2026 Worldwide Energy Conference

Fuel Quality Challenges – Refining and Pipeline

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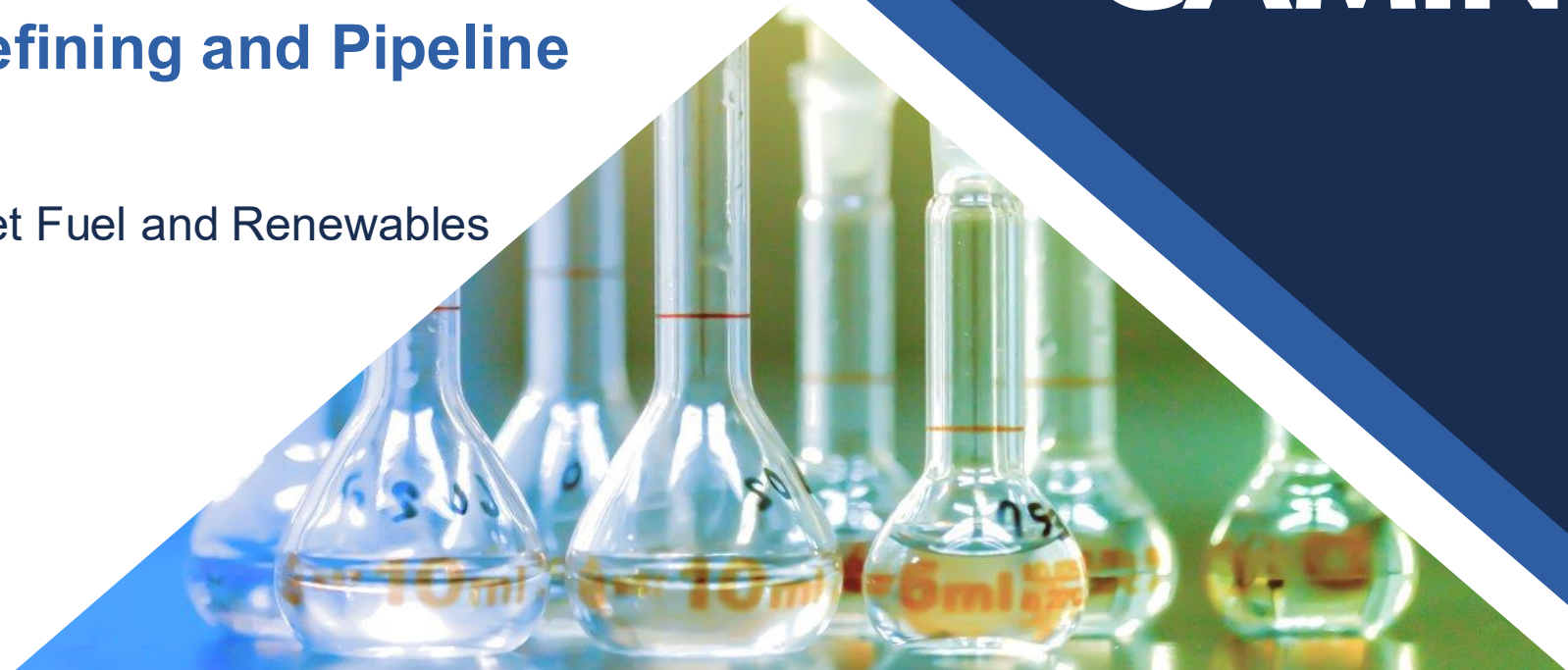

