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Welcome to

Diesel Emissions Underground: What Really Matters

Protecting Worker Health with Proven Solutions

Presented by
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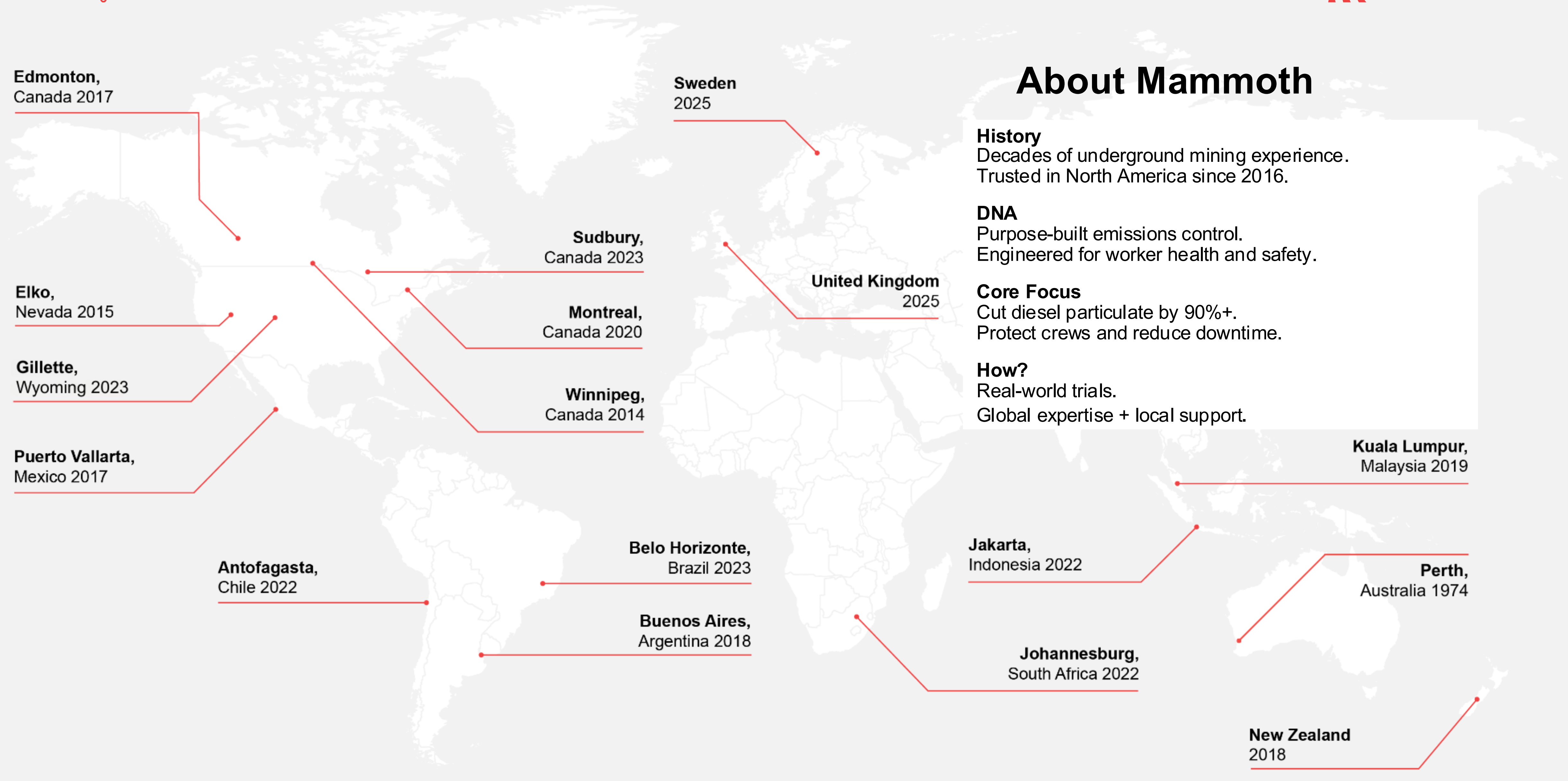

About Mammoth

History
Decades of underground mining experience.
Trusted in North America since 2016.

DNA
Purpose-built emissions control.
Engineered for worker health and safety.

Core Focus
Cut diesel particulate by 90%+.
Protect crews and reduce downtime.

