SECTION 2

2

ENGINE

How It Works

ZTX Series Tractors

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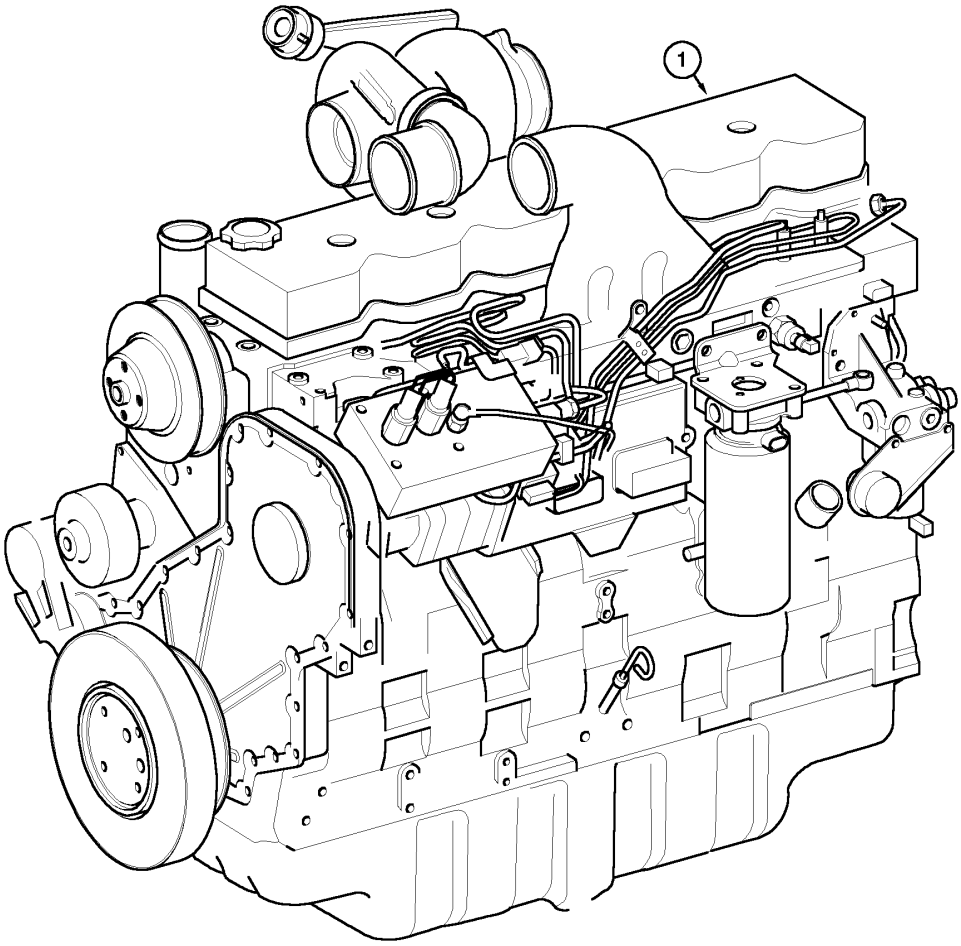
Engine Description

