BELL

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Bell wheeled loading shovel emissions technology

JOHN DEERE

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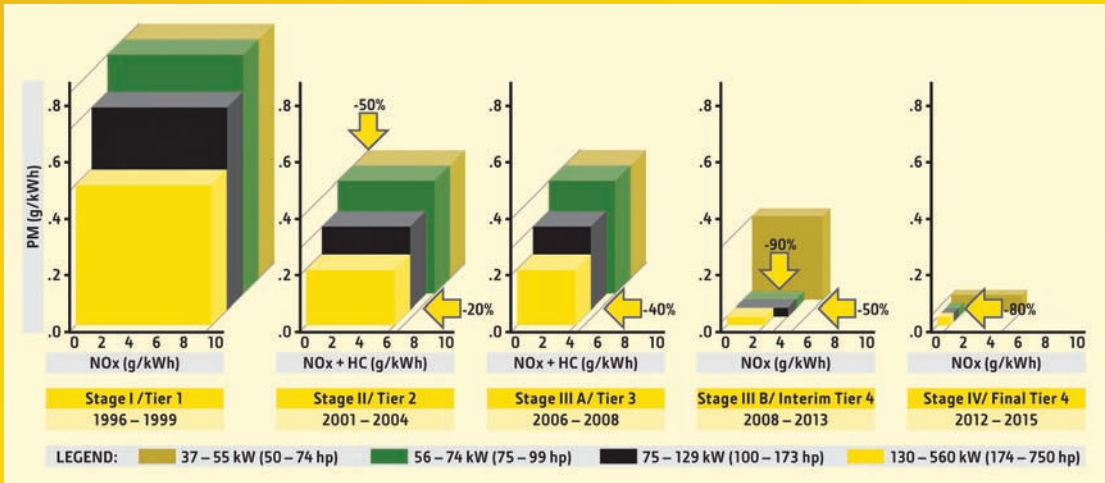
Strong Reliable Machines
Strong Reliable Support

Emissions technology

The biggest emissions reductions yet



NOx – Nitrogen oxides, which react in the atmosphere with hydrocarbons
HC – Hydrocarbons, a by-product of combustion
PM – Particulate matter, a non-gaseous product of combustion

The move to Stage III B/Interim Tier 4 emissions regulations is unquestionably the most significant to date. The regulations call for a 90 percent reduction in particulate matter (PM) along with a 50 percent drop in nitrogen oxides (NOx). Final Stage IV/Tier 4 emissions regulations, which will be fully implemented by 2015, will take PM and NOx emissions to near-zero levels.

EPA and EU off-highway emissions regulations: 37 – 560 kW (50 – 750 hp)

Built on proven PowerTech Plus technology

Bell Equipment, in conjunction with John Deere, has always been ahead of the game when it comes to meeting emissions regulations. Stage III B/Interim Tier 4 is no exception. We pioneered the use of many advanced technologies with our Stage III A/Tier 3 engines and proved their performance in off-highway applications. This gives us a head start for fuel economy as well as delivering higher power curve, more torque rise, and faster throttle response time.

First in the field

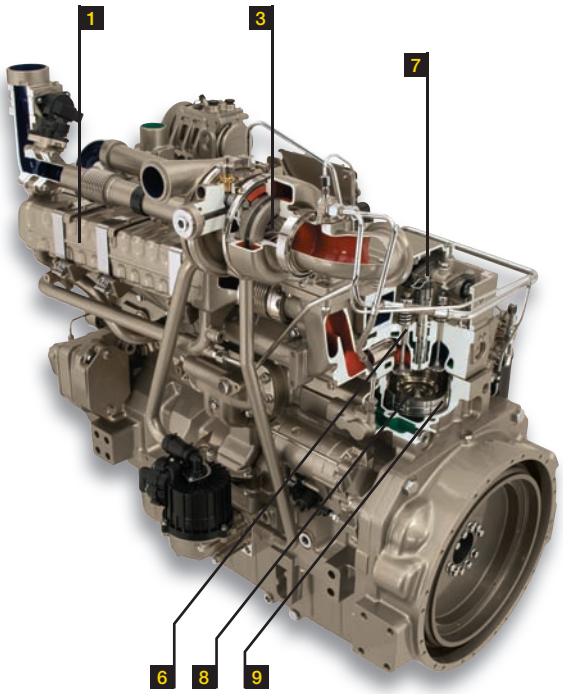
John Deere was the first engine manufacturer to take advantage of cooled exhaust gas recirculation (EGR) and variable geometry turbocharger (VGT) technologies in off-highway applications, introducing them with Stage III A/Tier 3 emissions regulations.

