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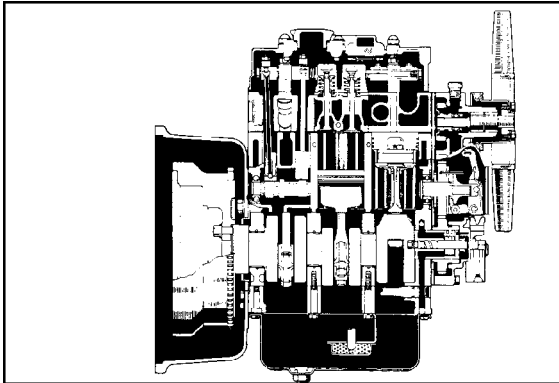
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NOTES

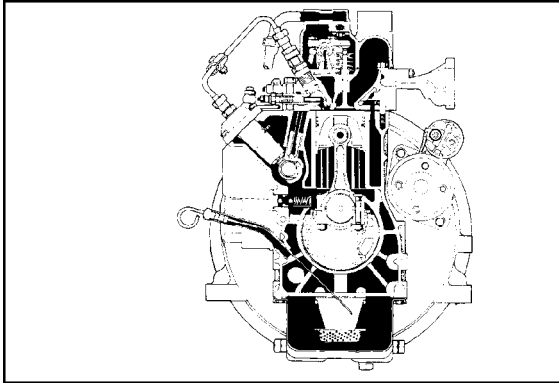
GENERAL INFORMATION

General Description

The 422/M2, 422T/M2 Series are four stroke, liquid-cooled, compression ignition engines, designed for durability, low weight and compactness. The engines are IDI (In Direct Injection). The linerless cylinder block, three-piece helical gear train, and flange-mounted fuel injection pump on the engine cam, reduce frictional power loss and engine weight. The special direct-injection or swirl chamber, along with the small bore multi-cylinder design, offers good fuel consumption, low noise, and excellent start-ability.



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Engine Component Descriptions

Cylinder Block

The cylinder block is made from high-grade cast iron with copper and chrome additives and is integral with the crankcase. The crankcase features five main bearings of the tunnel block design, with crankcase walls extending well below the crankshaft centerline for strength and rigidity. The cylinder's bores are plateau honed for oil retention and extended ring life. The non-machined surfaces are sealed to ensure cleanliness.

Crankshaft

The crankshaft is a chrome-molybdenum steel forging, full machined, static, and dynamically balanced with integral counterweights. All bearing surfaces are induction hardened. The axial location is by thrust washers at the number five main bearing. The five main journals run in replaceable steel-backed cast copper/lead alloy bearings. The front of the crankshaft is keyed.

Pistons and Connecting Rods

Pistons are cast from high silicon aluminum alloy and are heat-treated for low weight with high strength and good thermal conductivity. The piston is fitted with three rings; two cast iron, chrome-faced compression rings and one steel, chrome-faced controlled oil ring. The fully floating gudgeon pin (wrist pin) is made of chrome molybdenum steel alloy hardened by carbonizing and retained by the conventional retaining ring method. The connecting rods are machined from high-strength forged steel. The big end bearings are renewable steel-backed, copper/lead alloy overlay with tin plating. The small end bearings are a press fit plain bushing of tin-backed lead-bronze.

Camshaft

The camshaft is made of forged steel and is induction hardened. Three or four additional lobes at the front operate the fuel injection pump. At the rear, a fuel lift pump eccentric is machined. The camshaft is supported by roller and needle bearings and lubricated by splash feed. The nose of the camshaft supports the cam gear, governor weight cage, and governor slider assembly.

Cylinder Head

The cylinder head is made of high grade copper chrome cast iron, and incorporates replaceable heat-resistant alloy steel valve seats. Inlet and exhaust valves are made of high grade heat resistant alloy steel with tufttrided stems and induction hardened heads. Each stem is fitted with a chrome molybdenum steel cap for long life.

The valves are operated by cold drawn seamless tube push rods with hardened steel ball and forged cup ends. Flat-based tappets are made from case carburized chrome molybdenum steel operating in machined bores in the cylinder block. The rocker shaft is an induction hardened hollow steel tube. Valve clearances are adjusted by hardened ball-ended screws and locknuts.

Rocker Cover and Inlet Manifold

The cover is made of cast aluminum with an air intake, oil filler, and crankcase breather. It is located in position by rocker pillar studs and secured by cap nuts.

Gear Train

The gear train consists of three helical gears - the crankshaft gear located by a woodruff key, the idler gear houses the lube oil pump, and the cam gear incorporates the governor weight cage.

Fuel System

A flanged-mounted, Bosch-type fuel injection pump is mounted in the cylinder block and operated by lobes machined on the engine cam.

Lubricating System

A trochoid lobe oil pump located in the center of the idler gear sends lubricating oil to the main oil galley via a relief valve through a spin-on bypass oil filter to the main oil gallery. The rockers are pressure fed via an externally mounted oil pipe from the main oil gallery to the cylinder head.

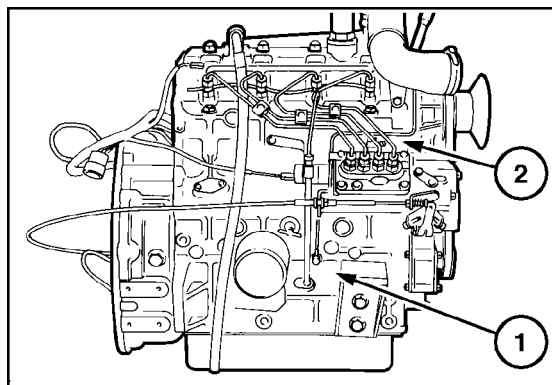
Cooling System

A belt-driven centrifugal water pump circulates coolant via the internal water passages. The coolant is radiator cooled and temperature controlled by a conventional thermostat.

Engine Model and Serial Number Location

The engine model number is located on the right side of the engine block at 1. The engine serial number is located at 2.

Throughout this manual, whenever the left- or right-hand side of the engine is referred to, it is that side of the engine when viewed from the flywheel end.



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Turbocharger Lubrication

The turbocharger used on the 422T/M2 diesel engine may not receive adequate lubrication on cool/cold weather (below 5°C, 40°F) start-up, leading to turbocharger bearing failure.

The following procedure must be used to ensure adequate lubrication oil is supplied to the turbocharger bearings before high-speed engine operation:

1. Set the engine throttle at 1/3 speed.
2. Turn the ignition switch and allow the automatic glow plug timer to preheat the engine until the EIC "beep" is heard.
3. Start the engine, but DO NOT OPERATE ABOVE 1,500 RPM for three minutes to allow for adequate oil flow at the turbocharger.

After full load operation, allow the engine to run at low idle for one minute before engine shutdown.

Safety Precautions

The following safety precautions are very important.

IMPORTANT: *Do not change the specification of the engine.*

Do not smoke when you put fuel in the tank.

Clean away any fuel which has spilled and move material which has fuel contamination to a safe place.

Do not put fuel in the tank during engine operation.

Never clean, lubricate or adjust the engine during operation unless otherwise specified in this manual. Use extreme caution when working around moving parts to prevent injury.

Do not make any adjustments you do not understand.

Ensure the engine is not in a position to cause a concentration of toxic emissions.

Persons in the area must be kept clear during engine and equipment or vehicle operation.

Do not permit loose clothing or long hair near parts which move.

Keep away from parts which turn during operation. Note that fans cannot be seen clearly while the engine is running.

Do not run the engine with any safety guards removed.

Do not remove the radiator cap while the engine is hot and the coolant is under pressure, as dangerous hot coolant can be discharged.

Do not use salt water in the fresh water cooling system or any other coolant which can cause corrosion.

Keep sparks or fire away from batteries (especially while charging) or combustion can occur. The battery fluid can burn and is also dangerous to the skin and especially the eyes.

Disconnect the battery terminals before you make a repair to the electrical system.

Only one person must be in control of the engine.

Ensure the engine is only operated from the control panel or operator's position.

If your skin comes into contact with high pressure fuel, get medical assistance immediately.

Diesel fuel and used engine oils can cause skin damage to some persons. Use protection on the hands (gloves or special skin protection solutions).

Do not move equipment unless the brakes are in good condition.

Be sure that the transmission drive control is in "Neutral" position before the engine is started.

IMPORTANT: *Do not use ether to start these engines.*

422/M2 GENERAL ENGINE SPECIFICATIONS

Engine Model	422/M2
Type	Vertical in-line 4-stroke - naturally aspirated
Basic Thread and Size	
Bore	84 mm (3.31 inches)
Stroke	100 mm (3.94 inches)
Combustion System	IDI (Indirect Injection/Special Swirl)
Compression Ratio	22.4:1
Swept Volume Liter (inch ³)	2216 L (135.3 inch ³)
Firing Order	1-3-4-2
Rotation	Counterclockwise viewed from flywheel
Low Idle	1050 ± 50 RPM
High Idle	3050 ± 50 RPM
Injection Pump	Flange-Mounted, Bosch-type plunger and barrel
Injectors	Bosch-type throttle
Injector Setting	147 - 157 Kilograms sq. cm kgf/cm ² (2132 - 2277 Pounds per sq. inch PSI)
Turbo	NO
Governor	Mechanical all speed
Cooling System	Liquid with water pump and radiator
Industrial Cooling System Capacity (less radiator)	3.5 Litres
Thermostat Operating	
Temperature degrees	71°/82° C (160°/180° F)
Oil Pressure Relief	3.6 - 4.6 kgf/cm ² (51 - 65 PSI)
Oil Pressure Switch	4.3 PSI
Electrical Starter	
Starter	12V
Alternator	12V
Weight, Bare Engine (Industrial)	205 kg (452 lbs)
Height	786 mm (30.9 inches)
Length	665 mm (26.2 inches)
Width	431 mm (17 inches)

Recommended Engine Fluids

Coolant Clean soft water. Maximum antifreeze concentration
50% (ethanediol base-ethylene glycol with corrosion inhibitor to
BS 6850:1985 or ASTM D3306-74 or AS 2108-1977)

Fuel Cetane number-45 minimum, Viscosity-2.5/4.5
centistokes at 40° C (104° F). Density-0.835/0.855
kg/liter, Sulfur -0.5% of mass maximum. Distillation
85% at 350° C (662° F). Aviation fuel JP4 is not
recommended; however, JP5 and JET-A are
acceptable, providing 5% spindle oil is added).

Lubricating

System Pressure feed with Trochoid pump

Oil Type API Service CH 4 SAE 10W-30
(SAE 5W30 for extended cold weather operation)

Engine Crankcase Capacity with Filter 8.7 L (9.2 US quarts)

Engine Crankcase Capacity Without Filter Change 8.5 L (9.0 US quarts)

422T/M2 GENERAL ENGINE SPECIFICATIONS

Engine Model	422T/M2
Type	Vertical in-line 4-stroke - Turbocharged
Basic Thread and Size	
Bore	84 mm (3.31 inches)
Stroke	100 mm (3.94 inches)
Combustion System	IDI (Indirect Injection/Special Swirl)
Compression Ratio	22.4:1
Swept Volume Liter (inch ³)	2216 L (135.3 inch ³)
Firing Order	1-3-4-2
Rotation	Counterclockwise viewed from flywheel
Low Idle	1050 ± 50 RPM
High Idle	3050 ± 50 RPM
Injection Pump	Flange-Mounted, Bosch-type plunger and barrel
Injectors	Bosch-type throttle
Injector Setting	147 - 157 Kilograms sq. cm kgf/cm ² (2132 - 2277 Pounds per sq. inch PSI)
Turbo	YES
Governor	Mechanical all speed
Cooling System	Liquid with water pump and radiator
Industrial Cooling System Capacity (less radiator)	3.9 Litres
Thermostat Operating	
Temperature degrees	71°/82° C (160°/180° F)
Oil Pressure Relief	3.5 - 4.5 kgf/cm ² (51 - 65 PSI)
Oil Pressure Switch	4.3 PSI
Electrical Starter	
Starter	12V
Alternator	12V
Weight, Bare Engine (Industrial)	212 kg (467 lbs)
Height	803 mm (31.6 inches)
Length	665 mm (26.2 inches)
Width	456 mm (18.0 inches)

Recommended Engine Fluids

Coolant Clean soft water. Maximum antifreeze concentration
50% (ethanediol base-ethylene glycol with corrosion inhibitor to
BS 6850:1985 or ASTM D3306-74 or AS 2108-1977)

Fuel Cetane number-45 minimum, Viscosity-2.5/4.5
centistokes at 40° C (104° F). Density-0.835/0.855
kg/liter, Sulfur -0.5% of mass maximum. Distillation
85% at 350° C (662° F). Aviation fuel JP4 is not
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Lubricating

System Pressure feed with Trochoid pump

Oil Type API Service CH 4 SAE 10W-30
(SAE 5W30 for extended cold weather operation)

Engine Crankcase Capacity with Filter 8.7 L (9.2 US quarts)

Engine Crankcase Capacity Without Filter Change 8.5 L (9.0 US quarts)

TROUBLESHOOTING

ENGINE WILL CRANK BUT DOES NOT START

CAUSE	CORRECTION
Faulty key switch	Correct the connection and/or replace switch
Fuel solenoid not operating	Check solenoid for battery voltage and correct
Insufficient charging or complete discharging of the battery	Charge or replace battery
Lack of fuel	Fill fuel tank
Air mixed in the fuel system	Bleed the air
Clogged fuel filter	Replace
Irregular and faulty fuel supply (electric fuel pump)	Check power supply; check fuse in fuse panel; check for corroded internal components (replace pump and in-line filter if corroded)
Irregular and faulty fuel supply (injection pump trouble)	Repair in an authorized service shop
Glow plug not heating	Failure of the glow plug; replace
Improper viscosity of the lubricating oil	Inspect and replace
Clogged air cleaner	Clean or replace
No Compression	Repair in a service shop

ENGINE WILL NOT CRANK OR START

CAUSE	CORRECTION
Faulty key switch	Correct the connection and/or replace switch
Insufficient charging or complete discharging of the battery	Charge or replace battery
Insufficient charging or complete discharging of the battery	Charge or replace battery

IRREGULAR RUNNING OF THE ENGINE

CAUSE	CORRECTION
Air mixed in the fuel system	Bleed the air from the system
Uneven fuel injection (faulty fuel injection pump)	Repair at authorized shop
Clogged fuel filter	Replace
Defective governor	Check and correct
Engine itself defective	Repair in a service shop

ENGINE STOPS DURING OPERATION

CAUSE	CORRECTION
Lack of fuel in the tank	Fill fuel tank and bleed air
Clogged fuel filter	Replace
Air mixed in the fuel system	Bleed the air
Faulty function of the engine	Repair in a service shop

OVERHEAT OF THE ENGINE

CAUSE	CORRECTION
Lack of cooling water	Supply water, inspect for leakage and correct
Loose or slipping fan belt	Remove oil, dust, etc. and tighten
Damaged fan belt	Replace
Clogged radiator	Flush the radiator
Clogged radiator fin	Clean
Dust or scale clogged in the cooling water passage	Flush the system
Faulty function of the thermostat	Inspect or replace thermostat
Lack of lubricating oil	Add oil
Overloading	Decrease the load

FAULTY CHARGING

CAUSE	CORRECTION
Loose fan belt	Correct belt tension
Faulty wiring	Inspect and correct
Faulty battery	Repair
Worn out alternator brush	Replace

STARTER MOTOR DOES NOT RUN

CAUSE	CORRECTION
Loose or disconnected wiring	Inspect and tighten
Low voltage of the battery	Charge the battery
Damaged started motor	Repair in a service shop

OIL PRESSURE LAMP NOT TURNED OFF

CAUSE	CORRECTION
Lack of engine oil	Fill oil to the specified level
Fault in the pressure switch	Replace the switch
Oil leakage from the lubricating system	Inspect and retighten
Clogged oil filter	Replace with new one

EXCESSIVE SMOKE/ENGINE MISS

CONDITION	CAUSE	CORRECTION
Good power, but misses or smokes at top engine speed	Top engine speed too high	Adjust top engine speed to factory limit
	Timing off	Check and adjust engine timing
White or blue exhaust smoke during all operating conditions	Excess engine oil	Check and correct the level
	Engine oil viscosity too low	Check and replace oil
	Faulty/late injection timing	Correct timing
Blue smoke on cold engine startup	Low combustion temperature	Check fuel injection timing, adjust inlet and exhaust valves, and test the cylinder
	Normal warm-up	May be difficult to stop blue smoke on startup completely
Dark exhaust smoke	Fuel cetane rating not optimal	Use only fuel with a cetane rating of 50 or higher
	Excess injection	Inspect and adjust (in service shop)
	Faulty function of the engine	Repair in service
	Overloading	Reduce the load
	Clogged air cleaner	Clean
	Leaks	Seal off all leaks
	Valve cover vent hose kinked or clogged	Shorten hose to 460 mm (18.1 inches)

422T/M2 TURBOCHARGER BEARING FAILURES

CAUSE	CORRECTION
Lack of lubrication during cold weather startup	Warm up below 1500 RPM for three minutes on start-up and allow to run at low idle for one minute before shutdown

422T/M2 ENGINE NOISE/WHISTLING

CAUSE	CORRECTION
Internal muffler restriction	Replace muffler
Turbocharger worn	Inspect turbocharger components

EXCESSIVE OIL CONSUMPTION (OR OIL SMOKE FROM EXHAUST)

CAUSE	CORRECTION
Leaks	Seal all leak sources
Valve cover vent hose kinked or clogged	Shorten hose to 460 mm (18.1 inches)

NOTE: See 422T/M2 *Excessive Oil Consumption* on the next page for more extensive troubleshooting procedures.

422T/M2 - EXCESSIVE OIL CONSUMPTION

The maximum allowable oil consumption for the turbocharged diesel engine is 0.8%, as measured using a log of fuel consumption to oil consumption.

If a customer complains about excessive engine oil consumption on the Model 422/M2 or 422T/M2 Engines, the following steps must be taken. If a cause is found, stop and correct the problem. If a cause is not found, continue to the next step.

1. Examine engine for signs of external oil leaks.

- Check gaskets: oil pan, timing gear case, head, head cover, injection pump, oil gallery, and dipstick.
- Oil seals: crankshaft, front and rear.
- Steel tubing and fittings that supply oil to the turbocharger and upper engine.
- Tubing, hose, and fittings for turbocharger oil drain to block.
- Damage to oil pan and drain plug.
- Crankcase breather hose (open and not kinked) preventing proper crankcase breathing.

2. Examine turbocharger area.

- Remove the hose between the turbocharger inlet and the air cleaner. Examine for signs of dirt in the hose and inlet to the turbocharger blower.

If carbon, oil, and dust are found, check:

- Air cleaner assembly for tightness of filter elements.
- Hose between air cleaner and turbocharger for damage or looseness of clamps.

If oil residue is evident on the clean air turbine, it might not be due to failed turbocharger bearings.

Check the air filter and air intake hose for signs of oil residue.

Check the exhaust area for leaks:

- Exhaust manifold gasket and hardware.
- Turbocharger gasket and hardware, if equipped.
- Muffler gasket and hardware.

- Muffler failure (cranks, misalignment).

Remove the hose between the turbocharger outlet and the intake manifold. Check for dirt in the hose, turbocharger outlet, and the air intake manifold.

If there is not dirt at the turbocharger inlet but there is a deposit at the turbocharger blower outlet (which is not due to signs of dirt in the hose and inlet to the turbocharger blower), it may be leakage from the turbocharger seals.

Check turbocharger shaft specifications:

Axial movement: maximum 0.09 mm (0.0035 inch)

Radial movement: maximum 0.17 mm (0.0067 inch)

3. Check the blowby hose (valve cover vent hose) for signs of blockage. If the hose is kinked or the end is blocked by debris, correct by cutting off the end of the hose so it is just below the bottom of the engine oil filter.

4. If there is no problem found in the 1, 2, and 3 checking points, then go to the next step to log oil consumption.

5. The customer must log oil consumption using the following procedure:

- Change the engine oil and filter. Use the oil specified in the operator's manual.

- Run the engine for two minutes.

- Check the dipstick and add oil, if required, so the level is at the fuel mark.

- Fill the fuel tank with fuel.

- Record fuel consumption (in gallons), oil added (in quarts), and hour reading. Record fuel and oil use for 100 hours of operation, which is the recommended oil change interval. Check the dipstick before running the engine each day.

The maximum allowable oil consumption is 0.8%.
The following table gives examples.

Fuel Consumption, Gallons	Oil Consumption, Quarts
50	1.6
100	3.2
200	6.4

A log example is shown in the following table.
The hour level is the Hourmeter reading when fuel is added. Dealer must file oil consumption log with customer file.

Fuel	Oil	Hour Level
Full	Full	100
XX Gallons	X Quart	150
XX Gallons	X Quart	200

6. If the oil consumption is greater than 0.8% of the fuel consumption, oil usage is excessive. A sample calculation for oil consumption follows:

$$\% \text{ Consumption} = \frac{(\text{quarts oil}/4) \times 100}{\text{gallons fuel}}$$

Assume one quart oil is added for 50 gallons fuel.

$$\% \text{ Consumption} = \frac{(1/4) \times 100}{50} = 0.5\%$$

7. The CNH dealer must check compression on all four cylinders and record.

The compression specifications are as follows:

Standard Value	To Be Repaired
More than 29.5 bar (429 PSI) at 200 - 250 engine cranking RPM	Less than 24.5 bar (356 PSI)

Compression testing can be performed using a special adapter (see "Special Tools" in the Additional Information Section) through the glow plug ports. Remove all glow plugs and test each cylinder.

This should be a "dry" compression check (do not put any oil in the cylinder).

If compression is low, recheck the air intake system for signs of dirt ingestion.

ENGINE SERVICE SPECIFICATIONS

SERVICE STANDARDS

Inspection	Standard Dimension	Standard Value	To Be Repaired	Allowable Limit	Remarks
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CYLINDER HEAD

Compression pressure of cylinder		More than 30 kg/cm ² (426.6 PSI)	Less than 25 kg/cm ² (355.5 PSI)		
Tightening torque of cylinder head		98 - 103 Nm (72.3 - 75.9 lb ft)			
Distortion of face of cylinder head		0.05 mm (0.0002 inch max.)	0.12 mm (0.0047 inch)		
Valve seat depth (Both intake and exhaust) Width Recess Valve Seat		0.65 - 0.95 mm (0.026 - 0.037 inch)	1.6 mm (0.063 inch)		Valve seat angle 45°
Valve seat width (intake)		1.5 - 2.0 mm (0.06 inch - 0.08 inch)	2.5 mm (0.1 inch)		
Valve seat width (exhaust)		1.94 - 2.16 mm (0.076 - 0.085 inch)	2.5 mm (0.1 inch)		

CYLINDER BLOCK

Type			Dry type (Unit type)		
Bore	84 mm (3.307 inch)	84 - 84.019 mm (3.307 - 3.308 inch)	84.2 mm (3.315 inch)	85.2 mm (3.354 inch)	Oversize 0.5, 1.0 mm (0.02/.04 inch)
Cylinder block type surface warpage		0.05 mm (0.002 inch max.)	0.12 mm (0.0047 inch)		

PISTON

Skirt long-diameter size	84 mm (3.307 inch)	83.948 - 83.963 mm (3.3050 - 3.3056 inch)		83.7 mm (3.295 inch)	Oversize 0.5, 1.0 mm (0.02/.04 inch)
Clearance with cylinder		0.038 - 0.072 mm (0.0015 - 0.0028 inch)		0.25 mm (0.01 inch)	20° C (68° F)
Piston pin hole inside diameter	28 mm (1.1024 inch)	27.999 - 28.003 mm (1.1023 - 1.1025 inch)			
Piston pin hole to pin clearance		0.01 ± 0.007 mm (-0.00004 ± 0.0028 inch)		0.02 mm (0.0008 inch)	

PISTON PIN

Pin outside diameter	28 mm (1.1024 inch)	27.996 - 28.0 mm (1.1022 - 1.1024 inch)		27.98 mm (1.1016 inch)	
Rod small end bushing to pin clearance		0.010-0.025 mm (0.0004 - 0.00098 inch)		0.1 mm (0.004 inch)	Oil clearance

Inspection	Standard Dimension	Standard Value	To Be Repaired	Allowable Limit	Remarks
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PISTON RING

Piston ring groove to ring clearance

1st ring		0.07 - 0.11 mm (0.0028 - 0.0043 inch)		0.25 mm (0.0098 inch max.)	
2nd ring		0.04 - 0.08 mm (0.0016 - 0.0031 inch)			
Oil ring		0.02 - 0.06 mm (0.0008 - 0.0024 inch)		0.15 mm (0.006 inch max.)	

