Applying VERT Particle Counting to Mining Equipment Emissions

Improving Maintenance, Compliance, and Mine Safety

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Mission Statement

Genuine Maintenance Inc.

To provide reliable support and resources to clients seeking solutions to Diesel emission maintenance excellence.

- Diesel emission solutions, Upgrades to aftertreatments, installs, training, and service support
- Mining Equipment Heavy Duty Diagnostics and Evaluation
- Maintenance Strategic planning consulting – Fleet evaluation and CMMS to reach best-in-class
- Onsite installation, repair, and support resource
- Over 32 years experience in mining maintenance.

Background

- Diesel-powered equipment is essential in underground mining
- Particulate emissions remain a major occupational health challenge
- Traditional PM mass methods are often below detection thresholds in Tier 4F engines

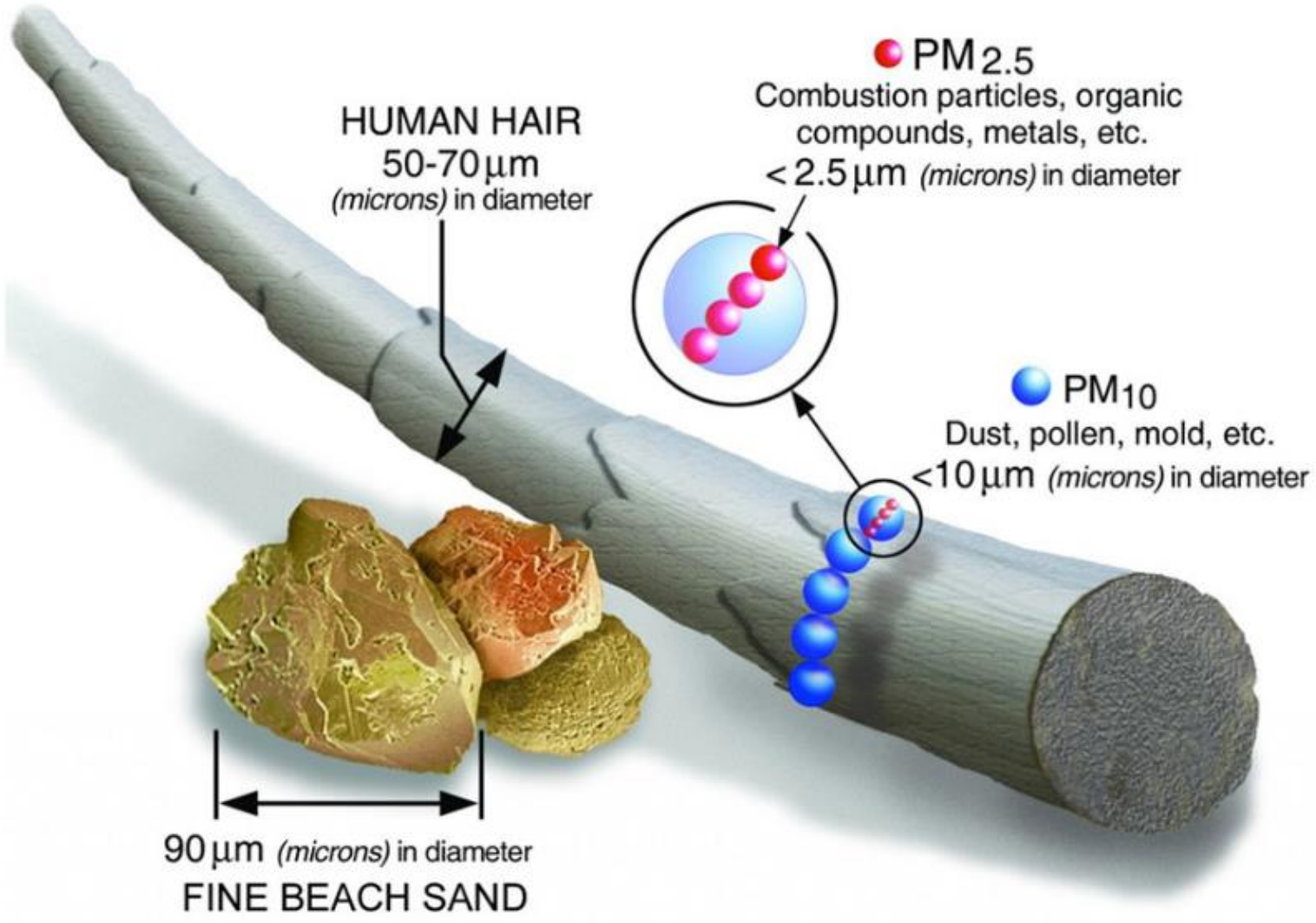
Emission Levels

- US MSHA: 160 µg/m^3 (Total Carbon)
- Canada (Ontario): 260 µg/m^3 (Total Carbon)
- Australia: 100 µg/m^3 (Elemental Carbon, 8-hour average)
- South Africa - Effective 26 June 2025, the South African government introduced a legally enforceable occupational exposure limit (OEL) of 0.1 mg/m^3 for elemental carbon, a key component of DPM.