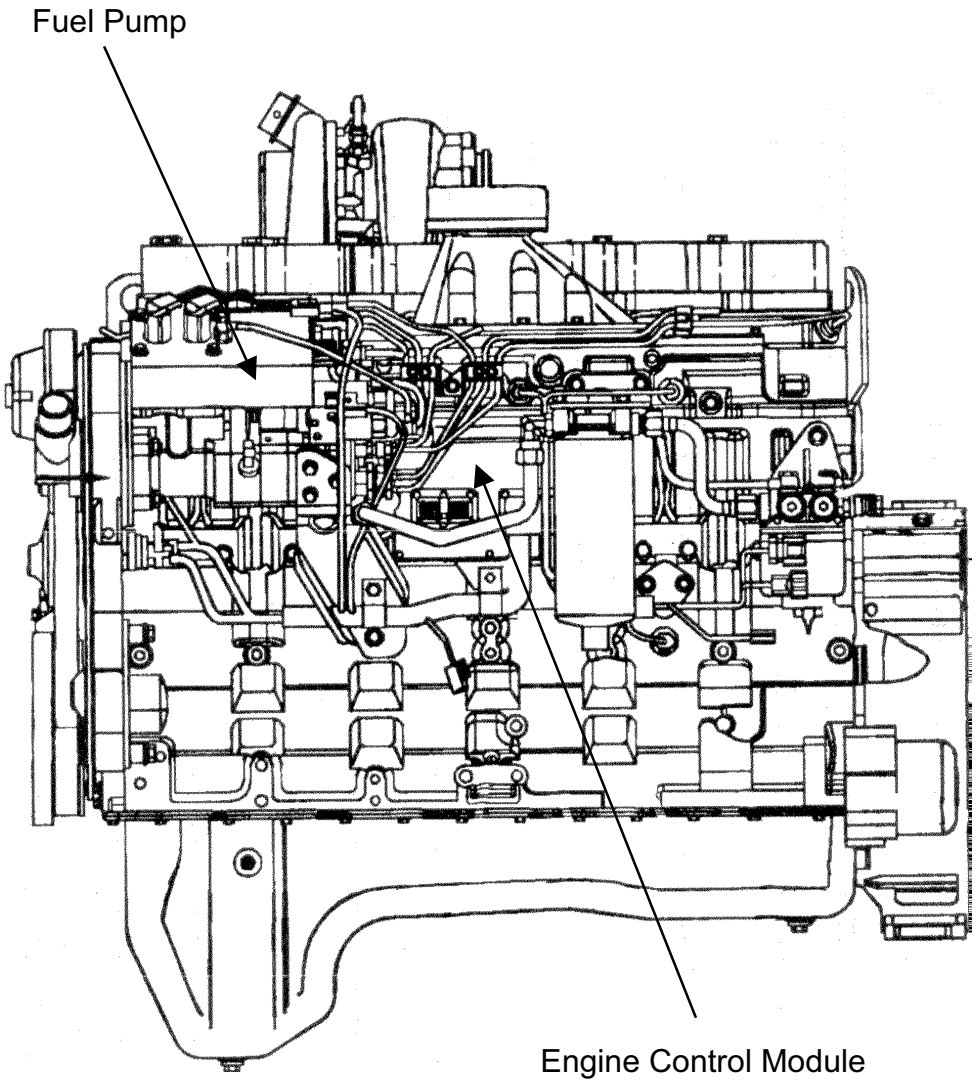
The ZTX, models ZTX230, ZTX 260 and ZTX 280, are fitted with the Cummins QSC 24 valve 8.3 Litre Engine. These engines have full authority electronic control. A vast number of changes have been implemented when compared to the previous C series 8.3-liter Cummins engines.

These engines have 24 valves, 4 valves per cylinder, to ensure optimum airflow, improved fuel economy and fully emissions compliant. The fuel injector is located in the center of the cylinder to provide a more centralized injection and improved fuel burn over conventional layouts.

The fuel system itself is totally electronically controlled and uses an engine mounted ECM (Engine Control Module) to process all relevant information, and make necessary adjustments.



Engine Electronic Control System



(View left-hand side of engine)

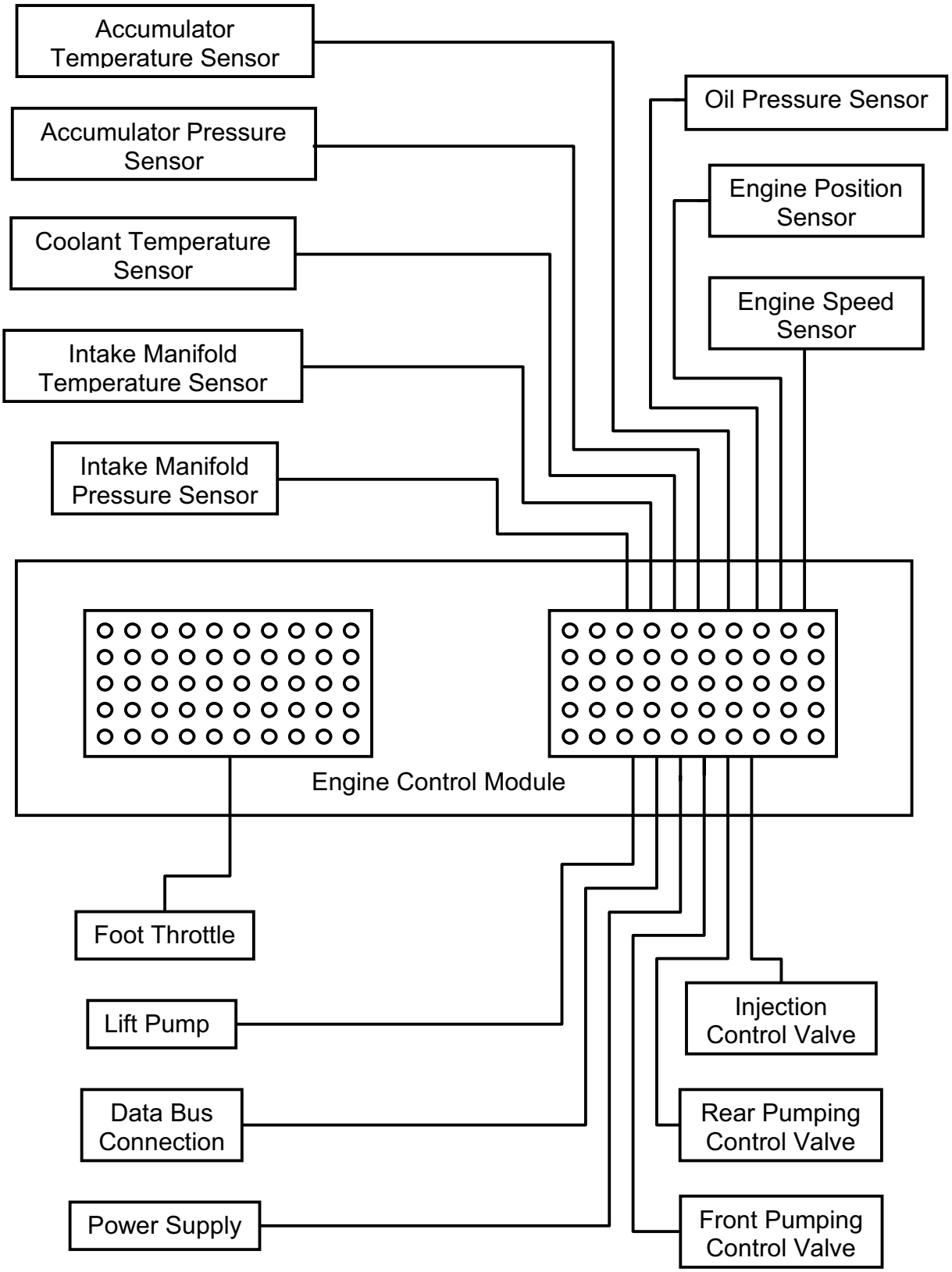
Engine Electronic Control System (Cont'd)

