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Title: Particle Size Distribution and Mass Emissions from a Minning Diesel Engine Equipped with a Dry System Technologies Emis sion Control System

ABSTRACT

Particle size distribution, number, and mass emissions from the exhaust of a 92 kW 1999 Isuzu 6BG1 nonroad diesel engine were measured. The engine was equipped with a Dry System Technologies (DST) auxiliary emission control device that included an oxidation catalyst, a heat exchanger, and a paper particulate filter. This technology was designed for diesel engines operating in underground coal mines. Particulate measurement was taken during the ISO 8 mode test for engine out, engine with catalyst and heat exchanger, and engine with the DST using a scanning mobility particle sizer (SMPS) and the traditional filter method (TFM) following the code of federal regulations (40 CFR).

For the ISO 8 mode test, the engine out size distributions were monomodal in nature with a number mean diameter between 80 nm to 100 nm, except for the light load modes where the number mean diameter was about 35 nm for idle and about 50 nm for mode 4 (rated speed, 10 percent load). The DST emission control device reduced the number of ultrafine and nanoparticles by three order of magnitude from about 10^8 part./cm³ to about 10^5 part./cm³. The DST efficiency of removing particles was about 99.9 percent based on particle number, 99 percent based on particle mass derived from number and size, and about 90 % percent based on mass derived the TFM.

Good correlation was found for engine out between mass emission derived the TFM and mass derived from size and number, assuming spherical particles with unit density, particularly for the medium to high load engine conditions of the ISO 8 mode test. However, no correlation was found for the same quantities for the DST out emissions. Measurements revealed that for DST out, the particulate matter collected on a filter using the TFM were mainly volatile organic compounds. Under such condition, there seemed to be a discrepancy between mass derived from the TFM and mass derived from particle size and number. In addition, there seemed to be a notable difference in the DST efficiency between particle number and size based efficiency and mass based efficiency as stated in the previous paragraph.

For the DST, particle number and mass, derived from particle number and size, efficiencies are much higher than the mass derived efficiency using the TFM. This suggests that the materials collected on a filter downstream of the DST are largely gas phase volatile compounds that are not detected by the particle size and number instrument as an aerosol in the form of particles or droplets. Thus, what is defined as particulate emissions, particularly downstream of an exhaust filter, is not really particle or droplet emissions to the atmosphere, it is rather gas phase volatile material that happen to adsorb or condense on the filter using the TFM following CFR 40.

Particle Size Distribution and Mass Emissions from a Mining Diesel Engine Equipped with a Dry System Technologies Emission Control System

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Outline

- Project Objectives
- Experimental Setup
- Findings
- Conclusions

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Objectives

- To determine the efficiency of diesel particulate matter mass removal from the exhaust of a 92 Kw Isuzu 6BG1 equipped with a Dry System Technologies (DST) auxiliary emission control device, which is designed for diesel engines operating in coal mines
- To determine the effect of DST on particle size and number emissions
- To compare particle mass and number data

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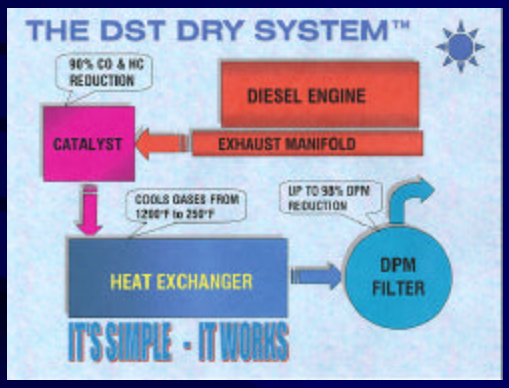
Dry System Technologies



