Great Lakes Binational Toxics Strategy

Draft Report

on

Alkyl-lead: Sources, Regulations and Options

October 1999

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EXECUTIVE SUMMARY

On April 7, 1997, Environment Canada (EC) and the U.S. Environmental Protection Agency signed the *Great Lakes Binational Toxics Strategy: Canada-United States Strategy for the Virtual Elimination of Persistent Toxic Substances in the Great Lakes* (Binational Strategy or BNS) (USEPA, EC, 1997). The Binational Strategy sets reduction goals for Canada and the U.S. to virtually eliminate persistent toxic substances, including alkyl-lead, in the Great Lakes. To guide EC and EPA, along with their partners, as they work toward virtual elimination of the strategy substances, the BNS outlined a four-step analytical framework. This report presents, for alkyl-lead, analysis results related to the first three steps of the BNS four-step process: gathering information, analyzing current regulations, initiatives, and programs, and identifying cost-effective options to achieving further reductions.

Organolead compounds are man-made compounds in which a carbon atom of one or more organic molecules is bound to a lead atom. Of these, the Tetraalkyllead compounds, Tetraethyllead [TEL] and Tetramethyllead [TML] are the most common alkyl-lead compounds that have been used in the past and are still in use today in the United States, primarily as a fuel additive to reduce "knock" in combustion engines. These two alkyl-lead compounds are the focus of this report.

Alkyl-lead is released to the environment primarily through evaporative emissions from unburned gasoline retained in an engine's carburetor or fuel tanks and through evaporative losses during the filling of gasoline tanks, accidental spillages, and releases during production. However, alkyl-lead compounds combine with other compounds during the combustion process to form inorganic lead halides that are subsequently emitted as microparticulates in exhaust. Therefore, the human exposure pathways for alkyl-lead include inhalation of leaded gasoline vapors and dermal exposure to leaded gasoline. Unlike metallic forms of lead, alkyl-lead is easily absorbed through the skin. Additionally, the lead halides exhausted through combustion can be inhaled. Subsequent deposition of these lead halides contributes to exposure to lead through ingestion of lead contaminated soil or dust, and ingestion of lead-contaminated food or water.

The use of alkyl-lead has been prohibited by legislation in on-road automotive gasoline, however, several authorized uses of alkyl-lead still remain. Currently, the largest use of alkyl-lead occurs in aviation gasoline for general aviation (piston-engine) aircraft. In 1998, the aviation industry used approximately 295.3 million gallons of leaded gasoline, which is estimated to contain 1.39 million pounds of TEL. Other uses of alkyl-lead include automotive racing gasoline, and recreational marine fuel. These current uses, as well as trace amounts of lead in automotive gasoline, result in releases to the environment.

There are a number of regulations that pertain to alkylated lead compounds. Most recently, alkyl-lead compounds have been regulated under the 1990 Clean Air Act Amendments (CAAA). The CAAA specifically prohibits the use of leaded gasoline for on-road vehicles, misfueling vehicles built after 1990 (or vehicles designated solely for unleaded gasoline) with

leaded gasoline, and the production of engines requiring leaded gasoline. The CAAA also contain requirements pertaining to the identification of sources of alkyl-lead and language specific to emissions of lead compounds resulting from the use of leaded gasoline.

In light of progress made to date in eliminating the use of alkyl-lead in automotive gasoline, there are two primary strategic directions for addressing the remaining alkyl-lead use and emissions in the United States:

1. Pursue voluntary initiatives to reduce the use of alkyl-lead in aircraft gasoline, race cars, and non-road vehicles.

2. Collect information and assess exposure in sensitive geographic areas for at-risk populations.

Table E1 summarizes options for key actions that could be undertaken by EPA to achieve further reductions toward the goal of virtual elimination.

Table E1. Options for Key Actions to Reduce Risks from Alkyl-lead

Focus	Action
1. Pursue voluntary initiatives	— Encourage a NASCAR voluntary phase-out partnership/program — Identify contacts in other racing (auto and non-auto) organizations to initiate similar programs/partnerships — Identify contacts in other organizations to initiate similar programs/partnerships — Work with Coordinating Research Council and FAA to promote alternative, unleaded fuels and the phase-out of leaded aviation gasoline
2. Collect information on lead emissions, leaded gas use, and exposure	— Refine CAA 112(c)(6) emission estimates — Investigate exposure to at-risk populations — Update inventory of leaded gasoline production and use — Determine the availability of leaded gasoline and the potential for misfueling

1.0 INTRODUCTION

On April 7, 1997, Environment Canada (EC) and the U.S. Environmental Protection Agency signed the *Great Lakes Binational Toxics Strategy: Canada-United States Strategy for the Virtual Elimination of Persistent Toxic Substances in the Great Lakes* (Binational Strategy or BNS) (USEPA, EC, 1997). The Binational Strategy sets reduction goals for Canada and the U.S. to virtually eliminate persistent toxic substances, including alkyl-lead, in the Great Lakes.

The Binational Strategy builds on existing Canadian and U.S. regulatory programs that address the targeted substances and affirms each country's commitment to virtually eliminate releases of the targeted substances to the Great Lakes Basin. A cornerstone of the Binational Strategy is its reliance on voluntary measures to dramatically reduce pollutant discharges to the Great Lakes Basin. It outlines a framework by which the countries can work together to achieve virtual elimination objectives.

As part of the Binational Strategy, alkylated lead compounds (or alkyl-lead) have been identified as a "Level I" substance. Therefore, the virtual elimination of alkyl-lead, through pollution prevention and other incentive-based actions, is considered an immediate priority for both governments.

Under the Binational Strategy, Environment Canada (EC) and the U.S. Environmental Protection Agency (EPA) have accepted the following challenges as significant milestones on the path toward virtual elimination of alkyl-lead emissions:

<u>U.S. Challenge:</u> *Confirm by 1998, that there is no longer use of alkyl-lead in automotive gasoline. Support and encourage stakeholder efforts to reduce alkyl-lead releases from other sources.*

<u>Canadian Challenge:</u> *Seek by 2000, a 90 percent reduction in use, generation, or release of alkyl-lead consistent with the 1994 Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem (COA).*

To guide EC and EPA, along with their partners, as they work toward virtual elimination of the strategy substances, the BNS outlined a four-step analytical framework:

1. Gather information

2. Analyze current regulations, initiatives, and programs which manage or control substances

3. Identify cost-effective options to achieve further reductions

4. Implement actions to work toward the goal of virtual elimination

This report presents analysis results related to the first three steps of the BNS four-step process. As part of Step 1, information gathering, Section 2 below describes the properties of alkyl-lead, its presence and fate in the environment, its impact, and its effects on human health. Also as part of Step 1, Section 3 provides an overview of historical and current production and uses of alkyl-lead in the U.S., and presents the available data to characterize environmental releases. Step 2 of the four-step process is covered in Sections 4 and 5 where regulations, initiatives, and programs aimed at reducing alkyl-lead use and/or release in the U.S. are outlined and discussed. Finally, taking the information on sources and regulations into consideration, potential cost-effective options for achieving alkyl-lead virtual elimination goals are presented in Section 6 to address Step 3 of the four-step process.

2.0 BACKGROUND INFORMATION ON ALKYL-LEAD

2.1 DESCRIPTION

Lead (CAS number 7439-92-1) is a naturally occurring, bluish-gray metal originating in the earth's crust. It is odorless, tasteless, and has no known physiological value. It does not dissolve in water and does not burn. The vast majority of lead chemical compounds are inorganic. However, lead can be combined with organic chemicals to form lead compounds with very different characteristics from metallic lead. This report addresses one of the more predominant types of organic lead compounds: alkyl-lead.

Organolead compounds are man-made compounds in which a carbon atom of one or more organic molecules is bound to a lead atom. Generally, "alkyl-lead" compounds are classified as "Tetraalkyllead" compounds (e.g., Tetraethyllead [TEL] and Tetramethyllead [TML]), "Trialkyllead" compounds (e.g., Trimethyllead chloride [TriML] and Triethyllead chloride [TriEL]), or "Dialkyllead" compounds (e.g., Dimethyllead chloride [DiML] and Diethyllead chloride [DiEL]). Of these, the Tetraalkyllead compounds, TEL and TML are the most common alkyl-lead compounds that have been used in the past and are still in use today in the United States. These two alkyl-lead compounds are the focus of this Step 1,2,3 Report.

Tetraethyl lead is also referred to as lead tetraethide, tetraethyllead, and tetraethylplumbane. It is a colorless, oily liquid, with a musty odor, and is typically dyed red, orange, or blue, depending upon its use. Tetramethyl lead is also colorless and oily, with a musty odor.

Alkyl-lead is produced through several different methods including through the electrolysis of an ethyl Grignard reagent or through alkylation of a lead-sodium alloy. Alkyl-lead is used primarily as a fuel additive to reduce "knock" in combustion engines. The most common alkyl-lead compound used as an anti-knock agent in gasoline is TEL lead, though TML lead is also used as an anti-knock agent. These alkyl-lead compounds also help to lubricate internal engine components and protect intake and exhaust valves against recession. On a global basis, lead in gasoline has been estimated to contribute 95 percent of the lead air pollution found in the world's major cities (USEPA, 1998c). Alkylated lead compounds were included in gasoline soon after their anti-knock properties were first discovered in 1921 (Nriagu, 1990). It was not until 1970, almost fifty years later, that the Clean Air Act (CAA) was introduced as the first legislative effort to reduce the amount of lead in gasoline in the United States. Currently, the largest uses of alkyl-lead are in aviation gasoline for general aviation (piston-engine) aircraft, and racing gasoline. Neither of these uses are subject to any of the U.S. regulations that restrict leaded motor gasoline use in on-road vehicles.

2.2 ENVIRONMENTAL FATE AND IMPACTS

Alkyl-lead is released to the environment primarily through evaporative emissions from unburned gasoline retained in an engine's carburetor or fuel tanks and through evaporative losses during the filling of gasoline tanks, accidental spillages, and releases during production. Typically, only a very small percentage of alkyl-lead is exhausted uncombusted when driving at constant speeds. However, alkyl-lead compounds combine with other compounds during the combustion process to form lead halogenides that are subsequently emitted as microparticulates in exhaust.

Alkyl-lead in the atmosphere degrades rapidly by direct photolysis, reaction with ozone, and by reaction with hydroxyl compounds. The half-lives of TEL and TML in summer atmospheres is approximately two hours and nine hours, respectively. In winter atmospheres, the half lives of both TEL and TML consists of several days. In water and soil, alkyl-lead compounds are also degraded to other forms of lead, eventually forming stable inorganic lead compounds. Therefore, alkyl-lead itself is not a persistent environmental compound. However, it breaks down in the environment (or is emitted following combustion) to other forms of lead which are much more persistent, eventually forming stable inorganic lead compounds such as lead phosphates.

