

Optimizing DPF Performance For Minimum Equipment Downtime

Mining Division – North America

www.mammothequipment.ca

Presented by:

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VISION

**Trusted, pioneering
technologies worldwide,
for generations to come.**

This vision is our north star,
guiding us in every project, every
conversation and every direction.



MISSION

**Stronger Together.
People First.
Global Connections.
Shared Growth.**

Our mission is to unite people, foster
global collaboration, and drive shared
growth with a people-first approach.

OUR VALUES



We care



We are always positive



We embrace the journey



We are one team



We are adaptable

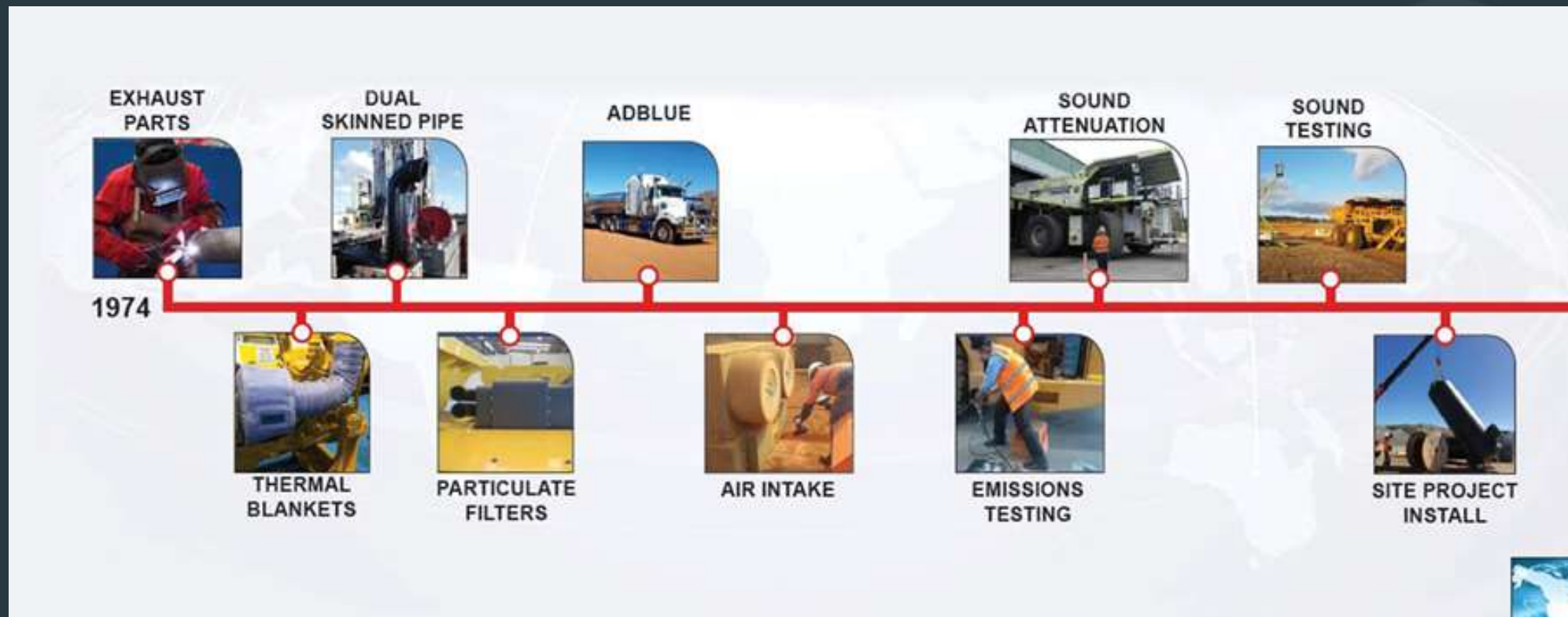


We are driven

Our values are the heart of who we are.

