EASA Fuel Quality Seminar

Why Fuel Quality Matters

Presenter Mark Wainwright

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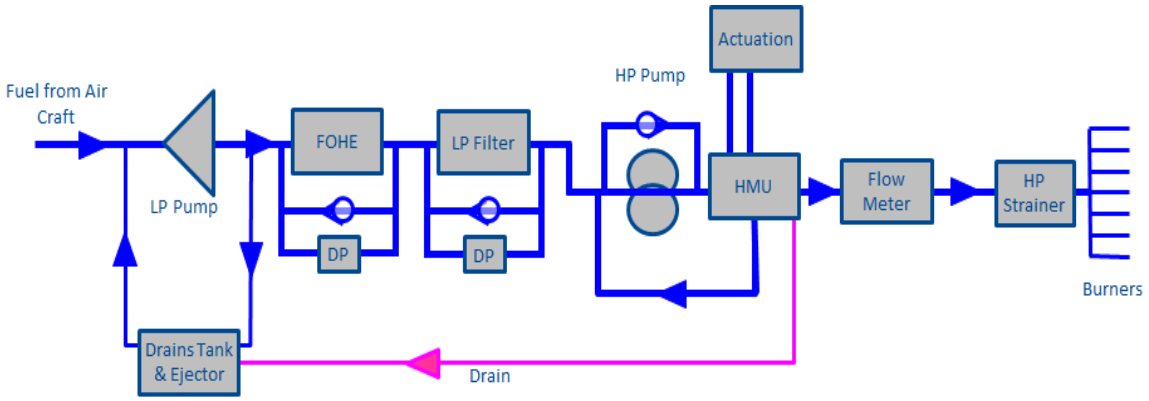
Fuel is a multi-functional fluid

- **Purpose**
  - Energy source for combustion ⟶ engine thrust
  - Heat exchange fluid
  - Hydraulic fluid
  - Lubricant
- **Key Properties**
  - Energy density
  - Flash point
  - Thermal stability
  - Thermal operating range
  - Combustion characteristics
  - Materials compatibility



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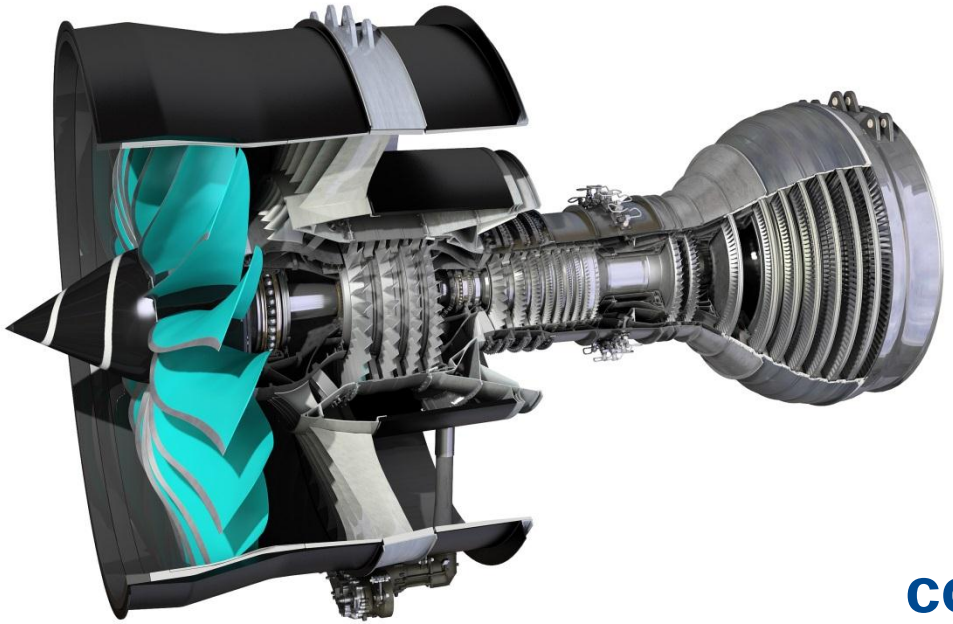
Impact of fuel properties

Performance

Safety

Reliability

Systems Design



Cold starting

Certification

Altitude relight

Maintenance

Material compatibility

Emissions

Hot end life

Deposition

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Fuel Specifications in Context

- **Fuel specifications define:**
  - **Properties, performance and composition**
  - **Limitations on source materials and processes**
- **Specifications provide:**
  - **Minimum quality level**
  - **Basis for purchase contract**
  - **Balance between user and producer**
- **What specifications do not always provide:**
  - **Adequate control of all properties**
  - **Prediction of fuel behaviour under certain system conditions**
  - **Current/future system design rules**

