

Subject: Updated References from the <https://close1d2.org> Team re Leaded Aviation Fuel with Tetraethyl Lead (TEL) and Ethylene Dibromide (EDB), Monday September 14, 2020 v5. Latest version of *this* document ([html](#)).

With Reference to Project: Lead Emissions from Piston-Powered General Aviation Aircraft TRB-CAAS-18-03. Project: ([html](#)). Our Work: ([html](#)) | Projects ([html](#)).

National Academies Public Access Records Office ([PARO](#)) Dropbox: TRB-CAAS-18-03 ([html](#)).

- National Academies ([NA](#)) [[Wikipedia](#)]
- National Academy of Sciences ([NAS](#))
  - Proceedings of the National Academy of Sciences ([PNAS](#)), official journal of the National Academy of Sciences (NAS)
  - Organization of the National Research Council (NRC) ([html](#))
  - Articles of Organization of the National Research Council (NRC) ([html](#))
  - The Research Council's Permanent Status and the Academy's New Home - The National Academy of Sciences ([html](#)) ([pdf](#)) - NCBI Bookshelf ([html](#)). Chapter: 9 The Research Council's Permanent Status and the Academy's New Home ([html](#))
- National Academy of Engineering ([NAE](#))
- National Academy of Medicine ([NAM](#))
- National Academies Press ([NAP](#))
  - Airport Cooperative Research Program (ACRP) Featured Reports & Resources from ACRP ([html](#))
- Transportation Research Board ([TRB](#)) - [TRB.org](#)
  - Airport Cooperative Research Program ([ACRP](#))
  - All Projects ([html](#)) | ACRP
  - Airport (ACRP) | Publications ([html](#))
  - Webinars ([html](#))
  - Webinars about Aviation ([html](#))
- TRB Webinar: Reducing the Impact of Lead Emissions at Airports April 25, 2017 ([html](#)) ([vimeo](#)) ([pdf](#)). [ACRP Report 162](#): Guidebook for Assessing Airport Lead Impacts. The guidebook also provides a history of lead in aviation gasoline and EPA regulations. The strategies examine how the impact from lead emissions may be minimized. The report includes a Frequently Asked Questions ([FAQ](#)) document about aviation and lead, and the Contractor's Final Report ([docx](#)). DOI: [10.17226/23625](#)
- International Civil Aviation Organization ([ICAO](#))
  - Environmental Protection ([html](#))
  - 2019 Environmental Report - Aviation and Environment ([html](#)) ([pdf](#)).

PubChem ([html](#)) | National Library of Medicine ([NLM](#)), National Center for Biotechnology Information ([NCBI](#))

Tetraethyl Lead ([TEL](#)).  
Ethylene Dibromide ([EDB](#)) 1,2-Dibromoethane.  
Ethylene Dichloride ([EDC](#)) 1,2-Dichloroethane.

Agency for Toxic Substances and Disease Registry ([ATSDR](#))

Toxicological Profile: Lead, CAS: 7439-92-1, August 2020 ([html](#)) ([pdf](#)). Updates for organic lead, e.g. Tetraethyl Lead (TEL), CAS: 78-00-2, absorption via inhalation exposure, oral exposure, dermal exposure, metabolism, etc.

Toxicological Profile: 1,2-Dibromoethane (Ethylene Dibromide EDB) CAS: 106-93-4, 09-2018 ([html](#)) ([pdf](#)) ([pdf](#)) (July 1992 [pdf](#)).

Toxicological Profile: 1,2-Dichloroethane (Ethylene Dichloride EDC) CAS: 107-06-2, 09-2001 ([html](#)) ([pdf](#)).

National Institute for Occupational Safety and Health ([NIOSH](#)) | Centers for Disease Control and Prevention ([CDC](#)) | Immediately Dangerous to Life or Health ([IDLH](#)).

Immediately Dangerous to Life or Health (IDLH) Value Profile: Ethylene Dibromide (EDB) (CAS: 106-93-4) July 2020 ([html](#)) ([pdf](#)).  
DOI: [10.26616/NIOSHPUB2020125](https://doi.org/10.26616/NIOSHPUB2020125).

Immediately Dangerous to Life or Health (IDLH) Concentrations: Tetraethyl lead (TEL) (as Pb) (CAS: 78-00-2) May 1994 ([html](#)).

Immediately Dangerous to Life or Health Concentrations (IDLH): 1,1-Dichloroethane (Ethylene Dichloride EDC) (CAS: 107-06-2) May 1994 ([html](#)).

Tetraethyllead (Tetraethyl Lead TEL) ([html](#)) – Wikipedia.  
1,2-Dibromoethane (Ethylene Dibromide EDB) ([html](#)) – Wikipedia.  
1,2-Dichloroethane (Ethylene Dichloride EDC) ([html](#)) – Wikipedia.

Environmental Protection Agency (EPA)

- [US EPA](#)
- Lead (Pb) Air Pollution ([html](#))
  - Basic Information about Lead Air Pollution ([html](#))
- Airport Lead Monitoring and Modeling | Regulations for Emissions from Vehicles and Engines ([html](#))
- National Service Center for Environmental Publications ([html](#))

- Simple Search ([html](#))
- Advanced Search ([html](#))
- Fields Search ([html](#))
- Browse Publications ([html](#))
- Fuels Registration, Reporting, and Compliance Help ([html](#))
  - Registered Fuels & Fuel Additives Under 40 CFR Part 79 ([html](#))
  - Alphabetical List of Registered Gasoline and Diesel Additives ([html](#))
  - List of Registered Gasoline Additives ([html](#))

For access to the rulemaking docket containing documents relevant to the EPA's evaluation & proposed finding on the question of endangerment visit either:

- [regulations.gov](http://regulations.gov) and enter EPA-HQ-OAR-2007-0294
- [regulations.gov](http://regulations.gov) Legacy EPA-HQ-OAR-2007-0294 ([html](#))
- [regulations.gov](http://regulations.gov) Beta EPA-HQ-OAR-2007-0294 (Beta [html](#))

NOTE: NEW [regulations.gov](http://regulations.gov) is in '[Beta test](#)', URLs may change in the future.

Sunday 09-13-2020: "Regulations.gov will start redirecting users to the Beta at <https://beta.regulations.gov> on Mondays, Wednesdays, and Thursdays for 24 hours starting at 8am ET. Please note that all comments that are submitted through the Beta, both during the redirect and regular operations are provided to agencies."

Two Current Ambient Air Quality Standards for Lead

Current Ambient Air Quality Standards for Lead		
	30-Day Average	Rolling 3-Month
Average		
National Ambient Air Quality Standard	None	0.15 µg/m <sup>3</sup>
California Ambient Air Quality Standard	1.5 µg/m <sup>3</sup>	None

Some experts suggested revising average limits as low as 0.025 µg/m<sup>3</sup> in 2007, this is even more urgent based on contemporary knowledge of Tetraethyl Lead (TEL) poisoning of vulnerable populations.

Decision on Lead Emissions Weighs Heavily on EPA 05-18-2007 ([html](#)) | [Science](#) | American Association for the Advancement of Science ([AAAS](#))

Lead & Health ([html](#)) | California Air Resources Board ([ARB](#)).

Intellectual Property (IP) Search

- Google Patents ([html](#))
  - unleaded aviation gasoline ([html](#)) ([csv](#)). About 654 results.
  - "unleaded aviation gasoline" ([html](#)) ([csv](#)). About 114 results.

- United States Patent and Trademark Office ([USPTO](#))
  - Search for patents ([html](#))
- World Intellectual Property Organization ([WIPO](#)). International and National Patent Collections.
  - WIPO – Simple Search ([html](#))
  - WIPO – Advanced Search ([html](#))
- Justia Patents Search ([html](#))
  - Search Patents – unleaded aviation fuel ([html](#))
  - Search Patents – “unleaded aviation fuel” ([html](#))

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- U.S. Government Publishing Office ([GPO](#))
  - govinfo ([html](#))
- Electronic Code of Federal Regulations ([eCFR](#))
  - Title 40: Protection of Environment ([html](#))
  - PART 80—Regulation of Fuels and Fuel Additives ([html](#))

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Aviation Fuels Technical Review ([pdf](#)). See chapters 7 thru 12 for overview info re Aviation Gasoline and Aircraft piston engines | Chevron Aviation Fuels ([html](#)) — [Chevron.com](#)

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Avgas ([html](#)) – Wikipedia

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.....2020s;.....  
The Environmental Protection Agency (EPA) is evaluating the impact of lead emissions from aircraft using leaded aviation gasoline in order to make a determination regarding whether aircraft lead emissions cause or contribute to air pollution which may reasonably be anticipated to endanger public health or welfare.