Ring width

1st ring	3.5 mm (0.1378 inch)	3.4 - 3.6 mm (0.1339 - 0.1417 inch)			
2nd ring	3.6 mm (0.1417 inch)	3.5 - 3.7 mm (0.1378 - 0.1457 inch)			
Oil ring	2.2 mm (0.0867 inch)	2.2 - 2.4 mm (0.0867 - 0.0944 inch)			

Piston ring end gap

1st ring		0.2 - 0.35 mm (0.0079 - 0.0138 inch)		1.0 mm (0.0394 inch)	
2nd ring		0.2 - 0.4 mm (0.0079 - 0.0157 inch)			
Oil ring		0.2 - 0.4 mm (0.0079 - 0.0157 inch)			

CONNECTING ROD

Twist between small and large end holes (per 100 mm)		0.08 mm (0.0031 inch max.)		0.2 mm (0.0079 inch)	
Straightness at 100 mm between small and large end hole		0.05 mm (0.0020 inch max.)		0.15 mm (0.0059 inch)	
Front-to-rear clearance between connecting rod and crank pin		0.1 - 0.3 mm (0.004 - 0.012 inch)		0.7 mm (0.0276 inch)	
Connecting rod bearing-to-crank pin clearance		0.035 - 0.085 mm (0.0014 - 0.0033 inch)		0.2 mm (0.0079 inch)	Oil clearance
Crush height of large end bearing		27.517 - 27.557 mm (1.0833 - 1.0849 inch)			
Connecting rod bearing (inner diameter x width)	55 x 19.8 mm (2.1654 x 0.779 inch)	55 x 19.8 mm (2.1654 - 0.779 inch)			
Connecting rod bolt torque		49 - 54 Nm (36.2 - 39.8 lb ft)			
Weight difference with piston assembly		10 g (less than 0.022)			

Inspection	Standard Dimension	Standard Value	To Be Repaired	Allowable Limit	Remarks
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CRANKSHAFT

Diameter of journal	68 mm (2.677 inch)	67.957 - 67.970 mm (2.6755 - 2.6760 inch)		67.4 mm (2.654 inch)	Undersize 0.25, 0.5 mm (0.01 - 0.02 inch)
Diameter of pin	52 mm (2.047 inch)	51.964 - 51.975 mm (2.0458 - 2.0463 inch)		51.4 mm (2.024 inch)	Undersize 0.25, 0.5 mm (0.01, 0.02 inch)
Roughness, main journal & crank pin	1.6Z				
Crankshaft deflection		0.03 mm (0.0012 inch max.)		0.06 mm (0.0024 inch)	
Axial play of crankshaft		0.01 - 0.4 mm (0.004 - 0.016 inch)			
Thickness of thrust washer		2.95 - 3.0 mm (0.116 - 0.118 inch)		2.8 mm (0.110 inch)	
O.D. x I.D. of bushing (journal bearing)	72 x 68 mm (2.8346 x 2.6772 inch)	72 x 68 mm (2.8346 x 2.6772 inch)			
Clearance between crankshaft journal bushing		0.044 - 0.116 mm (0.0017 - 0.0046 inch)		0.2 mm (0.008 inch)	Oil clearance
O.D. x I.D. of center bearing	72 x 68 mm (2.8346 - 2.6772 inch)	73 x 68 mm (2.8346 x 2.6772 inch)			
Clearance between crankshaft journal and center bearing		0.044 - 0.102 mm (0.0017 - 0.0040 inch)		0.2 mm (0.008 inch)	Oil Clearance

CAMSHAFT

Height For intake/exhaust		34.065 - 34.12 mm (1.3411 - 1.3433 inch)		33.7 mm (1.3268 inch)	
For injection pump		41.94 - 42.06 mm (1.6512 - 1.6559 inch)		41.94 - 42.06 mm (1.6457 inch)	
For feed pump		31.9 - 32.0 mm (1.2559 - 1.2598 inch)		30.0 mm (1.1811 inch)	
Camshaft deflection		0.03 mm (0.0012 inch max.)		0.1 mm (0.004 inch)	
Cam gear backlash		0.08 mm (0.00315 inch)		0.25 mm (0.01 inch)	

Inspection	Standard Dimension	Standard Value	To Be Repaired	Allowable Limit	Remarks
VALVE					
Diameter of intake valve stem	6.97 mm (0.2744 inch)	6.955 - 6.97 mm (0.2738 - 0.2744 inch)		6.89 mm (0.2713 inch)	
Diameter of exhaust valve stem	6.95 mm (0.2736 inch)	6.94 - 6.95 mm (0.2732 - 0.2736 inch)		6.84 mm (0.2693 inch)	
Clearance between valve stem and valve guide Inlet Exhaust		0.03 - 0.06 mm (0.0012 - 0.0024 inch)		0.2 mm (0.008 inch)	
		0.05 - 0.075 mm (0.002 - 0.003 inch)		0.25 mm (0.01 inch)	
Valve thickness		0.925 - 1.075 mm (0.0364 - 0.0423 inch)		0.5 mm (0.02 inch)	
Thickness					
Valve clearance (intake and exhaust)		0.2 mm (0.008 inch)	0.5 mm (0.02 inch)		Cold
Valve spring Spring force at 30.4 mm (1.2 in) Free height Squareness		8.2 kg (17.86 lbs)		7 kg (15.43 lbs)	
		35 mm (1.378 inch)		33.5 mm (1.319 inch)	
		1.2 mm (0.047 inch max.)		2.0 mm (0.079 inch)	
Intake valve Opening angle BTDC Closing angle ABDC	13°				
	43°				
Exhaust valve Opening angle BBDC Closing angle ATDC	43°				
	13°				

PUSHROD

Overall length		222.1 - 222.9 mm (8.075 - 8.106 inch)			
Outside diameter		6.2 - 6.4 mm (0.244 - 0.252 inch)			

ROCKER ARM

Rocker arm shaft OD		14.95 - 14.97 mm (0.5886 - 0.5894 inch)		14.87 mm (0.5854 inch)	
Rocker arm to shaft clearance		0.030 - 0.093 mm (0.0012 - 0.0037 inch)		0.2 mm (0.008 inch)	Oil Clearance

Inspection	Standard Dimension	Standard Value	To Be Repaired	Allowable Limit	Remarks
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OIL PUMP

Oil pressure switch actuating pressure	0.3 kg/cm ² (4.266 PSI)	0.2 - 0.4 kg/cm ² (2.844 - 5.688 PSI)			
Relief valve opening pressure	4.1 kg/cm ² (45.5 PSI)				
Tip clearance (rotor to vane gap)		0.01 - 0.15 mm (0.0004 - 0.006 inch)		0.25 mm (0.0098 inch)	
Axial clearance (rotor to cover)		0.1 - 0.15 mm (0.004 - 0.006 inch)		0.2 mm (0.0008 inch)	

INJECTION PUMP

Pump plunger diameter	5.5 mm (0.217 inch)				
Pump plunger stroke	7.0 mm (0.276 inch)				
Injection timing Before top dead center	422/M2, 22° 422T/M2, 19°	422/M2, 21° - 23° 422T/M2, 18° - 20°			
Piston displacement (BTDC) - 422/M2	4.740 mm (0.1866 inch)	4.326 - 5.171 mm (0.1703 - 0.2036 inch)			
Piston displacement (BTDC) - 422T/M2	3.535 mm (0.1399 inch)	3.193 - 3.932 mm (0.1257 - 0.1548 inch)			

INJECTION NOZZLE

Injection pressure	152 kg/cm ² (2205 PSI)	147 - 157 kg/cm ² (2132 - 2277 PSI)	130kg/cm ² (1849 PSI)		
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COOLING

Cooling system	Water cooled forced circulation				
Cooling water quantity (1) (Without radiator)		3.6			
Thermostat opening temperature	71° C (160° F)				
Thermostat full open temperature	82° C (180° F)				
V-belt (fan) slack - 5 kg (0.2 in) at center	5 kg (0.2 inch)				

ENGINE TORQUE SPECIFICATIONS

COMPONENT	SETTING/REMARKS
Bearing holder bolts - hex hole type	24 - 30 Nm (18 - 22 pound-feet)
Bearing holder bolts - hex bolt type	49 - 54 Nm (36 - 40 pound-feet)
Rear plate bolts	14 - 18 Nm (10 - 13 pound-feet)
Flywheel housing bolts	24 - 28 Nm (18 - 21 pound-feet)
Flywheel bolts	58 - 69 Nm (43 - 51 pound-feet)
Connecting rod nuts	49 - 54 Nm (36 - 40 pound-feet)
Suction filter bolt	9 - 12 Nm (7 - 9 pound-feet)
Sump bolts	9 - 12 Nm (7 - 9 pound-feet)
Crankshaft pulley nut	275 - 333 Nm (203 - 246 pound-feet)
Cylinder head bolts	98 - 103 Nm (72 - 76 pound-feet)/oiled
Injection pump bolts	9 - 12 Nm (7 - 9 pound-feet)
Injection pump nuts	9 - 12 Nm (7 - 9 pound-feet)
Rocker arm nuts	27 - 39 Nm (20 - 29 pound-feet)/4-cylinder engines
Head cover nuts	12 - 16 Nm (9 - 12 pound-feet)/4 cylinder engines
Cooling fan bolts	9 - 12 Nm (7 - 9 pound-feet)
Oil pipe banjo bolts	9 - 12 Nm (7 - 9 pound-feet)
Oil sump drain bolt	30 - 39 Nm (22 - 29 pound-feet)
Injection nozzle	58 - 69 Nm (43 - 51 pound-feet) IDI engines
Injection pipe	15 - 24 Nm (11 - 18 pound-feet)
Thermo switch	24 - 30 Nm (18 - 22 pound-feet)
Oil pressure switch	15 - 20 Nm (11 - 15 pound-feet)
Glow plug	15 - 20 Nm (11 - 15 pound-feet)
Stop solenoid	15 - 20 Nm (11 - 15 pound-feet)
Oil relief valve	60 - 69 Nm (44 - 51 pound-feet)
Smokeset nut (max fuel)	20 - 26 Nm (15 - 19 pound-feet)
Adjusting screw nuts	12 - 16 Nm (9 - 12 pound-feet)

SPECIAL TOOLS

1. (CAS 2382) or (FNH 00011) - Fitting - 1/8 BSPT x 7/16-20 UNF

Used to test engine oil pressure. Screws in place of the engine oil pressure sender. Fits normal pressure test line connection.

2. (CAS 2776) or (FNH 00120) - Compression Test Adapter

Used to test engine compression. Screws into the glow plug hole, allows compression testing without removing injectors. Use with FNH 02020 Diesel Compression test kit or equivalent.

3. (FNH 00122) - Compression Test Adapter

Right angle quick disconnect coupling. Use with FNH 00120 and FNH 02020.

4. (CAS 2778) or (FNH 00117) - Oil Pump Port Block Installer

Installs engine oil pump port block. Ensures part is installed straight, to the proper depth, with correct oil passage orientation and without damage.

5. (CAS 2779) or (FNH 11097) - Oil Pump Port Block Remover

Removes engine oil pump port block without removing oil pan.

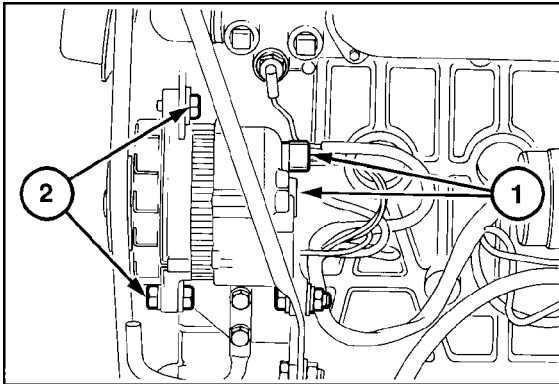
All of these tools are currently used on various Compact Tractors and may already be in dealerships.

ENGINE DISASSEMBLY

Alternator

Disconnect the alternator wire harness and wires, 1.

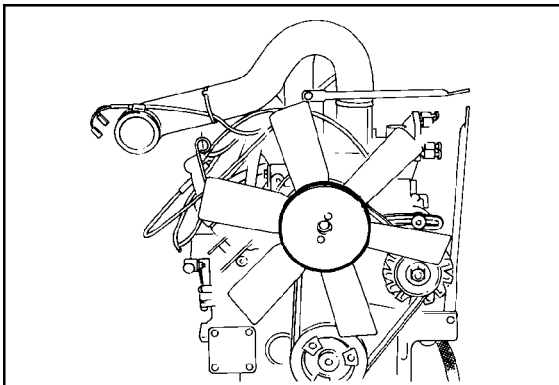
Remove the alternator pivot and adjusting bracket, hardware 2.



BS05B262

Remove Cooling Fan and Pulley

Remove the fan retaining hardware and spacers.

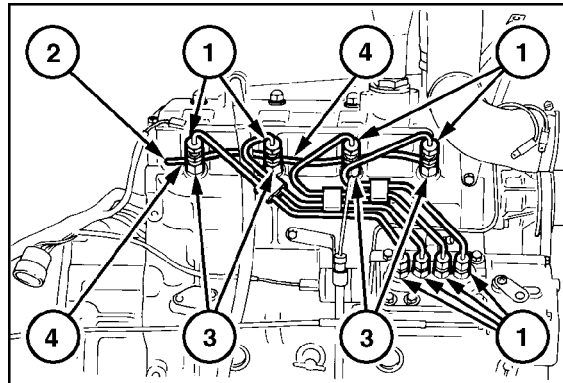


BS05B042

Fuel Injection Pipe

1. Loosen the fuel pipe nuts from the fuel injection pump and injectors, 1. Remove the pipes as an assembly.

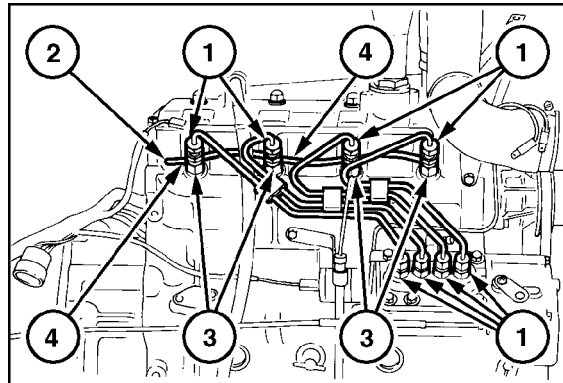
2. Remove the spring clamp and fuel return hose, 2.



BS05B264

Injector Assembly

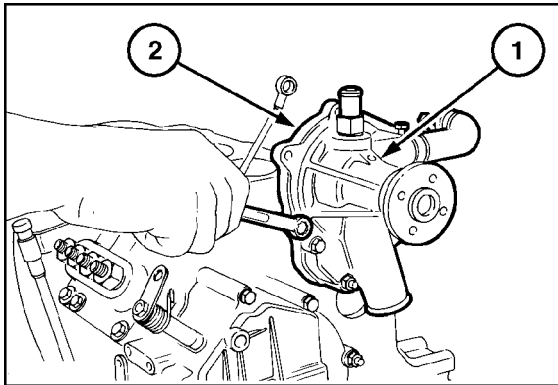
Loosen and remove the securing nuts, 3. Remove the leak-off rail, 4. Remove the aluminum washers and discard. Remove the injectors tagging or marking with the cylinder they were removed from.



BS05B24

Water Pump Assembly

Loosen the securing bolts and remove the water pump assembly, 1, and set plate, 2.

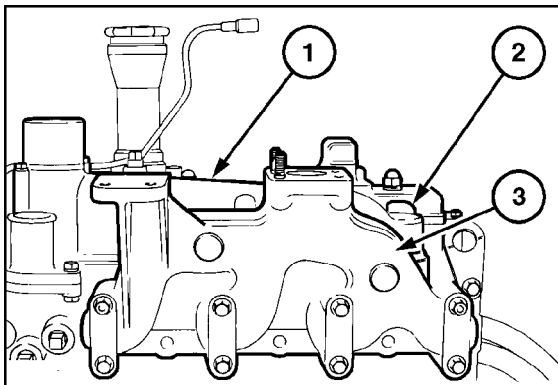


BS05B265

Exhaust Manifold

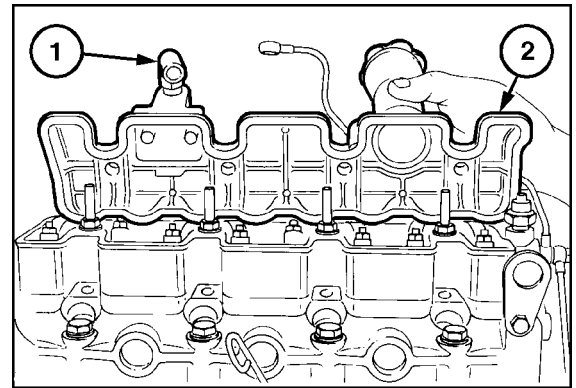
Remove the inlet manifold, 1, spacer, 2, and exhaust manifold, 3.

For the 422T/M2 turbocharged engine, refer to the turbocharger section of the manual for removal and replacement.



BS05B266

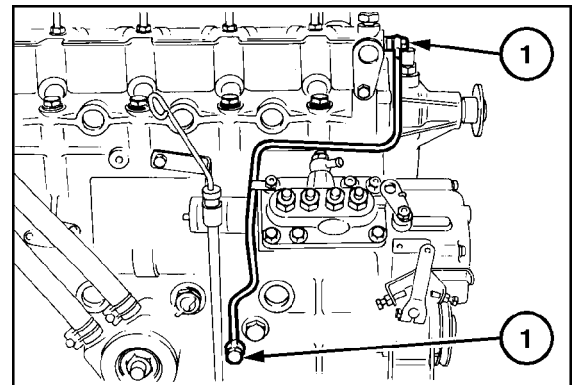
Remove the breather hose, 1. Loosen and remove four cap nuts with washers. Remove the rocker cover assembly, 2.



BS05B267

External Oil Pipe (422/M2)

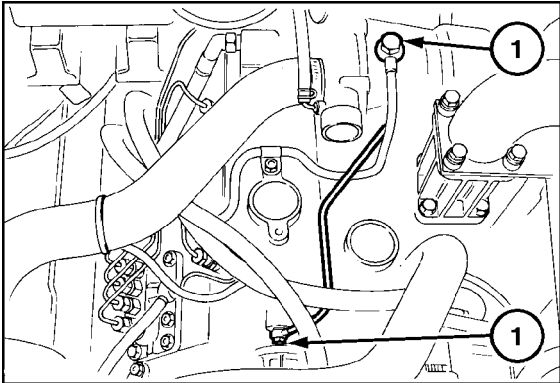
1. Loosen and remove the two banjo bolts at the cylinder block main oil gallery and cylinder head assembly.
2. Remove the clamp from the fuel injection pump.



BS05B268

External Oil Pipe (422T/M2)

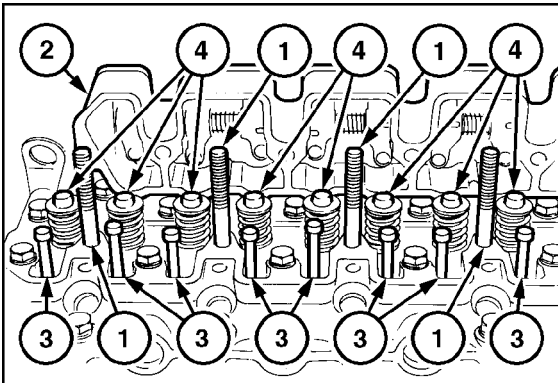
Loosen and remove the banjo bolts at the turbocharger and the cylinder head assembly.



BS05B269

Rocker Assembly

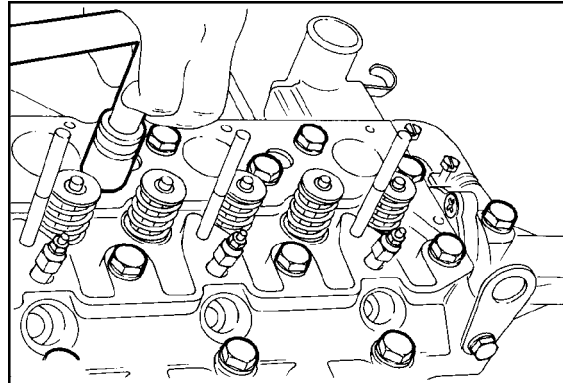
1. Loosen and remove nuts, lock washers, and flat washers from the rocker pillar stud, 1. Lift the rocker assembly, 2.
2. Remove the push rods, 3, and valve stem caps, 4.



BS05B270

Cylinder Head Assembly

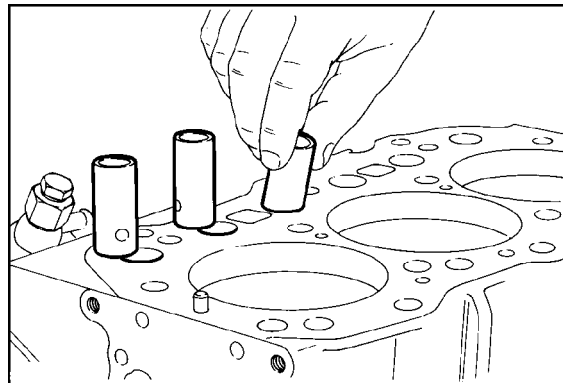
Loosen the cylinder head bolts, starting from the center, in a circular pattern, using several steps of equal torque. Remove the head.



BS05B271

Tappets

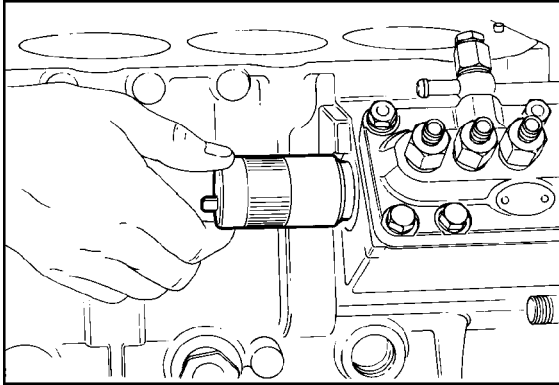
Pull the tappets from the machined bore in the cylinder block.



BS05B272

Stop Solenoid

Unscrew the stop solenoid. (if equipped)

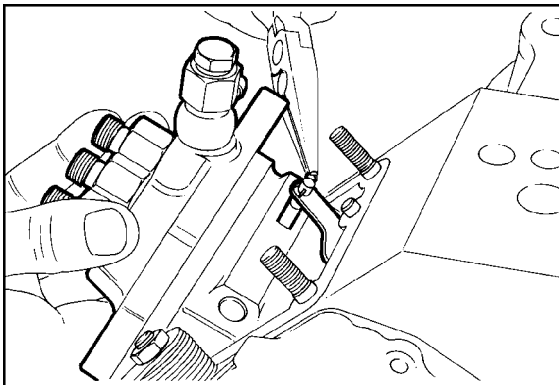


BS05B273

Fuel Injection Pump

1. Remove the bolts and nuts securing the fuel injection pump to the cylinder block. Slowly lift and position the fuel injection pump until access to the link snap pin is gained.
2. Remove the snap pin and remove the link from the control rack. Remove the fuel injection pump and shim pack.

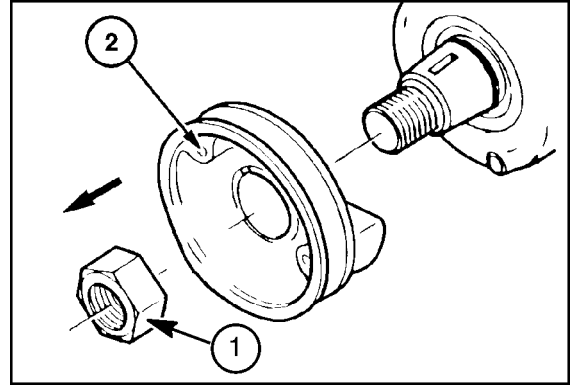
NOTE: Injection timing is determined by the shim pack between the fuel injection pump flange and cylinder block mounting face. The thickness and number of shims should be checked and recorded to aid reassembly.



BS05B274

Crank Pulley

Loosen the pulley nut, 1, and remove the pulley, 2.



BS05B275

Oil Filter

Remove the spin-on type oil filter and discard.

