

WHITE PAPER:

Aviation Fuel Quality Management & Microbiological Supply Chain Challenges

Why FUELSTAT® *Plus* Is the Ideal Microbial Contamination Test for Aviation Ground Fuel Handling Operations.

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EXECUTIVE SUMMARY

Aviation turbine fuel (Jet A-1) is among the most stringently controlled commodities in the global marketplace. Its quality directly underpins flight safety, aircraft reliability, and operational efficiency. Yet despite rigorous specifications and global handling standards, one persistent challenge remains: **microbial contamination**, a naturally occurring and highly destructive process driven by the presence of water in fuel systems.

This white paper examines the fuel supply chain through the lens of industry standards—Def Stan 91-091, ASTM D1655, EI/JIG 1530, ASTM D6469 and JIG TID #1—and provides an expanded analysis of the **microbial testing approaches available.** It demonstrates why **FUELSTAT® *Plus***, compliant with ASTM D8070, offers the aviation industry the most reliable, rapid, cost-effective, and operationally practical tool for fuel microbial detection in all fuel storage, supply chain and ground-refuelling environments.

References

A. **Defence Standard 91-091** Turbine Fuel, Kerosene Type Jet A-1; NATO Code F-35; Joint Service designation: AVTUR

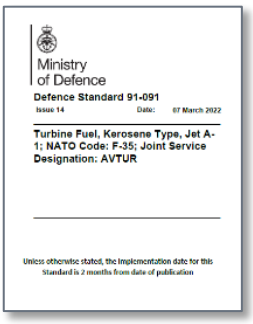
B. **ASTM D1655** Standard Specification for Aviation Turbine Fuels

C. **EI/JIG STD 1530** Quality Assurance for the Manufacture, Storage and Distribution of Aviation Fuels to Airports

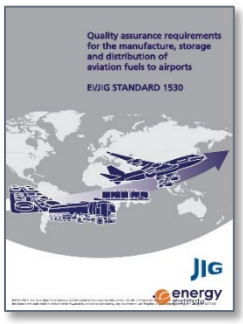
D. ASTM D6469 Standard Guide for Microbial Contamination in Fuels and Fuel Systems

E. **JIG TID #1** Microbial Growth in Fuel and Monitoring Strategies

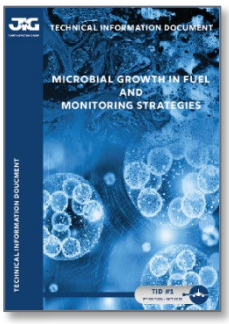
F. **EI 3203** Guidelines for the investigation of the microbial content of liquid fuels and for the implementation of avoidance and remedial strategies









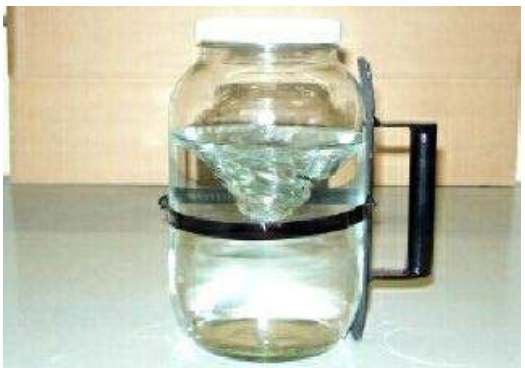




1. AVIATION FUEL QUALITY MANAGEMENT: A SYSTEM BUILT ON PREVENTION

Aviation turbine fuel, commonly referred to as *"jet fuel"* is one of the most controlled commodity products in the marketplace. The main reason is to ensure and preserve flight safety. The physico-chemical characteristics of jet fuel are prescribed in **Defence Standard 91-091** and **ASTM D1655**; being the major jet fuel standards in the aviation industry. Note that on-specification jet fuel, meeting the requirements of both references, shall be visually free of undissolved water, sediment, haze and suspended matter. Good fuel is typically water-white to light straw colour and shall be described as "***Clear & Bright***".