The EPA currently intends to issue a proposed finding on the question of endangerment in 2017. This proposed finding will then undergo public notice and comment. After evaluating comments on the proposal, EPA plans to issue a final determination in 2018 ([html](#)) (*still delayed as of September 2020*).

Fact Sheet: Technical Update for Reports on the Impact of Lead Emissions from Piston-Engine Aircraft on Air Quality Near U.S. Airports ([pdf](#)) (4 pp, 140 K, February 2020, EPA-420-F-20-008).

- Model-extrapolated Estimates of Airborne Lead Concentrations at U.S. Airports ([pdf](#)) (144 pp, 4.1 MB, February 2020, EPA-420-R-20-003). This report provides estimated ranges of lead concentrations at and near airports where leaded aviation gas is used.
  - EPA Response to External Peer Review Comments on the EPA Report: Model-extrapolated Estimates of Airborne Lead Concentrations at U.S. Airports ([pdf](#)) (67 pp, 1.4 MB, February 2020, EPA-420-R-20-004)
- National Analysis of the Populations Residing Near or Attending School Near U.S. Airports ([pdf](#)) (28 pp, 1 MB, February 2020, EPA-420-R-20-001). This report provides a national-scale analysis of the number of people who live or attend school within 500 meters (one half kilometer) of airport runways in the U.S.
  - EPA Response to External Peer Review Comments on the EPA Report: National Analysis of the Populations Residing Near or Attending School Near U.S. Airports ([pdf](#)) (135 pp, 2.7 MB, February 2020, EPA-420-R-20-002)

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Leaded Aviation Fuel May Present Long-Term Effects on Campus Life from the Adjacent Albert Whitted Airport, 08-25-2020 ([html](#)) ([pdf](#)) | [ChemRxiv](#) ([html](#)). AirNav: KSPG - Albert Whitted Airport ([html](#)). Albert Whitted Airport ([html](#)) – Wikipedia. Albert Whitted Airport ([html](#)) - St. Petersburg. University of South Florida, St Petersburg. City of St Petersburg: Albert Whitted Airport ([html](#)) - Google Maps.

Medical & University Facilities dangerous distance's from KSPG airport:

- University of South Florida, St. Petersburg - 100 m

- Johns Hopkins All Children's Hospital - 575 m
- Johns Hopkins All Children's Child Development and Rehabilitation Center - 655 m
- Ronald McDonald House - 530 m
- All Children's Hospital Outpatient Care Center - 629 m
- Bayfront Health St. Petersburg - 779 m

Lead emissions from the use of leaded avgas in Turkey 08-06-2020 ([html](#)) | Aircraft Engineering and Aerospace Technology ([html](#)) | Emerald Insight ([html](#)). DOI: [10.1108/AEAT-05-2020-0108](#)

Review of DoD's Proposed Occupational Exposure Limits for Lead 2020 DELS-BEST-18-05. Project: ([html](#)). Our Work: ([html](#)). | Projects ([html](#)) | [NAS](#) | [NAP](#). Consensus Study Report.

Introduction - Review of the Department of Defense Biokinetic Modeling Approach in Support of Establishing an Airborne Lead Exposure Limit ([html](#)) ([pdf](#)) | NCBI Bookshelf ([html](#)), National Center for Biotechnology Information ([NCBI](#)), U.S. National Library of Medicine ([NLM](#)).

Measuring Quality of Life in Communities Surrounding Airports 2020 ([html](#)) [NAP](#). ACRP Research Report 221.

Guidance for Using the Interactive Tool for Understanding NEPA at General Aviation Airports 2020 ([html](#)) | [NAP](#). ACRP Research Report 211.

Airport Environmental Research Roadmap Narrative Report 2020 ([html](#)) | [NAP](#). Web Only Document 45.

2010s  
 Progress Report on the Federal Action Plan to Reduce Childhood Lead Exposures and Associated Health Impacts, EPA October 2019 ([pdf](#)) (48 pp, 20 MB)

Implementation Status Report for EPA Actions under the December 2018 Federal Action Plan to Reduce Childhood Lead Exposures and Associated Health Impacts ([pdf](#)) (32 pp, 8 MB, April 2019, EPA 100-R-19-003)

Airport Management Guide for Providing Aircraft Fueling Services 2019 ([html](#)) | [NAP](#). ACRP Research Report 192.

The concurrent decline of soil lead and children's blood lead in New Orleans ([html](#)) ([pdf](#)). PNAS October 29, 2019 116 (44) 22058-22064; first published October 14, 2019 | [PNAS](#). Author comment: other researchers, however, have indicated that Pb contamination of soil from TEL [Tetraethyl Lead] is at least as

important, if not more so, than lead-based paint as a source of children's Pb exposure.

DOI: [10.1073/pnas.1906092116](https://doi.org/10.1073/pnas.1906092116)

Recent Increases in Air Pollution: Evidence and Implications for Mortality ([html](#))  
Karen Clay & Nicholas Muller, NBER Working Paper, October 2019. Air quality has worsened since 2016, associated with more premature deaths in U.S. The health implications of this increase in PM2.5 between 2016 and 2018 are significant. The increase was associated with 9,700 additional premature deaths in 2018. At conventional valuations, these deaths represent damages of \$89 billion.

Air quality has worsened since 2016, associated with more premature deaths in U.S. ([html](#)) ([pdf](#)) 11-27-2019 | [Phys.org](#). Decreases in enforcement of the Clean Air Act: Enforcement of this law may influence compliance by firms, and the study found that the most frequent type of enforcement of the Clean Air Act fell from 2009 to 2016 and continued to fall from 2016 to 2018.

Rethinking the Value of Life: A Critical Appraisal of the Value of a Statistical Life ([html](#)) ([pdf](#)) January 2020 | Center for Growth and Opportunity ([html](#)) at Utah State University ([html](#)). Given that current estimates of the Value of a Statistical Life (VSL) used in regulatory impact analysis are in the range of \$10 million dollars, and that these values are attached to the lives of the elderly, it seems likely that the EPA's benefits estimates are off. Therefore, it's worth considering how alternative metrics might change policy conclusions. This change alone would likely wipe out most of the benefits of EPA air regulations.

The Young, the Old, and the Economists: Rethinking How Agencies Account for Age in Cost-Benefit Analysis ([html](#)) ([pdf](#)) 2015 Yale Journal of Health Policy, Law, and Ethics ([html](#)) Volume 14 Issue 2 Article 3 | Yale Law School ([html](#)).

It might be time to re-examine EPA formulas for calculating the Value of a Statistical Life (VSL) and how this realistically relates to Health, Safety and Welfare of actual human lives, especially with respect to pregnant women, babies and school children.

For more details re EPA formulas see: Mortality Risk Valuation ([html](#)) | Environmental Economics ([html](#)) | [US EPA](#).

A Critical Assessment of the EPA's Air Program at Fifty and a Suggestion for How It Might Do Even Better 2020, E. Donald Elliott. Case Western Reserve Law Review ([html](#)) | Vol 70 | Issue 4 ([html](#)) | Article 6 ([html](#)) ([pdf](#)) | Case Western Reserve University School of Law ([html](#)) | Case Western Reserve University ([html](#)).

U.S. GAO - Environmental Regulation: EPA Should Improve Adherence to Guidance for Selected Elements of Regulatory Impact Analyses (RIA) ([html](#)) ([pdf](#)) (highlights [pdf](#)). GAO-14-519: Published: Jul 18, 2014. Publicly Released: Aug 11, 2014. First, EPA did not monetize certain benefits and costs related to the primary purposes or key impacts of the rules GAO reviewed, such as reducing hazardous air pollutants and water quality effects. EPA officials said resource and data limitations constrained the agency's ability to monetize these effects. OMB guidance acknowledges that monetizing effects is not always possible.

However, without doing so, the public may face challenges understanding the trade-offs associated with regulatory alternatives. Second, EPA estimated effects of its regulations on employment, in part, using a study that, according to EPA officials, represented the best reasonably obtainable data when they conducted their analyses. However, the study was based on data that were more than 20 years old and may not have represented the regulated entities addressed in the RIAs. **NOTE:** as of March 2020 the GAO is keeping two Recommendations in OPEN status:

- #1 As of March 2020, GAO is keeping this recommendation open to ensure the transparency and clarity of information presented for selected elements in and across EPA's Regulatory Impact Analyses (RIA)s.
- #4 As of March 2020, GAO is keeping this recommendation open until it is clearer how EPA is using the Science Advisory Board's (SAB) work to develop its regulatory impact analyses.

