



DISCOVERY SERIES II

Diesel Engine Td5

01-36-LR-W
Published by Technical Academy
1998 Rover Group Limited

PREFACE	1
DIESEL ENGINE Td5.....	3
New features	3
Engine construction.....	5
Cylinder head removal	5
Cylinder head	7
Engine ancillaries	7
Cylinder block disassembly.....	8
Cylinder block.....	11
Fracture split con-rods.....	11
Flywheel	12
Fuel supply system.....	13
Oil pump.....	34
Electronic unit injector (EUI).....	34
Oil filter	36
Turbocharger.....	36
Engine reassembly.....	36
Cooling system.....	37
Auxiliary drive belt	38
Crankcase ventilation.....	40
Torque wrench settings.....	40
DIESEL ENGINE MANAGEMENT.....	43
Overview	43
Driver inputs	44
Engine state inputs.....	47
Digital inputs from other vehicle systems.....	52
ECM outputs.....	53
ECM strategies.....	58
Configuration	61
ECM wiring connection.....	63
Exhaust gas recirculation	66
EGR Valve.....	69
Inlet Throttle (ILT) Valve.....	70
EGR system - type 1	71
EGR system - type 2	72
TestBook diagnostics	72

Preface

This document has been issued to support the Discovery model range. The information contained within this document relates to the features and specification of this model.

Every effort has been taken to ensure the information contained in this document is accurate and correct. However, technical changes may have occurred following the date of publication. This document will not necessarily have been updated as a matter of course. Therefore, details of any subsequent change may not be included in this copy

The primary function of this document is to support the Technical Academy training programme. It ***should not*** be used in place of the workshop manual. All applicable technical specifications, adjustment procedures and repair information can be found in the relevant document published by Rover Group Technical Communication.

Produced by:

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Diesel Engine Td5

New features

New Discovery is fitted with a diesel engine known as the Td5. This engine is all new and introduces innovative technology to the 4x4 utility vehicle marketplace. Land Rover engineers have developed a quiet, responsive engine which considerably reduces exhaust emissions. The Td5 engine complies with ECD2 (European Commission Directive) legislative requirements, without employing an oxidising catalyst.

Key features of the engine include:

- Five cylinder engine configuration
- Cast iron block with aluminium cylinder head and structural aluminium engine sump
- Overhead camshaft with a single rocker shaft
- Hydraulic lash adjusters with independent finger followers
- Electronic unit injectors
- Timing chain and chain-driven oil pump
- An aluminium lower ladder frame, incorporating the oil pump
- Centrifugal oil filter
- Fuel cooler
- Integrated oil cooler
- A new engine management system
- Sequential cyclone engine breathing system
- An integrated vacuum pump with the alternator

General engine data

General	
Type	2.5 litre in-line direct injection diesel, turbocharged and intercooled
Cylinder arrangement	5 in-line, No. 1 cylinder at front of engine
Bore	84.450 mm (3.3248 in)
Stroke	88.950 mm (3.5020 in)
Capacity	2498 cm ³ (152.5 in ³)
Firing order	1 - 2 - 4 - 5 - 3
Compression ratio	19.5 : 1
Direction of rotation	Clockwise viewed from the front of the engine
Dimensions:	
⇒ Length	766 mm (30.1 in)
⇒ Width	708 mm (27.8 in)
⇒ Height	788 mm (31.0 in)
Injection timing	Controlled by ECM
Injectors:	
⇒ Make/Type	Lucas EV1
⇒ Nominal operating pressure	1500 bar (21750 lbf.in ²)
Maximum governed speed	4850 rev/min
Maximum overrun speed	5460 rev/min
Idle speed:	
⇒ Manual gearbox	740 ± 50 rev/min
⇒ Automatic gearbox	760 ± 50 rev/min
Glow plugs	Beru 12 V. Four plugs in cylinders 1, 2, 3 and 4
Turbocharger	Garrett GT 20
Emissions standard	ECD 2

Diesel Engine Td5

General	
Valve timing	
Inlet valves: ⇒ Opens ⇒ Closes	14° BTDC 147° ATDC
Exhaust valves: ⇒ Opens ⇒ Closes	147° BTDC 14° ATDC
Lubrication	
Type	Wet sump, pressure fed
Pump type	Eccentric rotor, crankshaft driven integral with stiffener plate.
Filter type: ⇒ Primary ⇒ Secondary	Centrifuge filter Disposable canister with full flow by-pass
Pressure at idle (Cold)	3.0 bar (43.5 lbf.in ²)
Pressure at 3500 rev/min(Hot)	1.5-3.0 bar (21.75-43.5 lbf.in ²)
Relief valve opening pressure	4.0 bar (58 lbf.in ²)
Low oil pressure switch opening pressure	0.2-0.6 bar (3.0-8.8 lbf.in ²)
Crankshaft	
Main journal diameter	61.9875-62.0125 mm (2.4404-2.4414 in)
Crankpin journal diameter	53.99-54.01 mm (2.125-2.131 in)
End float	0.020 - 0.250 mm (0.0008 - 0.0098 in)
Main bearings	
Quantity	6 (5 main, 1 thrust)
Pistons	
Type	Graphite compound skirt with combustion chamber in crown
Clearance in cylinder bore. Measured at bottom of skirt, 90° to gudgeon pin	0.172-0.206 mm (0.007-0.008 in)
Diameter (Measured at right angles to gudgeon pin and 40.0 mm (1.5 in) from bottom of skirt)	84.270-85.254 mm (3.321-3.361 in)
Gudgeon pins	Fully floating, offset towards piston thrust side
Piston rings	
Type: ⇒ Upper compression ring ⇒ Lower compression ring ⇒ Oil control ring	2 compression, 1 oil control Barrel edge, chrome plated Taper faced Bevelled ring with spring
New ring to groove clearance: ⇒ Upper compression ⇒ Lower compression ⇒ Oil control	Not measured 0.050-0.082 mm (0.002-0.003 in) 0.050-0.082 mm (0.002-0.003 in)
Piston ring fitted gap in cylinder bore: ⇒ Upper compression ⇒ Lower compression ⇒ Oil control	0.30-0.45 mm (0.0118-0.0177 in) 0.40-0.60 mm (0.0157-0.0236 in) 0.25-0.40 mm (0.0098-0.0157 in)
Camshaft	
Bearings	6
Drive	Duplex chain

General	
End float	0.06-0.16 mm (0.002-0.006 in)
Tappets	
Type	Hydraulic lash adjusters with followers
Valves	
Stem diameter:	
⇒ Exhaust	6.905 ± 0.008 mm (0.271 ± 0.0003 in)
⇒ Inlet	6.915 ± 0.008 mm (0.272 ± 0.0003 in)
Head diameter:	
⇒ Exhaust	31.7 mm (1.25 in)
⇒ Inlet	34.7 mm (1.37 in)
Seat face angle:	
⇒ Exhaust	45°
⇒ Inlet	30°
Valve face angle:	
⇒ Exhaust	44° 48' ±12'
⇒ Inlet	29° 48' ±12'
Valve springs	
Type	Parallel, single coil

Engine performance figures

Maximum torque (manual gearbox fitted)	300 Nm
Maximum torque (automatic gearbox fitted)	315 Nm
Maximum power New Discovery	101.5 kW @ 4,200 rev/min.
Maximum power Defender 1999 MY	90.0kW @ 4,200 rev/min.

Engine construction

The engine is an in-line five cylinder, turbocharged direct injection compression ignition unit. The block is of cast iron construction with an aluminium cylinder head. The engine uses 'through bolt' technology. This provides excellent structural support and rigidity. An aluminium ladder frame secures to the bottom of the cylinder block to enhance the lower block rigidity. The ladder frame also incorporates a rotary oil pump. This oil pump passes pressurised oil through the aluminium ladder frame into the cylinder block. A gasket seals the ladder frame oil gallery and the cylinder block oil gallery. This gasket must be replaced whenever the ladder frame is removed.

Cylinder head removal

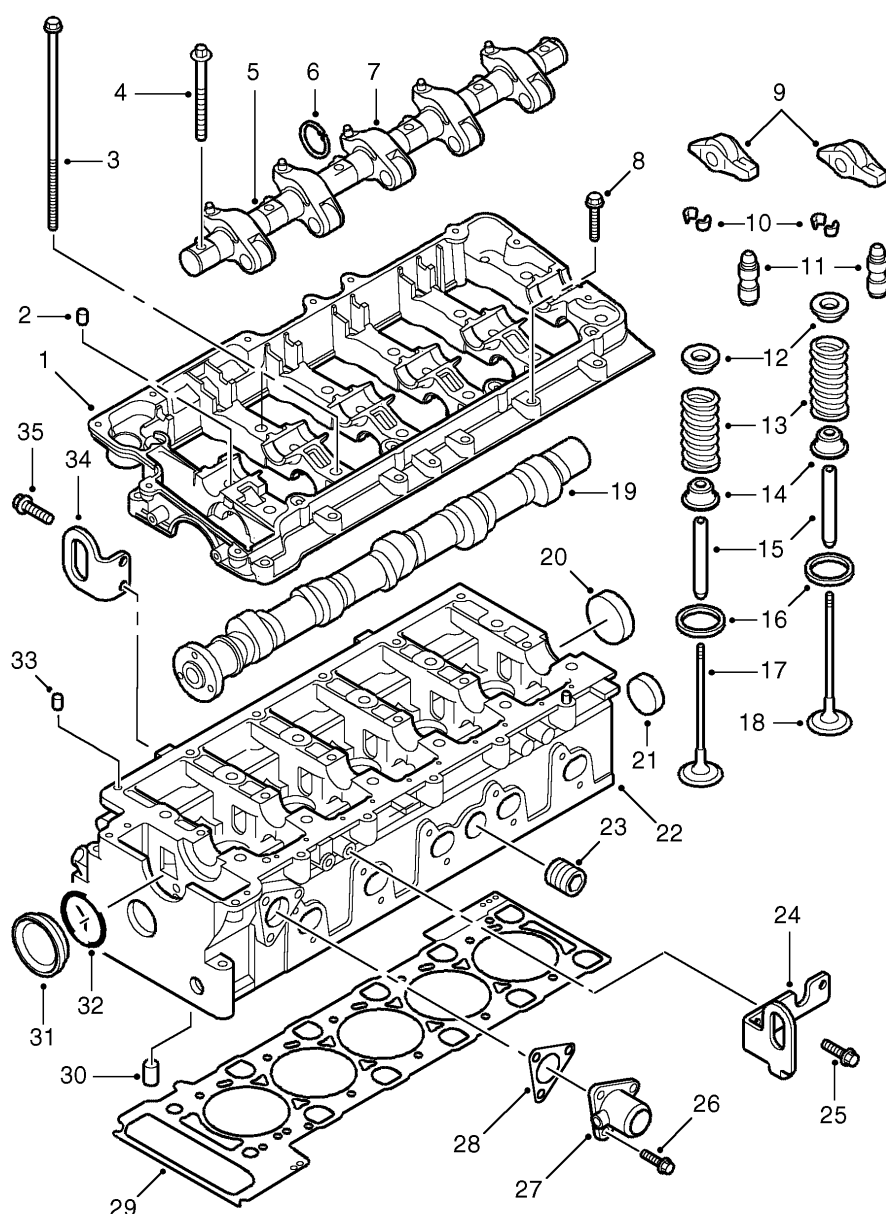
The engine will be disassembled following the procedure detailed in the work shop manual.

The cylinder head will need to be removed, follow SRO 12.29.02.01 for details on this operation

Follow the dismantle sequence of the SRO 12.29.19.01 to strip the cylinder head into its components.

The cylinder head should now be dismantled, ready to be rebuilt

Cylinder Head



M12 4655A

- | | |
|--|---|
| 1. Camshaft carrier | 18. Exhaust valve (5 off) |
| 2. Dowel rocker shaft to camshaft carrier (1 off) | 19. Camshaft |
| 3. Cylinder head bolts (12 off) | 20. Camshaft bore seal (rear) |
| 4. Rocker shaft to camshaft carrier bolts (6 off) | 21. Coolant jacket core plug |
| 5. Rocker shaft | 22. Cylinder head block |
| 6. Circlips (10 off) | 23. Water jacket threaded plug |
| 7. EUI Rocker arms (5 off) | 24. Engine lifting bracket (LH) |
| 8. Camshaft carrier to cylinder head screws (13 off) | 25. Engine lifting bracket bolts (2 off) |
| 9. Finger follower (10 off) | 26. Coolant outlet elbow to cylinder head bolts (3 off) |
| 10. Valve spring collets (20 off) | 27. Coolant outlet elbow |
| 11. Lash adjuster (10 off) | 28. Coolant outlet elbow gasket |
| 12. Valve spring retainer (10 off) | 29. Cylinder head gasket |
| 13. Valve spring (10 off) | 30. Non-return valve (not removable, integral in cylinder head) |
| 14. Valve stem seal (10 off) | 31. Camshaft bore end cap (front) |
| 15. Valve guide (10 off) | 32. End cap seal |
| 16. Valve seat insert (10 off) | 33. Cylinder head to cam carrier dowel (2 off) |
| 17. Inlet valve (5 off) | 34. Engine lifting bracket (RH) |
| | 35. Engine lifting bracket bolts (2 off) |

Cylinder head

The cylinder head face is heat treated to increase its durability, so it cannot be re-faced. The head houses four glow plugs (number 5 cylinder does not have one) and two valves per cylinder. It also features the machining for the camshaft, hydraulic lash adjusters, the electronic unit injectors and the low pressure fuel rail.

The camshaft locates between the head and the cam carrier. These two components are line bored, so form a matched pair. It is important to note that the head is subjected to a force equivalent to that of clamping the cylinder head to the surface block when it is line bored. This ensures that the camshaft bearing surfaces match the profile of the camshaft journals perfectly when the engine is in an operating condition. If the need arises to replace the cylinder head or the cam carrier, the other component must also be replaced. The cam carrier is sealed to the cylinder head by liquid sealer, in this case Hydrogrip 2000. It is important to apply the correct amount of sealer. Always follow the procedure detailed in the workshop manual to ensure that the correct amount of sealer is applied.

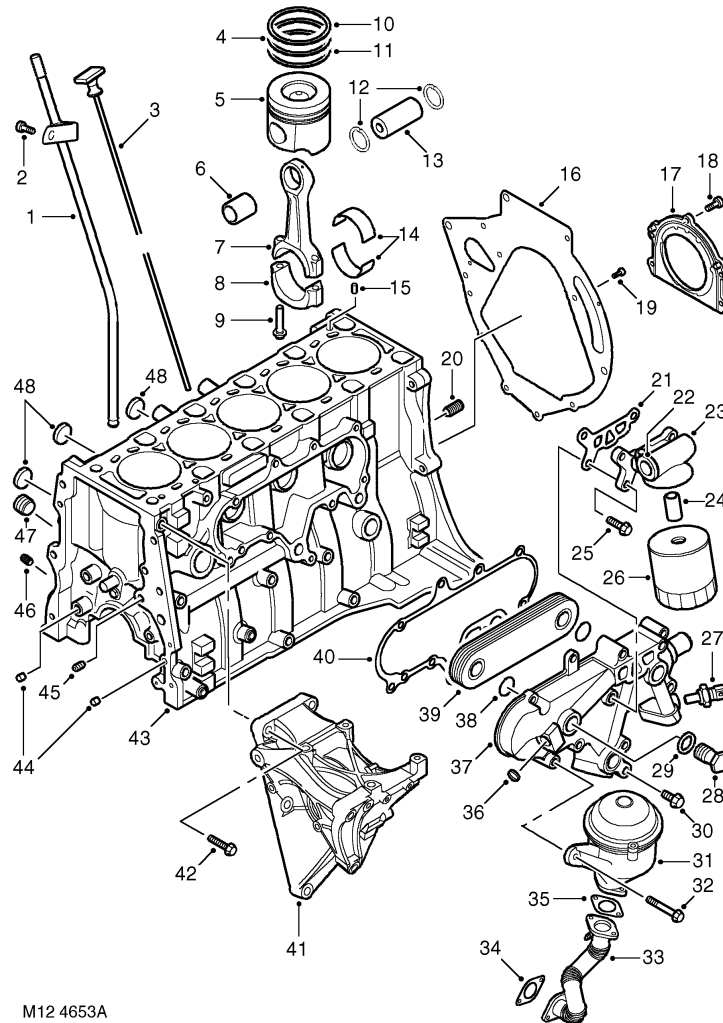
The rocker shaft sits above the camshaft in the cam carrier and has on it five rockers. These rockers are used to generate fuel pressure inside the EUI injectors.

The valves use finger followers to transfer the camshaft lobe movement into vertical valve movement. The finger followers locate over the hydraulic lash adjusters and the tops of the valves. The finger followers are not held rigidly into position, they hold their position by locating on top of the valve and locating over the hydraulic lash adjusters pivoting ball. The valve is activated by the lobe of the camshaft pressing down on the roller of the finger follower. **When the hydraulic lash adjusters are removed from the engine, they must be stored upright and in clean conditions. Failure to follow this procedure can result in serious engine damage when they are reinstalled.** The cylinder head incorporates the fuel gallery, as previously mentioned. Supply and return connections are located at the rear of the cylinder head. All the fuel pipes are connected by means of quick-fit connectors. A fuel cooler is mounted on the side of the inlet manifold. The fuel cooler cools the hot fuel from the cylinder head before it returns to the fuel filter. The fuel cooler has two coolant connections to the radiator. The radiator incorporates a small diameter tube dedicated to supplying coolant for the fuel cooler. The small diameter of the tube slows the coolant flow, which 'super cools' the coolant before it is supplied to the fuel cooler. The fuel cooler has a thermostat which opens when the coolant inside the fuel cooler reaches approximately 70 °C (160 °F). It is important to cool the fuel returning to the fuel filter, as this ensures that the fuel within the fuel circuit is kept at a predetermined temperature for optimum performance and emissions.

Engine ancillaries

All remaining engine ancillaries should now be removed, follow workshop manual if needed.

Cylinder block disassembly

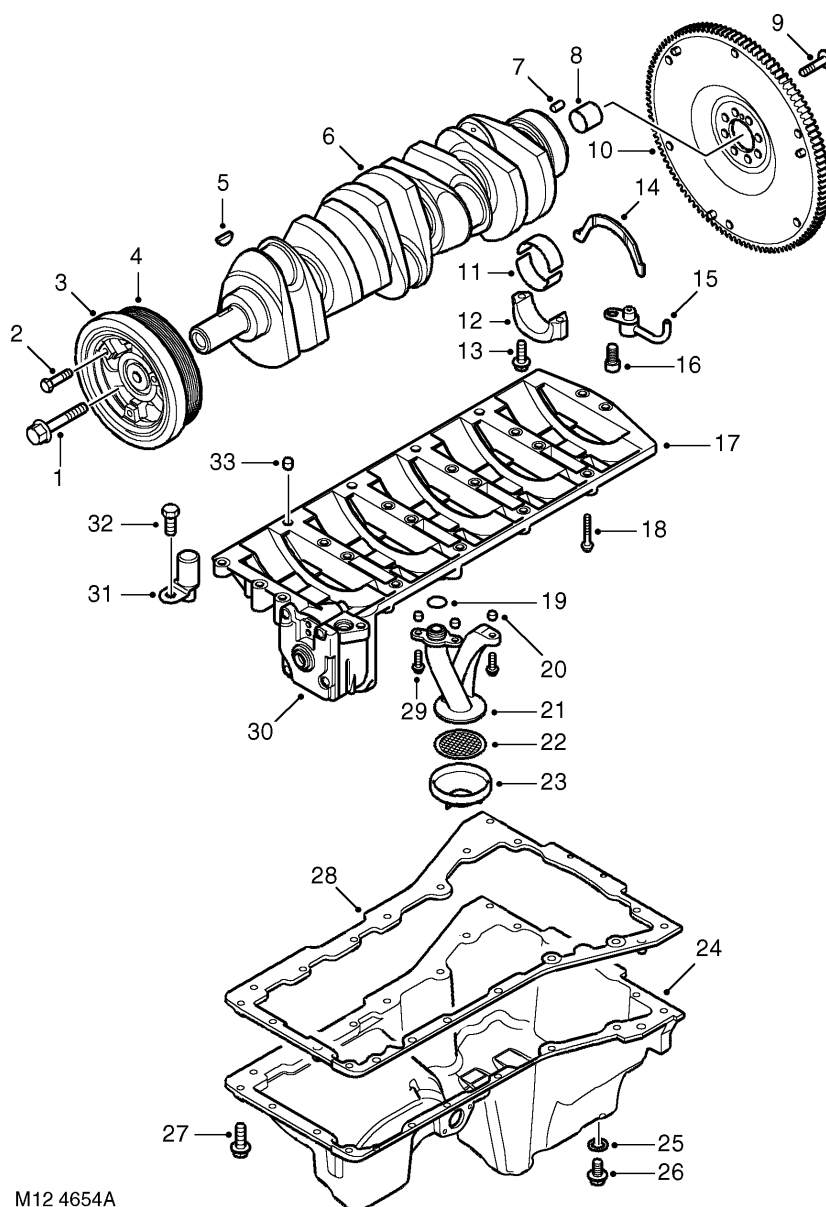


M12 4653A

- | | |
|--|---|
| 1.Oil dipstick tube | 24.Oil filter adaptor insert |
| 2.Screw oil dipstick tube to camshaft carrier | 25.Oil filter adaptor to cylinder block bolts (3 off) |
| 3.Oil dipstick | 26.Oil filter |
| 4.2nd piston ring | 27.Oil pressure switch |
| 5.Piston | 28.Oil cooler banjo bolts (2 off) |
| 6.Small-end bush | 29.O-rings oil cooler banjo bolts (2 off) |
| 7.Connecting rod | 30.Oil cooler to cylinder block bolts (7 off) |
| 8.Big-end bearing cap | 31.Centrifuge assembly |
| 9.Connecting rod bolt (2 off per connecting rod) | 32.Centrifuge to cylinder block bolts (3 off) |
| 10.Top piston ring | 33.Centrifuge oil drain pipe |
| 11.Oil control ring | 34.Oil drain pipe to sump gasket |
| 12.Circlips (2 off per gudgeon pin) | 35.Centrifuge to oil drain pipe gasket |
| 13.Gudgeon pin | 36.Oil cooler plugs (3 off) |
| 14.Big-end bearing shells | 37.Oil cooler assembly |
| 15.Dowels to cylinder head (2 off) | 38.Oil cooler matrix 'O-rings' (2 off) |
| 16.Gearbox shim plate | 39.Oil cooler matrix |
| 17.Rear crankshaft seal and housing | 40.Oil cooler gasket |
| 18.Screws crankshaft seal flange to engine block (5 off) | 41.Coolant and PAS pump assembly bracket |
| 19.Bolts Gearbox shim plate to engine block (2 off) | 42.Bracket bolts (5 off + 1 stud/nut) |
| 20.Main oil gallery plug (rear) | 43.Cylinder block |
| 21.Oil filter adaptor gasket | 44.Dowels to timing block cover (2 off) |
| 22.Oil filter adaptor thermostat | 45.Oil gallery delivery plug |
| 23.Oil filter adaptor assembly | 46.Cross drilling plug |
| | 47.Coolant jacket plug |
| | 48.Core plugs (3 off) |

The cylinder block should now be stripped, this is completed using various repair operations detailed in the workshop manual

Service Repair Number	Procedure
12.60.38.01	Remove engine sump
12.60.12.02	Remove the oil pump and ladder frame
12.65.05.01	Timing cover aucillaries
12.65.13.01	Timing cover
12.17.16.01	Big end bearings
12.17.02.01	Piston assemblies
12.21.33.01	Crankshaft



M12 4654A

- 1.Crankshaft pulley bolt
- 2.TV Damper to crankshaft pulley bolts (3 off)
- 3.TV Damper
- 4.Crankshaft pulley
- 5.Woodruff key
- 6.Crankshaft
- 7.Crankshaft to flywheel dowel
- 8.Spigot bush
- 9.Flywheel to crankshaft bolts (8 off)
- 10.Flywheel assembly (Manual shown)
- 11.Main bearing shells (6 pairs)
- 12.Main bearing caps (6 off)
- 13.Main bearing cap bolts (12 off)
- 14.Thrust washer (2 off at No. 3 Main bearing)
- 15.Piston lubrication jets (5 off)
- 16.Piston lubrication jet cap head screw (5

- off)
- 17.Stiffener plate (oil pump integral)
- 18.Stiffener plate / oil pump assembly to cylinder block bolts (22 off)
- 19.Oil pick-up pipe O-ring
- 20.Oil pick-up pipe inserts (2 x 6 mm; 1 x 10 mm)
- 21.Upper oil pick-up pipe
- 22.Oil pick-up pipe gauze
- 23.Lower oil pick-up pipe
- 24.Sump
- 25.Oil drain plug seal
- 26.Oil drain plug
- 27.Sump to cylinder block bolts (20 off)
- 28.Sump gasket
- 29.Oil pick-up pipe bolts (3 off)
- 30.Oil pump
- 31.Chain lubrication jet
- 32.Chain lubrication jet screw
- 33.Stiffener to cylinder block dowel (2 off)

Cylinder block

The cylinder block incorporates oil squirt jets which are used to cool the pistons. Each squirt jet incorporates a pressure valve which shuts off whenever the oil pressure falls below 1.5 Bar. The engine does not feature a conventional adaptor plate, instead, the gearbox bolts directly to the engine block. The gearbox casing itself houses the starter motor and provides access for the TDC positioning tool, which engages directly into the flywheel.

The engine has an aluminium structural sump sealed to the cylinder block with a rubber gasket. This gasket features integrated metal sleeves (compression limiters) at the points where the sump bolts pass through the gasket. This prevents the gasket from distorting as the sump bolts are tightened. The sump gasket should be fitted dry to cleaned and dry surfaces.

The crankshaft is constructed of iron and incorporates journals with rolled fillet radii to increase the crankshaft's ability to withstand 'bending' fatigue. It is not possible to regrind the crankshaft, due to its design and the techniques used in its construction. The crankshaft main bearings feature a grooved shell, which locates in the cylinder block and with a smooth shell in the cap. The number 3 main bearing includes provision for the two thrust washers; these washers are only available in a standard size. It should be noted that all the main bearing caps have a slight interference-fit with the cylinder block. This feature negates the need for main bearing locating dowels.

