THE INTERNATIONAL COUNCIL
ON METALS AND THE ENVIRONMENT

April 30, 1991

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From: Gary Nash, Secretary General

The attached chapter on lead from a recent Swedish government report may be of interest, particularly the marked sections on pages 107, 129, and 143.

Gary N.

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c/o The Mining Association of Canada
Suite 1105 - 350 Sparks Street, Ottawa, Ontario KIR 7S8
Telephone: (613) 233-9391 Facsimile: (613) 233-8897

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From: KEMI Report
No. 1/91.

Risk Reduction
of Chemicals

A government commission report

The Swedish National Chemicals Inspectorate (KEMI)

The Swedish Environmental Protection Agency (SNV)

CHAPTER 7

LEAD

Contents

SUMMARY AND PROPOSALS

Lead and lead compounds occur in numerous different product items and chemical products. Total annual lead consumption in Sweden is roughly 30,000 tonnes. Accumulator production alone accounts for 22,000 tonnes. Large quantities of lead and lead compounds are also used in the manufacture of plastic products and glass, cable sheaths and shot cartridges, and as a fuel additive. The term "lead" will henceforth be used both for the metal itself and for lead contained in alloys and chemical compounds.

Current lead use involves dispersion into all environmental media. Direct release into the environment results, for example, from the use of petrol and lead shot. Moreover, the use of lead gives rise to problems in the working environment. Lead bioaccumulates and is toxic. It can, for example, damage the nervous system, affect blood formation, impair the kidneys and cause foetal damage. Altogether, these factors make it urgent to restrict lead consumption.

OBJECTIVE: LONG-TERM CESSATION OF LEAD USE

The use of lead that is released direct into the atmosphere and soil via petrol, shot and lead-sheathed underground cables must, in the main, cease within the next five years.

Proposals

* In order to speed up the development and use of petrol without lead additives, we recommend that the government present a bill to the Riksdag (the Swedish Parliament) increasing the tax differential between leaded and unleaded petrol. The differential should be large enough to ensure that unleaded petrol is always markedly cheaper than the corresponding leaded quality for end users. This means that unleaded 98-octane petrol purchased by the consumer should also be priced well below leaded premium petrol. The present tax differential should therefore be increased enough to ensure that this is so.

The National Board for Consumer Policies should, after consul tions with the automotive and oil industries, provide consumer i formation on fuel options. If, one year after implementation, th measures have not brought about the desired increase in the sale unleaded petrol, SNV will initiate additional measures, includi a review of the transitional provisions in the Petrol Ordinance (S 1985:838). These provisions currently permit leaded petrol to imported, manufactured and sold.

* Lead shot and lead-shot cartridges may not be manufactured, i ported or sold after 1 January 1996. We recommend that t government issue regulations pursuant to the Act on Chemical Pr ducts.

* The use of lead accumulators must be discontinued in the lo term. We recommend that the government direct the Nation Board for Technical Development (STU) to take the initiative f technical development projects, and to monitor and evaluate tec nological development with respect to alternative accumulators a starting systems for vehicles. KemI and SNV intend after furth consideration, on the basis of the data compiled, to propose a da by which the use of lead accumulators is to cease.

  The recovery of accumulators and recycling of accumulator le must be stepped up in the short term. This may be achieved b means, for example, of environmental charges to finance t collection procedure and repayable deposits to give consumers a incentive to return accumulators. It is recommended that the colle tion procedure be made more efficient along the lines proposed i SNV's guidelines, which are undergoing evaluation at present. I environmental charges alone are insufficient to attain a degree o recovery in excess of 95 % in the short term, it is proposed th the system be supplemented with returnable deposits for accumula tors.

* All laying of new lead-sheathed underground cables must cease be fore the beginning of 1995. One means of achieving this i measures undertaken by the industry itself. The use of lead fo

sheathing of underwater cables is also to be discontinued in the long term. In order to obtain this objective, cable manufacturers must work to develop alternative, environmentally acceptable sheathing materials. SNV intends, after further consideration, to propose a date by which the use of lead-sheathed underwater cables is to cease. Regardless of the transition to non-lead-sheathed cable, the degree of recovery of discarded lead-sheathed cable must remain high. SNV will continuously monitor the recovery of cable lead in order to be capable of taking measures if the scope for recovery decreases.

* Sweden should act to promote changes in the international quality norms for crystal glass. The objective should be for the lead content of crystal glass to be reduced considerably. Research and development work on lead-free crystal is to be stimulated to a larger extent than it has been hitherto. The manufacture of lead-containing semi-crystal in Sweden is to cease before the beginning of 1992. One means of achieving this is measures undertaken by the industry itself. We also recommend that manufacturers of semi-crystal should start informing purchasers that their products are free of lead.

* A joint, combined proposal to introduce restrictions on plastic additives is to be drawn up by KemI and SNV, which will present a date by which the use of lead-containing plastic additives is to be discontinued. The work is to commence during the 1990/91 fiscal year.

* KemI will monitor the transition to lead-free pigments and drying agents in Swedish paint production. KemI will make international efforts to restrict the use of lead in paint.

Within the next few years, the supply of rustproofing agents containing lead in packaging sizes intended for private consumers should cease. One way to achieve this is by means of voluntary agreements in the paint industry. Testing of lead-free rustproofing agents and alternative application methods for large-scale use should continue. In addition, the major users of red lead oxide

should review their scope for using lead-free rustproofing agents even today in the parts of the country where this is feasible.

* We recommend that the government direct the National Food Administration to devise a plan for the phase-out of lead-soldered tins. Sweden should act internationally for a change-over from lead-soldering of tins to other methods.

* Lead used in other ways must be replaced as soon as possible by environmentally acceptable alternatives, wherever feasible. KemI will follow up the work of manufacturers and importers to replace lead, by means of checks and directed measures. KemI and SNV consider it essential to prevent the use of lead in new areas and for new applications, and they will act internationally to prevent such use from being permitted.

* KemI will pursue the issue of risk reduction of lead within the framework of the OECD's "Risk Reduction Project".

INTERNATIONAL OUTLOOK

For metals that are toxic and can be bioaccumulated, international targets have been adopted for a drastic reduction in discharges into marine areas. At the North Sea Conference in March 1990, one decision taken was to reduce discharges of lead by 70 % compared with 1985.

* KemI will pursue the issue of risk reduction of lead within the framework of the OECD's "Risk Reduction Project".

Internationally, there are regulations concerning the use of lead, for example as a constituent of glaze and in the form of lead shot. Canada has prohibited the sale of leaded petrol for motor vehicles with effect from 1 December 1990. In Brazil, no leaded petrol has been sold since 1989. In the USA, a massive lead-based paint abatement programme is being discussed. It is proposed that this programme be financed by a excise tax on raw lead.

GENERAL DESCRIPTION OF INCIDENCE AND APPLICATIONS

Global production

More than 60 % of all lead ore is extracted in mines where lead is found in conjunction with zinc; some 30 % is derived from "pure" lead ores, and some 10 % from other ores. Total production worldwide was 3.5 million tonnes of lead in 1987. Global consumption of refined lead in the same year was 5.7 million tonnes (Minerals Yearbook 1987, USBM).

Resources in Sweden

About 100 different mineral-lead deposits are known along the eastern border of the Scandinavian mountain chain. The most important is Laisvall, which is one of the biggest lead mines in Europe, containing roughly 4 % lead (SOU 1979:40).

Production in Sweden

In the years 1983-88, mining production remained stable. According to the Swedish Mine-Owners' Association, 113,000-133,000 tonnes of lead-ore concentrate was produced during the period. Roughly half the ore mined is exported direct (before refining), and the rest smelted and refined in the Rönnskär works in Skellefteå. Here, 41,200 tonnes of lead was produced, and of this 25,000 tonnes was exported (Boliden Mineral), in 1989.