See 'Recommendations' tab ([html](#)) for details.

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[SocArXiv](#) Papers | The social cost of leaded gasoline [Leaded 100LL Aviation Fuel]: Evidence from regulatory exemptions ([html](#)) ([pdf](#)) 92 pages, submitted September 22, 2019, last edited: October 23, 2019.  
DOI [10.31235/osf.io/rdy6g](https://doi.org/10.31235/osf.io/rdy6g)

Paper was updated, renamed, and resubmitted: The effect of leaded gasoline on elderly mortality: Evidence from regulatory exemptions. Alex Hollingsworth and Ivan Rudik, June 8, 2020.

Original paper: The social cost of leaded gasoline: Evidence from regulatory exemptions ([html](#)) ([pdf](#)) | Semantic Scholar.

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Response Surface Methodology (RSM) in Optimization of Performance and Exhaust Emissions of RON 97, RON 98, and RON 100 (Motor Gasoline) and AVGAS 100LL (Aviation Gasoline) in Lycoming O-320 Engine ([html](#)) 08-19-2019 (03-12-04-0029 Journal Article) - [SAE Mobilus](#). Federal Aviation Administration (FAA)'s 20 years of research and development with 200 unleaded blends and full-scale engine tests on 45 high-octane unleaded blends has *not* found a "drop-



in” unleaded replacement for aviation gasoline (AVGAS) 100 low lead (100LL) fuel.

DOI: <https://doi.org/10.4271/03-12-04-0029>

Aggressive Canton Plymouth Mettetal 1d2 airstrip expansion & growth by Michigan Department of Transportation (MDOT) in densely populated neighborhoods surrounded by schools directly correlates to 47% increase 07-19-2019 ([html](#)) | Hometown Life - in the number of Autism Spectrum Disorder (ASD) and Attention Deficit Hyperactivity Disorder (ADHD) students at Plymouth-Canton Community Schools ([PCCS](#)) over the last decade.

NOTE: [run-up](#) areas at [Canton Plymouth](#) Mettetal 1d2 airstrip ([html](#)) are dangerously close between 190m to 950m to THREE schools and TWO elderly assisted living & rehabilitation facilities! PCCS Hulsing Elementary School ([html](#)), Plymouth Christian Academy ([html](#)), PCCS East Middle School ([html](#)). Canton-Plymouth Mettetal Airport (1D2) ([html](#)) - Google Maps.

Curtailing Lead Aerosols: Effects of Primary Prevention on Declining Soil Lead and Children’s Blood Lead in Metropolitan New Orleans ([html](#)) ([pdf](#)). Int J Environ Res Public Health ([html](#)) 06-12-2019; 16(12): 68. TEL is a still a legal product in the U.S. and used as an additive to aviation gas or LL100 avgas (containing 0.56 g Pb per L). The U.S. EPA estimates that avgas now accounts for about 60% of the current Pb aerosol in the U.S. An outcome of avgas is that BPb is higher for children living within 0.5–1 km of airports where avgas is used compared with children living 1 km beyond these airports. Particularly concerning is the fact that all grades of fuel, leaded and unleaded gasoline, are transported through the same pipelines. To protect petroleum industry from liability due to lead contamination of fuel an allowable amount of TEL is permitted in unleaded gasoline.

IJERPH ([html](#)) | Free Full-Text | Curtailing Lead Aerosols: Effects of Primary Prevention on Declining Soil Lead and Children’s Blood Lead in Metropolitan New Orleans. ([html](#)) ([pdf](#)). DOI: [10.3390/ijerph16122068](https://doi.org/10.3390/ijerph16122068)

Elemental characterization of general aviation aircraft emissions using moss bags | SpringerLink. Received: 01-13-2019 / Accepted: 3 July 2019 / Published online: 15 July 2019 # Springer-Verlag GmbH Germany, part of Springer Nature 2019 ([html](#)) ([PubMed](#)).

Airport Air Quality Management 101 2018 ([html](#)) | [NAP](#). ACRP Research Report 185.

A review of phase separation issues in aviation gasoline fuel and motor gasoline fuels in aviation 2018 ([html](#)) ([pdf](#)) – [IOPscience](#)  
DOI: [10.1088/1757-899X/370/1/012007](https://doi.org/10.1088/1757-899X/370/1/012007)

Ethanol content concerns in motor gasoline (mogas) in aviation in comparison to aviation gasoline (avgas) 2018 ([html](#)) ([pdf](#)) – [IOPscience](#).

DOI: [10.1088/1757-899X/370/1/012009](https://doi.org/10.1088/1757-899X/370/1/012009)

Emissions of piston engine aircraft using aviation gasoline (avgas) and motor gasoline (mogas) as fuel – a review 2018 ([html](#)) ([pdf](#)) - [IOPscience](#)

DOI: [10.1088/1757-899X/370/1/012012](https://doi.org/10.1088/1757-899X/370/1/012012)

Concerns over use of leaded aviation gasoline (avgas) fuel, Chemical Engineering Transactions Vol. 63, 2018 ([pdf](#)) | ([html](#)) Semantic Scholar.

DOI: [10.3303/CET1863031](https://doi.org/10.3303/CET1863031)

A new bottom-up emissions estimation approach for aircraft sources in support of air quality modelling for community-scale assessments around airports ([html](#))

([pdf](#)) | [Europe PMC](#)

International Journal of Environment and Pollution, 12-31-2018, 65(123):43-58.

DOI: [10.1504/ijep.2019.101832](https://doi.org/10.1504/ijep.2019.101832)

Emission Due to Motor Gasoline Fuel in Reciprocating Lycoming O-320 Engine in Comparison to Aviation Gasoline Fuel 07-10-2018 ([pdf](#)). Environment & Ecosystem Science ([EES](#)) 2(2) (2018) 20-24.

DOI : [10.26480/ees.02.2018.20.24](https://doi.org/10.26480/ees.02.2018.20.24)

Pro-inflammatory responses to PM0.25 from airport and urban traffic emissions ([html](#)) | [Europe PMC](#)

The Science of the Total Environment, 06-04-2018, 640-641:997-1003.

DOI: [10.1016/j.scitotenv.2018.05.382](https://doi.org/10.1016/j.scitotenv.2018.05.382)

Chemical composition measurements confirmed that aircraft emissions were the major source to LAX PM0.25. Results demonstrated considerable toxicity of airport-related particles, even at low exposure concentrations, suggesting that airport emission as source of PM0.25 may also contribute to the adverse effects on public health attributable to PM.

Review of Alternative Fuel Initiatives for Leaded Aviation Gasoline (AVGAS) Replacement, 05-01-2018 ([html](#)) ([pdf](#)) | Chemical Engineering Transactions ([html](#)).

News release: Trump Administration Unveils Federal Action Plan to Reduce Childhood Lead Exposure EPA 12/19/2018 ([html](#)).

Federal Action Plan to Reduce Childhood Lead Exposures and Associated Health Impacts, EPA December 2018 ([pdf](#)) (24 pp, 9 MB).

The information EPA and others have been collecting is part of a broad set of information that EPA expects to consider when evaluating the question of whether aircraft lead emissions cause or contribute to air pollution which may

reasonably be anticipated to endanger public health or welfare. This evaluation has been identified as a long-term action in the current Unified Agenda of Regulatory and Deregulatory Actions, EPA RIN: 2060-AT10, Publication ID: Fall 2018 ([html](#)).

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Piston Aviation Fuel Initiative (PAFI) – A Review 2017 ([html](#)) ([pdf](#)) – [IOPscience](#). DOI: [10.1088/1757-899X/370/1/012010](#)

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Controlled Human Inhalation-Exposure Studies at EPA 2017 ([html](#)) | [NAP](#) Consensus Study Report.

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Development of an inhalation unit risk factor for ethylene dibromide, Inhalation Toxicology, International Forum for Respiratory Research, Volume 29, 2017 - Issue 7, 09-17-2017 ([html](#)) ([pdf](#)) DOI: [10.1080/08958378.2017.1369603](#)

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NIOSH Skin Notation Profiles: Tetraethyl Lead (TEL) (2017-190) August 2017 ([html](#)) ([pdf](#)) | National Institute for Occupational Safety and Health ([NIOSH](#)) | Centers for Disease Control and Prevention ([CDC](#)).

