

# Myths & Realities of Leaded Aviation Fuel

*Prepared by Center for Environmental Health for Friends of the Earth*



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## **Friends of the Earth**

### **PUBLICATION INFORMATION**

#### **Friends of the Earth US - Headquarters**

1101 15th Street NW 11th Floor  
Washington DC 20005  
Phone: 202-783-7400

#### **Friends of the Earth US - California Office**

2150 Allston Way Suite 360 Berkeley CA 94704  
Phone: 510-900-3150

Please visit us at [www.foe.org](http://www.foe.org)

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# CONTENTS

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Acknowledgements	4
Executive summary	5
The problem: Leaded aviation fuel	6
Myth #1: “Lead is not that toxic.”	7
Myth #2: “Didn’t we get lead out of fuel years ago?”	8
Myth #3: “Piston-engine aircraft cannot use unleaded fuel.”	9
Myth #4: “It is impossible to buy unleaded fuel for airplanes.”	10
Myth #5: “Switching to unleaded fuel is expensive.”	11
Myth #6: “Pilots do not like unleaded fuel.”	12
The solutions: Getting the lead out of avgas	13
Sources	14



# Acknowledgements

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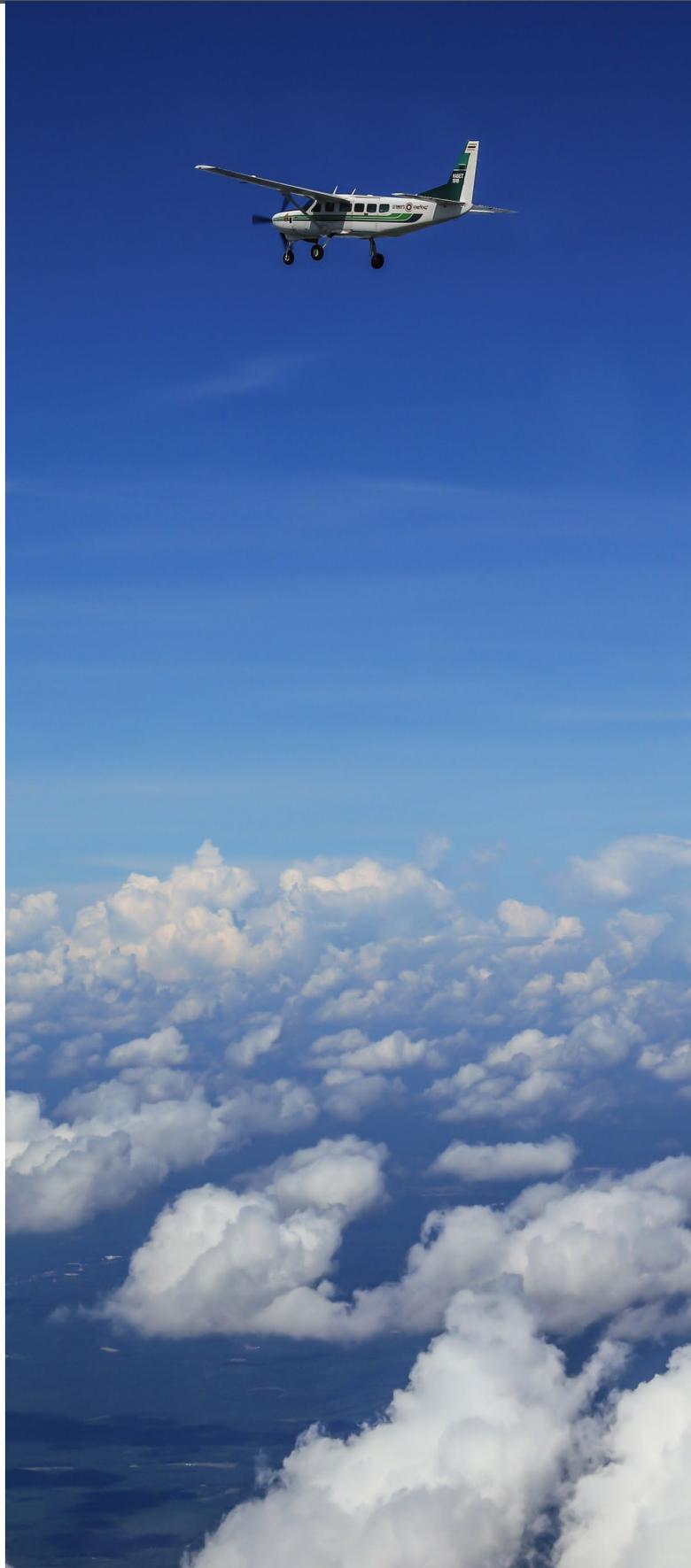
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# Executive Summary