Making Mines Safer

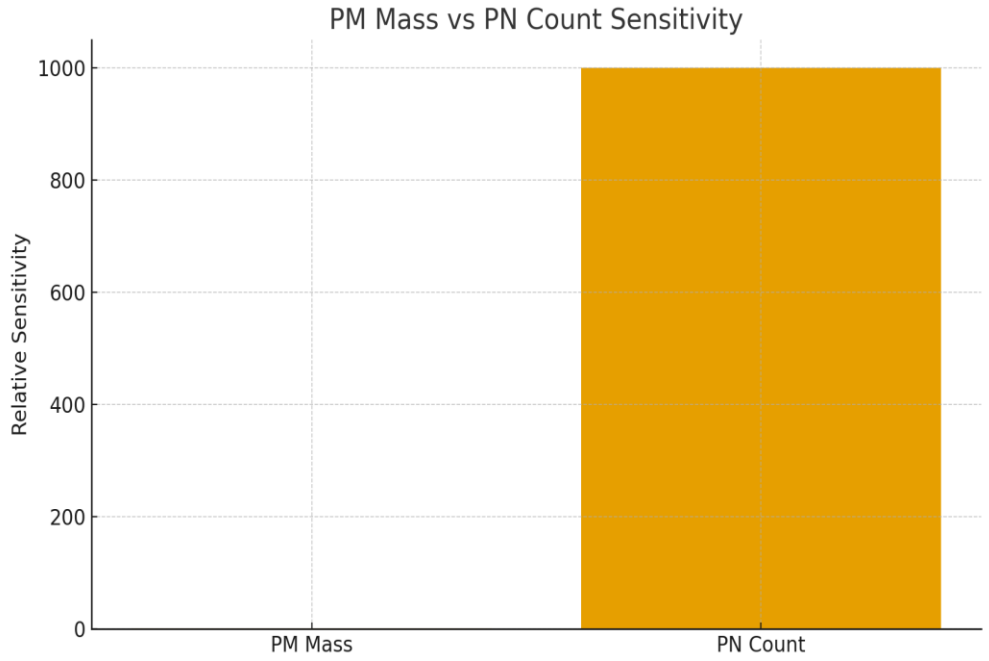
- Ultrafine particles (≤100 nm) are most harmful to human health
- PN monitoring reduces exposure to ALARA levels
- Protects workers and improves underground air quality
- VERT Recommended Limit 200,000. The total mass PM (mg/m3, mg/kWh)

Ultrafine Soot is present in all engines



Why Particle Number (PN) Counting Matters

- Ultrafine particles remain invisible in PM mass tests
- PN counting is up to 1,000× more sensitive
- Adopted by VERT Association for PTI in EU

