Fuel Additives for Improved Performance of Diesel Aftertreatment Systems

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Fuel Additives for Improved Performance of Diesel Aftertreatment Systems

Ethyl

- Background
- Catalyst Protection
- Diesel Particulate Filters
- Recent Data from HDD Testing
- Summary & Ongoing Diesel Research

Diesel Exhaust Aftertreatment

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- Many current and proposed aftertreatment hardware technologies are negatively affected by Phosphorous and Sulfur
- One solution involves scavenging P & S with additives before interaction with aftertreatment
- Regeneration continues to be problematic for particulate filters under certain operating cycles
- Additives can improve the performance of particulate filters and optimize regeneration strategies

Additives are Widely Used in Diesel Fuel

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- **Detergents** - maintaining engine cleanliness
- **Ignition (cetane) Improvers** - improve engine operation, reduce white smoke and noise, lower emissions, improve cold start and provide refinery flexibility
- **Lubricity Additives** - inhibit wear - pumps and injectors
- **Operability Additives** - reduce or eliminate wax build-up and filter plugging problems in cold weather
- **Stability Additives, Conductivity Improvers, Demulsifiers, Biocides**

Additives are Widely Used in Diesel Fuel

- **Phosphorous and Sulfur Scavengers** – help maintain aftertreatment efficiency
- **Combustion Improvers** - reduce smoke and particulate matter
- **Light-off Additives/Catalysts -** Fuel Borne Catalysts for Diesel Particulate Filters (DPF)

Fuel Additives Help Maintain Catalyst Efficiency and Improve Durability

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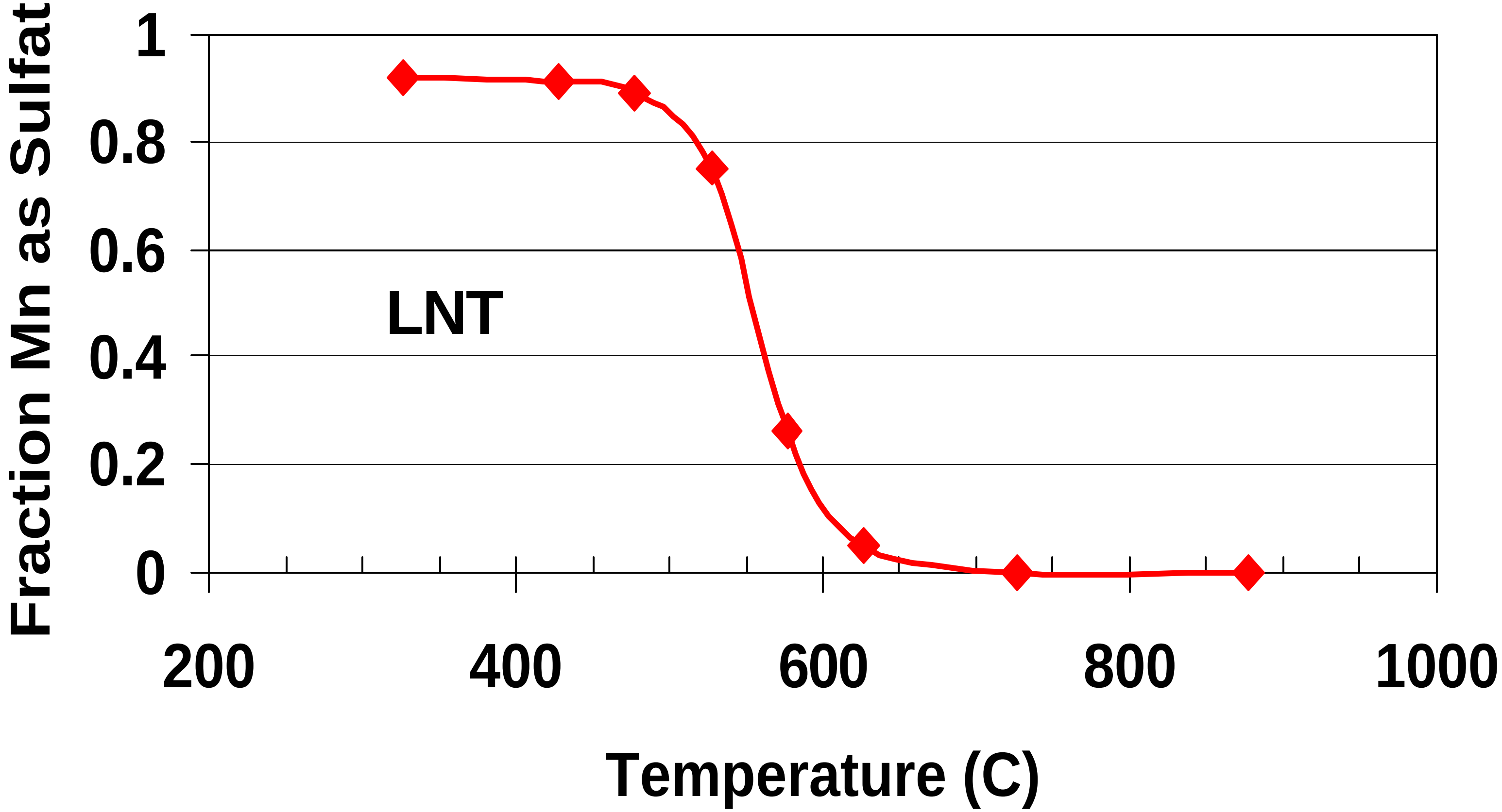
- Sulfur will continue to exist in most diesel fuels
- P & S chemistry is widely used in crankcase lubricating oil to prevent wear and oxidation
- The relative contribution of lube oil to the total exhaust sulfur is increasing
- Manganese based fuel additive (MMT) combustion products have been shown to scavenge phosphorus and sulfur and reduce deposition on catalysts

