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CATERPILLAR®

GLOBAL SERVICE LEARNING

TECHNICAL PRESENTATION

C4.2/C6.4 AND C4.4/C6.6 ACERT™ ENGINES WITH COMMON RAIL FUEL SYSTEM

MACHINE APPLICATIONS

Service Training Meeting Guide (STMG)

C4.2/C6.4 AND C4.4/C6.6 ACERT™ ENGINES
WITH COMMON RAIL FUEL SYSTEM
MACHINE APPLICATIONS

AUDIENCE

Level II - Service personnel who understand the principles of machine system operation, diagnostic equipment, and procedures for testing and adjusting.

CONTENT

This presentation provides an introduction and describes the components, systems operation, maintenance, and testing and adjusting procedures for the C4.2/C6.4 and the C4.4/C6.6 ACERT™ engines used in Caterpillar machines. This presentation may also be used for self-paced and for self-directed learning.

OBJECTIVES

After learning the information in this presentation, the technician will be able to:

1. identify the safety and contamination control requirements of the C4.2/C6.4 and the C4.4/C6.6 ACERT™ engines; and
2. identify the common components and explain the operation of the common rail fuel system in the C4.2/C6.4 and the C4.4/C6.6 ACERT™ engines; and
3. troubleshoot problems in the C4.2/C6.4 and the C4.4/C6.6 ACERT™ engines.

REFERENCES

"C4.4/C6.6 Awareness and Service Self Study Course"	SERV7037

PREREQUISITES

"Fundamentals of Electrical Systems Self Study Course"	TEMV3004
"Fundamentals of Engines Self Study Course"	TEMV3001

Estimated Time: 4 Hours
Illustrations: 67
Handouts: 22
Form: SERV1837-01
Date: 6/08

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NOTES

1

INTRODUCTION

This presentation covers the components, systems operation, and testing and adjusting procedures for the C4.2/C6.4 and the C4.4/C6.6 ACERT™ engines.

The C4.2 and C6.4 ACERT™ engines are the same design and the C4.4 and C6.6 ACERT™ engines are the same design. All the engines use a common rail fuel system.

The C4.2 and the C.4.4 ACERT™ engines are inline four cylinder engines with 4.2 and 4.4 liter displacements. The C6.4 and the C.6.6 ACERT™ engines are inline six cylinder engines with 6.4 and 6.6 liter displacements.

The common rail fuel system includes an electronically controlled high pressure fuel injection pump, a fuel manifold, and electronically controlled injectors.

The A4-E2 Engine ECM controls the pump solenoid, which controls the injection pump fuel flow through the high pressure pipes to the injectors. The Engine ECM also controls the ON/OFF fuel injector solenoids.

> ***NOTE:*** *This presentation can be used to supplement machine training and covers the common engine components on the C4.2/C6.4 and C4.4/C6.6 ACERT™ engines. This presentation may not cover all engine components that may be installed on specific machine applications.*

NOTE: *Additional C4.4/C6.6 engine training including disassembly, testing, adjusting, and diagnostics is available by attending the "3000 Series C6.6/C4.4 Engine with ACERT™ Technology" currently offered in Peoria, IL and Malaga, Spain.*

C4.2 / C6.4 and C4.4 / C6.6 ENGINE FEATURES

- High pressure fuel pump
- Electronically controlled injectors
- Four valves per cylinder
- Rigid structure engine block
- Aluminum pistons
- A4-E2 Engine ECM
- Smart wastegate (C4.4 / C6.6 only)
- Common rail fuel system

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Some of the C4.2/C6.4 and C4.4/C6.6 ACERT engine features are:

- The high pressure fuel pump is controlled by the Engine ECM and provides high pressure fuel to the injectors.

- The electronically controlled injectors are controlled by the ECM to inject high pressure fuel into the combustion chamber.

- The cylinder head includes 4 valves per cylinder.

- The engine block includes a scalloped crank case with extra ribbing, which provides a more ridged structure with a lower noise attenuation (sound absorption).

- The aluminum pistons have improved oil control.

- The A4-E2 Engine ECM controls fuel pressure, speed governing, air/fuel ratio, engine start/stop strategy, and provides diagnostics.

- A smart wastegate controls boost pressure throughout the operating range of the engine (C4.4/C6.6 only).

- The common rail fuel system allows tight control of injection events and optimizes engine performance across all load and speed ranges. The common rail system reduces combustion noise, and NOx and PM emissions.

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C4.4/C6.6 ACERT™ Engines

The C4.4/C6.6 ACERT™ engines meet U.S. Environmental Protection Agency (EPA) Tier III Emissions Regulations for the North America market and Stage IIIa European Emissions Regulations.

These ACERT engines are being targeted for machine applications where new or upgraded models will meet the latest emissions regulations. These include small and medium:

- Track-type tractors
- Wheel loaders
- Track loaders
- Underground loaders
- Wheeled excavators
- Paving products
- Motor graders
- Backhoe loaders

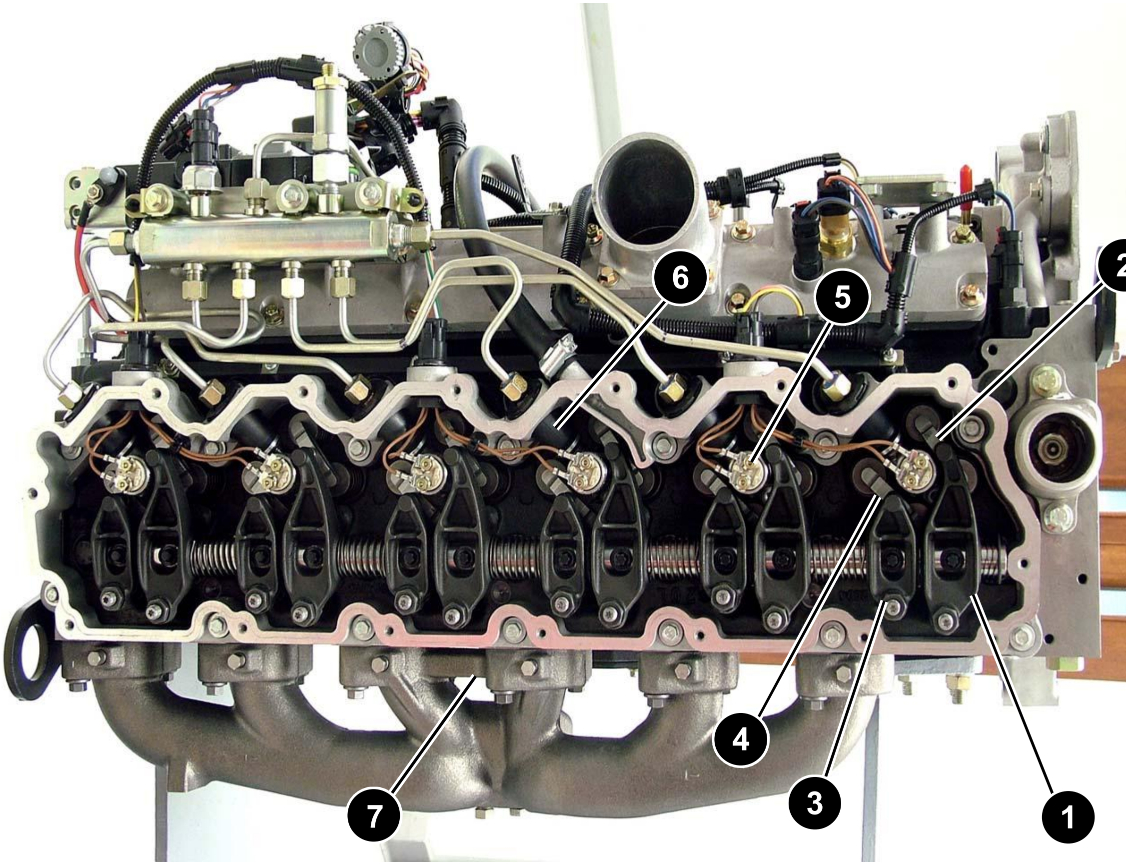
Many of these machines will be common to the rental market.

Basic machine specifications for the C4.4 engine are:

- Configuration: Four cylinders inline, 16-valve crossflow cylinder head
- Fuel System: Direct injection, common rail
- Aspiration: Turbocharged/Turbo-ATAAC
- ECM: A4E2
- Gross power: 62 - 106 bkW (83 - 142 bhp) @ 2200 rpm
- Displacement: 4.4 liter (269 in^3)
- Bore: 105 mm (4.13 in.)
- Stroke: 127 mm (5 in.)
- Compression ratio: 16.2:1

Basic machine specifications for the C6.6 engine are:

- Configuration: Six cylinders inline, 24-valve crossflow cylinder head
- Fuel System: Direct injection, common rail
- Aspiration: Turbo-ATAAC
- ECM: A4E2
- Gross power: 89 - 205 bkW (119 - 275 bhp) @ 1800 - 2500 rpm
- Displacement: 6.6 liter (402.8 in^3)
- Bore: 105 mm (4.13 in.)
- Stroke: 127 mm (5 in.)
- Compression ratio: 16.2:1



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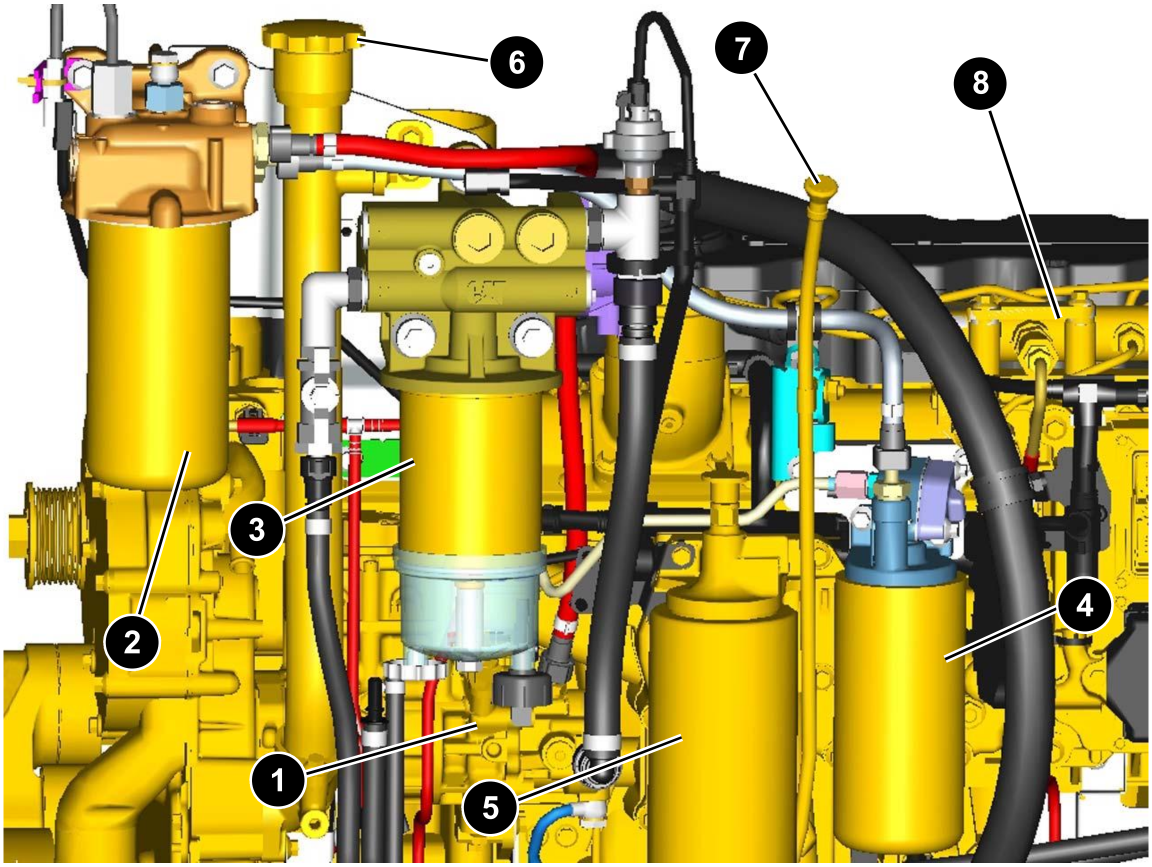
This illustration shows an overhead view of the C6.6 engine cylinder head with the rocker cover removed.

The C4.4 and C6.6 are four valve per cylinder engines with the valves arranged in an intake-exhaust manner from the front of the cylinder head to the rear. Intake valves are actuated by the long rocker arm (1) which presses down the intake valve bridge (2) and unseats the intake valve pair. Short exhaust rocker arms (3) are used to depress the exhaust valve bridge (4) and open the exhaust valves.

The electronic fuel injector (5) is centrally located between the intake and exhaust valve pairs for each cylinder. The Engine ECM will control the duration and timing of the fuel injector in relation to sensor inputs to achieve maximum fuel efficiency emissions compliance.

A large rubber boot (6) seals the opening in the valve cover base where the high pressure fuel injector supply line passes through the base and connects to the fuel injector.

The cylinder head features a "crossflow" design where the intake air enters the left side of the cylinder head and the exhaust gasses exit the right side through the exhaust manifold (7).



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The C4.4 and C6.6 engines are designed with most major service points located on the left side of the engine. This illustration of a C6.6 engine in a D6N Track-type Tractor shows the locations of key engine components:

- Fuel injection pump (1)
- Secondary fuel filter (2)
- Primary fuel filter (3)
- Safeguard (tertiary or third) fuel filter (4)
- Oil filter (5)
- Oil fill cap (6)
- Oil dipstick (7)
- Fuel manifold (8)

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C4.2/C6.4 ACERT™ Engines

The C4.2/C6.4 ACERT™ engines meet U.S. Environmental Protection Agency (EPA) Tier III Emissions Regulations for the North America market and Stage IIIa European Emissions Regulations.

These ACERT engines are being targeted for machine applications where new or upgraded models will meet the latest emissions regulations. These include small and medium excavators.

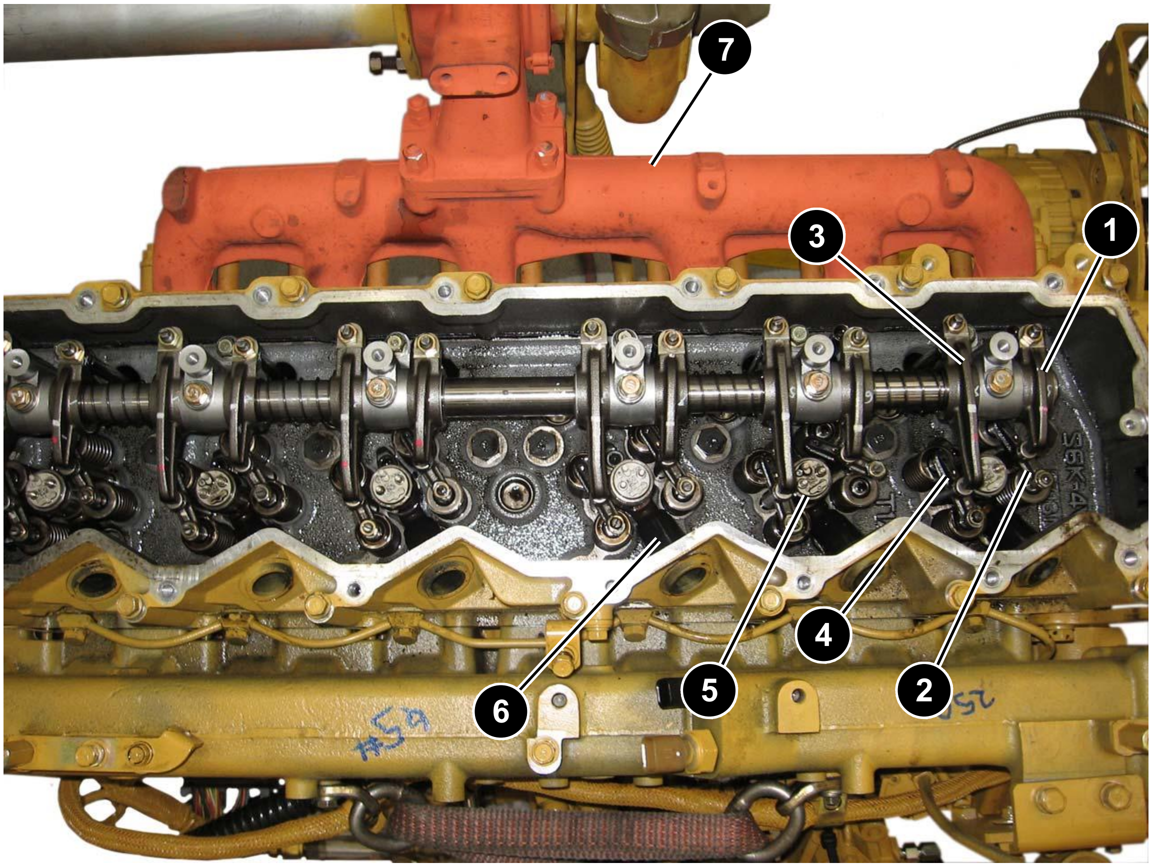
Basic machine specifications for the C4.2 engine are:

- Configuration: Four cylinders inline, 16-valve crossflow cylinder head
- Fuel System: Direct injection, common rail
- Aspiration: Turbo-ATAAC
- ECM: A4E2
- Rated power: 91 - 98 kW (122 - 131 hp) @ 1700 - 2200 rpm
- Displacement: 4.2 liter (256 in^3)
- Bore: 102 mm (4.02 in.)
- Stroke: 130 mm (5.12 in.)
- Compression ratio: 16.5:1

Basic machine specifications for the C6.4 engine are:

- Configuration: Six cylinders inline, 24-valve crossflow cylinder head
- Fuel System: Direct injection, common rail
- Aspiration: Turbo-ATAAC
- ECM: A4E2
- Rated power: 110 - 117 kW (148 - 157 hp) @ 1800 rpm
- Displacement: 6.4 liter (389 in^3)
- Bore: 102 mm (4.02 in.)
- Stroke: 130 mm (5.12 in.)
- Compression ratio: 17.7:1

NOTE: *The C4.2 and C6.4 engines use a 24 Volt system.*



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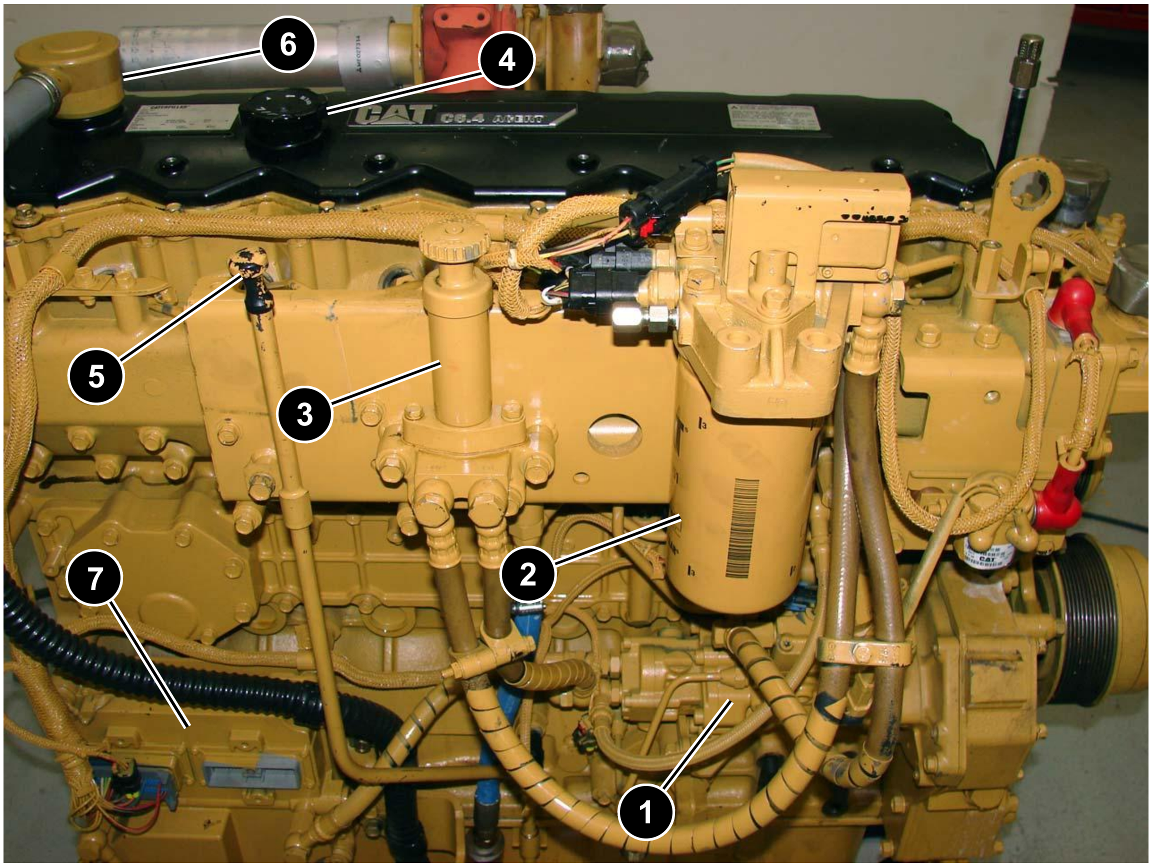
This illustration shows an overhead view of the C6.4 engine cylinder head with the rocker cover removed.

The C4.2 and C6.4 are four valve per cylinder engines with the valves arranged in an exhaust-intake manner from the front of the cylinder head to the rear. Exhaust valves are actuated by the short rocker arm (1) which presses down the exhaust valve bridge (2) and unseats the exhaust valve pair. Long intake rocker arms (3) are used to depress the intake valve bridge (4) and open the intake valves.

The electronic fuel injector (5) is centrally located between the intake and exhaust valve pairs for each cylinder. The Engine ECM will control the duration and timing of the fuel injector in relation to sensor inputs to achieve maximum fuel efficiency emissions compliance.

A large rubber boot (6) seals the opening in the valve cover base where the high pressure fuel injector supply line passes through the base and connects to the fuel injector.

The cylinder head features a "crossflow" design where the intake air enters the right side of the cylinder head and the exhaust gasses exit the left side through the exhaust manifold (7).



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The C4.2 and C6.4 engines are designed with most major service points located on the right side of the engine. This illustration of a C6.4 engine shows the locations of key engine components:

- fuel injection pump (1)
- secondary fuel filter (2)
- fuel priming pump (3)
- oil fill cap (4)
- oil dipstick (5)
- engine breather (6)
- Engine ECM (7): The Engine ECM is not mounted on the C4.2 engine, but is remotely located.

NOTE: *The tertiary (third) filter (not shown) is located to rear of the oil dipstick. The oil filter is located remotely from the engine.*

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MAINTENANCE

Contamination Control

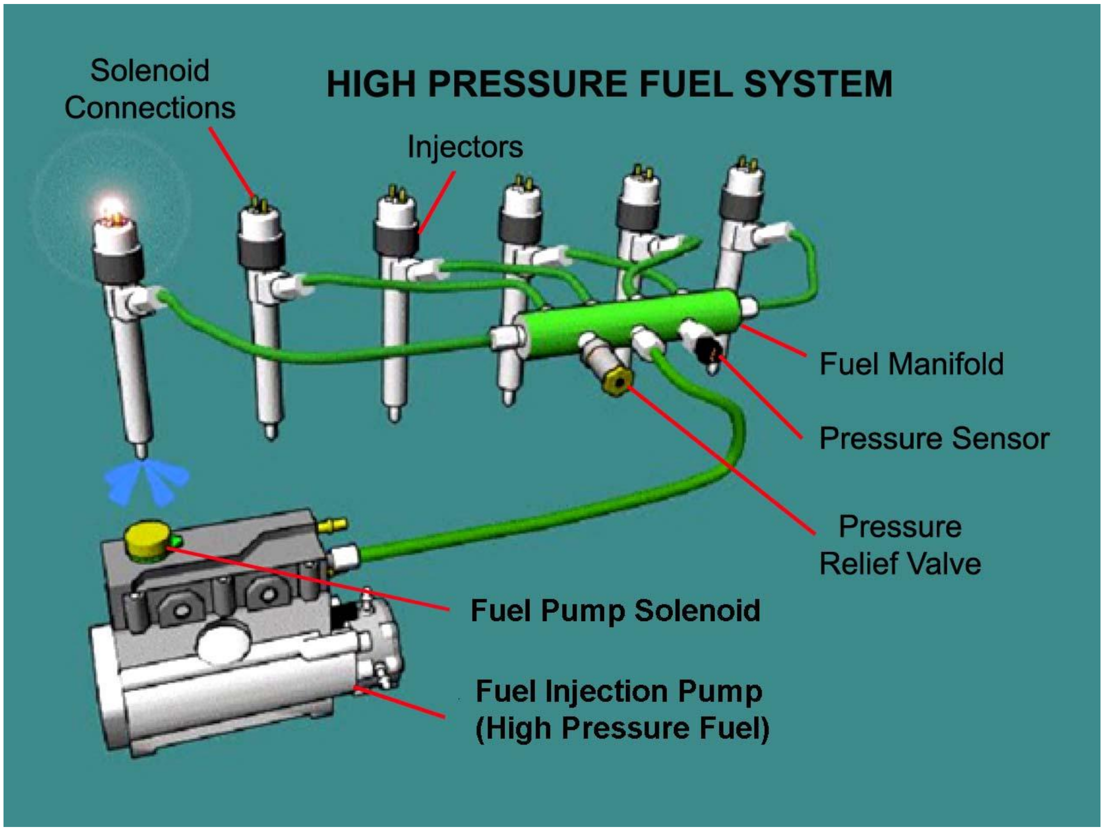
Contamination control is critical with the common rail fuel system. Very high pressures require close tolerances in the fuel injection pump and injectors. It is important that technicians pay close attention to cleanliness and contamination control during even the most routine maintenance.

Contamination can cause injector failure, high leakoff rates, and pump failure. Keep workbenches uncluttered and free of debris. Sweep the floors daily and clean up spills immediately. Avoid performing engine maintenance outdoors, especially in windy or dusty conditions.

Keep components in their original packaging until ready to install and inspect packaging to ensure components are still sealed and free of dirt or damage. During routine filter changes, have the replacement filters ready to install to minimize exposure to contaminants. Do not pre-fill fuel filters. If fuel filters are pre-filled fuel system failure will occur.

High pressure fuel lines are single use items and must be replaced after unseating any bolt. The common rail fittings/ports and the injector fittings/ports must be capped immediately after unseating. Do not remove the caps from new components until just before the fittings are tightened.

Fuel purity is critical to engine performance and fuel system integrity. Only use fuel that has been properly stored or transported in clean containers. Only use good quality fuel that is clean and free of water.



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Safety

Fuel pressures between the injection pump and fuel injectors can reach 160 Mpa (23,200 psi), so specific safety procedures must be carefully followed.

In spite of the high pressure, once the engine has been shut down, fuel rail pressure is reduced to zero within 60 seconds. If a fuel leak is suspected, do not check the fittings or fuel pipes unless the engine is OFF and the pressure has had time to neutralize.

The common rail fuel system is a self-bleeding fuel system that doesn't require air to be purged from the system. Fuel pipes should be left untouched and fittings should remain torqued at the specified settings. Once a fitting has been loosened, the entire fuel pipe must be replaced with a new part to ensure proper seating and safe, leak-free performance.

WARNING

Never loosen or open a high pressure fuel line while cranking or running a Common Rail fuel system engine. Common Rail fuel systems operate at extremely high pressures often in excess of 160 MPa (23,200 PSI). Extreme care should also be taken before disassembly of any high pressure fuel system components after an engine shutdown. Refer to the appropriate service information before performing any service on the high pressure fuel system components.

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General Service Procedures

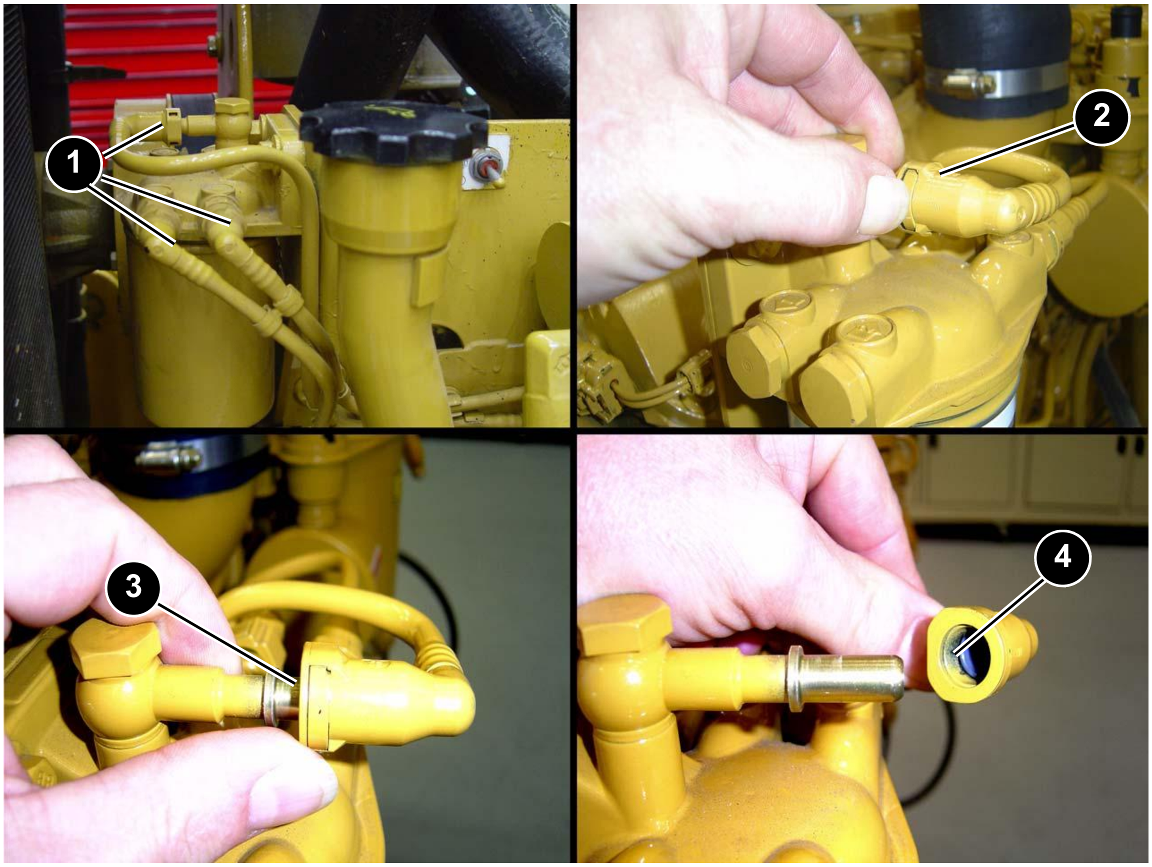
When working on the common rail system, all high pressure pipes are single use. Once pipes are removed, they cannot be reused. New pipes must be handled carefully and not bent in any way. If a sealing cap is not on each end of the pipe when a new pipe is removed from the packaging, it must not be used.

