DOC Light off Review and Implications

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Clean Fuels Technical Workshop

October 27, 2026

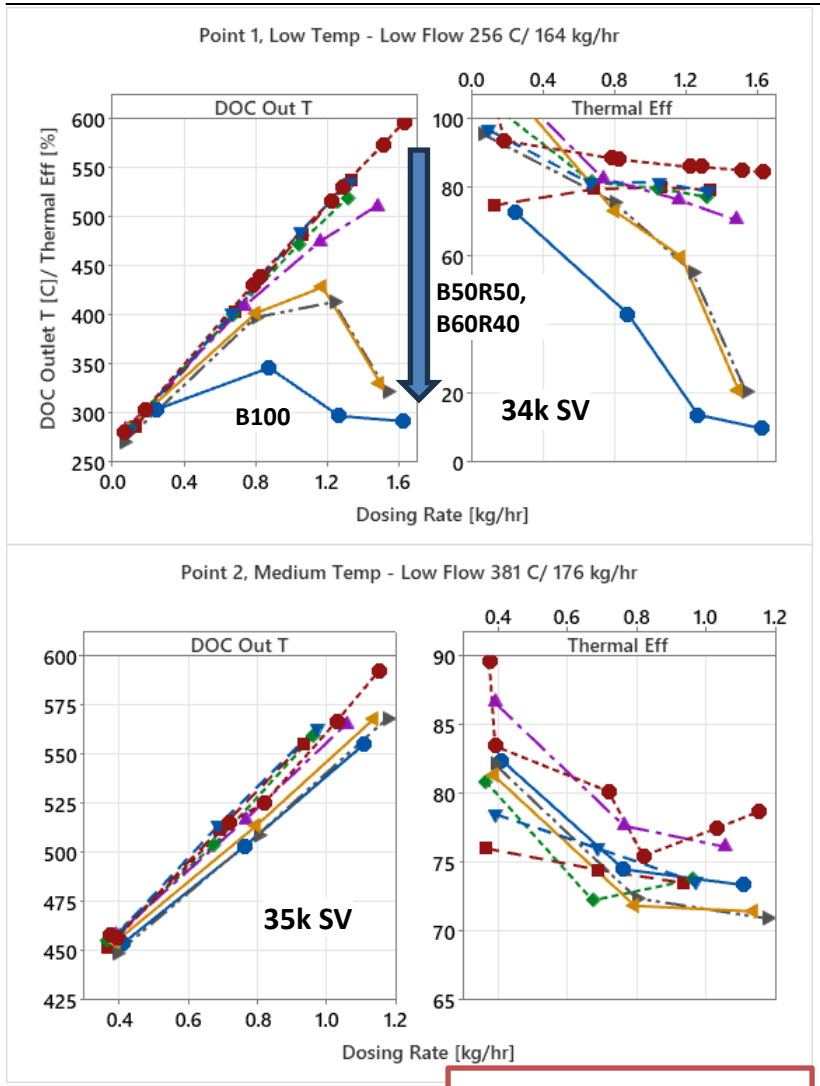
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Background

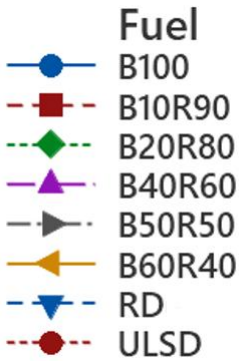
- SwRI has worked with CFA on the performance of biodiesel blends with OEM aftertreatment systems.
- One particular concern has been the performance of a conventional diesel oxidation catalyst (DOC) used to oxidize supplemental fuel during diesel particulate filter (DPF) soot regeneration.
- Data was generated on engine operating on petro-diesel.
- The fuel for the DOC performance was supplied from an external pressurized tank.
  - Biodiesel blends were prepared by mixing biodiesel (B100) with petro-diesel (ULSD) and renewable diesel (RD) on mass basis.
  - RD behaved similarly to ULSD and can be seen as a substitute for ULSD for data trends for this presentation.
- Steady-state test at six different flow and temperature conditions, and transient light-off test at three flow conditions were run to evaluate the fuels.