At the beginning of 2016, lead emissions and contamination were not at the top of most people's list of environmental and human health priorities. After all, bans on lead paint and leaded gasoline convinced the country that it had already won the battle against lead emissions. But just a few days into the New Year, Michigan Governor Rick Snyder declared a state of emergency in the city of Flint, Michigan for lead-contaminated drinking water. This declaration came after two years of residents' complaints, and several bacterial scares only culminated into action when a Flint physician found high levels of lead in the blood of local children.<sup>1</sup> Clearly, there was much more work to be done to prevent childhood exposure to lead.

Lead is the most well-studied of the long list of chemicals that are human toxicants or environmental pollutants. Lead emitted into the air is particularly problematic because it can be inhaled or ingested once it settles to the ground. There is no safe level of lead in the body.<sup>2</sup> Since blood lead level depends on both recent exposures and long-term exposure history, preventing each exposure is important to protecting the reproductive health of women and children.<sup>3</sup> From lead-contaminated water in Flint to chipped lead paint in aging homes across the U.S., each preventative action has the potential to avert irreversible damage caused by lead.

While lead has been banned or limited in consumer products, building materials and automotive gasoline,

no action to date has been taken to address the largest source of lead emissions into the air—leaded aviation fuel (“avgas”).

Approximately 50 percent of lead emissions in the United States are from piston-engine aircraft. From 1970 to 2007, general aviation aircraft emitted about 34,000 tons of lead into the atmosphere.<sup>2</sup> Twenty thousand airport facilities across the U.S. operate using leaded fuel and an estimated 16 million people live within 1 kilometer of the 20,000 airports where leaded avgas is used.<sup>2</sup> Three million children attend a school within 1 kilometer of these facilities,<sup>2</sup> and these children have demonstrably higher blood lead levels than those further from airports.<sup>4</sup>

In this report, Friends of the Earth separates the myths from realities about lead in avgas and provides recommendations to expedite a transition to unleaded general aviation fuel. Lead is highly toxic and avgas is the biggest airborne contributor to lead emissions in the United States. A transition to unleaded fuel is foreseeable, as 75 percent of general aviation aircraft could make the change immediately and would save money in the long run. However, The Federal Aviation Administration (FAA) and the United States Environmental Protection Agency (EPA) must collaborate with airports and the general aviation community to facilitate an efficient, prompt transition to unleaded fuel.

<sup>1</sup> Dixon, n.d.

<sup>2</sup> EPA, 2010

<sup>3</sup> Miranda, 2011

<sup>4</sup> Miranda, 2011

# The Problem: Leaded aviation fuel

In 1973, the EPA initiated what would be an almost 25-year process to get lead out of gasoline. At the end of the phase-out program in 1996, childhood blood lead levels had fallen seventy percent.<sup>5</sup> That year, the Clean Air Act effectively banned the sale of leaded fuel—but a provision allowing the sale of leaded fuel for off-road uses such as aircraft remains mostly intact to this day. As a result, half of all air lead emissions in the U.S. today are from piston-engine aircraft, otherwise known as general aviation.<sup>2</sup> These small planes are used by flight schools, recreational pilots and other similar stakeholders. Some helicopters also use leaded fuel.<sup>6</sup> The U.S. along with Afghanistan, Algeria, Iraq, Myanmar, North Korea and Yemen are the only countries in the world to still allow the use of leaded fuel.<sup>7</sup>

Though there are multiple types of leaded aviation fuel, avgas most commonly refers to “100LL” fuel (LL stands for low lead). Lead is added to avgas in the form of tetraethyl lead (TEL) because it raises fuel octane and prevents engine knock and other wear in high-performance engines.<sup>8</sup> Avgas is the largest current source of airborne lead.

