

# Controlling Diesel Particulate Matter Exposures in Underground Metal and NonMetal Mines

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304-547-2072

MDEC 2006

## Available Control Strategies

- ◆ Ventilation
  - ◆ Environmental Cabs
  - ◆ Administrative Controls
  - ◆ Diesel Engines
  - ◆ Fuels
  - ◆ Maintenance
  - ◆ Biodiesel Fuel
  - ◆ DPM Exhaust Filters
- Exposure Controls
- Emission Reduction
- 
- The diagram shows a list of control strategies on the left. A bracket on the right groups the first three items (Ventilation, Environmental Cabs, and Administrative Controls) under the heading 'Exposure Controls'. Another bracket on the right groups the remaining five items (Diesel Engines, Fuels, Maintenance, Biodiesel Fuel, and DPM Exhaust Filters) under the heading 'Emission Reduction'.

## VENTILATION

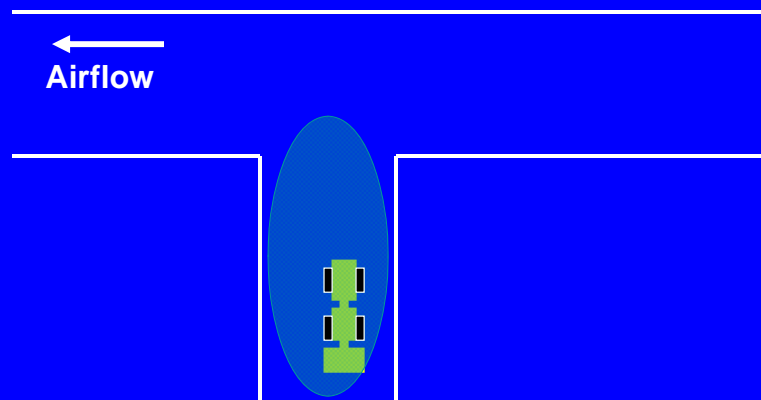
Widely used method for DPM control  
DPM reduction proportional to air flow

- Double air flow = 50% DPM reduction

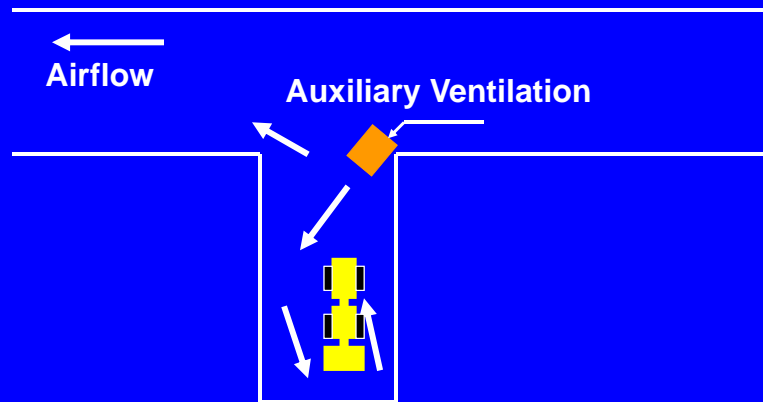
Types of upgrades

- Major ventilation upgrades: shafts and fans
- Auxiliary ventilation upgrades: booster fans and ventilation bags