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Low Flow Results, ~170 kg/hr



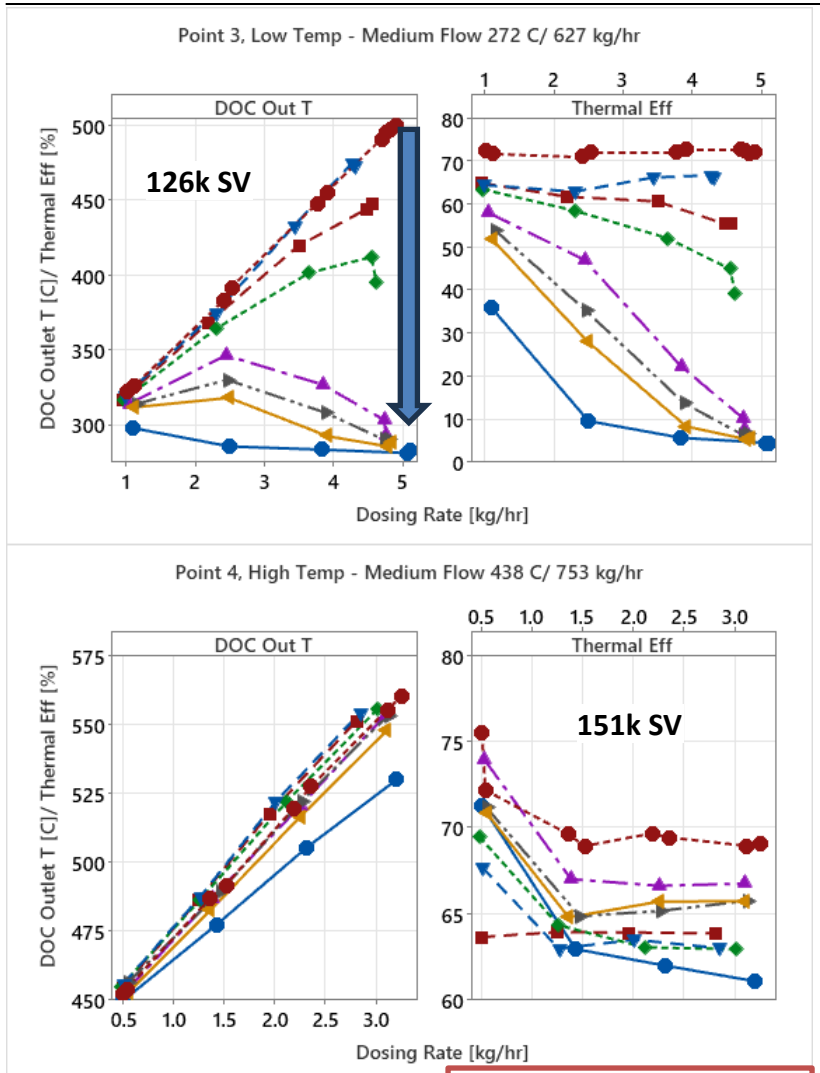
- Low Temperature: 253 °C
  - At lower temperatures, biodiesel fractions of 50% & higher struggle to generate heat with an increase in dosing rate.
  - Dosing rate at which quenching occurs decreases with an increase in biodiesel fraction.
  - Precipitous drop in oxidation of B100 with small increase in dosing rate.
- Medium Temperature: 381 °C
  - Lower exotherms across the DOC with increase in biodiesel fraction.