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[PEW](#) – The [Health Impact Project](#), a collaboration of the [Robert Wood Johnson Foundation](#) and [The Pew Charitable Trusts](#) | 10 Policies to Prevent and Respond to Childhood Lead Exposure: An assessment of the risks communities face and key federal, state, and local solutions, August 30, 2017 ([html](#)) ([pdf](#)).

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Lead (Pb) Toxicity: Key Concepts, CE Original Date: 06-12-2017, CE Expiration Date: 06-12-2021 ([html](#)) ([pdf](#)) | Agency for Toxic Substances and Disease Registry ([ASTR](#)) - Environmental Medicine & Environmental Health Education ([html](#)) - Case Studies in Environmental Medicine ([CSEM](#)).

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National Ambient Air Quality Standards ([NAAQS](#)) for Lead (Pb). Rule Summary – EPA September 16, 2016, based on its review of the air quality criteria for lead (Pb), the Environmental Protection Agency issued a decision to retain the existing 2008 standards without revision. The primary and secondary Pb standards are 0.15 micrograms per cubic meter Pb in total suspended particles as a 3-month average.

EPA Lead Compounds ([pdf](#)), September 2016.

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Fuels and Combustion Technologies for Aerospace Propulsion, September 2016 Final Report ([pdf](#)) AFRL-RQ-WP-TR-2016-0144. 11 December 2009 – 30 September 2016

- University of Dayton Research Institute ([UDRI](#)) : University of Dayton ([html](#)), Ohio
- Air Force Research Laboratory ([AFRL](#)) Aerospace Systems Directorate ([RQ](#)) - The Aerospace Systems Directorate brings together world-class

facilities including a fuels research facility, structural testing labs, compressor research facility, rocket testing facilities, supersonic and subsonic wind tunnels, flight simulation lab, and many other cutting-edge research labs.

- Wright-Patterson AFB ([WPAFB](#))
- Air Force Materiel Command ([AFMC](#))
- U.S. Air Force ([AF](#)), U.S. Air Force ([USAF](#))

See § 3.3.8 Unleaded Avgas. The Air Force utilizes leaded avgas (100LL) to fuel the MQ-1 Predator UAV to help carry out its mission. There are several problems with using 100LL: 1) a future ban on lead in avgas from the EPA, 2) there is only one supplier of the octane-enhancer additive tetraethyl lead (TEL), 3) lead deposits can decrease performance, increase maintenance, and shorten engine lifetime and 4) its costs outside the continental US are quite high. One solution to solving these problems is to find an unleaded high-octane replacement fuel that is lower in cost. This solution would align with USAF's Energy Strategic Plan in multiple ways. First, it could improve resiliency by negating the need for TEL and avoiding a ban on 100LL. Second, it could reduce demand by providing a solution that consumes less fuel. Third, it could ensure supply by utilizing a renewable fuel. The objective of this project was, therefore, to find an available low-cost unleaded fuel that is suitable for operation in the MQ-1 engine.

Conclusion: All of the four options available have the ability to solve the problems associated with 100LL and save the USAF millions of dollars annually.

- MQ-1B Predator September 23, 2015 ([html](#)) > U.S. Air Force > Fact Sheet Display
- Air Force announces official retirement date for iconic MQ-1 Predator drone 02-16-2018 ([html](#)) | Air Force Times ([html](#))
- General Atomics MQ-1 Predator ([html](#)) – Wikipedia
- Air Force to Retire MQ-1 Predator Drone, Transition to MQ-9 Reaper 02-27-2017 ([html](#)) > U.S. DEPARTMENT OF DEFENSE ([DoD](#)) > Defense Department News ([html](#))

Department of Defense ([DOD](#)) Standard Practice Quality Assurance/Surveillance for Fuels, Lubricants and Related Products 03-28-2016 ([pdf](#)). MIL-STD-3004D w/Change 1 28 MAR 2016, Superseding MIL-STD-3004D 10 October 2014.

Toward cleaner burning, better performing engines June 25, 2015 ([html](#)): University of Dayton ([html](#)), Ohio. The award included an initial work order for basic research in [combustion](#). Researchers will design, fabricate, assemble, instrument and develop tests and apparatus to perform experiments in research areas including flame chemistry, turbulence-chemistry interaction, emissions formation, alternative fuel combustion and more. Developing a better understanding of combustion processes will enable the development of higher performing, less polluting engines.

Impact assessment of Aviation gasoline formulation change on aircraft operating limitation, 05-04-2017 ([html](#)) ([pdf](#)) | TU Delft Repositories ([html](#)).

The Effect of Fuel Additives in a Natural Gas and Gasoline Engine ([pdf](#)) , Fall 2016 | Mountain Scholar ([html](#)). Thomas Falloon, Department of Mechanical Engineering ([html](#)) , Colorado State University ([html](#)), Fort Collins, Colorado, Fall 2016. Master's Committee Advisor: Anthony J. Marchese, Ph.D., Associate Dean for Academic and Student Affairs ([html](#)) CV ([pdf](#)).

14th Report on Carcinogens ([html](#)) U.S. Department of Health and Human Services released the 14th Report on Carcinogens on November 3, 2016. The Report on Carcinogens is a congressionally mandated, science-based, public health document that National Toxicology Program ([NTP](#)) prepares for the U.S. Department of Health & Human Services ([HHS](#)) Secretary ([html](#)).

- Complete 14th Report on Carcinogens ([zip](#))
- 1,2-Dibromoethane, Ethylene Dibromide (EDB) ([pdf](#))
- Lead and Lead Compounds ([pdf](#)) including Tetraethyl Lead (TEL)
- 1,2-Dichloroethane, Ethylene Dichloride (EDC) ([pdf](#))

Myths & Realities of Leaded Aviation Fuel September 2016 ([html](#)) ([html](#)) ([pdf](#)) | Prepared by Center for Environmental Health ([CEH](#)) for Friends of the Earth ([FoE](#)), funding provided by The New York Community Trust ([html](#)).

Costs of IQ Loss from Leaded Aviation Gasoline Emissions ([html](#)) ([pdf](#)). Environ Sci Technol. 2016 Sep 6; 50(17): 9026–9033. Published online 08-23-2016. doi: [10.1021/acs.est.6b02910](https://doi.org/10.1021/acs.est.6b02910)

Spatial Differences and Costs of Emissions at U.S. Airport Hubs ([html](#)) | [Europe PMC](#). Southeast Michigan shows annual airport damages of \$25 - \$50 million dollars annually. As the U.S. aviation system grows, it is possible to minimize human and environmental costs by shifting aircraft technologies and expanding service into airports where fewer impacts are likely to occur. Environmental Science & Technology, 03-23-2016, 50(8):4149-4158. DOI: [10.1021/acs.est.5b04491](https://doi.org/10.1021/acs.est.5b04491)

Past, present, future of Fuelling [sp?] ([html](#)) | News and views ([html](#)) | [Air BP](#). Initially developed as an unleaded fuel, a lead additive – Tetra Ethyl Lead (TEL) - was introduced around 80 years ago. TEL has been a vital ingredient in achieving the high octane quality of Avgas. The current grade Avgas 100LL (low lead), which was introduced in the 1970s, is still widely available around the world.

However, environmental pressures to eliminate the use of lead and seek cleaner, greener fuels now face the industry. Air BP introduced *unleaded Avgas (UL91)* in 2016 and will continue to explore and develop unleaded fuel options to satisfy demand.

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Guidebook for Assessing Airport Lead Impacts 2016 ([html](#)) | [NAP](#). ACRP Research Report 162.

Methodology to Improve AEDT Quantification of Aircraft Taxi/Idle Emissions 2016 ([html](#)) | [NAP](#). ACRP Web Only Document 26.

Exhaust Emissions from In-Use General Aviation Aircraft 2016 ([html](#)) | [NAP](#). ACRP Research Report 164.

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Atmospheric lead monitoring at Moorabbin Airport, Melbourne, Australia 04-06-2016 ([html](#)) ([pdf](#)) - [CORE](#).

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Fact Sheet: Program Overview on Airport Lead Monitoring ([pdf](#)) (4 pp, 215 K, EPA-420-F-15-003, January 2015). This Program Summary provides a final summary of the data on concentrations of lead measured at 17 airport facilities in the U.S.

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Effect of Gasoline Fuel Additives on Combustion and Engine Performance ([html](#)) ([pdf](#)), Mart Mägi. Submitted for the degree of Doctorate of Philosophy (Ph.D.) in Mechanical Engineering, 2015 | University College London ([UCL](#)) Discovery ([html](#)).

