Operational experience in MBG testing & mitigation procedures

Pratik Chandhoke | Technical Fuel| 09.06.2026 | JIG MTF Rome

Microbial Growth (MBG) and testing considerations

Tanks shall be kept free from the accumulation of water and particulate by routine draining of low points to avoid MBG and to ensure that only clear and bright product is transferred downstream

Undesired Operational Effects

- Blockage of fuel supply pipes and lines
- Premature blocking of fuel handling system & filters
- Corrosion
- Disarming of filter/water separators (FWS)
- Extensive ground time for MBG clean-up

Testing Considerations

Frequency varies based on:

- Geographic Location
- Weather patterns/events
- Tank construction (Roof/Bottom type)
- Hardware/infrastructure limitations
- Tank turnover/usage

MBG can depend on many factors but key is robust risk assessment and to actively manage rather than being reactive

Bottom type	Cone down/ cone up/ sloping	Cone down/ cone up/ sloping	Flat, or incorrectly lapped or internal impeding structures**	Flat,or incorrectly lapped or internal impeding structures**
Roof type	Fixed*	Open/external floating	Fixed*	Open/external floating
Maximum tank cleaning interval	5 years	5 years	3 years	2 years
Microbiological testing requirement	Yearly	6 monthly	3 monthly	Monthly

Neste MBG protocol consists of multiple assay testing

Neste conforms to EI/JIG 1530 and JIG TID #1 protocols for MBG management for all Neste sites that produce, store and distribute SBC, blends and conventional jet fuel

MBG Tests Kits Used

Neste utilizes a combination of advanced testing methods:

- **Echa MicrobMonitor2 (ASTM D7978/IP 385)**: Traditional culture method for all types of MBG (bacteria, fungi and mold)
- **LuminUltra Bugcount ATP test (ASTM D7687)**: Rapid molecular-based detection for microbial activity
- **Other kits used:** Fuelstat for rapid analysis of MBG presence

Insights

Comprehensive Analysis: The combination of both tests provides a good indication of MBG levels in the tanks

Identification: Multiple testing assay is essential to identify both MBG proliferation rate and microbial activity

Dual-assay testing ensures robust monitoring of microbial activity in the storage tanks

MBG monitoring, physical indicators and investigation procedures

Core Testing and Monitoring

- Testing frequency depends on risk assessment (location, environment, tank design) - monthly, quarterly or annually
- Sampling and testing is conducted by an experienced lab
- MBG test data is collected for trending and monitoring
- Elevated results require further investigation and potential tank quarantine

Physical Indicators

- Visual sampling to check for discoloration or presence of any biomass
- Any excessive Delta Pressure (DP) changes of FWS
- Filter sump samples are continuously hazy when drained
- Filter elements have “leopard spotting”

Growth Phase Identification (MM2 + ATP Combination)

None or Minimal Growth

Low colony count
Low ATP

No Action needed

Early Growth

Med colony count
Low ATP

Preventive Action can be taken

Active Proliferation

High colony count
High ATP results

Corrective Action required

Effective draining usually clears MBG issues

Actions and mitigation procedures for MBG detection and control

01. Sampling & Testing

Regularly sample tank bottom/drain and conduct MBG testing. Sampling and testing frequency depends on risk assessment

02. Analysis

Analyze results for Warning or Action level contamination (fuel or fuel/water sample)

03. Resample

Resample and test if warning or action level contamination is identified in initial test

04. Mitigation

If resample confirms high MBG levels, begin daily draining regime of affected tank(s)

05. Post-Mitigation Test

Test tank sump sample after the draining regime to check MBG levels

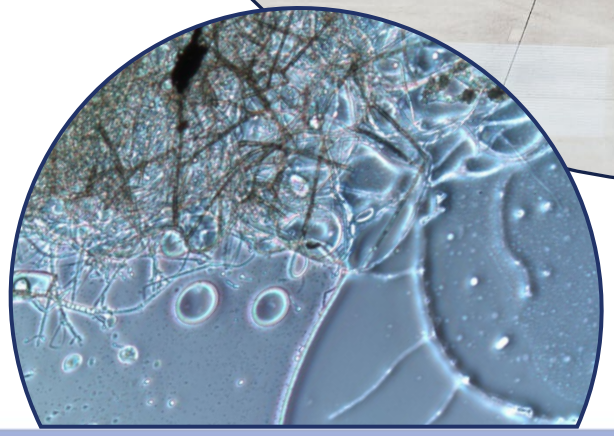
06. Completion

If MBG is below warning/action level, complete draining program otherwise conduct further draining and testing. Further actions might be required to clean tank.


NESTE
Change runs on renewables

MBG (Microbial Growth) Risk Management: Factors that elevate the risk of MBG at fuel facilities

Dr Gareth Williams, ECHA Microbiology Ltd



JIG Members' Technical Forum, Rome June 9th 2026

JOINT INSPECTION GROUP

NEWSFLASH

Joint Notice to Industry - MBG in Aviation Fuel - May 2026

JOINT NOTICE TO INDUSTRY

May 2026

The Joint Inspection Group (JIG), International Air Transportation Association (IATA), Airlines for America (A4A), and IATA Fuel Quality Pool (IFQP) are issuing the following joint notice to the aviation fuel industry:

Recent increases in reports of microbiological (MBG) contamination in airport fuel handling systems have highlighted the need for attention to this important subject. Fuel and fuel system microbiology can be complicated, so operators should be aware of these MBG fundamentals regardless of which operating standard you are using:

Microbial growth (MBG) in aviation fuels

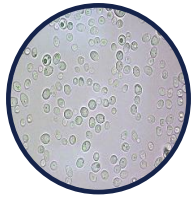
- **The Microbial Growth "Fire Triangle"**

NUTRIENTS;
- Middle Distillate Fuels
  - Jet Fuel
  - Kerosene
  - Diesels
  - Gas Oils
  - Heating Oils
- Additives
- Dirt & contaminants

