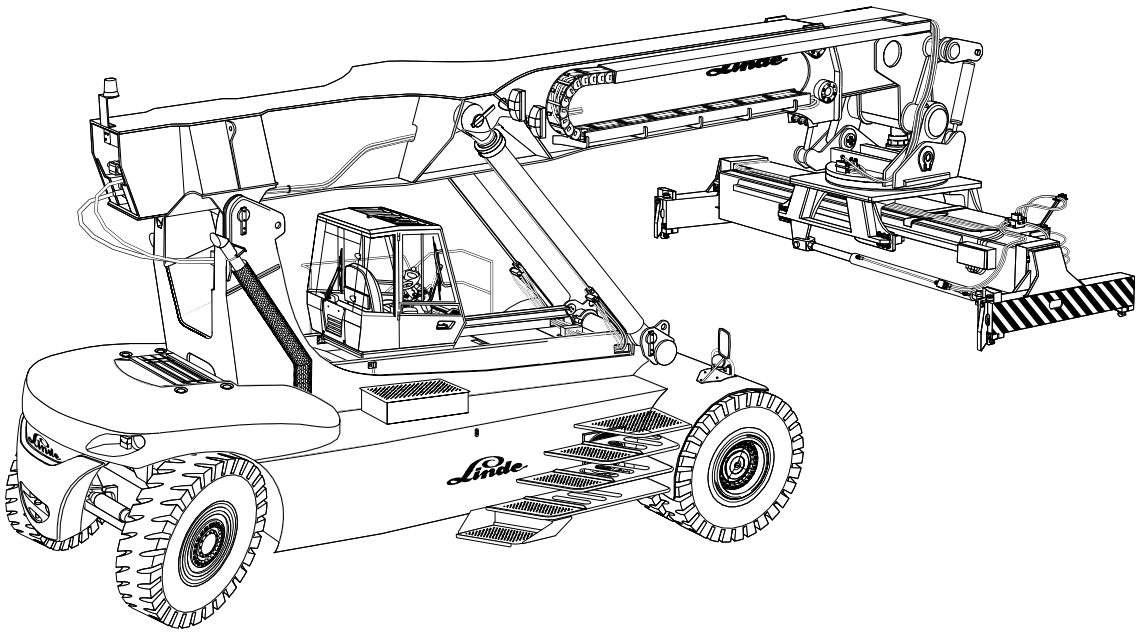
Service Training

Container handling truck
Toplift and Combi handler
Series 357-05



1 CUMMINS ENGINE.

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1.1 CUMMINS ENGINE.

The Cummins QSM11 engine is fitted into this model as an option to the standard unit.

DATA.

Engine type	Cummins. QSM11-c
Number of cylinders.	6
Power.	246Kw @ 2100 rpm.(330 HP)
Firing order.	1 5 3 6 2 4
Emission specification	Tier 3
Bore	125 mm (4.921")
Stroke	147 mm (5.787")
Displacement	10.8 ltr (659 CI")
Rotation direction, viewed from the front.	Clockwise
Low idle	700 rpm
EngineMaximum speed	2100 rpm
Valve clearance cold, Inlet	0.36 mm (0.014")
Valve clearance cold, Exhaust	0.69mm (0.027")
Minimum oil pressure at Maximum RPM	2 bar (30 psi)
Minimum oil pressure at idle speed	0.7 bar (10 psi)
Min/max dipstick difference	5 ltr (1.3 Gall)
Oil capacity	32 ltr (8.45 Gall)
Filter capacity LF9000	3 ltr (0.8 Gall)
Filter capacity LF9001	2.6 ltr (0.7 Gall)
Cooling system pressure	0.5 bar (7 psi)
Engine shutdown temperature	103°C(217.4F)
Thermostat begins to open at	82°C (179.6F)
Thermostat fully open at	93°C (199.4F)
Fuel system pressure (cranking speed)	1.72 bar (25psi) Minimum.
Fuel system pressure (1200 rpm)	8.27 bar (120psi) Minimum.
Fuel system pressure (maximum speed)	10.34-12.41 bar (150-180psi) Minimum.
Coolant capacity (system)	52 ltr (13.73 Gall) (engine only 9.5ltr)
Alternator	Leece Neville 8SC3009ZA . 24V/175A
Starter motor	Delco Remy 01E01
Weight, engine (dry)	940Kg

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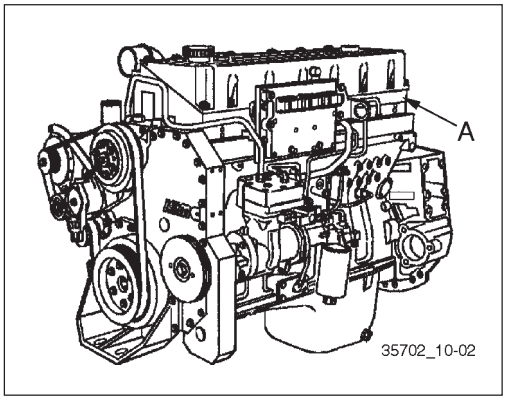
1.1.2 ENGINE SERIAL NUMBER

10.1.2.1 LOCATION OF ENGINE DATA PLATE

The engine data plate is located at the rear left hand side of the engine at the point arrowed "A".



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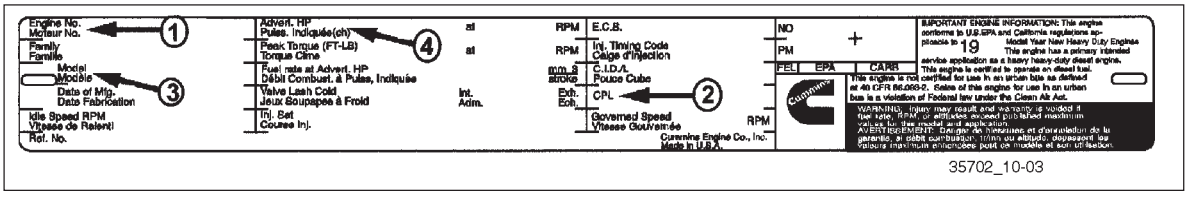
1.1.2.2 INFORMATION ON DATA PLATE

The engine data plate is as illustrated and carries all the engine data including the serial number. The engine model in current use is:-

