

Cat® Ventilation Reduction (VR)

Cleaner Air For Hard Rock Underground



Simple and Easy Cleaner Emissions Options

Many hard rock mines focus on the reduction of Diesel Particulate Matter (PM) from their mobile equipment because this value often drives a mine's required ventilation rate. The level of PM in the underground environment is carefully managed in order to meet regulatory requirements imposed by mine safety and health agencies around the world. Ventilation in the underground environment is a large percentage of a mine's operating cost and can affect the viability of a greenfield project or an expansion. The Ventilation Reduction engine utilizes selective engine hardware and software to minimize diesel particulate matter in selected Load Haul Dump (LHD) and Underground Articulated Truck (UAT) machines.

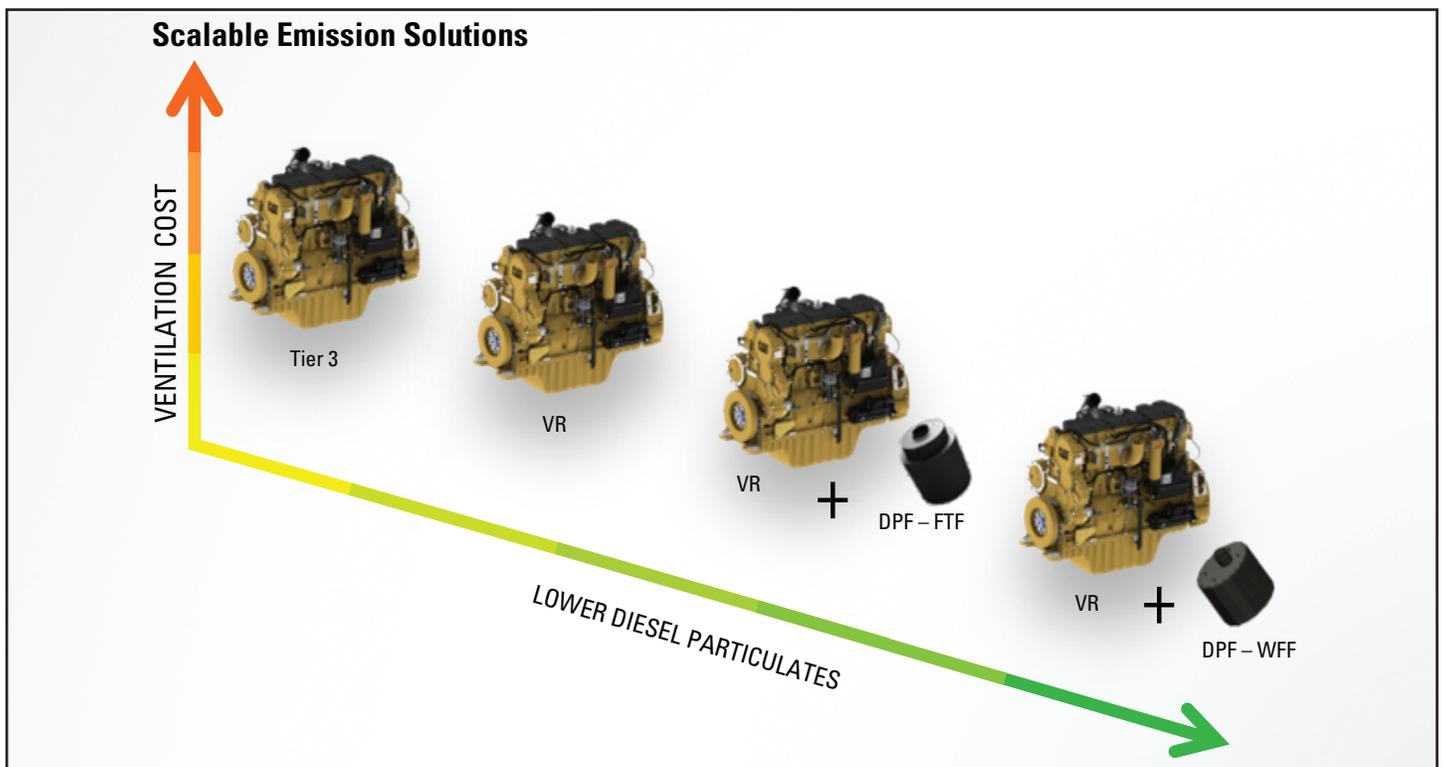


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Lowering Operation Costs

In development of the VR Package, customer value and requirements determined that selectively applied robust technology enhancements was applied to the already proven Cat engine line. By carefully considering the challenging underground environment as well as regulatory requirements for diesel engine emissions in underground mines, the VR engine ultimately drives down ventilation rates required by weighted PM (Particulate Matter). By achieving substantial decreases in ventilation rates, the VR Package option represents a great advancement in the underground mining industry. Underground mining customers find value in lower emissions and decreased ventilation rates, and this option will be a positive outcome for customers looking for reducing operation costs.



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What Drives Ventilation?

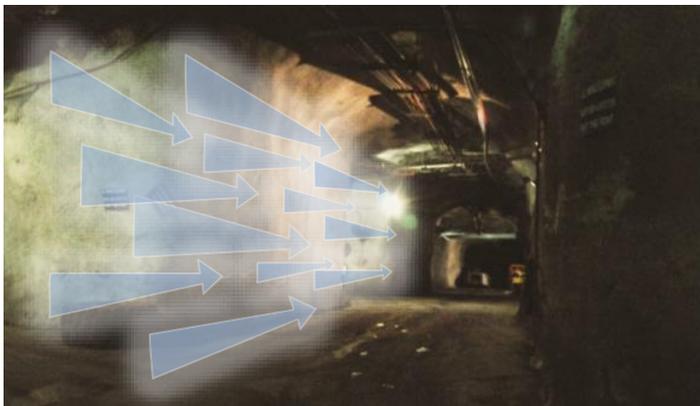
Around the world, many different agencies regulate mine ventilation for a specified engine exhaust level. These ventilation requirements can be based on personal exposure limits (PEL) for operators in the mine. The CANMET regulation used in Canada is generally accepted as the most comprehensive representation of actual engine emissions. CANMET measures 18 points throughout the engine's operating cycle, giving a broader range of sample points. This allows for a thorough and detailed comparison between engines in the underground environment.