The pistons feature a graphite coated skirt and incorporate an integral combustion chamber. The pistons have three piston ring grooves, housing two compression rings and one oil-control ring. An internal oil gallery, fed by the oil squirt jet, cools the piston. The piston design eliminates the need for additional strengthening rings using its shape to transfer the combustion forces through to the con-rod.

Fracture split con-rods

The con-rod is identical in design to the con-rod fitted to the Freelander L series engine. It is a fracture split con-rod. This means that the big end bearing cap has no machined surface in contact with the con-rod. In manufacture, the con-rod is bored to a nominal diameter as a one-piece unit. Two grooves are then machined into the inner land and then the cap is forced apart. This causes the metal to fracture, leaving a unique mating surface. Once this process is completed, the cap is refitted and tightened using two retaining bolts and the final internal diameter is machined. Utilising the fractured state of the cap ensures that the two pieces of the con-rod fit perfectly and possess a strong resistance to lateral movement (side-ways movement).

The bolts are located off-centre. This serves to ensure that the cap is fitted to the rod in the correct orientation. If, when the con-rod is out of the engine, the cap is fitted incorrectly (the wrong way round) and the bolts are tightened then the con-rod must be replaced. This is necessary because the unique profile of the mating surfaces will have been damaged when the cap was tightened. The cap will no longer locate correctly, even if it is turned back to the correct position.

The small end of the con-rod is machined to a taper. This allows for clearance between the piston head and the con-rod and provides increased load capability by increasing the surface area on both load sides of the gudgeon pin. The small end is lubricated by a splash-feed, facilitated by the squirt jets. The big end bearings have no featherway to locate them laterally. They rely solely on 'bearing nip' to control their position and to eliminate rotational and lateral movement. The bearing shell located in the con-rod is different to the bearing shell fitted in the con-rod cap. The con-rod bearing goes through a manufacturing process called 'sputtering'. This process is used to form very pure materials. In this case, the sputtering process is used to increase the con-rod bearing shell resistance to wear and is used to offset the greater wearing loads experienced by the top bearing shell. The sputter bearing can be identified by having a shiny surface (bearing shell to con-rod side), a dedicated part number and a different appearance when viewed from the working side of the bearing as compared to the back of the bearing.

Flywheel

The flywheel is a 'dual-mass' flywheel. This means it has a proportion of its mass mounted by an internal spring. A dual-mass flywheel helps to dampen the unavoidable variations in crankshaft rotational speed which occur at the point of combustion for each cylinder. This damping action helps to reduce drive train vibration particularly when the engine is at low speed and at idle. The flywheel also incorporates a series of holes drilled into the circumference. These holes work in conjunction with the crankshaft sensor to feed back information on the crankshaft speed and the crankshaft phase.

There are 31 drilled holes, spaced at 10 intervals, around the flywheel. At five 10 intervals the crankshaft has not been drilled. This acts in the same manner as having a 'missing pole' (i.e. as used on the V8 engine fitted to the Range Rover pre - 1999 MY). The missing holes are placed unevenly around the circumference of the flywheel. By having the crankshaft drilled in a unique sequence, the ECM is able to determine its position in the engine's cycle within a maximum of 130 of crankshaft rotation.

Using the information found in the overhaul SRO operations and within the workshop manual, check the:

- Cylinder head for distortion
- Piston ring gap and piston gap
- End float of the crankshaft and the camshaft
- Big end and main bearing clearance

Fuel supply system

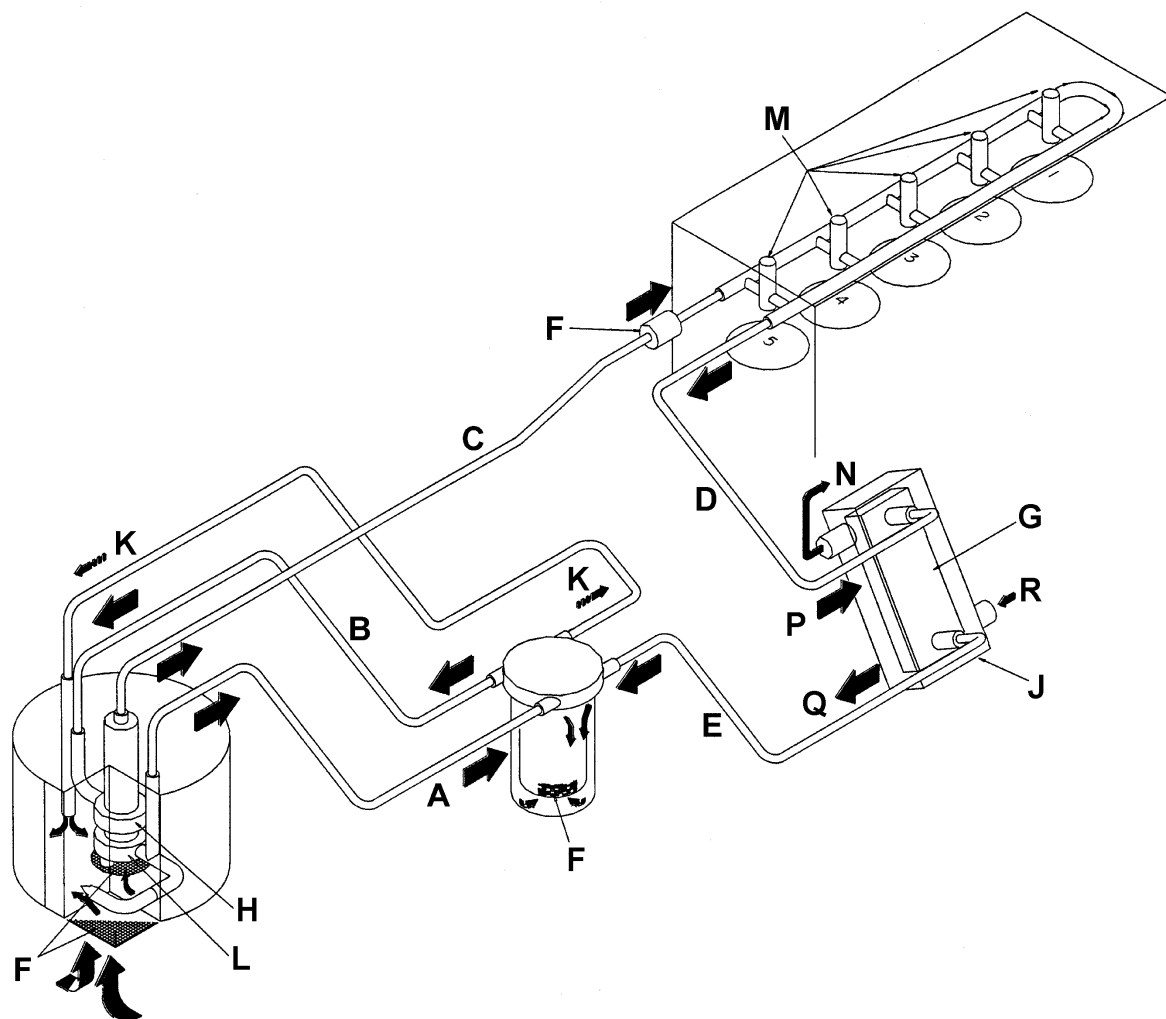
The fuel supply system on New Discovery diesel derivative uses an electric two-stage pump. The pump is submerged in the fuel tank. Fuel passes through the pump twice before it flows to the engine. In the first stage, the fuel is drawn from the swirl pot and flows out of the fuel tank to the fuel filter (line A). The fuel filter is located on the outside of the chassis on the right hand side of the vehicle, forward of the rear wheel. This fuel filter is of a canister design and should be replaced at scheduled intervals, according to the service maintenance service sheet. Once the fuel has passed through the filter, it returns to the fuel tank (line B) where it enters the fuel pump for the second time. The fuel pump then boosts the pressure to 4.0 Bar. The boosted fuel pressure is controlled by a pressure relief valve located in the aluminium fuel connector block, which is situated on the rear of the cylinder head. The pressure relief valve controls the fuel pressure by regulating the amount of fuel returning to the fuel filter. The fuel connector block also retains an additional 'fit for life' fuel filter. This filter should not be replaced under normal circumstances. However, if a blockage does occur, then the housing can be removed and the filter replaced.

It is extremely important that no dirt enters the fuel rail as this could lead to engine misfire by blocking an injector or making it stick open. It can also lead to combustion gases mixing with the fuel in the fuel rail, causing the engine to stop running. The fuel is supplied to the engine (line C) and into the gallery within the cylinder head. The injectors then use a proportion of the fuel. The return pipe allows the excess fuel from the head (line D) to flow into the fuel cooler. Finally, fuel flows to the fuel filter (line E) and back into the fuel pump, ready for the next cycle.

There is an extremely fine filter incorporated within the fuel filter housing that allow air to bleed from the top of the filter but does not allow fuel to pass, this air is returned to the fuel tank via (line K).

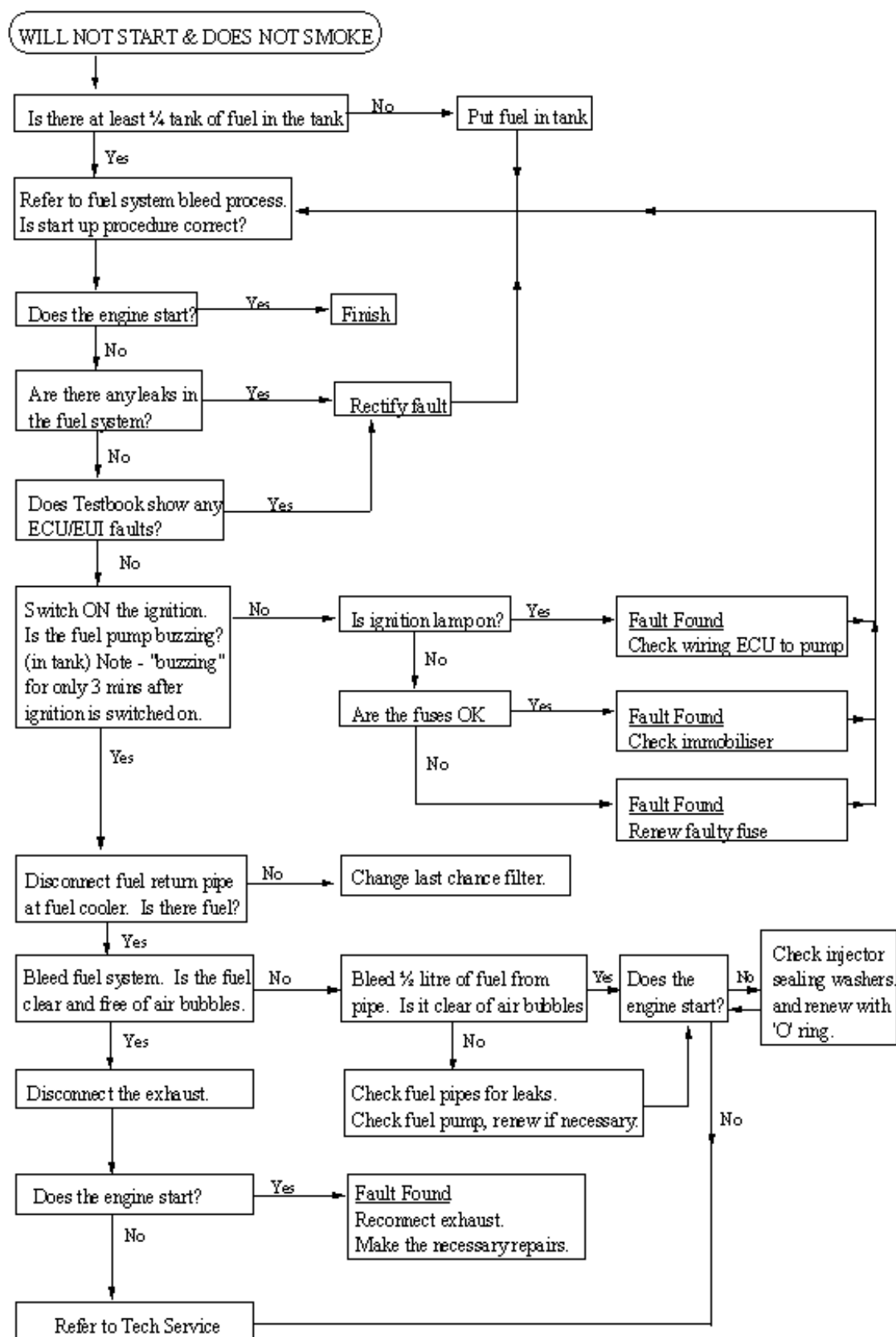
Care should be taken when disconnecting any part of the fuel system as it can contain hot pressurised fuel. In cases where an EUI needs to be removed, follow the procedure detailed in the workshop manual. Failure to disassemble the engine correctly, or to not take heed of the warning associated with allowing fuel to drain into the combustion chambers, can lead to engine damage.

Fuel flow

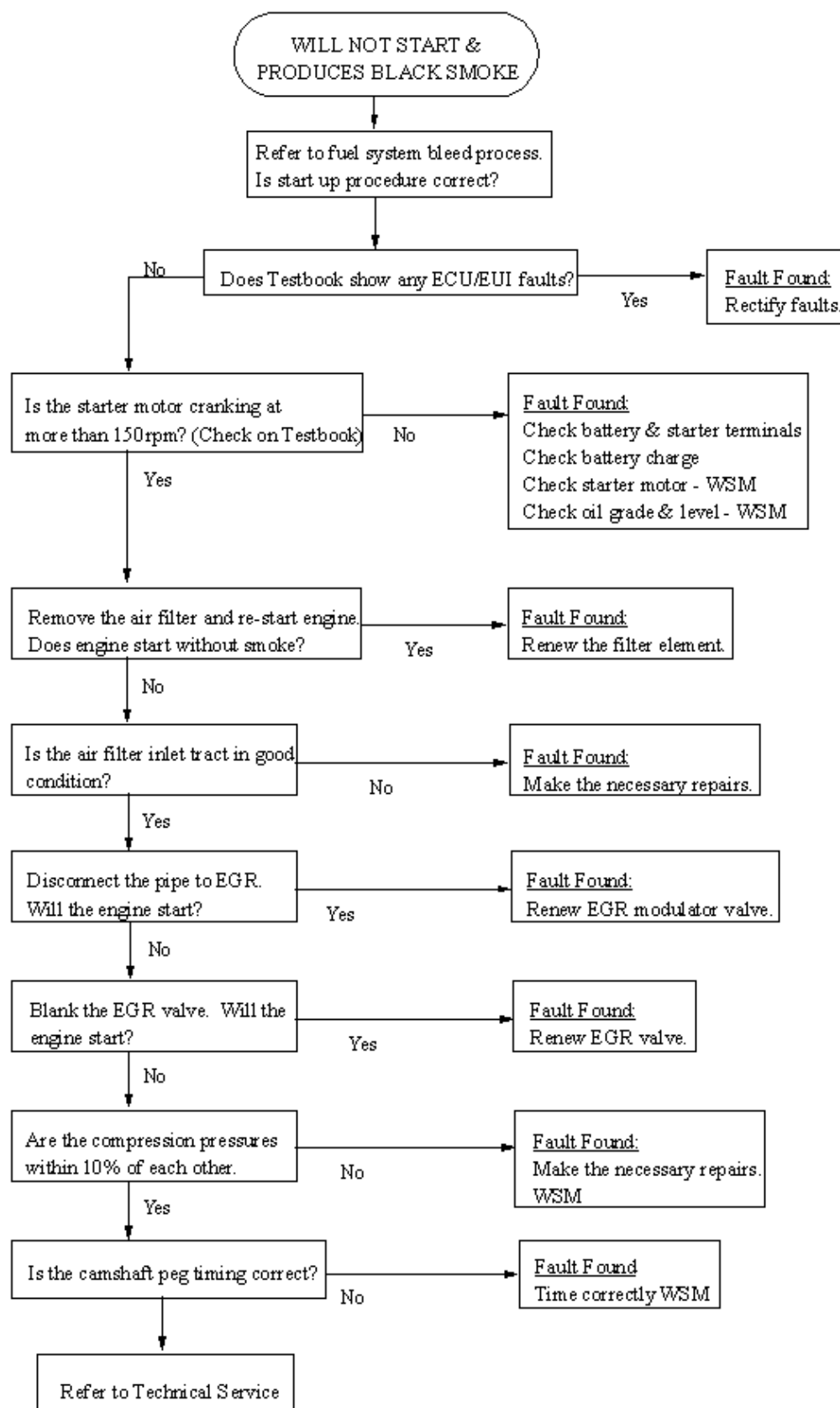


- a. LP out
- b. LP in
- c. HP out
- d. Return pipe
- e. Return pipe
- f. Spill return
- g. Filters
- h. Fuel cooler
- i. HP stage
- j. Water jacket
- k. Air bleed
- l. LP stage
- m. Electronic unit injectors
- n. Water out
- o. Hot fuel in
- p. Cool fuel out
- q. Cool water in

