DEPARTMENT OF THE AIR FORCE
Headquarters Air Force Life Cycle Management Center
Engineering and Technical Management/Services Directorate
Wright-Patterson AFB OH 45433-7017

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Airworthiness Advisory

FAME Contamination Limit Change for Commercial Jet Fuel (Jet A/Jet A-1)

PURPOSE:
Assessment of airworthiness impact of a change to the commercial jet fuel (Jet A/Jet A-1) specification (ASTM D1655).

SCOPE:
Applies to most USAF aircraft operating from or transitioning through CONUS bases.

CANCELLATIONS: NONE.

REFERENCED DOCUMENTS:
- ASTM D1655 (Commercial Jet Fuel Specification)
- MIL-HDBK-510 AEROSPACE FUELS CERTIFICATION HANDBOOK
- MIL-HDBK-516B AIRWORTHINESS CERTIFICATION CRITERIA HANDBOOK
- ENERGY INSTITUTE RESEARCH REPORT -- JOINT INDUSTRY PROJECT: SEEKING ORIGINAL EQUIPMENT MANUFACTURER (OEM) APPROVAL FOR 100 MG/KG FATTY ACID METHYL ESTER (FAME) IN AVIATION TURBINE FUEL (February 2014)

BACKGROUND:
The DoD is in the process of converting most CONUS aviation locations to commercial Jet A fuel. One challenge the Jet A conversion introduces is that the military services are no longer in control of changes to the specification for the fuel that USAF aircraft will now operate on.

American Society for Testing and Materials (ASTM) members voted to increase the permissible amount of Fatty Acid Methyl Ester (FAME) from 5 parts per million (PPM) to 50 PPM. The vote also adds guidance that the Original Equipment Manufacturers (OEMs) have agreed to permit use of jet fuel containing up to 100 PPM FAME on an emergency basis and the OEMs intend to consider further relaxing the FAME limit to 100 PPM after the 50 PPM limit has been in force for 2 years. The new FAME limits in the Jet A fuel specification became effective on 2 February 2015.

FAME is essentially biodiesel fuel. Biodiesel is manufactured from animal or vegetable fats/oils through a trans-esterification process with methanol. The reason ASTM made the specification change is to enable diesel fuel (containing biodiesel) to be transported in the same media (e.g. primarily barges and pipelines) as jet fuel.

Prior to evaluation testing, the three primary concerns with FAME contamination were:

- Potential to reduce the thermal stability of jet fuel
- Potential material compatibility problems with fuel system elastomers
- Engine cold start performance

DISCUSSION:

AFLCMC/EN-EZ has a standing team of technical experts who evaluate changes to the commercial jet fuel specification (ASTM D1655). This team consists of Subject Matter Experts from AFLCMC/EN-EZ, AFLCMC/LP (Propulsion Directorate), AFRL, AFPA (Air Force Petroleum Agency), and AFLCMC System Safety. This team reviewed the technical report (ENERGY INSTITUTE RESEARCH REPORT) generated to address concerns with increasing the allowable FAME in commercial jet fuel.

The technical team reviewed the impact of this fuel specification change against all MIL-HDBK-516 criteria. The team first determined that only Section 7 (Propulsion) and Section 8 (Subsystems) criteria could potentially be impacted by the FAME limit change. The team then reviewed each criterion to determine if it was applicable. Ultimately, the team determined 12 individual criteria were impacted (four in Section 7 [Propulsion] and eight in Section 8 [Subsystems]). The primary concerns for this change are: thermal stability, material compatibility, and cold starting. Each of these concerns was addressed through extensive testing at the material, component, and engine system level. These evaluation results are reported in the ENERGY INSTITUTE RESEARCH REPORT. The actual testing was performed with 400PPM concentration (eight times the revised specification value). The technical team produced a commodity MACC for 50 PPM FAME (up to 100 PPM for emergency use) contaminated jet fuel (attached).

The Alternative Fuel Technical Team also looked at potential long term reliability issues associated with operation with the increased amount of FAME and determined it is unlikely to negatively impact any reliability parameters, including engine average time on wing. The primary mechanism of concern for reliability impact was increased coke deposit rates (coking) due to potential for reduced thermal stability of fuel with FAME contamination. The Air Force Research Laboratory conducted a series of tests on various engine components concluding: *Extensive testing has been accomplished on a single FAME-sensitive fuel using bench scale (JFTOT® and QCM) test devices as well as a rig-scale simulator using three different test method/simulation protocols. In a variety of measurements and visual assessments, there is no substantial indication that FAME contamination in fuel up to 400 PPM causes any substantial coke deposition in a variety of engine hardware components. Further, the data does not indicate that there is any substantial degradation in performance or functionality of these components that would lead to service life or maintenance issues.* The Air Force Research Report is included in the ENERGY INSTITUTE RESEARCH REPORT.

General Electric performed engine endurance tests using fuel contaminated with 400 PPM FAME. This test was performed on two CFM56 engines (dash 5B and 7B configurations),

burning more than 300,000 gallons of fuel in each, and generally found no negative impact from the FAME. They did detect some increased level of coke deposit on the swirler, but no increased amounts on other engine components. Based on the results, they concluded:

- *No impact on engine thrust at fan speed or thrust response due to FAME*
- *No impact on fuel control components*
- *Higher coke buildup on combustor swirlers noted, but no detrimental impact on engine operation was noted*

The General Electric report is included in the ENERGY INSTITUTE RESEARCH REPORT.

To maintain consistency with the commercial fuel specification, the USAF is currently considering adding FAME limits to MIL-DTL-83133.

RECOMMENDATIONS:
AFLCMC/EN-EZ recommends no change to the planned use of commercial jet fuel (Jet A or Jet A-1) resulting from the ASTM D1655 specification change for allowable FAME.

POINTS OF CONTACT:
The AFLCMC/EN-EZ point of contact on this subject is Mr. Tom Condron at DSN 785-2023, Comm: (937) 255-2023, e-mail: thomas.condron@us.af.mil

JORGE F. GONZALEZ, SES
USAF Technical Airworthiness Authority
Director, Engineering & Technical Management/Services
Air Force Life Cycle Management Center

Attachment:
FAME Commodity MACC