

# **Diesel Particulate Matter in Underground Mines**

**Material Provided by:**

**Mine Safety and Health Administration**



**Presented by:**

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National Biodiesel Board**

# Background and Timeline

- ❖ 1960's to present: DPM epidemiological and occupational exposure studies showed that Diesel Particulate Matter is harmful to miners' health.
- ❖ Mid-1990's: MSHA DPM rulemaking activities initiated
- ❖ 1998 to present: iterative adoption and implementation to reduce DPM

# Sources of DPM



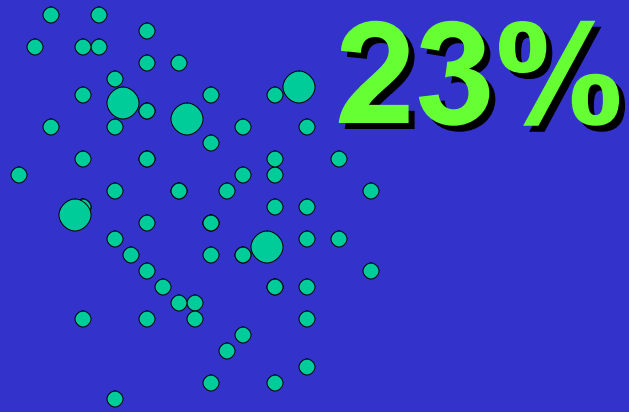
# **Diesel particulate matter consists of:**

- **solids, liquids, and vapors;**
- **burned and unburned hydrocarbons;**
- **oxides of sulfur, nitrogen;**
- **metal fragments, metal oxides,  
other substances**

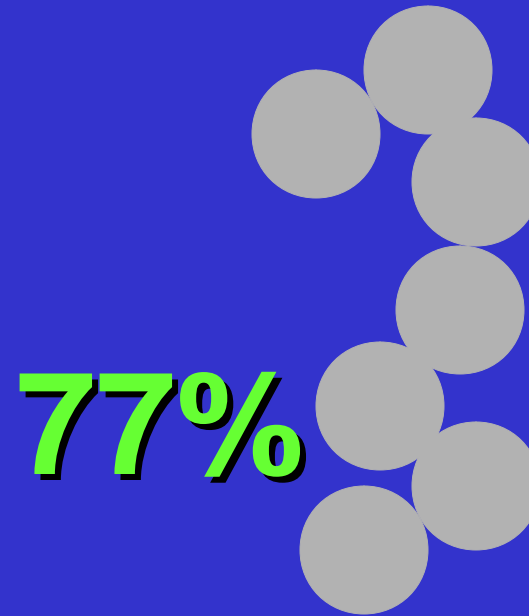
# Ways to Measure DPM

- ❖ Total DPM - difficult to measure
  - ❖ Total Carbon
  - ❖ Organic Carbon + Elemental Carbon
  - ❖ Elemental Carbon X 1.3
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- “Raw” mixture difficult to measure
  - Carbon components can be accurately measured at very low concentrations

# DPM Carbon Components



Vapor Phase  
Hydrocarbons (OC)