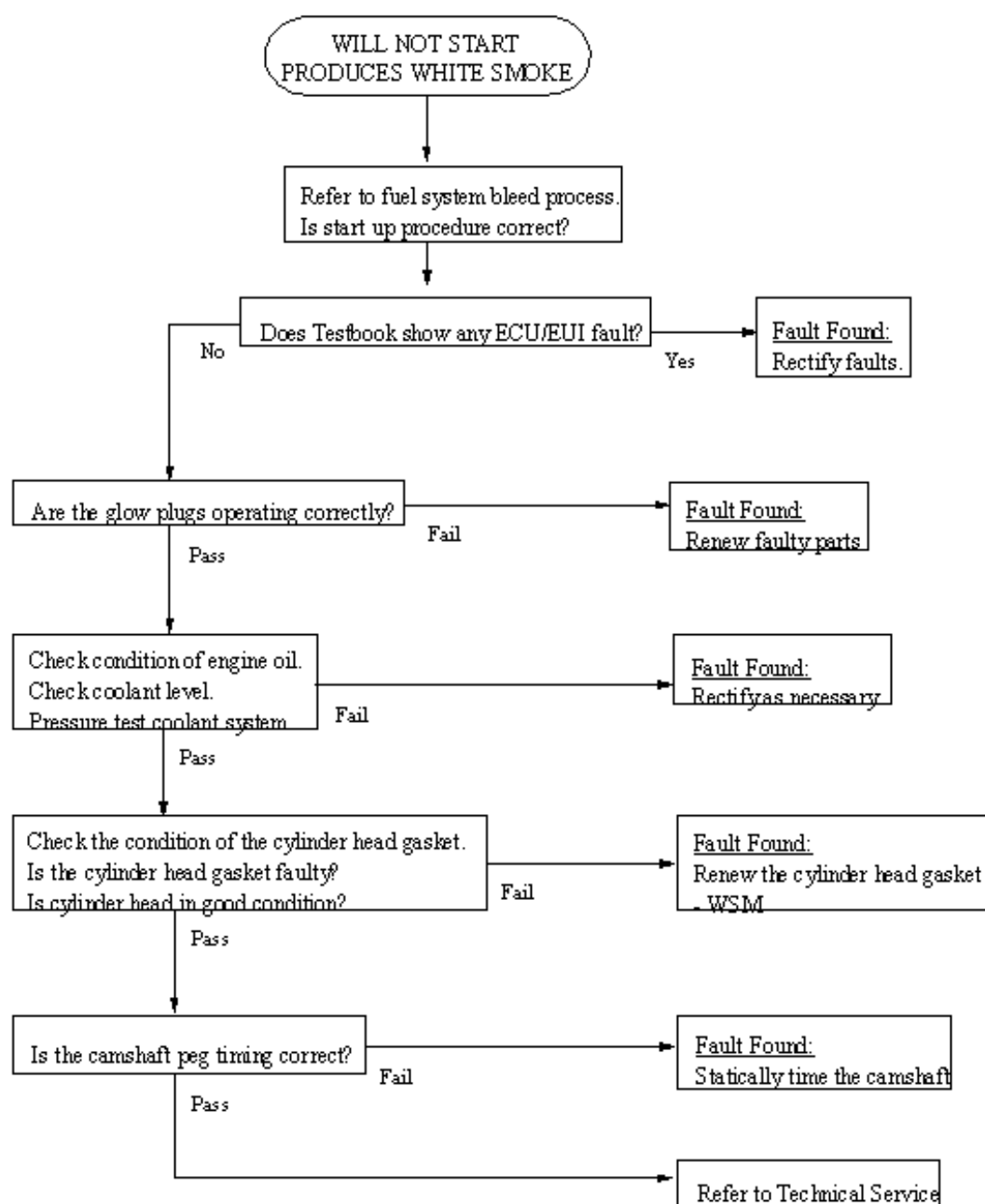
Mechanical diagnostic flow diagram 1



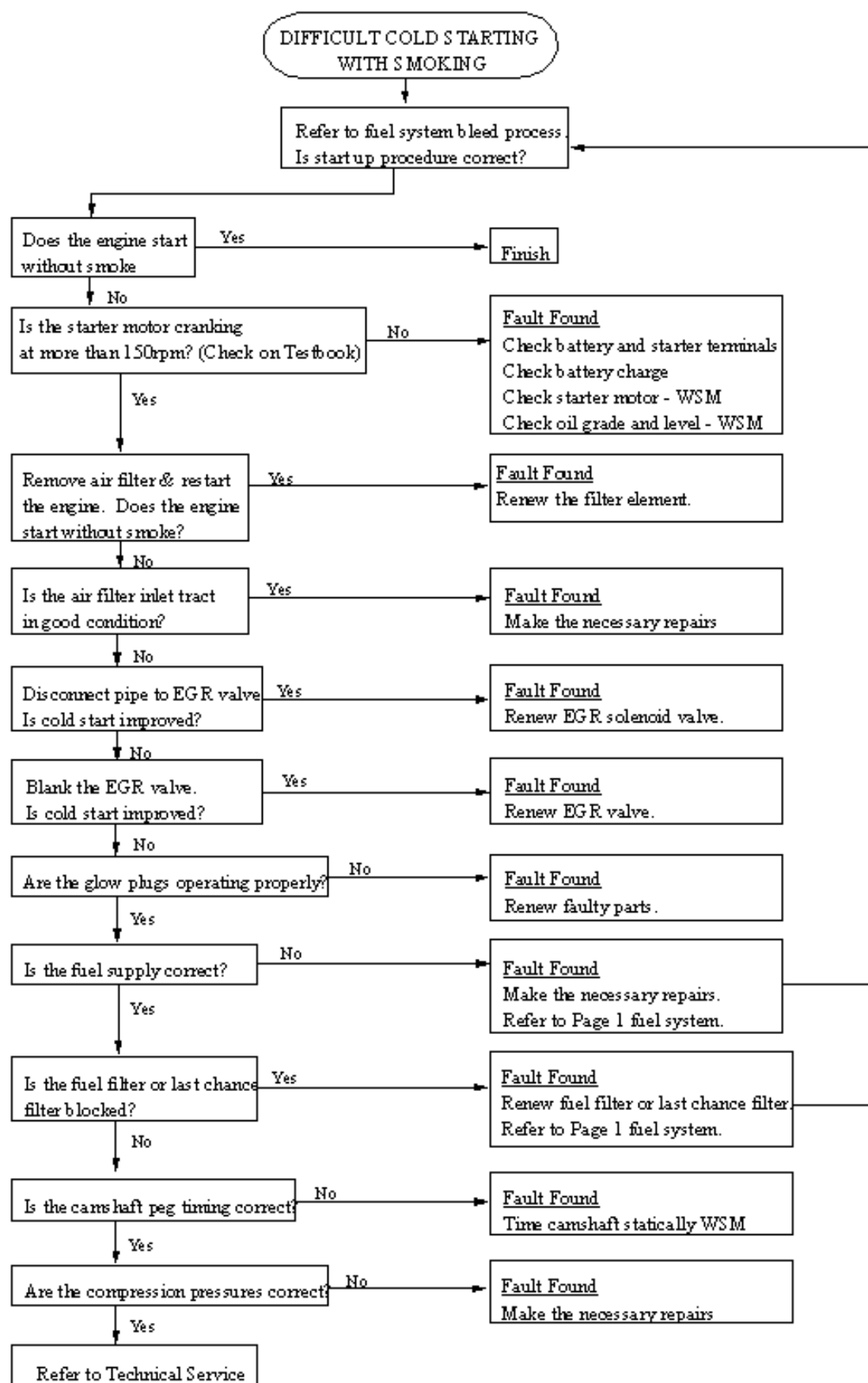
Mechanical diagnostic flow diagram 2



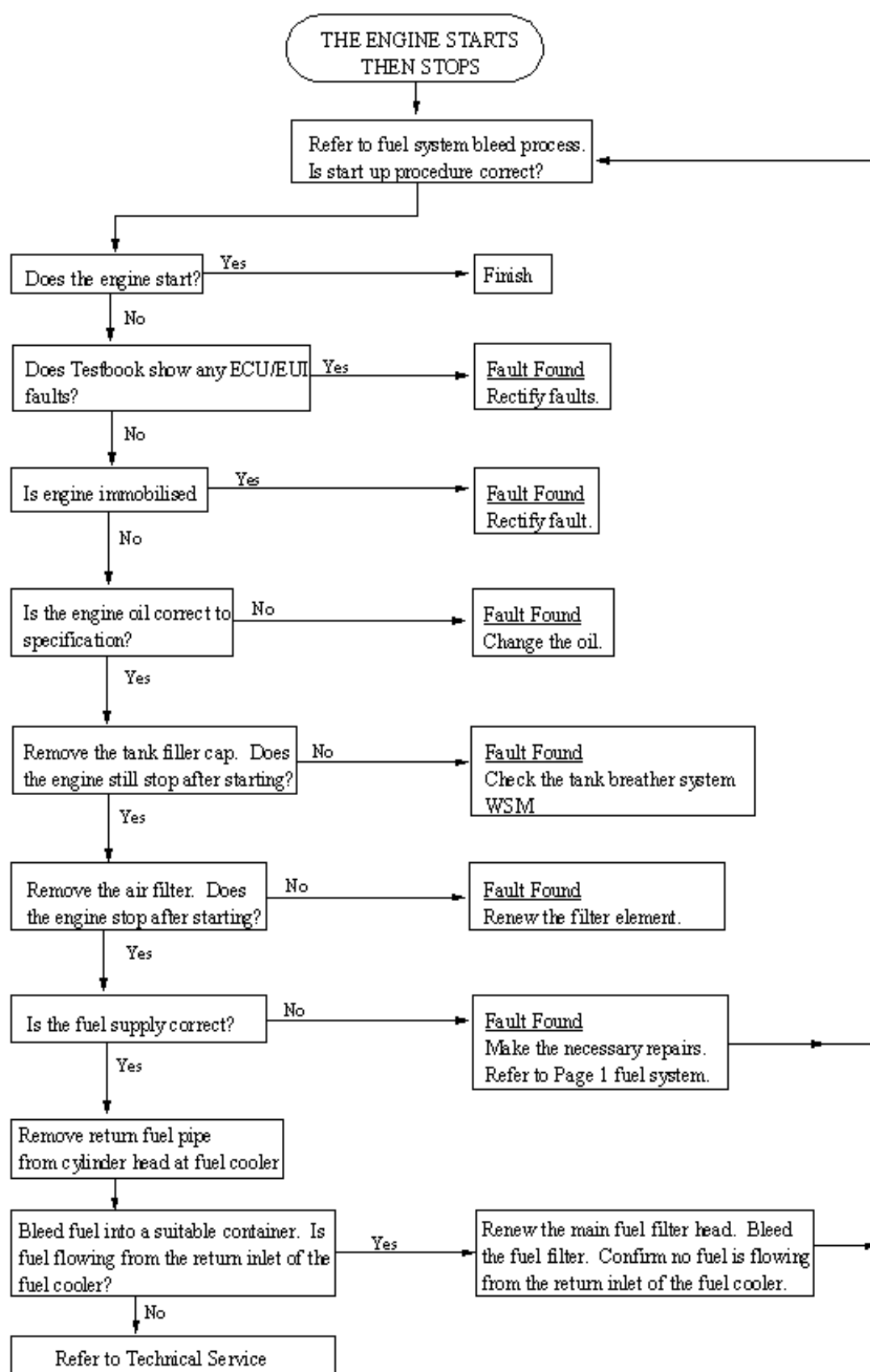
Mechanical diagnostic flow diagram 3



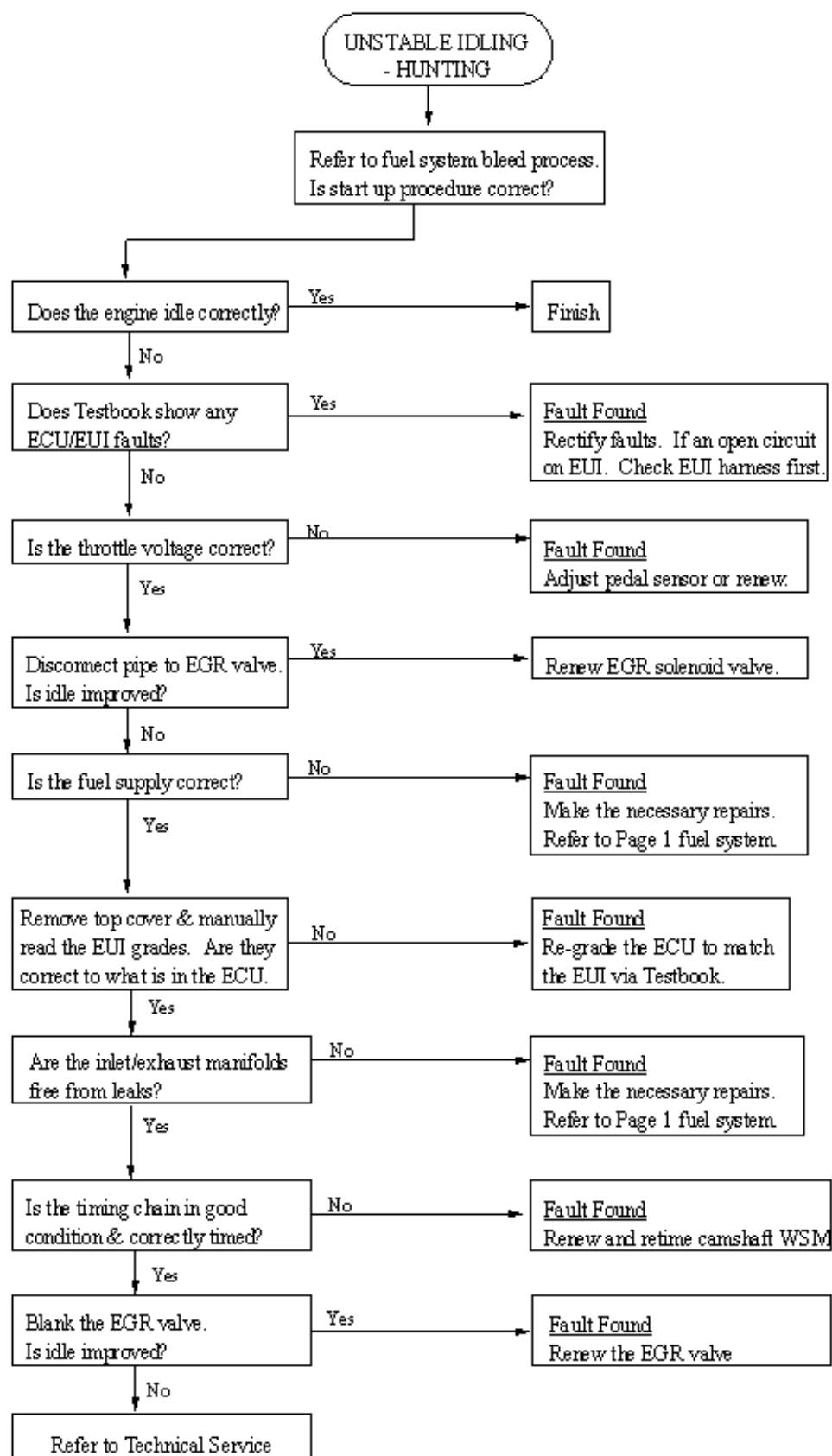
Mechanical diagnostic flow diagram 4



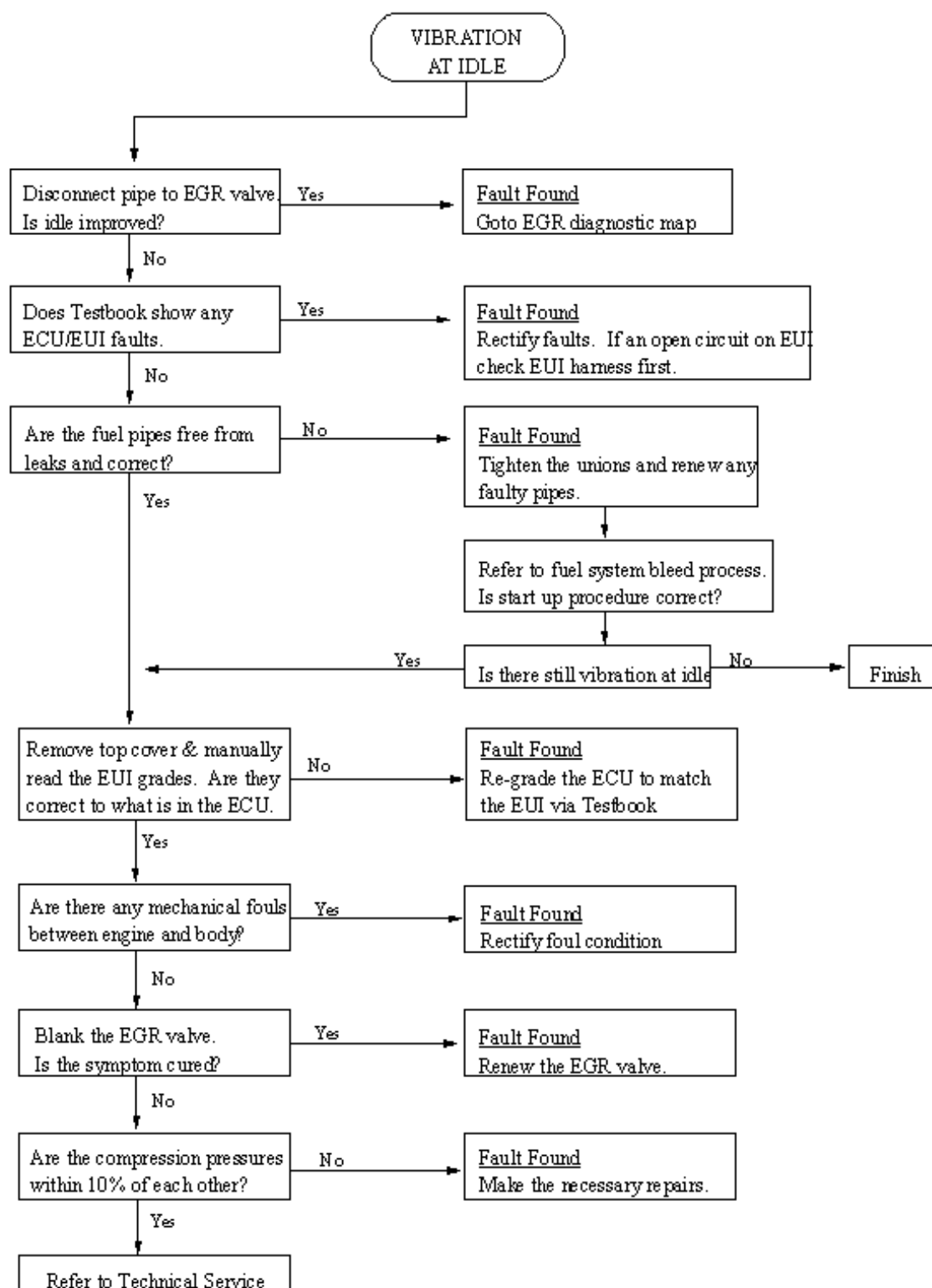
Mechanical diagnostic flow diagram 5



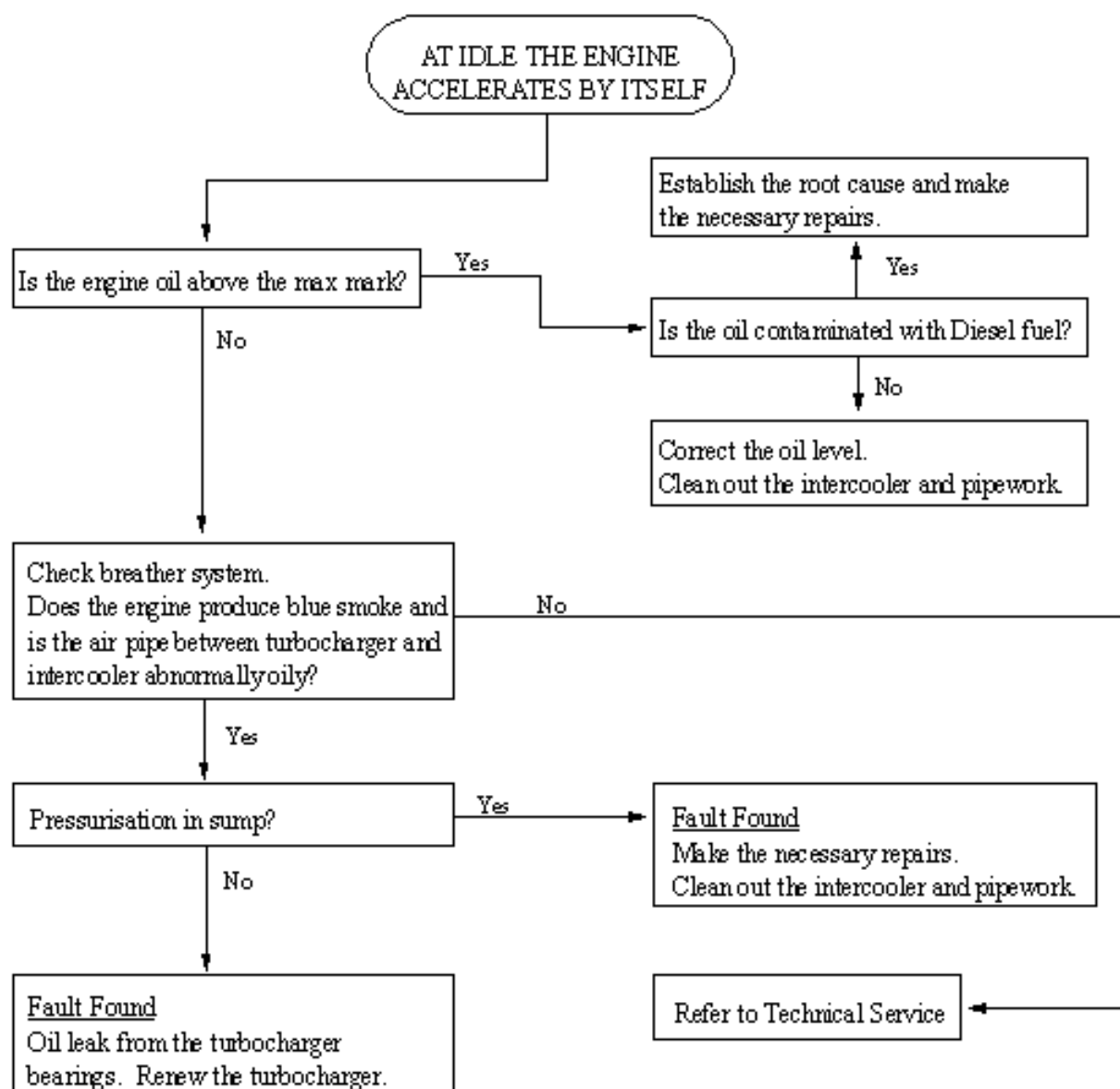
Mechanical diagnostic flow diagram 6



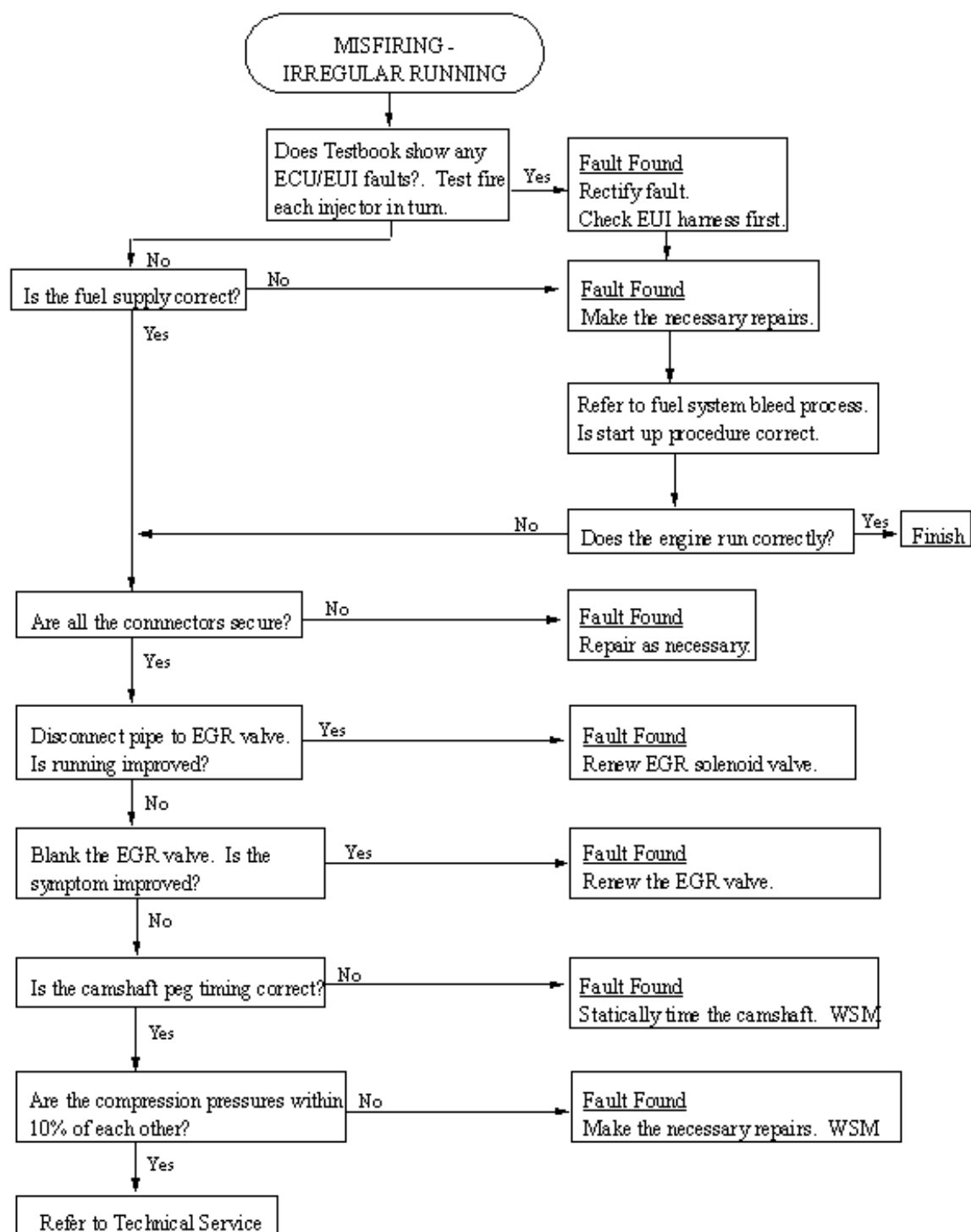
Mechanical diagnostic flow diagram 7



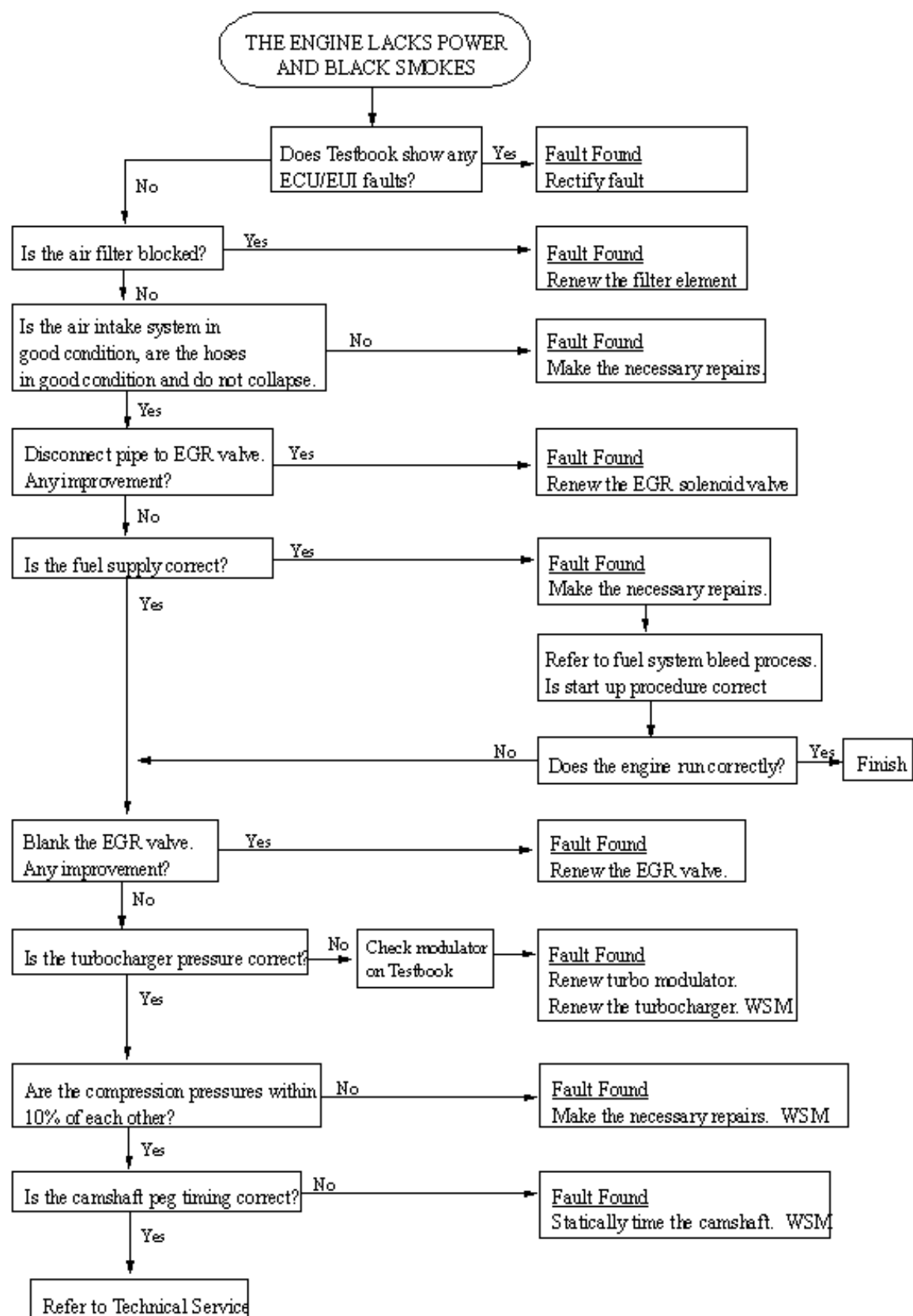
Mechanical diagnostic flow diagram 8



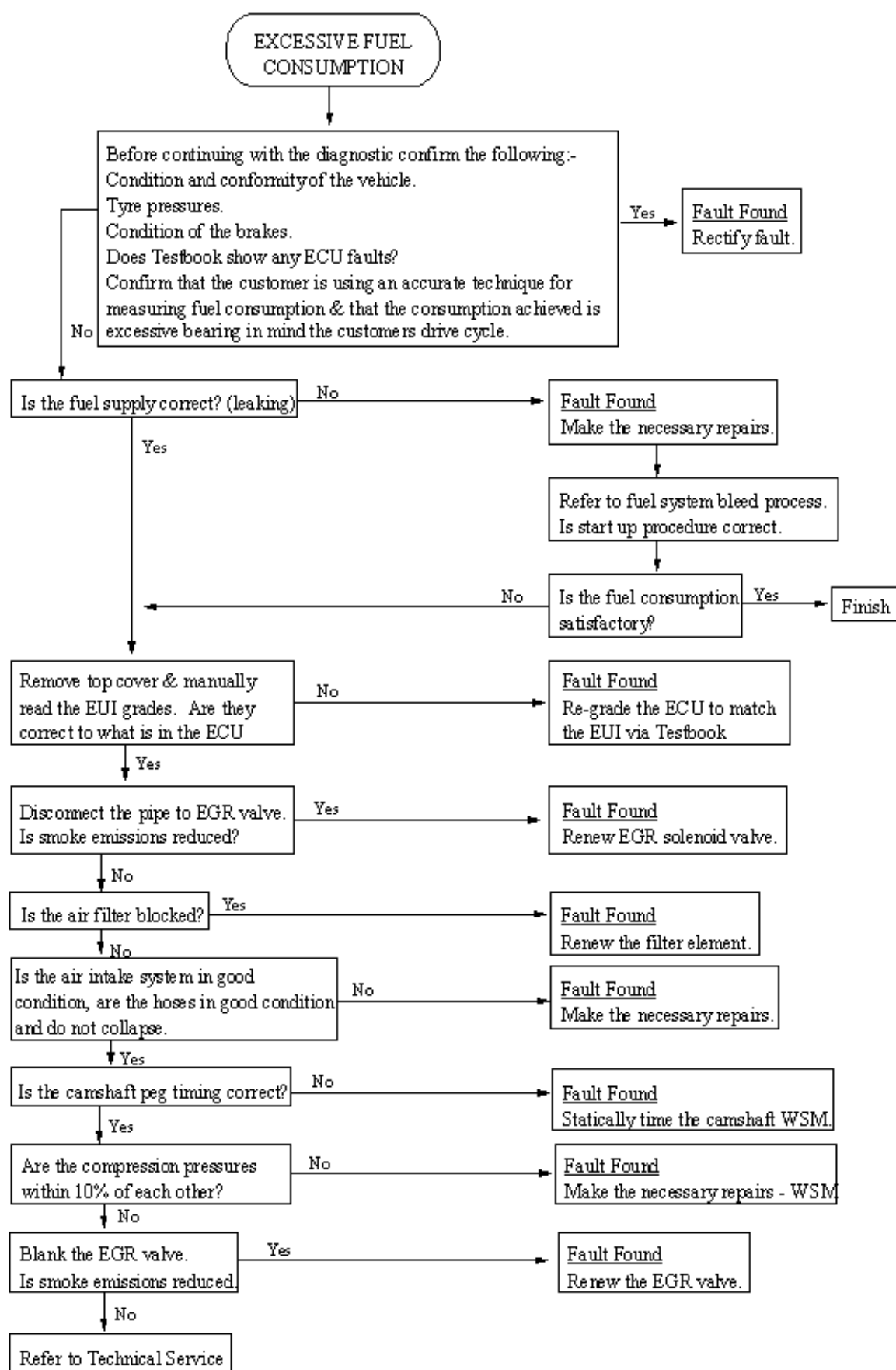
Mechanical diagnostic flow diagram 9



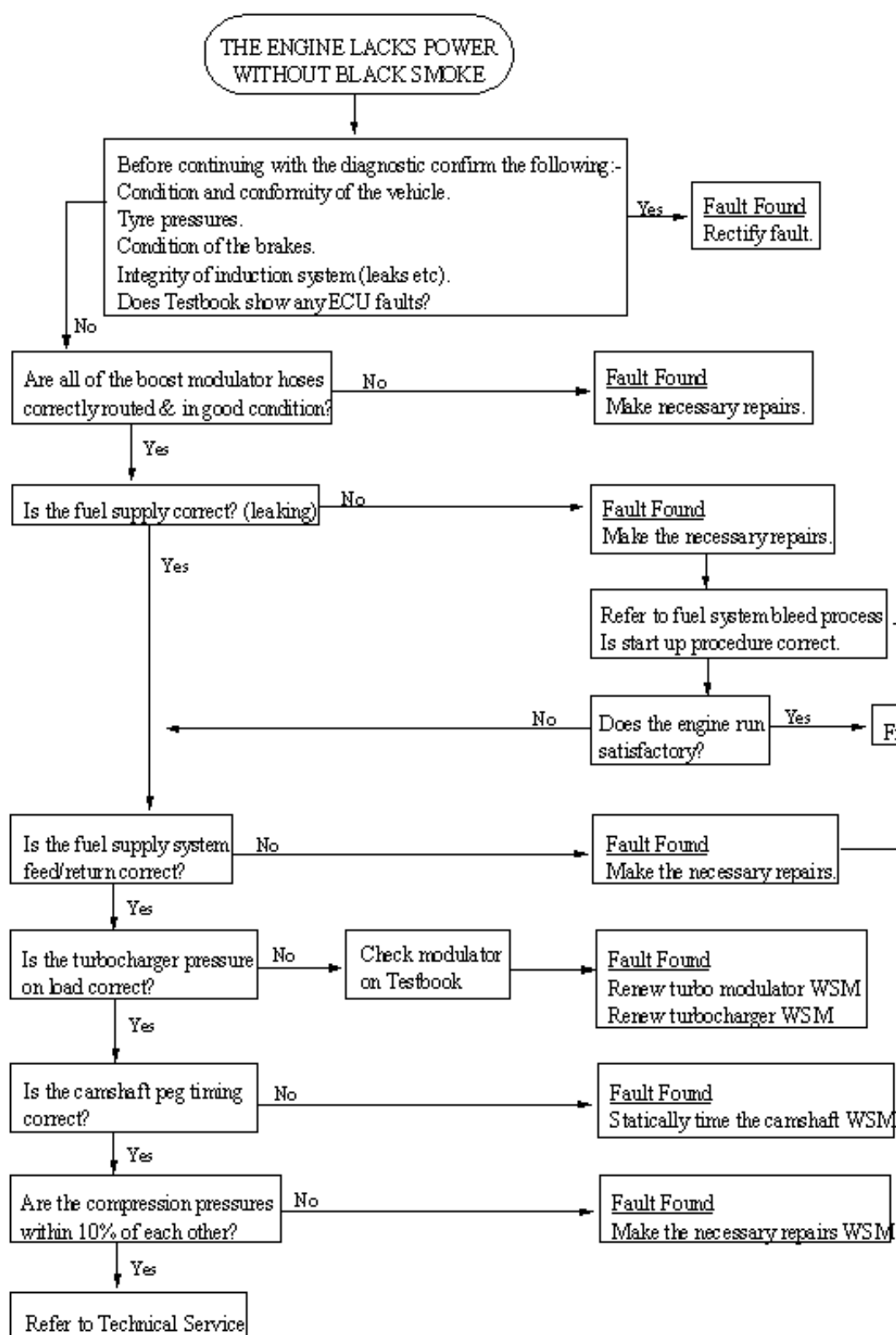
Mechanical diagnostic flow diagram 10



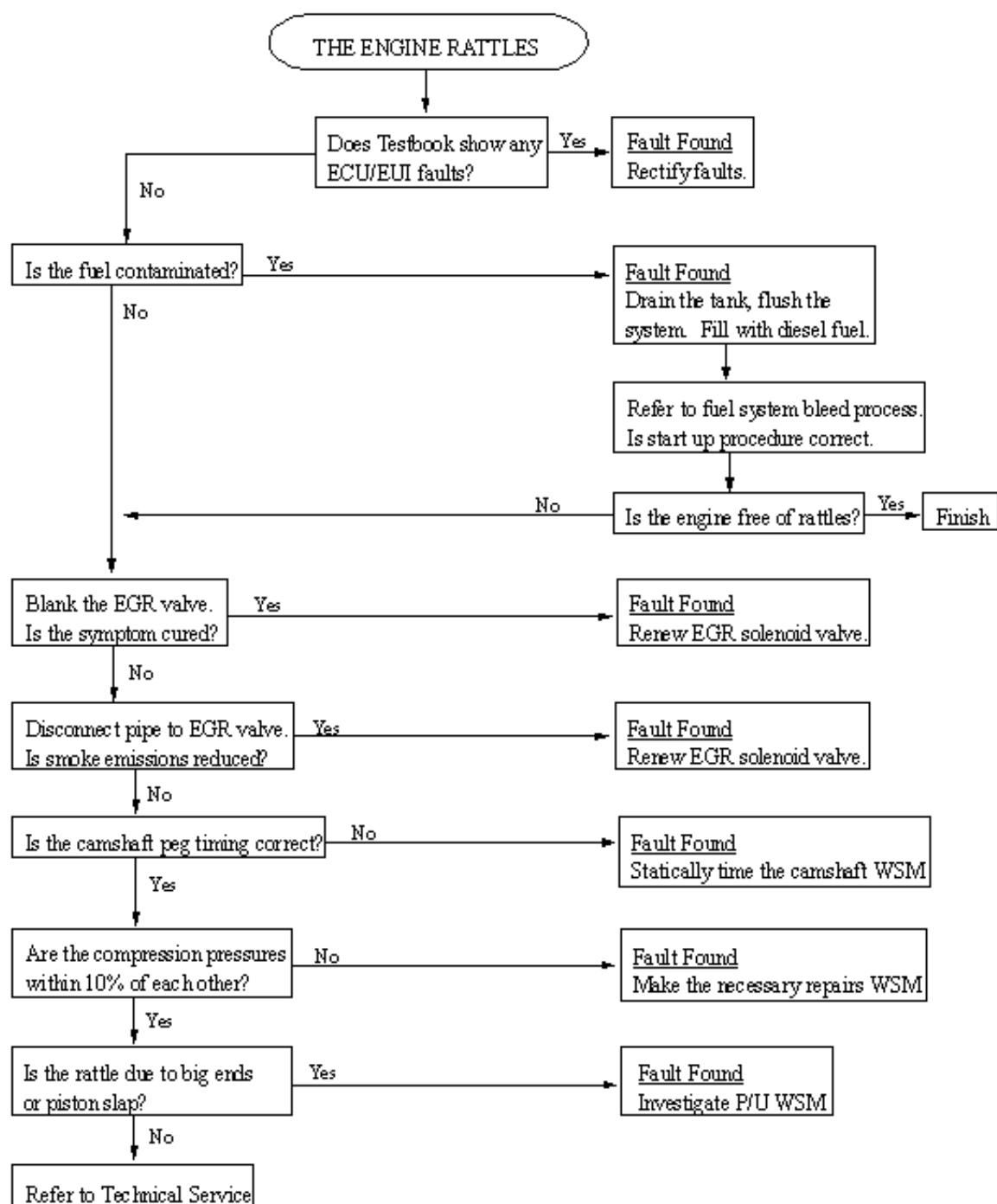
Mechanical diagnostic flow diagram 11



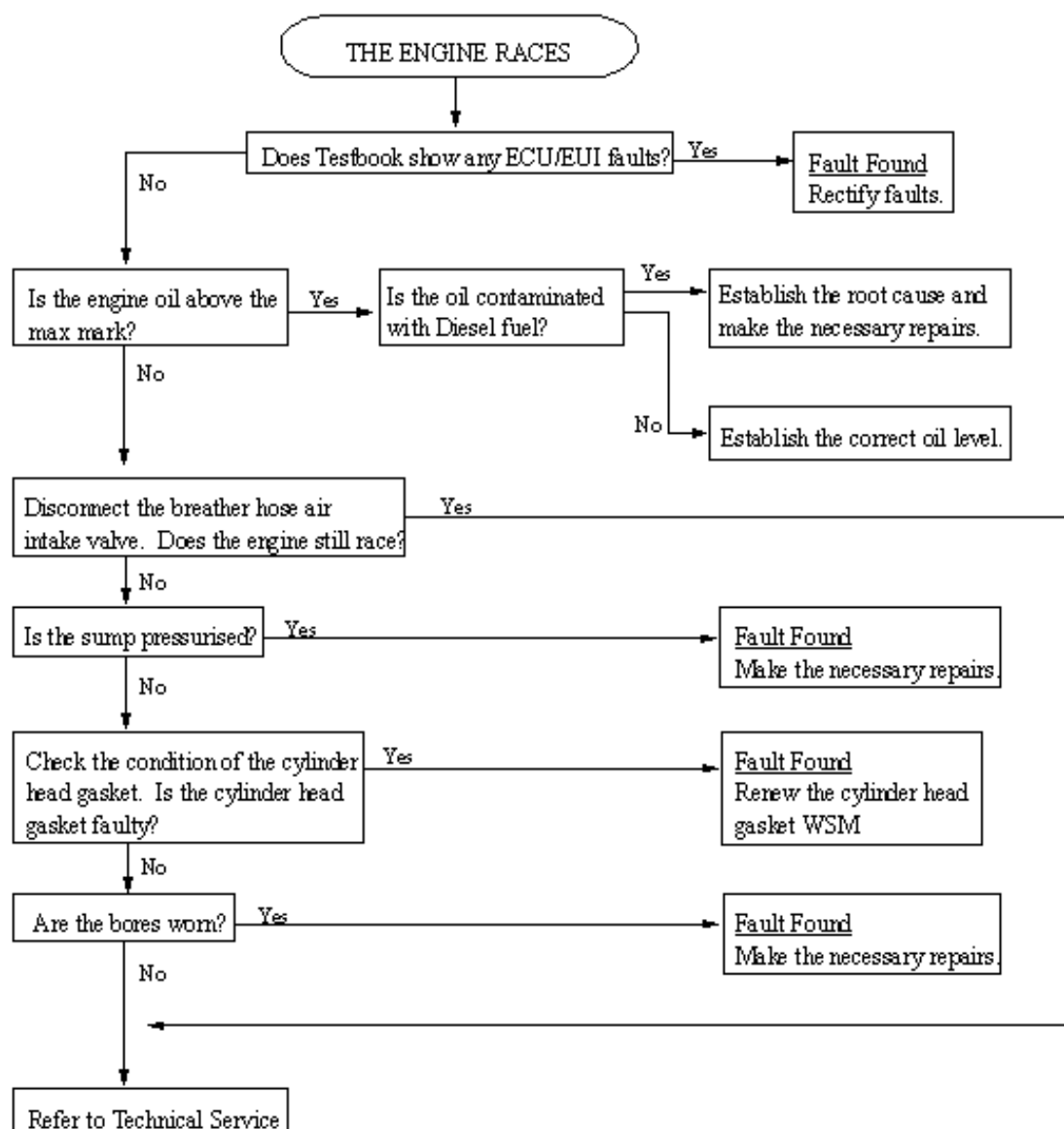
Mechanical diagnostic flow diagram 12



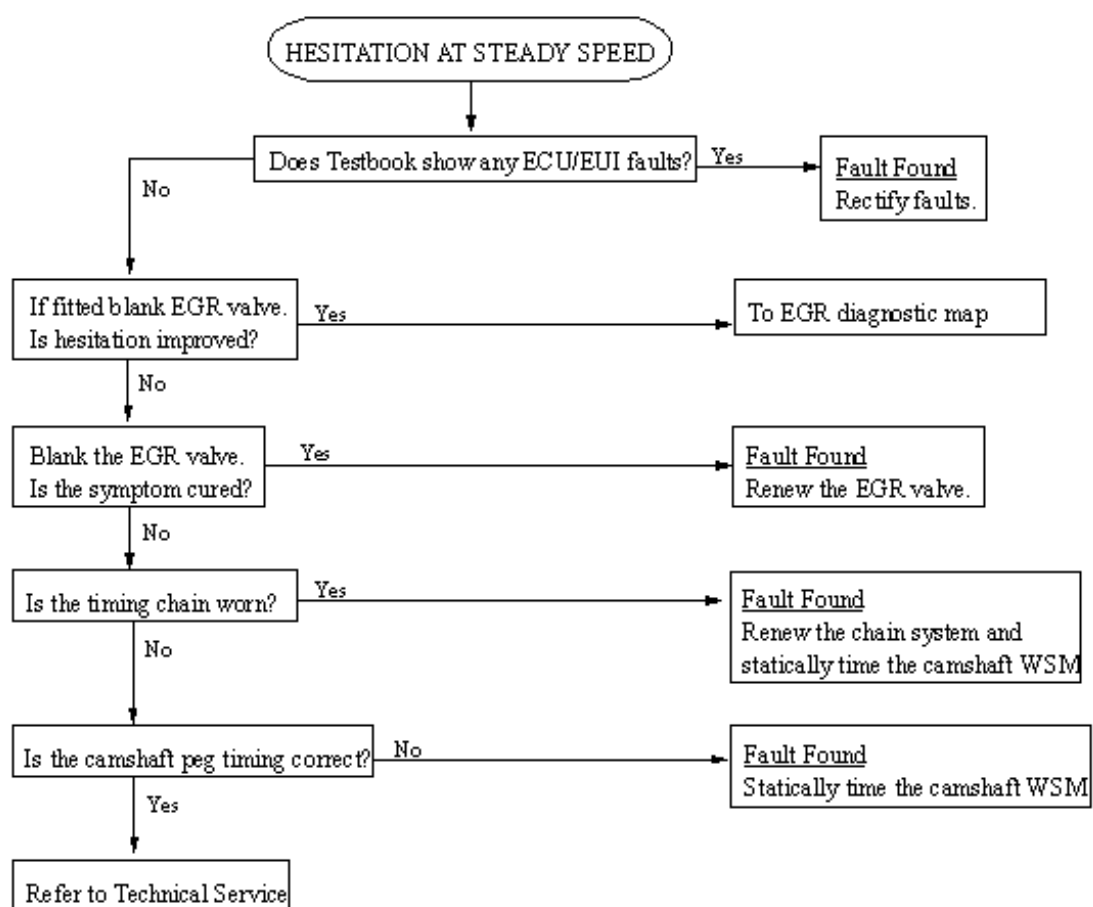
