2025
Aviation Fuel Handling
Training Symposium

Microbiological Growth in Aviation Fuels

18 February 2025, Dallas, TX

YOUR PANEL

Graham Hill

ECHA Microbiology

Pierre Poitras

Conidia Bioscience

Danika Nicoletti

LuminUltra Technologies

echa
Results that count

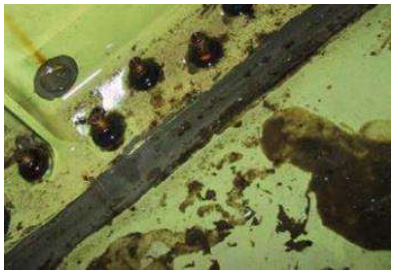
Why is microbial growth in aviation fuel a problem?

Graham Hill,

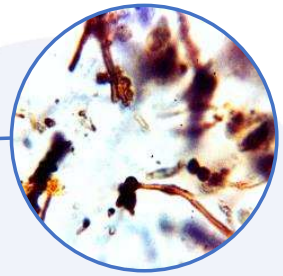
CEO

ECHA Microbiology

Aircraft Fuel System Issues

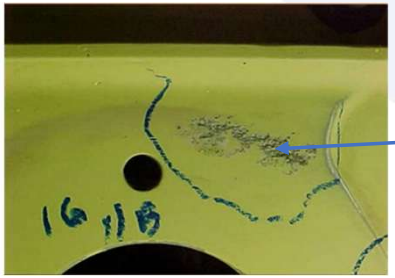


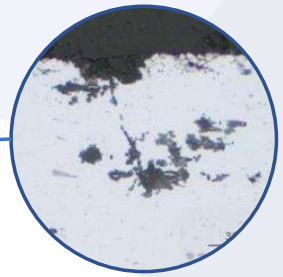
Floating Interface Biofilm
(Type I)



Fuel Filter
Clogging

Sessile Surface Biofilm
(Type II)





Corrosion of
Aircraft Fuel Tank

Operational risks:

- Filter clogging and by-pass – flight delays & diversions,
- FQIS malfunction - Erratic or erroneous fuel quantity indication,
- Aircraft boost pump failures,
- Airframe corrosion.

THERE ARE NO LAY-BYS IN THE SKY!!!

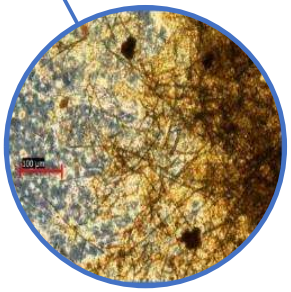
Case History: Aircraft Accident Case

- Turbine driven Piper MALIBU (PA-46-350P).
- October 2020 from Rottweil (EDSZ).
- Filter bypass indication during climb.
- 1 min later, engine lost power and could not be restarted; forced landing on an open field.
- Fuel filter was heavily contaminated with a brownish-black substance
- Heavy contamination (BIOFILM) was found in the header tank.

Source: https://www.bfu-web.de/DE/Publikationen/Bulletins/2020/Bulletin2020-10.pdf?__blob=publicationFile

Aviation Fuel Supply Issues

Microbial biomass in jet fuel



Emulsification at fuel water interface - Microscopic water droplets become suspended in fuel

Black/grey discolouration of water and fuel in tank bottoms due to sulphide generation by Sulphate Reducing Bacteria (SRB)

Operational risks:

- Off spec fuel due to:
  - Microbial biomass (particulate),
  - Bio-surfactants,
  - Sulphide.
- Biomass & biofilm (sludge) in storage tanks.
- Filter Water Separator disarming.
- Storage tank & pipeline corrosion.

Aviation Fuel Supply Issues

Microbial biofilm in jet fuel storage tank

Operational risks:

- Off spec fuel due to
  - Microbial biomass (particulate),
  - Bio-surfactants,
  - Sulphide.
- Biomass & biofilm (sludge) in storage tanks.
- Filter Water Separator disarming.
- Storage tank & pipeline corrosion.

Aviation Fuel Supply Issues

Leopard spotting / fungal growth on Filter Water Separator elements (EI 1581)

Active microbial growth is not common on other types of aviation fuel filter, but they can be pre-maturely clogged by microbial particulates from contaminated fuel (e.g. microfilters (EI 1590), dirt defence filters (EI 1590), water barrier filters (EI 1588)

Operational risks:

- Off spec fuel due to
  - Microbial biomass (particulate),
  - Bio-surfactants,
  - Sulphide.
- Biomass & biofilm (sludge) in storage tanks.
- Filter Water Separator disarming.
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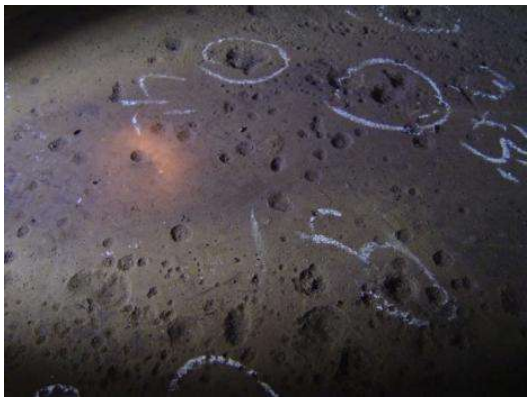
Aviation Fuel Supply Issues



SRB pitting corrosion of tank floor

SRB pitting corrosion of pipeline flange end

Operational risks:

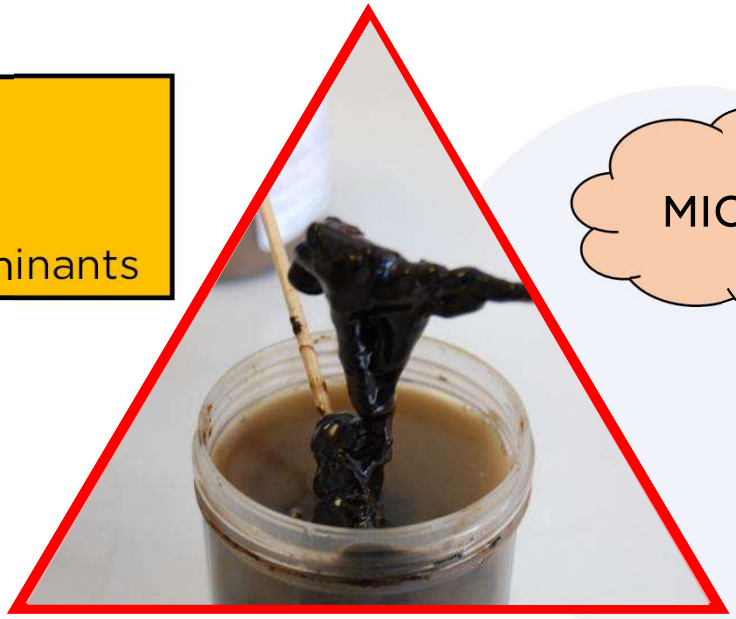
- Off spec fuel due to
  - Microbial biomass (particulate),
  - Bio-surfactants,
  - Sulphide.
- Biomass & biofilm (sludge) in storage tanks.
- Filter Water Separator disarming.
- Storage tank & pipeline corrosion.

Consequences of microbial growth in aviation fuel

- Fuel supply failures
- Aborted flights
- Unscheduled down time
- High cost for remediation
- Operational Safety Issues

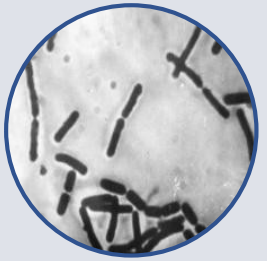
What makes microbes grow in fuel?