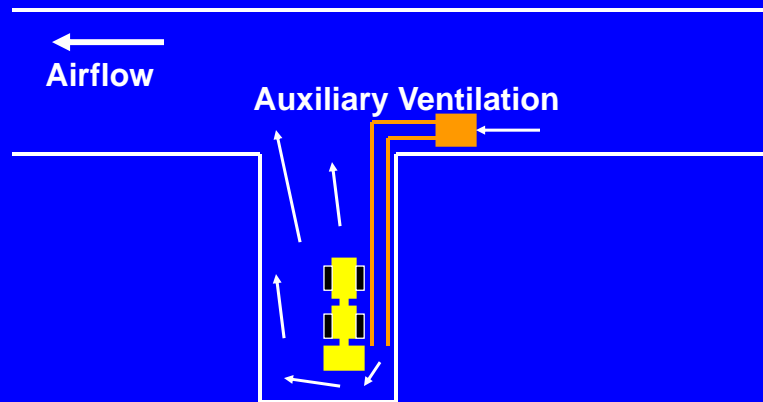
## Dead Ends



## Dead Ends - Free Standing Fan



## Dead Ends - Fan and Vent Bag



## Environmental Cabs

### ❖ Environmental Cabs Can:

- Reduce DPM exposure and EC levels
- Reduce noise exposure
- Reduce silica dust exposure

### ❖ Cabs Should Be:

- Tight - seal openings, repair broken windows
- Pressurized with filtered breathing air (follow regular filter change-out schedule - 250 hr)
- Operated with doors/windows closed (may need air conditioning)
- Maintained in good condition

## Cab Pressurization Monitoring



Magnehelic gage with rubber hose extending into cab



Magnehelic gage should register + 0.20" WG or more

## Administrative Controls

- ❖ Work Practices Can Affect Emissions And DPM Concentrations
  - Minimize engine idling
  - 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
  - Schedule blasters on non-production shifts
  - MSHA does not allow Job Rotation for dpm

## Available Control Strategies

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  - ◆ Biodiesel Fuel
  - ◆ DPM Exhaust Filters
- Exposure Controls
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- 
- The diagram shows a list of control strategies on the left. A bracket on the right groups 'Ventilation', 'Environmental Cabs', and 'Administrative Controls' under the heading 'Exposure Controls'. Another bracket on the right groups 'Diesel Engines', 'Fuels', 'Maintenance', 'Biodiesel Fuel', and 'DPM Exhaust Filters' under the heading 'Emission Reduction'. The background of the slide features a silhouette of a mountain range at the bottom.

## § 57.5067 (a) Engines

- ◆ Any Diesel Engine Introduced Underground
  - (a)(1) Have Affixed A Plate Evidencing Approval Under Subpart E of Part 7, Or Under Part 36
  - (a)(2) Meet Or Exceed The Applicable PM Emission Requirements Of The U.S. EPA Listed In Table 57.5067-1

### MSHA Approved Diesel Engines

Approval Number	Engine Manufacturer	Model	HP @ RPM at 1000ft Elevation	Particulate Index, CFM	DPM grams/hr weighted	DPM grams/hp-hr weighted	Gaseous Vent Rate, CFM
07-ENA040001	CUMMINS	QSB-155C	155 @ 2500	5500	8.87	0.11	9000
07-ENA040018	DEUTZ	F6L 914	117 @ 2300	3500	5.73	0.09	6000
07-ENA050001	MITSUBISHI	S4S-DT	77 @ 2500	4500	6.91	0.18	3500
7E-B001	DEUTZ	MWM 916	94 @ 2300	11500	19.54	0.42	4000
7E-B003	CATERPILLAR	3306 PCNA	150 @2200	23000	39.08	0.49	7500
7E-B035	DEUTZ	F8L 413FW	182 @ 2300	9500	16.14	0.16	10500
7E-B098	Mercedes	OM904L A	174 @ 2200	5000	8.5	0.09	7500

## MSHA Approved Engines

- ◆ Internet Listing of MSHA Approved engines
- ◆ <https://lakegovprod1.msha.gov/ReportView.aspx?ReportCategory=EngineAppNumbers>

