Draft

PBT National Action Plan

for Alkyl-lead

Prepared by

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EXECUTIVE SUMMARY

On November 16, 1998, the U.S. Environmental Protection Agency (EPA) released its Agency-wide Multimedia Strategy for Priority Persistent, Bioaccumulative, and Toxic (PBT) Pollutants (PBT Strategy). The goal of the PBT Strategy is to identify and reduce risks to human health and the environment from current and future exposure to priority PBT pollutants. This document serves as the Draft National Action Plan for alkyl-lead, one of the 12 Level 1 priority PBT pollutants identified for the initial focus of action in the PBT Strategy.

Alkyl-lead compounds are man-made compounds in which a carbon atom of one or more organic molecules is bound to a lead atom. Tetraethyllead [TEL] and Tetramethyllead [TML] compounds 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 National Action Plan. Alkyl-lead is used as a fuel additive to reduce "knock" in combustion engines and also to help lubricate internal engine components and protect intake and exhaust valves against recession. 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 regulations that restrict leaded motor gasoline use.

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 halides that are subsequently emitted as microparticulates in the exhaust. Once emitted, lead particles may remain airborne for about 10 days and 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. Alkyl-lead itself is not a persistent environmental compound but breaks down in the environment (or is emitted following combustion) to other forms of lead which are much more persistent.

In the body, alkyl-lead compounds are distributed through the blood to "soft tissues" particularly the liver, kidneys, muscles, and brain. 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. Lead poisoning due to the ingestion or inhalation of inorganic lead compounds emitted as exhaust through the combustion process (as a direct result of the use of alkyl-lead in gasoline) is a widely recognized public health problem.

With the phase-out of leaded gasoline used in on-road vehicles in the United States, there has been a substantial reduction in the risk of exposure for the general public. As a result of the 1990 Clean Air Act Amendments, the sale or use of gasoline containing alkyl-lead (greater than

0.05 grams of lead per gallon) is currently prohibited in on-road vehicles. However, the remaining uses of gasoline containing alkyl-lead, particularly for race cars and airplanes, potentially puts certain subpopulations at risk. These subpopulations include residents (particularly children) near sources such as race tracks and general aviation airports, fuel attendants, racing crew staff, and spectators. EPA does not have the authority under the CAA to regulate the use of unleaded gasoline for the racing industry, and the regulation of aircraft fuel lies with the FAA. However, NASCAR is evaluating and testing the use of unleaded racing gasoline (e.g., in the Busch Grand Nationals series). The FAA, working cooperatively with the Coordinating Research Council, has initiated an Unleaded Fuels Research Program to complete research on the development of unleaded aviation gasoline for civil aircraft.

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. Aided by U.S. efforts to promote the phase-out of leaded gasoline use in motor vehicles worldwide, several foreign countries have totally phased out the use of lead in gasoline while others have lowered the levels of lead added to leaded gasoline.

Recognizing the large reduction in lead emissions related to the use of alkyl-lead, primarily due to the regulated phase-out of leaded gasoline in on-road vehicles, the Agency has adopted the following strategic approach to address the remaining risks to human health and the environment from exposure to alkyl-lead: 1) contribute to international efforts to reduce the use of alkyl-lead worldwide, 2) pursue voluntary initiatives to reduce the use of alkyl-lead in aircraft gasoline, race cars, and non-road vehicles such as farm machinery, marine vessels, construction equipment, and recreational vehicles, and 3) collect information as possible, given resource constraints, related to production, use, emissions, and continued exposure scenarios. After consideration of priorities in light of recommended actions for all Level 1chemicals under the PBT Strategy, EPA proposes the following priority actions:

- Continue current international efforts to reduce the use of leaded gasoline, including participation in the United Nations Commission on Sustainable Development, Summit of the Americas, Earth Summit + 5, the G-8, and the Great Lakes Binational Toxics Strategy.

- Coordinate with NASCAR and NASCAR Sponsors to encourage a voluntary unleaded phase-in partnership/program to eliminate the use of leaded gasoline in the auto racing industry.

1.0 INTRODUCTION

On November 16, 1998, the U.S. Environmental Protection Agency (EPA) released its Agency-wide Multimedia Strategy for Priority Persistent, Bioaccumulative, and Toxic (PBT) Pollutants (PBT Strategy). EPA has a long history of successful programs in controlling PBT pollutants – pollutants that are toxic, persist in the environment, and bioaccumulate in food chains, and thus pose risks to human health and ecosystems. The challenges remaining for PBT pollutants stem from the fact that they transfer rather easily among air, water, and land, and span boundaries of programs, geography, and generations. As a result, single-statute approaches are not adequate for reducing these risks. To achieve further reductions, a multimedia approach is necessary. Accordingly, through the PBT Strategy, EPA has committed to create an enduring cross-office system that would address the cross-media issues associated with priority PBT pollutants.

The goal of the PBT Strategy is to identify and reduce risks to human health and the environment from current and future exposure to priority PBT pollutants. To attain this goal, EPA has identified several guiding principles:

- Address problems on multimedia basis through integrated use of all Agency tools
- Coordinate with and build on relevant international efforts
- Coordinate with relevant Federal programs and agencies
- Stress cost-effectiveness (e.g., amount of PBT removed for dollar spent)
- Involve stakeholders
- Emphasize innovative technology and pollution prevention
- Protect vulnerable subpopulations
- Base decisions on sound science
- Use measurable objectives and assess performance.