How?
Real-world trials.
Global expertise + local support.

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Our solutions engineered for you

Thermal blankets

Replacement exhaust

Exhaust aftertreatment

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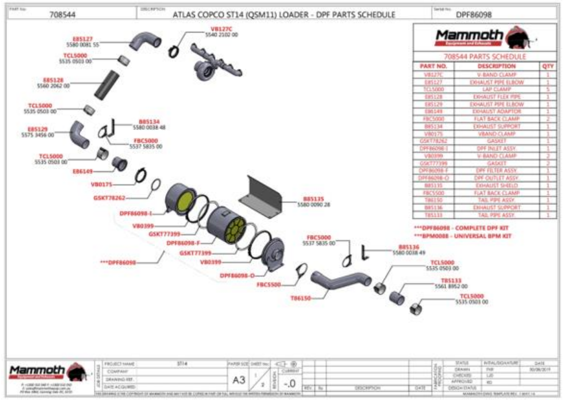
Setting the Stage

Diesel drives mining.

- Diesel powers 90%+ of underground mining equipment
- Worker exposure = critical health risk – DPM recognized as a #1 carcinogen by World Health Organization
- Increase in legislated restrictions around diesel emissions and worker exposure to pollutants
- In many sites accessiblity is very challenging meaning that mines want to maximize equipment life once underground. Lots of older equipment with poor to zero exhaust aftertreatment control

= Why emissions control can't wait.



DPFs in Practice

Influence airflow needs
Optimized design → better ventilation balance

Lower worker exposure
Cleaner air → healthier crews

Manage NO_2 formation
Smarter control → safer environments

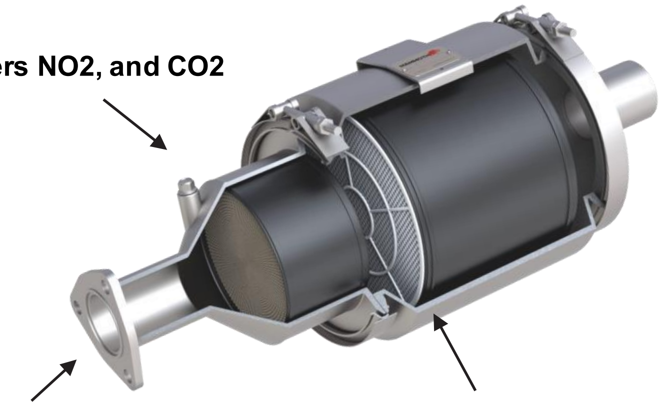
Simplify maintenance
Effective cleaning strategies

= Total system impact underground.

Know what you're fighting.

- Diesel particulate matter (DPM)
- Carbon Monoxide (CO)
- Nitrogen dioxide (NO_2)
- Confined space amplification

= The real threats to worker health.



Trusted tools that work.

- DPFs trap soot □ Cleaner Air
- DOCs reduce CO/HC □ Fewer Toxins
- Proprietary Back Pressure Monitoring System □ Reliable Performance

= A toolbox for underground protection.

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Real-World Results

Field-tested. Operator approved.

	Number of tests	Average DPM level	Exceedance count	% of tests in Exceedance
2020	9	0.105	9	100%
2023	128	0.082	56	44%
2024	77	0.042	8	10%
2025	134	0.047	9	7%