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Medium Flow Results ~700 kg/hr



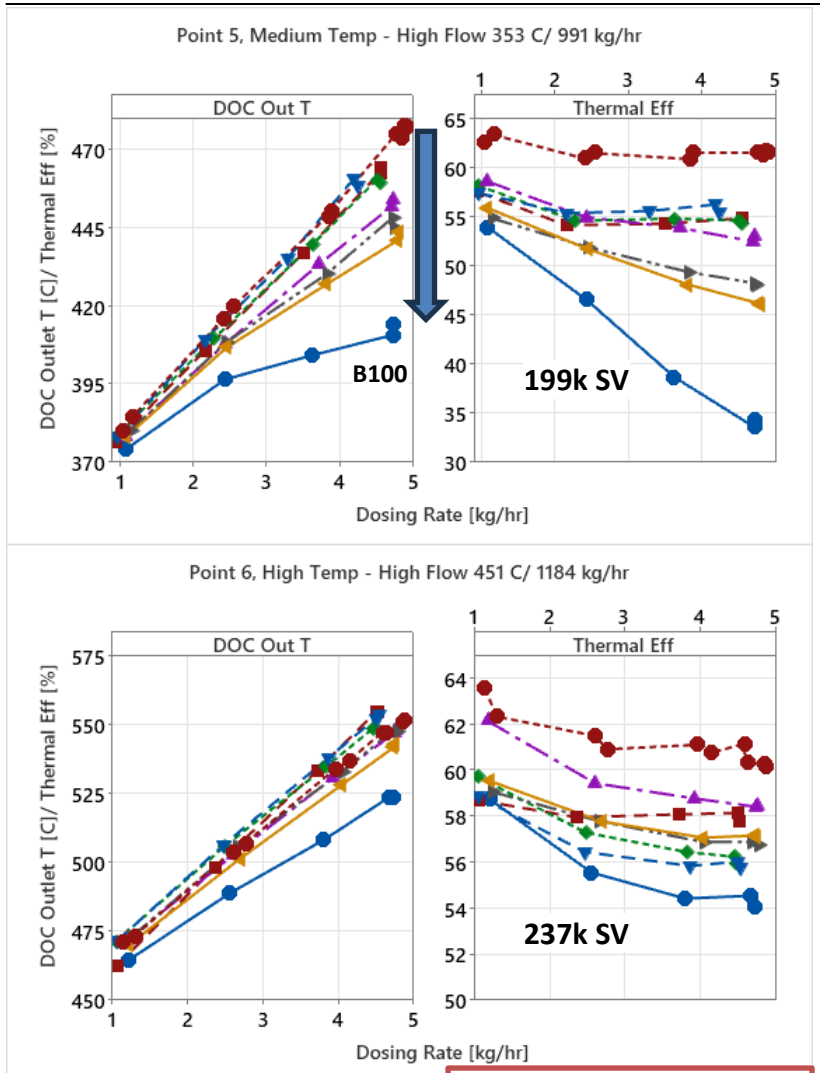
- Low Temperature: 272 °C
  - Even small amount of B100 in RD decreases its efficiency.
  - Fuel oxidation efficiency decreases with an increase in B100 fraction in fuel.
  - Fuel quenching occurs at lower dosing rate with an increase B100 fraction in the fuel.
  - Poor fuel oxidation even at 30% biodiesel at higher dosing rates.
- High Temperature: 438 °C
  - The differences between fuels appear to be small but progressively increase with increase in B100 fraction.

Fuel
B100
B10R90
B20R80
B40R60
B50R50
B60R40
RD
ULSD

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High Flow Results ~1100 kg/hr