## EPA DPM Limits MSHA Table 57.5067-1

- |                  |               |        |        |
|------------------|---------------|--------|--------|
| ◆ Hp < 11        | 0.75 g/bhp-hr | Tier 1 | MY2000 |
| ◆ 11 ≤ HP < 25   | 0.60 g/bhp-hr | Tier 1 | MY2000 |
| ◆ 25 ≤ HP < 50   | 0.60 g/bhp-hr | Tier 1 | MY1999 |
| ◆ 50 ≤ HP < 100  | 0.30 g/bhp-hr | Tier 2 | MY2004 |
| ◆ 100 ≤ HP < 175 | 0.22 g/bhp-hr | Tier 2 | MY2003 |
| ◆ 175 ≤ HP < 750 | 0.40 g/bhp-hr | Tier 1 | MY1996 |
| ◆ Hp ≥ 750       | 0.40 g/bhp-hr | Tier 1 | MY2000 |
- ◆ On highway diesel vehicles such as pickup trucks from 1994 vehicle model year

## Three Strikes and It's Out

- ◆ **Strikes:**
  - High horsepower (greater than 150),
  - High emissions (greater than 0.3 gm/hp-hr),
  - High use (greater than 6 hours per shift).
- ◆ **Target Equipment:**
  - Production Loaders and Trucks (primary),
  - Drills and Scalers (secondary)
  - PC engines (specialty mining equipment).
- ◆ **One bad engine can spoil the entire fleet.**

## Diesel Fuel

- ◆ MSHA §57.5065 requires diesel fuel with a sulfur content of less than 0.05 percent (500 ppm)
- ◆ EPA requirement for on-highway diesel fuel to be at 0.0015 percent (15 ppm) sulfur by mid – 2006
- ◆ EPA requirement for non-road diesel fuel to be at 0.0015 percent (15 ppm) sulfur by 2010



## Synthetic Fuels

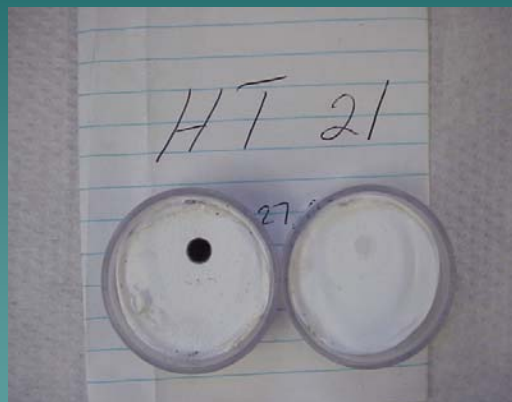
- ◆ MSHA Laboratory Tested 2 Types
- ◆ SYNPAR 200 – Solvent Based
- ◆ S-2 – Derived from Methane
- ◆ Approximate 31% reduction in EC
- ◆ Associated 4 – 6% loss in horsepower at sea level (1000 feet)
- ◆ Similar Results at High Altitude, 7500 feet (simulated)

## Engine Maintenance

- ◆ Cleaning: Engine, Radiators, Air/Oil Coolers
- ◆ Intake Systems: Air Filters, Turbo Boost Pressures, Leaks
- ◆ Exhaust Systems: Backpressure, Leaks
- ◆ Cooling Systems
- ◆ Fuel Systems: Proper Settings, Altitude
- ◆ Electronic Controlled Systems
- ◆ Emission Tests

## *Gaseous Emission Check Particulate “Smoke Dot” Check*

- *Torque stall the machine to achieve maximum load on the engine*
- *The concentration or changes in concentration of Carbon Monoxide above baseline will indicate a change in engine performance.*
  - *A dpm sample collected on a sample filter paper*
  - *Compare by “gray” scale the amount of dpm*