Our global footprint

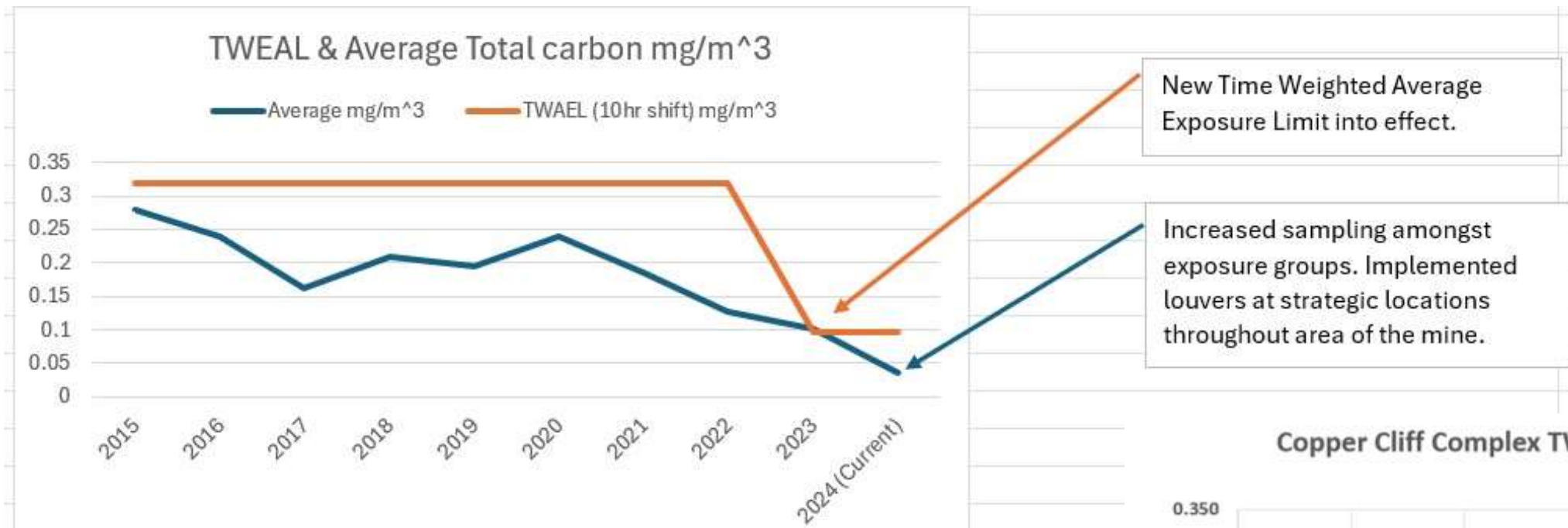




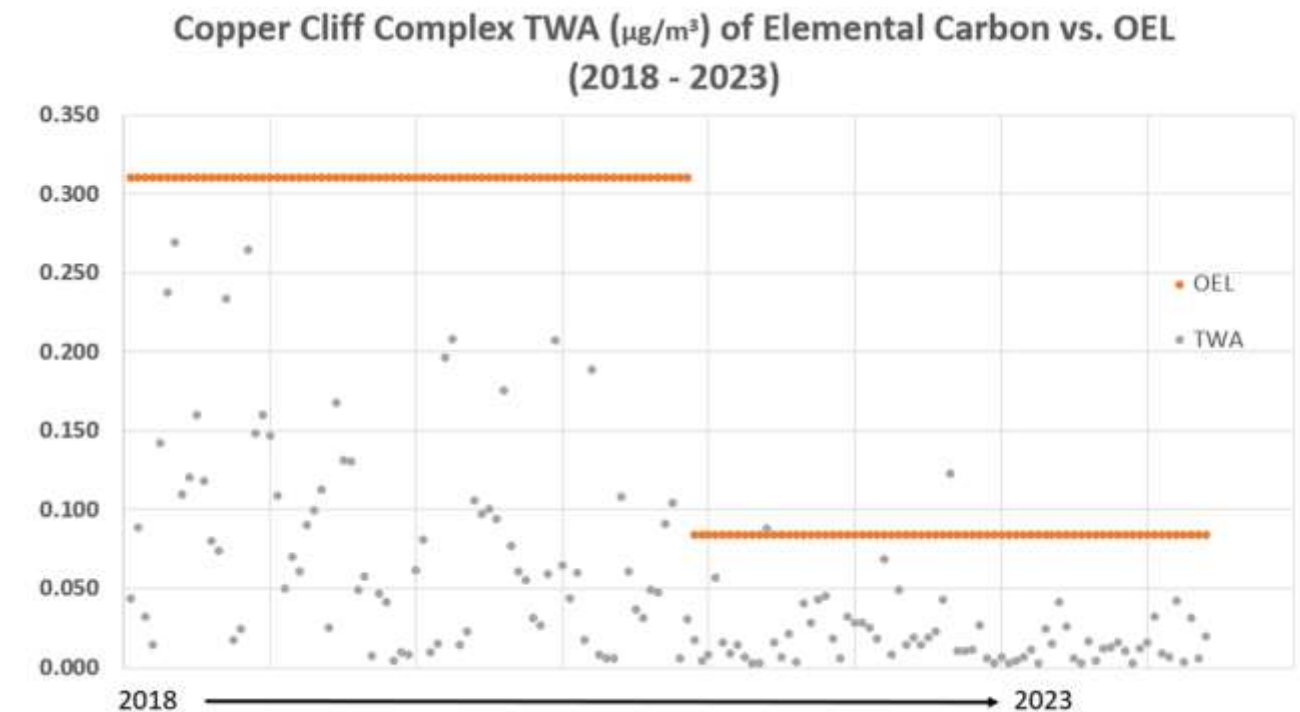
Making Good Machines Great!



