

Modern fuel filtration modules for HD Diesel applications

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- Introduction
- Current requirements
 - Fuels
 - Particle separation
 - Cleanliness
 - Water separation
 - Microbial activity
- Blue Drain® (automatic water drainage)
- Future requirements
 - Outlook
 - Active fuel prefilter system
- Summary

Modern filtration systems for diesel applications

Introduction

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- Euro 4 → Euro 5 → Euro 6 → ...
- Increasing use of alternative fuels: biodiesel, ...
- Particle separation → high level of functional integration
- Suction side applications → pressure side applications
- Local supply → world engines



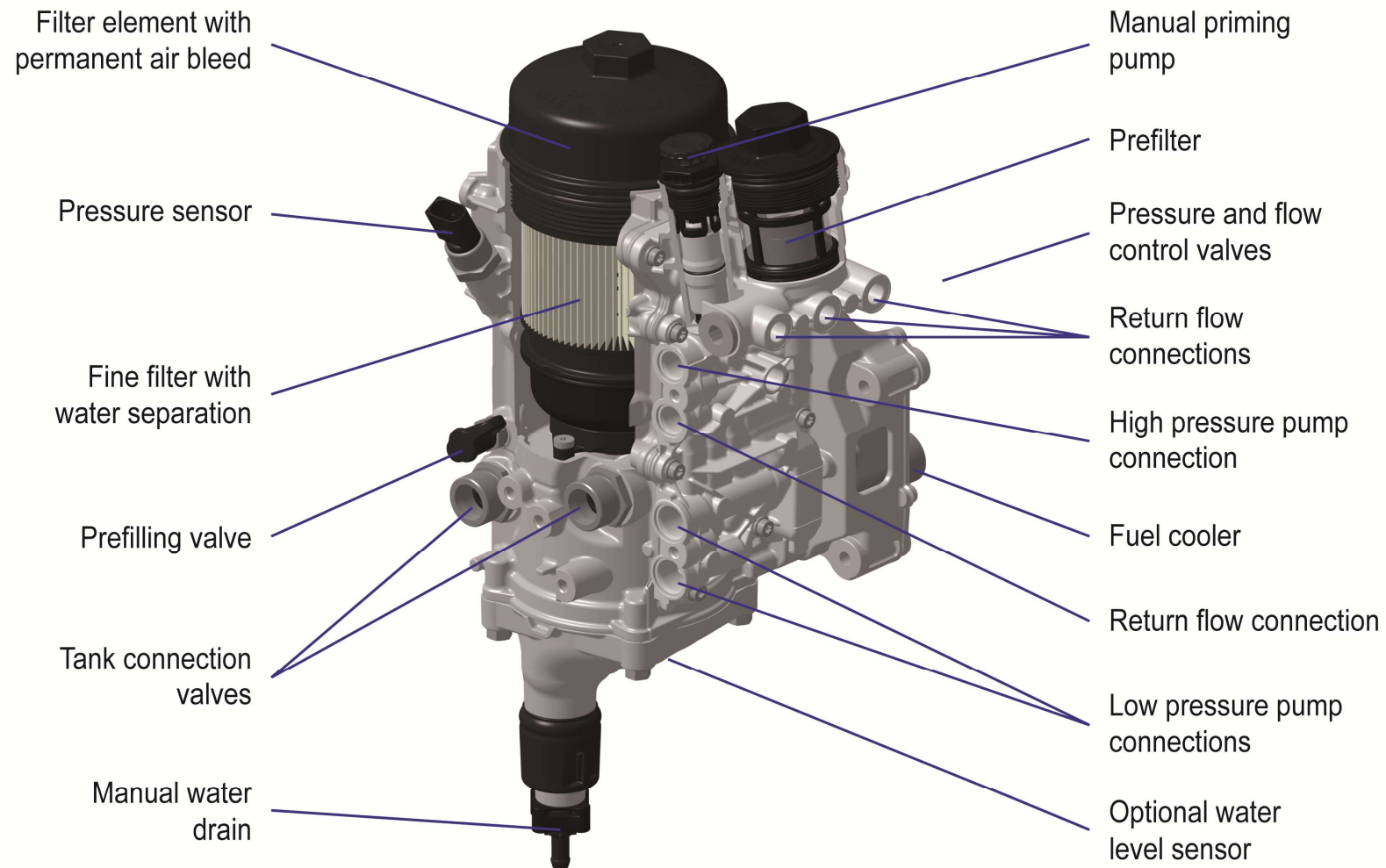
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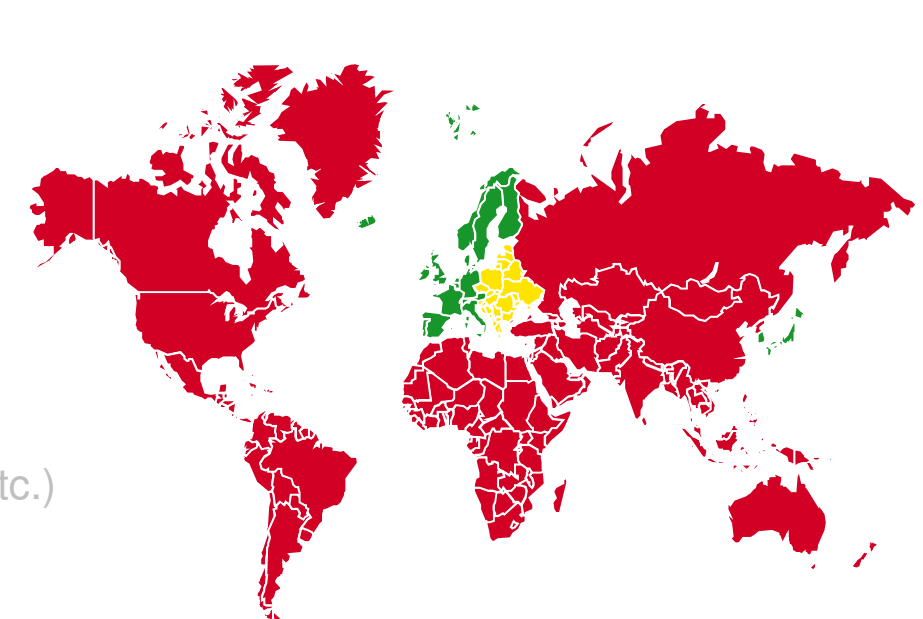
Current requirements – fuels

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- Europe: EN590
 - Additivation
- Bio diesel
 - Fuel quality
 - regional differences
 - Particle spectrum
 - Water content
 - Variety of raw materials (rape, soy, etc.)
 - Microbial activity
- Supply chain/ storage
- Testing
 - “F1” standardized test fuel

Global fuel quality



Waterseparation condition	Water content	Content of anti-corrosive additives
Difficult	> 500 ppm	low
Medium	< 500 ppm	high
Normal	< 200 ppm	high

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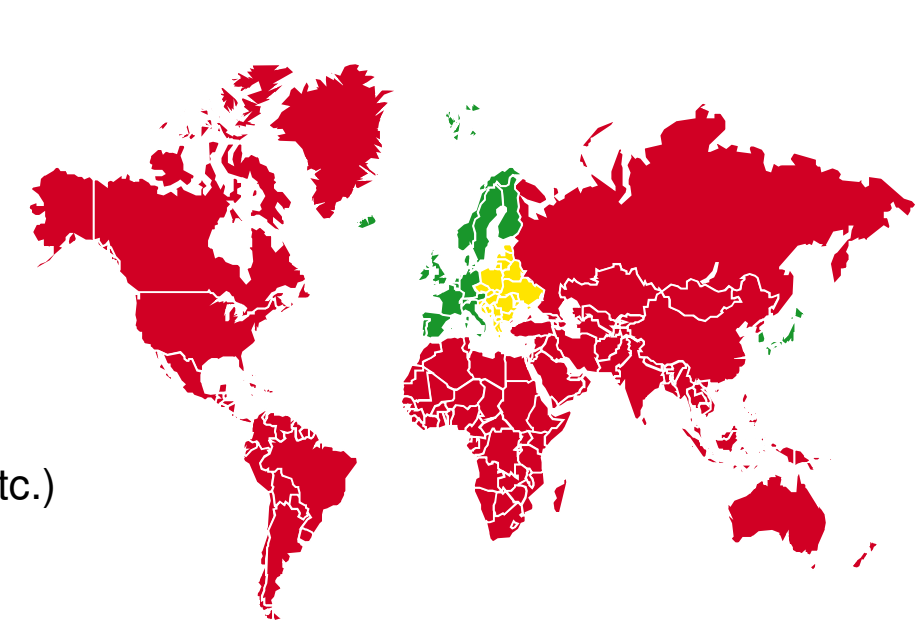
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 - Standardized test fuel
F2.2 acc. to ISO WD 16332

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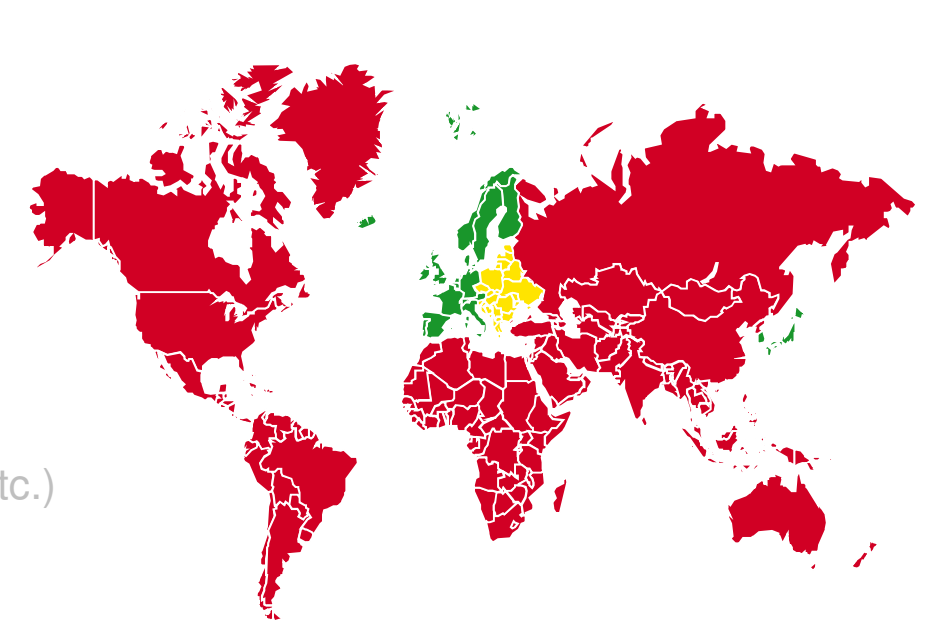
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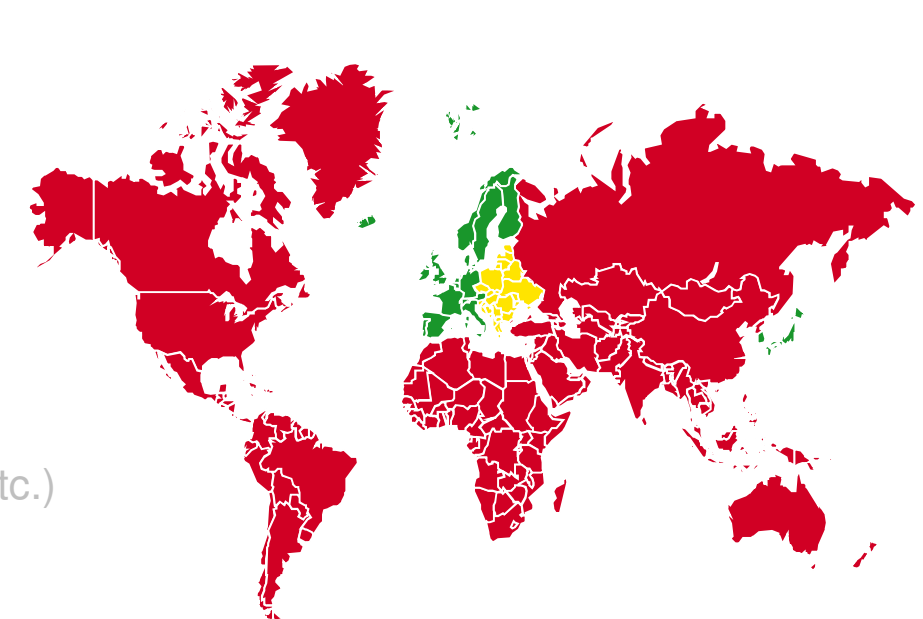
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Modern filtration systems for diesel applications

