Project 031(A) Alternative Jet Fuel Test and Evaluation

University of Dayton

Project Lead Investigator

Steven Zabarnick
Division Head
Energy & Environmental Engineering Division
University of Dayton Research Institute
300 College Park, Dayton, OH 45469-0043
937-255-3549
Steven.Zabarnick@udri.udayton.edu

University Participants

University of Dayton Research Institute

- P.I.(s): Steven Zabarnick, Division Head
- FAA Award Number: 13-C-AJFE-UD
- Period of Performance: April 8, 2015 to March 14, 2016
- Task(s):
    1. Evaluate candidate alternative fuels for their performance via the ASTM D4054 approval process

Project Funding Level

Funding level: $400,000
Cost share: to be obtained from fuel suppliers

Investigation Team

Matthew DeWitt, low temperature and combustion emissions properties
Richard Striebich, fuel chemical analysis and composition
Linda Shafer, fuel chemical analysis and composition
John Graham, fuel seal swell and materials compatibility
Zachary West, fuel properties

Project Overview

Alternative jet fuels offer potential benefits of reducing global environmental impacts, achieving national energy security, and stabilizing fuel costs for the aviation industry. The Federal Aviation Administration is committed to the advancement of “drop in” alternative fuels and has set the aspirational goal of enabling the use of 1 billion gallons annually by 2018. Successful adoption of alternative fuels requires approval for use of the fuel by the aviation community followed by large scale production of a fuel that is cost competitive and meets safety standards of conventional jet fuel. Alternative jet fuels must undergo rigorous testing in order to become qualified for use and incorporated into ASTM International Specifications.

Cost effective and coordinated performance testing capability (in accordance with ASTM D4054) to support evaluation of promising alternative jet fuels is needed. The objective of this project is to provide capability to conduct the necessary work to support alternative jet fuel evaluation of either a) to-be-determined fuel(s) that will be selected in coordination with the FAA, or b) a fuel test and evaluation project with a specific fuel(s) in mind.
The proposed program should provide the following capabilities:

- Identify alternative jet fuels (which may include blends with conventional jet fuel) to be tested and that have the potential to be economically viable and support FAA’s NextGen environmental goals.

- Perform engine, component, rig, or laboratory tests, or any combination thereof, to evaluate the performance of an alternative jet fuel in accordance with ASTM International standard practice D4054.
- Identify and conduct unique testing beyond that defined in ASTM International standard practice D4054 necessary to support evaluation of alternative jet fuels for inclusion in ASTM International jet fuel specifications.
- Obtain data for baseline and alternative jet fuels to demonstrate any effects of the alternative jet fuel on aircraft performance, maintenance requirements, and reliability.
- Coordinate effort with activities sponsored by Department of Defense and/or other government parties that may be supporting relevant work.
- Report relevant performance data of the alternative fuels tested including a quantification of the effects of the alternative fuel on aircraft and/or engine performance and on air quality emissions relative to conventional jet fuel. Reported data will be shared with both the FAA (NJFCP) and the broader community (e.g. ASTM International) and with ASCENT COE Program 33 "Alternative Fuels Test Database Library."

Task 1- Evaluate candidate alternative fuels for their performance via the ASTM D4054 approval process

University of Dayton Research Institute

Objective(s)

Cost effective and coordinated performance testing capability (in accordance with ASTM D4054) to support evaluation of promising alternative jet fuels is needed. The objective of this project is to provide capability to conduct the necessary work to support alternative jet fuel evaluation of either a) to-be-determined fuel(s) that will be selected in coordination with the FAA, or b) a fuel test and evaluation project with a specific fuel(s) in mind.

Research Approach

The intent of this program is to provide the capability of performing specification and fit-for-purpose (FFP) evaluations of candidate alternative fuels towards providing a pathway forward through the ASTM D4054 approval process. The UDRI team possesses the capability of performing a large of number of these evaluations, and we are prepared to work with other organizations such as SwRI and engine OEM's, as needed, for their unique test capabilities. These include additional engine, APU, component, and rig evaluations. The UDRI testing capabilities cover our efforts at the laboratories of the Fuels Branch of AFRL and at our campus laboratory facilities.

Appendix A is an example Technical Memorandum from 2012 prepared by UDRI for AFRL on two biofuels and a biofuel blend. This is an example of the type of information that UDRI has generated, analyzed and compiled for AFRL over the years. GCxGC chromatograms are also supplied to show compositional differences in a graphical format, see Figure 1.