Mechanical diagnostic flow diagram 13



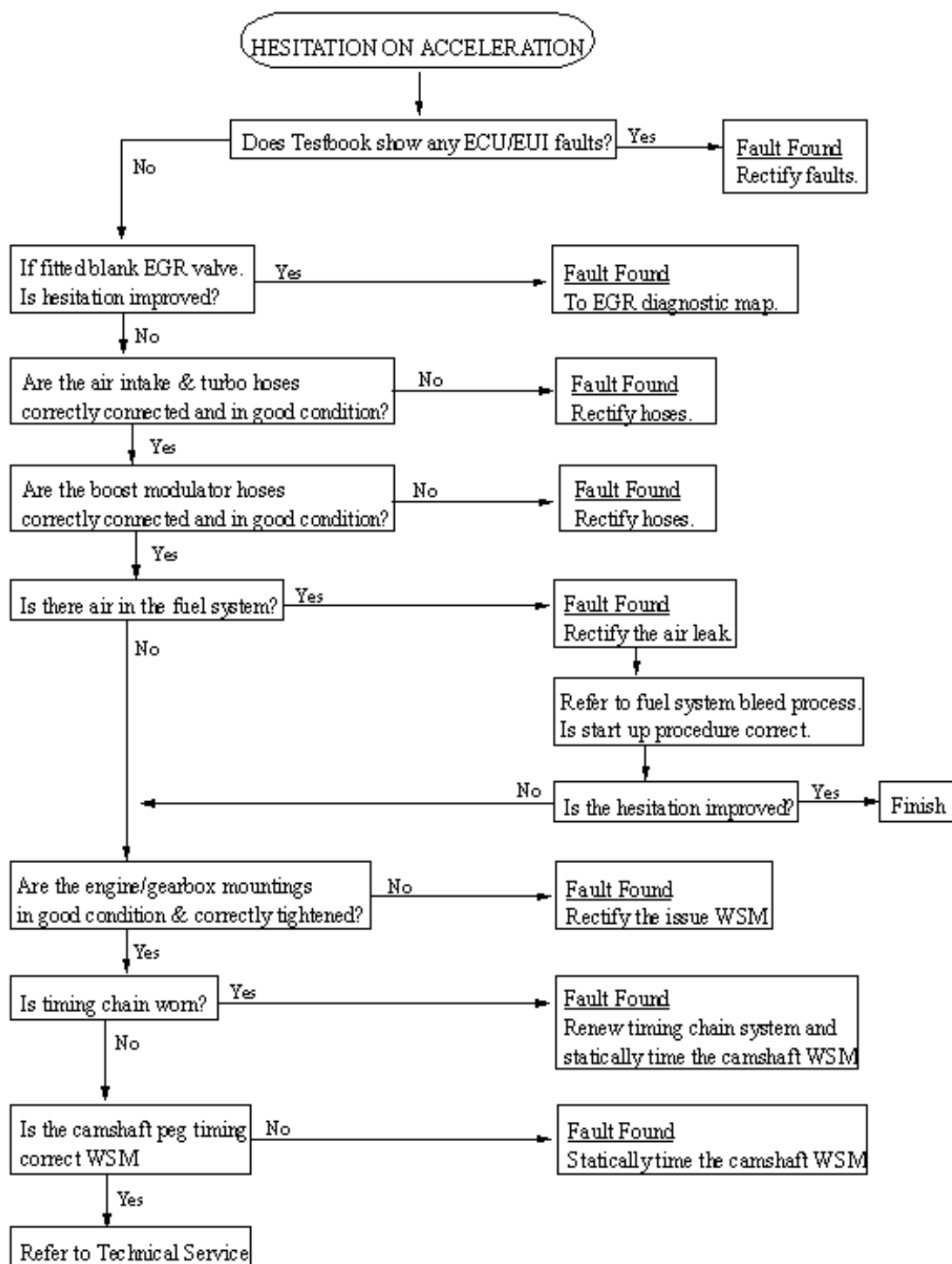
Mechanical diagnostic flow diagram 14



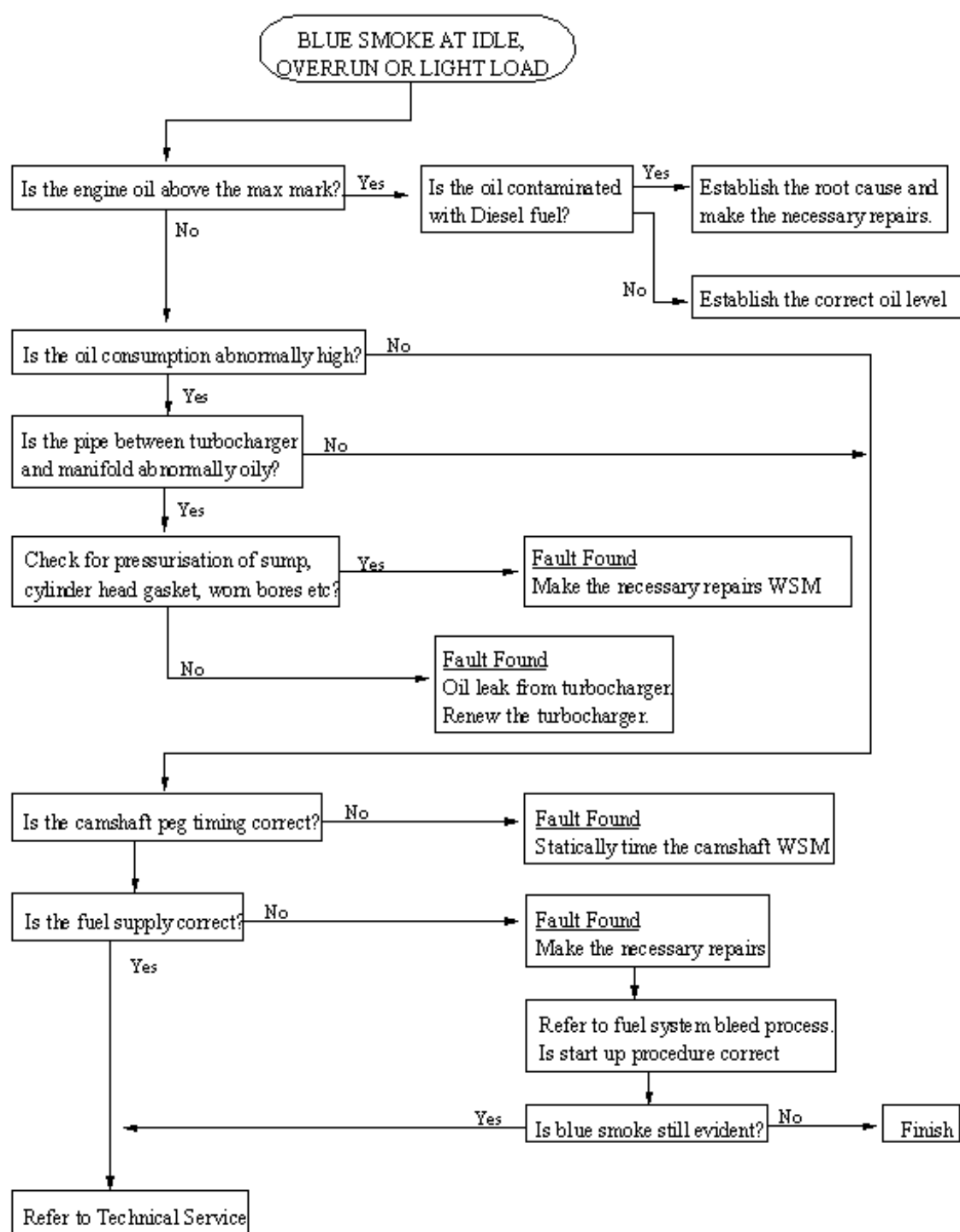
Mechanical diagnostic flow diagram 15



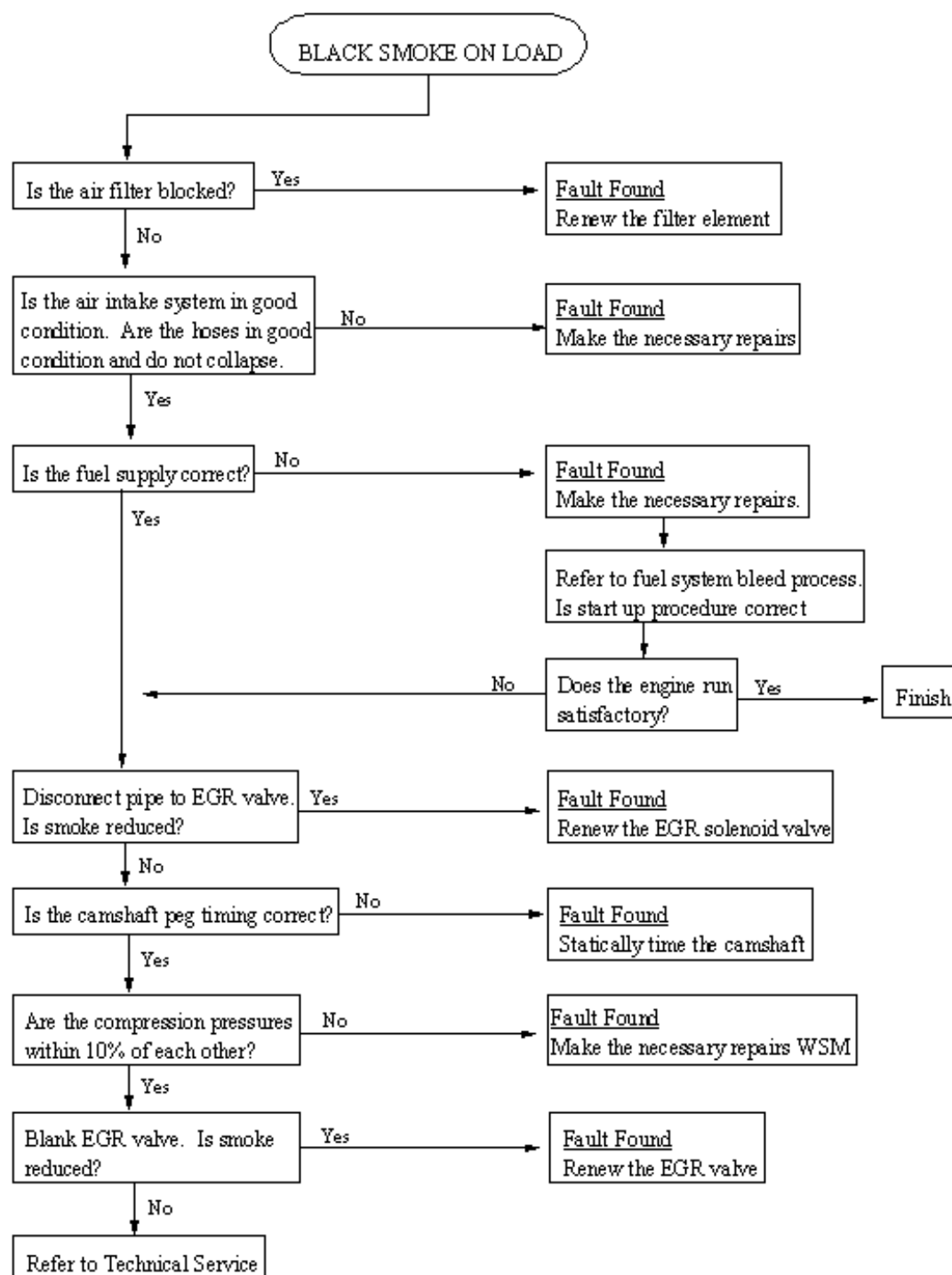
Mechanical diagnostic flow diagram 16



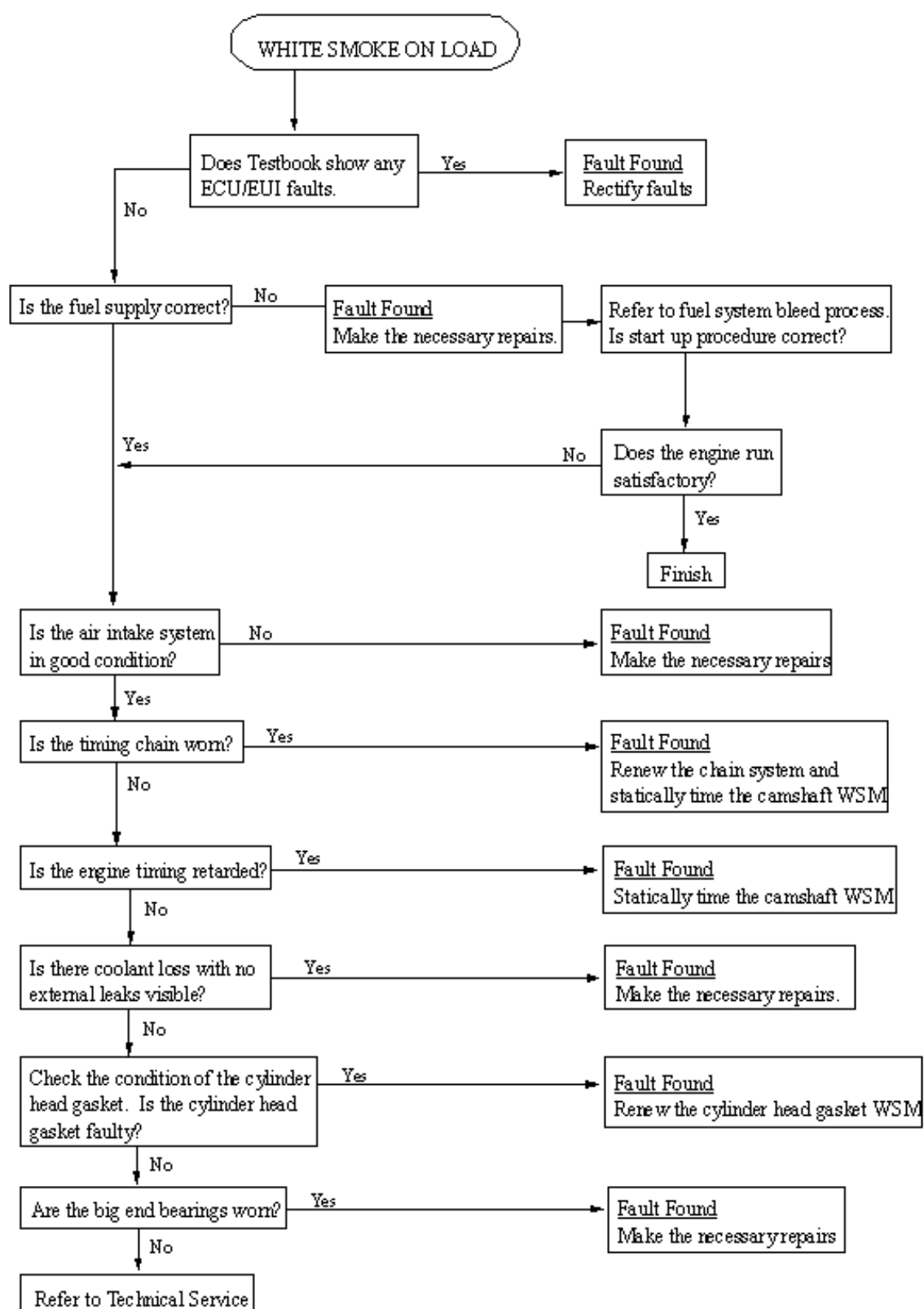
Mechanical diagnostic flow diagram 17



Mechanical diagnostic flow diagram 18



Mechanical diagnostic flow diagram 19



Oil pump

The oil pump, as previously mentioned, is located in the stiffener plate. A chain drives it from the crankshaft. The oil pump contains no serviceable parts except for the pressure relief valve spring. The free length measurement of this spring is detailed in the workshop manual. It is the free length of the oil pressure spring which determines whether the pump is suitable for refitting into the engine. Before the oil pump or crankshaft drive sprocket can be removed, the oil pump drive sprocket must first be removed.