Current requirements – particle filtration – comparison



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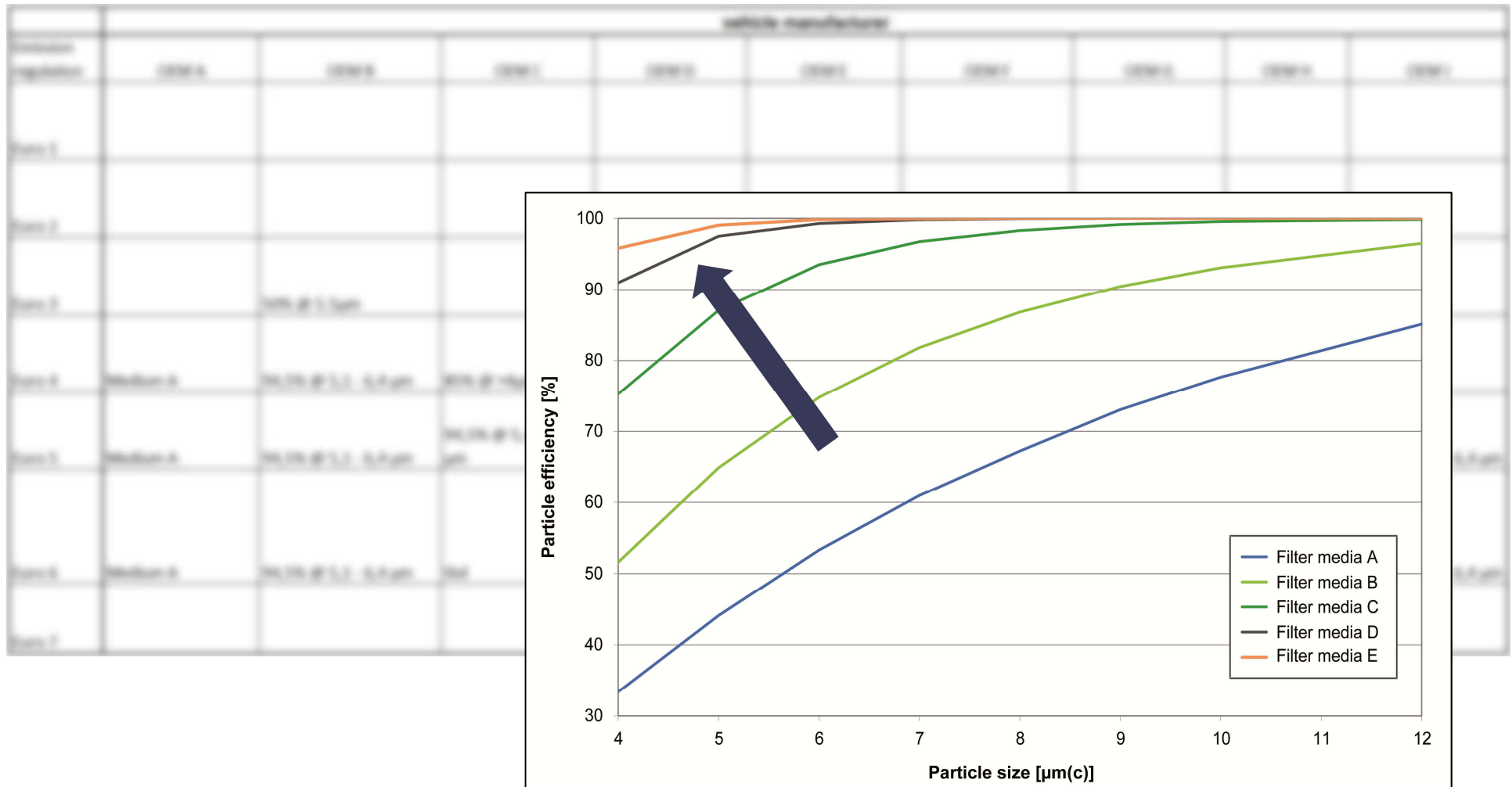
	vehicle manufacturer								
Emission regulation	OEM A	OEM B	OEM C	OEM D	OEM E	OEM F	OEM G	OEM H	OEM I
Euro 1									
Euro 2									
Euro 3		50% @ 5.5µm							
Euro 4	Medium A	94,5% @ 5,1 - 6,4 µm	85% @ >4µm	66.5% @ 5,1 - 6,4 µm	66.5% @ 5,1 - 6,4 µm		66.5% @ 5,1 - 6,4 µm		
Euro 5	Medium A	94,5% @ 5,1 - 6,4 µm	94,5% @ 5,1 - 6,4 µm	94,5% @ 5,1 - 6,4 µm	94,5% @ 5,1 - 6,4 µm	94,5% @ 5,1 - 6,4 µm	66.5% @ 5,1 - 6,4 µm		95,7% @ 5,1 - 6,4 µm
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Euro 7									

Modern filtration systems for diesel applications

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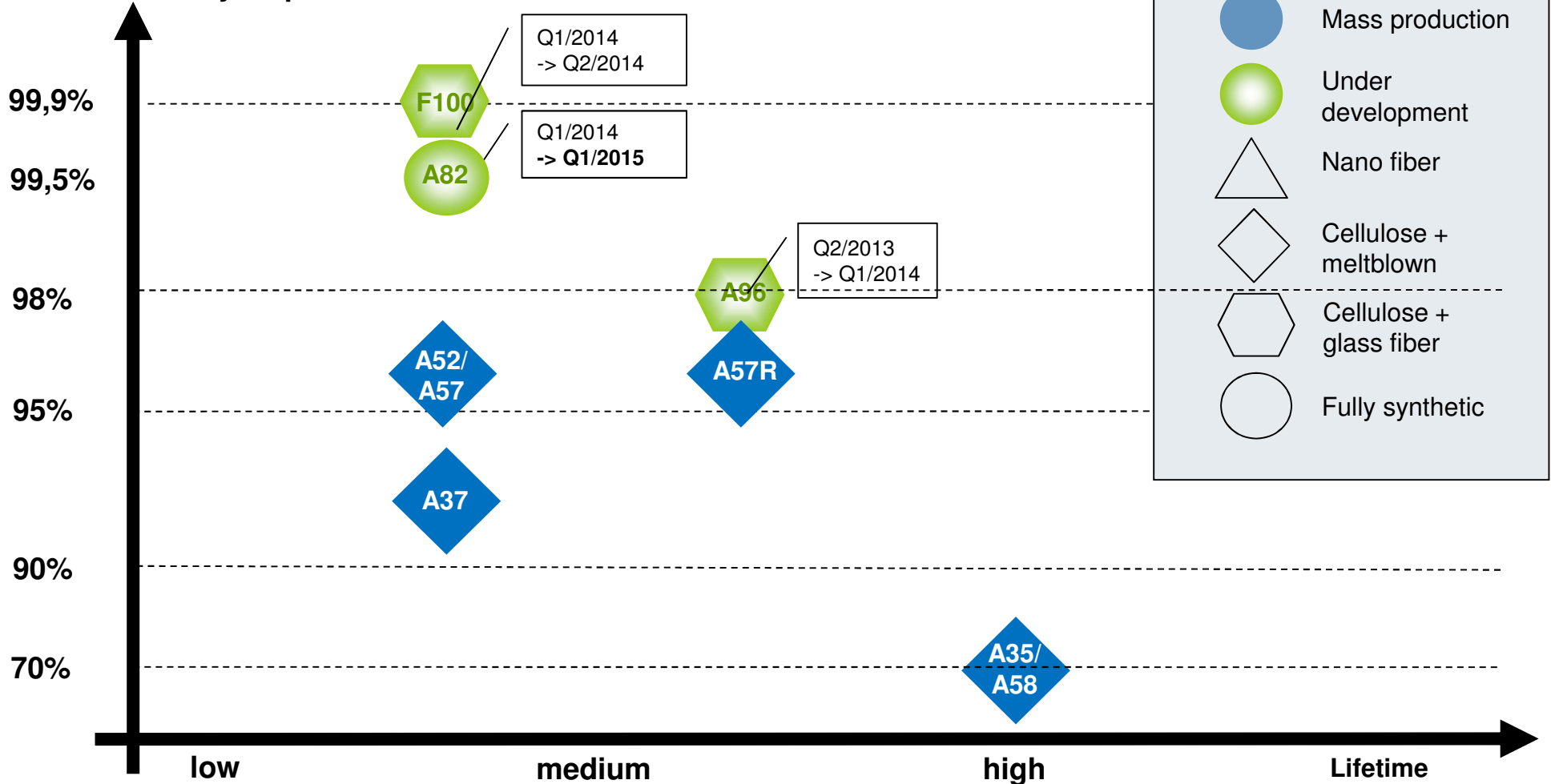
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Current requirements – particle filtration – media portfolio fuel

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Initial efficiency >4 µm© acc. ISO 19438



Modern filtration systems for diesel applications

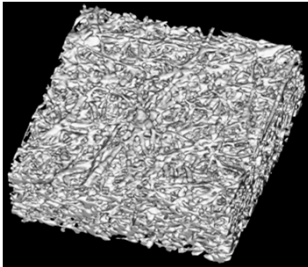
Current requirements – particle filtration