Imports and exports

Swedish imports and exports of lead-containing products, in tonnes, excluding chemical products, in 1988 (Statistics Sweden)

Product	Imports	Exports
Ore and concentrate	-	50,000
Unalloyed refined lead	120	56,500
Alloyed and unprocessed lead	2,800	13,000
Waste and scrap	23,200	3,400
Semi-finished products	1,300	800

Recovery

Lead recovered at present amounts to some 43,000 tonnes annually. Batteries make up roughly half the incoming lead, while scrap and ashes constitute the rest. The lead recovered is sold in alloyed and unalloyed form. The primary alloying material is antimony. Of the quantity recovered, some 25,000 tonnes is exported and the remainder used mainly for making accumulators, lead-sheathed cables and soldering.

Lead compounds

The products register lists some 65 lead compounds. Examples of inorganic lead compounds included in a large number of products are lead oxide, lead chromate and lead chromate molybdate sulphate red. More than 50 % of the lead oxide is imported, both in pure form and in chemical products with varying lead-oxide contents. Products containing lead chromate are manufactured largely in Sweden, but those containing lead chromate molybdate sulphate red are mainly imported. Among the organic lead compounds are a number of fatty-acid salts, such as lead octadecanoate and lead-2-ethyl-hexanoate. There are also cyclic carboxylic-acid soaps, such as lead cyclohexane carboxylate. More than 75 % of the two fatty-acid salts are imported, while the cyclic compound is mainly found in Swedish-made products.

Other lead compounds found in large quantities are tetramethyl lead and tetraethyl lead. These are used almost exclusively as fuel additives. Products containing tetramethyl lead are manufactured in Sweden on roughly the same scale as they are imported. For products containing tetraethyl lead, imports exceed the quantity produced in Sweden.

Estimated use of lead in Sweden in 1988/89 (tonnes), by product category

Accumulators	22,000
Cable sheathing	3,000
Plastic	2,000
Glass	1,500
Shot and bullets	800
Petrol	600
Paint and rustproofing agents	200
Lead-soldered tins	25
Rubber	10
Explosives	10
Ceramics	10
Miscellaneous uses, metallic lead	> 200

IMPACT ON HEALTH

Exposure to lead is via food, water and air. Lead is deposited mainly in bone tissue (90 %), and also in blood and soft tissues (10 %). Lead in blood has a half-life of about 20 days, while its half-life in bone is roughly 20 years. This long half-life in bone means that lead is released, causing internal exposure, even after the external exposure has ceased. Absorption, disposition and retention, however, vary greatly from one lead compound to another.

Lead can have a number of different effects on the body. It may damage both the central and the peripheral nervous system. Exposure to large quantities of lead may cause confusion and cramps, while exposure to small quantities can result in such symptoms as headache and insomnia. The effect on the peripheral nervous system may take the form of paralysis of muscle groups in the extremities.

Chronically raised lead concentrations in the blood have an adverse effect on blood formation, which may result in anaemia.

Kidney damage may occur, and a large proportion of patients suffering from uraemia are known to have been exposed to lead previously. Effects on the endocrine system have also been observed.

Children are more sensitive to lead than adults. Small children's intellectual development may be impaired as a result of lead exposure. Lead passes through the placenta and may cause foetal damage. Certain lead salts have, in animal experiments, been proved to cause reproductive disturbances and skeletal malformations, as well as affecting the behaviour of offspring.

The IARC concludes that there is sufficient evidence to regard inorganic lead compounds as definitely causing cancer in animals, but that there have been no epidemiological investigations permitting conclusions on the carcinogenic properties of lead compounds in humans (IARC 1987). However, there are studies indicating an excess frequency of cancer of the alimentary tract, stomach, kidneys, bladder and respiratory system after employment in the mining industry, in particular. KemI is currently investigating whether there is reason to classify inorganic lead compounds as carcinogenic.

Exposure to lead via water and food is comparatively low in Sweden. Large-leaved vegetables grown near main roads, like food from lead-soldered tins, may nevertheless contain high concentrations of lead. According to the National Food Administration's proposals, the 1983 MACs for lead in various foods will be lowered. Approximately 85 % of our lead intake is derived from our food and the remainder from the air we breathe.

Exposure in the external environment takes place mainly through air and soil. Discharges into the atmosphere have been reduced, very much owing to the lowered lead content of petrol. Where soil is concerned, small children are regarded as the most sensitive group. Soil from a park in central Stockholm, for example, has proved to contain high concentrations of lead.

As an example of miscellaneous non-industrial exposure to lead, mention may be made of a Danish investigation demonstrating the presence of lead in indoor dust. The sources of this lead have not been established with any certainty, but atmospheric deposition, flaking paint containing lead and lead-stabilised PVC are mentioned as probable sources. Exposure to lead may also occur, for example, as a result of polishing, scraping and painting with paints containing lead.

With respect to industrial exposure to lead, inhalation of dust or smoke containing lead is the principal means of exposure. The National Board of Occupational Safety and Health's regulations concerning lead (SFS 1984:12) prescribe, for example, checks on the content of lead in workers' blood where they may have been exposed to lead.

Lead checks covered 3,503 people at 424 workplaces in 1989. Of these, 32 had at one time or another a blood lead concentration of >3.0 µmol/l, which is the limit for redeployment; 132 had >2.5 µmol/l and 410 >2.0 µmol/l. Blood samples from workers at accumulator factories showed the largest number of concentrations, > 3.0 µmol/l. Other industries where raised blood lead concentrations occur are lead-smelters, metal foundries, scrap-processing works, glassworks and factories producing plastics and paints.

DISPERSAL IN AND EFFECTS ON THE EXTERNAL ENVIRONMENT

Direct dispersal in the environment

Lead is released into the air from car exhausts, smelting works, ironworks, mines, incineration plants and, for example, glassworks and rubber factories. The total amount of lead discharged into the atmosphere was estimated at 720 tonnes in 1987/88. Road vehicles accounted for 80 % of this figure. Most of the lead derived from road vehicles is deposited on the ground in the immediate vicinity of the road. The remainder may, however, be transported over long distances. Airborne lead can be absorbed via the lungs. Lead is also deposited on plants and can be absorbed by animals via the alimentary canal if the plants are eaten.

With ammunition and, for example, flaking lead-containing paint, lead is dispersed above ground. Lead shot may be eaten by birds, and this

has given rise to problems especially in wetlands. A single lead shot may be a lethal dose. Birds of prey may be indirectly poisoned by lead shot as a result of eating lead-poisoned animals or prey in which lead shot is embedded. There are indications, for example, that golden eagles have indirectly succumbed to lead poisoning from shot.

The soil receives airborne lead, lead dispersed above ground and lead released directly into the soil in the form, for example, of lead compounds in fertilisers and landfill materials. Most lead in the soil is bound to organic material, and lead concentrations in forest land are therefore highest in the uppermost layers, i.e. the raw humus. The substances in humus are gradually leached downwards in the soil, taking the lead with them. For the most part, however, these substances are deposited in the mineral layer. The components of humus are degraded sooner or later, but the lead may remain in this relatively superficial layer for a very long period. In the soil, lead may be assimilated by living organisms.

The lead content of soil is increasing. Measurements at Värsjö in Skåne in 1978-81 showed that the available lead content of soil there was increasing by 0.2 % annually. Investigations in the reference areas of SNV's PMK programme (for monitoring environmental quality) and close to a number of natural sources showed lead concentrations in raw humus of a few mg/kg of dry weight up to more than 100 mg/kg of dry weight. Concentrations in roadside and industrial sites may, however, be considerably higher (e.g. 500 mg/kg of dry weight in raw humus 6 metres from the E4 motorway in Småland, southern Sweden).

