Ozone Impacts of Diesel Particulate Filters in DFW: Project Number E6

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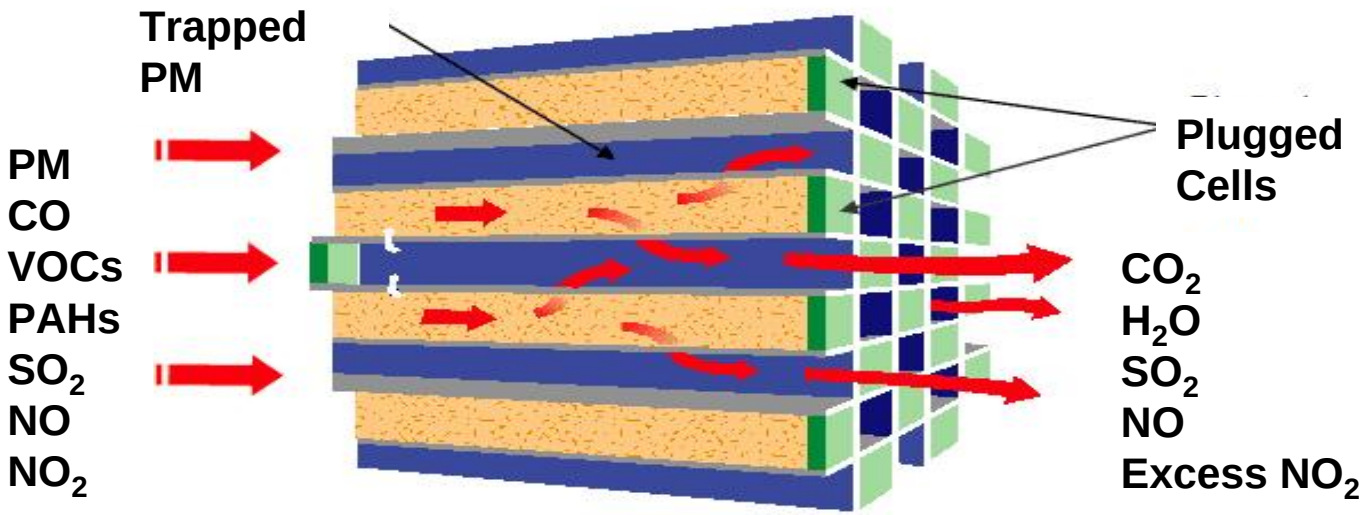
Outline

- **Many diesel engines use DOCs and catalyzed DPFs to meet stringent PM emissions standards**
- **DOC/DPF potentially creates excess NO_2 emissions that impact ozone & PM nitrate formation**
- **EPA's findings showed baseline NO_2 fraction of NOx was 6%, increased to 26% to 34% for DPF-equipped trucks**
- **Ozone impacts of excess NO_2 emissions may be especially problematic in the urban core of DFW area**

Diesel Particulate Filters (DPFs)



- DPF traps PM from engine exhaust, and regenerates by oxidizing PM at high temperature
- Active regeneration (e.g. plug in electric or fuel injection) or passive regeneration (e.g. catalyzed DPF)

Catalyzed DPFs

- Variety of strategies are used for continuous passive regeneration
- Most common is to place a Diesel Oxidation Catalyst (DOC) upstream of DPF or use catalyzed DPF
  - Converts exhaust NO to NO_2
  - Exhaust NO_2 assists soot combustion by acting as oxidizing agent for soot, and lowering catalyst "light-off" temperature
  - Excess NO_2 remaining after soot oxidation increases exhaust NO_2/NOx ratio

Catalyzed DPFs – Excess NO_2

- EPA found NO_2 emissions from DPFs can increase over baseline by 20% to 28% of total NOx
- MECA Studies also found that catalyzed DPFs emit excess NO_2 and recommended mitigation strategies
- CARB currently limits DPF *retrofit* devices to increase exhaust NO_2 to a max of 30% of total NOx mass starting Jan 2007, and 20% after Jan 2009
- EPA has not identified any specific compliance requirements for DPFs or DOCs with respect to NO_2 emissions

MECA: Manufacturers of Emission Controls Association

Ozone Impact of Excess NO_2

$$NO + O_3 \rightarrow NO_2 + O_2$$

- **Shifting chemical form of emitted NOx from NO to NO_2 reduces amount of ozone titrated by fresh NO emissions**
  - **Increase ozone in urban core**
  - **Enable more rapid ozone production downwind of urban core**

