DIESEL PARTICULATE FILTERS AND NO_2 EMISSION LIMITS

O. Ibrahim, H. Wenghoefer and C. Jackson

OUTLINE

- Background
- NO_2 Limits From Retrofit Technologies
- New Air Quality Standards for NO_2
- Diesel Oxidation Catalysts
- Passive Diesel Particulate Filters
- Active Diesel Particulate Filters
- New Oxidation/Reducing Catalysts
- Conclusions

BACKGROUND


- January 1, 2009
- EPA/CARB
- Limit increase in NO_2 emissions
- Less than 20% above baseline
- From Retrofit Technologies (DOC, DPF, .. etc)

BACKGROUND

CARB Verification

$NO_2 < 20\%$

Level 1 → Level 1 Plus

Level 2 → Level 2 Plus

Level 3 → Level 3 Plus

BACKGROUND

- June, 2009
- EPA Proposes New Air Quality Standards for NO_2
- EPA Goal is to reduce respiratory illness

BACKGROUND

Health Impact of NO_2

- ❑ Scientific evidence links short-term NO_2 exposures, with increased respiratory effects(asthma)
- ❑ Particularly in at-risk are:
  - Children
  - Elderly
  - Workers in confined spaces

Diesel Oxidation Catalysts

$CO + O_2$

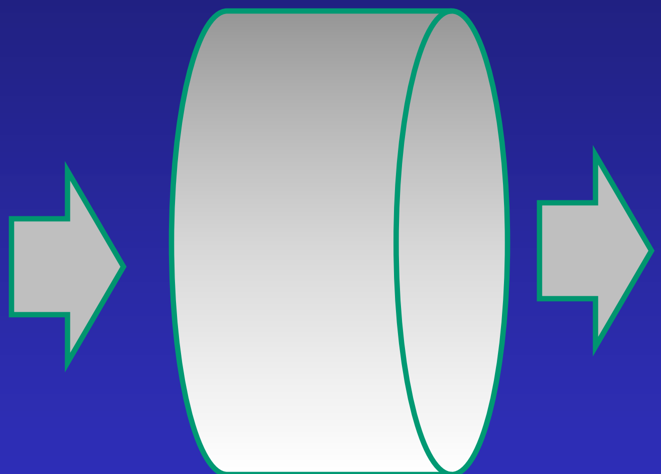
$THC + O_2$

$NO + O_2$

$SO + O_2$

