



# PuriNOx™ Low Emission Diesel Fuel

## Faster Freight Cleaner Air

Oakland, California

December 8, 2004



**Presented by: Ron O. Dunfee**  
**Market Development Manager**  
**The Lubrizol Corporation**

# What is PuriNOx™?

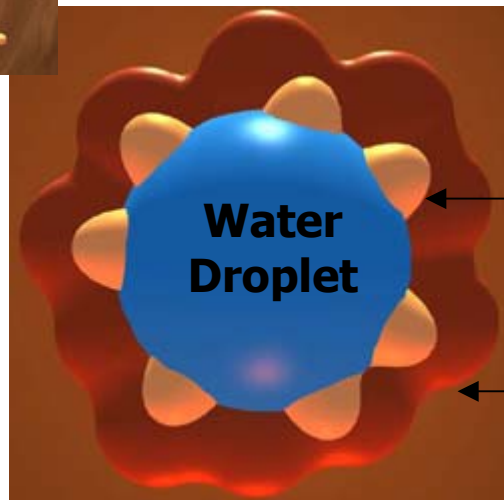
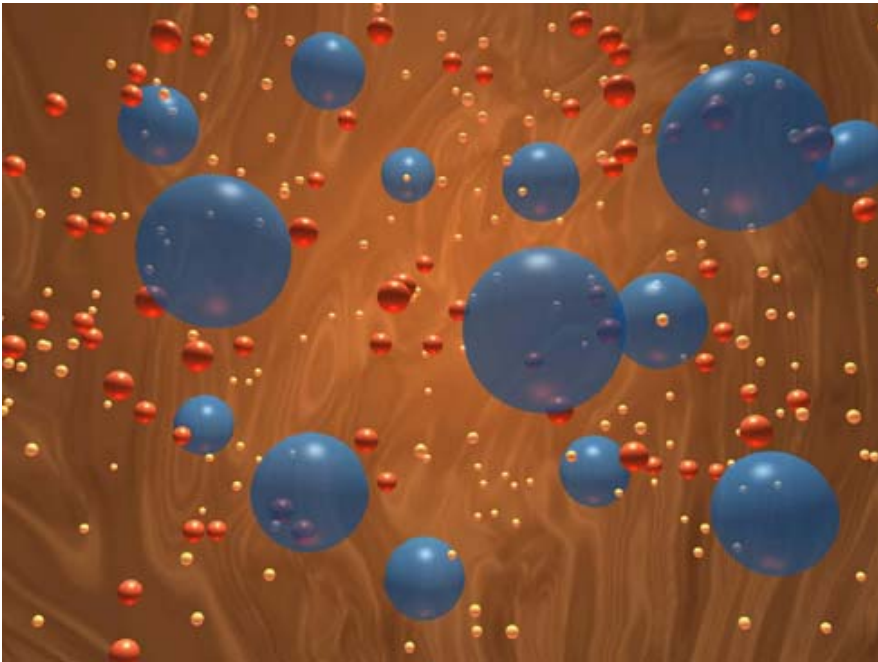
- **A pollution mitigation technology**
  - A means of reducing NOx and PM from diesel engine exhaust
  - Competes with other diesel engine mitigation technologies like natural gas
  - Does not compete with diesel fuel
  
- **An emulsified diesel fuel (EDF)**
  - Contains up to 20% emulsified water
  - Stable emulsion
  - Skim milk in appearance and consistency