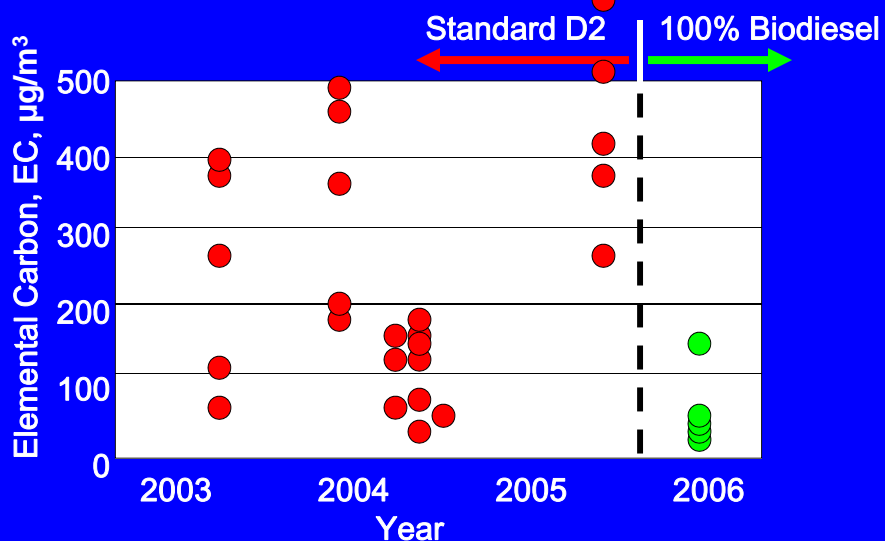


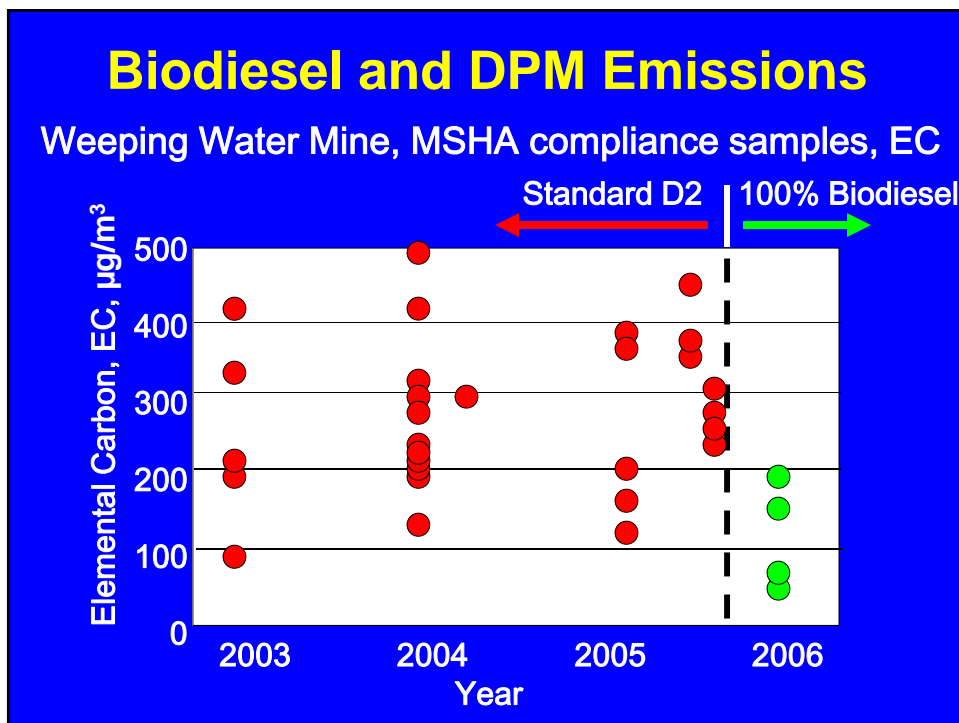
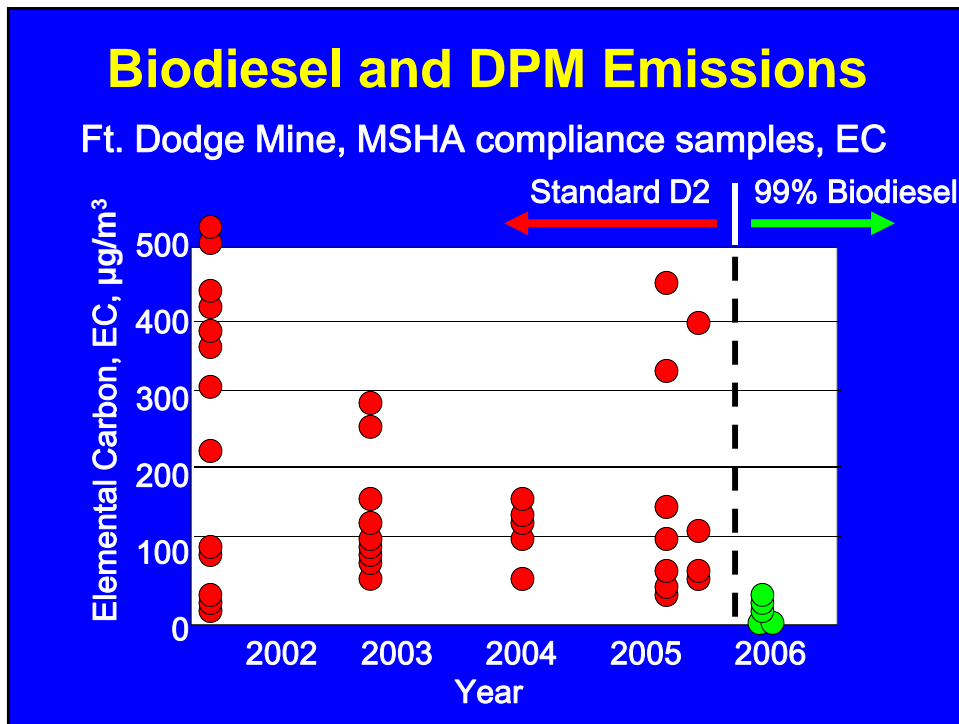
## Biodiesel

