Range Rover

Workshop Manual

Werkplaatshandboek

Manual d'Atelier

Werkstatthandbuch

Manuale d'Officina

Manual de Taller

Manual de Oficina

Workshop manual
RANGE ROVER
VOLUME 1

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This manual covers vehicles from introduction 1995

This manual supersedes:
Workshop manual VDR100370
Body Repair Manual LRL0085

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INFORMATION

INTRODUCTION

This workshop manual covers the New Range Rover vehicle from introduction in 1995, and is designed to be used in conjunction with Electrical Troubleshooting Manual LRL0329 and Electrical Circuit Diagrams YVB101590 (2nd Edition). Amendments and additional pages will be issued to ensure that the manual covers latest models. Amendments and additions will be identified by the addition of a dated footer at the bottom of the page.

This Workshop Manual is designed to assist skilled technicians in the efficient repair and maintenance of Range Rover vehicles.

Individuals who undertake their own repairs should have some skill and training, and limit repairs to components which could not affect the safety of the vehicle or its passengers. Any repairs required to safety critical items such as steering, brakes, suspension or supplementary restraint system should be carried out by a Range Rover Dealer. Repairs to such items should NEVER be attempted by untrained individuals.

WARNINGS, CAUTIONS and **NOTES** are given throughout this Manual in the following form:

WARNING: Procedures which must be followed precisely to avoid the possibility of personal injury.

CAUTION: This calls attention to procedures which must be followed to avoid damage to components.

NOTE: This calls attention to methods which make a job easier or gives helpful information.

DIMENSIONS

The dimensions quoted are to design engineering specification. Alternative unit equivalents, shown in brackets following the dimensions, have been converted from the original specification.

REFERENCES

References to the left or right hand side in the manual are made when viewing the vehicle from the rear. With the engine and gearbox assembly removed, the water pump end of the engine is referred to as the front.

To reduce repetition, some operations covered in this Manual do not include reference to testing the vehicle after repair.

It is essential that work is inspected and tested after completion and if necessary a road test of the vehicle is carried out particularly where safety related items are concerned.

REPAIRS AND REPLACEMENTS

When replacement parts are required it is essential that Range Rover parts are used.
Attention is particularly drawn to the following points concerning repairs and the fitting of replacement parts and accessories: Safety features embodied in the vehicle may be impaired if other than Range Rover parts are fitted. In certain territories, legislation prohibits the fitting of parts not to the vehicle manufacturer's specification. Torque spanner values given in the Workshop Manual must be strictly adhered to. Locking devices, where specified, must be fitted. If the efficiency of a locking device is impaired during removal it must be replaced with a new one. Certain fasteners must not be re-used. These fasteners are specified in the Workshop Manual.

POISONOUS SUBSTANCES

Many liquids and other substances used are toxic and should not be consumed under any circumstances, and should be kept away from open wounds. These substances amongst others include anti-freeze, brake fluid, fuel, oil, windscreen washer additives, air conditioning refrigerant, lubricants and various adhesives.

FUEL HANDLING PRECAUTIONS

The following information provides basic precautions which must be observed if fuel is to be handled safely. It also outlines other potential risks which must not be ignored.

This information is issued for basic guidance only; in any case of doubt, seek advice from your local Fire Officer or Fire Department.

Fuel vapour is highly flammable and in confined spaces is also very explosive and toxic.

When fuel evaporates it produces 150 times its own volume in vapour, which when diluted with air becomes a readily ignitable mixture. The vapour is heavier than air and will always fall to the lowest level. It can readily be distributed throughout a workshop by air currents, consequently, even a small spillage of fuel is very dangerous.

Always have a fire extinguisher containing **FOAM CO_2 GAS,** or **POWDER** close at hand when handling fuel, or when dismantling fuel systems and in areas where fuel containers are stored.

WARNING: It is imperative that the battery is not disconnected during fuel system repairs as arcing at the battery terminal could ignite fuel vapour in the atmosphere. Always disconnect the vehicle battery BEFORE carrying out work on the fuel system.

Whenever fuel is being handled, transferred or stored, or when fuel systems are being dismantled, all forms of ignition must be extinguished or removed, any leadlamps used must be flame proof and kept clear of spillage.

No one should be permitted to repair components associated with fuel without first having had fuel system training.

Hot fuel handling precautions

WARNING: Before commencing any operation requiring fuel to be drained from the fuel tank, the following procedure must be adhered to:

1. Allow sufficient time for the fuel to cool, thus avoiding contact with hot fuels.
2. Vent the system by removing the fuel filler cap in a well ventilated area. Refit the filler cap until the commencement of fuel drainage.

Fuel transfer

WARNING: Fuel must not be extracted or drained from any vehicle while it is standing over a pit.

The transfer of fuel from the vehicle fuel tank must be carried out in a well ventilated area. An approved transfer tank must be used according to the transfer tank manufacturer's instructions and local regulations, including attention to grounding of tanks.

Fuel tank removal

A **FUEL VAPOUR** warning label must be attached to the fuel tank upon removal from the vehicle.

Fuel tank repair

Under no circumstances should a repair to any tank be attempted.

SYNTHETIC RUBBER

Many 'O' ring seals, flexible pipes and other similar items which appear to be natural rubber are made of synthetic materials called Fluoroelastomers. Under normal operating conditions this material is safe, and does not present a health hazard. However, if the material is damaged by fire or excessive heat, it can break down and produce highly corrosive Hydrofluoric acid which can cause serious burns on contact with skin. Should the material be in a burnt or overheated condition, handle only with seamless industrial gloves. Decontaminate and dispose of the gloves immediately after use.

If skin contact does occur, remove any contaminated clothing immediately and obtain medical assistance without delay. In the meantime, wash the affected area with copious amounts of cold water or limewater for fifteen to sixty minutes.

RECOMMENDED SEALANTS

A number of branded products are recommended in this manual for use during maintenance and repair work.
These items include:
HYLOMAR GASKET AND JOINTING COMPOUND
and
HYLOSIL RTV SILICON COMPOUND.

They should be available locally from garage equipment suppliers. If there is any problem obtaining supplies, contact the following company for advice and the address of the nearest supplier.

MacDERMID LUBRICANTS LTD.
Hylo House,
Cale lane,
New Springs,
Wigan
WN2 1JR
United Kingdom

Tel: 01942 824242
Fax: 01942 501110

USED ENGINE OIL

WARNING: Prolonged and repeated contact with engine or motor oil will result in the removal of natural fats from the skin, leading to dryness, irritation and dermatitis.

Used engine oil contains potentially harmful contaminants which may cause skin cancer. Adequate means of skin protection and washing facilities should be provided.

Handling precautions

1. Avoid prolonged and repeated contact with oils, particularly used engine oils.
2. Wear protective clothing, including impervious gloves where applicable.
3. Do not put oily rags in pockets.
4. Avoid contaminating clothes, particularly underwear, with oil.
5. Overalls must be cleaned regularly. Discard unwashable clothing and oil impregnated footwear.
6. First aid treatment must be obtained immediately for open cuts and wounds.
7. Use barrier creams, before each work period, to help the removal of oil from the skin.
8. Wash with soap and water to ensure all oil is removed (skin cleansers and nail brushes will help). Preparations containing lanolin replace the natural skin oils which have been removed.
9. Do not use gasoline, kerosene, diesel fuel, petrol, thinners or solvents for washing the skin.
10. If skin disorders develop, obtain medical advice.
11. Where practicable, degrease components prior to handling.
12. Where there is a risk of eye contact, eye protection should be worn, for example, goggles or face shields; in addition an eye wash facility should be provided.

Disposing of used oils

Environmental protection precaution

It is illegal to pour used oil onto the ground, down sewers or drains, or into waterways.

Dispose of used oil through authorised waste disposal contractors. If in doubt, contact your Local Authority for advice on disposal facilities.

ACCESSORIES AND CONVERSIONS

DO NOT FIT unapproved accessories or conversions, as they could affect the safety of the vehicle.
Land Rover will not accept liability for death, personal injury, or damage to property which may occur as a direct result of the fitment of non-approved conversions to the Range Rover.

WHEELS AND TYRES

WARNING: DO NOT replace the road wheels with any type other than genuine Range Rover wheels which are designed for multi-purpose on and off road use and have very important relationships with the proper operation of the suspension system and vehicle handling. Replacement tyres must be of the make and sizes recommended for the vehicle, and all tyres must be the same make, ply rating and tread pattern.

CAUTION: When refitting a road wheel, apply a suitable anti-seize compound such as Raworth 33/04, to the spigot bore of the wheel. This will prevent possible seizure of the wheel to the hub spigot. Ensure that no compound comes into contact with the braking components.

STEAM CLEANING

To prevent consequential rusting, any steam cleaning within the engine bay **MUST** be followed by careful re-waxing of the metallic components affected.
Particular attention must be given to the steering column, engine water pipes, hose clips and ignition coil clamp.

SPECIFICATION

The specification details and instructions set out in this Manual apply only to a range of vehicles and not to any particular one. For the specification of a particular vehicle, purchasers should consult their Dealer.
The Manufacturers reserve the right to vary their specifications with or without notice, and at such times and in such manner as they think fit. Major as well as minor changes may be involved in accordance with the Manufacturer's policy of constant product improvement.

While every effort is made to ensure the accuracy of the particulars contained in this Manual, neither the Manufacturer nor Dealer, by whom this Manual is supplied, shall in any circumstances be held liable for any inaccuracy or the consequences thereof.

SPECIAL SERVICE TOOLS

The use of approved special service tools is important. They are essential if service operations are to be carried out efficiently, and safely. Where special tools are specified, **only these tools should be used to avoid the possibility of personal injury or damage to the components.** Also the amount of time which they save can be considerable.

Every special tool is designed with the close co-operation of Land Rover, and no tool is put into production which has not been tested and approved by us. New tools are only introduced where an operation cannot be satisfactorily carried out using existing tools or standard equipment. The user is therefore assured that the tool is necessary and that it will perform accurately, efficiently and safely.

Special tools bulletins will be issued periodically giving details of new tools as they are introduced.

All orders and enquiries from the United Kingdom should be sent direct to V. L. Churchill. Overseas orders should be placed with the local V. L. Churchill distributor, where one exists. Countries where there is no distributor may order direct from:

V. L. Churchill Limited,
PO Box 3,
Daventry, Northants,
England, NN11 4NF.

The tools recommended in this Workshop Manual are listed in a multi-language illustrated catalogue, publication number **LPA ST ML 95**, which is obtainable from V. L. Churchill Limited at the above address.

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JACKING

The following instructions must be carried out before raising the vehicle off the ground.

1. Use a solid level ground surface.
2. Apply parking brake.
3. Select 'P' or 1st gear in main gearbox.
4. Select Low range in transfer gearbox.

CAUTION: To avoid damage occurring to the under body components of the vehicle the following jacking procedures must be adhered to.

DO NOT POSITION JACKS OR AXLE STANDS UNDER THE FOLLOWING COMPONENTS.

Body structure	**Air suspension pipes**
Bumpers	**Fuel lines**
Brake lines	**Front radius arms**
Panhard rod	**Steering linkage**
Rear Trailing links	**Fuel tank**
Engine sump	**Gearbox bell housing**

CAUTION: If supporting vehicle by the front crossmember, the safety stands must be positioned carefully to avoid damage to air suspension pipes.

Vehicle jack

The jack provided with the vehicle is only intended to be used in an emergency, for changing a wheel. Do **NOT** use the jack for any other purpose. Refer to Owner's Manual for vehicle jack location points and procedure. Never work under a vehicle supported by the vehicle jack.

Hydraulic jack

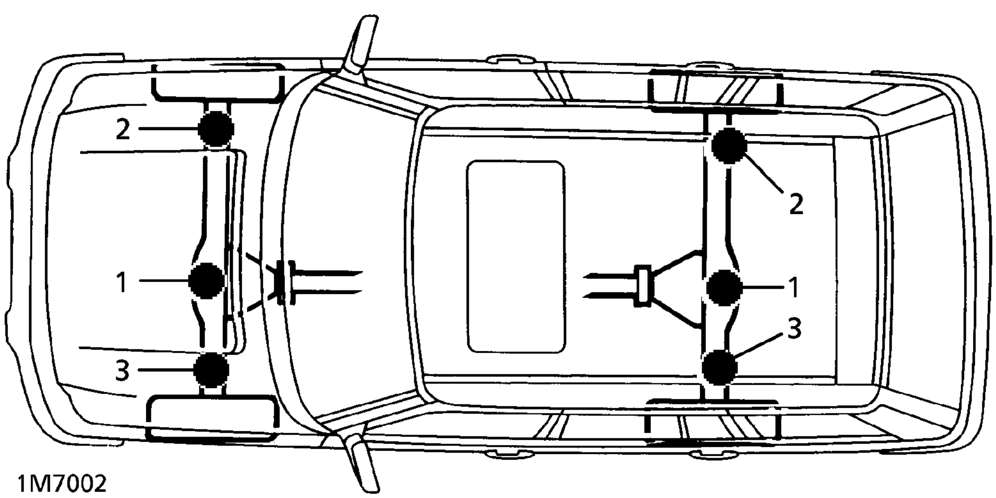
A hydraulic jack with a minimum 1500 kg, 3,300 lbs load capacity must be used.

CAUTION: Do not commence work on the underside of the vehicle until suitable axle stands have been positioned under the axle.

Raise the front of the vehicle

1. Position cup of hydraulic arm under differential casing.

NOTE: The differential casing is not central to the axle. Care should be taken when raising the front road wheels off the ground as the rear axle has less sway stiffness.



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2. Raise front road wheels to enable an axle stand to be installed under left hand axle tube.
3. Position an axle stand under right hand axle tube, carefully lower jack until axle sits securely on both axle stands, remove trolley jack.
4. Before commencing work on underside of vehicle re-check security of vehicle on stands.
5. Reverse procedure when removing vehicle from stands.

Raise rear of vehicle

1. Position cup of hydraulic arm under differential casing.
2. Raise vehicle to enable axle stands to be installed under left and right hand axle tubes.
3. Lower jack until axle sits securely on axle stands, remove trolley jack.
4. Before commencing work on underside of vehicle re-check security of vehicle on stands.
5. Reverse procedure when removing vehicle from stands.

HYDRAULIC VEHICLE RAMP (FOUR POST)

Use only a 'drive on' type ramp which supports vehicle by its own road wheels. If a 'wheel-free' condition is required, use a 'drive on' ramp incorporating a 'wheel-free' system that supports under axle casings. Alternatively, place vehicle on a firm, flat floor and support on axle stands.

TWO POST VEHICLE RAMPS

The manufacturer of RANGE ROVER VEHICLES DOES NOT recommend using 'Two Post' ramps that employ four adjustable support arms. These are NOT considered safe for Range Rover vehicles.
If a vehicle is installed on a Two Post ramp, responsibility for safety of the vehicle and personnel performing service operations is attributable to the Service Provider.

DYNAMOMETER TESTING - VEHICLES WITH ANTI-LOCK BRAKES (ABS)

WARNING: Do not attempt to test ABS function on a dynamometer

Four wheel dynamometers

NOTE: Before testing a vehicle on a four wheel dynamometer disconnect the valve relay. *See Electrical Trouble Shooting Manual.*
The ABS function will not work, the ABS warning light will illuminate. Normal braking will be available.

Provided that front and rear rollers are rotating at identical speeds and that normal workshop safety standards are applied, there is no speed restriction during testing except any that may apply to the tyres.

Two wheel dynamometers

IMPORTANT: Use a four wheel dynamometer for brake testing if possible.

NOTE: ABS will not function on a two wheel dynamometer. The ABS light will illuminate during testing. Normal braking will be available.

If brake testing on a single rig is necessary it must be carried out with propeller shaft to the rear axle removed, AND neutral selected in BOTH main and transfer boxes.

If checking engine performance, the transfer box must be in high range and drive shaft to stationary axle removed.

WARNING: Vehicles from 99 MY are fitted with 4 wheel traction control, which must be disabled prior to testing on a single axle dynamometer.

JUMP STARTING

WARNING: Hydrogen and oxygen gases are produced during normal battery operation. This gas mixture can explode if flames, sparks or lighted tobacco are brought near battery. When charging or using a battery in an enclosed space, always provide ventilation and shield your eyes.

Keep out of reach of children. Batteries contain sulphuric acid. Avoid contact with skin, eyes, or clothing. Also, shield eyes when working near battery to protect against possible splashing of acid solution. In case of acid contact with skin, eyes, or clothing, flush immediately with water for a minimum of fifteen minutes. If acid is swallowed, drink large quantities of milk or water, followed by milk of magnesia, a beaten egg, or vegetable oil. SEEK MEDICAL AID IMMEDIATELY.

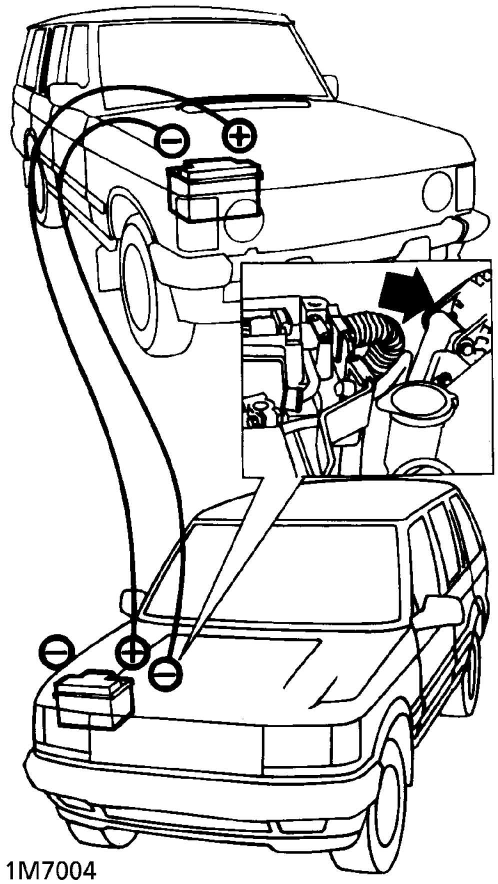
To Jump Start - Negative Ground Battery

WARNING: To avoid any possibility of injury use particular care when connecting a booster battery to a discharged battery.

1. Position vehicles so that jump leads will reach, ensuring that vehicles **DO NOT TOUCH,** alternatively a fully charged slave battery may be positioned on floor adjacent to vehicle.
2. Ensure that ignition and all electrical accessories are switched off; the parking brake must be applied and neutral selected on a manual gearbox; for an automatic gearbox select neutral (N) or park (P). Connect the jump leads as follows;

A. Connect one end of first jumper cable to positive (+) terminal of booster battery.
B. Connect other end of first jumper cable to positive (+) terminal of discharged battery.
C. Connect one end of second jumper cable to negative terminal of booster battery.
D. Connect other end of second jumper cable to a good earth point on the engine, **NOT TO NEGATIVE TERMINAL OF DISCHARGED BATTERY.** Keep jumper lead away from moving parts, pulleys, drive belts and fan blade assembly.

WARNING: Making final cable connection could cause an electrical arc which if made near battery could cause an explosion.



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3. If booster battery is installed in another vehicle, start engine and allow to idle.
4. Start engine of vehicle with discharged battery, following starting procedure in Owners' Manual.

CAUTION: If vehicle fails to start within a maximum time of 12 seconds, switch ignition off and investigate cause. Failing to follow this instruction could result in irrepairable damage to catalysts.

5. Remove negative (-) jumper cable from the engine and then terminal of booster battery.
6. Remove positive (+) jumper cable from positive terminals of booster battery and discharged battery.

ABBREVIATIONS AND SYMBOLS USED IN THIS MANUAL

Across flats (bolt size) .... AF
After bottom dead centre .... ABDC
Air Conditioning .... A/C
Air Fuel Ratio .... AFR
After top dead centre .... ATDC
Air Temperature Control .... ATC
Alternating current .... ac
Ambient Air Pressure .... AAP
Ambient Air Temperature .... AAT
Ambient Pressure .... AP
Ampere .... amp or A
Ampere hour .... amp hr
Anti-lock Braking System .... ABS
Anti-shunt Control .... ASC
Automatic .... Auto
Automatic Volume Control .... AVC
Auxiliary .... AUX

Battery Backed-Up Sounder .... BBUS
Before bottom dead centre .... BBDC
Before top dead centre .... BTDC
Body Electrical Control Module .... BeCM
Boost Pressure .... BP
Bottom dead centre .... BDC
Brake horse power .... bhp
Brake Pedal Positions .... BPP
British Standards .... BS

Camshaft Position .... CMP
Calculated Load Value CLV
Canister Vent Solenoid .... CVS
Carbon Dioxide .... CO_2
Carbon monoxide .... CO
Celsius C
Centimetre .... cm
Central Door Locking .... CDL
Centre Differential Control .... CDC
Centre High Mounted Stop Lamp .... CHMSL
Chlorofluorocarbon .... CFC
Clutch Pedal Position .... CPP
Compact Disc .... CD
Compact Disc - Read Only Memory .... CD-ROM
Controller Area Network .... CAN
Crankshaft Position .... CKP
Cubic centimetre .... cm^3
Cubic feet per minute .... ft^3/min
Cubic inch .... in^3

dB .... Decibels
Degree (angle) .... deg or °
Degree (temperature) .... deg or °
Diagnostic Control Unit .... DCU
Dial Test Indicator .... DTI
Diameter .... dia.

Digital Diesel Electronics .... DDE
Digital Signal Processing .... DSP
Digital Versatile Disc .... DVD
Direct current .... dc
Direct Ignition System .... DIS
Direct Injection .... DI
Directional Control Valve .... DCV
Double Overhead Camshaft .... DOHC
Dual Mass Flywheel .... DMF

Electronic Air Control Valve .... EACV
Electronic Air Suspension .... EAS
Electronic Automatic Transmission .... EAT
Electronic Brake pressure Distribution .... EBD
Electronic Control Unit .... ECU
Electronic Diesel Control .... EDC
Electronic Erasable Programmable Read Only Memory .... EEPROM
Electronic Fuel Injection .... EFI
Electronic Traction Control .... ETC
Electronic Unit Injector .... EUI
Electronic Vacuum Regulator .... EVR
Electrical Reference Library .... ERL
Emergency Key Access .... EKA
Emergency Locking Retractor .... ELR
Engine Control Module .... ECM
Engine Coolant Temperature .... ECT
Engine Fuel Temperature .... EFT
Engine Management System .... EMS
Enhanced Other Network .... EON
European Community Directive .... ECD
European Norm .... EN
European Economic Community .... EEC
European On Board Diagnostics .... EOBD
Evaporative Emission .... EVAP
Exhaust Gas Recirculation .... EGR

Fahrenheit .... F
Fast Throttle Control .... FTC
Feet .... ft
Feet per minute .... ft/min
Field Effect Transistor .... FET
Fifth 5th
First 1st
Fluid ounce .... fl oz
Foot pounds (torque) .... lbf.ft
Fourth 4th
Fuel Burning Heater .... FBH
Fuel Injection Pump .... FIP

Gallons .... gal
Gallons (US) .... US gal
Gramme (force) .... gf
Gramme (mass) .... g
Greenwich Mean Time .... GMT
Global Positioning System .... GPS
Gravity .... g

Heated Front Screen .... HFS
Heated oxygen sensor .... HO_2S
Heated Rear Window .... HRW
Height Dilation Of Precision .... HDOP
High .... HI
High compression .... hc
High Density Polyethylene .... HDPE
High Molecular Weight .... HMW
High Strength Low Alloy .... HSLA
High tension (electrical) .... HT or ht
Hill Descent Control .... HDC
Hour .... h
Hydrocarbons .... HC
Hydrofluorocarbon .... HFC

Idle Air Control Valve .... IACV
In Car Entertainment .... ICE
Inches of mercury .... in. Hg
Inches .... in
Inertia-fuel Shut Off .... IFS
Injector Pulse Width .... IPW
Inlet Throttle .... ILT
Intake Air Temperature .... IAT
Intermediate Frequency .... IF
Internal diameter .... I.D. or i.dia.
International Organisation for Standardisation .... ISO

Kilogramme (force) .... kgf
Kilogramme (mass.) .... kg
Kilogramme centimetre (torque) .... kgf.cm
Kilogrammes per hour .... kg/h
Kilogramme per square millimetre .... kgf/mm^2
Kilogramme per square centimetre .... kgf/cm^2
Kilogramme metres (torque) .... kgf.m
Kilometres .... km
Kilometres per hour .... km/h
KiloPascal .... kPa
Kilowatts .... kW
Kilovolts .... kV
Knock Sensor .... KS

Left-hand .... LH
Left-hand Drive .... LHD
Left-hand thread .... LHThd
Light Emitting Diode .... LED
Litres l
Liquid Crystal Display .... LCD
Liquid Vapour Separator .... LVS
Low .... LO
Low compression lc
Low Emission Vehicle .... LEV
Low tension .... l.t.

Malfunction Indicator Light .... MIL
Manifold Absolute Pressure .... MAP
Mass Air Flow .... MAF
Maximum .... max.
MegaPascal .... MPa
Metal Oxide Semiconductor Field Effect Transistor .... MOSFET
Metre .... m
Millilitre .... ml
Millimetre .... mm
Miles per gallon .... mpg
Miles per hour .... mph
Minus (of tolerance) .... -
Minimum .... min.
Minute (angle) .... '
Model Year .... MY
Modular Engine Management System .... MEMS
Motorised Valve .... MV
Multi-Function Logic .... MFL
Multi-Function Unit .... MFU
Multi-Point injection .... MPi
Multiport Fuel Injection .... MFI

Negative (electrical) .... -ve
Negative Temperature Coefficient .... NTC
Newton metres (torque) .... Nm
Nitrogen Dioxide .... NO_2
Non-Return Valve .... NRV
North American Specification .... NAS
Number .... No.

Off-road Mode .... ORM
Ohms .... ohm
On Board Diagnostics .... OBD
On Board Monitoring .... OBM
Organic Acid Technology .... OAT
Ounces (force) .... ozf
Ounces (mass) .... oz
Ounce inch (torque) .... ozf.in.
Outside diameter .... O.D. or o.dia.
Overhead Cam .... OHC
Oxides of Nitrogen .... NOx

Part number .... Part No.
Percentage .... %
Pints .... pt
Pints (US) .... US pt
Plus or Minus .... ±
Plus (tolerance) .... +
Polytetrafluorethylene .... PTFE
Position Dilation Of Position .... PDOP
Positive (electrical) .... +ve
Positive Crankcase Ventilation .... PCV
Positive Temperature Coefficient .... PTC
Pound (force) .... lbf
Pounds force feet .... lbf.ft
Pounds inch (torque) .... lbf.in
Pound (mass) .... lb(s)
Pounds per square inch .... psi
Pounds per square inch .... lbf/in^2
Power Assisted Steering .... PAS
Pressure Conscious Reducing Valve .... PCRV
Printed Circuit Board .... PCB
Programme Information .... PI
Pulses Per Second .... PPS
Pulse Width Modulation .... PWM

Radio Data Service .... RDS
Radio Frequency .... RF
Radius .... r
Ratio .... :
Read Only Memory .... ROM
Red/Green/Blue .... RGB
Reference .... ref.
Regionalisation .... REG
Research Octane Number .... RON
Rest Of World... ROW
Revolution per minute .... rev/min
Right-hand .... RH
Right-hand Drive .... RHD
Roll Over Valve .... ROV
Rover Engineering Standards .... RES

Second (angle) .... "
Second (numerical order) 2nd
Secondary Air Injection .... SAI
Self Levelling and Anti-Lock Brake System .... SLABS
Self Levelling Suspension .... SLS
Single Overhead Camshaft .... SOHC
Single Point Entry .... SPE
Society of Automotive Engineers .... SAE
Specific gravity .... sp.gr.
Square centimetres .... cm^2
Square inches .... in^2
Standard .... std.
Standard wire gauge .... s.w.g.
Supplementary Restraint System .... SRS
Synchroniser/Synchromesh .... synchro.