Airborne lead particles (such as those emitted as exhaust) may remain airborne for about 10 days and, therefore, may be transported far from the original source. Lead is removed from the atmosphere and deposited on soil and water surfaces via wet or dry deposition. In soils, most lead is strongly retained via the formation of stable solid phase compounds, precipitates, or complexes with organic matter. In general, most of these forms of lead are quite insoluble and thus not easily leached to underground water. However, leaching may occur under acidic conditions, where lead concentrations are extremely high, or in the presence of substances (e.g., soluble organic matter, high concentrations of chlorides or sulfates) which form relatively soluble complexes with lead. Transport of lead to surface waters most commonly occurs through direct deposition from the atmosphere or as lead associated with suspended solids in the erosional process. In water, lead is typically bound to sediments.

Inorganic lead may bioconcentrate in some aquatic animals, especially benthic organisms such as bottom feeding fish and shellfish such as mussels. Biomagnification of inorganic lead does not appear to be significant in aquatic organisms. Alkyl-lead compounds, however, have been found to significantly accumulate in both fish and shellfish. Some crops can become contaminated with lead by exposure to exhaust in the air or lead in the soil.

Selected physical and chemical properties affecting the environmental fate of TEL and TML are summarized in Table 1.

Table 1. Physical/Chemical Properties of Tetraethyl Lead and Tetramethyl Lead

Property	Tetraethyl Lead (TEL)	Tetramethyl Lead (TML)
Chemical Formula	$Pb(C_2H_5)_4$	$Pb(CH_3)_4$
CAS Registry Number	78-00-2	75-74-1
Molecular Weight	323.45	267.35
Melting Point	-130 °C	-27 °C
Boiling Point	200 °C	108 °C
Liquid Density	1.65 g/cm^3	2.0 g/cm^3
Water Solubility	0.29 mg/L	17.9 mg/L

2.3 HUMAN EXPOSURE AND HEALTH EFFECTS

The human exposure pathways for alkyl-lead include inhalation of leaded gasoline vapors and dermal exposure to leaded gasoline. Unlike metallic forms of lead, alkyl-lead is easily absorbed through the skin (Bress, 1991; Moore, 1980). Additionally, through the combustion process, alkyl-lead in gasoline is converted to lead halogenides (inorganic lead compounds) which are exhausted into the air where they can be inhaled. Subsequent deposition of these lead halogenides contributes to exposure to lead through ingestion of lead contaminated soil or dust, and ingestion of lead-contaminated food or water.

The absorption of lead is influenced by the route of exposure. Due to the lipophilic nature of alkyl-lead and its ability to permeate biological membranes, alkyl-lead is absorbed rapidly and extensively through the skin. For this reason, alkyl-lead is much more bioavailable and is considered to be much more toxic than inorganic forms of lead. Further, the toxicity of alkyl-lead compounds varies with the degree of alkylation. Tetraalkyllead compounds such as TEL and TML are considered to be more toxic than Trialkyllead or Dialkyllead compounds.

The specific biochemistry and toxicology of alkyl-lead compounds differs from that of inorganic lead. In the body, alkyl-lead compounds are metabolized in the liver by oxidative dealkylation catalyzed by cytochrome P-450. Through this process, alkyl-lead compounds are converted to triethyllead- and trimethyllead-metabolites and inorganic lead (Kimmel, 1977). It is these three compounds that are thought to cause the toxic effects of lead. Triethyllead and trimethyllead compounds are typically distributed through the blood to "soft tissues" particularly the liver, kidneys, muscles, and brain. Experiments on mice and rabbits have suggested that the highest concentration of triethyllead compounds is found in the liver, kidneys, brain, and muscles in that order (Grandjean, 1979). Over the course of several weeks, lead metabolites can move to and accumulate in "hard tissues" (e.g., bones, teeth). Lead stored in hard tissues can be mobilized back into soft tissues over time, particularly during periods of physiological stress. Lead in soft-tissues is thought to have a half-life of 35 to 40 days. Lead in hard tissues (about 90 percent of the total body-burden of lead) has a half-life of about 20 years (Lauwerys, 1983).

Once lead enters the body, it interferes with normal cell function and with a number of physiologic processes. Lead primarily affects the peripheral and central nervous systems, the blood cells, and metabolism of vitamin D and calcium. Lead also causes reproductive toxicity. Initial symptoms of alkyl-lead poisoning include among others: anorexia, insomnia, tremor, weakness, fatigue, nausea and vomiting, mood shifts such as aggression or depression, and impairment of memory. In the case of acute alkyl-lead poisoning, possible health effects include mania, convulsions, delirium, fever, coma, and in some cases even death. Children are at a higher risk of lead poisoning than adults due to their lower body weights and developing neurological systems. Health effects for children include premature births, reduced birth weight, decreased intelligence, learning and hearing difficulties, and reduced growth. Childhood lead poisoning, due largely to the ingestion or inhalation of inorganic lead compounds in soil and dust, is a widely recognized public health problem.

Blood-lead concentration is a commonly used measure of body lead burden. An extensive body of research relates the health effects of lead exposure to blood-lead concentration. Blood-lead concentrations as low as 10 to 15 μg/dL have been associated with neurological damage in children, and increasing blood-lead levels have been highly correlated with decreased performance on standardized intelligence tests (i.e., lower I.Q. test scores). Adverse health effects such as impaired hearing acuity and interference with vitamin D metabolism have been observed at blood-lead levels of 10 to 15 μg/dL. Increased blood pressure, delayed reaction times, anemia, and kidney disease may become apparent at blood-lead concentrations between 20 and 40 μg/dL. Symptoms of very severe lead poisoning, such as kidney failure, abdominal pain, nausea and vomiting, and pronounced mental retardation can occur at blood-level concentrations as low as 60 μg/dL. At even higher concentrations, convulsions, coma, and death may result. The relationship between the use of leaded gasoline in on-road vehicles and children's blood lead concentration in the United States is presented in Figure 1.

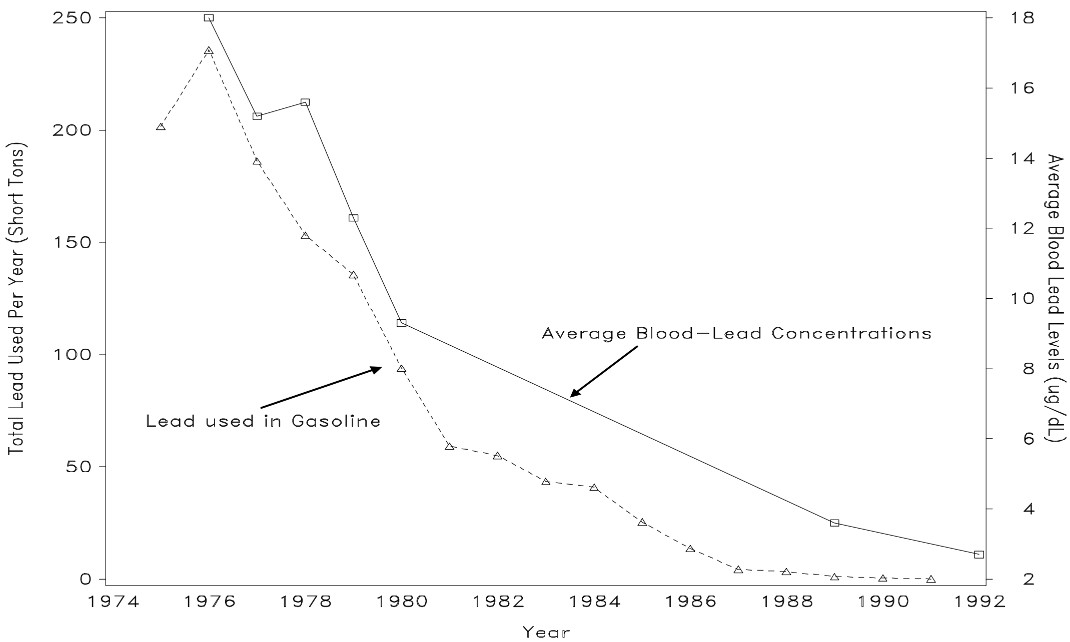

Figure 1. Relationship Between the Phase-out of Leaded Gasoline in On-road Vehicles and the Decline in Children's Blood-lead Levels in the U.S.

[Figure Produced using data from National Health and Nutrition Examination Survey (NHANES), Unpublished Gasoline Production from the DOE's Energy Information Agency (EIA), and the Trends Procedure Document (USEPA, 1998e)) for (lead content per gallon)]

2.4 SENSITIVE POPULATIONS AND GEOGRAPHIC AREAS

With the phase-out of the use of leaded gasoline in on-road vehicles, there has been a substantial reduction in the risk of alkyl-lead and lead exposure for the general public. As observed in Figure 1, the gradual phase-out of lead in automotive gasoline has correlated with a dramatic decline in children's blood-lead concentrations. Other factors, including the ban on the use of lead in house paint and reductions in dietary lead levels that took place during this time period (USFDA, 1998), also likely contributed to the declining blood-lead concentrations. With the reduction in leaded gasoline and dietary intake, deteriorating lead-based paint in homes is now considered to be the primary source of inorganic lead exposure for U.S. children (CDC, 1997). Nevertheless, air emissions of lead from both on-road and nonroad vehicle emissions (as well as airborne sources such as lead smelters) can contribute to childhood lead exposure through a variety of pathways including migration of lead from exterior soil to interior household dust. Current allowed uses of alkyl-lead in fuel (particularly for race cars and airplanes) may place certain subpopulations at risk.

As discussed in Section 2.2, lead particles can remain airborne for some time following the initial introduction into the atmosphere. Therefore, residents in the vicinity of race tracks and general aviation airports where leaded gasoline is still being used as fuel may have an increased risk of lead exposure. Similarly, spectators at racing events or air shows may also be exposed to alkyl-lead emissions resulting from fueling or to lead compounds emitted as exhaust. Information to quantify the risk of these exposure pathways is not currently available.

Aviation fuel attendants, mechanics, and racing crew staff are also potentially exposed due to inhalation of alkyl-lead compounds during fueling, evaporative emissions from spills, or evaporative emissions from unused gasoline remaining in the engine or fuel tanks. Further, these populations may be at risk because of possible dermal absorption of gasoline containing alkyl-lead compounds. Again information to quantify the risk of these exposure pathways is not currently available.

3.0 PRODUCTION, USE AND RELEASE OF ALKYL-LEAD

Although the use of alkyl-lead has been prohibited by legislation in on-road automotive gasoline, several authorized uses of alkyl-lead still remain. Currently, the largest use of alkyl-lead occurs in aviation gasoline for general aviation (piston-engine) aircraft, racing gasoline, and recreational marine. These current uses, as well as trace amounts of lead in automotive gasoline, result in releases to the environment.

Sources of alkyl-lead emissions include:

- Airport fuel terminals
- Bulk plants-aviation gasoline
- Bulk plants-leaded racing and other non-road vehicle gasoline
- Evaporative emissions from aircraft
- Evaporative emissions from non-road vehicles
- Spills from fuel loading, transfer, storage and fueling.

