



REDUCE WORKER DPM EXPOSURE THROUGH FILTRATION OF DIESEL EXHAUST

PRESENTED BY:

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Who is Mammoth?



Company Overview



A family owned & operated company established in 1974.

Specialists in developing & manufacturing standard and customized replacement exhaust components for all brands of marine, transport, earth moving and mining equipment.

Constantly develop products for exhaust and emission solutions.

Global reputation for industry proven products.

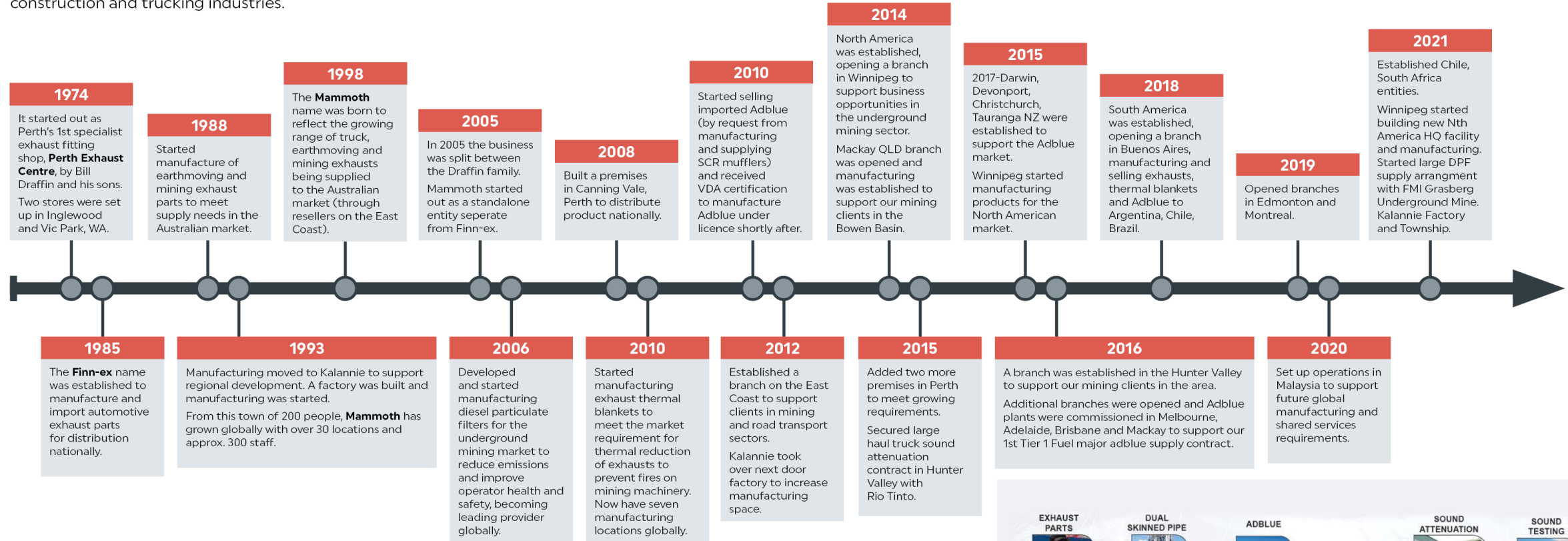
Innovative solution provider to the industry



OUR JOURNEY

About Mammoth Equipment

Mammoth is a 3rd generation family business that has been operating in the exhaust business since 1974 and has grown to become a leading global player in diesel exhaust and intake solutions in the mining, construction and trucking industries.



1974



COMPANIES WE WORK WITH:

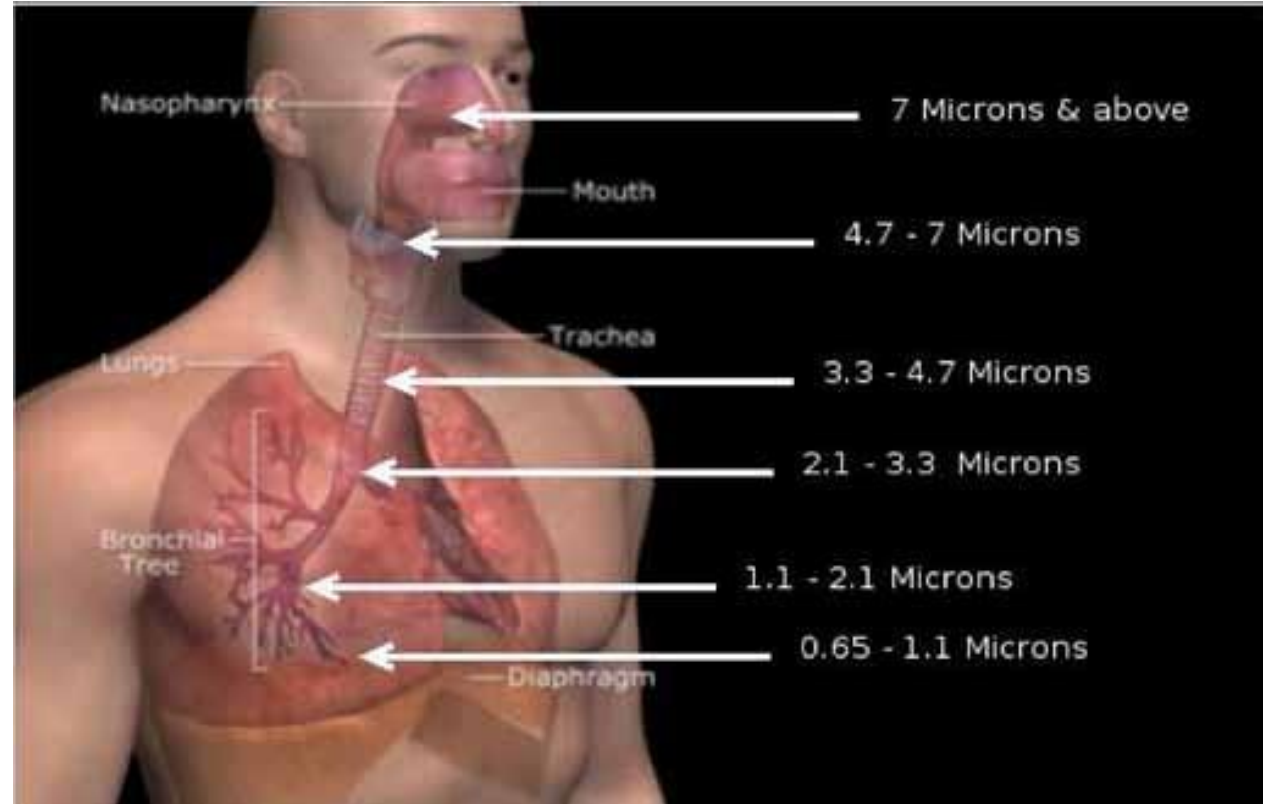


The Why? Why are exhaust
after-treatment systems
required?



