






Real-time DPM Monitoring in Underground Mines

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Presentation Outline

- Background Information
- DPM Sampling
- Experimental Considerations
- Evaluation of PAS 2000 as Real-time DPM Monitor
- Real-time DPM Monitoring of Diesel Production Activities
- Recommendations


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Objectives

- Evaluate the usefulness of the EcoChem Analytics PAS 2000 real-time PAH monitor for airborne DPM sampling
- Use PAS 2000 monitors mounted on diesel vehicles through the work shift for various types of mining tasks
- Look for instances of exposures that could have been lowered by applying simple solutions

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Modern Underground Mining

- 10,000+ tons per day hoisted to surface
- Heavily mechanized
- Multi-level serial ventilation networks (energy intensive)
- Diesel is usually the largest ventilation stress factor
- Diesel used for haulage, drilling, maintenance, personnel transportation, supervision, etc.

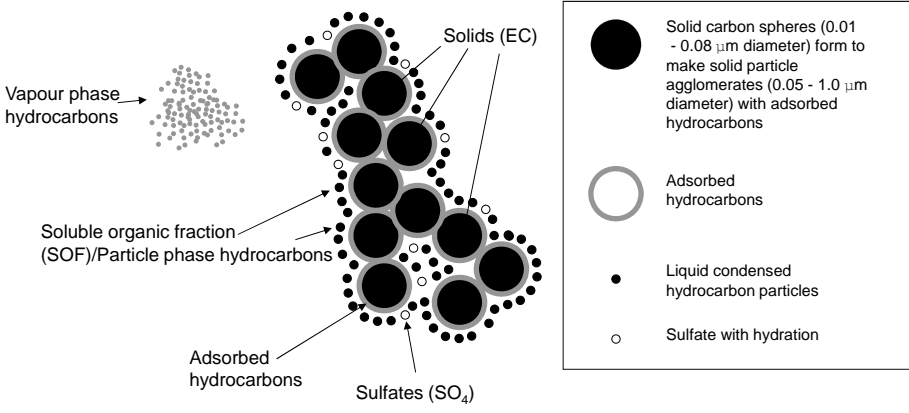


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Particulate Matter



Vapour phase hydrocarbons

Soluble organic fraction (SOF)/Particle phase hydrocarbons


Adsorbed hydrocarbons


Sulfates (SO₄)


Solids (EC)

- Solid carbon spheres (0.01 - 0.08 μm diameter) form to make solid particle agglomerates (0.05 - 1.0 μm diameter) with adsorbed hydrocarbons
- Adsorbed hydrocarbons
- Liquid condensed hydrocarbon particles
- Sulfate with hydration

Reproduced from HEI's Diesel Exhaust: A critical Analysis of Emissions, Exposure, and Health Effects


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Health Issues

- Hundreds of different compounds and chemicals
- Most of the particulate is sub-micron in diameter (respirable)
- Vapour phase contains irritants and toxic chemicals
- Many of the hydrocarbons associated with DPM are known human carcinogens

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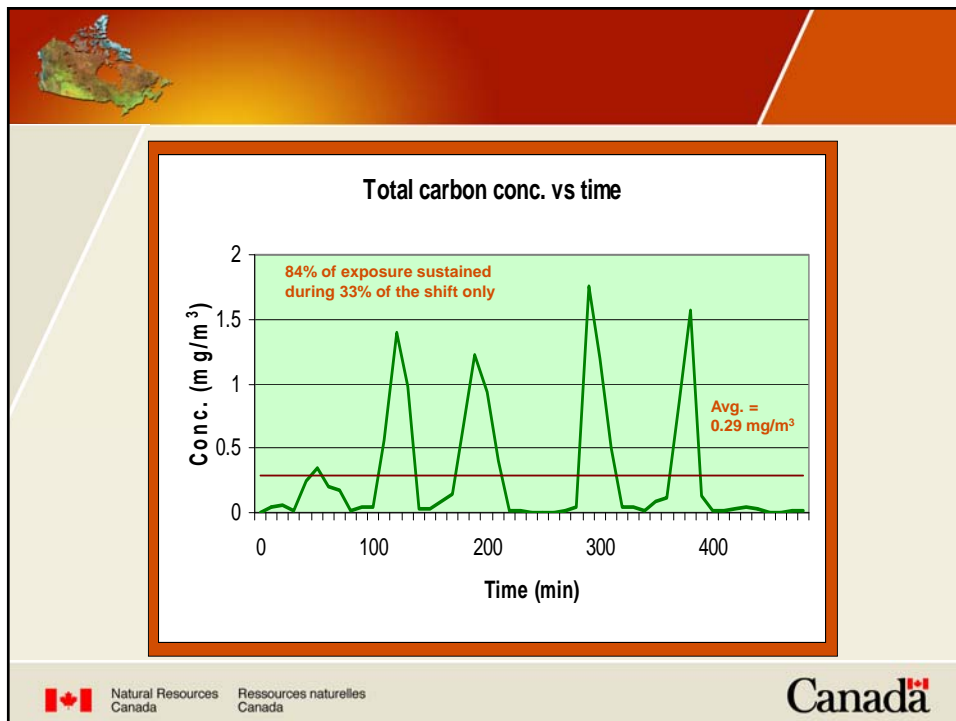