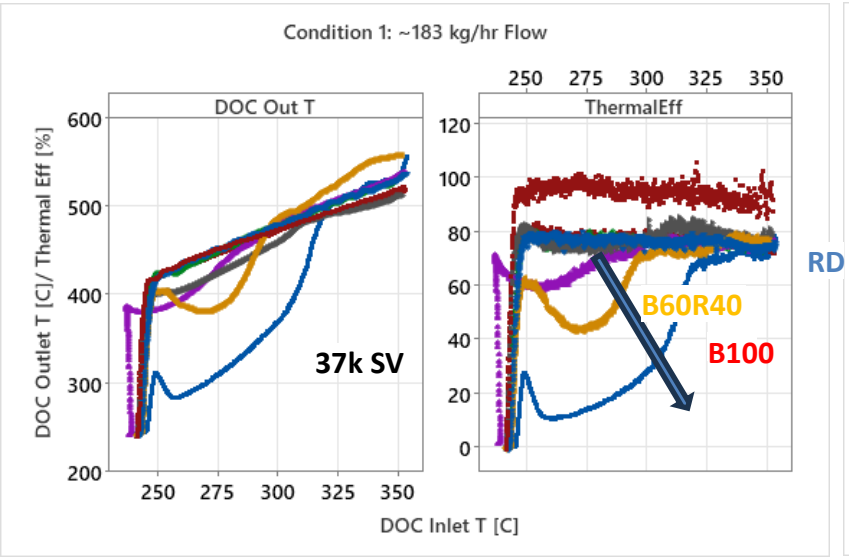
- Medium Temperature: 353 °C
  - Incremental decrease in exotherm across the DOC with an incremental increase in biodiesel fraction.
  - Thermal eff decreases significantly at 40%+ fraction of B100 with an increase in dosing rates.
  - No change in thermal efficiency for ULSD & RD with an increase in dosing rate.
- High Temperature: 451 °C
  - Small decrease in thermal efficiency with an increase in B100 fraction.

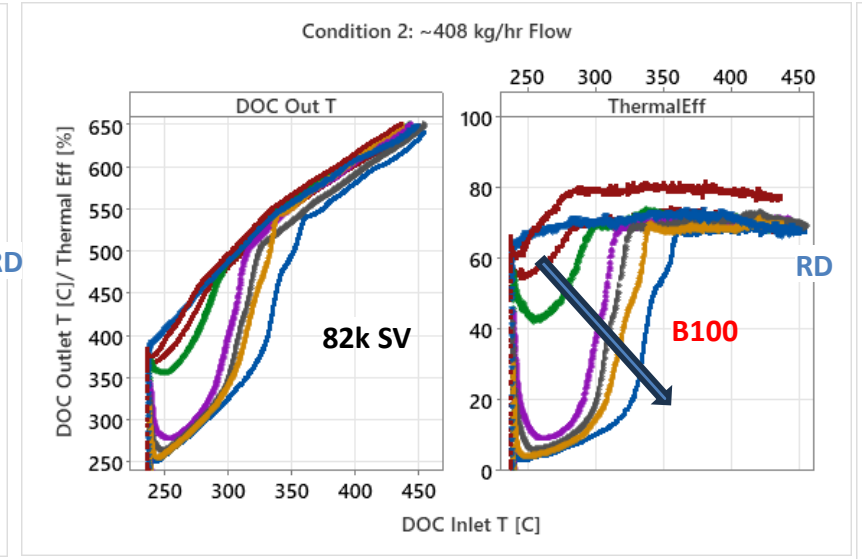
Fuel
B100
B10R90
B20R80
B40R60
B50R50
B60R40
RD
ULSD