WATER

MICROBES


Bacteria

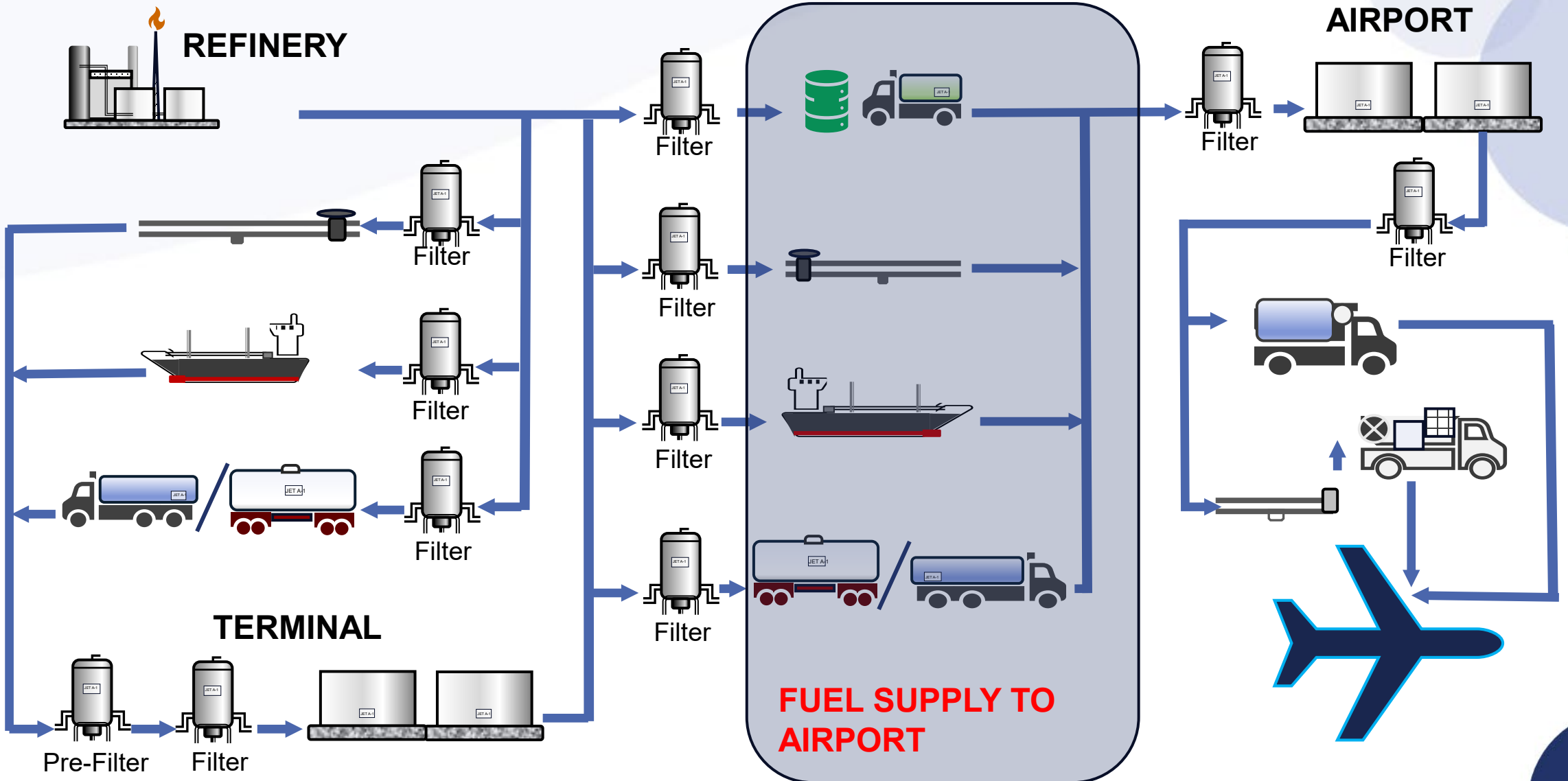

Yeast


Mould

FUNGI

ENVIRONMENT;
- Temperature
- pH
- Water Activity / Salinity
- Oxygen availability
- …..etc.

Aviation Fuel Supply Chain

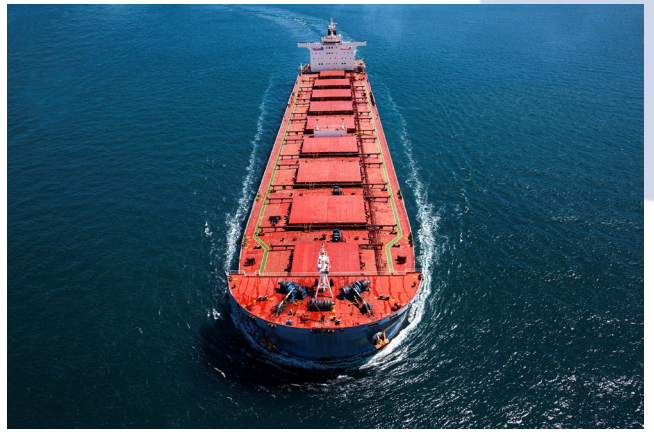


Aviation Fuel Supply to Airports

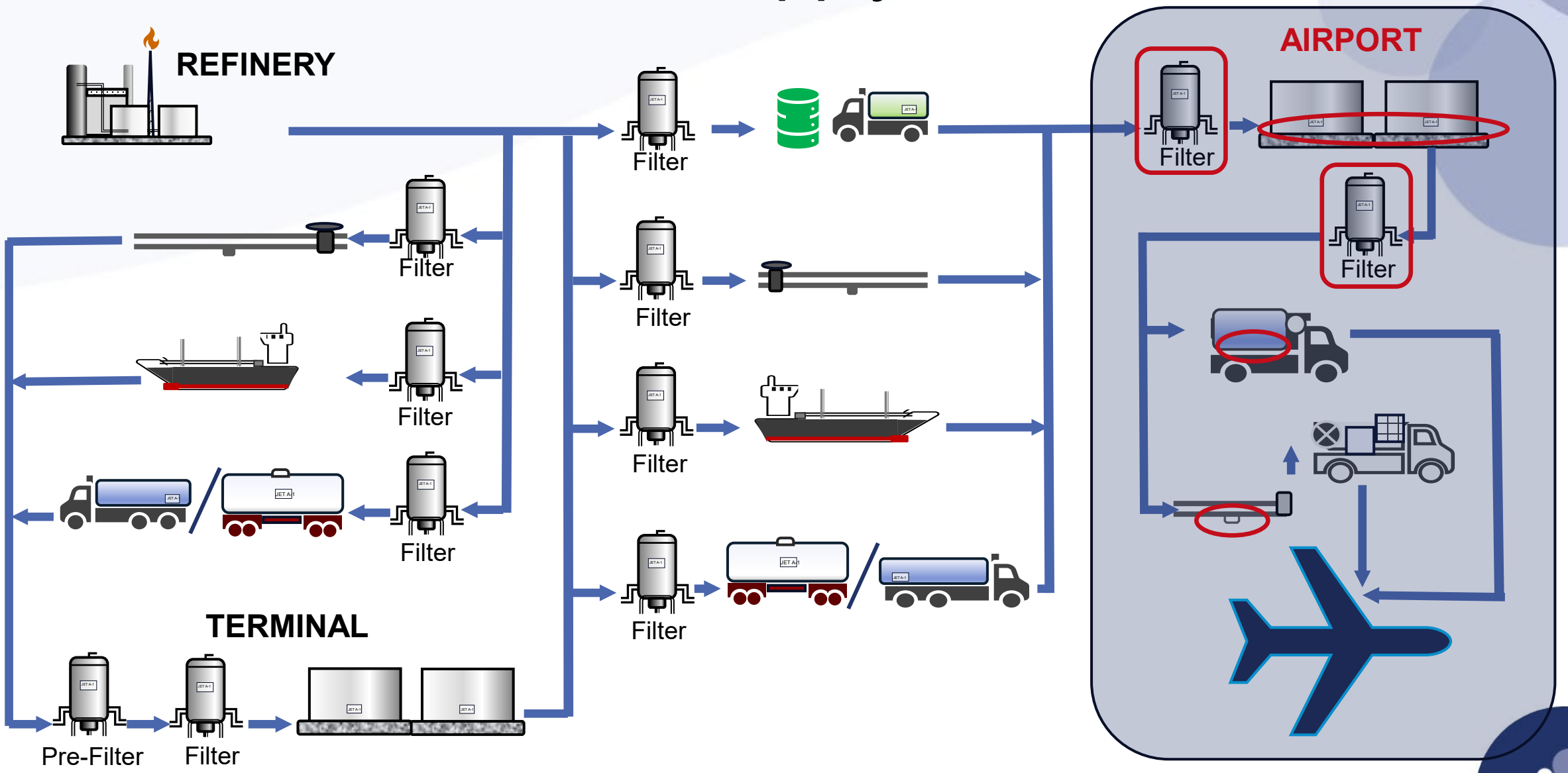
- Is the fuel supplied always of good quality?

- Some airport depots are at a higher risk of receiving fuel contaminated with MBG, for example;
  - Ship-fed facilities;
    - Sea water may enter ship's cargo tanks and then provide sustenance for microbial growth.
    - Higher risk of MBG when cargo tanks are used to store fuel for weeks or months.
  - Non-dedicated fuel supply;
    - Risk of cross-contamination with other products and microbes.
  - Fungible pipelines;
    - Provide an opportunity for receiving contaminated product parcels from other pipeline users.
- Consider supply QA procedures & infrastructure upstream.

- Don't assume that if supply is good there is no MBG risk!