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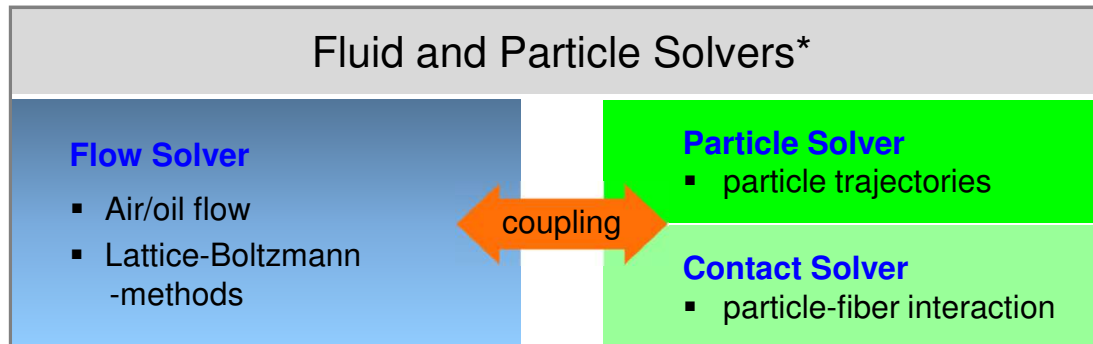
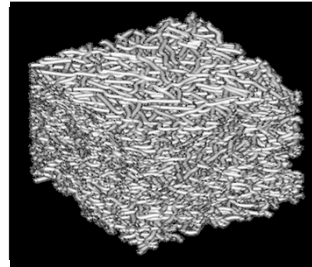
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Simulation strategy

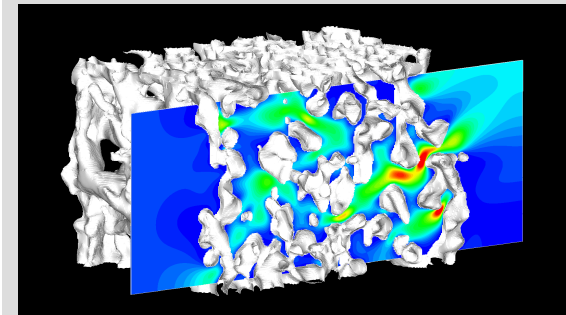
Real microstructures



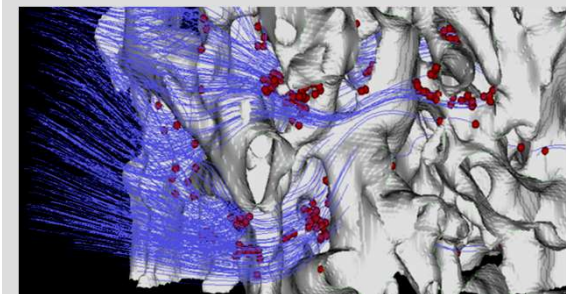
Virtual microstructures



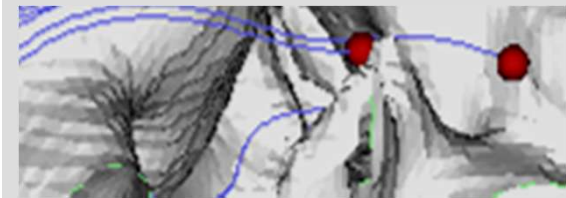
Fluid dynamics



Particle dynamics



Particle deposition



* MAHLE-internal codes

- Pressure loss
- Separation efficiency
- Dust capacity

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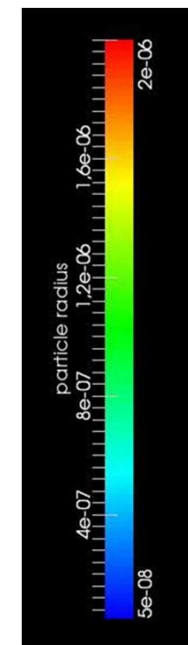
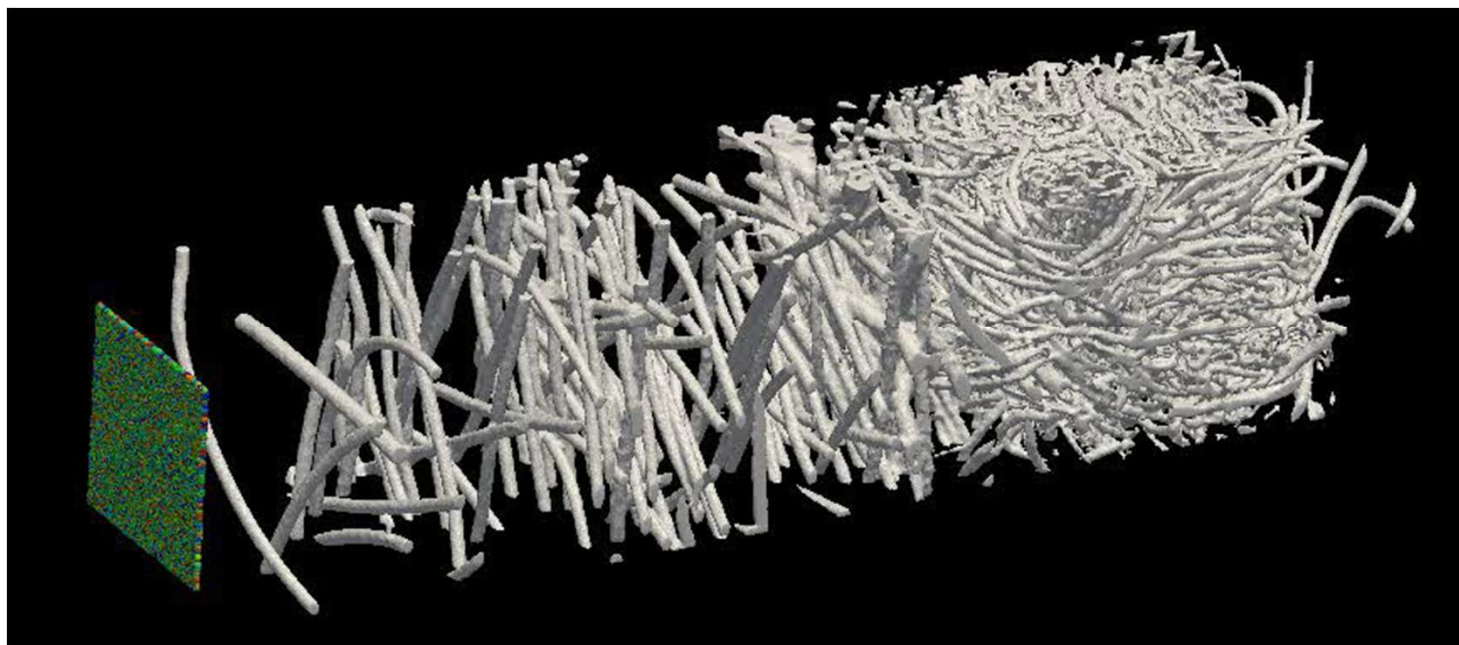
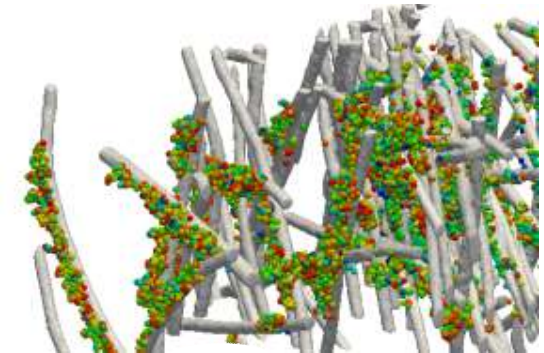
Current requirements – particle filtration

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Particle dynamic simulation

- Particle dynamics simulated for 20000 particles of different diameters ($0.1\mu\text{m}$ - $4\mu\text{m}$)
- Random particle start positions



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Modern filtration systems for diesel applications

Current requirements – cleanliness – clean room ISO class 7 (ISO 14644-1)

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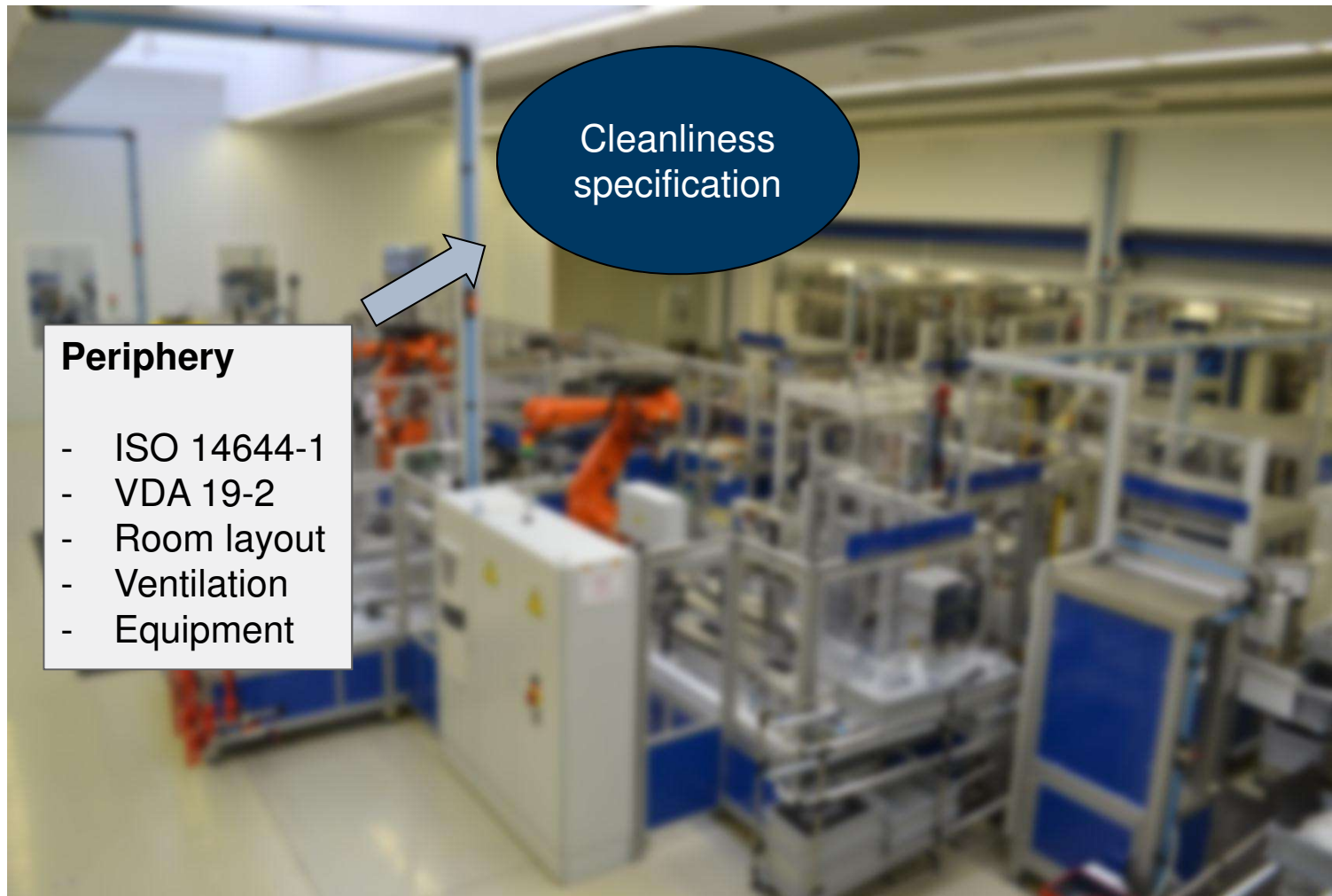


