2010 MaxxForce® 11 and MaxxForce® 13 Engine Training Program

Study Guide
TMT-121102

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Introduction

Welcome to 2010 model year MaxxForce® 11 and MaxxForce® 13 Engine Training Program.

Upon completion of this course, you will be able to locate the engine components, trace the flow of engine fluids, and identify the operation of each system.

This course is divided into this introduction and seven engine system modules. To start, let's take a brief look at the engine.

This engine family is available in two variations, the MaxxForce® 11 and MaxxForce® 13. Externally the engines are identical.

For identification purposes, the serial number is stamped on the crankcase and on the emissions label.

"The serial number is stamped on the crankcase and on the emissions label."

The first three digits of the serial number indicate the engine displacement. This will be either 106 for the MaxxForce® 11 engine, or 125 for the MaxxForce® 13.

The front gear train is located behind the front cover. The gear train drives the oil pump, low-mount cooling fan, and the accessory drive assembly.

The fuel filter module and high-pressure fuel pump are located on the left side of the engine. The pump is capable of 31,900 psi, or 2,200 bar of injection pressure.

"These engines are equipped with a single ECM."

These engines are equipped with a single engine control module, or ECM. The ECM has four connectors.

Connectors C1 and C2 are for the chassis inputs. Connector E1 is for the engine mounted sensors and actuators. Connector E2 is for the injectors.

Heavy Duty On-Board Diagnostics, or HD-OBD, requires that all diagnostic trouble codes be recorded with the date, time, and relevant sensor values.

"The SART module provides the time and date for the ECM."

To accomplish this, the new Stand Alone Real Time, or SART module is located remotely. The SART module provides the time and date for the ECM.

The rear gear train is located behind the flywheel housing. The rear gear train drives the camshaft, air compressor and optional PTO.

MaxxForce® 11 and 13 engines feature dual turbochargers, each with a wastegate actuator. Both are controlled by the same wastegate controller.

This concludes the introduction.

NOTES

Mechanical System & Engine Brake

Module 1

Overview

The following components will be discussed in this section: Air compressor, timing sensors, main and rod bearing caps, and the MaxxForce® Engine Brake by Jacobs®.

Air Compressors

"The air compressor is mounted on the left rear of the crankcase."

The air compressor is mounted on the left rear of the crankcase.

There are two kinds of compressors.

One type controls the air pressure using a governor on the air drier, and is available as a single or twin cylinder unit. This places a continuous load on the engine.

The other type uses a clutch on the compressor, and is only available as a twin cylinder.

This type has two lines, one delivers air to the air drier, the other returns pressure to the clutch. When the desired drier pressure is met, the compressor drive is disengaged. This eliminates compressor load on the engine when the air system is at pressure.

Timing Sensors

These engines use two sensors to determine the position and speed of both the crankshaft and camshaft. Both sensors are two-wire magnetic pick-up style sensors.

"The crankshaft position sensor is in the top of the flywheel housing."

The crankshaft position sensor is in the top of the flywheel housing. The camshaft position sensor is located at the rear of the cylinder head.

Main & Rod Bearing Caps

Inside the crankcase, both the connecting rod and main bearing caps feature cracked mating surfaces.

"Care must be taken when handling the connecting rod and cap...."

Care must be taken when handling the connecting rod and cap as well as the main bearing caps to prevent damaging the mating surfaces. Do not drop or rest the bearing caps on the cracked surface.

Always reinstall the main caps in their original positions. The stamped numbers on the main caps are oriented to the left side of the engine.

The connecting rod and cap have laser etched numbers that must be aligned on the same side of the connecting rod assembly.

The connecting rod must be installed in the crankcase so the bolt heads face the right side of the engine.

Engine Brake

The MaxxForce® Engine Brake by Jacobs® requires two brake assemblies, six additional stepped lobes on the camshaft, and six special exhaust valve bridges with actuator pins.

Each assembly controls three cylinders and includes: a solenoid valve, three control valves, three master roller pistons, and three slave pistons.
The brake assemblies use lube oil to operate.

Let's take a look at activation. When the brake solenoid is open, lube oil flows through the control valve to fill the brake assembly passages. The control valve acts as a one-way check valve to trap oil between the master piston and the slave piston.

