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INFORMATION:

Useful Information for Managing Microbial Contamination in Jet Fuel

Microbial contamination is a very serious issue for all users of jet fuel.

This paper discusses the issues caused by microbial contamination and the modern approach to fast and accurate fuel testing using the latest antibody testing technology.

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Background

Microbial growth consists of living micro-organisms (also called microbes) growing at a fuel and water interface. They may be yeast, fungus or bacteria. Fungus is a major source of problems in fuel. This type of contaminant appears as a stringy, web-like substance, usually grey or brown in color.

- MBG testing in fuel focuses on Bacteria, yeast (a subgroup of fungi) and Fungi (mainly filamentous fungi H.res).
- Fungi are simple aerobic organisms and may grow to form fungal mats. Fungi produce spores which are like seeds that germinate in the presence of water. Once a spore germinates in water, a fungus grows by using fuel for food, along with trace materials in the water and dissolved oxygen.
- Bacteria are microscopic single cell organisms.

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A wide variety of microorganisms may enter fuel systems via air, sea or fresh water, soil, or other means.

A fuel/water interface is an ideal place for fungi and bacteria to grow. The exact mechanisms of sludge and slime formation and corrosion from bacterial and fungal growth are complex.

In the right environment, bacteria and fungi may grow and result in ground fuel system problems such as: coalescer element spotting, clogging and/or disabling; dark colored water bottoms or smelly "black water;" and in extreme cases, fuel tank corrosion. In aircraft, microbial contamination of fuel may lead to fuel level gauge malfunctions, fuel system clogging, and fuel tank corrosion.

Water is necessary for microbial growth to become a problem in a fuel system. Microbial growth is almost always found where water is present in a fuel system (without a biocide). Usually the level of contamination is so low it does not cause an operational problem.

Problematic microbes such as fungi, bacteria, and yeasts metabolize (break down) fuel hydrocarbons, particularly straight-chain and sulfur-bearing compounds, enabling growth into slimes and mats. These growths can appear in a range of colors from black to green to red. ASTM D6469 and IATA Guidance Material on Microbiological Contamination in Aircraft Fuel Tanks are recommended as resource guides for microbiological growth in fuels.

The most practical means to minimize microbial contamination is by regular sampling and testing in addition to regular water draining. Frequency of sampling and testing can be established based on Risk Analysis recognizing that each circumstance can be influenced by various driving factors.

Jet fuel contamination and how to detect it

It is no secret that jet fuel contamination can be extremely costly to aviation businesses.

In fact, one instance of jet fuel contamination caused a large commercial aircraft to be grounded for over two weeks. This grounding was a consequence of microbial contamination and had a huge financial impact through both treatment of the contamination and lost revenue.

Also, with the growing economies in China, India, Brazil etc. and the resulting demand for aviation, more flights are now conducted in high-risk zones. As a result, it is more important than ever to detect contamination early.

What are the main causes of jet fuel contamination?

The most common contaminants are particulates, water, petroleum products (or their residues), and microbial growth, let us explore these in more detail:

Particulates

Despite the protective coatings on the interior surfaces of fuel tanks and pipes, they contribute particulates like rust and scale to fuel. Even small quantities of water in jet fuel distribution systems will lead to rust developing and eventually entering the fuel.

In addition, airborne particles like dust and pollen, rubber and fabric particles, and solids from microbial infestation (like cellular debris and microbial by-products) find their way into fuel.

Water

The accumulation of water is almost inevitable in stored aviation jet fuels and in operations. Even if the fuel has low water content when delivered at the airport, there are multiple opportunities for moisture to be taken up.

Moisture can come from free water gathered in low spots in a pipeline, rainwater leaking past the seals in floating-roof tanks, and moist outside air entering the vents of tanks. Air flowing in and out of a tank when fuel is added or removed may also change the moisture content of the air in contact with fuel.

Other petroleum products

If aviation fuel is contaminated with another petroleum product to the extent that the fuel's specification requirements are no longer met, then there is no remedy. The fuel must be returned to a refinery for reprocessing.