Date Sampled	Name or Location (Occupation)	Shift Length (Hours)	Shift (Days, Nights)	Actual Sampling Time (Min)	Theoretical Flow Rate Req'd (L/Min)	Pre-Calibration (L/Min)	Post-Calibration (L/Min)	Percent Difference (<5%)	Average-Calibration (L/Min)	Air Volume (litres) Calculated	Analyte (carbon type)	Total Weight, Carbon from SGS Galson lab (mg)	Carbon Concentration for Actual Sampling Time (mg/m3)	Less than Lab Detection Limit (less than 0.004 mg)	Ontario OEL-TWA for Carbon based on OEL for 8-hour work shift (mg/m3)	Adjustment Model (if >8 hr shift)	Adjusted Ontario OEL-based on extended hour shift length (mg/m3	Exceedances
2023-05-03	Area Sample #15	10.75	Day Shift	480		2.117	2.024	4.49%	2.071	993.8	Elemental	0.161	0.162	No	0.12	Brief Scala	0.074	EXCEEDED
2023-05-03	Area Sample #14	10.75	Day Shift	480		2.0509	2.0443	0.32%	2.048	982.8	Elemental	0.144	0.147	No	0.12	Brief Scala	0.074	EXCEEDED
2023-05-03	Area Sample #13	10.75	Day Shift	480		2.0437	2.0292	0.71%	2.036	977.5	Elemental	0.06	0.061	No	0.12	Brief Scala	0.074	No
2023-05-10	Area Sample #10	10.75	Night Shift	480	2	2.0611	2.0517	0.46%	2.056	987.1	Elemental	0.217	0.220	No	0.12	Brief Scala	0.074	EXCEEDED
2023-05-10	Area Sample #12	10.75	Night Shift	480		2.0621	2.0546	0.36%	2.058	988.0	Elemental	0.201	0.203	No	0.12	Brief Scala	0.074	EXCEEDED
2023-05-10	Area Sample #	10.75	Night Shift						0.000	0.0	Elemental		NA	N/A	0.12	Brief Scala	0.074	EXCEEDED
2023-05-16	Area Sample #9	10.75	Night Shift	384		2.0409	2.0376	0.16%	2.039	783.1	Elemental	0.186	0.238	No	0.12	Brief Scala	0.074	EXCEEDED
2023-05-29	Area Sample #8	10.75	Night Shift	480		2.0166	2.0227	0.30%	2.020	969.4	Elemental	0.183	0.189	No	0.12	Brief Scala	0.074	EXCEEDED
2023-05-16	Area Sample #7	10.75	Night Shift	363		2.0304	2.0349	0.22%	2.033	737.9	Elemental	0.072	0.098	No	0.12	Brief Scala	0.074	EXCEEDED
2023-05-18	Area Sample #6	10.75	Day Shift	480		2.0376	2.0514	0.67%	2.045	981.4	Elemental	0.065	0.066	No	0.12	Brief Scala	0.074	No
2023-05-18	Area Sample #5	10.75	Day Shift	480		2.0314	2.0307	0.03%	2.031	974.9	Elemental	0.091	0.093	No	0.12	Brief Scala	0.074	EXCEEDED
2023-05-18	Area Sample #4	10.75	Day Shift	480		2.0394	1.9664	3.64%	2.003	961.4	Elemental	0.209	0.217	No	0.12	Brief Scala	0.074	EXCEEDED
2023-05-20	Area Sample #1	10.75	Night Shift	480		1.9664	1.9398	1.36%	1.953	937.5	Elemental	0.196	0.209	No	0.12	Brief Scala	0.074	EXCEEDED
2023-05-20	Area Sample #2	10.75	Night Shift	480		2.0514	2.0352	0.79%	2.043	980.8	Elemental	0.093	0.095	No	0.12	Brief Scala	0.074	EXCEEDED
2023-05-20	Area Sample #3	10.75	Night Shift	480		2.0307	2.0155	0.75%	2.023	971.1	Elemental	0.011	0.011	No	0.12	Brief Scala	0.074	No
2023-05-22	Area Sample #14	10.75	Day Shift	480		2.0352	2.033	0.11%	2.034	976.4	Elemental	0.101	0.103	No	0.12	Brief Scala	0.074	EXCEEDED
2023-05-22	Area Sample #15	10.75	Day Shift	480		2.0155	2.0149	0.03%	2.015	967.3	Elemental	0.119	0.123	No	0.12	Brief Scala	0.074	EXCEEDED