The PBT Strategy outlines an approach to achieving PBT risk reductions which includes the development and implementation of national action plans for priority PBT pollutants. These action plans will draw upon the full array of EPA's statutory authorities and national programs, building on work initiated under *The Canada–United States Strategy for the Virtual Elimination of Persistent Toxic Substances in the Great Lakes Basin* (USEPA, EC, 1997) and using regulatory action where voluntary efforts are insufficient. The action plans will consider enforcement and compliance, international coordination, place-based remediation of existing PBT contamination, research, technology development and monitoring, community and sector-based projects, the use of outreach and public advisories, and opportunities to integrate efforts across chemicals.

This document serves as the Draft National Action Plan for Alkyl-lead, one of the 12 Level 1 priority PBT pollutants identified for the initial focus of action in the PBT Strategy.

2.0 DESCRIPTION OF ALKYL-LEAD

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 action plan does not address inorganic lead, but 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 National Action Plan.

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 as a fuel additive to reduce "knock" in combustion engines (by contrast, inorganic lead is used in leaded paint). 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. 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 regulations that restrict leaded motor gasoline use.

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 halides (e.g., PbBrCl, $2PbBrCl \bullet NH_4Cl$, etc.) 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.

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.

3.0 HEALTH EFFECTS

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. It is these three compounds that are thought to cause the toxic effects of lead. In the body, triethyllead and trimethyllead compounds are 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. 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.

The inorganic lead compounds emitted as exhaust (e.g., PbBrCl, $2PbBrCl \bullet NH_4Cl$, etc.) through the combustion process (as a direct result of the use of alkyl-lead in gasoline) also contribute to human exposure through ingestion and/or inhalation. The biochemistry and toxicology of inorganic lead differs from that of alkyl-lead compounds. However, lead poisoning due to the ingestion or inhalation of inorganic lead compounds is a widely recognized public health problem. Blood-lead concentration is a commonly used measure of body lead burden. Children are at a higher risk of lead poisoning than adults due to their lower body weights and developing neurological systems. 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 also 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.

4.0 HUMAN AND WILDLIFE EXPOSURE

The human exposure pathways for alkyl-lead are through inhalation of leaded gasoline vapors, or by dermal exposure to leaded gasoline. Unlike metallic forms of lead, alkyl-lead is easily absorbed through the skin. Additionally, through the combustion process, alkyl-lead in gasoline is converted to lead halides and exhausted into the air where it can be inhaled. These lead halides create the potential for exposure to lead through ingestion of soil or dust containing lead, 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 Trialkylead or Dialkyllead compounds.

With the phase-out of leaded gasoline used in on-road vehicles, there has been a substantial reduction in the risk of exposure for the general public. However, as gasoline containing alkyl-lead is still currently being used as fuel (particularly for race cars and airplanes), certain subpopulations may remain at risk.

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 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 are also at risk because of possible dermal absorption of gasoline containing alkyl-lead compounds. Information to quantify the risk of these exposure pathways is not currently available.

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.

5.0 ENVIRONMENTAL BASELINE

5.1 SCOPE OF THE PROBLEM AND CURRENT STATUS AND TRENDS

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

5.2 QUANTITATIVE AND QUALITATIVE DATA ON CURRENT SOURCES AND RESERVOIRS

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.

5.2.1 Aviation Fuel

Aviation gasoline (avgas) is currently the fuel with the greatest alkyl-lead (TEL) content, ranging from $4.4x10^{-3}$ to $8.8x10^{-3}$ 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 1.

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 x 2.128 g (TEL)/gallon = 628 billion grams of TEL, which is equivalent to 1.39 million pounds of TEL.

5.2.2 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).