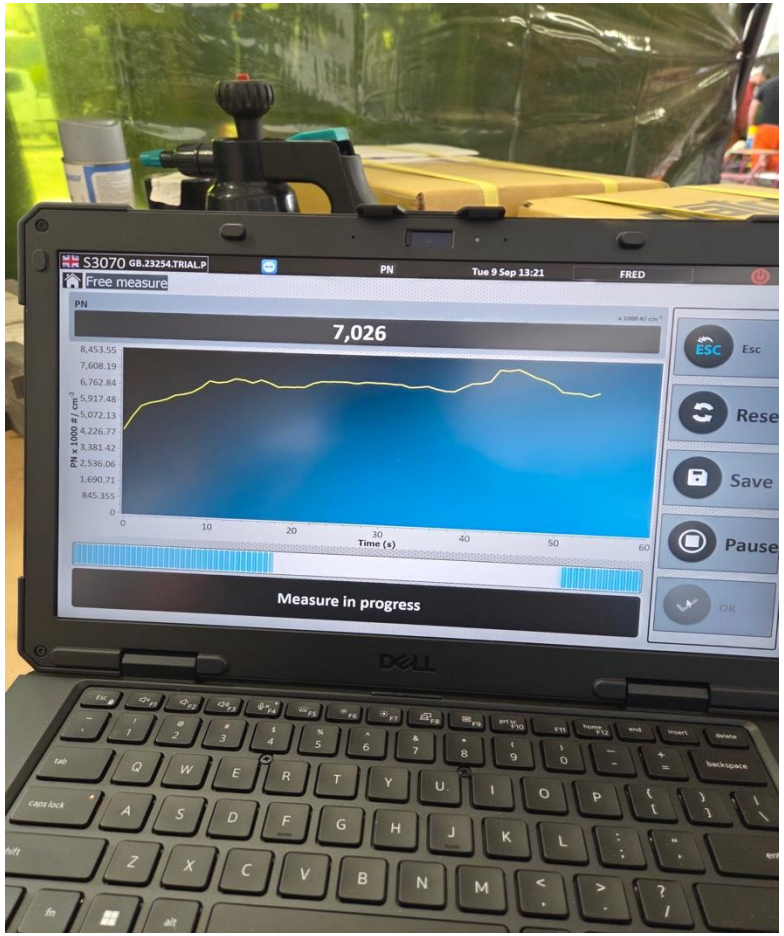


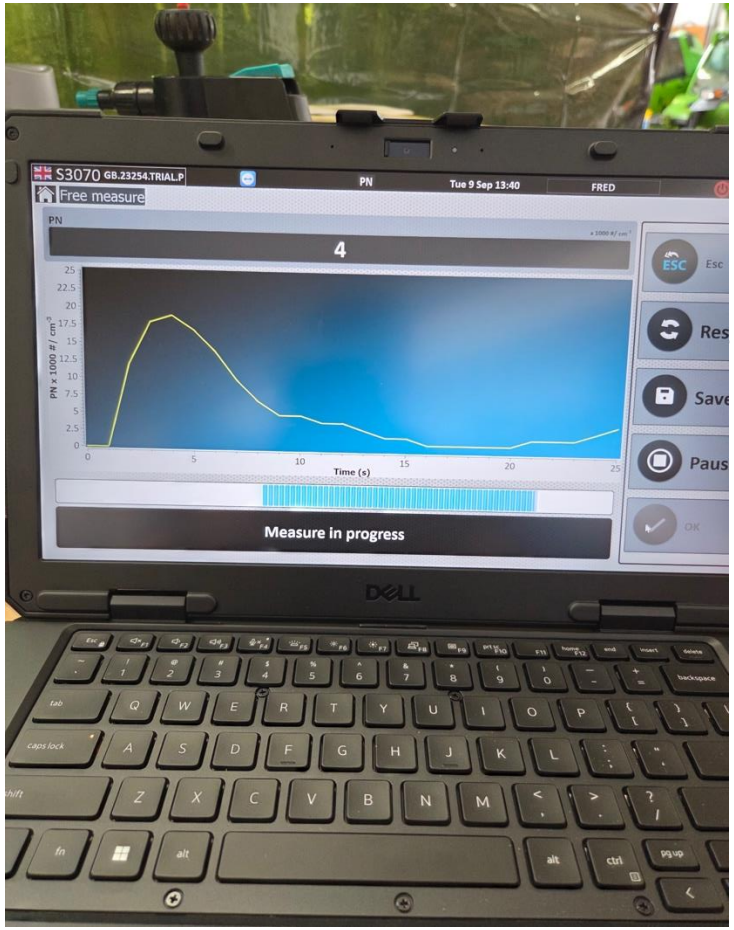
Case Studies in Tier 4F Engines

- Perkins, Deutz, Kubota, and Kohler Tier 4F engines tested
- Engines with DPF: strong reductions in ultrafine particles
- Engines without DPF: PN counts show significant particle release

Kohler KDI2504 Cont. : Sample of Particle Number Pre & Post DPF, Count using Capelec P3070 – VERT PTI test method

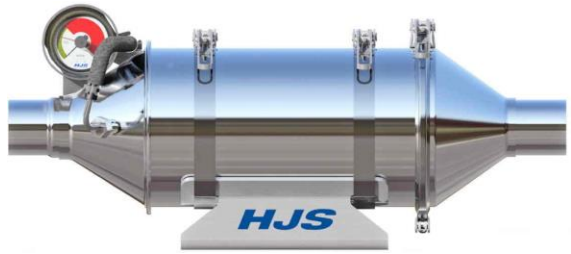
Engine at temp, low idle. Soot reduction is realized



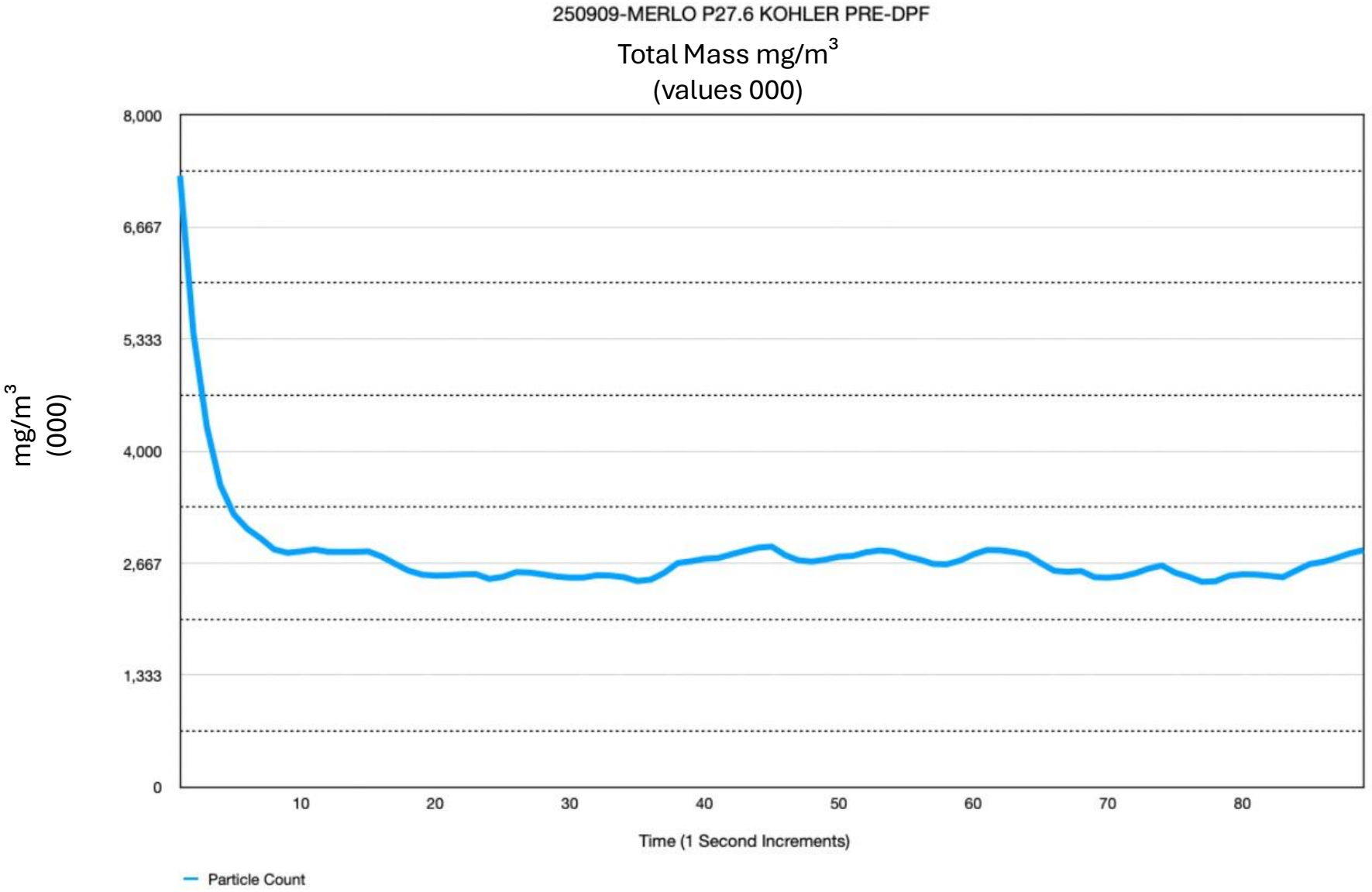


SMF-ER

Soot capture for low exhaust temperatures



Think about tomorrow. HJS Emission Technology



Tier 4 with HJS SMF-ER 2.8

USING PARTICLE COUNT AS DETECTION INDICES FOR LARGER EMISSION EMITTERS IN MOBILE FLEETS

1-IMPORTANCE OF PARTICLE COUNT VERSUS MASS FOR CARBON EMISSION (P.M.)
2- VERT ESTABLISHED - PTI (Periodic Technical Inspection 2022)
3- DOES TOTAL MASS OF PARTICLE MATTER? – YES, IT DOES , IT IS REDUCED WITH NEW TIER 4 F ENGINES –

