

Propelling Change: The Introduction of Unleaded Fuel at the University of North Dakota

Robert Kraus, Dean, John D. Odegard School of Aerospace Sciences
Dan Kasowski, Director of Maintenance

In June 2023, the University of North Dakota Aviation program transitioned its fleet to use Swift Fuels UL94, a 94-octane unleaded fuel. In October, an organizational decision was made to switch back to 100LL AVGAS after logging 46,000 hours and burning 386,000 gallons of UL94. There has been a lot of speculation as to what happened and this article will add details to what occurred. Two technical reports are being prepared to provide more data and results.

First, some background. The University of North Dakota's John D. Odegard School of Aerospace Sciences has been educating and training college students towards careers as professional pilots for more than 55 years. Over this time, the program has grown to more than 2,000 students enrolled, 1,600 of which are in the primary flying majors, Commercial Aviation or Aviation Management. For maintenance and technical support, UND Aerospace is an approved repair station under Part 145 and performs a majority of the maintenance on UND aircraft based in Grand Forks (KGFK).

The UND fleet consists of 76 Piper Archers and 14 Seminole. Additionally, 74 students in the Rotary Wing track of the Commercial Aviation major fly in 5 Robinson R44 helicopters. For the past several years, these aircraft have flown more than 100,000 hours annually with some months seeing up to 13,000 hours. It's not unusual for a given tail number to fly 1,200 hours in a given year. Through an FAA-approved progressive inspection schedule, each aircraft completes the equivalent of three to four annual inspections per year.

All aircraft in the fleet are equipped with the Garmin G1000 avionics system and also have a WiFi antenna installed for data transfer of exceedances (if any) after each flight. Weekly, the data card from each aircraft is swapped and the respective data downloaded, which records multiple parameters for each flight at 1Hz (1 data point per second). This data is input into the GE Event Measurement System (EMS) and the National General Aviation Flight Information Database (NGAFID) for analysis under the flight data monitoring (FDM) program. These programs are used in conjunction with UND's Aviation Information Management System (AIMS) which tracks all maintenance records in accordance with the repair station license.

In the summer of 2022 following a comprehensive safety risk assessment, we signed an agreement with SwiftFuels to switch the fleet to UL94, one of the first unleaded aviation fuels available in a large enough quantity for our fleet. All UND aircraft were approved to utilize UL94 fuel per Swift Fuels LLC - STC S01757WI. All UND aircraft engines are approved to use UL94 fuel per Lycoming Service instruction 1070AB. UND utilizes two large fuel storage tanks and has its own fuel trucks. UND's initial switch to UL94 was delayed from August 2022 to June 2023 due an unexpected change in cost between 100LL and UL94. It is important to note that UND's organizational preparation was focused on making an operational adoption of UL94 and not as a part of any funded research study. As the fuel was approved to be used in the engines, UND elected to switch the entire GFK-based aircraft over at the same time.

Within one week, the fuel storage tanks had been converted over and the first flight with UL94 occurred on June 23, 2023. While UL94 was used exclusively at Grand Forks, however all off-station refueling was with 100LL AVGAS. The fuels are mixable and interchangeable so no changes to performance

calculations or operating procedures were made. Leaning procedures were followed in accordance with the respective pilot's operating handbooks (POH). For the Piper Archers and Seminole, that is full rich for takeoff, climb and descent, while leaning for peak EGT (Best Economy) during cruise.

In late August, a Seminole experienced aircraft vibration and showed that one of the EGT's on the left engine was registering 500 degrees low. The aircraft returned to Grand Forks and was turned in to maintenance. The inspection revealed that an exhaust valve seat in one cylinder was severely recessed. This was something that was rarely experienced across the fleet so the cylinder was replaced and the aircraft returned to service. Notification was made to Lycoming after this first incident.

Over the next two months, 11 additional exhaust valve seat recessions were discovered leading to further investigation of the entire fleet. Following a recommendation from both Lycoming and SwiftFuels, the decision was made to stop using UL94 and switch back to 100LL AVGAS as a precaution until a cause could be determined. Due to our concern about the increasing failure rate, a walkthrough of the entire fleet was performed and a quick check uncovered another 15 aircraft (17 cylinders) with possible compression issues.

A triage plan was developed with Lycoming that included performing an immediate compression check and borescope of all 114 Lycoming engines before further flight. That check revealed nine more cylinders with recessed seats. Following that, a dry tappet check was required on each cylinder during phase inspection. While this is not proof of valve seat recession, it may indicate the need for further inspection/borescope/compression checks. Since switching back to 100LL and as aircraft have come through for their scheduled maintenance, the total number of recessed valve seats has grown to more than 128. None of the replaced cylinders have shown exhaust valve seat recession while operating on 100LL AVGAS.

Initial analysis showed that most aircraft had more than 400 hours using UL94 before seeing valve seat recession or loss of compression. A more detailed study is continuing to include reviewing multiple engine parameters recorded during flight, time spent flying cross country (with leaned mixture), refueling at other stations leading to mixed fuel, and the number of takeoffs/landings/touch and go's which correlates to the low-to-high power cycles on each engine.

We are continuing work with Lycoming and SwiftFuels to identify the specific causes of damage experienced here. Unleaded fuel is the future of general aviation and UND fully supports the industry moving towards further adoption in a safe and cost-effective manner.

The following people contributed to this article and ongoing analysis: Aaron Fettig, Nicholas Geinert, Ryan Guthridge, Jeremy Roesler, Aaron Terbest, Brandon Wild, Brian Willis, and Nicholas Wilson.