DPM Sampling Train Time-weighted Average Sampling



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Sampling for DPM

- TWA diesel particulate matter (DPM) sampling and analysis is challenging
- Real-time DPM sampling is even more complex
- Issues: size, chemistry, composition, interference, etc. lead to indirect means of analysis




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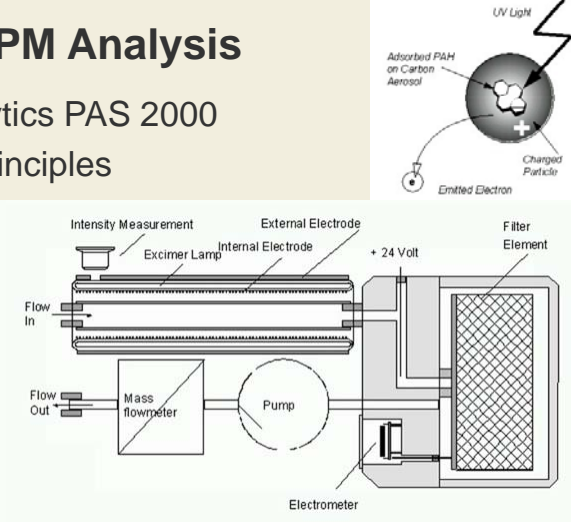





Real-time DPM Analysis


- EcoChem Analytics PAS 2000
- Photoelectric principles









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Other Real-time DPM Sampling Principles (Ambient)

- TEOM – Tapered element oscillating micro-balance
- Photo-acoustic methods
- Others

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Instruments



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Fitting Instruments to Vehicles