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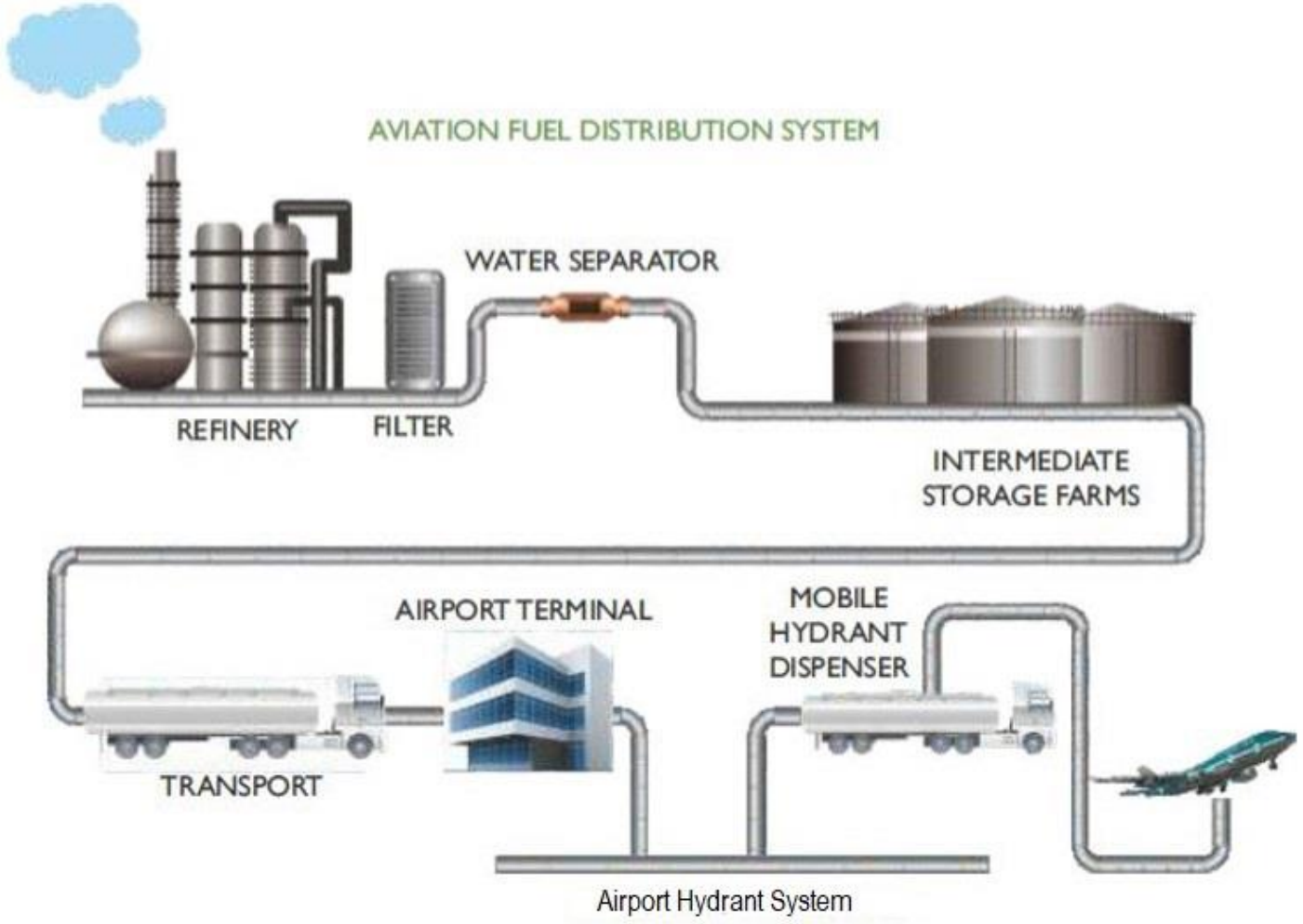
Pipelines



Jet fuel will travel at some point through a combination of multiproduct pipelines and dedicated pipelines to third-party terminals, off-airport terminals and to the airport terminals.

Dedicated vs Multi-Product Pipelines

Dedicated pipelines are used to transport a specific product (example Jet Fuel).