The electronic control system for the QSC Engine uses input information from a number of sensors installed on the engine and related equipment. This information is used to monitor the current engine operating conditions, and therefore allow the ECM to determine the quantity and timing of the fuel delivery to the engine.

The engine control module (ECM) is mounted on the left-hand side of the engine, just to the rear of the fuel pump. All the information received, and all corresponding outputs will enter and exit the ECM via two 50-pin connectors located on the body of the controller. All inputs and outputs use the rearmost 50-pin connector, the foot throttle is the only circuit that makes a connection through the front 50-pin connector.

Should there be a requirement to download software into the ECM, or to monitor data for the aid of diagnostics, this can be achieved using the Cummins EST (Electronic Service Tool) by an authorized Cummins agent. Although a connection is provided for at the controller, it is not used by McCormick Tractors as all fault code retrieval; data monitoring functions can be carried out through the diagnostics connector found in the operators cab.

Engine Control Circuits



Engine Control Circuits

The components that send information to the ECM are: -

- The accumulator fuel pressure and temperature sensors are located at the top rear of the injection pump and indicate the pressure available to inject fuel to the engine and the temperature of the fuel to be injected respectively. The accumulator pressure sensor has a working range between 0 bar (0 psi) and 1655 bar (24000 psi).

- The engine speed sensor is located at the left rear of the timing gear housing and indicates the speed of the engine. There is a 71-position signal indicator ring on the rear of the cam gear, which triggers this sensor. At top dead center, the signal indent is removed leaving a wide blank.

- The engine position sensor is located at the left rear of the timing gear housing, next to the engine speed sensor, and indicates the position of the crankshaft camshaft to allow for precise timing of fuel injection. There is a 71-position signal indicator ring on the rear of the cam gear that triggers this sensor.

- The intake manifold air temperature sensor is located on the left side of the cylinder head and indicates the temperature of the intake air.

- The intake manifold pressure sensor is located on the left side of the cylinder head and indicates the manifold boost pressure.

- The coolant temperature sensor is located on the right side of the engine, just behind the alternator, and indicates the operating temperature of the engine.

- The engine oil pressure sensor is located on the left side of the engine block behind the fuel filter. This sensor indicates the actual engine oil pressure and, This information is transmitted to the to the instrument cluster via the data bus.

- The foot throttle (accelerator pedal) is located in the cab and is connected to the engine control module via dedicated wiring through the front 50-pin connector on the ECM.

