Toxics in Vehicles: Mercury

A Report
by
Ecology Center
Great Lakes United
University of Tennessee Center for Clean Products and Clean Technologies

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Implications for Recycling and Disposal

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Ecology Center

The Ecology Center is a regional grassroots environmental organization which works for clean air and water, healthy communities, and environmental justice. The Auto Project of the Ecology Center works to address toxic and health issues related to the production of automobiles and promotes cleaner vehicle technologies.

Great Lakes United

Great Lakes United is an international coalition dedicated to preserving and protecting the Great Lakes - St. Lawrence River ecosystem. Great Lakes United develops and promotes effective policy initiatives, carries out education programs and promotes citizen action and grassroots leadership to assure:

- clean water and clean air for all citizens,
- better safeguards to protect the health of people and wildlife, and
- a conservation ethic that will leave a healthy Great Lakes.

University of Tennessee, Center for Clean Products and Clean Technologies

The Center for Clean Products and Clean Technologies (CCPCT) at the University of Tennessee, Knoxville is directed by Gary Davis, and its mission is to develop, evaluate, and promote cleaner products and cleaner technologies that minimize pollution at the source and contribute to long-term sustainable development.

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EXECUTIVE SUMMARY

The United States had a record 210 million automobiles on the road in 1999, up 15 million from 1994, and the total for all of North America in 1996 was more than 235 million. Each year, some 12 million of these vehicles are retired from useful life. Many of the materials used in their production create problems along the way, either in the vehicle's manufacture, use or end-of-life. This report examines the historic and continuing use of the highly toxic metal mercury in automobiles and estimates its releases to the environment from end-of-life vehicle (ELV) processing. The report will show that emissions from vehicle recycling and disposal processes are one of the largest sources of mercury contamination to the environment. The report also examines strategies for cleaner production and proposes key policy solutions to eliminate mercury hazards from both new and existing vehicles.

Mercury in Automotive Applications

Government agencies, and the automotive industry as well, have acknowledged concerns with automotive mercury use since the early 1990s. In 1995, a Task Force convened by the Michigan Department of Natural Resources determined that mercury switches were responsible for more than 99 percent of mercury use in automobiles - primarily in hood and trunk lighting, but also in antilock braking systems (ABS). As part of that process, automakers agreed to voluntarily phase out mercury switches within a few years and to educate auto recyclers on how to remove switches from existing vehicles.

Five years after the task force findings, however, mercury continues to be used in lighting switches and its use has even increased in ABS applications. The North American vehicle fleet may now contain as many as 250 million switches that, if not removed and properly managed, could release as much as 200 metric tons of mercury into the environment, causing harm to human health and wildlife.

Specific findings of this study include:

- Mercury-containing switches account for more than 99 percent of the mercury used in automobiles, with each switch containing approximately 0.8 grams of mercury.
- Approximately 11.2 tons of mercury were used in U.S.-made vehicles in 1996, with an average of 1.06 switches per vehicle.
- An estimated 215 million mercury switches (and perhaps as many as 250 million) in vehicles currently on the road account for some 172 to 200 metric tons of mercury.
- The 12 million vehicles disposed of annually in the United States and Canada contain an estimated 8.8 to 10.2 metric tons of mercury (U.S. ELVs alone contain 8 to 9.4 metric tons of mercury).
- While the use of mercury in convenience lighting switches declined some 62 to 77 percent since 1996, mercury use for ABS applications appears to have increased by at least 130 percent and perhaps by as much as 180 percent.
- Other uses of mercury in automobiles, such as high intensity discharge headlamps, navigational displays, and family entertainment systems, also appear to be on the rise.
- Automakers have never fully disclosed their historical uses of mercury nor specific vehicle models that contain mercury.

Mercury Releases from Auto Recycling Facilities

The first stop for most retired vehicles is an automotive dismantler. This can include high-value parts dismantlers or a common auto scrap yard. Once salvageable parts are removed, vehicle hulks are sent to shredder facilities where ferrous (steel) and nonferrous metals are recovered, or sent directly to electric arc furnaces (EAFs) as steel scrap. These EAFs use electrical energy to melt the scrap to make new steel products. During these dismantling and recycling processes, multiple opportunities exist for mercury contained in vehicles to be released to the environment.

While removal of mercury switches from convenience lighting applications is a fairly simple procedure, very little known recovery actually occurs. Even less likely is recovery of ABS mercury switches. This report analyzed recent emissions data from one shredder facility, four EAF facilities in three states, and three other steel smelting facilities (the only recent data available). The data confirm that significant mercury emissions occur at shredder and metal recovery facilities, where most, if not all, of the mercury from vehicles is currently released to the environment. Using national emissions estimates derived from these data, EAFs appear to be the single largest manufacturing source of mercury air emissions in the United States, and the fourth largest of all anthropogenic sources.

Specific findings include:

- The bulk of mercury releases from retired vehicles occur from melting contaminated scrap steel in EAFs. Mercury air emissions from U.S. EAFs are estimated in this study at 15.6 metric tons per year, of which mercury from automobiles is likely the single largest contributing source.
- EAFs constitute the largest manufacturing source of mercury air emissions in the United States, larger than all other manufacturing sources combined. EAFs also constitute the fourth largest of all mercury air emission sources, behind coal-fired utilities, municipal waste incinerators and commercial/industrial boilers (all combustion sources).
- Potential mercury air emissions from Canadian and Mexican EAFs are estimated at seven metric tons per year, but this estimate is more uncertain due to the absence of data in these countries.
- Some of the mercury in vehicles is also released at auto shredder facilities, either as an emission to the air or as a contaminant in waste material (i.e., “auto shredder residue”). At the only combined shredder/EAF facility where a mercury mass balance has been performed, mercury releases from the shredder accounted for more than 20 percent of the total.
- Mercury can also be released at auto scrap yards. There are approximately 10,000 to 14,000 auto scrap yards in the United States and Canada, many of which have been designated as environmental contamination sites (some with known mercury contamination).
- The vast majority of EAFs, shredders and scrap yards in North America are neither monitored nor regulated for mercury pollution.

Strategies for Clean Production and the Need for Producer Responsibility

Automakers can prevent mercury emissions from retired vehicles if they employ clean production principles. This means designing vehicles to avoid the use of toxic substances like mercury in the first place and accepting responsibility for the hazards of their vehicles even after they are sold. Furthermore, a range of public and private policy initiatives must be started to reduce the threat from vehicle-related mercury pollution.

Automakers can halt the proliferation of toxic contaminants in vehicles by utilizing “design for environment” approaches that consider life cycle environmental impacts in a product’s development. This should also include development of supplier specifications and material tracking systems to ensure that toxic substances like mercury are not used in parts supplied to auto manufacturers. Automakers can also voluntarily accept responsibility for hazards posed by their products at the end of their useful lives through product take-backs or by providing funding for a separate mercury collection and recovery system.

Governments can move to protect human and environmental health by instituting policies that promote cleaner production practices. The European Union (EU) has recently taken a major step in this direction by adopting the End-of-Life Vehicle Directive, which requires the phaseout of most applications of mercury and other heavy metals. The Directive also gives automakers financial responsibility and sets recycling targets for ELVs. Some U.S. states, such as Vermont and Minnesota, have required the labeling of mercury-added products (including automobile components) or restricted mercury-containing products from entering the waste stream. Northeast states are now collectively considering comprehensive mercury legislation, which would restrict sales, ban disposal, and provide a collection scheme for mercury-added products.

Although North American-based automakers pledged in 1995 to phase-out mercury-containing switches, their use has continued into the new millennium. There has also been little progress toward removing these switches from the existing vehicle fleet. By contrast, European-sold automobiles have not contained mercury switches since 1993, when mercury use was banned in Sweden. This suggests that proactive government policies may be the more effective approach to achieving clean production ends. With Europe setting the standard, it is time for North American governments to take action now to reduce mercury hazards from end-of-life vehicles.

Recommendations

Based on these findings, the following actions should be taken to eliminate mercury hazards from retired vehicles:

- Elimination of Mercury Switches from New Cars and Trucks: Automakers should immediately eliminate the use of mercury switches in the production of new cars and trucks to stop the introduction of new sources of mercury into the end-of-life vehicle waste stream.
- Producer Responsibility for Mercury Switch Removal, Collection and Replacement: Automobile producers should take responsibility for the removal and safe collection of mercury switches from the millions of vehicles in the existing fleet. This should include replacement of switches in vehicles on the road, where feasible, as well as full disclosure of historical uses of mercury.
- Phaseout of Other Uses of Mercury in Vehicles: Automakers should begin a phaseout of other uses of mercury in vehicles, following a timetable comparable to requirements in the EU ELV Directive.
- Labeling of Vehicles Containing Mercury: Automakers should label all new vehicles containing mercury, until such use has been fully phased out. Both mercury-containing parts as well as the vehicle itself should be labeled.
- Upgraded Environmental Standards for Automotive Recycling Facilities: Federal, state, and provincial governments in the United States and Canada should upgrade environmental standards for ELV management by scrap yards, shredders, EAFs, and other metals recovery facilities that process automotive scrap. In particular, they should: 1) require processors to remove and safely recover mercury-containing products before shredding or otherwise processing ELVs, and 2) establish and enforce mercury emission standards for metals recycling and recovery facilities with high mercury emissions, such as EAFs.

CHAPTER 1

INTRODUCTION: WHAT HAPPENS TO MERCURY IN END-OF-LIFE VEHICLES?

During 1999, a record number of U.S.-registered cars and light trucks — some 210 million vehicles — were on the road in the United States,[1] up 15 million from 1994.[2] For all of North America, the total was more than 235 million in 1996.[3] While most estimates place the average useful life of a car in North America at about 10 to 11 years, other estimates of vehicle life range up to 14 years.[5] In fact, U.S. registration data show some 30 million vehicles in use in 1996 were 15 years old or older.[6] This means that over the course of the next few decades more and more end-of-life vehicles (ELVs) are likely to be discarded each year, posing a risk of increased environmental degradation.

In 1996, nearly 11 million passenger cars in the United States were not re-registered and are assumed to have been disposed of [7] – either legally or left illegally along roadsides. Another one million vehicles are discarded each year in Canada.[8] For the most part, ELVs follow two major pathways to their final disposition: first, ELVs are partially disassembled and materials are recovered or recycled through various industrial processes; second, the leftover unusable materials are disposed of through incineration or landfilling. Significant amounts of chemical releases can and often do occur during all phases of vehicle disposal. However, many of these releases and their potential health impacts have not been well-documented.

Mercury in the Environment

Mercury is a naturally occurring element that can cause serious health and ecological effects when released to the environment through human activities. Each year an estimated 60,000 children are born at risk of developmental deficits, as a result of exposure to methylmercury in the womb, usually stemming from the mother's consumption of contaminated fish.[9] Methylmercury is the organic form of mercury that bioaccumulates in the environment. Elemental mercury released into the environment as a result of human activity can be converted into methylmercury and bioaccumulate up the food chain. Releases of mercury into the air eventually lead to contamination of water, because the mercury in the atmosphere then deposits on land and water. In fact, forty states have issued fish consumption advisories for some of their waters because of mercury contamination.[10]

Mercury is a potent neurotoxin. Methylmercury and metal vapors are the most harmful forms of mercury, because mercury in these forms more readily reaches the brain. Exposures to high levels of mercury can permanently damage the brain, kidneys, and developing fetus. In addition, the EPA has determined that mercuric chloride and methylmercury are possible human carcinogens.[11]

Although mercury emissions occur from natural sources such as volcanoes, recent studies suggest that anthropogenic sources contribute the majority of mercury releases, causing a 200 to 500 percent increase in the total atmospheric mercury burden since the beginning of the industrial age. Fish consumption advisories currently posted in 40 out of 50 U.S. states are testimony to the health risks posed by mercury in our rivers and lakes.[12] Because of its health and environmental risks and the availability of viable alternatives for most applications, mercury is increasingly the focus of policy initiatives that call for reductions in its deliberate use or the virtual elimination of anthropogenic discharges into the environment.

This report examines the use of mercury in automotive systems and estimates the environmental releases of mercury from the recycling and disposal of ELVs. It also proposes policy solutions for key issues. This report is the first in a series focusing on the potential environmental impacts of ELV processing. Future reports will examine the environmental release and dispersal of other toxic chemicals or toxic chemical precursors present in the automobile.

This report will show that mercury emissions from vehicle recycling and disposal processes are among the largest anthropogenic sources of mercury in the environment. Automobile manufacturers are now taking steps to: (a) reduce the amount of mercury in their products, at least in some applications, and; (b) better manage some sources of mercury in ELVs. However, if more substantial action is not taken soon, most of the mercury from past and present automotive uses could end up in our air, water, and soil. While it has often been thought that the disposal of auto shredder residue (ASR, the light fraction from auto shredding operations) is the most significant health and environmental issue for ELVs, a key finding of this report is that metal-recycling processes may also pose significant impacts due to emissions of mercury found in ELVs.

The remainder of this chapter is an overview of the materials composition of automobiles and the current ELV infrastructure. Chapter 2 discusses automotive applications of mercury and attempts to quantify the amount of mercury in the current North American vehicle fleet. Chapter 3 addresses mercury management issues at auto scrap yards, the first stop in the ELV recycling infrastructure. Chapter 4 estimates mercury releases from shredding and metal recycling processes. Chapter 5 summarizes mercury releases from the ELV recycling infrastructure and compares these to mercury releases from other sources. Finally, Chapter 6 discusses strategies and policies for cleaner ELV management.

MATERIALS COMPOSITION OF THE AUTOMOBILE

Table 1 presents the materials composition of a typical 1997 family vehicle, organized by generic materials categories. The material composition in the table is a simplified accounting of the different materials contained in a modern vehicle. The actual number is much larger, with categories such as plastics, steels, non-ferrous metals, and powder metals, each containing either a large variety of different materials or a number of different grades that fit within a category. For instance, a vehicle description published in the context of a life-cycle assessment lists 24 types of plastic in a generic automobile; these plastic types can be further subcategorized into several grades each.[13] The table doesn't account for mercury and many other materials present in automobiles in relatively small quantities.

Table 1: Materials Composition of a Typical 1997 Family Vehicle

Material	Pounds/Vehicle	Kilograms/Vehicle	Percentage
Regular steel, sheet, bar, rod	1,411.0	639.9	43.4
High/medium-strength steel	295.5	134.0	9.1
Stainless steel	47.5	21.5	1.5
Other steels	36.0	16.3	1.1
Iron	378.0	171.4	11.6
Plastics/composites	242.0	109.8	7.5
Aluminum	206.0	93.4	6.3
Copper and brass	46.5	21.1	1.4
Powder metal parts	31.0	14.1	1.0
Zinc die castings	14.0	6.3	0.4
Magnesium castings	6.0	2.7	0.2
Fluids/lubricants	197.5	89.6	6.1
Rubber	138.5	62.8	4.3
Glass	96.5	43.8	3.0
Other materials	102.0	46.3	3.1
Totals	**3,248.0**	**1473.0**	**100**

Source: AAMA, *Motor Vehicles, Facts and Figures*, 1997.

Of note here is that the materials composition of cars is changing. Automakers are using more plastics, not only because plastic is versatile, but because it can reduce the weight of the car, thus improving fuel economy. The environmental benefits that come from increased plastics use, however, must be weighed against the environmental costs at the end of the vehicle's useful life. The myriad types and grades of plastics currently used in vehicles not only decrease the recyclable fraction via the existing infrastructure, but also limit plastics recyclability where technologies to recycle plastics exist.

Automobile manufacturers rely on a large network of suppliers to provide the parts and materials that make up their products. Historically, automotive suppliers have built parts and components to performance specifications rather than materials specifications. Although suppliers submit drawings to the original equipment manufacturer (OEM) detailing the materials present in a part or component, most OEMs have no central repository where this information is compiled. As a result, many OEMs do not have a detailed record of the location and quantity of materials in their products, especially materials that provide a secondary function within a larger part or material. Such is the case with mercury, which has been used in a number of automotive applications, some of which may not yet be documented (see Chapter 2, "Mercury in Automotive Applications").

THE ELV RECYCLING INFRASTRUCTURE

The vehicle-recycling infrastructure currently in place in most developed countries is shown in Figure 1. Approximately 94 percent of ELVs enter this infrastructure, where the ferrous and non-ferrous metals are recovered. While this recycling rate is admirable, it has involved efforts that have primarily been directed toward the re-use of parts and the recovery and subsequent recycling of metals. Most sources currently estimate metal recovery at 75 percent of vehicle weight. The remaining 25 percent of vehicle weight, known as automotive shredder residue (ASR), or fluff, is either landfilled, as in many parts of the United States,[14] treated as hazardous waste in California,[15] or labeled as hazardous and incinerated (in Europe).[16]

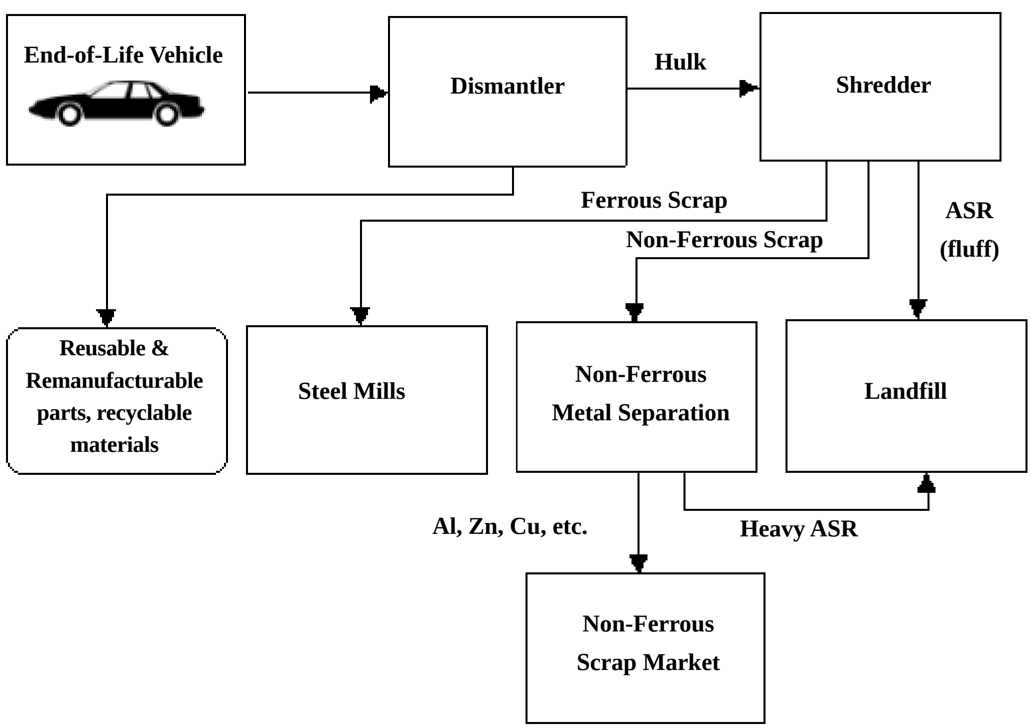


Figure 1: Existing Vehicle Recycling Infrastructure

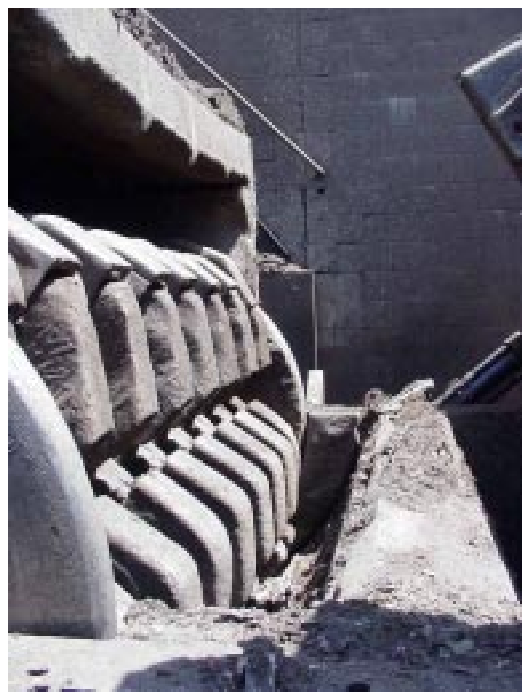
ELV Dismantlers

ELVs enter the recycling infrastructure via a high-value parts dismantler, or an automobile wrecking/scrap yard (also referred to generically as automotive dismantlers or auto salvage yards). High-value parts dismantlers tend to be high-volume operations that quickly process ELVs and either send them on to a shredder or to a scrap yard. The vast majority of automotive dismantlers are low volume, low technology operations that store the ELV while its parts are gradually removed and sold. Either type of dismantler may drain the vehicle of fluids, remove components of value that are easily accessible, and sell them for reuse, remanufacturing, or recycling. Tires, wheels, engines, transmissions, batteries, fuel tanks, radiators, air bags, motors, and catalytic converters are some of the parts that may be removed at the dismantling stage. Many parts, like instrument panels, are not designed to be reused or recycled and, therefore, end up entering the waste stream. Each year, in the United States alone, ELVs and regular vehicle maintenance annually generate 200 million scrap tires, 15 million waste batteries, and 800 million gallons of waste lubricant.[17]

North America has more than 10,000 dismantlers, 20 percent of which use advanced technologies and target late model vehicles.[18] The remaining 8,000 dismantlers conduct more traditional auto salvage operations. Many of these low volume, low technology operations are characterized by small, back yard shops that have historically operated with little regard for environmental protection. In fact, some crude dismantling operations result in the environmental release of gases (e.g., chlorofluorocarbons, gasoline vapors) and liquids such as motor oil, antifreeze (glycols), sulfuric acid/dissolved lead, methanol, brake fluid, and gasoline. Chapter 3 further examines auto salvage operations and mercury releases at automotive junk yards and scrap yards.