Multi-Product Pipelines are used to transport different hydrocarbon liquid products in batches. These batches are transported in a single pipeline and can include Diesel, Gasoline, Diluent, Kerosene, Jet Fuel and other petroleum products.

Multiproduct Pipeline Batch Systems

Some pipelines operate a **Segregated** batch systems and some operate a **Fungible** batch systems.

A shipper on **Segregated batch** system receives the batch that it tendered at the origin point.

The product put into the pipeline will be the product delivered from the pipeline.

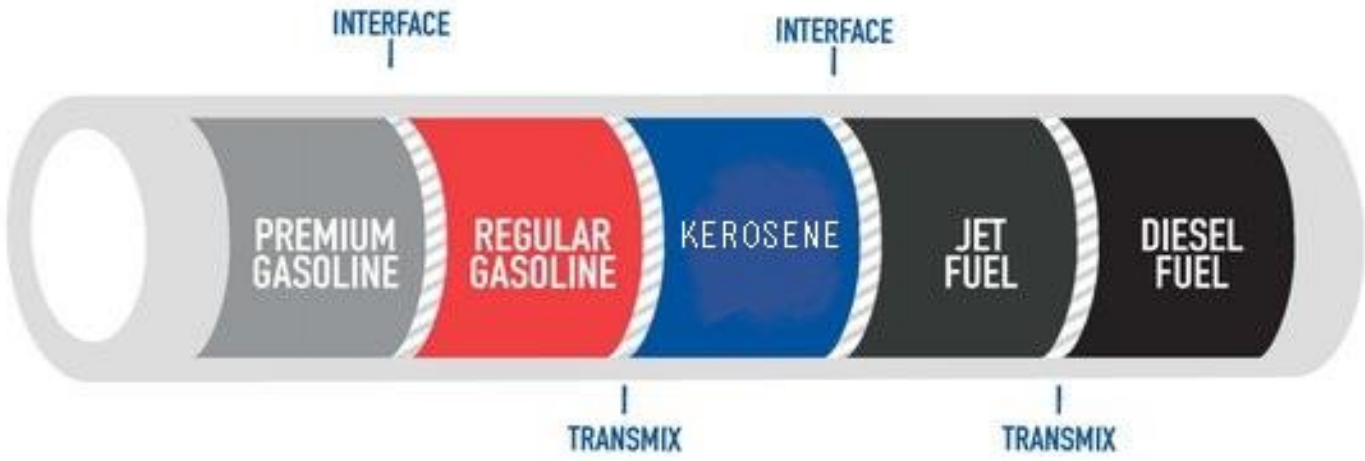
Dollars in are same dollars out.

A shipper on **fungible batch** system co-mingles products with the same specification without raising concerns about how the blended fuel will behave in pipelines, tanks and engines.

Dollars in are not the same dollars out….but are dollars!

Pipeline Batches

Pipeline Interface / Transmix



INTERFACE

When two products are similar, such as different grades of gasoline, the small amount of higher end product can be safely cut into the lower grade product

Example: Jet Fuel/ Kerosene mix

TRANSMIX

When consecutive products are batched in the pipeline with differing qualities.

Example: Gasoline / Jet Fuel mix

Pipeline Quality – monitored by pipelines

Manifolds

Product Contamination may occur if the wrong valve on the manifold is opened.

- Wrong Product loaded out of tank.