Engine Control Circuits (Cont'd)

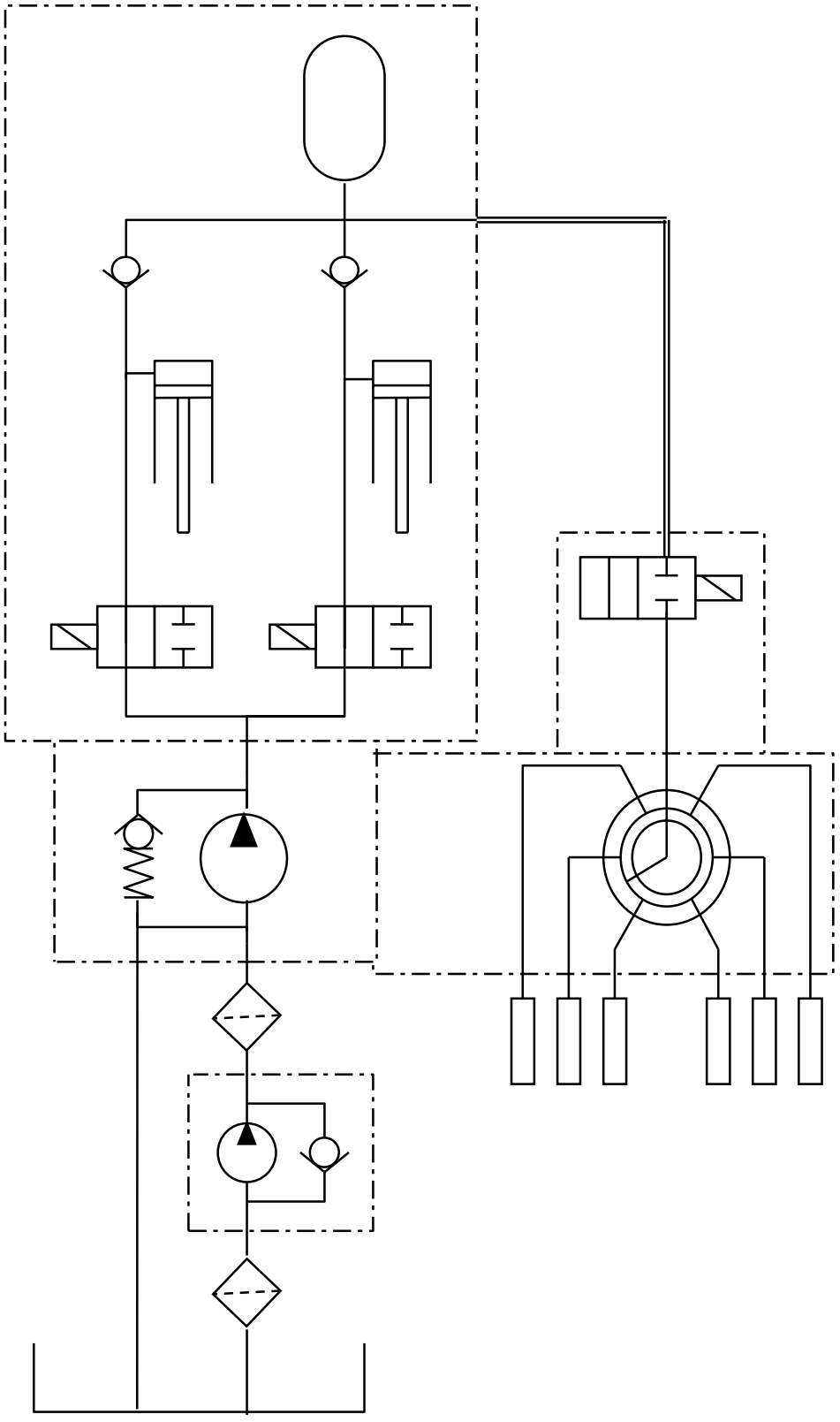
The outputs from the ECM that are used to control the operating state of the engine are: -

- The electrically operated lift pump is located at the left rear of the engine and is controlled by the engine control module. The lift pump only runs for the first 30 ñ 60 seconds after the key switch is turned on. It draws fuel from the tank and supplies pressurized fuel to prime the filter and gear pump. If additional priming is required, the key switch can be cycled to the off position and then returned to the on position. The gear pump provides the continuous fuel pressure required for the injection pump.

- The Cummins CAPS fuel system has two high-pressure pumps to pressurize fuel to the very high pressure required for injection. An electrically actuated pumping control valve individually controls each pumping element. The engine control module controls when the pumping control valve closes during the rotation of the injection pump crankshaft. At light load and idle, the pumping control valve closes later during the pumping cycle so that less fuel is delivered to the accumulator. When the engine is operating under heavy load and additional fuel is required, the pumping control valve closes earlier to deliver more pressurized fuel to the accumulator.

- The injection control valve is an electrically operated valve controlled by the engine control module, which controls the delivery of fuel to each cylinder. The opening of the injection control valve controls the timing of injection. The length of time that the valve as well as the fuel pressure stored within the accumulator controls the total amount of fuel delivered which in turn controls the power output. The single injection control valve ports fuel to each injector through a rotary distributor valve. As the injection pump rotates, the rotary distributor valve ports fuel to the correct injector based on crankshaft rotation.

