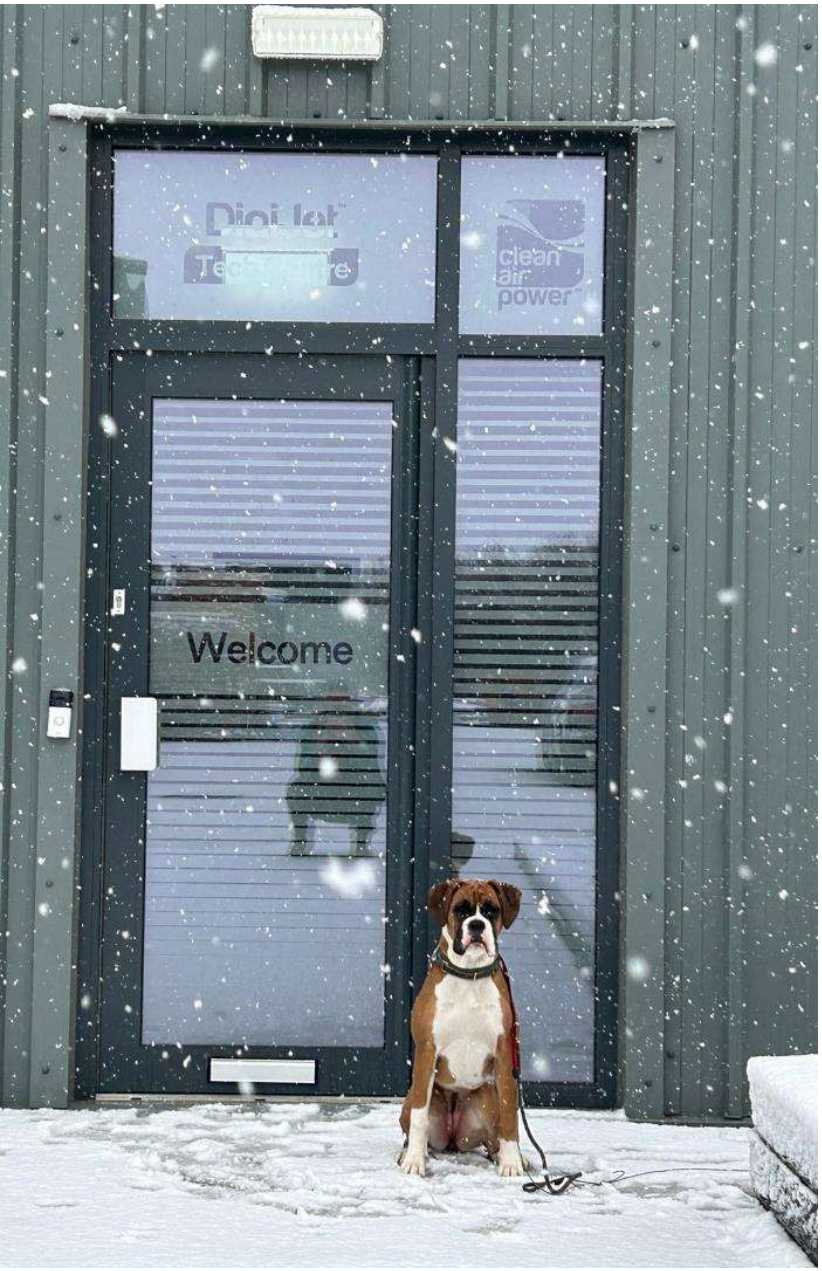

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Unlocking the power of
carbon free fuels

The Challenges and Opportunities of Injecting Ammonia

Ed Newman
Chief Engineer

17 Jun 2025

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Innovative
Collaborative
Transformative

Who are we?

