

The promise of an improved work environment and miner safety in underground mines.



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The Human Factor

- Diesel equipment is used in approximately 13,500 mining operations in the North America.
- These operations include approximately 300 underground and 11,000 surface metal and nonmetal mines and 180 underground and 2,000 surface coal mines.
- MSHA estimates that approximately 230,000 miners are working at these mines.

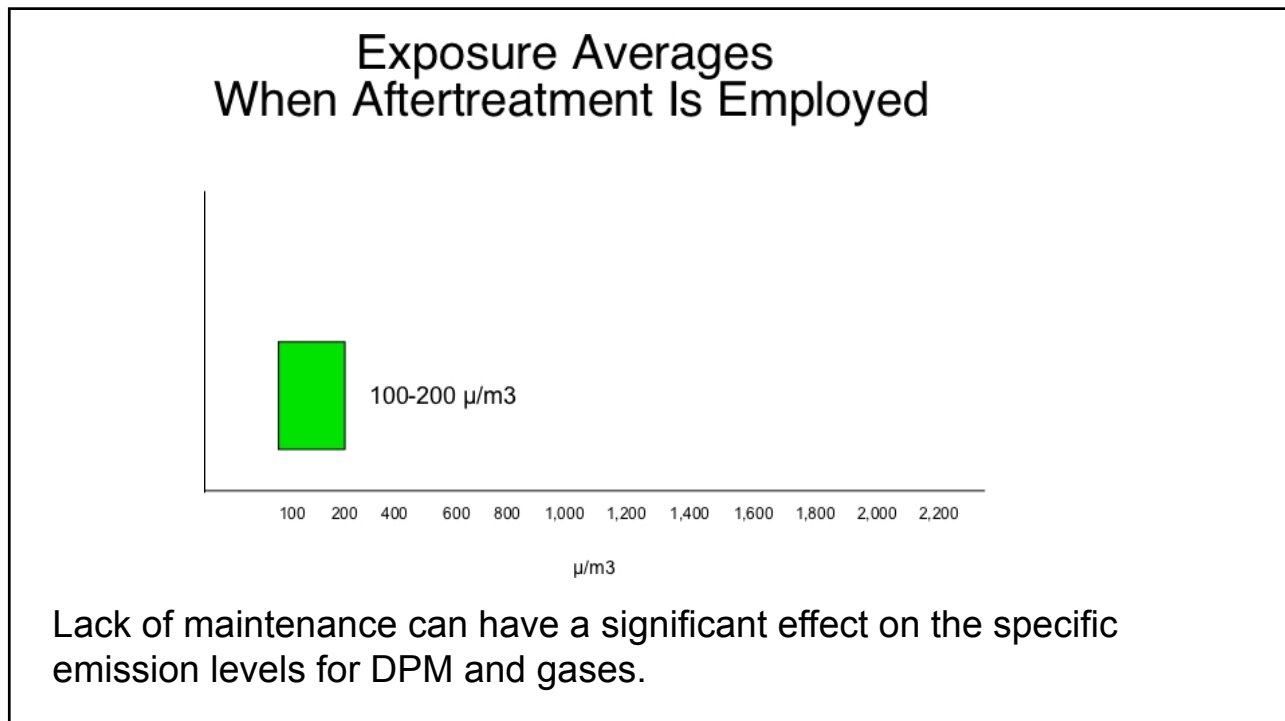
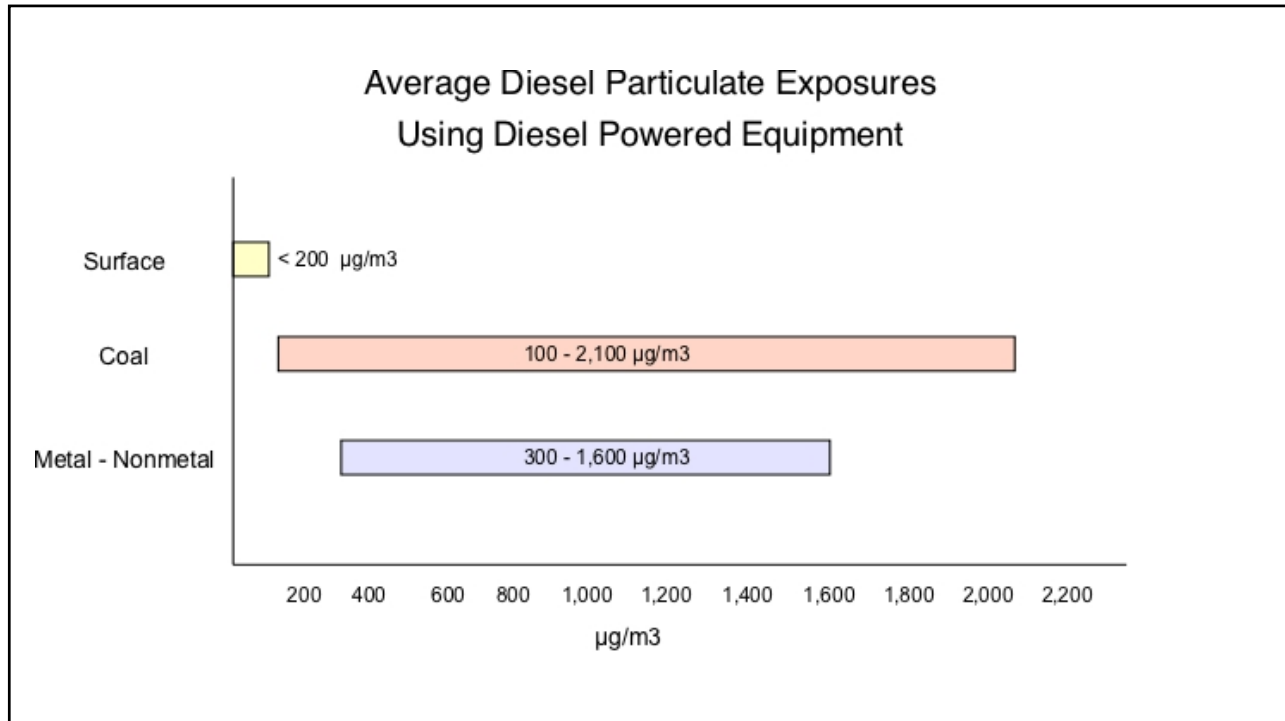
Exposure Contrasts

