



**WEST COAST COLLABORATIVE**  
Public-private partnership to reduce diesel emissions

# Diesel Exhaust Aftertreatment

## Retrofit Strategies for Controlling Diesel Emissions

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# Many Technologies – Buyer Beware

- Questions:
  - Fleet manager:
    - How do you know that a technology works?
    - How do you know that a technology is safe?
    - Is the technology well supported locally?
  - Air Agency:
    - How do you know that a valid air quality improvement claim can be made?
- Answer: Verification
  - CARB: [www.arb.ca.gov/diesel/verdev/verdev.htm](http://www.arb.ca.gov/diesel/verdev/verdev.htm)
  - EPA: [www.epa.gov/otaq/retrofit/retroverifiedlist.htm](http://www.epa.gov/otaq/retrofit/retroverifiedlist.htm)



# Diesel Emissions

- What emissions are produced by diesel engines?
  - The annual emissions from a “Fleet Average” heavy-duty diesel truck relative to the annual emissions from a catalyzed “Fleet Average” gasoline car<sup>1</sup>

<b>Emission</b>	<b>Car Equivalents</b>	<b>Health Effects</b>
Particulate Matter (PM)	112	Toxic, Carcinogenic
Oxides of Nitrogen (NO <sub>x</sub> )	131	Toxic (NO <sub>2</sub> ), Ozone-forming
Hydrocarbons (HC)	9	Toxic, Carcinogenic, Ozone-forming
Carbon Monoxide (CO)	2	Respiratory Irritant, Potentially Fatal

1. California emissions data from EMFAC comparing a “fleet average” catalyzed car with a “fleet average” heavy-duty diesel truck (over 33,000# GVWR)



# Controlling PM

Minor Control (5% - 10%)	Crankcase recirculation
Modest Control (15% - 25%)	Diesel Oxidation Catalyst (DOC)
Intermediate Control (25% - 70%)	<ul style="list-style-type: none"><li>•Partial Filter</li><li>•Turbulent Flow DOC</li></ul>
Maximum Control (85% - 95%)	<ul style="list-style-type: none"><li>•Diesel Particulate Filter (DPF)</li></ul>



# Crankcase Recirculation

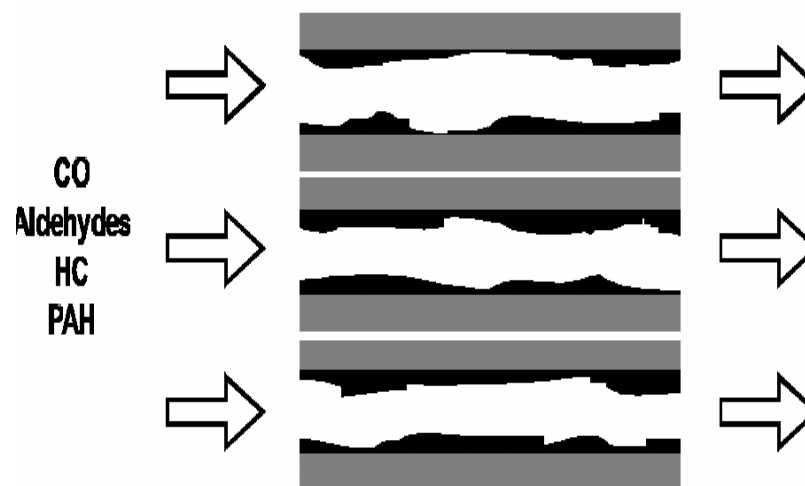
- Filters crankcase (breather tube) emissions and reintroduces them to the intake air



## Exhaust Aftertreatment – Oxidation Catalyst

- Reduces HC, CO and some PM
- Flow through that “converts” PM rather than “trap” PM
- PM reductions can be on the order of 15% to 25%
- No periodic cleaning necessary

