100SF SwiftFuel: A High Octane Alternative to 100LL

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Purdue Energy Camp

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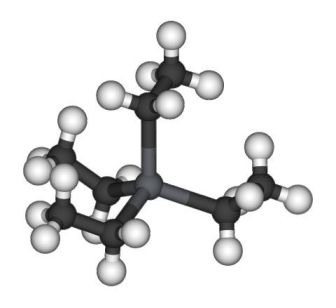


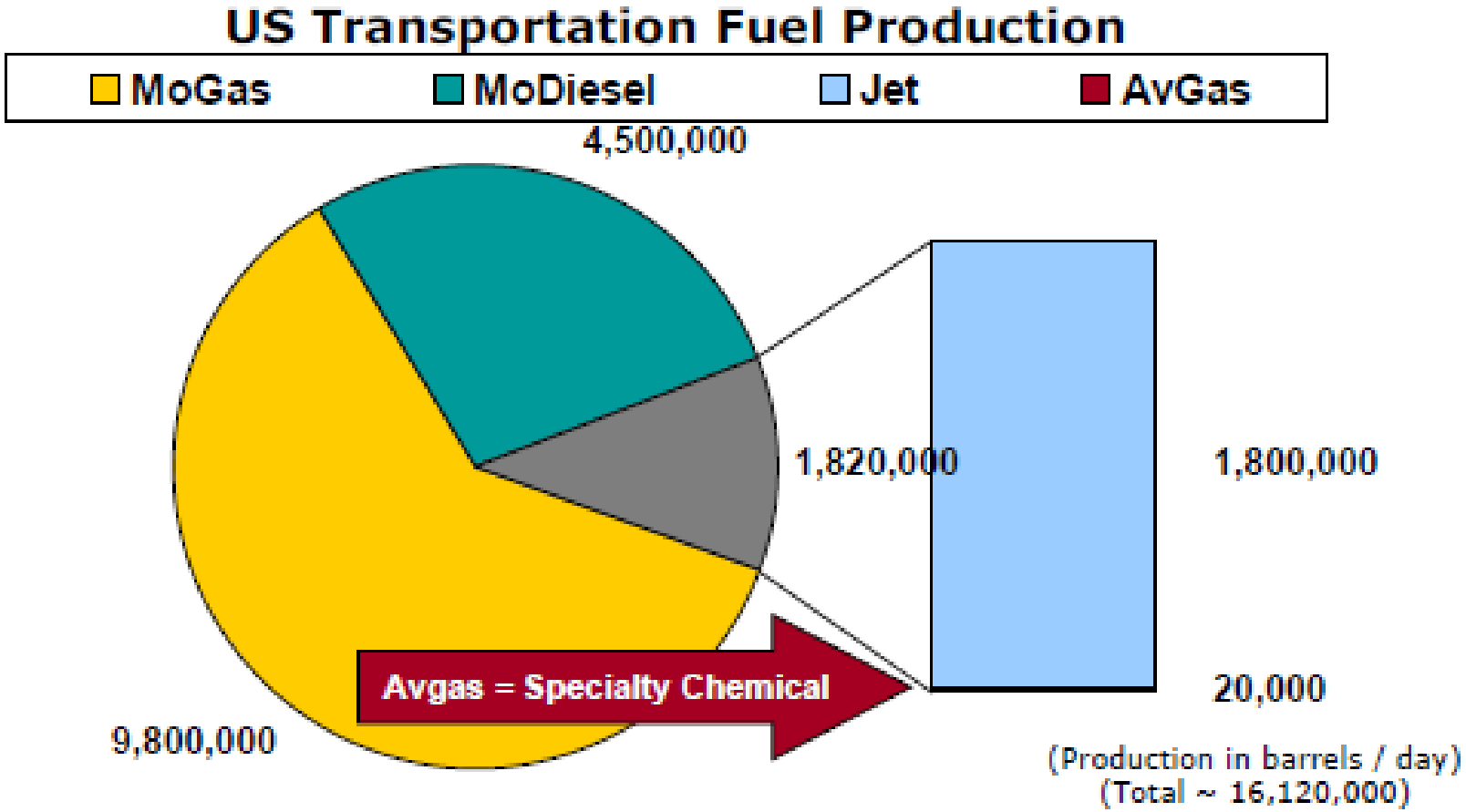
Tetraethyl Lead

$(C_2H_5)_4$ Pb

- Was highest during WWII.
- 115/145 avgas = 2 ½ X more lead than 100LL
- Necessary in order to obtain rated & war power
- Lead to development of larger engines, fighters, bombers, and transport aircraft to win the war.
- Started reducing lead content in late 1960's to 100/130 max, then 100LL in 1972