QSM11-C

This information indicates the following:-

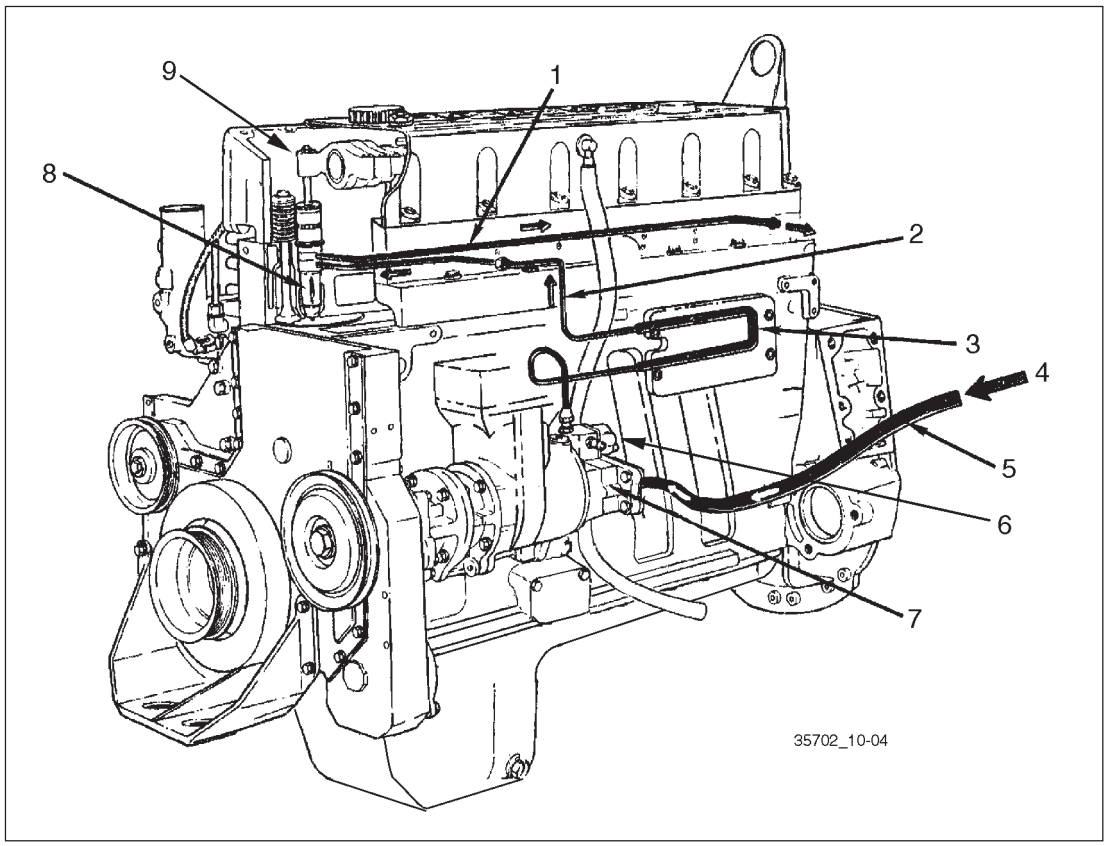


1 Engine serial number.
2 CPL. (Control parts list for spares purposes).
3 Engine model.
4 Power and rpm rating.

1.1.3 FUEL SYSTEM DESIGN AND FUNCTION

1.1.3.1 FUEL SYSTEM LAYOUT

The engine uses a fuel injecton system specific to Cummins; The system is known as the "PT system", there is no fuel injection pump only a charging pump that raises the fuel pressure to up to 12.4 bar at maximum rpm. (1.75 bar at cranking rpm). The fuel is passed through the ECM (Electronic control module) plate to act as a cooling medium for the electronics. The fuel is then passed to all the injectors where it is finaly pressurised and injected into each cylinder in turn by the action of a third rocker arm between the inlet and exhaust valve rocker arms and driven by the camshaft like the valve rockers.. Each cylinder has two inlet and two exhaust valves operated by a bridge plate from the normal rocker set, in the centre of these is the injector operated by the third "centre" rocker arm.

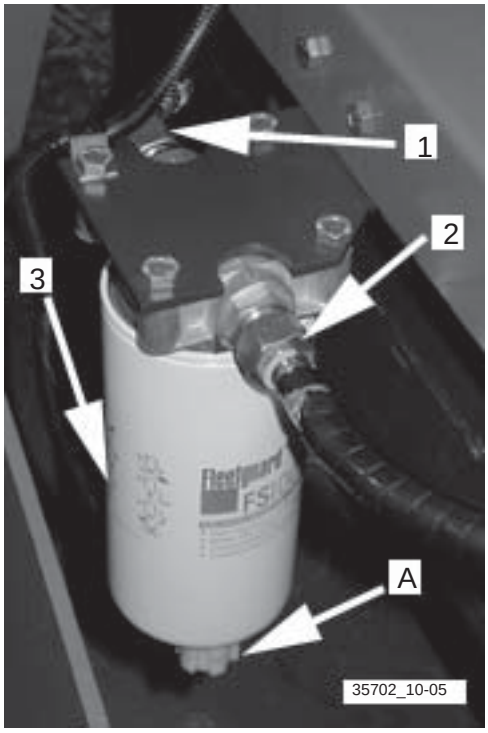


1 Fuel return to tank.
2 Fuel to injectors.
3 ECM Coolingplate.
4 Fuel feed from water trap.
5 Fuel feed pipe.
6 Fuel solenoid.
7 Fuel pump.
8 Injector.
9 Injector rocker.

1.1.4 FUEL SYSTEM COMPONENTRY.

1.1.4.1 FUEL FILTER AND WATER TRAP.

The fuel filter and water trap assembly is mounted on the chassis inside the access door to the battery compartment. Fuel from the tank line (1) is passed through the filter, water being denser than fuel, will sink to the bottom of the cannister preventing water being passed into the fuel injection system through the feed line (2).
The water trap should be drained daily by the truck operator by unscrewing the drain valve (A) in the bottom of the unit by two or three turns until clean fuel runs from the drain screw. The screw should then be retightened by hand pressure only. The 10 micron Filter assembly (3) can be changed at the usual service intervals or if the pressure difference across the filter exceeeds 0.4 bar (12"HG). In the bottom of the unit is a sensor that will illuminate a warning light if the water level in the filter becomes too high.