Do not use compressed air or solvent to clean any fuel system components. Do not remove components from the packaging until ready to install.

All fittings must be torqued to the correct specification. If a leak occurs, replace the pipe with new pipe. When installing a new pipe, be sure to leave the caps in place on both ends until the fittings are ready to be tightened.

The rubber boots that seal the valve cover opening are also single use parts.

Any retaining clips that are removed should be replaced with new clips to ensure they fasten properly. During reassembly, be sure the clips are placed in the proper locations to prevent vibration and potential leaks from occurring.



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The C4.4/C6.6 engines use a new "quick-connect" type of fuel fitting (1) on the low pressure side of the system. These fittings can be removed and installed without using any special tools.

To remove the fuel line connector, depress the lock release tab (2) on the fuel line fitting. The release tab is the narrow tab near the open end of the fitting. Light finger pressure is normally all that is required to depress the tab.

With the tab fully depressed, gently push the fitting away from the mating nipple (3). It may be necessary to slightly rotate the fitting while pushing it straight off the nipple to break the seal in the fitting. If the fitting will not slip off the nipple, make sure that the lock tab is fully depressed.

With the fitting removed, the quick connect nipple is now visible in the lower right photo. Also visible in this photo is the o-ring type seal (4) used in the fuel line fitting.

To reinstall the fitting, simply push the fitting straight on to the nipple until an audible "click" is heard. Gently pull on the fitting after reinstalling to make sure that the lock tab is engaged on the nipple.

NOTE: *The new "quick connect" fittings are serviced as a fuel line assembly only. If the fitting or the fuel line become damaged or they start to leak, a new fuel line assembly must be installed.*

ENGINE MAINTENANCE INTERVALS

- Engine Oil S•O•S	250 Hours
- Coolant S•O•S	250 Hours
- Oil and Filter Change	500 Hours
- Air Filter Clean/Replace	500 Hours
- Breather	500 Hours
- Fuel Filters	500 Hours
- Engine Valve Lash	1000 Hours

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Maintenance Intervals

For S•O•S fluid sampling, engine oil analysis should be taken every 250 service hours. Conventional heavy duty coolant/antifreeze that meets Cat EC-1 specs should have Level 1 samples every 250 hours. For extended life coolant (ELC), Level 1 analysis is optional. Level 2 analysis should be performed yearly for all coolant types.

Every 500 hours, the oil and oil filter should be changed. Air filter service differs by air cleaner design. On a dual element air cleaner, the primary element can be cleaned up to six times, but should be replaced at least once a year. Secondary air elements cannot be cleaned and should be replaced after every three cleanings of the primary element. The crankcase breather, along with the primary and secondary fuel filters, should also be replaced every 500 service hours.

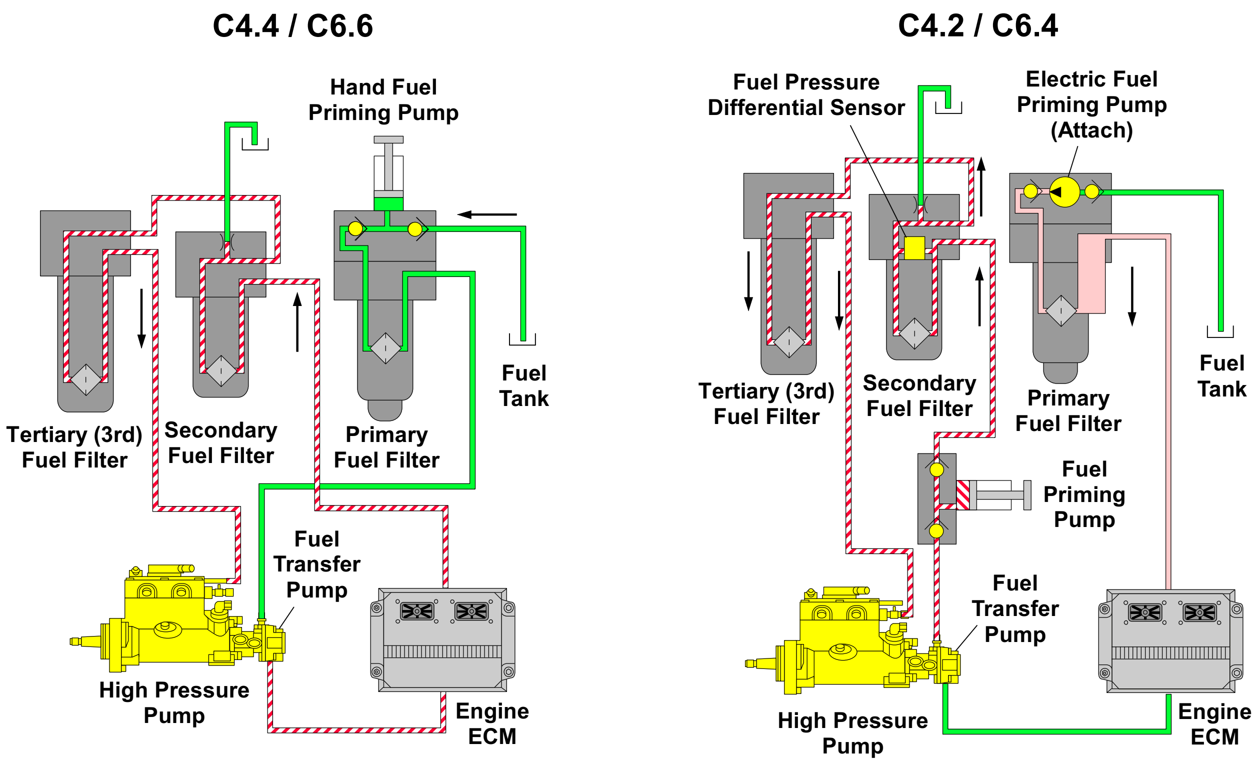
The tertiary (third) fuel filter should be replaced every 2000 service hours.

Engine valve lash should be checked and adjusted after the initial 500 hours, but thereafter every 1000 hours.

Engine load factor, sulfur levels in the fuel, oil quality, and altitude may negatively affect the extended oil change intervals.

> ***NOTE:*** *The maintenance intervals listed are typical maintenance intervals. Refer to the specific machine operation and maintenance manual when performing maintenance on the C4.4, C6.6, C4.2, or C6.4 engine.*

LOW PRESSURE FUEL SYSTEM



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COMMON RAIL FUEL SYSTEM

Low Pressure Fuel Circuit

The common rail fuel system includes a low pressure fuel circuit and a high pressure fuel circuit. This schematic shows the fuel flow through the low pressure fuel circuit.

The low pressure fuel circuit supplies filtered fuel to the fuel injection pump at a constant rate. The low pressure fuel circuit is also utilized to cool the Engine ECM. The low pressure fuel circuit consists of the following major components that are used to deliver low pressure fuel at approximately 296 - 400 kPa (43 - 58 psi) to the fuel injection pump:

- Primary fuel filter (10 or 20 Micron)

- Secondary fuel filter (high efficiency)

- Tertiary (third) fuel filter (high efficiency) (installed on most applications)

- Fuel tank

- Supply lines and return lines deliver the fuel to the different components.

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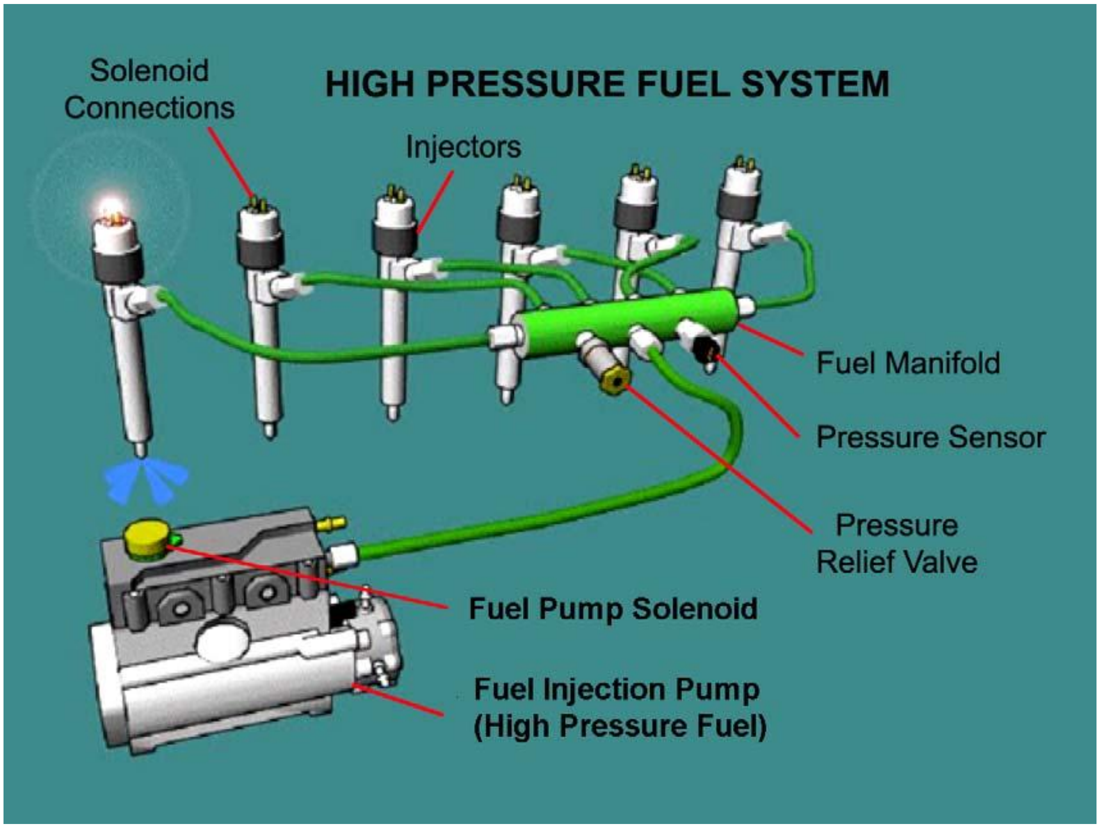
- Fuel transfer pump pulls fuel from the tank and supplies the fuel to the fuel injection pump. The transfer pump includes two orifices that control the pressure in the low pressure fuel circuit.

- Fuel priming pump (electric or manual) is used to evacuate the air from the fuel system. As the air is removed the system fills with fuel.

In the C4.4/C6.6 engines, the fuel transfer pump pulls fuel from the tank through the priming pump and primary fuel filter and sends the fuel through the Engine ECM, the secondary and tertiary (third) filter to the high pressure fuel injection pump.

In the C4.2/C6.4 engines, the fuel transfer pump pulls fuel from the tank through the primary fuel filter and the Engine ECM and sends the fuel to the priming pump. From the priming pump fuel flows through the secondary and tertiary (third) filter to the high pressure fuel injection pump.

NOTE: *The Engine ECM in the C4.2 engine is not cooled by the fuel. In some applications for the C6.6, C4.4, and the C6.4 the Engine ECM may not be cooled by fuel.*



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High Pressure Fuel Circuit

The high pressure fuel circuit supplies high pressure fuel from the fuel injection pump through the fuel manifold to the fuel injectors. The fuel injection pump supplies fuel at a pressure up to 160 MPa (23,200 psi) to the fuel injectors on the C4.4/C6.6 engines and up to 130 MPa (18,855 psi) to the fuel injectors on the C4.2/C6.4 engines. A solenoid mounted on the high pressure fuel injection pump controls the pump output pressure by allowing some of the high pressure fuel to return to the tank. A small amount of fuel is allowed to flow from each fuel injector back to the fuel transfer pump to help cool the fuel injectors.

NOTE: Normal fuel rail pressure for the C4.2/C6.4 engine is approximately 75-110 MPa (10,900-16,000 psi).

High pressure fuel from the high pressure pump enters the common rail manifold at the inlet fitting. The common rail manifold distributes the high pressure fuel evenly to the four or six "internally hardened" steel fuel injector supply pipes. The steel fuel pipes pass through the valve cover base and connect to individual fuel injectors.

The injectors inject the fuel into the combustion chamber based on an ON/OFF signal from the Engine ECM.

Due to the unique "internally hardened" manufacturing process of the fuel injector supply pipes, the fuel pipes must be replaced whenever they have been "cracked" or disconnected.

> ***NOTE:*** *Cracking or removing the fuel pipes can disturb the internal hardening of the high pressure fuel pipes and the pipe seal performance, which can cause the pipes to fail. Failure of a high pressure fuel pipe can result in a machine fire, personal injury or death. Order new genuine Caterpillar replacement fuel pipes whenever a fuel injector supply or high pressure pump output fuel pipe is removed.*

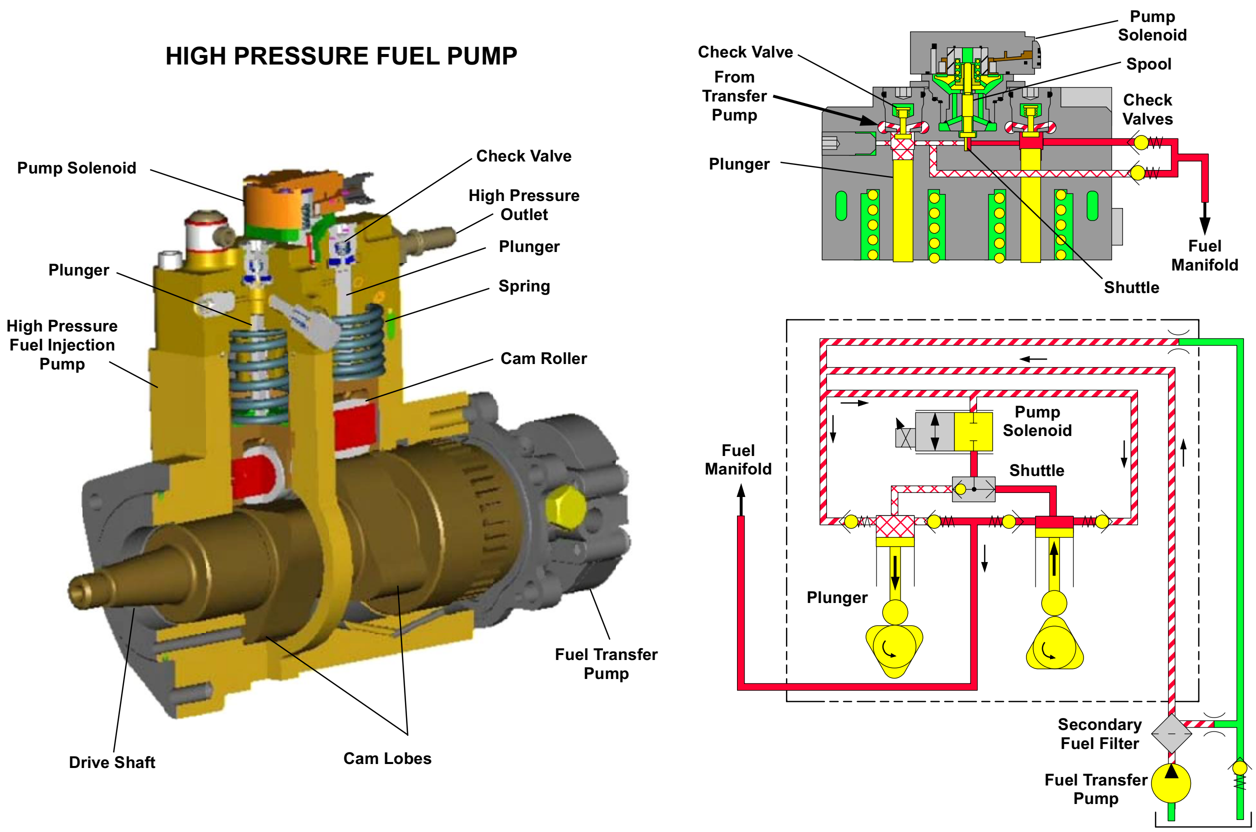
A fuel rail pressure sensor is used to monitor the pressure of the common rail high pressure fuel system. The Engine ECM will monitor the signal from the fuel rail pressure sensor and maintain optimum fuel system pressure for any given load or temperature condition.

If the fuel rail pressure sensor detects a rail pressure above 160 MPa (23,200 psi) a diagnostic code will be set and the Engine ECM will default to "Limp Home Mode." "Limp Home Mode" limits the engine to a maximum of 1300 rpm and will also limit turbocharger boost pressure and injector timing. The high fuel pressure diagnostic code must be cleared using Cat ET before the Engine ECM will return the engine to normal power. Stopping and restarting the engine by cycling the key start switch will not reset a "Limp Home" condition. The status of the fuel rail pressure sensor may be monitored using Cat ET.

> ***NOTE:*** *On the C4.2 and C6.4 engines if the rail pressure is 6000 kPa (870 psi) different from the target pressure, a 100% derate will occur. There is no "Limp Home Mode" on the C4.2 and C6.4 engines.*

A fuel pressure relief valve is used to protect the high pressure fuel system from fuel pressure spikes. The fuel pressure relief valve open at a constant pressure of 160 MPa (23,200 psi) and withstand a pressure spike of up to 190 Mpa (27,560 psi). Fuel that passes the fuel pressure relief valve is returned to the fuel tank. If the fuel pressure relief valve has opened, the engine will derate and a diagnostic code will result. The cause of the high pressure must be corrected. Cat ET and a factory password must be used to clear the diagnostic code and restore the engine to normal power levels.

A fuel line is connected from the fuel transfer pump to the rear of the cylinder head to keep a constant pressure between the fuel transfer pump and the injectors. Only injector leak off pressure higher than that generated by the transfer pump will return to the tank.



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The fuel injection pump combines the transfer pump (1) and high pressure fuel injection pump (2) in one unit.

The injection pump includes two pump plungers (3) and two cam journals (4). On the four cylinder engines injection pump each cam journal includes two cam lobes, which causes each pump plunger to stroke two times for each revolution of the pump. On the six cylinder engines injection pump (shown in this illustration) each cam journal includes three cam lobes, which causes each pump plunger to stroke three times for each revolution of the pump.

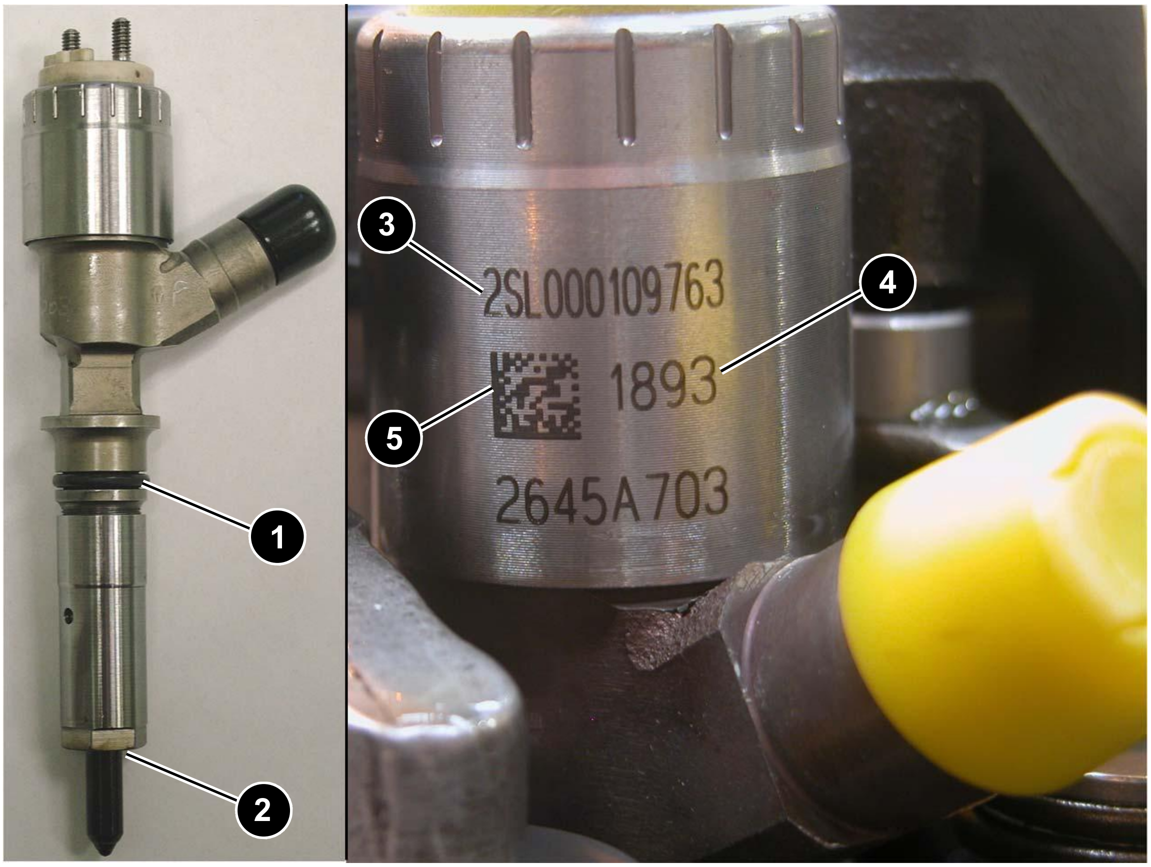
The injection pump and pump solenoid (5) are not serviceable. The transfer pump and the secondary speed/timing sensor (not shown) are the only serviceable components on the pump.

The high pressure fuel injection pump is capable of developing pressures up to 160 MPa (23,200 psi). The high pressure pump is lubricated by engine oil supplied by a pressure line from the left side engine oil galley.

The injection pump solenoid controls the injection pump output pressure to the common rail manifold. The Engine ECM sends a signal to the pressure control which will spill or "bleed off" excess pressure from the head of the high pressure pump. Excess fuel pressure not needed for injection is returned to the fuel tank.

Engine speed and engine position are determined by the secondary speed/timing sensor (not shown and located on the injection pump). The Engine ECM monitors the secondary speed/timing sensor and the primary speed/timing sensor (located at the rear of the engine) to determine crankshaft position and engine rpm.

If the Engine ECM does not receive a signal from the secondary speed/timing sensor due to a sensor or wiring fault, the engine will not start. However, if the secondary sensor or wiring fail while the engine is running, the Engine ECM will not shut down the engine. The Engine ECM but will continue to fire the fuel injectors based on the primary speed/timing position sensor signal the Engine ECM detected at last engine startup. The status of the engine speed sensors can be monitored using Cat ET.



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The left illustration shows the high pressure fuel injector. When replacing an injector, the following parts must also be replaced:

- injector pipe

- o-ring (1)

- copper injector washer. The copper washer is installed at the top of the injector tip (2).

- injector hold down bolt

- injector pipe

- rubber boot that seals the valve cover opening

- valve cover gasket

- valve cover bolt gasket (C4.2/C6.4 engines)

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When removing a pipe and reusing an injector, always cap the injector immediately until ready to install a new pipe. Then, finger tighten all pipes and clamps first, and torque properly.

Do not over tighten the solenoid connections on top of the injector. Use the proper torque specification in the service information.

> ***NOTE:*** *When removing an injector on the C4.4/C6.6 engine, move the intake rocker arms to gain access to the injector hold down bolt. It is not necessary to remove the complete rocker arm shaft.*

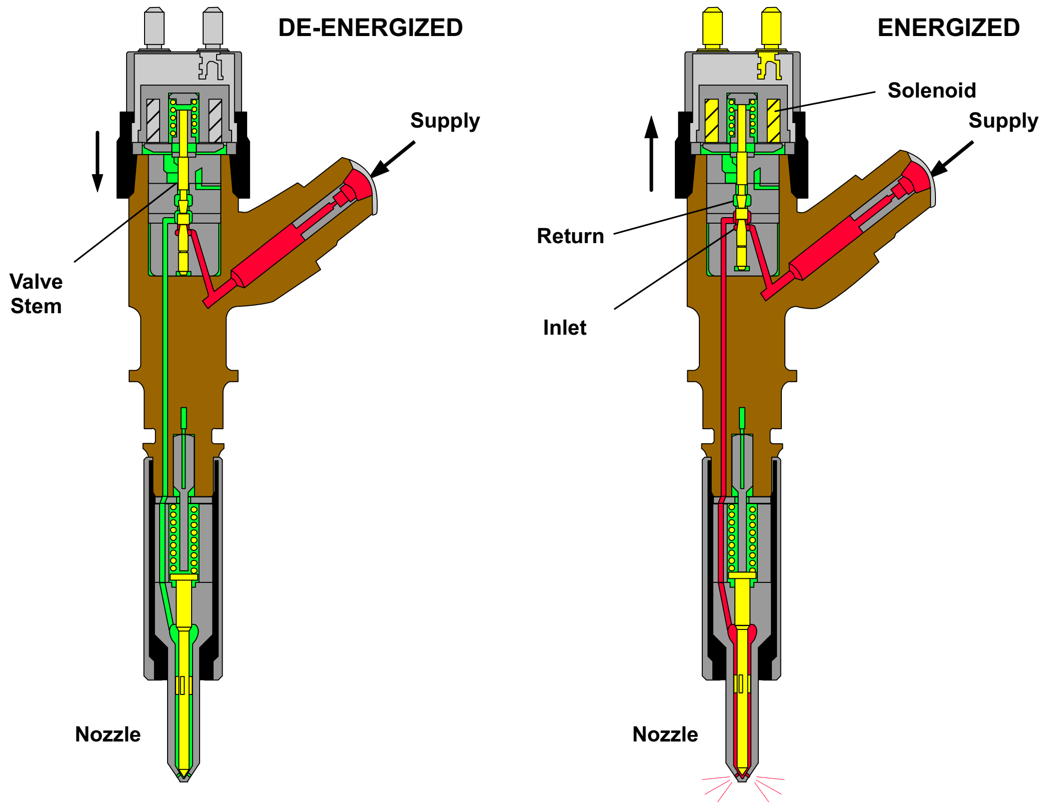
The injector serial number (3) and confirmation code (4) are used for trimming the injector. The bar code (5) is used during injector production. Document the injector serial number and confirmation code before installing a new injector.

Cat ET is used to flash the ECM with the proper injector trim file. The injector trim file can be found on the CD that comes with the replacement injector or on the Service Information System (SIS) Web.

The C4.4/C6.6 engines have an "Adaptive Trim" (self-calibration) process that occurs approximately every 125 hours. The Adaptive Trim process ensures injection efficiency and trims each injector accordingly. A slight audible change may be noticed, but the trim process has no effect on engine performance.

If any of the injectors are out of tolerance, a diagnostic code will be set. The Fuel System Verification Test in Cat ET can be used to manually perform the Adaptive Trim process if necessary.

FUEL INJECTOR OPERATION



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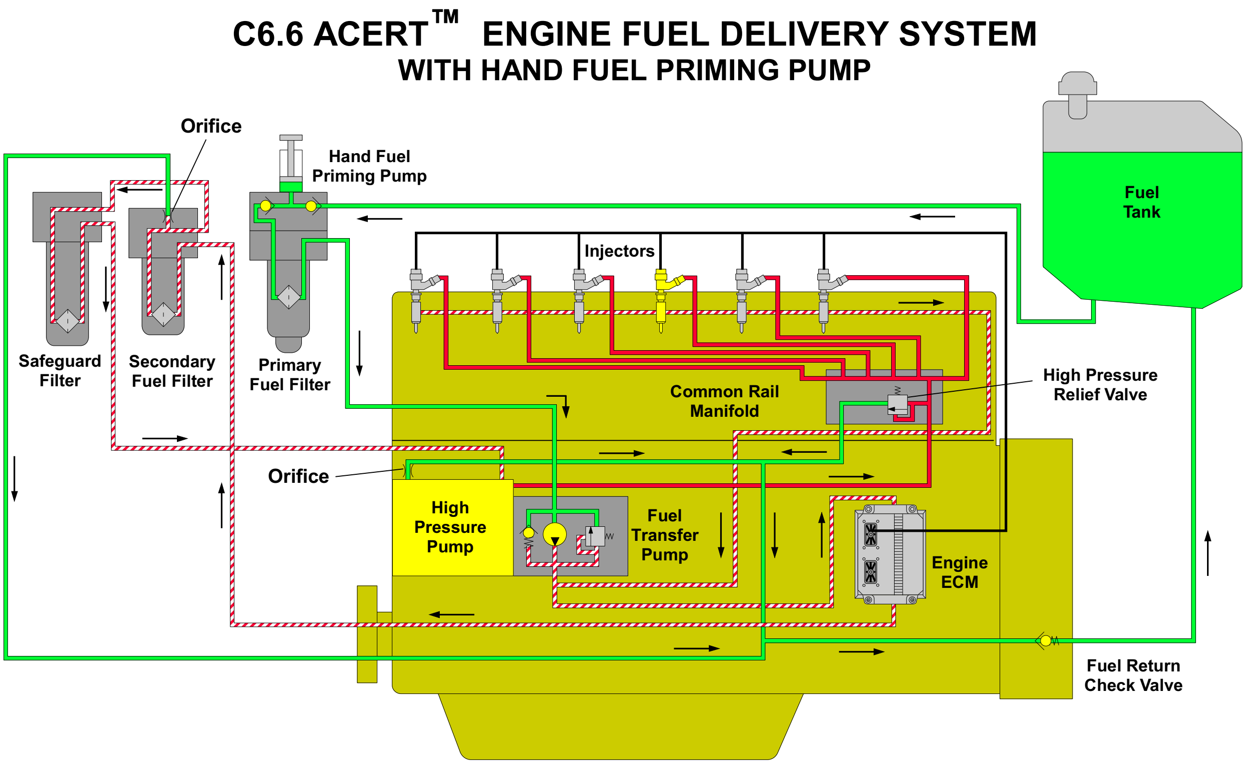
This illustration shows the internal components and fuel flow in the common rail fuel injector.

When the Engine ECM energizes the solenoid (start of injection), the valve stem raises. The valve stem directs fuel from the fuel rail manifold to the injector nozzle.

When the solenoid is de-energized by the Engine ECM, the valve closes and blocks fuel flow from the manifold.

With the nozzle closed, any excess fuel is sent to the upper face of the valve and directed into the leak off passage in the injector body.

The leak off fuel then passes through the gallery in the head to the return to the fuel tank.