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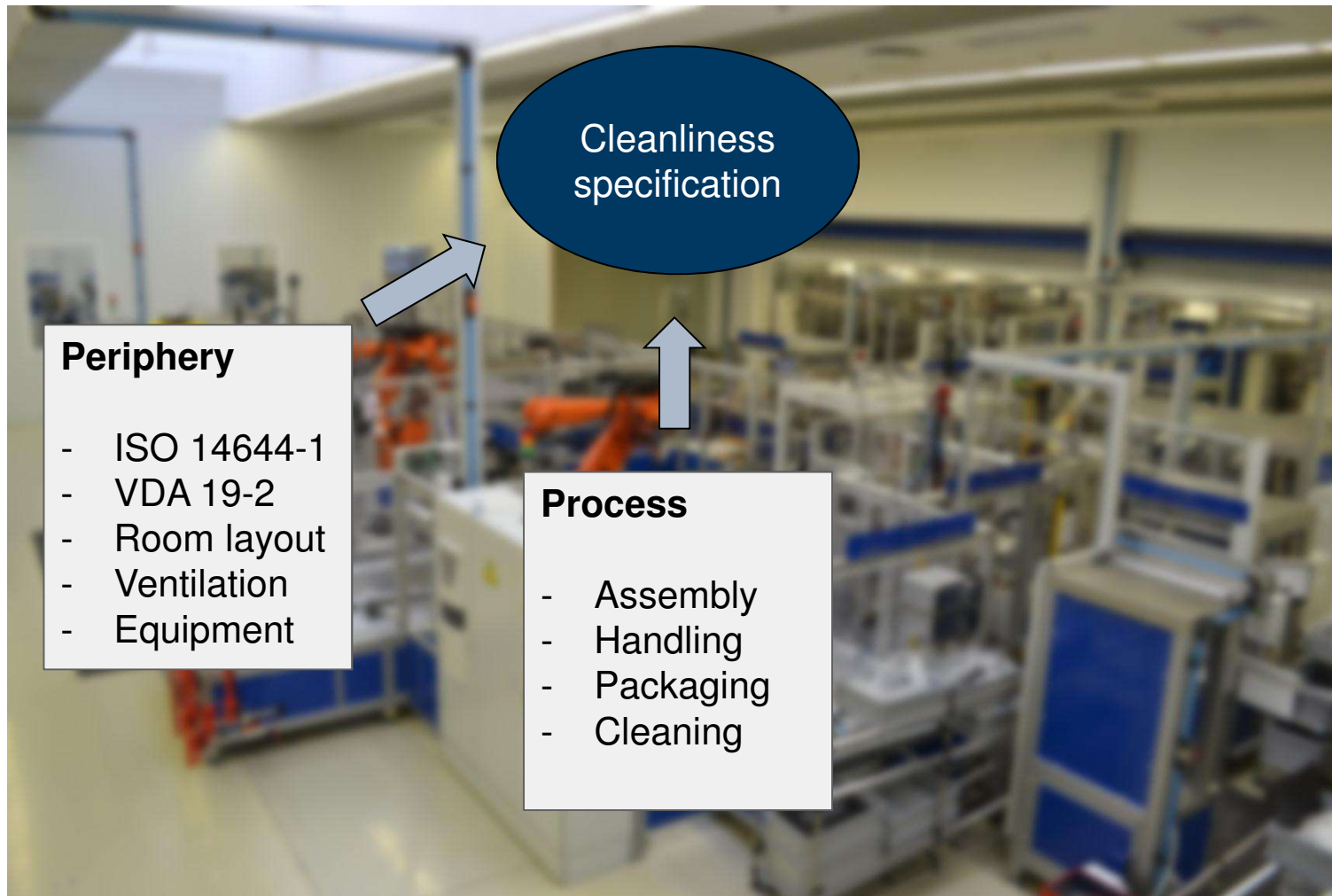


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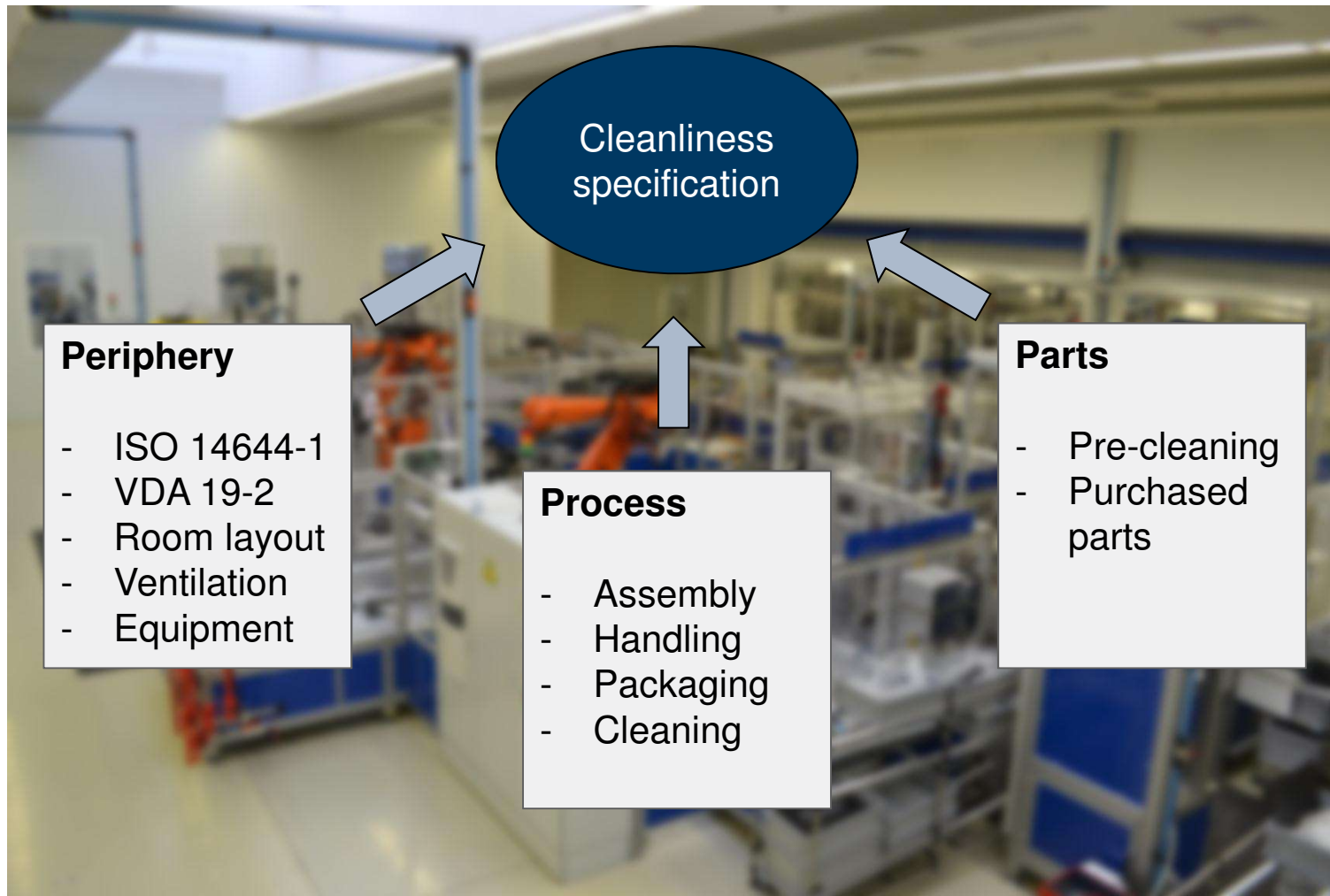


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Why water separation

- Free water can cause
 - Corrosion in the injection system
 - Cavitation at the injector tips
 - Hydrogen embrittlement
 - Degraded tribological properties
 - Microbial growth

- Negative impact on engine functions

- Fuels containing bio fuel have a higher affinity to water and reduce in parallel the interfacial tension (IFT), which also supports the generation of fine and stable emulsions.

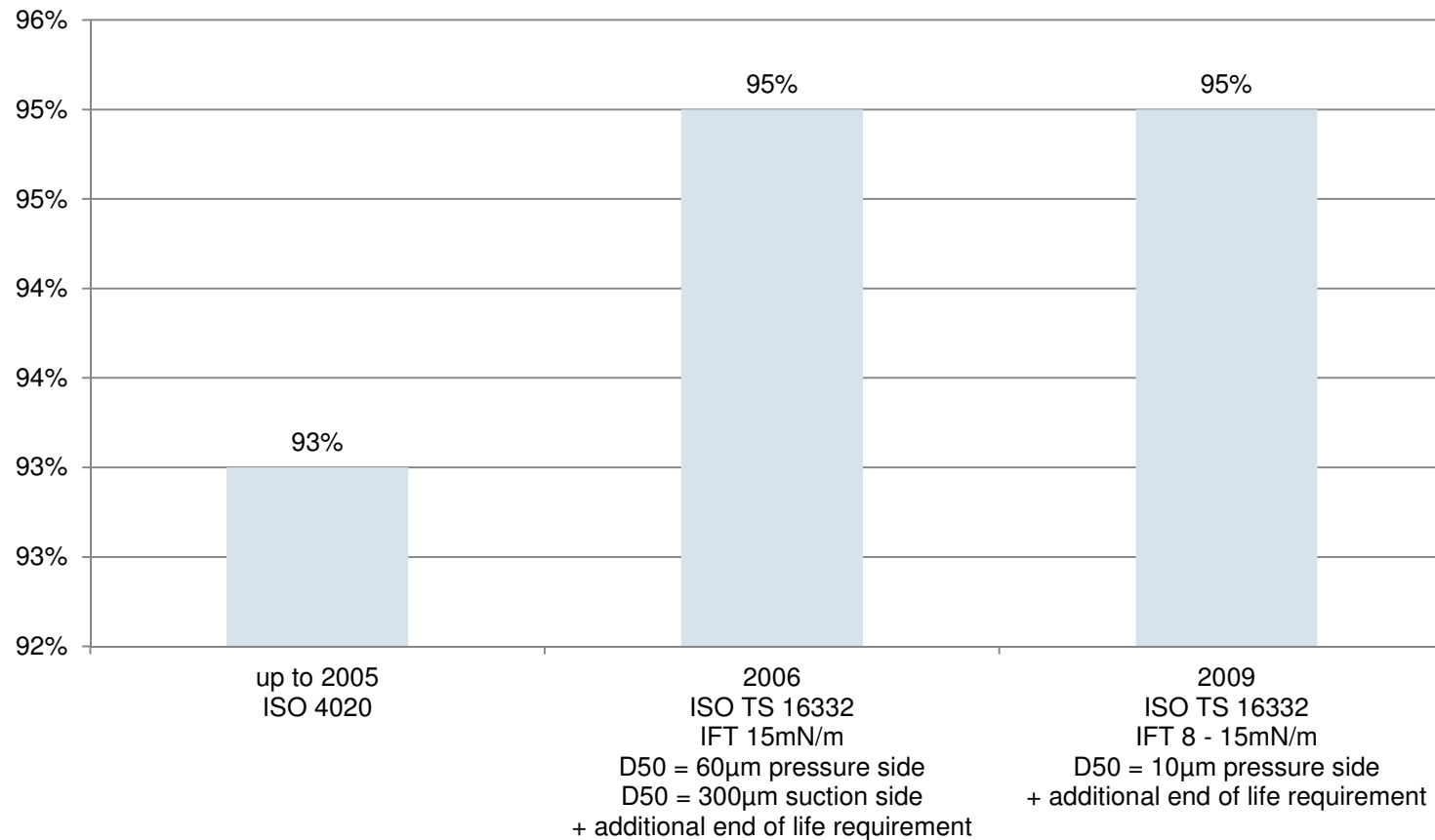
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Water separation efficiency requirement