Temperature, Manifold Absolute Pressure .... TMAP
Third 3rd
Thermostsatic Expansion Valve .... TXV
Three Way Catalyst.. TWC
Throttle Position .... TP
Top Dead Centre.. TDC
Torsional Vibration .... TV
Traffic Announcement .... TA
Traffic Management Control............................... TMC

United Kingdom.. UK
United States.. US
US gallons per hour .... US galls/h

Variable .... Var.
Variable Intake System .... VIS
Variable Reluctance Sensor................................ VRS
Vehicle Identification Number .... VIN
Vehicle Information Communications System .... VICS
Vehicle Speed Sensor.. VSS
Velocity Dilation Of Precision .... VDOP
Volts V

Watts .... W
Wide Open Throttle .... WOT

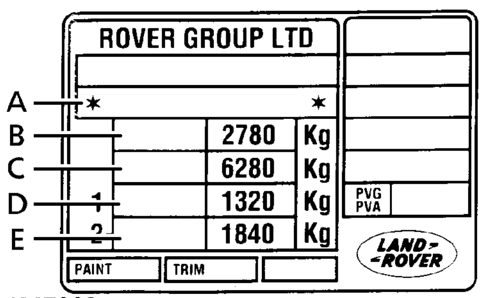
SCREW THREADS

American Standard Taper Pipe .... NPTF
British Standard Pipe .... BSP
Unified Coarse .... UNC
Unified Fine .... UNF

VEHICLE IDENTIFICATION NUMBER (VIN)

An adhesive label containing the Vehicle Identification Number and the recommended maximum vehicle weights is located on the left hand side of the bonnet locking platform.
The number is also stamped on the outside of the chassis in the front RH wheel arch to the rear of the anti-roll bar link.

NOTE: It may be necessary to remove underseal in order to locate the number; ensure underseal is restored on completion.



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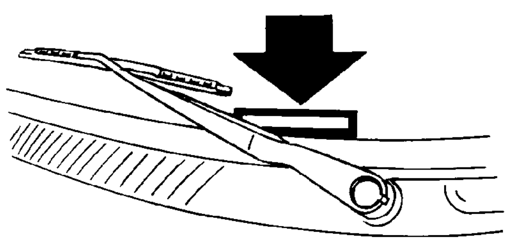
Key to Vehicle Identification Number Plate

A. VIN (17 digits)
B. Maximum permitted laden weight for vehicle
C. Maximum vehicle and trailer weight
D. Maximum road weight-front axle
E. Maximum road weight-rear axle



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In addition, the VIN is stamped on a plate which is visible through the left side of the windscreen.

Federal (USA) vehicle identification number

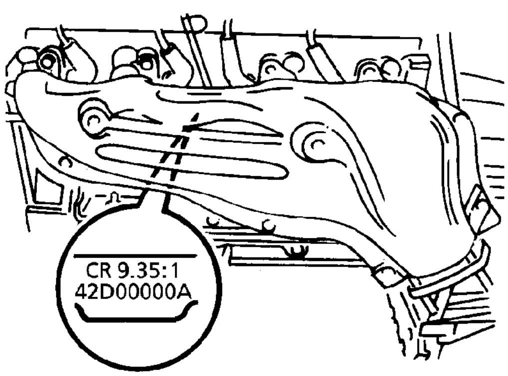
An adhesive label containing the Vehicle Identification Number, date of manufacture and gross axle weight ratings is fixed to the lock face of the front left hand door. The information includes wheel and tyre sizes and tyre pressures at gross axle weight ratings.

LOCATION OF IDENTIFICATION NUMBERS

Engine serial number - V8 engine

Stamped on a cast pad on the cylinder block, between numbers 3 and 5 cylinders.

NOTE: The engine compression ratio is stamped above the serial number.



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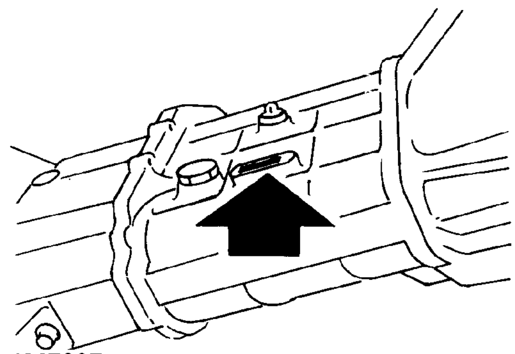
Engine serial number - BMW Diesel engine

Stamped on the LH side of the cylinder block above the sump.

Main gearbox R380 - 5 speed

Stamped on a cast pad on the bottom right hand side of the gearbox.



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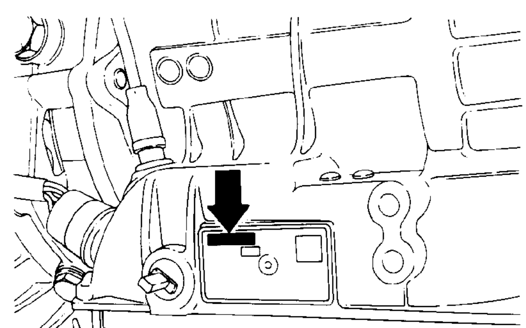
Automatic gearbox ZF4HP22/ZF4HP24

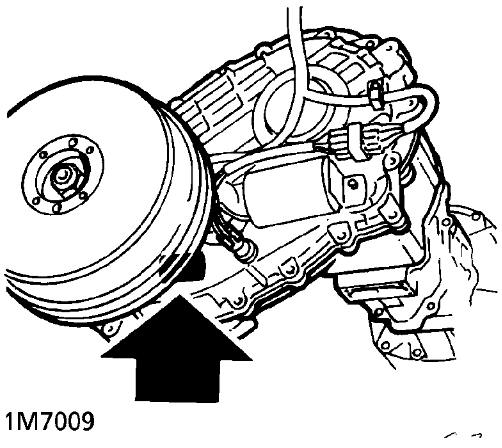
Stamped on a plate riveted to the bottom left hand side of the gearbox casing.



1M7008

Transfer gearbox-Borg Warner

Stamped on a plate attached to the gearbox casing, between filler/level and drain plug.



Front and rear axle

Stamped on the left hand axle tubes.

Vehicle identification number (VIN)

Made up of 17 digits, these numbers are used to identify manufacturer, model range, specification, body type, engine, transmission/steering, model year, plant and build sequence number and serve to identify the vehicle.

This example shows the sequence:

European code

S AL LP A M J 7 M A

S	Europe
AL	UK
LP	Range Rover
A	European Spec.
M	4 Door Station Wagon
J	4.6 Litre Fuel Injection
7	Manual right steering
M	1995 Model Year
A	Solihull

Federal (USA) code

S AL P V 1 2 4 2 S A

S	Europe
AL	UK
P	Range Rover
V	North America Spec.
1	4 Door Station Wagon
2	4.0 Litre fuel injection
4	Automatic, Left Hand Steering
2	Check Digit
S	1995 Model Year
A	Solihull

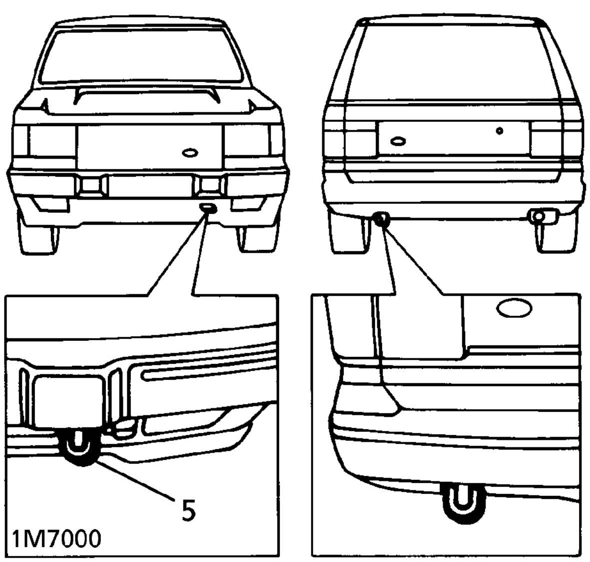
EMERGENCY TOWING

CAUTION: The New Range Rover has permanent four-wheel drive. The following instructions must be adhered to when towing:-

Towing the vehicle on four wheels

If it is necessary to recover the vehicle by towing on all four wheels, 'Transfer neutral' **MUST** be selected.

1. With the starter key removed, insert a fuse of 5 amps or more in fuse position '11' in the RH seat fuse box.
2. Turn the starter switch to position '2'; the transfer box will now automatically select neutral.
3. Wait until the message centre displays 'TRANSFER NEUTRAL' and then turn the starter switch off, position '0'.
4. Turn the starter switch to position '1' to unlock the steering and leave in this position while the vehicle is being towed.



5. Secure tow rope to the front towing eye.
6. Release the parking brake.

CAUTION: Power assistance for braking and steering systems will not be provided without the engine running. Greater pedal pressure will be required to apply the brakes, the steering wheel will require greater effort to turn the front wheels.
The vehicle tow connection should be used only in normal road conditions.

CAUTION: DO NOT remove the starter key or turn the switch to position '0' when the vehicle is in motion.

7. To reactivate the transfer box after towing, turn the starter switch off to position '0' and remove the fuse from position '11'. On automatic vehicles the transfer box will automatically engage the Low or High gear range.
8. On manual vehicles, first press the range change switch. The transfer box will then engage the Low or High gear range.

Suspended tow by breakdown vehicle

CAUTION: To prevent vehicle damage, front or rear propeller shaft MUST be removed, dependant upon which axle is being trailed.

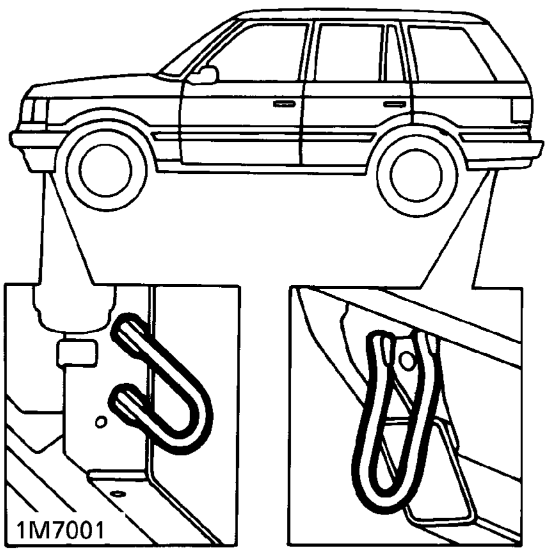
9. To facilitate reassembly, first mark the propeller shaft drive flanges at transfer box and axle.
10. Remove propeller shaft fixings and lift shaft from vehicle.
11. If the front axle is to be trailed, turn ignition key to position '1' to release the steering lock.

CAUTION: If the rear axle is to be raised, the steering wheel and/or linkage MUST be secured in a straight ahead position. DO NOT use the steering lock for this purpose.

TRANSPORTING THE VEHICLE BY TRAILER

If the vehicle should require transporting on a trailer or the back of a lorry, the air suspension must be set to 'ACCESS' before being lashed. ***See FRONT SUSPENSION, Description and operation.***

Lashing eyes are provided on the front and rear chassis cross members to facilitate the securing of the vehicle, as shown.



CAUTION: DO NOT secure lashing hooks or trailer fixings to any other part of the vehicle.

CAUTION: If the air suspension cannot be set to the 'ACCESS' position, then the vehicle must be lashed by its wheels and not the lashing eyes.

Install vehicle on the trailer and apply park brake. Select neutral in main gearbox; this will prevent damage to the parking pawl of the automatic gearbox.

04 - GENERAL SPECIFICATION DATA

CONTENTS

Page

ENGINE - 4.0 V8

Type	4.0 litre V8	
Number of cylinders	Eight, two banks of four	
Bore	94.00 - 94.04 mm	3.7008 - 3.7024 in
Stroke	71.04 - 71.20 mm	2.7966 - 2.8031 in
Capacity	3950 cm^3	241 in^3
Valve operation	Overhead by push-rod	
Compression ratio	**High Compression**	**Low Compression**
Up to 99MY	9.35:1	8.2:1
From 99MY	9.38:1	8.23:1
Maximum power (at 4750 rev/min)		
Up to 99MY	140 kW	132 kW
From 99MY		
All except NAS	136 kW	132 kW
NAS only	140 kW	-

Crankshaft

Main journal diameter	63.500 - 63.487 mm	2.50 - 2.4995 in
Crankpin journal diameter	55.513 - 55.500 mm	2.1856 - 2.1850 in
Crankshaft end thrust/end float	Taken on thrust washers of centre main bearing	
	0.10 - 0.20 mm	0.004 - 0.008 in

Main bearings

Number and type		
Up to 99MY	5, Vandervell shells	
From 99MY	5, Glacier Vandervell / AS15	
Material	Lead bronze with lead-indium overlay	
Diametrical clearance	0.010 - 0.048 mm	0.0004 - 0.002 in

Connecting rods

Type	Horizontally split big-end, plain small-end	
Length between centres	155.12 - 155.22 mm	6.1071 - 6.1110 in

Big-end bearings

Type and material		
Up to 99MY	Vandervell VP Lead bronze with lead-indium overlay	
From 99MY	Glacier Vandervell GPL2120 / AS124A	
Diametrical clearance	0.015 - 0.055 mm	0.0006 - 0.002 in

Piston pins

Length	60.00 - 60.50 mm	2.3622 - 2.3819 in
Diameter	23.995 - 24.000 mm	0.9447 - 0.9449 in
Fit-in connecting rod	Press fit	
Clearance in piston	0.015 - 0.006 mm	0.00059 - 0.00024 in

Pistons

Clearance in bore, measured 10 mm from base of skirt at right angles to piston pin		
Up to 99MY	0.020 - 0.050 mm	0.0008 - 0.0020 in
From 99MY	0.022 - 0.067 mm	0.0009 - 0.0026 in

Piston rings

Number of compression rings	2	
Number of oil control rings	1	
No 1 compression ring	Nitrided steel barrel faced	
No 2 compression ring	Tapered spherical barrel marked 'TOP'	
Width of compression rings		
Bottom	1.478 - 1.49 mm	0.0582 - 0.0587 in
Top		
Up to 99MY	1.21 - 1.23 mm	0.0476 - 0.0484 in
From 99MY	1.17 - 1.19 mm	0.0461 - 0.0479 in
Compression ring gap		
Bottom	0.40 - 0.65 mm	0.0157 - 0.0256 in
Top	0.3 - 0.5 mm	0.0118 - 0.0197 in
Oil control ring type		
Up to 99MY	Aclonoform	
From 99MY	3 Piece Aeconoform	
Oil control ring width	3.0 mm	0.1181 in
Oil control ring rail gap	0.38-1.40 mm	0.0150 - 0.0551 in

Camshaft

Location	Central	
Bearings	Non serviceable	
Number of bearings	5	
Drive	Chain 9.52 mm pitch x 54 pitches.	
Camshaft end float		
Up to 99MY	0.076 - 0.355 mm	0.003 - 0.014 in
From 99MY	0.075 - 0.350 mm	0.002 - 0.013 in

Tappets .... Hydraulic self-adjusting

Valves

Length		
Inlet	116.59 - 117.35 mm	4.590 - 4.620 in
Exhaust	116.59 - 117.35 mm	4.590 - 4.620 in
Seat angle	**Up to 99MY**	**From 99MY**
Inlet	46° - 46° 25'	45° - 45° 30'
Exhaust	46° - 46° 25'	45° - 45° 30'
Head diameter		
Inlet	39.75 - 40.00 mm	1.565 - 1.575 in
Exhaust	34.227 - 34.48 mm	1.3475 - 1.3575 in
Stem diameter		
Inlet	8.664 - 8.679 mm	0.3411 - 0.3417 in
Exhaust	8.651 - 8.666 mm	0.3406 - 0.3412 in
Stem to guide clearance		
Inlet	0.025 - 0.066 mm	0.0010 - 0.0026 in
Exhaust	0.038 - 0.078 mm	0.0015 - 0.0031 in
Valve lift (inlet and exhaust)	9.94 mm	0.3913 in
Valve spring length fitted		
Up to 99MY	40.40 mm (1.59 in) at pressure of 29.5 kg (65 lb)	
From 99MY	40.93 mm (1.61 in) at pressure of 29.5 kg (65 lb)	

Lubrication

System type	Wet sump, pressure fed
Oil pump type	Crank driven rotor
Oil pressure	
Up to 99MY	2.06 to 2.7 bar (30 to 40 lbf/in^2) at 2400 rev/min with engine warm
From 99MY	3.45 bar (50 lbf/in^2) at 2000 rev/min with engine warm
Oil filter-internal	Wire screen, pump intake filter in sump
Oil filter-external	Full flow, self-contained cartridge

ENGINE - 4.6 V8

Type	4.6 litre V8	
Number of cylinders	Eight, two banks of four	
Bore	94.00 - 94.04 mm	3.7008 - 3.7024 in
Stroke	81.92 - 82.08 mm	3.2252 - 3.2315 in
Capacity	4554 cm^3	278 in^3
Valve operation	Overhead by push-rod	
Compression ratio	**High Compression**	**Low Compression**
Up to 99MY	9.35:1	8.36:1
From 99MY	9.37:1	8.37:1
Maximum power (at 4750 rev/min)		
Up to 99MY	165.5 kW	157 kW
From 99MY		
All except NAS	160 kW	150 kW
NAS only	165.5 kW	

Crankshaft

Main journal diameter	63.500 - 63.487 mm	2.50 - 2.4995 in
Crankpin journal diameter	55.513 - 55.500 mm	2.21 - 2.20 in
Crankshaft end thrust/end float	Taken on thrust washers of centre main bearing	
	0.10 - 0.20 mm	0.004 - 0.008 in

Main bearings

Number and type		
Up to 99MY	5, Vandervell shells	
From 99MY	5, Glacier Vandervell / AS15	
Material	Lead bronze with lead-indium overlay	
Diametrical clearance	0.010 - 0.048 mm	0.0004 - 0.002 in

Connecting rods

Type	Horizontally split big-end, plain small-end	
Length between centres	149.68 - 149.78 mm	5.893 - 5.897 in

Big-end bearings

Type and material		
Up to 99MY	Vandervell VP Lead bronze with lead-indium overlay	
From 99MY	Glacier Vandervell GPL2120/AS124A	
Diametrical clearance	0.015 - 0.055 mm	0.0006 - 0.002 in

Piston pins

Length	60.00 - 60.50 mm	2.3622 - 2.3819 in
Diameter	23.995 - 24.000 mm	0.9447 - 0.9449 in
Fit-in connecting rod	Press fit	
Clearance in piston	0.015 - 0.006 mm	0.0006 - 0.0002 in

Pistons

Clearance in bore, measured at bottom of skirt at right angles to piston pin		
Up to 99MY	0.020 - 0.050 mm	0.0008 - 0.0020 in
From 99MY	0.022 - 0.067 mm	0.0009 - 0.0026 in

Piston rings

Number of compression rings	2	
Number of oil control rings	1	
No 1 compression ring	Nitrided steel barrel faced	
No 2 compression ring	Tapered spherical barrel marked 'TOP'	
Width of compression rings		
Bottom	1.478 - 1.49 mm	0.0582 - 0.0587 in
Top		
Up to 99MY	1.21 - 1.23 mm	0.0476 - 0.0484 in
From 99MY	1.17 - 1.19 mm	0.0461 - 0.0479 in
Compression ring gap		
Bottom	0.40 - 0.65 mm	0.0157 - 0.0256 in
Top	0.3 - 0.5 mm	0.0118 - 0.0197 in
Oil control ring type		
Up to 99MY	Aclonoform	
From 99MY	3 Piece Aeconoform	
Oil control ring width	3.0 mm	0.1181 in
Oil control ring rail gap	0.38-1.40 mm	0.0150 - 0.0551 in

Camshaft

Location	Central	
Bearings	Non serviceable	
Number of bearings	5	
Drive	Chain 9.52 mm pitch x 54 pitches.	
Camshaft end float		
Up to 99MY	0.076 - 0.355 mm	0.003 - 0.014 in
From 99MY	0.075 - 0.350 mm	0.002 - 0.013 in

Tappets .... Hydraulic self-adjusting

Valves

Length		
Inlet	116.59 - 117.35 mm	4.590 - 4.620 in
Exhaust	116.59 - 117.35 mm	4.590 - 4.620 in
Seat angle	**Up to 99MY**	**From 99MY**
Inlet	46° - 46° 25'	45° - 45° 30'
Exhaust	46° - 46° 25'	45° - 45° 30'
Head diameter		
Inlet	39.75 - 40.00 mm	1.565 - 1.575 in
Exhaust	34.227 - 34.48 mm	1.3475 - 1.3575 in
Stem diameter		
Inlet	8.664 - 8.679 mm	0.3411 - 0.3417 in
Exhaust	8.651 - 8.666 mm	0.3406 - 0.3412 in
Stem to guide clearance		
Inlet	0.025 - 0.066 mm	0.0010 - 0.0026 in
Exhaust	0.038 - 0.078 mm	0.0015 - 0.0031 in
Valve lift (inlet and exhaust)	9.94 mm	0.3913 in
Valve spring length fitted		
Up to 99MY	40.40 mm (1.59 in) at pressure of 29.5 kg (65 lb)	
From 99MY	40.93 mm (1.61 in) at pressure of 29.5 kg (65 lb)	

Lubrication

System type	Wet sump, pressure fed
Oil pump type	Crank driven rotor
Oil pressure	
Up to 99MY	2.06 to 2.7 bar (30 to 40 lbf/in^2) at 2400 rev/min with engine warm
From 99MY	3.45 bar (50 lbf/in^2) at 2000 rev/min with engine warm
Oil filter-internal	Wire screen, pump intake filter in sump
Oil filter-external	Full flow, self-contained cartridge

ENGINE - BMW DIESEL

Type	Indirect injection, turbocharged, intercooled	
Number of cylinders	6	
Bore	80.00 mm	3.15 in
Stroke	82.80 mm	3.26 in
Capacity	2497 cm^3	152 in^3
Compression ratio	22.5:1 ± 1:1	
Valve operation	OHC chain driven	
Turbo charger	Mitsubishi TD04 - 11G4	

Camshaft

Drive	Chain	
Number of bearings	7	

Cylinder head

Longitudinal warp	0.1 mm	0.004 in
Lateral warp	0.05 mm	0.002 in

Valves and guides

Valve head diameter:	Inlet	36.0 mm	1.42 in
	Exhaust	31.0 mm	1.22 in
Stem diameter - Standard:	Inlet	6.97 mm	0.274 in
	Service limit	6.95 mm	0.273 in
	Exhaust	6.95 mm	0.273 in
	Service limit	6.93 mm	0.272 in
Stem diameter - 1st oversize:	Inlet	7.07 mm	0.28 in
	Service limit	7.05 mm	0.277 in
	Exhaust	7.06 mm	0.278 in
	Service limit	7.04 mm	0.27 in
Stem diameter - 2nd oversize:	Inlet	7.17 mm	0.282 in
	Service limit	7.15 mm	0.28 in
	Exhaust	7.16 mm	0.281 in
	Service limit	7.14 mm	0.279 in
Valve head stand-down:	Inlet	0.65 to 0.85 mm	0.02 to 0.03 in
	Exhaust	0.85 to 1.05 mm	0.03 to 0.04 in
Valve head oversizes - increased thickness		0.25 and 0.50 mm	0.01 and 0.02 in
Valve tilt - inlet and exhaust		0.5 mm	0.02 in
Valve seats:			
Valve seat angle		45° ± 10'	
Correction angle - outside		15°	
Correction angle - inside		60°	
Seat face outside diameter	Inlet	35.5 mm	1.4 in
	Exhaust	30.6 mm	1.2 in
Valve seat width	Inlet	1.75 to 2.25 mm	0.007 to 0.09 in
	Exhaust	2.60 to 2.90 mm	0.10 to 0.11 in
Valve guides:			
Inner diameter for reaming - inlet and exhaust			
Standard		7.0 mm	0.275 in
1st oversize valve stem		7.1 mm	0.28 in
2nd oversize valve stem		7.2 mm	0.283 in

Crankshaft

Main bearing bearing journal diameter		
Yellow	59.984 to 59.990 mm	2.3616 to 2.3618 in
Green	59.977 to 59.983 mm	2.3612 to 2.3615 in
White	59.971 to 59.976 mm	2.3610 to 2.3611 in
Oversize bearings	0.25 and 0.50 mm	0.01 and 0.02 in
Big-end journal diameter:		
Standard	44.975 to 45.00 mm	1.770 to 1.771 in
1st undersize - Size 1 - 0.25 mm (0.01 in)	44.725 to 44.75 mm	1.761 to 1.762 in
2nd undersize - Size 2 - 0.50 mm (0.02 in)	44.475 to 44.50 mm	1.751 to 1.752 in
Oversize bearings	0.25 and 0.50 mm	0.01 and 0.02 in
Crankshaft end float	0.080 to 0.163 mm	0.003 to 0.006 in

Main bearings

Number and type	7 halved shells with oil grooves	
Diametrical clearance	0.020 to 0.058 mm	0.001 to 0.002 in

Connecting rods

Diametrical clearance (big-end bearings)	0.010 to 0.055 mm	0.0004 to 0.002 in
Gudgeon pin bush bore	28.995 to 29.021 mm	1.142 to 1.143 in
Maximum deviation of connecting rod parallelism	0.05 mm	0.002 in
Maximum distortion	0.5 mm	0.02 in

Pistons

Type	Aluminium alloy, combustion chamber in crown	
Piston diameter measured 7 mm (0.27 in) from lower edge and at right angles to gudgeon pin	79.96 $\pm$ 0.009 mm	3.14 $\pm$ 0.004 in
Intermediate size	80.04 $\pm$ 0.009 mm	3.15 $\pm$ 0.004 in
Oversize 1	80.21 $\pm$ 0.009 mm	3.16 $\pm$ 0.004 in
Piston running clearance	0.031 to 0.63 mm	0.0012 to 0.002 in

Piston rings

Type:		
Top	Double keystone	
Second	Taper faced	
Oil control	Bevelled ring with spring	
Gap in bore:		
All	0.2 to 0.4 mm	0.008 to 0.020 in
Clearance in piston grooves:		
Top	Not measured	
Second	0.040 to 0.072 mm	0.002 to 0.004 in
Oil control	0.030 to 0.065 mm	0.001 to 0.003 in

Cylinder bores

Standard	80.00 to 80.04 mm	3.150 to 3.151 in
Intermediate	80.08 to 80.12 mm	3.153 to 3.154 in
1st oversize	80.25 to 80.29 mm	3.20 to 3.21 in
Maximum ovality	0.04 mm	0.002 in
Maximum taper	0.04 mm	0.002 in

Lubrication

System	Wet sump, pressure fed	
Oil pressure, at idle	2.0 bar	29.0 lbf/in^2
Regulated pressure	3.8 bar	55.0 lbf/in^2
Oil pump:		
Type	Internal gear type pump, mounted on front of engine	
Drive	Direct from crankshaft	
Radial clearance:		
Inner rotor/bearing sleeve (max.)	0.065 mm	0.003 in
Outer rotor/pump body (max.)	0.4 mm	0.02 in
Axial clearance:		
Inner rotor/pump body	0.065 mm	0.003 in
Outer rotor/pump body	0.070 mm	0.004 in
Oil pressure relief valve	piston operated, non-adjustable	
Relief valve spring:		
Length relaxed	84.10 mm	3.3 in
Oil filter	Disposable cartridge	
Engine oil cooler	Mounted on front of coolant radiator	

ENGINE MANAGEMENT SYSTEM (EMS) V8 ENGINE

Type		
Up to 99MY	Sagem - Lucas Gems 8 hot wire system, electronically controlled	
From 99MY	Bosch Motronic M5.2.1, electronically controlled	
Fuel pump	High pressure electrical, immersed in the fuel tank	
Fuel pump delivery pressure		
Up to 99MY	2.4-2.6 bar	34-37 lbf/in^2
From 99MY	3.5 bar	50.75 lbf/in^2
Fuel filter	Bosch in-line filter 'canister' type	

Mass airflow sensor

Make and type	
Up to 99MY	Lucas 'Hot Wire' 20AM
From 99MY	Bosch EH1174 (includes air intake temperature sensor)

Injectors

Make and type	
Up to 99MY	Lucas D1000
From 99MY	Bosch EV6C

Electronic Control Module

Make and type	
Up to 99MY	Lucas GEMS 8.2
From 99MY	Bosch M5.2.1

Fuel pressure regulator

Make and type	
Up to 99MY	Lucas 8RV
From 99MY	Rochester (part of fuel pump)

Coolant temperature sensor

Make and type	Lucas 8TT

Bypass air valve (Stepper motor)

Make and type	
Up to 99MY	Lucas 3ACM
From 99MY	Bosch

Throttle position sensor

Make and type	
Up to 99MY	Lucas 3TP
From 99MY	Bosch DKG1

Heated oxygen sensor - catalyst vehicles
Make and type

Up to 99MY	Lucas 4LS
From 99MY	Bosch LSH

Camshaft position sensor
Make and Land Rover part no.