- SME based in Melton Mowbray, East Midlands
- Alternative fuel injector technology provider
- Retrofitter of alternative fuel systems
- Now focused on zero-carbon fuel injection
- Target off-highway, marine and mining
- Working with >40 net zero powertrain providers

Innovative
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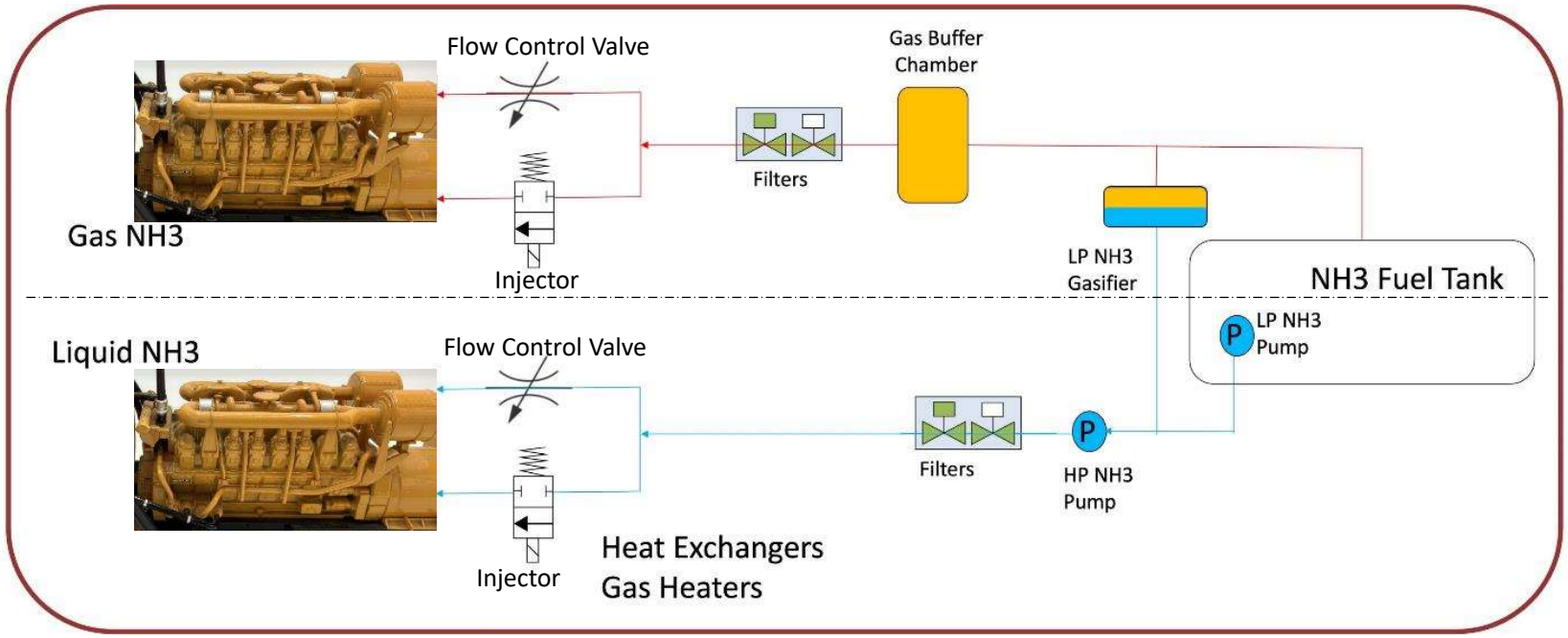
Our Move Back to Zero Carbon

- 2021 First of a Kind (FOAK) competition winner
- Dual-fuel retrofit on Class 66 to H_2, biomethane and HVO
- Injectors are lubricant-free, versatile and modular
- EMD710 – Direct injection, 12 cyl, 3000HP, 2-Stroke diesel

Department for Transport | Innovate UK | RSSB | A Better, Safer Railway | University of Birmingham BCRRE | NetworkRail | TARMAC

…2022 into NH3 and marine

The Whole Fuel System - Overview



Considerations

- Gasifier for NH3
- Liquid HP pump
- Basics (e.g. **filters**)

Filters – Debris!