Auto Shredders

Following the dismantling process to salvage any parts of economic value, the gutted vehicles (hulks) are either flattened by crushing, or sent directly (uncrushed) to a shredder facility. About 200 auto shredders process the vehicles discarded annually in North America.[19] For every 10 million vehicles (14.2 million metric tons or 15.6 million short tons), this results in the recovery of 10 million metric tons (11 million short tons) of steel, and 730,000 metric tons (800,000 short tons) of non-ferrous metals each year.[20] It also generates more than 2.7 million metric tons (3 million short tons) of ASR per year, roughly 270 kg (600 lbs) per vehicle.[21] If these figures are extrapolated out to the 12 million vehicles estimated to be retired in the United States and Canada each year, then 17 million metric tons of vehicle weight results in the recovery of 12 metric tons of steel, 960,000 metric tons of non-ferrous metals, and 3.3 million metric tons of ASR. Chapter 4 further discusses air emissions of mercury from auto shredding facilities and the mercury content of ASR.



Shredder Hammermills. Photo Credit: Michigan Department of Environmental

Vehicles typically are sold to shredder facilities at a price of about 3 cents per pound.[22] The shredding process separates the materials into three fractions: ferrous, non-ferrous, and ASR. The shredder uses hammermills to first break down the hulk into fist-sized chunks. The ferrous metals are then recovered by magnetic separation. This ferrous fraction is sent for recycling to steel smelters, almost exclusively electric arc furnaces. Historically, the ferrous fraction has accounted for about 70 percent of the weight of the car, but this proportion is decreasing as more and more plastics are used. Most of the lightweight waste material known as ASR or fluff, comprised of foam, textiles, plastics, glass, metal fines, residual fluids, and dirt is removed by air cyclone separation, then landfilled. The remaining material stream, rich in non-ferrous metals, may be sent to a non-ferrous metal separation facility, where metals like aluminum, copper, and zinc are recovered. The waste from this process, known as heavy ASR, is also landfilled.

The flattened hulks may also be sent directly to electric arc furnaces (EAFs) without any further material separation (#2 bundles). While some components are removed prior to crushing, significant quantities of plastics (trim, cabling, etc.) and other contaminants remain in the vehicle. Though flattened hulks are cheaper sources of material for steel mills, they also produce a lower quality of steel. It is not known what percentage of hulks go directly to steel mills.

Electric Arc Furnaces

EAFs use electric energy to melt and refine scrap in a batch process to make steel products. Additional process inputs include fluxes and additives, which may include fluorspar, dolomite, and alloying agents such as aluminum and manganese.[23] During melting, elements in the scrap – such as phosphorus, silicon, manganese, carbon, and other materials – are oxidized; this process forms a slag containing these oxidation products on top of the molten metal. Other documented byproducts of the EAF process include metal dusts, and gaseous byproducts. Since EAFs use scrap metal instead of molten iron, there are no coke-making or iron-making processes associated with this form of steel production.

Particulates and gases that evolve during the steel-making process are conveyed into either a wet or dry gas cleaning system. Particulate matter removed from the gas cleaning system is a listed hazardous waste (RCRA K061) called EAF dust if it is from a dry system or EAF sludge if it is from a wet system. The composition of EAF dust or sludge varies greatly, depending on the scrap composition and furnace additives. EPA reports that the primary hazardous constituents of EAF dust or sludge are lead and cadmium,[24] but Chapter 4 of this report shows that mercury also is a hazardous constituent of EAF dust. In light of this report, it is important to note that, 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.[25]

In 1999, there were 120 EAF minimills operating in the United States, 20 in Canada, and 19 in Mexico.[26] Total U.S. production for that year was approximately 45 million metric tons (50 million short tons), or roughly 81 percent of capacity (56 million metric tons or 62 million short tons).[27] Approximately 37 percent of all domestic ferrous scrap processed by the steel industry is supplied from the automotive recycling sector, which also processes discarded appliances and other industrial scrap steel.[28] Chapter 4 of this report also shows that EAFs are a significant source of mercury air emissions.

CHAPTER 2
MERCURY IN AUTOMOTIVE APPLICATIONS

Over the past decade, several states, agencies, and corporations have examined the use of mercury in automotive applications. For example:

- In 1991 U.S. automakers Chrysler (now DaimlerChrysler), Ford, and General Motors, along with the Michigan Department of Environmental Quality (MDEQ) began examining mercury usage through the Auto Pollution Prevention Project (Auto Project). The Auto Project explored approaches to reducing emissions of persistent toxics into the Great Lakes from automotive manufacturing operations.[29] At about the same time, a similar project was initiated in Canada.
- In 1994, Michigan convened its Mercury Pollution Prevention (M2P2) Task Force, which included an automobile subgroup that examined mercury use and pollution prevention opportunities in the automotive industry.[30]
- In 1995, the Minnesota Pollution Control Agency (MPCA) evaluated mercury switches in automobiles, toxic heavy metals in auto shredder residue (ASR) and their potential effect on the environment, and the heavy metal composition and leaching behavior of selected ASR components.[31]
- In 1999, the Directorate General Environment of the European Commission initiated a study of heavy metals in vehicles, including mercury.[32]
- In March 2000, Vermont's new Labeling of Mercury-Added Consumer Products law required automakers to label sources of mercury in model year 2000 vehicles.[33]
- Most recently, an End-of-Life Vehicle (ELV) Directive ratified by the European Union (EU) in September 2000, restricts or eliminates the use of several heavy metals in vehicles after July 2003, including most applications of mercury.[34] The EU ELV Directive is discussed in detail in Chapter 6.

As a result of such scrutiny, the North American automotive industry documented several automotive uses of mercury and agreed to voluntarily phase out mercury switches, where feasible, beginning with the 1997 and 1998 model years.[35] Appendix A of this report details the industry's commitments for a mercury switch phaseout. In a few instances, automakers have provided summary data on the amount of mercury used in particular applications. However, very little is known about the total quantities of mercury used in any one application, either historically or in emerging applications. This chapter describes some of the historical and current applications of mercury in automotive systems and attempts to quantify the amount of mercury present in the current vehicle fleet.

MERCURY SWITCHES

Mercury switches use a liquid pool of mercury to activate an electrical signal. According to a 1996 white paper developed by the Society of Automotive Engineers' (SAE) design and manufacture for the environment committee, mercury switches used in lighting, anti-lock brake, and ride-control systems account for 99.9 percent of all North American automotive uses of mercury.[36] At that time, approximately 14 million mercury switches were provided annually to the U.S. automotive industry.[37] Based on the 1996 U.S. production of 13,236,000 cars and light trucks,[38] this equates to 1.06 mercury switches per vehicle.

The mercury content of mercury switches varies from 0.7 grams to 1.5 grams, with an average of 0.8 grams per switch.[39] In 1996, light switches accounted for 87 percent of mercury use, antilock braking systems (ABS) for 12 percent, and active ride-control systems for 1 percent.[40] If we assume the average weight of mercury is the same in all switch types, this equates to 12.2 million mercury light switches, 1.7 million mercury ABS switches, and 140,000 ride-control switches. This may slightly overestimate the number of mercury switches in ABS systems and underestimate the number of mercury switches in other applications. Mercury ABS switches are reportedly made up of three individual switches, containing about one gram of mercury each.[41]

MPCA ASR Study: Mercury Switches

In March 1995, as part of a study of ASR, the MPCA evaluated the number of mercury switches generated by salvaged vehicles from four local salvage yards, apparently focusing on mercury switches used in convenience lighting. Some 34 percent of the 605 vehicles sampled contained one or more switches, yielding an overall average of 0.43 switches per car.[42]

The MPCA study is widely cited to determine both the average number of vehicles containing mercury switches (one in three vehicles) and the average number of mercury switches in vehicles (0.43 per car). However, judging from the 1996 data on mercury switches provided annually to the industry, the MPCA study greatly understates the problem. First, the study apparently did not account for switches used in applications other than convenience lighting, such as ABS switches. Second, mercury switches were found almost exclusively in American models, but no data were collected on the number of American vs international cars processed during the test period. European manufacturers reportedly phased out mercury switches in the early 1990s when Sweden banned mercury from vehicles sold in that country.[43] Finally, the study report does not document any quality control measures to ensure the auto salvage yards found all of the convenience lighting switches or kept accurate and complete records.

The SAE paper estimates total mercury use in switches at approximately 9.8 metric tons per year, but this figure translates to only 0.7 grams per switch. Assuming 0.8 grams per switch for the 14 million switches, a total of 11.2 metric tons or 12.3 short tons of mercury was making its way annually into U.S.-produced cars and light trucks.

Mercury Light Switches

Automakers use mercury light switches in convenience lighting (one switch per light), such as underhood and trunk lighting. Switches are designed so that when the hood or trunk reaches a certain opening angle, the mercury in the switch makes electrical contact, and activates the lamp.[44]

Some automakers are voluntarily curtailing their use of mercury switches by adopting mercury-free alternatives. The alternatives available are discussed in greater detail in Chapter 6. International automakers phased out mercury light switches in the early 1990s;[45] DaimlerChrysler phased them out in the late 1990s. Although both Ford and General Motors phased out mercury light switches in some models after 1996, some year 2000 models still use these switches (Table 2).[46]

In March 1998, Ford reported a 55 percent reduction (1.4 million) in the use of “mercury switches” from 1996 to 1997. Presumably, these are mercury light switches. Ford still uses mercury light switches in six year 2000 models, as well as in all of its F-series truck models (F150-550). Ford expects to eliminate all mercury-bearing underhood switches by 2002.[48]

Table 2: Model Year 2000 Mercury Light Switch Usage

Manufacturer [a]	Models with Mercury Light Switches
DaimlerChrysler	None
Ford [b]	F-Series Trucks (F150-550), Crown Victoria, Expedition, Navigator, Excursion, Explorer, Mountaineer
General Motors [c]	Cadillac Escalade, Chevrolet Cavalier, Chevrolet Express, Chevrolet Blazer, GMC Denali, GMC Envoy, GMX Jimmy, GMC Savanna, Pontiac Sunfire, Oldsmobile Bravada

Source: Certified Label Plans provided by automakers to Vermont under the Vermont Labeling of Mercury-Added Products Law.

[a] The internationally owned manufacturers, American Honda, Jaguar, Mazda North America, Mercedes Benz, Mitsubishi Motors, Nissan, Porsche Cars, Rover Group, Saab Cars USA, Subaru of America, Toyota, Volvo, and Volkswagen, have phased out mercury light switches.

[b] Ford reported using mercury-bearing “convenience lighting switches” in these models. The number of switches per model is not known.

[c] General Motors reported using a mercury-bearing hood light switch in these models.

The Association of International Automobile Manufacturers (AIAM) detailed historical automotive mercury switch usage in a 1996 letter to the MDEQ.[49] The European automakers listed in the letter had phased out all mercury light switches by 1992, commensurate with a Swedish ban on motor vehicles sold in that country, effective in January 1993. Japanese automakers reported no historical use of mercury light switches, but a mercury light switch was found in at least one Honda vehicle during the MPCA ASR study discussed previously (see box, “MPCA ASR Study: Mercury Switches”).[50] Per the EU ELV Directive, vehicles put on the EU market after July 1, 2003 cannot contain mercury switches.[51]

Example of a Ford truck light switch. Photo Credit: Tom Corbett, NY Department of Environmental Conservation

Example of a DaimlerChrysler hood light switch. Photo Credit: Tom Corbett, NY Department of Environmental Conservation

Example of a GM hood light switch. Photo Credit: Tom Corbett, NY Department of Environmental Conservation

ABS Switches

ABS braking systems, an important safety feature first introduced in the 1980s, are becoming standard on more and more vehicles. According to the 1996 SAE white paper on mercury in automotive systems, mercury switches are used on some 4-wheel drive ABS applications.[52] These mercury switches detect deceleration rates, take the 4-wheel drive out during slipping, and then re-engage the 4-wheel drive after the slipping event has passed. Usually 3 switches per vehicle are used[53] containing about 3 grams of mercury or one gram per switch.[54]

According to the SAE white paper, ABS mercury switches could be replaced by an integrated sensor, but no such sensors are known to be in production.[55] General Motors, however, does not use mercury-containing ABS systems, but offers anti-lock brakes on several models. In addition, several international car manufacturers that currently offer ABS systems, including Mercedes, Mitsubishi, Nissan, and Subaru, reported they had phased out the use of mercury switches in their ABS systems in the early to mid-1990s.[56] Although we found no information on the efficacy of mercury-containing ABS systems as compared to the alternatives, we assume the alternatives operate within acceptable parameters.

ABS Acceleration Sensor from a 1999 Jeep Grand Cherokee. Photo Credit: Jeff Gearhart.

Table 3 presents mercury ABS switch usage in model year 2000 vehicles reported by the automotive industry to the State of Vermont.[57] As shown in the table, DaimlerChrysler, Ford, and Mazda North America use mercury ABS switches on several 2000 models. In a recent letter to the M2P2 Task force, DaimlerChrylser reported the Grand Cherokee will be free of mercury in the ABS in model year (MY) 2002, the Wrangler in MY 2006, and the current Cherokee at the end of MY 2005.[58] Ford expects to eliminate mercury-containing ABS switches by 2001.[59]

Table 3: Model Year 2000 Automotive Mercury ABS Switch Usage

Manufacturer [a]	Models with ABS Mercury Switches [b]
DaimlerChrysler	4-Wheel Drive Jeeps (Grand Cherokee, Cherokee, Wrangler)
Ford	Explorer, Mountaineer, Ranger
General Motors	None
Mazda North America	B-Series Pickup Trucks (B2500, B3500, B4000)

Source: Certified Label Plans provided by automakers to Vermont under the Vermont Labeling of Mercury-Added Products Law.
[a] The internationally owned manufacturers, American Honda, Jaguar, Mercedes Benz, Mitsubishi Motors, Nissan, Porsche Cars, Rover Group, Saab Cars USA, Subaru of America, Toyota, Volvo, and Volkswagen, have phased out mercury ABS switches.
[b] DaimlerChrysler reported using mercury in ABS *switches*, while Ford reported using mercury in ABS *sensors*. We assume these applications are the same.

Of note here is that either the use of mercury-containing switches by Mazda and DaimlerChrysler has increased since the voluntary phaseout began or previous reporting by the automakers was inaccurate. In 1996, Mazda reported it no longer used mercury in any ABS systems.[60] It now uses mercury switches in its B-series pickup trucks. According to a recent M2P2 Task Force Progress Report, by 1998 DaimlerChrysler had phased out all mercury switches, except for mercury switches in the ABS system in its Grand Cherokee Jeep.[61] It now uses mercury switches in Grand Cherokee, Cherokee, and Wrangler models.

Also of note is that it appears mercury-containing ABS switches are not limited to 2-wheel drive vehicles, as suggested in the 1996 SAE white paper. Ford reported the use of mercury sensors on Explorer, Mountaineer, and Ranger models and Mazda North America on B-series pickup trucks.[62] Neither of the automakers specified 4-wheel drive vehicles only and specifications for 2001 models list ABS brakes as standard on both 2-wheel drive and 4-wheel drive models.[63] In addition, the Jeep web page lists ABS brakes on Grand Cherokee 2001 models and does not specify 2WD exclusively.[64] ABS brakes are listed as optional equipment on Cherokee or Wrangler models.

The presence of 4-wheel ABS on both 2-wheel and 4-wheel drive vehicles is confirmed by data in the trade publication, *Ward's Automotive Yearbook*. This publication reports statistics for the automotive industry, including the percent of specific models with factory installed 4-wheel drive and 4-wheel ABS. Table 4 presents these data for the DaimlerChrylser, Ford, and Mazda models in question. As shown in the table, in 1997 all Grand Cherokee, Explorer, and Mountaineer models contained 4-wheel ABS, regardless of the transmission (4-wheel drive or 2-wheel drive). Also of note is that most Ford Ranger and Mazda B-series pickup trucks did not have 4-wheel ABS in 1997; this feature is standard on 2001 models.

Table 4: DaimlerChrysler, Ford, and Mazda Models with 4-Wheel Antilock Brakes

Manufacturer	Vehicle Model	1997 Model Year	
		Percent with 4-Wheel Drive	Percent with 4-Wheel ABS
DaimlerChrysler	Jeep Wrangler	100	9.4
	Jeep Cherokee	79.1	14.5
	Jeep Grand Cherokee	77.1	100
Ford	Explorer	67.2	100
	Mountaineer	78	100
	Ranger	13.3	1.7
Mazda	B-Series Pickup Trucks (B2500, B3500, B4000)	11	4

Source: *Ward's Automotive Yearbook*, 1998.

Ride Control Systems

Mercury switches in active ride control systems accounted for about one percent of these switches supplied to North American automakers in 1996. At that time, most commonly two, and up to four, mercury switches were used on some vehicles to adjust the suspension during cornering events.[65] These switches contain approximately one gram of mercury per switch.[66]

None of the model year 2000 data provided by automakers to Vermont list ride control as a current application of mercury.[67] However, the record of the April 1999 Binational Toxics Strategy Mercury Workgroup lists active ride control as a current application of mercury switches in some vehicles, expected to be phased out by 2001.[68] Our study found no information on which U.S. vehicles use mercury switches for active ride control. We did find that Mercedes Benz used mercury switches for active suspension prior to 1992.[69]

Air Bag Sensors

Mercedes, Toyota and Volvo used mercury acceleration sensors for airbags, but phased this application out in 1992 and 1993.[70] During their investigation into the use of mercury in automotive systems, the SAE committee on design and manufacture for the environment did not confirm the use of mercury acceleration sensors in U.S-produced cars and light trucks.[71]

Total Number of Mercury Switches in Model Year 2000 Vehicles

It is difficult to make an accurate accounting of the number of mercury switches in model year 2000 vehicles for the following reasons:

- No data are available on which specific vehicle models contain mercury switches for ride-control systems.
- Only limited data are available on the percent of DaimlerChrysler, Ford, and Mazda North America vehicles that have mercury-bearing ABS switches within specific model groups.
- Ford reported convenience lighting switches in a number of models, but did not report the number of switches per vehicle.

Allowing for these uncertainties in the data, Table 5 lists the estimated number of switches present in model year 2000 vehicles and compares the totals by switch type to 1996 totals. Appendices B and C detail the methods used to calculate these totals.

Table 5: Model Year 2000 Automotive Mercury Light and ABS Switch Usage

Manufacturer	Component			
	Light Switches	**ABS Switches**	**Ride Control**	**Total Light and ABS Switches**
Daimler Chrysler	0	1.1-1.9 million [b]	Unknown	1.1-1.9 million
Ford	1.8-3.6 million [a]	2.7 million	Unknown	4.5-6.3 million
General Motors	0.98 million	0	Unknown	0.98 million
Mazda North America	0	0.06-0.15 million	Unknown	0.15 million
Total 2000	2.8-4.6 million	4.0-4.8 million	Unknown	6.7-9.3 million
Total 1996	12.2 million	1.7 million	0.14 million	14 million
Percent Change	77-62% decrease	13-180% increase	Unknown	52-34% decrease

[a] Ford's mercury light switches are given as a range due to uncertainty about the number of switches in each model.
[b] DaimlerChrysler's mercury ABS switches are given as a range due to uncertainty about the number of vehicles that contain 4-wheel ABS.

According to these figures, model year 2000 vehicles still contained some 6.7 to 9.3 million mercury switches. If we assume 0.8 grams of mercury per switch, between 5.4 and 7.4 metric tons of mercury are still finding their way into U.S.-produced passenger vehicles annually. The number of mercury light switches in automotive systems has decreased significantly since 1996, perhaps as much as 77 percent. During the same period, however, the number of mercury ABS switches has increased by at least 130 percent and perhaps as much as 180 percent. Further information is needed about this application of mercury-containing switches to determine why it is on the increase four years into a planned phaseout.

HIGH INTENSITY DISCHARGE (HID) HEADLAMPS

HID headlamps (i.e., fluorescent headlamps or gas discharge bulbs) are an emerging application for mercury that uses a mixture of mercury, sodium, scandium, and a small amount of thorium oxide and sometimes thallium as an illuminant.[72] Reportedly, these headlamps offer improved visibility, have a longer life span, and use less energy than standard halogen or tungsten filament headlamps.[73, 74] Each HID headlamp contains from 5 to 10 mg of mercury.[75]

HID headlamps were used by one importing manufacturer in the mid-1990's and by one domestic manufacturer as an option in one 1995 model.[76] At that time, total North American use of mercury in this application was estimated at less than 0.0001 metric tons per year.[77] In 2000, about 3.5 million HID headlamps were used in the production of new cars worldwide for a total of 0.00175 metrics tons (4 lbs) per year.[78]

Table 6 lists HID headlamp usage in model year 2000 vehicles. This usage is expected to increase because these headlamps are now being offered in less expensive models.[79] In addition, the EU ELV directive exempts mercury-containing bulbs from its ban on mercury in vehicles.