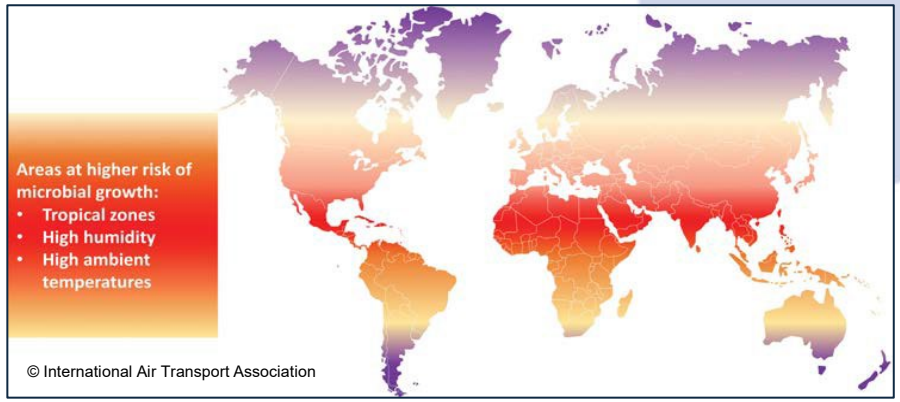
Aviation Fuel Supply Chain



Temperature and climate

Are environmental factors at facilities conducive to microbial growth?

- Microbes prefer warm, humid conditions; 20 – 35°C (68 - 95°F).
- Specialist microbes grow outside this temperature range.
- Remember - MBG is not precluded in cooler climates!



Facilities at Higher Risk of MBG
• Facilities in hot, humid climates. • High day time temperatures and low nighttime temperatures promote water condensation. • Warmer summer months for facilities in temperate climates.

Contamination and disarming of FWS elements

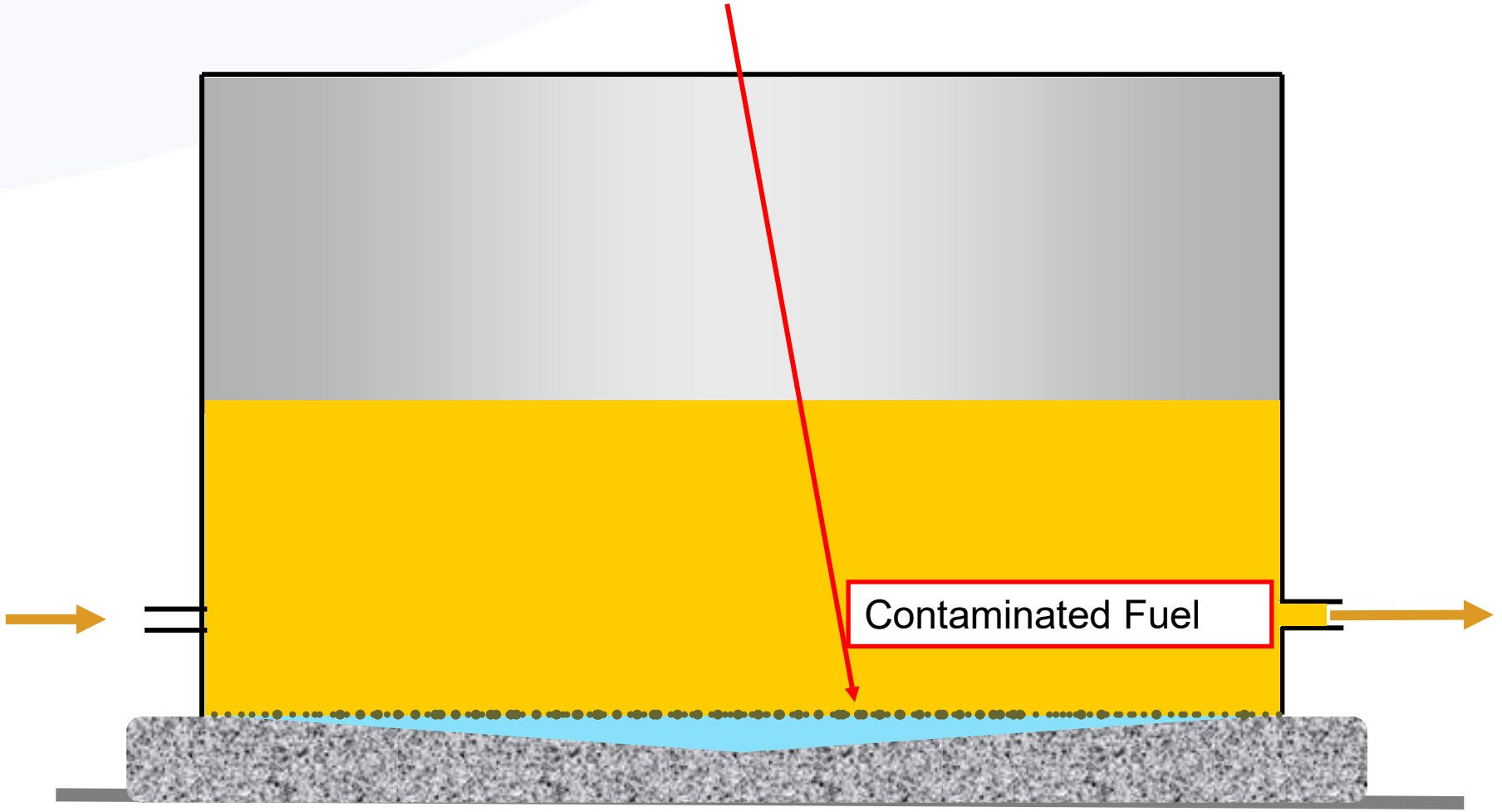
- Leopard spotting on coalescer elements (EI 1581 Filter Water Separators) is often one of the first visible indications that microbial growth is occurring in a fuel facility or in the fuel distribution system upstream.
  - Increased ratings of filter membrane colour testing can also indicate an MBG issue.
- Instead of removing microbial contamination, coalescer elements with leopard spotting become a source of contamination.
- A heavily contaminated FWS can fail to separate water effectively.

Facilities at Higher Risk of MBG
• Fuel flow rates are low. • FWS intermittently used or underutilised. • Infrequent visual inspection of coalescer elements and / or reliance on differential pressure readings.

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).

