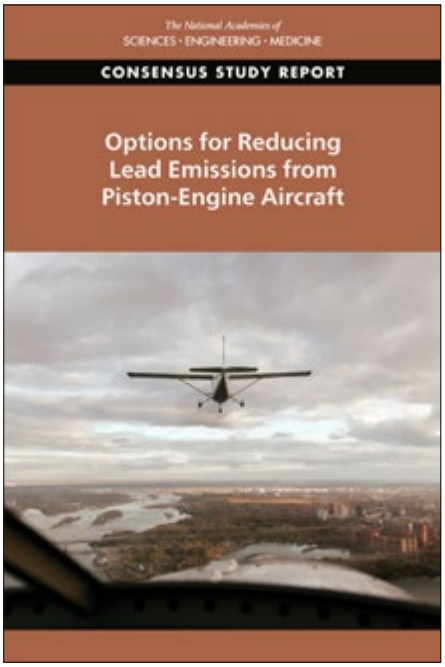
Consensus Study Report

January 2021

HIGHLIGHTS

Options for Reducing Lead Emissions from Piston-Engine Aircraft



Gasoline-powered, piston-engine aircraft are the single largest emitter of lead in the United States. Lead is added to aviation gasoline (avgas) to raise octane levels needed by many of these aircraft for safe performance in flight. When emitted from aircraft exhaust, lead can be inhaled by people living near and working at airports. Lead exposures can also occur from exhaust deposited on soil and other surfaces, spills and vapor emitted during refueling, and contact with residue left on aircraft engines and other components. Because lead is a highly toxic substance that can result in an array of negative health effects, these lead emissions and exposures are of concern. Even at low exposures, as measured by blood lead levels, lead has been linked to effects such as decreased cognitive performance in children.

At least one-third of the gasoline-powered aircraft fleet has high-compression piston engines, which require high-octane avgas with lead additives for safe operation. The other share of the fleet could use avgas with lower octane levels and no added lead. Most gasoline-powered aircraft are used for personal and recreational flying. They are also used for transportation in rural and remote regions and for performing critical societal functions such as medical airlifts, aerial firefighting, business transport, pilot training, and search and rescue. Because aircraft with high-compression engines perform many of these functions, they account for a disproportionately large share of avgas consumption. Due to the small total market for avgas and limited fueling infrastructure at most of the country's more than 13,000 airports, leaded avgas is usually the only fuel that is available to operators of all gasoline-powered aircraft, including operators of the many small aircraft that do not require high-octane fuel. The grade of avgas supplied is designated "100LL," where "100" refers to the octane level and "LL" stands for "low lead."

The FAA Reauthorization Act of 2018 called for this study by the National Academies of Sciences, Engineering, and Medicine of options for mitigating and reducing lead from aviation, including options for changing fuels and aircraft operations and practices at airports. To carry out the study, the National Academies formed a committee of 10 members providing expertise in air pollution, airport planning and operations, fuels and emissions regulation, health risk assessment, statistics, and mechanical and aviation engineering.

The National Academies of
SCIENCES • ENGINEERING • MEDICINE

After examining potential mitigation options, the committee concluded that there is currently no single option that could guarantee lead's full or near elimination and that achieving sustained and tangible reductions will require concerted efforts across a range of mitigation pathways. For nearly a decade, the Federal Aviation Administration (FAA), fuel developers, and the general aviation (GA) industry have been collaborating to develop an unleaded "drop-in" fuel that can be used by all gasoline-powered aircraft, including those that require high octane. Because of formidable technical challenges, success has remained elusive and is by no means certain. The committee recommends that those collaborative efforts continue as part of a comprehensive lead mitigation strategy that also includes pathways for making near- and mid-term progress in reducing lead emissions and exposures. The following is a summary of several recommendations.

CHANGES TO AIRPORT OPERATIONS AND PRACTICES

To ensure that pilots, aircraft owners, airport managers and personnel, and aircraft technicians understand the hazards created by leaded avgas, FAA, in partnership with prominent organizations within the GA community, should initiate an ongoing campaign for education, training, and awareness of aviation lead exposure that is targeted to pilots, aircraft technicians, and others who work at airports.