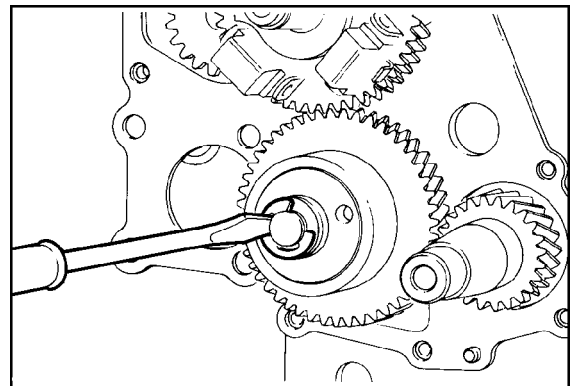
Gear Cover and Governor Assembly

Remove the securing bolts and lift the cover assembly off the locating dowels.

NOTE: Remove the fuel injection pump first.

Idler Gear and Oil Pump Assembly

Remove the retaining ring. Remove the entire assembly.

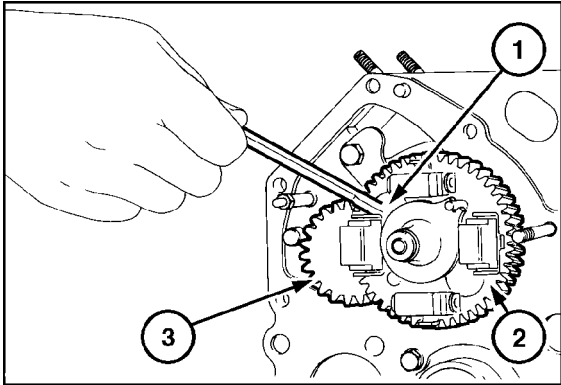


BS05B276

Camshaft Assembly, Tachometer Drive

1. Using the access hole in the cam gear, remove the keeper plate, 1.
2. Slide the cam shaft, 2, with the flyweight retainer out of the camshaft bore.

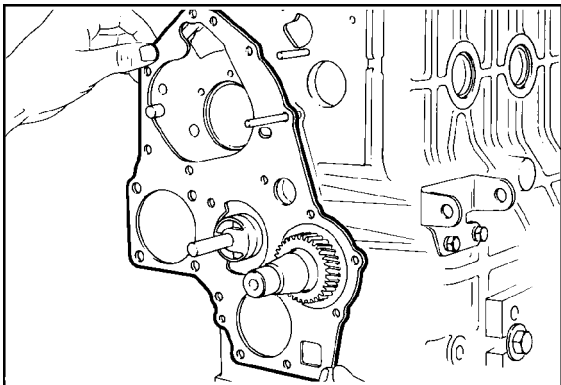
3. Pull the tachometer drive shaft (if equipped) 3, from its bore.



BS05B277

Front End Plate Assembly

Remove the retaining bolts and lift the front plate off its locating dowels. Remove the gasket and discard.



BS05B278

Dipstick Assembly

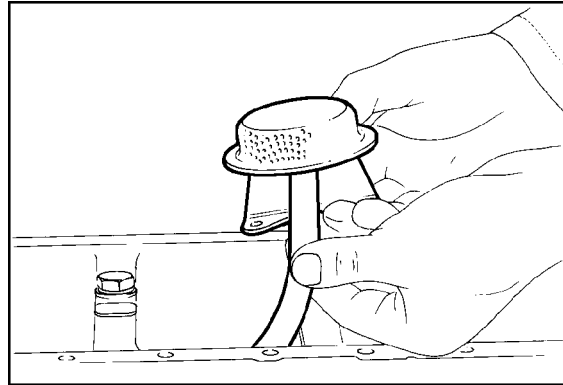
Loosen the retaining bolts and remove the assembly.

Oil Sump

Remove all bolts, lower sump, and discard the gasket.

Suction Pipe and Strainer

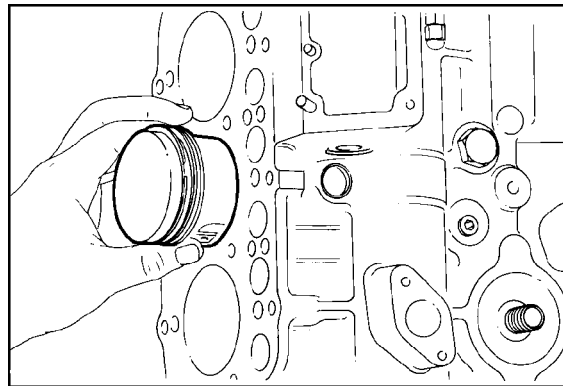
Remove two securing bolts. Rotate the suction pipe out of its bore.



BS05B279

Connecting Rod and Piston

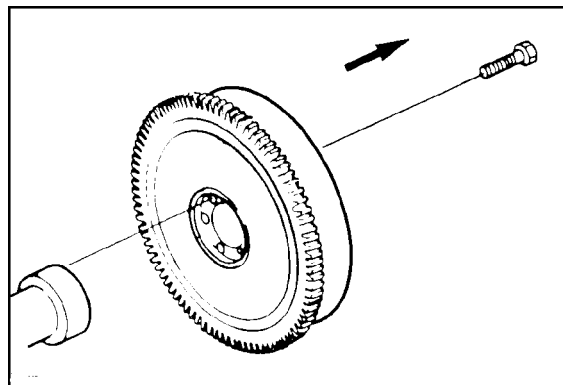
1. Loosen the connecting rod nuts and remove the rod cap.
2. Remove carbon from the cylinder bore. Push the piston and connecting rod through the cylinder block. Replace the rod cap to the piston assembly. Keep together in cylinder sequence.



BS05B280

Flywheel

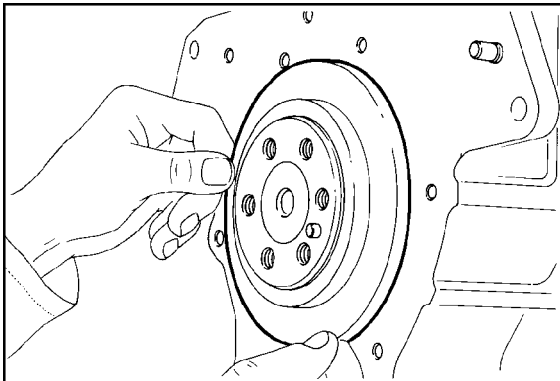
Loosen the bolts and remove the flywheel.



BS05B281

Backplate and Rear Oil Seal

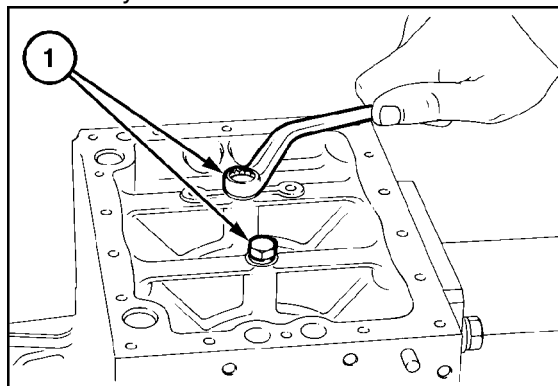
1. Loosen the two starter retaining nuts and remove the starter.
2. Loosen the backplate retaining bolts and remove the backplate.
3. Remove the oil seal.



BS05B282

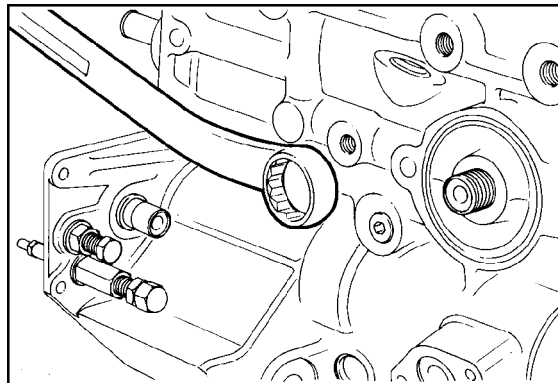
Crankshaft and Main Bearing

1. Remove the retaining bolts, 1, through the crankcase cross members.
2. Slide out the crankshaft and main bearing assembly.



BS05B283

3. Remove the relief valve assembly.



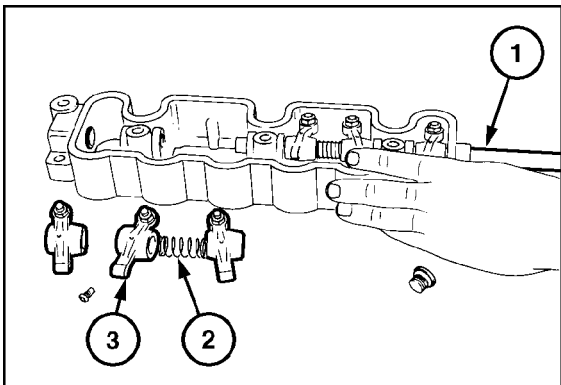
BS05B284

ENGINE COMPONENT

Disassembly and Assembly

Rocker Assembly

1. Loosen the M8 bolt at the rocker arm shaft end, if fitted.
2. Remove the screw located in the No. 1 cylinder rocker arm bracket, if fitted.
3. Pull out the rocker arm shaft, 1, springs, 2, and rocker arms, 3.



BS05B285

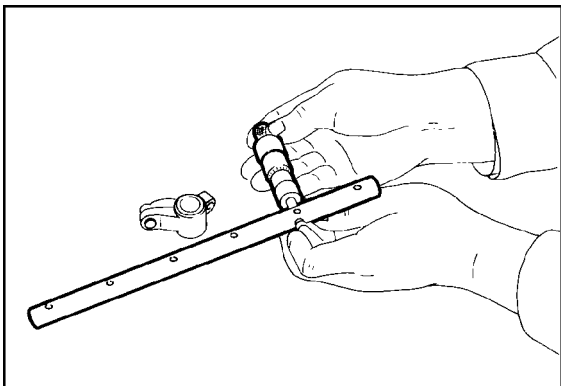
Inspection

1. Wear of Rocker Arm Shaft

Using a micrometer, check the outside diameter of the rocker arm shaft. If the rocker arm shaft is worn beyond the allowable limit, replace as required.

Standard dimension: 14.95 mm - 14.97 mm (0.588 inch - 0.589 inch)

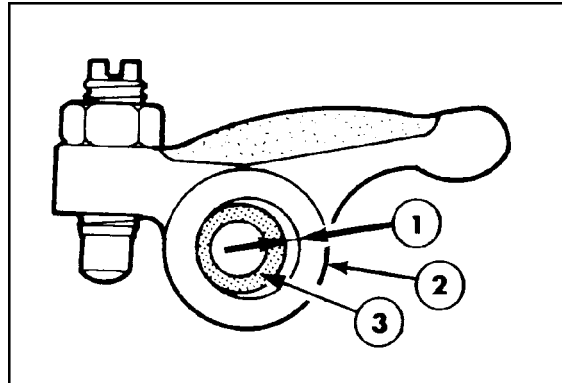
Allowable Limit: 14.87 mm max. (0.585 inch)



BS05B286

2. Rocker Arm-To-Shaft Clearance

Measure the inside diameter of the rocker arm. Calculate the clearance at 1, between the rocker arm, 2, and the rocker arm shaft, 3. If the clearance is excessive, replace as required.



BS05B287

Standard Clearance: 0.030 mm - 0.093 mm (0.0012 inch - 0.0037 inch)

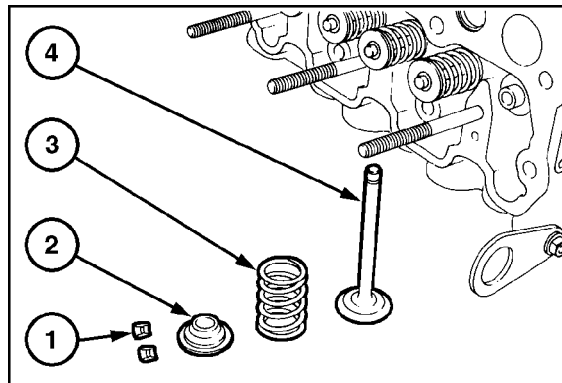
Allowable Limit: 0.2 mm (0.008 inch)

3. Wear on valve stem contacts face of the rocker arm.

Check the face for step wear or score. Slight wear may be corrected using an oil stone.

Cylinder Head Assembly

1. Using a valve spring replacer, compress the valve spring to remove the valve keepers, 1; retainer, 2; spring, 3; and valve, 4.
2. Remove the valve guide seals and glow plugs.

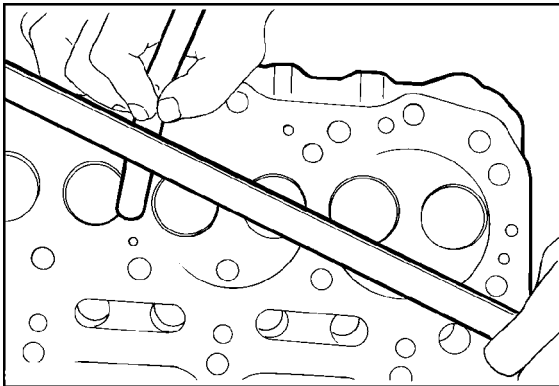


BS05B288

Inspection

Cylinder Head

With a straightedge and a thickness gauge, check for warping of the cylinder head lower face.

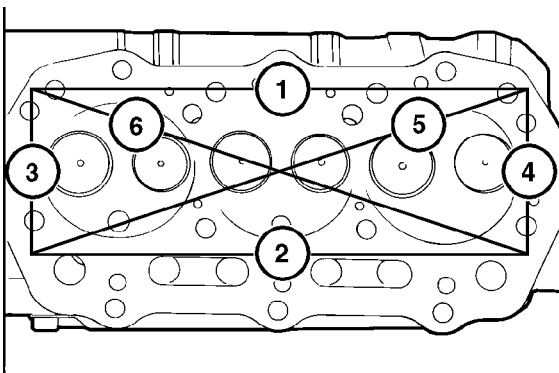


BS05B289

Check six positions (1 to 6 lines, as shown) for warping. If found to be warped excessively, correct with a surface grinder.

Standard value: 0.05 mm or less (0.002 inch)

Allowable limit: 0.12 mm (0.005 inch)

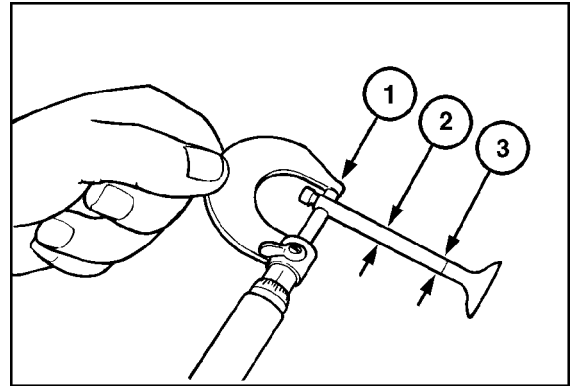


BS05B290

Valve Guide and Valve Stem

1. Check the valve stem for excessive wear or damage. If found to be excessively damaged, replace as required.

2. Check the valve stem diameters at positions 1, 2, and 3 with a micrometer. If the diameter is less than the allowable limit, replace as required.



BS05B291

Intake Valve

Standard Diameter: 6.955 mm - 6.97 mm
(0.2738 inch - 0.2744 inch)

Allowable Limit: 6.89 mm (0.271 inch)

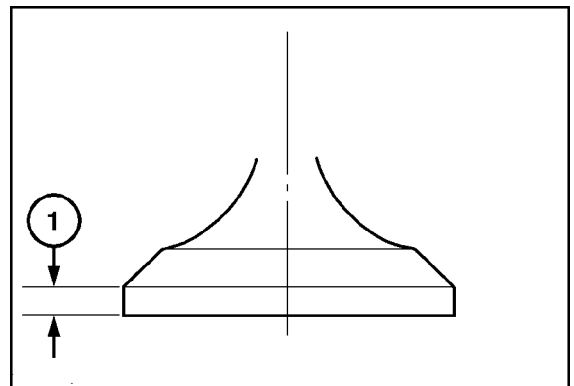
Exhaust Valve

Standard Diameter: 6.94 mm - 6.95 mm (0.2732 inch - 0.2736 inch)

Allowable Limit: 6.84 mm (0.269 inch)

Thickness of Valve Head

If valve head thickness at 1 is less than the allowable limit, replace the valve.



BS05B292

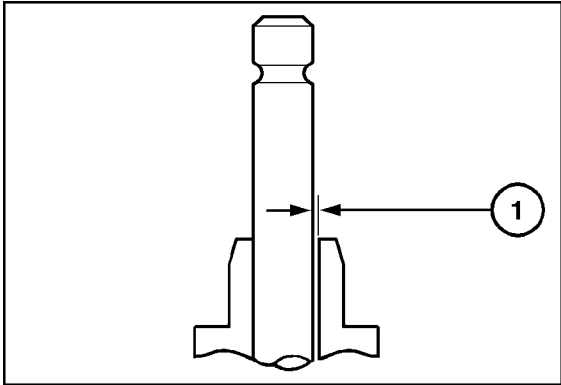
All Engines

Standard Thickness: 0.925 mm - 1.075 mm
(0.036 inch - 0.042 inch)

Allowable Limit: 0.5 mm (0.020 inch)

Valve to Valve Guide Clearance

Check the clearance at 1 between the valve and valve guide. If the clearance exceeds the allowable limit, replace as required.



BS05B293

Intake Valve - All Engines

Standard Clearance: 0.03 mm - 0.06 mm (0.0012 inch - 0.0024 inch)

Allowable Limit: Max. 0.2 mm (0.008 inch)

Exhaust Valve - All Engines

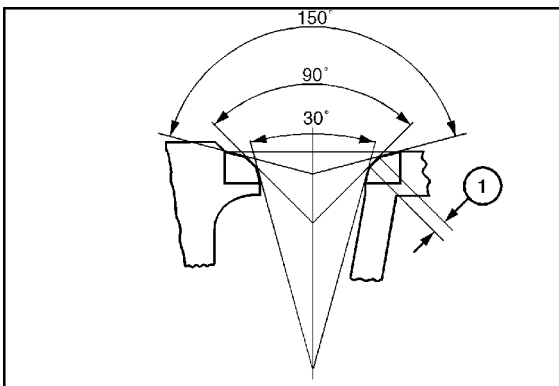
Standard Clearance: 0.05 mm - 0.075 mm (0.002 inch - 0.003 inch)

Allowable Limit: max. 0.25 mm (0.010 inch)

Valve Seat

Valve Seat Contact Width

If the contact width at 1 of the valve seat is more than the allowable width, check the wear condition of the valve guide first.



BS05B294

Using the seat cutters of 15°, 45°, and 75°, correct the seat.

Intake

Standard Width: 1.5 mm - 2.0 mm (0.06 inch - 0.08 inch)

Allowable Limit: 2.5 mm max. (0.098 inch)

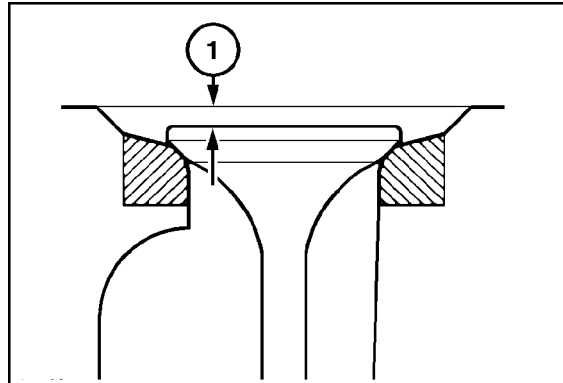
Exhaust

Standard Width: 1.94 mm - 2.16 mm (0.076 inch - 0.085 inch)

Allowable Limit: max. 2.5 mm (0.098 inch)

Valve Seat Recess

If the recess depth, 1, is more than the allowable limit, replace the valve seat (if fitted).



BS05B295

Standard Recess: 0.65 mm - 0.95 mm (0.026 inch - 0.037 inch)

Allowable Limit: 1.6 mm max. (0.063 inch)

Replacement of valve seat insert (where fitted):

Method 1: Using a gas burner, 700° C to 800° C (1300° F to 1475° F), heat diagonally across the valve seat insert. Leave in air for three to five minutes and remove the valve seat insert by light tapping (ensuring the head is not damaged).

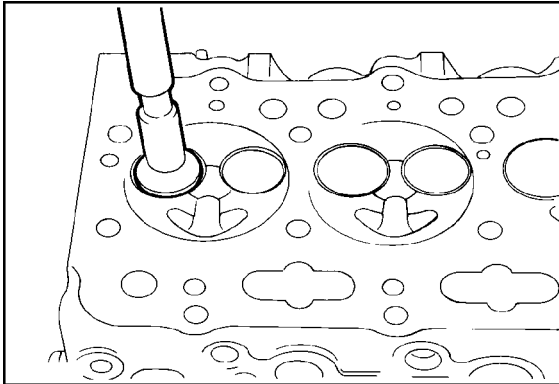
Method 2: Machine the insert out, taking care not to damage the head.

Clean up the insert bore and fit a new insert, using a press 1,000 kgf - 1,500 kgf (7,200 lbs - 10,850 lbs) and a suitable smooth surface tool. To assist the process, chill the valve seat insert with liquid nitrogen, etc., or heat the head to between 60° C and 100° C (140° F to 212° F).

Lapping of Contact Face of the Valve Seat

Correct valve seat contact using a valve lapper and lapping compound.

When using a new cylinder head, obtain correct seat contact width and seat recess using the seat cutter, and then carry out lapping.

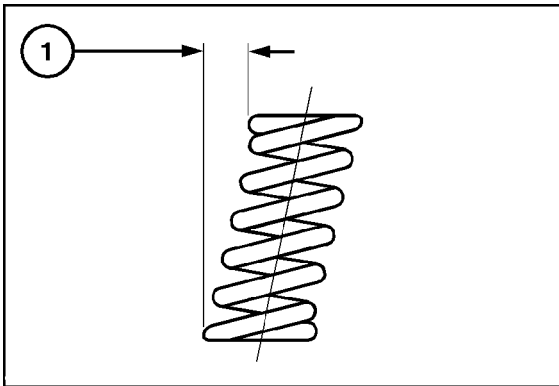


BS05B296

Valve Spring

Visually inspect the valve spring for damage.

Position the valve spring on a flat surface and check the squareness of it by using a square at 1, as shown. If it exceeds the allowable limit, replace the spring.



BS05B297

Using a spring tester, check spring force and free length.

Replace, if found to be beyond the allowable limit.

Standard Value

Squareness: 1.2 mm (0.047 inch)

Free length: 35 mm (1.378 inch)

Spring force when compressed to 30.4 mm (1.197 inch): 8.1 kg (17.9 lb ft)

Allowable Limit

Squareness: 2.0 mm (0.079 inch)

Free length: 33.5 mm (1.319 inch)

Spring force when compressed to 30.4 mm (1.197 inch): 7 kg (15.4 lb ft)

Inner face of combustion chamber. Check and clean the combustion chamber.

Reassembly

Reassemble the parts in the reverse order of disassembly.

NOTE: When assembling the valve spring, retainer, and keepers, take care not to damage the valve guide seal.

Tighten glow plugs to 15 Nm - 20 Nm (11 lb ft - 15 lb ft)

Cylinder Block

Inspection and Correction

Cylinder Block Top Face

Inspect the cylinder block top face for cracks, damage, and warping in the same way as for the cylinder head.

If outside the limit replace the cylinder block.

Standard Value: Less than 0.05 mm (0.002 inch)

Allowable Limit: 0.12 mm (0.005 inch)

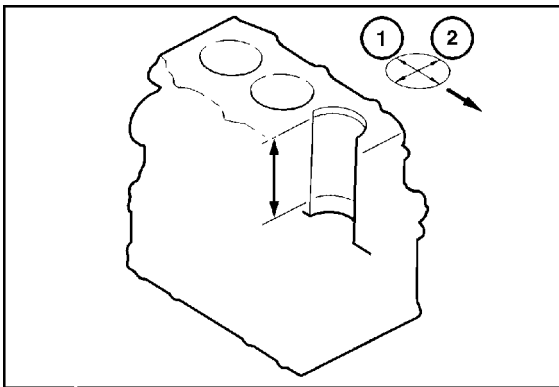
Cylinder Bore

1. Visually inspect the cylinder bore. There should be no scoring, rust, or corrosion.

Measure the cylinder bore at the upper, middle and lower areas (piston ring contact area) in the direction of the crankshaft (1 direction) and at right angle to the crankshaft (2 direction).