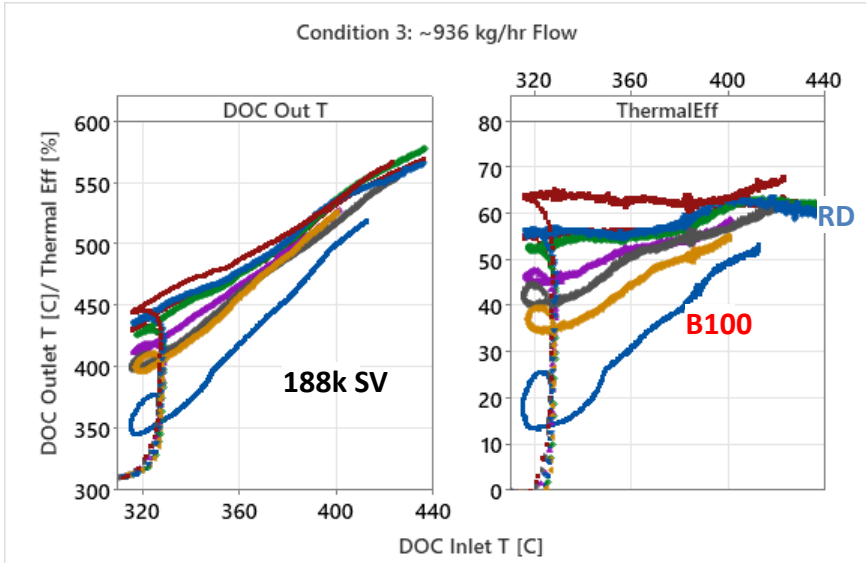
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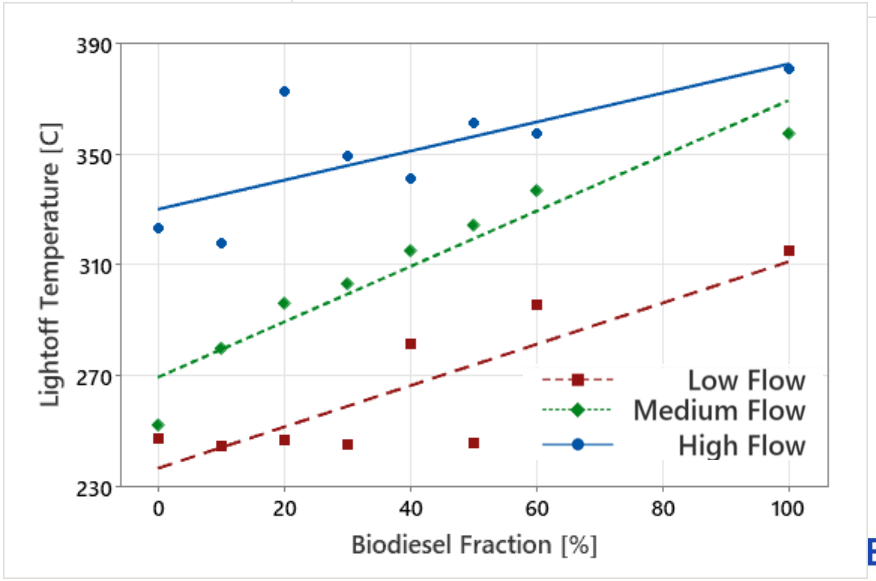
Lightoff







- Lightoff temperature increases as a function of biodiesel fraction.
- Flow rate (SV) has a large effect, with larger increase in lightoff temperatures at higher flow rates.



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Discussion

- The performance of the DOC is a function of exhaust flow, exhaust temperature, biodiesel fraction and dosing rate.
- At lower temperatures (<300 °C)
  - DOC functions well only at low flow rates at lower than 50% B100 fraction and lower dosing rates.
  - At higher flow rates or higher dosing rates, with even 10% B100 fraction, DOC efficiency decreased.
- At middle temperatures (~325-375 °C)
  - DOC functions only at low flow rates.
  - At high flow rates and higher fractions of B100 (40%+), DOC efficiency decreased with an increase in dosing rate.
- At higher temperatures (~375-450 °C)
  - DOC functions at slightly reduced efficiency but remains effective.
- The light-off data shows a steady increase in light-off temperature with an increase in B100 fraction.
  - The effect is most visible at middle & higher flow rate.

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Possible Solutions

- Larger catalyst with higher PGM. → Improve performance with lower SV & temperature
- In-cylinder fuel dosing
- Higher pressure doser
- Air assisted fuel doser → Improve performance with better atomization
- Heated fuel doser
- External heater → Improve performance with better vaporization

