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Advanced Engineering & Technology Division

ISO 9001 Registered

Synthetic Fuels Concerns for Gas Turbine Engines

4th International Conference on Bio-fuel Standards

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Overview: Aviation Synthetic Gas Turbine Fuels

- Commercial aviation: Active in developing semi-synthetic and fully synthetic fuels as part of compliance with carbon based regulations.
- Fuel blends of biological based synthetic paraffinic kerosene (Bio-SPK), synthetic paraffins & Aromatics and petroleum kerosene
  - Beneficial to life cycle CO_2 emissions.
  - Use recently developed sources of material, production processes and standards and procedures.
  - **Drop in fuel**: no changes required to existing aircraft, engines, manuals, etc.
  - Meet airworthiness requirements for commercial aviation use.
- Aviation industry (airlines, fuel suppliers, regulatory agencies, aircraft companies and engine companies)
  - Present systems are tolerant to petroleum based fuels.
  - ***Approach is to show Bio-SPK fuel blends are functionally equivalent to petroleum kerosene.***

Engine Manufacturer's Concerns

OEM Role:

- Design Fuel-efficient Engines
- Validate Alternative Fuels
  - Support customer initiatives
  - Evaluate impact on the engine
  - Provide a timely and cost-effective path for approval and field use
  - Provide political support, demonstrate commercial viability, fuel development

Aviation Bio-Fuel Expectation:

- High Energy Content
- Drop In-technology Invisible to the Engine
  - Requires no redesign, component development program, or re-certification
- Does No Harm

Fuel Relevance to FAR 33 Certification

Paragraph number	Paragraph title	Proposed substantiation for fuel change
33.5	Instruction Manuals	Revise installation and operating manuals
33.7	Engine Ratings and Operating Limitations	Establish approved fuels
33.65	Surge and stall	Address effects of fuel properties on starting and operability
33.67/.91	Fuel System/Component Tests	Certify fuel system for recharacterized/new fuels
33.68	Induction System Icing	Address effects of fuel properties on combustion efficiency and operability
33.69	Ignition System	Some engines use this section for starting
33.73	Power or Thrust Response	Address effects of fuel properties on operability
33.76	Bird Ingestion	Address effects of fuel properties on combustion efficiency and operability
33.78	Rain and hail ingestion	Address effects of fuel properties on combustion efficiency and operability
33.87	Endurance Test	Address effects of fuel properties on durability
33.89	Operation test	Address effects of fuel properties on operability

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Impact of Fuel Properties

Safety
Flash Pt., Freezing Pt.
Microsep

Certification
All Characteristics

Cost of Ownership
ThermalStab.
Exist. Gum
Sulfur

Durability
As Above
Lubricity
Acidity

Performance
Heating Value
Density
Flash/Freezing Pts.

