

TECHNOLOGY

TIER 4 ENGINE TECHNOLOGY OVERVIEW



View
Demonstration



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NEW TECHNOLOGY ENGINES



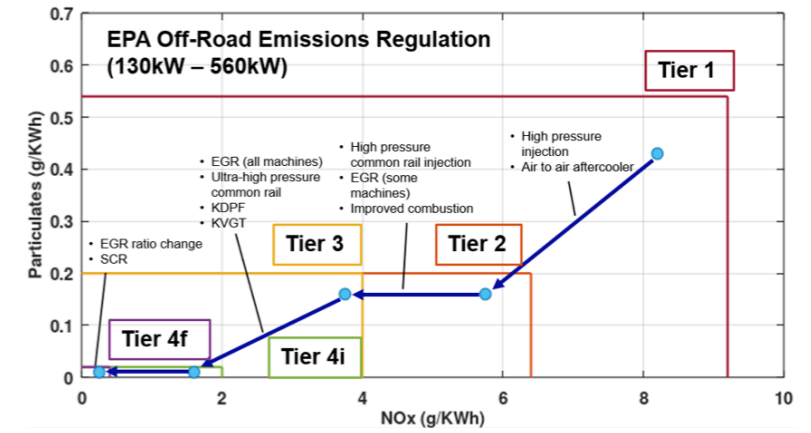
Komatsu's new technology engines include a number of innovations that help achieve the stringent requirements of environmental standards, as well as contributing to lower fuel consumption. They incorporate Komatsu proprietary technologies developed over many years to reduce emissions levels while maintaining the highest levels of reliability, productivity and efficiency.

Komatsu prides itself on creating products that exceed standards on all counts and the new Komatsu Tier 4 machines are no different. They have been engineered to exceed the toughest emissions standards without sacrificing power or fuel efficiency. Tier 4 Interim and Tier 4 Final regulations make up the fourth phase of the USA EPA's emissions regulations for non-road diesel engines, equivalent to EU Stage IV regulations.

The primary regulated diesel engine exhaust pollutants are:

- » Particulate matter (PM)
- » Nitrogen oxides (NOx)
- » Hydrocarbons (HC)
- » Carbon monoxide (CO)

Tier 4 emission standards focus mainly on reducing the amount of PM and NOx from the exhaust, both of which can cause serious health and environmental problems. Using years of engineering experience and innovative technologies, Komatsu's Tier 4 final machines have reduced the amount of PM and NOx by more than 90% compared to Tier 3, resulting in the most environmentally friendly machines while also reducing fuel consumption.



GET TO KNOW YOUR TIER 4 ENGINE



1 Komatsu Closed Crankcase Ventilation (KCCV)

The Komatsu Closed Crankcase Ventilation system takes blow by gases from the crankcase, passes them through a filter to remove any oil mist, and recirculates them into the air intake. Extracted oil can then drain back into the engine oil pan, and any emissions from blow by gases are eliminated.

2 Combustion System Optimisation

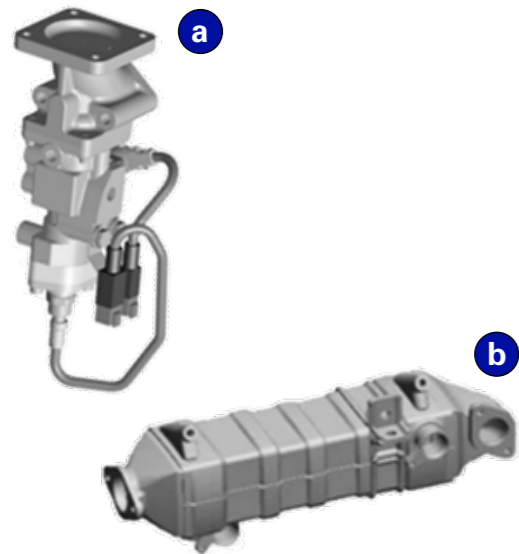
Decades of engineering experience has gone into optimising Komatsu's latest combustion system to improve fuel efficiency while lowering the production of particulate matter. The mixing of fuel and air in the combustion chamber has been enhanced by:

- » Modifying the shape of the combustion chamber after rigorous testing;
- » Increasing the fuel injection pressure with a state-of-the-art high pressure common rail system; and
- » Optimising injection system parameters with Komatsu's advanced fuel injectors.