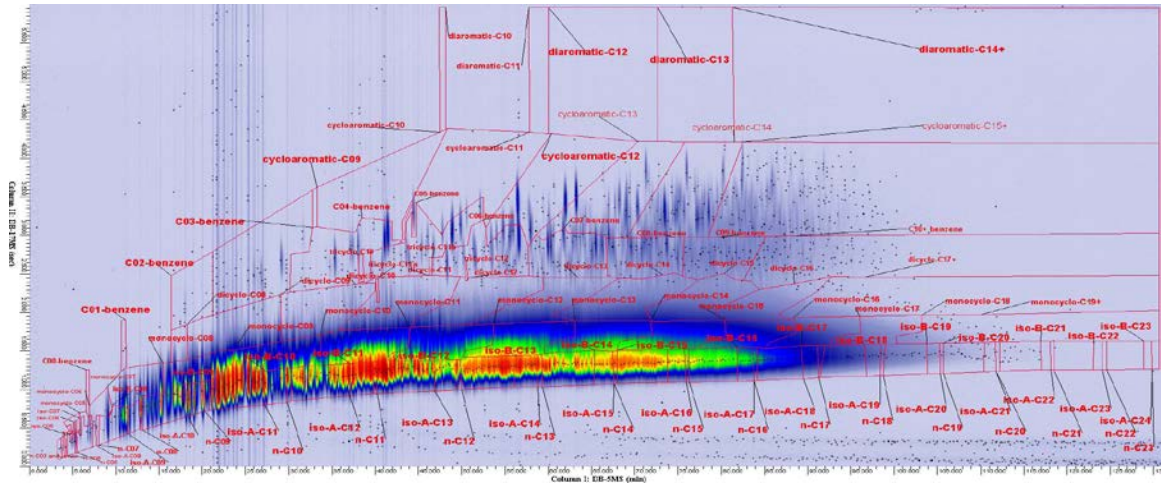

Figure 1. Example GCxGC chromatogram of a biofuel (LanzaTech PNNL).

The following are examples of the evaluations that UDRI is able to provide:

Tier I

1. Thermal Stability (Quartz Crystal Microbalance)
2. Freeze Point (ASTM D5972)
3. Distillation (ASTM D 86)
4. Hydrocarbon Range (ASTM D6379 & D2425)
5. Heat of Combustion (ASTM D 4809)
6. Density, API Gravity (ASTM D 4052)
7. Flash Point (ASTM D 93)
8. Aromatics (ASTM D 1319)

Tier II

1. Color, Saybolt (ASTM D 156 or D 6045)
2. Total acid number (ASTM D 3242)
3. Aromatics, (ASTM D 1319 & ASTM D 6379)
4. Sulfur (ASTM D 2622)
5. Sulfur mercaptan (ASTM D 3227)
6. Distillation temperature (ASTM D 86)
7. Flash point (ASTM D 56, D 93, or D 3828)
8. Density (ASTM D 1298 or D 4052)
9. Freezing point (ASTM D 2386, D 5972, D 7153, or d 7154)
10. Viscosity, at -20°C, (ASTM D 445)
11. Net heat of combustion (ASTM D 4809)
12. Hydrogen content (ASTM D 3343 or D 3701)
13. Smoke point (ASTM D 1322)
14. Naphthalenes (ASTM D 1840)
15. Calculated cetane index (ASTM D 976 or D4737)
16. Copper strip corrosion (ASTM D 130)
17. Existent gum (ASTM D 381)
18. Particulate matter (ASTM D 2276 or D 5452)
19. Filtration time (MIL-DTL-83133F Appendix B)
20. Water reaction interface rating (ASTM D 1094)
21. Electrical conductivity (ASTM D 2624)
22. Standard Test Method for Thermal Oxidation Stability of Aviation Turbine Fuels (ASTM D3241)

Extended Physical and Chemical Characterization

1. Lubricity Evaluation- BOCLE test (ASTM D 5001)
2. Low Temperature Properties – Scanning Brookfield Viscosity
3. Detect, quantify, and/or identify polar species - Analyze as necessary
4. Detect, quantify and/or identify dissolved metals - Analyze as necessary
5. Initial Material Compatibility Evaluation – Perform optical dilatometry and Partition Coefficient Measurements to determine the fuel-effected swell and the fuel solvency in 3 O-ring materials (nitrile, fluorosilicone and fluorocarbon) and up to 2 additional fuel system materials
6. Experimental Thermal Stability Evaluation – Quartz Crystal Microbalance – Measure thermal deposit tendencies and oxidation profile at elevated temperatures
7. Viscosity versus Temperature – (ASTM D 445) determination of the fuels viscosity at 40°C and -40°C to assess the fuel's viscosity's variation with temperature

In addition to the above physical and chemical fuel evaluation capabilities, UDRI also has extensive experience in evaluation of microbial growth in petroleum-derived and alternative fuels. These evaluations include standard lab culturing and colony counting methods, as well as advanced techniques such as quantitative polymerase chain reaction (QPCR) and metagenomic sequencing. These methods allow the quantitative measurement of microbial growth rates in candidate alternative fuels in comparison with petroleum fuels.

UDRI also has extensive experience in evaluation of elastomer degradation upon exposure to candidate alternative fuels. Various methods are used to evaluate seal swell and o-ring fixture leakage, including: optical dilatometry, measurement of sealing pressure, fuel partitioning into elastomer, and a pressurized temperature controlled o-ring test device.

UDRI is also able to perform fuel-material compatibility testing using the D4054 procedures for fuel soak testing, post-exposure non-metallic and metal materials tests, and surface and microstructural evaluation. Testing of both 68 “short-list” materials and the complete 255 materials list can be performed.

Milestone(s)

The schedule for this project is dependent upon receipt of alternative fuel candidates for testing. As candidate fuels are received a schedule of testing will be coordinated with the FAA and collaborators. Our existing relationships with these organizations will help expedite this process.

Major Accomplishments

Initial measurements have been performed for the first candidate jet fuel. The data are currently being compiled.

Publications

None

Outreach Efforts

None

Awards

None

Student Involvement

None

Plans for Next Period

Evaluations for the initial candidate fuel continue. Decisions will be made on the extent of future testing on this fuel through collaboration with FAA and AFRL.