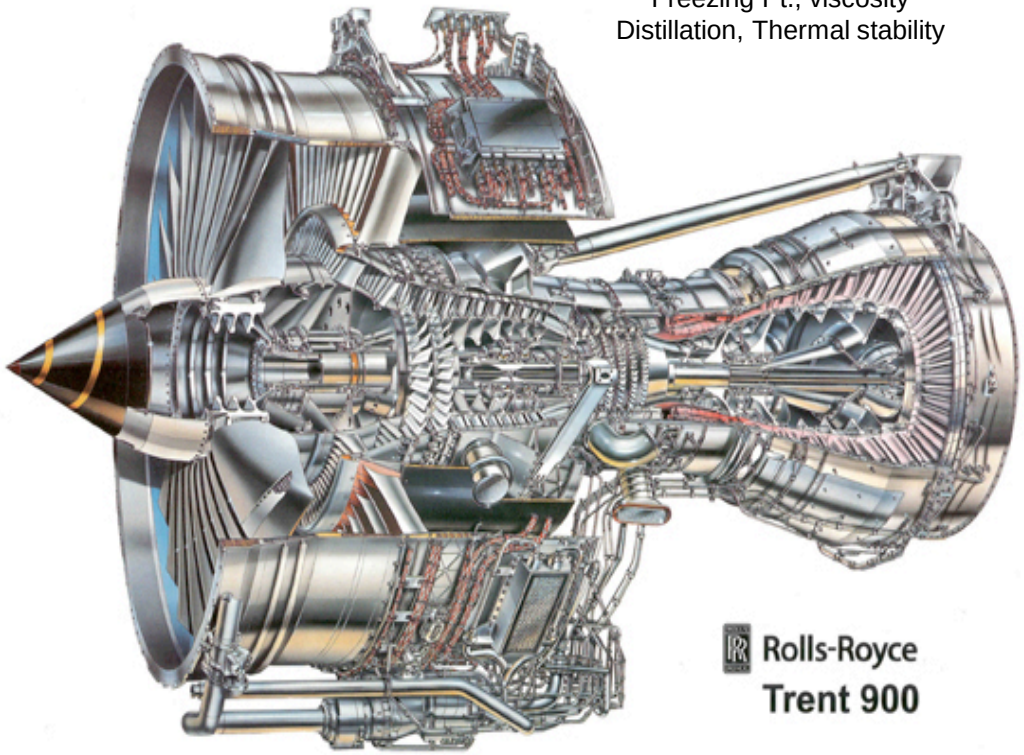
Maintenance
Same as Durability

System Design & Materials
All Characteristics

Future Technology
Specific Heat, Thermal Stab.
Aromatics, Sulfur/polar Materials

Legacy Hardware
Aromatics, lubricity

Fluid Performance Prediction
Freezing Pt., viscosity
Distillation, Thermal stability



Physical Properties

Deposition (coking)
Thermal stability, Gum,
Distillation

Hot- Section Life
Thermal Stability, Acidity
Aromatics, Sulfur

Emissions
Aromatics, Sulfur
distillation

Cold Start & Alt re-light
Flash Pt., Heating Value
Distillation, viscosity

Material Compatibility
Aromatics, freezing pt.
Acidity, Copper Strip

Chemical Properties

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GE Biofuels (HRJ) Testing

Continental - January, 2009. CFM56-7B. Ground test… performance, operability, emissions. Flight test…altitude relights.

KLM - November, 2009. CF6-80C2. Ground test…limited performance, operability.

F/A-18 Green Hornet - 1st half, 2010. F414. Component, ground, and flight tests.

F110 - AEDC altitude testing.

T700 Apache - Complex aerobatics. June 2010.

Azul Airlines - June, 2012, CF34-8. ATJ Fuel & E195, ground operation & flight testing

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Military Alternative Fuels…

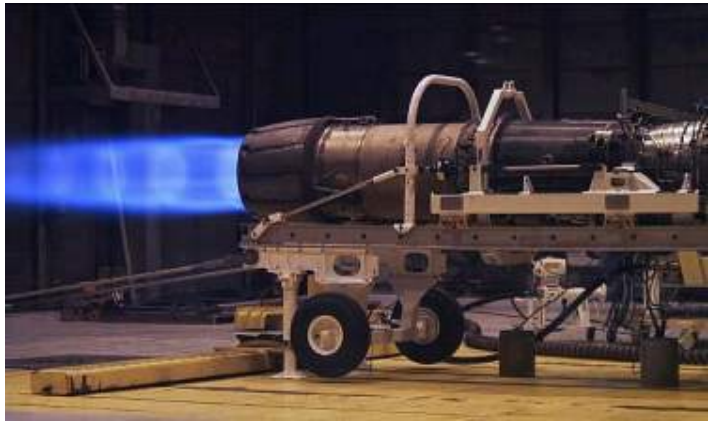
DOD is providing global leadership.

NAVY

- F414 Biofuels… component and ground test complete.
- Flight Test. 1st supersonic biofuels flight. 1st augmented flight.

Air Force

- F-T qualification.
- Biofuels qual initiatied. A-10 flight completed in late March.
- F110 ground test at AEDC.



Future Pathway Issues for ASTM & OEM's

- **Use Information Accrued to shorten the Approval Process**
  - Identified H/C within normal Jet fuel H/C distribution.
  - Identifying Process residuals and contaminates for remediation.
  - Re-scope Material Compatibility requirement.
- **Will Future Synthetic Fuels respond to current Test Methods?**
- **Diversity of Test Fuel Samples**
  - Are Multiple Producers Necessary?
    - Demonstrates "Robustness" of Process/Annex Criteria
  - How to Handle New Pathways With Proprietary Processes?
  - Alternatives for Demonstrating "Robustness" of Process/Annex Criteria?
  - Fuel production of capacity demonstrated by applicant.
- **D7566 Annex Definition Parameters**
  - Feedstock
  - Process
  - Fuel Composition and Manufacturer's Specification for QC purposes.

Acknowledgements

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