Getting the Lead Out

IMPACTS OF AND ALTERNATIVES FOR AUTOMOTIVE LEAD USES

July 2003

A report by: Environmental Defense, Ecology Center, Clean Car Campaign

Getting the Lead Out

IMPACTS OF AND ALTERNATIVES FOR AUTOMOTIVE LEAD USES

July 2003

AUTHORS

Jeff Gearhart, Ecology Center

Dean Menke, Environmental Defense

Charles Griffith, Ecology Center

Kevin Mills, Environmental Defense

Environmental Defense
1875 Connecticut Ave, NW, Suite 600
Washington, DC 20009
(202) 387-3500
www.environmentaldefense.org

Ecology Center
117 N. Division St.
Ann Arbor, MI 48104
(734) 761-3186
www.ecocenter.org

Clean Car Campaign
www.cleancarcampaign.org
info@cleancarcampaign.org

environmental defense
finding the ways that work

Ecology Center

Clean Car Campaign

Contents

Acknowledgments **iv**

Executive summary **v**

CHAPTER 1 **Introduction** **1**
Materials Composition of the Automobile 1
Health Effects of Lead 1
A Life-Cycle Approach 3

CHAPTER 2 **Lead in Automotive Applications** **4**
Lead-acid Batteries 4
Surface Treatments and Coatings 4
Electronics 5
Lead Alloys 6
Lead in Brake Linings 7
Vibration Dampers 7
Fuel Hoses 7
Polyvinyl Chloride Plastic (PVC) 8
Wheel Balancing Weights 8
Other Automotive Uses of Lead 8
Total Lead Content of New Automobiles and the North American Vehicle Fleet 8

CHAPTER 3 **Lead in Automotive Applications** **10**
Lead Production 13
Automobile Component Manufacturing and Vehicle Assembly 16
Vehicle Use 17
Lead Pollution from Wheel Weights 18
End-of-Life Vehicle Recycling 18
Lead Pollution from Auto Dismantling 21
Contribution of Auto Applications to Total Anthropogenic Lead Releases 24

CHAPTER 4 **Alternatives to Automotive Uses of Lead** **25**
Lead-Acid Batteries 25
Surface Treatments and Coatings 27
Lead-Free Electronics 28
Lead-free Alloys 28
Vibration Dampers 29
Fuel Hoses 29
Alternatives to PVC Stabilizers and PVC Plastic 29
Alternatives to Lead Wheel Weights 29

CHAPTER 5 **Strategies and Policies for Lead-Free Vehicles** **31**
Extended Producer Responsibility Policies 31
European Union End-of-Life Vehicle Directive 32
North American Policies on Automotive Batteries 35
Conclusions and Recommendations 35

References **38**

Acknowledgments

The authors are grateful to a number of individuals for their assistance with the research, development, review and production of this report. In particular, we thank Rajive Dingra and Hans Posselt for analytical work, Karen Thomas and John Balbus for work on the health effects of lead, and Erin Smith and Allison Cobb for report editing. We also deeply thank the Joyce Foundation and The New York Community Trust for their critical financial support for our work, including helping to make this report possible. The authors are solely responsible for the content of the report.

Executive summary

Over 19 million cars and trucks are sold each year in North America. Thousands of pounds of iron, steel, aluminum, plastic, rubber and glass go into making these vehicles. Each car that rolls off the assembly line also contains toxic chemicals–chemicals that impact our health and the environment from the time the car is built until it hits the junk heap.

Lead is one such chemical. Each car manufactured today contains approximately 27 pounds of lead used in many vehicle components. In fact, one car component, the lead acid battery, accounts for the majority of lead use in the world today.

Lead is extremely toxic. Scientific studies show that long-term exposure to even tiny amounts of lead can cause brain damage, kidney damage, hearing impairment and learning and behavioral problems in children. Children are most vulnerable because growing bodies absorb more lead. In adults, exposure to lead can increase blood pressure, cause digestive problems, kidney damage, nerve disorders, sleep problems, muscle and joint pain and mood changes.

Because of the dangers, lead was phased out of consumer products like gasoline and paint decades ago. But the largest remaining source of lead pollution–auto batteries–has been largely overlooked. Most auto batteries are recycled, giving the impression that the industry is "clean." However, a closer inspection reveals that lead is released to the environment at many points during vehicle manufacture, use and disposal. This lead pollution could be avoided if the auto industry used less toxic materials.

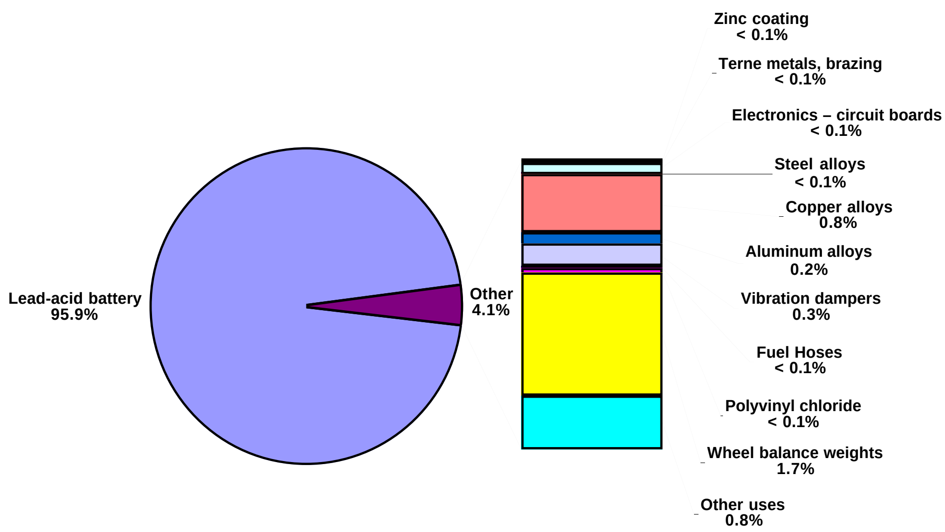
This report documents the historic and continuing uses of lead by automakers despite the availability of cleaner alternatives. It also examines the technology and policy options for eliminating lead and minimizing its impacts on human health and the environment. Among its recommendations are the phase-out of lead-acid batteries and a range of other unnecessary lead-containing components, such as lead wheel weights. Phasing out these two uses alone would go a long way toward eliminating lead's continuing environmental health threat.

Lead in Automotive Applications

In 2000, more than 2 million metric tons of lead were consumed in North America.[1] The auto industry was responsible for more than half of this total (at least 1.15 million metric tons). More than 90% of the lead in vehicles is used in lead-acid, starting-lighting-ignition (SLI) batteries found in most vehicles. An estimated 2.6 million metric tons of lead can be found in the batteries of vehicles on the road today.

Other automotive applications of lead include wheel balance weights, alloys and protective coatings, vibration dampers, solders in electronics and stabilizers in polyvinyl chloride (PVC) and other plastics. See Chart 1. Although the quantity of lead in these applications is significantly less than that in batteries, findings in this report suggest their contribution to lead contamination of the environment is still significant.

CHART 1
Automotive Lead Applications



Source: Table 1, Estimated Lead Content of Vehicles in North America. The non-battery uses on the chart represent an average of minimum and maximum values of lead use per vehicle as presented in Table 1.

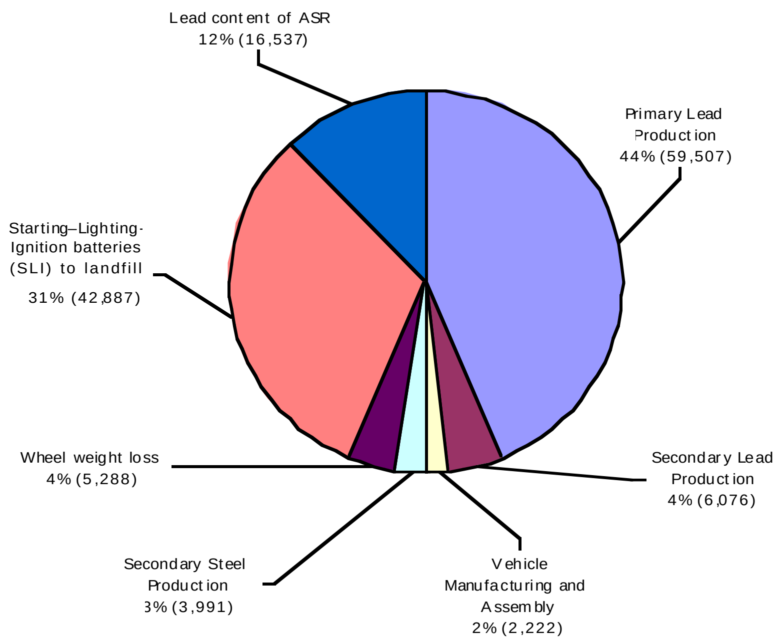
Environmental Releases from Automotive Lead Use

As the principle consumer of lead in North America, the automobile industry is responsible for the majority of lead pollution. The largest source of lead pollution is lead production–i.e., the mining and processing of lead ores and the recycling of lead scrap. Releases and transfers of lead from lead production and automotive-related manufacturing processes were 71,000 metric tons in 2000, according to federal Toxic Release Inventory data (See Chart 2).

Other lead releases occur during vehicle use and disposal. Although these releases are not officially reported, estimates made in this study suggest they may be significant sources of lead to the environment. Most of these releases occur because of inadequate vehicle dismantling and recycling processes, since many automotive components containing lead are not separated and collected. Even in the case of lead-acid batteries, the most recycled product known, more than 42,000 metric tons of lead are still lost to landfills each year. In addition, as many as 10% of lead wheel weights fall off during use, with more than 5,000 metric tons accumulating on our roadsides and washing into waterways. Lead in steel alloys and automotive coatings is released to the environment when the metals are recycled. Other lead-containing components, such as plastics and ceramics, enter landfills as a contaminant in auto-shredder residue or "fluff."

CHART 2

Automotive Related Lead Releases and Transfers (in metric tons)



Source: Table 7. The Automobile Industry's Contribution to Lead Releases Throughout the Vehicle Life Cycle

Alternatives to Automotive Lead Applications

Cost-effective alternatives exist for almost all uses of lead in automobiles, including the largest use, SLI lead-acid batteries. While some of the alternatives may cost more in the short-run, others may in fact be cheaper, especially if regulatory and liability costs for the continued use of lead are factored in.

LEAD-ACID BATTERIES

While the lead-acid SLI battery industry has been well entrenched in the automotive market for the last 75 years, lead-free alternatives exist. For example, nickel-metal hydride (NiMH) batteries already dominate the market in high-voltage battery systems used by electric and hybrid-electric vehicles, and lithium batteries common in electronics applications are emerging in automotive uses as well. These alternatives provide superior performance and significant potential for reduced environmental impact, although they cost somewhat more than their lead-acid equivalents. The automobile industry is expected to significantly increase its production of hybrid vehicles with these alternative battery systems over the next decade.

Despite these proven and available alternatives being used in high-voltage systems, however, some auto manufacturers are moving towards larger lead-acid batteries in other automotive applications. Some "mild" or low-voltage hybrids, and luxury vehicles that need additional onboard power for DVD players and other electronic equipment, are beginning to use 42-volt systems that nearly double per vehicle lead use. The expected rapid growth of 42-volt battery systems presents a key new opportunity to reduce the use of lead in automotive applications over the coming decade, rather than increase it. Strategic investments in lead-free 42-volt systems would help to bring down costs to ease the transition for standard 12-volt batteries as well.

OTHER LEAD APPLICATIONS

A number of lead-free alternatives exist for other applications as well, many with little or no cost disadvantage. Tin or steel, for example, can be used as a cost-effective alternative to lead for wheel balance weights. PVC plastics that use lead as a stabilizer can be replaced with more stable plastics, or by choosing alternative stabilizers. Lead-free or at least low-lead alloying agents can be used for the production of steel and aluminum alloys. These and other alternatives are currently available and can be implemented in a relatively short time.

Lead Component	**Alternative**
• SLI batteries	Nickel-metal hydride, Lithium- ion
• Wheel balancing weights	Tin, Steel
• Alloying agents	Limit as percentage of weight
• Coatings	Lead-free formulations
• Electronic applications	Lead-free solder
• Vibration dampers	Cast iron; more research needed
• Fuel hoses	Steel tubes; lead-free rubbers
• PVC Stabilizers	Polypropylene, other plastics

Recommendations

In light of the significant environmental releases resulting from the use of lead in automobiles, and the potential for increased lead use with the rise of 42-volt battery systems, new policies are needed to discourage lead use and support alternatives in this key industry. While a majority of states have enacted legislation requiring the recycling of lead-acid batteries, these laws do little to encourage the use of less hazardous materials in batteries or any other automotive components. The European Union, by contrast, has begun to phase out lead in automobiles through the 2000 End-of-Life Vehicles (ELV) Directive. The United States and Canada should develop their own policies for replacing lead in automobiles with safer alternatives.

Specific policy recommendations include the following:

° *Phase out the use of lead in SLI batteries:* The United States and Canada should develop a transition plan for the automotive industry to phase out the use of lead-acid batteries within 10 years (by model year 2014). This plan should include a near-term phase-out of lead-acid batteries in new 42-volt systems (by model year 2007), in order to prevent the growth of lead use in the meantime. A transition to non-lead battery systems could also help spur advanced vehicle technologies–such as hybrid gasoline-electric and fuel cell vehicles--making costs competitive for both high and low-voltage battery systems.

° *Phase out all other uses of lead in vehicles:* Governments should also develop policies for the near-term phase-out of all other uses of lead in vehicles (such as wheel balance weights, and lead used in electronic circuit boards). At a minimum, such policies should meet the phase-out requirements of the European Union's End-of-Life Vehicle (ELV) Directive. Governments can use both regulatory and purchasing restrictions in bringing about this phase-out.

- *Require producer responsibility for the recovery of lead automotive components:* During the transition to lead-free automobiles, automakers, battery manufacturers and other auto component manufacturers should take responsibility for ensuring the recovery and safe management of lead-containing automotive components. Despite impressive recycling rates, thousands of tons of automotive batteries still wind up in landfills every year, and up to half of wheel balance weights never make it to a vehicle's end-of-life. Governments should enact producer responsibility policies to significantly increase the recovery of lead in vehicles currently on the road.

- *Establish a lead retirement program and ban on lead mining:* As the transition is made away from lead in automobiles, lead that is recovered will need to be retired so that it does not re-enter commerce and become a contaminant in new products. Governments should also establish a ban on lead mining, so as not to add new sources of lead to the environment.

- *Improve the environmental standards for industries that handle end-of-life vehicles:* Governments should also more aggressively monitor and implement storm water plans and air pollution permit requirements to ensure best management practices for industries that routinely handle end-of-life vehicles.

CHAPTER 1

Introduction

Automobiles play an important role in North American life, offering personal mobility to millions, but they also cause significant environmental impacts. Included in the range of environmental impacts caused by automobiles are the human health and environmental effects caused by the release of toxic chemicals, including lead. Often present in small quantities in an individual vehicle, these toxic materials have large impacts when aggregated across the entire fleet of 246 million cars and light trucks on the roads of North America.[2]

Materials Composition of the Automobile

The average family sedan weighs about 1,500 kg (3,309 pounds), and is comprised largely of steel and iron (over 64% of the total weight), as well as plastics, aluminum, rubber and other materials.[3] Unfortunately, this crude breakdown does not sufficiently identify some of the materials that can have a significant impact on human health and the environment. Lead is one such toxic material.

Lead is used in a variety of automotive applications. The lead-acid battery in every automobile weighs approximately 15 kg (contributing to about 1% of the weight of the vehicle), 11 kg of which is lead and lead compounds.[4] The mass of lead in other automotive applications is considerably smaller–approximately 2 kg per vehicle in total–but still significant. It is estimated that the current North American vehicle fleet contains more than 2.8 million metric tons of lead. Most lead-acid batteries are recycled; however, even with the existing battery recycling infrastructure, significant quantities of lead are released into the environment. Furthermore, the lead contained in other automotive applications often remains unrecovered at the end of the vehicle's useful life, and the lead enters the environment, where it can cause adverse human health and environmental impacts.

Health Effects of Lead

Because lead targets the nervous system, children and fetuses are especially vulnerable to lead's toxic effects. Lead is easily absorbed into growing bodies, interfering with the developing brain and other organs and systems.[5] The developing bodies of fetuses, infants and children more easily absorb lead than adult bodies; in children, about 50% of ingested lead is absorbed, compared to 8–10% for adults.[6] Once absorbed into the bloodstream, lead spreads to practically all of the body's systems. Lead moves quickly to the soft tissues, such as the liver, lungs, spleen and kidneys, and eventually settles in the bones. Once in the bones, lead tends to stay there but can be mobilized during pregnancy, menopause, trauma or other times of high bone turnover. A person's nutritional status and eating behavior affects lead absorption and toxicity. Iron and calcium deficiencies result in increased lead absorption. Some absorbed lead can be eliminated from the body in urine and feces.

Acute symptoms of high-level lead exposure in children include abdominal pain, vomiting, headaches, loss of appetite and mental changes. Coma and death can result from excessive exposure. Long-term lead exposures in children can cause brain damage, affect a child's growth, damage kidneys, impair hearing, and cause learning and behavioral problems. In adults, exposure to lead can increase blood pressure, cause digestive problems, kidney damage, nerve disorders, sleep problems, muscle and joint pain and mood changes.[7] Increased blood levels of lead have resulted in increased mortality rates from a variety of causes.[8] The International Agency for Research on Cancer (IARC) lists lead and inorganic lead compounds in Group 2B, or as possible human carcinogens, based on sufficient evidence of carcinogenicity in animal studies.[9]

People are exposed to lead by eating food contaminated with lead or lead-containing soils or dusts, by drinking contaminated water, by inhaling lead particles and by using consumer products that contain lead.[10] Adult exposures typically result from occupational (e.g., lead-acid battery recycling) or recreational sources (e.g., indoor firing ranges), whereas childhood exposures commonly result from ingestion of deteriorating lead-based paint, which contaminates residential dust and soil.

