration in drinking water is 0.05 mg/l. Switzerland has set a general emission standard for combusters with a mass flow greater than 25 g/hr at 5 mg/m^3. For municipal waste incinerators, the sum of lead and zinc, including compounds emitted into the atmosphere, is not allowed to exceed 1 mg/m^3. The maximum tolerable lead concentration in air (suspended solids) is limited to 1 µg/m^3; the maximum tolerable deposition at 100 µg/m^3 per day. Waste water effluents must have a lead concentration of less than 0.5 mg/l. The quality criteria for surface water flows and impounded river water is set at 0.05 mg/l. The use of sewage sludge and compost is prohibited if their lead content exceeds 500 mg/kg or 120 mg/kg, respectively. The maximum allowable air lead concentration in the workplace is 0.1 mg/m^3 (time-weighted average over eight hours) for lead and lead compounds (except alkyl compounds), and 0.075/m^3 for tetramethyl and tetraethyl lead.

United Kingdom: The United Kingdom has implemented legislation concerning lead paint that prevents the use of lead carbonates and lead sulphates in paint. Under these rules, lead carbonates and sulphates may only be used in paint for certain historic buildings and for art preservation. The maximum allowable concentration of lead in gasoline is 0.15 g/l. Unleaded gasoline has a maximum allowable concentration of 0.013 g/l.

Rules governing the maximum concentration of lead in drinking water are set at 50 µg/l. Recently regulations have been proposed to prohibit the use of certain lead solders in domestic water supply installations. A maximum permissible concentration for lead in

soils of 300 mg/kg dry solids after the application of sewage sludge has been established.

The ambient air quality standard for lead is 2.0 µg/m^3 (mean annual concentration). The UK regulates air point sources and other lead works using the best practicable means. Industrial sources must meet an allowable lead concentration of 0.002 g/m^3. Total particulate emissions cannot exceed 0.1 g/m^3. Permissible lead concentrations in waste water effluent vary by industry and plant location. The typical range of permissible concentrations is 1.0-5.0 mg/l.

The UK has established quality and labelling standards for a range of consumer products, such as a general limit for lead in food of 1.0 mg/kg with lower limits for special types of food such as baby food (0.2 mg/kg). As of 1988, ceramic wares have been subject to regulation. Industry was given five years to meet maximum lead concentrations of 0.8 mg/dm^2 for flatware, 4.0 mg/l for small hollow-ware (less than three litres) and 1.5 mg/l for hollow-ware greater than three litres. The UK also restricts the use of lead-based paints in consumer products. Although there are no rules governing the disposal of lead batteries within the UK, there are very high recycling rates (exceeding 90 per cent) for lead-acid batteries used in buildings and automobiles.

The maximum allowable concentration of lead in the workplace is 0.15 mg/m^3 (eight-hour TWA), blood lead concentration of 70 µg/dl for men and 40 µg/dl for women. For the general population, the government advice published in 1982 recommended taking steps to reduce exposure if blood lead level exceed 25 µg/dl.

United States: The United States has restricted or banned the use of several products containing lead where risks from these products are high and where substitutes for lead or lead-based products are available. The Centers for Disease Control (CDC) lowered the childhood blood lead concentration of concern to 10 µg/dl in 1991. Earlier, the EPA had lowered the level of concern to 10µg/dl ("10-15 and possibly lower") in 1986. The Agency for Toxic Substance Disease Registry (ATSDR) identified the same level of concern in the 1988 Report to Congress on childhood lead poisoning.

One of the highest-risk sources of lead poisoning for children in the United States is lead-based paint. The federal government has set a standard for lead in residential paint of 0.06 per cent, which effectively bans lead use in residential paint. In 1992, the Residential Lead-based Paint Hazard Reduction Act of 1992 was enacted (Title X). This law provides the framework for a national approach to reduce hazards from lead-based paint exposure, primarily in housing.

The US restricts the amount of lead allowed per litre of leaded gas to 0.026 grams. Since 1988, all new light-duty vehicles, trucks, motorcycles and heavy-duty gasoline engines must operate on unleaded gas (0.01 g/l). Starting in 1995, a total ban on leaded gasoline and lead gasoline additives will be in place for highway use. A new regulation of 1991 outlines the treatment requirement for drinking water that sets an "action level" of 15 µg/l measured at the home source. A series of remediation steps are prescribed for households exceeding this level. Interim guidelines exist for abatement of lead-based paint in public housing. These guidelines recommend abatement at 1µg/cm^2 paint of 0.5 per cent lead by weight and clearance levels for lead in household dust of 200 µg/ft^2 for floors, 500 µg/ft^2 for window sills and 800 µg/ft^2 for window wells. The interim guidance for residential soil recommends that clean-up should attain soil concentrations of between

500 and 1000 mg/kg.

The US ambient air quality standard for lead is currently 1.5 µg/m^3 (quarterly average). The most stringent standard for surface water quality is a maximum four-day average of 1.3 µg/l with a one-hour maximum average of 34 µg/l. The US has proposed regulations for the use and disposal of sewage sludge containing lead that would allow a maximum concentration of lead in sludge of 300 mg/kg and cumulative pollutant loading for lead in the soil of 300 kg/ha. In the US, certain lead-containing wastes are specifically listed as hazardous. These wastes must be managed by a permitted treatment, storage or disposal facility.

The federal and state governments also regulate the use of lead paints and surface coatings used in toys, children's products and household furniture. The canning industry has undertaken a voluntary phase-out of the use of lead in food cans. The US government also regulates the lead content of ceramic glazes, food, wine and pesticides. A number of states have adopted legislation to limit the levels of lead used in packaging materials. A large recycling effort is ongoing in the US to deal with most lead-acid batteries (it is likely that many small consumer batteries may not be recycled). Recent studies indicate that more than 95 per cent of all such batteries are recycled.

The current Permissible Exposure Limit for air concentrations of lead in the workplace is 50 µg/m^3. Blood level monitoring is triggered by an air lead concentration above 30 µg/m^3. The medical removal blood lead concentration in the workplace, which became effective in 1983, is 50 µg/dl for three consecutive checks and 60 µg/dl for any one check. A worker is permitted to return to that workplace when his blood lead level falls below 40 µg/dl.

Nordic Countries: The Nordic countries have undertaken a number of joint initiatives towards protecting the environment. Denmark, Sweden and Norway have signed the Ministerial Declaration of the Third International Conference on the Protection of the North Sea. This declaration states that the emissions of lead (and other micropollutants) shall within 1995 be reduced by 70 per cent compared to the level in 1985. Denmark, Finland and Sweden have, through the Baltic Marine Environment Commission (HelCom), adopted the goal of reducing lead emissions by 50 per cent within 1995, using 1987 as a reference year.

The Nordic Working Group for the Chemicals Group of the Nordic Council of Ministers has prepared a draft report describing Nordic experiences regarding the technological possibilities for reducing the use of lead. The long-term goal for the Nordic countries is to completely eliminate the intentional use of lead in products and to minimize the amount of lead discharged to the environment. The strategy to reach this goal includes, in preferential order: cleaner technology (substitution and process modifications); effective recollection and recovery systems; and environmentally acceptable waste treatment.

European Community: The European Community has issued directives regulating lead in products, and across different environmental media and environmental sources. It is important to note that a directive is a legislative action addressed to Member States. It may either contain very specific information or be narrative in nature. A directive often sets a deadline for adoption by Member States into their own laws; typically, however, a directive will contain specific information and will set a deadline on the order of three

years. If a Member State fails to adopt the directive into law within the specified amount of time, then action may be taken against that Member in the European Courts.

Beginning in 1989, the EC prohibited the use of lead carbonates and lead sulphates in paints intended for all purposes other than preservation work. Also in 1987, the EC limited lead levels in gasoline in a directive which sets the maximum permitted lead compound level of leaded gas at 0.15 g/l and defines unleaded gasoline as that containing less than 0.013 g/l of lead. In 1993, the EC prohibited the use of lead capsules for overcorking wine bottles.

All sources of drinking water should have a maximum allowable lead concentration of 0.05 mg/l. In 1989, standards were established for sewage sludge used in agricultural application. The lead concentration limit for soils with pH levels ranging from 6-7 is 50-300 mg/kg dry matter, while the limit in sewage sludge is 75-1200 mg/kg and the annual limit of sewage sludge applied to agriculture is 15 kg/ha (based on a ten-year average).

The EC has set feed standards to limit the exposure of livestock to lead. As of 1988, the marketing of cosmetic products containing lead was prohibited. No more than 20 mg/kg lead may be contained in colouring matters, and not more than 10 mg/kg lead in antioxidants and emulsifiers used for food. The maximum leaching rate for ceramic articles that can be filled is 4 mg/l and for ceramic cookware 1.5 mg/l.

Beginning in 1988, paints, varnishes, printing inks and similar products that have one per cent weight associated with heavy metals must be classified, packaged and labelled according to EC standards. In 1986, the EC established concentration limits for air of 0.15 mg/m^3 and blood lead of 70 µg/dl, and action levels for air of 40 µg/m^3 and blood lead of 40 µg/dl.

Industry: The international non-ferrous metals industry has effected a variety of initiatives which can be considered lead "risk reduction" measures. Summaries of these activities are provided in this section. These initiatives generally fall into one of several categories, as follows: 1) changes in processing technology and/or emission controls; 2) implementation of medical surveillance and occupational hygiene programmes for exposed workers; 3) support of research to validate the effectiveness of existing occupational and general population exposure limits and develop new monitoring procedures for ensuring human and environmental health; and 4) implementation of product stewardship programmes to inform downstream users of lead of the precautions which should be exercised so as to protect the health of employees and consumers.

Occupational standards for exposure to lead vary among OECD countries. For example, OECD countries have established maximum occupational exposure limits for lead in blood ranging between 40 and 80 µg/dl. Standards for occupational exposure to airborne lead also vary among OECD countries, with 50, 100 and 150 µg/m^3 all being specified in national regulations or legislation. Engineering controls backed by personal hygiene and other protective programmes are employed by lead producing and consuming industries to minimize worker exposure. In areas where exposure limits cannot otherwise be met, personal respirators are employed. Correlations between lead in air and lead in blood are generally poor, with good personal hygiene widely regarded as the most significant factor in limiting exposure. This factor also serves to minimize the transport of lead particles into the home. The European Federation of Capsule Manufacturers (EUCAPA) agreed in

June 1990 to stop the production of lead-containing capsules for overcorking wine bottles.

The information presented in this overview was, in large part, collected via a questionnaire administered to the international industry by the International Lead Zinc Research Organization in early 1992. Respondents to the questionnaire included corporations whose lead production capacities comprise a significant proportion of both annual global production and production in OECD Member countries. Responses to this questionnaire were not received from all lead-producing industries. As a result, the information presented must be viewed as a qualitative overview that is likely to be incomplete in some areas. Similarly, risk reduction measures implemented by the industry show evidence of geographic variation that is reflective of regional differences in the perception of relative risk associated with lead exposure. The nature and extent of risk reduction activity by industry in individual countries is thus variable.

6. Summary and Considerations

Almost all OECD countries have introduced regulatory or non-regulatory measures to reduce unreasonable human and ecosystem risks from exposure to lead. The risk assessments and risk characterizations that have led countries to take actions have a national character. Although some countries have taken the same number of measures, no two countries have adopted the same set of risk reduction measures (i.e. initiatives relating to environmental media, industrial or municipal releases, products, occupational exposures, etc.).

Blood lead sampling is one of the methods most widely used to assess human risk from exposure to lead. Approximately 30 per cent of OECD countries have reported blood lead monitoring data for the general population and/or segments of the population at greatest risk. These countries have reduced average blood lead levels for the general population to below 10 µg/dl by introducing either a few measures or a considerable number of initiatives.

Data for those Member countries that monitor lead in various media also indicate that the average concentrations of lead in environmental media have declined to below national levels of concern. However, some countries have identified releases of lead from point sources and/or the long-range transport of lead in air as concerns. Others have indicated that, given the recent progress in reducing lead in air, there are more significant domestic concerns such as lead in imported canned food, lead in drinking water (especially for critical groups such as bottle-fed infants), or lead in dust and chips from deteriorating old household paint.

It is suggested that when considering risk reduction strategies for lead, Member countries not already doing so may wish to undertake environmental and blood lead sampling to identify populations at highest risk and to evaluate the extent of lead exposure in their general population. Countries may also want to draw on experiences described in the document when developing regulatory and non-regulatory measures to reduce unreasonable risks from exposure. These measures may include: regulations and standards (for example, on lead in food packaging, lead in gasoline, smelter emissions) aimed at reducing ongoing releases of lead to air, water, soil, dust and the workplace; implementation of cleaner technology (for example, substitution, process modifications), effective recollection and recovery systems, or environmentally acceptable waste treatment; abatement activities to reduce risks from exposure to historical sources of release (for example, deteriorating paint, piping in potable water systems); and voluntary industry product stewardship programmes such as the industry phaseout in some countries of high-risk applications

(for example, lead in soldered food cans or household paints).

In addition, consideration should be given to reviewing progress every few years with lead risk reduction strategies. This could include the collection of Member countries' environmental and blood lead monitoring data, as well as of new information on their regulations, criteria, standards or national policies regarding exposure to lead.

EXPOSE DE SYNTHESE

Le présent document sur la réduction des risques liés au plomb a pour principal objectif de :

- résumer les informations relatives aux rejets de plomb dans l'environnement, à l'exposition qui s'ensuit pour la santé humaine et pour la salubrité de l'environnement, ainsi qu'à la façon dont les pays Membres de l'OCDE et les pays jouissant du statut d'observateur auprès de l'Organisation perçoivent les risques associés à l'exposition au plomb ;

- de décrire les dispositions que ces pays et les industries concernées ont prises ou envisagent de prendre afin de réduire les risques associés à l'exposition au plomb ; et

- d'identifier les avantages, en termes de protection de la santé humaine et de l'environnement, susceptibles de découler de ces mesures, pour autant que l'on dispose d'informations les concernant.

Ce document s'inspire d'informations fournies de 1990 à 1992 et doit être considéré comme un "instantané" des réflexions les plus récentes et des activités de cette période. Il peut aider à évaluer l'efficacité des stratégies nationales de réduction des risques liés au plomb en identifiant les tendances communes lors de l'établissement de critères, de normes ou de politiques nationales. Il indique également les domaines dans lesquels des actions internationales concertées se justifieraient et seraient possibles.

Les activités visant à réduire les risques associés au plomb devraient normalement continuer d'alimenter des flux d'informations et de technologies entre pays Membres, et encourager l'acquisition et l'échange de connaissances relatives à la nature et à l'efficacité de mesures prises pour faire face aux risques inacceptables que pose l'exposition au plomb.

Résumé des différents chapitres

1. Production, utilisation et élimination

Le plomb est un élément présent à l'état naturel dans la croûte terrestre. Son extraction remonterait jusqu'à 5 000 ans avant Jésus Christ. Facile à façonner et hautement apprécié pour sa malléabilité et sa ductilité, le plomb était utilisé autrefois pour fabriquer des vernis de poterie, des objets d'art, des pièces de monnaie et des canalisations d'eau.

Aujourd'hui, plus de 50 pays produisent du plomb à partir de minerais et de concentrés et/ou par recyclage. En 1990, la production mondiale de plomb métal a atteint 5 659 millions de tonnes d'une valeur dépassant 4,6 milliards de dollars des Etats Unis, dont un peu plus de la moitié provenait de matériaux recyclés. Cette année là, les pays de l'OCDE ont réalisé 50 pour cent de la production mondiale de minerais et de concentrés contenant du plomb et environ 64 pour cent de la production mondiale du plomb métal.

Le plomb primaire obtenu par extraction est souvent un sous-produit ou un coproduit de l'exploitation d'autres minerais comme ceux de zinc, d'argent, de cuivre et de cadmium. En 1989, 155 mines réparties dans 35 pays ont produit 2,21 millions de tonnes de plomb sous forme de concentrés, s'accompagnant d'une coproduction (de cuivre, de zinc et d'argent, par exemple), d'une valeur dépassant les 9 milliards de dollars des Etats Unis.

En outre, le plomb figure parmi les métaux non ferreux les plus recyclés au monde. La production secondaire (à partir de matériaux recyclés) augmente régulièrement. Elle a dépassé la production primaire pour la première fois en 1989. Cette progression illustre les conditions économiques favorables associées au recyclage du plomb, et aussi le fait que le plomb recyclé conserve ses propriétés physiques et chimiques. Comme ce métal est utilisé dans le monde entier, le plomb de rebut est devenu une ressource facilement renouvelable à laquelle ont accès les pays dépourvus de mines de plomb.

Depuis 1970, la demande mondiale de plomb, dont les propriétés chimiques, électriques et physiques sont uniques, a augmenté de 25 pour cent pour atteindre un niveau record de 5 627 millions de tonnes en 1990. Les pays de l'OCDE ont représenté 65 pour cent de la demande mondiale en 1990 alors que la part des pays d'Europe centrale et orientale était de 21 pour cent. L'Asie est maintenant la troisième grande région consommatrice de plomb, représentant 9 pour cent de la demande mondiale, et ses besoins sont ceux qui augmentent le plus vite.

La demande en plomb des pays de l'OCDE ont augmenté de 10 pour cent entre 1970 et 1990. C'est le secteur des piles et batteries qui a enregistré la plus forte croissance. Ce secteur représentait 63 pour cent de la demande en 1990. Pendant la même période, les inquiétudes, tant pour la santé que pour l'environnement, ont été largement responsables du recul de l'utilisation du plomb dans l'essence, les boites de conserve soudées, les soudures et tuyauteries des réseaux d'eau potable, et dans les pigments utilisés dans les peintures à usage domestique. Le déclin de la plupart d'autres usages, comme le gainage de câbles, correspond à une évolution de la technologie et des besoins suivant les lois du marché pour des produits plus légers, plus efficaces, et d'un prix plus compétitif.

On est en train de mettre au point de nouvelles applications pour le plomb et ses composés dans la micro-électronique, les supraconducteurs, l'asphalte, les matériaux para-sismiques, la protection contre le radon et pour le stockage permanent, ou avec possibilité de reprise, des déchets nucléaires, pour n'en citer que quelques-unes. L'industrie a admis que l'adoption de nouveaux produits devait s'accompagner d'analyses de risques, et qu'il était nécessaire, le cas échéant, de prévoir des modalités de recyclage et de réutilisation.

Les prix du plomb s'établissent au jour le jour sur la base des mécanismes du marché international, puisque ce métal fait l'objet d'échanges dans le monde entier. Au niveau des régions, l'Europe et le Japon sont celles qui importent le plus de concentrés de plomb et l'Europe est celle qui importe les plus grandes quantités de lingots de plomb et de plomb raffiné. L'Australie, le Canada et le Pérou sont les principaux fournisseurs, aussi bien de concentrés de plomb que de plomb métal. Le Mexique reste un exportateur important de plomb raffiné.

Le plomb peut être libéré naturellement dans l'environnement (du fait, par exemple d'érosion, de la croûte terrestre, du volcanisme) ou il peut provenir de sources liées à l'activité humaine comme l'industrie, la production d'énergie (combustion de charbon et de pétrole), et de l'utilisation et de l'élimination de produits de consommation. Les déchets industriels (émissions,

effluents et déchets solides) font souvent l'objet de réglementations dans les pays de l'OCDE. Les déchets des produits de consommation contenant du plomb peuvent être réglementés, selon leur classification en termes de danger et/ou leur destination (c'est-à-dire recyclage, élimination finale, commerce international).

Les matériaux contenant du plomb qui peuvent être recyclés vont des déchets des industries et de la consommation aux résidus d'actions curatives ou antipollution. Les déchets de produits de consommation représentent plus de 80 pour cent des déchets destinés au recyclage, parmi lesquels les piles peuvent représenter jusqu'à 90 pour cent pour une année donnée.

Dans de nombreux pays, les taux de recyclage des piles sont élevés, dépassant parfois 90 pour cent. Quoiqu'il en soit, il est apparu que le maillon le plus faible dans la chaîne du recyclage demeure d'ordinaire le consommateur qui conserve ou qui jette une pile usée plutôt que de la retourner pour qu'elle soit recyclée. Dans un certain nombre de pays, les pouvoirs publics et l'industrie s'efforcent ensemble d'intensifier le recyclage en mettent l'accent sur le cycle de vie des piles et batteries et en encourageant les consommateurs à rendre celles qui sont usagées.

Lorsque les déchets industriels solides et les déchets de produits de consommation contenant du plomb ne sont pas recyclés ou réutilisés, ils sont généralement envoyés dans des décharges pour être éliminés ou bien ils sont incinérés. La composition et le volume des déchets destinés à l'élimination finale, ainsi que les méthodes utilisées, varient suivant les pays et les régions en fonction de facteurs tels que les modes d'utilisation finale, les taux de recyclage et la densité de population.

D'après les estimations, dans certains pays, ce sont les piles et les produits de consommation électroniques qui représentent l'essentiel du plomb présent dans les déchets ménagers solides. Dans d'autres pays, c'est le plomb des soudures des boites de conserve qui a été reconnu comme étant la principale source de plomb dans les déchets ménagers. On a remarqué que le volume de plomb diminue dans les résidus urbains de certains pays. Des études ont, en outre, montré que les problèmes d'hygiène sont minimes lorsque les décharges sont correctement gérées et que le ruissellement et la lixiviation y sont surveillés, et qu'il est possible de maîtriser les émissions de plomb à partir des incinérateurs, grâce à une technologie adéquate dont l'efficacité peut atteindre ou dépasser 99 pour cent. Si l'on peut pratiquement supprimer la dispersion dans l'atmosphère du plomb provenant de l'incinération, celui qui est piégé par les dispositifs de lutte contre les émissions ou qui reste dans les cendres doit être correctement éliminé, d'ordinaire en décharge.

2. Le devenir du plomb dans l'environnement : transport et localisation

Les activités humaines extraient le plomb de la croûte terrestre où il est relativement immobile et le transfèrent dans les divers compartiments de l'environnement. Les possibilités d'exposition de l'homme et des écosystèmes s'en trouvent considérablement accrues. L'industrialisation a largement accéléré le transport du plomb aux voies d'exposition de l'être humain et de l'environnement. Hommes et écosystèmes peuvent être substantiellement exposés au plomb dans tous les compartiments de l'environnement.

D'après les estimations, la quantité de plomb émise chaque année dans l'atmosphère du fait d'activités humaines a diminué de 30 pour cent par rapport aux 332 350 tonnes évaluées en 1983. On peut estimer que les sources des émissions de plomb dans l'atmosphère se répartissent

entre deux grandes catégories : sources mobiles (véhicules automobiles consommant des carburants contenant du plomb) et sources fixes (raffinage, fabrication et incinération). Les émissions atmosphériques des fonderies, des installations de traitement et des incinérateurs de déchets solides sont, soit des rejets de sources ponctuelles à partir des cheminées, soit des rejets fugaces associés au stockage, au traitement ou à la manutention des matériaux. Des concentrations de plomb allant de 0,5 µg/m^3 jusqu'à 10 µg/m^3 ont été enregistrées dans l'atmosphère urbaine de certains pays de l'OCDE au coeur des zones urbaines à forte circulation. Toutefois, les limitations des niveaux de plomb dans l'essence décidées dans de nombreux pays se sont traduites par une diminution sensible des quantités émises dans l'atmosphère par les véhicules à moteur. Les concentrations atmosphériques au voisinage des sources ponctuelles sont encore souvent élevées.

Le plomb s'accumule dans les sols et dans les sédiments. On estime que la totalité de la charge de plomb dans les sols du fait des diverses activités humaines dans le monde entier a baissé par rapport aux quantités évaluées en 1983 -- 479 000 à 1 113 000 tonnes par an -- à la suite de la diminution des émissions de plomb dans l'atmosphère. Les dépôts de plomb d'origine atmosphérique constituent une source majeure de contamination des sols et des sédiments. La concentration du plomb dans les sols proches des routes à grande circulation dépend de la densité de la circulation, des conditions météorologiques locales, de la végétation et de la topographie. Les concentrations de plomb décroissent au fur et à mesure que l'on s'éloigne de la route et que l'on s'enfonce dans le sol. Les concentrations de plomb associées à des sources fixes dépendent de la cadence des émissions à partir de la source, de la dispersion et du taux de retombée. En général, la concentration de plomb dans le sol diminue de façon exponentielle sous le vent d'une source ponctuelle.

Les peintures à usage domestique contenant du plomb peuvent contribuer substantiellement aux concentrations en plomb des poussières ménagères ou du sol près des habitations. Les plombs utilisés pour le tir et pour la pêche apportent de grandes quantités de plomb dans les sols et dans les sédiments. Le plomb a tendance à être immobilisé par la fraction organique du sol et y reste fixé. Il a été avancé que le plomb ainsi immobilisé pouvait être libéré par des baisses de pH des précipitations. Toutefois, on ne dispose pas encore de preuves confirmant que les pluies acides influencent la chimie et le transport du plomb dans les sols.

Le plomb est un constituant naturel, en quantité négligeable d'ordinaire, des eaux de surface et des eaux souterraines. On estime, comme pour le plomb dans les sols, que l'apport total de plomb aux écosystèmes aquatiques dans le monde entier a diminué par rapport aux valeurs évaluées en 1983 qui se situaient entre 97 000 et 180 000 tonnes par an, en raison de la diminution des émissions atmosphériques de plomb. Le plomb apporté aux écosystèmes aquatiques peut provenir de sources telles que déchets industriels, effluents issus des procédés d'extraction minière, de fusion, de raffinage et de transformation, épandage de boues d'épuration et retombées atmosphériques. La plupart du plomb atteignant les eaux de surface est facilement absorbé dans les sédiments où il forme des complexes avec les matières organiques. Comme il est relativement peu mobile dans l'eau, le plomb a tendance à s'accumuler là où il est rejeté (par exemple, près des sources ponctuelles).

3. Relations avec l'exposition

Inhalation et ingestion (d'eaux, d'aliments, de peinture, de terre et/ou de poussières) sont les principales voies de l'exposition humaine au plomb. Il est difficile d'évaluer l'importance relative

de chaque source. Cette importance variera suivant la situation géographique, le climat et les phénomènes géochimiques locaux. De façon similaire, l'intensité de l'exposition subie par un individu peut varier en fonction de l'âge, du sexe, du métier, du statut socio-économique, du régime alimentaire, et des pratiques culturelles. On estime, de plus, que la quantité de plomb absorbée dans l'organisme varie en fonction de la concentration et de la composition (par exemple, taille des particules, forme chimique) du plomb inhalé ou ingéré.

Quelques pays surveillent les concentrations du plomb dans les divers compartiments de l'environnement, ainsi que dans le sang, de façon à évaluer les risques associés à l'exposition et l'efficacité des mesures prises pour réduire ces risques. Dans les pays où l'on surveille l'évolution des concentrations de plomb, les données montrent que si la demande de produits contenant du plomb (et éventuellement la quantité de plomb destinée à l'élimination finale) a augmenté, les concentrations moyennes de plomb dans l'air, l'alimentation et le sang ont diminué en deçà des seuils considérés dangereux au niveau national. Cependant, on a trouvé dans quelques pays des groupes de population où les concentrations continuent de dépasser ces seuils. Ces expositions élevées au plomb sont souvent liées à des rejets de source ponctuelle, à l'utilisation antérieure de peintures contenant du plomb, ou à des canalisations et des soudures en plomb dans les réseaux d'eau potable.

Les raisons de la diminution des concentrations de plomb varient suivant les pays ou les régions et sont partiellement influencées par des facteurs locaux (par exemple, climat, conditions socio-économiques). La diminution des concentrations de plomb dans les divers milieux de l'environnement et dans le sang est ordinairement attribuée aux facteurs suivants :

- limitations et réduction des utilisations susceptibles de disperser le plomb ou de le rendre facilement biodisponible, telles que :

  - plomb dans l'essence
  - plomb dans les boites de conserve soudées
  - soudures et canalisations de plomb dans les réseaux d'eau potable,
  - plomb dans certaines peintures, et
  - pesticides au plomb ;

- mise en place de mesures de nature réglementaire et non réglementaire pour la gestion des émissions et des rejets industriels (à partir des fonderies, par exemple);

- surveillance des réseaux de distribution d'eau et contrôle du pH afin de réduire la solubilité du plomb à partir de canalisations contenant du plomb ;

- mise au point et application de règlements et de techniques pour une gestion sûre des déchets contenant du plomb destinés à être éliminés définitivement dans des décharges ou des incinérateurs.

4. Exposés des positions nationales sur les risques actuels imputables au plomb

Les déclarations des pays Membres, qui figurent dans le présent document, fournissent l'analyse raisonnée de toutes les dispositions qui ont été prises pour faire face aux conséquences de l'exposition au plomb pour la santé de l'homme et de l'environnement. Les évaluations et caractérisations des risques qui ont amené des pays à prendre des mesures ont un caractère

national. Ces pays ne prennent position sur les mesures nécessaires pour réduire les risques qu'après avoir analysé le danger et la gravité de certaines expositions et pris en compte divers facteurs locaux d'ordre social, économique et politique. Ces positions sont adoptées d'ordinaire après examen approfondi des nombreux facteurs en cause et diffèrent d'un pays Membre de l'OCDE à l'autre.

Ce chapitre contient également l'évaluation des risques liés au plomb qui a été établie sur une base internationale par le Programme international sur la sécurité des substances chimiques (PISSC). L'évaluation qui est reproduite provient des Chapitres 1 et 9 du projet de texte du document sur le plomb de la série "Critères de l'hygiène de l'environnement" qui a été récemment mis à jour et dont la publication est prévue pour 1993 ou 1994.

5. Dispositifs pour la réduction des risques

Au cours de ces dernières décennies, la plupart des pays Membres ont pris des dispositions pour réduire les risques inacceptables que l'exposition au plomb fait courir à l'homme et aux écosystèmes. Les limitations imposées à l'utilisation du plomb dans certains produits susceptibles d'entraîner une exposition importante (par exemple, peintures d'intérieur, essence) figurent parmi les plus efficaces de ces mesures. En accompagnement de celles-ci, des dispositions ont été prises pour mettre au point des critères fixant les concentrations de plomb acceptables dans les divers milieux de l'environnement, pour limiter les émissions industrielles de plomb dans l'environnement, pour réduire les expositions professionnelles et pour définir des indicateurs biologiques permettant d'identifier les populations à risque. Bien que bon nombre de ces mesures aient réussi à réduire l'exposition au plomb, quelques pays Membres continuent d'envisager des initiatives susceptibles d'abaisser encore l'exposition au plomb, à la lumière, notamment, de nouveaux éléments donnant à penser que des concentrations considérées auparavant comme innoffensives pouvaient avoir des effets sur la santé.

Ce chapitre passe en revue les activités que les pays Membres ont consacrées à la gestion des risques. Il contient aussi l'examen de dispositions déjà prises pour réduire l'exposition au plomb, ainsi que d'activités en cours et de mesures éventuelles que certains pays envisagent de prendre à l'avenir. *Les activités de gestion de risque spécifiquement nationales sont résumées dans le tableau 5.1.* Comme le montre ce tableau, l'ampleur de ces activités varie considérablement d'un pays à l'autre.

Ce chapitre décrit les activités menées pour réduire les risques liés au plomb dans treize pays (Allemagne, Australie, Canada, Danemark, Etats-Unis, Finlande, France, Japon, Mexique, Nouvelle-Zélande, Royaume-Uni, Suède, Suisse), les pays nordiques et la Communauté européenne, et propose ensuite un résumé des dispositions prises en la matière par l'industrie. On trouvera à la fin de ce chapitre, une série de tableaux qui récapitulent les données disponibles sur les dispositions prises dans tous les pays Membres et au Mexique pour réduire les risques. Tous les pays Membres ont été invités à plusieurs reprises en 1991 et en 1992 à fournir des informations sur les activités visant à réduire les risques associés au plomb. Dans le présent rapport, l'absence d'informations pour un pays donné signifie, soit que ce pays ne consacre pas d'activités à la réduction des risques, soit qu'il n'a pas répondu aux demandes d'informations.

Les paragraphes suivants résument succinctement les informations figurant dans ce chapitre, en dehors de celles données dans les tableaux :

Allemagne : S'agissant de peintures, les composés à la céruse sont interdits à la vente et celle de peintures anticorrosives contenant du plomb est en train d'être abandonnée. Les récipients de peintures dont la concentration en plomb dépasse 0.15 pour cent doivent être étiquetés en conséquence. La teneur maximum de l'essence au plomb est limitée depuis 1976 à 0.15 g/l et l'essence sans plomb (teneur inférieure à 0.013 g/l) est commercialisée depuis 1982. En 1992, la part du marché de l'essence sans plomb a dépassé les 80 pour cent.

Les autorités municipales responsables des systèmes de distribution d'eau de boisson doivent maintenir aux principaux branchements du réseau une concentration de plomb inférieure à 40 µg/l. Les canalisations de plomb ne sont plus utilisées et les vieux réseaux en plomb sont progressivement remplacés. Les tuyaux de cuivre doivent être soudés avec des alliages sans plomb. Beaucoup de Länder allemands ont limité la concentration de plomb dans le sol. Par exemple, le Land de Rhénanie du Nord-Westphalie limite à 20 mg/kg la concentration de plomb dans les bacs à sable des enfants. La concentration maximum de plomb acceptable dans l'air est limitée à 2.0 µg/m^3 (moyenne annuelle) ; le maximum des dépôts sur le sol est fixé à 0.25 mg/m^2 et par jour. La totalité des émissions métalliques (plomb compris) à partir des fonderies de plomb est limitée à 5 mg/m^3. Pour les rejets directs dans l'eau, les limites varient entre 0.3 et 2.0 mg/l, selon la catégorie de l'installation. L'utilisation de boues d'épuration à des fins agricoles est interdite par la loi si la teneur en plomb de ces boues dépasse 900 mg/kg.

En Allemagne, des valeurs limites (Richtwerte für Schadstoffe in Lebensmitteln, ZEBS) ont été fixées pour la plupart des denrées alimentaires et vont de 0.03 à 2.0 mg/kg. En outre, le "règlement sur le vin" a instauré un plafond pour le vin. Des lignes directrices relatives au plomb ont été établies pour d'autres denrées alimentaires. On n'utilise plus de boîtes de conserve soudées pour le conditionnement des denrées alimentaires. Les capsules de plomb pour le surbouchage des bouteilles de vin sont interdites à partir de 1993, conformément à un règlement de la Communauté européenne. Le taux de recyclage des piles et batteries plomb-acide serait supérieur à 95 pour cent. Sur le lieu de travail, la concentration maximale de plomb acceptable dans l'air est de 0.10 mg/m^3 (moyenne pondérée sur une période de 8 heures). La concentration maximale admissible de plomb dans le sang des travailleurs est de 70 µg/dl pour les hommes et pour les femmes au-dessus de 45 ans, et de 30 µg/dl pour les femmes de moins de 45 ans. D'après les recommandations de certains physiologistes et toxicologues, les concentrations de plomb dans le sang des adultes ne devraient pas dépasser 15 µg/dl, et 10 µg/dl chez les enfants et les femmes en âge de procréer.

Australie : le Gouvernement australien encourage les modes de production et d'utilisation du plomb qui sont conformes aux principes de développement durable sur le plan écologique. Ce pays limite la fabrication et l'utilisation des peintures d'intérieur au plomb ayant une teneur de 0.25 pour cent de produit non volatil, et impose une concentration de plomb dans l'essence qui doit se situer, suivant les régions, entre 0,3 et 0,84 gramme par litre. Depuis le 1er janvier 1986, toutes les voitures neuves importées ou fabriquées sur place sont tenues de fonctionner à l'essence sans plomb (c'est-à-dire contenant moins de 0,013 gramme de plomb par litre). Le résultat de cette politique est qu'à l'heure actuelle les ventes d'essence sans plomb approchent les 50 pour cent des ventes totales. Vers la fin de la présente décennie, ce chiffre devrait avoisiner les 80 pour cent. En outre, dans ce pays, la concentration de plomb dans les émissions à partir de sources ponctuelles fixes ne doit pas dépasser 1,5 µg/m^3 en moyenne sur trois mois. Dans l'eau de boisson,

cette concentration ne doit pas dépasser 0,05 mg/l et les concentrations de plomb acceptables dans des aliments donnés se situent entre 0,2 et 2,5 mg/kg, selon la denrée considérée. La concentration du plomb dans les vernis pour céramiques est limitée de même que dans les crayons à papier, les jouets, les crayons de couleur et les couleurs pour la peinture artistique (jusqu'à 0,01 pour cent). Bien qu'il n'existe pas de règlement régissant le recyclage des piles et batteries au plomb, l'industrie signale que plus de 90 pour cent du plomb utilisé dans les piles et batteries est recyclé.

Canada : La publicité concernant des peintures contenant du plomb, ainsi que leur importation et leur vente, sont limitées. Le plomb est toléré dans les produits (peintures), uniquement destinés à l'utilisation extérieure, qui doivent être étiquetés dans ce sens. L'industrie canadienne de la peinture a volontairement cessé en 1991 d'utiliser du plomb dans les peintures destinées aux habitations (intérieur et extérieur). Ce pays a interdit en 1990 d'utiliser de l'essence au plomb (dont la teneur ne doit pas dépasser 5 mg/l), sauf dans le cas d'utilisation dans des équipements essentiels (où la teneur ne doit pas dépasser 26 mg/l). Actuellement, il limite la concentration de plomb dans l'eau de boisson à 10 µg par litre et, en matière de plomberie, à 0,2 pour cent pour les soudures et les fondants en contact avec l'eau de boisson.

Dans l'alimentation, les concentrations de plomb autorisées varient entre 0,08 mg/kg dans les aliments pour nourrissons et 1,5 mg/kg pour les produits à base de tomate. Il existe des normes nationales applicables à la qualité des eaux ambiantes (0,001 à 0,007 mg de plomb par litre pour les eaux douces à faune ou à flore aquatiques), aux sols et à l'atmosphère (0,023 à 0,046 g/m^3 pour les particules émises à partir de fonderies de plomb de deuxième coulée). La teneur en plomb est limitée à 0,5 pour cent dans les matières de revêtement d'objets destinés aux enfants. Le Canada recycle, selon les estimations, 93 pour cent des piles et batteries plomb-acide. Les piles et batteries au plomb remplies d'acide sont classées comme dangereuses et, de ce fait, leur transport et leur stockage sont réglementés par des dispositions fédérales et provinciales. Les compétences en matière de réglementation visant la manutention de déchets contenant du plomb sont réparties entre autorités fédérales et provinciales. Le Canada a lancé des programmes approfondis d'enseignement et d'étiquetage visant à sensibiliser la collectivité aux dangers associés à l'exposition au plomb.

Danemark : Les activités sur la réduction des risques liés au plomb visent une élimination totale de l'utilisation du plomb grace à une réglementation ainsi que des accords librement consentis. Les moyens à mettre en oeuvre seraient la substitution et à défaut l'amélioration du recyclage. En outre une action internationale parait nécessaire afin d'arriver à l'élimination de l'utilisation du plomb.

Etats-Unis : Les Etats-Unis limitent ou interdisent l'utilisation de produits contenant du plomb lorsque les risques associés à ces produits sont élevés et qu'il existe des produits de remplacement pour le plomb ou les produits à base de plomb. En 1991, les centres chargés du contrôle des maladies (Centers for Disease Control) ont abaissé le seuil de concentration de plomb admissible dans le sang des enfants à 10 µg/dl. Avant cela, en 1986, EPA avait situé la concentration préoccupante à 10-15 µg/dl et possiblement plus bas. Dans un rapport au Congrès de 1988, ATSDR (Agency for Toxic Substance Disease Registry) donnait le même niveau préoccupant.

L'une des sources de plomb présentant le risque d'empoisonnement le plus élevé chez

l'enfant aux Etats-Unis est constituée par les peintures contenant du plomb. Le Gouvernement fédéral a établi pour les peintures d'intérieur une norme de 0.06 pour cent pour le plomb, ce qui, en fait, interdit l'utilisation du plomb dans ces peintures. Une loi (Residential-based Paint Hazard Reduction Act) adoptée en 1992 a fourni le cadre pour une action au niveau fédéral visant à réduire les dangers liés à l'exposition à des peintures à base de plomb utilisées dans les maisons. Dans l'essence au plomb, la quantité de plomb autorisée par litre aux Etats-Unis est de 0.026 g. Tous les nouveaux véhicules utilitaires légers, camions, motocycles et poids-lourds à essence doivent fonctionner à l'essence sans plomb (0.01 g/l). A partir de 1995, l'essence au plomb et les additifs au plomb dans l'essence seront totalement interdits pour la circulation routière. Un règlement récent adopté en 1991 précise les conditions requises pour le traitement de l'eau de boisson en fixant le "seuil d'intervention" à 15 µg/l mesuré au robinet. Une série de mesures d'amélioration est prescrite pour les ménages où cette concentration est dépassée. Il existe des directives transitoires pour lutter contre l'utilisation de peintures à base de plomb dans les logements. Ces directives recommandent un abaissement à 1 $\mu g/cm^2$ de la peinture à 0,5 de plomb et de ne pas dépasser des concentrations en plomb dans la poussière de 200 $\mu g/pied^2$ (environ 100 cm^2) au sol, 500 $\mu g/pied^2$ aux appuis de fenêtre et 800 $\mu g/pied^2$ aux soupiraux. La directive transitoire pour les sols des habitations recommande que le nettoyage ramène les concentrations au sol entre 500 et 1000 mg/kg.

A l'heure actuelle, la norme de qualité d'air ambiant pour le plomb est de 1.5 $\mu g/m^3$ (moyenne trimestrielle) aux Etats-Unis. La norme la plus stricte pour la qualité des eaux de surface fixe à 1.3 µg/l au maximum la moyenne sur quatre jours avec une moyenne maximale de 34 µg/l sur une heure. Les Etats-Unis ont proposé, pour l'utilisation et l'élimination de boues d'épuration contenant du plomb, des règlements qui fixent la concentration maximale de plomb dans les boues à 300 mg/kg et limitent la charge polluante cumulée dans le sol à 300 kg de plomb à l'hectare. Aux Etats-Unis, certains déchets contenant du plomb sont spécifiquement répertoriés comme dangereux et doivent être pris en charge par une installation autorisée de traitement, d'élimination ou de stockage.

En outre, les autorités fédérales et celles des Etats soumettent à réglementation l'utilisation de peintures et de revêtements de surface contenant du plomb dans les jouets, dans les produits destinés aux enfants et dans l'ameublement à usage domestique. L'industrie de la conservation a entrepris volontairement de supprimer progressivement l'utilisation du plomb dans les boîtes de conserve. De plus, les autorités des Etats-Unis limitent la teneur en plomb dans les vernis pour la céramique, les produits alimentaires, les vins et les pesticides. Un certain nombre d'Etats ont adopté une législation limitant les concentrations de plomb présentes dans le matériel d'emballage. Un effort de recyclage considérable porte, aux Etats-Unis, sur la plupart des piles et batteries plomb-acide de toutes catégories. Des études récentes montrent que plus de 95 pour cent de ces batteries sont recyclées.

Dans le cas des concentrations de plomb dans l'air sur les lieux de travail, la limite admissible est actuellement fixée à 50 $\mu g/m^3$. Lorsque la concentration de plomb dans l'air est supérieure à 30 $\mu g/m^3$, un contrôle du taux de plomb dans le sang est exigé. En 1983, un congé de maladie a été instauré pour les travailleurs ayant eu trois prises de sang consécutives atteignant 50 µg/dl ou une prise de sang atteignant 60 µg/dl. Le travailleur peut retourner sur son lieu de travail lorsque les analyses auront révélé que le taux de plomb dans le sang est descendu en dessous du seuil de 40 µg/dl.

Finlande : L'utilisation de céruse et de sulfate de plomb est interdite dans les peintures d'intérieur depuis 1929. Les carbonates et sulfates de plomb ne seront plus autorisés dans les peintures à partir du 1er janvier 1993, sauf dans les peintures visant à la restauration et à l'entretien d'oeuvres d'art et de bâtiments historiques. Dans l'essence, la concentration de plomb est limitée à 0,013 g/l (essence sans plomb) et à 0,15 g/l (essence au plomb). Les valeurs plafond pour les émissions dans l'air et dans l'eau à partir d'installations sont fixées au cas par cas au cours des procédures d'autorisation du point de vue de l'environnement. La concentration maximum de plomb acceptable dans

l'air sur le lieu de travail est de 0,10 mg/m^3 (moyenne pondérée sur une durée de huit heures). La concentration maximum de plomb autorisée dans le sang des travailleurs exposés est de 50 µg/dl. Norme de sécurité alimentaire : la teneur maximum de plomb dans les fruits, légumes et boissons est de 0,3 mg/kg, et de 1,0 mg/kg dans les denrées en conserve. La lixiviation maximum de plomb à partir d'ustensibles en céramique destinés au contact alimentaire a été définie. L'eau de boisson ne doit pas contenir plus de 0,05 mg de plomb par litre.

France : La teneur en plomb de l'essence a été ramenée à 0,15 g/l en 1991 et l'essence sans plomb (moins de 0,013 g de plomb par litre) a bénéficié d'allègements fiscaux qui rendent son prix de détail inférieur à celui de l'essence au plomb. En France, les eaux de surface destinées à la production d'eau potable ne doivent pas dépasser une concentration maximum de plomb de 0,05 mg/l. La concentration de plomb dans l'air ambiant doit respecter la moyenne annuelle de 2 µg/m^3. Il existe des normes pour limiter les émissions de plomb à partir d'installations industrielles et autres. La concentration en plomb dans les boues d'épuration épandues sur les sols ne doit pas dépasser 800 ppm. La France limite les quantités de plomb qui peuvent migrer d'ustensiles de cuisine en céramique dans les aliments, n'autorise de soudure qu'à l'extérieur des boites de conserve, et se conforme à l'interdiction, imposée par la Communauté européenne à partir de janvier 1993, d'utiliser des capsules de plomb pour le surbouchage des bouteilles de vin. L'importation et la vente de peintures contenant des dérivés blancs du plomb sont interdites depuis le 1er février 1993. Le recyclage des piles et batteries s'effectue dans le cadre de dispositifs facultatifs conçus pour faciliter la récupération et le transport des piles et batteries usées.

Japon : Le Japon n'interdit pas l'utilisation de peintures au plomb mais limite, grâce à des accords volontaires, l'ampleur de l'utilisation de ces peintures (qui sont interdites pour les jouets et dans les habitations). Les peintures au plomb sont essentiellement utilisées dans la construction, les automobiles et les produits électroniques. L'essence au plomb n'est ni produite, ni importée, ni utilisée au Japon. La concentration maximale admissible de plomb dans l'eau de boisson est de 0.1 mg/l. Le Japon a défini pour les fonderies et les autres installations de traitement du plomb des normes d'émission comprises entre 10 et 30 mg/m^3 selon les installations. Dans les rejets d'eaux usées, la concentration en plomb doit être inférieure à 1 mg/l. La concentration autorisée sur les lieux de travail est fixée à 0.1 mg/m^3.

Mexique : Le Mexique poursuit un programme énergique en vue de réduire la concentration de tétraéthylplomb dans l'essence ordinaire. Ce pays a commencé à utiliser en 1990 de l'essence sans plomb (moins de 0.01 g/l). Il a diminué de 88 pour cent la teneur en plomb de l'essence entre 1988 et 1992. Pour l'eau de boisson, les autorités ont fixé pour le plomb un plafond de 0.05 mg/l. En outre, le Mexique a fixé des normes pour le plomb dans les denrées alimentaires, les produits pharmaceutiques et les produits cosmétiques. La concentration maximale admissible de plomb dans la sauce tomate est de 0.36 mg/kg et de 10 ppm dans les pigments organiques synthétiques ajoutés à la nourriture, les boissons, les produits pharmaceutiques et les produits cosmétiques. Le Mexique a supprimé l'utilisation de la soudure au plomb dans l'assemblage des boîtes en fer blanc et fixé la concentration maximale admissible de plomb dans les peintures de revêtement à 90 mg/kg. Les industries ont accepté de supprimer l'utilisation de minium et de carbonate au plomb dans les pigments, la laque, l'émail, la peinture et le vernis sur les jouets, les crayons, les articles scolaires, les encres d'imprimerie, les produits cosmétiques, les meubles et les peintures d'intérieur. Les produits contenant du plomb

doivent maintenant être étiquetés en conséquence. En outre, un groupement d'industriels et d'artisans est convenu avec les autorités responsables de taux maximaux de solubilité pour la poterie vernie cuite au four. Le Mexique a fixé à 150 µg/m^3 la concentration maximale admissible de plomb sur les lieux de travail et envisage de l'abaisser encore jusqu'à 50 µg/m^3.

Nouvelle-Zélande : Les composés à la céruse ne peuvent pas être fabriqués, importés ou utilisés dans les peintures, les détrempes, les revêtements pulvérulents, les pigments ou dans les produits anti-salissure. La quantité maximale admissible de plomb dans la peinture est de 5 000 mg/kg, cependant, cette concentration devrait être ramenée à 2 500 mg/kg courant 1993. La concentration maximale admissible de plomb dans l'essence est de 0.013 g/l (essence sans plomb) et de 0.46 g/l (essence au plomb). La date limite pour la suppression totale du plomb dans l'essence a été fixée au mois de janvier 1996. Les fournitures utilisées pour écrire, dessiner, marquer ou peindre, contenant plus de 100 mg/kg de plomb, sont interdites. La quantité maximale admissible de plomb dans les produits de revêtement pour les jouets est de 5 000 mg/kg. Cette concentration sera ramenée à 2 500 mg/kg lorsque la réglementation sur les substances toxiques, datant de 1983, sera modifiée pour la quatrième fois. Dans les matières plastiques facilement accessibles sur les jouets, la quantité maximale acceptable de plomb est limitée à 250 mg/kg.

La directive de la Nouvelle-Zélande sur l'eau de boisson fixant la concentration de plomb à 0.05 mg/l s'appuie sur les directives de l'OMS relatives à la qualité de l'eau de boisson, datant de 1984. Il a été proposé de ré-examiner cette norme en 1993 de façon à l'aligner sur les nouvelles directives de l'OMS. Les fractions maximales admissibles de plomb dans l'alimentation vont de 0.2 à 10 ppm, selon le produit alimentaire considéré. Les concentrations de plomb dans les boues d'épuration destinées à être épandues sur des terres arables ont été limitées en 1992. La concentration maximale acceptable de plomb dans les boues d'épuration sèches est de 600 mg/kg, la valeur maximale acceptable dans le sol est de 300 mg/kg, et la charge maximale cumulée étant de 125 kg/ha. La Nouvelle-Zélande a proposé une directive nationale sur la qualité de l'air ambiant de 1.0 µg de plomb par m^3 pour une durée moyenne de 3 mois, en moyenne glissante. Sur les lieux de travail, la norme d'exposition au plomb dans l'air est de 0.15 mg/m^3.

Royaume-Uni : S'agissant des peintures au plomb, le Royaume-Uni a adopté une législation qui interdit l'utilisation de carbonates et de sulfates de plomb dans les peintures. Conformément à ces dispositions, ces carbonates et sulfates ne peuvent être utilisés que dans des peintures destinées à certains bâtiments historiques et pour la protection d'oeuvres d'art. La concentration maximale admissible de plomb est de 0.15 g/l dans l'essence au plomb et de 0.013 g/l dans l'essence sans plomb.

La règlementation applicable à l'eau de boisson fixe la concentration maximale de plomb à 50 µg/l. Il a été récemment proposé une réglementation interdisant l'utilisation de certaines soudures au plomb dans les installations locales d'approvisionnement en eau à usage non industriel. La concentration maximale admissible de plomb dans le sol, après épandagee de boues d'épuration, a été fixée à 300 mg/kg de matière solide sèche.

La norme de qualité pour l'air ambiant est de 2.0 µg de plomb par m^3 (concentration annuelle moyenne). Le Royaume-Uni contrôle les sources ponctuelles d'émissions atmosphériques et autres installations émettant du plomb en recourant aux meilleures

méthodes applicables dans la pratique. Les sources industrielles doivent respecter une concentration admissible de plomb de 0.002 g/m^3 et celle de l'ensemble des particules émises ne doit pas dépasser 0.1 g/m^3. Les concentrations admissibles de plomb dans les eaux usées varient suivant les industries et l'emplacement des installations. D'ordinaire, les concentrations admissibles se situent entre 1.0 et 5.0 mg/l.

Le Royaume-Uni a établi des normes de qualité et d'étiquetage pour toute une gamme de produits de consommation de sorte que la concentration du plomb soit généralement limitée dans les denrées alimentaires à 1.0 mg/kg, avec des valeurs inférieures pour des catégories particulières d'aliments comme ceux qui sont destinés aux nourrissons (0.2 mg/kg). Depuis 1988, les ustensiles en céramique sont soumis à réglementation. L'industrie s'est vu accorder cinq ans pour respecter les concentrations maximales de plomb de 0.8 mg/dm^2 dans les ustensiles plats, 4.0 mg/l pour les petits récipients creux (moins de 3 litres) et 1.5 mg/l pour les récipients creux de contenance supérieure à 3 litres. En outre, le Royaume-Uni limite l'utilisation de peintures au plomb dans les produits de consommation. Bien qu'il n'existe pas de règlements régissant l'élimination des piles et batteries et batteries dans le pays, les taux de recyclage sont extrêmement élevés (plus de 90 pour cent) pour les batteries plomb-acide utilisées dans les bâtiments et dans les véhicules automobiles.

Sur les lieux de travail, la concentration maximale admissible de plomb est de 0.15 mg/m^3 (moyenne pondérée sur une période de 8 heures). La concentration admissible de plomb dans le sang est de 70 µg/dl pour les hommes et de 40 µg/dl pour les femmes. Pour la population en général, la recommandation des pouvoirs publics publié en 1982 préconisait de prendre des mesures afin de réduire l'exposition si la concentration de plomb dans le sang dépassait 25 µg/dl.

Suède : En 1991, le gouvernement a décidé que des measures soient prises afin d'éliminer progressivement l'utilisation du plomb grace à des accords volontaires et de parvenir à long terme à son élimination totale. Les composés à la céruse n'entrent pas dans la composition des peintures ; on utilise cependant de petites quantités de plomb dans les peintures en tant que pigments, siccatifs et agents antirouille. La Suède limite la teneur du plomb dans l'essence à 0.15 g/l pour l'essence au plomb et à 0.013 g/l pour l'essence sans plomb. Une proposition récente vise à l'interdiction de la fabrication et de l'importation d'essence contenant du plomb à partir du 1er juillet 1994. L'eau où les concentrations en plomb sont inférieures à 0.01 mg/l est estimée propre à l'utilisation comme eau de boisson. Les normes pour l'air et pour l'eau sont fixées au cas par cas, au cours du processus d'autorisation d'installations. Pour les denrées alimentaires, les seuils acceptables ont récemment été abaissés à 0.3 - 0.5 mg/kg pour la plupart des aliments en boîte de conserve, et se situent entre 0.02 et 0.05 mg/kg pour diverses denrées alimentaires (des concentrations plus élevées sont admises pour les épices et certains autres produits). Les ustensiles en céramique, destinés à contenir des aliments et des boissons, sont interdits à la vente si l'on observe une lixiviation du plomb dépassant 3 mg/l au cours d'un essai normalisé avec de l'acide acétique. La Suède a lancé un programme énergique de recyclage de batteries qui est financé en grande partie par les taxes sur les piles et batteries. Sur les lieux de travail, la concentration maximale admissible de plomb dans l'air est de 0.10 mg/m^3 (du volume total) et de 0.05 mg/m^3 (du volume respirable).

Suisse : L'utilisation des dérivés du plomb dans les peintures d'intérieur est interdite. La teneur en plomb est limitée à 0,15 g/l dans l'essence au plomb, à 0.013 g/l dans l'essence

sans plomb et à 0,56 dans le kérosène pour avions. La concentration autorisée dans l'eau potable est de 0,05 mg/l. La norme d'émission pour les appareils de combustion avec un débit de masse supérieur à 25 g/h est de 5 mg/m^3. La norme d'émission pour les incinérateurs municipaux est de 1 mg/m^3 pour le plomb et le zinx cumulés. Pour le plomb présent dans l'air sous forme de particules la concentration tolérée est de 1 µg/m^3. La déposition sur le sol ne doit pas dépasser 100 µg/m^2. Les rejets d'eaux usées ne doivent pas contenir plus de 0,5 mg/l. Pour les eaux de surface la norme est de 0.05 mg/l. Les boues d'épuration et les composts sont interdits pour l'épandage si les teneurs en plomb dépassent respectivement 500 et 120 mg/kg. La valeur limite de la concentration du plomb et de ses dérivés dans l'air sur le lieu du travaul (moyenne pondérée sur 8 heures) est de 0,1 mg Pb/m^3, à l'exception cependant des dérivés alkylés, pour lesquels elle est fixée à 0,075 mg Pb/m^3.

Pays nordiques : Les pays nordiques ont lancé ensemble un certain nombre d'initiatives pour la protection de l'environnement. Le Danemark, la Suède et la Norvège ont signé la déclaration ministérielle de la troisième Conférence internationale sur la protection de la Mer du Nord. Selon cette déclaration, les émissions de plomb (et d'autres micropolluants) devront avoir été réduites en 1995 de 70 pour cent par rapport au niveau de 1985. Le Danemark, la Finlande et la Suède se sont fixé comme objectif pour 1995, par l'intermédiaire de la Commission pour la protection de l'environnement marin de la Mer Baltique, d'avoir réduit de moitié leurs émissions de plomb, par rapport à l'année de référence, 1987.

Le Groupe de travail nordique a établi, pour le Groupe des produits chimiques du Conseil des Ministres des pays nordiques, un projet de rapport décrivant les expériences dans cette région sur les options technologiques permettant de réduire l'usage du plomb. L'objectif à long terme des pays nordiques est d'éliminer complètement l'utilisation délibérée du plomb dans les produits et de réduire au maximum les quantités de plomb libérées dans l'environnement. La stratégie adoptée pour remplir cet objectif comprend, par ordre de préférence : l'adoption de technologies moins polluantes (produits de remplacement et modifications des procédés) ; systèmes efficaces de ramassage et de récupération et traitement des déchets acceptable au plan de l'environnement.

Communauté européenne : La Communauté européenne a promulgué des directives fixant la teneur en plomb dans les produits et dans les divers milieux et sources de l'environnement. Il est important de noter qu'une directive constitue un acte législatif en direction des pays Membres et peut, soit contenir des informations très spécifiques, soit revêtir un caractère descriptif. Souvent, une directive fixe aux pays Membres une date limite pour intégrer sa teneur dans leur propre législation ; d'ordinaire toutefois, une directive contiendra des informations précises et fixera un délai d'exécution de l'ordre de trois ans. Si un pays Membre n'incorpore pas la directive dans sa législation dans l'intervalle de temps spécifié, une action peut alors être introduite à son encontre devant les tribunaux européens.

Début 1989, la Communauté a interdit l'utilisation de carbonates et de sulfates de plomb dans les peintures destinées à toute fin autre que les travaux de conservation. En outre, elle a limité en 1987 les concentrations de plomb dans l'essence dans une directive qui fixe à 0.15 g/l la concentration maximale admissible de composés au plomb dans l'essence au plomb et défini comme essence sans plomb celle qui en contient moins de 0.013 g/l. En 1993, la Communauté a interdit l'utilisation de capsules de plomb pour le

surbouchage des bouteilles de vin.

Dans toutes les sources d'eau de boisson, la concentration maximale acceptable devrait être de 0.05 mg/l. En 1989, des normes ont été fixées pour les boues d'épuration utilisées en épandage agricole. La concentration limite de plomb dans les sols, dont le pH se situe entre 5 et 7, est de 50 à 300 mg/kg de matière sèche, tandis que la concentration limite dans les boues d'épuration est de 75 à 1 200 mg/kg et la quantité annuelle de boues d'épuration entrant dans les épandages agricoles est limitée à 15 kg/ha (sur une moyenne de 10 ans).

La Communauté européenne a établi des normes pour l'alimentation animale afin de limiter l'exposition du bétail au plomb. Depuis 1988, la commercialisation de produits cosmétiques contenant du plomb est interdite. Les matières colorantes ne peuvent pas contenir plus de 20 mg de plomb par kilo et les antioxydants et émulsifiants utilisés dans l'alimentation pas plus de 10 mg de plomb par kilo. Le taux maximal de lixiviation pour les récipients en céramique est de 4 mg/l et de 1.5 mg/l pour les ustensiles de cuisson.

Depuis 1988, les peintures, vernis, encres d'imprimerie et produits similaires dont un centième du poids est assimilable à des métaux lourds doivent être répertoriés, emballés, et étiquetés conformément aux normes de la Communauté. Celle-ci a fixé en 1986 les concentrations limites de plomb à 0.15 mg/m^3 dans l'air et à 70 µg/dl dans le sang et les seuils d'interventions à 40 µg/m^3 pour l'air et à 40 µg/dl pour le sang.

Industrie : L'industrie internationale des métaux non ferreux a pris toute une variété d'initiatives qui peuvent être considérées comme des mesures de réduction des risques associés au plomb. Ces activités sont résumées dans la section consacrée à l'industrie. Elles appartiennent généralement à l'une des différentes catégories suivantes : 1) modifications du procédé technique et/ou lutte contre les émissions ; 2) mise en place d'une surveillance médicale et de programmes d'hygiène professionnelle pour les travailleurs exposés ; 3) financement de recherches visant à vérifier l'efficacité des limites en vigueur pour l'exposition professionnelle et celle du public en général et à mettre au point de nouvelles méthodes de surveillance de façon à protéger la santé humaine et l'environnement ; et 4) application de programmes de bonne gestion des produits destinés à informer les utilisateurs ultérieurs des précautions qui doivent être prises pour protéger la santé des employés et des consommateurs.

Les normes professionnelles relatives à l'exposition au plomb sont différentes suivant les pays de l'OCDE. Ceux-ci ont, ainsi, fixé des limites maximales d'exposition professionnelle qui vont de 40 à 80 µg de plomb par décilitre de sang. Les normes d'exposition professionnelle au plomb en suspension dans l'air varient également entre les pays de l'OCDE, on rencontre des seuils de 50, 100 ou 150 µg/m^3 dans les différentes règlementations ou législations nationales. Les industries productrices et consommatrices de plomb recourent à des contrôles techniques complétés par des programmes d'hygiène personnelle et autres programmes de protection afin de réduire au maximum l'exposition des travailleurs auxquels ils imposent le port de respirateurs individuels, lorsque ces limites d'exposition ne peuvent pas être respectées autrement. Il existe généralement peu de corrélation entre le plomb dans l'air et le plomb dans le sang, une bonne hygiène personnelle étant généralement considérée comme le facteur le plus important pour limiter l'exposition. Ce facteur permet aussi de minimiser les quantités de particules de plomb ramenées au foyer. L'Association européenne de capsules de surbouchage

(EUCAPA) a décidé en juin 1990 d'arrêter la production de capsules contenant du plomb destinées au surbouchage des bouteilles de vin.

Les informations présentées dans ce tour d'horizon ont été en grande partie obtenues grâce à un questionnaire adressé début 1992 à l'industrie internationale par l'Organisation internationale de recherche pour le plomb et le zinc. Les réponses fournies au questionnaire provenaient notamment d'entreprises dont les capacités de production de plomb représentent une proportion considérable, aussi bien de la production annuelle mondiale que de celle des pays Membres de l'OCDE. Toutes les industries productrices de plomb n'ont pas répondu à ce questionnaire. Par conséquent, l'information présentée ici doit être considérée comme donnant un apperçu qualitatif qui risque d'être incomplet dans certains domaines. De façon similaire, les mesures prises par l'industrie pour réduire les risques révèlent des variations géographiques qui reflètent les différences régionales dans la façon dont est perçu le risque relatif lié à l'exposition au plomb. La nature et l'ampleur des activités consacrées par l'industrie à la réduction des risques sont donc variables suivant les pays.

6. Résumé et observations

Presque tous les pays de l'OCDE ont adopté des mesures, de nature réglementaire ou non, pour réduire les risques inacceptables que l'exposition au plomb fait courir à l'homme et aux écosystèmes. Les évaluations et les caractérisations du risque qui ont conduit les pays à réagir conservent un caractère national. Si quelques pays ont pris un nombre comparable de mesures, il n'y en a pas deux qui aient adopté le même ensemble de mesures pour la réduction des risques (c'est-à-dire des inititatives portant sur les milieux de l'environnement, les rejets industriels ou urbains, les produits, les expositions professionnelles, etc.).

L'étude par échantillonnage de la plombémie reste l'une des méthodes les plus utilisées pour évaluer les risques que l'exposition au plomb fait courir à la santé humaine. Environ 30 pour cent des pays de l'OCDE ont communiqué des données réunies sur la plombémie obtenues lors la surveillance de la population générale et/ou de fractions de cette population les plus exposées. Ces pays ont ramené la moyenne de la plombémie dans la population générale à moins de 10 µg/dl, soit en recourant à quelques mesures spécifiques, soit en lançant un nombre considérable d'initiatives.

Dans les pays qui surveillent la présence du plomb dans les divers compartiments de l'environnement, les données révèlent, en outre, que les concentrations moyennes de plomb ont diminué en deçà des seuils réglementaires nationaux. Certains pays ont cependant estimé que les émissions de plomb à partir de sources ponctuelles et/ou le transport de plomb en suspension dans l'air à grande distance étaient préoccupantes. D'autres ont indiqué que, si on avait récemment réussi à diminuer les concentrations de plomb dans l'air, de plus graves problèmes subsistaient au niveau domestique comme la présence de plomb dans les boites de conserves importées, dans l'eau de boisson (spécialement pour des groupes critiques comme les nourrissons au biberon) ou dans la poussière et les éclats provenant d'anciennes peintures d'intérieur détériorées.

L'idée serait que, lorsque les pays Membres réfléchissent aux stratégies permettant de réduire le risque lié au plomb, ils envisagent de procéder, s'ils ne font déjà, à des échantillonnages du plomb dans l'environnement et dans le sang de façon à déterminer les populations les plus

exposées et à évaluer l'ampleur de l'exposition pour leur population générale. Ils pourraient, en outre, chercher à s'inspirer d'expériences décrites dans le présent document lorsqu'ils mettront au point des mesures, de nature réglementaire ou non, afin de réduire les risques excessifs associés à l'exposition au plomb. De telles mesures pourraient comporter : des réglements et des normes (portant, par exemple, sur le plomb dans les emballages alimentaires, dans l'essence, dans les émissions des fonderies) en vue de réduire les rejets actuels de plomb dans l'air, dans l'eau, dans le sol, dans la poussière et sur le lieu de travail ; la mise en oeuvre de technologies moins polluantes (produits de remplacement, modifications des procédés, par exemple) ; des systèmes efficaces de ramassage et de récupération ou un traitement des déchets acceptable du point de vue de l'environnement ; des mesures de lutte visant à réduire les risques encourus du fait de l'exposition à des sources de rejet de plomb héritées du passé (peintures en cours de détérioration, canalisations des réseaux d'eau de boisson, par exemple) ; ainsi que des programmes industriels volontaires pour la gestion de certains produits, comme l'abandon progressif par les industries de quelques pays d'applications à haut risque (utilisation de plomb dans les boites de conserve soudées ou dans les peintures d'intérieur, par exemple).

Il faudra, en outre, envisager d'examiner à intervalles réguliers les résultats obtenus en quelques années à l'aide des stratégies visant à réduire les risques associés au plomb. On pourrait, entre autres, réunir les données fournies par divers pays Membres sur la surveillance des niveaux de plomb dans l'environnement et dans le sang, ainsi que des informations récentes sur leurs réglementations, critères, normes ou politiques nationales concernant l'exposition au plomb.