Diesel Oxidation Catalyst Functional Diagram





## Exhaust Aftertreatment – Turbulent Flow

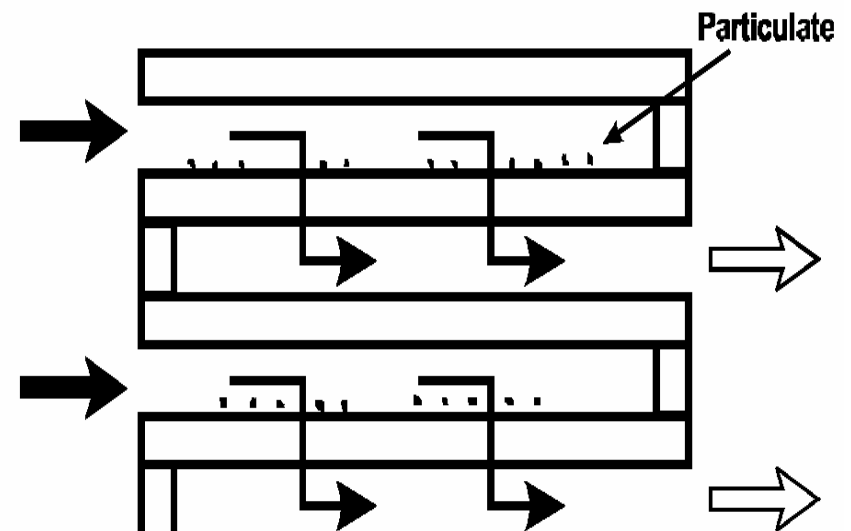
- Typically catalyzed to reduce HC, CO and lower PM regeneration temperature
- Flow through “turbulent” path
  - Wire mesh or metal foil
- PM reductions can be on the order of 50% to 70%
- No periodic cleaning necessary



# Exhaust Aftertreatment - Filter

- Non-catalyzed filter – Reduces PM
  - Traps PM
- Catalyzed filter – Reduces PM, HC & CO
  - Traps PM
  - Catalyzes HC and CO
- Requires high heat to burn off PM (like a self-cleaning oven)
  - Exhaust heat from engines under high load
  - Electric elements or fuel burners
- Non combustible materials stay in filter and must be removed periodically

Diesel Particulate Filter Schematic





# Filter Maintenance

Captured in tail pipe . . .



Collected in filter bags . . .



Stored onsite . . .