The impact of lead on soil respiration and thus the release of nutrients is probably slight in normal forest land. An investigation of soil beside a road with lead concentrations of up to 500 mg/kg of dry matter in the raw-humus layer gave no clear evidence of an impact on soil respiration. However, the toxic effects of the lead may have been hidden by other road pollutants that raised the pH and calcium content of the soil. Studies involving the addition of lead to various soils have shown that lead concentrations must be high to disrupt soil processes if the soil is not deficient in humus or clay or has a very low pH value.

One investigation in an area of sandy soil (pH-$CaCl_2$ 3.9) contaminated by lead shot showed that the lead in the soil was bioavailable. The lead shot had presumably been converted into Pb^{2+} absorbed by, for example, earthworms and plant roots. These then serve as food for small rodents and shrews, which showed greatly raised lead concentrations in the liver, kidneys and bone tissue. Moreover, a study of forest fertilisation with municipal sewage sludge in the USA showed absorption of lead by lower mammals, but this study did not describe soil conditions.

Since lead is bound hard in normal soils, plant absorption is low. The lead absorbed seems to be rapidly assimilated into the cell walls, and lead is normally transported within the plant organism only on a small scale.

The fact that lead lodges in soil means that concentrations in the groundwater are normally low. However, acidification may affect the mobility of lead. In groundwater with a pH value of 4-5, one study showed average lead concentrations three times that in groundwater with a pH value of 6-7.

Lead can enter surface water by means of run-off from surrounding areas, direct deposition of airborne lead and direct discharges. Direct inputs of lead into water amount to some 20 tonnes p.a. These discharges come from mining waste and the mining industry, various other industries and sewage-treatment works. There is also an input in stormwater that has not passed through any treatment plant. The scale of this input is unknown, but assessments in Lake Mälaren indicate that the input of lead with stormwater may be 10 tonnes p.a. to that lake alone. The lead in stormwater is largely derived from lead in petrol. Direct deposition of airborne lead on the surfaces of lakes may often exceed the input in run-off water.

In a survey of some 80 Swedish lakes in 1980, the average lead concentration in the counties of Halland and Småland was 0.7 $\mu g/l$, and

in Västmanland and Lappland 0.4 $\mu g/l$. These were winter values; summer values are normally slightly lower. The lead concentrations in lakes are to some extent pH-dependent, but also depend on the humus content. Lead concentrations are higher in humus-rich lakes than in those with a low humus content. In lakes, part of the lead is deposited in sediments.

The highest test results for acute toxicity of inorganic lead have been obtained in lake dwelling invertebrates with LC_{50}-values of some 100 $\mu g/l$. Sensitivity is generally higher for organic lead. The highest acute toxicity of tetraethyl lead has been shown in fish and crustaceans, with LC_{50} at 20 $\mu g/l$.

Atmospheric deposition accounts for some 95 % of the total anthropogenic input of lead into our marine areas. In the Baltic, the deposition level is high and the lead remains in the water for 0.4 years. In one Baltic survey, the concentration of soluble lead in the water was found to be 0.08-0.21 $\mu g/l$, and in the coastal sediment lead concentrations were 32-230 mg/kg of dry weight. Near one industrial discharge point in the Baltic, however, 5060 mg/kg of dry weight was found in the sediment in 1980. In the same area, the lead concentration found in sea mussels was 380 mg/kg of dry weight, against 2-4 mg/kg of dry weight in the less affected parts of the Baltic.

In the Rönnskär area there are direct discharges of lead into water. There, an increased incidence of spinal injuries has been noted in the four-horned sculpin (a species of bullrout) with moderately raised lead and cadmium concentrations. Lead may thus be a critical factor.

Dispersal from waste incineration, deposition and sewage-treatment plants

Plastic, glass, paint, weights, accumulators, electronic appliances, etc. generate lead-containing waste that is disposed of. Accumulators must be treated as environmentally hazardous waste. Lead-containing waste produced in manufacturing industry is also classified as environmentally hazardous. This may be, for example, metal-hydroxide sludge, melted glass or paint sludge. Environmentally hazardous waste is deposited or incinerated. With respect to accumulators and, to some extent, construction materials containing lead, the recovery rate is high.

Non-hazardous waste contains just under 2,000 tonnes of lead p.a., of which roughly half goes to waste incineration and the rest is deposited directly. After incineration, about 90 % of the lead is contained in the slag and roughly 10 % in the dust from the flue-gas scrubbing process. Atmospheric emissions amount to some 10 tonnes p.a. Slag and dust from incineration are used for landfill.

What happens to lead that is deposited varies according to the nature of the individual landfill and what is deposited there. The availability of deposited lead also varies over time, as the landfill undergoes different phases.

The leaching of metal from a landfill that does not contain significant quantities of industrial waste follows a "bathtub-shaped" curve. At a relatively early stage in the existence of the landfill, an acid phase commences as a result of the formation of organic acids. As the pH value of the leachate falls, a mobilisation of metals may take place. The acid phase is followed by a methane phase in which the acids are converted into methane and carbon dioxide; the pH value rises and the redox potential falls. The metals are precipitated as sparingly soluble sulphides. With respect to lead, sorption to active iron-exchange groups in the waste may be an important mechanism of deposition. Leaching is very low during the methane phase. Finally, a maturity phase in which biological activity declines and redox potential increases takes place. Metal sulphides may be oxidated, forming sulphates, with increased metal-leaching as a result. Residual organic material is transformed into humus-like substances that may form complexes with metals, thereby helping to mobilise them.

Metal may leach from environmentally hazardous waste in various ways. Leaching from metal-hydroxide sludge is determined by the solubility of the metals in the leachate, and is thus proportional to the flow of leachate. From solid particles, such as paint sludge, leaching is greatest initially and subsequently diminishes, since the metals in

the surface layer of the particle are more readily available than those further inside the particle.

Metal-hydroxide sludge and paint sludge are regarded as potential candidates for mixed-waste landfill with household waste, in which some sorption of metals is possible provided that the pH value exceeds about 5. However, excessive metal concentrations may affect biological activity, preventing the establishment of a stable methane phase.

Slag and dust from incineration are deposited. In this material, the concentration of organic material is very low, and the dust particles in particular are small, with the result that metals leach out relatively easily. In Sweden, there are 24 landfills where dust from flue-gas scrubbing is deposited. The extent of the metal-leaching depends on the manner in which deposition takes place.

Lead can spread from landfills via leachate and dusting, and enter the atmosphere as a result of uncontrolled fires. How far it spreads depends, as we have seen above, on such factors as what has been deposited, the configuration of the landfill and its age.

In 1985, there were a total of 400 landfills in Sweden. At 300 of these, leachate was taken care of; at the remainder, it was released directly into the countryside. The same applies at a large number of old, disused landfill sites. Much of the lead dispersed in the natural environment is deposited in the soil or sediment in brooks relatively near the landfill. The size of the area actually affected depends on such factors as the ground's capacity for sorption of metals and sedimentation conditions in watercourses.

There are more than 1,200 sewage-treatment plants in Sweden. Around 80 % of the total incoming lead comes with waste water, and the rest with chemicals added at the sewage-treatment plants. Just under 50 % of the lead in waste water comes from industry and the remainder from stormwater, households, etc. After treatment, 90 % of the lead remains in the sludge, while 10 % is washed out with the purified water. The total amount of lead discharged in water from Swedish municipal sewage works is 1-5 tonnes p.a. The lead concentration in sludge is 50-300 mg/kg of dry weight, and the total quantity of sludge is just under 200,000 tonnes of dry weight p.a. This means that the sludge from Sweden's sewage works contains lead in the order of 30 tonnes p.a. Of this lead, 60 % was spread on agricultural land in 1985, while 30 % was deposited and 10 % used for green open spaces.