Consideration for - The total mass PM (mg/m3, mg/kWh) of these tiny particles is extremely low and is often below the detection limit of gravimetric detection in modern engines,

But the number concentration of ultrafine particles PN (1/cm3, 1/kWh), is high and can be measured very accurately even in clean engine exhaust gas at low idle speeds. credit to VERT report "Dirty Tails" https://doi.org/10.1007/s40825-024-00257-0

UNDERSTANDING AND CHALLENGING MAINTENANCE PRACTICES(DPF)

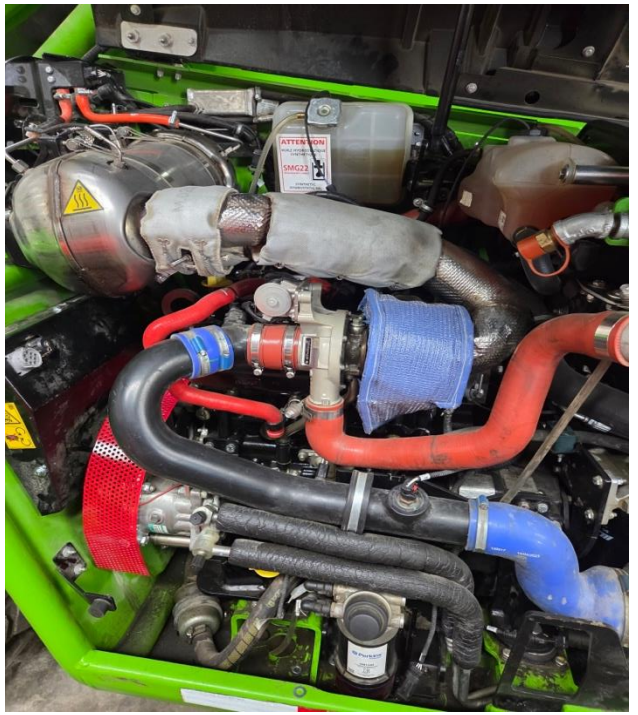
- ✓ P.M. MASS
- ✓ USE OF NIOSH 5040 SAMPLE, AMBIENT AIR
- ✓ SOME SAMPLING USING GRAVIMETRIC TOOLS,
- ✓ LIMITED TO HIGHER CONCENTRATION, PARTICLES ARE DIFFICULT TO WEIGH

- ✓ P.M. COUNT
- ✓ USE OF PARTICLE COUNTER
- ✓ PARTICLE COUNTING ADOPTED BY E.U (VERT)
- ✓ ABILITY TO COUNT WITH REPEATABILITY.
- ✓ SERVES AS MAINTENANCE DETECTION FOR DPF STATE OF HEALTH (PTI VERT)

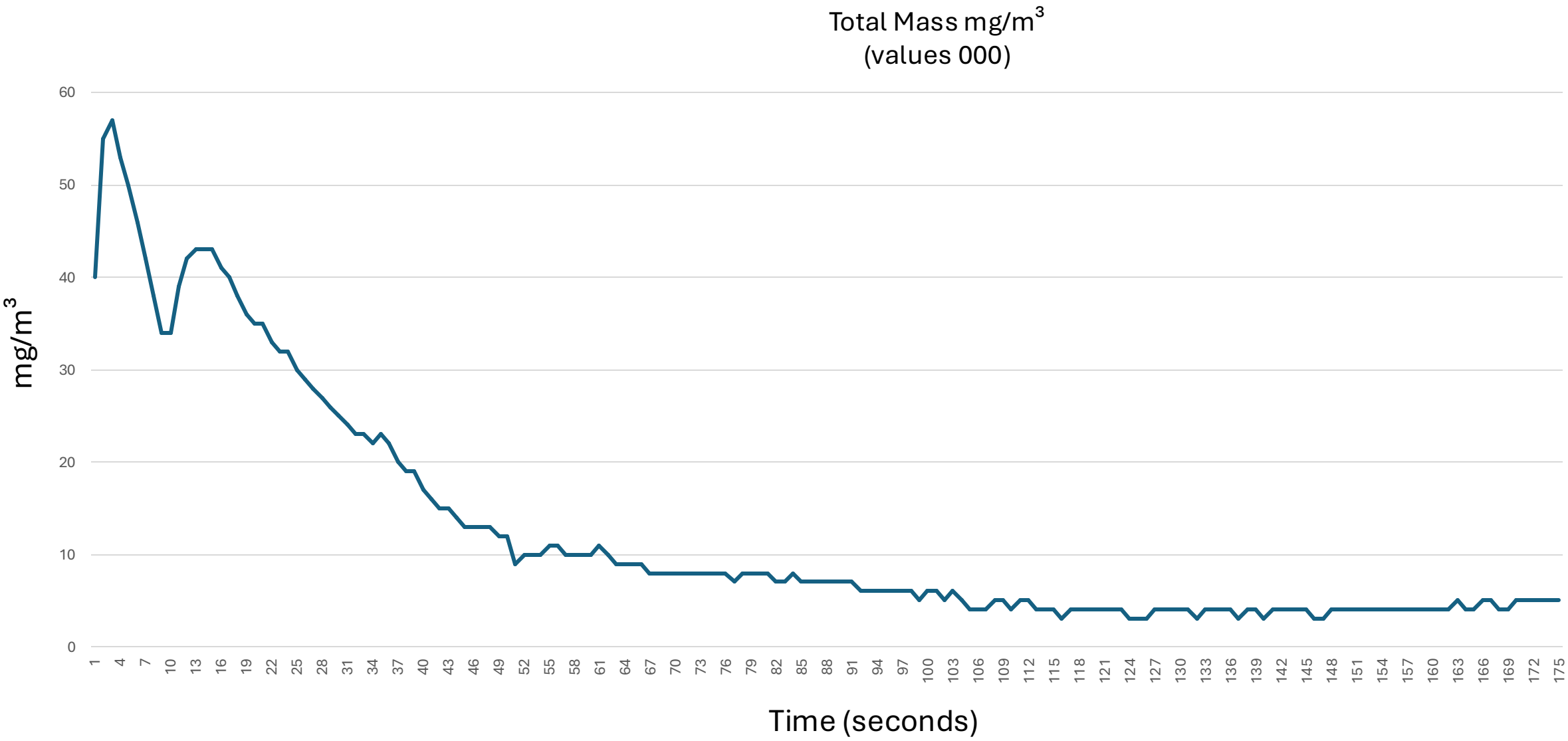
P.N. COUNT TESTS ON NEW TIER 4F ENGINE (1)