May need to  
be handled  
as a  
hazardous  
material

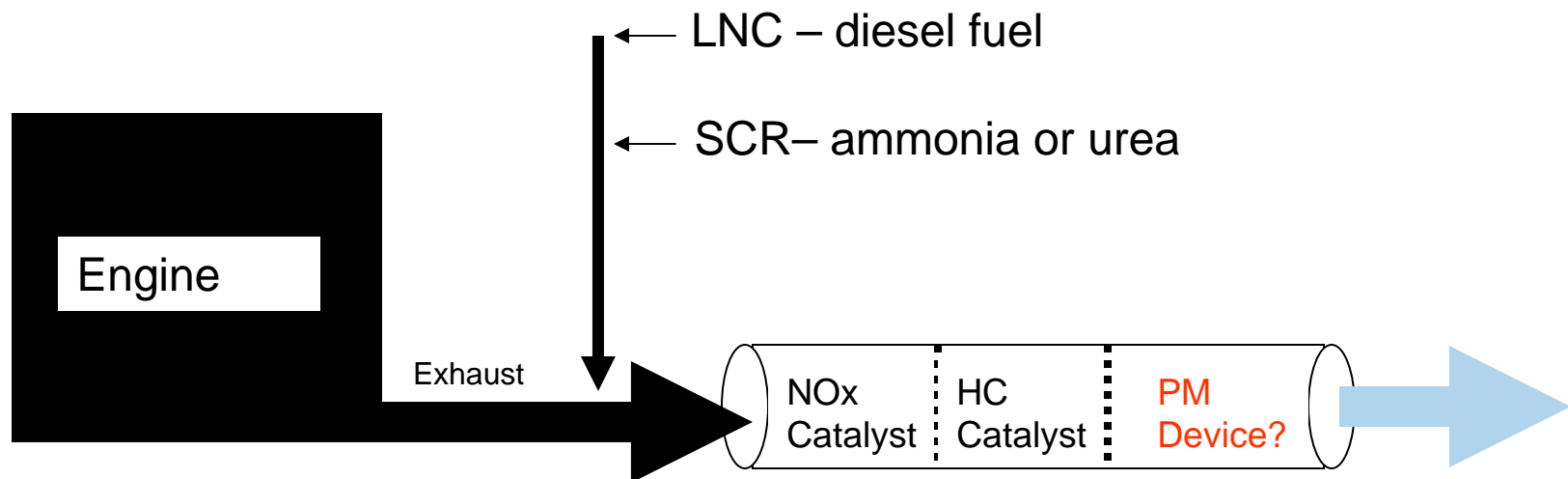


# Controlling NOx

<b>Level of Control</b>	<b>Technology</b>
Modest Control (25% - 35%)	Lean NOx Catalyst (LNC)
Intermediate Control (30% - 50%)	Exhaust Gas Recirculation (EGR)
Maximum Control (60% - 90%)	Selective Catalytic Reduction (SCR)

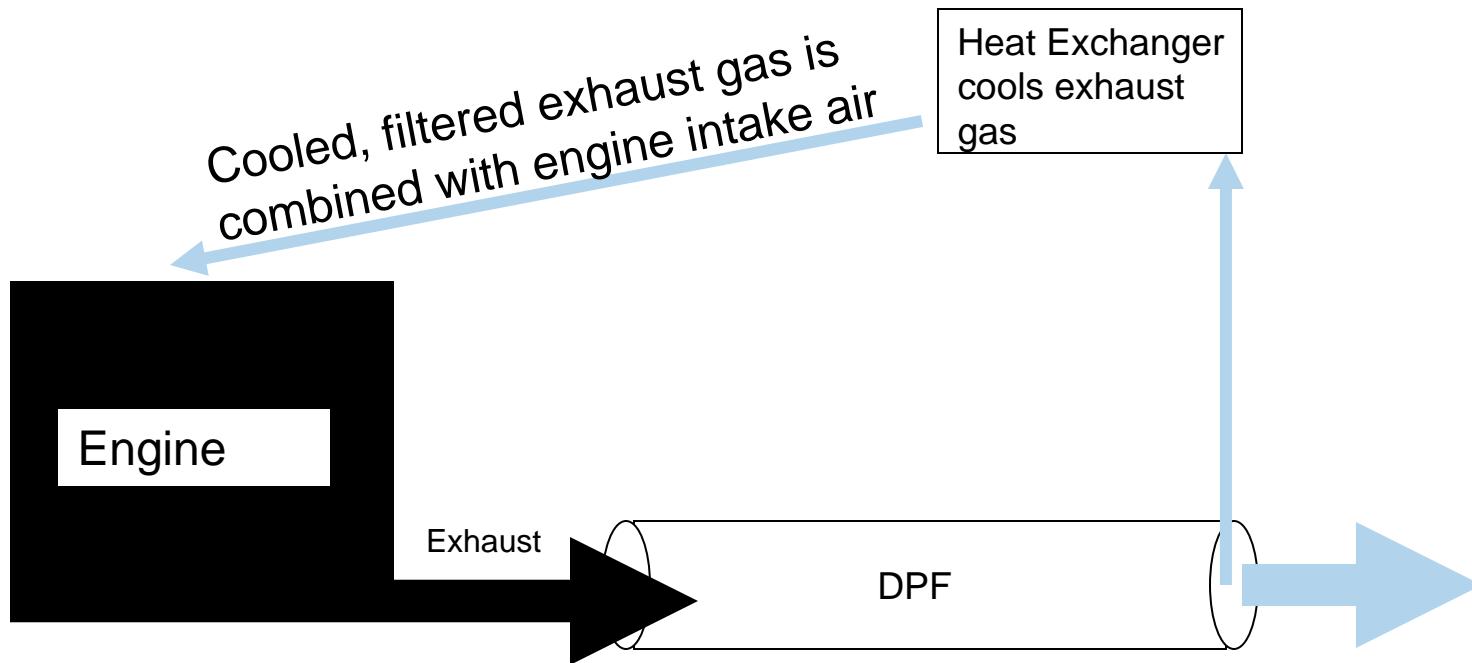


# LNC & SCR





# EGR





# Controlling HC and CO

- Catalytic coatings on aftertreatment devices will reduce HC and CO by 40% - 95% depending on catalyst loading and exhaust heat