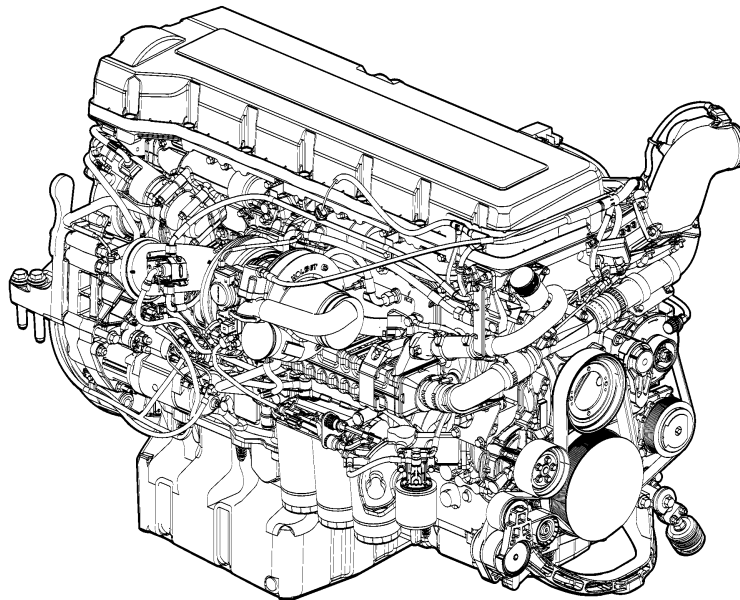


Exhaust After-Treatment System
Design and Function
D16F

Exhaust After-Treatment System



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This information covers design and function of the Exhaust After-Treatment System (EATS) on the Volvo D16F engine.

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Note: Information is subject to change without notice.
Illustrations are used for reference only and may differ slightly from the actual vehicle being serviced. However, key components addressed in this information are represented as accurately as possible.

Design and Function

Exhaust After-Treatment System, (EATS)

The Exhaust After-Treatment System (EATS) consists of many engine and exhaust components and sensors working together to lower emissions to meet the stringent 2007 emission requirements for the heavy truck industry. The following bulletin provides a brief description of each of the main components and how these components

interact with each other to allow the EATS system to lower emissions and provide optimal fuel economy. This bulletin also provides a list of the various modes of operation that the emission system passes through during normal engine operation.

EATS Operational Modes Definitions

Normal Mode

The engine is controlled by its normal calibration. The engine exhaust forms Particulate Matter (PM) or soot, most of which gets trapped in the Diesel Particulate

Filter (DPF). Eventually the soot needs to be removed or oxidized.

In the normal mode no active regeneration is in progress, however passive regeneration may be occurring.

Passive Regeneration

A continuous, slow oxidation (burning) process of soot due to sufficient filter temperature and NO_x/soot ratio. The

engine exhaust supplies the required heat under normal engine operating conditions.

Heat Mode

An engine control mode that allows the exhaust temperature to raise to a minimum temperature required to allow hydrocarbon (aftertreatment fuel) injection (active

regeneration mode). Heat mode is activated when an active regeneration is required.

Active Regeneration Mode

A hydrocarbon (aftertreatment fuel) injector is used to inject fuel into the exhaust flow to raise the DPF filter temperature to a controlled value, currently about 575°C to 625°C (1067°F to 1157°F). The increased temperature is used to allow oxygen oxidation (burning)

of the soot to occur in the DPF. The active regeneration mode is used when the passive regeneration mode is insufficient to allow the filter from reaching certain soot levels.

Service Mode

The service mode is performed by a trained service technician at the service center. The technician determines whether the filter ash accumulation is excessive and if the filter should be removed from the DPF and cleaned externally or exchanged. If the ash accumulation is below the removal level, the service technician could initiate a manual stationary regeneration through the use of the VCADS service tool.



CAUTION

The service technician must ensure that the truck is in a safe and suitable location to withstand the high temperatures that occur during the regeneration process. Equipment damage or personal injury may occur if combustibles are too close to the exhaust pipe or muffler.