FOOD;
- Fuel
- Additives
- Dirt & contaminants

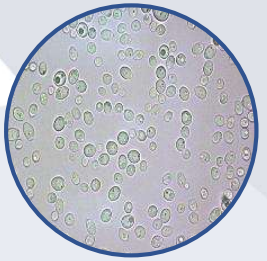


MICROBES

WATER



Bacteria



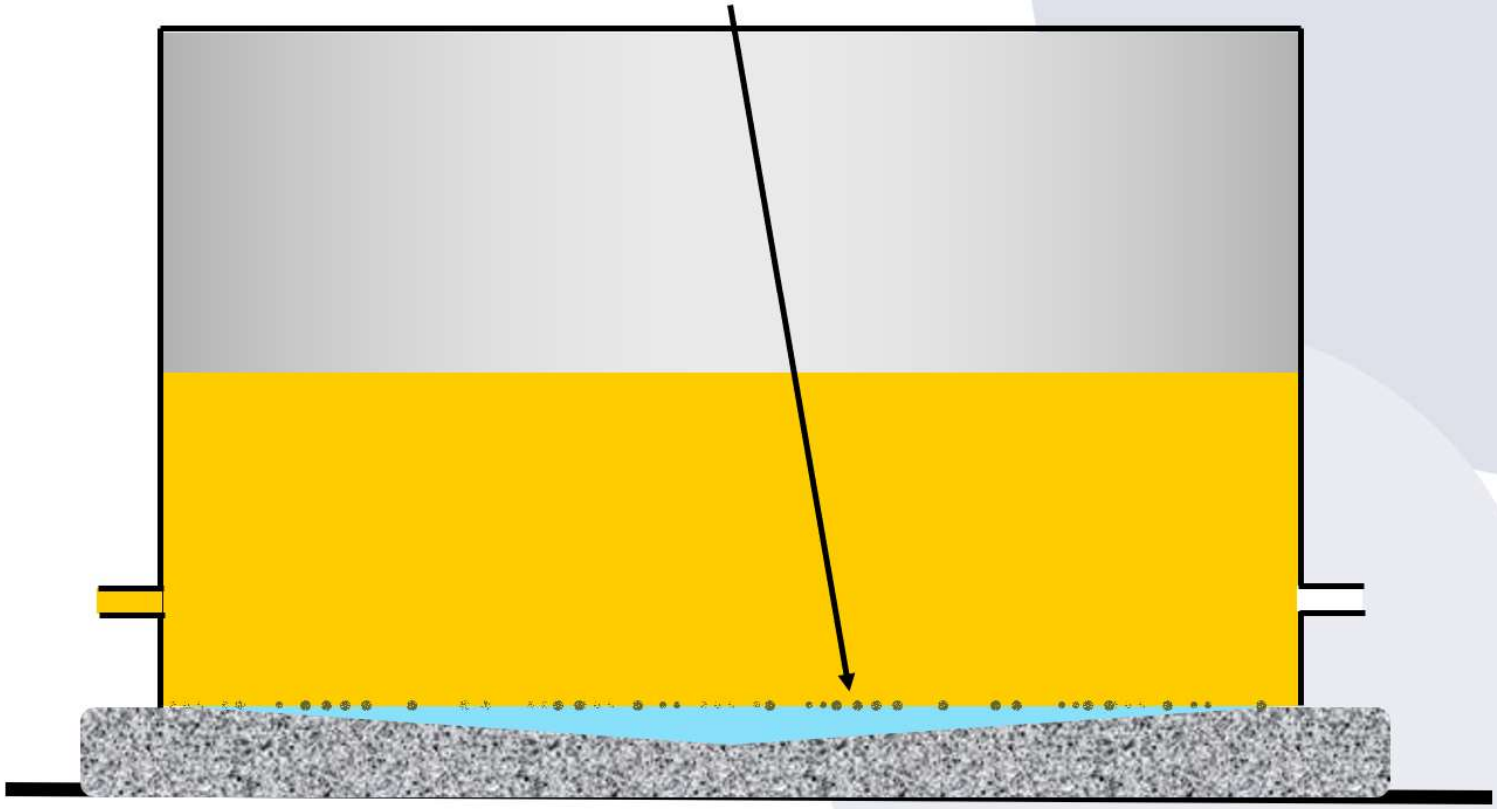
Yeast

Mould

FUNGI

Contamination of Fuel in Storage Tanks

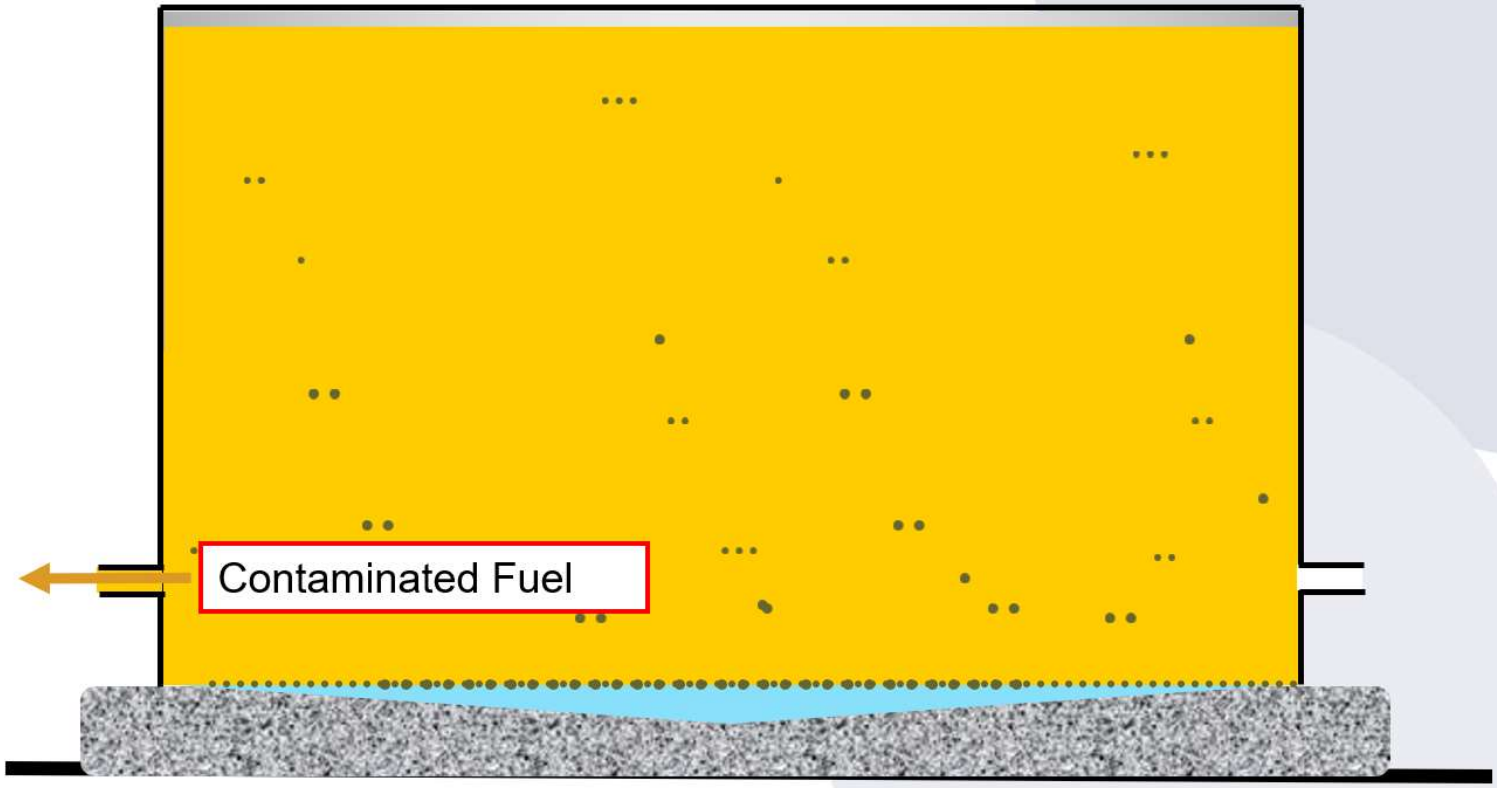
- Fuel receipts disturb microbial biomass into fuel



Contamination of Fuel in Storage Tanks

echa
Results that count

- Fuel receipts disturb microbial biomass into fuel



Microbial Growth in the Into-plane operation

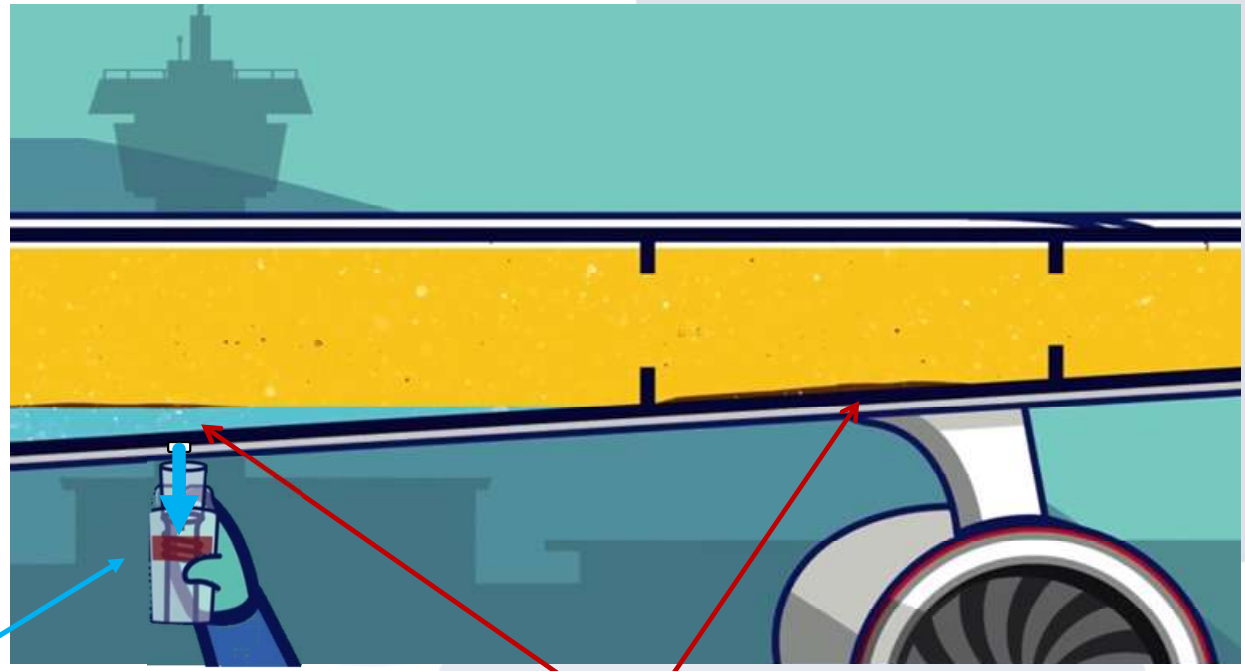
- Fuel requires high standard of cleanliness prior to uplift to aircraft.
  - Final filtration at hydrant dispenser / refueller is a critical fail safe!
- Hydrant systems can become contaminated and support microbial growth e.g.
  - Pipe bore is wide relative to fuel throughput
    - no effective scouring / flushing
    - water and microbial growth can accumulate
  - Spurs with dead ends are not effectively flushed
  - Poor cleanliness on commissioning new systems