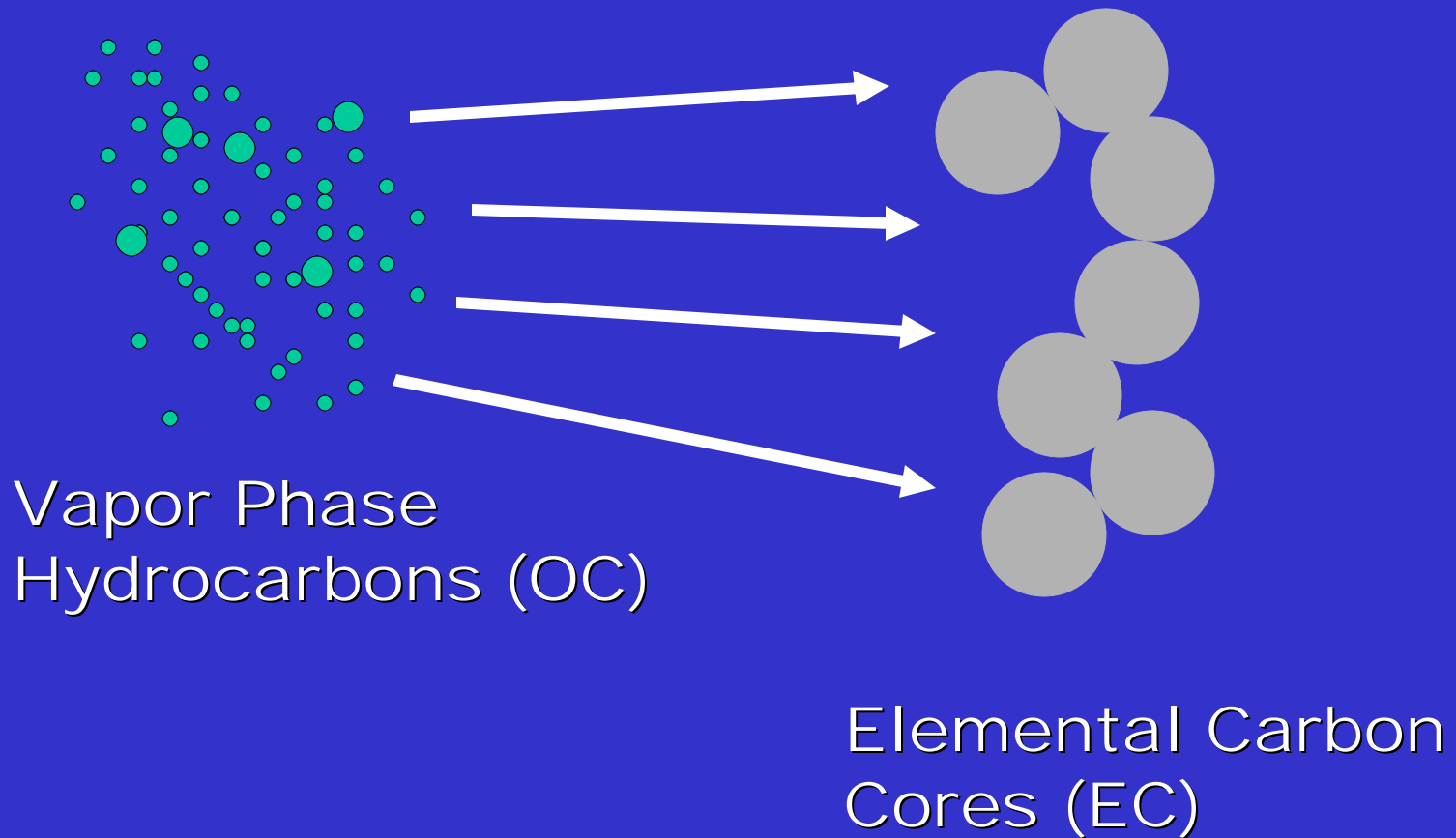


Elemental Carbon  
Cores (EC)

$$77\% \times 1.3 = 100\%$$

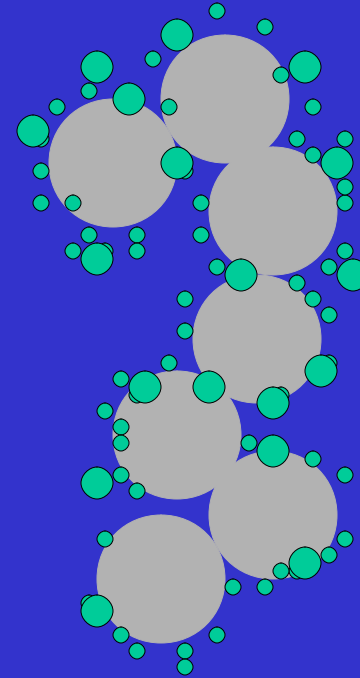
$$EC \times 1.3 = TC$$

# DPM Carbon Components



# DPM Carbon Components

Hydrocarbons  
Adsorbed Onto  
Elemental Carbon  
Cores (OC + EC)



$$OC + EC = TC$$

*Original Rule: Interim Limit =  $400_{TC} \mu\text{g}/\text{m}^3$*


# Personal Exposure Level

❖ Interim PEL is  $308_{EC} \mu\text{g}/\text{m}^3$

vs.