System Components

EGR System

The EGR system is designed to recirculate exhaust gases into the combustion chambers to reduce the nitrogen oxide (NO_x) emissions.

The NO_x content increases with higher combustion temperatures. Recirculating cooled exhaust gases reduces the temperature in the combustion chamber and lowers the level of NO_x emissions. To be able to do this, the pressure must be higher in the exhaust side than in the inlet side — this is controlled by the VGT turbo.

On the exhaust manifold an EGR valve (Exhaust Gas Recirculation) is mounted. This valve is managed by the oil pressure and regulates recirculation of exhaust gases.

A portion of the exhaust gas is redirected from the exhaust manifold into the exhaust gas (EGR) cooler, through the Venturi pipe, which measures the gas flow, and into the EGR mixing chamber. There the exhaust gas is mixed with intake air cooled by the charge air cooler before it is led into the intake manifold.

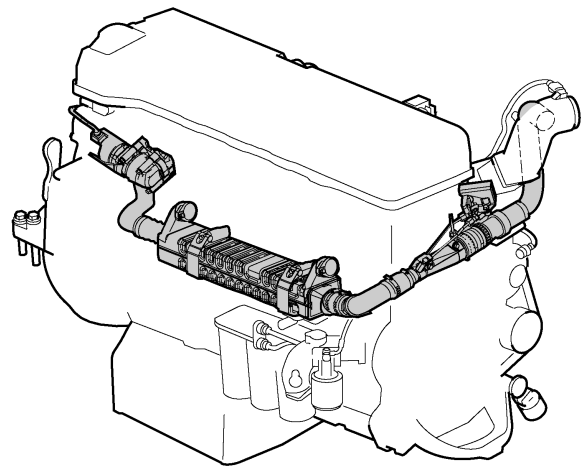
The amount of recirculated exhaust gases is controlled by the engine Electronic Control Unit (ECU) and depends on engine load, coolant temperature and various other factors.

Variable Geometry Turbocharger

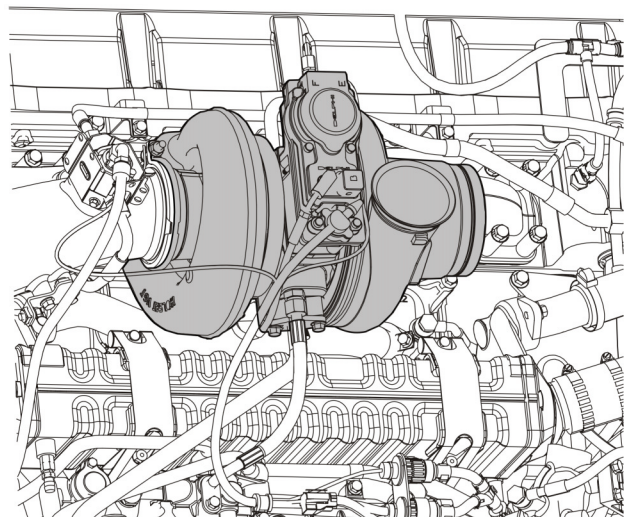
In order to be able to quickly regulate the charge air pressure and drive the EGR, a new type of turbocharger unit with variable geometry has been introduced. This turbocharger contributes to lower emissions, provides optimal fuel consumption and increases power output. The extent of turbocharger function can be varied by the speed of the gases entering into the turbine. This is controlled by an electrically-operated actuator. The turbocharger bearing housing and the actuator are both cooled by engine coolant.

The variable geometry turbocharger (VGT) has a set of vanes and a sliding nozzle ring that maintains sufficient backpressure in the exhaust manifold for proper operation of the EGR system. A certain amount of backpressure is required to push the exhaust gases into the pressurized intake air at the EGR mixer.

Additionally, the sliding nozzle ring of the turbocharger controls exhaust backpressure not only for proper operation of the EGR system, but also for enhanced braking. By fully closing the VG nozzle mechanism, the turbocharger performs as an exhaust brake.



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Particulate Filter

The Diesel Particulate Filter (DPF) with oxidation catalyst and particulate trap greatly reduces the emission of particulate (soot), hydrocarbons (HC) and carbon monoxide (CO).