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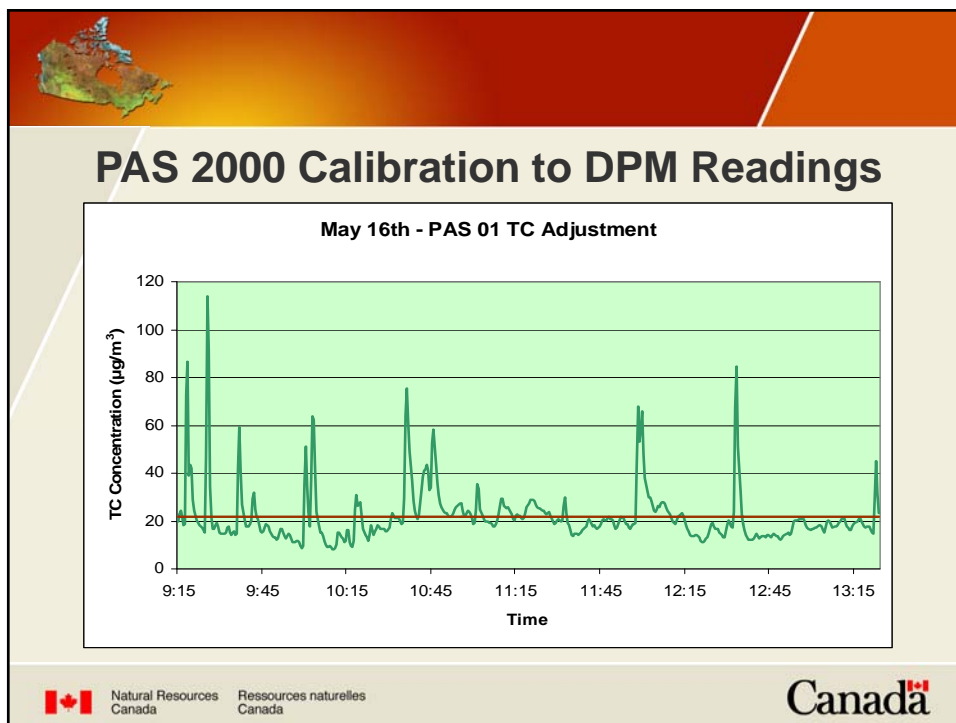
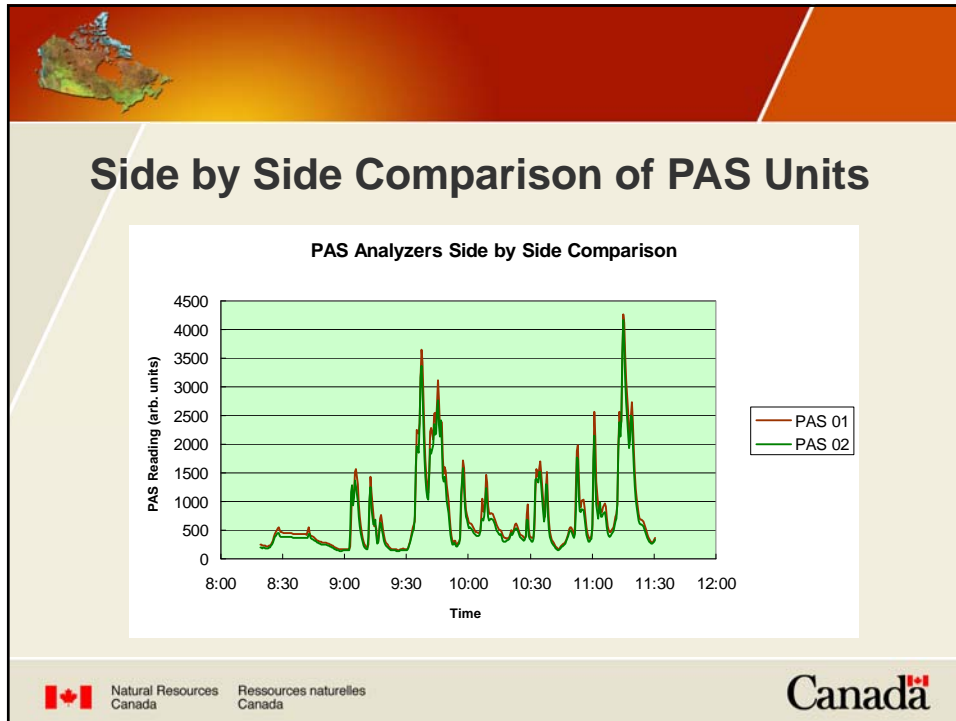
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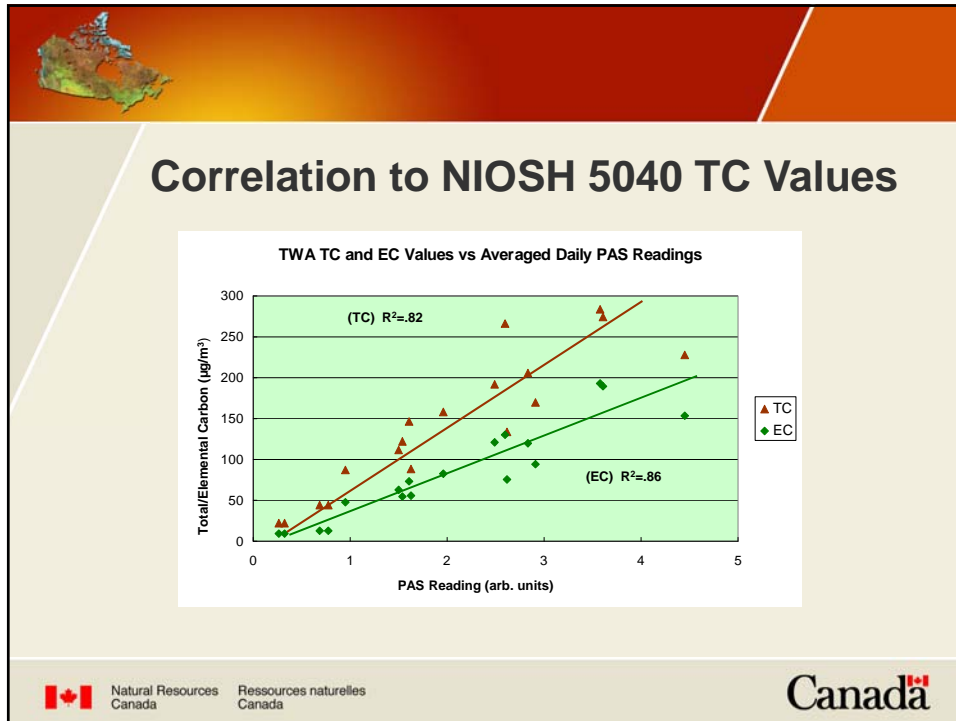