2024 PERKINS 3.6L DIESEL , TIER 4 F , C/W DOC, DPF AND SCR TECHNOLOGY.

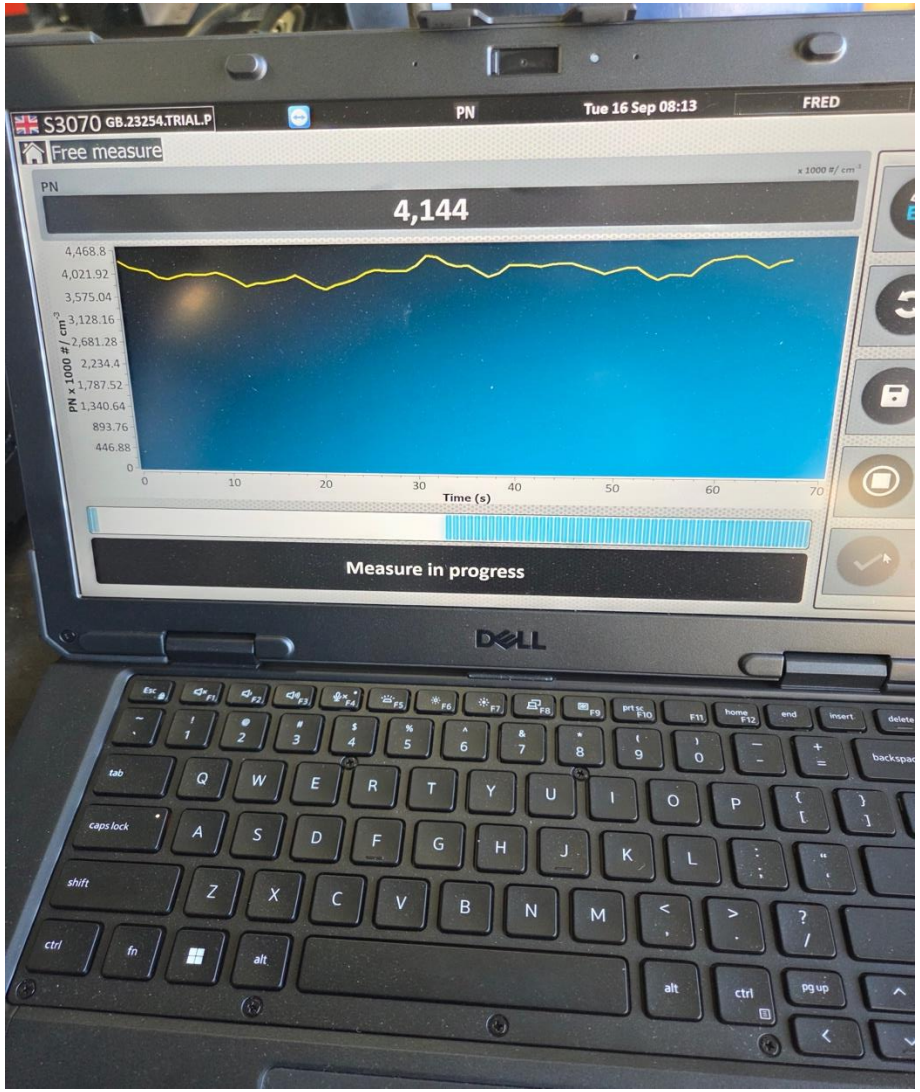
EQUIPMENT – 2024 MERLO, MODEL 40.13 TELEHANDLER



Perkins Tier 4 3.6L

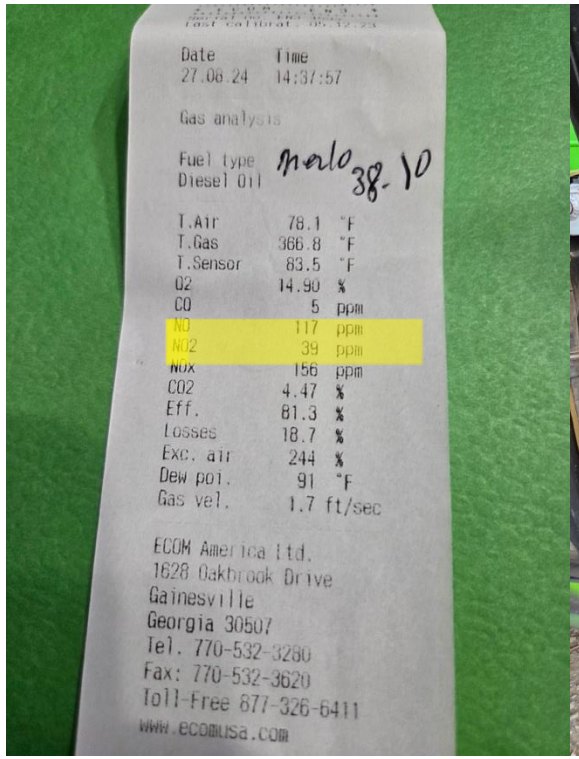


P.N. COUNT TESTS ON NEW TIER 4F ENGINE (2)