3 Cutting Edge Engine Control Unit

The brain of the entire engine system is Komatsu's leading engine control unit (ECU) which allows the seamless operation of the Tier 4 machines. The ECU system performs high speed processing of all signals from sensors installed in the vehicles providing total control of equipment in all conditions of use. Engine condition information is displayed via an on-board network to the monitor inside the cab, providing necessary information to the operator. Additionally, managing the information via KOMTRAX provides pre-emptive warning of developing issues allowing maintenance to be planned, reducing down time.



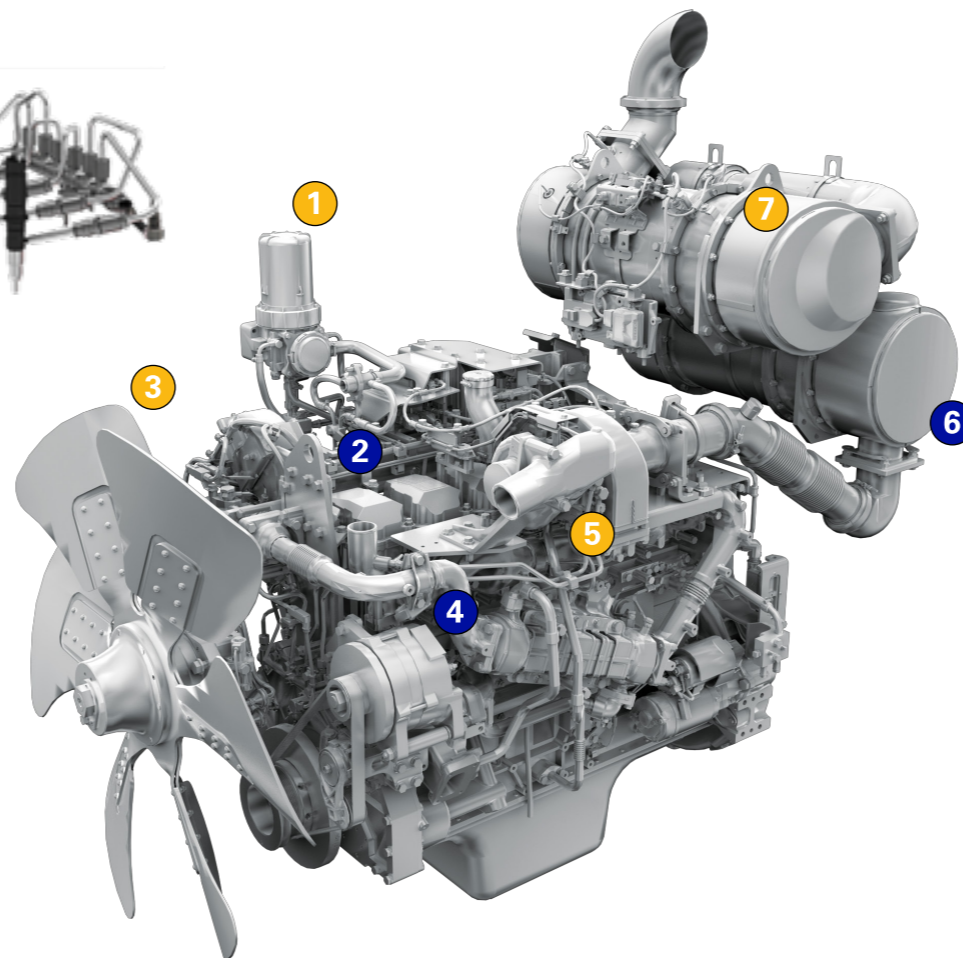
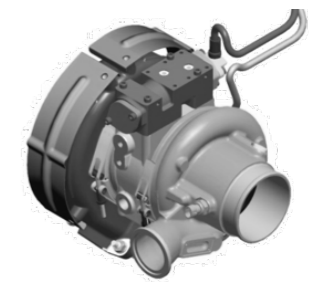
4 Exhaust Gas Recirculation (EGR)

Komatsu uses an Exhaust Gas Recirculation system to reduce the production of NOx during diesel combustion. The EGR takes a portion of the exhaust gas and recirculates it to the air intake where it mixes with fresh air. This results in lower combustion temperatures, leading to reduced NOx production. The EGR system is comprised of two parts the EGR valve and the EGR cooler:

- a) The EGR valve is hydraulically actuated to finely control the amount of exhaust gas that is fed into the air intake.
- b) The EGR cooler is connected to the engine coolant, and cools the recirculated exhaust gases before they are combined with the intake gases.