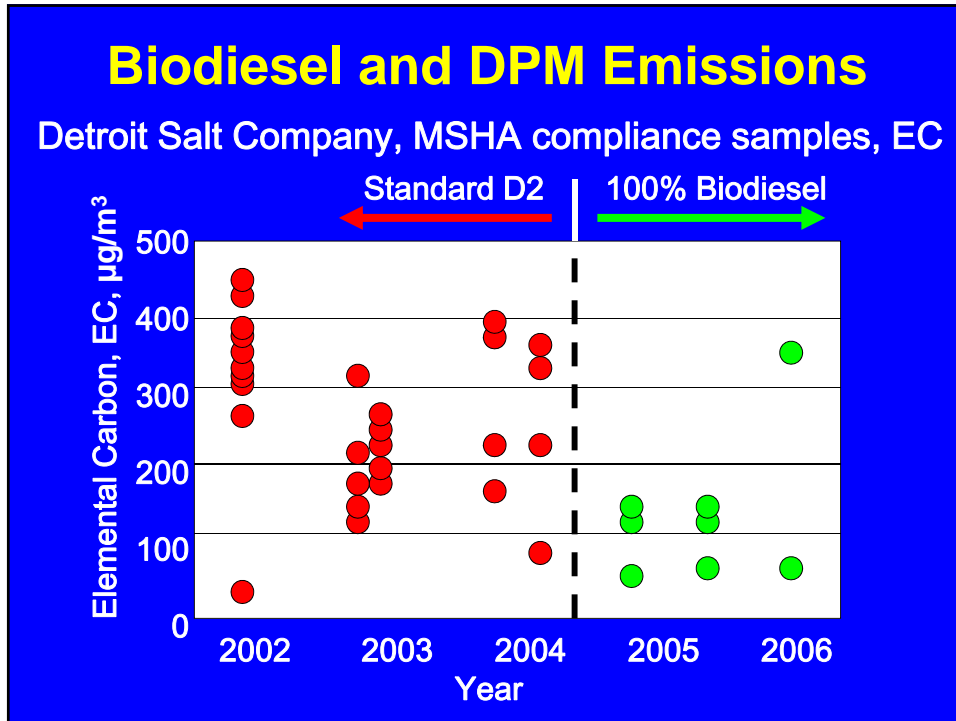
- ❖ EPA registered diesel fuel
- ❖ 100% biodiesel, B100
- ❖ Biodiesel blend - biodiesel mixed with petrodiesel, called Bxx where xx is the volume % of biodiesel in the blend
  - B20 – 20% biodiesel, B2 – 2% biodiesel