The upper area described above corresponds to the top ring when the piston is at the T.D.C. (about 10 mm (0.40 inch) below the cylinder block top surface). The lower area corresponds to the piston oil ring when the piston is at the B.D.C. (about 100 mm (3.94 inch) from top face).

Check the bore using a cylinder gauge.



BS05B298

2. If the bore is found to be outside the allowable limit, re-bore to the oversize dimension as shown.

Grinding stone size: 100 L x 4W

Speed: 162 RPM

Feed (shaft direction): 13 m/min.

Gauge pressure: 15 kg/cm² (5 kg/cm² - finish)
213 PSI (71 PSI - finish)

Finish stroke: 9

Honing depth: 0.04 mm (0.0016 inch) diameter

Cross hatch angle: 40°

Surface roughness: 2-4 micron

Bore Specifications

Standard Bore: 84 mm - 84.019 mm (3.307 inch - 3.308 inch)

Allowable Limit: 84.2 mm (3.315 inch)

First Re-bore: 0.5 mm (0.02 inch)

New Standard Bore: 84.5 mm - 84.519 mm (3.327 inch - 3.328 inch)

Allowable Limit: 84.7 mm (3.335 inch)

Second Re-bore: 0.5 mm (0.02 inch)

New Standard Bore: 85 mm - 85.019 mm (3.346 inch - 3.347 inch)

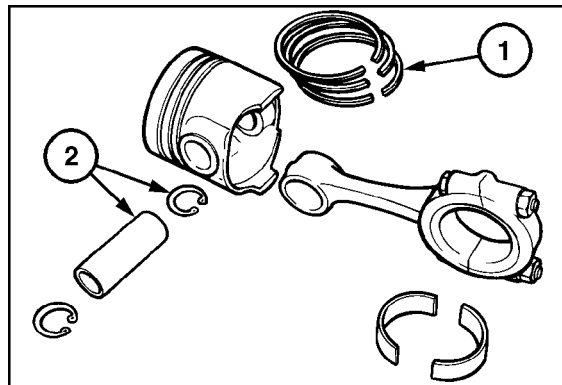
Allowable Limit: 85.2 mm (3.354 inch)

Replace the block as required.

Piston and Piston Rings

Disassembly

1. Remove piston rings, 1, using a piston ring tool.
2. Remove the retaining ring and remove the piston pin, 2.



BS05B299

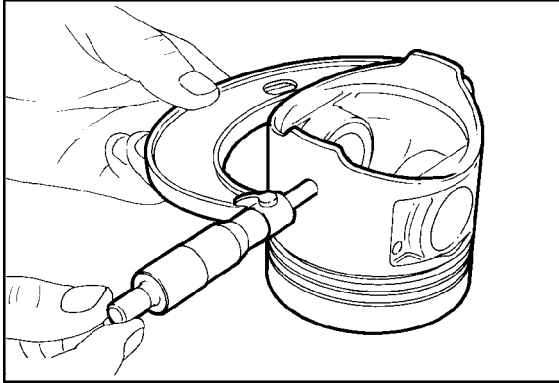
Inspection

Piston

If the outer surface of the piston is excessively damaged (cracked, scored, burning, etc.) replace as required.

Piston Skirt

Check the larger diameter of the piston skirt 10 mm (0.40 inch from bottom), and check diameter (thrust direction) of the cylinder. Calculate the clearance between the cylinder and piston. If this clearance is more than allowable, or piston diameter is less than the allowable limit, replace the piston as required.



BS05B300

Oversized Piston

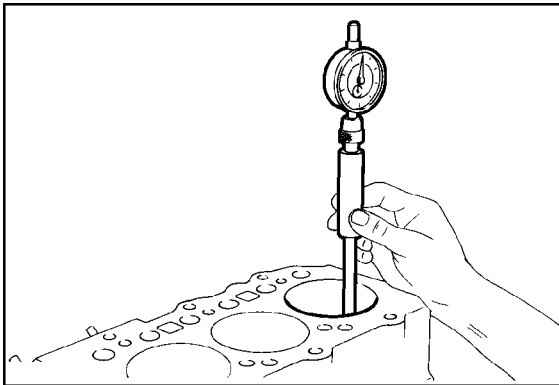
When the cylinder is oversized, be sure that an oversized piston is used.

Standard Clearance: 0.038 mm - 0.072 mm
(0.0015 inch - 0.0028 inch)

Allowable Limit: 0.25 mm max. (0.010 inch)

Standard Diameter (Piston): 83.948 mm - 83.963 mm
(3.3050 inch - 3.3056 inch)

Allowable Limit: 83.7 mm min. (3.2953 inch)



BS05B301

Large Diameter of Piston Skirt

Standard: 83.948 - 83.963 mm (3.3050 inch - 3.3056 inch)

0.5 mm (0.0197 inch) Oversize: 84.448 - 84.463 mm
(3.3247 inch - 3.3253 inch)

1.0 mm (0.039 inch) Oversize: 84.948 - 84.963 mm
(3.3444 inch - 3.3450 inch)

Clearance between wrist pin hole and wrist pin.

Check the inside diameter of the wrist pin hole and the outside diameter of the wrist pin, and calculate the clearance between them.

If the clearance is more than the allowable limit, replace as required.

Standard Clearance: -0.001 mm to + 0.007 mm
(-0.000039 inch to +0.00028 inch)

Allowable Limit: 0.02 mm (0.0008 inch)

Piston Ring

If the piston ring is worn or damaged, replace as required.

Piston Ring Gap

Insert the rings into the cylinder at a right angle to the cylinder bore and measure the gaps with a thickness gauge. If the gap is more than the allowable limit, replace as required.

#1 Ring

Standard Gap: 0.20 mm - 0.35 mm (0.008 inch - 0.014 inch)

Allowable Limit: 1.0 mm (0.039 inch)

#2 Ring

Standard Gap: 0.20 mm - 0.40 mm (0.008 inch - 0.016 inch)

Allowable Limit: 1.0 mm (0.039 inch)

Oil Ring

Standard Clearance: 0.20 mm - 0.40 mm (0.008 inch - 0.016 inch)

Allowable Limit: 1.0 mm (0.039 inch)

Measure the clearance between the piston ring groove and ring. If the clearance exceeds the allowable limit, replace the ring as required.

#1 Ring

Standard Clearance: 0.07 mm - 0.11 mm (0.0028 inch - 0.0043 inch)

Allowable Limit: 0.25 mm (0.0098 inch)

#2 Ring

Standard Clearance: 0.04 mm - 0.08 mm (0.0016 inch - 0.0032 inch)

Allowable Limit: 0.25 mm (0.0098 inch)

Oil Ring

Standard Clearance: 0.02 mm - 0.06 mm (0.0007 inch - 0.002 inch)

Allowable Limit: 0.15 mm (0.0059 inch)

Oversize Piston Ring

If the cylinder is oversized, an oversized piston ring set should be installed.

Mounting Position of the Piston Ring

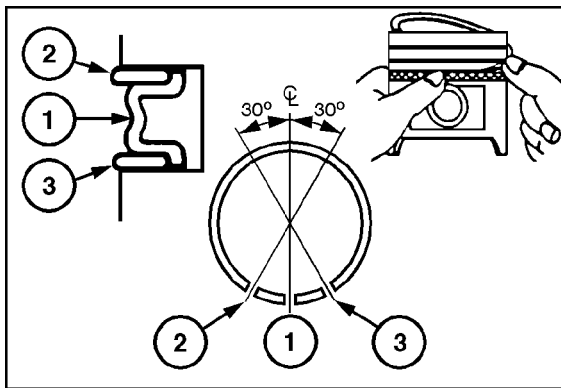
Confirm the third piston ring is set, as shown here.

IMPORTANT: *Fit the third ring as follows:*

Put the expander, 1, into position in its groove. Ensure the ends of the expander do not overlap.

Fit the upper side rail, 2, on top of the expander. Insert the end of the side rail into the groove and hold it in position with the thumb. Slide the rail into position with the other thumb.

Fit the lower side rail, 3, in a similar manner.



BS05B302

Ensure the side rails are free to move in both directions and the gaps of the expander and the side rails are in the correct positions.

Standard OD: 27.996 mm - 28.0 mm (1.1022 inch - 1.1024 inch)

Allowable Limit: 27.98 mm minimum (1.1016 inch)

Piston Pin

Check the outside diameter of the piston pin. If it is less than the allowable limit, replace as required.

Connecting Rod

Inspection

Distortion or Damage

Check the connecting rod for distortion between the large and small ends of the connecting rod with a connecting rod aligner. If the result exceeds the allowable limit, replace as required.

Distortion - 100 mm (3.937 inch)

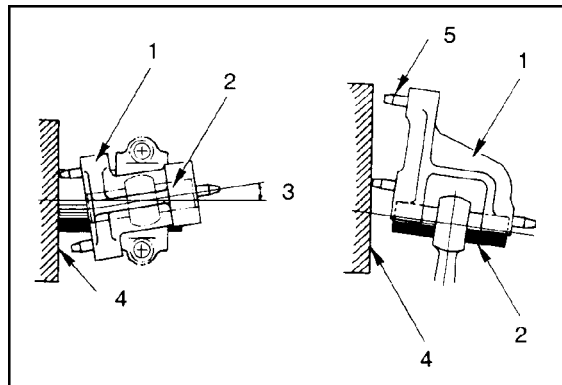
Standard Value: Less than 0.08 mm (0.003 inch)

Allowable Limit: 0.2 mm (0.0078 inch)

Parallel - 100 mm (3.937 inch)

Standard Value: Less than 0.05 mm (0.0019 inch)

Allowable Limit: 0.15 mm (0.0059 inch)



BS05B303

1. GAUGE
2. PISTON PIN
3. DISTORTION
4. FLAT SURFACE OF THE ALIGNER
5. PIN

Clearance Between the Small End Bushing and the Piston Pin

Measure the inside diameter of the connecting rod small end bushing.

If the clearance exceeds the allowable limit, replace.

Standard Clearance: 0.010 mm - 0.025 mm (0.0004 inch - 0.001 inch)

Allowable Limit: 0.08 mm (0.003 inch)

Play Between the Connecting Rod and the Crankshaft

Assemble the connecting rod to the crankshaft and measure the play in shaft direction. If the play is more than the allowable limit, replace the connecting rod as required.

Standard Play: 0.1 mm - 0.3 mm (0.0039 inch - 0.0118 inch)

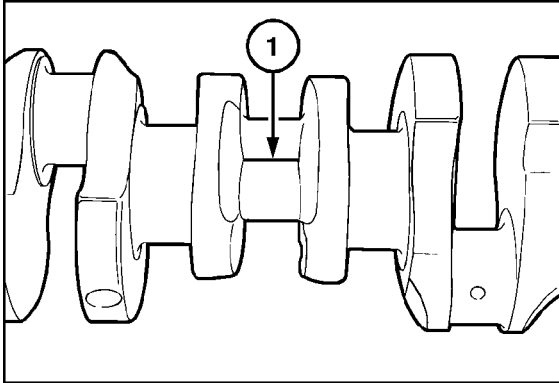
Allowable Limit: 0.7 mm (0.0275 inch)

Oil Clearance

Using the plasti-gauge, check the oil clearance as follows:

Remove oil or foreign matter from the bearing and crankshaft.

Cut the plasti-gauge to the same width as the bearing. Place it on the crankshaft at 1. Avoid the oil hole.

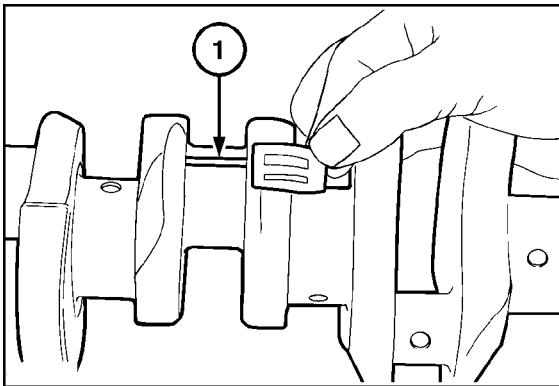


BS05B304

Assemble the connecting rod and connecting rod cap and tighten to the specified torque. All engines 49 Nm - 54 Nm (36 lb ft - 40 lb ft).

NOTE: *Never rotate the connecting rod.*

Remove the connecting rod cap. Measure the oil clearance (plasti-gauge) with the scale printed on the gauge bag.



BS05B305

NOTE: *Measure the widest area.*

Standard Play: 0.035 mm - 0.085 mm (0.001 inch - 0.003 inch)

Allowable Limit: 0.2 mm (0.0078 inch)

If the oil clearance exceeds the allowable limit, replace the bearing or grind the crankshaft and use an oversize bearing.

NOTE: *When grinding the outside diameter of the crankshaft, be sure that the oil clearance is correct before reassembly.*

Crankshaft Pin O.D. Dimension (mm)

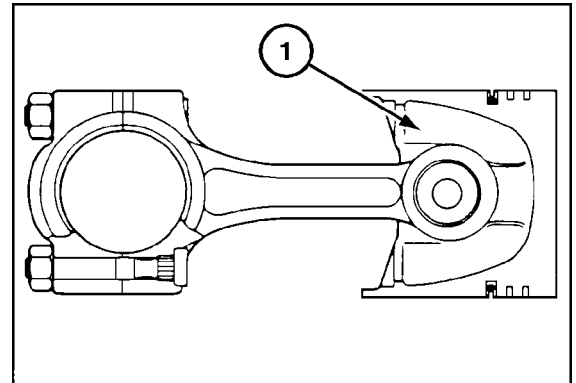
S.T.D.: 51.964 mm - 51.975 mm (2.0458 inch - 2.0463 inch)

0.25 mm (0.010 inch): 51.714 mm - 51.725 mm (2.0360 inch - 2.0364 inch)

0.50 mm (0.020 inch): 51.464 mm - 51.475 mm (2.0261 inch - 2.0266 inch)

Reassembly

1. Reassemble the piston on the connecting rod as follows.
2. With a piston heater or the like, heat the piston to approximately 100° C (212° F). Assemble the piston to the connecting rod by aligning the set marks.
3. Set the "SHIBAURA" marks, or other mark, 1, as shown. Align the set marks on the connecting rod.



BS05B306

4. Replace the piston ring on the piston. Position the scribe mark uppermost.
5. When the connecting rod or piston/piston pin has been replaced, the difference in the weight of the assembly (connecting rod plug piston rings) should not exceed 10 grams between cylinders.

Bearing Holder

Disassembly and Inspection

Center Bearing

1. Remove the bearing holder and check it for peeling, melting, stepped wear, and other damage. If it is excessively damaged, replace as required.

- Using the plasti-gauge, measure the oil clearance between the crankshaft center journal and the bearing.

If the oil clearance is more than the allowable limit, replace the bearing or grind the crankshaft center journal and use an undersized bearing (refer to "Crankshaft").

Standard Oil Clearance: 0.044 mm - 0.102 mm
(0.0017 inch - 0.0040 inch)

Allowable Limit: 0.2 mm (0.0078 inch)

Crankshaft Center Journal Diameter (mm)

S.T.D.: 67.957 mm - 67.970 mm (2.6755 inch - 2.6760 inch)

0.25 mm (0.010 inch): 67.707 mm - 67.720 mm
(2.6656 inch - 2.6661 inch)

0.50 mm (0.020 inch): 67.457 mm - 67.470 mm
(2.6558 inch - 2.6563 inch)

Thrust Clearance

Check the thrust washer for wear, poor contact, burning, or other defects. Defective washers must be replaced.

Standard Thickness: 2.95 mm - 3.0 mm (0.116 inch - 0.118 inch)

Allowable Limit: 2.8 mm (0.11 inch)

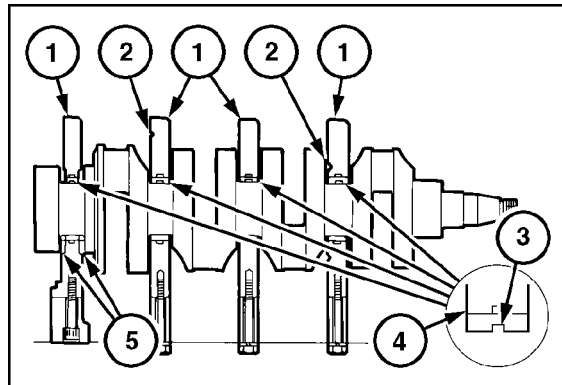
Reassembly

Reassemble the bearing holder, center bearing, and thrust washer as follows:

- Face the chamfered part, 1, of the bearing holder toward the front. Install the bearing holder which has a notch, 2. Install the bearing holder on which the thrust washer is to be mounted at the flywheel side.
- Install the thrust washer, 5. Face its oil groove toward the thrust face of the crankshaft.

Tightening torque of the bearing holder: 49 - 54 Nm (36 - 40 lb ft).

- Set the bearing with the oil groove, 3, to the upper part, 4, while setting the bearing without the groove to the lower part.



BS05B307

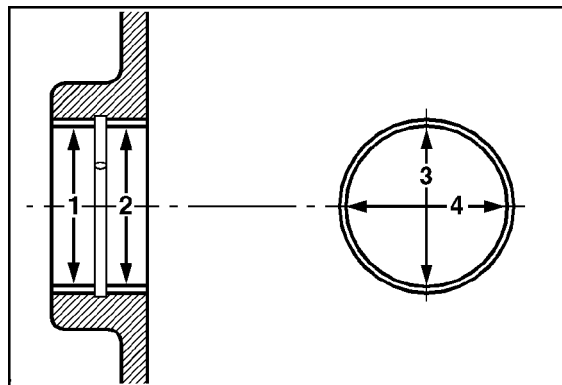
Crankshaft Bearing (Bushing)

Inspection

Check the bearing (bushing) for peeling, melting, seizure, or poor contact. If found to be defective, replace as required.

Using a cylinder gauge and micrometer, measure the oil clearance between the bearing (bushing) and the crankshaft journal.

Measure the inside diameters at positions 1 and 2. At each position, measure in both directions 3 and 4. The oil clearance can be obtained by subtracting this value from the maximum crankshaft journal diameter.



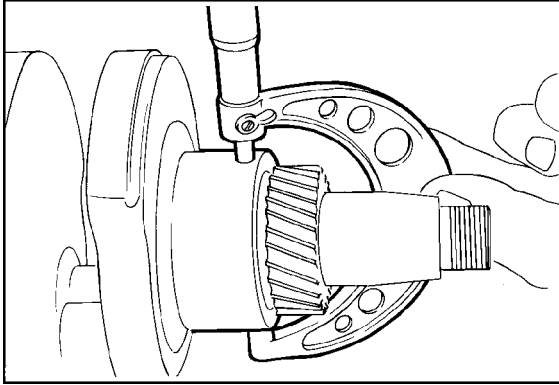
BS05B308

Standard Oil Clearance: 0.044 mm - 0.116 mm
(0.0017 inch - 0.0046 inch)

Allowable Limit: 0.2 mm (0.0078 inch)

If the oil clearance exceeds the allowable limit, replace the bearing (bushing) or grind the crankshaft journal. In this case, use an undersized bearing (bushing).

When replacing the crankshaft journal (bushing), use a press to install.



BS05B309

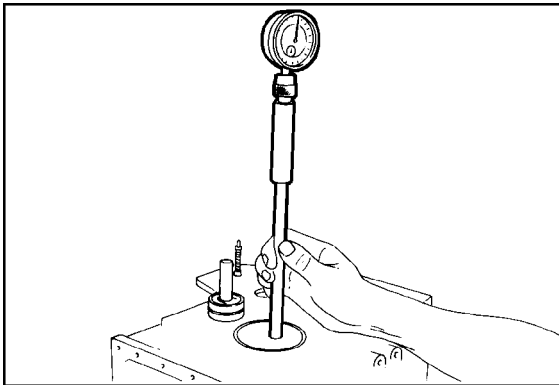
Crankshaft Journal (Bushing)

Outside Diameter

Standard: 67.957 mm - 67.970 mm (2.6755 inch - 2.6760 inch)

0.25 mm (0.0098 inch): 67.707 mm - 67.720 mm (2.6656 inch - 2.6666 inch)

0.50 mm (0.0196 inch): 67.457 mm - 67.470 mm (2.6558 inch - 2.6563 inch)



BS05B310

Crankshaft Bushing Replacement

Bushing Removal

Remove the bushing from the housing (cylinder block) using a bushing driving tool to prevent damage.

Press-fitting the Bushing

1. Prior to installing the bushing, inspect the bushing housing for marks, scratches, etc.
2. The bushing should be smoothly pressed in to the correct depth by using a bushing driving tool, adjusting the oil hole and direction of bushing.

— Press in the bushing to the cylinder block from the engine front side.

NOTE: Do not press in the bushing to the cylinder block from the opposite side.

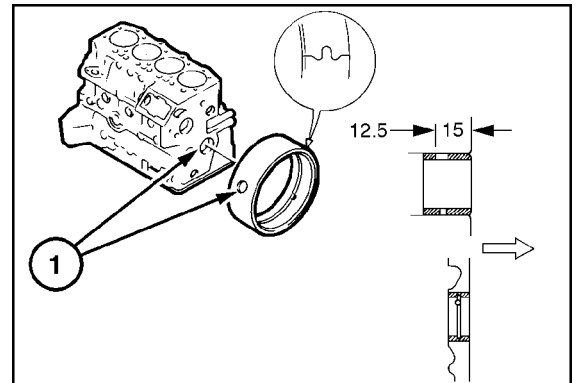
The correct pressing side is chamfered, etc., to allow smooth operation.

— Align the oil hole, 1, of the housing and bushing.

— Install the bushing, confirming the mark and oil groove (hole).

— Lubricate at the outer surface of the bushing.

— Press in the bushing to the housing until correct depth, by using a bushing driving tool.



BS05B311

3. Confirm after installation.

Confirm the alignment of the oil hole of the housing and the bushing. Also make sure the inner diameter is within tolerance.

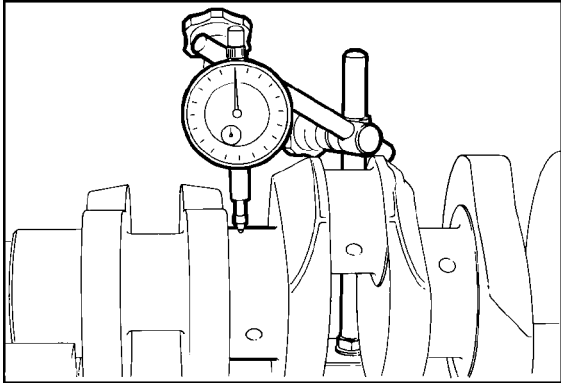
After grinding the crankshaft journal, check the oil clearance.

Crankshaft

Inspection

Crankshaft Deflection

Support the crankshaft with V-block. Position a dial gauge on the crankshaft center journal and turn the crankshaft gradually by one full turn. If the gauge reading is more than the allowable limit, correction or replacement of the crankshaft is needed.



BS05B312

Standard Deflection: 0.03 mm or less (0.0011 inch)

Allowable Limit: 0.06 mm (0.0023 inch)

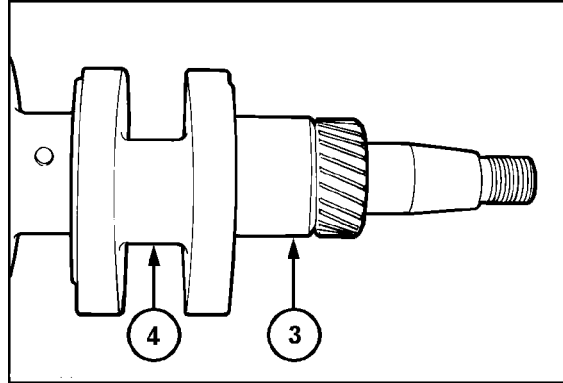
Oil Seal Contact Face and Oil Holes

Check the oil seal contact face for damage or wear.
Check oil holes for clogging.

Check Crankshaft Journal, 3, and Pin, 4, for Stepped Wear

Take four measurements (AA and BB diameters at positions 1 and 2, Figure BS05B314). If the maximum difference between the measurements is more than the allowable limit, correction is required.