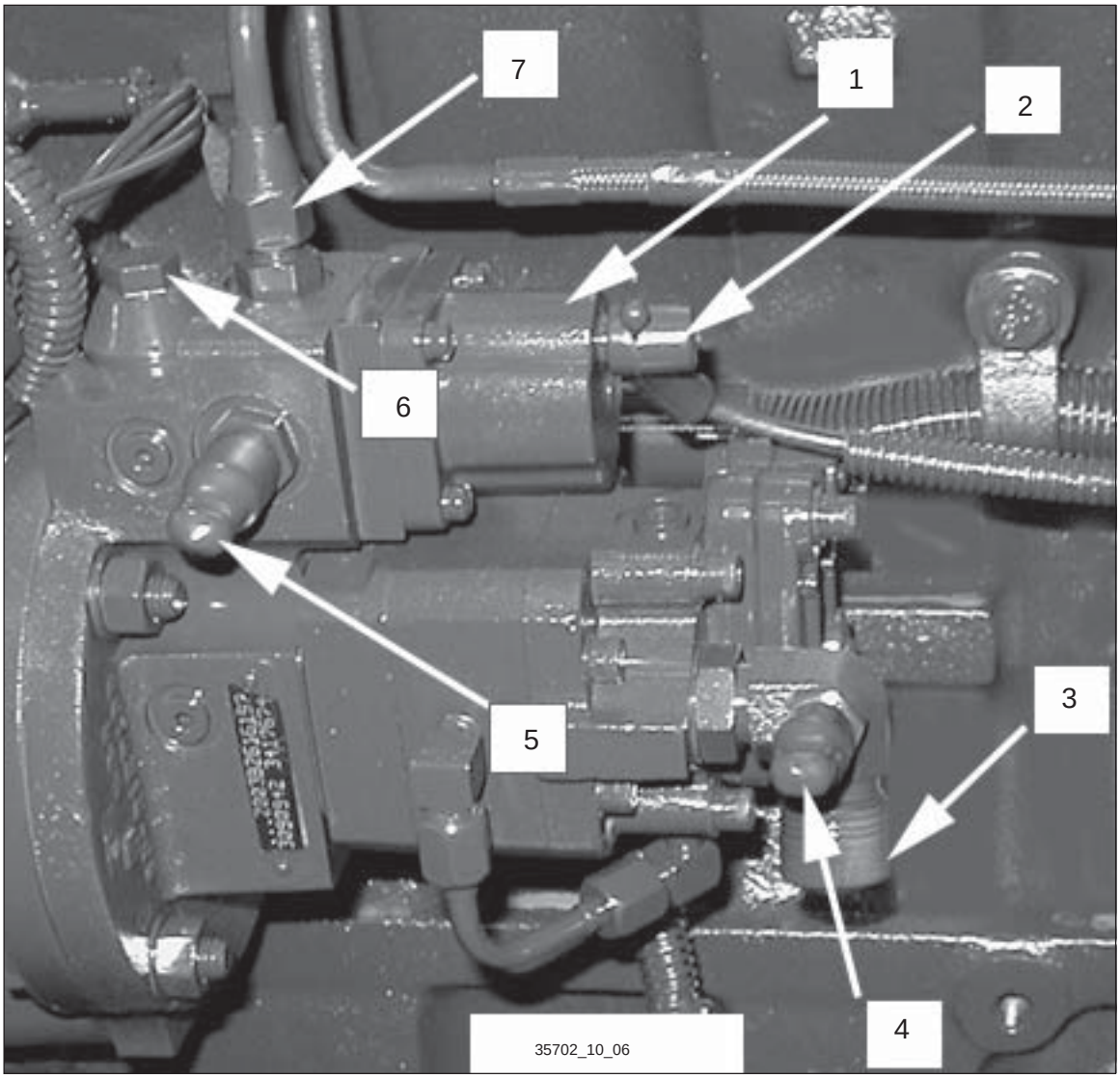


1.1.4.2 FUEL CHARGE PUMP AND SOLENOID.

The charge pump is driven by the engine timing gears, it draws fuel from the tank, through the fuel filter and water trap assembly and passes the fuel into the injector feed pipes. The pressure of the fuel within the sytem will depend on the engine speed. The limits and characterisitcs are defined by the manufacturer as follows.

Inlet line restricton (maximum)	254 mm HG. (10" HG)
Fuel system pressure (cranking speed)	1.72 bar (25psi) Minimum.
Fuel system pressure (1200 rpm)	8.27 bar (120psi) Minimum.
Fuel system pressure (maximum speed)	10.34-12.41 bar (150-180psi) Minimum.
Minimum cranking speed to achieve effective fuel pressure.	150 rpm.
Fuel solenoid coil resistance 12v HD.	7-9 ohms.

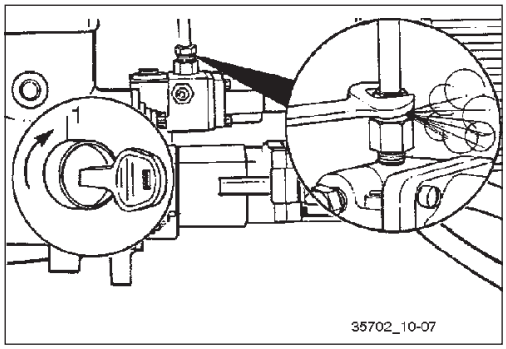
1.1.4.2 FUEL CHARGE PUMP AND SOLENOID.



1 Fuel shut down solenoid.
2 Connection to soilenoid.
3 Fuel feed to charge pump.
4 Test point quick release adaptor A. For measuring inlet line restriction.
5 Test point quick release adaptor B. For measuring charge pump pressure.
6 Charge pump quick fill port.
7 Feed pipe to injectors.

1.1.4.3 TESTING THECHARGE PUMP AND SOLENOID.

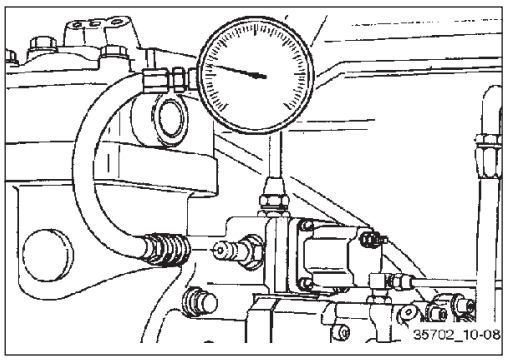
1.1.4.3.1 FLOW TEST.



A series of checks can be made to test the operation of the fuel charge system as follows.

Check the fuel flow from the charge pump by loosening the outlet pipe to the injector inlet line. Clean fuel should flow when the engine is being cranked at normal speed. If no fuel flows the fuel pump may need priming. See page 9.

1.1.4.3.2 PRESSURE TEST.

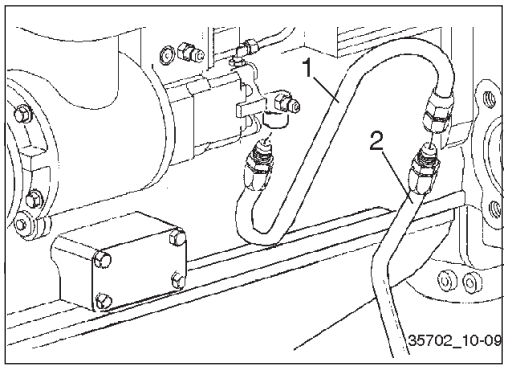


The pressure within the system can be measured by connecting a pressure gauge (0-10 bar) into the quick release coupling in the charge pump.
Crank the engine and observe the gauge, the pressure should rise to 1.75 bar (25psi). If this pressure is not achieved the pump may need priming or another fault exists. The engine must crank at it's standard speed of 220 rpm for this test to be effective.

If the engine will start run the engine at 1200 rpm with no load and observe the pressure gauge. The gauge should show a minimum pressure of 8.27 bar (120 psi).

Increase the engine rpm to maximum, the gauge should show a fuel pressure of between 10.34-12.41 bar (150-180psi) Minimum.

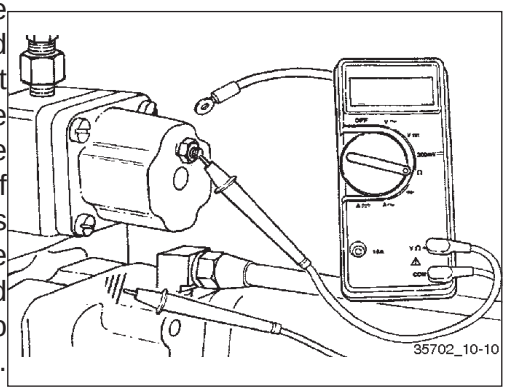
1.1.4.3.3 LEAKADGE TEST.



A leakadge test may be carried out by adding a length of clear hose (1) to the fuel pipe (2) feeding the charging pump. The hose must be to Tygon R3606 type with stratoflex number 10 hose fittings. Start and run the engine and allow the air to purge out of the pipe. No bubbles must appear in the pipe. Switch off the engine and observe the fuel in the pipe. A small air space will appear in the tube that is drawn from the fuel filter.
Observe the pipe for up to one hour, the air space should not increase in size as fuel should not run back into the tank. If fuel is running back to the tank with bubbles rising from the tank then the leak is in the tank, filter or pipework. if fuel is running back to the tank with no bubbles from the tank end then the leak is in the system from the charge pump to the injectors.

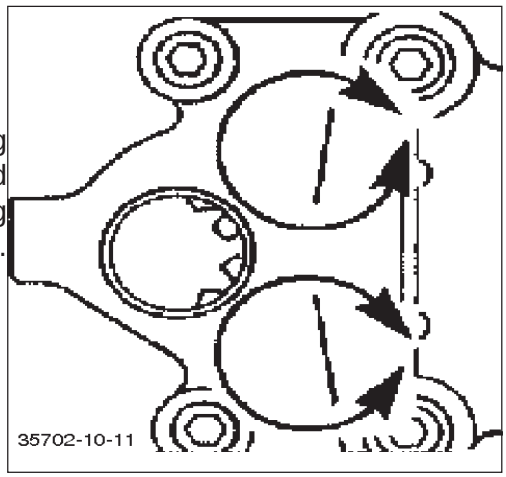
1.1.4.3.4 TESTINGTHE FUEL SOLENOID.