## Biodiesel and DPM Emissions

Durham Mine, MSHA compliance samples, EC





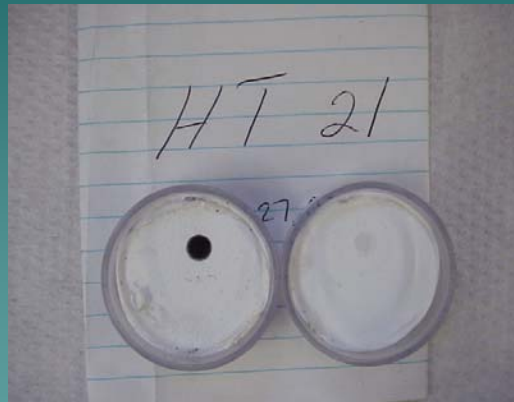


## Diesel Particulate Filters (DPF)

- ◆ Filters filter.
- ◆ 80 to 99% efficient.
- ◆ Regeneration issues.
- ◆ Control Technologies:  
<http://www.msha.gov/01-995/Coal/DPM-FilterEfflist.pdf>



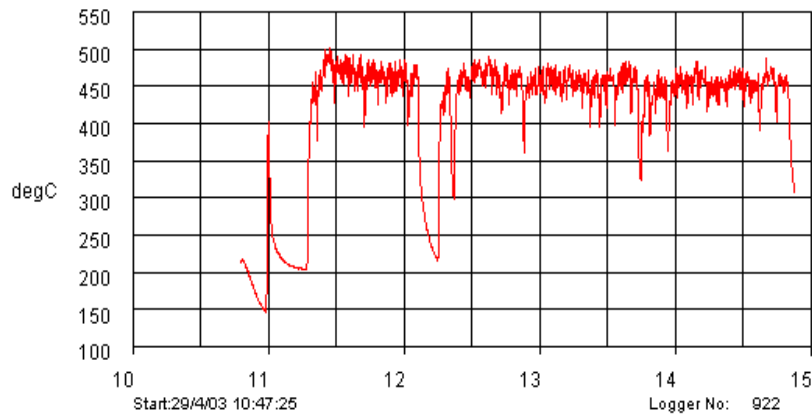
## Effectiveness of DPM Filters



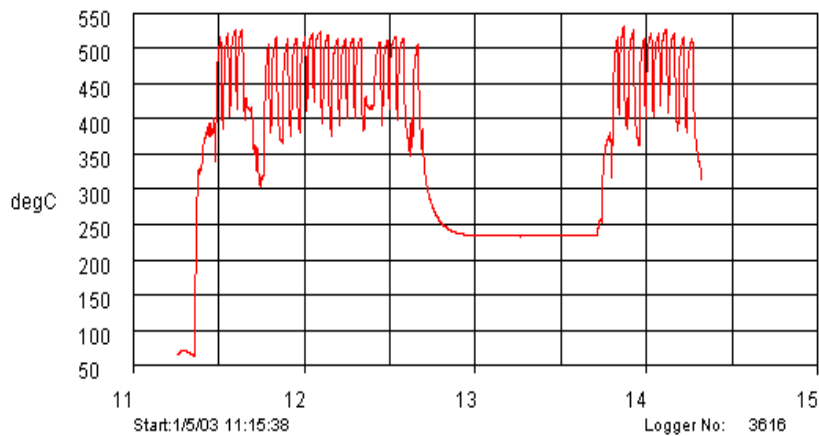
## Choosing a Ceramic DPF

- ◆ NIOSH and MSHA developed a DPF Selection Guide
  - <http://www.msha.gov/nioshmnmfilt/erselectionguide/dpmfilterguide.htm>
- ◆ Provides information for choosing the correct DPF, Do's and Don'ts
- ◆ Exhaust Temperature Profiles/Traces
- ◆ How to apply the information