- **"Clear"** assesses particulate contamination and means the absence of visible particles, sediment, solids, or dye (unusual fuel colour). Clear fuel has no floating or suspended matter.
- **"Bright"** assesses water contamination and means no water present either as liquid in bottom, drops on jar walls or haze in the fuel (air bubbles causing haze usually clear within one minute after drawing sample)

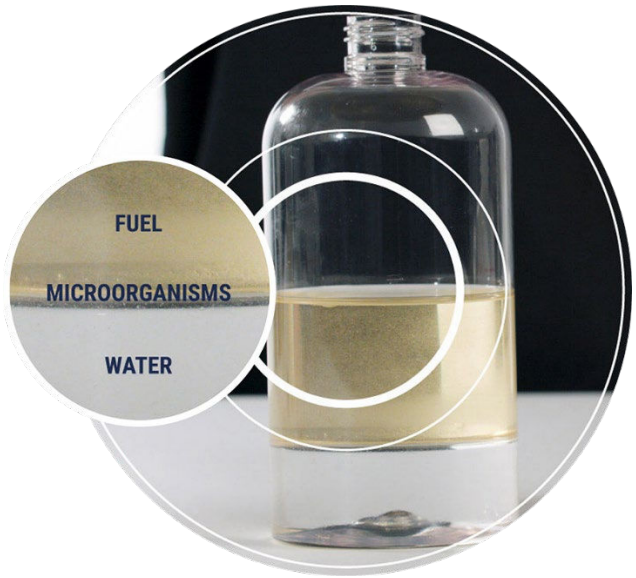


Clear and Bright Jet Fuel Sample

However, achieving Clear & Bright fuel at the refinery does not guarantee it will be without microbiological contamination in the future. Once fuel enters tanks, pipelines, hydrant systems, or mobile refuelling equipment, it becomes vulnerable to **water accumulation**, the single biggest enabler of microbial growth. Discoloured water phases or lacy films at the fuel/water interface are typically early warning indicators of microbial activity—and a precursor to potentially severe operational issues.



Lacy Fuel/Water Interface



2. THE TRACEABILITY IMPERATIVE

Along with being Clear & Bright, at point of manufacturing, each batch of fuel must comply with the requirements of these standards (**DefStan 91-091** and **ASTM D1655**), and the various characteristics of each batch are declared on Refinery Certificate of Quality (RCQ). When fuel batches are re-certified during its transportation to an airport, a certificate of Analysis (CoA) is generated to confirm its quality. This concept of traceability is described in **EI/JIG STD 1530**.

This is to minimize any possible deviation or fuel contamination. Any deviation or possible contamination of fuel batches must be investigated and rectified prior to delivery to an airport and/or aircraft.

Quality Assurance

During its production and distribution, jet fuel batches can be affected by incidental materials or degraded if in contact with other products. Companies involved in managing and handling jet fuel must institute the right level of quality control testing to prevent any possible contamination. **EI/JIG STD 1530** chapter 2 provides the necessary guidelines and directives to the industry to ensure fuel quality in the fuel supply chain. Having said this, periodic testing is prescribed to confirm fuel quality and monitoring of the presence of fuel contaminants such as microorganisms.

This document is written mainly to address concerns regarding the formation of microbiological growth (MBG) in fuel storage tanks and associated equipment. If present and left to proliferate, microbial contaminants can and will degrade the fuel itself along with fuel systems equipment.

3. UNDERSTANDING MICROBIAL CONTAMINATION IN AVIATION FUEL SYSTEMS

Microbial contamination arises mainly at the **fuel/water interface**, where microorganisms such as bacteria, yeasts, and filamentous fungi have access to all necessary nutrients to proliferate. **ASTM D6469** and **JIG TID #1** outline the conditions in which microbial growth occurs, its symptoms, and its consequences:

Root Causes

Microbial contamination almost always correlates with the presence of **free water**, which commonly results from:

- Tank condensation
- Leaks and ingress
- Poor drainage capability
- Aged or unfavourable tank geometry
- Long fuel storage durations
- Heavily cycled or intermittently used refuelling vehicles

Despite regular water draining, complete water elimination is rarely achievable. Therefore, **monitoring for microbial growth is essential and non-negotiable.**

Symptoms & Consequences

- Hazy fuel
- Discoloured water bottoms
- “Lacy” films at the fuel/water interface
- Black or brown biomass deposits
- Corrosion of tanks, filter vessels and refuelling assets
- Fuel degradation
- Filter clogging or fuel-flow restrictions
- Operational delays
- Increased maintenance costs