Historically, consumer products such as gasoline, paint, food cans and plumbing contained lead. As government controls have eliminated or drastically curtailed these uses, lead exposures from these sources have declined dramatically. Prior to its phase-out in the late 1970s and early 1980s, leaded gasoline was by far the leading cause of lead exposure.

As with other toxic chemicals, a little bit of lead goes a long way. According to the Residential Lead Hazard Standards set by the U.S. Environmental Protection Agency, lead contamination is considered a hazard if there are 40 micrograms of lead in dust per square foot on floors; 250 micrograms of lead in dust per square foot on interior window sills; and 400 parts per million (ppm) of lead in bare soil in children's play areas (1,200 ppm average for the entire yard). Using the EPA standard for floors, a single kilogram of lead released into the air has the potential to contaminate 2 million square meters of floorspace.

The workplace is also a significant site of lead exposure. According to the U.S. Occupational Safety and Health Administration (OSHA), overexposure to lead is a leading cause of workplace illness. The current OSHA limit for the blood lead level (BLL) of lead is 50 µg/dL, a level that is far higher than allowable levels of exposure for children, and that has been associated with chronic damage to the adult nervous system.[11] Workplace exposures can also lead to exposures in the co-habitants of the worker through contaminated work clothes. Many industries directly associated with vehicle manufacturing use and emit lead, such as lead mining and processing, lead recycling, battery manufacturing, vehicle component assembly and auto and steel recycling. As other sources of lead exposure have decreased over the years, the more than 1 million metric tons used in automotive applications has become proportionately more significant.

Through its National Health and Nutrition Examination Surveys, the Centers for Disease Control (CDC) has been tracking blood lead levels (BLLs) in the United States since the 1970s and in 1991 set the "level of concern" (the level at which further investigation into the child's exposure is indicated) at 10 µg/dL. Over the years, the surveys have documented a decrease in BLLs, from a geometric mean of 15 µg/dL among children aged one through five in the late 1970s to a geometric mean of 2.2 µg/dL in the most recent survey (1999–2000). However, according to this most recent survey, about half a million U.S. children younger than six years of age have blood lead levels high enough to adversely affect their intelligence, behavior and development.[12] Recent studies suggest that loss of intelligence in children occurs with BLLs below 10 μg/dL and raises the question of whether exposure to lead at any level causes measurable harm to children's brains.[13]

A Life-Cycle Approach

To assess the full environmental impacts associated with the use of lead by the automotive industry, this report takes a life-cycle approach. This report estimates that automotive applications of lead comprise 56% of annual North American lead consumption. Total lead use by the entire transportation sector accounts for 76% of U.S. lead consumption.[14]

The life-cycle emissions from lead are inextricably linked to the automotive life cycle. Environmental releases of lead take place at every life-cycle stage. Lead and other toxic chemicals are released from the extraction and processing of lead ores, and the subsequent refining of these ores to produce lead. As lead is incorporated into automotive parts and components, the manufacturing processes and automobile assembly facilities release lead into the environment. During vehicle use, the wear, replacement and disposal of lead-containing parts contribute to the environmental load attributable to the automobile life cycle. Finally, lead contaminates the materials that are later recycled, releasing the lead into the environment, or contaminating materials destined for landfills.

While environmental regulations have been effective in reducing lead emissions to date, a more preventive approach must now be fostered in order to eliminate the root cause of lead emissions. A more preventive approach for this industry is to design lead out of automobiles and the manufacturing processes that produce them. While progress has been made in reducing or eliminating lead from some applications, other, more pervasive, applications remain; and the most significant use–lead-acid batteries–persists. By documenting the relationships between the automotive uses of lead and lead emissions, this report identifies policy recommendations for the phase-out and management of lead in automobiles.

CHAPTER 2

Lead in automotive applications

While it is commonly known that an automotive battery contains lead, considerable amounts of this heavy metal are designed into a variety of other automotive components as well. The most prominent applications of lead, including lead-acid batteries, are discussed below, drawing on research completed for the European Commission, and published in the report, "Heavy Metals in Vehicles."[15]

Lead-acid Batteries

The single largest use of lead worldwide is for lead-acid batteries, which represents 75% of total western world lead use.[16] The most common form of lead-acid battery is the starting-lighting-ignition (SLI) battery for automobiles; 80% of the western world lead battery market is represented by SLI batteries.[17] As the name implies, this battery is used to start the vehicle's engine, and to supply a stable source of power for its electrical system. The SLI battery is a mature technology that has changed little in 75 years.[18] The low cost of a lead-acid battery system is its main advantage over new technologies, and the industry seems unwilling to adopt lead-free alternatives despite their advantages.

The average automotive SLI battery weighs approximately 15 kg. It consists of a plastic container (typically polypropylene), positive and negative internal lead plates immersed in a liquid electrolyte, and plate separators made of either polyethylene, PVC, or fiberglass. The positive lead plate is lead dioxide supported on a metallic lead grid; the negative lead plate is sponge lead; and the liquid electrolyte is a 35% sulfuric acid solution in water.[19] The average composition of a lead-acid battery varies around the world, but lead and lead compounds typically make up about 75% of the mass of each battery (or about 11 kg), acid approximately 15% and plastics about 5%. The remaining 5% is made up of residual materials, including silica used for bulking up the separators.[20]

Automotive battery shipments for North America in 2001 totaled 106.6 million batteries (86.2 million replacement batteries and 20.4 million original equipment batteries),[21] or approximately 1.12 million metric tons of lead. In the batteries of North American vehicles on the road today, there are approximately 2.6 million metric tons of lead and lead compounds.

Surface Treatments and Coatings

E-COAT—VEHICLE BODY

A number of different steps are required to give cars and trucks their brightly colored, shiny finish. The electro-deposition primer coat (or e-coat) is an early step in the process that provides a layer of corrosion resistance and ensures good adhesion of subsequent coatings. To apply the electro-deposition primer coating, the vehicle body is immersed in a liquid bath and an electrical current is applied to the system. Because of the electrical charge, the primer is attracted to the metallic vehicle body, thus coating it with the protective layer. After the vehicle body is coated, it is rinsed with water to remove excess primer and then oven-cured. Wastes are generated by the process in the periodic maintenance of the bath (e.g., filtration to remove sludge, or complete bath change-out), chemical carry-over to the rinse tank and accidental spills.

By 2002, most automakers had eliminated the use of lead in this surface treatment and coatings process. When used, however, leaded e-coat contained an estimated 20-180 grams of lead per vehicle.[22] For the North American fleet of vehicles already on the road, the quantity of e-coat lead is estimated to be 4,400–39,800 metric tons (estimate considers recent lead phase-out by industry).

ZINC COATINGS—VEHICLE BODY

Galvanizing is another process for improving the corrosion resistance of steel through the application of a zinc coating. In the galvanizing process, the steel reacts with the zinc to form a zinc/steel alloy coating. The zinc is deposited onto the vehicle body when the steel is dipped into the hot-dip galvanizing bath. Lead is added to this galvanizing bath to improve viscosity and assist in the drainage of excess solution when the steel is removed from the hot-dip bath. In addition to improving the quality of the zinc coating, lead also protects the kettle against corrosion. Lead is deposited on the steel, along with zinc, as a contaminant of the galvanized coating. Other than helping in the galvanizing process, lead contributes little to the final properties of the galvanized steel product. The overall amount of lead contained in the zinc layer is approximately 1 gram per vehicle,[23] or 246 tons in the existing fleet of 246 million North American vehicles.

TERNE METALS—FUEL TANKS

Some automobile fuel tanks are made using terne metal–a steel sheet that has been coated with a lead/tin alloy in a hot-dip process. In 1998, 70% of all fuel tanks produced in North America were made of terne metal.[24] Several automakers, however, have moved away from the use of terne metals for fuel tanks, choosing instead from a number of available options. No data is available on the amount of lead used in this application; however the amount of lead used may be substantial. This is particularly significant since fuel tanks are not dismantled and will become part of the ferrous scrap stream generated by the vehicle recycling infrastructure. Like other metals coatings, this lead is a contaminant that must be managed when the steel is recycled.

Once formed, many steel tanks are also brazed with an additional coating containing 70% lead. For this coating, the amount of lead falls in the range of 30–60 grams per vehicle.[25] Assuming that 70% of the North American vehicles on the road are equipped with brazed steel tanks, the amount of lead from this application is estimated to be between 5,170–10,330 metric tons. This estimate does not include the contribution from terne metal coatings.

Electronics

Automotive electronics continue to increase as manufacturer options and consumer demands for safety, security and gadgetry increase. Radios, navigation systems, engine control systems, air bags and so on all must contain electronic devices to operate properly. These electronic devices have printed circuit boards that contain lead as a soldering element.

Although the quantity of lead contained in the printed circuit boards of each of these devices is not large, the increasing electronics content in today's vehicles makes the quantity of lead in automotive electronics likely to continue to increase. The total amount of lead contained in automotive electronics is 53–100 grams per vehicle.[26] For the fleet of North American vehicles on the road today, that is approximately 13,000–24,600 tons of lead contained in automotive electronic circuit boards.

Lead Alloys

STEEL ALLOYS

Low concentrations of lead (between 0.15% and 0.35%, by weight)[27] are added to some types of steel to improve machinability. Automotive applications of steel-lead alloys include transmission, power steering and air conditioning parts, crankshafts, connection rods, fitting turn-offs and high-pressure fuel injector parts.[28] Automakers believe that a maximum lead content of 0.3% is usually sufficient.[29] Therefore, the amount of lead used in machining steel per vehicle is estimated to be 10–50 grams, though it may be as high as 100 grams for some cars produced in Japan.[30] For the fleet of vehicles now on the road, there is an estimated 2,460–12,300 tons of lead contained in steel alloys.

COPPER ALLOYS

Copper alloys containing up to 4% lead are used in bearing shells and bushes. In addition, numerous other parts are made of brass and other alloys of copper, which also contain lead, e.g., nozzles, connection parts, fixtures or locks. The amount of lead in these applications is estimated to be in the range of 50–1,000 grams per vehicle.[31] For the North American fleet, an estimated 12,300–246,000 metric tons are currently on the road.

ALUMINUM ALLOYS AND LEAD IMPURITIES IN ALUMINUM

Aluminum is increasingly used in automobile production because of its weight-reduction potential (which leads to better fuel economy) over steel. A very small percentage of lead is typically present, as an impurity, in the aluminum alloys that are used for a majority of automotive applications. Because it is cost prohibitive to completely remove lead from recycled aluminum, secondary aluminum always contains lead impurities. The lead content in standardized casting aluminum alloys is typically around 0.1% by weight, though up to 0.35% is allowable in the case of certain alloys. Based on an average aluminum content of 116 kg and an average lead concentration of 0.1%, the total quantity of lead contained as an impurity in aluminum alloys is around 116 grams.[32] For a few minor applications, however, aluminum alloys are formulated with a lead content of up to 1%, for improved machinability. Machined aluminum contributes an additional 1–5 grams of lead per vehicle,[33] taking the total lead content of aluminum alloys to approximately 119 grams per vehicle, or 10,580 metric tons for the vehicle fleet currently on the road in North America.

Lead in Brake Linings

Lead and lead compounds have historically been used as performance enhancers for brake linings. The friction materials of brakes have contained an average of 2% lead, but up to 10% lead was possible. Friction material suppliers in the United States have stated, however, that original equipment brake manufacturers phased out lead in the early to mid 1990s.[34] Despite this U.S. phase-out, auto manufacturers around the world have requested an extension of the European Union's directive that phases out this use of lead. Under a revised schedule, auto manufacturers have until July 2004 to comply with the phase-out. Even after this date, brake linings will still be allowed to contain up to 0.5 % lead by weight. In Europe, estimates for the 1990s suggest that 100,000 metric tons of brake linings, containing 800 metric tons of lead, were produced each year for passenger cars (vehicle class M1) and light commercial vehicles (vehicle class N1).[35] Friction producers in Europe estimated that a typical brake lining had 1.38 grams of lead.[36] For the purposes of this analysis no estimates of lead use were made due to the uncertain status of lead use in brake linings.

Vibration Dampers

Vibration dampers made of lead are often used to alleviate noise and vibration problems that may occur during the use of the automobile. They usually consist of a lead weight connected to the vibrating part via a spring that absorbs the vibration energy. They may be used on the axle from gearbox to wheel, the steering column, or in various places on the chassis. Though automakers avoid using vibration dampers in new vehicles (as they increase vehicle weight and connote poor design), they are sometimes necessary to eliminate noise problems that become apparent later, especially in lighter weight vehicles that make use of more plastics in their construction, or sports cars or convertibles, where increased rigidity is sought. Vibration dampers, whether installed by original equipment manufacturers or in the aftermarket, typically contribute an additional 100–300 grams of lead to the automobile, though much heavier ones weighing several kilograms can be used.[37] Assuming an average of 100–300 grams per vehicle, an estimated 1,767–5,300 metric tons of lead are used per year as vibration dampers.

Fuel Hoses

Lead compounds are often employed as vulcanizing agents in the production of high pressure hoses and fuel lines, such as those used in fuel tubes, power steering and hydraulic applications. The presence of lead in the vulcanizing system provides resistance against heat aging and swelling in water. The quantity of lead in fuel lines alone–up to 4.7% by weight–is estimated to be in the range of 4–40 grams per vehicle,[38] or 980–9,840 metric tons of lead in the North American fleet of vehicles now on the road. Other high-pressure hoses contain additional quantities of lead.

Polyvinyl Chloride Plastic (PVC)

Lead is also used as a stabilizer in polyvinyl chloride (PVC) and other plastics. The main reason for this application of lead is to make plastics resistant to heat during production and against visible light and UV radiation during use. Lead use came into being when the more problematic use of cadmium was phased out. The major applications of PVC in the automotive industry are underseal coatings (for protection from abrasion to prevent rust and corrosion), electrical cables, upholstery and skin-material (faux-leather) of instrument panels and interior trims. Lead concentrations in PVC range between 0.5–3%, by weight, with interior and exterior trim representing the lower end of this range and cabling and wire harnesses representing the higher end.[39] Considering these applications, the average vehicle contains between 6–7 kg of PVC with a lead content of 50–60 grams per vehicle. The total fleet of North American vehicles therefore contains 13,000–15,250 metric tons of lead in PVC applications.

Wheel Balancing Weights

Lead weights are used worldwide to balance the wheels (tires and rims) of vehicles. While new vehicle wheels come pre-balanced from the assembly plant, there is a significant demand for wheel weights in the aftermarket for re-balancing, usually after tire replacement. The majority of wheel weights currently in use are the clip-on types that are fixed at the edge (horn) of the wheel rim. Some new shapes of aluminum rims, however, require adhesive weights. Though efforts are made to collect and recycle these wheel weights from end-of-life vehicles, a large number of them are overlooked and often end up entering the environment or contaminating the recycled metals from shredder facilities. A surprisingly high number drop off onto the road during vehicle use.

The amount of lead in weights used per vehicle varies between 200 and 250 grams,[40] based on an average of 20–25 grams per weight and 10 weights per vehicle (two on each of the four wheels and two more on the spare). The entire North American fleet contains 49,200–61,500 tons of lead as wheel weights. Each year, lead wheel weight use is roughly 20% original equipment manufacturer installation and 80% tire replacement for the vehicles on the road; or approximately 17,590–21,990 metric tons per year.

Other Automotive Uses of Lead

Small amounts of lead are also used in the ceramic glazes of spark plugs and piston coatings. The lead-silicate glass found in spark plugs contains 50% lead, amounting to an overall quantity of about 0.15 grams per plug.[41] The amount of lead in spark plugs is, therefore, estimated to be in the range of 0.6–1.2 grams per vehicle for vehicles with four to eight cylinders. Other applications in which either small or unknown amounts of lead are used include piston coatings, valve seats (up to 24 grams per vehicle), carbon brushes for electric motors and starters (10 grams for starters, 0.1 grams for smaller motors) and pyrotechnic initiators for air bags (up to 310 mg per vehicle).[42] The exact amounts and extent of use by automakers are not known for many of these applications. However, lead consumption data indicates that lead is used in amounts beyond those identified above.[43] As a result, it is estimated that other uses of lead total approximately 500 grams per vehicle.

Total Lead Content of New Automobiles and the North American Vehicle Fleet

This assessment of automotive lead applications shows its use pervades many, if not all, automotive systems. New vehicle designs continue to include lead in many applications, while the fleet of vehicles now on the road represents a rolling reservoir of lead capable of contaminating our environment and impacting human health.

The total quantity of lead currently contained in the fleet of 246 million vehicles now on the roads of North America is estimated to be 2,860,630–3,228,940 metric tons. The industry also consumes more than 1.15 million metric tons of lead per year (see Table 1) in the production of new cars and trucks, as well as replacement batteries and wheel weights. Based on these figures, the automotive industry accounted for approximately 56% of North American lead consumption in 2000.

TABLE 1
Estimated Lead Content of Vehicles in North America

Application	**Use per Vehicle** (min–max) (g/vehicle)	**New Fleet, MY2000** (metric tons)	**Existing Fleet on Road** (metric tons)
Lead-acid battery	10,500	1,120,000[a]	2,583,000
Electro-coat	20–180	NA	4,400–39,800[b]
Zinc coating	1	18	246
Terne metals, brazing	30–60	370–740	5,170–10,330
Electronics—circuit boards	53–100	937–1,767	13,000–24,600
Steel alloys	10–50	177–884	2,460–12,300
Copper alloys	50–1,000	884–17,673	12,300–246,000
Aluminum alloys	119	2106	29,274
Vibration dampers	100–300	1,767–5,300	24,600–73,800
Fuel Hoses	4–40	70–707	980–9,840
Polyvinyl chloride	50–60	884–1,060	13,000–15,250
Wheel balance weights	200–250	17,591–21,988[a]	49,200–61,500
Other uses[c]	500	8,836	123,000
Total	11,637–13,160	1,153,640–1,181,079	2,860,630–3,228,940

Please see Chart 1 in the Executive Summary for a graphical representation of this data.