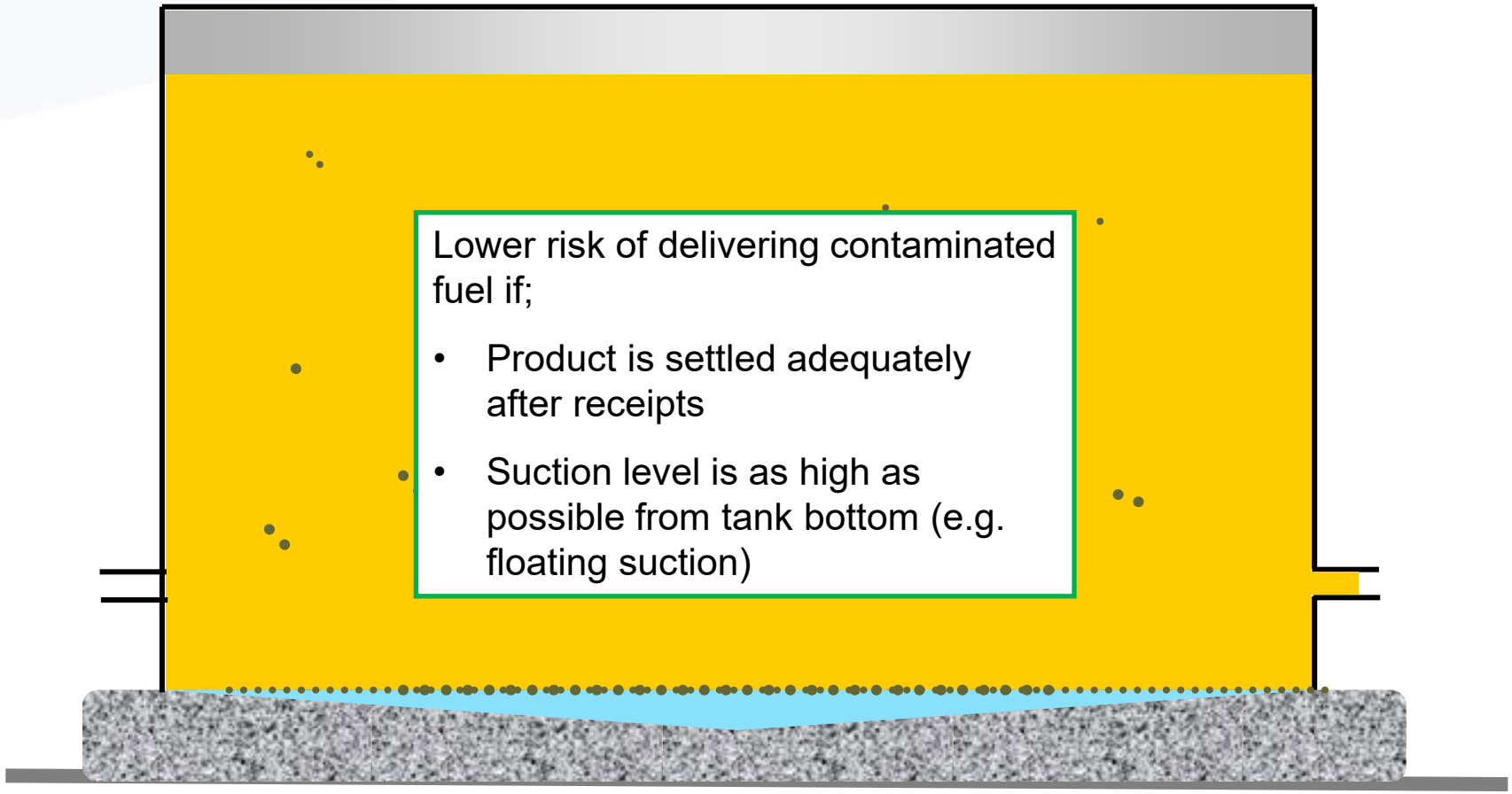
Contamination of fuel in Storage Tanks

- Fuel receipts disturb microbial biomass into fuel



Contamination of fuel in Storage Tanks

- With time microbial biomass re-settles to the bottom of the tank



Microbial growth (MBG) in storage tanks

Key MBG prevention procedures;

- Regular water draining,
- Product settling after receipts.

Facilities at Higher Risk of MBG
• Tank design may impede effective water removal (e.g. internal structures can obstruct flow of water to drain points). • Ageing infrastructure may present challenges to effective water removal (e.g. subsidence of tank floor, roof seal failure, failure of water drainage pipes). • Operational constraints on effective product settling after receipts.

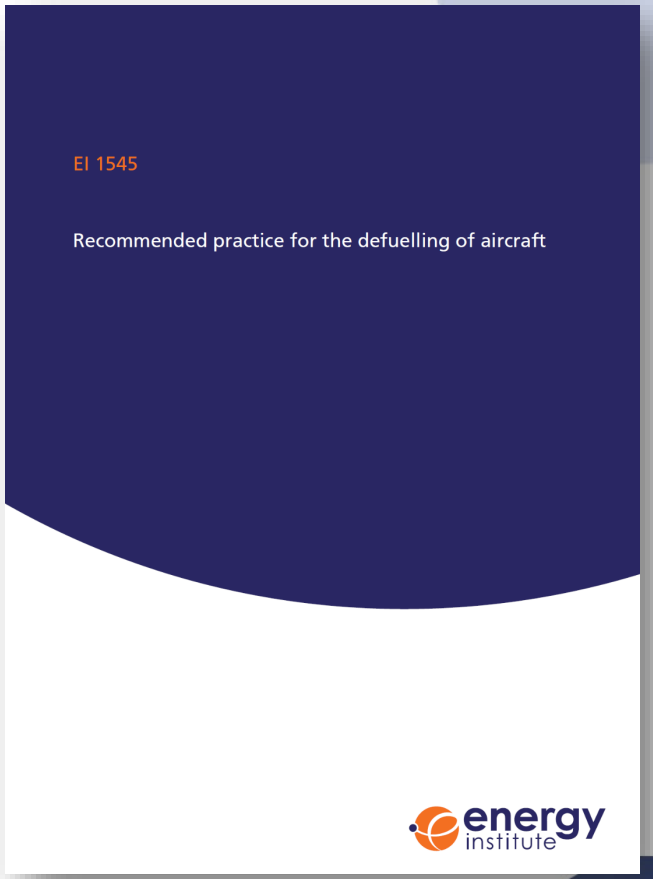
MBG in the into-plane operation

- MBG can contaminate refuellers, hydrants, and dispensers.
- Final filtration at hydrant dispenser / refueller is a critical fail safe!
  - More widespread use of FWS could potentially increase risk of MBG.

Facilities at Higher Risk of MBG
• Wide bore hydrant systems and/or where fuel throughput is relatively low. • Hydrant spurs with dead legs will not be flushed effectively and may provide locations where microbial growth can occur.

Defuelling

- Defuelling presents a risk of introducing microbial contamination (and unapproved fuel additives) from the aircraft into the airport fuelling system.
- Procedures should be conducted in accordance with EI 1545 *Recommended practice for the defuelling of aircraft.*



Facilities at Higher Risk of MBG
• Airport facilities where defuels are not kept separate from main storage

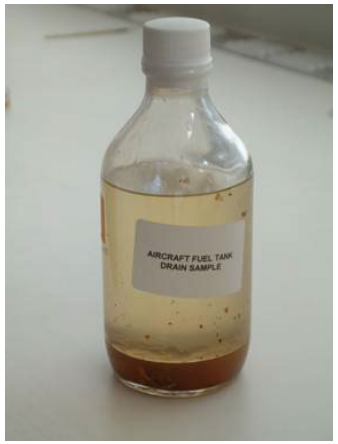
Control of Microbial Growth in Fuel

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

The role of MBG Monitoring

- Microbiological monitoring is a necessary part of fuel quality assurance.
- Key aspects:
  - Visual assessment of fuel samples.
  - Routine inspection of equipment.

- When it looks like this you already have a problem!



- Routine microbiological testing of system samples;
  - Enables early detection of a developing problem and early intervention.
  - Provides assurances that the system is in control.

JIG Guidance – Technical Information Document #1

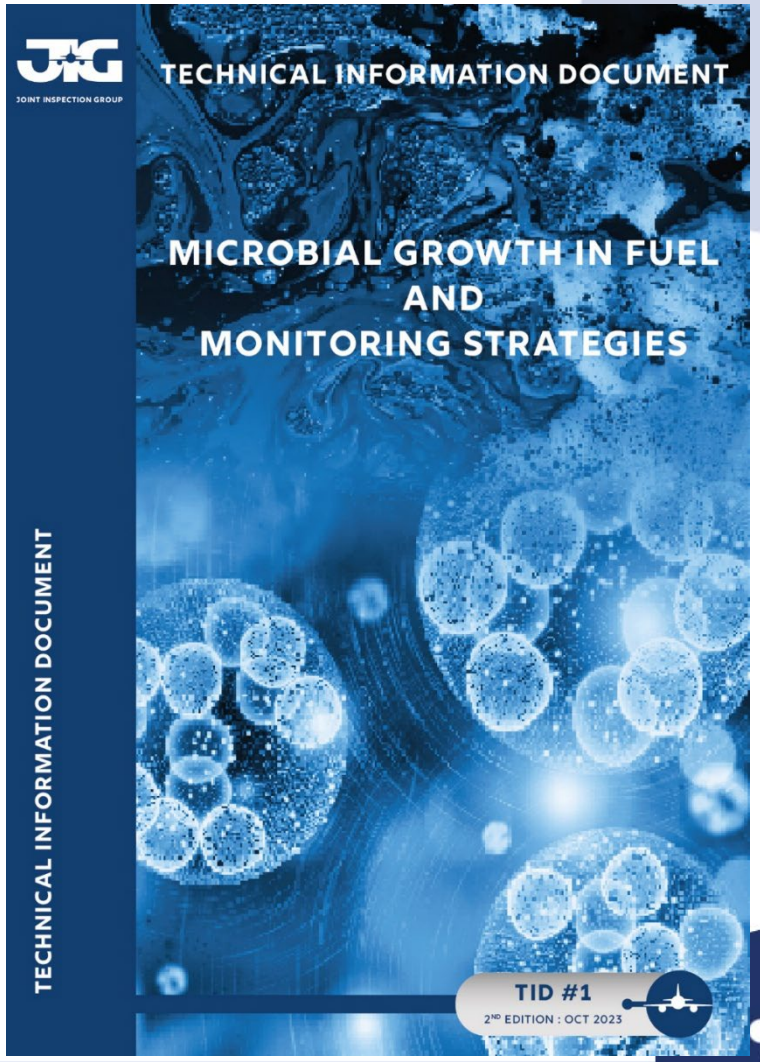
- Provides guidance on appropriate monitoring strategies for use throughout the aviation fuel supply chain up to the point of delivery to aircraft.