The fuel solenoid can be tested with a voltmeter to ensure the correct voltage exists at the the terminal. With the ignition switched on there should be a 12 volt feed to the solenoid. A resistance test can be made by switching the ignition off and disconnecting the feed cable to the solenoid, with the test meter set to the ohms scale measure the resistance across the solenoid to earth. A reading of between 6 and 10 ohms should be seen. A reading outside this limit indicates a fault in the solenoid coil. A physical test can be made by switching the ignition on and touching the end of the feed cable to the solenoid terminal, the solenoid should be heard to make a click as it is energised. A faulty solenoid must be replaced.



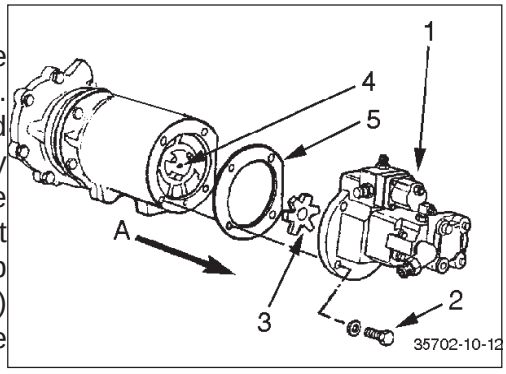
1.1.4.3.5 INSPECTING THE CHARGE PUMP.

If the pump does not perfom adequatly during any of the preceding tests it's operation should be inspected by removing the fuel feed pipe and adaptor and observing the gears while the engine is being cranked. If the gears do not rotate the pump should be removed.



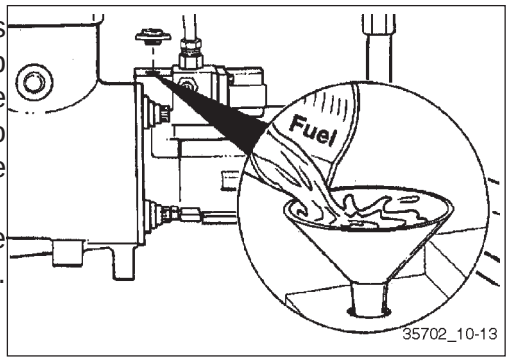
1.1.4.3.6 REMOVING THE CHARGE PUMP.

In order to remove the pump (1) for further investigation remove the screws (2) and pull the pump in the direction of the arrow (A). Carefully inspect the coupling spider (3) for wear or damage and replace if neccesary. Crank the engine and observe the accessory drive shaft (4) for rotation. If the accessory drive shaft rotates the charge pump (1) is faulty, If the accessory drive shaft does not rotate the dive arrangement in the engine is faulty. Fitting the pump is the reverse of the removal procedure, always ft a new gasket (5) between the pump and hte accessory rive housing and inspect the pump mounting face for wear or damage.

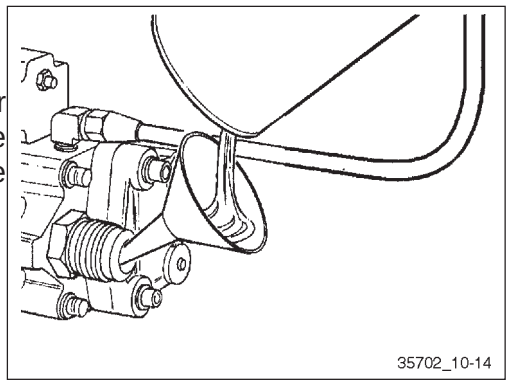


1.1.4.3.6 PRIMING THE CHARGE PUMP.

When the fuel pump has been removed or replaced, or a fault has occured that has caused the fuel to drain out of the charge pump the unit may need to be primed with fuel prior to start up. There are two ways to prime the pump by either introducing clean fuel into the priming port in the top of the pump or by pouring fuel into the inlet port.
To fill the charge pump by the priming port remove the plug in the top of the charge pump assembly and fill the pump with clean fuel.

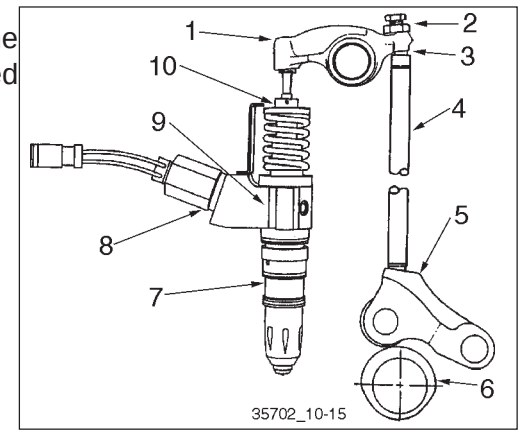


To fill the pump by the fuel inlet if access to the fill port is poor remove the fuel feed pipe and adaptor and pour clean fuel into the charge port. If the fuel pipe Tank or feed end is easily accessible the fuel may be poured into the pipe to charge the pump.



1.1.4.4 FUEL INJECTORS.

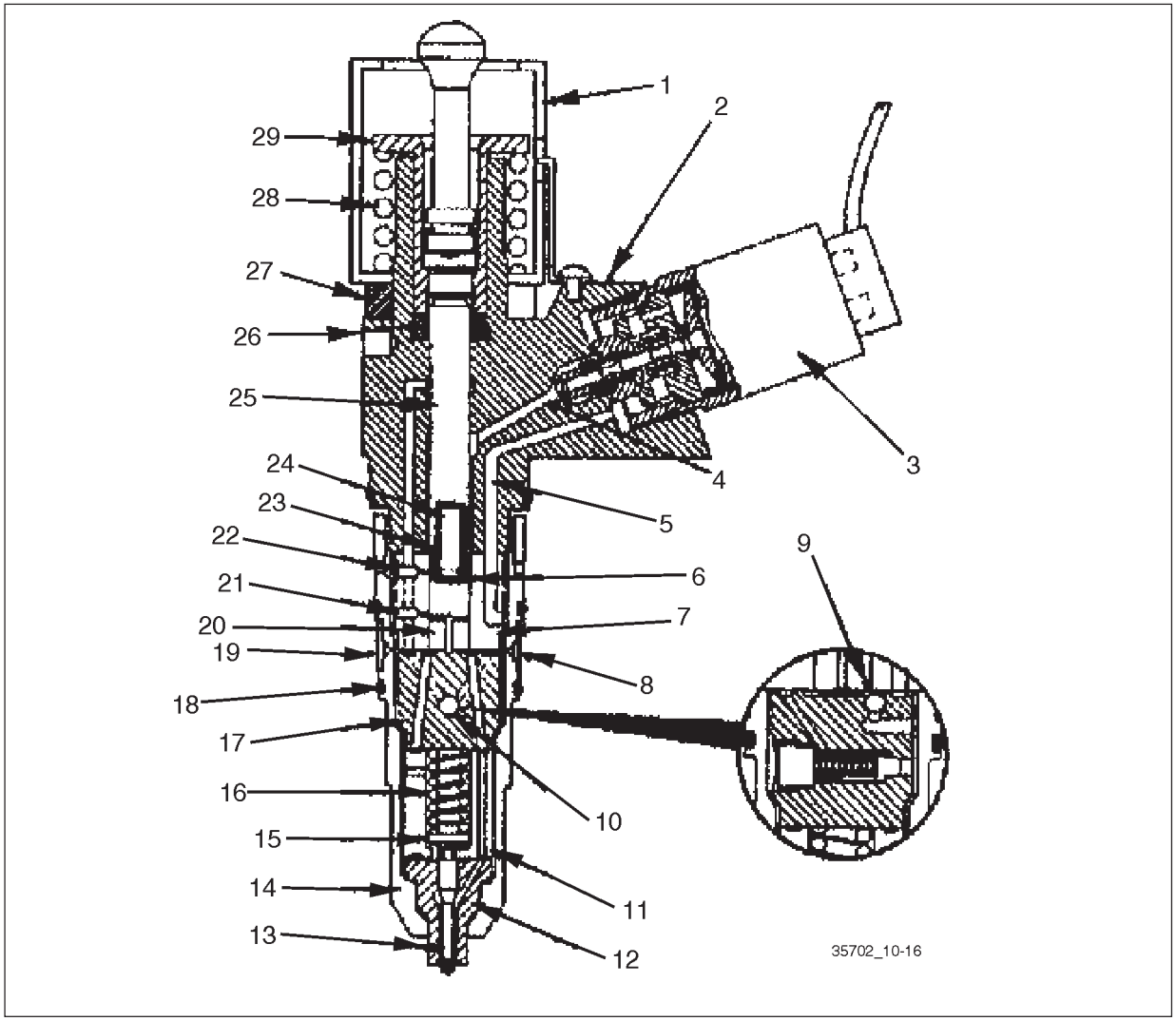
The fuel injectors are electronically controlled by the engine electronic control module (ECM), they are mechanicaly operated by an additional rocker assembly driven by the camshaft.