Less Mass - The Nanoparticle Problem

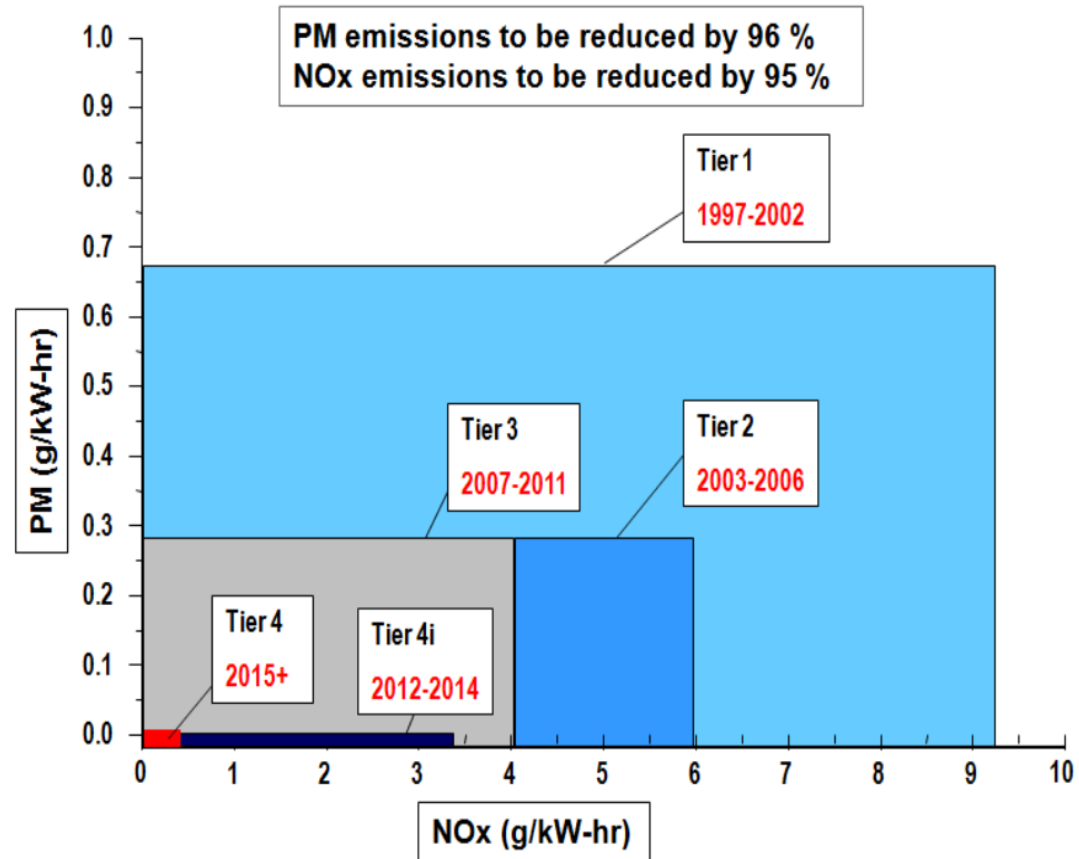
- DPM was classified by IARC as a **group 1 carcinogen**
 - Health impact dependent on particle size
 - PM10 – captured in nose and throat
 - PM2.5 – reaches the lungs
 - **Nanoparticles/PM0.1 – transfer to bloodstream**



What makes a vehicle comply with Tier 4 emission requirements?



- To meet Tier 4 emissions requirements engines had to meet both DPM (particulate matter) and NOx emissions levels – 75-750hp
 - 0.4 g/kWh for Nox
 - 0.2 g/kWh for DPM
- For Euro Stage V (5) emissions the only difference is a particulate count level has been added. A DPF is an effective aftertreatment system for both particulate mass and count.

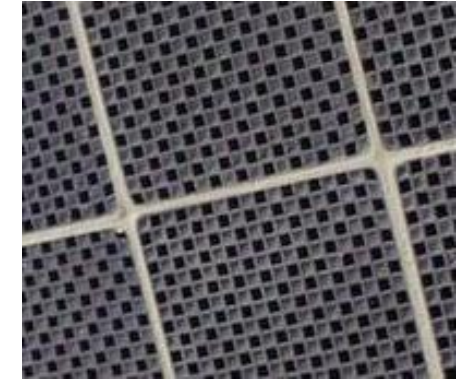
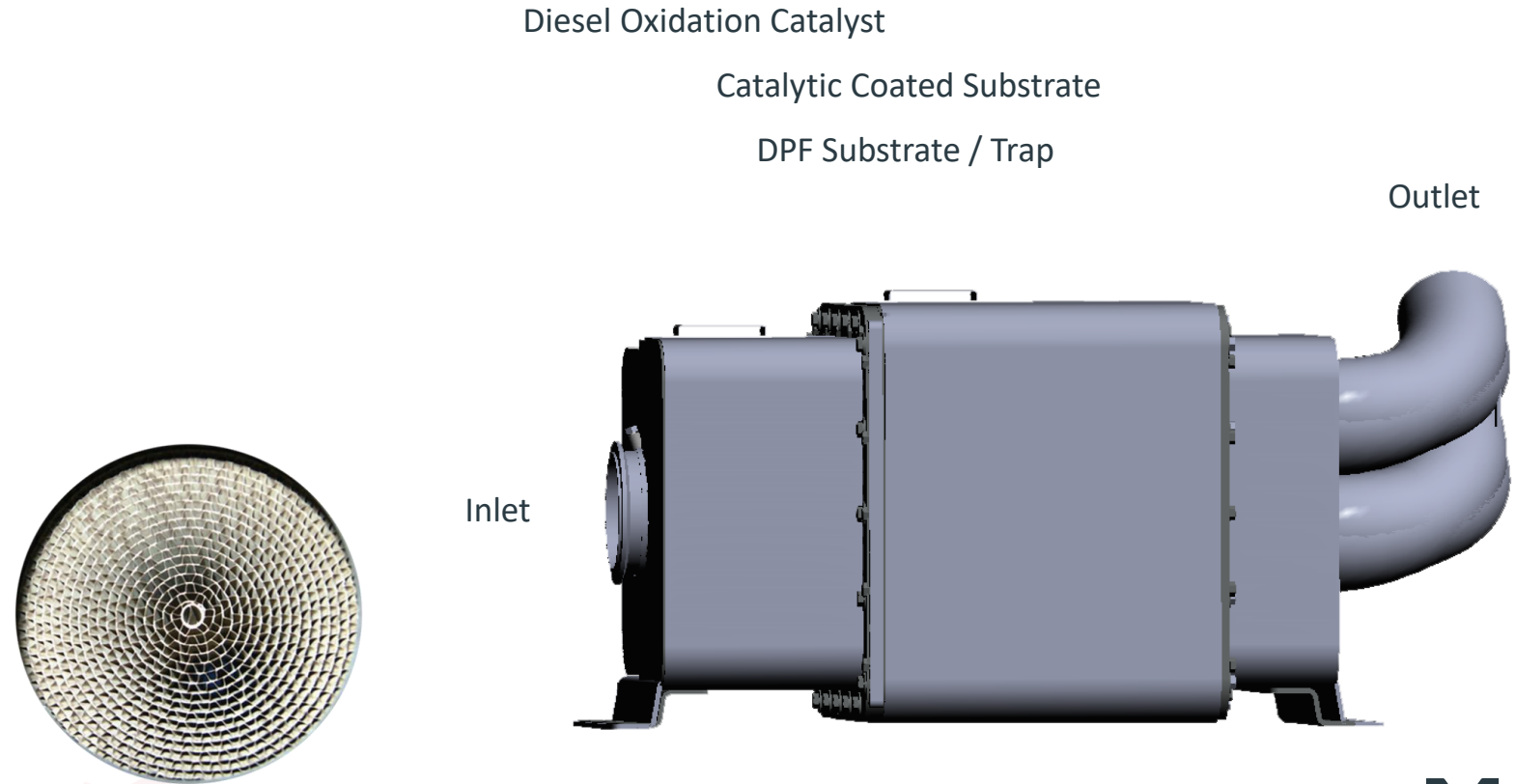