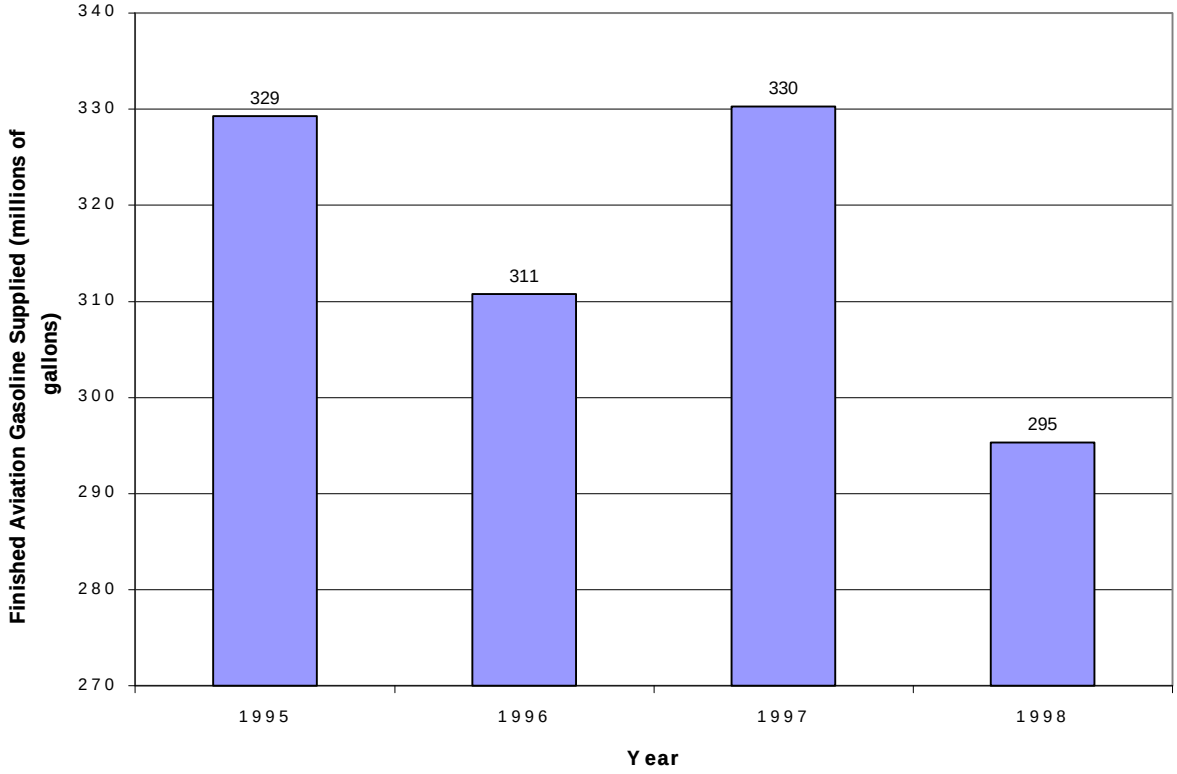

Figure 1. Finished Aviation Gasoline Supplied in the U.S. 1995-1998.

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).

5.2.3 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 suppliers 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 1 illustrates several suppliers and the types of racing fuel they offer.

Table 1. Illustration of Available Racing Gasoline

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

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, Tosco 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.

5.2.4 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.

5.2.5 Overall Lead Emissions

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, 1997b) Figure 2 summarizes estimates of total lead emissions by year.

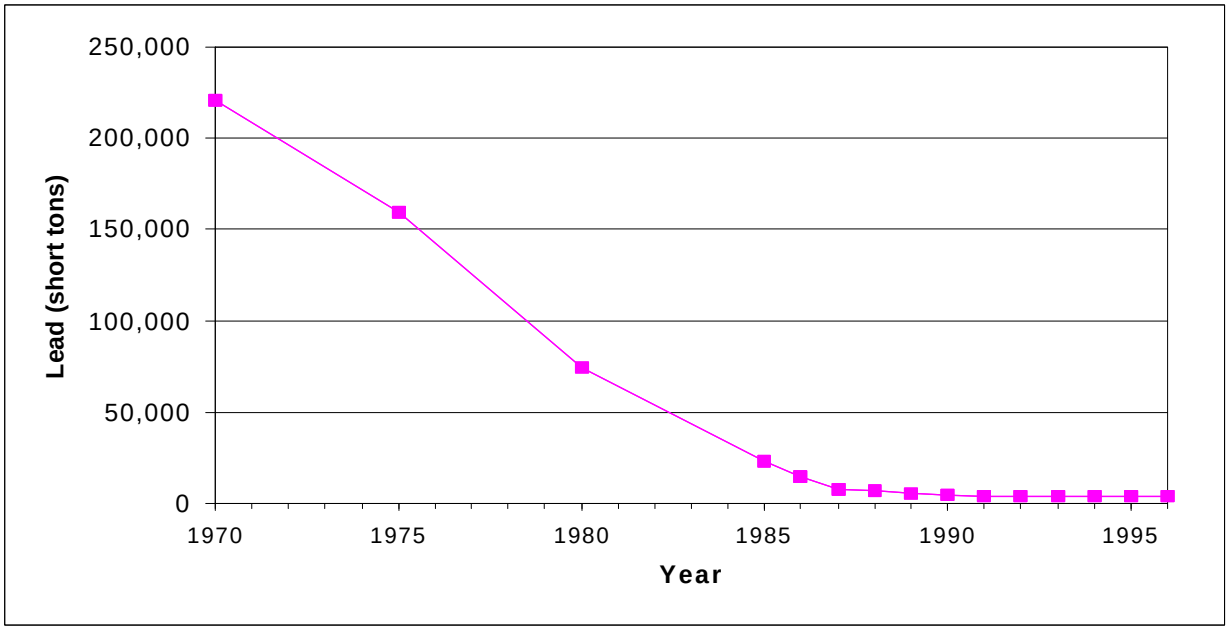

Figure 2. Total Lead Emissions (Short Tons) by Year.

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

Most notable in Figure 2 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 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.

Exhaust Emissions

As seen in Figure 3, 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, 1998c; USEPA, 1997a). In 1996, metals processing was estimated to be the 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 Clean Air Act Amendments (CAAA), this trend is expected to continue.

