Using VoD, new ventilation regulations, and DPM monitoring to increase production

DPM

Monitoring Solutions

Overview

- Opportunity
  - CANMET engine certification revision.
  - Good previous history of DPM personal monitoring & tail-pipe exhaust monitoring.
  - Theoretical application of the CANMET certification to existing fleet.
  - Determining new Ventilation Requirements
- Validation
  - Increase the frequency of personal monitoring
  - Introduce real-time DPM monitoring.
  - Real-Time DPM Monitoring testing with fans.
- Proposal for change
  - Presenting plan to Health and Safety Committee for Review
  - Ongoing testing and sampling
- Post implementation – validation
  - Comparative tests of personal pumps with real-time DPM monitor.
  - EC/TC/DPM ratios

Opportunity

With the new ventilation regulations, would we have the capacity to safely increase production?

- In 2023, CANMET updated their ventilation requirements for certified equipment with improved diesel engines and technology.
- In 2023, the OEL for DPM was reduced from 400ug/m3 (TC) to 120ug/m3 (EC) . However, the mine was already **pro-actively** following a stricter corporate std of 100 µg/m³ EC.
- Prior to this opportunity, the mine had performed well with DPM testing (both personal & exhaust).
- Existing ventilation capacity of 220 CMS available at 100% VoD.

Previous DPM sampling results (personnel pumps)

- 65 tests in 2023, only 2 exceedances. Both involved a scoop operator with SC35.
- A DPM filter was installed in September 2023, no exceedances following install.
- The results of the 2024 sampling campaign showed no exceedances.

Date	Area	Job Position	Shift Length (hr)	EC TWA (mg/m3)	Adjusted OEL (mg/m3)	Equipment
4/30/2023	330 WEZ, 360 WEZ, 285 CEZ	Scoop Operator	11	0.182	0.100	SC 035
6/20/2023	345 W W0Z	Scoop Operator	11	0.111	0.100	SC 035

Previous tail-pipe exhaust testing

- Diesel vehicle tail-pipe exhaust testing by the maintenance department on all diesel equipment every month.
- Only two failed their test accross 2023 and 2024:
  - FP01 (Minecat face prep tractor) failed its test for 723ppm NOX in Feb 2023
  - ET30 (Minecat electrical tractor) failed its test for 739ppm NOX in Jan 2024
- Note: When an equipment fails the test they redo the test. Sometimes it could be due to the equipment not being hot enough.

CO 480 PPM+ is a fail
NOX 650 PPM+ is a fail
NO2 50 PPM+ is a fail

Review of Regulation Changes 2023

- The Canadian Centre for Occupational Health and Safety, through CANMET certifications, introduced updated ventilation requirements for new generation diesel engines, reflecting technological advances in cleaner diesel engines and filters.

	Previous Legislation	New Legislation	Company Guideline
Ventilation Requirements	0.06 CMS per KW	CANMET engine certification when available. If not available, use previous legislation guidance.	
Diesel emissions exposure limit (8hr TWA) for elemental carbon	308 µg/m^3	120 µg/m^3	100 µg/m^3

- The OEL for DPM was reduced from 400ug/m3 (TC) to 120ug/m3 (EC) . However, the mine was already **pro-actively** following a stricter corporate std of 100 µg/m³ EC.

Electric Equipment List

Equipment Number	Equipment Type
DD01-DD02-DD03-DD30	Jumbo
BL04-BL05	Bolter
CC01-CC02-CC03-CC04	Cassette Carrier
BH01	Blockholer
SL01-SL02-SL03	Scissor Lift
FP02	Face Prep Tractor
LH01	Production Drill
SC02-SC03-SC04-SC05	Scoop
GP01-GP03-GP04 GP06 thru to GP14	Gopher (Light Vehicle)
LT33	Electric Toyota
ET01	Electric Tractor
Total	34 Electric Equipment