DPF systems overview

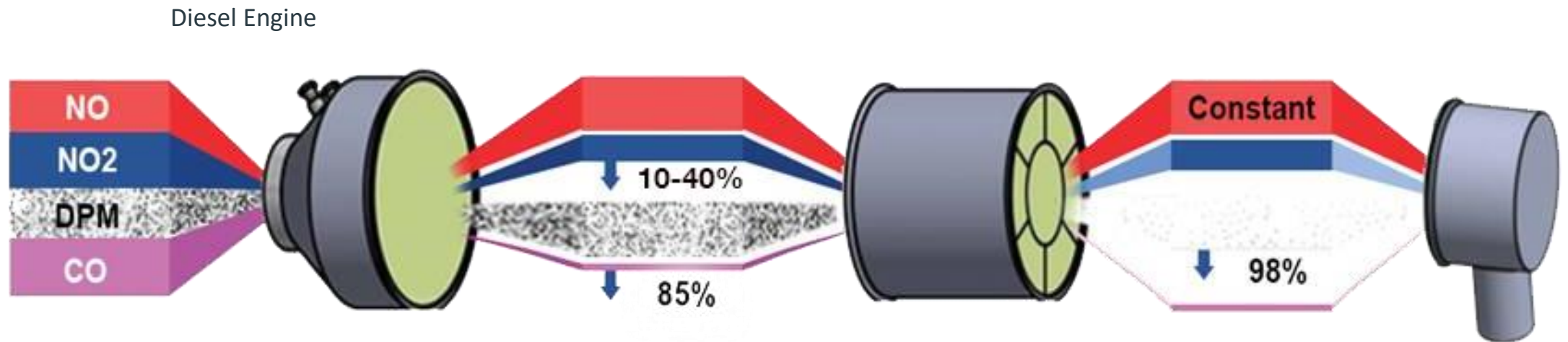


ANATOMY OF A PASSIVE DPF



What happens in a DPF?

An emissions control device designed to remove diesel particulate matter (soot) from the exhaust gas of a diesel engine.



MAMMOTH 

Mammoth - What We Do

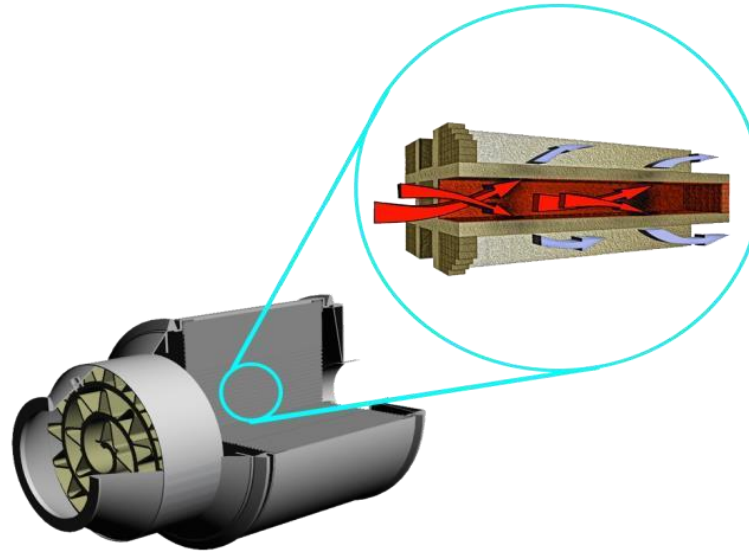
Diesel Particulate Filters

Key Components:

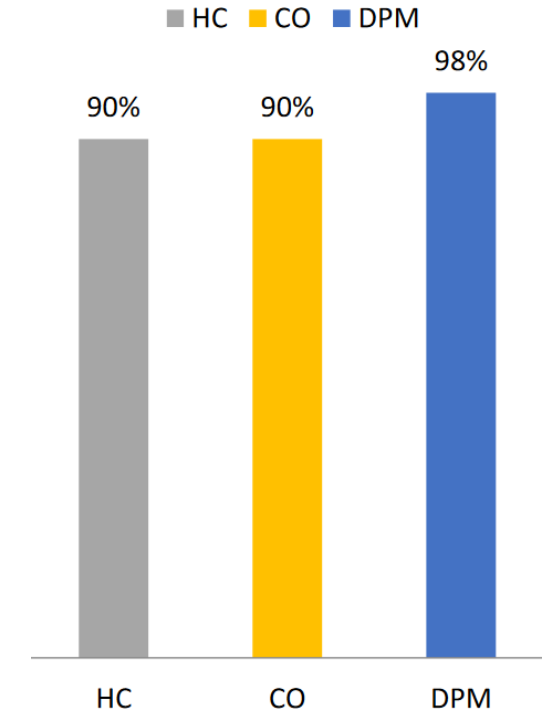
1. Diesel Oxidation Catalyst (DOC)
2. Silicon Carbide or Cordierite Substrate
3. Offset Closed Cell Channels Specifications:
 - High Thermal Durability (Resistance to thermal shock, low specific heat)
 - High DPM Reduction Efficiency (99%)
 - DOC enables catalysed regeneration (280-330°C)
 - Particulate Filtration efficiency not contingent on temperature