The use of Ultra Low Sulphur Diesel (ULSD) meeting a limit of 15 parts per million sulphur is required to prevent fouling of the DPF. Additionally, the maximum allowable blending of biodiesel is 5%.

In the DPF system, soot is trapped within a catalyzed ceramic monolith, particulate filter with unique noble metal coating. The particulate filter is regenerated either passively, or actively by the means of a "hydrocarbon injector" that injects a small amount of diesel fuel to reburn the exhaust gases using catalytic reaction. This will reduce the soot quantity and extend the function of the filter.

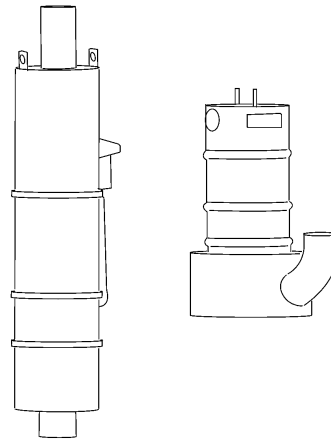
The DPF system has been designed to provide primarily "passive" regeneration in order to increase fuel economy. During passive regeneration, the soot is chemically removed out of the monolith by an ongoing catalytic reaction process that uses no additional fuel.

If the duty cycle is more "stop-and-go", it may be insufficient to remove the soot passively, and "active" regeneration will sometimes occur. In this process, additional diesel fuel is introduced into the exhaust stream at the turbocharger outlet by a "hydrocarbon injector". The fuel travels to the precatlyst, where a chemical reaction occurs which raises temperatures in the monolith to the oxidation level, and the soot is simply consumed. Active regeneration takes about 20-30 minutes and consumes a liter or two of fuel. The driver will have the ability to postpone regeneration until later if one is not desired. To increase the exhaust temperature and to keep it during regeneration, a Discharge Recirculation Valve (DRV) is connected on the compressor side of the turbocharger. It recirculates a portion of warm charge air from the outlet to the inlet of the turbo. The on/off of the DRV is controlled by a solenoid valve.

There are two variants of the muffler with particulate filter: the Compact DPF that is frame mounted behind the right front wheel, and the Vertical DPF that can be mounted behind the cab for certain chassis configurations. The Vertical DPF includes the NO_x sensor, while the Compact DPF has this sensor mounted on a separate pipe.

The particulate filter continuously oxidizes the trapped particles in the filter module. A small amount of the particulate trapped in the filter consists of inorganic material (ash) that cannot be oxidized. If the filter is not serviced, this ash will eventually build up and block the filter, causing exhaust gas back pressure. This leads to increased fuel consumption and can also lead to de-rate and possibly excessive engine wear or damage and can damage the particulate filter itself.

Note: All gaskets must be replaced every time they are loosened.

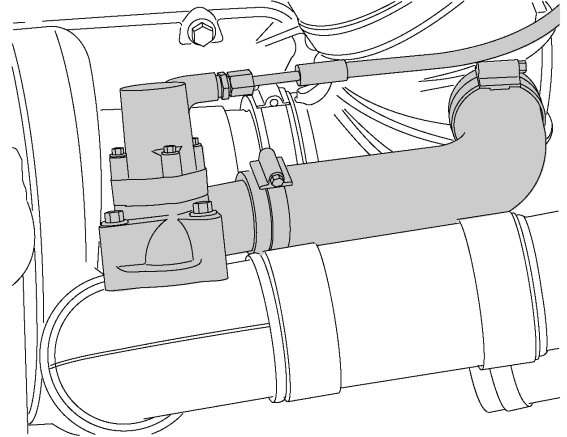


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Discharge Recirculation Valve (DRV)

Under some conditions the exhaust temperature is not hot enough for the Diesel Oxidation Catalyst (DOC) to oxidize, or burn, the hydrocarbons (fuel) that are being injected into the exhaust flow. Typically the condition where more heat is needed is at lower torque levels. Heat mode is automatically activated as necessary during active regenerations.