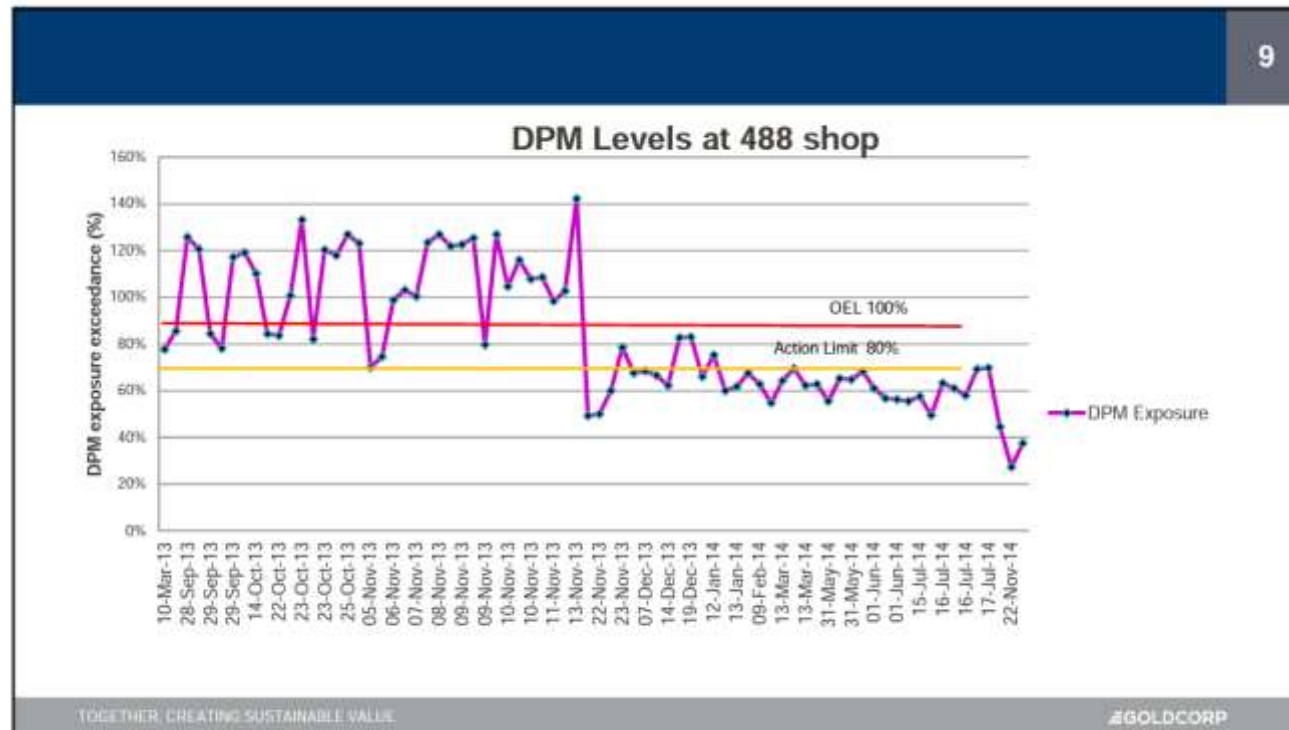
IMPACT OF DPF IMPLEMENTATION



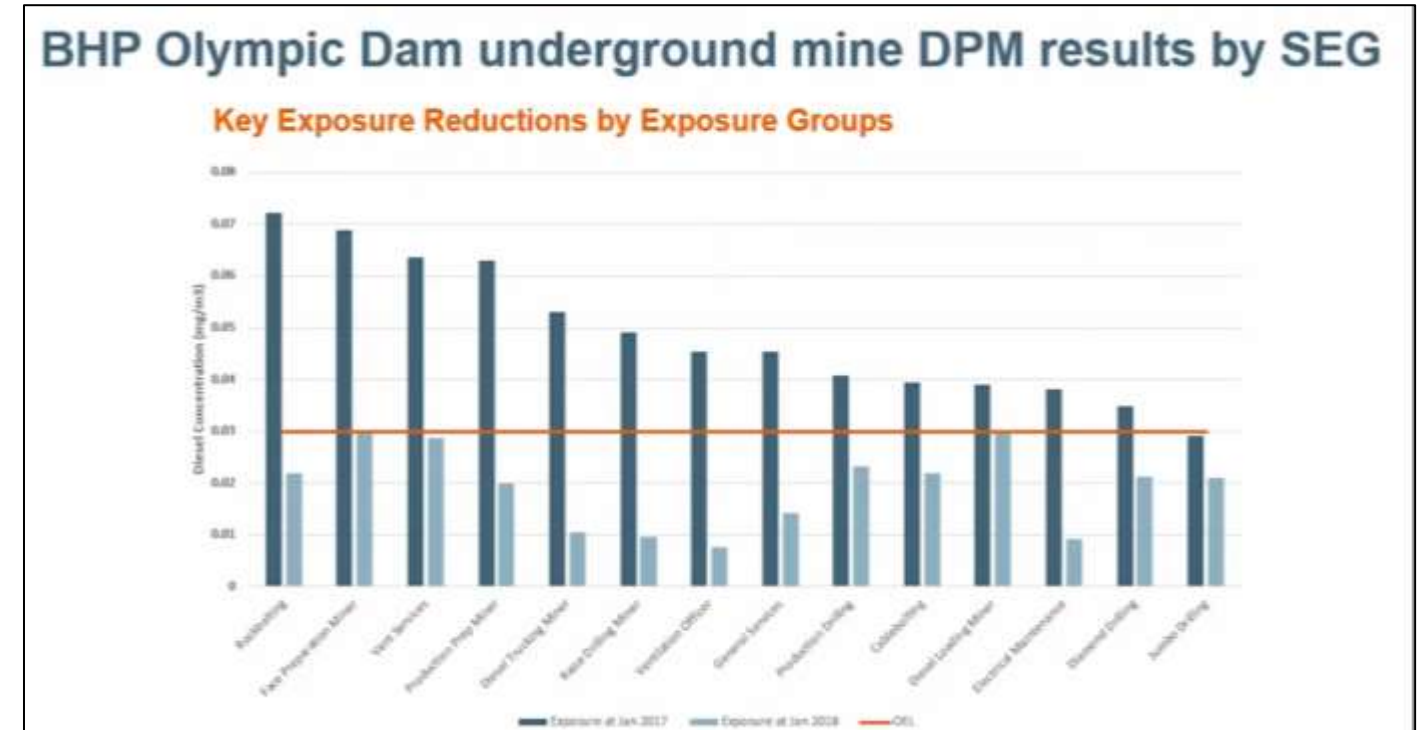
- New MOL Reg 854 regulations introduced Apr 2023 with implementation from Sep 1, 2023
- Many mines have been on the journey of reducing worker DPM exposure for many years
- Excellent to see the DPM exposure results coming through from many sites showing a decline in DPM exposure levels



