

# DIESEL PARTICULATE MATTER

## Diesel Particulate Control Technologies: Summary of Testing at MSHA A&CC Diesel Laboratory

NIOSH Control Technologies Workshop  
July 30, 2003

Russell Stackpole  
Technical Support-Approval and Certification Center

Jul 30, 2003

MSHA A&CC DPM Testing

1

## Summary of Testing

### Types of Control Technologies:

1. Disposable Filters for Cooled Exhaust
  - Paper media filters
  - Synthetic (polymer) media filters
  - Glass fiber media filters
  
2. Continuous-Use Filters (Traps) for Hot Exhaust Gas
  - Highly-catalyzed (platinum) filters
  - Lightly-catalyzed (platinum) filters
  - Base-metal catalyzed filters
  - uncatalyzed filters

Jul 30, 2003

MSHA A&CC DPM Testing

2

## Summary of Testing

### Types of Control Technologies (continued):

3. Other types of Control Technologies
  - DOCs
  - Disposable hot gas filters
  - Fuel Additives
  - Other after-market Technologies
4. Other influences in DPM emissions
  - High altitude effects
  - Altitude Compensators
  - Electronic Engines
  - Engine settings / variability

## A&CC Diesel Laboratory

### Equipment (fully instrumented lab for Part 7 approval testing):

- 2 General Electric engine Dynamometers (400/1000HP)
- Superflow Pro-ATC Control and DA system
- Sierra BG-2 Particulate Sampling system (gravimetric, or total dpm mass, analysis)
- Horiba Gas Measurement system (CO, CO<sub>2</sub>, NO/Nox, CH<sub>4</sub>)
- EC/OC DPM analysis (samples sent to NIOSH for analysis)

## Disposable Filters (Cooled Exhaust)

- Number of Tests Performed to Date: ~50
- Test Setup:
  - Heat exchanger aftertreatment system with multiple types of filter canisters
  - Use of CAT 3306 PCNA engine (multiple) on same heat exchanger
  - MSHA purchase of new CAT 3306 and after-treatment system for use in all future filter tests
- Definition of testing protocol and equivalence criteria for comparing filter performance
- Filters tested in accordance with Part 7 methods with Additional procedures to accommodate filter sampling

Jul 30, 2003

MSHA A&CC DPM Testing

5

## Disposable Filters: Testing Protocol

- Each Candidate filter is directly compared to the standard Paper filter (media) as msha ran at SwRI: Donaldson P530866: a test for a candidate requires a test using P530866 under like conditions for analysis
- Equivalence Criteria:  $EQ = (EFF_{\text{candidate}} / EFF_{\text{P530866}})$   
EQ > or = 0.97 "passing" and listed on web list
- Filter Fails if:
  - Filter Fails to achieve EQ of 0.97 or greater
  - Filter shows Excessive backpressure during test
  - Filter is physically damaged by exposure to Exhaust Stream

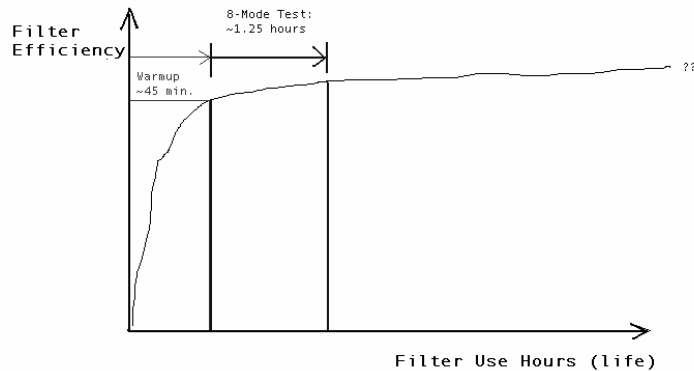
Jul 30, 2003

MSHA A&CC DPM Testing

6

## Disposable Filters: Testing Protocol

- Test uses consistent warm-up period for engine and filters tested over same portion of life