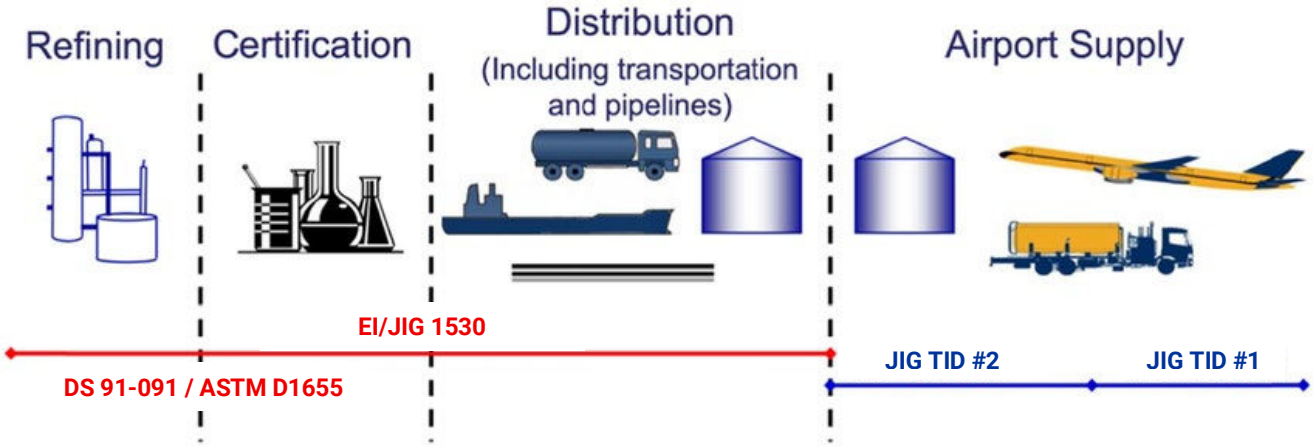


Biomass Deposits in Bulk Storage Tank

These symptoms indicate not simply biological presence, but an active ecosystem that can rapidly damage fuel system components, interrupt operations, or—if left unchecked—pose risks to aircraft fuel systems.

4. MICROBIAL FUEL TESTING

References **EI/JIG STD 1530, EI 3203, ASTM D6469** and **JIG TID #1** are written to guide operators on when to test and what is best approach regarding MBG testing in the fuel supply chain and at airports. Let's try to link these industry guideline documents to have a better comprehension on how to address and prevent MBG contamination:



EI/JIG 1530 Chapter 9.5 Storage Procedures advocates routine draining of all low points where water accumulates to prevent MBG contamination while **Chapter 9.5.4 Testing for Microbiological Growth** advocates the guidance for acceptable limits for results. To confirm the presence of MBG, periodic sampling and testing must be instituted using field test kits such as **FUELSTAT® *Plus***. These test kits are designed to be used at the tank-side.

ASTM D6469 is a guide providing operators with an understanding of the symptoms, occurrence, and consequences of chronic microbial contamination. Furthermore, this guide suggests means for detection and control of microbial contamination in fuels. A friendly reminder here is that presence of MBG in fuel and fuel systems is a direct function of the presence of free water and is sometimes present due to a lack of maintenance in eliminating free water from fuel systems and associated equipment. Despite good maintenance practice, water removal is never complete, especially from storage tanks. Due to either bad design or older installation, some tank configurations make it impossible to remove all water. Most bulk storage tanks with installed water removal system still retain water after draining. Tank bottom configuration has a major impact on water removal capabilities.

To monitor the presence of MBG, a good microbial contamination control strategy is to complement regular water drainage activity from fuelling equipment such as storage tanks, filter vessels and refuelling equipment with a regular testing regime of the fuel. Whenever water is drained from fuel it is good practice to conduct an MBG test on that drained water, water is still less transient than fuel and helps with a more complete understanding of what is happening in the fuel system. Fuel testing entails trend monitoring of fuel assets for MBG at set frequency using meaningful test kits. **JIG TID #1** lists FUELSTAT® *Plus* described in ASTM D8070 as a meaningful industry test method.

Furthermore, **ASTM D6469 Chapter 8 on Sampling** recommends on how to take representative fuel samples for MBG testing and provide guidance on the timing for fuel testing; it stipulates that fuel samples shall be ***tested no later than 24 hours of sample taking*** and if the sample is dispatched to a remote laboratory, it ***must be kept on ice*** to minimize fuel contamination profile. So, consider when sending routine fuel samples for a variety of tests at a remote laboratory, if microbial contamination testing is to be conducted, then that sample must be packed and sent in ice, be stored in the fridge at the lab and tested within 24 hours of the sample collection from the tank to prevent biological changes.



This is **impractical** in real-world aviation operations and introduces delays that can:

- Compromise sample integrity
- Increase operational risk
- Delay return-to-service of critical fuelling equipment

Testing with FUELSTAT test kits is conducted at the tank, immediately, with results in 30 minutes, with no requirement for samples to be transported on ice.