CHAPTER 1

LEAD PRODUCTION, USE AND DISPOSAL

1.1 Production

Lead is produced from the beneficiation of ores and concentrates and/or from recycled materials in over 50 countries. In 1990, world production of lead metal was 5.659 million tonnes, valued at over $4.6 billion with slightly over 50 per cent derived from recycled materials. In that year OECD countries accounted for 50 per cent of the world's production of lead in ores and concentrates and about 64 per cent of the world's metal production (**Figure 1**).

Primary lead metal production (from ores and concentrates) has remained relatively stable since 1970, although there has been an overall decline in output. Secondary production (from recycled materials) has risen steadily, and surpassed primary output for the first time in 1989 (**Figure 3**).

Periodic declines in production often reflect economic downturns, such as the oil crisis in 1975 or the recession of the early 1980s (**Figure 3**). During the 1982 recession, primary production was impacted to a lesser degree than secondary production, in part because primary lead is often produced as a by-product or co-product with other metals such as zinc, silver, copper and cadmium. In 1989, 155 mines in 35 countries produced 2.21 million tonnes of lead in concentrate, with co-product (copper, zinc, silver) output valued at over US$ 9 billion.

Lead is among the most recycled non-ferrous metals. As indicated in **Figures 2 and 3**, secondary production of lead has grown steadily in spite of declining lead prices. This growth can be attributed to the following factors which, when combined, reflect the favourable economic conditions associated with recycling lead:

- Lead retains its physical and chemical properties when recycled.

- The lead-acid battery is almost entirely recyclable. This includes the polypropylene case and the electrolyte, which can be safely neutralized or processed by modern technologies for use in the production of fertilizers or other saleable products.

- The battery's dominance is growing as the main end use for lead. In addition, the battery has a somewhat predictable life span and contains a high proportion of lead (estimated to average 50 per cent of the automobile battery's weight or about 8 kg of lead).

- Lead applications are used worldwide. Scrap lead is a readily accessible renewable resource which countries without lead mines can easily obtain. For example, EC countries produce very little lead in ores and concentrates, but virtually all of them have secondary lead metal processing facilities.

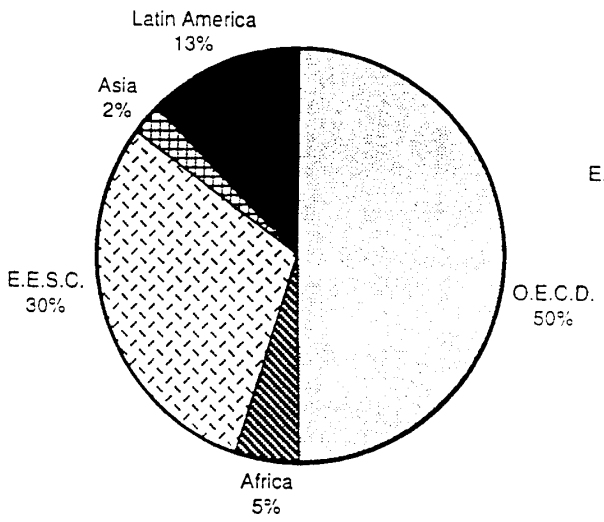
- The energy required for producing lead from recycled scrap is lower than that required for primary production. However, because of its co-product nature, primary lead is

already produced with a relatively low energy consumption in comparison with other metals.

Figure 1

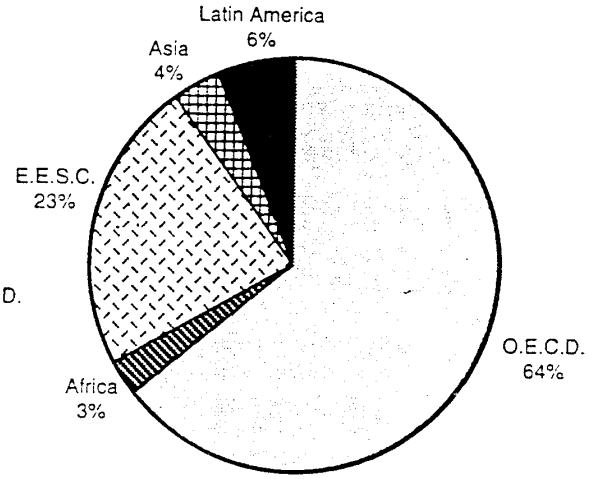
World Mine Production

(Lead in Ores and Concentrates)
1990
(3 344 000 tonnes)



World Lead Metal Production

(Primary and Secondary)
1990
(5 659 000 tones)

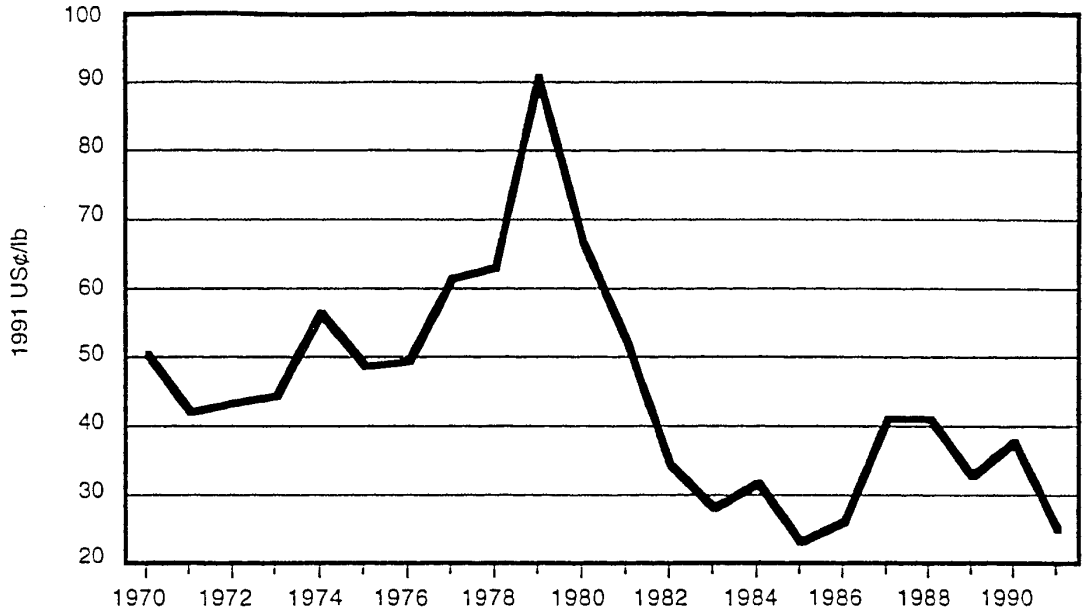


E.E.S.C. - Eastern European and Socialist Countries
Source: ILZSG 1990, 1992b.

Figure 2

London Metal Exchange

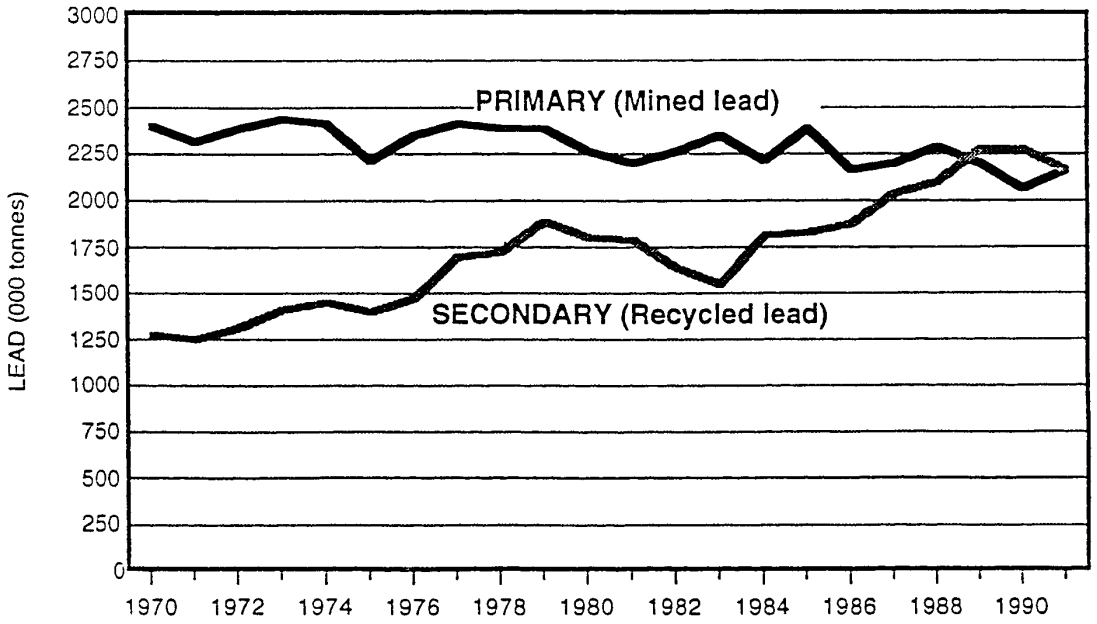
Lead Price (Real $ 1991)



Source: EMR (1970-1991) (based on US GNP inflator).

Figure 3

World Lead Metal Production*



* excludes - Eastern European and Socialist Countries

Source: ILZSG 1990, 1992b.

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- The recycling rate of lead-acid batteries has increased in most countries, reaching an estimated 98 per cent in the United States in 1990. The increase in the recycling rate is largely due to market factors, but also to joint action by industry and government in recent years to increase recycling (BCI, 1992).

1.2 Processing and technology

Lead metal is produced through a series of process stages. The number of stages required to produce metal is dependent on the type of feed material (i.e. mined ore or scrap material). Lead-bearing ores must first be mined and then concentrated before being smelted and refined into lead and lead alloys. Prior to smelting and refining of lead-bearing scrap (batteries), the battery cases must be broken and the acid, plastic/ebonite and lead components separated. The lead content of some scrap, such as lead sheet, pipe or boat keels, is high enough to allow it to be directly refined or remelted for reuse.

1.2.1 Mining and concentrating

The common minerals in lead ores are galena (PbS), cerussite ($PbCO_3$) and anglesite ($PbSO_4$). Galena is the most common mineral and is usually found with other sulphide ores -- most frequently those of zinc, copper and silver. Ore bodies near the surface are mined by open-pit methods, while those that occur at depth must be extracted. Ore is first drilled, then blasted, crushed and carried by trucks and/or conveyors to a mill. There the metal-bearing sulphides are finely ground, separated by froth flotation from waste (iron and minerals that are not metal-bearing), and concentrated into separator bulk lead, zinc and copper concentrates. The concentrates are often dried to a specific moisture content, then shipped for smelting. The lead content in concentrate typically ranges from 50-70 per cent. The waste material (tailings) is carried in slurry form for use as back-fill in the mine or for disposal in an on-site tailings pond where particulate matter settles out and the effluent can be monitored and/or treated if necessary.

Methods to minimize the risk of dusting or spillage of concentrates and tailings can involve ensuring that materials are moist and non-dusting, that the mechanical design of handling systems is used to minimize spillage and permit clean-up, and that old tailings sites can be rehabilitated through options such as flooding, covering with topsoil and/or vegetation, or converting to wetlands/wetcovers.

1.2.2 Smelting and refining

Lead-bearing concentrates or scrap must be metallurgically treated to separate lead metal from various impurities, such as sulphur and silicate minerals in concentrates, or sulphates, oxides and other metals in scrap.

To extract lead from concentrates requires the conversion of lead sulphide into lead oxide, and then the reduction of the oxide to metallic lead (bullion). The two traditional methods are the Imperial Smelting Process (ISP), which simultaneously processes lead and zinc ores and is energy-intensive, or the sinter and blast furnace process, which will be discussed further as it is the most commonly used method at present. Newer, more efficient direct-smelting technologies have

been developed and implemented in recent years.

1.2.3 The conventional sinter and blast furnace process

Concentrates are often pelletized to increase porosity. Then heat and oxygen are applied to drive off the sulphur, as SO_2, leaving a sinter of lead metal, lead oxide and other metal oxides or silicates. The SO_2 off-gas is blown through a cooling and dust collection system before going to an adjacent plant, where it can be used to make sulphuric acid or other sulphur products. Lead oxide is then reduced to metallic lead (bullion) in a blast furnace, while silicates and other impurities form a residual product called slag.

Lead recoveries in modern blast furnaces range from 97 to 99 per cent of the lead content in the feed (SRI, 1983). Some operations recover additional metal from the slag by passing it through a fuming furnace to oxidize and drive off lead and zinc, which can then be collected in the form of flue dust. The molten slag is tapped from the furnaces. It is either granulated and vitrified, by being subjected to a water spray, or cooled and solidified slowly by the air. The slag can then be stored in piles either on-site or in a designated landfill site, or it can be used for construction purposes such as in block form as rip rap for dams. Where slag is used in construction, leachability must be considered. Flue dusts are usually recycled back through the smelting process.

1.2.4 The direct smelting process

The direct smelting process skips the sintering stage described above. Within a single furnace/chamber it uses the exothermic sulphide-roasting reactions, with air to provide the heat requirements to convert PbS to PbO and then produce lead bullion and slag (SRI, 1983). This method has the potential to provide a cleaner working environment by reducing the possibility for vagrant emissions of lead oxide (fume). The SO_2 off-gas, dusts and slag are collected and treated in the same manner as described for the sinter-blast furnace process.

The evolving processes are the Kivcet (Russian design), Isasmelt (Australian), QSL (German) and TBRC/Kaldo (Swedish). There is also the Outokumpu Oy (Finnish) process, which has not yet been constructed on a commercial scale for lead.

1.2.5 Refining

Lead bullion from the smelting stage is refined to remove remaining impurities and traces of other metallic elements, including precious metals, either by the electrolytic or pyrometallurgical process. In electrolytic refining the lead bullion is cast at the smelter into plates weighing several hundred kilograms, which serve as anodes. Thin sheets of pure lead are inserted into electrolytic tanks with the anodes to act as cathodes. The continuous application of electricity in the solution dissolves the anodes, while the pure lead is deposited on the cathodes. Impurities such as precious metals that settle in the tank are removed for further processing. The refined lead, up to 99.999 per cent purity, is then cast into slabs, called pigs, for market.

Pyrometallurgical refining is carried out in a series of large covered or semi-covered kettles. The molten lead is transferred from one kettle to the other by pumping, or by ladle and

crane, and each impurity or precious metal is progressively removed from the lead. Some secondary and primary lead producers may also choose to remove or add various metals to produce alloys. The techniques vary with the types of impurities and by-product metals contained in the molten lead. Selective reagents are added to the lead under carefully controlled temperatures, and the different drosses, containing impurities, that collect on the surface are skimmed off. When all impurities have been removed or the proper alloy is obtained, the lead metal or alloy is cast into pigs. In most cases, drosses are processed to remove precious and other non-ferrous metals.

1.3 Demand and end uses

Lead is a dense, bluish-white metal whose physical and chemical properties find application in the manufacturing, construction and chemical industries. It is easily shaped and has long been prized for its malleability and ductility.

Some experts believe that lead was used in Egypt as early as 5000 B.C. for pottery glazes. The oldest archaeological evidence of lead use may be a figurine found in the Dardenelles (Asia Minor), dating from around 3800 B.C. Lead was also used in China around 2000 B.C. in coins. It was mined in Greece from around 1200 B.C. and used in coins, ornaments, missiles for slings, and many other articles. The best known use of lead in ancient times is probably as piping in Roman water systems.

Since 1970, the world demand for lead has increased by 25 per cent to a record level of 5.627 million tonnes in 1990. OECD countries accounted for 65 per cent of world demand in 1990, with the Central and Eastern European countries consuming 21 per cent (**Figure 4**). Asia is now the third largest and fastest-growing lead-consuming region. During the last two decades, Asian demand for lead increased by a factor of 6 and now accounts for 9 per cent of world demand. The increase largely reflects the rapid pace of economic growth in this region.

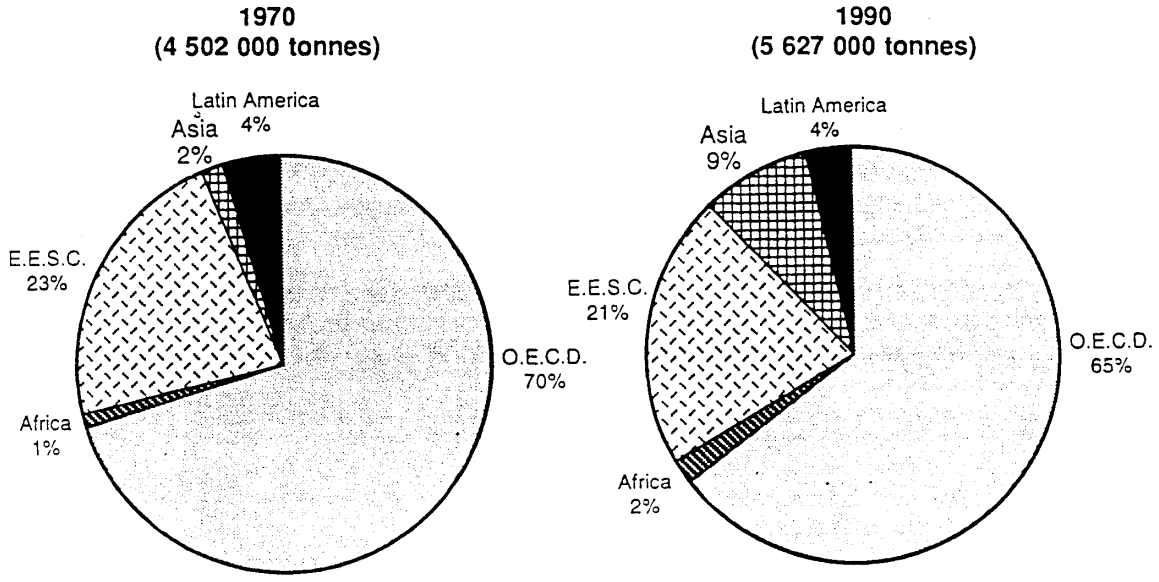
The International Lead and Zinc Study Group (ILZSG) collects annual statistics for lead demand by eight broad categories: batteries, gasoline additives, rolled and extruded products, alloys, pigments and compounds, cable sheathing, shot and ammunition, and miscellaneous products. These data are the most comprehensive for OECD countries.

Figure 5 gives a breakdown of lead demand in OECD countries in 1970 and 1990 by end use categories. Over this period, demand in OECD countries increased by 10 per cent, with the battery sector recording the greatest growth and accounting for 63 per cent of demand in 1990. During the same period, demand significantly declined for lead in gasoline, alloys and cable sheathing. Health and environment concerns were largely responsible for the decline in the use of lead in gasoline and in certain alloys (for example, lead solders for potable water systems). However, most of the decline largely reflects changes in technology and market-driven requirements for lighter, more cost-competitive and efficient products.

Detailed trends in end use demand in OECD countries by broad category are shown in **Figures 6-16**. The data were assembled by the Lead Development Association (LDA) from information provided by industry in various regions. The following sections briefly describe end uses and trends by broad category.

Figure 4

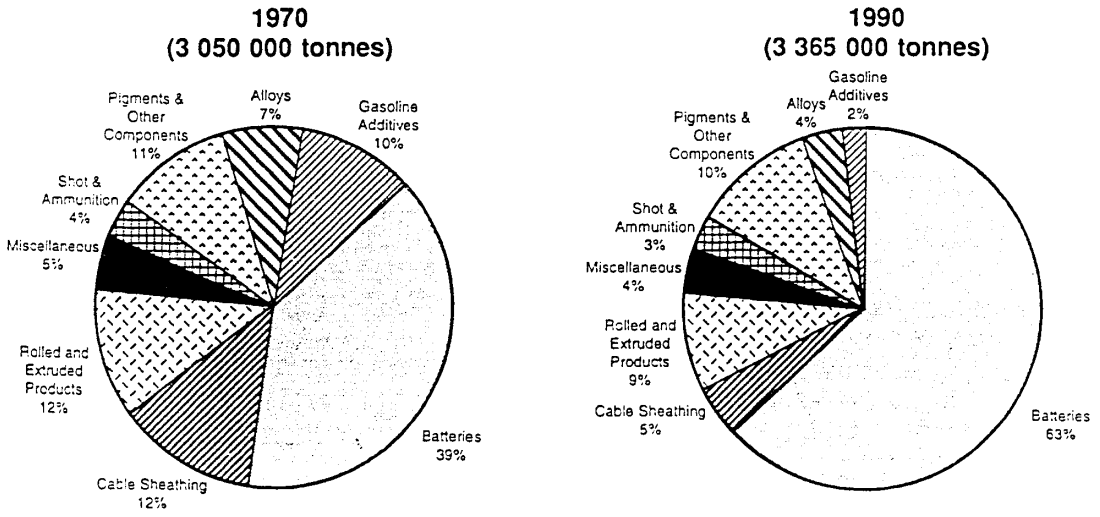
World Demand for Lead



E.E.S.C. - Eastern European and Socialist Countries
Source: ILZSG 1990, 1992b.

Figure 5

OECD Demand by End Use Category



Source: ILZSG 1990, 1992a.

1.3.1 Batteries

Since 1970, the battery sector's demand for lead has increased by 79 per cent to 2.12 million tonnes in 1990. **Figure 6** shows how lead demand has steadily increased over the last 20 years for all types of lead-acid batteries: starting, lighting and ignition (SLI), electric vehicle, industrial, and small consumer products.

SLI batteries, which are used in cars, trucks, buses, etc., accounted for 78 per cent of the battery market in 1990. Batteries to power electric vehicles, such as fork lift trucks, airport ground support vehicles, delivery vans and golf carts, were the second largest category at 14 per cent. The third largest category was industrial batteries, such as those used as stand-by power to provide uninterruptible electrical energy supplies for telephone exchanges, public buildings, hospitals, submarines and various industries.[1]

Lead oxides and alloys with antimony, calcium, etc., are used in the production of battery components such as paste, grids and posts. Other battery components include plastic or ebonite cases, separators and electrolyte (sulphuric acid). All components can be easily separated and either recycled, reused or safely disposed. Technology is available not only to neutralize the acids, but also to convert the sulphur for use in fertilizer or detergent products. The extent of application depends, of course, on the availability of markets for these products.

1.3.2 Gasoline additives

Lead tetraethyl and tetramethyl gasoline additives improve engine performance. Their economic efficiency resulted in their wide use throughout the world. The demand for lead for the production of gasoline additives in OECD countries peaked during the early 1970s at 340 000 tonnes, but declined to about 72 000 tonnes in 1990 (**Figure 7**). The decline in demand occurred in two phases, the first of which followed the introduction of unleaded fuel for vehicles with catalytic convertors. During the 1970s, governments (largely North American) required catalytic convertors on new vehicles in order to reduce SO_2, NO_2 and other gas emissions. Unleaded gas was developed for these vehicles, as lead caused adverse effects to the exhaust emission control systems. The second phase began in the late 1970s and early 1980s when governments reduced the allowable level of lead in gasoline because of concern that lead compounds discharged into the air along with motor vehicle exhaust gases constituted an unreasonable risk to human health and the environment.

1.3.3 Rolled and extruded products

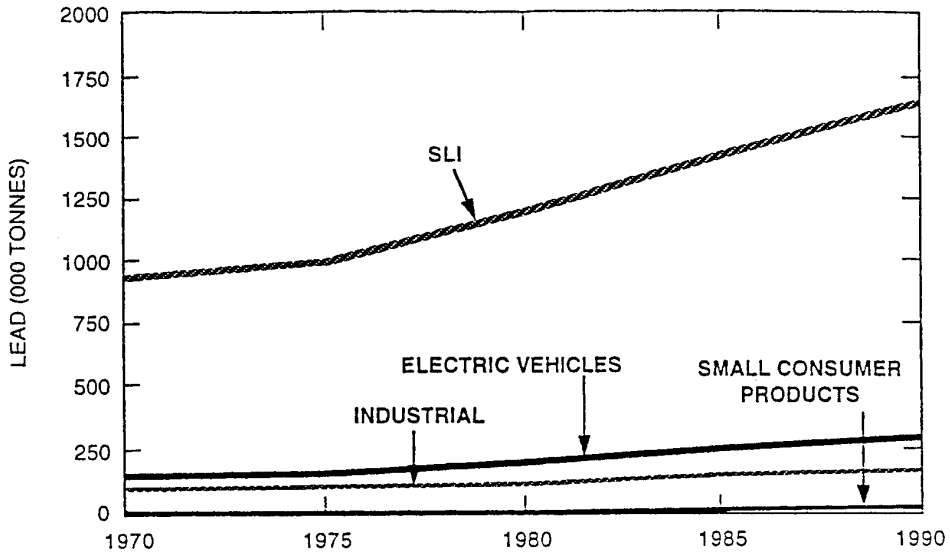
Lead's softness and ability to be alloyed with other metals allow it to be rolled into sheets (largely for construction purposes such as roofing, damp-proof courses at the base of walls, and cames for stained glass and leaded windows) or to be extruded to form pipes for carrying water or

[1] Industrial batteries can also be used by electric utility companies for load levelling purposes. The battery provides additional electricity during peak power usage periods of the day and is recharged during periods of low electrical demand, usually at night. Load levelling provides utility companies with the flexibility to meet new demand, without increasing capacity by building new generating facilities or expanding existing ones.

chemicals.

Figure 6

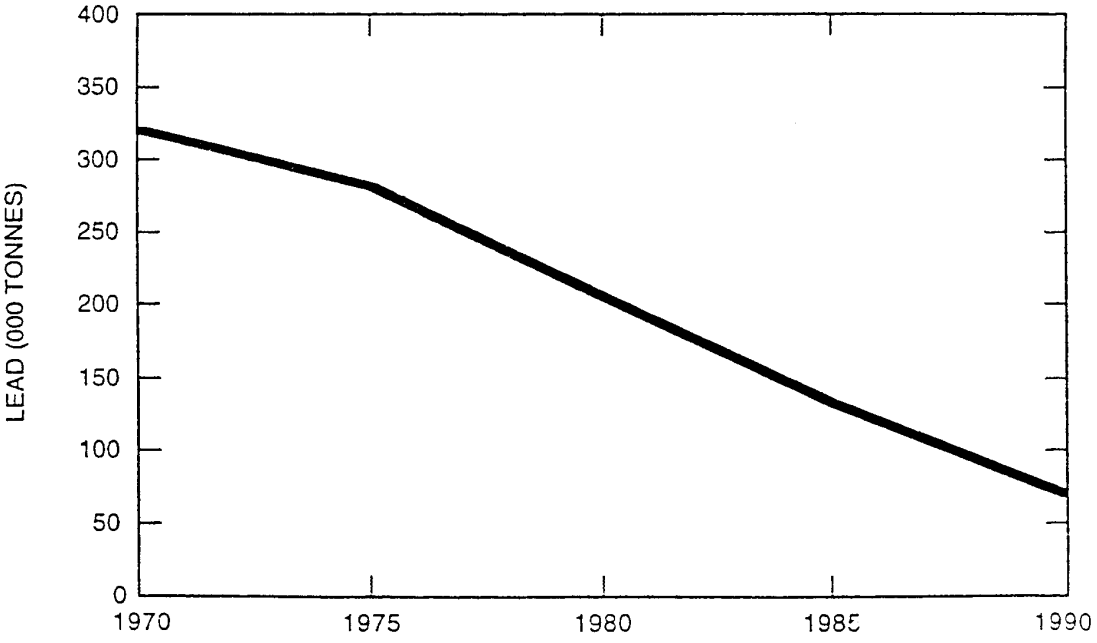
Batteries



SLI - to start, light and ignite cars, trucks, buses, boats, etc.
Source: LDA 1992, ILZSG 1992a.

Figure 7

Gasoline Additives



Source: LDA 1992, ILZSG 1992a.

The properties identified above also permit lead to be used for some packaging materials, such as collapsible tubes for containing corrosive substances (for example, glues) or for wine bottle capsules, a use in rapid decline at this time.

The sound and radiation attenuation properties of lead, as well as its corrosion-resistant nature, lend it to use either alone or in the form of sheets bonded to plywood, steel or other material for shielding in X-ray rooms, small isotope containers, enclosures containing noise sources, and linings for reaction vessels and laboratory surfaces, to name a few.

Lead used in the ways identified above is retrievable and can easily be recycled at the end of product life. The demand for lead in construction, shielding and sound proofing materials has grown, while its use in all other rolled and extruded products has declined (**Figures 8 and 9**). Although this decline is largely attributed to the introduction of pliable, chemical-resistant and more cost-effective plastic substitutes, the sharp decline of lead use in piping is also attributed to health concerns associated with the presence of lead in potable water systems. The reduction in the amount of lead used for wine bottle capsules during the late 1980s reflects concerns over lead toxicity, and also an increase in the use of plastic substitutes as an industry measure to reduce costs.

1.3.4 Alloys

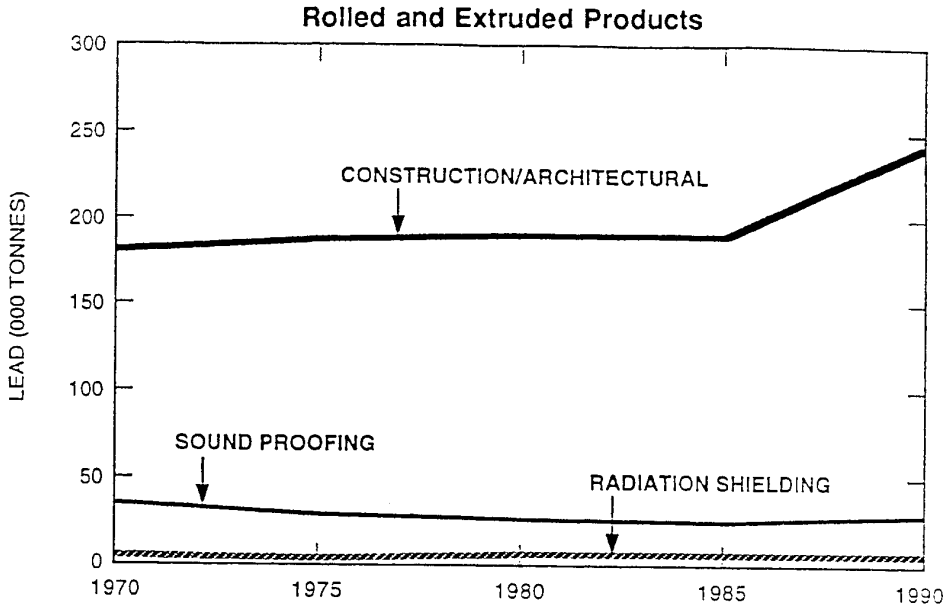
Lead is easily alloyed with tin, antimony, copper or zinc for use in solders and bearings, or in the production of brass and bronze. There are a variety of applications, as shown in **Figures 10 and 11**, that will not be described as they are essentially self-explanatory with the exception of terne plate. Terne plate refers to a process whereby a lead/tin alloy (about 50 per cent lead) is used as a corrosion-resistant coating on items such as car fuel tanks and stainless steel roofing materials.

The use of lead is declining for the majority of applications in this category, with the exception of terne plating and electronics. The computer and electronic gadget boom of the 1970s and 1980s has resulted in growth in the use of lead solders for electrical connections.

Because of health concerns, the use of lead in plumbing solder in drinking water systems has been restricted. These solders are now largely used to join pipes in central heating systems. The use of lead solder for food cans has also been declining because of health-related concerns. However, the demand for lead in the remaining applications has largely declined because of cost-cutting and technological changes: for example, aluminium radiators have replaced lead soldered copper radiators in some cars because they are lighter in weight.

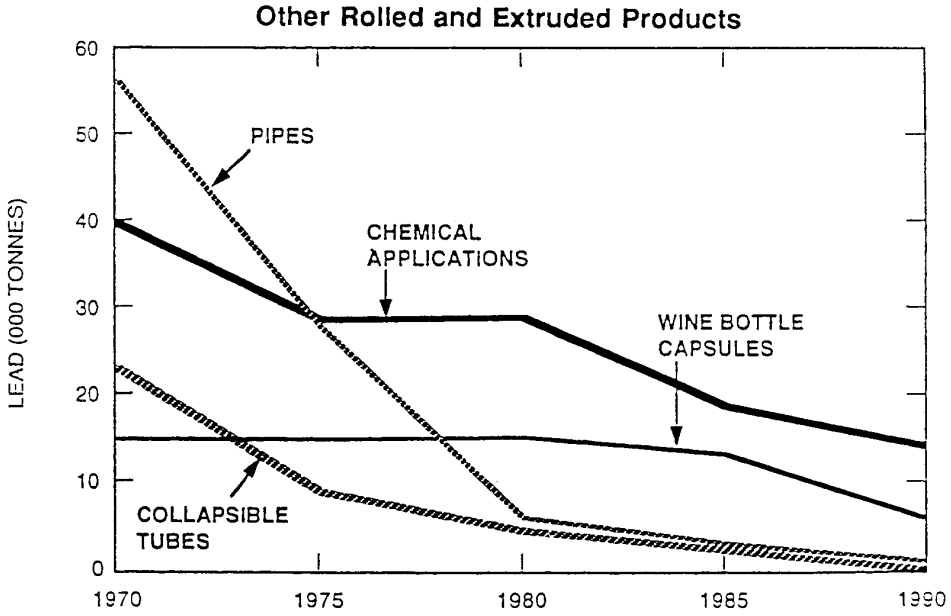
Exposure concerns associated with electronic applications relate more to the disposal of components than to their use. In general, electronic scrap represents a valuable source of many base and precious metals, and there is an economic incentive for appropriate recovery processes. Certain primary copper smelters that process complex concentrates also recover precious and base metals, including lead, from scrap electronic components.

Figure 8



Source: LDA 1992, ILZSG 1992a.

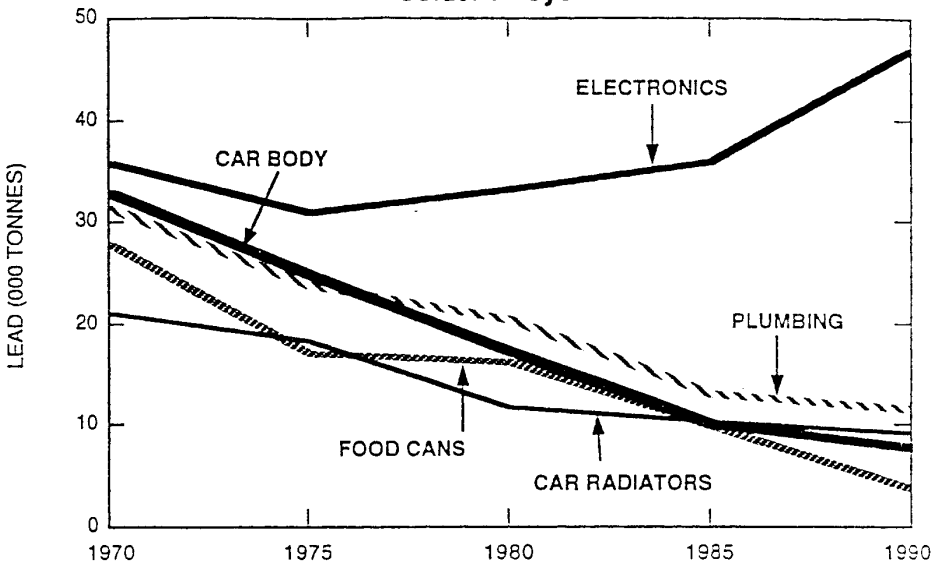
Figure 9



Source: LDA 1992, ILZSG 1992a.

Figure 10

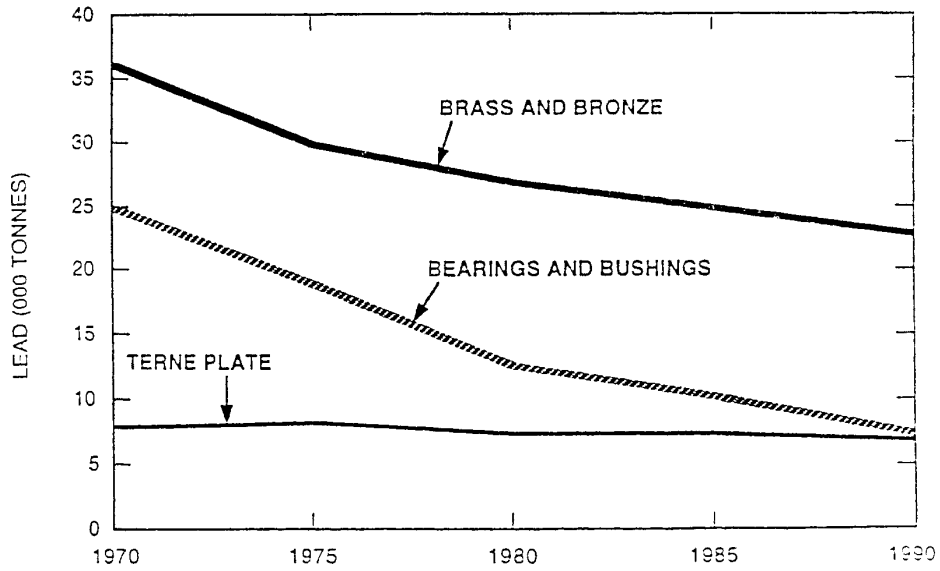
Solder Alloys



Source: LDA 1992, ILZSG 1992a.

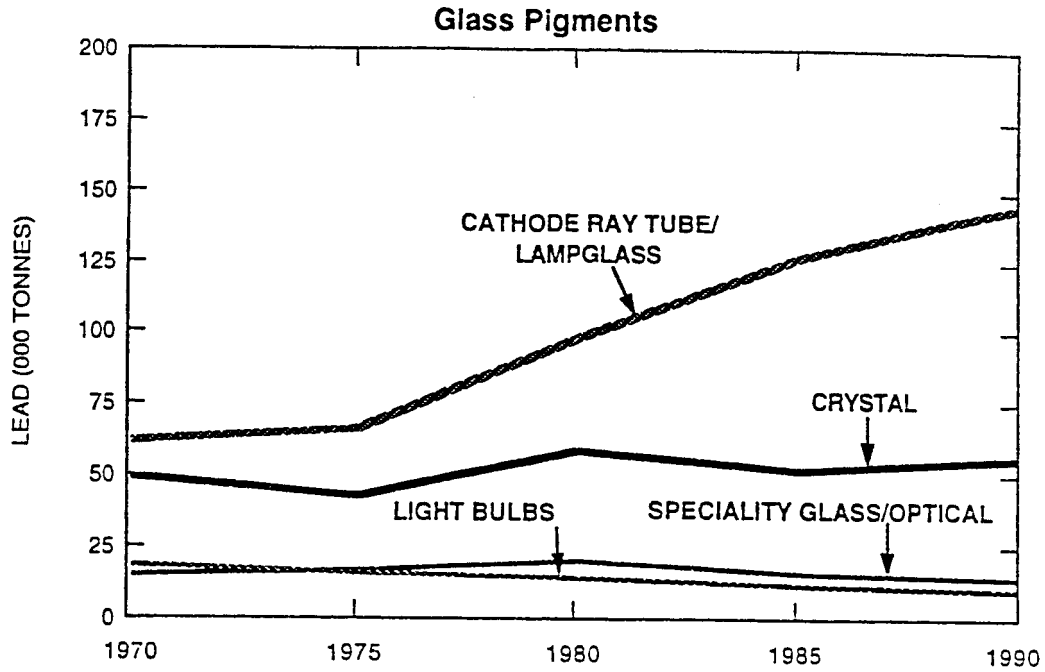
Figure 11

Other Alloys



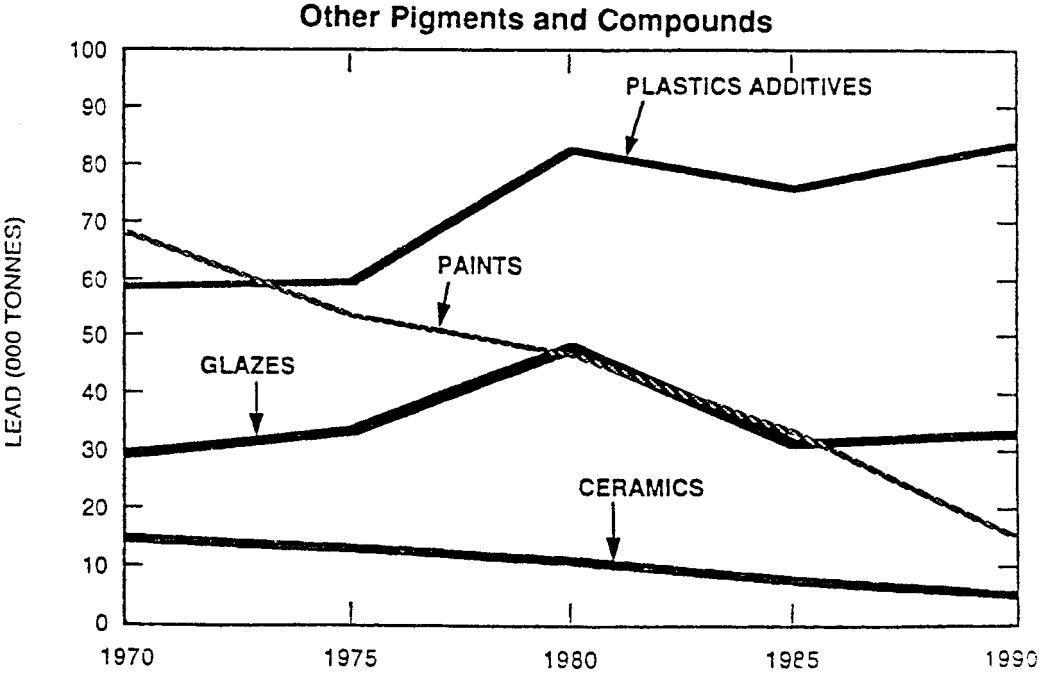
Source: LDA 1992, ILZSG 1992a.

Figure 12



Source: LDA 1992, ILZSG 1992a.

Figure 13



Source: LDA 1992, ILZSG 1992a.

1.3.5 Pigments and other compounds

Lead pigments are used in glass to improve the refractive index in crystal, which contains up to 36 per cent lead, or optical instruments (for example, binoculars, microscopes, telescopes, etc.). Lead is also added to glass to prevent exposure to harmful radiation from televisions, computers, video game screens and other cathode ray tubes. In addition, lead-containing glass is also used to provide a seal between metal and glass in fluorescent lamps and light bulbs. **Figure 12** indicates that lead demand for glass has remained stable for most applications, with the exception of cathode ray tubes where the growth in usage reflects the increase in demand for video and computer terminals.

Lead pigments and compounds are used in ceramic glazes or as a component of ceramic products (for example, tiles, foodware, insulators, capacitors and other electrical materials). The demand for inorganic lead compounds added to glazes, for appearance or for scratch- and corrosion-resistant purposes, peaked in 1980 and has since dropped. The demand for inorganic lead compounds used under glazes to give colour and/or durability to ceramic products has been declining slowly as a result of technological changes.

Inorganic lead compounds are also used to give colour and/or corrosion resistance to paints. The greatest decline in the use of inorganic lead compounds has occurred in household paints. Most OECD countries no longer permit their use in such paints because of health concerns regarding exposures to lead due to the deterioration of the paint and wall surfaces. Since 1970, the use of lead in paints in OECD countries has declined by a factor of 4, to 15 700 tonnes in 1990. Most leaded paint is used today for exterior purposes such as road markings, or as a corrosion inhibitor on iron or galvanized steel.

Inorganic and organic lead compounds are also added to plastic (mainly polyvinyl chloride -- PVC) as a stabilizer, to prevent degradation caused by heat during processing or ultra-violet light during use. The demand for lead in plastics increased by 70 per cent during the 1970s and has since been relatively stable at about 80 000 tonnes per year. Lead-stabilized PVC is mainly used for cable jacketing, conduits, and other building applications such as siding, rainwater-resistant products, window framing and general trim. Extensive use is also made of PVC for a wide range of piping and fittings. Without stabilizers, the life of PVC products is inadequate for most applications involving exposure to sunlight and weathering. There has been some concern over the use of lead stabilizers in small bore PVC water pipes. As a precautionary measure, alternative stabilizers such as organotin, barium or zinc compounds are available for some applications; however, some of these may also raise health concerns.

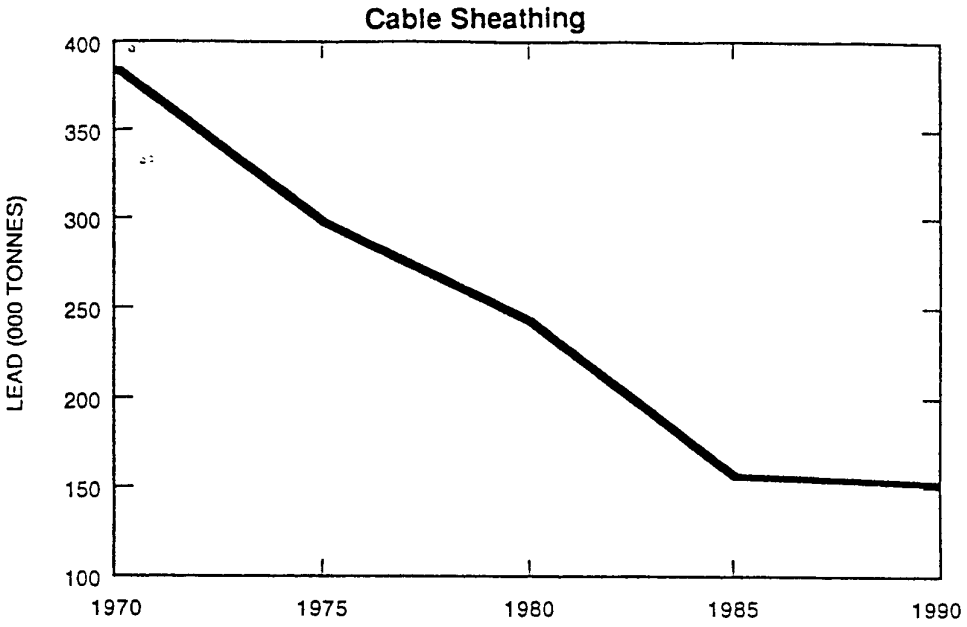
Lead compounds have been used for medicinal purposes and in cosmetics (as a hair darkener or an eye brightener) within certain populations. However, these are unreported uses.

1.3.6 Cable sheathing

Lead can be extruded into a continuous covering to prevent water penetration of underground or underwater power and telecommunications cables. Although this use is recyclable, its demand has been declining because of the development of alternate technologies that replace paper-insulated lead cables with polyethylene and PVC. Since 1970, the use of lead for cable sheathing has declined by a factor of 2.5, to 153 800 tonnes in 1990 (**Figure 14**). The remaining market is largely for marine cables. Scrapped cable is usually recycled to recover the lead in

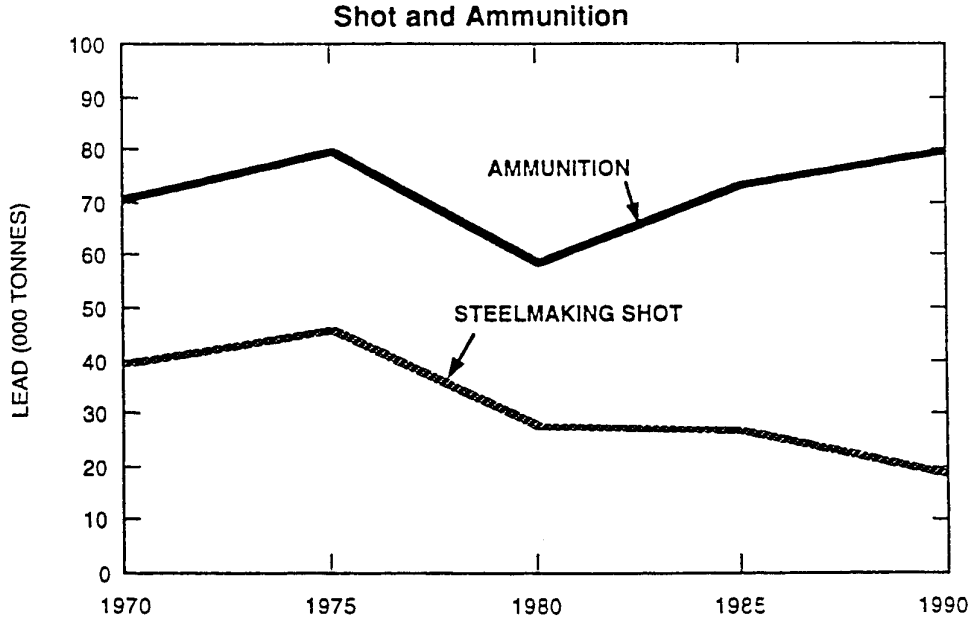
sheathing, as well as the copper conductor.

Figure 14



Source: LDA 1992, ILZSG 1992a.

Figure 15



Source: LDA 1992, ILZSG 1992a.

1.3.7 Shot and ammunition

Lead is formed into spherical lead shot to be used as ammunition, or added to certain steel alloys (steelmaking shot) to improve the steel machinability. **Figure 15** shows that the demand for both steelmaking shot and ammunition declined in 1980 in response to the economic downturn. The demand for lead in steel shot continued to slide because of technological changes, while ammunition demand recovered.

Concerns have arisen regarding the ingestion of used ammunition shot by water fowl, as it can be picked up from sediment in wetlands, and also as a result of the leachability of lead shot in acidic soil conditions. Some countries restrict the use of lead in such locations. Iron shot is considered an alternative, but it has an inferior performance and higher cost. It also increases the wear on gun barrels. Due to its sparking characteristics, iron shot can present a fire risk in certain situations.

1.3.8 Miscellaneous uses

Lead can be cast in a variety of forms for products such as yacht keels, and for counterbalance, curtain weights and fishing sinkers, to name a few. **Figure 16** shows a fluctuating trend in demand for lead in these products, which reflects economic cycles that can be linked to the 1975 oil crisis and the recession of the early 1980s.

The use of lead weights for balancing vehicle wheels has increased along with the increase in the number of vehicles worldwide.

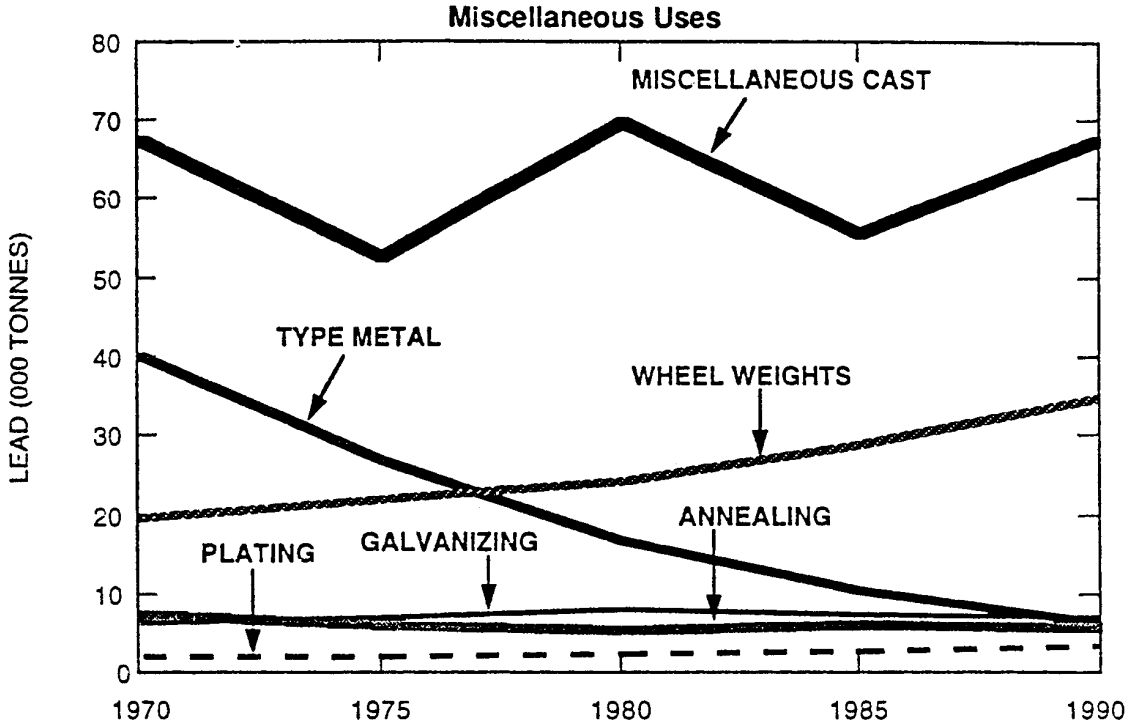
Lead-tin-antimony alloys are sometimes cast into moveable pieces or lines for typesetting in letterpress printing. This use has been declining steadily due to both technological changes and health concerns.

Thin layers of lead can be electrically plated on to steel items for corrosion resistance. This represents a very small but stable demand for lead.

Lead can be recovered from many of these uses through the scrap steel recycling system, or through the secondary lead system.

Lead is also used in the manufacturing processes of other products. In galvanizing, a layer of molten lead is used in the bottom of a molten zinc bath to assist the separation of dross (impurities) as zinc coatings are applied to steel for corrosion resistance. Baths of molten lead are also used in annealing processes for quenching (controlled cooling) of steel products (notably wire) during manufacturing. Lead is reused in these processes. Demand has been small but stable over the last 20 years.

Figure 16



Source: LDA 1992, ILZSG 1992a.

1.3.9 New uses

New applications are being developed for lead and lead compounds in microelectronics and superconductors, as an antioxidant in asphalt to prolong the life of road paving, in earthquake damping materials, in radon gas shielding, in nuclear waste containment receptacles, in advanced lead-acid batteries for electric vehicles, in specialized lead-acid batteries for remote area power supply systems coupled to solar and wind power generators, in a new power generation device using liquid metal magneto-hydrodynamics (LMMHD), and in load levelling batteries for use in mass transit systems (for example, to boost power during periods of peak demand).

These applications use the unique chemical, electrical and physical properties of lead. Industry has acknowledged that risk analyses should accompany the introduction of new products, and that recycling and reuse concepts should be developed where appropriate.

1.3.10 Stockpiling/storage

Stockpiles of lead are maintained for strategic defence purposes in the United States. This is because of the widespread use of lead in many defence-related products and technologies. Stockpiles may contain refined lead, lead alloys, and/or scrap lead. In 1990, the US federal defence stockpile contained 545 000 tonnes against a goal of 998 000 tonnes.

Lead producers and consumers maintain operating stocks to meet normal commercial requirements and to safeguard against any short-term disruption in production or supply. Stocks are also held in warehouses approved by the London Metal Exchange (LME). At the end of 1990, reported commercial stocks held in countries other than the Central and Eastern European countries totalled 438 000 tonnes.

1.4 World markets and trade

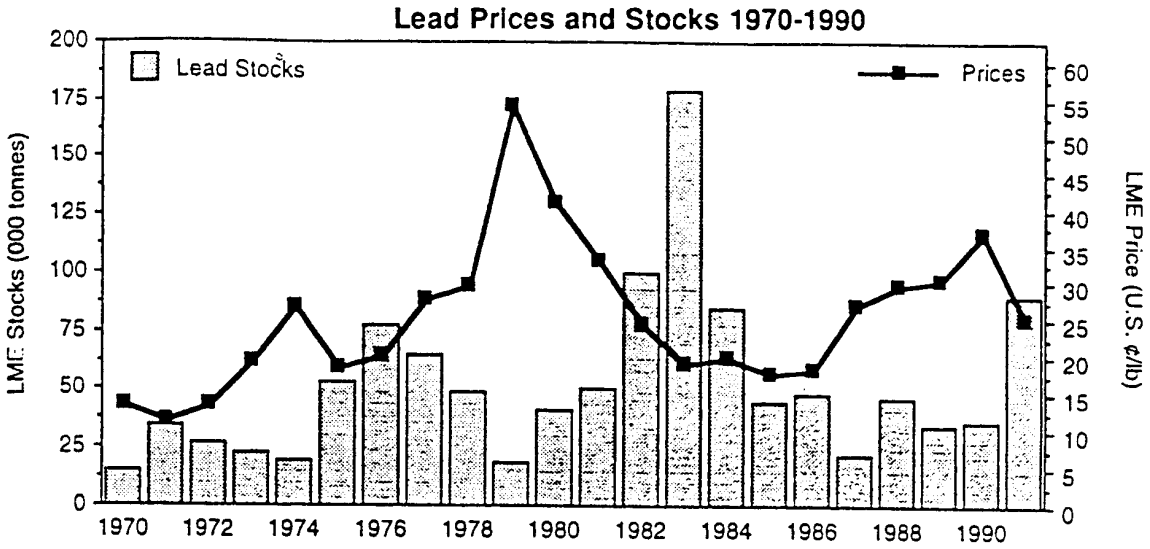
Daily prices for lead are based on international market factors, as it is produced, traded and consumed worldwide. Regionally, Europe and Japan are the largest importers of lead concentrates and Europe is the major importer of lead bullion and refined lead. Australia, Canada and Peru are principal suppliers of both lead concentrates and lead metal, while Mexico is also a major exporter of refined lead.

The balance between supply and demand is usually reflected in stock levels. As stocks rise, the price of lead generally falls and vice-versa (**Figure 17**). Daily prices of refined lead are set by the London Metal Exchange (LME) for both prompt and forward trading. They are widely accepted as the basis of sales by producers to consumers, subject to transport costs, tariffs and other trading expenses.

1.5 Disposal (recycling, incineration, landfill)

Environmental releases of lead can be natural in origin (for example, crustal weathering, volcanism) or can occur from anthropogenic sources relating to industrial activity, power generation (coal and oil burning), and the use and disposal of consumer products.

Figure 17



LME: London Metal Exchange
Stocks - Annual average of month-end stocks
Price - Annual average
Source: ILZSG 1990, 1992b; EMR (1970-1991).

Industrial releases (i.e. emissions, effluent and solid waste) are usually regulated within OECD countries. Post-consumer wastes containing lead may be regulated, depending on the product's hazard classification and/or its destination (i.e. recycling/recovery, final disposal, international trade).

1.5.1 Recycling

Lead is one of the most recycled non-ferrous metals in the world. Annual production from recycled materials (i.e. secondary lead) has risen steadily. It exceeded primary output for the first time in 1989 (Figure 3). Factors that influence lead recycling include: type of product, historical demand levels, product life span, collection system infrastructure (including transportation), international trade, scrap separation and processing technologies, prices of scrap lead compared with lead metal, currency exchange rates, environmental regulations, and the return of spent products by consumers.

Technology is available to recover lead as well as other metals and materials (for example, plastics) from lead-bearing residues and waste. Lead-bearing feed for recycling can vary from industrial scrap (for example, plating or chemical solution/sludge, baghouse dusts, refining drosses, dirt residues from fragmentizer plants used for shredding steel cars, domestic appliances, etc.) to remediation and abatement wastes such as lead paint removal debris, lead-contaminated soil, and firing range soils. Post-consumer product scrap constitutes more than 80 per cent of the scrap supply for recycling (for example, batteries, cable sheathing, radiation and sound attenuation materials, sheeting, crystal glass, wheel weights, and electronic equipment, which also contains precious metals), with batteries accounting for up to 90 per cent of this amount in a given year.

Recycling rates are usually stated for batteries, as they account for over 60 per cent of world demand for lead. As for other recyclable lead products, recycling rates are not usually available since they tend to have variable life spans, which makes it difficult to determine the amount of material available for recycling in a given year. **Table 1.1** shows battery recycling rates in some OECD countries.

Battery recycling rates are determined by comparing the amount of lead recycled from batteries with the quantity available for recycling, in a given year. Recycling facilities can usually provide data on the amount of lead produced from scrapped batteries. However, the amount of lead available for recycling is largely influenced by the battery's life span. Therefore, to determine the amount of lead available from batteries for recycling in a given year requires historical data on battery production and average lead content, as well as import and export data on new batteries and vehicles containing batteries. Also required are current data on the lead content of batteries in scrapped vehicles and import/export data on scrap lead, scrap batteries, and scrapped vehicles containing batteries. Methods of calculating recycling rates may vary by country, according to available data.

It should be noted that the average lead content in batteries has decreased over time because of technology changes. The life span can also vary depending on climatic conditions and energy demand requirements (for example, air conditioning, heaters). The average battery life for passenger vehicles is estimated at four years in the United States and three years in Japan.

Table 1.1 Battery Recycling Rates in Some OECD Countries

	1986	1987	1988	1989	1990	1991
Australia						>90
Belgium	77					
Canada						93
France	80			90		90
Germany FR	83					>95
Italy	83					
Japan	93.3	92.5	95.2	93.8	92.2	
Norway						50*
Spain	83					
Sweden						>100[e]
United Kingdom	84					93
United States		88.6	91.0	95.3	97.8	

* There are no lead recycling facilities in Norway. Scrap batteries are collected and then exported to other countries for recycling.

e = estimated.

Note: Methods used to determine recycling rates may vary by country. Recycling rates can exceed 100 per cent when stored or stockpiled batteries are returned.

Sources: Commonwealth Environment Protection Agency, Australia, 1992; Energy, Mines and Resources, Canada, 1992; Federal Environment Agency, Germany, 1992; State Pollution Control Authority, Norway, 1992; National Chemicals Inspectorate (KEMI), Sweden, 1992; US Bureau of Mines, 1992; US Department of Commerce, 1992; ILZSG, 1991b; Battery Council International (BCI), 1992.

As indicated in Table 1.1, battery recycling rates are high in many countries. This is largely because of the favourable economics associated with recycling batteries. However, it has become apparent that the weakest link in the recycling chain is usually the consumer who discards a used battery rather than returning it for recycling. In a number of countries, governments are working with industry to increase recycling by focusing on the battery life cycle and persuading the consumer to return used batteries. Initiatives include: mandatory take-back requirements for retailers and manufacturers; requirement of a cash deposit if an old battery is not returned when a new one is purchased; a small tax on new replacement batteries that can be used to offset the cost of transporting used batteries from remote regions; or a deposit/refund scheme by which consumers pay a deposit when purchasing a battery and are reimbursed when it is returned. It should be noted that the latter scheme could stimulate vehicle battery thefts if the cash deposit/refund were set too high.

1.5.2 Incineration/Landfill

When industrial solid wastes and post-consumer products that contain lead are not recycled or reused, they are generally disposed of in landfills or incinerators.

Lead-bearing solid wastes from mineral and metal processing facilities that are not recycled (for example, mine tailings and smelter slag) are either reused, like tailings for back-fill in underground mine workings and slag in various construction applications, or disposed of in tailings impoundment or landfill sites where effluent can be monitored and treated if necessary. A few facilities are permitted to discharge tailings or granulated vitrified slag to water systems, where the impact is considered to be minimized because of leachate characteristics, dilution factors, or the somewhat anaerobic environment that exists at depth.

Most industrial solid wastes from the manufacturing of lead-bearing products or the recycling of steel products are reused or recycled. Examples are drosses, bag house dusts and bags, pasting belts, lead-bearing oil and hydraulic fluids, pesticides, floor sweepings, disposable clothing, and respiratory cartridge filters.

Without detailed sampling or monitoring data, it is difficult to assess accurately the composition and volume of post-consumer products disposed of in landfill or incinerator facilities. Difficulties in modelling analyses occur because of the variability in demand patterns, life spans and recycling rates for products, as well as the often incomplete nature of import/export data.

The volume and characteristics of lead in post-consumer products destined for final disposal have been estimated in the United States, Norway, France, Sweden and Germany. A material flow analysis for lead-bearing products in the United States estimated that lead discards to municipal solid waste sites consist primarily of batteries and consumer electronics products. Batteries were also identified by a materials flow analysis as the main source of lead in municipal solid waste in Norway. A study in France concluded that, of the total lead coming from household refuse, lead in soldered cans accounted for 35 to 41 per cent of lead discards, with paper products contributing the second largest amount at about 19 per cent. Sweden has estimated that non-hazardous waste from households contains just under 2000 tonnes of lead per year, of which about half goes to waste incineration with the rest destined for landfill. In Germany, the amount of lead in domestic and industrial waste streams is declining.

Waste management methods can vary by country and region, depending on land mass and population density. In some countries, the trend towards incineration is increasing as existing landfill facilities reach capacity and land availability for new sites becomes limited.

The main concern in regard to the presence of lead in landfills is the potential for the lead to leach and contaminate drinking water supplies. Since elemental lead and lead compounds are stable, health concerns are minimal for a properly managed landfill with runoff and leachate controls (US EPA, 1992).

Although incineration is generally more costly than landfills, it minimizes land use requirements by reducing waste volumes up to 90 per cent and often provides some revenue from energy recovery (for example, steam for heat or electricity generation). Lead emissions are the primary concern in regard to the incineration of lead-bearing materials. With the proper technology, however, lead emissions from combustible and non-combustible components of municipal solid waste can be controlled with 99 per cent or greater efficiency (US EPA, 1992). Though the atmospheric dispersion of lead from incineration can be significantly reduced, the lead captured by emissions control devices and the lead remaining in ashes must be disposed of properly, usually in landfills (US EPA, 1992).

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CHAPTER 2

ENVIRONMENTAL FATE, TRANSPORT AND OCCURRENCE

2.1 Sources of Lead in the Environment

2.1.1 Natural Sources

Lead has been present on earth for all of geological time. It occurs naturally in the earth's crust at average levels of 5-50 µg/g (US EPA, 1989). In the natural cycle, lead is released to the earth's surface through a variety of processes which include weathering of rocks, volcanic activity, and uptake and subsequent release by plants. Other natural sources include sea sprays, windblown dusts, and wild forest fires (Nriagu, 1978a,b). The weathering of rocks releases lead to soils and aquatic systems. This process plays a significant role in the global lead cycle, but only rarely results in elevated concentrations in any environmental compartment. Soils derived from carboniferous black shales are an exception, as they can contain up to 200 µg lead/g (Hawkes and Webb, 1962). Similarly, non-ferrous ore bodies which contain lead can contaminate adjacent water courses and soils.

The US National Research Council (NRC, 1980) estimated the natural concentrations of lead in air, soil, water and food in the United States (**Table 2.1**). Such an exercise is extremely difficult, however, and estimates, often based on concentrations measured in remote ares, are difficult to validate. The effect of a long environmental residence time, combined with the fact that man has been mining and processing lead for thousands of years, is that concentrations of lead measured in remote areas do not necessarily reflect natural concentrations and may well include a component of anthropogenic origin.

Table 2.1 Lead Concentrations Estimated as Natural in the United States

Medium			Estimated "natural concentration"
Air -	Rural/remote		0.01-0.1 µg/m^3
	-	Inhabited	0.1-1.0 µg/m^3
Soil	-	Rural/remote	5-25 µg/g
	-	Inhabited	5-25 µg/g
Water	-	Fresh	0.005-10 µg/l
	-	Marine	0.001 µg/l
Food			0.0001-0.1 µg/g

Source: NRC, 1980.

2.1.2 Anthropogenic Sources

Human activities remove lead from the earth's crust and transfer it to environmental media, where its potential for resulting in both human and ecosystem exposure is greatly increased (**Figure 18**). While uses of lead have been known since ancient times, industrialization has vastly accelerated its transport into human and environmental exposure pathways. Lead is released into the environment during the mining and smelting of its ores, the production, use, recycling and disposal of lead-containing products, and the burning of fossil fuels and wood (Royal Commission on Environmental Pollution, 1983).

Estimates of the dispersal of lead emissions into the environment indicate that the atmosphere is the major initial recipient. The development of lead fuel additives in the 1920s and the increasing use of the automobile greatly escalated the rate at which lead was released to the atmosphere. The amount of lead emitted from this source has, of course, now greatly decreased. Mobile and stationary sources of lead emissions tend to be concentrated in areas of high population density and near smelters. From these emission sources, lead moves through the atmosphere to various compartments of the environment. It is deposited on soil, surface waters and plants and thus is incorporated into the food chain of animals and man.