Allowable Difference (stepped wear): .05 mm (0.0019 inch)



BS05B313

Crankshaft Pin Diameter

Standard Diameter

Standard: 51.964 mm - 51.975 mm (2.0458 inch - 2.0463 inch)

0.25 mm (0.01 inch): 51.714 mm - 51.725 mm (2.0360 inch - 2.0364 inch)

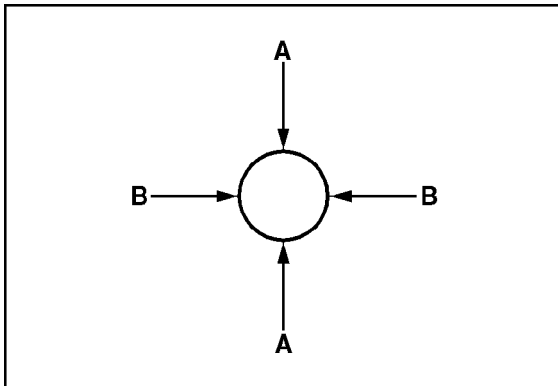
0.50 mm (0.02 inch): 51.464 mm - 51.475 mm (2.0261 inch - 2.0266 inch)

Allowable Limit

Standard: 51.90 mm (2.0433 inch)

0.25 mm (0.01 inch): 51.65 mm (2.0335 inch)

0.50 mm (0.02 inch): 51.4 mm (2.0236 inch)



BS05B314

Crankshaft Journal Shaft Diameter**Standard Diameter**

Standard: 67.957 mm - 67.970 mm (2.6755 inch - 2.6760 inch)

0.25 mm (0.01 inch): 67.707 mm - 67.720 mm (2.6656 inch - 2.6661 inch)

0.50 mm (0.02 inch): 67.457 mm - 67.470 mm (2.6558 - 2.6563 inch)

Allowable Limit

Standard: 67.90 mm (2.6732 inch)

0.25 mm (0.01 inch): 67.65 mm (2.6634 inch)

0.50 mm (0.02 inch): 67.40 mm (2.6535 inch)

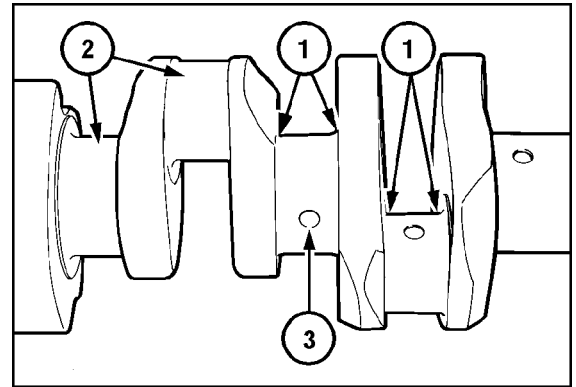
NOTE: When grinding the crankshaft, work with the following specifications:

1. Radius at pin/journal: 3 mm $\pm$ 0.2 mm (0.118 inch $\pm$ 0.0078 inch)

2. Finish precision: 1.6Z.

3. Radius around oil hole: 2 mm (0.0787 inch) maximum 5 mm (0.916 inch) minimum.

Use No. 400 emery cloth for final polishing.

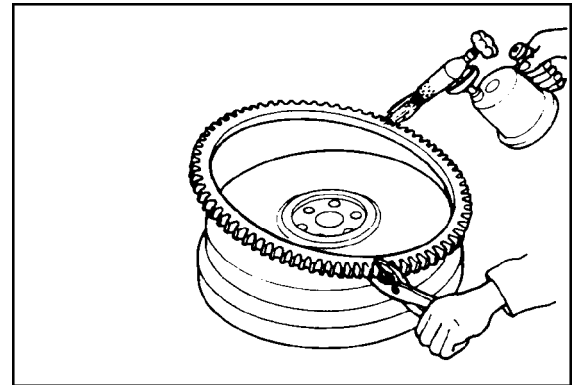


BS05B315

Flywheel and Ring Gear**Inspection**

Check the ring gear. If it is excessively damaged or worn, replace as required.

When wear is not excessive, remove the ring gear and reinstall 90° from original position. To install, preheat the ring gear up to 120° C - 150° C (248° F - 300° F).



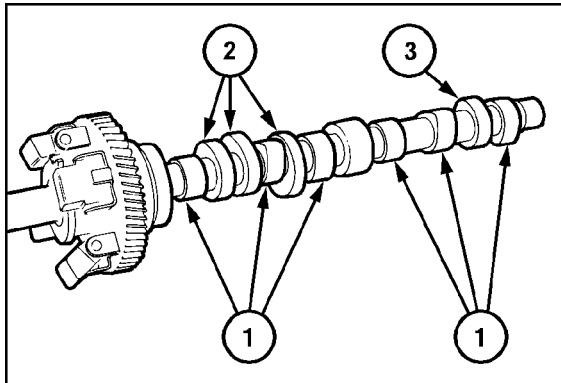
BS05B316

Camshaft Assembly

Inspection

Check the journals and cams for wear and damage. Replace if the allowable limit is exceeded.

Correct uneven wear or small scratches on the cam surface with oil stone.



BS05B317

Cam Height (intake and exhaust cams)

Standard Value: 34.065 mm - 34.12 mm (1.3411 inch - 1.3433 inch)

Allowable Limit: 33.7 mm (1.3268 inch)

Height of Cam for Injection Pump

Standard Value: 41.94 mm - 42.06 mm (1.6512 inch - 1.6559 inch)

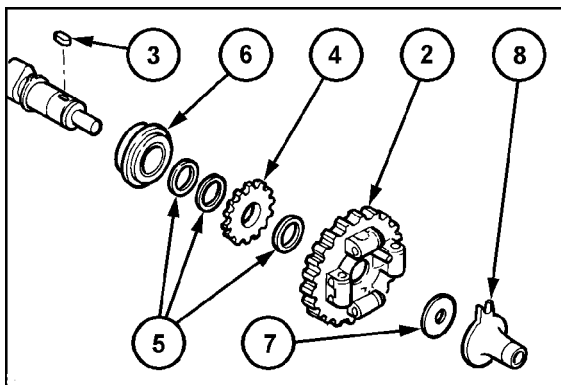
Allowable Limit: 41.8 mm (1.6457 inch)

Height of Cam for Fuel Feed Pump

Standard Height: 31.9 mm - 32.0 mm (1.2559 inch - 1.2598 inch)

Allowable Limit: 30.0 mm (1.1811 inch)

Camshaft Gear and Bearing Assembly



BS05B318

2. CAMSHAFT GEAR
3. CAMSHAFT
4. TACHOMETER GEAR
5. SPACER
6. ROLLER BEARING
8. SLIDER

If these items have been replaced, it is essential that the spacers, shims, etc. are assembled in the order illustrated here.

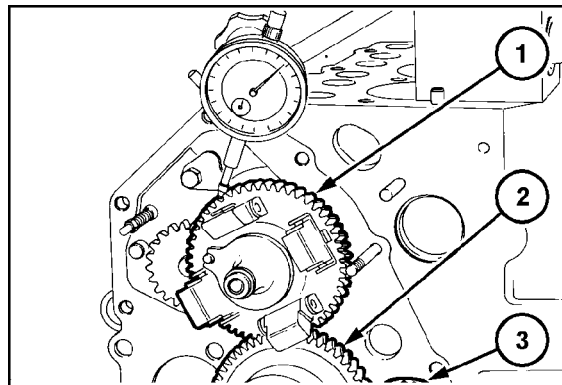
To replace the camshaft gear assembly, the assembly will require pressing off and on.

Timing Gear

Inspection

Check the timing gears for wear and damage on the contact area. Replace if any defect is found.

Measure the backlash of gears with a thickness gauge or dial gauge. If the allowable limit is exceeded, replace all timing gears.



BS05B319

1. CAMSHAFT GEAR
2. IDLER GEAR
3. CRANKSHAFT GEAR

Standard Backlash: 0.08 mm (0.003 inch)

Allowable Limit: 0.25 mm (0.010 inch)

Oil Pump

Disassembly

Remove the snap ring.

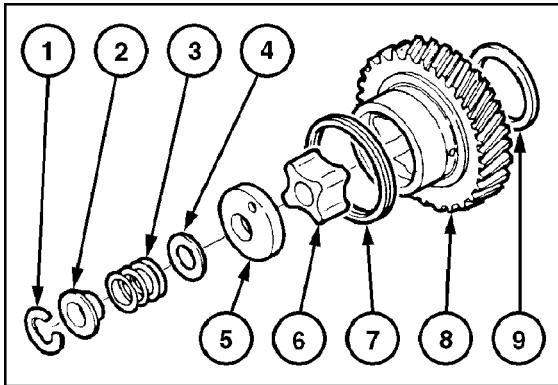
Take out the collar spring and shim.

Remove the idler gear vane and oil pump cover together.

Pull out the rotor and thrust washer.

Pull out the oil pump cover from the idler gear.

Remove the spring from the idler gear.



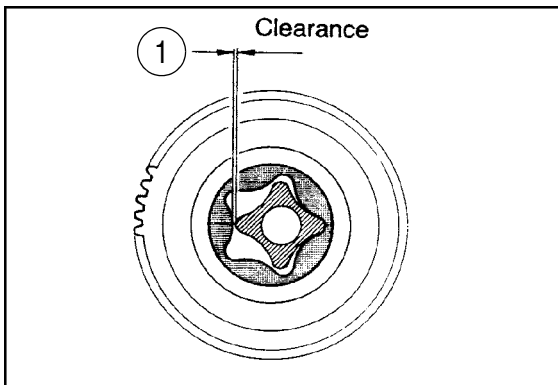
BS05B320

1. SNAP RING
2. COLLAR
3. SPRING
4. SHIM
5. OIL PUMP COVER
6. ROTOR
7. SPRING
8. IDLER GEAR
9. THRUST WASHER

Inspection

Check the oil pump cover, rotor, and vane for wear. If excessively worn or damaged, replace as required.

Check the clearance at 1 between the rotor and the vane.



BS05B321

Reassembly (see Idler Gear)

Reassemble the oil pump in the reverse order of disassembly.

Align the set marks on the crankshaft gear and idler gear to reassemble.

Make sure the tip clearance at 1, between the rotor and the vane is 0.01 mm to 0.15 mm (0.0004 inch to 0.006 inch). Allowable limit is 0.25 mm (0.009 inch).

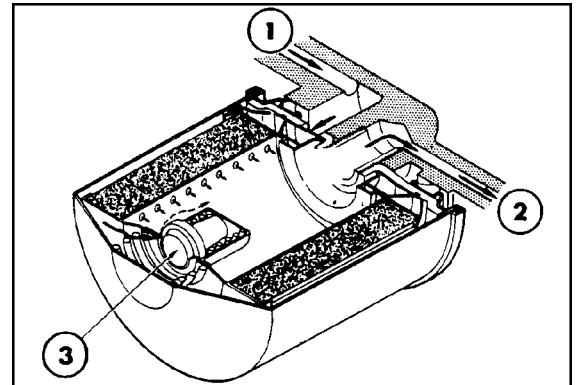
Oil Filter

Construction and Function

This engine employs a cartridge-type filter.

Pressurized oil from the pump enters from 1 and is filtered by a full flow filter before discharge through 2.

When the full flow filter is clogged, the safety valve, 3, opens to bypass the oil.



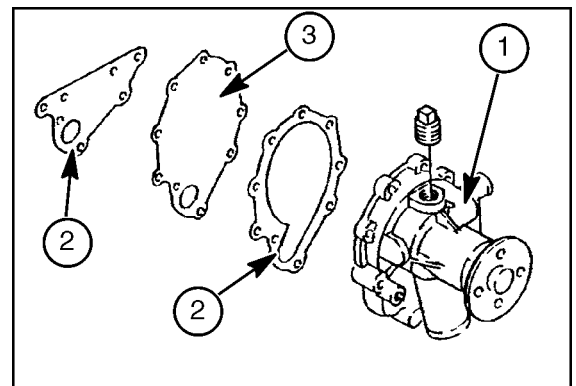
BS05B322

Water Pump Assembly and Thermostat Housing

Disassembly

Remove the backplate and gaskets.

Remove the thermostat and spring from the thermostat housing.



BS05B323

1. WATER PUMP
2. GASKETS
3. SET PLATE

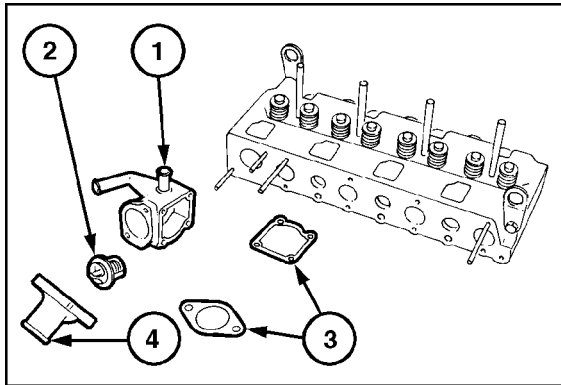
Inspection

Thermostat Removal

Replace the thermostat if the valve opens at ambient temperature.

Place the thermostat into water. Raise the water temperature gradually and inspect the valve opening temperature and valve lift. (Standard values are as described in the "Specifications" section.)

NOTE: Three to five minutes will be required before the valve starts operating.



BS05B324

	422/M2	422T/M2
Type	Wax Pellet Type	Wax Pellet Type
Temperature when starting to open	71° C (160° F)	71° C (160° F)
Temperature when fully open	180° F (82° C)	180° F (82° C)
Valve lift fully open	8.0 mm (0.315 inch)	8.0 mm (0.315 inch)

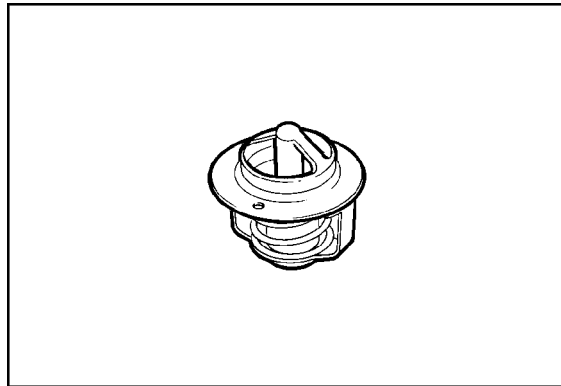
Water Pump

Check for cracks, wear, leaks, bearing roughness, or damage. If defective, replace assembly.

Reassembly

Assemble the thermostat and spring in the housing. Install the gasket and backplate on the water pump.

Rotate the fan holder to confirm there is no obstruction or interference.



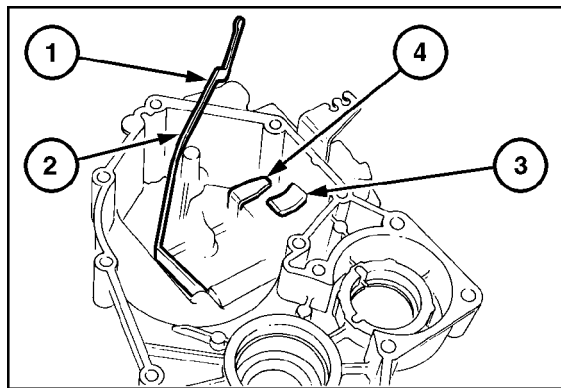
BS05B325

Governor

Construction/Function

A mechanical all-speed governor is used. It is housed in the gear case.

A flyweight assembly is mounted on the camshaft. The movement of the flyweight is transmitted to the injection pump control rack by way of the slider, control lever, and link, 1. A spring which is hooked to the arm, 3, and tension lever, 4, regulates the movement of the flyweight.



BS05C001

By changing the set angle of the governor lever, tension on this spring is changed. Thus, the engine speed can be regulated by the governor lever.

Maximum Speed Set Bolt

The set bolt is mounted on the cylinder block. This bolt limits the movement of the arm and has been adjusted and sealed at the factory.

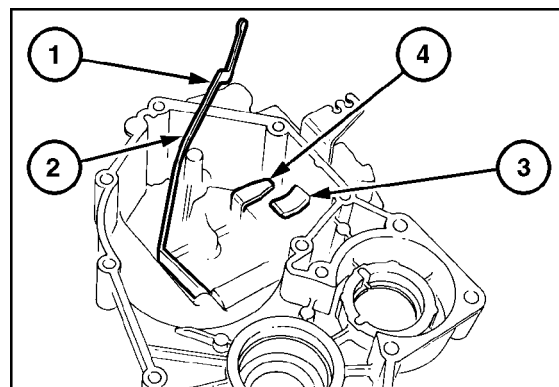
Maximum Fuel and Start Spring

These are built into the cylinder block to regulate fuel injection at high speed. Regulation of fuel injection in the middle speed range is by torque spring to realize higher torque.

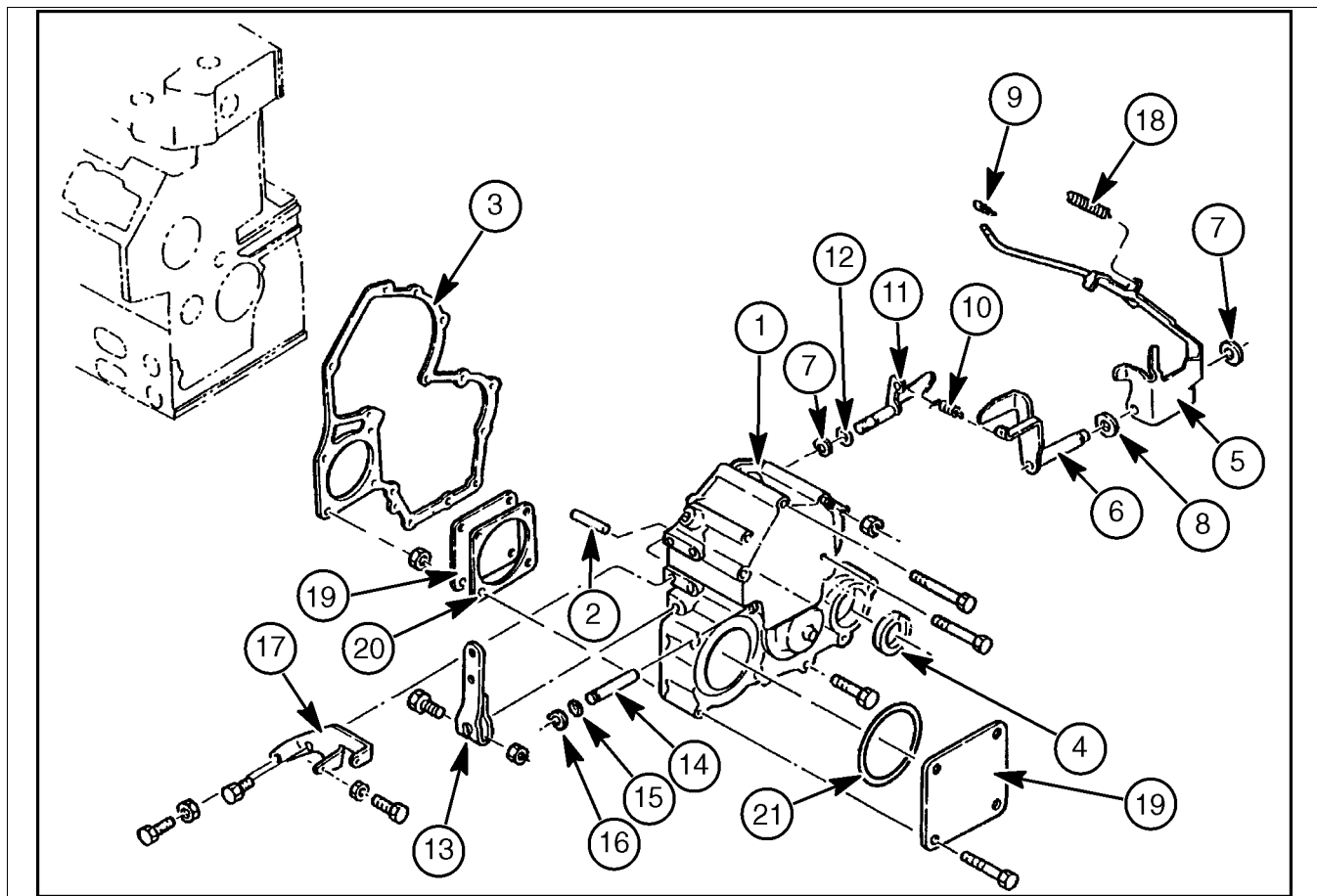
A start spring, 2, is placed between the gear case and link. This spring automatically functions to increase fuel during the start mode.

An idling spring at the gear case stabilizes engine idling speed.

The maximum fuel has been adjusted at the factory and sealed.



BS05C001



BS05C002

1. TIMING GEAR COVER
2. PIN
3. GASKET
4. OIL SEAL
5. ARM ASSEMBLY
6. SPRING HOLDER ARM
7. SNAP RING

8. WASHER
9. SNAP PIN
10. GOVERNOR SPRING
11. THROTTLE ARM
12. O-RING
13. THROTTLE LEVER
14. PIVOT SHAFT

15. O-RING
16. SNAP RING
17. THROTTLE STAY
18. DAMPENER SPRING
19. COVER
20. GASKET
21. O-RING

ENGINE GOVERNOR ASSEMBLY

Engine Governor Assembly

Reassembly

Precautions Before Assembling

Wash parts before assembling (especially oil gallery, bearings, piston, and cylinder bores should be washed thoroughly).

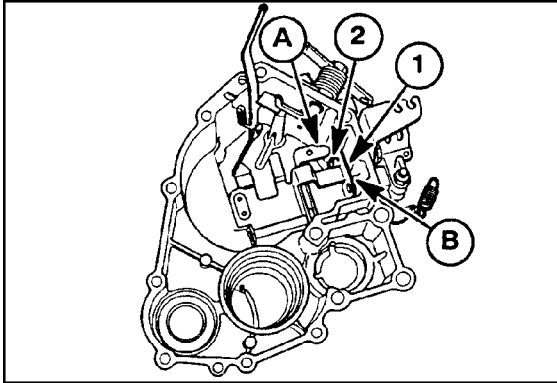
Apply new oil to sliding and rotating surfaces of cylinder bores, piston, and bearings, etc.

Replace gasket, packing, etc. Use liquid gasket to prevent oil leakage where necessary.

Never over-tighten bolts and nuts used on aluminum alloy. Tighten to specified tightening torques.

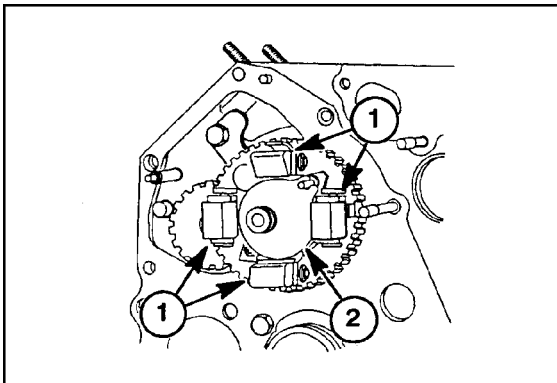
Governor Operation

As the engine speed increases, the throttle arm, 1, contacts the fuel screw adjuster at contact point A, and the high speed idle stop screw at B. During the engine speed increase, tension is placed on the governor spring, 2.



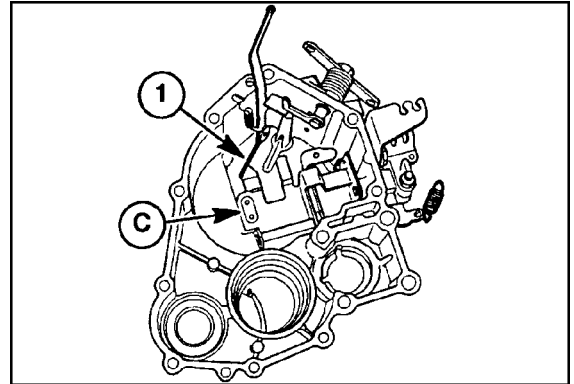
BS05C003

As the engine speed increases, the four governor weights, 1, pivot outward and push on the slider cone, 2. The weights and slider cone are located on the end of the camshaft.



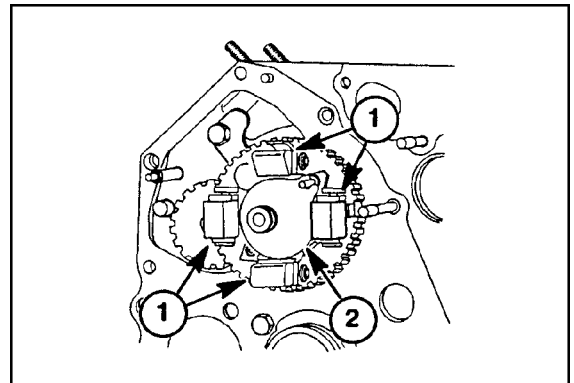
BS05C004

The slider cone, 2, (see below) contacts the governor linkage arm, 1 at contact pad, C. As the cone moves forward, it pushes the linkage arm, 1, forward, which is connected to the injection pump rack assembly. When the injection pump rack moves forward, the fuel delivery is decreased and the engine speed decreases.