PART 1 Microbial Monitoring Strategies, Risk Management & Testing:

- Indicators of Contamination,
- Sampling Strategies & Determination of Site Background Contamination Levels,
- Classification of Risks,
- Test Kit Protocol Quick Guide for Routine Monitoring,
- Warning & Action Level Recommended Practice,
- Action for Operations Following JIG Standards.

PART 2 Informative Annex on MBG & Monitoring Strategies:

- Fundamentals, History, Impacts, Corrosion, Remediation….



echa MICROBIOLOGY

Energy Institute Guidance

EI Guidelines for the investigation of the microbial content of liquid fuels and for the implementation of avoidance and remedial strategies. 3rd Edition (2019).

- The factors which cause and exacerbate MBG and the problems caused.
- Practical advice for controlling, monitoring, investigating, and remediating microbial contamination.

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SAMPLING, SAMPLE HANDLING & VISUAL INDICATIONS OF MICROBIOLOGICAL GROWTH IN FUELS

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JIG-MTF, Rome

9th June 2026

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WHERE IN THE TANK ARE THE MICROBES?

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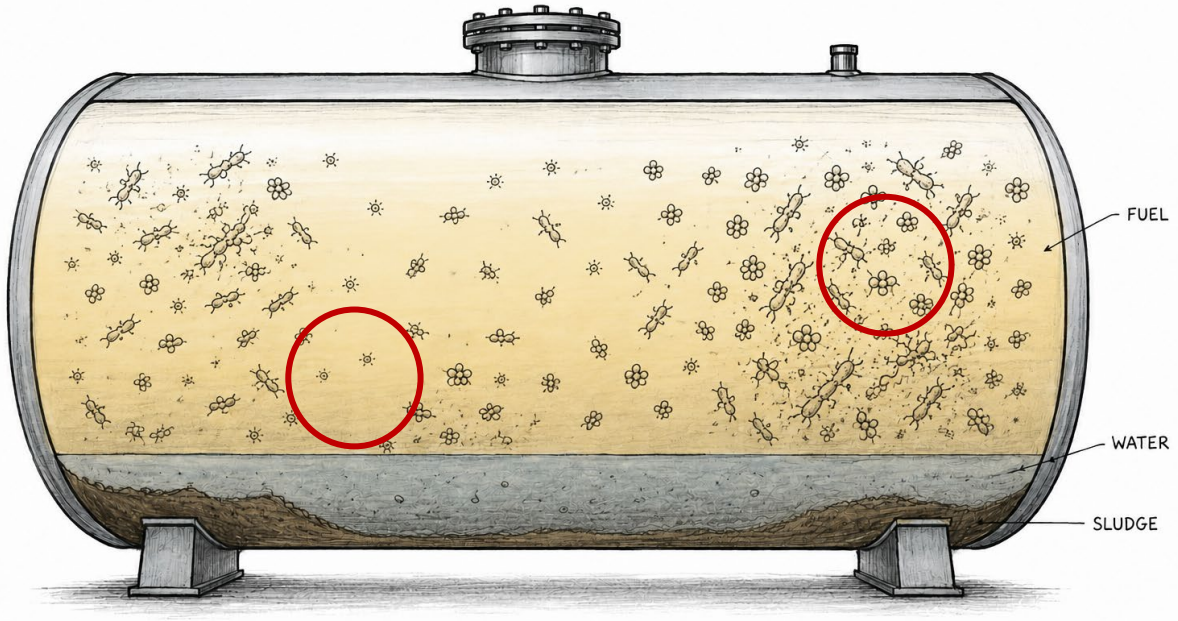
- Water is the root cause of microbiological contamination.
- All fuel contains some water (free at the bottom, suspended or dissolved).
- Microorganisms live predominantly in the water phase and in the interface between water & fuel.
- Aiming for the worst-case scenario of microbiological growth (MBG)?.... **Look where the water is !!!**

THE TEST IS AS GOOD AS THE SAMPLE

- **For highest MBG potential:** sample lowest points (tank bottoms, sump drains, filter drains, hydrant low points)
- MBG in the fuel phase is variable (depends on where the suspended water is); microbes will gather around water pockets
- **Holistic approach**: sample different asset locations, obtain replicate samples, both water and fuel phase
- For **trend analysis**, be consistent (sample same point, same sample type-fuel or water, same sample procedure/ test method)

Result of a single sample =

in testing time



MICROBIAL CONTAMINATION IN THE FUEL IS HETEROGENEOUS.
SOME AREAS HAVE HIGHER MICROBIAL DENSITY THAN OTHERS.
SAMPLNG FROM DIFFERENT LOCATIONS CAN RESULT IN DIFFERENT TEST RESULTS.

TAKE CARE OF SAMPLING EQUIPMENT!!!

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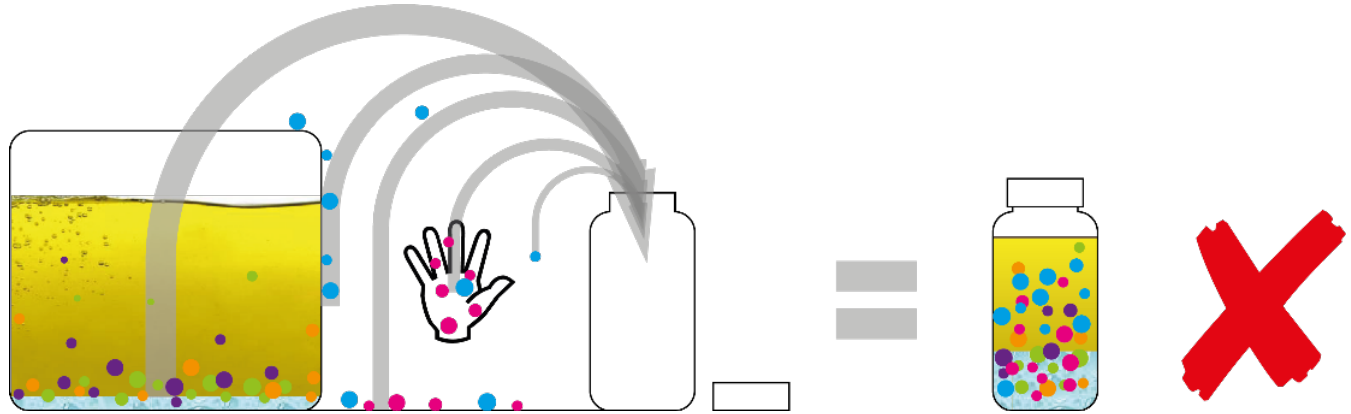
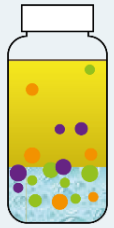
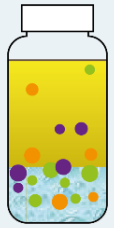
- **Minimise cross-contamination, avoid false positives!** Sterility measures were possible:
  - Use disposable nitrile gloves.
  - Do not touch the inside of the sampling equipment, or sample container.
  - Clean the sampling tap and drain points thoroughly with 70% alcohol, also in between samples.
  - Use sterile, disposable sampling containers or rinse well with 70% alcohol. Let alcohol evaporate before sampling.
  - Do not leave your sampling container open (except when obtaining the sampling) at any point.
- Use borosilicate glass or fuel compatible plastic (HDPE) container; clear material for visual inspection but protect from light.
- Do not forget to label your sample!