Results – Ability of PAS 2000 to Measure the Presence of DPM

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TWA TC and EC Values – NIOSH 5040

Task	Vehicle	TC (µg/m³)	EC (µg/m³)	TC/EC
Mucking to orepass	LHD #099	88	56	1.6
Mucking to orepass	LHD #103	134	76	1.8
Mucking to orepass	LHD #092	302	154	2.0
Mucking to orepass	LHD #092	345	209	1.7
Mucking to orepass	LHD #037	274	189	1.4
Supervisor	T #6001	112 +	63 +	1.8
Road maintenance	GR #116	506	274	1.8
Stope maint. (vent., sprays)	ST #413	430	246	1.7


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TWA TC and EC Values – NIOSH 5040


Task	Vehicle	TC ($\mu\text{g}/\text{m}^3$)	EC ($\mu\text{g}/\text{m}^3$)	TC/EC
Drilling chunks	BHD #048	1066	800	1.3
Drilling chunks	BHD #822	284	193	1.5
Supervisor	PC #1094	87	48	1.8
Stope maint. (vent., sprays)	ST #545	299 ⁺	137 ⁺	2.2
Ore Haulage	HT # T13	228	153	1.5
Loading haulage truck	LHD #1005	366	188	1.9
Road maintenance	GR #4	266	130	2.0
Haulage	HT #T13	206	120	1.7
Road maintenance	GR #2	164	88	1.9


TC: 87 – 1066 $\mu\text{g}/\text{m}^3$, EC: 48 – 800 $\mu\text{g}/\text{m}^3$, TC/EC: 1.3 – 2.2 (avg. 1.7 \pm .2)



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Measuring Real-time DPM Concentration with the PAS 2000...

- Side by side comparison shows that instrument reacts strongly in the presence of diesel equipment
- Strong linear correlation to NIOSH 5040 total carbon and elemental carbon samples
- PAS 2000 cannot measure DPM directly or absolutely exactly but is a very good surrogate measurement for real-time monitoring applications (engineering tool, not a regulatory compliance tool)



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Results – Monitoring Mining Activities

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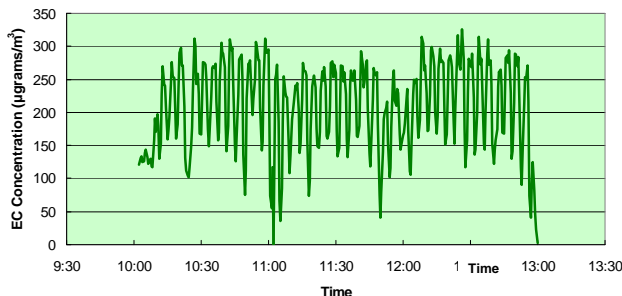
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Load-Haul-Dump




