Biofuel Combustion Characteristics and Flame Sensor Response

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Overview

- Advanced flame sensor response testing at NORA
- Test implemented to analyze cutoff in pumps that operated on biodiesel
- Dissection of pumps to observe wear and tear
- Rigorous combustion testing on biodiesel including emissions analysis

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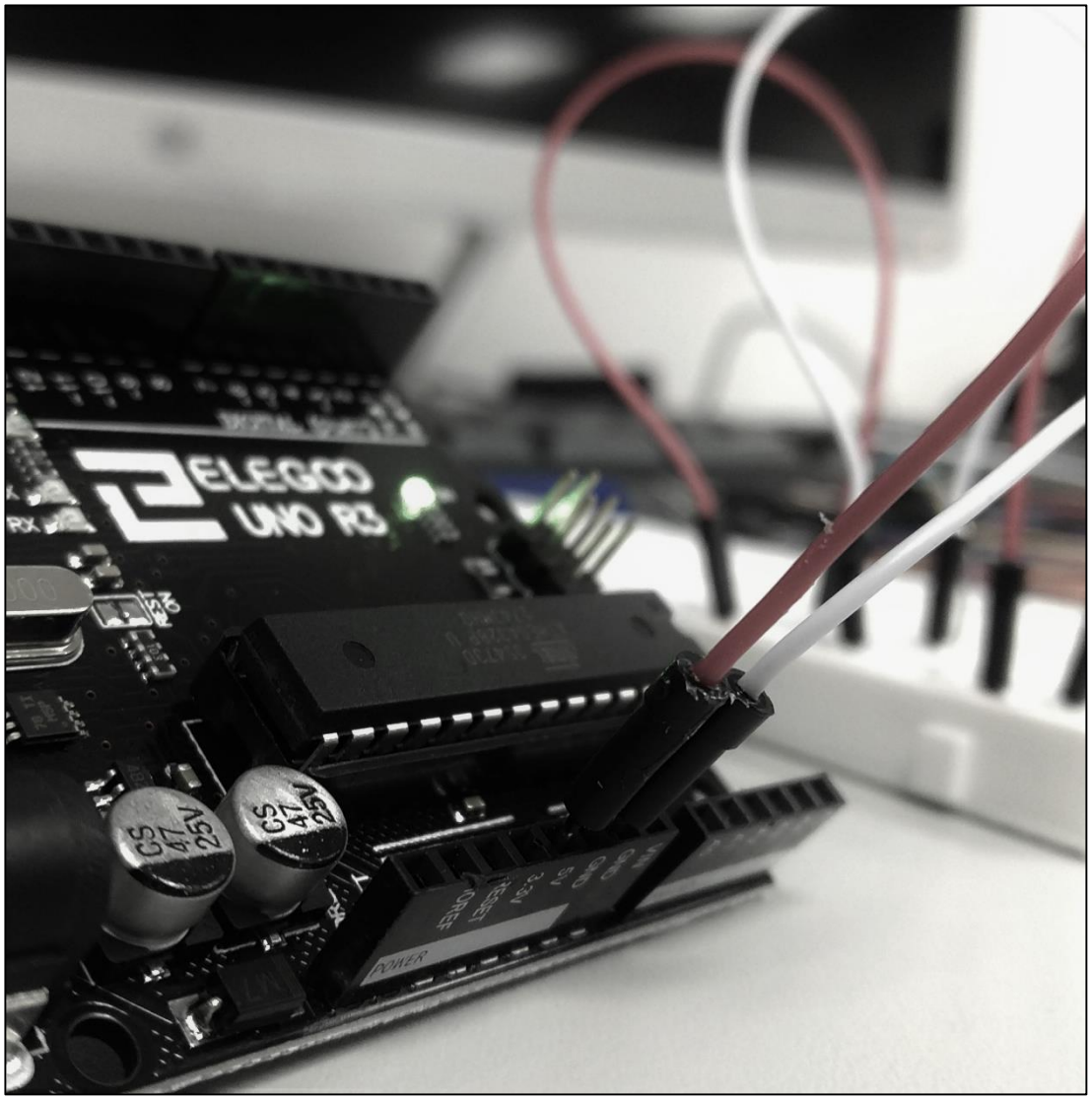
Advanced Flame Sensor Testing: Methodology

- CAD cell connected to voltage source
- DAQ system collects voltage data every 100ms to show flame behavior
- Pumps from field tested: 12 that ran B20 at least ~10 years, 7 on No. 2 for same time
- Run in cold-start and steady state to analyze transient start and cutoff responses



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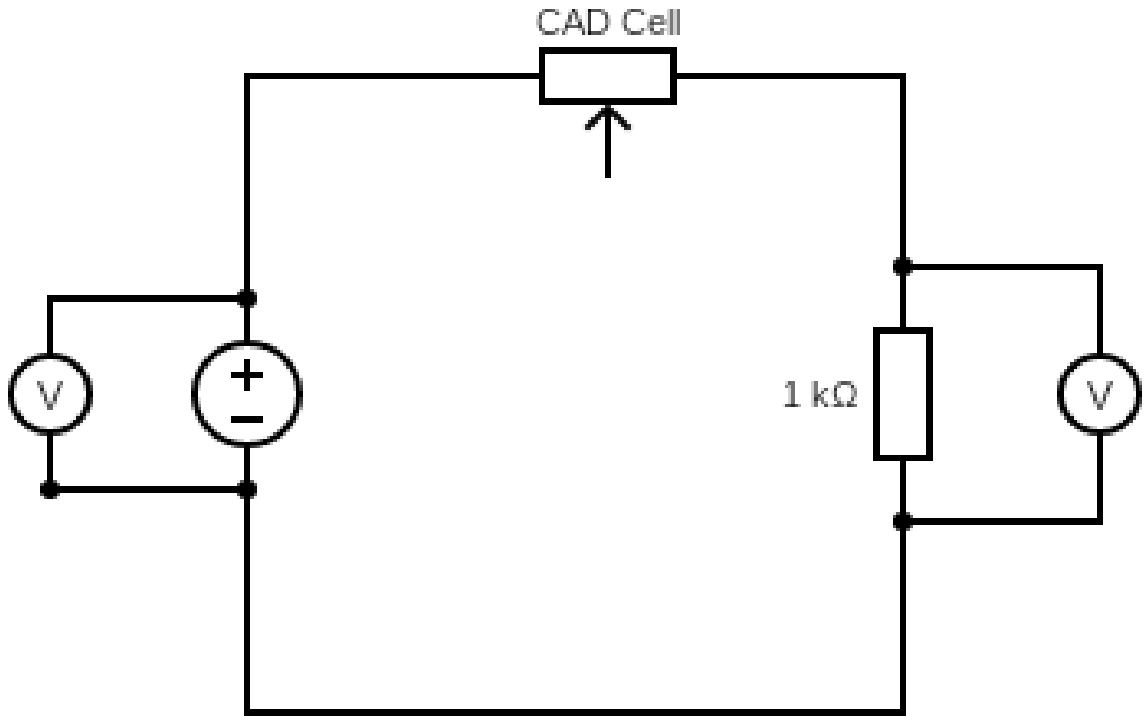
Simple Circuit for CAD Cell Testing



