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HIGH-OCTANE AND MID-OCTANE DETONATION PERFORMANCE OF LEADED AND UNLEADED FUELS IN NATURALLY ASPIRATED, PISTON, SPARK IGNITION AIRCRAFT ENGINES	March 2007
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16. Abstract

The full-scale engine detonation performance of mid- and high-octane leaded and unleaded fuels were compared at the onset of light detonation in a naturally aspirated Lycoming IO540-K and a naturally aspirated Lycoming IO320-B engine. The fuels were stressed by performing both mixture lean-outs and by increasing the manifold pressure. The high-octane fuels (100 motor octane number (MON) and above) were tested in the IO540-K engine, and the mid-octane (91 to 95 MON fuels) were tested in the IO320-B engine. For this testing, the MON was determined by ASTM International (ASTM) specification D 2700 and the supercharge rich rating was determined by ASTM D 909. A specially blended 100 low-lead (100 LL) aviation gasoline was tested. The 100 LL blend contained the maximum amount of allowable lead, while meeting the minimum MON of 100 and the minimum supercharge rich rating of 130 (described as 100/130 lead (L)), and met all current ASTM aviation gasoline specification D 910. The 100 LL blend performed significantly better than a 100 MON unleaded isooctane and a 100 MON and 161 supercharge rich rating unleaded amine-laden fuel in the IO540-K engine. The 100 LL did not perform as well as a 104 MON and 161 supercharge rich rating unleaded amine-laden fuel. The 100 LL fuel performed the same as a 100 MON and 100 supercharge rich rating leaded (100/100 L) fuel at the lower cruise power settings but performed much better at the higher power settings. This testing showed that the 100 LL significantly outperformed unleaded fuels of equivalent MON, even those with much higher supercharge rich ratings. The data also showed that the supercharge rich rating for leaded, hydrocarbon fuels is of greater significance at the higher power settings.

A 91 MON and 98 supercharge rich rating leaded fuel (91/98 L) significantly outperformed an unleaded 91 MON and 98 supercharge rich rating fuel (91/98 unleaded (UL)) in the IO320-B engine. The leaded 91/98 L fuel performed better than the 93 MON and 98 supercharge rich rating unleaded fuel (93/98 UL) and not as well as the 94 MON and 98 supercharge rich rating unleaded fuel (94/98 UL). For a mid-octane (~91 MON), straight hydrocarbon, unleaded and nonmetallic fuel to perform as well as a leaded fuel of equivalent motor octane and supercharge rich rating in a full-scale engine, the unleaded fuel would require 2 to 3 higher MON. The high-octane study was inconclusive in determining the equivalent unleaded MON detonation performance to the leaded MON.

17. Key Words	18. Distribution Statement
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LIST OF ACRONYMS AND SYMBOLS

AFL	Air-to-fuel ratio for the left bank cylinder
AFR	Air-to-fuel ratio for the right bank cylinder
ASTM	ASTM International
BHP	Brake horsepower
BSFC	Brake-specific fuel consumption
BTDC	Before top dead center
CHT	Cylinder head temperature
EGT	Exhaust gas temperature
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FR	Full rich
hp	Horsepower
in. Hg	Inches of mercury
L	Leaded aviation gasoline
lb/bhp hr	Pounds per brake-horsepower hour
MAP	Manifold absolute pressure
MON	Motor octane number as determined by ASTM D 2700
NRP	Normal-rated power
PRF	Primary reference fuel
psi	Pounds per square inch
psig	Pounds per square inch gauge
rpm	Revolutions per minute
R&D	Research and development
TEL	Tetra-ethyl lead
TO	Takeoff
UL	Unleaded aviation gasoline
100 LL	Low-lead aviation gasoline
WOT	Wide-open throttle