Table 6: Model Year 2000 Automotive HID Headlamp Usage

Manufacturer	Models with HID Headlamps
Daimler Chrysler	None
Ford	None
American Honda	Acura 3.5 RL, Acura 3.2 TL, Acura 3.2 CL, Acura unnamed new model
General Motors	GMC Envoy
Jaguar	Considering HID headlamps
Mazda North America	None
Mercedes Benz	Optional on all Mercedes models
Nissan	Infiniti 130, Infiniti Q45, Infiniti QX4
Porsche Cars	911, Boxster
Rover Group	None
Saab Cars USA	None
Subaru of America	None
Toyota	Lexus LS 400, Lexus GS 400, Lexus GS 300, Lexus ES 300
Volvo	None
Volkswagen	Beetle (optional), Audi A4, Audi S4, Audi A6, Audi A8, Audi TT

Source: Certified Label Plans provided by automakers to Vermont under the Vermont Labeling of Mercury-Added Products Law.

OTHER FLUORESCENT LAMPS

In addition to their application in headlamps, fluorescent lamps used for background illumination in automotive displays are another emerging application of mercury.[80] In 1996, the virtual image instrument panel of one North American vehicle used two mercury lamps, each containing from 5 to 10 mg of mercury. Today at least nine automobile manufacturers use mercury in fluorescent lamps in a variety of applications on several models. The amount of mercury used in each of these applications is not known, with estimates ranging from 1.2 mg for background lighting in navigation systems to less than 40 mg for speedometer systems.[81, 82] Evidently, one main reason for using this type bulb is the restricted space available for lighting.[83]

Table 7 lists fluorescent lamp usage in model year 2000 vehicles. The EU study, “Heavy Metals in Vehicles,” concluded that a phaseout of mercury in background lighting devices is not yet possible,[84] which suggests there are no alternatives. This means that either the amount of mercury backlighting has been greatly underreported (e.g., it is used in all vehicles with backlit instruments) or the backlit instruments in vehicles not listed in Table 7 have different requirements.

Fluorescent lamps may also be used in aftermarket exterior lighting, such as running board lights. No information was found in this study about the extent of mercury usage in these aftermarket applications. Bulbs and instrument panel displays are exempted from the EU ELV Directive’s 2003 ban on mercury in vehicles sold in EU member countries.

Table 7: Model Year 2000 Fluorescent Lamp Usage

Manufacturer	Component	Models
DaimlerChrysler	None	None
Ford	Back-Lit Instruments	Continental
American Honda	Navigational Display	Honda Odyssey, Acura 3.5 RL, Acura 3.2 TL, Acura unnamed new model
General Motors	Night Vision Display	Cadillac Deville Option
	Navigational Display	Cadillac Deville and Seville options
	I/P Cluster Lighting	Cadillac Seville and Deville options, Chevrolet Corvette
Jaguar	None	None
Mazda North America	None	None
Mercedes Benz	Navigational Display	Optional on all Mercedes models
	Back-Lit Instruments	Mercedes S-Class, Mercedes CL-Class
Mistsubishi Motors	None	None
Nissan	Backlight Display Assy-AV	Infiniti 130, Infiniti Q45, Infiniti QX4
Porsche Cars	Navigational Display	911, Boxster
Rover Group	None	None
Saab Cars USA	None	None
Subaru of America	None	None
Toyota	Optitron Instrumentation (speedometer and tach)	Lexus LS 400, Lexus GS 400, Lexus GS 300, Lexus ES 300, Lexus SC 400, Lexus SC 300, Lexus ES, 300, Lexus LX 470, Lexus RX 300
	Navigational Display	Lexus LS 400, Lexus GS 400, Lexus GS 300
	Information Display	Avalon XLS
Volvo	Navigational Display	Volvo S80
Volkswagen	Head Restraint Display	Bentley Arnage, Bentley Azure, Bentley Continental R, Bentley Continental SC, Bentley Continental T, Rolls-Royce Silver Seraph (Optional for all)
	Navigation Display	Audi A4, Audi S4, Audi A6, Audi A8, Bentley Arnage, Bentley Azure, Bentley Continental R, Bentley Continental SC, Bentley Continental T, Rolls-Royce Silver Seraph (Optional for all)

Source: Certified Label Plans provided by automakers to Vermont under the Vermont Labeling of Mercury-Added Products Law.

OTHER APPLICATIONS OF MERCURY

Other applications of mercury reported under the Vermont Labeling of Mercury-Added Products Law include the family entertainment system on the Ford Windstar and Villager models, the combination meter on the Mitsubishi Diamante, and the cluster meter on Nissan Infiniti models. The automakers did not describe how the mercury was used in these systems, whether for backlighting or some other application.

Other sources of mercury in the automobile may not yet be documented. As part of its 1995 study of auto shredder residue, the MPCA evaluated the heavy metal composition and leaching behavior of selected ASR components from vehicles less than 10 years old.[85] The metals selected for analysis were cadmium, chromium, copper, lead, mercury, nickel, and zinc. Mercury results are discussed here while results for the other metals will be discussed in a later report.

The study sampled and tested twenty-four types of automotive components in two phases. The first phase tested total heavy metal composition of components from five salvaged vehicles that were 10 years old or less. The second phase tested total heavy metal composition and leachability (determined using the Toxicity Characteristic Leachate Procedure [TCLP]) on vehicles that were three years old or less. Table 8 presents Phase I samples exhibiting mercury levels above background levels. Phase I and Phase II samples had similar levels of heavy metals in the components tested.[86]

Table 8: Phase I Samples Exhibiting Mercury Levels Above Background Levels

Part Code	Part Description	Mercury Level (mg/kg)
A19	Paint Flakes	0.1
B19	Paint Shavings	0.04
C19	Paint Shavings	0.04
D19	Paint Shavings	0.04
E19	Paint Shavings	0.04
A10	Seatbelt Material	0.06
C10	Seatbelt Material	0.05
D10	Seatbelt Material	0.1
E10	Seatbelt Material	0.06
A22	Headliner	0.03
C22	Headliner	1.8
D22	Headliner	2.3
E22	Headliner	0.05
B11	Carpeting	0.04
C11	Carpeting	0.03
E11	Carpeting	0.04
C12	Seat Foam	0.03
D12	Seat Foam	0.03
D1	Steering Wheel	0.03
E9	Steering Wheel	0.04
C8	Dashboard	0.03
C13	Body Panels	1.0
F7	Bumper	0.04

Source: MCPA, *Automobile Shredder Residue Report*, 1995.

All five of the paint samples had mercury levels above the background level of 0.01 mg/kg. Mercury has been used as a paint fungicide, but whether this is why mercury was present in the paint samples is not known. Four seatbelt samples and four headliner samples had mercury levels above background, with the highest levels of mercury found in a sample of blue headliner material. The source of mercury in these and the other components with mercury above background levels is not known.

MERCURY CONTENT OF THE CURRENT VEHICLE FLEET

Historically, mercury switches accounted for 99.9 percent of the mercury used in vehicles; this trend continues today. Although U.S. automakers have agreed to the voluntary phaseout of mercury switches – and, indeed, have already phased out mercury light switches in some models – the number of mercury ABS switches in use has increased significantly since 1996. Table 9 summarizes the known applications of mercury in automotive vehicles.

Table 9: Summary of Known Automotive Applications of Mercury

Application	Quantity of Hg Used	Use Status	Mercury Content of U.S. Made Vehicles (metric tons)	
			1996	2000
Light Switches	0.7 to 1.5 g per switch, 0.8 g average	62 to 77% decrease in number of switches in U.S. automaker fleets since 1996. Phased out by international automakers in early 1990s.	9.7[a]	2.2 to 3.7[a]
ABS Switches	3 g per system	130 to 180% increase in number of switches in U.S. automaker fleets since 1996. Phased out by international automakers in early 1990s.	1.4[a]	3.2 to 3.8[a]
Ride-Control Switches	1 g per switch	Scheduled for phaseout in 2001.	0.11[a]	Unknown
HID Headlamps	5 to 10 mg Hg per lamp	More than 10-fold increase since 1996 and more expected. No phaseout planned.	0.0001	Unknown (0.00175 worldwide)
Other Fluorescent Lamps	1.2 to < 40 mg per lamp	Used by one OEM in one vehicle model in 1996. Used by nine OEMs in numerous models in 2000. No phaseout planned.	Unknown	Unknown

[a] Based on the average value of 0.8 grams mercury per switch for all switch types.

There are a number of limitations to the data, which make it difficult to estimate the mercury content of the current vehicle fleet. In particular:

- There were 210 million vehicles on the road in the United States in 1999 and 235.4 million in North America (United States, Canada, and Mexico) in 1996. Given the fact that the number of vehicles in use tends to increase annually, we assume the current North American vehicle fleet comprises more than 235.4 million vehicles.
- The current vehicle fleet encompasses vehicles from one to 14 years old and older, but mercury data are available only for the 1996 and 2000 model years.
- International automakers phased out mercury switches in the early to mid-1990s, but no information is available on the average number of switches in their vehicles before the phaseout. Imports accounted for 14.0 percent of the North American market from 1989 to 1997.[87] This is the most recent data available for the period covered by the majority of the current vehicle fleet, assuming the average useful life of a car is about 10 to 11 years.
- The total amount of mercury in HID headlamps and other fluorescent lamp applications is not known, but this value is expected to be small compared to mercury switch usage.

Allowing for these uncertainties, Table 10 summarizes our estimate of the mercury content of the North American vehicle fleet. If we assume all 235.4 million vehicles contain 1.06 mercury switches (the average number in the 1996 U.S.-built fleet), the current North American vehicle fleet contains about 250 million mercury switches. At 0.8 grams per switch this equates to 200 metric tons (220 short tons) of mercury. This may over estimate the mercury content because international manufacturers completed a phaseout of mercury switches in 1992 and 1993 and U.S automakers have decreased mercury switch usage in the last few years. However, it could also underestimate the problem because the current North American vehicle fleet is expected to contain more than 235.4 million vehicles and if pre-1996 vehicles contain more mercury than the baseline year, 1996.

Table 10: Mercury Content of the Current North American Vehicle Fleet

Fleet	No. of Vehicles	No. of Switches	Fleet Mercury Content [a] (metric tons)	Average Mercury Content (grams/vehicle)
North American	235.4 million [b]	250 million [c]	200	0.85
		215 million [d]	172	0.73
United States	210 million [e]	223 million [c]	178	0.85
		191 million [d]	153	0.73

[a] Assuming 0.8 grams of mercury per switch.
[b] Number of vehicles in use in 1996, from AAMA, *Motor Vehicles, Facts and Figures*, 1998.
[c] Assuming all vehicles in the fleet contain 1.06 mercury switches.
[d] Assuming fourteen percent of vehicles contain no mercury switches.
[e] Number of vehicles in use in 1999, from Automotive News, *2000 Market Data Book*, May, 2000.

Reducing the overall total by 14 percent (the market share of international manufacturers from 1989 to 1997) yields 215 million mercury switches and 172 metric tons (189 short tons) in the current North American vehicle fleet. Again, this may slightly overestimate the numbers, because U.S. manufacturers began a slow mercury switch phaseout in 1996. But it is more likely to underestimate the fleet mercury content because the current fleet is expected to contain more than 235.4 million vehicles and international automakers used mercury switches prior to 1993.

Thus, the more than 235 million vehicles in the current North American vehicle fleet contain an estimated 172 to 200 metric tons of mercury; U.S. vehicles alone contain some 153 to 178 metric tons. While elimination of mercury switches by the industry is the most effective way to reduce releases of mercury into the environment, it will be at least 10 to 14 years before the majority of vehicles in the existing North American fleet are retired and processed. Therefore, unless efforts are directed toward systematically removing switches prior to shredding and metal recovery processing (currently done in only a few states), all of this mercury could eventually be released to the environment.

Furthermore, as shown in Table 11, the 12 million vehicles disposed of annually in the U.S. and Canada contain an estimated 8.8 to 10.2 metric tons of mercury, with U.S. ELVs alone containing 8 to 9.4 metric tons of mercury. Currently, there is very little known recovery of mercury from ELVs and limited to no mercury pollution controls on metal recovery processes. Therefore, we must assume that most, if not all, of this mercury enters the environment each year.

Table 11: Mercury Content of ELVs Processed Annually

Country or Continent	No. of ELVs Per Year	Mercury Content [a] (metric tons)
North America	12 million [b]	8.8 to 10.2
United States	11 million [c]	8.0 to 9.4
Canada	1 million [d]	0.73 to 0.85

[a] Assuming 0.73 to 0.85 grams of mercury per vehicle.
[b] Includes ELVs in the United States and Canada only.
[c] Number of ELVs in 1996, from AAMA, *Motor Vehicles Facts and Figures*, 1997.
[d] Number of ELVs estimated to be discarded each year, from Kincaid, et.al., *Vehicle Recycling and Disposal Policies in Industrialized and Developing Countries*, 1996.

CHAPTER 3
MERCURY RELEASES AT AUTO SCRAP YARDS

The first stop for most end-of-life vehicles (ELVs) on their way through the ELV recycling infrastructure is an automotive dismantler, whether a high-value parts dismantler or an auto scrap yard. Very little is known about mercury releases (or any other type of releases) from these operations, but a number of scrap yards have been listed as Superfund sites in the United States due to heavy metal contamination. This is due mainly to bad storage practices and lack of regulatory oversight of auto scrap yards, many of which are small facilities that have historically fallen beneath the regulatory radar screen. This chapter discusses mercury switch removal and gives examples of mercury contamination at auto scrapyards.

MERCURY SWITCH REMOVAL

Prior to the mid-1990s, auto salvage yards and shredding facilities made little or no effort to recover mercury switches from ELVs.[88] Since then some attention has focused on removing mercury light switches from ELVs, including efforts by the automotive industry, State agencies, and at least one automotive recycling association.

In the middle to late 1990s, the former American Automobile Manufacturers Association (AAMA) and the Society of Automotive Engineers (SAE) developed a mercury switch removal procedure for current vehicles, as recommended by the M2P2 Task Force. SAE then issued SAE surface-vehicle standard J2456, "Mercury Switch Removal Process," in May 1998. This standard describes the location of mercury light switches used in underhood and trunk lighting applications, gives procedures for removing the switches, and describes storage, shipping, and mercury spill cleanup methods, as well as first-aid measures for contact with mercury.[89] Michigan is distributing the SAE Mercury Switch Removal Procedure to all Michigan auto salvage yards,[90] and has started requiring the removal of mercury-containing switches as a permit condition for auto shredders.

The SAE procedure does not address mercury switches used in ABS applications, however; nor does it address mercury light switches used in applications other than underhood or trunk lighting, such as glove compartment lighting. In fact, no one has developed removal procedures for these applications of mercury switches. Considering that ABS switches may now be the single largest application of mercury switches in late model vehicles (see Chapter 2), it is particularly important to devise removal standards for ABS switches in retired vehicles.

This study did confirm the viability of removing at least some ABS switches by removing an ABS acceleration sensor from a 1999 Jeep Grand Cherokee. The sensor is located in the center of the vehicle, under the rear seat. Removal was completed in 15 minutes and required lifting the rear seat, pulling back carpeting and removing two screws that hold the switch in place.

In a separate initiative, the Automotive Recyclers of Michigan (ARM) is cooperating with various state and local agencies to distribute educational materials through a "Pull the Switch" campaign. Prior to the campaign, virtually no salvage yard operators were removing mercury switches.[91] ARM plans to keep track of those participating and the number of switches collected.[92]

Minnesota law requires vehicle salvage facility operators to remove mercury switches from automobiles before the auto bodies are crushed.[93] The Alliance of Automobile Manufacturers is working with New York State on a pilot program to develop educational materials on how to remove, collect, and recycle mercury switches. The educational materials are being distributed to auto dismantlers/scrap yards.[94] Beyond these activities no information was found in this study about whether or how the SAE procedure or other information regarding mercury switch removal is being disseminated to U.S. auto recyclers or whether it is being followed. Very limited information from Tennessee suggests auto salvage yards outside of the few states focusing on mercury switches in autos know little to nothing about mercury switches in vehicles, much less about the SAE mercury switch removal procedure (see sidebar).

Mercury Switch Removal in East Tennessee

In a spot check of three auto salvage yards in East Tennessee, none of the operators were even aware that mercury switches exist in automobiles. None of the facilities remove switches from cars nor are they aware of any procedures for removing mercury switches.[95,96,97]

MERCURY CONTAMINATION AT AUTO SCRAP YARDS

Historically, auto scrap yards were used to store not only used cars but other metal scrap or waste as well. Scrap yards first came into existence in the 1940s and 50s when cars were disposed of in open fields. At that time, shredding technology was not available and inoperative cars 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 inoperative car may linger an average 2 to 5 years in storage before being processed.[98] During this time, wrecked and corroding vehicles may slowly release contaminants into the soil, air (through volatilization), or water (through stormwater runoff). Many of the scrap yards that are Superfund sites are contaminated with used oil and heavy metals as well as PCBs (from PCB transformers). Concentrations of these toxic chemicals can invade the soil and surrounding waters as well as the underlying groundwater. Various levels of contamination at each site testify to the age of the site and the types of activities that have occurred at the site. Following are two examples of mercury contamination at auto scrap yard Superfund sites.

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 automobile scrap yard and for salvage activities.[99]

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. An on-site well also had elevated levels of mercury.[100] The site was remediated at a cost of $2,244,680 in federal cleanup funds and was deleted from the NPL in September 1999.[101]

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 due to the nearby automobile salvage operations.[102]

MANAGEMENT PRACTICES IN THE INDUSTRY

Currently, EPA stormwater regulations require auto recyclers to obtain a federal National Pollutant Discharge Elimination System (NPDES) stormwater permit. The NPDES permit requires a detailed stormwater 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.[103] These range from lack of knowledge of best practices and lack of environmental stewardship to more technical barriers, such as difficulty in separating components.[104] 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.

CHAPTER 4

MERCURY RELEASES FROM SHREDDERS AND METAL RECOVERY PROCESSES

The shredder-derived ferrous fraction of the automobile (65 to 70 percent of its weight) is sent for recycling to steel smelters, primarily electric arc furnaces (EAFs). In the case of a flattened hulk directly fed to an EAF, any material contained in, adhering to, or entrained in the steel particles becomes part of the ferrous-metal recycling process. Chapter 2 showed that the 12 million cars and light trucks disposed of each year in the United States and Canada contain an estimated 8.8 to 10.2 metric tons of mercury, primarily in mercury switches. The more than 235 million cars and light trucks currently on the road contain an estimated 172 to 200 metric tons of mercury.

With very little known recovery of mercury from automotive vehicles, we must assume that most, if not all, of this mercury eventually enters the environment. Some mercury is released from wrecked and corroding vehicles at auto scrap yards, but it appears that the vast majority of automotive mercury is released from shredders and metal-recovery processes, especially EAFs. This chapter examines mercury releases from these facilities and estimates national mercury emissions from EAFs.

OVERVIEW OF MERCURY RELEASE AND TRANSFERS FROM SHREDDERS AND ELECTRIC ARC FURNACES

Very little is known about the final disposition of mercury in the automobile as it makes its way through the shredding and ferrous-metal recovery process. The most complete data, albeit preliminary, are from a mercury mass balance voluntarily performed by North Star Steel (NSS) in 1999 as the first phase in NSS' participation in the Minnesota Mercury Reduction Initiative.[105] NSS is located in St. Paul.

NSS is an EAF minimill that employs its own shredder operation to obtain about one-third of its charge (e.g., feed to the EAF). The remainder (67 percent of the charge) is purchased from scrap dealers in a seven-state region. NSS used a combination of measured and estimated data to perform its mass balance, including stack test data, and measured mercury concentrations in scrap and auto-shredder residue.

Tables 12 and 13 present the results of the shredder and EAF mass balances, respectively. Table 14 presents results for the NSS shredder and EAF combined.

As shown in Table 12, NSS estimated the mercury inputs to the shredder based on the mass of auto scrap fed to the shredder in 1998 and the estimated average concentration of mercury in auto scrap. The latter value was derived from the average number of mercury switches in ELVs (0.43 switches per car at one gram per switch) determined by the Minnesota Pollution Control Agency's (MPCA) Auto Shredder Residue Study. However, as discussed in Chapter 2, the MPCA study may underestimate the number of mercury switches in the average auto, which suggests that the NSS input concentration may be underestimated. NSS removes some mercury switches from automobiles prior to on-site shredding. Approximately 40 pounds of switches containing 11 pounds of mercury were removed prior to shredding and are not accounted for in the shredder inputs presented here.

Mercury outputs from the shredder were estimated based on stack test data, the measured concentration of mercury in one sample of shredder frag, and the measured concentration of mercury in the auto-shredder residue (ASR). Shredder frag is the shredded metal fragment from the shredder which is fed to the EAF. The NSS analysis found the majority of mercury (53 percent) was transferred to ASR, but a substantial fraction (40 percent) was contained in the frag product.