"The control valve acts as a one-way check valve to trap oil between the master and slave pistons."

Near the bottom of the intake stroke, the first step on the camshaft lobe pushes against the roller. The trapped oil transfers cam movement to the slave pistons. The slave piston pushes on the actuator pin causing the exhaust valve to open. With the valve open, exhaust adds pressure to the cylinder. The valve closes and the energy is absorbed as the piston is driven against the compression stroke.

As the piston nears the top of the compression stroke, the second step of the cam lobe forces the exhaust valve open again. This relieves compression from the cylinder to reduce the downward push on the piston and increase the braking power of the engine.

NOTE

During valve adjustment, each slave piston has an adjusting stud that must be set.

When the operator depresses the throttle, the brake solenoid closes and oil flow to the brake assembly stops. Oil in the brake assembly drains past the brake adjusting screw causing the brake action to end.

This concludes the Mechanical & Engine Brake System.

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Lubrication System

Module 2

Overview

Let's start our discussion of lubrication by identifying the system components. The key parts are: the pickup tube, the oil pump, and the oil filter/cooler module.

The oil pump is located behind the front cover. Pressurized oil from the pump enters the oil filter module on the right side of the engine.

"The oil pump is located behind the front cover."

The module consists of the filter element, the cooler assembly, the pressure and temperature sensors, and the pressure regulator.

Oil passes from the filter element to the cylinder head through an external flange. The oil lubricates the valve train components and gears. Filtered oil also enters the crankcase passages directly from the oil filter module. This oil lubricates internal components and is also directed to the piston cooling jets. The turbochargers are lubricated with filtered oil from an external supply tube. Oil from the turbos then drains back to the crankcase through the low and high-pressure turbocharger oil return pipes.

System Sensors

The engine oil level sensor is located on the lower left side of the crankcase.

The ECM sends a signal to this sensor when the ignition is turned On and the engine is Off. The ECM measures the time it takes for the signal to return back to the ECM. Based on the engine oil level, this signal time will vary. This measurement is used to notify the operator if the engine oil level is low.

Two sensors are mounted on the filter module. The engine oil pressure sensor is located on the module housing, while the temperature sensor is located on the elbow that supplies the cylinder head. The ECM monitors both sensors for engine operation and protection.

Filter Module

The engine uses a cartridge-type oil filter.

"The bypass valve is located in the filter cap."

The bypass valve is located in the filter cap and allows oil to bypass the filter if it is restricted.

The anti-drain back valve is located below the oil filter element. This valve prevents oil from draining from the oil filter when the engine is not running.

The oil cooler and pressure regulator valve are both located between the module and the crankcase. The regulator limits the maximum engine oil pressure. It threads into the filter/cooler housing and is serviceable. The oil cooler is used to limit lube oil temperatures with the use of engine coolant.

"The regulator limits the maximum engine oil pressure."

Component Lubrication

Both the accessory drive housing and the compressor are lubricated through a port in the block. Oil then drains back to the oil pan directly from the opening in the housing.

Pan Heater

As an optional starting aid, an oil heater is installed in the oil pan. This is used to keep the oil warm for improved cold weather start up. The remote-mounted bypass filter receives non-filtered oil from a port on the filter/cooler module. Oil enters this centrifugal filter element and passes through two opposing nozzles. This action causes the element to spin at high speed. The centrifugal forces separate soot and fine contaminants. Filtered oil then returns to the pan through a drain port on the right side of the crankcase.

"An optional oil heater is used to keep the oil warm for improved cold weather start up."

This concludes the Lubrication System.

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Cooling System

Module 3

Overview

Next, Let's cover the features and Let's start our discussion of the cooling system by identifying the main components:

the water pump, distributor housing, crankcase, cylinder head, two-stage EGR cooler, coolant control valve, low temperature radiator, and the thermostats.

The cooling system flow begins with the water pump mounted to the distributor housing. Coolant from the pump flows through the crankcase and the cylinder head independently. Flows from the crankcase and cylinder head join at the outlet elbow and pass through the EGR cooler. Coolant then enters the thermostat housing.

Coolant also flows externally. It is supplied to the air compressor through an external line.