Sinks include:

- Soils and sediments
- Fish and shellfish

3.1 DISCONTINUED USE OF ALKYL-LEAD IN AUTOMOTIVE GASOLINE

In 1990, the Clean Air Act Amendments (CAAA) completely prohibited the use of leaded gasoline as fuel for on-road automotive use in the United States. As a result of these CAA regulations, the production of leaded gasoline and its use in on-road vehicles has declined dramatically, as have estimates of lead emissions resulting from on-road vehicles.

As shown in Figure 2 below, the production of leaded gasoline decreased from 77.5 billion gallons in 1967 to 3.1 billion gallons in 1991 (unpublished data, USEPA, 1991), or to about 3 percent of all gasoline produced. Conversely, the production of unleaded gasoline has risen sharply, also shown in Figure 2. In 1991, 94.9 billion gallons of unleaded gasoline were produced, which represents approximately 97 percent of all gasoline produced (unpublished data, USEPA, 1991).

More current leaded gasoline production estimates, discussed in Section 3.2.2, indicate that the amount produced is not sufficient to serve as fuel for a significant proportion of on-road vehicles. This suggests that illegal misfueling of on-road vehicles with leaded gasoline is likely to be rare, if it occurs at all. Further, emissions of lead (see Section 3.3) have decreased since leaded gasoline was phased out, and on-road vehicles are estimated by EPA to account for less than one-half of one percent of the total amount of lead emitted in 1996. Thus, it is clear that the vast majority of on-road vehicles use unleaded gasoline as their primary fuel. In general, these

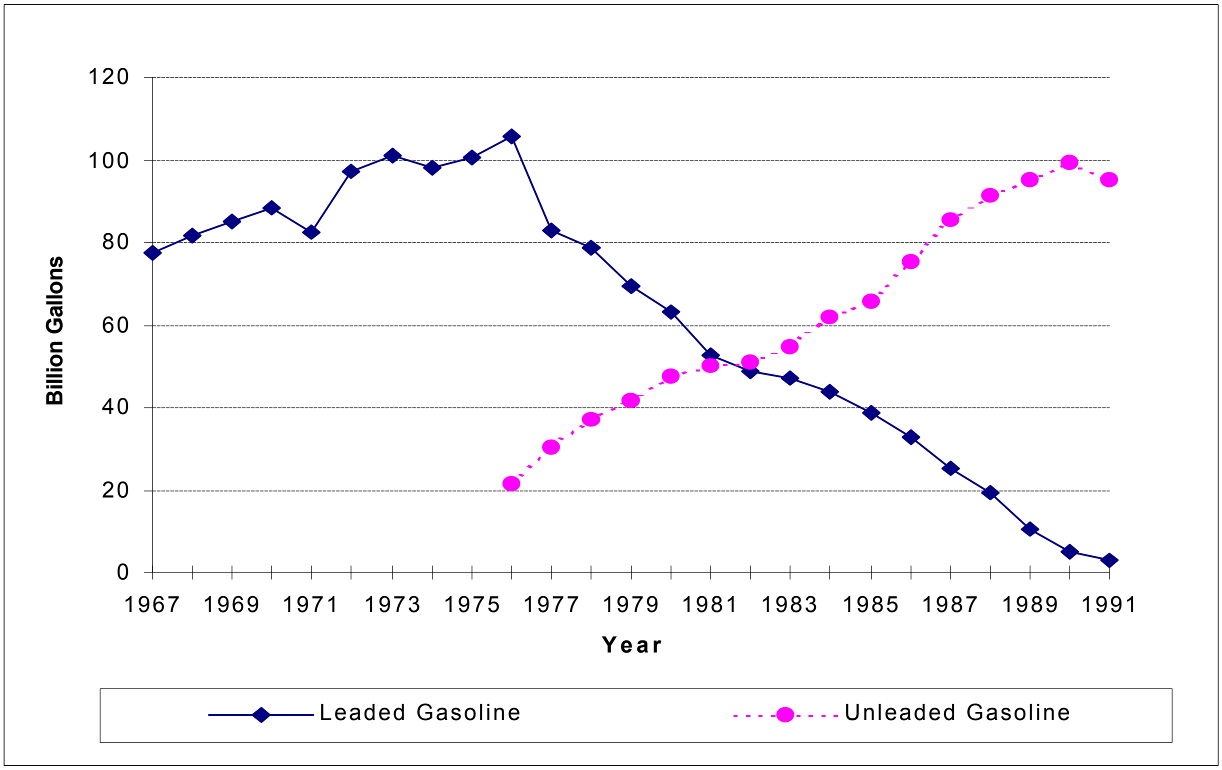

Figure 2. Summary of Unleaded vs. Leaded Gasoline Production 1967-1991.

[Figure produced using unpublished data, USEPA 1991.]

data confirm that alkyl-lead has been virtually eliminated from use in automotive gasoline in on-road vehicles. However, leaded gasoline is still produced and legally used as fuel for a variety of other vehicles in the United States. Current production and use estimates for these remaining sources, as well as emissions data, are presented below.

3.2 CURRENT DOMESTIC USE

Leaded gasoline (containing alkyl-lead) is used as fuel predominantly in the general aviation (piston engine) industry, but also in a variety of non-road uses, including competition race vehicles, construction equipment, farm machinery, and marine vessels.

Current overall production and use rates of alkyl-lead in gasoline in the U.S., particularly for non-road motor vehicles, are difficult to determine due to the fact that the U.S. Department of Energy discontinued the tracking of leaded gasoline in 1990. Thus, most of the available information on alkyl-lead use in gasoline is limited to older data on sales, imports, exports and throughput at bulk distribution plants.

The EPA TSCA Chemical Inventory Chemical Update System indicates that alkyl-lead was not manufactured domestically as of 1994. However, the U.S. Department of Commerce web site documents that, in 1998, the quantity of antiknock preparations imported into the U.S. was approximately 14.4 million pounds per year (based on TEL or TEL/TML mixtures) and the quantity exported was 7.07 million pounds per year (based on lead compounds) (U.S. Department of Commerce, 1998). It is reasonable to assume the majority of the 7 million pound difference between imports and exports was used for the production of leaded gas.

3.2.1 Aviation Fuel

Aviation gasoline (avgas) is currently the fuel with the greatest alkyl-lead (TEL) content, ranging from 4.4×10^{-3} to 8.8×10^{-3} lbs as lead/gal (USEPA, 1998a). Only TEL is used in aviation gasoline. The other aviation fuels, such as Jet kerosene and JP-4, do not contain alkylated lead compounds. Leaded avgas is currently available in several grades with differing lead concentrations, and is used primarily in civil aviation for reciprocating piston engine aircraft. Avgas 80/87 has the lowest lead content at 0.5 grams lead per gallon, and is only used in very low compression ratio engines. Avgas 100/130 is a higher octane grade aviation gasoline, containing about 4 grams of lead per gallon. Finally, a lower-lead blend, Avgas 100LL ("low lead") was designed to replace Avgas 100/130. Avgas 100LL contains about 2 grams of lead per gallon, and is typically the most commonly used aviation gasoline (Purvis, 1999).

First sales of total aviation gasoline (all grades) in 1990 totaled 322.6 million gallons (U.S. DOE, 1991), and throughput at bulk plants was also 322 million gallons (USEPA, 1993). In 1998, the quantities of finished aviation gasoline (all grades) produced at refineries and imported into the U.S. totaled 298.8 million gallons and 1.8 million gallons, respectively (U.S. DOE, 1998). There were no exports of aviation gasoline in 1998 (U.S. DOE, 1998). Adjusting for changes in avgas stocks, the total volume of aviation gasoline supplied as a product in 1998 was 295.3 million gallons (U.S. DOE, 1998). Trends in the total finished aviation gasoline supplied in the U.S. between 1995-1998 are summarized in Figure 3.

As the volumes above represent only total gallons of aviation gasoline, the exact amount of alkyl-lead associated with this total is unknown without information which breaks down the production and use of aviation gasoline by grade. However, based on ATSM specifications for 100LL aviation gasoline (which typically constitutes the majority of avgas consumption), a rough conservative estimate of TEL used in aviation can be derived for 1998 as 295.3 million gallons of gasoline * 2.128 g (TEL)/gallon = 628 billion grams of TEL, which is equivalent to 1.39 million pounds of TEL.

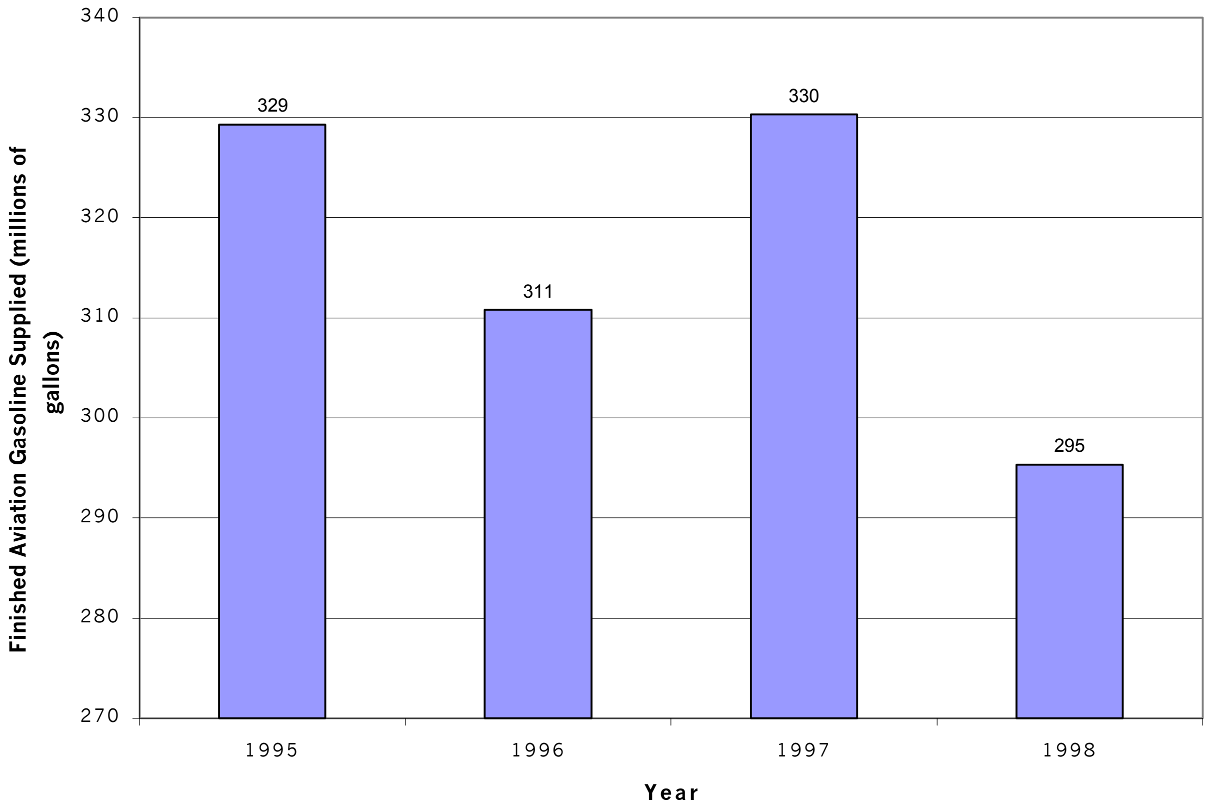

Figure 3. Finished Aviation Gasoline Supplied in the U.S. 1995-1998

[Additional, information from NATA to be incorporated here regarding estimates of 100LL aviation gas, and other grades if available]

3.2.2 Other Non-highway Uses

In addition to aviation, non-road leaded fuel consumption includes use in competitive race vehicles (cars, boats, etc.), construction machinery, agricultural equipment, logging equipment, industrial and light commercial equipment, recreational equipment (boats, ATVs, jet skis, snowmobiles, etc.), airport service equipment, and lawn and garden equipment (USEPA, 1993). In 1990, first sales of leaded motor gasoline in the U.S. were estimated to total 5.8 billion gallons, which comprised about 4.8 percent of the total gasoline sales (U.S. DOE, 1991). By 1991, use of leaded gasoline had declined to 3.1 billion gallons representing 3.2 percent of total gasoline use. (Unpublished data, USEPA, 1991).