Microbial growth in aircraft tanks

It is difficult to prevent formation of free water in aircraft fuel tanks:

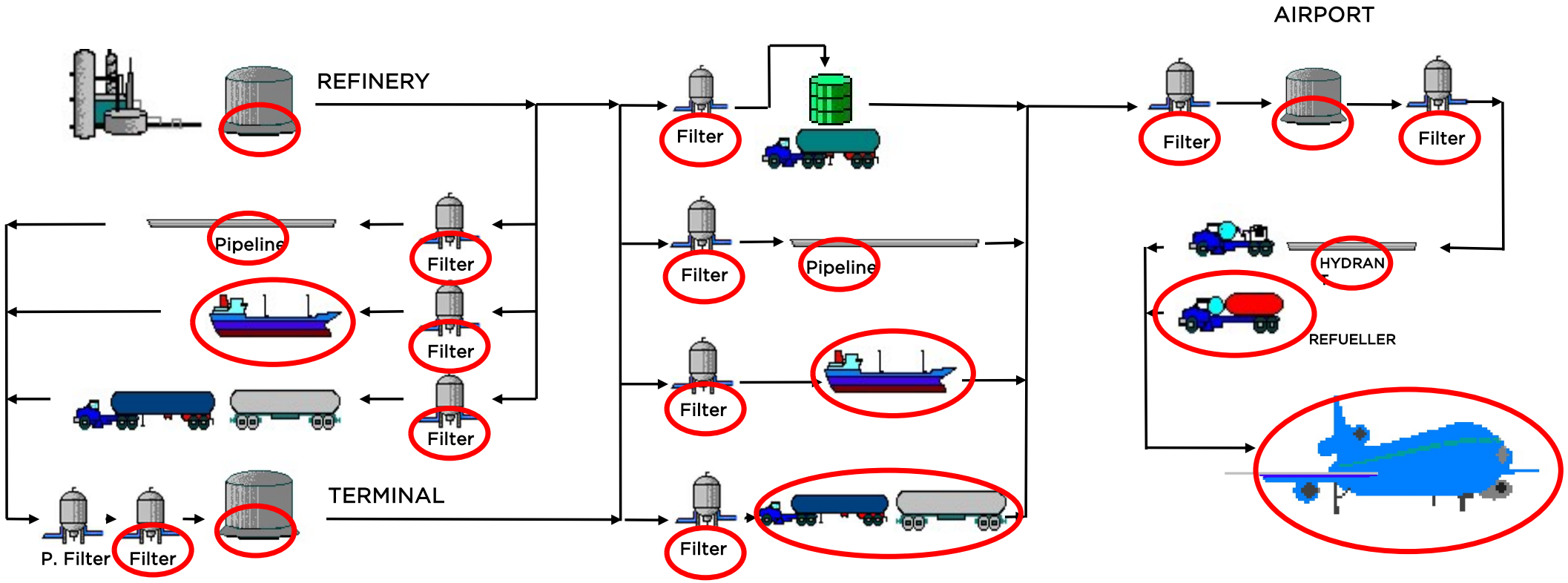
- Dissolved water in fuel precipitates out due to cooling as the aircraft ascends,
- Condensation develops on tank surfaces when humid air enters cold tanks on descent.

Routine sumping to remove water is the key measure in minimizing microbial growth.



Active microbial growth occurs in pockets of water or in condensate films on fuel tank surfaces.
Biofilm is disturbed into the fuel with any agitation.

Free Water and Microbial Growth

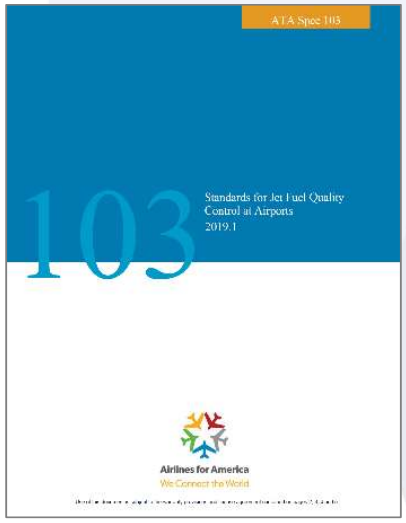


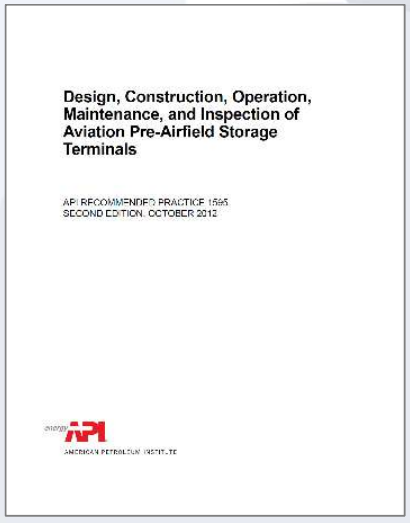
Attention to water removal from refinery to wing!

Industry Guidance

Key aviation industry guidance documents on Quality Assurance for Aviation Fuel provide some guidance on prevention, monitoring and remediation of microbial contamination.