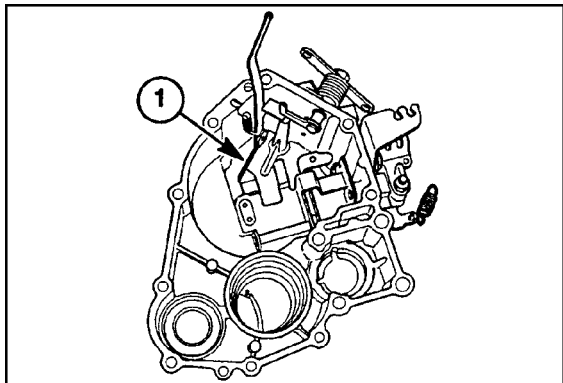
BS05C005

As the engine speed decreases, the governor weights, 1, pivot inward allowing the slider cone, 2, to move rearward.



BS05C006

As the slider cone, 2, (see below) moves rearward, the governor linkage arm, 1, allows the fuel injection pump rack to move rearward to the full fuel position and the engine speed increases.



BS05C007

Engine speeds depends upon several factors: the throttle setting determined by governor spring tension; the pressure exerted by the slider cone on the governor linkage; and positioning of the injection pump rack.

All the governor linkage parts are located inside the engine timing gear cover. To inspect or replace any of the governor linkage parts, the timing gear case and injection pump must be removed from the engine.

ENGINE REASSEMBLY

Precautions

Thoroughly wash parts before reassembly. Ensure oil galleries are clean and unobstructed.

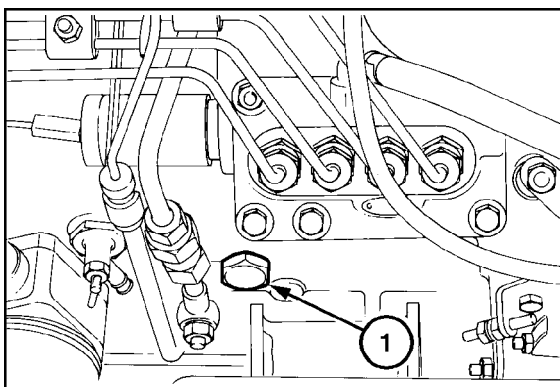
Lubricate all rotating and sliding components before assembly.

Clean all gasket surfaces, using care not to scratch mating surfaces. Use special care on aluminum parts. Discard and replace all removed gaskets. Use liquid gasket where necessary.

Never over-tighten threaded fasteners used on aluminum parts. Tighten only to specified torque values.

Oil Pressure Relief Valve Assembly

Install an O-ring on the relief valve assembly.

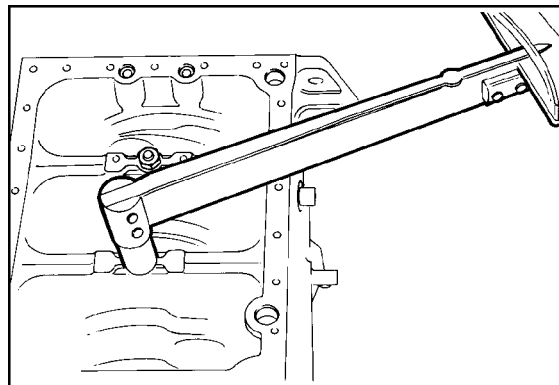


BS05C008

Relief valve tightening torque: 58 Nm - 68 Nm (43 lb ft to 50 lb ft).

Crankshaft and Bearing Holder Assembly

1. Install the bearing holders on the crankshaft. Insert this in the bushing at the front end of the cylinder block.



BS05C009

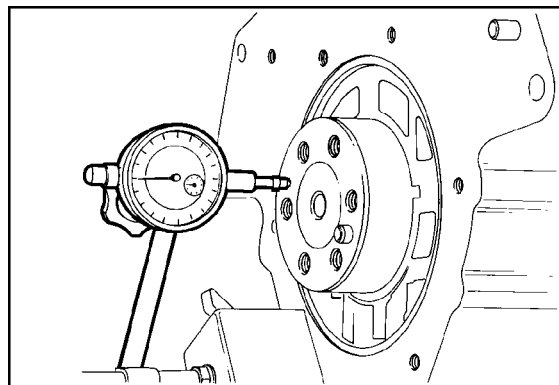
2. Align the bolt hole at the lower part of the cylinder block with thread hole on the bearing holder and tighten with bolts. For flywheel end, use two special bolts, hex recess in its head.

Bearing holder tightening torque:

Hex hole bolts - 24 - 30 Nm (18 to 22 lb ft)

Hex bolts - 49 to 54 Nm (36 to 40 lb ft)

3. Measure crankshaft end float.



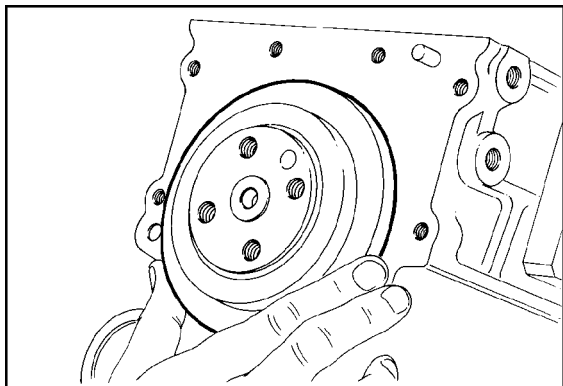
BS05C010

Standard Play: 0.1 mm - 0.4 mm (0.004 inch - 0.016 inch)

Allowable Limit: 0.5 mm (0.020 inch)

Rear Oil Seal

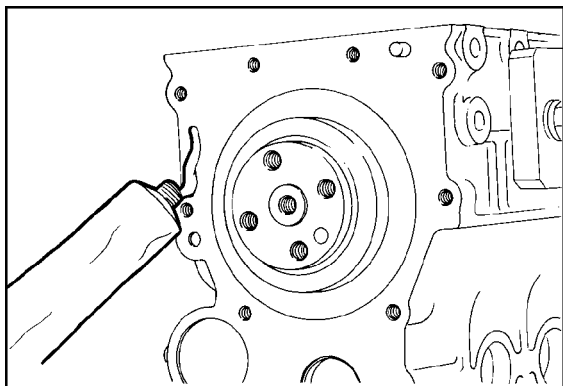
This is a press-fit, retained by the backplate.



BS05C011

Back Plate/Flywheel Housing

Coat the area around the M8 threaded holes with liquid packing solvent-based sealant and fix the backplate with bolts.



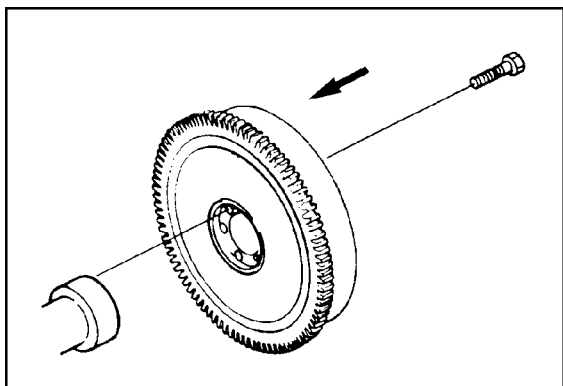
BS05C012

Backplate tightening torque: 14 - 18 Nm (10 - 13 lb ft)

Housing tightening torque: 24 - 28 Nm (18 - 21 lb ft)

Flywheel

Fit the flywheel. Note the location of the spring pin.



BS05C013

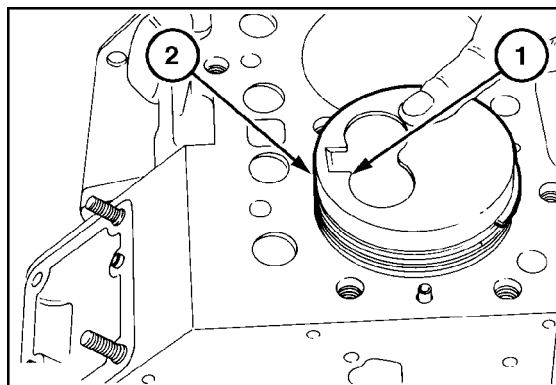
Flywheel tightening torque: 58 - 68 Nm (43 - 50 lb ft).

Piston and Connecting Rod

Coat the bearing face, piston, and piston ring with clean engine oil.

Slide the piston ring to permit a sufficient amount of oil to be applied in the groove. Set the piston ring gaps 90° apart from each other. However, do not position these gaps toward the piston pin or the right angle of the pin.

Insert the piston using a ring compressor. Face the reference mark, 1, on the piston toward the injection pump side, 2, as indicated. Also, face the connecting rod mark towards the fuel pump side.



BS05C014

NOTE: Install pistons from the front in ascending order.

Tighten the connecting rod cap to the specified torque.

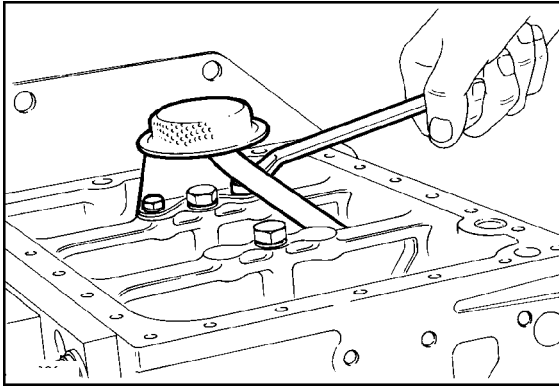
Connecting rod tightening torque: 49 - 54 Nm (36 - 40 lb ft).

NOTE: After installation, ensure the crankshaft moves freely. Ensure the axial play of 0.1 mm to 0.3 mm (0.004 inch to 0.012 inch) is provided.

Oil Intake and Oil Strainer

Install an O-ring on the suction pipe and insert the pipe into the cylinder block.

Fit the end of the suction pipe to the oil strainer and fix the oil strainer.



BS05C015

Suction filter tightening torque: 8.8 - 12.9 Nm (6.5 - 9.5 lb ft).

Oil Sump

Tighten the bolts diagonally and evenly.

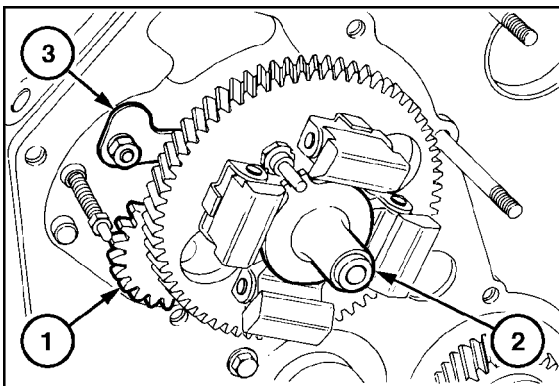
Dipstick and Tube

Install the dipstick and tube using two O-rings.

Front Plate

Camshaft Assembly, Tachometer, and Plate

1. Install the tachometer shaft.
2. Install the camshaft assembly. Avoid damaging bearings.
3. Fix the tachometer shaft and camshaft with the retaining plate.



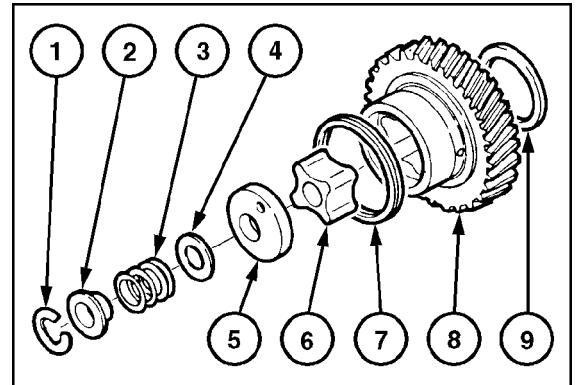
BS05C016

Plate tightening torque: 8.8 - 12.9 Nm (6.5 - 9.5 lb ft).

Idler Gear and Oil Pump Assembly

Install the thrust washer on the idler gear shaft.

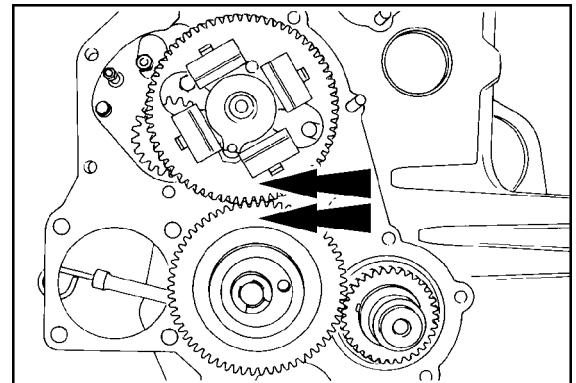
Assembly the vane, knock pin, and spring on the idler gear.



BS05C017

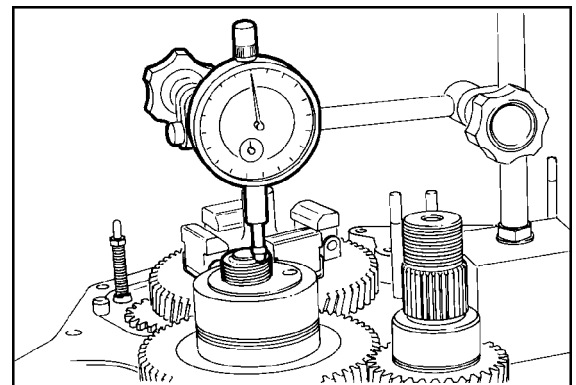
1. SNAP RING
2. COLLAR
3. SPRING
4. SHIM
5. OIL PUMP COVER
6. ROTOR
7. SPRING
8. IDLER GEAR
9. THRUST WASHER

Align set marks on the idler gear, crankshaft gear, and camshaft gear, and assemble on the idler gear shaft.



BS05C018

Install the rotor.



BS05C019

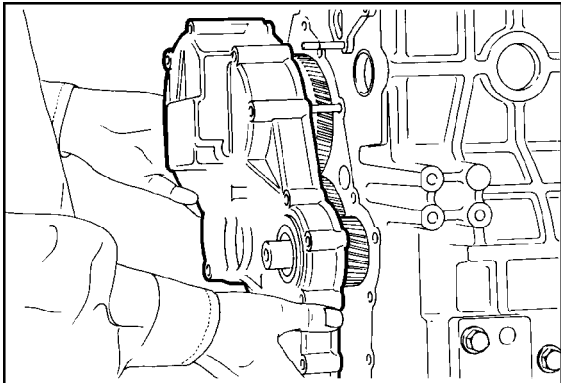
Install the oil pump cover, shim, spring, and collar. Fix them with the retaining ring.

Adjust with shim 0.1, 0.15, 0.2, 0.5 mm so the axial clearance of the oil pump, rotor, and vane is in the range of 0.1 mm to 0.15 mm (0.004 inch - 0.006 inch). The allowable limit is 0.2 mm (0.008 inch).

NOTE: Coat both faces of the rotor and vane with grease for assembly.

NOTE: Never turn the crankshaft until the timing gear case is fitted.

By turning the oil pump cover to either direction, set the spring pin insert hole to the middle position and fit the gear case.

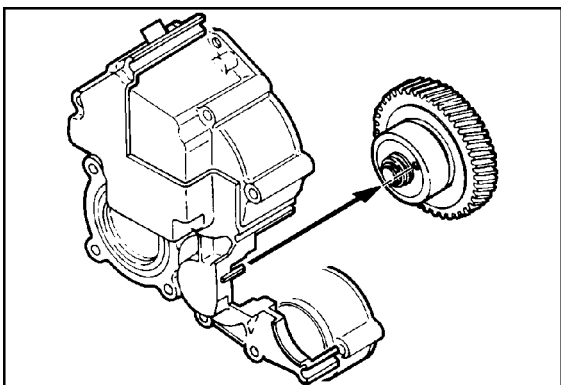


BS05C020

Timing Gear Case

Install the start spring.

Insert the link through the hole in the cylinder block. Rotate the oil pump cover to the position spring pin hole to the center position. Install the cover locating pin in the oil pump cover plate (PB094).



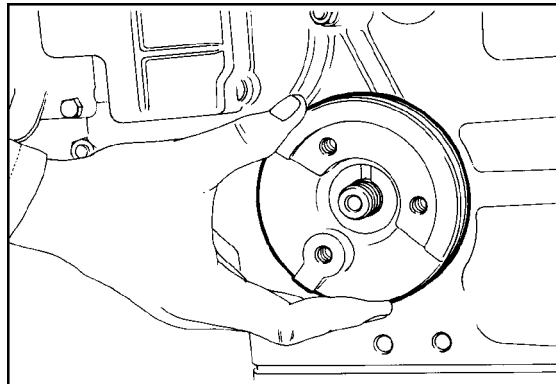
BS05C021

NOTE: Do not damage the oil seal when fitting. Turn the mechanical stop lever clockwise to assist assembly.

Crankshaft Pulley

Align the keyway and key on the crankshaft pulley and crankshaft and assemble them.

Crankshaft pulley tightening torque: 275 - 333 Nm (203 - 246 lb ft).

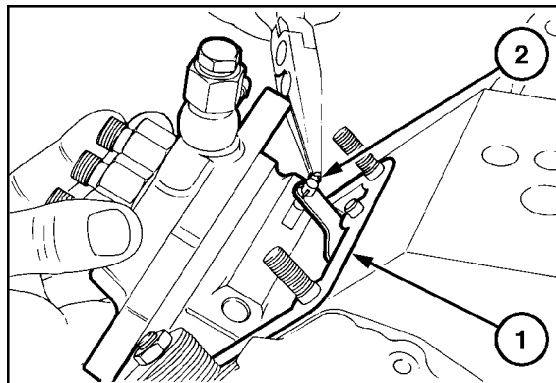


BS05C022

Injection Pump Installation

Reinstall the shim, 1. Connect the control rack of the injection pump with the link, 2, and fix with the snap pin.

Tighten the injection pump bolts and nuts.



BS05C023

Adjusting the Fuel Injection Timing

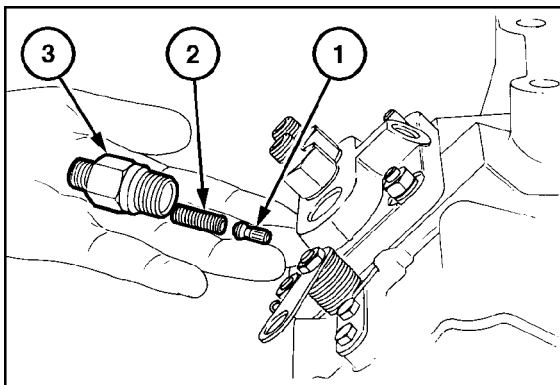
Normally, this procedure provides correct injection timing. However, when the new injection pump, camshaft assembly, or cylinder block is used, fuel injection timing should be adjusted as explained below.

Reassemble the injection pump according to the procedures above. Use the shim of 0.5 mm thickness. Remove the delivery valve holder at the front side (radiator side) of the injection pump.

Injection Timing and Crankshaft Positions

Engine Model	Degrees Crank BTDC			
	X	Y	Z	Injection Timing
422T/M2	19	18	20	18 - 20
422/M2	22	21	23	21 - 23

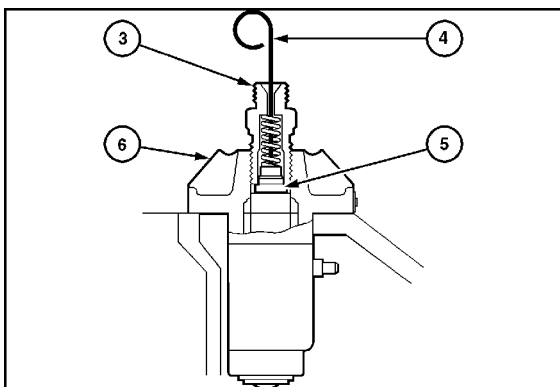
Pull out the delivery valve, 1, (IN), and reinstall the spring, 2, and delivery valve holder, 3.



BS05C024

NOTE: When reassembling the delivery holder, adjust the location of the delivery valve (OUT) to correct position using a wire, 4.

Move the governor control lever to "Maximum Fuel" position and send fuel with the No. 1 piston at around "X" degrees BTDC in its compression stroke. At this time, fuel flows from the delivery holder.



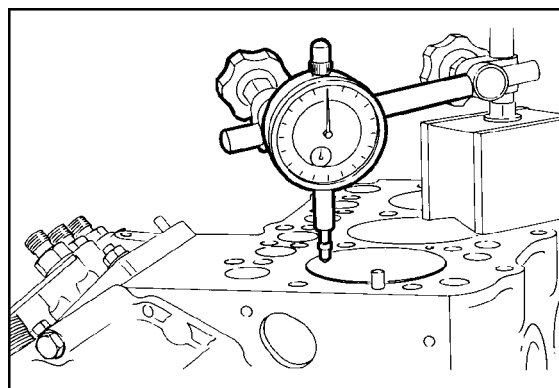
BS05C025

Piston Position in Relation to the Crankshaft Angle (BTDC)

422/M2, 422T/M2

Crankshaft Angle (BTDC)	Position
13	1.677 mm (0.0660 inch)
14	1.943 mm (0.0765 inch)
15	2.228 mm (0.0877 inch)
16	2.532 mm (0.0997 inch)
17	2.854 mm (0.1124 inch)
18	3.195 mm (0.1258 inch)
19	3.554 mm (0.1399 inch)
20	3.932 mm (0.1548 inch)
21	4.328 mm (0.1704 inch)
22	4.741 mm (0.1867 inch)
23	5.172 mm (0.2036 inch)
24	5.620 mm (0.2213 inch)
25	6.086 mm (0.2396 inch)
26	6.569 mm (0.2586 inch)

Slowly turn the crankshaft clockwise until flowing fuel from the delivery holder is stopped. Check the piston position at this point. If the position is later than "Y" BTDC, use a thinner shim. If the position exceeds "Z" BTDC, use a thicker shim.



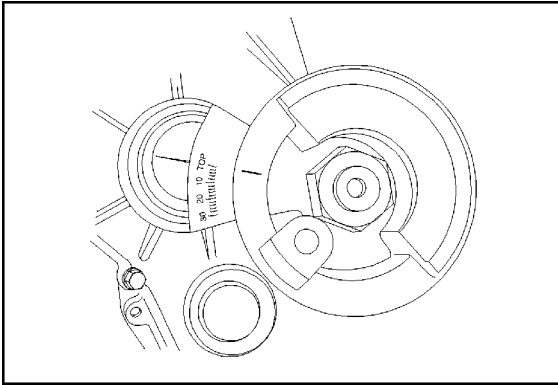
BS05C026

Changing the shim thickness by 0.1 mm (0.004 inch) will change the timing approximately one degree. Adding shims decreases the angle, while subtracting shims increases the angle.

NOTE: When the shim is not needed, assemble by coating, using liquid sealant.

Spill-Timing Procedure

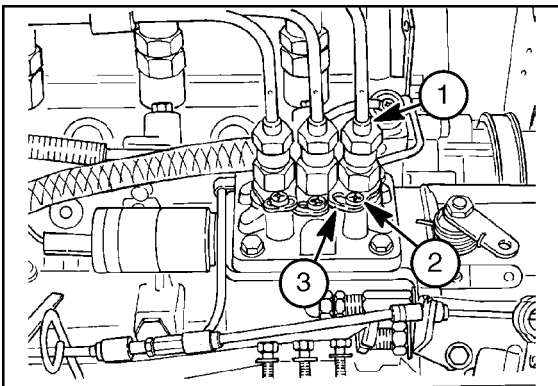
1. Verify that the timing mark on the crankshaft pulley is in line with the "TOP" mark on the timing scale. If the mark on the crankshaft pulley is not in line with the "TOP" mark, verify piston top-dead center with a dial indicator. If the pulley mark is slightly off, re-mark the pulley and proceed.