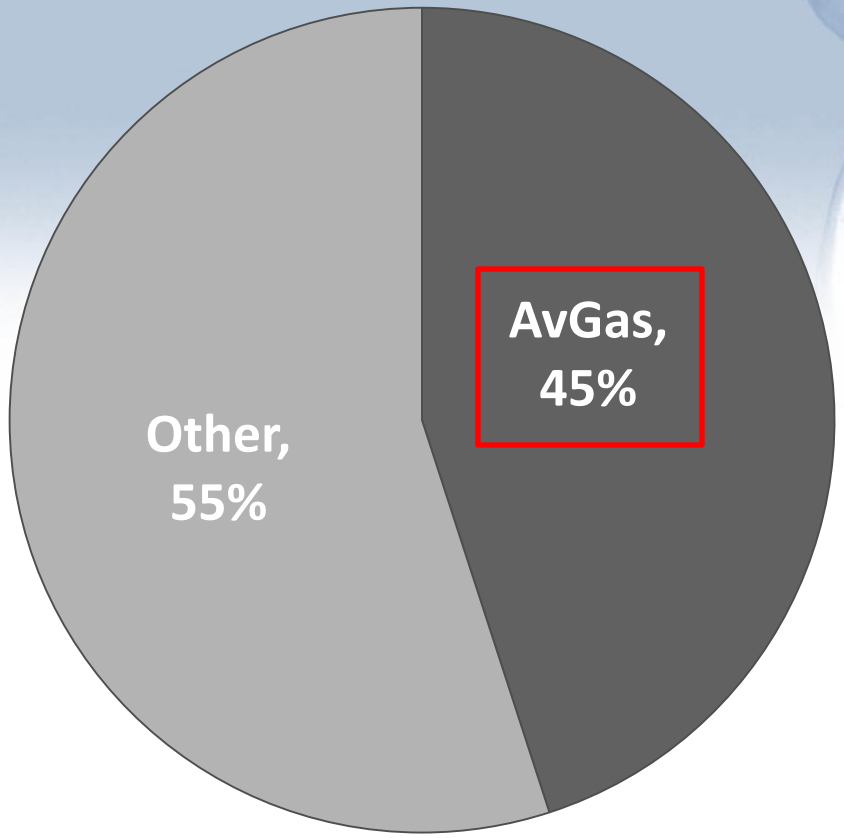
Small Market, Large Problem

Total Fuel Consumption



Small Market, Large Problem

Sources of Lead Emissions - 2009



The Swift Fuel Solution

100SF is a two component, synthetic hydrocarbon fuel replacement for 100LL

- 100SF is produced from processed biomass that is then catalytically reacted into full hydrocarbons
- 100SF contains no oxygenates or lead
- 100SF has been extensively tested in aircraft engines, both on the ground and in the air
- 100SF is currently the only 102+ MON alternative to replace 100LL

ASTM D7719

- ***Approved May 1, 2011***
- ***Issued Number D7719***

Designation: D7719 – 11

Standard Specification for High Octane Unleaded Test Fuel[1]

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Standard Specification for High Octane Unleaded Test Fuel[1]

This standard is issued under the fixed designation D7719; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

This new test fuel specification is for a high-octane unleaded fuel to be used for gathering data toward a commercial research report and specification on an unleaded high-octane aviation gasoline.

A new high-octane unleaded test fuel has been developed which maintains the key performance parameters of existing reciprocating aircraft engines. The two essential performance parameters of MON and VP are inversely related with respect to composition and thus can uniquely define a composition range of the two components. The values for VP and MON in Table 1 reflect the limiting values of the two components. The binary fuel exhibits a higher volumetric energy density (net heat of combustion times density) which is of great performance interest, although not explicitly stated in Table 1. The distillation parameters reflect the binary compositional effects. This is an unleaded fuel, so the limit of TEL in Table 1 is the same as is used in Specification D4814 for mogas and is meant to mitigate unintentional contamination by TEL. Lastly, references to dyes remain in the specification so that test groups may use them as necessary.