$SOF + O_2$

$C + O_2$



CO_2

$CO_2 + H_2O$

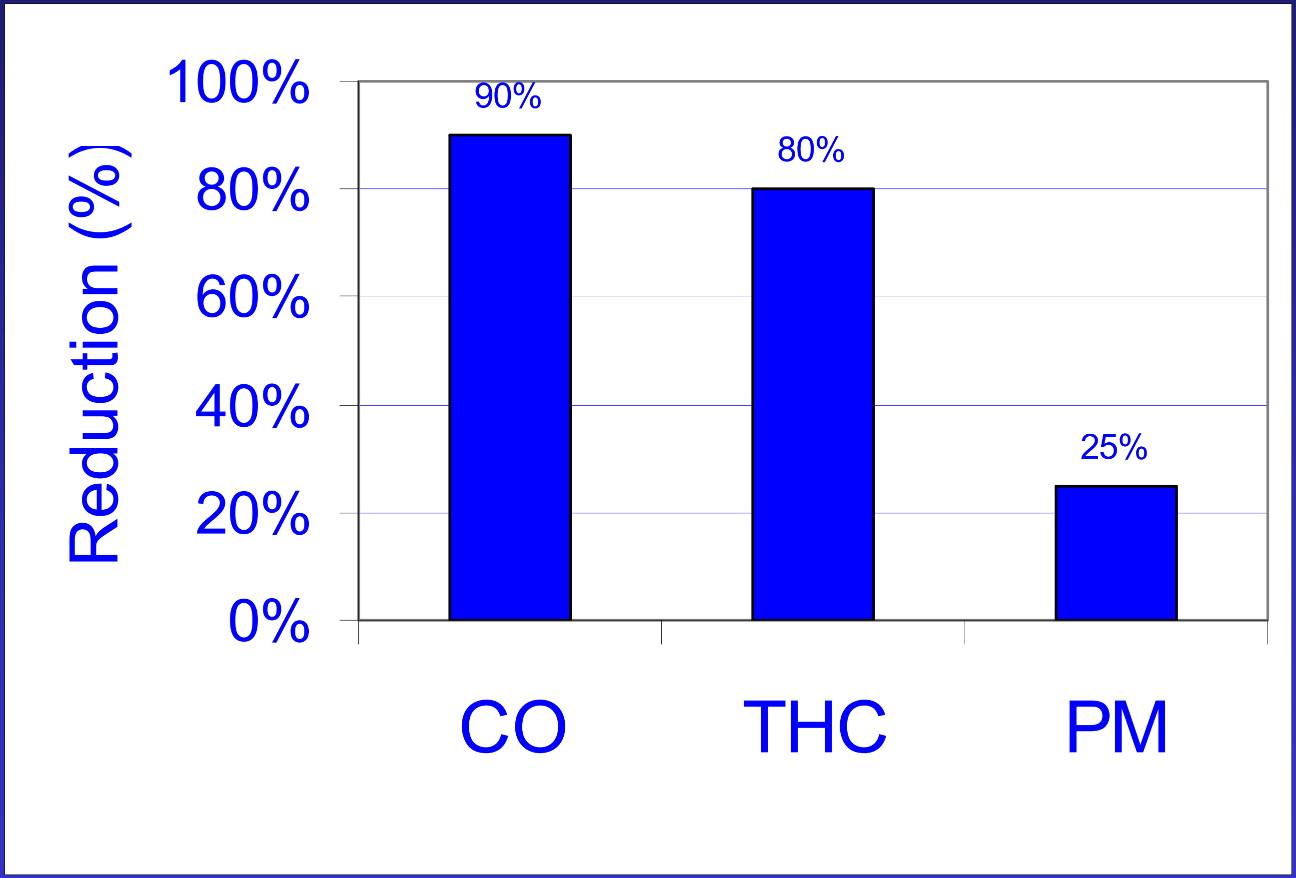
NO_2

SO_2

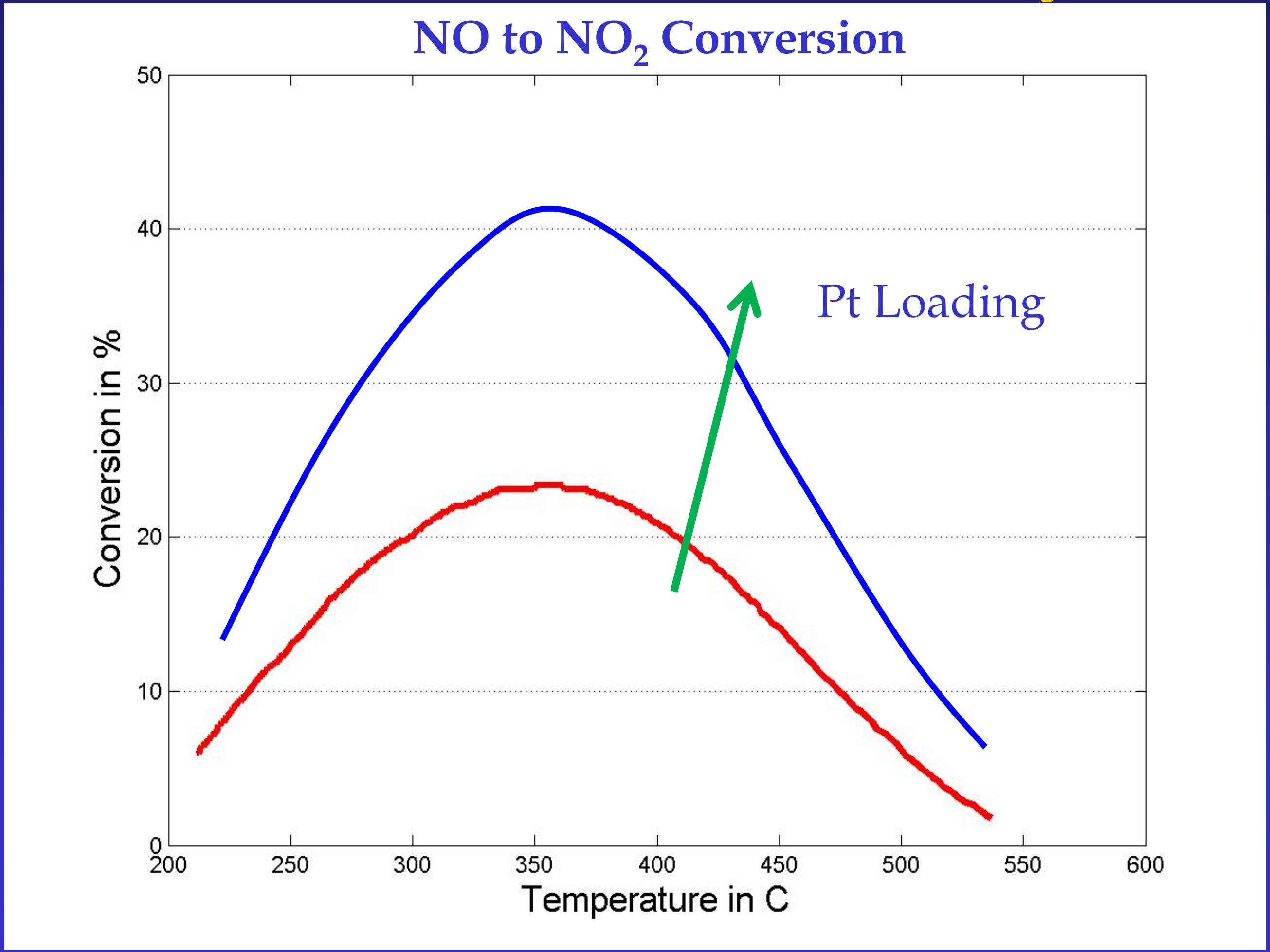
$CO_2 + H_2O$

CO_2

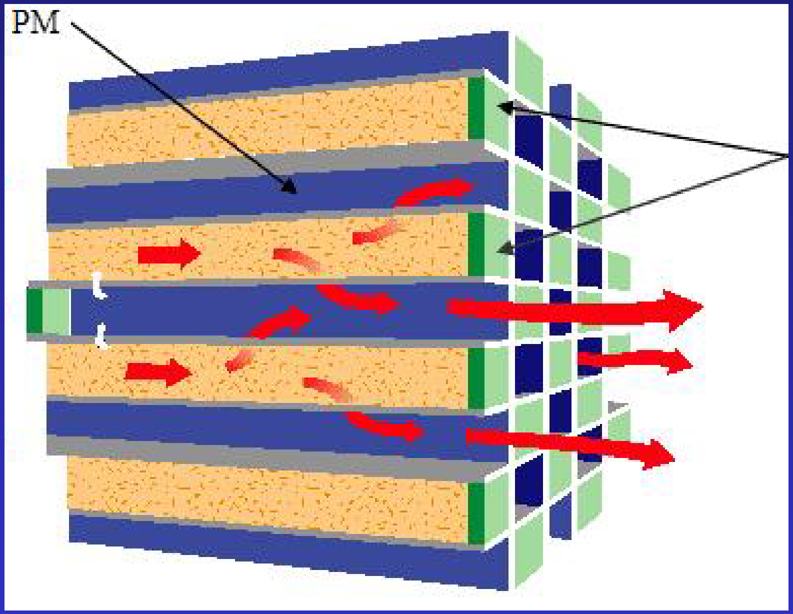
Diesel Oxidation Catalysts



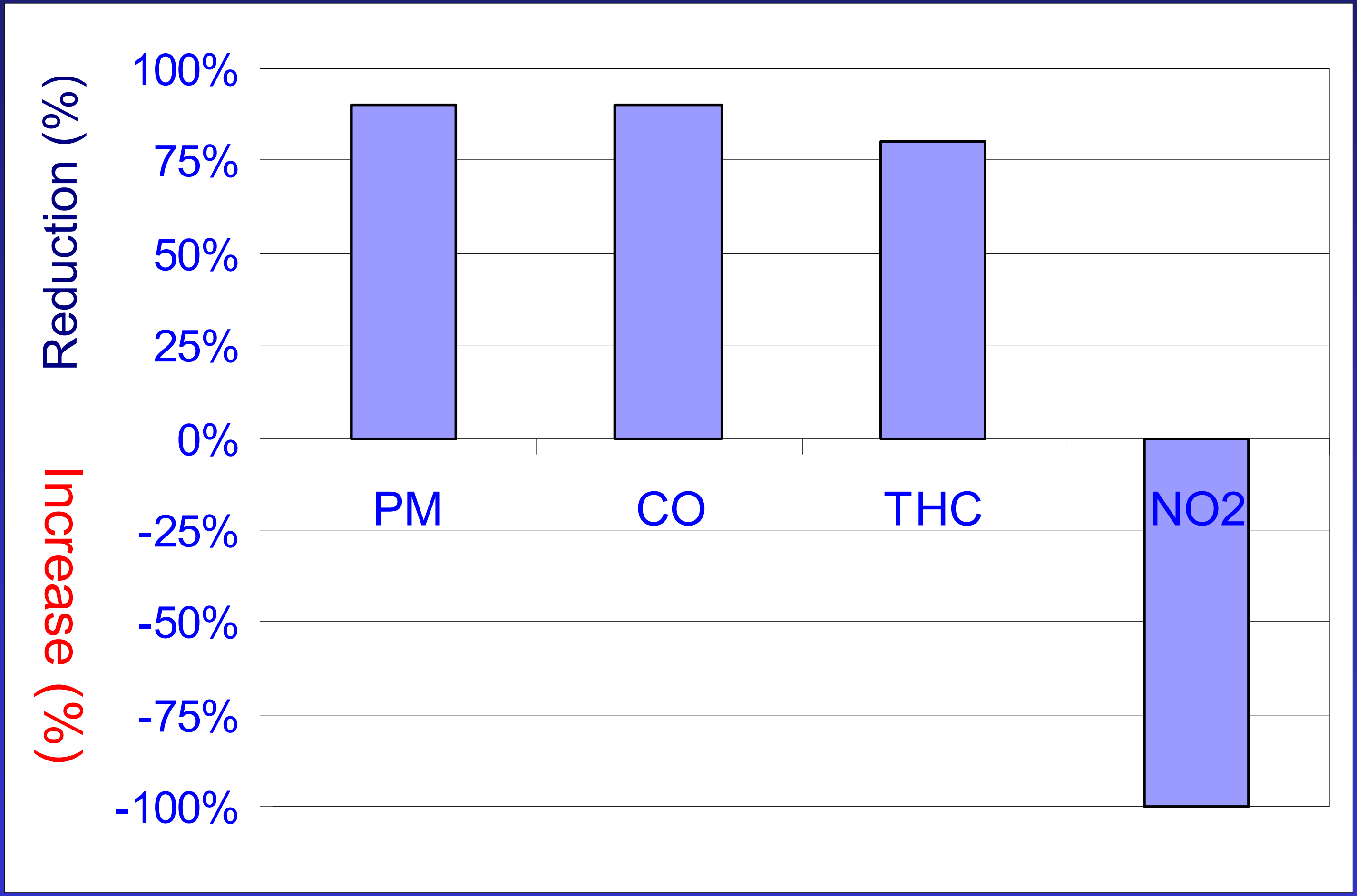
Diesel Oxidation Catalysts



Passive Diesel Particulate Filters

$CO + O_2$		CO_2
$THC + O_2$		$CO_2 + H_2O$
$NO + O_2$		NO_2
$SO + O_2$		SO_2
$SOF + O_2$		$CO_2 + H_2O$
$C + O_2$		CO_2

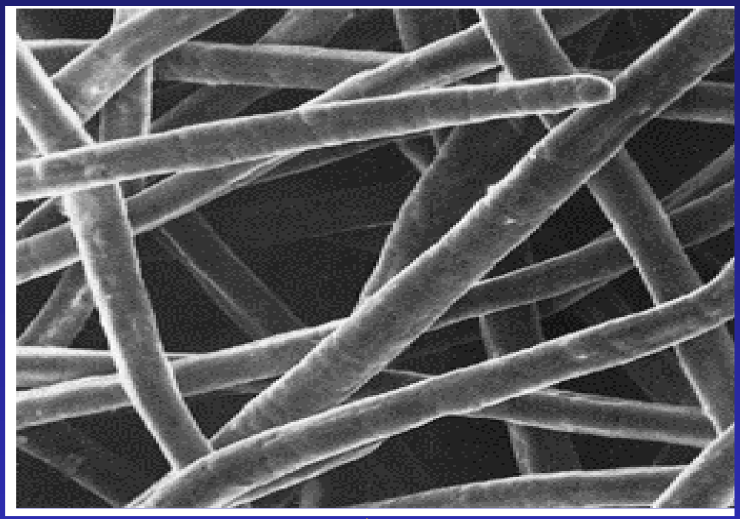
Passive Diesel Particulate Filters