Although more recent data on total motor gasoline production levels is available, the proportion of leaded gasoline produced, as well as the rate of leaded gasoline use by each of the non-road sources, is unknown. Total (leaded and unleaded) motor gasoline supplied in the U.S.

between the years 1995 and 1998 has gradually increased from 119.4 billion gallons in 1995 to 126.5 billion gallons in 1998 (U.S. DOE, 1998). If the supply of leaded gasoline has not increased from the 1991 level of 3.1 billion gallons, the percentage of leaded gas based on 1998 total motor gasoline supply levels would be 2.45%. However, it is more likely that the volume of leaded gasoline supply has actually decreased since 1991.

In 1997, imports of leaded gasoline into the U.S. totaled more than 9.4 million gallons, and exports were about 9.1 million gallons (U.S. Bureau of the Census, 1998).

Competition Vehicles (Cars, Boats, etc.)

Currently, no readily available source of information exists on the amount of leaded fuel used by racing cars and boats. However, there are many different supplies of leaded racing fuel in the United States. Almost all of these suppliers offer racing fuel at various octanes and lead content. For example, 76 Racing Gasoline, the "Official Fuel of NASCAR," offers four different types of racing gasoline: 100 Octane Unleaded, 110 Octane Leaded, 114 Octane Leaded, and 118 Octane Leaded. In addition to 76, many suppliers offer unleaded fuel as well as leaded fuel. Therefore, it seems likely that, to some extent, unleaded gasoline is being used for races or at least in particular race vehicles. Table 2 illustrates several suppliers and the types of racing fuel they offer.

As an alternative to the purchase of commercial racing gasoline, gasoline additives may be purchased that can be added to unleaded motor gasoline to raise the octane level. For example, Torco Racing Fuels offers the "Accelerator Race Fuel Concentrate" in both a leaded and unleaded form.

There is also evidence that, to some degree, leaded aviation gasoline may be added to the fuel used for some racing vehicles. For example, some of the suppliers of gasoline additive products present information on how their concentrate can be blended with 100LL to create a higher octane racing fuel.

[Additional information needed on specific consumption of custom-blended leaded racing fuels]

Non-road Equipment (Farm Machinery, Construction/Industrial Equipment, etc.)

[Additional information needed on specific consumption of leaded gasoline for these uses]

Recreational Vehicles

[Additional information needed on specific consumption of leaded gasoline for these uses. Coast guard may have information on marine vessel / recreational boat usage (largest TML source in 1990)]

Table 2. Illustration of Available Racing Gasoline

Supplier	Racing Gasolines Offered	Octane	Lead Content
76 Racing Gasoline (Union 76)	76 Unleaded Racing Gasoline 76 Leaded Racing Gasoline 76 Superstock Racing Gasoline 76 Prostock Racing Gasoline	100 110 114 118	Unleaded TBD TBD TBD
Phillips 66	Phillips B-32 Phillips B-33 Phillips B-35 Phillips B-37 Phillips B-42	110 114 101 118 105	4.0 ml/gal 4.0 ml/gal Unleaded 6.0 ml/gal Unleaded
Sunoco	Sunoco GT Unleaded Sunoco GT Plus Unleaded Sunoco Standard Sunoco Supreme Sunoco Maximal Sunoco Supreme N.O.S Sunoco Maximal #5	100 104 110 112 116 117 116	Unleaded Unleaded TBD TBD TBD 5.0 ml/gal 6.0 ml/gal
RAD Racing Fuel	RAD 110	110	4.5 g/gal

3.2.3 Bulk Terminals, Bulk Plants and Service Stations

Bulk gasoline terminals are the major distribution points for the gasoline produced at refineries, while bulk plants are the secondary distribution facilities that received gasoline from the bulk terminals before it is distributed to smaller consumers such as service stations. Bulk terminals and plants may distribute both leaded and unleaded gasolines for various uses (e.g., motor vehicle gasoline and aviation gasoline). In 1990, the number of major facilities nationwide were estimate at 748 bulk terminals, 12,600 bulk plants, and 387,750 Service stations (USEPA, 1993). Airports were considered to be bulk plants as they receive direct deliveries from refineries.

3.3 OVERVIEW OF EMISSIONS AND RELEASES

Overall lead emissions (all forms of lead and lead compounds, including alkyl-lead) in the U.S. have decreased by two orders of magnitude between 1970 (220,869 short tons emitted) and 1996 (3,869 short tons emitted) (USEPA, 1997) Figure 4 summarizes estimates of total lead emissions by year.

Most notable in Figure 4 is that the greatest reduction in lead emissions occurred between 1970 and 1985. This large reduction is a direct result of the regulated phase-out of leaded

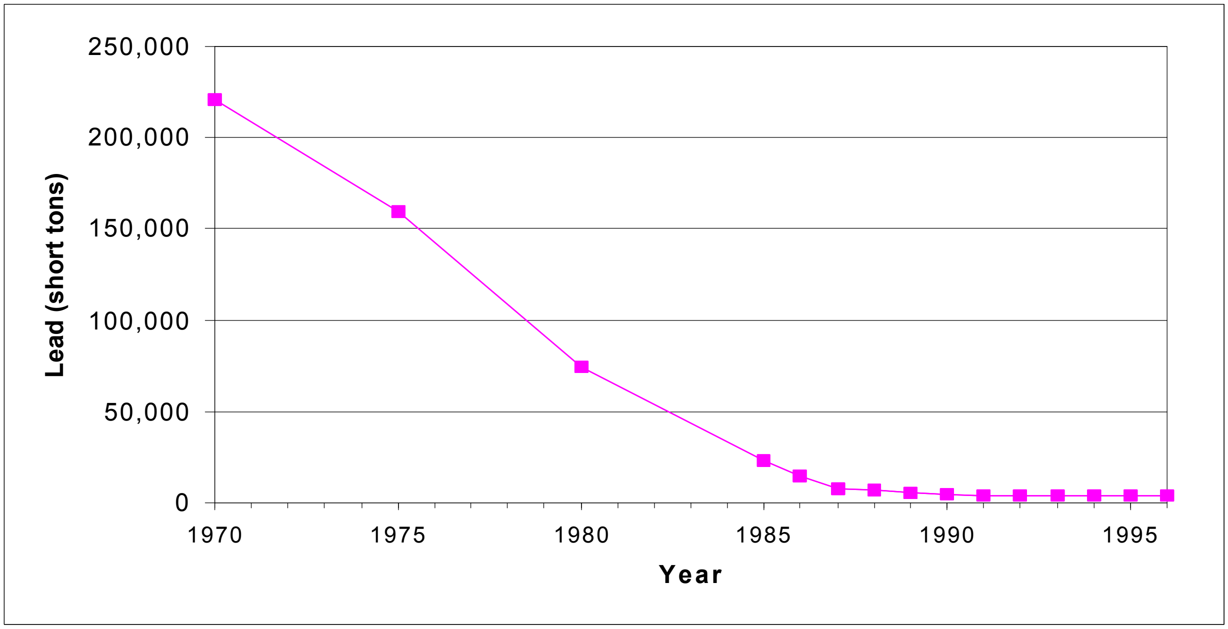

Figure 4. Total Lead Emissions (Short Tons) by Year.

[Figure reproduced from National Air Pollutant Emission Trends Report, 1900-1996 (USEPA, 1997)]

gasoline (reductions in both the lead content per gallon and the total gallons produced) and the increased availability of unleaded gasoline (USDHHS, 1997). Currently, there are several remaining major sources of airborne lead emissions[1], including bulk production plants for aviation gasoline, nonroad vehicles, waste incinerators, metal processing facilities, and other fuel combustion facilities (e.g., electrical utility, industrial). The available data on specific types of releases of lead compounds are discussed below, including exhaust emissions, evaporative emissions, and spills and/or leaks (from fuel loading, transfer, storage, and fueling). The focus of the discussion is on lead emissions attributable to the use of alkyl-lead, either direct alkyl-lead emissions or lead emissions resulting from combustion of fuel containing alkyl-lead. Data specific to alkyl-lead are presented where possible. However, in some cases, the information is limited to reports of inorganic lead releases only.

3.3.1 Exhaust Emissions

As seen in Figure 5, on-road exhaust emissions (the predominant emissions source in the 1970s and 1980s) contributed less than one-half of one percent to the total lead emissions in 1996 (USEPA, 1998d; USEPA, 1997). In 1996, metals processing was estimated to be the

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[1] Through the combustion process in automotive engines, alkyl-lead compounds combine with fuel scavengers to form lead oxides. Alkyl-lead is the only known significant source of lead in gasoline. Typically, only a very small percentage (0.2%-0.4%) of alkyl-lead is exhausted uncombusted when driving at constant speeds (Grandjean, 1983).

predominant source of lead emissions. Therefore, not only have total lead emissions been reduced, but the relative contribution of on-road vehicles has also been reduced. With the continued implementation of provisions of the 1990 CAAA, this trend is expected to continue.

Table 3 summarizes the information contained in Figures 4 and 5. Lead emissions from on-road vehicles were estimated by EPA to be approximately 19 tons in 1996. However, this estimate does not imply a widespread use of leaded gasoline as a fuel source for on-road vehicles. Rather, the estimate reflects the trace amount of lead remaining in unleaded gasoline. This trace amount of lead is due to the sharing of distribution systems utilized by gasoline manufacturers for the production of leaded and unleaded gasoline and residual amounts of lead in crude oil. EPA has determined that requiring manufacturers to eliminate this trace amount is not economically feasible. As production of leaded gasoline has decreased, so too has the trace amount of lead in unleaded motor gasoline.

Table 3 and Figure 5 also show that aircraft accounted for 545 tons (14.1%) of the total lead emissions. EPA did not develop estimates for non road emissions (other than those for aviation) because they were deemed to be extremely low relative to other sources. Of the remaining mobile lead sources, aircraft are most significant in terms of exhaust emissions of lead.