Mechanism For Sulfur Scavenging

Manganese from combustion of MMT interacts with sulfur species in the exhaust to form Mn sulfate which is stable below 500°C



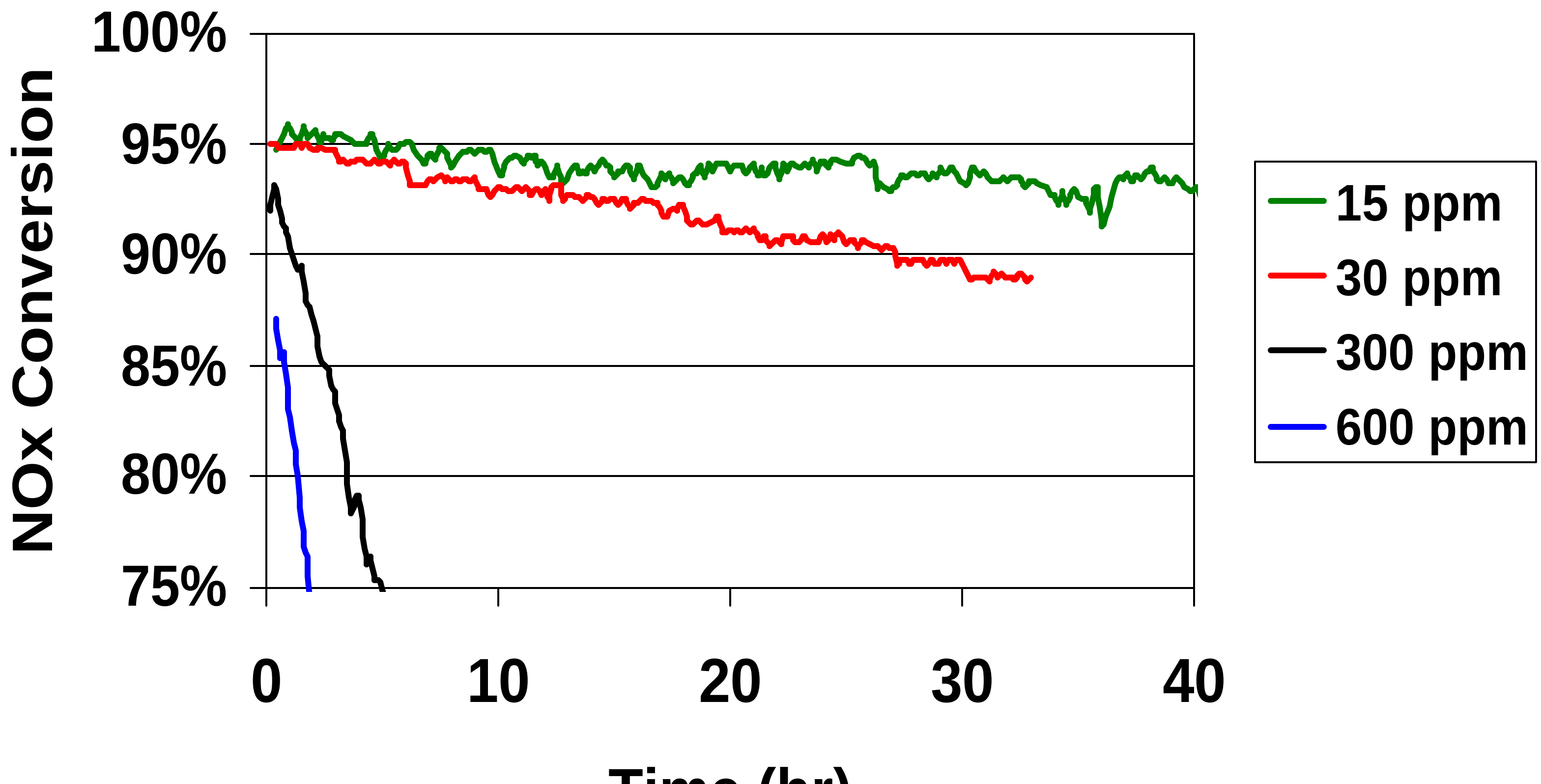
Combustion Products from Engines Operating on Fuel Treated with MMT