Jul 30, 2003

MSHA A&CC DPM Testing

7

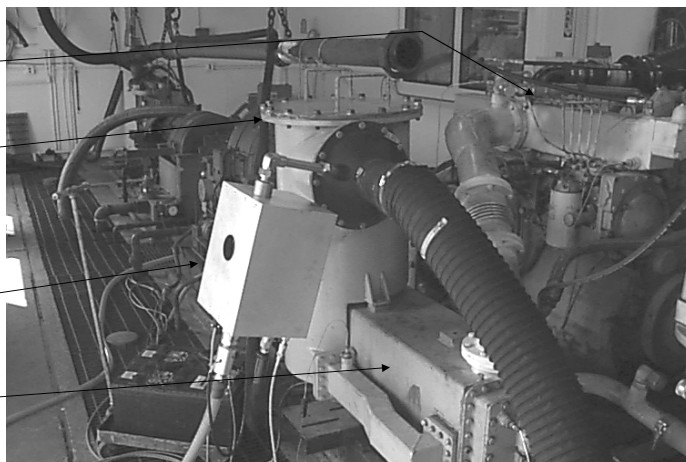
## Disposable Filters: Testing Setup

CAT 3306  
Engine

Filter  
Canister

BG-2 DPM  
Sampling

Heat  
Exchanger



Jul 30, 2003

MSHA A&CC DPM Testing

8

## Disposable Filters: Results

Equivalence Numbers for filters tested (that will be listed):

<u>FILTER SUPPLIER</u>	<u>FILTER MODEL</u>	<u>Equivalency</u>
Donaldson	P530866	1.00
Donaldson	P604516	1.00
Getman Corporation	605810	1.04
Getman Corporation	605811	0.98
Getman Corporation	605811**	1.05
Getman Corporation	605803 with 605807 pre-filter	1.00
Getman Corporation	605803	0.99
MICROFRESH	DA101	1.05
Champion (Luber-Finer)	LAF3931	1.04
Champion (Luber-Finer)	LAF3931**	1.02
Champion (Luber-Finer)	LAF3931	1.04
Champion (Luber-Finer)	LAF3931FR	1.01
Baron Filtration (Sparks)	Spunbond	0.98
Baron Filtration (Sparks)	Spunbond	1.01
Ed Molish	ENK20-29270	1.02
ENDUSTRA	R020001	1.02
ENDUSTRA	R020042	0.99
Jeffrey (DBT)	518404	0.99

\* - repeat test on clean filter

\*\* - repeat test on used filter

Jul 30, 2003

MSHA A&CC DPM Testing

9

## Hot Gas Filters (Traps): Test Protocol

- Testing to date using Deutz F6L912W engine
- Test Protocol similar to that used for disposable filters
- “break-In” period before testing is performed
- Measure DPM output of filter and after-filter gas Emissions (NO<sub>2</sub>)
- Some repeated testing over time to analyze Alterations in performance (aging)