Interim Conc. Limit of  $400_{TC} \mu\text{g}/\text{m}^3$

Comparable,  
based on 1.3  
conversion





# Federal Register

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Thursday,  
May 18, 2006

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Part II

## Department of Labor

Mine Safety and Health Administration

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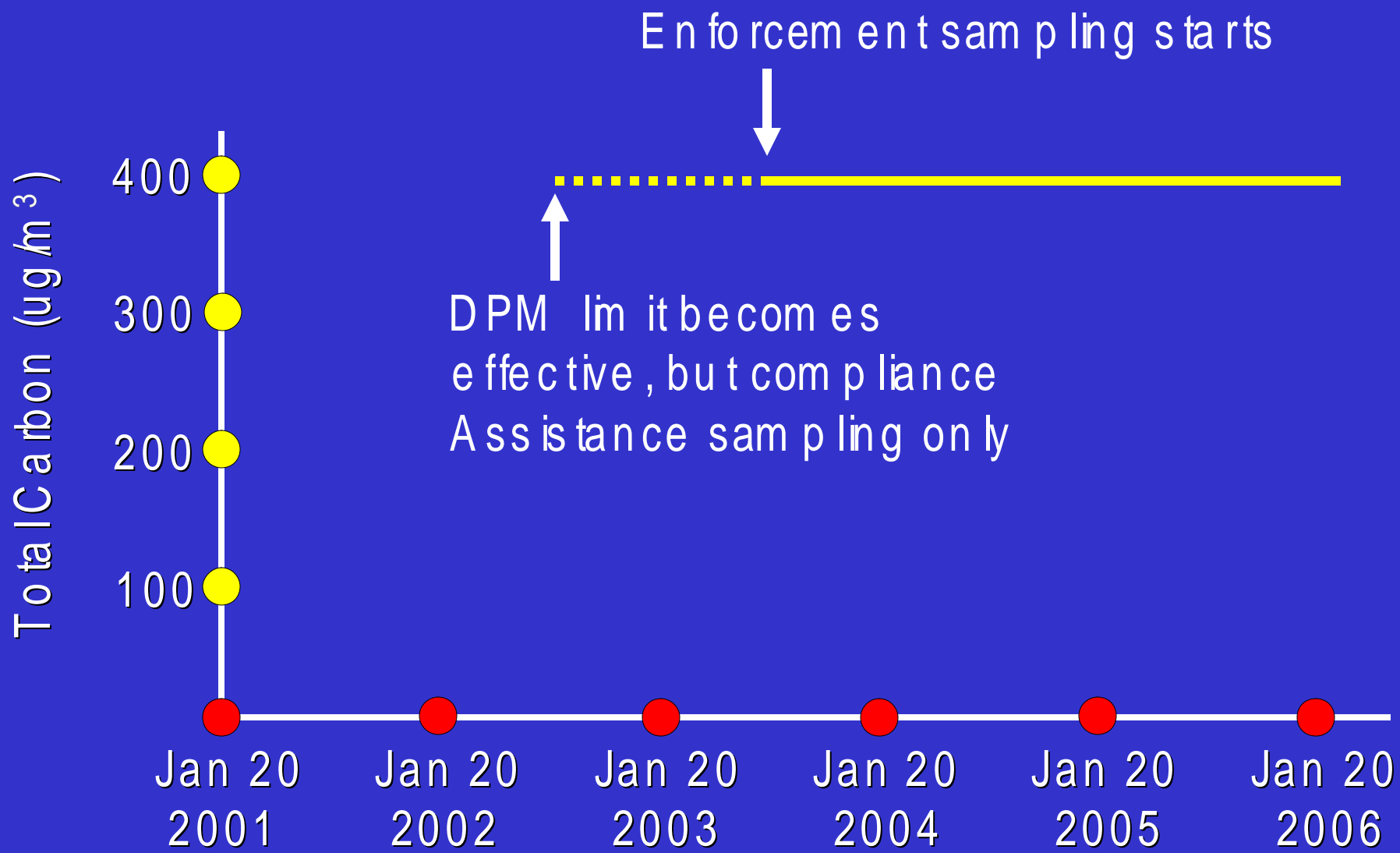
30 CFR Part 57  
Diesel Particulate Matter Exposure of  
Underground Metal and Nonmetal Miners;  
Final Rule