Electronic unit injector (EUI)

The injectors used by the Td5 engine are located in the cylinder head. A copper washer and an 'O' ring are used to seal the injector nozzle and injector body to the cylinder head. If, at any time, an injector is removed special tool **LRT-154/1** must be used. Special tool **LRT-154/4** should be used to remove the copper washer from the end of the injector and special tool **LRT-12-154/3** must be used to fit a new washer. The 'O' ring must be also be replaced every time the injector is removed, this operation requires special tool **LRT-12-154/2** to ensure no dirt or rubber particles are allowed into the injectors fuel ports. Extreme care must be taken when removing an injector from the cylinder head as the tip of the injector can be damaged if it is handled incorrectly. If the copper washer fails to seal the injector to the cylinder head, combustion gases will contaminate the fuel in the fuel gallery. This results in the fuel becoming aerated. If this happens, the engine will suffer poor starting and poor performance. Even with relatively small amounts of combustion gas in the fuel, the engine performance will suffer noticeably. The injectors 'O' ring prevents the fuel in the fuel gallery from entering the engine oil supply.

The EUI injectors are very susceptible to foreign matter in the fuel rail or any dirt or particles around or in injector body between the 'O' ring and the copper washer. No attempt to clean this part of the injector should be made. Always follow the procedure detailed in the workshop manual when removing the EUI injectors.

The injectors are electronically operated units in which the fuel injected is pressurised mechanically. Each EUI consists of a hydraulic plunger, a conventional injector nozzle and an electric solenoid. The hydraulic plunger is driven mechanically by the camshaft and rocker assembly. The injector operates in four stages:

1. The camshaft lobe turns and transfers mechanical force and motion to the rocker, which is in contact with the injector hydraulic plunger. This transfer of mechanical force starts to move the plunger down inside the injector. At this point, the injector has fuel flowing through it because of the action of the pump located in the fuel tank. N.B. Fuel exits the injector via the spill hole back into the fuel rail
2. As the plunger travels down, it closes the inlet port and prevents more fuel entering the injector. The fuel already in the injector can still exit the injector at this stage because the EUI solenoid has not shut off the spill port
3. At a calculated time, the ECM will supply a voltage to the injector solenoid, causing it to activate. This will close the injector spill port and cause the pressure within the injector to rise very rapidly. At this point, the injector will spray fuel into the combustion chamber at very high pressure (up to 1500 Bar. As a comparison, the current 300 Tdi engine injects fuel at approximately 600 Bar)
4. At the calculated time, the ECM will remove the voltage to the EUI injector solenoid. By doing so, the spill port will open and fuel will now flow through the injector, rather than out through the nozzle. The hydraulic plunger will return to its rest position by means of a powerful spring. The EUI is now ready for the next injection sequence

It is critical that each injector delivers the desired quantity of fuel at the required time. To do this, its opening and closing times must be controlled precisely. Despite the fact that the injectors are manufactured to extremely close tolerances, an amount of variation may exist between them. This is due to slight differences in spring tension and nozzle bore dimensions. As a result of this variation, the ECM must be informed of the precise specification of each injector. This enables the ECM to adjust its opening and closing injection points to gain the maximum fuel efficiency. This procedure is called the calibration process.

The rockers which transfer the downward force on the EUI must be adjusted correctly at all times. The process used to set the adjustment is dissimilar to conventional tappet adjustment procedures. The procedure is as follows :

1. Loosen the lock nuts on all the adjusting screws (this should have been completed before the rocker shaft was removed)
2. Set the engine to a position where the EUI to be adjusted is fully compressed, i.e. the cam lobe is at its highest point. There is a timing mark on the front of the camshaft for each of the injector's lobes. This mark will align with the edge of the cam carrier housing to signify that the relevant injector lobe is at its maximum point
3. Screw the adjuster 'in' to further compress the EUI hydraulic plunger spring (this will feel quite stiff). Stop when the plunger contacts the base of the injector (at this point it will not be possible to screw the adjuster in further)
4. Turn the adjusting screw back 1 turn and tighten the lock nut
5. Repeat steps 2 - 4 for the other four injectors

This adjustment procedure should be carried out whenever the rocker shaft has been removed. When adjusted correctly, the injector plunger travels the correct distance. If not adjusted correctly the plunger could either travel too far and make contact with the base of the chamber or may not travel far enough. In both cases, damage and a reduction in engine performance could result.

Oil filter

The Td5 engine features two oil filters. The primary oil filter is a conventional canister type. The primary oil filter filters all the oil entering the oil gallery and the oil entering the secondary oil filter. The primary filter features a paper element which is used to trap particles as small as 15 microns (0.015 mm) in diameter. But diesel engine produces many particulate impurities smaller than this and these particles are removed efficiently by the secondary centrifugal filter. Therefore, the service life of the primary oil filter canister can be greatly extended. Always refer to the maintenance check sheet for the correct service interval for both the primary and secondary oil filters.

The secondary oil filter is a centrifugal oil filter which is housed in a 'pot' located by the exhaust manifold. The pot lid is sealed to the pot by an 'O' ring. This 'O' ring should be replaced when the centre canister is replaced. The oil filter works by the replaceable centre unit spinning very rapidly. The unit has two very fine holes drilled at an obtuse angle so that when oil flows through them under pressure it spins the centre filter unit. The centre of the centrifugal filter can rotate at speeds up to 15,000 rev/min. The inner surface of the spinning canister gets coated in a gel of old engine oil and carbon particles. The centrifugal filter is capable of retaining much finer carbon particles than a traditional canister type oil filter.

The oil pressure warning switch is located in the housing under the turbocharger. The oil pressure switch will go to an open circuit state (light off) when the oil pressure rises above 0.5 0.68 Bar .

The housing between the two oil filters and the cylinder block incorporates an oil cooler. The oil is passed through the oil cooler via a thermostat in the oil filter housing, which has a 72 °C (160 °F) opening temperature. The oil is then cooled by the cylinder block water jacket.

Turbocharger

The turbocharger used on the Td5 engine is a Garrett GT20. This unit features an electronic modulating wastegate. This enables the ECM to control accurately the amount of boost pressure the engine receives. The conventional care points should be observed when starting and stopping the Td5, i.e. allow the engine to idle for 15 seconds immediately following start-up and before the engine is switched off.

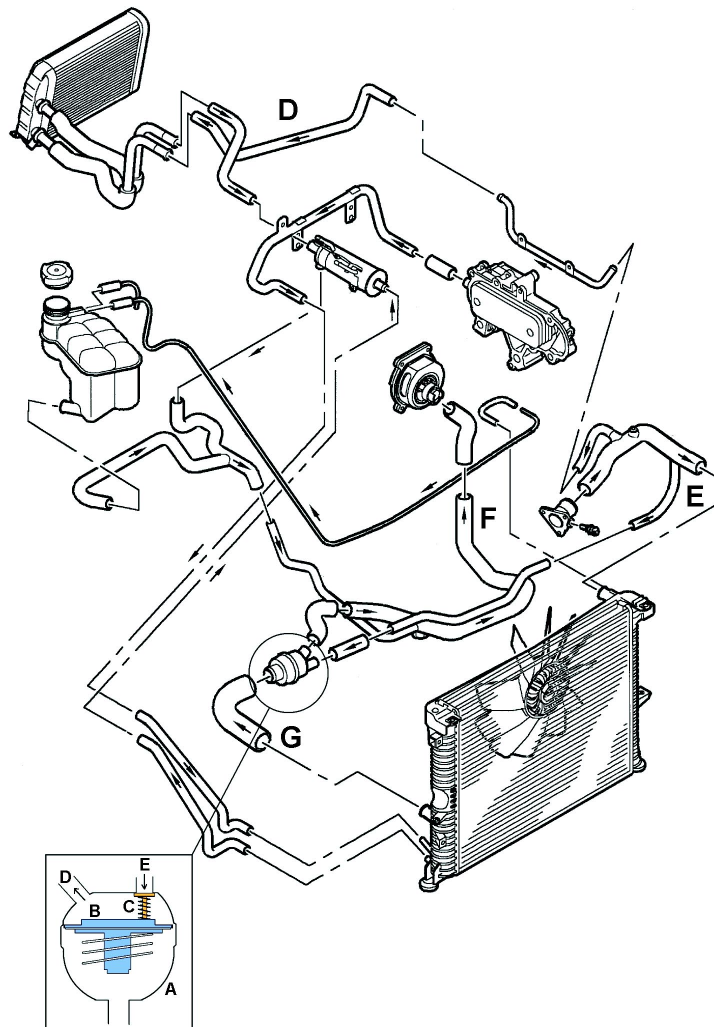
Engine reassembly

Follow the procedures below to rebuild the engine.

Service Repair Number	Procedure
12.21.33.01	Refit crankshaft
12.17.02.01	Refit pistons
12.17.16.01	Refit big end bearings
12.60.12.02	Refit ladder frame and oil pump
12.65.13.01	Refit timing cover
12.60.38.01	Refit engine sump
12.29.19.01	Re-build the cylinder head
12.29.02.01	Refit the cylinder head
12.13.02	Adjust the injector rockers
	Refit all other removed ancillaries

Cooling system

System layout



The cooling system uses a 50/50 antifreeze/water mix. The specified antifreeze to be used in this application is Texaco XLC. The capacity of the system is approximately 10 litres. The workshop manual details the procedure to drain and refill the cooling system.

The cooling system hoses have been fabricated to incorporate a thermostat housing. This thermostat housing has three hose connections. The coolant is drawn into the water pump via hose (F) from either the heater matrix circuit (D) or from the thermostat housing (A). When the thermostat (B) is closed, the water pump will draw fluid from the bypass hose (E). Before it is able to do this, it will need to overcome a spring-loaded valve (C) inside the thermostat housing (A). This spring is rated so that, when the engine speed is below approximately 1500 rev/min, all the coolant will circulate around the heater circuit (D). This serves to aid fast 'warm-up' when the vehicle is operated in cold climate conditions. If the engine speed exceeds approximately 1500 rev/min, the suction the water pump creates will be sufficiently strong to lift the spring-loaded valve (C) off its seat. This will allow coolant to circulate through the bypass hose (E), as well as through the heater circuit (D). When the coolant temperature exceeds 82 °C (180 °F), the thermostat (B) will open, allowing the coolant to flow through the top hose (E), through the radiator and into the thermostat housing, via hose (G). Finally, it will be drawn into the water pump via hose (F).

Auxiliary drive belt

The auxiliary drive belt is used to drive the following items (depending upon the vehicle specification):

- 1.The viscous fan
- 2.The water pump
- 3.The alternator
- 4.The vacuum pump (via the same pulley as the alternator)
- 5.The power steering pump
- 6.The air conditioning compressor
- 7.The active cornering enhancement control pump

The auxiliary drive belt is tensioned with an auto-tensioner. The auto-tensioner has an uprated spring to provide the belt with greater tension than the 300 TDI. This is needed because of the extra power transfer required to drive the above components.

The Td5 engine features an integrated 120 amp alternator and vacuum pump. It is driven directly by the auxiliary belt and supplies vacuum for the servo assisted brakes, and for the EGR modulating valve.

There are four auxiliary drive belts, each of differing length. The drive belt fitted is determined by the specific components fitted to the vehicle. Each drive belt is colour coded to assist with identification. The table below identifies which belt is used for each vehicle derivative and provides a key to the colour coding.

Colour	Length (mm)	Configuration	Figure number
White	1716	No ACE or A/C	"Auxiliary drive belt with no ACE or A/C fitted" on page 38
Yellow	1820	ACE only	"Auxiliary drive belt with only ACE fitted" on page 39
Green	1801	A/C only	"Auxiliary drive belt with only A/C fitted" on page 39
Red	1867	Both ACE and A/C	"Auxiliary drive belt with ACE and A/C fitted" on page 39

The following illustrations should allow you to accurately identify which auxiliary drive belt is fitted.

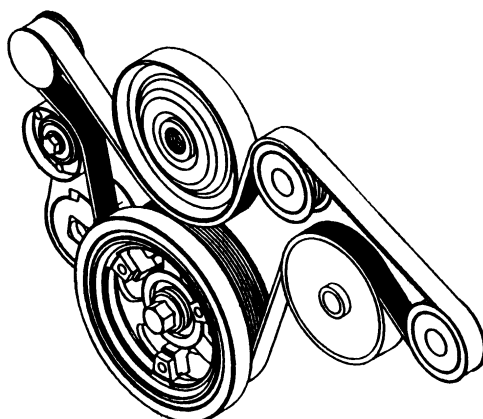


Figure 1: Auxiliary drive belt with no ACE or A/C fitted

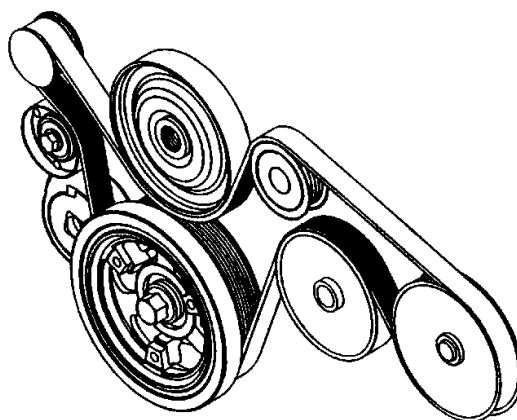


Figure 2: Auxiliary drive belt with only ACE fitted

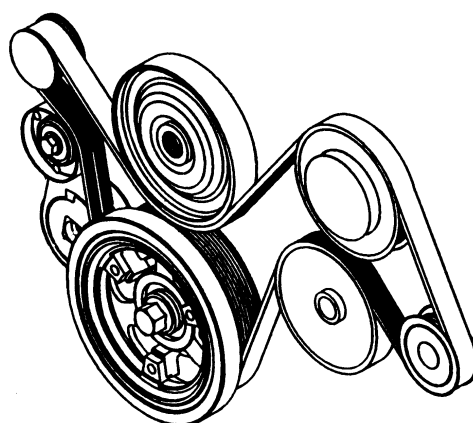


Figure 3: Auxiliary drive belt with only A/C fitted

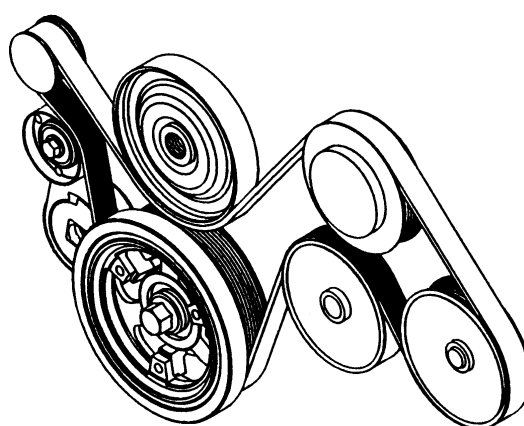
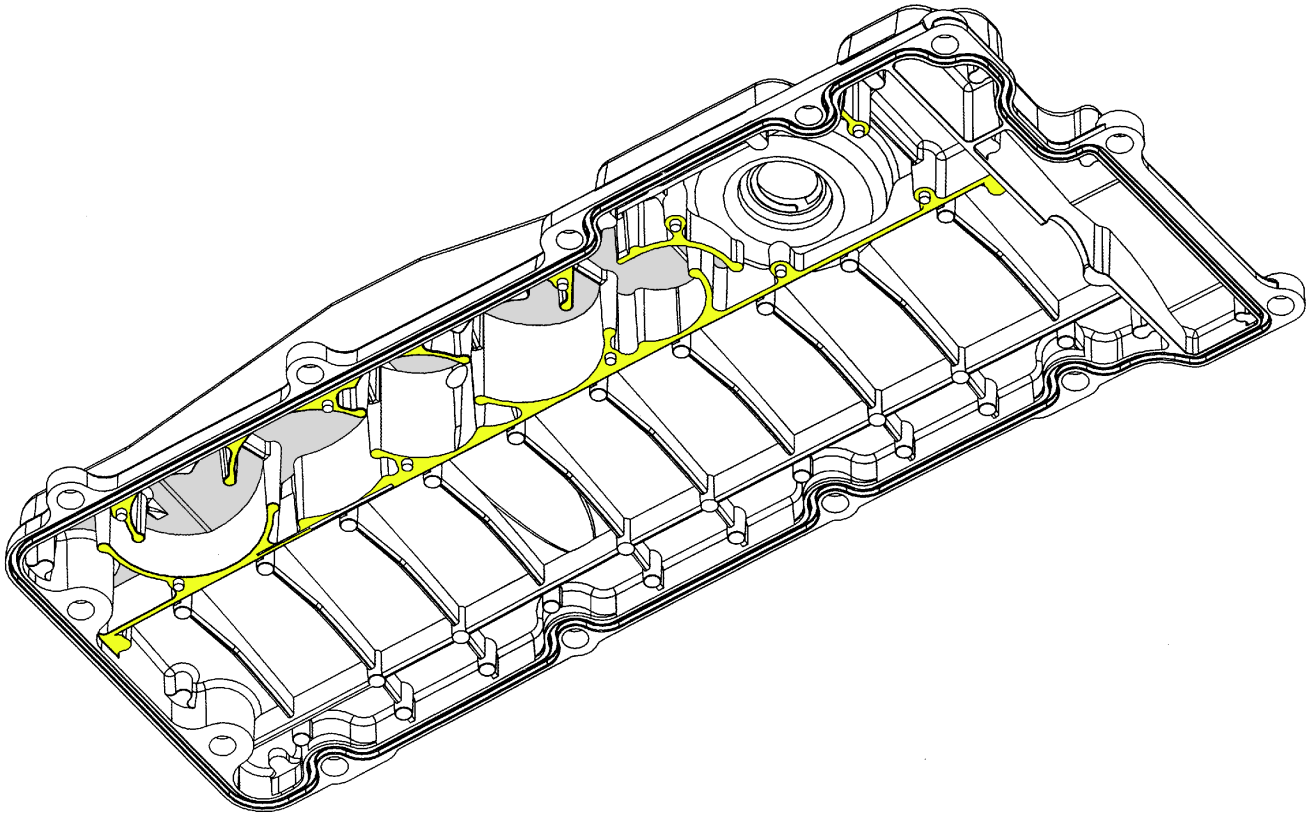


Figure 4: Auxiliary drive belt with ACE and A/C fitted

Crankcase ventilation



The Td5 engine features an innovative solution in the control of crankcase emissions. The new system ensure that very low levels of oil mist enters the combustion process or escapes to the atmosphere. The new rocker cover has cast into it five circular, sequentially positioned chambers. These chambers force the oil mist into a cyclononic movement from one chamber to the next. As the mist races around each chamber, any oil particles are flung to the chamber walls where it then collects and falls back into the cylinder head via the two air inlet holes located at each end of the rocker cover.

Torque wrench settings

Note: Although every precaution has been taken to ensure that these torque figures are accurate at the time of going to press, the Workshop Manual should be referred to for the latest information.

TORQUE DESCRIPTION	METRIC	IMPERIAL
ACE pump bolts.	25 Nm	(18 lbf.ft)
A/C compressor bolts.	25 Nm	(18 lbf.ft)
Alternator support bracket to cylinder head bolts.	25 Nm	(18 lbf.ft)
Alternator/vacuum pump oil feed pipe union.	10 Nm	(7 lbf.ft)
Camshaft cover to camshaft carrier bolts.	9 Nm	(7 lbf.ft)
Camshaft sprocket to camshaft bolts.	37 Nm	(27 lbf.ft)
Centrifuge cover bolts.	10 Nm	(7 lbf.ft)
Centrifuge oil drain pipe to sump bolts (or nuts).	10 Nm	(7 lbf.ft)
Centrifuge to oil drain pipe bolts.	10 Nm	(7 lbf.ft)
Centrifuge to oil cooler housing bolts.	25 Nm	(18 lbf.ft)
CKP sensor bolt.	9 Nm	(7 lbf.ft)
Coolant pipe bolt.	50 Nm	(37 lbf.ft)
Connecting rod bolts.	20 Nm	(15 lbf.ft)
Crankshaft pulley bolt.	455 Nm	(336 lbf.ft)
Crankshaft pulley TV damper bolts.	80 Nm	(59 lbf.ft)
Crankshaft rear oil seal housing bolts.	9 Nm	(7 lbf.ft)
Cylinder head bolts initial tighten	30 Nm	(22 lbf.ft)
Cylinder head bolts final tighten, then a further 90°, then a further 180° and finally a further 45°.	65 Nm	(48 lbf.ft)
Dipstick tube to camshaft carrier bolt.	10 Nm	(7 lbf.ft)
Drive plate (automatic transmission) to crankshaft bolts.	115 Nm	(85 lbf.ft)
EGR pipe clamp to cylinder head bolt.	25 Nm	(18 lbf.ft)
EGR pipe to exhaust manifold Allen screws.	10 Nm	(7 lbf.ft)
Engine mounting (front) to cylinder block bolts.	48 Nm	(35 lbf.ft)
Engine mounting (front) to chassis nuts.	85 Nm	(63 lbf.ft)
Engine mounting bracket (rear) bolts.	48 Nm	(35 lbf.ft)
Flywheel to crankshaft (manual transmission) bolts, then a further 90°	40 Nm	(30 lbf.ft)
Front crossmember bolts.	26 Nm	(20 lbf.ft)
Fuel connector block bolts.	25 Nm	(18 lbf.ft)
Fuel cooler to inlet manifold bolts.	25 Nm	(18 lbf.ft)
Gearbox housing to engine bolts.	50 Nm	(37 lbf.ft)
Heater pipe to cylinder head bolts.	25 Nm	(18 lbf.ft)
Main bearing cap bolts then a further 90°.	33 Nm	(24 lbf.ft)
Oil cooler housing to cylinder block bolts.	25 Nm	(18 lbf.ft)
Oil cooler pipe clip bolts.	9 Nm	(7 lbf.ft)
Oil filter adaptor housing to oil cooler housing bolts.	25 Nm	(18 lbf.ft)
Oil pick-up strainer screws.	10 Nm	(7 lbf.ft)
Oil pick-up strainer screws.	9 Nm	(7 lbf.ft)
Oil pressure switch.	9 Nm	(7 lbf.ft)
Oil pump drive sprocket bolt.	25 Nm	(18 lbf.ft)
Oil pump pressure relief valve plug.	25 Nm	(18 lbf.ft)
Oil pump and stiffener assembly to cylinder block bolts.	13 Nm	(10 lbf.ft)
Oil sump to cylinder block bolts.	25 Nm	(18 lbf.ft)
Oil sump to gearbox bell housing bolts.	13 Nm	(10 lbf.ft)
PAS pump bracket bolts.	27 Nm	(20 lbf.ft)
PAS pump pulley bolts.	27 Nm	(20 lbf.ft)
Rocker arm adjusting screw locknuts.	16 Nm	(12 lbf.ft)
Rocker shaft bolts.	32 Nm	(24 lbf.ft)
Timing chain adjustable guide bolt.	25 Nm	(18 lbf.ft)
Timing chain cover bolts.	27 Nm	(20 lbf.ft)
Timing chain cover to cylinder block stud.	7 Nm	(5.2 lbf.ft)

Diesel Engine Td5

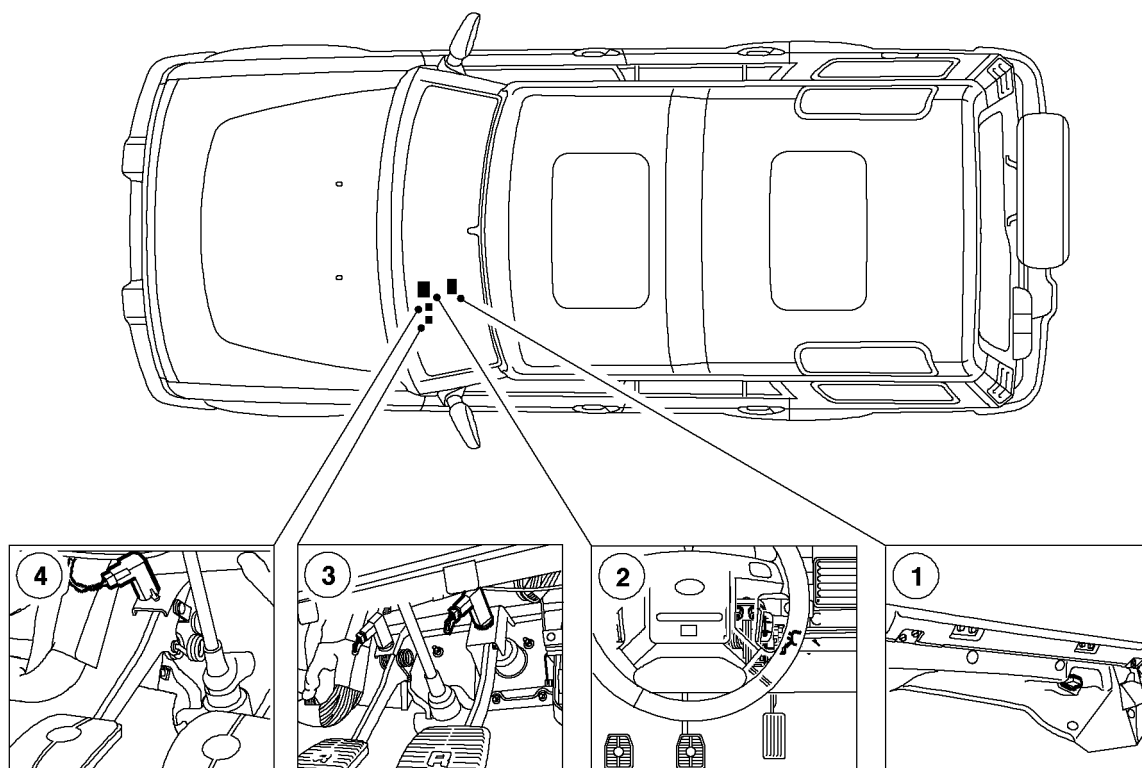
TORQUE DESCRIPTION	METRIC	IMPERIAL
Timing chain fixed guide retaining pin.	25 Nm	(18 lbf.ft)
Timing chain cover to cylinder head nut and bolt.	25 Nm	(18 lbf.ft)
Timing chain fixed guide (M6) bolt.	10 Nm	(7 lbf.ft)
Timing chain fixed guide (M10) bolt.	45 Nm	(33 lbf.ft)
Timing chain lubrication jet bolt.	10 Nm	(7 lbf.ft)
Timing chain tensioner.	45 Nm	(33 lbf.ft)
Torque converter to drive plate (automatic transmission) bolts.	50 Nm	(37 lbf.ft)
Turbocharger heatshield bolts.	9 Nm	(7 lbf.ft)
Turbocharger oil feed pipe banjo bolt.	25 Nm	(18 lbf.ft)
Turbocharger to exhaust manifold nuts.	30 Nm	(22 lbf.ft)
Vacuum pump oil feed pipe to cylinder head union.	10 Nm	(7 lbf.ft)
Viscous fan nut.	45 Nm	(33 lbf.ft)

Diesel Engine Management

Overview

The diesel electronic engine management system fitted to derivatives of New Discovery equipped with the Td5 diesel engine is referred to as the diesel modular engine management system (diesel MEMS). The system features a single engine control module located next to battery and vehicle jack.