2.2 Lead in the Atmosphere

Humans are exposed directly through inhalation of lead emitted into the air. Importantly, air also acts to transport lead into other human exposure media, including dust, soil, food and water. Deposited lead can be re-entrained into air with wind-blown dust. Most atmospheric lead is from anthropogenic emissions. The most recent worldwide estimates of anthropogenic emissions of lead to the atmosphere are for 1983 (Nriagu and Pacyna, 1988). These are shown in **Table 2.2**. The authors based their estimates on a review of emissions studies in the United States, Western Europe, Canada and the former Soviet Union for various sources.

The emissions are given as plausible ranges, due to the considerable difficulties of estimation. While these figures provide an overall global perspective, it must be borne in mind that considerable regional and local variation will occur, reflecting factors such as the locations of major industrial point sources and the consumption of leaded gasoline.

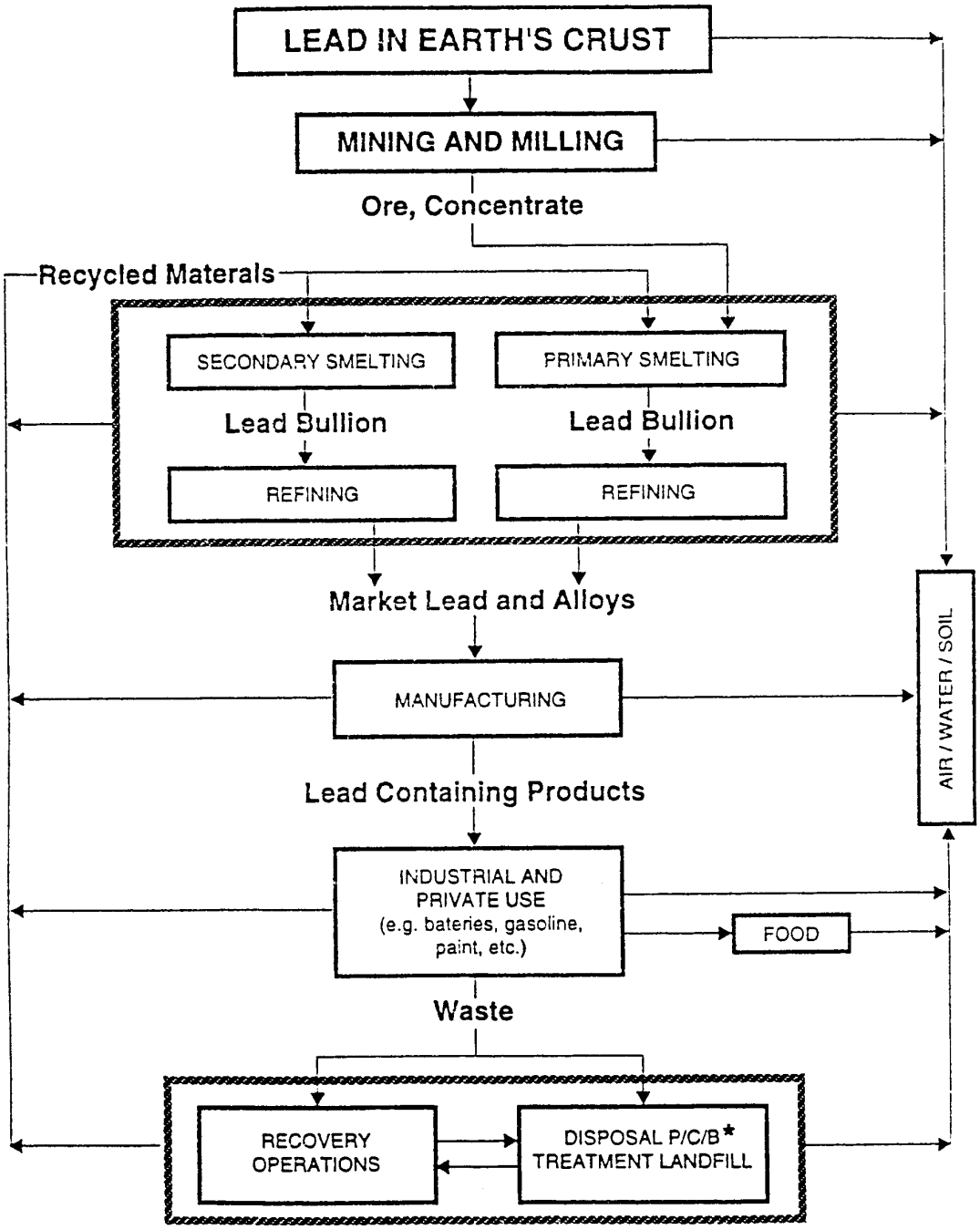
By far the largest source category is "mobile source", reflecting leaded gasoline consumption. Automobiles are the primary mobile source of lead in air (several reports suggest they are responsible for as much as 90 per cent), although trains, boats, farm vehicles and aeroplanes can also be important mobile sources (Nriagu, 1978b). The majority of lead emissions occur following the combustion of leaded gasoline in the engine, although some lead is also released with gasoline vapours during refueling. Current (1992) estimates for such emissions would be considerably lower given the reduction in the use of tetraethyl-lead that has occurred since 1983 (refer to the table).

Air emissions from smelters, processing facilities and solid waste incinerators occur as controlled releases from stacks and fugitive releases from storage, processing or materials handling. Although worldwide it has been estimated that the non-ferrous metal industry is the

second largest lead emitter, there are likely to be large regional and natural differences.

Figure 18

Life Cycle of Lead and Release into Environmental Media



* Physical / Chemical / Biological.

Levels of airborne lead are strongly reflective of the distance from local sources, since atmospheric dispersal processes rapidly dilute the lead compounds as they are carried downwind from the source. These follow a general sequence of being highest adjacent to a major source such as a highway or smelter, with concentrations lower at rural locations and lowest at remote marine locations. Caution is required when interpreting individual short-term measurements of lead in air, as these may grossly misrepresent the long-term picture. For this reason, and because the human physiological response to lead is on a time scale of weeks or longer rather than hours, regulatory standards for lead in ambient air are set in terms of annual average (EC) or quarterly average (US EPA) concentrations. These standards are 2.0 µg/m^3 and 1.5 µg/m^{3,} respectively, and have been in existence since 1982 (EC) and 1978 (US EPA).

Atmospheric lead levels in remote continental areas fall in the range of 0.1-10 µg/m^3. Marine atmospheres generally contain less lead than continental air. Concentrations of lead in urban air in various OECD countries in the 1970s ranged from 0.5 µg/m^3 up to 10 µg/m^3 in densely trafficked inner cities (Nriagu, 1978b). However, restrictions on lead levels in gasoline imposed since that time in many countries have markedly decreased automotive emissions of lead into the atmosphere.

The air lead levels presently found in European and North American cities are in the range of 0.2-0.8 µg/m^3, and in rural areas usually in the range of 0.05-0.3 µg/m^3. However, the general population spend much of their time inside buildings. Concentrations of lead in indoor air are generally much lower than those outdoors, a typical ratio being around 60 per cent (Davies et al., 1987) for sites influenced predominantly by automotive lead. Sites adjacent to industrial lead emitters may show different ratios due to a differing particle size distribution for lead.

Despite declines in general atmospheric concentrations of lead in some countries, areas of higher concentrations still exist due to the presence of local sources. In the UK, concentrations of lead in ambient air near smelters have been reported to average 0.4-0.8 µg/m^3 (Carroll, 1987) and 2.2-6.0 µg/m^3 (Reed, 1987). In 1980, air lead concentrations in a smelter town in Yugoslavia were as high as 21.3 to 29.2 µg/m^3. Pollution control measures were installed at the smelter in 1985, but concentrations around the smelter were still as high as 12.8 µg/m^3 after these controls were put into place (Graziano et al., 1990).

Particle Size Distribution and Chemical Forms of Lead in Air:

Industrial lead emissions and the major proportion of automotive emissions are in the form of particles of inorganic compounds of lead. These particles have very small dimensions, but cover a range of sizes which confer different properties upon them.

Primary vehicle exhaust lead comprises particles of around 0.015 µm in diameter, and may be attached to particles of carbon of similar dimensions (Chamberlain et al., 1979). Particles of this size very rapidly combine with other particles. When they have grown to around 0.1 to 1.0 µm, they cease to grow and can have an atmospheric lifetime of around seven to 24 days. Particles arising from industrial process emissions cover a variety of sizes, dependant largely upon the nature of the control devices employed. Sizes of 0.1-5.0 µm are typical (Bennett and Knapp, 1989). Lead from other sources, such as windblown road dust and fugitive losses from stockpiles, are substantially larger in size, typically 5-50 µm. Particles of 10 µm and larger are subject to rather rapid settling due to gravity and have a very short atmospheric lifetime, and thus range of travel.

Table 2.2 Estimated Worldwide Anthropogenic Emissions of Lead to the Atmosphere (1983)

Source category	Emission rate (thousand tonnes)
Coal combustion	
- electric utilities	0.78-4.65
- industry and domestic	0.99-9.90
Oil combustion	
- electric utilities	0.23-1.74
- industry and domestic	0.72-2.15
Pyrometallurgical non-ferrous metal production	
- mining	1.70-3.40
- lead production	11.7-31.2
- copper-nickel production	11.0-22.1
- zinc-cadmium production	5.52-11.5
Secondary non-ferrous metal production	0.09-1.44
Steel and iron manufacturing	1.07-14.2
Refuse incineration	
- municipal	1.40-2.80
- sewage sludge	0.24-0.30
Phosphate fertilizers	0.06-0.27
Cement production	0.02-14.2
Wood combustion	1.20-3.00
Mobile sources[1]	248.03
Miscellaneous	3.90-5.10
Total	**289-376**
Median value	**332**

[1] Current (1992) estimates for such emissions would be considerably lower given the reduction in the use of tetraethyl lead that has occurred since 1983. According to the International Lead and Zinc Study Group, worldwide (excluding Economies in Transition and China) use of lead in the production of tetraethyl lead had declined to 68 000 tonnes in 1992. Approximately 75 per cent of this amount would be emitted to the atmosphere, with the remaining 25 per cent being deposited in the engine oil and tailpipe (US EPA, 1986).

Source: Adapted from Nriagu and Pacyna (1988).

Airborne lead particles can exist in a range of chemical forms, which in turn may influence their environmental properties and toxicity. A water-soluble form will be both more mobile in the environment, and more readily absorbed by the human body, than the insoluble form. Automotive lead emissions are mainly in the form of lead bromochloride (Hirschler et al., 1975; Habibi, 1973). This appreciably water-soluble compound is rather rapidly converted in the atmosphere to ammonium lead sulphate, a rather less soluble species (Biggin and Harrison, 1979). The chemistry of industrial emissions depends upon the process in which they arise. Amongst emissions from smelters, oxide and sulphate forms of lead are prevalent (Pacyna, 1987). These forms are less water-soluble than automotive emissions, but will become more available through environmental weathering processes. Lead associated with windblown ores tends to be in the form of sulphides and sulphate (Harrison and Williams, 1982). The former are very insoluble, but can oxidize to the more soluble sulphate in the environment.

Depending on the particle size, airborne suspended particles may have a long residence time in the atmosphere. Studies from remote areas indicate that lead-containing particles are transported over substantial distances, up to thousands of kilometres, by general weather systems. Murozumi et al. (1969) and Boutron (1982) have found significantly increased lead levels in polar ice and glaciers, resulting from long-range transport of lead-containing airborne particles. Steinnes et al. (1987) have demonstrated that lead compounds are enriched in mosses, podzolic soils, ombrotropic peat and other environmental targets in southernmost Norway from deposition of long-range transported atmospheric pollution.

Studies of lead in the motorway environment can account for deposition of less than 10 per cent of emitted lead within 100 metres of the road (Wiffen, 1977; Harrison et al., 1985). The remaining 90 per cent plus escapes local deposition and travels greater distances. Measurement of lead over the North Sea shows average concentrations of 0.005-0.09 $\mu g/m^3$ (Harrison and Ottley, 1990), only a little below typical rural levels in the United Kingdom.

Lead may be removed from the atmosphere by either wet or dry deposition. The consequence of the removal is the contamination of surface waters (rivers, lakes and oceans) and soils. The most efficient clearing system is rain (wet deposition). According to the distance of atmospheric transport, the transport pattern has been described as "near fall-out", "far fall-out" and "airborne". "Near fall-out" is defined as the deposition in the immediate surroundings of the emission sources (roadways, stationary sources). "Far fall-out" is defined as that away from the emission sources, but within the geographic area (20-200 km). Small particles which are subject to long-range atmospheric transport and are ultimately deposited elsewhere are designated as "airborne". According to data of Huntzicker et al. (1975) on the distribution of lead emissions from motor vehicles in the Los Angeles basin, about 55 per cent of the emitted lead can be attributed to the category of "near fall-out", 10 per cent to "far fall-out" and 35 per cent to "airborne".

In rural areas of Europe and North America, the annual deposition rates (wet and dry) are typically in the range of 20-80 $\mu g/m^2$/day. Although there are very few data available, it appears that in less industrialized areas of the world the lead deposition rates are considerably lower. In Greenland and the Antarctic, values below 1 $\mu g/m^2$/day have been recorded. In large cities the deposition rates are about 1.5-10 times higher than in rural areas.

Trends in concentrations of lead in rainwater are reflective of those for lead in air. In a study in Minnesota, average concentrations of lead in rainwater fell from 29 to 4.3 µg/l at an urban site and from 5.7 to 1.5 µg/l at a rural site between 1979 and 1983, correlating closely with decreased use of lead in gasoline (Eisenreich et al., 1986). Valenta et al. (1986) found between

about 15 and about 50 µg $lead^{2+}$/l rain in the former Federal Republic of Germany, and a wet deposition of about 30 µg $lead^{2+}/m^2$/day in rural regions, 50 µg $lead^{2+}/m^2$/day in urban areas, and 100-150 µg $lead^{2+}/m^2$/day in regions with metallurgical industry, varying with time and having in general a decreasing tendency.

Deposition rates of lead can be very high near point sources of the metal. For example, in Wollongong, Australia, a value of 4.7 kg/ha/y was measured at a distance of 100 m from a copper smelter by Beavington (1977), while an extremely high deposition rate of 30 kg/ha/yr was found near a lead works in the United Kingdom by Turner et al. (1980).

2.3 Lead in Water

Lead is a natural, usually very minor constituent of surface and ground waters. Nriagu and Pacyna (1988) estimated, for 1983, inputs of 97 000-180 000 tonnes per year of lead to aquatic ecosystems worldwide from sources such as industrial wastes, effluents from mining, smelting, refining, manufacturing processes, atmospheric fall-out, and dumping of sewage sludge. Atmospheric fall-out represents over half of the total. In this context, it is considered that the total annual input of lead to aquatic ecosystems has declined since 1983, given the reduction that has occurred in lead emissions from mobile sources. It is important to emphasize that point sources of discharge, although not of great worldwide importance, may have large local impacts. In contrast, the globally important atmospheric deposition is spread over vast areas of ocean and may have little local impact.

Lead deposited from the atmosphere can enter aquatic systems through direct fall-out or through erosion of soil particles. In general, there is little correlation between lead concentrations in rain and snow and concentrations in streams that drain watersheds. Lead tends to be immobilized by the organic component in soil and remains bound to the soil, thus inhibiting migration to groundwater.

Lead entering a river is rather rapidly transported to the sea. In the course of downstream dispersion, some lead may be removed by transfer to sediments on the river bed. During periods of high flow, some of this deposited lead may become resuspended and enter the water in suspended solids. Water in lakes and reservoirs is not subject to such energetic processes, and transfer is likely to be solely out of the water column.

For marine waters, inputs from rivers, sea outfalls and the atmosphere are dispersed and diluted by mixing with cleaner sea water from deep ocean areas. Lead also tends to precipitate in the rather alkaline waters of the sea, and will deposit into sediments on the sea bed. In estuarine zones, where freshwater and sea water mix, enhanced precipitation of lead into estuarine sediments, or occasionally removal of sediment to the sea, may occur.

In general, lead decreases in concentration from rainwater (generally acidic; about 20 µg/l lead) to freshwater (generally neutral; about 5 µg/l lead) to sea water (alkaline; below 1 µg/l lead). In the course of this decreasing concentration gradient, lead is removed to bottom sediments which provide a long-term sink in which the metal is stored in a relatively unavailable form.

Concentrations of lead in rivers are mainly dependant upon local source inputs, as residence times are short. The local geochemistry may also be important. In areas of lead

mineralization, rivers can contain lead concentrations as much as ten times higher than in unmineralized areas. In areas without lead mineralization, background levels of lead in the water tend to be very low, and normally well below 10 µg/l. When point source inputs of lead enter a river, downstream concentrations may be appreciably elevated.

It is not only the concentration of lead in the effluent which influences the final concentration in the river, but also the relative flow rates of the effluent stream and river and the chemical properties of the receiving water body (for example, water hardness, pH). Point source effluents may have an appreciable impact on water quality. Storm runoff waters, especially from roadways and other paved areas, may contain appreciable levels of lead in excess of 400 µg/l (Harrison et al., 1985) and these may cause significant incremental pollution of surface waters where dilution capacities are limited.

Alexander and Smith (1988) have reported trends in lead concentrations in major rivers in the United States. At about one-third of sites, declines in dissolved lead concentrations were statistically significant. This was attributed primarily to reduced usage of leaded gasoline. For example, the Potomac River in Washington, D.C. showed a decline in dissolved lead from 5 to 2.5 µg/l between 1974 and 1985.

Infiltration of rainwater into groundwaters and entry into aquifers normally involve passage through soil. Rainwater can contain appreciable concentrations of lead. These, however, diminish on passage through the soil, as lead binds to soil minerals and humus. Groundwaters therefore normally contain very low concentrations of lead, typically below 10 µg/l.

Coastal waters are subject to appreciable inputs both from rivers and from sources such as sewage sludge dumping, sewage outfalls and atmospheric deposition. Because of limited dispersal rates, concentrations of lead in coastal waters closely reflect riverine inputs containing lead from areas of mineralization, as well as from industrial, automotive and domestic sources. In general, seawater concentrations observed are below those of river waters.

In the remote ocean, seawater has no immediate aquatic inputs of lead and only a modest input from the atmosphere. Due to very long residence times, suspended solid concentrations are very low. For these reasons lead concentrations are extremely low, much less than 1 µg/l.

2.3.1 Physico-chemical Speciation

The most important forms of lead in environmental waters are: free and solvated lead ions and ion pairs (highly mobile and available); organic complexes with dissolved humus materials of a wide range of molecular sizes (binding is rather strong and limits availability); lead attached to colloidal particles such as iron oxide (strongly bound and less mobile when available in this form than as free or solvated ions); and lead attached to solid particles of clay, or to dead remains of organisms (very limited mobility and availability).

The identification of different physico-chemical species of lead is very difficult and currently an area of much research activity. In acidic waters, lead is more likely to be present as free or solvated ions and ion pairs, and to be both mobile and available for uptake. In less acidic environments, it will tend to form one of the less available species and may precipitate to the bottom of a river, lake or sea. Thus, acidic lead-bearing effluents are normally neutralized or made alkaline before discharge, so as to precipitate the lead and reduce its mobility. Once lead enters a

watercourse, it will progressively adjust its speciation to reflect the conditions of the water (Laxen and Harrison, 1983). Since most surface waters are neutral or alkaline, lead will tend to associate with less mobile physico-chemical forms. An exception is mine drainage water, which can be strongly acidic and can sustain high concentrations of dissolved lead. Mine effluent can, however, be treated by lime neutralization to control the discharge of contaminants.

2.3.2 Lead in Drinking Water

Water for potable supplies is normally derived from surface freshwater or groundwater sources, which in most cases have a lead content of less than 10 µg/l. Water treatment prior to distribution does not normally add to this amount, and usually reduces the lead content (often by as much as 50 per cent).

In the United Kingdom, it has been concluded that nearly all the lead in tapwater is derived from sources of contamination in domestic pipes and storage tanks. Mains water is virtually free from lead (Royal Commission on Environmental Pollution, 1983). Concentrations of lead in UK drinking water were the subject of an extensive survey in 1975-76 (Department of the Environment, 1977). This survey revealed higher concentrations in first draw samples than in well flushed, daytime samples. Lead concentrations even in the latter kind of sample were well in excess of those in water leaving the treatment works.

Many first draw water samples (i.e water which has stood in the pipe overnight) show concentrations in excess of 50 or even 100 µg/l. This problem arises from the leaching of lead from the distribution system and domestic pipework and lead-containing fittings and faucets: a process known as plumbosolvency (DeMora and Harrison, 1984). It is particularly acute where lead pipes are used. The most plumbosolvent are soft, acidic waters; these are now treated with lime to neutralize the acidity prior to entering the distribution system. Very hard waters can also be plumbosolvent, and these are dosed with orthophosphate at the treatment works to reduce the solublility of lead (Sheiham and Jackson, 1981).

Average lead levels in drinking water in the United States ranged between 10 and 30 µg/l, but the combination of corrosive water (i.e. soft or acidic) and lead pipes or lead soldered joints in distribution systems or houses created localized zones of high lead concentrations up to 380 µg/l (US EPA, 1989c). The combination of new solder and corrosive water can result in even larger concentrations.

2.4 Lead in Soil

In rural and remote areas, lead in soil is derived mainly from natural geological sources and lead concentrations reflect those of the underlying bedrock or transported parent material. Some rocks, such as marine black shales, may contain up to 200 µg/g lead (see Section 2.1). Phosphates can also be particularly rich in lead, with phosphorites containing on average 50 µg lead/g (Nichelatti, 1992; Altschuler, 1980). Where soils are derived from mineralized rocks, natural concentrations may range from several hundred to several thousand µg/g lead.

As lead accumulates in soil, where it is relatively immobile and has a long residence time, present-day amounts of lead in surface soils largely reflect anthropogenic inputs arising from

industrial, urban and agricultural activities. Nriagu and Pacyna (1988) have estimated that the inputs worldwide for 1983 total 479 000-1 113 000 tonnes per year (**Table 2.3**). They show important sources of lead arising from atmospheric fall-out, the disposal of commercial products, fly ash from the coal burning power industry, and urban refuse. It is considered that the total annual input of lead to soils has declined since 1983, given the reduction that has occurred in lead emissions from mobile sources.

Appreciable inputs to land arising from mine tailings and smelter wastes nearly equal all other sources combined. Nriagu and Pacyna (1988) calculated that uniform dispersion over a cultivated land area of 16×10^{12} square metres would result in an application of lead to soil of around 50 g/ha/yr. It should be noted that inputs are not uniform, and that lead enhancement in soil is most marked in the vicinity of specific industrial and mining activities and in urban areas. However, such local and regional contamination occurs on a frequent enough basis to make the problem of soil lead contamination of widespread interest.

Concentrations of lead in soil range widely, depending on the nature of the parent material, land use, and location in relation to deposition from industrial, automobile and urban emissions. This is illustrated by data compiled for over 1500 agricultural soils from England and Wales (Archer and Hodgson, 1987) in which the highest lead contents are in areas contaminated by historical mining and smelting. Regional patterns of lead in the surface environment have been clearly shown by published geochemical maps, such as that in the Wolfson Geochemical Atlas of England and Wales (Webb et al., 1978) and a similar German geochemical atlas. Both atlases focus on areas with elevated lead levels due to mining, smelting and other industrial activities. In Britain alone it has been estimated that some 4000 square miles are affected by historical mining and smelting (Thornton, 1980).

Typical values for "uncontaminated" rural soils have been reported as 15-106 µg/g, with a geometric mean of 42 µg/g in the UK (Davies, 1983) and from 2780 soils a geometric mean of 48 µg/g in England (McGrath, 1986). In comparison, Holmgren et al. (1983) reported values for over 3000 surface soils from cropland in the United States, where the median concentration of lead was 11 µg lead/g and the mean 18 µg/g. It may be concluded that the relatively high values found in the United Kingdom compared with those in the United States indicate widespread low-level contamination over the centuries of industrial and metallurgical activity.

Several investigations have provided clear evidence of elevated lead concentrations in urban soils compared with those in rural and agricultural situations. In the United States, a study of city parks (where children are likely to be in contact with soil) recorded soil lead levels of between 200 and 3300 µg/g (US EPA, 1989). A comprehensive survey of lead in urban garden soils from 53 representative towns and city boroughs in the United Kingdom confirmed elevated concentrations of lead in surface garden soils, compared with agricultural soils (Culbard et al., 1988). Lead concentrations ranged from 13 µg/g to 14 100 µg/g (geometric mean 230 µg/g) in locations excluding London and areas affected by mining and smelting. In seven London boroughs, the mean value was 654 µg/g lead. Garden soils in lead mining villages in Derbyshire ranged from 1180 to >20 000 µg lead/g (geometric mean 5610 µg/g), and would seem to pose a special "geochemical hotspot" problem in terms of environmental exposure of local populations.

A major mechanism of soil and sediment contamination is atmospheric deposition of lead (Nriagu, 1978a; Nriagu and Pacyna, 1988). The concentration of lead in soils near highways is related to traffic density, local meteorological conditions, vegetation and topography. In general, lead concentrations decrease with distance from the highway and with depth in the soil column (Nriagu, 1978a). Lead soil concentration is greatest within 10 metres of the road and within the top

one to five centimetres (US EPA, 1989).

Table 2.3 Worldwide Emissions[1] of Lead into Soils (1983) (kg x 10^6)

Source category	
Agricultural and food wastes	1.5-27
Animal wastes, manure	3.2-20
Logging and other wood wastes	6.6-8.2
Urban refuse	18-62
Municipal sewage sludge	2.8-9.7
Miscellaneous organic wastes including excreta	0.02-1.6
Solid wastes, metal manufacturing	4.1-11
Coal fly ash, bottom fly ash	45-242
Fertilizer	0.42-2.3
Peat (agricultural and fuel use)	0.45-2.0
Wastage of commercial products	195-390
Atmospheric fall-out	202-263
Total input to soils	**479-1113**
Mine tailings	130-390
Smelter slags and wastes	195-390
Total discharge on land	**808-1893**

[1] Current estimates (1992) would be lower, given the reduction that has occurred in airborne emissions of lead from mobile sources. Many of these emissions are localized due to the nature of the particulate matter.

Source: Nriagu and Pacyna (1988).

A typical picture of lead accumulation in soils along a highway is demonstrated in a study in Belgium by Deroanne-Bauvin et al. (1987). Lead was enriched in a relatively narrow zone along either side of the road, and its distribution was shown to be influenced by the distance from the road, duration of exposure, traffic density, climatic conditions, profile of the road, and state of growth of vegetation.

Lead concentrations associated with stationary sources are dependent on rate of release from source, dispersion, and deposition rate; generally, the concentration of lead in soil decreases exponentially downwind of a point source (Nriagu, 1978a, b). Concentrations are usually highest within three kilometres of a point source (US EPA, 1989).

There are numerous published results showing elevated concentrations of lead and other metals close to and downwind of industrial smelting and refining operations in the United States. Typical results are given in **Table 2.4**.

Table 2.4 Metal Concentrations in Surface Soils Adjacent to an Industrial Smelting Complex

Distance from stack (km)	Soil lead (µg lead/g)
0.65	1525
1.3	925
4.0	190
7.3	85
control	16

Source: US EPA (1979).

Soil contamination can arise as a result of the mining, storage and transport of the mineral ores and from associated waste materials such as tailings and spoil heaps. Colbourn and Thornton (1978) found high concentrations of lead in agricultural soils of a historical mining district in the United Kingdom, ranging from several hundred to several thousand µg lead/g over about 250 km^2. Contamination of mine soils has been reported from several other parts of the world, including Italy (Leita et al., 1988).

Continuous applications of sewage sludge to land results in an accumulation of lead in soil. The lead content of sludges is very variable and depends on the amounts of industrial effluents and waste incorporated. Typical sludges contain <1000 µg lead/g. Every effort is now made to lower lead content to meet the requirements of legislation. Soil receiving heavy sludge applications over a long period was found to contain 425 µg lead/g compared with 47 µg lead/g in an unsludged soil (Beckett et al., 1979). The possibility that lead might accumulate in crop plants to dangerous levels has led to several countries drawing up guidelines for sludge use. For example, in the United Kingdom a maximum waste permissible concentration for lead in soils of

300 mg/kg dry solids after application of sewage sludge has been established, along with an average annual rate of addition of lead amounting to 15 kg/ha calculated over a ten-year period. In Germany, the lead content of sludge should not exceed 900 µg/g dry sludge and, if soil contains >100 µg lead/g, sludge should not be applied. There is, however, a general conclusion that lead in soil derived from applied sludge has only low availability to plants.

House paint containing lead can significantly contribute to concentrations of lead in soils. The US Department of Housing and Urban Development (1990) estimated that 18 per cent of privately owned housing units have soil lead levels above EPA guidelines of 500 µg/g, while 27 per cent of public housing units with lead-based paint have soils exceeding guidelines.

2.4.1 Chemical Species of Lead in Soils

The main components of lead in soil are the soil solution, the absorption surfaces of the clay-humus exchange complex, precipitated forms, secondary iron and manganese oxides and alkaline earth carbonates, the soil humus and silicate lattices. For example, kaolinitic clay can absorb up to 2500 µg lead/g (Wedepool, 1970; Nichelatti, 1992). Soil solution is the immediate source of lead for plant roots. The results of analysing soil solutions derived from lead-contaminated soils reported by Gregson and Alloway (1984) show that only a very small portion of the soil lead is present in solution. However, the concentrations reported are some 1000 to 100 000 times higher than those recorded for non-contaminated soils. In heavily polluted soils, part of the lead was present as a high molecular weight organo-lead complex and the proportion represented by this form was greater in soils of higher pH. From acid soils cationic forms of lead were predominant, accounting for as much as 95 per cent of lead in solution. In a carbonate-rich soil, neutral species predominated (Alloway et al., 1984). The level of lead in soils (as well as in water) is controlled by lead carbonate across the whole range of pH. In very acidic soil the controlling role of phosphate appears predominant, whereas in a reducing medium, like that provided by wetlands, sulphide conrols the lead concentration (Nriagu, 1984).

While many metals are converted to organic forms by micro-organisms in soil, there is little evidence to suggest that the natural production of methylated lead has any general environmental significance.

It has been suggested that acidification of the surface environment may influence the chemical species of metals present, their transport pathways and cycling (Ward, 1985). There is as yet no evidence that acid precipitation is influencing the chemistry and transport of lead in the soil environment.

Recent studies in an old lead mining district in central England, in which some garden soils contain one per cent or more of lead, have shown that long-term weathering of the lead ore galena (PbS) has resulted in the formation of pyromorphite, a stable soil-lead mineral with an extremely low solubility and thus low bioavailability (Cotter-Howells and Thornton, 1991). The presence of this mineral was used to explain the normal blood lead concentrations in young children exposed to these heavily contaminated soils.

2.4.2 Lead Availability and Uptake into Plants

Although various soil parameters can affect the availability of lead, the total amount of the

element present is one of the major factors affecting the lead content of plants. It has been found by many workers that there is a positive linear relationship between lead concentrations in plant and soil, and that this relationship exists for a wide range of uncontaminated and contaminated soils (Davies and Thornton, 1989). At higher soil lead levels, however, plant uptake has been found to decline with increasing soil lead concentrations and a curvilinear relationship has been reported. There is general agreement that only a small proportion of the lead in soil is available for uptake by plants (Davies and Thornton, 1989).

The amount of lead absorbed by plants depends not only on the total lead content of the soil, but also on its chemical form. For example, Alloway and Morgan (1986) found that lead in soils contaminated with inorganic sources, such as metalliferous mining and smelting, tended to be more readily accumulated by vegetables than that from soils amended with sewage sludge.

Many researchers have attempted to predict the uptake of lead by plants using soil extractants such as nitric acid, ammonium acetate, calcium chloride and others. In addition to extractant type, factors such as soil properties and plant species have also been shown to affect the prediction of plant concentrations (Adriano, 1986). Attempts so far have met with limited success, primarily because relatively little is known about which factors control the availability of metals at the root-soil interface. Enough is known, however, to suggest that empirical relationships that attempt to relate metal uptake directly to soil concentrations need to take into account soil pH, organic matter content and major ion status (Davies et al., 1987). Soil pH is one of the most important factors affecting the solubility, mobility and bioavailability of lead (Adriano, 1986).

Other soil factors influencing the bioavailability of lead include cation exchange capacity, organic matter content, soil texture and clay mineralogy, redox potential, and the levels of other elements including the nutrients phosphorus, sulphur and nitrogen and the heavy metal cadmium.

Plant species differ widely in their ability to absorb, accumulate and tolerate lead. For example, Alloway and Morgan (1984) found that of all soil types, the percentage accumulation was higher in the leafy crops, lettuce and cabbage, than in the root crops, radish and carrot. Phytotoxicity may occur for ray-grass or radishes if grown in limonitic soils containing more than 200 µg lead/g or sandy soil with between 150 to 200 µg lead/g (Gomez, 1982; Nichelatti, 1992). In addition, there is little doubt that lead of atmospheric origin can contribute significantly to the lead content of field crops (Chamberlain, 1983). Even in rural regions of Denmark, aerially derived lead has been shown to account for 90-99 per cent of the lead found in grass (Tjell et al., 1979). However, the degree to which lead deposited on plant foliar surfaces is actually absorbed by the plant and subsequently translocated within it is still a matter for debate.

A proportion, typically around 50 per cent, of the lead content of vegetables and fruit crops can be removed by washing. Much of the remainder is incorporated into the cuticle and cell walls of the leaves or peel. It appears that much of the lead deposited on the leaves may be present as a surface coating which is not absorbed into the plant (Moir, 1992). In the case of root crops, the importance of aerially derived lead to the lead content of their edible portion is probably slight, whereas in leafy crops it may be more important, particularly in areas of high atmospheric lead deposition.

2.4.3 Lead Intakes by Grazing Animals

Grazing animals such as sheep, cattle and horses can ingest large quantities of soil. In winter, when the soil is wet and the herbage is short, cattle and sheep may ingest up to 30 per cent of their dietary intake of dry matter as soil (Thornton and Abrahams, 1981). Because many soils contain up to several thousand µg lead/kg, these animals will normally have much higher intakes of lead than non-herbivorous animals. In areas of previous metalliferous mining and smelting, it has been demonstrated that the largest proportion of total lead intake by grazing livestock was acquired directly by the involuntary ingestion of lead-contaminated soil.

2.5 Lead in Dust

The general consensus is that the results from numerous investigations over the past two decades point to the presence of elevated lead concentrations in dust, both external to and within the home. Exposure to lead in dust can occur through ingestion, especially likely in children, or inhalation of resuspended dust.

Deposition of airborne lead from leaded gasoline combustions and stationary sources such as smelters are the major contributors to dust lead in the outdoor environment. An additional major source of lead in dust is the peeling and flaking of lead-based paint. Lead in dust is found primarily as sulphate, along with small amounts of oxide and halide salts (US EPA 1989). The lead particles are usually large, ranging between 40 and 1000 µm (US EPA, 1989). Unlike lead that is incorporated into soils, lead in surface dusts is mobile and will decrease with declining input, precipitation, wind, and street and housecleaning.

Typical lead levels in street dust in the United States range from 80-130 µg/g in rural settings to 100-5000 µg/g in urban settings (US EPA, 1989). House dust ranges from 50-500 µg/g in rural settings to 50-3000 µg/g in urban settings to 100-20 000 µg/g near point sources of lead such as smelters.

A 1981 study of roadway dust in the United Kingdom found lead levels in urban street dust to average between 1000 and 4000 µg/g, while rural street dust contained lead concentrations of 440 µg/g (Harrison et al., 1985). An extensive study of household dust in the UK in 1981 and 1982 found a geometric mean of lead concentration in house dust of 561 µg/g, with around 10 per cent of homes exceeding 2000 µg/g (Thornton et al., 1990). The geometric mean for house dust in London exceeded 1000 µg/g. In a subsequent investigation, the concentration of house dust in 1985 in the city of Birmingham was found to be 424 µg/g. Both of the UK sampling efforts were conducted before mandated reductions of lead in gasoline, so current concentrations may well be lower.

An environment survey conducted by the German Ministry for Environment in 1991 showed a median lead content in indoor dust (dust deposit, element concentration in the dust bag of a vacuum cleaner) of 0.42 µg lead/m^2/day. Where the neighbourhood was of the apartment block type without green areas, inhabitants were found to be exposed to higher dust deposits, containing almost all elements investigated, than inhabitants of areas with less compact construction and more green areas.

As discussed above, the presence of lead-based paint in dwellings is also associated with

dust and soil levels in dwellings. The US Department of Housing and Urban Development (HUD) guidelines state that dust concentrations in homes should not exceed a clearance level of 200 µg/ft^2 on the floor, 500 µg/ft^2 on the window sills, and 800 µg/ft^2 on window wells (US HUD, 1990). A 1990 HUD study estimated that 10.7 million homes had dust levels exceeding one or more HUD guidelines, and that 1 million had concentrations exceeding HUD guidelines on the floor, where children are most likely to come into contact with dust (US HUD, 1990).

In the UK National Survey of Metals in Dusts and Soils (Culbard et al., 1988), a highly significant relationship was found between lead concentrations in house dusts and garden soils, though there was more lead in house dust than in surface soil, indicating the importance of internal sources such as paint. In this study it was proposed that around 25 per cent of indoor dust originated from garden soil.

There is general agreement that, in many cases, local lead contamination of the outdoor environment, around both primary and secondary lead smelters and lead processing plants, results in enhanced lead concentrations in dusts within the home.

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CHAPTER 3

LINKAGES TO EXPOSURE

3.1 Introduction

The primary routes of human exposure to lead are inhalation and ingestion (of water, food, paint, soil and/or dust). The relative importance of any single source of exposure is difficult to predict and will vary with geographic location, climate and local geochemistry. Similarly, the intensity of exposure experienced by an individual can vary as a function of age, sex, occupation, socio-economic status, diet and cultural practices. In addition, the amount of lead taken up into the body is believed to vary depending on the concentration and composition (for example, particle size, chemical form) of the lead inhaled or ingested.

Some countries monitor levels of lead in environmental media, as well as in blood, as a basis for assessing risks of exposure and the effectiveness of measures to reduce these risks. Trend data have also been used to link anthropogenic sources of release to human exposures. However, it should be noted that even strong correlations do not necessarily prove a linkage with a given source, as most countries have taken multiple measures to reduce risks from exposures.

The following section briefly describes the pathways of human exposure to lead (see also **Figure 19**). In Section 3.4, trends in lead concentration in various environmental media (as well as in food and blood) in some OECD countries are examined. The information in that section was received from government agencies, academia and industry. Explanations for variations in trends were sometimes also provided. In some cases, a rise or fall in blood lead levels was linked to changes in demand for specific lead-containing products. This linkage was generally demonstrated by correlating trends for lead in blood and demand for products with trends in the concentration of lead in air, food, etc.

The information presented in this chapter is as received. No attempt has been made to correlate data between countries, due to variations in survey methods and other confounding factors.

3.2 Pathways of Human Exposure

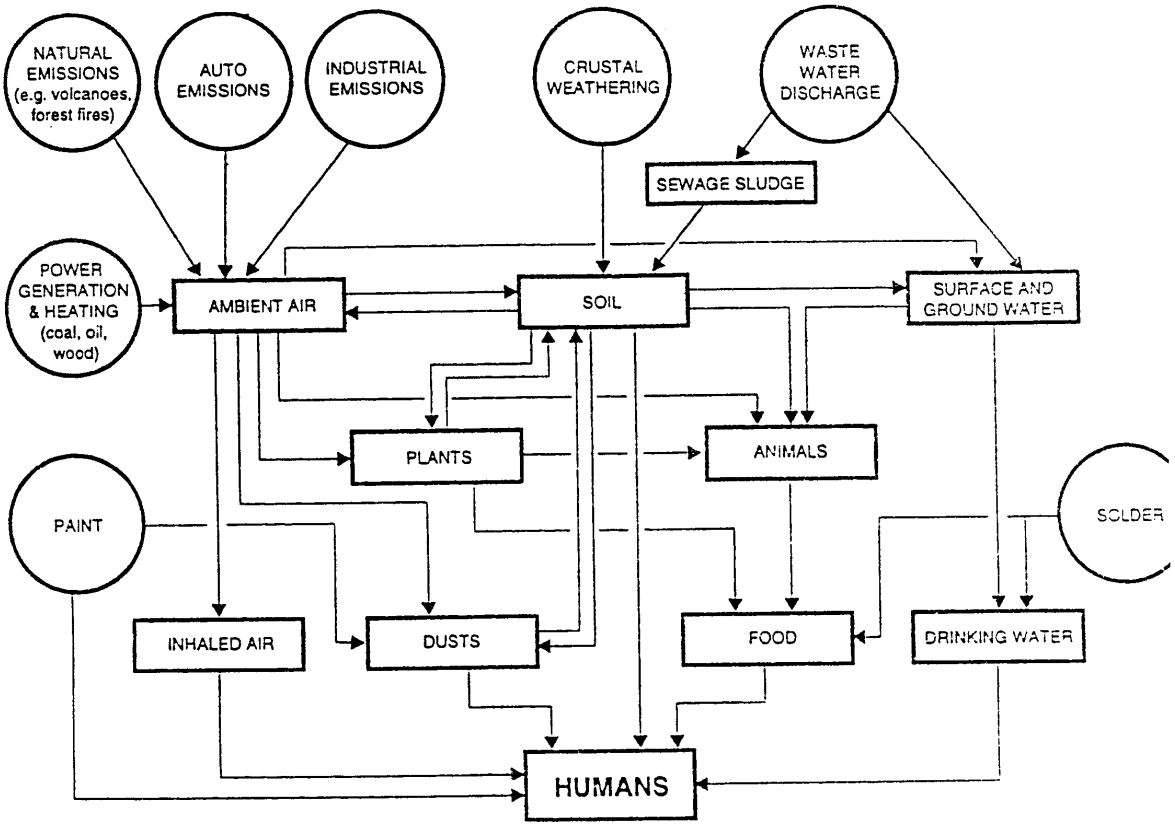
3.2.1 Lead in Paint

Lead in paint constitutes a major source of bioavailable lead in the environment. Although many OECD countries have banned or restricted the use of lead in interior paints, there remains a huge reservoir of contaminated material in existing structures where leaded paint has been used. Children are especially susceptible to exposure to lead in paint. They may chew on pieces of peeling or flaking paint, or may ingest house dust generated as a result of deterioration of indoor paint, restoration, rehabilitation work, and garden soil contaminated by deteriorated leaded exterior paint. The US HUD (1990) has estimated that 57 million privately owned and occupied homes built before 1980 have lead paint; of these, 9.9 million are occupied by families with children under the age of seven. An estimated 3.8 million homes occupied by young children have deteriorated paint

(i.e. peeling or flaking).

Figure 19

Pathways of Human Exposure



3.2.2 Lead in Soils/Sediments

Lead accumulates in soils and sediments. Loading can occur from both natural sources (for example, local geology, volcanic activity, sea spray, forest fires, etc.) and anthropogenic sources such as agricultural and food wastes, logging, urban refuse, municipal sewage sludge, solid wastes, coal and fly ash, fertilizer, commercial product wastes and atmospheric fall-out. Lead-based house paint can also significantly contribute to soil concentrations of lead. Children may contact lead-bearing soils during outdoor play; in addition, contaminated soils may be tracked indoors on shoes, clothing, etc. A major mechanism of soil and sediment contamination is atmospheric deposition of lead from gasoline combustion and from stationary sources.

Lead is retained in soil in organic complexes or adsorbed to hydrous oxides near the soil surface. The mobility of lead in the soil depends on the soil pH and organic content. In general, lead's relative immobility in soil tends to decrease its bioavailability to humans and other terrestrial life. However, its immobility also increases its residence time in soils.

3.2.3 Lead in Dust

Dust is found both in the home and in the outdoor environment. Exposure to lead in dust can occur through ingestion, especially likely in children, or inhalation of resuspended dust. Depositions of airborne lead from leaded gasoline emissions and from stationary sources, such as smelters and coal-powered generating stations, are the major anthropogenic contributors of dust lead in the outdoor environment. An additional major source of lead in dust is the peeling and flaking of lead-based paint. Lead in dust is found primarily as sulphate, along with small amounts of oxide and halide salts (US EPA, 1989). Unlike lead that is incorporated into soils, lead in surface dusts is mobile and is believed to decrease with declining input, precipitation, wind, or street and housecleaning.

Accidental ingestion of dust or soil (dirt) by hand-to-mouth activity is an important source of lead exposure to young children.

3.2.4 Lead in Food

The ingestion of food is a major component of most individuals' total lead uptake, although the relative contribution is a function of one's size, body weight, age and type of diet. The occurrence of lead in the diet may be a result of: a) natural sources of lead; b) deposition of airborne lead particles onto crops, forage, feed, soils and water; and c) harvesting, processing, transport, packaging, preparation and storage of food. The concentrations of lead in foods are typically less than 100 µg/kg fresh weight, though certain foods can reach much higher concentrations (Sherlock, 1987; Dabeka and McKenzie, 1987, 1988; US EPA, 1989). In the 1980s in the UK, the majority of foods contained less than 50 µg/kg (Sherlock, 1987).

Canned foods often have much higher concentrations of lead than foods packaged in another manner. The US EPA estimated that about 42 per cent of lead in food comes from lead soldered cans or other metal sources (US EPA, 1986), though this contribution should now be less. Canned food may absorb substantial quantities of lead from lead solder used to seal the can, especially if the food is at a low pH. Foods packed in lead soldered cans may have lead levels as high as 100 to 400 µg/kg, or five to 30 times the lead content of frozen or fresh foods (US EPA,

1989).

Atmospheric deposition is also another important source of lead in food. In the United Kingdom, deposited lead on soil and crops is estimated to contribute 13 to 31 per cent of the total dietary consumption of lead by children (Ministry of Agriculture, Fisheries and Foods, 1989). In the United States, 45 per cent of lead in a typical diet is assumed to originate from depositions (US EPA, 1986). Foods with high surface areas (such as spinach) also tend to have higher concentrations of lead due to atmospheric deposition. In the UK, a series of surveys between 1983 and 1987 failed to demonstrate any consistent decline in the lead content of vegetables which might have been associated with the reduction in lead content of petrol within the same period. Cooking food in lead-contaminated water can elevate lead concentrations in food. Sherlock (1987) reported that every 10 µg/l in water increased the lead concentration in cooked vegetables by about 6 µg/kg.

Other sources of lead in foods include leaching from ceramic containers in which lead glazes have been used, contamination of roadside fruits such as blackberries with vehicle-derived lead, uptake of lead from lead-rich urban garden soils into home-grown vegetable crops, and uptake of lead into crops from sewage sludge applied to farmland.

3.2.5 Lead in Water

Lead is a natural, usually minor constituent of surface and groundwaters. Anthropogenic input of lead to aquatic ecosystems can occur from sources such as effluents from mining, smelting, refining and manufacturing processes or the dumping of sewage sludge and atmospheric fall-out. Lead deposited from the atmosphere can enter aquatic systems through direct fall-out or through erosion of soil particles. In general, there is little correlation between lead concentrations in rain and snow and concentrations in streams that drain watersheds.

Lead tends to be immobilized by the organic component in soil and remains bound to the soil. For the same reason, the migration of lead to groundwater is inhibited. In surface water, qualities such as pH and hardness influence lead content.

Lead concentrations in drinking water result primarily from lead leaching from water delivery systems (i.e. water mains, connecting pipes and in-house plumbing), and from previously contaminated drinking water sources. Plumbing systems may contain lead pipes, lead soldering, and bronze or brass fittings. Corrosion of these materials, aggravated by water with low pH, and subsequent leaching into the drinking water can contribute significant quantities of lead in systems where these materials are used (US EPA, 1989).

The physical and chemical form of lead in water has a strong influence upon its toxicity (Prosi, 1989). For instance, a dissolved ion of lead is highly mobile and readily transported into the human body if ingested. At the opposite extreme, a large suspended particle of lead sulphide is of low mobility as it will rapidly settle out and, if ingested, is very poorly absorbed.

3.2.6 Lead in Air

Lead in air can be inhaled or, as previously mentioned, can be deposited in the form of dust on soils, water and food crops. Loading to air can occur from natural emissions (for

example, volcanoes, forest fires, etc.) and anthropogenic releases such as gasoline combustion, coal burning or industrial emissions.

The health effects of respired lead are dependent upon particle size. A high proportion of inhaled small particles (less than 2.5 µm) is deposited in the deepest alveolar portion of the respiratory system (Hinds, 1982), from which lead is absorbed with almost 100 per cent efficiency into the bloodstream. Particles in the range 2.5 to 10 µm most typically deposit in the tracheobronchial and naso-pharyngeal region, from which they are elevated and swallowed. Absorption of lead through the gastrointestinal tract is far less efficient in adults (8 to 10 per cent) but can be up to 50 per cent in children. Thus, a large proportion of lead in these sizes does not enter the bloodstream (Chamberlain and Wiffen, 1978). Particles of greater than 10 µm enter the nose with only low efficiency and do not represent an appreciable inhalation hazard unless present in very high concentrations. Such particles can, however, contribute to the lead content of surface dusts and soils.

3.2.7 Lead in the Workplace

Occupational exposures to lead have been noted in various industries, such as inorganic pigments manufacturing; primary and secondary lead metal processing; brass, bronze and copper foundries; battery manufacturing; machinery manufacturing; electronic capacitors manufacturing; auto repair services and garages; bridge, tunnel and elevated highway repairs; stone, glass and clay products manufacturing; munitions manufacturing; and firing ranges (Maizlish et. al., 1990). In addition, lead exposures can occur during renovation and abatement of lead-painted homes and other structures. Para-occupational exposures occur when lead in the form of dust is easily carried out of the workplace (on clothing, shoes, etc.) and into worker residences, where spouses and children of lead workers can then be exposed.

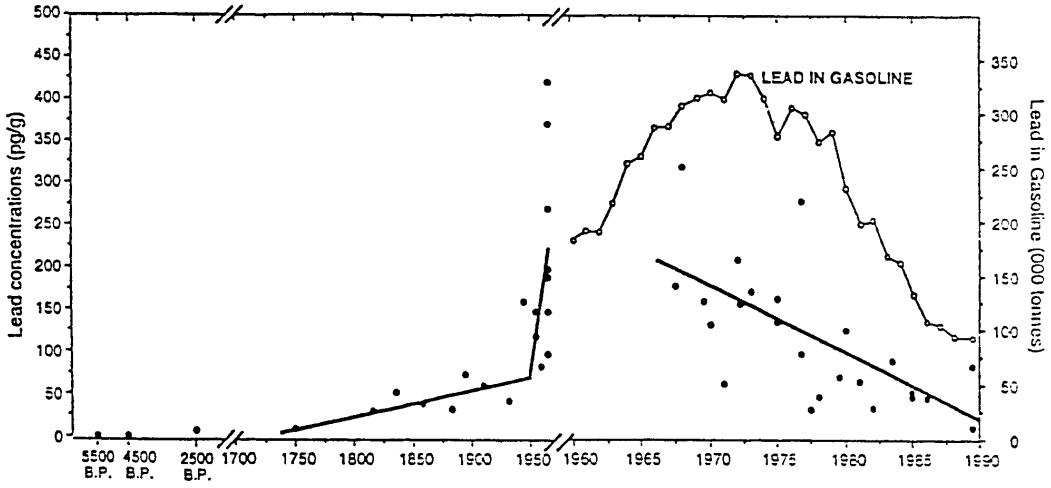
3.3 Global Baseline Data

Because of regional disparities, there is very little baseline or trend data for lead concentrations in environmental media on a global or long-term scale. However, an attempt has been made to establish historical baseline data on lead concentrations in the atmosphere by analysing core samples of Greenland ice dating back as far as 5500 years before the present. The graph in **Figure 20**, based on data collected in two studies (see Boutron et al., 1991), indicates that concentrations of lead in ice began to increase in the eighteenth century, possibly reflecting the beginning of industrialization.

Superimposed on the graph is the trend in demand for lead used in gasoline in OECD countries. These countries account for the majority of the world's production of leaded gasoline. As the graph suggests, there appears to be a correlation between decreased use of lead in gasoline and lower lead concentrations in the ice after 1972. However, the demand for lead in gasoline is shown to have been at its highest in 1972, about 20 years after the highest concentrations of lead in the ice shown here.

Figure 20

Lead Concentrations in Snow and Ice
Greenland
and OECD Usage of Lead in Gasoline



B.P. - Before Present
Sources: Boutron et. al., 1991; ILZSG 1992a.

3.4 Country Data

Figures 21-58 presenting country data follow this section.

3.4.1 Australia

Between 1985 and 1988, lead emissions declined in all states and territories, resulting in an average reduction of 18 per cent for Australia (**Figure 21**). More than 90 per cent of these emissions derive from leaded petrol, and the decline has been attributed first to a reduction in the concentration of lead in petrol in 1983 and, second, to the introduction of unleaded petrol containing 0.013 g/l or less of lead. Since 1 January 1986, all vehicles, whether manufactured locally or imported, have been required to operate on unleaded petrol. Although overall emissions have declined, there are concerns relating to specific point source releases, such as smelters, that regularly exceed recommended guidelines.

In Australia's largest capital cities, lead in air levels have declined substantially over the last five to ten years. However, many lead in air levels recorded in recent years were above the National Health and Medical Research Council's recommended maximum of 1.5 µg lead/m^3 (averaged over 90 days) (CEPA 1992).

Since 1977, dietary intakes of lead for all segments of the population have declined dramatically and are well below the Provisional Tolerable Weekly Intake recommended by the WHO (**Figure 22**). For example, the estimated intake for infants has been reduced by 90 per cent. Improvements are believed to be the result of changes to food canning technology and the discontinued use of pesticide sprays, based on lead arsenate, in agriculture.

Blood lead data indicate that in most localities less than 10 per cent of children have blood lead levels greater than or equal to 25 µg/dl.

According to aggregated data, the mean blood lead level of exposed workers declined from 40 µg/dl to 30 µg/dl between 1986 and 1992. During the same period, the proportion of workers with blood lead levels greater than or equal to 50 µg/dl also decreased by 71 per cent (**Figure 23**).

3.4.2 Austria

Since 1970, lead emissions from vehicles have been declining while gasoline consumption has risen steadily (**Figure 24**). It is believed that these opposing trends are a result of the introduction of unleaded fuel and a reduction in the permissible level of lead in leaded gasoline.

Figure 25 indicates that the monthly lead uptake from food did not significantly change during the period 1979 to 1988.

Blood lead levels for the general population declined slightly, to below 25 µg/dl, between 1972 and 1982 (**Figure 26**). According to the Ministry for Environmental Conservation and Protection, more recent measurements show that blood lead levels for occupationally exposed

individuals average 40 µg/dl, while the range for the general population is between 5 and 25 µg/dl.

3.4.3 Belgium

Trend data for the 1980s, where available, indicate that the average levels of lead in air for rural and urban sites have remained relatively constant or have declined, and are well below the maximum permissible level of 2 $\mu g/m^3$ set in an EC Directive (**Figure 27**).

The average blood lead levels for various segments of the population have steadily declined during the 1980s (**Figure 28**). The decline has been, in part, attributed to reductions in the permissible level of lead in gasoline. Trends shown in Figure 28 also suggest that smokers tend to have higher blood lead levels than non-smokers of the same gender.

3.4.4 Canada

The average levels of lead in air have steadily declined over the last few decades (**Figure 29**). The decline has been largely attributed to reductions in the use of lead in gasoline, as lead emissions from other sources (for example, mineral and processing facilities) have remained relatively constant (**Figure 30**). It should be noted that lead emissions from the lead industry were relatively constant during the 1980s, as the majority of reductions occurred when federal and provincial controls were introduced prior to 1978. The reduction of lead in air since 1987 is, in part, attributed to a decline in lead emissions from gasoline combustion and copper-nickel production.

The average blood lead levels for the population at greatest risk from exposure (i.e. children) also declined to about 6 µg/dl in 1988, well below the 25 µg/dl level of concern which is currently under review (**Figure 31**). Although there is a strong correlation between blood lead levels in children and air lead levels, it has been suggested that the decline may also be related to other factors such as a voluntary industry phase-out of lead soldered food cans and a decline in the use of lead in indoor paints.

3.4.5 Finland

Use: In Finland, the total use of lead was about 22 650 tonnes in 1990. The greatest portion, 9 500 tonnes, was used by the battery industry.

Air: The estimated lead emissions to the atmosphere were 286 tonnes/yr in 1990, of which 152 tonnes was from motor vehicles. The total emission has decreased by 36 per cent from the 1988 level, primarily as a result of the decreased use of leaded gasoline. At present, the use of unleaded gasoline is about 70 per cent of the total gasoline use. However, industrial emissions have increased by 19 per cent.

The average airborne lead level in Helsinki has declined sharply from 1 $\mu g/m^3$ in the 1970s to 0.05 $\mu g/m^3$ in 1990 due to the use of low-lead and unleaded gasoline. In more remote areas, the background concentration of lead in the air is 0.005 $\mu g/m^3$.

Atmospheric lead deposition in the snowpack during winter in Finland has also been studied. In southern Finland, it was 4.8 µg/l (mean value) and in northern Finland, 2.2 µg/l in 1990. In the 1970s, the lead deposition in Finland was estimated to be 28.4 mg/m^2 per year. But a

recent climatological model study indicates that the lead deposition in southern Finland varies between 4 to 7 mg/m^2 per year, and in northern Finland between 1.5 to 2.5 mg/m^2 per year.

Water: The discharge of lead into the aquatic environment was calculated to be 2.9 t/yr. in 1990, which is a decrease of 42 per cent from the estimated value of 5.0 t/yr. in 1980.

A recent study on 8 500 water samples from drinking water supply sources revealed that lead concentration in 8 490 of the samples was below 1 µg/l. The remaining ten samples contained about 50 µg/l of lead.

Groundwater samples at 56 stations were studied during 1975-1988. The maximum lead concentration was 80 µg/l with a mean value of 2.8 µg/l.

Snow samples from 54 stations were also analysed between 1976 and 1988. The maximum lead concentration was observed to be 70 µg/l with a mean value of 4.2 µg/l. The mean lead deposition in snowpack was 1.14 mg/m^2 per year, and the range varied between 0.18-42.0 mg/m^2 per year.

Soil: Lead discharged via wastes and other lead-containing materials in soil was estimated to be 5 890 tonnes in 1990. This is an increase of 15 per cent over the estimated discharge for the early 1980s.

The lead concentration in Finnish soil generally varies between 15-20 µg/g, but it can be quite high in industrial and urban areas. The mean lead concentration in cultivated soil was 1.66 mg/l in 1987, which is 16 per cent less than the mean value of 1.98 mg/l observed in 1974.

Foodstuffs, etc.: Dietary intake of lead is 40-60 µg per day. Respiratory air can increase the lead exposure in urban areas by about 5 µg per day (however, absorption via the lungs is greater than via the gastrointestinal tract). Drinking water is of minimal importance, since lead pipes have not been used in Finland. Lead concentration in drinking water is below 1 µg/l.

Blool lead levels: Average blood lead levels have decreased from 11 µg/dl (only men studied) to 2.8 µg/dl (men and women, N = 200) in 1975-1992.

In Helsinki, the average blood lead level of children has decreased from 4.6 to 3.0 µg/dl between 1983 and 1988 (children in day care centres). The maximum level observed was 8.3 µg/dl (N = 35). In the same period, car exhaust emissions of lead decreased by 75 per cent in the capital area.

Occupational health: Blood lead concentration for exposed workers has decreased from about 20 µg/dl to 14 µg/dl (median values) for men between 1973 and 1982. The highest values have decreased from 120-160 µg/dl to 80-90 µg/dl among men, and from 100-110 µg/dl to about 50 µg/dl among women.

3.4.6 France

Surface water: The river authorities monitor the concentration of lead in surface water. Between 1971 and 1986 there was a steady decrease of the proportion of high values over 100

µg/l and a concurrent increase for the medium values 20 to 100 µg/l.

In 1987, monitoring sites were redistributed to include more sites in zones of high risk. This gave a sudden rise in the proportion of measurements of high concentrations for the year 1987. Data obtained after 1987 confirm the previously observed decrease of high concentrations. In 1990, for the first time levels between 50 and 100 µg/l were more frequently measured than levels above 100 µg/l.

Air pollution from automobiles: Emission into air from automobiles is monitored at 24 sites in areas of dense traffic. After implementation of Directive 82/884/EEC by the French authorities, the limit value of 2 $\mu g/m^3$ was never transgressed at any of the sites. One-year averages varied between 0.2 and 1.9 $\mu g/m^3$.

Pollution from industrial souces: The main sectors discharging lead into air and water are non-ferrous smelters, battery plants, and plants manufacturing gasoline additives and regenerating spent oil. Minor discharges stem from iron, steel, copper and bronze smelters, coke production, and municipal waste incinerators.

Yearly discharges into water from ten emitting plants were calculated in the period 1988-1991:

SITE	**LOCATION**	**EMISSIONS IN KG/KJ**			
		1991	**1990**	**1989**	**1988**
1 Octel Kuhlmann	44 Paimboeuf	53.5	40.1	72	
2 Metaleurop	62 Noyelles Godault	18.4	9.1	8.5	662.0
3 Roussel Uclaf	69 Neuville sur Seine	5.0	5.0		
4 Norsk Hydro azote	76 Le Havre	4.4	5.0	5.0	
5 Metaleurop	60 Rieux	3.1			
6 CEAC	59 Lille	3.0	4.6	3.4	1.3
7 SFPO	62 Boulogne	2.1			
8 Verreries d'Arques	62 Arques	1.7			1.5
9 Unimetal Normandie	14 Mondeville	1.5	1.5	1.5	10.0
10 Than & Mulhouse	76 Le Havre	1.1	1.2		1.6

Limit values for discharges of lead into water and air established by ministerial decrees promulgated between 1985 and 1991 are:

water **air**

surface treatment	1 mg/l	1 mg/m^3
waste incinerators	1 mg/l	5 mg/m^3 (Pb, Cu, Cr, Mn)

A ministerial decree applicable to all hazardous installations is being developed. Already all discharges into groundwater are prohibited. A system of auto-surveillance by industry imposes daily or weekly monitoring of discharges when these exceed established thresholds.

Air pollution by lead from industrial sources is monitored at 38 sites. In general, levels found are very low. The only transgression of the established limit value was registered in the vicinity of a battery plant.

Food: The data presented below are based on the results of a monitoring programme conducted in 1978-1979. It was concluded from this study that the average weekly exposures to lead via food are between 25 and 100 per cent of the tolerated weekly dose established by WHO.

Type of Food	Category	Level (ppb)	Consumption (mg/h/y)
Wine		118	11.80
Bread		107	6.19
Potatoes	Fresh vegetables	51	3.14
Eggs		108	1.10
Corned beef	Canned food	411	0.88
Green beans	Fresh vegetables	189	0.80
Sardines	Canned food	711	0.79
Beer		43	0.75
Celery	Fresh vegetables	731	0.73
Lettuce	Fresh vegetables	129	0.73
Green beans	Canned food	214	0.70
Apples	Fresh fruit	37	0.60
Mackerel	Canned food	705	0.56
Butter		70	0.56
Cooked/raw carrots	Fresh vegetables	53	0.55
Rice		140	0.53
Pure fruit juice		141	0.52
Fresh tomatoes	Fresh vegetables	46	0.52
Tuna	Canned food	341	0.46
Brie/camembert cheeses		111	0.45
Breakfast cocoa		369	0.38
Sugar		25	0.37

Blood lead levels: Blood lead levels in infants monitored by the Centre for the Protection of Mothers and Infants established in the north-east of Paris. The data collected between 1987 and 1991 are represented in the following table. They show that 60 per cent of the group of infants studied had blood levels exceeding 15 µg/dl and 10 per cent needed medical care.

Year	Scale of Seriousness					
	< 15 µg/dl	15-25 µg/dl	25-50 µg/dl	> 50 µg/dl	Total	per cent
1987	35	66	60	28	189	7
1988	98	123	82	56	359	14
1989	171	220	115	62	568	22
1990	336	264	115	62	777	30
1991	413	186	66	59	724	28
Total	1053	859	438	267	2617	
per cent	40	17				

3.4.7 Germany

The average concentration of lead in air in rural areas has decreased since 1973 and is well below the maximum tolerable amount of 2 µg/m^3 (**Figure 32**). The reduction has been attributed to the phasing out of lead in gasoline.

Between 1972 and 1985, the lead concentration in the clay fraction of sediments in the Rhine and Elbe rivers also declined (**Figure 33**).

Various studies indicate that average blood lead levels in schoolchildren and adults (male and female) have declined since 1975 (**Figure 34**). The reductions are believed to be a result of the decrease of lead in air. Germany has also phased out the production of lead soldered food cans and prohibited the use of lead-based pesticides and paints, with the exception of anti-corrosive paints for industrial repair coatings.

3.4.8 New Zealand

The current mean blood level is 7 µg/dl. Lead from paint and food and drink containers are the major sources of the New Zealand mean blood level. Petrol lead accounts for 5 per cent. Studies conducted between 1974 and 1984 show that blood lead levels dropped by 40 per cent for adult males and 35 per cent for adult females and children (**Figure 36**). This reduction was attributed to the removal of lead from food and drink containers. Leaded petrol consumption was not considered to be a significant factor in the decline of blood lead levels, as it tended to fluctuate within a relatively stable range during the period (**Figures 35 and 36**). In 1986, the lead content of petrol was reduced from 0.84 g/l to 0.45 g/l but no significant reduction in lead blood level was observed.

3.4.9 Norway

The estimated and known discharges of lead to air, water and soil decreased by about 49 per cent between 1985 and 1990, whereas the quantity of lead disposed of to landfill is estimated to have increased by a factor of 4 during the same period (**Figure 37**). The substantial rise in lead going to landfill has been related to a six-fold increase in disposals from the metallurgical industry. However, the significant decline in lead released to water has been associated with a 98 per cent reduction of lead within metallurgical industry effluent.

The decline of lead emitted to air has been largely attributed to a reduction in the use of leaded petrol. This reduction in lead emissions is believed to have resulted in a decrease of lead in precipitation (**Figure 38**). The only exception is an unexplained temporary increase in lead deposition in southern Norway for 1988. With regard to deposition patterns, a study of lead in moss found that the atmospheric deposition of lead in Norway and other Nordic countries decreased from south to north parallel to population density and intensity of traffic. The study also identified the long-range transport of lead from densely populated areas of central Europe as a contributing factor to lead deposition.

Blood lead levels in Norway are considered to be directly related to the concentration of lead in air. A cohort study in 1983 and 1984 found that, despite low to moderate blood lead concentrations, the inhabitants of a town with moderate traffic pollution had higher blood lead levels than residents of a small town with very little traffic (NILU, 1990). After considering a number of contributing factors, it was recognized that children exposed to passive smoking and adult smokers had higher blood lead concentrations. It was also noted that as lead in air levels declined, the decrease in blood lead concentration was greater in non-drinkers than in individuals who drank small to moderate amounts of alcohol.

3.4.10 Sweden

The levels of lead emitted to air or deposited from air have declined during the last two decades (**Figure 39**). Overall, the amount of lead emitted tends to be less than the quantity deposited. The difference may, in part, be attributed to the long-range transport of lead from densely populated areas in Europe (Nordic Council of Ministers, 1992). Reductions in leaded gasoline are considered to have largely contributed to reduced emissions. However, the reduction of the permissible level of lead in gasoline from 0.4 to 0.15 g/l in 1981 does not appear to have influenced the downward trend in lead emitted to air.