Notes:
Figures assume 17.7 million vehicles in New Fleet, Model Year 2000 and 246 million vehicles in the *Existing Fleet on the Road in 2000*.
a. New vehicle fleet estimates for batteries and wheel balance weights include original equipment installation as well as in-use replacement demands.
b. North American fleet estimate considers recent phase-out of e-coat from new vehicle fleet.
c. Other uses of lead include applications such as piston coatings, valve seats, starters, electric motors , rubber goods and pyrotechnic initiators for air bags.

Sources :

Estimates are largely based on vehicle lead content estimates contained in :

Sander, et al. *Heavy Metals in Vehicles*. Report compiled for the Directorate General Environment, Nuclear Safety and Civil Protection of the Commission of the European Communities. Hamburg, Germany. March 27,2000

Lohse, et al. *Heavy Metals in Vehicles II*. Report compiled for the Directorate General Environment, Nuclear Safety and Civil Protection of the Commission of the European Communities. Hamburg, Germany. July 2001

In addition, a variety of North American references were used to modify the European Union estimates where appropriate.

CHAPTER 3

Environmental releases of lead from the automotive life cycle

The use of lead in automobiles contributes to toxic releases to the environment throughout the products' life cycles–from the production of lead for use in automobiles through the disposal of these vehicles. To assess the potential impacts of automotive lead applications on human health and the environment, a life-cycle approach is taken. The following life-cycle stages are considered in this approach: lead production (including the extraction and processing of ore and lead recycling); component manufacturing and vehicle assembly; vehicle use; and end-of-life vehicle (ELV) disposal. Because lead-acid batteries represent the single largest use of automotive lead, the battery life cycle has also been pulled from the aggregate and presented separately on pages 11 and 12.

This assessment focuses on lead releases to the environment (i.e., releases directly into the air, into surface waters, or disposal on land) and the transfer of lead wastes to treatment and disposal facilities. Actual releases and transfers of lead are quantified when possible, and these releases and transfers are placed in context with an assessment of total toxic chemical releases and transfers, when data are available. Data for North America has been obtained from the U.S. Toxic Release Inventory (TRI) and the Canadian National Pollutant Release Inventory (NPRI). Similar data for Mexico are not available.

Limitations to these inventories do exist. In 2000, the most recent year for which data are available, U.S. facilities were not required to report releases or transfers unless they manufactured or processed more than 25,000 pounds (11.34 metric tons) of toxic chemicals, or otherwise used more than 10,000 pounds (4.54 metric tons), annually.[a] Similar thresholds apply in Canada–only facilities that employ more than 10 full time employees and use or manufacture more than 10 metric tons of a Schedule 1, Part 1 NPRI-listed substance (which includes lead and its compounds) are required to report to Environment Canada.[44] These high thresholds cause lead releases from smaller facilities to go undocumented; therefore, the lead emissions documented in this report from the vehicle life cycle, particularly component manufacturing, will be underestimated, and the potential for adverse human health effects conservative.

[a] In January 2001, the U.S. EPA issued a final rule under section 313 of the Emergency Planning and Community Right to Know Act (EPCRA), under which the TRI reporting thresholds for lead and lead compounds were lowered. The new rule lowers the annual reporting threshold to 100 pounds (0.045 metric tons) for facilities that manufacture, process, or otherwise use lead or lead compounds, with the exception of lead contained in stainless steel, brass, and bronze alloys. This new rule went into effect on February 16, 2001, and will apply to TRI reports covering 2001 (released in 2003) and subsequent years.

As this report went into final production, U.S. EPA released its 2001 TRI data. Preliminary review of the new data for the six SIC codes most closely associated with the automotive industry indicates consistent patterns in releases and transfers that confirm the findings of this report. It also shows a spike in the number of facilities reporting lead releases and transfers to 247 from 92, indicating that lead is more commonly present in automotive production than had previously been documented.

Life-Cycle of Lead-Acid Automotive Batteries

The lead-acid batteries found in most automobiles account for the majority of lead use in North America. The activities associated with these batteries–producing the lead required, manufacturing the batteries, and disposing of them–all release lead to the environment. These toxic emissions, and the associated human health impacts, could be avoided if the automotive industry chose to eliminate lead from its battery systems by adopting one of the several lead-free alternatives now available.

LEAD PRODUCTION

The automobile industry consumes 56% of all lead production. Lead-acid batteries in automobiles accounted for over 95% of this use. Automakers, therefore, are responsible for most of the pollution from lead production, about 58,500 metric tons of lead released directly to the environment. This figure refers only to lead releases from the primary production of lead.

BATTERY MANUFACTURING

The vast majority of storage batteries produced for the North American market are manufactured in the United States. Automotive starting-lighting-ignition (SLI) batteries represent more than 80% of the storage battery market. This means that more than 80% of lead releases and transfers from battery manufacturing are attributable directly to the automotive industry, or 478 metric tons of lead released and transferred to disposal facilities.

BATTERY RECYCLING AND DISPOSAL

To prevent lead-acid batteries from going to landfills, most states have banned their disposal. These laws are usually supported by a deposit-refund system that encourages consumers to return spent batteries to retail outlets or collection centers when they purchase new ones. At the end of a vehicle's life, its battery is removed by the dismantlers and also recycled. Each year in the United States alone, an estimated 114 million lead-acid batteries are disposed of through replacing lead-acid batteries in vehicles on the road and end-of-life vehicles salvage.

RECYCLED BATTERIES

In the recycling process, each battery is separated into constituent materials. The batteries are cracked by dropping them from a considerable height onto a hard, inclined surface. The acid is allowed to drain away, and is later neutralized and discharged into the public sewer system or converted to sodium sulfate, which is used in laundry detergents, glass and textile manufacturing.

The cracked batteries are crushed into small pieces using a hammermill. These pieces are then sprayed with water to remove soluble lead (lead oxide, lead dioxide and lead sulfate), followed by a hydrodynamic separation process to remove metallic lead from the plastic casing pieces. The soluble lead water slurry is treated with either sodium hydroxide or sodium carbonate, causing the lead to precipitate out of solution in the form of lead oxide or lead carbonate. These solids are removed and recycled, along with the separated metallic lead in the secondary lead smelting process. The plastic from the battery casing is also recycled.

Automotive batteries provide the single largest source of lead scrap for the production of secondary lead. In the United States, automotive lead-acid batter ies alone accounted for 90% of the scrap lead recycled in 2000. Therefore, the automobile industry is responsible for 90% of the emissions generated by secondary lead production: 156 metric tons of lead released directly into the environment, and 5,920 metric tons transferred to treatment and disposal facilities.

NON-RECYCLED BATTERIES

Unfortunately, not all spent lead-acid batteries enter this battery recycling infrastructure. Figures from the Battery Council International indicate that as many as 7% of spent automotive batteries are not recycled. The fate of these batteries is not known; for this analysis, it is assumed that these batteries enter landfills or are discarded in the broader environment illegally. Considering the best estimates for the number of lead-acid batteries recycled each year, the quantity of lead entering the environment illegally in North America is 52,668 metric tons.

In landfills, lead has the potential to leach into surrounding soils and groundwater. While landfills may reduce atmospheric exposure by burying batteries under other materials, recent studies by landfill experts have seriously questioned the long-term integrity of landfills. Lead concentrations found in municipal landfill leachates can be as high as 1.6 mg/l in pre-1980 landfills and 0.15 mg/l in post-1980 landfills. A more detailed study and literature review of hundreds of landfills around the world showed that the average lead concentration in landfill leachate is consistently elevated.

Lead Releases and Transfers Attributable to the Automotive Industry from Lead-Acid Batteries

	Automaker Responsibility	**Lead Releases** (metric tons)	**Lead Transfers** (metric tons)
Primary Lead Production (SIC 1031 and 3339)	56%	58,500	707
Battery Manufacturing (SIC 3691)	80%	115	267
Secondary Lead Production (SIC 3341)	90%	156	5,920
Illegal Disposal	100%	--	52,668
Total		58,771	59,562

Emissions data sources: U.S. Environmental Protection Agency's Toxics Release Inventory, as presented by the Right-to-Know Network, http://www.rtk.net/rtkdata.html; and Environment Canada's National Pollutant Release Inventory, http://www.ec.gc.ca/pdb/npri/index.html.

[i]A detailed list of existing state laws related to used lead-acid batteries is provided in Appendix E.
[ii]Rubber Manufacturer's Association web site. http://www.rma.org/scraptires/facts_figures.html Accessed July 3, 2001.
[iii]USGS. *2000 Minerals Yearbook: Lead. U.S. Geological Survey*. 2000.
[iv]Reasbeck. P and J.G. Smith. *Batteries for Automotive Use.* Research Studies Press Ltd., Somerset, England. 1997.
[v]Battery Council International Web site. http://batterycouncil.org/recycling.html Accessed March 27, 2001.
[vi]Lee, G.F. and Jones-Lee, A. *Assessing the Potential of Minimum Subtitle D Lined Landfills to Pollute: Alternative Landfilling Approaches.* Proc. Air and Waste Management Assoc. 91st Annual Meeting, San Diego, CA, available on CD ROM as paper 98-WA71.04(A46), 40pp, June (1998).
[vii]Lee, G. F. and Jones-Lee, A. *Geosynthetic Liner Systems for Municipal Solid Waste Landfills: An Inadequate Technology for Protection of Groundwater Quality.* Waste Management & Research, 11:354-360 (1993).
[viii]EPA Lead Battery Risk Assessment. SCSP-00144.D. September, 1991
[ix]Rooker, Alexandria Pettway. A Critical Evaluation of Factors Required to Terminate the Post-Closure Monitoring Period at Solid Waste Landfills. M.S. Thesis by Alexandria Pettway Rooker, N.C. State University; Department of Civil Engineering; 2000

Lead Production

Lead is produced from lead ore mined from the ground (primary lead production) or from the recycle of scrap lead (secondary lead production). Combined primary and secondary lead production in North America produced 1,907,075 metric tons in 2000, approximately 29% of the world's total lead production that year.[45] The most significant force behind the flow of lead is the automobile industry's demand for the production of SLI lead-acid batteries. As previously mentioned, at least 1,120,000 metric tons of lead were consumed by automotive batteries alone in the year 2000. The aggregate of all automobile applications represented more than 56% of total North American lead consumption. Because of this automotive demand for lead, a significant portion of the emissions resulting from the production of lead is inextricably linked to automotive life-cycle emissions.

PRIMARY LEAD PRODUCTION

After lead ore is extracted from the ground and concentrated, the primary lead production process consists of four basic steps: sintering, smelting, drossing and pyrometallurgical refining. The sintering process uses hot air to burn off sulfur impurities from the lead ore; other raw materials such as iron, silica, limestone fluxes, coke, soda ash, pyrite, zinc, caustics or pollution control particulates are added to the ore to aid in processing. The resulting lead "sinter" is then sent to a blast furnace for smelting. In the blast furnace, sinter is mixed with coke, limestone, recycled scrap and other fluxing agents, and then melted.

As melting occurs, several layers form in the furnace. The molten lead layer sinks to the bottom of the furnace; other layers include the lightest elements, such as arsenic and antimony, at the top of the furnace (the "speiss"), a layer of copper and metal sulfides (the "matte") and slag consisting mostly of silicates. The lead from the blast furnace, called lead bullion, then undergoes the drossing process, which further purifies the lead. The bullion is agitated in kettles, then cooled to 700–800 degrees Celsius. This process results in molten lead and dross. Dross refers to the lead oxides, copper, antimony and other elements that float to the top of the lead. Dross is usually skimmed off and sent to a dross furnace to recover the non-lead components, which are sold to other metal processors. Finally, the molten lead is refined. Pyrometallurgical methods are usually used to remove the remaining non-lead components of the mixture. The refined lead may be made into alloys or directly cast.

A variety of toxic wastes are generated from each step in the primary lead production process. These either are released directly into the environment or transferred off-site for treatment or disposal. These releases and transfers from primary lead production, summarized in Table 2, include lead, arsenic, antimony and cadmium. Lead producers in the United States are subject to Maximum Achievable Control Technology (MACT) standards. The MACT standards for allowable emissions are based on the best-performing facilities (top 12%) in each industry sector. While both primary and secondary lead smelters (including lead-acid battery manufacturers) are governed by MACT standards, the mining industry is not.[46] Emissions from these facilities, therefore, are significantly larger than those from lead smelting and refining.

In 2000, primary lead production in North America was 629,863 metric tons. Lead ores were mined from 18 mines in the United States and five mines in Canada; data for Mexico were not available.[47] Direct releases to the environment–emissions directly to air, water or disposed of on land–dominate the environmental profile of these facilities. According to TRI and NPRI data (Table 2), 101,679 metric tons of lead were released to the environment from lead and zinc ore mining in the United States and Canada in 2000, and 3,321 metric tons from primary non-ferrous smelting and refining (primarily lead processing). Total lead releases per metric ton of primary lead produced in 2000 were 215.8 kg/ton for the United States and Canada combined.

TABLE 2
Primary Lead Production Toxic Chemical Releases and Transfers

	U.S.	Canada	Total
Lead/Zinc Ore Mining (SIC 1031)			
Lead Releases (metric tons)	101,666	13	101,679
Total Releases (metric tons)	340,956	185	341,141
Lead Transfers (metric tons)	0	0	0
Total Transfers (metric tons)	0	4	4
Lead/Zinc Ore Mining (SIC 1031)			
Lead Releases (metric tons)	2,965	356	3,321
Total Releases (metric tons)	29,334	9,025	38,359
Lead Transfers (metric tons)	958	306	1,264
Total Transfers (metric tons)	2,437	11,685	14,122
Primary Lead Production	341,000	145,640	486,640
Lead Releases, Normalized (kg/metric ton produced)	306. 8	2.5	215.8
Total Releases, Normalized (kg/metric ton produced)	1,085.9	63.2	779.8
Lead Transfers, Normalized (kg/metric ton produced)	2.8	2.1	2.6
Total Transfers, Normalized (kg/metric ton produced)	7.1	80.3	29.0

Sources :

U.S. Environmental Protection Agency's Toxics Release Inventory 2000, as presented by the Right-to-Know Network, http://www.rtk.net/rtkdata.html; and Environment Canada's National Pollutant Release Inventory, http://www.ec.gc.ca/pdb/npri/index.html.

Primary Lead Production: USGS, Minerals Yearbook–Lead, 2000.

SECONDARY LEAD PRODUCTION

The United States is the world's largest recycler of lead scrap. Scrap recycling alone represents 77% of the country's total lead production, or 1,130,000 metric tons.[48] In North America, secondary lead smelters and refiners produced 1,267,212 metric tons of lead in 2000.[49] There are 23 secondary lead smelters in the United States; eight companies operating 16 of these smelters produced nearly all (about 98%) of the secondary lead here in 2000.[50] There are six lead metallurgical plants in Canada, producing 231,000 metric tons per year. (See Appendix A for a complete list).

In North America, secondary lead smelters use two types of scrap: old and new. Sources of new scrap are production wastes and smelter-refinery drosses, residues and slags. Old scrap comes chiefly from automotive lead-acid batteries, which account for about 90% of the raw material feed stock for secondary smelters.[51] An estimated 114 million lead-acid batteries were recycled in the United States in 2000, based on EPA's reported recovery of 1,710,000 metric tons of lead-acid batteries in that year,[52] and the average battery weight of 15 kg.

The majority of lead battery scrap is processed in blast furnaces or rotary reverberatory furnaces. In a reverberatory furnace, about 47% of the charge is recovered as lead product, 46% is removed as slag to be processed later in blast furnaces, and the remaining 7% escapes as dust or fumes. In a blast furnace, 82.5% of the charge is made up of lead oxides, refining dross and reverberatory slag from metal processing facilities; the remaining charge consists of siliceous slag from previous runs (4.5%), scrap iron (4.5%), limestone (about 3%) and coke (about 5.5%). Approximately 70% of a blast furnace's charge is recovered as lead product, while 18% is recovered as slag, 5% is retained for reuse, and the remaining 7% escapes as dust or fumes.[53]

Secondary lead smelter facilities emit a number of toxic air pollutants, including lead and lead compounds; a summary of releases and transfers is presented in Table 3. In 2000, secondary lead smelting and refining facilities in the United States released 171.9 metric tons of lead; total toxic chemical releases were 224 metric tons. Canadian facilities released 1.5 metric tons of lead and lead compounds and transferred 155 metric tons. Based on a United States-Canada com-

TABLE 3

Secondary Lead Production Toxic Chemical Releases and Transfers

	U.S.	Canada	Total
Secondary Lead Smelting (SIC 3341)			
Lead Releases (metric tons)	171.9	1.5	173.4
Total Releases (metric tons)	224.0	155	379.0
Lead Transfers (metric tons)	6,461.0	117	6,578.0
Total Transfers (metric tons)	7,679.6	272	7,951.6
Secondary Lead Production	1,130,000	137,212	1,267,212
Lead Releases, Normalized (kg/metric ton produced)	0.15	0.01	0.14
Total Releases, Normalized (kg/metric ton produced)	0.2	1.1	0.3
Lead Transfers, Normalized (kg/metric ton produced)	5.7	0.9	5.2
Total Transfers, Normalized (kg/metric ton produced)	6.8	2.0	6.3

Sources :

U.S. Environmental Protection Agency's Toxics Release Inventory 2000, as presented by the Right-to-Know Network, http://www.rtk.net/rtkdata.html; and Environment Canada's National Pollutant Release Inventory, http://www.ec.gc.ca/pdb/npri/index.html.