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Challenges for Ammonia

As a fuel	In a fuel system
• More lubrication than H_2	• Gaseous & liquid
• Toxicity	• Aggressive solvent
• Safety	• Rubber
• Public perception	• Plastic
• Harder to burn	• Brass
	• Copper

Flow Control

Flow regulator

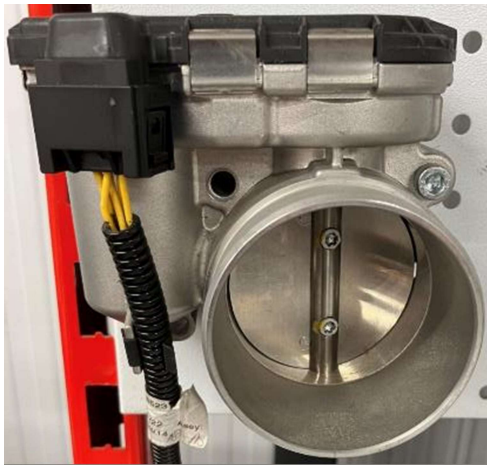
- Throttle Valve
- High flow rate
- Limited control

DI Injectors

- Fuel compatibility
- Greater efficiency
- Modification to cylinder heads

PFI Injectors

- Fuel compatibility
- Greater control



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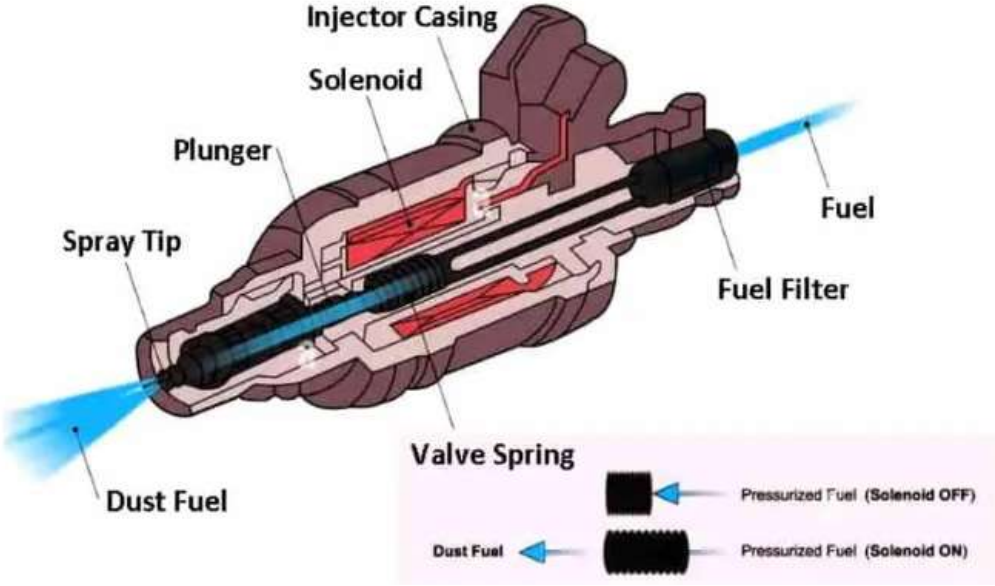
Challenges of Ammonia – Fuel Control

Can attack component materials

- ‘O’ rings
- Seals
- Bushes/guides
- Coil

Range of temperature issues

- Diesel & Gasoline – hot
- Overheating coils
- Ammonia – refrigerant
- Potential cold issues