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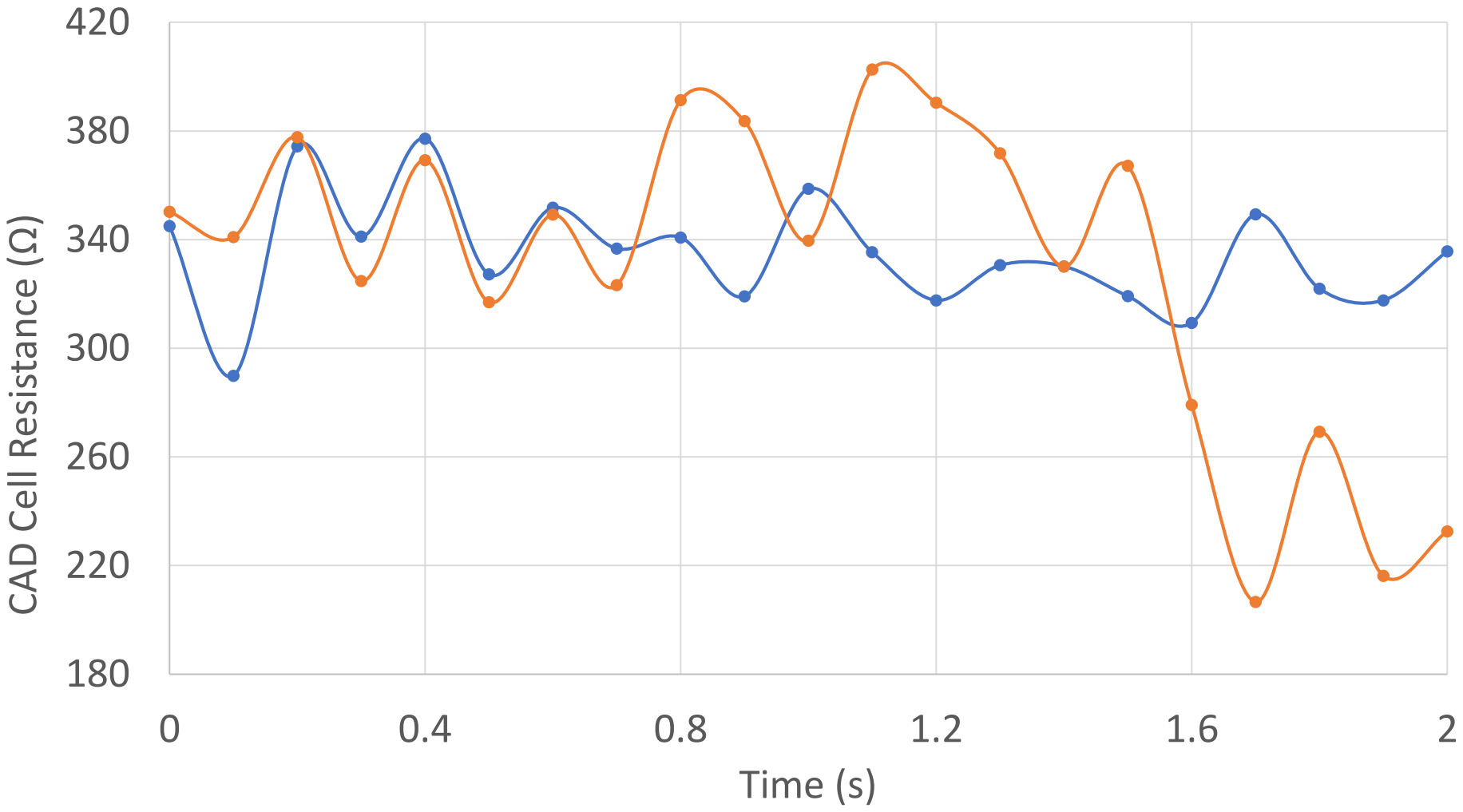
Notable Observation



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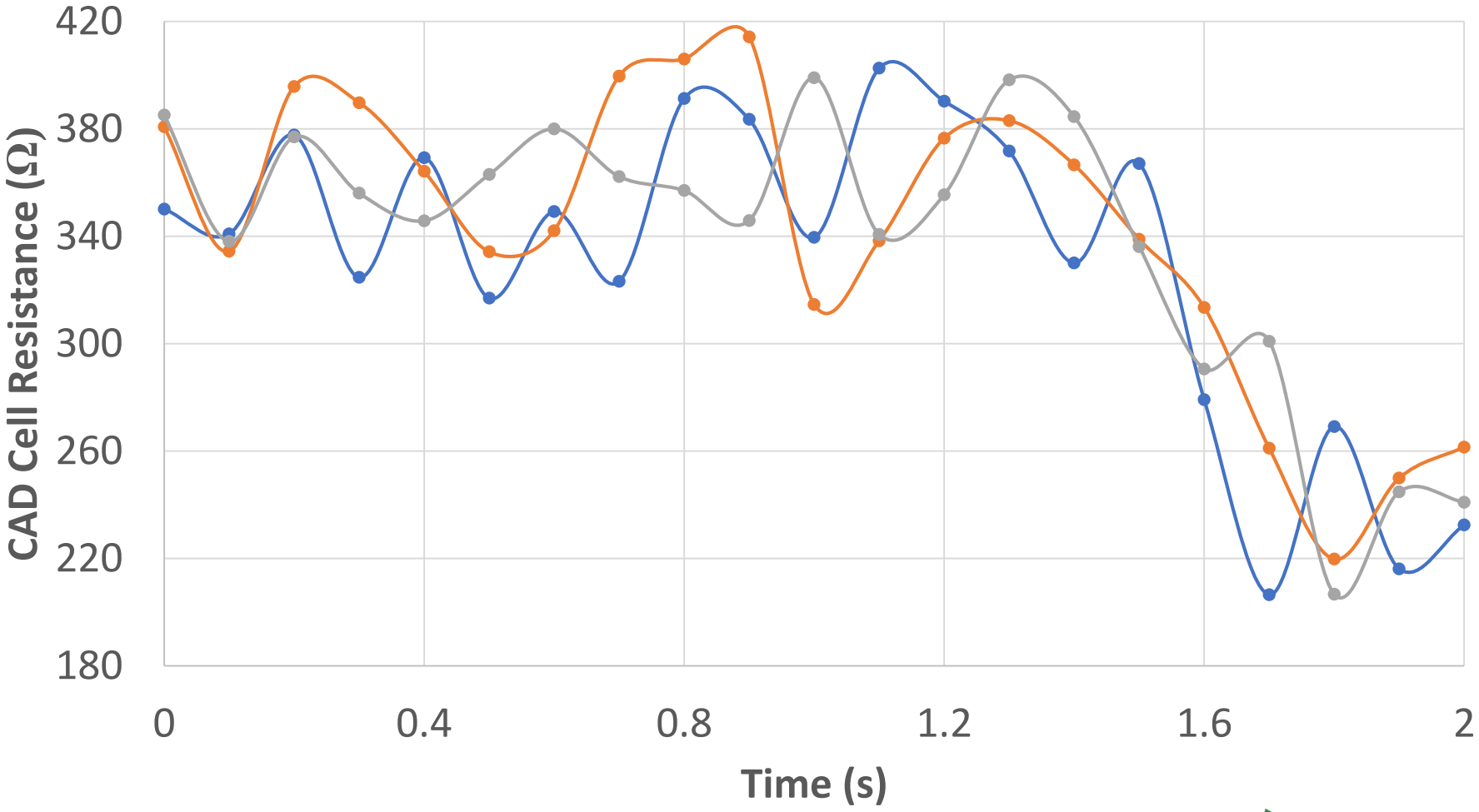
Repeatability of the Trend