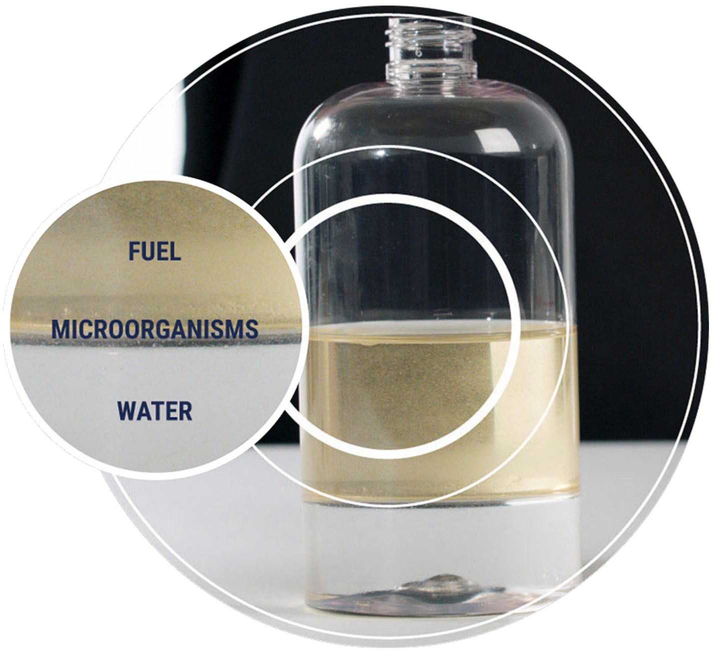
One contaminant that has been encountered in airport supply systems in recent years is Fatty Acid Methyl Ester (FAME). This material is most likely to be found when biodiesel fuel has passed through a common unsegregated fuel distribution system.

Microbial growth

Although aviation fuels are sterile when first produced, they inevitably become contaminated with microorganisms that are omnipresent in both air and water. Microorganisms found in aviation jet fuels include bacteria, yeasts and fungi.

When these microorganisms grow, they form solid debris that effectively plugs fuel filters. Some microorganisms also produce acidic by-products that can accelerate metal corrosion. Since most microorganisms need free water to grow, microbial growth is most commonly found in any place where fuel meets water.

How do I detect contaminated jet fuel?



Particulates like rust, scale, dust and pollen are determined by visual inspection of the fuel sample. Chemical analysis can also be employed to detect particulates beyond visual inspection levels.

Water in aviation jet fuel can be detected in several different ways. The most common method is known as a water tablet test for fuel. This very briefly indicates whether the water in fuel is above or below 30 ppm, the maximum allowed limit.

There are many other products and analysis equipment commercially available that can test for jet fuel water contamination.

Microbial contamination in jet fuels is typically detected through CFU tests, ATP tests, or Immunoassay-based Antibody tests. The CFU method usually requires sending fuel off-site for testing, which can take up to 10 days. ATP gives results in minutes but requires to be done in a laboratory with special equipment so is not generally classed as on-site. Immunoassay Antibody tests are done on-site, on the spot, and require little training and no special equipment. Results come in 10-15 minutes in an easy to interpret format. We will highlight the benefits in more detail later in this document.

Which type of contamination is most dangerous?

All fuel contamination can impact the quality of aviation jet fuel, particularly with stored products and reserves. But in general, microbial contamination is the most troublesome. The danger posed depends on the type of organism, the jet fuel itself, and any additives used.

While a wide range of potentially dangerous microorganisms is found in aircraft tanks, one of the most serious is the filamentous fungus, Hormoconis resinae (H.res). It is present in many cases of contamination found in aviation jet fuel, according to IATA (International Air Transport Association) who classify H.res as the predominant fungus found in jet fuel. The other cases are made up of bacteria and other fungi, including some yeasts.

H.res is damaging in fuel because of several reasons:

- **Size and bulk.** When compared to yeasts and bacteria, H.res produces far more biomass and is thus more likely to cause blockage problems.
- **Corrosive effects.** The by-products of microbial metabolism from H.res, along with other microorganisms, can induce harmful corrosion in aircraft fuel tanks.
- **Staying power** because of the way H.res grows between fuel and water. It usually starts on small water droplets, then covers the droplet, holding it in place. It then continues its growth, generating more water due to its metabolism. In the process, it firmly attaches itself to the tank, staying even after the water is drained.

Operational issues

Operational issues from microbial contamination can be very costly to aviation customers particularly if it results in unscheduled AOG taking aircraft out of operation with the risk of substantial lost revenues.