5. MICROBIAL CONTAMINATION TESTING METHODS

As mentioned earlier, **JIG TID #1** is a technical document educating operators on the risks associated with MBG. **Chapter 1.5 Test Kit Protocol Quick Guide for Routine Monitoring** lists the various test kits available in the marketplace including **FUELSTAT® *Plus* (ASTM D8070)**.

5.1 Traditional Laboratory Culture-Based Method (IP 385)

IP 385 is a laboratory-based culture method used to assess microbial contamination in middle distillate fuels by detecting the presence of viable microorganisms capable of growing under controlled incubation conditions. The test involves filtering a certain volume of a fuel/water sample and then placing the filter paper onto a specialised nutrient medium, incubating it typically for **5–7 days**, and then assessing microbial growth by visually counting colonies on the filter paper. It is designed to quantify microorganisms in terms of viable colony-forming units (CFUs), providing data on microbial populations present at the time of sampling.

Although IP 385 is a recognised and widely used method, it has notable limitations when applied to aviation fuel operations. Because microorganisms can die or multiply during transport, ASTM D6469 requires samples to be shipped **on ice** to preserve integrity—an impractical requirement in most airport or supply-chain environments. The long incubation times delay operational decisions, and the method requires laboratory facilities, trained personnel, sterile and controlled environmental conditions, making it unsuitable for rapid, field-based fuel-quality assurance.

What IP 385 Is

- Laboratory culture-based test for microbial contamination in fuels and fuel-associated water
- Detects CFUs (Colony Forming Units) through nutrient media incubation
- Requires CFU counts after **5–7 days** of incubation
- Requires specialised equipment, sterile conditions, and trained lab personnel

Limitations

- **Slow**: typically requires **3–7 days** for results
- **Lab-dependent**: requires incubation, lab facilities, temperature control
- **Sample degradation risk** during transport (hence the ASTM requirement to ship samples **on ice**)
- Results can be **unreliable** due to:
  - Viability loss in transit
  - Microbes that cannot grow on culture media
  - Inaccurate CFU counting and/or not following the protocol (e.g. lack of replication, dilutions, inappropriate media preparation, incorrect filter papers etc)
  - Non-sterile conditions resulting in false positives
- **Not practical** for rapid operational decision-making in aviation
- High cost per test when logistics and cold-chain handling are included

Operational Impact

- Delayed fuel-release decisions
- Higher risk of misdiagnosis due to sample instability
- Poor fit for aviation fuel supply chains where decisions must be made in minutes, not days

5.2 On-site Culture-Based Test Kits

Culture-based methods for detecting microbial contamination in fuels are designed to measure the growth of bacteria and fungi on culture media over time. Samples are incubated for **3–7 days at controlled temperatures**, allowing viable microorganisms to multiply sufficiently for detection. These methods rely on counting or estimating the number of microbial colonies which grow on the media, giving operators an indication of microbial growth in fuel systems.

Culture-based tests have incubation requirements, making them less suitable for **rapid operational decision-making**. They depend on temperature control, sterile conditions, and ideally laboratory facilities, and results are delayed due to the incubation period. If samples are to be transported to a site with sterile conditions and incubation facilities, microbial viability may be affected, reducing accuracy of results.

What Culture-based kits are

- Culture media-containing tests for the assessment of microbial growth in fuel-associated waters and (some of them) in fuels
- Measure bacterial and fungal growth over 3–7 days
- Require controlled temperature incubation
- Provide quantitative indication of microbial growth through counting of CFUs (Colony Forming Units)

Advantages

- Sensitive to viable microorganisms
- Useful for trend monitoring and research
- Culture media may contain a dye that promotes colour change, for an alternative semi-quantitative assessment of MBG

Limitations

- Long incubation time delays operational decisions
- Requires controlled temperature and ideally sterile technique
- Sample transport can affect microbial viability and accuracy
- Cannot provide immediate tank-side results
- Ideally some operator training, and in many cases an incubator, are required
- Not suitable for non-culturable microorganisms
- Some methods are only suitable for fuel-associated water samples but not for fuel samples
- Fully quantitative result depends on counting CFUs, which often is impractical (e.g. overgrowth)

Operational Impact

- Best suited for detailed monitoring, quality audits, or research studies
- Not practical for routine, rapid fuel-quality decisions

5.3 On-site Laboratory-Based ATP Fuel Testing

Adenosine Triphosphate (ATP) testing is a rapid microbiological monitoring method that detects the presence of living organisms in fuel and fuel-associated water by measuring ATP—the universal energy molecule found in all living cells. ATP is released from microbial cells in a fuel or water sample, and a bioluminescence reaction generates light proportional to the amount of ATP present. The light output is measured using a luminometer, providing a relative measure of microbial contamination. ATP testing is valued for its speed and ability to indicate overall microbial activity without requiring traditional culture-based growth.