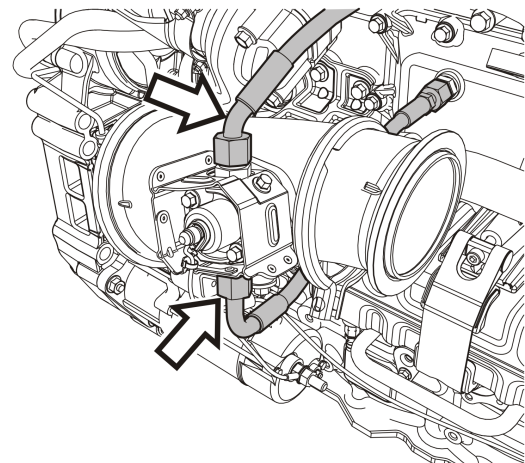
One method of achieving higher exhaust temperatures requires reducing turbocharger effectiveness. This is done by using the Discharge Recirculation Valve (DRV). The DRV allows boosted air to be re-circulated back into the turbocharger compressor inlet. This function is used to help elevate the exhaust temperature and maintain the DOC temperature to a level which supports active regeneration.



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Aftertreatment Fuel Injector (AFI)

The aftertreatment fuel (hydrocarbon) injector is used with the DPF muffler systems to inject diesel fuel into the exhaust stream to increase the exhaust temperature to the extent needed to allow active regeneration. Active regeneration mode is used when the passive regeneration is insufficient to prevent the filter from reaching certain soot levels. Active regeneration can be triggered automatically by the engine ECU or manually by a service technician in a suitable location.

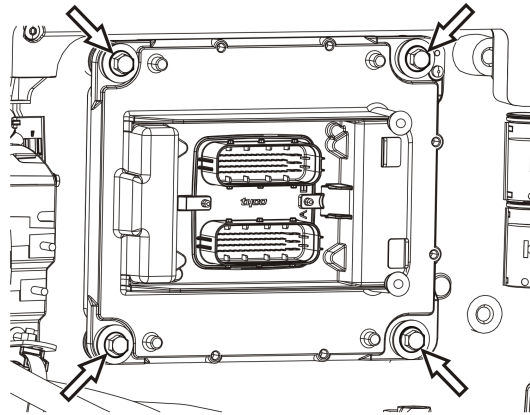


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Electronic Control Unit (ECU)

The engine Electronic Control Unit (ECU) provides total control of the exhaust after-treatment system. The engine ECU monitors lapsed time, distance traveled, fuel consumption and soot accumulation, plus many other sensor signals to determine when conditions are right to trigger a DPF regeneration event.

The engine ECU is also responsible for monitoring all the valves and components that are required to ensure that DPF regeneration is controlled and successful. These would include, but are not limited to control of the DRV, turbocharger actuator and EGR valve position. Control of these and many other components are all important to a successful DPF regeneration.



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Emission Control Sensors

The engine control unit could not provide the total control of the emissions system without the feedback provided by the many sensors throughout the EATS system. These include monitoring of the turbocharger, EGR system, engine coolant, engine position and the DPF muffler. Additionally, many chassis-mounted sensors are required, including the ambient air temperature and turbocharger wheel speed sensor. An example of some of the main engine sensors are listed below. However, sensors will vary dependent upon the DPF system used.

1 Turbocharger

- Turbocharger Wheel Speed Sensor
- VGT Position Sensor
- Boost Pressure Sensor
- Boost Temperature Sensor

2 Engine Position

- Camshaft Speed Sensor
- Crankshaft Speed Sensor

3 Engine Coolant

- Coolant Temperature Sensor

4 Diesel Particulate Filter

- Pre-Oxidation Catalyst Temperature Sensor
- Downstream Oxidation Catalyst Temperature Sensor
- Downstream DPF Temperature Sensor
- Differential Pressure Sensor
- NO_x Sensor
- AFI Pressure Sensor

5 EGR System

- EGR Temperature Sensor
- EGR Flow Sensor (Differential Pressure Sensor)

6 Inlet Air Sensors

- Inlet Air Temperature Sensors
- Inlet Air Humidity Sensors
- Ambient Air Temperature Sensors
- Ambient Air Pressure Sensors