Table 3. 1995 and 1996 National Lead Emissions by Source Category

Source Category	Emissions (short tons)	
	1995	1996
Metals	2,067	2,000
Primary lead production	674	636
Secondary lead production	432	400
Gray iron production	366	339
All other	595	625
Fuel combustion other	414	414
Chemical and Allied Products (lead oxide and pigments)	144	117
On-road	19	19
Nonroad[(a)]	545	545
Nonroad gasoline	0	0
Aircraft	545	545
All other	754	774
Total	3,943	3,869

[Table reproduced from Table 2-1 in the National Air Pollutant Emission Trends Report, 1900-1996, EPA 1997.] (a) EPA did not develop estimates for Nonroad emissions (other than those for aviation) because they were deemed to be extremely low relative to other sources.

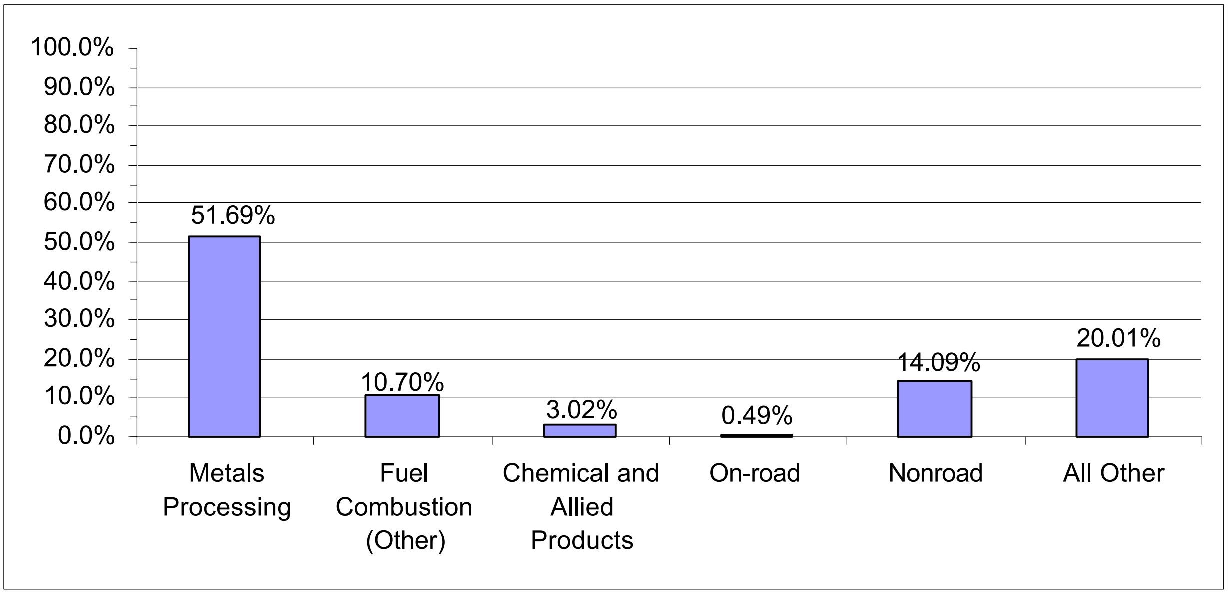


Figure 5. Percentage of 1996 National Emission Estimates by Source (Short Tons).

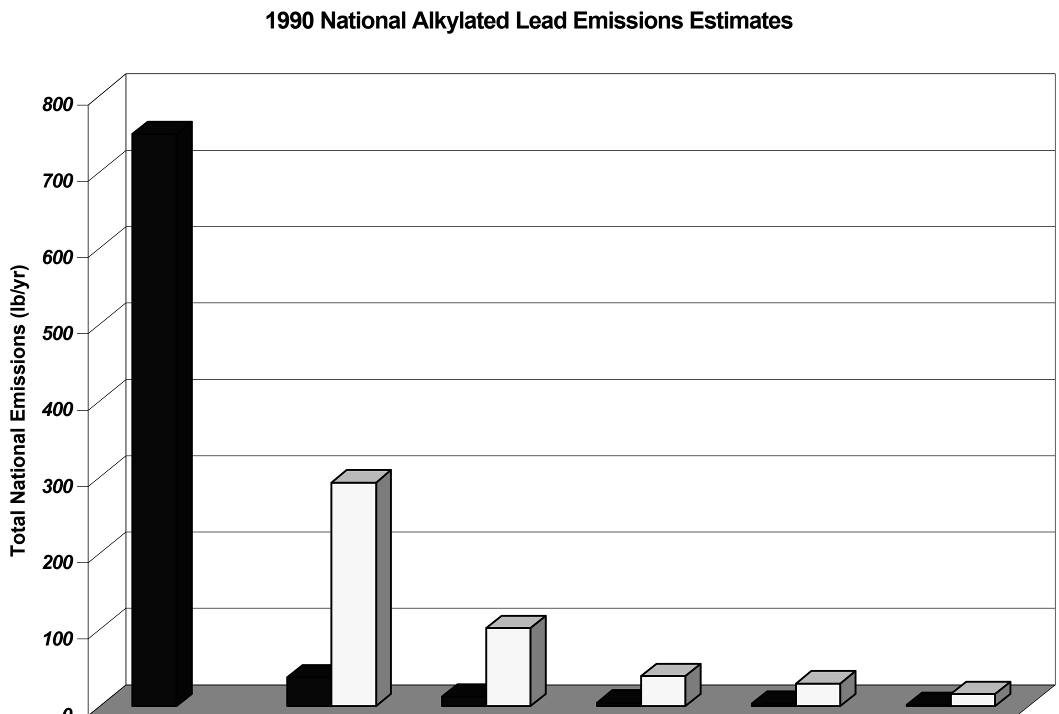
[Figure produced using data from National Air Pollutant Emission Trends Report, 1900-1996. USEPA, 1997.]

3.3.2 Evaporative Emissions

No significant amounts of alkyl-lead have been observed to be released via tailpipe emission during the combustion of leaded gasoline (USEPA, 1993) (releases occur in the form of inorganic lead / lead halides). Alkyl-lead releases from these sources are primarily associated with evaporative emissions or spills that may occur during fuel distribution or refueling, as well as evaporative emissions that can originate from unburned fuel in the carburetor or gas tank.

In response to the 1990 CAAA, which call for the identification of source categories emitting 90 percent of the total national alkyl-lead emissions (plus six other air toxics) the EPA published the *1990 Emissions Inventory of Section 112(c)(6) Pollutants* in April of 1998. In the inventory, the total national emissions of TEL and TML in 1990 were estimated to be 810.6 lbs of TEL and 481.23 lbs of TML. Together, aviation bulk plants (58%), non-road vehicles (26%), and service stations (9%) comprise roughly 93% of the total estimated alkyl-lead emissions (USEPA, 1998a).

As shown in Figure 6, bulk aviation gasoline plants were the major sources of TEL emissions (749.57 lbs/yr). Transport of gasoline produced at refineries to the bulk terminals occurs via pipeline, ship, or barge. Tank trucks transport gasoline from the bulk terminal to the bulk plant, where it is transferred to storage tanks until distribution to smaller volume clients (e.g., service stations, farms, other business) occurs by tank truck. Thus, emissions associated with bulk terminals and plants are associated with loading and unloading of tank trucks, storage



	Bulk Plants - Aviation Gasoline	Non-road Vehicles Evaporative	Service Stations	Bulk Plants - Motor Vehicle Gasoline	Bulk Terminals	Pipelines
■ TEL	749.57	37.92	12.72	4.81	3.62	1.96
□ TML		293.21	102.29	39.68	29.98	16.07

Figure 6. National 1990 Alkylated Lead Emissions Estimates in Pounds Per Year.

[Figure produced using data from the *1990 Emissions Inventory of Section 112(c)(6) Pollutants*. USEPA, 1998.]

tank emissions, and fugitive emissions from leaking pumps and valves. Service station emissions may occur as a result of fugitive vapor or spills / leaks during storage tank filling or vehicle refueling. In the 1993 EPA study, *Estimation of Alkylated Lead Emissions*, only three states were identified that still marketed leaded gasoline through service station outlets: Montana, Colorado, and Georgia (USEPA, 1993).

Evaporative emissions from non-road vehicles were the major source of TML (293.21 lbs/year) in 1990. The distribution of evaporative TML emissions from nonroad engines and source and vehicles, by source categories, is shown in Figure 7. As can be seen, in 1990 recreational marine uses constitute the overwhelming majority (93.91%) of non-road TML emissions, as well as TML emissions overall.

It should be noted, however, that there were potential sources of alkyl-lead emissions for which credible emissions estimates in the 112(c)(6) report could not be developed, due to

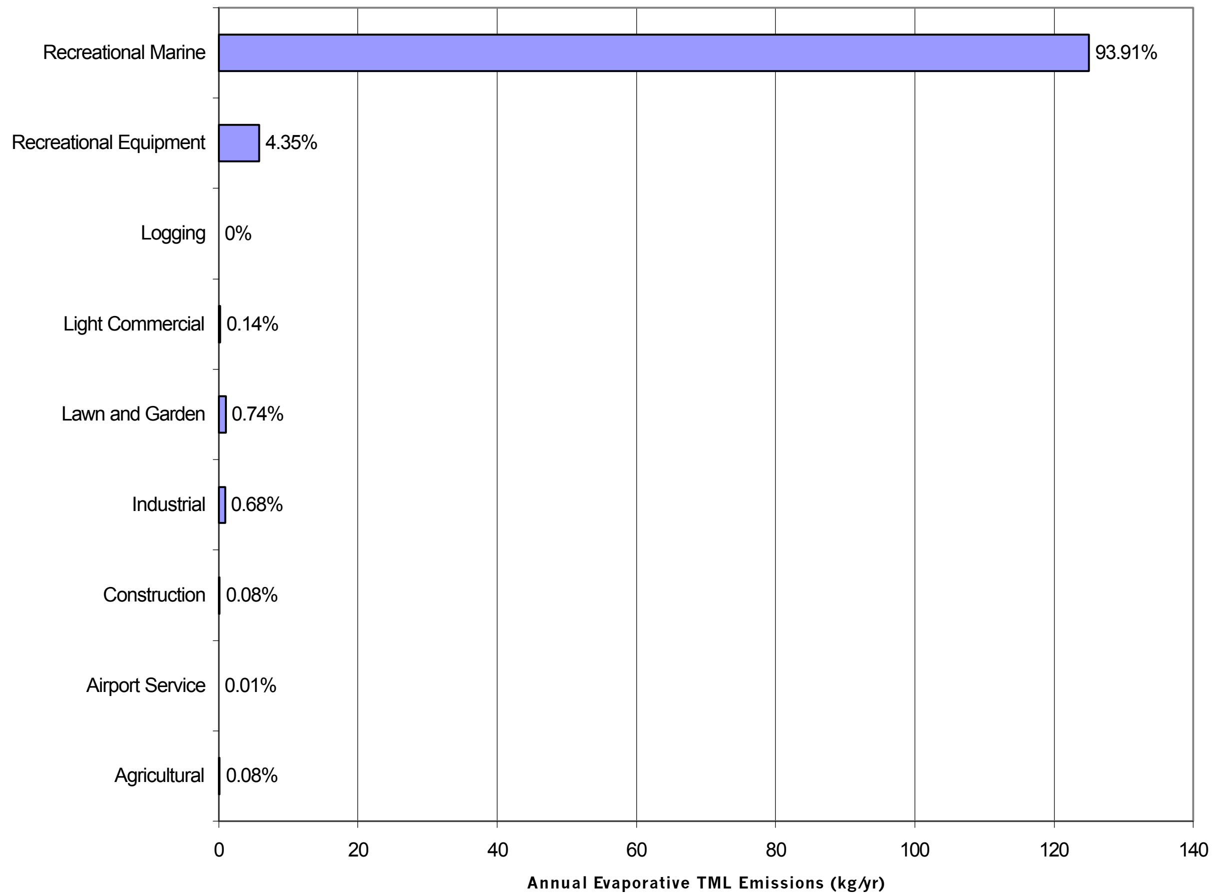


Figure 7. Annual Evaporative Emissions of TML From Non-road Engines

[Figure reproduced using *data from Estimation of Alkylated Lead Emissions Final Report*. USEPA, 1993.] Aviation emissions are not included as Avgas does not contain TML.