- ***ASTM D7464***:*Standard Practice for Manual Sampling of Liquid Fuels, Associated Materials and Fuel System Components for Microbiological Testing*
- ***JIG TID #1***: *Microbial Growth in Fuels and Monitoring Strategies*

TIME IS CRITICAL!

Source: ASTM D6469 - Standard Guide for Microbiological Contamination in Fuels and Fuel Systems

TANK	ON-SITE TEST
	

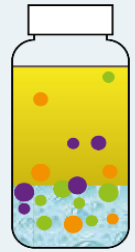
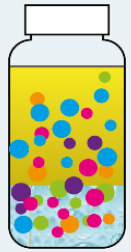
Tested sample = reality in the tank!!

Section 8.3: "Ideally, all testing should be accomplished **at the sampling site**, **within a few minutes** after a sample is drawn."

Why?

- "Both biological and nonbiological deterioration processes continue in a sample during the period between collection and analysis"

Source: ASTM D6469, Section 8.5

Sample Taken **Microbe test ideally conducted at time of sampling**	**Transportation of sample** **If not tested onsite must be kept on ice**	**Sample Tested** **No later then 24 hours**
TANK 		**OFF-SITE TEST** 

Tested sample **no longer represents** the reality in the tank!!

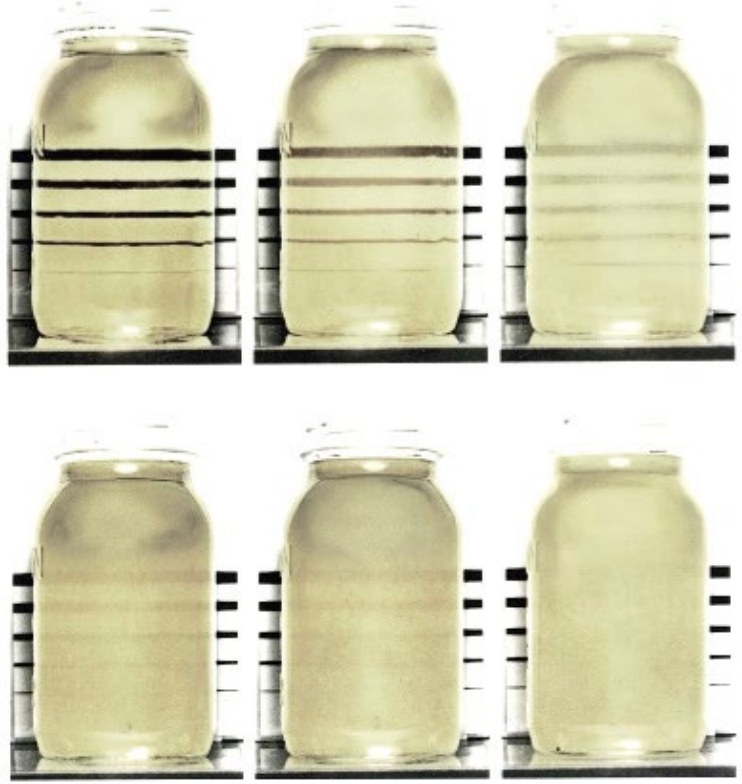
- "Samples for Microbiological testing should be **kept on ice for transport** to the laboratory."
- "Tests should be performed within 4 hours and **no later than 24 hours** after sampling."
- "Samples stored at higher temperatures, or for longer times, can show the presence of microbiological contamination that does not represent actual fuel system conditions."

VISUAL INSPECTION

- At least **1 litre sample** to enable both visual inspection and microbiological testing
- Hold sample to the light -> swirl gently -> **examine** for particulates, discoloration, haze, turbidity, emulsified or free water
- What type of MBG testing to run?... Allow sample to stand for any water to separate from the fuel:
  - is fuel visually clear of free water?
  - is there a fuel/water mix?
  - is there a water bottom sample?

FUEL HAZINESS

Haziness is Water



- **ASTM D4176:** *"Standard Test Method for Free Water and Particulate Contamination in Distillate Fuels (Visual Inspection Procedures)."*
- The ideal fuel "**Clear and Bright**" :
  - **"Clear"** = absence of any cloudiness or haze (no suspended water)
  - **"Bright"** = no sparkling appearance of the fuel (no fine particulates or air bubbles)
- Fuel haziness is indicative of emulsified water, typically associated with MBG
- Water content at delivery to equipment **< 30 ppm**

MICROBIAL SPOILAGE IN PICTURES

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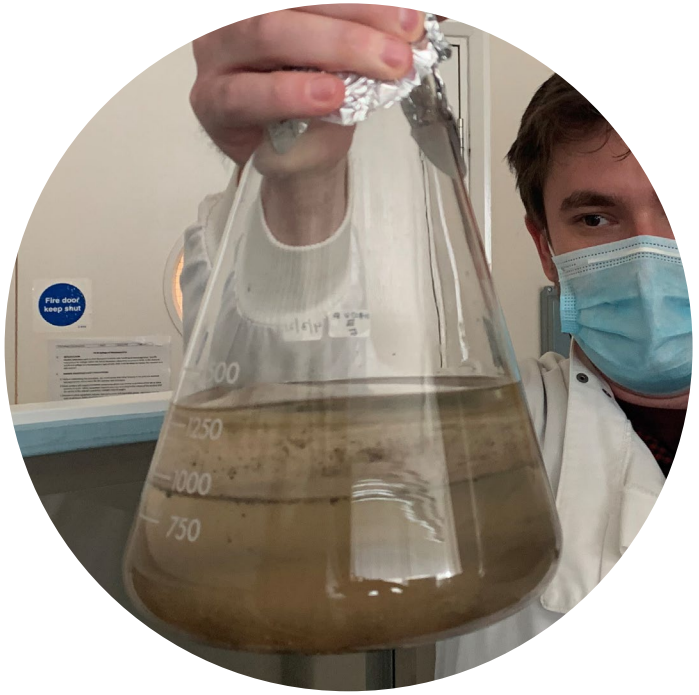
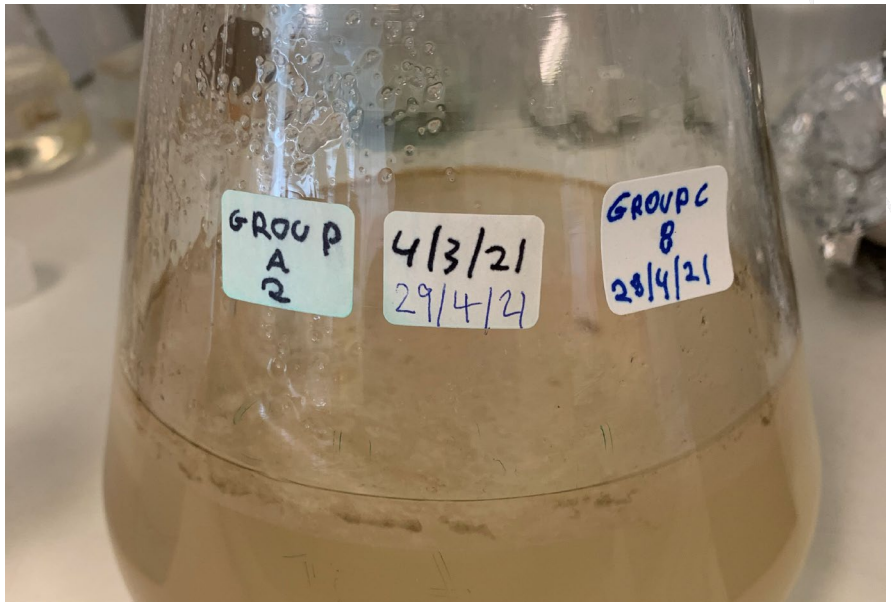


Hazy water or fuel phase due to microbial surfactants.



Lacy “film” like material (microbial polysaccharides) at fuel-water interface.