Table 12: Mercury Mass Balance at North Star Steel Shredder, St. Paul, MN

Input or Output Type		Mercury		Percent Contribution
		lbs/yr	kg/yr	
Shredder Inputs	Auto scrap [a]	125	47	100
Shredder Outputs	Total	146	199	100
	Air emissions [b]	11	5.0	7.5
	Auto shredder residue [c]	77	35	52.7
	Frag [d]	58	97	39.7

Source: Ebersviller, Judd, 1999.

[a] Based on scrap mass to shredder in 1998 and estimated concentration of mercury in auto scrap from MPCA's Auto Shredder Residue Study. Does not include 11 pounds of mercury in recycled mercury switches.

[b] Based on measured stack test data from an unspecified control technology and 1997 hours of operation.

[c] Based on average measured mercury concentration in ASR (1.15 ppm) and measured ASR mass for 1998.

[d] Based on measured mercury concentration in one frag sample (0.20 ppm) and 1998 frag mass (75 percent of scrap mass to shredder).

As shown in Table 13, most mercury inputs to the EAF are in scrap from off-site suppliers, which includes scrap bundles and heavy melt #1 and #2. However, this input value was back calculated based on mercury inputs in the frag and baghouse outputs. The actual amount of mercury in the shredder frag is highly uncertain, given its expected non-uniformity and the fact that this value is based on only one sample. NSS has already initiated additional sampling and analysis to better define the concentration of mercury in scrap.[106]

Of the mercury emitted to air from the EAF, more than 60 percent was contained in the flue dust collected by the gas cleaning system, while almost 40 percent was emitted directly to the atmosphere. The mercury-control efficiency of the NSS gas-cleaning system is much higher than expected because EAF gas-cleaning systems are designed to remove particulate matter and would not be expected to capture mercury vapors. In its 1997 Mercury Study Report to Congress, EPA concluded that soluble species of mercury compounds, such as mercuric chloride and mercuric oxide, can be effectively captured in a wet-scrubber system, but collection efficiencies will be limited if there are significant levels of elemental mercury in the flue gas.[107]

EAF dust from the gas-cleaning system is a listed hazardous waste, which is either recycled on site, recycled off site to recover its zinc content, or disposed of off site. As noted in Chapter 1, 10 to 20 kg of EAF dust are generated per metric ton of steel produced (20 to 40 pounds/short ton) depending on production practices).[108] Some 500,000 metric tons (550,000 short tons) of EAF dust are generated annually in the U.S.[109]

On-site recycling of EAF dust involves pelletizing the EAF dust to form briquettes and then reusing the briquettes to charge the furnace. If the NSS data are representative of the industry, this practice serves to enrich mercury in the input materials before cycling it back through the furnace, where additional mercury emissions occur. For example, if the NSS EAF produces EAF dust at the national rate of 10 to 20 kg per metric ton of steel, it would produce from 4,200 to 8,400 metric tons of EAF dust having a mercury concentration ranging from 0.0012 to 0.023 kg per metric ton (i.e., 97 kilograms per year of mercury divided by 4,200 to 8,400 metric tons of EAF dust). This mercury concentration – 12 to 23 ppm – is 60 to 115 times higher than the concentration measured in the single frag sample (0.20 ppm).

Table 13: Mercury Mass Balance at North Star Steel EAF, St. Paul, MN

Input or Output Type		Mercury		Percent Contribution
		lbs/yr	kg/yr	
EAF Inputs	Total	351	159	100
	Frag from on-site shredder [a]	58	26	16.5
	Scrap from suppliers [b]	290	132	82.7
	Other materials (fluxes) [c]	2.5	1.1	0.7
EAF Outputs	Total	350	159	100
	Air emissions [d]	136	62	38.9
	EAF silo dust [e]	214	97	61.1

Source: Ebersviller, Judd, 1999.
[a] Based on measured mercury concentration in one frag sample (0.20 ppm) and 1998 frag mass (75 percent of scrap mass to shredder).
[b] Based on scrap mass from suppliers times mercury concentration in scrap (0.50 ppm, back calculated from mass balance, given output from baghouse and frag concentration).
[c] Based on mass of materials and measured concentration of mercury in materials.
[d] Based on measured stack test data and annual hours of operation.
[e] Estimation method not specified, but reportedly based on at least one analytical sample.[110]

Table 14 allows us to evaluate the distribution of mercury between the shredder and the EAF. In this example, approximately 20 percent of total mercury inputs was emitted from the shredder, while 80 percent was emitted from the EAF. Since NSS uses scrap from its on-site shredder to supply only one-third of its EAF charge, it should be noted that the mass balance understates the contribution of shredder emissions to total mercury releases associated with North Star's steel-smelting process. Other mercury emissions and additional mercury-contaminated ASR would be generated at scrap supplier sites. The NSS Star shredder data are the only measured shredder air-emissions data found in this study.

Table 14: Mercury Mass Balance at North Star Steel Shredder and EAF Combined, St. Paul, MN

Input or Output Type		Mercury		Mercury Input or Output Per Unit of Steel Produced [a]		Percent Contribution
		lbs/yr	kg/yr	lbs/ton	kg/metric ton	
Inputs	Total	429	195	0.00092	0.00046	100
	Scrap	426	193	0.00072	0.00046	99.3
	Other materials (fluxes)	2.5	1.1	5.4×10^{-6}	2.6×10^{-6}	0.7
Outputs	Total	438	199	0.00094	0.00047	100
	Shredder air emissions	11	5.0	2.4×10^{-5}	1.2×10^{-5}	2.5
	Auto shredder residue	77	35	0.00017	8.3×10^{-5}	17.6
	EAF silo dust	214	97	0.00046	0.00023	48.9
	EAF air emissions	136	62	0.00029	0.00015	31.0

Source: Ebersviller, Judd, 1999.
[a] Based on 1998 production of 422,000 metric tons (465,000 short tons) estimated from process inputs.

Currently, NSS is preparing a final Phase I report. The final report is expected to address some of the uncertainties in the preliminary data, such as the concentration of mercury in scrap recycled at the site and the unexpectedly high estimated mercury-control efficiency of the flue gas cleaning system.[111]

MERCURY AIR EMISSIONS FROM SHREDDERS AND ELECTRIC ARC FURNACES

Mercury Air Emissions from Auto Shredders

The shredding process for metal recovery generates intense heat, which can vaporize volatile metals, such as mercury. Other than the NSS data, however, no data are available on mercury air emissions from auto-shredder facilities.

As part of a new source review for a shredder at S&S Metal Processing in Flint, Michigan, the Michigan Department of Environmental Quality (MDEQ) reviewed shredder air permits in Indiana, Michigan, Ohio, and Wisconsin. None of the permits reviewed contained mercury-emissions limits, and only one permit in one state (Michigan) contained any provisions at all for mercury. That permit requires mercury switches to be removed prior to shredding.[112]

For the S&S Metal Processing permit, the MDEQ evaluated potential emissions of a number of metals, including mercury, to determine if they would exceed health-screening standards in Michigan. Only two data sources were found to estimate metal air emissions from shredders:

- SPECIATE is the U.S. EPA's repository of total organic-compound and particulate-matter speciated profiles. It contains an auto-shredder speciated profile, which was used to estimate mercury emissions from shredders.
- The Institute of Scrap Recycling Industries has a Title V applicability workbook, which looks at air-pollution-control systems that could be attached to shredders. The workbook doesn't address mercury specifically.[113]

Because these data sources are limited for mercury, the MDEQ also used data from the MPCA auto-shredder study on the number of mercury switches per vehicle (0.43) to develop a worst-case emissions estimate.[114] However, as noted before, the MPCA study may greatly underestimate the number of mercury switches in automobiles.

A review of mercury emission factors from all of these sources shows that there is no adequate emission factor for mercury emissions from shredders. In public comments on the proposed S&S shredder permit, mercury emission estimates based on a variety of worst-case scenarios found that these emissions are at levels that potentially violate Michigan health-based standards.[115]

The proposed air permit for S&S Metal Processing's new shredder would set a particulate limit and require a stack test, which will test for several metals, including mercury.[116] Clearly, additional measured emissions data are needed to ensure shredder facilities do not remain unregulated for air toxics simply because of lack of data.

Mercury Air Emissions from Electric Arc Furnaces

In 1992, EPA identified EAFs as a possible source of hazardous air pollutants (HAPs) subject to a maximum achievable control technology (MACT) determination under the Clean Air Act (CAA).[117] That same year EPA requested existing information from EAFs regarding HAP emissions, including mercury, from their operations.[118] To satisfy the request industry was not required to perform additional monitoring or emissions testing.

Mercury emission estimates submitted by 19 EAFs to EPA are presented in Appendix D. These estimates ranged from 0.005 to 54 kg/yr (0.01 to 120 pounds/yr), with emissions from 18 of the facilities less than one kg per year.[119] The estimates are reportedly based on stack-test data, but it is not known whether stack tests were performed using EPA methods.[120] Based on these and other HAP data submitted by the industry, EPA determined that the impact was much less than originally anticipated and elected not to pursue a MACT standard.[121] As a result, steel minimills are not regulated for mercury emissions at the federal level, and typically do not employ mercury-emissions controls.

A few states set mercury-emissions limits for EAFs and require stack testing at these facilities. More recent data from New Jersey and Ohio suggest that mercury emissions from EAFs may be several orders of

magnitude higher than indicated by the data submitted by industry to EPA. In addition to the NSS data discussed previously, this study found recent mercury stack-test data for three of the 120 EAFs in the U.S., including one facility in Ohio and two in New Jersey:

- **Marion Steel Inc.** of Marion, Ohio, uses shredded automotive steel scrap as well as compacted car hulks as raw materials for its EAF. Three stack tests were conducted at the facility in 1999.[122] Annual mercury emissions from this facility were found to range from 168 to 272 kg (371 to 600 pounds) assuming 8,000-hours-per-year operation and depending on the composition of the raw material mix. The upper value represented a 1,000-fold increase over Marion Steel's allowable mercury emission rate of 0.000065 lbs/hr (0.52 lbs/yr).[123] Raw materials used in these tests included relatively clean pre-consumer as well as post-consumer steel scrap and steel processing by-products with unknown mercury content. Car hulks, shredded steel, and particularly briquettes made from steel processing baghouse dust are suspected as major contributors of mercury. This assumption is well supported by the mercury mass balance conducted at the NSS facility, discussed above.

  Marion Steel reported mercury emissions data to EPA under the CAA information request discussed previously. At that time, the facility's estimated mercury emissions were only 0.15 kg per year (0.34 pounds per year). No information is available to explain the discrepancy between these data and the more recent data.

- **Co-Steel Sayreville** in Sayreville, New Jersey, (formerly New Jersey Steel) and the New Jersey Department of Environmental Protection (NJDEP) conducted several stack tests at the company's EAF from 1998 to 2000. Co-Steel Sayreville obtains 99 percent of its charge from scrap.[124] This study did not determine whether this includes briquettes made from EAF dust.

  Table 15 presents annual mercury emissions based on stack-test results and the allowable hours of operation (8760 hours) from the facility's permit. The highest value was almost eight times the plant's permit limit of 613 pounds per year (278 kg per year).[125]

Table 15: Mercury Emissions from the Co-Steel Sayreville, NJ, Facility

Stack Test Date	Estimated Hg Emissions Low		Estimated Hg Emissions High		Average Estimated Hg Emissions	
	lbs/yr	kg/yr	lbs/yr	kg/yr	lbs/yr	kg/yr
June 15, 1998 to June 23, 1998	No data	No data	No data	No data	350	159
June 1999	218	99	4730	2145	1772	804
December 1999	175	79	263	119	216	98
June 2000	24	11	70	32	51	23
Average Mercury Emissions, 1998 to 2000					597	271

Sources:
Agrawal, Sunila, NJ DEP, October 30, 2000.[126]
Cosolaro, Rebecca, NJ DEP, August 9, 2000.[127]
Cosolaro, Rebecca, NJ DEP, October 25, 2000.[128]

As shown in the table, mercury emissions from the Co-Steel Sayreville plant are highly variable, with substantially lower emissions measured in the June 2000 stack test. Co-Steel Sayreville did not implement new emission controls during the period covered by the stack tests.[129] Evidently, mercury emissions at the facility are influenced by the type and quality (i.e., degree of mercury contamination) of scrap used to charge the furnace.

The Co-Steel Sayreville plant (then New Jersey Steel) also reported mercury emissions data to EPA under the CAA information request. Estimated mercury emissions were 120 pounds per year (54 kg per year). This emission estimate is significantly lower than the more recent stack-test data, except for the June 2000 data.

- **Co-Steel Raritan** in Perth Amboy, New Jersey, conducted a stack test in August 1999, as required by the NJDEP. Co-Steel Raritan obtains 87 percent of its charge from scrap and 13 percent from pig iron.[130] The facility's permit limit for allowable hours of operation is 7840 hrs.[131] Estimated annual mercury emissions based on the August 1999 stack test range from 129 to 323 lbs/yr and average 224 lbs/yr.[132] Co-Steel Raritan's permit limit for mercury is 197 lbs/yr.[133]

Of note here is that measured emissions from each of these facilities exceeded its state-established mercury permit limit in one or more instances. Emissions testing is needed at other EAFs in North America to determine the true extent of mercury emissions from these sources. Also of note is that the emissions estimates from different stack tests at any one plant are inconsistent, differing by more than two orders of magnitude at the Co-Steel Sayreville facility. Without significant changes in operating procedures or pollution controls, it appears actual mercury emissions may depend on the type and quality of the scrap charge.

National Mercury Air Emissions Estimates from Electric Arc Furnaces

The number and annual capacities of North American steel smelters vary widely from state to state and country to country, as does the amount of regulatory oversight of these sources. Figure 2 illustrates the location of EAFs in the United States.

Figure 2: Location of EAFs in the United States
Source: Iron and Steel Society. Iron and Steel Maker. *"EAF Roundup Issue." May, 2000.*
Map: Environmental Background Information Center

U.S. EAFs have a total nominal capacity of 56 million metric tons (61.6 million short tons).[134] The highest geographic concentration of EAFs in the United States is in the six Great Lake states: New York, Pennsylvania, Ohio, Indiana, Illinois, and Michigan. Together these states account for 47 percent of the EAFs and 40 percent of EAF capacity in the United States.[135] The South is the next largest steel-producing region via the EAF production method, with Texas alone having 12 EAFs with 8 percent of U.S. production capacity. Canadian EAF facilities are mainly located in Ontario and Quebec and can produce 11.8 million metric tons (13 million short tons) of steel annually.[136]

Assuming the stack-test results discussed above are representative of the industry as a whole, these data were combined with annual capacity data to estimate an average mercury emission factor for U.S. based EAF's (Table 16). The emissions factors for each of the facilities tested range from 0.00028 pounds of mercury per ton of steel produced to 0.0014 pounds/ton. The average emission factor for the four facilities is 0.00069 pounds/ton (0.00035 kg/metric ton).

The emission factor from Table 16 was combined with EAF capacity data to estimate mercury emissions from all U.S.-based EAFs (Table 17). Based on this analysis, more than 19 metric tons of mercury (about 21.2 short tons) could be emitted annually from U.S.-based EAFs operating at capacity. If we adjust these figures downward to account for the differences in 1999 production (45.2 million metric tons or 49.7 million short tons)[137] vs.1999 capacity (56 million metric tons or 61.6 million short tons), an estimated 15.6 metric tons (17.2 short tons) of mercury were emitted to the environment in 1999 from EAFs alone. This estimate is uncertain due to the very limited data on mercury emissions from EAFs, but it illustrates the potential magnitude of the problem, the need for better accounting of mercury emissions from these sources, and the need for safe removal of mercury from automobiles prior to shredding.

Due to the complete absence of data on mercury emissions from EAFs in Canada and Mexico, the U.S. emission factor was also used to estimate potential mercury emissions from these facilities (Table 18). This estimate is more uncertain than the U.S. data for two main reasons: first, scrap used at these facilities may have significantly different mercury concentrations than that at U.S. facilities; second, environmental management practices, control technologies, and the amount of regulatory oversight may also differ. Nonetheless, the emissions estimates illustrate the potential magnitude of the problem, with potential mercury emissions at capacity totaling more than 7 metric tons (almost 8 short tons).

Table 16: Mercury Emission Factors for EAFs (1997 - 2000 test data)

Company	State	Production [a] Capacity Short Tons/year	Estimated Hg Emissions Low Lbs/yr	Estimated Hg Emissions High Lbs/yr	Average Estimated Hg Emissions Lbs/yr	Average Emission Factor	
						Lbs Hg /ton	Kg Hg /metric ton
Marion Steel	OH	365,000	371	572	514	0.0014	0.0007
Co-Steel Sayreville	NJ	750,000	24	4,730	597	0.00080	0.00040
North Star Steel	MN	465,000 [b]	136	136	136	0.00029	0.00011
Co-Steel Raritan	NJ	800,000	129	323	224	0.00028	0.00014
Overall average emission factor						0.00069	0.00035

Note: Except for NSS, estimated mercury emissions are based on actual stack-test data for pounds of mercury emitted per hour times the allowable operating hours per year. NSS mercury emissions are based on actual stack-test data times the annual hours the EAF is under power.

[a] Except for NSS, production capacity data from Iron & Steel Maker, EAF Roundup, May 2000.

[b] Based on estimated 1998 production instead of capacity.

Table 17: Estimated Mercury Emissions from U.S. EAFs [a]

Location	No. of Plants	Nominal Capacity ('000s of Short Tons/Yr)	Potential Hg Emissions		Estimated 1999 Emissions	
			(Short Tons/Year)	(Metric Tons/Year)	(Short Tons/Year)	(Metric Tons/Year)
Alabama	5	3,300	1.14	1.03	0.92	0.84
Arkansas	4	2,930	1.01	0.92	0.82	0.74
Arizona	1	500	0.17	0.16	0.14	0.13
California	1	700	0.24	0.22	0.20	0.18
Colorado	1	1,200	0.41	0.38	0.34	0.30
Delaware	1	400	0.14	0.13	0.11	0.10
Florida	1	600	0.21	0.19	0.17	0.15
Georgia	1	850	0.29	0.27	0.24	0.22
Iowa	3	1,618	0.56	0.51	0.45	0.41
Illinois	7	4,825	1.66	1.51	1.35	1.22
Indiana	8	2,855	0.98	0.89	0.80	0.72
Kansas	1	70	0.02	0.02	0.02	0.02
Kentucky	4	2,813	0.97	0.88	0.79	0.71
Maryland	2	1,110	0.38	0.35	0.31	0.28
Michigan	4	1,615	0.56	0.51	0.45	0.41
Minnesota	1	600	0.21	0.19	0.17	0.15
Mississippi	2	460	0.16	0.14	0.13	0.12
North Carolina	2	1,450	0.50	0.45	0.41	0.37
Nebraska	1	1,000	0.35	0.31	0.28	0.25
New Jersey	3	1,662	0.57	0.52	0.46	0.42
New York	4	676	0.23	0.21	0.19	0.17
Ohio	12	7,330	2.53	2.29	2.05	1.86
Oklahoma	1	600	0.21	0.19	0.17	0.15
Oregon	3	1,542	0.53	0.48	0.43	0.39
Pennsylvannia	21	7,266	2.51	2.27	2.03	1.84
South Carolina	4	3,100	1.07	0.97	0.87	0.79
Tennessee	3	1,700	0.59	0.53	0.48	0.43
Texas	12	4,968	1.71	1.55	1.39	1.26
Utah	1	500	0.17	0.16	0.14	0.13
Virginia	2	1,910	0.66	0.60	0.53	0.48
Washington	1	840	0.29	0.26	0.23	0.21
Wisconsin	2	491	0.17	0.15	0.14	0.12
West Virginia	1	100	0.03	0.03	0.03	0.03
U.S. Total	**120**	**61,581**	**21.2**	**19.3**	**17.2**	**15.6**

Number of plants and capacity data from Iron and Steel Society. Iron and Steel Maker. "EAF Roundup Issue." May 2000.
[a] Based on an emission factor of 0.00069 lbs/short ton (0.00035 kg/metric ton)

Table 18: Potential Mercury Emissions from Canada and Mexico EAFs [a]

Location	No. of Plants	Nominal Capacity ('000s of Short Tons/Yr)	Potential Hg Emissions	
			(Short Tons/Year)	(Metric Tons/Year)
Alberta	1	350	0.12	0.11
British Columbia	1	9	0.003	0.003
Manitoba	1	360	0.12	0.11
Nova Scotia	1	800	0.28	0.25
Ontario	10	7,801	2.69	2.44
Quebec	5	2,473	0.85	0.77
Saskatchewan	1	1,200	0.41	0.38
Canada Total	**20**	**12,993**	**4.5**	**4.1**
Mexico Total	**19**	**9,752**	**3.4**	**3.1**

Number of plants and capacity data from Iron and Steel Society. Iron and Steel Maker. "EAF Roundup Issue." May 2000.
[a] Based on an emission factor of 0.00069 lbs/short ton (0.00035 kg/metric ton)

CONTRIBUTIONS OF MERCURY IN ELVS TO EAF EMISSIONS FROM ELV PROCESSING

Although this report analyzes the potential emissions of mercury due to mercury in ELVs in North America, data are more limited in Canada and Mexico than in the United States. Thus, the following discussion assesses the potential contribution of U.S. ELVs to U.S. EAF air emissions.