Fuel Pump Schematic



Fuel Pump Operation

When the key switch is initially actuated, the lift pump runs for 30 - 60 seconds and draws fuel from the tank to prime the system. The lift pump pressurizes the system to approximately 6.5 bar (95 psi). The lift pump also incorporates a check valve to allow fuel flow when it is not running. The fuel filter is located between the lift pump and gear pump on the left side of the engine.

The gear pump is part of the injection pump assembly and is driven by the input shaft. Its purpose is to provide fuel flow to the system during engine operation. This fuel flow is delivered to both the front and rear pumping control valves (PCV), which are mounted on the top of the accumulator housing. A pressure regulator valve that is integral to the gear pump housing controls the output pressure from the gear pump. This regulator valve is set to a pressure of 11.5 bar (165 psi) and is considered non adjustable.

The two pumping control valves are normally open solenoid valves and will close when commanded to do so by the ECM. Closing these solenoid valves will result in the high pressure pumping units to increasing the fuel pressure from approximately 11.5 bar (165 psi) to between 345 1035 bar (5000 to 15000 psi) required for injection. The output pressure from these pumping elements is determined by the fuel requirement of the engine.

The input shaft in the injection pump body has two tri-lobe cams on the shaft, which actuate the high pressure pumping units. Each high pressure-pumping unit actuates three times each revolution of the injection pump shaft. The duration of the revolution that the pumping control valve is closed controls the quantity of high-pressure fuel that is delivered. During the time that the pumping control valve is open, the output of the high pressure-pumping unit returns to the fuel tank via the pressure regulator valve. When the pumping control valves are closed the high pressure pumping elements will deliver the fuel flow, through one way check valves, into the accumulator housing.

Fuel Pump Operation (Cont'd)

The point at which the pumping control valves are commanded on can be monitored using the Cummins Electronic Service Tool (EST). The parameter that should be viewed is the Valve Crank Angle (VCA) and relates to the angle, in degrees of rotation, before top dead center when the control valves are energized.

The accumulator stores pressurized fuel, typically at pressures between 345 to 1035 bar (5000 to 15000 psi), ready for injection event. The accumulator is also connected to the, normally closed, injection control valve (ICV) via the ìRate Shape Tubeî. The injection control valve opens at the required time to control the injection timing to each cylinder. The length of time that the injection control valve is open controls the amount of fuel delivery, which in turn controls the power output.

The output of the injection control valve is connected to the rotary distributor valve at the lower rear of the injection pump. This rotary distributor valve is driven by the pump drive shaft and is used to direct the fuel to the required injector.

CAPS Fuel System

The Cummins Accumulator Pump System (CAPS) consists of six basic components, components are separate assemblies and will be discussed individually.

The fuel pump body is directly connected to the engine timing cover and includes the input shaft and camshaft lobes that actuate the high pressure pumping units.

The gear pump is mounted to the rear of the fuel pump body and is driven by the input shaft; a small internal coupling connects the two components. The gear pump will take fuel from the fuel tank and pass it through the fuel filter. It will then make it available to the inlet of the high pressure pumping units. The outlet pressure of this pump is regulated to approximately 11.5 bar (165 psi).

The accumulator assembly mounts directly to the top of the fuel pump body and consists of the following components: -

- The camshaft in the fuel pump body actuates the high-pressure pumping units. These units take fuel delivered by the gear pump and increase the pressure to that required for injection into the combustion chamber. The outlet pressure of these units is typically regulated between 345 to 1035 bar (5000 to 15000 psi). Individual pump control valves control the outlet flow of these pumping units.

- Electrically operated pump control valves are located on the top of the accumulator assembly. The timing of the actuation of these valves controls the quantity of fuel delivered by the high pressure pumping units and therefore the injection pressure. The engine control module controls these valves. These pump control valves are installed and calibrated on initial assembly and cannot be adjusted. Replacement of a faulty pumping control valve would require a new accumulator assembly