Some coolant from the rear crossover tube also flows through the Aftertreatment Fuel Injector. This reduces the temperature of the injector.

"Some coolant from the rear crossover tube also flows through the Aftertreatment Fuel Injector."

The coolant then flows to the inlet of the road draft tube heater and returns to the inlet of the water pump.

An optional coolant heater is available as a starting aid. The heater is installed in the water pump inlet adapter.

"If service is required, lubricate the connector with petroleum jelly during assembly."

The cooling system uses rubberized pipe connectors at many of the system's connections. If service is required, lubricate the connector with petroleum jelly during assembly.

EGR Cooler and Coolant Control Valve

The EGR cooler is divided into two sections. A cold section at the front and a hot section at the back. Coolant from the crossover tube enters the hot section. This coolant flows through the hot section to a separate passage in the front of the cooler to the return elbow, and then to the thermostat housing.

Cold section coolant comes from the coolant control valve assembly. After passing through the cold section, coolant flows to the low-pressure charge-air-cooler and the EGR valve. The EGR vent at the top of the EGR cooler purges air to the de-aeration tank.

The coolant control valve assembly also controls coolant flow through the engine mounted charge-air-cooler and the Low Temperature Radiator, or LTR.

The valve assembly consists of a flow control valve and a mixing valve. During operation, the flow control valve varies the coolant flow through the two coolers, while the mixing valve controls the amount of coolant that passes through the LTR.

At low coolant temperatures, the mixing valve bypasses the LTR, and sends the coolant directly to the EGR cooler. When engine conditions require, the mixing valve will pass up to 100% of the coolant to the LTR for additional cooling. At the same time, the flow valve regulates the volume of coolant that passes through the coolers. The flow minimum is 20%, with an increase up to 100%, as conditions require.

"At low temperatures, the mixing valve bypasses the LTR and sends the coolant directly to the EGR cooler."

Thermostats & System Sensors

The engine has two thermostats for increased reliability and higher flow capacity.

Both thermostats open at 180° Fahrenheit which is about 83° Celsius.

The Engine Coolant Temperature 1 sensor is located on the coolant crossover tube. This sensor provides the ECM with the coolant temperature before it enters the hot section of the EGR cooler. The Engine Coolant Temperature 2 sensor is located on the cold section of the EGR cooler at the coolant outlet. During operation, the ECM monitors this sensor and commands the flow and mixer valves to meet the requirements of the engine.

Fan Drive

MaxxForce® 11 and 13 engines are available with either a low-mount or high-mount fan drive.

The low-mount drive is gear driven off the front gear train. Engines with a low-mount fan feature an ECM controlled variable speed viscous drive.

The variable speed viscous feature allows the torque load on the gear train to be controlled.

"The high mount fan uses a pneumatic clutch or a two-speed electronic clutch."

The high mount fan is driven by a serpentine belt. The belt is driven off a pulley attached to the front of the vibration damper. This type of fan drive uses a pneumatic clutch or a two-speed electronic clutch.

This concludes the Cooling System.

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Fuel System

Module 4

Overview

2010 MaxxForce® 11 and 13 engines feature high-pressure common rail.

This fuel system uses the following components: a low-pressure pump, a remote-mounted primary filter, an engine mounted filter, a high-pressure pump, a high-pressure rail, high-pressure lines, and injectors with injector quantity correction.

There are three sections of the fuel system: Supply, High-Pressure, and Return.

The low pressure pump draws from the tank through the remote-mounted filter to the strainer/primer pump assembly. Fuel from the pump is delivered to the engine mounted filter module. Filtered fuel is then delivered to the cold start assist solenoid, the aftertreatment metering unit, and the high-pressure pump. The high-pressure pump delivers fuel to the rail through two high-pressure lines. Steel lines from the rail deliver fuel to each injector. Fuel returned from the engine filter module, injectors, and the high-pressure pump merges into one line. The return fuel

"The high pressure pump delivers fuel to the rail through two high-pressure lines."

will either pass through the remote filter assembly, or return directly to the tank.

Primary Fuel Filter and Strainer

"Both modules feature a serviceable 10 micron filter."