Dark-brown fungal growth forming a mat at the fuel-water interface.

No visual MBG indication does not imply absence of MBG!!!
You still need to **test your sample**!

MICROBIAL INDICATORS

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➢In tanks

- Dark formations of attached biomass in fuel residues (“d coatings.
- Microbially produced acids i surfaces, sealants.

➢On filters

ate in water that remains on the oalescer elements -> Dark spots ”). MBG may be upstream the fuel n.

ntamination source: Fuel passing ents can become contaminated.

- MBG can impair coalescers ability to remove water.

TAKEAWAY MESSAGES

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Follow basic **sterility**; minimise cross-contamination!

Samples from **low points** provide the worst-case scenario of MBG. Recommended for best risk management!

Any test is only AS GOOD AS THE SAMPLE!!!

Time is of essence! Test samples as soon as possible after sampling.

Visual observations are a first step, but no visual MBG indication does not mean no MBG! **MBG testing** is necessary for timely action!

What type of sample? Consider your testing **objectives** (e.g. thorough asset assessment, trend monitoring) and operational **risk**.

From Data to Decisions

Defining Baselines, Monitoring Trends, and Managing Microbial Risk

Madison Tomlinson, Application Scientist
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JIG Members Technical Forum, Rome, June 9, 2026

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confidence in every count

How Should We Interpret Microbial Data?

Context, baselines, and trends are essential for meaningful decisions.

Single Results Provide Limited Context

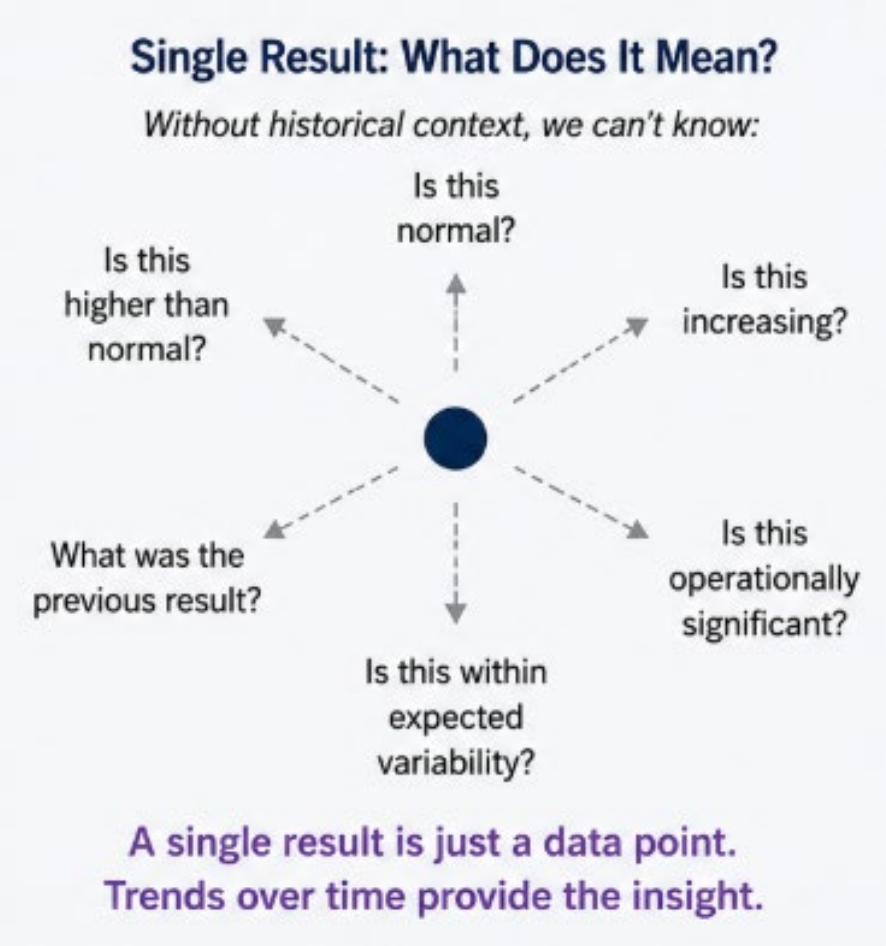
One test result does not tell us if conditions are normal or changing.

Baseline Defines What is Normal

A baseline is the typical microbial profile for your system, including range and variability over time.

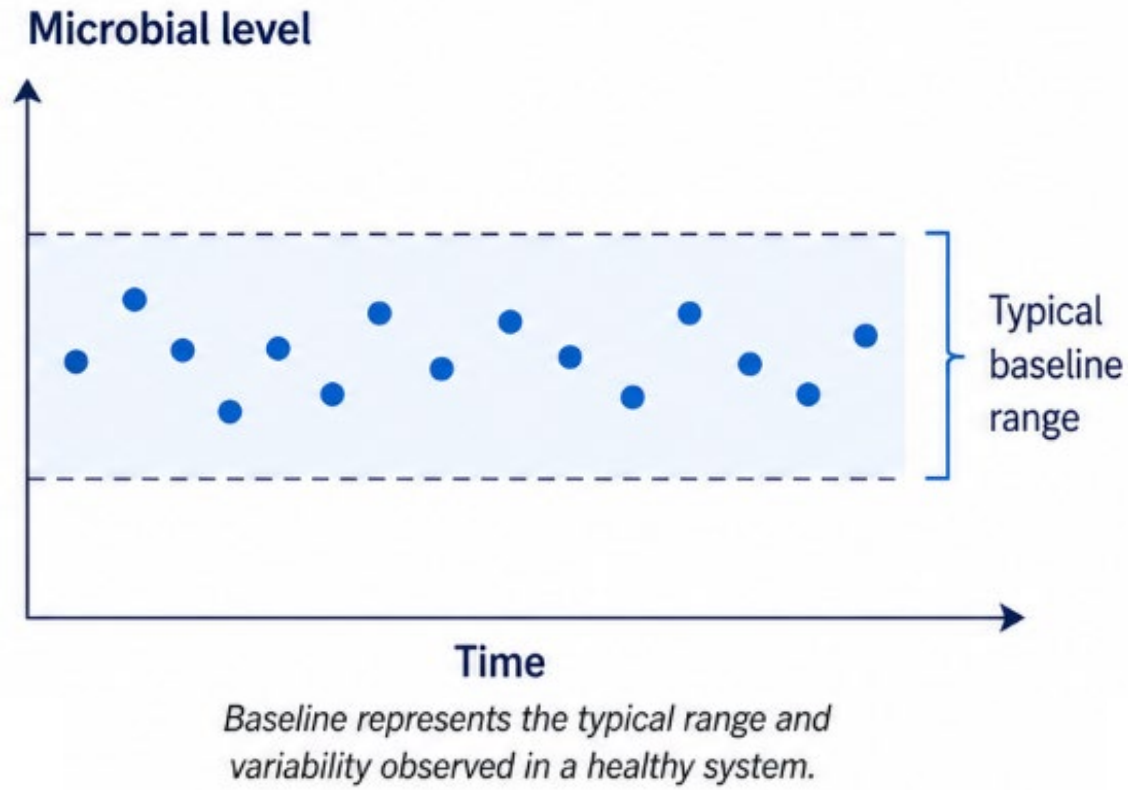
Trends Reveal Meaningful Change

Increasing or decreasing patterns over time help us understand system behavior



What is a Baseline?

- The normal microbial profile for a specific system
- Defined over time, not from a single test
- Includes typical range and expected variability
- Unique to each facility



Baseline represents the typical range and variability observed in a healthy system.

A baseline gives meaning to individual test results

How Do You Establish a Baseline?