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Larger Catalyst Solution

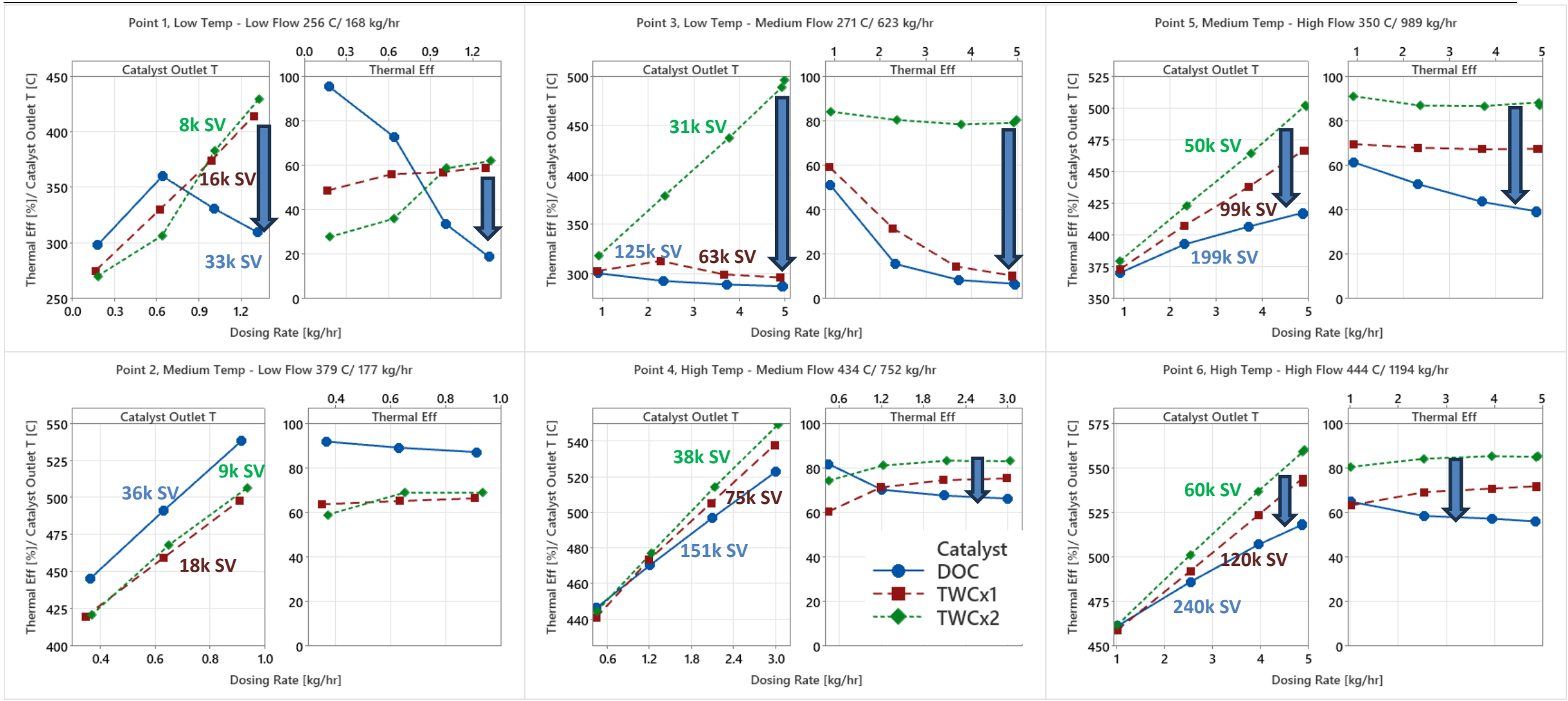
- A larger catalyst with higher PGM
  - Improve low temperature and high SV performance
- A two-brick three-way catalyst (TWC) to test this theory
  - Each brick of 26.7 cm diameter x 15.2 cm length (8.51 liters)
  - Single brick of 8.51 liters and two bricks of 17.02 liters
  - Reference OEM DOC of 26.7 cm diameter x 7.6 cm length (4.26 liters)
  - PGM of TWC unknown but expected to be higher than DOC