Fuel Type	Mn Oxides %	Mn Sulphates + Mn Phosphates %
Gasoline	19-25	75-81
Diesel	1-6	94-99

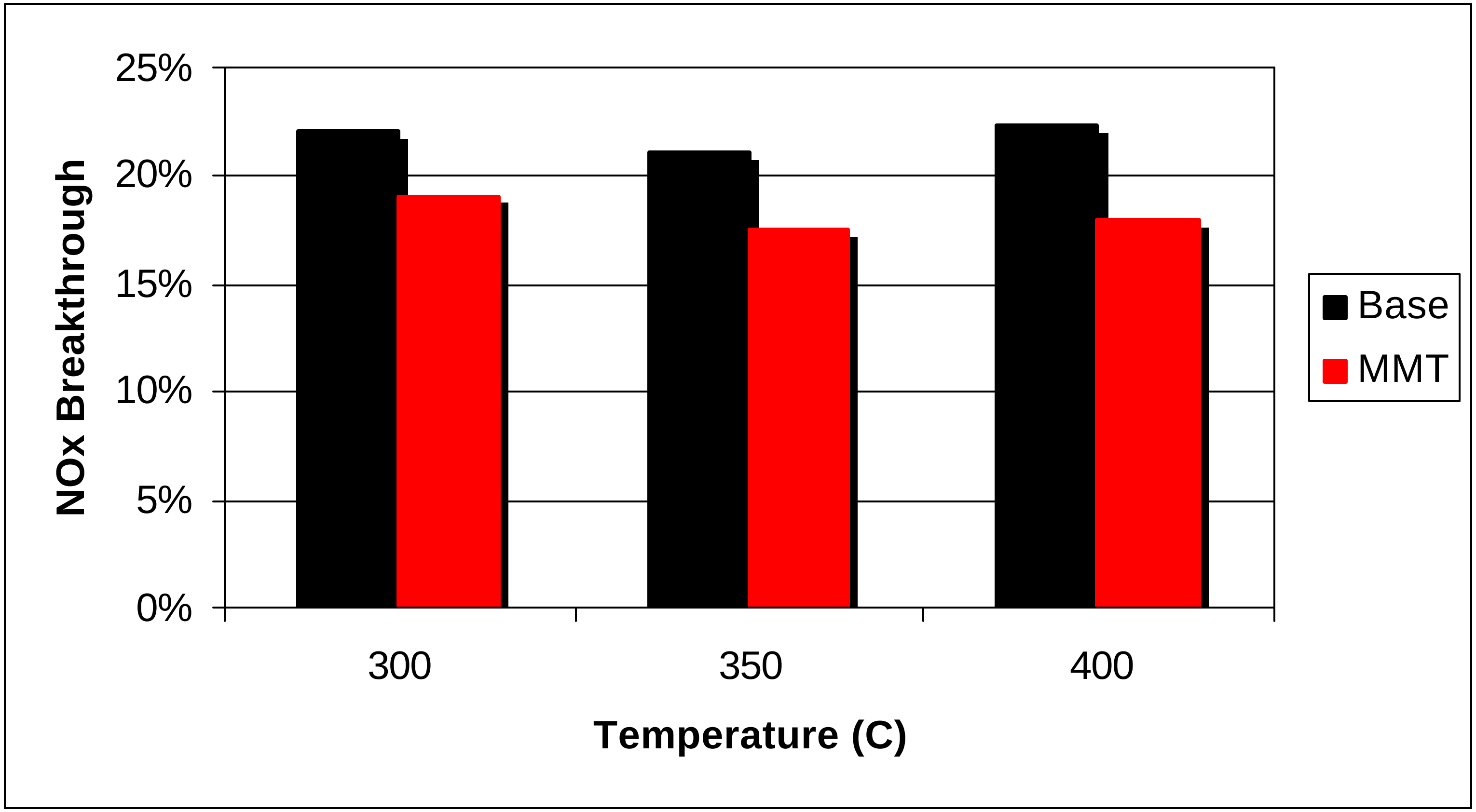
- Samples generated in CVS dilution tunnel over transient engine dynamometer cycles
- Manganese present in divalent form as mixture of Mn phosphate, Mn sulfate and Mn oxide