Review of Ventilation Requirement Changes

Equipment	Previous CMS	CANMET CMS	Proposed
TR01-TR02	24.3 * 2 = 48.6	7.88 * 2 = 15.76	11.82 * 2 = 23.64
TR03-TR04-TR05-TR06	24.3 * 4 = 97.2	7.98 * 4 = 31.92	11.97 * 4 = 47.88
TR07-TR08	30.9 * 2 = 61.8	10.81 * 2 = 21.62	16.22 * 2 = 32.44
TR09	35.1	12.74	19.11
SC06	14.1	8.07	12.11
SC35	11.8	9.77	11.8 (filtre DPM installé)
SC37	15.9	5.9	8.85
SC07	15.9	6.37	9.56
SC40 (Rental extended to October 2025)	12.6	4.34	6.51
LH30 (Leaves in June 2025)	6.8	4.34	6.8 (Not counted in Total)
CB01	7.62	6.4	7.62
LH31 (DL-431)	6.6	4.34	6.51
LH31 diesel compressor	8.28	7.1	8.28
FP01-Major Minecat-ET30	4.43 * 3 = 13.29	4.8 * 3 = 14.4	4.8 * 3 = 14.4

Equipment	Previous CMS	CANMET CMS	Proposed
Kubota RTV-1140 or MMX4 x 6	1.1 * 6 = 6.6	0.85 * 6 = 5.1	1.1 * 6 = 6.6
LT01-LT Major-LT Orica-Redpath Personnel Carrier	6 * 4 = 24	3.4 * 4 = 13.6	6 * 4 = 24
TH01	6.3	Not Certified	6.3
TH04	5.4	3.3	5.4
BT Boom Truck	9.6	5.66	8.49
UT99-UT30	4.7 * 2 = 9.4	2.83 * 2 = 5.66	4.7 * 2 = 9.4
GENMB01 (Genset)	18.9	6.61	9.92
GR02	8.82	6.7	8.82
Polaris x 2 (RTV7-RTV8)	1.1 * 2 = 2.2	Not Certified	15.66
Electric Equipment	0	0	0
Personnel	0.83	0.83	0.83
Total (all equipment)	458.99 *410.39	217.18	308.82 **285.18
Maximum Mine Ventilation output	220	220	220

9 haulage trucks total
* 6 haulage trucks
** 7 haulage trucks

Opportunity

With the new ventilation regulations, would we have the capacity to safely increase production?

- Yes, theoretically 6 haulage trucks could be increased to 7.
  - This includes multiple safety factors
- This theoretical will need to be tested and validated with practical testing.
- If validated, this will need approval from the health and safety committee.

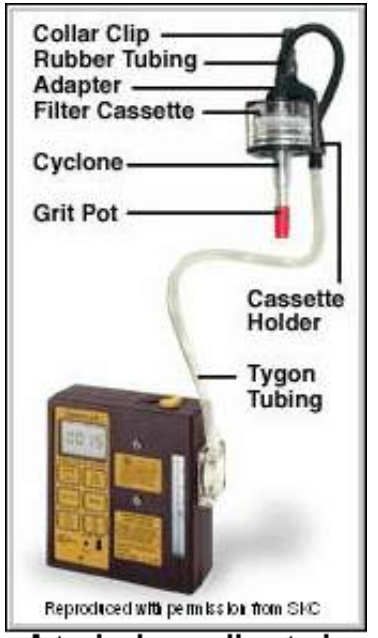
Planning the validation of ventilation needs

- Continue tail-pipe exhaust gas testing of diesel equipment.
- Increase the frequency of personal NIOSH-5040 DPM sampling among personnel to validate a safe working environment for underground workers.
- Test changes in ventilation requirements by equipment and capacity.
- Introduce real-time DPM monitoring to validate contamination levels and ventilation system health.