DPM exposure levels reduced by DPF implementation

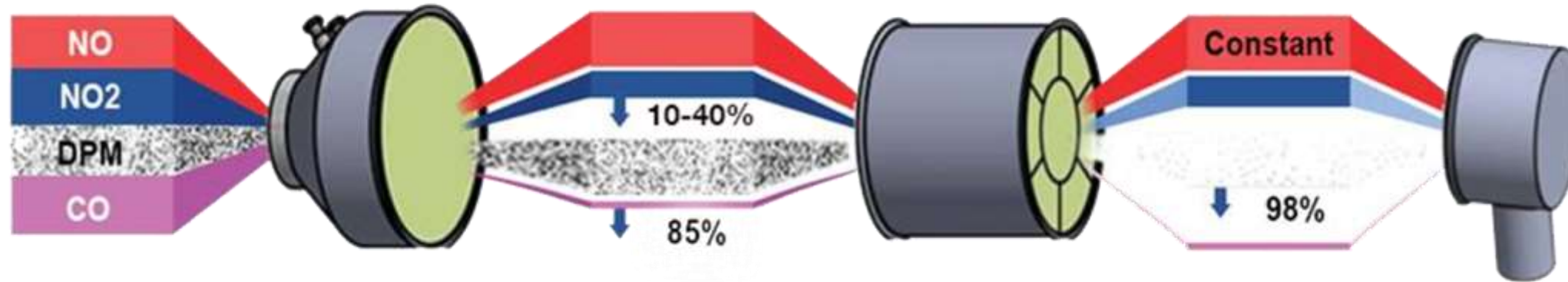


Fit out of selected prime movers with Diesel Particulate Filters



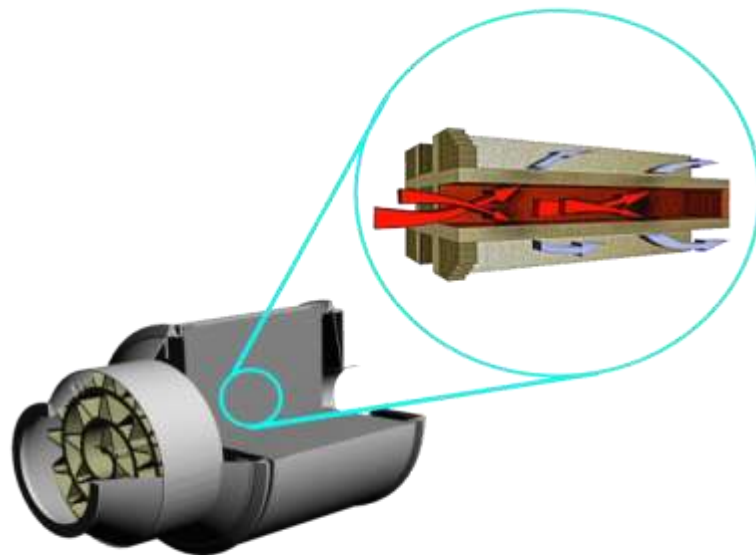
Post Fleet Implementation of Diesel Particulate Filters – effects on different roles across the site

How does a DPF work?

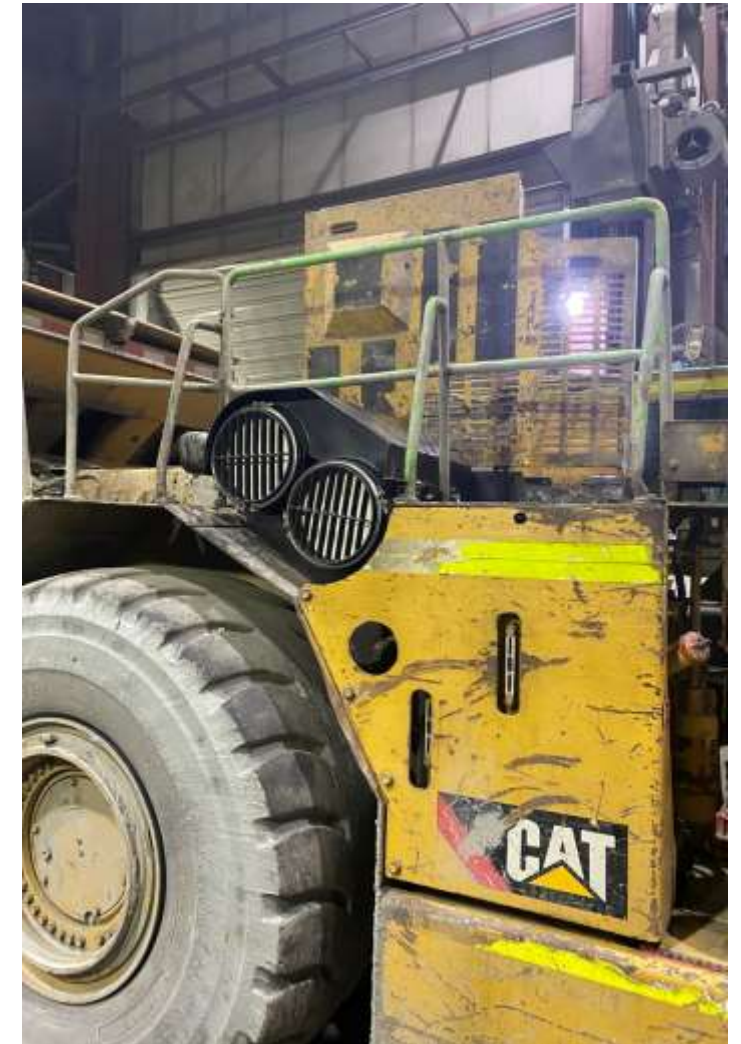


DOC

(Diesel Oxidation Catalyst)



SOOT FILTER



DPM (Diesel Particulate) Filtration

- Wall Flow filter substrates
 - Available in Silicon Carbide or Cordierite typically
 - Achieve 98-99% DPM reduction consistently regardless of engine load
- Partial / Flow Through filter substrates
 - Typically, a metal core material
 - Achieve 40-50% DPM reduction generally
 - Can experience catch and release with unpredictable DPM reduction levels

DPF Maintenance

- As the soot is captured and regenerated into ash it will require that the filter be serviced periodically
- The higher filtration filters will need more servicing than those that filter less DPM
- The hours between servicing is directly connected to several factors – utilization, engine maintenance, work cycle