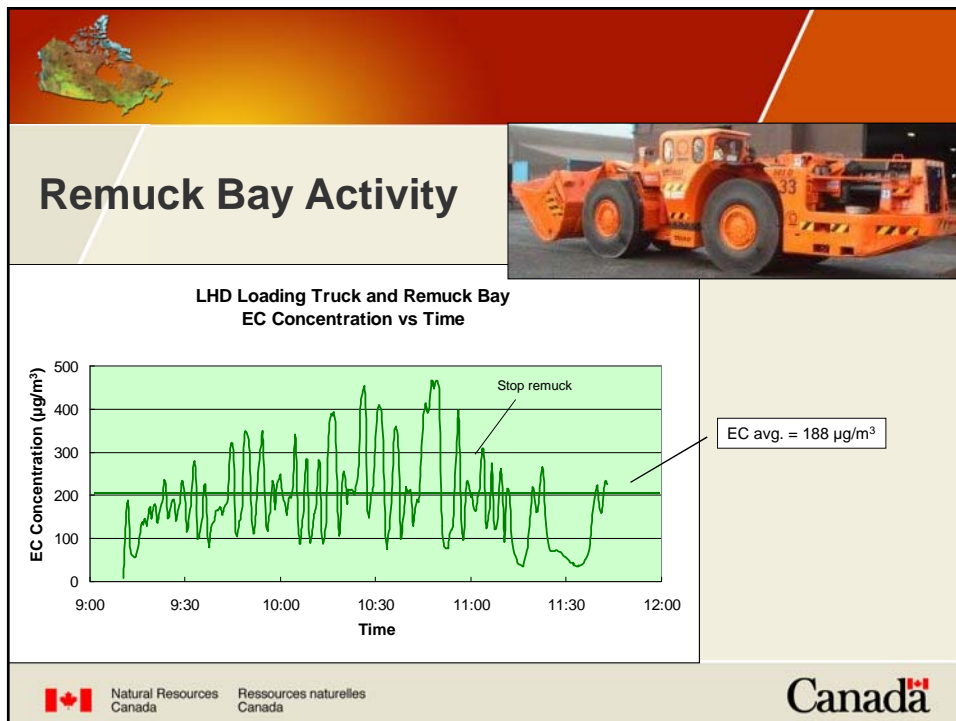
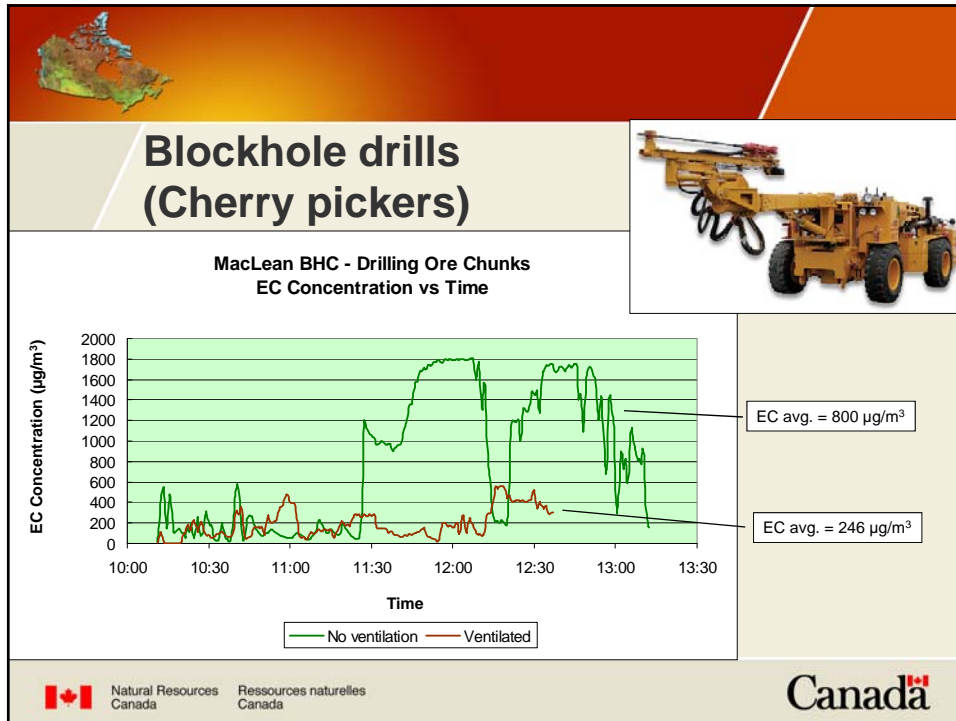
Wagner LHD #092 - Draw Point to Ore Pass - 2600 Level
EC Concentration vs Time