Excess NO_2 Concern – DFW Area

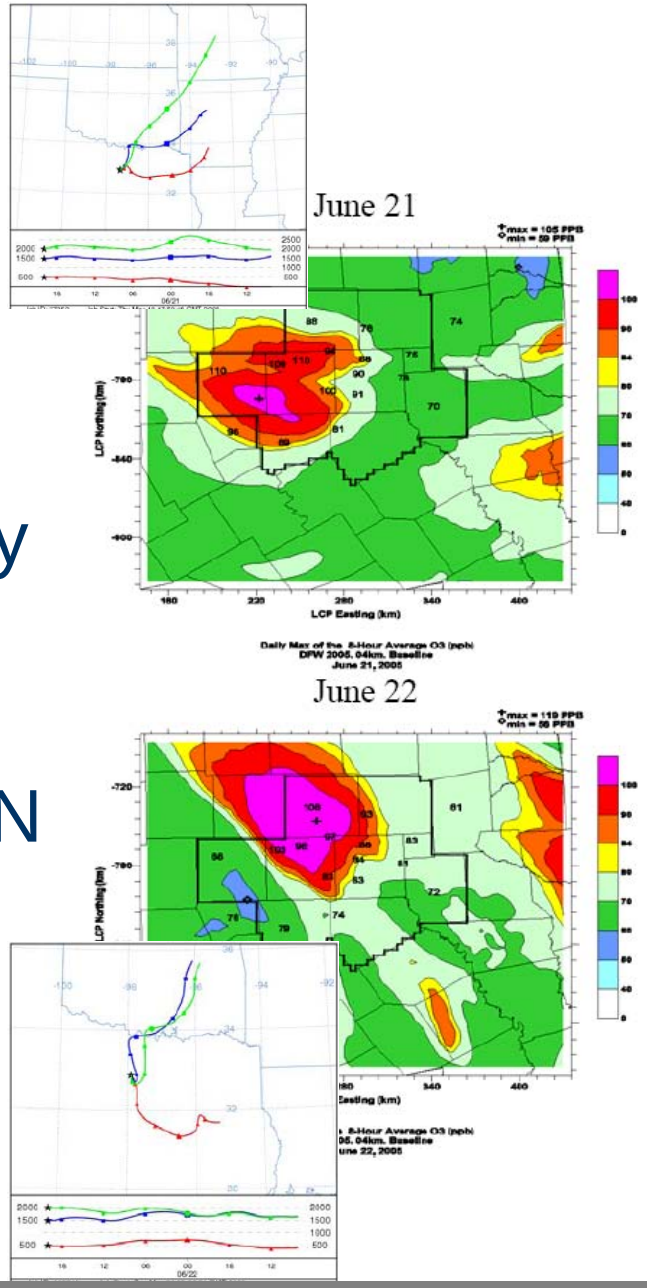
- Ozone impacts of excess NO_2 emissions most problematic when emissions are concentrated and occur in an area where ozone formation is inhibited by high NOx concentrations, as in the urban core of DFW
- Large fleets of HD diesel vehicles and off-road engines used in construction and other industries

Project Suggestion

- **Evaluate ozone impacts of excess NO_2 from DPFs using the June 2005 ozone episode developed for DFW in TERC project H60**
- **Project Objective – To show whether excess NO_2 emissions from DPFs will hamper progress toward attaining ozone standard in DFW and other parts of Texas**

H60 Model for DFW

- June 18-23, 2005
  - 2009 future year available
- Stagnation period with winds progressing from northeasterly to southerly
- MM5 meteorology by TAMU
- Emissions by TCEQ/ENVIRON
  - Mobile sources based on NCTCOG travel demand model
  - Detailed information for HDDVs



Project Approach

- **TCEQ emissions inventory will be used for fleet characteristics of on-road HD diesel engines and off-road diesel equipment categories**
- **Estimate of penetration rates of DPFs into these fleets**
- **Latest findings from EPA- and CARB-sponsored studies/reports will be used to quantify effect of DPFs on NO_2/NOx ratio of emissions**
- **Develop several scenarios for excess NO_2 emissions in several future years (e.g., 2012 and 2018)**

Project Approach (cont.)

- Conduct ozone modeling to evaluate the ozone impacts of DPFs for 2009 future year
  - Actual penetration of DPFs by 2009 will be limited by slow fleet turnover of heavy-duty diesels
  - Conduct sensitivity tests to evaluate how significant the ozone impacts of DPFs could ultimately become
  - Sensitivity tests also will investigate whether excess NO_2 emissions produce different magnitudes of ozone impacts in urban vs. rural environments

Expected Benefits/Policy Relevance

- TERC Strategic Research Plan: “Special attention should be given to mobile sources since they contribute a large portion of NOx and VOC emission”
- Diesel particulate filters are being *utilized now* in new heavy-duty diesel vehicles
- Demostrate whether excess NO_2 emissions from DPFs will hamper progress toward attaining the ozone standard in DFW and other parts of Texas.

Emission Benefits of Advances in Low-NOx Burner Technology

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Advanced Burner Design

- **Manufacturers continuously refine burner designs**
  - Lean premixed combustion, staged fuel combustion and flue gas recirculation are the preferred control strategies
  - Prototype burners in test furnaces have achieved NOx levels as low as 5 ppm
  - Current commercial burners can achieve NOx levels about 20-50% below those of the prior generation of burners (2001)
- **Process heaters:**
  - Key suppliers of advanced burner designs include Zeeco, John Zink and Callidus Technologies
  - NOx emissions of 10-15 ppm have been achieved in commercial applications
  - Reductions in burner diameter and flame length have improved retrofitting
- **Boilers:**
  - Key suppliers of advanced burner designs include TODD Combustion and COEN
  - Suppliers have guaranteed NOx levels as low as 9 ppm

Advanced Burner Performance

Category	Current HGB ESADs (30 TAC 117.310(a))	Potential Emission Reductions with Commercially Available Burner Technologies
Gas-fired Boilers (≥ 100 MMBtu/hour)	0.020 lb/MMBtu	20-50%
Gas-fired Boilers (40-100 MMBtu/hour)	0.030 lb/MMBtu	20-50%
Gas-fired Boilers (< 40MMBtu/hour)	0.036 lb/MMBtu	20-50%
Process Heaters (≥ 40 MMBtu/hour)	0.025 lb/MMBtu	20-50%
Process Heaters (< 40MMBtu/hour)	0.036 lb/MMBtu	20-50%

ENVIRON Project Concept

- Approach:
  - Determine achievable NOx emission limits by emission source category for combustion retrofits using state of the art, commercially available technologies
  - Define current HGB combustion inventory performance:
    - NOx control plans
    - ECT-1Annual Compliance Reports
    - Facility surveys
  - Estimate reduction in emissions and costs of control if state of the art combustion technologies were applied to the HGB inventory
- Project cost range: $100K - $150K
- Refine analysis by working with a limited number of facilities to develop more robust emissions and cost data (Phase II)

Q & A