The quantity of lead in effluents entering water has declined by 80 per cent since 1977 and was reported to be 14 tonnes in 1990 (**Figure 40**). It is also reported that atmospheric deposition accounts for 95 per cent of the total anthropogenic input of lead to Sweden's marine area (KEMI, 1992).

Average blood lead levels of children living near smelters or in rural or urban environments have been declining since 1978, to below 5 µg/dl in 1988 (**Figure 41**). Average blood lead levels for the general population in Stockholm also fell to below 6 µg/dl by 1984. Important factors contributing to the decline in blood lead levels were considered to be the reduction in the permissible level of lead in gasoline, a decrease in the use of lead soldered food cans, and improvements in occupational hygiene (KEMI, 1992). In this latter regard, occupational exposures have also declined. The average blood lead level fell by 30 per cent between 1977 and 1989

(**Figure 42**).

3.4.11 Switzerland

The release of lead into the atmosphere is decreasing since 1970 (**Figure 43**). The reduction can be attributed to the phasing out of leaded gasoline as well as to improvements of the flue gas treatment in municipal wate incinerators.

The general population exposure is decreasing since the last decade. This is shown by the MONICA study (MONItoring of trends and determinants in CArdiovascular disease) in which blood lead concentration of men and women of different ages were analysed (FOEFL, 1992).

3.4.12 United Kingdom

The levels of lead in various sludges and industrial waste entering the North Sea from the United Kingdom declined significantly during the latter half of the 1980s (**Figure 46**). An explanation for the variations is not provided.

Concentrations of lead in air at rural and urban sites have declined. One of the greatest drops correlates with a 1985-1986 reduction in the maximum permissible level of lead in gasoline from 0.40 to 0.15 g/l (**Figures 47 and 48**).

The average blood lead concentrations for children, as well as adult females and males, also declined steadily during the mid-1980s, with the average levels being well below the 25 µg/dl level of concern (**Figure 49**). According to the UK Department of the Environment, the reduction in the permissible level of lead in gasoline during 1985 had a minimal impact on the already downward trend in blood lead levels in adults, but did appear to contribute slightly to the decrease of lead in the body burden of children. It was also suggested that the decline reflected a long-term trend that related to several personal, social and environmental factors such as reductions in lead intake from food (**Figure 50**) or water. Two studies in Glasgow and Ayr, Scotland, showed that bottle-fed infants accumulated considerable quantities of lead in response to exposure from lead in water. Since both these studies, the water suppliers have adjusted the pH of the water to 8 and 8.5 to reduce leaching of lead. This resulted in a marked fall in blood lead concentrations in Glasgow mothers (Moore et al., 1981) and a drop in water-lead concentration of around 80 per cent in Ayr (Sherlock and Quinn, 1986).

3.4.13 United States

During the 1980s, the average annual concentrations of lead in air declined at urban and point source sites and are well below the National Ambient Air Quality Standard of 1.5 $\mu g/m^3$ (**Figure 51**). The downward trend has, in part, been related to reductions in emissions from transportation, stationary fuel combustion, industrial, solid waste and other miscellaneous sources (**Figure 52**). Transportation emissions have dropped by more than 98 per cent since 1970. The decline has been attributed to a decrease in the lead content of leaded gasoline from approximately 2 g/gallon (.528 g/l) in the early 1970s to 0.1 g/gallon (0.026 g/l) in 1986 (ENVIRON, 1991). Reductions in emissions at point sources are believed to be related to changes in productivity, process technology and emission control devices.

Lead intake from food for various segments of the population, including children, declined during the 1980s (**Figure 53**). Reasons for the decline range from improved food preparation, canning and hygiene practices to reductions in the level of lead in food crops, which is linked through soil to crustal weathering, lead deposition from air, and/or lead concentrations in irrigation and groundwaters. It has been suggested that the steady decline in the use of lead soldered food cans during the 1980s was a major contributing factor to the decline of lead intake from food (**Figure 54**).

Discards of lead in municipal solid waste (MSW) are estimated to have increased during the last few decades, with batteries identified as the largest contributor (**Figure 55**). However, there is uncertainty about the quantity of lead entering the waste stream. The estimates shown in Figure 52 were based on a materials flow analysis which required assumptions such as the estimated lifetime and recycling rate of a product. Industry assessments of the data indicate that the quantity and relative contribution of discards by end use product can vary substantially and could be much less, depending on the recycling rate used (LIA, 1991). Alternative estimates using concentrations of lead in incinerator ash or actual sampling of MSW suggested that the materials flow method overstates lead discards (LIA, 1991).

According to a national health and nutrition survey, NHANES II, the average annual blood lead level for children declined during the latter half of the 1970s and continued to register well below the level of concern, at the time, of 25 µg/dl for children (**Figure 56**).[2] The decline has been attributed to reductions of lead in air from decreases in lead in gasoline, a voluntary programme by the domestic food industry to discontinue use of lead solder in food cans, and the decline of the use of lead in residential paints (EPA, 1992).

Although overall blood lead levels in children declined, there was statistically significant evidence to indicate that black children had higher blood lead levels. It was noted that urbanization and income were directly associated with lead exposures and that children in high risk categories (for example, inner-city black children in families with low social economic standing) have more complex exposures, such as leaded paint, weathering and chalking, than US children as a whole (Report to Congress, 1988).

Some data suggest that lead exposures had decreased in the US even before the removal of lead in gasoline. **Figure 57** is a scatter plot of US blood lead values from 1935 to 1990 that were sourced by the International Lead and Zinc Research Organization (ILZRO) from litreature referenced in **Appendix A**. Comparison of Figure 57 with **Figure 58** suggests that the decline in blood lead levels is consistent with the reduction in the use of lead in gasoline after leaded fuel demand peaked in the early 1970s, but not prior. The discrepancy in trends may reflect declines in lead exposure from other sources such as paint, drinking water and food. It should also be noted that early blood lead surveys were generally not conducted with the same carefully randomized protocols as later surveys. In addition, older data was generated using a range of analytical procedures without consistent quality controls and the methodology was less sensitive than that employed today. Modern methods also take greater care in blood sampling to reduce the likelihood of contamination during sample collection.

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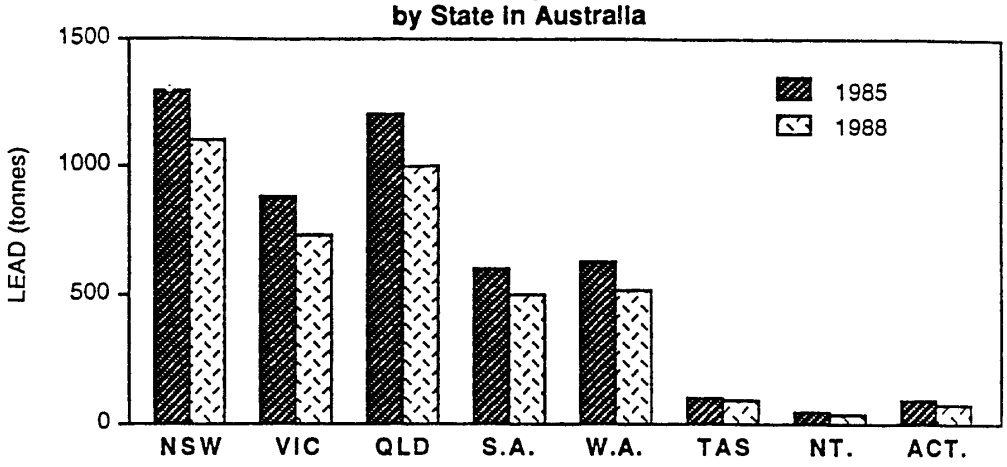
[2] In 1991, the United States adopted a three-tiered system to assess blood lead exposure. Refer to the section in the following chapter on risk reduction measures in the United States.

FIGURES 21-58

COUNTRY DATA

Figure 21

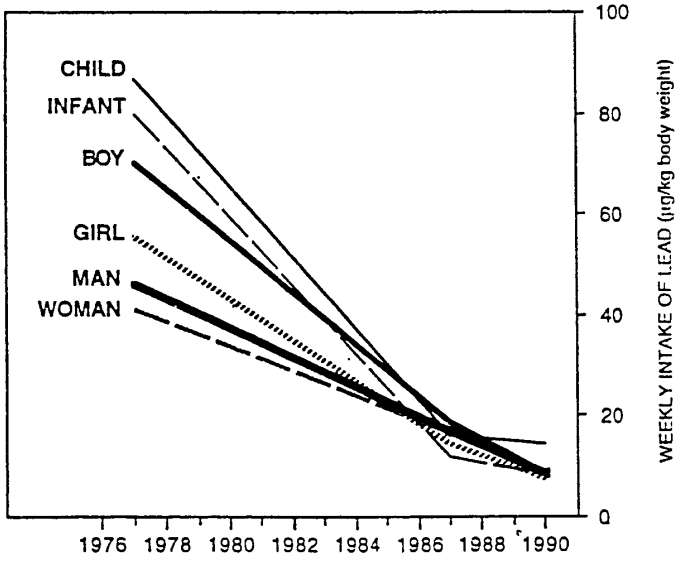
Lead Emission Estimates
Cars, Trucks and Motorcycles in 1985 and 1988
by State in Australia



Source: Australian Bureau of Statistics,1992.

Figure 22

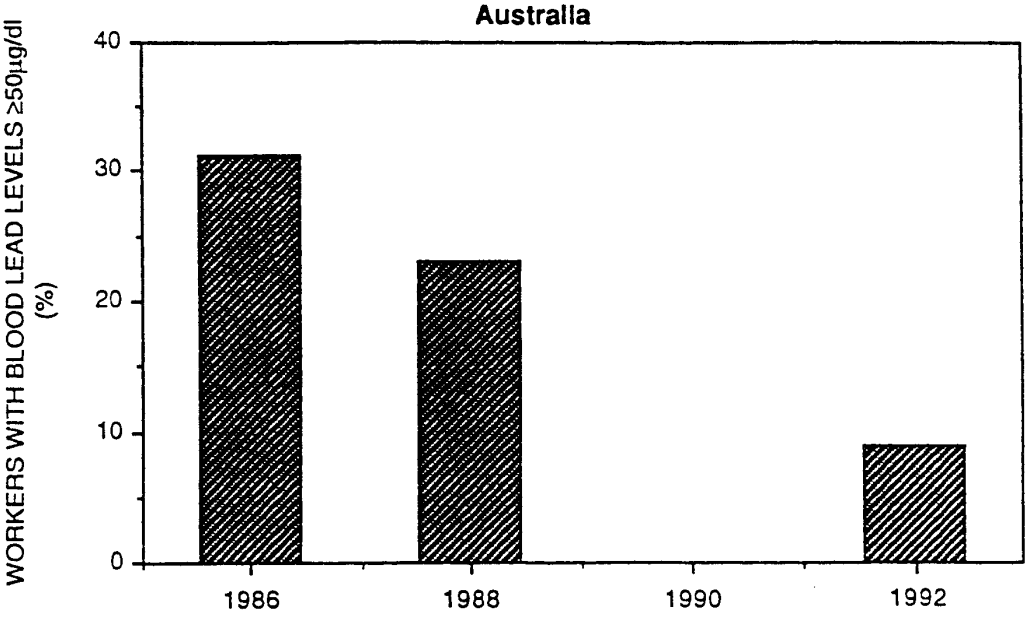
Estimated Dietary Intake of Lead
Australia



Source: Australian Academy of Science 1981 and National Health and Medical Research Council 1990.

Figure 23

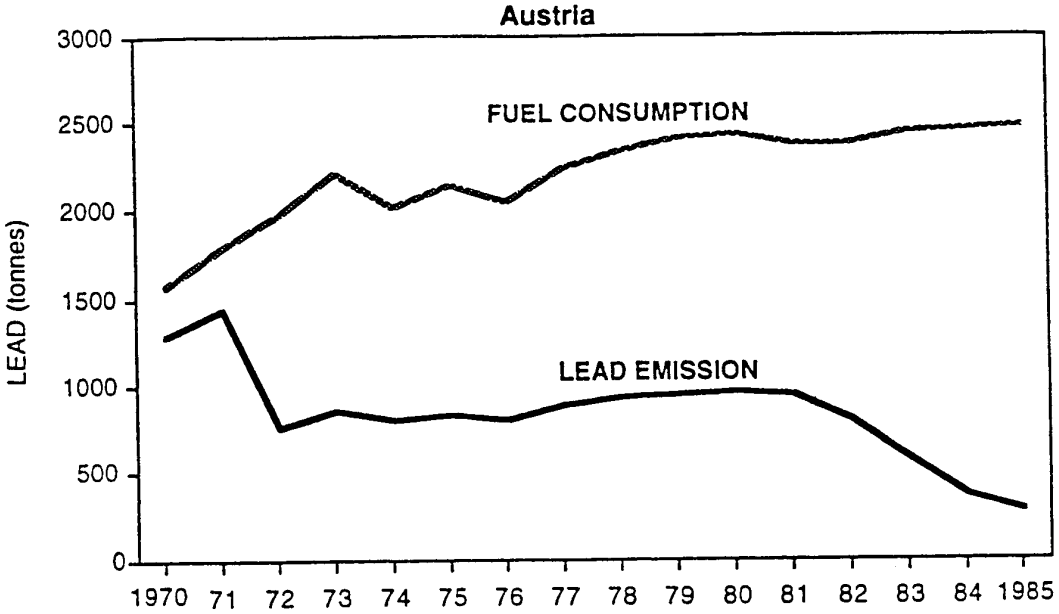
Proportion of Exposed Workers with Blood Levels Above or Equal to 50 µg/dl Australia



Source: Australian Lead Development Association, 1992.

Figure 24

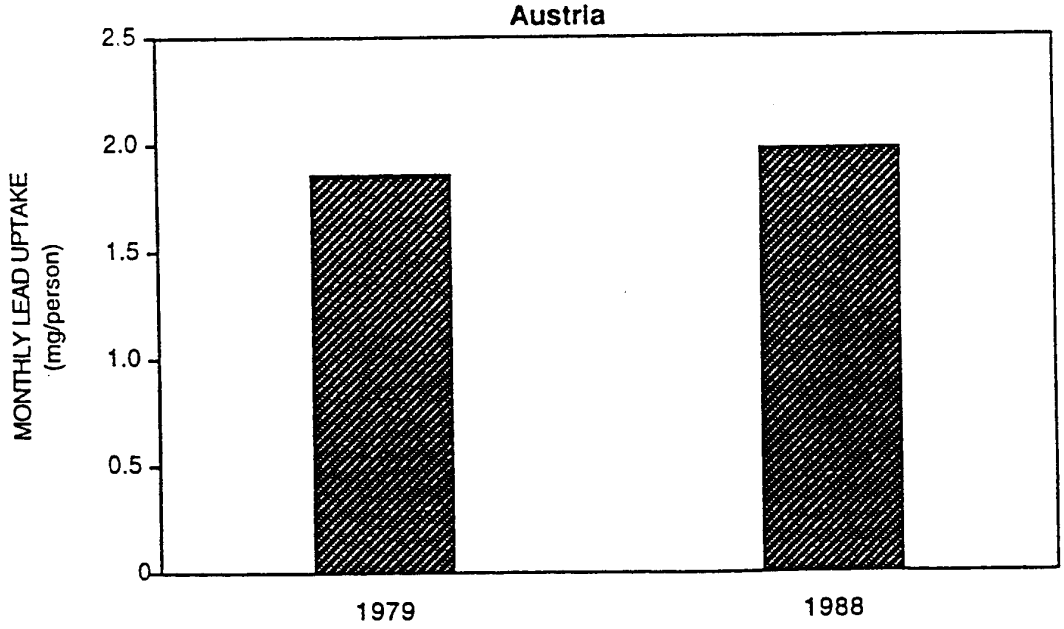
Lead Emission From Traffic and Fuel Consumption
Austria



Source: Federal Ministry for Environment, Youth and Family, 1992.

Figure 25

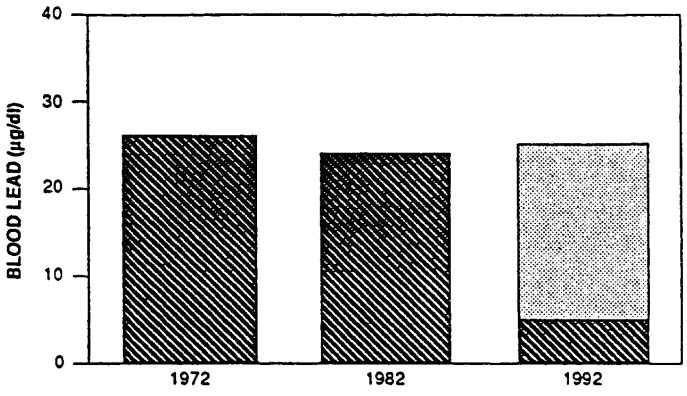
Dietary Lead Uptake
Austria



Source: Federal Ministry for Environment, Youth and Family, 1992.

Figure 26

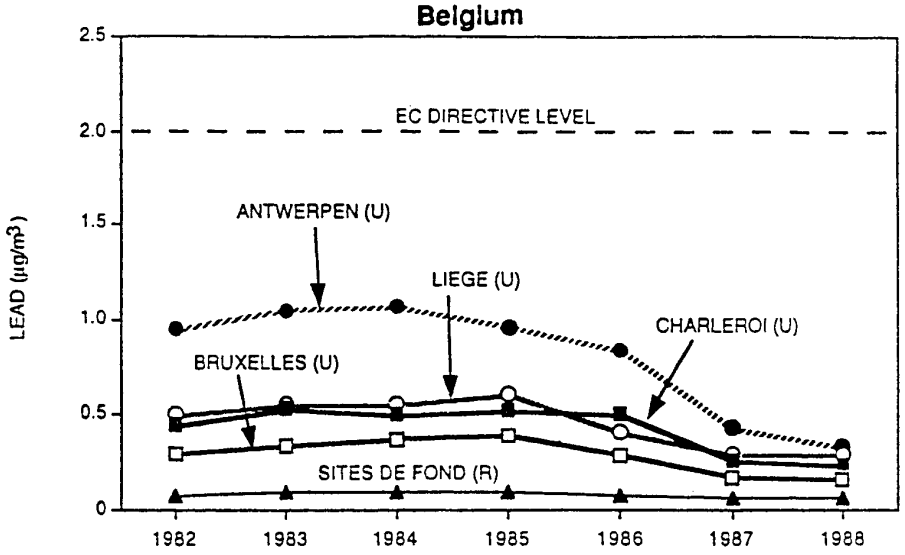
Blood Lead Levels, General Population
Austria



Source: Federal Ministry for Environment, Youth and Family, 1992.

Figure 27

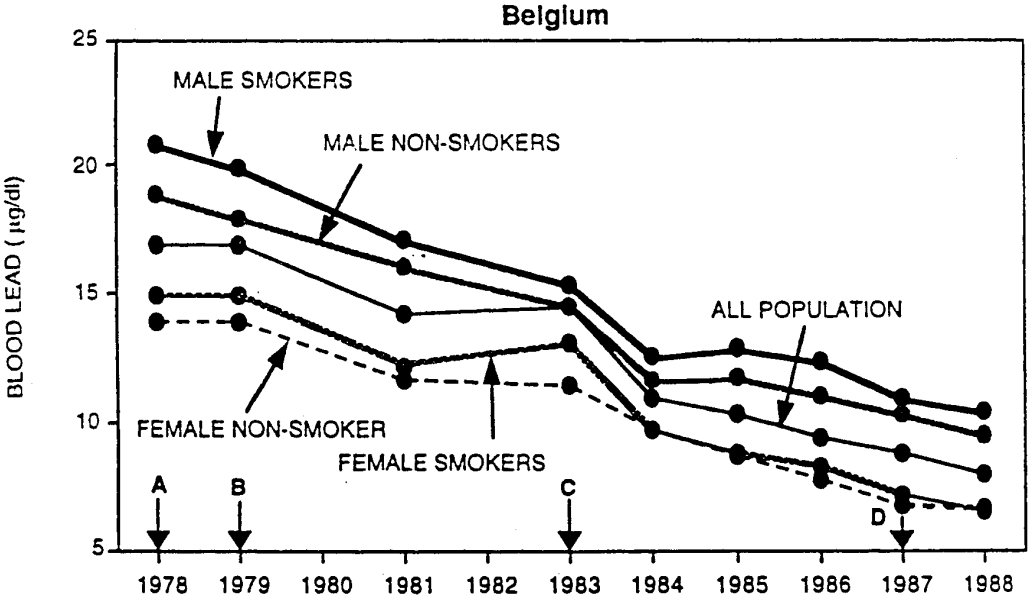
Concentration of Lead in Air
Belgium



(U) Urban; (R) Rural
Source: Commission of European Communities, DGXI, 1992.

Figure 28

Average Blood Lead Levels, 1978-88
Belgium

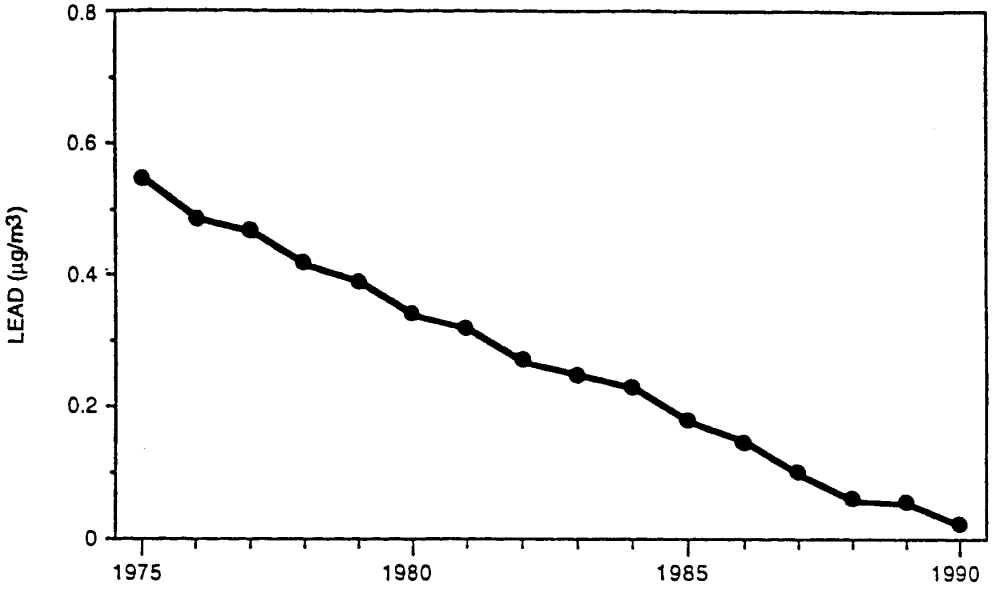


Change in maximum permissible level of lead in gasoline:
A - to 0.55 g/l
B - to 0.45 g/l
C - to 0.40 g/l
D - to 0.15 g/l

Source: Belgium Ministry of Health and Environment, 1989.

Figure 29

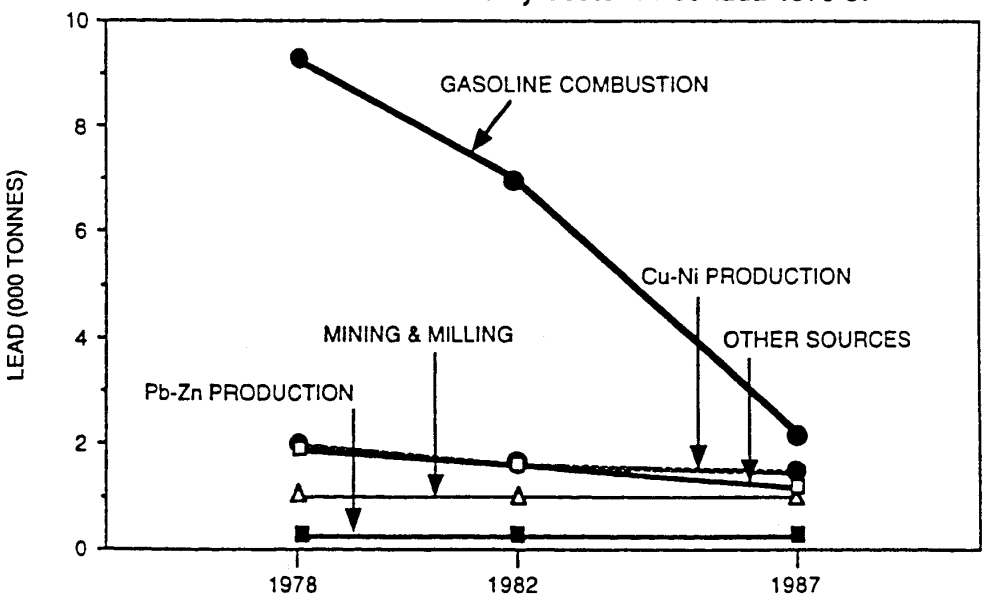
Canadian Trends in Geometric Mean Concentration of Lead in Air 1975-90



Source: Environment Canada, 1990.

Figure 30

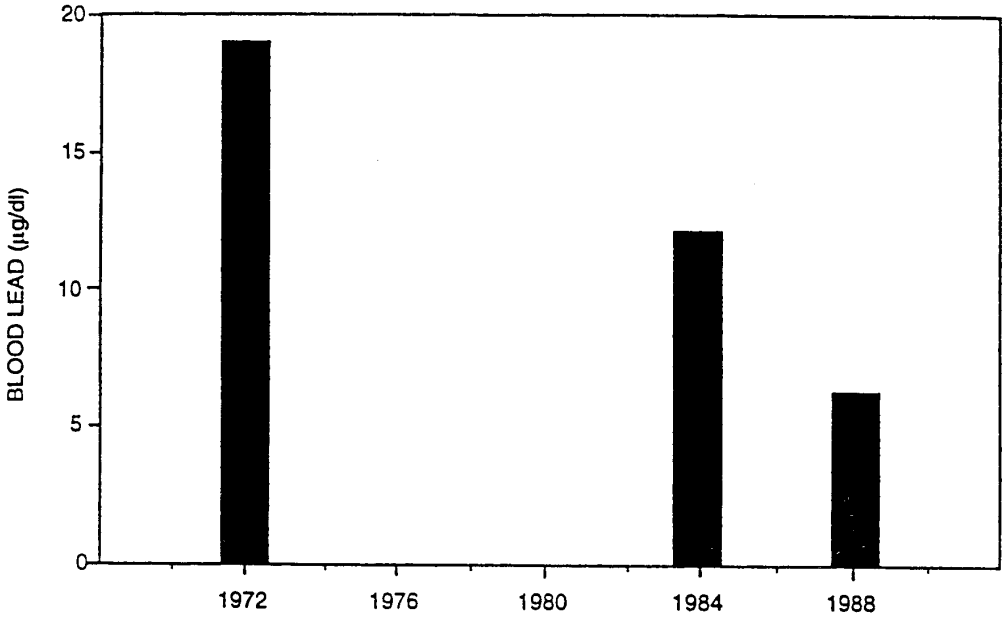
Estimated Lead Emissions by Sector in Canada 1978-87



Source: Environment Canada, 1989.

Figure 31

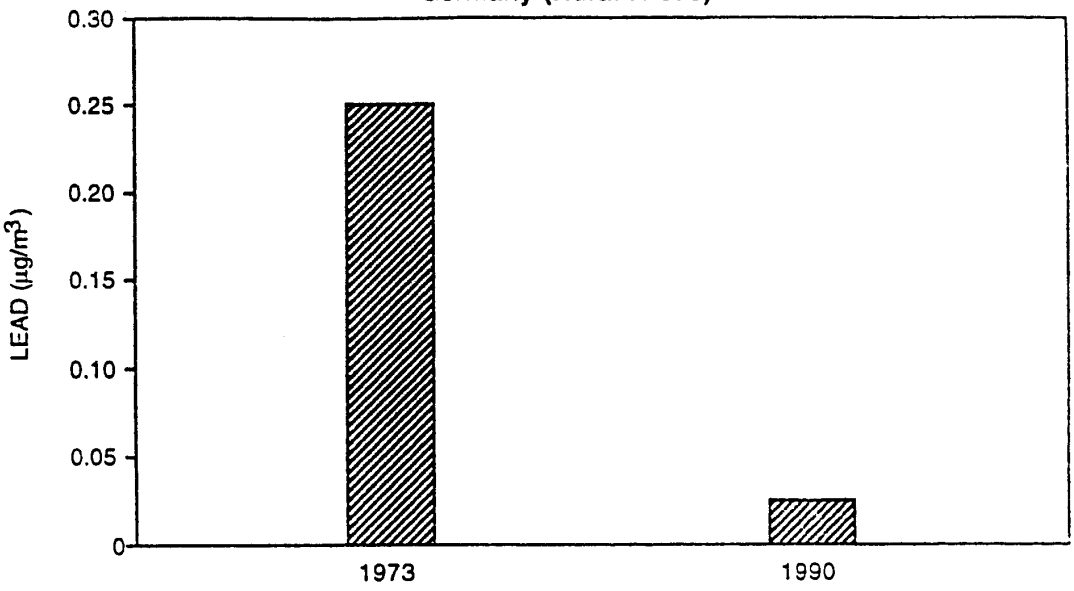
Average Blood Lead Levels for Children
Canada



Note: The level of concern for lead in blood is 25 µg/dl. Sample populations varied by year.
Source: Health and Welfare Canada, 1992.

Figure 32

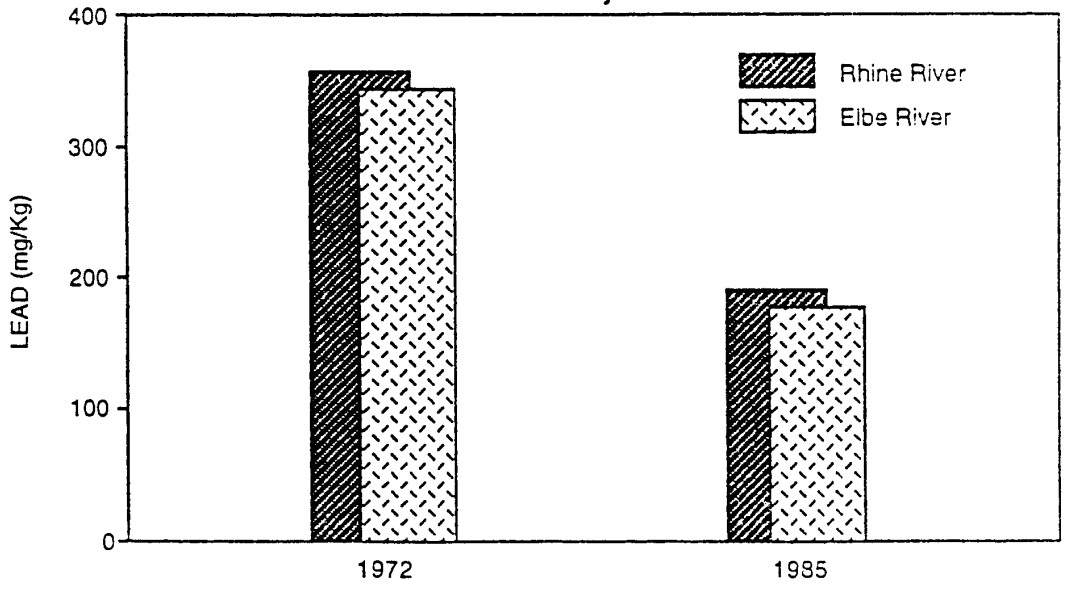
Mean Concentration of Lead in Air
Germany (Rural Areas)



Note: Maximum permissible level of lead in air is 2.0 µg/m3 (annual mean).
Source: German Federal Environmental Agency, 1992.

Figure 33

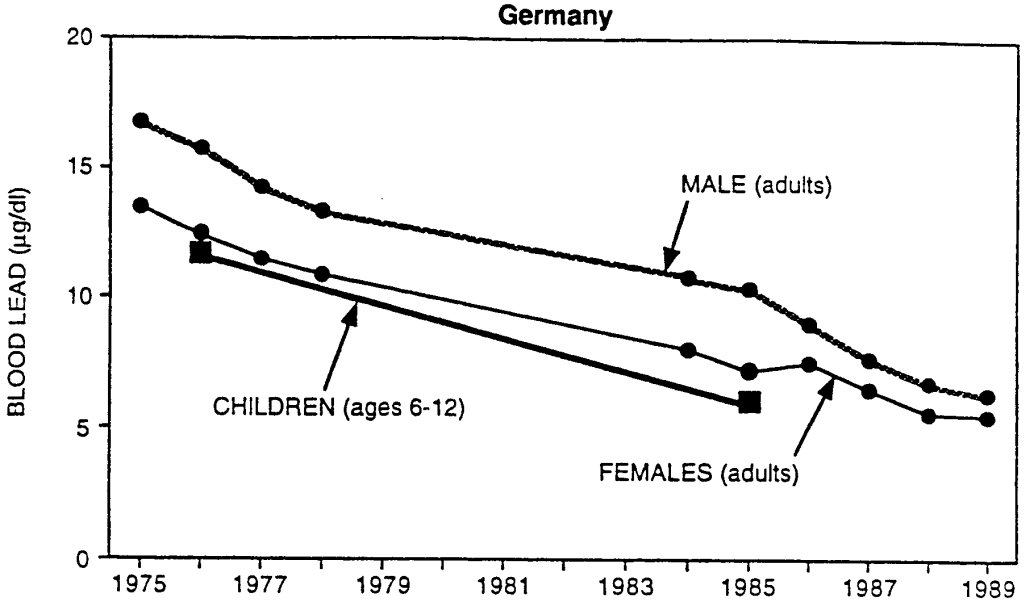
Mean Concentration of Lead in River Sediments
Germany



Source: German Federal Environmental Agency, 1992.

Figure 34

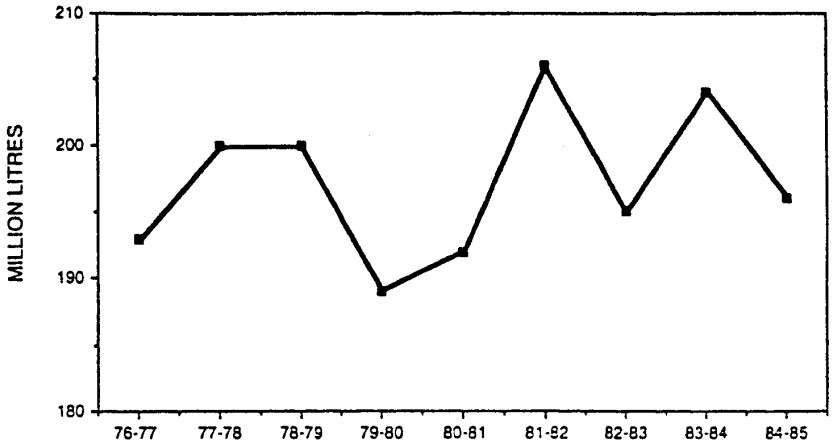
Blood Lead Levels
Germany



Note: Children surveyed were from elementary schools in Berlin.
Source: German Federal Health Agency, 1992.

Figure 35

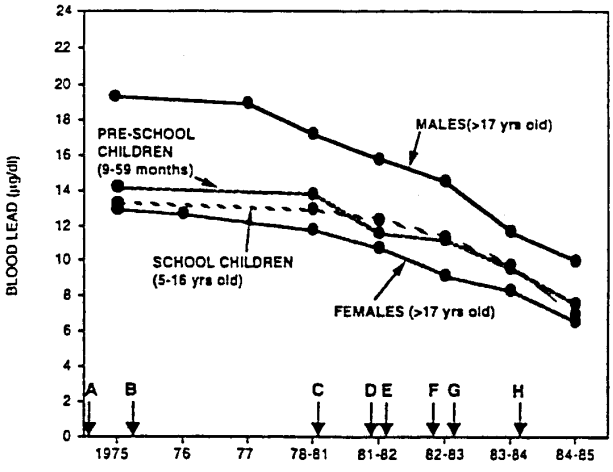
Leaded Gasoline Consumption for Greater Christchurch Area New Zealand



Source: Hinton et.al., 1986.

Figure 36

Average Blood Lead Levels New Zealand (Christchurch)



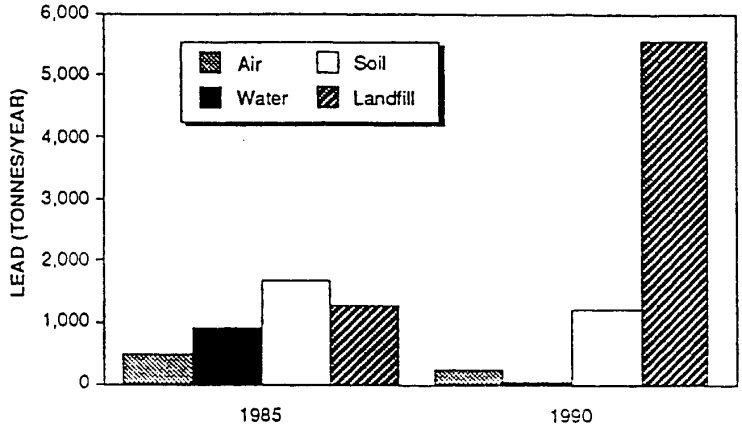
POSSIBLE INFLUENCING FACTORS - INTRODUCTION OF LEAD-FREE PACKAGING MATERIALS

A - Baby food (cans)
B - Carbonated beverage (cans)
C - Milk powder (cans)
D - Food (cans)
E - Fruit juice (foil packets)
F - Fruit juice (cans)
G - Beer (cans)
H - Evaporated and dried milk (foil packets)

Note: Average household water lead content remained constant 1978-85 at 0.22 umol/l.
Source: Hinton et. al., 1986.

Figure 37

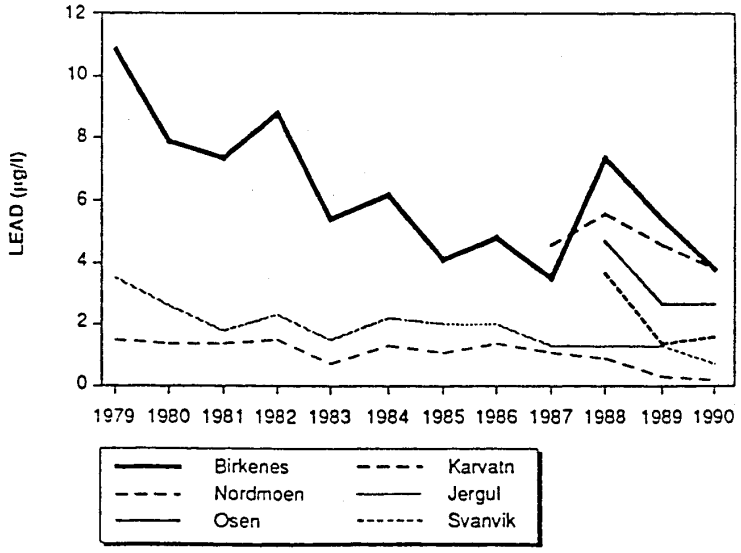
Estimated and Known Discharges of Lead to the Environment 1985 and 1990 Norway



Source: State Pollution Control Authority, 1992.
Norwegian Institute for Air Research, 1992.

Figure 38

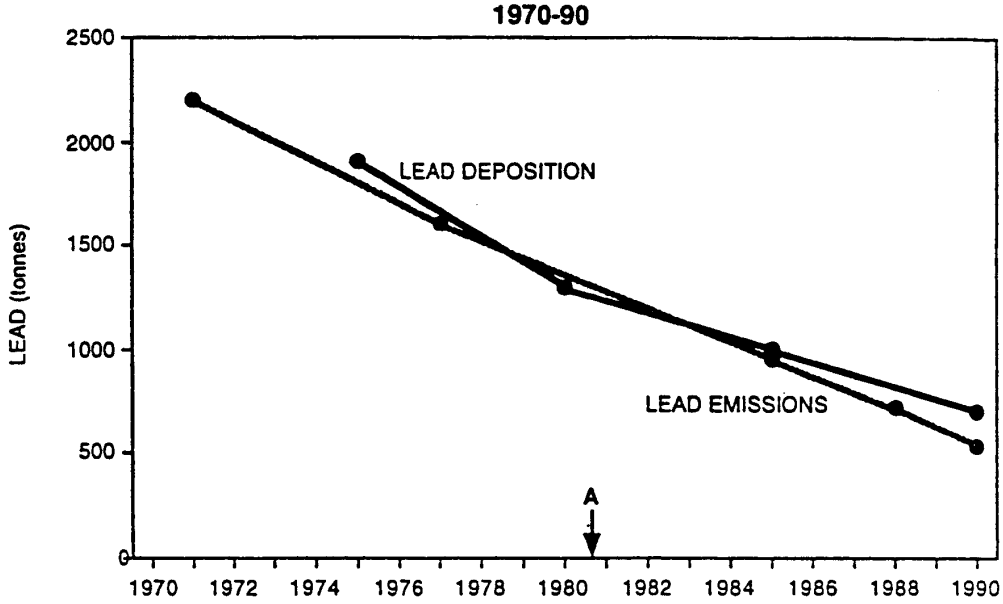
Lead Deposition From Air Norway



Source: State Pollution Control Authority, 1992.

Figure 39

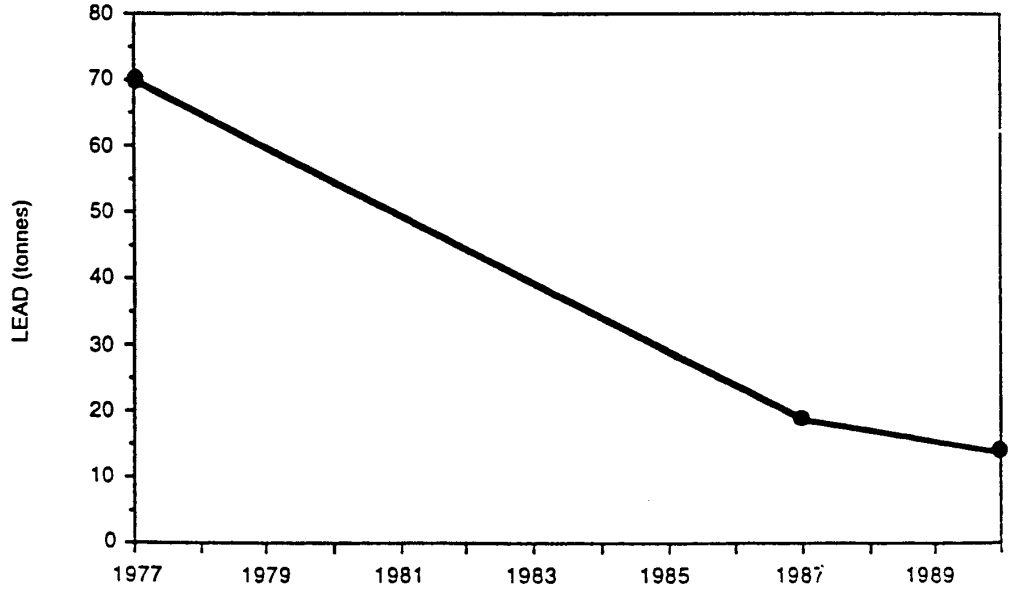
Airborne Lead in Sweden
1970-90



A Permissible level of lead in gasoline reduced from 0.4 to 0.15 g/l
Source: National Chemicals Inspectorate, Sweden, 1992.

Figure 40

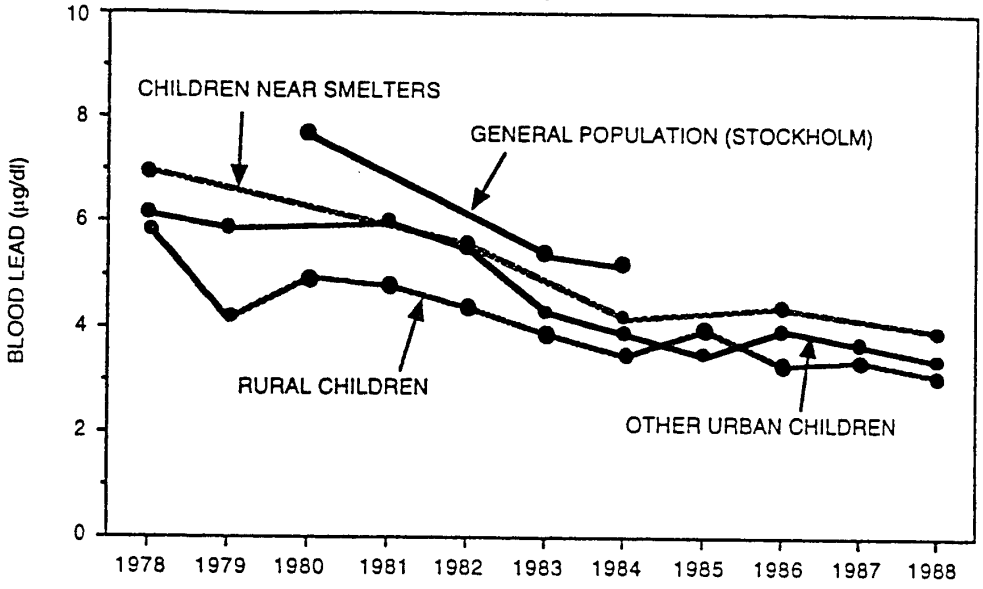
Effluents of Lead to Water in Sweden
1977-90



Source: National Chemicals Inspectorate, Sweden, 1992.

Figure 41

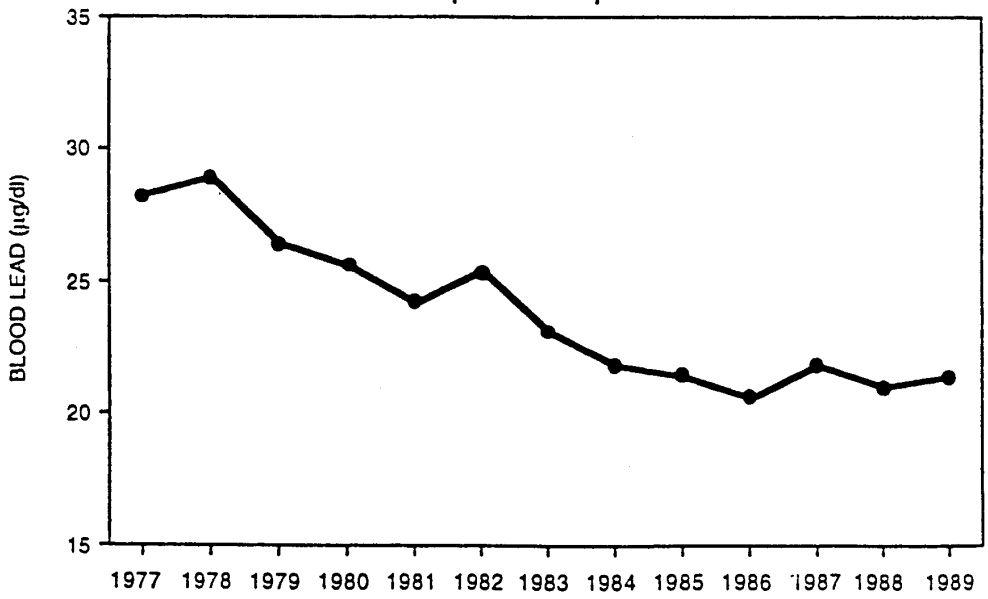
Average Blood Lead Levels in Sweden
1978-88



Source: National Chemicals Inspectorate, Sweden, 1992.

Figure 42

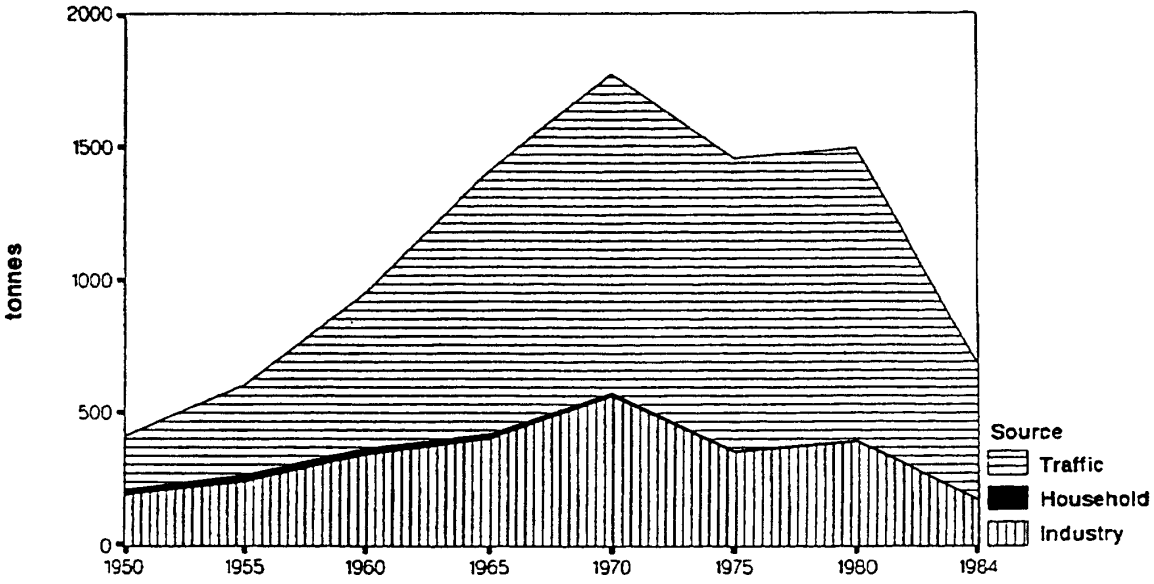
Average Blood Lead Levels in Sweden
Occupational Exposure



Source: National Chemicals Inspectorate, Sweden, 1992.

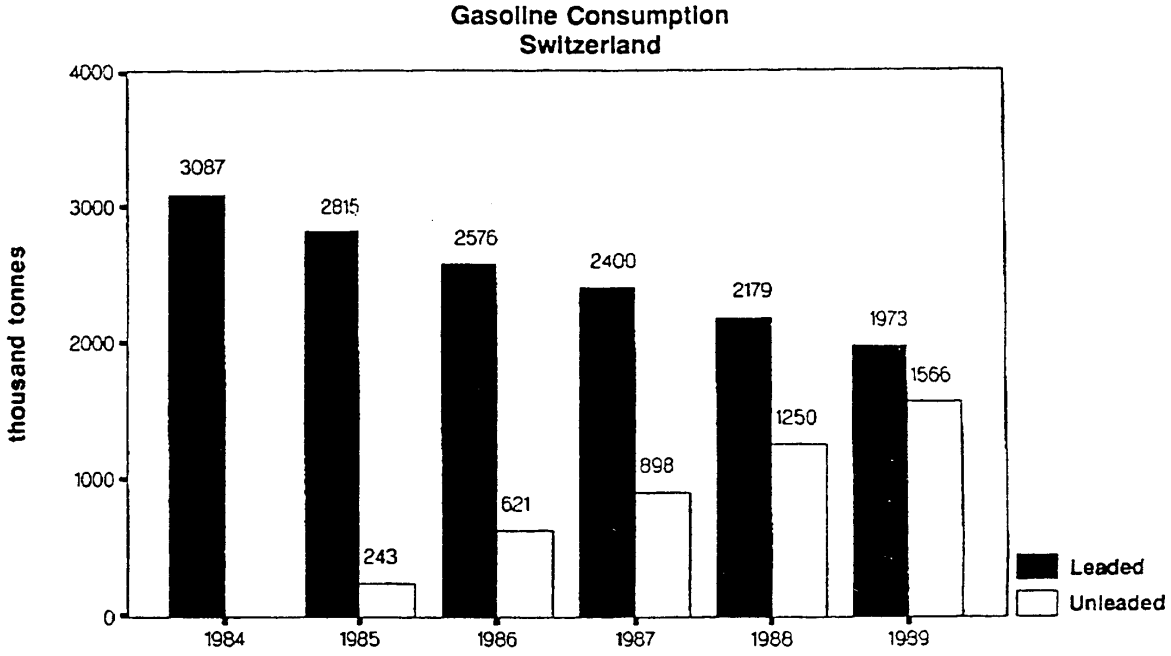
Figure 43

Lead Release into the Environment
Switzerland



Source: Federal Office of Environment, Forests and Landscape, 1992

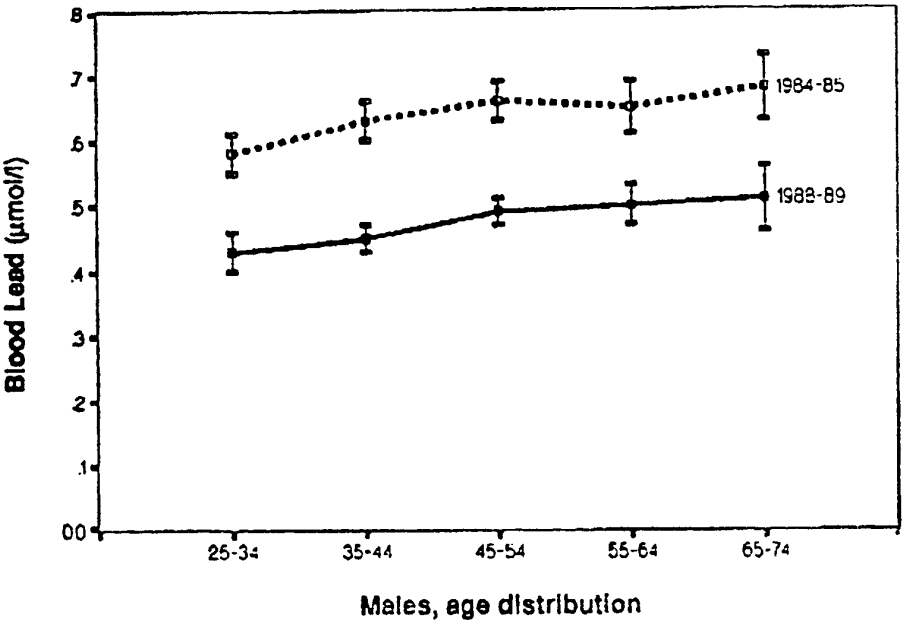
Figure 44



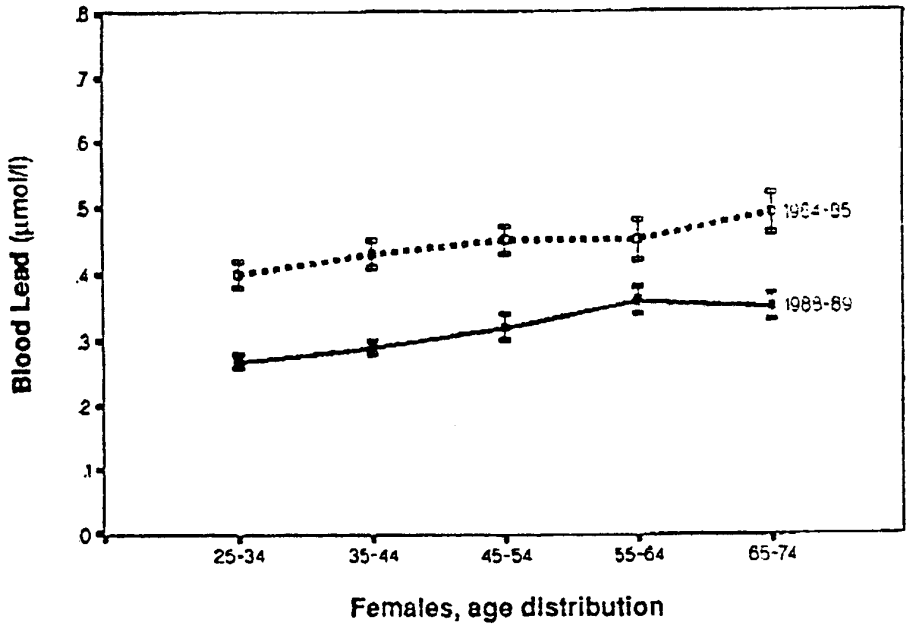
Source: Federal Office of Environment, Forests and Landscape, 1992

Figure 45

Average Blood Lead Levels
Switzerland



Males, age distribution

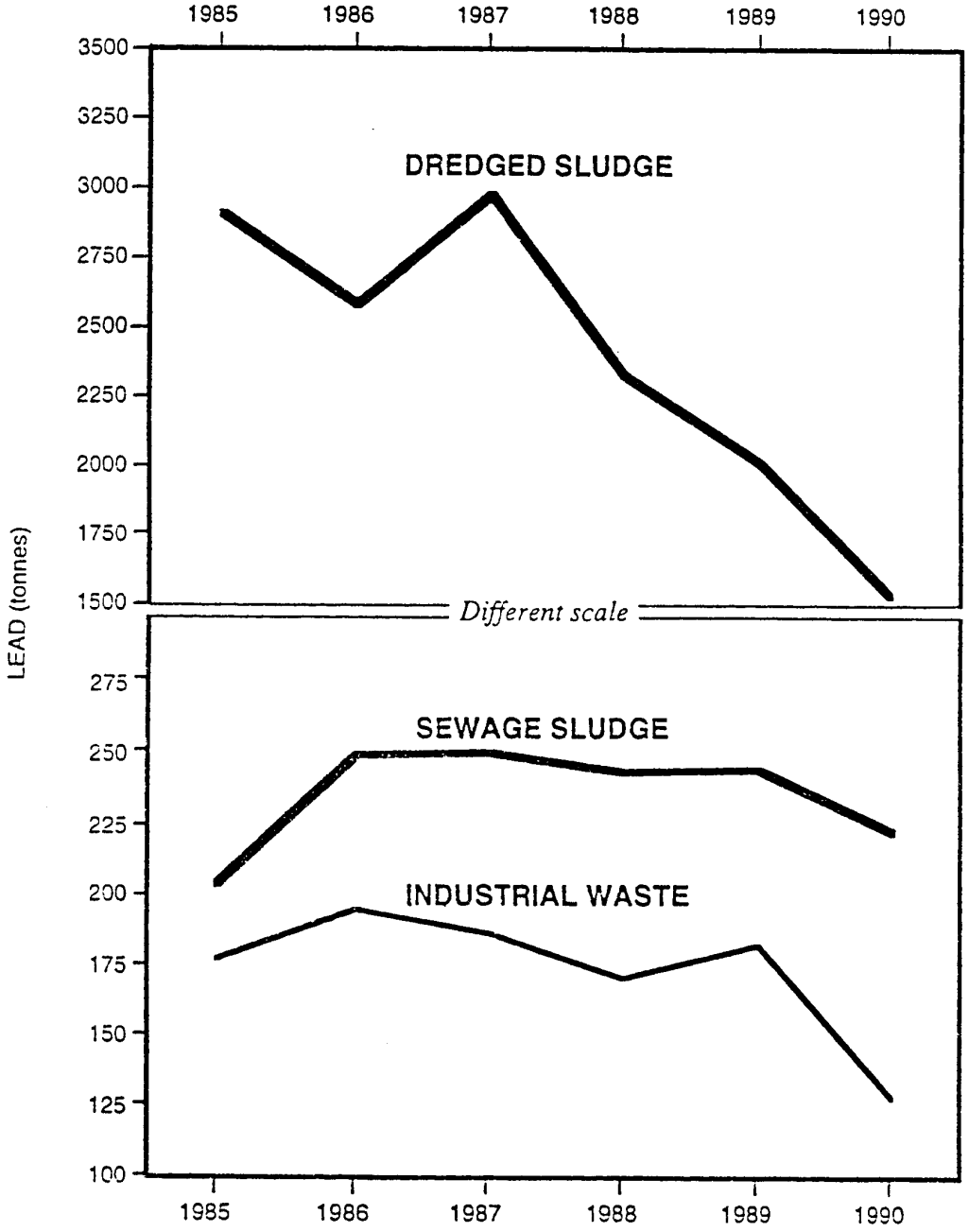


Females, age distribution

Source: Federal Office of Environment, Forests and Landscape, 1992

Figure 46

Lead in Materials Entering the North Sea
from the
United Kingdom



Source: U.K. Department of the Environment, 1992.

Figure 47

Concentration of Lead in Air at Urban Sites
United Kingdom

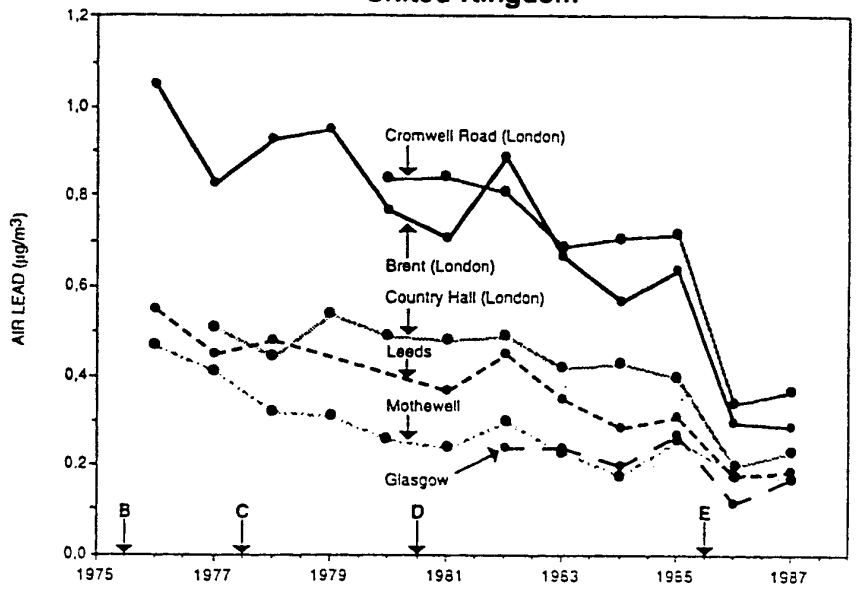
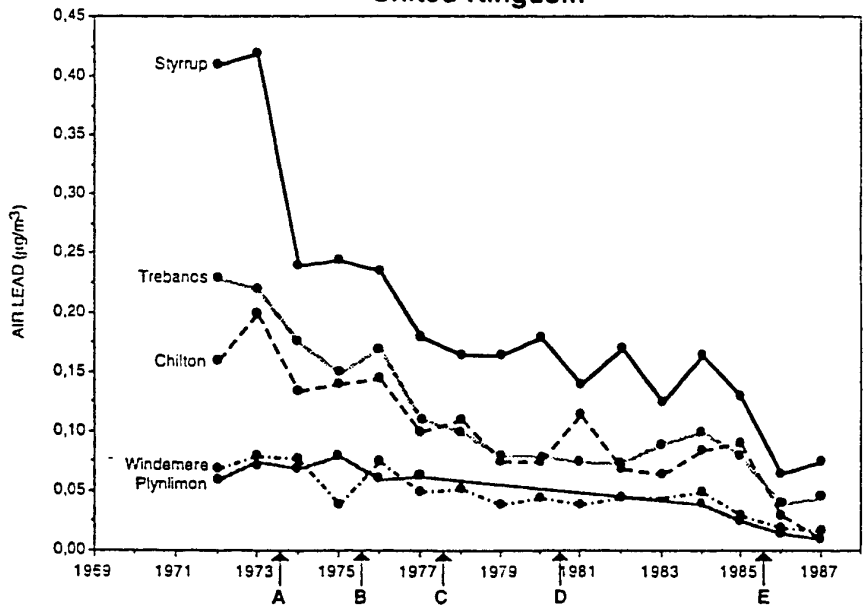


Figure 48

Concentration of Lead in Air at Rural Sites
United Kingdom



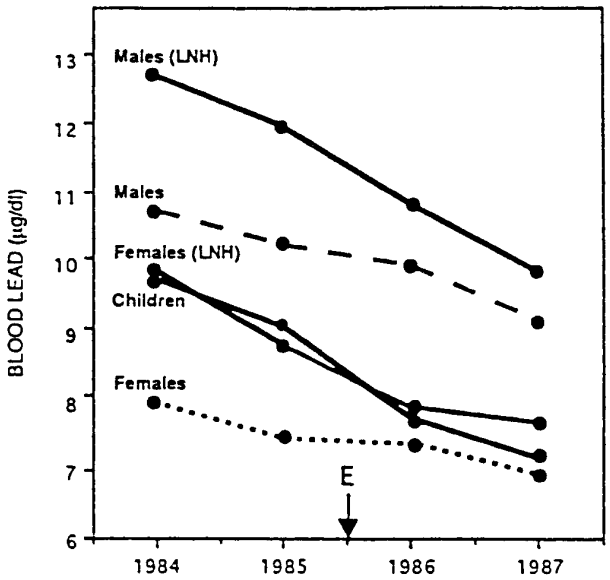
Reductions in the maximum permissible level of lead in gasoline:

A	0.64 to 0.55 g/l	D	0.45 to 0.40 g/l
B	0.55 to 0.50 g/l	E	0.40 to 0.15 g/l
C	0.50 to 0.45 g/l		

Source: U.K. Department of the Environment, 1992.

Figure 49

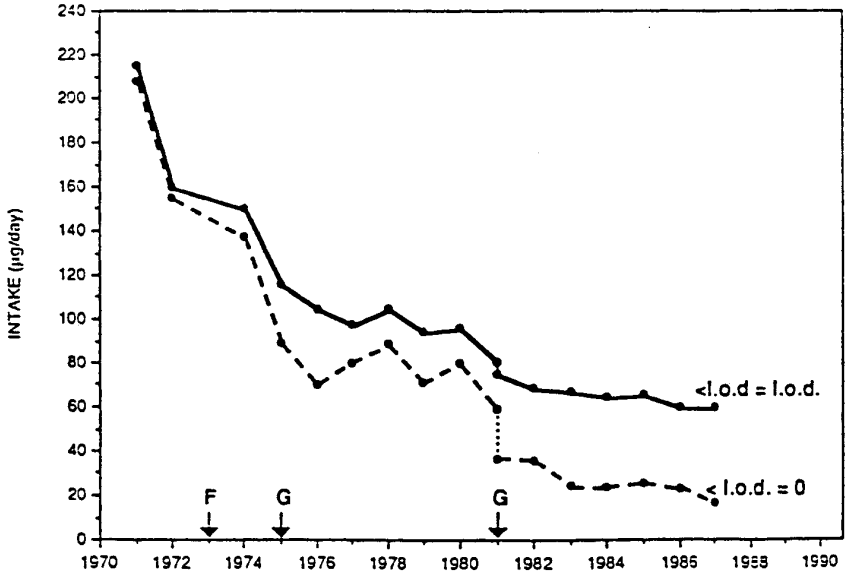
Average Blood Lead Levels
United Kingdom



E Lead in gasoline reduced from 0.40 to 0.15 g/l.
(LNH) Living Near Highways.
Note: The level of concern for lead in blood is 25ug/dl.
Source: U.K. Department of the Environment, 1992.