# PuriNOx™ Fuel

## Water-in-Diesel Fuel

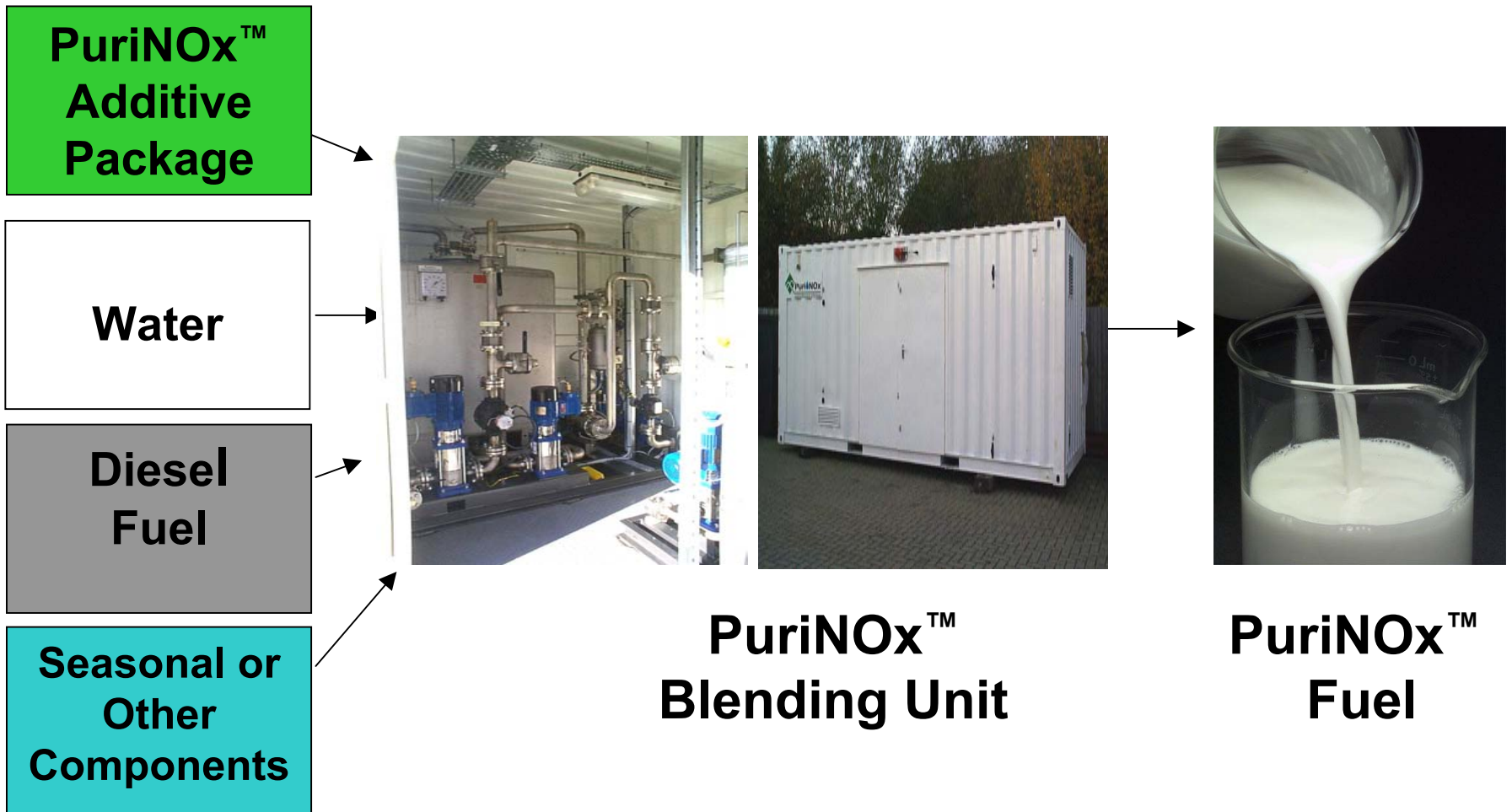
- Diesel is the outside phase
- Similar properties to diesel
- Handles like diesel
- Mixes with diesel fuel