insufficient data. These included: evaporative emissions for operations of aircraft, evaporative emissions from operation of onroad vehicles, and alkylated lead production processes (in 1990) and facilities. In addition, it should also be noted that the 112(c)(6) estimates assumed that evaporative emissions associated with the use of alkyl-lead in custom blended fuels (i.e., in competitive race vehicles) was negligible compared to evaporative emissions associated with aviation and other off-road uses.

3.3.3 Spills / Leaks (From Fuel Loading, Transfer, Storage, and Fueling)

[Additional information needed - TRI or National Response Center? Must at least have info on gasoline spills?

4.0 FEDERAL REGULATIONS GOVERNING ALKYL-LEAD

Current regulations and programs targeting lead emissions and releases (including alkyl-lead compounds) are summarized in Table 4.

Table 4. Current Regulations and Programs

	CAA / CAAA	CWA	SDWA	RCRA	SARA / EPCRA	CERCLA
Current Standards and Regulations	§109: NAAQS is 1.5 µg/m³ (lead) §112(b): Designated a HAP; Major source categories identified under §112(c)(6); MACT standards to be promulgated §220: Use of gasoline containing > 0.05 grams of lead per gallon in on-road vehicles prohibited (Leaded gasoline is still permitted in non-road vehicles) §211(g): Prohibits misfueling of vehicles built after 1990 designed for unleaded gasoline	CWA Priority: Lead and lead compounds are listed priority pollutants (40CFR 423); subject to NPDES effluent limitations under §304(b) (40CFR 122) and general pretreatment (40CFR 403)	NPDWR: Action Level is 0.15 mg/L lead (treatment technique) MCL Goal is zero	Subtitle C: Lead-containing substances are (T) classified hazardous wastes based on toxicity characteristic(40 CFR 261.33); subject to hazardous waste regulations (40CFR 302.4) and ground water monitoring requirements (40CFR 264) Universal treatment standards for lead and lead compound levels in waste (40CFR 268.48)	§313: Releases of lead and lead compounds (by facilities with 10 or more employees and that process 25,000 lbs., or otherwise use 10,000 lbs.) must be reported to TRI (40CFR 372.65)	§103: Spills of tetraethyl lead > 10 lbs. must be reported to the National Response Center
Policy and Programs	– Binational Toxics Strategy Level 1 substance – International Joint Commission (IJC) Critical Pollutant – Tier I chemical under the Canada-Ontario Agreement – Recognized pollutant in Lake Superior Lakewide Management Plan (LaMP) – Targeted chemical in the Great Lakes Regional Air Toxic Emissions Inventory Project – Included in the USEPA Cumulative Exposure Project (lead compounds) – Included in CAA §112(m) program, Atmospheric Deposition to Great Lakes and Coastal Waters – Children's blood lead levels monitored in NHANES					

4.1 REGULATIONS CONTROLLING USE

In the early 1970s, EPA issued two regulations under the statutory authority of the 1970 (CAA). First, EPA required major gasoline retailers to begin selling one grade of unleaded gasoline by July 1, 1974. This mandate was primarily focused on preventing the deterioration, as a result of leaded gasoline, of emissions control systems (e.g., catalytic converters) in motor vehicles so equipped. In developing these regulations, EPA first established the working definition of "unleaded" gasoline as "gasoline containing not more than 0.05 gram of lead per gallon and not more than 0.005 gram of phosphorus per gallon" [38FR1255, January 10, 1973]. Second, EPA issued a regulation calling for the gradual phase-out of leaded gasoline. The schedule for reduction of lead content in automobile gasoline was 1.7 grams per gallon (g/gal) in 1975, to 1.4 g/gal in 1976, 1.0 g/gal in 1977, 0.8 g/gal in 1978, and 0.5 g/gal in 1979 [38FR33741, December 6, 1973]. Subsequent regulations reduced the allowable lead content to 0.1 g/gal in 1986 [50FR9397, March 7, 1985], and prohibited leaded gas use after 1995 [61FR3837, February 2, 1996].

Most recently, alkylated lead compounds have been regulated under the 1990 Clean Air Act Amendments (CAAA). Section 220 of the CAAA specifically targets the use of leaded gasoline for on-road vehicles, calling for a complete prohibition on the use of leaded gasoline in on-road vehicles after December 31, 1995. However, as outlined below, the 1990 CAAA specifically exempt fuels for race cars or "Competition Use Vehicles." Also, although Section 213 of the 1990 CAAA requires EPA to consider regulating emissions from off-highway vehicles (construction equipment, marine vessels, farm machinery, lawn equipment, recreational vehicles, etc.), these vehicles are currently permitted to use leaded gasoline. The following components of the 1990 CAAA relate to the use of alkyl-lead in gasoline:

- <u>Prohibition on the Use of Leaded Gasoline in On-Road Vehicles</u>. Section 211(n) of the 1990 CAAA states: "After December 31, 1995, it shall be unlawful for any person to sell, offer for sale, supply, offer for supply, dispense, transport, or introduce into commerce, for use as fuel in any motor vehicle (as defined in Section 219(2)) any gasoline which contains lead or lead additives." This provision applies only to on-road vehicles. Enacting regulations were promulgated [61FR3837, February 2, 1996].

- <u>Misfueling with Leaded Gasoline</u>. Section 211(g) of the 1990 CAAA prohibits misfueling vehicles built after 1990 (or vehicles designated solely for unleaded gasoline) with leaded gasoline.

- <u>Prohibition on Production of Engines Requiring Leaded Gasoline</u>. Section 218 of the 1990 CAAA requires USEPA to promulgate rules that prohibit the "manufacture, sale, or introduction into commerce of any engine that requires leaded gasoline." Further, these rules apply to all motor vehicle engines and nonroad engines manufactured after the 1992 model year.

Thus, the sale or use of gasoline containing alkyl-lead (greater than 0.05 grams of lead per gallon) is now prohibited in on-road vehicles [40CFR Part 80.22].

4.2 REGULATIONS GOVERNING EMISSIONS, RELEASES AND SPILLS

The 1990 CAAA also contains language specific to emissions of lead compounds resulting from the use of leaded gasoline. In particular, Section 213 of the 1990 CAAA requires USEPA to consider regulating emissions from off-highway vehicles[2] (construction equipment, boats, farm equipment, lawn equipment, etc.). Currently, these vehicles are permitted to use leaded gasoline, but may be regulated in the future.

Lead compounds (not alkyl-lead specifically) are included in the CAA Title III list of hazardous air pollutants (HAPs). Facilities releasing HAPs will be subject to standards established under Section 112, including maximum achievable control technology standards (MACT)(40CFR Part 61 and 63).

The Clean Water Act (CWA) prohibits any person from discharging a pollutant from a point source into navigable waters without a National Pollutant Discharge Elimination System (NPDES) permit (33 U.S.C. sec. 1342, 40 CFR 122). Under the CWA, lead and lead compounds are listed priority pollutants (40CFR 423). As a result, many facilities are subject to lead effluent limits or monitoring requirements in their NPDES permits.

Lead-containing substances are classified as hazardous wastes under the Resource Conservation and Recovery Act (RCRA), Subtitle C (40CFR 261.33). As such, lead-containing wastes are subject to hazardous waste regulations (40CFR 302.4) and ground water monitoring requirements (40CFR 264). RCRA also establishes Universal Treatment Standards for lead and lead compound levels in wastes (40CFR 268.48).

Section 313 of Title III of the 1986 Superfund Amendments and Reauthorization Act (SARA) also requires that releases of lead and lead compounds to air, water, or land be reported to the Toxic Releases Inventory (TRI) by manufacturing facilities (SIC codes 20-39, plus other specific facilities), that have 10 or more full time employees, and manufacture/process 25,000 lbs. of a listed chemical, or otherwise use 10,000 pounds of a listed chemical (40CFR 372.65).

Finally, Section 103(a) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requires that any spills/releases of tetraethyl lead in quantities exceeding 10 lbs. must be reported immediately to the National Response Center (40CFR302.4).

4.3 REGULATIONS CALLING FOR SOURCE IDENTIFICATION

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[2] Fuels for Race Cars or "Competition Use Vehicles" are exempted from regulation under the Clean Air Act.

The CAAA also contain requirements pertaining to the identification of sources of alkyl-lead. Section 112(c)(6) of the CAAA specifically directs EPA to identify sources of alkyl-lead (and six other chemicals) that account for 90% of the aggregate emissions of alkyl-lead by 1995, and to promulgate alkyl-lead standards, using MACT standards, by 2000. In response, EPA refined emission inventories of known sources of each pollutant and added two source categories to the previous 1990 inventory on April 3, 1998: 1) open burning of scrap tires, and 2) gasoline distribution Stage I aviation (including evaporative losses associated with the distribution and storage of aviation gas containing lead).

4.4 COMPLIANCE AND ENFORCEMENT

As leaded gasoline is still produced in the United States for use in nonroad vehicles (primarily as aviation fuel, but also in farm machinery and race cars), and is dispensed by private citizens, the potential for illegal misfueling cannot be entirely eliminated. Historically, EPA's Office of Enforcement has not found this to be the case in public gasoline service stations. In previous years, EPA's Office of Enforcement screened for lead during routine inspections at service stations. However, as leaded gasoline became increasingly scarce, the number of violations related to the misuse of leaded gasoline dropped dramatically, as shown in Table 5 (USEPA, 1998f). As a result of finding virtually no cases of misfueling, EPA's Office of Enforcement no longer routinely screens for lead as part of the typical inspection process. It does continue to test for lead on a case-by-case basis if illegal misfueling is suspected. Typically, very few cases of suspected misfueling with leaded gasoline are investigated in a given year.