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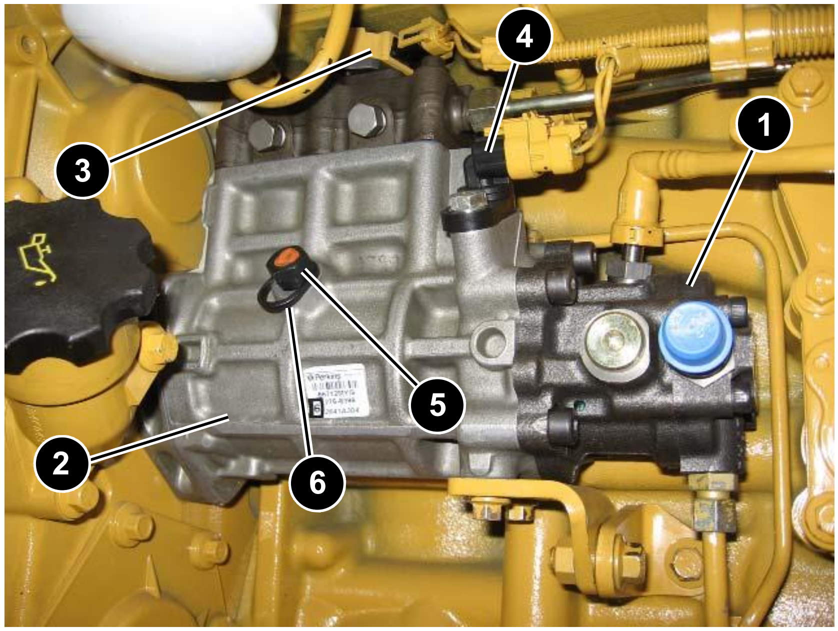
C4.4/C6.6 ENGINE COMPONENTS AND OPERATION

Fuel System

This illustration shows the components and the fuel flow through the C6.6 fuel system. The C4.4 fuel system is similar, but includes four injectors.

As previously described, the low pressure fuel circuit supplies filtered fuel to the fuel injection pump at a constant rate of 296-400 kPa (43-58 psi) and the high pressure fuel circuit supplies high pressure fuel from the fuel injection pump through the fuel manifold to the fuel injectors.

The fuel transfer pump pulls fuel from the tank through the priming pump and primary fuel filter and sends the fuel through the Engine ECM, then through the secondary and tertiary (third) filter, to the high pressure fuel injection pump. The check valve allows excess fuel to return to the tank but will not allow fuel from the tank into the low pressure fuel circuit.



20

The fuel injection pump is gear driven and mounts to the back of the front timing cover on the left side of the engine. The transfer pump (1) is mounted on the rear of the injection pump.

The injection pump (2) and pump solenoid (3) are not serviceable. The injection pump is serviceable as a unit. The transfer pump and the secondary speed/timing sensor (4) are the only components serviced separately on the pump.

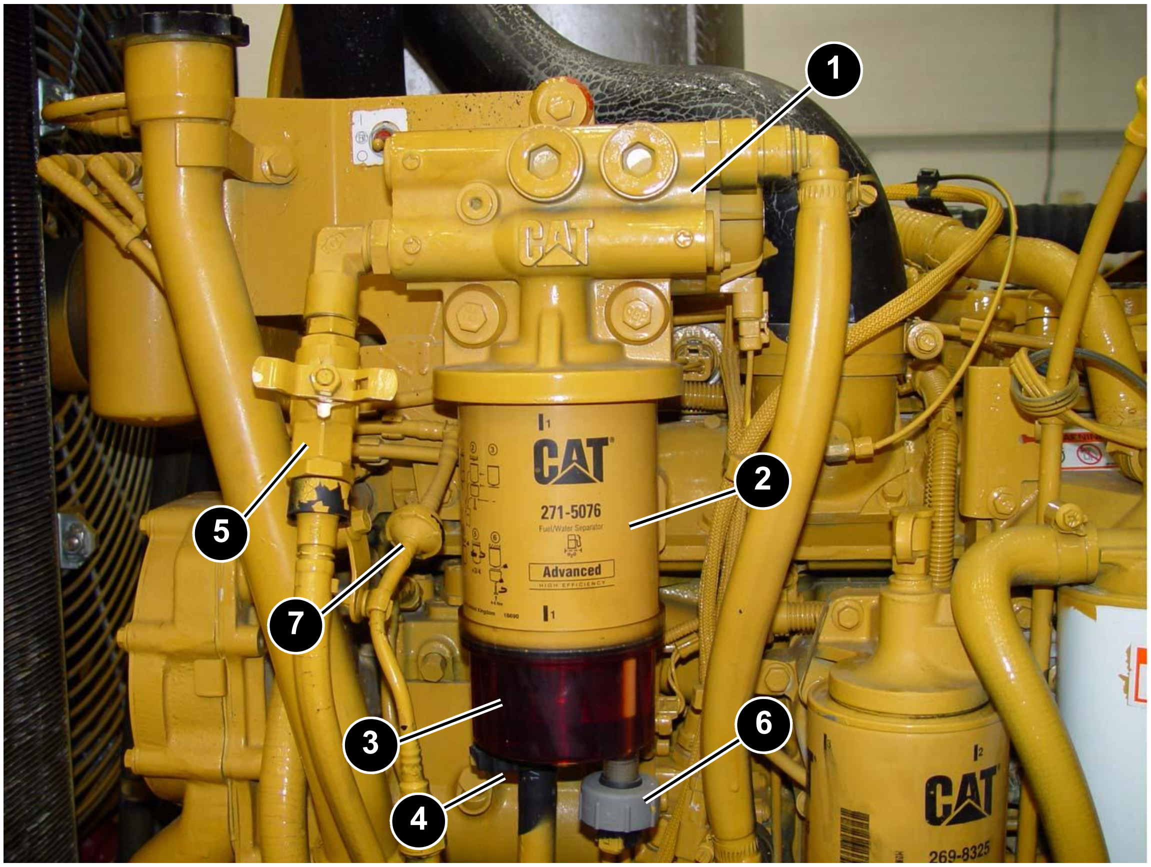
The fuel injection pump must be timed to the engine and the pump must be removed to be timed. The fuel pump must also be locked before removal. To lock the pump, loosen the locking pin (5) and slide the washer (6) so that the shoulder of the locking pin fits through the larger hole in the washer. Tighten the locking pin to the proper torque to lock the pump.

Fuel injection pump timing is necessary for two reasons:

- The pump stroke must be in phase with the fuel injection

- The speed/timing sensor must be timed with the engine

NOTE: *When the pump is removed, a special tool is required to ensure the fuel pump shaft is in the correct position (timed to the engine).*



21

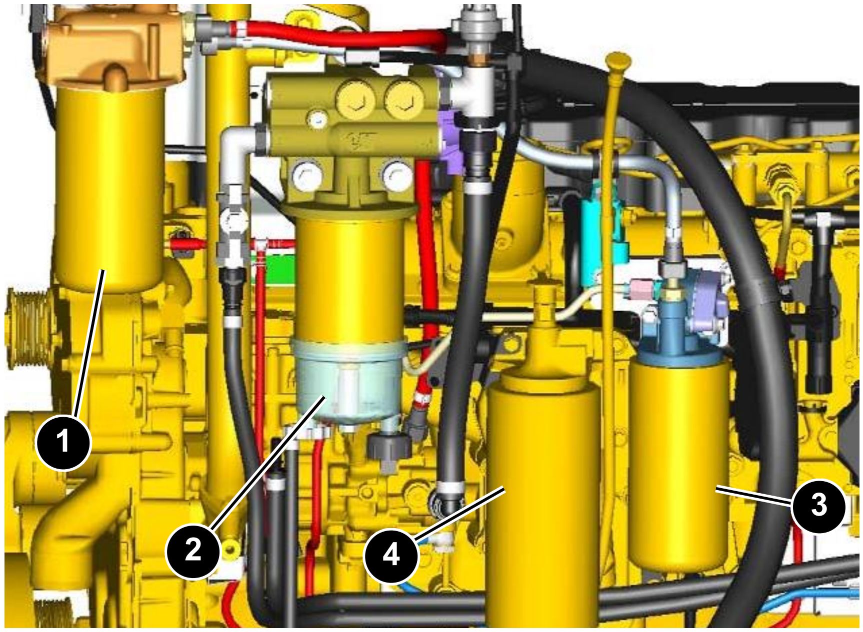
This illustration shows the left side of the C6.6 engine in the D6N Track-type Tractor.

The primary fuel filter assembly consists of the fuel filter base (1), the primary fuel filter element (2), and the fuel/water separator (3). Water in a high pressure fuel system can cause premature failure of the fuel injectors due to corrosion and lack of lubrication. Water should be drained from the water separator daily using the drain valve (4) at the bottom of the filter.

A fuel supply shutoff valve (5) may be installed in the primary filter supply line. This valve will shut off the fuel supply from the fuel tank.

Some C4.4 and C6.6 engines may be equipped with a water in fuel sensor (6) that signals the Engine ECM when there is water present in the separator bowl. The Engine ECM monitors the number 1 output circuit of the sensor. When this circuit is open the ECM will illuminate the action lamp and display an event message on the monitoring system display.

The fuel return to tank check valve (7) can be seen between the fuel supply shutoff valve and the primary fuel filter.



22

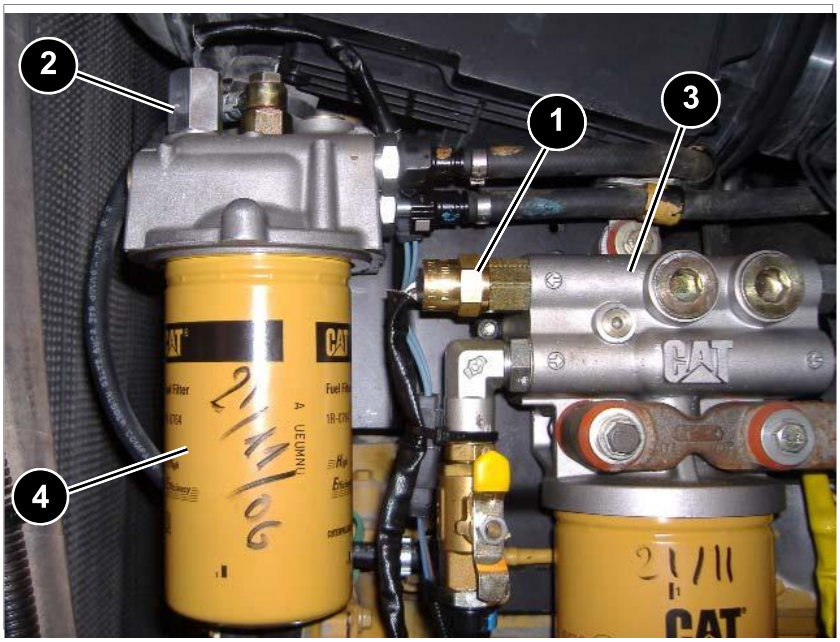
This illustration shows the left side of the C6.6 engine in the D6N Track-type Tractor.

The secondary fuel filter (1) is a high efficiency filter located next to the primary filter (2). Fuel flows from the transfer pump through the Engine ECM and then to the inlet of the secondary filter.

The Safeguard fuel filter (3) is the tertiary (third) fuel filter in the C4.4/C6.6 fuel system. Similar to the secondary fuel filter, the Safeguard filter is a high efficiency filter. All fuel entering the high pressure section of the injection pump must pass through the secondary and Safeguard filters.

Also shown in this illustration is the engine oil filter (4).

> **NOTE:** *The maintenance schedule for the Safeguard filter is different than the maintenance schedule for the primary and secondary fuel filters. Refer to the appropriate operation and maintenance manual for the recommended service interval for all fuel system filters.*

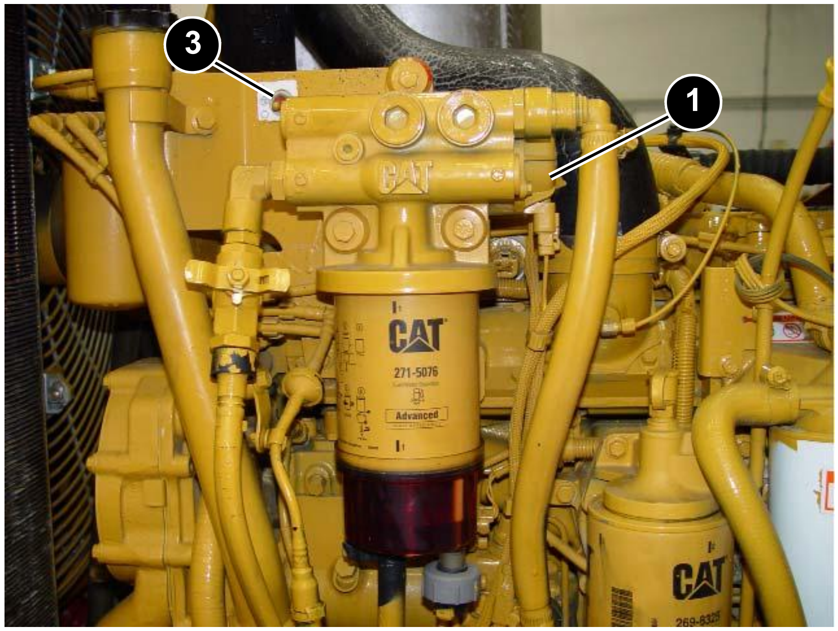


23

Some C4.4 and C6.6 engines may be equipped with a fuel temperature sensor (1) and/or a secondary fuel pressure switch (2) as shown in this illustration of the C6.6 engine in the D6N Track-type Tractor.

The fuel temperature sensor mounts to the primary filter base assembly (3). The fuel temperature sensor is part of the fuel filter monitoring system. By monitoring the temperature of the fuel entering the fuel filtration system, the fuel temperature sensor helps to prevent false fuel filter restriction events in either the primary or secondary filters due to cold, high viscosity fuel.

The secondary fuel pressure switch monitors the secondary fuel filter (4) for filter restriction. If the secondary fuel filter becomes clogged, the secondary fuel pressure switch will open and the Engine ECM will activate the action lamp in the cab and log a secondary fuel filter restriction event.



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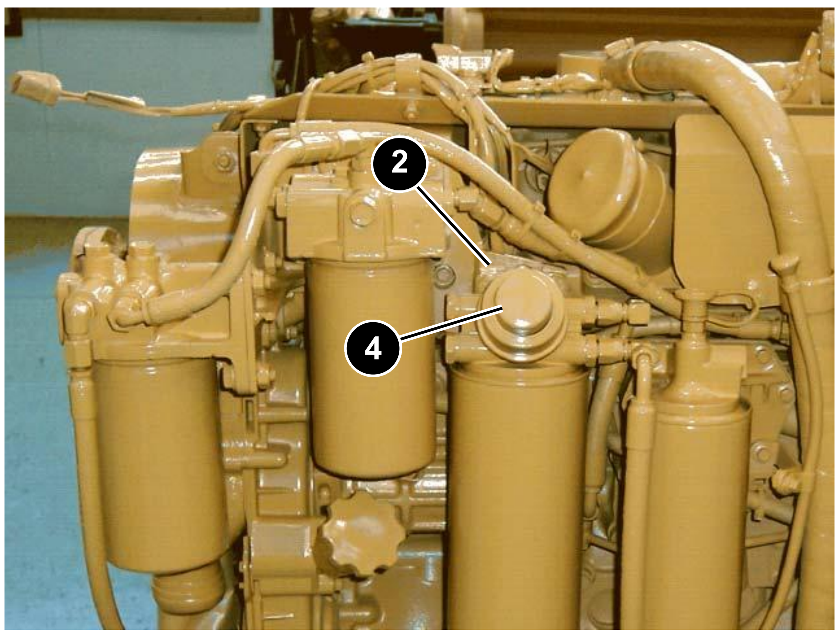


25

When replacing a fuel filter on the C4.4 or C6.6 engine, the fuel system must be primed prior to starting or cranking the engine. Do not prefill new fuel filters prior to installation on the engine. Prefilling the filters can introduce contaminants into the fuel system and cause damage.

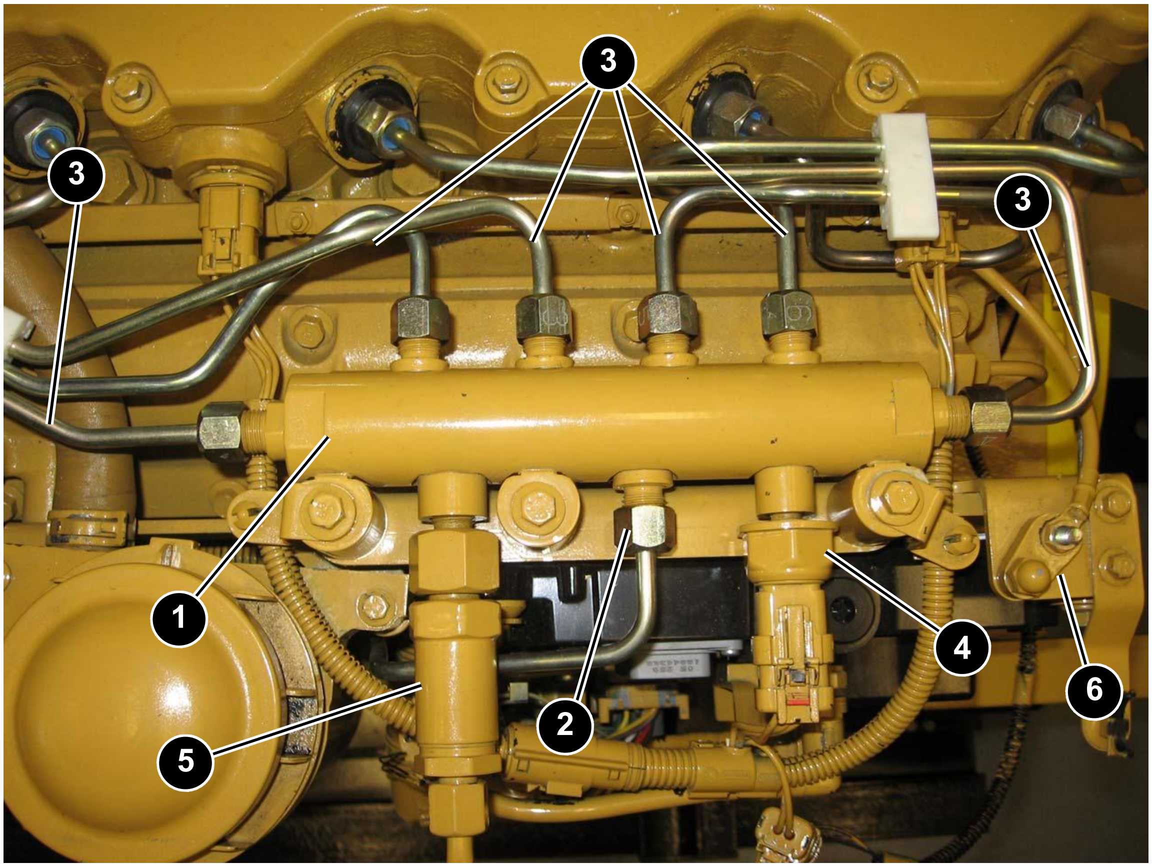
Depending on how the engine is equipped, priming is accomplished using either an electric priming pump (1) or a hand priming pump (2). The top illustration shows an electric priming pump on a C6.6 engine in the D6N Track-type Tractor. The bottom illustration shows a hand priming pump on a C6.6 engine in the R1300G II Underground Loader.

If equipped with an electric priming pump, fuel filter priming is activated using the toggle switch (3). With the battery disconnect switch ON and the machine start switch OFF, hold the toggle switch open for approximately 90 seconds to sufficiently prime the filters.

If equipped with a manual priming pump, pump the plunger (4) 100 times to prime the system.

After priming the fuel system using the electric or the manual pump, there should be sufficient fuel in the filters to allow the engine to start and run. Do not open any fuel lines during the priming procedure.

> ***NOTE:*** *All C4.4 engines are equipped with an electric priming pump. Some C6.6 engines may not be equipped with a priming pump.*



26

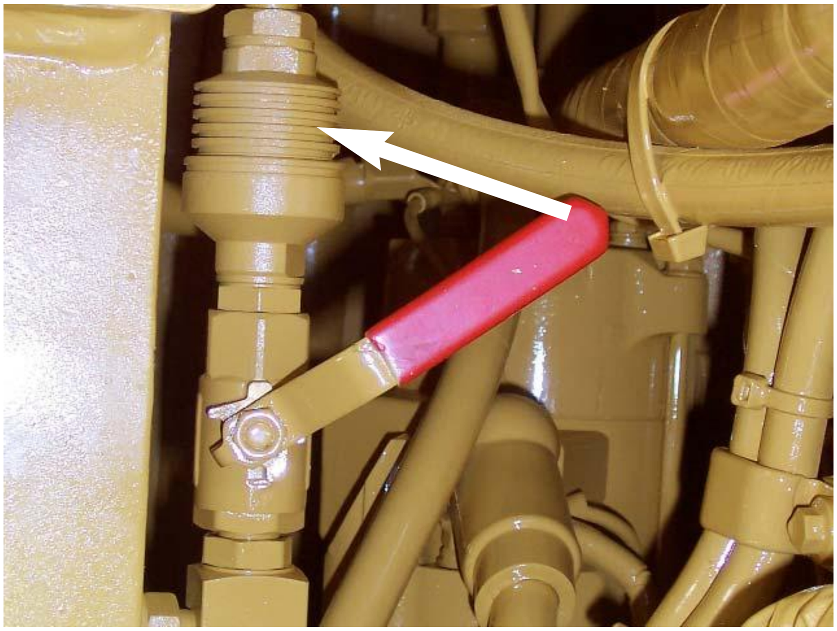
The common rail fuel manifold (1) is mounted to the rear of the inlet air manifold on the left side of the engine. High pressure fuel from the fuel injection pump enters the common rail manifold at the inlet fitting (2). The common rail manifold distributes the high pressure fuel evenly to the four or six fuel injector supply pipes (3). The steel fuel pipes pass through the valve cover base and connect to individual fuel injectors.

A fuel rail pressure sensor (4) is used to monitor the pressure of the common rail high pressure fuel system. The Engine ECM will monitor the signal from the fuel rail pressure sensor and maintain optimum fuel system pressure for any given load or temperature condition. The fuel rail pressure sensor is serviceable separately from the fuel manifold.

A fuel pressure relief valve (5) is used to protect the high pressure fuel system from fuel pressure spikes. The fuel pressure relief valve will start to open at 160 MPa (23,200 psi) and withstand a pressure spike of up to 190 Mpa (27,560 psi). The fuel pressure relief valve is not serviceable separately from the fuel manifold. If the fuel pressure relief valve fails, the fuel manifold and associated parts must also be replaced.

The glow plug buss bar (6) is visible at the left rear of the cylinder head. Some C4.4 and C6.6 engines do not require glow ignition and therefore no electrical connection is made at the buss bar stud.

> ***NOTE:*** *An ether injection starting system is available as an attachment on some machine applications for cold climate machine operation.*

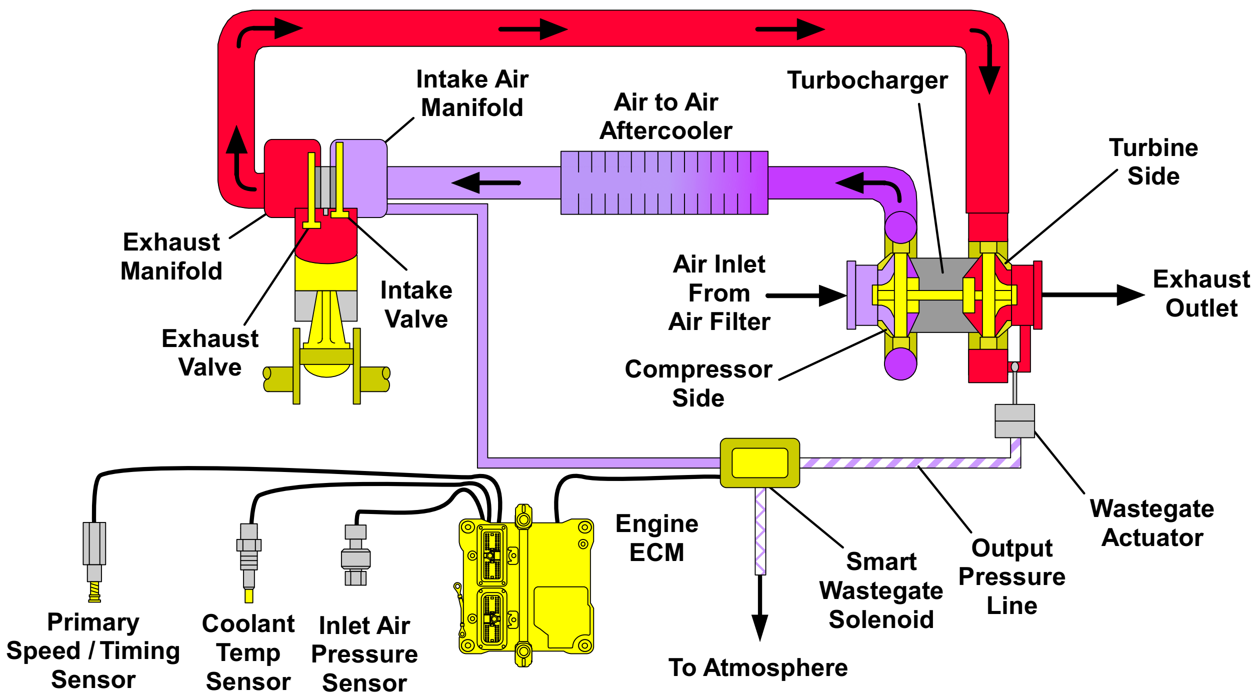


27

The C6.6 engine in the R1300G II Underground Loader is equipped with a magnetic screen (arrow) located in-line between the tank and primary fuel filter to pick up small magnetic particles before entering the fuel system.

Some C4.4 and C6.6 engines are equipped with a fuel cooler (not shown), which is located between the fuel transfer pump and the Engine ECM.

C4.4 / C6.6 ACERT™ AIR INTAKE AND EXHAUST SYSTEM



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Air Inlet System

Intake air is drawn into the engine air precleaner by the vacuum created by the compressor wheel in the turbocharger. The precleaner removes any large particles from the intake air and ejects them through the exhaust stack. The intake air is then drawn through the air cleaner elements in the air cleaner housing where any fine contaminants are removed by the filter elements. Cleaned intake air is then drawn into the compressor side of the turbocharger.

The turbocharger compresses the intake air and forces it out of the compressor outlet. The heated and compressed intake air next flows to the inlet of the ATAAC core. As the intake air passes through the ATAAC core, the air is cooled by the flow of air from the engine fan and becomes more dense.

Compressed, cooled intake air is next directed to the inlet air manifold, through the inlet air tube, and into the cylinder head. During the intake stroke, air is forced into the cylinders around the intake valves in the cylinder head.

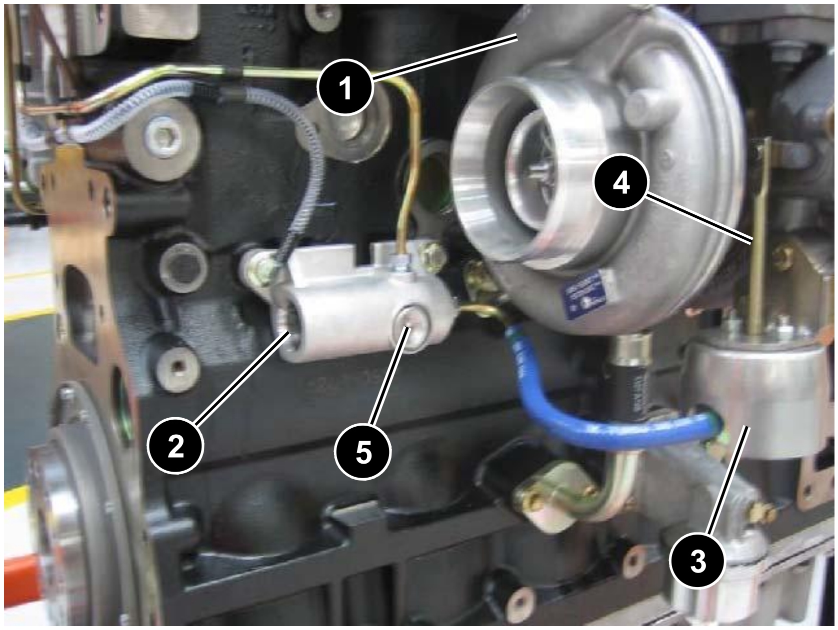
The exhaust manifold directs exhaust gasses to the turbine side of the turbocharger. Hot, high pressure exhaust gasses contact the blades of the turbine wheel inside the turbine housing causing the turbine shaft to spin. The turbine shaft is mechanically connected to the compressor wheel on the inlet side of the turbocharger.

The hot exhaust gas stream gives up most of its energy to the exhaust turbine wheel. This low energy exhaust stream exits the turbine housing through the turbine nozzle, flows through the exhaust pipe and into the muffler, and finally exits at the exhaust stack.

The turbocharger on the C4.4 and C6.6 engines use a solenoid controlled wastegate. The wastegate acts as a bypass valve for exhaust gasses to the turbine wheel. Maximum boost pressure developed in the compressor section of the turbocharger can be controlled by using the wastegate to divert some of the exhaust gas stream past the turbine housing.

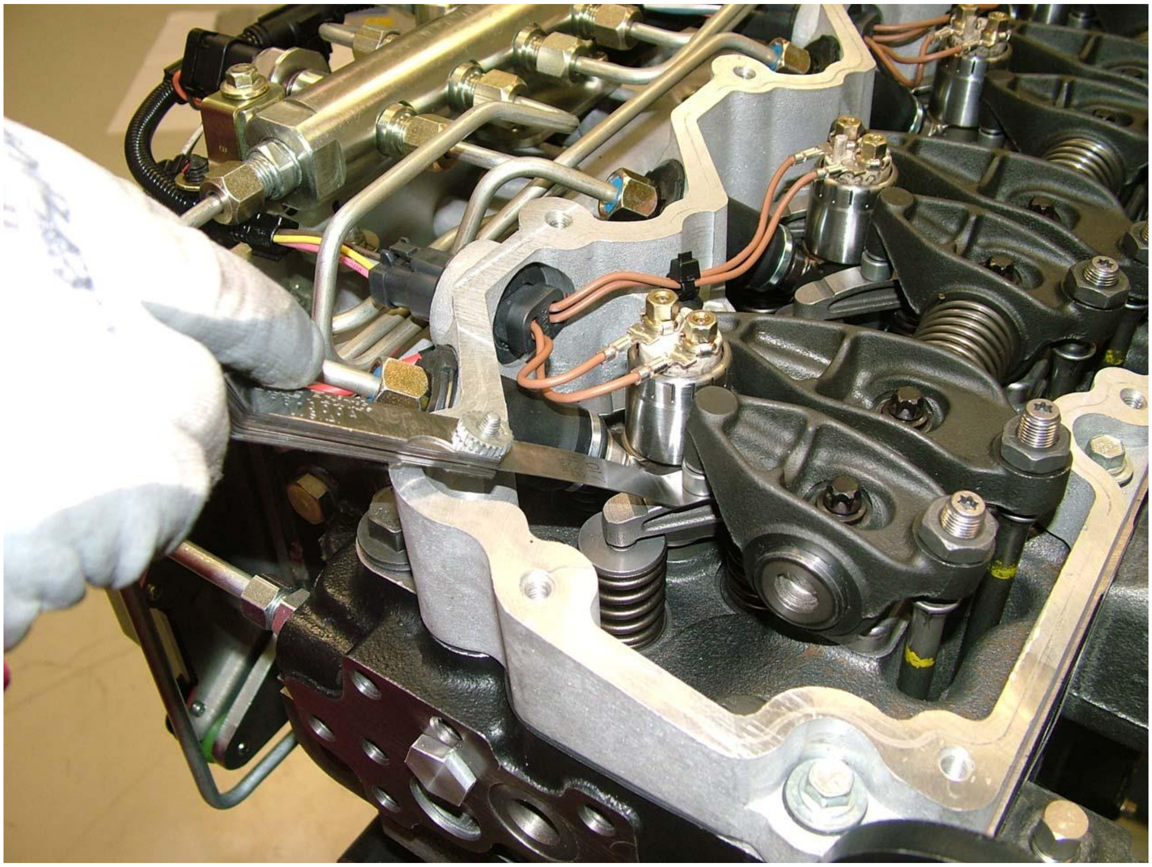
Wastegate control is accomplished with an electrical solenoid that is controlled by the Engine ECM. Based on inputs from the speed timing sensor, the coolant temperature sensor, and the inlet air pressure sensor, the Engine ECM will optimize turbocharger boost pressure to suit engine load and speed conditions. This technology is referred to as a "Smart Wastegate."