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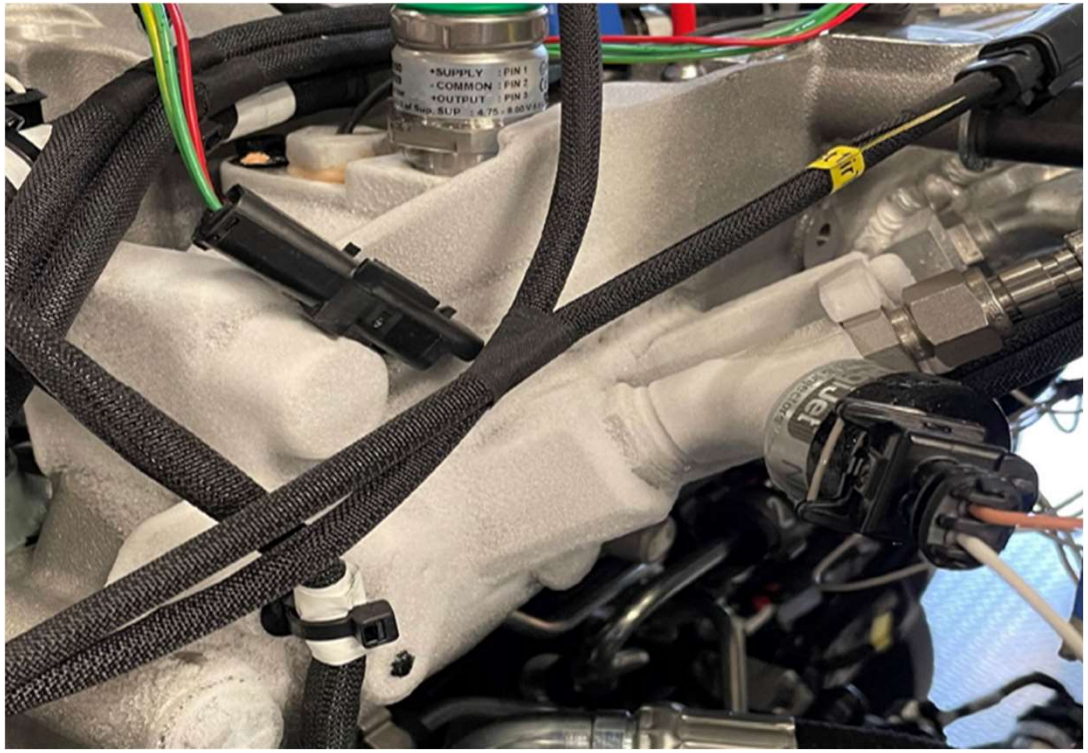
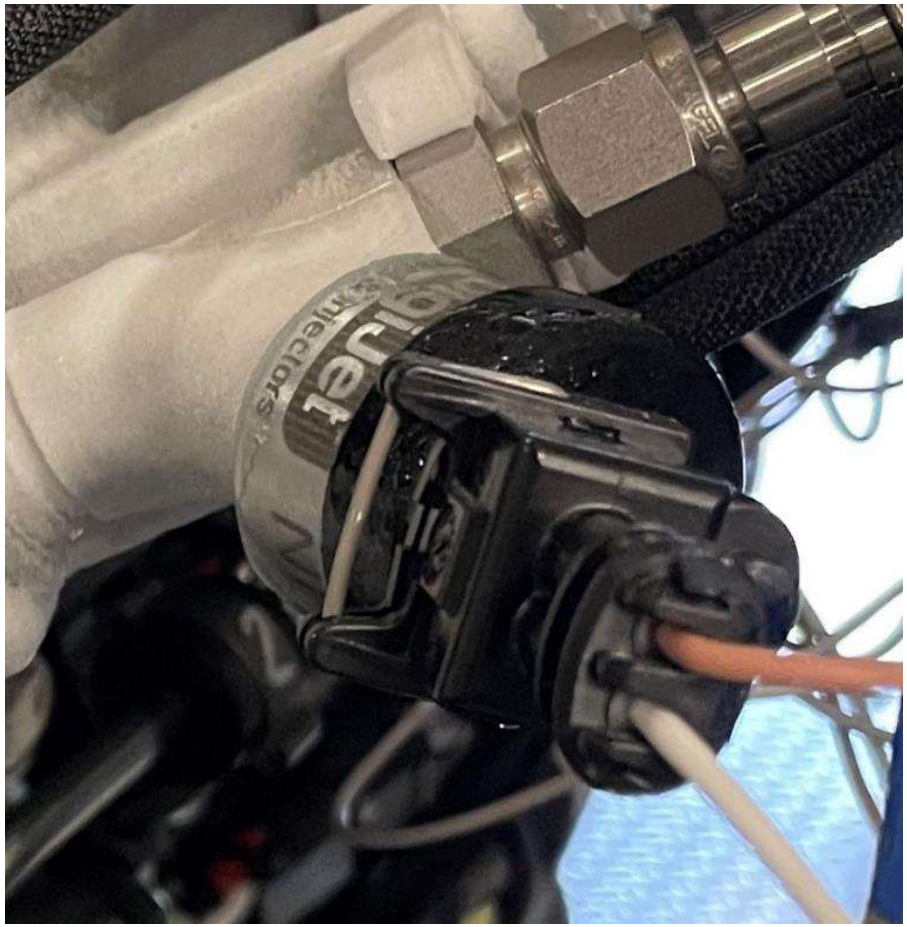
Ammonia as a Refrigerant