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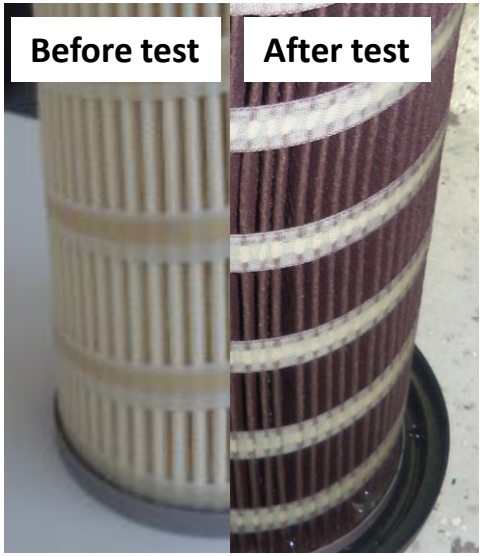
Fuel System Design and Verification

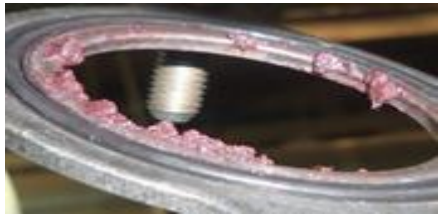
System Design

- Evolutionary building on best experience.
- Specifically designed to tolerate contaminant.
- Specifically considers most demanding fuel properties
- Mechanical complexity has tended to reduce.
- Future system complexity likely to increase.



Verification

- Generally assessed with full system rig test.
- Contaminant agreed with the airframer, (CS-E560)
- CS-E560 requires ≈ 200grams contaminant.
  - RR tests typically present >3kg contaminant
- CS-E560 don't require unfiltered operation RR test unfiltered anyway – ALARP



Contaminate Build up during test

(ALARP – As Low As Reasonably Practicable)

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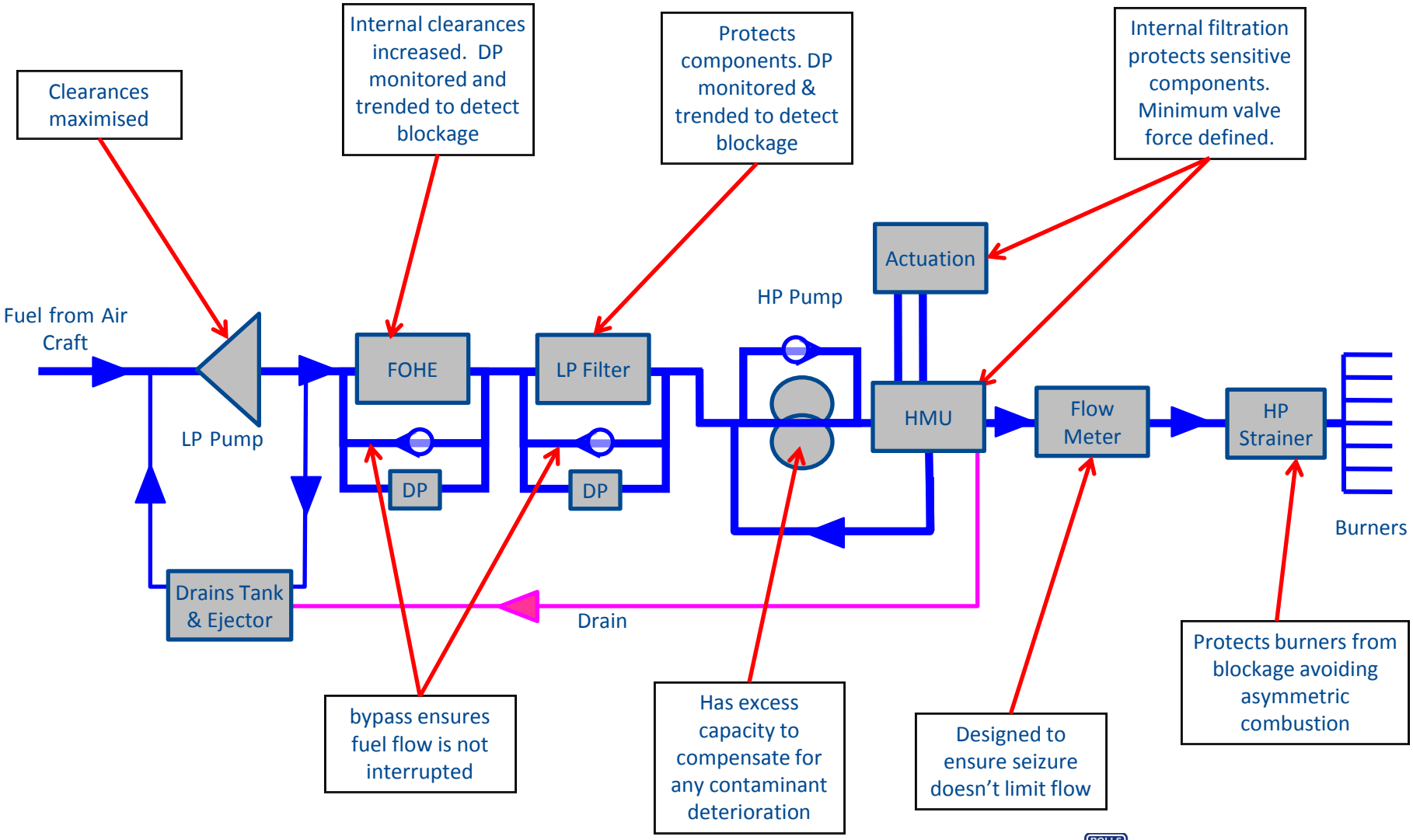
Fuel System Design for Contaminant