An ATAAC core is mounted to the right of the radiator for cooling of the compressed inlet air.



29

The Engine ECM will optimize turbocharger (1) boost pressure by varying the position of the wastegate solenoid (2) using a Pulse Width Modulated signal. This position variation controls pressure needed to accurately operate the wastegate by the actuator diaphragm (3) and the connecting rod (4). Excess pressure is bled off by a vent valve (5).



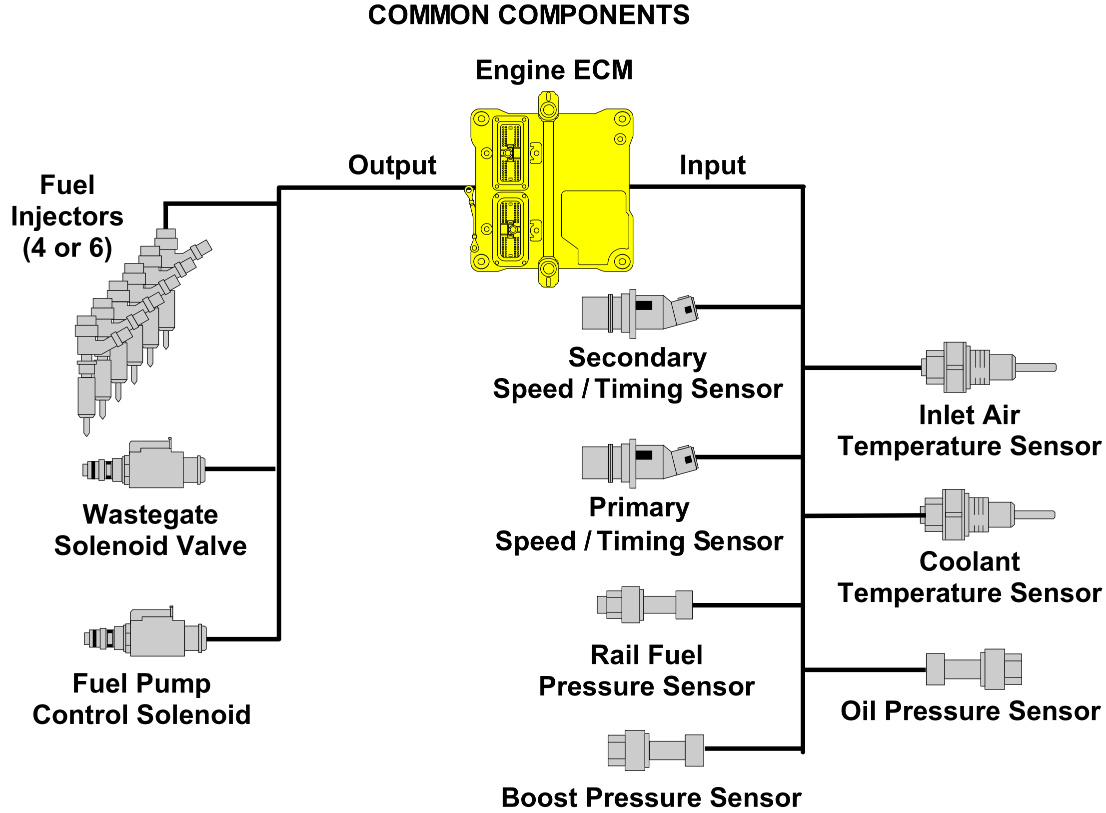
30

The valve lash adjustment sequence on the C4.4/C6.6 engines is different from the conventional valve lash procedure on typical engines. It is important to follow the procedure in the service information when adjusting the valve lash on the C4.4/C6.6 engines.

Shown in this illustration, is an angled feeler gauge that is used to complete the valve adjustment.

The valve lash setting is the same for intake and exhaust valves.

C4.4 / C6.6 ENGINE ELECTRONIC CONTROL SYSTEM



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Electrical System

This diagram shows the common components of the C4.4/C6.6 engine electronic control system. The sensors shown on the right provide the Engine ECM with input that controls the fuel injectors, turbo wastegate, and fuel pump. The Engine ECM has two 64-pin sockets connecting to the engine harness and machine harness.

The engine electronic control system primarily performs the engine fuel control function. A solenoid on each injector receives an ON/OFF signal from the Engine ECM that triggers the timing and amount of fuel delivered to the combustion chamber. The engine electronic control system also monitors other functions that are critical for engine performance, such as lubrication, combustion air, and cooling.

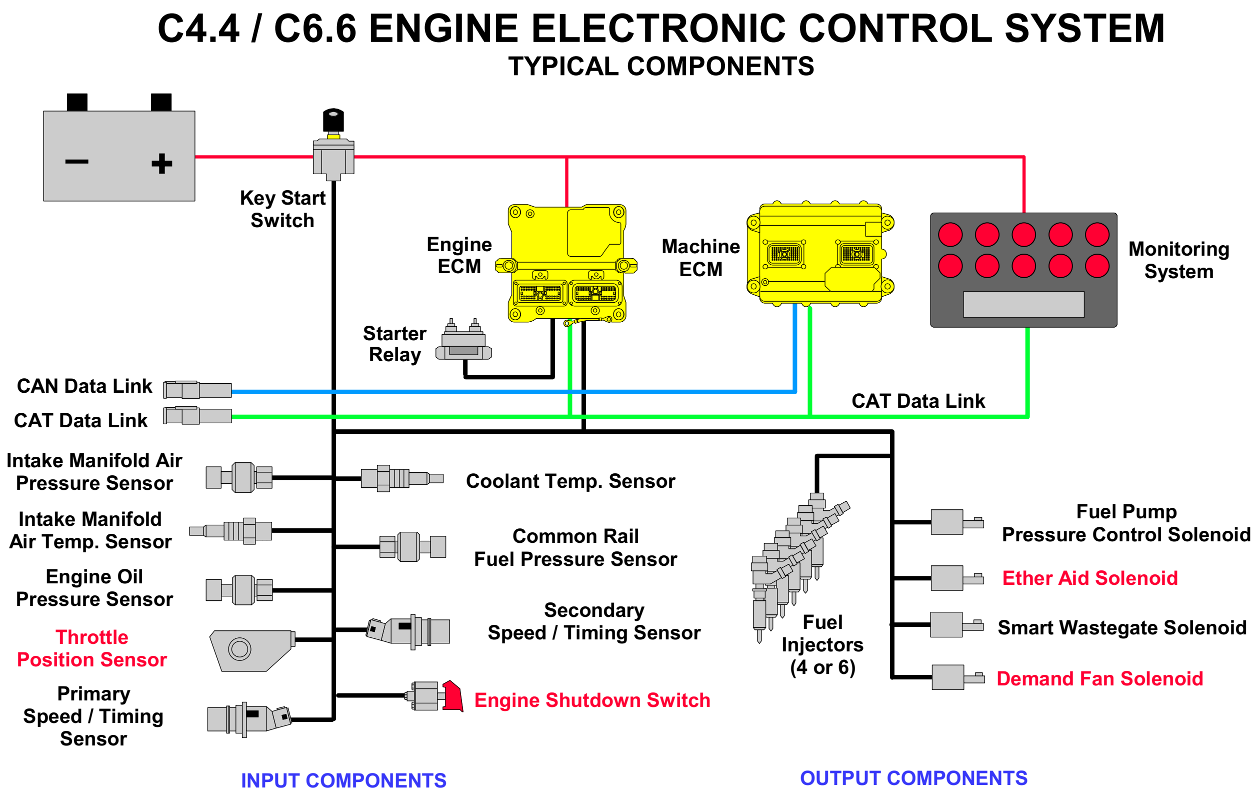
> ***NOTE:*** *This illustration shows the common input and output components on the C4.4/C6.6 engines. Other input and output components are installed on specific machine applications.*

Basic C4.4/C6.6 Engine ECM Input Component Specifications:

- **Primary Engine Speed/Timing Sensor** - active sensor, 2-wire Hall effect
- **Secondary Engine Speed/Timing Sensor** - active sensor, 2-wire Hall effect
- **Engine Oil Pressure Sensor** - active 5 V supply; 3-wire; rated to 882 kPa ABSOLUTE (kPaA) (128 psi)
- **Intake Manifold Air (Boost) Pressure Sensor** - active 5 V supply; 3-wire; rated to 339 kPa ABSOLUTE (kPaA) (49.2 psi)
- **Fuel Rail Pressure Sensor** - active 5V supply; 3-wire; rated to 270 MPa (31,908 psi)
- **Intake Manifold Air Temperature Sensor** - passive; 2-wire; minimum temperature -40° C (-40° F), maximum temperature 150° C (302° F)
- **Engine Coolant Temperature Sensor** - passive; 2-wire; minimum temperature -40° C (-40° F), maximum temperature 150° C (302° F)

Basic C4.4/C6.6 Engine ECM Output Component Specifications:

- **Fuel Injectors** - 70 V supply
- **Smart Wastegate Solenoid** - PWM solenoid
- **Fuel Pump Pressure Control Solenoid** - 70 V supply



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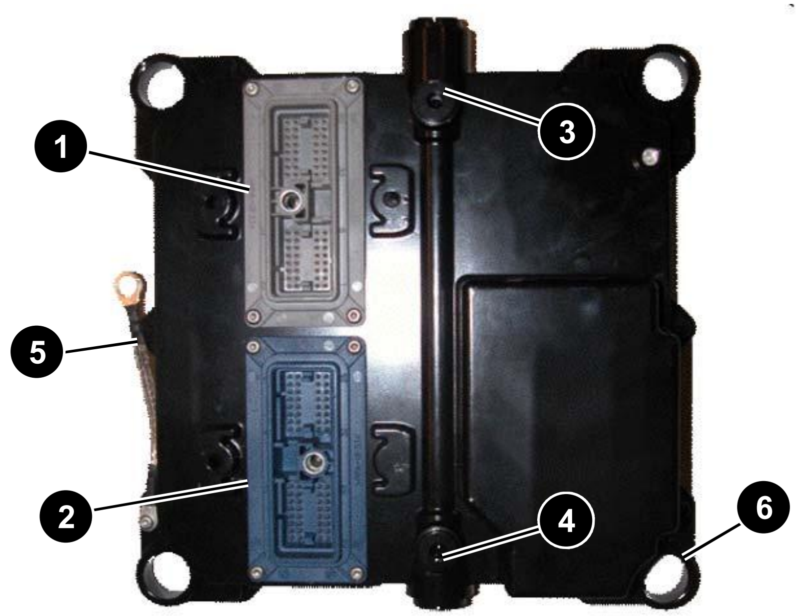
This diagram shows some of the typical input and output components of the C4.4/C6.6 engine electronic control system in addition to the common components shown in the previous illustration.

Many machine applications include an additional ECM to control some of the machine systems and a monitoring system to monitor the engine and machine systems. The input and output components shown in red are also installed on many machine applications.

In some machine applications the throttle input from the operator is an input to the Machine ECM. The Machine ECM then sends a signal to the Engine ECM over the CAT or CAN Data Link.

The throttle position sensor is typically powered by an 8 volt supply from the ECM.

> ***NOTE:*** *To determine the engine electronic control system components on a specific machine, refer the the appropriate machine specific service information.*



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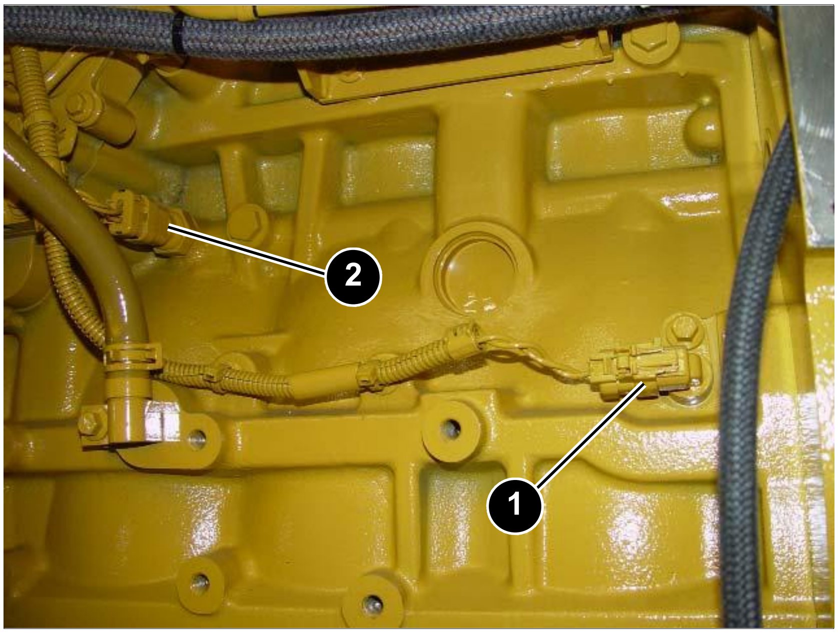
C4.4/C6.6 uses an A4-E2 Engine ECM. The ECM controls:

- Fuel pressure
- Speed governing
- Air/fuel ratio
- Start/stop sequence
- Engine protection devices/diagnostics

The ECM features two 64-pin sockets for the machine harness connector (1) and the engine harness connector (2). A new pin removal tool is available.

The ECM case is completely sealed against dirt and moisture. The sealed case is cooled with fuel from the primary fuel filter to help dissipate heat from the electronics inside. Fuel enters at the top (3) and exits at the bottom (4).

When reinstalling the ECM, make sure the grounding strap (5) is secured to a clean connection and the fasteners are properly torqued. Anti-vibration mounts fit into the holes at each corner (6).

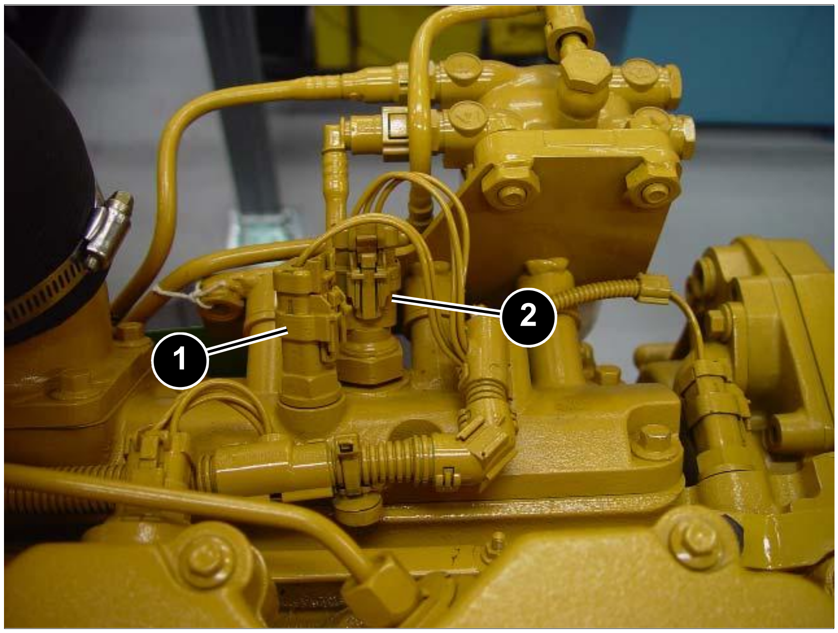


34

Primary engine speed data is provided by the primary engine speed/timing sensor (1), or crank speed/timing sensor. The primary engine speed/timing sensor is located at the left rear of the engine block. Failure of the primary engine speed sensor while the engine is running will cause the Engine ECM to look at the secondary speed/timing sensor for engine speed information. The engine will continue to run using only the secondary speed/timing sensor signal for engine rpm, but will derate to 1200 rpm.

The engine oil pressure sensor (2) is also located on the left side of the cylinder block. The sensor is installed in the left engine oil galley below and forward of the Engine ECM. Low engine oil pressure, sensor failure, or wiring failure will not result in an engine derate or shutdown but will cause a fault to be logged in the Engine ECM.

The status of the primary engine speed sensor and the engine oil pressure sensor can be viewed with Cat ET.



35

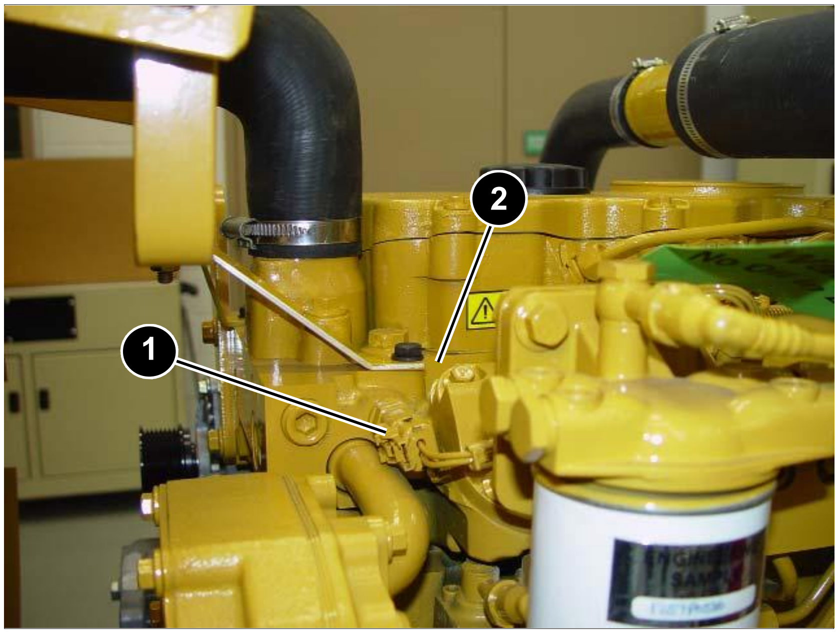
The inlet air temperature sensor (1) and the inlet air pressure (boost) sensor (2) are installed in the air inlet manifold on the left front of the engine.

The inlet air temperature sensor is a passive 2 wire sensor and is an input to the Engine ECM. The signals from the inlet air temperature sensor and the coolant temperature sensor are used to determine engine starting aid requirements and to trim (adjust) injector pulse width as engine operating temperatures change.

The air inlet pressure sensor is an active 3 wire sensor. The Engine ECM will use the signal from this sensor to determine boost pressures supplied by the turbocharger. The air inlet pressure sensor is used with the Engine ECM to control the air/fuel ratio electronically. This feature allows very precise smoke control, which was not possible with mechanically governed engines.

> ***NOTE:*** *The air inlet pressure sensor also acts as an atmospheric pressure sensor by taking a snap shot of atmospheric pressure when the key start switch is first turned to the ON position. The other engine sensors are also calibrated to the boost sensor atmospheric pressure reading.*

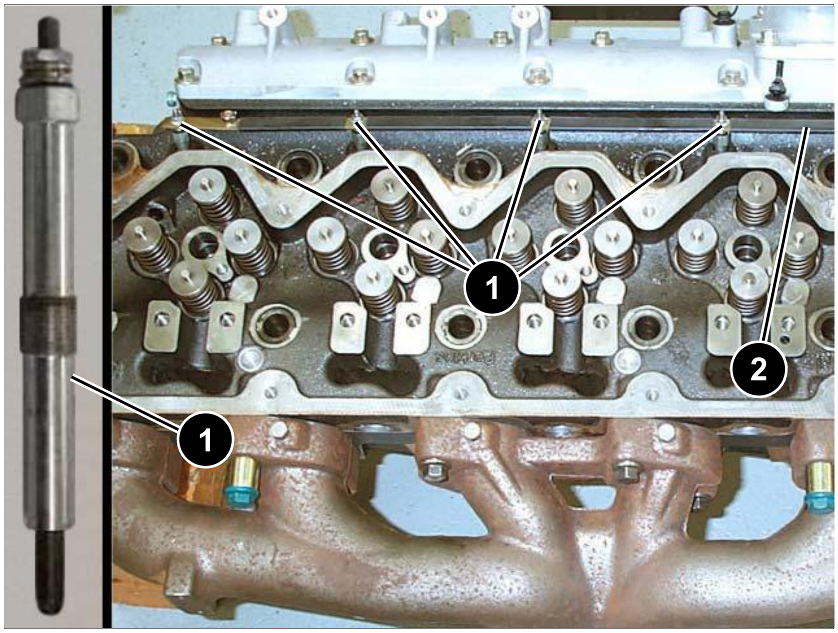
The status of the inlet air temperature sensor and the inlet air pressure sensor can be viewed with Cat ET.



36

The coolant temperature sensor (1) is installed in the front left corner of the cylinder head (2). The coolant temperature sensor is a "passive" two wire thermistor type sensor that sends a signal to the Engine ECM indicating coolant temperature.

When the value of either the coolant temperature sensor or the intake manifold temperature sensor (whichever is lowest) indicates an engine temperature of 4° C (40° F) the Engine ECM will activate the cold starting aid (if equipped).



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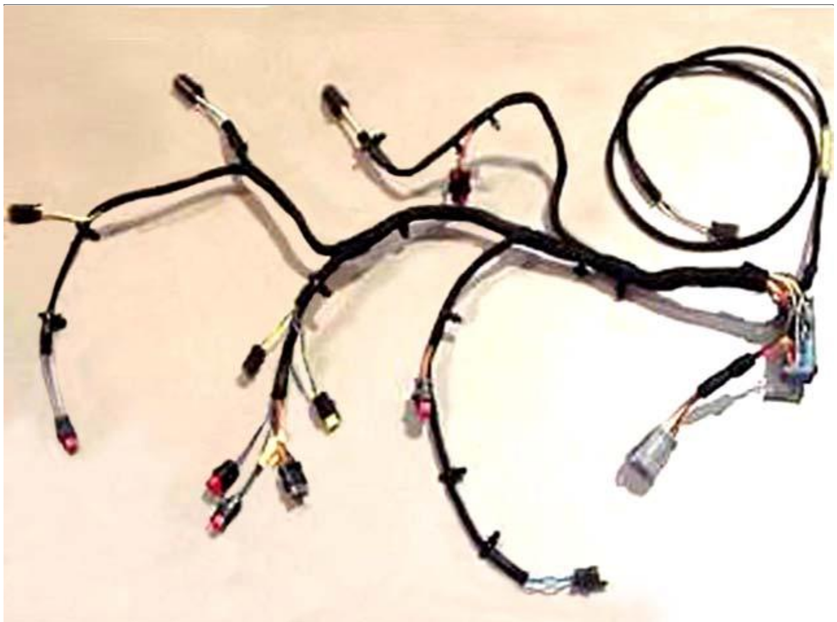
An improved glow plug design is being used that reaches peak temperature faster than the previous plug. The new glow plugs (1) heat to 850° C (1560° F) in four seconds, providing more immediate cold starting performance.

The glow plugs are installed on the intake side of the head. There is one glow plug per cylinder. Each glow plug is connected to a common buss bar (2) that supplies electric current from the key start switch via the glow plug relay. The Engine ECM controls the glow plug relay by providing the ground contact.



38

The wiring harness and its connectors are serviceable. All harness connectors can be replaced separately except the pump solenoid connector. The pump solenoid connector is serviced as a "pigtail" connector. The injector harnesses (not shown) below the valve cover are serviced separately.

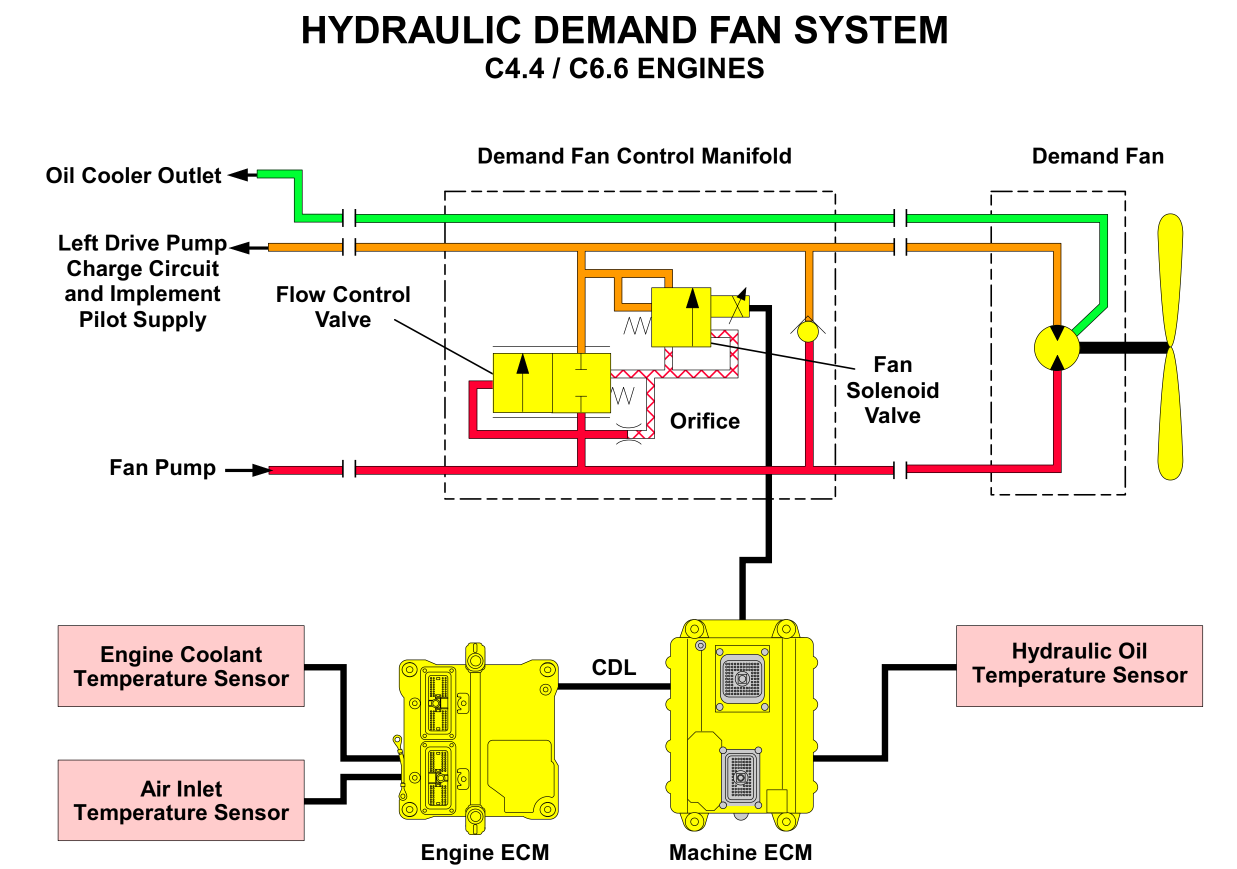
When working on the harness, always secure the harness in the original position with the correct clips and away from pinch points, heat, and sharp edges.

The connectors are keyed to fit in only one direction, which ensures proper pin to socket alignment. Never force connectors, as they should fit together with minimal effort.

Connectors are designed to seal out dirt and moisture without the use of electrical grease. When servicing the harness, inspect the condition of the seals on the connectors. When pins are unused, be sure to use blanking plugs to protect the connector against dirt and moisture.

Two general purpose connector kits are available for servicing DT and AMPSeal connectors.

The ECM connector 0.75 mm (0.030 in.) pins are available as service parts. The pins are replaced using a Deutsch service tool.



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Demand Fan

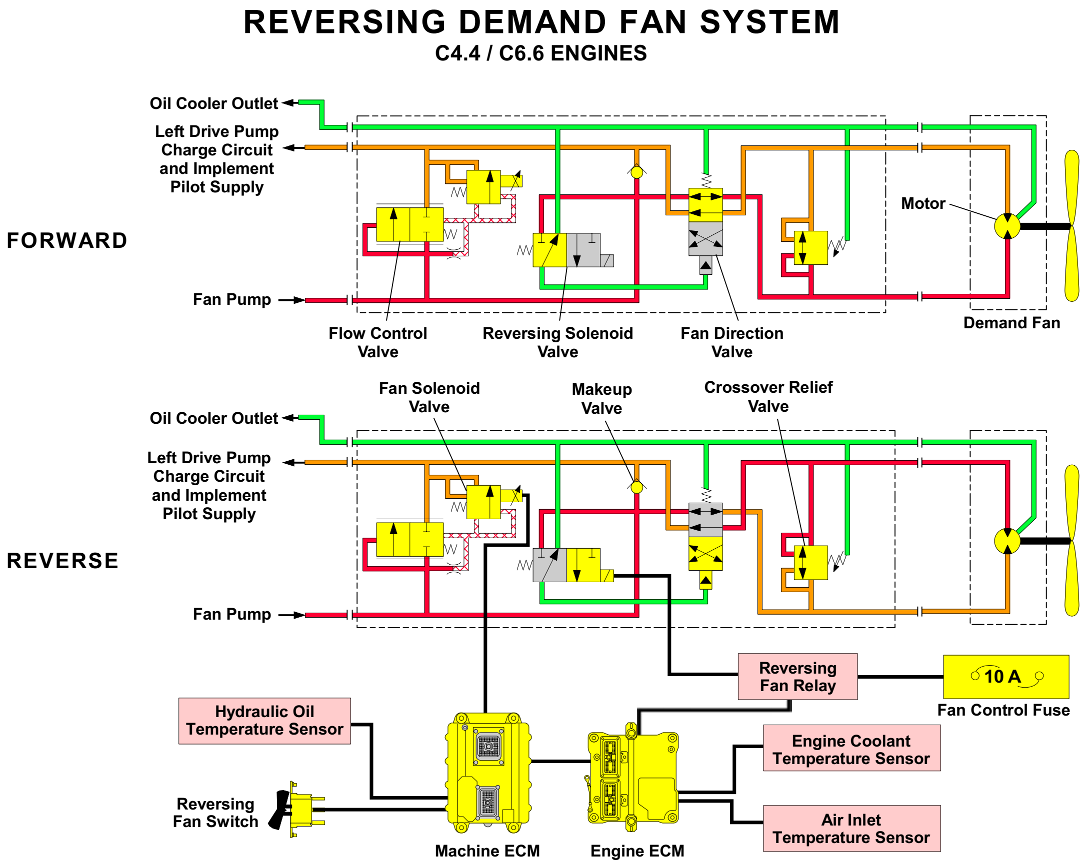
This illustration shows the hydraulic demand fan system in the D6K Track-type Tractor. The hydraulic demand fan system is installed on some machine applications with the C4.4 or C6.6 engines.