Fuel efficient

Our cooled EGR engines operate efficiently with ultra-low sulfur diesel (ULSD) as well as biodiesel blends, providing optimal performance and fuel-choice flexibility.

Off-highway diesel engines

Many of the engine features proven with our PowerTech Plus engines have been enhanced for Stage III B/Interim Tier 4. We continue to improve performance while meeting more stringent emissions regulations.



1. Increased levels of cooled EGR lower combustion temperature and reduce NOx.
2. Air-to-air aftercooled aspiration lowers in-cylinder temperatures, reduces NOx, and increases power density.
3. VGT varies exhaust pressure based on load and speed to ensure proper EGR flow and provide increased performance.
4. Low-pressure fuel system with auto prime feature eliminates hand priming and hard starting. It provides sensors that detect water in fuel and low fuel pressure.
5. Faster electronic controls are integrated to manage the exhaust filter as well as the fuel system, air-to-fuel ratio, VGT output, and cooled EGR.
6. 4-valve cylinder head increases efficiency, power, and torque.
7. High pressure common rail (4.5L, 6.8L and 9.0L) fuel systems provide increased fuel pressures for more efficient combustion and PM reduction.
8. Steel single-piece low-friction piston with integrated oil cooled gallery improves fuel economy, reduces emissions, and increases durability (9.0L engine).
9. Directed top liner cooling contributes to improved oil control and increased durability (6.8L and 9.0L engines).
10. 500-hour oil change intervals.

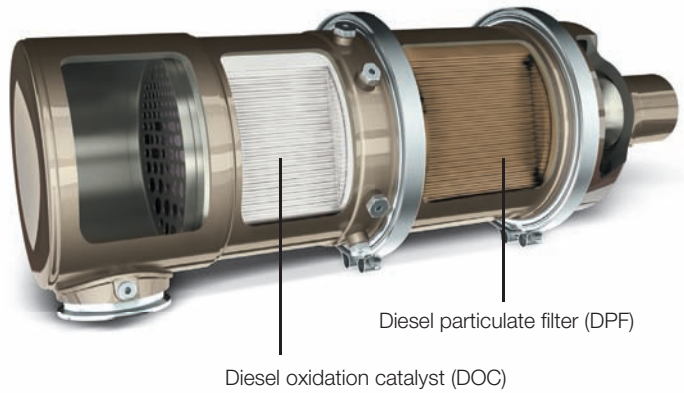
Off-highway diesel engines

Exhaust gas recirculation (EGR)

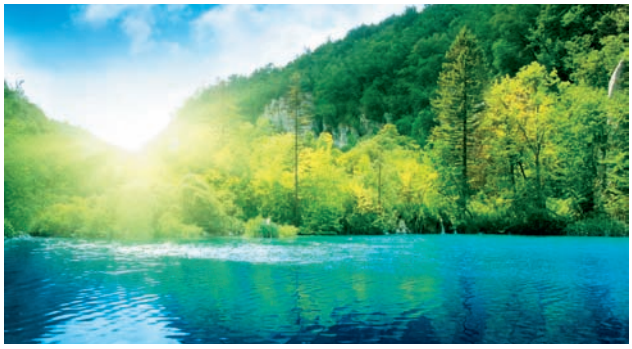
Bell chose cooled EGR with an exhaust filter to meet Stage III B/Interim Tier 4 (IT4) emissions regulations. Cooled EGR doesn't require a second fluid (urea), and it doesn't require you to change how you operate your equipment. There's virtually no difference in performance between our Stage III and Stage III B engines — and that's by design.

Nitrogen Oxide (NOx) reduction through cooled EGR. During certain conditions of engine operation, the EGR valve opens and measured amounts of cooled exhaust gas are routed back into the intake manifold and mixed with the incoming fresh air. Since this process removes oxygen from the air, the exhaust temperatures in the combustion process are lowered and the levels of NOx are reduced.

PowerTech Stage III B/Interim Tier 4 engines utilize a catalysed exhaust filter that contains a diesel oxidation catalyst (DOC) and a diesel particulate filter (DPF). Under normal operating conditions, the DOC reacts with exhaust gases to reduce carbon monoxide, hydrocarbons, and some particulate matter (PM). The downstream DPF forces exhaust gases to flow through porous channel walls, trapping and holding the remaining PM. Trapped particles are eventually oxidised within the DPF through a natural cleaning process called passive regeneration, utilising exhaust heat created under normal operating conditions.



Particulate Matter (PM) reduction through exhaust filters. The diesel particulate filter (DPF) traps and holds particulates in the exhaust stream. During normal operating conditions (temperature, load, and speed) the engine's natural heat breaks down the PM and cleans the exhaust filter.