Figure 50

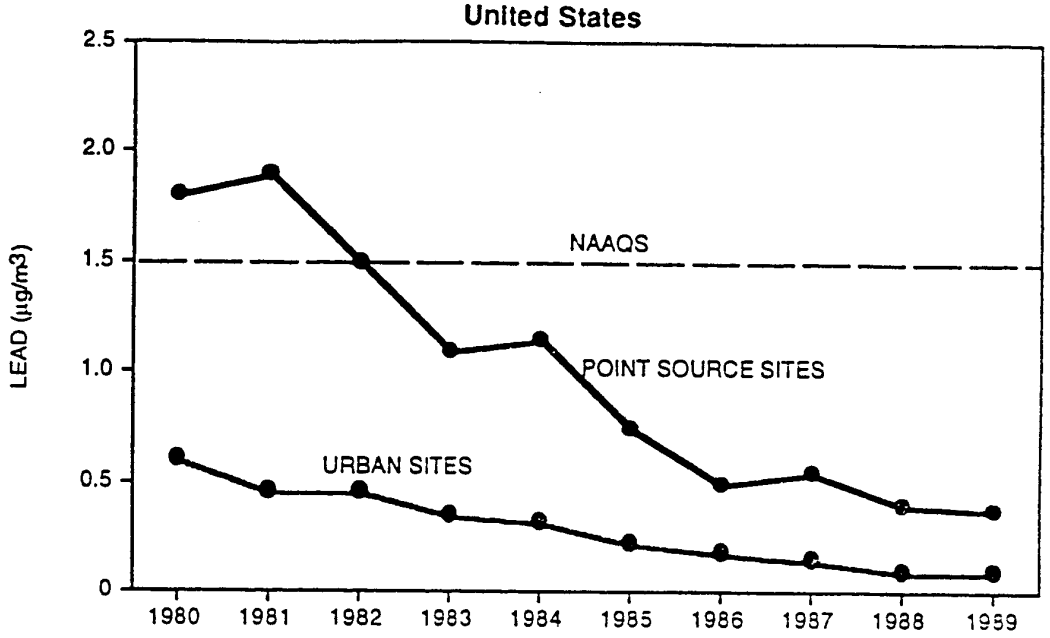
Lead Intake From Food
United Kingdom



NOTE: F no sampling; G changes in methodology occurred; l.o.d. (limit of detection)
Source: U.K. Department of the Environment, 1992.

Figure 51

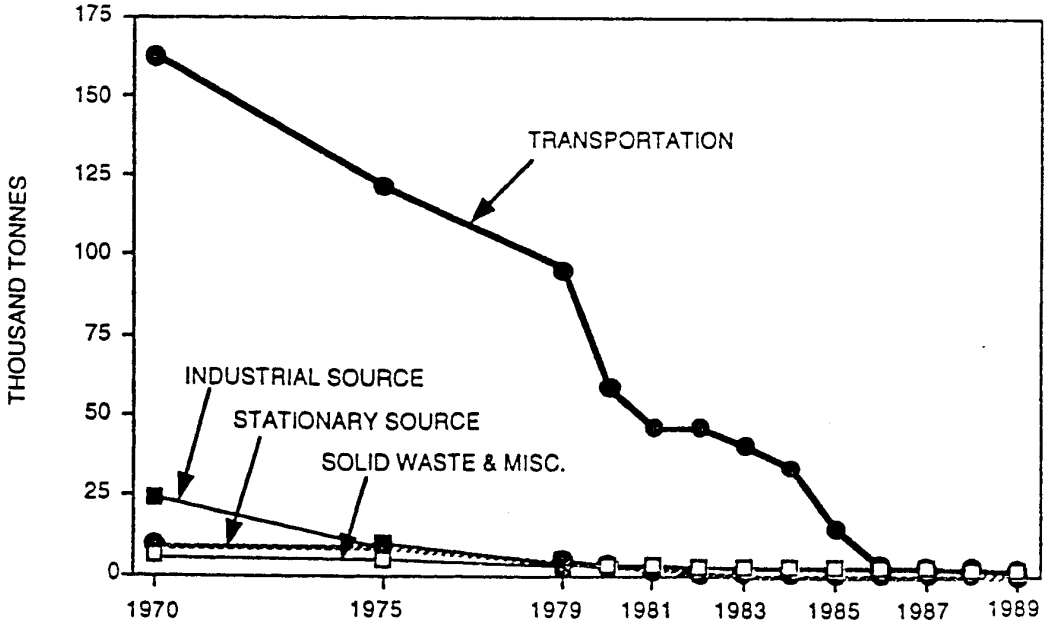
Concentration of Lead in Air
United States



NAAQS National Ambiant Air Quality Standard.
Source: US EPA, 1991: ENVIRON, 1991.

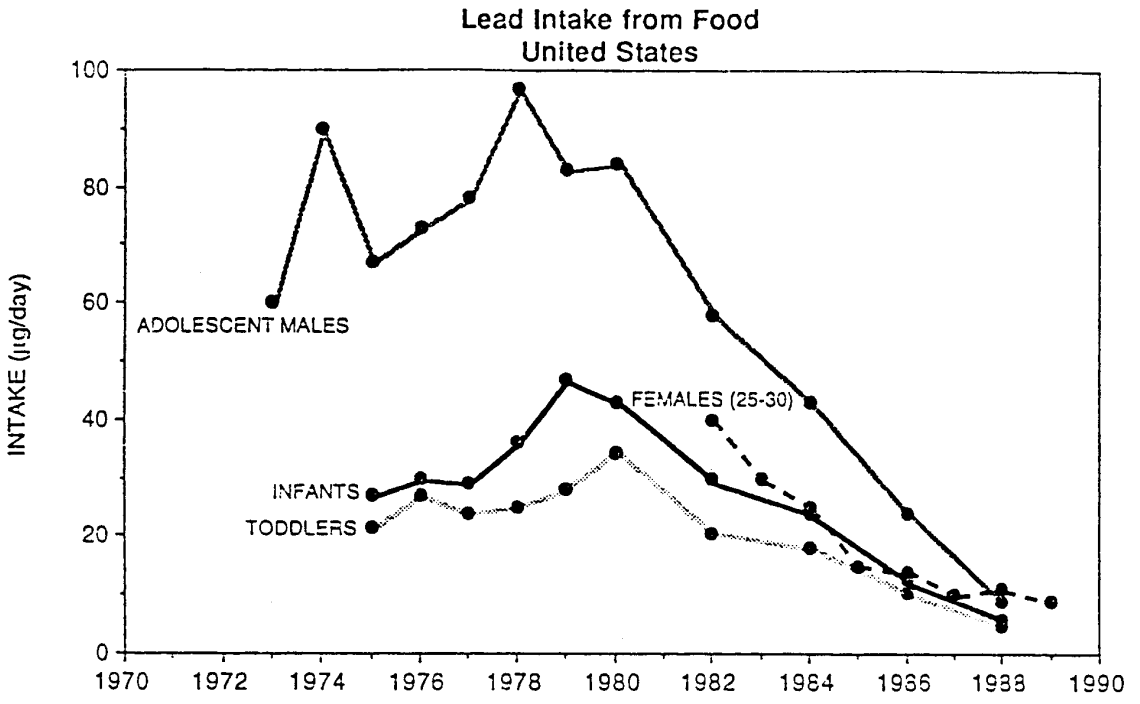
Figure 52

Trends In Emissions of Lead 1970-89
United States



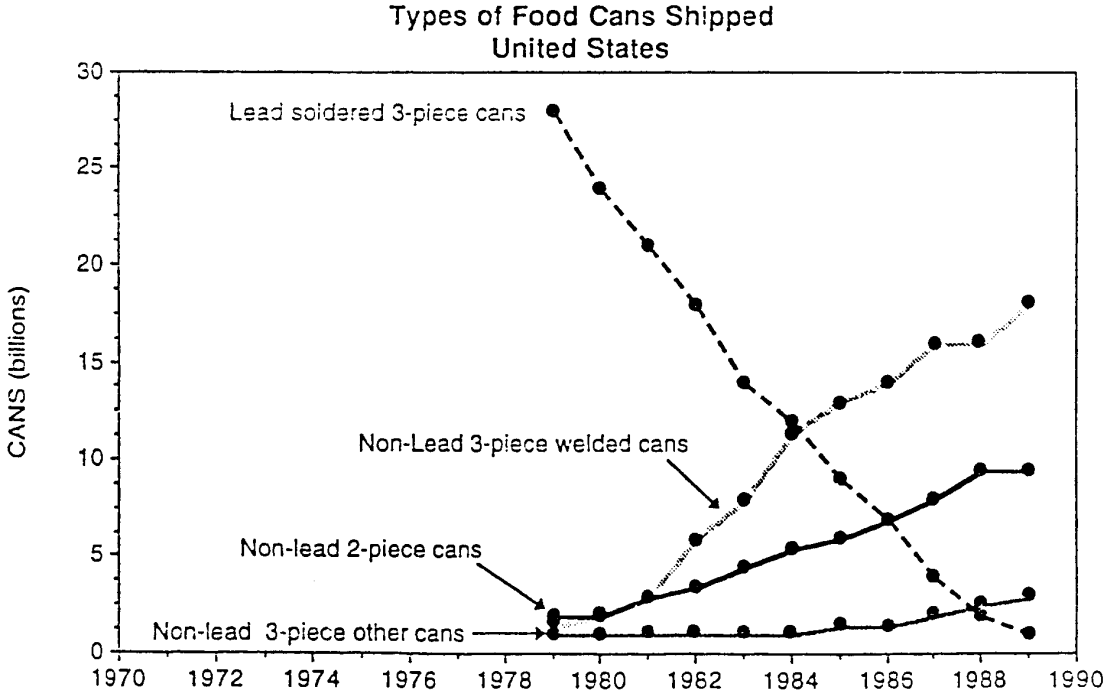
Source: ENVIRON, 1991: USEPA, 1991.

Figure 53



Source: Bolger, M. et al. 1991, U.S. E.P.A. 1992 a, ENVIRON 1991 (Based on U.S. F.D.A. Data).

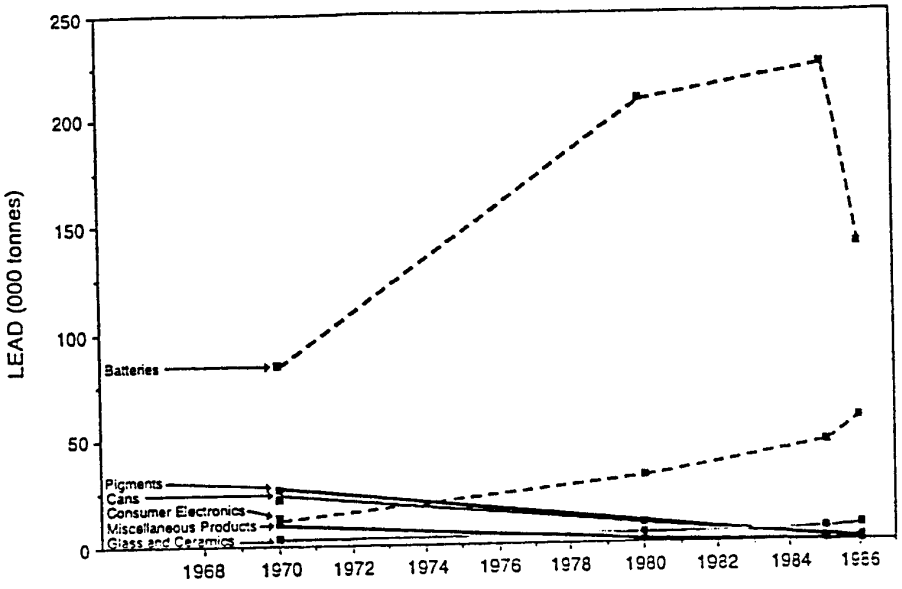
Figure 54



Source: Bolger, M. et al. 1991, ENVIRON, 1991.

Figure 55

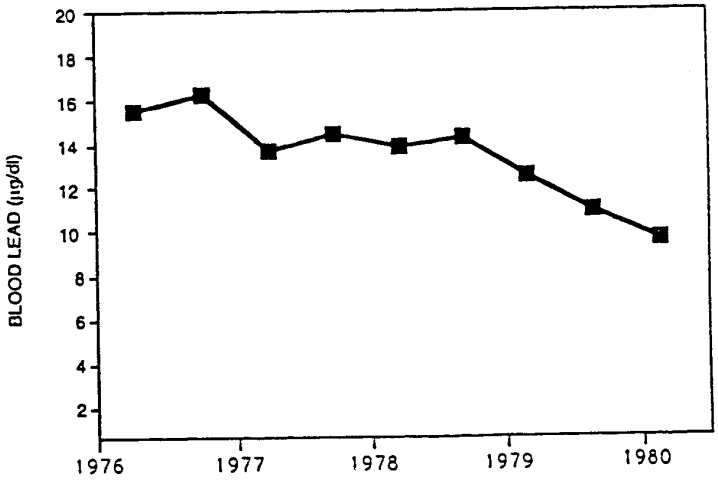
Estimated Discards of Lead in Municipal Solid Waste
1970-1986
United States



Notes: For plastics, used oil, light bulbs, and brass/bronze, the estimated annual discards are below 4,000 tonnes. There is considerable uncertainty about the quantity of lead entering the waste stream. Levels may be lower than indicated, refer to text.
Source: USEPA. Contract Report: The lead problem and lead managment activities, 1990.

Figure 56

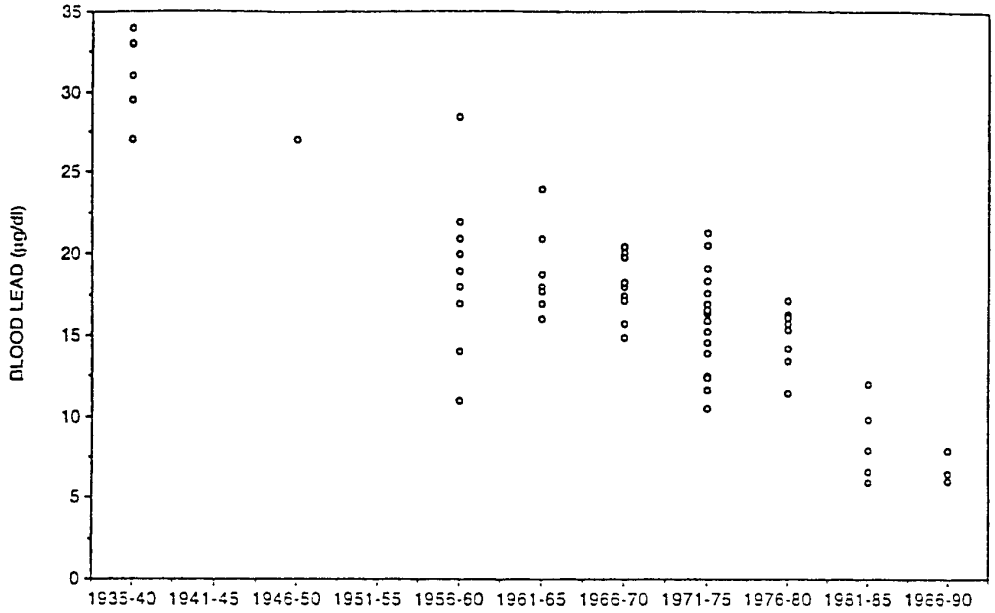
Average Blood Lead Levels
United States



Source: US Environmental Protection Agency, 1992b.

Figure 57

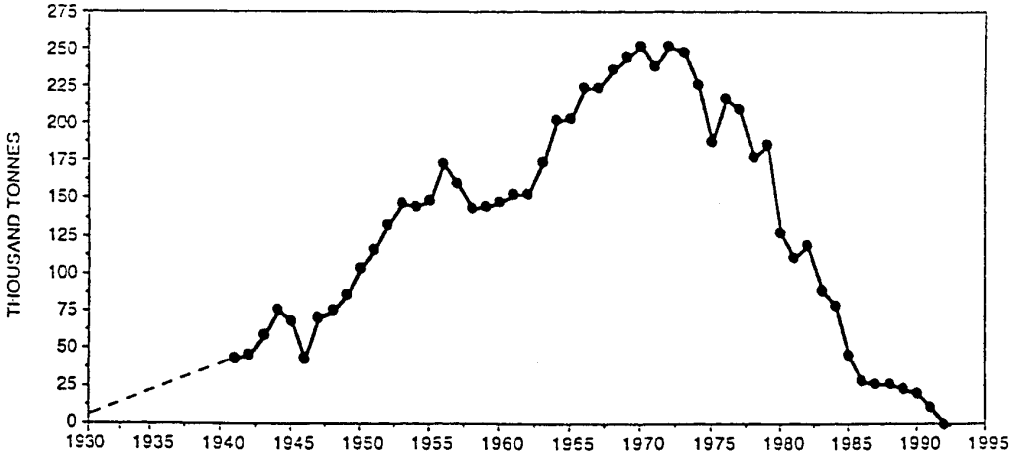
Blood Lead Levels
United States



Note: Circles represent blood lead values taken from literature referenced in appendix A.
Source: ILZRO, 1991.

Figure 58

Lead Used in the Production of Gasoline
United States



– – 1930-1941: Inferred usage - data included under miscellaneous and undefined categories.
Source: U.S. Bureau of Mines, 1992.

APPENDIX A (CHAPTER 3)

United States blood lead values from literature references (1935-1990) used in generating the data in Figure 57.

APPENDIX A

Year	Mean Blood Lead, µg/100 ml or /100 g	No. in Group	Location	Reference
1935	58	71	U.S.A.	Kehoe 1
1936	34	89	St. Louis	McMillen 2
1938	33	36	Phila., PA	Smith 3
1938	31	126	Baltimore	Kaplan 4
1939	27	30	U.S.A.	Kehoe 5
1939	29.5	22	Phila., PA	Letonoff 6
1946	27	30	U.S.A.	Kehoe 7
1956	28.5	261	Cincinnati	3-City 8
1960	21	81	L.A., CA	3-City 8
1960	17	93	L.A., CA	3-City 8
1960	11	37	Alpine Co., CA	3-City 8
1960	22	123	New Orleans	Hofreuter 9
1960	18	128	Dallas	Hofreuter 9
1960	19	131	Denver	Hofreuter 9
1960	20	97	Chicago	Hofreuter 9
1960	20	112	New York	Hofreuter 9
1960	20	137	Cincinnati	Hofreuter 9
1960	14	162	Rural Ohio	Hofreuter 9
1961	18	237	Phila., PA	3-City 8
1962	17.7	518	L.A., CA	3-City 8
1962	18.8	10	Washington, DC	Siegel 10
1963	24	381	Cincinnati	3-City 8
1963	17.7	47	Pasadena	Butt 11
1963	17	33	California	Goldwater 12
1963	21	105	New York	Goldwater 12
1963	16	40	Ohio	Goldwater 12
1967	20.1	490	U.S.A.	McLaughlin 13
1968	19.8	528	U.S.A.	McLaughlin 13
1969	17.5	193	Pasadena	Tepper 14
1969	17.2	80	Los Alamos	Tepper 14
1969	18	150	Ardmore	Tepper 14
1969	20.5	136	Rittenhouse Sq., Phil. PA	Tepper 14
1969	14.9	191	Los Alamos	Tepper 14
1969	15.7	162	Oceana, OH	Tepper 14
1970	18.3	869	U.S.A.	McLaughlin 13
1971	15.3	198	Port Washington, NY	Tepper 14
1971	16.6	140	Greenwich Village, NY	Tepper 14
1971	17.6	147	Bridgeport, IL	Tepper 14
1971	13.9	208	Lombard, IL	Tepper 14

APPENDIX A

45	1971	12.5	191	Houston	Tepper	14
46	1971	19.2	219	Washington, DC	Tepper	14
47	1972	19.2	420	U.S.A.	McLaughlin	15
48	1973	11.7	403	S. California	Goldsmith	16
49	1973	15.9	114	Hartford	Osborne	17
50	1973	17	76	Honolulu	Joselow	18
51	1974	14.6	89	Ann Arbor, MI	Hecker	19
52	1974	16.4	126	Los Angeles	Johnson	20
53	1974	10.5	119	Lancaster, CA	Johnson	20
54	1975	18.4	36	Houston	Johnson	21
55	1975	21.3	36	Houston	Johnson	21
56	1975	12.4	81	Houston	Johnson	21
57	1975	16.6	258	U.S.A.	Baker	22
58	1975	20.6	236	Fontana, CA	Wei Liang	23
59	1976	17.2	56	Upstate, NY	Perkins	24
60	1976	15.7	60	Salt Lake City	Smith	25
61	1977	14.2	76	Culver City, CA	Report	26
62	1977	13.5	25	Culver City, CA	Report	26
63	1977	16.3	19	U.S.A.	Hammond	27
64	1978	16.3	67	Culver City, CA	Report	26
65	1978	15.4	43	Culver City, CA	Report	26
66	1978	16.1	44	Culver City, CA	Report	26
67	1979	11.5	9	Atlanta	Landrigan	28
68	1981	9.85	695	Louisville	Angell	29
69	1982	6.6*	11837	Boston, MA	Rabinowitz	30
70	1983	12	122	Pinehurst, ID	CDC	31
71	1983	6	61	Helena, MT	CDC	31
72	1983	8		Festus, MO	Phillips	32
73	1986	6.5*	216	Boston, MA	Bellinger	33
74	1986	6.5	118	Cleveland, OH	Ernhart	34
75	1986	6.1	258	Telluride, CO	Albert	35
76	1987	8	305	Cincinnati, OH	Dietrich	36
77						
78						

APPENDIX A

U.S. BLOOD LEAD LITERATURE DATA 1935 - 1990

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CHAPTER 4

NATIONAL POSITIONS ON CURRENT RISKS FROM LEAD

This chapter contains statements of national positions on current risks from lead. Essentially, these statements provide the rationale for any actions the country has taken to address effects associated with environmental or human health exposures to lead. The national statements are based on conclusions concerning the hazards of lead and data from human health or environmental monitoring carried out to determine levels of exposure.

The national risk assessments and risk characterizations that have led countries to take action have a strong national character. Countries develop positions on the need for risk reduction activities only after they have analysed the hazard and the significance of certain exposures and have factored in local social, economic and political considerations. These positions are usually arrived at after considerable debate on the numerous factors involved, and thus are not expected to be consistent across OECD Member countries.

This chapter also contains an internationally agreed assessment of the risks of lead from the International Programme on Chemical Safety (IPCS). The IPCS assessment is taken directly from Chapters 1 and 9 of the recent Task Group-approved update of the Environmental Health Criteria Document on Lead, which will be published in late 1993 or early 1994.

AUSTRALIAN NATIONAL RISK STATEMENT OF LEAD

As a major producer of lead, Australia has some towns affected by point source emissions. There are also urban contamination problems, largely due to the population's heavy reliance on cars, the relatively high lead content of leaded petrol and the slower than expected change of the nation's car fleet to unleaded petrol.

Public Health

The National Health and Medical Research Council (NHMRC) has promulgated National Guidelines for *Lead in Drinking Water* (50 µg/l), *Lead in Blood* (25 µg/dl) and *Lead in Air* (1.5 µg/m^3, averaged over three continuous months). These Guidelines are generally used by Australian States and Territories to determine lead risk reduction measures.

The *Lead in Drinking Water* Guideline was developed in Australia, taking into consideration other national guidelines and the World Health Organization's 1984 revision of drinking water guidelines. The *Lead in Blood* and *Lead in Air* Guidelines were developed on the basis of an Australian Government report which examined the toxicology of lead in blood and air.

The *Lead in Blood* and *Lead in Air* Guidelines are presently the subject of review. The revised values are anticipated to be available in the middle of 1993. The review will include:

- a commissioned research review of Australian ambient lead in air and lead in blood, both in major metropolitan centres and in populations at particular risk from historical and present lead exposures from industrial activities. This report is expected to be available in August 1992;

- a review of national and international positions adopted by responsible legislatures and the rationale for their adoption of particular guideline values;

- a socio-economic and environmental impact assessment taking into account revised draft recommended values. This phase will also include extensive public consultation to evaluate the actual or projected costs and associated benefits of any future revision. Given the high level of public interest, consultation will be important if the Guidelines are to be relevant to community expectations;

- hosting of an IPCS Working Group on Evaluation of Methodologies Used to Assess Neurobehavioural Effects of Lead in Children from 12 to 15 October 1992, to examine the epidemiological studies used to generate data at low blood lead levels which have never been analysed by experts outside the field, including psychologists, neurologists and pediatricians. This group would have as its base document relevant chapters of the draft IPCS Environmental Health Criteria; and,

- an International Scientific Consensus Conference on Lead from 5 to 9 October 1992, which examined broader non-occupational toxicological issues. This meeting was conducted with appropriate scientific rigour with expert participants identified by all relevant bodies including industry.

It is likely that the *Lead in Drinking Water* Guideline will be amended following this review of

the lead in blood and air guidelines.

Occupational Lead Exposures

In 1980, the National Health and Medical Research Council (NHMRC) recommended an occupational maximum blood lead level of 70 µg/dl for males and 40 µg/dl for females. However, those guidelines will soon be abolished in anticipation of the National Occupational Health and Safety Commission's proposed standard.

The National Occupational Health and Safety Commission expects to declare a National Inorganic Lead Control Standard and Code of Practice for the Control and Safe Use of Lead at Work during 1993. Lead smelting and the manufacture of lead products are major industries in Australia.

The *draft* Standard Code aims to progressively reduce lead exposures in the workplace, thereby minimizing the risk of adverse health effects. The *draft* National Standard seeks to accommodate occupational health, safety, economic and equal employment opportunity objectives. The latter is particularly for women, as they are sometimes excluded from certain jobs in the lead industry because of potential foetal damage, which could lead to early childhood developmental problems.

In brief, the *draft* Standard includes the following measures:

- prior to particular jobs commencing, employers are to determine whether the work entails significant risk of lead exposure (i.e. whether employee blood lead levels could be expected to rise above 30 µg/100 ml);

- employers to ensure that the level of lead in air likely to be inhaled by employees does not exceed 0.15 mg/m^3 (calculated as a time weighted concentration over an 8 hour day) or if not practicable, that respiratory protective equipment is provided;

- employers to provide health surveillance programmes, including monitoring of blood lead levels of employees in lead-risk jobs;

- employees with high[3] blood lead levels to be removed from the lead-risk job until the blood lead level is sufficiently low[1];

- the following exposure control hierarchy is to be followed by employers in reducing the lead exposure of employees as far as practical, particularly when employee blood lead levels are consistently raised[1]:

    a) elimination;
    b) substitution;
    c) isolation;
    d) engineering hazard control measures;
    e) adoption of safe work practice;
    f) administrative control measures;
    g) personal protective equipment;

[3] The definitions for "high", "low" and "consistently raised" blood lead levels have not yet been determined.

- employers to provide employees with information, induction and training on the nature of hazards and means of assessing and controlling exposure to workplace lead.

The Australian lead industry (1988) recommended a maximum occupational blood lead level of 70 µg/dl for males and 30 µg/dl for females, and in 1992 recommended a maximum of 65 µg/dl for males. The Australian lead industry further recommends concentrations of lead in blood at which return to occupational exposures may occur (50 µg/dl for males, 25 µg/dl for females).

Several states prohibit females and young males (under 16 or 18) from working in lead processes.

The *draft* National Standard also provides for collection of information by States and Territories, from all workplaces where lead-risk jobs are carried out, regarding compliance and monitoring results. This information will be used to review the Standard within four years.

Environmental Exposures

Sources of ecosystems or non-human exposure to lead include leaded petrol, battery breaking plants, lead smelters, lead shot, and lead fishing weights. These have impacted on water, air and soil quality and, in turn, have impacted on aquatic and terrestrial (including avian) life.

With respect to strategies for reducing the risks of lead to ecosystems, the Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites present a good strategy for reducing risks associated with lead contaminated soil. The Australian Water Quality Guidelines for Fresh and Marine Waters provide guidance to ensure protection of water systems from lead risks. In some States[4], environmental audit systems provide mechanisms for the identification and subsequent reduction of unacceptable risks. The rationale for these measures include national concern for maintenance or improvement in water and soil quality, the need to minimize the risks of exposure of ecosystems to lead and similar activities being undertaken in other countries.

Lead toxicosis, following ingestion of lead shot, has long been recognized as a significant cause of mortality in waterfowl. As in other countries, Australia has needed to deal with problems caused in certain areas through the use of lead shot in hunting. For example, following ingestion of lead shot, lead toxicosis has been observed in Magpie geese, Black swans, several species of duck (including Black duck and Musk duck) and Hardhead. The level of ingestion of lead shot and the concentration of lead in the tissue of several species of waterfowl has been shown to be above criteria used in other countries at which action is taken.

To date, there has been no national approach to reducing risks of lead exposure to the non human environment. As is generally the case with chemicals management in Australia, action is initiated at the State level.

Two States do not allow waterfowl hunting and two States have partial bans on the use of lead shot for waterfowl hunting. Monitoring in three of the four States indicates that the level of ingestion of lead shot is equal to or greater than the levels set in the US at which management action is taken. In the remaining State, monitoring has indicated that there are no known incidents

[4] States refers to either States or Territories.

at this stage (refer to the following table for details).

CURRENT CONTROLS OVER USE OF LEAD SHOT IN AUSTRALIA

STATE/TERRITORY	ACTION UNDERTAKEN
South Australia	Partial ban current, total ban possible by 1994.
Northern Territory	Use of lead shot is banned in two of its four hunting reserves and a complete ban on use of lead shot for waterfowl is proposed from 1996.
Western Australia	Hunting of all waterfowl banned as of 1991.
Australian Capital Territory	Hunting of native wildlife banned.
Victoria	Following consultations, proposal is to ban lead shot at some public wetlands from 1993, ban lead shot for waterfowl from 1995 onwards throughout the State and undertake hunter education and community education programmes to reduce impact.
Remaining States	Situation being monitored.

The rationale for these actions is primarily:

- domestic scientific studies that have demonstrated elevated concentrations of lead in waterfowl tissues;
- domestic and overseas studies that demonstrate the consequences of elevated concentrations of lead in waterfowl tissues;
- similar actions undertaken in overseas countries have proven to be effective in reducing the risk; and
- public pressure from conservation groups in some States.

The rationale behind the total bans on all waterfowl hunting is based on animal welfare and conservation arguments and the type of shot is secondary. At some hunting grounds, steel shot is obligatory and consideration is being given elsewhere to voluntary use of steel and other non toxic shot.

CANADIAN POSITION STATEMENT:

HEALTH RISKS DUE TO ENVIRONMENTAL EXPOSURE TO LEAD

There are no known beneficial effects of lead in humans or other animals.

Many adverse health effects are well documented for exposures to high lead levels, for example, anaemia, renal damage and encephalopathy. Recent research data have shown that adverse health effects may occur at low blood lead levels, previously thought not to result in adverse effects. Children are particularly susceptible to the toxic effects of low lead levels; the effects observed include lower scores on indices of mental development and lower birth weights. Exposure of pregnant women to lead may also result in exposure of the fetus and a higher risk of pre-term delivery. Recent conclusions regarding the health risks in Canada have been based largely on the weight of evidence of neurotoxicity, while recognizing controversy over some individual studies.

In Canada, the responsibility for taking measures to reduce the health risks of lead is shared between several federal and provincial departments and organizations. To a large degree, the actions taken in this country result from initiatives of, or recommendations made by, the Health Protection Branch of the Department of National Health and Welfare. In view of the recent health-related data, the Health Protection Branch has adopted the position that exposure to lead should be reduced as much as possible.

The actions taken with respect to lead in automotive gasolines, for example, were based on the best health data available at the time, and an exposure assessment that indicated that 30-40 per cent of children's blood lead was derived from lead in gasoline. In 1983, the Canadian government took action to reduce (starting in 1987) the maximum amount of lead that could be added to gasolines and, in 1986, decided to phase out lead in automotive gasolines by the end of 1992. Subsequently, the date of implementation was brought forward to December 1990.

Exposures from all media (air, food, water, soil, consumer products) are usually taken into account in determining the need for additional control measures; blood lead levels are used as an indicator of total exposure from all sources. Before implementing any regulatory initiatives, the health-based position of reducing exposure to lead "to the extent possible", needs to be reviewed in light of possible socio-economic impacts; the resulting approach can be a tempering of the proposed controls provided that no unreasonable risks from the health protection viewpoint result.

Initiatives that have been implemented to reduce exposure to lead from all sources in Canada range from regulatory measures to a programme of information and education and include:

- the reduction and ultimate phase-out of lead additives in automotive gasolines;
- reduction in the permitted release of lead from ceramic ware;
- establishment of maximum limits for lead in certain foods, for example: tomatoes and tomato products, beverages and infant formula;
- regulations which limit the amount of lead in protective coatings on furniture and other articles intended for children; on toys, equipment and other products for use by children in learning to play; and on pencils and artists' brushes;

- support of a voluntary industry phase-out of lead solder in food cans;
- support of a voluntary industry agreement to eliminate lead from all consumer paints;
- revision of the Canadian guideline for lead in drinking water from 50 µg/l to 10 µg/l;
- implementation of recommendations made by the Department of National Health and Welfare that the use of lead solder in plumbing for drinking water be discontinued; and
- implementation of a national information programme to create an awareness of, and promote action to reduce, the health risks associated with removing leaded paint from older homes.

There is evidence that the actions taken as a whole in Canada have had a significant health benefit; average blood lead concentrations in Canadian children have shown a steady decline, from about 19 µg/dl in 1972, to 12 µg/dl in 1984, and to 6 µg/dl in 1988.

DENMARK

NATIONAL LEAD RISK STATEMENT

Lead has several harmful properties with respect to health and to the environment. Lead bioaccumulates and is in general very toxic. The current use today results in dispersion into all environmental media. The use of lead in products and as a metal will sooner or later end in waste and thereby be spread into the environment. The emissions today are adding to the present contamination of the environment, and will if the use is continued give rise to serious problems in the future.

NORWAY

GENERAL STATEMENT

Lead has no known essential role in biological processes, but is a poison that is harmful both to the environment and human health.

Lead is used in numerous products. Some of these applications give rise to direct emissions of lead to the environment, others give rise to a waste problem and a more slow contamination by lead/leaching of lead to water and soil. In the long run this leaching may add up to major pollution and health problems.

Lead ought to be substituted wherever possible. It is most important to reduce/substitute the use of lead in those applications that give risk to direct emissions/spreading and that involve greatest risk of hazardous effects. Research and development should be encouraged to find acceptable substitutes for areas of application where they do not exist today, so that the use of lead in the long term can be phased out.

In the meanwhile the amount of lead discharged to the environment should be minimized, and highly effective recollection and recovery systems for lead containing products should be established.

FRANCE

NOTE ON NATIONAL RISK REDUCTION STRATEGIES ASSOCIATED WITH LEAD

Public Health: Domestic Exposure

An important action is undertaken jointly by the Ministries of Environment, Health and Housing. It concerns children's exposure to lead in decrepit dwellings. The main conclusions from a report concerning an action of decontamination of 59 apartments are given hereafter:

- Renovation gives rise to dust, necessitating relodging families.

- The majority of current industrial vacuum cleaners do not retain very tiny particiles.

- Workers are quickly contaminated. Lead levels in blood can be threefold in a week. Biological monitoring is necessary. It is however not obligatory under current regulations. Moreover, working with partial or complete protective clothing reduces the working time to three or four consecutive hours. This is a cost factor and constitutes a major difficulty for small- and medium-size enterprises.

- Renovation of just apartments is not enough. Also, common areas need to be renovated. The agreement of all co-owners is necessary.

- The rubble contains important quantities of lead and needs to be notified to the authorities before disposal in an authorised landfill.

Concerted effort within as well as outside Europe is necessary.

GERMANY

GENERAL STATEMENT

The health risks connected with the intake of even relatively low doses of lead have gained growing attention worldwide in the last decades.

Lead can cause neurotoxicological effects and other biochemically tangible alterations in the organism of young children.

During pregnancy, lead can pass from the mother's blood circulation into the fetal organism without effective barrier.

This leads to the recommendation of physiologists and toxicologists, that blood lead levels of adults should not exceed the concentration of 15 µg/100 ml and those of children and women in the age of possible pregnancy should not exceed 10 µm/100 ml.

The abatement of lead pollution was one of the first aims of German environmental policy in the 1960s. One of the first examples of environmental legislation was the Lead-in-petrol-law (Benzinbleigesetz) of 1971.

Germany has today a two-fold comprehensive regulatory scheme for reducing exposure to lead:

- A regulatory system covers all the production facilities (emissions to air, water, soil, including waste disposal, as well as occupational health at the workplace).

- A consumer or product related system guarantees the safe use of industrial products.

In those cases where scientifically proven limit values could not be identified, the "precautionary principle" (*Vorsorgeprinzip*) has been the imminent rule and decisive basis for environmental standards, measures and controls.

In application of the "precautionary principle" of the German environment policy, many measures were taken in order to reduce the exposure of humans and the environment against lead. Such measures -- on a regulatory as well as on a voluntary agreement basis -- include:

- Restrictions of use of lead. These measures apply especially in cases where non-acceptable risks are proven.

- Reduction of emissions of lead at production level.

- Reduction of emissions of lead at user's level (i.e. voluntary agreements on collection and redelivery, incentives for a more effective recycling, etc.)

- Safer treatment and deposition of lead-containing wastes.

In some cases, proposed regulations concerning lead contents in commercial products

could not be implemented in Germany with respect to the rules of international free trade and regulations of the European Common Market, or their implementation was delayed (for example, introduction of unleaded gasoline).

SWEDEN

NATIONAL LEAD RISK STATEMENT/ RATIONALE FOR RISK REDUCTION MEASURES

Lead bioaccumulates and is, in general, very toxic. Current lead use involves dispersion into all environmental media and also gives rise to lead-containing waste that sooner or later will spread in the environment. Metallic lead in the environment will slowly transform and may be taken up by organisms. Exposure to lead may give rise to a number of serious effects on health, especially in occupationally exposed workers and in children. Therefore, the use of lead should be phased out.

In 1991, the Swedish Government decided that measures should be carried out in order to phase out the use of lead on a voluntary basis, and in the long run ensure its cessation. Work to ensure that the phaseout is carried through is now on-going, both at the responsible authorities and within industry.

SWITZERLAND

STATEMENT ON CURRENT RISKS FROM LEAD

Nature of Concern for Lead

Environment

The main general risk of lead was the fine dispersion in the environment by car traffic and the interrelated food intake by man and animals. However, this main source is rapidly decreasing in Switzerland (1984: 510 tonnes lead in fuel; 1990: 290 tonnes; 1995: 130 tonnes; 2000: 20 tonnes.)

Lead emission of municipal waste incinerators is decreasing due to extended flue gas treatment. The remaining main source of lead will be the metalworking industry, which is of local concern. Due to the use of wine capsules, about 200 tonnes of lead is found in urban solid waste.

The general population exposure is strongly decreasing since the last decade. This is shown by analysing food and pottery and by monitoring human blood levels of lead (FOEFL, 1992).

Workplace

Although the classic sources of exposure to lead at the workplace have been eliminated or greatly reduced, for certain professions, for example battery manufacturing, repairing of steel constructions of the cable industry, lead still has to be regarded as a severe health problem. The occupational exposure limit value ("MAX-Wert") for lead and its compounds (except alkyl compounds) is at present 0.1 mg/m^3.

Children

Recent results of epidemiological investigations indicate that blood lead concentrations of pregnant women as low as 10 to 15 µg/dl may have a detrimental effect on the development of the central nervous system of the foetus. At present in Switzerland blood lead concentrations in women of child bearing age in most cases do not exceed this value. (**Figure 45**, Chapter 3)

Lead in dust and soil is considered to contribute significantly to childhood lead exposure. The blood lead concentration of children is highly correlated with lead concentrations in dust and soil (playgrounds). Children -- especially young children -- show a high hand-to-mouth-behaviour. In addition, lead absorption in children is higher (40-60 per cent) than in adults (8-10 per cent). Prolonged exposure to the pollutant resulting in blood lead levels of 10 µg/dl and higher is known to lead to a reduction of IQ scores and behavioural difficulties in children.

THE UNITED KINGDOM VIEW OF RISKS ASSOCIATED WITH EXPOSURE TO LEAD

Introduction

Lead ore is plentiful, accessible and simple to smelt. The metal is heavy, pliable and resistant to corrosion. It is easily melted down and re-used. These properties account for its comprehensive use both traditionally in building, plumbing and shooting and in more modern applications like electrical insulation, radiation screening and battery manufacture. Even where substitutes are now preferred or required, artifacts from earlier times survive and are still in widespread use.

The Government recognizes that the cumulative effect of centuries of use is that lead is now one of the most widely dispersed of environmental pollutants. Moreover, so far as it is known, there is no harmless form into which lead can be converted in the environment, although the low solubility of many of its compounds limits their availability to living organisms. Thus, not only is there widespread human exposure to lead today but future generations too will be exposed to the lead which is already in the environment.

Health Effects

Frank lead poisoning is rare today and, where identified, is usually associated with exposure to specific localized sources. In recent years, however, there has been growing concern that lead in the body resulting from general environmental exposure may be harmful at concentrations which fall short of those at which clinical signs and symptoms appear.

In 1983, in a response to the Royal Commission report on lead in the environment, the Government accepted that, despite considerable research, no level has been established at which lead can be assumed to be safe (DOE 1983). The Government also accepted that, given the health uncertainties and the particular characteristics of lead as a widespread toxic pollutant, it was prudent to reduce exposure to it wherever practicable.

Lead is a neurotoxin which can affect the nervous system of developing children at lower levels than in adults. Particular attention therefore has been paid to the possible health effects on the intelligence and behaviour of young children.

A report from the Medical Research Council's Advisory Group on Lead and Neuropsychological Effects in Children (MRC 1983) suggested that any effects of lead at the exposure levels seen in the UK were very small and cannot be detected with any certainty. This conclusion was still largely applicable when the group reported again in 1988 but the evidence for an association between body burden and IQ was now stronger (MRC 1988).

The group observed that whilst statistical associations detailed in the numerous studies reviewed were consistent with the hypothesis that low level lead exposure has a small negative effect on the performance of children in ability and attainment tests, the limitations of the epidemiological studies in drawing causal inferences were such that is was not possible to conclude that exposure to lead at current urban levels was definitely harmful. In view of these

conclusions it was recommended that it would be prudent to continue to reduce the exposure to environmental lead.

Exposure

The average blood lead levels in the population as a whole have declined substantially over the past decade by 4 to 5 per cent per annum. Figures from the last national survey of blood lead levels in 1987 (DOE 1990) gave a geometric mean in the region of 6.9 to 9.7 µg/dl blood lead for adults and 7.1 to 7.5 µg/dl blood lead for children. Recent small scale local investigations indicate that the trend of declining average blood lead is continuing. Blood lead levels can be influenced by numerous factors, most are related to the sources of exposure.

A report titled "Lead in the Environment and its Significance to Man", produced by the Department of the Environment in 1974, provided the first comprehensive summary of the exposure pathways to humans (DOE 1974). Several key sources of exposure were identified and a programme to safeguard human health was outlined. These included lead in paint, petrol, drinking water and food. Subsequent action was later reviewed in the report of the Royal Commission on Environmental Pollution (RCEP 1983). Amongst the numerous recommendations which the Royal Commission called for were, further reduction in the lead content of petrol leading to the phasing out of lead additives altogether, reductions in the use of lead in household paints and continued remedial programmes of water treatment and lead pipe replacement. The various policy objectives and risk reduction measures taken are detailed in the summary of United Kingdom actions.

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UNITED STATES POSITION ON CURRENT RISKS FROM LEAD

Agencies in the United States concerned with the health and environmental effects of lead exposure, including the US Environmental Protection Agency, the Centers for Disease Control, the Department of Health and Human Services, the Department of Housing and Urban Development, the Food and Drug Administration, the Consumer Product Safety Commission, the National Institute for Occupational Safety and Health, and the Occupational Safety and Health Administration, have drawn a number of conclusions regarding current lead exposure:

Lead exposure is widespread. A combination of factors (for example, lead's physical characteristics and cost) make lead an attractive material for a wide variety of applications; therefore, lead provides large economic benefits to its users. However, lead's widespread use has resulted in large amounts of lead being deposited to air, land and water. Lead is an elemental pollutant that does not disintegrate. Thus, the total amount of lead pollutants resulting from human activity will increase with time no matter how little additional lead is added to the environment. The current production, use and disposal of lead are highly regulated with demonstrably effective results. However, because of its previous widespread use and persistence, lead exposure is a pervasive problem, affecting a number of local populations.

Lead is a powerful toxicant and produces adverse effects even at low levels. Lead is a poison that affects virtually every system in the body. Severe exposures can cause coma, convulsions and death. Lower levels cause adverse effects on the central nervous system, kidneys, reproductive system and blood production system (1). Children are particularly susceptible to lead poisoning. Blood lead (PbB) levels at least as low as 10 to 15 µg/dl are associated with decreased intelligence and slowed neurological development; low levels have also been associated with deficits in growth, vitamin metabolism and effects on hearing. Chronic childhood lead exposure may not produce clinical symptoms especially at lower levels, and many cases go undiagnosed and untreated. Lead's neurological effects on children are profound and are likely persistent. In 1992, the Residential Lead-based Paint Hazard Reduction Act of 1992 was enacted (Title X). This law provides the framework for a national approach to reduce hazards from lead-based paint exposure, primarily in housing. It will establish a national infrastructure of trained workers, training programmes and proficient laboratories, and a public education programme to reduce hazards from exposure to lead in paint in the nation's housing stock.

Lead is deposited in bone over the lifetime of the exposed individual. Long after exposure has ceased, some physiological event such as serious illness or pregnancy may release this stored lead from the bone and produce adverse health effects such as impaired hemoglobin synthesis, alteration in the central and peripheral nervous systems, hypertension, effects on male and female reproductive systems, and damage to the developing fetus. These effects may occur at PbB levels below 50 µg/dl and are likely to be dependent on the level and duration of exposure (2)(3)(11).

Because of continuing epidemiological research that has detected adverse health effects from lead at levels lower than those previously regarded as toxic, the level of concern for childhood lead poisoning in the US has been steadily lowered over the past twenty years. Scientific evidence showing effects of PbB levels below 25 µg/dl in children has recently compelled the Centers for Disease Control (CDC) to lower the threshold for lead poisoning prevention activities to PbB levels of 10 µg/dl. Earlier, EPA had lowered the level of concern to 10 µg/dl in 1986 (8) and ATSDR identified the same level of concern in the 1988 report to Congress on childhood lead poisoning

(10).

Childhood lead poisoning is widely recognized in the US as the most widespread and preventable childhood health problem associated with environmental exposures. In 1984, an estimated 2.4 million (17 per cent) of children living in Standard Metropolitan Statistical Areas in the US had PbB levels above 15 µg/dl (10). Though widely perceived as a problem of inner city minority children, in fact, lead poisoning in the US affects children from all areas and from all socio-economic groups.

Adults also face health risks from lead, possibly at low PbB levels. NIOSH has issued a health alert to construction workers warning them to the possibility of adverse health effects resulting from long-term, low-level exposure (11). NIOSH has committed to a goal of eliminating occupational exposures that result in workers having blood lead levels greater than 25µg/dl (11).

Though the average level of lead exposure has dropped, the prevalence of poisoning and population exposures are still of concern. The percentage of children with elevated blood lead has declined substantially over the last twenty years, with average PbB levels dropping from over 15 to about 5 µg/dl (1). The US has made important strides in reducing exposures to lead, notably through reductions of lead in gasoline; in food can solder; in atmospheric deposition in soil/dust and on food crops; and in new residential paint (1). However, despite progress in reducing average lead exposures, current lead exposures among children at risk remain problematic, especially since there is little margin of safety between current blood lead levels and levels now believed to cause effects in children. Though the effects of lead at low levels are not as severe as those at high-levels, a larger number of children are affected at these levels, making these exposures an important public health concern (10).

Household dust derived from deteriorated lead-based paint is the most important source of high-level lead exposures in the US. Because lead is a multi-media pollutant, all sources contribute to the overall problem. However, there is general consensus that deteriorated lead-based paint (applied prior to actions taken to ban the use of lead in residential paint) is the major source of high-dose lead poisoning in US children. Other sources contribute to overall exposure, but such paint is associated with highest exposures (5). Millions of private homes in the US with lead-based paint continue to be occupied by families with small children, and there is no apparent correlation between incidence of lead-based paint and income of the household (7). Notably, many houses with lead-based paint are rental units that will be rented to many different families over the years. Thus, a single house with deteriorated lead-based paint can be the source of exposure for many children (8).

Other important sources of lead exposure include soil/dust; drinking water; occupational exposures; airborne lead from point sources (for example, smelters); hazardous waste sites; and products containing lead. Lead-contaminated soil and dust are widespread, and are often associated with structures containing lead-based paint (such as houses, bridges, and water tanks). Drinking water can be contaminated with lead that can leach from pipes carrying water to homes, from lead-soldered pipe joints, and from lead in brass and bronze plumbing fittings and fixtures. Given the actions taken to date to control other sources of lead, in some areas of the US drinking water remains an important source of lead exposure, especially to children.

US regulatory activities, such as decreases of lead in gasoline and in residential paint and the voluntary programme by the domestic food industry to discontinue use of lead solder in food cans, have resulted in significant reductions in average levels of lead exposure. Nevertheless, the US still considers current levels of lead exposure to be an important public health problem,

especially in high risk communities. In recognition of the extent and severity of lead exposure in the US, various Federal government agencies and bodies have initiated further activities to reduce lead exposures in a variety of settings. These activities include:

The Centers for Disease Control (CDC) have lowered the level of PbB of concern in children from 25 µg/dl to 10 µg/dl (1). Recognition of this level of concern in the United States dates back to 1986 (8)(10). CDC has also identified an agenda for the first five years of a 20-year effort to reduce the number of lead-poisoned children in the US, including: screening high-risk communities, with appropriate environmental and medical follow-up for poisoned children; conducting studies to determine the impact of interventions on children's blood lead levels; and establishing national surveillance for children with elevated PbB levels (5).

The National Institute for Occupational Safety and Health (NIOSH) has been involved in several activities related to the prevention of occupational exposures to lead. These include the publication of an alert providing recommendations for preventing lead poisoning during blasting, sanding, cutting, burning or welding of bridges and other steel structures coated with lead paint (11). NIOSH also collaborated with the Occupational Safety and Health Administration (OSHA) on guidelines for the prevention of lead exposure for construction workers (12). NIOSH has also committed to a goal of eliminating occupational exposures that result in workers having blood lead levels greater than 25 µg/dl. Finally, NIOSH is currently evaluating health data in the development of criteria for a recommended occupational standard for lead.

The Occupational Safety and Health Administration (OSHA) of the US Department of Labor has established environmental and biological standards for lead-using industries. Standards take the form of both permissible workplace air contaminants and permissible blood levels in workers. Environmental and biological monitoring must be conducted by the employer. Elevated blood lead levels may require the removal of an individual from the work place. The current Permissible Exposure Level (PEL) generally limits air concentrations of lead to 50 µg/m^3. OSHA's general industry lead standard also requires employers who have employees exposed to lead above an action level of 30 µg/m^3 to implement a programme that includes provisions for methods of compliance, medical surveillance, exposure monitoring, training, regulated areas, respiratory protection, protective work clothing and equipment, housekeeping, hygiene facilities and practices, signs and labels, recordkeeping and the need to limit exposures below 50 µg/m^3. OSHA's PEL for lead in the construction industry is 200 µg/m^3. Under Title X, OSHA is required to promulgate interim final standards for occupational exposure to lead in the construction industry.

The Consumer Product Safety Commission (CPSC) Lead Poisoning Project seeks to prevent lead poisoning of consumers. In 1990, CPSC published a consumer safety alert/brochure on lead paint in the home (13), based on the HUD abatement interim guidelines. CPSC is also evaluating lead test kits for safety, efficacy, and consumer-friendliness. These kits are potential screening devices that may be used by the consumer to detect lead in paint and other materials. The Commission staff is also evaluating recent data on lead toxicity to determine the need to lower the existing allowable lead limit for paint (currently 0.06 per cent by weight in dried paint film). In support of this effort, national marketplace samples of residential paint are being analysed for lead.

The Department of Housing and Urban Development (HUD) submitted to Congress a comprehensive plan to address the lead-based paint problem in private housing (7). Activities include updating the lead-based paint regulations in HUD programmes; updating regulations for dealing with lead-based paint in Federally owned property; providing support for local screening programmes; increasing public education; supporting research to reduce the cost and improve the

reliability of testing and abatement; supporting research on the cost-effectiveness of various abatement techniques; evaluating strategies to address exterior soil lead and dust and interior dust lead; increasing state and local support; and providing more money to support abatement in low and moderate income households. HUD estimated that the total cost of testing and abatement in high-priority hazard homes would be about $8 to 10 billion annually over ten years. The costs could be lowered substantially by integrating abatement with other renovation activities. In 1992, HUD awarded $47.7 million to states and communities for the abatement of lead-based paint in privately-owned low and middle income housing. The agency plans to award an additional $90 million in 1993.

The Environmental Protection Agency (EPA) has developed a strategy to reduce lead exposures "to the fullest extent practicable, with particular interest in reducing the risk to children, to avoid high blood lead levels" (6). Two specific objectives of the lead strategy are (a) to significantly reduce the incidence of PbB levels above 10 μg/dl in children, and (b) to reduce lead exposures that are anticipated to pose risks to children, the general public, or the environment. EPA aims to accomplish these goals by identifying geographical "hot spots," implementing a lead pollution prevention programme, strengthening environmental standards, developing and providing information on cost-effective abatement technologies, encouraging the availability of environmentally safe recycling, implementing a public information programme, aggressively enforcing existing environmental standards, and increasing research in many of these areas.

Under Title X, EPA is mandated to promulgate regulations ensuring that those engaged in abatement activities are trained and that training programmes are certified, to establish standards for abatement activities, to promulgate model State programmes from compliance with training and accreditation regulation, to establish a laboratory accreditation programme, to establish a clearinghouse for dissemination of information, to promulgate regulations for the disclosure of lead hazards at property transfer, to conduct a study on the hazards of renovation and remodeling activities, and to develop regulations to identify lead hazards in paint, dust, and soil.

The Food and Drug Administration (FDA) has continued with its programme to identify and mitigate sources of lead in the diet, particularly those in foods consumed by infants, children and pregnant women. Voluntary efforts as well as reduced action levels have resulted in reducing lead exposures from food cans and from lead-glazed ceramic ware. Other sources of dietary lead for which regulatory measures are being introduced include wine, dietary supplements, crystal ware, food additives and bottled water.

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IPCS ASSESSMENT OF THE RISK OF LEAD:

CHAPTERS 1 AND 9 OF THE TASK GROUP-APPROVED DRAFT ENVIRONMENTAL HEALTH CRITERIA DOCUMENT

1. Summary and Conclusions[5]

This monograph focuses on the risks to human health associated with exposure to lead and inorganic lead compounds. Emphasis has been given to data which have become available since the publication of Environmental Health Criteria 3: Lead (WHO 1977). The environmental effects of lead are discussed in Environmental Health Criteria 85: Lead - Environmental Aspects (WHO 1989).

1.1 Identity, physical and chemical properties, and analytical methods

Lead is a soft, silvery grey metal, melting at 327.5 ◦C. It is highly resistant to corrosion, but is soluble in nitric and hot sulfuric acids. The usual valence state in inorganic lead compounds is +2. Solubilities in water vary, lead sulfide and lead oxides being poorly soluble and the nitrate, chlorate and chloride salts reasonably soluble in cold water. Lead also forms salts with such organic acids as lactic and acetic, and stable organic compounds such as tetraethyllead and tetramethyllead.

The most commonly used methods for the analysis of low concentrations of lead in biological and environmental materials are flame, graphite furnace, and inductively coupled plasma and atomic absorption spectroscopy and anode stripping voltammetry. Depending on sample pretreatment, extraction techniques and analytical instrumentation, detection limits of 0.12 µmoles lead/litre blood (2.49 µg/dl) can be achieved. However, reliable results are obtained only when specific procedures are followed to minimize the risk of contamination during sample collection, storage, processing and analysis.

1.2 Sources of human exposure

Levels of lead in the earth's crust are about 20 mg/kg. Lead in the environment may derive from either natural or anthropogenic sources. Natural sources of atmospheric lead include geological weathering and volcanic emissions and have been estimated to produce 19 000 tonnes/year, compared to an estimate of 126 000 tonnes/year emitted to the air from the mining, smelting and consumption of over 3 million tonnes of lead per year.

Atmospheric lead concentrations of 50 pg/m^3 have been found in remote areas. Background levels of lead in soil range between 10 and 70 mg/kg, and a mean level near roadways of 138 mg/kg has been reported. Present levels of lead in water rarely exceed a few microgrammes per litre; the natural concentration of lead in surface water has been estimated to be 0.02 µg/litre.

[5] The content of this chapter has been approved by an IPCS Task Group, 1-6 February 1993. During technical editing corrections may be made to numbers quoted, however, these will not affect the conclusions shown.

Lead and its compounds may enter the environment at any point during mining, smelting, processing, use, recycling or disposal. Major uses are in batteries, cables, pigments, petrol (gasoline) additives, solder and steel products. Lead and lead compounds are also used in solder applied to water distribution pipes and to seams of cans used to store foods, in some traditional remedies, in bottle closures for alcoholic beverages and in ceramic glazes and crystal tableware. In countries where leaded petrol is still used, the major air emission is from mobile and stationary sources of petrol combustion (urban centres). Areas in the vicinity of lead mines and smelters are subject to high-levels of air emissions.

Airborne lead can be deposited on soil and water, reaching humans through the food chain and in drinking-water. Atmospheric lead is also a major source of lead in household dust.

1.3 Environmental transport, distribution and transformation

The transport and distribution of lead from fixed, mobile and natural sources is primarily via air. Most lead emissions are deposited near the source, although some particulate matter (< 2 µm) is transported over long distances and results in the contamination of remote sites such as arctic glaciers. Airborne lead can contribute to human exposures by the contamination of food, water and dust, as well as through direct inhalation. The removal of airborne lead is influenced by atmospheric conditions and particulate size. Large amounts of lead may be discharged to soil and water. However, such material tends to remain localized because of the poor solubility of lead compounds in water.

Lead deposited in water, whether from air or through run-off from soils, partitions rapidly between sediment and aqueous phase, the rate depending upon pH, salt content, and the presence of organic chelating agents. Above pH 5.4, hard water may contain about 30 µg lead/litre and soft water about 500 µg lead/litre. Very little lead deposited on soil is transported to surface or ground water except through erosion or geochemical weathering; it is normally quite tightly bound (chelated) to organic matter.

Airborne lead can be directly transferred to biota or through uptake from soil. Animals can be exposed to lead directly through grazing and soil ingestion or by inhalation. There is little biomagnification of inorganic lead through the food chain.

1.4 Environmental levels and human exposure

In the general non-smoking adult population, the major exposure pathway is from food and water. Airborne lead may contribute significantly to exposure, depending upon such factors as use of tobacco, occupation, proximity to motorways, lead smelters, etc., and leisure activities (for example, arts and crafts, firearm target practice). Food, air, water and dust/soil are the major potential exposure pathways for infants and young children. For infants up to 4 or 5 months, air, milk formulae and water are the significant sources of lead exposure.

Levels of lead found in air, food, water and soil/dust vary widely throughout the world and depend upon the degree of industrial development, urbanization and lifestyle factors. Ambient air levels of over 10 µg/m^3 have been reported in urban areas near a smelter, whereas lead levels below 0.2 µg/m^3 have been found in cities where leaded petrol is no longer used. Lead intake from

air can, therefore, vary from less than 4 µg/day to more than 200 µg/day.

Levels of lead in drinking-water sampled at the source are usually below 5 µg/litre. However, water taken from taps (faucets) in homes where lead is present in the plumbing can contain levels in excess of 100 µg/litre, particularly after the water has been standing in the pipes for some hours.

The level of dietary exposure to lead depends upon many lifestyle factors, including foodstuffs consumed, processing technology, use of lead solder, lead levels in water, and use of lead glazed ceramics.

For infants and children, lead in dust and soil often constitutes a major exposure pathway. Lead levels in dust depend upon such factors as the age and condition of housing, the use of lead-based paints, lead in petrol and urban density. The intake of lead will be influenced by the age and behavioural characteristics of the child and bioavailability of lead in the source material.

Inhalation is the dominant pathway for lead exposure of workers in industries producing, refining, using or disposing of lead and lead compounds. During an 8-h shift, workers can absorb as much as 400 µg lead, in addition to the 20-30 µg/day absorbed from food, water and ambient air; significant intake may occur from ingestion of large inhaled particulate material.

1.5 Kinetics and metabolism in laboratory animals and humans

Lead is absorbed in humans and animals following inhalation or ingestion; percutaneous absorption is minimal in humans. Depending upon chemical speciation, particle size, and solubility in body fluids, up to 50 per cent of the inhaled lead compound may be absorbed. Some inhaled particulate matter (larger than 1 µm) is swallowed following mucociliary clearance from the respiratory tract. In experimental animals and humans, absorption of lead from the gastrointestinal tract is influenced by the physicochemical nature of the ingested material, nutritional status, and type of diet consumed. In adult humans approximately 10 per cent of the dietary lead is absorbed; the proportion is higher under fasting conditions. However, in infants and young children as much as 50 per cent of dietary lead is absorbed, although absorption rates for lead from dusts/soils and paint chips can be lower depending upon the bioavailability. Diets that are deficient in calcium, phosphate, selenium or zinc may lead to increased lead absorption. Iron and vitamin D also affect absorption of lead.

Blood lead (PbB) levels are used as a measure of body burden and absorbed (internal) doses of lead. The relationship between blood lead and concentration of lead in exposure sources is curvilinear.

Once it has been absorbed, lead is not distributed homogeneously throughout the body. There is rapid uptake into blood and soft tissue, followed by a slower redistribution to bone. Bone accumulates lead over much of the human life span and may serve as an endogenous source of lead. The half-life for lead in blood and other soft tissues is about 28-36 days and much longer in the various bone compartments. The percentage retention of lead in body stores is higher in children than adults. Transfer of lead to the human fetus occurs readily throughout gestation.

Blood lead is the most commonly used measure of lead exposure. However, techniques are now available for measuring lead in teeth and bone, although the kinetics are not fully

understood.

1.6 Effects on laboratory mammals; in vitro systems

In all species of experimental animals studied, including non-human primates, lead has been shown to cause adverse effects in several organs and organ systems, including the haemopoietic, nervous, renal, cardiovascular, reproductive and immune systems. Lead also affects bone and has been shown to be carcinogenic in rats and mice.

Despite kinetic differences between experimental animal species and humans, these studies provide strong biological support and plausibility for the findings in humans. Impaired learning/memory abilities have been reported in rats with PbB levels of 0.72-0.96 µmoles/litre (15-20 µg/dl) and in non-human primates at PbB levels not exceeding 0.72 µmol/litre (15 µg/dl). In addition, visual and auditory impairments have been reported in experimental animal studies.

Renal toxicity in rats appears to occur at a PbB level in excess of 2.88 µmol/litre (60 µg/dl), a value similar to that reported to initiate renal effects in humans. Cardiovascular effects have been seen in rats after chronic low-level exposures resulting in PbB levels of 0.24-1.92 µmol/litre (5-40 µg/dl). Tumours have not been shown to occur below the maximum tolerated dose of 200 mg lead (as lead acetate) per litre of drinking-water. This is the maximum dose level not associated with other morphological or functional changes.

1.7 Effects on humans

In humans, lead can result in a wide range of biological effects depending upon the level and duration of exposure. Effects at the subcellular level, as well as effects on the overall functioning of the body, have been noted and range from inhibition of enzymes to the production of marked morphological changes and death. Such changes occur over a broad range of doses, the developing human generally being more sensitive than the adult.

Lead has been shown to have effects on many biochemical processes; in particular, effects on haem synthesis have been studied extensively in both adults and children. Increased levels of serum erythrocyte protoporphyrin and increased urinary excretion of coproporphyrin and δ-aminolaevulinic acid are observed when blood lead concentrations are elevated. Inhibition of the enzymes δ-aminolaevulinic acid dehydratase and dihydrobiopterin reductase are observed at lower levels.

The effects of lead on the haemopoietic system result in decreased haemoglobin synthesis, and anaemia has been observed in children at blood lead concentrations above 1.92 µmol/litre (40 µg/dl).

For neurological, metabolic and behavioural reasons, children are more vulnerable to the effects of lead than adults. Both prospective and cross-sectional epidemiological studies have been conducted to assess the extent to which environmental lead exposure affects CNS-based psychological functions. Lead has been shown to be associated with impaired neurobehavioural functioning in children.

Impairment of psychological and neurobehavioural functions has been found after long-term lead exposure of workers. Furthermore, electrophysiological parameters have been shown to be useful indicators of subclinical lead effects in the CNS.

Peripheral neuropathy has long been known to be caused by long-term high-level exposure at the workplace. Slowing of nerve conduction velocity has been found at lower levels. These effects have often been found to be reversible after cessation of exposure, depending on the age and duration of exposure.

The effect of lead on the heart is only indirect and occurs via the autonomic nervous system; it has no direct effect on the myocardium. The collective evidence from population studies in adults indicates very weak associations between blood lead concentration and systolic or diastolic blood pressure. Given the difficulties of allowing for relevant confounding factors, a causal relationship cannot be established from these studies. There is no evidence to suggest that any association of blood lead concentration with blood pressure is of major health importance.

Lead is known to cause proximal renal tubular damage, characterized by generalized aminoaciduria, hypophosphataemia with relative hyperphosphaturia and glycosuria accompanied by nuclear inclusion bodies, mitochondrial changes and cytomogaly of the proximal tubular epithelial cells. Tubular effects are noted after relatively short-term exposures and are generally reversible, whereas sclerotic changes and interstitial fibrosis, resulting in decreased kidney function and possible renal failure, require chronic exposure to high lead levels. Increased risk from nephropathy was noted in workers with a PbB level of over 3.0 µmol/litre (about 60 µg/dl). Renal effects have been recently seen among general populations where more sensitive indicators of function were measured.

The reproductive effects of lead in the male are limited to sperm morphology and count. In the female, some adverse pregnancy outcomes have been attributed to lead.

Lead does not appear to have deleterious effects on skin, muscle or the immune system. Except in the case of the rat, lead does not appear to be related to the development of tumours.

1.8 Evaluation of human health risks - Conclusions

Lead adversely affects several organs and organ systems, with subcellular changes and neurodevelopmental effects appearing to be the most sensitive. An association between blood lead and hypertension (blood pressure) has been reported. Lead produces a cascade of effects on the haem body pool and affects haem synthesis. However, some of these effects are not considered adverse. Calcium homeostasis is affected thus interfering with other cellular processes.

a) The most substantial evidence from cross-sectional and prospective studies of populations with PbB levels generally below 1.2 µmol/litre (25 µg/dl) relates to detriments in IQ. It is important to note that such observational studies cannot provide definitive evidence of a causal relationship with lead exposure. However, the size of the apparent IQ effect, as assessed at 4 years and above, is a deficit between 0 and 5 points (on a scale with a standard deviation of 15) for each 0.48 µmol/litre (10 µg/dl) increment in PbB level, with a likely apparent effect size of between 1 and 3 points. At PbB levels above 1.2 µmol/litre (25 µg/dl), the relationship between PbB and IQ may differ. Estimates of effect size are group averages and only apply to the individual child in a probabilistic manner.

   Existing epidemiological studies do not provide definitive evidence of a threshold. Below the PbB range of 0.48 to 0.72 µmol/litre (10-15 µg/dl), the effect of confounding

variables and limits in the precision of analytical and psychometric measurements increases the uncertainty attached to any estimate of effect. However, there is some evidence of an association below this range.

b) Animal studies provide support for a causal relationship between lead and nervous system effects, reporting deficits in cognitive functions which occur at PbB levels as low as 0.53-0.72 µmol/litre (11-15 µg/dl) and which can persist well beyond the termination of lead exposure.

c) Reduction in peripheral nerve conduction velocity may occur with PbB levels as low as 1.44 µmol/litre (30 µg/dl). In addition, sensory motor function may be impaired with PbB levels as low as about 1.92 µmol/litre (40 µg/dl), and autonomic nervous system function (electrocardiographic R-R interval variability) may be affected at an average PbB level of approximately 1.68 µmol/litre (35 µg/dl). The risk of lead nephropathy is increased in workers with PbB levels above 2.88 µmol/litre (60 µg/dl). However, recent studies using more sensitive indicators of renal function suggest renal effects at lower levels of lead exposure.

d) Lead exposure is associated with a small increase in blood pressure. The likely order of magnitude is that for any two-fold increase in PbB (for example, from 0.8 to 1.6 µmol/litre, i.e. 16.6 to 33.3 µg/dl), there is a mean 1 mmHg increase in systolic blood pressure. The association with diastolic pressure is of a similar but smaller magnitude. However, there is doubt regarding whether these statistical associations are really due to an effect of lead exposure or are an artifact due to confounding factors.

e) Some but not all epidemiological studies show a dose-dependent association of pre-term delivery and some indices of fetal growth and maturation at PbB levels of 0.72 µmol/litre (15 µg/dl) or more.

f) The evidence for carcinogenicity of lead and several inorganic lead compounds in humans is inadequate.

g) Effects of lead on a number of enzyme systems and biochemical parameters have been demonstrated. The PbB levels, above which effects are demonstrable with current techniques for the parameters that may have clinical significance, are all greater than 0.96 µmol/litre (20 µg/dl. Some effects on enzymes are demonstrable at lower PbB levels, but the clinical significance is uncertain.