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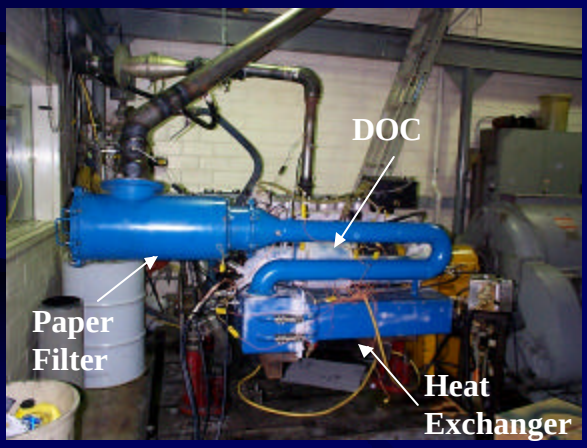
Engine Setup with DST



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Clean and Dirty Filters

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Micro-Tunnel Coupled to CVS

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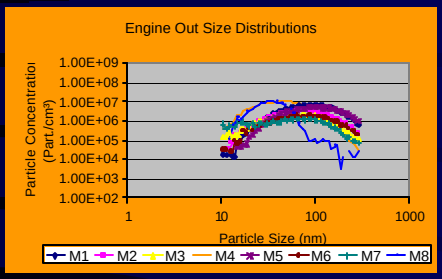
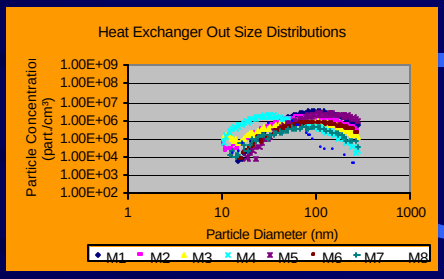
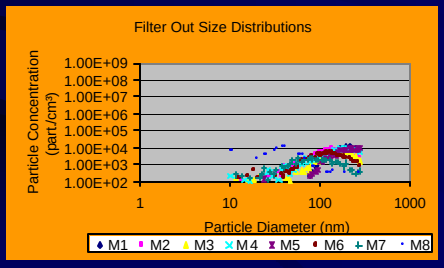
Engine, Heat Exchanger, and Filter Out Size Distributions







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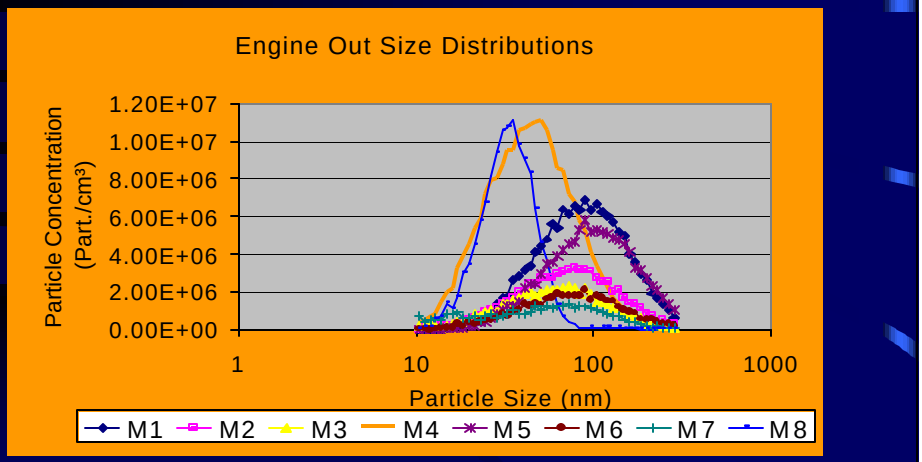
Engine Out Size Distributions



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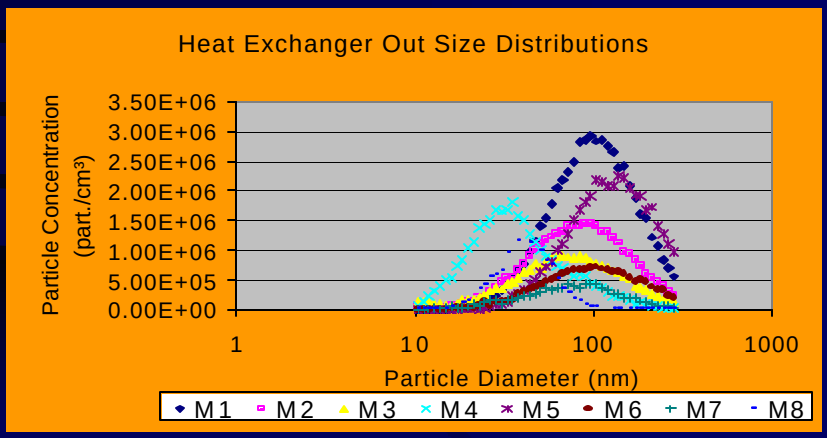
Heat Exchanger Out (Filter In) Size Distributions