Secondary Lead Production: USGS, Minerals Yearbook–Lead, 2000.

bined secondary lead production of 1,267,212 metric tons,[54] the total lead releases to the environment in 2000 were 0.14 kilograms per metric ton produced.

Emissions from lead production facilities directly attributable to the automotive industry include 58,956 metric tons of lead and lead compounds released directly into the environment (or 212,861 metric tons of total toxic chemical releases) and 6,628 metric tons of lead-containing wastes. These figures represent 56% (fraction of automotive lead consumption relative to North American total) of releases and transfers from primary lead production, and 90% (automotive batteries' contribution to raw material feed stock of secondary lead production) of releases and transfers from secondary lead production.

Automobile Component Manufacturing and Vehicle Assembly

Automobile manufacturing involves a complex web of suppliers of the materials and components for final assembly at the original equipment manufacturer (OEM, i.e., the automaker) facilities. Individual parts that go into the vehicle could be manufactured at any one or more of hundreds of supplier facilities. The first-level (or Tier 1) suppliers provide parts and components directly to the automaker and depend, in turn, on the second-level (or Tier 2) suppliers for their own needs, and so on. The extent of manufacturing that takes place at an automaker's own facility (termed "vertical integration") varies from manufacturer to manufacturer, and some facilities are more vertically integrated than others.

Emissions reported by the OEM facilities (automobile assembly plants) themselves are directly attributable to auto applications. OEM facilities report toxic emissions under SIC code 3711–Motor Vehicles and Passenger Car Bodies. However, the vast majority of automotive parts are manufactured by suppliers that are not captured by SIC 3711 and are scattered over a number of other industrial classifications. Assessing emissions to the environment from these facilities, therefore, is difficult. Emissions data are either not reported (small facilities are not subject to regulatory reporting requirements), or it is not possible to separate emissions attributable to the automotive industry from other industry sectors (e.g., emissions from a printed circuit board manufacturer cannot be readily attributed to auto applications since it supplies other industries as well).

In addition to examining emissions reported under SIC 3711, this report assesses emissions from the following industrial sectors that capture many of the Tier 1 suppliers for the automotive industry: SIC 3714–Motor Vehicle Parts and Accessories; SIC 3465–Automotive Stampings; SIC 3592–Carburetors, Pistons, Piston Rings and Valves; SIC 3694–Electrical Equipment for Internal Combustion Engines; and SIC 3691–Battery Manufacturing.

In 2000, these manufacturing facilities sent a total of 2,071 metric tons of lead waste to treatment and disposal facilities and released a total of 151.2 metric tons directly to the environment. See Table 4. Even though lead-containing wastes represented less than 1% of all reported toxic releases and transfers for these industry sectors and the lead releases and transfers for these sectors are small compared to emissions from lead production, these lead emissions and transfers are significant because of the potential exposure to populations located nearby.

TABLE 4

Automotive Manufacturing and Vehicle Assembly Toxic Chemical Releases and Transfers

	U.S.	**Canada**	**Total**
Automotive Manufacturing and Vehicle Assembly (SIC 3711, 3714, 3465, 3592, 3694, 3691)			
Lead Releases (metric tons)	151	0.2	151.2
Total Releases (metric tons)	24,249	5916	30,165
Lead Transfers (metric tons)	2,060	6	2,071
Total Transfers (metric tons)	144,093	370	144,463
Car and Truck Production[a]	12,814,190	2,921,601	15,735,791
Lead Releases, Normalized (kg/metric ton produced)	0.00001	NA	0.00001
Total Releases, Normalized (kg/metric ton produced)	0.002	0.002	0.002
Lead Transfers, Normalized (kg/metric ton produced)	0.0002	NA	0.0002
Total Transfers, Normalized (kg/metric ton produced)	0.01	0.0001	0.01

Sources :
U.S. Environmental Protection Agency's Toxics Release Inventory 2000, as presented by the Right-to-Know Network, http://www.rtk.net/rtkdata.html; and Environment Canada's National Pollutant Release Inventory, http://www.ec.gc.ca/pdb/npri/index.html.

Note:
Not all reported chemical releases and transfers can be attributed to the automotive industry. Some facilities reporting under these industrial codes supply the automotive OEMs as well as other industry sectors. Considering the size of the automotive industry and its supply chain, however, a significant fraction of these emissions can be attributed to the industry.

a. An additional 1,937,631 vehicles were produced by facilities in Mexico *(Automotive News, 2001 Market Data Book)*. Emissions data was not available for these facilities.

Vehicle Use

The use stage of the vehicle life cycle also contributes to the release of lead to the environment; leaded gasoline, not yet eliminated worldwide, still constitutes a significant health threat in many countries, and the wear and replacement of lead-bearing automotive parts in the United States and Canada contribute to the total environmental load of lead from the vehicle life cycle.

LEADED GASOLINE

From 1930 to the mid-1990s almost 10 million metric tons of lead were used as gasoline additives worldwide.[55] In the United States and Canada, the gasoline additive tetraethyl lead (TEL) was the major source of lead emissions and poisonings before it was gradually phased out between 1976 and 1986. Worldwide, lead use in gasoline peaked in 1974 at nearly 400,000 metric tons per year. This use declined to 50,000 metric tons per year globally by 1995. In the late 1990s, however, the rate of leaded gasoline phase-out has slowed, and 44,755 metric tons of lead were still being used as fuel additives worldwide in 2000.[56] (See Appendix B for the current status of the global phase-out of leaded gasoline).

Approximately 50 countries have verifiably completed phase-out, while more than 100 countries still use leaded gasoline. To address this problem, the Alliance to End Childhood Lead Poisoning has created a Global Lead Initiative (GLI). The goal of GLI is to "catalyze expedited completion of leaded gasoline phase-out and to identify and eliminate other exposure sources."[57] The continued use of leaded gasoline remains the major source of lead exposure in many parts of the world, and a tremendous human health threat.

WEAR AND REPLACEMENT OF LEAD-CONTAINING AUTOMOTIVE PARTS

During the useful life of the automobile (spanning an average of 120,000 miles or 10 years), numerous parts need to be replaced. The lead-containing parts of significance that are usually replaced during use are lead-acid batteries, wheel balancing weights, brake pads, starter motors and vibration dampers (both original equipment and aftermarket add-ons). In the absence of maintenance and replacement data, this study does not attempt to estimate total lead emissions from the use of the automobile. The study does quantify lead pollution due to the loss of wheel weights. (See Lead Pollution from Wheel Weights section) Efforts have also been made to document the quantities of lead in high lead-containing parts, wherever possible. Battery recycling is dealt with in more detail in a later section.

LEAD POLLUTION FROM WHEEL WEIGHTS

One noteworthy quantity of lead released during the use stage of the automobile is from the loss of wheel weights and their subsequent abrasion on roads across North America. A recent study by Robert Root, formerly of Battelle Memorial Institute, documents this previously unaccounted for load of lead to our environment.[58] Based on his findings, it is estimated that 5,288 metric tons of lead is released into the environment each year. This is based on the amount of lead believed to be contained in wheel weights (Section 2.11) and the assumption that 10% of it is likely to get deposited in the streets each year. Based on the vehicle fleet strength in the United States vs. Canada, approximately 92% (4,865 metric tons) are estimated to be lost in the United States and 8% (423 metric tons) in Canada. The Root study documented that within eight days of deposition on the road nearly 50% of the lead was no longer visible. The remaining weights were abraded, some severely, or broken into smaller pieces.

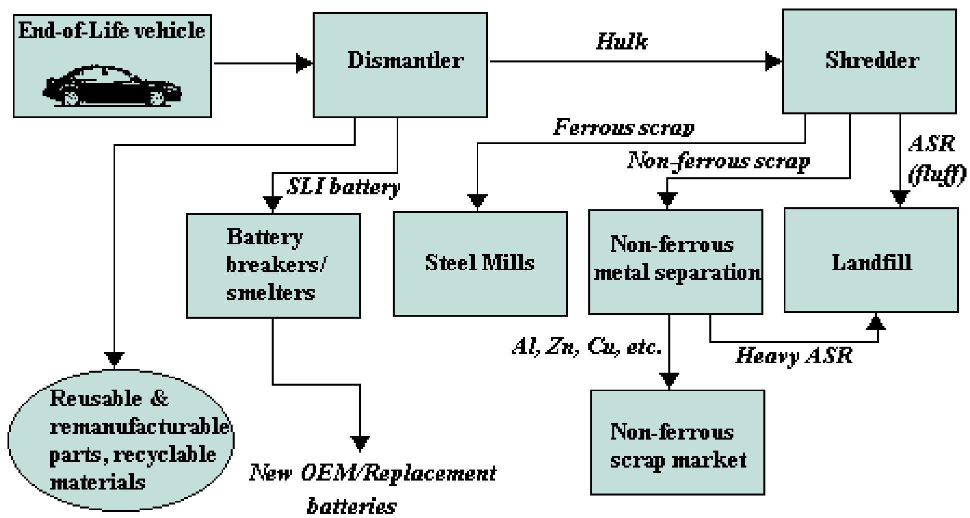
Lead wheel weights frequently drop off and are gradually abraded and reduced in size. The resulting lead dust is dispersed into the air, contaminating soils and potentially inhaled. In residential areas, this wheel weight abrasion can contribute to the lead contamination of dust on floors, on window sills and in soils. Lead dust can also migrate into nearby homes as it adheres to pedestrians' shoes or pets' feet.

A study on lead loading of urban streets by vehicle wheel weights estimates the "pool of lead rolling over U.S. highways" to be on the order of 25 million kg (25,000 metric tons or 27,558 short tons).[59] This is based on the assumption that there are 200 million automobiles and light trucks in the U.S., and 130 grams of lead are contained in the wheel weights for each vehicle. Performing a similar calculation given the current North American fleet strength of 235 million automobiles and assuming 225 grams per vehicle instead of 130 grams (average obtained from the European Commission report on heavy metals in vehicles, cited earlier), it is estimated that 52,875 metric tons of lead are currently "rolling over" North American highways.

End-of-Life Vehicle Recycling

In 2000, more than 13 million vehicles (passenger cars and light trucks) were retired from the roads in the United States and Canada.[60] Approximately 94% of these end-of-life vehicles (ELVs) enter the well-established vehicle recycling infrastructure depicted in Figure 1. This infrastructure removes parts and components of value through the dismantling process and then separates the remaining materials into recyclable materials (mostly ferrous and non-ferrous metals) and wastes (e.g., plastics, fabric, carpeting and foams) through the auto shredding process. Most sources currently estimate materials recovery at 75% of vehicle weight, most of which is represented by the recovery of iron, steel and other metals. The remaining 25% of vehicle weight, known as automotive shredder residue (ASR), or fluff, is landfilled, as in many parts of the United States,[61] or treated as hazardous waste and landfilled, as in California.[62] In Europe these wastes are labeled as hazardous waste and incinerated.[63]

FIGURE 1
Existing Vehicle Recycling Infrastructure



The fate of automotive lead in this process varies and depends, in part, on its use in each automotive component. Larger pieces of lead, such as wheel weights and vibration dampers, may be segregated and recovered by vehicle dismantlers or in the metals recovery process of auto shredders. Lead contained in alloys, hoses, plastics, electronics, cables, or in coatings adhering to metals, on the other hand, cannot be segregated and are not easily recovered. This lead will either remain with the metals fraction and contaminate the metals recycling process, or end up in ASR fractions that are disposed of in landfills, with the potential of leaching into groundwater.

DISMANTLERS

North America has more than 10,000 dismantlers, 20% of which use advanced technologies and target late model vehicles for high-value parts.[64] The remaining 8,000 dismantlers conduct more traditional auto salvage operations and are referred to generically as auto salvage yards or scrap yards. High-value parts dismantlers tend to be high-volume operations that quickly process late-model ELVs and either send them on to a scrap yard for further processing or directly to a shredder facility for materials recovery. In comparison, salvage yards tend to be low-volume, low technology operations that store ELVs while parts are gradually removed and sold.

Eventually, the remaining vehicle hulks are crushed (optional) and sent to a shredder facility for materials recovery. Both facilities typically remove tires, wheel rims, engines, transmissions, batteries, fuel tanks, radiators, air bags, motors and catalytic converters for reuse, remanufacturing or recycling. Many parts, such as instrument panels, seats and carpeting, are not designed to be reused or recycled and, therefore, remain with the vehicle hulks where efforts are made to separate them from materials of value in the auto shredding process.

Chemical releases to the environment from these facilities are not reported under federal law; most dismantling facilities are small enough to fall outside existing regulatory requirements. However, the historical record of salvage yards does show the potential environmental impacts that can occur if proper management of these facilities is not followed. Poorly managed dismantling operations can release to the environment gases such as freon, gasoline vapors and liquids such as motor oil, antifreeze (glycols), sulfuric acid or dissolved lead from lead-acid batteries, methanol, brake fluid and gasoline.

Management Practices in the Industry

EPA storm water regulations require auto recyclers to obtain a federal National Pollutant Discharge Elimination System (NPDES) storm water permit. The NPDES permit requires a detailed storm water pollution prevention plan that incorporates Best Management Practices (BMPs) to reduce water quality impacts. However, a recent study identified a number of barriers to implementing such plans at auto salvage yards.[70] These range from a lack of knowledge of best practices and a lack of environmental stewardship to more technical barriers, such as difficulty in separating components.[71] Despite known problems of contamination at auto scrap yards, many of these sites continue to operate with only limited regulatory oversight. Stricter regulatory controls for the auto recycling industry would not only make recyclers more mindful of implementing best management practices, but also encourage automakers first to eliminate the use of toxic substances in their vehicles and, second, to design them with fewer, easily separable, and more recyclable materials.

SHREDDERS

Following the dismantling process, the gutted vehicle hulks (crushed, or not) are sent to auto shredder facilities for materials recovery. About 200 auto shredders process ELVs, as well as discarded appliances (e.g., washing machines), in North America.[72] Vehicles typically are sold to shredder facilities at a price of about 3 cents per pound.[73] As the name implies, these facilities first shred the vehicle hulks into fist-sized pieces. These pieces are then separated into three fractions: ferrous metals, non-ferrous metals and auto shredder residue (ASR). The ferrous metals are magnetically separated and sent to metal recyclers, typically electric arc furnaces; the ASR fraction, consisting of foam, textiles, plastics, glass, metal fines and dirt, is removed by air cyclone and landfilled; the remaining material, rich in

Lead Pollution from Auto Dismantling

Historically, scrap yards were used to store not only ELVs but other metal scrap and wastes as well. Scrap yards first came into existence in the 1940s and '50s when cars were disposed of in open fields. At that time, the shredding technology was not available and ELVs were stored for their parts. Scrap yards were usually located on the fringes of towns and cities, often on farmland. Over the years, some of these facilities started accepting other wastes, such as transformers containing polychlorinated biphenyls (PCBs), spent chemicals and other industrial wastes. Little attention was paid to environmental management practices until recently, when environmental contamination issues began to emerge at a number of poorly managed sites.

An ELV may be stored for two to five years in a scrap yard before being processed.[65] During this time, wrecked and corroding vehicles may slowly release contaminants into the soil, air (through volatilization) or water (through storm water runoff). Many scrap yards are contaminated with used oil and heavy metals, as well as PCBs—a testament to the types of activities that occurred there. As a result, a number of scrap yards have been listed as Superfund sites in the United States because of heavy metal contamination. This is mainly a result of bad storage practices and lack of regulatory oversight of scrap yards, many of which are small facilities that have historically fallen below the regulatory radar screen. Hebelka Auto Salvage Yard and Steven's Scrap Yard are two facilities that exemplify the possible environmental impacts from this life-cycle stage.

HEBELKA AUTO SALVAGE YARD, LEHIGH COUNTY, PENNSYLVANIA

The Hebelka Auto Salvage Yard is located in rural Lehigh County, Pennsylvania. The 20-acre site is bordered primarily by agricultural fields, but three residences are located on or adjacent to the site. From 1958 to 1979 and again from 1989 to at least 1991 the property was used as an automo bile scrap yard and for salvage activities.[66] The Hebelka Auto Salvage yard was placed on the National Priorities List (NPL) after a 1985 inspection by U.S. EPA and the Pennsylvania Department of Environmental Resources revealed large piles of uncovered battery casings on the site. On-site soils, sediments in a drainage way and sediments in an off-site stream contained elevated levels of lead and mercury.[67] The site was remediated at a cost of $2,244,680 in federal cleanup funds and was deleted from the NPL in September 1999.[68]

STEVEN'S SCRAP YARD, LITTLETON, MAINE

Steven's scrap yard and metal reclamation, located in Littleton, Maine, on Road Number 1 in Aroostock County, has operated since 1976. The scrap yard and metal reclamation facility is located on the eastern portion of 62 acres of former farmland. The rest of the property now comprises overgrown vegetation and woods; about 100 feet from the metal reclamation operations, a small stream flows.

During a U.S. EPA investigation, inspectors found 55-gallon drums partially or wholly filled with waste oil contaminated with PCBs (between 50 to 210 parts per million) on the property. An order was placed to remove the PCB-contaminated oil from the site and to clean up the immediate area. The waste oil and contaminated soils were removed and disposed of in Braintree, Massachusetts.