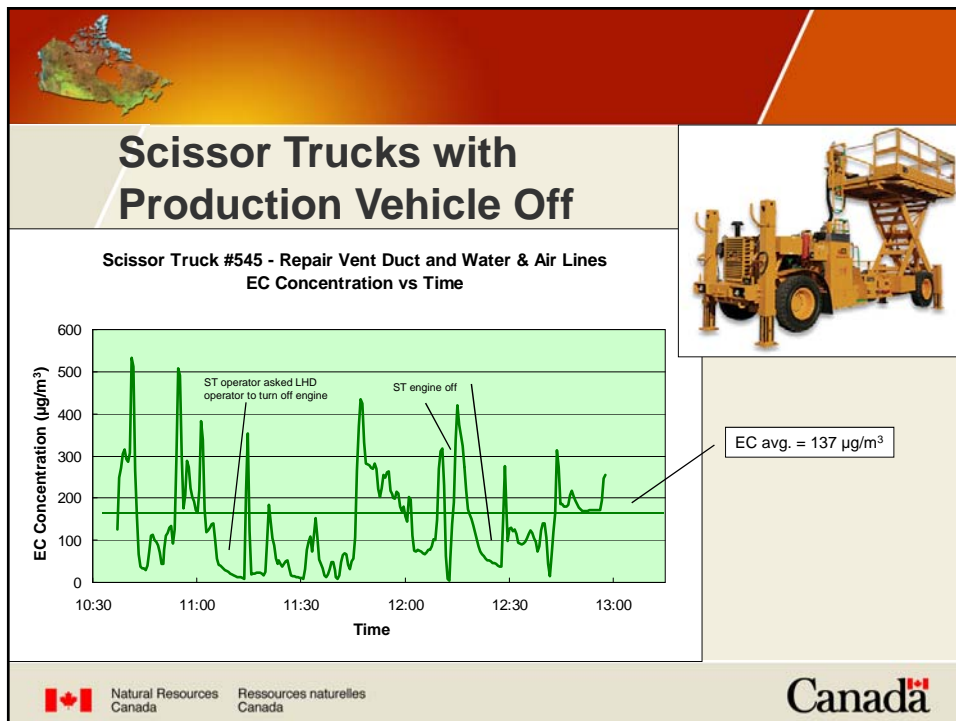
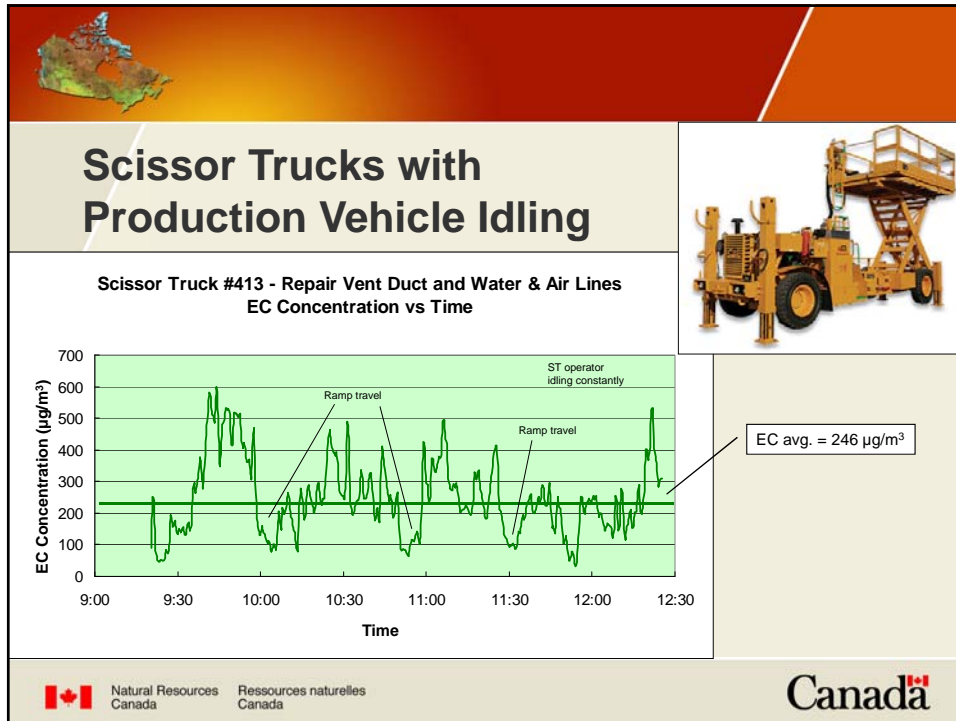