Over 75 percent of piston-engine, general aviation aircraft can run on unleaded automotive fuel (“mogas”) that is ethanol free.<sup>9</sup> These planes can easily switch to unleaded fuel if they obtain the necessary permit and if unleaded avgas is made available at more airports. However, the 25 percent of aircraft that do require high-octane, leaded fuel are larger aircraft that fly longer distances and therefore consume the majority of all avgas.<sup>10</sup>

Once lead is released into the environment, it does not break down and tends to stick to particles in the soil and settle on the ground.<sup>11</sup> If deposited into soil or water, lead can be readily taken into the tissues of plants and animals.<sup>12</sup> Lead’s persistence in the environment makes preventing emissions extremely important: no amount of lead exposure is safe for children.

Several studies in the U.S. and Canada suggest that lead levels in air and soil near airports are significantly higher than lead levels in areas that are distant from airports—and that there is an exponential decrease in lead levels with increasing distance from runways. Children are the most vulnerable to lead poisoning, and even low dose exposures to lead can impair children’s mental and physical development.<sup>13</sup>

In a 2011 study published in the National Institute of Environmental Health Science’s “Environmental Health Perspectives”, Marie Lynn Miranda’s team from Duke University used geospatial analysis and the North Carolina state registry of blood lead surveillance to explore the relationship between children’s blood lead levels and the proximity of their homes to airports.

They conclude that lead from avgas has a significant effect on blood lead levels of children living within 1,000 meters (just over a half mile) of an airport where avgas is used. Today, over 3 million children attend school within one kilometer of these airports.<sup>14</sup>

Given the harmful effects of leaded avgas, unleaded alternatives should be adopted now in order to protect future generations.



<sup>5</sup> EPA, 1996

<sup>6</sup> EarthFix, 2015

<sup>7</sup> <http://articles.chicagotribune.com/2014-05-20/news/ct-leaded-gas-planes-met-20140520> 1 airborne-lead-avgas-lead-emissions

<sup>8</sup> AOPA, n.d.

<sup>9</sup> Kessler, 2013

<sup>10</sup> Millner, 2006

<sup>11</sup> CDC, 2007

<sup>12</sup> EPA, Office of Transportation and Air Quality.

<sup>13</sup> Miranda, 2011

<sup>14</sup> EPA, 2010

## Myth #1: “Lead is not that toxic.”

**Reality:** *Lead is a stunningly toxic metal. Virtually all people are exposed to lead, and we store the metal in our bones, soft tissues and blood.*

The most well-known health problems caused by lead exposure are its effects on children’s developing brains. Lead exposure results in lower scores on IQ tests and decreased success in school.<sup>15</sup> Some of these effects are irreversible: effects on the brain persist in adults who were exposed as children. In addition, lead causes anxiety and depression in children. Hyperactivity and lack of attention are related to lead exposure in children, teenagers and young adults.<sup>15</sup>

One of the most striking results of lead’s damage on developing brains is that children with higher lead exposures are more likely to commit crimes when they become young adults. This relationship has been found in studies from multiple countries. The direct costs of the crime associated with blood lead levels in children elevated by just one microgram per deciliter (the action threshold for elevated blood lead levels in the U.S. is now 5 micrograms per deciliter) in the United States amount to a lifetime total of \$1.7 billion using conservative estimates.<sup>16</sup>

Children with elevated blood lead levels are more likely to require special education and health services. These children are also less likely to graduate from high school and pursue higher education, leading to lower lifetime earnings. According to a 2009 lifetime cost-benefit analysis by Elise Gould, reducing lead hazards in children under six could save billions of taxpayer dollars in a net lifetime. For example, an estimated \$11 to \$53 billion are spent on lifetime health care costs and \$25 to \$35 billion are lost in tax revenue from lower lifetime earnings as a result of childhood lead exposure.<sup>14</sup> Altogether, between \$17 and \$221 billion is spent on social services related to lead exposure.<sup>14</sup>