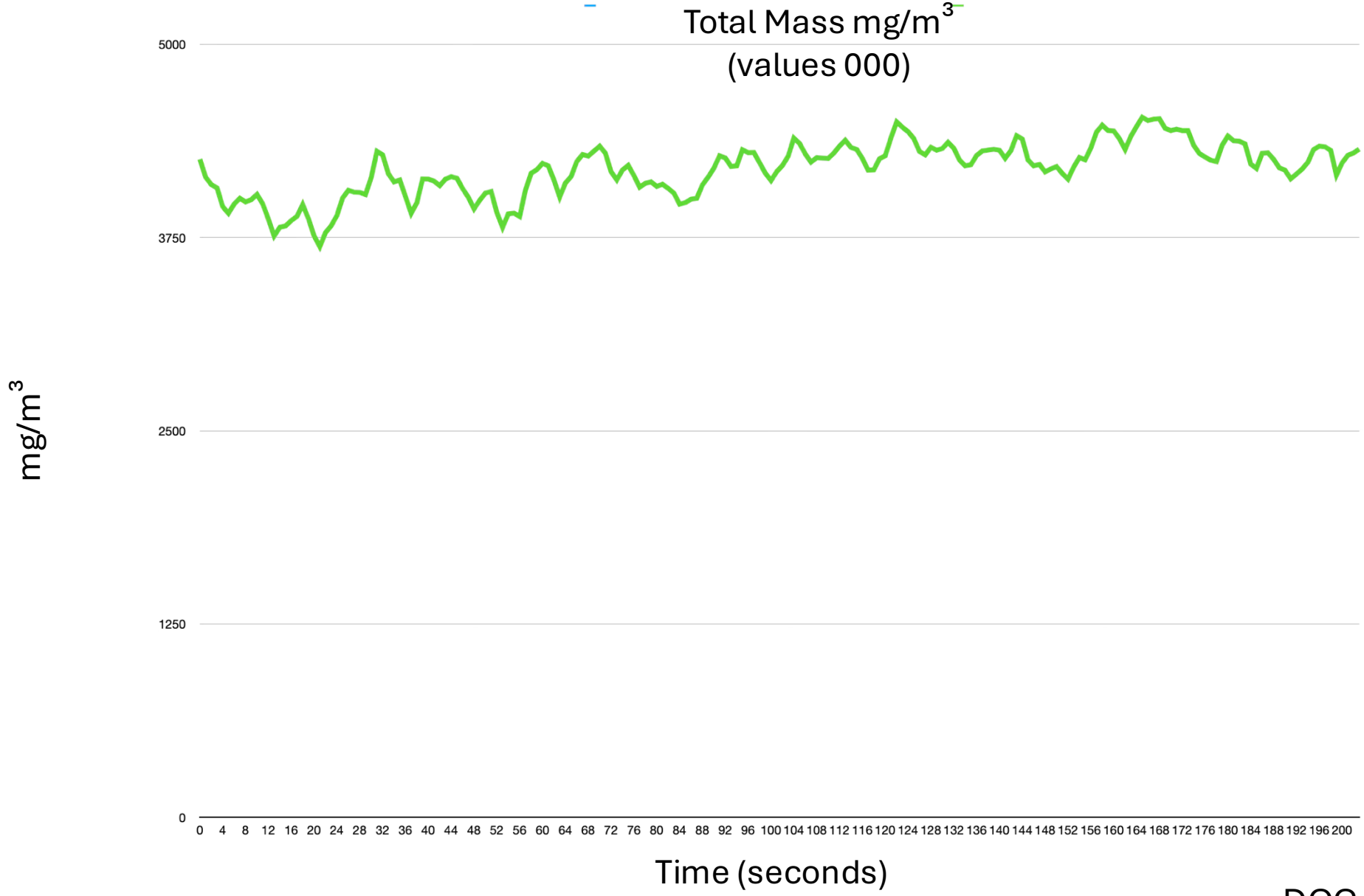


2020 DEUTZ 3.6L4 DIESEL , TIER 4 F , C/W DOC, SCR TECHNOLOGY.

EQUIPMENT – 2021 MERLO, MODEL 72.10 TELEHANDLER