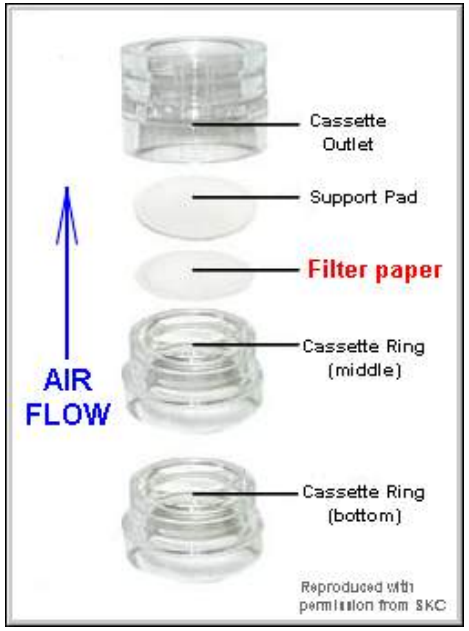
Monitoring Methods for Diesel Emissions

PERSONAL MONITORING Gravimetric measurement (regulatory via NIOSH 5040)

- Gravimetric Sampling for DPM
  - Pre-loaded 37 or 25mm filter cassette
  - Volume of Air that has passed through filter
  - Flow compensated pump for NIOSH compliance
  - Time the pump was running for
- Results
  - Cassettes are secured/labelled and sent to the lab for analysis
  - Results are provided in 2 weeks time
    - TWA for that shift
      - 856 ug/m3 over 8 hours (107 ug/m3)



A typical sampling train



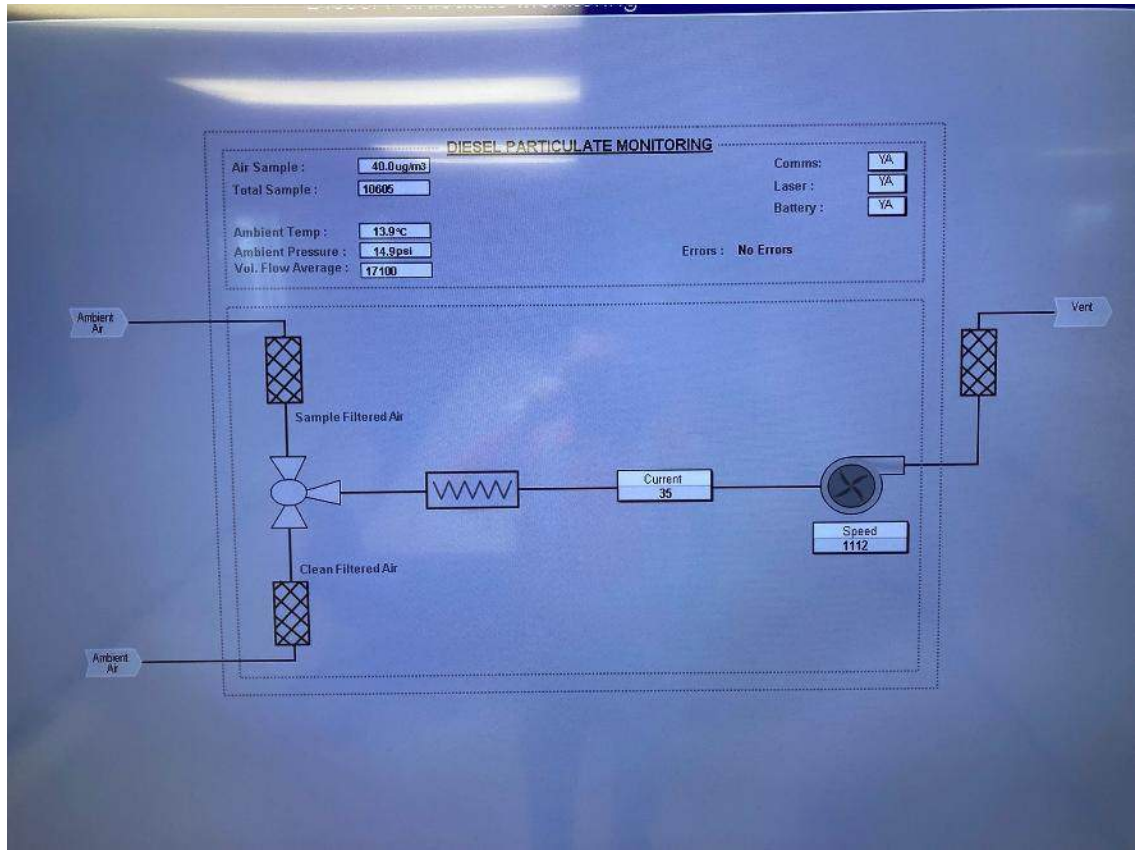
Introduce real-time DPM Monitoring

- The real time DPM monitor has been in operation since March 20, 2024.
- Sampling occurs every 5-minutes, 24/7. (Continuous monitoring)
- The mine now has the advantage of investigating if DPM increases – in real time.