Up to 99MY	Honeywell ERR2261
From 99MY	Lucas ERR6170

Crankshaft position sensor
Make and type

Up to 99MY	Lucas 4CS
From 99MY	Bosch DG6

Knock sensor
Make and type

Up to 99MY	Lucas 2KS
From 99MY	Bosch KS1S

Intake air temperature sensor
Make and type

Up to 99MY	Lucas 10TT
From 99MY	Not applicable (combined with MAF sensor)

Ignition coils
Make and type

Up to 99MY	Lucas 2DIS2
From 99MY	Bosch 0 221 503 407

Fuel temperature sensor
Make and type

Up to 99MY	Lucas 6TT
From 99MY	Not applicable

FUEL SYSTEM - BMW DIESEL ENGINE

Injection pump type	Bosch rotary R515
Injection pump timing	0.95 $\pm$ 0.02 mm lift at TDC
Injectors	***See ENGINE TUNING DATA, Information.***
Heater plugs	***See ENGINE TUNING DATA, Information.***
Fuel lift pump type	Electric in tank fuel pump
Fuel filter	Paper element type
Air cleaner	Paper element type
Turbocharger	Mitsubishi TD04 11G4

COOLING SYSTEM - V8 ENGINE

System type	Pressurized, spill return, thermostatically controlled water and anti freeze mixture. Vertical flow radiator with remote header tank and pump assisted.	
Cooling fan	9 blade axial flow. Viscous coupling.	
Pump type	Centrifugal, impeller, belt driven.	
Thermostat opening		
Up to 99MY	88 °C	190 °F
From 99MY	85 $\pm$ 5 °C	185 $\pm$ 9 °F
Expansion tank cap pressure (system pressure)	1.0 bar	15 lbf/in^2

COOLING SYSTEM - BMW DIESEL ENGINE

System type	Pressurized, spill return, thermostatically controlled water and anti freeze mixture. Pump assisted thermo syphon. Coolant radiator combined with oil cooler and turbo intercooler.	
Cooling fan	11 blade axial flow 433 mm diameter. 1.44:1 drive ratio. Viscous coupling.	
Pump type	Centrifugal, impeller, belt driven.	
Thermostat opening	80 °C	176 °F
Expansion tank cap pressure (system pressure)	1.0 bar	15 lbf/in^2

MANUAL TRANSMISSION

Clutch

Make and type - V8 engine	AP Borg and Beck, diaphragm spring
Clutch plate diameter	265 mm (10,43 in.)
Make and type - Diesel engine	Valeo, diaphragm spring
Clutch plate diameter	242 mm (9.53 in.)

Transfer gearbox

Borg Warner	Two speed reduction on main gearbox output, front and rear drive permanently engaged via a centre differential controlled by a Viscous unit giving a 50/50 nominal front and rear torque split.

Transfer gearbox ratios

High	1.216:1
Low	3.271:1

Manual gearbox

Type R380	5 speed, single helical constant mesh with synchromesh on all gears

Manual gearbox ratios:

5th	0.731:1
4th	1.000:1
3rd	1.397:1
2nd	2.132:1
1st	3.321:1
Reverse	3.429:1
Diesel models low first gear	3.692:1

Overall ratio (final drive):	**High transfer**	**Low transfer**
5th	3.15:1	8.46:1
4th	4.30:1	11.58:1
3rd	6.01:1	16.18:1
2nd	9.18:1	24.69:1
1st	14.29:1	38.45:1
Reverse	14.76:1	39.70:1
Diesel models low 1st gear	15.89:1	42.75:1

Propeller shafts

Type:	
Front	Tubular 51mm diameter
Rear	Tubular 51mm diameter
Universal joints	Open type Hooks O3EHD

Rear axle

Type	Spiral bevel
Ratio	3.54:1

Front axle

Type	Spiral bevel
Ratio	3.54:1

AUTOMATIC TRANSMISSION

Automatic gearbox

Model	
2.5 litre Diesel & 4.0 litre Petrol	ZF4HP22
4.6 litre Petrol	ZF4HP24
Type	Four speed and reverse epicyclic gears with fluid torque converter and lock up.

Transfer gearbox

Borg Warner	Two speed reduction on main gearbox output, front and rear drive permanently engaged via a centre differential controlled by a Viscous unit giving a 50/50 nominal front and rear torque split.

Transfer gearbox ratios

High	1.216:1
Low	3.271:1

Automatic gearbox ratios

4th	0.728:1
3rd	1.000:1
2nd	1.480:1
1st	2.480:1
Reverse	2.086:1

Overall ratio (final drive):	**High transfer**	**Low transfer**
4th	3.13:1	8.43:1
3rd	4.30:1	11.58:1
2nd	6.37:1	17.14:1
1st	10.67:1	28.72:1
Reverse	8.98:1	24.15:1

Propeller shafts

Type:	
Front	Tubular 51mm diameter
Rear	Tubular 51mm diameter
Universal joints	Open type Hooks O3EHD

Rear axle

Type	Spiral bevel
Ratio	3.54:1

Front axle

Type	Spiral bevel
Ratio	3.54:1

STEERING

Power steering box

Make/type	ZF type 8055, recirculating ball steering gear
Steering wheel turns, lock-to-lock	3.2

Steering pump

Make/type:	
V8 engine	ZF type 7691, vane type
Diesel engine	ZF type7681, vane type

Steering geometry

Steering wheel diameter	406.4mm (16 in.)	
Toe-out measurement	0.6 to 1.80mm (0.02 - 0.07 in.)	
Toe-out included angle	0°5’ to 0°15’	
Camber angle	0°	**NOTE:**
Castor angle	4°	**Check at**
Swivel pin inclination static	8°	**kerbweight**

SUSPENSION

Type:	
Air suspension	Variable rate air springs controlled by an ECU giving 5 height profiles. Automatic self levelling. Automatic standard and low profiles. Driver selected access, low and high profiles. Lateral location of axle by Panhard rod.
Front	Fore and aft location by two radius arms. Lateral location of axle by a Panhard rod.
Rear	Fore and aft movement controlled by two trailing arms. Lateral location of axle by a Panhard rod.

SHOCK ABSORBERS

Type	Telescopic, double-acting non-adjustable

AIR CONDITIONING

System	CFC free expansion valve system
Compressor	
V8 up to 99MY	Sanden TRS105N
V8 from 99MY and diesel	Nippon Denso 10PA17

BRAKES

Front service brake

Caliper	Lucas Colette, single sided, two piston
Operation	Power hydraulic, self-adjusting
Disc	Reverse ventilated, outboard
Disc diameter	297.2 mm (11.7 in.)
Disc thickness	25 mm (1 in.)
Wear limit	22.0 mm (0.87 in.)
Disc run out maximum	0.15 mm (0.006 in)
Pad area	64.9 cm^2 (10 in^2) per pad
Total swept area	844 cm^2 (130.8 in^2) per disc
Pad minimum thickness	2 mm (0.08 in.)

Rear service brake

Caliper	Lucas Colette,single sided, single piston
Operation	Power hydraulic, self-adjusting
Disc	Solid, outboard
Disc diameter	304.0 mm (12 in.)
Disc thickness	12.6 mm (0.5 in.)
Wear limit	11.7 mm (0.46 in.)
Disc run out maximum	0.15 mm (0.006 in)
Pad area	34.4 cm^2 (5.33 in^2) per pad
Total swept area	798 cm^2 (123.7 in^2) per disc
Pad minimum thickness	2 mm (0.08 in.)

Parking brake

Type	Mechanical-cable operated drum brake on the rear of the transfer gearbox output shaft
Drum internal diameter	254 mm (10 in.)
Width	70 mm (2.75 in)

Anti-lock brake system

Manufacturer/type	Wabco/power hydraulic - 4 channel, 4 wheel sensed integrated anti-lock brake system.
ABS control	Microprocessor based ECU
System split	Front/rear
Power source	Electrically driven pump
Power storage	Hydraulic accumulator
Maximum boost pressure	180 bar
Reservoir	Built in low fluid warning. Supplies clutch hydraulic system

Electronic traction control

Type	Integrated with ABS system
ETC control	Integrated with ABS ECU

ELECTRICAL

System .... 12 volt, negative ground

Battery
Make: .... Land Rover Parts and Equipment maintenance free
Type:
V8 .... 072, 72 amp/hr
Diesel .... 664, 107 amp/hr

Alternator
Make and type
V8 up to 99MY and diesel .... Magnetti Marelli A133, 100A, 105A or 120A
V8 from 99MY .... Bosch NC90/150, 150A

Fuses
Type .... Autofuse (blade type) blow ratings to suit individual circuits

Horns
Make/type .... Klamix (Mixo) TR99

Starter motor
Make and type:
V8 Engine .... Bosch 331.303.006.808 pre-engaged
Diesel Engine .... Bosch 0.001.362.092 pre-engaged

REPLACEMENT BULBS

BULB LOCATION	TYPE
Exterior:	
Dip/main headlamps	12V - 60/55W (Halogen)
Inboard main beam headlamps	12V - 55W (Halogen)
Front fog lamps	12V - 55W H3 (Halogen)
Sidelamps	12V - 5W capless
Tail lamps	12V - 5W capless
Rear fog lamps	12V - 21W bayonet
Reverse lamps	12V - 21W bayonet
Stop lamps	12V - 21W bayonet
Direction indicator lamps	12V - 21W bayonet
Side repeater lamps	12V - 5W capless
Number plate lamps	12V - 5W capless
Interior:	
Front interior roof lamps	12V - 10W 'Festoon'
Map reading lamp	12V - 5W capless
Rear interior roof lamps	12V - 5W 'Festoon'
Map reading lamp	12V - 5W capless
Puddle lamps	12V - 3W capless
Glovebox lamp	12V - 5W 'Festoon'
Vanity mirror lamp	12V - 1.2W 'Festoon'
Rear footwell lamp	12V - 5W 'Festoon'
Load space lamp	12V - 10W 'Festoon'
Clock illumination	12V - 2W bayonet
Cigar lighter illumination	12V - 1.2W capless
Auxiliary switch illumination	12V - 0.2W capless
Auxiliary switch warning lamp	12V - 0.2W capless
Heater/air conditioning graphics illumination	12V - 1.2W capless
Instrument panel:	
Instrument panel illumination	14V - 3.4W T10 bulb/holder unit
Warning lamps	14V - 1.4W T5 bulb/holder unit
LCD background	14V - 1.4W T5 bulb/holder unit

NOTE: The correct specification Toshiba bulbs must be used in the instrument panel to ensure the correct level of illumination.

CAUTION: The fitting of new bulbs with wattages in excess of those specified will result in damage to vehicle wiring and switches.

VEHICLE WEIGHTS AND PAYLOAD

When loading a vehicle to its maximum (Gross Vehicle Weight), consideration must be taken of the vehicle kerb weight and the distribution of the payload to ensure that axle loadings do not exceed the permitted maximum values. It is the customer's responsibility to limit the vehicle's payload in an appropriate manner such that neither maximum axle loads nor Gross Vehicle Weight are exceeded.

GROSS VEHICLE WEIGHT

	Petrol Models	Diesel Models
Front Axle	1320 kg (2910 lb)	1320 kg (2910 lb)
Rear Axle	1840 kg (4056 lb)	1840 kg (4056 lb)
Total	2780 kg (6129 lb)	2780 kg (6129 lb)
Maximum Payload	603 kg (1329 lb)	596 kg (1314 lb)

EEC KERB WEIGHT AND DISTRIBUTION

	4.0 Litre Manual	4.0 Litre Automatic	4.6 Litre Automatic
EEC Kerb Weight	2090 kg (4607 lb)	2100 kg (4629 lb)	2220 kg (4894 lb)
Front Axle	1095 kg (2414 lb)	1100 kg (2425 lb)	1165 kg (2568 lb)
Rear Axle	995 kg (2193 lb)	1000 kg (2204 lb)	1055 kg (2325 lb)

	2.5 Diesel Manual	2.5 Diesel Automatic
EEC Kerb Weight	2115 kg (4662 lb)	2130 kg (4695 lb)
Front Axle	1110 kg (2447 lb)	1120 kg (2469 lb)
Rear Axle	1005 kg (2215 lb)	1010 kg (2226 lb)

NOTE: EEC KERB WEIGHT is the minimum vehicle specification plus full fuel tank and 75 kg (165 lb) driver.

NOTE: GROSS VEHICLE WEIGHT is the maximum all-up weight of the vehicle including driver, passengers, and equipment. This figure is liable to vary according to legal requirements in certain countries.

NOTE: MAXIMUM ROOF RACK LOAD (including weight of rack) 75 kg (165 lb) must be included in total vehicle weight.

VEHICLE DIMENSIONS

	mm	inches
Overall length	4713	185.6
Width excluding door mirrors	1853	73.0
Width including door mirrors	2228	87.7
Overall height at standard profile	1817.5	71.6
Wheelbase	2745	108.1
Track:		
Front	1540	60.6
Rear	1530	60.2

Turning circle between kerbs .... 11.9 m (39 ft)

TYRE PRESSURES

Normal on and off-road use. All speeds and loads

	Front	Rear
bar	1.9	2.6
lbf/in^2	28	38
kgf/cm^2	2.0	2.7

NOTE: Check pressures with tyres cold

WARNING: After any off-road driving, tyres and wheels should be inspected for damage, particularly if high cruising speeds are subsequently to be used.

WHEELS AND TYRES

Wheel type and size .... Alloy 7.00J X 16 (use with 235/70 tyres)
Alloy 8.00J X 16 (use with 255/65 tyres)
Alloy 8.00J X 18 (use with 255/55 tyres)

WARNING: All vehicles are fitted with tubeless alloy road wheels as original equipment. Note that these wheels DO NOT accept inner tubes and tubed tyres MUST NOT be fitted.

05 - ENGINE TUNING DATA

CONTENTS

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INFORMATION

ENGINE - 4.0 V8

Type	4.0 Litre V8	
Firing order	1-8-4-3-6-5-7-2	
Cylinder Numbers		
Left bank	1-3-5-7	
Right bank	2-4-6-8	
No 1 Cylinder location	Pulley end of left bank	
Spark plugs		
Make and type		
Up to 99MY	Champion RN11YCC	
From 99MY	Champion RC11PYB4	
Gap		
Up to 99MY	0.90 - 1.00 mm	0.035 - 0.040 in
From 99MY	1.00 $\pm$ 0.05 mm	0.040 $\pm$ 0.002 in

NOTE: Do not attempt to adjust the gaps of RC11PYB4 spark plugs.

Valve timing	**Inlet**	**Exhaust**
Opens	28°BTDC	66°BBDC
Closes	77°ABDC	39°ATDC

Idle speed - controlled by Engine Management System	
Up to 99MY	700 $\pm$ 20 rev/min
From 99MY	660 rev/min
Base idle setting	Not adjustable (idle air control valve position checked via TestBook)
CO at idle (vehicles without heated oxygen sensors)	
Up to 99MY	1.0 - 2.0 %
From 99MY	0.5 - 1.0 %
Calculated Load Value (CLV) - Engine fully warm, in neutral gear, with all loads off	
At Idle	2.8 to 3.8%
At 2500 rev/min	10% $\pm$ 1%
Air mass flow at sea level - Engine fully warm, in neutral gear, with all loads off	
At Idle	20 $\pm$ 3 kg/hr
At 2500 rev/min	60 $\pm$ 3 kg/hr

ENGINE - 4.6 V8

Type	4.6 Litre V8	
Firing order	1-8-4-3-6-5-7-2	
Cylinder Numbers		
Left bank	1-3-5-7	
Right bank	2-4-6-8	
No 1 Cylinder location	Pulley end of left bank	
Spark plugs		
Make and type		
Up to 99MY	Champion RN11YCC	
From 99MY	Champion RC11PYB4	
Gap		
Up to 99MY	0.90 - 1.00 mm	0.035 - 0.040 in
From 99MY	1.00 ± 0.05 mm	0.040 ± 0.002 in

NOTE: Do not attempt to adjust the gaps of RC11PYB4 spark plugs.

Valve Timing	**Inlet**	**Exhaust**
Up to 99MY		
Opens	14°BTDC	64°BBDC
Closes	70°ABDC	20°ATDC
From 99MY		
Opens	28°BTDC	72°BBDC
Closes	64°ABDC	20°ATDC

Idle speed - controlled by Engine Management System

Up to 99MY	700 ± 20 rev/min
From 99MY	660 rev/min
Base idle setting	Not adjustable (idle air control valve position checked via TestBook)

CO at idle (vehicles without heated oxygen sensors)

Up to 99MY	1.0 - 2.0 %
From 99MY	0.5 - 1.0 %

Calculated Load Value (CLV) - Engine fully warm, in neutral gear, with all loads off

At Idle	2.8 to 3.8%
At 2500 rev/min	10% ± 1%

Air mass flow at sea level - Engine fully warm, in neutral gear, with all loads off

At Idle	20 kg/hr ± 3 kg\hr
At 2500 rev/min	61 kg\hr ± 3 kg\hr

ENGINE - BMW DIESEL

ENGINE

Type	2.5 Litre turbocharged diesel, indirect injection engine with intercooler	
Firing order	1-5-3-6-2-4	
Injection timing at TDC, No.1 cylinder	0.95 ± 0.02 mm lift	0.04 ± 0.0008 in lift
Timing marks:		
Valve timing	Slot for pin in flywheel	
Injection timing	Dial gauge inserted into pump	
Maximum governed speeds:		
Full load (speed cut-off starts)	4400 rev/min	
No load (flight speed)	4950 ± 150 rev/min	
Idle speed	750 ± 50 rev/min	

INJECTION PUMP

Make/type:		
Digital Diesel Electronic Control - DDE	Bosch rotary R515 type with electronic control of fuel and timing. Constant pressure delivery valves.	
Direction of rotation	Clockwise, viewed from drive end	

INJECTORS

Make/type		
Standard	Bosch KCA 21 S 71	
Nozzle type	DN O SD 300	
Opening (injection) pressure		
Minimum pressure	140 bar	2030 lbf/in^2
Maximum pressure	160 bar	2320 lbf/in^2
Maximum pressure deviation	10 bar	145 lbf/in^2
Needle lift sensor in no.4 injector	Bosch KCA 21 S 76	

HEATER PLUGS

Make/type	Beru, probe type, 12 volts
Temperature after 5 seconds of operation	800°C
Resistance at 20 °C	0.4 - 0.6 Ohms

TURBOCHARGER

Make/type	Mitsubishi/TD04 - 11G4

06 - TORQUE VALUES

CONTENTS

Page

Description	Nm	lbf.ft
10 - MAINTENANCE		
Road wheels	108	80
Spark plugs	20	15
Air suspension air reservoir drain plug	70	52
Sump drain plug - BMW diesel		
- M12	25	18
- M22	60	44
Sump drain plug - V8 petrol up to 99MY	45	33
Sump drain plug - V8 petrol from 99MY	32	24
Automatic gearbox oil drain plug	15	11
Automatic gearbox oil filler / level plug	30	22
Manual gearbox oil drain plug	30	22
Manual gearbox oil filler/level plug	30	22
Transfer gearbox oil drain plug	30	22
Transfer gearbox oil filler/level plug	30	22
12 - ENGINE - BMW DIESEL		
Adaptor DA 102-85 to No. 1 glow plug location	20	15
Glow plug to cylinder head	20	15
Feed wires to glow plugs	4	3
* Camshaft cover bolts	15	11
+ Crankshaft pulley hub bolt:		
- Stage 1	100	74
- Stage 2 - Tighten further	60°	60°
- Stage 3 - Tighten further	60°	60°
- Stage 4 - Tighten further	30°	30°
Damper and pulley to hub bolts	23	17
Pulley to water pump bolts	10	7
Crankshaft rear oil seal to cylinder block:		
- M6 bolts	10	7
- M8 bolts	22	16
Manual gearbox harness bracket bolt	6	4
+ Propeller shaft flanges nuts and bolts	48	35
Engine mounting nuts	45	33
Manual gear lever bolts	25	18
Pipes to air conditioning compressor bolts	23	17
Pipes to air conditioning condenser	15	11
Feed hose to PAS pump union	30	22
Pipes to gearbox oil cooler	30	22
+ Flywheel to crankshaft bolts - manual gearbox	105	77
+ Drive plate to crankshaft bolts - automatic gearbox	120	88
Front cover to cylinder block bolts	10	7
Steering pump bracket to front cover / cylinder block bolts	22	16

+ * Cylinder head bolts:		
- Stage 1 - Tighten to	80	59
- Stage 2 - Slacken	180°	180°
- Stage 3 - Tighten to	50	37
- Stage 4 - Tighten further	90°	90°
- Stage 5 - Tighten further	90°	90°
- Stage 6 - Run engine	25 mins	25 mins
- Stage 7 - Allow to cool	-	-
- Stage 8 - Tighten further	90°	90°
Cylinder head to timing cover nut and bolts:		
- M6	10	7
- M7	15	11
- M8	20	15
Camshaft cover blanking plate bolts	22	16
Drive belt tensioner plug	20	15
+ Camshaft sprocket bolt:		
- Stage 1 - Tighten to	20	15
- Stage 2 - Tighten further	35°	35°
Turbocharger to exhaust manifold bolts	45	33
Pipes to engine oil cooler	30	22
Oil filter bolt	33	24
Oil filter head to cylinder block bolts	22	16
Oil pump bolts	22	16
Oil pick-up strainer bolts	10	7
Oil pressure switch	40	30
Oil sump to cylinder block bolts:		
- M6 8.8	10	7
- M6 10.9	12	9
- M8	20	15
Oil pump cover screws	20	15
Oil sump drain plug:		
- M12	25	18
- M22	60	44
Fuel injection pump sprocket nut	50	37
Timing chain tensioner access plug	40	30
Camshaft bearing cap nuts:		
- M6	10	7
- M7	15	11
- M8	20	15
+*Main bearing cap bolts:		
- Stage 1	20	15
- Stage 2 - Tighten further	50°	50°
Oil cooling jets	12	9
+ Reinforcing plate bolts:		
- M8	22	16
- M10	43	32

Cylinder block coolant drain plug	25	18
+*Big-end bearing cap bolts:		
- Stage 1	5	4
- Stage 2	20	15
- Stage 3 - Tighten further	70°	70°

+ New nuts/bolts must be fitted
* Tighten in sequence

12 - ENGINE - V8 PETROL

Alternator mounting bracket to engine bolts	40	30
Camshaft drive gear bolt	50	37
Coolant rail to inlet manifold bolt	22	16
Crankshaft pulley bolt	270	200
Water pump pulley bolts	22	16
Hub aligner to crankshaft Allen screws		
- automatic gearbox	85	63
Drive plate clamp ring bolts - automatic gearbox	45	33
Flywheel to crankshaft bolts - manual gearbox	80	59
Manual gearbox harness bracket bolt	6	4
+ Propeller shaft flanges nuts and bolts	48	35
Engine mounting nuts	45	33
Manual gear lever bolts	25	18
Pipes to air conditioning compressor bolts	23	17
Pipes to air conditioning condenser	15	11
Feed hose to PAS pump union	16	12
Pipes to engine oil cooler	30	22
Gearbox cooler pipes to LH engine mounting bracket bolt	18	13
Pipes to gearbox oil cooler	30	22
Fuel pipe to fuel rail union	16	12
Camshaft position sensor to timing cover bolt	8	6
Oil pressure switch to timing cover	15	11
Water pump to timing cover bolts	22	16
* Timing cover bolts	22	16
Camshaft position sensor multiplug bracket bolts	22	16
* Cylinder head bolts:		
- Stage 1	20	15
- Stage 2 - Tighten further	90°	90°
- Stage 3 - Tighten further	90°	90°
Oil cooler pipes to front cover	15	11
Auxiliary drive belt tensioner bolt - up to 99MY	50	37
Auxiliary drive belt tensioner bolt - from 99MY	45	33
Auxiliary drive belt idler pulley bolt	50	37
Auxiliary drive belt cover bolts	18	13
Oil filter head adaptor	13	9
Oil pick-up strainer bolts	8	6
Oil pick-up strainer to main bearing cap nut	25	18
+ Engine mounting flange nuts	45	33
Engine rear mounting to gearbox bolts	45	33

Crossmember to chassis	45	33
+ Gearbox mounting to crossmember nuts/bolts	45	33
Rear engine mounting to gearbox bolts	45	33
Rocker cover to cylinder head bolts - up to 99MY:		
Stage 1	4	3
Stage 2	8	6
Stage 3 - re-torque to:	8	6
+ Rocker cover to cylinder head bolts - from 99MY:		
Stage 1	3	2.2
Stage 2	7	5.2
* Rocker shaft to cylinder head bolts	38	28
* Oil sump to cylinder block nuts/bolts	23	17
Oil sump to bell housing bolts	45	33
Oil sump drain plug - up to 99MY	45	33
Oil sump drain plug - from 99MY	32	24

+ New nuts/bolts must be fitted
* Tighten in sequence

17 - EMISSION CONTROL

SAI control valve to engine manifold bracket bolts	10	7
Vacuum reservoir to mounting bracket bolt	10	7
SAI pump rubber mountings	10	7
SAI pump to mounting bracket nuts	10	7
SAI air injection pipe unions	25	18

19 - FUEL SYSTEM - BMW DIESEL

Fuel injection pump flange nuts	22	16
Rear support bolt	22	16
Fuel injection pump access hole bolt	25	18
High pressure pipes to fuel injection pump unions	20	15
High pressure pipes to injectors unions	20	15
Air suspension drier to air cleaner bolt	8	6
Engine coolant temperature sensor	18	13
Crankshaft position sensor to bracket bolt	8	6
Fuel feed pipe to fuel injection pump and filter union	14	10
Glow plugs to cylinder head	20	15
Feed wires to glow plugs nuts	4	3
+ Sprocket to fuel injection pump nut	50	37
Fuel return pipe to fuel injection pump	25	18
Adaptor to fuel filter	10	7
Fuel filter hollow bolt	14	10
Fuel injectors to cylinder head	65	48
Air intake sensor to inlet manifold	14	10
Throttle position sensor bolts	5	4
Turbocharger to exhaust manifold bolts	45	33
Oil feed pipe to turbocharger banjo bolt	25	18
Fuel feed and return pipes to tank unit	16	12

+ New nut must be fitted

19 - FUEL SYSTEM - V8 PETROL

Intake air temperature sensor to air cleaner	8	6
Air suspension drier to air cleaner bolts	8	6
Camshaft position sensor to timing cover bolt	8	6
Engine coolant temperature sensor to manifold	20	15
Crankshaft position sensor to cylinder block adaptor plate bolts	6	4
Fuel pressure regulator to fuel rail bolts	10	7
Ignition coil bracket to inlet manifold nuts	8	6
Fuel feed pipe to fuel rail union	16	12
Ram housing to inlet manifold bolts	24	18
Fuel temperature sensor to fuel rail	17	13
Heated oxygen sensor	20	15
Spark plugs to cylinder head	20	15
Fuel rail/ignition coil bracket to manifold nuts	8	6
Throttle position sensor clamp plate bolts	2	1.5
RH knock sensor to cylinder block	16	12
Fuel pressure regulator bolts	10	7
Stepper motor bolts	2	1.5
Idle air control bolts	2.3	2
Water jacket to plenum chamber bolts	13	10
Throttle linkage bracket to plenum chamber bolts	8	6
Plenum chamber to ram pipe housing bolts	24	18
Throttle potentiometer to stepper motor bolts	2	1.5
Fuel hoses to filter	20	15
Fuel feed and return pipes to tank unit	16	12
Fuel spill return pipe to tank	16	12
Fuel feed pipe to filter	20	15