Despite its speed, ATP testing has limitations for aviation fuel operations. The ATP methods are highly sensitive to sample handling. Fuel or water samples must be carefully collected and transported to maintain ATP integrity, as degradation can occur rapidly. Additionally, the equipment required—a luminometer and reagents—is relatively expensive and requires some operator training, making ATP testing less practical for frequent, on-site tank-side monitoring compared to field kits like FUELSTAT® *Plus*.

What ATP Testing Is

- Measures total microbial activity via ATP detection
- Bioluminescence reaction produces light proportional to the amount of ATP in the sample, which is indicative of the microbial load
- Provides rapid assessment (often within minutes)
- Detects live microbial cells in fuel or water

Advantages

- Fast compared to culture-based methods
- Sensitive to total microbial activity
- Can detect microbes that are otherwise difficult to culture
- Provide fully quantitative results via the measurement of ATP concentration in the sample

Limitations

- Sensitive to sample handling; ATP can degrade during transport
- Requires specialized equipment (luminometer) and reagents
- Operator training required for accurate measurements
- For methods that don't target only cellular ATP, higher risk of false positive signal from non-microbial ATP (NB all living cells contain ATP that may be released and give signal)

Operational Impact

- Good for laboratory or controlled environment testing

5.4 Rapid in-field FUELSTAT® Fuel Testing

FUELSTAT® *Plus* is a simple, rapid, field-deployable lateral flow test designed to detect microbial contamination in aviation fuel at the point of storage or refuelling. The test targets microbial contamination commonly found in Jet A-1 and other middle-distillate fuels. Results are available in **15–30 minutes**, eliminating the need for laboratory facilities, incubation, or cold-chain sample transport. FUELSTAT® *Plus* is fully compliant with **ASTM D8070** and is referenced by **EI 3203 and JIG TID #1** as a reliable method for tank-side microbial monitoring.

Because FUELSTAT® is performed on-site with fast results, it allows operators to make immediate decisions regarding fuel use, system maintenance, or contamination mitigation. The test is simple to use, requires minimal training, and comes with a mobile app for automated interpretation and digital traceability. Its rapid, accurate, and operationally practical results make FUELSTAT® uniquely suited to the needs of the aviation industry, particularly for routine fuel-quality assurance and trend monitoring across storage tanks, hydrant systems, filter vessels, and mobile refuelling assets.

What FUELSTAT® *Plus* Is

- Rapid, on-site lateral flow test for microbial contamination
- Results in **15–30 minutes**
- Compliant with **ASTM D8070** and industry guidance

Advantages

- Fast, accurate, and tank-side usable
- Eliminates need for sample transport or lab incubation
- No capital outlay or specialist equipment required
- Minimal training required for operators
- Provides digital traceability and trend monitoring via mobile app
- Suitable for all ground-refuelling operations

Limitations

- Semi-quantitative test selective to fuel-degrading micro-organisms
- Does not provide specific species identification (not usually needed operationally), but does indicate separately levels of bacteria, fungi (including yeasts) and the filamentous fungus *Homorconis resinae* contamination
- Must follow correct sampling technique (as required by all test methods)

Operational Impact

- Immediate detection of microbial contamination
- Supports proactive maintenance and fuel-quality assurance
- Reduces operational risk and prevents downstream equipment issues
- Ideal for routine monitoring, compliance, and safety-critical aviation applications

6. FUELSTAT® OUTPERFORMS ALL OTHER METHODS IN AVIATION GROUND-REFUELLING

FUELSTAT® *Plus* is the **industry-leading** rapid immunoassay test kit for aviation fuel, fully aligned with **ASTM D8070**, and referenced by **EI 3203** and **JIG TID #1** as an accepted field-deployable test method.



Key Advantages of FUELSTAT®

Operates at the Point of Risk

FUELSTAT® *Plus* is performed exactly where contamination is likely to occur:

- Bulk storage tanks
- Hydrant pits
- Filter water separators
- Dispensers
- Bowsers
- Intermediate refuelling tanks

Eliminates ASTM D6469 Transport Concerns



ASTM requires cooled transport for samples sent to labs. FUELSTAT® *Plus* eliminates this need entirely, providing results immediately after sampling.