Other health problems in children that are related to lead exposure are hearing loss and decreased

motor skills. Increases in allergies and asthma are also associated with lead exposure.<sup>15</sup> In teens, lead exposure causes delayed puberty.<sup>15</sup>

Health problems caused by lead exposure in adults are less well-known than those in children, but are also significant. Research has consistently shown that lead exposure causes hypertension (increased blood pressure) and heart disease (including heart attacks). Some studies indicate that lead exposure is associated with artery disease (atherosclerosis). Studies in laboratory animals indicate that lead exposure decreases the ability to fight off infections, and lead exposure decreases men’s ability to father children by damaging sperm.<sup>15</sup>

In addition, lead exposure in adults causes some health problems that are similar to lead effects in children. Multiple studies have found lead exposure is related to loss of memory and other cognitive functions, anxiety and depression.<sup>15</sup>

Lead can cause ecological harm when it is released into the environment. Lead exposure causes problems in animals that are similar to the problems in humans, impairing animals’ ability to grow, reproduce and survive.<sup>15</sup>



<sup>15</sup> EPA, 2013

<sup>16</sup> Gould, 2009

## Myth #2: “Didn’t we get lead out of fuel years ago?”

**Reality:** *Approximately 50 percent of airborne lead emissions in the U.S. are from piston-engine aircraft.*<sup>13</sup>

In the 1970s, emissions from cars and trucks were one of the largest sources of lead in the U.S. Then, the newly-formed EPA began to regulate lead emissions from automotive gasoline through a phase-down program and by 1975 new cars were required to be manufactured with catalytic converters that used lead-free fuel only.<sup>17</sup>

In 1996, the Clean Air Act banned all sale of leaded gasoline for on-road vehicles but the sale of leaded fuel for piston-engine (general aviation) aircraft was still permitted. With passenger vehicles cleaned up, piston-engine aircraft remain the largest source of lead in outdoor air.<sup>18</sup>

In 2003, Friends of the Earth,<sup>19</sup> represented by the Golden Gate University Environmental Law and Justice Clinic, commented on the EPA’s rulemaking on proposed amendments to existing emission standards for nitrogen oxides (NOx) in newly certified commercial aircraft gas turbine engines with rated thrust greater than 26.7 kilonewtons (kN) (68 Fed. Reg. 56,226). In their comments on the NOx standards, Friends of the Earth also noted concern about the lack of regulation of lead emissions from general aviation aircraft.

Friends of the Earth further argued that the EPA should find, under the Clean Air Act § 231, that aviation gas endangered public health and welfare in light of the facts that there is no safe level of lead exposure and general aviation aircraft produce a relatively high proportion of airborne lead pollution. By 2006, the EPA still had not taken action to regulate lead in avgas. In response, Friends of the Earth petitioned the EPA for rulemaking that would address lead emissions from general aviation.

Finally in April 2010, the EPA filed an “Advance Notice of Proposed Rulemaking on Lead Emissions from Piston-Engine Aircraft Using Leaded Aviation Gasoline.” In 2012, the EPA formally responded to Friends of the Earth’s 2006 petition and announced that it was “actively engaged in investigating whether lead emissions from piston-engine aircraft cause or contribute to air pollution” and thereby endanger public health, but also declared more studies were necessary before it could issue an endangerment finding. The EPA stated that it intends to release a proposed endangerment determination in 2017 and a final endangerment determination in 2018.<sup>20</sup>



<sup>17</sup> EPA, 1996

<sup>18</sup> AOPA, n.d.

<sup>19</sup> Bluewater Network was the group that filed the 2003 comments with U.S. EPA. In 2005 Bluewater Network merged with Friends of the Earth.