- EI/JIG Standard 1530 Quality Assurance Requirements for the Manufacture, Storage and Distribution of Aviation Fuels to Airports (2nd Ed. 2019)
- JIG Aviation Fuel Quality Controls and Operating Standards for Into-Plane Fuelling Services (JIG 1, Issue 13), Airport Depots and Hydrants (JIG 2, Issue 13) and Smaller Airports (JIG 4, Issue 4)
- ATA Spec 103 Standards for Jet Fuel Quality Control at Airports (2023.1)
- API RP 1595 Design, Construction, Operation, Maintenance, and Inspection of Aviation Pre-Airfield Storage (Ed. 2).
- EI 1545 Recommended Practice for the defueling of aircraft (1st Ed. 2021)

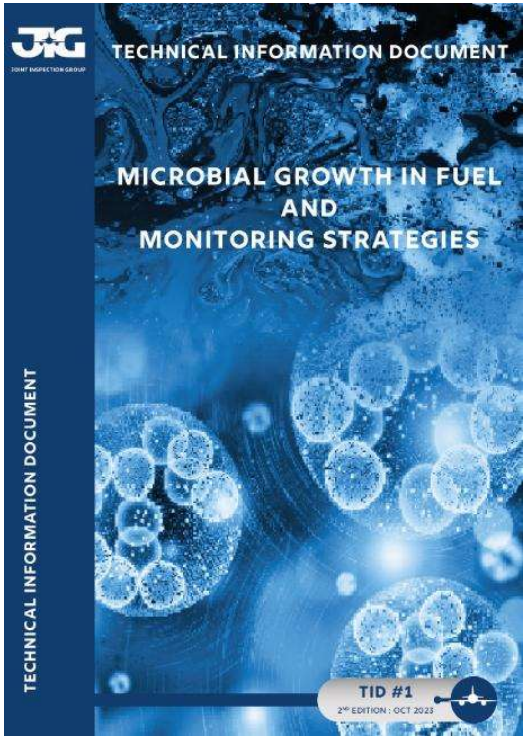




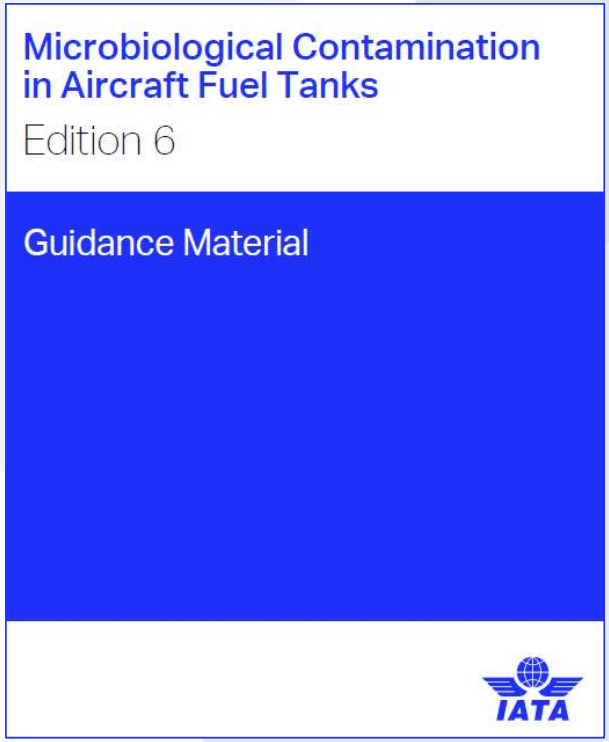
Industry Guidance

For detailed and specific information on microbiological issues in aviation fuel see:

Fuel Supply & Distribution



Aircraft



Control of Microbial Growth in Fuel

PREVENT	MONITOR	REMEDIATE
Keep it clean (as far as practicable!) Prevent ingress and accumulation of free water	Test at routine intervals to identify risk before it becomes a problem	When monitoring indicates control is lost, or if problems are experienced

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PREVENTIVE MAINTENANCE PRACTICES

Presented by:
Pierre Poitras - Technical Consultant

ConidiaBioscience

WATER IN FUEL FORMATION

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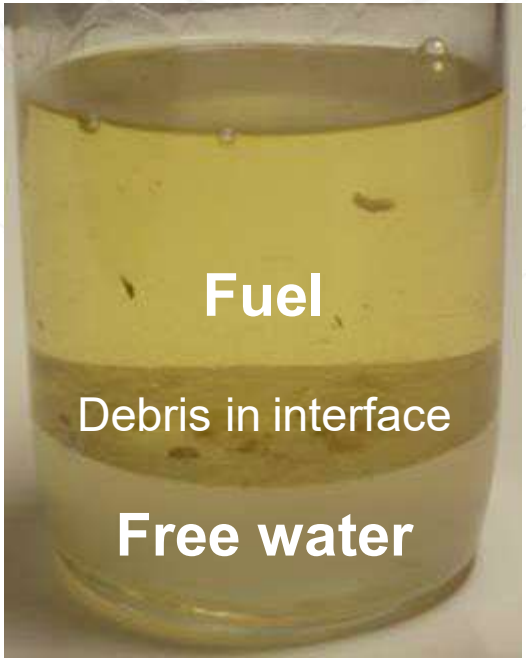
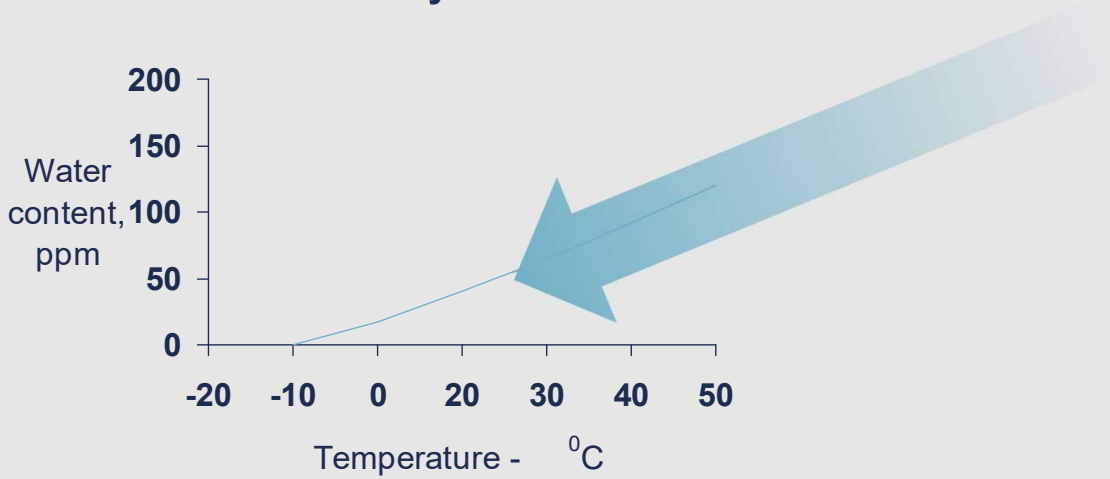
- ***Microbial growth in fuel systems requires little amount of free water***
- ***Free water in fuel is enemy No 1***
- Fuel haziness is due to presence of dissolved water in fuel which is normal
- Free (undissolved) water must be addressed; minimized and eliminated
- Water content in fuel is a function of the fuel temperature