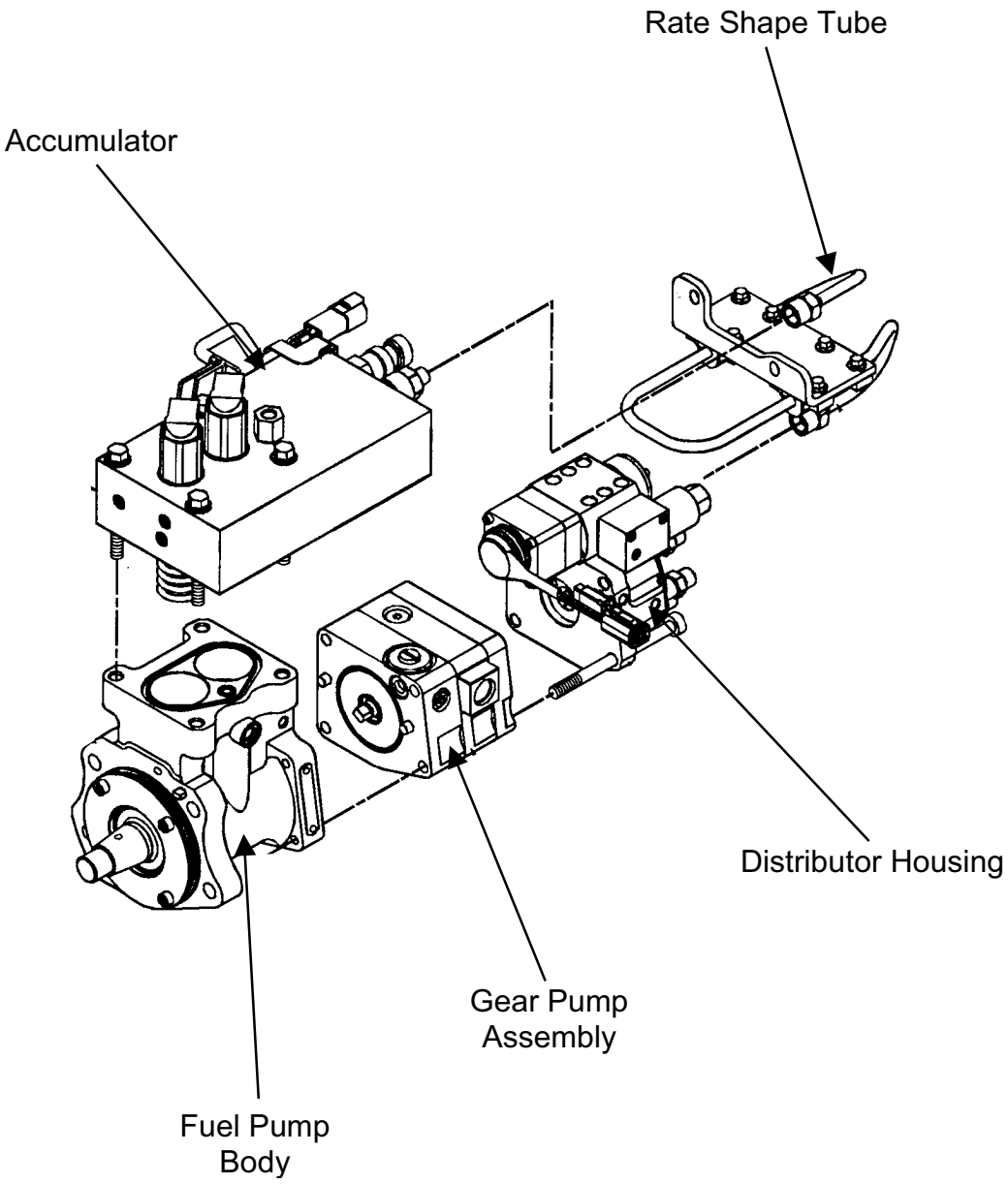
- The accumulator portion of the accumulator assembly consists of drilled passages within the accumulator body. The accumulator function is based on the fact that diesel fuel is approximately 8% compressible at 1035 bar (15000 psi). These drilled passages are sealed with plugs that have seal discs under them. These seal discs are currently not available as separate service parts.

CAPS Fuel System (cont'd)