	DOC	1xTWC	2xTWC
Size	0	+	++
PGM	0	+	+

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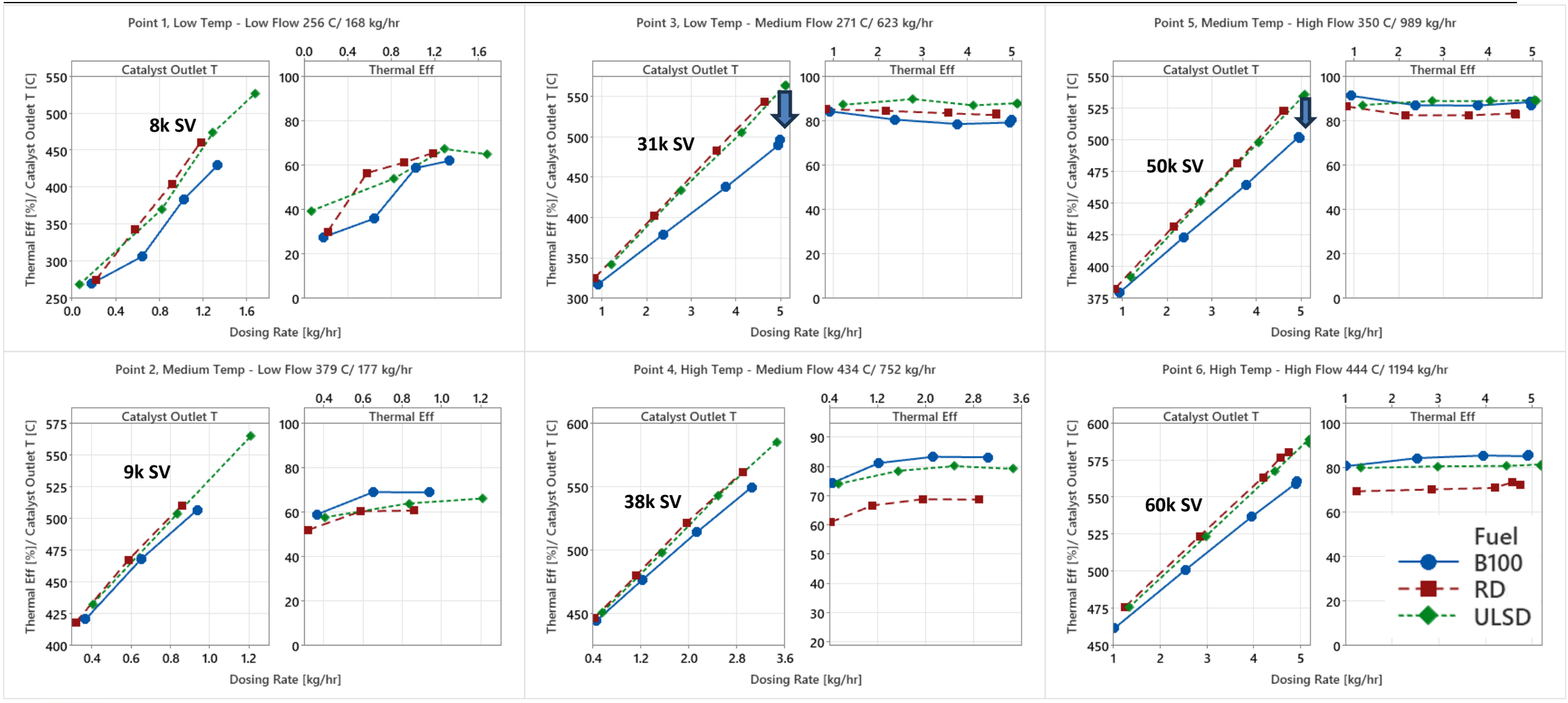
B100



DOC severely struggles at <300 °C, and underperforms even at higher temperatures

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Two Bricks of TWC (17.04L)



All fuels function well with two bricks of TWC, though B100 is slightly low

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Discussion

- Low performance on DOC with biodiesel can be overcome with higher PGM and larger size.
- The electronic controllers are generally robust but they will have to know the fuel the engine is operating on, so it can compensate accordingly.
  - The fuel blend (biodiesel fraction) can be estimated based on different inputs even if not a direct sensor.
  - The estimation does not have to be accurate and can be made to function even with an error of ~20%.
- Currently biodiesel blends of 20-30% are transparent to the existing hardware/ software.
  - The larger catalyst can expand the operating transparency level of fuel blends to 80%+ fraction.
  - Other solutions might expand the operating transparency level of fuel blends to 50%+ fraction.
  - The solution would have to work with OBD.

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