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Brunswick Mine Diesel Particulate Filter Extended Field Study

About the Project

The Brunswick Mine Diesel Particulate Filter Study was one of the final DEEP projects. It was conducted at Noranda's Brunswick Mine in Bathurst, NB by Noranda crews with the cooperation of CANMET, NIOSH, Andreas Mayer, and particulate filter suppliers.

The study was started in early 2000. Field evaluations continued for 20 months. The final report—authored by Sean McGinn—was submitted to DEEP in the autumn of 2003.

Background and Objective

The DEEP program had identified diesel particulate filters (DPF) as the most promising technology to provide 90% or better reduction of diesel particulate matter (DPM) emissions. The purpose of the Noranda's Brunswick Mine project was to determine the effectiveness and economic maintainability of current generation DPF technology as applied to underground mining operations.

The project team selected four heavy production vehicles to be tested with DPFs over a period of 4000 hours. Two of the vehicles were ST8-B scooptrams—vehicles that operate as front-end loaders to dig into a pile of ore, tram the load over a distance, dump it to a transfer point, and return to the load point to repeat the cycle. The other two vehicles were MT436-B haulage trucks—machines designed to haul large loads over longer distances, typically loaded either by an LHD or at an overhead chute. All four vehicles were powered by electronically controlled DDC Series 60 engines rated at 242 kW (325 hp) in scooptrams and at 278 kW (375 hp) in trucks.

Request for proposals was submitted to particulate filter manufacturers, which included detailed descriptions of the vehicles and their duty cycles, including recordings of exhaust gas temperatures. Based on this information, the emission control manufacturers produced proposals for particulate filter systems for each application. The filter systems finally chosen for the project are listed in the following table.

Supplier	DPF System	Vehicle
ECS	Cordierite; base metal catalyst; passive	ST8-B Scooptram
ECS (Unikat)	SiC; Fe/Sr fuel additive + diesel oxidation catalyst; passive	MT436-B Truck
DCL	SiC; Pt catalyst + electric heater	ST8-B Scooptram
Oberland Mangold	Knitted glassfiber cartridges; Fe/Sr fuel additive; passive	MT436-B Truck

Project Methodology

Performances of the DPF systems during the project were evaluated by:

- Qualitative feedback information, logged from vehicle operators, mechanics, maintenance crew, and mine management, and
- Quantitative measurements, including (1) raw exhaust emissions, (2) ambient concentrations of pollutants, and (3) vehicle and DPF operating statistics.

Emissions Measurement

Instruments and methods were developed to accommodate the day to day monitoring, as well as more precise scientific evaluations done at regular intervals. Three instrument setups were used through the project for measuring undiluted emissions, mostly based on the Ecom gas analyzer (electrochemical measuring cells) and the NanoMet diesel particulate characterization system—an instrument incorporating a diffusion charger (DC) and a photoelectric aerosol (PAS) sensor.

Ambient DPM Sampling

Sampling and analysis was conducted through the project for ambient concentrations of diesel particulate matter. The samples were taken with both the Respirable Combustible Dust (RCD) method and the NIOSH 5040 method for organic and elemental carbon.

Vehicle and DPF Operating Statistics

The DPF systems were tracked for basic operating statistics. The engine control modules (ECM) provided data for actual operating hours, fuel consumption, idling hours, and operating profiles with engine rpm and load versus time. In addition, datalogging of exhaust temperature and filter pressure drop were performed to evaluate DPF regeneration.

DPF Systems Experience

ECS Catalyzed Filter

The ECS filter was a fully passive system utilizing a cordierite wall-flow monolith coated with a base metal catalyst. This filter performed well in all aspects (emissions, regeneration,…) during the study. It accumulated a total of 4053 operating hours.

ECS (Unikat) Filter with Fuel Additive

The Unikat filter utilized two parallel silicon carbide (SiC) substrates with oxidation catalysts in the upstream position. The filter was passively regenerated using Octimax 4804 iron/strontium (Fe/Sr) based fuel additive by Octel. The additive was blended to the fuel in a separate fueling system maintained for vehicles with additive-assisted DPFs. The concentration of metals in the fuel was 20 ppm, with a 16:4 Fe:Sr ratio.

After an initial period of satisfactory operation, this filter started building excessive pressure drop due to slow regeneration, despite high exhaust gas temperatures. After some time the filter substrate failed due to uncontrolled regeneration of the overloaded filter. A replacement unit was also damaged due to uncontrolled regeneration. The first filter unit performed over 2500 hours, the second unit over 1620 hours.

DCL Catalyzed/Electric Filter

The DCL filter utilized platinum-catalyzed SiC substrate, as well as a 600 V electric heater at the inlet face of the filter. In order to regenerate with the electrical heating system, it was planned that the vehicle would be brought to the shop and connected to shore power and a source of compressed air at the end of each shift (an inconvenient requirement opposed by the mine crew). Initially, the electrical regeneration system caused considerable technical and safety (electrical fault) problems.

As became apparent during the project, the filter was able to passively regenerate due to the Pt catalyst. The electrical regeneration system was thus deemed redundant. The filter system performed well over 4260 hours.

Oberland Fiber Filter with Fuel Additive

This filter utilized cartridges with knitted fiberglass filter media. Filter regeneration was facilitated using the same Fe/Sr fuel additive (and vehicle fueling system) as used in the Unikat filter.

The first version of the filter was undersized, causing backpressure problems. After it was replaced by a larger unit, the filter performed well. The biggest problem with this system was perhaps the large geometrical size of the unit, making it difficult to install on vehicle. The manufacturer has since abandoned the fiber cartridge design, and so the experience has mostly historical significance.

Conclusions

The project demonstrated that all tested DPFs were able to provide over 90% reduction in the PM mass emissions, as well as reductions in other emissions and in ambient PM exposures.

It was emphasized that the DPF selection process is the most critical factor in successful implementation. Current DPF technology is not yet ready to offer off-the-shelf solutions. Careful application engineering is needed for every individual vehicle and its duty cycle.

The final report contains a wealth of conclusions and recommendations on underground application of DPF systems. Ultimately, the success in implementing DPF technology in an underground mine may have little to do with which system is chosen and everything to do with the process and team that a mine puts together in selecting, installing, measuring, maintaining, and verifying the systems.