In machine applications equipped with the hydraulic demand fan system, the Machine ECM and Engine ECM work together via the Cat Data Link to determine the appropriate fan speed for proper system cooling. The Engine ECM monitors coolant temperature and air inlet temperature while the Machine ECM monitors hydraulic oil temperature.

Based on system monitoring input, the Machine ECM sends the appropriate signal to the fan solenoid valve in the demand fan control manifold. The demand fan solenoid valve provides the proper fan speed for the cooling system. The solenoid valve decreases fan speed using the flow control valve by rerouting some of the supply oil to the oil cooler instead of the fan. Maximum fan speed occurs when the fan solenoid valve is de-energized and all of the pump flow is directed through the fan motor for increased cooling.

The return oil from the fan motor is directed through the oil cooler and filter to the tank. Both the cooler and the filter are equipped with bypass valves.

The makeup valve prevents cavitation in the fan motor. During a quick deceleration, the flow of oil to the fan motor can stop. The makeup valve will open to allow oil to flow from the outlet side of the fan motor to the inlet side of the fan motor.



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Reversing Fan

This illustration shows the reversing demand fan system in the D6K Track-type Tractor.

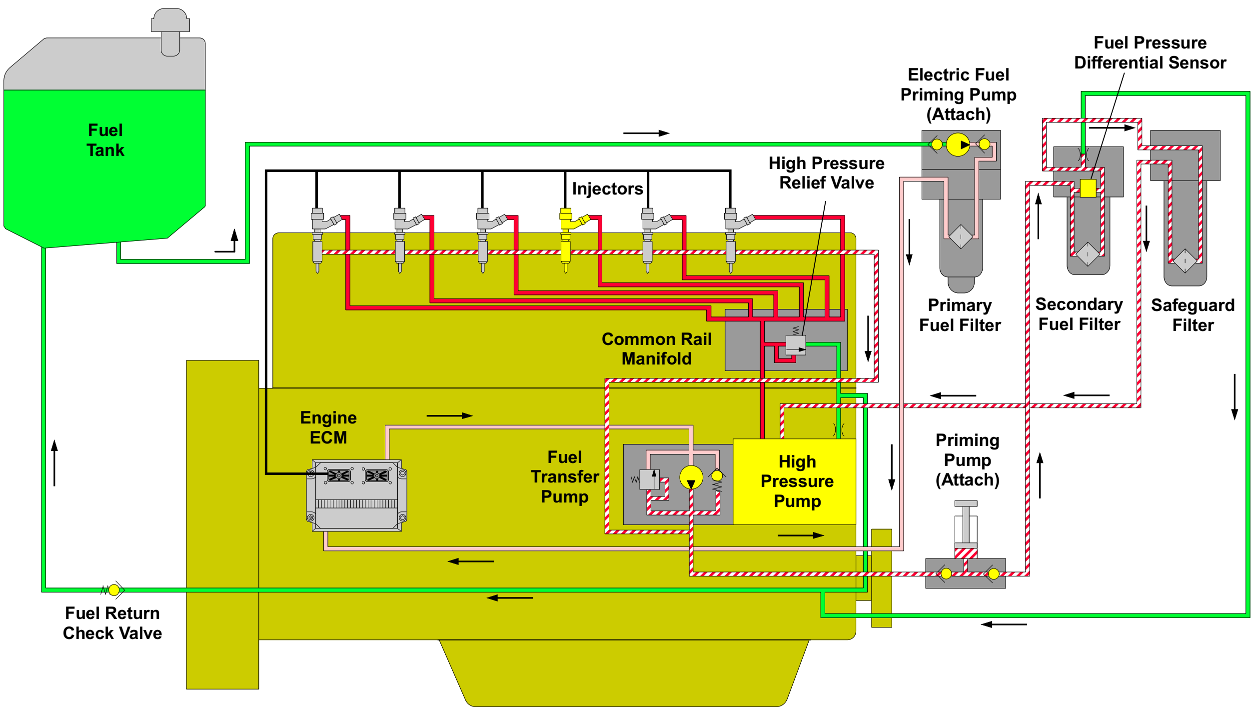
The optional reversing hydraulic fan system has a reversing solenoid controlled by the Engine ECM. When the top of the reversing fan switch is depressed, the Engine ECM closes the reversing fan relay to energize the solenoid.

The reversing fan solenoid directs supply oil to the fan direction valve and moves the direction valve up to reverse pump flow to the fan motor. Supply oil from the pump is directed to the other side of the fan motor, while the other side of the fan motor is open to the cooler circuit.

The fan reverses for 10 seconds. When the bottom of the reversing fan switch is depressed, the fan reversing solenoid is energized to reverse the fan for 10 seconds. This will repeat every 30 minutes until the reversing fan switch is returned to the center position.

The crossover relief valve prevents cavitation in the fan motor. During a quick deceleration, the flow of oil to the fan motor can stop. The crossover relief valve will open to allow oil to flow from the outlet side of the fan motor to the inlet side of the fan motor.

C6.4 ACERT™ ENGINE FUEL DELIVERY SYSTEM



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C4.2/C6.4 ENGINE COMPONENTS AND OPERATION

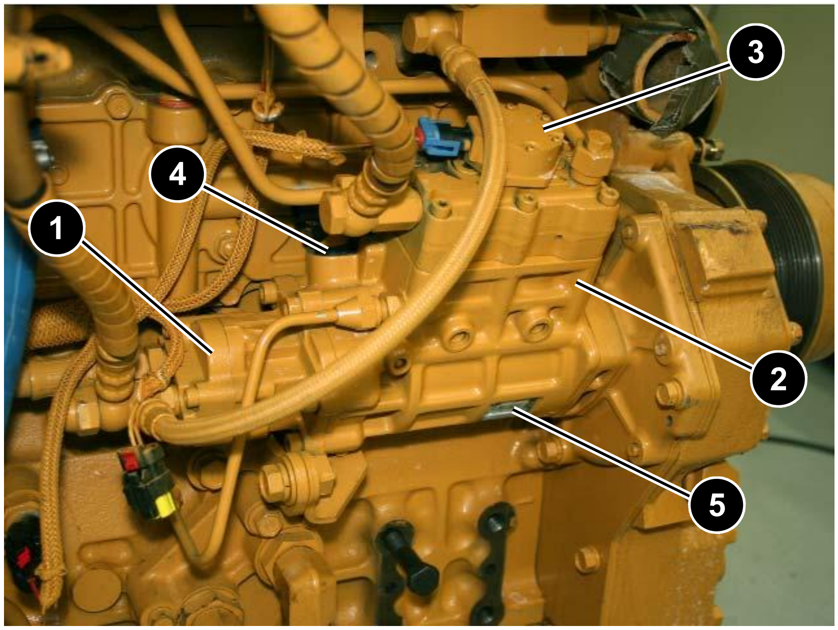
Fuel System

This illustration shows the components and the fuel flow through the C6.4 fuel system. The C4.2 fuel system is similar, but includes four injectors.

As previously described, the low pressure fuel circuit supplies filtered fuel to the fuel injection pump at a constant rate and the high pressure fuel circuit supplies high pressure fuel from the fuel injection pump through the fuel manifold to the fuel injectors.

The fuel transfer pump pulls fuel from the tank through the primary fuel filter and the Engine ECM and sends the fuel to the priming pump. From the priming pump fuel flows through the secondary and tertiary (third) filter to the high pressure fuel injection pump.

NOTE: *The Engine ECM in the C4.2 engine is not cooled by the fuel.*



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The fuel injection pump is gear driven and mounts to the back of the front timing cover on the right side of the engine. The transfer pump (1) is mounted on the rear of the injection pump. The transfer pump includes a weep hole on the bottom of the pump to allow a fuel path if fuel seeps from the pump. To remove the fuel transfer pump, special tool 239-6824 is required.

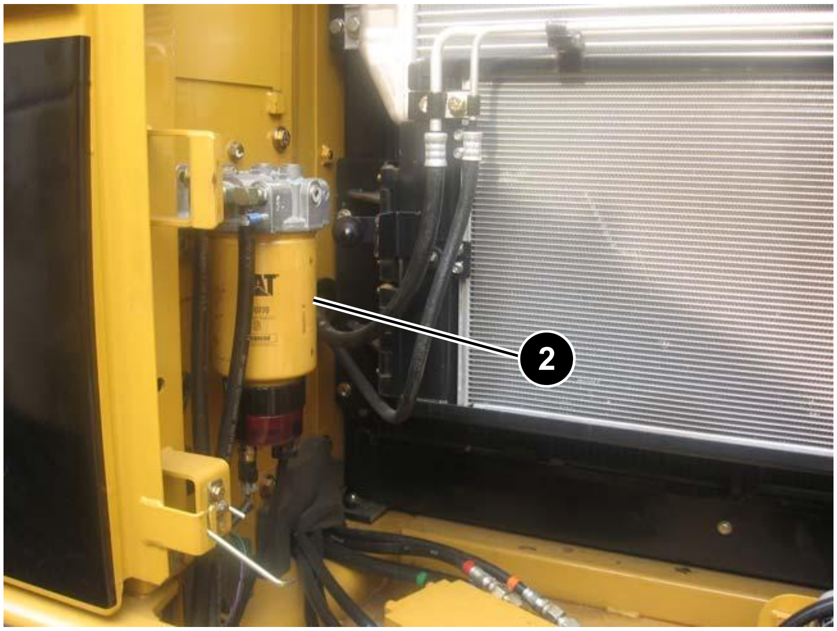
The injection pump (2) and pump solenoid (3) are not serviceable. The injection pump is serviceable as a unit. The transfer pump and the secondary speed/timing sensor (4) are the only components serviced separately on the pump. The primary and secondary speed/timing sensor are the same part number.

> ***NOTE:*** *The pump must be removed from the engine to remove the secondary speed/timing sensor*

The fuel injection pump must be timed to the engine and the pump must be removed to be timed. The injection pump gear is keyed to the pump shaft. To time the injection pump to the engine, the pump gear must be aligned to the engine gears by aligning the timing marks on each gear. Note the injections pump's original position by observing the paint marks on the front gear train before removing the pump.

The engine will start and run and will not derate if the pump timing is incorrect up to 8°, but a diagnostic code will be set. If the pump timing is off more than 8° the engine will not start and a diagnostic code will be set.

> ***NOTE:*** *The flywheel, if removed, must be aligned upon installation. To align the flywheel use a guide bolt to align the flywheel to the crankshaft until the flywheel bolts are installed. Then remove the guide bolt.*



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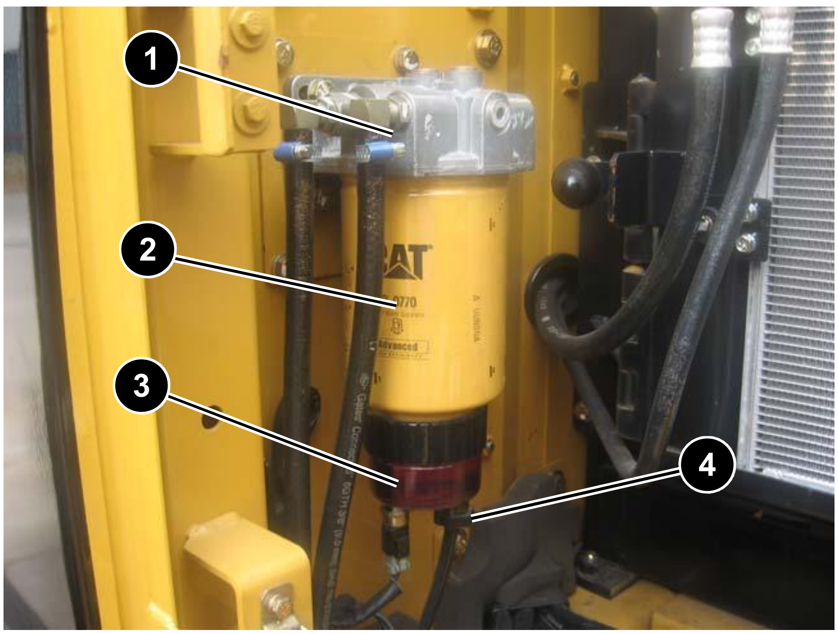

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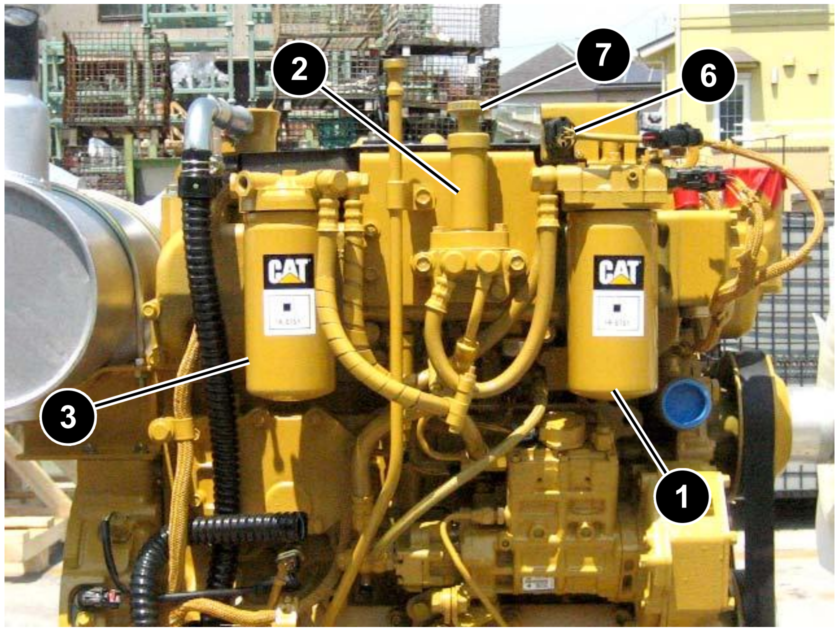
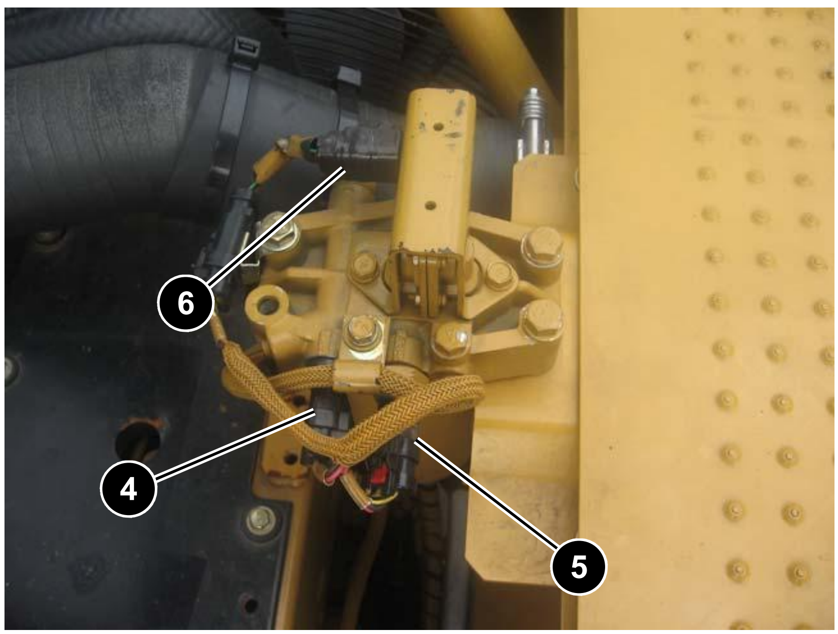
These illustrations show the primary fuel filter in the left rear compartment of a 320D Hydraulic Excavator. The primary fuel filter is installed remotely on the C4.2 and C6.4 engines.

The primary fuel filter assembly consists of the fuel filter base (1), the primary fuel filter element (2), and the fuel/water separator (3). Water in a high pressure fuel system can cause premature failure of the fuel injectors due to corrosion and lack of lubrication. Water should be drained from the water separator daily using the drain valve (4) at the bottom of the filter.



45



46

The secondary fuel filter (1) is a high efficiency filter located on the right side of the engine. Fuel flows from the transfer pump through the priming pump (2) and then to the inlet of the secondary filter.

The Safeguard fuel filter (3) is the tertiary (third) fuel filter in the C4.2/C6.4 fuel system. Similar to the secondary fuel filter, the Safeguard filter is a high efficiency filter. All fuel entering the high pressure section of the injection pump must pass through the secondary fuel filter and the Safeguard filters.

NOTE: *The maintenance schedule for the Safeguard filter is different than the maintenance schedule for the primary and secondary fuel filters. Refer to the appropriate operation and maintenance manual for the recommended service interval for all fuel system filters.*

The fuel temperature sensor (4) and the fuel pressure sensor (5) are installed in the secondary filter base assembly. The fuel temperature sensor is part of the fuel filter monitoring system. By monitoring the temperature of the fuel entering the fuel filtration system, the fuel temperature sensor helps to prevent false fuel filter restriction events in either the primary or secondary filters due to cold, high viscosity fuel. The fuel pressure sensor monitors the fuel pressure in the low pressure fuel circuit.

The fuel differential pressure sensor (6) monitors the secondary fuel filter for filter restriction. If the secondary fuel filter becomes clogged, the secondary fuel pressure switch will open and the Engine ECM will activate the action lamp in the cab and log a secondary fuel filter restriction event. The engine will also derate 20% if the secondary fuel filter is 80% restricted.

When replacing a fuel filter on the C4.2 or C6.4 engine, the fuel system must be primed prior to starting or cranking the engine. Do not pre-fill new fuel filters prior to installation on the engine. Pre-filling the filters can introduce contaminants into the fuel system and cause damage.

Priming is accomplished using the hand priming pump. Open the air bleed plug. Pump the plunger (7) more than 100 times to prime the system.

After priming the fuel system there should be sufficient fuel in the fuel filters to allow the engine to start and run. Do not open any fuel lines during the priming procedure.

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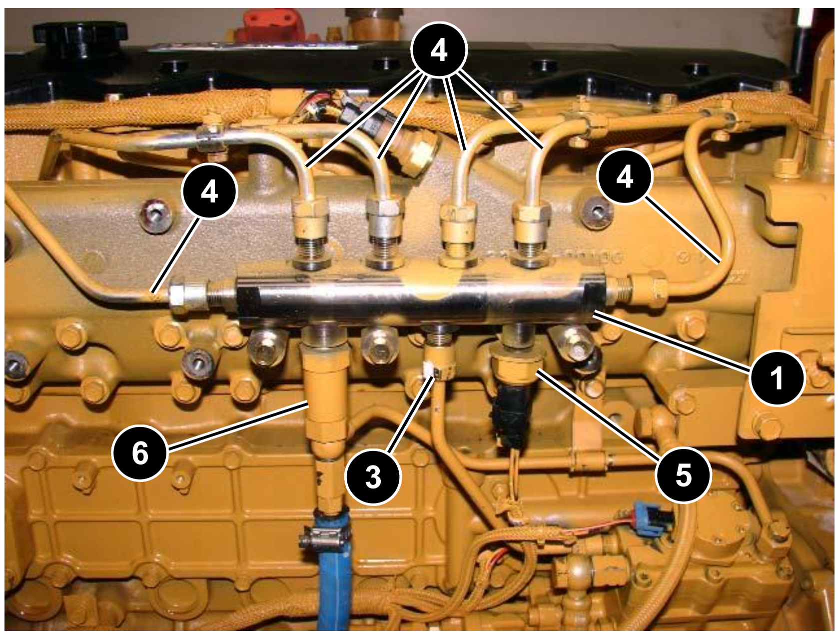


48

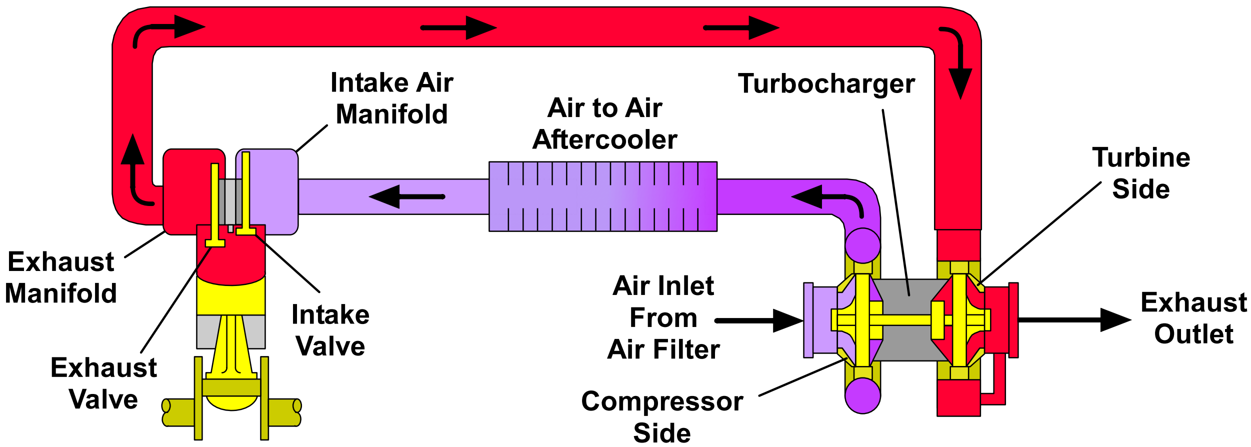
The common rail fuel manifold (1) is mounted to the right side of the inlet air manifold on the right side of the engine. To access the manifold a cover (2) must be removed.

High pressure fuel from the fuel injection pump enters the common rail manifold at the inlet fitting (3). The common rail manifold distributes the high pressure fuel evenly to the four or six fuel injector supply pipes (4). The steel fuel pipes pass through the valve cover base and connect to individual fuel injectors.

A fuel rail pressure sensor (5) is used to monitor the pressure of the common rail high pressure fuel system. The Engine ECM will monitor the signal from the fuel rail pressure sensor and maintain optimum fuel system pressure for any given load or temperature condition.

A fuel pressure relief valve (6) is used to protect the high pressure fuel system from fuel pressure spikes. The fuel pressure relief valve will open at a constant pressure of 130 MPa (18,855 psi) and withstand a pressure spike of up to 190 Mpa (27,560 psi).

C4.2 / C6.4 ACERT™ AIR INTAKE AND EXHAUST SYSTEM



49

Air Inlet System

Intake air is drawn into the engine air precleaner by the vacuum created by the compressor wheel in the turbocharger. The precleaner removes any large particles from the intake air and ejects them through the exhaust stack. The intake air is then drawn through the air cleaner elements in the air cleaner housing where any fine contaminants are removed by the filter elements. Cleaned intake air is then drawn into the compressor side of the turbocharger.

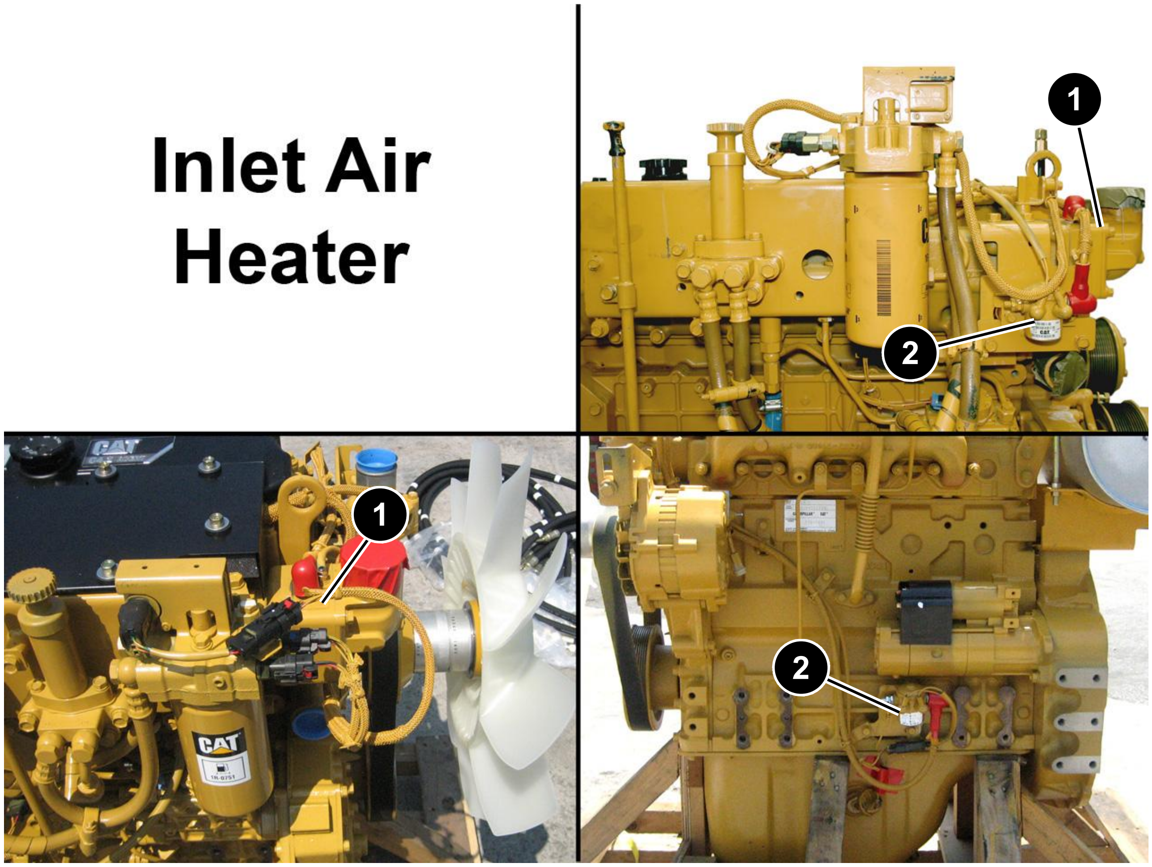
The turbocharger compresses the intake air and forces it out of the compressor outlet. The heated and compressed intake air next flows to the inlet of the ATAAC core. As the intake air passes through the ATAAC core, the air is cooled by the flow of air from the engine fan and becomes more dense.

Compressed, cooled intake air is next directed to the inlet air manifold, through the inlet air tube, and into the cylinder head. During the intake stroke, air is forced into the cylinders around the intake valves in the cylinder head.

➡

The exhaust manifold directs exhaust gasses to the turbine side of the turbocharger. Hot, high pressure exhaust gasses contact the blades of the turbine wheel inside the turbine housing causing the turbine shaft to spin. The turbine shaft is mechanically connected to the compressor wheel on the inlet side of the turbocharger.

The hot exhaust gas stream gives up most of its energy to the exhaust turbine wheel. This low energy exhaust stream exits the turbine housing through the turbine nozzle, flows through the exhaust pipe and into the muffler, and finally exits at the exhaust stack.

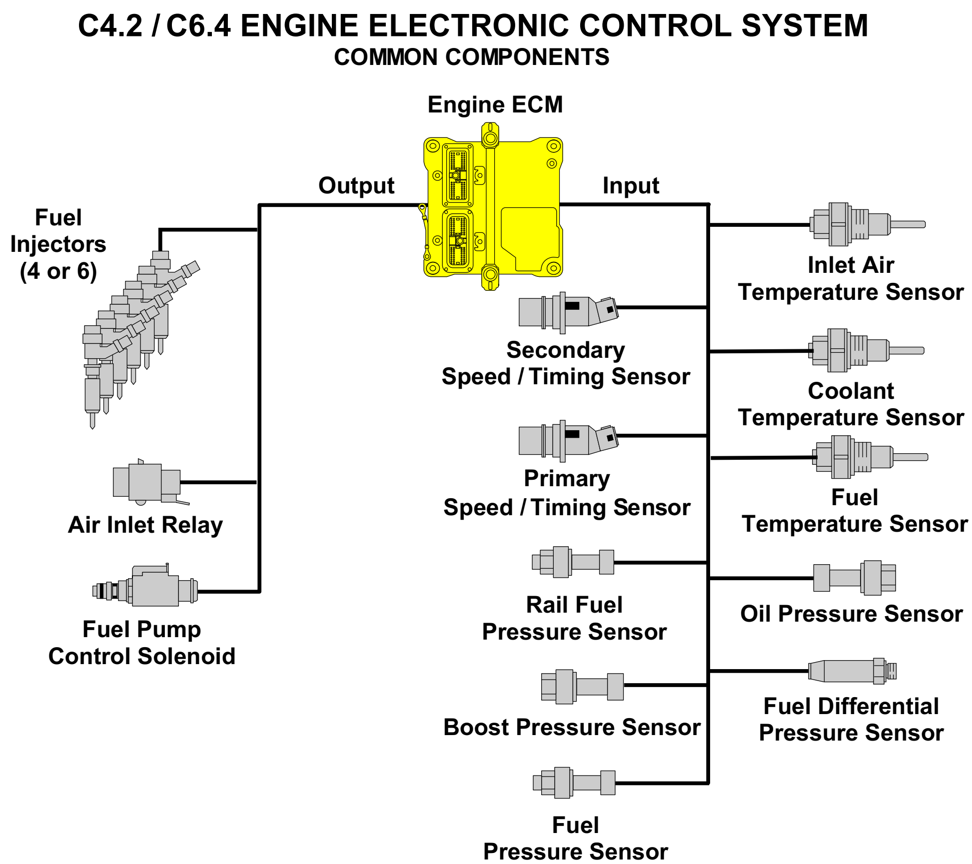


50

For cold weather starting, the C4.2 and C6.4 engines use an inlet air heater (1). The inlet air heater heats the incoming air to aid in engine starting during cold weather.

The air inlet heater relay (2) is controlled by the Engine ECM. Based on the engine air and engine coolant temperature, the ECM will energize the air inlet relay, which provides power to the inlet heating element.

The top right illustration shows the inlet air heater and relay on the C6.4 engine. The bottom illustrations show the inlet air heater and relay on the C4.2 engine.



