Chevron Products Company
6001 Bollinger Canyon Road
San Ramon, CA 94583

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Chevron

Aviation Fuels
Technical Review

Our Family of Brands

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Please note: This information is accurate as of fall 2004. It may be superseded by new regulations, specifications, or advances in fuel or engine technologies.

Written, edited, and designed by employees and contractors of Chevron: Greg Hemighaus, Tracy Boval, John Bacha, Fred Barnes, Matt Franklin, Lew Gibbs, Nancy Hogue, Jacqueline Jones, David Lesnini, John Lind and Jack Morris.

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Aviation Fuels Technical Review (FTR-3)

Notes

of fuel and air results in more complete combustion and, thus, less carbon formation. Newer engines emit much less smoke because of design changes that improve mixing.

Stability

A stable fuel is one whose properties remain unchanged. Factors that can lead to deleterious changes in fuel properties include time (*storage stability*) and exposure to high temperatures in the engine (*thermal stability*).

Jet fuel instability involves multi-step chemical reactions, some of which are oxidation reactions. Hydroperoxides and peroxides are the initial reaction products. These products remain dissolved in the fuel, but may attack and shorten the life of some fuel system elastomers. Additional reactions result in the formation of soluble gums and insoluble particulates. These products may clog fuel filters and deposit on the surfaces of aircraft fuel systems, restricting flow in small-diameter passageways.

Storage Stability Instability of jet fuel during storage is generally not a problem because most fuel is used within weeks or months of its manufacture. Storage stability is an issue for the military, which often stores fuel for emergency use. And it can be an issue at small airports that don't use a lot of fuel. Jet fuel that has been properly manufactured, stored, and handled should remain stable for at least one year. Jet fuel subjected to longer storage or to improper storage or handling should be tested to be sure it meets all applicable specification requirements before use.

Because it is the more reactive fuel components that cause instability, storage stability is influenced by fuel composition. It is also influenced by storage conditions; instability reactions occur faster and to a greater extent at higher ambient temperatures. Antioxidants may be added to fuel to improve its storage stability (*see page 31*).

Thermal Stability Thermal stability is one of the most important jet fuel properties because the fuel serves as a heat exchange medium in the engine and airframe. Jet fuel is used to remove heat from engine oil, hydraulic fluid, and air conditioning equipment. As noted above, the resulting heating of the fuel accelerates the reactions that lead to gum and particulate formation. These gums and particles may deposit:

- On fuel filters, increasing the pressure drop across the filter and reducing fuel flow.
- In fuel injector nozzles, disrupting the spray pattern, which may lead to hot spots in the combustion chamber.
- In the main engine control, interfering with fuel flow and engine system control.
- On heat exchangers, reducing heat transfer efficiency and fuel flow.

These deposits may lead to operational problems and increased maintenance. Antioxidants that are used to improve fuel storage stability are not generally effective in improving thermal stability.

Engine problems related to inadequate fuel thermal stability typically become evident only after hundreds or thousands of hours of operation. The long time and the large volume of fuel consumed make it impractical to test fuel thermal stability under conditions identical to those that exist in engines. Instead, the fuel is subjected to more severe conditions in a bench test in order to be able to see a measurable effect in a reasonable period of time.

Test equipment has been developed to pump fuel over a heated aluminum surface and then through a filter to collect any solid decomposition products. The equipment is intended to model two sensitive areas of an engine: the surface of a fuel-oil heat exchanger and a fuel injection nozzle. The first standardized apparatus (ASTM D 1660) was called the *Coker.* It has now been replaced by the *Jet Fuel Thermal Oxidation Tester* (JFTOT; pronounced *jef´tot*) (ASTM D 3241).

Lubricity

Lubricity is the ability to reduce friction between solid surfaces in relative motion, so it is a measure of a material's effectiveness as a lubricant. Jet fuel must possess a certain degree of lubricity because jet engines rely on the fuel to lubricate some moving parts in fuel pumps and flow control units.