1 Rocker.
2 Adjuster.
3 Lash Gap area.
4 Pushrod.
5 Cam follower.
6 Camshaft
7 Injector metering plunger area.
8 Injector solenoid.
9 Injector timing plunger area.
10 Operating plunger.

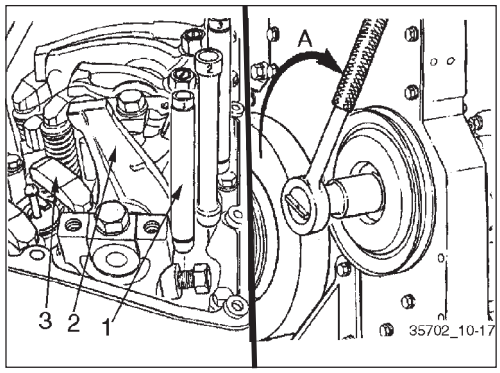
1.1.4.4.1 FUEL INJECTOR OPERATION.

The injector remains closed, with the plunger (25) held at it's lowest position by the operation of the engine camshaft. As the camshaft rotates the spring (28) forces the plnger (25) upward. The solenoid (3) is switched on by the ECM so fuel will flow through line (4) into the injector filling the timing chamber (23) and metering barrel (8) with a precisely measured amount of fuel, excess fuel flows out through the return line (5).
The plunger (25) now begins its downward stroke. At the appropriate time the ECM will switch the fuel solenoid off trapping the metered amount of fuel in the Injector. The downward movement creates a hydraulic link in the timing chamber (23) driving the metering plunger (20) downward increasing the pressure in the metering barrel (8).
When the pressure reaches 345 bar (5000 psi) the needle valve (13) will be forced of its seat, atomising and injecting the fuel into the combustion chamber. When the spill port in the metering plunger (20) passes into line with the spill passage (21) injection pressure is lost and the needle valve (13) will close, abrubtly ending the injection phase.

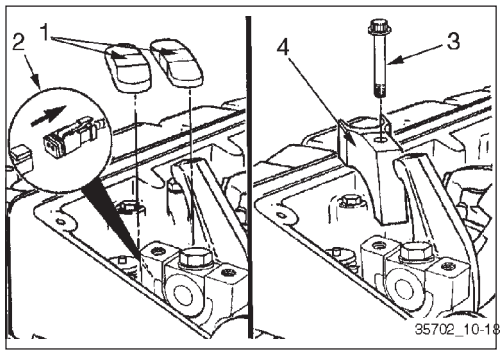


1.1.4.4.2 FUEL INJECTOR REMOVAL.

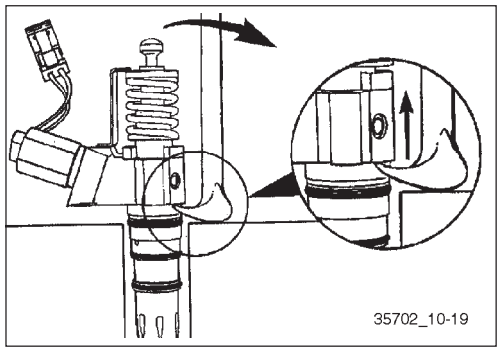
Remove the rocker cover and rockers (2), mark or number the components, especially the pushrods(1) as they should go back into their original positions. Remove and mark the bridge pieces (3). As the rockers may be under load from the pushrods and camshaft the tappet adjusters may be loosened and the crankshaft can be rotated in the direction of the arrow (A) at the timing setting pulley.



When the bridge pieces (2) have been removed and marked. the injector can be unplugged from the ECM output (2). Remove the injector clamp capscrew (3) and the injector clamp (4).



The injector can be carefully prised upward using a pry bar under the injector and levering against the cylinder head.
Replacing the injector is the reverse of this procedure. Before fitting the injector ensure that the injector sleeve in the cylinder head is clean and undamaged.
Always fit new O ring seals to the injector and lubricate them with 15W40 oil prior to fitting.
The O rings must be fitted in the correct order.



Top O ring	Red.
Middle O ring	White.
Bottom O ring	Blue.

Do not twist the O rings during fitting.

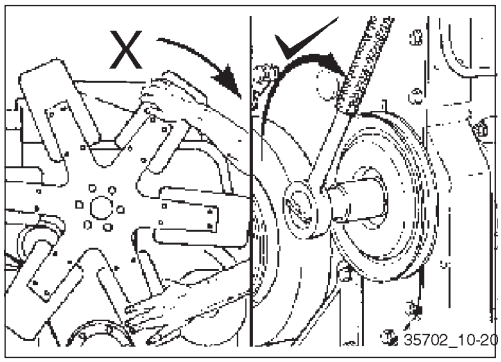
Adjust the valves and injectors.

1.1.4.4.3 ADJUSTING THE VAVLES AND INJECTORS.

The valve clearances and injector "lash" are adjusted at each cylinder in turn in the same pattern as the firing order.

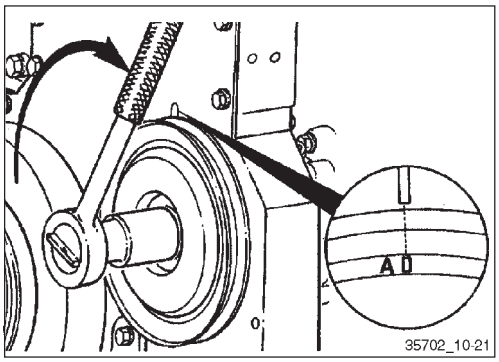
1 5 3 6 2 4

The crankshaft can be rotated by turning the pulley opposite the charge pump drive. Do not attempt to rotate the crankshaft by using the cooling fan as a lever.



Rotate the pulley until the timing mark "A" on the pulley alignes with the timing mark on the timing chest cover and adjust each injector and then the valves on each cylinder in turn acording to the table to within the specified limit with the engine cold.

Injector lash	120°	
Inlet valve	0.36mm	(0.014")
Exhaust valve	0.69mm	(0.027")



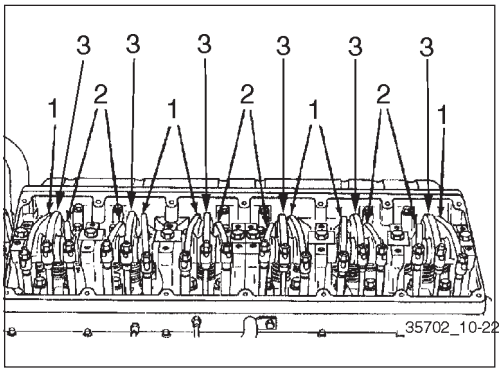
ROTATE CRANKSHAFT	PULLEY POSITION	SET INJECTOR NUMBER	SET CYLINDER NUMBER
1 START	A	1	1
2 Advance to	B	5	5
3 Advance to	C	3	3
4 Advance to	A	6	6
5 Advance to	B	2	2
6 Advance to	C	4	4

Each cylinder has three rocker levers.

