EUROPEAN DEFENCE AGENCY

Fact sheet

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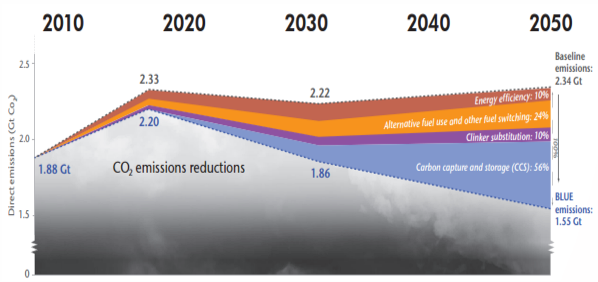
The Use of Alternative and Synthetic Fuels in the Military

Why?

Concerns over climate change, the finite nature of oil reserves, and concerns over security of supply from the oil producing regions have triggered a broad effort in the search for new sources and conversion processes for the production of alternative fuels. The increasing availability of liquid alternative fuels, and their mixing with conventional petroleum distillate fuels, have led to a need for the military to more closely study and mitigate any negative effects of the introduction of such fuel blends on their systems (air, land or naval) as well as operational procedures.



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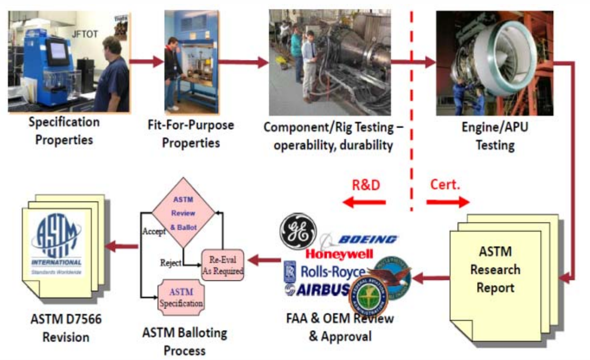
How?

The adoption of synthetic fuels is described in several military and NATO standards.

To be eligible for use, "new alternative" jet fuels must undergo a full approval process defined by the ***ASTM D4054*** standard (Standard Practice for Qualification and Approval of New Aviation Turbine Fuels and Fuel Additives). The fuel is submitted to a large range of tests (physico-chemical properties, component testing, engine testing, etc.). The objective of this approach is to demonstrate the safety of use of the jet fuel. The US military developed a process to evaluate, approve, and certify fuels and fuel additives for use in military aviation-fuel using and handling equipment. This process was developed to fill a known gap in knowledge and provide a single integrated and cost effective process for clearing all military platforms instead of a system by system evaluation.



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The ***ASTM D4054*** (solely for jet fuels) approach is divided into several stages. The first step corresponds to a physico-chemical analysis of the fuel as it is conventionally done to check whether the fuel conforms to the specifications. If the fuel is found to be in compliance, it is then possible to take the next step. This corresponds to the 'Fit for purpose' tests. At this stage non-standard physico-chemical characterisations are carried out. The aim is often to look at the evolution of a property as a function of the temperature, and to evaluate properties that are not checked explicitly in the specifications. The conformity of the 'new' fuel is evaluated in this step by comparison with the classic behaviour of conventional fossil fuel. If no significant

[1] Industry's emission reduction goals 2010-2050

[2] Pictorial overview of the ASTM D4054 fuel an additive approval process

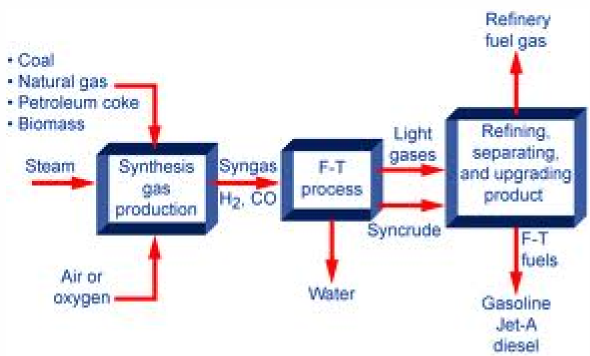
difference has been observed, the next steps are undertaken. Next, a characterisation by tests related to the interactions between the fuel and single engine or fuel system elements and by tests related to the fuel and complete systems is performed. Only those tests requested by the ***Original Equipment Manufacturers*** (***OEM***) after their inspection, will be performed. All the results are then compiled in a comprehensive technical document, which is submitted for evaluation.

For marine fuels, there is no industry standardised method for the approval of these synthetic fuels. The approvals are achieved via US Navy's protocols, which follow a similar approach but with a focus on naval applications.

Benefits to the Defence Sector

Two types of alternative fuels are "suitable" for military applications:

- Fuels produced via a ***Fischer-Tropsch*** synthesis



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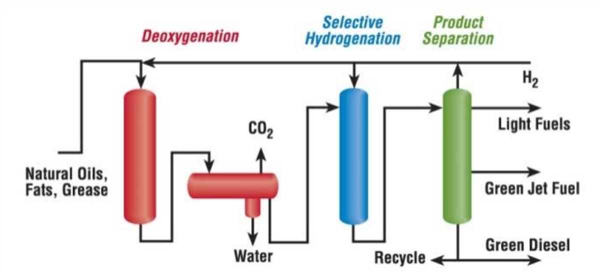
- Fuels produced by processing vegetable oils and animal fats with hydrogen.