High Filtration, Some Maintenance vs Lower Filtration and Lower Maintenance

Causes of High DPF maintenance



The Typical causes of high DPF maintenance (low hours between servicing)

- Low work cycle – Typical operating usage does not create sufficient heat for regeneration
 - How hot? Typical light off temperatures of many DPF's is 280-350 C
 - How long? Many DPF's need 8-10 minutes at this temperature to properly regenerate
 - How often? Is the regularity of regeneration matched to the speed of soot loading
- High soot loading – DPF is being loaded faster than it can regenerate/oxidize the soot
 - Imbalance in air/fuel ratio
 - Filter sized to be soot loaded at a certain rate – filter loading faster than expected
- Incorrectly sized DPF
 - High restriction/back pressure
 - Filter not regenerating soot vs speed of soot loading
 - DOC not coated appropriately for the application
- The DOC/DPF are worn out and the soot is not oxidizing under the expected conditions



Expected Service Life suitability for Full DPFs



Light:

LVs
Welders
Generators



Light-Med:

Jacon
Normet
Drills



Med-Heavy:

R1700s
LH514s
Loaders similar



Heavy:

AD55/AD60
R2900s
LH621s
MT65
TH663



To minimise servicing requirements a compromise may choose to be made on DPF filtration efficiency i.e use of Partial DPF or SMF configurations for lighter duty cycle equipment.

Some operations may elect to purchase and operate DPF cleaning equipment on site for cost effective maintenance of diesel particulate filters.

DPF REGENERATION



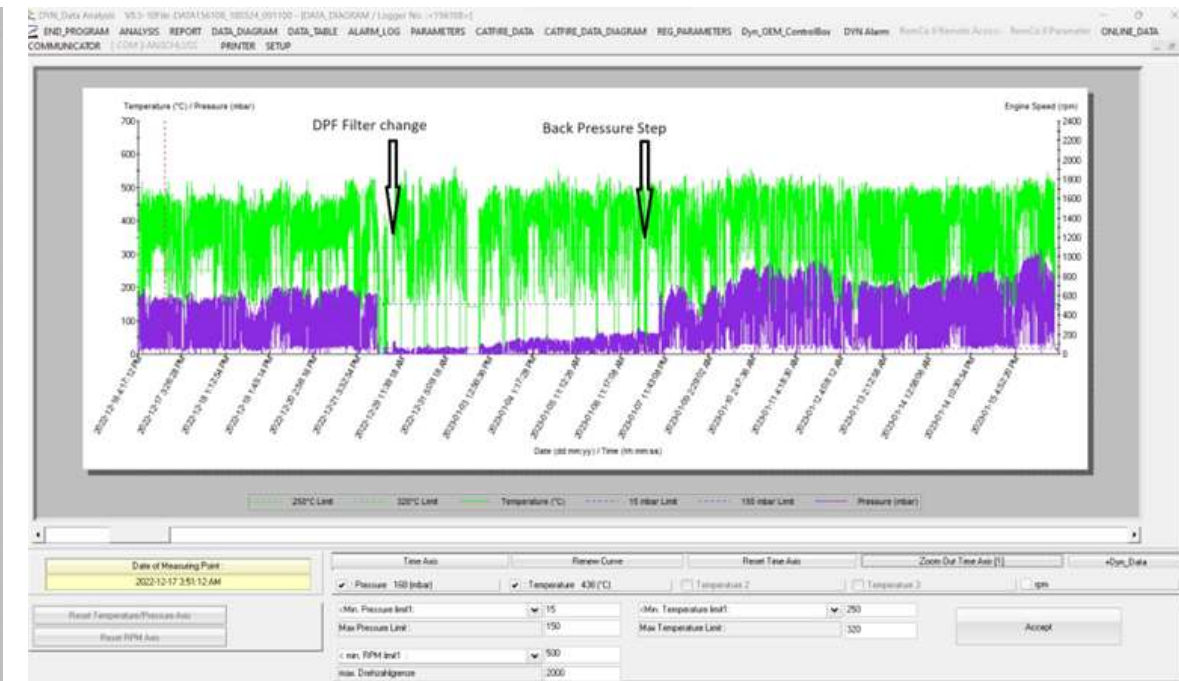
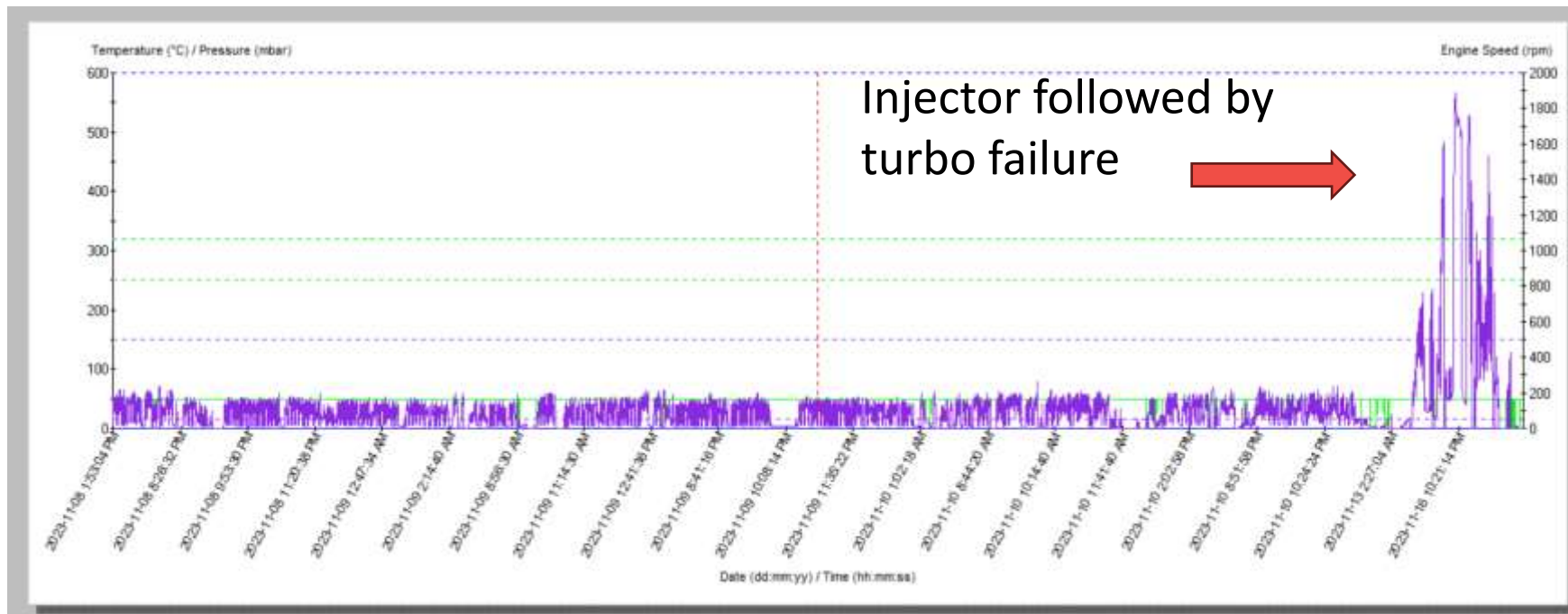
- A wall flow DPF filter (cordierite or silicon carbide) will continue to filter at +/- 95-99% across all engine modes
- Sufficient heat, often enough and regularly enough is required for maximum hours between cleaning/servicing of the filter
- General guide would be 8-10 minutes of 320 C+ 30-35% of the time for optimal conditions