PETROL

Incidence

Lead is used in petrol in the form of tetraethyl lead and tetramethyl lead. In 1988, discharges of lead from road transport amounted to about 600 tonnes. In unleaded petrol, the maximum permitted lead concentration is 0.013 g/l. According to the Ordinance on Motor Gasoline (SFS 1985:838), motor fuel that is not unleaded, or that contains a higher percentage of benzene by volume than 5, may not be produced, imported or sold for commercial use in Sweden. However, transitional regulations allow 98-octane petrol to be imported, produced and sold if the lead content does not exceed 0.15 g/l. In older vehicles that cannot be run on unleaded petrol, the function of the lead is to raise the octane rating, thus counteracting the "knocking" or detonation tendency. Another function of the lead is to lubricate the valves.

The use of leaded petrol is decreasing as new cars supersede old. All new vehicles in Sweden, with effect from 1989, are equipped with catalytic converters and must therefore run on unleaded petrol. However, the average life of Swedish cars is high and road vehicles will therefore cause discharges of lead over a long period unless the lead in petrol is replaced. "Marine 90 - Action Programme Against Marine Pollution" indicates an expected decrease in annual lead emissions from road vehicles by some 360 tonnes between 1988 and 1995. This would mean that car exhausts would still, in 1995, be the largest source of lead discharged into the atmosphere.

Exposure

With car exhausts, lead is spread in the atmosphere mainly in the form of lead halides and as a double salt with ammonium halides.

Atmospheric lead can be absorbed through the lungs, and is also deposited on plants and the ground. Absorption through the alimentary canal takes place when the plants are eaten. Children can also ingest lead by eating soil. The lead that is not deposited in the immediate vicinity of roads may be dispersed very widely.

Alternatives

Alternatives to lead in petrol are currently available. Since June 1989, one oil company has been selling unleaded petrol with a 98-octane rating. The octane rating has been raised without an increase in the content of aromatics. Within the immediate future, several other major oil companies should also be launching unleaded 98-octane petrol. This grade can be used for cars requiring octane ratings of over 95 but in which the valves do not require lubrication.

The lubricant effect of the lead may be attained with other additives, and several such additives have been produced. There is, for example, a sodium-based additive that is currently used in Austria. The company that manufactures the additive has an agency in Sweden, but no sales as yet. An additive with a lubricant effect costs only a few öre (SEK 0,02) per litre of petrol.

Producing an unleaded petrol with a high octane rating without raising the content of aromatics is relatively expensive. Today, the Swedish tax differential between unleaded and leaded petrol is 30 öre (SEK 0,30)/l inc. VAT). Nevertheless, the unleaded 98-octane petrol costs the consumer about 7 öre (SEK 0,07) more per litre than the leaded 98-octane petrol.

Proposals

In order to hasten the trend and promote the use of petrol without lead additives, we recommend that the government submit a bill to the Riksdag introducing a larger tax differential between leaded and unleaded petrol. This differential should be large enough for unleaded petrol always to be a good deal cheaper for end users than the corresponding leaded quality. This means that unleaded 98-octane petrol, too, should also be markedly cheaper for consumers than leaded premium petrol. The present tax differential should therefore be increased enough to ensure that this is so.

The National Board for Consumer Policies should, after consultations with the automotive and oil industries, provide consumer information on fuel options.

If, one year after implementation, these measures have not brought about the desired increase in the sale of unleaded petrol, SNV will take further steps, including an overview of the temporary provisions in the Ordinance on Motor Gasoline (SFS 1985:838). These transitional provisions permit the importation, production and sale of leaded petrol at present.

Background

Road vehicles appear likely, at least for most of the 1990s, to be the largest source of lead discharges into the atmosphere if no measures are adopted. It is therefore essential for the development and use of petrol without lead additives to be speeded up. This may be effected by removing the temporary provision permitting leaded petrol to be imported, produced and sold. Alternatively, the tax differential between leaded and unleaded petrol may be increased. In order to maximise the environmental gains thereby made, rapid implementation of the measure chosen is required. An increased tax differential, which could be effected in one year, is therefore recommended in preference to a cancellation of the temporary provision, which is likely to take longer.

In order for the tax differential to exert the desired effect, it must be made large enough to cover the additional costs of producing an environmentally acceptable 98-octane unleaded petrol, and also provide scope for a differential in consumer prices. If all unleaded petrol becomes significantly cheaper than the corresponding leaded alternatives, demand for unleaded petrol will increase. By the same token, this would enhance motivation to provide unleaded alternatives for all vehicles on the road (and this would then also include the introduction of alternative lubricants).

In all the other Nordic countries, the tax differential between leaded and unleaded petrol is greater than in Sweden. In Denmark, the differential is equivalent to about 65 Swedish öre, SEK 0,65, (May 1990). There, this large differential combined with a public information campaign has led to an obvious increase in the demand for unleaded petrol. It would appear that an increase in the Swedish tax differential to at least the Danish level is required in order for the measure to have the desired effect.

The increased tax differential is expected to result in the provision of unleaded petrol for all vehicles on the road, and cause motorists to switch to unleaded petrol. SNV should, if necessary, take additional steps, including a review of the transitional provisions in the Ordinance on Motor Gasoline. At an early stage, the automotive industry should be informed about the purpose of these measures, so that it is prepared for these temporary provisions to be cancelled. Accordingly, a cancellation can be effected rapidly.

Consequences

The increased tax differential may initially entail extra costs for motorists who cannot use petrol without lubricants. The extent of these consequences depends on how rapidly alternative lubricants are launched on the Swedish market.

Since an environmentally acceptable unleaded 98-octane petrol is relatively expensive to produce, some supervision of petrol quality may be required in order to ensure that the octane rating is not raised by means, for example, of a higher benzene content than that of present-day leaded 98-octane petrol. However, some supervision may be needed even in the absence of the measures proposed, since several petrol companies are likely to launch a 98-octane unleaded petrol of their own accord.

LEAD SHOT

Incidence

Roughly 500-600 tonnes of lead is used annually in Sweden in shot cartridges for hunting and sport shooting. Lead shot is no longer manufactured in Sweden; on the other hand, imported shot is inserted in cartridges in one factory. Imported shot cartridges make up the majority of those used; this is due to cheap shot cartridges imported from Eastern Europe.

A quantity in the order of 300 tonnes of lead is used annually for bullets. Domestically produced lead wire is used as a raw material, and the import share is small. The lead used in both shot and bullets is alloyed with about 1 per cent antimony and arsenic.

An estimated 75-80 % of lead ammunition is used in limited areas for shooting practice. Consequently, the corresponding proportion of lead is deposited on the ground in these practice areas. According to information received, there is no recovery of lead from these areas at present, although occasionally the target area at a shooting range may be cleared of bullets for safety reasons. The recovery of lead in the bullets is impeded by the fact that they are usually enclosed in copper, which makes metal separation necessary.

Exposure

In the manufacture of lead-shot cartridges, lead dust is a working-environment problem. Critical stages of the work are associated with the handling of the shot bags, during which employees may be exposed to the lead-containing dust. Exposure may be checked by means of blood tests.

An estimated 100 tonnes of lead is released annually as a result of hunting in Sweden while the remainder, roughly 400-500 tonnes, is used on shooting-ranges for sport shooting and shooting practice.

Birds can eat shot, and those particularly exposed to this risk are seafowl. A single shot may be a lethal dose. Birds of prey may be poisoned by lead shot that has lodged in the muscles of wounded prey animals. They may also be indirectly poisoned by consuming lead-poisoned prey. The peregrine falcon, the white-tailed or sea eagle and the golden eagle are among those birds of prey at risk from lead shot.