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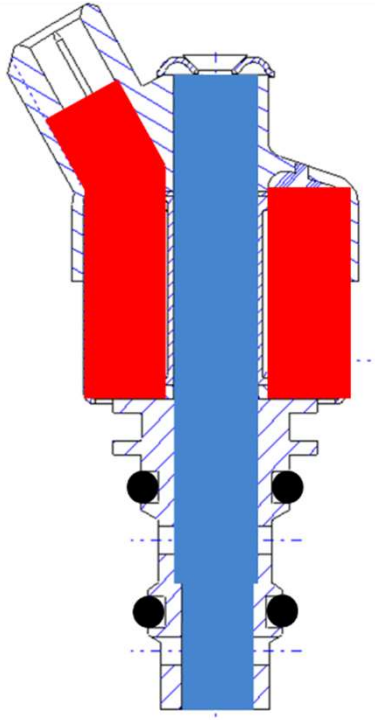
What we did…

- Came from a gas injector base
- ‘O’-rings changed
- The coil is outside fuel flow
- Gas injector design with large clearances
- Considered material selection
- Using alternative materials where appropriate
- Some surface treatments



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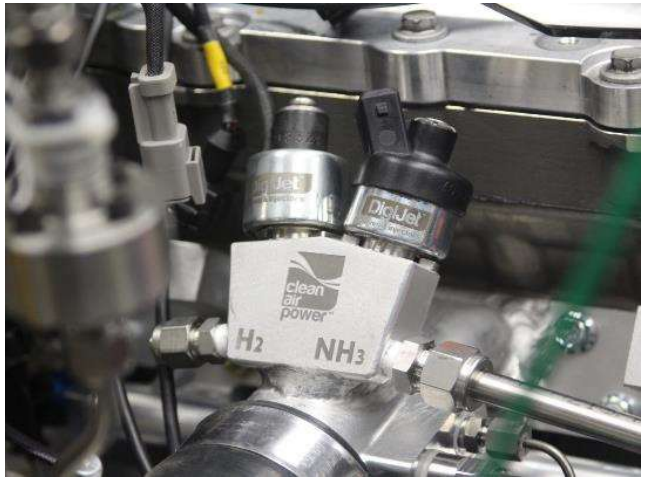
DigiJet NH3ICE Injectors in Application

- Ignition (high ignition temperature)
  - Spark ignition
  - Diesel pilot
  - H2 pilot
- Phase change
  - Gas to liquid
  - Liquid to gas
- Refrigerant
- Changing requirements
- Flexibility