[Additional information is needed regarding documentation / investigation of misfueling of leaded fuel intended to fuel farm machinery or racing cars]

Although it is possible for misfueling of on-road automobiles to occur using leaded racing gasoline, such misfueling, if it occurs at all, is likely to be rare. Limited supply, limited distribution, higher costs, incompatibility with emission control systems on production automobiles, and limited performance benefits in production automobiles designed for unleaded gasoline all weigh against use of leaded racing gasoline in on-road automobiles.

Table 5. Violations Issued for Excess Lead-Levels in Gasoline [Source: USEPA,1998f]

Year	Number of Service Station Inspections	Number of Violations Issued	Violation Rate
1980	5,021	83	1.65%
1981	10,179	73	0.72%
1982	10,266	60	0.5%
1983	9,896	41	0.41%
1984	4,652	24	0.52%
1985	5,363	30	0.56%
1986	5,363	8	0.15%
1987	9,003	4	0.04%

4.5 CHANGES / POTENTIAL CHANGES IN ALKYL-LEAD REGULATION

In the January 5, 1999 Federal Register, the EPA proposed an amendment to the Toxics Release Inventory (TRI) which would lower the TRI reporting threshold for lead compounds to 10 pounds per year, as well as require the filing of separate reports for TEL and TML (64 FR 687). Currently, only the reporting of total lead compounds is required. This amendment would allow identification of facilities that have these specific lead compounds and facilitate the tracing of TEL and TML. As stated in the proposed rule,

> *"Under this proposal, if any of the current manufacture, process, or otherwise use reporting thresholds for the lead compounds category are met, a facility would file one report for all members of the category excluding the two alkyl lead compounds. If the facility has 1 pound or more of tetraethyl or tetramethyl lead applicable toward the threshold determinations for the lead compounds category then separate reports would be filed for tetraethyl and tetramethyl lead. As an alternative proposal, the amounts of tetraethyl and tetramethyl lead could be combined and included in a single separate report."*

In addition to facilitating the tracking of alkyl-lead, collecting information on the manufacture, process, and use of alkyl-lead would provide a means by which EPA could measure progress towards the virtual elimination of alkyl-lead releases.

5.0 NON-REGULATORY PROGRAMS AND INCENTIVES

5.1 PROGRAMS

The Binational Strategy (BNS), discussed previously, and the PBT Alkyl-lead Workgroup provide an established process for engaging stakeholders and seeking voluntary reduction efforts. The Binational Strategy builds on existing regulatory programs that address alkyl-lead, it will primarily rely on the utilization of voluntary measures to dramatically reduce pollutant discharges to the Great Lakes Basin. The PBT Alkyl-Lead Workgroup offers an opportunity for the Agency to solicit and recognize efforts toward the virtual elimination of alkyl-lead in the context of the Binational Strategy.

NASCAR is currently evaluating and testing the use of unleaded racing gasoline (e.g., in the Busch Grand Nationals series). Canada proposed a ban on leaded gas in racing and an unleaded racing series as an alternative [*need update on Canada status]*. Currently, the automobile racing industry (i.e., NASCAR) has indicated they may be receptive to participating in a voluntary unleaded phase-in partnership/program. Specifically, representatives from Tosco Company, NASCAR's "Fuel 76" supplier and partner have expressed interest in partnering with EPA to develop an unleaded fuel for NASCAR use.

Several international initiatives have also begun to address alkyl-lead, including the International Joint Commission (IJC), which has designated alkyl-lead a Critical Pollutant.

5.2 RESEARCH

Several research programs are currently underway to collect information relating to the reduction of lead compounds in the environment and the identification of sensitive subpopulations or geographic areas, as well as research on the development of unleaded aviation gasoline for civil aircraft. Of particular relevance to the Binational Strategy, an industry group called the Coordinating Research Council (CRC) has formed a task force for the purpose of finding a no-lead gasoline substitute. Working cooperatively with the CRC, the FAA has initiated an Unleaded Fuels Research Program. Under this program, engine and fuel testing (e.g., engine performance, emissions, fuel consumption changes, etc.) at the FAA's small-engine and fuel test facilities began in 1994. Data from this testing will aid the FAA in replacement fuel certification for 100-octane low-lead gasoline, as well as developing fuel specifications with the American Society of Testing and Materials. Currently, FAA has certified a new 85% ethanol based fuel for use in at least one plane (EERC, 1999). However, considering all of the testing that must be conducted (different conditions, different engine/airframe combinations, toxicity, etc.) as well as the approvals from FAA and the acceptance by the aviation industry, petroleum companies, and gasoline distributers that must be obtained, the time frame for widespread implementation of an unleaded high-octane aviation gasoline is projected to be 8-10 years.

Other research programs that may provide useful information towards BNS efforts include the Great Lakes Regional Air Toxic Emissions Inventory Project, the CAA §112(m) Atmospheric Deposition to Great Lakes and Coastal Waters Program, the USEPA Cumulative Exposure Project (lead compounds), and the monitoring of children's blood lead levels in the National Health and Nutrition Examination Survey (NHANES) conducted by the Centers for Disease Control (CDC).

6.0 OPTIONS FOR ACHIEVING ALKYL-LEAD REDUCTION GOALS

EPA recognizes that tremendous progress has been made in reducing lead emissions related to the use of alkyl-lead. Total lead emissions have been reduced from 220,869 short tons in 1970 to 3,869 short tons in 1996, totaling a reduction in emissions of approximately 98 percent. This large reduction is primarily due to the regulated phase-out of leaded gasoline in on-road vehicles. However, there remain some cost effective options for achieving further reductions toward the goal of virtual elimination.

It should be noted that this report deals only with options for reductions in the U.S. However, the United States is committed to being a world leader in promoting the phase-out of leaded gasoline use in motor vehicles. Since 1994, national governments have committed to the phase-out of lead in gasoline at key international and regional agreements, including the United Nations Commission on Sustainable Development, Summit of the Americas, Earth Summit + 5 and the G-8. As a result of the active campaign to remove lead from gasoline, spearheaded by EPA's Administrator since 1994, seven countries in Latin America, one country in Eastern Europe and two countries in Asia have totally phased out the use of lead in gasoline. Efforts by the United States have resulted in lower levels of lead added to the leaded gasoline in one country in Asia, two in Latin America, and one in Eastern Europe where leaded gasoline is still sold.

The impact of the activities undertaken by EPA in Latin America and the Caribbean has been to accelerate the formulation and implementation of lead phase-out plans throughout the region. The use of leaded gasoline is declining rapidly. By the year 2001, about 85 percent of the gasoline consumed in the region will be lead-free. According to World Bank figures, the amount of lead added to gasoline in Latin America and the Caribbean declined from 27,000 metric tons in 1990 to 8,200 tons in 1996. It is estimated that, based on national phase-out, the lead added to gasoline in 1999 will be approximately 4,200 metric tons.

Worldwide, at least 25 additional countries have made significant commitments to phase-out, but are hampered from comprehensive action by technical complications. Using the Implementer's Guide on Phase-out of Lead in Gasoline that EPA recently completed, associated workshops will be planned and conducted to target the 25 countries with technical difficulties. EPA will continue in its current efforts to enhance and promote the phase-out of leaded gasoline worldwide.

6.1 ISSUES ASSOCIATED WITH IDENTIFYING COST-EFFECTIVE OPTIONS

Data Gaps

EPA's 1990 Clean Air Act (CAA) Inventory of Section 112 (c) (6) Pollutants estimates national alkyl-lead emissions for source categories accounting for not less than 90 percent of the aggregate emissions of alkyl-lead. However, sufficient data were not available to develop emissions estimates for operations of aircraft, operations of non-road vehicles, or alkyl-lead production. In particular, Section 112 (c)(6) of the CAA requires emissions inventories from oil refineries, but gross estimates are currently used that do not provide a clear picture of the production and release quantities.

Additionally, other than aviation gasoline, very little data exists on current levels of leaded gasoline use. Since 1991, the Department of Energy (DOE) stopped tracking information on the production of leaded gasoline for non-aviation uses. Consequently, there is no readily accessible information on how much leaded gasoline is being produced for the continued, legal use of alkyl-lead in racing cars, off-road, non-road vehicles, etc. However, it may be possible to derive upper bound estimates for these uses from other available information.

Finally, there is insufficient information to assess whether the remaining uses of leaded gasoline result in adverse environmental or health effects. Most notably, there is no information to determine whether there is increased risk of lead exposure to at-risk populations (especially children) living in the vicinity of race tracks or general aviation airports, spectators at racing events or air shows, and fuel handlers (aviation or racing crews).

Stakeholder Issues/Concerns

The identification of alternatives for general aviation gasoline presents a technical challenge. There are a large number of experimental aircraft with lower performance piston engines that use unleaded gasoline, as well as various alternative fuels that have been researched. These alternatives include those containing alcohols (e.g. ethanol), aromatics (e.g. toluene) and ethers (e.g MTBE and ETBE). A manganese-based additive, MMT (methyl-cyclopentadienyl manganese tricarbonyl), has also been used in gasoline blends as an octane booster, although research indicates it will probably not find widespread usage due to deposit-control problems (RADFC, 1996). For many years, MTBE (methyl tert-butyl ether) has been used as a blending agent in gasoline to raise the octane number, eliminate corrosive action, and serve as an oxygenate. In fact, reformulated gas (containing MTBE) is required to be sold in many states to reduce air pollution (smog) levels. Recently however, due to evidence that MTBE is polluting groundwater supplies, EPA has formally recommend that Congress no longer require oil companies to sell MTBE-blended gas, and that use of MTBE be sharply reduced (USEPA Press Release, July 27, 1999).

While an alternative fuel for aircraft is desirable, care must be taken not to move too quickly to mandate an alternative fuel. Aircraft are certified for very specific fuels. The performance of an alternative unleaded high-octane aviation gasoline under all possible operational and environmental conditions must be thoroughly tested because of concerns regarding aircraft safety. High-performance piston aircraft engines require high-octane gasoline, and lead is extremely efficient at raising the octane without causing any other undue performance effects. To re-certify aircraft for a different fuel is time-consuming and expensive. For these reasons, and also in light of potential financial hardships it would impose on the small aircraft industry, EPA has not historically focused on fuel alternatives.

Regulatory Constraints

The regulation of aircraft fuel lies with the FAA. However, under the CAA, EPA can indirectly impose regulations by establishing lead emissions standards for aircraft such that the FAA would have to restrict the lead content in gasoline.

EPA also does not have the authority under the CAA to regulate the use of unleaded gasoline for the racing industry. There is a provision in the CAA that prohibits EPA from regulating engines (or their fuels) that are designed solely for competition, but the regulation of fuel could potentially occur under the TSCA Section 6 Rule.