AIR-FUEL RATIO



- DPF's design considerations include engine size, horsepower, flow rate and soot loading rate
- Soot is the result of unburnt fuel/incomplete combustion in the cylinder
- An imbalance in the air/fuel ratio will drastically change the soot loading rate and will be a result of:
 - Air intake
 - Fuel supply
 - Combustion performance – ignition/compression
 - Altitude/depth – change in atmospheric pressure
 - Radiator/intercooler issues negatively affecting intake temperatures



EMISSIONS TESTING



While tailpipe emissions testing is a legal requirement in most jurisdictions it should be viewed as an excellent means of engine health monitoring for preventative maintenance

- Carbon Monoxide is an indicator of combustion performance.
- Typically it is seen that there is a correlation between CO and DPM number
- MOL tailpipe limits in Reg 854 is 600ppm
- Typical emissions testing has shown that most Tier 2/Tier 3 diesel engines can produce less than 100ppm of CO when operating in a stall condition
- If mechanics get familiar with what a good result/bad result looks like they can drill into issues if they receive results that are out of line on a machine
- Consistent Emissions Testing methods required for the tailpipe numbers to be useful
 - Engine warmed up – consistent oil temperature
 - Conditions
 - Similar RPM
 - Similar load – engage highest forward gear
 - Test results saved at the same time each test



INSIGHTS FROM TESTING



Truck #	TRUCK 1		TRUCK 2		TRUCK 3	
Truck hrs	3721hrs		3892hrs		4258hrs	
Emissions	PRE	POST	PRE	POST	PRE	POST
DPM (mg/m3)	321	0.041	20.53	0.03	19.9	0.1
CO (PPM)	589	132	294	176	347	208
NO (PPM)	612	606	641	628	594	445
NOx (PPM)	636	617	680	638	626	451
O2 (%)	14.43	14.45	14.24	14.36	17.95	17.82