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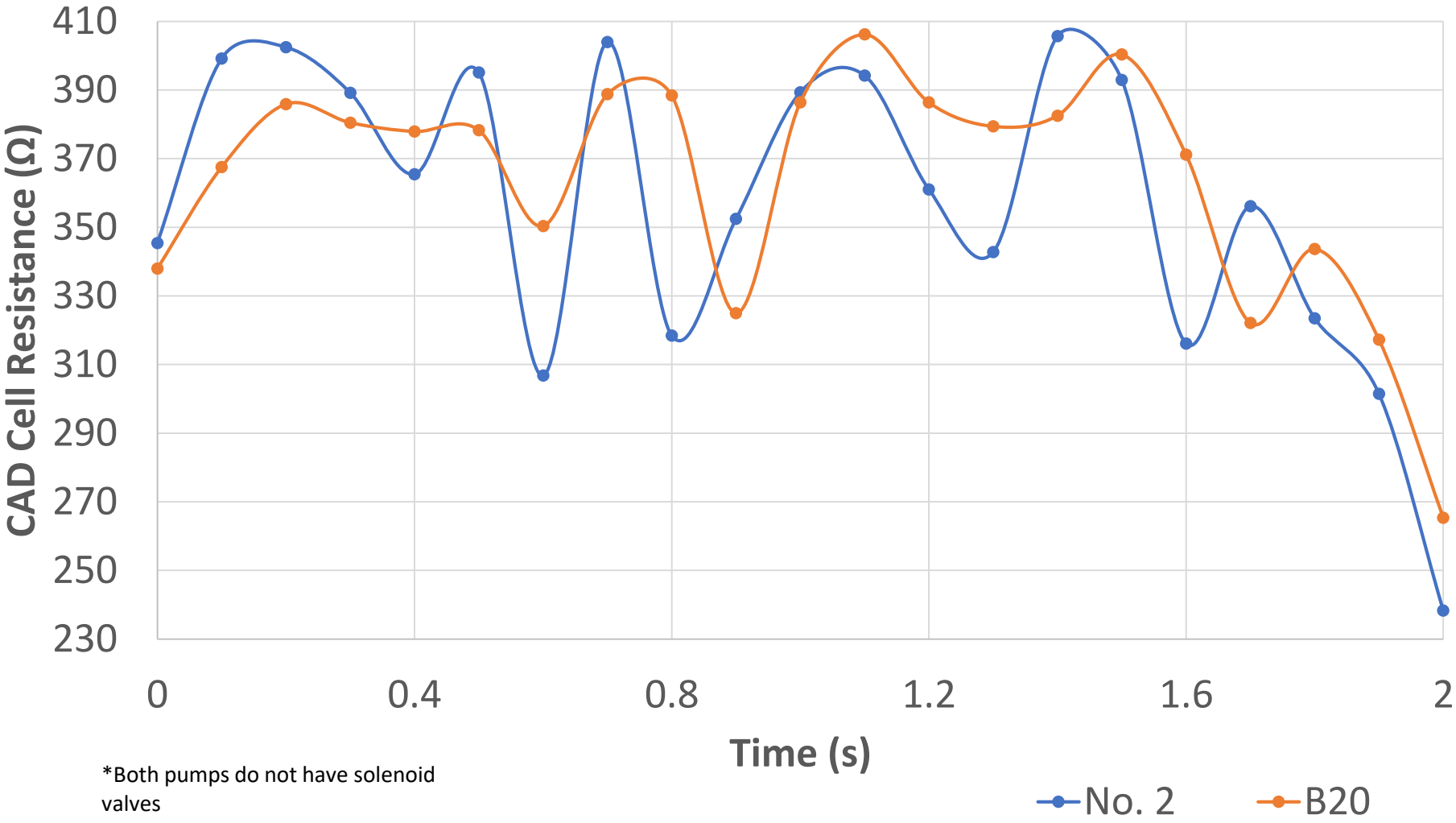
Cutoff Comparison



*Both pumps do not have solenoid valves

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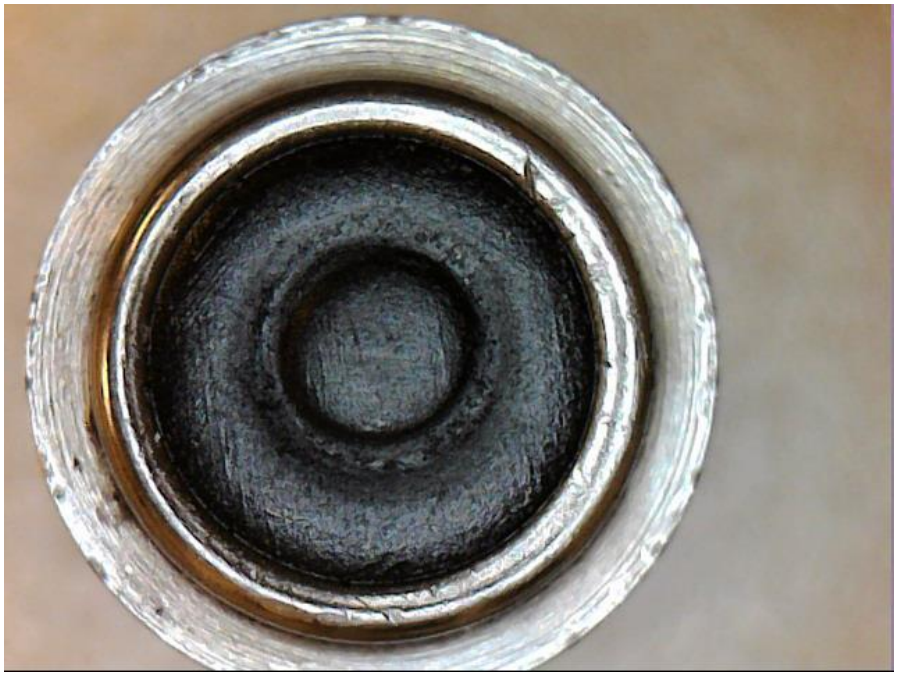
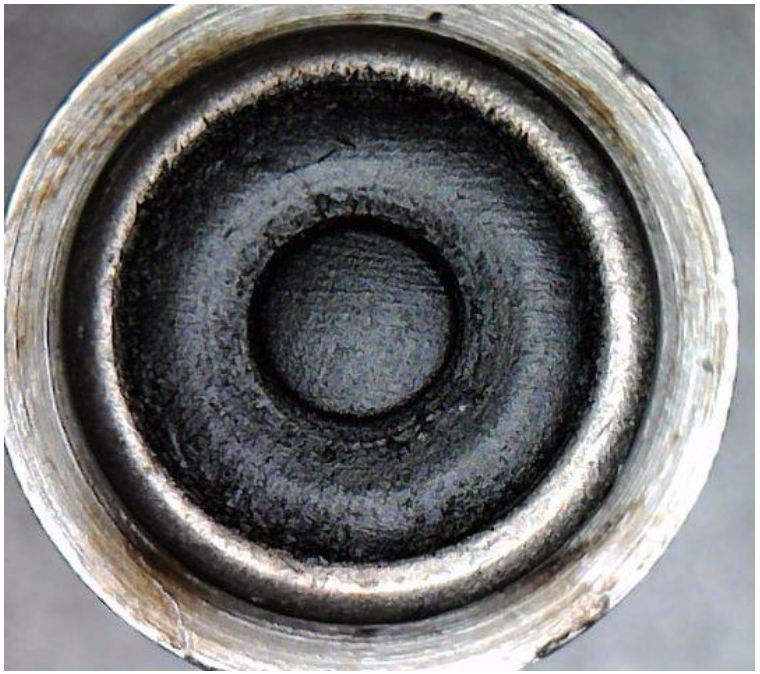
Examination of Parts