6.2 TWO KEY STRATEGIC DIRECTIONS

In light of progress made to date in eliminating the use of alkyl-lead in automotive gasoline and current remaining uses, there are two primary strategic directions for addressing alkyl-lead use and emissions in the United States:

1. Pursue voluntary initiatives to reduce the use of alkyl-lead in aircraft gasoline, race cars, and non-road vehicles.

2. Collect information and assess exposure in sensitive geographic areas for at-risk populations.

Pursue Voluntary Initiatives

Regulatory options are limited for uses including aircraft gasoline, race cars, and non-road vehicles (i.e., farm machinery, marine vessels, construction equipment, and recreational vehicles) under the CAA. However, there are voluntary initiatives already underway, which the BNS can encourage and support to achieve cost-effective reductions in these remaining uses of leaded gasoline. The BNS approach can consider support and encouragement of current industry efforts to conduct research on alternatives to alkyl-lead for aviation fuel, the largest source of TEL emissions, to be key in achieving the virtual elimination of alkyl-lead. These efforts will help to address the goal of virtual elimination as well as EPA's Ten Year Strategic goals calling for clean air, the reduction of blood-lead levels in children, and greater innovation to address public health and environmental problems.

Continue Information Collection / Risk Assessment Efforts

Information collection efforts focused on estimating the production and use of leaded gasoline for continuing legal uses, refining air alkyl-lead emission estimates reported in the CAA Section 112(c)(6) report, and assessing whether exposure in the vicinity of general aviation airports or race tracks contributes to elevated blood-lead levels in at-risk populations (especially children) are needed to inform decisions on how close the United States is to the virtual elimination of alkyl-lead.

6.3 KEY OPTIONS FOR ACTIONS

Stakeholder Involvement and Voluntary Initiatives

Stakeholder involvement is essential to reaching the goal of virtual elimination. EPA will invite comment on this report and will encourage all interested partners to join in establishing voluntary agreements to reduce risk to human health and the environment from exposure to alkyl-lead.

Key players within the Agency to help implement these reduction options include the Office of International Affairs (OIA), Office of Air and Radiation (OAR), Great Lakes National Program Office (GLNPO), the Office of Mobile Sources (OMS) Ann Arbor Facility, and the Office of Pollution Prevention and Toxics (OPPT). The EPA PBT Workgroup will take the lead in coordinating voluntary initiatives. Primary non-Agency stakeholders include the Federal Aviation Administration (FAA), the National Association of Stock Car Auto Racing (NASCAR), other racing organizations (other automobile racing, boat racing, etc.), construction and farm machinery manufacturers and associations, the Coordinating Research Council (CRC), Agency for Toxic Substances and Disease Registry (ATSDR), National Oceanic and Atmospheric Administration (NOAA), the U.S. Coast Guard, National Institute of Occupational Safety & Health (NIOSH), and Occupational Safety & Health Administration (OSHA). EPA anticipates that each of these groups, and possibly others, will have a significant role in reducing the use, releases, and exposure to alkyl-lead compounds. In particular, EPA can conduct the following activities with these stakeholders:

- Auto Racing Industry: EPA can coordinate with NASCAR to encourage a voluntary unleaded phase-in partnership/program to eliminate the use of leaded gasoline in the auto racing industry. EPA can also identify and begin a dialogue process with other auto racing stakeholders (such as open wheel, motor cross, etc.) about similar partnerships/programs.

  EPA does not have the authority under the Clean Air Act to regulate the use of leaded gasoline for the racing industry. However, the auto racing industry is investigating the use of unleaded gasoline. Therefore, a voluntary partnership with EPA may be the most effective means of reducing the use of alkyl-lead in the auto racing industry.

- Non-Auto Racing Organizations: EPA can investigate the extent to which leaded racing gasoline is employed by non-auto racing organizations such as marine racing, motorcycle racing, snowmobile racing, etc. As appropriate, EPA can initiate a dialogue process with representatives from these organizations to establish a voluntary phase-out of leaded gasoline.

- Federal Aviation Administration(FAA) and Coordinating Research Council (CRC): EPA can establish a dialogue with the FAA to continue discussions surrounding the use of leaded gasoline in aviation and the possibilities of reducing the lead content and/or replacing leaded gasoline with unleaded. Similar discussions can be held with the CRC task force investigating alternative (no-lead) gasoline for aircraft. EPA can continue to support and encourage such research activities as that undertaken by the CRC task force, as well as other organizations such as the Renewable Aviation Fuels Development Center

- Other Federal Agencies: EPA is committed to working with its Federal partners to reduce health risks from alkyl-lead to at-risk populations. EPA meets routinely with representatives from NIOSH and OSHA to discuss common strategies for risk reductions and to coordinate activities. In particular, the three agencies have formed a common committee referred to as the "One Committee" to discuss just such issues. EPA can continue to pursue opportunities for coordination and collaborative effort by including alkyl-lead as an item for the One Committee to discuss. Other actions such as the development of memos of understanding (MOUs) between the agencies can be undertaken as appropriate.

- Other Stakeholders: EPA can investigate the extent to which leaded gasoline is employed by other sources such as marine craft, construction equipment, and farm machinery. As appropriate, EPA can initiate a dialogue process with representatives from these organizations to establish a voluntary phase-out of leaded gasoline. EPA will continue in its attempts to identify other possible stakeholder groups using leaded gasoline and will begin dialogues with these groups as they are identified.

Regulatory Actions

As discussed in Section 4, there are a number of regulations currently in place, most notably the 1990 CAAA, that address alkyl-lead. In addition, as discussed above, there are regulatory constraints with respect to regulating leaded gasoline for aviation and competitive use vehicles. Therefore, no new regulatory options have been identified. However, the regulatory changes in the Toxics Release Inventory PBT Chemicals Proposed Rule (FR Volume 64, Number 2, January 5, 1999) (TRI Rule), discussed in Section 4.5, pertaining to alkyl-lead still need to be promulgated in the final TRI rule.

Research / Information Collection

Research on several issues can be conducted to address the data gaps identified above and as the initial step in promoting the voluntary phase-out of leaded gasoline. In particular, the following research activities and information collection efforts can be conducted:

- Refine CAA 112(c)(6) Emission Estimates: The 1990 CAAA requires EPA *" to identify the source categories and subcategories emitting alkylated lead compounds."* Further, *"the source categories and subcategories identified must account for 90 percent of the alkylated lead emissions..."* EPA completed this requirement in 1993 and published the results in 1998. However, since the development of these emission estimates, the overall use of leaded gasoline has been reduced. Further, though estimates are given for several non-road engine and vehicle categories, estimates are not provided for competitive use vehicles (such as those used by NASCAR). EPA can consider the possibility of developing rough estimates of the potential emissions from race cars through modeling of emissions, monitoring during races, soil sampling in the vicinity of race tracks, or other means as appropriate.

- Investigate Exposure to At-Risk Populations: As discussed above, gasoline containing alkyl-lead compounds is still being used today and as such there remains the potential for exposure to certain populations. EPA can undertake research activities to evaluate the risk for these subpopulations. Of particular concern are spectators of racing events and nearby residents.

- Update Inventory of Leaded Gasoline Production and Use: As stated above, the Department of Energy (DOE) stopped tracking information on the production of leaded gasoline for non-aviation uses. Information on the extent to which leaded gasoline is currently used can be developed through published statistics, discussions with petroleum manufacturers, and discussions with end-users.

- Determine the Availability of Leaded Gasoline and Potential for Misfueling: The extent to which racing gasoline containing lead is available for purchase at the roadside can be estimated. Although EPA's Office of Enforcement no longer routinely screens for lead during routine inspections at service stations, information on the extent to which misfueling occurs can be consolidated and the feasibility of developing estimates of the extent of misfueling assessed.

The BNS can also utilize and coordinate with other research programs that may provide useful information relating to the reduction of lead compounds in the environment or identification of sensitive subpopulations or geographic areas. These programs may include the Great Lakes Regional Air Toxic Emissions Inventory Project, the CAA §112(m) Atmospheric Deposition to Great Lakes and Coastal Waters Program, the USEPA Cumulative Exposure Project (lead compounds), and the monitoring of children's blood lead levels in the National Health and Nutrition Examination Survey (NHANES) conducted by the Centers for Disease Control (CDC).

Outreach / Education

EPA, along with others, has conducted an extensive outreach/education campaign to make the general public aware of the dangers of lead. However, these efforts have primarily focused on inorganic forms of lead such as those found in lead-based paint.

While EPA will continue its efforts to inform the general public on the dangers of inorganic lead, it may also investigate new possibilities for expanding the outreach/education campaign to include targeted audiences. For example, EPA can investigate the possibility of having a well known NASCAR driver support and encourage "lead free" races as a way of reinforcing the negative environmental and health impacts of using leaded gasoline.

Other possible outreach/education campaigns can be investigated and implemented if deemed appropriate. For example, outreach/education campaigns on the dangers of alkyl-lead (especially the hazards of dermal exposure) could be targeted to persons that routinely fuel vehicles with leaded gasoline.

6.4 BASELINE MEASURES

EPA can use the following measures to track progress in reducing risks from alkyl-lead: (1) environmental or human health indicators, (2) chemical release, waste generation, or use indicators, or (3) programmatic output measures.

In addition to the goals and measures given in Table 6, EPA can measure progress towards the virtual elimination of alkyl-lead production and use throughout the United States by comparison to the following quantifiable baseline measures:

- The amount of leaded aviation gasoline produced: In 1996, U.S. refineries produced 305,718,000 gallons of aviation gasoline.

- The amount of antiknock preparations imported into the US: In 1998, the United States imported approximately 14,318,800 lbs of antiknock preparations based on TEL and/or TML and 1,316,800 lbs of antiknock preparations based on lead compounds.

- The lead content in aviation gasoline: Currently, aviation gasoline has a maximum lead TEL standard of 0.13 mL TEL/L for Grade 80, 0.53 mL TEL/L for Grade 100LL, and 1.06 mL TEL/L for Grade 100. The maximum lead standard is 0.14 g Pb/L for Grade 80, 0.56 g Pb/L for Grade 100LL, and 1.12 g Pb/L for Grade 100.

- The number of petroleum refining facilities submitting lead or lead compound reports to TRI: In 1995, 29 petroleum refining facilities (SIC 2911) submitted forms to TRI. *[Updated TRI reporting information to be incorporated]*

Table 6. Measures of Progress for Actions to Reduce Risks from Alkyl-lead

Focus	Action	Measure of Progress
1. Pursue voluntary initiatives	— Encourage a NASCAR voluntary phase-out partnership/program — Identify contacts in other racing (auto and non-auto) organizations to initiate similar programs/partnerships — Identify contacts in other organizations to initiate similar programs/partnerships — Work with Coordinating Research Council and FAA to promote alternative, unleaded fuels and the phase-out of leaded aviation gasoline	— NASCAR Agreement — Agreements with other organizations including (boating, non-auto racing, construction, farm machinery, etc.) — Continued dialogue with CRC and FAA — Reductions in lead exposure and blood-lead levels among at-risk populations
2. Collect information on lead emissions, leaded gas use, and exposure	— Refine CAA 112(c)(6) emission estimates — Investigate exposure to at-risk populations — Update inventory of leaded gasoline production and use — Determine the availability of leaded gasoline and the potential for misfueling	— Revised 112(c)(6) estimates — Exposure study results published — Inventory updated

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