9. Evaluation of Human Health Risks[6]

9.1 Exposure assessment

Lead is an ubiquitous element detected in all environmental media. However, natural sources contribute only a small fraction of the amounts of lead found in air, food, water and dust. The majority of lead in these media arises from automobile and industrial emissions and from the use of lead-containing solder and paints. Adults and older children receive the largest proportion of lead intake from foods, whereas for young children dust, soil and food all make significant contributions to the total lead intake. The major contributions to lead in soil and outdoor dust are from the combustion of fossil fuels (principally leaded petrol), stationary sources such as smelters, and peeling and flaking of lead-based paint.

9.1.1 General population exposure

In the absence of specific stationary sources of lead, concentrations in ambient air are directly related to the density of traffic and whether lead is still utilized as an additive in petrol. Reduction or elimination of lead in petrol in those countries which have instituted regulations has resulted in a decline by as much as eight-fold in ambient air concentrations of lead.

Levels of lead in indoor air are affected by the presence of cigarette smoke and dust from lead-painted surfaces. Without such sources, air lead levels indoors are about 60 per cent of those in ambient air.

For most adults, the total daily exposure to lead is via food, water and air. For infants aged up to five months, formula or breast milk, and water are the main sources of lead. In children, an additional source of exposure is dust and soils. Absorption is dependent on the chemical form of lead, type of soil and particle size (bioavailability). Lead intake may be augmented from unusual sources such as folk remedies, cosmetics and hobby activity. Community contamination and workplace practices may contribute to lead exposure.

Food (including drinking-water and beverages) is the major source of lead exposure for the general population. Infants and children may receive an added lead burden from soil and dust. The most significant foodstuffs vary from country to country. In areas still utilizing lead-soldered cans, levels of lead are substantially higher. Depending upon life-styles, there may be significant oral intake of lead from some alcoholic beverages and due to the leaching of lead from low-temperature-fired ceramic containers.

Most drinking-water supplies contain lead levels of less than 5 µg/litre when they leave the treatment plant. However, where the water is known to be plumbo-solvent, up to 40 per cent of the samples may exceed 100 µg/litre in homes where lead solder, lead pipes and/or brass fixtures have been used.

[6] The content of this chapter has been approved by an IPCS Task Group, 1-6 February 1993. During technical editing corrections may be made to numbers quoted, however, these will not affect the conclusions as shown.

Absorption of lead from the lung is a function of particle size and pulmonary deposition pattern. Small particles (< 0.5 µm) characteristic of ambient air will be deposited deeply in the lungs with absorption rates of 90 per cent. Larger particles, such as may be encountered in occupational settings, exhibit high deposition rates in the upper airway. Absorption of such particles will be a function of both dissolution in the lung and particle clearance to the gastrointestinal tract.

Human dermal absorption of inorganic lead through unabraded skin is of limited significance.

9.1.2 Occupational exposures

In addition to exposure from lead in ambient air, water and food, some workers may be exposed to airborne lead and dust within the workplace. Actual levels will vary according to the engineering design of the process equipment and the industrial hygiene practices utilized.

9.2 Critical issues related to exposure evaluation

In view of the heterogeneity of responses to lead within human populations, the complex interrelationships between exposure to lead and a biological indicator for internal dose require consideration of several key issues in order to assess human exposures.

9.2.1 Sampling and analytical concerns

Reliable comparisons of reported levels of exposure and/or dose can only be made where authors have described the analytical and sampling procedures in sufficient detail to allow the reader to assess, for example, the integrity of the sampling procedures as well as the specificity, precision and accuracy of all analytical methods. Problems related to sampling cord blood also need to be considered.

Most studies have utilized analytical procedures of high quality. However, in comparing results, consideration must be given to blood collection procedures (finger stick versus venepuncture).

9.2.2 Data presentation

Inter-study comparisons of lead exposures are complicated by the variety of methods used to present results including median values as well as geometric and arithmetic means. Some authors have used log transformed data.

In assessing exposure from data on teeth, one must know which tooth and which compartments within the tooth were sampled. Also, if data are to be compared between studies, authors must state explicitly that all teeth analysed were without caries and were shed spontaneously.

The exposure index lifetime average blood lead (PbB) level has assisted in the

assessment of cumulative exposures from serial blood lead data. It should not be interpreted as being equivalent to a single blood lead determination at a single point in life.

For some data/analytical purposes, age-specific PbB levels may be more appropriate than a lifetime average.

9.3 Relationship between exposure and dose

The most widely used surrogate for the absorbed dose is whole PbB concentration.

The relationship between PbB level and lead intake is curvilinear over a wide range of PbB values. On the basis of a single study of 17 infants, the relationship between PbB level and lead intake from food has been determined to be 0.16 µg lead/dl blood per µg lead intake per day for a median PbB level of approximately 10 µg/dl.

Most studies of the relationship between PbB level and lead exposures apply to a single environmental source, i.e. air, food, water or soil/dust. A summary of the relationship between PbB level and lead intake from individual media is given in Table 9.1.

Table 9.1. Representative relationships of blood lead level (median blood lead level: 10 µg/dl) to intake of lead for the general population[a]

Medium	Children	Adults
Air[b]	1.92 µg/m^3 per µg/m$^{3\ intake}$ (0.09 µmol)	1.64 /µg/dl per µg/m^3 intake[c] (0.079 µmol)
Water		0.6 µg/dl per µg/litre intake (0.003 µmol)
Food	0.16 µg/dl per µg/day intake (0.01 µmol)	0.04-0.06 µg/dl per µg/day intake (0.002-0.003 µmol)
Dust[b]	1.8 µg/dl per 1000 µg/g intake (0.09 µmol)	
Soil[b]	2.2 µg/dl per 1000 µg/g intake (0.11 µmol)	

[a] These data are provided for illustrative purposes, recognizing that the relationships are curvilinear in nature, and are broad guidelines that will not apply at lower or higher levels of exposure.

[b] A value of between 3 and 5 µg/dl per µg/m^3 intake is obtained when one considers indirect contribution through deposition on soil/dust.

[c] The relationship of air lead to blood lead concentrations in occupational settings is best described by a curvilinear relationship having slopes between 0.02 and 0.08 μg/dl per μg/m^3 air. The slope is variable but lower than that found for humans in the general environment (1.6-1.9 μg/dl per μg/m^3 air).

9.4 Surrogate measures of dose

9.4.1 Blood

Whole PbB values are widely used as a measure of absorbed dose. However, it is believed that plasma lead concentrations may better reflect the ``active'' fraction of lead in blood and define the relationship between blood lead and tissue or organ accumulation (and effect), although there is little experimental data (because of analytical limitations). Blood lead is distributed between plasma and the erythrocyte, with less than 5 per cent being in the plasma; most of the lead is bound to haemoglobin.

Venous and capillary blood levels are generally equivalent provided that the sampling technique has been demonstrated to be adequate.

9.4.2 Urine

Urinary measurements of lead concentration are of limited value, although they are used occasionally as a screening test for occupational population groups.

9.4.3 Bone

Bone lead may be measured by non-invasive X-ray fluorescence but it is limited in sensitivity at present.

9.4.4 Tooth

Shed deciduous teeth have been used to provide an index of exposure in early childhood. Interpretation of the analytical data is dependent on which tooth and which part of that tooth (whole tooth, dentine or circumpulpar dentine) is analysed.

9.4.5 Hair

Hair is not useful as a measurement of lead exposure.

9.5 Biochemical effects of lead

9.5.1 Haem synthesis

Evaluation of the quality of analytical data is an important aspect in considering reports

describing effects attributed to lead. It should be noted that much of the data presented in this area has not been as vigorously scrutinized as, for example, psychometric study data.

An increase in EP in children occurs between PbB levels of 0.72 and 1.2 µmol/litre (15-25 µg/dl). Increases in EP can be detected in men when the PbB level is above 1.20-1.44 µmol/litre (25-30 µg/dl); and in women when it is above 0.96-1.44 µmol/litre (20-30 µg/dl). It should be noted that the effect of lead on haem is confounded by low iron status.

9.5.1.1 Urinary coproporphyrin

The coproporphyrin concentration in urine increases significantly with PbB levels in excess of 1.92 µmol/litre (40 µg/dl).

9.5.1.2 Urinary ALA - children

In children 1-5 years old, there is a linear relationship with PbB in the range 1.2-3.6 µmol/litre (25-75 µg/dl). Data for children with PbB levels of 0.24-1.92 µmol/litre (5-40 µg/dl) show essentially no correlation with urinary aminolaevulinic acid (ALA) excretion. Elevation of ALA-U is evident at about 1.68 µmol/litre (35 µg/dl).

9.5.1.3 Urinary ALA - general population

Urinary excretion of ALA increases in men at PbB levels above 2.16 µmol/litre (45 µg/dl) and in women above 1.68 µmol/litre (35 µg/dl).

9.5.1.4 δ-Aminolevulinic acid dehydratase (ALAD)

There was a negative exponential relationship between PbB level and ALAD activity in a population of 10- to 13-year-old children with PbB levels in the range 0.19-1.97 µmol/litre (4.7-41 µg/dl). An effect was seen at a PbB level of approximately 0.48 µmol/litre (10 µg/dl). There is an apparent lack of a clearly defined threshold for lead inhibition of ALAD in different age groups.

9.5.2 Vitamin D metabolism

In the presence of adequate nutritional status, PbB levels below 0.96 µmol/litre (20 µg/dl) appear to have no demonstrable effect on circulating concentrations of 1,25-dihydroxy vitamin D. A PbB level above 0.9 µmol/litre (20 µg/dl) is associated with a decrease in the serum level of 1,25-dihydroxy vitamin D.

9.5.3 Dihydrobiopterin reductase

Inhibition of dihydrobiopterin reductase has been shown in humans where the mean PbB level is as low as 0.48 µmol/litre (10 µg/dl).

9.5.4 Haemopoietic system

9.5.4.1 Anaemia - adults

The estimated PbB level associated with a decrease in haemoglobin is 2.40 µmol/litre (50 µg/dl).

Table 9.2. Biochemical effects of lead

Parameter	Blood lead level above which the biochemical effect is demonstrable with current techniques (µg/dl)
Protoporphyrin level	20-30
Coproporphyrin level	40
ALA urine level	35
ALAD activity	10
1,25-Dihydroxy vitamin D	20
Dihydrobiopterin reductase	10

9.5.4.2 Anaemia - children

Decreased haemoglobin levels in children occur at a PbB level of approximately 1.92 µmol/litre (40 µg/dl). Anaemia, defined as a haematocrit below 35 per cent, is not found at a PbB level of less than 0.92 µmol/litre (20 µg/dl). The risk of having a haematocrit value below 35 per cent for a 1-year-old child was 2 per cent at a PbB level of 0.96-1.87 µmol/litre (20-39 µg/dl); the contribution of iron deficiency may account for a substantial proportion of this 2 per cent. Induction of anaemia is demonstrable at 1.92 µmol/litre (40 µg/dl).

9.5.4.3 Erythrocyte pyrimidine-5'-nucleotidase

A reduction by 20 per cent or more in erythrocyte pyrimidine-5'-nucleotidase activity is associated with PbB concentrations above 10 µg/dl.

It was concluded that effects of lead were demonstrable on a number of enzyme systems and biochemical parameters. The PbB levels, above which effects are demonstrable with current techniques for the parameters which may have clinical significance, are all greater than 0.96 µmol/litre (20 µg/dl). Some clinically insignificant effects on enzymes are demonstrable at lower levels of PbB.

9.6 Nervous system

9.6.1 Adults

9.6.1.1 Central nervous system (CNS)

With acute lead exposure resulting in a PbB level in excess of 80 µg/dl, severe encephalopathy and/or coma may occur. CNS symptoms are found in lead-exposed adults when there is a history of several years of exposure to lead at PbB levels that may not have exceeded

3.36 µmol/litre (70 µg/dl) and a PbB at the time of clinical assessment of at least 1.92 µmol/litre (40 µg/dl).

Impaired neurobehavioural test performance has been found in lead-exposed workers. Changes in critical flicker fusion test have been detected at a PbB level of about 2.4 µmol/litre (50 µg/dl). Sensory motor function is generally more sensitive than cognitive end-points in many neurobehavioural evaluations, with the lowest-observed-effect level being at about 1.92 µmol/litre (40 µg/dl).

It appears also that neuroelectrophysiological tests are sensitive indicators of the CNS effects of lead. Reductions in latencies of sensory evoked potentials and auditory event-related potentials have been found in workers with average PbB levels of approximately 1.92 µmol/litre (40 µg/dl).

9.6.1.2 Peripheral nervous system

Numerous studies have measured the conduction velocity of electrically stimulated sensory and motor nerves in workers exposed to lead. These nerve conduction velocity (NCV) studies have yielded somewhat mixed results, with many showing a decrease in NCV in relation to lead exposure (indexed as PbB) and a few showing no effect or occasionally even an increase in NCV associated with lead exposure. Differences in the nerves evaluated, methodologies, characterization of lead exposure, and control of confounding variables underlie some of the variability in results across studies. A statistical meta-analysis of 32 NCV studies has indicated that NCV is significantly reduced in lead-exposed workers compared to reference subjects, but that the median motor nerve shows more reliable effects of lead than other nerves. This collective view of the evidence is supported by key studies that provide compelling evidence of a causal relationship between lead exposure and reductions in NCV, extending to PbB levels as low as 1.44 µmol/litre (30 µg/dl). These effects may be reversible depending on the duration and level of exposure.

9.6.1.3 Autonomic nervous system

Two reports examining the electrocardiographic RR interval variability during deep breathing and the component CV of respiratory sinus arrythmia demonstrated dysfunctions at an average PbB level of 35 µg/dl. These results suggest autonomic nervous system dysfunction, particularly involving the parasympathetic nervous system.

9.6.2 Children

Prospective and cross-sectional studies of children demonstrate associations of lead exposure, measured by various indices, and intellectual performance. The association has been noted across a wide range of exposure levels and in a variety of populations before factors other than lead have been accounted for.

A key question is whether this statistical association is directly attributable to the causal influence of lead on child IQ. It is important to consider alternative contributory explanations, i.e. random chance, unexplained confounding factors, reverse causality and selection bias.

It is a matter of debate and conjecture as to the extent to which these four issues should inhibit claims of a causal relationship in the epidemiological studies. The essential problem is that observational epidemiology cannot provide definitive evidence of causality when the key statistical association is small, the temporal relationship is unclear and major confounders are present. Animal studies provide qualitative support for the claim of a causal role for lead in affecting neuropsychological performance, but provide limited assistance in establishing quantitative dose-effect relationships.

9.6.2.1 Type of effect

The clearest and most consistent associations have been found with global measures, such as IQ, where the largest body of evidence is available. Efforts to delineate the neuropsychological foundations of this association with a wide variety of tests of specific neuropsychological domains have not so far been successful.

9.6.2.2 Magnitude of effect

Based on the evidence from cross-sectional and prospective studies of populations with PbB levels generally below 25 µg/dl, the size of the apparent IQ effect (at age 4 and above) is a deficit between 0 and 5 points (on a scale with a standard deviation of 15) for each 0.48 µmol/litre (10 µg/dl) increment in PbB level, with a likely apparent effect size of between 1 and 3 points. At PbB levels above 1.2 µmol/litre (25 µg/dl), the blood relationship between PbB level and IQ may differ. Estimates of effect size are group averages and only apply to the individual child in a probabilistic manner.

Existing epidemiological studies do not provide definitive evidence of a threshold. Below the PbB range of 0.48-0.72 µmol/litre (10-15 µg/dl), the effect of confounding variables and limits in the precision of analytical and psychometric measurements increases the uncertainty attached to any estimate of effect. However, there is some evidence of an association below this range.

9.6.2.3 Reversibility/persistence

Whilst the Task Group could not unequivocally state that effects of early childhood exposure were persistent beyond childhood, because the current data are too meagre, it was held that neurobehavioural effects detected at age seven or later usually persist. Measures in later childhood tend to be more predictive of subsequent performance than those made earlier. It is more likely than not that effects seen during school years are to some degree irreversible. This has also been observed in later follow-up studies conducted on non-lead topics of child development research. One of the difficulties is that there are too few data concerning long-term outcome in children with high early exposures whose sources of exposure are subsequently removed.

Virtually no useful data are available concerning the effects on IQ of removing children from a ``high'' exposure environment to one of ``low'' exposure or on reduction of body lead burden in children. This is not to say that exposure should not be reduced when possible.

9.6.2.4 Age-specific sensitivity

From prospective studies it is not possible to determine an age of critical sensitivity. This reflects the findings that serial blood lead measures taken at 2 years and later are positively correlated, with individual rankings remaining approximately constant, and this limits the ability to identify sensitive periods of exposure.

9.6.2.5 Interactions/subgroups (gender, socio-economic status)

The evidence is inconclusive regarding whether apparent effects are more or less marked in different gender or socioeconomic status (SES) subgroups. However, where there are suggestions of SES-related differences, the apparent effects tend to be more marked in lower SES subgroups.

9.6.3 Animal studies

Experimental animal studies of CNS effects provide support for the associations between PbB levels and neurobehavioural deficits described in human epidemiological studies of lead. There is supportive evidence both in terms of demonstrating causal relationships and in the levels of PbB at which such effects are observed (11-15 µg/dl). Moreover, they provide qualitative parallels in the nature of the effects described, as these effects include changes in learning and memory functions. Experimental animal studies indicate that these CNS effects may depend upon task complexity and can persist long beyond the termination of lead exposure. These studies also provide information possibly relevant to understanding mechanisms of effect. In addition, the experimental animal studies provide such evidence in the absence of the confounding factors and co-variates, such as parental IQ, socioeconomic status, and quality of the home environment, that are problematic to human epidemiological endeavours, and in the absence of nutritional deficiencies that may arise in human populations.

9.7 Renal system - adults

Renal function impairment was not associated with a PbB level below 3.0 µmol/litre (62 µg/dl) when measured by blood urea nitrogen and serum creatinine in lead workers. However, renal tubular effects were detected in workers with a PbB level below 3.0 µmol/litre when measured by more sensitive indicators such as NAG.

Most studies on the general population attempting to relate renal function impairment to PbB concentration have not demonstrated an effect with PbB levels below 1.8 µmol/litre (37.3 µg/dl). More sensitive indicators of renal function may indicate a renal effect of lead below this level.

9.8 Liver

Over exposure to lead may inhibit drug metabolism in the liver.

9.9 Reproduction

9.9.1 Female

Data are mixed with respect to the risk of spontaneous abortion and reduced birth weight associated with maternal PbB levels below 1.44 µmol/litre (30 µg/dl). Recent epidemiological studies have shown exposure-related perturbations in length of gestation, significantly greater risks being associated with PbB levels of 0.72 µmol/litre (15 µg/dl) or more.

9.9.2 Male

Blood lead concentrations above 1.92 µmol/litre (40 µg/dl) have been shown to affect sperm morphology and function. At present, the reproductive consequences of these changes are not known.

9.10 Lead and blood pressure

A quantitative assessment of the collective evidence from all the observational studies in adults is made difficult by the fact that studies have adopted different policies regarding adjustment for potential confounding factors (for example, alcohol consumption). Also quantitative findings from the two largest studies (BRHS and NHANES II) have depended on whether adjustment is made for geographic variations in blood pressure and blood lead.

The limited size of most observational studies has inevitably meant that they could not consistently demonstrate a statistically significant relationship. However, an overview of all the studies shows that evidence is consistent with the centre-adjusted analysis of the two main studies, i.e. there are very weak but statistically significant associations between PbB level and both systolic and diastolic blood pressure. The likely order of magnitude is that for any two-fold increase in PbB level (for example, from 0.8 to 1.6 µmol/litre) there is a mean 1 mmHg increase in systolic blood pressure. The association with diastolic blood pressure is of a similar magnitude.

Animal studies have provided plausible mechanisms for an effect of lead on blood pressure. However, from such a small magnitude of statistical associations in the presence of important confounders, one cannot infer that low level lead exposure is causally related to blood pressure.

The two population studies relating PbB level to cardiovascular disease events show no statistically significant associations. Hence, there is no clear evidence to suggest that lead has an impact of public health importance as regards hypertension or risk of cardiovascular disease.

9.11 Carcinogenicity

Renal tumours occur in rats and mice administered high doses of lead. However, the evidence for the carcinogenicity of lead and inorganic lead compounds in humans is inadequate.

9.12 Immune system

There is no evidence in humans of an effect of lead on the immune system.

CHAPTER 5

MECHANISMS FOR RISK REDUCTION

During the past few decades, most Member countries have taken steps to reduce unacceptable human and ecosystem risks from exposure to lead. Among the most successful of these measures have been restrictions on the use of lead in certain products with significant exposure potential (for example, interior paint, gasoline). Accompanying these measures have been actions to establish criteria for acceptable levels of lead in environmental media, to limit industrial emissions of lead to the environment, to control occupational exposures, and to identify biologically based indices for determining populations at risk. Despite the success of many of these measures in reducing lead exposure, some Member countries continue to consider possible steps to further reduce lead exposure. This is because of the uncertainty regarding establishing a blood lead level below which there is an absence of risk from adverse health effects.

This chapter reviews risk management activities among Member countries and one non-Member country, Mexico, which has observer status. Included are discussions of steps taken in the past to reduce lead exposure, as well as current activities and potential future measures contemplated by certain countries. Country-specific risk management activities are summarized in **Table 5.1**. As shown in this table, the extent of these activities varies substantially among Member countries.

The lead risk reduction activities of thirteen countries (Australia, Canada, Denmark, Finland, France, Germany, Japan, Mexico, New Zealand, Sweden, Switzerland, the United Kingdom and the United States), the Nordic countries and the European Community are described in this chapter. The descriptions are based on information provided by countries. The remaining Member countries did not provide enough information to develop a detailed description of their risk reduction activities. A summary of industry risk reduction activities is also included.

The series of tables in **Appenix A** at the end of this chapter summarize available data on lead risk reduction activities in Member countries and in Mexico. Information in these summary tables was either taken from detailed descriptions, or extracted from secondary sources or government publications. Repeated requests for information on lead risk reduction activities were made to all Member countries in 1991 and 1992. Lack of information in this report on a particular Member country means either that no risk reduction activities have taken place in that country, or that the Member country has declined to respond to the requests for information.

Table 5.1 Areas in which Member Countries and Mexico Have Developed Environmental Policies for Lead

	Environmental Media					Environmental Sources						Products							Environmental Health	
	Drinking Water (Pipes)	Surface Waters	Ambient Air	Soil	Air Point Sources	Water Point Sources	Sewage Sludge	Lead Containing Wastes	Dust	Foodstuffs or Feed	Paint	Gasoline	Batteries	Pesticides	Hunting/Fishing	Food Containers	Miscellaneous	Occupational Exposures	Child Blood Lead
AUSTRIA	X	X	X	X	X	X	X	X		X	X	X	X	X		X	X	X	
AUSTRALIA	X	X	X		X	X				X	X	X	X			X	X	X	
CANADA	X	X		X	X	X				X	X	X	X			X	X	X	X
FINLAND	X				X	X	X	X		X	X	X	X			X		X	
ICELAND																			
JAPAN	X	X		X	X	X				X	X	X	X						
MEXICO	X	X			X	X		X		X	X	X				X	X	X	
NEW ZEALAND	X		P				P			X	X	X				X	X	X	
NORWAY					X	X	X	X	X		X	X	X		X	X	X	P	X	
SWEDEN	X				X	X				X	X	X	X		X	X	X	P	X	
SWITZERLAND	X	X	X	X	X		X		X		X	X	X			X	X	X	X	
TURKEY																				
UNITED STATES	X	X	X	X	X	X	P	X	X	X	X	X	X	X	X	X	X	X	X	X
EC	X	X	X	X	X	P	X	X		X	X	X	P	X		X	X	X	X	P
BELGIUM			X		X	X						X	X	X				X		
DENMARK			X		X	X						X	X		X			X		
FRANCE	X	X	X	X	X	X	X	X		X	X	X	X	X		X	X	X	X	X
GERMANY	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X		
GREECE												X						X		
IRELAND	X	X	X		X						X	X	X			X		X		
ITALY			X		X	X						X						X		
LUXEMBOURG												X						X		
NETHERLANDS	X		X		X	X					X	X	X		X	X		X		
PORTUGAL												X								
SPAIN	X	X	X		X	X						X						X		
UNITED KINGDOM	X	X	X	X	X	X	X	X		X	X	X	X		X	X	X	X	X	X

X: Existing Regulation/Activity P: Proposed Regulation/Activity

AUSTRALIA

Australia has taken risk reduction measures on both the national and state/territory levels. In Australia, the Federal Government has responsibility for co-ordinating national approaches to chemical related issues. The Federal Government also represents Australia in international fora such as the OECD. It also co-ordinates guidelines for environmental standards such as air and water quality criteria.

Responsibility for chemicals control and risk management generally resides with the six State governments (New South Wales, Tasmania, Victoria, Western Australia, Queensland, South Australia) and the two Territory governments (Australian Capital Territory and Northern Territory) unless specifically legislated for the Federal government. The following discussion describes Commonwealth, State and Territory activities in Australia. This information was provided by the Commonwealth Environmental Protection Agency (Bainton, 1992; Garton, 1990a) except as noted.

Lead-based Paint

Like most other OECD countries, Australia has established restrictions on the manufacture and use of lead-based paint. There are general restrictions on the use of lead paints in Australia, including: roofs used to collect drinking water; furniture; toys; non-industrial dwellings; and factory premises used for food preparation, processing or producing of products for human consumption. Manufacturing of lead-based paint has been prohibited for the most part since 1960. Reductions on the use of lead in household (building) paint have applied since the early 1960s, and are currently at 0.25 per cent non-volatile content. In Queensland, action can be taken under the Health Act to require the removal of lead-based paint in situations where it is considered to pose a risk to health.

Current use of lead-based paint in Australia is primarily for industrial purposes. In Tasmania, two classes of lead paint are used. Class 1 paint, with more than one per cent of non-volatile components as lead, requires warning labels and is primarily used on exteriors. Lead is less than one per cent of the non-volatile component in Class 2 paint. In Queensland, lead paint is still used on bridges and boats. Major Australian companies no longer prepare lead-based paint for the domestic market.

Lead in Gasoline

The use of tetraethyl lead as an anti-knock additive in gasoline has been linked to high-levels of atmospheric lead and subsequent human exposure via inhalation and ingestion pathways. Because of the widespread exposure caused by this end-use, restrictions on lead gasoline additives have been implemented in many countries. The regulations for lead content in gasoline are not uniform throughout Australia; lead content restrictions range from 0.3 g/l in some city areas to 0.84 g/l in country areas. In New South Wales, the concentration of lead in gasoline has been regulated since 1974, with the current standard of 0.4 g/l instituted in 1980, while in Victoria, regulations for leaded and unleaded fuel went into effect in 1983 and 1985. Queensland has reduced the lead content of its gasoline from 0.84 to 0.4 g/l in the capital city area, and this standard will be progressively extended to the rest of the state by 1993. Also, it is now prohibited in

Queensland to use any combustible material that has, or contains fuel having, a lead content exceeding 0.02 per cent by weight. Unleaded gasoline[7] was introduced in Australia in 1985. The Federal Motor Vehicles Standards Act requires that all cars manufactured or imported after January 1, 1986 operate on unleaded gasoline.

Lead in Drinking Water

In 1987, the National Health and Medical Research Council (NHMRC) set the drinking water lead standard at 0.05 mg/l. This limit has legal standing in Australian Capital Territory (ACT) (for domestic water) and in Western Australia (for drinking water) (ILZSG, 1989a). The ACT also limits the concentration of lead in the *raw* water supply to 0.05 mg/l. Several states have policies to limit lead exposure through drinking water. In Tasmania, potential sources of lead contamination in drinking water are removed when this is practical, and the use of potential lead sources in new installations are prevented by local government authorities. In Queensland, lead pipes are not used for water reticulation.

Standards for Environmental Media and Point Source Controls

The NHMRC recommends an air concentration of 1.5 $\mu g/m^3$ averaged over three continuous months. This limit has legal standing in Victoria, Tasmania and ACT. NHMRC recommends an emissions limit at ground level around stationary sources of 10 mg/m^3. This limit is legally enforceable in most states and territories; however, in Western Australia and Northern Territory, the limit is still a recommendation. The Queensland Clean Air Act Regulations, 1982, limit the total emissions of lead, arsenic, antimony, and mercury (and compounds of these elements) to 20 mg/m^3 (ILZSG, 1989a); however, the Queensland Department of Environment and Heritage has the power to impose stricter emissions limits for lead as a condition of license. The ACT Air Pollution Act 1984 limits emissions from municipal combustors to 10 $\mu g/m^3$ of residual gases. Generally, these emissions limits are enforced through a combination of industry emissions reporting and monitoring requirements and state or territorial government auditing of stacks and of the industry-operated monitors.

Certain states make allowances for higher emissions from older facilities. In Tasmania, emissions from installations in operation before 1975 are limited such that the total concentrations of lead, arsenic, cadmium, mercury and compounds of these metals cannot exceed 23 mg/m^3. Installations in operation after 1975 are limited to 10 mg/m^3. Similarly, primary and secondary smelters in operation in New South Wales before 1972 are limited to 20 mg/m^3, while any subsequent plant must meet the 10 mg/m^3 standard. In New South Wales, bag filter technology is used at both primary and secondary smelters. The NSW Environmental Protection Authority (NSW EPA) requires industry to monitor and report emissions and performs audit testing on plant stacks and monitors. Industry must also operate ambient monitors outside plant boundaries; these monitors are also audited by NSW EPA.

The Australian Water Quality Guidelines for Fresh and Marine Waters, published by the Australia and New Zealand Environment and Conservation Council (1992), recommend the

[7] Note: It is generally accepted internationally that unleaded gasoline is defined as gasoline containing less than 0.013 g of lead per litre.

following median values to protect aquatic ecosystems,

- 0.001 - 0.005 mg/l in freshwater (depending on hardness),
- 0.005 mg/l in marine waters.

Ambient water quality goals are also established for fresh water and saltwater by individual states and territories. Limits on industrial effluent have been established as one means to achieving the ambient goals.

The limits set for the discharge of lead to water depend on the nature of the environment and the industry and the uses or the value of the water body, but are typically around 0.05 mg/l. In Victoria, minimum levels which are easily achievable are set via statutory policy at 0.10 mg/l. More stringent levels are often set where the environment is sensitive or when lower levels are practicable.

Lead in Food

The NHMRC Food Standards Code 1987 has set maximum permissible levels for lead in specific foods between 0.2 and 2.5 mg/kg, depending on the foodstuff. If a food additive is not specifically included in the standards, the additive may not contain more than 10 µg/kg of lead. All food offered for sale in Australia (domestic or imported) must meet these limits. NHMRC monitors consumption of lead in food through market basket surveys. When excessive levels are found, legal action can be taken. State and Territory health authorities also conduct food surveillance and monitoring programmes.

The canning industry in Australia produces lead solder side seam cans and welded cans for food use. Although there are no regulations governing the amount of lead used in solder, NHMRC limits the lead content of food. These range from 0.3 mg/kg for infant food and milk to 2.5 mg/kg for meat, tomatoes and fruit juices. Cans for infant food are understood to be welded.

Lead in Products

Australia limits the lead content of a number of consumer products. In 1976, the NHMRC recommended applying the British standard "Permissible Levels of Metals Released from Glazed Ceramic Ware." In 1980, NHMRC recommended that any utensil or appliance used to contain food or drink should not release more than 0.2 mg/l lead. These limits apply to both domestic and imported goods. NHMRC also recommended in 1976 restrictions of 0.01 per cent for the lead content of pencils, toys, crayons, pastels and other art pigments, and a lead content of not greater than 0.25 per cent of lead or lead compounds in coating materials.

Recycling

Though there are no regulations governing the disposal of used lead batteries in Australia, recycling is common. For some end uses of lead, such as roofing, there is great potential for recycling although the time between installation and removal is often considerable. Lead use in brass or bronze, for example, is unlikely to be recycled to any great extent because the associated costs are considered prohibitive, while for other lead uses, such as wheel weights, the lead is lost to the environment (ALDA, 1992). However, recent Australia-wide industry studies regarding the fate of lead-acid batteries indicate that the recycling rate is greater than 90 per cent.

Occupational Standards

Australian regulation limits both workplace air concentrations of lead and maximum allowable blood lead concentrations for workers. In 1980, the National Health and Medical Research Council (NHMRC) recommended an occupational maximum blood lead level of 70 µg/dl for males and 40 µg/dl for females. However, those guidelines will soon be abolished in anticipation of the National Occupational Health and Safety Commission's proposed standard. All states have legally adopted this level; however, in Queensland and Western Australia it only applies for mines.

The Australian lead industry (1988) recommended a maximum occupational blood lead level of 70 µg/dl for males and 30 µg/dl for females, and in 1992 recommended a maximum of 65 µg/dl for males. The Australian lead industry further recommends concentrations of lead in blood at which return to occupational exposures may occur (50 µg/dl for males, 25 µg/dl for females).

CANADA

Canadian risk reduction efforts have been a combination of national and provincial regulation, educational efforts, and voluntary industry initiatives.

Blood Lead Action Level

The Federal Provincial Advisory Committee on Environmental and Occupational Health has recommended 25 µg/dL as the national "action level" for blood lead levels in children that is, the level at which intervention is appropriate. This level is under review (Health and Welfare Canada, 1989).

Lead in Consumer Products

Lead is limited to 0.5 per cent in coating materials applied to children's products such as furniture and toys as well as to pencils and artists brushes (Hazardous Products Act, 1991; Hazardous Products Regulations, Chapter 928, 1988). These regulations were under review as of January 1992. Leachable lead from glazed ceramics is currently under review as well. It is expected that the limit for lead (currently 7 ppm in leachate) will be substantially reduced (Hazardous Products Regulations, Chapter 925, 1988; McBain, 1992).

Lead-based Paint

Canada restricts the advertisement, importation and sale of paints containing lead. Lead is permitted in products (paints) only if it is for use on the exterior surface of a building and is labelled: "Caution: contains lead. Do not apply to surfaces that children may chew." This regulation is currently under review (Hazardous Products Act, Chapter 928, 1988; McBain, 1992; Health and Welfare Canada, 1991). On the recommendation of the Canadian Paint and Coatings Association (the trade association for Canadian paint manufacturers), the Canadian paint industry voluntarily stopped using lead in consumer paint at the beginning of 1991. The trade association represents greater than 90 per cent of the liquid coatings market in Canada (Health and Welfare Canada, 1991; McBain, 1992).

Lead in Gasoline

Between 1976 and 1985, airborne lead concentrations decreased by 76 per cent. This drop is believed to be largely attributable to the increased use of unleaded gasoline (Health and Welfare Canada, 1989). In 1989, Canada reduced its tax on lead-free gasoline and prohibited, in December, 1990, the use of leaded gasoline, except in critical equipment such as farm, marine and commercial transportation and piston driven aircraft engines, in order to avoid premature engine wear (Gasoline Regulations, 1990). In these exceptional cases, gasoline may contain a maximum of 0.026 g/l lead. A maximum of 5 mg/l is permitted for any other purpose. Enforcement of these restrictions is carried out through regional inspectors and through reporting requirements for refineries.

Lead in Pesticide Products

All agricultural and forestry pesticides, wood preservatives and disinfectants in use in Canada must be registered under the Pest Control Products Act (1991) and Pest Control Product Regulations (1978). These products and their ingredients are subject to a comprehensive review to ensure the protection of human health, safety and the environment, conducted by the Departments of Agriculture, National Health and Welfare, Environment, and Forestry. Lead is not used as an active ingredient in any pesticide product registered in Canada.

Lead in Explosives and Ammunition

Lead azide is classified as a primary explosive. It is used as an ingredient in detonators, blasting caps, and primers. Civilian applications of lead azide are controlled under the Explosives Act (1991) and Explosives Regulations (1978) by the Department of Energy, Mines and Resources. A separate regulatory scheme exists for military uses of lead azide, under the control of the Minister of National Defence (Minister of National Defence, 1992; Defence Production Act, 1991).

The discharge of a lead projectile from a firearm results in microscopic shearing of lead particles from the bullet as it passes down the barrel. These particles are subsequently sprayed from the barrel, along with a cloud of lead compounds generated from lead stypanate in cartrige primers. Indoor firing ranges are ventilated to reduce airborne lead levels. Lead free ammunition is now under development by the Department of National Defence.

Lead in Drinking Water

Canada currently allows a maximum of 10 µg/l in drinking water (Minister of National Health and Welfare, 1989). This level was approved by all provinces in the fall of 1989. Possible sources of lead in drinking water include solder and brass plumbing fixtures. The 1990 *Canadian Plumbing Code* permits a maximum lead content of 0.2 per cent for solder and fluxes in contact with potable water (National Research Council of Canada, 1990). The Canadian Standards Association is currently preparing amendments to the standard limiting lead content of brass fittings to 8 per cent. Generally, fittings do not contain more than 8 per cent lead, but this limit is not specified in current regulations. Another possible source of lead in drinking water is lead supply pipes that still remain in many municipalities, although these lines may have acquired a lime interior capable of preventing contact between lead and drinking water.

Lead in Food

Lead levels in food have been regulated since the mid-1970s. Cooperation between government and the canning industry led to reductions in the use of lead in soldering cans and a reduction of lead spattering during can production. Canned baby food has been phased out, with most baby food now packed in glass jars. It is estimated that only about 5 per cent of canned food in Canada is still packaged in lead soldered cans.

The Canadian government has set tolerances for lead in various foods which are consistent with international standards (Technical Reports from Annual Meetings of the Joint FAO/WHO

Expert Committee on Food Additives). These tolerance levels vary between 0.08 mg/kg for ready-to-serve infant formula to 1.5 mg/kg for tomato paste and sauce. Tolerance levels are 0.2 mg/kg in fruit juices, cider, wine, other beverages (as consumed), and water in sealed containers. The tolerance level is 0.5 mg/kg in dried fish protein concentrate. A level of 10 mg/kg is allowed for edible bone meal (Food and Drugs Act, 1991).

Standards for Environmental Media and Point Source Controls

The Canadian Environmental Protection Act (CEPA) (1988) provides the federal government with powers to protect human health and the environment from the effects of toxic substances that are not already covered under other laws such as the Hazardous Products Act or the Food and Drugs Act. The CEPA approach is a comprehensive "cradle to grave" system for the regulation and control of toxic substances in Canada.

The Domestic Substances List (DSL) (1991) published under the authority of CEPA cites 84 entries for lead and lead compounds. The Non-domestic Substances List (NDSL) (1991) published under the authority of CEPA cites 118 entries for lead compounds. These entries in the DSL and NDSL will determine the status of lead compounds with respect to the Regulations Respecting Notification of Substances New to Canada (in press) scheduled to come into force in 1993. Lead and its compounds listed on the DSL are deemed to be existing substances in Canada and are not subject to the New Substances notification process. All other lead compounds will be subject to notification schedules depending on the volume to be imported or produced.

The Canadian federal government has established ambient water quality criteria for the protection of health and the environment. Criteria for lead concentrations in freshwater with dwelling fauna are 0.001 to 0.007 mg/l, with levels of 0.2 mg/l for irrigation (tentative guideline) and 0.1 mg/l for livestock watering (Environment Canada and Health and Welfare Canada, 1990). Elemental lead and all lead compounds are regulated under CEPA with respect to ocean dumping (Ocean Dumping Regulations, 1989). The discharge of lead and lead compounds from ships in Canadian territorial waters is regulated under the Canada Shipping Act (1991) and the Pollutant Substances Regulations (1978).

Soil criteria have been recommended as part of the *Interim Canadian Environmental Quality Criteria for Contaminated Sites* (Canadian Council of Ministers of the Environment, 1991). They include both assessment and remediation criteria. Assessment criteria are benchmarks against which the degree of contamination at a site is assessed. The assessment criterion for lead in soil is 25 mg/kg dry weight. Remediation criteria are intended as generic guidance benchmarks to evaluate the need for further investigation or remediation for a specific land use. When applied to site-specific conditions, they become remediation objectives. Suggested interim remediation criteria for lead in soil are 375 mg/kg for agricultural use, 500 mg/kg for residential/parkland, and 1000 mg/kg for commercial/industrial use.

The recommended maximum lead concentration, as specified in the *National Guidelines on Physical-Chemical-Biological Treatment of Hazardous Wastes*, is 0.1 mg/l in liquid effluents from waste treatment sites (Canadian Council of Ministers of the Environment, 1989).

Canada has national legislation for lead emissions from secondary lead smelters. The Secondary Lead Smelter Release Regulations (1991), which were first enacted under the Clean Air Act in 1977 and subsequently incorporated into CEPA in 1991, limit emissions of particulates to

23 mg/m^3 or 46 mg/m^3, depending on the type of operation. The amount of lead is limited to the equivalent of 63 per cent by weight of the particulate matter. The regulations further prohibit the release of particulate matter into the ambient air from the storage of lead-bearing scrap or lead-bearing material in or about a secondary smelter, other than as a result of handling. The federal government does not regulate other stack emissions of lead, however, primary lead smelters have been required to comply with these requirements since 1989. Most provinces have licensing systems in place to regulate stack emissions of particulates, on the order of 29 mg/m^3 for smelters (other than secondary smelters) and 14 to 15 mg/m^3 for refineries. Some provincial controls are in place that specifically regulate lead emissions, such as Ontario's Clean Air Programme (Government of Ontario, Environmental Protection Act; Ambient Air Quality Criteria Regulation, 1980; General - Air Pollution Control Regulation, 1980).

Controls on lead in industrial effluent exist on both the national and provincial level. Under the federal Fisheries Act (1991), the Metal Mining Liquid Effluent Regulations and Guidekines (1977) are in place to control concentrations of lead and other metals in effluent for metal mining operations. Maximum liquid effluent emissions are limited to 0.2 mg/l monthly average, 0.4 mg/l maximum in a sample (Environment Canada, 1977). *Metal Finishing Liquid Effluent Guidelines* (Department of Fisheries and Oceans, 1978) limit lead in effluent to 1.5 mg/l. Provinces have licensing systems which control effluent discharges on a site-specific basis. For example, Ontario's Municipal and Industrial Strategy for Abatement (MISA) programme will also include controls for lead (Government of Ontario, Environmental Protection Act).

Recycling

Canada recycles an estimated 93 per cent of lead-acid batteries. Lead batteries that are filled with acid are classified as hazardous and, as a result, their transportation and storage are regulated by Federal and provincial requirements (International Lead and Zinc Study Group, 1989b). Regulation of the transport and handling of lead-bearing scrap is divided between the federal Transport of Dangerous Goods Act and the provincial authorities. British Columbia is drafting provincial lead-acid battery regulations to consolidate these rules (British Columbia Battery News, 1991a). The British Columbia Lead-acid battery Collection System is a provincial programme to increase recycling, particularly in remote regions of the province. The goal is to achieve a province-wide recycling rate of 98 per cent. To attract more returns from remote areas, the government offers a cash incentive to offset transportation costs (British Columbia Battery News, 1991b). The revenue for this programme comes from a $5.00 green tax on new batteries. Started in 1991, programme recycling facilities have seen a substantial increase in returns from remote areas (Keating, 1992).

Education/Labelling

Labelling requirements exist for lead paints, lead-acid batteries, and other lead products. Under Canada's Hazardous Products Act, bilingual labelling for all lead-based paints is required. Also, the Department of National Health and Welfare has undertaken extensive education and awareness programmes aimed at the arts, crafts and hobby communities to increase awareness about the hazards associated with some of the materials used in these activities (Health and Welfare Canada, 1990).

The Health Protection Branch of Health and Welfare Canada has published two recent issue

papers to convey general information to the public on issues related to lead. One paper provides facts on lead and health (Health and Welfare Canada, 1989), and a second paper provides information on removing lead based paint during home renovations (Health and Welfare Canada, 1991). One million copies of a joint federal government-private sector publication entitled *Old Paint, Lead, and Your Family's Health* were distributed through retail paint outlets during 1992 (Canadian Paint and Coatings Association, 1992).

Lead and its compounds are included on the Ingredient Disclosure List (IDL) (1987). The IDL is part of the Workplace Hazardous Materials Information System (WHMIS). WHMIS is a national system of hazard communication for workplace hazardous substances mandated by the Hazardous Products Act and the Controlled Products Regulations (1988). Under this system, administered by the Departments of National Health and Welfare, Labour, and Consumer and Corporate Affairs, requirements are specified for the labelling of controlled products, the information that must be on Material Safety Data Sheets (MSDS), and for employee instruction and training. The presence of lead in excess of the limit specified in the IDL must be disclosed on the MSDS and the product label.

Radionuclides of lead are regulated under the Atomic Energy Control Act (1985), the Atomic Energy Control Regulations (1978) and the Transport Packaging of Radioactive Materials Regulations (1983). Under the Atomic Energy Control Regulations, possession of lead radionuclides which exceed 3.7 kBq of activity per kilogram of substance requires a license from the Atomic Energy Control Board of Canada. The Transport Packaging of Radioactive Materials Regulations (1983) specify minimum standards for the safe packaging and transportation of materials containing radioactive lead.

Occupational

Exposures to air containing lead, inorganic dust and fumes, as lead, averaged over a full work shift, must not exceed 0.15 mg/m^3. The short term exposure limit (STEL) is 0.45 mg/m^3. The cited limits are prescribed in Part X "Hazardous Substances" of the Canada Occupational Safety and Health Regulations (1986), issued pursuant to the Canada Labour Code (1991). The regulations state that no employee shall be exposed to a concentration of an airborne chemical agent in excess of the value for that agent adopted by the American Conference of Governmental and Industrial Hygienists (ACGIH) in its publication entitled *Threshold Limit Values and Biological Exposure Indices for 1985-86*. However, Part X is currently being reviewed and consideration is being given to referencing the current TLVs, as 0.15 mg/m^3 (the TLV-STEL value for lead has been deleted).

DENMARK

The Danish risk reduction activities on lead are based on a concern for both human health and the environment.

The Danish risk reduction measures on lead are to phase out the use of lead totally through a set of different actions. Possible actions are regulation and voluntary agreements, and the means could be substitution and, where this is not possible, improved recycling.

Risk reduction for lead is clearly an international issue. Trade is spreading worldwide and the application has an enormous dimension and scope. International actions are therefore a necessary means to eliminate the use of lead.

FRANCE

The following information pertaining to the policies implemented by France to reduce exposure to lead was obtained through the Minister of Environment (Deschamps, 1990; Nichelatti 1992).

Lead-based Paint

Old paint:

The results of detection activities carried out in the Centre for Child Protection in the north-eastern Paris area from 1987 to 1991 included more than 1550 children with lead levels in blood exceeding 15 µg/dl. An additional study carried out by the hospital services in Paris between 1987 and 1989 identified 300 supplementary cases. More than 690 children required specialized care by a hospital team. The criteria used by the epidemiological study have led to the identification of a population at high intoxication risk, comparable to population groups considered as the most exposed ones in the United States.

A joint working group of the Ministries of Health, Environment and Housing, in co-operation with Public Health medical teams, has financed a series of studies concerning:

- the identification of risk factors in domestic accommodations in the Paris urban area. This study showed that in 35 per cent of the habitats and 59 per cent of the common areas which were investigated lead levels were above 1 mg/m^2 and above 10 mg/g in flakes of paint. This study should allow the development of a method for drawing up an inventory of domestic accommodations at risk;

- the determination within six French departments of lead levels in blood for children between 12 and 47 months old. This study aims to evaluate the extent of this phenomenon at the national level. From 26 to 27 per cent of children between one and six years had levels above 150 µg/l; and

- the evaluation of detection methods used by general practitioners.

Furthermore, a monitoring network for infant lead poisoning has been recently created in the department of the Ile de France, based on the demands for laboratory tests.

New paint:

Since February 1993, the sale of paints containing white lead is prohibited. The first French "eco-labels" will be granted to paints and varnishes not containing lead (and fulfilling other criteria).

Lead in Gasoline

The lead content of gasoline and of high-octane gasoline has been reduced from 0.55 g/l in 1981 to 0.15 g/l on June 1, 1991. Since July 1, 1989, unleaded gasoline has been granted a tax reduction which makes its retail price lower than the price of leaded high-octane gasoline. As a result, consumption of unleaded gasoline has risen rapidly; in July 1991, 27 per cent of the gasoline sold contained less than 0.15 g of lead per litre.

Current substitutes for lead in gasoline are benzene or other aromatic components. It should be noted that benzene is a known carcinogen. Research is under way concerning aldehydes. However, aldehydes influence the substances emitted from the exhaust pipe, the toxicity of which differs from the toxicity of the substances contained in gasoline. Other substitutes are also under research.

Lead in Drinking Water

Directive 75/440/CEE on the quality of surface waters destined for the production of drinking water in the EC Member States sets at 0.05 mg/l the lead content of the three quality types of surface waters defined by this directive. To enforce directive 80/778/EEC, French regulation has set the lead limit for drinking water at 50 µg/l.

The effects of soft water (i.e. water containing < 85 ppm calcium carbonate) on lead piping, and especially the creation of soluble lead salts, has been an important cause for concern for the authorities since the late 1970s. Monitoring of drinking water carried out in Amiens indicated cause for concern. A strategy was designed to combat lead poisoning from water ingestion. The components of this strategy have been the detection of cases of lead poisoning and the establishment of neutralization facilities, to be completed by the end of 1992, for supplied water in zones which have been identified as hard water areas.

The discovery, both in the scientific litreature and in the city of Amiens, of lead dissolving in so-called non-aggressive waters has widened the range of action priorities of the Health Ministry concerning the lead content of water destined for human consumption. Activities include:

- establishing a synthesis of the scientific and technical information, evaluating the priorities and informing decision-makers concerning public waters, as well as informing and improving the awareness of the medical profession.

- identifying new zones at risk, especially waters with calco-carbonic equilibrium of a pH less than 7.5, supplied by a network including lead piping.

- analysing water samples. Particular precautions should be taken when measuring tap water samples, such as taking samples as soon as the tap is turned on and not allowing leaks.

- taking measures for water exceeding regulatory limits, including gradual replacement of lead connections in the public network and modification of building interiors. Pending completion of the work, a public collective treatment can be set up, aimed at modifying the quality of supplied water. Efforts could include:

    - partially decarbonizing the water and adding lime in order to reduce mineral carbon content and subsequently the quantity of dissolved lead salts,

- in case of water with low calcium content, using zinc orthophosphates, which, combined with lead, form salts with a low solubility over a wide pH range.

- informing the affected public. If the quality standards are exceeded, distribute a set of recommendations by the Higher Council of Public Health to the public, such as:

  - pregnant women, infants and children up to six years old should use bottled water for drinking and preparing feeding bottles.

  - water which has been standing in the faucet should be eliminated by briefly flushing the system before collecting drinking and cooking water.

- announcing a definitive prohibition regarding the use of lead piping for public distribution of water and for interior use.

Lead in Soils

The Ministry of Agriculture in France has assessed the heavy metal content, including lead, in fertilizers as part of a strategy to reduce heavy metals in fertilizers and soil. **Appendix B** at the end of this chapter contains a table outlining the concentration of heavy metals in fertilizers in France.

Standards for Environmental Media and Point Source Controls

The average annual limit value for the ambient air concentration of lead is 2 $\mu g/m^3$. A national network for continuous automatic sampling has existed since 1984. Standards exist for limiting lead emissions from industrial and other facilities. For incineration facilities for urban waste, a January 25, 1991 decree defines an emission limit value of 5 mg/m^3 for a facility of nominal capacity greater than 1 tonne of waste per hour. The limit represents a total value for four heavy metals: lead, chromium, copper and manganese. For incineration facilities for industrial waste, a 1983 Circular defines an emission limit value in gases of 5 mg/m^3; however, this value will have to be reduced to 0.5 mg/m^3 following the development of a relevant European Directive. For smelters, local authorities define by regulation the conditions applicable in each specific case.

Limits also exist to protect water from lead contamination. For example, there is a prohibition of lead discharges to the underground waters coming from hazardous installations. For the incineration facilities for urban waste, the concentration limit value, before discharge, is 1 mg/l.

Several standards have been established to protect soils and sediments. Spreading of sewage sludge must respect the AFNOR U-44-041 standard, which is 800 mg/kg for lead. The approval of fertilizers takes into account the heavy metal content of the preparations or specialties according to the quantities deposited per hectare and the quantities marketed. This approach allows managing the risk of introducing heavy metals by means of fertilizers. In addition to these standards, the Ministry of Environment set up in 1985 an observatory for soil quality, which allows the co-ordination of the study, research, evaluation and management of soil pollution.

Lead in Products

France has several rules governing lead in products. For food cans, only external

soldering of the cans is allowed. There are also limits on the migration of lead from ceramic kitchen utensils into food. These limits are defined according to the dimensions of the utensils. France also adheres to the prohibition of lead capsules for overcorking wine bottles imposed by the EEC on the 1st of January 1993. This prohibition has accelerated research and development of substitutes. Tin capsules are considered too expensive and are reserved for upper-market products. Plastic capsules don't seem to satisfy consumers, who are accustomed to the touch of lead-tin capsules. This consideration seems to have been taken into account in the development of aluminium-polyethylene capsules.

Recycling

Two agreements concerning the recovery of spent storage batteries have been set up between the administration and the various professions involved in lead recovery. The first one is an engagement by the garage owners, gas stations and recovery operators to take back batteries free of charge. The second one aims at facilitating the transport of batteries full of acid (electrolyte) in appropriate containers.

GERMANY

Germany has initiated a number of measures to reduce lead exposure and risk. The following information was obtained from the Umweltbundesamt (UBA, 1992).

Blood Lead Action Levels

The concentration of lead in blood of adults and children shows a clear decreasing trend for the last 15 years. In 1990, mean levels for children and adults were in the range of 6-7 µg/dl. This decline is probably attributable to the reduction of lead in gasoline, starting in 1976. In Germany, some physiologists and toxicologists recommend that the blood lead level of adults should not exceed the concentration of 15 µg/dl and those of children and women of childbearing age should not exceed 10 µg/dl.

Lead-based Paint

Germany has taken a number of measures to reduce lead in paint. White lead compounds ("lead white") are banned from sale. Lead-based anti-corrosive paint ("red paint") is being phased out; its use is restricted to repair coatings. In 1989, 880 tonnes were produced, compared with 2200 tonnes in 1983. In this application, lead is being replaced by zinc coatings. Other lead-based pigments (lead chromates and lead molybdates) are used as colouring agents for plastics, printer's ink and lacquer for surface painting. Containers for paint with more than 0.15 per cent lead content must be labelled ("Paint contains lead; not for objects which can be reached by small children") (Gefahrstoff-Verordnung).

Lead in Gasoline

The maximum lead content of leaded motor gasoline has been restricted to 0.15 g/l since 1976. Unleaded gasoline has been on the market since 1982. Economic and fiscal instruments have been used to promote the introduction of catalytic converters in private cars and the consumption of unleaded gasoline in cars with and without catalytic converters. Since 1988, regular grade gasoline has been required to be unleaded. At present, there are one leaded and three unleaded types of motor gasoline in the market:

- Regular, unleaded, 92 RON
- EURO-Super, unleaded, 95 RON
- Premium, unleaded, 98 RON
- Premium, leaded, 98 RON

In January 1992, the market share of the unleaded types of gasoline was higher than 80 per cent. The consumption of leaded gasoline is further decreasing and is expected to disappear from the market within a few years [Benzinbleigesetz (1971, Amendment 1987), German Standard DIN 51600 and 51607].

Lead in Drinking Water

Lead pipes are the most important source of lead in drinking water in Germany. Lead pipes have not been installed in new piping systems since the middle of this century; systems that do still exist are gradually being replaced by lead-free materials (German Standards DIN 1988 and 2000).

Municipalities responsible for the drinking water supply system have to maintain a lead level of less than 40 µg/l at the mains connection. (Trinkwasserverordnung, 1975). The house-owner/landlord is obliged to provide drinking water at the tap with a lead concentration of less than 40 µg/l. If this concentration is exceeded, on request, the owner has to replace the piping (Trinkwasserverordnung, 1990 Amendment). Copper pipes for drinking water supply systems have to be soldered with lead-free alloys (such as SnCu or SnAg) (German Standard DIN 1707 and DVGW, Blatt GW 2 of 1983).

Lead in Food

Germany has set only one limit value for lead in foodstuffs. This limit, for wine, is set at 0.3 mg/l. For other foodstuffs, guideline values for lead have been established as follows (in mg/kg): beer, 0.2; milk, 0.03; meat and eggs, 0.25; liver, 0.5; fish, 0.5; leafy vegetables, 0.8; kale, 2.0; and fruit, 0.5 (Lebensmittelgesetz).

Animal Feed

A value of 20-40 mg lead/kg of dry matter (Futtermittelgesetz, 1975 und Verordnungen).

Standards for Environmental Media and Point Source Controls

Surface Water

While no environmental quality standards have been established, authorities generally use the relevant European standards from EEC Directive 75/440 as a guide. This value for lead is 0.05 mg/l.

Lead in Ambient Air

The maximum tolerable lead concentration in air is limited to 2.0 µg/m^3 (annual mean); the maximum deposition on soil is limited to 0.25 mg/m^2/day. Diffuse (fugitive) emissions of dust from storage and distribution facilities, including transportation, are also restricted by this rule (Bundesimmissionsschutzgesetz, TA Luft, 1986, Directive 82/884 EEC).

The lead concentration in air, measured at monitoring sites in rural regions, has decreased continuously from about 0.250 µg/m^3 in 1973 to about 0.025 µg/m^3 in 1990 (mean values). This reduction is mainly due to the phasing out of leaded gasoline.

Lead in Soil

A recent compilation of soil data for Northrhine-Westphalia shows that upper bound values (95th percentile) of lead content are very high in inner cities (315 mg/kg) as compared to rural agricultural soils (56 mg/kg). After the evident reduction of lead in air and blood, the limiting factors for further risk reduction are now secondary sources of inner city dust and soil. Consequently, many German states have limited the lead concentration in the soil of children's playgrounds [for example, Northrhine-Westphalia: playground soil, 200 mg/kg; playground (sandbox) sand, 20 mg/kg].

Taking into account the great spatial variability of soils and their differing capacity to accumulate lead, no trends in soil lead levels of statistical significance are expected. However, the deposition of airborne lead to soil is limited to 0.25mg/m²/day.

Point Source Controls

Metal emissions from lead smelters and other non-ferrous metallurgical works are limited to 5 mg/m^3 in total for lead (Pb), antimony (Sb), arsenic (As), chromium (Cr), cobalt (Co), copper (Cu), manganese (Mn), nickel (Ni), vanadium (V), tin (Sn), platinum (Pt) and palladium (Pd). The total dust emission, of which lead is a constituent, is limited to values between 10 (for lead plants) and 20 mg/m^3 (for other non-ferrous sources). The lead emissions from battery-manufacturing sites are limited to 0.5 mg/m^3 (TA Luft 1986).

The total dust emission from waste incinerators is limited to 10 mg/m^3. In the dust, the emission in total of Pb, Sb, As, Cr, Co, Cu, Mn, Ni, V, Sn, Pt and Pd must not exceed 1 mg/m^3 (Abfallverbrennungsanlagen-Verordnung, 17. BImSchV, 1990).

For direct discharges to water, limits vary from 0.3 to 2.0 mg/l, according to the type of plant. The recommendation for indirect discharges in several Federal States is 0.2 mg/l; effluent from non-ferrous metal plants, mills, foundries and electroplating plants is limited to 0.5 mg/l. There is also an overall limit of 15 g of lead per tonne of production (Wasserhaushaltsgesetz mit Verordnungen).

The use of sewage sludge for agricultural purposes is legally restricted if its lead content exceeds 900 mg/kg. Agricultural soils with a lead content of 100 mg/kg or more may not be treated with any sewage sludge (Klärschlammverordnung, 1992 Amendment).

Lead paint removal operations on steel bridges have to take place under effective emission control measures; if feasible, wet sandblasting is required. In cases of dry sandblasting, the structure has to be housed and the blast air to be treated (TA Luft 1986; Special Regulations of the German Railways).

Lead in Products

Significant quantities of lead are used as stabilizers for PVC, cable sheathing, optical and technical glass, TV picture tubes, and crystal glass. In these applications, the lead is regarded as immobile and fixed in an insoluble matrix, from which it cannot be leached.

The use of lead in certain products is restricted. There is no use of soldered cans for food packaging any longer. Food cans are resistance welded (longitudinal seam) and folded (lid and

bottom). It is estimated that some 10 per cent of food cans, imported from non-European Community countries, are soldered. As mentioned above, there are guideline values for the maximum lead content of canned food. In addition, the application of lead compounds in pesticides is strictly prohibited. Replacement of lead in ammunition (small shot and bullets) is under development. Positive results with steel shot are being reported.

Recycling

In 1989, the total production of lead in Germany consisted of more than 50 per cent recycled materials:

Primary production	170 200 tonnes
Secondary production	180 500 tonnes
Total lead production 1989:	350 700 tonnes

There is a continuous trend towards higher recycling rates. The amount of lead in domestic and industrial waste streams is decreasing. The complete collection, safe handling, processing and final storage of all kinds of waste is regulated by law and controlled by state authorities (Blei-Bilanz 1984-1989/ LGA Bayern, 1991; Abfallgesetz, 1986, mit Verordnungen; TA Abfall).

Lead batteries are by far largest use of lead in Germany (1989: 178 500 t = 49 per cent of total consumption). The recycling rate for batteries is greater than 95 per cent.

Occupational Standards

In the workplace, the maximum allowable air lead concentration is 0.10 mg/m^3 (time-weighted average over eight hours) (MAK). The maximum allowable blood lead concentration of workers is 70 µg/dl for men and for women over 45, and 30 µg/dl for women under 45 (BAT). The concentration of d-Amino-laevulinic acid (ALA) in urine should not exceed 15 mg/l in men and in women over 45, and should not exceed 6 mg/l in women under 45 (BAT) (Ref: Maximale Arbeitsplatzkonzentrationen (MAK) und Biologische Arbeitsstofftoleranzwerte (BAT) 1991).

Lead paint removal operations on steel bridges have to take place under effective emission control measures: if feasible, wet sand blasting is required. In cases of dry sand blasting, the structure has to be housed and the resulting contaminated air must be treated.

JAPAN

Japan has implemented measures to reduce the risks from lead in products, from environmental point sources, and within the workplace.

Lead-based Paint

Japan does not restrict the use of lead paints. Instead, through voluntary agreements with manufacturers, Japan limits the extent to which lead paint is used. For example, on a voluntary basis, lead paint is not used for toys (1960) or household painting (1980). Lead compounds are used in paints for colouring purposes, and lead pigments are used for anticorrosive purposes in paints. Lead-based paints continue to be used primarily in construction, automobiles and electronic products (Sasaki, 1990).

Lead in Gasoline

Japanese Industrial Standards limit the lead content in gasoline, and since the 1970s, these limits have encouraged gasoline makers to decrease or eliminate the amount of alkyl and tetraethyl lead compounds in gasoline. In the 1980s, leaded gasoline accounted for only one to two per cent of Japan's gasoline production. In more recent years, gasoline containing lead is not manufactured, imported or used in Japan (MITI, 1991).

Lead in Drinking Water

The Japanese maximum permissible lead concentration in drinking water was 0.1 mg/l (IRPTC/UNEP, 1990).

Lead in Food

The Food Sanitation Law of Japan establishes lead content limits for a range of plant products. These limits range from 1.0 to 5.0 mg/kg (IRPTC/UNEP, 1990).

Standards for Environmental Media and Point Source Controls

The Air Pollution Control Law establishes Japanese emissions standards for lead smelters, processing facilities and other combustors. Japan has set air emission standards for smelters and other lead processing facilities at 10 to 30 mg/m^3, depending on the facility. In addition to meeting these air emission standards, facilities are subject to government requirements regarding pollution control technologies for new plants (Sasaki, 1990). Prefectural Government Ordinance may impose stricter air emission standards ranging from 1.5 to 7.0 mg/m^3 (ILZSG, 1989a).

Since 1958, Japan's Water Pollution Control Law has restricted the lead concentration in effluent discharged from almost all industrial sectors. Effluent must have a lead concentration of less than 1 mg/l (MITI, 1991; IRPTC/UNEP, 1990). Prefectural Government Ordinance may impose more rigid maximum allowable water lead concentrations ranging from 0.1 to 0.8 mg/l

(ILZSG, 1989a).

Japan also restricts the disposal, sale, production, and reclamation of industrial wastes with high lead quantities. The Wastes Disposal and Public Cleaning Law established requirements for the treatment and handling of such wastes including limits on the spreading or overflow of wastes, as well as restrictions on the locations of potential reclamation areas (MITI, 1991).

Lead in Products

A significant portion of the lead consumed by Japan is dedicated to the production of lead-acid batteries. The majority of these batteries are designed for use in automobiles. Because such a large portion of the lead-acid batteries are sold to consumers, Japan has used market incentives (at different points of sale) to promote recycling of lead-acid batteries. Today almost the entire amount of lead used for these batteries is being collected and recycled (MITI, 1991).

Occupational Standards

The administrative level for lead in the workplace is set at 0.1 mg/m^3

MEXICO

In light of the level of lead exposure of Mexican populations and potential adverse health effects, the Mexican government has taken both regulatory and nonregulatory actions, most over the last ten years, to reduce lead exposure. These activities can be placed into four general categories:

- a programme to reduce the use of lead in gasoline;
- a programme to develop standards and criteria;
- establishment of an agreement between government and representatives of industrial, craftsmen and environmental groups to reduce lead in consumer products; and
- a health education programme.

All information on Mexican lead policy was obtained from Cortinas de Nava (1992).

Lead in Gasoline

In 1980, a programme to reduce tetraethyl lead concentration in the regular gasoline (NOVA) was initiated. In 1988, the automobile industry was committed by the government to introduce catalytic convertors on new model cars beginning in 1991. In 1990, unleaded gasoline (MAGNA SIN) was introduced with the same specifications as the most frequently purchased US gasolines. Overall, from 1988-1992, an 88 per cent reduction in the lead content of gasoline took place, decreasing lead concentrations from approximately 1.0 to 0.1 g/l. Notably, a 50 per cent reduction occurred between 1991 and 1992. In 1992, the price of unleaded gasoline decreased and the price difference between leaded and unleaded gasoline diminished from 40 to 15 per cent.