Shortly before takeoff, a pilot briefly brings up the engine of the stationary aircraft to high power to confirm the engine's safe operation. Air quality studies at airports have shown that engine run-ups can contribute to significant airborne lead concentrations near run-up areas. **FAA should update its guidance on the location of run-up areas to reflect the results of recent research, including the need to account for both the emissions of engine run-ups and takeoffs when analyzing the geographic distribution of lead emissions at the airport.**

CHANGES TO EXISTING FUELS AND THEIR SUPPLY

A high-octane grade of avgas that contains less lead than 100LL, known as "100VLL" (very low lead), could be used by all piston-engine aircraft. Fleetwide use of 100VLL could reduce total lead emissions by nearly 20 percent; however, this grade of leaded avgas is not currently being produced. **FAA should research public policy options, which could be implemented as quickly as possible by federal and state agencies as well as by Congress, for motivating refiners to produce and airports to supply 100VLL.**

A large portion of the current piston-engine fleet could use lower-octane unleaded avgas, including an existing grade known as "UL94." If all of these eligible aircraft were to use this fuel, aviation lead emissions could be reduced by about 30 percent. However, this outcome would require investments by airports in additional fuel storage and dispensing capacity. **FAA should research public policy options, including those that may require congressional involvement, that will enable and encourage greater use of available unleaded avgas. The options might include providing incentives for airports to supply unleaded avgas and pilots to use it on eligible aircraft.**

Credit: Darren Hall, Fargo Jet Center.

PURSUIT OF LEAD-FREE FUELS AND PROPULSION SYSTEMS

Although technically challenging, the development and deployment of lead-free, high-octane avgas has the potential to eliminate lead emissions without requiring changes to aircraft equipment and operations, or airport investments in additional fuel storage and dispensing capacity. Therefore, **FAA should continue to collaborate with the GA industry, aircraft users, airports, and fuel suppliers in the search for and deployment of an acceptable and universally usable unleaded replacement fuel.**

Tangible success is being demonstrated by aircraft engine makers in creating high-performance gasoline engines that can run on existing grades of unleaded avgas. In addition, innovations in lead-free propulsion technologies (such as diesel, electric, and gas turbine) are showing increasing potential for GA aircraft. In light of these developments, **a clear goal should be established that, after a certain point in time, all newly certified and newly produced gasoline-powered aircraft are able to operate with at least one unleaded fuel. Congressional action to establish the goal and timeframes would be desirable.**

A FEDERALLY COORDINATED EFFORT

Success in designing and implementing a multi-pathway lead mitigation strategy will require continued coordination by federal agencies having relevant responsibilities and authorities, such as the Environmental Protection Agency and the Occupational Safety and Health Administration. It will also require an ongoing commitment to research, data collection, and analysis. The committee's consensus study report recommends a number of steps in that regard.

COMMITTEE ON LEAD EMISSIONS FROM PISTON-POWERED GENERAL AVIATION AIRCRAFT

AMY R. PRITCHETT (*Chair*), The Pennsylvania State University; **BRIAN J. GERMAN,** Georgia Institute of Technology; **JACK D. GRIFFITH (NAS),** University of North Carolina at Chapel Hill; **KIMBERLY A. KENVILLE,** University of North Dakota; **MARIE LYNN MIRANDA,** University of Notre Dame; **ROBERT A. K. MITCHELL (NAE),** Northrop Grumman Aerospace Systems (*retired*); **GLENN W. PASSAVANT,** Ingevity Corporation (*retired*); **BERNARD I. ROBERTSON (NAE),** Daimler Chrysler Corporation (*retired*); **JAY R. TURNER,** Washington University; **ASCIATU J. WHITESIDE,** Dallas/Fort Worth International Airport; **RAYMOND A. WASSEL** (*Study Director*).

For More Information . . . This Consensus Study Report Highlights was prepared by the Transportation Research Board based on the Consensus Study Report Options for Reducing Lead Emissions from Piston-Engine Aircraft (2021). The study was sponsored by the Federal Aviation Administration. Any opinions, findings, conclusions, or recommendations expressed in this publication do not necessarily reflect the views of any organization or agency that provided support for the project. Copies of the Consensus Study Report are available from the Transportation Research Board or https://www.nap.edu/catalog/26050.

Transportation Research Board

The National Academies of
SCIENCES • ENGINEERING • MEDICINE

The nation turns to the National Academies of Sciences, Engineering, and Medicine for independent, objective advice on issues that affect people's lives worldwide.
www.nationalacademies.org