Definite Problem

WATER FORMATION IN FUEL



- Above the water solubility line, fuel will become hazy and can generate free water
- Note:
  80 ppm dissolved water in a 300 K Gal tank of jet fuel can produce 20 Gal of free water when exposed to a temperature drop below -10ºC

PREVENTIVE MAINTENANCE

- Proper fuel systems design and operational equipment meeting industry standards. ***Avoid fuelling equipment with no sump drain or easy access for visual inspection !***
- Scheduled maintenance considerations:
  - Daily water drain from operational storage tanks, FWS, refuelling vehicles
  - Eliminate dead legs and ensure proper low points flushing of hydrants systems
  - Regular fuel recirculation as needed including unused refuelling hoses
  - Retrofit of filter monitor housing to FWS; ***No sump drain!***
  - Special attention to recovery tanks and stored/unused fuelling equipment. ***Minimum settling time required to eliminate free water***
  - Unusual fuel appearance is cause for investigation, especially when positive test results are obtained

Is there water in my fuel?

REMEDIATION / CORRECTIVE MAINTENANCE

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- Faulty fuel systems shall not be used
- Quarantine contaminated equipment
- Clean all affected equipment
- Repair and /or replace faulty equipment
- Eliminate any potential source of water ingress
- Consideration and use for biocides (aircraft only), as applicable (EI 1566) – limited efficacy on Type II biofilm/biomass formation
- ***Importance of taking representative sample(s) from your affected equipment***
- ***Institute practical MBG protocols and regular testing program with industry recognized test kits***

Type II Biofilm being a catalyst to corrosion (MIC)

REMEDIATION / CORRECTIVE MAINTENANCE

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- Institute investigative processes and measures
- Consider human factors. Educate and trained personnel in quality assurance processes and control regarding MBG testing.
- Institute adequate record keeping
- Promote good communication with concerned parties involved in operating a fuelling equipment
- Operate your fuel system based on recognized standards and fuel industry practices; ASTM, ATA, EI, JIG, IATA etc.
- ***Implement proper fuel testing regime with industry recognized test kits. Understand the performance and limitation of test kits.***
- ***MBG testing is NOT a jet fuel specification test but a critical quality control measure to ensure the delivery of on-spec fuel***

SUMMARY

- Good water management program will minimise risk of MBG formation
- Timeliness of test results is important to support operational decisions
- Identify and implement corrective measures as soon as unusual circumstances is encountered
- Consider condition monitoring approach and adapt your sampling and testing program to your environment and equipment.
- Institute sound preventive measures to ensure the operability of your fuel facility via sampling and testing and equipment maintenance
- Type II (sessile) surface biofilm should not be dismissed as it leads to more sever problems (e.g. corrosion). Tank checks and testing for Type II biofilm wherever possible is recommended.
- Complaisance will lead to failure
- Prevention is more cost effective and less disruptive than fixing problems
- ***Fuel sampling and testing is key to prevent MBG***

TAKE HOME MESSAGE

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- Regular maintenance of fuelling equipment including elimination of free water along with sound fuel management program (sampling and testing) is key to ensure flight safety

Microbial Contamination in Fuels: **Sampling, Advances in Knowledge and What is Next in Microbial Testing in Fuels**

Gammon Aviation Fuel Handling Symposium - February 2025

Danika Nicoletti

LUMINULTRA®

Sampling: Importance of Sampling Practices in Microbiological Testing

Where to sample?

Low points (tank bottoms, filter drains, hydrant low points) are the best location to sample

What to sample?

Water phase (tank bottom water) samples will best represent microbial contamination. Microbes live in water.

Fuel phase testing is more prone to variation (i.e. settling vs disturbance in interphase)

Best Practices for sampling for microbial testing:

CONSISTENCY

in **what** and **how** you are sampling

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Guidance for Sampling

ASTM D7464 Standard Practice for Manual Sampling of Fuels, Associated Materials and Fuel System Components for Microbiological Testing

JIG TID #1 Microbial Growth in Fuel and Monitoring Strategies (Edition 2) for further guidance (i.e. sampling frequency, locations)

ITEM	SAMPLING LOCATION	SAMPLING FREQUENCY		
		HIGH RISK FACILITY (>1 Action level microbe event in previous 2 years)	MODERATE RISK FACILITY (Single Action level microbe detected in previous 2 years, or cause - see above)	LOW RISK FACILITY
Fixed Storage tanks	Storage tank sump drain line or dead bottom sample	Monthly	Quarterly to 6-monthly adiviseable	ANNUAL monitoring after initial (at least) quarterly screening for 1 year to determine background contamination levels
Product Recovery tanks	Storage Tank sump drain line or dead bottom sample	Monthly	Quarterly	QUARTERLY where visual inspection is not possible
Defuelling Vehicle	Vehicle Tank sump drain line	Monthly	Quarterly	6-MONTHLY for vehicle routinely used for defuelling in the absence of cause