The long rocker lever (N°1) is the exhaust valve lever.

The short rocker lever (N°2) is the inlet valve lever.

The centre rocker lever (N°3) is the injector lever.



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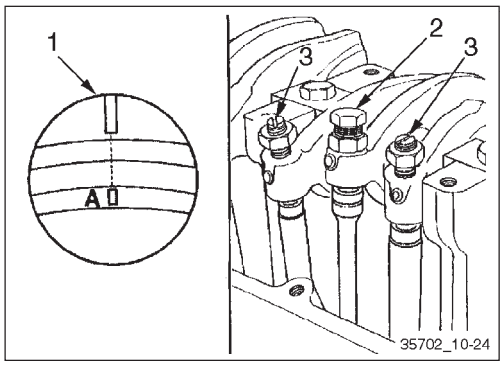
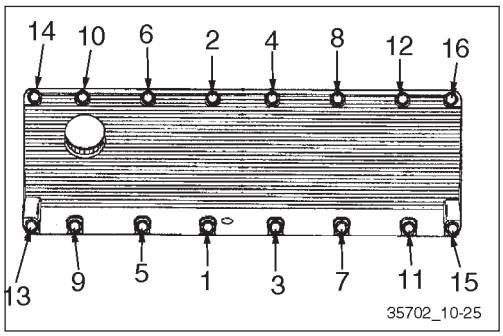
Ensuring the alignment of the timing mark (1) adjust the injector first by loosening the rocker locknut on the centre adjuster (2) and bottoming the injector by tightening the adjuster down gently until it bottoms then loosen it again. Do this three or four times to remove all the fuel from the injector. Tighten the injector again until it bottoms then undo it 2 flats (120°). Tighten the locknut. Each of the valve rockers (3) can be adjusted to the appropriate setting.



Inlet valve	0.36mm	(0.014")
Exhaust valve	0.69mm	(0.027")

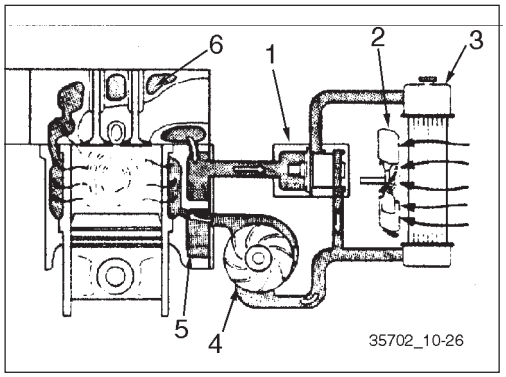
The crank should then be rotated to set the next cylinder in turn according to the table on page 12.

The valve cover should be replaced, the isolators fitted and the 16 cap screws tightened to 15 Nm (130 inch/lb) in the correct order as shown. Ensure that the breather tubes and charge air pipes are fitted correctly.



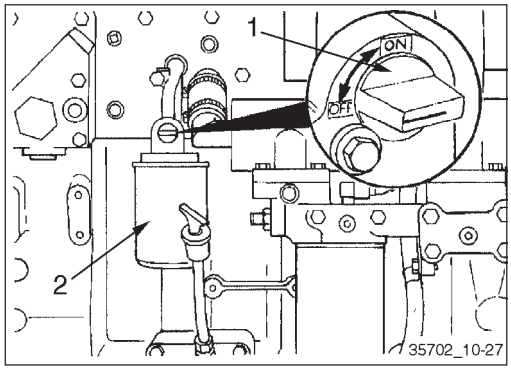
1.1.4.5 ENGINE COOLING SYSTEM.

The cooling system of the Cummins QSM engine is similar to other engines, a pump (4) drives the coolant around the engine block (5) and cylinder head (6) until the engine attains normal operating temperature, at this temperature the the thermostat (1) opens to direct the coolant through the radiator (3) where it is cooled by the fan (2) to maintain the engine temperature within an optimum range (82-93°c). As with all pressurised cooling systems the water must have 50% antifreeze added at all times and must be pressure tight (0.5bar) to prevent the coolant boiling. Additionally the Cummins engine has a water filter that contains soluble crystals (SCA, supplemental cooling additive), these dissolve in the coolant over time and prevent damage to the engine liners and cylinder head caused by hydrogen implosion. Correct maintenance of this filter at the specified intervals is important, failure to replace this filter could lead to early engine failure.



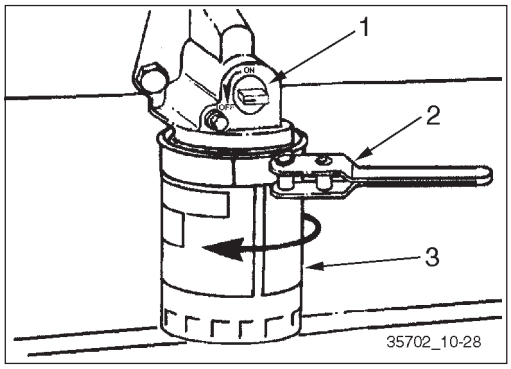
1.1.4.5.1 REPLACING THE WATER FILTER.

Replacement of the water filter should be carried out at the normal service interval at the same time as the fuel and oil filters are changed. Before removing the filter ensure that the system is cool and that the pressure is relieved by removing the radiator filler cap. Switch the valve on the filter head (1) to the off position.



Caution
Ensure that the engine is cool before working on the cooling system. Danger of burning or scalding.

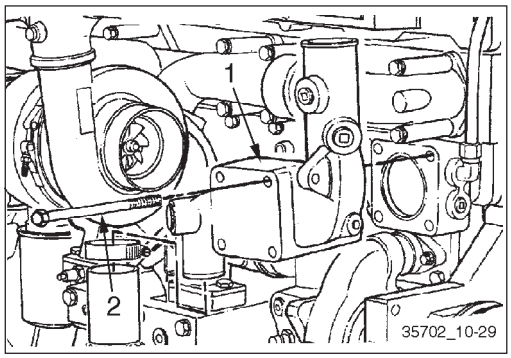
Ensure that the filter valve (1) is switched to the "OFF" position. Use a filter wrench (2) to remove the cannister (3). Before fitting the new filter clean the filter head and smear the rubber seal on the cannister with clean engine oil. Screw the new filter on until the rubber seal is in contact with the filter head then tighten the cannister by a further ½ to ¾ turn.



☞ Note
Do not overtighten the filter cannister, damage or leakadge may occur.

1.1.4.5.2 REMOVING AND INSPECTING THE THERMOSTAT.

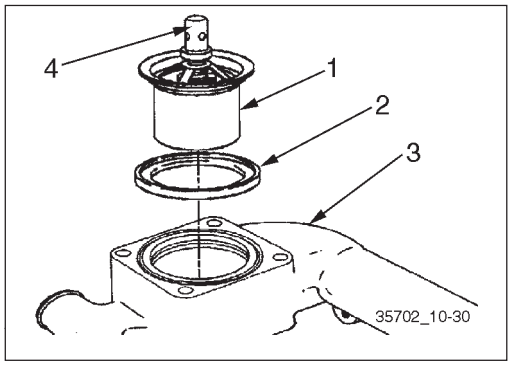
The alternator must be removed to gain access to the thermostat housing (1). Drain the coolant into a clean receptacle for re-use.



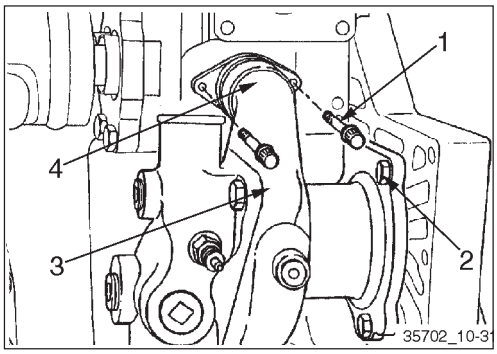
Caution
The coolant is toxic, exercise care at all times.