BS05C027

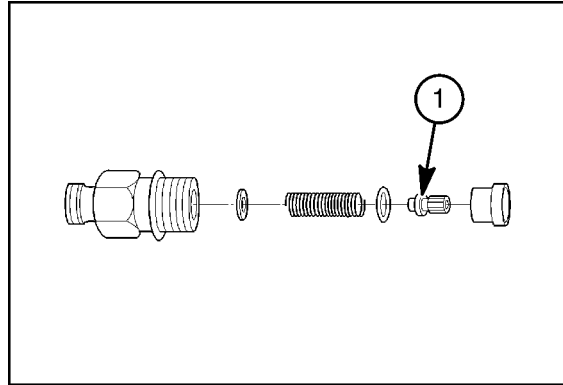
NOTE: Color the timing mark on the crankshaft pulley and appropriate marks on the timing scale to increase visibility.

2. Reinstall the valve spring, keepers, rocker arm assembly, and valve cover.
3. Shut off the fuel supply to the injection pump at the fuel filter.
4. Remove the No. 1 injection line from the No. 1 injector, 1.
5. Remove the lock screw, 2, and remove the injector locking plate, 3.



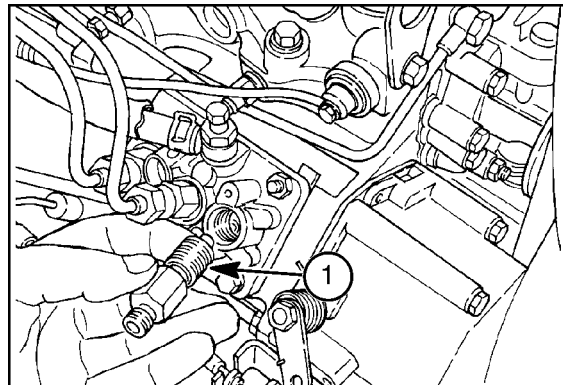
BS05C028

6. Remove the delivery valve piston, 1, from the No. 1 delivery valve.



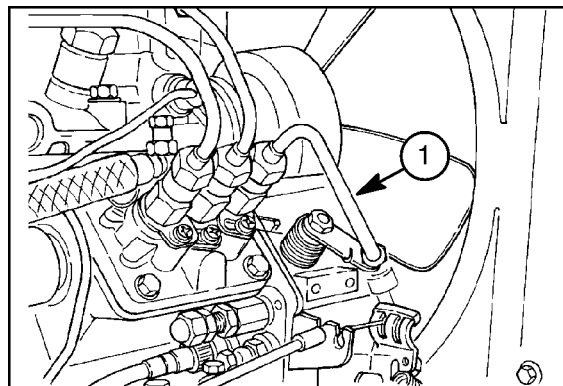
BS05C029

7. Reinstall the spring and holder, 1, into the injection pump and tighten securely.



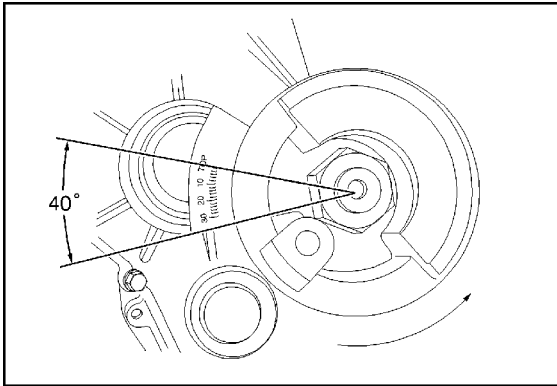
BS05C030

8. Fabricate a spill tube, 1, from a discarded injection line and install the tube on the No. 1 port on the injection pump.
9. Remove the fuel shut-off solenoid from the injection pump.



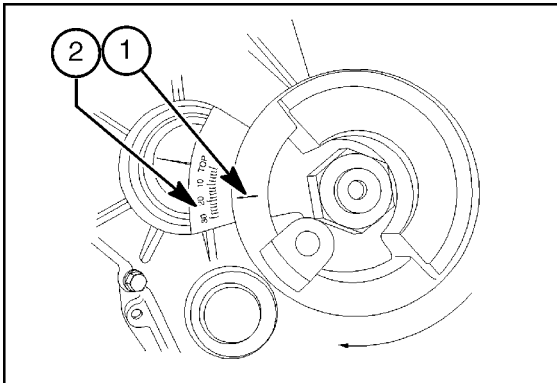
BS05C031

10. Rotate the crankshaft counterclockwise (viewed from the front of the engine) approximately 40°.
11. Turn on the fuel supply to the injection pump. Fuel should flow out of the spill tube on the No. 1 cylinder port.



BS05C032

12. Rotate the crankshaft clockwise. When the timing mark on the crankshaft pulley, 1, is in line with the 19° (422T/M2) or 22° (422/M2) mark on the scale, 2, fuel should stop flowing from the spill tube.



BS05C033

13. If fuel does not stop flowing at the appropriate timing mark, the injection pump timing must be adjusted by adding or removing shims located between the injection pump and the engine block.
14. Adding shims will retard the pump timing and removing shims will advance the pump timing.

NOTE: A shim thickness of 0.1 mm (0.004 inch) will change the pump timing by approximately 1°.

15. Assemble the components that were removed from the engine and fuel system.

Assemble the delivery valve (IN).

NOTE: Delivery holder tightening torques: 39 - 45 Nm (29 - 33 lb ft).

Oil Filter

Coat the mounting face with a thin film of oil, and then hand-tighten.

Bur 6-79550

Feed Pump

Insert using securing bolts.

Tappet

Coat the tappet with oil, and then assemble.

Cylinder Head

Set the piston to the top, dead center, and measure the amount of protrusion above the cylinder block with a depth gauge or a dial gauge.

NOTE: Take measurement by pressing the piston lightly.

Measure the protrusions for 4 cylinders. Use the highest reading as a reference.

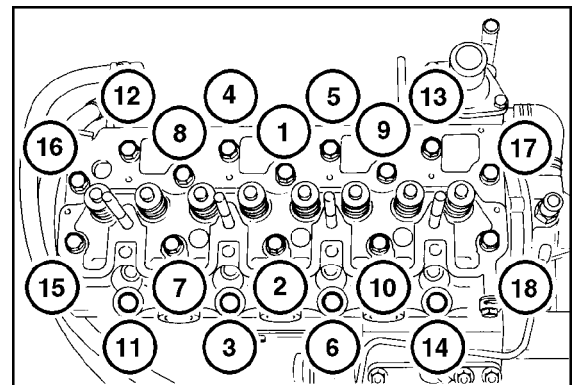
Ensure the cylinder head gasket meets the tolerance levels.

422/M2, 422T/M2

Measurement	Gasket No.	Tightened Thickness
0.3 - 0.45 mm (0.019 - 0.0023 inch)	111147580	t=0.4 mm (t=0.047 inch)
0.5 - 0.8 mm (0.023 - 0.031inch)	111147590	t=0.5 mm (t=0.051 inch)

NOTE: The last four digits of code numbers are stamped on the head gasket. Install the head gasket with code numbers at the top.

Tighten the cylinder head in 3-step procedures, in the order shown in the illustration. Finally, tighten with specified torque.



BS05C0034

Specified torque: 98 - 103 Nm (72 - 76 lb ft)

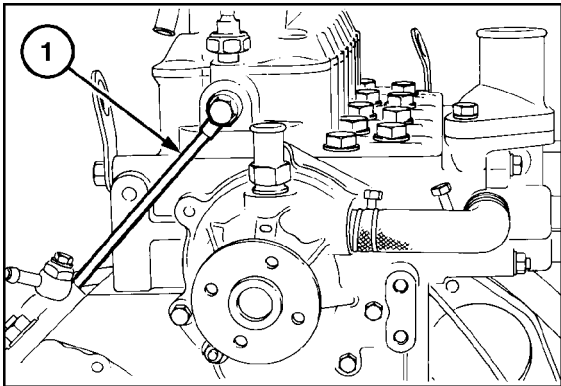
NOTE: Spring pin is used for positioning.

Coat threads of bolts with grease based with molybdenum disulfide.

Oil Pipe

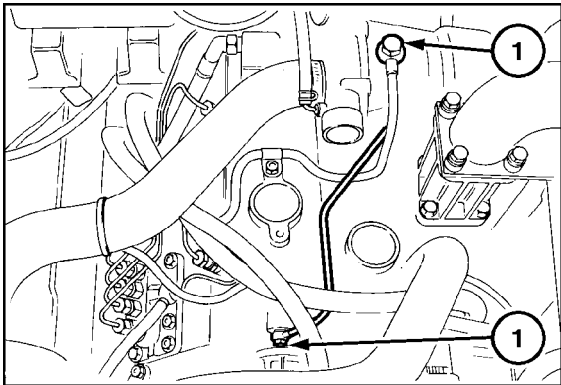
Eyebolt tightening torque: 9 - 12 Nm (7 - 9 lb ft)

422/M2 engine - the oil pipe, 1, will be connected to the block.



BS05C035

422T/M2 engine - the oil pipe will be connected to the turbocharger.



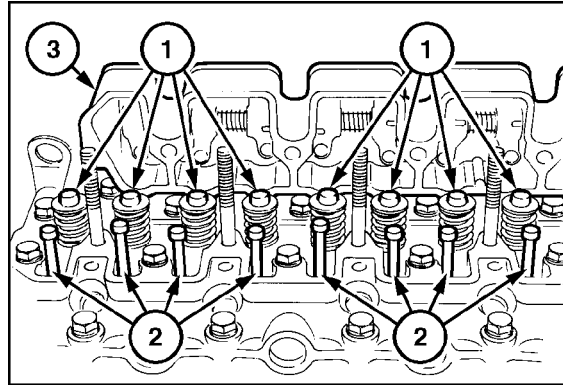
BS05B269

Cap, Push Rod, and Rocker Arm Assembly

Install the caps, 1, on the end of the valve stem.

Install the push rods, 2, and rocker arm assembly, 3.

Rocker arm assembly tightening torque: 27 - 39 Nm (20 - 29 lb ft) 4-cylinder engines.

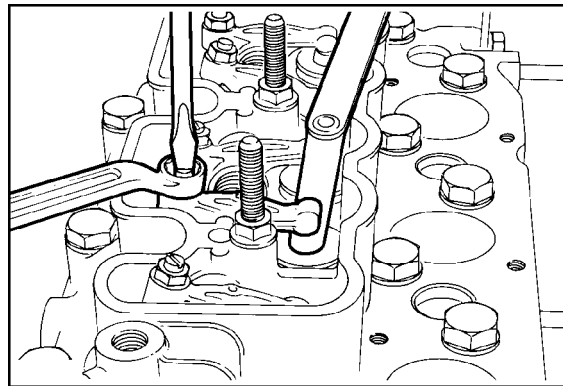


BS05C036

Valve Clearance Adjustment

Loosen the nut and adjust the clearance of both the intake and exhaust valves to 0.2 mm (0.0078 inch) with the adjust screw.

NOTE: Adjust when the engine is cold. Set the No. 1 piston to TDC of compression stroke and adjust the No. 1 cylinder intake, exhaust valves, No. 2 cylinder intake valve, and No. 3 cylinder exhaust valve. Turn the crankshaft 360° in a clockwise direction, viewed from the front, and adjust the remaining valves.



BS05C037

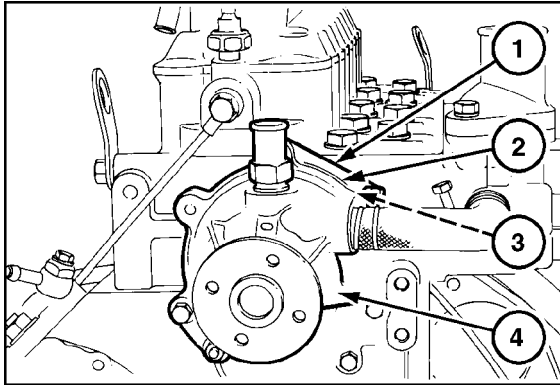
Cylinder Head Cover

Evenly tighten the cylinder head cover. Ensure the oil ring gasket remains in location.

Cylinder head cover tightening torque: 12 - 16 Nm (9 - 12 lb ft).

Water Pump Assembly and Thermostat Housing

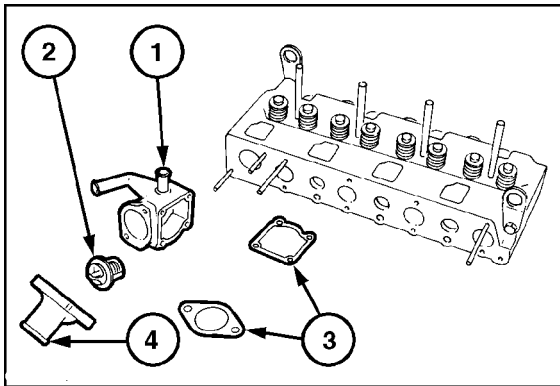
Install in the sequence of the gasket, plate, gasket and water pump assembly.



BS05C038

1. GASKET
2. PLATE
3. GASKET
4. WATER PUMP

Connect the thermostat housing and hoses.



BS05C039

1. THERMOSTAT HOUSING
2. THERMOSTAT
3. GASKET
4. ADAPTER

Glow Plug and Connector

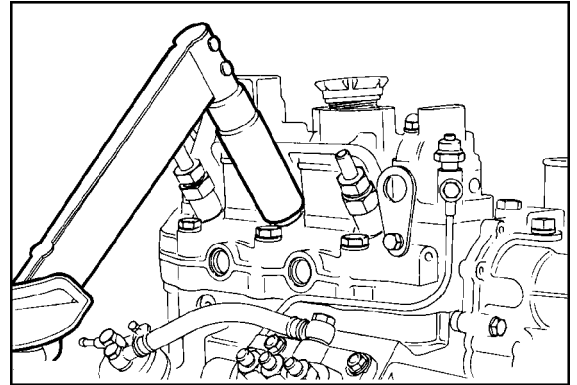
Glow plug tightening torque: 15 - 20 Nm (11 - 14.5 lb ft).

Oil Pressure Switch

Oil pressure switch tightening torque: 15 - 20 Nm (11 - 14.5 lb ft)

Nozzle/Holder Assembly

Install the nozzle and holder assembly with a socket for the nozzle holder. Install the return pipe.

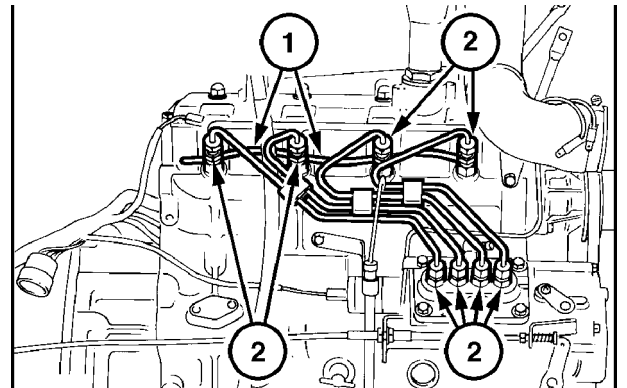


BS05C040

Nozzle/holder tightening torque: 60 - 69 Nm (44 - 51 lb ft)

Return Pipe and Injection Pipe

After installing the return pipe, 1, install injection pipes, 2.



BS05C041

Injection pipe tightening torque: 15 - 24 Nm (11 - 18 lb ft)

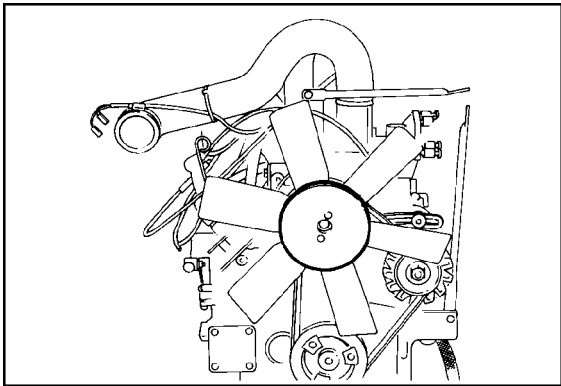
Alternator Assembly

Install the assembly, and check the belt groove alignment.

V-Belt, Fan Pulley and Cooling Fan

After mounting the fan pulley, cooling fan, spacers, install the V belt.

Depress the belt at the center between the crankshaft pulley and the alternator pulley, with a force of approximately 5 kg (2.27 lb ft). The fan belt tension should be adjusted so the deflection becomes (0.2 inch (5 mm) upon the above check.



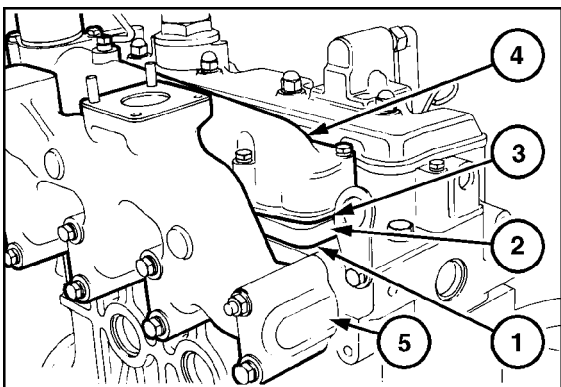
BS05C042

Cooling fan tightening torque: 8.8 - 13 Nm (6.5 - 9.5 lb ft)

Intake/Exhaust Manifolds

Install in sequence of gasket, 1; spacer, 2; gasket, 3; and intake manifold, 4.

Install exhaust manifold, 5.



BS05C043

How To Operate the Engine After Overhaul

1. Check the quantity of the coolant, engine oil, and fuel.
2. Disconnect the wiring harness connector at the engine stop solenoid.
3. Move the hand throttle lever to the low, 1/3-throttle position.
4. Turn the key switch to the start position (rotate the starting motor) until the oil pressure lamp goes off (about 20 - 30 seconds).

5. Connect the wiring harness connector at the engine stop solenoid.
6. Move the hand throttle lever to the 1/3 to 1/2 throttle position, start the engine, and operate at no more than 1500 RPM.

7. Adjust the low speed 1500 RPM with the engine running and warm up for 30 minutes. At the same time:

- Check for abnormal sound
- Check for temperature of engine coolant
- Check temperature of engine oil
- Check for leaks of engine oil, coolant, and fuel
- Check color of exhaust gas

A gradual running-in of the overhauled engine is necessary for delivery of the lubricating oil to the bearings, etc.

8. Refer to the turbocharger section of this manual for information on operating a turbocharged engine after overhaul.

Fuel Injection Nozzle and Holder

Specification

Nozzle type: Throttle type

Needle valve diameter: 4 mm (0.16 inch)

Pintle diameter: 1 mm (0.04 inch)

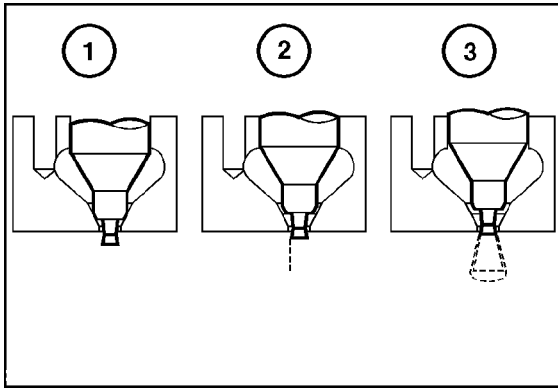
Valve setting pressure: 153 - 163 atm (155 - 165 kg/cm²)

Spraying angle: 4°

Construction/Function

The nozzle has been machined to inject fuel which is pressure-fed from the injection pump to the combustion chamber. Fuel is pressure-fed from the oil hole of the nozzle holder to the nozzle body and sprayed from the nozzle compressing the spring when the pressure exceeds the specified value. Some fuel lubricates and cools the nozzle and nozzle body and returns via the return pipe.

Throttle-Type Nozzle



BS05C044

1. VALVE CLOSED
2. VALVE OPEN
3. FULL OPENING (MAIN JET)

Disassembly/ Inspection

1. Place the nozzle holder (body) in a vise and turn the nozzle nut to disassemble.

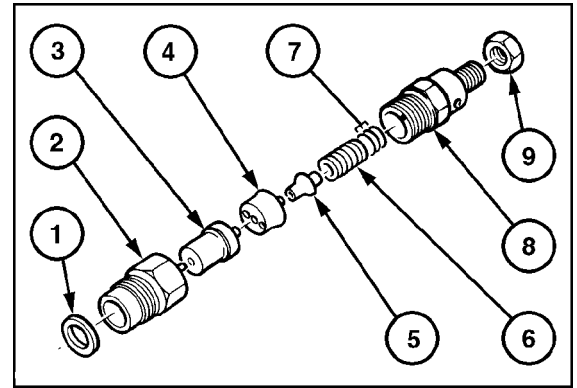
NOTE: Care should be taken so the needle valves do not fall when the nozzle is removed.

2. Wash the nozzle body and needle valve and inspect the nozzle for seizure, sticking and fuel leakage on the seat surface. If fuel leakage is detected, replace the nozzle.
3. Inspect the upper and lower contact surfaces of the distance piece and correct so that positive contact can be obtained.
4. Check the nozzle needle valve-contact surface on the push rod for wear and spring seat for cracks.

Reassembly/Adjustment

1. Before fitting a new nozzle assembly, soak it in heated light oil 50° C - 60° C (120° F - 140° F) to remove the anticorrosive agent from the nozzle. Slide the body on the needle valve so they slide smoothly.
2. Turn the nozzle body upside down, fit the shim, spring, rod spacer and nozzle in this order, and tighten with a nozzle nut.

Throttle-Type Nozzle



BS05C045

1. GASKET
2. NOZZLE NUT
3. NOZZLE
4. SPACER
5. ROD
6. SPRING
7. SHIMS
8. BODY TIGHTEN TORQUE 30 - 49 NM (22 - 36 LB FT)
9. NUT TIGHTEN TORQUE 24 - 30 NM (18 - 22 LB FT)

3. After reassembly, inspect the injection pressure of the nozzle.

Adjust the pressure with adjusting shims, using a nozzle tester so the injection starts at 150 kg/cm² (throttle type) and 210 kg/cm² (hole type). (The pressure increases or decreases about 9.7 atm, 10 kg/cm² 142 PSI, with a shim of 0.1 mm thick).

4. Spray Condition

— Fuel drops should not be mixed in the spray pattern.

— Fuel should be sprayed in conical shape with respect to the nozzle axis.

— Be sure the fuel is sprayed in a circular shape when tested.

— Hold the pressure at 130 kg/cm², lower by 20 kg/cm², 20 atm than specified (150 kg/cm²) and check that no test oil drops from the nozzle tip.

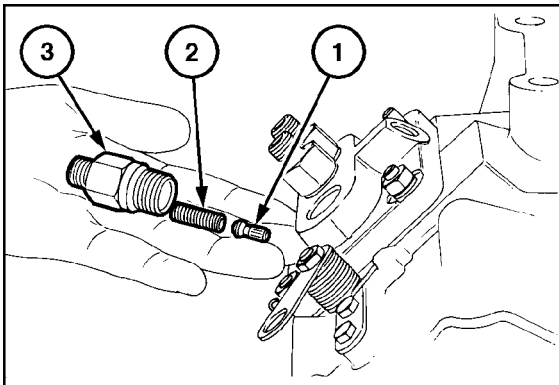
Fuel Injection Pump

If trouble has been traced to this pump, disassembly, inspection, assembly, and testing/setting must only be carried out by fuel equipment specialists.

Fuel Injection Timing

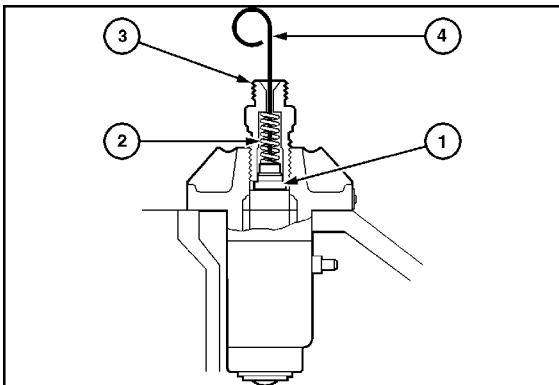
Engine Model	Degrees Crank BTDC			
	X	Y	Z	Injection Timing
422T/M2	19	18	20	18 - 20
422/M2	22	21	23	21 - 23

1. Pull out the delivery valve, 1, (IN), and reinstall the spring, 2, and delivery valve holder, 3.



BS05C046

NOTE: When reassembling the delivery holder, adjust the location of the delivery valve (OUT) to the correct position using a wire, 4.