Accutron INSTRUMENTS

Monitoring DPM in Real Time

DPM Monitor



Continuous DPM Monitoring Data Review– May 7th, 2024

Continuous DPM Monitor

Observations reviewing the DPM monitoring data for the period **March to May 2024**:

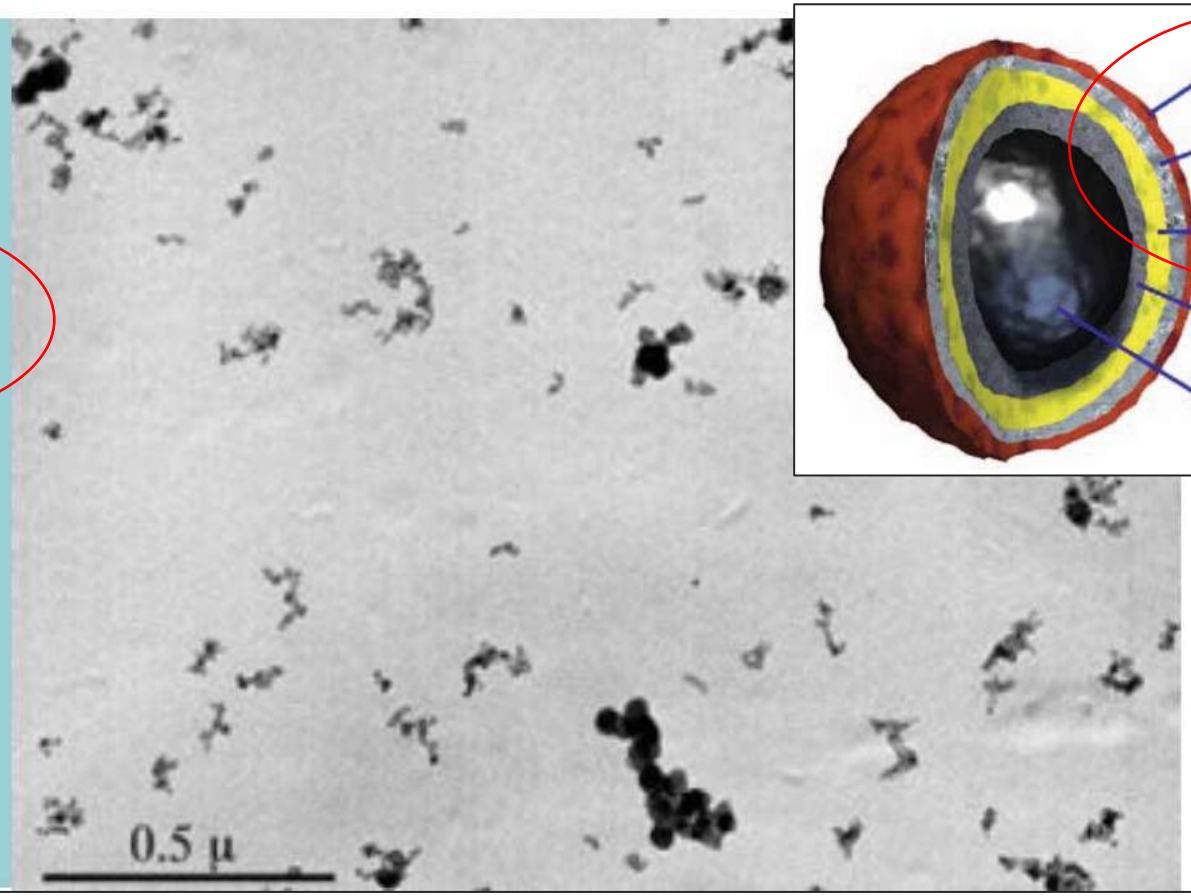
- We did not exceed 100 µg/m³ over an 8-hour period, but we came very close, with values reaching 99 µg/m³ (including blasting).
- We exceeded 100 µg/m³ for 1 hour on 6 occasions (due to blasting).
- We exceeded 100 µg/m³ for 1 hour 27 times during our shift.
- These exceedances are not greater than the regulation for 8 hours.
- A future opportunity was identified where trigger points / alerts could be applied.
- When compared to the regulation, the continuous DPM monitoring data has some safety factors. (ref next page)