Modern filtration systems for diesel applications

Current requirements – water separation

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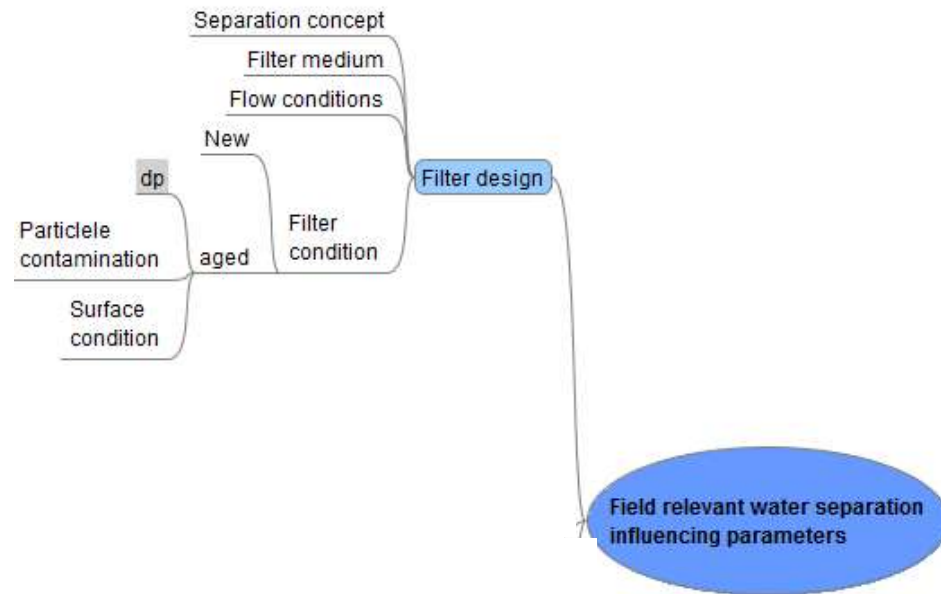


Modern filtration systems for diesel applications

Current requirements – water separation

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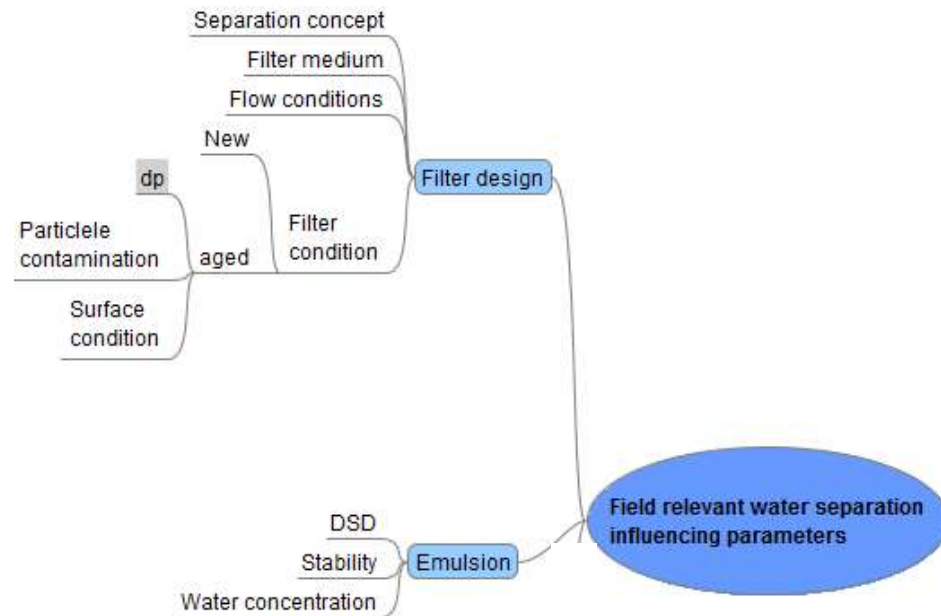


Modern filtration systems for diesel applications

Current requirements – water separation

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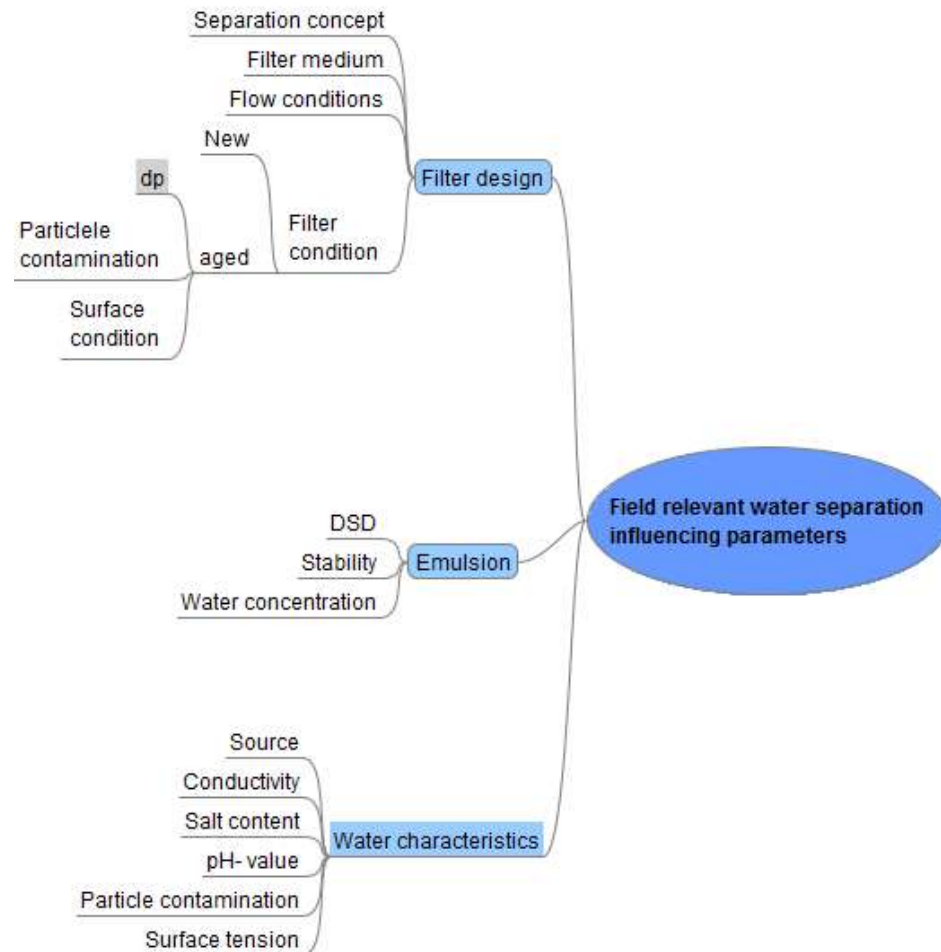


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Current requirements – water separation

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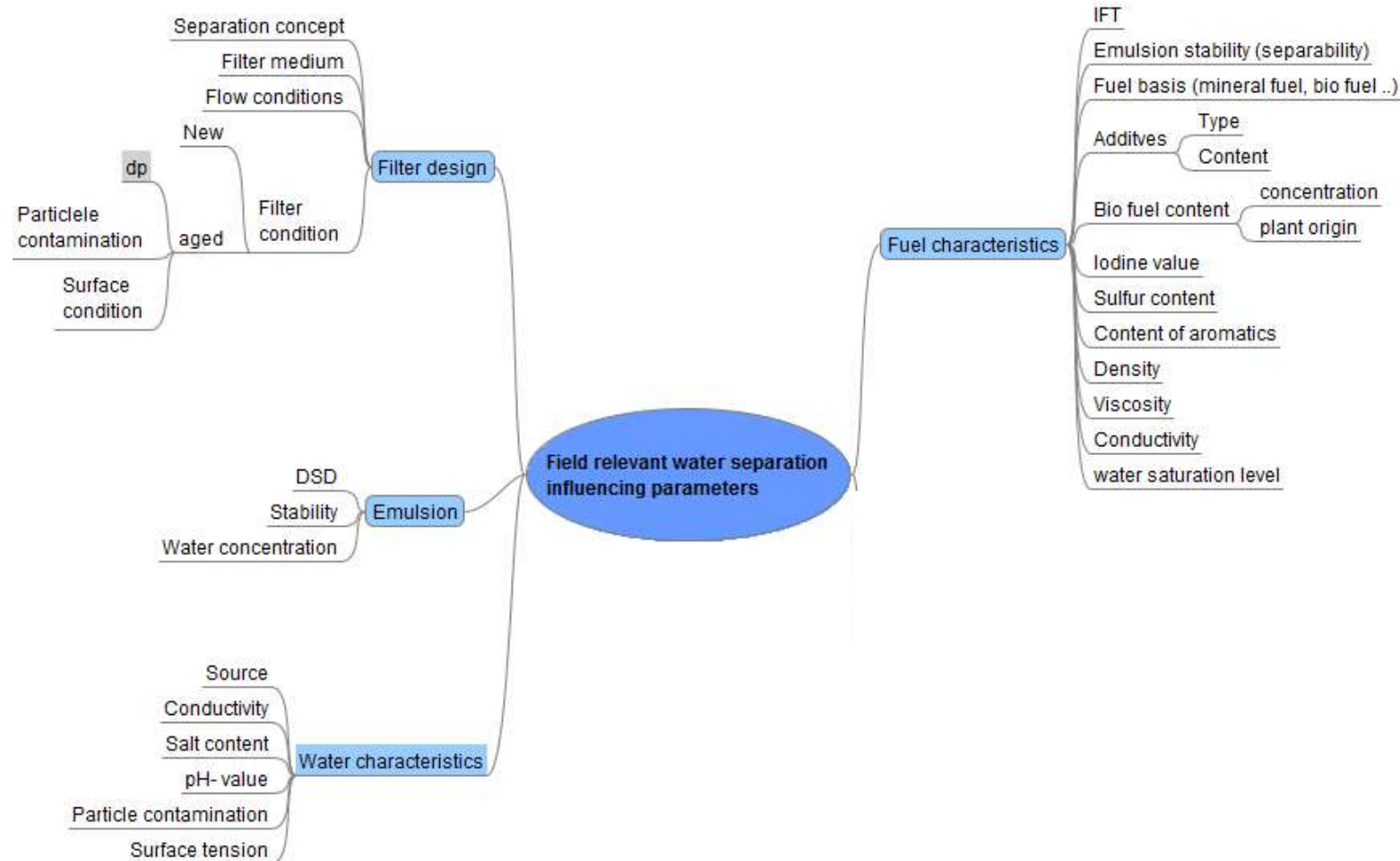