Lead in Drinking Water

For drinking water, the General Health Law Regulation published in 1988 established a lead level of 0.05 mg/l. In 1989, the Ecological Water Quality Criteria set the following surface water quality criteria:

freshwater: average lead concentration adjusted for hardness over 4 days should not exceed once each 3 years the following values:

$$Pb(mg/l) = e^{1.273*\ln(\text{hardness}) - 4.705}$$

where hardness = mg/l $CaCO_3$

saltwater: 0.006 mg/l (should not be exceeded once each three years on an average)

water for agricultural irrigation: 5.0 mg/l

drinking water for livestock: 0.1 mg/l

Lead in Food

Mexico has also set several standards for lead in foodstuffs, drugs and cosmetics. The maximum permissible level of lead in tomato sauce is 0.36 mg/kg according to a Mexican Official Norm (NOM) published in 1982, while the maximum permissible level in vegetable shortening is 0.1 mg/kg, according to the General Health Law Regulation published in 1988. The maximum permissible level of lead in synthetic organic dyes (No. 6 twilight yellow) added to food, beverages, drugs and cosmetics is 10 mg/kg, according to a NOM published in 1975.

Standards for Environmental Media and Point Source Controls

The following waste water effluent limits were established as Technical Ecological Norms (the first two in 1988, the next two in 1991):

metal industry effluents: 0.1 mg/l daily average

copper industry effluents: 1.0 mg/l

automobile maintenance, gas stations, dry cleaning, and photography developing water effluents: 1.0 mg/l daily average

urban and municipal waste water used for agricultural irrigation: 0.50 mg/l.

Lead is included in the list of substances that, if present in waste at concentrations higher than 5.0 mg/l, make it hazardous, according to an Technical Ecological Norm published in 1988. A new Norm that will substitute for the current one includes a list of industrial activities that generate hazardous wastes containing lead, as:

- galvanoplasty and metal finishing,
- extraction, separation, and beneficiation of metals,
- battery production.

Lead in Products

On June 5, 1991 President Carlos Salinas de Gortari gave instructions to establish within 30 days a programme to reduce lead content in consumer products.

Government authorities and representatives of industries, artisans and non-governmental environmental groups entered into an agreement on July 5, 1991 that establishes the following:

- Lead-soldered cans: the metallic can industry representatives agreed to eliminate the use of lead solder and introduce a new welding technology by October 1992. In July 1992, the goal was attained. The approximate cost of technology substitution was $30 million (US). A Mexican Official Norm has been elaborated to specify requirements for food cans.

- Paints and pigments: representatives of industries that produce paints and pigments, together with government officials, modified two lead standards for the use of lead on products used to cover the surface of toys and school articles. Two NOMs were published on the January 6-7, 1992. A maximum permissible level of lead in surface

paint of 90 mg/kg was established.

Industries agreed to eliminate the use of lead red oxide, and lead basic carbonate from pigments, lacquer, enamel, paint and varnish, on toys, pencils, color pencils and other school articles, printing inks, cosmetics, furniture, and paints for interiors, in three months. A Technical Health Norm has been elaborated to regulate the use of lead oxides and carbonates.

Three NOMs had been published in 1992 describing methods to determine lead in paints and pigments, as well as on dry surface paints.

A month after the signature of the Agreement, labels warning about the presence of lead on paints and health effects from inhalation or ingestion were introduced on all the products in the market or in stocks. In June 1992, a Technical Health Norm concerning labeling of paint products containing lead was published.

- Lead glazed pottery: Representatives of artisans, together with government officials, modified the maximum solubility levels on glazed pottery kiln-fired at 990°C as follows:

  flat items: 7.0 mg/l
  small hollow items: 5.0 mg/l
  big hollow items: 2.5 mg/l
  decorative items: 2.5 mg/l

  Those requirements are considered in a NOM published on December 1991. An additional NOM concerning the method to determine lead solubility was published at the same time. In 1988, a NOM was published to establish lead solubility standards on lead based glass decoration.

  A research group was established to study technological alternatives to substitute the use of lead on glazed pottery or to decrease lead solubility without changing the typical characteristics of regional glazed pottery. This programme was given 1000 million Mexican pesos in support from the National Solidarity Programme. More funding will be provided to change fuels to fire the glazed pottery.

Education

The Health Secretariat has established an education programme to transmit messages to show alternatives to reduce lead exposure.

Occupational Standards

The maximum permissible level in air in the work place is 150 $\mu g/m^3$, as established by No. 10 Instructive of the Hygiene and Occupational Health Regulation. The reduction of this standard to 50 $\mu g/m^3$ is being considered.

NEW ZEALAND

The following information to reduce risks to health and the environment from exposure to lead was obtained from Dr. N. Foronda (Public and Personal Health -- New Zealand, 1992).

The current mean blood level in New Zealand is 7 µg/dl. Lead from paint and food and drink containers are the major sources of the New Zealand mean blood level. Petrol lead accounts for 5 per cent. Studies conducted between 1974 and 1984 show that blood lead levels dropped by 40 per cent for adult males and 35 per cent for adult females and children. This reduction was attributed to the removal of lead from food and drink containers. In 1986, the lead content of petrol was reduced from 0.84 g/l to 0.45 g/l but no significant reduction in lead blood level was observed.

Lead-based Paint

The Toxic Substances Regulations 1983 requires that the maximum permissible amount of lead in paint is 5000 mg/kg. This level will be reduced to 2500 mg/kg in the proposed fourth amendment of the regulations which are anticipated to be promulgated in June 1993.

The current regulations also specify that no person shall manufacture, import, supply, sell, or use any paint, distemper, powder coating, pigment, or anti-fouling composition that contains basic lead carbonate which is also known as white lead.

Labelling

The container of any paint, distemper, or powder coating that contains in its dry weight more than 5000 mg/kg must be labelled as prescribed under the Toxic Substances Regulations 1983.

Lead in Petrol

An amendment to the Ministry of Energy (Petroleum Products Specifications) Regulations 1988 has been made which reduced the maximum permissible level of lead contamination in New Zealand unleaded petrol from 0.05 g/l to 0.013 g/l.

In 1986, the maximum permissible level of lead in leaded gasoline was 0.84 g/l. This level was reduced significantly to 0.46 g/l.

The target date for elimination of lead in petrol has been set as January 1996.

Lead in Drinking Water

The "Drinking Water Standards for New Zealand" have been prepared from the WHO Guidelines for Drinking Water Quality 1984 and provides a guideline value of 0.05 mg/l. The New Zealand standard is proposed to be reviewed in 1993 to align with the new WHO Guidelines. The draft proposal for the WHO Guidelines has been released and they will be finalized in June 1993.

Lead in Food

The Food Regulations 1984 establishes maximum permissible proportions for a range of food products. These levels range from 0.2 to 10 parts per million (First Table to Regulation 257).

Lead in Ambient Air

New Zealand has proposed a national ambient air quality guideline of 1.0 $\mu g/m^3$ for an average time of three-month moving average.

Lead in Sewage Sludge

In 1992, recommended limits for lead in sewage sludge intended for application to arable land were established. The maximum acceptable concentration in dry sewage sludge is 600 mg/kg, the limit value allowable in soil is 300 mg/kg, and the maximum cumulative loading is 125 kg/ha.

Lead in Products

The Toxic Substances Regulations 1983 prohibit the manufacture, importation, packing or selling of any graphic material that contains more than 100 mg/kg of lead. A graphic material is defined as any material used for writing, drawing, marking or painting.

The maximum permissible amount of lead is 5000 mg/kg in coating materials as required in the New Zealand Specification for the Safety of Toys. This level will be reduced to 2500 mg/kg in the Fourth Amendment of the Toxic Substances Regulations 1983. Accessible plastics material on a toy is restricted to a maximum permissible amount of 250 mg/kg.

Occupational Standards

The Workplace Exposure Standards for New Zealand has adopted a value of 0.15 mg/m^3 for air.

SWEDEN

Sweden has undertaken an aggressive approach to controlling lead exposure. Sweden advocates an ambitious long term objective of the cessation of lead use. Many of the proposals put forth by Sweden to control lead exposure are more rigid than other OECD countries. In the near term, Sweden's active stance is reflected in the range of regulatory policies and measures adopted. Sweden has implemented risk reducing strategies aimed at a variety of environmental media, environmental point sources, and industrial and consumer products.

Lead-based Paint

In Sweden, white lead compounds are not used in paints; however, some lead is used in paint as pigments, drying agents, and rust-proofing agents. Most lead paint is used on exterior structures and equipment. Through a voluntary agreement with the Sweden National Chemicals Inspectorate, Swedish paint producers agreed to eliminate the use of lead chromate pigments in paint by July of 1990 (Andersson, 1990). There is work on-going aiming at further voluntary agreements to limit the use of lead in paint.

Lead in Gasoline

In Sweden, limits on the lead content in gasoline are 0.15 g/l for leaded gasoline and 0.013 g/l for unleaded gasoline. In addition to these limits, Sweden requires all new automobiles to have catalytic converters and operate on unleaded gasoline (Andersson, 1990). These limits and requirements were effective in 1989, and the Swedish government anticipates a 360 tonne reduction in lead emissions from motor vehicles from 1988 to 1995 (NCI, 1990). In addition, in 1991, the tax on leaded gasoline was raised in an effort to decrease its use (Wahlstrom, 1992). There is a proposal to further limit lead emissions from motor vehicles by revising standards on gasoline and motor vehicles imported, produced, and sold in Sweden (NCI, 1990). In 1993, the tax difference between leaded and unleaded gasoline will be raised once again. Recently the Swedish Environment Protection Agency in a report to the Government has proposed a ban to manufacture or import leaded gasoline from July 1, 1994. The proposal has not been considered by the Government yet.

Lead in Drinking Water

Since there are no lead pipes in Sweden, lead in drinking water is considered to be a minor problem. Nevertheless, beginning in 1980, the National Food Administration set definitions for suitable and unsuitable waters. Waters with lead concentrations less than 0.01 mg/l are deemed suitable; waters with lead concentrations from 0.01 mg/l to less than 0.05 mg/l are deemed suitable with remark; and waters with lead concentrations greater than or equal to 0.05 mg/l are deemed unsuitable. In 1989, a special ordinance was issued that prescribed that installations in contact with drinking water must be made of materials that leach less than 0.05 mg/l of lead (Andersson, 1990).

Lead in Food

Swedish food tolerance levels have recently been lowered to 0.3-0.5 mg/kg for most canned food, and to between 0.02-0.5 mg/kg for various foodstuffs (higher values for spices etc.). Sweden wishes to eliminate imported lead soldered cans (virtually all cans manufactured in Sweden are welded) (Wahlstrom, 1992). Sweden also wishes to subject canned foods to the same standards as fresh foods (Andersson, 1990).

Standards for Environmental Media and Point Source Controls

In Sweden, air and water emission standards are set on a case by case basis during the facility licensing process. For air point sources, the Environmental Protection Act states that lead gases are expected to be collected and controlled by fabric filters (ILZSG, 1989a). For smelters and other combustors, licenses given to facilities are contingent on facilities using the best available technology (BAT), limiting disturbances and/or interferences, and meeting industry specific flue dust standards. For example, primary smelters after 1991 must limit total annual air emissions to 30 tonnes. In addition, they must meet a maximum allowable flue dust concentration (of the process gas after filter) of 20 mg/m^3 dry gas (Andersson, 1990).

A similar regulatory structure is used to control water point sources. Water that is discharged and contains heavy metals (for example, lead) are subject to BAT requirements and review (ILZSG, 1989a). For example, primary smelters after 1991 must limit total annual water emissions to 2 tonnes. In addition, they must meet a maximum allowable concentration in effluent water of 0.1 mg/l (Andersson, 1990).

Lead in Products

Sweden has worked to actively reduce risks to health and the environment from lead in products. As part of this effort, Sweden has implemented product quality standards, recycling policies, and information campaigns.

Ceramic standards were enacted by industry. Ceramic wares intended for handling food or beverages are prohibited from sale if more than 3 mg/l lead is leached out during a standardized acetic acid leaching test (Andersson, 1990).

Sweden also proposes to eliminate the use of underground sheathing cables and lead plastic additives (NCI, 1990). The goal is to eliminate use of lead-sheathed underground cables by 1995. There is currently a voluntary effort to not use underground lead-sheathed cables after 1994 (Wahlstrom, 1992). Another future area of interest/control is crystal. In this area, Sweden is assisting with the development of semi lead-free crystal and eventually whole lead-free crystal (NCI, 1990). Industry voluntarily agreed not to use lead in the manufacturing of semi-crystal after 1991 and today no glassworks use lead for semi-crystal (Wahlstrom, 1992). Miscellaneous uses are presently being investigated, to form a basis for discussions with industry about voluntary measures.

A total of around 1000 tonnes of lead shot is used in Sweden annually. Since 1991, a voluntary reduction, stimulated by information and educational campaigns, is being attempted. The goal is to shift to lead-free alternatives by the beginning of the 21st century. Unless significant results can be for seen, bans may be considered in the near future.

Recycling

In Sweden, the Environmental Protection Agency has levied a tax on all batteries to be paid for by producers and importers. The tax is used to support the companies that receive, store and transport batteries for final disposal. So successful is this programme that in its first 3 years more batteries were returned than had been sold during the same period; presumably, many consumers returned discarded batteries they had previously stored (Andersson, 1990). Further efforts to control lead exposure from batteries (i.e. occupational, disposal, and manufacture) have been proposed. These include increased support for the recycling initiative described above (i.e. returnable deposits for new batteries) as well as increased support for lead battery design improvements and/or the development of potential lead-free substitutes (NCI, 1990).

Occupational Standards

In Sweden, the maximum allowable air lead concentration in the workplace is 0.10 mg/m^3 (total) and 0.05 mg/m^3 (respirable) expressed as a time weighted average over eight hours. The maximum blood lead values for both male and female are 50 µg/dl in three consecutive checks and 60 µg/dl in one check (ILZSG, 1989a). New regulations will come into force on January 1, 1994. The medical removal blood lead concentration in the workplace will be 1) for men and for women over 50 years: 40 µg/dl for 3 consecutive checks and 50 µg/dl for any one check, and, 2) for women under 50 years: 25 µg/dl for 3 consecutive checks and 30 µg/dl for any one check.

SWITZERLAND

Lead-based Paint

The use of lead in different colours and writing materials is regulated in the Order concerning prohibited toxic substances and in the Ordinance on food (Lebensmittelverordnung). The regulations have been implemented in order to protect the general population from direct lead intake. They can be summarized as follows:

- The use of lead and its compounds is prohibited in water paints and non-washable distempers used for interior paintwork. Lead is prohibited as well in dyes for clothing.

- Coatings and leads of writing and painting materials for household and school are not allowed to release more than 250 mg Pb/kg coating when incubated for one hour into 0.07 mol/l HCl at 21◦C; the maximum concentration of lead in refills and liquid inks is 250 mg/kg dry residue.

- Water colours for household and school may not release more than 100 mg PB/kg when incubated for one hour into 0.07 mol/l HCl at 21◦C.

Lead in Gasoline, aircraft petrol and heating fuel

The lead content in gasoline is limited to 0.15 g/l (leaded), to 0.013 g/l (unleaded) and to 0.56 g/l in aircraft petrol. In 1992 the market share of unleaded gasoline has reached about 65 per cent. The lead content of heating fuel "Extra leicht" is limited to 1 mg/kg whereas the fuel qualities "Mittel" and "Schwer" may not contain more than 5 mg/kg.

Lead in Drinking Water

The permissible lead concentration in drinking water is 0.05 mg/l. The use of lead containing pipes and tubes is prohibited.

Standards for Environmental Media and Point Source Controls

Effluents discharged into surface waters or public sewers must have a lead concentration of less than 0.5 mg/l. The quality criteria for surface water flows and impounded river water is set at 0.05 mg/l.

In Switzerland the general emission limit for combusters with a mass flow greater than 25 g/hr is set at 5 mg/m^3. For municipal waste incinerators the sum of lead and zinc including its compounds emitted into the atmosphere must not exceed 1 mg/m^3. The maximum tolerable lead concentration in air (suspended dust) is limited at 1 $\mu g/m^3$ per day.

In order to guarantee long-term soil fertility, Switzerland has implemented guide levels for soil pollutants. According to the ordinance relating to pollutants in soil the total lead content is limited to 50 mg/kg, soluble lead to 1 mg/kg. The use of sewage sludge and compost for agricultural purposes is prohibited if its lead content exceeds 500 mg/kg or 120 mg/kg, respectively.

Occupational Standards

The maximum allowable air lead concentration in the workplace is 0.1 mg Pb/m^3 (time-weighted average over eight hours) for lead and lead compounds (except alkyl compounds), and 0.075 mg Pb/m^3 for tetramethyl and tetraethyl lead. The maximum allowable blood lead concentration is 30 µg/dl for women and 70 µg/dl for men.

UNITED KINGDOM

Over the period from 1973 to 1974, the United Kingdom conducted its first comprehensive study of lead. This study was unique in the sense that no such study had been conducted for almost any other environmental pollutant. The goal established at that time by the Department of Environment's Central Unit on Environmental Pollution was to implement lead pollution control policies that would ensure that lead exposure in the United Kingdom would not increase. Areas and circumstances of high exposure to lead were to be identified and remedied (Whitehead, 1989).

Much of the United Kingdom's concern stemmed from high-levels of exposure that were found in the early 1970s at works sites in East London. In the area surrounding these industrial sites, families and workers were identified with elevated blood lead levels and air and dust samples revealed high lead concentrations (Reed, 1987). These sites would prove to have much influence on the UK's lead control strategy which, like many other countries, has been focussed on identifying and remedying hot spots.

To date, the United Kingdom has shown initiative in establishing lead risk reduction strategies that influence environmental media and sources, consumer products, and environmental health. It is important to note that many of the UK's efforts were done in accordance to European Community guidelines. When problems were not addressed by the EC, however, the United Kingdom has relied on a variety of strategies including legal quality standards, voluntary agreements, action programmes, and subsidized public and private remedial actions (Whitehead, 1989).

Blood Lead Action Levels

United Kingdom government advice published in 1982 recommended taking steps to reduce exposure if blood lead levels exceed 25 µg/dl (Rea, 1991).

Lead-based Paint

There have been substantial reductions in the use of white and red lead pigments in paints within the United Kingdom. Some uses remain, however, including those for corrosion control on steel work and for protection of outdoor work. In addition, lead chromates continue to be used in paint for road markings (Rea, 1991).

A voluntary agreement between the government and the Paint Makers Association (who account for over 90 per cent of the UK's production of solvent thinned alkyd paint) was established to eliminate the use of lead additives in decorative paints and varnishes by 1987 (Whitehead, 1989). The United Kingdom has implemented legislation concerning lead paint that prevents the use of lead carbonates and lead sulphates in paint. Under these rules, lead carbonates and sulfates may only be used in paint for certain historic buildings and art preservation (Atherton, 1992).

Lead in Gasoline

In 1983, the Royal Commission on Environmental Pollution estimated that adults in the United Kingdom derived up to 20 per cent of their body lead burden from gasoline lead. At this

time, the United Kingdom concurred with certain other European countries (for example, Germany) to phase out the use of lead additives in gasoline entirely (Whitehead, 1989). Since 1973, the allowable lead content in gasoline has been steadily reduced within the United Kingdom. Most recently, in 1986, the maximum allowable concentration of lead in gasoline was set at 0.15 g/l. Unleaded gasoline was first widely introduced in 1986 with a maximum allowable lead concentration of 0.013 g/l (85/210/EEC). Beginning in 1988, the Road Vehicle and Type Approval Regulations specified that all new vehicles must be capable of running on unleaded gasoline in the 1990s (Rea, 1991).

Observing the period from 1986 to 1987, it was estimated that the amount of lead discharged by motor vehicles in the UK dropped by 60 per cent after the 1986 reduction. Similarly, average airborne lead concentrations at twenty-one of the UK monitoring sites fell by nearly 50 per cent over this same time period (Reed, 1987).

Lead in Drinking Water

In 1973, regional authorities within the United Kingdom were made responsible for water supply, treatment, and management. As part of this responsibility, authorities were asked to maintain "wholesome" drinking water quality. A survey in 1983, however, revealed that approximately 10 per cent of the water supplies required reduction in the plumbsolvency of the water (Whitehead, 1989). In response to this concern, the 1989 Water Supply Regulations set the maximum concentration of lead in drinking water at 50 µg/l (the same level proscribed by the EC in 80/778/EEC). These regulations also require water companies to install further treatment where there is risk of exceeding the standard at the customer's tap. Discretionary grants are also made available to customers who require treatment at or near their kitchen tap (Rea, 1991).

Studies concerning lead in drinking water have been conducted in two areas of Scotland. In Glasgow, several areas with high plumbsolvency in their water supplies were identified. To assess the potential impact of this exposure source, a sample consisting of 131 infants and their mothers were analysed. Mean blood levels were 18 µg/dl for mothers; 20.8 µg/dl for bottle-fed infants; and 9.7 µg/dl for breast-fed infants. The study revealed a curvilinear relationship between blood lead and lead intake, suggesting that blood lead was strongly affected by low lead intakes. These results raised concerns about drinking water as a contributor to lead exposure particularly for infants (Reed, 1987).

To demonstrate the value of abatement efforts, a study was also conducted in Ayr. The sample included 74 women. After replacing lead service lines/pipes, the median blood lead level of the sample dropped from 21 µg/dl to 13 µg/dl (Reed, 1987).

The UK government has recently proposed regulations to prohibit the use of certain lead solders and the supply of integral solder ring copper fittings containing lead solder in domestic water supply installation, and to impose restrictions on the labelling and display of solders. In the regulations, lead solder is defined as that which contains more than 0.1 per cent lead (Atherton, 1992).

Lead in Food

The estimated mean weekly intake of lead through the dietary pathway (excluding drinking water) in the UK is 0.42 mg per person (MAFF, 1989). The United Kingdom has established quality and labeling standards for a range of consumer products. Since 1979, the UK government has

enforced a general limit for lead in food of 1.0 mg/kg, with exceptions for certain specified foods (i.e. 0.2 mg/kg baby food, 2.0 mg/kg for liver). Since lead solder has been phased out from use in cans manufactured in the UK (and in a number of other countries), the general limit of 1.0 mg/kg also applies to food stuffs supplied in these containers. A survey of cans from 1983 to 1987 revealed marked reductions in lead levels with only one can of the 1987 sample not passing the limits (MAFF, 1987). The United Kingdom has also considered subjecting imported food products to the same lead in food products limits (Reed, 1987).

Lead in Soils

An analysis of metals in urban dust and soils in the UK conducted over several years, beginning in 1981, showed elevated urban dust and soil concentrations relative to agricultural soil concentrations (Emerson et al., 1992). There are currently no UK standards for lead levels in soils. However, the Department of the Environment promotes guidance drawn up by the Interdepartmental Committee on the Redevelopment of Contaminated Land for the assessment of polluted soils (ICRCL, 1987). This guidance incorporates the concept of "trigger concentrations," which depend on the intended use of the contaminated site. The trigger concentration for lead is set at 500 mg/kg (air dried soil) for land used as domestic gardens and allotments, and 2000 mg/kg for parks and playing fields. When levels at a site are known to exceed these concentrations, it is recommended that further investigation be conducted to ascertain the risks to human health associated with the use of the land, and recourse to remedial action is dependent on the outcome of such a study.

United Kingdom Regulations implementing EC Directive 86/278/EEC were designed to protect soils when sewage sludge is used in agriculture. A maximum permissible concentration for lead in soils of 300 mg/kg dry solids after the application of sewage sludge has been established along with an average annual rate of addition of lead amounting to 15 kg/hectare calculated over a ten year period. These limits are accompanied by more detailed requirements for sludge producers and landowners, aimed at protecting the wider environment and, in particular, grazing animals.

Standards for Environmental Media and Point Source Controls

The United Kingdom has followed the guidelines set forth by the European Community for controlling ambient air emissions. The limit for lead is 2.0 $\mu g/m^3$ expressed as a mean annual concentration (ILZSG, 1989a).

The United Kingdom regulates air point sources such as smelter and other lead works. Best practicable means (BPM) are used to treat and control air emissions. BPM technologies are agreed upon through negotiations between the government and industry. Using these technologies, industrial sources must meet an allowable lead concentration of 0.002 g/m^3 with the exception of some sources that must meet an allowable lead concentration of 0.01 g/m^3. Total particulate emissions cannot exceed 0.1 g/m^3 (Rea, 1991).

Some water point sources, such as industrial effluents, are also regulated in the United Kingdom. Permissible lead concentrations vary with the plant location and receiving water. Overall, the typical range of permissible lead concentrations is 1.0 through 5.0 mg/l (ILZSG, 1989a). The content of lead in the effluent should correspond to the Environmental Quality Standard for the receiving waters established by the Department of the Environment (DOE, 1989). These standards vary between freshwater and salt water and with total hardness (mg/l $CaCO_3$)

and whether the water is abstracted to potable supply.

Under the 1974 Control of Pollution Act, the United Kingdom placed some restrictions on the production, disposal, and import of special waste. Wastes consisting of or containing lead are included in the special waste category. Individuals wishing to produce, dispose, or import such wastes are required to complete a consignment note for disposal authorities (Reed, 1991). Since 1986, the United Kingdom has also required operators that transport lead-containing wastes to meet specific transport requirements (i.e. vehicle design, driver training) (ILZSG, 1989b).

Lead in Products

As of 1988, ceramic wares have also been subject to regulations. Industry was given five years to meet maximum lead concentrations of 0.8 mg/dm^2 for flatware; 4.0 mg/l for small hollowware (volume less than 3 litres); and 1.5 mg/l for large hollowware (volume greater than 3 litres). Follow-up surveys conducted by the Ministry of Agriculture, Food, and Fisheries have shown close to 100 per cent compliance with these limits in the UK (Rea, 1991).

In addition to food and ceramic wares, the United Kingdom also restricts the use of lead-based paint in consumer products. Lead in dry paint film on toys is limited to 0.25 per cent by weight. The soluble lead content of a paint coating applied to a pencil, pen, or brush is limited to 0.025 per cent by weight (Rea, 1991).

Recycling

There are currently no regulations governing the disposal of lead batteries within the United Kingdom. Despite this fact, recycling rates are approximately 100 per cent for batteries installed in buildings and close to 90 per cent for those installed in automobiles. There is much discussion of passing regulation that would control the disposal of lead batteries in coordination with the European Community proposals on this subject (Rea, 1991). The transport of lead batteries is regulated as individuals transporting batteries that contain more than 1 litre of electrolyte must abide by restrictive transport conditions (i.e. manifest and vehicle requirements) (ILZSG, 1989b).

Education/Labelling

In the United Kingdom, a joint informational campaign between the Lead Development Association and angling groups has resulted in a phase-out of lead weights in fishing. The United Kingdom also specifies that all paints and varnishes containing more than 0.15 per cent lead by weight must be labelled accordingly (Rea, 1991).

Occupational Standards

In January of 1981, the maximum allowable concentration of lead in the workplace in the United Kingdom was set at 0.15 mg/m^3 (expressed as a time weighted average over 8 hours). The maximum allowable blood lead concentrations were also set at this time at 80 µg/dl for men and 40 µg/dl for women (ILZSG, 1989a). In 1986 the blood lead limit for men was reduced to 70 µg/dl.

UNITED STATES

Throughout the past 25 years, the United States has been quite active in sponsoring regulatory measures to reduce potential human exposures to lead, many of which have been successful. The US has restricted or banned the use of many products containing lead where risks from these products are high and where substitutes for lead or lead-based products are available. For products where risks to human health and/or the environment are lower, or for which technically and economically adequate substitutes are not available, lead control strategies have focused on recycling, emissions controls on the mining and processing of lead, and the ultimate disposal of lead-containing products. Finally, in certain important areas where exposure is based on past uses of lead, education and abatement programmes have been used. The US continues to pursue additional lead risk reduction measures, focusing on those sources with greatest exposure and risk potential.

Blood Lead Action Levels

The definition of a blood lead level that defines a level of concern for lead in children continues to be an important issue in the United States. The childhood blood lead concentration of concern in the US has been steadily lowered by the Centers for Disease Control (CDC) from 40 µg/dl, in 1970, to the current action level of 10 µg/dl established in 1991. Earlier, the EPA had lowered the level of concern to 10µg/dl ("10-15 and possibly lower") in 1986. The Agency for Toxic Substance Disease Registry (ATSDR) identified the same level of concern in the 1988 Report to Congress on childhood lead poisoning.

The CDC has issued recommendations for actions at different blood lead levels in children (CDC, 1991a). For a community with a significant number of children having blood lead levels between 10-14 µg/dl, initiation of community-wide lead poisoning prevention activities is recommended. For individual children with blood lead levels between 15-19 µg/dl, CDC recommends nutritional and educational interventions. Blood lead levels of 20 µg/dl and higher should trigger investigations of the affected individual's environment and medical evaluations. Lead screening for children has recently increased significantly.

The medical removal blood lead concentration in the workplace, which became effective in 1983, is 50 µg/dl for three consecutive checks and 60 µg/dl for any one check. Blood level monitoring is triggered by an air lead concentration above 30 $\mu g/m^3$. A worker is permitted to return to work when his blood lead level falls below 40 µg/dl.

Lead-based Paint

One of the highest-risk sources of lead for children in the US is lead-based paint. In 1977, the US Consumer Product Safety Commission set a standard for lead in residential paint of 0.06 per cent (16 CFR 1303). Although this restriction effectively banned lead in residential paint in the US, an estimated three million tons of lead in paint still remains in US dwellings (ATSDR, 1988). The US Department of Housing and Urban Development (HUD) has proposed an extensive programme to reduce exposure from deteriorating lead-based paint, including research, technical assistance, funding for abatement in public housing and assistance to local governments (HUD, 1990). As part of their comprehensive plan, HUD estimated that if 500 000 high-priority homes were tested every year, the total cost of testing these homes and performing abatement where

necessary would be $1.9 to $2.4 billion. In a separate analysis, the US Department of Health and Human Services' Centers for Disease Control (1991b) estimated that total present cost of abatement of the 23 million occupied pre-1950 housing units containing lead paint would be $34 billion, if abatements were conducted over a 20-year period. While these costs are high, the estimated benefits of such a programme are also substantial: CDC also estimated that the present value monetized health benefits of the 20-year abatement programme would be $62 billion over the lifetime of the occupants; the present value of net benefits (benefits minus costs) was estimated to be $28 billion (CDC, 1991b).

To help address the problems of lead-based paint abatement, HUD has established an Office of Lead-based Paint Abatement and Poisoning Prevention. There is also an Interagency Lead-based Paint Task Force that includes EPA and HUD (co-chairs), the Department of Health and Human Services, Department of Labor's Occupational Safety and Health Administration (OSHA), the National Institute for Occupational Safety and Health (NIOSH), the Department of Commerce's National Institute for Standards and Technology (NIST), the National Institute for Environmental Health Services (NIEHS), the Consumer Product Safety Commission (CPSC), the Agency for Toxic Substances Disease Registry (ATSDR), the Department of State, the Council for Environmental Quality (CEQ), the Department of Defense (DOD), branches of the military, the Resolution Trust Corporation (RTC), the Department of Veteran Affairs and the Department of Energy. Major Task Force activities include integrating various agency lead strategies into a unified approach to address childhood lead poisoning and lead paint abatement; establishing an information clearinghouse on lead paint and other lead exposures; and investigating improved analytical technology.

EPA is particularly active in evaluating abatement technologies and measurement technologies, establishing programmes to assure a trained skilled work force is available, and in furthering technology transfer and outreach. A national public education campaign is expected to be launched in 1993 by the President's Commission on Environmental Quality, a public/private partnership group.

OSHA is required to develop an interim final standard for lead in construction in 1993. This regulation is being developed in part to address exposure to lead-based paint.

In addition to Federal activity, several individual US states have also instituted aggressive programmes to reduce exposures to lead in residential buildings. States have also proposed restrictions on paint removal activities to limit exposures during abatement. For example, Texas is proposing a ban on sandblasting painted structures when paint contains more than 1 per cent lead and the structure is located near a residential or public area. Minnesota has developed a set of pollution control recommendations for the removal of paint that contains more than 1 per cent lead (EPA, 1991c).

In October 1992, the Residential Lead-based Paint Hazard Reduction Act of 1992 was enacted. This law provides the framework for a national approach to reduce hazards from lead-based paint exposure, primarily from housing. The law requires HUD to provide grants to States to reduce hazards in non-Federally-owned or -assisted housing, to evaluate and reduce lead hazards in Federally-owned or -assisted housing, and to issue guidelines for performing risk assessments, inspection, in-place management and abatement of lead hazards. EPA is mandated to promulgate regulations ensuring that those engaged in abatement activities are trained and that training programmes are certified, to establish standards for abatement activities, to promulgate model State programmes from compliance with training and accreditation regulation, to establish a laboratory accreditation programme, to establish a clearinghouse for dissemination of information, to promulgate regulations for the disclosure of lead hazards at property transfer, to conduct a study

on the hazards of renovation and remodeling activities, and to develop regulations to identify lead hazards in paint, dust, and soil.

Lead in Gasoline

The US restricts the amount of lead allowed per litre of leaded gasoline to 0.026 grams. In addition to this limit, the United States required that, beginning in 1988, all new light duty vehicles and trucks, motorcycles and heavy duty gasoline engines must operate on unleaded gasoline. Unleaded gasoline may not contain more than 0.01 g/l of lead (IRPTC/UNEP, 1990). As of March 1991, tetraethyl lead is no longer produced in the US. Under the Clean Air Act Amendments of 1990, reformulated gasoline shall have no lead content. As of December 31, 1995, a total ban on leaded gasoline and lead gasoline additives will be in place for highway use. In addition, all motor vehicle engines and non-road engines manufactured after model year 1992 that require leaded gasoline will be prohibited.

Reduction of lead in gasoline has been successful at reducing the level of lead in blood in several countries, although the magnitude of the reduction has varied. A number of studies in the US (Annest et al., 1983; Schwartz and Pitcher, 1989) have attributed a drop in blood lead levels in general populations from about 15 µg/dl to about 5 µg/dl to reductions in lead in gasoline (EPA, 1991a). Such reductions could yield substantial benefits. A 1985 study conducted by EPA examined the benefits of reducing lead in gasoline in the US (EPA, 1985a). This study examined both health benefits and materials benefits of reducing exposure due to misfueling, improved fuel economy, and reduced maintenance costs associated with reducing the corrosive effects of lead on engines and exhaust systems. The net benefits of the lead phase-down were estimated to range from $6 billion and $7 billion.

Lead in Drinking Water

In rules promulgated in June of 1991, the US EPA outlined new treatment requirements for drinking water systems (EPA, 1991b). The regulation requires tap water sampling from high risk homes (for example, lead service lines or lead soldering installed since 1982). The first flush sample must be collected after water has sat in the household plumbing at least six hours. If at least 10 per cent of home tap samples exceed 15 µg/l (the "action level"), corrosion control treatment and public education is required. Replacement of lead service lines is required if corrosion control fails to bring water lead levels below the "action level." The potential benefits of increased corrosion control are significant. EPA estimates that corrosion control treatment to comply with this rule will reduce lead exposure from drinking water two to three fold, and that monetized health benefits will total approximately $3-4 billion annually. Total monitoring and treatment costs of the rule are estimated to range between $500 and $800 million per year (EPA, 1991b).

EPA has also taken other activities related to lead in drinking water. Pursuant to the Lead Contamination Control Act of 1988, EPA identified drinking water coolers that are not lead free (EPA, 1990). Based on this action, such water coolers became subject to action under CPSC jurisdiction. As a result of this action, in 1990, CPSC entered into a consent agreement with a major manufacturer of such water coolers to fund their repair/removal (CPSC, 1990a).

Several additional future regulations are under consideration by EPA to reduce exposure to lead in drinking water (EPA, 1992b). First, a more comprehensive ban on the sale of lead solder for use in drinking water plumbing is being considered. Even though the Safe Drinking Water Act of 1986 prohibited the use of lead solder in drinking water plumbing, lead solder can still be legally purchased by plumbers and home repairers. Further, this ban applied only to plumbing systems connected to public water systems (i.e. systems that serve more than 25 people or have more than 15 connections). Second, new regulations on fittings for drinking water plumbing are being

contemplated. This would first specify a performance standard for leaching of lead from these fittings to ensure compliance with EPA's new drinking water regulations. After ten years, the performance standard would be replaced with lead content standard. Meanwhile, EPA is continuing discussions with industry (through the National Sanitation Foundation International) on the development of lead leaching standards for certification of plumbing fittings. Proposed legislation in the US Congress also addresses lead in drinking water. Proposals include provisions for amending drinking water regulations with regard to sampling and compliance activities, increasing restrictions on lead solder, and setting performance standards for lead in plumbing fixtures.

Standards for Environmental Media and Point Source Controls

The Department of Housing and Urban Development has set interim guidelines for abatement of lead-based paint in public housing. These guidelines recommend abatement at 1 $\mu g/cm^2$ paint of 0.5 per cent lead by weight and clearance levels for lead in household dust of 200 $\mu g/ft^2$ for floors, 500 $\mu g/ft^2$ for window sills and 800 $\mu g/ft^2$ for window wells (HUD, 1990). No guidelines currently exist for residential soils, but the EPA has adopted an interim guidance citing levels to be attained once remediation at uncontrolled hazardous waste sites is determined to be necessary. The interim guidance recommends that clean-up should attain soil concentrations of between 500 and 1000 mg/kg. Generally, these levels are believed to be protective of children in the residential setting but are not intended to protect for ecological effects. EPA is conducting studies in several large cities and will consider these studies in developing final guidance. Soils removed during remedial activities at waste sites must pass a leaching test or be subject to disposal as hazardous waste.

Strategies aimed at reducing ongoing exposures to lead include emissions standards for sources of lead in air and water. The United States ambient air quality standard for lead is currently 1.5 $\mu g/m^3$ (quarterly average), but a more stringent standard is now being considered. Surface water quality criteria exist for both freshwater and saltwater. In the United States, freshwater lead standards vary by water hardness. The most stringent standard allows a maximum four day average of 1.3 $\mu g/l$ with a one hour maximum average of 34 $\mu g/l$. Saltwater criteria for the US limit lead concentrations to an average of 5.6 $\mu g/l$. This limit cannot be exceeded more than once over a three-year period. Also, the EPA has proposed regulations for the use and disposal of sewage sludge containing lead. These proposed rules allow a maximum concentration of lead in sludge of 300 mg/kg and cumulative pollutant loading in the soil of not more than of 300 kg/ha. The Agency is reviewing comments on this proposal and is developing a final regulation under Section 405D of the Clean Water Act to be published in December, 1992.

FDA has established acceptable lead levels for bottled water and table wine. There is a voluntary industry standard for calcium supplements (FDA, 1992a). Other standards for food and cosmetic additives range from 10 to 70 mg/kg (IRPTC/UNEP, 1990).

Point Source Controls

The United States requires various lead smelting and processing facilities to use the best practicable control technology for new facilities and reasonable available control technologies for existing facilities. In addition, lead emissions from these and other industries are controlled via specific facility permits written by states. The states are responsible for ensuring air quality in each state meets, at a minimum, EPA's ambient air quality standards discussed above. To do so, states write site-specific permits for each lead source, designed to reduce emissions to the extent needed

to meet EPA ambient air standards.

EPA has initiated a voluntary programme based on the Toxics Release Inventory reporting, called the "33/50 Project," which encourages industry to curtail emissions of 17 toxic pollutants, including lead. The specific aim of the project is to obtain commitments from companies to reduce voluntarily reported emissions, effluents and offsite transfers of these 17 pollutants that are applicable to their operations in two phases -- 33 per cent by 1992 and 50 per cent by 1995 -- using 1988 as the baseline year. As of 1992, 850 companies have agreed to participate in this programme.

Federal effluent guidelines and pretreatment limits for lead-containing effluents exist for over 20 industries. These limits are implemented by states through facility-specific permits, and may be more stringent than federal requirements, depending on state water quality standards.

In the US, certain lead-containing wastes are specifically listed as hazardous. These include wastes generated by inorganic pigment manufacturing, primary metals production, and secondary lead smelting. Other wastes are identified as hazardous if they exhibit a characteristic. The toxicity characteristic (TC) is determined by extracting the waste with a simulated leachate. If the concentration of lead in the extract exceeds the regulatory limit of 5 µg/l, the waste is hazardous.

Hazardous wastes must be managed by a permitted treatment, storage or disposal facility. Land disposal of most untreated hazardous waste is prohibited. Permitted facilities must perform groundwater monitoring and may be subject to corrective action if lead is found at levels exceeding specified concentration limits. Special rules apply to used oil, lead-acid batteries, and hazardous waste burned as fuel in boilers and industrial furnaces. Currently, municipal solid waste combustion ash is exempt from classification as a hazardous waste; in the past, this material was classified as hazardous because of failure of the TC test.

EPA continues to consider regulations for industries that discharge lead into the air and water. These regulatory actions are taken in the context of overall effluent guidelines for various industries or air emissions limitations for new sources.

Lead in Products

Restrictions on lead in two major products, paint and gasoline, were discussed earlier. In addition to residential paint, the Consumer Product Safety Commission also regulates the use of lead paints and surface coatings used in toys, children's products and household furniture (16 CFR 1303). Food cans and utensils are other important source of lead exposure. The US canning industry has undertaken a voluntary phase-out of the use of lead in food cans since alternative, affordable processes for sealing the seams of tin containers are available (FDA, 1992a). The US Food and Drug Administration regulates use of ceramics as food containers. Ceramics fired at low temperatures must carry warnings or have a hole to prevent use with food. Ceramic glazes are regulated under the Federal Hazardous Substances Act and must be labelled with health warnings and instructions for use (EPA, 1991c). In November 1991, FDA published non-binding guidelines for acceptable levels of lead in ceramic ware, which significantly reduce previous levels (FDA, 1991). Through voluntary co-operation of industry with FDA, it is expected that lead foil will not be used on wine bottles after 1993. The crystal ware industry is also sharing technology to reduce leaching of lead from lead crystal (FDA, 1992b). Eight US states have adopted legislation to limit the levels of lead in packaging materials (EPA, 1991c).

The US has also instituted controls on lead in other products. The US restricts the use of lead ammunition in an effort to reduce risks to wildlife that may inadvertently ingest lead shot, especially birds. Recently, the EPA requested information on pesticide products that contained lead as an inert ingredient. As a result, 11 pesticides containing lead were canceled, and four were reformulated with ingredients other than lead. There are no known current pesticides that use lead as a pesticide ingredient (EPA, 1992a).

Recycling

Evidence suggests that lead-acid batteries are frequently recycled in the United States. Thirty-nine states and one city have enacted legislation to encourage recycling of lead-acid batteries, and a number of other states are considering similar proposals. Of these jurisdictions, 33 states and one city adopted laws that prohibit the disposal of lead-acid batteries in municipal solid waste and require all levels of the collection chain to accept used lead-acid batteries. Ten of these 33 states also adopted a deposit in lieu of trade system, with deposits ranging from $5 to $10 per battery. Six states have banned the disposal of lead-acid batteries in municipal solid waste (ITA, 1993). US legislation proposed in 1992 would encourage or require recycling for all lead-acid batteries.

The lead-acid battery not only accounts for the majority of lead consumption but has a higher recycling rate than any other recoverable material. The EPA's 1985 Report on the National Small Quantity Hazardous Waste Generator Survey (US EPA, 1985b) indicated that nearly 90 per cent of spent lead-acid batteries disposed by automobile service stations were sent to recycling facilities. A recycling rate study released by the Battery Council International (a trade association representing the US and international lead-acid battery industry) reported an increase in the recycling rate from 88.6 per cent in 1987 to 97.8 per cent in 1990 (ITA, 1993).

Education/Labelling

New proposed regulations for solder and brass plumbing fittings would require labels on products with information on the applicable use restrictions and rule language (EPA, 1992b). Arts and crafts materials containing lead must be labelled in accordance with the Labeling of Hazardous Art Materials Act of 1988. The Consumer Product Safety Commission has issued several publications on lead, including an alert on lead-based paint (CPSC, 1990b) and lead solder (CPSC, 1988). Increased public education and expanded requirements for product labelling are elements of recent proposed US lead legislation. A Federal Lead Clearinghouse/Hotline (1-800-532-3394), funded by EPA, HUD, the Department of Defense and CDC was put into service in 1992. Information on lead exposure and what parents and homeowners can do to reduce lead in their child's environment is available.

Occupational Standards

The Occupational Safety and Health Administration of the US Department of Labor has established environmental and biological standards for lead-using industries. Standards take the form of both permissible workplace air concentrations and permissible blood lead levels in workers. Environmental and biological monitoring must be conducted by the employer. Elevated blood lead levels may require the removal of an individual from the workplace (Niemeier, 1991). The current Permissible Exposure Limit (PEL) generally limits air concentrations of lead to 50 $\mu g/m^3$, except for the construction industry, which, if not achievable with engineering controls, may require the use of personal respirators.

OSHA is required to lower the permissible exposure limit for lead in construction from 200 $\mu g/m^3$ to 50 $\mu g/m^3$. Subsequent rulemaking will deal with provisions for methods for compliance, medical surveillance, exposure monitoring training, and the need to limit exposures below 50 $\mu g/m^3$. These activities are slated for 1993.

Regulations established by OSHA prohibit general industry employees exposed to lead in their workplace from taking lead-contaminated work clothes from the work site, and require employers to provide hygiene facilities (showers, washing facilities) to lead workers. These provisions are designed to ensure that family members will not be subjected to secondary exposure to lead as a result of lead workers' occupational exposures. Recent legislation requires OSHA to promulgate a final interim standard on occupational exposure to lead in the construction industry by mid-1993 (OSHA, 1992).

NORDIC COUNTRIES

Nordic countries have undertaken a number of joint initiatives towards protecting the environment. Denmark, Sweden and Norway have signed the Ministerial Declaration of the Third International Conference on the Protection of the North Sea. This declaration states that the emissions of lead (and other micropollutants) shall within 1995 be reduced by 70 per cent compared to the level in 1985. Denmark, Finland and Sweden have through the Baltic Marine Environment Commission (HelCom) adopted the goal of reducing lead emissions by 50 per cent within 1995, using 1987 as a reference year.

On the commission of the Nordic Chemicals Group under the Nordic Council of Ministers, a report describing Nordic experiences regarding the technological possibilities for reducing the use of lead (G. Havenstrom & S.L. Bjornstad, 1992) has been elaborated. The long-term goal for the Nordic countries is to completely eliminate the intentional use of lead in products and to minimize the amount of lead discharged to the environment. The strategy to reach this goal includes in preferential order:

- cleaner technology (substitution and process modifications);
- effective recollection and recovery systems;
- environmentally acceptable waste treatment.

EUROPEAN COMMUNITY

Although the European Community published environmental programmes in 1973, 1977, and 1983, there were no explicit legal provisions for Community environmental actions prior to the Single European Act taking effect in 1987. Despite this fact, over 100 instruments (mostly directives for harmonizing environmental protection measures) for environmental protection were proposed by Member States from 1972 through 1986. Reflected in these instruments, as well as in those proposed after 1987, is a desire to control lead in the environment.

The European Community has issued directives regulating lead in products and across different environmental media and environmental sources. It is important to note that a directive is a legislative action that is addressed to Member States and may either contain very specific information or be narrative in nature. A directive often sets a deadline for the Member States to adopt the directive into their own countries' law; typically, however, a directive will contain specific information and will set a deadline on the order of three years. If a Member country fails to adopt the directive into law within the specified amount of time, then action may be taken against that Member in the European courts.

Legal realities compound the difficulty of achieving environmental protection across the twelve Member States of the European Community, for the Member States are at different stages of environmental control, with varied levels of environmental awareness and/or concern, and have distinct regulatory entities. In regulating lead and other environmental hazards, the European Community must simultaneously prevent Member States from adopting rules that would inhibit trade within the community and limit the extent of weak and inadequate environmental policies.

The experience of developing a lead policy in the EC exemplifies this regulatory challenge. For example, the European Community has issued policies that establish allowable lead contents for leaded and unleaded gasoline and encourage the use and manufacture of unleaded gasoline. Several European Community countries have switched to unleaded gasoline, but in countries such as Spain and Portugal, unleaded gas is a rare commodity. Despite these types of problems, the European Community has assembled an amalgam of instruments designed to control lead in the environment.

Blood Lead Action Levels

In 1977, the European Community introduced a directive on biological screening of the population for lead (77/312/EEC) designed to identify and control sources of unacceptable lead exposure. Each Member State was required to survey blood lead levels of groups of at least 100 persons in urban areas (population greater than 500,000) and in areas where significnt exposure might be expected. At least two campaigns were required in each sampling area within a period of four years. Reference blood lead levels adopted for the study were 20 mg/dl for 50 per cent of a group, 30 mg/dl for 90 per cent, and 35 mg/dl for 98 per cent.

For most of the study populations, blood lead levels fell well within the reference values. However, a small number of areas were found in which reference values were exceeded and remedial measures were subsequently employed. A general decrease in population blood levels with time was apparent in most populations studied.

Lead-based Paint

Beginning in 1989, the European Community prohibited the use of lead carbonates and lead sulfates in paints intended for all purposes other than preservation work (89/677/EEC; Rea, 1987).

Lead in Gasoline

Beginning in 1987, the European Community limited lead levels in gasoline. No specific deadline is designated to the Member States for meeting standards, but a committee was developed to provide scientific and technical support for meeting the standards. The directive (82/210/EEC) sets the maximum permitted lead compound level of leaded gasoline at 0.15 grams lead per litre and defines unleaded gasoline as gasoline that contains less than 0.013 grams lead per litre (0.020 grams lead per litre applied in certain exceptional cases until 1991) (IRPTC/UNEP 1990).

Lead in Drinking Water

Beginning in 1977, the European Community under Directive 75/440/EEC established classifications (i.e. A1, A2, and A3) for surface waters to be used as drinking water. Treatment methodologies were proposed for each classification with all sources having to meet a maximum lead level of 0.05 milligrams lead per litre (von Moltke, 1987). This directive was supplemented by another in 1981 (76/869/EEC) that recommended uniform methods of measurement and analysis for Member States. Effective in August of 1982, the Community maximum allowable lead concentration was established at 0.05 milligrams per litre (80/778/EEC) (von Moltke, 1987).

Lead in Sewage Sludge

The European Community has made concerted efforts to coordinate analysis of the treatment and use of sewage sludge among Member States. In July of 1989, standards (86/278/EEC) for sewage sludge used in agricultural applications became effective. The lead concentration limit for soils with pH levels ranging from 6 to 7 is 50 to 300 mg/kg dry matter, while the limit for lead concentrations of substances in sewage sludge is 750 to 1200 mg/kg and the annual limit for lead in sewage sludge applied to agriculture is 15 kg/ha (based on a ten-year average). In addition to these standards, the directive established analysis and record keeping guidelines for the treatment and use of sewage sludge (IRPTC/UNEP, 1990).

Standards for Environmental Media and Point Source Controls

Several policies have been established within the European Community to protect shellfish areas, ground and surface waters, and bathing waters. In order to support shellfish communities, the European Community has designated (as necessary) coastal and brackish waters for protection and improvement (79/923/EEC). Beginning in 1981, Member States were asked to implement pollution reduction programmes within six years to protect these areas from lead as well as other heavy metal pollutants. The directive was written to support shellfish communities rather than bolster human consumption of shellfish (IRPTC/UNEP, 1990).

The European Community initiated efforts to protect exploitable ground water supplies in

1982 (80/68/EEC). At this time, inventory and surveillance measures were established to assess the extent of direct and indirect discharge of heavy metal pollutants into underground water sources (IRPTC/UNEP, 1990). Effective in January of 1988, these measures were extended to include inland, surface, territorial, and coastal waters (76/464/EEC) (IRPTC/UNEP, 1990). Direct discharge methods and other disposal methods that may lead to indirect discharges are subject to the authorization of the European Community. Pollution reduction programmes are also encouraged to co-ordinate the authorization process as well as the development of alternative control options (von Moltke, 1987).

The quality of bathing water (76/160/EEC) is specifically designated to be raised or maintained over time for both health and amenity benefits. Several parameters, including lead concentrations in water, are used to determine the quality of the water. The European Commission has also adopted measures to specifically protect the Mediterranean Sea from ocean dumping (von Moltke, 1987). Programmes to coordinate ocean dumping prevention and assessment were initiated in 1977 after the Barcelona Convention. Other additional policy measures have been proposed to restrict ocean dumping of lead by requiring permits on a case by case basis (von Moltke, 1987).

Beginning in December of 1987, the limit for ambient air concentrations of lead in air (expressed as an annual average mean concentration) was set at 2 $\mu g/m^3$ (82/884/EEC) (von Moltke, 1987). Member States that anticipate exceeding this level are required to notify the Commission and must implement measures to ensure no repeat exceedences.

In 1982, the European Community encouraged the exchange of air monitoring data within the community (82/459/EEC) (von Moltke, 1987). By doing so, the community established a framework for comprehensive ambient air monitoring efforts. Beginning in June of 1987, the information exchange was formalized and plants that emitted high levels of pollutants, including lead, were required to use the best available technology (BAT), except in cases where costs were prohibitively excessive (84/360/EEC) (von Moltke, 1987).

The burning and refining of used oil contributes markedly to ambient air pollution. Recognizing this source of air pollution, the European Community has taken measures to encourage the safe collection and disposal of waste oil. Beginning in 1990, the discharge of waste oils to water and drainage systems, deposit or discharge to soil, uncontrolled discharge of residues from processing, or any processing which causes high air pollution levels is prohibited (75/439/EEC) (von Moltke, 1987, IRPTC/UNEP, 1990).

The use of chemicals in agricultural production may contribute to groundwater pollution, as well as ecological and human health risks. The European Community has established a committee to set maximum permissible levels for heavy metals (including lead) in fertilizer products (76/116/EEC) (von Moltke, 1987). To date, however, no standards have been set.

The European Community has also taken initiatives to control the storage, treatment, and disposal of toxic and dangerous waste. To produce or hold these wastes requires a permit within the European Community; whereas, the storage, treatment, and deposit of these wastes must be authorized (78/319/EEC). Beginning in 1987, the European Community agreed to conform to the standards set forth by the UN Economic Commission for Europe. These standards include labeling, contractual, and safety requirements (85/469/EEC) (IRPTC/UNEP 1990; ILZSG, 1989a).

The European Commission has set feed standards to limit the exposure of livestock to lead. Maximum allowable lead contents were established for several products: straight feeding stuffs (10 mg/kg); complete feeding stuffs (5 mg/kg); complementary feeding stuffs (10 mg/kg);

mineral feeding stuffs (30 mg/kg); and certain specified feeding stuffs (5 to 40 mg/kg) (IRPTC/UNEP, 1990).

Lead in Products

To prevent product standards from hindering free trade, the European Community has taken steps to harmonize much of the quality standards and labeling standards for consumer products. As of 1988, the marketing of cosmetic products containing lead was prohibited (with the exception of capillary products containing lead acetate) (76/768/EEC) (IRPTC/UNEP 1990). Beginning in 1987, no more than 20 mg/kg lead may be contained in colouring matters and not more than 10 mg/kg lead in antioxidants and emulsifiers used for food (IRPTC/UNEP 1990). The maximum leaching rate for ceramic articles that can be filled is 4 mg/l; for ceramic cookware the maximum leaching rate is 1.5 mg/l. In addition to these standards, there is a proposal to restrict the maximum bioavailability resulting from children's use of toys to 0.7 µg for lead (von Moltke, 1987).

Recycling

A 1991 directive on batteries and accumulators containing dangerous substances (91/157/EEC) requires that Member States ensure that spent batteries containing more than 0.4 per cent lead by weight are collected and disposed of under controlled conditions. Specific requirements of the directive include marking of batteries to indicate metal content and need for separate collection, design of electrical appliances to enable ready removal of batteries, and the organization of separate collection systems including, if necessary, the use of economic instruments such as deposit systems to encourage recycling.

Education/Labelling

Beginning in June of 1988, paints, varnishes, printing inks, varnishes, and similar products that have one per cent weight associated with heavy metals (including lead), must be classified, packaged, and labelled according to European Commission standards (77/728/EEC) (IRPTC/UNEP, 1990, von Moltke, 1987).

Occupational Standards

Beginning in December of 1983, the European Community designated 14 measures to control occupational exposure to lead. These measures provided the basis for industrial programmes, requiring medical surveillance and providing workers with open access to medical results and knowledge of potential dangers in the workplace (80/1107/EEC) (IRPTC/UNEP, 1990; von Moltke, 1987). In 1986, the European Community supplemented these basic measures with monitoring and analysis techniques, concentration limits for air (0.15 mg/m^3) and blood lead (70 µg/dl), and action levels for air (40 µg/m^3) and blood lead (40 µg/dl) (82/605/EEC) (ILZSG, 1989a; von Moltke, 1987).

INDUSTRY RISK REDUCTION INITIATIVES

The international non-ferrous metals producing industry has effected a variety of initiatives which can be considered lead "risk reduction" measures. Summaries of these activities are provided in this section. These initiatives generally fall into one of several categories, as follows: 1) changes in processing technology and/or emission controls; 2) implementation of medical surveillance and occupational hygiene programmes for exposed workers; 3) support of research to validate the effectiveness of existing occupational and general population exposure limits and to develop new monitoring procedures for insuring human and environmental health; and 4) implementation of product stewardship programmes to inform downstream users of lead of the precautions which should be exercised so as to protect the health of employees and consumers.

The information presented in this overview was, in large part, collected via a questionnaire administered to the international industry by the International Lead Zinc Research Organization in early 1992. Respondents to the questionnaire included corporations whose lead production capacities comprise a significant proportion of both annual global production and production in OECD Member countries. Responses to this questionnaire were not received from all lead producing industries. As a result, the information presented must be viewed as a qualitative overview that is likely to be incomplete in some areas. Similarly, risk reduction measures implemented by the industry show evidence of geographic variation that is reflective of regional differences in the perception of relative risk associated with lead exposure. The nature and extent of risk reduction activity by industry in individual countries is, thus, variable. The following summary attempts to depict industry risk reduction efforts that have been effected throughout most of the industry in OECD Member countries. Efforts unique to a specific geographic region or country are noted as such.

Changes in Processing Technology

A broad variety of processing changes have been implemented at mining/smelting operations, resulting in a net reduction in the emission of lead to the environment. Many of these changes reflect the natural evolution of processing technology towards more efficient and inherently less polluting methods. Some changes have been made in response to regulatory agencies, others through voluntary emission reduction initiatives. This overview will summarize the nature and costs of the changes which have been effected over the past 20 years and will focus upon production facilities whose primary product is lead. However, it should be recognized that co-production of metals is the norm in the nonferrous metals industry and that lead is often a significant "by-product" of the production of other metals. Technological advancements have also produced emission reductions from facilities that co-produce significant quantities of lead (for example, zinc or copper production facilities), but the information received was not adequate to discuss these facilities in detail.

The costs associated with various risk reduction measures are difficult to ascertain with accuracy. Where feasible, cost estimates are provided in US$ to provide a bench-mark measure of industry activity in specific areas. However, these cost estimates must be viewed with recognition of the limitations of the varied data base from which they have been drawn. Risk reduction initiatives have been implemented over time and in different regions of the globe. Adjustments for inflation and changing currency exchange rates are problematic in general. Questionnaire responses indicate that international expenditures for risk reduction activities comprise 15 to 25 per cent of the annual operating costs of a typical primary or secondary lead production facility. Analysis of regulatory compliance costs in the United States by the US Bureau

of Mines reinforces this estimate (Bureau of Mines, 1987a,b; 1988). Approximately 40 per cent of capital costs associated with the construction of new facilities were estimated to be for purposes of risk reduction.

Reduction of fugitive dust emissions from concentrates to be used by smelters has been commonplace throughout the international industry. Upgrading or replacement of systems for concentrate storage and/or transport has been implemented at multiple facilities. Costs associated with such capital improvements are variable, but have typically been on the order of $2 to 10 million per production facility. Windborne migration at many facilities is further limited by intensive on-site water sprinkling programmes.

Lead emissions during the smelting process have been reduced by a variety of measures. Upgrading of existing facilities, or replacement with new smelting technologies, has been commonplace throughout OECD Member countries. Although the adoption of more sophisticated and efficient smelting technologies is not entirely for the specific purpose of emission reduction, such objectives are generally a significant part of the justification for such changes.

Specific measures to limit airborne emissions during smelting have been implemented throughout the industry. Technology for reducing the lead content of exhaust gases has been evolving and industry adoption of newer methods is widespread. Replacement of scrubbers and other methods of fume collection by high-efficiency electrostatic and bag filters had been implemented, or is ongoing, in multiple sectors of the international industry. Incorporation of more sophisticated emission control systems on ancillary systems (for example, electrostatic precipitators on acid plants) have also reduced lead emissions. Costs for the installation of such emission control systems are highly variable and dependent upon the nature and scale of the facility.

Technology for the reduction of lead in wastewater has been evolving similarly. Water purification plants and upgraded sewer systems have been installed at many lead production facilities at costs that range up to $20 million per facility.

Solid waste materials produced by smelters are disposed of in accordance with regional regulatory requirements. The volume of waste generated, and/or its lead content, has generally evidenced a steady decline. At least two factors contribute to this trend. The advent of more sophisticated smelting technologies has improved the efficiency with which lead is extracted from concentrates. Improved process efficiency also permits production facilities to divert significant volumes of formerly discarded waste material back into the lead smelting process.

The preceding control efforts have had a significant impact upon lead emissions from smelting facilities. Based upon industry data, atmospheric emissions of lead over the past 20 years have typically been reduced by up to 90 per cent. Much of this reduction has been achieved over the past five to ten years. Discharges of lead in water have evidenced similar declines, with much of this similarly occurring over the past five to ten years. Large lead production facilities reported cumulative expenditures of up to $100 million each to achieve these reductions.

Several large lead production facilities maintain monitoring programmes which permit some assessment of the impact of emission control efforts upon surrounding human populations and the environment. Voluntary blood lead monitoring programmes have been established in the vicinity of several smelters within the past five to ten years. Declines in children's blood lead levels, ranging from 25 to 65 per cent, have been reported. These declines must be interpreted within the context of overall declines in general population blood lead levels evident throughout much of the OECD membership, but do provide evidence that emission control systems have significantly

reduced the lead exposure of nearby residents. Only very limited monitoring of biota in the vicinity of smelters was reported, but appear to evidence a similar trend (for example, 50 per cent decline in the lead content of marine organisms).

As more sophisticated technologies for ore processing and emissions control are developed, the discharge of lead into the environment by the producing sectors of the industry should evidence further declines. In addition, the major lead producing companies in the United States have announced their intention to participate in the voluntary "33-50" pollution reduction initiative announced by the United States government. These companies will actively work to achieve an additional 33 per cent reduction in emissions by 1992, and a target of 50 per cent reduction by 1995.

Implementation of Medical Surveillance and Occupational Hygiene Programmes

In accordance with regional regulatory guidelines, most of the international lead industry maintains rigorous medical surveillance programmes for the monitoring of occupational exposures to lead. Regional differences with respect to these guidelines are apparent. Medical removal levels for lead workers will typically range between 50 and 80 µg/dl of blood lead. Standards for occupational exposure to airborne lead also vary among OECD countries, with 50, 100 and 150 $\mu g/m^3$ all being specified in national regulations or legislation.

Over the past five years, industries in several geographic regions of the OECD membership have made significant voluntary efforts to improve occupational hygiene practices and to reduce average blood lead levels. Engineering controls backed by personal hygiene and other protective programmes are employed by lead producing and consuming industries to minimize worker exposure, and, in areas where exposure limits cannot otherwise be met, personal respirators are employed. Correlations between lead in air and lead in blood are generally poor, with good personal hygiene widely regarded as the most significant factor in limiting exposure. This factor also serves to minimize the transport of lead particles into the home.

The cost of such voluntary efforts, which set in-plant goals to lower worker exposure, are difficult to estimate. However, the implementation of such programmes has resulted in significant reductions in blood lead levels in the industry. The general lead industry in OECD Member countries reports reductions of the average employee blood lead level of approximately 30 to 40 per cent over the past 20 years. As a reflection of this, the number of individuals exceeding the various regional medical removal standards has fallen dramatically. Typically, a facility employing 1,000-2,000 employees may experience only a few medical removal cases per year. This represents an approximate 90 per cent decline in the frequency of medical removal actions.

Research Support

The international industry funds significant environmental health research programmes through the International Lead Zinc Research Organization (ILZRO). Annual ILZRO expenditures for the conduct of lead health-related research will typically range between $400,000 and $600,000. Many of these programmes are oriented towards the assessment of the adequacy of existing medical removal standards or elucidation of any health effects which might be observed at current occupational blood lead levels. Substantive efforts are also being made to develop new technologies and biomarkers for the monitoring of worker health. Finally, multiple research programmes have been implemented to investigate the effect of lead exposure upon the general population and the environment. Many of these research programmes are conducted in

cooperation with, and frequently with co-sponsorship by, regional regulatory bodies. Thus, cooperative research programmes with funding entities such as the EC or US EPA has been occurring with increasing frequency.

Research sponsorship by a variety of regional organizations has also become increasingly commonplace. In addition, the international industry has encouraged worker participation in a broad variety of independent research efforts seeking to more accurately define the effects of lead exposure. Recent studies conducted in North America, the EC and Northern Europe provide good examples of such interactions.

Product Stewardship Initiatives

Regional industry trade associations have been implementing product stewardship programmes so as to advise downstream users of lead, as well as consumers, of the potential hazards associated with lead exposure. These activities are highly varied in both nature and scope and are probably best described by example.

The Lead Industries Association of the United States (LIA), for instance, has been active in the production and distribution of training materials designed to acquaint downstream users of lead of the precautions which should be observed in the occupational environment. This effort has included an annual Health Conference for Physicians and Allied Health Professionals designed to acquaint health professionals with the medical issues associated with lead exposure. LIA has also encouraged monitoring programmes to survey the blood lead levels of children and other at-risk individuals residing in the vicinity of primary and secondary smelters and promoted the adoption of voluntary in-plant goals to lower worker lead exposures to below regulatory limits. In an effort to enhance lead recycling by the small industry user, LIA has also developed and circulated a lead recycling directory which identifies specific locations in North America which will accept certain types of lead scrap. Finally, LIA has undertaken the organization of research efforts to assess the exposure risk to the general population posed by specific product applications.

The activities of organizations such as LIA have been complemented by the actions of specific user groups such as the Battery Council International (BCI). As an organization representing the interests of the automotive and industrial lead-acid battery manufacturers, BCI has successfully undertaken the development of initiatives to encourage the recycling of batteries. Model legislation developed by BCI to help further this goal has been adopted by a number of regions in the United States.

The European Federation of Capsule Manufacturers (EUCAPA) agreed in June 1990 to stop the production of lead containing capsules for over corking wine bottles.

Paint producers and can manufacturers in some OECD countries have voluntarily agreed to phase out the use of lead in high risk applications (for example, food cans, residential paints).

Finally, the international industry has recently formed the International Council on Metals in the Environment (ICME). The members of this organization are associated with the production of numerous non-ferrous metals, including lead. ICME is in the process of developing guidelines designed to facilitate international efforts to insure the safe use of metals, such as lead, by multiple sectors of industry.