Within the diesel MEMS system, all inputs are converted into electrical signals and processed by the ECM. Inputs are received from the driver, various sensors located strategically on and around the engine, and from other vehicle systems. The unit exercises full control over the fuel injection system and supports a sequential injection strategy by way of the EUI injectors. The system utilises 'drive by wire' technology and, therefore, does not incorporate a direct mechanical connection between the throttle pedal and the engine.



M180354

1.Diagnostic connector
2.Throttle position sensor

3.Brake pedal switch
4.Clutch pedal switch

Driver inputs

The system receives several inputs from the driver. The ECM processes the information received and controls the outputs accordingly. The driver inputs are:

- Ignition switch
- Driver demand sensor (throttle position sensor - TPS)
- Brake pedal switch
- Clutch pedal switch (manual only)
- Cruise control switch (if fitted)
- Cruise set/acceleration switch (if fitted)
- Cruise resume/suspend switch (if fitted)

Ignition switch

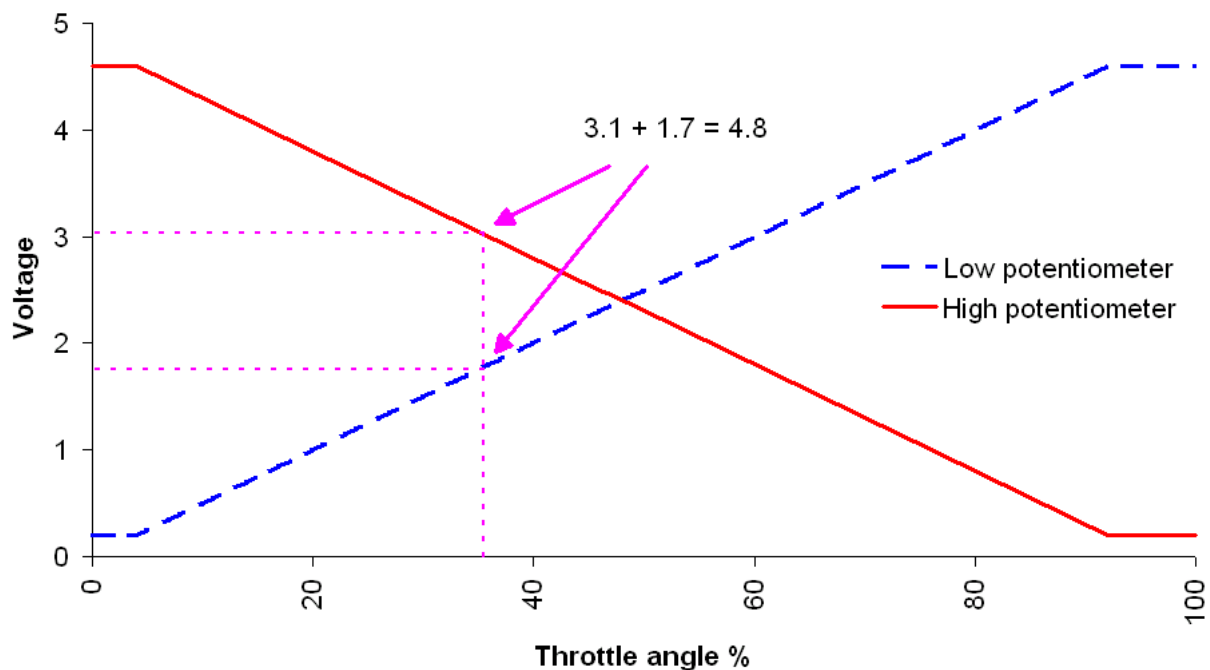
The ignition switch does not supply the ECM with a signal when the ignition switch is in position 0 or 1 (off or auxiliary). When the ECM 'wakes-up' it will complete various self-test functions and security functions in preparation for engine start. The ECM does not receive a starting signal, it only knows the engine is cranking by monitoring the crankshaft sensor.

Driver demand sensor

The driver demand sensor (TPS) is integrated into the throttle pedal housing and performs the function of the throttle position sensor. The sensor cannot be replaced separately from the throttle pedal housing and requires no adjustment in service.

The sensor comprises two opposing potentiometers housed within its body. Its body is located precisely on the throttle pedal housing and 'timed' with the position of the throttle pedal. The potentiometers are referred to as the high potentiometer and the low potentiometer. The ECM provides a 5 volt supply to both potentiometers. The ECM receives two input signals back, one from each potentiometer.

Driver demand sensor



The graph illustrates the signal returned to the ECM by the driver's demand sensor, over its complete throttle range. At idle, i.e. throttle released (0 throttle angle), the high potentiometer will return 4.6 volts, whilst the low potentiometer will return 0.2 volts. The sum of these two figures adds up to 4.8 Volts. At a 75% throttle angle (3/4 fully open), the high potentiometer will return 1.4 volts, whilst the low potentiometer will return 3.4 volts. Again the sum of these two figures adds up to 4.8 volts. The ECM uses this strategy so it can error-check the throttle signal.

Brake pedal switch

The brake pedal switch monitors the position of the brake pedal. This switch is located on the pedal housing. It comprises a main body, plunger and two internal switches. The two switches are designed to operate simultaneously in response to plunger movement. The ECM receives an input from each individual switch.

When the brake pedal is released, i.e. brakes off, one switch is normally open and one is normally closed. In this state, the open switch will not allow current to flow, whilst the closed switch will allow current to flow. When the brake pedal is pushed, i.e. brakes applied, the switches will change state. At this time the previously open switch will change state to closed and the previously closed switch will change state to open. The use of two switches increases the system's fail-safe capability.

The brake switch inputs are used by the ECM to cancel cruise control operation, if it is set at the time.

Clutch switch

The clutch switch is fitted only to vehicles equipped with a manual gearbox. The switch is an hydraulic pressure switch and is located next to the clutch master cylinder. When the clutch is engaged, i.e. pedal released, the switch will be in the open state. When the pedal is pushed and the clutch is disengaged, the switch will change to the closed state. The ECM will suspend cruise control operation in response to this change of state. The ECM will also reduce fuelling in response to this signal, to reduce engine surging (dampens the effects of fast throttle transitions to eliminate jerky vehicle movements). If the clutch switch fails at any time then the ECM will not support cruise control operation. In addition, the engine will be more susceptible to surging at times when the engine is decelerating quickly.

Cruise control switch

The cruise control switch is located in the binnacle surrounding the instrument pack. The switch is pressed by the vehicle user whenever cruise control operation is required. It is a latching switch which changes state when pressed. In response to this change of state, the ECM will enable cruise control functions.

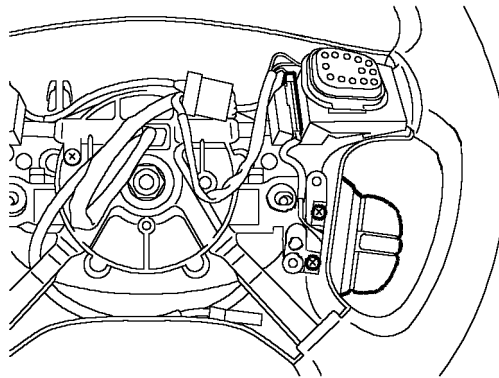
Cruise control suspend/resume switch

This switch is located on the steering wheel. It is a 'momentary' switch, i.e. it is normally open but will change state to closed when pushed and held, immediately changing back to open when released. The switch has two functions. It is used to inform the ECM that the driver wants to either suspend the operation of cruise control, or requires the cruise control system to resume operation to the same target speed as previously set.

Cruise control set/accelerate switch

This switch is also located on the steering wheel. Like the suspend/resume switch, it is a momentary switch. The switch has two functions. It is used to inform the ECM that the driver wants to either set a target speed for the cruise control system, or increase its present target speed. The precise increase in speed will depend upon the length of time the switch is held for. It is important not to depress the switch for more than 60 seconds, as this action will cause a 'stuck switch' fault within the ECM memory and will disable cruise control operation. The driver can also increment the target speed by 'tapping' the switch. This operation will raise the speed in 1.6 km/h (1 mph) increments.

Cruise control switches



The set/acceleration switch and the suspend/resume switch require the following conditions to operate:

1. The vehicle speed must be in excess of 50 km/h (32 mph)
2. The cruise control master switch must be active
3. The brake pedal must not be depressed
4. The clutch pedal must not be depressed
5. The vehicle must be in drive (automatic vehicles only); the ECM performs a 'valid gear' ratio calculation if the vehicle has manual transmission. The calculation is derived from the road speed and engine rev/min.

Engine state inputs

The engine management system requires information on the current operating conditions of the engine. It uses several electrical devices to feed back this information. It uses the information received to calculate the precise opening time and duration of the EUJ's which, in turn, determines the quantity of fuel injected into the engine.

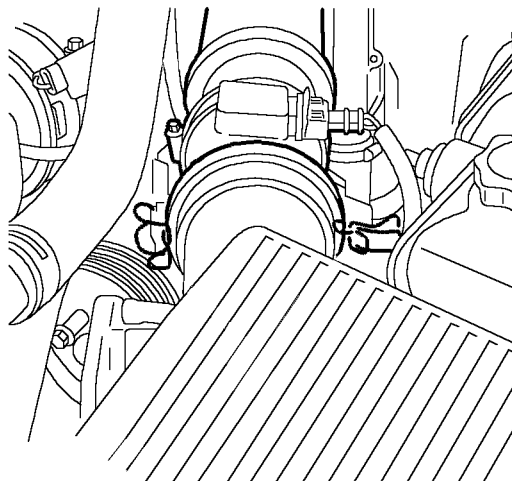
The engine state inputs are supplied to the ECM by the following:

- Mass air flow sensor (MAF)
- Ambient air pressure sensor
- Engine coolant temperature sensor (ECT)
- Crankshaft position sensor (CKP)
- Fuel temperature sensor
- Manifold absolute pressure sensor
- Inlet air temperature sensor

Air flow meter

The air flow meter is located in the 'air out' tube of the air intake box. The specification and dimensions of the air out tube are critical and determine precisely the air flow. It is, therefore, important that the air tube is not altered or modified in any way and that the air flow meter is not moved or fitted incorrectly. Any of these actions will adversely effect air flow and the performance of the air flow meter in correctly determining the quantity of air entering the engine.

Air flow meter



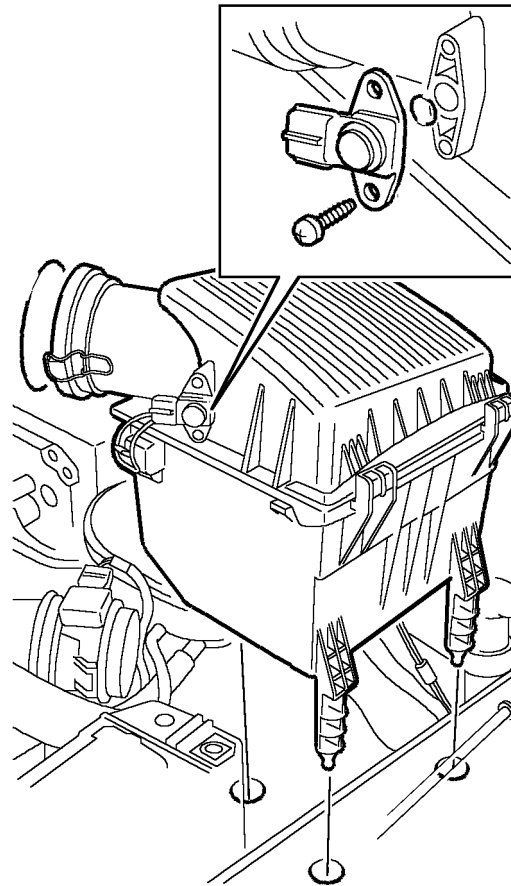
The air flow meter uses thick film technology to produce an accurate reading of the amount of air entering the engine. It operates by monitoring the amount of electrical current required to keep the film inside the meter at a predetermined temperature. The amount of current required to do this will vary in response to the amount of air entering the engine. The airflow meter modifies a voltage and returns it to the ECM in proportion to the amount of current being consumed (the amount of air entering the engine).

To help control EGR operation (see EGR description below) the ECM uses the signal supplied by the air flow meter. If the ECM detects that the air flow meter has failed, it will log a fault code. The ECM will not attempt to operate EGR while an air flow meter fault is present.

Atmospheric air pressure sensor

The ambient pressure sensor is located in the air filter housing. The unit receives a 5 volt supply from the ECM. It returns a proportion of this supply to the ECM. The value of the signal returned to the ECM enables the ECM to calculate the current atmospheric air pressure. Using this information, the ECM alters its fuelling characteristics and EGR operation. This input is particularly significant when the vehicle is travelling at high altitudes.

Ambient air pressure sensor



If the ambient pressure sensor fails, the vehicle may experience excessive exhaust emissions (smoke) when operating at altitudes above 2,000 meters (6,500 feet).

Engine coolant temperature sensor

The engine coolant temperature sensor is located in the water outlet elbow. It is in direct contact with the engine coolant. It supplies a non-linear (NTC) analogue output voltage to the ECM, which it uses to determine the temperature of the engine coolant. The ECM uses this information to modify its basic fuelling calculations. The ECM sends the engine coolant signal to the instrument pack to drive the temperature gauge. The ECM also uses the signal supplied by the coolant temperature sensor to alter the condenser fan and compressor clutch operation, whenever the engine coolant temperature exceeds a predetermined value.

If the signal from the engine coolant temperature sensor is interrupted or corrupted at any time, a back-up signal will be implemented. The ECM calculates the value of this signal. The calculation is based on the amount of time for which the engine has been operating, at the point the sensor failed and other temperature related information such as the fuel temperature and air temperature values. The ECM is not able to display the engine coolant temperature via the temperature gauge, or give excess temperature warnings at times when a back-up signal is implemented.

Crankshaft speed and position sensor

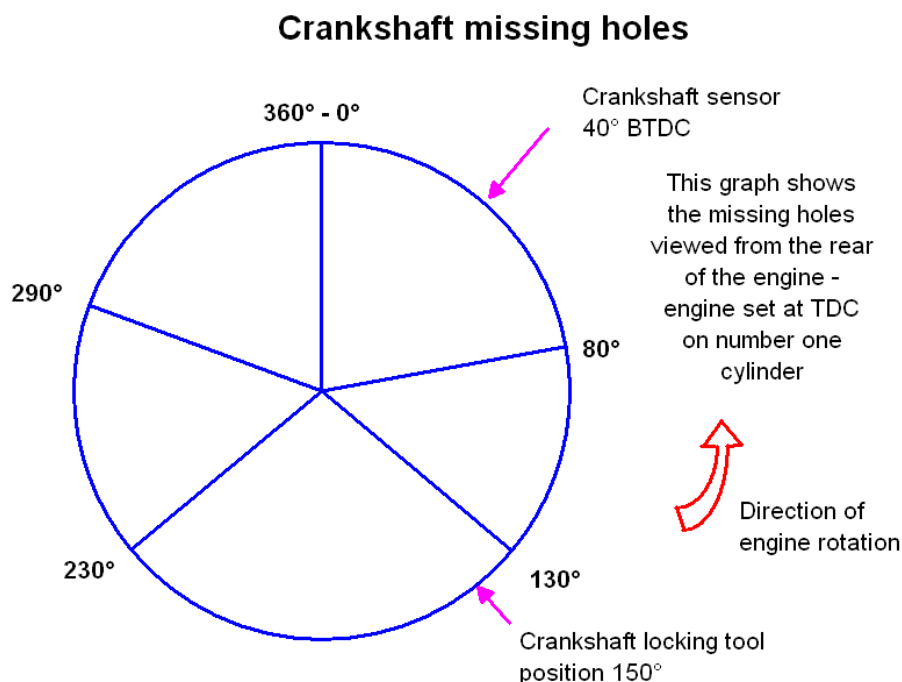
The crankshaft position sensor is an inductive sensor. It is located in the gearbox bell housing. It provides a signal to the ECM which enables it to calculate the exact speed and position of the crankshaft. The signal is supplied to the ECM in the form of an analogue sine wave. This signal is generated by the sensor in response to holes drilled into the circumference of the flywheel or drive plate. These holes are in close proximity to the end of the crankshaft position sensor. As the flywheel rotates, the holes alter the magnetic flux formed around the end of the sensor. The change in magnetic flux caused by this movement generates the voltage signal.



As previously mentioned, the crankshaft is drilled at 10 intervals and features 5 missing holes. Because the missing holes are positioned at uneven intervals around the circumference of the flywheel, the ECM is able to calculate the exact position of the crankshaft within each 360 of rotation.

In addition to detecting the crankshaft position, the ECM is able to assess relative acceleration and deceleration of the crankshaft, caused by a pistons compression cycle and firing strokes. This function is explained in the section on diesel engine strategies.

The signal supplied to the ECM by the crankshaft position sensor is used to support its fuelling strategy. The ECM also uses this signal to calculate engine speed and supplies this information to a number of other vehicle systems. The ECM is also able to calculate the exact position of the crankshaft relative to the firing position of the engine. This information is used to calculate the exact point of injection.



If the signal from the crankshaft position sensor fails or is corrupted the engine will cease to run and will not start again until the problem has been rectified. The MIL lamp will also be illuminated in these circumstances.

Fuel temperature sensor

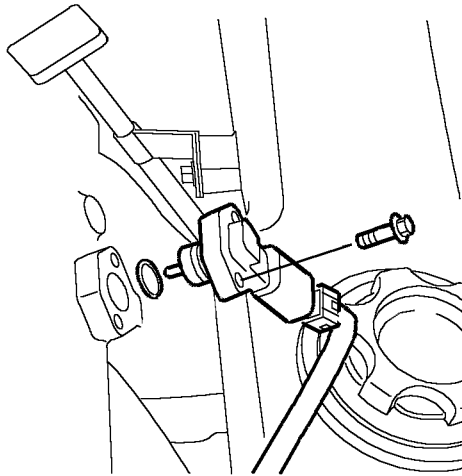
The fuel temperature sensor is located in the fuel connector block at the rear of the engine. It is in direct contact with the fuel and measures its temperature continuously between a range of -40°C to 140°C (-40°F to 285°F). The ECM uses this information within its fuelling strategy. It ensures the appropriate quantity of fuel is injected into the engine to compensate for any change in density caused by a change in the fuel's temperature.

If the signal from the fuel temperature sensor is interrupted or corrupted at any time then the ECM will implement a predetermined default value of 60°C (140°F).

Absolute manifold pressure sensor and air temperature sensor

The manifold absolute pressure sensor and intake air temperature sensor are both located within a single unit. The unit is located on the inlet manifold. It supplies two dedicated signals to the ECM relating to the pressure within the manifold and the temperature of the air entering the engine. This information is used by the ECM within its fuelling strategy. It is also used to control the amount of turbocharger boost pressure.

Manifold air pressure and temperature sensor



If the manifold pressure signal is interrupted or corrupted at any time the ECM will use a predetermined default value of 100 kPa in its place. The use of the default value will always result in a reduction in engine performance, as the ECM will assume a 'safe' fuelling/boost map in these circumstances. If the intake air temperature signal fails then a fixed default value of 60°C (140°F) will be assumed.

Digital inputs from other vehicle systems

The following additional vehicle systems communicate with the EMS ECM:

- The air conditioning system
- The automatic gearbox
- The SLABS ECU
- BCU
- Inertia switch

Air conditioning

The air conditioning (ATC) ECU communicates requests for the compressor clutch and cooling fan operation to the EMS ECM. The ECM will enable operation as requested at all times, other than when the driver requires full engine torque or the engine coolant exceeds certain parameters.

Operation of the cooling fans is required whenever the compressor clutch is engaged to aid condenser cooling. It is also activated when the coolant temperature exceeds a predetermined value.

The automatic gearbox

The automatic gearbox TCU communicates with the ECM via the CAN bus. The precise nature of the information transmitted and received is described in detail in the section entitled Automatic gearbox.

The automatic gearbox TCU cannot illuminate the MIL lamp on diesel engine applications.

If the CAN bus fails, then the EMS ECM and the gearbox TCU will both register the fault, providing both ECUs receive a power and an ignition feed. The automatic gearbox will also default into 3rd or 4th gear depending upon the current operating conditions.

SLABS interface

The EMS ECM communicates directly with the SLABS ECU. It provides information related to the driver demand, engine torque and engine type. The SLABS ECU sends information to the EMS ECM related to a rough road signal, a vehicle speed signal and a fault signal.

The two units use pulse width modulation (PWM) to transfer this information between each other through a single wire. If the communication link between the two units fails at any time, then the HDC and cruise control features are suspended. Details of any fault detected at this time will be stored in both systems fault memories.

BCU

The EMS ECM and the BCU communicate with one another regarding the status of the security system (specifically engine immobilisation). In service, the ECM must receive a coded signal from the BCU before each engine start. If this signal is not received, or not recognised, then the ECM will disable the engine management system, which will cause the engine to stall immediately after initially starting. If either the BCU or the ECM is replaced in service, then this code will need to be reset using TestBook. The engine immobilisation signal is transmitted in a PWM form. This ensures the minimum wiring is required.

Inertia switch

The inertia switch is located on the bulkhead under-bonnet, behind the exhaust turbocharger. It is wired in series with the main relay. Whenever the inertia switch is tripped by a sudden deceleration of the vehicle (over and above the capacity of the braking system), the main power feed to the ECM will be interrupted. This action will stop the fuel pump and the engine by means of the ECM no longer operating the EUI's. The vehicle will not restart until the inertia switch has been reset.

ECM outputs

Like all electronic control units the EMS ECM collects information, processes it and then sends signals back out. On New Discovery the ECM controls the following systems:

- Electronic unit injectors (EUI)
- Electronic EGR vacuum modulator (Japanese specification has two)
- Turbocharger wastegate modulator
- Malfunction indicator lamp (MIL)
- Glowplug lamp
- Glowplug relay
- Air conditioning compressor clutch
- Air conditioning condenser fans
- Main ECM supply relay
- Fuel pump relay
- Tachometer
- Temperature gauge

Electronic unit injectors

There are five EUI's located in the cylinder head (one per cylinder). The ECM controls the operation of each EUI by supplying a voltage to activate its solenoid. The exact timing of this voltage and the calibration coding associated with the EUI's is explained in the section on the Td5 diesel engine.