- Each pump was dissected after testing
- Pictures of parts taken for comparison
- Piston heads below are examples



Never exposed to bio

Ran B20 ~ 10 years



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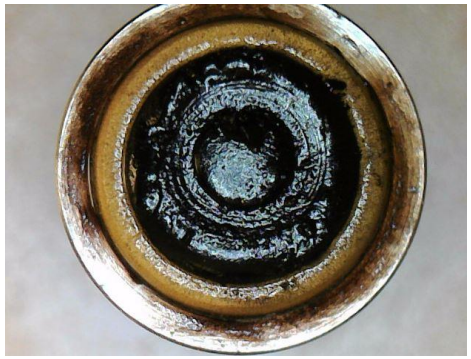
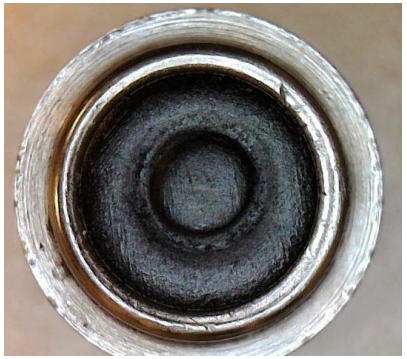
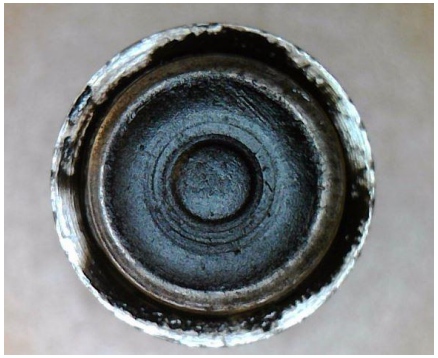
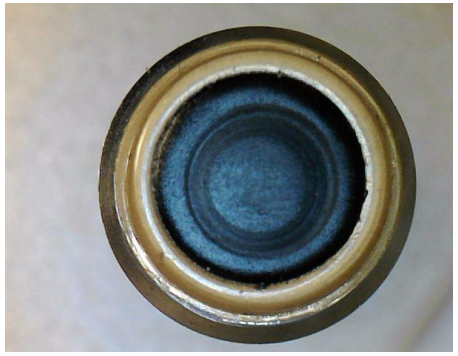
Piston Head – Nominal B0

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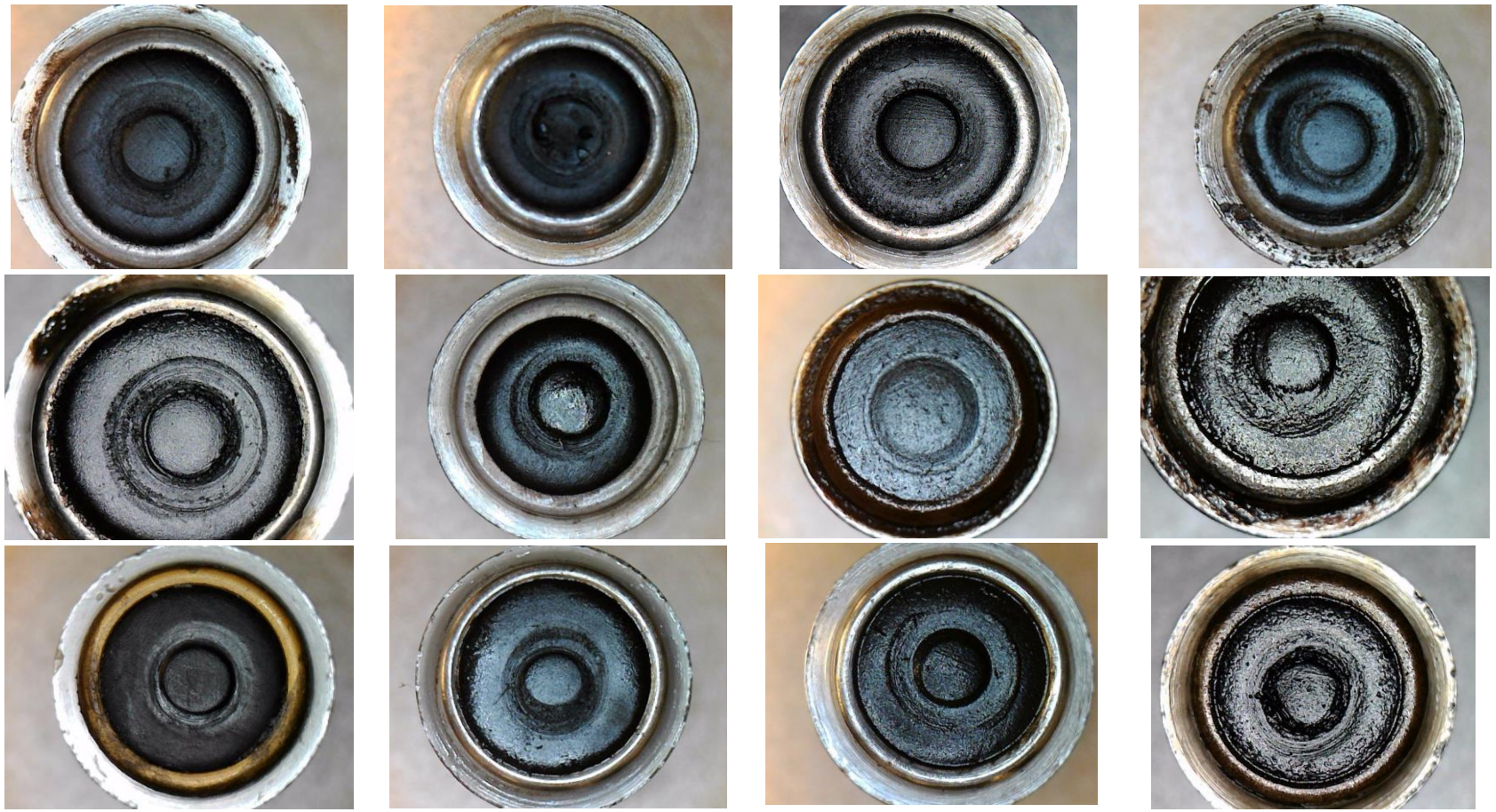
Piston Head – Nominal B20