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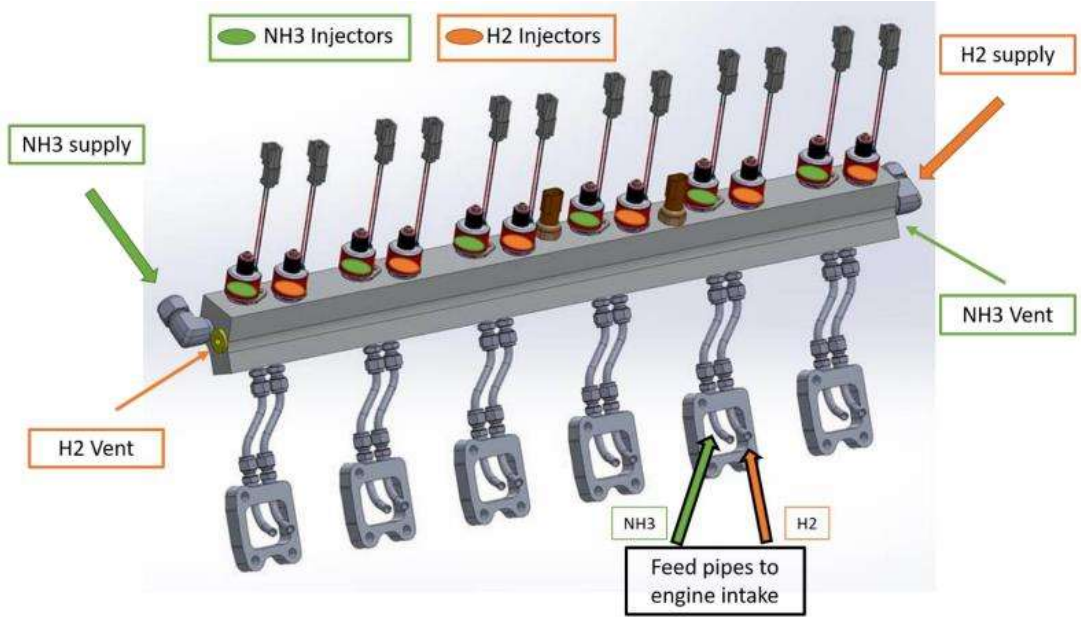
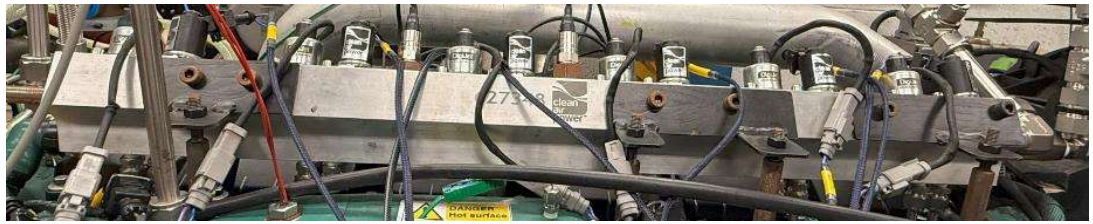
Getting NH3 to Burn

- Diesel
- Methanol
- H2
- Space on engine
- Non-optimum injection positioning

- Hydrogen & Ammonia
- Cracker
- Mahle Jet Ignition
- Temperature of gas
  - 400˚C
- Mixed/combined problems





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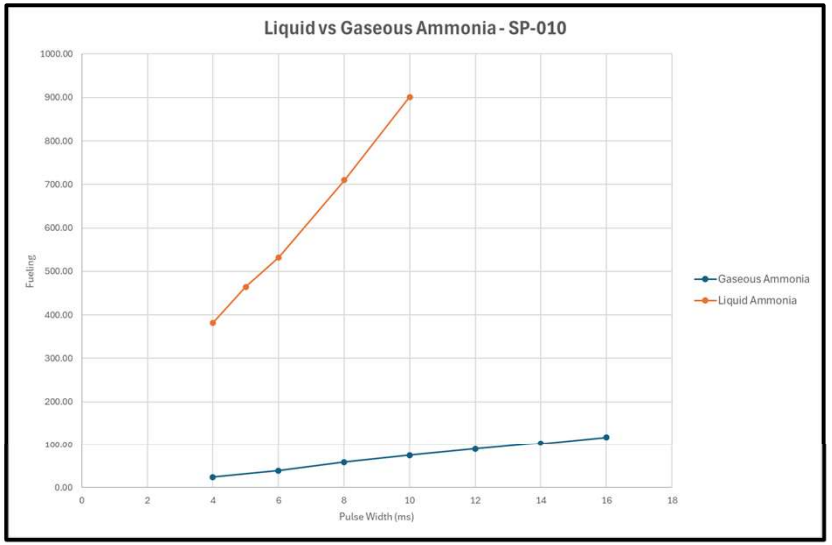
Which Phase?