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Quantifying Aircraft Lead Emissions at Airports 2015 ([html](#)) | [NAP](#). ACRP Web Only Document 21.

Overview of Airport Fueling Operations 2015 ([html](#)) | [NAP](#). ACRP Synthesis 63.

Understanding Airport Air Quality and Public Health Studies Related to Airports 2015 ([html](#)) | [NAP](#). ACRP Report 135.

Best Practices Guidebook for Preparing Lead Emission Inventories from Piston-Powered Aircraft with the Emission Inventory Analysis Tool 2015 ([html](#)) | [NAP](#). ACRP Report 133.

Measurement, Modeling, and Mitigation of Lead Impacts from General Aviation 12-15-2015 ([html](#)) ([pdf](#)) | Washington University Open Scholarship ([html](#)) | Washington University in St. Louis ([html](#)) | McKelvey School of Engineering ([html](#)).

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Guidance on the Determination of Helicopter Emissions ([html](#)) Edition 2 - December 2015 ([pdf](#)), Helicopter Emissions Table (186 kB, 27.07.2017) ([xls](#)) | Swiss Federal Office of Civil Aviation ([FOCA](#)).

The Effect of Leaded Aviation Gasonline [sp?] on Blood Lead in Children ([html](#)) ([pdf](#)) by Zahran, Sammy and Iverson, Terrence and McElmurry, Shawn ([html](#)), Wayne State University ([WSU](#)), Detroit, Michigan and Weilar, Stephan (2014).

An updated version was published in the Journal of the Association of Environmental and Resource Economists ([home](#)): Vol 4, No 2, April 11, 2017 ([html](#)) DOI: [10.1086/691686](#) with the corrected spelling of the title “The Effect of Leaded Aviation Gasoline on Blood Lead in Children”.

Aircraft engine exhaust emissions and other airport-related contributions to ambient air pollution: A review ([html](#)) ([pdf](#)) | PubMed Central® ([PMC](#)) | National Center for Biotechnology Information ([NCBI](#)) | U.S. National Library of Medicine ([NLM](#)).

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Gasoline toxicology: overview of regulatory and product stewardship programs 2014 ([html](#)) | PubMed ([html](#)) | National Center for Biotechnology Information ([NCBI](#)), U.S. National Library of Medicine ([NLM](#)).

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Federal Aviation Administration ([FAA](#)) Aviation Gasoline – About Aviation Gasoline ([html](#)). FAA Timeline:

- No clear indication re public declaration of ‘program’ start or estimated finish date, milestones, deliverables, financials, etc. or commitments / accountability. Appears to be a 50 year plus open-ended science fair project with no clearly defined boundaries or project plan(s).
- June 10, 2013, FAA issued a request for candidate fuel producers to submit unleaded fuel formulations to be evaluated as replacements for 100LL.
- Latest Status: August 20, 2020: Piston Aviation Fuels Initiative (PAFI) Update.

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Health Hazard Evaluation Report: Exposures to Lead and Other Metals at an Aircraft Repair and Flight School Facility, NIOSH #20042888 07-2013 ([html](#)) ([pdf](#)) | Center for Disease Control and Prevention ([CDC](#)), National Institute for Occupational Safety and Health ([NIOSH](#)). Semantic Scholar | ([html](#)) ([pdf](#)).

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Ethyl-leaded Gasoline: How a Classic Occupational Disease Became an International Public Health Disaster 07-19-2013 ([html](#)) ([pdf](#)): International Journal of Occupational and Environmental Health ([html](#)), Volume 11, 2005 - [Issue 4: Corporate Corruption of Science](#).



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Fact Sheet: Program Update on Airport Lead Monitoring ([pdf](#)) (4 pp, 210 K, EPA-420-F-13-032, June 2013). This Program Update provided a summary of the data on concentrations of lead measured at 17 airport facilities in the U.S.

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Low Level Lead Exposure Harms Children: A Renewed Call for Primary Prevention. Report of the Advisory Committee on Childhood Lead Poisoning Prevention of the Centers for Disease Control and Prevention ([CDC](#)), 01-04-2012 ([html](#)) ([pdf](#)) ([pdf](#)). CDC response to Advisory Committee on Childhood Lead Poisoning Prevention recommendations in "Low level lead exposure harms children: a renewed call for primary prevention." Atlanta, GA: US Department of Health and Human Services, CDC; 2012 ([pdf](#)).

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National Toxicology Program (NTP) Monograph On Health Effects of Low-level Lead, 06-13-2012 ([html](#)) ([pdf](#)) ([PubMed](#)) | National Toxicology Program ([NTP](#)) is at National Institute of Environmental Health Sciences ([html](#)), part of the National Institutes of Health ([html](#)).

- Appendices A-E: Human Studies ([pdf](#)) (includes all appendices).
- Appendix A: Human Studies – Neurological Studies ([pdf](#)).
- Appendix B: Human Studies – Immune ([pdf](#)).
- Appendix C: Human Studies – Cardiovascular ([pdf](#)).
- Appendix D: Human Studies – Renal ([pdf](#)).
- Appendix E: Human Studies – Reproductive and Developmental ([pdf](#)).

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Guidance for Quantifying the Contribution of Airport Emissions to Local Air Quality 2012 ([html](#)) | [NAP](#). ACRP Report 71.

Alternative Fuels as a Means to Reduce PM2.5 Emissions at Airports 2012 ([html](#)) | [NAP](#). ACRP Web Only Document 13.

EPA Response to the 2006 Petition from Friends of the Earth Regarding Lead Emissions from Piston-Engine Aircraft ([pdf](#)) (2 pp, 135K, EPA-420-F-12-050, July 2012)

EPA Response Memorandum to the 2006 Petition from Friends of the Earth Regarding Lead Emissions from Piston-Engine Aircraft ([pdf](#)) (20 pp, 10 MB, EPA July 18, 2012)

ASTM D 910 - Standard Specification for Aviation Gasolines, 08-31-2011 ([pdf](#)).

Collective Knowledge on Aviation Gasolines, Purdue University, 7-10-2011 ([html](#)) ([pdf](#)).

Comparison The Piston Air Engine Performance With Aviation Gasoline (Avgas) Or The E-85 Ecological Fuel Supply ([pdf](#)) | Instytut Techniczny Wojsk Lotniczych - Air Force Institute of Technology ([html](#)) | Journal of KONES Powertrain and Transport ([html](#)), Vol. 17, No. 3, 2010 ([html](#)). Semantic Scholar ([pdf](#)).

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URI: <http://hdl.handle.net/20.500.11822/27635>

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Global mortality attributable to aircraft cruise emissions ([html](#)) ([pdf](#)) | [Europe PMC](#).

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Final Report June 2010 ([pdf](#)), Research Results Unleaded High Octane Aviation Gasoline, CRC Report No. AV-7-07, CRC Project No. AV-7-07 | Coordinating Research Council ([CRC](#)). NOTE: Executive Summary issued April 24, 2008.

Analysis of Organometallic Gasoline Additives with the Composition-Explicit Distillation Curve Method ([html](#)) ([pdf](#)). Thermophysical Properties Division ([html](#)), National Institute of Standards and Technology ([NIST](#)), Boulder, Colorado 80305 Received May 25, 2010. Revised Manuscript Received August 17, 2010. Energy Fuels 2010, 24, 5508–5513: DOI: [10.1021/ef1006403](https://doi.org/10.1021/ef1006403) Published on Web 09/09/2010.

Analysis of Organometallic Gasoline Additives with the Composition-Explicit Distillation Curve Method ([html](#)) | Energy & Fuels.

Development and Evaluation of an Air Quality Modeling Approach for Lead Emissions from Piston-Engine Aircraft Operating on Leaded Aviation Gasoline ([pdf](#)) (86 pp, 6.5 MB, EPA-420-R-10-007, February 2010)

This final report presents the results of EPA's study to develop a modeling approach to quantify how emissions from piston-engine aircraft affect ambient lead levels at the local scale.

- Advance Notice of Proposed Rulemaking ([pdf](#)) (30 pp, 719 K, EPA published April 28, 2010). Federal Register/Vol. 75, No. 81/Wednesday, April 28, 2010/Proposed Rules.
  - Extension of Comment Period ([pdf](#)) (2 pp, 141 K, EPA published June 24, 2010)

Memorandum on Selection of Airports for the Airport Monitoring Study ([pdf](#)) (40 pp, 15 MB, EPA November 18, 2010).