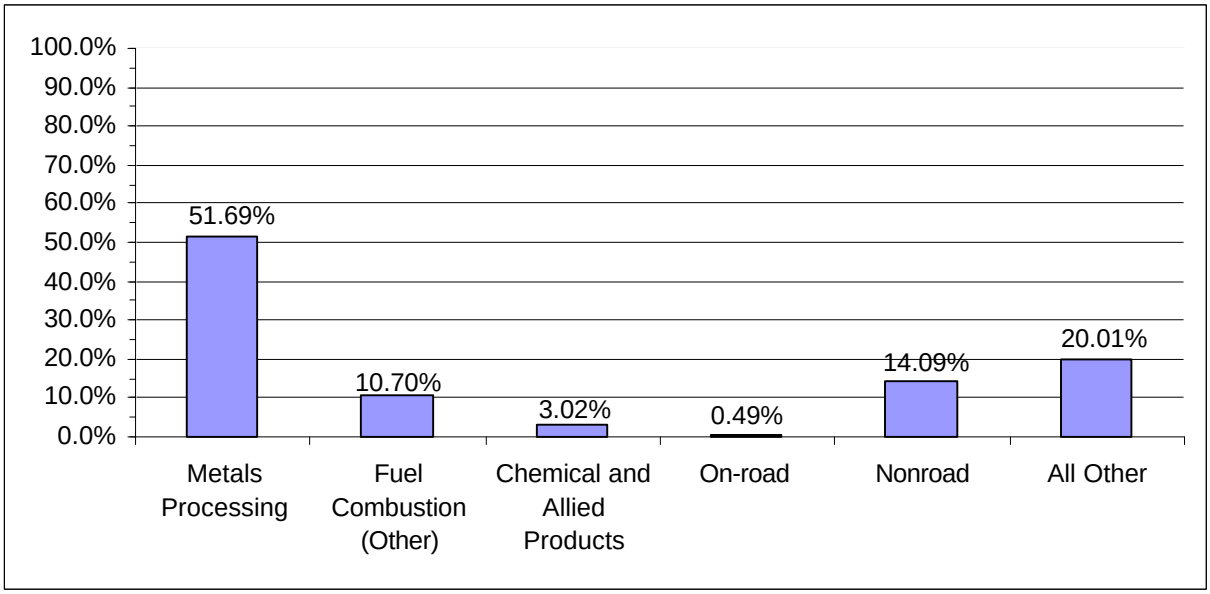

Figure 3. Percentage of 1996 National Emission Estimates by Source (Short Tons).

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

[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).

Table 2 summarizes the information contained in Figures 2 and 3. 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 2. 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 1997a.]

(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.

Table 2 and Figure 3 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.

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 4, 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 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 5. 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 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.

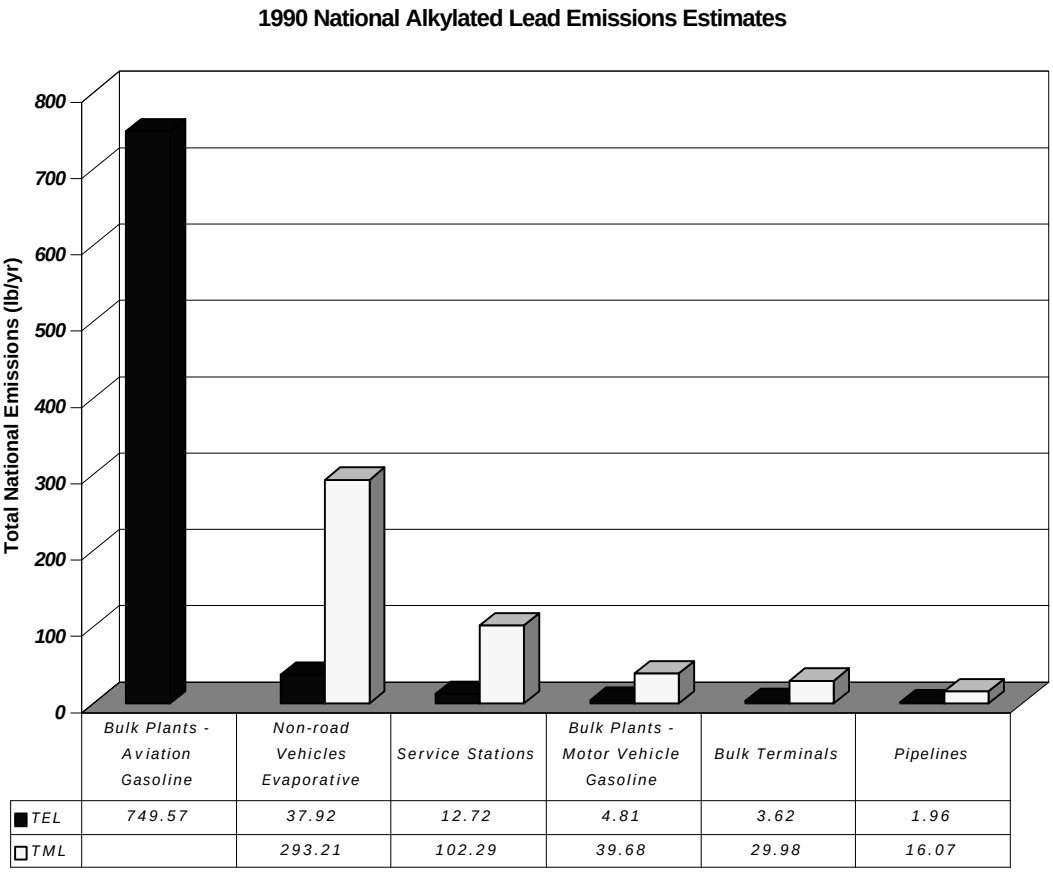

Figure 4. National 1990 Alkylated Lead Emissions Estimates in Pounds Per Year.