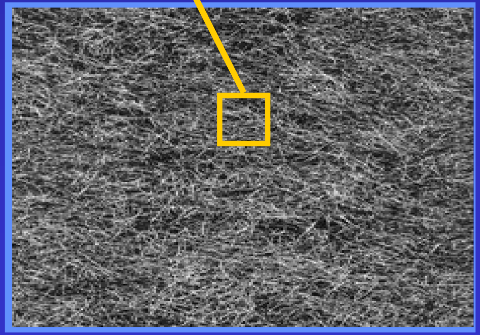


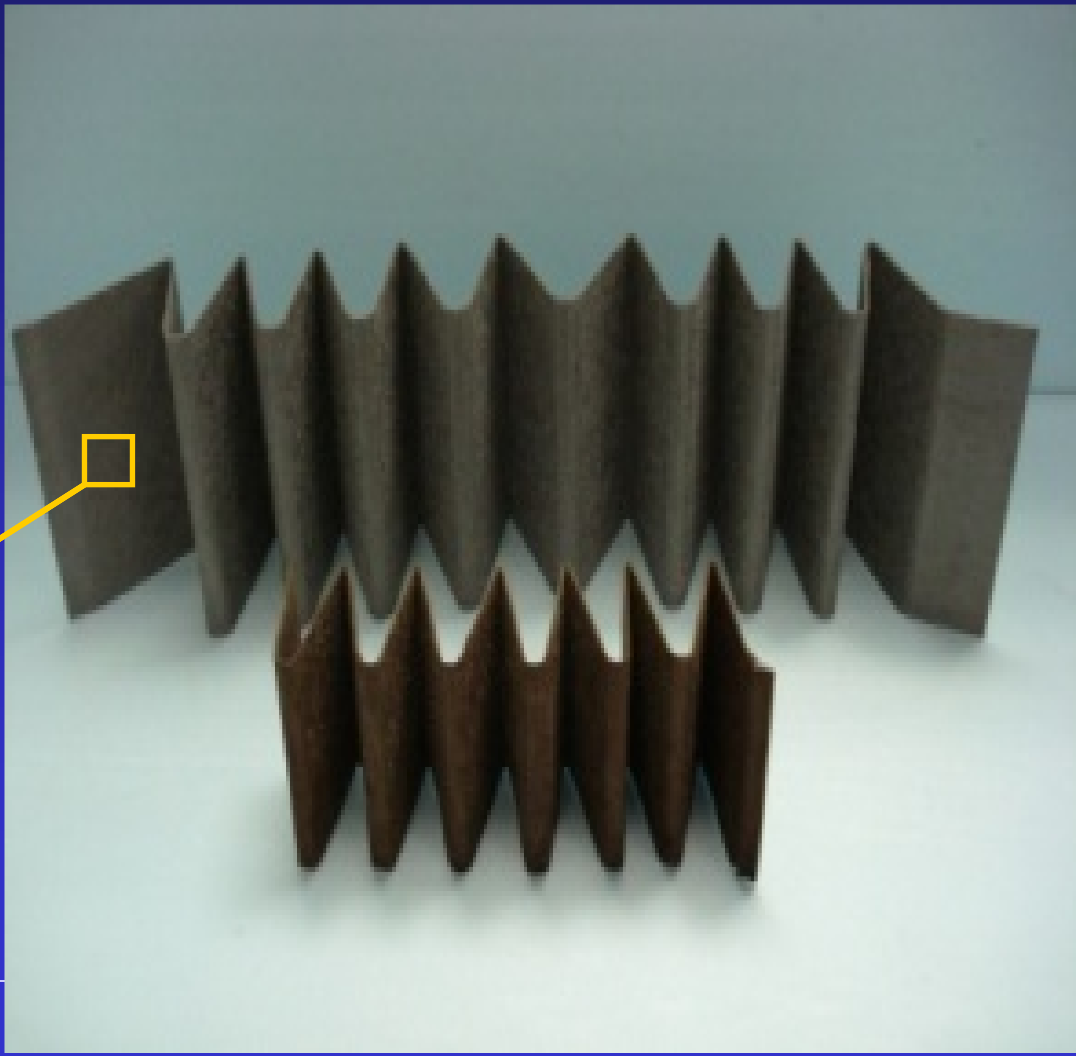
Active Diesel Particulate Filters

- Filters are not coated with oxidation catalysts
- Soot and other particulates are collected as a fluffy layer with high surface area.
- Soot, similar to activated carbon, is able to adsorb hydrocarbons and other gases
- The high surface area increases the reaction probability between carbon and nitrogen dioxide
- Mild diesel oxidation catalysts are used after DPF, thus minimizing the oxidation of NO into NO_2.