Sulfur Impact on NOx Trap

Increased sulfur increases rate
at which NOx conversion declines



LNT NOx Breakthrough - 30 ppm S

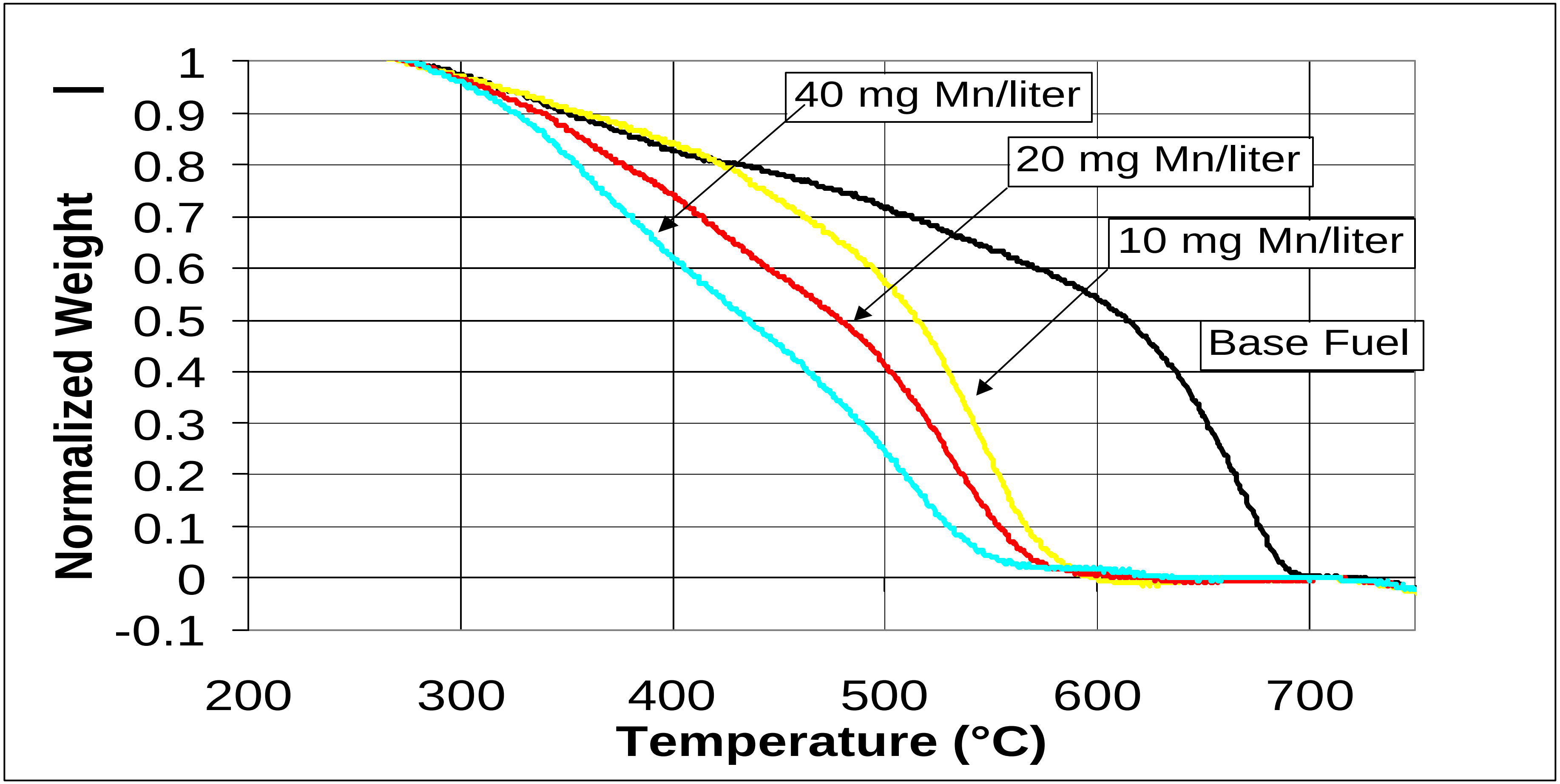


Catalyst aged 46 hrs with 30ppm base fuel followed by regeneration and then 46 hrs with MMT (18mg Mn/L)