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

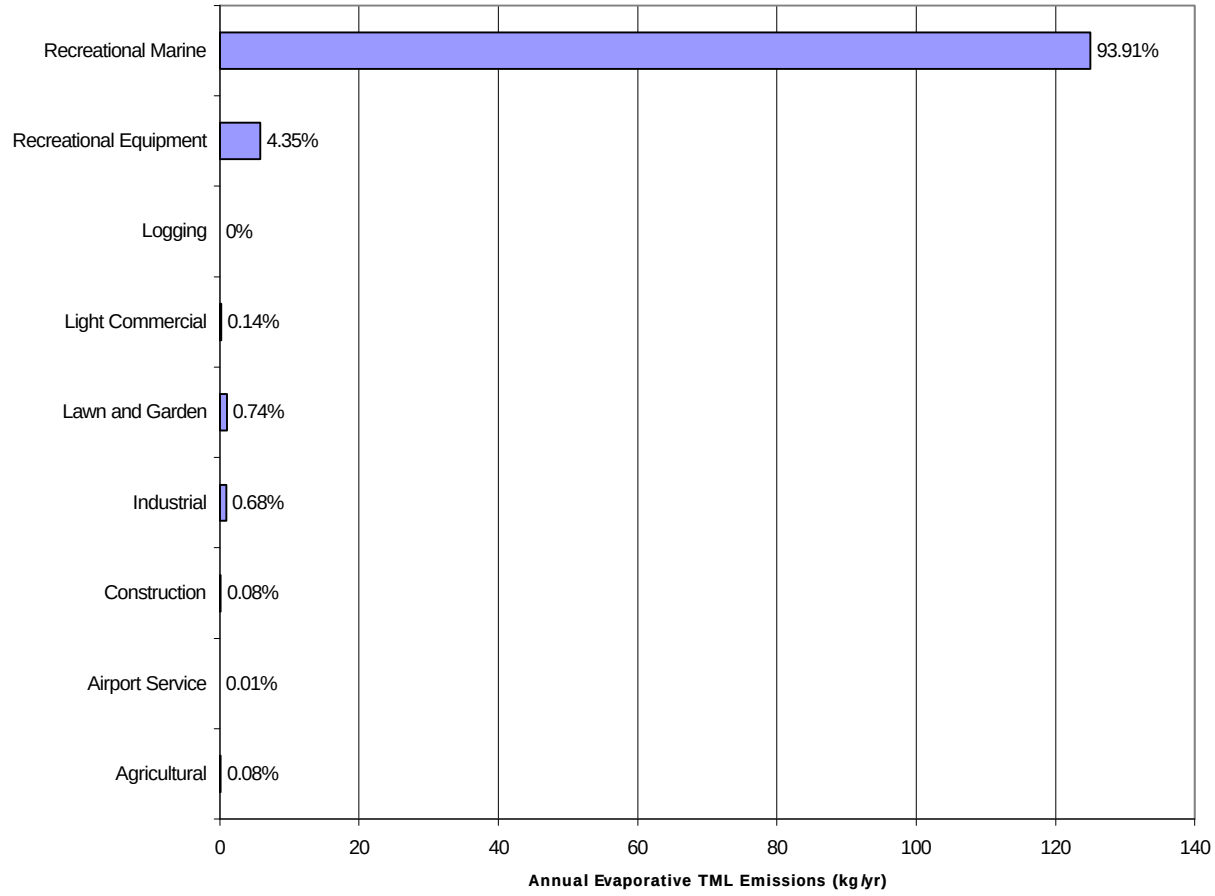

Figure 5. Annual Evaporative Emissions of TML From Non-road Engines

[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.

6.0 EPA'S PROGRAMMATIC BASELINE

6.1 OVERVIEW OF CURRENT REGULATIONS AND PROGRAMS

Current regulations and programs targeting lead emissions and releases (including alkyl-lead compounds) are presented in Table 3.

Table 3. Current Regulations and Programs

	Regulations					
	CAA	**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(40CFR 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) Oct. 29, 1999 Federal Register amendment to lower the TRI reporting threshold for lead compounds to 10 lbs/year (64FR 687)	§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 – OIA program on international efforts to phase-out lead in gasoline					

As seen in the table, the 1990 CAAA specifically target 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 (§220). However, the 1990 CAAA specifically exempt fuels for race cars or "Competition Use Vehicles." Also, though the 1990 CAAA require 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.

6.2 BASELINE ACTIVITIES

6.2.1 Regulations Controlling Use

In the early 1970s, EPA issued two regulations under the statutory authority of the 1970 Clean Air Act (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 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:

- Prohibition on the Use of Leaded Gasoline in On-Road Vehicles. 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].

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

- Prohibition on Production of Engines Requiring Leaded Gasoline. 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].

6.2.2 Regulations Governing Emissions, Releases and Spills

The 1990 CAAA also contain 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). An amendment to lower the USEPA Toxics Release Inventory (TRI) reporting threshold to 10 pounds for lead compounds, as well as require the filing of separate reports for TEL and TML, was published October 29, 1999 (64 FR 687), and became effective January 1, 2000. This amendment will allow identification of facilities that have specific lead compounds and facilitate the tracing of TEL and TML.