5 Komatsu Variable Geometry Turbocharger (KVGT)

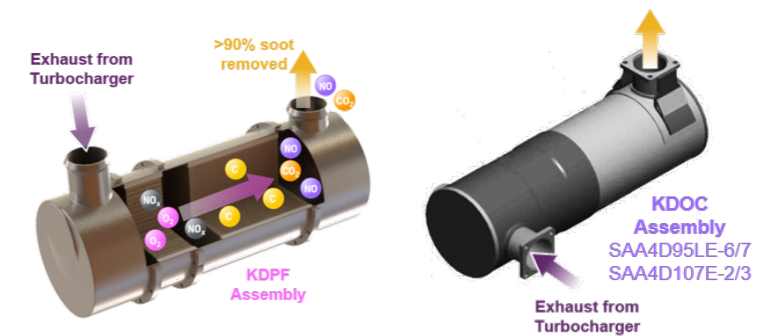
The Komatsu Variable Geometry Turbocharger is able to alter the geometry of its turbine housing to optimise the boost pressure over a wide range of engine speeds. The KVGT achieves this by hydraulically actuating sliding vanes to allow for precise and reliable operation, while having few moving parts makes it very durable and reliable. The ECU is able to control the geometry to ensure these machines have superior throttle response.



6 Komatsu Diesel Particulate Filter (KDPF)

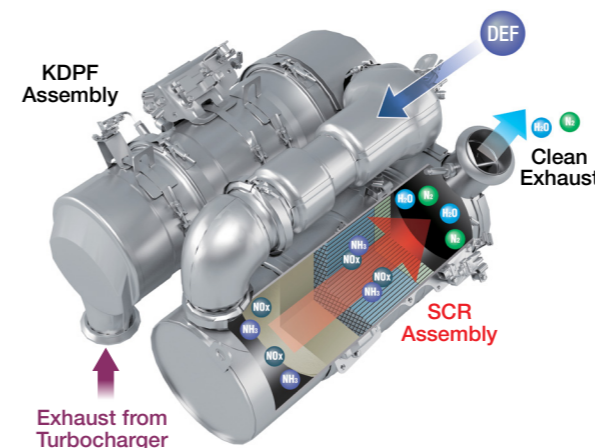
The Komatsu Diesel Particulate Filter is a regenerating filter used to remove PM/soot from the exhaust, and forms part of the exhaust aftertreatment system. The KDPF is comprised of the Komatsu Catalysed Soot Filter (CSF) and the Komatsu Diesel Oxidation Catalyst (KDOC).

- » The CSF is a wall flow filter that allows exhaust gases to flow through while trapping solid soot particles. The exhaust exiting the KDPF has more than 90% of the soot removed.
- » The KDOC and catalysts are used to prolong the life of the soot filter by promoting chemical reactions to clean the filter during machine operation.
- » Soot is oxidised into carbon dioxide gas which can flow freely out of the filter. With sufficient exhaust temperature this happens during normal operation.
- » Komatsu's ECU monitors the state of the KDPF through a range of sensors and will run active regenerations, controlling the temperature of the exhaust to accelerate the oxidation reactions and clean the filter, prolonging KDPF and machine uptime.
- » Some of Komatsu's smaller horsepower engines (SAA4D95LE-6/7 and SAA4D107E-2/3) only require the KDOC in their aftertreatment system to be able to keep the exhaust gases clean and exceed the emissions standards.



7 Selective Catalytic Reduction (SCR)

Tier 4 Final regulations call for further reduction of Nitrogen Oxide (NOx) levels, exceeding that which the EGR can efficiently achieve on its own. Komatsu have added a new component to the exhaust aftertreatment system called Selective Catalytic Reduction which removes the NOx from the exhaust gases before they are released into the atmosphere. This has meant the EGR ratios are decreased allowing for more efficient combustion and greater fuel efficiency, while still surpassing the NOx emissions standards. The SCR system requires a urea solution - AdBlue/DEF - which is injected into the exhaust gas stream. The AdBlue/DEF and catalysts inside the SCR reduce the NOx into water vapor and nitrogen gas. The ECU will control the amount of AdBlue/DEF injected into the gas to ensure all NOx is reduced. Any excess AdBlue/DEF is removed by a final catalyst before the exhaust exits the SCR.