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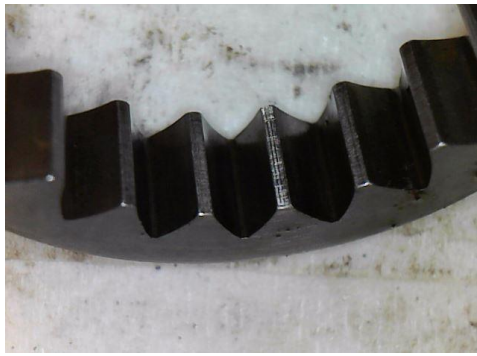
Pump Gear– Nominal B0

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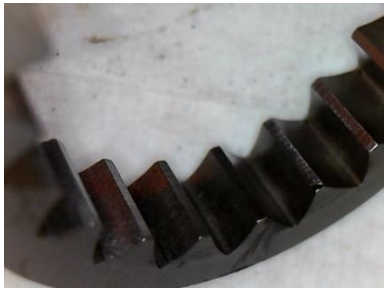
Pump Gear– Nominal B20

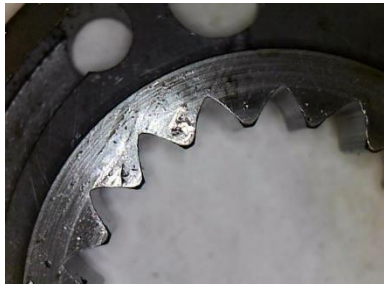












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Pump Face– Nominal B0

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Pump Face – Nominal B20

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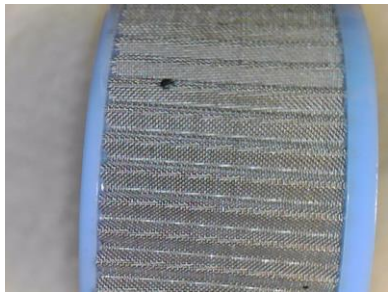
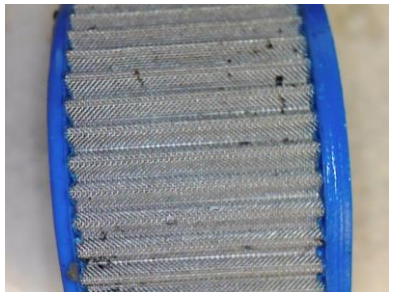
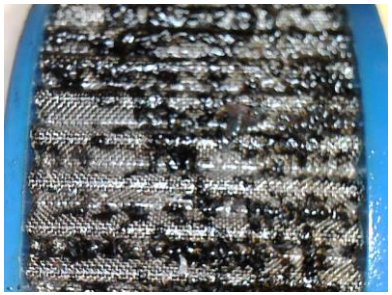
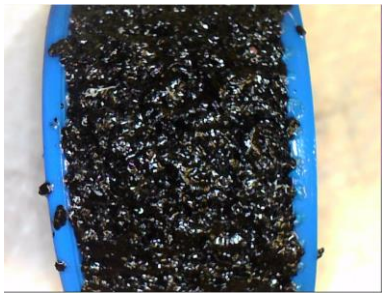
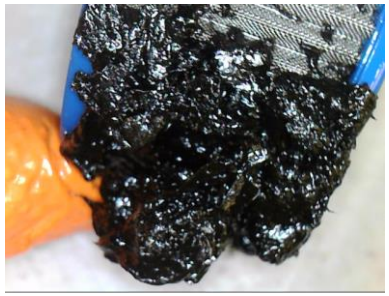
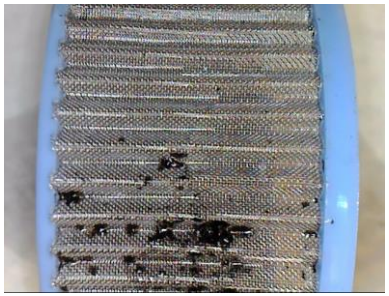
Pump Strainer – Nominal B0



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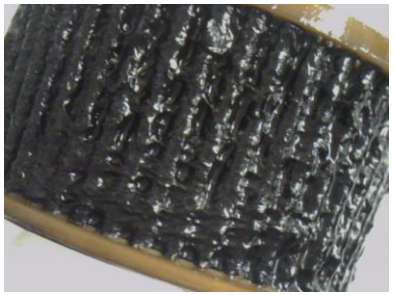
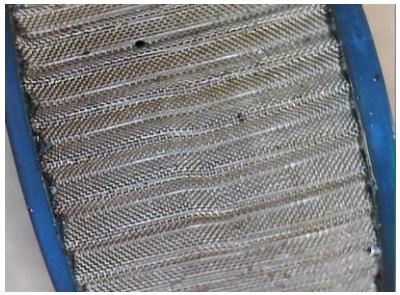
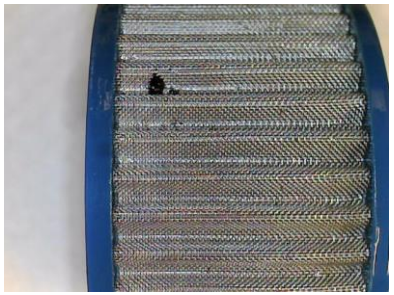
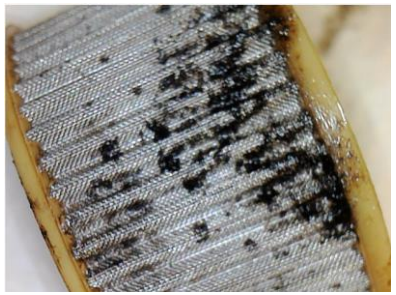
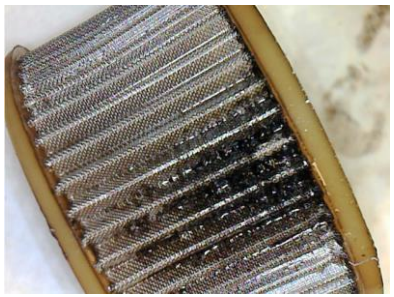
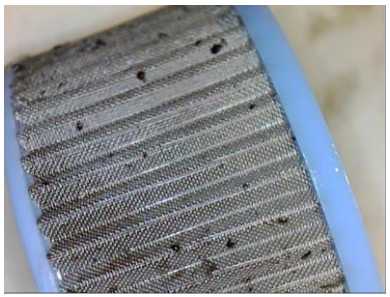
Pump Strainer – Nominal B20