As discussed in Chapter 1, approximately 11 million ELVs are disposed of annually in the United States. Chapter 2 estimates the mercury content of autos in the current vehicle fleet at between 0.73 and 0.85 grams each. Thus, approximately 8 to 9.4 metric tons of mercury are in the 11 million U.S. ELVs disposed of annually. The actual mercury content of ELVs could be much higher or much lower, however, due to the limited data available to derive this estimate. Nonetheless, given the very limited recovery of mercury in ELVs, any mercury contained therein is almost all likely to be released at some point during ELV processing, either to air (through volatilization), land (through spills from broken mercury switches or from landfilling of solid wastes), or water (through stormwater runoff or wastewater discharges).

This chapter estimates 1999 mercury air emissions from U.S. EAFs at some 15.6 metric tons based on a mercury-emission factor derived from stack tests at four facilities. Like the ELV mercury-content estimates, actual emissions may be much higher or much lower. It also shows that at least some mercury may be contained in the EAF silo dust, as evidenced by the NSS mass balance. Later sections will demonstrate that mercury emissions are not limited to EAFs, but also occur at other facilities that process automotive scrap.

Combined, these data indicate that mercury air emissions from EAFs alone are up to 95 percent greater than the mercury content of ELVs processed annually. This suggests that other sources of metal scrap may also be heavily contaminated with mercury. However, as shown in Table 19, a sensitivity analysis of the data indicates that ELVs could be the source of virtually all EAF mercury air emissions if the baseline estimate of ELV mercury content is low and the baseline estimate of EAF air emissions is high. The more likely scenario is that ELVs are the single largest contributor to EAF mercury emissions but that other sources of ferrous scrap are also contaminated with mercury, including white goods and industrial equipment.

Table 19: Sensitivity Analysis of ELV and EAF Mercury Estimates

Type of Estimate	Baseline (metric tons/yr)	Baseline +50% (metric tons/yr)	Baseline -50% (metric tons/yr)
Mercury content of ELVs	8 to 9.4	12 to 14.1	4 to 4.7
Mercury air emissions from EAFs	15.6	23.4	7.8

Many auto shredders process appliances and ELVs together. Mercury switches and flame sensors are used in some gas ranges and freezers, and mercury-containing fluorescent lights are used to backlight control panels on ranges and clothes washers. Finally, clothes washers manufactured before 1972 had mercury switches in some models.[138] The estimated mercury content in appliances processed annually is about one metric ton or greater.[139]

Until 1998, mercury-consumption data were published annually by the U.S. Geological Survey (USGS) in its mineral yearbook series. Fifty-seven metric tons of mercury were used in wiring devices and switches in 1997,[140] down from 106 metric tons in 1980 and 70 tons in 1990.[141] This includes mercury in industrial equipment and may include autos and appliances. It also includes devices not likely to be associated with metal scrap, such as thermostats. The USGS reports do not give the distribution of mercury in wiring devices and switches among industry sectors.

Twenty-four metric tons of mercury were used in measurement and control instruments in 1997,[142] down from 105 metric tons in 1980 and 106 in 1990.[143] This also includes devices not likely to be associated with metal scrap, such as medical devices. The USGS reports do not give the distribution of mercury in measurement and control instruments among industry sectors.

Other sources of mercury that might be associated with scrap include pigments and paints. As noted in Chapter 2, the MPCA's Auto Shredder Residue study found mercury above background levels in five of five samples of paint from ELVs.

MERCURY EMISSIONS FROM OTHER FERROUS METAL RECOVERY PROCESSES

Most automotive ferrous scrap is reclaimed by EAFs, but some is used in other steel-production processes, such as those used to produce high-strength iron and steel castings in foundries. Mercury emissions from contaminated scrap are likely to occur from these steel-production processes, but insufficient data are available to estimate national mercury emissions from these sources. However, the NJDEP has on file mercury stack-test data from three foundries in New Jersey, all of which melt scrap and employ a cupola in their iron- and steel-production process. These data, presented in Table 20, show that emissions from melting mercury-contaminated scrap are not limited to EAFs.

As shown in Table 20, the average mercury emission factor for these facilities is almost three times lower than the average emission factor from EAFs, discussed above. No information is available on the percent of charge from scrap at these facilities, but it is expected to be significantly lower than EAFs, which receive almost all of their charge from scrap.

Table 20: Mercury Emissions from New Jersey Foundries

Facility	Permitted Production Capacity (short tons/yr)	Mercury Permit Limit (lbs/yr)	Stack Test Date	Mercury Emissions (lbs/yr)	Average Mercury Emission Factor	
					(lbs/short ton)	(kg/metric ton)
Atlantic States Iron Pipe Co.	234,000	137	11/93	40	0.00032	0.000016
			11/99	108		
Griffin Pipe Products	182,000	312	9/97	10	0.000055	0.000027
U.S. Pipe and Foundry, Inc.	262,964	80	9/97	96	0.00037	0.00018
Average Emission Factor					0.00025	0.00012

Source: Agrawal, Sunila, NJ DEP, October 30, 2000.[144]

MERCURY EMISSIONS FROM NONFERROUS METAL RECOVERY PROCESSES

Currently, the metal contained in the nonferrous shredder fraction is between 6 to 8 percent of the dismantled weight of the vehicle. This primarily includes the metals aluminum, stainless steel, copper, brass, bronze, lead, magnesium, nickel, and zinc. It also includes impurities, such as mercury, cadmium, and chromium. This study did not attempt to quantify mercury emissions from nonferrous metal recovery processes. However, because mercury tends to form amalgams with many nonferrous metals, it is likely that some automotive mercury is contained in the nonferrous fraction during shredding and subsequently released into the environment during nonferrous metal separation and recovery. Up to 50 percent by weight of the nonferrous fraction received by metal-recovery facilities is a nonmetallic residue (also known as heavy ASR), which is currently landfilled in the United States.[145]

Nonferrous Metal Separation

Shredders often use eddy-current separation techniques or flotation systems to recover aluminum and zinc alloys or to increase the concentration of metals prior to shipping to a heavy-media separation specialist.[146] Most nonferrous shredder wastes generated east of Colorado are shipped to Huron Valley Steel Corporation (HVSC), located in Belleville, Michigan.

Loading of non-ferrous and heavy ASR into separation plant at Huron Valley Steel Corporation, Belleville, MI. Photo Credit: Huron Valley Steel Corporation.

HSVC currently processes about 1 million pounds of mixed metals daily,[147] or 65 percent of all the nonferrous shredder material from the eastern United States.[148] The operation is completely mechanized and sorts the incoming mix to a high degree of purity by mainly employing principles based on density, color, and reflectivity. The separated metals include aluminum, brass, bronze, copper, lead, magnesium, nickel, stainless steel, and zinc. The large amount of water needed in the various separation processes is treated and recycled in a closed-loop system. Dust and fumes are collected in baghouse filters to comply with state and federal air regulations. Apart from the complex and voluminous separation process, HVSC also smelts zinc into large ingots. Any nonmetallic material, about 50 percent by weight, is transferred to local landfills. Huron Valley Steel is not aware of any mercury problems or emissions.[149] However, as discussed previously, mercury is likely to be contained in the nonferrous shredder wastes received by HVSC and, therefore, emitted during subsequent metal reclamation processes.

Secondary Aluminum Smelters

Because of great savings in energy and resources, a high percentage of scrap aluminum is currently being recycled. Mercury and aluminum easily form an amalgam, indicating that aluminum smelters may also release high mercury emissions from mercury-contaminated scrap. A study report from the state of New Jersey ranks mercury-emissions estimates from aluminum scrap smelting as some of the highest of all industry sectors.[150]

MERCURY IN AUTO SHREDDER RESIDUE

ASR as explained earlier in this report, is the 25 percent of the vehicle that is not recycled or recovered. Some 10 million cars discarded per year will create, on average, 2.7 million metric tons (3 million short tons) of ASR, or 1.5 percent of the total solid waste generated in the United States. Due to the complex composition of ASR, there are no current technologies available on a commercial scale to recycle the resources contained in this lighter fraction of vehicular wastes. More important, ASR contains significant levels of toxic contaminants and is therefore considered a hazardous waste in California[151] and, usually, as a hazardous waste in Europe.[152]

Toxics Concentrations and Waste Classification

Table 21 presents the concentrations of toxic contaminants in ASR, as reported in four studies. The most complete data are from a report by the German Umweltsbundesamt (Environmental Agency), which found high concentrations of a number of contaminants in ASR, including mercury. The U.S. EPA conducted a pilot study of ASR, which also found high concentrations of PCBs, lead, and cadmium. The EPA study did not evaluate mercury. Based on its 1989 evaluation of analytical data on untreated ASR, the California Department of Health Services concluded that mercury is one of the metals of concern in ASR.[153] Finally, NSS in St. Paul, Minnesota, determined the mercury content of the ASR it generates on-site as part of the mercury mass balance discussed previously. It should be noted that NSS has a program to collect and recycle some mercury switches prior to processing ELVs in its shredder.

According to a December 1999 EPA announcement, ASR cannot be reused or recycled due its high content of Polychlorinated Biphenyls (PCBs), which are regulated under the Toxic Substances Control Act. This rule applies to any material containing PCBs. ASR may only be used (not re-used) as landfill cover material.[158] As mentioned previously, ASR is treated as a hazardous waste in California.

The European Union (EU) does not generally classify ASR as hazardous in the European Waste Catalogue unless the content of toxic compounds exceeds certain specified levels in the new waste categories listed under 19 10 03 and 19 10 04. [159]

Table 21: Toxic Contaminants in Automotive Shredder Residue

Contaminant	Concentration in mg/kg			
	German ASR [a]	U.S. ASR [b]	California ASR [c]	NorthStar Steel ASR [d]
Mercury	6-15	Not measured	0.7	0.33-3.2 Mean: 1.15
Lead	3,500-7,050	570-12,000 mean: 2,700	2330-4616	Not measured
Cadmium	60-100	14-200 mean: 47	46-54	Not measured
Chromium	370-770	Not measured	247-415	Not measured
Arsenic	57-63	Not measured	Not measured	Not measured
PVC/phthalates etc.	ca. 6%	Not measured	Not measured	Not measured
Other (e.g. PCB's)	Unknown	1.7-210 mean: 32	Not measured	Not measured

Sources:
[a] Weiss et al., 1996.[154]
[b] U.S. EPA, 1991.[155]
[c] Nieto, Eduardo, 1989.[156]
[d] Ebersviller, Judd, 1999.[157]

Disposal Pathways and Their Impacts

In the absence of economically feasible technologies to recover valuable resources from ASR, most ASR is landfilled or incinerated. The bulk of the ASR currently generated in North America is disposed of in landfills meeting EPA requirements for liners, leachate collection systems, and closure and post-closure care. Due to its high density and uniformity, ASR is also frequently used as daily cover in land disposal operations. Landfill covers containing ASR are vulnerable to spontaneous combustion and subsequent formation and release of highly toxic compounds.[160]

In light of the eventual failure of even the best state-of-the-art landfills, leaching and release of toxins into ground water is of great environmental concern. Landfill environments contain complex organic chemicals, such as surfactants, humic acid, and solvents, as well as inorganic chemicals that facilitate the leaching of heavy metals. These environments also contain soluble toxins from ASR and other wastes. Mercury is emitted from landfills as a trace constituent of landfill gas.[161] The leaching of other heavy metals, used as stabilizers in PVC, has been observed during the initial acidogenic stage of landfills.[162]

Incineration and Co-Incineration

Though incineration of ASR results in reduced waste volume (by approximately 80 percent) and enables recovery of energy from the waste materials, it is not considered a long-term solution because it destroys the constituent materials that could otherwise have been reused or recycled into new products. European studies of incineration of municipal waste containing inorganic or organic chlorine have demonstrated that the heavy metals, copper, zinc, cadmium, tin, and lead will volatize as chlorides during combustion temperatures of about 1000° C but are largely captured with the filter dust,[163] which is primarily transferred to landfills. Subsequent release of these metals could occur during the leaching of these landfills.

Due to the enormously high cost of oil and landfill space, European countries are currently experimenting with co-incineration of the light ASR fraction and plastic scrap as a reducing agent/fuel in steel blast furnaces and as a supplementary fuel in cement making.[164] Capture efficiencies for pollution controls for heavy metals for these industries are far from sufficient to protect public health and the environment. For instance, modern cement kilns emit the majority of their mercury intake through their stacks.[165] Co-incineration in steel smelters raises the emission levels of mercury, dioxins, PCBs, and hexachlorophenol by several hundred percent.[166]

CHAPTER 5
CONTRIBUTION OF ELVS TO ANTHROPOGENIC MERCURY EMISSIONS

Previously, most analyses have focused on the sources of mercury in end-of-life vehicles (ELVs), with little attention to how this mercury is distributed throughout the vehicle recycling infrastructure and subsequently emitted to the environment. We now know that mercury emissions and/or incidences of mercury contamination occur at auto scrap yards, shredders, and ferrous metal recovery facilities; we suspect these occur at nonferrous metal recovery facilities as well. A key question, then, is how significant are these emissions compared to other anthropogenic sources of mercury in the environment.

This chapter summarizes some of the mercury estimates presented earlier in this report and compares the magnitude of ELV-associated releases to other anthropogenic sources of mercury. Because mercury emissions inventories and country-specific electric-arc furnace (EAF) emissions estimates are lacking or less certain for Canada and Mexico, most data presented here are for U.S. sources.

FINAL DISPOSITION OF MERCURY IN ELVS

Figure 3 traces the mercury in U.S. ELVs as it makes its way through the U.S. vehicle recycling and disposal infrastructure. Since virtually none of the 8 to 9.4 metric tons of mercury in U.S. vehicles retired annually is recovered, we must assume it is virtually all released or transferred to air, land, or water during ELV recycling and disposal.

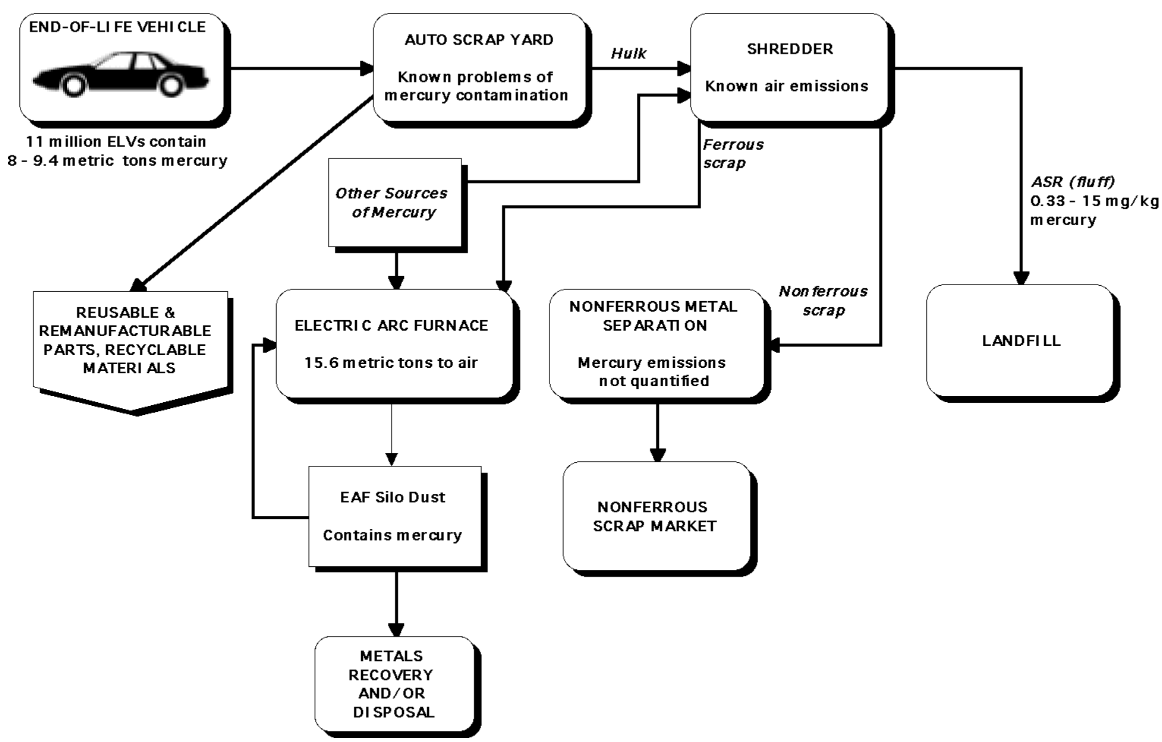


Figure 3: Final Disposition of Mercury in ELVs

Auto scrap yards are the first stop for most ELVs, where components of value are removed for reuse, remanufacturing, or recycling. Mercury contamination has been documented at some of these sites and is likely to exist at others. Scrap yards send gutted automotive hulks to auto shredders where they are processed into ferrous and nonferrous metal fractions and auto shredder residue (ASR). Mercury is a known contaminant of ASR, which is primarily disposed of in landfills. In addition to the ASR contamination, mercury was found in stack emissions from the only shredder facility for which stack emissions data are available.

Auto shredders sell the ferrous fraction of their product to steel production facilities, primarily EAFs. U.S.-based EAFs emit an estimated 15.6 metric tons of mercury to the atmosphere annually. Canadian and Mexican EAFs are also expected to have high mercury emissions – as much as 7 metric tons combined per year at capacity – but these estimates are more uncertain. The most likely source of mercury emissions from EAFs is ferrous scrap contaminated with mercury-containing devices, including devices from ELVs, appliances and industrial equipment. Appliances disposed of annually contain an estimated one metric ton of mercury.[167] We know less, however, about the final disposition of industrial equipment processed annually; we found no data to confirm the amount of mercury such equipment contains or whether mercury devices are removed prior to processing.

Some EAFs use briquettes made from EAF silo dust to charge the furnace. Because some mercury from contaminated scrap is contained in the silo dust, these briquettes are enriched with mercury, effectively increasing mercury stack emissions.

The nonferrous fraction of the automobile is sent to nonferrous metal separation facilities where it is prepared for the nonferrous scrap market. Since mercury tends to form amalgams with many nonferrous metals, it is likely that some automotive mercury is contained in the nonferrous fraction during shredding and subsequently released to the environment during nonferrous metal separation and recovery. This study did not attempt to quantify mercury emissions from nonferrous metal recovery processes.

U.S. MERCURY INVENTORIES

Table 22 lists sources of mercury emissions identified in two recently released reports on mercury emissions and use, specifically the USEPA 1997 Mercury Study Report to Congress,[168] and the USEPA source category listing for Clean Air Act (CAA) Section 112 (d) (2) rulemaking pursuant to Section 112 (c)(6) requirements.[169] The 1997 Mercury Study Report to Congress assesses the magnitude of U.S. mercury emissions in 1994 -1995, the health and environmental implications of those emissions, and the availability and cost of control technologies. The U.S. EPA source category listing provides emissions inventories of seven specific hazardous air pollutants (HAPs) for 1990, which includes mercury as required by Section 112 (c)(6) of the CAA, as amended. This section requires EPA to assure that source categories accounting for a minimum of 90 percent of the inventory of any of the seven specific HAPs are identified and subjected to maximum achievable control technology (MACT) standards.

The 1997 Mercury Study Report to Congress divides emission sources into two categories: area sources and point sources. Area sources are typically small and numerous and cannot be readily located geographically. Point sources are associated with a fixed geographic location. Based on these definitions we consider ELVs themselves to be area sources until they are shredded and no longer considered ELVs *per se*. The discrete facilities that comprise the ELV recycling and disposal infrastructure are point sources.

Neither the 1997 Mercury Study Report to Congress nor the Section 112(c)(6) inventory list air emissions estimates for ELV area sources. However, we expect mercury emissions from these sources to be relatively small, occurring mainly from wrecked and corroding vehicles prior to shredding. More importantly, both inventories either neglect or grossly underestimate mercury emissions from the ELV recycling and disposal infrastructure. In particular:

- The 1997 Mercury Study Report to Congress does not account for mercury emissions from EAFs or other metals recovery source categories. The Section 112(c)(6) inventory does include a steel mills and blast furnace source category, but 1990 mercury emissions from this category are estimated at only 0.23 metric tons.

- At 15.6 metric tons per year, mercury emissions from EAFs are the single largest manufacturing source of mercury air emissions and the fourth largest of all air emission sources, behind utility boilers, municipal waste combustors, and commercial/industrial boilers. In fact, based on the 1994-1995 mercury inventory, mercury emissions from EAFs are greater than all other manufacturing sources of mercury air emissions combined. In addition, mercury emissions from EAFs equal almost 11 percent of the total 1994 -1995 mercury inventory and more than seven percent of the 1990 mercury inventory.
- Average annual mercury emissions from the four EAFs evaluated in Chapter 4 are 0.7 metric tons, enough alone to rank EAFs as the fifth largest manufacturing source of mercury air emissions in the environment, which could be enough to make the EAF source category subject to regulation under Section 112 (c)(6) of the CAA, as amended.