Water Soluble  
"Head"  
of Additive

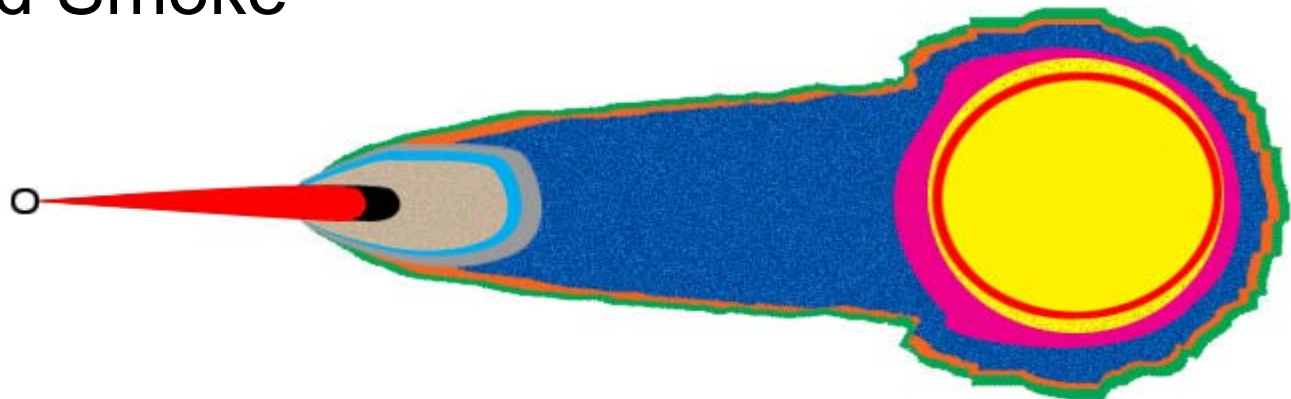
Fuel Soluble  
"Tail" of Additive

# How is PuriNOx™ Made?



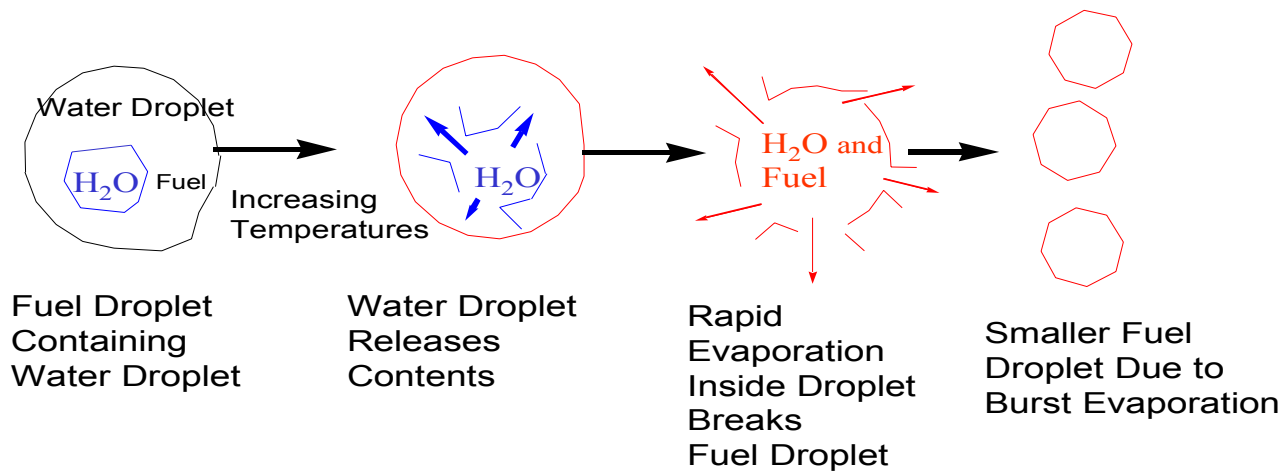
## What Water Does in The Emulsified Fuel

- Water Reduces Combustion Temperature Which Reduces NO<sub>x</sub>
- Water Changes the Combustion Process to Burn the Fuel More Efficiently
  - Which Reduces Particulate Matter and Smoke



# Combustion Mechanism

Burst Evaporation Leads to Enhanced Vaporization of the Fuel and Turbulent Mixing Results in Improved Combustion



The Loss of Energy in the Vaporization Process Decreases Combustion Temperature Which Slows the Reaction Between Oxygen and Nitrogen to Form NO<sub>x</sub>