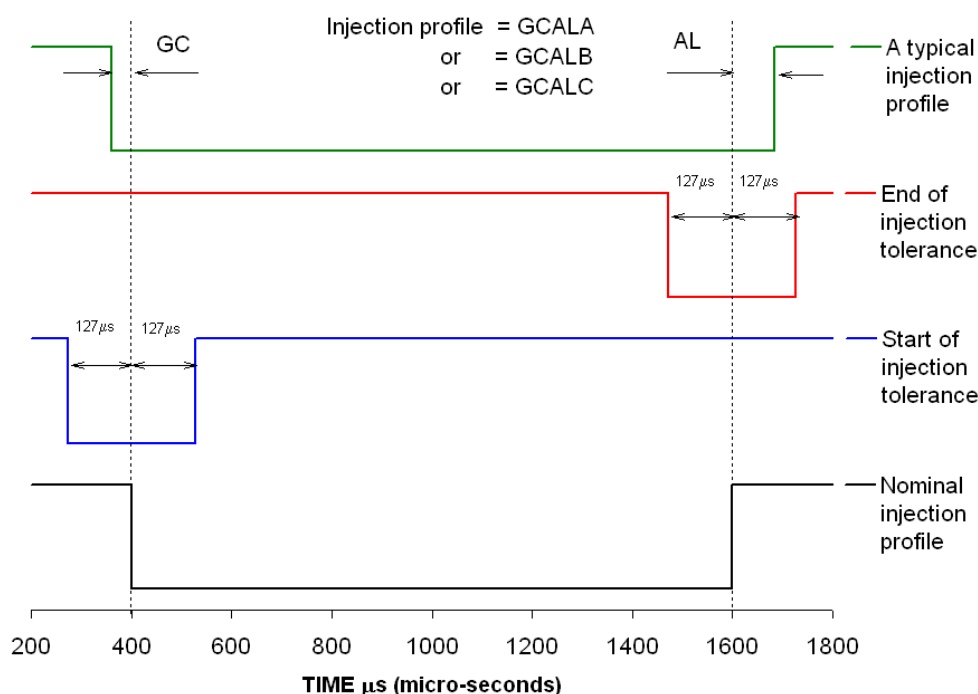
The ECM does not simply switch the voltage 'on' and 'off' to operate the injectors. Instead, it controls the amount of current supplied to each EUI solenoid. It calculates the current requirement using a current/time relationship map stored within the ECM.

The ECM uses a strategy of 'hit and hold' when operating the EUI's. This strategy will initially allow a very large current to flow to the solenoid 'hit'. This ensures the injector opens very quickly. After approximately 20% of the injection period, the ECM will start to pulse the current supplied to the solenoid 'hold'. By doing this the overall current consumption of each injector can be reduced and the amount of heat energy generated inside the ECM can be reduced.

On top of the injector there is a five letter code. This code is used in the EUI calibration process. It details the exact performance or 'profile' of the injector. Each injector is tested after manufacture and is measured against a nominal start of injection point, end of injection point and an idle quality factor. The graph below demonstrates how this alpha code is used to tighten the tolerance of the EUI.

The first two letters of the alpha code refer to the degree of variance from a nominal injector to the measured injectors start point. The second two letters in the alpha code refer to the end of the injectors tolerance. The tolerance band for the start and end of injection is 127mS (0.000127 seconds). The last letter in the alpha code is a measured variance in idle performance. The injector is given one of three idle letters: A, B or C.

Injection profile



The alpha codes used for both the start point and the end point are not sequential, i.e. not AA through to ZZ. The codes have been picked at random to stop the possibility of deliberately over-fuelling the engine in the search for greater performance.

The letters do not denote that one injector is better than another injector. The letters give the ECM the mapping adjustment needed for that particular injector, to enable very precise fuelling and smooth idle performance.

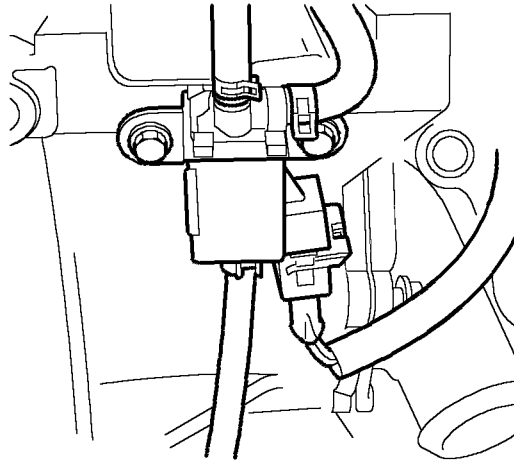
It is important that the injector code is programmed into the ECM if an injector is replaced, or if the order of the injectors is mixed up. This procedure is completed with the aid of TestBook.

The injectors are operated electrically by the ECM, which is able to produce a voltage of approximately 80 volts at 8 amps to shut the injector spill port. This is a considerable amount of electrical energy. Appropriate care should be taken while working with a running engine.

Turbocharger wastegate modulator

The turbocharger wastegate modulator is located on the engine, by the air conditioning compressor mounting platform. The modulator enables the ECM to control the quantity of exhaust gas passing the turbocharger turbine and, therefore, the pressure of the air entering the engine. The ECM monitors the pressure and temperature of the intake air continuously. Using this information, it calculates the maximum boost pressure the inlet manifold should be experiencing and controls the turbocharger wastegate modulator by supplying a PWM signal to ensure that this maximum is not exceeded. The ECU cannot increase the boost pressure, it can only reduce it.

Turbocharger wastegate modulator



Malfunction indicator lamp

The malfunction indicator lamp (MIL) is located in the instrument pack. The ECM will illuminate the lamp for 2 seconds whenever the ignition is switched on. This will allow the driver to check the operation of the bulb. In certain circumstances, the ECM will illuminate the MIL lamp to inform the driver that a fault with the EMS has been detected. However, most engine/EMS faults will not illuminate the MIL lamp. See description of inputs for full details.

Glowplug lamp

The glowplug lamp is located in the instrument pack. The ECM will illuminate the lamp whenever the driver switches the ignition switch from position I to position II, as long as it detects the need to operate the glowplugs. No attempt to start the engine should be made before the ECM extinguishes the glowplug lamp.

It should be noted that the operation of the warning lamp does not necessarily coincide with the operation of the glow plugs. The ECM will supply a voltage to the glowplugs whenever it identifies a need, regardless of the status of the glowplug lamp in the instrument pack.

Glow plugs

There are only four glowplugs fitted to the engine (number five cylinder is not fitted with one). The ECM activates the glowplugs via a relay. When activated the glowplugs heat to approximately 1000°C (1800°F). Τη ηεατ γενερατεδ βψ τηε γλωωπλυγσ ηελπσ τηε ατομισεδ fuel injected into the engine to vaporise and combust.

The ECM activates the glowplugs by energising the glowplug relay. It does this to provide the engine with both preheat and post-heat, (i.e. before the engine is started and when the engine is running but still cold). The amount of preheat provided is determined by battery voltage and engine coolant temperature. The amount of post-heat provided is determined by engine coolant temperature only.

Post-heat is provided to reduce emissions created by slower combustion of the fuel at times when the engine is still cold, and to give the engine greater stability when idling. If the coolant temperature sensor fails at any time, then the ECM will implement default preheat and post-heat times.

Air conditioning compressor clutch relay & condenser relay

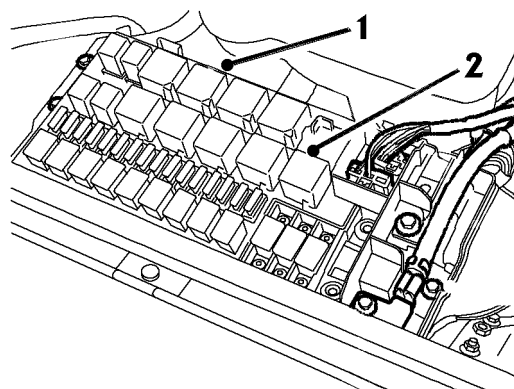
The ECM has full control over the operation of the condenser fans and the compressor clutch. If the engine coolant temperature rises and/or the air conditioning ECU indicates the refrigerant pressure is high, the ECM will supply a path to ground, thus energising the condenser fan relay. If the ECM receives a request from the air conditioning ECU to run the compressor, then the ECM will supply a path to ground, and so energise the compressor clutch relay. The ECM has final control because of the need to protect engine performance and to prepare the engine for the extra load if the engine is idling.

Main relay and fuel pump relay

The main relay and the fuel pump relay are located in the engine compartment fusebox.

The ECM controls the operation of the main relay (which supplies the ECM) and the fuel pump relay. The ECM needs to control its own power so that it can operate its 'power down' strategy. This strategy operates as follows: When the driver switches the ignition off, the ECM is signalled to start the power down sequence. The precise duration of the power down sequence will vary according to the status of the engine at the time when the ignition is switched off. At the end of the sequence the ECM will allow the main relay to switch off. At this time, the main power source to the ECM is switched off. A time period of at least 15 seconds should be allowed for this process to complete. If the ECM detects that it is likely the engine temperature will exceed a given value, the ECM will remain active until the coolant temperature starts to decline. In this condition it may take several minutes before the ECM finally powers down.

Fusebox



1.Main EMS relay
2.Fuel pump relay

Tachometer and coolant temperature signal

The ECM receives an engine speed signal from the crankshaft position sensor. It uses this information within its fuelling strategies, as previously described. It also forwards an engine speed signal to the instrument pack. The frequency of the signal reflects the current engine speed. The tachometer then converts this frequency signal into a pulse width modulated (PWM) signal which it uses to drive the needle.

The ECM also supplies the instrument pack with a signal relating to the current engine coolant temperature. The signal is supplied by the ECM in PWM form. The instrument pack will drive the engine temperature gauge needle to the appropriate position to indicate engine temperature. If the instrument pack does not receive the signal at any time, it will assume the engine temperature is cool. In these circumstances, the instrument pack will illuminate the engine overheat warning lamp.

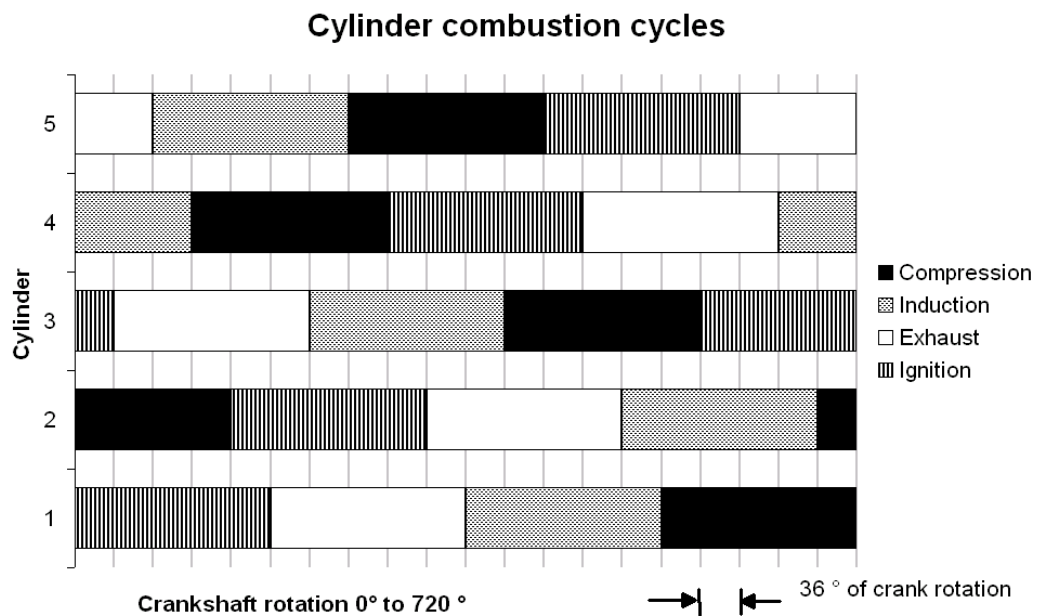
ECM strategies

The ECM uses the system input signals to calculate the precise injection timings and quantity of fuel required by the engine during all running conditions. The ECM supports a sequential fuel injection strategy, i.e. it times the injection of fuel to each individual cylinder's requirements.

Engine position calculations

To ensure the ECM injects fuel at the correct time, it must know the exact position of the crankshaft and the firing point of each cylinder. In a sequential conventional EMS system (where this information is required), a camshaft sensor is used to provide the ECM with the firing point information. The Td5 engine is not fitted with a camshaft position sensor. Therefore, the ECM used on the Td5 engine employs a different strategy to identify the firing position of each cylinder.

In this application, the signal provided by the crankshaft position sensor identifies the exact position of the crankshaft within each revolution. This information enables the ECM to determine which one of the five pistons is approaching TDC at any given time.



In the Td5 diesel engine, the crankshaft speed 'slows' as each piston travels up the bore on its compression stroke. The graph identifies the compression cycle over 720 ° of crankshaft rotation. This characteristic allows the ECM to determine the firing position of the engine using the relative acceleration and deceleration of the pulses within the engine speed signal provided by the crankshaft sensor.

Engine idle strategy

The ECM uses a different fuelling strategy when idling than when not idling. The use of these two different strategies ensures the ECM maximises the efficiency of the engine.

As previously mentioned, the EUI's inject fuel when the camshaft lobe, via the rocker shaft assembly, forces the plunger down inside the injector. The ECM decides when to close off the spill port during the plungers descent to control the injector opening time. When the engine is accelerating or under load, the ECM will shut off the spill port earlier and leave it closed for longer. This has the effect of advancing the ignition point and injecting more fuel into the engine.

When the driver requires the engine to idle, the ECM injects a small quantity of fuel twice within each firing cycle (at two different points within the downward stroke of the injector plunger). It does this to support a pre-burn cycle inside the combustion chamber, which occurs prior to the main combustion cycle. Engine noise is reduced using this strategy and the engine idle characteristics are improved still further.

Starting strategy

The ECM implements an excess fuel strategy to initiate combustion when starting. When the engine is cranking, the ECM ignores the driver's demand sensor (TPS) and fuels the engine according to its starting strategy. This strategy is dependent on the temperatures of the fuel, engine coolant and intake air.

Anti-surge strategies

The ECM incorporates software to control the rate of engine acceleration and deceleration. This feature, referred to as the anti-surge strategy, “damps” the engines response when changing gear (engine does not flare). It also improves the vehicles driving characteristics in circumstances when the driver's demand is lower than the current engine speed (i.e. lifting off). The software inside the ECM alters the rate at which the engine decelerates to suit the conditions. This rate will alter according to the current engine rev/min, the target rev/min and the duration of engine deceleration. The rate of deceleration will also increase if the driver depresses the clutch (activating the clutch switch).

The anti-surge strategy is cancelled if the driver selects low range. This improves the engine braking performance when the vehicle is travelling at low speeds.

Fuel purging strategy

If the vehicle runs out of fuel, or the fuel level is so low that the fuel system draws air into the fuel rail, the fuel rail will need to be purged before the engine will start. This can be achieved by following a set procedure. The process does not require the use of any specialist equipment and can be performed by the driver of the vehicle. The process is as follows:

1. Turn off the ignition
 2. Wait 15 seconds
 3. Turn the ignition 'on' (position II) for 30 seconds
 4. Turn the ignition off (position I or 0) for 5 seconds
- Repeat items 3 and 4 a total of six times. i.e. 6 times 30 seconds = 3 minutes
5. Option 1: The vehicle has run out of fuel, or a new injector has been fitted.
Depress the throttle pedal to more than 90% of its total travel (to the throttle stop)
- Option 2: An injector has been removed or the fuel rail drained.
- Do not** depress the throttle
6. Crank the engine keeping the throttle pedal depressed

The ECM will then enter fuel purging mode. This mode will initiate after 10 engine rotations. Once initiated, the ECM will inject approximately 4 times the maximum quantity of fuel into the engine. This excess fuel delivery will help purge any air from the EUI's. It is important that this purging sequence is not initiated on a vehicle that has not run out of fuel. If it is carried out unnecessarily it can lead to the engine flooding and failing to start.

This mode of operation will be cancelled:

1. As soon as the engine speed exceeds 600 rev/min.
2. The driver allows the throttle pedal to close to a position less than 90% of its travel.
3. The key is released from position III (start). There is no direct electrical connection between the ECM and position III of the ignition switch, the ECM detects the engine has stopped cranking by the lack of signal from the crankshaft sensor.

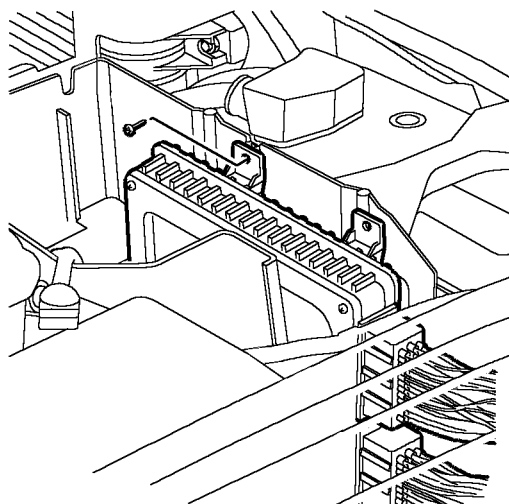
It should also be noted that the engine must not be cranked for more than 30 seconds in any one period.

If the engine does not start during this initial period of purging, the driver of the vehicle will need to repeat the sequence.

Configuration

The ECM needs to be configured before it will operate correctly. There are two levels of configuration. If the ECM or the BCU is replaced in service, the immobilisation code will need to be reconfigured. The engine will not run unless this operation has been completed. The ECM will also need to be configured with the vehicle details. This process must be carried out when the ECM is first fitted to the vehicle, or whenever a new ECM is fitted in service.

Engine control module



Connector C0158

Pin No.	Input/Output	Function	Signal type	Value	Interfaces
A1	Output	Injector 5	Analogue	0	
A2	Not used				
A3	Output	EGR modulator	Digital	0-12	
A4	Not used				
A5	Input	FT sensor earth	0 volts	0	
A6	Input	MAP sensor	Analogue	0-5 volts	
A7	Input	ECT sensor	Analogue	0-5 volts	
A8	Sensor supply	Sensor supply	5 volts	5 volts	
A9	HT pin				
A10	Input	AAP sensor	Analogue	0-5 volts	
A11	Input	MAF sensor	Analogue	0-5 volts	
A12	Not used				
A13	Input	CKP sensor positive	Analogue		
A14	Not used				
A15	Input	Sensor earth 5	0 volts	0 volts	
A16	Input	CKP sensor screened earth	0 volts	0 volts	
A17	Input	Sensor earth 6	0 volts	0 volts	
A18	Input	Sensor earth 3	0 volts	0 volts	
A19	Input	FT sensor	Analogue	0-5 volts	
A20	Input	Sensor earth 2	0 volts	0 volts	
A21	Output	Turbocharger wastegate modulator	Digital	0-12 volts	
A22	Output	Injector common 2	Analogue	0-85 volts	
A23	Output	Injector common 1	Analogue	0-85 volts	
A24	Output	Injector 4	Analogue	0 volts	
A25	Output	Injector 1	Analogue	0 volts	
A26	Output	Injector 2	Analogue	0 volts	
A27	Output	Injector 3	Analogue	0 volts	
A28	Not used				
A29	Output	Glow plug relay	Analogue	0-90 volts	
A30	Input	Sensor earth 4	0 volts	0 volts	
A31	Not used				
A32	Input/Output	CAN negative	Digital	2.5-5 volts	EAT
A33	Input	High/ low ratio switch	Digital	0-5 volts	EAT, SLABS
A34	Input	IAT sensor	Analogue	0-5 volts	
A35	Input/Output	Can positive	Digital	2.5-5 volts	EAT
A36	Input	CKP sensor negative	0 volts	0 volts	

Connector C0658

Pin No.	Input/Output	Function	Signal type	Value	Interfaces
B1	Input	Earth 1	0 volts	0 volts	
B2	Input	Earth 4	0 volts	0 volts	
B3	Input	Supply battery voltage	12 volts	12 volts	
B4	Output	Cooling fan relay	Switch	12-0 volts	A/C ECU
B5	Output	Fuel pump relay	Switch	12-0 volts	
B6	Output	MIL	Switch	12-0 volts	Instruments
B7	Output	Temperature gauge	Digital	0-12 volts	Instruments
B8	Not used				
B9	Input	A/C clutch request	Switch	12-0 volts	A/C ECU
B10	Input	Normally closed brake switch	Switch	12-0 volts	
B11	Input	Cruise control SET+ switch	Switch	12-0 volts	
B12	Input	TP sensor 1	Analogue	0- volts	
B13	Input	Vehicle speed	Digital	0-12 volts	
B14	Input	TP sensor supply	5 volts	5 volts	
B15	Input	Cruise control master switch	Switch	12-0 volts	
B16	Input	Normally open brake switch	Switch	0-12 volts	
B17	Input	Cruise control RES switch	Switch	12-0 volts	
B18	Input/Output	Serial communication link	Digital	0-12 volts	All ECU's
B19	Output	Tachometer engine speed	Digital	0-12 volts	Instrument Cluster
B20	Not used				
B21	Output	Main relay	Switch	0-12 volts	
B22	Input	Supply battery voltage	12 volts	12 volts	
B23	Input	A/C fan request	Switch	12-0 volts	
B24	Input	Earth 3	0 volts	0 volt	
B25	Input	Earth 2	0 volts	0 volts	
B26	Input	TP sensor earth	0 volts	0volts	
B27	Input	Supply 2	12 volts	12 volts	
B28	Not used				
B29	Output	A/C relay	Switch	12-0 volts	
B30	Output	Glow plug warning light	Switch	12-0 volts	Instrument Cluster
B31	Not used				
B32	Output	ABS	digital	0-5 volts	SLABS
B33	Input	Ignition	Switch	0-12 volts	
B34	Input	Security code	digital	0-5 volts	
B35	Input	Clutch switch	Switch	12-0 volts	
B36	Input	TP sensor 2	Analogue	5-0 volts	

The ECM also needs to be programmed with the 5 sets of injector alpha codes. These codes relate to the EUI calibration (see diesel engine section). A new ECM is programmed with blank codes. If EUI codes are not entered at this stage, the ECM will allow the engine to rev up to a maximum of only 3,000 rev/min.

The ECM cannot verify the EUI alpha codes. If incorrect codes are entered, engine performance will be significantly impaired. This process must also be carried out when one or more injectors are replaced, or the order of injectors in the cylinder head is unknown.

ECM wiring connection

The ECM has two ports, the wire colours and destination should always be referenced from the ERL, but are included in this document to support this course.

Connector C0158

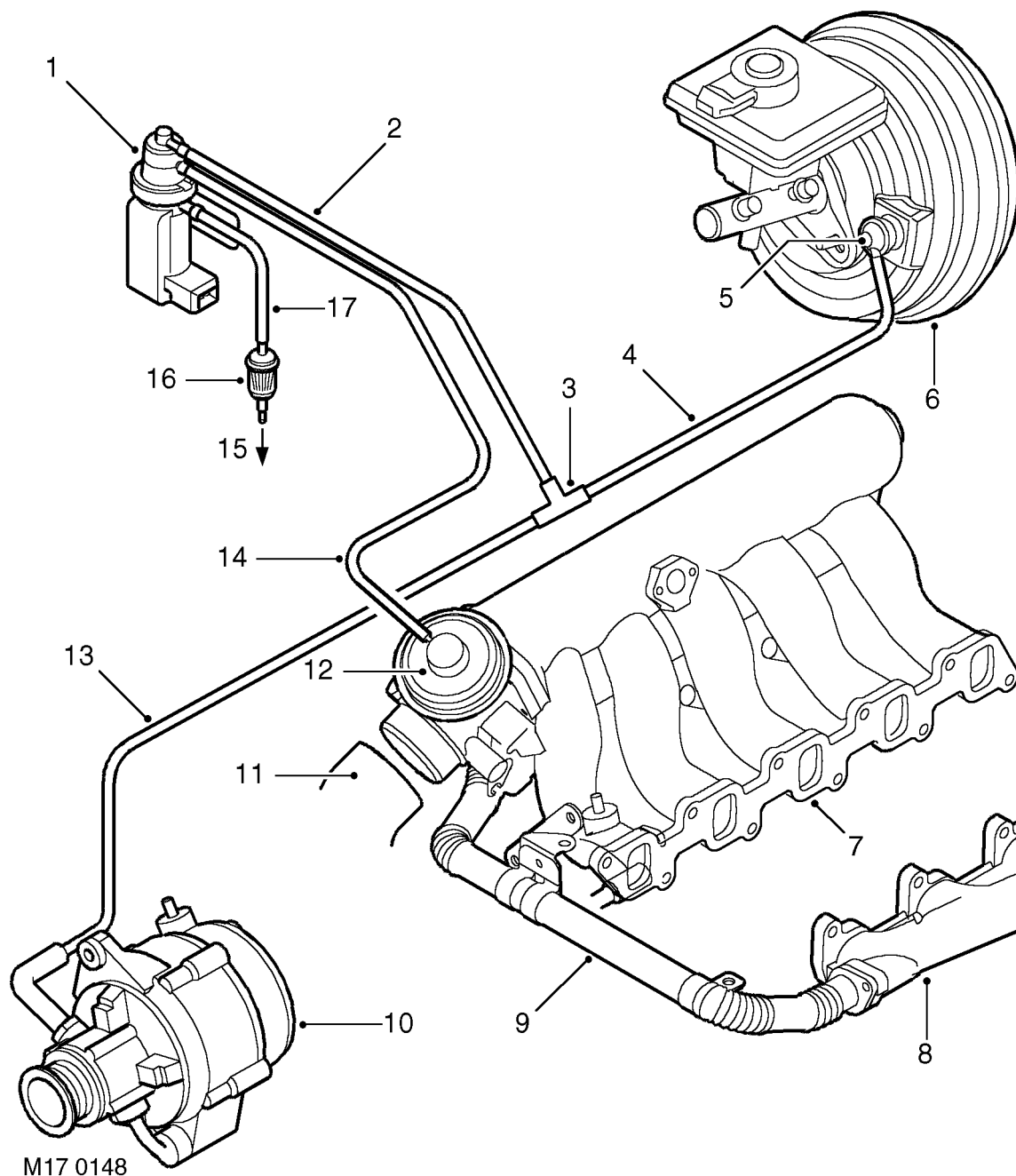
Pin No.	Input/Output	Function	Signal type	Value	Interfaces
A1	Output	Injector 5	Analogue	0	
A2	Not used				
A3	Output	EGR modulator	Digital	0-12	
A4	Not used				
A5	Input	FT sensor earth	0 volts	0	
A6	Input	MAP sensor	Analogue	0-5 volts	
A7	Input	ECT sensor	Analogue	0-5 volts	
A8	Sensor supply	Sensor supply	5 volts	5 volts	
A9	HT pin				
A10	Input	AAP sensor	Analogue	0-5 volts	
A11	Input	MAF sensor	Analogue	0-5 volts	
A12	Not used				
A13	Input	CKP sensor positive	Analogue		
A14	Not used				
A15	Input	Sensor earth 5	0 volts	0 volts	
A16	Input	CKP sensor screened earth	0 volts	0 volts	
A17	Input	Sensor earth 6	0 volts	0 volts	
A18	Input	Sensor earth 3	0 volts	0 volts	
A19	Input	FT sensor	Analogue	0-5 volts	
A20	Input	Sensor earth 2	0 volts	0 volts	
A21	Output	Turbocharger wastegate modulator	Digital	0-12 volts	
A22	Output	Injector common 2	Analogue	0-85 volts	
A23	Output	Injector common 1	Analogue	0-85 volts	
A24	Output	Injector 4	Analogue	0 volts	
A25	Output	Injector 1	Analogue	0 volts	
A26	Output	Injector 2	Analogue	0 volts	
A27	Output	Injector 3	Analogue	0 volts	
A28	Not used				
A29	Output	Glow plug relay	Analogue	0-90 volts	
A30	Input	Sensor earth 4	0 volts	0 volts	
A31	Not used				
A32	Input/Output	CAN negative	Digital	2.5-5 volts	EAT
A33	Input	High/ low ratio switch	Digital	0-5 volts	EAT, SLABS
A34	Input	IAT sensor	Analogue	0-5 volts	
A35	Input/Output	Can positive	Digital	2.5-5 volts	EAT
A36	Input	CKP sensor negative	0 volts	0 volts	