51

Electrical System

This diagram shows the common components of the C4.2/C6.4 engine electronic control system. The sensors shown on the right provide the Engine ECM with input that controls the fuel injectors, air inlet relay, and fuel pump. The Engine ECM has two 64-pin sockets connecting to the engine harness and machine harness.

The engine electronic control system primarily performs the engine fuel control function. A solenoid on each injector receives an ON/OFF signal from the Engine ECM that triggers the timing and amount of fuel delivered to the combustion chamber. The engine electronic control system also monitors other functions that are critical for engine performance, such as lubrication, combustion air, and cooling.

> ***NOTE:*** *This illustration shows the common input and output components on the C4.2/C6.4 engines. Other input and output components are installed on specific machine applications.*

Basic C4.2/C6.4 Engine ECM Input Component Specifications:

- **Primary Engine Speed/Timing Sensor** - active sensor, 2-wire Hall effect

- **Secondary Engine Speed/Timing Sensor** - active sensor, 2-wire Hall effect

- **Engine Oil Pressure Sensor** - active 5 V supply; 3-wire; rated to 882 kPa ABSOLUTE (kPaA) (128 psi)

- **Intake Manifold Air (Boost) Pressure Sensor** - active 5 V supply; 3-wire; rated to 339 kPa ABSOLUTE (kPaA) (49.2 psi)

- **Fuel Pressure Sensor** - on/off 5 V supply, 3-wire

- **Fuel Differential Pressure Sensor** - active 5 V supply; 3-wire

- **Fuel Rail Pressure Sensor** - active 5 V supply; 3-wire; rated to 270 MPa (31,908 psi)

- **Intake Manifold Air Temperature Sensor** - passive; 2-wire; minimum temperature -40° C (-40° F), maximum temperature 150° C (302° F)

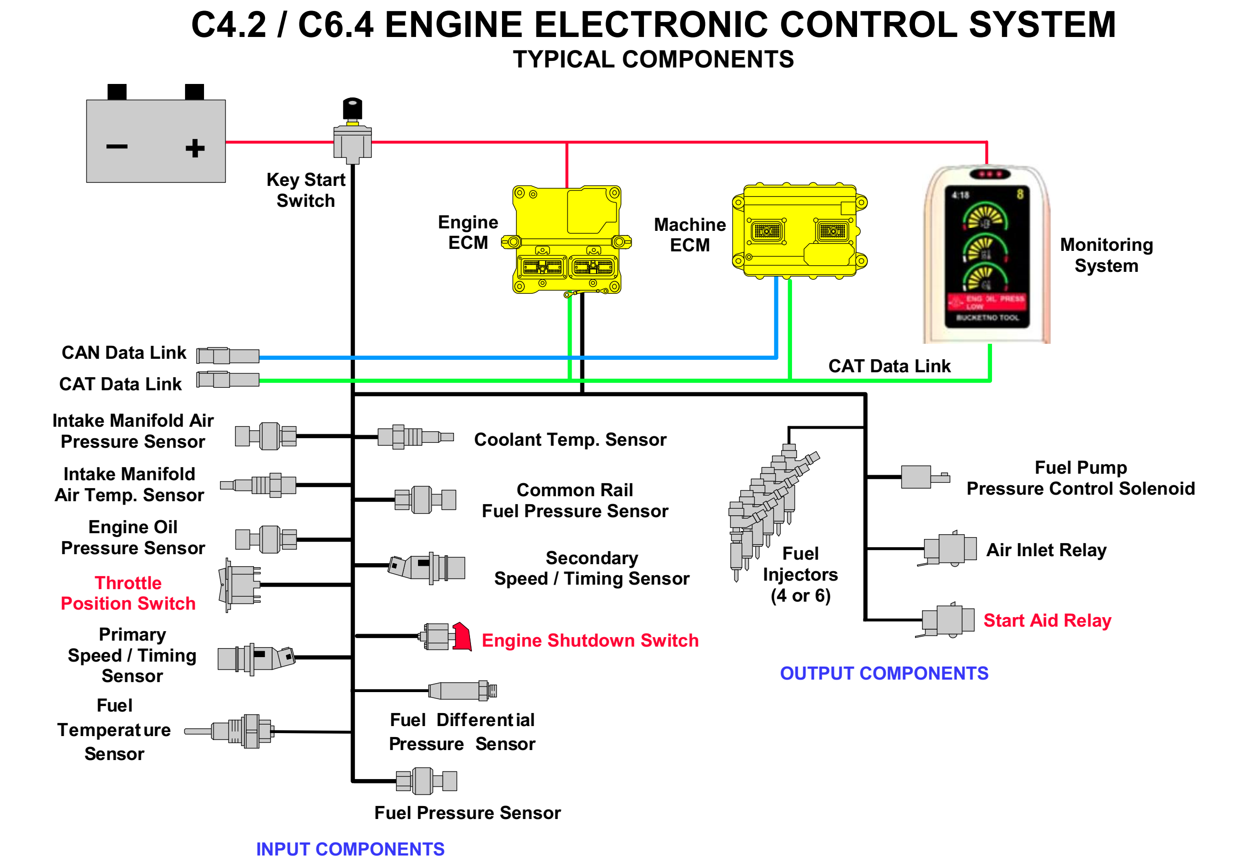
- **Engine Coolant Temperature Sensor** - passive; 2-wire; minimum temperature -40° C (-40° F), maximum temperature 150° C (302° F)

- **Fuel Temperature Sensor** - passive; 2-wire

Basic C4.2/C6.4 Engine ECM Output Component Specifications:

- **Fuel Injectors** - 70 V supply

- **Fuel Pump Pressure Control Solenoid** - 70 V supply



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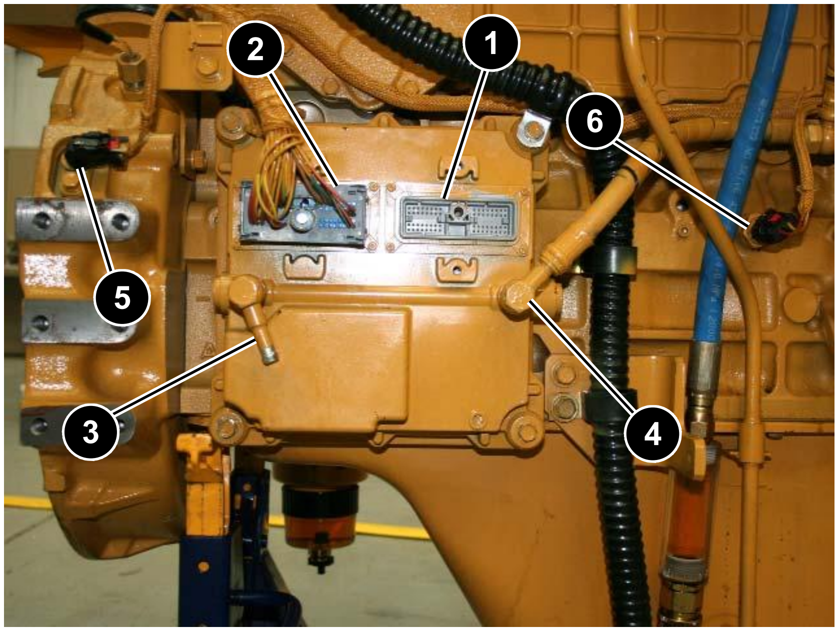
This diagram shows some of the typical input and output components of the C4.2/C6.4 engine electronic control system in addition to the common components shown in the previous illustration.

Many machine applications include an additional ECM to control some of the machine systems and a monitoring system to monitor the engine and machine systems. The input and output components shown in red are also installed on some machine applications.

In some machine applications the throttle input from the operator is an input to the Machine ECM. The Machine ECM then sends a signal to the Engine ECM over the CAT or CAN Data Link.

> ***NOTE:*** *To determine the engine electronic control system components on a specific machine, refer to the appropriate machine specific service information.*



53

C4.2/C6.4 uses an A4-E2 Engine ECM. The ECM controls:

- Fuel pressure
- Speed governing
- Air/fuel ratio
- Start/stop sequence
- Engine protection devices/diagnostics

The ECM features two 64-pin sockets for the machine harness connector (1) and the engine harness connector (2). A new pin removal tool is available.

The ECM case is completely sealed against dirt and moisture. The sealed case is cooled with fuel from the primary fuel filter to help dissipate heat from the electronics inside. Fuel enters at the left (3) and exits at the right (4).

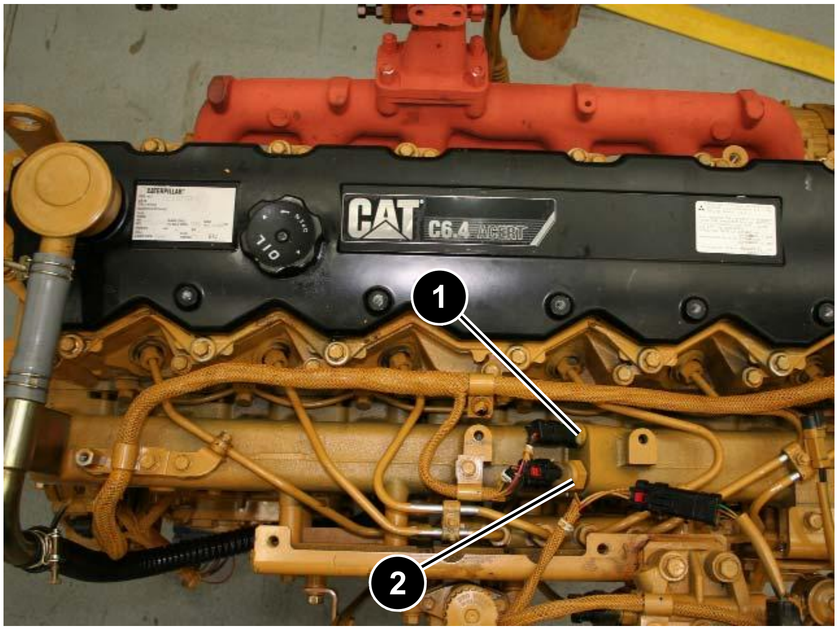
NOTE: *This illustration shows the Engine ECM on a C6.4 engine. The Engine ECM is not mounted on the C4.2 engine, but is remotely located.*

When reinstalling the ECM, make sure the grounding strap is secured to a clean connection and the fasteners are properly torqued. Anti-vibration mounts fit into the holes at each corner.

Primary engine speed data is provided by the primary engine speed/timing sensor (5), or crank speed/timing sensor. The primary engine speed/timing sensor is located on the flywheel housing at the right rear of the engine block. Failure of the primary speed/timing sensor while the engine is running will cause the Engine ECM to look at the secondary speed/timing sensor for engine speed information. The engine will continue to run using only the secondary speed sensor signal for engine rpm.

The engine oil pressure sensor (6) is also located on the right side of the engine block. The sensor is installed in the right engine oil galley forward of the Engine ECM. Low engine oil pressure, sensor failure, or wiring failure will not result in an engine derate or shutdown but will cause a fault to be logged in the Engine ECM.

The status of the primary engine speed sensor and the engine oil pressure sensor can be viewed with Cat ET.



54

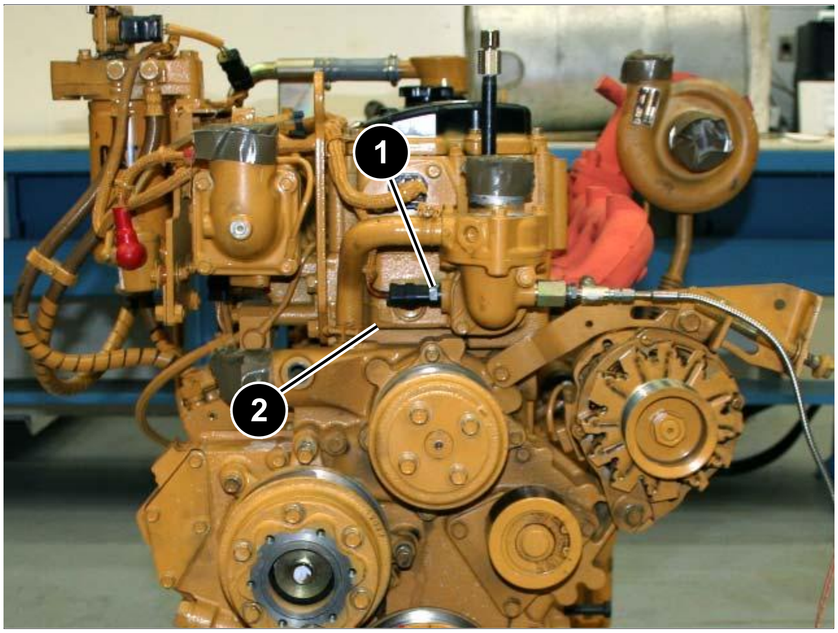
The inlet air temperature sensor (1) and the inlet air pressure (boost) sensor (2) are installed in the air inlet manifold on the right side of the engine.

The inlet air temperature sensor is a passive 2 wire sensor and is an input to the Engine ECM. The signals from the inlet air temperature sensor and the coolant temperature sensor are used to determine engine starting aid requirements and to trim (adjust) injector pulse width as engine operating temperatures change.

The air inlet pressure sensor is an active 3 wire sensor. The Engine ECM will use the signal from this sensor to determine boost pressures supplied by the turbocharger. The air inlet pressure sensor is used with the Engine ECM to control the air/fuel ratio electronically. This feature allows very precise smoke control, which was not possible with mechanically governed engines.

> ***NOTE:*** *The air inlet pressure sensor also acts as an atmospheric pressure sensor by taking a snap shot of atmospheric pressure when the key start switch is first turned to the ON position.*

The status of the inlet air temperature sensor and the inlet air pressure sensor can be viewed with Cat ET.



55

The coolant temperature sensor (1) is installed in the front left corner of the cylinder head (2). The coolant temp sensor is a "passive" two wire variable resistor type sensor that sends a signal to the Engine ECM indicating coolant temperature.

CAT ET DIAGNOSTICS

- View engine derates
- View component status
- Configure engine parameters
- View diagnostic codes and events
- Flash ECM
- Perform diagnostic tests

56

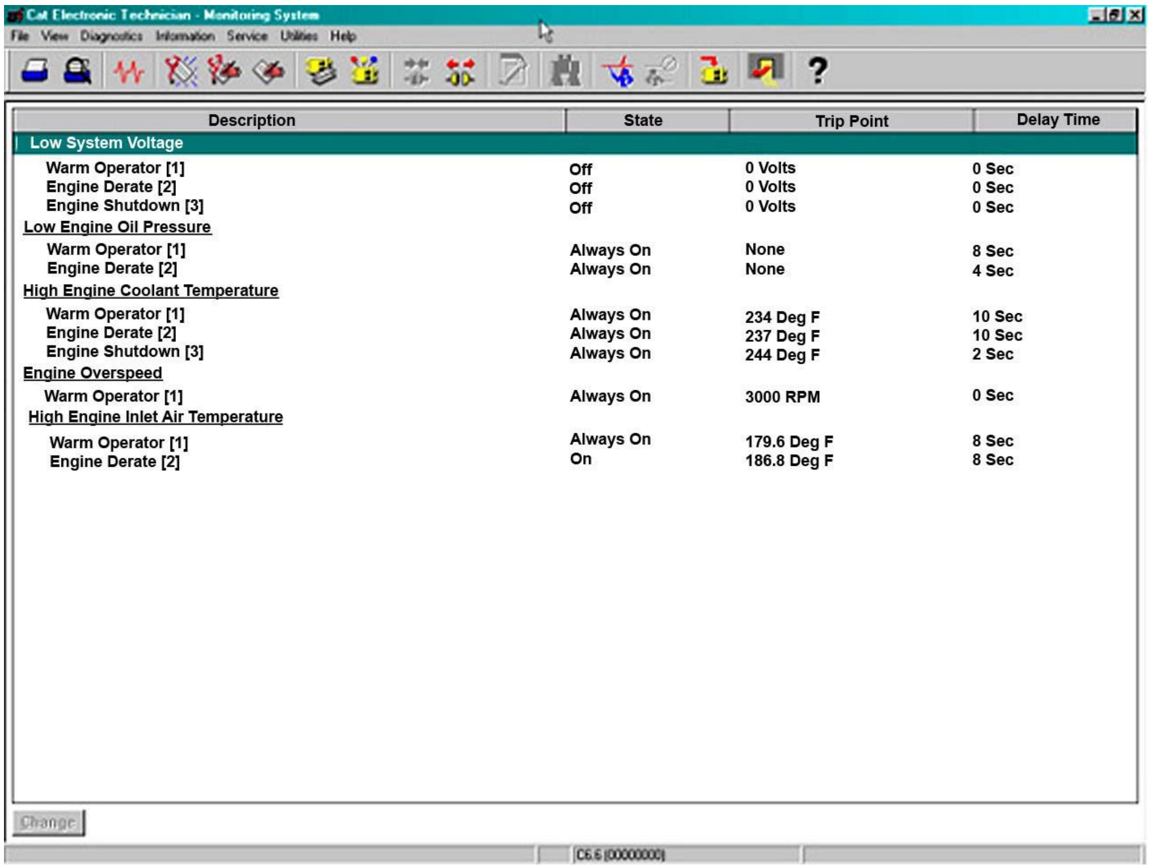
ENGINE DIAGNOSTICS

Caterpillar Electronic Technician (Cat ET)

Cat ET can be used to diagnose problems with the C4.2/C4.4 and C4.4/C6.6 engines. The following tasks can be performed with Cat ET to aid in engine diagnosis:

- View engine derates
- View component status
- Configure engine parameters
- View diagnostic codes and events
- Flash ECM
- Perform diagnostic tests

Before performing the above tasks ensure the engine cranking speed is greater than 150 rpm and the fuel rail pressure (while cranking engine) is greater than 17235 kPa (2500 psi).



57

This screen displays all the warning, derate, and shutdown levels that are currently set within the ECM.

The derates cannot be changed but the derate information can be useful for diagnosing engine faults.

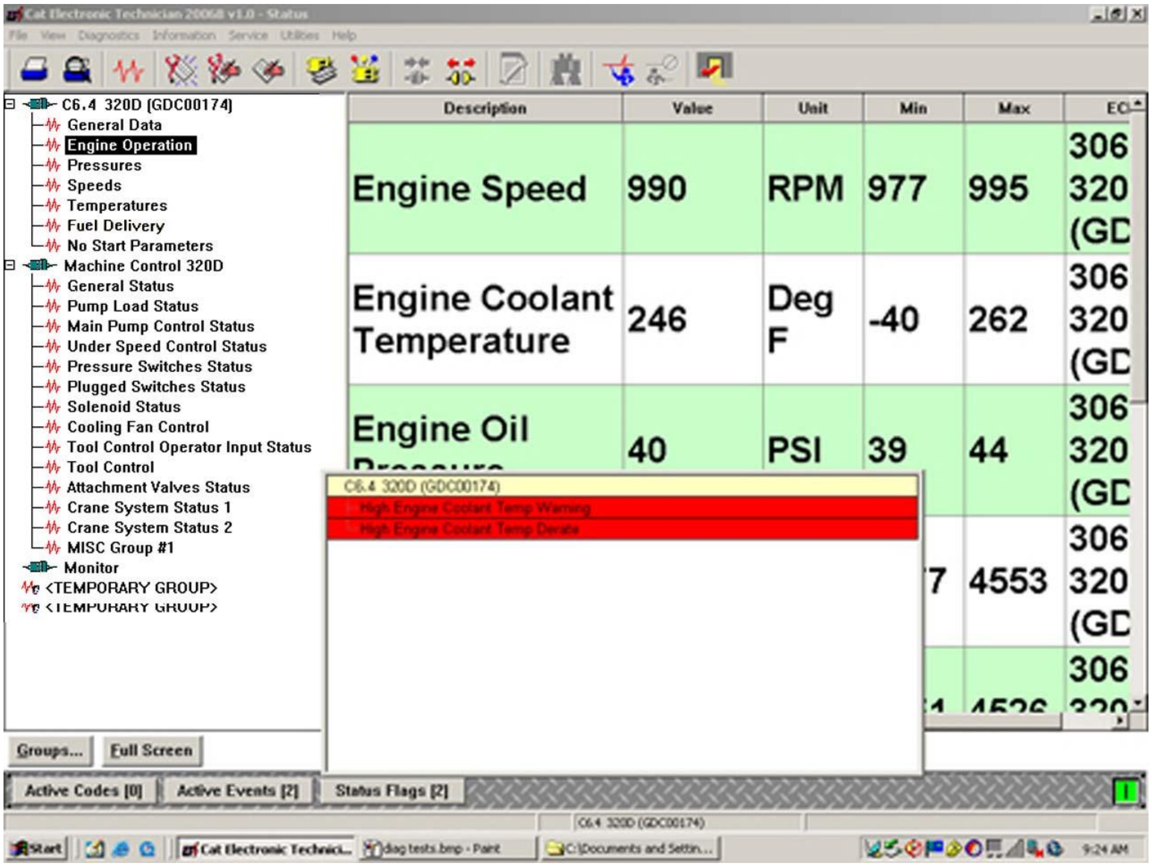
A warning represents a serious problem with engine operation, but a warning condition does not require a derate or a shutdown.

When an engine derate parameter is reached, the Engine ECM decreases the engine's power to help prevent possible engine damage.

When an engine shutdown parameter is reached, the Engine ECM shuts down the engine to help prevent possible engine damage.

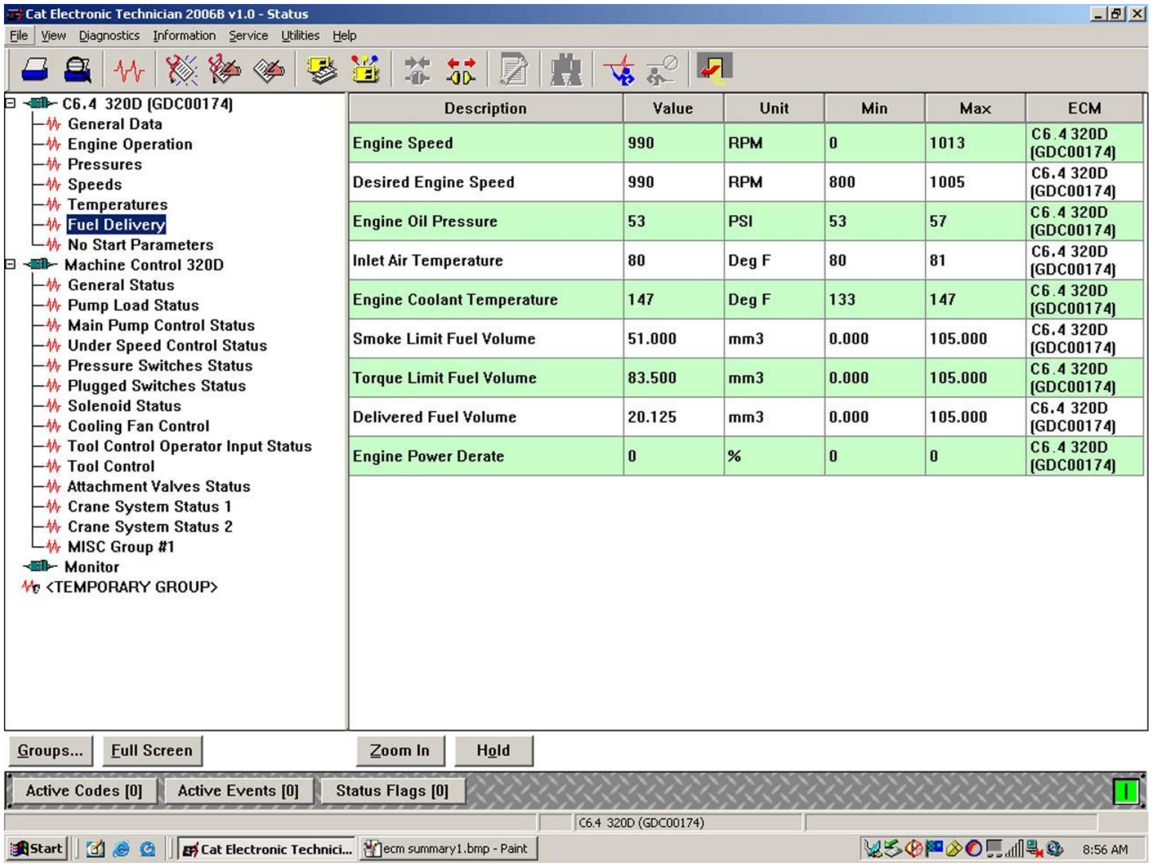
When the Engine is derated by the Engine ECM, the ECM will decrease engine power by reducing fuel and limiting engine speed. The engine is derated according to the derate map in the specific machine application.

> ***NOTE:*** *The engine derate information as shown in this illustration is not always available and is dependent on the particular flash file.*



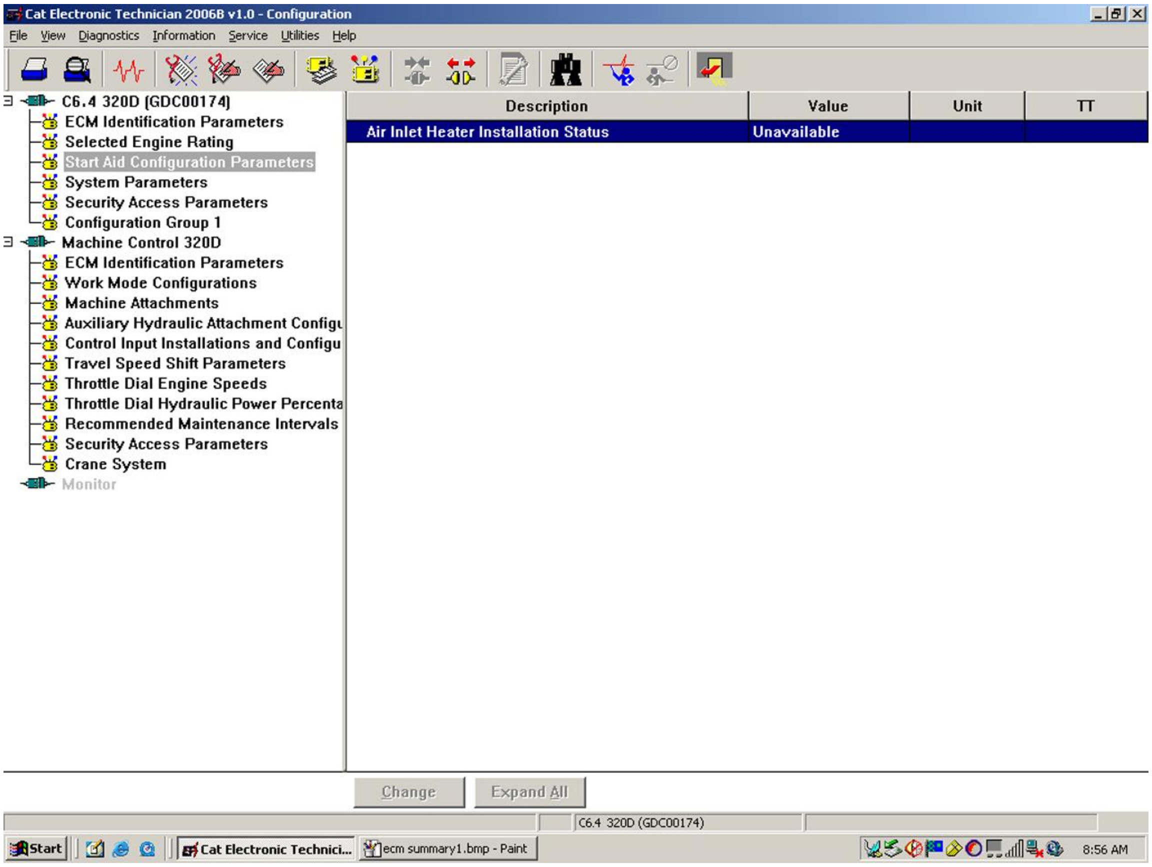
58

This illustration shows an engine coolant warning and derate condition on the Cat ET status screen.



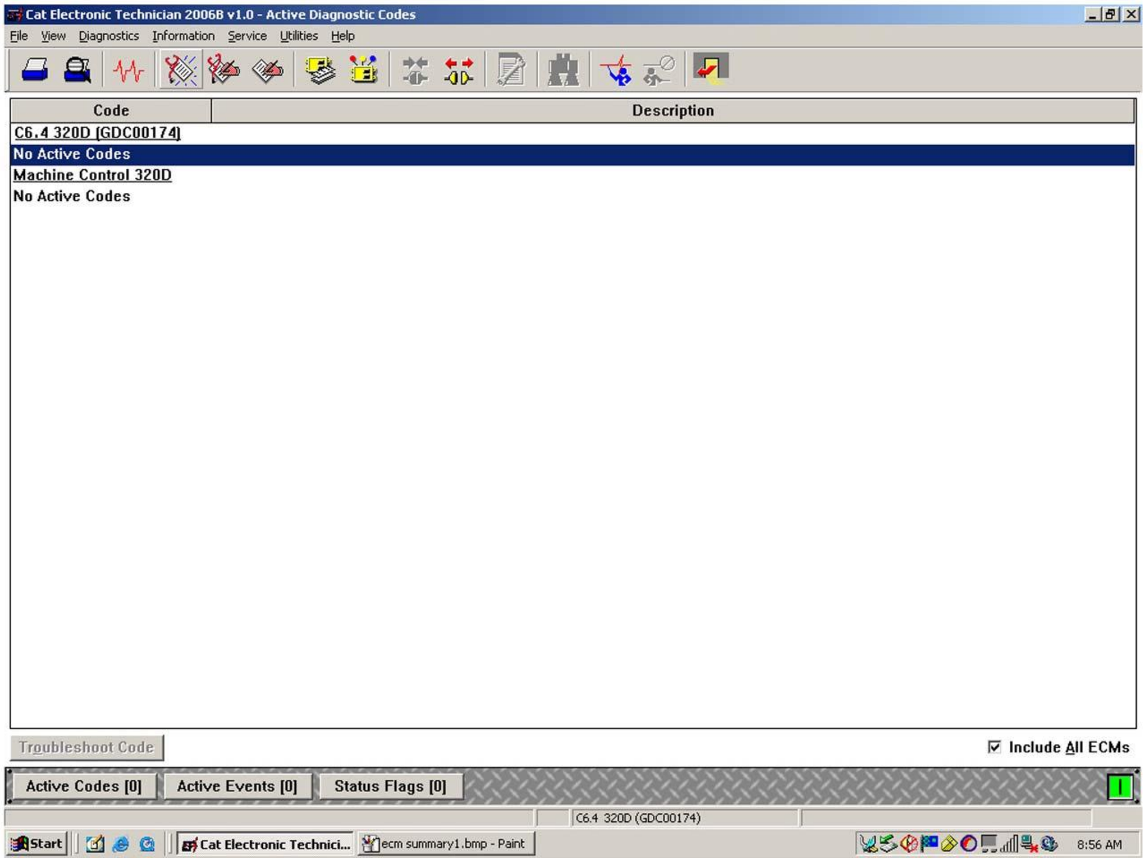
59

This illustration shows a Cat ET status screen on the C6.4 engine in a 320D Hydraulic Excavator. The status screens can be used to view the component parameters to help detect engine problems.