Sintered Metal Fibers





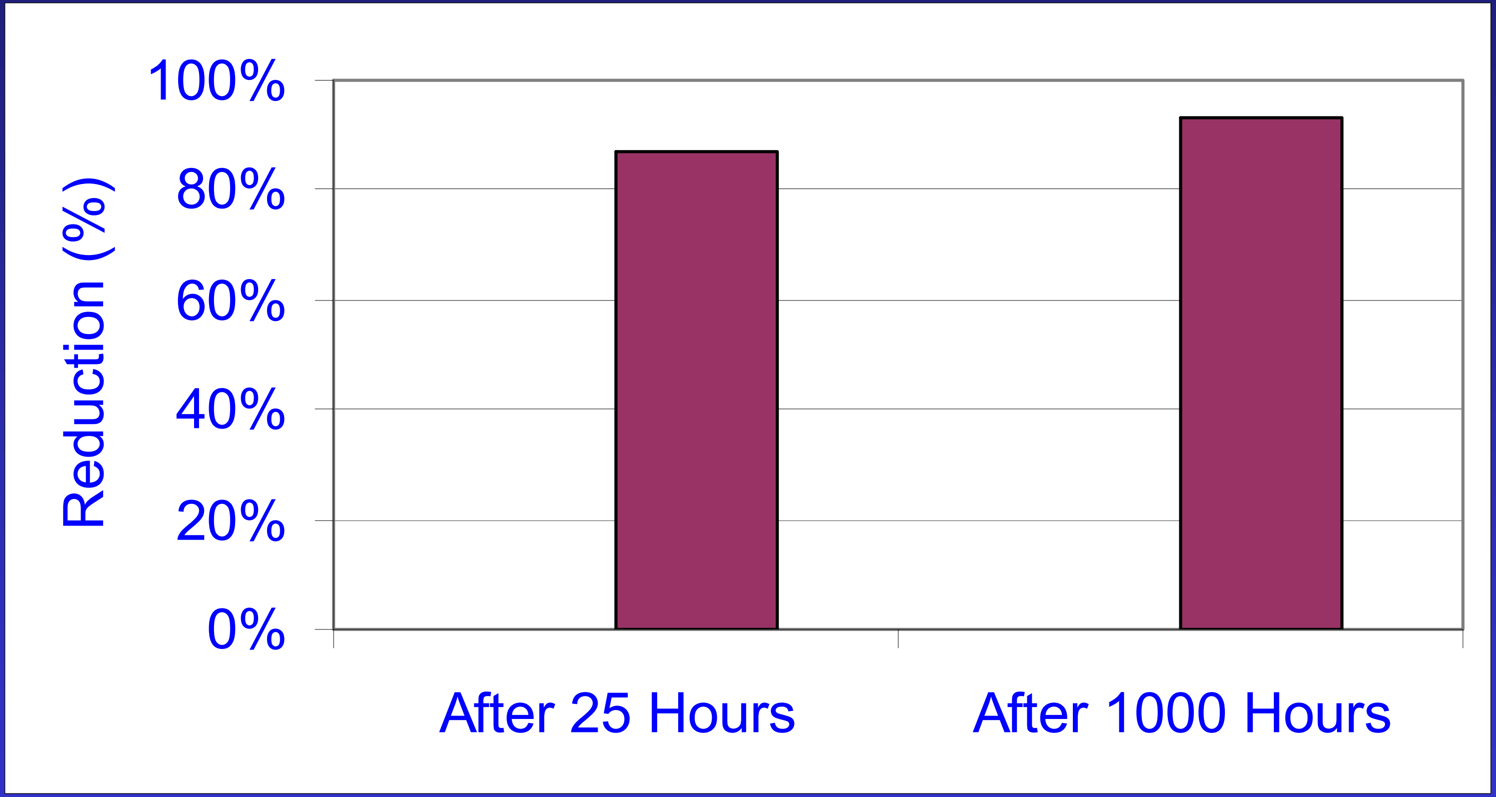


Active Diesel Particulate Filters

Electric Regeneration

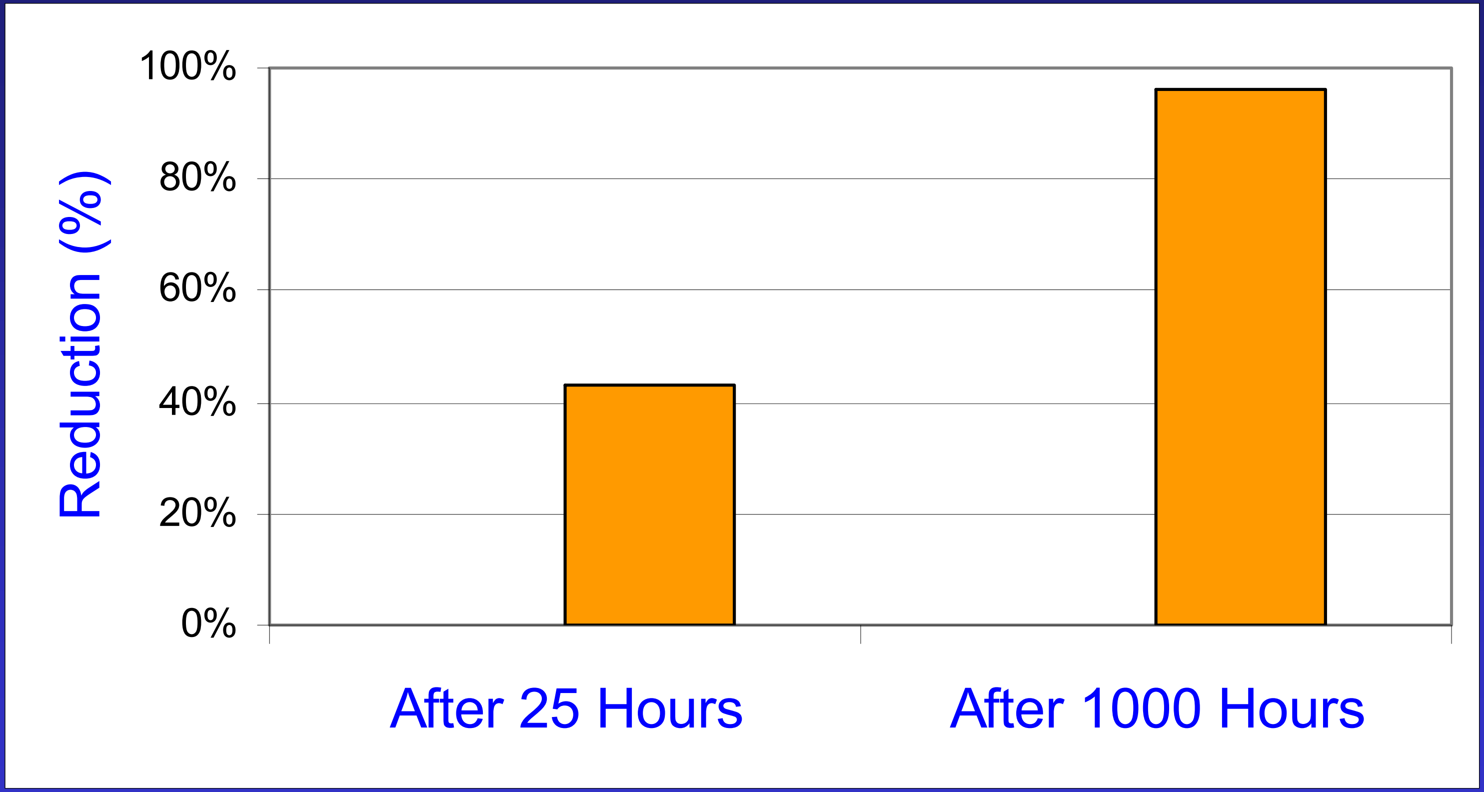
Active Diesel Particulate Filters