Advanced Notice of Proposed Rulemaking on Lead Emissions from Piston Engine Aircraft Using Leaded Aviation Gasoline ([pdf](#)) (3 pp, 560 K, EPA-420-F-10-013, April 2010)

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European Automobile Manufacturers' Association ([ACEA](#)) Position on Metal Based Fuel Additives ([pdf](#)), 11-16-2009. Policy makers have a duty to act proactively to prevent harm rather than reactively when the harm occurs.

The precautionary principle was not applied to lead, and this failure yielded significant public health costs. As early as 1924, public health scientists including Yendell Henderson of Yale University stated that widespread use of tetraethyl lead constituted a “probable industrial and public health hazard”. Despite this awareness and the lack of scientific certainty on the matter, no restrictions were placed on tetraethyl lead. The cumulative mental health effects of lead exposure would have been avoided with the precautionary principle.

In the 1970s, the US Court of Appeals applied the precautionary principle to a regulation on lead phase-out. It found that the EPA does not have to prove that a product is a public health hazard in order to prohibit its use. It merely should show that the product is likely to be dangerous. This finding allowed the phase-out and the eventual ban on leaded gasoline [for automobiles].

Aircraft emission impacts in a neighborhood adjacent to a general aviation airport in southern California ([html](#)) | [Europe PMC](#).  
Environmental Science & Technology, 10-01-2009, 43(21):8039-8045.  
DOI: [10.1021/es900975f](#)

The observation of highly elevated ultrafine particle concentrations in a large residential area downwind of this local airport has potential health implications for persons living near general aviation airports.

BTW: Santa Monica( SMA) airport is officially closing 2028. SMO: Santa Monica Municipal Airport ([html](#)). Past, Present, Future disposition.

FAA Caves In to City Demand To Close Santa Monica Airport 01-29-2017 ([html](#)) | General Aviation News: Aviation International News.

According to FAA Administrator Michael Huerta, “Mutual cooperation between the FAA and the city enabled us to reach this innovative solution, which resolves longstanding legal and regulatory disputes. This is a fair resolution for all concerned because it strikes an appropriate balance between the public's interest in *making local decisions about land-use practices* and its interests in safe and efficient aviation services.”

Santa Monica Airport will close in 2028 and be replaced by a park, officials say 01-28-2017 ([html](#)) - Los Angeles Times.

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A Personal Perspective on the Initial Federal Health-Based Regulation to Remove Lead from Gasoline August 2009 ([html](#)) ([pdf](#)). [Environ Health Perspect.](#) August 2009; 117(8): 1195–1201. | National Center for Biotechnology Information ([NCBI](#)), U.S. National Library of Medicine ([NLM](#)).

DOI: [10.1289/ehp.0800534](#)

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Aircraft hydrocarbon emissions at Oakland International Airport [Michigan] ([html](#)) | [Europe PMC](#). *Environmental Science & Technology*, 02-12-2009, 43(6):1730-1736.

DOI: [10.1021/es801307m](#)

Using estimates of operational fuel flow rates at idle, this analysis suggests that current emission inventories at the temperatures encountered at this airport underestimate hydrocarbon emissions from the idle phase of operation by 16-45%.

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Methodology to estimate particulate matter emissions from certified commercial aircraft engines ([html](#)) ([pdf](#)) | [Europe PMC](#).

*Journal of the Air & Waste Management Association* (1995), 12-31-2008, 59(1):91-100.

DOI: [10.3155/1047-3289.59.1.91](#)

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USEPA (2008) Lead Emissions from the Use of Leaded Aviation Gasoline in the United States October 2008 (Beta [html](#)) ([pdf](#)) - Technical Support Document [EPA420-R-08-020].  
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USEPA (2008) Natural Attenuation of the Lead Scavengers EDB [Ethylene Dibromide] and 1, 2-DCA [Ethylene Dichloride EDC, DCE] September 2008 (Beta [html](#)) ([pdf](#)) [EPA 600/R-08/107].

Flight performance testing of ethanol/100LL fuel blends during cruise flight 05-2008 ([html](#)) ([pdf](#)). Timothy James Compton, M.S. Thesis | Baylor University ([html](#)) | A Nationally Ranked Christian University, Undergraduate & Graduate Research Colleges Universities Schools in Texas. Approved by the Institute for Air Science ([html](#)), Maxwell E. Shauck, Jr., Ph.D. (CV [pdf](#)), Chairperson.

Executive Summary April 24, 2008 ([pdf](#)), CRC Research Results, Unleaded High Octane Aviation Gasoline, A Report to the CRC Unleaded Avgas Development Panel | Coordinating Research Council ([CRC](#)).

Membership of the CRC Unleaded AVGAS Development Panel currently consists of over 60 individuals representing over 40 different organizations. Working in parallel with this panel, and with mostly a common membership, is the CRC Aviation Engine Octane Rating Panel. Members include:

- Aircraft Owners and Pilots Association ([AOPA](#)) [[Wikipedia](#)]
- Air BP ([html](#))
- Cessna Aircraft | Jet, Turboprop and Piston Models ([html](#)) | Textron Aviation ([html](#))
- Chevron Aviation Fuels ([html](#)) — [Chevron.com](#)
- ConocoPhillips ([html](#)) | Phillips 66 Aviation ([html](#))
- Dixie Services
- EAA Experimental Aircraft Association ([EAA](#)) [[Wikipedia](#)]
- Ethyl Corporation ([html](#))
- ExxonMobil Aviation ([html](#)) | Avgas ([html](#)) | ExxonMobil ([html](#))
- Federal Aviation Administration ([FAA](#)) | William J. Hughes Technical Center ([html](#))
- GAMA General Aviation Manufacturers Association ([GAMA](#)) [[Wikipedia](#)]
- LyondellBasell Fuels ([html](#)) | LyondellBasell Industries ([html](#)) [previously Lyondell Chemical]
- Etc.

## Summary

- Motor Octane Number (MON) Screening of 202 Unleaded Fuel Blends
- Full Scale Engine Testing of 30 Unleaded Blends (2002)
- Full Scale Engine Testing of 45 Unleaded Blends (2005 – 2007)
- Engine Tests of Leaded Vs Unleaded Fuels of Similar MON
- ASTM D 6424 was implemented in 1999 and applies to the octane rating of normally aspirated aircraft engines
- NOTE: Final Report issued June 2010

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Aircraft and Airport-Related Hazardous Air Pollutants: Research Needs and Analysis 2008 ([html](#)) | [NAP](#). CRP Report 7.

Research Needs Associated with Particulate Emissions at Airports 2008 ([html](#)) | [NAP](#). ACRP Report 6.

Summarizing and Interpreting Aircraft Gaseous and Particulate Emissions Data 2008 ([html](#)) | [NAP](#). ACRP Report 9.

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Calculating Piston-Engine Aircraft Airport Inventories for Lead for the 2008 National Emissions Inventory ([pdf](#)) (22 pp, 738 K, EPA-420-B-10-044, December 23, 2010). This Technical Support Document (TSD) provides the methodology used to estimate airport-specific lead emissions for the National Emissions Inventory (NEI).

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Cover letter to Bryan Manning from Dave Atwood, Coordinating Research Council ([CRC](#)), Vice Chairman, Aviation Gasolines Committee 8/29/2007 (Beta [html](#)) ([pdf](#)), concerning 2003 executive summary report describing efforts to find an unleaded replacement for 100LL leaded aviation gasoline, August 29, 2007; and presentation given to Coordinating Research Council (CRC) in 2006 covering recent testing results.

## Two attachments

- Executive Summary, Coordinating Research Council (CRC) Research Results Toward Development of an Unleaded High Octane Aviation Gasoline, April 1, 2003 (MS Word [doc](#))
- Presentation to Coordinating Research Council (CRC) Unleaded Avgas Development Group Meeting, May 1, 2006 (MS Powerpoint [ppt](#))

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Request for Public Comment on Petition to Limit Lead Emissions from General Aviation Aircraft ([pdf](#)) (4 pp, 153 K, EPA-HQ-OAR-2007-0294, November 16, 2007)

Petition from Friends of the Earth ([pdf](#)) (12 pp, 311 K, EPA October 3, 2006)

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Leaded-Gasoline Additives Still Contaminate Groundwater 09-15-2005 ([html](#)) ([pdf](#)) | Environmental Science & Technology 2005, 39, 18, 378A–384A, DOI: [10.1021/es053352k](#) | Environmental Science & Technology ([EST](#)). Ethylene dibromide (EDB) and 1,2-dichloroethane (ethylene dichloride, EDC) persist at high levels despite a phaseout in the late 1980s, but they get little attention.