There are two types of remotely-mounted primary fuel filter modules. Both types feature a serviceable 10 micron filter, a water-in-fuel sensor, and an optional primer pump.

The first type has return fuel from the engine passing through the module. This helps warm the fuel in cold weather.

The second type does not pass return fuel through the module. In this application, return fuel from the engine flows directly to the fuel tank.

Fuel from the primary filter module flows to the strainer/primer pump located on the engine's filter module.

The 300 micron strainer is serviced by unthreading the clear plastic bowl.

The primer pump is used to prime the system after it's opened or serviced.

Fuel Supply Pump

Fuel from the strainer flows to the low-pressure pump. This pump is mounted on the back of the high–pressure pump.

The pump is internally regulated with an output of approximately 72-130 psi, or 5 to 12 bar.

Fuel from the low-pressure pump flows to the engine mounted filter assembly where it passes through the 3-5 micron filter.

After passing through the filter, fuel flows to the high-pressure pump, the aftertreatment metering unit, and the cold start assist solenoid.

Fuel Supply System Sensor

The fuel supply system has both a water-in-fuel and engine fuel pressure sensor.

The engine fuel pressure sensor is located on the fuel filter module. This measures pressure on the non-filtered side of the supply system.

"The engine fuel pressure sensor is located on the fuel filter module."

The water-in-fuel sensor is located in the remote mounted filter. This sensor monitors the water level in the filter housing. If the water level is high, a light in the instrument panel will illuminate.

⚠ WARNING

To avoid the risk of death or personal injury to yourself or other shop personnel, properly relieve pressure before opening the fuel system for service.

When the engine is off, the fuel pressure in the HP fuel side is still above 14,000 PSI, or 1,000 BAR.

High Pressure Fuel System Pump

The high-pressure pump is driven by the accessory drive housing.

The pump increases the fuel pressure in the common rail to a maximum of 31,900 psi, or 2,200 bar.

The ECM controlled Fuel Pressure Regulator valve is mounted on the rear of the pump and is used to regulate the rail pressure.

An increase in the duty cycle results in a lower pressure, while a lower duty cycle results in a higher pressure.

High Pressure Fuel Lines and Pipes

From the common rail, fuel passes through high-pressure lines to the injector pipes.

The injector pipes deliver fuel through drilled passages in the cylinder head to the injectors.

Both the high-pressure lines and the injector pipes are one-time use only and will not seal if reused.

High Pressure Fuel Rail

The high-pressure fuel rail is mounted to the cylinder head.

The Rail Fuel Pressure sensor is located at the front of the rail.

The 3-wire micro-strain gage sensor monitors the pressure in the rail. The ECM uses this input to help calculate the signals to the Rail Fuel Pressure Regulator.

The Pressure Limiting Valve is located at the rear of the high- pressure rail.

The valve relieves the pressure in the rail if it exceeds 37,000 psi, or 2,600 Bar. When this valve opens, the system pressure drops and maintains about 14,000 psi, or 1,000 bar.

"The Pressure Limiting Valve relieves the pressure in the rail if it exceeds 37,000 psi or 2,600 Bar."

When the valve is open, excess fuel is returned back to the tank.

Fuel Return

During operation, return fuel is collected from several sources.

Unused fuel from the injectors is collected within a passage in the cylinder head. This fuel exits the head and enters a return line.

If the pressure limiting valve opens, the relieved fuel enters a return line.

Fuel used to cool and lubricate the internal parts of the fuel pump enters a return line.

Excess fuel from the cold start assist system is collected at the filter module and enters a return line.

The excess fuel from these components is then returned back to the fuel tank.

Injector Quantity Correction

The 2010 MaxxForce® 11 and 13 engines feature Injector Quantity Correction.

"Quantity Correction enables the ECM to maintain precise control of the injector."

Quantity Correction enables the ECM to maintain precise control of the injector.

This feature requires proper programming of the ECM when replacing one or more injectors.

Technicians will need to enter the serial number and cylinder placement of the new injector using the electronic service tool.

This concludes the Fuel System.

CAUTION

If the injectors are to be reused, they MUST be reinstalled in the same cylinder. These injectors are NOT backward compatible to the 2008-2009 model year engines.