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Biodiesel Combustion Testing

- Combustion testing on biodiesel with varying viscosities
- Baseline No. 2 oil test for comparison
- Varying excess air – CO_2 sweep from ~9-10% to ~15%
- Emissions characteristics for CO_2, CO and NOx and SMOKE
- CAD Cell Resistance measured over 10 seconds and averaged
- Graphs made with CO_2 as independent variable

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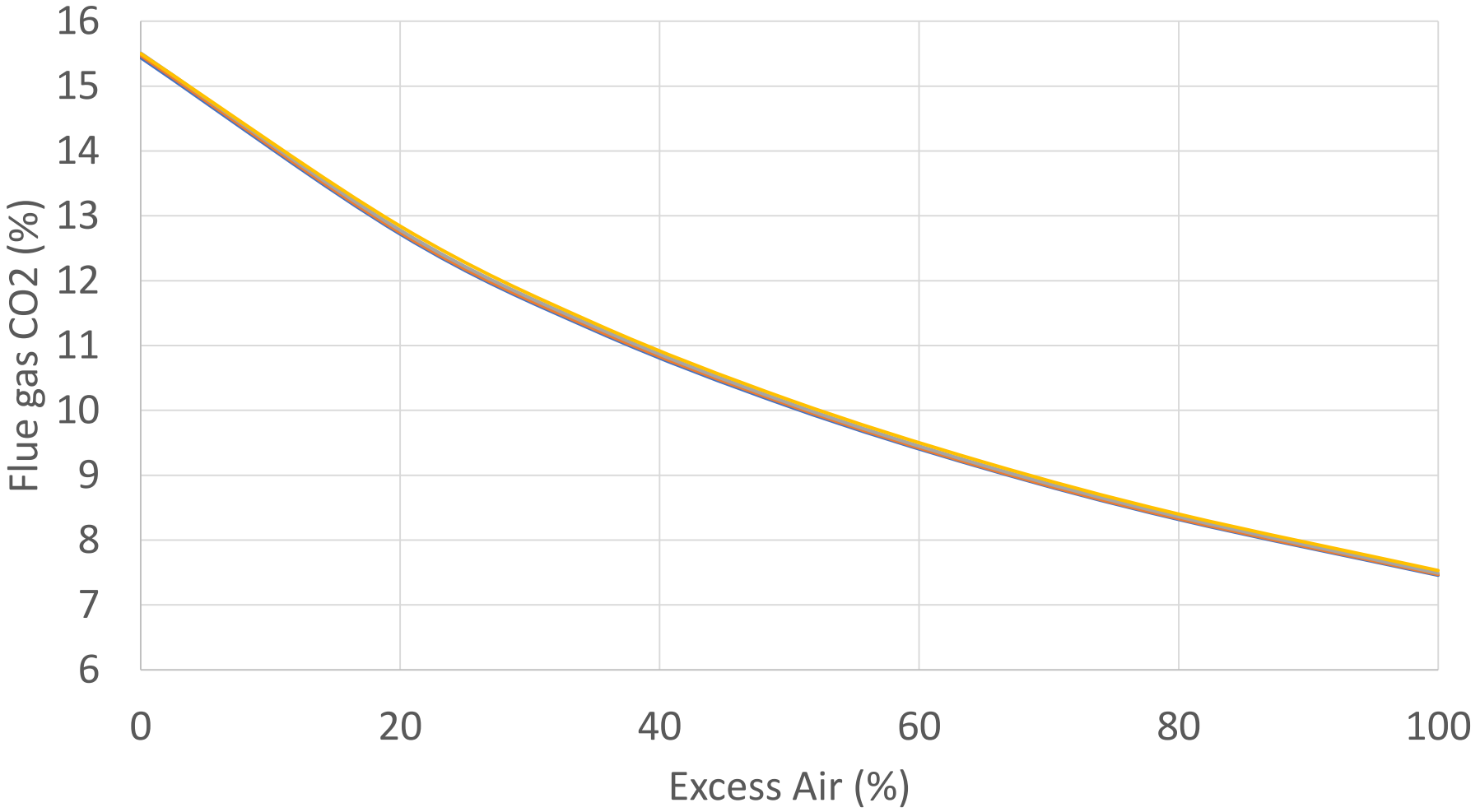
CO_2 and Excess Air Relationship



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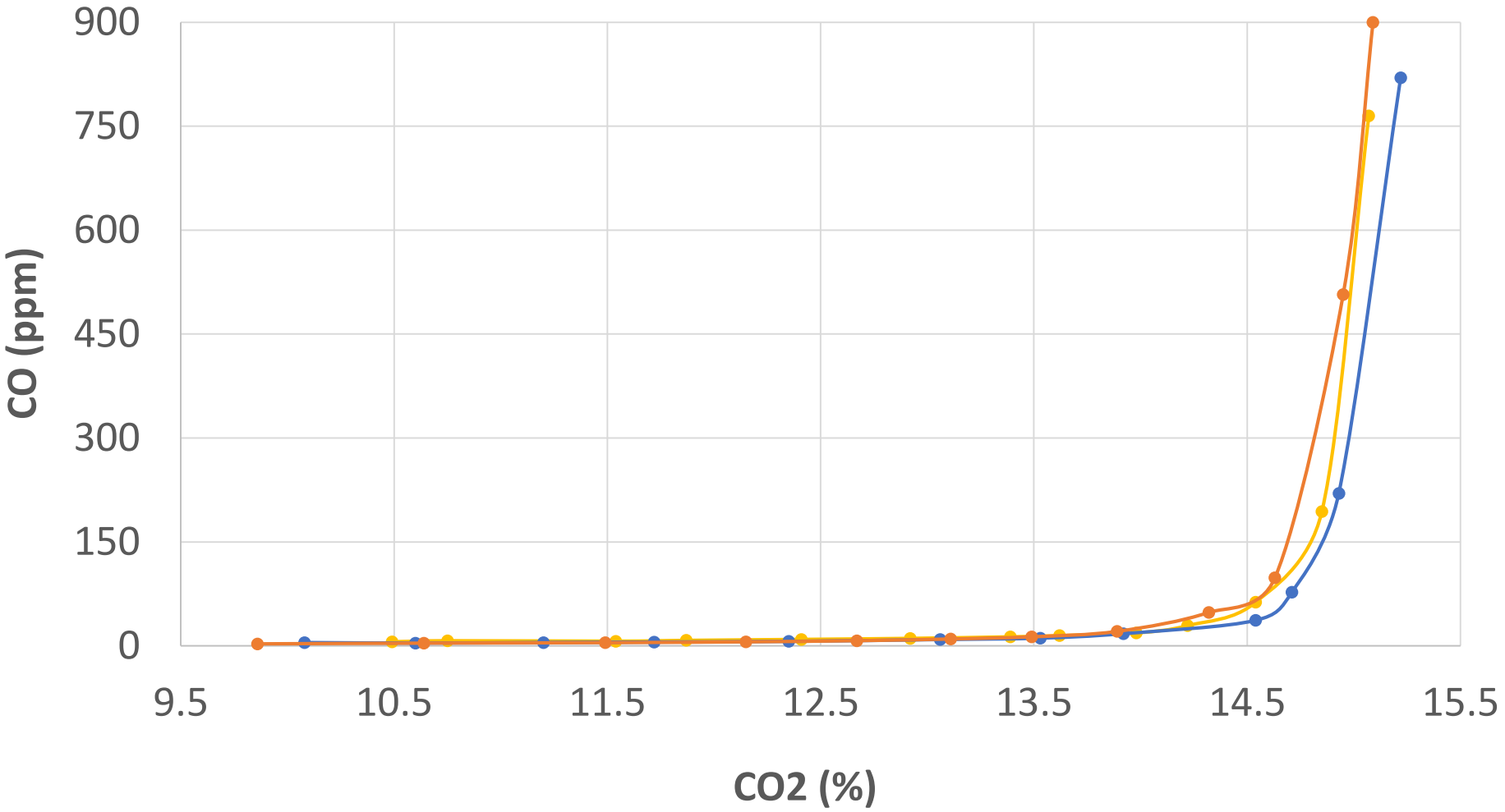
B20 Comparison: Carbon Monoxide