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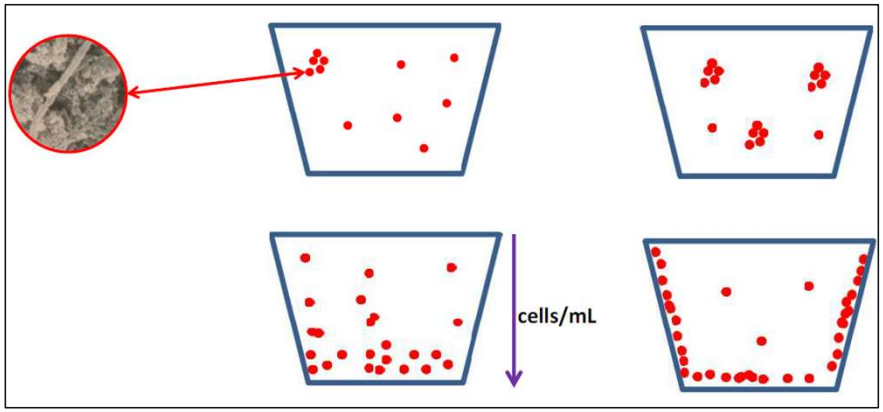
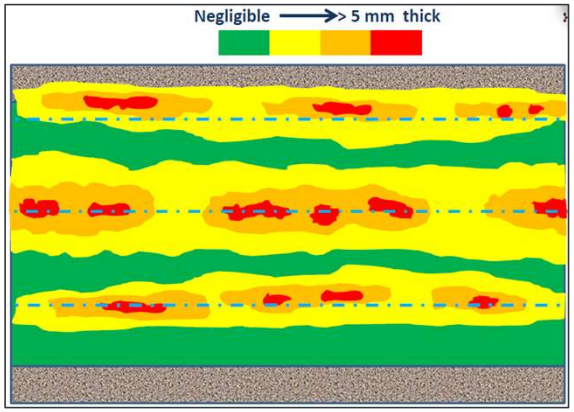
Sampling at regular intervals and using best practices helps to overcome inherent variability in microbial growth in fuel tanks

Microbiological testing of all kinds is prone to contamination, the threat starts at sampling activities – working with clean equipment and taking care is important

Microbes are not heterogeneously distributed in a fuel tank or on surfaces





BCA Biodeterioration Fuel Microbiology Webinar Series, 2021

Regular sampling/testing, and using **best practices for sampling** helps to overcome variability and identify proliferation in microbial growth before it becomes critical.

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Routine Testing Technologies

- There are several **industry-recognized routine testing technologies published as ASTM Standards**.
- These tests have **traffic-light systems** to help **connect results to action**.
- Which technology is used depends on many factors and operational considerations
- Each have advantages and limitations.

Technology	ASTM Standard Test Method	What does it measure?
ATP	D7687, D7463	Active Biomass
Culture	D7978	Viable Culturable Biomass
Immunoassay	D8070	Active Biomass
DNA	D8412	Dead, dormant, and live cells

Engage with test kit manufacturers for more information!

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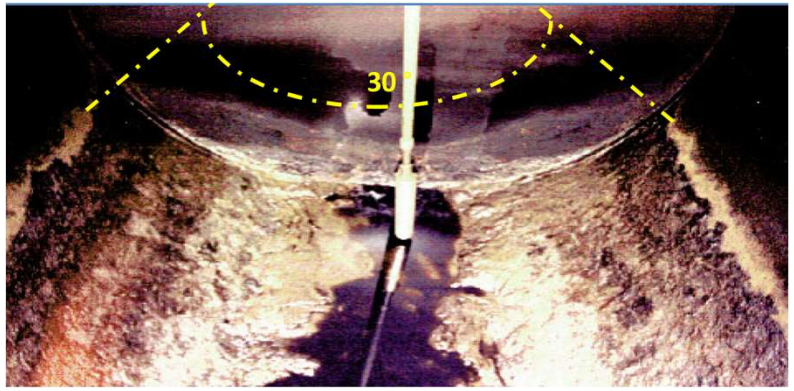
Advances in Knowledge: Microbiologically Influenced Corrosion (MIC)

- **Corrosion is an electrochemical process** where electrons are removed from a material and exchanged to an electron-accepting entity
- **Microbes can accelerate the electrochemical process** causing infrastructure degradation and reducing projected lifespan of an asset (for example a fuel storage tank), Type II biofilms (surface)

Biofilm formation in UST



Microbial growth between UST coating and tank shell

Deposits from long term corrosion

Images from BCA Biodeterioration Fuel Microbiology Webinar Series, 2021

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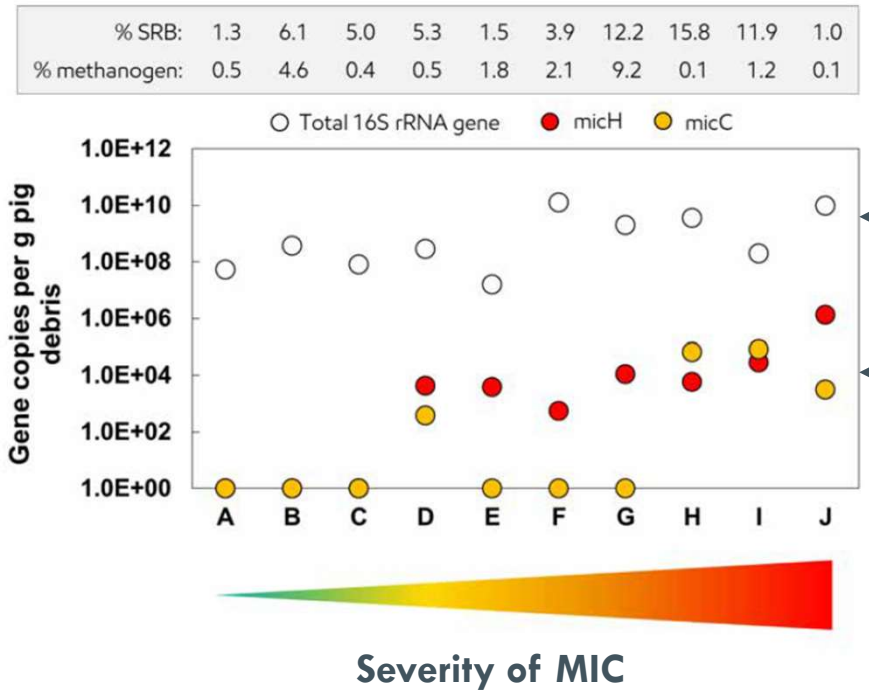
Advanced Microbial Testing using DNA-based methods for Diagnostic Testing

- DNA-based methods typically do not lend themselves easily to a routine testing regime
- However, for **diagnostics** (for example, MIC investigation), DNA-based methods like **quantitative PCR (qPCR) and Sequencing tell an important part of the story**



Total – remains relatively consistent

MIC Biomarkers – increase with MIC severity

Adapted from Lahme *et al.* Detection and Monitoring of Corrosive Oilfield Microorganisms via Novel Biomarker Technologies, ADIPEC, 2022, DOI 10.2118/211238-MS