Diesel Particulate Filters (DPFs)

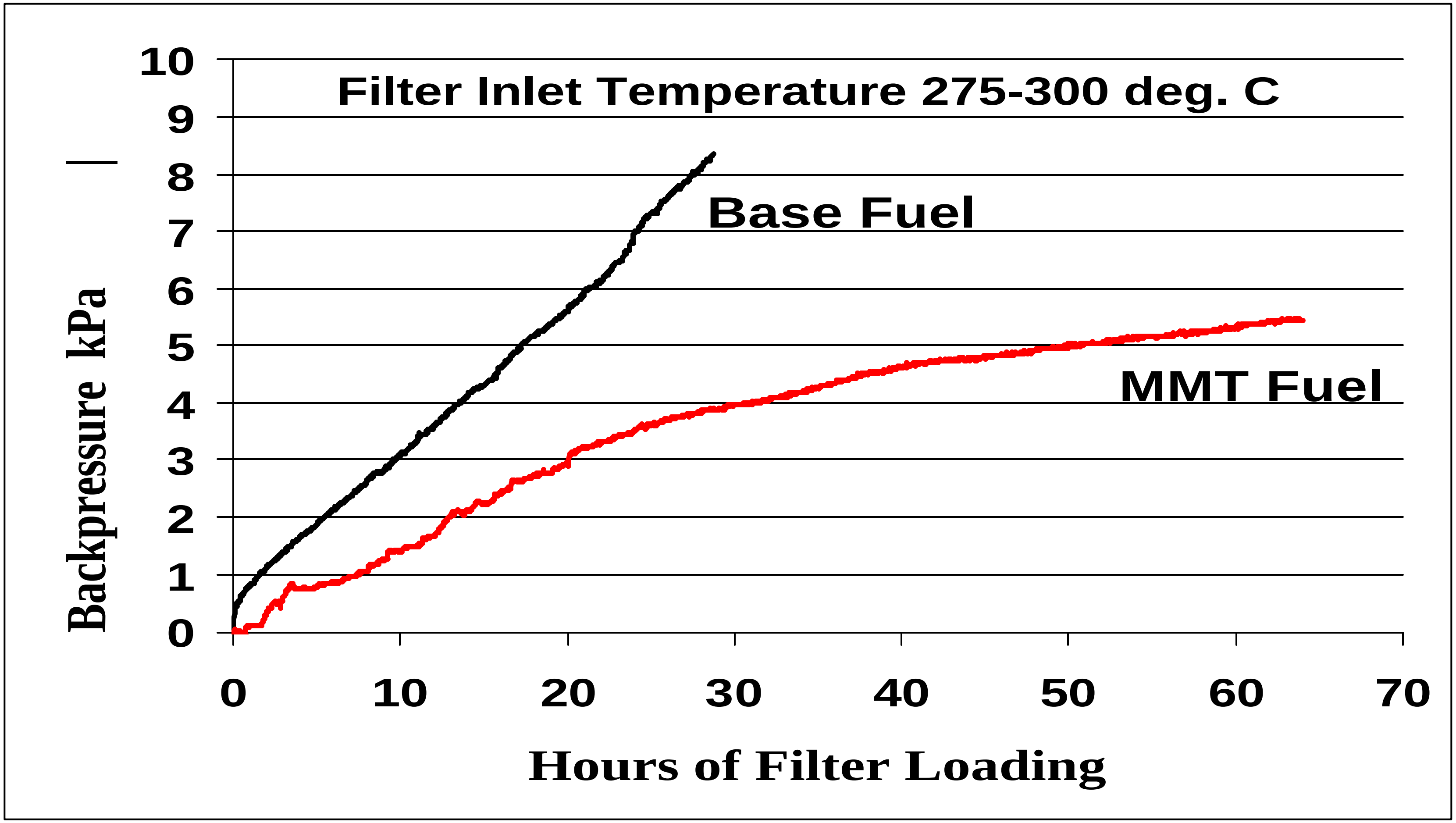
- Low temperature diesel duty cycles often require heat addition to regenerate or clean Diesel Particulate Filters (DPFs)
- Catalytic elements ahead of the DPF or coatings integral to the DPF have associated cost and other issues
- Exhaust back pressure from loaded DPFs reduce engine efficiency and durability
- DPFs reach balance point and regenerate at lower temperatures with the fuel additive MMT