Date Sampled	Name or Location (Occupation)	Shift Length (Hours)	Shift (Days, Nights)	Actual Sampling Time (Min)	Theoretical Flow Rate Req'd (L/Min)	Pre-Calibration (L/Min)	Post-Calibration (L/Min)	Percent Difference (<5%)	Average-Calibration (L/Min)	Air Volume (litres) Calculated	Analyte (carbon type)	Total Weight, Carbon from SGS Galson lab (mg)	Carbon Concentration for Actual Sampling Time (mg/m3)	Less than Lab Detection Limit (less than 0.004 mg)	Ontario OEL-TWA for Carbon based on OEL for 8-hour work shift (mg/m3)	Adjustment Model (if >8 hr shift)	Adjusted Ontario OEL-based on extended hour shift length (mg/m3	Exceedances
2025-04-14	Area Sample #4.1	10.75	Night Shift	480.00	2	1.895	1.8356	3.18%	1.865	895.3	Organic	0.078	0.087	No	0.12	N/A	N/A	No
2025-04-14	Area Sample #4.1	10.75	Night Shift	480.00	2	1.895	1.8356	3.18%	1.865	895.3	Elemental	0.043	0.048	No	0.12	Brief Scala	0.074	No
2025-04-14	Roby truck	10.75	Night Shift	480.00	2	1.9662	1.9106	2.87%	1.938	930.4	Organic	0.04	0.043	No	0.12	N/A	N/A	No
2025-04-14	Roby truck	10.75	Night Shift	480.00	2	1.9662	1.9106	2.87%	1.938	930.4	Elemental	0.01	0.011	No	0.12	Brief Scala	0.074	No
2025-04-20	Area Sample #6	10.75	Night Shift	480.00	2	1.8682	1.8219	2.51%	1.845	885.6	Organic	0.066	0.075	No	0.12	N/A	N/A	No
2025-04-20	Area Sample #6	10.75	Night Shift	480.00	2	1.8682	1.8219	2.51%	1.845	885.6	Elemental	0.056	0.063	No	0.12	Brief Scala	0.074	No
2025-04-20	Offset LHD	10.75	Night Shift	480.00	2	1.8999	1.909	0.48%	1.904	914.1	Organic	0.044	0.048	No	0.12	N/A	N/A	No
2025-04-20	Offset LHD	10.75	Night Shift	480.00	2	1.8999	1.909	0.48%	1.904	914.1	Elemental	0.013	0.014	No	0.12	Brief Scala	0.074	No
2025-04-28	Area Sample #7	10.75	Night Shift	480.00	2	2.0103	1.9437	3.37%	1.977	949.0	Organic	0.062	0.065	No	0.12	N/A	N/A	No
2025-04-28	Area Sample #7	10.75	Night Shift	480.00	2	2.0103	1.9437	3.37%	1.977	949.0	Elemental	0.021	0.022	No	0.12	Brief Scala	0.074	No
2025-04-28	Roby Truck	10.75	Night Shift	480.00	2	1.9632	1.8769	4.49%	1.920	921.6	Organic	0.004	0.004	No	0.12	N/A	N/A	No
2025-04-28	Roby Truck	10.75	Night Shift	480.00	2	1.9632	1.8769	4.49%	1.920	921.6	Elemental	0.003	0.003	YES	0.12	Brief Scala	0.074	No
2025-05-12	Area Sample #4.1	10.75	Night Shift	480.00	2	1.8935	1.8849	0.46%	1.889	906.8	Organic	0.045	0.050	No	0.12	N/A	N/A	No
2025-05-12	Area Sample #4.1	10.75	Night Shift	480.00	2	1.8935	1.8849	0.46%	1.889	906.8	Elemental	0.053	0.058	No	0.12	Brief Scala	0.074	No
2025-05-12	Roby LHD	10.75	Night Shift	480.00	2	1.9067	1.9191	0.65%	1.913	918.2	Organic	0.036	0.039	No	0.12	N/A	N/A	No
2025-05-12	Roby LHD	10.75	Night Shift	480.00	2	1.9067	1.9191	0.65%	1.913	918.2	Elemental	0.013	0.014	No	0.12	Brief Scala	0.074	No

Real-World Results

5 years on......consistent results

DPM ↓ 94%

CO ↓ 82%

NO2↓ 47%+

Proven Durability

Safer, more productive mines.

Make/Model	Engine	Horsepower (hp)	CO - Pre (ppm)	CO - Post (ppm)	Difference	CO2 - Pre (%)	CO2 - Post (%)	O2 - Pre (%)	O2 - Post (%)
Epiroc ST1030	Cummins QSL9	250	345	57	83%	6.0	5.7	12.9	13.3
CAT R1700G	CAT C11	353	476	98	79%	6.7	7.5	11.8	10.9
Epiroc ST1030	Cummins QSL9	250	263	9	97%				
Epiroc MT5020	Cummins QSK19	650	677	14	98%	9.3	1.4	8.5	19.1
Epiroc MT5020	Cummins QSK19	650	756	80	89%	5.4	1.3	13.7	19.1
CAT R1700G	CAT C11	353	257	67	74%	4.7	7.5	14.6	10.9
CAT R2900G	CAT C15	409	215	99	54%	5.7	6.3	13.3	12.4
CAT R2900G	CAT C15	409				5.0	5.1	14.2	14.1
Averages					**82%**		**5.0**		**14.2**