EC/OC/TC/DPM - Information

Slide from Professor Sandra Dorman, Ontario, Canada

Physical/Chemical Properties

- Shape
- Contents
- Size



CROSH CRSST
centre for research in occupational safety and health | centre de recherche sur la santé et sécurité au travail

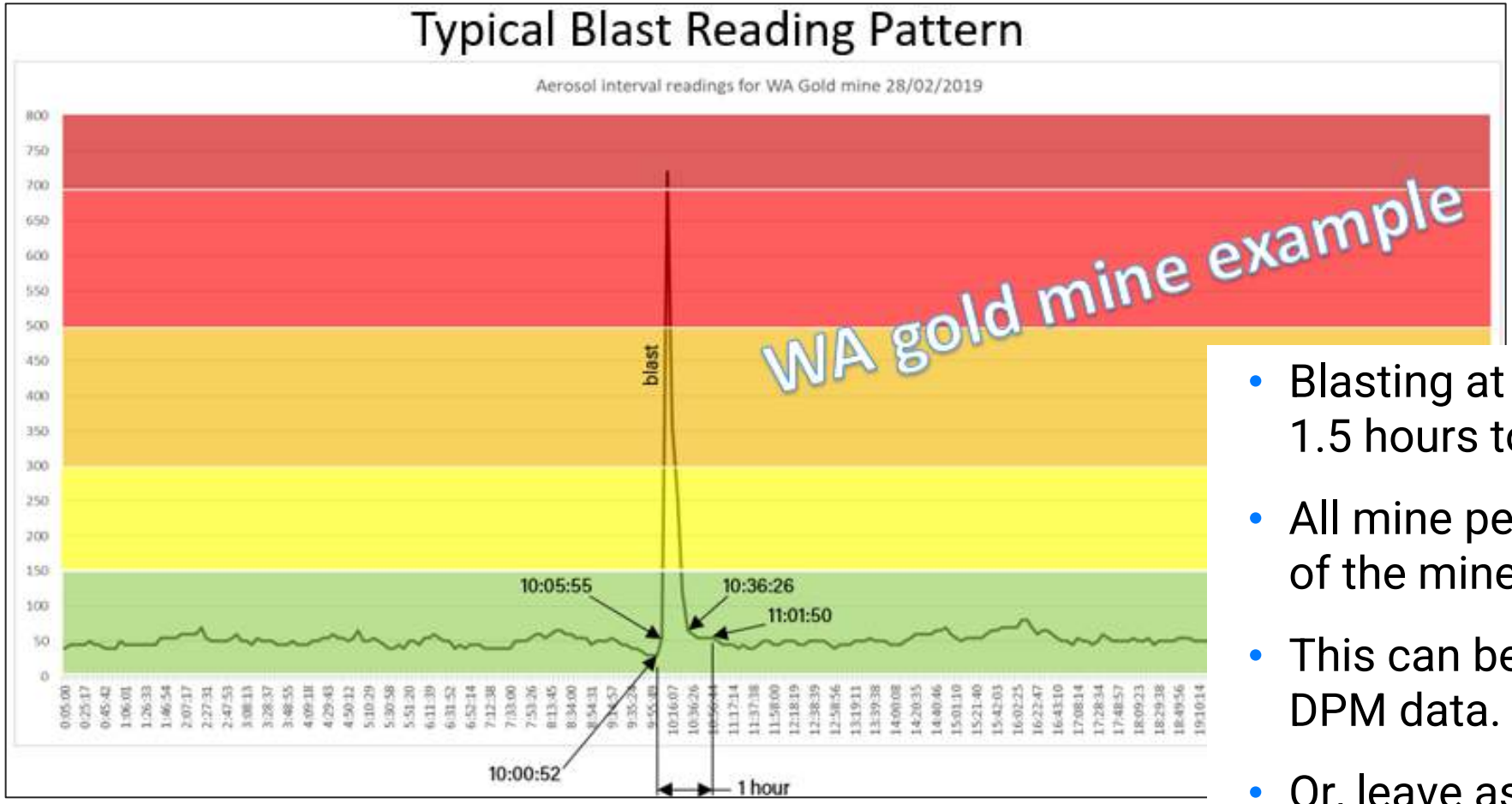
DPM consists of:-
1. Non-Carbon portion
2. Total carbon potion (OC + EC)
3. Elemental Carbon