Air Quality Management in the United States 2004 ([html](#)) | [NAP](#). Consensus Study Report.

Research Priorities for Airborne Particulate Matter: IV. Continuing Research Progress 2004 ([html](#)) | [NAP](#). Consensus Study Report.

Full-Scale Engine Knock Tests of 30 Unleaded, High-Octane Blends September 2004 (Beta [html](#)) ([pdf](#)), David Atwood and Julian Canizales, Final Report, DOT/FAA/AR-04/25.

Direct Identification of Trace Metals in Fine and Ultrafine Particles in the Detroit Urban Atmosphere 03-17-2004 Environ. Sci. Technol. 2004, 38, 8, 2289–2297 ([html](#)) | Environmental Science & Technology ([html](#)). Most of the trace element particles detected in this study were within a range of 0.01–1.0 µm in size, which has the longest atmospheric residence time (~100 days). Increased chemical reactivity owing to the size of nanoparticles may be expected for most of the trace metal particles observed.

DOI: [10.1021/es035010p](https://doi.org/10.1021/es035010p)

Direct Identification of Trace Metals in Fine and Ultrafine Particles in the Detroit Urban Atmosphere ([html](#)) | [PubMed](#) | ([html](#)) ([pdf](#)) | [CiteSeerX](#).

The Rise and Fall of Tetraethyllead | Organometallics ([html](#)) 2003, 22, 25, 5154–5178, 12-01-2003 ([html](#)) ([pdf](#)) DOI: [10.1021/om030621b](https://doi.org/10.1021/om030621b)

Controlling Lead Exposure During the Process of Cleaning Aviation Spark Plugs, Embry-Riddle Aeronautical University Prescott Arizona Campus, 05-2003 ([html](#)) ([pdf](#)).

Controlling Airport-Related Air Pollution ([html](#)) ([pdf](#)), 2003 — Northeast States for Coordinated Air Use Management ([NESCAUM](#)).

Four decades of gasoline lead emissions and control policies in Europe: a retrospective assessment 07-20-2003 ([html](#)) [Science of The Total Environment, Volume 311, Issues 1–3](#), 20 July 2003, Pages 151-176 – [ScienceDirect](#) | ([html](#)) – PubMed | ([pdf](#)) - [CiteSeerX](#).

DOI: [10.1016/S0048-9697\(03\)00051-2](https://doi.org/10.1016/S0048-9697(03)00051-2)

[Resources](#) - [Library Contents](#) - [FAA](#) - [FAASTeam](#) - [FAASafety.gov](#). 2002 - All About Fuel - P-8740-35 ([html](#)). In 1971, the oil companies began development of a single grade avgas that would meet the needs of all reciprocating powered aircraft. The 70s appear to be the start of the transition from 80/87 to 100LL.

Use of Alternate Fuels in Light Aircraft (2002-01-1539) 04-16-2002 ([html](#)) | Society of Automotive Engineers ([SAE](#)). Research to date demonstrates that there are no real problems and many benefits when operating aircraft on ethanol

fuel, and that there are no problems operating an ethanol-converted airplane on aviation fuel.

Assessment of health effects in workers at gasoline station ([html](#)) ([pdf](#)). Bosnian Journal of Basic Medical Sciences([BJBMS](#)) 2 (1-2) 2002.  
DOI: [10.17305/bjbms.2002.3579](#)

Research Priorities for Airborne Particulate Matter: III. Early Research Progress 2001 ([html](#)) | [NAP](#). Consensus Study Report.

Global Air Quality: An Imperative for Long-Term Observational Strategies 2001 ([html](#)) | [NAP](#). Consensus Study Report.

Airports and the General Conformity Process 03-01-2001 ([html](#)) ([pdf](#)) | Institute of Transportation Studies ([html](#)) | UC Berkeley ([html](#)).  
Permalink: <https://escholarship.org/uc/item/8nw2z88q>

Airports and the General Conformity Process 03-2001 ([html](#)) | Transport Research International Documentation ([TRID](#)) | Transportation Research Board ([TRB](#)).

Combustion aerosols: factors governing their size and composition and implications to human health ([html](#)) ([pdf](#)) | [Europe PMC](#).  
Journal of the Air & Waste Management Association (1995), 08-31-2000, 50(9):1565-618; discussion 1619-22.

DOI: [10.1080/10473289.2000.10464197](#)

PM from internal combustion (IC) engines burning gasoline and diesel, are a significant source of primary particles smaller than 2.5 microns (PM<sub>2.5</sub>) in urban areas. Particles containing transition metals, ultrafine particles, and soot are emphasized because these types of particles have been studied extensively, and their emissions are controlled by the fuel composition and the oxidant-temperature-mixing history from the flame to the stack.

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Evaluation of Reciprocating Aircraft Engines With Unleaded Fuels, David Atwood and Kenneth Knopp, December 1999 (Beta [html](#)) ([pdf](#)), Final Report, DOT/FAA/AR-99/70, FAA Technical Center ([html](#)).

Development of the First Unleaded Aviation Gasoline ASTM Specification (1999-01-1569) 04-20-1999 ([html](#)) Society of Automotive Engineers ([SAE](#)).  
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Implementer's Guide to Phasing Out Lead in Gasoline ([pdf](#)) 160-B-99-001, March 1999. United States Environmental Protection Agency (EPA), Office of International Activities ([html](#)). This Guide is written for officials who are responsible for implementing the phase out of lead additives in gasoline. It assumes that their governments have already made the decision to eliminate the



use of lead additives, but have not yet determined how and when to accomplish this.

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Research Priorities for Airborne Particulate Matter: II. Evaluating Research Progress and Updating the Portfolio 1999 ([html](#)) | [NAP](#). National Research Council (NRC).

Review of the U.S. Department of Energy Office of Fossil Energy's Research Plan for Fine Particulates 1999 ([html](#)) | [NAP](#). National Research Council (NRC).

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Research Priorities for Airborne Particulate Matter: I. Immediate Priorities and a Long-Range Research Portfolio 1998 ([html](#)) | [NAP](#). National Research Council (NRC).

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Locating and Estimating Air Emissions from Sources of Lead and Lead Compounds May 1998 ([pdf](#)) EPA-454/R-98-006. United States Environmental Protection Agency (EPA), Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711.

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Proceedings of the First International Conference on Alternative Aviation Fuels ([pdf](#)), May 1996 Final Report, DOT/FAA/AR-96/42. Office of Aviation Research, Washington, D.C. 20591.

- In about two years [~1998], the U.S. Environmental Protection Agency (EPA) is going to banish TEL(tetra-ethyl-lead) form Avgas (aviation gasoline).
- The EAA's (Experimental Aviation Association) Autogas program is a very good example of both. EAA showed great initiative in responding to the need for safety using Autogas. As a result many light aircraft now operate legally, economically and safely with Autogas.

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Prohibition on Gasoline Containing Lead or Lead Additives for Highway Use. SUMMARY: The Clean Air Act prohibits the introduction of gasoline containing lead or lead additives into commerce for use as a motor vehicle fuel after December 31, 1995 ([pdf](#)). Federal Register / Vol. 61, No. 23 / Friday, February 2, 1996, Direct final rule.

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Lead in the Americas: A Call for Action 1996 ([html](#)). Institute of Medicine ([html](#)), Washington, DC: The National Academies ([html](#)). DOI: [10.17226/9168](#). National Research Council (NRC). Introduction: Of special concern is lead's impact on children, whose nervous systems are particularly sensitive. Among the most deleterious neuropsychological effects of lead poisoning on the very young are learning and reading disabilities, reduced psychometric intelligence, and childhood behavioral disorders. All of these have been recognized over time to

occur at progressively lower levels of exposure, and all may be predictive of serious behavioral and other disorders later in life.

Permissible Exposure Levels for Selected Military Fuel Vapors 1996 ([html](#)) | [NAP](#). National Research Council (NRC).

Federal Aviation Administration ([FAA](#)) Advisory Circulars ([ACs](#)): Type Certification [[Wikipedia](#)] of Automobile Gasoline In Part 23 Airplanes with Reciprocating Engines ([pdf](#)), Date: 3/2/95 AC No: 23.1521-1B.

Measuring Lead Exposure in Infants, Children, and Other Sensitive Populations 1993 ([html](#)) | [NAP](#). National Research Council (NRC).