APPENDIX A (CHAPTER 5)

LEAD RISK REDUCTION ACTIVITIES: SUMMARY TABLES

*Proposed or planned actions are **in bold**.*

ENVIRONMENTAL MEDIA Source: Drinking Water (Pipes)	
Country	**Actions**
Australia	NH & MRC recommends maximum lead concentration in water for domestic requirements 0.05 mg/l (legal in ACT and WA); in ACT, maximum lead concentration in raw water supply 0.05 mg/l
Austria	maximum permissible lead concentration 0.05 mg/l (guideline value)
Belgium	
Canada	maximum lead concentration in drinking water 10 µg/l; new plumbing code permits maximum 0.2% lead content for solder that contacts potable water; brass fittings to be limited to 8% lead content
Finland	maximum permissible lead concentration in drinking water is 0.05 mg/l; the use of lead-containing pipes is forbidden in drinking water systems
Denmark	
France	maximum lead concentration in drinking water is 50 µg/l
Germany	leaded pipes are no longer being installed in new piping systems and are gradually being replaced in existing installations; maximum lead concentration in drinking water at the mains connection is 0.04 mg/l; if the lead concentration exceeds 0.04 mg/l at the tap, the house owner or landlord must replace the piping on request; copper pipes for drinking water supply systems have to be soldered with lead-free alloys (SnCu, SnAg)
Greece	
Iceland	no data available
Ireland	Ireland adheres to the EC's maximum lead concentration in drinking water of 0.05 mg/l; lead piping is gradually being removed in response to public awareness campaigns
Italy	
Japan	maximum permissible lead concentration in drinking water is 0.1 mg/l; **the value will be revised to 0.05 mg/l in December 1993**
Luxembourg	
Netherlands	the EC standard of 0.05 mg/l has been enacted in Dutch legislation; lead service lines are removed whenever repairs are made; however, there are no incentives for removing old lead pipes
New Zealand	guideline value of 0.05 mg/l; the standard is proposed to be reviewed in 1993 to align with the new WHO Guidelines
Norway	drinking water is considered unsuitable when the lead concentration is over 0.02 mg/l; good drinking water shall contain less that 0.005 mg/l
Portugal	
Spain	the Bureau of Standards specifications recommend a limit of 0.05 mg/l but allow 0.1 mg/l; **under the Health Act, 0.1 mg/l will become a legal limit**
Sweden	drinking water is considered unsuitable when the lead concentration reaches 0.05 mg/l; installations that are in contact with drinking water must be made of materials that leach less than 0.05 mg/l; water pipes are not made out of lead
Switzerland	maximum allowable level of lead in drinking water is 0.05 mg/l; the use of lead-containing pipes or tubes is prohibited
Turkey	no data available

ENVIRONMENTAL MEDIA Source: Drinking Water (Pipes) continued	
Country	**Actions**
United Kingdom	the maximum concentration of lead in drinking water at the point of supply is 50 µg/l; regulations also require water companies to install further treatment where there is a risk of the standard being exceeded at the customer's tap; water companies are required to replace their lead communication pipe where requested to do so by a customer who has replaced his lead supply line to the kitchen tap; some discretionary grants made available to customers for repair and replacement
United States	effective December of 1992, the 90th percentile measurement of a sampling of tap water may not exceed the lead action level of 15 µg/l; if the sampled tap water exceeds the lead action level, then the water systems will be required to optimize corrosion control and take other measures until the 90th percentile measurement falls below the lead action level (6/7/91 56 FR 26460); until the effective date of the new rule, the 1975 standard for water of 0.05 mg/l remains effective; future regulations for solder and brass fittings contemplated
European Community	maximum allowable level of lead in drinking water is 0.05 mg/l
Mexico	drinking water and its sources must not exceed 0.05 mg/l lead

ENVIRONMENTAL MEDIA Source: Surface Waters	
Country	**Actions**
Australia	limits for Victoria: FRESH WATER: 0.03 mg/l; MARINE WATER: 0.05 mg/l
Austria	surface water quality is improved by limitation of industrial emissions to 0.5 mg/l; bathing water is also monitored
Belgium	
Canada	FRESHWATER: maximum permissible lead content 0.001 to 0.007 mg/l; IRRIGATION: 0.2 mg/l; LIVESTOCK WATERING: 0.1 mg/l
Denmark	
Finland	
France	surface waters that are used for the production of drinking water are limited to 50 µg/l of lead except in exceptional circumstances after the advice of the Conseil supérieur d'hygiène publique
Germany	EC limit value is used: <0.05 mg/l
Greece	
Iceland	no data available
Ireland	SEA WATER: 0.1 mg/l; FRESH WATER: 0.05 mg/l (recommendation)
Italy	
Japan	surface water: 0.1 mg/l; value revised to 0.01 mg/l as of March 1993
Luxembourg	
Netherlands	
New Zealand	
Norway	no guidelines are presented; the observed values are low
Portugal	
Spain	PROTECTED WATERWAYS: 0.1 mg/l; CONTROLLED WATERWAYS: 0.5 mg/l
Sweden	
Switzerland	Quality Standard: 0.05 mg/l
Turkey	no data available
United Kingdom	guided by Environmental Quality Standards
United States	FRESH WATER: varies by water hardness; most stringent standards: maximum 4-day average of 1.3 µg/l and maximum 1-hour average of 3.4 µg/l; SALT WATER: maximum average concentration of 5.6 µg/l, not to be exceeded more than once over a 3-day period
European Community	MARINE WATER QUALITY: Member States are to establish pollution reduction programs such that within six years of designation the waters conform with values set by Member States for the protection of shellfish and their larvae; SURFACE WATER QUALITY: pollution reduction programmes encouraged for dischargers that threaten the quality of surface waters; BATHING WATER QUALITY: is also monitored
Mexico	SALTWATER: lead concentration must not exceed 0.006 mg/l more than once over a 3-year period; WATER FOR AGRICULTURAL IRRIGATION must not exceed 5.0 mg/l lead; DRINKING WATER for livestock must not exceed 0.1 mg/l lead

ENVIRONMENTAL MEDIA Source: Ambient Air	
Country	**Actions**
Australia	recommended criteria set at 1.5 ug/m^3, averaged over 3 continuous months; adopted as legal limit in Victoria, ACT, and Tasmania
Austria	ambient air quality (lead content) is influenced by regulations for gasoline lead content and emissions of air from point sources
Belgium	the lead concentration in the general atmosphere, annually averaged, must not exceed 2.0 ug/m^3
Canada	
Denmark	2.0 ug/m^3 annual average (EC directive)
Finland	
France	Air Quality Criteria is 2 ug/m^3, annual average value (EC directive)
Germany	maximum lead concentration in the general atmosphere 2.0 ug/m^3 (annual mean); the maximum lead deposition rate from air onto soil is 0.25 mg/m^2 per day
Greece	
Iceland	no data available
Ireland	Ireland adheres to the EC's limit on maximum lead levels in ambient air of 2 ug/m^3
Italy	maximum concentration of lead in the atmosphere is 2.0 ug/m^3, as mandated by the EC directive
Japan	
Luxembourg	
Netherlands	Air Quality Guideline: lead concentration not to exceed 2.0 ug/m^3 (24-hour average)
New Zealand	New Zealand has proposed a national ambient air quality guideline of 1.0 µg/m^3 for an average time of 3-month moving average
Norway	no guidelines are presented; the observed values are low, and decreasing
Portugal	
Spain	maximum lead concentration in the general atmosphere 2.0 ug/m^3 by Royal Decree
Sweden	
Switzerland	maximum permissible lead concentrations (annual averages): suspended dust: 1 µg/m^3, redeposition: 100 µg/m^2 per day
Turkey	no data available
United Kingdom	UK adheres to the EC directive which limits lead in air to 2.0 µg/m^3, mean annual concentration
United States	maximum permissable lead concentration: 1.5 µg/m^3 (quarterly average); more stringent standard being considered
European Community	maximum permissible lead concentration 2 µg/m^3 (annual average mean concentration)
Mexico	

ENVIRONMENTAL MEDIA Source: Soil	
Country	**Actions**
Australia	
Austria	limit for agriculture is 100 mg/kg soil; an Austrian ordinance defines a limit for the lead input of dust deposited in woodland to 2.5 kg/ha per year
Belgium	
Canada	contaminated sites: criteria for assessment, 25 µg/g; for remediation, 375 µg/g for agricultural land, 500 µg/g for residential, 1000 µg/g commercial
Denmark	
Finland	
France	the heavy metal content, including lead, in fertilizers has been assessed as part of a strategy to reduce heavy metals in fertilizers and soil
Germany	many German states have limited the lead concentration in the soil at children's playgrounds to 200 mg/kg; in Northrhine-Westphalia playground (sandbox) sand is limited to 20 mg Pb/kg
Greece	
Iceland	no data available
Ireland	
Italy	
Japan	limit: 0.1 mg/l by leach test - test liquid is prepared by mixing and shaking the soil sample with 10 times as much water as the weight of the sample
Luxembourg	
Netherlands	
New Zealand	
Norway	no guidelines are presented, but criteria in the "Dutch list" for contaminated land are used (50-600 mg/kg dry soil)
Portugal	
Spain	
Sweden	
Switzerland	total lead limited to 50 mg/kg; soluble lead to 1 mg/kg
Turkey	no data available
United Kingdom	500 mg/kg domestic, 2000 mg/kg recreational
United States	the EPA adopted an interim guidence on 12/3/89 stating that soil cleanup activities at CERCLA sites where the current or predicted land use is residential should take place when the soil lead levels exceed 500 to 1000 ppm; if leachate from soil contains > 5 mg/l, lead, soil is subject to RCRA and/or CERCLA actions (remediations and restricted disposals)
European Community	maximum permissible lead concentration in soil to receive sewage sludge 50 to 300 mg/kg (depending on pH); the limit on sewage sludge applied to agricultural soils is 15 kg of lead/ha/yr (based on 10-year average)
Mexico	

ENVIRONMENTAL SOURCES Source: Air Point Sources	
Country	**Actions**
Australia	individual states set technology requirements and air quality standards for smelters and processing facilities; most standards set at 10 mg/m^3; ACT limit for municipal combustors 10 µg/m^3
Austria	guideline for lead emissions from smelters and other non-ferrous metallurgical processes is 10 mg/m^3; other industrial emissions have an upper limit for dust containing inorganic substances set at 5 mg Pb/m^3, for emissions exceeding 25 g dust/hour; according to the Austrian Steam Boiler Act, the sum of lead, tin and chromium including their compounds in boiler plant emissions is limited to 2-5 mg/m^3, depending on the magnitude of the combuster
Belgium	no general standard, limits set individually for different plants but typically 20 mg/m^3
Canada	secondary smelters: particulate emissions limited from 23 mg/m^3 to 46 mg/m^3 depending on the operation; other operations are limited by provinces on the order of 29 mg/m^3 for smelters, and 14 to 15 mg/m^3 for refineries
Finland	provincial governments set limits for particulate emissions from individual facilities; by this means, the emissions of lead are also reduced
Denmark	limits set for individual plants
France	the sum of the concentrations of 4 heavy metals (Pb, Cr, Cu, and Mn) in the emissions from industrial waste incinerators with a nominal capacity of 1 ton of waste per hour must not exceed 5 mg/m^3; various regional authorities set limits ranging from 5 to 30 mg/m^3 for total dust emissions; local authorities define regulations for smelters on a specific basis
Germany	lead emissions from lead smelters and other non-ferrous metallurgical works are limited to 5 mg/m^3; total dust emissions, of which lead is a constituent, is limited to values between 10 and 20 mg/m^3; the lead emission from battery manufacturing sites is limited to 0.5 mg/m^3; dust emissions from waste incinerators, containing Pb, Sb, As, Cr, Co, Cu, Mn, Ni, V, Sn, Pt and Pd must not exceed 1 mg/m^3
Greece	
Iceland	no data available
Ireland	emission limits may be set by local authorities as a condition of granting planning permission
Italy	permissible lead concentrations in industrial emissions are variable depending on the location of the plant (e.g. in Lombardy region, typical standards for particulates in the air are 10 mg/m^3 and for lead in the air are 3.3 mg/m^3)
Japan	roasting furnace, convertor, smelting furnace, and drying furnace used for refining lead etc.: 10 mg/m^3; baking furnace and smelting furnace used for glass manufacturing: 20 mg/m^3; sintering furnace and blast furnace used for refining lead: 30 mg/m^3; stricter standards exist by Prefectural Government Ordinance
Luxembourg	
Netherlands	the 1986 Dutch Combustion Guideline defines a limit of 1.0 mg/m^3 for the combined concentration of 9 metals, including lead, in the combustion of industrial and chemical waste and household refuse; the standard is enforced by prescribing the precise types of machinery to be used in relation to the type of waste being incinerated
New Zealand	
Norway	individual discharge permits issued for each plant, normally 5 mg/m^3
Portugal	
Spain	lead in industrial emissions varies depending on the size and date of construction of the plant - for plants emitting less than 300 m^3/min limits are 120, 100, and 80 mg/m^3 for those built before 1975, between 1975 and 1980, and since 1980 respectively; for plants emitting more than 300 m^3/min, the corresponding limits are 20, 15, 10 mg/m^3; ground level emissions are also limited to 50 g/m^3 (30-minute maximum) or 10 g/m^3 (8-hour maximum)

ENVIRONMENTAL SOURCES Source: Air Point Sources (continued)	
Country	**Actions**
Sweden	no national standard exists; however, under the Environmental Protection Act, lead-containing gases should be appropriately collected and controlled by fabric filters; standards vary by facility and according to Best Available Technologies (BAT)
Switzerland	general emission limit for combustors with mass flow greater than 25 g/hr: 5 mg/m^3; the maximum concentration of the sum of lead and zinc from municipal incinerators: 1 mg/m^3; redeposition limited to 100 $\mu g/m^2/day$; suspended dust limit 1 $\mu g/m^3$ (annual average)
Turkey	no data available
United Kingdom	the Best Practicable Means (BPM) must be used to treat/control industrial emissions; the normal limit for lead is 0.002 g/m^3 and 0.01 g/m^3 in cases of special difficulty; total particulates must not exceed 0.1 g/m^3
United States	emissions standard determined for individual plants by State authorities responsible for implementation of Federal ambient air quality standards; various lead smelting and processing facilities are required to use the best practicable and/or available control technology
European Community	licensing of lead polluting industrial facilities is required; Best Available Technology (BAT) is also required
Mexico	lead emissions from lead smelters and other non-ferrous metallurgical works are limited to 5 mg/m^3; total dust emissions, of which lead is a constituent, are limited to values between 10 and 20 mg/m^3; lead emissions from battery manufacturing sites are limited to 0.5 mg/m^3; dust emissions from waste incinerators, containing Pb, Sb, As, Cr, Co, Cu, Mn, Ni, V, and Sn, must not exceed 1 mg/m^3

ENVIRONMENTAL SOURCES Source: Water Point Sources	
Country	**Actions**
Australia	industrial effluents variable, typically 0.05 mg/l; ocean 1.0 mg/l; 0.008 to 0.2 mg/l for estuaries
Austria	lead in industrial effluents limited to 0.5 mg/l; **proposed: 0.5 mg/l metallic surface coating plants and leachate; 0.05 mg/l for textile finishing plants**
Belgium	limits vary according to nature of plant and receiving water - typically 0.05 to 3.0 mg/l
Canada	for all operations opening or increasing production after 1977: MINES, lead concentration in effluents 0.2 mg/l (monthly average) and 0.4 mg/l (single maximum); METAL FINISHING, lead concentration in effluents 1.5 mg/l; for pre-1977 mines, 1.5 mg/l of lead in effluents is a guideline
Finland	emission limits are set on a case by case basis during the environmental permit procedures
Denmark	limits vary from 0.1 to 0.5 mg/l, according to the nature of the receiving water
France	lead concentrations in industrial effluents (from incineration facilities for urban waste) is limited to 1.0 mg/l of lead (before discharge) and is governed by regional authorities; discharges to groundwater of wastes containing lead from hazardous waste installations has been prohibited
Germany	for direct discharges, limits vary from 0.3 to 2.0 mg/l according to the type of plant; the recommendation for discharge into municipal water treatment systems in several Federal states is 0.2 mg/l; effluents from non-ferrous metals plants, mills, foundries and electroplating plants is 0.5 mg/l
Greece	
Iceland	no data available
Ireland	
Italy	maximum concentration of lead in industrial effluents discharged to sewers is 0.3 mg/l and discharged directly to surface waters is 0.2 mg/l
Japan	lead in industrial effluents limited to 1.0 mg/l by a national law **(revision of this value is currently being considered)**; standards vary from 0.1 to 0.8 mg/l by Perfectual Governmental Ordinance
Luxembourg	
Netherlands	lead in industrial effluents varies according to the nature and location of plant and nature of receiving water; for plating and comparable industries the recommended limit is 3.0 mg/l
New Zealand	no data available
Norway	individual discharge permits issued for each plant, normally between 0.5-1.0 mg/l
Portugal	
Spain	industrial effluents discharged into rivers, lakes, etc. are limited to 0.5 mg/l; industrial effluents discharged into the sea from the land, through submarine outlets: 50% of the samples must be less than 7.5 mg/l and not more than 10% may exceed 15 mg/l
Sweden	no national emission limits exist, but water containing heavy metals including lead should be treated; limits vary by facility and according to Best Available Technologies (BAT)
Switzerland	effluent limited to 0.5 mg/l
Turkey	no data available

ENVIRONMENTAL SOURCES Source: Water Point Sources (continued)	
Country	**Actions**
United Kingdom	permissible lead concentration varies according to the location of the plant and nature of the receiving water - typically 1.0 to 5.0 mg/l
United States	INDUSTRIAL EFFLUENTS: primary and secondary smelters: 0.13 mg/l monthly maximum, 0.28 mg/l daily maximum; battery manufacturers: 0.20 mg/l; monthly maximum, 0.42 mg/l daily maximum; lead oxide plants: zero discharge standard; industry-specific guidelines for over 20 industries
European Community	**proposal to restrict ocean dumping of lead-containing products**
Mexico	daily lead concentration averages: metallic industry effluents 0.1 mg/l; copper industry effluents: 1.0 mg/l; automobile maintenance, gas stations, dry cleaning, and photography developing, water effluents: 1.0 mg/l; urban and municipal wastewater used for agricultural irrigation: 0.50 mg/l

ENVIRONMENTAL SOURCES Source: Sewage Sludge	
Country	**Actions**
Australia	
Austria	Austrian states have different regulations for lead content in sewage sludge; upper limit for agricultural use is between 100 and 500 mg Pb/kg dry substance
Belgium	
Canada	
Finland	guidelines for lead content in sewage sludge used on agricultural land: lead content of sludge 150 mg/kg d.w., distribution of lead through sludge on agricultural soils 150 g/ha per year
Denmark	
France	spreading of sewage sludge must not occur if the lead content exceeds 800 ppm
Germany	the use of sewage sludge for agricultural purposes is legally restricted if its lead content exceeds 900 mg/kg; agricultural soils with a lead content greater than or equal to 100 mg/kg may not be treated with any sewage sludge
Greece	
Iceland	no data available
Ireland	
Italy	
Japan	
Luxembourg	
Netherlands	
New Zealand	recommended limits for lead in sewage sludge intended for application to arable land are: a maximum acceptable concentration in dry sewage sludge of 600 mg/kg, a limit value allowable in soil of 300 mg/kg, and a maximum cumulative loading of 125 kg/ha.
Norway	sewage sludge limited to 300 g lead tonne dry weight; future regulations for sewage limit 100 g lead tonne dry weight for agricultural use and limit 300 g lead/tonne dry weight for other uses
Portugal	
Spain	
Sweden	
Switzerland	for spreading in agriculture, lead content limited to 500 mg Pb/kg
Turkey	no data available
United Kingdom	regulations cover lead content of soils receiving sludge as well as controls on application of sludge containing lead
United States	proposed regulations for use and disposal of sewage sludge containing lead; for land application, cumulative lead loading of lead limited (2/6/89 54 FR 5380)
European Community	maximum concentration of lead in sewage sludge 750-1200 mg/kg
Mexico	

ENVIRONMENTAL SOURCES Source: Lead-Containing Wastes	
Country	**Actions**
Australia	
Austria	limit of emissions of lead+zinc+chromium+their compounds caused by combustion of waste oils in power stations is 4 mg/m^3; products containing toxic metals are defined as hazardous after their lifetime; handling and reporting of hazardous waste is also regulated
Belgium	
Canada	
Finland	classified as hazardous wastes
Denmark	
France	
Germany	disposal covered by Waste Disposal Law
Greece	
Iceland	no data available
Ireland	
Italy	
Japan	
Luxembourg	
Netherlands	
New Zealand	
Norway	defined as hazardous waste and required to be delivered to an approved collector/recipient under the system for dealing with hazardous waste
Portugal	
Spain	
Sweden	
Switzerland	disposal limits for solid wastes
Turkey	no data available
United Kingdom	consignment and transport disposal requirements for lead-containing wastes
United States	certain solid wastes containing lead listed as hazardous under RCRA; others are characteristic waste if leachate from the waste contains lead in concentrations greater than 5 mg/l; hazardous wastes subject to strict handling and disposal requirements
European Community	production or storage of lead-containing wastes requires permit; safety and labeling requirements must be met by all handlers
Mexico	any substance that contains greater than 5.0 mg/l lead is classified as a hazardous waste

ENVIRONMENTAL SOURCES Source: Dust	
Country	**Actions**
Australia	
Austria	
Belgium	
Canada	
Denmark	
Finland	
France	
Germany	maximum lead concentration of 0.50 g/kg in dust on materials transported or stored by industry; lead paint removal operations on steel bridges have to take place under effective emission control measures
Greece	
Iceland	no data available
Ireland	
Italy	
Japan	
Luxembourg	
Netherlands	
New Zealand	
Norway	individual discharge permits issued for each plant, normally 50 mg/m^3
Portugal	
Spain	
Sweden	
Switzerland	the suspended particulate standard for lead in dust is 1 $\mu g/m^3$
Turkey	no data available
United Kingdom	
United States	HUD Interim Guidelines set clearance levels in household dust: 200 µg/sq. ft. on floors, 500 µg/sq. ft. on window sills, 800 µg/sq. ft. on window wells (HUD, 1990)
European Community	
Mexico	

ENVIRONMENTAL SOURCES
Source: Foodstuffs or Feed

Country	Actions
Australia	maximum permissible lead concentration varies by food type: beverages and other liquid foods = 0.2 mg/kg; bran = 2.5 mg/kg; fish in tinplate containers = 2.5 mg/kg; fruit juices and fruit juice drinks = 0.5 mg/kg; infants' foods in other than tinplate = 0.3 mg/kg; infants' foods in tinplate containers = a mean level of 0.3 mg/kg in 10 samples with no one sample exceeding 0.8 mg/kg; meat in tinplate containers = 2.5 mg/kg; milk, condensed milks and liquid milk products in tinplate containers = 0.3 mg/kg; molluscs = 2.5 mg/kg; tomato products in tinplate containers = 2.5 mg/kg; vegetables = 2.0 mg/kg; wheat germ = 2.5 mg/kg; all other foods = 1.5 mg/kg; food additives not otherwise listed = 10 mg/kg
Austria	limits for different food range between 0.1 and 0.8 mg/kg, in most cases (e.g. limits for wheat, meat and vegetables range between 0.25 and 0.5 mg/kg - guideline levels); feed is not regulated; however, the plan is to adopt relevant EC regulations.
Belgium	
Canada	0.2 ppm fruit juice, cider, wine, water in sealed containers (other than mineral water); 10 ppm edible bone meal; 0.15 ppm evaporated and concentrated milk and concentrated infant formula; 0.5 ppm fish protein; 0.08 ppm ready-to-serve infant formula; 1.5 ppm tomato paste and sauce; 0.5 ppm whole tomatoes (all listed levels are food tolerances)
Finland	food safety standard: the maximum lead content in fruits and vegetables is 0.3 mg/kg, in drinks 0.3 mg/kg and in canned foods 1.0 mg/kg. Maximum lead content (0.02-0.5 mg/kg) have been proposed for several other foodstuffs
Denmark	
France	
Germany	maximum permissible lead concentration in: wine, 0.3 mg/l; beer, 0.2 mg/l; milk, 0.03 mg/l; meat and eggs, 0.25 mg/kg; liver, 0.5 mg/kg; fish, 0.5 mg/kg; leafy vegetables, 0.8 mg/kg; kale, 2.0 mg/kg; fruit, 0.5 mg/kg; animal feed, 20-40mg/kg of dry matter.
Greece	
Iceland	no data available
Ireland	
Italy	
Japan	maximum lead content for plant products ranges from 1 to 5 mg/kg
Luxembourg	
Netherlands	
New Zealand	maximum permissible proportions of lead in food products range from 0.2 to 10 parts per million.
Norway	new limits for maximum permissible lead concentration in animal feed will be 10 ppm for straight feedingstuff with the exception of yeast, grain and phosphate which will be 5, 30 and 40 ppm respectively. In foodstuff intended for human consumption, it is suggested to implement the following maximum tolerable levels: • cow's milk and substitutes for human milk: 0.02 ppm • other products intended for infants and young children: 0.05 ppm • soft drinks, including canned: 0.05 ppm • fresh and frozen meat, fish and eggs: 0.05 ppm • cereals, legumes, pulses and products thereof: 0.1 ppm • fresh and frozen fruits and vegetables: 0.3 ppm • fresh and frozen leafy and brassica vegetables: 0.3 ppm • wines and fortified wines: 0.3 ppm • liver and kidney from cattle and swine: 0.5 ppm
Portugal	
Spain	

ENVIRONMENTAL SOURCES Source: Foodstuffs or Feed (continued)	
Country	**Actions**
Sweden	Swedish food tolerance levels have recently been lowered to 0.3-0.5 mg/kg for most canned food, and to 0.02-0.5 mg/kg for various food stuffs (higher values for spices etc.)
Switzerland	Swiss tolerance or permissible levels for lead in foodstuffs are in the range 0.1-0.5 mg/kg
Turkey	no data available
United Kingdom	the standard for lead in food is 1 mg/kg; exception for baby food, where standard, is 0.2 mg/kg
United States	bottled water: 0.05 mg/l (21 CFR 103.25); table wine: 300 µg/l (FDA interim guidance); calcium supplements; 5 mg/l (voluntary industry standard); yeast: 0.2 to 0.4 mg/kg; other food additives, drugs and cosmetics: 10 to 70 mg/kg
European Community	maximum permissible lead concentration in animal feed varies with feedstuff; maximum lead concentration in colouring materials for use in foodstuffs intended for human consumption, 20 mg/kg; maximum lead content of straight feedingstuffs, 5 mg/kg; complete feedingstuffs, 10 mg/kg; complementary feedingstuffs, 10 mg/kg; mineral feedingstuffs, 30 mg/kg; and specified others 5 to 40 mg/kg
Mexico	maximum permissible lead concentrations in tomato sauce: 0.36 mg/kg; maximum permissible lead concentration in synthetic organic dyes added to foods, beverages, drugs and cosmetics: 10 ppm; maximum permissible lead concentration in vegetable shortening: 0.1 mg/kg

PRODUCTS Source: Paint	
Country	**Actions**
Australia	the use of lead-based paint is prohibited on roofs used for collecting potable water, on furniture, on dwellings other than industrial installations, on factory premises used for food preparation, processing and producing of products intended for human consumption, and on toys; the manufacture of white lead-based paint, except for its application as mirror backing paint, has been prohibited since 1960s; lead content of household building paint is restricted to 0.25% non-volatile content; lead is < 1% of the non-volatile components, requires an appropriate warning on the label
Austria	paints containing more than 0.15% lead must be properly labelled; a ban is proposed for white lead compounds (i.e. lead carbonate and lead sulphates)
Belgium	
Canada	bilingual labelling is required on all lead-based paints under Canada's Hazardous Products Act; lead paints and other liquid coatings intended for consumer use are currently limited to 0.5% by weight, unless the product is properly labelled; lead is also limited to 0.5% in coating materials applied to children's products such as furniture and toys as well as to pencils and artists' brushes; the Canadian Paint and Coatings Association (CPCA) has recommended that the Canadian paint industry stop using any lead compounds in consumer paint by the end of 1991
Finland	the use of white paint and lead sulphate has been prohibited in interior paints since 1929 (with some exceptions); the use of lead carbonates and lead sulphate is prohibited as of January 1, 1993 (except for restoration and maintenance of works of art and historical buildings)
Denmark	
France	in February of 1988, the use of white lead in works was prohibited; since February 1993, there is a total ban on sales of paints containing white lead; paints containing more than 0.15 per cent of lead in other forms have to be labelled; one criterion for attributing an eco-label to paint is that it is formulated without lead
Germany	white lead compounds ("lead white") are banned from sale; lead-based anti-corrosive paint ("red paint") is being phased out and its use is restricted to repair coatings; other lead-based pigments (lead chromates and lead molybdates) are used as colouring agents for plastics, printer's ink and lacquer for surface painting; containers for paint with more than 0.15% lead content have to be labelled "Paint contains lead; not for objects which can be reached by small children"
Greece	
Iceland	no data available
Ireland	there is a voluntary ban by industry on the use of lead in paint intended for the domestic market; lead paint in toys, pencils and graphic instruments is restricted by federal statutes; labelling is required when paints contain > 0.5% lead
Italy	
Japan	no rectrictions on the use of lead-based paint exist; however, on a voluntary basis lead-based paints are not used for toys and household painting
Luxembourg	
Netherlands	white lead and lead sulphate have been prohibited in paints for use on the inside of buildings and vessels since 1939; lead-based zinc white in paints is also prohibited; as directed by the EC, the use of lead carbonate and lead sulphate in paint, except for use in preservation, will be prohibited.
New Zealand	maximum permissible amount of lead in paint is 5000 mg/kg; the level will be reduced to 2500 mg/kg in the proposed fourth amendment of the regulations which are anticipated to be promulgated in June 1993; current regulations also specify that no person shall manufacture, import, supply, sell or use any paint, distemper, powder coating, pigment or anti-fouling composition that contains basic lead carbonate, which is also known as white lead
Norway	white lead, lead sulphate and lead carbonate have been prohibited in paints for use on the inside of buildings since 1929. Exception for these is use for preservation; containers with paint containing lead shall carry the following labelling: "Contains lead which may cause poisoning. Not to be used on objects which may be chewed or sucked by children."

PRODUCTS Source: Paint (continued)	
Country	**Actions**
Portugal	
Spain	
Sweden	white lead compounds are not used in Sweden; as of July 1990, the Swedish paint producers agreed voluntarily to discontinue the use of lead chromate in paint; there is work on-going aiming at further voluntary agreements to limit the use of lead in paint
Switzerland	the interior use of lead-containing paint is prohibited
Turkey	no data available
United Kingdom	the Paintmakers Association (who account for over 90% of the UK's production of solvent thinned alkyd paint) voluntarily agreed to ban lead additives to decorative paints and varnishes beginning in July 1987; UK restricts lead carbonates and lead sulphates in paint except for certain restoration purposes; lead in dry paint film on toys limited to 0.25% by wgt; the soluble lead content of a paint coating applied to a pencil, pen or brush is limited to 0.025% by weight; paints and varnishes containing more than 0.15% lead must be labelled
United States	in 1977 the Consumer Products Safety Commission set the standard for lead in paint at 0.06%
European Community	lead carbonates and lead sulphates may not be used in paints except for preservation work
Mexico	the maximum permissible level of lead in surface paint (used to cover toys and school articles) is 90 mg/kg; industries have agreed to eliminate the use of lead red oxide and lead basic carbonate from pigments, laquer, enamel, paint and varnish on toys, pencils, colour pencils and other school articles, printing inks, cosmetics, furniture and paints for interiors; standards have been published which describe methods for determining lead concentrations in paints and pigments, as well as surface paints; in June 1992 a technical standard addressing the labelling of paints that contain lead was published

PRODUCTS Source: Gasoline	
Country	**Actions**
Australia	concentrations of lead in leaded gas varies from 0.3 g/l in some city areas to 0.84 g/l in country areas; unleaded gas limited to 0.013 g/l*; all cars manufactured or imported after January 1, 1986 are required to use unleaded gasoline
Austria	lead content of gasoline must not exceed 0.013 g/l* as of August 1, 1993 (production) and November 1, 1993 (consumption)
Belgium	maximum allowable concentration of lead in gasoline 0.15 g/l
Canada	maximum concentration of lead in gasoline used in engines that require a small amount of lead to avoid premature failure (i.e. those used in farming, marine and commercial transportation equipment), 0.026 g/l (quarterly average) and 0.030 g/l (maximum); gasoline used for all other purposes is limited to 0.005 g/l (extract, Canada Gazette, Part I, 7/15/89); the use of leaded gasoline was phased out in December 1990
Finland	maximum concentration of lead in gasoline is 0.013 g/l* (unleaded) and 0.15 g/l (leaded); extra tax on leaded gasoline
Denmark	maximum allowable concentration of lead in gasoline is 0.15 g/l
France	maximum lead concentration in petrol, as of June 1991, is 0.15 g/l; in an effort to increase the use of lead-free petrol, its tax has been partially reduced since July of 1989
Germany	maximum concentration of lead in leaded gasoline 0.15 g/l; unleaded 0.013 g/l*; tax advantages for lead-free gas and cars that run on lead-free gas
Greece	maximum allowable concentration of lead in gasoline, 0.40 g/l; in Athens, 0.15 g/l
Iceland	no data available
Ireland	maximum level of lead in petroleum products is 0.15 g/l
Italy	maximum allowable lead concentration in gasoline 0.15 g/l (May 1982)
Japan	lead compounds are not used in gasoline; the Japanese Industrial Standards limit the lead content in petroleum
Luxembourg	maximum allowable concentration of lead in leaded gasoline, 0.15 g/l; unleaded, 0.013 g/l*
Netherlands	maximum allowable concentration of lead in leaded gasoline, 0.15 g/l; since 1986 there has been an extra tax on leaded gasoline
New Zealand	in 1988, the maximum permissible level of lead contamination in unleaded petrol was reduced from 0.05 g/l to 0.013 g/l*; in 1986, the maximum permissible level of lead in leaded gasoline was 0.84 g/l - this level was reduced significantly to 0.46 g/l; a target date for elimination of lead in petrol has been set as January 1996
Norway	lead in fuel limited to 0.013 g/l* for unleaded and 0.15 g/l for leaded; there is also an environmental tax depending on the lead content
Portugal	maximum allowable concentration of lead in leaded gasoline, 0.40 g/l; since January 1986
Spain	maximum allowable concentration of lead in leaded gasoline, 0.40 g/l as of 1986

PRODUCTS Source: Gasoline (continued)	
Country	**Actions**
Sweden	unleaded petrol must not contain more than 0.013 g/l* of lead; leaded petrol must not contain more than 0.15 g/l of lead; tax on leaded gas as of 7/91; proposal being considered to revise trade requirements for gasoline and autos; recently the Swedish Environment Protection Agency in a report to the Government has proposed banning manufacture or import of leaded gasoline from July 1, 1994
Switzerland	unleaded petrol: 0.013 g/l*; leaded petrol: 150 mg/l; aircraft petrol: 560 mg/l; heating fuel, Extra Leicht: 1 mg/kg; heating fuel, Mittel: 5 mg/kg; heating fuel, Schwer: 5 mg/kg
Turkey	no data available
United Kingdom	maximum concentration of lead in petrol is limited to 0.15 g/l; unleaded petrol is defined as having a maximum lead concentration of 0.013 g/l*; beginning in 1990, all new vehicles must be capable of running on unleaded gasoline
United States	in 1986 the EPA set the maximum allowable concentration of lead in leaded gasoline to 0.026 g/l; in addition, all new automobiles are required to operate on unleaded gasoline (1988); maximum lead content of unleaded gas 0.01 g/l.
European Community	lead in leaded petrol is limited to 0.15 g/l; unleaded petrol defined as having no greater than 0.013* g/l of lead
Mexico	in 1990 an unleaded gasoline with the same specifications as the most frequently purchased US gas was introduced; as of 1992, the lead concentration in regular gasoline was lowered to 0.4 g/l; in 1988, the automobile industry was committed by the government to introduce catalytic converters on new models

* It is generally accepted internationally that unleaded gasoline is defined as containing less than 0.013 g Pb/l.

PRODUCTS Source: Batteries	
Country	**Actions**
Australia	there are no regulations governing the disposal of lead batteries; however, the safe loading of vehicles with scrap lead acid batteries is strictly policed by State and Territory laws; up to 80% recycled
Austria	regulations govern the storage and transportation of lead acid batteries
Belgium	adopted EC regulation of transfrontier shipments of hazardous waste as Belgian law; enforced by regional and municipal authorities
Canada	all lead-acid batteries, if they are filled with acid, are classified as corrosive hazardous waste and their transportation and storage are regulated; other scrap lead and drained scrap lead-acid batteries are not regulated (storage regulated by provinces); in British Columbia, a transportation incentive programme has been set up to help encourage recycling; the size of the incentive is based on how far one had to travel to the nearest used battery processor; the incentive amounts are paid in addition to the scrap value of a used battery delivered to a processor
Finland	used lead batteries are classified as hazardous waste; regulations on labelling and collection of lead-containing batteries are under preparation
Denmark	information campaign to increase battery recycling
France	two different protocols for battery collection are currently under development to discourage disposal of batteries with household waste and encourage recycling and improved transportation; lead battery disposal is regulated under a 1976 law
Germany	regulations governing the transportation of lead-acid batteries; the recycling rate for batteries is estimated to be above 95%
Greece	
Iceland	no data available
Ireland	there are no regulations in force governing the disposal of lead batteries; however, many batteries are melted down to recover the lead
Italy	
Japan	the collection, labelling, classification and storage of lead-acid batteries are not regulated, but market incentives are used along different points of sale (i.e. primary and secondary producers) to promote collection and recycling
Luxembourg	
Netherlands	only one type of lead battery (an accumulator) contains lead; all of these batteries are recycled to recover the lead without incentives
New Zealand	
Norway	required to be labelled when the lead content is 0.4% or more by weight; retailers who sell batteries or accumulators that are required to be labelled are under obligation to accept a comparable type of battery in return; each municipality is responsible for establishing a system for collecting returned batteries and accumulators.
Portugal	
Spain	
Sweden	used lead batteries are classified as hazardous waste and the local authorities are responsible for their collection; transportation of used batteries is also regulated; a tax is levied on batteries (paid for by producers and importers), to subsidize disposal/recycling efforts; if the environmental charges alone cannot sustain a collection rate of 95%, the Swedish EPA has also proposed supplementing the system by setting up a returnable deposit on new batteries

PRODUCTS Source: Batteries (continued)	
Country	**Actions**
Switzerland	lead batteries are considered hazardous waste and must be collected separately; many of the lead accumulators and batteries are recycled
Turkey	no data available
United Kingdom	there are no regulations governing the disposal of lead batteries; however it is believed that nearly 100% of lead batteries installed in buildings and roughly 90% of car batteries are recycled; regulations exist governing the transportation of lead-acid batteries when > 1 L of electrolyte is carried
United States	storage and transportation of scrap batteries are not federally regulated below the smelter level, except for water transport; however, 36 states have enacted battery recycling legislation that features trade-in or deposit requirements; also 4 states have enacted state laws banning the disposal of batteries in municipal solid waste landfills
European Community	**proposal to control disposal of and encourage recycling of lead-acid batteries**
Mexico	

PRODUCTS Source: Pesticides	
Country	**Actions**
Australia	
Austria	pesticides containing lead compounds were banned on August 1, 1992, but allowed to remain on the market until December 1992
Belgium	lead compounds prohibited for use in agriculture before 1970
Canada	
Denmark	
Finland	
France	
Germany	application of lead compounds is strictly prohibited
Greece	
Iceland	no data available
Ireland	
Italy	
Japan	
Luxembourg	
Netherlands	
New Zealand	
Norway	no regulations
Portugal	
Spain	
Sweden	
Switzerland	
Turkey	no data available
United Kingdom	
United States	in March 1989 the EPA issued data call-in notices to the product managers of 13 pesticide products that contained lead as an inert ingredient; as a result, 11 of the pesticides were cancelled and 2 were reformulated without lead.
European Community	committee has been established to set permissible levels for heavy metals in agricultural chemicals; no standards issued to date
Mexico	

PRODUCTS Sources: Hunting/Fishing	
Country	**Actions**
Australia	
Austria	
Belgium	
Canada	
Denmark	maximum permissible quantity of lead in shotgun cartridges 28.5 g; hunting with lead shot is restricted in certain wetland areas
Finland	
France	
Germany	replacement of lead in ammunition (small shot and bullets) is under development
Greece	
Iceland	no data available
Ireland	
Italy	
Japan	
Luxembourg	
Netherlands	as of 1986, guidelines exist for pigeon shooting to prevent soil contamination by lead; research is currently underway to find alternatives for lead in sea and freshwater fishing; the Netherlands hopes to ban lead-containing "hailstones" (12 caliber rifles) by 1994
New Zealand	
Norway	ban on lead shot for most birds in wetlands; voluntary reduction in other uses of lead shot; by the year 2000, lead cartridges shall account for only 10 per cent of total cartridge consumption
Portugal	
Spain	
Sweden	since 1991 a voluntary reduction, stimulated by information and educational campaigns, is being attempted; the goal is to shift to lead-free alternatives by the beginning of the 21st century; unless significant results can be for seen, bans may be considered in the near future
Switzerland	
Turkey	no data available
United Kingdom	a joint campaign between the Lead Development Association and angling groups has led to a phase-out of lead weights in fishing
United States	limit on lead content of shotgun cartridges
European Community	
Mexico	

PRODUCTS Source: Food Containers	
Country	**Actions**
Australia	leaching of lead from ustensils limited to 0.2 mg/l; lead from glazed ceramics limited by standards for overall leaching of metals; there are no regulations governing the amount of lead used in solder for food cans
Austria	the use of lead or lead alloys for tableware was prohibited in 1960; exempted are lead-tin alloys with a maximum lead content of 10%
Belgium	
Canada	tin/lead solder allowed only on the outside of food cans; leachate from ceramic ustensils is limited to 7 mg/l
Finland	maximum concentrations have been set for lead leaching from ceramic ware that will come into contact with foodstuffs
Denmark	
France	lead-tin alloy is permitted only on the outside of cans; the penetration of the leaded alloy inside the container should occur only accidentally and may not result from the method of production itself; standards have been set for lead in ceramic ustensils; refillable objects: 4.0 mg/l; cooking and storage ustensils with a minimum capacity of 3 L: 1.5 mg/l; refillable and non-refillable objects with a maximum inside depth of less than or equal to 25 mm: 0.8 mg/dm^2.
Germany	there is no longer any use of soldered cans for food packaging
Greece	
Iceland	no data available
Ireland	
Italy	
Japan	
Luxembourg	
Netherlands	lead solder is only allowed on the outside of food packaging unless the uppermost layer contains less than 0.05% lead; the lead content of ceramic food ustensils is limited to: 0.8 mg/sq dm; for packaging, barrels and ustensils: volume greater than 3 litres 1.5 mg/l and less than 3 litres 4 mg/l
New Zealand	
Norway	hollow vessels shall not liberate more than 2 mg/l of lead; flat articles shall not liberate more than 1 mg/sq dm of lead
Portugal	
Spain	
Sweden	Swedish food tolerance levels have recently been lowered to 0.3-0.5 mg/kg for most canned food; Sweden wishes to eliminate imported lead soldered cans (virtually all cans manufactured in Sweden are welded) and subject canned foods to the same standards as fresh foods
Switzerland	
Turkey	no data available
United Kingdom	
United States	in March 1989 the EPA issued data call-in notices to the product managers of 13 pesticide products that contained lead as an inert ingredient; as a result, 11 of the pesticides were cancelled and 2 were reformulated without lead
European Community	committee has been established to set permissible levels for heavy metals in agricultural chemicals; no standards issued to date
Mexico	

PRODUCTS Source: Miscellaneous	
Country	**Actions**
Australia	pencils, toys, finger colours, showcard colours, pastels, crayons, poster paints, and coloured chalks should not have a total lead content greater than 0.01%; coating materials should not contain greater than 0.25% of lead or lead compounds; in Queensland the use of any combustible material that is or contains fuel having a lead content exceeding 0.02% by weight
Austria	no lead in chain saw oils
Belgium	
Canada	the arts, crafts, and hobby communities have been targeted for eduction on the hazards associated with some of the materials used in these activities
Denmark	
Finland	
France	a departmental order of the health ministry, dated November 1978, prohibited the use of lead salts in imitation pearls in jewelry
Germany	significant quantities of lead are still used in the following applications: stabilizers for PVC, cable sheathing, optical and technical glass, TV picture tubes, and crystal glass; the lead in these applications is considered immobile and fixed in an insoluble matrix
Greece	
Iceland	no data available
Ireland	
Italy	
Japan	
Luxembourg	
Netherlands	
New Zealand	it is prohibited to manufacture, import, pack or sell material used for writing, drawing, marking or painting that contains more than 100 mg/kg of lead; maximum permissible amount of lead is 5000 mg/kg in coating materials for toys; this level will be reduced to 2500 mg/kg in the Fourth Amendment of the Toxic Substances Regulations 1983; accessible plastic material on a toy is restricted to a maximum permissible amount of 250 mg lead/kg
Norway	products containing more than 1 per cent lead will be classified as causing birth defects and reduced fertility; products containing more than 1 per cent of lead chromate and 0.1 per cent of lead phosphate are classified as carcinogenic; migration of lead from toys shall not exceed 90 mg/kg toys; cosmetics shall not contain lead
Portugal	
Spain	
Sweden	**proposals to eliminate lead sheathing cables and lead plastic additives and to support research on lead-free crystal have been issued**; there is currently a voluntary agreement not to use underground lead sheath cables after 1994, and not to use lead in semi-crystal after 1991; today no glassworks use lead for semi-crystal; miscellaneous uses are being investigated to form a basis for discussion with industry on voluntary measures
Switzerland	use of lead in clothing dyes is prohibited
Turkey	no data available
United Kingdom	**UK is formulating regulations to control supply and use of lead solders (>0.1% Pb) and plumbing equipment**
United States	

PRODUCTS Source: Miscellaneous	
Country	**Actions**
European Community	labelling and packaging requirements exist for all goods containing more than 0.1% lead by weight; lead banned from use in cosmetics; **proposal that bioavailability resulting from the use of toys shall not exceed 0.7 ug; proposal to control used oil disposal**
Mexico	the Health Secretary has established an education programme designed to promote awareness of alternative methods of reducing lead exposure

ENVIRONMENTAL HEALTH
Source: Occupational Exposures

Country	Actions
Australia	the National Occupational Health and Safety Commission (NOHSC) recommends a maximum allowable air concentration of lead in the workplace of 0.15 mg/m³ (time-weighted average over 8 hours); in 1980, the National Health and Medical Research Council (NHMRC) recommended an occupational maximum blood lead level of 70 µg/dl for males and 40 µg/dl for females, however, those guidelines will soon be abolished in anticipation of the National Occupational Health and Safety Commission's proposed standard; the Australian lead industry (1988) recommended a maximum occupational blood lead level of 70 µg/dl for males and 30 µg/dl for females, and in 1992 recommended a maximum of 65 µg/dl for males; the Australian lead industry further recommends concentrations of lead in blood at which return to occupational exposures may occur (50 µg/dl for males, 25 µg/dl for females); New South Wales requires and Northern Territory recommends 70 µg/dl for men, 40 µg/dl for women; ACT, South Australia recommend 80 µg/dl for men, 40 µg/dl for women; Queensland Code of Practice requires 80 µg/dl for men, 40 µg/dl for women; Victoria legally mandates 75 µg/dl (no distinction male or female); Western Australia 10 mol/litre (=about 100µg/dl); Western Australia mandates no males under 16 and no females on lead work; Victoria mandates no females on lead work; South Australia, New South Wales, Tasmania recommended no males under 18 and no females on lead work
Austria	maximum allowable air concentration of lead in the workplace 0.10 mg/m³ for men and 0.02 mg/m³ for women (time-weighted average over 8 hours); maximum allowable blood lead concentration in the workplace 100 µg/dl (men); ALA in urine 20-25 mg/l; coproporphyrin in urine 300 mg/l; punctate basophilia in blood 5%
Belgium	maximum allowable air concentration of lead in the workplace 0.15 mg/m³ (time-weighted average over 8 hours); maximum allowable blood lead in blood 50 µg/dl; in urine, 150 µg/g creatinine; zinc protoporphyrin (after 1 month exposure) 100 µg/dl in blood, or 250 µg/dl erythrocytes
Canada	maximum allowable air concentration of lead in the workplace is 0.15 mg/cu m (time-weighted average over 8 hours) and 0.45 mg/cu m (maximum); maximum blood lead concentration allowable in the workplace is 70 µg/dl (legally adopted by provinces)
Finland	the maximum allowable concentration of lead in workplace air is 0.10 mg/m³ (time-weighted average over 8 hours); the maximum allowable lead concentration in the blood of exposed workers is 50 µg/dl (if higher concentrations are found it is prohibited to put the person to tasks where he is exposed to lead)
Denmark	maximum allowable air concentration of lead in the workplace 0.10 mg/cu m (time-weighted average over 8 hours); maximum allowable blood lead concentration in the workplace 50 µg/dl (guideline)
France	maximum allowable air lead concentration in the workplace 0.15 mg/m³ (time-weighted average over 40 hours); there is no blood lead standard in France; however, the French shall adopt the EC's maximum allowable blood lead concentration in the workplace of 70 µg/dl (with exceptions to 80 µg/dl); ALA in urine limited to 20 mg/l
Germany	maximum allowable air lead concentration in the workplace 0.10 mg/m³ (time-weighted average over 8 hours); maximum allowable blood lead concentration in the workplace 70 µg/dl (men and women over 45) and 30 µg/dl (women under 45); ALA in urine 15 mg/l (men and woman over 45), 6 mg/l (women under 45)
Greece	maximum allowable blood lead concentration in the workplace 70 µg/dl, with exceptions up 80 µg/dl if the following conditions apply: the ALAU < 20 mg/g creatinine, zinc protoporphyrin < 20 µg/g hemaglobin, or ALAD level > 5 European unit's
Iceland	no data available
Ireland	maximum allowable air lead concentration in the workplace 0.15 mg/m³ (time-weighted average over 8 hours); maximum allowable blood lead concentration in the workplace 80 µg/dl (recommendation)
Italy	maximum allowable air lead concentration in the workplace 0.15 mg/m³ (time-weighted average over 8 hours); maximum allowable blood lead concentration in the workplace 70 µg/dl (Code of Practice)
Japan	maximum allowable air concentration of lead in the workplace 0.10 mg/cu m; maximum allowable blood lead concentration in the workplace 60 µg/dl

ENVIRONMENTAL HEALTH
Source: Occupational Exposures (continued)

Country	Actions
Luxembourg	maximum allowable blood lead concentration in the workplace is 70 µg/dl, with exceptions up to 80 µg/dl if the following conditions apply: the ALAU < 20 mg/g creatinine, ZPP (zinc protoporphyrin) < 20 µg/g hemaglobin, or ALAD level > 6 European units
Netherlands	maximum allowable air lead concentration in the workplace is 0.15 mg/m^3 (time-weighted average over 40 hours) (recommended), 0.10 mg/m^3, legal; maximum allowable blood lead concentration in the workplace 60 µg/dl; blood lead action levels 30 and 50 µg/dl
New Zealand	Workplace Exposure Standards: New Zealand has adopted a value of 0.15 mg/m^3 for air
Norway	recommended maximum allowable air lead concentration in the workplace is 0.05 mg/m^3 (time-weighted average); maximum allowable blood lead concentration in the workplace 60 µg/dl; **however, it is planned that the limit will be lowered to take account for lead in air value**
Portugal	
Spain	maximum allowable air lead concentration in the workplace is 0.15 mg/m^3; legal maximum allowable blood lead concentration in the workplace 70 µg/dl (if the amino laevulinic acid (ALA) level > 20) and 80 µg/dl (if ALA < 20)
Sweden	maximum allowable air lead concentration in the workplace 0.10 mg/m^3 (total) and 0.05 mg/m^3 (respirable) (time-weighted average over whole day); maximum allowable blood lead concentration in the workplace 50 µg/dl (female) and 60 µg/dl (male); new regulations will come into force on January 1, 1994; medical removal blood lead concentration in the workplace will be: 1) for men and for women over 50 years: 40 µg/dl for 3 consecutive checks and 50 µg/dl for any one check, 2) for women under 50 years: 25 µg/dl for 3 consecutive checks and 30 µg/dl for any one check
Switzerland	maximum allowable air lead concentration in the workplace is 0.1 mg Pb/m^3 (time-weighted average over 8 hours) for lead and lead compounds (except alkyl lead compounds) and 0.075 mg Pb/m^3 for tetramethyl and tetraethyl lead; maximum allowable blood lead concentration is 30 µg/dl for women and 70 µg/dl for men
Turkey	no data available
United Kingdom	maximum allowable air concentration of lead in the workplace is 0.15 mg/m^3 (time-weighted average over 8 hours); for men the maximum allowable blood lead concentration in the workplace is 70 µg/dl, with exceptions up to 80 µg/dl if the following conditions apply: the ALAU < 20 mg/g creatinine, ZPP (zinc protoporphyrin) < 20 µg/g hemaglobin, or ALAD > 6 European units; for women the blood lead limit is 40 µg/dl
United States	for general industry the maximum allowable air concentration of lead in the workplace (the Permissible Exposure Limit), which became effective in 1979 and was updated in 1991, is 50 µg/m^3; the medical removal blood lead concentration in the workplace, which became effective 1983, is 50 µg/dl for 3 consecutive checks and 60 µg/dl for any one check; for the construction industry the Permissible Exposure Limit is 200 µg/m^3 with no further provisions for biomonitoring or medical removal; **proposed reduction to 50 µg/m^3 for construction industry**; additional regulations established by OSHA prohibit general industry employees exposed to lead from taking lead-contaminated clothing from the worksite and require employers to provide hygiene facilities to lead workers to ensure that the worker's family members are not subject to secondary exposures to lead
European Community	maximum allowable air lead concentration in the workplace of 0.15 mg/m^3 (time-weighted average over 40 hours); maximum allowable blood lead concentration in the workplace is 70 µg/dl, with exceptions up 80 µg/dl if the following conditions apply: the ALAU < 20 mg/g creatinine or ZPP (zinc protoporphyrin) < 20 µg/g hemaglobin, or ALAD level > 6 European units
Mexico	maximum permissible lead concentration in air in the workplace: 150 g/m3, however, the level may be lowered to 50 g/m^3 in the near future

ENVIRONMENTAL HEALTH
Child Blood Lead

Country	Actions
Australia	level of concern is 25 µg/dl, under review in 1992/1993
Austria	
Belgium	
Canada	action level set at 25 µg/dl, under review as of 1989
Denmark	
Finland	
France	the Ministries of Health, Environment, and Housing are financing a series of studies aimed at identifying risk factors in domestic housing in the Paris urban area, and determining the magnitude and extent of the lead poisoning problem in the country; a national programme aimed at the reduction of sources is underway
Germany	mean blood lead levels have been found to be decreasing for a group of school children aged 6 to 12 in Berlin over the period from 1976 to 1985
Greece	
Iceland	no data available
Ireland	
Italy	
Japan	
Luxembourg	
Netherlands	
New Zealand	
Norway	
Spain	
Sweden	
Switzerland	
Turkey	no data available
United Kingdom	1982 government advice suggests that actions should be taken if blood lead exceeds 25 µg/dl
United States	10-14 µg/dl, community-wide educational, nutritional and environmental intervention; 15-19 µg/dl, educational and nutritional interventions; 20-44 µg/dl, medical evaluation, environmental investigation and remediation; 45 µg/dl and higher requires medical intervention
European Community	**considering lowering the action level to 10 or 15 µg/dl**
Mexico	

APPENDIX B (CHAPTER 5)

FRANCE: HEAVY METAL CONTENT IN FERTILIZERS

**Source: Ministry of Agriculture and Rural Development,
Department for Plant Protection,
Commission for the Study of Toxicity of Antiparasites**

EXEMPLE DE TENEURS EN METAUX LOURDS DES MATIERS FERTILISANTES ET SUPPORTS DE CULTURE (ppm)

TYPE D'ENGRAIS	Cd	Hg	Pb	Cr	Cu	Ni	Se	Zn	As	Mo
ENGRAIS MIN NFU 42-001 (DEC 81)	mg/kg									
4.1.1. Engrais simples azotés										
Ammonitrate (33.5) (300 kg/ha/an)	≤1	≤0.03	≤0.5	6	≤1	1	≤0.1	≤2	≤0.1	≤0.5
Sulfate d'ammoniaque	≤10	1	≤10	≤10	≤10	≤10	≤5	≤10	≤1	≤10
4.1.2. Engrais simples phoshatés										
type 1 scories Thomas	0.05	0.05	25-40	1415-1760	13-14	8-18		50-57		
type 2c superphosphate triple (200 kg/ha/an)	43-53	0.1-0.16	0.5-5	145-315	9-60	5-66	LD	141-625	16	28
type 7 phosphate naturel tendre (300 /kg/ha/an)	9-30	0.04-0.1	12-18	92-200	9.7-12	18.6-29	LD	203-250	LD	LD
type 6 phosphate alumino-calcique	90-100	0.05	40	1350	25	10	LD	145	LD	LD
4.1.3. Engrais simple potassique										
type 3 chlorure de potassium	0.07	0.05-0.2	7	1-3	0.1-2	0.13	LD	0.5-4	≤0.7	≤0.01
type 5 sulphate de potassium (240 kg/ha/an)	2	0.4-2	5-15	0.5-5	1-10	2	LD	1-15	≤2	LD
4.2 Eng. comp: NP, NK, NPK, PK (class II)										
type 1 Engrais NPK										
engrais NPK	3- 24	0.16-6	0.5-25	54-200	3-26	3-55	0.1-11	51-200	2-70	0.5-38
type 4 Engrais PK (hors suspension et solution)										
superpotassique 0.25-25 (400 kg/ha/an)	9.4-36	0.15-1	0.7-6	135-208	5.3-38	11-44	0.6-0.9	156-325	5.7-11	1.5-13
phosphopotassique 0.15.25 (600 kg/ha/an)	11.8	0.6	9.7	116	6	11.7	0	119	0	0
scories phosphopotassiques 0.17.17 (600 kg/ha/an)	9.7	0.06	13.2	482	8.2	13.5	0	113	0	0
scories potassiques 0.12.12	0.05	0.06	27	1100	10.6	10.5		45		
divers PK 0.24.12 (super+Phos nat+KCl) (400 kg/ha/an)	19	0.05	9	162	7	14.2	0	170	0	0

TYPES D'ENGRAIS	Cd	Hg	Pb	Cr	Cu	Ni	Se	Zn	As	Mo
ENGRAIS APPORTANT DU Ca, Mg, et/ou S										
type 2a sulphate de magnésium (750 kg/ha/an)	0.07	0.06	4.5	3	2.9	6.3	0	12	0	0
type 1b amendement calc phosphaté sidérurigique	8.9	0.27	207	184	136	288	≤0.01	468	3.33	9.6
AMENDEMENTS MINERAUX										
Carbonate (800 kg/ha/an)	0.231	0.015	0.12	6.15	7.49	3.44	0.006	6.59	5.28	16
calcaire (CaO - 54%) (800 kg/ha/an)	0.011	0.048	3.91		16			80	1.28	1.62
AMENDEMENTS ORGANIQUES										
Tourbe brune	0.04	0.005	3.2	1.5	1.2	0.9	0.3	8	0.5	0.3
Fumier de cheval	0.03	0.02	5.2	6	6	6	0.07	33	1	1.9
Lombricompost	0.197	0.06	16	0	26.9	12	0.05	226	3.97	1.73
Amendements org.=fumiers naturels ou artificiel	1.6	2.2	250	60	160	25	1.7	930	10	1.2
Fumier mg/kg sur brut (frais: 10000kg/ha/an)	0.02-0.03	0.01-0.02	3-5.2	4.2-6	3.7-6	4-6	0.05-0.07	23-33	0.7-1	0.5-1.9
Marc composté										
Matière végétale brute										
Amendement végétal non fermenté	0.1-1.2	0.02-1.2	1-130	0.5-45	1.8-110	0.6-12.5	0.1-1.5	14-645	1.4-8	0.6-1.5
Amendement végétal fermenté	0.1-1.2	0.02-1.2	1-130	0.5-45	1.8-110	0.6-12.5	0.1-1.5	14-645	1.4-8	0.6-1.5
Compost végétal										
Compost d'écorces de bois										
Compost urbain frais (mg/kg MS - 55.3% eau)	1.55-1.6	1.65-1.75	290-315	ND	ND	4.5-4.8	ND	ND	ND	ND
Compost urbain demi-mûr (mg/kg MS)	1.7-7.5	1.3-12.7	28-1366	24.3-127	50-52.3	24.7-446.5	ND	61-2193	ND	3-321
Compost urbain mur										
Gadoues										
Tourbe acide										
Tourbe dite alcaline										
Compost de tourbe										
Boues de stations d'épusation (3500 kg/ha/an)	20	10	800	1000	1000	200	100	3000	40	4

SUPPORTS DE CULTURE	Cd	Hg	Pb	Cr	Cu	Ni	Se	Zn	As	Mo
Terreau (ppm sur brut 60 à64% d'eau)	0.1-0.22	0.01-0.08	1.6-12	1.74-5	1.2-16	0.7-50	0.2-0.6	7.6-47	0.5-3.5	0.6-40
Terreau de tourbe										
Terre dit de bruyère (ppm sur brut 45% d'eau)	0.11-0.14	0.05-0.06	10.4-13	7.4-9.3	12-15	25-31	0.11-0.13	9.5-12	0.57-12	4.5
Terre de tourbière										
Tourbe support en %	LD	LD	LD	LD	0.13-0.2		LD	0.04-0.07	LD	0.2-2.2
Substrat végétal non fermenté ni supplémenté mg/kg MS	1-1.5	1-1.2	30-50	ND	30-50	7-10	ND	80-100	ND	ND
Substrat végétal fermenté mg/kg MS	1-1.5	1-1.2	30-50	ND	30-50	7-10	ND	80-100	ND	ND
Substrat organo-minéral										
Sable										
Graviers										
Fibres minérales mg/kg sur tel que	0.04	0.01	0.08	7	31	48	LD	29	0.16	0.18
Argile expansée										
Perlite										
Vermiculite										
Schistes expansés										
Pouzzolane										

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CHAPTER 6

SUMMARY AND CONSIDERATIONS

Lead is a naturally occurring element within the earth's crust. Its softness, density, low melting point, opacity to radiation, chemical reactivity and resistance to corrosion give it considerable functional value, both in its pure state and in alloys or compounds.

Lead is normally extracted from mined ores containing zinc, silver and minor amounts of copper; however, recycled materials have become an increasing source of supply and currently account for over 50 per cent of world production.

World demand for lead and its products has steadily increased. Lead-acid batteries, used for applications such as starting automobiles, powering electric vehicles or operating as an emergency power source, account for the greatest growth. Demand for most other uses has remained relatively stable, or has declined due to competitive factors or in response to health and environmental concerns.

Environmental releases of lead can occur naturally (for example, through crustal weathering, volcanism) or from anthropogenic sources relating to industrial activity, incineration, power generation (coal and oil burning), the use of fertilizers and sewage sludge, and the use and disposal of consumer products.

Human exposure to lead occurs through inhalation of contaminated air or ingestion of contaminated water, food, soil, dust or paint. The magnitude of exposure depends on the concentration of lead in the various media and its bioavailability. There are several approaches to estimating human exposure to lead:

- Monitoring of blood lead levels within an exposed population can provide data reflecting current levels of human exposure.

- Monitoring of environmental media concentrations, together with estimates of human uptake rates from these media, allow estimation of the extent to which individual media are responsible for human exposure.

Almost all OECD countries have introduced regulatory or non-regulatory measures to reduce unreasonable human and ecosystem risks from exposure to lead. The risk assessments and risk characterizations that have led countries to take actions have a national character. Countries develop positions on the need for risk reduction activities after having analysed the hazard and the significance of certain exposures, and after factoring in local social, economic and political considerations. These positions are usually arrived at after considerable debate on the numerous factors involved, and thus are not expected to be consistent across Member countries. For example, the number of recorded measures initiated by an individual country varies from a few up to at least 18. Although some countries have taken the same number of measures, no two countries have adopted the same set of risk reduction measures (i.e. initiatives relating to environmental media, industrial or municipal releases, products, occupational exposures, etc.). This variance reflects, in part, the disparate sources of release, exposures, concerns and priorities within countries. Another example of the variance in country priorities is reflected in the effectiveness of the nature and extent of actions taken by countries to reduce risks from exposure to lead.

Blood lead sampling is one of the methods most widely used to assess human risk from exposure to lead. Approximately 30 per cent of OECD countries have reported blood lead monitoring data for the general population and/or segments of the population at greatest risk. Data for the general population (for example, adults, children) in these countries indicate that average levels of lead in blood have declined to below levels of national concern. However, some countries have identified portions of the population that are exposed to levels of exposure above those of national concern.

The data also indicate that there is no direct relationship between the number of measures introduced and their effectiveness in reducing blood lead levels. Some countries have reduced average blood lead levels to below 10 µg/dl by introducing only a few regulatory and non-regulatory measures, while others have initiated many more to obtain similar results.

Given the number of confounding factors, it is difficult to assess the effectiveness of a single measure to reduce risks. However, monitoring the level of lead in blood and environmental media over time has allowed countries to determine the extent and magnitude of lead exposure problems and assess the need for, and the potential effectiveness of, future risk reduction initiatives. The most common measures associated with reductions of lead in various environmental media and human blood within OECD countries are:

- initiatives to restrict dispersive *uses* of lead that result in its being readily bioavailable, such as lead in gasoline, packaging where lead is in direct contact with food (for example, lead soldered food cans, ceramic coatings), lead solders and piping in drinking water systems, lead in household paints or paints for toys, etc., and lead-based pesticides;

- regulatory and non-regulatory measures that monitor and control industrial *emissions and effluents*;

- replacing lead piping in drinking water systems or, where lead solders and piping cannot be easily replaced, reducing the lead in *drinking water* by controlling the pH (in order to reduce the solubility of lead);

- development and implementation of technology for the safe *management of wastes*, including those that contain lead, destined for final disposal in landfills or incinerators; and

- regulatory and non-regulatory measures for the *workplace*, such as the establishment of maximum allowable blood lead and lead-in-air levels and the implementation of medical surveillance and occupational hygiene programmes for exposed workers.

For those Member countries that monitor lead in various media, data also indicate that the average levels of lead in environmental media have declined to below national levels of concern. However, some countries have identified releases of lead from point sources and/or the long-range transport of lead in air as concerns. Others have indicated that, given the recent progress on reducing lead in air, there are more significant domestic concerns such as lead in imported canned food, lead in drinking water (especially for critical groups such as bottle-fed infants), or lead in dust and chips from deteriorating old household paint. The latter sources of concern are largely the result of past practices. In order to address these concerns, a number of governments are undertaking studies to determine the magnitude and extent of their problems. Where the risk from exposure to lead is high, abatement measures, educational activities, continued monitoring and, in

instances of severe lead poisoning, medical treatment such as chelation therapy, form integral components of the risk reduction strategy.

It is suggested that when considering risk reduction strategies for lead, Member countries may wish to take into account the following:

- Countries, not already doing so, may wish to undertake environmental and blood lead sampling to identify populations at highest risk and to evaluate the extent of lead exposure in their general population. This would facilitate the establishment of local, regional and national risk reduction priorities, and provide the means to gauge the success of any subsequent risk management strategies. Monitoring also plays a key role in assessing compliance with national standards or possible international agreements.

- Countries may also want to draw on experiences described in the document when developing regulatory and non-regulatory measures to reduce unreasonable risks from exposure. Measures may include: regulations and standards (for example, lead in gasoline, smelter emissions) aimed at reducing ongoing releases of lead to air, water, soil, dust and the workplace; implementation of cleaner technology (for example, substitution, process modifications), effective recollection and recovery systems, or environmentally acceptable waste treatment; abatement activities to reduce risks from exposure to historical sources of release (for example, deteriorating paint, piping in potable water systems); and voluntary industry product stewardship programmes such as the industry phase-out in some countries of high-risk applications (for example, lead in soldered food cans or household paints).

In addition, consideration should be given to reviewing progress every few years with lead risk reduction strategies. This could include the collection of Member countries' environmental and blood lead monitoring data, as well as new information on their regulations, criteria, standards or national policies regarding exposure to lead.