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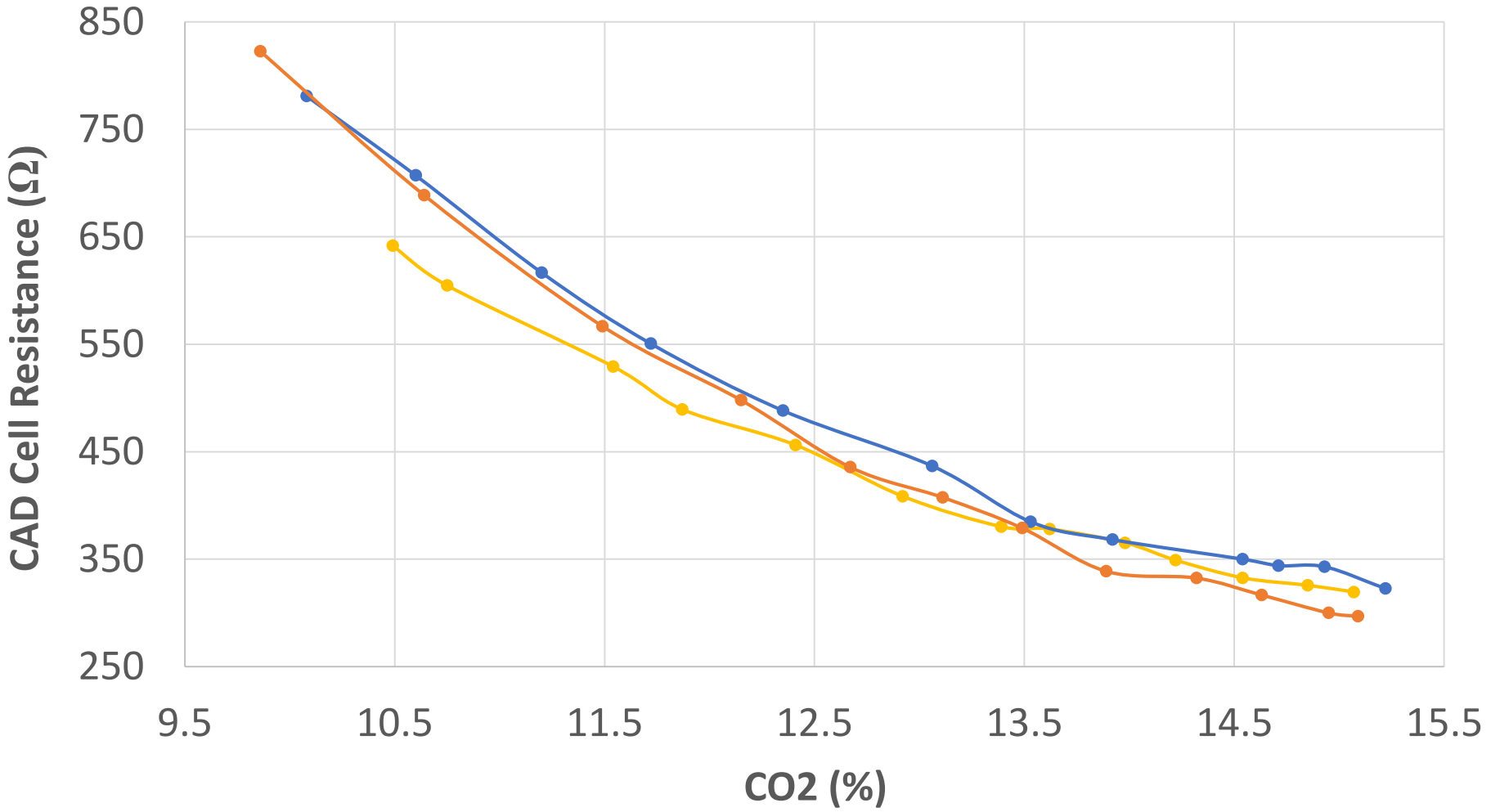
B20 Comparison: CAD Cell Resistance