NO - Pre (ppm)	NO - Post (ppm)	Difference	NO2 - Pre (ppm)	NO2 - Post (ppm)	Difference	NOx - Pre (ppm)	NOx - Post (ppm)	Difference	DPM - Pre (mg/m3) - whole test	DPM - Post (mg/m3) whole test	Difference
124	230	-85%	23.0	3.0	87%	147.0	233.0	-59%	4.3	0.1	99%
289	303	-5%	32.5	4.3	87%	321.5	307.3	4%	8.3	2.9	65%
269	337	-25%	53.3	0.7	99%	322.3	337.0	-5%	15.0	0.0	100%
257	155	40%	20.6	43.0	-109%	277.6	198.2	29%	130.7	0.5	100%
153	106	31%	2.5	1.3	48%	155.5	107.3	31%	6.9	0.1	99%
326	268	18%	40.5	6.1	85%	366.5	274.1	25%			
263	162	38%	39.0	15.2	61%	302.0	177.2	41%	15.4	0.1	100%
155	181	-17%	8.8	7.3	17%	163.8	188.3	-15%	222.7	0.0	100%
		-1%			**47%**			**7%**			**94%**

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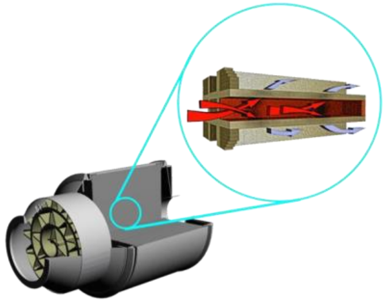
What does this mean for a mine site?



Benefits of lower DPM levels underground

- Mine operates in compliance with legislated regulations
- Safely adopt lower ventilation airflow rates (e.g. CANMET recommended rates vs 100CFM/hp rule)
- Operate more equipment in the same space without risk of worker DPM exposure exceedance
- Improved visibility, less cloudiness
- Attracts workers – underground workers feel safer

Sampling for diesel particulate matter in mines

Where diesel-powered equipment is operating, section 183.3 requires employers to test:

- the volume of airflow in underground haulageways and workings
- the concentrations of carbon monoxide (CO), nitrogen dioxide (NO_2) and elemental carbon in the atmosphere of the workplace

The time-weighted average exposure of a worker to elemental carbon shall not be more than 0.12 milligrams per m^3 of air . The time-weighted average airborne concentration of a biological or chemical agent to which a worker may be exposed is usually calculated based on an eight-hour workday or forty-hour work week. An Occupational Exposure Limit (OEL) Adjustment Tool is available to help those workplaces to calculate OEL for irregular or extended work shifts.

Section 183.3 requires that employers at underground mines conduct at least weekly testing of the volume of air flowing in underground haulageways and workings where diesel-powered equipment is operating.

- Soon.......
  - Even Lower ventilation airflow requirements as a result of engine and DPF package certification.

Passive vs Active DPFs

Why Passive DPF?

- Pro:
  - Simple uncomplicated systems
  - Minimal operator input required
  - Installation requires zero to minimal vehicle modification
  - Ideal for high work cycle operation
- Cons:
  - Reliant on engine work cycle (exhaust heat) for regeneration
  - Can plug quickly in a low work cycle operation

Why Active DPF?

- Pro:
  - Ability to perform a regen on demand
  - Extended hours between cleanings as not dependant on exhaust heat solely for regeneration
- Cons:
  - More complex system with additional electrical controls and typically a fuel supply
  - Often a larger system requiring some vehicle modification to be accommodated on the machine

How to extend DPF life and improve performance

Ensuring DPF longevity and maximum equipment uptime

- Work cycle – diesel engines are built to work hard. Idling and working under minimal load continuously will significantly impact DPF performance – filter will not regenerate, soot loading will not be optimal
- Regular maintenance – keeping the DPF filter on a regular program of cleaning ensures that back pressure is kept to a minimum protecting the engine and extending the filter life
- Correct cleaning process – ensuring that the DPF filter receives the proper cleaning process extends the hours between cleanings
- Engine maintenance – DPF filters are designed and sized based on engine size and expected soot loading rate – deterioration or failure with an injector, valve or even air filter condition will impact the soot loading rate

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Let’s get started!

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