# Regulatory Credentials

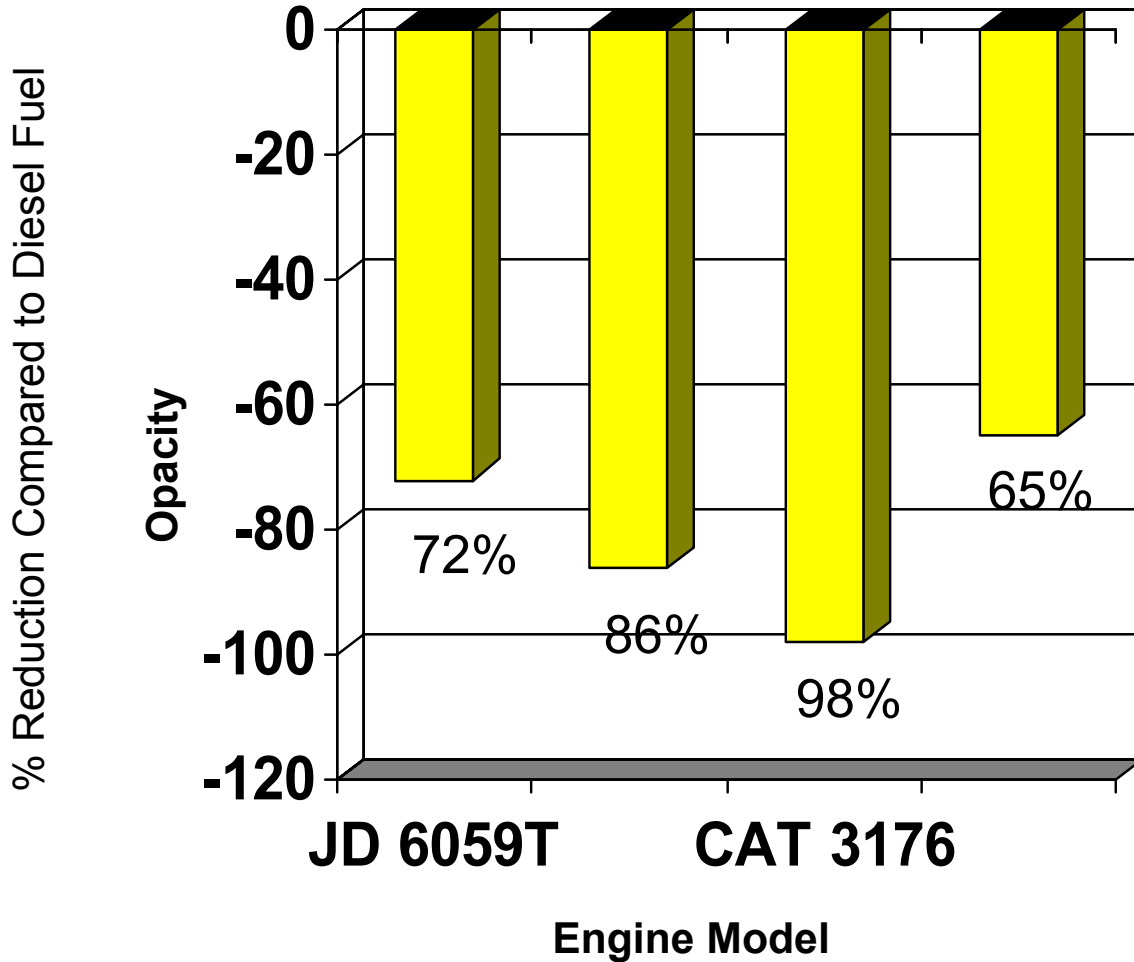
- EPA Registered
- EPA Verified
  - On-Road
  - Off-Road
- CARB Voluntary Verification
- CARB Regulated Verification Level II

# Emission Reduction Summary

	<b>NOx</b>	<b>Particulate Matter</b>
<b>Lubrizol Market Claim</b>	<b>5 - 30%</b>	<b>20 - 65%</b>
<b>Average from Dynamometer Tests</b>	<b>12.6%</b>	<b>46.4%</b>
<b>Average from Field Tests</b>	<b>26.6%</b>	<b>45.3%</b>
<b>CARB Voluntary Verification</b>	<b>14%</b>	<b>63%</b>
<b>CARB Regulated Level II Verification</b>	<b>20%</b>	<b>50%</b>
<b>EPA On-Highway Verification</b>	<b>9-13%</b>	<b>51-58%</b>
<b>EPA Off-Highway Verification</b>	<b>17-20%</b>	<b>17-23%</b>