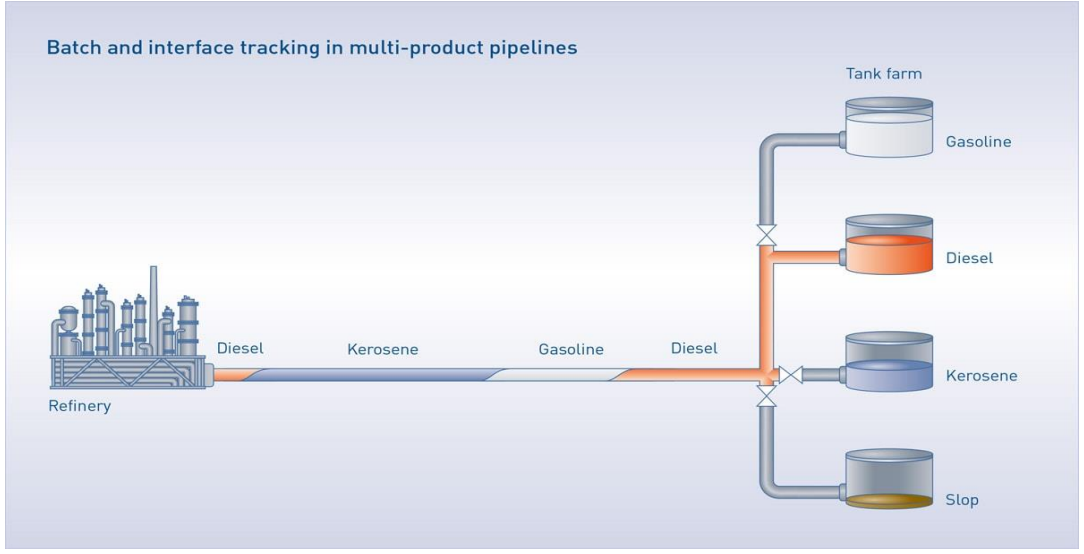
Quality issues can occur if there is a valve leak.

- Continuous contamination throughout batch

Cuts *(Missed Cuts)*

Additional issues are seen when a valve is either opened too soon or closed too late.

***Cuts** – When switching the pipeline flow from one product tank to another, the "cut" is typically based on Gravity. If a "bad" cut is made, the interface/transmix may go into a tank causing a drop in quality when tested.*



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Issues/Controls on Multiproduct Pipelines

Issue	Specific Concern	Key Controls
1. Transmix Contamination	Diesel/Jet Fuel cross-contamination Jet Fuel/Gasoline cross-contamination	Inline density control, interface monitoring, batch sequencing, product cuts (interface, heart cuts, or transmix) and sampling/testing
2. Additives and Incidental materials	Residual additive films, DRA trailback, FAME desorption	Pigging, flushing, “Jet clean” segments (heart cuts)
3. Water and Microbial Growth	Water in Fuel, Water Soluble contaminants, and Microbial Growth	Use of Drain Dry Tanks, Sumping , Use of Filter-separators, coalescers, filter monitors, filter maintenance, and use of biocides

TRANSMIX

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Transmix Contamination

When transmix gets into a Product – "Bad Cut"

Fuel Incompatibility

- Gasoline cut into Jet Fuel – Low Flash Pt.
- Diesel Cut into Jet Fuel – Low MSEP or Thermal instability
- Biodiesel blend into Jet Fuel – off- specification (<50 ppm)

Detection of Transmix

Use of ***Inline*** monitoring systems as well as sampling/testing practices protect fuel quality.

Inline detection:

Density/Gravity Detector

Interface Detector

Manual Detection: Manual sampling and testing for properties that distinguish one product from another:

Flash Point – detection of gasoline transmix/interface

Distillation – detection of low IBP, Elevated EP and residue

MSEP – detection of surfactants

Sulfur – detection of product specification limits / cross contamination

Visual Appearance – detection of haze and/or discoloration

ADDITIVES

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Additives and Incidental Materials

While various additives are used to enhance performance and safety (e.g., static dissipators, anti-icing agents), they are present in limited quantities and are subject to strict specifications and regulatory approval processes.

Unapproved additives and incidental materials pose risk for off-specification jet fuel.

Unapproved Additives

- Previous cargos on vessels
- Pipeline batches prior to Jet Fuel (trailback).