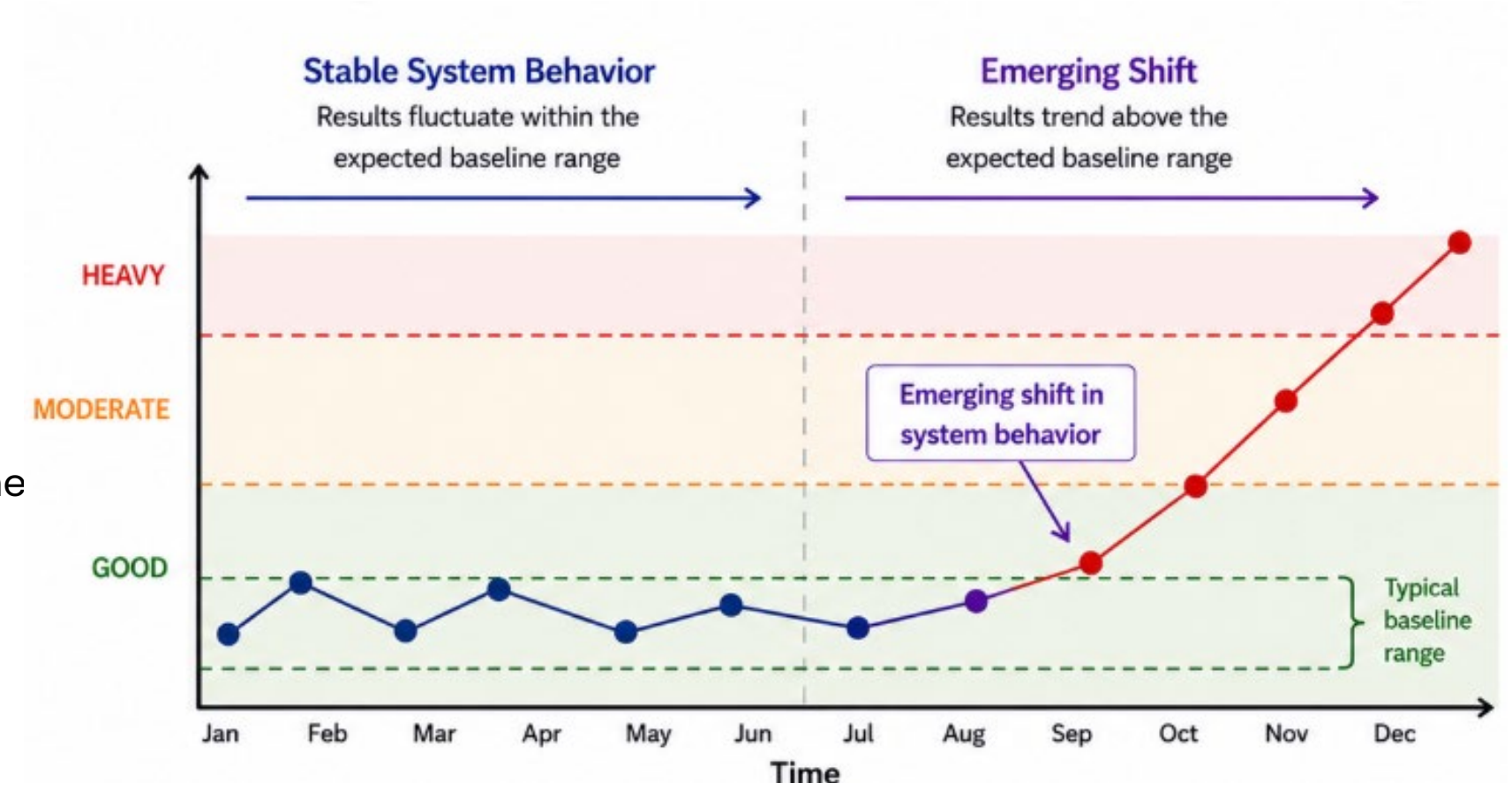
Consistency in sampling is critical to enable meaningful comparison over time

1 Consistent Sampling	Same location, same condition, same method, sample type
2 Monitor over time	Routine monitoring over time builds historical context
3 Capture variability	Include seasonal and operational variations
4 Combine multiple indicators	Combine microbial testing and visual observations

Monitoring Over Time Reveals Meaningful Change

Early Insight Enables Action

- Gradual increases can signal emerging issues before severe contamination or operational impact occur.
- Early intervention can reduce the need for complex corrective actions



How Monitoring Supports Risk Assessment

Microbial Results

- Microbial test results (good, moderate, or heavy)
- Trend direction
- Repeat or confirmed results

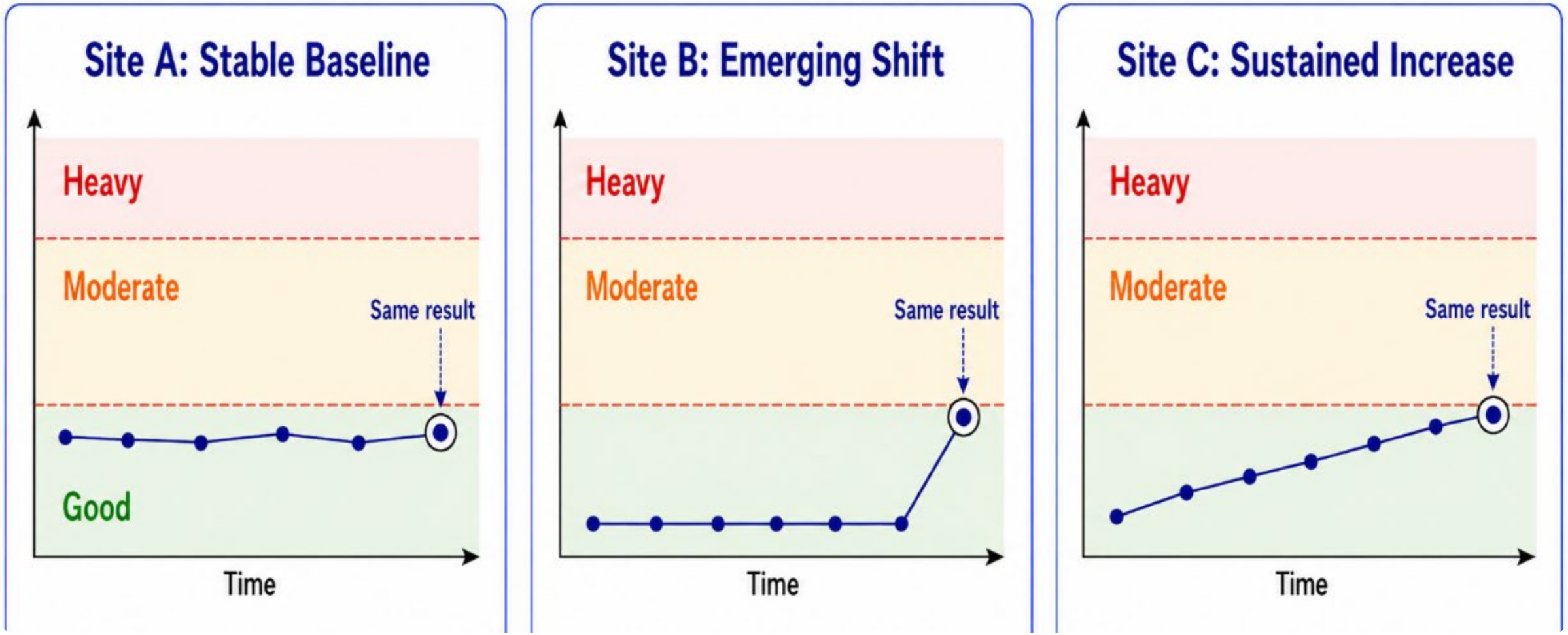
System Conditions

- Water presence
- Temperature / seasonality
- Fuel Turnover
- Recent maintenance or operational change

Operational Indicators

- Visual appearance
- Low-point / sump observations
- Filter performance
- Tank, filter, or vehicle inspection findings

Same Result, Different Meaning



From Baseline to Risk-Based Response

1

Consistent Sampling

Same locations, procedures, sample type

2

Routine Data Collection

Build historical context for each system

3

Quantitative & Visual Results

Use microbial test results alongside appearance and observations

4

Trend-Based Interpretation

Look for changes from normal system behavior

5

Risk-Based Response

Confirm, investigate and respond based on risk