May 20, 2008

Total Carbon  
Limit Becomes

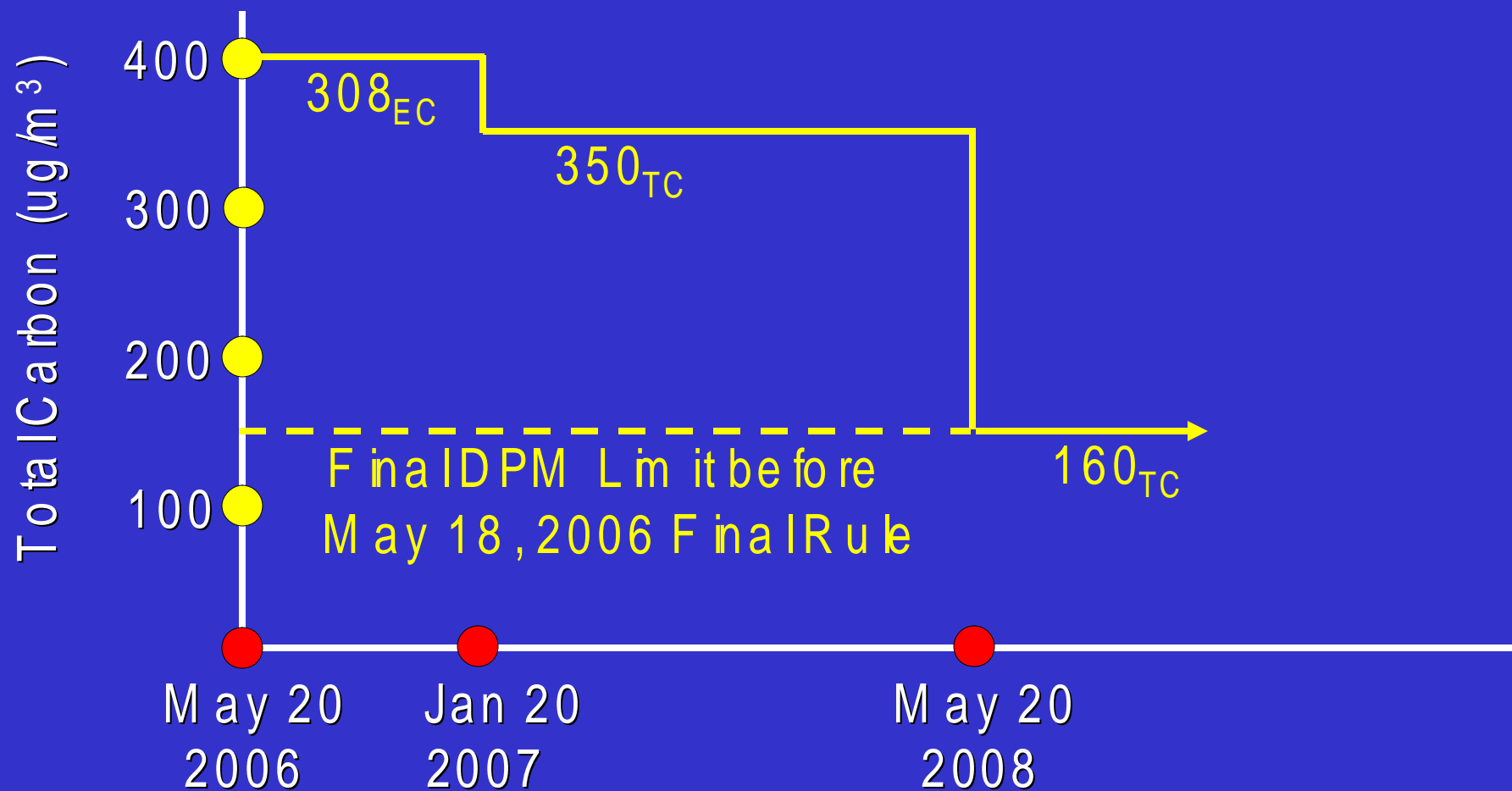
$160_{TC} \mu g / m^3$

# DPM Exposure Limit Time Line



# DPM Exposure Limit Time Line

Final DPM limit phased-in over 2 years



# Case Studies

- ❖ **MSHA Baseline Sampling**
- ❖ **Compliance Assistance Sampling**
- ❖ **Enforcement Sampling**
- ❖ **Control Implementation**
- ❖ **Abatement Sampling**

# Salt Mine

- ❖ **Baseline = 80 - 392 EC ug/m<sup>3</sup>**
- ❖ **16 of 18 compliance samples greater than 160<sub>EC</sub> ug/m<sup>3</sup>**
  - **Implemented 100% biodiesel fuel**
- ❖ **After Implementation = 59 – 358 EC ug/m<sup>3</sup>**
- ❖ **7 of 9 compliance samples since implementation of 100% biodiesel were less than 160<sub>EC</sub> ug/m<sup>3</sup>. Other 2 samples were 185<sub>EC</sub> ug/m<sup>3</sup> and 358<sub>EC</sub> ug/m<sup>3</sup>.**
- ❖ **Biodiesel significantly reduced EC levels**
  - **good ventilation air distribution still required**

# Limestone

- ❖ **Baseline Samples = 89 - 500 ug/m<sup>3</sup>**
- ❖ **7 of 20 compliance samples greater than 308<sub>EC</sub> ug/m<sup>3</sup> (7 DPM citations).**
- ❖ **11 of 20 compliance samples greater than 160<sub>EC</sub> ug/m<sup>3</sup>.**
  - **Changed to a 100% biodiesel fuel throughout mine.**
- ❖ **Subsequent compliance samples ranged from 36 to 156 EC ug/m<sup>3</sup>.**

# Limestone

- ❖ **Baseline Sample = 1089 ug/m<sup>3</sup>**
  - In 2002 = 1461 ug/m<sup>3</sup> for the front end loader.
  - Changed to a 30% biodiesel blend in the loader.
- ❖ **Enforcement Sampling 3/4/2004 = 552 ug/m<sup>3</sup>**
  - Added a mine shaft to increase mine ventilation.
- ❖ **Abatement: 11/3/2004 = 321 ug/m<sup>3</sup>**