Fatty Acid Methyl Ester (FAME)

- Cross contamination in cargo vessels
  - Not typically transported in pipelines that carry Jet Fuel.
- Contamination at terminals handling Biodiesel and Biodiesel blends

Vessel Cleaning agents, such as chlorinated solvents.

Drag Reducing Agent

- Trailback from products injected with DRA
- Not used in Jet fuel as residues of DRA can cause minor color changes and can contribute to filter plugging or deposits.

Detection of Additives and Incidental Materials

Sampling/testing practices protect fuel quality.

<u>Detection Methods</u>

Conductivity Meter – detection Static dissipator additive

MSEP – detection of Static Dissipator additive

FTIR detectors for FAME content

NEW HPLC detection of Metal Deactivator Additive (ensuring <5.7 ppm specification)

WATER

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Water

Free water / dispersed water / dissolved water

How does water get into pipelines?

Free water naturally present in the oil reservoir. The ingress of water can also occur through leaks and improper storage.

Water can accumulate in storage tanks through condensation or rainwater leaking in through faulty vents or seals.

Since water is denser than petroleum, it settles at the bottom of the tank, where it can enter the pipeline during pumping.

Condensation within the pipeline occurs when product is delivered to the pipeline from the refinery at a temperature above ambient temperature.

Water contamination can lead to Biological Contamination

Fuel / Water layers

Microbial Contamination

Aircraft fuel tank sump

Presence of water (dissolved, dispersed, or free) in fuel systems promotes microbial growth.

Biological contamination of aviation/jet fuel is growth of microorganisms (bacteria, fungi, yeasts) and their biomass.

Visual Indicators: Microbial mats at fuel-water interface, dark slime in tanks, and clogged filters,

Water and Microbial Contamination

Microbes can attach to surfaces such as:

- Filter media
- Tank walls
- Coalescer socks

Biofilms grow and detach particles or fragments that can:

- Plug downstream filters
- Increase Differential Pressure
- Reduce Water Separation
- Causes PTDs

Seeing the "Leopard" spotting is a symptom,

The presence of Free or Dispersed water is critical for microbial growth in Aviation/jet fuel.

Why It Matters — Effects & Risks

Contaminated Fuel Filter

Contaminated Aircraft Filter

Aircraft Wing Corrosion

Operational impacts:

- filters clog
- injectors/valves may malfunction
- fuel flow can be restricted.

Safety/corrosion risks:

- microbial growth can lead to tank/system corrosion.
  (MIC — microbially influenced corrosion)

Cost/maintenance:

- more frequent filter replacements
- Downtime
- potential for major system intervention.

Sulfate Reducing or Nitrate Reducing Bacteria

SRB and/or NRB **don't usually degrade jet fuel directly**, but they thrive in water layers in storage tanks and produce **hydrogen sulfide**, causing **corrosion, sludge, and operational problems**.

Potential secondary effects:

- Formation of **biofilms** and sludges at the fuel-water interface, which can **plug filters** and clog pumps.
- **Hydrogen sulfide contamination**, which is corrosive and toxic, can dissolve into fuel and water.
- Accelerated **oxidation of fuel** if acidic microenvironments are created.

Detection of Water and Microbial Growth

Use of monitoring systems and water mitigation practices protect both fuel quality and tank integrity.

Detection Methods

Visual Inspection

Regular sampling for water/particulates.

Rapid immunoassay or ATP tests for microbes

Culture tests (liquicult, growth media – 30 hrs to 72 hrs)

Control / Prevention - Water

Managing water, monitoring microbial growth, and occasional biocide use are essential to protect both fuel quality and tank integrity.

<u>Control and Prevention</u>

Remove free water via sumping and drainage

Use approved biocides when needed (need to verify compliance requirements)

Maintain good fuel system housekeeping to limit microbial growth

Proper Filter maintenance

Note: Hydrant systems may have a low point in order to collect and drain water, this is not typical in a multiproduct pipeline system.

Certification

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Certificates of Analysis

What does the result mean?