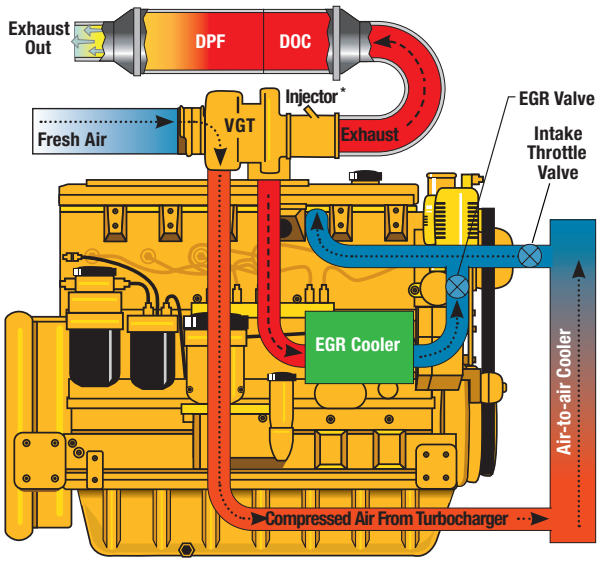
Convenient exhaust filter cleaning

Our exhaust filter is integrated into the engine design to provide a convenient and reliable solution. The engine control unit (ECU) and exhaust temperature management (ETM) system work together to continuously regenerate, or clean, the exhaust filter.

Passive regeneration. John Deere engines and exhaust filter components are designed for uninterrupted operation using passive regeneration, a natural cleaning process. It occurs during normal engine operating conditions, which is the most fuel-efficient way to clean. Passive regeneration does not impact machine operation or require operator involvement.

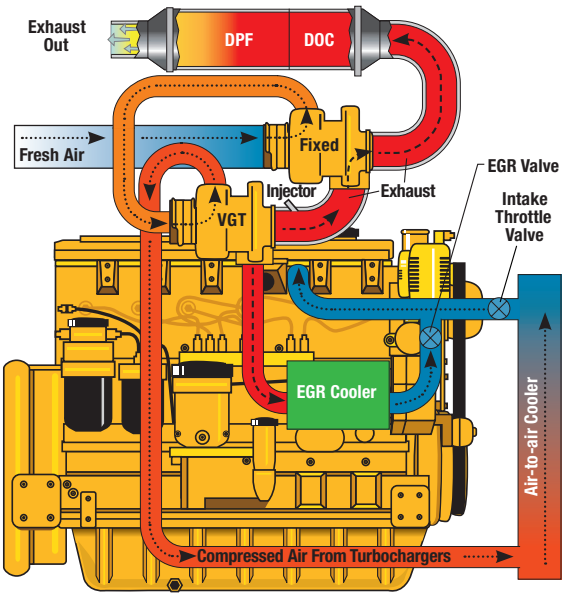
Active regeneration. If passive regeneration cannot be achieved, then PM must be removed using active regeneration, an automatic cleaning process. This requires injecting fuel in the exhaust stream and elevating exhaust temperatures to clean the filter. **Remember, active regeneration cleaning occurs only when passive regeneration is not possible** based on temperature, load, and speed. It serves as a backup system. In most cases, active regeneration does not impact machine operation or require operator involvement.

PowerTech PVX
Stage III B/IT4 technology



PVX L1806, L2106

PowerTech PSX
Stage III B/IT4 technology



PSX L2606

L1806E & L2106E
Variable geometry turbochargers

We know VGT technology. The performance of our PowerTech Plus Stage III A/Tier 3 engines proved it. That's why we decided to continue this technology with our Stage III B/Interim Tier 4 engine lineup.

VGT tailors the amount of recirculated exhaust gas that mixes with the fresh air. Precise electronic controls open or close the variable vanes in the turbocharger depending on engine load and speed. The optimised airflow generates more boost while maximizing low-speed torque, throttle response, peak torque, and fuel economy.

L2606E
Two turbochargers give you more

In series turbocharging, fresh air is drawn into the low-pressure turbocharger (fixed geometry), where air pressure is boosted. This pressurised or boosted air is then drawn into the high-pressure turbocharger (VGT), where air intake pressure is further raised. The high-pressure air is then routed to an air-to-air aftercooler, where the air is cooled and then routed to the engine's intake manifold.

By splitting the compression of the charge air between two turbochargers, both can operate at peak efficiency and at slower rotating speeds. This lowers stress on turbocharger components and improves reliability. Series turbocharging also delivers higher power density, improved low-speed torque, and improved high-altitude operation.