More often than not in normal flying conditions, that is 7 days a week 10 hours utilization, it is issues to FQIS probes and filters that occur first but there is always a threat, especially in hot and humid regions, that growth can be very quick (in weeks) and cause corrosion of tanks.

When an airline grounds an aircraft for any reason the main issue to look at is corrosion although FQIS probes and filters issues may occur as well as engines are fired up and any biomass from contamination is circulated around the system.

The operational issues, with risk of assets out of operation, from microbial contamination are:

- Fuel Quantity Indication System (FQIS) malfunctions resulting in incorrect fuel load readings
- Blocked filters leading to activation of Fuel Filter Bypass Warning lights
- Contaminated water scavenge systems

As an example, an airline that has a FQIS probe issue at an outlying airfield with no replacement stock is not ready to fly until the probe has been replaced. This could be days to get a new unit therefore a substitute aircraft may be required, if available, at this perhaps infrequently used airfield or risk of potential cancellation of flights and revenue loss is possible is possible.

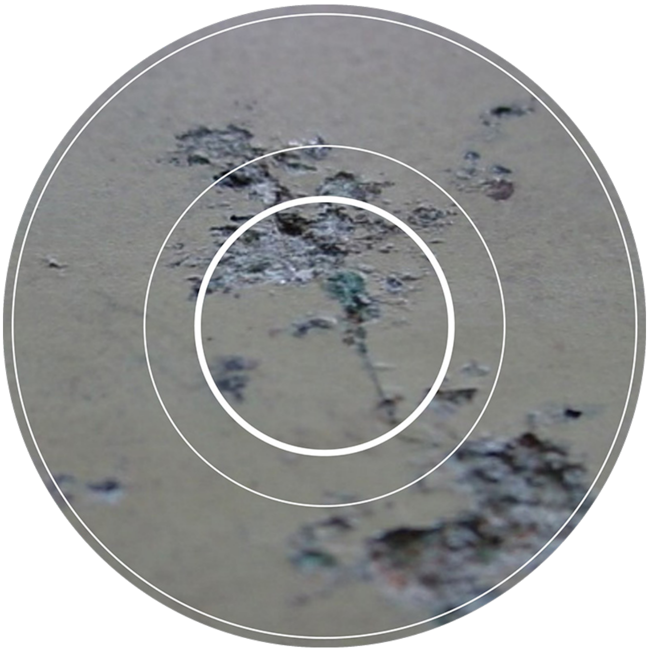
Activation of Fuel Filter Bypass warning lights also causes risk of delays and even cancellations as does the risk of contamination being spread by the filters in the water scavenge systems.

Impact of corrosion

There is also the impact of corrosion to consider for both aircraft in operation and grounded aircraft:

- Microbially Influenced Corrosion (MIC) is also a realistic threat (can be in weeks in some cases) from microbial infections where metal structures are used to store fuel.

An operator in Asia was forced to write off 2 narrow body jets after the effects of MIC took hold and costs of replacing whole wing structure was prohibitive is a recent case study that we are aware of.



Safety implications

And most severally has serious safety implications:

- Complete fuel system failure due to issues caused by contamination may affect safety of flight in some circumstances

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Testing for microbial contamination

Testing for microbial contamination is a very well-established way to try and catch microbial growth at its earliest and cheapest to remedy stages.

Testing for the presence of microbiological growth (MBG) material in fuel systems can be performed using the various commercial test kits, see IATA Guidance Material on Microbiological Contamination in Aircraft Fuel Tanks. Testing shall be done on both the water phase, if any, and on the fuel phase when microbial contamination is suspected.

There are different technologies applied to testing from traditional methods called CFU tests, methods using ATP technology and the most modern Antibody test technology.

There are several tests that measure Colony Forming Units (CFU) based on techniques that originate with Louis Pasteur is late 19th century. Still valid these tests are often done off site, so the samples must be transported, no easy task, and tested within 24 hours. CFU tests must be incubated, which is an additional cost, and results are in 4-8 days typically.

There is a more modern but highly scientific test also called ATP (adenosine triphosphate) and this gives much more rapid results but is generally done in laboratories and requires expensive hardware called a luminometer to furnish results.