<sup>20</sup> McCarthy, 2012

## Myth #3: “Piston-engine aircraft cannot use unleaded fuel.”

**Reality:** *Unleaded ethanol-free (E0) premium gasoline has been an FAA-approved aviation fuel since the 1980s and can be used in most general aviation engines.<sup>21</sup>*

Piston-engine aircraft, otherwise known as general aviation,<sup>2</sup> are typically the small planes operated by businesses and flight schools, and for sightseeing, search and rescue and recreation. Some helicopters also use leaded fuel.<sup>6</sup>

Though there are multiple types of leaded aviation fuel, avgas most commonly refers to “100LL” fuel (LL stands for low lead). Lead is added to avgas in the form of tetraethyl lead (TEL) because it raises fuel octane and prevents engine knock and other wear in high-performance engines.<sup>8</sup> Although 100LL is the most commonly used avgas, it is estimated that about 75 percent of general aviation engines can run on Aviation Lean Octane Fuel (Avgas 80/87) and just 25 percent require Aviation Rich Octane Fuel (Avgas 100/130).<sup>22</sup> Aviation Lean has an octane rating that is about the same as Automotive Motor Octane or “premium mogas”—and thus Aviation Lean avgas can be easily substituted with E0, premium mogas.<sup>23</sup> Ethanol’s corrosive properties make flying with unleaded gas that contains ethanol both illegal and unsafe. The availability of ethanol-free unleaded avgas is important because it provides a viable, safe alternative to leaded Aviation Lean fuel.

There is no easy substitute for planes that require Aviation Rich fuel currently approved by the FAA. However, planes that do not require 100/130 octane gain no benefit by using higher octane fuel. In lower-performance engines, higher octane fuel does not provide any additional power. On the contrary, 91 octane mogas has three to five percent more BTUs per gallon than 100LL avgas.<sup>21</sup> In other words, mogas provides more power per volume than 100LL even though it contains no lead.

For most general aviation planes (low compression 80/87 octane engines), few if any major mechanical modifications are needed to fly with mogas. Instead, an FAA licensed mechanic merely evaluates the plane engine and installs supplemental type certificate (STC) fuel and engine placards. These STCs are defined by the FAA as “a type certificate issued when an applicant has received FAA approval to modify an aeronautical product from its original design”<sup>24</sup>—in this case, the modification is the use of mogas. For some planes, some minor engine modifications are required to obtain an STC. Otherwise, the only limitation set by the FAA is that planes carrying paying passengers cannot fly using mogas.<sup>25</sup>

While the shift to unleaded fuel has moved at a slow pace in the U.S., some places like Europe have moved swiftly, keeping planes in the sky and public health as a priority. In 2010, the European Aviation Safety Agency (EASA) took action to remove regulatory barriers for unleaded fuels by clearing Hjelmsco Oil’s unleaded 91/96 and 91/96 avgas for use in any aircraft where the manufacturer has approved the fuel.<sup>26</sup> A number of other unleaded 91 avgas fuels from other countries in Europe have followed Hjelmsco’s path, making unleaded fuel available across the continent.

However, it is important to note that the needs of aircraft in the U.S. and in Europe differ in that high-performance engines requiring high-octane fuel make up a larger portion of the U.S. fleet. Nonetheless, EASA’s regulatory steps can provide a useful framework for bringing existing unleaded fuels to market here in the U.S.

<sup>21</sup> Misgades, 2011

<sup>22</sup> Billing, 2014

<sup>23</sup> Millner, 2006

<sup>24</sup> FAA, n.d.

<sup>25</sup> Auto Fuel STC, 2015

<sup>26</sup> Misgades, 2010

## Myth #4: “It is impossible to buy unleaded fuel for airplanes.”

**Reality:** *Unleaded, E0 premium gasoline is sold at thousands of gas stations and airports across the United States and Canada, and fuel companies are working to bring unleaded options to more airports throughout the 2016 flying season.*