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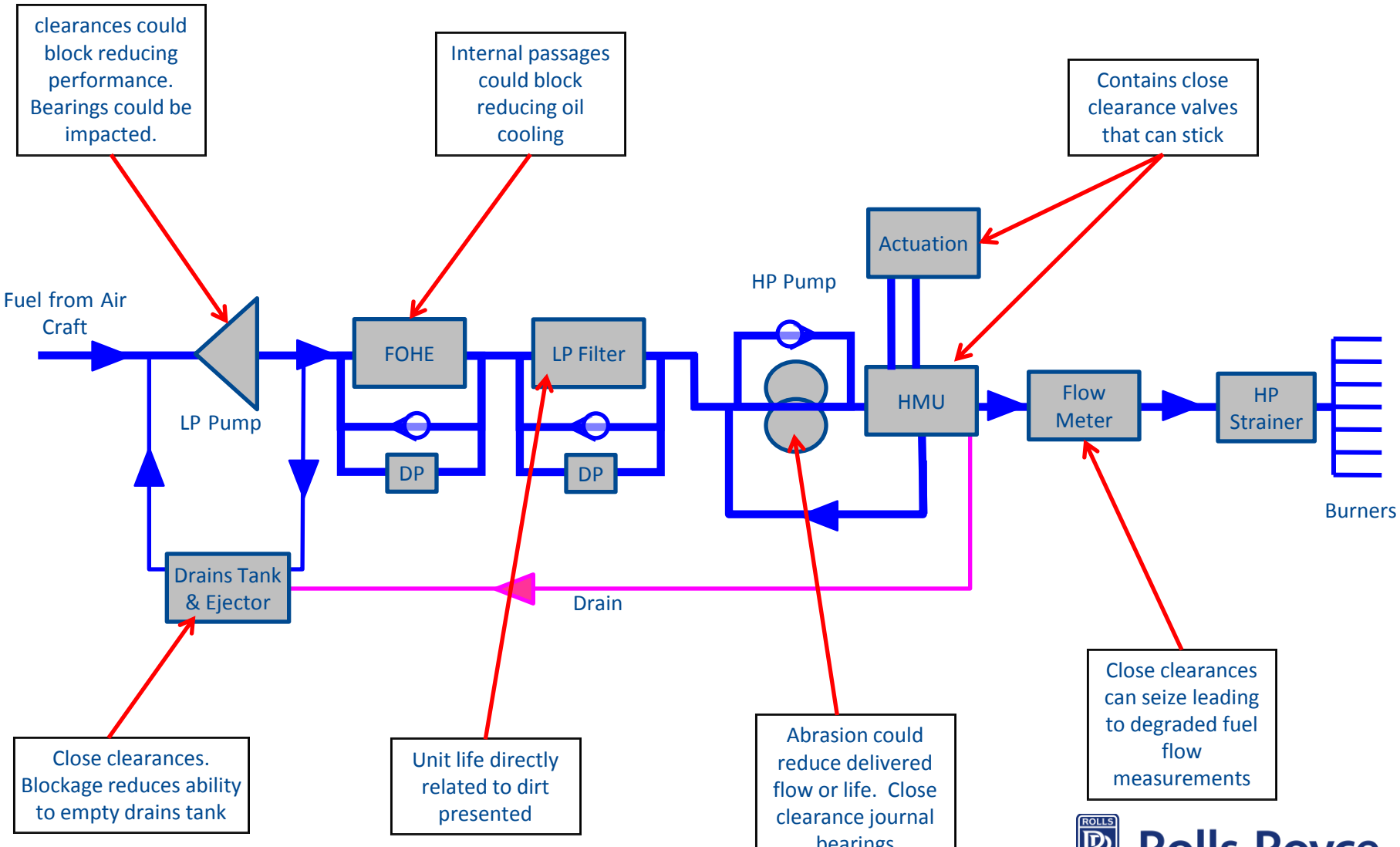
Areas of Potential Sensitivity to Contaminant