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

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).

6.2.3 Regulations Calling for Source Identification

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.

6.2.4 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 4 (USEPA, 1998d). 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.

Table 4. Violations Issued for Excess Lead-Levels in Gasoline [Source: USEPA,1998d]

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%

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.

6.2.5 International Activities

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 and the U.S. Agency for International Development (USAID) 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.

6.2.6 Activities Related to Products

Alternative Aviation Fuel Research. Industry is currently researching an alternative to alkyl-lead for aviation fuel. An industry group, the Coordinating Research Council (CRC) has formed a task force for the purpose of finding a no-lead gasoline substitute for the existing aviation fleet. Working cooperatively with the CRC, the FAA has initiated an Unleaded Fuels Research Program to complete research on the development of unleaded aviation gasoline for civil aircraft. 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. 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 implementation of an unleaded high-octane aviation gasoline is projected to be 8-10 years.

Racing Gasoline. NASCAR is 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. Therefore, the automobile racing industry may be receptive to participating in a voluntary unleaded phase-in partnership/program.

7.0 PROPOSED GOALS AND ACTIONS

7.1 EPA'S ASSESSMENT AND STRATEGIC APPROACH

The Agency 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 (USEPA, 1997b). This large reduction is primarily due to the regulated phase-out of leaded gasoline in on-road vehicles. To address the remaining risks to human health and the environment from exposure to alkyl-lead, the strategic approach of the Agency will focus on the following areas:

1. Contribute to international efforts to reduce the use of alkyl-lead worldwide. 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. Goal 6 of EPA's Ten Year Strategic Plan GPRA Goals calls for the reduction in worldwide levels of lead in gasoline.

2. Pursue voluntary initiatives to reduce the use of alkyl-lead in aircraft gasoline, race cars, and non-road vehicles such as farm machinery, marine vessels, construction equipment, and recreational vehicles. Regulatory options are limited for these uses under the CAA. However, there are voluntary initiatives already underway, which the Agency will encourage and support to achieve cost-effective reductions in these remaining uses of leaded gasoline. These efforts will help to address Goal 1, Goal 4, and Goal 8 of EPA's Ten Year Strategic Plan GPRA Goals, which call for clean air, the reduction of blood-lead levels in children, and greater innovation to address public health and environmental problems, respectively.

3. Collect information as possible, given resource constraints, to estimate the production and use of leaded gasoline for legally continued uses, to refine air alkyl-lead emission estimates reported in the CAA Section 112 (c)(6) report, and to assess whether

exposure in the vicinity of general aviation airports or race tracks contributes to elevated blood-lead levels in at-risk populations (especially children).

Priorities

As discussed previously, alkyl-lead is one of 12 chemicals identified as Level 1 priority PBT pollutants. Historically, the health effects and environmental concerns related to the use of alkyl-lead are well documented and current domestic use may still pose a threat to certain populations. However, because of funding constraints, EPA will need to consider the proposed actions for alkyl-lead in the larger context of the proposed actions for all twelve Level 1 substances.

The specific actions within the Alkyl-lead National Action Plan will be prioritized based on several key factors such as the likelihood of health risks, amount of resources required, the availability and willingness of non-agency partners and stakeholders, and the anticipated impact on the amount of alkyl-lead released into the environment. These key factors need to be examined simultaneously to determine the appropriate prioritization. For example, at the current time, data seem to indicate that the amount of leaded aviation gasoline is significantly higher than the amount of leaded gasoline used by the automotive racing industry. However, technical considerations may limit the amount of progress that can be made toward an alternative aviation fuel. On the other hand, there are fewer technical limitations associated with racing fuel and representatives from the automotive racing industry have expressed a willingness to work with EPA to develop alternatives. Actions that will initially be implemented as part of this action plan are described in Sections 7.3.1-7.3.3. Actions that have been considered but are not presently able to be implemented due to a lack of resources are described in Section 7.3.4.

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 the gross estimates of emissions that are currently provided do not also provide a clear picture of the production and release quantities of alkyl-lead.

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 and from industry representatives.

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).

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. Further, under 112 (c)(6), EPA is committed to promulgating MACT standards for aviation fuel distribution. Thus, one way that EPA can regulate evaporative emissions is to set a particular standard for the fuel delivery system requiring the recapture of vapors that would otherwise evolve at the gas tank.

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.

Stakeholder Issues/Concerns

The identification of alternatives for aviation gasoline will present 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 that it will probably not find widespread usage due to deposit-control problems. For many years MTBE (methyl test-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 gasoline (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, an independent Blue Ribbon panel has recommended to EPA that oil companies should not be required to sell MTBE-blended gas, and that use of MTBE be sharply reduced (USEPA, 1999b).

While an alternative fuel for aircraft is desirable, care must be taken to balance this with safety concerns. 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. To date, EPA has not focused on fuel alternatives due to the financial hardships it would impose on the small aircraft industry.