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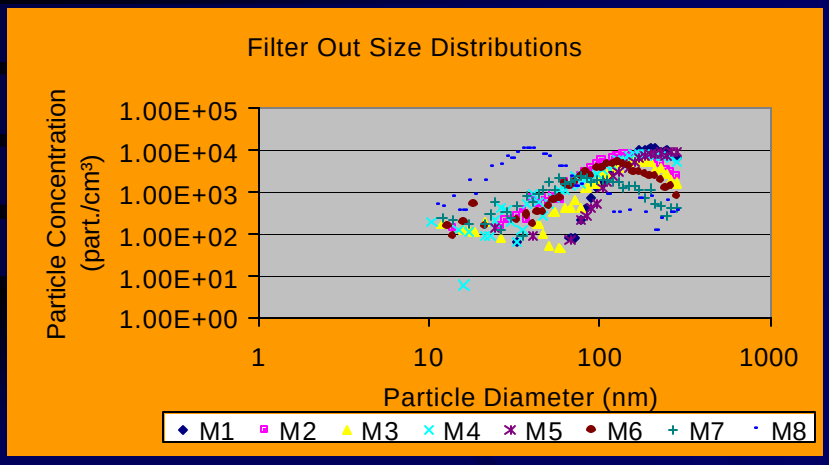
Filter Out Size Distributions



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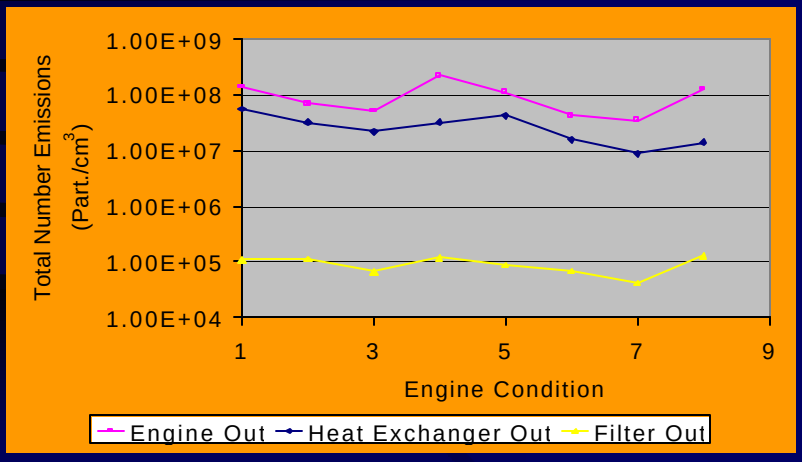
Total Number Emissions with Different Exhaust Configurations)



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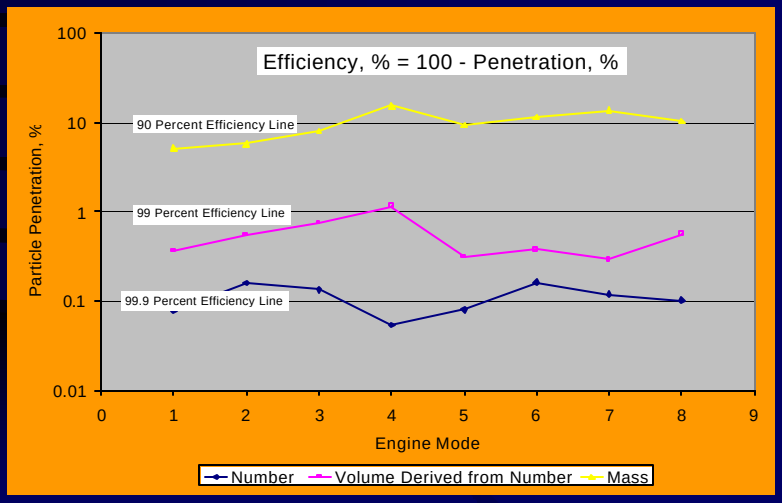
Particle Penetration Through DST (Lower Penetration=Higher Efficiency)