## 972 Loader, Caterpillar 3306 B 34% @ 470°C



## Cannon Drill, Caterpillar 3304 PC 30% @ 480°C



## High Temperature “Synthetic” Filter Media

- ◆ 80-99% Efficient
- ◆ Operating Time Will Vary Between Replacement
- ◆ Temperature Limit – 650 F
- ◆ May require a heat exchanger prior to media
- ◆ Filter Location
- ◆ Disposable





## Diesel Particulate Reactor <sup>TM</sup>

- ◆ Substrate is a catalytic emissions reduction system
- ◆ Woven stainless steel alloy fabric cartridge
- ◆ MSHA lab results showed a 21% whole dpm reduction based on the 8 mode test



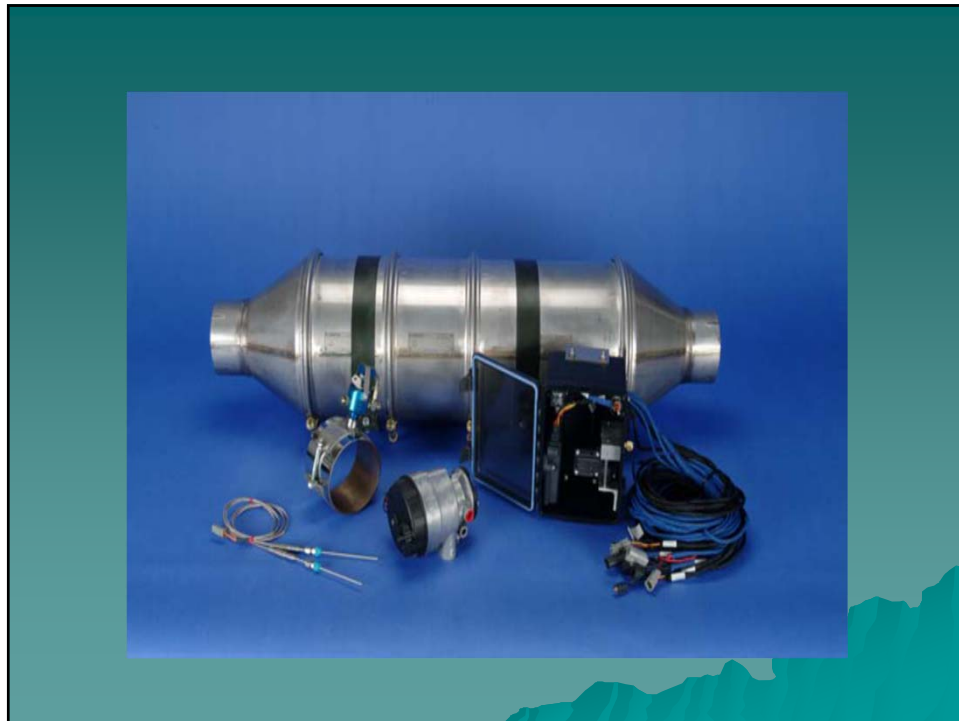
## Rypos

- ◆ Sintered metal fibers can be designed to achieve any filter efficiency by changing fiber sizes, porosity, and thickness of filter medium.
- ◆ Active Regeneration DPF where the Filter element is the Heating element
- ◆ MSHA lab test showed a 83% whole dpm reduction based on the 8 mode test



## Fleetguard Longview Lean NOX Catalyst Filter

- ◆ Ceramic – Silicon Carbide Catalyzed Filter Media
- ◆ Injects fuel prior to the filter to reduce NOX emissions using a NOX reducing catalyst
- ◆ Passive Regeneration
- ◆ Data reviewed by MSHA did not show any increase in the NO<sub>2</sub> emissions from engine baseline



Questions ????????