Jul 30, 2003

MSHA A&CC DPM Testing

10

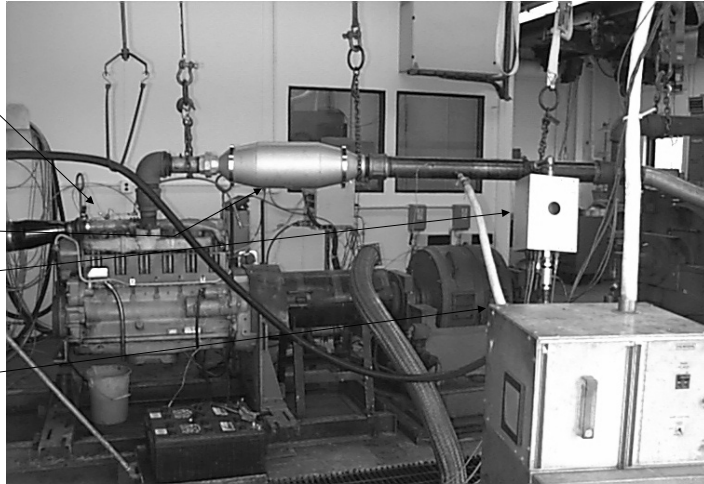
## DPM Traps: Testing Setup

F6L912W  
Engine

DPM Trap

BG-2 DPM  
Sampling

Gas Sampling



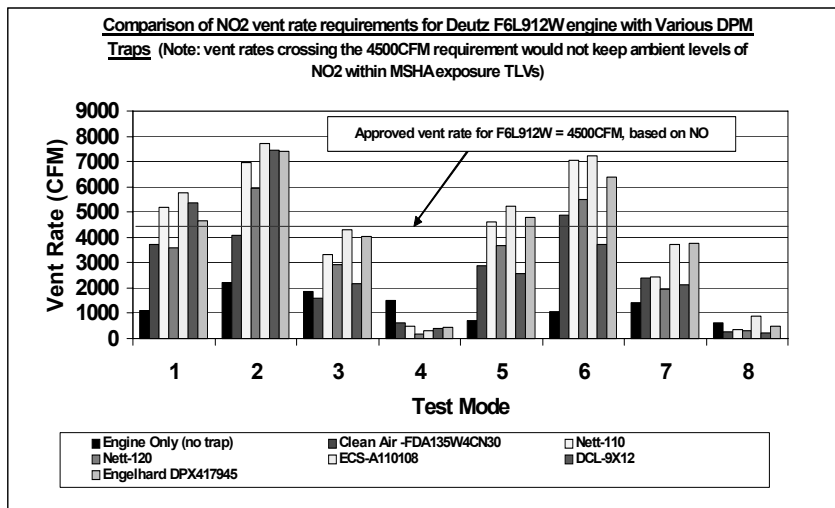
Jul 30, 2003

MSHA A&CC DPM Testing

11

## NO2 Emission from Traps

“High” Levels of No2 Emissions (high Pt catalyzed)



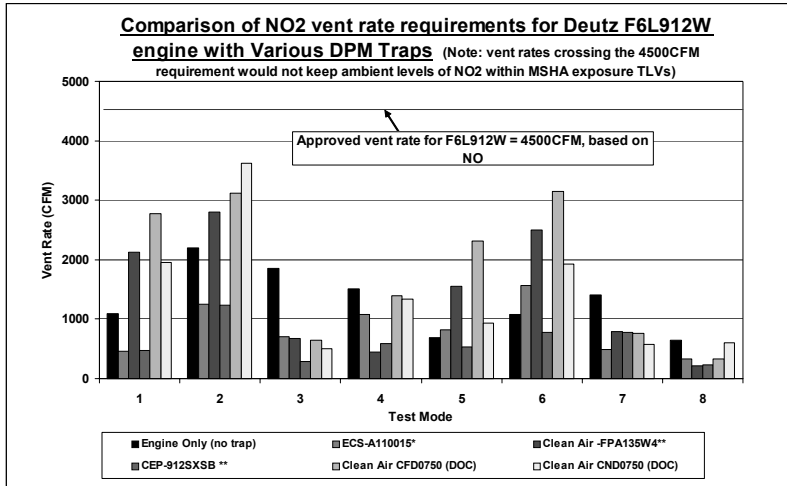
Jul 30, 2003

MSHA A&CC DPM Testing

12

# NO2 Emission from Pt Traps

“Low” Levels of No2 Emissions (light Pt, Base metal, uncatalyzed, DOCs)



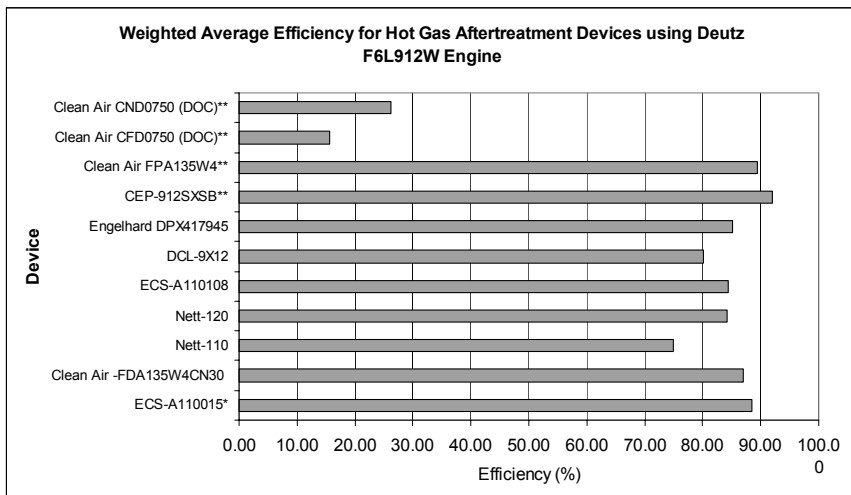
Jul 30, 2003

MSHA A&CC DPM Testing

13

# DPM Efficiency from Hot Gas Devices

**Weighted Average Efficiency for Hot Gas Aftertreatment Devices using Deutz F6L912W Engine**



\*. base metal catalyst

\*\*-platinum/cerium fuel additive

Jul 30, 2003

MSHA A&CC DPM Testing

14

## Other/Continuing Work

### Hot Gas Devices:

- “Hybrid” Systems
  - DOC with FTF
  - Hot Gas Disposable filters with/without DOCs
- More low NO<sub>2</sub> traps
  - Other light Pt catalyzed designs
  - More base metal designs
- Other After-market technologies
  - Additives
  - Fuel catalysts
  - Alternate after-treatments

### Cooled Exhaust Devices:

- Test more filters to add to list as-received