1. Scope

1.1 This specification covers formulating specifications for purchases of a high octane unleaded test fuel under contract and is intended solely for use by purchasing agencies for testing purposes.[2]

1.2 This specification defines a specific type of high octane unleaded test fuel for use as an aviation spark-ignition fuel.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

2. Referenced Documents

2.1 *ASTM Standards:*[3]

D86 Test Method for Distillation of Petroleum Products at Atmospheric Pressure

D130 Test Method for Corrosiveness to Copper from Petroleum Products by Copper Strip Test

D323 Test Method for Vapor Pressure of Petroleum Products (Reid Method)

D873 Test Method for Oxidation Stability of Aviation Fuels (Potential Residue Method)

D1094 Test Method for Water Reaction of Aviation Fuels

D1266 Test Method for Sulfur in Petroleum Products (Lamp Method)

D1298 Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method

D2386 Test Method for Freezing Point of Aviation Fuels

D2622 Test Method for Sulfur in Petroleum Products by Wavelength Dispersive X-ray Fluorescence Spectrometry

D2624 Test Methods for Electrical Conductivity of Aviation and Distillate Fuels

D2700 Test Method for Motor Octane Number of Spark-Ignition Engine Fuel

D3237 Test Method for Lead in Gasoline by Atomic Absorption Spectroscopy

D4052 Test Method for Density, Relative Density, and API Gravity of Liquids by Digital Density Meter

D4057 Practice for Manual Sampling of Petroleum and Petroleum Products

D4171 Specification for Fuel System Icing Inhibitors

D4177 Practice for Automatic Sampling of Petroleum and Petroleum Products

D4306 Practice for Aviation Fuel Sample Containers for Tests Affected by Trace Contamination

[1] This specification is under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.J0 on Aviation Fuels.

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[2] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1721.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

7.1 The high octane unleaded test fuel shall conform to the requirements prescribed in Table 1.

7.2 Test results shall not exceed the maximum or be less than the minimum values specified in Table 1. No allowance shall be made for the precision of the test methods. To determine the conformance to the specification requirement, a test result may be rounded to the same number of significant figures as in Table 1 using Practice E29. Where multiple

Method D873 except that wherever the letter X occurs (referring to oxidation time) insert the number 5, designating the number of hours prescribed in this specification.

11.1.11 *Water Reaction*—Test Method D1094.

11.1.12 *Electrical Conductivity*—Test Method D2624.

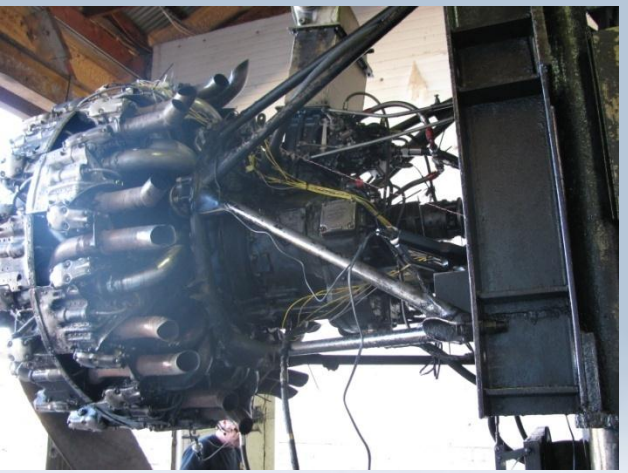
12. Keywords

12.1 aviation fuel; binary; high-octane; unleaded

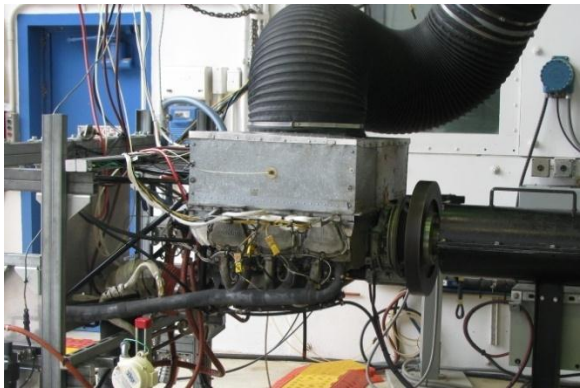
TABLE 1 Detailed Requirements for High Octane Unleaded Test Fuel

Octane Ratings		Grade UL102	ASTM Test Method
Knock value, Motor Octane Number	min	102.2	D2700
Density at 15°C, kg/m3	min	790	D1298 or D4052
	max	825	
Distillation			D86
Initial boiling point, °C	Report		D86
Fuel Evaporated			D86
10 volume % at °C	max	75	D86
40 volume % at °C	min	75	D86
50 volume % at °C	max	165	D86
90 volume % at °C	max	165	D86
Final boiling point, °C	max	180	D86
Sum of 10 % + 50 % evaporated temperatures, °C	min	135	D86
Recovery, volume %	min	97	D86
Residue, volume %	max	1.5	D86
Loss, volume %	max	1.5	D86
Vapor pressure, 37.8°C, kPa	min	38.0	D323, D5190 , or D5191
	max	49.0	
Freezing point, °C	max	-58	D2386
Sulfur, mass %	max	0.05	D1266 or D2622
Net heat of combustion, MJ/kg	min	41.5	D4809
Corrosion, copper strip, 2 h at 100°C	max	No. 1	D130
Oxidation stability (5 h aging)			D873
Potential gum, mg/100 mL	max	6	
Water reaction			D1094
Volume change, mL	max	±2	
Electrical conductivity, pS/m	max	450	D2624
Tetraethyl Lead, g Pb/L	max	0.013	D3237 or D5059

