Jet Fuel Quality:
Flying Clean and Dry

By John Bagnall, P.E.

Each day, millions of gallons of fuel are put into jet aircraft. One of the things airlines and fuel service companies try to ensure is that their fuel is "clean" and "dry." Because there are so many contaminants that can infect the fuel, many tests must be performed to ensure quality.

Fuel Contaminants

The primary contaminants in jet fuel are: water, surfactants, sediment or particulate, microbial growth and other petroleum products. These contaminants can cause complications ranging from fuel system corrosion, fouling or disarming of fuel filtration components to failure of aircraft fuel system instrumentation and possible shutdown of fuel supply to engines on an aircraft during flight.

Water — The composition of Jet A fuel allows water to be easily absorbed and held in suspension. But if enough water is present in an aircraft fuel system, ice crystals can form at higher altitudes and clog fuel lines or system components, disturbing or stopping fuel supply to the engine. Water also promotes corrosion of steel and generation of microbial growth.

Particulate — Almost anything one could imagine, from rags and two-by-fours to dead animals, have been found in systems following construction. Wear and corrosion of system components introduce rust, metal shavings and rubber or plastic fragments. System screens and filter elements collect particulate. The "loading" of these elements must be monitored, or excessive differential pressures could develop that would rupture them and possibly generate even more particulate contamination.

Surfactants — Surfactants are soap or detergent-like compounds that emulsify water and particulate, complicating or preventing their removal.

These compounds can be introduced from refinery processes; pipeline or truck cross-contamination with other products or cleansing agents; or from fuel additives. Surfactants can disarm the water-removing ability of critical system filtration.

Microbial Growth — Microbial growth can occur at a stagnant water-fuel interface. Certain bacteria and fungi are capable of existing in the water at the fuel interface and can propagate rapidly, producing a sludge-like substance. In sufficient quantity, growth can cause corrosion on steel and aluminum surfaces. Growth can also foul filters and system instrumentation.

Fuel System Design

A crucial parameter of maintaining jet fuel quality is the design of the fueling system. The system must be arranged to minimize the potential for fuel contamination. Current practice is to internally line or coat all system piping, storage tanks and major equipment. The exception to this is welded pipe joints and smaller pipe fittings, which are left uncoated. High solids epoxy paint, suitable for hydrocarbon immersion service, is the coating of choice. Its slicker surface minimizes corrosion and sediment build-up on the vast majority of fuel-exposed surfaces. The use of copper, brass, cadmium or zinc (galvanizing) in fuel-exposed equipment and piping is undesirable, because these metals can affect the thermal properties of the fuel or damage engine parts.

Organizations

API-American Petroleum Institute

ASTM-American Society for Testing and Materials

ATA-Air Transport Association of America

IATA-International Air Transport Association

NATA-National Air Transportation Association

Jet Fuel Composition

ASTM D 1655-Specification for Aviation Turbine Fuels

DERD-2494, British Aviation Turbine Fuel Specification

IATA-Guidance Material for Aviation Turbine Fuels

Aviation Fuel Quality Requirements for Jointly Operated Systems

Fuel Quality Control Measures

API 1500, Storage and Handling of Aviation Fuel at Airports

API 1581, Specifications and Qualification Procedures for Aviation Jet Fuel Filter / Separators

ASTM MNL 5, Manual of Aviation Fuel Quality Control Procedures (This publication references several ASTM standards for individual testing procedures)

ATA 103, Standards for Jet Fuel Quality Control at Airports

NATA Refueling and Quality Control Procedures for Airport Service and Support Operations

Fuel Quality Standards, Guidelines and Supporting Organizations
Table 1

Most critical is the adequate sloping of fuel piping and tank bottoms to low points and providing for the draining of accumulated water and particulate from these and equipment low points. As a rule of thumb, as much as 1 ppm of water can condense from jet fuel per degree of fuel temperature drop. Water, being approximately 25 percent heavier than jet fuel, settles to low points (when freed from solution) and must be removed. Failure to provide adequate draining provisions can lead to problems with microbial growth and freezing. Also, the system piping should be optimally sized to provide sufficient fuel velocity (typically 3 to 5 feet per second or higher) to prevent the accumulation of particulate.

A number of established national and international standards and guidelines exist for fuel and fuel systems. The major ones affecting jet fuel quality assurance are identified in Table 1.

Filtration

As the fuel passes from manufacturer to the aircraft, varying levels of filtration achieve the required level of fuel quality at each point. It is commonly said, "this stuff is filtered to death" before it reaches the aircraft tank – I think that most of us would have it no other way! The fuel is filtered at the refinery, filtered as it is received at the airport storage facility, sometimes filtered as it passes from receiving tankage to issue tankage, filtered as it leaves the airport storage facility and finally filtered before being uplifted into the aircraft. The aircraft has onboard filtration as well.

The filter / separator, with currently available API 1581 Third Edition coalescer and separator cartridges, can remove water down to less than 5 ppm and particulate down to 0.3-micron size. These units are typically present at a minimum of three locations within an airport fuel system: 1) at pipeline and truck unloading receipt facilities, 2) downstream of the fueling system issue pumps and 3) on the trucks or carts actually fueling the aircraft. Filter separators in airport fuel systems are equipped with a water defense system. If high water levels are reached in the vessel water collection sump, a "water slug valve" shuts down flow through the unit. A high water level alarm is also sent to the system operator. Other less critical filtration vessels used include prefilters (micronics), water coalescers (haypacks), and clay treaters.

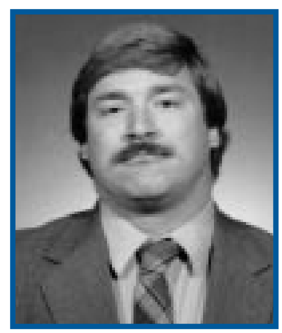
Fuel System Construction

Proper measures taken during fuel system construction promote good fuel quality. Fuel piping stored on-site should be kept as clean inside as possible and have the ends covered with heavy plastic caps at all times to prevent the introduction of dirt and debris. Partial in-trench piping installations need to be provided with watertight plugs or "nightcaps" to prevent water, mud, debris and even animals from entering the pipe. In instances where nightcaps were not used, piping systems have been filled with mud and water (and animals). Costly cleanings have been required, involving additional cost. Adequate flushing of the new system piping is critical to fuel quality. Fuel should be used as the flushing media since water is a major contaminant. An adequate flushing fluid velocity must be maintained, typically 10 feet per second or higher. Three to five piping volume changes of fuel are typically displaced during a flushing operation. The flushed fuel is routed to either tank trucks, larger portable tanks or system storage tanks temporarily dedicated to the flushing operation.

Toward the end of a system flush, the fuel is sampled, visually inspected and tested by standardized methods. Testing is done for color (clearness), odor, particulate, water and surfactant content, and microorganisms. The samples must pass visual inspections and meet guideline criteria, such as 5 ppm water maximum and very low allowable particulate and surfactant content, for the piping system to be accepted and put into service. When piping is added to an existing fuel system (e.g., to provide fuel to new aircraft parking positions or gates) this piping must also be flushed, samples taken and the same sampling criteria met.

Any of the above precautions and procedures can be taken to ensure that your fuel is "clean" and "dry," and make flying safer for all of us.

Portions of Mr. Bagnall's article previously appeared in Petroleum Equipment & Technology magazine.



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