NOTES

Air Management System Module 5

Overview

The air management system can be divided into three subsystems: air induction, exhaust gas recirculation, and crankcase ventilation.

The main components include a dual turbocharger assembly, a low-pressure charge-air-cooler, a high-pressure charge-air-cooler, a two-stage EGR cooler, and a centrifugal crankcase breather.

The system starts with air induction and the air filter element. The low-pressure turbo compresses the filtered air and directs it to the low-pressure charge-air-cooler. The low-pressure charge-air-cooler reduces the air temperature and directs it to the high-pressure turbo. The high-pressure turbo compresses the air and directs it to the high-pressure charge-air-cooler. The cooled air then flows through the throttle valve and into the mixer housing. The mixer housing directs the charge-air into the intake manifold.

"The low-pressure turbo compresses the filtered air and directs it to the low-pressure charge-air-cooler."

On the turbine side, exhaust leaves the manifold and enters the high-pressure turbo. The high-pressure turbo outlet is connected directly to the low-pressure turbo inlet. After passing through the low-pressure turbo, the exhaust enters the turbo downpipe.

Some of the flow that leaves the exhaust manifold is diverted to the EGR system. The diverted exhaust enters the EGR valve. If the valve is open, exhaust passes through the cooler and flows through the crossover tubes to the mixer housing. The mixer blends the cooled exhaust gases with the charge-air.

The centrifugal breather separates oil from the gases which then flow to the road draft tube.

"The ECM monitors eleven air management system sensors."

The ECM monitors eleven air management system sensors. These sensor inputs are used to control the system through the EGR valve, the Intake Throttle Valve, and the Air Management Control Assembly.

Air Induction

These engines use dual turbochargers. Both turbos are mounted on the right side of the engine with the high-pressure turbo located above the low-pressure turbo.

On the charge-air side, the low-pressure turbo draws in air through the filter element. Compressed air flows from the low-pressure turbo, to the low-pressure charge-air-cooler. The cooled air then flows to the high-pressure turbo. The high-pressure turbo compresses the air and forces it through the high-pressure charge-air-cooler, and then to the mixer housing.

Charge Air Coolers

The Low-Pressure Charge-Air-Cooler, or LP-CAC, is an air–to-water inter-cooler.

The LP-CAC is located on the lower right side of crankcase. The cooler reduces the temperature of the air that enters the high-pressure turbo.

The inlet uses an o-ring seal and the outlet uses a rubberized pipe connector. To aid in assembly, lubricate these components with petroleum jelly. Be sure the o-ring is seated properly after installing the cooler.

"Be sure the o-ring is seated properly after installing the cooler."

The High-Pressure Charge-Air-Cooler, or HP-CAC, is an air-to-air cooler. The HP-CAC mounting depends on the application. Charge air from the turbo passes through the cooler transferring excess heat to the ambient air. This cooler reduces the temperature of the air entering the mixer housing.

Boost Control

Each turbo has a wastegate in the turbine housing. A wastegate is used to divert some of the exhaust flow away from the turbine wheel. Both are operated by a separate pneumatic actuator.

If the high-pressure turbo wastegate is closed, all of the exhaust enters the high-pressure turbine. If the wastegate is open, some exhaust bypasses the high-pressure turbine and flows directly to the low-pressure turbine.

"The Air Management Control valve uses regulated air pressure to control the wastegate actuators."

The Air Management Control valve uses regulated air pressure, such as vehicle air, to control the wastegate actuators. The control valve requires a minimum of 90 psi to operate, but the control valve regulates the air pressure for the two wastegate actuators to 25-45 psi.

When the ECM commands the control valve to open a wastegate, the vent port is closed, and air pressure is supplied to the actuator. This action overcomes the internal actuator spring and the wastegate is forced open.

When the ECM commands a wastegate closed, actuator air pressure is vented to the atmosphere and the actuator spring forces the wastegate to close.

Air Induction Sensors

The air induction sub-system uses four types of sensors: flow, temperature, pressure, and humidity.

The Mass Air Flow sensor, often called a MAF sensor, is located in the low-pressure turbo inlet duct. This sensor is used to measure the air flow to calculate the amount of fuel to be injected.