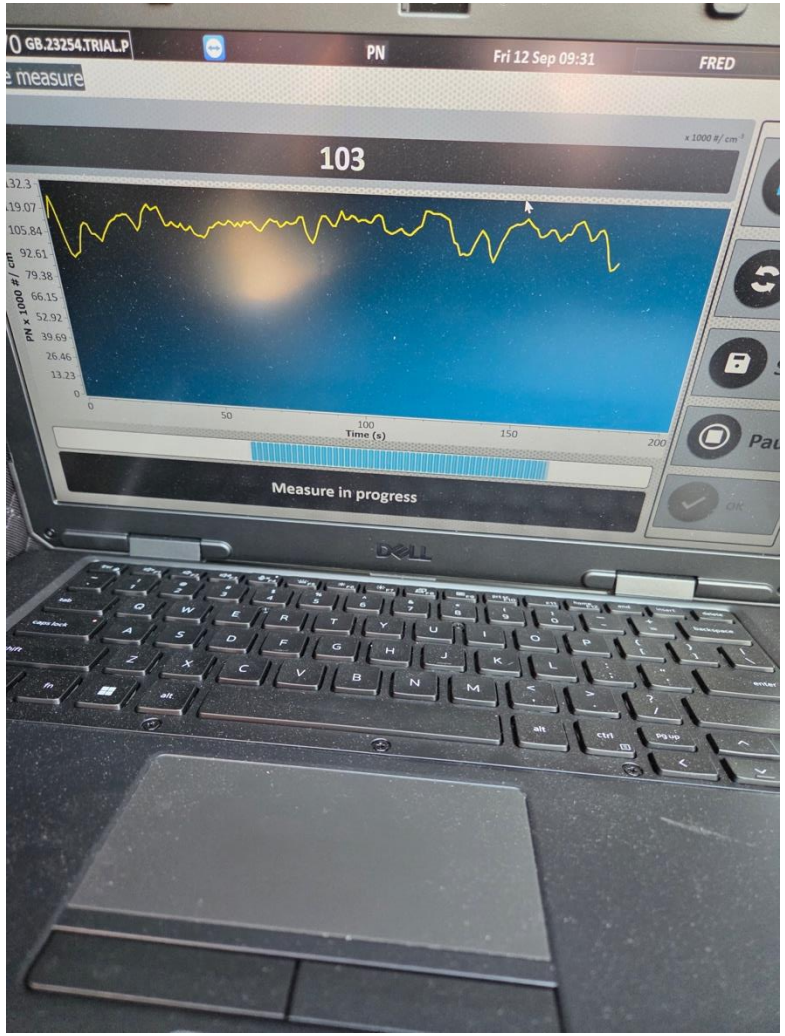


Deutz 3.6L4



DOC & SCR Installed

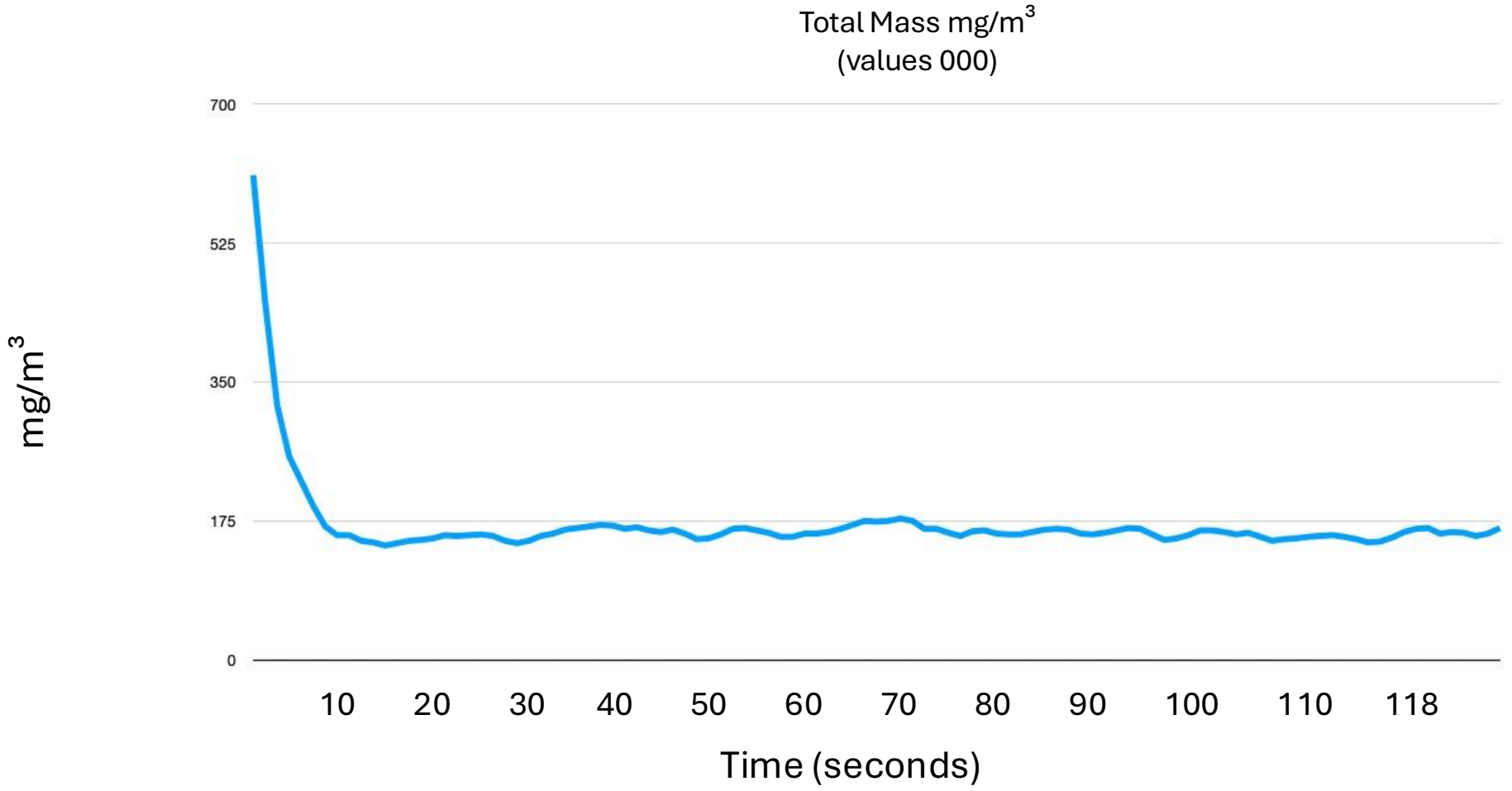
P.N. COUNT TESTS ON NEW TIER 4F ENGINE (3)