Key point:-

Elemental carbon is a portion of DPM

Real-time DPM Blasting Information

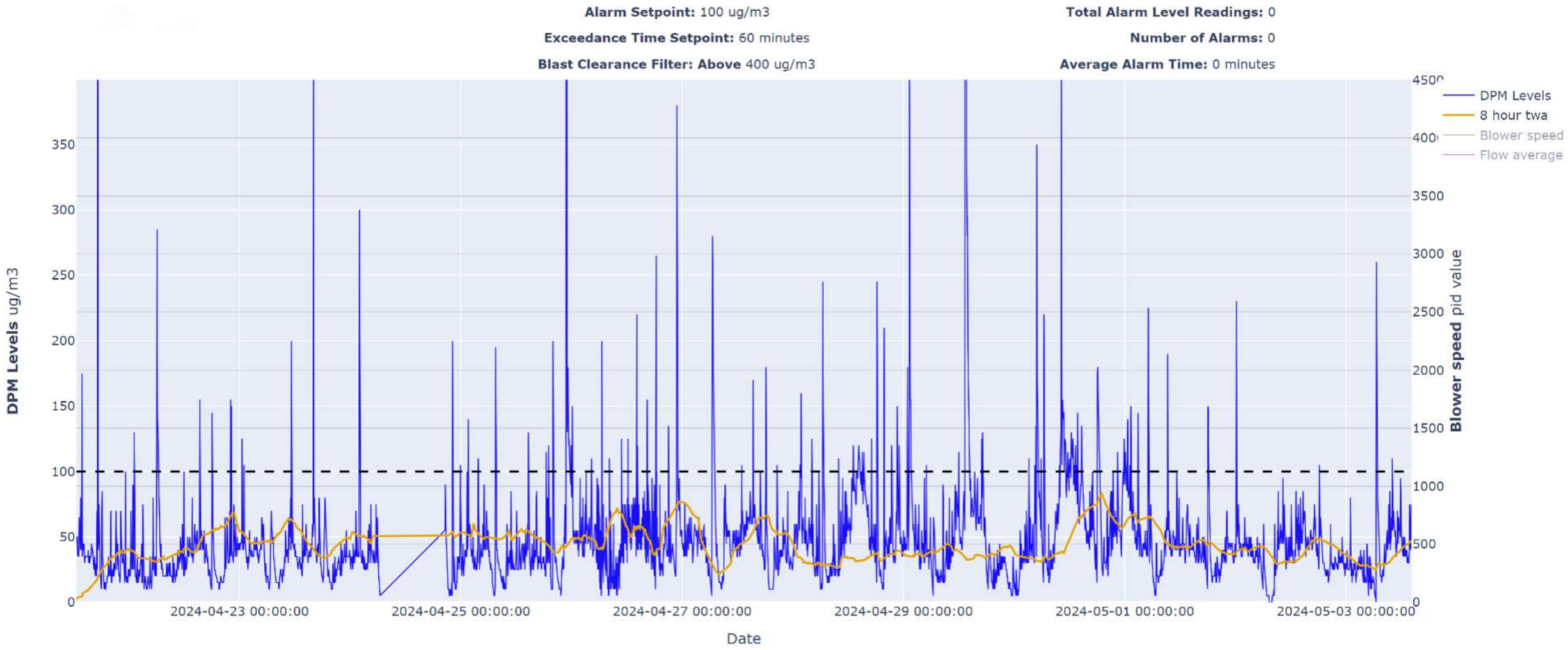
DPM Monitor Data



- Blasting at mines generally take 1 to 1.5 hours to clear.
- All mine personnel are evacuated out of the mine during this time.
- This can be excluded when analyzing DPM data.
- Or, leave as a safety factor.