Both CFU and ATP detect general microbial presence either directly or indirectly, at least as much as can be grown or detected from the sample and can be cross contaminated by microbes present all around us as well. Results can be higher than the conditions actually are in the tank at sampling due to these factors with risk of unnecessary maintenance, downtime and costs being higher than required.

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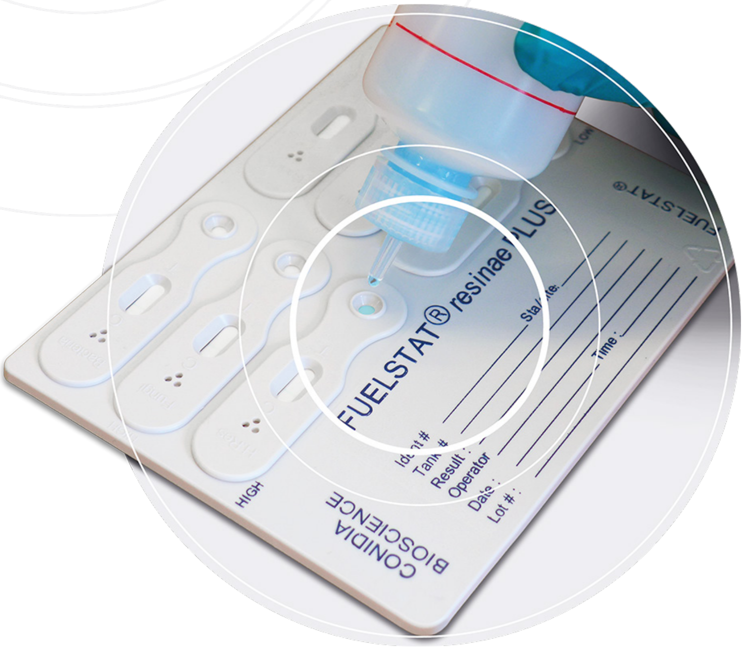
FUELSTAT®: the simple on-site test



FUELSTAT® is a simple on-site test to detect specifically only the microbes that thrive and do damage in fuels with a total time from start to production of detailed electronic report of less than **15 minutes**.

Advanced 21st century antibody test technology means that FUELSTAT® is the only true on-site test that gives dependable results even in the dirtiest of conditions.

Just as a pregnancy test will only search for the markers of human chorionic gonadotropin and ignores all other microorganisms present FUELSTAT® only searches for the markers of specific microorganisms that are known to thrive in and do damage to fuel systems and ignores other microbes that may be in the sample taken or have entered the sample in the handling and transport phases. Perfect sterility, akin to a hospital operating theatre is not required so FUELSTAT® narrowing in on the specific contamination species only allied to the vastly reduced risk of cross contamination means users have a very fast test, simple to do giving results that are very accurate.

FUELSTAT® detects H.res specifically, in addition to other fungi and bacteria, so the tester understands what is there and in what amounts (negligible, moderate, or heavy contaminations). Its unique technology means that it is only detecting the waste products from the microbes so, unlike older technology, will identify microbial contamination that is stuck on to tank walls, not just what is floating in the sample.

The total process for FUELSTAT® is four easy steps and is very suitable for solo working. All equipment needed for the test is included in the test kit, barring a clean sampling container. The online training videos can be viewed on your smartphone before conducting the test. The test itself is simple and can be conducted under wing. All the tester has to do is put four drops of sample fluid into 6 wells, results can be read manually or read with the free app FUELSTAT® Result.

FUELSTAT® Result is an app available on iOS and Android that verifies the result and users have option of saving results to a central portal for record keeping and longer- term analysis. It makes the use of FUELSTAT® a 100% paperless exercise cutting down both on cost, time taken and potential mistakes.

This all translates to FUELSTAT® being the most accurate, fastest and most simple test on the market. Treating microbial contamination at the earliest stage is both good practice and good business and FUELSTAT® helps all users and suppliers to ensure this.

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Who we are:

FUELSTAT® fuel tests are developed, manufactured and marketed by Conidia Bioscience Limited. Based in UK, Conidia Bioscience Limited was founded in early 2000’s by experts in immunoassay techniques and holds the internationally patented intellectual property for FUELSTAT®.

Where to find us:

FUELSTAT® is distributed globally by a network of specialist distributors covering the major sectors. Contact info@conidia.com who will arrange for a distributor to support you.

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