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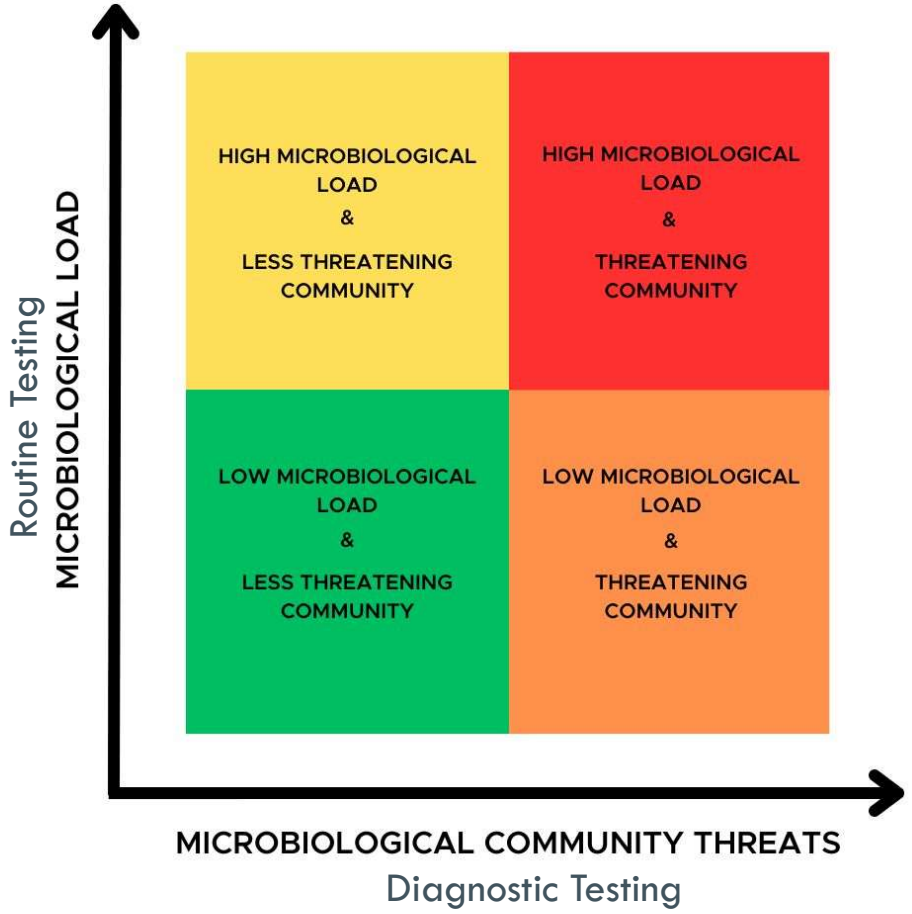
Risk Matrix for Microbial Contamination

MIC risk and severity does not only relate to total microbial loading

Microbial composition along with total loading is critical to understand MIC threat

i.e. **who is there?** How much?

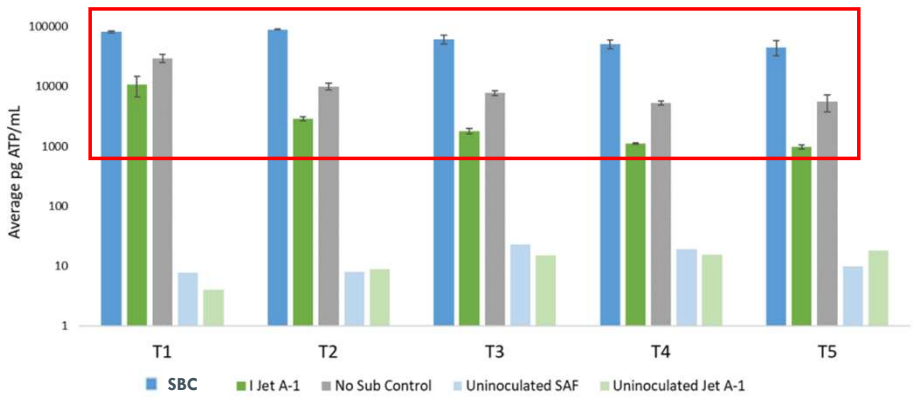
Molecular microbiological methods like **quantitative PCR** and **next generation sequencing** help to address this question.

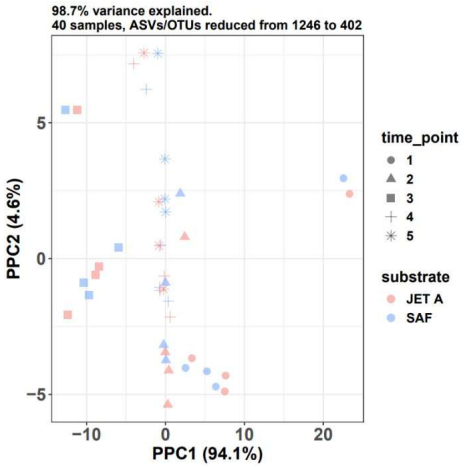


New Research: Characterization of Microbial Contamination in SBCs/SAF

Recent research showed HEFA-SPK (one of 6 approved SBC pathways) **had higher microbial activity in a high contamination storage scenario, but indistinguishable microbial community**

→ **Similar microbial threat**





- **Much more work needs to be done** to understand if there are any differences in microbial contamination susceptibility in SBCs
- **Resource development underway for characterizing current knowledge of microbial contamination in SAF in EI Aviation Fuel Microbiology group**

Summary

- Sampling – Consistency is key, utilize guidance material, data is only as good as your sample
- You can't control if you don't monitor – Routine Monitoring
- Advanced molecular microbiological methods can help address diagnostic needs
- Exciting research ongoing to help build industry knowledge on microbial contamination in fuels to support fuel quality and industry safety

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Thank You!

Graham Hill

ECHA Microbiology

ghill@echamicrobiology.com

www.echamicrobiology.com

Pierre Poitras

Conidia Bioscience

pierre.poitras@conidia.com

www.conidia.com

Danika Nicoletti

LuminUltra Technologies

danika.nicoletti@luminultra.com

www.luminultra.com