Remove the four bolts (2) securing the thermostat housing (1) to the engine and remove the thermostat housing.

Inspect the thermostat seal (2) and the thermostat (1) for damage and replace if faulty. Note the nominal temperature stamped on the body of the thermostat at (4). Test the thermostat by suspending it in hot water and raising the temperature of the water. The thermostat must begin to open within 1°c of the nominal temperature and must be fully open at the nominal temperature +12°c. It is advisable to fit new seals to the thermostat housing (3) if possible before re-assembly. Refit the unit and tighten the screws to 54Nm (40 lb/ft). Refill the system with the saved coolant. If new coolant is used it must be a 50/50 mix of water and anti freeze.



1.1.4.5.2 REMOVING THE WATER PUMP.



Removal of the alternator and thermostat housing will facilitate access to the water pump. Remove the hose connections to the water pump. Remove the two water pump transfer tube screws (1) and the three water pump mounting screws (2).
The body of the water pump (3) can then be rotated to bring the transfer tube (1) away from the cylinder block. The water pump can then be removed for inspection, repair or replacement as required. Fitting the water pump is the reverse of this procedure. Fit and rotate the pump into position, fit and tighten the mounting screws (2) to 47Nm (35 Lb/ft). Fit the transfer tube screws (1) and tighten them to 24Nm (18 Lb/ft).

Caution

Ensure that the engine is cool before working on the cooling system. Danger of burning or scalding.

Caution

The coolant is toxic, exercise care at all times.

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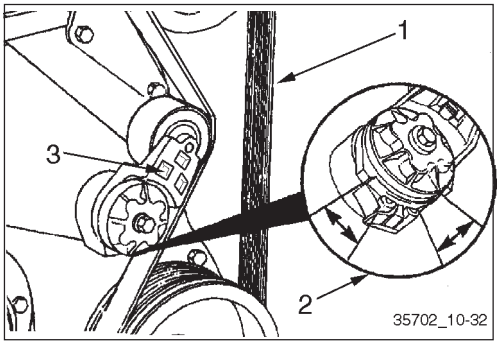
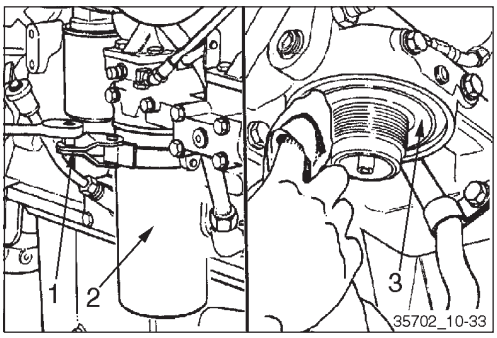
1.1.4.5.3 REMOVAL OF THE PULLEY BELT.



The pulley belt (1) drives the cooling fan and alternator. It is self adjusting between set limits by an automatic tensioner (2) and requires only periodic inspection.
To remove the belt fit a square drive bar into one of the holes in the tensioner (3) and lever the tensioner away to free the belt. Hold the tensioner in the loose position and remove the belt.
Inspect the belt and the pulleys for damage and replace as necessary.

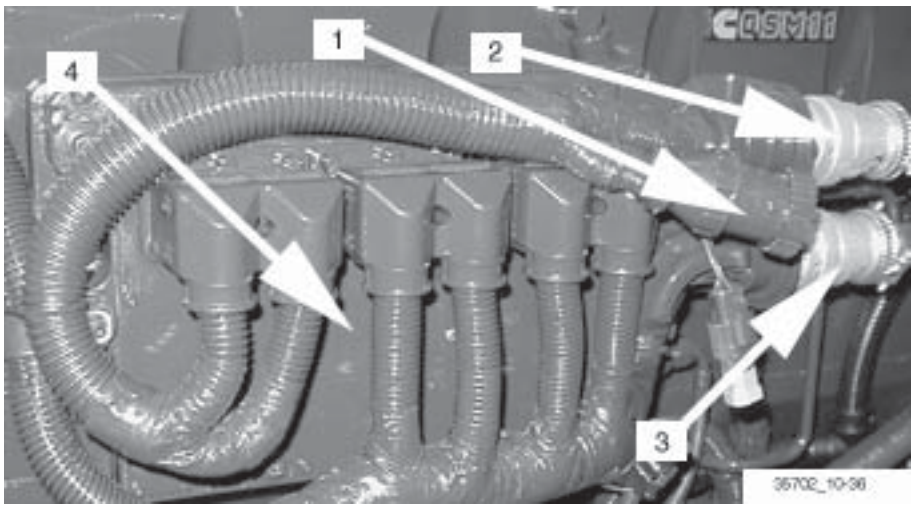
1.1.4.6 OIL FILTER REPLACEMENT.



Use a filter wrench to loosen and remove the filter. Thoroughly clean the filter head, ensuring no particles of the old seal are sticking to the head. Fill the new filter with clean engine oil and aplly a light film of oil to the filter seal, screw the filter onto the head until the seal makes contact and tighten the cannister a further ½ turn approximatly. Start and run the engine ensuring that the oil pressure is correct and there are no leaks.

1.1.4.7 ELECTRICAL SYSTEM.

The Cummins QSM engine uses an advanced electronic monitoring and fuel injection system controlled by the ECM (electronic control module)(4). This unit will indicate faults or potential problems within the engine by illuminating one of three warning lights in the cabin. There is also the facility for plug in analysis with an appropriate laptop computer into the test port (1). The plugs on the end of the unit (2) and (3) are the connections to the Linde harness.
In the front face of the ECM are three double plugs these are from left to right, Linde fault analysis plug in. The centre plug is the actuator outputs to provide and recieve signals to various optional devices. The third plug is the engine sensor inputs.



When any fault or error is detected in any part of the system the ECM will detect it and respond by either shutting the engine down or lighting a warning lamp in the cabin.

The nature of the fault can be analysed by reference to the three warning lights in the cabin mounted in the right hand instrument pod, see page 17. One of these lights will illuminate to indicate the the fault.
The fault can then be analysed by switching the engine off, wait a few moments and switch the ignition back on (do not start the engine). Fully press and release the accelerator pedal three times while observing the warning lights.
The light will flash a "fault code", the number of times the light comes on in a pattern and the colour of the light illuminated indicates the type or seriousness of the fault.

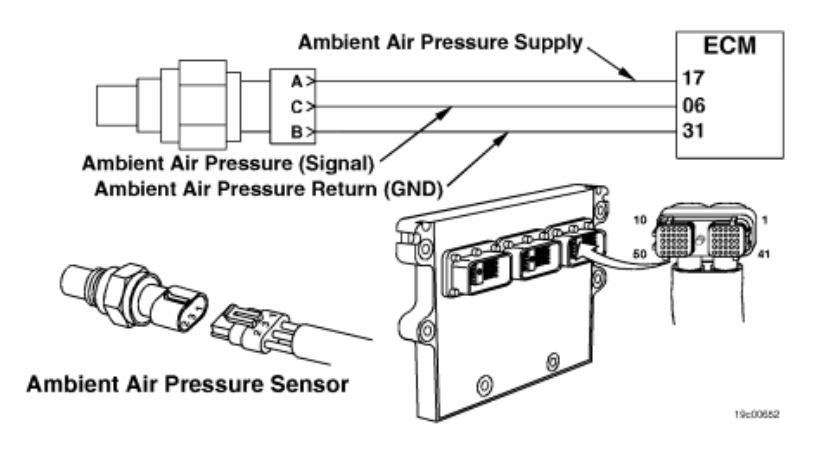
CAUTION
Failure to observe the warning codes could lead to serious engine damage.