Off-highway diesel engines

Ready for Final Stage IV/Tier 4

John Deere is continuously developing and testing the technologies it will adopt to achieve Final Stage IV/Tier 4 emissions regulations. The purpose of Final Stage IV emissions regulations is to further reduce NOx. For engines 130 kW (174 hp) and greater beginning in January 2014, proven technologies such as cooled EGR and VGT will likely be the foundation for meeting those regulations. However, we are evaluating emerging technologies for their effectiveness and for their ability to provide reliable and durable products in off-highway applications. We'll continue to tailor our Final Stage IV/ Tier 4 engine solutions to fit the variety of off-highway applications and customer requirements.

Stage III B/Interim Tier 4 frequently asked questions

Why use cooled EGR and exhaust filters for Stage III B engines?
Building on John Deere's experience with cooled EGR engines, we consider the combination of an exhaust filter to achieve Stage III B/ Interim Tier 4 emissions levels in our wheeled loaders. Like the cooled EGR system and the VGT, the exhaust filter was specifically designed to meet the demands of off-highway applications. The exhaust filter also has the benefit of replacing the silencer in most applications.

Does cooled EGR add more complexity than other technologies?
While cooled EGR engines require additional sensors and actuators, the control logic is designed into the engine control unit, which allows the complexity to be transparent. Cooled EGR is a proven technology that is used to control NOx emissions by most on-road diesel engine manufacturers, as well as millions of diesel passenger cars.

Does use of cooled EGR decrease power density?
With cooled EGR and the VGT, we have maintained or increased the power density for each engine platform.

What is regeneration?
The exhaust filter is integrated into the engine design to provide a simple and reliable solution for reducing particulate matter (PM). A single engine control unit (ECU) manages both the engine and exhaust filter, via an exhaust temperature management (ETM) system, to regenerate (clean) the exhaust filter when sufficient heat cannot be generated to passively clean the filter.

Passive regeneration – The engines and exhaust filter components are designed for uninterrupted operation using passive regeneration, a natural cleaning process where engine exhaust temperatures are sufficient enough to oxidize the PM trapped in the exhaust filter. The process occurs during normal engine operating conditions, which is the most fuel-efficient way to clean. Passive regeneration does not impact machine operation or require operator involvement.

Active regeneration – If conditions (temperature, speed, and load) for passive regeneration cannot be achieved, then PM must be removed using active regeneration, an automatic cleaning process. For a short duration, this requires injecting a small quantity of fuel in the exhaust stream and elevating exhaust temperatures to clean the filter. Remember, active regeneration cleaning occurs only when passive regeneration is not possible based on temperature, load, and speed.

How do the regeneration process steps work?
Stage III B/Interim Tier 4 PowerTech engines will utilise a catalysed exhaust filter that contains a diesel oxidation catalyst (DOC) and a diesel particulate filter (DPF). Under normal operating conditions, the DOC reacts with exhaust gases to reduce carbon monoxide, hydrocarbons, and some PM. The downstream DPF forces exhaust gases to flow through porous channel walls, trapping and holding the remaining PM. Trapped particles are eventually oxidized within the DPF through a continuous cleaning process called passive regeneration, utilising exhaust heat created under normal operating conditions.

How does ETM work?
If conditions (ambient temperature, speed, and load) for passive regeneration cannot be achieved, ETM is an automated engine operating mode used to increase the DOC inlet temperature to initiate and maintain an active regeneration. To increase the DOC inlet temperature, ETM may reduce the amount of fresh air entering the engine via an intake air throttle valve, include a later post injection (after main injection event), retard engine timing for the main injection event, or vary the VGT vane position and elevate low idle speed. Once the needed DOC inlet temperature is achieved, a small quantity of fuel is injected into the exhaust stream. This process creates the heat needed to oxidize the PM trapped in the DPF when passive conditions cannot be achieved. In addition, ETM provides an additional benefit of a controlled warm-up and cool-down period, increasing the durability of the exhaust filter.

How will John Deere Stage III B/Interim Tier 4 engines stand out from the competition?
John Deere is an innovator in the commercial application of cooled EGR and variable geometry turbocharger (VGT) technologies for off-highway use. Throughout Stage III A/Tier 3, John Deere has gained experience with these technologies over a wide range of applications and has established a proven record of reliability; other engine manufacturers are just now considering adopting these technologies for off-highway applications. John Deere engines have a strong reputation of performance, durability, and reliability, and we are designing our new engines to exceed those expectations. These new engines will also feature more power and increased performance, world-class fuel economy, reduced noise, and low overall operating costs.