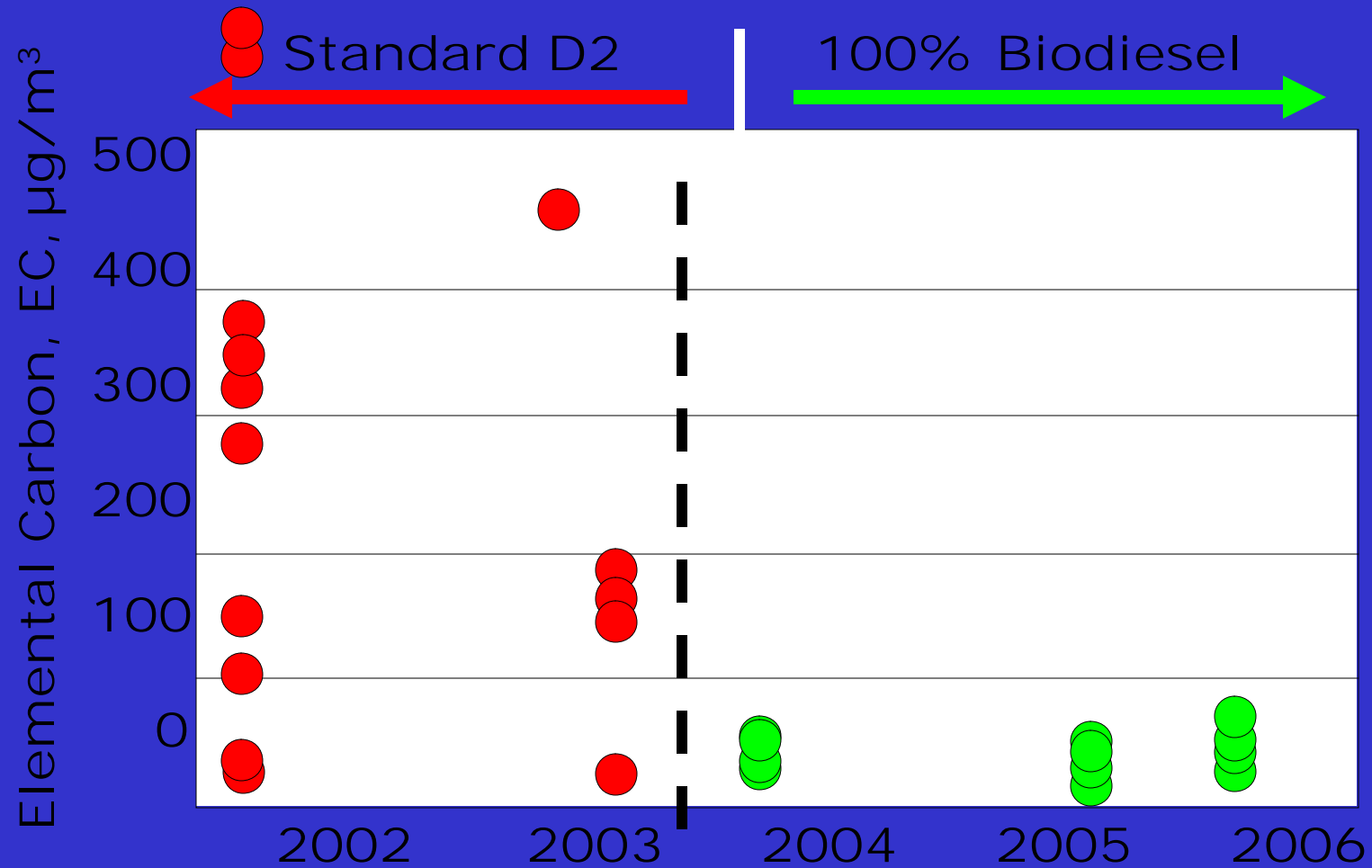
# Limestone

- ❖ **Baseline Sample = 720 ug/m<sup>3</sup>**
  - **Performed vehicle maintenance on trucks.**
  - **Switched to 25% biodiesel blend fuel.**
  - **Added a mine opening on the opposite side of the mine near the mining face to increase mine ventilation.**
- ❖ **Abatement Sample: 3/23/2004 = 220 ug/m<sup>3</sup>**