QSM 11 engine sensor positions & diagnostics

1. Ambient air pressure sensor

The ambient air pressure sensor is located below the engine ECM.

The ambient air pressure sensor monitors the atmospheric pressure & passes the information to the electronic control module (ECM) through the engine harness.



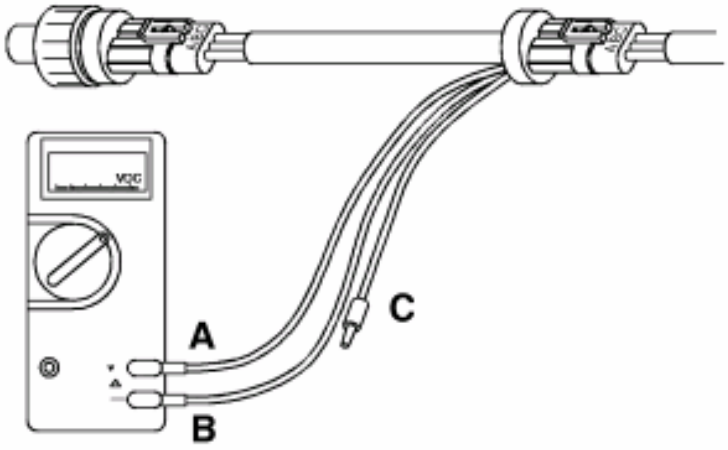
1.1. Check the ECM ambient air pressure sensor supply voltage

Caution: To reduce the possibility of pin or harness damage, use the following test lead when taking measurements: P/N 3824774 - breakout cable.

Condition
- Install breakout cable, P/N 3824774, between the sensor and the sensor harness connector.
- Turn ignition key ON.

Action
Check the ECM ambient air pressure sensor supply voltage.

- Measure the supply voltage from pin A to pin B of the breakout cable.



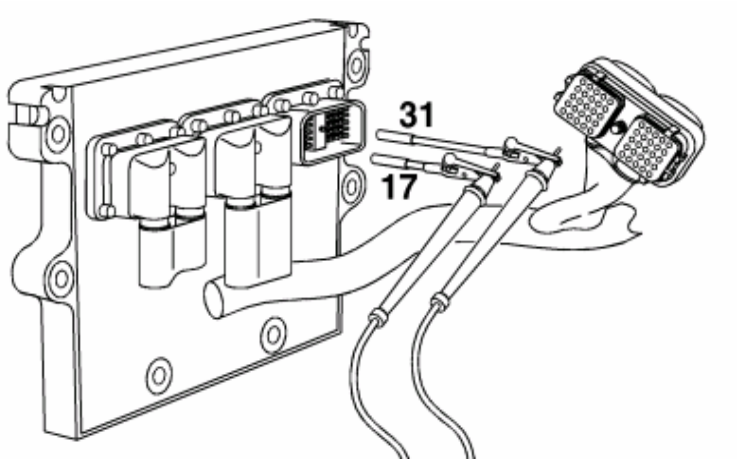
OK:
+4.75 to 5.25 VDC

NOT OK:
- Check voltage supply from the ECM between pin 31 (GND) and pin 17 (Positive)

1.2. If the sensor voltage supply is not correct to the voltage test in step 1.1, measure voltage supply at the ECM connector

Caution: To reduce the possibility of pin or harness damage, use the following test lead when taking measurements: P/N 3822917 - female DEUTSCH/AMP/Metri-Pack test lead.

Condition
- Disconnect the sensor harness from the ECM.
- Turn ignition key ON



Action
Measure the voltage out of the ECM.

- Measure the voltage at the ECM from pin 17 (Positive) to pin 31 (GND) of the ECM sensor connector port.

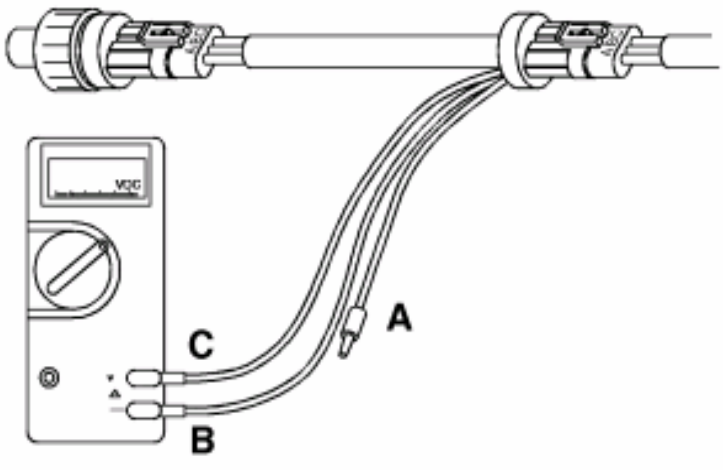
OK:
+4.75 to 5.25 VDC
- Repair or replace the engine

NOT OK:
- Replace the ECM

1.3. Check the ECM ambient air pressure sensor signal voltage

Caution: To reduce the possibility of pin or harness damage, use the following test lead when taking measurements: P/N 3824774 - breakout cable.

Condition
- Install breakout cable, P/N 3824774, between the sensor and the sensor harness connector.
- Turn ignition key ON.



Action
Check the ECM ambient air pressure signal voltage

- Measure the signal voltage from pin C to pin B of the breakout cable.

OK:
Altitude (m) = Voltage (VDC)
- 0m (sea level) = 3.4 to 4.5 VDC
- 1000 m = 2.8 to 3.8 VDC
- 1800 m = 2.2 to 3.25 VDC
- 2700 m = 1.7 to 2.7 VDC
- 3600 m = 1.2 to 2.2 VDC

NOT OK:
- Check harness for corroded, bent, broken, pushed back or expanded pins

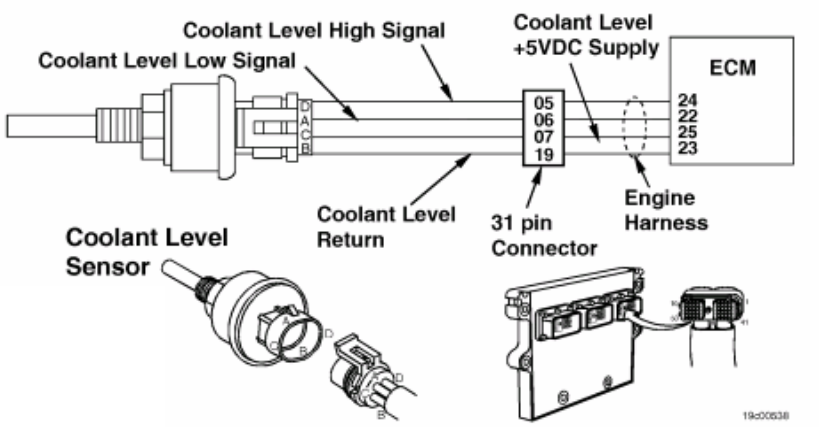
Or

- Replace the ambient air pressure sensor

2. Coolant level switch

The coolant level sensor is located in the radiator top tank.

The coolant level sensor monitors the coolant level within the coolant system and passes information to the electronic control module (ECM) through the sensor harness. This sensor is very complex. **Do not** use a multimeter to check the coolant level sensor. If the radiator coolant level drops below a certain level, a power derate will occur and become greater as time goes by.



3. Coolant temperature sensor

The coolant temperature sensor is located at the front of the engine near the water pump.

The coolant temperature sensor is used by the ECM to monitor the temperature of the engine coolant. The coolant temperature is used by the ECM for the engine protection system, timing, and fuel control.