The draft report, *Mercury Sources and Regulations, 1999 Update,* notes the omission of mercury emissions from scrap-metal recycling in EPA mercury emissions inventories. The report uses stack test data from one EAF and two cupolas in New Jersey to estimate national mercury emissions from iron and steel production at 6.4 to 16 metric tons annually.[170] The report was prepared by the Great Lakes Binational Toxics Strategy, a joint initiative of Canada and the United Sates, but contains preliminary information that has not been fully reviewed by the U.S. EPA.[171]

Table 22: U.S. EPA Mercury Emissions Inventory Data

Sources of Mercury Emissions		Mercury Emissions			
		1994-1995 [a]		1990 [b]	
		Metric Tons/yr	Short Tons/yr	Metric Tons/yr	Short Tons/yr
Area Sources	Lamp Breakage	1.4	1.5	1.4	1.5
	General Laboratory Use	1.0	1.1	0.7	0.8
	Dental Preparations	0.6	0.7	ND	ND
Total, Area Sources		**3.1**	**3.4**	**2.1**	**2.3**
Combustion Sources	Utility Boilers [c]	47.2	52.0	46.5	51.3
	Municipal Waste Combustors	26.9	29.6	49.9	55.0
	Commercial/Industrial Boilers [d]	25.8	28.4	26.1	28.8
	Medical Waste Incinerators	14.6	16.0	45.4	50.0
	Hazardous Waste Combustors	6.4	7.1	2.9	3.2
	Industrial Stationary Internal Combustion Engines	ND	ND	4.1	4.5
	Industrial Turbines [e]	ND	ND	1.5	1.7
	Residential Boilers	3.3	3.6	2.7	3.0
	Sewage Sludge Incinerators	0.9	1.0	ND	ND
	Wood-fired Boilers	0.2	0.2	0.2	0.2
Total, Combustion Sources		**125**	**138**	**179**	**198**
Manufacturing Sources	Chlor-alkali	6.5	7.1	8.9	9.8
	Portland Cement Manufacturing	4.4	4.8	6.2	6.9
	Aerospace Industry (surface coating)	ND	ND	3.6	4.0
	Pulp and Paper Manufacturing	1.7	1.9	ND	ND
	Instruments Manufacturing	0.5	0.5	0.5	0.5
	Industrial Inorganic Chemicals Manufacturing	ND	ND	0.9	1.0
	Secondary Mercury Production	0.4	0.4	ND	ND
	Electrical Apparatus [f]	0.3	0.3	0.8	0.9
	Carbon Black Production	0.3	0.3	0.3	0.3
	Lightweight Aggregate Kilns	ND	ND	0.3	0.3
	Blast Furnace and Steel Mills	ND	ND	0.23	0.25
	Other Miscellaneous	ND	ND	0.23	0.25
	Other Secondary Nonferrous Metals Recovery	ND	ND	0.10	0.11
	Other Structural Clay Products	ND	ND	0.23	0.25
	Lime Manufacturing	0.1	0.1	0.6	0.7
	Primary Lead Smelting	0.1	0.1	1.2	1.3
	Compound Purchased Resins Manufacturing	ND	ND	0.1	0.1
Total, Manufacturing Sources		**14.4**	**15.8**	**24.0**	**27.5**
Misc. Sources	Geothermal Power	1.3	1.4	1.2	1.3
Total Emissions, All Sources		**144**	**158**	**207** [g]	**229** [g]

Note: Sources with <0.1 ton per year of mercury emissions are not listed in the table.
ND: No data.
[a] Source: U.S. EPA, Mercury Study Report to Congress, 1997.
[b] Source: U.S. EPA, Source Category Listing for Section 112(d)(2) Rulemaking Pursuant to Section 112(c)(6) Requirements, 1998.
[c] Includes coal, oil and natural gas utility boilers.
[d] Includes coal and oil commercial/industrial boilers.
[e] Includes natural gas- and diesel-fired turbines.
[f] Listed as electronics and other electric equipment manufacturing in the Section 112 (c)(6) inventory.
[g] The EPA inventory lists total emissions for all sources at 212.78 metric tons (234.59 short tons), but the sum of all of the individual sources in the EPA inventory is only 207.41metric tons (228.67 short tons).

CHAPTER 6
STRATEGIES AND POLICIES FOR CLEANER ELVs

There are two basic strategies for reducing the releases of mercury and other toxic substances from end-of-life vehicles (ELVs): prevent future releases by eliminating uses of mercury in vehicles and reduce current releases by removing, collecting, and recovering mercury from mercury-containing parts. Neither of these strategies faces technological hurdles or significant cost barriers. Eliminating uses of mercury in vehicles will result in greater benefits than those achieved by adopting cleaner recycling processes at end of life. In addition, impacts from "upstream" releases and worker exposures will be reduced as mercury mining and processing is curtailed.

More than 99 percent of the automotive use of mercury is reported to be in switches, either for convenience lighting or anti-lock braking systems. Automobile designers, engineers, and purchasing personnel, therefore, have an important role to play in finding, developing, testing, and approving nontoxic alternatives for use in vehicles. Fortunately, alternatives to mercury light switches are available at a small incremental cost over the conventional mercury switch. Not only is this extra cost easily offset when life cycle management (LCM) costs are considered, but one automaker (DaimlerChrysler) has found that substitution of nonmercury alternatives even results in a net saving.

For mercury-containing parts in the existing vehicle fleet, the best option is to remove the parts before cars are shredded and the metals sent to smelters or furnaces where mercury easily vaporizes. Removal is relatively simple and could be facilitated by automakers who would specify material content and provide accessibility information for easy identification and removal of the components involved. The biggest impediments to removing and recovering mercury-containing switches are the cost and difficulty of organizing the collection network and the costs associated with management of the recovered mercury.

Currently, automakers in the United States and Canada have little incentive to eliminate mercury from automobiles or to take responsibility for the collection and recycling of mercury switches. European countries, however, have mandated comprehensive Extended Producer Responsibility (EPR) that requires producers to eliminate uses of mercury and to take responsibility for the financial impacts of ELV management. Some U.S. states have begun to address mercury-containing products, including cars, through labeling laws and disposal bans.

This chapter discusses proactive measures that can reduce the environmental and health impacts of ELV management. It also discusses existing policies for ELV management in Europe and North America, including those that are specifically focused on mercury use and disposal. Because current policies (governmental and corporate) in North America are not adequately addressing the mercury-in-ELV issue, the report concludes with recommendations for changes in policies.

ENVIRONMENTAL STRATEGIES AND CLEAN PRODUCTION ALTERNATIVES

Automobile manufacturers, material processors, part suppliers, and recyclers can employ a number of strategies to resolve many environmental problems associated with ELVs. Such strategies include initiatives on the part of automakers to accept extended responsibility for their products; design cars to minimize their life-cycle environmental impacts; develop newer, more environmentally friendly materials; phase out toxic substances in manufacturing; and devise ways to increase vehicle recyclability. Some of these are discussed below.

Design for the Environment

Design for the Environment (DFE) is the environmental outgrowth of the Design for "X" methodologies (Design for Manufacturability, Assembly, Serviceability, Disassembly, Recyclability, etc.). A powerful tool for effecting environmental improvements throughout a product's life cycle, DFE is based on the philosophy that additional effort invested to address specific issues at the design stage results in the elimination of numerous problems further downstream.

DFE is a proactive approach to integrating pollution prevention and resource conservation strategies into the development of more ecologically and economically sustainable products. DFE emphasizes reduced dependence on natural resources, minimizes wastes, maximizes reuse and recycling, employs production processes that cause minimal environmental impact, and results in the creation of products that are safe for the environment during use and at the end of their lives when they are either recycled or disposed of. In order to satisfy all the above requirements concurrently, it is important to include these considerations at the product design stage. Thus, taking action up front (at the design stage) is key to success in the quest for minimizing the life-cycle environmental burdens of manufactured products.

U.S. automobile manufacturers (Ford, DaimlerChrysler, and General Motors) are beginning to take steps in the right direction, as is evident by the introduction of GM's worldwide specification GMW3059, which in 1998 replaced the Restricted and Reportable Material Specification that had earlier been in force since 1994, Ford's "Substance Use Restrictions" standard for elimination of hazardous substances, and DaimlerChrysler's Regulated Substances and Recyclability Certification (RSRC) system. However, for these systems to be effectively implemented, automakers must collect more data from their suppliers on the materials that go into their vehicles. This would help account for all the materials contained in the vehicles (including materials of concern), while providing an opportunity to assess the life-cycle environmental impacts likely from their use.

An Example of DfE Implementation in Automobile Manufacturing – Volvo

A process adopted by Volvo is an example of how some automobile manufacturers incorporate environmental considerations into their product development process. When the Product Planning Department at Volvo initiates a new project, environmental criteria are specified along with other design criteria. Environmental requirements, such as materials choices, fuel consumption, minimization of hazardous materials, and emissions, follow the same procedures as other (cost and performance) requirements. This simplifies the introduction of environmental concerns into product development (Volvo Website – http://vcc.volvocars.se/environment/inc_file/pdf/ft.pdf) (Accessed December 12, 2000).

Specifications for a complete vehicle enumerate the environmental characteristics of each system. This makes it possible for engineers to see the environmental demands on a specific system component. When there are two or more alternatives, the most suitable one is determined from an environmental viewpoint using internal or external tools to calculate environmental impacts of various choices.

Mercury Alternatives

Several alternatives to mercury light switches exist, including pendulum, rolling ball, transistor, and limit switches.[172] These alternatives eliminate mercury, but reportedly can be more expensive and less robust.[173] Engineers in General Motors' Mid-Size and Luxury Car Group worked with suppliers to develop the most effective ball-type switch for underhood lamp activation. They determined that although ball-type switches cost about $0.09 more per switch, the extra cost can be recovered by avoiding the costs associated with removing and disposing of switches from ELVs and by manufacturing lamp lenses from recycled plastic material.[174]

DaimlerChrylser conducted a life-cycle management study of convenience lighting alternatives that considered piece price together with environmental, health, safety, and recycling considerations. The study found the piece price for the alternatives was about $0.11 higher than for mercury switches but total LCM costs of mercury switches exceeded that of the alternatives by $0.12 per switch.[175] DaimlerChrysler completed its phase-out of mercury light switches by March 1998.[176]

As discussed in Chapter 2, mercury-free alternatives exist for antilock brake systems (ABS) as well. Several U.S. and international automobile manufacturers offering antilock brakes on their vehicles appear to be using such alternatives and according to their reports have phased out mercury use in their ABS switch applications.

EXTENDED PRODUCER RESPONSIBILITY

Extended Producer Responsibility (EPR), sometimes called Product Stewardship, is an emerging principle for a new generation of pollution-prevention policies that focus 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 itself, and downstream impacts from the use and ultimate disposal of the products.[177] 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 packaging – where 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.

The policy initiative that gave rise to the term "Extended Producer Responsibility" is the German Packaging Ordinance of 1991, which is an ambitious program for collecting and recycling product packaging to reduce the demand on scarce disposal capacity in Germany.[178] The Ordinance requires distributors (retailers) of packaged goods to take back the packaging for recycling, but allows them the opportunity to avoid the direct take-back obligation for packaging if it is part of the packaging-producer-funded collection and recycling system Duales System Deutschland (DSD or Dual System Germany). DSD was initiated in 1990 as a private system (apart from the municipal waste management systems) for collecting and recycling packaging paid for by fees collected from producers. Producers who pay the fees are entitled to label their packaging with a green dot that tells retailers and consumers that the packaging will be collected and managed by the DSD.

The packaging ordinance has been successful in reducing the amount of packaging waste disposed in Germany and has also resulted in source reduction of packaging. Because the fee required by DSD to participate in the system is mass-based and is higher for difficult-to-recycle packag-

An Example - Chrysler's Regulated Substances and Recyclability Certification (RSRC) System

DaimlerChrysler's RSRC data collection and reporting system aims to identify and track the use of hazardous substances, track recycled content, and to assess the recyclability of their vehicles. The following types of LCM data are collected:

- *CFC Use*
- *Recyclability*
- *Ease of Disassembly*
- *Recycled Content (Pre- and Post-Consumer)*
- *Material Name and Weight*
- *Substances of Concern (concentration)*
- *Plastics Identification*
- *Usage Identification*

(http://www.epa.gov/commonsense/autos/Lcmdsr.html)

ing materials, there is a direct feedback loop to the packaging producers and product designers to make packaging lighter and more recyclable. Similar legislation shifting at least some of the responsibility for managing packaging waste has been adopted in other European countries, including Sweden, France, Finland, Austria, and the United Kingdom.

Take-back legislation has also been developed in Europe for other end-of-life products, including automobiles and consumer electronics.[179] Sweden, the Netherlands, and Germany have take-back and recycling requirements for automobiles and the EU has recently passed a Directive for ELVs (see below). Legislation for electronics goods has been adopted or is being considered in Germany, the Netherlands, Norway, Sweden, and Switzerland. The European Commission has also proposed legislation for electronics.[180]

THE EUROPEAN UNION END OF LIFE VEHICLE DIRECTIVE

The European Union (EU) adopted an ELV Directive in September 2000, which establishes producer responsibility for the management of ELVs, sets increased recycling requirements, and begins a phase-out of certain heavy metals, including mercury used in automotive components (see Appendix E).[181] The ELV Directive must be implemented by member nations by the adoption of appropriate legislation and regulations by April 2002. Some member nations have already implemented extended producer responsibility legislation for ELVs, and the EU Directive permits member nations to implement the extended producer responsibility provisions earlier than required by the directive.

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 organizations — operated jointly by manufacturers and importers of cars — already 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.

Phaseouts of Heavy Metals

The EU directive recognizes the dangerous environmental and health consequences associated with the disposal of heavy metal content in vehicles, and thereby establishes a program that phases out most uses of four heavy metals — lead, mercury, cadmium, and hexavalent chromium — in 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 phaseouts.

The purpose of the phaseouts is primarily to prevent the release of these heavy metals into the environment from 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 phaseouts are contained in an Annex to the 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 phaseouts, including bulbs and instrument panel displays containing mercury, so that they can be stripped before shredding.

Increased Recycling Requirements

The directive 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 percent by weight on average, and recycling and reuse must be increased to 80 percent 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, the reuse and recovery must be increased to a minimum of 95 percent by weight. Recycling and reuse must be increased to a minimum of 85 percent by that date.

> “We see it as an opportunity in the U.S. where we are getting into the recycling business. We’re presently considering the European market situation. And there will be other major changes. Future transportation may not involve owning a car. Instead, you may own the right to transportation. We will make vehicles and either lease or loan them to you. We’ll end up owning a vehicle at the end-of-life and have to dispose of it. We will treat it as a technical nutrient, making it into a car or truck again. We’re getting ourselves ready for the day when this is truly a cradle-to-cradle. We’re not fighting it, we’re embracing it.”
>
> - Bill Ford, Chairman of Ford Motor Company

To aid the achievement of the increased levels of recycling, cars put on the market after the end of 2004 must be reusable and/or recyclable to a minimum of 85 percent of vehicle weight and reusable and/or recoverable to a minimum of 95 percent per vehicle. The European Commission will draft amendments to the EU Directive on motor vehicles standards to include the means of determining recyclability, which should be adopted by the end of 2001.

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 DFE, including reductions in 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.

ELV POLICIES IN THE UNITED STATES

While no national legislation on ELV recycling or management has been passed in the United States, such measures have been introduced on at least one occasion. In September 1991, H.R. 3369 was introduced that would have created the "Automobile Recycling Study Act of 1991." The proposed legislation would have required the EPA, in consultation with the Secretaries of Transportation and Commerce, to study the potential for increased recycling of the automobile; at minimum the study would:

- Identify major obstacles to increased recycling of automobile components and develop ways to overcome those obstacles.
- Define methods for incorporating recyclability into the planning, design, and manufacturing of new autos.
- Identify the toxic and nonrecyclable materials presently used in automobiles and possible substitutes for those materials.
- Study the feasibility of establishing design standards for automobiles that would result in gradual phaseout of hazardous and nonrecyclable materials used in autos.
- Examine methods for creating more recyclable plastics for use in automobiles.

The bill was referred to the House Committee on Energy and Commerce, but does not appear to have been referred out of committee.

MERCURY REDUCTION/ELIMINATION POLICIES

A number of national, international, and state initiatives are underway to reduce the use of mercury and promote the safe disposal of mercury and mercury-containing products. Notable among these are the Great Lakes Water Quality Agreement, which calls for virtual elimination of anthropogenic mercury sources; and mercury reduction and labeling laws in Minnesota, Vermont, New Hampshire, and Maine. In addition, the Northeast Waste Management Officials' Association has drafted model mercury legislation for consideration by other states in the Northeast as a regional approach to mercury-containing products in the waste stream. These Northeast mercury-reduction initiatives were spawned by the Conference of New England Governors and Eastern Canadian Premiers, which adopted a Mercury Action Plan in June 1998 that calls for the virtual elimination of anthropogenic mercury emissions. The Mercury Action Plan aims to reduce mercury emissions 50 percent by the year 2003.[182]

U.S.-Canada Great Lakes Binational Toxics Strategy

The Great Lakes Binational Toxics Strategy is a response by Canada and the United States to their commitment that "the discharge of toxic substances in toxic amounts be prohibited and the discharge of any or all persistent toxic substances be virtually eliminated." The two governments made this commitment in Article II of the Great Lakes Water Quality Agreement as amended in 1987. Signed by top environmental administrators on April 7, 1997, the strategy is the outcome of a four-year process that included consultations with scientists and other representatives of the International Joint Commission, industry, government agencies, and Great Lakes Basin environmental groups.

Under the joint strategy, mercury is a Level I substance targeted for virtual elimination. The United States and Canada have each proposed "challenges" to significantly reduce both the use of mercury and its emission into the environment. The United Sates has agreed to seek by 2006, a 50-percent reduction in the deliberate use of mercury and a 50 percent reduction in mercury releases resulting from human activity. The Canadian government agreed to seek by 2000, a 90-percent reduction in mercury releases and, where warranted, reduction in the use of mercury in polluting sources, resulting from human activity in the Great Lakes Basin.[183]

Vermont Mercury-Added Consumer Products Law

The Vermont mercury-added consumer products law, which went into effect March 1, 2000, requires labeling of mercury-containing products and requires manufacturers to report on mercury-containing consumer products they sell in Vermont.[184] The law also bans the landfilling of labeled mercury-added consumer products, requires source separation of these products from solid waste to allow proper collection and management, requires municipalities to establish collection programs and education efforts, and creates an advisory committee on mercury pollution to coordinate further reductions in mercury releases.[185] All mercury-containing products sold in Vermont after the law's effective date must be labeled.

Mercury Reduction Initiatives in Minnesota

In Minnesota, a comprehensive mercury-reduction law was passed in 1999 as the outcome of a two-year advisory council process and recommendations made by the Minnesota Pollution Control Agency (MPCA).[186] The law establishes goals for reducing mercury releases by 60 percent by the end of 2000 and 70 percent by the end of 2005, using 1990 as the baseline year. In addition to setting goals, the law lists reduction strategies and requires progress reports to the state Legislature in 2001 and 2005. The reduction strategies include soliciting voluntary commitments to reduce mercury emissions, instituting a national mercury product labeling program or law, encouraging consumers to avoid mercury-containing products, collecting mercury-containing household hazardous waste, and continuing research on sources of mercury, releases, and impacts.

Labeling is included as part of a larger package of mercury reduction measures in Minnesota, including a disposal ban, producer and servicer responsibility requirements, and the Special Waste Pilot Project/Universal Waste Rule to facilitate end-of-life management for all mercury-containing products. In 1992, the Minnesota Legislature passed laws governing the sale, use, labeling and disposal of mercury and mercury-containing products. The major purposes of the labeling requirement are: to provide disclosure of hazardous contents to sellers and purchasers; to encourage the sale, purchase, and use of nonmercury products (where appropriate alternatives exist); and to provide information about content and disposal prohibitions to the consumer at the time of disposal, which helps ensure management in accordance with the state's disposal ban.[187]

The New York State Mercury Switch Replacement Program

In an effort to prevent the release of mercury in the Great Lakes Basin, and to pressure automakers into phasing out the use of mercury in automobile switches in all new models, the New York State Department of Conservation (NYDEC), with the help of a grant from EPA Region II launched a pilot program to replace these toxic switches in currently operating cars and salvage yards in Western New York. The project was spearheaded by Tom Corbett (NYDEC), one EPA Region II staffer, and a member of the Toronto-based Pollution Probe with a 'hands on mission' in the streets of Buffalo. The team initially collected the mercury from dozens of taxicabs and is currently expanding this voluntary initiative to service stations. The program goal is to collect 500 pounds of mercury from 250,000 switches contained in 125,000 vehicles with the participation of commercial service companies and public vehicle inspection stations in several western New York counties. The cost of replacement switches is $0.38/switch and installment takes less than one minute.