TGA Results - Oxidation of PM



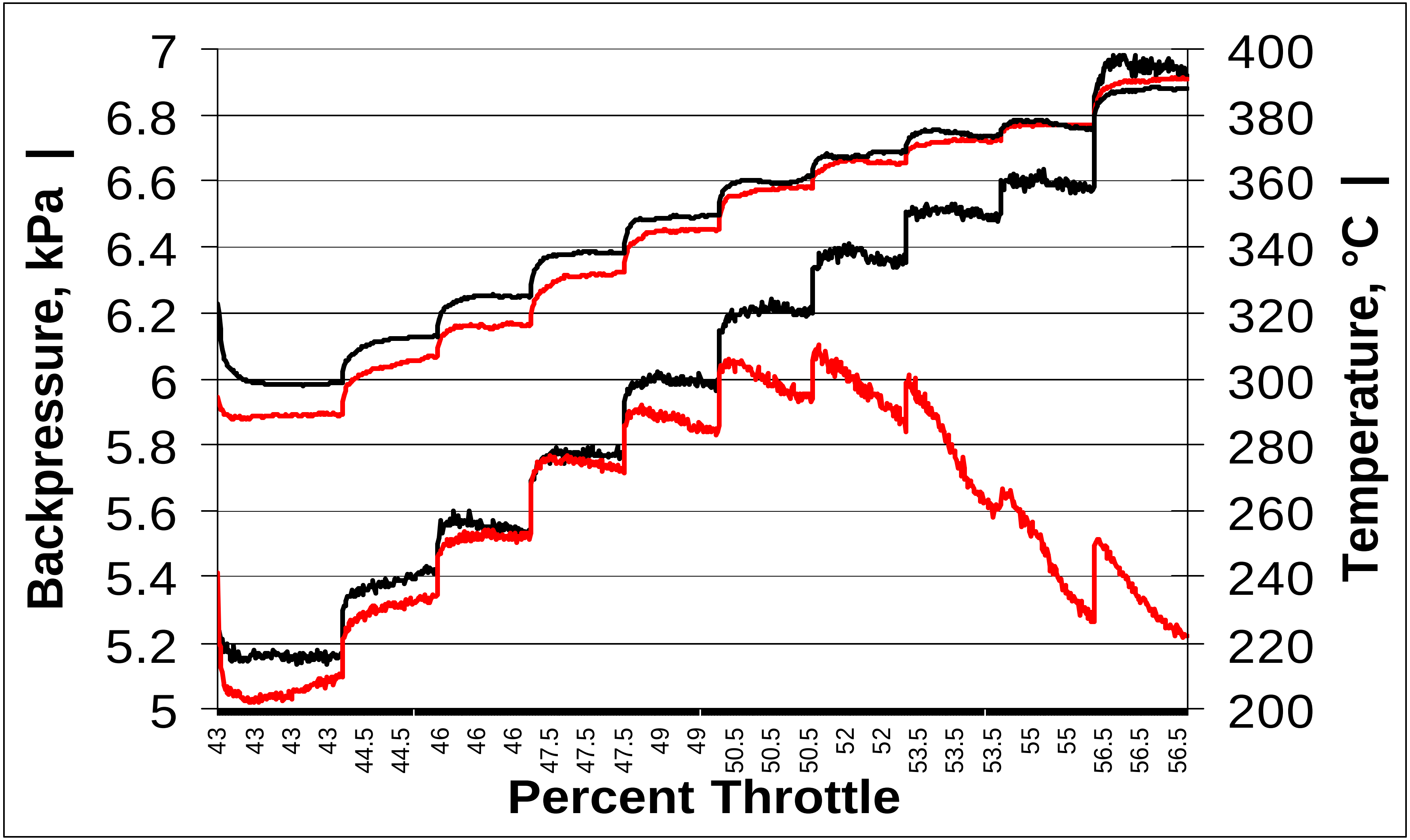
Particulate Matter (PM) collected from Cummins M11 operated over triplicate HDD transient cycles