MAINTAINING YOUR KOMATSU MACHINE

REGENERATION CLEANING FUNCTION OF THE AFTERTREATMENT SYSTEM

Here are a couple of tips to help keep your Komatsu Tier 4 engine running smoothly.

Low Ash Oil

Always use the specified Komatsu genuine low ash oil. If any other oil is used, the ash can clog the KDPF quickly and can increase fuel consumption and cause failure in the KDPF.

Ultra-low sulphur diesel (ULSD)

Komatsu Tier 4 vehicles needed to be fuelled with ultra-low sulphur diesel fuels. The sulphur levels have been reduced in common diesel fuels because high sulphur levels inhibit emissions reductions and can damage the aftertreatment components.

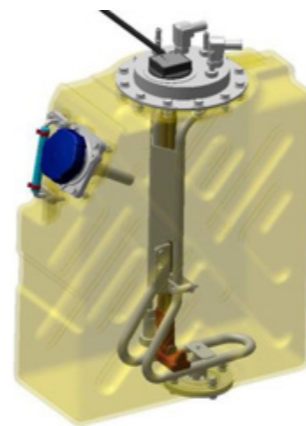
AdBlue/Diesel Exhaust Fluid (DEF)

AdBlue/DEF is a urea solution made up of 32.5% urea and 67.5% deionised water. It is injected into the exhaust stream before the SCR, where the heat in the exhaust decomposes the urea into ammonia. Within the SCR the ammonia reduces the NOx into water vapor and nitrogen gas. The efficiency of the SCR at reducing NOx depends entirely on the concentration of the AdBlue/DEF so it is extremely important that certified AdBlue/DEF is used and stored correctly. Any contamination or inferior products can severely effect the SCR and the machine. Proper AdBlue/DEF is a clear and colourless fluid with a slight ammonia smell. It should NOT be used if it is at all cloudy, has any colour tint, or has a strong ammonia smell.

Komatsu Tier 4 machines have a whole range of sensors to keep track of the AdBlue/DEF and SCR, and will display warnings on the monitor and derate the machine to stop any possible component damage. The machine AdBlue/DEF tank is sized to so that 1 tank of AdBlue/DEF will last approximately 2 tanks of fuel (exact amounts depends on operation). The tank is sealed to protect against contamination and both the tank and hoses are heated to prevent freezing in cold weather operation. To protect against AdBlue/DEF crystallisation in the hoses or injector, the Komatsu ECU will initiate a purge of the hoses after the engine is turned off. This purge will take 6-7 minutes. During this time the machines main power supply is still on and **the battery should NOT be isolated** (see more information in Best Practice).

Following these simple steps will increase your AdBlue/DEF shelf life and keep your machine running smoothly. Make sure your AdBlue/DEF:

- » Conforms to ISO22241 standard;
- » Is stored in a tightly sealed, non-metallic, container;
- » Is kept out of extreme temperatures and sunlight to prevent crystallisation; and
- » Is kept at a reasonable level in the machine tank to ensure there is enough for the aftertreatment system to work.



KOMPLIMENTARY MAINTENANCE

PEACE OF MIND

3 YEARS | 2000 HOURS

Protects the value of your equipment and increase resale value with detailed maintenance records and transferable program benefits.

You can count on Komatsu Complimentary Maintenance to:

- » Lower your cost of ownership
- » Improve equipment uptime and reliability
- » Ensure that proper maintenance is performed by factory certified technicians with OEM parts

Every Komatsu Tier 4 machine comes standard with Komatsu Complimentary Maintenance providing scheduled maintenance for the first 2,000 hours or 3 years, and Complimentary exchange of the following **Komatsu Tier 4** maintenance items:

AdBlue/DEF tank breather

Element replacement at 1,000 hours

AdBlue/DEF and CCV filters

Replacement interval of 2,000 hours

AdBlue/DEF tank flush & KDPF exchange/clean interval

4,500 hours for engines with gross power over 128kW

The process of cleaning the aftertreatment devices by chemically removing PM and other contaminants from the exhaust system.

PASSIVE Regeneration

What the operator sees:

Change on Monitor: NONE
Operator Action Required: NONE
Effect on Operation: NONE
Possible to Disable: NO



What the Machine does:

Reasons for regeneration: Normal soot oxidation
Action of ECU: Normal
What occurs: The exhaust has reached a sufficient temperature (>250°C) that soot is oxidised and exiting the filter faster than it is being produced and trapped.