26 - COOLING SYSTEM - BMW DIESEL

Radiator drain plug	6	4
Oil cooler pipes to radiator - manual gearbox	30	22
Water pump bolts	10	7
Pulley to water pump bolts	10	7
Fan to coupling bolts	10	7
Viscous coupling to water pump	40	30
Thermostat housing to front cover bolts	10	7
Coolant connecting pipe to front cover bolt	10	7

26 - COOLING SYSTEM - V8 PETROL

Radiator drain plug	6	4
Fan to coupling bolts	24	18
Fan assembly to water pump	56	41
Water pump bolts	22	16
Pulley to water pump bolts	22	16

30 - MANIFOLD AND EXHAUST SYSTEM - BMW DIESEL

* Exhaust manifold to cylinder head nuts	22	16
Turbocharger to manifold bolts	45	33
Coolant connecting pipe to front cover bolt	10	7
Front pipe to turbocharger nuts:		
- Stage 1	14	10
- Stage 2 - Slacken 2.5 turns	-	-
* Inlet manifold to cylinder head nuts	22	16
Intermediate exhaust pipe flange nuts	25	18
97MY on:		
Tail pipe flange to intermediate pipe flange nuts	25	18

* Tighten progressively working from centre outwards

30 - MANIFOLD AND EXHAUST SYSTEM - V8 PETROL

* Exhaust manifold to cylinder head bolts	55	40
Outer heat shield bolts	8	6
RH shock absorber top mounting bolt	85	63
Front exhaust pipe to manifold nuts - up to 99MY	50	37
Front exhaust pipe to manifold nuts - from 99MY	30	22
Front exhaust pipe to intermediate pipe nuts	25	18
+ Gearbox cross member to chassis nuts and bolts	45	33
+ Gearbox mounting to cross member flange nuts	45	33
* Inlet manifold to cylinder head bolts:		
Ignition coil bracket to inlet manifold nuts	8	6
Fuel feed pipe to fuel rail union	16	12
Inlet manifold to cylinder head bolts:		
- Stage 1 - Tighten gasket clamp bolts	0.7	0.5
- Stage 2 - Tighten manifold bolts	10	7
- Stage 3 - Tighten manifold bolts	50	37
- Stage 4 - Tighten gasket clamp bolts	17	12
97 MY on:		
Heated oxygen sensor to front pipe	20	15
LH to RH tail pipe clamps	65	48
Tail pipe flange to intermediate pipe flange nuts	25	18
RH tail pipe to LH tail pipe nut	65	48

+ New nuts/bolts must be fitted
* Tighten in sequence

33 - CLUTCH - BMW DIESEL

Cover to flywheel bolts:		
- M8 8.8	24	18
- M8 10.9	34	25
Clutch housing bolts:		
- M8	27	20
- M10	51	38
- M12	86	63
Slave cylinder to clutch housing bolts	45	33

33 - CLUTCH - V8 PETROL

Cover to flywheel bolts	40	30
Clutch housing bolts	40	30
Slave cylinder to clutch housing bolts	45	33

37 - MANUAL GEARBOX - R380

Bell housing extension to gearbox bolts	45	33
Clutch release bearing spigot bolts	18	13
Transfer gearbox to gearbox bolts	45	33
Gearbox to bell housing bolts	45	33
+ Propeller shafts to transfer box drive flanges nuts	48	35
Gear lever bolts	25	18
Selector remote housing to gearbox bolts	25	18
Pipes to oil cooler unions	22	16

+ New nuts must be fitted

41 - TRANSFER GEARBOX

Ratio motor to transfer gearbox bolts	10	7
+ Front and rear output shaft flanges Nyloc nut	148	109
+ Propeller shaft flanges nuts	48	35
Transfer gearbox to gearbox bolts	45	33
Gear lever bolts	25	18

+ New nuts must be fitted

44 - AUTOMATIC GEARBOX - ZF

Oil drain plug	15	11
Oil filler / level plug	30	22
Extension housing bolts	25	18
Parking pawl guide Torx screw	10	7
Breather pipes to gearbox bolts	15	11
Intermediate plate Allen plugs (M14)	40	30
Intermediate plate Allen plugs (M20)	50	37
Fluid pump to intermediate plate bolts	10	7
Oil cooler adaptors	42	30
Valve block to gearbox bolts	8	6
Lock-up solenoid valve, retaining fork Torx screw	8	6
Lock-up solenoid valve assembly to valve body Torx screws	8	6
Pressure regulator to valve body Torx screws	8	6
Fluid filter to valve block bolts	8	6
Oil pick-up tube bolt	8	6
Fluid pan to gearbox bolts	8	6
Oil filler tube to fluid pan (up to 99MY)	70	52
Snubber bar to crossmember (from 99MY)	45	33
Transfer gearbox to gearbox bolts	45	33
Gearbox to engine bolts	45	33
Fluid cooler pipe unions	22	16
Gearbox mounting assembly bolts	45	33
+ Propeller shafts to transfer box output flanges nuts	48	35
Torque converter to drive plate bolts - from 99MY	50	37

+ New nuts must be fitted

47 - PROPELLER SHAFTS

+ Front propeller shaft nuts	48	35
+ Rear propeller shaft to differential drive flange nuts	48	35
Rear propeller shaft to brake drum nuts	48	35

+ New nuts must be fitted

51 - REAR AXLE AND FINAL DRIVE

Axle to trailing arms:		
- M12 nuts and bolts	125	92
- M16 nuts and bolts - 8.8 Grade	160	118
- M16 nuts and bolts - 10.9 Grade	240	177
Trailing arms to chassis bolts	160	118
Shock absorbers to axle nuts	45	33
Panhard rod to axle bolt	200	148
+ Propeller shaft to rear axle nuts	48	35
Differential to axle case nuts	40	30
Differential drive flange:		
- Nut (to 1997.5 MY)	135	100
- Bolt (1997.5 MY onwards)	100	74
Mass damper to rear axle bolts	45	33

+ New nuts must be fitted

54 - FRONT AXLE AND FINAL DRIVE

Differential to axle case nuts	40	30
+ Propeller shaft to differential nuts	48	35
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Radius arms to chassis nuts	160	118
Shock absorbers to axle nuts	45	33
Air spring securing pin retaining bolts	20	15
+ Propeller shaft to front axle nuts	48	35
Track rods to steering knuckles nuts	50	37
Panhard rod to axle bolt	200	148
Drag link to steering knuckle nut	50	37
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Mass damper to front axle bolts	45	33

+ New nuts must be fitted

57 - STEERING

Fluid pipes to PAS pump:		
- M14	30	22
- M16	50	37
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- BMW diesel	30	22
- V8 petrol	16	12
Track rod adjuster clamps nuts and bolts:		
- 8 mm	22	16
- 10 mm	47	35
Steering column to bulkhead bolts	25	18
Steering column to pedal box nuts and bolts	25	18
Steering column universal joints bolts	25	18
Drag link clamps nuts and bolts:		
- 8 mm	22	16
- 10 mm	47	35
Drag link to drop arm and swivel hubs nuts and bolts	50	37
Damper to drag link nut and bolt:		
- 95 & 96 MY	125	92
- 97 MY on	50	37
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Feed hose to steering box banjo bolt	30	22
Return hose to steering box banjo bolt	50	37
Bleed screw	4	3
Steering box to chassis nuts and bolts	125	92
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PAS pump to bracket bolts	22	16
PAS pulley to pump bolts	22	16

V8 petrol:		
- PAS pump and compressor mounting bracket to engine bolts	40	30
- PAS pump to mounting bracket bolts - up to 99MY	18	13
- PAS pump to mounting bracket bolts - from 99MY	22	16
- Pulley to PAS pump bolts	25	18
Steering wheel bolt	33	24
Pad to steering wheel bolts	8	6
Track rods to steering knuckles nuts	50	37
Road wheel nuts	108	80
Composite link to axle nuts:		
- M12	125	92
- M16	160	118
Composite link to chassis nut	160	118
PAS reservoir to radiator bracket bolt	10	7
PAS pipes to steering box nut	25	18

60 - FRONT SUSPENSION

Air hose to compressor union	7	5
Compressor to air supply unit nuts	2	1.5
Air reservoir to air bracket bolts	25	18
Anti-roll bar rubber bush clamp bolts	125	92
Anti-roll bar link nuts	125	92
Compressor air inlet filter	1	0.75
Air drier to bracket	12	9
Height sensor retaining bolts:		
- 95 & 96 MY	12	9
- 97 MY on	6	4
Height sensor link to radius arm nut	8	6
Heat shield bracket/height sensor bolts	6	4
Heat shield to bracket bolts	6	4
Hub and drive shaft assembly bolts	135	100
Drive shaft nut	260	192
Panhard rod to chassis nut and bolt	200	148
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Panhard rod to axle securing bolt locking plate screw	20	15
Radius arm to chassis	160	118
Radius arm to axle nut and bolt	125	92
Shock absorber upper retaining bolt	125	92
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Pressure switch to valve block	23	17
Solenoid coil to valve block screws	1.5	1
Front air spring to axle bolt	20	15
Air distribution box to body bolt	6	4
Air drier to air cleaner bolt	3	2

64 - REAR SUSPENSION

Height sensor to chassis bolts:		
- 95 & 96 MY	12	9
- 97 MY on	6	4
Hub to axle case bolts	65	48
Drive shaft nut	260	192
Panhard rod to chassis nut and bolt	200	148
Panhard rod to axle bolt	200	148
Panhard rod to axle locking plate screw	20	15
Shock absorber top mounting bolt	125	92
Shock absorber lower mounting nut	45	33
Road wheel nuts	108	80
Trailing arm to chassis nuts and bolts:		
- M12	125	92
- M16	160	118

70 - BRAKES

Parking brake shoe adjusting bolt	25	18
High pressure hose to pump banjo bolt	24	18
Pump/motor to mounting nuts	8	6
High pressure hose to booster unit banjo bolt	24	18
Booster unit to pedal box bolts	45	33
Brake pipes to booster unit unions	14	10
Front caliper to hub bolts	165	122
Flexible hose to front caliper banjo bolt	32	24
Rear caliper to hub bolts	100	74
Flexible hose to rear caliper banjo bolt	32	24
ECU to bracket bolts	6	4
Front brake disc shield bolts	8	6
Brake disc screw	25	18
Rear brake disc shield strap bolts	8	6
Rear brake disc shield bolts	8	6
Rear brake disc screw	25	18
Rear caliper bolts	100	74
Front brake pads guide pin bolt	30	22
Road wheel nuts	108	80
Rear brake pads guide pin bolts	30	22
Propeller shaft to parking brake drum bolts	48	35
PCRV valve to valance bolts	8	6
Pipes to PCRV unions	14	10
Pump motor to valance nuts	8	6
High pressure hose to pump banjo bolt	24	18
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75 - SUPPLEMENTARY RESTRAINT SYSTEM

Crash sensor bolts	9	7
DCU bolts	9	7
Driver's air bag module to steering wheel bolts	9	7
Passenger's air bag module to fascia Torx screws	9	7
Side impact airbag nuts	5.5	4

76 - CHASSIS AND BODY

Front door hinge bolts	30	22
Striker bolts	22	16
Rear door hinge bolts	25	18
Chassis crossmember to chassis nuts and bolts	45	33
Gearbox mounting to crossmember nuts	45	33
Front bumper valance bolts	70	52
Rear bumper and support bracket bolts	29	22
Rear bumper valance mounting bolts	70	52
Road wheel nuts	108	80
Pedal box to fascia bolt	25	18
Fascia to base of 'A' post nuts	25	18
Fascia to scuttle panel bolts	25	18
Fascia to tunnel brackets nuts	25	18
Gear lever to gearbox remote bolts	25	18
Air conditioning pipes to TXV clamp bolt	6	4
Seat belt top mountings - 'B' and 'D' posts bolts	25	18
Front seat belt stalk bolt	35	26
Front seat belt reel bolts - up to 99MY	35	26
Front seat belt reel bolts - from 99MY	32	24
Front seat belt upper anchorage bolt - up to 99MY	25	18
Front seat belt upper anchorage bolt - from 99MY	22	16
Front seat belt to seat mounting bolt - from 99MY	32	24
Seat belt adjustable mounting to 'B' post bolts	25	18
Seat belt adjustable mounting to 'D' post bolts	25	18
Rear seat belt to seat pan bolt	35	26
Rear seat stalk to squab hinge bolt	35	26
Rear seat belt to upper anchorage point nut	25	18
Rear seat belt reel bolt	35	26
Rear seat squab to cushion bolts	45	33
Tailgate hinge bolts	25	18
Tailgate support stays to body bolt	22	16
Tailgate striker bolts	8	6
Wind deflector Torx screws	2	1.5
Sunroof guide assembly screws:		
Front	3	2.2
Rear	1.5	1.1
Sunroof motor screws	2	1.5
Sunroof cable locator screws	3	2.2
Sunroof to body bolts	6	4.5
Sunroof tilt mechanism screws	5	4
Sunroof panel nuts	5	4

78 - SEATS

Front seat fixing bolts	29	21
Front seat slides to cushion frames bolts	30	22
Rear seat squab latch securing screws	14	10
Rear seat front and rear retaining bolts	29	22
Seat outstation - cushion pan to frame bolts	29	21
Rear seat belt stalk to latch bolt	35	26
Rear seat latch to cushion and squab bolt	30	22

82 - AIR CONDITIONING

Compressor to mounting bracket bolts - V8 from 99MY	22	16
Pipes to condenser	15	11
Pipes to compressor bolt	23	17

84 - WIPERS AND WASHERS

Headlamp wiper arm to spindle nut	9	7
Headlamp wiper motor securing nut	9	7
Screen wiper spindle housing to scuttle nuts	11	8
Screen wiper motor securing bolts	7	5
Rear wiper arm to spindle nut	17	12
Rear wiper motor mounting bolts	7	5
Rear wiper motor spindle seal retaining nut	4	3
Front wiper arm to spindle nut	19	14

86 - ELECTRICAL

BMW diesel:		
- Pulley to alternator nut	50	37
- Starter motor securing nuts and bolts	48	35
- Clutch fluid pipe bracket lower bolt	86	63
V8 petrol:		
- Battery lead to starter solenoid nut - from 99MY	18	13
- Engine harness to alternator nuts - from 99MY		
B+ terminal	18	13
D+ terminal	5	3.5
- Engine harness to cylinder head bolt - from 99MY	20	15
- Earth lead to alternator bracket bolt - from 99MY	20	15
- Earth lead to RH front wing valance nut - from 99MY	10	7
- Pulley to alternator nut	40	30
- Alternator to mounting bracket bolts	25	18
- Tensioner securing bolt	39	29
- Tensioner pulley bolt	50	37
- Starter motor securing bolts	45	33
All vehicles:		
Headlamp wiper arm to spindle nut	10	7
Temperature gauge sensor	8	6

88 - INSTRUMENTS

BMW diesel - Coolant temperature sensor	20	15
V8 petrol - Coolant temperature sensor	10	7

NOTE: Torque values given below are for all screws and bolts not listed.

METRIC	Nm	lbf.ft
M5	6	4
M6	10	7
M8	25	18
M10	45	33
M12	90	66
M14	105	77
M16	180	132

UNC/UNF		
1/4	10	7
5/16	24	18
3/8	39	29
7/16	78	58
1/2	90	66
5/8	136	100

CONTENTS

GENERAL FITTING REMINDERS

WORKSHOP SAFETY IS YOUR RESPONSIBILITY!

The suggestions, cautions and warnings in the section are intended to serve as reminders for trained and experienced mechanics. This manual is not a course in automotive mechanics or workshop safety.

Shop equipment, shop environment, and the use and disposal of solvents, fluids, and chemicals are subject to government regulations which are intended to provide a level of safety. It is your responsibility to know and comply with such regulations.

PRECAUTIONS AGAINST DAMAGE

1. Always fit covers to protect wings before commencing work in engine compartment.
2. Cover seats and carpets, wear clean overalls and wash hands or wear gloves before working inside vehicle.
3. Avoid spilling hydraulic fluid or battery acid on paint work. Wash off with water immediately if this occurs. Use Polythene sheets to protect carpets and seats.
4. Always use a recommended Service Tool, or a satisfactory equivalent, where specified.
5. Protect temporarily exposed screw threads by replacing nuts or fitting plastic caps.

SAFETY PRECAUTIONS

1. Whenever possible use a ramp or pit when working beneath vehicle, in preference to jacking. Chock wheels as well as applying parking brake.

WARNING: Do not use a pit when removing fuel system components.

2. Never rely on a jack alone to support vehicle. Use axle stands carefully placed at jacking points to provide rigid support.
3. Ensure that a suitable form of fire extinguisher is conveniently located.
4. Check that any lifting equipment used has adequate capacity and is fully serviceable.
5. Disconnect negative (grounded) terminal of vehicle battery.

WARNING: Do not disconnect any pipes in air conditioning refrigeration system, unless trained and instructed to do so. A refrigerant is used which can cause blindness if allowed to contact eyes.

6. Ensure that adequate ventilation is provided when volatile degreasing agents are being used.
7. Do not apply heat in an attempt to free stiff nuts or fittings; as well as causing damage to protective coatings, there is a risk of damage to electronic equipment and brake linings from stray heat.

PREPARATION

1. Before removing a component, clean it and its surrounding areas as thoroughly as possible.
2. Blank off any openings exposed by component removal, using greaseproof paper and masking tape.
3. Immediately seal fuel, oil or hydraulic lines when separated, using plastic caps or plugs, to prevent loss of fluid and entry of dirt.
4. Close open ends of oilways, exposed by component removal, with tapered hardwood plugs or readily visible plastic plugs.
5. Immediately a component is removed, place it in a suitable container; use a separate container for each component and its associated parts.
6. Before dismantling a component, clean it thoroughly with a recommended cleaning agent; check that agent is suitable for all materials of component.
7. Clean bench and provide marking materials, labels, containers and locking wire before dismantling a component.

DISMANTLING

1. Observe scrupulous cleanliness when dismantling components, particularly when brake, fuel or hydraulic system parts are being worked on. A particle of dirt or a cloth fragment could cause a dangerous malfunction if trapped in these systems.
2. Blow out all tapped holes, crevices, oilways and fluid passages with an air line. Ensure that any O-rings used for sealing are correctly replaced or renewed, if disturbed.
3. Use marking ink to identify mating parts, to ensure correct reassembly. If a centre punch or scriber is used they may initiate cracks or distortion of components.
4. Wire together mating parts where necessary to prevent accidental interchange (e.g. roller bearing components).
5. Wire labels on to all parts which are to be renewed, and to parts requiring further inspection before being passed for reassembly; place these parts in separate containers from those containing parts for rebuild.
6. Do not discard a part due for renewal until after comparing it with a new part, to ensure that its correct replacement has been obtained.

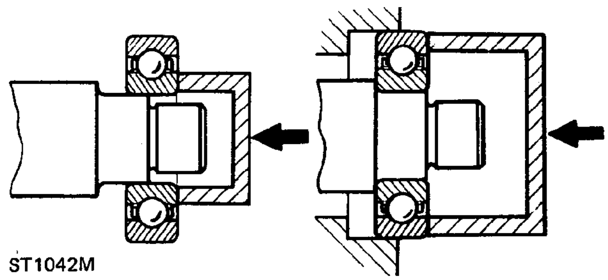
INSPECTION-GENERAL

1. Never inspect a component for wear or dimensional check unless it is absolutely clean; a slight smear of grease can conceal an incipient failure.
2. When a component is to be checked dimensionally against figures quoted for it, use correct equipment (surface plates, micrometers, dial gauges, etc.) in serviceable condition. Makeshift checking equipment can be dangerous.
3. Reject a component if its dimensions are outside limits quoted, or if damage is apparent. A part may, however, be refitted if its critical dimension is exactly limit size, and is otherwise satisfactory.
4. Use 'Plastigauge' 12 Type PG-1 for checking bearing surface clearances. Directions for its use, and a scale giving bearing clearances in 0,0025 mm steps are provided with it.

BALL AND ROLLER BEARINGS

CAUTION: Never refit a ball or roller bearing without first ensuring that it is in a fully serviceable condition.

1. Remove all traces of lubricant from bearing under inspection by washing in a suitable degreaser; maintain absolute cleanliness throughout operations.
2. Inspect visually for markings of any form on rolling elements, raceways, outer surface of outer rings or inner surface of inner rings. Reject any bearings found to be marked, since any marking in these areas indicates onset of wear.
3. Holding inner race between finger and thumb of one hand, spin outer race and check that it revolves absolutely smoothly. Repeat, holding outer race and spinning inner race.
4. Rotate outer ring gently with a reciprocating motion, while holding inner ring; feel for any check or obstruction to rotation, and reject bearing if action is not perfectly smooth.
5. Lubricate bearing generously with lubricant appropriate to installation.
6. Inspect shaft and bearing housing for discoloration or other marking suggesting that movement has taken place between bearing and seatings. (This is particularly to be expected if related markings were found in operation 2).
7. Ensure that shaft and housing are clean and free from burrs before fitting bearing.
8. If one bearing assembly of a pair shows an imperfection it is generally advisable to replace both with new bearings; an exception could be made if the faulty bearing had covered a low mileage, and it could be established that damage was confined to it only.
9. When fitting bearing to shaft, apply force only to inner ring of bearing, and only to outer ring when fitting into housing. (Refer to ST1042M).



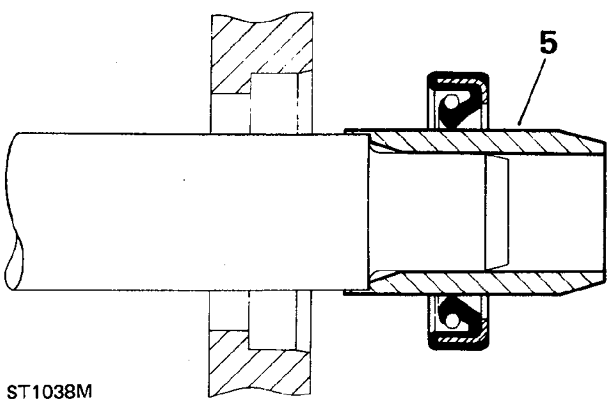
ST1042M

10. In the case of grease lubricated bearings (e.g. hub bearings) fill space between bearing and outer seal with recommended grade of grease before fitting seal.
11. Always mark components of separable bearings (e.g. taper roller bearings) when dismantling, to ensure correct reassembly. Never fit new rollers in a used outer ring, always fit a complete new bearing assembly.

OIL SEALS

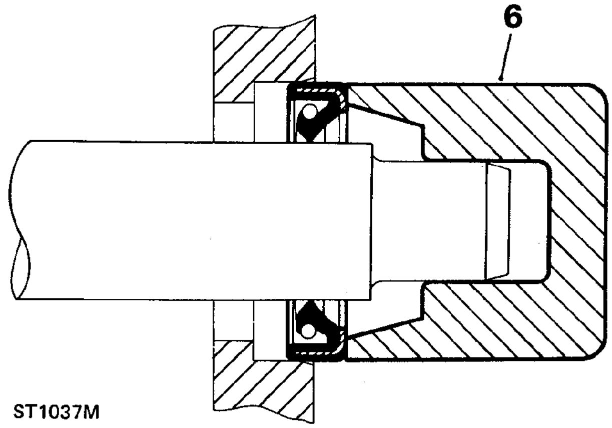
NOTE: Ensure that the seal running track is free from pits, scores, corrosion and general damage prior to fitting replacement seal.

1. Always fit new oil seals when rebuilding an assembly.
2. Carefully examine seal before fitting to ensure that it is clean and undamaged.
3. Coat the sealing lips with clean grease; pack dust excluder seals with grease, and heavily grease duplex seals in cavity between sealing lips.
4. Ensure that seal spring, if provided, is correctly fitted.
5. Place lip of seal towards fluid to be sealed and slide into position on shaft, using fitting sleeve when possible to protect sealing lip from damage by sharp corners, threads or splines. If fitting sleeve is not available, use plastic tube or tape to prevent damage to sealing lip.



ST1038M

6. Grease outside diameter of seal, place square to housing recess and press into position, using great care and if possible a 'bell piece' to ensure that seal is not tilted. (In some cases it may be preferable to fit seal to housing before fitting to shaft). Never let weight of unsupported shaft rest in seal.



ST1037M

7. If correct service tool is not available, use a suitable drift approximately 0.4mm (0.015 in) smaller than outside diameter of seal. Use a hammer **VERY GENTLY** on drift if a suitable press is not available.
8. Press or drift seal in to depth of housing if housing is shouldered, or flush with face of housing where no shoulder is provided. Ensure that the seal does not enter the housing in a tilted position.

NOTE: Most cases of failure or leakage of oil seals are due to careless fitting, and resulting damage to both seals and sealing surfaces. Care in fitting is essential if good results are to be obtained. NEVER use a seal which has been improperly stored or handled, such as hung on a hook or nail.

JOINTS AND JOINT FACES

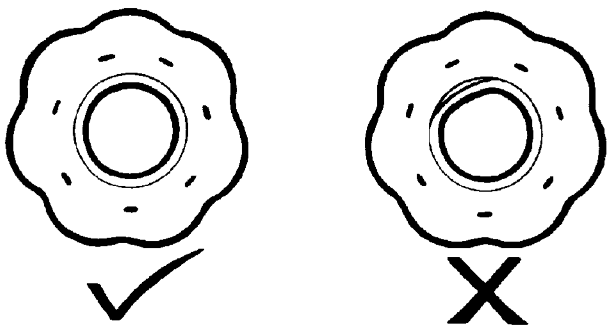
1. Always use correct gaskets where they are specified.
2. Use jointing compound only when recommended. Otherwise fit joints dry.
3. When jointing compound is used, apply in a thin uniform film to metal surfaces; take great care to prevent it from entering oilways, pipes or blind tapped holes.
4. Remove all traces of old jointing materials prior to reassembly. Do not use a tool which could damage joint faces.
5. Inspect joint faces for scratches or burrs and remove with a fine file or oil stone; do not allow removed material or dirt to enter tapped holes or enclosed parts.
6. Blow out any pipes, channels or crevices with compressed air, fit new 'O' rings or seals displaced by air blast.

FLEXIBLE HYDRAULIC PIPES, HOSES

1. Before removing any brake or power steering hose, clean end fittings and area surrounding them as thoroughly as possible.
2. Obtain appropriate plugs or caps before detaching hose end fittings, so that ports can be immediately covered to exclude dirt.
3. Clean hose externally and blow through with airline. Examine carefully for cracks, separation of plies, security of end fittings and external damage. Reject any hose found faulty.
4. When refitting hose, ensure that no unnecessary bends are introduced, and that hose is not twisted before or during tightening of union nuts.
5. Containers for hydraulic fluid must be kept absolutely clean.
6. Do not store brake fluid in an unsealed container. It will absorb water, and fluid in this condition would be dangerous to use due to a lowering of its boiling point.
7. Do not allow brake fluid to be contaminated with mineral oil, or use a container which has previously contained mineral oil.
8. Do not re-use brake fluid bled from system.
9. Always use clean brake fluid to clean hydraulic components.
10. Fit a cap to seal a hydraulic union and a plug to its socket after removal to prevent ingress of dirt.
11. Absolute cleanliness must be observed with hydraulic components at all times.
12. After any work on hydraulic systems, inspect carefully for leaks underneath the vehicle while a second operator applies maximum pressure to the brakes (engine running) and operates the steering.

FUEL SYSTEM HOSES

CAUTION: All fuel hoses are made up of two laminations, an armoured rubber outer sleeve and an inner viton core. If any of the fuel system hoses have been disconnected, it is imperative that the internal bore is inspected to ensure that the viton lining has not become separated from the amoured outer sleeve. A new hose must be fitted if separation is evident.