Rapid Decision-Making

Aviation operations cannot wait days for laboratory results. FUELSTAT® *Plus* gives actionable data in minutes.

High Specificity to Aviation-Relevant Microbes

FUELSTAT® *Plus* targets the organisms of greatest concern in Jet A-1 systems, including:

- *Hormoconis resinae* (H. res)
- Bacteria and fungal species commonly found in fuel and water bottoms

Digital Results with Compliance Traceability

The FUELSTAT® *Result* app ensures:

- Automated interpretation
- Audit-ready digital storage
- Trend analysis for fuel assets
- Alignment with EI/JIG quality assurance requirements

Minimal Training Required

Any fuel operative trained in sampling can perform the test reliably.

Globally in Use Across the Aviation Industry

Used by:

- Airlines
- Maintenance and Repair Organisations (MROs)
- Airports
- Military organisations
- Refineries
- Storage terminal operators
- Fuel logistics providers

7. A PRACTICAL MBG CONTROL STRATEGY FOR AVIATION FUEL OPERATIONS

Based on EI/JIG guidance documents and ASTM D6469, an effective strategy should include:

Water Management

Routine and recorded drainage of:

- Storage tanks
- Filter vessels
- Bowsers and dispensers
- Hydrant systems low points

Scheduled Microbial Testing

Increased testing frequency for:

- Bulk storage tanks (highest MBG risk)
- Intermittently used assets
- Tanks with known geometry challenges
- Equipment showing water retention

Trend Monitoring

Digital tracking through the FUELSTAT® *Result* app enables operators to see contamination trends early and act before asset degradation occurs. Operators should carry out a risk assessment, looking at worst case scenarios on which to base monitoring frequences for various areas of the fuel supply chain. This can lead to further guidance as to which areas need more frequent monitoring, and which can then be reduced as data evidence is collected.

Rapid Intervention

Using FUELSTAT® *Plus* allows operators to:

- Confirm contamination immediately
- Take assets out of service
- Clean tanks or take corrective action without delay
- Return equipment to service in minimal time

This is simply not possible with lab-based or culture methods.

8. SUMMARY

On-specification jet fuel should always be Clear and Bright with no evidence of significant microbial contamination. By instituting regular maintenance of fuel systems, including frequent water drainage is necessary to prevent microbial growth. Special attention should be given to bulk storage tanks, and filter vessels where most bacterial activity takes place. Microbial contamination in aviation fuel is an operational inevitability driven by water ingress and storage conditions. Testing is not optional—it is an industry requirement.

9. CONCLUSION: FUELSTAT® AS THE OPTIMUM SOLUTION

When the advantages and limitations of each microbial testing method described in **ASTM D6469** are evaluated against the operational needs of the aviation fuelling environment, the conclusion is clear:

- Culture test kits are slow.
- Lab methods cause delays, are complex and costly, and sample transport compromise's reliability.
- Operational windows are too short for delayed results.

Only **FUELSTAT®** provides all of the following:

- Reliable, accurate tank-side results
- Immediate operational decision support
- Compliance with EI documents, ASTM D6469 & D8070 and JIG TID #1
- Elimination of cold-chain requirements
- Digital interpretation and traceability
- Suitability for aviation fuel handling application

FUELSTAT® Plus is not just an option—it is the optimal solution for aviation microbial fuel testing.

Take Away Message: Regular maintenance of fuelling equipment including elimination of free water along with sound fuel management program (sampling and testing) is key to ensure on-spec fuel throughout the supply chain, and ultimately flight safety. Periodic testing with FUELSTAT is recommended to monitor MBG in your fuel system.

Who we are:



Conidia Bioscience research, design, develop, manufacture and globally distribute innovative solutions for maintenance of fuel systems. Our products are designed to offer practical and easy to use, industry leading solutions to both maintain and monitor the stored fuel in your system, whether that be a fixed ground installed diesel fuel tank, or in an aircraft wing. Through simple steps of ensuring water doesn't develop within stored fuel, and instant testing at the tank, we keep fuel contamination free and ready to use, avoiding costly remedial action and fuel system failures.

FUELSTAT® fuel tests are developed, manufactured and marketed by Conidia Bioscience Limited. With headquarters in the UK and subsidiary in the USA, Conidia Bioscience 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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