On the ground, the metallic lead may undergo conversion. In a Danish investigation of shooting-ranges on four different ground types, 5-17 % of the lead shot in the ground had been converted in 6-13 years. Another study has shown that small rodents and shrews in a lead-contaminated area had markedly raised concentrations of lead in the liver, kidneys and bone tissue. There, the lead in shot had probably been transformed into Pb^{2+}, which was absorbed by earthworms, plant roots and other organisms that were subsequently eaten by the small rodents and shrews.

The environmental effects of lead bullets, at least in the short term, are less perceptible owing to the size of the bullet, the copper casing, the areas of use and the smaller total quantity.

Alternatives

Iron shot has already, to some extent, replaced lead shot, especially in Denmark and certain states in the USA, where restrictions have been imposed on the use of lead shot. In Sweden, too, small amounts of iron shot are used.

Proposals

Lead shot and lead-shot cartridges may not be manufactured, imported or sold after 1 January 1996. We recommend that the government issue provisions pursuant to the Act on Chemical Products. KemI will attempt to induce the organisations concerned to take the initiative, on a voluntary basis, for a more rapid change-over to iron-shot shooting at shooting-ranges and in particularly sensitive areas.

This prohibition is justified by the fact that the release of lead into the environment in the form of shot takes place on a large scale and has been proved to have undesirable effects on animal life, in particular.

The recommended date when the prohibition should become effective, 1 January 1996, is justified as follows:

- The change-over to iron shot must be regarded in shooting training, and the interest organisations affected need time to inform and to train their members.

- Hunters should be given the opportunity to become accustomed to iron shot in the course of a reasonable transition period.

- In sport shooting, where iron shot has not been used to date, time is required for adjustment to the new ammunition.

- The Swedish sport-shooting organisation should, during the transition period, have an opportunity of working in its international association for a change-over to iron shot in sport shooting.

- Sufficient adaptation of the arsenal of weapons currently in use to the requirements imposed by the use of iron shot must be feasible.

- Manufacturers of shot cartridges must have time to adapt their production to iron shot and also be given an opportunity to develop new iron-shot grades.

At shooting-ranges, where the bulk of lead shot is used, a transition to shooting with iron shot should be possible with a shorter transition period than that proposed above. Similarly, it is particularly urgent that there should be a rapid switch to iron shot for hunting in particularly vulnerable areas (wetlands). However, differentiated regulations are not considered feasible, owing to the difficulty of following up and checking compliance with such regulations.

Consequences

A ban on the use of lead shot means that lead in the form of shot is no longer released into the environment. This does not, of course, eliminate the environmental effects caused by lead shot that has already entered the environment.

A shift in shot-cartridge production to iron shot in Sweden does not require large-scale technical production measures or investments. At present, iron-shot cartridges available on the market are slightly more expensive than lead-shot cartridges. Nevertheless, it is reasonable to assume that the price of iron shot will fall when its production increases and production costs can thereby be reduced. However, in the short term sport-shooting enthusiasts, who use a great deal of ammu-

nition, may incur increased costs. For regular hunting purposes, on the other hand, the cost increase is marginal.

At present, the use of lead shot in sports shooting is relatively extensive: iron shot has not been used on any significant scale in Sweden to date. On the other hand, it has been used in Denmark for competition purposes without any major problems. For weapons used in certain types of competition, using iron shot may entail major or minor problems, owing to e.g. narrow-bore gun-barrels.

If an international agreement on the transition to iron shot in sports shooting has not been attained by 1996, i.e. when the lead-shot prohibition should come into force, dispensation proceedings may be necessary in view of international competitions. At present, about 100 Swedish marksmen compete with shot weapons in various events at international level.

Iron shot differs, of course, in its technical properties from lead shot. However, the shooting technique is broadly the same. Surveys to date have not succeeded in demonstrating any significant differences in wounding frequency between iron and lead shot.

Higher gas pressure and narrow-bore barrels may mean that the use of iron shot causes greater wear and tear on the weapon.

At present, there is no supervision of shot weapons and ammunition sold in Sweden, in contrast to the situation in most other countries. Such supervision would make it possible for the hunter/sport shooter to ensure that his weapon and ammunition are compatible. The situation today is such that the shot consumer is obliged to rely on the trade description he receives. If iron-shot cartridges with considerably higher gas pressure than for lead shot are used, the weapon should be pressure-tested if this has not been done, or if it has been done at insufficient pressure.

Pursuant to the Product Safety Act (1988:1604), traders can be enjoined to provide safety information about their products. This applies, of course, to the sale of shot cartridges as well. The National Board for Consumer Policies may, if necessary, initiate negotiations with dealers with the purpose of obliging them to give consumers correct information. The Board can then take the matter to the Market Court for decision.

At present, it is difficult to estimate how large a proportion of shot weapons are unsuited to iron-shot use. Weapons used for competition purposes are often of such a quality that iron shot entails no major problems, while older weapons designed for hunting, in particular, suffer more wear and tear. Weapons of a newer type are, as a rule, pressure-tested and have an iron-shot capability. Pressure-testing takes place at pressures considerably exceeding those produced by iron-shot cartridges.

At present, no systematic pressure-testing of weapons currently in use is carried out, but according to information received it should be possible to arrange this adjacent to weapon workshops. Many of the shot weapons used by hunters today are of a more modern type, and these should also withstand a higher gas pressure. A change-over to iron shot therefore does not entail increased weapon costs for all the shot marksmen in the country. A new weapon suitable for iron-shot use costs from about SEK 4 000 upwards. A narrow-bore weapon may be given an iron-shot capability by drilling the barrel wider, which may cost an estimated SEK 1 000.

It is essential for shot marksmen to be well informed before a change-over to iron shot. In this context, it is important to provide information on how well suited various shot weapons are to the use of iron shot.

Iron shot in timber may possibly cause minor damage to certain tools used in the woodworking industry, unlike lead shot which, owing to its softness, has no damaging effects. In the industry, misgivings have been expressed that iron shot might cause problems in planing and veneer manufacture, since the tools used are sensitive and might possibly be damaged by individual pieces of shot. In sawing and wood-chip production, the tools used are less sensitive; accordingly, problems are unlikely to arise in these cases. It has not been estab-

lished whether iron shot penetrates further into tree-trunks than lead shot, but it appears probable that most of the shot remains in the bark, and is therefore discarded when the timber is barked. In practice, shot is very seldom found in timber, and a switch to iron shot should have very little bearing on the profitability of the industry.

Summing up, the transition to iron shot is thus primarily a question of cost, since shooting with iron shot probably shortens the service life of weapons slightly, or - in other words - causes a somewhat faster depreciation in their value.

ACCUMULATORS

Incidence

Lead is used in accumulators in the form of pure lead, lead oxide and lead sulphate. The electrodes in an accumulator contain lead, alloyed with small quantities of antimony. Accumulators may be divided into three types: storage batteries (in vehicles), traction batteries (in trucks and electric cars) and stationary batteries (reserve sources of electricity at factories, hospitals, etc.). Altogether, roughly 22,000 tonnes of lead is used for the production of accumulators annually. Imports exceed exports, and the net of lead imported in accumulators is some 5,000 tonnes (1988). Two companies in Sweden manufacture lead accumulators for both industrial use and vehicles.

Exposure

In the manufacture of accumulators, lead is released into both air and water. The lead discharged by the Swedish industry in 1988 amounted to some 0.2 tonnes into the air and about 0.4 tonnes into water. In addition, minor discharges of lead in the form of dust also probably take place. At the Swedish recovery plant for lead, where roughly half the raw material comes from accumulators, lead discharges in 1988 were approximately 1.2 tonnes into the air and 0.01 tonnes into water. Lead exposure occurs at certain phases of the process of accumulator manufacture. Employees' exposure is checked by means of blood tests, and accumulator manufacture is among the industries in which the highest lead concentrations in employees' blood have been found. Lead exposure is due mainly to inhalation of dust containing lead.