ACTIVE - Automatic Regeneration

What the operator sees:

Change on Monitor: Regeneration Pilot Lamp
Operator Action Required: NONE
Note: Check for flammable material near the exhaust (dry leaves, paper, etc.)
Effect on Operation: NONE
Possible to Disable: Yes, see below.



What the Machine does:

Reasons for regeneration:

- » Time since last regeneration
- » Soot level between 3-5
- » SCR efficiency less than 70%
- » Low exhaust temperatures

Action of ECU: Will either run the engine at 1000rpm to slowly warm the aftertreatment system or adjust the KVGT and inject fuel into the exhaust stream to raise the exhaust temperature to 500°C.
What occurs: The temperature in the exhaust allows the chemical reactions in the aftertreatment system to happen more efficiently.

Disable Regeneration

What the operator does:

Reasons to DISABLE regeneration:

1. The machine is operating around flammable materials.
2. The machine needs to be shut down at the end of the day.

Steps to DISABLE regeneration:

- » Press the menu button until you enter the KDPF Regeneration screen.
- » Ensure the 1st option - Regeneration Disable - is selected
- » Confirm by pressing F6 or the ✓ button.

Steps to ENABLE regeneration:

- » After engine shutdown, regenerations will default to enabled.
- » OR Select the Cancel of Regeneration Disable option on the KDPF Regeneration screen.

ACTIVE - Manual Stationary Regeneration

What the operator sees:

Change on the Monitor: Soot Accumulation Caution Lamp with additional action level L01 or L03.
Operator Action Required: YES



1. Finish current task, and park the machine in a safe location away from flammable materials.
2. Press the menu button to get to the KDPF Regeneration screen and select Manual Stationary Regeneration.



Effect on Operation: YES, the machine must be parked in the correct idle position and cannot be operated till MSR is complete.
Possible to Disable: YES, see below.

What the Machine does:

Reasons for regeneration:

- » Soot level between 4-7
- » SCR efficiency less than 20%
- » Low exhaust temperatures when machine is NOT in the correct idle position

Action of ECU: Will either run the engine at 1000rpm to slowly warm the aftertreatment system or adjust the KVGT and inject fuel into the exhaust stream to raise the exhaust temperature to 550°C.

What occurs: The temperature in the exhaust allows the chemical reaction in the aftertreatment system to happen more efficiently.

Note: This is a backup function and is required to be performed while the machine is stationary for the protection of the system and personnel.



What the Machine does:

Change on Monitor: Aftertreatment Devices Regeneration Disable Pilot Lamp

Effect on Operation: Regenerations that heat the exhaust to higher than normal temperatures will not be able to run.

After regeneration DISABLE: If the regeneration pilot lamp lights up while regeneration is disabled, **DO NOT WORRY**. A regeneration that keeps the exhaust temperatures at a normal operation level is still able to occur. There will be no effect on machine operation.

After regeneration ENABLE: When regeneration is enabled again the machine may start one immediately, so check your surroundings before enabling.

REASONS FOR REGENERATION

The majority of aftertreatment system regeneration occurs passively, i.e. nothing changes about the machine condition. The oxidation reactions occur under normal operation when the exhaust temperature exceeds 250°C.

Even with passive regeneration the life of the aftertreatment system can be prolonged by occasional periods of increased exhaust temperature to accelerate the oxidation reactions. When the ECU determines that higher exhaust temperatures are needed it will enter the Exhaust Gas Temperature Raise Control Mode. It will adjust the KVGT and inject the optimal amount of fuel into the exhaust gas stream to raise the exhaust to a certain temperature.

Time Since Last Regeneration

Komatsu's Tier 4 machines will actively increase the exhaust temperature if a certain amount of time has passed since the last active regeneration. Depending on the machine type and engine horsepower, the time trigger will be 24, 48 or 96 hours – the most effective time for that system. The ECU will raise the exhaust temperature to 500 °C for approximately 15-30 minutes.



Soot Level

There is a differential pressure sensor across the KDPF filter that gives the ECU information about the PM/soot that is within the filter. This information can be seen from the soot level icon on the KDPF Regeneration screen.

When the soot level is between 3-5 the ECU will run an automatic regeneration to raise the exhaust temperature and accelerate the oxidation of soot that is trapped in the filter. The ECU will raise the exhaust temperature to 500 °C until the soot level decreases.