Therefore, the next generation of engines for LHD's and UAT's will be optimized for the lowest possible CANMET ventilation rate.

The CANMET measurement provides the following advantages:

- Weighted heavily towards PM among all other exhaust gases
- Largest number of sampling points in the machine operating curve
- Published figures are based on the highest vent rate samples
- Accounts for fuel sulfur levels and altitude effects

Cat R2900G C15 ACERT Tier 3 Standard Engine
35,700 cubic feet per minute



Diesel Engine Exhaust Components

PM
(Particulate Matter)

CO
(Carbon Monoxide)



NOx
(Oxides of Nitrogen)

HC
(Hydrocarbons)

Many mining industry regulations require adequate ventilation underground to keep the level of NOx, PM, HC, and CO at acceptable levels.

Ventilation in the underground environment is a large percentage of a mine's operating cost. Caterpillar is committed to supplying Hard Rock Underground Loaders and Trucks with engine packages that minimize the level of ventilation required.

Cat R2900G C15 ACERT with VR Technology
20,700 cubic feet per minute



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Caterpillar has developed specifically tuned Diesel Particulate Filters (DPF) – Flow Through Filters (FTF) and Wall Flow Filters (WFF) for fitment to Cat[®] Ventilation Reduction engines to further reduce diesel particulate matter output.

- Optimized to reduce particulates greater than 50% and greater than 98%, respectively, while Maintain same NOx Level
- Meets Cat engine backpressure requirements
- Utilizes current muffler space claim
- Does not require specialized services
- Requires Ultra Low Sulfur Diesel (ULSD) and low ash oil (ECF-3, CJ-4)



DPF Breakdown

- Uses Flow Through Filter/Wall Flow Filter technology and catalytic conversion to effectively reduce particulate matter emissions
- FTF incorporates a metal filter medium to trap particles and effectively oxidise them by means of a catalytic coating
- WFF - the DPM flows to solid wall and then is forced in a perpendicular manner to original flow path through the substrate
- Muffler / flow through filter offers the same or better noise attenuation
- No increased NOx emissions as compared to the existing DOC muffler