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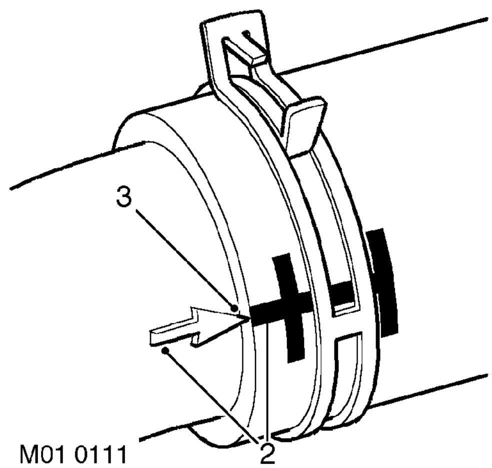
COOLING SYSTEM HOSES

CAUTION: The following precautions MUST be followed to ensure that integrity of cooling hoses and their connections to system components are maintained.

Hose orientation and connection

1. Correct orientation of cooling hoses is important in ensuring that the hose does not become fatigued or damaged through contact with adjacent components.
2. Where 'timing' marks are provided on the hose and corresponding connection, these must be used to ensure correct orientation.
3. Hoses must be pushed fully onto their connection points. Usually, a moulded form on the stub pipe provides a positive indicator.



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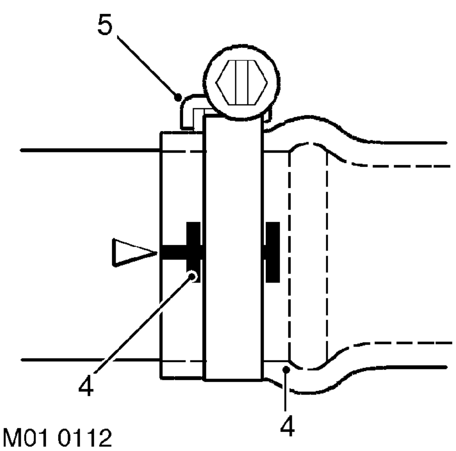
Hose clips

4. Markings are usually provided on the hose to indicate the the correct clip position. If no markings are provided, position the clip directly behind the retaining lip at the end of the stub as shown.
5. Worm drive clips should be oriented with the crimped side of the drive housing facing towards the end of the hose, or the hose may become pinched between the clip and the stub pipe retaining lip.



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6. Worm drive clips should be tightened to ***3 Nm (2 lbf.ft) unless otherwise stated.***

CAUTION: Ensure that hose clips do not foul adjacent components.

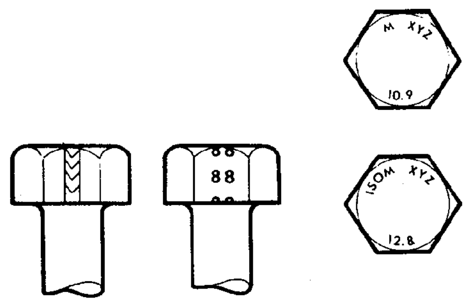
Heat protection

7. Always ensure that heatshields and protective sheathing are in good condition. Replace if damage is evident.
8. Particular care must be taken when routing hoses close to hot engine components, such as the exhaust manifold and the Exhaust Gas Recirculation (EGR) pipe.

CAUTION: Hoses will relax and deflect slightly when hot; ensure this movement is taken into account when routing and securing hoses.

METRIC BOLT IDENTIFICATION

1. An ISO metric bolt or screw, made of steel and larger than 6 mm in diameter can be identified by either of the symbols ISO M or M embossed or indented on top of the head.
2. In addition to marks to identify the manufacture, the head is also marked with symbols to indicate the strength grade, e.g. 8.8, 12.9 or 14.9, where the first figure gives the minimum tensile strength of the bolt material in tens of kgf/mm^2.
3. Zinc plated ISO metric bolts and nuts are chromate passivated, a gold-bronze colour.



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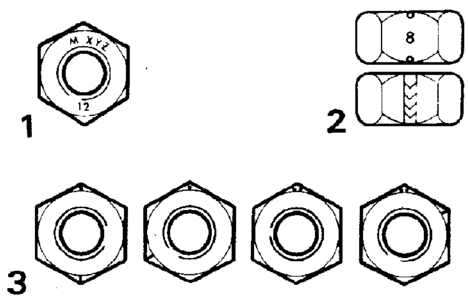
METRIC NUT IDENTIFICATION

1. A nut with an ISO metric thread is marked on one face or on one of the flats of the hexagon with the strength grade symbol 8, 12 or 14. Some nuts with a strength 4, 5 or 6 are also marked and some have the metric symbol M on the flat opposite the strength grade marking.
2. A clock face system is used as an alternative method of indicating the strength grade. The external chamfers or a face of the nut is marked in a position relative to the appropriate hour mark on a clock face to indicate the strength grade.
3. A dot is used to locate the 12 o'clock position and a dash to indicate the strength grade. If the grade is above 12, two dots identify the 12 o'clock position.



ST1036M

KEYS AND KEYWAYS

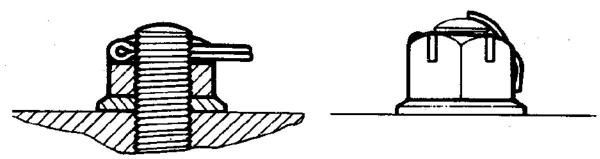
1. Remove burrs from edges of keyways with a fine file and clean thoroughly before attempting to refit key.
2. Clean and inspect key closely; keys are suitable for refitting only if indistinguishable from new, as any indentation may indicate the onset of wear.

TAB WASHERS

1. Fit new washers in all places where they are used. Always fit a new tab washer.
2. Ensure that the new tab washer is of the same design as that replaced.

SPLIT PINS

1. Fit new split pins throughout when replacing any unit.
2. Always fit split pins where cotter pins were originally used. Do not substitute spring washers: there is always a good reason for the use of a split pin.
3. All split pins should be fitted as shown unless otherwise stated.



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NUTS

1. When tightening a slotted or castellated nut never loosen it back to insert split pin or locking wire except in those recommended cases where this forms part of an adjustment. If difficulty is experienced, alternative washers or nuts should be selected, or washer thickness reduced.
2. Where self-locking nuts have been removed it is advisable to replace them with new ones of the same type.

NOTE: Where bearing pre-load is involved nuts should be tightened in accordance with special instructions.

LOCKING WIRE

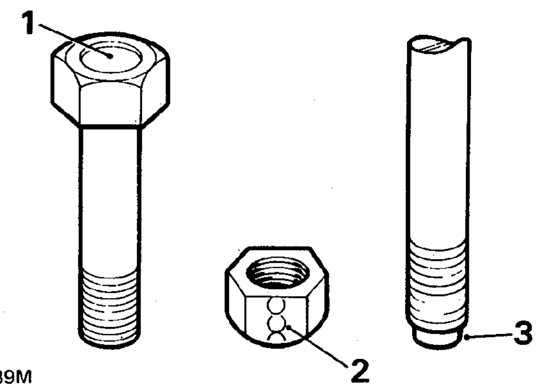
1. Fit new locking wire of the correct type for all assemblies incorporating it.
2. Arrange wire so that its tension tends to tighten the bolt heads, or nuts, to which it is fitted.

SCREW THREADS

1. Both UNF and Metric threads to ISO standards are used. See below for thread identification.
2. Damaged threads must always be discarded. Cleaning up threads with a die or tap impairs the strength and closeness of fit of the threads and is not recommended.
3. Always ensure that replacement bolts are at least equal in strength to those replaced.
4. Do not allow oil, grease or jointing compound to enter blind threaded holes. The hydraulic action on screwing in the bolt or stud could split the housing.
5. Always tighten a nut or bolt to the recommended torque value. Damaged or corroded threads can affect the torque reading.
6. To check or re-tighten a bolt or screw to a specified torque value first loosen a quarter of a turn, then re-tighten to the correct value.
7. Oil thread lightly before tightening to ensure a free running thread, except in the case of threads treated with sealant/lubricant, and self-locking nuts.

UNIFIED THREAD IDENTIFICATION

1. **Bolts**
   A circular recess is stamped in the upper surface of the bolt head.
2. **Nuts**
   A continuous line of circles is indented on one of the flats of the hexagon, parallel to the axis of the nut.
3. **Studs, Brake Rods, etc.**
   The component is reduced to the core diameter for a short length at its extremity.



ST1039M

09 - LUBRICANTS, FLUIDS AND CAPACITIES

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INFORMATION

RECOMMENDED LUBRICANTS AND FLUIDS - NAS VEHICLES

COMPONENT	SPECIFICATION	VISCOSITY	AMBIENT TEMPERATURE °C -30 -20 -10 0 10 20 30 40 50
Engine	Use oils to API service level SG, SH or SJ or ILSAC GF2 or ACEA A2:96	5W/20	
		5W/30	
		5W/40	
		5W/50	
		10W/30	
		10W/40 10W/50 10W/60	
		15W/40 15W/50	
		20W/40 20W/50	
Final drive units	Texaco Multigear	75W 90R	
Main Gearbox Automatic	ATF Dexron III		
Main Gearbox Manual	Texaco MTF 94		
Transfer box	ATF Dexron III		
Power steering	ATF Dexron III or Texamatic 9226		

See page 3 for remaining vehicle fluids

RECOMMENDED LUBRICANTS AND FLUIDS - ALL EXCEPT NAS VEHICLES

All climates and conditions

			AMBIENT TEMPERATURE °C								
COMPONENT	**SPECIFICATION**	**VISCOSITY**	**-30**	**-20**	**-10**	**0**	**10**	**20**	**30**	**40**	**50**
Petrol models Engine sump Oil can	Use oils to API service level SG or SH or ACEA A2:96	5W/30									
		5W/40 5W/50									
		10W/30									
		10W/40 10W/50 10W/60									
		15W/40 15W/50									
		20W/40 20W/50									
		25W/40 25W/50									
Diesel models Engine sump	ACEA A3:96 ACEA B3:96	5W/30									
		5W/40 5W/50									
		10W/30									
		10W/40 10W/50									
Final drive units	Texaco Multigear	75W 90R									
Main Gearbox Automatic	ATF Dexron III										
Main Gearbox Manual	Texaco MTF 94										
Transfer box	ATF Dexron III										
Power steering	ATF Dexron III or Texamatic 9226										

Propeller shaft Front and Rear Lubrication nipples	NLGI - 2 Multi-purpose Lithium based GREASE
Door check straps	Rocol SM500 molygrease
Door locks	Fuchs Renocal FN745
Brake and clutch reservoirs	Brake fluids having a minimum boiling point of 260°C (500 °F) and complying with FMVSS 116 DOT4
Engine cooling system	Use an ethylene glycol based anti-freeze (containing no methanol) with non-phosphate corrosion inhibitors suitable for use in aluminium engines to ensure the protection of the cooling system against frost and corrosion in all seasons.
Battery lugs, earthing surfaces where paint has been removed	Petroleum jelly. **NOTE: Do not use Silicone Grease**
Air conditioning system refrigerant	Refrigerant R134a **CAUTION: DO NOT use any other type of refrigerant.**
Air conditioning compressor oil	
V8 up to 99MY	Sanden SP10
V8 from 99MY and diesel	Nippon Denso ND-OIL 8
ABS sensor bush	Silicone grease: Staborags NBU - Wabco 830 502,0634 Wacker chemie 704 - Wabco 830 502,0164 Kluber GL301

LUBRICATION PRACTICE

Use a high quality oil of the correct viscosity range and service classification in the engine during maintenance and when topping up. The use of oil not to the correct specification can lead to high oil and fuel consumption and ultimately to damaged components.

Oil to the correct specification contains additives which disperse the corrosive acids formed by combustion and prevent the formation of sludge which can block the oilways. Additional oil additives should not be used. Always adhere to the recommended servicing intervals.

WARNING: Many liquids and other substances used in motor vehicles are poisonous. They must not be consumed and must be kept away from open wounds. These substances, among others, include anti-freeze windscreen washer additives, lubricants and various adhesives.

CAPACITIES

The following capacity figures are approximate and provided as a guide only. Refer to Section 10 for correct checking procedure for powertrain oil levels.

Engine sump and filter - Petrol		
From dry	6.6 litres	14.0 US pints
Refill	5.8 litres	12.3 US pints
Engine sump and filter - Diesel		
From dry	9.5 litres	20 US pints
Refill	8.7 litres	18.4 US pints
Manual gearbox		
From dry	2.7 litres	5.7 US pints
Refill	2.2 litres	4.6 US pints
Automatic gearbox		
4.6 V8 up to '99MY	11 litres	23.2 US pints
4.0 V8 (& 4.6 V8 from '99MY)	9.7 litres	20.5 US pints
Diesel	9.7 litres	20.5 US pints
Transfer box		
From dry	2.4 litres	5.0 US pints
Refill	2.0 litres	4.2 US pints
Front axle		
From dry	1.7 litres	3.6 US pints
Refill	1.6 litres	3.4 US pints
Rear axle		
From dry	1.7 litres	3.6 US pints
Refill	1.6 litres	3.4 US pints
Power steering box and reservoir	1.7 litres	3.6 US pints
Cooling system	11.3 litres	24 US pints
Fuel tank		
Petrol	100 litres	26.4 US gallons
Diesel	90 litres	24 US gallons
Air conditioning system		
Refrigerant charge weight		
V8 up to 99MY	1250 grammes	44 oz
V8 from 99MY	1380 $\pm$ 25 grammes	49 $\pm$ 1 oz
Diesel	1100 grammes	39 oz
Refrigerant oil in system		
V8 up to 99MY	150 cm^3	0.32 US pint
V8 from 99MY	180 cm^3	0.38 US pint
Diesel	140 cm^3	0.30 US pint

ANTI-FREEZE

ENGINE TYPE	MIXTURE STRENGTH	PERCENTAGE CONCENTRATION	PROTECTION LOWER TEMPERATURE LIMIT
V8 Engine Diesel Engine	One part anti-freeze One part water	50%	
Complete protection Vehicle may be driven away immediately from cold			- 33°F - 36°C
Safe limit protection Coolant in mushy state. Engine may be started and driven away after warm-up period			- 41°C - 42°F
Lower protection Prevents frost damage to cylinder head, block and radiator. Thaw out before starting engine			- 47°C - 53°F

⚠ **CAUTION: Anti-freeze content must never be allowed to fall below 25% otherwise damage to the engine is liable to occur. Also, anti-freeze content should not exceed 60% as this will greatly reduce the cooling effect of the coolant.**

FUEL REQUIREMENTS

Catalyst vehicles

Vehicles equipped with catalytic converter are designed to use ONLY unleaded fuel. Unleaded fuel must be used for the emission control system to operate properly. Its use will also reduce spark plug fouling, exhaust system corrosion and engine oil deterioration.

Using fuel that contains lead will result in damage to the emission control system and could result in loss of warranty coverage. The effectiveness of the catalysts in the catalytic converters will be seriously impaired if leaded fuel is used. The vehicle is equipped with an electronic fuel injection system, which includes two oxygen sensors (4 oxygen sensors on NAS vehicles). Leaded fuel will damage the sensors, and will deteriorate the emission control system.

Regulations require that pumps delivering unleaded fuel be labelled **UNLEADED.** Only these pumps have nozzles which fit the filler neck of the vehicle fuel tank.

RECOMMENDED FUEL

Petrol engines

Use petrol conforming to European standard EN228

Low compression engines
- With catalytic converter .... 91 RON minimum unleaded
- Without catalytic converter
  - 4.0 litre .... 91 RON minimum unleaded or 91 RON minimum leaded
  - 4.6 litre .... 91 RON minimum unleaded or 91 RON minimum leaded

High compression engines .... 95 RON minimum unleaded

NOTE: It is possible to use unleaded fuel with a 91 RON minimum octane rating for high compression engines, but performance will be adversely affected.

Using fuel with an octane rating lower than stated above could seriously impair vehicle performance.

Diesel engines .... Diesel fuel to European standard EN 590; minimum Cetane No. 45

In the interests of optimum vehicle performance, the use of oxygenated fuels such as blends of methanol/gasoline or ethanol/gasoline (e.g. 'Gasohol') is not recommended. If oxygenated fuels are to be used, be aware of the following maximum limits for the percentage of fuel additive that is allowed in the relevant markets:

NAS specification:
Methyl Tertiary Butyl Ether (MTBE) 15%
Ethyl Tertiary Butyl Ether (ETBE) 15%
Ethanol (Ethyl or grain alcohol) 10%

CAUTION: Wherever possible, avoid using fuel containing Methanol

European specification (EN 228):

Methyl Tertiary Butyl Ether (MTBE) 15%
Ethyl Tertiary Butyl Ether (ETBE) 15%
Ethanol (Ethanol (Ethyl or grain alcohol) 5%
Methanol with co-solvents 3%

CAUTION: Take care not to spill fuel during refuelling.

10 - MAINTENANCE

CONTENTS

SERVICE SCHEDULE

The following section describes the items detailed in the vehicle Service Schedule. Where required, instructions are given for carrying out the service procedure, or a cross reference is given to where the procedure may be found in the manual.

Service schedule sheets are published separately to reflect the needs and intervals for each vehicle variant. Procedures given in the workshop manual must be used in conjunction with the service schedule sheets.

Service schedule sheets are available in pads from:

Land Rover Merchandising
PO Box 534
Erdington
Birmingham B24 0QS
England

VEHICLE INTERIOR

CHECK CONDITION AND SECURITY OF SEATS, SEAT BELT MOUNTINGS AND BELTS, BUCKLES AND OPERATION OF INERTIA SEAT BELTS.

CHECK CONDITION/OPERATION OF FRONT/REAR/HEADLAMP WASHERS AND WIPER BLADES.

CHECK OPERATION OF PARK BRAKE, ADJUST IF NECESSARY.

The park brake should be fully operational on third notch of ratchet. If adjustment is required. ***See BRAKES, Adjustment.***

VEHICLE EXTERIOR

CHECK/ADJUST HEADLAMP AND AUXILIARY LAMP ALIGNMENT.

REMOVE ROAD WHEELS. CHECK TYRES.

Check tyres (including spare) for compliance with manufacturers' specification. Check visually for cuts, lumps, bulges, uneven tread wear and tread depth. Check tyre pressures.

INSPECT BRAKE PADS FOR WEAR, CALIPERS FOR LEAKS AND DISCS FOR CONDITION

Fit new pads if minimum thickness is less than 3.0 mm (1/8 in.)

For front brake pad renewal. ***See BRAKES, Repair.***

For rear brake pad renewal. ***See BRAKES, Repair.***

WARNING: When renewing brake pads, it is essential that only genuine components with correct grade of lining are used. Always fit new pads in axle sets, NEVER individually or as a single wheel set. Serious consequences could result from out of balance braking due to mixing of linings.

REFIT ROAD WHEELS

Fit road wheels in original hub position. Secure in position with wheel nuts, do not fully tighten wheel nuts at this stage, lower vehicle and finally tighten wheel nuts. Tighten to ***108 Nm (80 lbf.ft)***

CAUTION: When refitting a road wheel, apply a suitable anti-seize compound such as Raworth 33/04, to the spigot bore of the wheel. This will prevent possible seizure of the wheel to the hub spigot. Ensure that no compound comes into contact with the braking components.

CHECK FRONT WHEEL ALIGNMENT

Use recognised wheel alignment equipment to perform this check. ***See STEERING, Adjustment.***

LUBRICATE DOOR LOCKS, CHECK STRAPS, BONNET CATCHES AND FUEL FLAP.

UNDER BONNET MAINTENANCE

CHECK COOLING, INTERCOOLER AND HEATER SYSTEMS FOR LEAKS, HOSES FOR SECURITY AND CONDITION. TOP UP AS NECESSARY.

CAUTION: Cooling system hoses should be changed at first signs of deterioration.

RENEW SPARK PLUGS

CAUTION: Take great care when fitting spark plugs not to cross-thread plug, otherwise costly damage to cylinder head will result. It is essential that correct type of spark plugs is fitted. Incorrect grade of plugs may lead to piston overheating and engine failure. Only use approved spark plugs, use of unapproved spark plugs may cause the misfire detection system to malfunction.

Remove

1. Disconnect battery negative lead.
2. Remove H.T. leads from spark plugs.

NOTE: Note lead connections to ensure correct re-assembly.

CAUTION: To avoid damage to H.T. leads, remove them by pulling the rubber boot NOT the lead.

3. Remove plugs and washers.
4. Ensure plugs are set to correct gap: 1.0 ± 0.05 mm (0.040 ± 0.002 in). ***See FUEL SYSTEM, Repair.***

NOTE: Do not attempt to clean or adjust gaps on spark plugs fitted after 99MY. If a spark plug problem exists, try substituting the defective spark plug with a new one.

5. Fit new spark plugs and washers. Tighten to ***20 Nm (15 lbf ft)***
6. Ensure H.T. leads are correctly refitted. ***See FUEL SYSTEM, Repair.***
7. Reconnect battery negative lead.

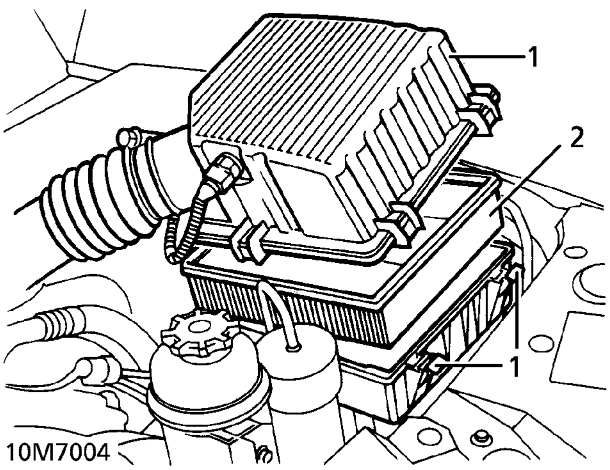
RENEW FUEL FILTER ELEMENT (DIESEL)

Renew fuel filter. ***See FUEL SYSTEM, Repair.***

DRAIN WATER FROM FUEL FILTER (DIESEL)

RENEW AIR FILTER ELEMENT AND CLEAN DRAIN HOLE (DIESEL)

RENEW AIR FILTER ELEMENT AND CLEAN DRAIN HOLE (V8)



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1. Release 4 clips, lift air cleaner cover.
2. Remove air filter element.
3. Fit new element ensuring it locates correctly in air cleaner body.

RENEW POLLEN FILTERS

Renew pollen filters. ***See HEATING AND VENTILATION, Repair.***

RENEW EVAP CANISTER, CHECK EVAPORATIVE LOSS SYSTEM AND FILLER CAP SEAL (V8)

Renew EVAP canister. ***See EMISSION CONTROL, Repair.***

CHECK CONDITION OF ANCILLARY DRIVE BELT/S (poly V)

Renew drive belts if damaged.

RENEW ANCILLARY DRIVE BELT (POLY V)

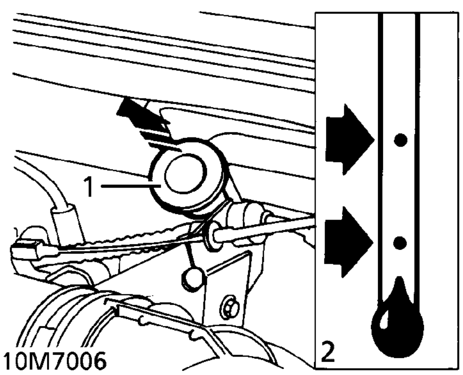
Alternator Drive Belt - Renew. ***See ELECTRICAL, Repair.***

CHECK/TOP UP AUTOMATIC TRANSMISSION FLUID - up to 99MY

CAUTION: When replacing the dipstick, ensure that the handle lugs fully engage with tube.

NOTE: Check the fluid level only when the engine and gearbox are cold.

1. Ensure vehicle is level, then select 'P' (park) and start the engine.
2. With the engine running at idle speed and both footbrake and hand brake applied, move the selector lever to position '1' and then back to position 'P'.
3. Still with the engine running remove dipstick, wipe using lint free cloth.
4. Reinsert the dipstick fully and withdraw again to check the level.



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5. Check fluid level registers between MAX and MIN marking on dipstick. For fluid recommendations. ***See LUBRICANTS, FLUIDS AND CAPACITIES, Information.***

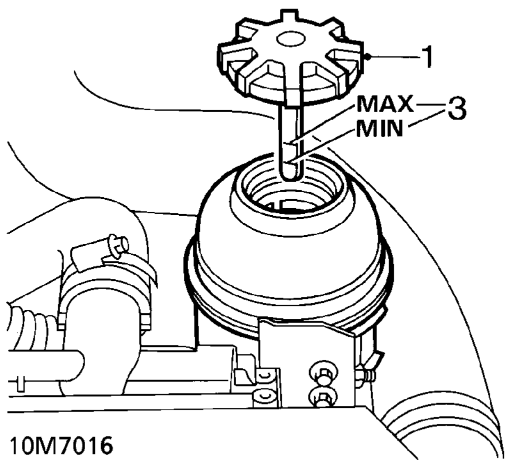
CHECK/TOP UP AUTOMATIC TRANSMISSION FLUID - from 99MY

1. Refer to gearbox drain and refill procedure. ***See AUTOMATIC GEARBOX, Repair.***

CHECK/TOP UP POWER STEERING FLUID RESERVOIR

NOTE: Power steering fluid level is checked when fluid is cold with engine switched off.

1. Clean filler cap.
2. Remove dipstick, wipe using lint free cloth.



3. Fit cap fully, remove cap, check fluid level registers between the two markings on the dipstick. For fluid recommendations. ***See LUBRICANTS, FLUIDS AND CAPACITIES, Information.***

CHECK/TOP UP BRAKE/CLUTCH FLUID RESERVOIR

WARNING: Clean reservoir body and filler cap before removing cap. Use only fluid from a sealed container.

NOTE: Clutch master cylinder is supplied by the brake fluid reservoir. Use following procedure if topping up is required.

1. Turn ignition ON, to activate hydraulic pump. If pump does not activate, depress brake pedal several times until it is heard to operate.
2. When pump stops, check that level is between 'MIN' and 'MAX' marks.
3. If level is below 'MIN' mark on reservoir, top up, using correct fluid. ***See LUBRICANTS, FLUIDS AND CAPACITIES, Information.***

CHECK/TOP UP WASHER RESERVOIR

Top up washer reservoir to within 25 mm of bottom of filler neck. Use the correct quantity of screen washer additive to assist removing mud, flies and road film and protect against freezing.

LUBRICATE ACCELERATOR AND CRUISE CONTROL LINKAGES

REMOVE BATTERY CONNECTIONS

Clean, coat with petroleum jelly and refit terminals.

The exterior of the battery should be wiped clean to remove any dirt or grease.

NOTE: From '96 MY, the alarm sounder may be fitted with a back-up battery, the purpose of which is to power the anti-theft alarm if the main battery is disconnected. On these vehicles it is essential to adopt the following procedure before disconnecting the terminals in order to prevent the alarm from sounding:

1. Turn starter switch 'on' and then 'off'.
2. Disconnect the battery WITHIN 17 SECONDS (if the battery is not disconnected within 17 seconds, the alarm will sound).

WARNING: Hydrogen and oxygen gases are produced during normal battery operation. This gas mixture can explode if flames, sparks or lighted tobacco are brought near battery. When charging or using a battery in an enclosed space, always provide ventilation and shield your eyes.

Batteries contain sulphuric acid. Avoid contact with skin, eyes, or clothing. Also, shield your eyes when working near battery to protect against possible splashing of acid solution. In case of acid contact with skin, eyes, or clothing, flush immediately with water for a minimum of fifteen minutes. If acid is swallowed, drink large quantities of milk or water, followed by milk of magnesia, a beaten egg, or vegetable oil.
SEEK MEDICAL AID IMMEDIATELY.

A low maintenance battery is installed in the vehicle. Dependent upon climate conditions electrolyte levels should be checked as follows:

Temperate climates every three years.

Hot climates every year.

CHECK INTERCOOLER/RADIATOR FOR EXTERNAL OBSTRUCTIONS

FLUSH DIESEL INTERCOOLER ELEMENT

Remove intercooler. ***See FUEL SYSTEM, Repair.***

Flush the intercooler using Intercooler flushing solvent following the manufacturer's instructions. Dry the intercooler completely and check for damage or deterioration. Fit a new intercooler if necessary.