Toxic heavy metals: materials cycle optimization ([html](#)) ([pdf](#)) PNAS February 1, 1992 89 (3) 815-820 | [PNAS](#). In fact, there are also major flows of toxic heavy metals into the environment resulting from inherently dissipative use. Tetraethyl lead added to gasoline is the classic example of such a dissipative use. DOI: [10.1073/pnas.89.3.815](#)

Human Exposure Assessment for Airborne Pollutants: Advances and Opportunities 1991 ([html](#)) | [NAP](#). Consensus Study Report.

The Rise And Fall of Leaded Gasoline ([pdf](#)). The Science of the Total Environment ([html](#)), 92 (1990)1~28 13 [Elsevier](#).

Fuels to Drive Our Future 1990 ([html](#)) | [NAP](#). Consensus Study Report.

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Alternate Fuels for General Aviation Aircraft with Spark Ignition Engines ([pdf](#)), June 1988 Final Report, DOT/FAA/CT88/05. FAA Technical Center Atlantic City International Airport N.J. 08405.

Air Pollution, the Automobile, and Public Health 1988 ([html](#)) | [NAP](#). Consensus Study Report.

Autogas in General Aviation Aircraft March 1987 (Beta [html](#)) ([pdf](#)), H. Stewart Byrnes et al., Final Report, DOT/FAA/CT-87/05, FAA Technical Center ([html](#)).

Avgas/Autogas Comparison: Winter Fuels ([pdf](#)) July 1986. DOT/FAA/CT-86/21, AD-A174 091. Federal Aviation Administration (FAA) Technical Center ([html](#)), US DOT ([html](#)) | Defense Technical Information Center ([DTIC](#)).

Epidemiology and Air Pollution 1985 ([html](#)) | [NAP](#). National Research Council (NRC).

A 'gift of God'?: The public health controversy over leaded gasoline during the 1920s, April 1985 | PubMed ([html](#)) | PubMed Central ([html](#)) ([pdf](#)) ([pdf](#)). [Am J Public Health](#). 1985 April; 75(4): 344–352.

DOI: [10.2105/ajph.75.4.344](https://doi.org/10.2105/ajph.75.4.344)

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1982, Experimental Aircraft Association (EAA) successfully changed Federal Aviation Administration (FAA) policy to consider the use of automobile gasoline in aircraft. The EAA type certificate program resulted in an FAA Supplemental Type Certificate (STC) being issued for the use of automobile gasoline, rather than aviation gasoline, in the Cessna 150 aircraft, powered by a Continental O-200 engine.

Although it is not clearly stated or recorded when the first legal flight was performed, apparently an engine and airplane were approved to use automotive gasoline ("autogas") by supplemental type certificates (STC) SE634GL and SA730GL, respectively. Both STCs were held by the Experimental Aircraft Association (EAA). The STC documentation stated that compliance was attained "by installation of placards and airplane flight manual supplement."

Auto Fuel ([html](#)) Federal Aviation Administration ([FAA](#)) Supplemental Type Certificate ([STC](#)) | Experimental Aircraft Association ([EAA](#)). The first pilot to legally fly in an aircraft with automobile gasoline was then-FAA Administrator J. Lynn Helms [[Wikipedia](#)]. Since then, more than 24,000 STCs have been issued by EAA.

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Aviation Gasolines and Future Alternatives ([html](#)) ([pdf](#)) | NASA Technical Reports Server ([NTRS](#)). NASA Conference Publication 2267, Proceedings of a workshop held at Lewis Research Center Cleveland, Ohio. February 3-5, 1981. Participants included Mooney Aircraft, Cessna, Lycoming, EAA, FAA, GAMA, NATA, Shell, Philips, Exxon, NASA, etc.

.....1970s;.....  
Recommendations for the Prevention of Lead Poisoning in Children 1976 ([html](#)) | [NAP](#). National Research Council (NRC).

.....  
38 FR 1254 (1973) First Regulation of Lead in Fuel (Beta [html](#)) ([pdf](#)), Federal Register, Volume 38, No. 6 – Wednesday January 10, 1973.

Friday, September 21, 1973, Volume 38 Number 183, pages 26435 - 26593  
Title 40 Protection of environment.  
Chapter 1 Environmental protection Agency.  
Part 80 – regulation of fuels and fuel additives.  
Controls applicable to motor vehicle manufacturers ([pdf](#)).  
On January 10, 1973 (38 FR 154).

.....  
1970s – 100LL aviation fuel introduced, 1940s piston propulsion technology virtually unchanged, e.g. basically the same technology used in 2020.

Octane - Tetraethyl Lead (TEL) concentration AMOUNT			
80	100	100LL	
0.13	1.06	0.56	(mL / L)
0.49	4.02	2.12	(g / gal)

NOTE: 100LL has over four times the amount of lead (in milliliters/liter) as 80.

.....1960s.....  
 Experimental Aircraft Association (EAA). EAA began testing and evaluating alternate fuels for aircraft piston engines in 1964 ([html](#)).

Other than bragging rights on who was first to start the alternate aviation fuels effort it is certainly not clear what has been *really* accomplished in 56 years.

.....Summary.....

Over a half century of massive amounts of resources, time, effort and money, not to mention the continuous destruction of the Health, Safety and Welfare via Tetraethyl Lead (TEL) & Ethylene Dibromide (EDB) poisoning of so many vulnerable populations in this protracted time-frame doesn't sound like progress to many. There is still no end in sight as of September 2020 or any clear project plan, accountability, commitment or the demonstrated will to do so.

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 Additional Thoughts

**Thought #1**

Journal of Public Health Management and Practice ([html](#)) January/February 2019 - Volume 25 – Issue ([html](#)) Commentary: Lead Elimination for the 21st Century ([html](#)) observes that:

Over time, scientific evidence has accumulated and no safe level of lead for children has been identified. Why then has the elimination of lead hazards in the environment not been more of a priority for society as a whole? Lead poisoning is the longest-lasting childhood epidemic in the United States and has *never* been treated as one.

Tetraethyl Lead(TEL) & Ethylene Dibromide (EDB) poisoning remains an urgent health crisis that requires action, not just calls for more evidence or further studies!

**Thought #2**

Reddit ([html](#)): Flying ([html](#)) is a community for discussion among pilots, students, instructors and aviation professionals created September 3, 2008, a small but dedicated community with roughly ~134k Members. After filtering through hostile, threatening, profane almost violent rhetoric from anonymous nom de guerre members, which btw appears to be a standard

contemporary response mechanism, a chosen default modus operandi, a recent post appears to capture one view of the reality of modern flying quite succinctly ([html](#)):

. . . I also feel like inaction by GA in general hasn't helped. 100LL is a health hazard. Most General Aviation companies seem happy to just leave things as they are, with the *vague* hope that the FAA will approve a suitable alternative soon. The vast majority of new certified single-engine piston aircraft still rely on 100LL; that seems like *an industry with its head in the sand* to me.

Likewise, very little seems to be being done to reduce aircraft noise. The design of modern aircraft should adapt to modern conditions - flying in or out of a lot of airports nowadays causes a fair bit of noise pollution for literally thousands of people. Is a *modern* C172 any quieter than a 1960s one? Why not? . . .

NOTE: optimistically the threatening & violent rumblings *against* protecting the Health, Safety & Welfare of Vulnerable Populations do NOT generally represent aviation, aerospace & defense professionals & related workers, enthusiasts, devotees or responsible airmen and airwomen, or do they?

### Thought #3

A disappointing note is that Occupational Safety and Health Administration (OSHA) 1910.1025 App A - Substance data sheet for occupational exposure to Lead ([html](#)) notes that OSHA does NOT address Tetraethyl Lead (TEL)! Workers and the general public have rights to be protected or at least notified re TEL hazards.

### Thought #4

Leaded 100LL Aviation Fuel with Tetraethyl Lead (TEL) & Ethylene Dibromide (EDB) is the unrecognized "[Secondhand Smoke](#)" of the first decade of the 21<sup>st</sup> century ([html](#)) ([html](#)), only ten times deadlier! *The Lancet* ([html](#)) paper Low-level Lead Exposure and Mortality in US Adults March 12, 2018 ([html](#)) ([pdf](#)), found that exposure to low levels of lead contributes to as many as 412,000 premature deaths ([html](#)) of residents across the United States each year. This places premature death from lead exposure almost on a par with deaths caused by smoking, which takes more than 480,000 American lives each year ([html](#)) | American Lung Association.