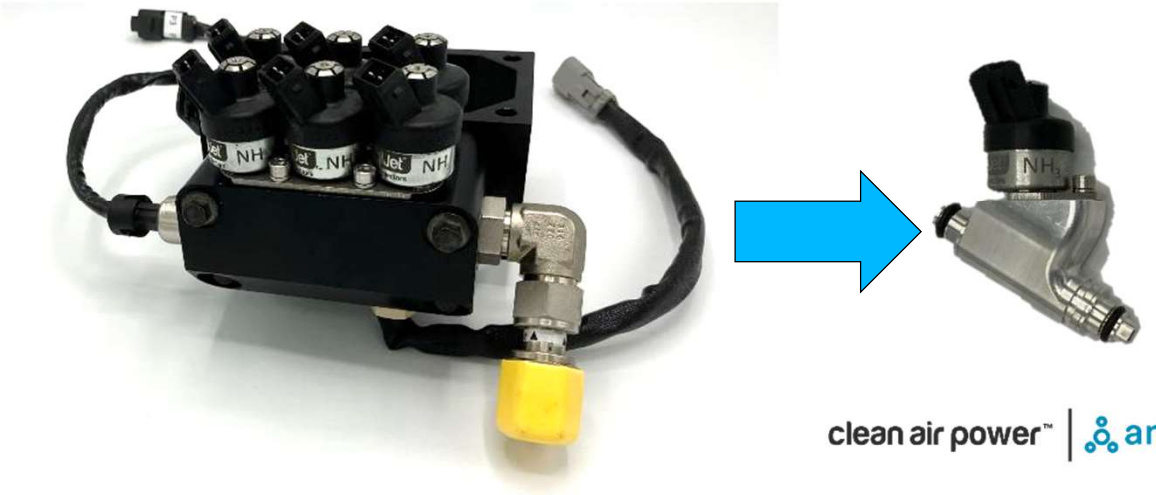
•Gas

- Better combustion currently
- Gasification
- Drop out
- Heated lines
- Flow
- Pressure – up to 20 bar



•Liquid

- Density
- Phase change
- Emissions
- Spray
- Refrigerant effect
- Pressure – up to 50 bar



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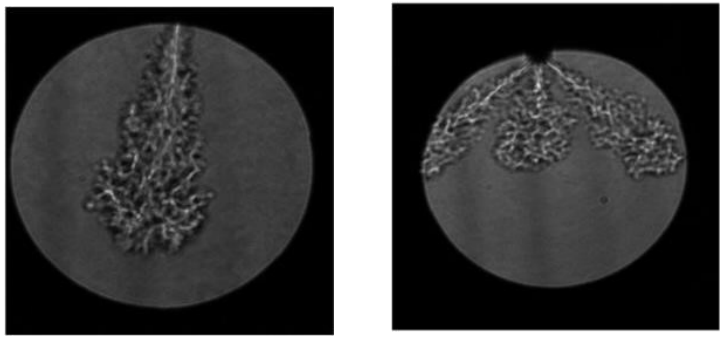
Spray Pattern

- Supplied injectors for spray research & development
- Developing requirements
- Injector location – not central if DI
- Flexibility of injector & spray patterns



Summary/Key Points

- Ammonia as a fuel has a lot of potential
- Important to remember the basics – new fuels old lessons
- Changed temperature requirements
- Lots of choices – gas vs liquid
- Fast changing space with evolving requirements
- Flexible fuel systems needed to respond to this

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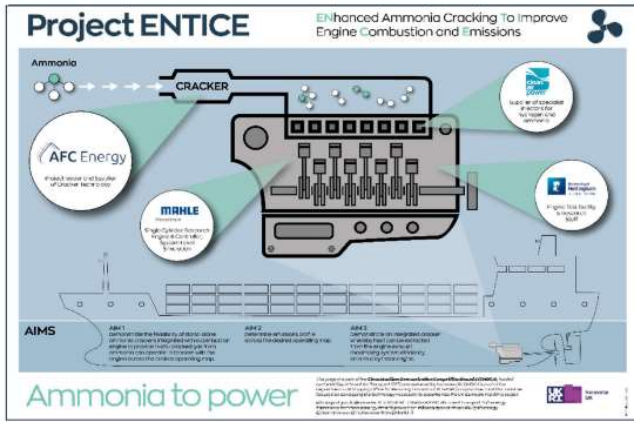
What Next? -Move to Demo



MAHLE Powertrain

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