2020 KUBOTA V3307-T, 3.3L DIESEL , TIER 4 F , C/W DOC, DPF TECHNOLOGY.

EQUIPMENT – MANITOU 625 TELEHANDLER

250912-3 MANITOU 625 KUBOTA



TIER 4 F C/W DOC & DPF

Observations: Using Particle counter as Maintenance tool

- Engine technologies have made great progress; most manufacturers have achieved remarkable results in lowering emissions, toxins, and soot mass levels to reach EPA Tier4F.
- Toxins from emissions during combustion have been reduced in all areas. Carbon Monoxide is at its lowest level. NO2 is controlled using internal engine components, EGR, and Selective Catalytic Reduction systems. Soot-carbon is controlled with DPF systems.
- As samples demonstrate, not every system is designed equally; some have achieved emission limits to meet EPA Tier 4F with a different approach and using some of the same components.
- What the samples demonstrate is that, with some form of system, they reduced the amounts of toxins and soot by a large percentage. However, it also demonstrates that some without a DPF have not removed all the toxins.
- A large amount of ultra-fine particles is allowed to be expelled from the engine's outlet without using a DPF.
- **The easy use of such a tool to identify large emitters of soot in a fleet environment can facilitate triage and place control at the proper level.**

FINAL THOUGHTS: Maintenance approach using Particle Counter as a tool to Engine Performance

" Of Course – the simple sample of one to draw PN count does not identify what the problem is", but with high P.M. count and using gas analyzer such as ECOM En2 can trigger proper Maintenance action to remedy cause and not symptoms in a repeatability manner.
Measuring ; "the detection level of P.M. is currently specific as 0.1mg/M3 for the best systems, so measuring the number of particle is around 1000 times more sensitive than gravimetric measurements."

Using PN count instrumentation with ECOM, from a data baseline collection, high count specific to this engine and related aftertreatment would activate maintenance intervention.

- Basic checks to engine would be carried out, fuel contamination, air inlet restriction, valve lash, cooler condition, turbo, oil consumption.
- Fuel injection tests, condition and pressure measurements.
- Engine foundation, compression check, cylinder leak down, crankcase ventilation condition.
- After treatment system condition, test EGR, test EGR Cooler, test DPF, Test SCR and dosage.

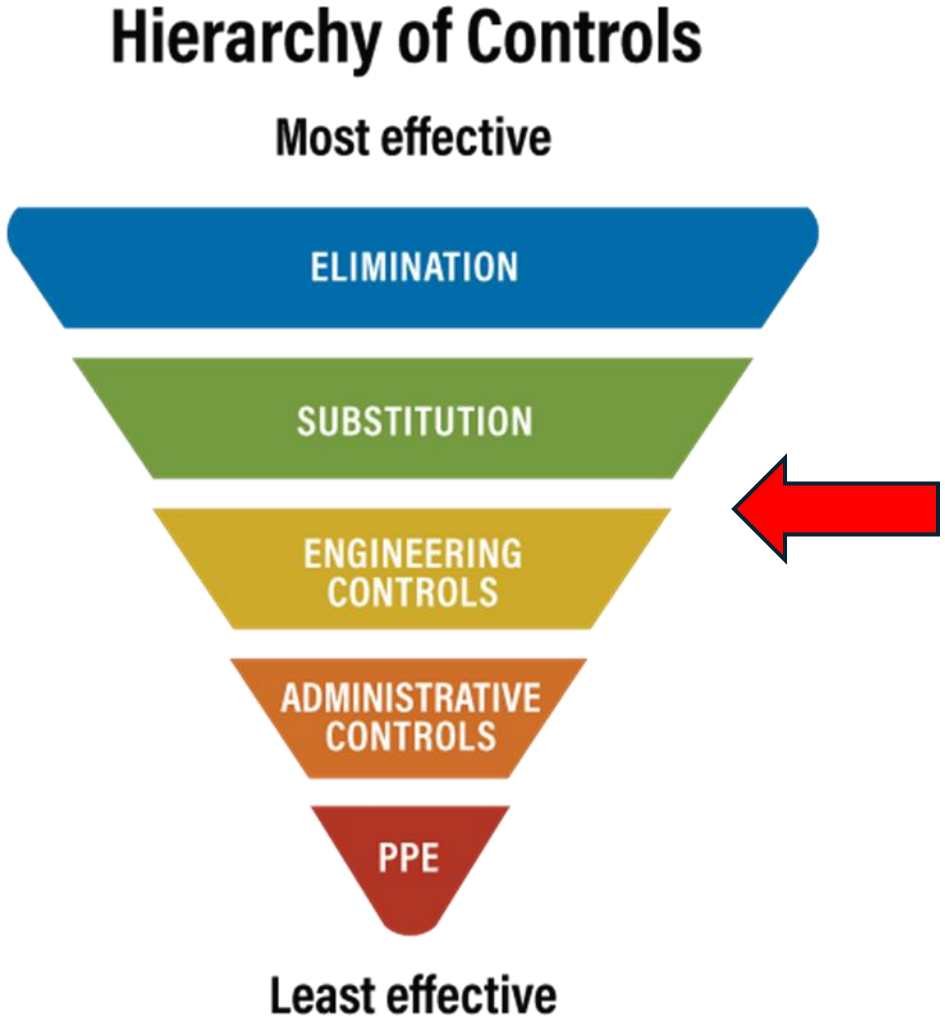
Clean air is our passion

Credit to "VERT- The Dirty Tail Paradigm "

Conclusion

- VERT PN counting makes mines safer and more efficient by providing unmatched sensitivity, actionable diagnostics, and reliable compliance monitoring.

Maintenance approach using Particle Counter as a tool to Engine Performance



USING PROVEN METHODS AND TOOLS TO LOWER EXPOSURE AS RESONABLY ACHEIVABLE TO TOXIN AND PARTICLE MATTER IN OUR MINING WORKPLACE IS POSSIBLE.

USING AND INSTALL OF DPF WILL AFFECT AIR QUALITY IN ANY MINING OPERATION.

USING BEST QUALITY OF PRODUCT WILL HAVE THE HIGHEST RESULTS AND OPERATIONAL RELIABILITY.

Clean air is our passion

* Credit to “VERT- The Dirty Tail Paradigm “