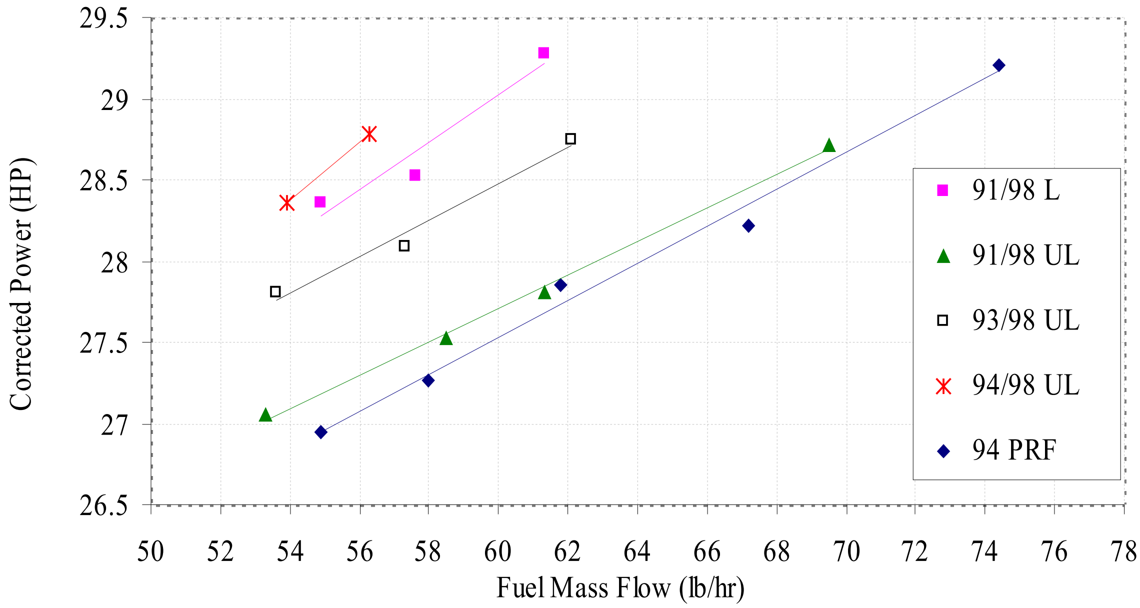
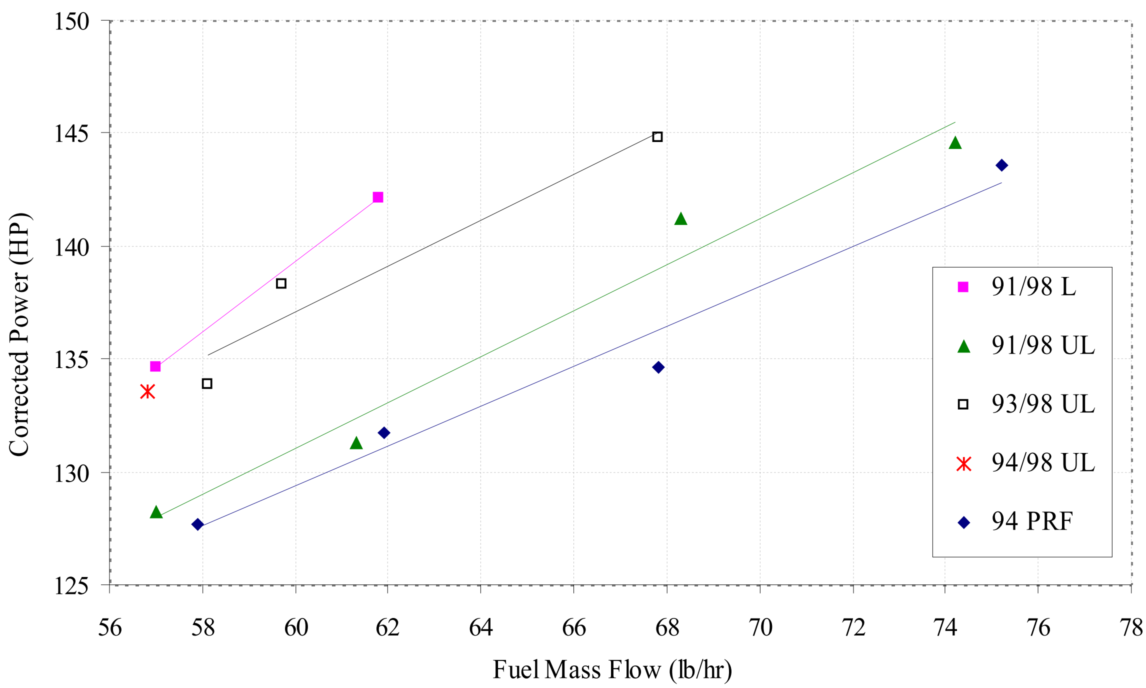


Figure 6. Lycoming IO320-B Engine Manifold Pressure Detonation Onset for Leaded and Unleaded Fuels at 2600 rpm



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