In 1995, Maine's Department of Environmental Protection (ME EPA) conducted a sampling and investigation of the same site. This time officials looked for inorganic toxic contaminants in surrounding neighborhood properties. They found high levels of inorganic substances in nearby residential wells, including lead, cadmium, mercury and chromium levels above the reference concentration. The ME EPA concluded the elevated levels of toxic heavy metals were attributable to the nearby automobile salvage operations.[69]

non-ferrous metals, is further processed (on-site or at another facility) to recover aluminum, copper and zinc. The waste from this non-ferrous metals separation process, called heavy ASR, is also landfilled by facilities in North America. In one year, the 12 million vehicles processed by auto shredders in North America generate 12 metric tons of steel, 960,000 metric tons of non-ferrous metals and 3.3 million metric tons of ASR.[74] Lead contaminates each of these material fractions, and contributes to lead emissions to the environment.

FERROUS METALS RECYCLING IN ELECTRIC ARC FURNACES

Electric arc furnaces (EAFs) use electric energy to melt and refine ferrous scrap in a batch process to make a variety of steel products. EAFs are unique in the fact that they use only scrap metals as primary raw materials, and ferrous scrap from auto shredders is a significant source of raw materials for these facilities.[75] As the scrap melts in the EAF, impurities in the raw materials are removed as slag or released as dust and gaseous by-products to the environment. It is this process of melting that releases lead, which contaminates the ferrous fraction from auto shredders.

Particulates and gases that evolve during this steel-making process are conveyed into either a wet or dry gas cleaning system. EAF sludge and EAF dust generated by the wet and dry gas cleaning systems, respectively, are listed as hazardous waste. The composition of EAF dust or sludge varies greatly, depending on the scrap composition and furnace additives. The U.S. EPA reports, however, that the primary hazardous constituents of EAF wastes are lead and cadmium.[76] Recovery of lead from EAF dust is practiced only when zinc concentrations are above 16% by weight, as the sole recovery of lead is not profitable in itself; otherwise the dust is disposed of in industrial waste landfills. Depending on production practices, 10–20 kg of EAF dust (or 20–40 lbs/short ton) may be generated per metric ton of steel produced, and 500,000 metric tons (550,000 short tons) of EAF dust are generated annually in the United States alone.[77] Despite these cleaning steps, the secondary steel industry releases lead and other toxic chemicals to the environment.

In 1999, there were 120 EAF minimills operating in the United States, 20 in Canada and 19 in Mexico.[78] Approximately 37% of all domestic ferrous scrap processed by the steel industry is supplied by the automotive recycling sector, which also processes discarded appliances and other industrial scrap steel.[79] As presented in Table 5, EAFs released 407 metric tons of lead to the environment, and transferred 10,379 metric tons to treatment and disposal facilities in 2000. The quantity of steel scrap coming from the automotive industry in the United States is about 12,700,590 metric tons[80], or about 28.2% of EAF steel production in 1999. Therefore, by applying this percentage to the industry's emissions, the automotive industry is responsible for about 115 metric tons of lead released directly into the environment and 2,927 metric tons of lead waste transferred to treatment and disposal facilities.

Landfilling of ASR

The quantity of lead contained in ASR has been estimated from levels reported in three studies. One of these, a study conducted by the German Umweltsbundesamt (Federal Environmental Agency), which presents the most complete data, found high concentrations of toxic contaminants in ASR, including lead.[81] The U.S. EPA conducted a pilot study of ASR, which also found high concentrations of lead, as well as PCBs and cadmium.[82] And based on its 1989 evaluation, the California Department of Health Services concluded that lead is one of the metals of concern in ASR–research that supported the state's designation of ASR as hazardous.[83]

TABLE 5

Secondary Steel Production Toxic Chemical Releases and Transfers

	U.S.	Canada	Total
Secondary Steel Production (EAFs)			
Lead Releases (metric tons)	261	146	407
Total Releases (metric tons)	25,299	3,150	28,449
Lead Transfers (metric tons)	10,379	0	10,379
Total Transfers (metric tons)	194,282	11,989	206,271
EAF Steel Production Capacity	55,865,340	11,787,050	67,652,390
EAF Steel Actual Production	45,062,590	NA	NA
Lead Releases, Normalized (kg/metric ton produced)	5.7E-06	1.5E-05	7.45E-06
Total Releases, Normalized (kg/metric ton produced)	0.00056	0.0003	0.00052
Lead Transfers, Normalized (kg/metric ton produced)	0.00023	0	0.0002
Total Transfers, Normalized (kg/metric ton produced)	0.0043	0.0013	0.0038

Sources :

U.S. Environmental Protection Agency's Toxics Release Inventory 2000, as presented by the Right-to-Know Network, http://www.rtk.net/rtkdata.html; and Environment Canada's National Pollutant Release Inventory, http://www.ec.gc.ca/pdb/npri/index.html.

EAF Steel Production Capacity: Iron and Steel Society, Iron and Steel Maker, EAF Roundup Issue, May 2000.

EAF Steel Actual Production: American Iron and Steel Institute, http://www.steel.org/stats/1999.htm.

TABLE 6

Lead Content of Auto Shredder Residue (ASR)

Data Source	**Lead Concentration** (mg/kg)	**Lead in ASR, Average** (metric tons per year)[a]	
		U.S.	**Canada**
Umweltsbundesamt, Germany[b]	3,500–7,050	15,825	1,583
Environmental Protection Agency, USA[c]	570–12,000	18,855	1,886
Dept. of Health Services, California[d]	2,330–4,616	10,419	1,042
Average	--	15,033	1,504

a. Based on 3 million metric tons of ASR potentially landfilled each year in the U.S. and 300,000 metric tons in Canada.

b. Weiss et al. Ermittlung und Verminderung der Emissionen von Dioxinen und Furanen aus Thermischen Prozessen, Forschungsbericht 104 03 365/17, Umweltsbundesamt (UBA). 1996.

c. U.S. EPA. PCB, Lead and Cadmium Levels in Shredder Waste Materials: A Pilot Study; EPA 560/5-90-00BA. April 1991.

d. Nieto, Eduardo. Treatment Levels for Auto Shredder Waste, State of California Department of Health Services, June 1989.

Contribution of Auto Applications to Total Anthropogenic Lead Releases

The automobile industry's demand for lead in SLI batteries, as well as many other automotive applications, contributes to toxic chemical releases and transfers throughout the automobile life cycle. The automobile industry is responsible for lead emission in each stage of the life cycle, from the extraction and processing of lead to the ultimate disposal of vehicles. Table 7 summarizes these life-cycle lead releases and transfers reported by industries in the United States and Canada.

In comparison, the total reported lead emissions (releases and transfers) for North America in 2000 were 175,531 metric tons.[84] Therefore, from the data presented in Table 7, it is estimated that the automobile industry is responsible for at least 41% of the known lead releases and transfers in North America. The other major industry sectors responsible for lead emissions in the U.S. are mining of copper, silver and gold ores.

TABLE 7

The Automobile Industry's Contribution to Lead Releases Throughout the Vehicle Life Cycle

	Lead Releases (metric tons)	**Lead Transfers** (metric tons)
Reported Emissions		
Primary Lead Production[a]	58,800	707
Secondary Lead Production[b]	156	5,920
Vehicle Manufacturing and Assembly[c]	151. 2	2,071
Secondary Steel Production[d]	151	3,840
Total Reported Emissions	59,258	12,538
Unreported Emissions		
Wheel weight loss	5,288	--
SLI batteries to landfill	--	42,887
Lead content of ASR	--	16,537
Total Releases and Transfers	64,546	71,962

Notes:

a. The automobile industry consumes 56% of total lead production.

b. SLI batteries represent over 90% of the raw material feed stock for Secondary Lead Production.

c. Assumes 100% attributable to the automobile industry. The contributions to this total from every facility captured by these industries, however, may not be fully attributable to the automotive industry; some automotive suppliers manufacture similar products for different industry sectors.

d. Automotive ferrous scrap represents 37% of the raw material feed stock for Electric Arc Furnaces and the Secondary Steel Production industry.

Sources:

Reported emissions : U.S. Environmental Protection Agency's Toxics Release Inventory 2000, as presented by the Right-to-Know Network, http://www.rtk.net/rtkdata.html; and Environment Canada's National Pollutant Release Inventory

Unreported emissions : Wheel weights : Wheel weight deposition rate derived from Root, Robert A. Lead Loading of Urban Streets by Motor Vehicle Wheel Weights. Environmental Health Perspectives, Volume 108, Number 10. October 2000.

SLI batteries to landfills : Deposition rate derived from EPA estimates of percentage battery content in waste and Battery Council International 5 year average weight of batteries available for recycling. EPA. Municipal Solid Waste in the United States : 2000 Final Report (2000 data). April 2000. http://www.epa.gov/epaoswer/non-hw/muncpl/report-00/report-00.pdf. Accessed December 1, 2002 ; and Battery Council International website. http://batterycouncil.org/recycling.html Accessed March 27, 2001.

Lead Content of ASR : Content estimate is average of data referenced in Endnotes 81, 82 and 83 multiplied times ASR generation.

CHAPTER 4

Alternatives to automotive uses of lead

The hazardous nature of lead and its potential health impacts call for switching to more benign alternatives, wherever possible. Several alternatives do exist for a large number of automotive lead applications, including the single largest use, SLI lead-acid batteries. In some cases, procurement of lead-free alternatives might be more expensive; the human health benefits and life-cycle savings from the elimination of lead in automobiles, however, can justify increased cost. Designing lead out of automobile parts by replacing them with non-toxic alternatives would, in the long run, result in lower environmental, health and safety costs for personal protective equipment, emissions control devices, accidents (both human health- and environment-related), hazardous waste disposal, recording keeping, reporting and labeling. This chapter discusses some available alternatives.

Lead-Acid Batteries

The electronic content of the average automobile has been growing steadily, threatening to exceed the capacity of the current 12-volt, SLI lead-acid battery. This evolution has been spurred by changing needs, including a growing emphasis on safety, increased demand for additional features that provide enhanced levels of comfort and entertainment, and consumers' increasing information-access needs. To meet these increased electrical demands, automakers are working with battery manufacturers to develop new battery technologies to replace the 12-volt lead-acid battery. Industry research and development into battery options for electric and hybrid gasoline-electric vehicles have also contributed to the advancement of lead-free battery options. Research advances in nickel-metal hydride (NiMH), lithium-ion (LiIon) and other lead-free alternative battery technologies have vastly improved upon these systems' power density, weight, longevity and expected cost competitiveness. Two available battery alternatives for the existing 12-volt battery are the dual-battery system and high voltage (24-, 36-, 42-volt) battery system.[85]

A dual-battery system employs two batteries to meet the growing demands on the existing 12-volt lead-acid battery. One battery would be used exclusively to start the vehicle; the other battery would serve as the continuous source of power to run the electronics of the vehicle (e.g., lights, radio, power windows, etc.). One possible battery combination is a small-sized lead-acid battery as the starter battery, and a NiMH or LiIon battery to supply continuous power.

A high-voltage system could also employ NiMH or LiIon battery technologies to eliminate completely the use of lead in automotive battery systems. Such a high-voltage system could satisfy the growing electrical demands of today's automobiles while offering opportunities to improve other environmental aspects of the automobile. If integrated into new vehicle designs, a high-voltage system could be coupled with existing advanced technologies (sometimes termed "soft hybrid" technologies) to improve fuel economy and vehicle emissions. For example, an integrated starter-generator, in combination with a lead-free, 42-volt, NiMH battery system, could eliminate vehicle idle, thereby increasing fuel economy and decreasing vehicle emissions. The integrated starter-generator allows a vehicle's engine to turn off at stop lights, in stop-and-go traffic and other idling situations and start again automatically when the accelerator is pressed.

Yet another option for the elimination of lead from automotive batteries is to use the NiMH or LiIon technology in 12-volt batteries. Extensive research has been underway to develop these technologies for use in electric and hybrid gasoline-electric vehicles.[86] Using a design and costing model developed from this national research effort, Tim Lipman of the University of California at Davis developed a sophisticated electric vehicle battery production cost model in 1999.[87] Cost estimates for lead-free, NiMH 12-volt batteries are analyzed in Table 8. The model, developed for large battery packs, was reduced proportionally to produce single module, 12-volt batteries; additional cost reductions were calculated based on a higher volume production and the fact the battery itself is smaller. All other cost factors are identical to those used in the original model.[88]

TABLE 8

Selling Price Estimates for 12-Volt NiMH Batteries Generation 3 and Generation 4 Batteries

Generation and cell size	Low cost price		High cost price	
	$/kWh	**$/battery**	**$/kWh**	**$/battery**
Gen 3: 520,000 batteries/yr				
50 Ah; 12Volt (600Wh)	359.95	215.97	409.24	245 54
Salvage Value	20.58	12.35	20.58	12.35
Price minus Salvage Value	339.37	203.62	388.66	233.19
Gen 3: 2.6 million batteries/yr				
50 Ah; 12Volt (600 Wh)	306.84	184.1	358.18	214.91
Salvage Value	20.58	12.35	20.58	12.35
Price minus Salvage Value	286.26	171.75	337.6	202.56
Gen 4: 520,000 batteries/yr				
60 Ah; 12Volt (720 Wh)	238.69	171.86	269.02	193.69
Salvage Value	20.58	14.82	20.58	14.82
Price minus Salvage Value	218.11	157.04	248.44	178.87
Gen 4: 2.6 million batteries/yr				
60 Ah; 12Volt (720 Wh)	199.23	143 45	225.66	162.48
Salvage Value	20.58	14.82	20.58	14.82
Price minus Salvage Value	178.65	128.63	205.08	147.66

Source:

Based on cost estimates contained in Lipman, Timothy A., "The Cost of Manufacturing Electric Vehicle Batteries," Institute of Transportation Studies, UCLA at Davis, May 1999. Tables 17 and 21.

Notes:

Production numbers in source tables (Lipman, 1999) are for battery packs containing 26 modules of 10 cells each. Production numbers in table are extrapolated accordingly. Lipman reviewed four generations of NiMH battery technology. These generations are partly based on projections of the advanced NiMH battery technology for Electric Vehicle applications (Gifford, 1997), and partly based on additional assumptions made by Lipman, 1999. Gen 3 is the most likely scenario and Gen 4 is possible based on specifications for materials which are in an active research and development phase.

As shown in Table 8, at a production level of 2.6 million using advance generation 4 technology (6 Ah, 12 Volt/720 Wh), a selling price for 12-volt NiMH batteries of between $143 to $162 per battery is possible in the future. Achieving large production volume is vital to achieving this selling price and would require major commitments from automakers to assure these volumes could be met. The cost to the user could be cut in half because NiMH batteries are likely to have at least double the life of lead acid batteries. A further cost reduction of $25 is realized from the higher salvage value of NiMH batteries at end of life.

Despite the availability of these alternatives, and the clear environmental and human health benefits they offer, automakers are still looking to the lead-acid battery for answers. Automakers and battery manufacturers seek to increase the specific energy of lead-acid batteries, and even increase their size for high-voltage applications. These efforts, unfortunately, will significantly increase the use of lead in batteries–already the single largest use of lead in the world.

Surface Treatments and Coatings

LEAD-FREE E-COAT

Coating manufacturers have developed lead-free primer alternatives that offer a quality coating, as good as or better than the lead-containing counterpart.[89] These lead-free formulas do not require special or unique application equipment, and they provide advantages such as 1) the elimination of lead-containing hazardous waste; 2) improved performance of the filtration system (which removes contaminants from the electro-deposition bath); and 3) simplified rinse water treatment and disposal. There are many different lead-free e-coat formulations available, depending on the manufacturer. PPG Industries, Inc., for example, has developed Environ-Prime 2000, a lead-free primer alternative that also contains less than 0.5% volatile organic compounds (over 99% VOC-free). In addition to eliminating lead, this primer coating reduces VOC emissions, is compliant with hazardous air pollutant regulations, covers more efficiently, and cures at lower temperatures to reduce energy consumption and carbon dioxide emissions.

By model year 2002, all North American automakers had switched to lead-free e-coatings. DaimlerChrysler was the first to commit to a lead-free e-coat system. Working with PPG Industries, Inc., DaimlerChrysler began phasing out leaded e-coat in the mid-1990s in the United States, and completed the change in 2001 with two final facilities in Mexico.

The change to lead-free e-coat by General Motors was more abrupt. In 2000, GM's experience with lead-free e-coats had been negative. From their perspective, not only was the lead-free formulation and process more expensive than the traditional leaded e-coat, but GM was also having difficulties achieving the desired quality with the alternative. In less than two years, these limitations were overcome, and the automaker was able to implement lead-free e-coat in all its manufacturing facilities.

All of Ford's North American plants were converted to lead-free e-coat in July 2001.[90]

Lead-Free Electronics

A number of efforts are underway to develop lead-free solder technologies for the electronics industry. Recently, the industry announced a global alliance–the Global Environmental Coordination Initiative (GECI)–to help plan for an early transition to lead-free solders by the end of 2003.[91] This voluntary deadline is far ahead of the proposed European Union deadline that would have banned leaded solders by 2008.

There are two different types of electronic applications specific to the automobile. Low-temperature applications are one type; these electronics are those typically found within the passenger compartment of the vehicle and are not exposed to heat, moisture and dirt. High-temperature electronics are the second type of application; these electronics are typically found in areas of the vehicle exposed to the elements, as well as to the extreme heat of the engine compartment (e.g., transmission, engine mount applications).

While lead-free alternatives exist for the low-temperature applications, the high-temperature applications appear to be the remaining hurdle for the automobile. Recent research by the electronics industry, however, has resulted in positive results with newly developed alloys. Specific selenium-silver-copper (Sn/Ag/Cu) alloys have passed all thermal cycling tests including temperature ranges from −40 to 125 degrees Celsius, and the National Electronics Manufacturers Initiative has chosen Sn/Ag/Cu alloys as the new target standard. Other options include alloys of copper/silver (Cu/Ag) and bismoth/senineum (Bi/Sn) for substitute candidates for lead solder applications.[92]

In addition to research and development efforts by the electronics industry, the National Institute of Standards and Technology is helping electronics manufacturers convert to these lead-free alloys and implement the accompanying manufacturing processes.