The Charge Air Cooler Outlet Temperature sensor is mounted on the LPCAC air outlet. This sensor is used to measure the charge air temperature before entering the high-pressure turbo.

The Boost Temperature 1 sensor is located on the mixer housing. This sensor is used to measure the air temperature from the HP-CAC.

Two sensors are used to measure the boost pressure. The Boost Pressure 2 sensor is located in the ducting after the LPCAC. The Intake Manifold Pressure sensor is located on the mixer housing after the intake throttle valve.

"Two sensors are used to measure the boost pressure."

The humidity sensor is located on the inlet duct to the low-pressure turbo. This sensor is combined with the Intake Air Temperature sensor and is used to measure the humidity for emissions control.

Exhaust Gas Recirculation

The Exhaust Gas Recirculation, or EGR, system features an intake throttle valve, an EGR cooler, an oxygen sensor, and an electronic EGR valve.

"During engine operation, EGR flow is controlled by the ECM."

During engine operation, EGR flow is controlled by the ECM according to multiple inputs including: engine load, coolant temperature, manifold temperature, boost pressure, and the oxygen level in the exhaust.

When EGR flow is required, the ECM commands the EGR valve open, allowing exhaust gas to flow through the cooler. Cooled exhaust then flows into the mixer housing where it is mixed with intake air. If additional EGR flow is required, the ECM closes the intake throttle valve accordingly.

"An internal sensor monitors the motor's position."

The EGR valve assembly is located at the rear of the EGR cooler. The assembly consists of a motor, two butterfly valves, and a sensor. The ECM controlled motor is used to position the butterfly valves. An internal sensor monitors the motor's position. The valve assembly is coolant cooled to increase the durability of the actuator.

There are three temperature sensors and an oxygen sensor for the EGR system.

First, the EGR Temperature sensor is located on the exhaust outlet of the EGR cooler. Next, the Engine Coolant Temperature 2 sensor is located on the cold section of the EGR cooler. This pair of sensors allows the ECM to monitor the temperature of the exhaust and coolant coming out of the EGR cooler. The third sensor is the Intake Manifold Air Temperature sensor. It is located on the intake manifold and is used to inform the ECM of the EGR temperature in the intake manifold.

The oxygen sensor is the feedback to the ECM for proper positioning of the EGR valve. The sensor is installed in the exhaust pipe before the aftertreatment fuel injector. During initial engine warm-up, the oxygen sensor heater element is activated after the engine coolant reaches 104°Fahrenheit ,or 40°Celsius, and the exhaust gas temperature exceeds 212° Fahrenheit, or 100° Celsius, for more than 30 seconds.

"The oxygen sensor is the fedback to the ECM for proper positioning of the EGR valve."

The EGR system operates when the oxygen sensor is warm enough to become active, at approximately 1,400° Fahrenheit, or 760° Celsius.

Intake Throttle Valve

The intake throttle valve is mounted on the left front of the cylinder head.

The valve consists of a motor, a butterfly valve, and an internal sensor. The ECM controlled motor is used to position the butterfly valve. An internal sensor monitors the motor's position.

This valve is used to restrict intake airflow which then causes additional EGR flow.

Crankcase Breather

The centrifugal breather is mounted within a cavity on the oil cooler.

"Crankcase gases enter the module and pass into the breather."

Crankcase gases enter the module and pass into the breather. An internal element, driven by oil pressure to rotate at high speeds, separates the oil mist from the crankcase gases. Oil drains to the crankcase, and the gases exit the road draft tube.

There are two magnets located in the top of the spinning breather element. A magnetic pickup sensor is used to monitor the speed of the assembly. If the ECM detects a fault with the speed, a DTC will be set.

Coolant flows through a passage at the end of the road draft tube. This heater is used to prevent ice blockage in the opening of the tube.

This concludes the Air Management System.

NOTES

Aftertreatment System Module 6

Overview

The Aftertreatment system has components mounted both on and off the engine. System components on the right side of the engine are: the turbo downpipe with the exhaust back pressure valve, Pre-Diesel Oxidation Catalyst, and the aftertreatment injector. Components on the left side are: the intake throttle valve, ECM, and the fuel metering unit. Other components located remotely are: the diesel-oxidation-catalyst and the diesel particulate filter.