Unleaded aviation fuel is becoming more popular due to leaded aviation fuel’s high price, environmental concerns, and adverse health effects. Several general aviation organizations have taken action to make unleaded fuel options more accessible. For example, Pure-Gas.org lists 10,501 gas stations across the U.S. and Canada that sell ethanol-free, unleaded gasoline.<sup>27</sup> Flyunleaded.com also maintains a list of airports in the U.S. that supply mogas and has its own running list of ethanol-free gasoline suppliers.<sup>28</sup>

The Aviation Fuel Club, an organization of sports aviators that were dedicated to keeping sport aviation affordable and sustainable, worked with manufacturers like U-Fuel to develop low-cost fuel stations at airports.<sup>29</sup> The organization’s members also established a number of small mogas distributors, including Clear Gas of Merced, California that is in the process of bringing unleaded fuel to California airports.

Dean Billing, Flyunleaded.com founder and activist, compiles a number of other useful resources for pilots and airports that want to switch to mogas, including a tutorial on making an inexpensive, do-it-yourself fuel trailer from parts that can be purchased at any local hardware store.

In addition to do-it-yourself mogas solutions, companies like Swift Fuels are actively developing unleaded fuel options for aircraft. Swift Fuels Unleaded 94 MON (Motor Octane) Avgas is already available and approved for many lower-performance planes, and Swift is taking the next steps to ensure that their fuel is accessible in key markets. Eight airports are already carrying 94 MON Avgas, including Brooks Field

Airport in Michigan and Anderson Municipal Airport-Darlington Field in Indiana. San Carlos Airport in California also carries unleaded avgas.

Both Swift and Shell are currently testing unleaded avgas for high performance planes that require higher octane fuel with the FAA for a 2018 release.



<sup>27</sup> Hokin, n.d.

<sup>28</sup> Billings, 2015

<sup>29</sup> Aviation Fuel Club, n.d.

## Myth #5: “Switching to unleaded fuel is expensive.”

**Reality:** *For pilots, switching to unleaded fuel is cheaper in the long run — especially for planes that can already run on mogas without physical modification — because mogas itself costs \$1 to \$3 less per gallon on average than 100LL.<sup>30</sup>*

According to American aircraft engine manufacturer, Lycoming Engines, removing lead from fuel will actually reduce the total-lifecycle costs of aircraft ownership.<sup>31</sup> In a flyer Lycoming Engines released in 2013, Lycoming states that unleaded avgas actually improves engine functions by eliminating lead deposit buildup that can corrode parts overtime.<sup>31</sup>

Facilities for selling mogas do not need to be expensive either, as companies like U-Fuel and Sport Fuel have built low-cost self-service mogas fueling stations for airports. Do-it-yourself stations can be made even more inexpensively.

Even considering the infrastructure, distribution, taxes and other costs associated with the development

and distribution of an unleaded 100LL, or high-performance, alternative, a 100 octane unleaded (100UL) fuel would likely be slightly cheaper or similar in price to 100LL.<sup>30</sup> Moreover, a 100UL option would reach a broader market than 100LL does because the general aviation pilots who switch to low-performance mogas in order to reduce lead emissions could also use 100UL without worrying about lead emissions.<sup>32</sup>

Investing in the development of 100UL and making mogas options available are financially and environmentally responsible steps that would lower the cost of flying overall.



<sup>30</sup> Misgades, 2011

<sup>31</sup> Lycoming, 2013

<sup>32</sup> Miller, 2014

## Myth #6: “Pilots do not like unleaded fuel.”

**Reality:** *Surveys and testimonials from the aviation community show increasingly favorable attitudes toward mogas.<sup>33</sup>*

While misinformed concerns about the safety of unleaded mogas still exist, education and awareness programs by groups like the Aviation Fuel Club and Flyunleaded.com have corrected some of these long-held misconceptions through opinion pieces, fly-ins, maps of unleaded fuel stations and partnerships with environmental groups.

On top of these education efforts, environmental organizations like Friends of the Earth have brought the issue of leaded avgas to public light through their regulatory comments and petitions to the EPA. Litigation against airports in California under the State’s Safe Drinking Water and Toxic Enforcement Act of 1986 by the nonprofit group the Center for Environmental Health along with studies like the one conducted by the team from Duke University in North Carolina have also helped shed light on lead air emissions from general aviation.