Application:

- Heavier duty cycle equipment (e.g. load and haul)



Typical Full DPF Results



Mammoth - What We Do



DIESEL PARTICULATE FILTERS



Top benefits of Mammoth DPFs

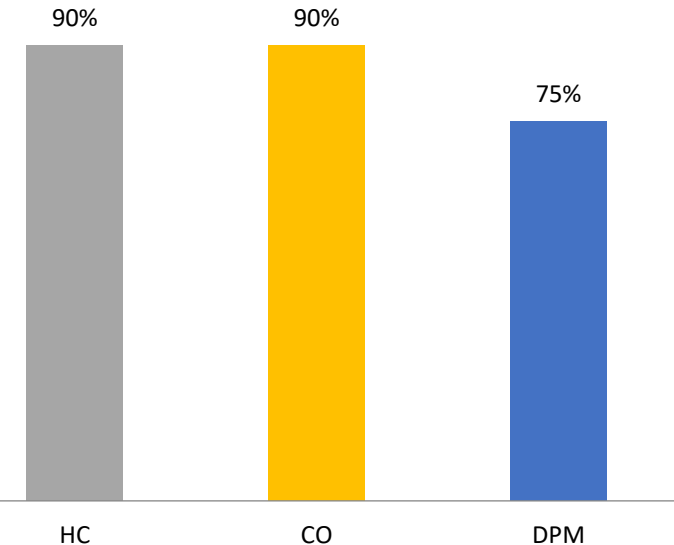


- Reduces DPM output by 99.99%
- Passively regenerates
- Easy and convenient bolt-on replacement parts that fit existing brackets
- Refurbished and replacement parts available
- Custom design solutions
- Retrofit – Replaces the OEM muffler in most diesel-powered equipment
- DPM Testing results recorded using MAHA



Typical Partial DPF Results

■ HC ■ CO ■ DPM



Expected Service Life suitability for Full DPFs



Light:

LVs
Welders
Generators



Light-Med:

Jacon
Normet
Drills



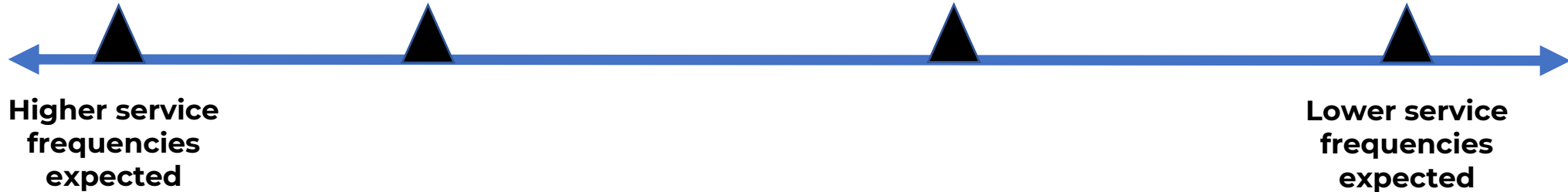
Med-Heavy:

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.



Gas/DPM Testing methods



In Field Testing Equipment

PERSONAL DPM SAMPLING



AREA SAMPLING



TAILPIPE DPM TESTING



TAILPIPE GAS TESTING



Baseline Emissions – Tailpipe Testing



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Gas analysis

Fuel type
Diesel Oil

T.Air	87	°F
T.Gas	606	°F
P.Sensor	87	°F
O2	14.8	%
CO	202	PPm
NO	379	PPm
NO2	30	PPm
NOx	409	PPm
CO2	4.5	%
Eff.	67.0	%
Losses	33.0	%
Exc. air	3.39	
Dew poi.	92	°F
Gas vel.	0.3	m/sec

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Gas analysis

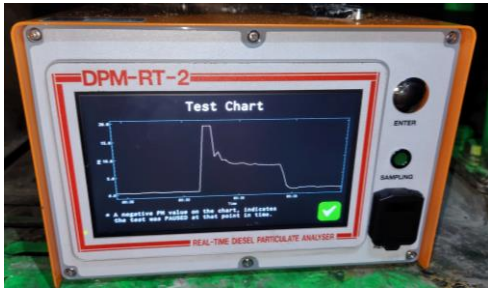
Fuel type
Diesel Oil

T.Air	89	°F
T.Gas	634	°F
P.Sensor	87	°F
O2	14.9	%
CO	15	PPm
NO	396	PPm
NO2	15	PPm
NOx	411	PPm
CO2	4.5	%
Eff.	64.7	%
Losses	35.3	%
Exc. air	3.44	
Dew poi.	92	°F
Gas vel.	0.4	m/sec

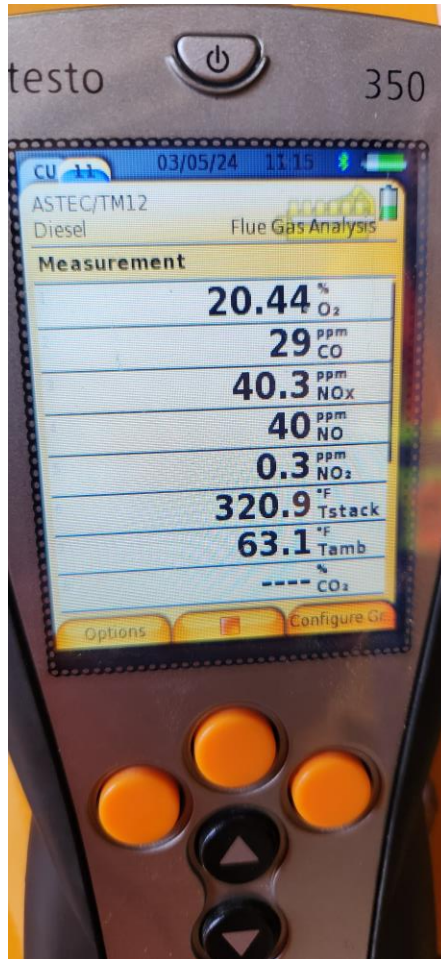
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DIATELY.