- Studies conducted by MSHA of diesel particulate exposures in the U.S. mining industry indicate that diesel particulate exposures in surface mining operations are generally less than 200 $\mu\text{g}/\text{m}^3$.
- Higher exposures are typically associated with front-end loaders and haul-trucks.
- Exposure appears to be more related to the specific operating conditions than the size of the engine.

DPF's/ Aftertreatment

- Commercially available after-treatment devices are capable of reducing DPM by 25 to 99 percent.
- Reductions in exposure to DPM are dependent on the application of available engine emission control technology and modifications to mine ventilation systems.
 - Use an accredited product certified or listed by:

MSHA, CARB, or VERT



Impact of Exposure

Three factors influence diesel particulate exposure:

- Mine ventilation
- Engine diesel particulate emissions
- The effectiveness of engine after-treatment devices

Diesel exposure is inversely proportional to the ventilation rate.

As ventilation increases, the diesel exposure decreases and as ventilation decreases, the diesel exposure increases (Haney, 1992).

Increasing ventilation can be difficult and costly

- Major upgrades

Example: 16-foot diameter shaft = \$1,000/foot

- Power

Example:

250,000 cfm at 1-inch wg = 40 hp

40 hp x 100 hours/week @ 10¢/kw-hour = \$15,000/year

1.25x airflow = 2x hp = 2x electricity cost

2x airflow = 8x hp = 8x electricity cost

Concentration of Emissions

- Aftertreatment efficiencies can range from 50 to 99 percent. It is important to note that an after-treatment device that is 90 percent efficient is twice as effective for removing diesel particulate as an 80 percent efficient device. That is because 10 percent instead of 20 percent of the particulate would be remain in the environment.
- The concentration of airborne diesel particulate can be estimated from the formula:

$$\text{Concentration} = \frac{\text{Emission} \times (1 - \text{Control Eff.}) \times 1000 \times 35,317}{\text{Ventilation Rate}}$$

Where:

Concentration is in $\mu\text{g}/\text{m}^3$,

Emissions are expressed in grams per minute, g/min,

Control Efficiency is expressed as a decimal, Ventilation Rate is in cubic feet per minute, cfm.

Market Drivers

- Mining makes up a very small fraction of the markets for diesel engine manufacturers and does not have a significant enough share of the total market to drive the technology on its own.