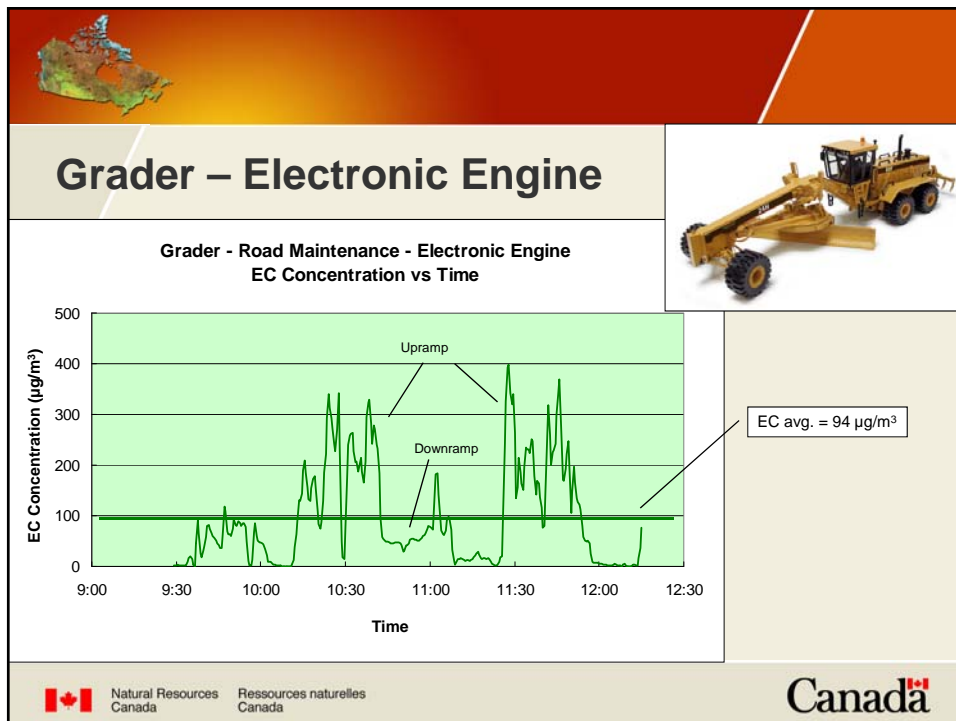
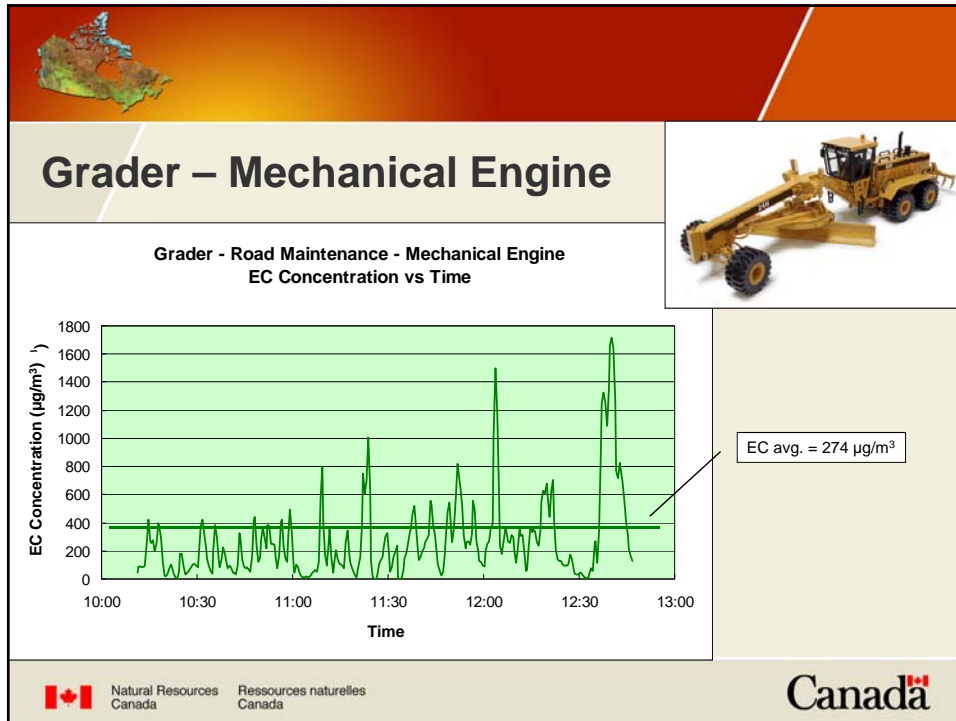
The graph displays EC Concentration (ugrams/m³) on the y-axis (0 to 350) against Time on the x-axis (9:30 to 13:30). The concentration shows high-frequency, high-amplitude fluctuations, generally staying between 100 and 300 ugrams/m³, with occasional peaks near 350 and troughs near 50.