Lead batteries do not cause lead discharges during use, but when discarded they give rise to lead-containing waste. Batteries that are not collected for recycling go with other waste to incineration plants, are dumped on landfills or ended up as litter in the natural environment in some other way. More than 1,000 tonnes of lead is released annually, despite recycling.

Alternatives

Research and development work on accumulators has been under way for many decades, and numerous types of battery have been produced. Among these is the nickel/iron accumulator, which could replace the lead battery in traction applications. The nickel/iron accumulator has high energy density and a long service life, but is considerably more expensive than the lead accumulator. Nickel/iron accumulators are not made in Sweden, but production is planned abroad. Another accumulator is the nickel/cadmium accumulator, which in many respects has good technical characteristics but is as undesirable as the lead accumulator from the environmental point of view. It should be noted that measures against the use of lead accumulators may result in a change-over to nickel/cadmium accumulators, and vice versa. Moreover, there are a number of other batteries on which research is being, or has been, carried out: these include nickel/hydride accumulators, sodium/sulphur accumulators and accumulators with polymer electrodes.

Alternatives to lead batteries are currently being developed, especially for traction applications since it is essential to find batteries with high energy density for electric cars. Where storage batteries are concerned, there is in practice no substitute for the lead battery at present. Virtually no development work on alternative storage batteries is under way, since the lead accumulator is priced considerably lower than conceivable alternatives.

With respect to storage batteries, the potential of research and development to devise alternative systems for starting engines, whereby vehicles can be equipped with smaller storage batteries or, indeed, manage without them altogether, must also be taken into account.

In the short term, an intensified collection of used lead accumulators appears to be the most efficient means of tackling the environmentally detrimental impact of discarded batteries. The Swedish lead-recycling plant has the capacity to process a larger number of scrapped accumulators than it is handling at present.

In 1988, SNV proposed to the government measures to reduce environmental disturbances resulting from lead batteries. These measures related to collection, liability and legislation. The proposal involved, for example, levying an environmental charge on storage batteries imported or manufactured in Sweden for use in this country. The charge is to be paid by producers and importers and administered by a company formed for the purpose, Returbatt. It was proposed that the charge should finance increased compensation to companies that receive, store and transport batteries for final disposal. It was also proposed that this charge should finance the consumer information required, the reception centres and other forms of support for collection.

When the system came into use, the proportion of returned batteries was 60 %. At present, the number of storage batteries collected exceeds the number of new storage batteries sold. This may be explained by the fact that consumers have stored discarded batteries for a long period.

Proposals

In the long term, the use of lead accumulators must cease. We recommend that the government give the National Board for Technical Development (STU) a directive to initiate technical development projects and to monitor and evaluate technical development with respect to alternative accumulators and alternative starting systems for vehicles. KemI and SNV intend after further consideration, and on the basis of the results of that work, to suggest a date for the cessation of lead-accumulator use.

In the short term, the collection of accumulators and recovery of lead in accumulators must increase. This may be achieved by means, for example, of environmental charges to finance the collection procedure and of returnable deposits to give consumers an incentive to hand in their accumulators. If environmental charges alone are insufficient to attain a continuous collection rate exceeding 95 %, supplementing the system by returnable deposits on accumulators, is recommended. Work to enhance collection efficiency should follow the guidelines proposed by SNV that are currently undergoing evaluation.

Explanatory statement

The lead accumulator is cheaper than conceivable alternatives and, in most applications, has satisfactory technical characteristics. Environmental arguments alone do not provide enough of a driving force for alternatives to be developed. A year by which the use of lead in accumulators must cease would give an effective boost to research and development in the field. It has not been possible, within the scope of this remit, to specify a year for the cessation, since more thorough technical assessments than have been feasible are required.

Environmental charges aimed at promoting a change-over to alternatives have not been considered realistic, since they must be made very heavy in order to have the desired effect.

Since research and development are required, the period between now and the year of cessation will probably be relatively long. Effective recovery of lead accumulators is therefore essential in the meantime.

Consequences

A phase-out of lead accumulators would entail a considerable overall decrease in lead use. A more detailed appraisal of consequences cannot be made until a proposal of a date by which lead-accumulator use should have ceased is presented.

Environmental charges and returnable deposits will raise the price of accumulators. This should hardly affect sales as long as there is no alternative; instead, the sole effect should be to raise the collection rate. To the motorist, the cost of an accumulator is relatively marginal, and this fact is unlikely to be altered by environmental charges and returnable deposits.

Increased recycling of accumulator lead means that the use of raw lead can be reduced.

LEAD-SHEATHED CABLES

Incidence

The cable industry uses lead for sheathing direct-current power cables and telecom cables. Lead sheathing is used mainly for cables for underwater use, i.e. "marine cables". Lead-sheathed underground cables are still used, however, in certain distribution networks. When they are replaced, it is largely by non-lead-sheathed cables. In other countries, lead sheathing is used for certain types of underground cable on a considerably larger scale than in Sweden.

The reasons why lead is used for cable-sheathing are that lead provides a reliable barrier to moisture and good mechanical protection, and that lead also has good electrical characteristics for d.c. use. Moreover, it is highly durable and does not corrode.

Lead is used alloyed with silver and tin to strengthen the sheath. The lead sheathing on marine cable is very seldom in direct contact with water because there are protective layers outside the actual lead sheath. In large power cables, there may be more than 10 protective layers. The most frequently occurring layer consists of oil-impregnated paper, impregnated crêpe, bitumen, etc.

Some lead-sheathed cable is imported, mainly from Eastern Europe owing to low prices there. The major manufacturers' average annual consumption of lead for cable-sheathing amounts to about 1,500 tonnes. The quantity may vary greatly, depending on sporadic major orders. In PVC-insulated cable, an additional 50 tonnes or so of lead compounds are used annually as stabilisers. Roughly half of domestic production is exported. It may also be mentioned that domestic lead producers export lead for cable-sheathing.

The technique for recovering cable lead has been improved in the past few years, and combined with favourable price trends for lead this has made recovery profitable. It has also proved possible to export scrapped cable. Between 1,000 and 2,000 tonnes of lead from cable is recovered annually, and used for various purposes, such as the production of new cable sheathing or boat keels.

Exposure
No figures on lead discharges into water and air during cable manufacture are available. The discharges are probably small, since it is a matter of pressing heated lead onto the cable. During production, some scrap containing lead is formed; this is recycled or sent to a lead-processing plant.

The lead from discarded lead-sheathed cables is largely recovered by scrap merchants, who either use the scrap-lead themselves or send it elsewhere for processing. However, it may be assumed that some sheath lead is released into the environment with building waste or other waste. Old marine cables are usually lifted when new ones are laid, but disused underground cables may remain in place.

Exposure to lead in cable manufacture occurs, but does not appear to constitute a major problem at present.

Alternatives
The use of lead for cable-sheathing has declined considerably in the past few years, and a continuous change-over to materials other than lead is under way. Polythene, PVC and aluminium are examples of materials that are replacing lead sheathing in several cable applications. The price of imported lead-sheathed cable is expected to rise in the long term; this, too, favours substitution. According to the cable manufacturers, however, it is difficult to find alternatives to lead sheathing for large marine cables.

This is because lead represents a combination of properties that other materials cannot match at present. For the time being, no large-scale research and development work aimed at replacing lead in marine cables is under way. However, it may be mentioned that fibre-optic cable for telecommunication may be sheathed in copper even when it is used as marine cable.