When the soot level gets between 4-6 the ECU will request a manual stationary regeneration with a L01 action level. The ECU will require the machine to be stationary so that the exhaust temperature can be safely raised to 550 °C accelerating the oxidation reaction even more.

If the soot level reaches level 7 the action level is increased to L03 because the machine needs an immediate manual stationary regeneration to prevent damage to the exhaust and aftertreatment system. The machine will be derated by 25% or more.

Finally, if the soot level reaches 8 the action level changes to L04 and regenerations are too dangerous to occur, the machine will be derated by more than 50% and a Komatsu technician should be contacted.

Low Exhaust Temperatures

Low exhaust temperatures can cause unburnt diesel fuel to remain inside the KDOC/KDPF. This is an undesired state as it inhibits regeneration and can cause uncontrolled temperature increases leading to component damage. Low exhaust temperatures can be due to:

- » Light load operation
- » Long idle times
- » Cold temperatures
- » A combination of above



Komatsu's ECU monitors the exhaust temperatures and if they have been low for too long the temperature needs to be slowly increased to safely remove the unburnt fuel from the KDPF.

With the Machine in the Correct Idle Position: The ECU will automatically run a regeneration to protect the system. The engine speed will be raised to 1000rpm and exhaust fuel disabled until the temperatures inside the KDPF have reached reasonable levels. This regeneration will not disable as the exhaust temperatures do not rise beyond safe levels.

With the Machine NOT in the Correct Idle Position: If the temperatures are low while the machine is NOT in the correct idle position, it is NOT safe to run. This will result in a manual stationary regeneration request with an L01 action level.



If this request is ignored by the operator for 30 minutes, the caution level is changed to L03 and the engine will begin to derate. The regeneration must be run immediately so that the exhaust temperatures can be raised safely.

SCR Efficiency

If SCR sensors measure that the efficiency of the SCR has fallen below 70% then the ECU will request an automatic regeneration. To accelerate the chemical reactions within the SCR the exhaust temperature will be raised to 500 °C for approximately 1 hour. This will also help remove any crystallised AdBlue/DEF that could cause problems in the aftertreatment system.



If the SCR efficiency gets below 20% the ECU will request a L01 manual stationary regeneration. The exhaust temperature will be increased, and AdBlue/DEF injection stopped to get the SCR operation back to normal. If the L01 action level is ignored, the engine will be derated and a Komatsu technician should be contacted.

RUNNING A MANUAL STATIONARY REGENERATION (MSR)

The safety net of your aftertreatment system

A manual stationary regeneration (MSR) is a built-in feature Komatsu Tier 4 machines have to prevent any damage to aftertreatment components. *Excavator monitor shown.

- When the ECU requests a manual stationary regeneration, the following screen will appear. After 30 seconds the L01 action level will disappear.
- Continue working the machine until your work is finished
 - » Move the machine to a safe location away from any hazards or flammable materials
 - » Park the machine in the correct idling position
 - » Press the menu button (a)
- Keep pressing the menu button (b) or use the arrows (c) until the KDPF Regeneration (c) screen, shown below, is displayed.
- Use arrow buttons (d) until the 2nd option – Manual Stationary Regeneration – is highlighted.
- Press the tick (e) to run the Manual Stationary Regeneration.
 - » Now a manual stationary regeneration is running and the machine needs to stay in this position until it has completed.
- Press the arrow (f) to return to the standard screen.

Regeneration Action Levels

Action Level: L01	Action Level: L03	Action Level: L04
Caution Lamp: On	Caution Lamp: On	Caution Lamp: On
Buzzer: Does not sound	Buzzer: Sounds intermittently	Buzzer: Sounds Continuously
<p>Manual Stationary Regeneration Request. When current work is completed, move the machine to a safe place, park it in the correct idle position perform a manual stationary regeneration.</p>	<p>Manual Stationary Regeneration Required. Stop current work, move the machine to a safe place, park it in the correct idle position and perform a manual stationary regeneration.</p>	<p>KDPF system failure – manual stationary regeneration is disabled. Stop the engine IMMEDIATELY. The KDPF system requires inspection and maintenance. Contact your Komatsu distributor for assistance and service.</p>

SEVERITY



BEST PRACTICE FOR YOUR KOMATSU MACHINE

CORRECT IDLE POSITION

Operating a Tracked Machine (Excavator or Bulldozer)

Set the Throttle Dial to MAX: When operating the vehicle. This prevents unnecessary soot accumulation and Manual Stationary Regenerations in the KDPF.