CHECK CONDITION OF STEERING INTERMEDIATE SHAFT

The intermediate shaft has a red indicator clip fitted which must be inspected at service, or after the vehicle has been subjected to an impact. If the clip is not present, or is not fully seated against the clamp plate, a new intermediate shaft must be fitted. ***See STEERING, Repair.***

DEPRESSURISE ELECTRONIC AIR SUSPENSION.

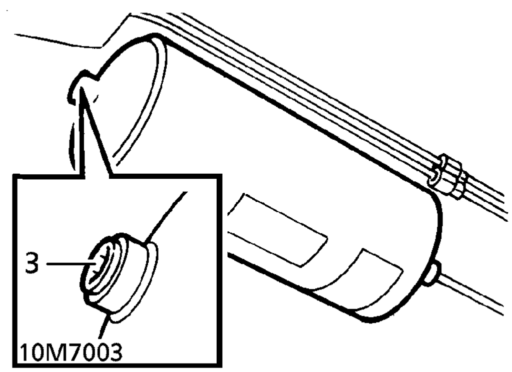
Depressurise air suspension system using TestBook.

RENEW ELECTRONIC AIR SUSPENSION COMPRESSOR INTAKE AND EXHAUST FILTERS.

Compressor inlet filter. ***See FRONT SUSPENSION, Repair.***

REMOVE/REFIT AIR RESERVOIR DRAIN PLUG.

1. Clean area around reservoir drain plug.
2. Partially open drain plug, allow residual air to escape.



3. Remove drain plug.
4. Renew air dryer if there is evidence of water in the system. ***See FRONT SUSPENSION, Repair.***
5. Fit drain plug. Tighten to ***70 Nm (52 lbf.ft)***

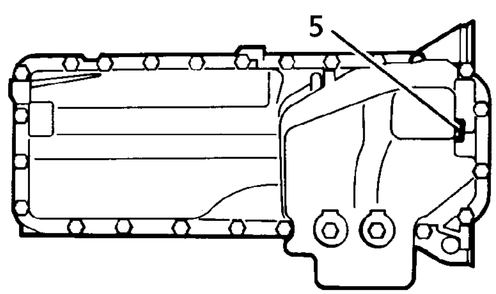
REPRESSURISE AIR SUSPENSION SYSTEM.

UNDER VEHICLE MAINTENANCE

This section covers renewal of lubricating oils for vehicle major units and other components requiring lubrication, as detailed in the Service Schedule. For lubricant recommendations. ***See LUBRICANTS, FLUIDS AND CAPACITIES, Information.***
If possible drain oil when it is warm. Always clean drain and filler/level plugs before removing.
Disconnect vehicle battery to prevent engine being started and vehicle moved inadvertently, while oil changing is taking place.
Allow oil to drain completely, except where blown sand or dirt can enter drain holes. In these conditions clean and refit drain plugs immediately main bulk of oil has drained.
Always refill with oil of correct make and specification recommended in lubrication charts and from sealed containers.

RENEW ENGINE OIL AND FILTER - DIESEL

1. Ensure vehicle is level.
2. Run engine to warm oil, switch off ignition.
3. Disconnect battery negative lead.
4. Place a suitable drain tray under drain plug.



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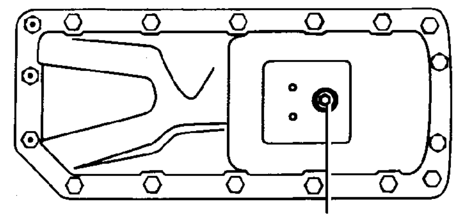
5. Remove drain plug from sump. Allow oil to drain completely.
6. Fit new sealing washer, fit plug and tighten to:-
   M12 plug - ***25 Nm (18 lbf.ft)***
   M22 plug - ***60 Nm (44 lbf.ft)***
7. Fit new oil filter. ***See ENGINE, Repair.***
8. Fill engine with correct quantity of new oil, check level.
9. Reconnect battery negative lead.
10. Start engine and run at 2500 rpm until oil warning lamp extinguishes (approximately 5 seconds).
11. Stop engine, check for oil leaks, check oil level. Top-up if necessary.

RENEW ENGINE OIL AND FILTER - V8

1. Ensure vehicle is level.
2. Run engine to warm oil, switch off ignition.
3. Disconnect battery negative lead.
4. Place suitable drain tray under drain plug.



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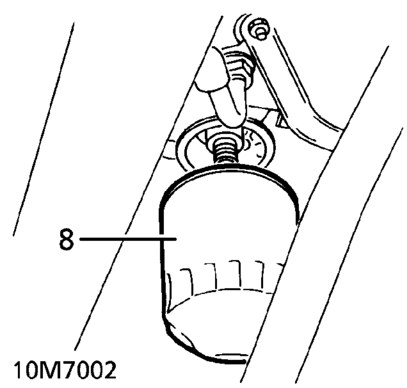
5. Remove drain plug from sump. Allow oil to drain completely.
6. Fit new copper washer and refit plug. Tighten to:
   Up to 99MY - ***45 Nm (33 lbf.ft).***
   From 99MY - ***32 Nm (24 lbf.ft).***
7. Place drain tray under oil filter.



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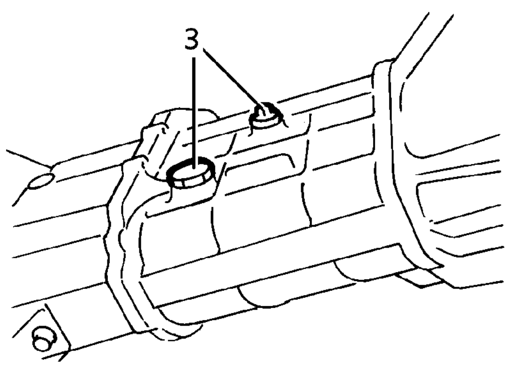
8. Unscrew filter anti-clockwise.
9. Clean oil cooler adaptor mating face. Coat rubber washer of new filter with clean engine oil. Screw filter on clockwise until rubber sealing ring touches machined face, tighten a further half turn by hand only. **DO NOT** overtighten.
10. Clean outside of oil filler cap, remove from filler neck. Clean inside cap.
11. Pour in correct quantity of new oil of correct grade from a sealed container to high mark on dipstick and firmly replace filler cap. **DO NOT FILL ABOVE 'HIGH' MARK.**
12. Reconnect battery negative lead.
13. Run engine and check for leaks from filter. Stop engine, allow oil to run back into sump for a few minutes, check oil level again and top up if necessary.

NOTE: When checking oil level, ensure that the oil can symbol on dipstick is correct way up when viewed from left hand side of vehicle.

RENEW MANUAL GEARBOX OIL.

1. Ensure vehicle is level. Place a suitable drain tray under gearbox.
2. Disconnect battery negative lead.
3. Clean area around filler/level and drain plugs. Remove both plugs. Allow oil to drain completely.



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4. Fit and tighten drain plug to ***30 Nm (22 lbf.ft)***
5. Inject new oil into the gearbox until it runs out of filler hole. Fit and tighten plug to ***30 Nm (22 lbf.ft)***
6. Reconnect battery negative lead.

CHECK/TOP UP GEARBOX OIL

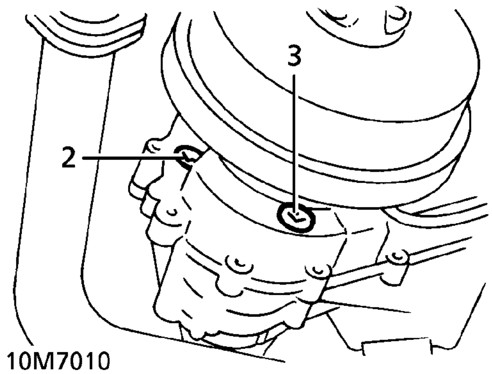
1. Ensure vehicle is level.
2. Remove oil filler level plug. If necessary, inject new oil into the gearbox until it runs out of filler hole. Fit and tighten plug to ***30 Nm (22 lbf.ft)***

RENEW AUTOMATIC GEARBOX FLUID AND FILTER

For procedure. ***See AUTOMATIC GEARBOX, Repair.***

RENEW TRANSFER BOX OIL

1. Ensure vehicle is level. Place a suitable drain tray under gearbox. Disconnect battery negative lead.
2. Clean area around filler/level plug. Remove filler/level plug.
3. Clean area around drain plug. Remove drain plug. Allow oil to drain completely.



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4. Thoroughly clean drain plug threads, apply Hylomar sealant. Fit drain plug. Tighten to ***30 Nm (22 lbf.ft)***
5. Inject new oil into the gearbox until it runs out of filler hole.
6. Thoroughly clean filler/level plug threads, apply Hylomar sealant. Fit plug. Tighten to ***30 Nm (22 lbf.ft)***
7. Reconnect battery negative lead.

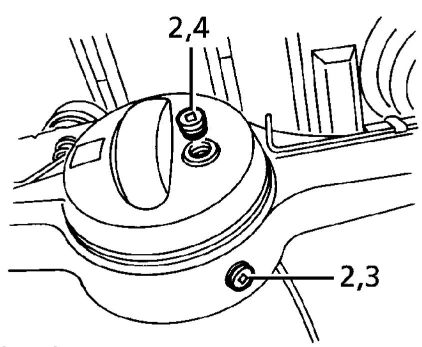
CHECK TRANSFER BOX OIL LEVEL

1. Ensure vehicle is level. Place a suitable drain tray under gearbox.
2. Disconnect battery negative lead.
3. Clean area around filler/level plug.
4. Remove plug. If required, inject new oil into the gearbox until it runs out of filler hole.
5. Thoroughly clean filler/level plug threads, apply Hylomar sealant. Fit plug to ***30 Nm (22 lbf.ft)***
6. Reconnect battery negative lead.

RENEW FRONT AND REAR AXLE OIL

NOTE: To ensure correct oil level the vehicle must be in 'STANDARD' ride height when checking/topping up axle oil.

1. Ensure vehicle is level. Place a suitable drain tray under axle to be drained.
2. Clean area around filler/level and drain plugs. Remove both plugs. Allow oil to drain completely.



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3. Clean and fit drain plug. Inject new oil into the axle until it runs out of filler hole.
4. Clean and fit filler/level plug. Wipe away surplus oil.

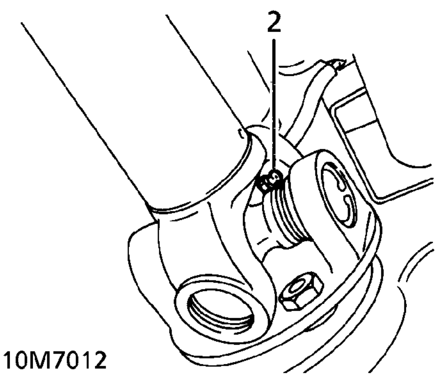
CHECK FRONT AND REAR AXLE OIL LEVEL

NOTE: To ensure correct oil level the vehicle must be in 'STANDARD' ride height when checking/topping up axle oil.

1. Place vehicle on lift or level ground.
2. Clean area around filler plug. Remove filler plug.
3. If necessary, inject new oil into the axle until it runs out of filler hole.
4. Clean and fit filler/level plug. Wipe away surplus oil.

LUBRICATE PROPELLER SHAFT SLIDING AND UNIVERSAL JOINTS

1. Clean all grease nipples on front and rear propeller shafts.
2. Using a low pressure hand grease gun, apply recommended grease to grease nipples on propeller shaft universal and sliding joints.



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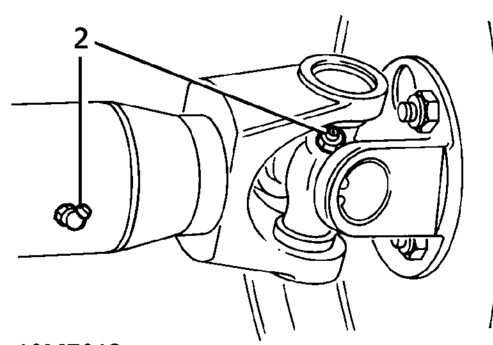

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REPLACE FUEL FILTER (V8)

To renew fuel filter. ***See FUEL SYSTEM, Repair.***

CHECK VISUALLY HEATSHIELDS, BRAKE, FUEL, CLUTCH PIPES/UNIONS FOR CHAFING, LEAKS AND CORROSION. INVESTIGATE IF NECESSARY.

CHECK EXHAUST SYSTEM FOR LEAKS, SECURITY AND DAMAGE.

RENEW HEATED OXYGEN SENSORS (HO_2S) (CATALYST VEHICLES).

To renew oxygen sensors. ***See FUEL SYSTEM, Repair.***

RENEW CATALYTIC CONVERTERS (V8)

To renew catalytic converters. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***

CHECK FOR CHAFING, CORROSION AND FLUID LEAKS FROM STEERING AND SUSPENSION SYSTEMS, HYDRAULIC PIPES AND UNIONS.

CHECK/TIGHTEN SUSPENSION, STEERING UNIT AND STEERING ROD BALL JOINT FIXINGS, CHECK CONDITION OF BALL JOINTS AND DUST COVERS.

Ball joints are lubricated for their normal life during manufacture and require no further lubrication. Joints should be checked at specified intervals but more frequently if the vehicle is used continuously under arduous conditions. Any ball joints exhibiting wear or dislodged/damaged dust covers will require the entire joint to be replaced.

CHECK AIR SUSPENSION PIPES AND SPRINGS FOR SECURITY AND DAMAGE.

CHECK SHOCK ABSORBERS/HEIGHT SENSORS AND HARNESS ASSEMBLY FOR LEAKAGE AND DAMAGE.

CHECK ROAD WHEEL SPEED SENSOR HARNESS FOR DAMAGE.

CARRY OUT ROAD TEST, CHECK FOR CORRECT FUNCTION OF ALL VEHICLE SYSTEMS.

ENDORSE THE SERVICE RECORD.

REPORT ANY UNUSUAL FEATURES OF VEHICLE CONDITION AND ADDITIONAL WORK REQUIRED.

IMPORTANT

Antifreeze

At three yearly intervals, or at the onset of the third winter, the cooling system must be drained, flushed and refilled with the correct water and antifreeze solution

Air bags

The front air bags on SRS vehicles must be renewed every 10 years. The side air bags must be renewed every 15 years.

IT IS RECOMMENDED THAT:

At 20,000 km (12,000 miles) intervals, clean sunroof drain tubes and channels, lubricate guide rails and slides.

At 60,000 km (36,000 miles) intervals or every 3 years, whichever is the earlier, the hydraulic brake fluid should be completely renewed.

At 120,000 km (72,000 miles) intervals or 6 years, whichever is earlier, all hydraulic brake fluid seals and flexible brake hoses should be renewed. All working surfaces of the caliper cylinders should be examined and components renewed where necessary.

Vehicles used extensively in arduous/off road operating conditions will require the road wheel speed sensors, brake pads, calipers, hoses and pipes to be checked at 1600 km (1000 mile) intervals.

Vehicles used extensively in arduous/off road operating conditions will require the air suspension compressor inlet and exhaust filters to be replaced at more frequent intervals.

Every 3 years the vehicle locking handset batteries should be renewed.

When the vehicle is used in dusty or field conditions or deep wading, frequent attention to the air cleaner may be required.

WARNING: Two wheel roller tests must not be carried out. Four wheel roller tests must be restricted to 5 km/h (3 mph).

CONTENTS

DESCRIPTION

The diesel engine fitted to New Range Rover is a 2.5 litre, liquid cooled, 6 cylinder, in-line unit. It has an electronically regulated fuel injection system and is turbocharged. Power output is increased by the turbocharger which delivers compressed air to the combustion chambers via an intercooler.

The engine develops 100 kW (134 hp) at 4400 RPM.

Engine performance is managed by a Digital Diesel Electronics (DDE) system. This system monitors and controls all engine functions such as the injection timing, delivery volume and charge-air intercooling. For full description of the DDE system, ***See FUEL SYSTEM, Description and operation.***

The flywheel is a dual-mass unit and is hydraulically damped to prevent transmission rattle in all operating conditions. Attached to the flywheel, around its circumference at 60 degree intervals, are six position pins. These are used by the DDE system to determine engine speed and crankshaft position.

The engine comprises the following main systems and components:

Crankcase
Cylinder head
Air intake system
Forced aspiration system
Injection system - ***See FUEL SYSTEM, Description and operation.***
Lubrication system
Cooling system - ***See COOLING SYSTEM, Description and operation.***
Auxiliary driven assemblies

Crankcase

The cast steel crankcase, which incorporates a cooling water jacket, is machined and bored to form a cylinder block (cylinder bore 80 mm) and a crankshaft housing. These contain the pistons, connecting rods and the crankshaft. Bolted to the underside of the crankcase is an aluminium reinforcement plate with an integrated oil deflector. The reinforcement plate increases crankcase stability and prevents oil foaming and ventilation losses.

Pistons

Each piston is manufactured from aluminium and has three grooves to accommodate piston rings. The top ring is a 15°keystone ring, the centre ring is a tapered compression ring and the lower ring is spring-loaded oil ring. The piston skirt is phosphated and graphited while the piston crown has a V-patterned groove machined into it. The V-patterned groove forms part of the combustion chamber, which is designed on a swirl chamber principle. This reduces fuel consumption, exhaust emission and smoke produced at full load. Piston cooling is by oil which is directed to the underside of each piston through crankcase-mounted spray jets; drillings in the piston allow oil to circulate thoroughly.

Pistons have a stroke of 82.8 mm and are attached to the connecting rods by 27 mm diameter gudgeon pins

Connecting rods

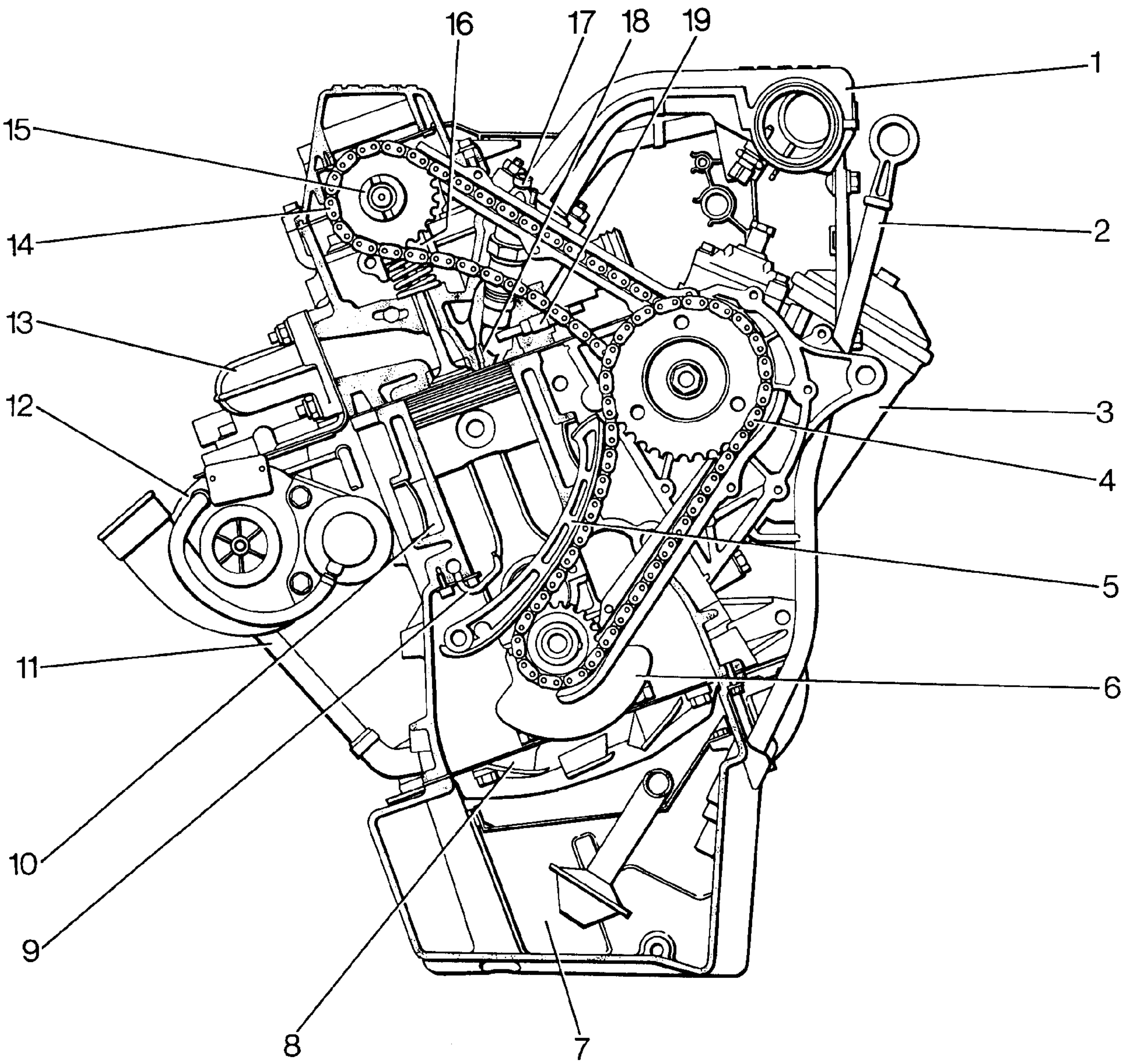
Power is transmitted to the crankshaft through the forged steel connecting rods.

Crankshaft

The crankshaft is forged from high-tensile steel and has seven main bearing journals. Journals are supported in bearing shells fitted to the crankcase; dynamic balancing of the crankshaft is achieved by the use of 12 balance weights. An axially decoupled torsional vibration damper suppresses longitudinal vibration of the crankshaft to reduce noise.

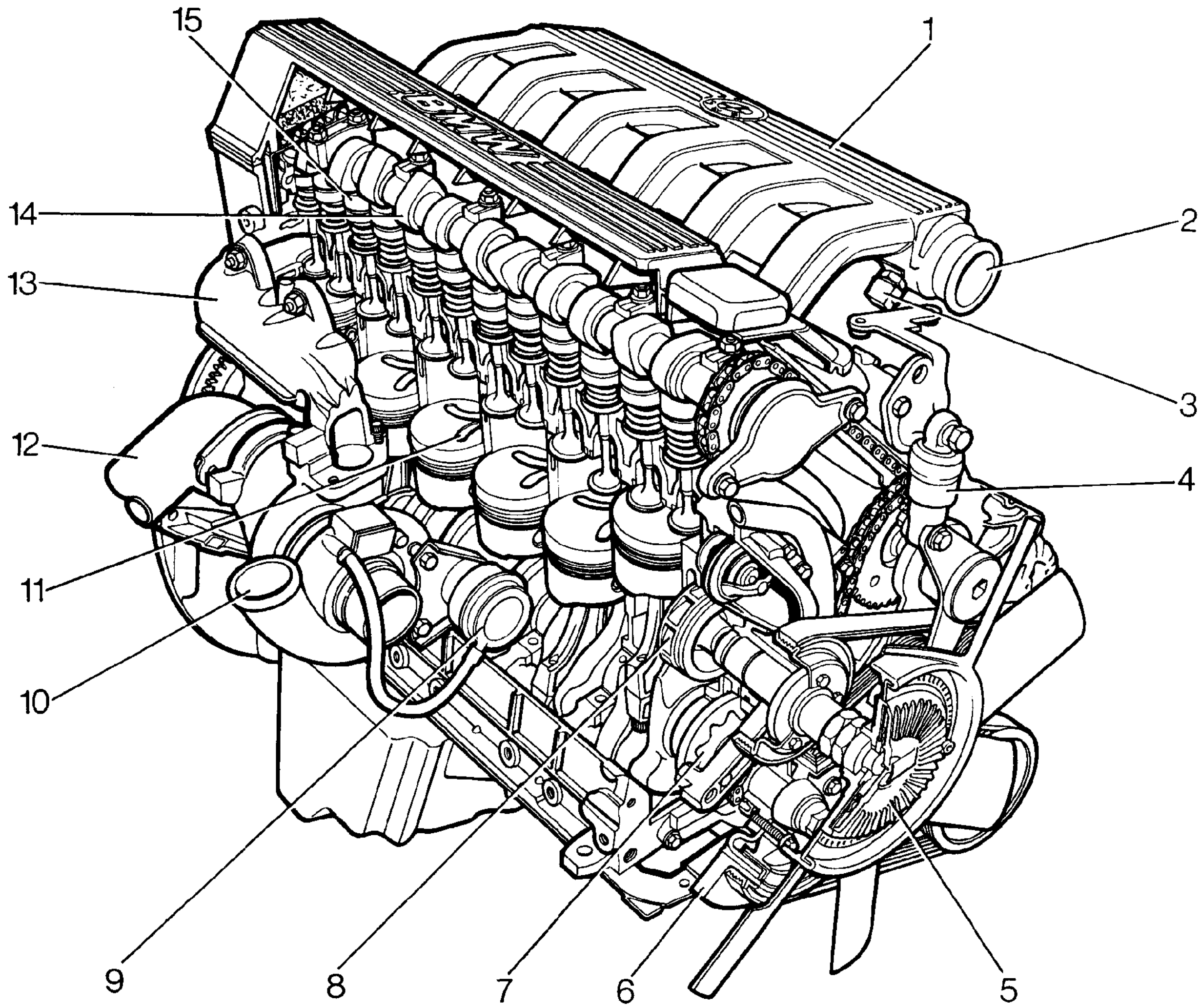
Crankshafts are available in three sizes which have different journal sizes - standard size, undersize 1 and undersize 2. A colour code, yellow, green or white denotes the actual size of the journals.

At its front end, the crankshaft drives a close coupled oil pump for the engine lubrication system and the fuel injection pump timing chain. The timing chain connects the crankshaft mounted sprocket and injector pump drive sprocket. A second timing chain takes drive from the injector pump sprocket to the overhead camshaft in the cylinder head.



12M7135

1. Charge air collector
2. Oil dipstick
3. Oil filter
4. Fuel injection pump chain drive
5. Tensioner rail - chain drive
6. Crankshaft
7. Oil sump
8. Reinforcement plate
9. Piston cooling jet
10. Cooling water jacket
11. Oil return from turbocharger
12. Turbocharger
13. Exhaust manifold
14. Camshaft drive chain
15. Camshaft
16. Hydraulic tappet
17. Fuel injector
18. Swirl chamber
19. Glow plug



12M7136

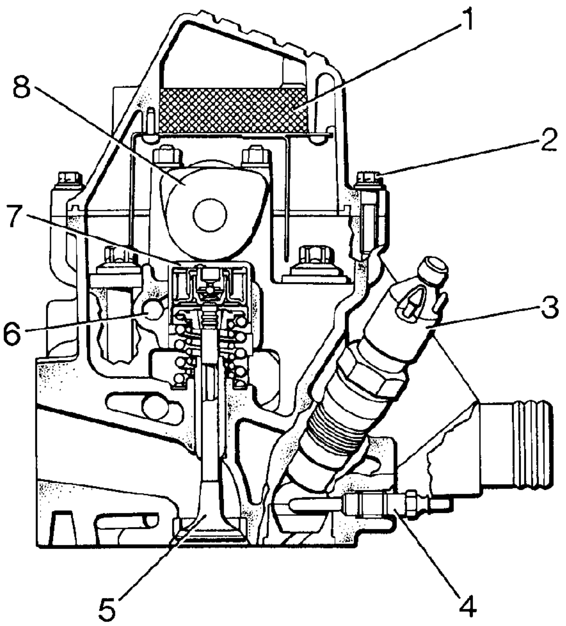
1. Charge air collector
2. Connection from intercooler
3. Intake air temperature sensor groove
4. Hydraulic damper - tensioner roller
5. Radiator fan and viscous coupling
6. Torsional vibration damper
7. Oil pump
8. Water pump
9. Vacuum cell for turbocharger
10. Turbocharger air intake
11. Piston crown, V-pattern
12. Exhaust pipe from turbocharger
13. Exhaust manifold
14. Overhead camshaft
15. Hydraulic tappet

Cylinder head

The aluminium cylinder head houses the chain driven overhead camshaft, the valve gear and fuel injectors.