Proposals
All laying of new lead-sheathed underground cable must have ceased before the beginning of 1995. The most appropriate means of achieving this is for the industry to adopt its own measures. The use of lead for sheathing marine cable must cease in the long term. To achieve this, cable manufacturers must work to produce alternative, environmentally acceptable sheathing materials. SNV intends to propose a date by which the use of lead-sheathed marine cables should have ceased. Regardless of the change-over to non-lead-sheathed cable, the recovery rate of scrapped, lead-sheathed cable must remain high. SNV will monitor the recovery of cable lead continuously in order to be able to take measures if the prospects of recovery deteriorate.

Consequences
A shift from lead-sheathed underground cable to other alternatives involves higher costs in the short term. The price differential prevailing at present is, however, artificial since the lead-sheathed underground cable is usually imported from Eastern Europe at prices that may fall below production costs. The present-day price differential will therefore probably be evened out in the longer term.

GLASS

Incidence
Lead oxide is used as a raw material in the manufacture of glass batch for lead crystal. According to international norms, lead crystal is classified as heavy whole-crystal, whole-crystal and semi-crystal glass. The proportions of lead oxide in these types of crystal glass are 30 %, 24 % and 5 % respectively. However, in semi-crystal glass the lead may be replaced by other substances. The lead oxide gives the glass the desired thermomechanical properties and also sparkle and brilliance.

Sweden has one glass-batch manufacturer and some 15 glassworks, of which the ownership structure is concentrated. An estimated 1,000 tonnes of lead oxide is used annually for the manufacture of lead crystal. Glass imports considerably exceed exports, which means that the total annual quantity of lead in glass may be estimated at some 1,500 tonnes.

Exposure
Atmospheric discharges of lead from glassworks in 1988 amounted to roughly 3 tonnes, while lead discharges into water made up less than 2 tonnes. In the handling of the glass granulate, exposure to lead-containing dust occurs. Workers in glassworks have raised concentrations of lead in their blood.

Glass waste arising from the manufacture of glass contains lead and arsenic, and is classified as environmentally hazardous. It is transported to a landfill in Emmaboda, southern Sweden, where the waste deposited is banked in and covered with canvas.

Crystal-glass products have a long life but sooner or later enter household waste and are thus deposited directly on landfills or, via waste incineration, in the form of slag on landfills.

The leaching of lead from glass waste with a low pH value has been investigated, and found to depend on the size of the crushed fragments.

Alternatives
Lead-free semi-crystal glass is already being manufactured today, since international norms do not require a lead additive in semi-crystal glass. The manufacturers compensate for the absence of lead by using larger amounts of barium, potassium and zinc. The production of lead-free semi-crystal glass has increased in Sweden in recent years. Research into lead-free whole-crystal glass is also under way, but no market breakthrough is feasible here until the international quality system is altered.

Proposals
Sweden should work for changes in the international quality norms for crystal glass. The aim should be to reduce the content of lead in crystal glass considerably. Research and development work on lead-free crystal is being stimulated more than hitherto. The production of

semi-crystal glass containing lead in Sweden must be discontinued before the beginning of 1992. The most appropriate means of achieving this is for the industry to implement measures of its own. Manufacturers of semi-crystal glass are also recommended to begin informing customers that their products are free from lead.

Consequences
A change-over to lead-free semi-crystal glass does not entail higher production costs for the glass industry, and will therefore not result in raised prices of semi-crystal products. Moreover, the need to purify waste water and flue gases will diminish as a result of the change-over.

PLASTIC PRODUCTS

Incidence
Lead compounds are used as stabilisers and lubricants in the manufacture of PVC products, in particular, and as pigments in plastics. Stabilisers make up a few per cent and the lubricant about 1 per cent of the material.

As stabilisers, lead sulphate, phosphite, phthalate, stearate and carbonate are used. These lead stabilisers prevent the plastic from degrading at high processing temperatures by dealing with the chlorine radicals that form.

Lead stearate also has a lubricant capacity and may serve a dual function. Lubricant is added to plastic to improve its flow properties and reduce the tendency of the melted plastic to adhere to machine parts. Lubricant is also used in other thermoplastics, such as polystyrene and polyolefins, owing to high production rates and stringent quality requirements. Non-lead-containing compounds are the norm; lead compounds make up only a small proportion of the lubricants used.

Lead chromate and similar lead compounds are also used as pigments to colour plastic red or yellow. Inorganic pigments are generally used when processing temperatures are high and good opalescence is required.

The annual consumption of PVC in Sweden amounts to some 120,000 tonnes, of which an estimated 60 % is lead-stabilised. The annual consumption of lead compounds for this purpose is around 2,000 tonnes. In addition, lubricants and pigments used are thought to amount to some 300 tonnes p.a. When these are added to PVC, PVC compound - a semi-finished product in plastics manufacture - is obtained. This compound is produced either by compound manufacturers or by producers of plastic products themselves.

Lead-stabilised PVC is used mainly for production of cable-insulation, pipes and profiles for in- and outdoor applications. In Sweden there are some ten major manufacturers of these products, and they produce the compound themselves. There are also two Swedish compound manufacturers which do not produce plastic products. These compound manufacturers have an estimated 200 customers. Imports of lead-stabilised compound make up just under half of total consumption. Lead-stabilised PVC is also imported in the form of finished products, such as pipes and cables. The lead-containing additives are mainly supplied by foreign companies.

Exposure

The manufacture of plastic products and compound gives rise to solid waste that may be partially reused in the manufacturing process. Discharges into air and water are insignificant. Lead-stabilised PVC products are generally durable, but in the long term they are deposited on landfills or incinerated with other waste. Only small amounts of lead-containing additives leach out of PVC under normal conditions. In incineration, some 80 % of the lead enters the slag. The lead load on the environment derived from PVC is thus connected with landfill management.

Lead-containing additives are usually in powder form, and the dust constitutes a problem of the working environment when additives are used. On the other hand, levels of exposure to lead-containing dust are considerably lower when PVC compound is used, since this is normally supplied in the form of granulate.

Alternatives

In pipes and cables, a steady transition to stabilisers based on calcium zinc and polyols is taking place. Restraining factors are the highe price and, to some extent, the superior properties of lead. Alternative to lead pigments are organic colorants, such as azo pigments. Organi pigments are more expensive, but the demand for lead-free pigment is growing.

Another alternative is to replace PVC by other materials. The Swedis packaging industry has voluntarily undertaken to develop alternativ materials and replace PVC plastic in packaging by the end of Jun 1990 at the latest.

Increased recovery of plastic from the products concerned is also con ceivable. In West Germany, for example, there is a company speciali sing in recovering PVC from cables.

Proposals

A joint proposal concerning restrictions on plastic additives will b drawn up by KemI and SNV. They will propose a date by which th use of lead-containing plastic additives must be discontinued. Th work is to be commenced during the 1990/91 fiscal year.

PAINT, LACQUER AND RUSTPROOFING AGENTS

Incidence

Lead is used in paint in certain pigments and in drying agents (sicca tives). Drying agents are used in solvent-based paint. Lead is als used for rustproofing. The lead content in paints, lacqenrs and rust proofing agents that are both manufactured and imported is currentl 100-1,500 tonnes, comprising 20-650 tonnes in pigments, 30-150 i drying agents and 50-700 tonnes in rustproofing agents.

Twenty-five different lead compounds, as well as pure lead, are use in paints and lacquers. In terms of weight, the predominant com pounds are lead chromate, lead diethyl hexanoate (a drying agent), lead chromate molybdate sulphate red and lead sulphochromate yellow. In rustproofing agents, lead oxide (red lead) is mainly used.