Connector C0658

Pin No.	Input/Output	Function	Signal type	Value	Interfaces
B1	Input	Earth 1	0 volts	0 volts	
B2	Input	Earth 4	0 volts	0 volts	
B3	Input	Supply battery voltage	12 volts	12 volts	
B4	Output	Cooling fan relay	Switch	12-0 volts	A/C ECU
B5	Output	Fuel pump relay	Switch	12-0 volts	
B6	Output	MIL	Switch	12-0 volts	Instruments
B7	Output	Temperature gauge	Digital	0-12 volts	Instruments
B8	Not used				
B9	Input	A/C clutch request	Switch	12-0 volts	A/C ECU
B10	Input	Normally closed brake switch	Switch	12-0 volts	
B11	Input	Cruise control SET+ switch	Switch	12-0 volts	
B12	Input	TP sensor 1	Analogue	0- volts	
B13	Input	Vehicle speed	Digital	0-12 volts	
B14	Input	TP sensor supply	5 volts	5 volts	
B15	Input	Cruise control master switch	Switch	12-0 volts	
B16	Input	Normally open brake switch	Switch	0-12 volts	
B17	Input	Cruise control RES switch	Switch	12-0 volts	
B18	Input/Output	Serial communication link	Digital	0-12 volts	All ECU's
B19	Output	Tachometer engine speed	Digital	0-12 volts	Instrument Cluster
B20	Not used				
B21	Output	Main relay	Switch	0-12 volts	
B22	Input	Supply battery voltage	12 volts	12 volts	
B23	Input	A/C fan request	Switch	12-0 volts	
B24	Input	Earth 3	0 volts	0 volt	
B25	Input	Earth 2	0 volts	0 volts	
B26	Input	TP sensor earth	0 volts	0volts	
B27	Input	Supply 2	12 volts	12 volts	
B28	Not used				
B29	Output	A/C relay	Switch	12-0 volts	
B30	Output	Glow plug warning light	Switch	12-0 volts	Instrument Cluster
B31	Not used				
B32	Output	ABS	digital	0-5 volts	SLABS
B33	Input	Ignition	Switch	0-12 volts	
B34	Input	Security code	digital	0-5 volts	
B35	Input	Clutch switch	Switch	12-0 volts	
B36	Input	TP sensor 2	Analogue	5-0 volts	

Exhaust gas recirculation

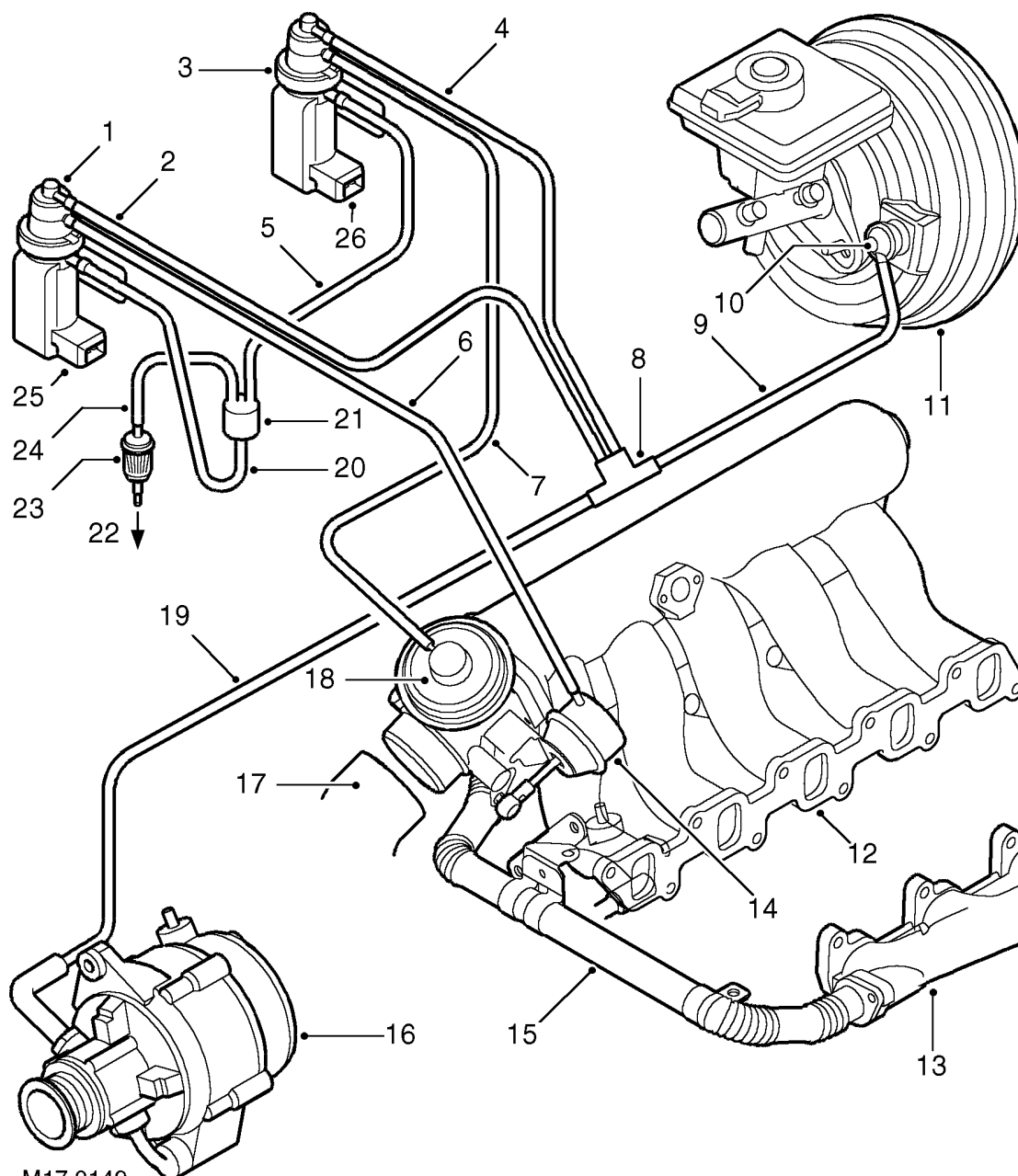
The exhaust gas recirculation system can be one of two types.



M17 0148

- 1.EGR valve modulator
- 2.Vacuum hose (brown)
- 3.'T'-piece
- 4.Vacuum hose to brake-servo
- 5.Non-return valve
- 6.Brake-servo
- 7.Inlet manifold
- 8.Exhaust manifold

- 9.EGR pipe
- 10.Vacuum pump/alternator assembly
- 11.Air intake hose from intercooler
- 12.EGR valve assembly
- 13.Vacuum hose to vacuum pump
- 14.Vacuum hose to EGR valve suction port (blue)
- 15.To atmosphere
- 16.In-line filter
- 17.Vent hose – modulator to in-line filter (green)



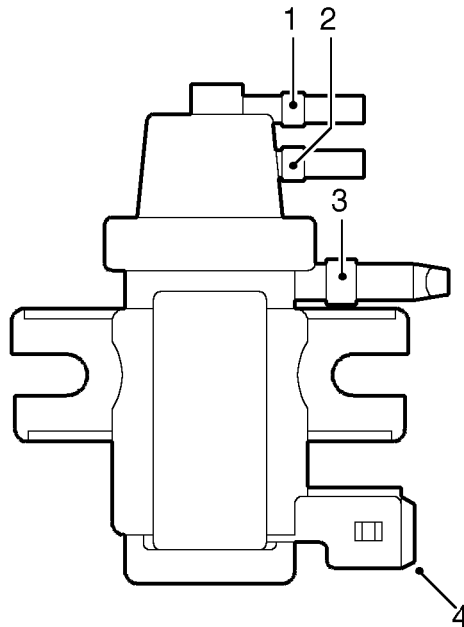
M17 0149

- | | |
|---|--|
| 1.ILT valve modulator | 14.ILT valve |
| 2.ILT modulator vacuum hose (brown) | 15.EGR pipe |
| 3.EGR valve modulator | 16.Vacuum pump / alternator assembly |
| 4.EGR modulator vacuum hose (brown) | 17.Air intake hose from intercooler |
| 5.Vent hose – EGR modulator to in-line filter (green) | 18.EGR valve(incorporating ILT valve) assembly |
| 6.Vacuum hose to ILT valve suction port (blue) | 19.Vacuum hose to vacuum pump |
| 7.Vacuum hose to EGR valve suction port (blue) | 20.Vent hose – ILT valve modulator to in-line filter (green) |
| 8.'T'-piece (4-way) | 21.3-way connector |
| 9.Vacuum hose to brake-servo | 22.To atmosphere |
| 10.Non-return valve | 23.In-line filter |
| 11.Brake-servo | 24.Vent hose – in-line filter to 3-way connector |
| 12.Inlet manifold | 25.ILT modulator harness connector (green) |
| 13.Exhaust manifold | 26.EGR modulator harness connector (black) |

Electronic exhaust gas recirculation vacuum modulator

The electronic vacuum regulator is located in the engine compartment, on the left-hand side under the coolant expansion tank when viewed from the front of the vehicle. It is secured on a rubber mounting, which is designed to reduce the level of operating noise transferred though to the vehicles passenger compartment. If the vehicle is to Japanese specification, the additional modulator is located next to it.

Electronic exhaust gas recirculation modulator



M17 0150

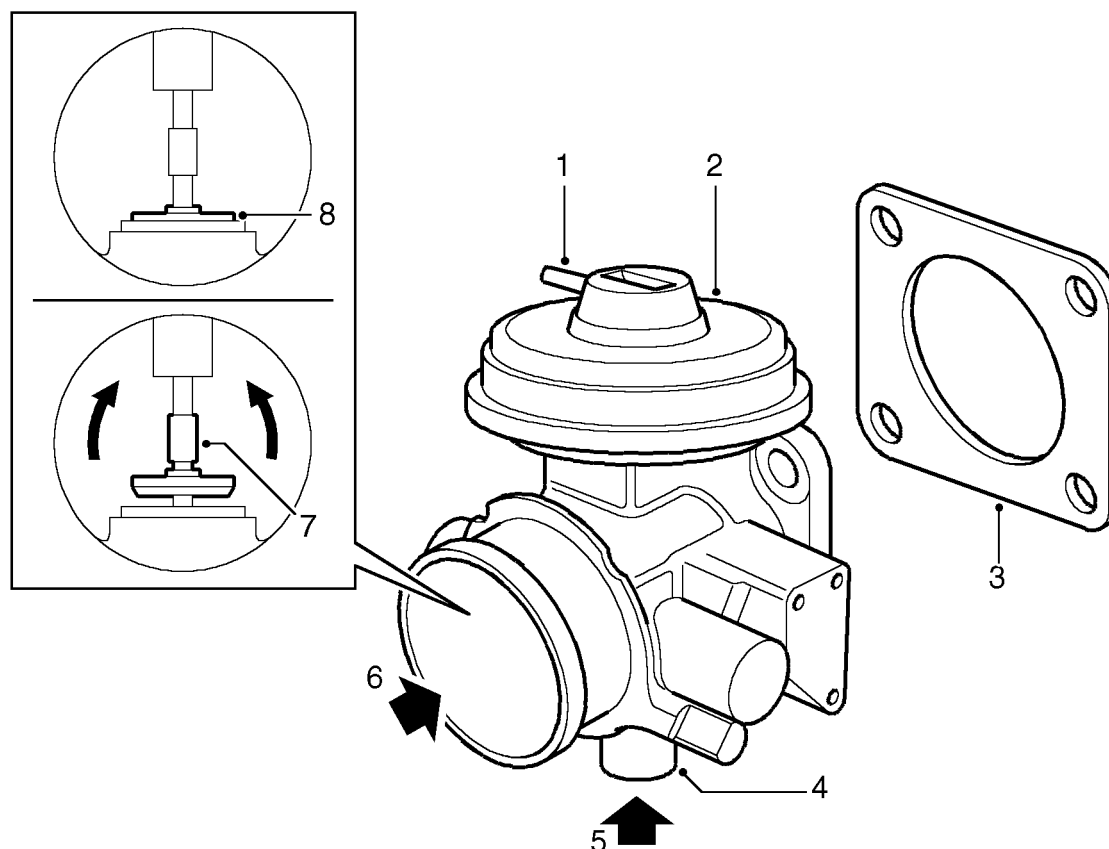
The modulator connects to three vacuum pipes:

1. The first pipe connects the modulator to the vacuum source (i.e. the vacuum pump located on the engine)
2. The second pipe connects the regulator to the EGR valve
3. The third pipe is connected to a filter mounted on the rear of the plate. The other side of the filter is unconnected and allows the air to fill the vacuum previously generated to increase the amount of exhaust gas entering the engine via the EGR modulator valve
4. The electrical connection

The ECM controls the modulator using a PWM signal (Japanese specification additional modulator is controlled in the same manner).

Vehicles built to a Japanese specification incorporate an additional EGR exhaust modulator. This additional modulator controls an inlet manifold butterfly which creates an additional vacuum in the inlet manifold, so increasing the quantity of exhaust gas draw into the manifold under certain engine operating conditions.

EGR Valve



M17 0153

- 1.EGR valve vacuum port
- 2.EGR valve assembly
- 3.Gasket – EGR valve to inlet manifold
- 4.EGR pipe connection

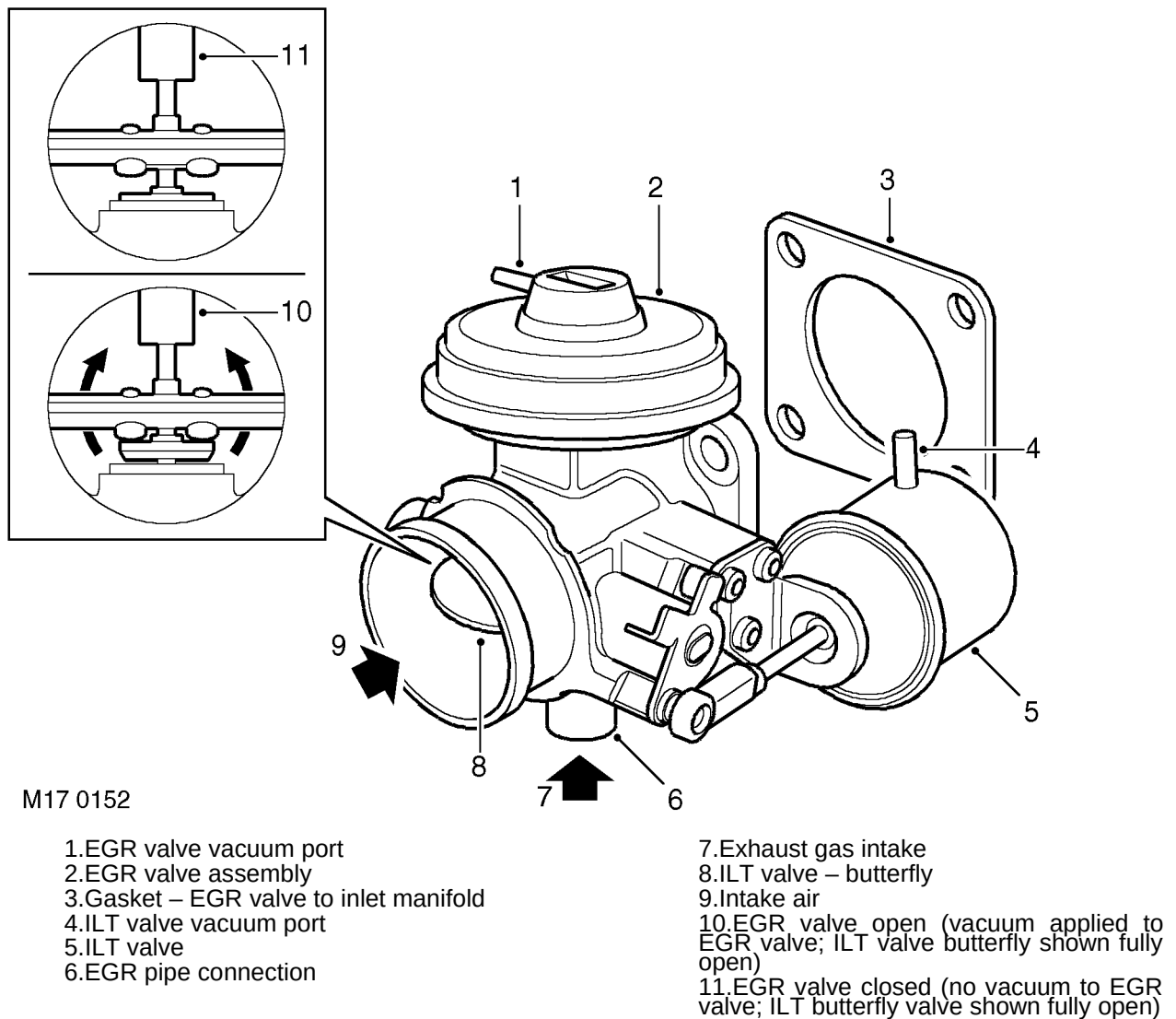
- 5.Exhaust gas intake
- 6.Intake air
- 7.EGR valve open (vacuum applied to EGR valve)
- 8.EGR valve closed (no vacuum to EGR valve)

The EGR valve is a cast and machined assembly which locates on the front end of the inlet manifold assembly. The machined faces of the EGR assembly and the inlet manifold are attached together using four screws passing through the four corners of a flange in the EGR assembly to tappings in the front face of the inlet manifold. A gasket is used to seal the interface between the EGR valve and the front face of the inlet manifold. The gasket should be changed every time the EGR valve assembly is removed from the air intake manifold.

The intake side of the EGR valve allows the passage of fresh intercooled air through to the inlet manifold via a rubber hose which is attached to the front face of the EGR valve assembly by a metal band clamp. The bottom port of the EGR valve is connected to the EGR pipe using a metal band clamp.

A vacuum port on top of the EGR valve connects to the EGR modulator through a blue, small-bore suction hose. When a vacuum is applied to the EGR valve suction port it causes a spindle with sealing disc (EGR valve) to be raised, thereby opening the port at the EGR pipe to allow the recirculated exhaust gas to pass through into the inlet manifold. When the vacuum is removed from the suction port the EGR valve returns to its rest position under the influence of a spring to tightly close the exhaust gas port. Thus controlled opening of the EGR valve determines the mass of recirculated exhaust gas allowed to flow through to the inlet manifold.

Inlet Throttle (ILT) Valve



The ILT valve is used on certain exhaust gas recirculation systems in addition to the standard EGR valve described above. The ILT valve assembly is mounted at right angles to the EGR valve on the left hand side of the EGR valve assembly. It is fixed to the EGR valve assembly by three screws.

A vacuum port on top of the ILT valve connects to the ILT modulator through a blue, small-bore suction hose. When a vacuum is applied to the inlet throttle (ILT) valve suction port, a butterfly valve in the inlet manifold closes via a spindle and lever mechanism, limiting the supply of fresh intercooled air and creating a depression in the intake manifold which in turn causes a greater suction at the open port to the EGR delivery pipe. When the vacuum source is removed from the ILT valve suction port, a spring returns the butterfly to its fully open position. The ILT valve and EGR valve are operated in conjunction to control the proportional masses of fresh intake air and recirculated exhaust gas that is allowed to flow through to the inlet manifold.

The EGR valve and ILT valve should be replaced as a single assembly.

EGR system - type 1

This EGR system features a single modulator which is electrically controlled to modulate a vacuum source to the EGR valve. The controlled vacuum opens and closes the valve by the amount required to ensure the optimal proportion of exhaust gas is allowed through to the inlet manifold to be combined with the fresh air intake. Control feedback is achieved by monitoring the mass of fresh air flowing through the mass air flow sensor.

The modulator operation is controlled by a signal from the ECM which determines the required amount of EGR needed in response to inputs relating to air flow and engine operating and ambient conditions. The ECM is low-side driven, sinking current returned from the vacuum modulator for switching operating condition.

The exhaust gases are routed from the exhaust manifold through a shaped metal pipe which connects to the underside of the EGR valve. The pipe is held securely in position to the front of the cylinder head using a clamp bracket. The EGR pipe is attached to a mating port at the front end of the exhaust manifold using two Allen screws and at the EGR valve assembly by a metal band clamp. The two Allen screws fixing the EGR pipe to the exhaust manifold should be replaced every time the EGR pipe is removed. **Extreme care should be exercised when removing and refitting the EGR pipe to avoid damage.**

When a vacuum is applied to the EGR suction port, it causes a spindle with sealing disc (EGR valve) to be raised, thus opening the port at the EGR pipe to allow the recirculated exhaust gas to pass through into the inlet manifold. The valve is spring loaded so that when the vacuum is removed from the suction port the valve returns to its rest position to tightly close the exhaust gas port.

By controlling the quantity of recirculated exhaust gas available in the inlet manifold, the optimum mix for the prevailing engine operating conditions can be maintained, which ensures the intake gas to the combustion chambers will have burning rate properties which will reduce the NO_x emissions to an acceptable level. Normally, full recirculation is only applicable when the NO_x emissions are most prevalent.

EGR system - type 2

This system features twin modulators mounted one above the other on a metal plate located on the inner wing at the RH side of the engine. The modulators are electrically controlled by the engine management system and are used to modulate a vacuum source to the EGR valve and a supplementary Inlet Throttle (ILT) valve; the two valves are controlled to operate in tandem. The ILT valve vacuum pot is mounted adjacent to the EGR valve housing and has a linkage which connects to a butterfly valve mounted in front of the EGR valve at the air intake manifold.

The modulator operations are electrically controlled by signals from the engine management system which determines the required volume of exhaust gas needed in response to inputs relating to air flow, engine operating conditions and ambient parameters such as temperature and altitude. The engine management ECU switches on the circuit by completing the path to ground, operating the vacuum modulators..

The exhaust gases are routed from the exhaust manifold through a shaped metal pipe which connects to the underside of the EGR valve. The pipe is held securely in position to the front of the engine cylinder head using a metal clamp bracket. The EGR pipe is attached to a mating port at the front end of the exhaust manifold using two Allen screws and at the EGR valve assembly by a metal band clamp. The two Allen screws fixing the EGR pipe to the exhaust manifold should be replaced every time the EGR pipe is removed. **Extreme care should be exercised when removing and refitting the EGR pipe to avoid damage.**

When a vacuum is applied to the EGR suction port, it causes a spindle with sealing disc (EGR valve) to be raised, opening the port at the EGR pipe to allow the recirculated exhaust gas to pass through into the inlet manifold. The valve is spring loaded so that when the vacuum is removed from the suction port the valve returns to its rest position to tightly close the exhaust gas port.

A vacuum is simultaneously applied to the inlet throttle (ILT) valve suction port which causes the butterfly valve in the inlet manifold to close by means of a spindle and lever mechanism. Closing the butterfly valve limits the supply of fresh intercooled air entering the inlet manifold and causes a depression within the inlet manifold to create a greater suction at the open port to the EGR delivery pipe. In this condition a greater mass of recirculated exhaust gas is drawn into the inlet manifold for use in the combustion process. When the vacuum is released from the ILT valve suction port a spring returns the butterfly valve to its fully open position.

By controlling the quantities of recirculated exhaust gas and fresh intake air available in the inlet manifold, the optimum mix for the prevailing engine operating conditions can be maintained which ensures the intake gas to the combustion chambers will have burning rate properties which will reduce the NO_x emissions to an acceptable level. Normally, full recirculation is only applicable when the NO_x emissions are most prevalent.

TestBook diagnostics

The ECM supports on board diagnostics (OBD). To do this it monitors its inputs and the effects of its outputs. If it detects that an implausible signal (a signal of a value which significantly differs from the expected value), it assumes a fault exists. It will store a fault code in its memory and initiate the appropriate strategy.

TestBook incorporates software designed to interrogate the ECM's memory. It can be used in service to retrieve fault codes and assist with diagnostics. The faults stored by the ECM are categorised into two states.

1. Historical - This flag will be set if the fault has previously happened once in the vehicles past, or until the last time TestBook cleared the fault code memory
2. Present - This flag is set if the fault currently exist within the system

This additional information on the status of a fault code is included in the majority of the TestBook diagnostics. It can aid with diagnosing a fault within the system.

Fault codes remain inside the ECM memory until they are removed using TestBook.

Real time data

TestBook can retrieve and display input data received by the ECM. This information can be used to analyse system performance in cases where a fault condition is suspected. TestBook can display single or multiple readings.

When a single reading is displayed, TestBook displays the current value of the signal being examined, the plausible value of the signal (minimum/maximum) and an explanation of the reading.

If multiple readings are displayed, no written information on the acceptable parameters will be displayed.

TestBook can also drive many of the ECM outputs via the ECM. This feature can be used to test systems which are currently outside their normal operating parameters (e.g. the ECM can be made to drive an injector solenoid without the engine running).