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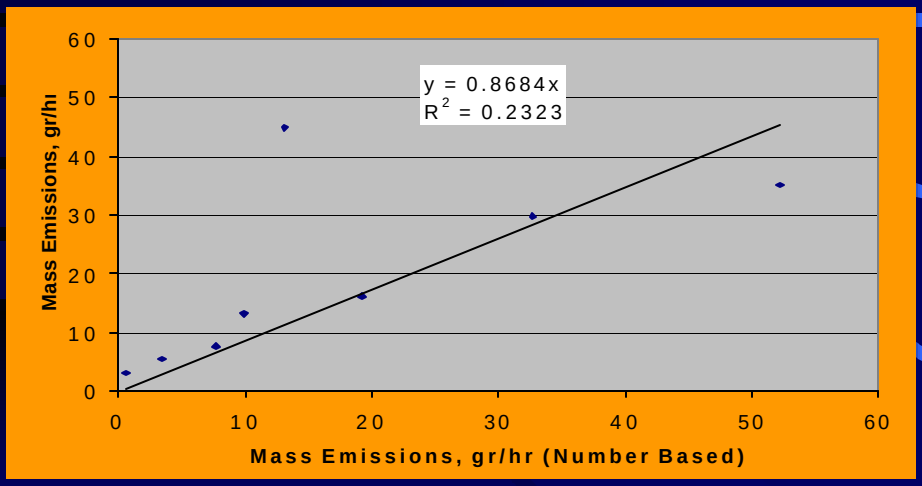
Correlation for Engine Out Between Filter Based and Mass derived from Particle Number and Size (ISO 8 Mode)



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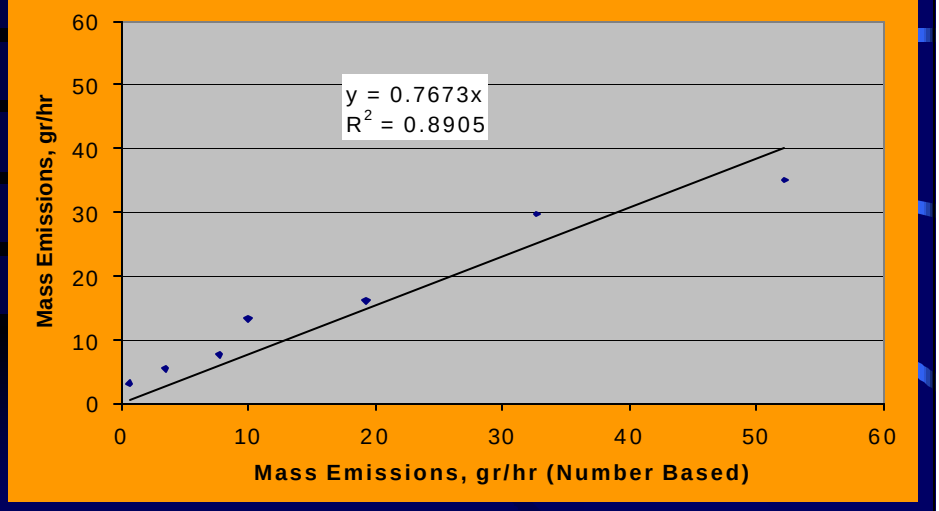
Correlation For Engine Out Between Filter Based and Mass derived from Particle Number and Size (ISO 8 Mode Except Rated Speed, 10 % Load)



