Fuel borne catalysts and diesel aerosols emissions

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INTRODUCTION

The results of long-term evaluation tests and field and laboratory emission tests showed that the Mann-Hummel SMF-AR® system (currently marketed by NIOSH) is potentially a viable control technology that can be used to substantially reduce the exposure of underground miners to aerosols emitted by light-duty underground mining diesel-powered vehicles.

The operation of the SMF-AR® system requires the use of fuel additives containing iron-based fuel borne catalysts (FB Cs).

Potential emissions of nano-sized metallic aerosols with high surface reactivity and toxicity and their potentially adverse effects in underground environments is of concern.

The NIOSH and Vale conducted a laboratory study to characterize the effects of selected fuel additives on the emissions of aerosols and criteria gases emitted by a diesel engine equipped with the SMF-AR® system.

BACKGROUND

The system evaluated in this study is a hybrid (passive/active) DPF system.

The filter element was made of sintered metal plates with 10 μm mean pore size, 45% porosity, and 0.38-mm wall thickness. When needed, the electrical heater mounted at the back of the filter element is used to actively regenerate the system. The additive plays an important role in the regeneration process and operation of the system.

The emissions were assessed for three fuels:

- Ultralow sulfur diesel (ULSD);
- USLD doped with Sataocene® (Innospec Ltd., Cheshire, U.K.) and marketed under name DT8; and
- USLD doped with Eolys Powerflex®, (Rhodia, La Rochelle Cedex, France) marketed as DT9.

Both additives introduced approximately 30 ppm of iron in the fuels.

OBJECTIVES

The objective of this study was to evaluate the effects of the system and fuel additives on:

- Integrated mass concentrations of total carbon (TC) and elemental carbon (EC);
- Aerosol number concentrations;
- Aerosol size distributions; and
- Integrated total mass concentrations of Fe.

METHODS

The testing took place at the Diesel Laboratory at NIOSH OMSHR, Pittsburgh, PA.

The system was evaluated using a Cummins L240 engine coupled to an eddy-current dynamometer. The engine was operated at four steady-state (R50, R100, IS, and 1100) and one transient cycle (ISO LHD cycle).

The emissions were assessed for three fuels:

- Ultralow sulfur diesel (ULSD);
- USLD doped with Sataocene® (Innospec Ltd., Cheshire, U.K.) and marketed under name DT8i; and
- USLD doped with Eolys Powerflex®, (Rhodia, La Rochelle Cedex, France) marketed as DT9i.

Both additives introduced approximately 30 ppm of iron in the fuels.

RESULTS

The system dramatically reduced TC and EC concentrations in diluted exhaust (TC results shown below). Since the FOout TC and EC concentrations were at or below the limit of quantification of the TOT-EGA analysis, the efficiency of the system in reducing TC and EC concentrations was estimated to be better than 99%.

The emissions of the system were determined using the results of measurements made in undiluted exhaust using the Fourier Transform Infrared (FTIR) analyzer (Gasmet, Model 4000).

The effects of the additives on TC and EC concentrations were found to be function of engine operating conditions. In the cases of R50, R100, IS, and I100 tests, the EDout TC and EC concentrations were substantially lower when fuels treated with ULSD+DT8i and USLD+DT9 were used in place of neat ULSD. In the cases of R100, the EDout TC and EC concentrations were lower when ULSD+DT8i was used, but not when ULSD+DT9 was used in place of neat ULSD.

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CONCLUSIONS

- The tests showed that the evaluated system was very effective in reducing EC, TC, and total number concentrations of aerosols.
- With the exception of a couple test conditions, the evaluated additives slightly increased EDout total number concentrations.
- The fuels with additives consistently produced higher EDout aerosol concentrations.
- In some cases, substantial fractions of FOout aerosols were found in pronounced nucleation modes.
- For all test conditions, Fe introduced with the additives substantially increased the Fe concentration in the EDout aerosol samples.
- However, the ULSD+DT8i and USLD+DT9 Fe concentrations were much lower than ULSD EDout concentrations.

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