Lead-free Alloys

To maintain the machinability of some steels, lead can be replaced by a number of other metals. Such alternatives to lead in steel alloys are calcium, bismuth or tin. Recently published research at the University of Pittsburgh School of Engineering[93] reported the development of a "green steel" in which 0.05% tin (12T14 steel) replaces the usual 0.3% lead (12T14) in steel alloys. Steelmakers claim that 12T14 poses fewer manufacturing and environmental problems than the commonly used lead-based alloys, while maintaining machinability. In Europe, where there is an increasing interest and mandate for vehicle recycling, steel-lead alloys are being eliminated. According to Milton Harris, CEO of Harris Steel Group, "Recycling is a serious issue in Europe, where there has been a strong attempt to ban lead from shredded auto scrap. Both Mercedes-Benz and Volkswagen have said that they will not accept leaded steel beginning with the 2001 model."[94] Calcium is another alternative to lead to maintain the machinability of some steels. The cost of this lead-free steel alloy, however, is prohibitive; a cost premium of 20–30% is possible with steel-calcium alloys.

In the majority of aluminum alloys, lead is an undesirable impurity that must be tolerated, given the current recycling infrastructure. However, in some applications in which lead is deliberately introduced to aid machining, there are two possibilities: Do away with the use of lead altogether in those applications that are less machining-intensive; or use alternatives such as tin and bismuth. Another reason for keeping lead contamination in aluminum as low as possible is that secondary aluminum smelters will either not accept scrap containing high concentrations of lead or will accept it at a reduced price because it requires additional quantities of clean scrap.

Vibration Dampers

While the use of lead in vibration dampers easily solves vibration problems in automobiles, the imposition of this additional heavy burden goes against worldwide efforts currently underway to reduce vehicle weight and maximize fuel efficiency. Some alternatives being tested use cast iron or filled polyacrylates in place of lead. However, these materials are not as effective as lead in absorbing vibrations. More research needs to be done to either eliminate vibration problems altogether, or to find application-specific solutions.

Fuel Hoses

Lead compounds are used to aid vulcanization in high-temperature resistant rubbers suitable for fuel hoses. One alternative is the use of steel tubes to carry fuel, thereby reducing the length of the rubber hose to a few centimeters only (with the sole purpose of dampening engine vibrations). Alternative rubbers are also being developed that are free of lead. Lead-free rubbers, however, involve costly modifications to existing production processes.

Alternatives to PVC Stabilizers and PVC Plastic

While there are alternatives to lead as a stabilizer for automotive PVC applications, replacing PVC plastic with other, lead-free plastics could be the best environmental choice for the industry. Lead-free alternatives are already being used for the underseal application, while the use of PVC upholstery is on the decline. Polypropylene, polyurethanes and other polymers are being increasingly used in place of PVC skins for instrument panels and interior trims. Substitutes being developed for lead-free cables include those that use cadmium/barium, barium/zinc or calcium/zinc as a stabilizer for PVC. Calcium/zinc systems are preferable because of their relative non-toxicity. Even if the lead is taken out of PVC, reproductive toxins like pthalates and other chemicals used in PVC plastics still make it a dangerous material to use in cars.

Alternatives to Lead Wheel Weights

A number of materials are being considered as potential alternatives to the use of lead in wheel weights. They include tin, steel, tungsten, plastic (thermoplastic polypropylene) and ZAMA (an alloy of zinc, aluminum and copper). Injecting plastic beads into the tire is also being considered as an alternative to wheel weights. Though tin appears to be a favorable alternative and is considered a "drop-in" replacement for lead, it is lighter; for the same cross-section, a tin weight will have to be about 50% longer than a lead weight. Plastic-coated tin wheel weights are recommended for alloy wheels (to minimize corrosion).[95] These alternatives are not yet used in any appreciable quantity by the industry.

Other Automotive uses

Several car manufacturers have switched to lead-free alternatives for fuel tanks, ranging from alternate coating materials on steel, such as tin-zinc, aluminum, or nickel, to plated-zinc or plastic tanks. In the case of valve seats, in which lead is used as a lubricant, other lubricants such as MnS, MoS_2, CaF_2 or graphite can be used. Developing and testing of these alternatives is underway.

CHAPTER 5

Strategies and policies for lead-free vehicles

Two basic strategies exist for reducing the releases of lead and other toxic substances from the production, use and end-of-life processing of vehicles: 1) prevent releases by eliminating uses of lead in vehicles and 2) reduce releases by removing, collecting and recovering lead from lead-containing vehicle components. Both of these strategies have been used, although for the dominant use of lead in vehicles–batteries–the second strategy has been the primary choice. In general, however, eliminating uses of lead will result in greater benefits than those achieved by adopting more effective recycling processes for a product at its end of life.

Eliminating lead use will also help to curtail impacts from both "upstream" and "downstream" lead releases associated with mining, production and processing, including worker exposures. Close to 90% of automotive lead use, and as much as 75% of all lead use, is due to the production of lead-acid batteries. Even with high rates of recycling and recovery, lead production and recycling processes associated with automotive batteries are still responsible for a majority of lead releases to the environment. With the emerging introduction of higher power 42-volt electrical systems in new vehicles, automotive-related releases of lead may grow, rather than decline. Therefore, any strategy or policy for reducing lead releases must address this dominant use.

Other automotive uses of lead should not be ignored, however. Non-battery automotive applications still account for over 5% of total non- battery lead use (and release). Many of these applications are not recovered and recycled as batteries are, making the lead a contaminant in other recycling and disposal processes. Again, the best solution is to find alternatives to lead in these applications. Where that is not possible, the auto recycling system should be improved to better remove and recover lead-containing components.

Currently, automakers in the United States and Canada have little incentive to eliminate lead from automobiles or to take responsibility for the collection and recycling of lead-containing components. European countries, however, have mandated comprehensive Extended Producer Responsibility (EPR) legislation that requires producers to eliminate uses of lead and to take responsibility for the financial impacts of vehicle end-of-life management. Many U.S. states now require the recycling of lead-acid batteries, with the primary responsibility falling on battery producers, but there is little incentive to find alternatives to lead in batteries or other automotive components here in North America.

This chapter discusses measures that can help reduce the environmental and health impacts of automotive lead use. It will focus on existing policies and practices for end-of-life vehicle management in Europe and North America, including those specifically addressing lead use and disposal. Because current policies and practices in North America are not adequately addressing this issue, the report concludes with specific recommendations for change.

Extended Producer Responsibility Policies

Extended Producer Responsibility (EPR), sometimes called Product Stewardship, is an emerging principle for a new generation of pollution-prevention policies that focuses on product systems instead of production facilities. Implementation of EPR relies on the life-cycle concept of identifying opportunities to prevent pollution and reduce resource and energy use in each stage of a product's life cycle (or product chain) through changes in product design and process technology.

EPR as a broad principle states that producers of products bear a significant degree of responsibility for the environmental impacts of their products throughout the products' life cycles, including upstream impacts inherent in the selection of materials for the products, impacts from the manufacturer's production process, and downstream impacts from the use and disposal of the products.[96] Responsible producers design their products to minimize life-cycle environmental impacts, and they accept legal, physical, economic or informational responsibility for mitigating the environmental impacts that cannot be eliminated by design.

Governments can encourage producers to accept responsibility through a variety of policy measures that differ significantly from past pollution prevention policies focusing on production facilities. Although the roots of EPR can be traced back to the deposit-refund system for beverage packagingæwhere bottlers take back packaging for refilling the use of one-way packaging in states without deposit-refund laws has effectively transferred the responsibility for managing empty beverage containers to local taxpayers.

EPR legislation has now also been developed for other end-of-life products in Europe, including automobiles and consumer electronics.[97] Sweden, the Netherlands and Germany developed take-back and recycling requirements for automobiles in the mid-1990s. This was followed in 2000 by passage of a European Union Directive for End-of-Life Vehicles (ELVs) (see following section). All EU member states are required to adopt ELV legislation meeting the Directive's criteria. The European Union has also recently passed legislation for waste electronics and electrical equipment (WEEE).[98]

European Union End-of-Life Vehicle Directive

The European Union (EU) End-of-Life Vehicle (ELV) Directive, adopted in September 2000, establishes producer responsibility for the management of ELVs, sets increased recycling requirements and begins a phase-out of certain heavy metals, including lead, used in automotive components (see Appendix C).[99] The ELV Directive required member nations to adopt appropriate legislation and regulations by April 2002, but as of April 2003, only Germany, the Netherlands and Sweden had completed the process.[100] Legislative development is underway in most EU member countries. There are four main aspects of the Directive that must be applied.

TAKE BACK

EPR is the cornerstone of the directive. In fact, the directive requires manufacturers and importers of cars to pay for the costs of end-of-life management, so that the last owner of the car does not have to bear the costs of proper management. The last owner will be induced to turn the car over for proper management because registration fees must be paid until the owner provides a certificate from the dismantler that says the car has been recycled. The member countries decide how best to set up the system of producer responsibility. In some countries, producer responsibility organizationsæoperated jointly by manufacturers and importers of carsæalready collect fees on the sale of new cars to fund the end-of-life management of scrap cars.

Under the EU plan, producers will be responsible for the costs of recycling cars put on the market after July 1, 2002. They will not be responsible for the costs of recycling cars put on the market before July 1, 2002, until January 1, 2007. At that time, they will be responsible for the costs of recycling all cars, without regard to age.

PHASE-OUT OF HEAVY METALS

The EU directive recognizes the environmental and health consequences associated with the disposal of heavy metals in vehicles, and thereby establishes a program that phases out most uses of four heavy metalsælead, mercury, cadmium and hexavalent chromium æin automotive components. EU member states must adopt legislation to ensure that vehicles put on the market after July 1, 2003, do not contain these heavy metals, except in certain components excluded from the phase-outs.

The purpose of the phase-outs is primarily to prevent the release of these heavy metals into the environment from the end-of-life management of vehicles, but the directive also recognizes other pollution prevention benefits in eliminating these toxic metals from the automobile's life cycle. In fact, the preamble to the EU Directive states that "it is important that preventative measures be applied from the conception phase of the vehicle onwards and take the form, in particular, of reduction and control of hazardous substances in vehicles, in order to prevent their release into the environment, to facilitate recycling and to avoid the disposal of hazardous waste; in particular the use of lead, mercury, cadmium and hexavalent chromium should be prohibited."

Significant exclusions from the phase-outs are contained in an Annex to the Directive, which was recently updated. (See the section in this report titled "Exemptions from the EU Directive.") These include well-known uses, such as lead in lead-acid batteries and hexavalent chromium as a corrosion-preventative coating (up to 2 grams per vehicle). The exclusions also contain some less-acknowledged uses of these heavy metals, including lead-containing alloys of steel, aluminum and copper; lead as a coating inside fuel tanks; and mercury in headlamps. The directive requires labeling of some components that are exempt from the phase-outs, including bulbs and instrument panel displays containing mercury, so that they can be stripped before shredding.

INCREASED RECYCLING REQUIREMENTS

The directive also requires producers to increase levels of reuse and recycling for ELVs, and to improve recyclability of vehicles, with the means of determining recyclability to be established by regulations. By January 1, 2006, reuse and recovery of ELVs must be increased to a minimum of 85% by weight on average, and recycling and reuse must be increased to 80% by weight. “Reuse” means that the components are used for the same purpose for which they were conceived. “Recycling” means reprocessing ELV materials for their original or other use but excludes energy recovery. “Recovery” includes material recycling, but also includes combustion of waste materials with energy recovery. By January 1, 2015, reuse and recovery must be increased to a minimum of 95% by weight. Recycling and reuse must be increased to a minimum of 85% by that date.

To aid the achievement of the increased levels of recycling, cars put on the market after the end of 2004 must be reusable or recyclable to a minimum of 85% of vehicle weight and reusable or recoverable to a minimum of 95% per vehicle. The European Commission has intended to draft amendments to the EU Directive to include the means of determining recyclability.

OTHER PROVISIONS

The EU Directive is a comprehensive approach to reducing the environmental impacts of ELV management. The directive says that

- Member states must encourage Design for Environment, including reductions in the use of hazardous substances and design for dismantling, reuse and recycling.

- Vehicle manufacturers and their suppliers must increase the quantity of recycled materials in their products.

- Vehicle manufacturers and suppliers must code components and materials to facilitate product identification for material reuse and recovery.

- Producers must provide dismantling information for every vehicle they build.

- Producers and member states must report periodically on ELV management and product design measures that enhance reuse and recycling.

- ELV management systems must be upgraded in accordance with more stringent environmental standards that call for registration of collection and treatment facilities; improvements in treatment facility design; and removal of fluids, hazardous materials and recyclable materials from ELVs before shredding.

EXEMPTIONS FROM THE EU DIRECTIVE

As noted above, the Directive provided exemptions for the phase-outs of heavy metals. These exemptions are contained in Annex II and are to be updated regularly by the European Commission (EC). In July 2002, a number of amendments were made based in part on recommendations made in the Heavy Metals in Vehicles II report published by Okopol (July 2001).[101] These amendments included labeling requirements, changes to existing exemption limits and changes to several lead requirements. (See Appendix D.)

Some of the key provisions of the amended Annex include:

• Lead as an alloying agent	limited as a percentage of weight
• Lead in wheel balancing weights	phase out by 2003–2005
• Lead in coatings	phase out by July 2005
• Lead in batteries	exempted, with labeling
• Lead in vibration dampers	exempted, with labeling
• Lead in electronic applications	limited to 60g/vehicle
• Lead in valve seats	phase out by 2003–2006
• Lead in glass and spark plugs glaze	phase out by 2005

The above EU requirements will clearly be a driver globally for future lead-free automotive component designs. However, there is no guarantee that automakers will put in place identical practices for vehicles intended solely for the North American market. Past experience with the use of mercury in automotive lighting and anti-lock brake (ABS) switches gives reason for concern here.[102] North American policies should be developed that match or provide additional guidance to that of its trans-Atlantic partners.

North American Policies on Automotive Batteries

EPR laws relating to batteries, including SLI lead-acid batteries, have been adopted in the United States. While no federal "take back" requirements exist, legislation at the state level has led to the creation of a voluntary system nationwide. Laws in 42 states for lead-acid batteries generally require a consumer deposit on batteries to encourage recovery, which must be refunded by battery retailers. Retailers must accept any batteries returned by consumers, and are required to send them to licensed battery recyclers. Disposal in landfills is also prohibited. (See Appendix E for a summary of U.S. State Lead-Acid Battery Laws.) Despite the relative success of these battery recycling requirements, with recovery rates of 93% reported by the battery industry, more than 42,000 metric tons of lead may still be improperly managed and released to the environment.

Conclusions and Recommendations

This report has documented that the continuing use of lead in automobiles contributes to significant environmental releases of this hazardous material, posing risks to public health and the environment. Government policies in North America have so far failed to discourage lead use in automobiles. While a majority of states have enacted legislation requiring the recycling of lead-acid batteries to help ensure high levels of lead recovery from ELVs, these laws do little to encourage the substitution of less hazardous materials in batteries or other automotive components.

The European Union (EU), by contrast, has begun to phase out lead use in automobiles through the 2000 End-of-Life Vehicles Directive. In a global automotive economy, the EU requirements may help to drive similar efforts here in North America, but there are no assurances. It is time for the United States and

Canada to develop their own policies to replace lead and other hazardous materials in automobiles with safer alternatives.

Based on the findings of this report, and a review of policy options available, the following actions are recommended:

PHASE OUT THE USE OF LEAD IN SLI BATTERIES

The dominant use of lead globally is for automotive batteries. Batteries in turn are responsible for the majority of lead releases, despite high levels of recycling. Automotive lead use could grow even more, given the expected increase in 42-volt battery systems that use up to twice the amount of lead per battery. While the lead-acid SLI battery industry has been well entrenched in the automotive market for the last 75 years, alternatives are now available (e.g., nickel-metal hydride, lithium-ion) that offer improved performance and reduced environmental impact. With key investments in manufacturing capacity, and associated purchase commitments, these alternative battery systems could also become economically competitive.

Federal governments in the United States and Canada should develop a transition plan for the automotive industry to phase out lead-acid batteries within 10 years (by 2014). This plan should include a near-term phase-out of lead-acid batteries from new 42-volt systems (or by the 2007 model year), in order to prevent the growth of lead use in the meantime. Investments in lead-acid alternatives will also help spur advanced vehicle technology, such as hybrid gasoline-electric, fuel cell and electric vehicles, since these technologies rely more heavily on lightweight, high-performance energy storage systems. With a plan for transition to non-lead batteries, costs could become competitive for both high and low-voltage systems.

PHASE OUT OTHER USES OF LEAD IN VEHICLES

Governments in North America should also phase out other uses of lead in vehicles no later than 2006, and should include the use of lead in wheel balance weights, protective paints, carbon brushes and valve seats, as well as limits for the amount of lead used as an alloying agent in steel, aluminum and copper, and in electronic components. Annex II of the EU's End-of-Life Vehicles Directive, which establishes phase-out requirements that have been determined to be technically and economically feasible, should serve as a starting point. Additional phase-out requirements should be established for other lead-containing products currently exempted in the Annex, including large auto parts like vibration dampers. More progress is also possible in reducing or eliminating the use of lead as an alloying agent. Governments should also use their purchasing power to seed early market introduction of alternatives prior to these phase-out dates.