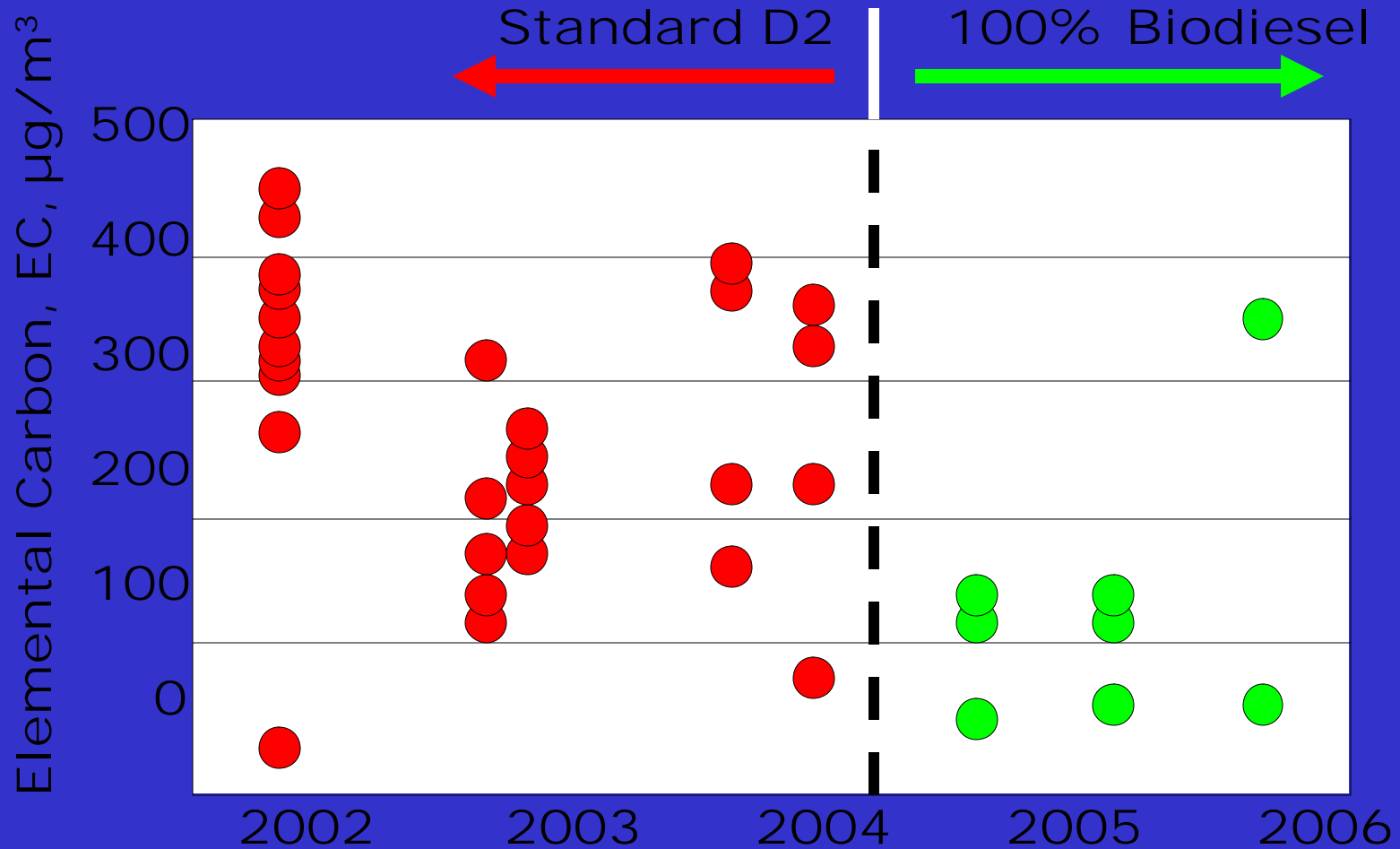
# Biodiesel and DPM Emissions

MSHA compliance samples, EC



# Biodiesel and DPM Emissions

## MSHA compliance samples, EC



# Summary of Case Studies

Average “before” DPM level = 715 ug/m<sup>3</sup>

Range: 96 to 1089 ug/m<sup>3</sup>

Average “after” DPM level = 260 ug/m<sup>3</sup>

Range: 33 to 399 ug/m<sup>3</sup>

Controls implemented:

Clean engines

Ventilation

Bio-diesel

Environmental cabs

Upgraded maintenance

# Effectiveness of Alt Fuels

❖ **Alternate fuels - effect depends on fuel blend, engines, etc.**

- **20% bio-diesel (B20) fuel reduces EC 5-25%**

- **50% bio-diesel (B50) fuel reduces EC 20-40%**

- **100% bio-diesel (B100) fuel reduces EC 50-80%**

# Effectiveness of Engr. Controls

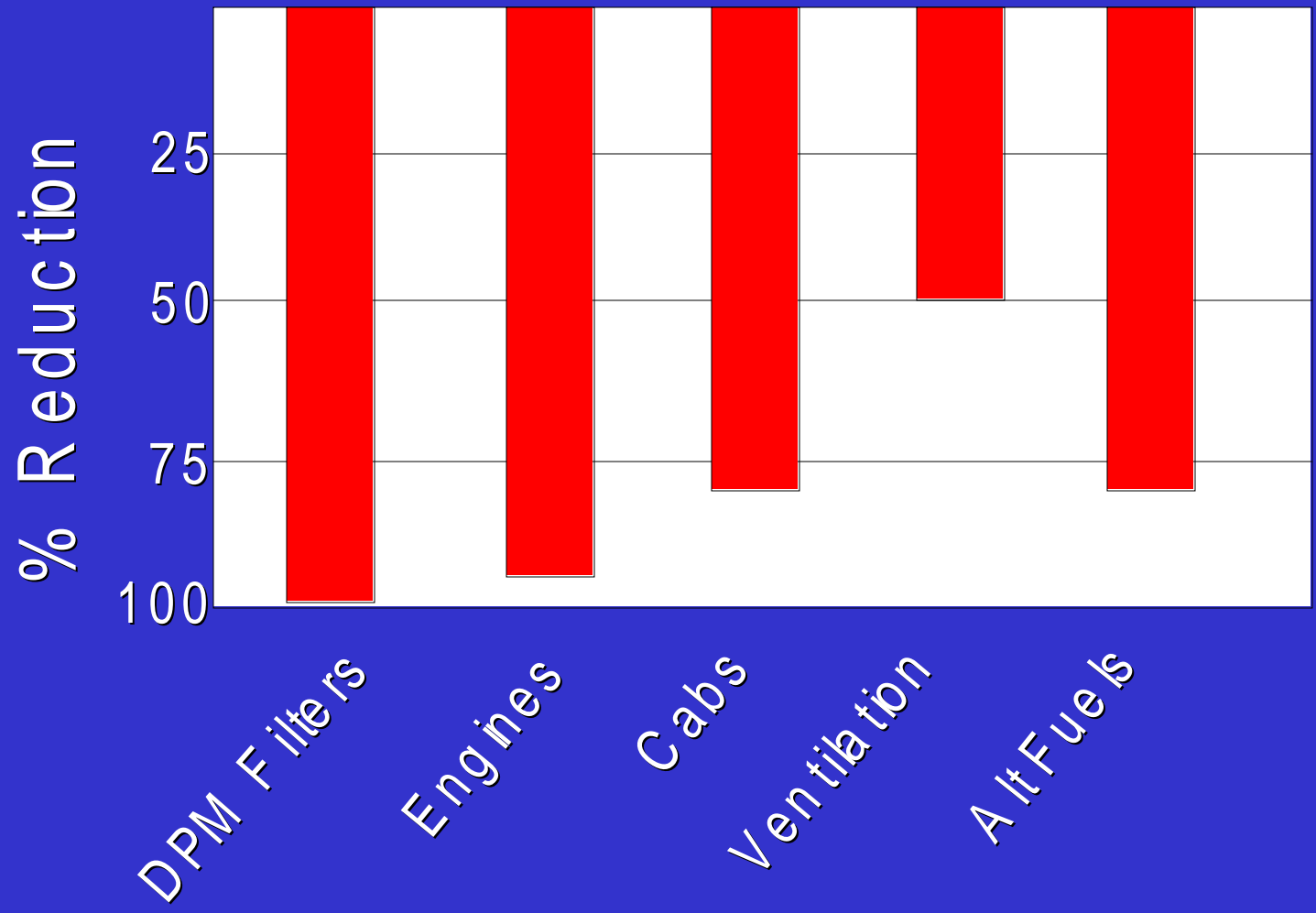
- ❖ DPM exhaust filters - 80 to 99% efficient
- ❖ Low emission engines - effect depends on engines - 95+% reduction possible
  - Example: old “dirty” engine (emissions of 1.0 g/bhp-hr) replaced by new “clean” engine (emissions of 0.05 g/bhp-hr)
- ❖ Environmental cabs 50 - 80% reduction

# **Work Practices Can Affect Emissions And DPM Concentrations**

- **Minimize engine idling**
- **Avoid lugging engines (low RPM - high load)**
- **Keep fuel and lube oil clean**
- **Traffic control**
  - ◆ **Route traffic away from areas where miners work outside cabs**
  - ◆ **Route haul trucks in return air, especially when ascending ramps loaded**
  - ◆ **Limit HP in work area based on available CFM's**

# Typical Maximum Effectiveness of DPM Controls

*Actual Reductions Depend on Specific Situations and Controls Used*



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