DPF's are not set it and forget it

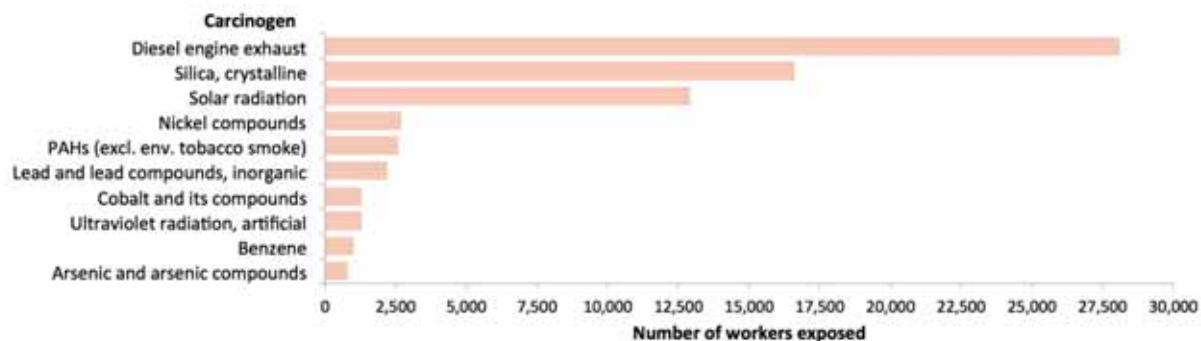
- The maintenance of diesel engines and emissions control systems is the single most important factor in any mine's emissions control strategy.
- Regardless of what technologies are being brought into the strategy, within a very short period of time they will require verification and maintenance in order to continue performing within expected limits.
- The underground mining environment presents some of the most severe operating conditions found anywhere and maintaining mobile equipment in a mine requires highly skilled people, facilities, tools, and support.

Maintenance & Commitment The Achilles Heel Of Success

- Engine Maintenance
- DPF Maintenance & Operator Training
- Management buy -in



Miner Exposure to Carcinogens



Diesel Particulate Exposure

- There is no diesel OEL in Ontario, in Regulation 833 (Control Of Exposure to Biological or Chemical Agents), there is mention of diesel particulate matter in section 183.1 of Regulation 854 (Mines and Mining Plants).
- In section 183.1, the regulation addresses ventilation for underground mines where diesel equipment is operating. According to this section the maximum acceptable exposure is 400 $\mu\text{g}/\text{m}^3$ measured as total carbon (approximately 307 $\mu\text{g}/\text{m}^3$ elemental carbon).
- Standards have been developed in other jurisdictions and include:
 - United States Mine Safety and Health Administration: 160 $\mu\text{g}/\text{m}^3$ (total carbon).
 - Australian Institute of Occupational Hygienists: 100 $\mu\text{g}/\text{m}^3$ (elemental carbon)
 - Finnish Institute of Occupational Health:5 $\mu\text{g}/\text{m}^3$ for general workplaces and 20 $\mu\text{g}/\text{m}^3$ as an underground mining-specific target level (both based on elemental carbon)

Set lower exposure limits

- The Occupational Cancer Research Centre recommends reducing personal exposure to 0.02 mg/m³ measured as elemental carbon.
- More than a 10-fold reduction from the current ON mining limit

Reg. 854: MINES AND MINING PLANTS 183.1 (4)

Commitment – It Can Be Done

Switzerland

- Diesel engines used in new construction machines must comply with a Swiss particle number (PN) emission limit.
- The PN emission requirements ensures that all construction machines sold in Switzerland be fitted with diesel particulate filters
- As of 2017: 120,000 DPF equipped engines

Switzerland (SUVA, 2000)

- Diesel equipment must be equipped with DPF systems
- Meet Suva SAFEL filter list quality requirement
- Some exemptions
 - Equipment Not used for regular work and less than 1 hour per day
 - Engine less than 50 kW, with service less than 2 hours

Employers still responsible for protecting workers

- Even though there isn't an OEL for diesel exhaust yet, employers are still responsible for assessing the risk it poses to their workers.
- According to [section 5.2 of the Occupational Health and Safety Regulation](#), employers must inform workers about hazardous substances in their workplaces and develop safe work procedures.

Awareness of DPM Exposure

- Between 2000 and 2017 – 2,150 seminars/conferences around the world have made the industry aware of the correlation between emissions and DPM and the harmful effects on worker health.
- Over the same time span 5,800 technical papers have been published or presented regarding Diesel Exhaust, research, effects, and field experience.
- The consensus is aftertreatment devices dramatically reduce exposure rates of workers.

The Sad Truth

- Less than 10% of Diesel engines underground employ a DPF or advanced aftertreatment.
- Most mines do not have a purchasing strategy specific to DPFs.

Why?