A result is the numerical (or qualitative) outcome of an analytical test performed.

It is obtained using defined method(s), using calibrated equipment and following validated procedures

The measured value is compared against predefined acceptance criteria or specification limits.

- The result indicates whether the sample **meets**, **exceeds**, or **fails** the specification.
- Understanding the results does not just mean pass or fail.
  - Passing results may indicate an issue if significantly different from the origin result
    - This may indicate an issue during transport
  - Repeatability and Reproducibility ***cannot*** be used to state that a result is on-spec if the result reported below 38.0 C (example 37.5 C).
    - It is already understood that the reported result has a repeatability of 1.2 C and reproducibility of 3.1 C.

Certificate of Analysis Results - Interpretation

What do the results mean?

Acidity 0.10 max – When lower than origination, the fuel has been exposed to a basic compound. *Look for Basic Nitrogen compounds.

Flash Point 38 C min – This is a transportation safety issue. Low flash product in cold temperature environments are not an issue. If Flash Point is 38 C (100 F) and is being transported by truck in Phoenix, AZ, a potential flash could occur if the product is above 100 F.

Freezing Point -40 C – When using an automatic Freezing Point apparatus, off-spec freezes have been seen due to humidity. Manual freeze points do no freeze with humidity and is referee in cases of dispute.

Microseparometer– This is meant for Jet Fuel at the point of manufacture. It's a good indicator downstream when surfactants or micro-particulates get into the fuel. Clay filtration will remove most polar compounds that cause low MSEP readings.

Conductivity – Prohibited in pipelines as it can disarm Clay Filtration systems. Conductivity additive is needed to prevent static discharge when loading trucks and is typically added to the truck when loading.

Existent Gum – Although 7 is maximum, the presence of gum above 2 is typically indicative of a refining issue.

Note: Differences can be seen between ASTM D381 (Steam) and IP 540 (Air). Higher results are seen when performing IP 540 (air). ASTM D381 is referee and always uses steam to remove water soluble gums. IP 540 can be performed with air or steam. When reporting IP 540, it is required to state the media that is used.

Properties that *cannot* be controlled or detected by the pipeline

Some fuels may require additional testing to determine cause.

Example:

Jet Fuel Thermal Oxidation Stability

- Caused by
  - Basic Nitrogen Compound
  - Reactive Sulfur Compounds
  - FAME
  - Polynuclear Aromatics
  - Phenolic Compounds
  - Sulfate Reducing Bacteria
  - Trace Heavy Metals (Cu, Cd, Zn, Fe, Co, Pb)
  - Unapproved Additives
  - Reaction between Merox Processed and Hydrotreated Jet Fuels

Some fuels may require benchtop testing to determine if blending, filtration or additive will fix the issue.

Note: Thermal Stability has been addressed on pipeline systems to prevent the disruption of the fuel arriving to airports. MDA and/or Clay Filtration have been shown to improve Thermal Stability.

Control - Quality Systems

Know what quality systems that the laboratory is using.

At minimum, all laboratories should be ISO 9001 certified.

- This certification indicates that a quality program has been written.
- This certification is “Say what you do and do what you say.”

- ISO 17025 certification specifies requirements for competency to carry out test methods and/or calibrations, including sampling.
  - Method specific - Each test method on the scope of the certificate meets the quality requirements including SQC charts, round robin data and calibrations/verification data.
  - Any laboratory can be ISO 17025 certified. Certifications can have 1 method or 100+ methods. Always request the scope of the certification to see if the test methods being performed are in the scope of the certificate.

Summary

In summary, global best practice integrates specification compliance, controlled product transfer, testing, documentation, and audit systems — all aligned with the ASTM D1655 and other Global specifications framework.

Based on Sheer volume of product transported daily, there are relatively few pipeline related quality issues that disrupt the flow of the fuel to the airports.

QUESTIONS?

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Thank you

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