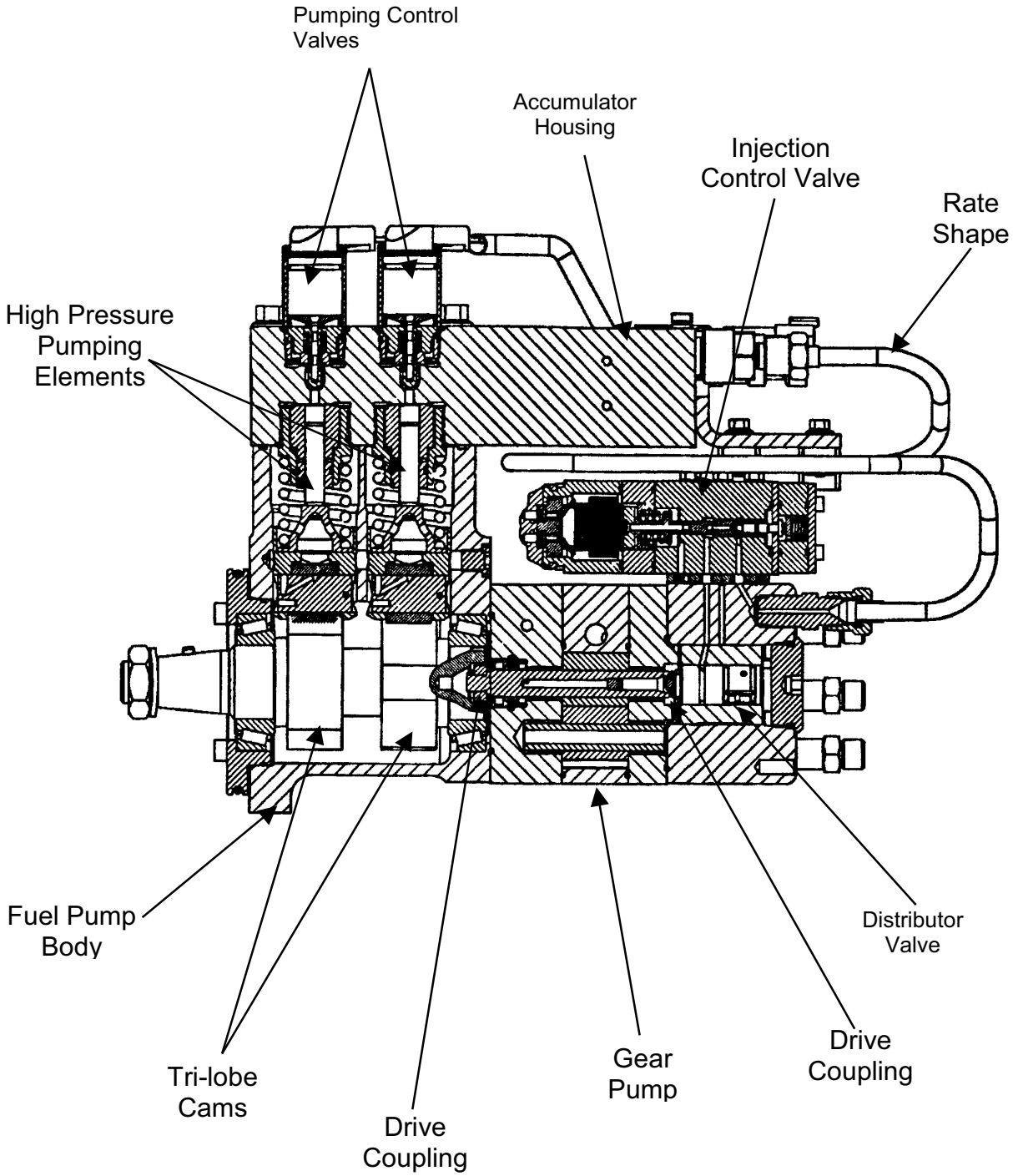
- The accumulator fuel pressure and temperature sensor is located at the rear of the accumulator assembly. This sensor monitors the pressure and temperature of the high-pressure fuel stored in the accumulator. This sensor sends information to the engine control module.

- The rate shape tube is located at the top rear of the injection pump assembly and ports the high-pressure fuel from the accumulator to the injection control valve. The length of this tube controls the shape of the injection line pressure rise curve. The length of this tube affects NOX emissions. Do not bend this tube during or after installation.

CAPS Fuel Pump Components



CAPS Fuel Pump



CAPS Fuel System (cont'd)

The injection control valve (ICV) is located at the rear of the injection pump. This control valve is an electrically operated valve commanded by the engine control module (ECM), which controls the delivery of fuel to each cylinder. The opening of the injection control valve controls the timing of injection. The length of time that the valve is open, as well as the fuel pressure stored within the accumulator controls the total amount of fuel delivered, which in turn controls the power output. The single injection control valve ports fuel to individual injectors through a rotary distributor valve.

The rotary distributor control valve is located at the lower rear of the injection pump and is driven from the gear pump shaft; a small internal coupling connects the two components. As the injection pump rotates, the distributor will control which injector is supplied with fuel, based on the rotation of the crankshaft.

The injectors are located at the top of the cylinder head centered over the pistons. The injectors inject atomized fuel into the combustion chamber during the power stroke of the combustion cycle.

Engine Troubleshooting

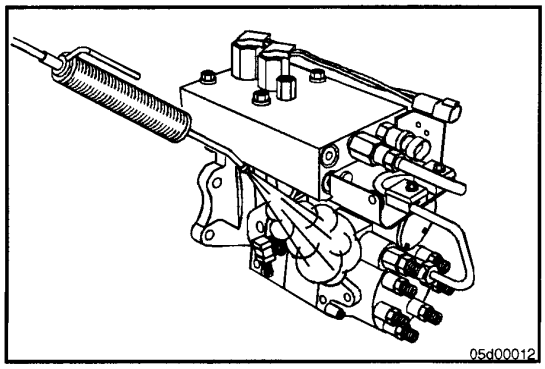
Retrieval of fault code information from the Engine Control Module can be done through the instrument cluster, or with the Cummins Electronic Service Tool and the McCormick Diagnostic Tool

Engine troubleshooting information is available in the QSC Engine Troubleshooting Manual (available from Cummins).