Coolant enters the cylinder head from the crankcase. The coolant flow is across the cylinder head and out to the heater matrix and radiator.

An oil separator with wire mesh filter is installed in the camshaft cover.

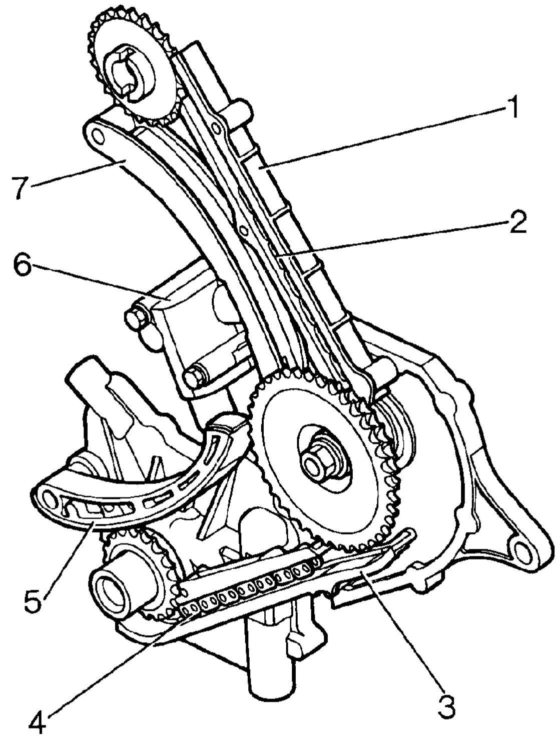


12M7137

1. Oil separator
2. Camshaft cover bolts
3. Fuel injector
4. Glow plug
5. Outlet valve
6. Oil supply duct
7. Hydraulic tappet
8. Camshaft

Camshaft

Seven bearings support the camshaft in the cylinder head. The camshaft is chain driven from the fuel injection pump drive sprocket, which itself is chain driven from the crankshaft. Both the injection pump timing chain and the camshaft timing chain run within guide rails and are tensioned automatically by tension rails and a chain adjuster mechanism.



12M7138

1. Guide rail
2. Camshaft drive chain
3. Guide rail
4. Injection pump drive chain
5. Tension rail
6. Chain adjuster
7. Tension rail

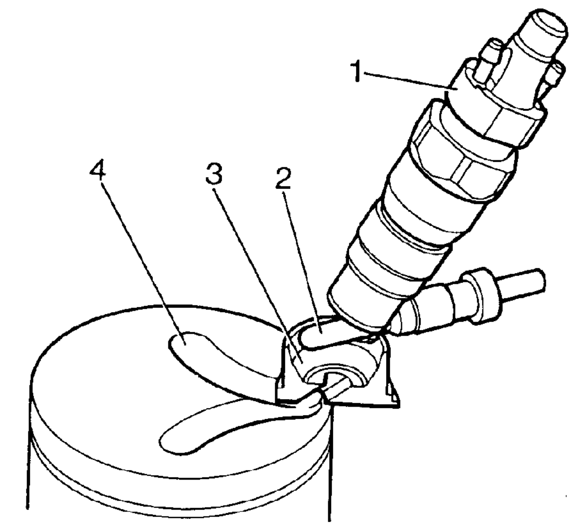
Valve gear

The camshaft operates the inlet and exhaust valves through bucket-type tappets with hydraulic valve clearance adjustment. The hydraulic tappets are leakproof, eliminating rattle during the first few revolutions of the engine. Valves are available in standard size or oversize and are identified by a number stamped on the stem. Valves are coated during manufacture and DO NOT need to be lapped when they are renewed.

Fuel injectors

Fuel is delivered to each cylinder through fuel injector nozzles. An injector is screwed into a pre-combustion chamber (swirl chamber) at each cylinder position.

The precombustion chambers are also fitted with glow plugs. Each injector comprises a nozzle holder and contains a spring-loaded needle valve; the nozzle holder of cylinder No 4 incorporates a sender which senses the time of fuel ejection by recognising needle movement. This information is utilised by the DDE system - ***See ENGINE MANAGEMENT, Description.***



12M7139

1. Fuel injector
2. Glow plug
3. Pre-combustion chamber
4. Piston crown, V-patterned groove

Air intake

Fresh air is drawn in through an air cleaner assembly secured to the left hand inner wing of the vehicle. The air cleaner assembly comprises a housing which contains a paper filter element. The rectangular, two-part housing is constructed from moulded plastic and incorporates an air inlet and an air outlet.

The air cleaner delivers filtered air to the turbocharger.

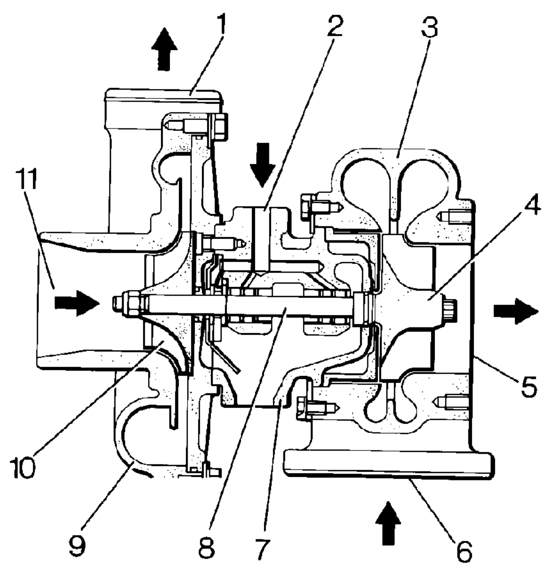
Forced aspiration system

Forced aspiration is by an exhaust driven turbocharger. Compressed air, from the turbocharger, passes through an intercooler to the charge air collector mounted on the cylinder head.

Turbocharger

The turbocharger consists of a compressor housing and a turbine housing bolted to the exhaust manifold. The compressor housing has an ambient air inlet and a compressed air outlet. The turbine housing has an exhaust gas inlet and an exhaust gas outlet. Both compressor and turbine housings are bolted to a central bearing housing. The bearing housing contains two pressure lubricated bearings which provide support for the rotor shaft. An exhaust-gas driven turbine mounted at one end of the rotor shaft, drives a centrifugal compressor mounted at the other.

To regulate charge air pressure, a by-pass plate is installed on the exhaust side of the turbocharger. The by-pass plate is connected to a pneumatic pressure actuator.



12M7140

1. Charge air outlet
2. Pressurised oil from engine
3. Turbine housing
4. Turbine
5. Exhaust gas outlet
6. Exhaust gas inlet
7. Bearing housing
8. Rotor shaft
9. Compressor housing
10. Compressor
11. Air intake

Intercooler

To lower the temperature of the charge air, and therefore increase its density, an intercooler is fitted between the turbocharger and the charge air collector.

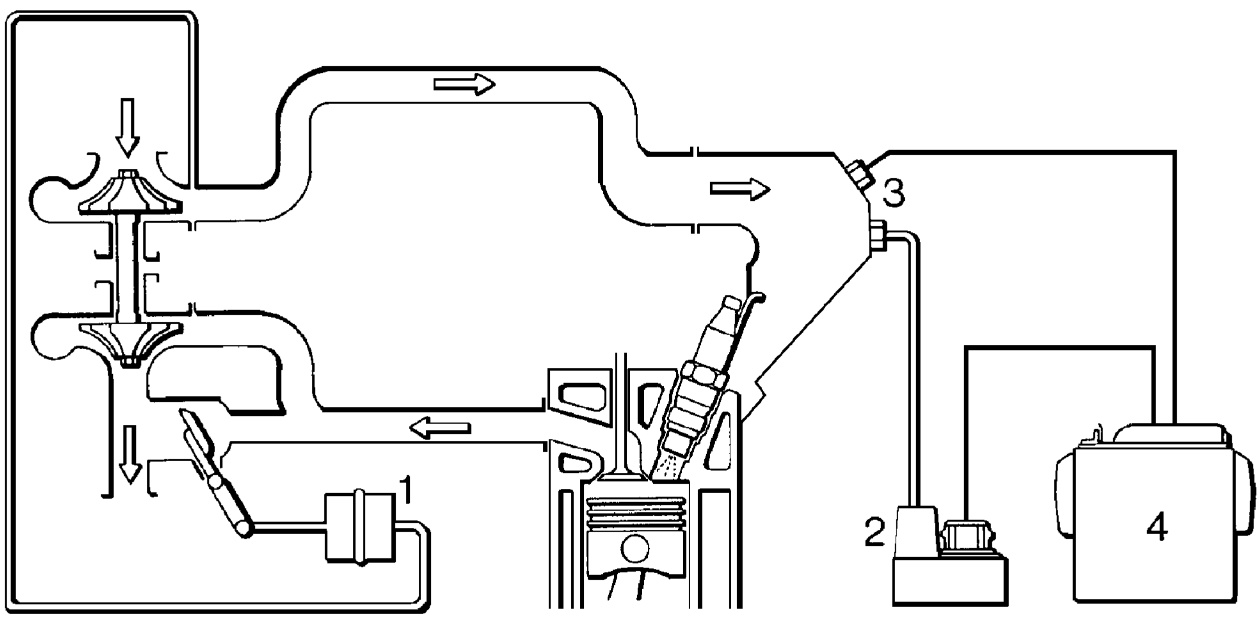
Charge air collector

The charge air collector is bolted to the cylinder head and consists of a manifold having a single inlet and six individual outlets, one to each cylinder. Intake charge air pressure and charge air temperature sensors mounted on the collector are linked to the control unit of the DDE system. The air temperature sensor has a black connector and is fitted at the front of the air collector. The pressure sensor is a small, black plastic sensor mounted on the fuel filter bracket. It is connected to the air collector through a tube.

Operation

When the engine is running, exhaust gas impinges on the turbine vanes of the turbocharger causing the turbine to rotate. The rotor shaft transmits drive from the turbine to the inlet centrifugal compressor. Air is drawn into the compressor from the air cleaner and compressed air is discharged to the charge air collector via the intercooler.

Charge air pressure is regulated by operation of the by-pass plate.



12M7141

1. By-pass plate actuator
2. Charge air pressure sensor
3. Intake air (charge air) temperature sensor
4. DDE system control unit

Lubrication system

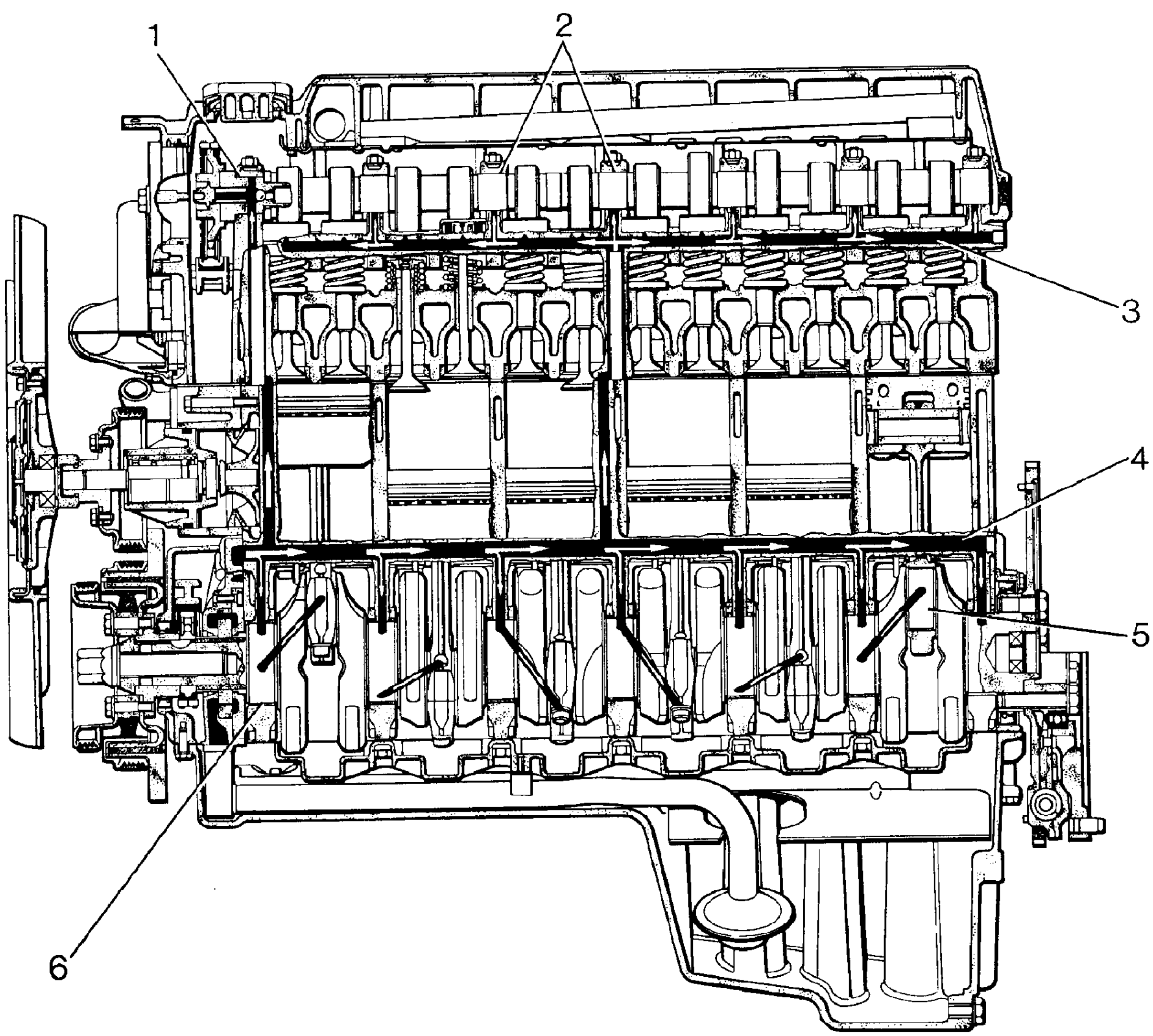
The lubrication system comprises the sump, pump, oil filter and oil ducts.

Sump

This is a one-piece, rigid, aluminium, die-cast unit bolted to underside of the crankcase. An oil deflector plate is attached to the crankcase reinforcing shell above the sump. The sump incorporates a drain plug and a dip-stick guide pipe.

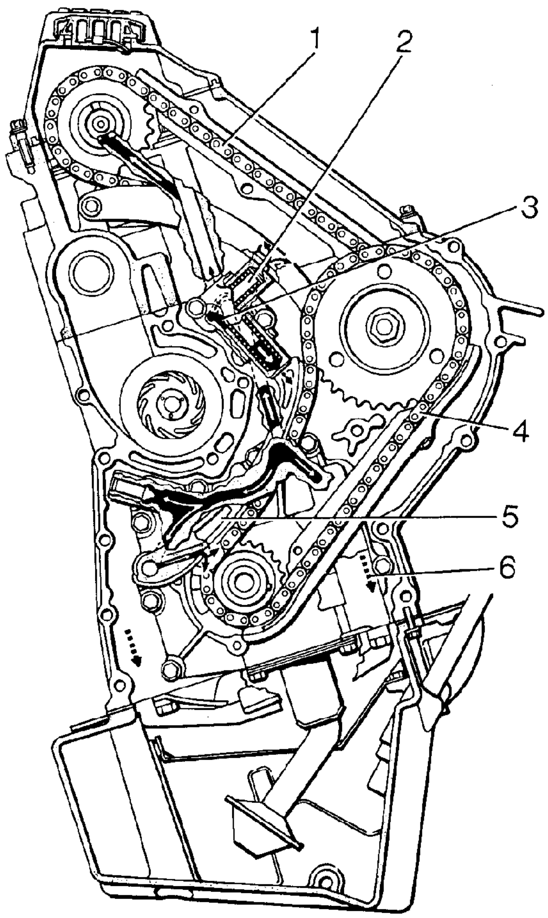
Oil pump

An internal gear-type pump is mounted on the front end of the crankshaft. It is directly driven by the crankshaft. The pump consists of a body which houses a driven rotor and a stator. Pump pressure is regulated by a piston operated pressure relief valve housed within the body of the pump.



12M7142

1. Camshaft bearing
2. Camshaft bearings
3. Oil duct
4. Main oil duct
5. Big end bearing
6. Main crankshaft bearing



12M7143

1. Camshaft timing chain drive
2. Upper tension rail
3. Chain adjuster
4. Injection timing
5. Lower tension rail
6. Oil return

Oil filter

The oil filter is vertically-mounted below the charge air collector. It consists of a filter element contained within a housing which is screwed to a filter head. A filter by-pass valve is installed in the housing, while the filter head holds a thermostat. The thermostat promotes quick warm up of the engine by preventing oil circulating through the oil cooler when the oil temperature is low. The thermostat operates at 80°C.

Oil ducts

Oil circulates around the engine, and is delivered to the turbocharger bearings, through ducts and oilways. A longitudinal main oil duct allows oil to be delivered to the crankshaft bearings. Vertical ducts from the main duct allow oil to the piston cooling jets and to the camshaft bearings.

Operation

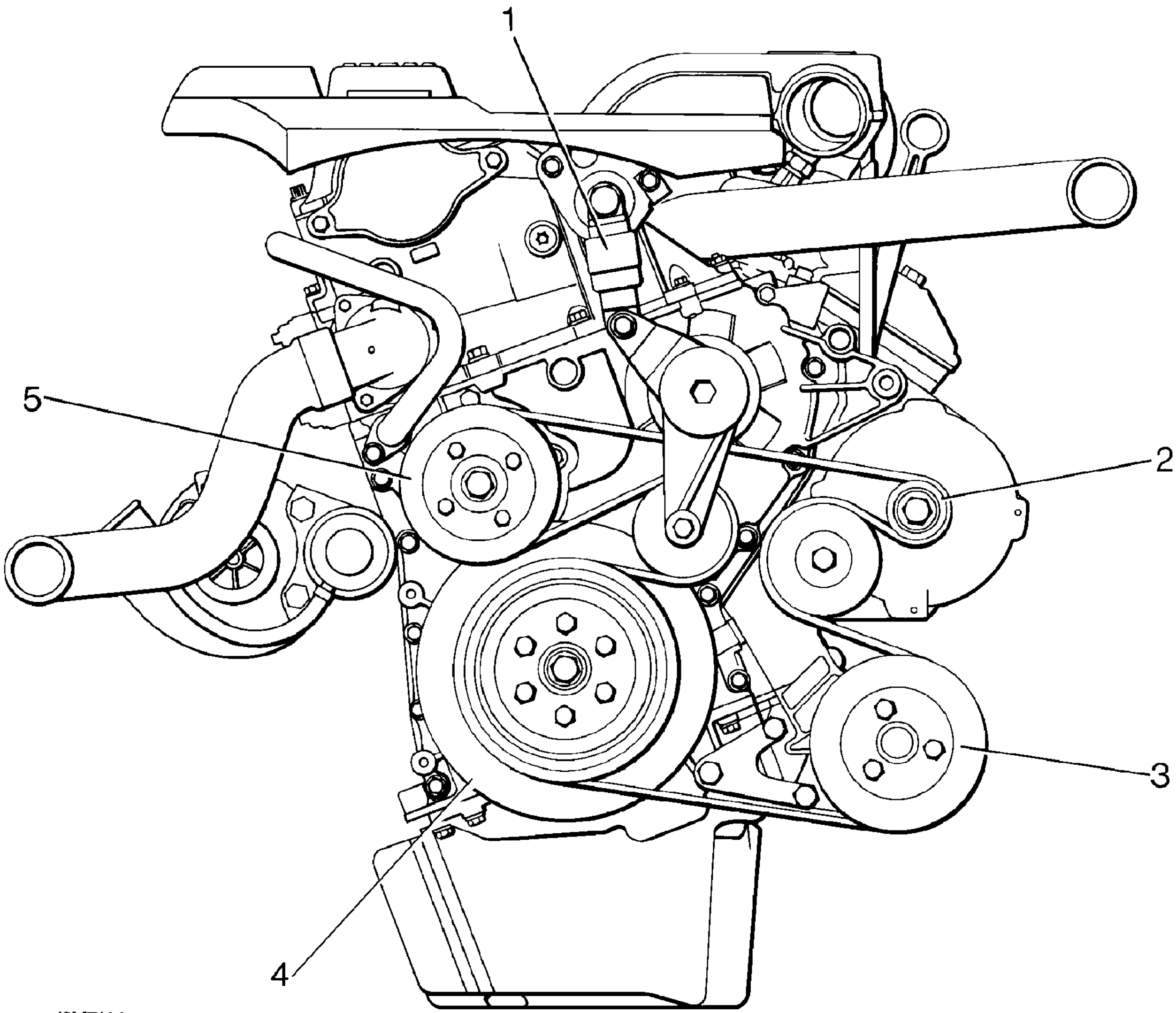
Refer to the lubrication system circuit diagrams for lubrication system operating details.

Auxiliary driven assemblies

The auxiliary driven assemblies consist of the following:

Water pump
Power steering pump
Alternator

The water pump, alternator and power steering pump are driven from the crankshaft by means of a decoupled pulley and a 5-rib, automatically tensioned, V-belt.



12M7144

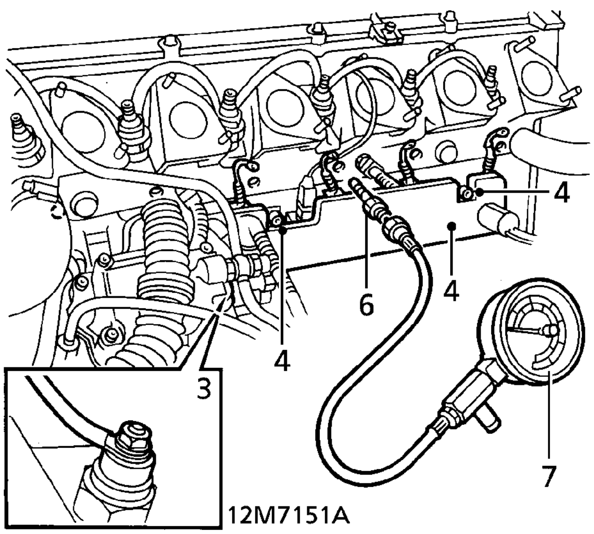
1. Belt tensioning element
2. Alternator drive
3. Power steering pump drive
4. Torsional vibration damper with decoupled pulley
5. Water pump drive

CYLINDER PRESSURE CHECK - DIESEL

Service repair no - 19.60.31

NOTE: Test must only be carried out with battery in good condition. Compression tests should not be used as the sole means of assessing the state of an engine. They must only be used to support other symptoms or the results of other tests.

1. Disconnect battery negative lead.
2. Remove glow plugs. ***See FUEL SYSTEM, Repair.***
3. Release cover and disconnect lead from stop solenoid.
4. Remove 2 screws securing harness trunking to cylinder block and position trunking aside.
5. Reconnect battery negative lead.
6. Using kit LRT-19-007 fit adaptor DA 102-85 to number 1 glow plug location. Tighten to ***20 Nm (15 lbf.ft).***
7. Connect gauge to adaptor and tighten securely.



12M7151A

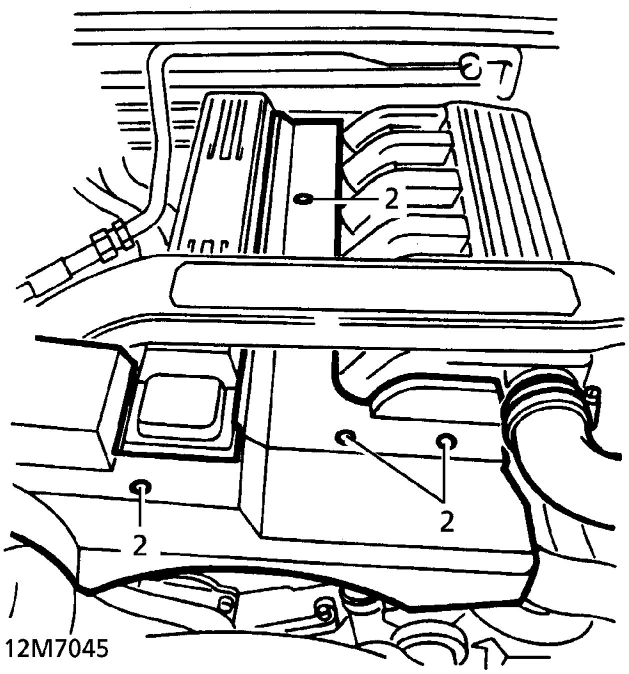
8. Operate the starter motor until the gauge needle reaches its highest reading and mark with the pointer.
9. Repeat operations 6 to 8 on remaining cylinders.
10. All readings should be at least 20 bar and within approximately 3 bar of each other.
11. If any reading is low, inject 4 shots of clean engine oil into glowplug hole and repeat test. Low readings on both wet and dry tests indicate a badly seating valve or leaking cylinder head gasket. Low readings on a dry test and satisfactory wet test results indicate piston ring and/or cylinder bore problems.
12. Disconnect battery negative lead.
13. Remove test equipment.
14. Connect stop solenoid.
15. Align harness trunking and secure with screws.
16. Fit glow plugs, ***See FUEL SYSTEM, Repair.***
17. Reconnect battery negative lead.

CAMSHAFT COVER GASKET - NON EGR

Service repair no - 12.29.40

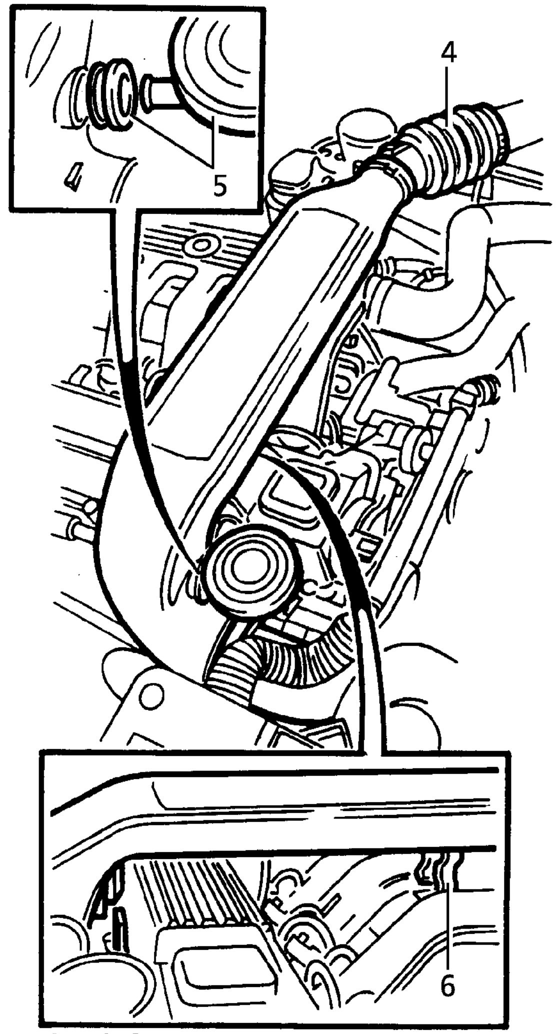
Remove

1. Disconnect battery negative lead.
2. Remove 4 screws securing injector covers. Remove covers.



12M7045

3. Release intake hose from ducting.
4. Release turbocharger intake hose from ducting.

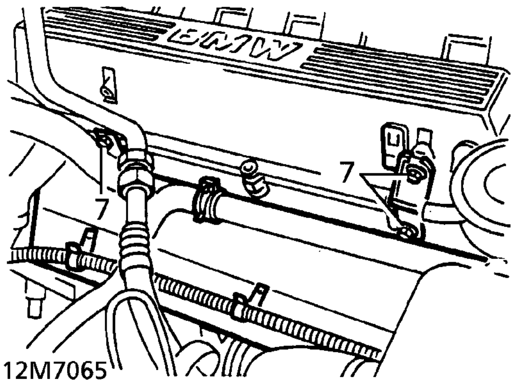


12M7046

5. Release breather valve from intake ducting grommet.

NOTE: Collect grommet. Refit to ducting.

6. Disengage 2 clips. Remove intake ducting.
7. Remove 3 bolts securing intake ducting bracket and exhaust manifold heat shield to camshaft cover. Collect bracket.