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With regard to synthetic jet fuels, these are just as safe as the regular fuels. The fuel meets the same stringent international fuel specifications as conventional jet fuel. Drop-in fuels share the same properties as (or even better properties than) the jet fuel we use today and can simply be blended with the current fuel supply as they become available. For instance ***Fischer-Tropsch*** fuels are paraffins. The aromatic content is very low and sulphur levels are nearly zero. This results in reduced emissions of particulate matter, sulphur oxides and possibly other air pollutants known to pose health threats.

Aviation synthetic fuels can be tailored to produce superior properties in several respects: thermal stability (better heat exchange potential), freezing point (higher altitudes), flash point (handling safety), etc.

The approval process for new formulations of synthetic jet fuel is very involved, due to the range of conditions under which jet fuel must perform (downstream of the blending, the presence of synthetic components in the distribution chain does not necessarily have to be mentioned on the fuel quality certificate).

Sustainable synthetic aviation fuels will play an important role in meeting the industry's ambitious carbon emissions reduction goals: a carbon neutral growth from 2020 and halving CO_2-emissions by 2050, relative to 2005.

Unlike the ground transport sector, which can use electric energy from batteries or fuel cells, aviation needs new liquid fuels compatible with existing systems. Sustainable synthetic aviation jet fuels have been identified as one of the key elements in helping to achieve these goals.

Biodiesel (known as Fatty Acid Methyl Ester - ***FAME***) and bioethanol are unsuitable for use in weapon systems. They pose a severe safety risk, reduce performance, unduly complicate fuel delivery and storage, and generate maintenance problems.

Financial benefits over time are evident when investing in local renewable energy production with or without connection to the national energy grid.

Challenges

A tendency has been observed on the part of some OEM's, particularly those not as well integrated with the ***ASTM*** process for approval of synthetic jet fuels, to seek elaborate testing of already ***ASTM*** approved synthetic fuels prior to their introduction in military platforms. This adds significant cost, time and effort for the certification of such platforms when the effort may already be redundant.

All fuels with a same NATO code have to be interchangeable. However the fact that some nations already approved these kind of fuels and others still haven't, may lead to interchangeability problems.

The impact of the use of Jet fuels on the Single Fuel Policy has not thoroughly been studied until now (only for 2 synthetics). The ***Single Fuel Policy*** concerns the capability of using Jet fuel as the battlefield fuel for ground vehicles and for land-based military aircraft.

Since the main concern of the Aviation community is the use of "drop-in" alternative fuel, there are no major changes expected in the ***Single Fuel Policy***. However, these "drop-in"

3 Schematic overview ***Fischer-Tropsch*** process

4 Schematic overview ***HVO*** process

components in the jet fuels should be closely monitored to anticipate any difficulty with ground equipment.

Existing fuel specifications do not address all of the properties needed to evaluate or specify non-petroleum based fuels. Properties like the cetane number, the kinematic viscosity at 40°C and the fuel lubricity are of relevance in assessing the suitability of the fuels for ground applications. Properties that are important to the use of jet fuels in ground vehicles and equipment are:

- *Density*: the density will lower with increased volume of synthetic blend. Some engines have fuel injection systems that are sensitive to fuel density.
- *Cetane number*: a minimum cetane number ensures that synthetic blends will have an acceptable ignition quality allowing reliable starting of compression ignition engines, especially cold engines.
- *Kinematic viscosity at 40°C*: the jet fuel specifications have no requirement for the viscosity at this temperature. On the other hand, diesel fuel specifications typically have a viscosity at high temperature requirement.
- *Lubricity*: to Jet fuels a lubricity improver additive can be added. It is known that some synthetic fuels can have poor lubricity characteristics.
- *Bulk modulus*: the bulk modulus of a fluid is a measure of its resistance to compression. It has been reported that the bulk modulus of some synthetic fuels has been lower than of petroleum based fuels.

The use of biodiesel (Fatty Acid Methyl Ester ***- FAME***) in several nations has led to problems like:

- Corrosion issues
- Poor cold flow properties
- Affinity for water
- The presence of micro-organisms
- Poor storage stability

With these problems some nations switched back to 100% conventional fossil diesel fuel. ***FAME*** remains an issue for the military and should be avoided to ensure operational readiness.

Status in the Defence Sector

Some NATO members have already approved the use of synthetic fuels in their military platforms like Belgium, Canada, France, The Netherlands and the US.

In order to facilitate the progress of certifying alternative fuels for the aviation, a military user's guide for the certification of Aviation Platforms on Synthetic Jet fuels was developed and made available to nations to assist their national certification program. A comprehensive list of national approvals is available.

For the Marine fuels synthetic fuels have also entered the military and NATO specifications. Apart from density, properties like demulsification, cetane number and lubricity, the bulk modulus and the materials compatibility are of concern and will need to be investigated when synthetic blends are used.

With regard to the single fuel policy, the use of synthetics in land equipment has only been studied for the ***Fischer-Tropsch*** synthetics and the Hydrogenated Vegetable Oils. The ***SIP***, ***SKA*** and ***ATJ*** have already been adopted in ***ASTM D7566*** (Standard specification for Aviation Turbine Fuel containing Synthesised Hydrocarbons).

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