Modern filtration systems for diesel applications

Current requirements – water separation

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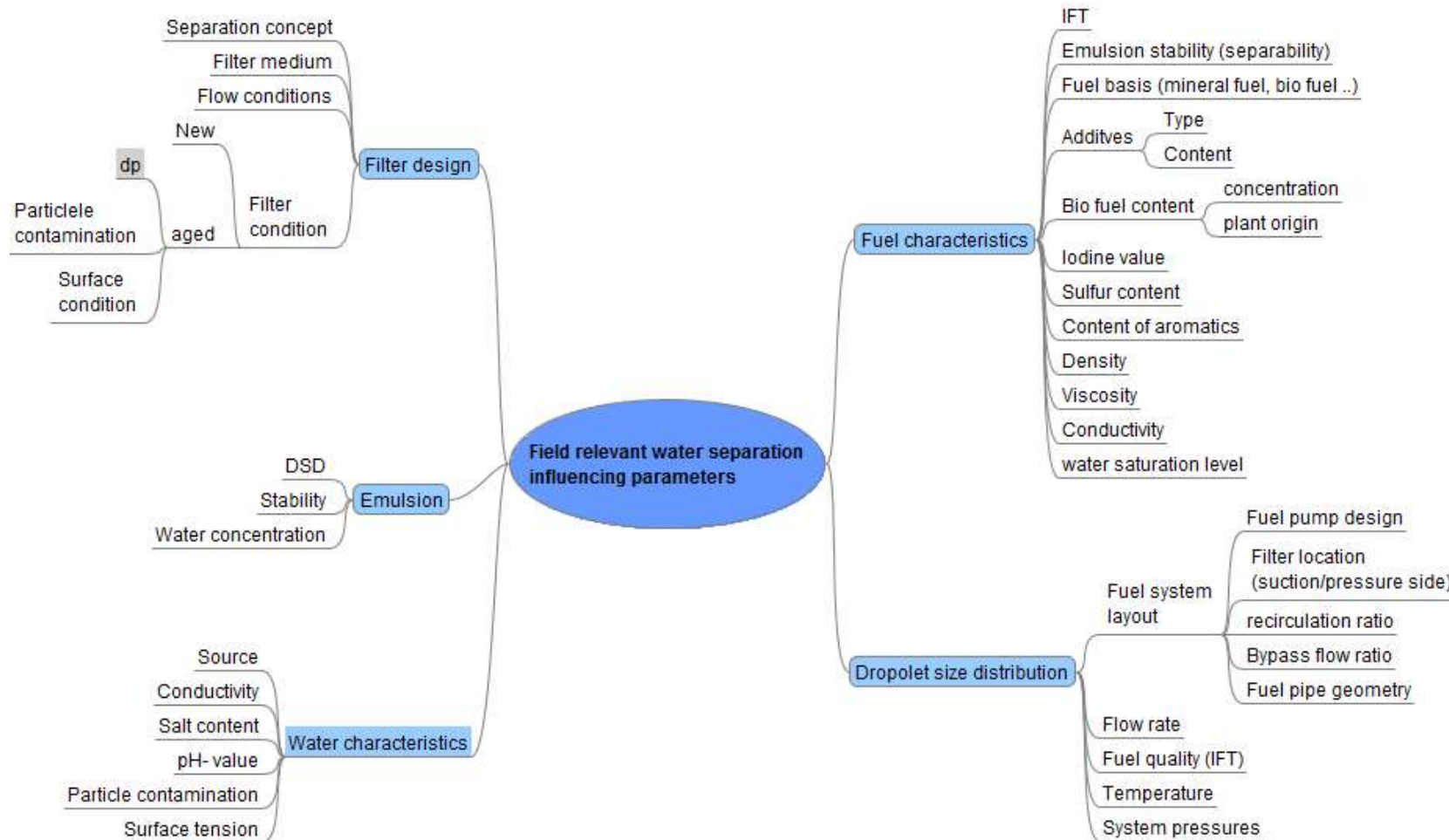


Modern filtration systems for diesel applications

Current requirements – water separation

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Source: ISO 16332 workgroup

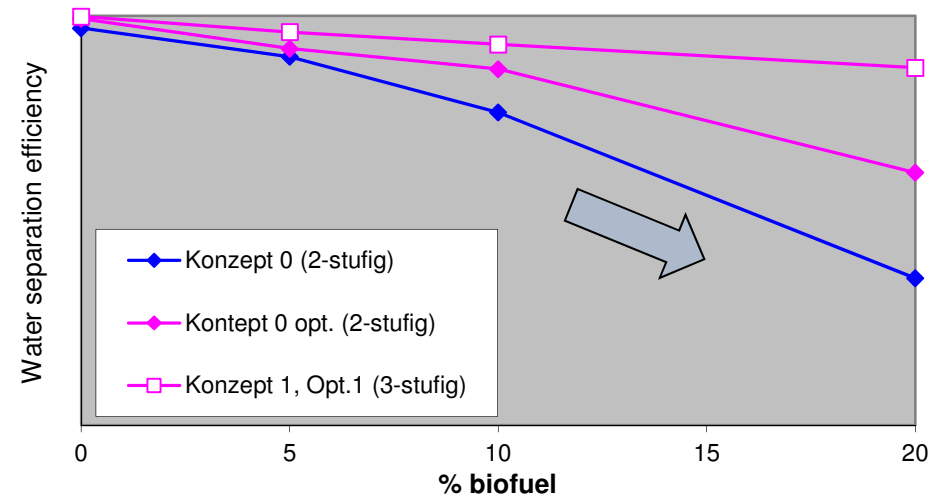
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Current requirements – water separation

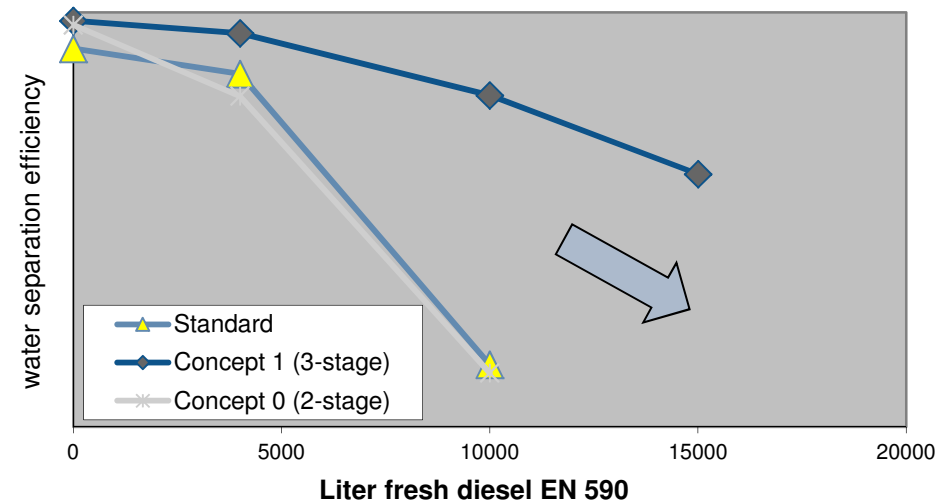
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- Concept comparison – influence of biofuel
 - water separation acc. to ISO TS 1633 (modified), new condition
 - DSD: 10µm
 - Test fuels: B0, B5, B10, B20



- Concept comparison – influence ageing
 - water separation acc. to ISO TS 16332 (modified), aged filter
 - Ageing: DPT with appr. 10.000 l EN 590 diesel fuel
 - DSD: 10µm
 - Test fuel: B20