Set the Throttle Dial to MIN: To idle or park the machine.



Idling or Parking a Machine

ALWAYS ENSURE THE MACHINE IS IN THE CORRECT IDLE POSITION WHEN PARKING OR IDLING FOR LONG PERIODS.

The correct idling position is described on the next page and is:

- » The safest position for idling;
- » Helps save fuel; and
- » Allows aftertreatment device regeneration to run when necessary.

Isolating the Battery on a Machine

DO NOT ISOLATE THE BATTERY WHILE THE SYSTEM OPERATING LAMP (AMBER OR GREEN LIGHT) IS ON.



It is recommended that the battery disconnect switch is kept in the ON position unless:

- » The machine needs to be stored for more than a month;
- » Isolation is required for safety;
- » The electrical system needs to be repaired;
- » Electric welding needs to be performed;
- » The battery needs to be handled; or
- » Any fuses need to be replaced, etc.

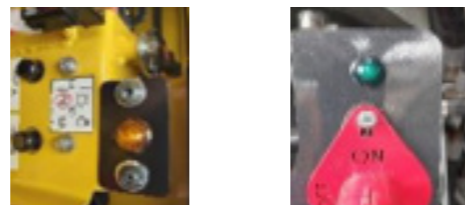
When the engine starting switch is turned to OFF: the engine stops, but the machine's main power supply is not turned off immediately. The ECU is:

- » Memorising the operation status;
- » Terminating the system; and
- » Purging the AdBlue/DEF hoses to ensure the AdBlue/DEF does not crystallise in the hoses and cause blockages while the machine is off.

The System Operating Lamp will only turn off once these processes are completed, and this process will take up to **7 minutes**.

NOTE: on Tier 4 Interim machines the process will take up to **2 minutes** as there is no AdBlue/DEF.

When the System Operating Lamp is OFF: the machine is ready to isolate.

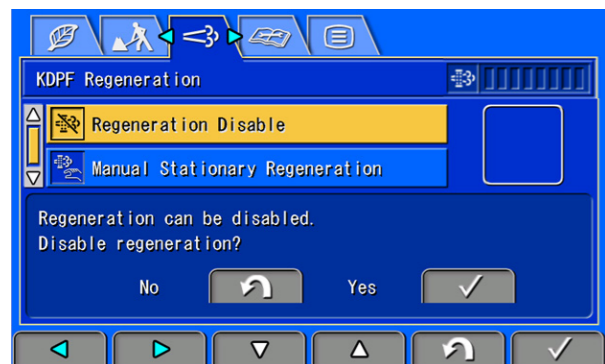


Shutting Off the Engine on a Machine

DO NOT STOP THE ENGINE ABRUPTLY EXCEPT IN THE CASE OF AN EMERGENCY. Doing so can considerably reduce the service lives of the component parts.

To Stop the Engine:

1. Check if an aftertreatment device regeneration is running. If the Regeneration Pilot Lamp can be seen on the monitor, disable the regeneration from the KDPF Regeneration screen.



2. Place the machine in the correct idle position.
3. Run the engine at low idle for approximately 5 minutes to cool down gradually.
4. Turn the starting switch to **OFF** to stop the engine.

Always ensure the machine is in the correct idle position when idling for long periods.

Excavators



- 1 Ensure all work equipment is resting on the **GROUND**.
- 2 Ensure the throttle dial is in the **MIN** position.
- 3 Ensure the safety lock lever is in the **LOCK** position.



Bulldozers



- 1 Ensure all work equipment is resting on the **GROUND**.
- 2 Ensure the throttle dial is in the **MIN** position.
- 3 Ensure the work equipment lock lever is in the **LOCK** position.
- 4 Ensure the travel lock lever is in the **LOCK** position.



Wheel Loaders, Dump Trucks and Motor Graders



- 1 Ensure all work equipment is resting on the **GROUND** / is **LOWERED**.
- 2 Ensure the gear shift is locked in **NEUTRAL**.
- 3 Ensure the park brake is **ON**.
- 4 Ensure the machine is **IDLING** / foot is away from the accelerator.

Note: Depending on the model and operator preference, the forward and reverse shift may be located next to the steering wheel **2a**, next to the work equipment levers **2b**, or on models with joystick steering it will be on the steering lever.





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