The Aftertreatment system is designed to capture and oxidize soot in the exhaust. During engine operation, exhaust exits the turbo downpipe and flows through the Pre-Diesel Oxidation Catalyst, the Diesel Oxidation Catalyst, then into the Diesel Particulate Filter. The Particulate filter captures the particulate matter or soot in the exhaust. Under certain operating conditions, part of the soot is continuously reduced through a process called passive regeneration. Passive regeneration does not require action from the ECM.

"The Aftertreatment system is designed to capture and oxidize soot in the exhaust."

Under some conditions, soot begins to accumulate in the Diesel Particulate

Filter. When it reaches a certain level, the ECM initiates strategies to oxidize the soot. These include the use of the downstream injector, the intake throttle valve, and the exhaust back-pressure valve. This process is called active regeneration.

"If the soot load reaches a certain level, the engine cannot operate."

If the soot load reaches a certain level, the engine cannot operate under a constant load and stationary regeneration must be used to oxidize the soot.

PDOC, DOC & DPF

Downstream of the injector is the Pre-Diesel Oxidation Catalyst, or PDOC, followed by the Diesel Oxidation Catalyst, or DOC, then the Diesel Particulate Filter, or DPF.

The PDOC and DOC have a series of small passages that pass through the catalyst. As exhaust flows through the passages, any unburned fuel reacts with the catalyst. The reaction generates heat, increasing the temperature of the exhaust.

"The DPF passages are plugged at one end."

The DPF is located in the exhaust system after the diesel oxidation catalyst. The DPF passages are plugged at one end. Half of the passages are plugged at the forward end, the other half are plugged at the back end. This allows the DPF to act as a filter and traps the soot.

All three components are coated with precious metals that react with both the particulate matter, and the unburned fuel in the exhaust. These metals allow the system to oxidize the soot and reduce any other solids to ash for storage in the DPF.

Active & Stationary Strategies

Intake Throttle Valve & Exhaust Back Pressure Valve

Let's take a closer look at the devices and strategies used during active and stationary regeneration.

One strategy used by the ECM during active and stationary regen is activation of the intake throttle valve and the exhaust back-pressure valve. This action will restrict air intake and exhaust flow. The ECM partially closes the throttle valve which results in an increase in exhaust temperature. Under low load conditions, such as idle, the ECM partially closes the back-pressure valve, which helps to increase the exhaust temperature.

"Activation will restrict air intake and exhaust flow."

To position the back-pressure valve, the ECM signals the air management control valve assembly. The control assembly, which is located on the right side of the engine, uses a remote air supply to operate the back-pressure valve's pneumatic cylinder. Air pressure from the control assembly overcomes the return spring in the cylinder to partially close the back-pressure valve. When the control assembly vents the air pressure, the return spring forces the back-pressure valve to the open position.

The ECM monitors the turbine outlet pressure to aid in the positioning of the exhaust back-pressure valve. A sensor is located inside the air management control valve assembly. A tube connects the sensor to the turbine outlet pipe. This sensor is specifically for back-pressure valve operation.

Downstream Injection

"DSI adds fuel to the exhaust stream before the exhaust enters the PDOC and DOC."

A second strategy used by the ECM during active and stationary regen is Down-Stream Injection, or DSI. DSI adds fuel to the exhaust stream before the exhaust enters the PDOC and DOC. The fuel reacts with the catalysts, increasing the exhaust temperature to promote oxidation of the soot.

The components used for downstream injection are: the fuel metering unit, the fuel lines, and the aftertreatment injector. The ECM controls the injection through the metering unit. The metering unit includes a shut off valve, doser valve, and 2 sensors.

To achieve injection, the ECM opens the fuel shutoff valve. At the same time, the module uses a fuel inlet sensor to monitor the pressure and temperature of the fuel entering the metering unit. The ECM signals the doser valve to open, and a specific amount of fuel enters the injector supply line.

"The ECM signals the doser valve to open, and a specific amount of fuel enters the injector supply line."

Fuel pressure in the supply line causes a pintle in the injector to lift, allowing fuel to spray out of the injector nozzle into the exhaust stream.