Comparing the numbers – temperature matters



- 320 C vs 400 C
- Both results would pass the 600ppm CO and 60ppm NO₂ test
- However the 400 C test has significantly better results as a result of better engine combustion
- Recommended minimum exhaust stack temperature is 550 F or 290 C



DPM contribution by machine

Unit Number	Description of technical object	Blended DPM	Engine	BHP	BHP CFM	CANMET	Hours/Day	DPM x Utilization	% Share	Rank	Stage
HTK-318	HAUL TRUCK - CAT AD30 HTK-318	6.159	C15 AD30 PN#319-7503	409	40,900	20,700	8.16	50.24	1.80%	15	1
HTK-317	HAUL TRUCK - CAT AD30 HTK-317	4.3945	C15 AD30 PN#319-7503	409	40,900	20,700	6.24	27.43	1.00%	43	1
HTK-319	HAUL TRUCK - CAT AD30 HTK-319	4.3945	C15 AD30 PN#319-7503	409	40,900	20,700	5.84	25.66	0.90%	48	1
TRT-020	TRACTOR MINECAT KM200 TRT-020	29.264	0	100	10,000	-	3.27	95.64	3.40%	1	2
SCT-703	SCOOPTRAM-ATLAS COPCO ST1030- 7Y SCT 703	1.339	QSL 9	250	25,000	20,900	1.56	2.09	0.10%	114	2
SCT-604	SCOOP - TAMROCK EJC 210-6Y-REM SCT 604	6.08	MBE926	230	23,000	18,858	0.3	1.82	0.10%	115	2
MCT-793	TOYOTA - HZJ79L - CAPT MCT 793 MINE	9.267	1HZ PCNA	136	13,600	7,300	3.93	36.39	1.30%	31	3
SCT-613	SCOOPTRAM - CAT R1600G Rental-6Y SCT 613	2.31	C11	263	26,300	24,500	5.55	12.82	0.50%	69	3
SCT-707	SCOOPTRAM - CAT R1700G Rental-7Y SCT 707	2.31	C11	353	35,300	21,300	5.22	12.05	0.40%	72	3
MCT-816	TOYOTA - MCT-816 SERVICE BOX ENG SURVEY	9.267	1HZ PCNA	136	13,600	7,300	2.39	22.16	0.80%	52	4
MCT-819	TOYOTA - MCT-819 MANCARRIER H & S	9.267	1HZ PCNA	136	13,600	7,300	1.97	18.22	0.60%	61	4
BOL-002	BOLTER MACLEAN MEM-975 BOL-002	3.08	904	150	15,000	9,196	1.01	3.11	0.10%	101	5
BOL-003	BOLTER MACLEAN MEM-975 BOL-003	3.08	904	150	15,000	9,196	1.01	3.11	0.10%	102	5
MCT-825	TOYOTA - MCT-825-MAN CARRIER-MINE DEVELO	9.267	1HZ PCNA	136	13,600	7,300	0.33	3.09	0.10%	103	5
JUD-008	JUMBO - ATLAS COPCO BOOMER 282 JUD-008	2.93	D914L04	75	7,500	13,700	1.05	3.08	0.10%	104	5



The Results



Implementation of DPF's - results

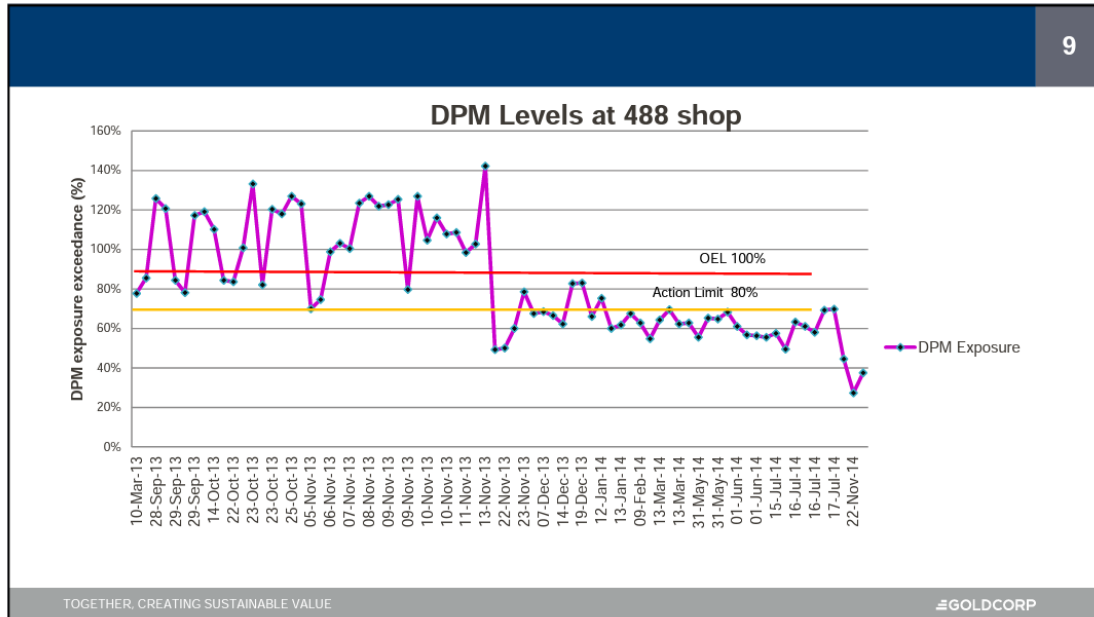
2020 DPM Sampling Results					Limiting Concentration (0.32 mg/m3 limit)	DPM Limit Exceedances
	Date	Location	Shift Length	Occupation		
1	2/01/2020	1230	10	Sill Miner	0.436	>Exceedance
2	13/01/2020	1230	10	Sill Miner	0.904	>Exceedance
3	14/01/2020	1230	10	Sill Miner	0.44	>Exceedance
4	18/01/2020	1230	10	Area Sample	0.411	>Exceedance
5	21/01/2020	1185	10	Area Sample	0.403	>Exceedance
6	21/01/2020	1160 (ramp just below the level)	10	Area Sample	0.292	Clear (Prev Ontario Limit)
7	23/01/2020	1040 (ramp just below the level)	10	Area Sample	0.202	Clear (Prev Ontario Limit)
8	23/01/2020	1230	10	Area Sample	0.359	>Exceedance
9	28/01/2020	1075 (just below in the ramp)	10	Area Sample	0.318	Clear (Prev Ontario Limit)
10	28/01/2020	985 Ramp	10	Area Sample	0.272	Clear (Prev Ontario Limit)
11	28/01/2020	1160 Ramp	10	Area Sample	0.296	Clear (Prev Ontario Limit)
12	28/01/2020	1230 Level	10	Area Sample	0.338	>Exceedance
13	30/01/2020	1040 Ramp	10	Area Sample	0.267	Clear (Prev Ontario Limit)
14	30/01/2020	1075 Ramp	10	Area Sample	0.276	Clear (Prev Ontario Limit)
15	1/02/2020	415 Vent Acc	10	Area Sample	0.104	Clear Current Limit of 0.12
16	7/02/2020	415 RAR	10	Area Sample	0.189	Clear (Prev Ontario Limit)
17	7/02/2020	1230 Level	10	Area Sample	0.334	>Exceedance
18	7/02/2020	1250 Level	10	Area Sample	0.331	>Exceedance
23	27/02/2020	1230 Level	10	Area Sample	0.272	Clear (Prev Ontario Limit)
24	27/02/2020	1075 Ramp	10	Area Sample	0.186	Clear (Prev Ontario Limit)
25	27/02/2020	1160 Ramp	10	Area Sample	0.316	Clear (Prev Ontario Limit)
26	4/03/2020	1230 Level	6	Area Sample	0.257	Clear (Prev Ontario Limit)