REQUIRE PRODUCER RESPONSIBILITY FOR THE RECOVERY OF LEAD AUTOMOTIVE COMPONENTS

During the transition to lead-free automobiles, automakers, battery manufacturers and other auto component manufacturers should take responsibility for ensuring the recovery and safe management of both past and continuing uses of lead-containing automotive components. While a significant percentage of the larger lead components (including batteries) are currently separated and recovered for recycling, a substantial amount of automotive lead nonetheless remains an unmanaged contaminant in the vehicle end-of-life system and should be recovered. In addition, despite impressive recycling rates cited by battery manufacturers, as much as 40,000 tons of lead from automotive batteries still makes its way to landfills or other locations. Additional policy measures, such as higher battery deposits or stiffer penalties for improper disposal, should be put in place during the transition to lead-free batteries. Replacement programs for lead wheel weights should also be required. Automakers and auto component manufacturers should provide the public with regular reporting on its activities to increase the effectiveness of these recovery efforts.

ESTABLISH LEAD RETIREMENT PROGRAM AND BAN ON LEAD MINING

Federal governments in the United States and Canada should also establish programs for the retirement of lead. As the transition is made away from lead in automobiles, lead that is recovered will need to be retired so that it does not re-enter commerce and become a contaminant in new products. Governments should also establish a ban on lead mining, so as not to add new sources of lead to the environment.

IMPROVE THE ENVIRONMENTAL STANDARDS FOR END-OF-LIFE INDUSTRIES THAT HANDLE VEHICLES

The United States and Canada should aggressively monitor and implement storm water plans and air pollution permit requirements to ensure best management practices (BMPs) for industries that routinely handle end-of-life vehicles. Additional record keeping and enforcement will also be required to help assure compliance.

References

Notes:
[1] Natural Resources Canada, *Canadian Minerals Yearbook*, 2001.

[2] American Automobile Manufacturers Associaiton (AAMA). *Motor Vehicle Facts and Figures.* Detroit, MI. 1998. 1996 figures for North America were extrapolated to 1999 assuming the same growth rate experienced in the United States.

[3] AAMA Motor Vehicles, *Facts and Figures*, 1997.

[4] Sander, et al. *Heavy Metals in Vehicles.* Report compiled for the Directorate General Environment, Nuclear Safety and Civil Protection of the Commission of the European Communities. Hamburg, Germany. March 27, 2000.

International Lead Management Center Conference Paper. *Battery Design for Cleaner Production* Third Asia Pacific Roundtable for Cleaner Production Conference, Manila, Philippines. February 28-March 2, 2000.

[5] Alliance to End Childhood Lead Poisoning Web site. www.aeclp.org. Accessed June 4, 2003.

[6] Minnesota Pollution Control Agency Web site. http://www.pca.state.mn.us/air/emissions/pb.html. Accessed June 4, 2003.

[7] National Safety Council Web site. Lead Factsheet. http://www.nsc.org/library/facts/lead.htm. Accessed June 4, 2003.

[8] Lustberg, M. and E. Silbergeld. 2002. Blood Lead Levels and Mortality. Archives of Internal Medicine 162:2443-2449. http://www.protectingourhealth.org/newscience/cancer/2002/2002-1125lustbergandsilbergeld.htm.

[9] International Agency for Research on Cancer. Lead Monograph. Vol. 23. Supplement 7. 1987. http://www-cie.iarc.fr/htdocs/monographs/suppl7/leadandleadcompounds.html.

[10] Juberg, Daland R., Ph.D. *Lead And Human Health: An Update*. Prepared for the American Council on Science and Health (ACSH). New York. July 2000. http://www.acsh.org/publications/booklets/lead_update.pdf.

[11] Balbus-Kornfeld J.M.; Stewart W.; Bolla K.I.; Schwartz B.S. Cumulative exposure to inorganic lead and neurobehavioral test performance in adults: An epidemiologic review. Occup Environ Med. 1995; 52: 2-12.

[12] Centers for Disease Control and Prevention Web site, http://www.cdc.gov/nceh/lead/about/about.htm Accessed May 28, 2003.

[13] Rogan WJ, Ware JH. (2003) Exposure to Lead in Children- How Low is Low Enough? New Engl J Med 348:16 1515-1516.

[14] United States Geological Survey (USGS), *Mineral Commodities Summaries*, January 2002.

[15] Sander, et al. *Heavy Metals in Vehicles.*

[16] Natural Resources Canada, *Canadian Minerals Yearbook*, 2001

[17] Ibid.

[18] Reasbeck. P and J.G. Smith. *Batteries for Automotive Use.* Research Studies Press Ltd., Somerset, England. 1997.

[19] ILMC Conference Paper. *Battery Design for Cleaner ProductioNorth* Third APRCP Conference, Manila, Philippines. February 28 - March 2, 2000.

[20] Ibid.

USGS, Lead recycling in the United States in 1998. U.S. Geological Survey. 1998.

[21] Cooper, Allan. *Mining Annual Review.* The Mining Journal, Ltd. October 2002.

[22] Sander, et al. *Heavy Metals in Vehicles.*

[23] Ibid.

[24] Alvarado, Peter. Steel vs. Plastics: The Competition for Light Vehicle Fuel Tanks. JOM, 48(7), pp. 22-25. 1996. http://www.tms.org/pubs/journals/JOM/9607/Alvarado-9607.html

[25] Sander, et al. Heavy Metals in Vehicles.

[26] Ibid.

[27] Ibid.

[28] Ibid.

Laurel Steel. Cold Finished Steel Bar, "Green" Steel Eliminates Lead, December 1999, http://www.laurelsteel.com/greensteel.html.

[29] Lohse, et al. *Heavy Metals in Vehicles II.* Report compiled for the Directorate General Environment, Nuclear Safety and Civil Protection of the Commission of the European Communities. Hamburg, Germany. July 2001.

[30] Ibid.

[31] Lohse, et al. *Heavy Metals in Vehicles II.*

[32] Ibid.

[33] Ibid.

[34] Personal communication, Jeff Gearhart with friction materials consultant, November 22, 2002.

[35] Lohse, et al. *Heavy Metals in Vehicles II.*

[36] Ibid.

[37] Ibid.

[38] Ibid.

[39] Sander, et al. *Heavy Metals in Vehicles.*

Daimler Chrysler, *PVC usage in DCX vehicles*, e-mail to State of Minnesota, Department of Administration, Material Management Division. October 2001.

Englehart, B. *Handbook of Polyvinyl Chloride Formulating*, Chapter 10: Lead Stabilizers. Edited by Edward J. Wickson, Jossey-Bass, 1993

Daimler Chrysler, *PVC usage in DCX vehicles*, e-mail to State of Minnesota, Department of Administration, Material Management Division. October 2001.

Englehart, B. *Handbook of Polyvinyl Chloride Formulating*, Chapter 10: Lead Stabilizers.

[40] Lohse, et al. *Heavy Metals in Vehicles II.*

[41] Ibid.

[42] Ibid.

[43] USGS. *2000 Minerals Yearbook: Lead.* U.S. Geological Survey. 2000.

[44] Environment Canada. *Guide for Reporting to the National Pollutant Release Inventory 2000.* Canadian Environmental Protection Act. Available at http://www.ec.gc.ca/pdb/npri/documents/Guide_2000.pdf. Accessed August 13, 2001.

[45] USGS. *1999 Minerals Yearbook: Lead.* U.S. Geological Survey. 1999.

Ibid.

[46] *Overview of MACT Standards.* http://www.socplas.org/public/oheic/mactstds.htm Accessed August 13, 2001.

EPA Web site. *Summaries of EPA's Final Air Toxics MACT Rules.* http://www.epa.gov/airprogm/oar/oaqps/takingtoxics/p2.html Accessed August 13, 2001

[47] USGS. *2000 Minerals Yearbook: Lead.* U.S. Geological Survey, 2000.

[48] EPA Sector Notebook: Nonferrous Metals. September 1995.

USGS. 2000 Minerals Yearbook: Lead. U.S. Geological Survey, 2000.

[49] Ibid.

[50] USGS. *1999 Minerals Yearbook: Lead.* U.S. Geological Survey. 1999.

[51] USGS. *2000 Minerals Yearbook: Lead.* U.S. Geological Survey, 2000.

[52] EPA. *Municipal Solid Waste in the United States: 2000* Final Report (2000 data). April 2000. http://www.epa.gov/epaoswer/non-hw/muncpl/report-00/report-00.pdf. Accessed December 1, 2002.

[53] EPA Sector Notebook: Nonferrous Metals. September 1995.

[54] USGS. *2001 Minerals Yearbook: Lead.* U.S. Geological Survey, 2001.

[55] Thomas, et al. *Bromine Emissions From Gasoline.* Geophysical Research Letters, Vol. 24, No. 11, pages 1371-

1374, June 1, 1997.

[56] Alliance to End Childhood Lead Poisoning. Personal Communication With Laura Fudala. October 26, 2002.

[57] Alliance to End Childhood Lead Poisoning. *The Global Lead Initiative: A Proposed Outcome for the World Summit on Sustainable Development*. August 2002.

[58] Root, Robert A. *Lead Loading of Urban Streets by Motor Vehicle Wheel Weights*. Environmental Health Perspectives, Volume 108, Number 10. October 2000.

[59] Ibid.

[60] AAMA. *Motor Vehicle Facts and Figures*. Detroit, MI. 1997.

Kincaid, et al. *Vehicle Recycling and Disposal Policies in Industrialized and Developing Countries*. Center for Clean Products and Clean Technologies, University of Tennessee, Knoxville. July, 1996.

[61] Great Lakes Institute for Recycling Markets. *Auto Recycling Demonstration Project: Final Report*. Resource Recycling Systems, Inc., 416 Longshore Dr., Ann Arbor, MI 48105. 1998.

[62] California Code of Regulations; Title 22; Div 4:5; Chapter 18; Article 2, Paragraph 66268.29.

[63] Commission of the European Communities. "Commission Decision of May 3, 2000." Brussels. May 3, 2000.

[64] Great Lakes Institute for Recycling Markets. *Auto Recycling Demonstration Project: Final Report*.

[65] Recycling Council of Ontario. Management of End-of-Life Vehicles (ELVs) in Ontario: Proceeding and Draft Recommendations of the RCO Forum, April 1999, 32 pages. Toronto. 1999.

[66] U.S. EPA. *Superfund Record of Decision (ROD) Abstracts: Hebelka Auto Salvage Yard*. http://www.epa.gov/superfund/sites/rodsites/0301568.html. Accessed October 27, 2000.

[67] U.S. EPA. *NPL Site Narrative at Listing: Hebelka Auto Salvage Yard*. http://www.epa.gov/oerrpage/superfund/sites/npl/nar345.html. Accessed October 27, 2000.

[68] U.S. EPA Region 3. *Hebelka Auto Salvage Yard*. http://ww.epa.gov/reg3hwmd/super/hebelka/pad.html. Accessed October 27, 2000.

[69] U.S EPA (Fact Sheet) Steven's Scrap Yard. Littleton, Maine. Boston, 4 pages. 1999

[70] Sustainable Conservation. *Working in Urban Watersheds: Industry Analyses-Auto Recycling, Scrap Processing, Tires and Marine Paint*. Final Report to the Arco Foundation. January, 2000.

[71] Ibid.

[72] Great Lakes Institute for Recycling Markets. *Auto Recycling Demonstration Project: Final Report*.

[73] Ibid.

[74] Ibid.

[75] U.S. EPA. Office of Compliance Sector Notebook Project. *Profile of the Iron and Steel Industry*. EPA/310-R-95-005. September, 1995.

[76] Ibid.

[77] Ibid.

[78] Iron and Steel Society. *Iron and Steel Maker*. "EAF Roundup Issue." May, 2000.

[79] Great Lakes Institute for Recycling Markets. *Auto Recycling Demonstration Project: Final Report*.

[80] Steel Recycling Institute Web site. http://www.recycle-steel.org/cars/autorec.html Accessed April 25, 2002.

[81] Weiss et al. *Ermittlung und Verminderung der Emissionen von Dioxinen und Furanen aus Thermischen Prozessen*, Forschungsbericht 104 03 365/17, Umweltsbundesamt (UBA). 1996.

[82] U.S. EPA. PCB, Lead and Cadmium Levels in Shredder Waste Materials: A Pilot Study; EPA 560/5-90-00BA. April 1991.

[83] Nieto, Eduardo. Treatment Levels for Auto Shredder Waste, State of California Department of Health Services, June 1989.

[84] U.S. EPA Web site. *2000 Public Data Release Report*. Available at http://www.epa.gov/tri/tridata/tri00/pdr/index.htm. Accessed May 20, 2003.

Environment Canada; National Pollutant Release Inventory. http://www.ec.gc.ca/pdb/npri/npri_dat_rep_e.cfm#annual. Accessed April 19, 2002.

[85] Battery Council International Web site. http://www.batterycouncil.org/news-anniv.html. Accessed July 3, 2001.

[86] General Accounting Office (1994), Northeast Alternative Vehicle Consortium (1994), U. S. Department of Energy (1995), New York State Energy Research and Development Authority (1995), U. S. Congress, Office of Technology Assessment (1995), Rand Institute (1996), Argonne National Laboratory (1999) as well as several studies by the University of California, Davis Institute of Transportation Studies

[87] Lipman, Timothy, E. *A Review of Electric Vehicle Cost Studies: Assumptions, Methodologies, and Results.* University of California, Davis. Institute of Transportation Studies, UCD-ITS-RR-99-8, May 1999

Lipman, Timothy, E. The Cost of Manufacturing Electric Vehicle Batteries. University of California, Davis. Institute of Transportation Studies, UCD-ITS-RR-99-5, May 1999

[88] Ibid.

[89] Hess, John. "HAPs- and Lead-Free Electrocoat for Alternative Applications," PR Online, undated www.pfonline.com/articles/049602.html.

[90] Ford Motor Co. Personal Communication with Tim O'Brien. August 27, 2001.

[91] Lycos Environmental News Service. *Electronics Makers Plan for Lead Free Products.* http://ens-news.com/ens/aug2001/2001L-08-13-04.html Accessed August 21, 2001.

[92] Prasad, Swaminath. *Lead-Free—An Overview of Temperature Cycling, Aging, Bend Testing and Plating Chemical Evaluation Results.* Presentation at Summit on Lead-Free Solder Implementation, January 10, 2001. San Jose State University, San Jose, CA. http://geia.org/sstc/G12/leadfree/. Accessed August 21, 2000.

Costlow, Terry. NEMI backs lead-free solder alloy for standard. EE Times, January 24, 2000. http://www.eetimes.com/story/OEG20000124S0029. Accessed August 21, 2001.

[93] San Diego Earth Times Web site. http://www.sdearthtimes.com/et0799/et0799s16.html. Accessed May 10, 2002.

[94] Laurel Steel Web site. http://www.laurelsteel.com/greensteel.html. Accessed May 10, 2002.

[95] Trax BW Web site. http://www.traxadm.demoNorthco.uk/tin1.html. Accessed July 5, 2001.

International Tin Research Institute (ITRI) Web site. http://www.itri.co.uk/wweights.htm. Accessed March 26, 2001.

[96] Davis, Gary A. *Extended Producer Responsibility: A New Principle for a New Generation of Pollution Prevention.* In <u>Proceedings of the Extended Producer Responsibility Symposium, Washington, D.C., November 14-15, 1994</u>, Catherine Wilt and Gary Davis ed., University of Tennessee Center for Clean Products and Clean Technologies, Knoxville, Tennessee. 1995; *Extended Producer Responsibility in the OECD Area Phase I Report: Legal and Administrative Approaches in Member Countries and Policy Options for EPR Programmes.* Organisation for Economic Co-Operation and Development. OCDE/GD(96)48, Paris, 1996.

[97] *Extended Producer Responsibility in the OECD Area Phase I Report: Legal and Administrative Approaches in Member Countries and Policy Options for EPR Programmes.* Organisation for Economic Co-Operation and Development. Paris, 1996.

[98] Tojo, Naoko. *Analysis of EPR Policies and Legislation Through Comparative Study of Selected EPR Programmes for EEE.* Masters Thesis. International Institute for Industrial Environmental Economics, Lund University, Lund Sweden. 2000.

[99] Directive 2000/53/EC of the European Parliament and of the Council on End-of-Life Vehicles. See Appendix D. September 18, 2000.

[100] Detroit News, "EU Tells 10 Countries to Enforce Auto Recycling Laws," October, 21, 2002.

Environment Daily, "Tardy states tackled over EU scrap car rules," April 8, 2003.

[101] Directive 2000/53/EC of the European Parliament and of the Council on End-of-Life Vehicles. See Appendix D. September 18, 2000.

[102] *Toxics in Vehicles: Mercury*, Ecology Center, Great Lakes United, and the University of Tennessee Center for Clean Products and Clean Technologies, January, 2001.

APPENDIX A

Secondary lead smelters in the U.S.

1) Sanders Lead Co. - Troy, Alabama
2) GNB, Inc. - Vernon, California
3) RSR Corp. - City of Industry, California
4) Gulf Coast Recycling, Inc. - Tampa, Florida
5) GNB, Inc. - Columbus, Georgia
6) Exide Corp. - Muncie, Indiana
7) Refined Metals Corp. - Beech Grove, Indiana
8) RSR Corp. - Indianapolis, Indiana
9) Delatte Metals - Ponchatoula, Louisiana
10) Schuylkill Metals Corp. - Baton Rouge, Louisiana
11) Gopher Smelting & Refining, Inc. - Eagan, Minnesota
12) Doe Run Co. - Boss, Missouri
13) Schuylkill Metals Corp. - Forest City, Missouri
14) RSR Corp. - Middletown, New York
15) Master Metals, Inc. - Cleveland, Ohio
16) East Penn Manufacturing Co. - Lyon Station, Pennsylvania
17) Exide Corp. - Reading, Pennsylvania
18) General Smelting & Refining Co. - College Grove, Tennessee
19) Refined Metals Corp. - Memphis, Tennessee
20) GNB, Inc. - Frisco, Texas
21) Tejas Resources, Inc. - Terrell, Texas
22) PBX, Inc. - Norwalk, Ohio
23) Ross Metals - Rossville, Tennessee

Source:

http://www.epa.gov/ttn/oarpg/t3/fact_sheets/secldfa.pdf

APPENDIX B

Countries that have phased out leaded gasoline, 2001

Country Name	Country Name *(Continued from previous column)*
Albania	India
Antigua	Ireland
Argentina	Jamaica
Austria	Japan
Bangladesh	Luxembourg
Belgium	Mexico
Belize	Netherlands
Bolivia	New Zealand
Brazil	Nicaragua
Canada	Norway
Colombia	Philippines
Costa Rica	Saudi Arabia
Denmark	Singapore
Dominican Republic	Slovakia
Ecuador	South Korea
El Salvador	Sweden
Finland	Switzerland
Germany	Taiwan
Guatemala	Thailand
Haiti	United Kingdom
Honduras	United States
Hungary	Vietnam
Iceland	

Note:
This includes countries that have verifiably completed phase-out as of November 2001. It does not include countries that have laws and regulations on the books that have not been fully implemented.