If QSC engine running problems are encountered: -

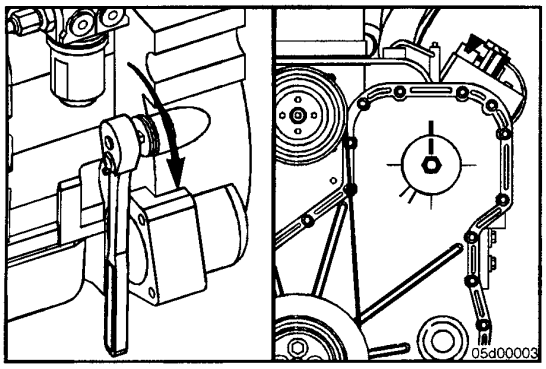
- Inspect the fuel level in the tanks;
- Check for air leaks and restrictions in the fuel inlet system;
- Inspect for air intake problems;
- Inspect for mechanical problems;
- Inspect for rotary distributor valve problems;
- Inspect for injector problems;
- Check for fault codes using the tractor instrumentation or the electronic service tool.

Fuel Pump Distributor Valve Inspection

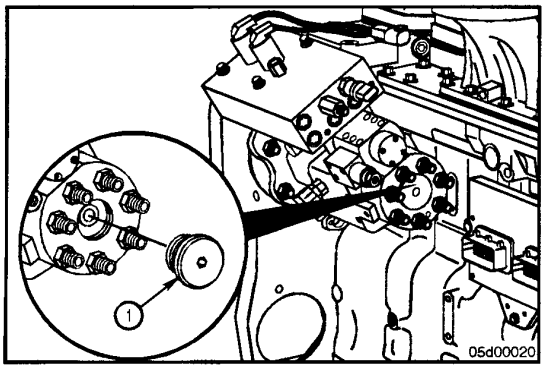


Remove the key from the ignition switch to prevent any attempt at starting the engine.

Thoroughly clean the area around the fuel pump. Pay particular attention to the rear connections area.

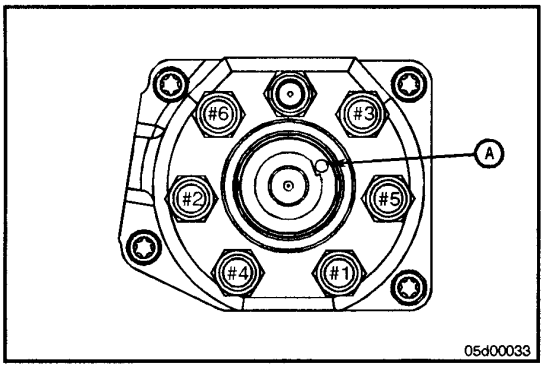


After removing the front access cap, rotate the engine using the turn over tool until the Timing mark on the pump drive gear aligns with the TDC mark on the timing cover.



Remove the distributor plug (1).

Do not attempt to start the engine with the distributor plug removed. To do so could result in the rotor being ejected from the distributor, causing damage to the rotor.



Check the position of the notch on the rotor. It should line-up with the alignment mark (A) on the outside of the distributor. If the alignment is correct the rotor is properly timed to the engine.

If the alignment is incorrect inspect the internal drive couplings.

Replace distributor plug oíring as necessary.

Recommendations For Bleeding CAPS Fuel System

Crank the engine, checking for exhaust smoke or no exhaust smoke and follow the appropriate troubleshooting tree of the Insite diagnostic information.

If the engine cranks but does not start after running out of fuel, and there is no smoke from the exhaust, carry out the following procedure: -

- Confirm that the fuel level is low and fill.
- Check instrumentation for engine faults.
- Confirm the electric lift pump run after the key switch is activated.
- Refer to the relevant sections service manual as required.

    1. Loosen the fitting (1/18" pipe plug) at the outlet of the fuel filter.
    2. Cycle the electric lift pump with the key switch until air is purged.
    3. If air cannot be purged after several cycles of the lift pump, an air leak may be present. Check the fuel supply system from the fuel tank to the fuel filter.

- If engine does not start after purging air, check for battery voltage.
- Check Engine Control Module for 6.5 VDC minimum during engine cranking.
- Recheck for exhaust smoke during cranking and go back to appropriate fault trouble shooting tree.