- Consistent testing highlights areas of non-compliance i.e. Truck 1 shown here has a pre-DPF DPM result 15X higher than the other 2 trucks.
- Truck 1 also has the highest CO result which typically indicates incomplete combustion (consistent with high DPM)
- Reviewing the mechanical history of Truck 1 it was found there was severe issues with intercooler clogging → increasing the intake temp → negatively impacting the air fuel ratio → premature blocking of the DPF

Options for optimizing DPF's



- If the hours between cleanings aren't being achieved as desired, what are my options:
 - Review equipment usage, idle times, how hot, how often for how long – is there periods of sustained steady heat or is it in short bursts
 - Review operator driving style – heavy on the throttle or steady RPM
 - Can idle times be minimized?
 - Review maintenance plan – DPF will mask visible smoke – need to ensure that there is a plan in place to monitor:
 - Air filter restriction
 - Valves
 - Injectors
 - Turbos
 - Correct DPF for the application – not enough heat maybe a partial DPF will provide a reasonable reduction in DPM for the equipment usage without overwhelming maintenance
 - Determining a safe max back pressure limit
 - Checking the oil type – using a low ash oil
 - Ensuring good quality fuel (ULSD – less than 15ppm Sulfur)

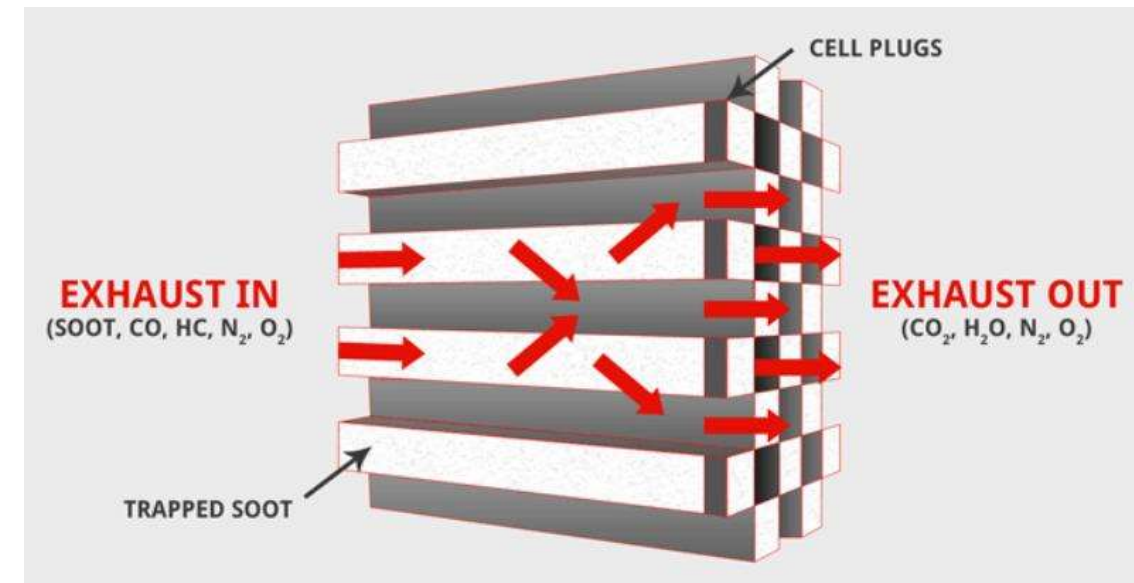
DPF/DOC cleaning



- DPF regeneration will leave a residue of ash as a result of the soot oxidizing
- DOC's create the conditions for regeneration to occur
- Over time DOC's can become worn/poisoned and this will cause higher temperatures to be required for regeneration to occur
- A build up of ash in the filter will cause back pressure to increase
- Regular cleaning of the DPF filter will maintain low back pressure. This will reduce risk of engine harm and extend DPF filter life.

BENEFITS OF A CLEAN DPF:

- Improved vehicle performance
- Increased fuel economy
- Less downtime
- Extended DPF life
- Experience fewer regenerations
- Lower maintenance costs



Heat retention/Fire protection



- Heat/temperature a key component of DPF regeneration
- Retaining heat can make a difference to DPF performance
 - Exhaust blankets
 - Dual wall insulated exhaust
- Exhaust wraps will reduce surface temperature by 75-80%
- Provide fire safety by lowering surface temperature from 450+C to below 150 C



THANK YOU

QUESTIONS?