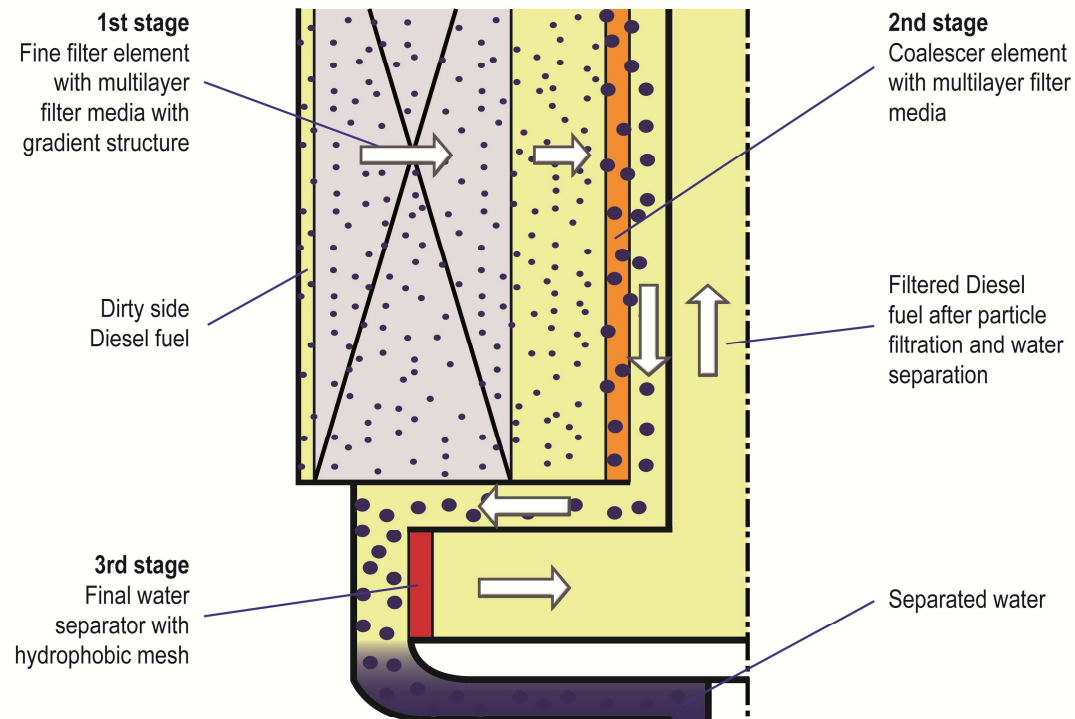


Modern filtration systems for diesel applications

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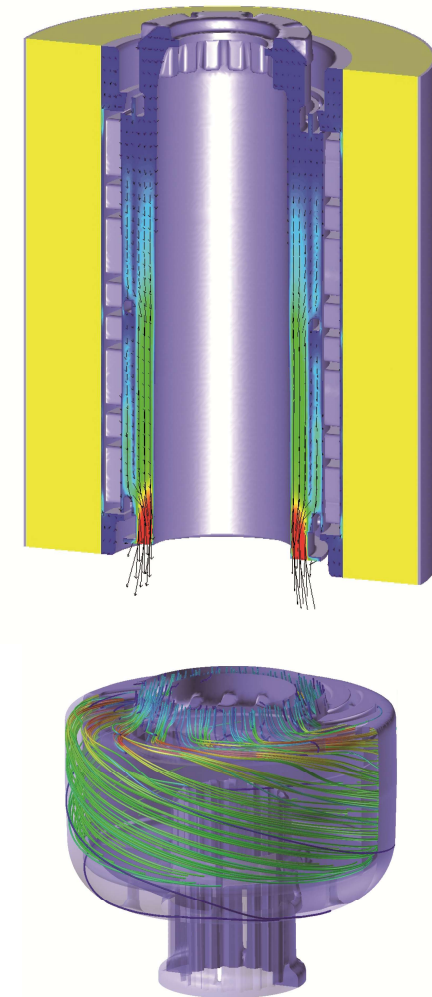
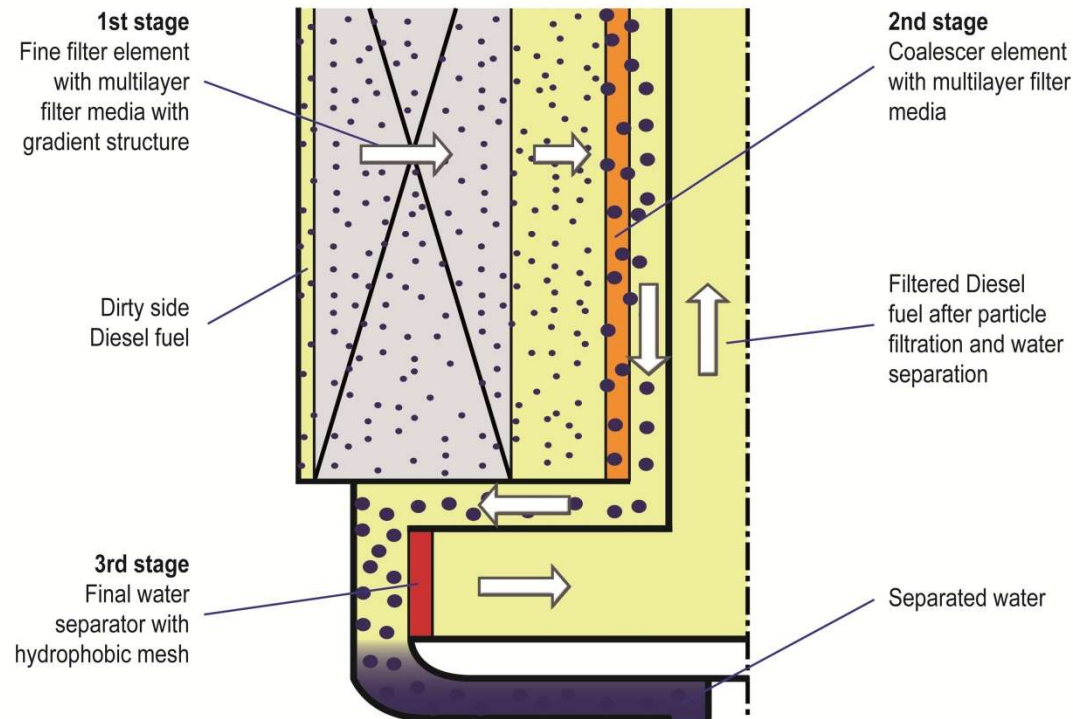


Modern filtration systems for diesel applications

Current requirements – water separation

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■ Challenges

- High volumetric flow → descent rate → large droplets
- Small droplets caused as well by fine particle separation → $d_{50} = 10 \mu\text{m}$
- Cornering/tilted position
- Ageing of the filter media – smaller droplets/fiber properties

■ Technical solutions

- High water separation performance over lifetime requires multi stage systems with coalescer and/or final separator
- Multi-layer coalescer media
- Application of Active Fuel Prefilter System to achieve best possible adaption of low specific volumetric flow rate to filter area and media.

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Current requirements – microbial activity

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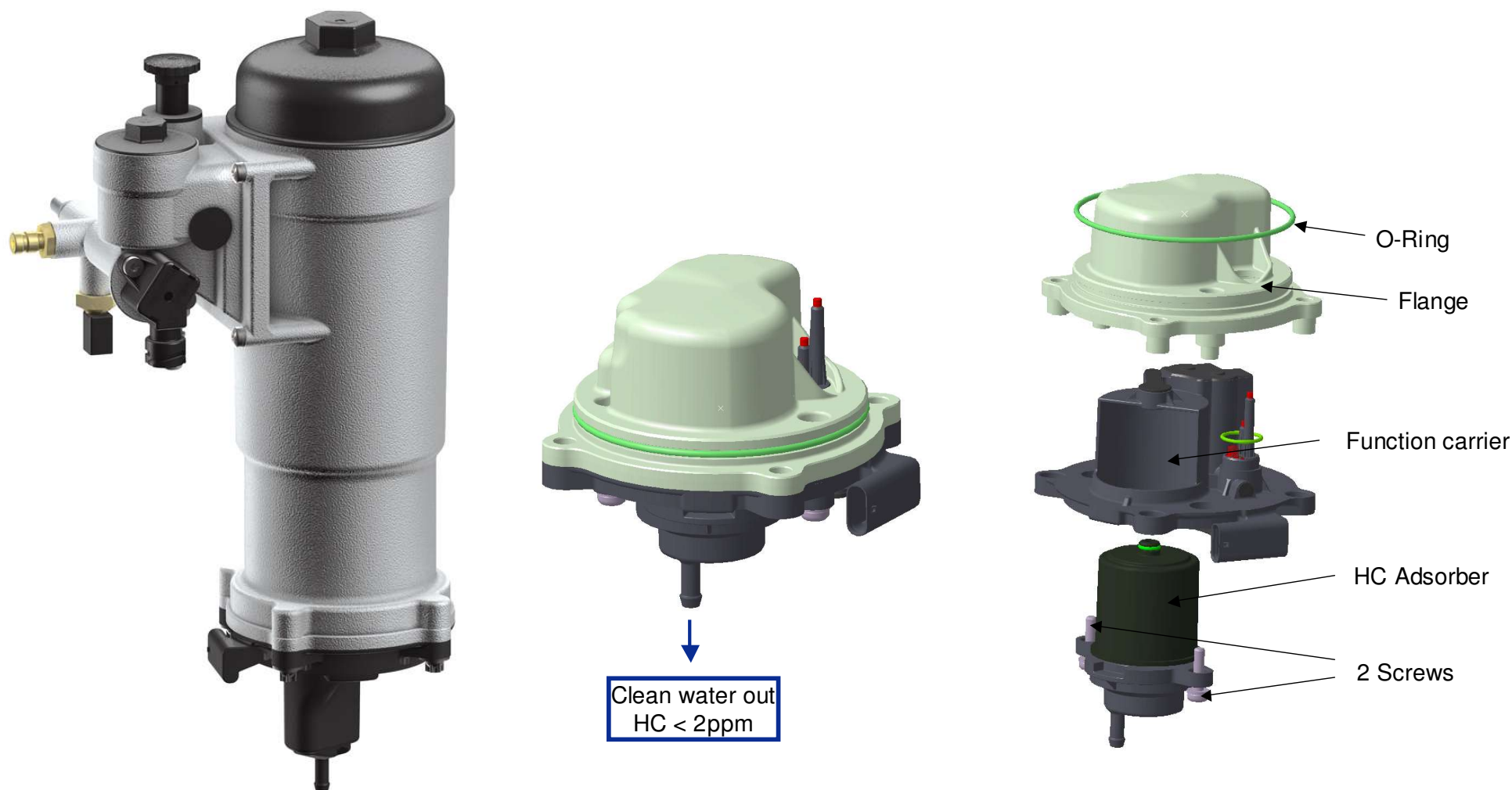
- Microbial activity
 - Effects
 - MIC (microbial induced corrosion)
 - Sludge
 - Solutions
 - Material selection
 - Coating/ plating
 - Highly efficient water separation
 - Cleanable prefilter mesh



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Automatic water drainage – MAHLE BlueDrain® system

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Automatic water drainage – MAHLE BlueDrain® system

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- Design
 - Integration of functions
 - Location in the vehicle
 - Trend towards plastic housing (plastic hybrid/plastic components)
- Testing
 - Verification of the water separation performance with a more realistic test method taking into consideration the use of alternative fuels
- Media
 - Particle filtration efficiency will remain at 99,9% / >4µm(c) (ISO 11171)
 - Increased dust holding capacity and subsequently service life/ reduced package
 - High tech fibers with specialized surface properties
- Water separation $\geq 93\%$ - 98% for
 - critical fuels as bio fuel blends, with an IFT of: 8 -15 mN/m
 - more realistic average droplet size $D_{3,50}$: $10 \pm 1 \mu\text{m}$
 - high water separation efficiency over lifetime

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■ Objectives

- Filtration module for trucks to meet current and future water separation requirements
- High water separation over lifetime
- Cost and weight optimized plastic concept
- Application for all markets and all future fuel types (Diesel/ Bio Diesel)
- High adaptability to the specific vehicle application
- Self-controlling module with or w/o integrated fluid management

■ Function

■ Status



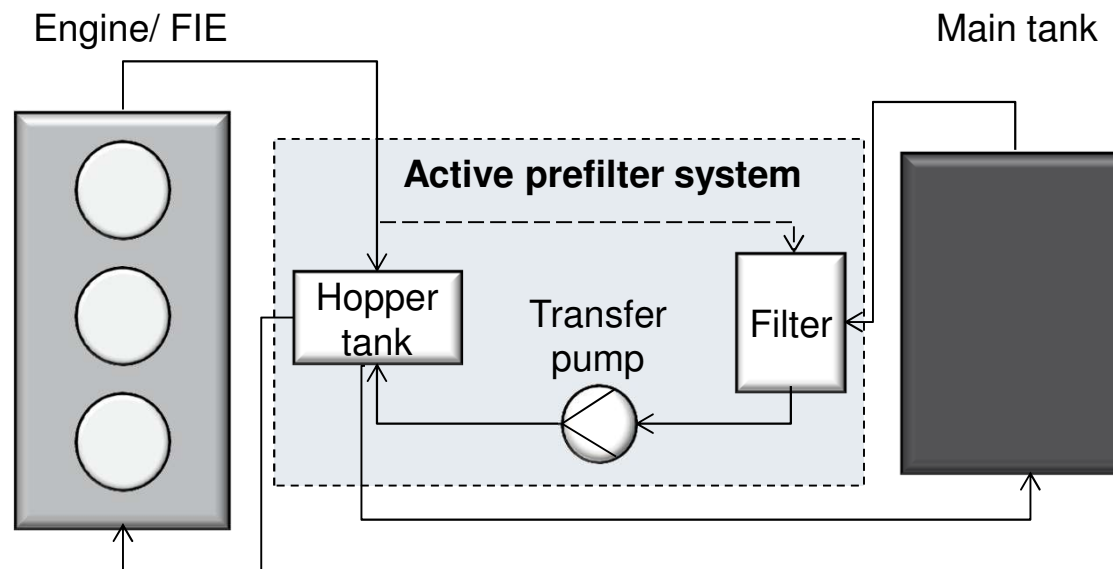
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Future requirements – active fuel prefilter system