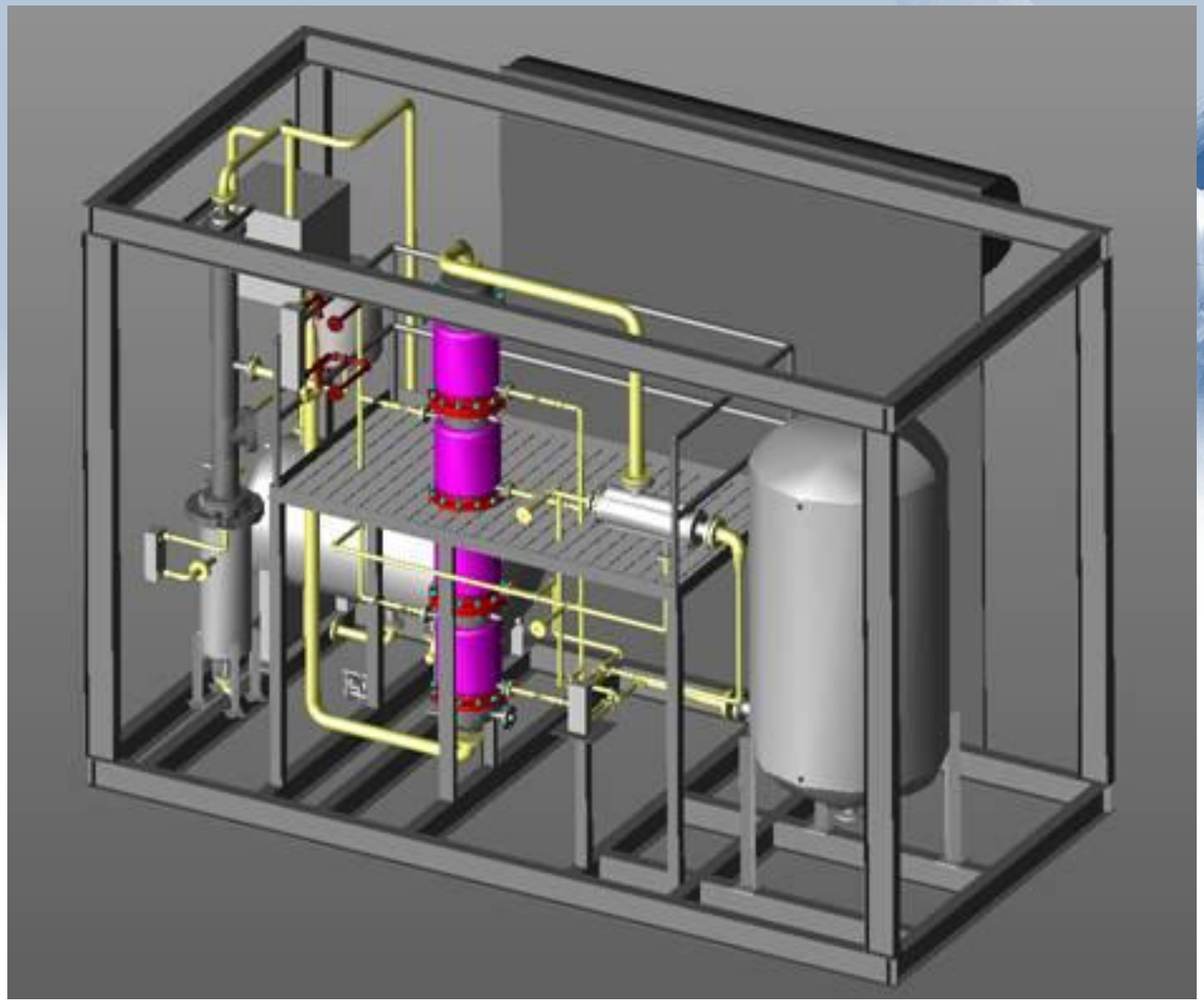
Engine Testing on 100SF



- Lycoming TIO-540-J2BD & IO-540-K
  (FAA, Lycoming, & Purdue University)
- Cessna 150/Continental O-200-A
  (Albertson Aerodata Analytics)
- P&W R-2800-CB17 Radial (Anderson Aeromotive)
- M-14P Radial (Rick Volker Airshows)



Production Update – Lafayette Pilot Plant



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