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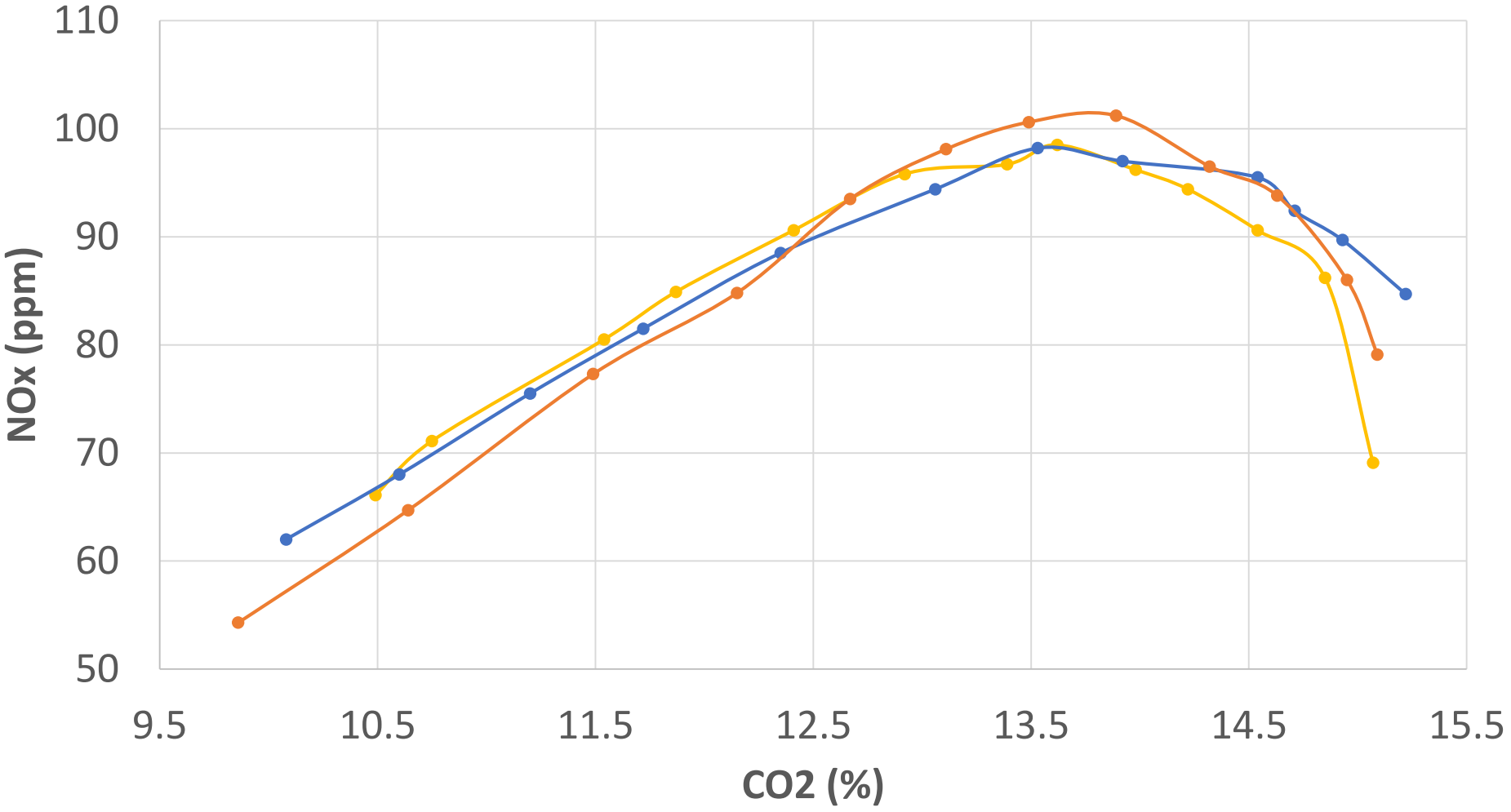
B20 Comparison: Nitrogen Oxides



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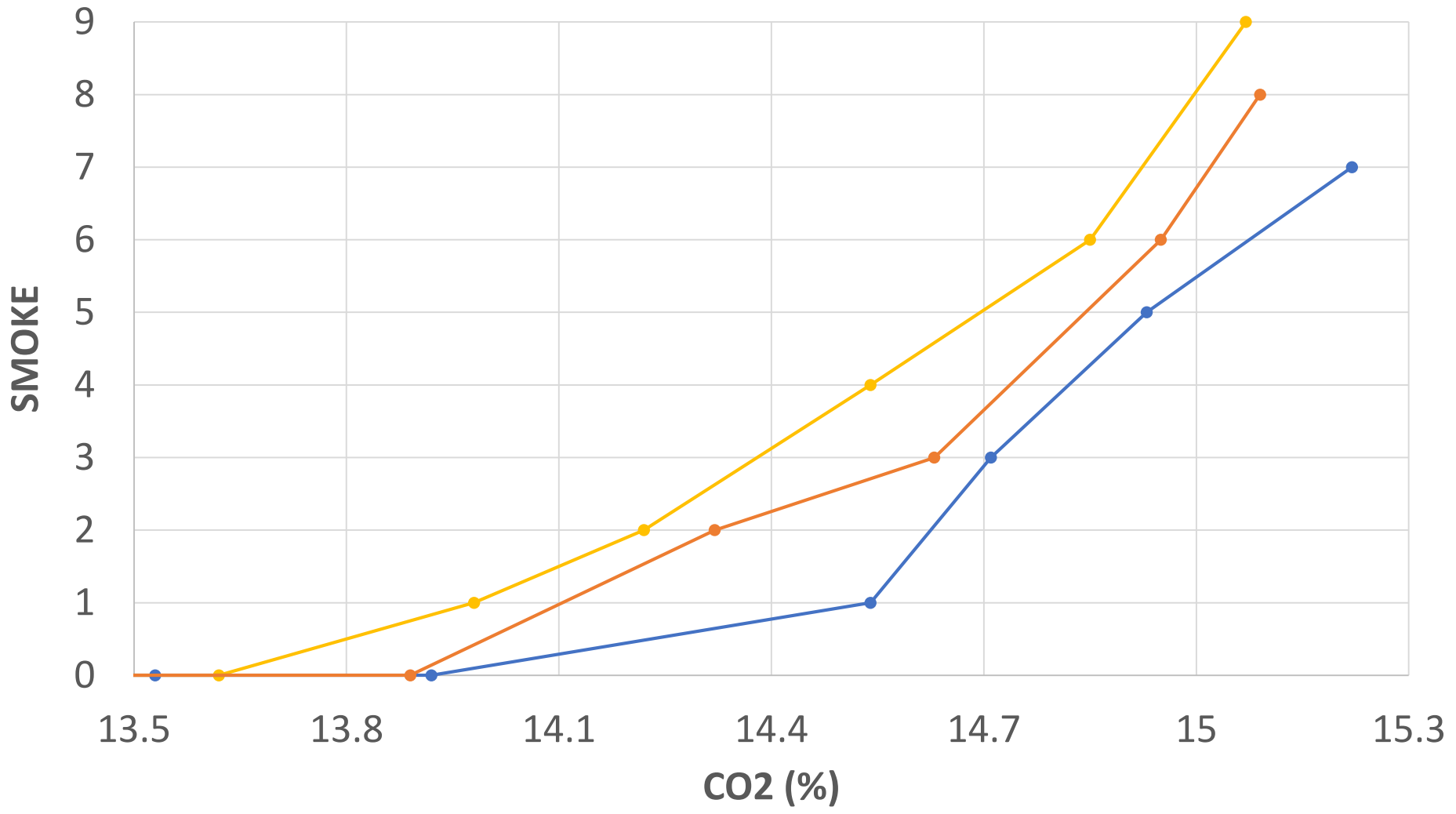
B20 Comparison: SMOKE



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What's the Big Deal?

- Advanced flame sensor testing analyzing pump cutoff shows that operation of pumps with B20 does not hinder performance
- Wear and tear of pumps operating on B20 are essentially the same as those on No. 2 oil
- Combustion performance of B20 means seamless transition from No. 2 oil

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