# Opacity

In-Service Vehicle Opacity Test SAE J1667



No. 2 Diesel Fuel

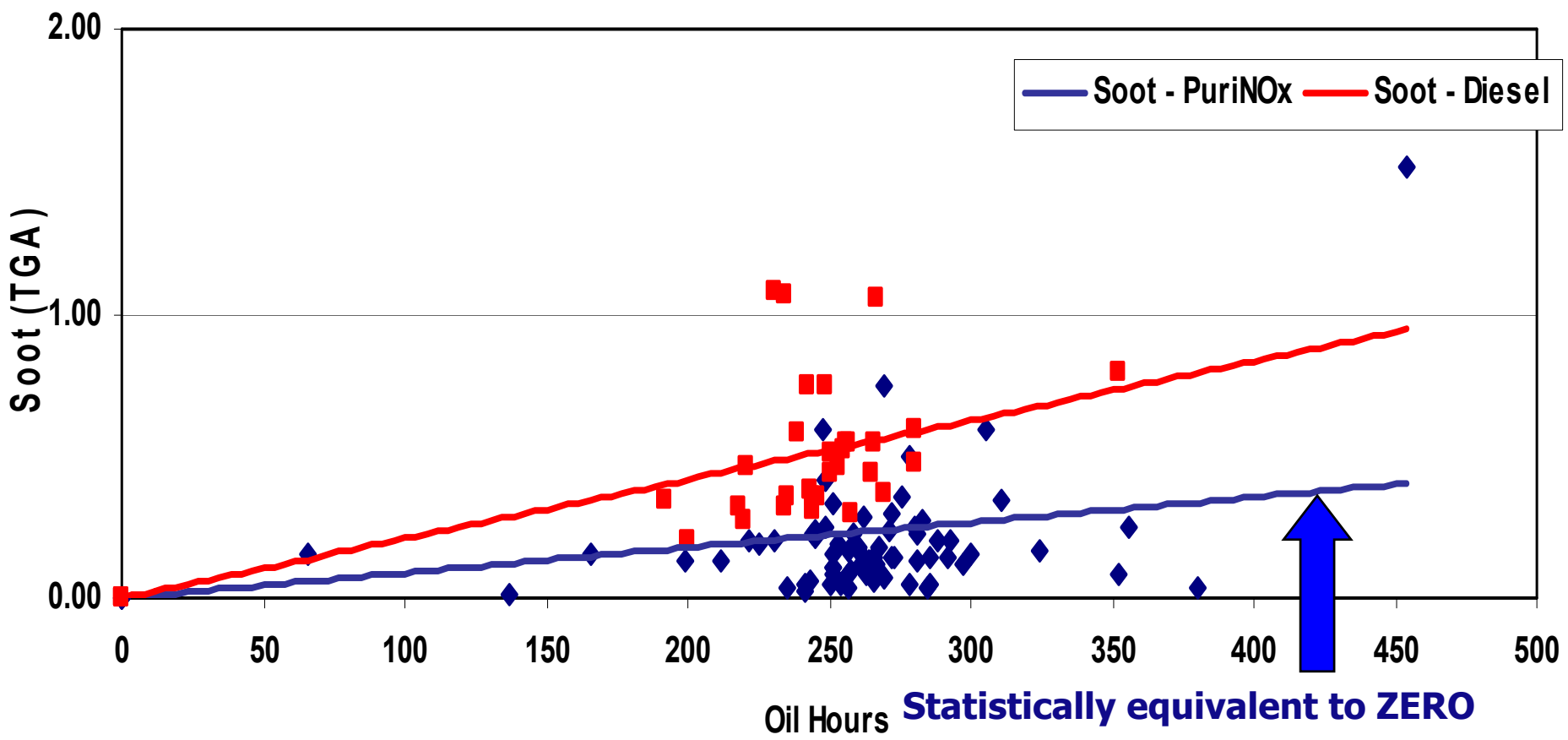


PuriNOx™ Fuel



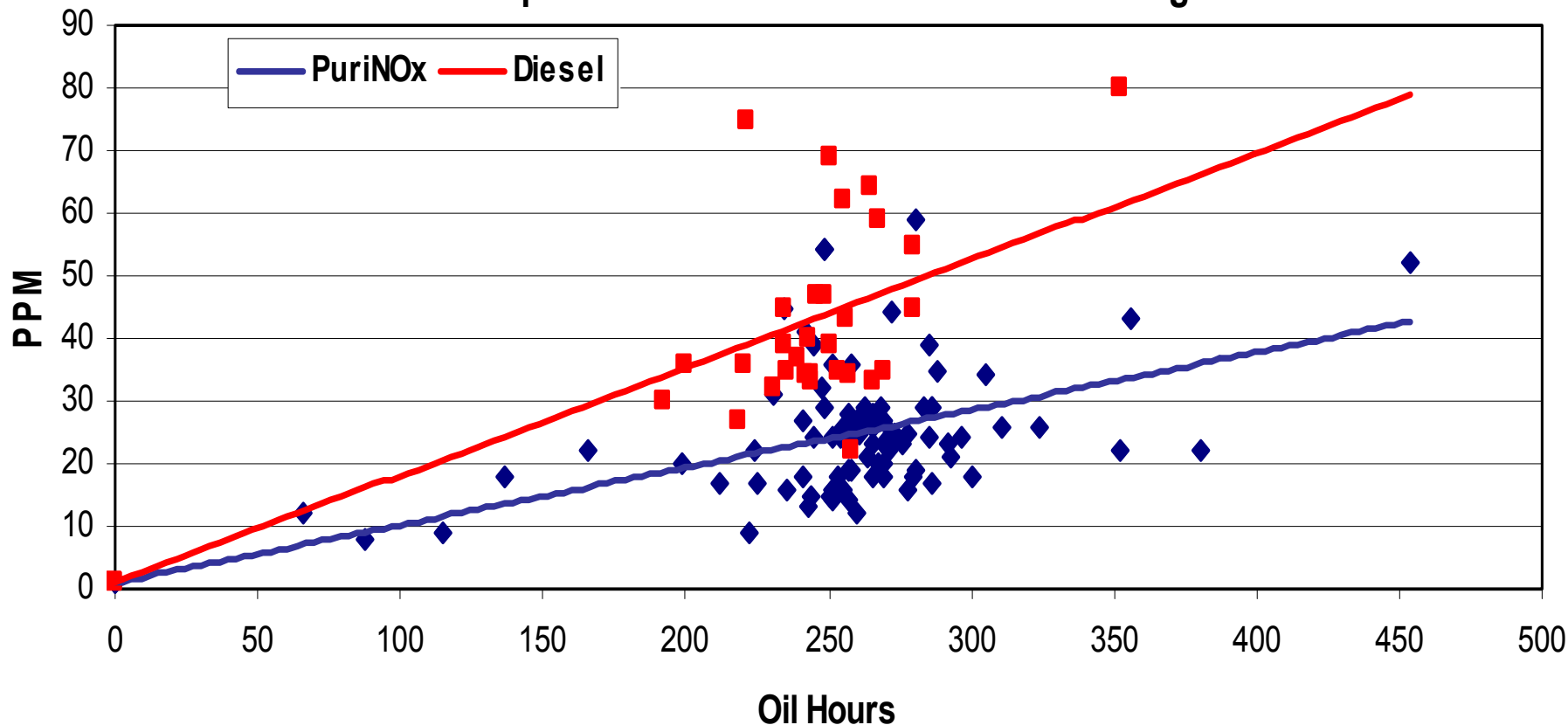
# Field Durability - Soot Accumulation in the Oil

Used Oil Analysis - Soot  
Caterpillar 988F Wheel Loaders w/3408E engine



# Field Durability Update – Wear Metals

Used Oil Analysis - Wear Metals (Iron)  
Caterpillar 988F Wheel Loaders w/3408E engine



# Pacific Harbor Lines – Port of LA

## Unit GP7:

- GM-EMD 1500 HP
- Operating on PuriNOx™ since ~ March 2000
- Top ends passed inspection at 92 day intervals



## Unit GP8:

- GM-EMD 1800 HP
- Converted to PuriNOx™ ~ July 2003

Contact Andrew Fox, President  
(310/834-4594)

# Lubrizol Deer Park, Texas Plant

Switchers owned and leased  
GM-EMD engine models (1200 HP)

- 12-567-B (owned)
- 12-557-C (leased)
- 12-645-E (leased)