2023 DPM Sampling Results					Limiting Concentration (0.32 mg/m3 limit)	DPM Limit Exceedances
	Date	Location	Shift Length	Occupation		
1	4/01/2023	1450 Mucking	10	Sill Miner	0.051	Clear Current Limit of 0.12
2	6/01/2023	1345 NA2 East	10	Sill Miner	0.568	>Exceedance
3	6/01/2023	Down Ramp	10	Sill Miner	0.095	Clear Current Limit of 0.12
4	26/01/2023	1345 Level	10	Area Sample	0.097	Clear Current Limit of 0.12
5	27/01/2023	1475-115 Level	10	Area Sample	0.146	Clear (Prev Ontario Limit)
6	27/01/2023	1345 Level	10	Area Sample	0.274	Clear (Prev Ontario Limit)
7	1/02/2023	Down Ramp	10	Area Sample	0.218	Clear (Prev Ontario Limit)
8	26/05/2023	1475 RAR ACC	10	Area Sample	0.297	Clear (Prev Ontario Limit)
9	6/06/2023	1275 NB2 E	10	Area Sample	0.145	Clear (Prev Ontario Limit)
10	6/06/2023	Mine General	10	Area Sample	0.2	Clear (Prev Ontario Limit)
11	6/06/2023	Mine General	10	Area Sample	0.2	Clear (Prev Ontario Limit)
12	20/07/2023	1450 NB West	10	Area Sample	0.197	Clear (Prev Ontario Limit)
13	20/07/2023	1475 RAR	10	Area Sample	0.173	Clear (Prev Ontario Limit)
14	27/07/2023	1450 Level ACC	10	Area Sample	0.251	Clear (Prev Ontario Limit)
15	8/08/2023	1345 Shop Area Sample	10	Area Sample	0.27	Clear (Prev Ontario Limit)
16	9/08/2023	1345 Shaft Area Sample	10	Area Sample	0.184	Clear (Prev Ontario Limit)
17	16/08/2023	1475 RAR Area Sample	10	Area Sample	0.005	Clear Current Limit of 0.12
18	16/08/2023	1345 Shop Area Sample	10	Area Sample	0.04	Clear Current Limit of 0.12
19	24/08/2023	1475 Area Sample	8	Area Sample	0.138	Clear (Prev Ontario Limit)
20	29/08/2023	Mine General	8	Area Sample	0.03	Clear Current Limit of 0.12

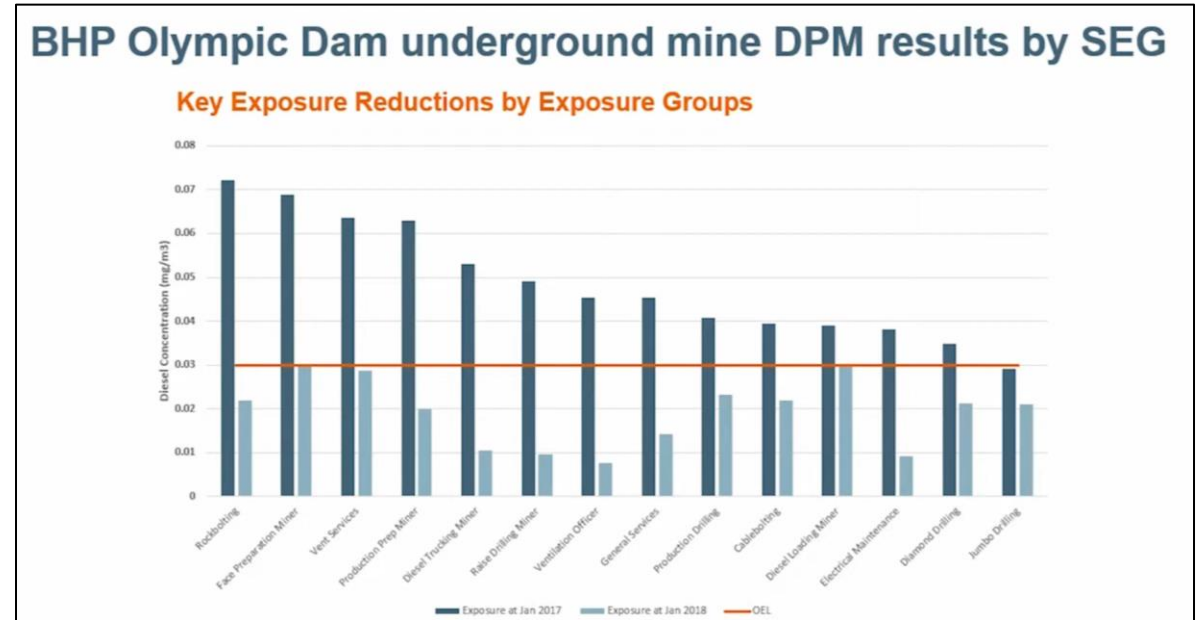
Jan 2020 (Pre DPFs) Average Concentration:	0.372	>Exceedance
Feb 2020 (2 Truck DPFs) Average Concentration:	0.247	Clear (Prev Ontario Limit)