DPM Monitoring Data– May 7th, 2024

DPM Monitor Data



Continuous DPM Monitoring Data Review– May 7th, 2024

Continuous DPM Monitor

- We reviewed the continuous DPM monitor data with the control room.
- DPM exceedance should be treated as a throttle exceedance. Therefore, ventilation should be increased and/or the amount of diesel equipment in the affected area reduced.
- We reviewed the data and found that the DPM monitor did not appear to be affected by the secondary blasting during the shift.

Continuous DPM Monitoring testing with fans– June, 2024

Continuous DPM Monitor

- We conducted a test comparing the DPM monitor to the main fan settings. It was shown that manually switching to 90% of the main fans, which were set at 60% VOD, was very effective in reducing DPM values.
- The test with the main fans at 100% was carried out on June 4, 5 and 6, 2024.
- We obtained two additional months of real-time DPM data. This data was reviewed by the manufacturer and presented on July 3.
- The test shows a direct relationship between main fan speed and DPM level. With the main fans at 100%, we fluctuated between 40 and 50 µg/m³ for 8 hours. When the fans are in VOD mode, DPM values reach a peak of approximately 75 µg/m³.

Continuous DPM Monitoring data with fans– June, 2024

DPM Monitor Data vs Fan Speed @100%

Continuous DPM Monitoring data with fans– July, 2024

DPM Monitor Data vs Fan Speed

Ventilation Management Proposal

Adding a haulage truck to the equipment list

- Allow 7 haulage trucks underground at any time, up from the previous maximum of 6.
- Use CANMET ventilation requirements with a 50% safety factor for trucks and loaders (except SC35). Continue to use CMS ventilation requirements per kW or CANMET ventilation requirements if higher for all light vehicles and SC35.
- Request increased individual oversight of DPMs during the transition.
- Review DPM results quarterly basis to ensure DPM levels remain within guidelines.

Outcome

Adding a haulage truck to the equipment list

- The ventilation and DPM management strategy was presented to the health and safety committee.
- The proposal was accepted on August 13, 2024.
- We have ordered new signs to identify the equipment's ventilation requirements. Authorization for a seventh haulage truck began in November 2024, once all the signs have been received and installed.

Post implementation -validation

Adding a haulage truck to the equipment list

- A new review of the DPM data was conducted in April 2025.
- The real-time DPM monitor was recording high values, but within the standards. This is including blasting and total DPM particle.
- Personal pumps were showing significantly lower results, as Elemental Carbon.
- We decided to conduct several tests where personal pumps were installed at the location where the real-time DPM monitor was installed.
- Comparison testing was conducted through NIOSH 5040 method of two sample pumps at monitor’s location to compare live readings vs EC regulatory results.

SITE SAMPLING DATA:

NIOSH 5040 GRAVEMETRIC SAMPLING RESULTS

DATE	SHIFT	LOCATION	SAMPLE TIMES	EC (ug/m3)	TC (ug/m3)	EC/TC RATIO
2025-05-03	DAY	270 RAMP	8:00 - 15:00	37	60	62%
2025-05-03	DAY	270 RAMP	8:00 - 15:00	36	57	63%
2025-05-03	NIGHT	270 RAMP	20:00-4:00	46	66	70%
2025-05-03	NIGHT	270 RAMP	20:00-4:00	48	71	68%
2025-05-06	DAY	270 RAMP	8:00 - 16:00	25	44	57%
2025-05-06	DAY	270 RAMP	8:00 - 15:00	25	42	60%
2025-05-06	NIGHT	270 RAMP	20:00-4:00	21	34	62%
2025-05-06	NIGHT	270 RAMP	20:00-4:00	22	38	58%

EC/TC ratios ranged from 57-70%. (range of 13%)

SITE SAMPLING DATA:

NIOSH 5040 GRAVEMETRIC SAMPLING RESULTS

DATE	SHIFT	LOCATION	SAMPLE TIMES	EC (ug/m3)	TC (ug/m3)	EC/TC RATIO	Relative Percent Difference (RPD) EC	Relative Percent Difference (RPD) TC
2025-05-03	DAY	270 RAMP	8:00 - 15:00	37	60	62%	2.7%	5.1%
2025-05-03	DAY	270 RAMP	8:00 - 15:00	36	57	63%		
2025-05-03	NIGHT	270 RAMP	20:00-4:00	46	66	70%	4.3%	7.3%
2025-05-03	NIGHT	270 RAMP	20:00-4:00	48	71	68%		
2025-05-06	DAY	270 RAMP	8:00 - 16:00	25	44	57%	0.0%	4.7%
2025-05-06	DAY	270 RAMP	8:00 - 15:00	25	42	60%		
2025-05-06	NIGHT	270 RAMP	20:00-4:00	21	34	62%	4.7%	11.1%
2025-05-06	NIGHT	270 RAMP	20:00-4:00	22	38	58%		

EC/TC ratios ranged from 57-70%. (range of 13%)

SITE SAMPLING DATA:

NIOSH 5040 SAMPLE RESULTS Vs. DPM MONITORING DATA

DATE	NIOSH 5040 - GRAVEMETRIC SAMPLES						REAL TIME DPM DATA		
	SAMPLE TIMES	EC (ug/m3)	TC (ug/m3)	EC/TC RATIO	Relative Percent Difference (RPD) EC	Relative Percent Difference (RPD) TC	DPM DATA Avg (ug/m3)	EC VS DPM DATA	SAMPLE TIMES
2025-05-03	8:00 - 15:00	37	60	62%	2.7%	5.1%	55.79	0.66	8:00-14:57
2025-05-03	8:00 - 15:00	36	57	63%				0.65	
2025-05-03	20:00-4:00	46	66	70%	4.3%	7.3%	75.21	0.61	20:00-3:57
2025-05-03	20:00-4:00	48	71	68%				0.64	
2025-05-06	8:00 - 16:00	25	44	57%	0.0%	4.7%	38.40	0.65	8:02-15:59
2025-05-06	8:00 - 15:00	25	42	60%			38.29	0.65	8:02-14:58
2025-05-06	20:00-4:00	21	34	62%	4.7%	11.1%	30.05	0.70	20:00-3:57
2025-05-06	20:00-4:00	22	38	58%				0.73	

EC/TC ratios ranged from 57-70%. (range of 13%)

EC over live DPM Data ratios ranged from 61-73%. (range of 12%)

SITE SAMPLING DATA:

NIOSH 5040 SAMPLE RESULTS Vs. DPM MONITORING DATA

- Based on the testing conducted in May 2025
  - NIOSH 5040 sample results of EC/TC ratios ranged from 57-70%. (range of 13%)
  - EC over live DPM Data ratios ranged from 61-73%. (range of 12%)
- For future reference, the real time DPM data could be viewed at 0.75 or 75% conservatively as a guide to regulatory EC levels in real time.
- Additional comparison testing was conducted in September 2025, we are awaiting the results to be provided from the laboratory to do further analysis.

Summary

- Opportunity identified following CANMET engine certification revision.
- Validation using practical monitoring
- Proposal for change with data was approved
- The allowance of an additional haulage truck underground in November 2024 resulted in a 17% increase in haulage capacity.
- Increase utilization across current fleet of haulage trucks.
- Post implementation – validation of decision, more data.

Ongoing initiatives

- Review of September 2025 NIOSH 5040 test samples vs DPM data to establish EC/DPM factor.
- Review and introduce real-time alerts with EC/DPM factor.
- Introduce TARPs with alerts as trigger points.
- Continued and ongoing testing/review data of sample pumps, exhaust and real time DPM.
- Review opportunities for potential increase of production **safely**.

Questions and Discussions

Building a better world starts by building healthier workplaces.

Take care of your team with continuous monitoring of diesel engine exhaust emissions and make every breath positive progress.

What we can measure, we can manage!

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