In 2013 AV Web, an online aviation news source, conducted a survey of 1,200 general aviation pilots. Fifty-seven percent of pilots said they would consider using mogas, which is up from the 49 percent that responded in 2011.<sup>33</sup>

Looking at the question another way, the number of pilots that said they would absolutely not consider using mogas (49 percent in 2011) has fallen to just 24 percent in 2014<sup>34</sup>—demonstrating a large shift for mogas from its place as a “fringe” fuel to a reliable, cost-conscious alternative to avgas. Furthermore, two-thirds of respondents thought the Aircraft Owners and Pilots Association (AOPA) and the FAA should be more involved in making mogas available at airports.

One of the survey respondents, Stuart Kollas, commented: “With an STC [supplemental type certificate] on a recently owned C-150, mogas was

used as much as possible resulting in excellent running and reduced lead deposits. Mogas is burned almost exclusively in my present Rotax 912ULS which reduces the oil change requirement by one half. If the engine can safely use mogas, it is difficult to argue against it.”<sup>34</sup>

Pilots and airport owners have also commented favorably on new unleaded avgas options. “I’ve been very satisfied using Swift’s UL94 avgas in my new SkiGull experimental aircraft. The fuel starts well, runs smooth and offers an unleaded alternative to 100LL for the environmentally sensitive areas I enjoy flying in. I am confident pilots will enjoy flying [with] this premium fuel,” said Burt Rutan, a legendary aeronautical pioneer, inventor and entrepreneur. These types of comments highlight the reality that pilots are embracing unleaded fuel, and that General Aviation as a whole is actively engaging in the conversation about unleaded fuel with a forward-thinking attitude.



<sup>33</sup> Bertorelli, 2013

<sup>34</sup> Bertorelli, 2013

# The solutions: Getting the lead out of avgas

This year marks the 10th anniversary of Friends of the Earth's 2006 petition to the EPA to begin a rulemaking investigation into air emissions from leaded aviation fuel, and the adverse effects of lead are as visible as ever. Swift action must be taken to prevent unnecessary, irreversible exposures to lead from aviation.

## ***We recommend the following solutions to address air emissions from leaded avgas:***

1. The EPA should make an endangerment finding on leaded avgas as soon as possible. Once that finding has been made, the EPA should work with the FAA to facilitate the phase-out of leaded avgas over a reasonably prompt timeframe.
2. The FAA should fast track making unleaded fuel available and meet the deadlines set for its test program. Simultaneously, the FAA must highlight and advocate for the appropriate use of unleaded fuel options currently available (such as mogas and 100UL), rather than waiting for single fuel that works for the entire general aviation fleet. It should also make the certification process easy and clear for pilots, while clearing up misinformation about the safety of unleaded fuels.
3. Airports should work to phase out avgas by bringing in unleaded fuel and partnering with unleaded fuel suppliers. The FAA can require or provide grants to airports to help them construct or install the infrastructure necessary to provide unleaded fuel, reducing the upfront costs that might deter small airports.
4. The EPA, FAA, AOPA and local airports must collaborate with the general aviation community to make unleaded options more affordable and accessible. The 2013 AV Web survey shows that the general aviation community has taken proactive action to get lead out of their emissions, such as asking their local base operators to carry mogas. However, confidence that other stakeholders such as the FAA and AOPA are doing enough to get the lead out is low.<sup>35</sup> These stakeholders with the most resources and power should be leading the movement to clean up avgas.
5. Finally, the EPA should evaluate the current extent of lead contamination near airports through a program that either finances or requires lead air emission monitoring and soil testing at airports where leaded avgas is being used.



<sup>35</sup> Bertorelli, 2013

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**Friends of  
the Earth**

**Washington, D.C.**

1101 15th Street NW 11th Floor Washington DC 20005  
Phone: 202-783-7400 • Website: [www.foe.org](http://www.foe.org)

**California**

2150 Allston Way Suite 360 Berkeley CA 94704  
Phone: 202-783-7400



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