In Sweden there are some 15 manufacturers and about 40 importers of paint containing leaded pigments and/or drying agents. About one-quarter of the lead-containing paint used in Sweden is imported. Exports of lead-containing paint are on a small scale - less than 15 tonnes of lead p.a. Lead paint is also imported and exported on ready-painted products.

For the manufacture of rustproofing agents, 46-610 tonnes of red lead is used annually. The imported quantity of red lead in rustproofing agents is 4-77 tonnes. According to the products register, Sweden has seven producers of rustproofing agents and paint containing red lead.

Paint manufacturers in Sweden have concluded a voluntary agreement to stop using lead chromate by the end of June 1990. The use of lead chromate molybdate sulphate red and lead sulphochromate yellow will also diminish drastically by this date. Accordingly, only very small quantities of lead-containing pigments will remain in Swedish paint manufacture. The trend is also towards reduced use of lead in drying agents.

The biggest user of paint containing leaded pigments and drying agents is the metalworking industry (e.g. car-spraying). Small quantities go to households and professional painters. A total of 0.6-20 tonnes of lead is used annually in printing ink, mainly in the form of lead chromate. All printing ink is imported.

Roughly one-third of rustproofing agents go to private consumption (12-260 tonnes out of a total of 53-687 tonnes, according to the products register). The Swedish railway and road authorities, like the municipalities, are major users of red lead, which is used mainly for external renovation, where it is difficult to clean surfaces and red lead is superior to other rustproofing agents for this reason. In new engineering production, other rustproofing agents - often zinc-based - are almost exclusively used nowadays.

Outdoor steel structures corrode at different rates in different parts of the country. The west coast, in the south of Sweden, for example, is considerably worse affected than Norrland, in the north. On the west coast, repainting must take place relatively often even when red lead is used. If, with present-day options, a switch to another rustproofing agent were effected, repainting would need to be even more frequent. In other parts of the country, where steel structures are less exposed to corrosion by rust, there should be a greater potential for using other rustproofing agents.

Exposure

Workers in the paint industry may have blood lead concentrations exceeding 3.0 μmol/l. Exposure may also occur during application and polishing. In the blasting of surfaces previously treated with red lead, lead-oxide dust is formed.

The quantities of waste from paint manufacture are small. In industrial application, waste is generated in the form of paint sludge from spraying boxes, for example. This waste, like waste from the manufacturing process, must be treated as environmentally hazardous. To the extent that application or polishing takes place by uncontrolled means, there may be direct inputs into the environment.

Products with lead paint are very widespread in our society, and the same is therefore also true of the waste. It may be deposited directly in the natural environment (owing to flaking); it may also be incinerated or deposited on landfills.

Alternatives

Organic dyes, for example, are used as substitutes for lead in paints and lacquers. The paint then becomes more expensive, and its lustre is altered. Where drying agents are concerned, a number of other metals - such as molybdenum, cobalt and manganese - may be used. However, since function varies somewhat the choice is not entirely unrestricted.

The main alternatives to red lead as a rustproofing agent are zinc-based paints, such as zinc phosphate. Paints containing neither lead nor zinc are also conceivable, and one example is paint based on fish oils. Alternatives to red lead are more expensive and some necessitate more frequent repainting, which entails a further increase in costs.

The Swedish State Railways and its Fixed Installations Division co-operate with paint manufacturers in field trials of alternative rust-proofing agents. Testing alternatives takes a long time. Some exchange of information concerning rustproofing agents takes place between the railway authorities and the National Road Administration.

If the surfaces to be treated can be blasted, there is greater scope for replacing red lead as a rustproofing agent. One Swedish company is working to develop a robot that can blast lamp-posts and also paint them with rustproofing paint.

Proposals

KemI will monitor the change-over to lead-free pigments and drying agents in Swedish paint production. KemI will also work internationally for restrictions on the use of lead in paint.

The provision of lead-containing rustproofing agents in package sizes intended for the private consumer should be discontinued over the next few years. The most appropriate means of achieving this is voluntary agreements in the paint industry. Testing of lead-free rust-proofing agents and alternative application methods for large-scale use should continue. In addition, the major users of red lead should review their scope for using lead-free rustproofing agents even now, in those parts of the country where this is feasible.

LEAD-SOLDERED TINS

Incidence

Tinplate containers used for foodstuffs may be divided into two main groups: soldered and welded tins. The soldering material consists of lead or a mixture of lead and tin. The welding material used to seal welded tins contains only negligible amounts of lead. Virtually all food tins manufactured in Sweden are welded.

Roughly half of all tins on the Swedish market are imported. Of these, about 20-30 per cent are soldered with lead, which in round figures corresponds to 25 million tins annually. The lead content may be roughly estimated at 25 tonnes p.a.

The major wholesalers in the food industry carry out measurements to check the lead content of their imported tinned foods, and also place certain requirements on their suppliers concerning non-lead-soldered food tins. Nevertheless, a relatively large proportion of lead-soldered tins are imported. Lead-soldered tins are imported mainly from China and the rest of Southeast Asia, and from Eastern Europe.

Exposure

Lead may be released from the lead-soldered tin into the food contained therein. The extent to which this occurs depends partly on storage periods, the quality of the tin material and the type of food contained.

Foods packed in lead-soldered tins often contain lead concentrations of between 0.1 and 0.4 mg/kg, which is 5-30 times higher than the lead content in fresh or frozen foods. The MAC for lead in tinned foods is 2 mg/kg, according to the National Food Administration's directives of 1983 (1983:1). On occasions, this limit is exceeded. The cause is then usually tins with defective soldering where pieces of lead have become detached from the soldered edge and entered the food. The Food Administration is considering the option of abolishing the specific MAC for tinned foods. The same MACs as apply to fresh foodstuffs would then apply to tinned foods as well. These vary according to the type of food: large-leaved vegetables, for example, are subject to an MAC of 0.3 mg/kg, while for other vegetables and fruit it is 0.1 mg/kg.

The majority of lead-soldered tins enter household waste and are then deposited on landfills either directly or after waste incineration.

Alternatives

In Sweden, as we have seen above, no lead-soldering of tins takes place. The method used is welding. The proportion of imported tins that are lead-soldered has declined in recent years.

Proposals

We recommend that the government give the National Food Administration a directive to draw up a plan to phase out lead-soldered tins. Sweden should act internationally for a switch from lead-soldering of tins to other methods.

OTHER USES OF LEAD

Both metallic lead and lead compounds are used for many purposes other than those touched on above. It is very difficult to estimate the quantities concerned for these varied applications. This account of the use of lead does not claim to be complete with respect to either quantities or areas of application. However, it is entirely clear that the description presented above, sector by sector, covers the portion of lead use that is most perceptibly harmful to health and the environment, and also represents the greater part of total lead consumption.

The use of metallic lead is highly diversified. Lead is used for various construction materials, e.g. for radiation protection and in window mountings. Another relatively widespread use of lead is in various kinds of weights, such as boat keels and balancing weights.

Another example is the use of lead in various forms of fishing tackle.

Lead also occurs in several alloys, among which soldering alloys are a relatively large group. Lead compounds are used, for example, in the manufacture of rubber, ceramics and explosives, and in the surface treatment of metal used in the manufacture of circuit boards, for example. However, the total amount of lead compounds used for these purposes is comparatively small.

In the long term, the use of lead must cease. In the short term, the load on the environment may be reduced by a raised recovery rate.

Research and development on alternatives to lead should be intensified in all areas of use.

Lead is also being introduced in new areas and for new applications. KemI considers that such use must be prevented.

Proposals

Lead used in other ways must be replaced by environmentally acceptable alternatives as soon as possible, wherever feasible. KemI, by checks and directed measures, will monitor manufacturers' and importers' efforts to replace lead. KemI and SNV consider it essential to prevent the use of lead in new areas and for new applications, and they will act internationally to prevent such use from being permitted.