Although there are a large number of experimental aircraft that use unleaded gasoline for lower performance piston engines, there appears to be no ready substitute for the 100-octane low-lead gasoline used by high performance piston engines. However, one new fuel specification has been approved by ASTM. This new fuel, which will be known as 82UL, is an unleaded aviation grade fuel that can be used only by the low compression ratio segment of the reciprocating-engine-aircraft fleet. The initial production and supply of this new fuel is currently being studied by fuel suppliers. As a move forward in promoting 82UL, the FAA has extended approval for use of this fuel by aircraft previously approved to use auto fuel under Supplemental Type Certificates (STC). In addition, the FAA has recently certified another new unleaded fuel, AGE85, developed by the National Alternate Fuels Laboratory (NAFL) at the University of North Dakota Energy and Environmental Research Center (EERC). With the initial certification completed, the developers of the fuel are moving forward to obtaining FAA certification for more engine and airframe combinations (EERC, 1999).

7.2 GOALS

The goal of the PBT Strategy, to identify and further reduce risks to human health and the environment from existing and future exposure to PBTs, is the guiding principle in the development of the strategic approaches for alkyl-lead in this action plan. In addition, this action plan supports several goals outlined in EPA's 1997 Five Year Strategic Plan. As required under the Government Performance and Results Act of 1993 (GPRA), EPA's Strategic Plan describes EPA's mission and sets forth ten major goals that serve as the framework for the Agency's planning and resource allocation decisions. These ten goals apply to all of EPA's programs and projects and, therefore, clearly encompass many goals, targets and programs that do not apply to alkyl-lead. There are, however, several GPRA goals and sub-objectives that do call for programs promoting reductions in the environmental presence of all toxics of concern, and thus effectively contribute to the desired outcome of alkyl-lead exposure risk reduction. These broader GPRA goals that are relevant to alkyl-lead and the associated strategy described in this report are listed in Appendix A.

The goal of this alkyl-lead action plan is to identify and reduce risks to human health and the environment from current and future exposure to alkyl-lead.

The overall PBT Strategy builds upon the objectives and goals contained in *The Canada-United States Strategy for the Virtual Elimination of Persistent Toxic Substances in the Great Lakes Basin* (Binational Toxics Strategy), which was established in 1997. For alkyl-lead, the Binational Toxics Strategy identifies the following national challenge goal:

"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."

The Binational Toxics Strategy has the overall goal of virtual elimination of persistent toxic substances in the Great Lakes Basin and in the case of alkyl-lead, throughout the United States. Significant work has already been completed by EPA's Great Lakes National Program Office to confirm the "no-use of alkyl-lead in automotive gasoline." (USEPA, 1999a)

7.3 FUTURE DIRECTION AND ACTIVITIES

7.3.1 Stakeholder Involvement

EPA considers stakeholder involvement essential to reaching the goal of the PBT Strategy. EPA will seek stakeholder input in the development and implementation of this draft national action plan for alkyl-lead. EPA will also invite comment on the draft national action plan 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.

The key Agency players will be the Office of International Affairs (OIA), Office of Air and Radiation (OAR), Great Lakes National Program Office (GLNPO), Office of Mobile Sources (OMS) Ann Arbor Facility, and the Office of Pollution and Prevention Toxics (OPPT). The EPA PBT Alkyl-lead Workgroup will take the lead in coordinating voluntary initiatives. Primary non-Agency stakeholders in this effort will be 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 will conduct the following activities with these stakeholders:

- Auto Racing Industry: EPA will coordinate with NASCAR and NASCAR Sponsors to encourage a voluntary unleaded phase-in partnership/program to eliminate the use of leaded gasoline in the auto racing industry. EPA will identify and begin a dialogue process with other auto racing stakeholders (such as the National Hot Rod Association (NHRA) and similar associations for 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.

- Federal Aviation Administration (FAA) and Coordinating Research Council (CRC): EPA will 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 will be held with the CRC task force investigating alternative (no-lead) gasoline for aircraft. EPA will continue to support and encourage such research activities as that undertaken by the CRC task force.

7.3.2 International Efforts

EPA will continue its commitment to international efforts to reduce the use of leaded gasoline, as described in Section 6.2.5. This includes participation in the United Nations Commission on Sustainable Development, Summit of the Americas, Earth Summit + 5, the G-8, and the Great Lakes Binational Toxics Strategy.

7.3.3 Measurement

As stated in the PBT Strategy, EPA will 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 5, EPA will 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 305,000,000 gallons of aviation gasoline (USDOE, 1998).

- The amount of leaded gasoline used by the racing industry: In 1998, approximately 100,000 gallons of leaded gasoline were used by NASCAR (National Motor Sports Council, 1999).

- The amount of anti-knock preparations imported into the US: In 1998, the United States imported approximately 14,318,800 pounds of anti-knock preparations based on TEL and/or TML and 1,316,800 pounds of anti-knock preparations based on lead compounds (U.S. Department of Commerce, 1998). (These compounds are used to make leaded fuel for aviation, racing fuel, marine vessels, etc.) Assuming anti-knock agents containing TEL typically contain 62 percent TEL, a rough estimate for the amount of TEL imported into the U.S. in 1998 would be about 9.7 million pounds of TEL. However, according to Ethyl Corporation (1999), only approximately 2,866,000 pounds of anti-knock fluid were consumed in the U.S. in 1998, equating to approximately 1,129,000 pounds of alkyl-lead. Approximately 331,000 pounds of this anti-knock fluid was used to serve the NASCAR industry.