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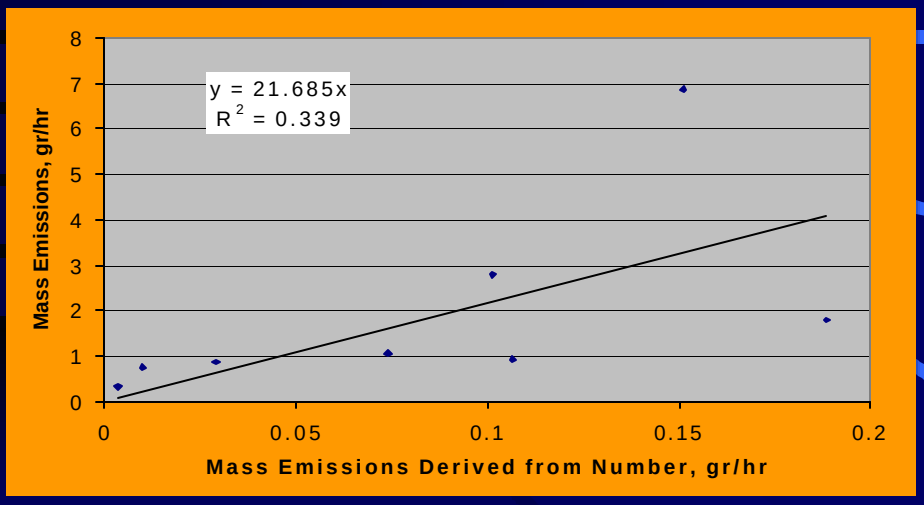
Correlation for Filter Out Between Filter Based and Number and Size based Mass Emissions



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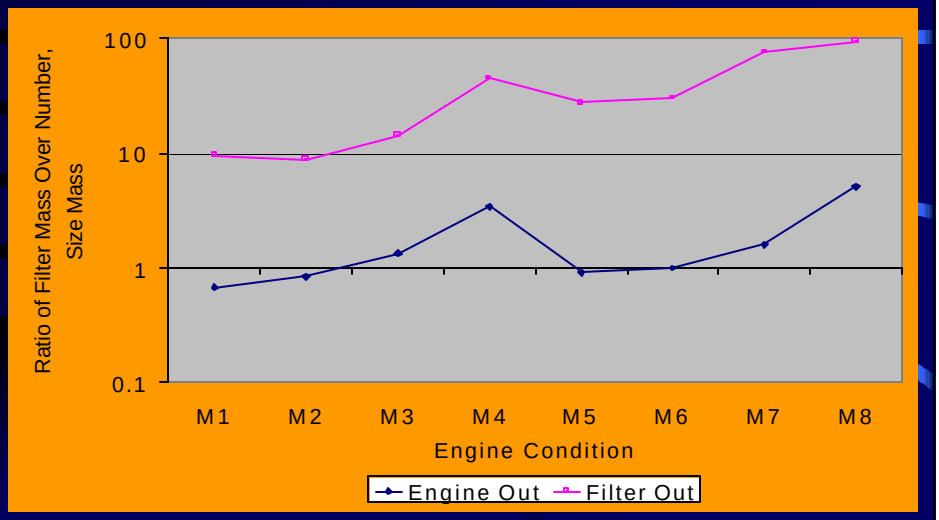
Discrepancy Between Filter Based and Number and Size Based Mass Emissions



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Summary

- Better than 99 percent efficiency based on Particle Number was shown with the DST
- Ultrafine as well as nanoparticles were significantly reduced using the DST
- Good correlation for engine out was found between particle mass derived from number and size and mass measured using traditional filter measurement method when mode 4 of the ISO 8 Mode test was eliminated. This mode is usually highly volatile and was previously shown to be very sensitive to the measurement method
- Weak Correlation for Filter Out was found between mass derived from number and size and mass measured using traditional filter measurement method

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Finally

- If the interest is to measure particles, which measurement method should we believe, the mass collected on a filter or the number and size method?
  - This work suggests that downstream of a filter where most of the particles are volatile, mass collection on a filter tends to exaggerate the emissions of particulate matter due to the collection of gas phase volatile compounds on the filter.

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