Jan 2023 (All Trucks with DPFs) Average Concentration:	0.205	Clear (Prev Ontario Limit)
August 2023 (+Loaders with DPFs) Average Concentration:	0.111	Clear Current Limit of 0.12

DPM exposure levels reduced by DPF implementation



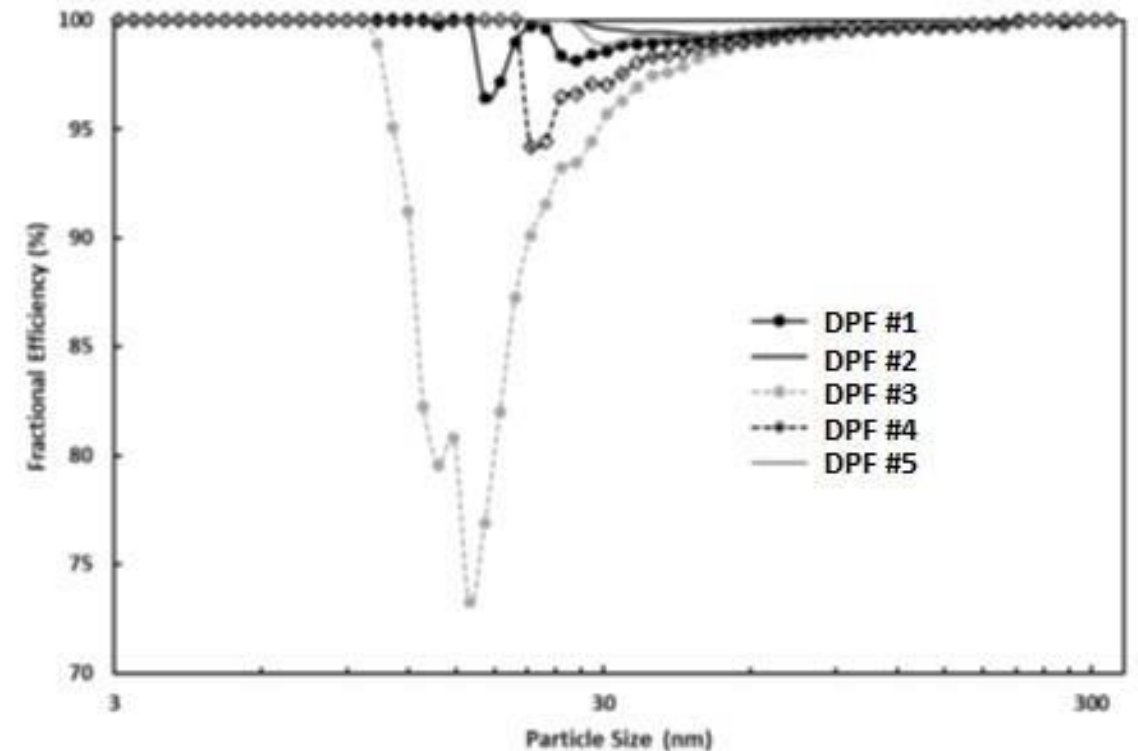
November 2013 – Fit out of selected prime movers with Diesel Particulate Filters



Jan 2017 vs Jan 2018 – Post Fleet Implementation of Diesel Particulate Filters

Which particle size ranges does a DPF capture

- Curtin University tested 5 full wall flow DPFs (various types age and manufacturer)
- Particle capturing efficiency in the size range 1-15nm were still captured at 98-99.5% efficiency as were particles 50nm – 300nm
- MPPS (Most Penetrating Particle Size) was in the range 15-30nm) showed a filtration performance dip down to 73%



Insights from emissions

Truck #	TRUCK 1		TRUCK 2		TRUCK 3	
Truck hrs	3721hrs		3892hrs		4258hrs	
Emissions	PRE	POST	PRE	POST	PRE	POST
DPM (mg/m ³)	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
NO _x (PPM)	636	617	680	638	626	451
O ₂ (%)	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

What emissions are indicating? high co

High Carbon Monoxide (CO):

- *Mechanical Indication:* High CO emissions can be attributed to various mechanical issues, including those affecting intake air temperature, fuel injectors, air filters, and emissions control devices like DPFs.

Possible Mechanical Causes:

- **Blocked Radiator or Intercooler**
- **Malfunctioning Fuel Injectors**
- **Air Intake Issues**
- **DPF Regeneration Issues**
- **DOC Failure or Contamination**



What emissions are indicating? high DPM

High Diesel Particulate Matter (DPM):

- *Mechanical Indication: The mass of particulate matter emissions is a measure of solid particles, including soot and other fine particles, released in the exhaust.*

Possible Mechanical Causes:

- **Incomplete Combustion**
- **DPF Efficiency**
- **Air Intake Issues**



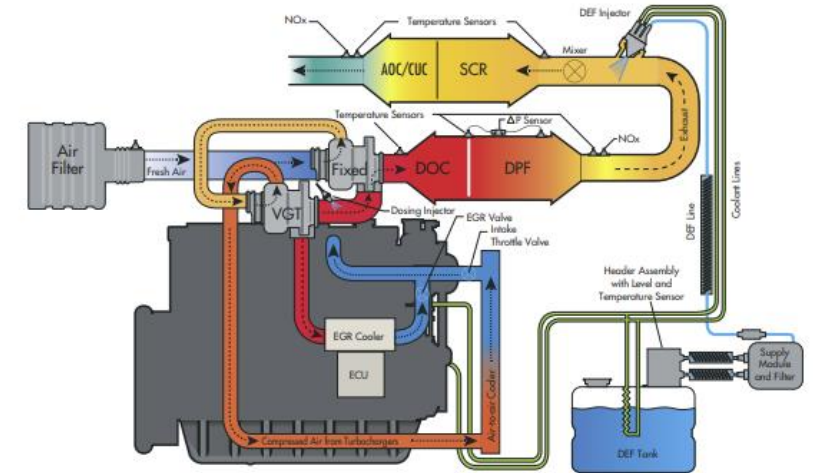
What emissions are indicating? high NOx

High Nitrogen Oxides (NOx):

- *Mechanical Indication:* Elevated NOx emissions can be influenced by mechanical factors related to intake air temperature, combustion efficiency and temperature and/or the emissions control devices.