PM Reduction



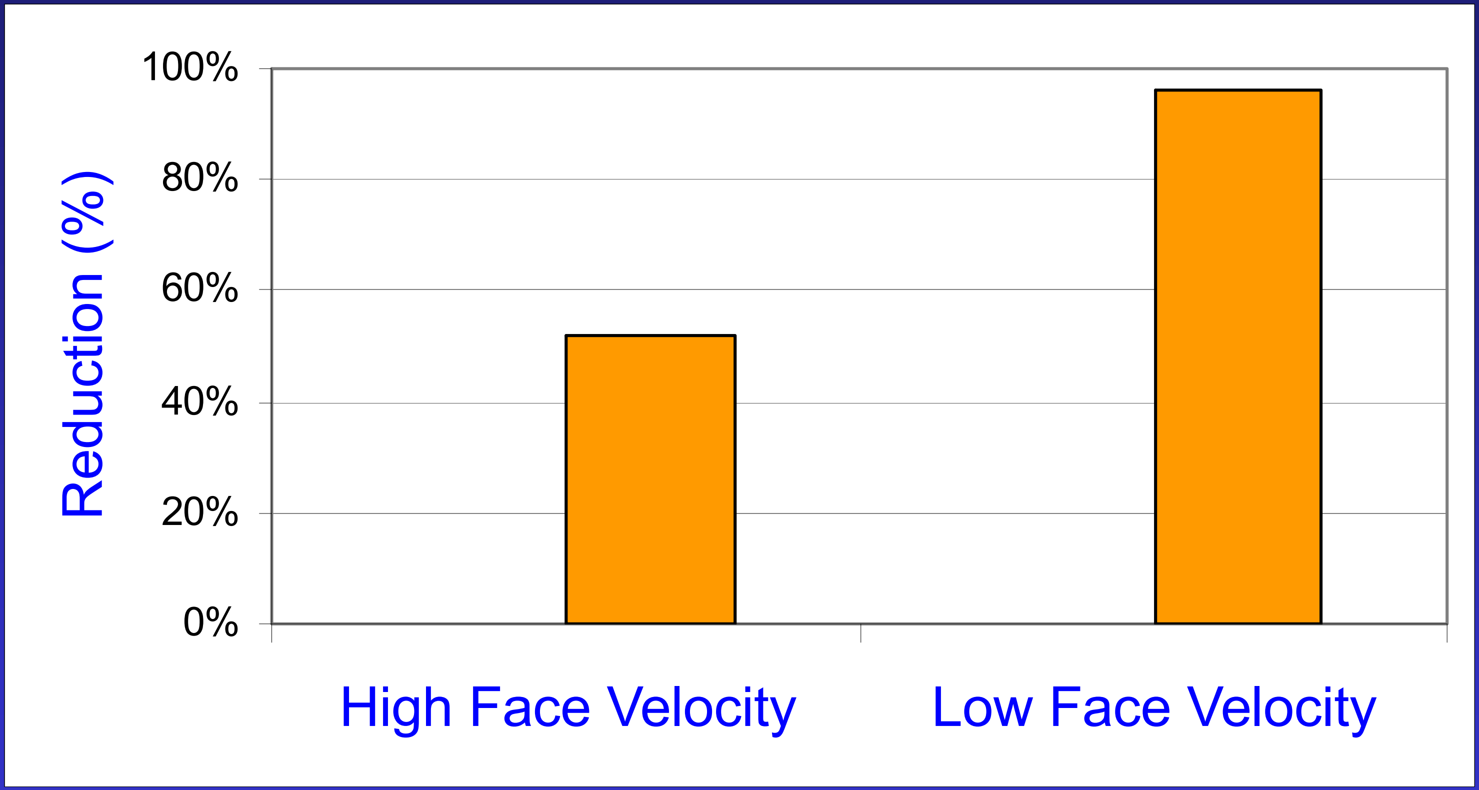
Active Diesel Particulate Filters

NO_2 Reduction



Active Diesel Particulate Filters

NO_2 Reduction



New Washcoat



Objectives:

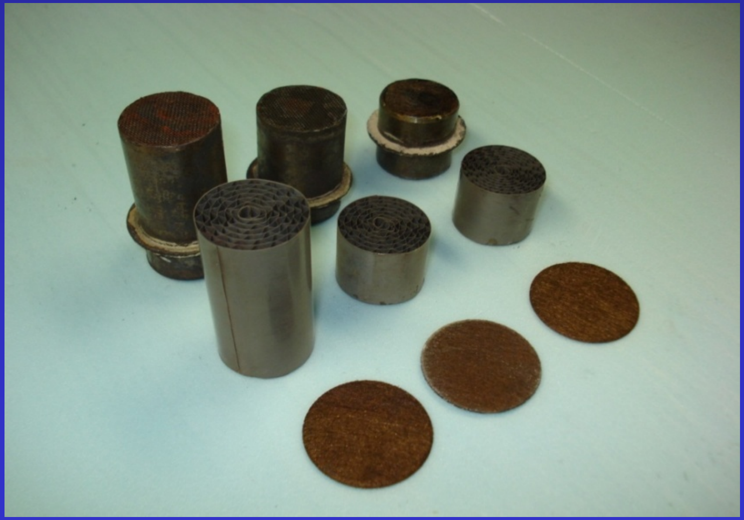
1. Develop washcoats for sintered metal fibers.

2. Develop catalytic topcoats with precious and non-precious metal coating formulations to reduce CO, HC and NO_2.

New Diesel Oxidation/Reducing Catalysts

Emission Reduction Targets

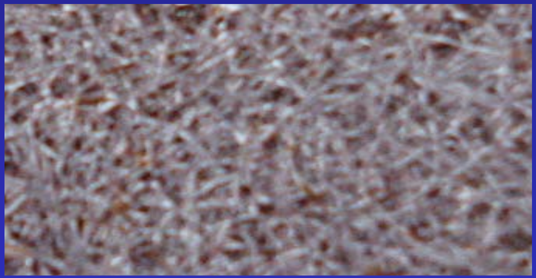
- ❑ PM Reduction: >90%
- ❑ CO Reduction: >90%
- ❑ THC Reduction: >90%
- ❑ NO_2 Reduction: >90%