Ventilation Reduction Engine Technology

The Ventilation Reduction Package utilizes selective engine hardware and software to minimize diesel particulate matter. Depending on the machine and the engine, it involves a combination of two or more of the following (compared to today's Tier 3 engines):

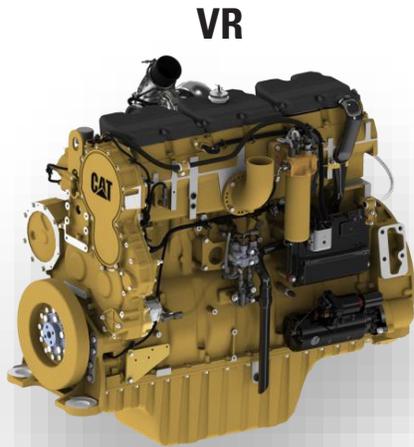
- New engine software
- New injectors
- New turbo
- New camshaft

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Systems Overview

Selecting VR as a factory option or upgrading an existing engine in the field has multiple performance improvements and cost saving incentives



VR



- **Reduced Certified Ventilation Rate**
- **Reduced Diesel Particulate Output**



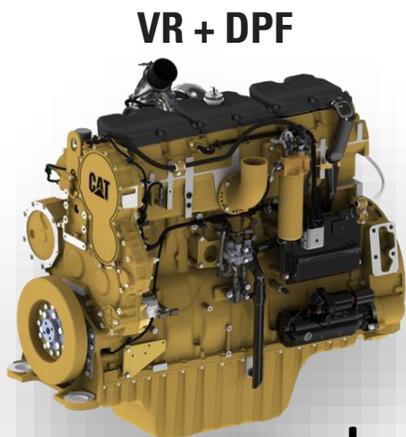
- **3 – 7% Fuel Economy Improvement ***
- **Ventilation Rate Energy Saving**



- **Retrofittable to Existing Fleets ****
- **Fuel Sulfur Level Flexibility**

* Over non-VR engine packages

** Depending on model prefix and serial number



VR + DPF



- **Reduced Certified Ventilation Rate**
- **50%+ Reduction in Diesel Particulate Output**



- **3 – 7% Fuel Economy Improvement ***
- **Energy Savings From Reduced Ventilation**



- **Fuel Sulfur Level 15ppm or Better**
- **ECF-3 (CJ-4) Engine Oil**



- **Retrofittable to Existing Fleets ****

* Over non-VR engine packages

** Depending on model prefix and serial number



DPF

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Key Advantages of the VR Package:

- Significant CANMET Ventilation Rate Reduction
 - Up to 58%+ reduction compared to Tier 3, when used with the Cat DPF
- Significant Diesel Particulate Matter (DPM) Reduction
 - Up to 81%+ reduction compared to Tier 3, when used with the Cat DPF
- Improved fuel economy
 - 3% to 7% reduction compared to today's engines, depending on the model
- Maintained / Improved Machine Performance (increased rimpull)
 - Machine performance will not be impacted and in some cases will be improved
- Fuel quality flexibility – not limited to 15ppm fuel – can use higher sulfur fuels (non DPF only)
- Compatible with Diesel Particulate Filter (DPF) after treatment systems
- Existing Tier 3 engines can be converted to VR engines
- Engine service intervals and component life to overhaul will remain the same

Ease of Maintenance

The VR engine package has little to limited customer impact depending on whether a standard VR engine is used or the addition of a Cat DPF. The Flow Through DPF requires no maintenance or backpressure monitor. The Wall Flow DPF is fully serviceable and offers extended service life with minimal to no impact to maintenance schedules.

VR Engine



1

Fuel (500 ppm sulfur)
Biodiesel up to B20 can also be used

2

Standard ECF-2 (CI-4) Engine Oil

VR Engine + DPF



1

Ultra Low Sulfur Diesel (ULSD)
Fuel (15 ppm sulfur)
Biodiesel up to B20 can also be used

2

API CJ-4 (ECF-3) Low Ash Engine Oil

For more complete information on Cat products, dealer services, and industry solutions, visit us on the web at mining.cat.com and cat.com

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