Possible Mechanical Causes:

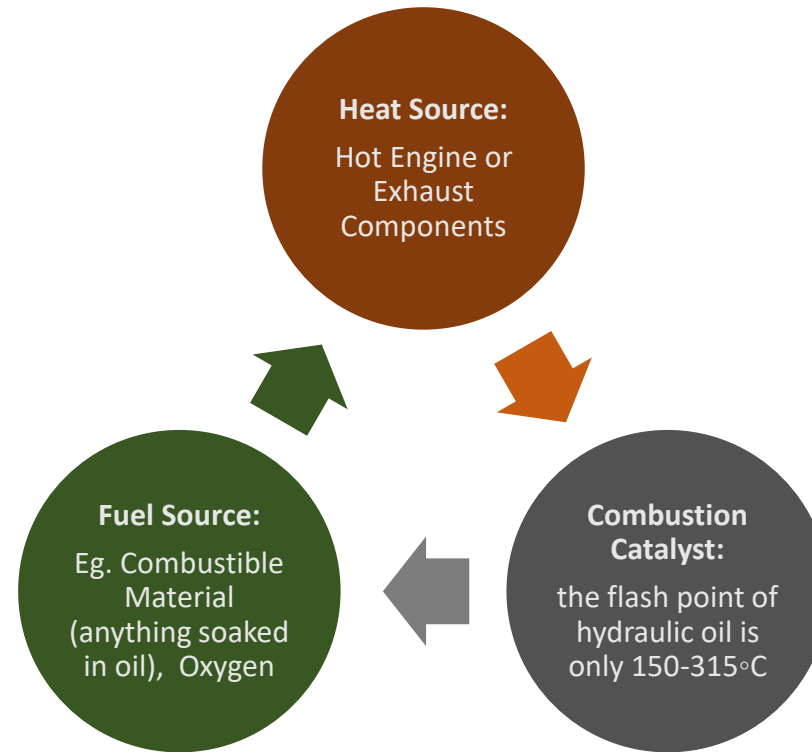
- Blocked Radiator or Intercooler
- Faulty EGR System
- DPF Efficiency
- SCR System Issues
 - E.g. SCR catalyst contamination, DEF dosing, DEF injectors, DEF quality issues etc.





Fire Prevention Systems – hot surface insulation

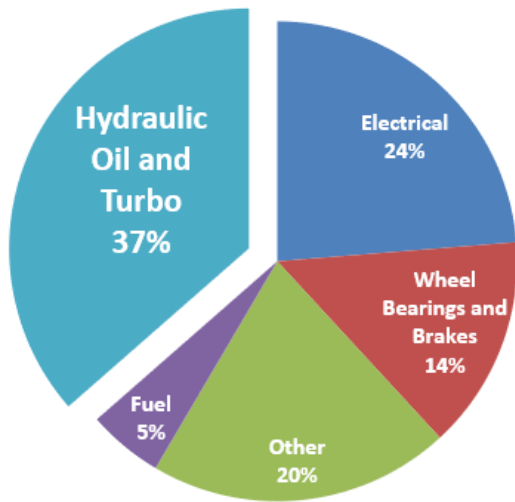




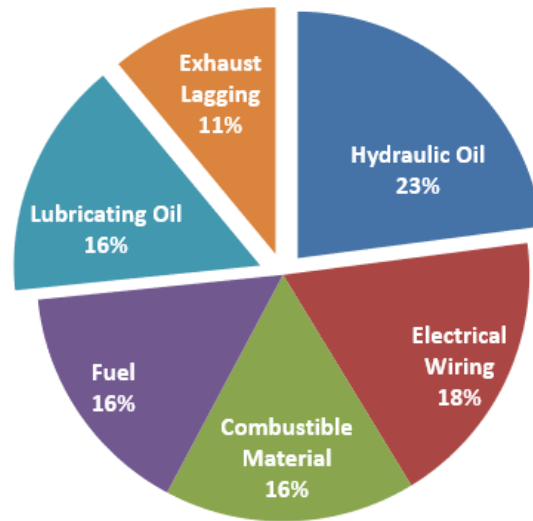
ANALYZING THE CONTRIBUTING FACTORS AND CAUSES OF FIRES ON MINING EQUIPMENT:



QLD Mines Causes of Fires Analysis
Source: DNRM 2008



NSW Mines Fuel Source of Fires Analysis
Source: Resources and Energy 2008-2012



1. Engine oil leak spraying over a hot exhaust system
2. Worn electrical cables
3. Other oil leak spraying over a hot exhaust system
4. Overheating of engine fluids falling over hot exhaust
5. Overheating of a broken catalyzer

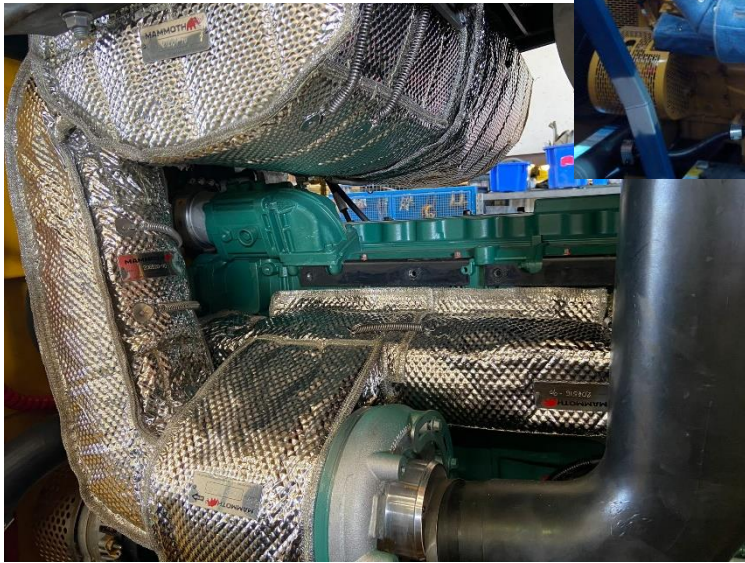
THERMAL EXHAUST BLANKETS



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- Schematics to ensure you have the information you need to order the right part with confidence.
- Fitting sheets and design considerations to ensure you maximise the benefit of the Pyrogard blanket.
- Best product available for minimising oil absorption and ensuring you have a long lasting, safe product .



Thank you / Contact details

Ralph Deayton

Technical Sales

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THANK YOU