When the dosing valve closes, pressure in the supply line decreases, and the pintle in the injector closes. The module continuously monitors feedback from the fuel-pressure-2 sensor to verify that dosing is complete.

"When the dosing valve closes, pressure in the supply line decreases."

Fuel Supply Line & Aftertreatment Injector

The fuel supply line routes fuel from the metering unit to the aftertreatment injector. The line is located on the rear of the engine, and has very precise length, inside diameter, and tubing thickness specifications.

The aftertreatment injector is mounted downstream of the exhaust back-pressure valve on the turbo downpipe. A metal gasket and two special, high temperature bolts seal the injector to the turbo downpipe.

Exhaust Sensors

There are four exhaust sensors in the aftertreatment system: one differential pressure sensor and three temperature sensors.

"The DPF Differential Pressure sensor compares the inlet and outlet pressures of the DPF."

The DPF Differential Pressure sensor is located on a bracket mounted to the DPF. This sensor compares the inlet and the outlet pressures of the DPF. When the soot load is high, the passages in the DPF are restricted and the pressure difference is high. This sensor allows the ECM to determine the soot load in the DPF.

The DOC inlet temperature sensor monitors the exhaust before the DOC. This sensor allows the ECM to determine if the exhaust temperature is high enough to perform downstream injection.

The DPF inlet temperature sensor is located after the DOC. The ECM uses this signal to determine if the DOC is functioning effectively. The DPF outlet temperature sensor is located after the

DPF. The DPF outlet temperature, when compared to the DPF inlet temperature, determines if regeneration occurred.

For an active regeneration to be successful, exhaust temperature must be within the range of approximately 950 to 1,100° Fahrenheit, or 500 to 600° Celsius. If the temperature is too great at the DPF outlet, the ECM limits downstream injection.

Stationary, or Parked, Regeneration

When the passive and active regen strategies do not sufficiently reduce the soot in the DPF, stationary regen, is needed. The aftertreatment system notifies the operator that a manually activated stationary regen is required. Refer to the operator's manual for the proper procedure to initiate a stationary regen.

"When the passive and active regen strategies do not sufficiently reduce the soot in the DPF, stationary regen is needed."

During a stationary regen, the ECM controls engine speed, partially closes the intake and exhaust back pressure valve, and injects fuel into the exhaust. With the increased heat, the DPF soot load will be reduced.

This concludes the Aftertreatment System.

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Cold Start Assist System

Module 7

Overview

MaxxForce® 11 and 13 engines feature Cold Start Assist. This system is designed to heat the intake air to aid in cold-start conditions. This is made up of the cold start relay, cold start fuel igniter, and the cold start fuel solenoid.

When the operator turns the ignition-key On, the wait-to-start lamp in the instrument panel illuminates. Based on barometric pressure, coolant, oil, and the ambient air temperature, the ECM determines if the cold start assist is required. If needed, the ECM activates the relay. The relay then powers the Fuel Igniter. Once the Igniter is heated, the wait-to-start lamp begins to flash, telling the operator to crank the engine.

"The ECM determines if the cold start assist is required."

During cranking, the Fuel Solenoid opens and fuel contacts the igniter. Fuel is vaporized by the heat of the igniter and drawn into the cylinders. After the engine starts, the igniter and solenoid will remain powered while the wait-to-start lamp is flashing. When the lamp is no longer illuminated, the relay and solenoid are de-activated.

Relay, Fuel Igniter & Solenoid

"The cold start relay is used by the ECM to power the fuel igniter."

The cold start relay is used by the ECM to power the fuel igniter. The igniter is mounted in the mixer housing and acts as a glow plug and a fuel injector.

The Cold Start Fuel Solenoid mounts to the ECM bracket and controls the fuel flow to the igniter via a signal from the ECM. The fuel supply is regulated by an orifice and a pressure-relief valve located in the engine fuel filter module. This regulated fuel flows through a supply line to the solenoid and on to the igniter. Excess fuel pressure that passes by the relief valve is routed back to the tank through return lines.

This concludes the Cold Start Assist System.

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Conclusion

This concludes the 2010 MaxxForce® 11 and MaxxForce® 13 Engine Training Program.

Thanks for your participation.

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