Maine Mercury Reduction Act

Maine passed a law in May 2000 to reduce the release of mercury into the environment from consumer products. The law requires labeling of mercury-added products sold in the state after January 1, 2002, and prohibits disposal of mercury-added products in solid waste. The law does not apply to automobile components until July 15, 2002, and provides automobile manufacturers the opportunity to present alternative compliance plans to the Department of Environmental Protection on or before January 1, 2002. The law also establishes a Mercury Advisory Committee to assess, among other things, whether manufacturers of mercury-added products should be required to establish programs for collection and recycling of their products.[188]

New Hampshire Mercury Emissions Reduction and Control Program

The New Hampshire program, enacted by the state legislature in 1999, requires prior notification by manufacturers to the regulatory agency before mercury-added products can be sold in the state.[189] While the law does not require labeling, it authorizes the agency to participate in a regional, multi-state clearinghouse for notification of mercury-added products and for labeling.

NEWMOA Model Mercury Containing Products Legislation

The Northeast Waste Management Officials' Association (NEWMOA) recently drafted model legislation that would incorporate many of the features of the laws discussed above. The draft includes an interstate clearinghouse for cooperation and coordination among the states, restrictions on sale of certain mercury-added products (modeled after Minnesota), disposal bans (modeled after Minnesota), labeling (modeled on the Vermont legislation), and a collection scheme for banned or phased-out mercury-added products (modeled after proposed legislation in Massachusetts).[190]

CONCLUSIONS AND RECOMMENDATIONS

This report documents the continued use of mercury in millions of electrical switches in automobiles, despite the availability of inexpensive alternative designs and despite public pledges of U.S. and Canadian automakers to voluntarily phase out mercury use. New uses of mercury in the automobile, for which there also are readily available alternatives, are being introduced at the same time. Because there is no nationwide reporting required for the use of mercury or other toxic substances in vehicles, it is impossible to determine accurately whether the amounts of mercury being released into the environment from end-of-life vehicles is increasing or decreasing. Meanwhile, in the European Union, automobile manufacturers have been given a firm regulatory timeline for phasing out nearly all mercury uses in vehicles.

Future phaseouts of mercury use, however, do nothing to secure the millions of mercury switches in either the existing vehicle fleet on the highways today or vehicles being retired from service. This report suggests that, as a result of mercury in the vehicle fleet, the recycling processes for end-of-life vehicles, particularly shredding and recycling of metals, are significant unregulated sources of mercury releases into the environment. Currently, no existing program prevents mercury in the existing fleet from entering the environment. State disposal bans place the ultimate burden on scrap yards and shredders that have little oversight, and provide no incentives for manufacturers to accept responsibility for the removal and recovery of mercury switches.

Based on the findings of this report, mercury releases from ELVs warrant the following actions:

- **Immediate Elimination of Mercury Switches in New Cars and Trucks:** Automobile producers and importers should immediately eliminate mercury switches from new cars and trucks produced and sold in the United States and Canada. If they do not voluntarily eliminate mercury switches, then federal, state and provincial governments should mandate a phaseout of their use as soon as possible, but in any event no later than July 1, 2003.
- **Producer Responsibility for Mercury Switch Collection and Recovery:** Automobile producers and importers should take responsibility for removing, collecting, and recovering mercury switches from the millions of cars on the road today. Federal, state, and provincial governments in the United States and Canada should enact legislation to ensure that producers take responsibility for these mercury switches. Producers should organize a program for removing and replacing switches that can be feasibly replaced in cars currently on the road. For cars that have reached the end of their lives, such as those currently in scrap yards, the legislation should require immediate implementation of a program to remove mercury switches before shredding, with collection and recovery arranged by producers and importers. Finally, the legislation should require full disclosure by automakers of their past and current uses of mercury in vehicles, as well as progress reports on the removal, collection, and recovery of mercury switches.
- **Phase Out of Other Uses of Mercury in Vehicles:** Federal, state, and provincial governments in the United States and Canada should adopt legislation or regulations requiring the phaseout of other uses of mercury in vehicles by July 1, 2003, consistent with the European Union ELV Directive. As does the EU Directive, legislation or regulations in the United States and Canada should re-evaluate the exemption for mercury in headlamps by 2003 to determine whether the use of mercury is avoidable or to establish maximum concentrations for mercury in headlamps.
- **Labeling of New Vehicles Containing Mercury:** Federal governments in the United States and Canada should adopt uniform legislation, similar to the legislation in Vermont and other states, requiring the labeling of new, mercury-containing vehicles until bans and phaseouts are imposed. Both the part(s) containing mercury and the vehicle itself should be labeled, and the label should warn that the mercury-containing part must be removed before shredding, recycling, or disposal of the ELV. The label should provide instructions on proper dismantling, collection, and recovery.

- **Requirement to Remove Mercury Switches Before Shredding or Recycling ELVs, and Mercury Switch Disposal Ban:** Federal, state, and provincial governments in the United States and Canada should enact legislation or regulations that: a) require shredders and recyclers to remove mercury switches before processing ELVs, and b) prohibit the disposal of these switches. This requirement should be coupled with the responsibility of producers and importers to provide for the collection and recovery of mercury switches.
- **Upgraded Environmental Standards for ELV Management:** Federal, state, and provincial governments in the United States and Canada should upgrade environmental standards for ELV management by scrap yards and shredders, devoting particular attention to mercury and other heavy-metal emissions. Minimum standards should be consistent across the United States and Canada to deter handlers from making transboundary transfers of ELVs to avoid more stringent regulations.
- **Upgraded Environmental Standards for Automotive Materials Recycling Industries:** For material recycling industries that receive significant portions of materials from ELVs, the U.S. and Canadian governments should immediately review the adequacy of regulatory standards governing releases of mercury and other heavy metals. New Toxics Release Inventory data and increased monitoring of these facilities should be considered in such a review. If this review shows that existing standards do not reflect current knowledge about potential mercury and heavy metal releases from these facilities, emissions standards for such operations as electric arc furnaces should be reopened to upgrade the standards. In the United States, the U.S. EPA should immediately begin the process of revising the source category listing for Clean Air Act Section 112(d)(2) rulemaking to include electric arc furnaces, pursuant to Section 112(c)(6) requirements.

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Appendix A

Automobile Manufacturer Commitments for Mercury Phase-Out

1994: Michigan Mercury Pollution Prevention (M2P2) Taskforce

Parallel to an effort to reduce the release of persistent toxics in the Great Lakes region, the State of Michigan's Department of Natural Resources (now MDEQ) formed the M2P2 taskforce with multiple stakeholders. Through this effort, the M2P2:

(1) initiated contacts with the Big 3 automakers and secured their commitment to phase out mercury switches and other applications, where feasible, to develop removal guidelines for dismantlers and to foster safe handling and disposal;

(2) initiated contacts with SAE resulting in the development of a mercury "white paper" focusing on pollution prevention opportunities at the design end of the automotive business; and

(3) provided recommendations to the chairpersons of the National Mercury Task Force on a variety of mercury reduction initiatives.

(4) The Automobile Subgroup also reached out to the following organizations: AAMA, AIAM, USCAR, MPCA (Minnesota Pollution Control Agency).

Responses by the Big 3:

7/26/95 GM:

"Our Plan is to be out of applications using mercury (*switches*), where feasible substitutes are available, by 1997 model year. Any new or remaining uses of mercury in our products will be evaluated from a total life-cycle risk management approach. The issue of mercury in the existing fleet is being addressed on an industry-wide basis by the AAMA in conjunction with USCAR."

Apparently dismantlers were given detailed instructions for removing these switches.

8/22/95 Ford:

"Our overall strategy is to introduce mercury-free switches in all identified applications as soon as practicable. While plans and designs for vehicles scheduled to be launched during the 1998 model year are nearly complete, we believe there is still some opportunity to identify suitable mercury-free switching devices for use in these vehicles. If this goal proves to be too ambitious and reliable alternatives are not available for introduction with the 1998 models, we will advise you of the revised schedule….. With respect to mercury switches at the end of their useful life, we support the development of an industry-wide recommended removal practice to assist independent vehicle dismantlers/recyclers."

8/30/95 Chrysler:

"Chrysler expects to be mercury-free for switches used in convenience lighting applications during 1997…. With respect to the existing vehicle population, Chrysler will work with the AAMA to develop a common approach/system to identify and remove mercury switches."

July, 2000: Auto Industry Proposal for Eliminating Mercury from the Motor Vehicle Fleet

The Alliance of Automobile Manufacturers (which replaced the AAMA) and the Association of International Automobile Manufacturers (AIAM) issued a proposal for eliminating mercury from the motor vehicle fleet (attached). In this proposal, the industry again pledged to phase out the use of mercury switches in new vehicle components, and committed to expand distribution of educational information to dismantlers/scrap yards—expanding to other states a pilot project in the State of New York. The industry also encouraged states to not support legislation requiring labeling, recordkeeping or "any other provisions relating to motor vehicles and mercury-containing parts," and instead to support a voluntary educational approach.

Additional Auto Company Commitments:

11/10/2000 DaimlerChrysler:

"Our new Jeep sport utility vehicle scheduled for introduction in April 2001 will launch without mercury in the ABS. The Grand Cherokee will be free of mercury in the ABS in MY 2002. The Wrangler will be free of mercury in the ABS in MY 2006 and the current Cherokee will be free of mercury at the end of MY 2005."

11/20/2000 Ford and GM:

"Ford and GM have pledged to finish this phase-out of mercury switches for convenience lighting with the 2002 model year." (Communication from the AAM.)

12/7/2000 General Motors:

"We project by the 2004 model year all mercury convenience lighting switches will be replaced with non-mercury alternatives in all GM vehicles.......One of the vehicle programs changes to non-mercury alternatives for the 2002 model year and the last program is a low volume vehicle that isn't scheduled for a redesign until 2004."

Alliance of Automobile Manufacturers

AIAM The World's Leading Automakers

Auto Industry Proposal for Eliminating Mercury from the Motor Vehicle Fleet

The auto industry recognized the concern over mercury and began a process to reduce the amount of mercury in motor vehicles in the early 1990s. Most convenience light switch use has been eliminated and, as agreed to in Wisconsin, the use of these switches continues to be phased out with all new car designs.

The industry believes that the most environmentally beneficial action that can be taken regarding mercury in motor vehicles is for dismantlers and those involved in the scrapping of vehicles to remove these convenience light switches at the end of the vehicle life. Therefore, the industry is willing to commit to a series of steps in conjunction with State environmental agencies to help provide those involved in dismantling vehicles information on how to locate and remove mercury-containing convenience light switches, as outlined below.

- The auto industry commits to systematically phasing out the use of mercury switches in the design of new vehicle components.

- The auto industry, through its suppliers, will continue to research replacements for those mercury uses still present in new motor vehicles, taking into account safety, cost and other practical considerations.

- The auto industry will expand current distribution of educational information on mercury switches to the dismantler/scrap yard industries. The industry will handle distribution itself or, for states that prefer to provide this information directly, will provide the state with information for it to disseminate as outlined below.

- This program will start with a pilot program between the State of New York (and possibly one or two other states) and the auto industry, where the auto industry will work with the state(s) on an educational document. This document would also provide a list of recycling sites in the state that will accept mercury. Either the State or the auto industry will provide this information to the dismantlers/scrap yards in the state(s). This program will be expanded to other states after an evaluation of this pilot program.

- State Governments will petition EPA to review any hazardous waste regulations that apply to the transportation and record-keeping requirements regarding mercury to ensure that these regulations do not inhibit the safe and easy transport of mercury capsules or switches containing mercury to collection sites.

- Should any proposed legislation requiring labeling, recordkeeping or any other provisions relating to motor vehicles and mercury-containing parts arise in any state, state environmental directors shall work with the industry to explain the above-outlined cooperative program as a preferable alternative which accomplishes the goals of the legislation in a more efficient and cost-effective manner.

Appendix B

Mercury Light Switches in Model Year 2000 Vehicles

Manufacturer	Vehicle	Component	1999 Production	No. Switches*	No. Switches**
Ford	F-Series Truck (F150-550)	Conv. Lighting Switches	824,789	824,789	1,649,578
	Crown Victoria	Conv. Lighting Switches	124,002	124,002	248,004
	Expedition	Conv. Lighting Switches	256,562	256,562	513,124
	Navigator	Conv. Lighting Switches	42,689	42,689	85,378
	Excursion	Conv. Lighting Switches	29,685	29,685	59,370
	Explorer	Conv. Lighting Switches	507,091	465,466	930,932
	Mountaineer	Conv. Lighting Switches	51,628	51,628	103,256
Ford Subtotal				**1,794,821**	**3,589,642**
General Motors	Cadillac Escalade	Hood Light Switch	28,846	28,846	28,846
	Chevrolet Cavalier	Hood Light Switch	269,564	269,564	269,564
	Chevrolet Express	Hood Light Switch	121,818	121,818	121,818
	Chevrolet Blazer	Hood Light Switch	272,857	272,857	272,857
	GMC Denali	Hood Light Switch	no data	no data	no data
	GMC Envoy	Hood Light Switch	no data	no data	no data
	GMC Jimmy	Hood Light Switch	92,233	92,233	92,233
	GMC Savanna	Hood Light Switch	51,403	51,403	51,403
	Pontiac Sunfire	Hood Light Switch	110,089	110,089	110,089
	Oldsmobile Bravada	Hood Light Switch	28,547	28,547	28,547
General Motors Subtotal				**975,357**	**975,357**
TOTAL				**2,770,178**	**4,564,999**

Note: The model and type of mercury-bearing components were provided to Vermont under the Vermont Mercury Labeling law. This information was combined with 1999 production (as a surrogate for model year 2000 production) to calculate total number of switches. A range is provided for Ford since it reported convenience lighting "switches" but did not indicate the number fo switches per vehicle.

* Assumes one mercury light switch per Ford vehicle and one mercury switch per GM vehicle.

** Assumes two mercury light switches per Ford vehicle and one mercury switch per GM vehicle.

Appendix C

Mercury Anti-Lock Brake System (ABS) in Model Year 2000 Vehicles

Manufacturer	Vehicle	Component	1999 Production	No. ABS Switches
Daimler Chrysler*	4-Wheel Drive Jeeps	ABS Switch	630,598	*
	Wrangler	ABS Switch	100,946	*
	Cherokee	ABS Switch	186116	*
	Grand Cherokee	ABS Switch	343,536	1,030,608
Daimler Chrysler Subtotal				**1,030,608**
Ford	Explorer	ABS Sensor	507,091	1,521,273
	Mountaineer	ABS Sensor	51,628	154,884
	Ranger	ABS Sensor	355,421	1,066,263
Ford Subtotal				**2,742,420**
Mazda North America	B-Series Pick-up truck (B2500, B3000, B4000)	ABS Sensor	49,587	**148,761**
TOTAL				**3,921,789**

Note: The model and type of mercury-bearing components were provided to Vermont under the Vermont Mercury Labeling law. This information was combined with 1999 production (as a surrogate for model year 2000 production) to calculate total number of switches. We assumed 3 switches per vehicle although some 2WD models may contain less.
* DaimlerChrysler reported its "4-wheel drive jeeps" contain mercury ABS switches; the Vermont DEP has interpreted this to mean all of the Jeep brand name (Wrangler, Cherokee, and Grank Cherokee) with 4-wheel drive (Personal Communication, Karen Busshart to Jeff Gearhart, October 17, 2000). However, the 1998 M2P2 Task Force Progress Report notes that Daimler-Chrysler has phased out the use of mercury switches, with the exception of its Grand Cherokee Jeep, which uses three mercury switches in its ABS system. The Jeep web page lists ABS brakes on Grand Cherokee models and does not specify 2WD only (http://www.jeepunpaved.com/gr-cherokee/specs/index.html). It does not list ABS brakes on Cherokee or Wrangler models. Due to this confusing array of conflicting data, production figures are given here for all of the Jeep brand name, but we have assumed ABS mercury switches are only present in Grand Cherokee models, whether 2WD or 4WD.

Appendix D

Mercury Emissions Resulting from Mercury in Steel Scrap (Pre-1992 data)

Facility Name	Location	Emissions (lb/yr)	Steel Production (tons/yr)	Emissions/Product (lb/1000 ton)
Atlantic Steel	Cartersville, GA	0.01	631,253	0.00002
Birmingham Steel	Birmingham, AL	0.34	336,000	0.001
Birmingham Steel	Bourbonnais, IL	0.02	467,045	0.00004
Firstmiss Steel	Hollsopple, PA	0.08	100,601	0.0008
Florida Steel	Baldwin, FL	0.43	431,790	0.001
Florida Steel	Charlotte, NC	0.27	259,000	0.001
Florida Steel	Jackson, TN	0.47	420,000	0.001
Florida Steel	Knoxville, TN	1.56	280,000	0.006
Florida Steel	Tampa, FL	0.21	200,000	0.001
Kentucky Steel	Newport, KY	0.13	225,000	0.0006
Lukens Steel	Coatsville, PA	0.18	985,000	0.0002
Macsteel	Fort Smith, AR	0.04	250,000	0.0002
Marion Steel	Marion, OH	0.34	380,000	0.0009
New Jersey Steel	Sayreville, NJ	120.0	932,000	0.13
Newport Steel	Wilder, KY	0.06	214,487	0.0003
Nucor	Crawfordsville, IN	10.0	854,248	0.01
Nucor-Yamato	Blytheville, AR	0.06	1,200,000	0.00005
Oregon Steel	Portland, OR	0.02	250,000	0.00008
Salmon Bay Steel	Seattle, WA	0.41	478,934	0.0009

Note: Data collected in 1992 from industry by EPA as part of a Clean Air Act information request. Data are reportedly based on stack tests, but it is not known whether tests were performed using EPA methods.

Source: Cain, Alexis, US EPA. Electronic communication to Lori Kincaid, UT CCPCT. (Included file "Mercury Emissions Resulting from Mercury in Steel Scrap," author unknown.) November 2, 2000.

Appendix E

DIRECTIVE 2000/53/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL
of 18 September 2000
on end-of life vehicles

THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty establishing the European Community, and in particular Article 175(1) thereof,

Having regard to the proposal from the Commission ([1]),

Having regard to the opinion of the Economic and Social Committee ([2]),

Having consulted the Committee of the Regions,

Acting in accordance with the procedure referred to in Article 251 of the Treaty in the light of the joint text approved by the Conciliation Committee on 23 May 2000 ([3]),

Whereas

(1) The different national measures concerning end-of life vehicles should be harmonised in order, first, to minimise the impact of end-of life vehicles on the environment, thus contributing to the protection, preservation and improvement of the quality of the environment and energy conservation, and, second, to ensure the smooth operation of the internal market and avoid distortions of competition in the Community.

(2) A Community-wide framework is necessary in order to ensure coherence between national approaches in attaining the objectives stated above, particularly with a view to the design of vehicles for recycling and recovery, to the requirements for collection and treatment facilities, and to the attainment of the targets for reuse, recycling and recovery, taking into account the principle of subsidiarity and the polluter-pays principle.

(3) Every year end-of life vehicles in the Community generate between 8 and 9 million tonnes of waste, which must be managed correctly.

(4) In order to implement the precautionary and preventive principles and in line with the Community strategy for waste management, the generation of waste must be avoided as much as possible.

(5) It is a further fundamental principle that waste should be reused and recovered, and that preference be given to reuse and recycling.

([1]) OJ C 337, 7.11.1997, p. 3, andOJ C 156, 3.6.1999, p. 5.
([2]) OJ C 129, 27.4.1998, p. 44.
([3]) Opinion of the European Parliament of 11 February 1999 (OJ C 150, 28.5.1999, p. 420), Council Common Position of 29 July 1999 (OJ C 317, 4.11.1999, p. 19) and Decision of the European Parliament of 3 February 2000 (not yet published in the Official Journal). Council Decision of 20 July 2000 and Decision of the European Parliament of 7 September 2000.

(6) Member States should take measures to ensure that economic operators set up systems for the collection, treatment and recovery of end-of life vehicles.

(7) Member States should ensure that the last holder and/or owner can deliver the end-of life vehicle to an authorised treatment facility without any cost as a result of the vehicle having no or a negative, market value. Member States should ensure that producers meet all, or a significant part of, the costs of the implementation of these measures; the normal functioning of market forces should not be hindered.

(8) This Directive should cover vehicles and end-of life vehicles, including their components and materials, as well as spare and replacement parts, without prejudice to safety standards, air emissions and noise control.

(9) This Directive should be understood as having borrowed, where appropriate, the terminology used by several existing directives, namely Council Directive 67/548/EEC of 27 June 1967 on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances ([4]), Council Directive 70/156/EEC of 6 February 1970 on the approximation of the laws of the Member States relating to the type-approval of motor vehicles and their trailers ([5]), and Council Directive 75/442/EEC of 15 July 1975 on waste ([6]).

(10) Vintage vehicles, meaning historic vehicles or vehicles of value to collectors or intended for museums, kept in a proper and environmentally sound manner, either ready for use or stripped into parts, are not covered by the definition of waste laid down by Directive 75/442/EEC and do not fall within the scope of this Directive.