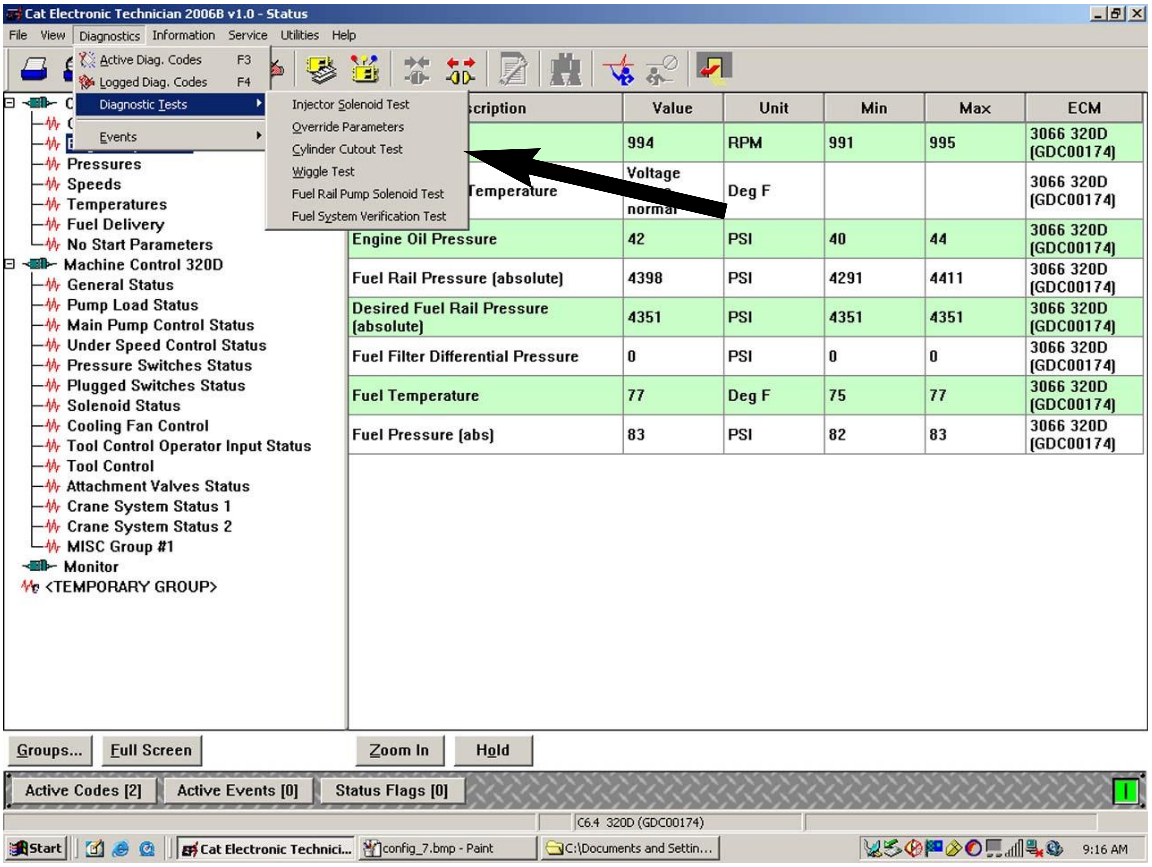
60

Cat ET configuration screens are used to configure engine parameters. This configuration screen shows the installation status of the air inlet heater on the C6.4 engine in the 320D Hydraulic Excavator.



61

Diagnostic codes and events can be viewed and cleared with Cat ET. This illustration shows no active diagnostic codes on the C6.4 engine.



62

This illustration shows the diagnostic tests (arrow) that can be performed with Cat ET. The diagnostic tests are:

- **Injector Solenoid Test** - The Injector Solenoid Test verifies that the circuits from the ECM to the injector are functioning properly. The ECM injector power supply, the wiring harnesses, and the injector solenoids are tested.

- **Override Parameters** - The Override Parameters function enables circuits such as the check engine lamp to be turned on or off for troubleshooting purposes.

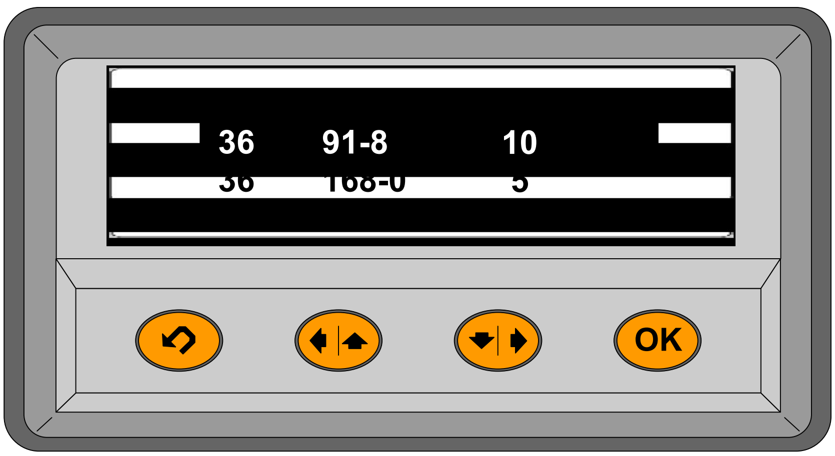
- **Cylinder Cutout Test** - The Cylinder Cutout Test allows selected cylinders to be disabled ("cutout") to help determine if a cylinder is misfiring.

- **Wiggle Test** - The Wiggle Test function allows the user to determine if there is an intermittent wiring problem by indicating which parameter on the screen has moved beyond a predetermined range while "wiggling" the wiring harness, sensors, connector, etc.

- **Fuel Rail Pump Solenoid Test (C4.4/C6.6 only)** - The Fuel Rail Pump Solenoid Test verifies that the circuits from the ECM to the pump solenoid are functioning properly. The ECM pump solenoid power supply, the wiring harnesses, and the pump solenoid are tested.

- **Fuel System Verification Test** - The Fuel System Verification Test performs corrections if needed to the current "start of injection time." The verification test ensures all injectors are trimmed correctly, running efficiently, and maintaining emissions output from the engine.

63



64

Monitoring Systems

Most machine applications are equipped with a monitoring system that can also be used to diagnose the engine.

The top illustration shows the Messenger display module in the D6K Track-type Tractor. The bottom illustration shows the diagnostics option that displays a diagnostic code. Each line on the list will show the following information:

- SRC (Source ID)
- CODE
- OCC (Number of occurrences of the event or code)
- ACT (if the code is active or inactive)

65

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These illustrations show the monitoring system display in the 320D Hydraulic Excavator. The top illustration shows a coolant temperature derate. The bottom illustration shows three logged error codes.

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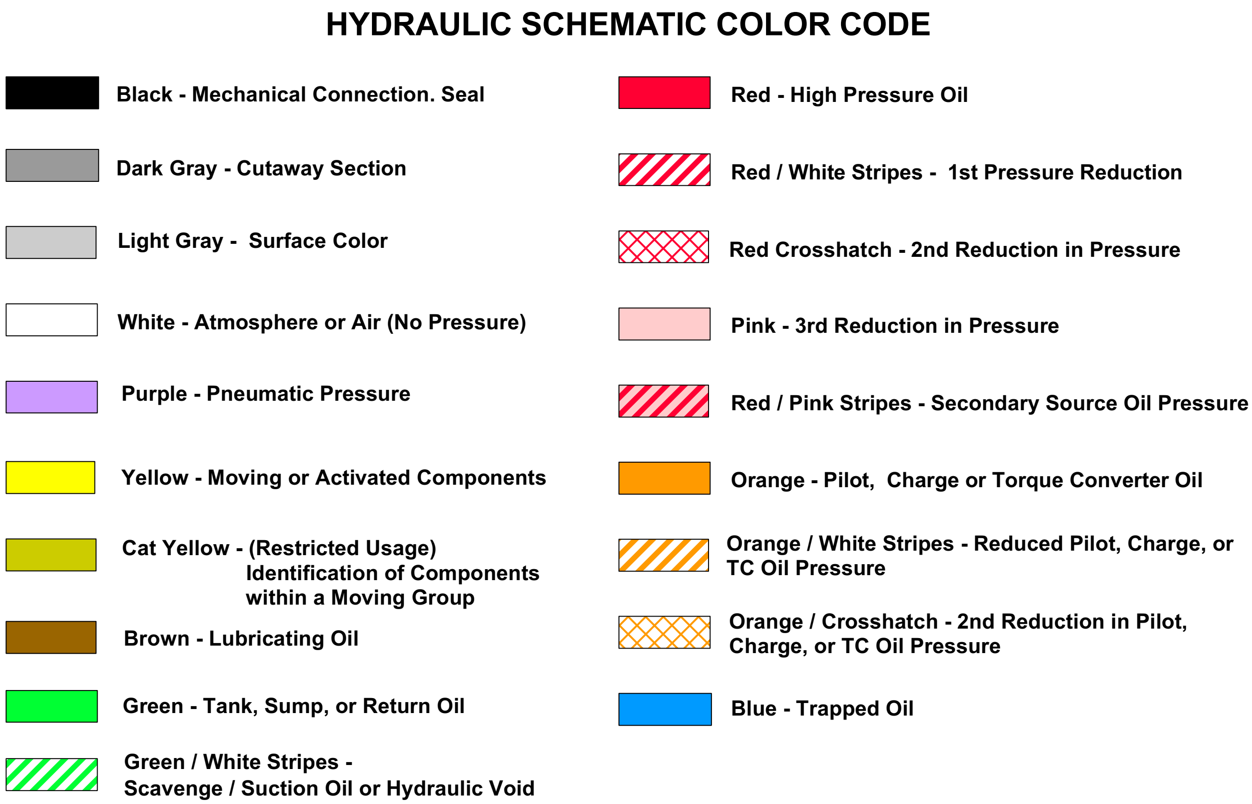
CONCLUSION

This concludes the presentation on the C4.2/C6.4 and C4.4/C6.6 ACERT™ engines. When used in conjunction with the service manual, the information in this package should permit the technician to analyze in-chassis engine problems on these engines.

VISUAL LIST



HYDRAULIC SCHEMATIC COLOR CODE

This illustration identifies the meanings of the colors used in the hydraulic schematics and cross-sectional views shown throughout this presentation.

HYDRAULIC SCHEMATIC COLOR CODE

- Black - Mechanical Connection. Seal
- Dark Gray - Cutaway Section
- Light Gray - Surface Color
- White - Atmosphere or Air (No Pressure)
- Purple - Pneumatic Pressure
- Yellow - Moving or Activated Components
- Cat Yellow - (Restricted Usage) Identification of Components within a Moving Group
- Brown - Lubricating Oil
- Green - Tank, Sump, or Return Oil
- Green / White Stripes - Scavenge / Suction Oil or Hydraulic Void
- Red - High Pressure Oil
- Red / White Stripes - 1st Pressure Reduction
- Red Crosshatch - 2nd Reduction in Pressure
- Pink - 3rd Reduction in Pressure
- Red / Pink Stripes - Secondary Source Oil Pressure
- Orange - Pilot, Charge or Torque Converter Oil
- Orange / White Stripes - Reduced Pilot, Charge, or TC Oil Pressure
- Orange / Crosshatch - 2nd Reduction in Pilot, Charge, or TC Oil Pressure
- Blue - Trapped Oil

C4.4/C6.6 Engine Component Identification

_____ Fuel injectors

Function:

Location:

_____ Fuel injection pump

Function:

Location:

_____ Fuel manifold

Function:

Location:

_____ Coolant temperature sensor

Function:

Location:

_____ Inlet manifold temperature sensor

Function:

Location:

_____ Inlet manifold (boost) pressure sensor

Function:

Location:

C4.4/C6.6 Engine Component Identification (continued)

_____ Oil pressure sensor

Function:

Location:

_____ Fuel rail pressure sensor

Function:

Location:

_____ Primary (crank) speed/timing sensor

Function:

Location:

_____ Secondary (cam) speed/timing sensor

Function:

Location:

_____ Wastegate solenoid valve

Function:

Location:

_____ Fuel pump solenoid valve

Function:

Location:

C4.4/C6.6 Engine Component Identification (continued)

_____ **Engine ECM**

Function:

Location:

_____ **Fuel pressure relief valve**

Function:

Location:

_____ **Primary fuel filter**

Function:

Location:

_____ **Secondary fuel filter**

Function:

Location:

_____ **Tertiary (third) fuel filter**

Function:

Location:

_____ **Fuel return check valve**

Function:

Location:

C4.2/C6.4 Engine Component Identification

_____ Fuel injectors

Function:

Location:

_____ Fuel injection pump

Function:

Location:

_____ Fuel manifold

Function:

Location:

_____ Coolant temperature sensor

Function:

Location:

_____ Inlet manifold temperature sensor

Function:

Location:

_____ Inlet manifold (boost) pressure sensor

Function:

Location:

C4.2/C6.4 Engine Component Identification (continued)

_____ Oil pressure sensor

Function:

Location:

_____ Fuel rail pressure sensor

Function:

Location:

_____ Primary (crank) speed/timing sensor

Function:

Location:

_____ Secondary (cam) speed/timing sensor

Function:

Location:

_____ Fuel temperature sensor

Function:

Location:

_____ Fuel pump solenoid valve

Function:

Location:

C4.2/C6.4 Engine Component Identification (continued)

_____ Engine ECM

Function:

Location:

_____ Fuel pressure relief valve

Function:

Location:

_____ Primary fuel filter

Function:

Location:

_____ Secondary fuel filter

Function:

Location:

_____ Tertiary (third) fuel filter

Function:

Location:

_____ Fuel pressure switch

Function:

Location:

C4.2/C6.4 Engine Component Identification (continued)

_____ Air inlet heater

Function:

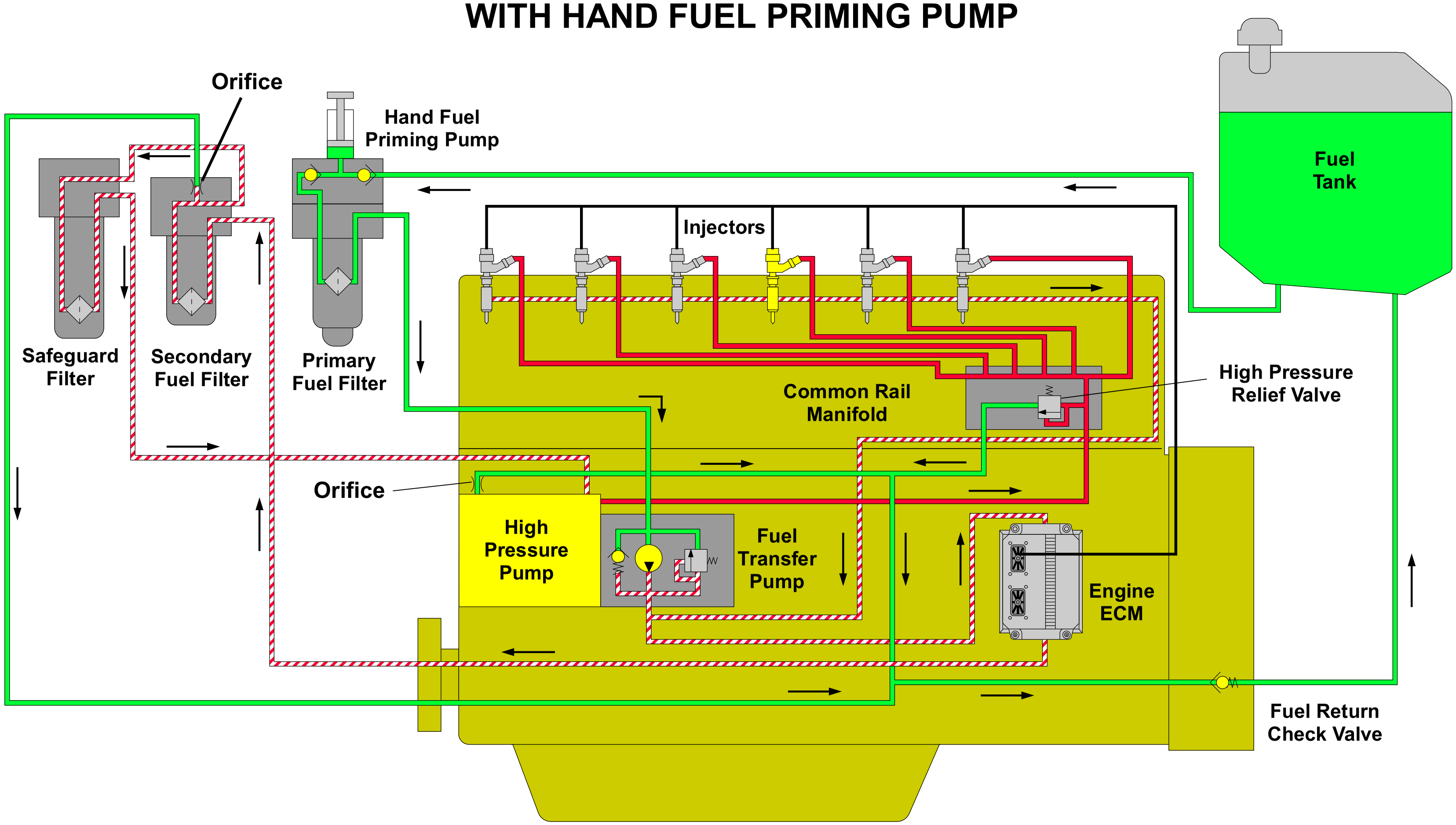
Location:

_____ Air inlet heater relay

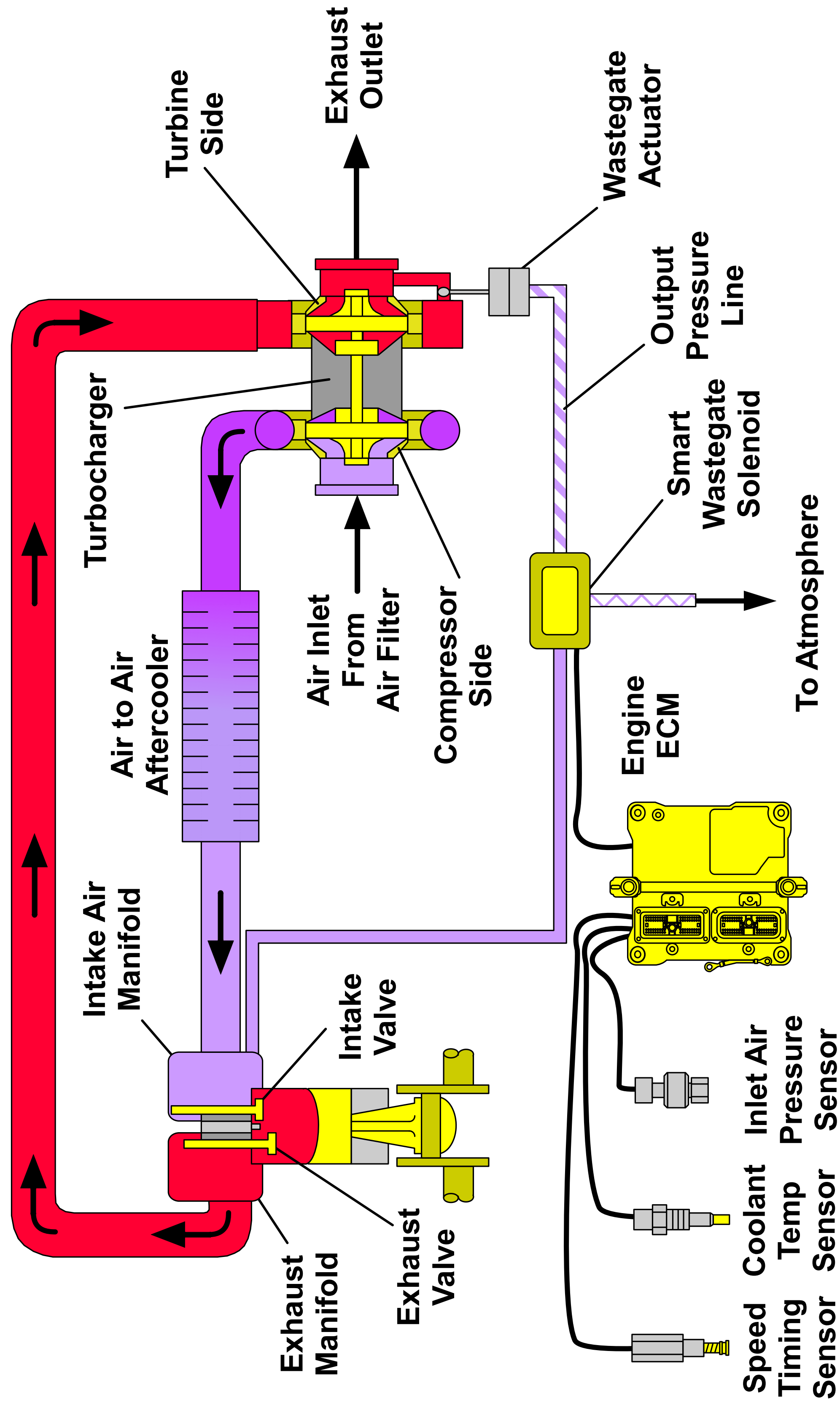
Function:

Location:

C6.6 ACERT™ ENGINE FUEL DELIVERY SYSTEM
WITH HAND FUEL PRIMING PUMP

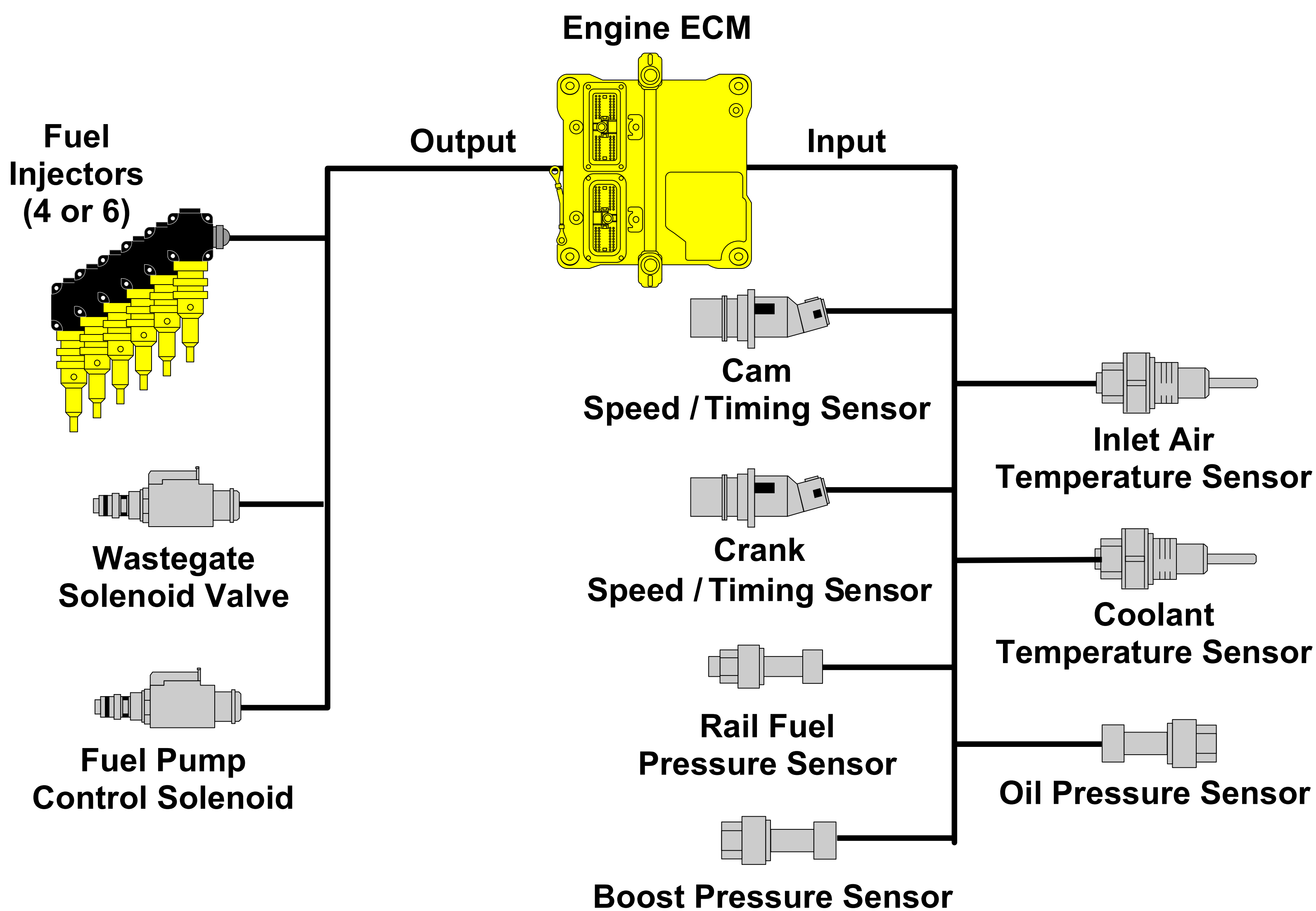


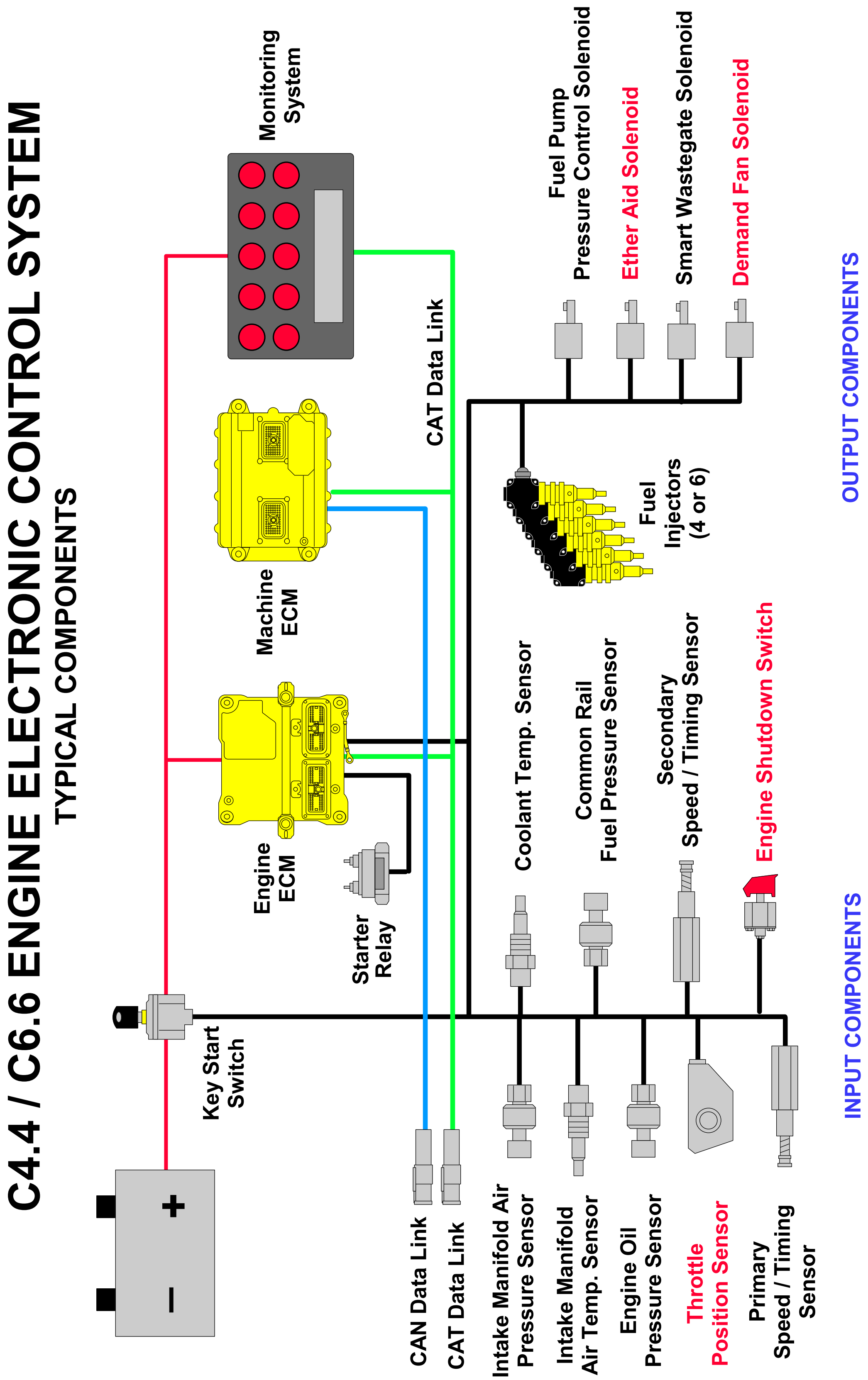
C4.4 / C6.6 ACERT™ AIR INTAKE AND EXHAUST SYSTEM