Why is Bell choosing EGR for the wheeled loaders?
Bell has researched both of the different technologies, and from a global perspective, believes that cooled EGR with the addition of an exhaust filter is the best approach for meeting Stage III B/Interim Tier 4 emissions regulations in wheeled loaders. Cooled EGR is a simple approach, has a proven track record throughout Tier 3, and is already supported by Bell UK.

Will serviceability and service intervals change with Stage III B/ Interim Tier 4 engines?
Current engine maintenance intervals remain unchanged. The oil change interval will be the same interval offered for Stage III A/Tier 3 engines at 500 hours. One difference will come with the addition of the exhaust filter. While the regulations require an exhaust filter ash service interval of 4,500 hours.

Does a cooled EGR-equipped diesel engine have a higher internal combustion temperature than an SCR-equipped engine?
As its name implies, cooled EGR cools and mixes measured amounts of exhaust gas with incoming fresh air to lower the engine's peak combustion temperature, thereby reducing nitrogen oxide (NOx) emissions to an acceptable level. The exhaust gases are then routed through an exhaust filter, which traps the particulate matter (PM).
In contrast, engines equipped with SCR technology usually operate at higher combustion temperatures in order to reduce particulate matter to acceptable emissions levels. To reduce NOx, a diesel exhaust fluid (AdBlue) is injected into the exhaust stream, which combines with the exhaust gases in the SCR catalyst.
Our cooled EGR engines actually have cooler internal engine combustion temperatures than SCR engines. Cooled EGR engines do place more cooling requirements (higher heat rejection) on the cooling system; however, Bell has adopted new variable speed fan drives and cooling system designs for Stage III B/IT4 that meet cooling needs in the most efficient method possible.
Our approach to Stage III B/IT4 allows for cooler combustion temperatures, and delivers the same or better power and torque performance and improved levels of durability.

What is the difference in total fluid consumption between cooled EGR and SCR engine technologies?
Selective catalytic reduction (SCR)-equipped engines consume less fuel but require the consumption and added cost of sourcing, storing, and handling a second fluid called diesel exhaust fluid (DEF). In most cases, DEF is more expensive than diesel fuel.
Our cooled EGR approach leverages the proven fuel efficiency of our PowerTech Plus engine. By adding a smart exhaust filter, we will not only meet the more stringent Stage III B/Interim Tier 4 emission regulations, but will continue to provide the best total fluid economy in a simple single-fluid approach. We've researched the different technologies, and from a global perspective, believe that cooled EGR is the right choice now.

Acronyms used in this brochure

DEF	Diesel exhaust fluid
DOC	Diesel oxidation catalyst
DPF	Diesel particulate filter
ECU	Engine control unit
EGR	Exhaust gas recirculation
ETM	Exhaust temperature management
IT4	Interim Tier 4
NOx	Nitrogen oxides
NTE	Not to exceed (emsisions regulations)
PM	Particulate matter
ppm	Parts per million
ULSD	Ultra-low sulfur diesel
VGT	Variable geometry turbocharger

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Fast Facts

- **World Class Product, superb pedigree** manufactured in the USA by **John Deere** to Bell's high specification.
- **High specification cab** – ensures operator acceptance
- **Quad cool system** – by far the best cooling system available when working in dusty environments
- **Fully isolated engine bay** – reduces dust build up in the engine
- **Cyclonic engine air pre-cleaner** – designed to give additional protection when working in dusty environments during the drier months
- **Automatic ride control** – activates at speeds above 3.2kph to give boom suspension to smooth out fore / aft machine bounce
- **Quarry health and safety items fitted as standard** – machine is supplied as a complete package, ready for work
- **Ground level daily operator checks and fuel fill point**, located on the same side of the machine – easy checks, no risk from working at height
- **Keyless start** – number coded and Cesar registered for machine security
- **Heavy duty axles with axles coolers as standard** – high capacity axles for the rigors of round the clock working or load & carry applications
- **Steel bodywork panels** – uncommon in the industry today, these resist knocks better than plastic / composite panels and are easily repaired
- **Unique oil immersed park brake** – eliminates risk of fire from build up of grass or straw
- **Full belly guards to front and rear chassis** – protects high value components to ensure durability and reliability
- **Embedded weigh load system** – enables operator to monitor loads
- **Automatic idle speed reduction and engine shut down** – saves fuel in non productive periods
- **100% hydraulically locking front axle differential** – machine achieves high tractive force (pushing power) even when working in slippery conditions
- **Traction control** – allows the operator to match the machine power to the ground conditions for exceptional climbing ability, limits tyre spin to prolong tyre life

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