(11) It is important that preventive 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

([4]) OJ 196, 16.8.1967, p. 1. Directive as last amended by Commission Directive 98/98/EC (OJ L 355, 30.12.1998, p. 1).
([5]) OJ L 42, 23.2.1970, p. 1. Directive as last amended by Directive 98/91/EC of the European Parliament and of the Council (OJ L 11, 16.1.1999, p. 25).
([6]) OJ L 194, 25.7.1975, p. 39. Directive as last amended by Commission Decision 96/350/EC (OJ L 135, 6.6.1996, p. 32).

chromium should be prohibited. These heavy metals should only be used in certain applications according to a list which will be regularly reviewed. This will help to ensure that certain materials and components do not become shredder residues, and are not incinerated or disposed of in landfills.

(12) The recycling of all plastics from end-of life vehicles should be continuously improved. The Commission is currently examining the environmental impacts of PVC. The Commission will, on the basis of this work, make proposals as appropriate as to the use of PVC including considerations for vehicles.

(13) The requirements for dismantling, reuse and recycling of end-of life vehicles and their components should be integrated in the design and production of new vehicles.

(14) The development of markets for recycled materials should be encouraged.

(15) In order to ensure that end-of life vehicles are discarded without endangering the environment, appropriate collection systems should be set up.

(16) A certificate of destruction, to be used as a condition for the de-registration of end-of life vehicles, should be introduced. Member States without a de-registration system should set up a system according to which a certificate of destruction is notified to the relevant competent authority when the end-of life vehicle is transferred to a treatment facility.

(17) This Directive does not prevent Member States from granting, where appropriate, temporary deregistrations of vehicles.

(18) Collection and treatment operators should be allowed to operate only when they have received a permit or, in case a registration is used instead of a permit, specific conditions have been complied with.

(19) The recyclability and recoverability of vehicles should be promoted.

(20) It is important to lay down requirements for storage and treatment operations in order to prevent negative impacts on the environment and to avoid the emergence of distortions in trade and competition.

(21) In order to achieve results in the short term and to give operators, consumers and public authorities the necessary perspective for the longer term, quantified targets for reuse, recycling and recovery to be achieved by economic operators should be set.

(22) Producers should ensure that vehicles are designed and manufactured in such a way as to allow the quantified targets for reuse, recycling and recovery to be achieved. To this end the Commission will promote the preparation of European standards and will take the other necessary measures in order to amend the pertinent European vehicle type-approval legislation.

(23) Member States should ensure that in implementing the provisions of this Directive competition is preserved, in particular as regards the access of small and medium-sized enterprises to the collection, dismantling, treatment and recycling market.

(24) In order to facilitate the dismantling and recovery, in particular recycling of end-of life vehicles, vehicle manufacturers should provide authorised treatment facilities with all requisite dismantling information, in particular for hazardous materials.

(25) The preparation of European standards, where appropriate, should be promoted. Vehicle manufacturers and material producers should use component and material coding standards, to be established by the Commission assisted by the relevant committee. In the preparation of these standards the Commission will take account, as appropriate, of the work going on in this area in the relevant international forums.

(26) Community-wide data on end-of life vehicles are needed in order to monitor the implementation of the objectives of this Directive.

(27) Consumers have to be adequately informed in order to adjust their behaviour and attitudes; to this end information should be made available by the relevant economic operators.

(28) Member States may choose to implement certain provisions by means of agreements with the economic sector concerned, provided that certain conditions are met.

(29) The adaptation to scientific and technical progress of the requirements for treatment facilities and for the use of hazardous substances and, as well as the adoption of minimum standards for the certificate of destruction, the formats for the database and the implementation measures necessary to control compliance with the quantified targets should be effected by the Commission under a Committee procedure.

(30) The measures to be taken for the implementation of this Directive should be adopted in accordance with Council Decision 1999/468/EC of 28 June 1999 laying down the procedures for the exercise of implementing powers conferred on the Commission [1].

(31) Member States may apply the provisions of this Directive in advance of the date set out therein, provided such measures are compatible with the Treaty,

[1] OJ L 184, 17.7.1999, p. 23.

HAVE ADOPTED THIS DIRECTIVE:

Article 1

Objectives

This Directive lays down measures which aim, as a first priority, at the prevention of waste from vehicles and, in addition, at the reuse, recycling and other forms of recovery of end-of life vehicles and their components so as to reduce the disposal of waste, as well as at the improvement in the environmental performance of all of the economic operators involved in the life cycle of vehicles and especially the operators directly involved in the treatment of end-of life vehicles.

Article 2

Definitions

For the purposes of this Directive:

1. 'vehicle' means any vehicle designated as category M_1 or N_1 defined in Annex IIA to Directive 70/156/EEC, and three wheel motor vehicles as defined in Directive 92/61/EEC, but excluding motor tricycles;

2. 'end-of life vehicle' means a vehicle which is waste within the meaning of Article 1(a) of Directive 75/442/EEC;

3. 'producer' means the vehicle manufacturer or the professional importer of a vehicle into a Member State;

4. 'prevention' means measures aiming at the reduction of the quantity and the harmfulness for the environment of end-of life vehicles, their materials and substances;

5. 'treatment' means any activity after the end-of life vehicle has been handed over to a facility for depollution, dismantling, shearing, shredding, recovery or preparation for disposal of the shredder wastes, and any other operation carried out for the recovery and/or disposal of the end-of life vehicle and its components;

6. 'reuse' means any operation by which components of end-of life vehicles are used for the same purpose for which they were conceived;

7. 'recycling' means the reprocessing in a production process of the waste materials for the original purpose or for other purposes but excluding energy recovery. Energy recovery means the use of combustible waste as a means to generate energy through direct incineration with or without other waste but with recovery of the heat;

8. 'recovery' means any of the applicable operations provided for in Annex IIB to Directive 75/442/EEC;

9. 'disposal' means any of the applicable operations provided for in Annex IIA to Directive 75/442/EEC;

10. 'economic operators' means producers, distributors, collectors, motor vehicle insurance companies, dismantlers, shredders, recoverers, recyclers and other treatment operators of end-of life vehicles, including their components and materials;

11. 'hazardous substance' means any substance which is considered to be dangerous under Directive 67/548/EEC;

12. 'shredder' means any device used for tearing into pieces or fragmenting end-of life vehicles, including for the purpose of obtaining directly reusable metal scrap;

13. 'dismantling information' means all information required for the correct and environmentally sound treatment of end-of life vehicles. It shall be made available to authorised treatment facilities by vehicle manufacturers and component producers in the form of manuals or by means of electronic media (e.g. CD-ROM, on-line services).

Article 3

Scope

1. This Directive shall cover vehicles and end-of life vehicles, including their components and materials. Without prejudice to Article 5(4), third subparagraph, this shall apply irrespective of how the vehicle has been serviced or repaired during use and irrespective of whether it is equipped with components supplied by the producer or with other components whose fitting as spare or replacement parts accords with the appropriate Community provisions or domestic provisions.

2. This Directive shall apply without prejudice to existing Community legislation and relevant national legislation, in particular as regards safety standards, air emissions and noise controls and the protection of soil and water.

3. Where a producer only makes or imports vehicles that are exempt from Directive 70/156/EEC by virtue of Article 8(2)(a) thereof, Member States may exempt that producer and his vehicles from Articles 7(4), 8 and 9 of this Directive.

4. Special-purpose vehicles as defined in the second indent of Article 4(1)(a) of Directive 70/156/EEC shall be excluded from the provisions of Article 7 of this Directive.

5. For three-wheel motor vehicles only Articles 5(1), 5(2) and 6 of this Directive shall apply.

Article 4

Prevention

1. In order to promote the prevention of waste Member States shall encourage, in particular:

(a) vehicle manufacturers, in liaison with material and equipment manufacturers, to limit the use of hazardous substances in vehicles and to reduce them as far as possible from the conception of the vehicle onwards, so as in particular to prevent their release into the environment, make recycling easier, and avoid the need to dispose of hazardous waste;

(b) the design and production of new vehicles which take into full account and facilitate the dismantling, reuse and recovery, in particular the recycling, of end-of life vehicles, their components and materials;

(c) vehicle manufacturers, in liaison with material and equipment manufacturers, to integrate an increasing quantity of recycled material in vehicles and other products, in order to develop the markets for recycled materials.

2. (a) Member States shall ensure that materials and components of vehicles put on the market after 1 July 2003 do not contain lead, mercury, cadmium or hexavalent chromium other than in cases listed in Annex II under the conditions specified therein;

(b) in accordance with the procedure laid down in Article 11 the Commission shall on a regular basis, according to technical and scientific progress, amend Annex II, in order to:

(i) as necessary, establish maximum concentration values up to which the existence of the substances referred to in subparagraph (a) in specific materials and components of vehicles shall be tolerated;

(ii) exempt certain materials and components of vehicles from the provisions of subparagraph (a) if the use of these substances is unavoidable;

(iii) delete materials and components of vehicles from Annex II if the use of these substances is avoidable;

(iv) under points (i) and (ii) designate those materials and components of vehicles that can be stripped before further treatment; they shall be labelled or made identifiable by other appropriate means;

(c) the Commission shall amend Annex II for the first time not later than 21 October 2001. In any case none of the exemptions listed therein shall be deleted from the Annex before 1 January 2003.

Article 5

Collection

1. Member States shall take the necessary measures to ensure:

— that economic operators set up systems for the collection of all end-of life vehicles and, as far as technically feasible, of waste used parts removed when passenger cars are repaired,

— the adequate availability of collection facilities within their territory.

2. Member States shall also take the necessary measures to ensure that all end-of life vehicles are transferred to authorised treatment facilities.

3. Member States shall set up a system according to which the presentation of a certificate of destruction is a condition for deregistration of the end-of life vehicle. This certificate shall be issued to the holder and/or owner when the end-of life vehicle is transferred to a treatment facility. Treatment facilities, which have obtained a permit in accordance with Article 6, shall be permitted to issue a certificate of destruction. Member States may permit producers, dealers and collectors on behalf of an authorised treatment facility to issue certificates of destruction provided that they guarantee that the end-of life vehicle is transferred to an authorised treatment facility and provided that they are registered with public authorities.

Issuing the certificate of destruction by treatment facilities or dealers or collectors on behalf of an authorised treatment facility does not entitle them to claim any financial reimbursement, except in cases where this has been explicitly arranged by Member States.

Member States which do not have a deregistration system at the date of entry into force of this Directive shall set up a system according to which a certificate of destruction is notified to the relevant competent authority when the end-of life vehicle is transferred to a treatment facility and shall otherwise comply with the terms of this paragraph. Member States making use of this subparagraph shall inform the Commission of the reasons thereof.

4. Member States shall take the necessary measures to ensure that the delivery of the vehicle to an authorised treatment facility in accordance with paragraph 3 occurs without any cost for the last holder and/or owner as a result of the vehicle's having no or a negative market value.

Member States shall take the necessary measures to ensure that producers meet all, or a significant part of, the costs of the implementation of this measure and/or take back end-of life vehicles under the same conditions as referred to in the first subparagraph.

Member States may provide that the delivery of end-of life vehicles is not fully free of charge if the end-of life vehicle does not contain the essential components of a vehicle, in particular the engine and the coachwork, or contains waste which has been added to the end-of life vehicle.

The Commission shall regularly monitor the implementation of the first subparagraph to ensure that it does not result in market distortions, and if necessary shall propose to the European Parliament and the Council an amendment thereto.

5. Member States shall take the necessary measures to ensure that competent authorities mutually recognise and accept the certificates of destruction issued in other Member States in accordance with paragraph 3. To this end, the Commission shall draw up, not later than 21 October 2001 the minimum requirements for the certificate of destruction.

Article 6

Treatment

1. Member States shall take the necessary measures to ensure that all end-of life vehicles are stored (even temporarily) and treated in accordance with the general requirements laid down in Article 4 of Directive 75/442/EEC, and in compliance with the minimum technical requirements set out in Annex I to this Directive, without prejudice to national regulations on health and environment.

2. Member States shall take the necessary measures to ensure that any establishment or undertaking carrying out treatment operations obtains a permit from or be registered with the competent authorities, in compliance with Articles 9, 10 and 11 of Directive 75/442/EEC.

The derogation from the permit requirement referred to in Article 11(1)(b) of Directive 75/442/EEC may apply to recovery operations concerning waste of end-of life vehicles after they have been treated according to Annex 1(3) to this Directive if there is an inspection by the competent authorities before the registration. This inspection shall verify:

(a) type and quantities of waste to be treated;

(b) general technical requirements to be complied with;

(c) safety precautions to be taken,

in order to achieve the objectives referred to in Article 4 of Directive 75/442/EEC. This inspection shall take place once a year. Member States using the derogation shall send the results to the Commission.

3. Member States shall take the necessary measures to ensure that any establishment or undertaking carrying out treatment operations fulfils at least the following obligations in accordance with Annex I:

(a) end-of life vehicles shall be stripped before further treatment or other equivalent arrangements are made in order to reduce any adverse impact on the environment. Components or materials labelled or otherwise made identifiable in accordance with Article 4(2) shall be stripped before further treatment;

(b) hazardous materials and components shall be removed and segregated in a selective way so as not to contaminate subsequent shredder waste from end-of life vehicles;

(c) stripping operations and storage shall be carried out in such a way as to ensure the suitability of vehicle components for reuse and recovery, and in particular for recycling.

Treatment operations for depollution of end-of life vehicles as referred to in Annex I(3) shall be carried out as soon as possible.

4. Member States shall take the necessary measures to ensure that the permit or registration referred to in paragraph 2 includes all conditions necessary for compliance with the requirements of paragraphs 1, 2 and 3.

5. Member States shall encourage establishments or undertakings, which carry out treatment operations to introduce, certified environmental management systems.

Article 7

Reuse and recovery

1. Member States shall take the necessary measures to encourage the reuse of components which are suitable for reuse, the recovery of components which cannot be reused and the giving of preference to recycling when environmentally viable, without prejudice to requirements regarding the safety of vehicles and environmental requirements such as air emissions and noise control.

2. Member States shall take the necessary measures to ensure that the following targets are attained by economic operators:

(a) no later than 1 January 2006, for all end-of life vehicles, the reuse and recovery shall be increased to a minimum of 85 % by an average weight per vehicle and year. Within the same time limit the reuse and recycling shall be increased to a minimum of 80 % by an average weight per vehicle and year;

for vehicles produced before 1 January 1980, Member States may lay down lower targets, but not lower than 75 % for reuse and recovery and not lower than 70 % for reuse and recycling. Member States making use of this subparagraph shall inform the Commission and the other Member States of the reasons therefor;

(b) no later than 1 January 2015, for all end-of life vehicles, the reuse and recovery shall be increased to a minimum of 95 % by an average weight per vehicle and year. Within the same time limit, the re-use and recycling shall be increased to a minimum of 85 % by an average weight per vehicle and year.

By 31 December 2005 at the latest the European Parliament and the Council shall re-examine the targets referred to in paragraph (b) on the basis of a report of the Commission, accompanied by a proposal. In its report the Commission shall take into account the development of the material composition of vehicles and any other relevant environmental aspects related to vehicles.

The Commission shall, in accordance with the procedure laid down in Article 11, establish the detailed rules necessary to control compliance of Member States with the targets set out in this paragraph. In doing so the Commission shall take into account all relevant factors, inter alia the availability of data and the issue of exports and imports of end-of life vehicles. The Commission shall take this measure not later than 21 October 2002.

3. On the basis of a proposal from the Commission, the European Parliament and the Council shall establish targets for reuse and recovery and for reuse and recycling for the years beyond 2015.

4. In order to prepare an amendment to Directive 70/156/EEC, the Commission shall promote the preparation of European standards relating to the dismantlability, recoverability and recyclability of vehicles. Once the standards are agreed, but in any case no later than by the end of 2001, the European Parliament and the Council, on the basis of a proposal from the Commission, shall amend Directive 70/156/EEC so that vehicles type-approved in accordance with that Directive and put on the market after three years after the amendment of the Directive 70/156/EEC are re-usable and/or recyclable to a minimum of 85 % by weight per vehicle and are re-usable and/or recoverable to a minimum of 95 % by weight per vehicle.

5. In proposing the amendment to Directive 70/156/EEC relating to the ability to be dismantled, recoverability and recyclability of vehicles, the Commission shall take into account as appropriate the need to ensure that the reuse of components does not give rise to safety or environmental hazards.

Article 8

Coding standards/dismantling information

1. Member States shall take the necessary measures to ensure that producers, in concert with material and equipment manufacturers, use component and material coding standards, in particular to facilitate the identification of those components and materials which are suitable for reuse and recovery.

2. Not later than 21 October 2001 the Commission shall, in accordance with the procedure laid down in Article 11 establish the standards referred to in paragraph 1 of this Article. In so doing, the Commission shall take account of the work going on in this area in the relevant international forums and contribute to this work as appropriate.

3. Member States shall take the necessary measures to ensure that producers provide dismantling information for each type of new vehicle put on the market within six months after the vehicle is put on the market. This information shall identify, as far as it is needed by treatment facilities in order to comply with the provisions of this Directive, the different vehicle components and materials, and the location of all hazardous substances in the vehicles, in particular with a view to the achievement of the objectives laid down in Article 7.

4. Without prejudice to commercial and industrial confidentiality, Member States shall take the necessary measures to ensure that manufacturers of components used in vehicles make available to authorised treatment facilities, as far as it is requested by these facilities, appropriate information concerning dismantling, storage and testing of components which can be reused.

Article 9

Reporting and information

1. At three-year intervals Member States shall send a report to the Commission on the implementation of this Directive. The report shall be drawn up on the basis of a questionnaire or outline drafted by the Commission in accordance with the procedure laid down in Article 6 of Directive 91/692/EEC [1] with a view to establishing databases on end-of life vehicles and their treatment. The report shall contain relevant information on possible changes in the structure of motor vehicle dealing and of the collection, dismantling, shredding, recovery and recycling industries, leading to any distortion of competition between or within Member States. The questionnaire or outline shall be sent to the Member States six months before the start of the period covered by the report. The report shall be made to the Commission within nine months of the end of the three-year period covered by it.

The first report shall cover the period of three years from 21 April 2002.

(1) OJ L 377, 31.12.1991, p. 48.

Based on the above information, the Commission shall publish a report on the implementation of this Directive within nine months of receiving the reports from the Member States.

2. Member States shall require in each case the relevant economic operators to publish information on:

— the design of vehicles and their components with a view to their recoverability and recyclability,

— the environmentally sound treatment of end-of life vehicles, in particular the removal of all fluids and dismantling,

— the development and optimisation of ways to reuse, recycle and recover end-of life vehicles and their components,

— the progress achieved with regard to recovery and recycling to reduce the waste to be disposed of and to increase the recovery and recycling rates.

The producer must make this information accessible to the prospective buyers of vehicles. It shall be included in promotional literature used in the marketing of the new vehicle.

Article 10

Implementation

1. Member States shall bring into force the laws, regulations and administrative provisions necessary to comply with this Directive by 21 April 2002. They shall immediately inform the Commission thereof.

When Member States adopt these measures, these shall contain a reference to this Directive or shall be accompanied by such reference on the occasion of their official publication. The methods of making such a reference shall be laid down by Member States.

2. Member States shall communicate to the Commission the text of the main provisions of domestic law, which they adopt in the field governed by this Directive.

3. Provided that the objectives set out in this Directive are achieved, Member States may transpose the provisions set out in Articles 4(1), 5(1), 7(1), 8(1), 8(3) and 9(2) and specify the detailed rules of implementation of Article 5(4) by means of agreements between the competent authorities and the economic sectors concerned. Such agreements shall meet the following requirements

(a) agreements shall be enforceable;

(b) agreements need to specify objectives with the corresponding deadlines;

(c) agreements shall be published in the national official journal or an official document equally accessible to the public and transmitted to the Commission;

(d) the results achieved under an agreement shall be monitored regularly, reported to the competent authorities and to the Commission and made available to the public under the conditions set out in the agreement;

(e) the competent authorities shall make provisions to examine the progress reached under an agreement;

(f) in case of non-compliance with an agreement Member States must implement the relevant provisions of this Directive by legislative, regulatory or administrative measures.

Article 11

Committee procedure

1. The Commission shall be assisted by the committee established by Article 18 of Directive 75/442/EEC, hereinafter referred to as 'the Committee'.

2. Where reference is made to this Article, Articles 5 and 7 of Decision 1999/468/EC shall apply, having regard to the provisions of Article 8 thereof.

The period laid down in Article 5(6) of Decision 1999/468/EC shall be set at three months.

3. The Committee shall adopt its rules of procedure.

4. The Commission, according to the procedure laid down in this Article, shall adopt:

(a) the minimum requirements, as referred to in Article 5(5), for the certificate of destruction;

(b) the detailed rules referred to in Article 7(2), third subparagraph;

(c) the formats relating to the database system referred to in Article 9;

(d) the amendments necessary for adapting the Annexes to this Directive to scientific and technical progress.

Article 12

Entry into force

1. This Directive shall enter into force on the day of its publication in the *Official Journal of the European Communities*.

2. Article 5(4) shall apply:

— as from 1 July 2002 for vehicles put on the market as from this date,

— as from 1 January 2007 for vehicles put on the market before the date referred to in the first indent.

3. Member States may apply Article 5(4) in advance of the dates set out in paragraph 2.

Article 13

Addressees

This Directive is addressed to the Member States.

Done at Brussels, 18 September 2000.

For the European Parliament	*For the Council*
The President	*The President*
N. FONTAINE	H. VÉDRINE