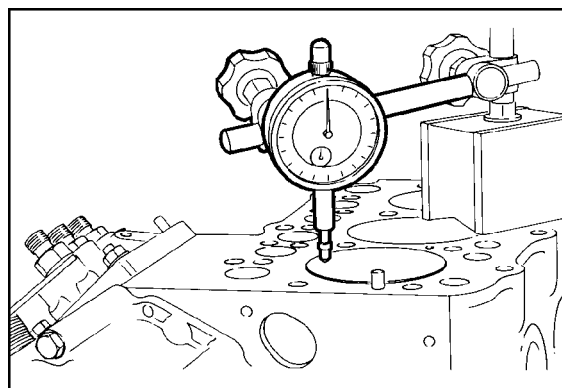
BS05C047

2. Move the governor control lever to "Maximum Fuel" position and send fuel with the No. 1 piston at around "X" degrees BTDC in its compression stroke. At this time, fuel flows from the delivery holder.

422/M2, 422T/M2

Crankshaft Angle (BTDC)	Position
13	1.677 mm (0.0660 inch)
14	1.943 mm (0.0765 inch)
15	2.228 mm (0.0877 inch)
16	2.532 mm (0.0997 inch)
17	2.854 mm (0.1124 inch)
18	3.195 mm (0.1258 inch)
19	3.554 mm (0.1399 inch)
20	3.932 mm (0.1548 inch)
21	4.328 mm (0.1704 inch)
22	4.741 mm (0.1867 inch)
23	5.172 mm (0.2036 inch)
24	5.620 mm (0.2213 inch)
25	6.086 mm (0.2396 inch)
26	6.569 mm (0.2586 inch)

3. Slowly turn the crankshaft clockwise until flowing fuel from the delivery holder is stopped. Check the piston position at this point. If the position is later than "Y" BTDC, use a thinner shim. If the position exceeds "Z" BTDC, use a thicker shim.

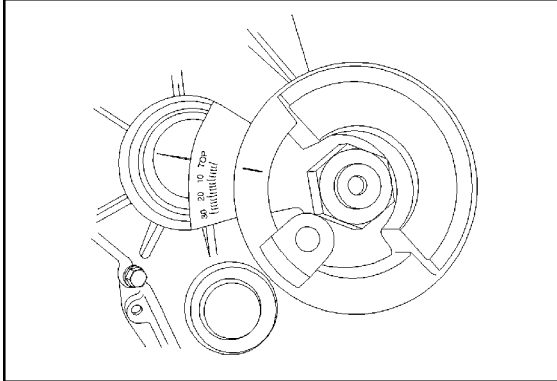


BS05C048

Changing the shim thickness by 0.1 mm (0.004 inch) will change the timing approximately one degree. Adding shims decreases the angle, while subtracting shims increases the angle.

NOTE: When the shim is not needed, assemble by coating, using liquid sealant.

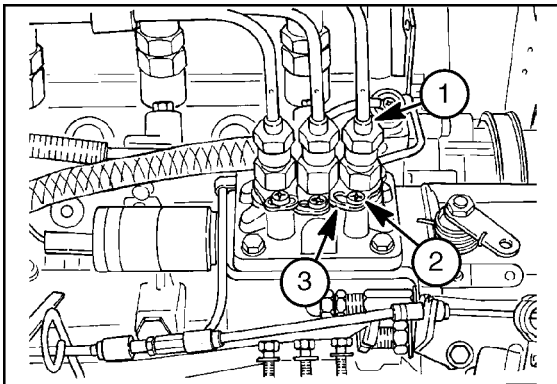
4. Verify that the timing mark on the crankshaft pulley is in line with the "TOP" mark on the timing scale. If the mark on the crankshaft pulley is not in line with the "TOP" mark, verify piston top-dead center with a dial indicator. If the pulley mark is slightly off, re-mark the pulley and proceed.



BS05C049

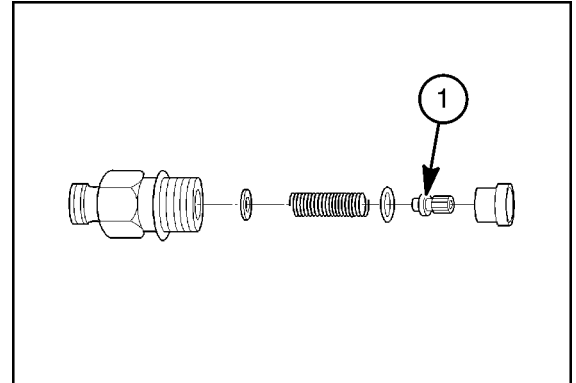
NOTE: Color the timing mark on the crankshaft pulley and appropriate marks on the timing scale to increase visibility.

5. Reinstall the valve spring, keepers, rocker arm assembly, and valve cover.
6. Shut off the fuel supply to the injection pump at the fuel filter.
7. Remove the No. 1 injection line from the No. 1 injector, 1.
8. Remove the lock screw, 2, and remove the injector locking plate, 3.



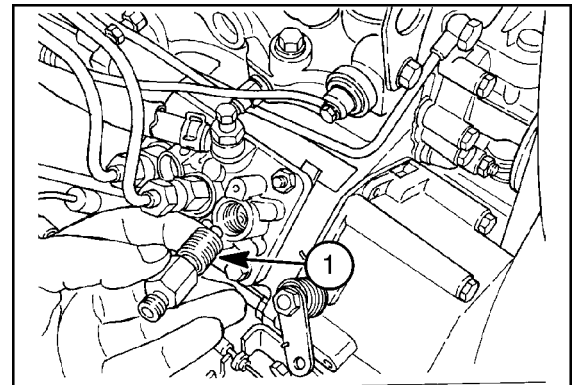
BS05C050

9. Remove the delivery valve piston, 1, from the No. 1 delivery valve.



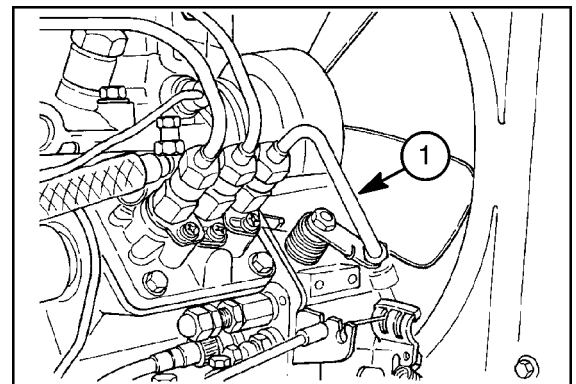
BS05C051

10. Reinstall the spring and holder, 1, into the injection pump and tighten securely.



BS05C052

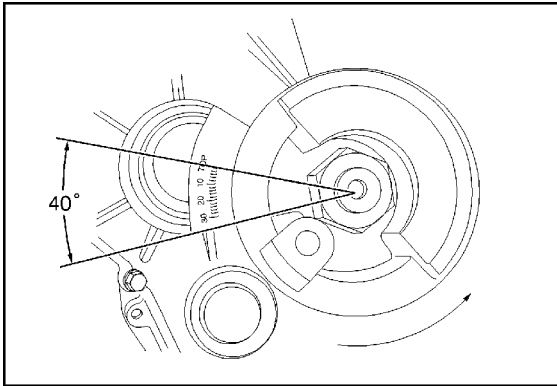
11. Fabricate a spill tube, 1, from a discarded injection line and install the tube on the No. 1 port on the injection pump.
12. Remove the fuel shut-off solenoid from the injection pump.



BS05C053

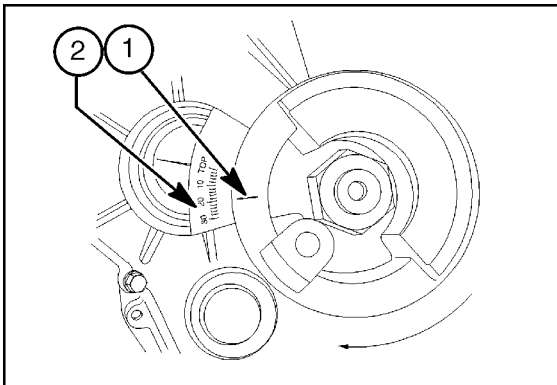
13. Rotate the crankshaft counterclockwise (viewed from the front of the engine) approximately 40°.

14. Turn on the fuel supply to the injection pump. Fuel should flow out of the spill tube on the No. 1 cylinder port.



BS05C054

15. Rotate the crankshaft clockwise. When the timing mark on the crankshaft pulley, 1, is in line with the 19° (422T/M2) or 22° (422/M2) mark on the scale, 2, fuel should stop flowing from the spill tube.



BS05C055

16. If fuel does not stop flowing at the appropriate timing mark, the injection pump timing must be adjusted by adding or removing shims located between the injection pump and the engine block.

17. Adding shims will retard the pump timing and removing shims will advance the pump timing.

NOTE: A shim thickness of 0.1 mm (0.004 inch) will change the pump timing by approximately 1°.

18. Assemble the components that were removed from the engine and fuel system.

NOTE: Delivery holder tightening torques: 39 - 45 Nm (29 - 33 lb ft).

TURBOCHARGER - 422T/M2 ENGINE

Specifications

ITEM	DESCRIPTION	SPECIFICATIONS
Turbocharger	Lubrication	Pressure-fed from external source
Turbine	Axial-flow turbine maximum continuous permissible speed (RPM)	180000
Blower	Centrifugal blower dry weight lbs. (kg)	3.2 kg (7.0 lbs)

Turbocharger Troubleshooting

TURBOCHARGER IS SLUGGISH IN PICKING UP SPEED

POSSIBLE CAUSE	CORRECTION
The sealed part of turbine wheel is heavily carboned, causing the rotor to offer much resistance to turning	Change Oil (engine oil) Disassemble and clean
Incomplete fuel combustion in the engine, due to a faulty condition in the fuel injection system	Disassemble and clean Check the injection system for cause, and repair
Lack of lubrication during cold weather startup	Warm up below 1500 RPM for three minutes on startup and allow to run at low idle for one minute before shutdown

EXCESSIVE OR ABNORMAL VIBRATION

POSSIBLE CAUSE	CORRECTION
A loose pipe connection at the turbine or blower side or at the bearing	Tighten and repair
Bearing failure causing the rotor to run rough	Replace Turbocharger
Turbine wheel or blower wheel has broken vanes caused by entry of metal or solid objects	Replace Turbocharger
Loss of dynamic balance in the rotor	Replace Turbocharger

DIRTY EXHAUST SMOKE

POSSIBLE CAUSE	CORRECTION
Not enough intake air	A clogged element in the air cleaner, clean or replace element
	Closed air intake inlet, open inlet
	Air leakage from a connection, check and repair

POSSIBLE CAUSE	CORRECTION
The turbocharger is not running	Gum or sludge formation in the turbine-side seal, causing the turbine to resist turning. Check the oil quality and charge Clean or replace Turbocharger
	Seized bearings Replace Turbocharger
	Oil temperature too high, change engine oil
	Dynamic imbalance in the rotor Replace Turbocharger
	Turbine wheel or blower wheel rubbing or broken, (remove foreign matter, if any, and check air cleaner and engine to locate the cause) Replace Turbocharger
Not enough gas pressure	Gas leakage through a connection on upstream side of turbine, check and repair A large constriction in the exhaust line, due to distorted gas passages, check and repair

WHITE EXHAUST SMOKE

POSSIBLE CAUSE	CORRECTION
Oil return pipe is clogged or distorted, causing the lube oil to leak into turbine and blower	Repair or replace the pipe
Seal rings are abnormally worn or broken due to worn-down bearings	Replace Turbocharger

ABNORMALLY HIGH OIL CONSUMPTION

POSSIBLE CAUSE	CORRECTION
Seal rings are abnormally worn or broken due to worn-down bearings	Replace Turbocharger

ENGINE LACKS OUTPUT POWER

POSSIBLE CAUSE	CORRECTION
Gas leakage in the exhaust line	Check and repair
Air leakage in the blower outlet side, resulting in reduced boost pressure	Check and repair
A clogged element in the air cleaner	Clean or replace
The turbocharger is internally fouled with foreign matter or its running parts are damaged	Clean or Replace Turbocharger

ABNORMAL RUNNING NOISE

POSSIBLE CAUSE	CORRECTION
Restrictions in exhaust gas passage, particularly due to the nozzle ring approaching a clogged condition	Disassemble and clean
Restrictions in the air outlet side of the blower, causing the air to surge at the blower wheel when the engine accelerates	Disassemble and clean
The casing is being rubbed by turbine wheel or blower wheel	Replace Turbocharger

Turbocharger Lubrication

The turbocharger used on the 422T/M2 diesel engine may not receive adequate lubrication on cool/cold weather (below 5° C, 40° F) start-up, leading to turbocharger bearing failure.

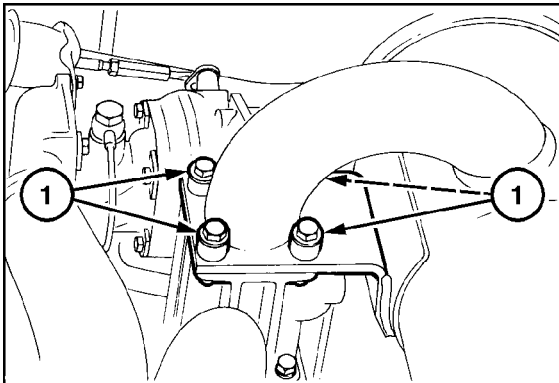
The following procedure must be used to ensure adequate lubrication oil is supplied to the turbocharger bearings before high-speed engine operation:

1. Set the engine throttle at 1/3 speed.
2. Turn the ignition switch and allow the automatic glow plug timer to preheat the engine.
3. Start the engine, but **DO NOT OPERATE ABOVE 1,500 RPM** for three minutes to allow for adequate oil flow at the turbocharger.

After full load operation, allow the engine to run at low idle for one minute before engine shutdown.

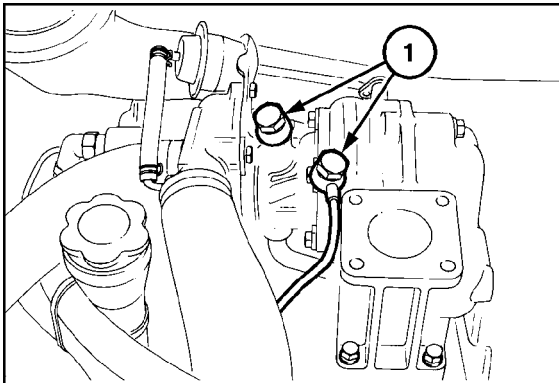
Turbocharger Removal

1. To remove the turbocharger, first remove the muffler from the turbo adapter assembly at 1.



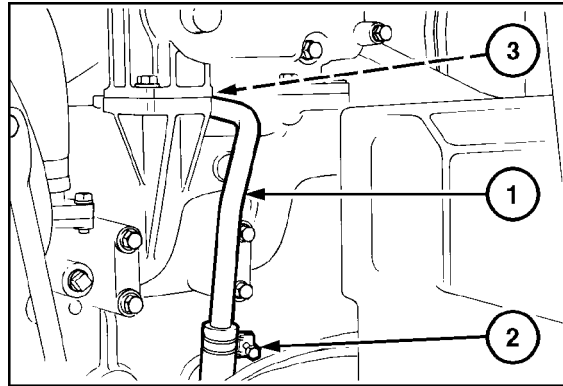
BS05C056

2. Remove the turbocharger oil pressure line, 1, at the block and at the turbo housing.



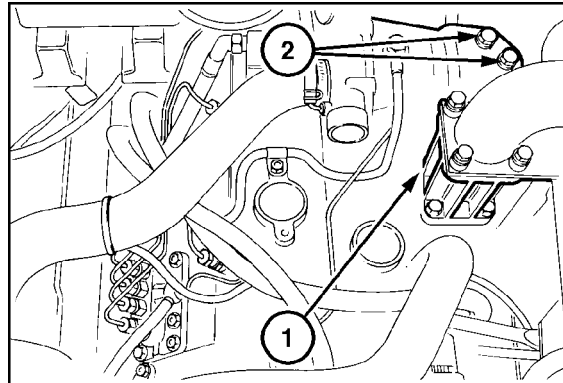
BS05C057

3. Remove the turbocharger oil return line, 1, at the top hose clamp, 2, and from the turbo assembly at 3.



BS05C058

4. Remove the turbocharger assembly and adapter from the exhaust manifold, 1, and support, 2.



BS05C059

Inspection Before Disassembly

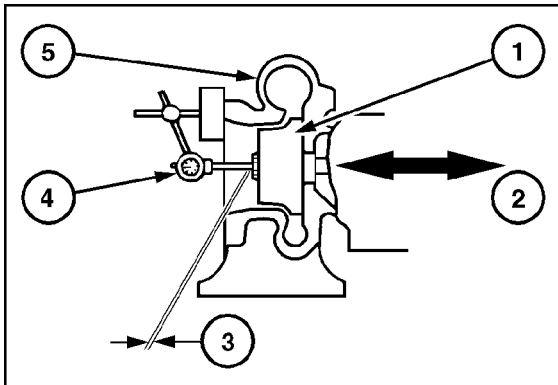
NOTE: The turbocharger does not have any serviceable parts. If the turbocharger does not meet the specifications outlined in Inspection, replace the turbocharger.

Visually check the running clearances of the turbine and blower wheels for evidence of contact between the vanes and casing. Spin the rotor by hand to see if it rotates smoothly.

Check the turbine fin and housing clearance, intake and exhaust.

Check to ensure the rotor and shaft turns smoothly with no bearing roughness or binding.

Using a dial indicator, measure the end play movement of the turbine and shaft, 1, by placing a dial indicator on the end of the shaft at 2.



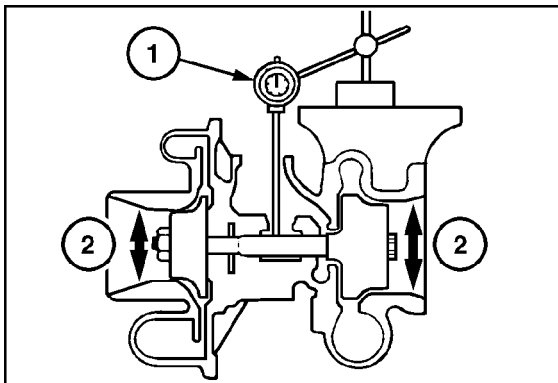
BS05C060

End Play Movement

Standard: 0.03 mm - 0.06 mm (0.001 inch - 0.002 inch)

Allowable Limit: 0.09 mm (0.0035 inch)

Check the radial movement in the turbine shaft by placing a dial indicator through the oil outlet in the turbo housing at, 1. Move the right and left side of the turbine shaft toward the radial, 2, simultaneously and take a reading.



BS05C061

Radial Movement

Standard: 0.08 mm - 0.13 mm (0.003 inch - 0.005 inch)

Allowable Limit: 0.17 mm (0.0067 inch)

NOTE: The turbocharger does not have any serviceable parts. If the turbocharger does not meet the specifications outlined in Inspection, replace the turbocharger.

Checking the Rotor for Movement

Measure the axial (end movement) and radial (up and down movement) of the rotor in the reassembled turbocharger, as described earlier in 'Inspection Before Disassembly.'

Make sure the movement readings are within the following specifications:

Axial movement of rotor - 0.03 mm - 0.06 mm (0.001 inch - 0.0023 inch)

Radial movement of rotor - 0.08 mm - 0.13 mm (0.003 inch - 0.005 inch)

Turbocharger Installation

Preliminary steps for installing the turbocharger on the engine:

Attach the turbocharger and adapter assembly to the exhaust manifold and support with the hardware previously removed.

Turbocharger Lubrication System

Oil the lubricated parts by pouring clean engine oil into the oil inlet and by rotating the turbine shaft by hand. This will wet the journal, floating bearings, thrust bearing, and other surfaces.

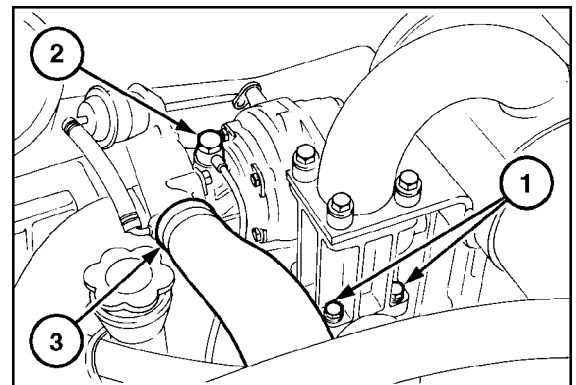
Thoroughly clean the oil inlet pipe and outlet pipe by flushing, making sure the pipes are absolutely free of foreign particles. Be sure the pipes have no restrictions due to denting or bending.

When installing the pipes between the turbocharger and engine, be sure to make each connection leak free.

Intake Air system

Clean the parts conveying the intake air, making sure each part is absolutely free of foreign particles.

When connecting the turbocharger to the air cleaner and air duct tube, be sure that each joint is leak free.



BS05C062

After Turbocharger Service, Check the Exhaust System

1. Make sure the exhaust gas passages are perfectly clean and free of foreign particles.
2. The bolts and nuts used on the joints of the exhaust line are of heat-resistant material; never use ordinary bolts and nuts instead of the heat resistant hardware. Apply the antiseize compound to the threads of bolts and nuts just before installing them.

Secure Each Connection Good and Tight, Making It Perfectly Leak Free

Starting the Turbocharger for the First Time After Reinstallation on the Engine

1. Disconnect the wire to the fuel stop solenoid to insure that the engine will not start. Prime the lubrication circuit of the turbocharger by cranking the engine with the starting motor for ten seconds at a time. After the first ten seconds of cranking, pause for thirty seconds and then crank the engine again. Repeat the process until the oil warning lamp goes out.

NOTE: *Cranking the engine longer than ten seconds at a time is very hard on the battery and may cause damage to the starter motor. Limit each cranking to ten seconds, and pause at least thirty seconds after each cranking to allow the starter motor to cool down.*

2. Reconnect wire to the fuel stop solenoid. Move the hand throttle lever to the low, 1/3 throttle position.

3. Operating the engine at no more than 1500 RPM for two to three minutes to insure lubrication oil is getting to the turbo.

NOTE: *Listen to the turbocharger to be sure that it is running smoothly without making any abnormal noise.*

4. Inspect the pipes and connections for any sign of oil leakage.
5. Operate the engine normally.
6. Stopping the engine, move the engine speed control lever to the low idle position. After full load operation, idle the engine for one minute to allow components to cool.

IMPORTANT: *Never stop the engine when it is running at high speed. Doing so may cause serious engine damage.*

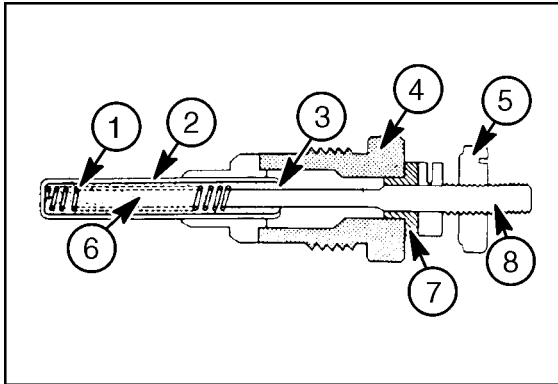
The high operating speed of the turbocharger makes it essential that adequate lubrication is ensured when the engine is started.

MISCELLANEOUS ENGINE ELECTRICAL

Glow Plug

A sheathed-type plus is employed and provides excellent starting.

Specifications



BS05C063

1. HEAT WIRE
2. SHEATH
3. ASBESTOS
4. BODY
5. NUT
6. MAGNESIUM OXIDE POWDER
7. INSULATION BUSHING
8. CORE

Structure

Coiled thin heat wire is placed in the sintered magnesium oxide powder enclosed by stainless sheath. One end of the heat wire is welded to the sheath end and the other end to the central electrode. By setting the key switch to the run position, the glow plug preheats the air in the combustion chamber.

Disconnection of the Glow Plug

The glow plug operates even when any one of the plugs is disconnected because it is connected in parallel. However, when disconnected, preheating time of the glow signal is extremely extended.

Testing a Glow Plug

Check/remove the connector and check the continuity between each plug terminal and body ground. If continuity is not observed, it shows disconnection and the glow plug should be replaced.

The glow plug is of a simple structure and a short circuit is rarely caused. However, if the central electrode, body, sheath, etc. come in contact, wiring of the preheating circuit is burnt during start-up.

Correction: Remove the connector and measure the resistance of each plug terminal and ground with a tester. The tester reading should be 1.0 ± 0.1 .

Resistance of 0 indicates a short circuit.

NOTES