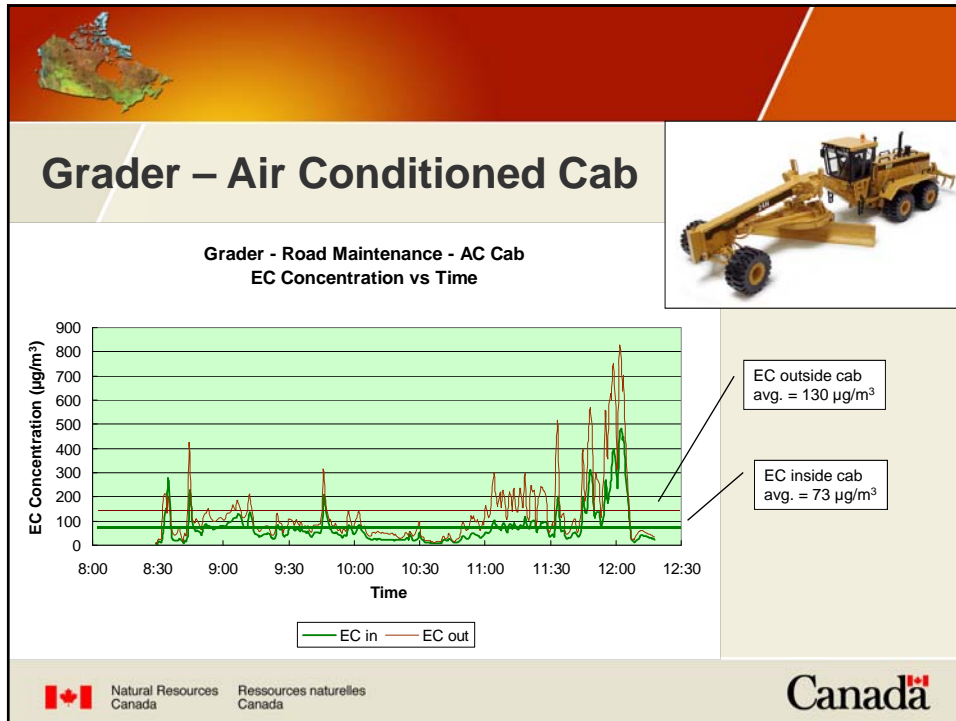
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- ## Findings
- What workers can do for themselves:
 - Make sure that your vehicle and those in the vicinity of his/her work area are working properly (mechanically sound)
 - Ensure that idling is kept to a minimum
 - Ensure that local ventilation infrastructure is working, that it is properly maintained and that volumes are delivered correctly
 - Whenever possible travel with the exhaust downstream to ensure quick effective dilution
 - Participate in Workplace Occupational Health and Safety Committees
 - Request training as required
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Findings

- What the company can do for the worker:
 - Supply adequate primary and auxiliary ventilation volumes
 - Ensure proper distribution of ventilation
 - Ensure proper maintenance of ventilation infrastructure (proximity to work face, integrity of ducting, etc.) and distribution controls
 - Make sure vehicles are maintained on a regular schedule and that maintenance is exhaust quality based
 - Invest in the latest technology (modern engines, AC cabs, exhaust control modules)
 - Provide training to workers on a regular basis to reinforce the importance of the above parameters and highlight what they can do for themselves



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Conclusion

- TWA sampling is needed for regulatory assessment of worker exposure, but...
- Real-time DPM monitoring is very useful in identifying opportunities for exposure reduction
- PAS 2000 monitor is a good indirect way to measure the presence of DPM in real-time



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 VALE INCO

 xstrata

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