Source:

Global Lead Network Website http://www.globalleadnet.org/advocacy/initiatives/countries.cfm

(Accessed April 17, 2002)

ANNEX II

Materials and components exempt from Article 4(2)(a)

Materials and components	To be labelled or made identifiable in accordance with Article 4(2)(b)(iv)
Lead as an alloying element	
1. Steel (including galvanised steel) containing up to 0,35 % lead by weight	
2. Aluminium containing up to 0,4 % lead by weight	
3. Aluminium (in wheel rims, engine parts and window levers) containing up to 4 % lead by weight	X
4. Copper alloy containing up to 4 % lead by weight	
5. Lead/bronze bearing-shells and bushes	
Lead and lead compounds in components	
6. Batteries	X
7. Coating inside petrol tanks	X
8. Vibration dampers	X
9. Vulcanising agent for high pressure or fuel hoses	
10. Stabiliser in protective paints	
11. Solder in electronic circuit boards and other applications	
Hexavalent chromium	
12. Corrosion preventative coating on numerous key vehicle components (maximum 2 g per vehicle)	
Mercury	
13. Bulbs and instrument panel displays	X

Within the procedure referred to in Article 4(2)(b), the Commission shall evaluate the following applications:

— lead as an alloy in aluminium in wheel rims, engine parts and window levers
— lead in batteries
— lead in balance weights
— electrical components which contain lead in a glass or ceramics matrix compound
— cadmium in batteries for electrical vehicles

as a matter of priority, in order to establish as soon as possible whether Annex II is to be amended accordingly.As regards cadmium in batteries for electrical vehicles, the Commission shall take into account, within the procedure referred to in Article 4(2)b and in the framework of an overall environmental assessment, the availability of substitutes as well as the need to maintain the availability of electrical vehicles.

COMMISSION DECISION

of 27 June 2002

amending Annex II of Directive 2000/53/EC of the European Parliament and of the Council on end-of-life vehicles

(notified under document number C(2002) 2238)

(Text with EEA relevance)

(2002/525/EC)

THE COMMISSION OF THE EUROPEAN COMMUNITIES,

Having regard to the Treaty establishing the European Community,

Having regard to Directive 2000/53/EC of the European Parliament and of the Council of 18 September 2000 on end-of-life vehicles ([1]), and in particular Article 4(2)(b) thereof,

Whereas:

(1) Under Directive 2000/53/EC the Commission is required to evaluate certain hazardous substances prohibited pursuant to Article 4(2)(a) of that Directive.

(2) Having carried out the requisite technical and scientific assessments the Commission has reached a number of conclusions.

(3) Certain materials and components containing lead, mercury, cadmium or hexavalent chromium should be exempt or continue to be exempt from the prohibition, since the use of these hazardous substances in those specific materials and components is still unavoidable.

(4) Some exemptions from the prohibition for certain specific materials or components should be limited in their scope and temporal validity, in order to achieve a gradual phase-out of hazardous substances in vehicles, given that the use of those substances in such applications will become avoidable.

(5) Cadmium in batteries for electrical vehicles should be exempt until 31 December 2005 since, in view of present scientific and technical evidence and the overall environmental assessment undertaken, by that date, substitutes will be available and the availability of electrical vehicles will be ensured. The progressive replacement of cadmium should, however, continue to be analysed, taking into account the availability of electrical vehicles. The Commission will publish its findings and, if proven justified by the results of the analysis, may propose an extension of the expiry date for cadmium in batteries for electrical vehicles.

(6) The exemption from the prohibition relating to lead for coating inside petrol tanks should be deleted, since the use of lead in these specific components is already avoidable.

(7) Since it is evident that a total avoidance of heavy metals is in some instances impossible to achieve, certain concentration values of lead, mercury, cadmium or hexavalent chromium in specific materials and components should be tolerated, provided that these hazardous substances are not intentionally introduced.

(8) Directive 2000/53/EC should therefore be amended accordingly.

(9) The measures provided for in this Decision are in accordance with the opinion of the Committee established by Article 18 of Council Directive 75/442/EEC of 15 July 1975 on waste ([2]), as last amended by Commission Decision 96/350/EC ([3]),

HAS ADOPTED THIS DECISION:

Article 1

Annex II to Directive 2000/53/EC is replaced by the text set out in the Annex to this Decision.

Article 2

Member States shall ensure that cadmium in batteries for electrical vehicles is not put on the market after 31 December 2005.

In the framework of the overall environmental assessment already undertaken, the Commission shall continue to analyse the progressive substitution of cadmium, taking into account the need to maintain the availability of electrical vehicles. The Commission shall finalise and make public its findings by 31 December 2004 at the latest and may make, if proven justified by the results of the analysis, a proposal to extend the deadline in accordance with Article 4(2)(b) of Directive 2000/53/EC.

([1]) OJ L 269, 21.10.2000, p. 34.

([2]) OJ L 194, 25.7.1975, p. 39.

([3]) OJ L 135, 6.6.1996, p. 32.

Article 3

This Decision shall apply from 1 January 2003.

Article 4

This Decision is addressed to the Member States.

Done at Brussels, 27 June 2002.

For the Commission

Margot WALLSTRÖM

Member of the Commission

ANNEX

'ANNEX II

Materials and components exempt from Article 4(2)(a)

Materials and components	Scope and expiry date of the exemption	To be labelled or made identifiable in accordance with Article 4(2)(b)(iv)
Lead as an alloying element		
1. Steel for machining purposes and galvanised steel containing up to 0,35 % lead by weight		
2. a) Aluminium for machining purposes with a lead content up to 2 % by weight	1 July 2005 ([1])	
b) Aluminium for machining purposes with a lead content up to 1 % by weight	1 July 2008 ([2])	
3. Copper alloy containing up to 4 % lead by weight		
4. Lead-bronze bearing shells and bushes		
Lead and lead compounds in components		
5. Batteries		X
6. Vibration dampers		X
7. Wheel balance weights	Vehicles type-approved before 1 July 2003 and wheel balance weights intended for servicing of these vehicles: 1 July 2005 ([3])	X
8. Vulcanising agents and stabilisers for elastomers in fluid handling and powertrain applications	1 July 2005 ([4])	
9. Stabiliser in protective paints	1 July 2005	
10. Carbon brushes for electric motors	Vehicles type-approved before 1 July 2003 and carbon brushes for electric motors intended for servicing of these vehicles: 1 January 2005	
11. Solder in electronic circuit boards and other electric applications		X ([5])
12. Copper in brake linings containing more than 0,5 % lead by weight	Vehicles type-approved before 1 July 2003 and servicing on these vehicles: 1 July 2004	X
13. Valve seats	Engine types developed before 1 July 2003: 1 July 2006	

Materials and components	Scope and expiry date of the exemption	To be labelled or made identifiable in accordance with Article 4(2)(b)(iv)
14. Electrical components which contain lead in a glass or ceramic matrix compound except glass in bulbs and glaze of spark plugs		X (6) (for components other than piezo in engines)
15. Glass in bulbs and glaze of spark plugs	1 January 2005	
16. Pyrotechnic initiators	1 July 2007	
Hexavalent chromium		
17. Corrosion preventive coatings	1 July 2007	
18. Absorption refrigerators in motorcaravans		X
Mercury		
19. Discharge lamps and instrument panel displays		X
Cadmium		
20. Thick film pastes	1 July 2006	
21. Batteries for electrical vehicles	After 31 December 2005, the placing on the market of NiCd batteries shall only be allowed as replacement parts for vehicles put on the market before this date.	X

(1) By 1 January 2005 the Commission shall assess whether the phase-out time scheduled for this entry has to be reviewed in relation to the availability of substitutes for lead, taking into account the objectives of Article 4(2)(a).
(2) See footnote 1.
(3) By 1 January 2005, the Commission shall assess this exemption in relation to road safety aspects.
(4) See footnote 1.
(5) Dismantling if, in correlation with entry 14, an average threshold of 60 grams per vehicle is exceeded. For the application of this clause, electronic devices not installed by the manufacturer on the production line shall not be taken into account.
(6) Dismantling if, in correlation with entry 11, an average threshold of 60 grams per vehicle is exceeded. For the application of this clause, electronic devices not installed by the manufacturer on the production line shall not be taken into account.

Notes:

— a maximum concentration value up to 0,1 % by weight and per homogeneous material, for lead, hexavalent chromium and mercury and up to 0,01 % by weight per homogeneous material for cadmium shall be tolerated, provided these substances are not intentionally introduced (1),

— a maximum concentration value up to 0,4 % by weight of lead in aluminium shall also be tolerated provided it is not intentionally introduced (2),

— a maximum concentration value up to 0,4 % by weight of lead in copper intended for friction materials in brake linings shall be tolerated until 1 July 2007 provided it is not intentionally introduced (3),

— the reuse of parts of vehicles which were already on the market at the date of expiry of an exemption is allowed without limitation since it is not covered by Article 4(2)(a),

— until 1 July 2007, new replacement parts intended for repair (4) of parts of vehicles exempted from the provisions of Article 4(2)(a) shall also benefit from the same exemptions.'

(1) "Intentionally introduced" shall mean "deliberately utilised in the formulation of a material or component where its continued presence is desired in the final product to provide a specific characteristic, appearance or quality". The use of recycled materials as feedstock for the manufacture of new products, where some portion of the recycled materials may contain amounts of regulated metals, is not to be considered as intentionally introduced.
(2) See footnote 1.
(3) See footnote 1.
(4) This clause applies to replacement parts and not to components intended for normal servicing of vehicles. It does not apply to wheel balance weights, carbon brushes for electric motors and brake linings as these components are covered in specific entries.

APPENDIX E

Summary Of U.S. state lead-acid battery laws

Summary Of U.S. State Lead-Acid Battery Laws
October 2000

State/County	Effective Date	Battery Council International Model Legislation	Deposit[a] (Refundable)	Split Of Deposit	Deposit Refund Period	Point Of Sale Sign[b]	Fee (Nonrefundable)
Arizonac	09/27/90	Yes	$5 in-lieu of a trade-in (T)	100% Retailer	30 days	Retailer	
Arkansas	07/1/92	Yes	$10 (T)	100% Retailer	30 days	State	
California	01/1/89	Yes				None	
Connecticutd	10/1/90	Yes	$5 (T)	100% Retailer	30 days	Retailer	
Florida	01/1/89	Yes				None	$1.50°
Georgia	01/1/91	Yes				Retailer	
Hawaii	01/1/90	Yes				State	
Idaho1	07/1/91	Yes	$5 (T)	100% Retailer	30 days	Retailer	
Illinois	09/1/90	Yes				Retailer	
Indiana	01/1/91	Yes				Retailer	
Iowa	07/1/90	Yes				Retailer	
Kansas City,e	03/14/90	Yes				Retailer	
Missouri	03/14/90	Yes				Retailer	
Kentucky	07/13/90	Yes				Retailer	
Louisiana	09/1/89	Yes				Retailer	
Maine	10/30/89	Yes	$10 (T)	100% Retailer	7 days	State	$1.00p
Massachusetts	12/31/90	Nog				None	
Michigan	04/1/90	Yes				State	
Minnesota	10/4/89	Yesf	$5 (%)	100% Retailer		State	
Mississippi	07/1/91	Yes				State	
Missouri	01/1/91	Yes				State	
Nebraska	09/1/94	Noi					
Nevada	01/1/92	Nog				None	
New Hampshire	01/1/91	Nog				None	
New Jersey	10/9/91	Yes				Retailer	
New Mexico	12/31/91	Nog					
New York	01/1/91	Yes	$5 (T)	100% Retailer	30 days	Retailer	
North Carolina	01/1/91	Yes				Retailer	
North Dakota	01/1/92	Yes				None	
Oklahoma	09/1/93	Yest				Retailer	
Oregonh	01/1/90	Yes				Retailer	

State/County	Effective Date	Battery Council International Model Legislation	Deposit[a] (Refundable)	Split Of Deposit	Deposit Refund Period	Point Of Sale Sign[b]	Fee (Nonrefundable)
Pennsylvania	07/26/89	Yes				State	
Rhode Island	01/1/89	Yes	Seeu			State	
South Carolina	05/27/91	Yes	$5 (T)	100% Retailer	30 days	State	$2.00m
South Dakotar	07/1/92	Yes				None	
Tennessee	07/1/90	Yesq				None	
Texas	09/1/91	Yes				State	$2.00/$3.00n
Utahk	01/1/92	Yes				Retailer Wholesaler	
Vermont	06/17/94	Yes				Retailer	
Virginia	07/1/90	Yes				State	
Washington	07/23/89	Yes	$5 (T)	100% Retailer	30 days	State	
West Virginia	04/6/94	Yess				Retailer/ Wholesaler	
Wisconsin	01/1/91	Yes	Seej			State	See[j]
Wyoming	06/8/89	Yes				State	

Footnotes:

a This refers to a deposit in lieu of a trade-in (T).

b This refers to whose responsibility it is to make the educational signs, the state or the retailer. A "None" indicates that there is no sign requirement."

c AZ requires all lead batteries sold to be labeled with a universally accepted recycling symbol. AZ also requires that State agencies and political subdivisions comply with the battery recycling law.

d Retailers in CT must take back batteries one-for-one at the point of sale.

e Kansas City's ordinance requires that retailers take back up to 3 batteries not at the point of sale, and it requires that junk batteries be stored in "an adequately ventilated enclosure in good repair that protects its contents from any precipitation, etc." Any spilled acid must be immediately collected and neutralized.

f MN now requires that retailers take back up to 5 batteries not at the point of sale.

g NH, NM, NV and MA placed a ban on the landfilling and incineration of lead batteries only. NV will allow lead battery disposal at stat "permitted" facilities, however.

h OR requires that until 12/31/93 retailers must accept at least 1 battery from consumers, after which they must only accept batteries one-for-one at the point of sale.

i NE placed a prohibition on only the landfilling of lead batteries.

j WI law allows retailers to charge a $5 deposit in lieu of a trade-in, and to charge $3 for taking a battery.

k UT requires retailers to take back a maximum of two used lead batteries from customers. In addition to the BCI model law, a 1998 regulation prohibits solid waste disposal of lead acid batteries.

l ID requires all lead batteries sold to be labeled with a universally accepted recycling symbol. In addition, batteries used in motorcycles, off-road recreation vehicles or lawn and garden equipment are exempt from the deposit in lieu of a trade-in requirement.

m SC requires retailers to collect a $2.00 fee for lead batteries sold to the ultimate consumer. The retailer may retain three percent of the collected fees to cover administrative costs. Fees collected by the state treasurer are to be deposited into a Solid Waste Management Trust Fund. Small sealed lead-acid batteries are now exempt from the fee and BCI model provisions; however, a study on the recycling of these batteries is required. See S.C. Code Ann. x 44-96-40(23).

n TX requires the collection of a $2.00 and $3.00 fee for batteries less than 12volts, and, equal to or greater than 12 volts respectively. Exempted from the fee is any battery that is: 1) rated at less than 10 ampere hours; 2) sealed so that no access to the interior of the battery is possible without destroying the battery; and 3) with dimensions (sum of height, width and length) less than 15 inches. The fees are to be collected by any wholesaler or retailer who sells a battery not for resale. To cover administrative costs, the dealer may retain 2-1/2 cents per unit. All remaining money, less four percent to cover state administrative costs, goes to the state comptroller to be placed in a waste remediation fund.

o FL requires the collection of a $1.50 fee per battery at the retail level.

p ME requires the collection of a $1.00 fee per battery at the retail level.

q TN prohibits landfills or incinerators in the state from accepting lead-acid batteries for incineration or disposal. Further, lead-acid battery retailers must accept used lead-acid batteries as trade-in batteries.

r SD requires wholesalers and retailers to "accept, on a one for one exchange basis, used lead-acid batteries and . . . ensure the proper handling and disposal of the batteries." Further, after July 1, 1995, all lead-acid batteries shall be eliminated from landfilled wastes."

s WV requires retailers and wholesalers to collect used lead-acid batteries from customers and post point-of-sale signs.

t OK requires that retailers of lead-acid batteries post and maintain a sign at or near the point of display or sale to inform the public that lead-acid batteries are accepted for recycling.

u RI law specifies that retailers may voluntarily add a core charge (amount unspecified) to the price of a new vehicle battery. The core charge must be refunded if a used battery is returned within 7 days of the date of purchase.

Final Note: Several states have adopted separate household or dry cell battery recycling laws that include provisions strictly applicable to small sealed lead-acid batteries. These states are California, Florida, Illinois, Iowa, Maine, Maryland, Minnesota, New Hampshire, New Jersey, New York, Oregon, and Vermont.

Source:

Battery Council International http://www.batterycouncil.org/states.html