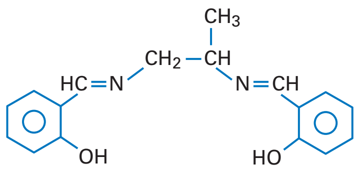
The lubrication mechanism is a combination of *hydrodynamic lubrication* and *boundary lubrication.* In hydrodynamic lubrication, a layer of the liquid lubricant prevents the opposing moving surfaces from contacting each other. Higher viscosity liquids provide more hydrodynamic lubrication than lower viscosity liquids. While jet fuel specifications do not include an explicit lower limit on viscosity, the distillation specification serves as a surrogate limit. Jet engines are designed to work with jet fuels within the normal viscosity range, and therefore, typical jet fuels provide adequate hydrodynamic lubrication.

When close tolerances squeeze out most of the liquid layer that provides hydrodynamic lubrication, boundary lubrication becomes important. Now, small areas of the opposing surfaces are in contact. Boundary lubricants are compounds that form a protective anti-wear layer by adhering to the metal surfaces.

Straight-run jet fuels (*see page 34*) are good boundary lubricants. This is not due to the hydrocarbons that constitute the bulk of the fuel, but is attributed to trace amounts of certain oxygen-, nitrogen-, and sulfur-containing compounds. Evidence for the role of trace quantities is the fact that adding as little as 10 ppm of a lubricity enhancing additive to a poor lubricity fuel can make it acceptable.

The naturally occurring compounds that provide jet fuel with its natural lubricity can be removed by hydrotreating – the refining process used to reduce sulfur and aromatic content (*see page 35*). However, low sulfur or aromatics levels in jet fuel are not, per se, signs of inadequate lubricity. The boundary lubricity of jet fuel cannot be predicted from bulk physical or chemical properties, it can only be measured in a specially designed test apparatus (*see page 23*). Fuels with similar sulfur and aromatics content can have different lubricity.

Metal Deactivator



N,N´-disalicylidene-1,2-propane diamine

Metal Deactivator

Metal deactivators are *chelating agents* – chemical compounds that form stable complexes with specific metal ions. More active metals, like copper and zinc, are effective catalysts for oxidation reactions, and degrade fuel thermal stability. These metals are not used in most jet fuel distribution systems or turbine engine fuel systems. However, if fuel becomes contaminated with these metals, metal deactivators inhibit their catalytic activity. The only approved metal deactivator is N,N´-disalicylidene-1,2-propane diamine.

Corrosion Inhibitors/Lubricity Improvers

The tanks and pipelines of the jet fuel distribution system are constructed primarily of uncoated steel. Corrosion inhibitors prevent free water and oxygen in the jet fuel from rusting or corroding these structures.

Lubricity additives are used to compensate for the poor lubricity of severely hydrotreated jet fuel. They contain a polar group that adheres to metal surfaces, forming a thin surface film of the additive. The film acts as a boundary lubricant when two metal surfaces come in contact (*see page 6*). These compounds are usually carboxylic acids, whose compositions are proprietary.

Both corrosion and lubricity are surface phenomena. Perhaps it is not too surprising that corrosion inhibitors also improve lubricity.

Electrical-Conductivity Additive

Since the naturally poor electrical conductivity of jet fuel (*see page 10*) presents a potential safety hazard in certain circumstances, additives have been developed that improve the fuel's conductivity. Conductivity additives are often referred to as static *dissipator additives* (SDA). When the additive is used, the conductivity of the fuel must be between 50 and 450 CU at the point of delivery into the aircraft. The only additive currently approved for use in jet fuel is Stadis®450, whose composition is proprietary.

Leak Detection

Tracer A® can be used in Jet A and Jet A-1 to assist in detecting leaks in fuel handling systems. The additive is a gas that can be detected at very low concentrations. Tracer A is mixed with fuel as it is pumped through the distribution system. If any fuel leaks from the system, it will evolve the Tracer A® gas. The presence of this gas outside of a fuel system can be used to locate a leak.

Biocides

Biocides are designed to kill microorganisms, which include bacteria and fungi (yeasts and molds) (*see page 9*). Since biocides are toxic, any water bottoms that contain biocides must be disposed of appropriately. Currently approved biocides are Biobor™ and Kathon™.