New Washcoat

A

B



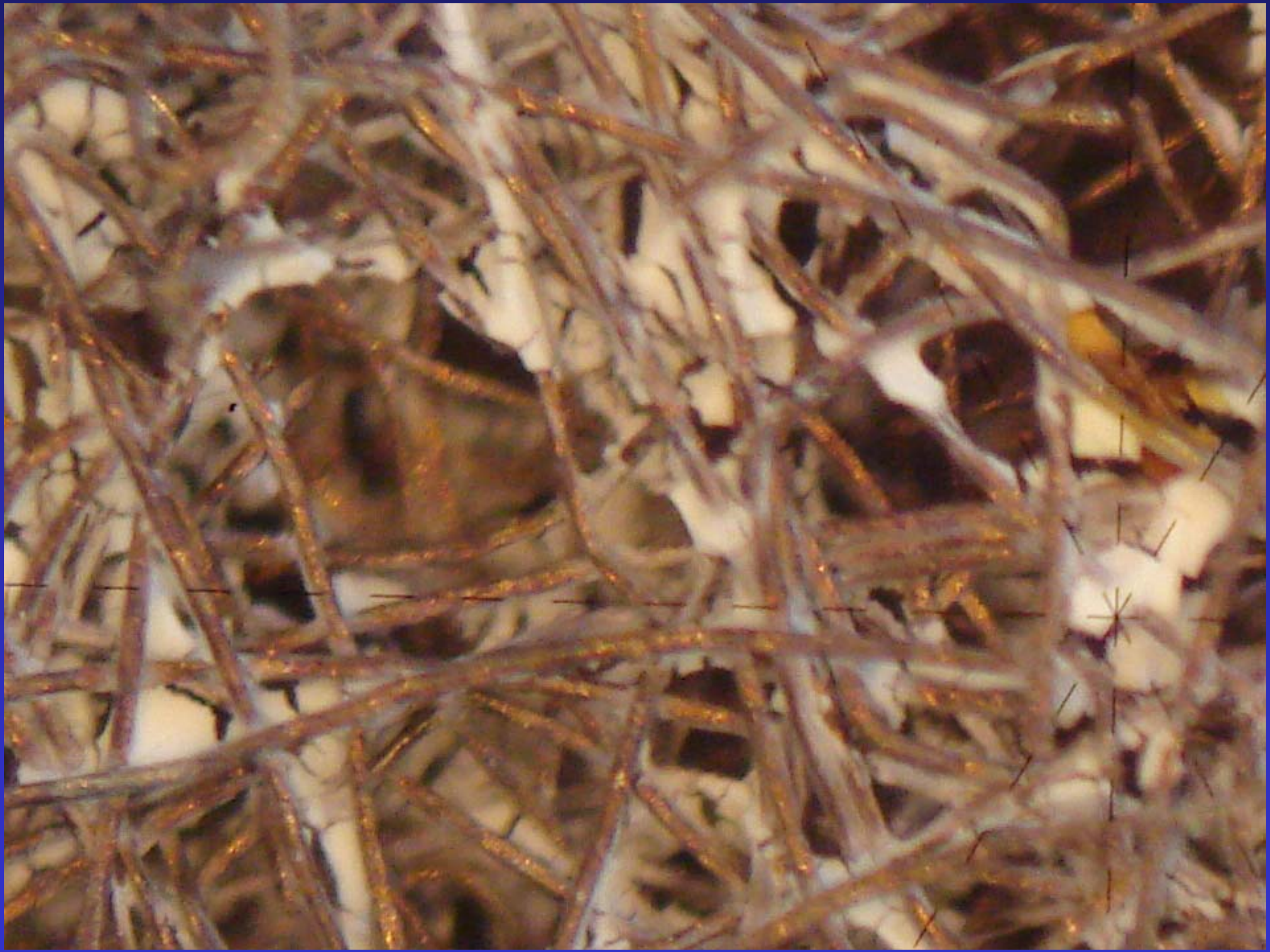
C

Goals

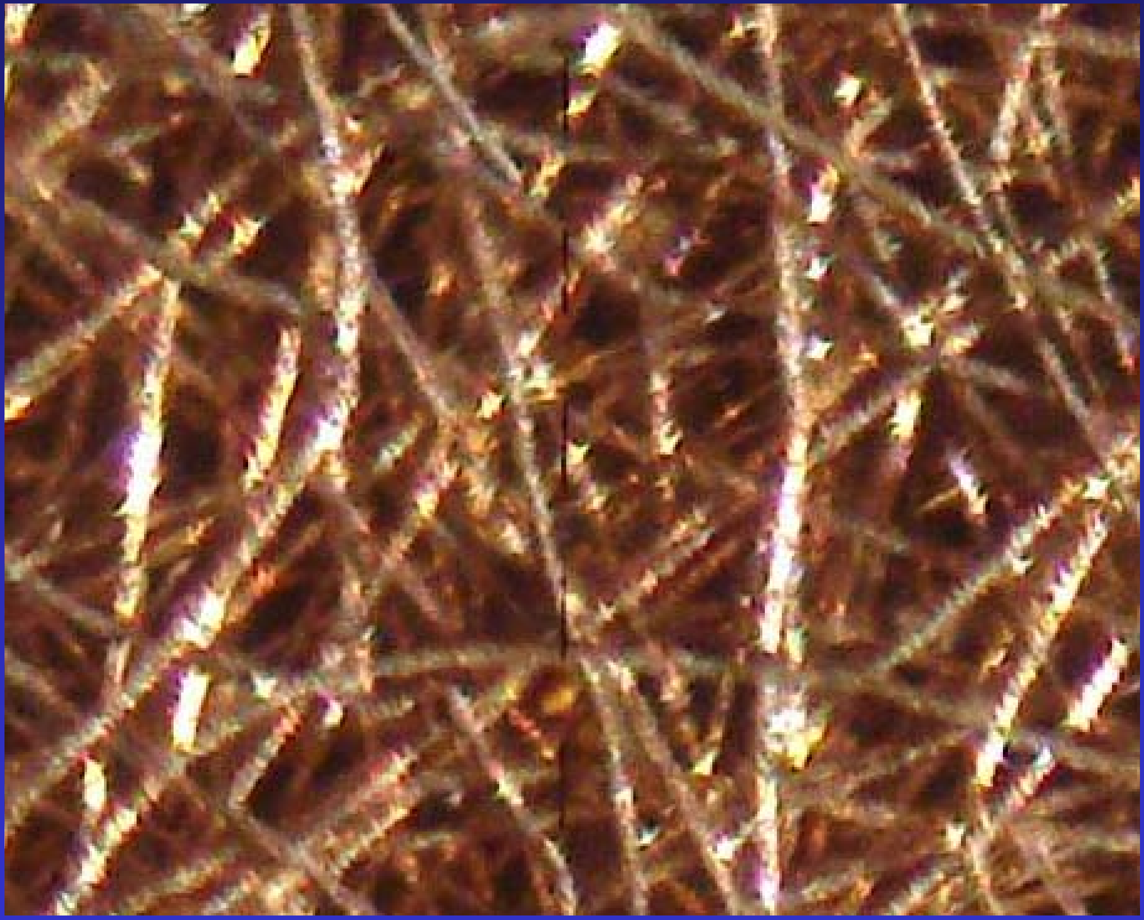
- ❑ Minimize wash-coat material
- ❑ Coat individual fibers
- ❑ Minimize webbing and shedding
- ❑ Minimize the use of precious metals
- ❑ Use of non-precious metals

Washcoat C

Washcoat B



Washcoat A



Emission Testing

- Testing was conducted at Intertek Lab.
- Test Engine was 2005 MY Cummins 5.9L engine.
- Rated at 287 HP @ 2600 rpm
- Test Cycles: ISO 8187-C1 and FTP

ISO 8187-C1 Test Results

	PM	NOx	NO_2	CO	THC
	g/hp-hr	g/hp-hr	g/hp-hr	g/hp-hr	g/hp-hr
Baseline	0.074	2.195	0.080	0.470	0.027
HDPF2	0.007	2.345	0	0.200	0.005
	91%	-3%	100%	58%	82%

FTP Test Results

	PM	NOx	NO_2	CO	THC
	g/hp-hr	g/hp-hr	g/hp-hr	g/hp-hr	g/hp-hr
Baseline	0.073	2.243	0.150	0.780	0.070
HDPF2	0.004	2.345	0	0.360	0.005
	95%	-4%	100%	54%	84%

Summary/Conclusions

- EPA's New air quality standards for NO_2 will impact future DPF designs
- Passive DPFs increase NO_2 emissions
- Active DPFs reduce NO_2 emissions
- Passive/Active DPFs can provide extra degree of freedom to meet NO_2 limits
- New Oxidation/Reducing Catalysts are needed to reduce CO, THC and NO_2