**Converted to PuriNOx™ March 2001**

**Collectively operate ~ 9.5 hrs per day**

**~ 8,300 operating hours to date**

**Contact George Kimes**

**(281/479-2851, Ext. 7131)**



# Lubrizol Painesville, Ohio Plant

## 1967 GE-EMD 110 Ton Switcher Locomotive

- Cummins NTA engine models (380 HP)
  - 855C
  - 360



**Converted to PuriNOx™ March 2001**

**Operates ~ 9.5 hrs per day**

**~ 9,500 operating hours to date**

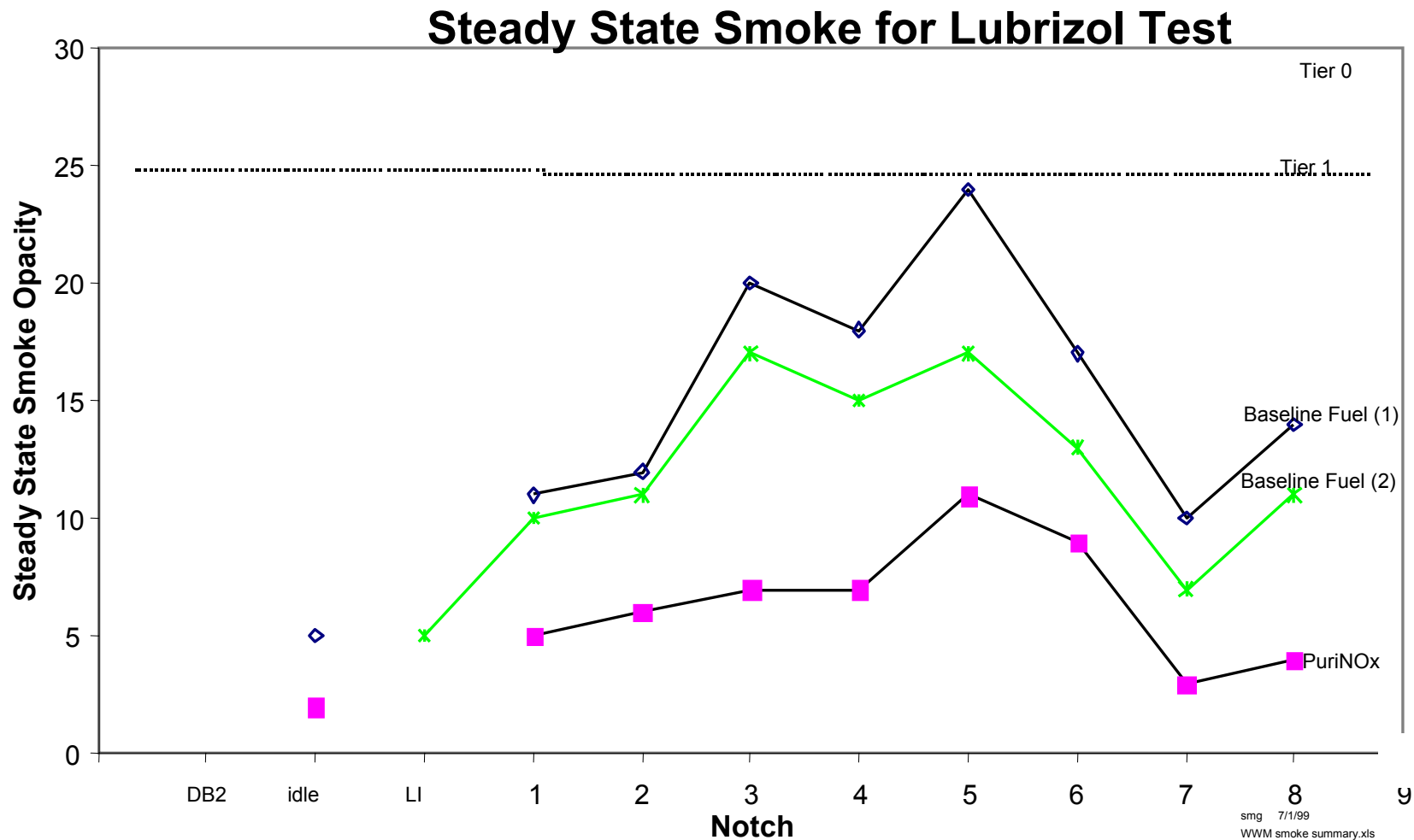
**Contact Sam Gillette**

**(440/347-3756)**

# PuriNOx™ GETS Testing

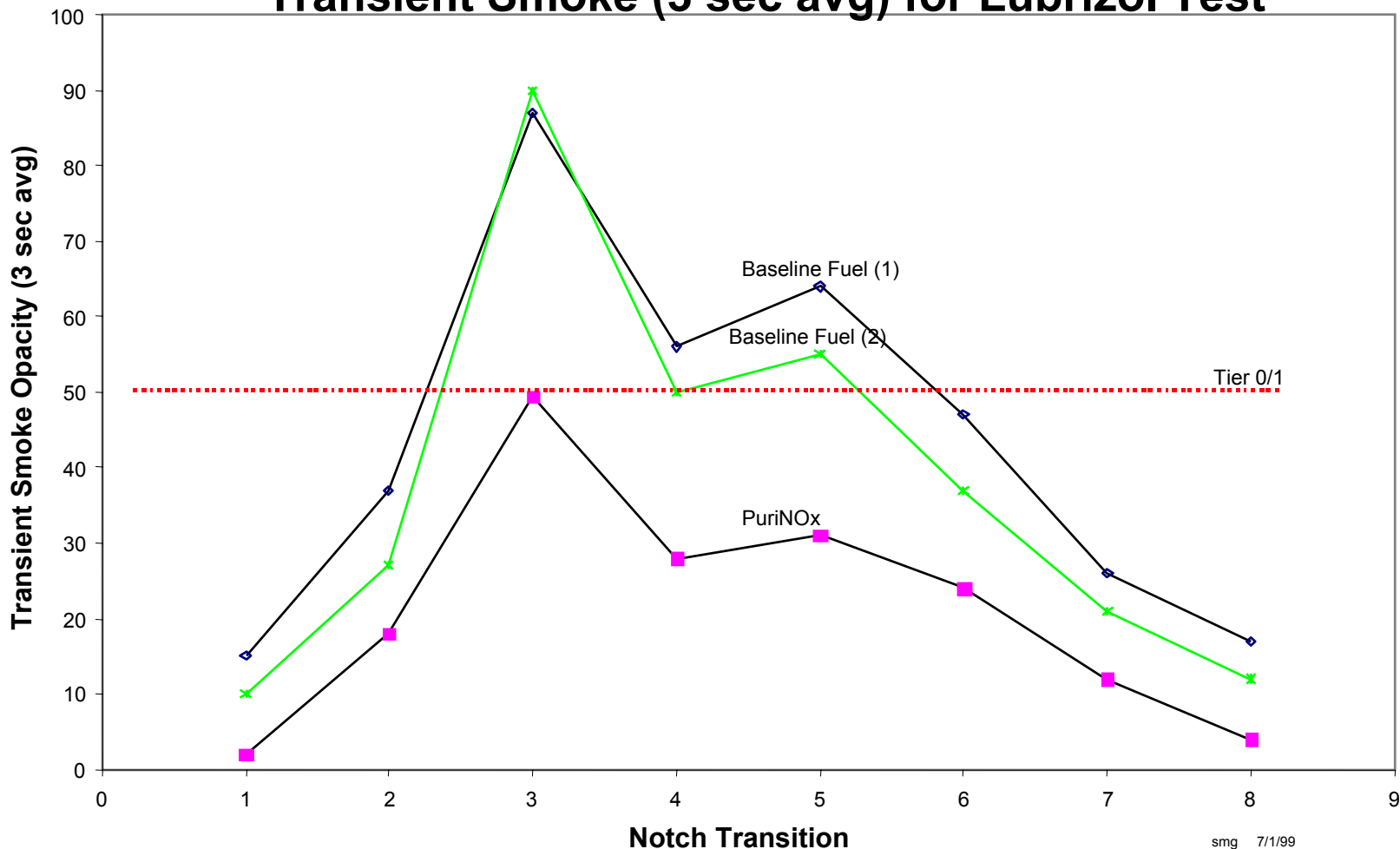
- PuriNOx Fuel was tested in a GETS Locomotive GECX001 3300 bhp @ 1050 RPM
- Base fuel used for comparison and for PuriNOx blend was GE low cetane fuel
- Line Haul and Switch Haul Conditions
- No significant wear of injectors
- 7 to 8% NOx Reduction, 59% avg. Opacity Reduction and 30 to 45% PM Reduction
- Fill and Go, No Engine Adjustments

# PuriNOx™ GETS Emissions



# PuriNOx™ GETS Emissions

## Transient Smoke (3 sec avg) for Lubrizol Test



# PuriNOx Technology California Suppliers



# Conclusions

## PuriNOx



- ✓ can lower NOx AND Particulates at the same time
- ✓ lowers emissions immediately
- ✓ can be used in most centrally fueled fleets
- ✓ can be used with most generations of diesel engines with excellent durability characteristics
- ✓ Requires no significant capital expense for the end user

# Thank You

- **Ron O. Dunfee**  
**The Lubrizol Corp.**  
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