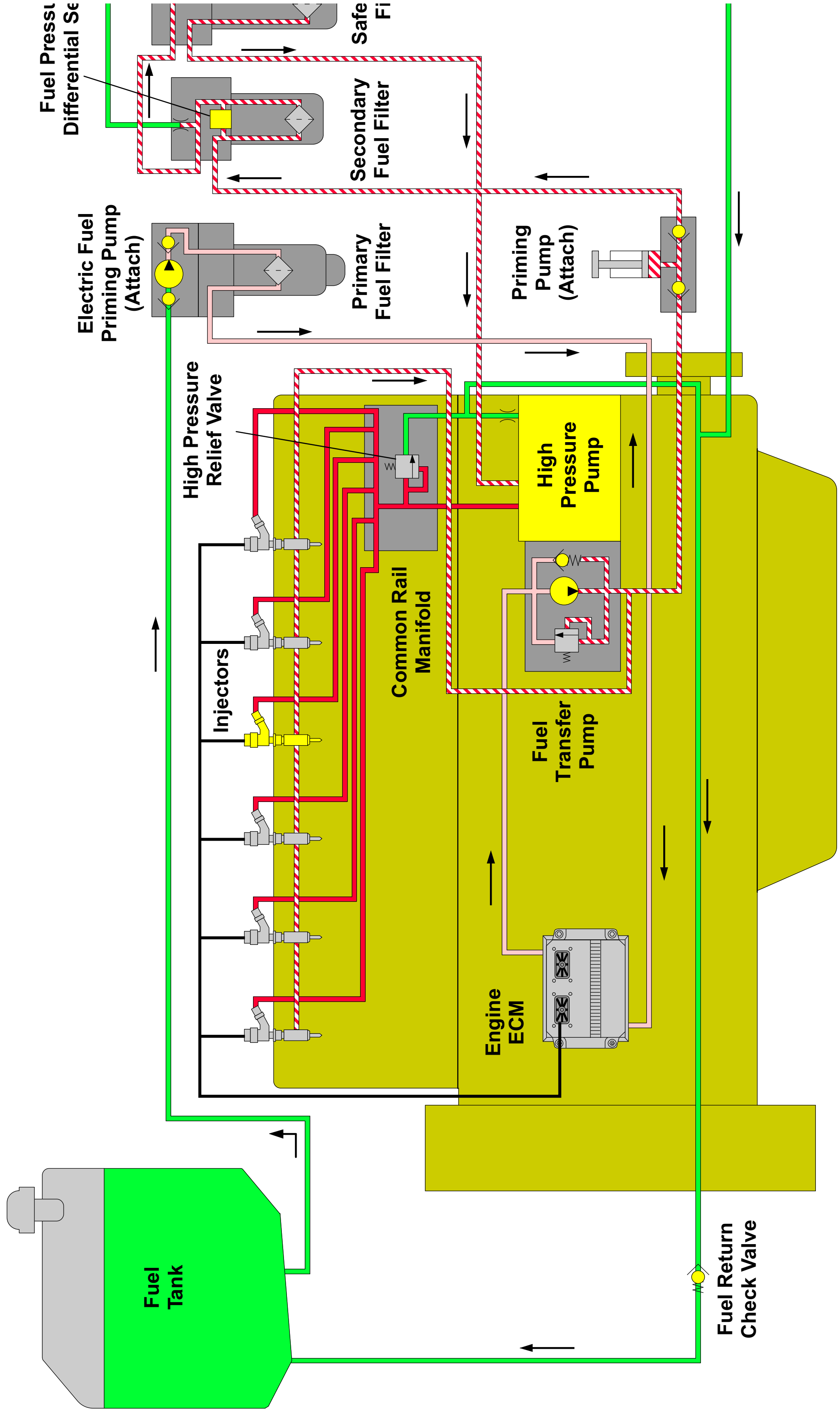
C4.4 / C6.6 ENGINE ELECTRONIC CONTROL SYSTEM

COMMON COMPONENTS



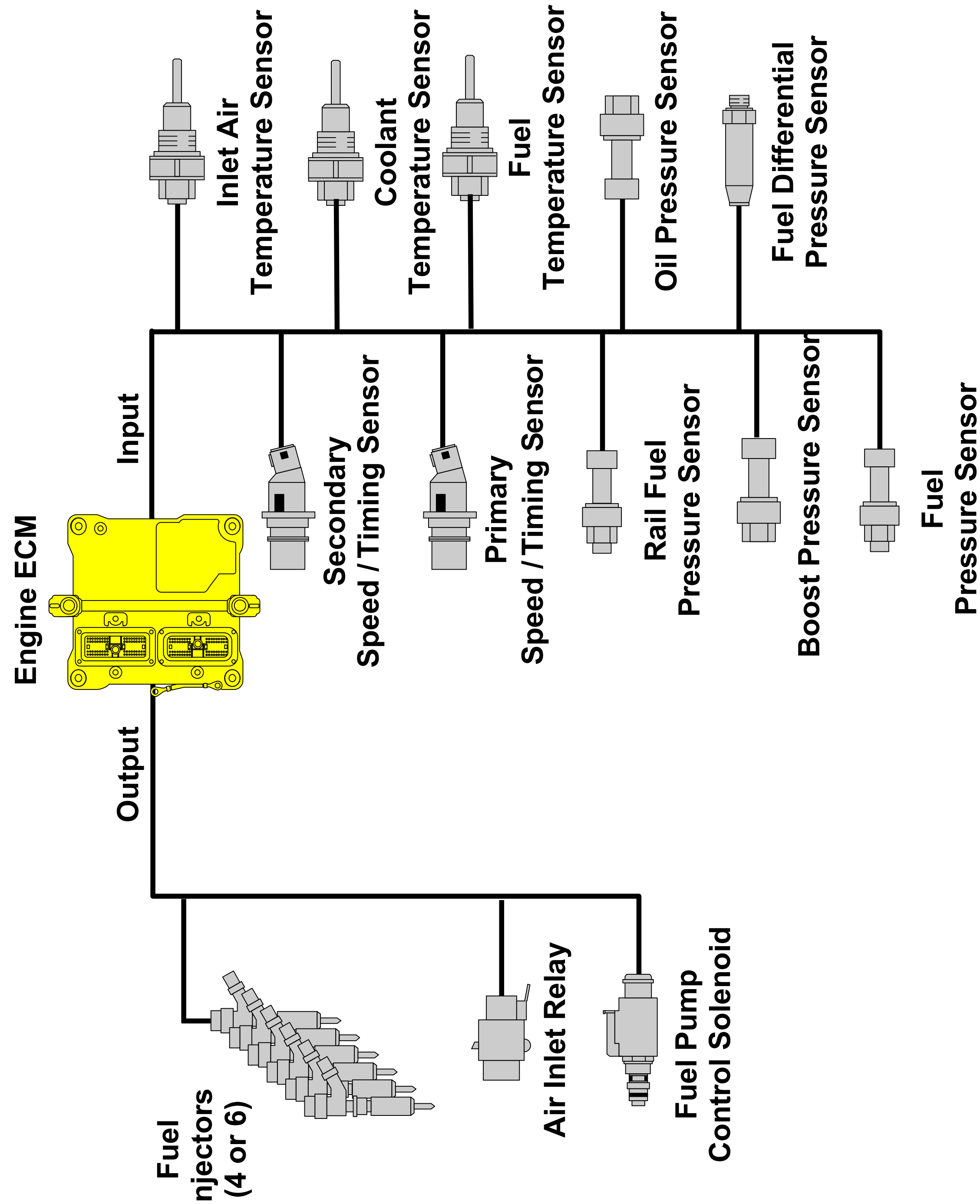

C4.4 / C6.6 ENGINE ELECTRONIC CONTROL SYSTEM
TYPICAL COMPONENTS
+
–
Key Start Switch
Engine ECM
Starter Relay
Machine ECM
Monitoring System
CAT Data Link
CAN Data Link
CAT Data Link
Intake Manifold Air Pressure Sensor
Intake Manifold Air Temp. Sensor
Engine Oil Pressure Sensor
Throttle Position Sensor
Primary Speed / Timing Sensor
Coolant Temp. Sensor
Common Rail Fuel Pressure Sensor
Secondary Speed / Timing Sensor
Engine Shutdown Switch
Fuel Injectors (4 or 6)
Fuel Pump Pressure Control Solenoid
Ether Aid Solenoid
Smart Wastegate Solenoid
Demand Fan Solenoid
INPUT COMPONENTS
OUTPUT COMPONENTS

C6.4 ACERT™ ENGINE FUEL DELIVERY SYSTEM



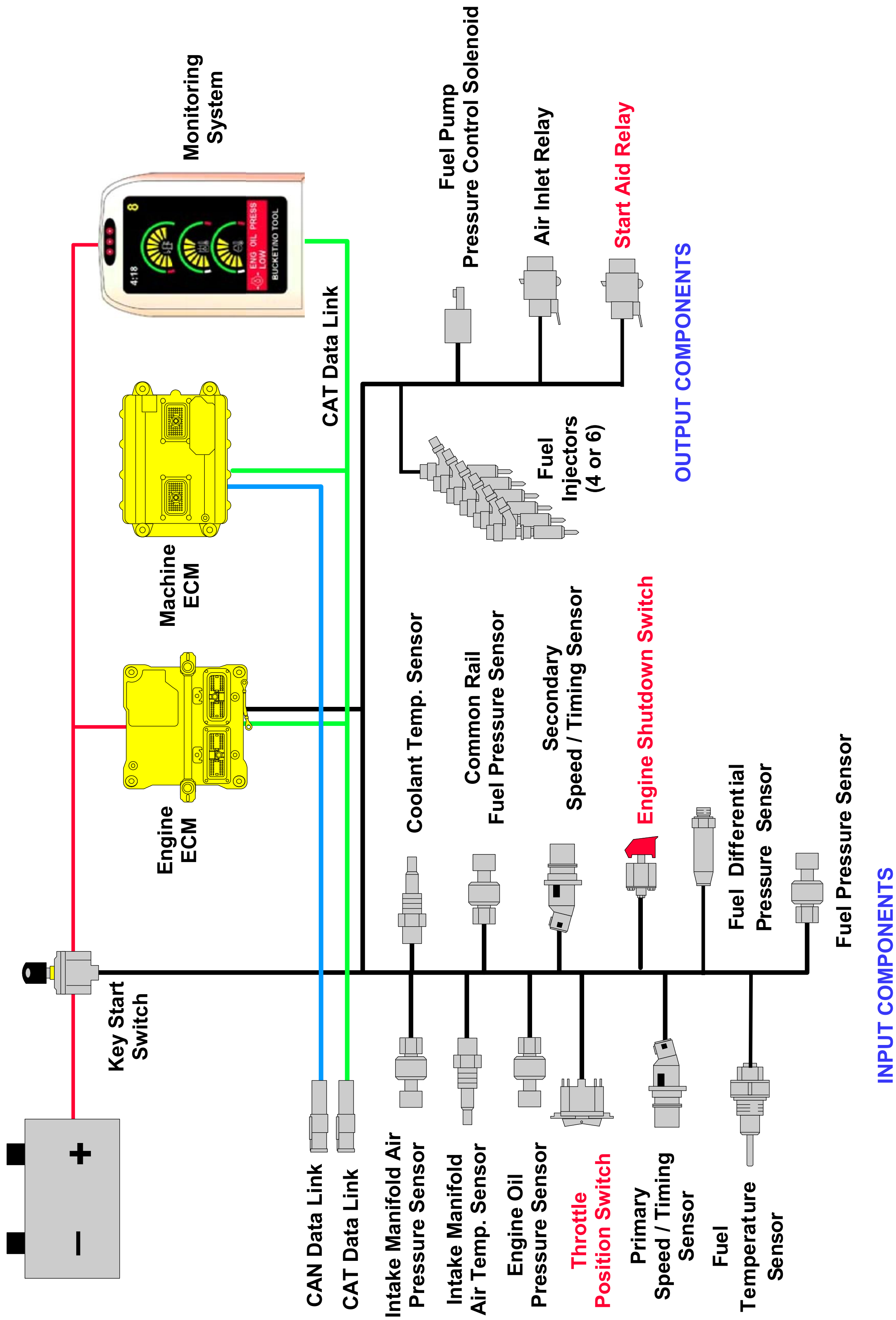
C4.2 / C6.4 ENGINE ELECTRONIC CONTROL SYSTEM

COMMON COMPONENTS

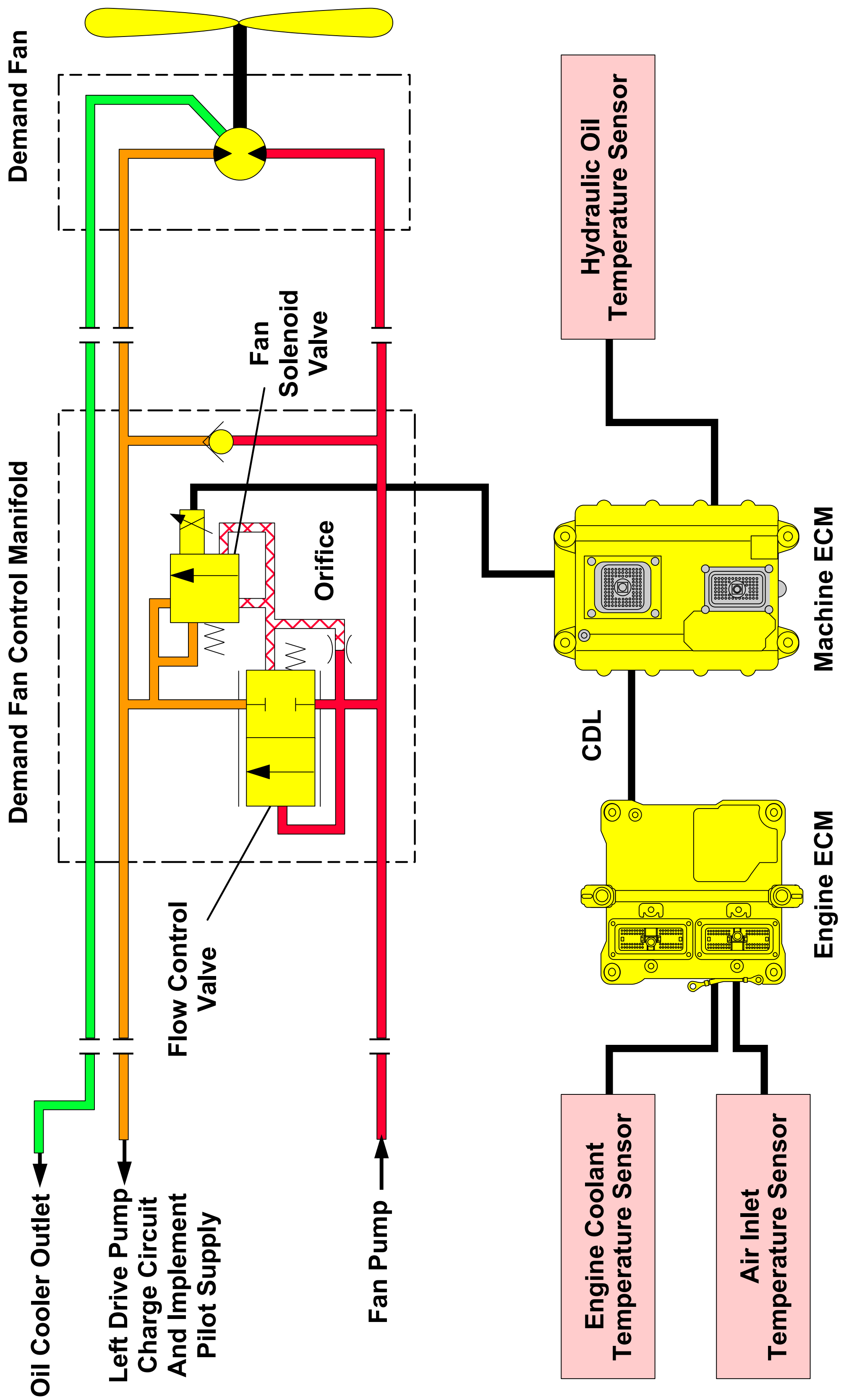


C4.2 / C6.4 ENGINE ELECTRONIC CONTROL SYSTEM

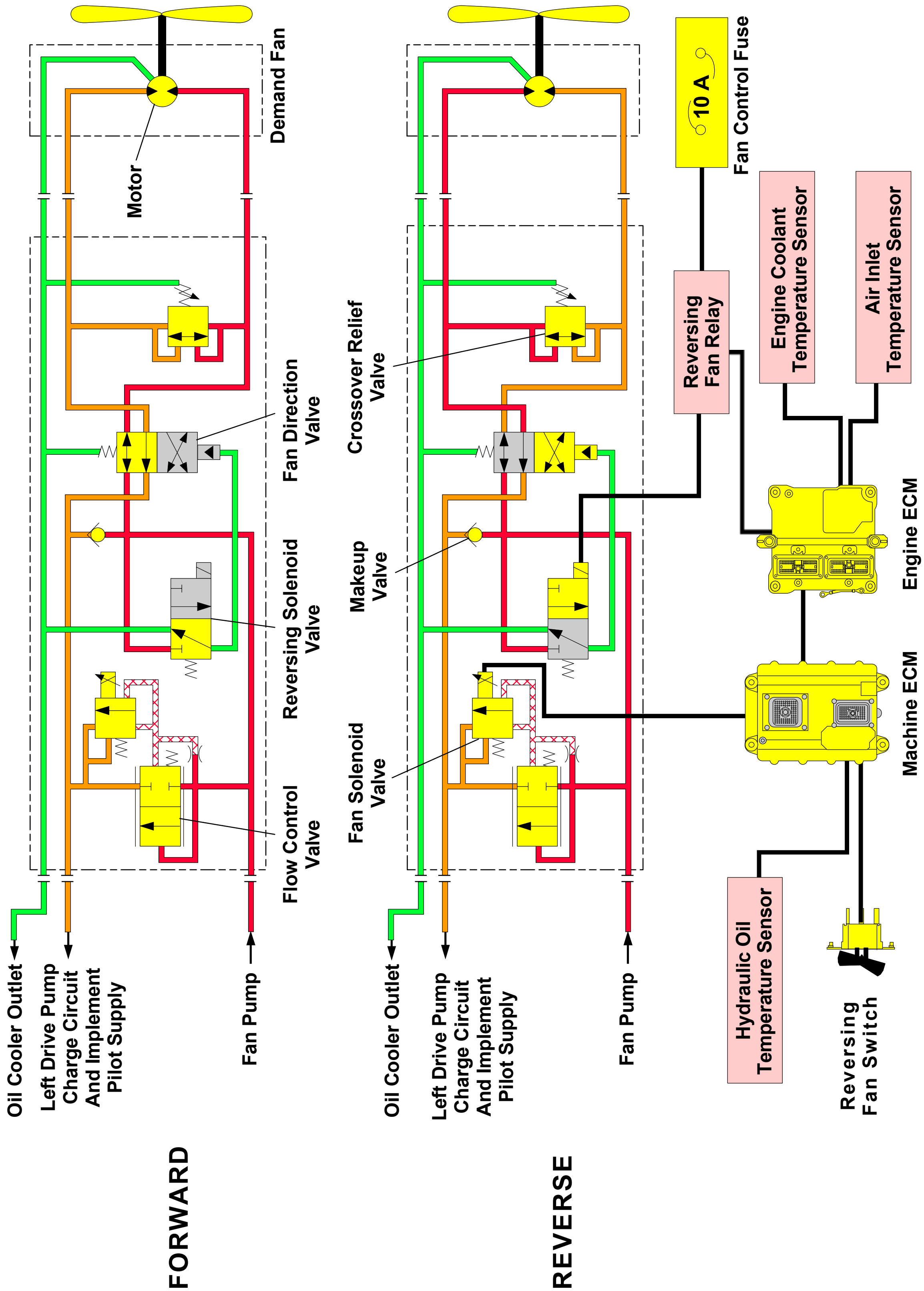
TYPICAL COMPONENTS

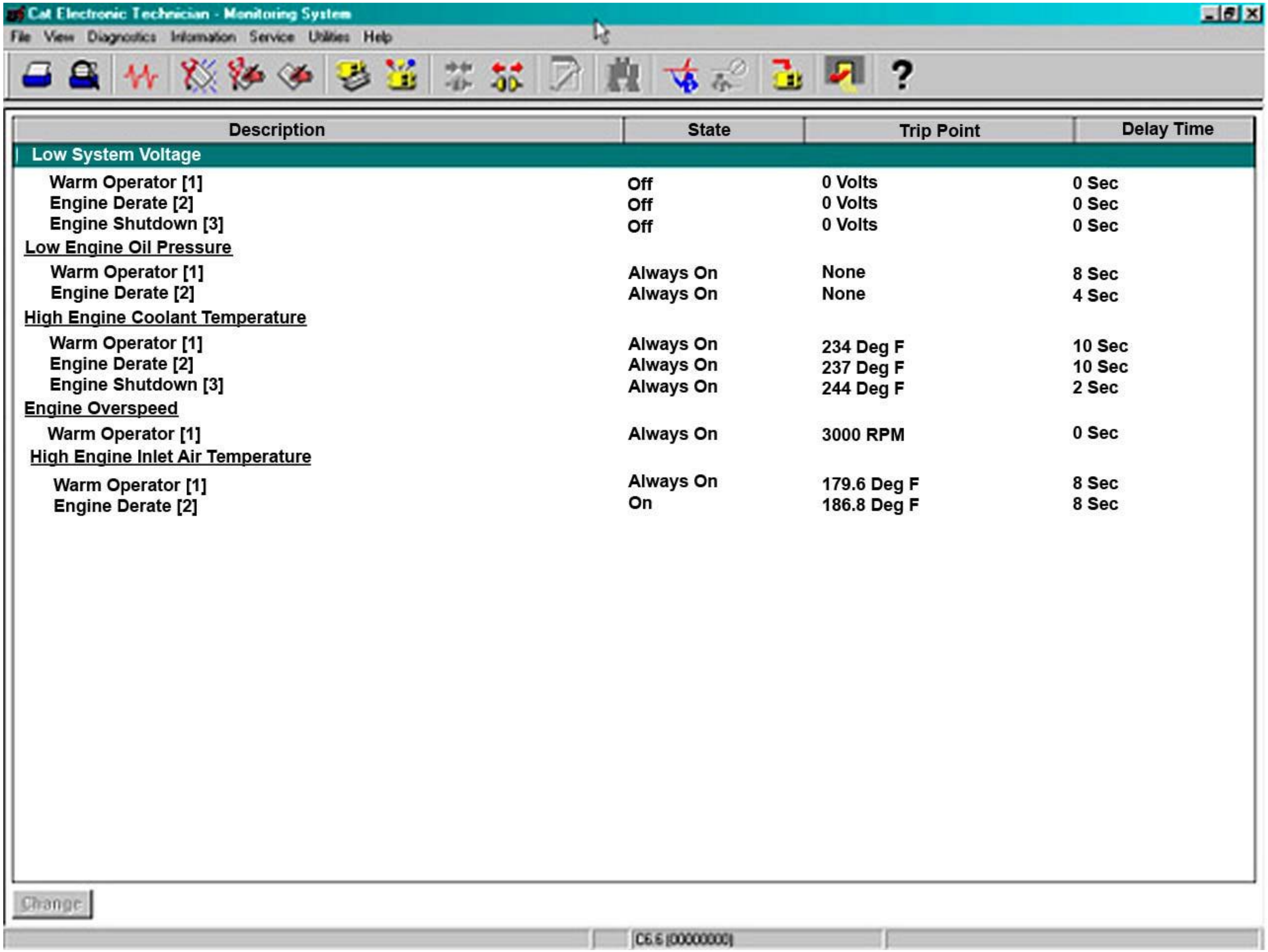


HYDRAULIC DEMAND FAN SYSTEM

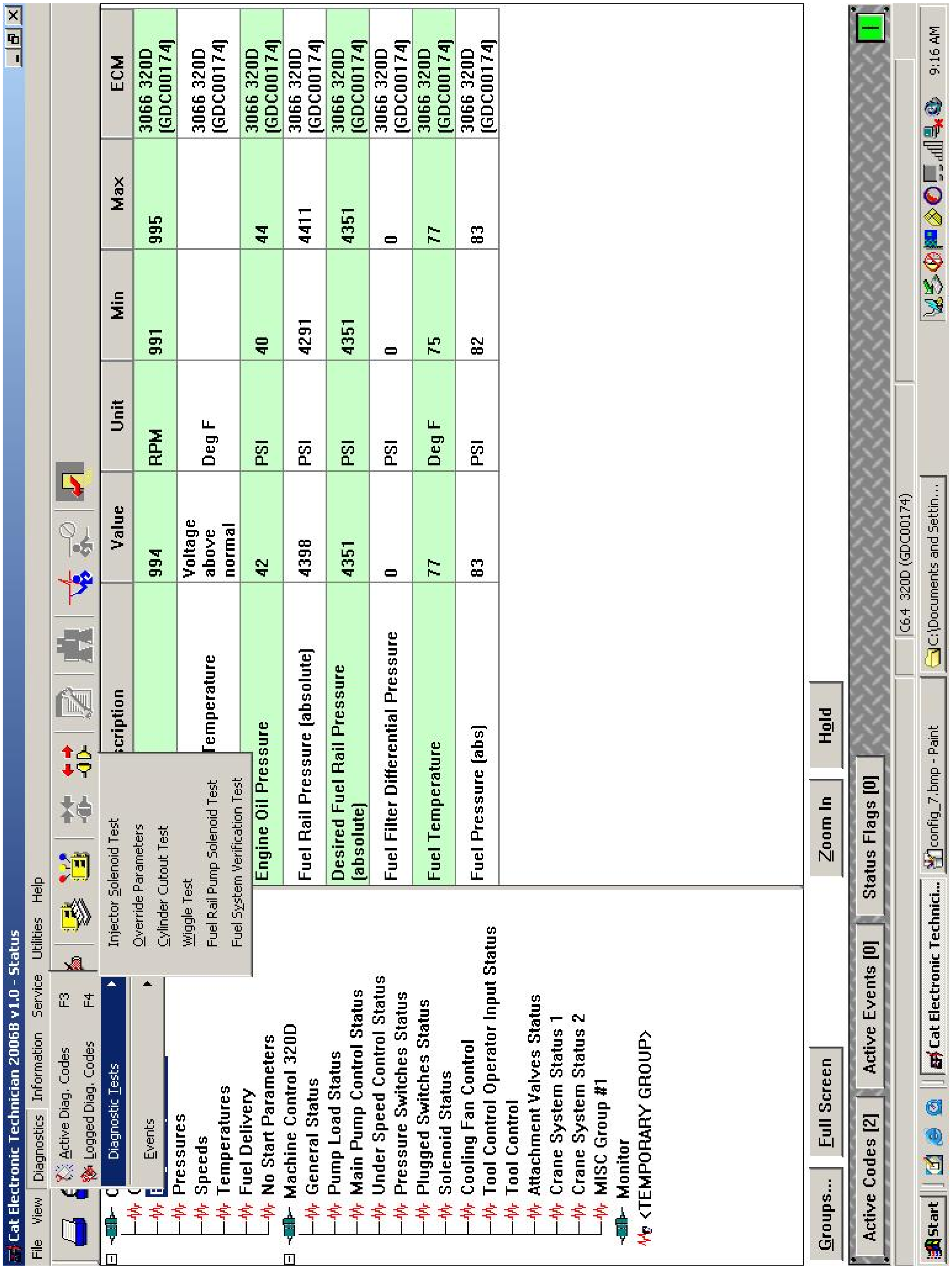


REVERSING DEMAND FAN SYSTEM





Description	State	Trip Point	Delay Time
Low System Voltage			
Warm Operator [1]	Off	0 Volts	0 Sec
Engine Derate [2]	Off	0 Volts	0 Sec
Engine Shutdown [3]	Off	0 Volts	0 Sec
Low Engine Oil Pressure			
Warm Operator [1]	Always On	None	8 Sec
Engine Derate [2]	Always On	None	4 Sec
High Engine Coolant Temperature			
Warm Operator [1]	Always On	234 Deg F	10 Sec
Engine Derate [2]	Always On	237 Deg F	10 Sec
Engine Shutdown [3]	Always On	244 Deg F	2 Sec
Engine Overspeed			
Warm Operator [1]	Always On	3000 RPM	0 Sec
High Engine Inlet Air Temperature			
Warm Operator [1]	Always On	179.6 Deg F	8 Sec
Engine Derate [2]	On	186.8 Deg F	8 Sec


Cat Electronic Technician 2006B v1.0 - Status
File View Diagnostics Information Service Utilities Help
Active Diag. Codes F3
Logged Diag. Codes F4
Diagnostic Tests
Events
Injector Solenoid Test
Override Parameters
Cylinder Cutout Test
Wiggle Test
Fuel Rail Pump Solenoid Test
Fuel System Verification Test
Pressures
Speeds
Temperatures
Fuel Delivery
No Start Parameters
Machine Control 320D
General Status
Pump Load Status
Main Pump Control Status
Under Speed Control Status
Pressure Switches Status
Plugged Switches Status
Solenoid Status
Cooling Fan Control
Tool Control Operator Input Status
Tool Control
Attachment Valves Status
Crane System Status 1
Crane System Status 2
MISC Group #1
Monitor
<TEMPORARY GROUP>
Description | Value | Unit | Min | Max | ECM
994 | RPM | 991 | 995 | 3066 320D (GDC00174)
Temperature | Voltage above normal | Deg F | | | 3066 320D (GDC00174)
Engine Oil Pressure | 42 | PSI | 40 | 44 | 3066 320D (GDC00174)
Fuel Rail Pressure (absolute) | 4398 | PSI | 4291 | 4411 | 3066 320D (GDC00174)
Desired Fuel Rail Pressure (absolute) | 4351 | PSI | 4351 | 4351 | 3066 320D (GDC00174)
Fuel Filter Differential Pressure | 0 | PSI | 0 | 0 | 3066 320D (GDC00174)
Fuel Temperature | 77 | Deg F | 75 | 77 | 3066 320D (GDC00174)
Fuel Pressure (abs) | 83 | PSI | 82 | 83 | 3066 320D (GDC00174)
Groups...
Full Screen
Zoom In
Hold
Active Codes [2]
Active Events [0]
Status Flags [0]
C6.4 320D (GDC00174)
Start
Cat Electronic Technici...
config_7.bmp - Paint
C:\Documents and Settin...
9:16 AM

Posttest

1. The C4.2/C6.4 and C4.4/C6.6 engines meet:

   A. Tier 1 requirements
   B. Tier 2 requirements
   C. Tier 3 requirements
   D. Tier 4 requirements

2. How many valves do the C4.2/C6.4 and C4.4/C6.6 engines have per cylinder?

   A. 2
   B. 3
   C. 4
   D. 5

3. After the high pressure fuel lines are removed from the engine they must be:

   A. Thoroughly cleaned with solvent and compressed air before reinstalling on the engine
   B. Capped with plastic caps and placed in an air tight bag
   C. Checked for deformities
   D. Thrown away and never reused

4. The C4.2 or C4.4 high pressure fuel pump has a camshaft with ______ cam lobes per pumping plunger.

   A. 1
   B. 2
   C. 3
   D. 4

5. If the crankshaft speed timing sensor malfunctions:

   A. The engine will still start and run
   B. The engine will still run but not restart
   C. The engine will not start and will not run
   D. The engine will default to "limp home mode"

6. Which of the following components are installed on the fuel manifold?

   A. Fuel pressure sensor
   B. Fuel differential pressure switch
   C. Fuel temperature sensor
   D. All of the above

Posttest (continued)

7. Which of the following components controls pump output pressure?

   A. Fuel pressure relief valve
   B. Fuel manifold
   C. Pump solenoid
   D. None of the above

8. Which of the following components on the injection pump are serviceable?

   A. Pump solenoid
   B. Transfer pump
   C. Secondary speed/timing sensor
   D. B and C

9. If the fuel pressure relief valve has opened, which of the following must be done?

   A. Clear the diagnostic code
   B. Replace the relief valve
   C. Replace the fuel rail manifold
   D. All of the above

10. Which of the following sensors is common to all C4.2/C6.4 and C4.4/C6.6 engines?

    A. Air inlet temperature sensor
    B. Fuel pressure sensor
    C. Atmospheric pressure sensor
    D. Oil level sensor

Posttest Answer Key

1. C
2. C
3. D
4. B
5. A
6. A
7. C
8. D
9. A
10. A