Table 5. Measures of Progress and GPRA Goals for Actions to Reduce Risks from Alkyl-lead

Focus	Action	GPRA Goal	Measure of Progress
1. Contribute to international efforts	# Support international efforts to reduce the use of leaded gasoline	Goal 6	Number of countries that have initiated/reached a phase-out of leaded gasoline; amount of leaded gasoline used worldwide
2. Pursue voluntary initiatives	# Encourage a NASCAR voluntary phase-out partnership/program	Goal 4, Goal 8	NASCAR Agreement
	# Identify contacts in other racing (auto and non-auto) organizations to initiate similar programs/partnerships	Goal 4	Agreements with other organizations including (boating, non-auto racing, construction, farm machinery, etc.)
	# Identify contacts in other organizations to initiate similar programs/partnerships	Goal 4	Continued dialogue with CRC and FAA
	# Work with Coordinating Research Council and FAA to promote alternative, unleaded fuels and the phase-out of leaded aviation gasoline	Goal 4	Reductions in lead exposure and blood-lead levels among at-risk populations

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 (ASTM, 1997).

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 (USEPA, 1998b). This number may have an increase from 1995 levels with the proposed threshold reductions. Also, this number may change as reporting requirements are refined from lead and lead compounds to alkyl-lead compounds.

7.3.4 Actions Considered but Not Able to Be Implemented Due to a Lack of Resources

As discussed in Section 7.1, proposed actions for alkyl-lead were evaluated in the larger context of proposed actions for all Level 1 substances and in the context of available resources. Following are actions that were considered to have merit but which could not be implemented or planned at this point in time in light of other higher priorities.

Proposed 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 was proposed that the Agency also investigate new possibilities for expanding the outreach/education campaign to include targeted audiences. For example, EPA might 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 were also raised. 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.

Proposed Research/Information Needs

Research on several issues was proposed 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 were considered:

- # Refine CAA 112(c)(6) Emission Estimates: The 1990 CAAA require 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 1998. However, since the development of these emission estimates, the overall use of leaded gasoline may have been further 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 considered 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 considered 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 could 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 could 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 could be consolidated and estimates of the extent of misfueling developed.

- # Determine the Extent to Which Leaded Gasoline Is Available for Purchase at Marine Fuel Docks: It is unknown whether leaded gasoline is still being widely used as a marine fuel. However, fuel is known to overflow from fuel tanks frequently during operations into waterways, lakes, etc. While the quantities may be small, the number of such sites may be much larger than for race tracks.

Stakeholder Involvement

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

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GLOSSARY

ATSDR	Agency for Toxic Substances and Disease Registry
CAA	Clean Air Act
CAAA	Clean Air Act Amendments
CRC	Coordinating Research Council
FAA	Federal Aviation Administration
GLNPO	Great Lakes National Program Office
GPRA	Government Performance and Results Act of 1993
NASCAR	National Association of Stock Car Auto Racing
NAAQS	National Ambient Air Quality Standards
NIOSH	National Institute of Occupational Safety & Health
NOAA	National Oceanic and Atmospheric Administration
OAR	EPA Office of Air and Radiation
OIA	EPA Office of International Activities
OMS	EPA Office of Mobile Sources
OSHA	Occupational Safety & Health Administration
PBT	Persistent, Bioaccumulative, and Toxic
TEL	Tetraethyllead
TML	Tetramethyllead
TRI	Toxics Release Inventory
TSCA	Toxic Substances Control Act

APPENDIX A:

LIST OF KEY CONTACTS AND GRPA GOALS

LIST OF KEY CONTACTS

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Joseph Valentine	Texaco Additives International Research and Development	(914) 838-7718
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GPRA GOALS

The goal of this action plan is to identify and reduce risks to human health and the environment from current and future exposure to alkyl-lead. This goal is consistent with the goal of the PBT Strategy. Achieving this goal will help EPA meet the following Government Performance and Results Act of 1993 (GPRA) goals that pertain to alkyl-lead:

GPRA Goal 1: Clean Air

- By 2010, reduce air toxics emissions by 75% from 1993 levels to significantly reduce the risk to Americans of cancer and other serious health effects caused by airborne toxics;

- By 2005, improve air quality for Americans living in areas that do not meet NAAQS for carbon monoxide, sulfur dioxide, lead, and nitrogen dioxide;

GPRA Goal 4: Preventing Pollution and Reducing Risk in Communities, Homes, Workplaces, and Ecosystems

- By 2005, the number of young children with high levels of lead in their blood will be significantly reduced from numbers in the early 1990's;

GPRA Goal 6: Reduction of Global and Cross-Border Environmental Risks

- By 2005, consistent with international obligations, the need for upward harmonization of regulatory systems, and expansion of toxics release reporting, reduce the risks to U.S. human health and ecosystems from selected toxics (including pesticides) that circulate in the environment at global and regional scales. Results will include a 50% reduction of mercury from 1990 levels in the United States. Worldwide levels of lead in gasoline will be below 1993 levels;

GPRA Goal 8: Sound Science, Improved Understanding of Environmental Risk, and Greater Innovation to Address Environmental Problems

- Incorporate innovative approaches to environmental management into EPA programs, so that EPA and external partners achieve greater and more cost-effective public health and environmental protection.