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## Diesel Engine Maintenance and Exhaust Emissions

### About the Project

The engine maintenance project was performed by a team led by Sean McGinn, from Noranda Technology Centre, Pointe Claire, Quebec. Project objectives included developing a model for auditing mine maintenance procedures and facilities, a guideline for good maintenance practice with emphasis on reducing emissions, implementing good maintenance practice in a mine, and evaluating its effects on diesel emissions. The implementation and evaluation were conducted in Falconbridge's Strathcona Mine in Onaping, Ontario.

Three documents were developed during the project and submitted to DEEP in 2000:

- *Diesel Engine Maintenance Audit Plan*,
- *Maintenance Guidelines and Best Practices for Diesel Engines in Underground Mining*,
- Final Report.

Special emphasis should be put on the "Maintenance Guidelines" document, which has been designed as a practical tool to educate and train mine personnel on the importance of maintenance for reducing diesel emissions.

### Project Activities

To accomplish the project objectives, the project plan was broken into five stages, as follows:

- Preparation of an audit model for engine maintenance operations; application of the audit at two mines sites; selection of a host site for the project;
- Development of guidelines and best practices for engine maintenance to reduce diesel emissions;
- Emissions testing to acquire baseline emission values for mobile equipment included in the study;
- Implementation of improved engine maintenance strategy through changes to process, tools and training;

- Analysis of the impact of improved maintenance practices on emissions and formulation of recommendations resulting from fieldwork.

### Diesel Engine Maintenance Audit Plan

Building on an existing health and safety audit framework, the researchers developed a model for auditing mine site diesel engine maintenance. The audit protocol was based on previous research, which identified the six diesel engine systems that most affect emissions. It allowed the researchers to evaluate both scheduled and unscheduled maintenance activities. The completed model was tested at two mine sites, and the results of the audit reviewed with mine personnel at both sites. The audits allowed the researchers to identify problems in maintenance facilities and practices that could give rise to increased diesel emissions, and also helped identify a good candidate site for implementing and evaluating an improved maintenance program. Mine personnel at the host site agreed that the audit process was effective in identifying strengths and weaknesses in their maintenance program.

Strathcona Mine was selected as the host site for the project.

### Maintenance Guidelines and Best Practices

A five person panel, including technical personnel from the diesel engine industry, mine maintenance staff and diesel emissions researchers, was recruited to work together to construct guidelines for ensuring that maintenance practices were effective in reducing diesel emissions. The panel drew from a combination of previous research, proprietary reference materials, personal and industry experience.

The guide is divided into two categories: (1) *operational issues* which discusses the general practices of both mechanics and operators concerning diesel engines; (2) the *system*

*specific* section which recommends best practices for maintaining the six primary engine systems that affect diesel emissions, including:

- Intake system – evaluating the installation and sizing of intake system components; testing and maintaining piping, filter housing, gaskets, connections and seals; installation of appropriate gauges; appropriate servicing intervals; detection and correction of problems.
- Exhaust system – monitoring exhaust backpressure and emissions; evaluating installation and damage of exhaust system components; monitoring the condition and performance of aftertreatment devices.
- Fuel Injection System – diagnosing problems; scheduling checks of primary fuel pressure; selecting and examining filters; verifying air/fuel ratio; checking fuel temperature and air in fuel; using filtered vents on fuel tanks; adjustment and replacement of components.
- Cooling System – scheduling maintenance and cleaning of cooling systems; important service practices; verifying operating condition of gauges and alarm sensors; diagnosing and correcting problems.
- Fuel Quality and Handling – proper storage, transfer of fuels, filtration and cleanliness.
- Lubrication System – operation fundamentals, oil and filter service practices, and used oil analysis techniques.

### Emissions Testing

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#### Equipment

Emissions testing equipment used in the study consisted of a gaseous emissions test system from Noranda Technology Centre called the Undiluted Gas Analysis System (UGAS) and a particulate emissions test system from CANMET called the Undiluted Particulate Sampling System (UPSS). The two systems were situated on a maintenance shop floor in the mine as a tool for mechanics.

#### Baseline Tests

The equipment was first used to collect data on emissions before the new maintenance program was initiated. In total 16 mechanics were

trained to use the equipment, and 13 vehicles were tested over the baseline stage of 3 months.

#### Case Studies

Mechanics were trained in the improved maintenance process. Afterwards, its effectiveness was evaluated by conducting case studies on four vehicles. For each vehicle, emissions were measured at the start of the day, before any changes or maintenance activity. Then improved maintenance procedures were applied. Emissions were measured again when the vehicle was ready to return to work.

Results from the case studies showed that gaseous and particulate emissions could be significantly reduced through maintenance procedures. Emission reductions of up to 65% were demonstrated for gases (CO), and up to 55% for DPM.

#### Recommendations

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The following recommendations for improved diesel engine maintenance were made in the study's Final Report:

- Build a team focused on implementing an improved maintenance strategy. Team members should include mechanics, operators, supervision, planning, and management from the mine. Ensure that sufficient time, tools, and training resources are available to the team.
- Construct an engine maintenance audit program. The model provided by the study could serve as a template. The audit should be conducted at least once per year.
- Create and implement a strategy for improving existing maintenance practices to reduce diesel emissions, drawing on the *Maintenance Guidelines and Best Practices*.
- Test undiluted tailpipe emissions on underground vehicles. Set action limits on emissions to ensure response to problems. Establish clear action requirements once action limits are reached.
- Make use of the suppliers of diesel engines and related equipment for training and updating maintenance personnel. Suppliers improve their relationships with mine staff by working with them hands-on to find solutions to problems, as described in the case studies for this project.