Balance Point Test – Filter Loading

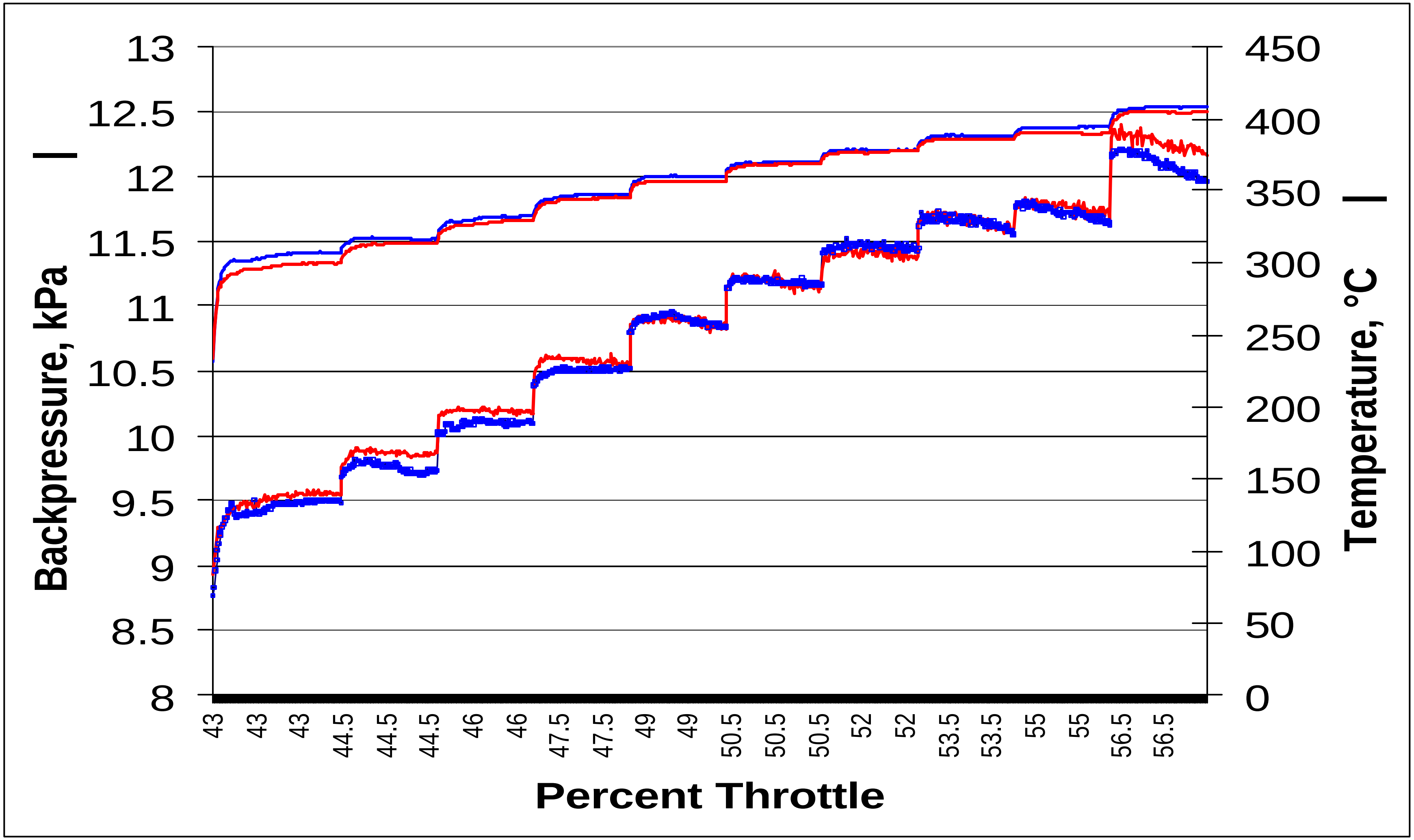


- ESC Mode 11, 1643 rpm, 25% load – 1998 Cummins M11-330hp

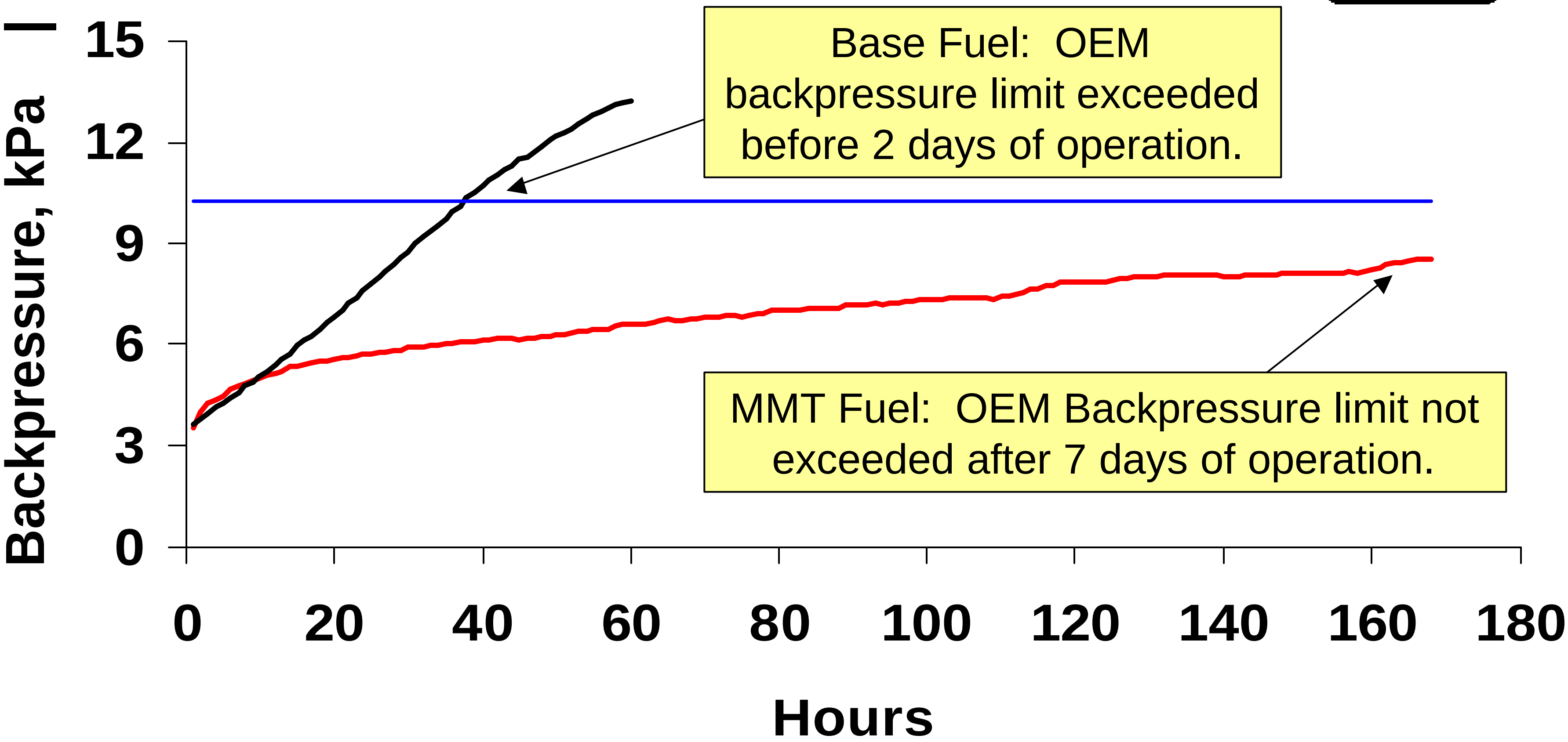
Balance Point Test – DECSE Method



Balance Point Test – No Residual Mn Effects



DPF Loading – Transient Cycles



- 3 HDD Transient Cycles – Avg DPF Inlet Temp 270 C
- 1 ESC Mode 13, 1643 rpm, 50% load, Inlet Temp 350 C

MMT Summary - Catalysts

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Use of MMT in Diesel Fuel Improves Aftertreatment Performance

Phosphorous and Sulfur scavenging have been demonstrated during diesel combustion.

Aftertreatment protection from P & S helps to preserve catalyst conversion efficiency.

- **Higher lifetime catalyst efficiency will allow optimization of emission control systems**
- **Reduced warranty and initial equipment costs**

MMT – Diesel Particulate Filters

MMT decreases the rate of soot accumulating in a DPF. There is also a significant reduction in soot oxidation temperature leading to regeneration.

- **Resulting lower average exhaust back pressure improves fuel economy and prolongs engine life**
- **Will reduce the need for heat addition to regenerate DPFs resulting in reduced fuel consumption penalty**
- **May reduce the need for catalytic elements or active regeneration hardware that have associated cost and other issues**

Ongoing Diesel MMT Research

- Treat rate response and optimization
- Different aftertreatment combinations
- Quantify beneficial long term effects on efficiency and durability
- Field demonstration