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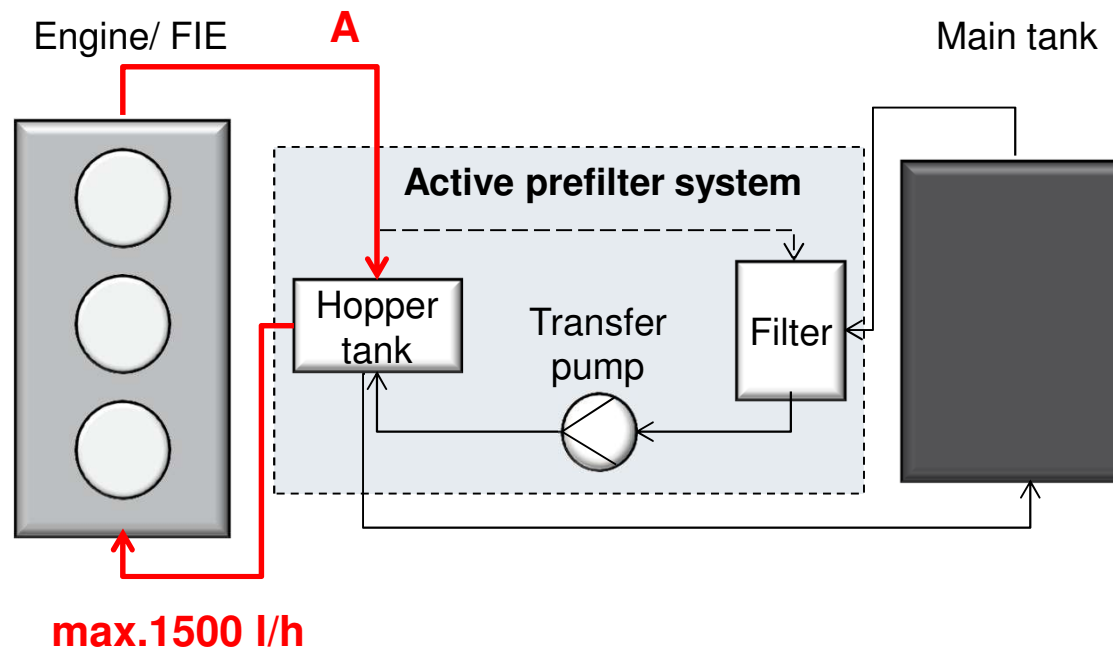
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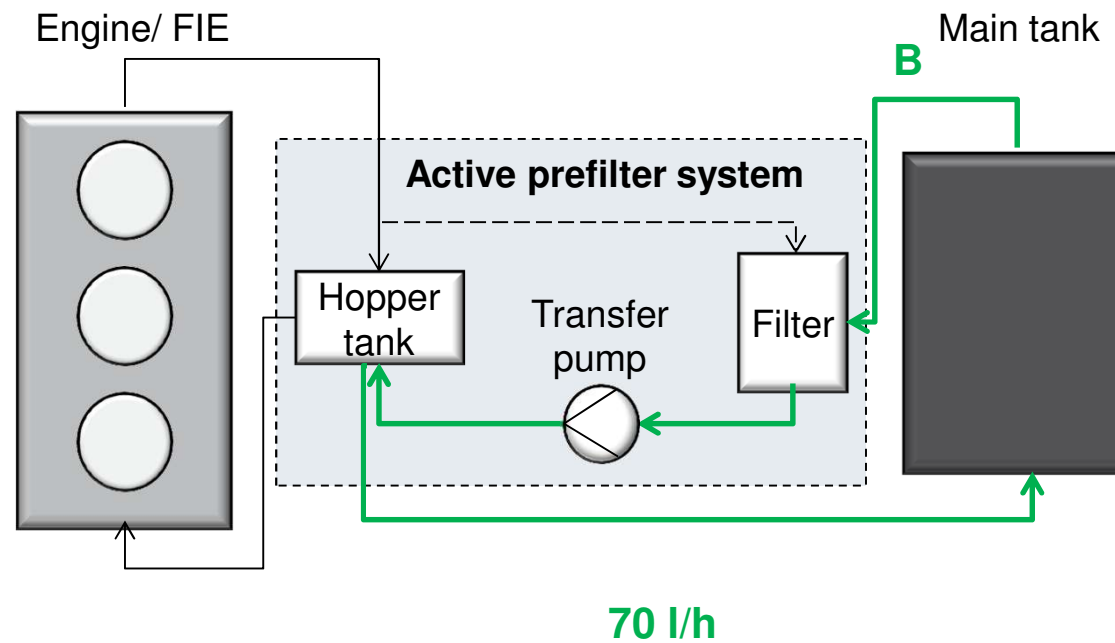
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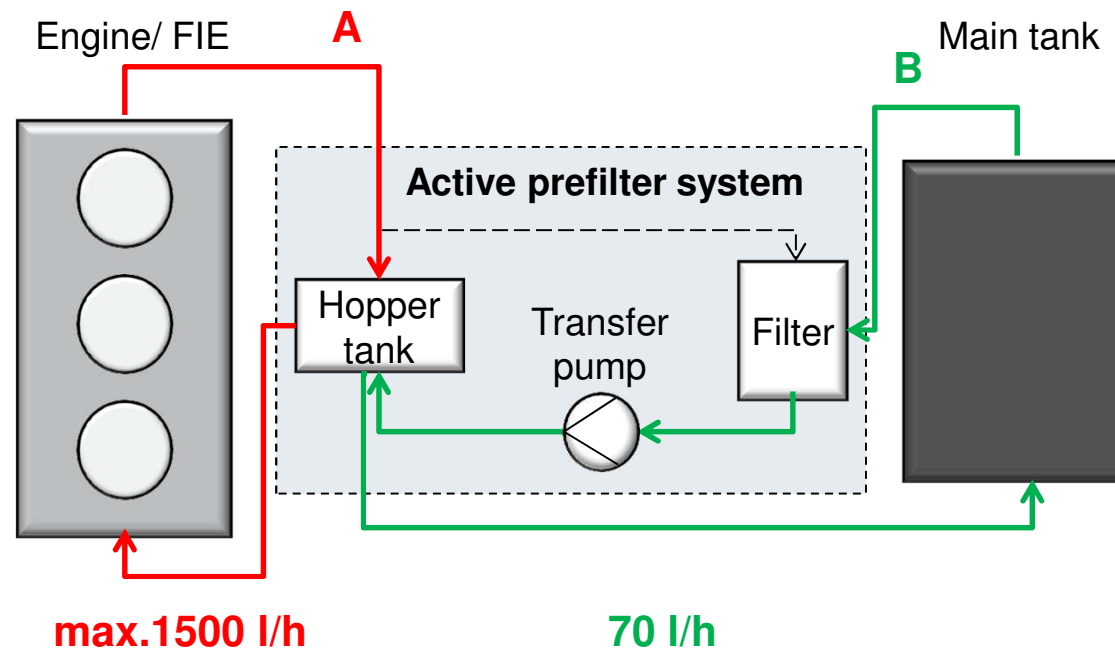
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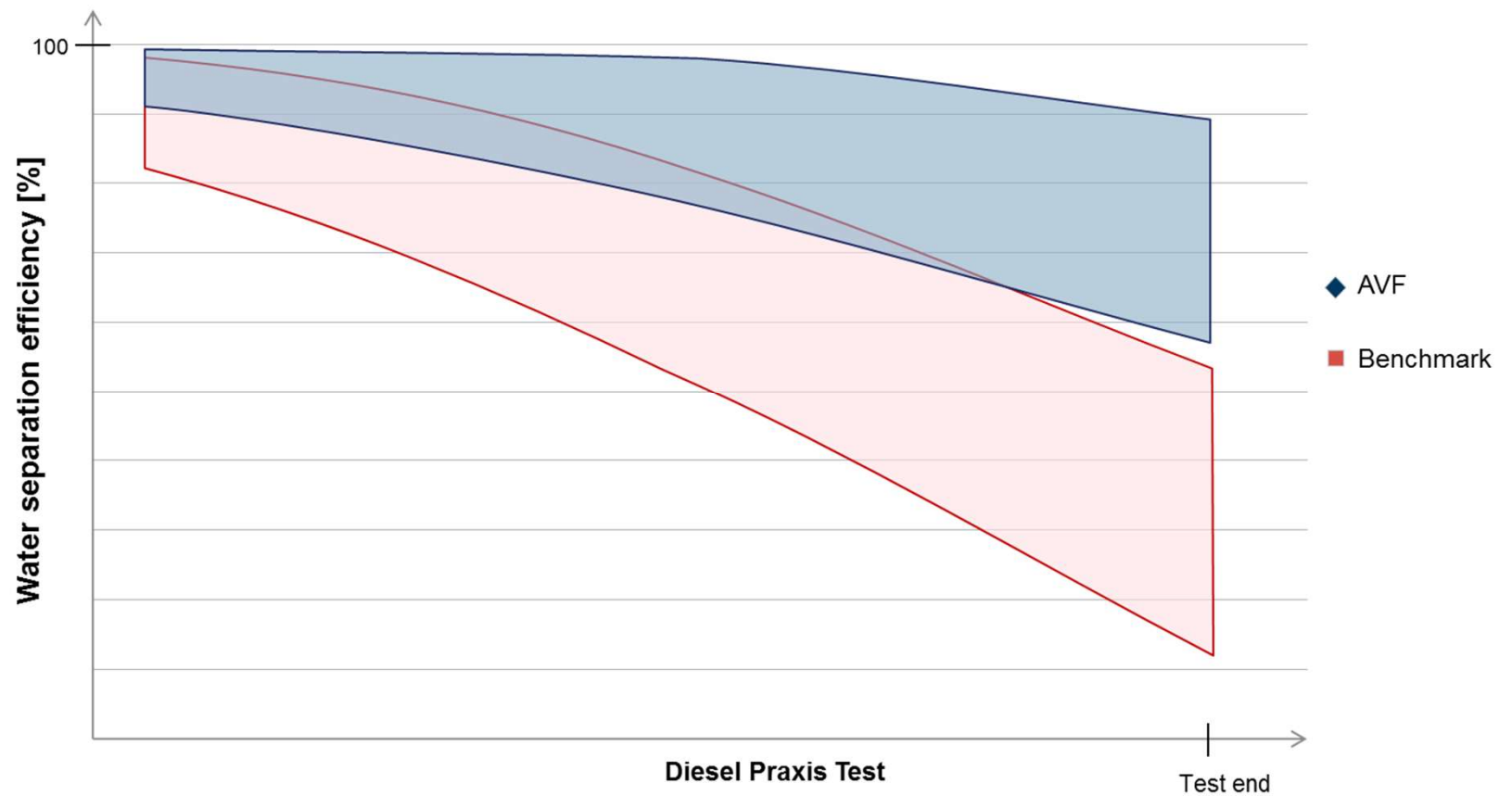
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Key subjects

- Euro 4/5/6/...
- Increasing use of alternative fuel
 - Impact on water separation
 - Microbial activity
 - Chemical characteristics
- Increasing particle filtration requirements + reduced package

Solutions

- High performance water separation over lifetime → dry fuel
- Suitable material selection
- Optimized production processes in a cleanroom environment
- High tech filter media

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THANK YOU FOR YOUR ATTENTION!

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