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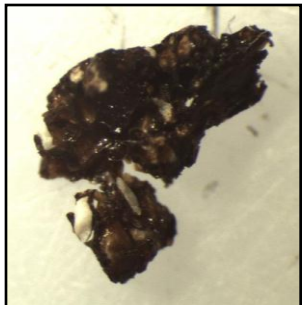
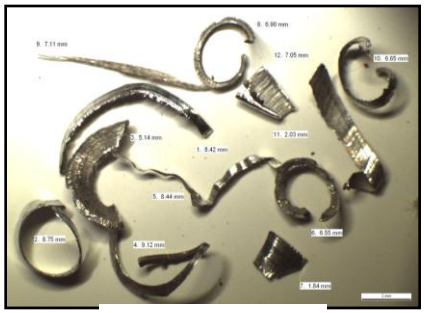
In Service Contaminant

- **The Engine Fuel System is exposed to contaminant not defined in the specification.**
  - **Primary source appears to be Aircraft build and maintenance.**
  - **There has been exposure due to on ground fuel handling failings**
- **Generally function is not impacted but life may be degraded.**



Abrasive material



Metal Swarf

Carbon fibre, lint and plastic (flight test)

Non Metallic

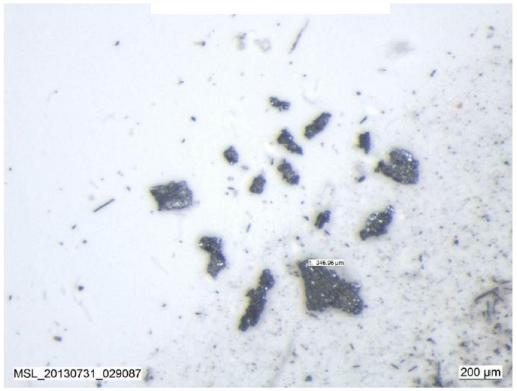


Figure 19
Post EGR Engine #2. Typical black, soft non-metallic debris flakes noted up to circa 350 µm.

Seal material & plastic

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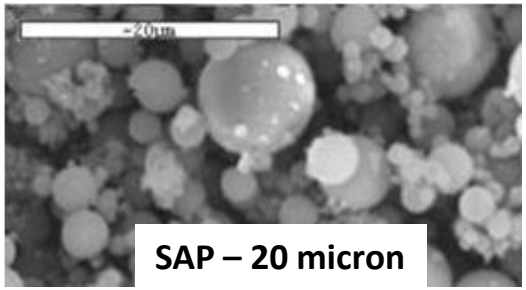
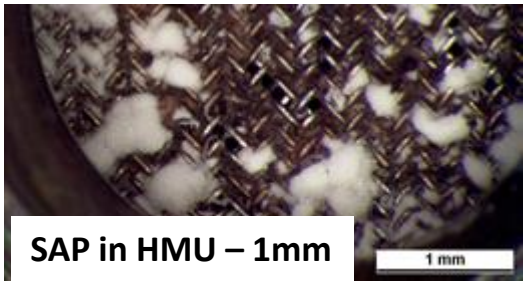
Super Absorbent Polymer (SAP)

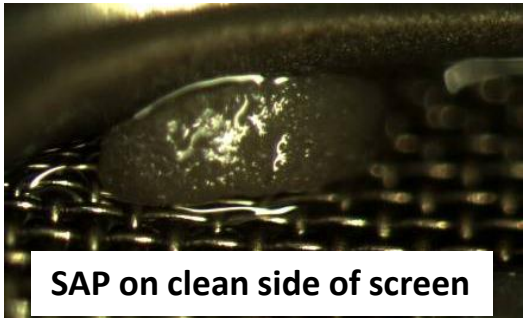
- SAP - from ground filtration.
  - Used for water removal.
- RR have had 4 events on Trent 700
  - 1 Dual Engine Loss of Thrust Control
  - 3 failed starts on ground.
- SAP is different:-
  - Malleable, not overcome by chip shear
  - Squeezes through filters & screens
  - May agglomerate
- RR System and component tests
  - All assessed architectures malfunctioned but at concentration above 4.5g/4500 litres.
- No plausible design solution identified
- Particle detection assessed, malfunctioned due to SAP.



SAP – 20 micron



SAP in HMU – 1mm


SAP on clean side of screen


Test SAP in LP filter

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Conclusions and Recommendations

- **Fuel is a multi functional fluid.**
- **System design considers contaminant.**
- **There is exposure to out of spec contaminant.**
  - **System is generally robust**
  - **Not always**
- **Future systems may be more sensitive.**
- **New Aircraft materials / processes increase risk.**
- **Engine manufacturers & Airframers should continue to work closely.**

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