12M7065

8. Remove 10 bolts securing camshaft cover to cylinder head.
9. Remove camshaft cover. Collect gasket and discard.

Refit

10. Ensure mating faces are clean.
11. Fit gasket to camshaft cover.
12. Position camshaft cover on cylinder head. Ensure gasket is correctly seated.

NOTE: Protrusion on rear of gasket can snag on bearing cap during positioning of cover.

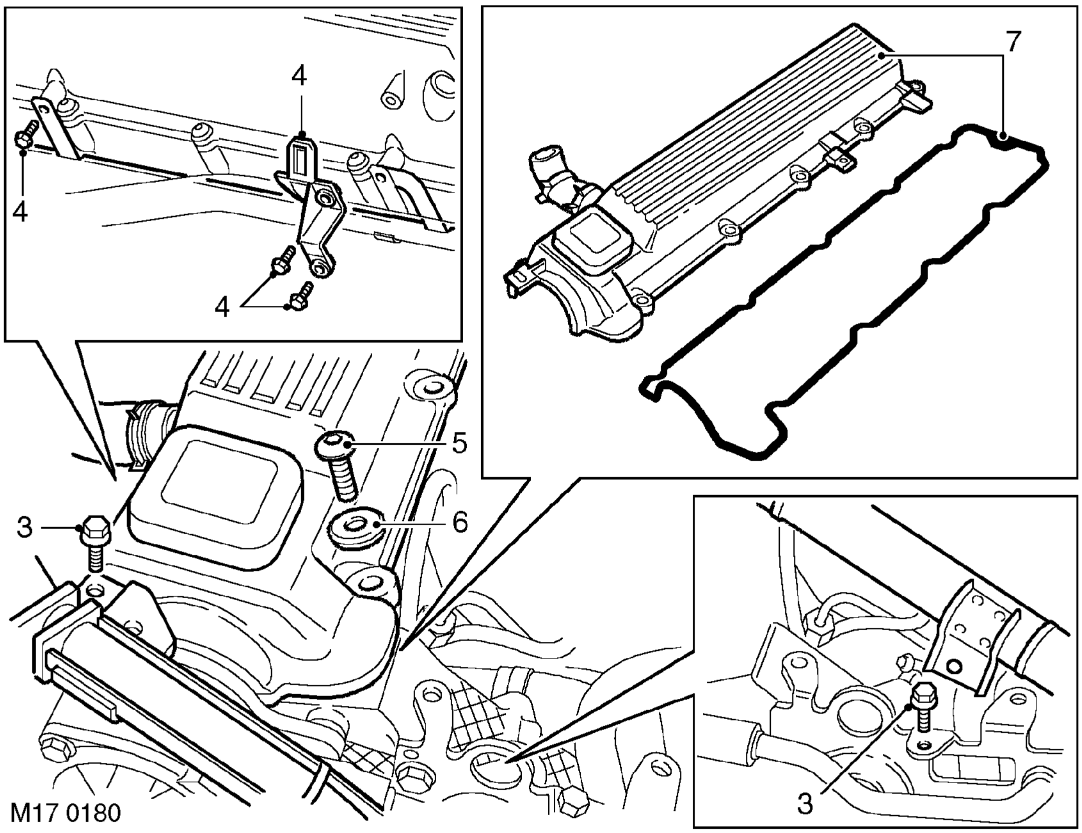
13. Fit camshaft cover bolts. Tighten in diagonal sequence, working from centre outwards to ***15 Nm (11 lbf.ft)***
14. Align exhaust manifold heat shield. Position intake ducting bracket.
15. Secure ducting bracket and heat shield with bolts.
16. Position intake ducting. Engage clips.
17. Engage breather valve into ducting grommet.
18. Connect ducting to turbocharger intake hose. Secure clip.
19. Connect intake hose to ducting. Secure clip.
20. Fit injector covers. Secure with screws.
21. Reconnect battery negative lead.

CAMSHAFT COVER GASKET - WITH EGR

Service repair no - 12.29.40

Remove

1. Disconnect battery negative terminal.
2. Remove air intake ducting. ***See FUEL SYSTEM, Repair.***
3. Remove 2 bolts securing harness trunking and position trunking aside.
4. Remove 3 bolts securing intake ducting bracket and exhaust manifold heat shield to camshaft cover. Collect bracket.
5. Remove 10 bolts securing camshaft cover to cylinder head.
6. Collect sealing washers.
7. Remove camshaft cover. Collect gasket and discard.



Refit

8. Inspect sealing washers, renew as necessary.
9. Ensure mating faces are clean.
10. Fit gasket to camshaft cover.
11. Position camshaft cover on cylinder head. Ensure gasket is correctly seated.

NOTE: Protrusion on rear of gasket can snag on bearing cap during positioning of cover.

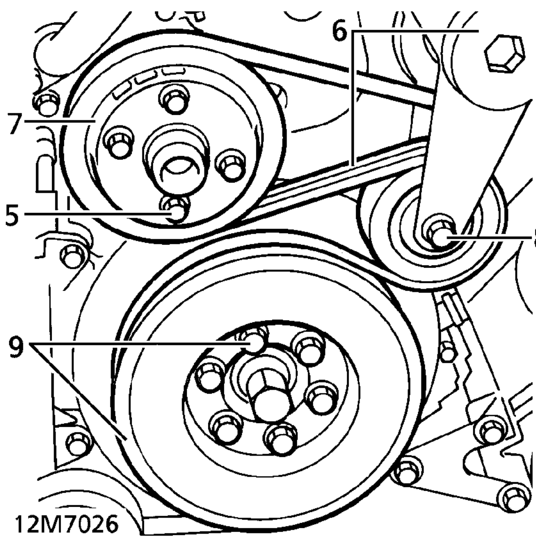
12. Fit camshaft cover bolts. Tighten in diagonal sequence, working from centre outwards to ***15 Nm (11 lbf.ft).***
13. Align exhaust manifold heat shield. Position intake ducting bracket.
14. Secure ducting bracket and heat shield with bolts.
15. Fit air intake ducting. ***See FUEL SYSTEM, Repair.***
16. Connect battery negative terminal.

CRANKSHAFT PULLEY AND FRONT COVER OIL SEAL

Service repair no - 12.21.01 - Crankshaft Pulley
Service repair no - 12.65.05 - Timing Gear Cover Oil Seal

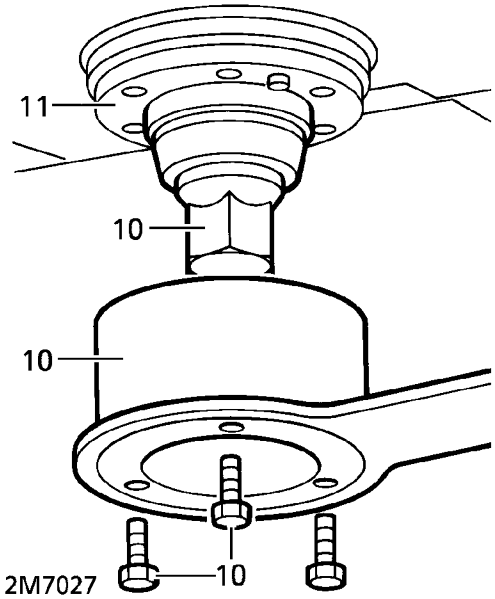
Remove

1. Disconnect battery negative lead.
2. Remove radiator. ***See COOLING SYSTEM, Repair.***
3. Remove cover from air conditioning drive belt tensioner.
4. Release drive belt tension. Remove drive belt.
5. Slacken 4 water pump pulley bolts.



12M7026

6. Release auxiliary drive belt tension. Remove belt.
7. Remove water pump pulley bolts. Remove pulley.
8. Remove bolt from auxiliary drive belt tensioner pulley. Remove pulley.
9. Remove 6 bolts securing vibration damper and air conditioning pulley to vibration damper hub. Remove damper and pulley.



12M7027

10. Secure LRT-12-105 to hub with 3 bolts. Remove and discard hub retaining bolt.
11. Note orientation of shouldered washer. Remove hub and tool.
12. Remove seal from front cover.

Refit

13. Ensure mating faces are clean.
14. Lubricate outer face of seal.
15. Locate seal in timing cover.
16. Using LRT-12-111, push seal home until flush with face of timing cover.
17. Lubricate lip of oil seal. Fit crankshaft pulley hub.
18. Hold hub using LRT-12-105. Secure with new bolt and tighten to ***100 Nm (74 lbf.ft) plus 150 ° torque angle.***
19. Fit damper and pulley to hub. Secure with bolts. Tighten to ***23 Nm (17 lbf.ft)***
20. Fit auxiliary belt tensioner pulley. Secure with bolt.
21. Fit pulley to water pump. Secure with bolts. Tighten to ***10 Nm (7 lbf.ft)***
22. Rotate auxiliary drive belt tensioner. Fit drive belt.
23. Fit and tension air conditioning drive belt. ***See AIR CONDITIONING, Repair.***
24. Fit radiator. ***See COOLING SYSTEM, Repair.***
25. Reconnect battery negative lead.

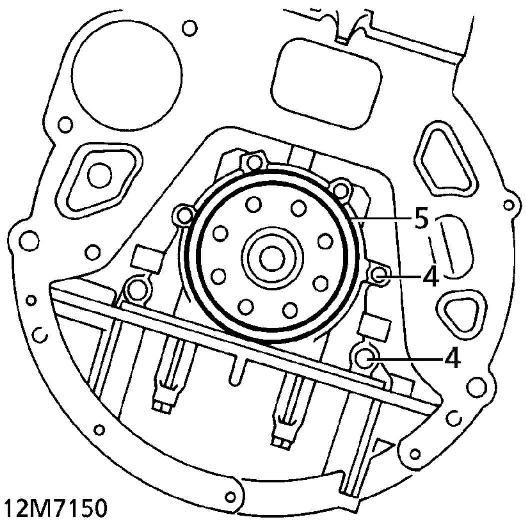
CRANKSHAFT REAR OIL SEAL

Service repair no - 12.21.20

NOTE: Seal and carrier are supplied as an assembly.

Remove

1. Disconnect battery negative lead.
2. Remove flywheel. ***See this section.***
3. Remove sump. ***See this section.***
4. Remove 6 bolts securing seal carrier to cylinder block.



12M7150

5. Remove seal carrier from location dowels.
6. Collect gasket and discard.

Refit

7. Ensure mating faces are clean.
8. Position new gasket.
9. Lubricate seal guide LRT-12-107 with engine oil. Position over crankshaft boss.
10. Lubricate oil seal lip. Position seal carrier squarely over guide. Locate carrier onto dowels.
11. Remove guide.
12. Secure carrier with bolts.
    M6, Tighten to ***10 Nm (7 lbf.ft)***
    M8, Tighten to ***22 Nm (16 lbf.ft)***
13. Fit sump. ***See this section.***
14. Fit flywheel. ***See this section.***
15. Reconnect battery negative lead.

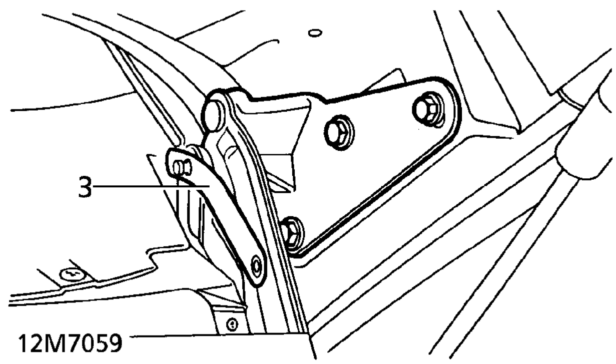
ENGINE AND GEARBOX

Service repair no - 12.37.01.99

Remove

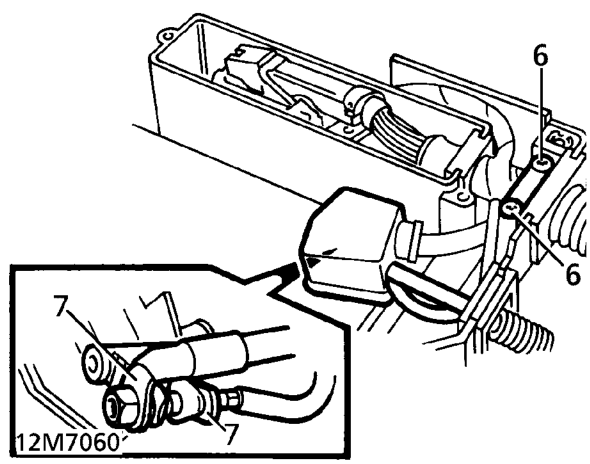
1. Position vehicle on four post lift.
2. Remove battery. ***See ELECTRICAL, Repair.***
3. With assistance, release bonnet struts from body locations. Retain bonnet in vertical position using stay clips.

WARNING: Only open the bonnet to the vertical position with the vehicle on a horizontal surface in the workshop. This position is not intended to be used outdoors where the bonnet could be affected by winds.



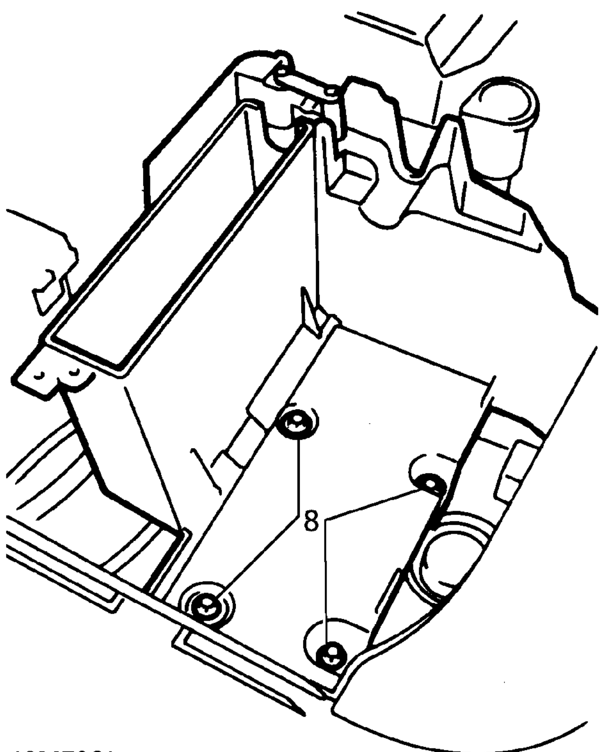
12M7059

4. Remove inlet manifold. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***
5. Remove ECM. ***See FUEL SYSTEM, Repair.***
6. Remove 2 screws securing engine harness clamp to battery tray. Collect harness clamp.



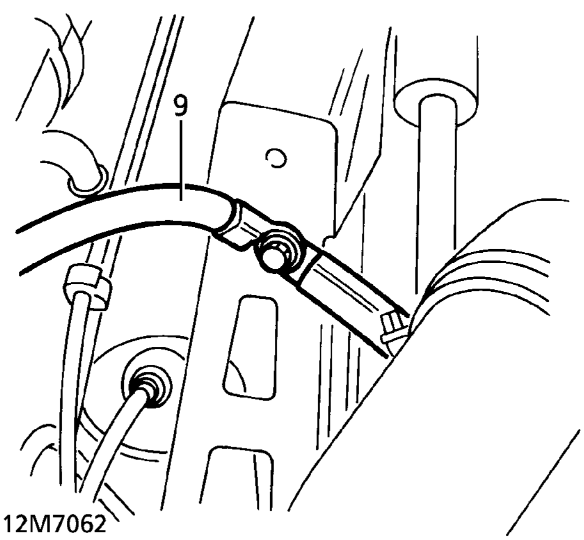
12M7060

7. Release starter feed wire and glow plug relay feed from battery terminal clamp.
8. Remove 4 bolts securing battery tray. Remove battery tray.



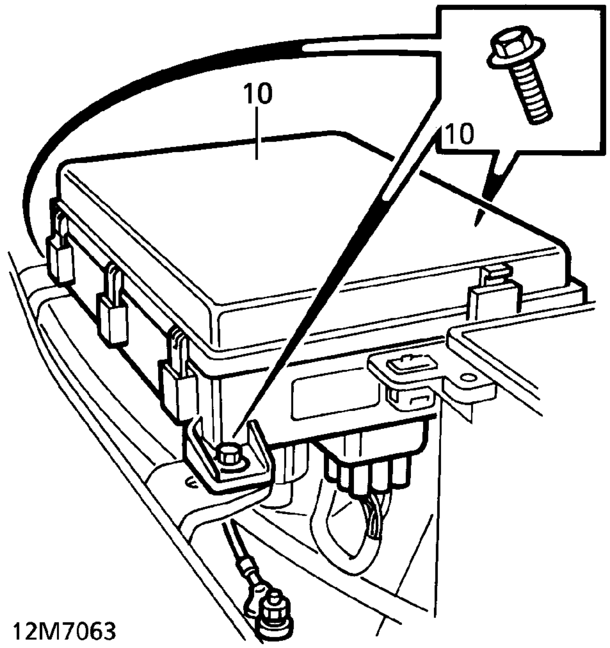
12M7061

9. Release earth lead from shock absorber turret.



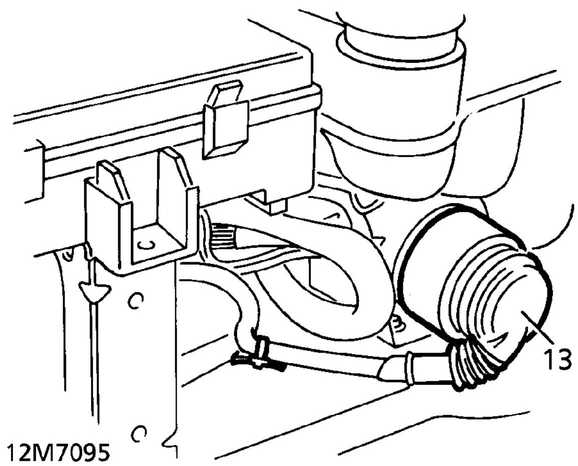
12M7062

10. Remove 3 bolts securing fuse box. Lift fuse box for access.



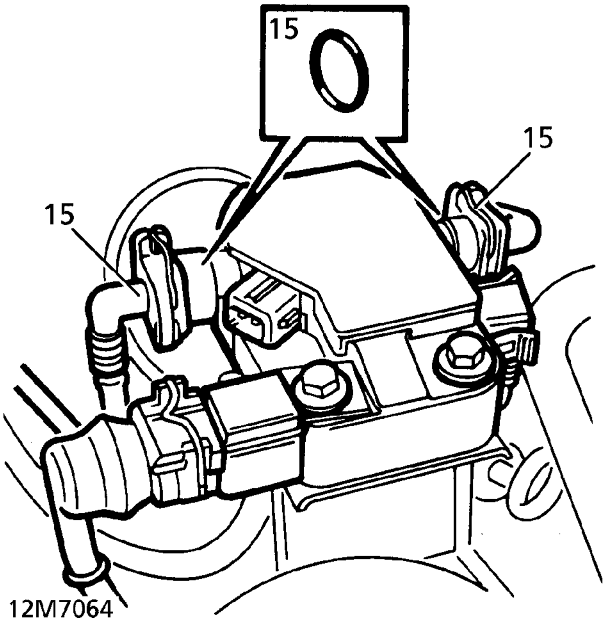
12M7063

11. Disconnect engine harness multiplug from base of fuse box.
12. Release earth wire from valance stud.
13. Disconnect engine harness multiplug from main harness.

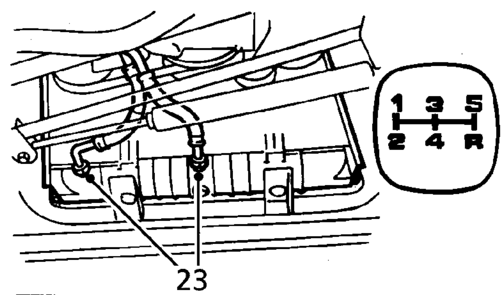


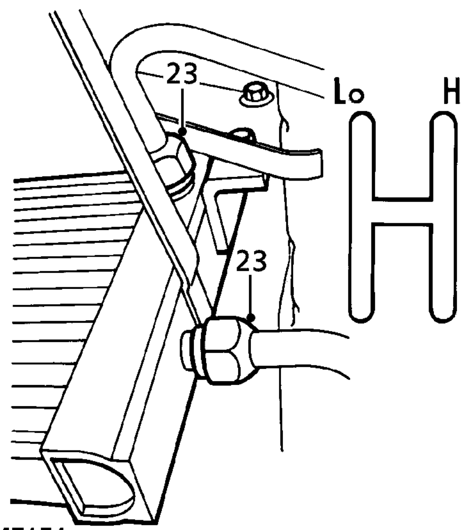
12M7095

14. Release engine harness clip from valance. Tie harness aside over engine.
15. Disconnect fuel feed line from fuel heater/filter head. Remove 'O' rings and discard.



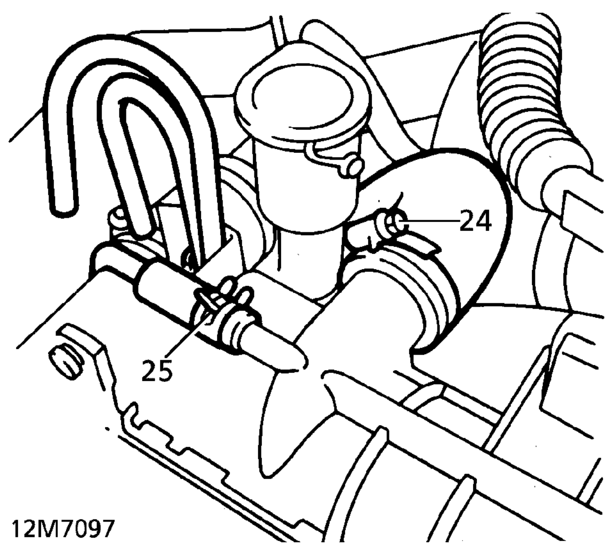
16. Release clip. Disconnect fuel return hose from Fuel Injection Pump (FIP).
17. Disconnect multiplugs from fuel heater and turbo boost sensor.
18. Position harness aside over engine.
19. Drain cooling system. ***See COOLING SYSTEM, Repair.***
20. Discharge air conditioning system. ***See AIR CONDITIONING, Adjustment.***
21. Remove cooling fan. ***See COOLING SYSTEM, Repair.***
22. Remove engine oil cooler. ***See this section.***
23. Disconnect gearbox oil cooler. Remove 'O' rings and discard. Tie pipes aside on engine.





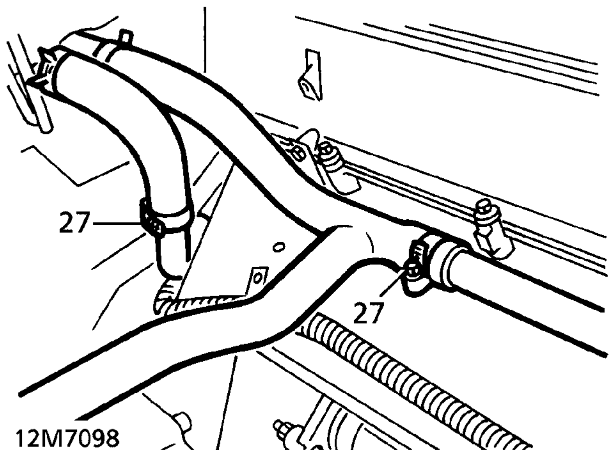
CAUTION: Where pipes are disconnected, plug pipes and ports to prevent ingress of dirt.

24. Disconnect bottom hose from radiator.

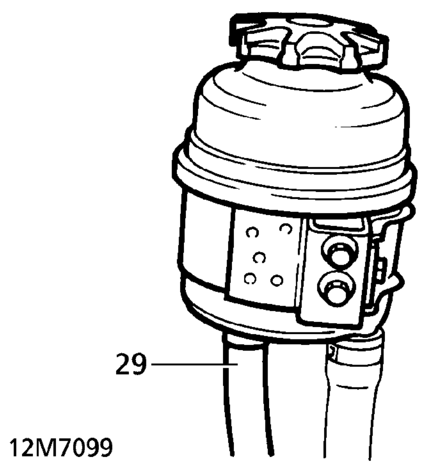


25. Disconnect coolant bleed hose from radiator.

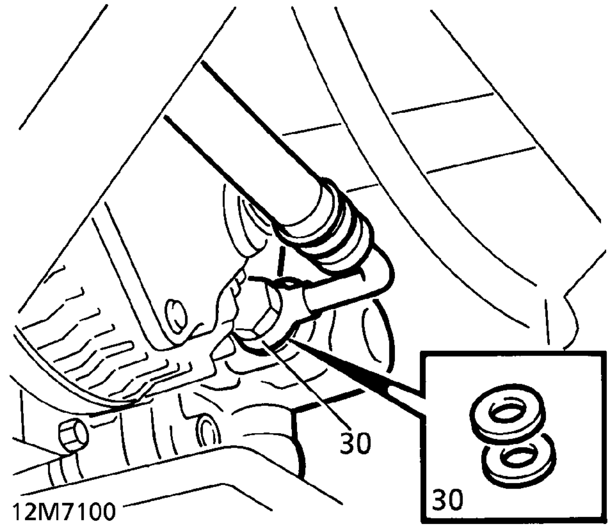
26. Release 2 fog lamp breather hoses from clips on either side of radiator.
27. Disconnect 2 heater hoses from engine coolant pipes.



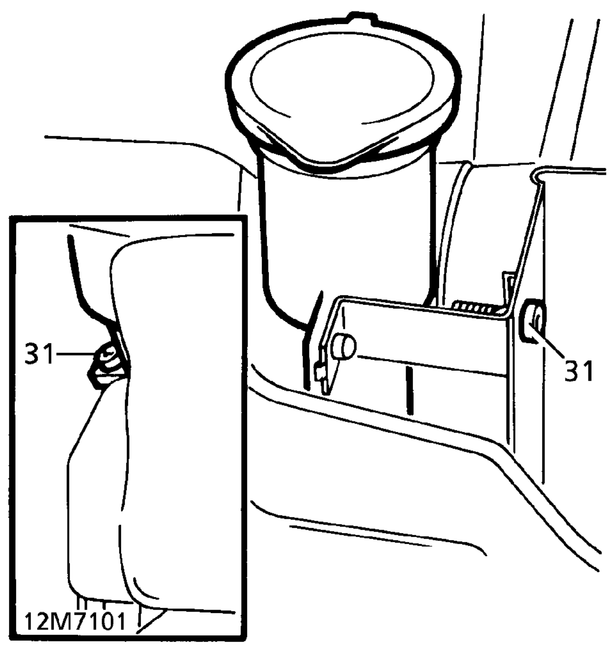
28. Position container beneath power steering reservoir to catch spillage.
29. Disconnect return pipe from reservoir. Tie reservoir aside to engine.



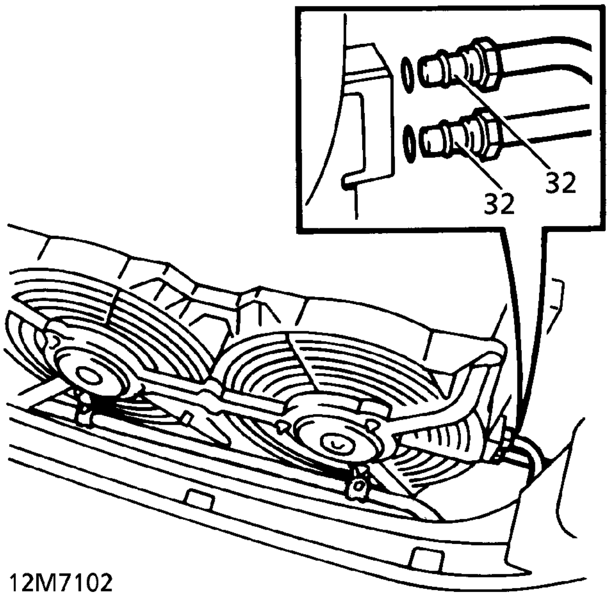
30. Disconnect feed pipe from power steering pump. Remove sealing washers and discard. Tie pipe aside to chassis.



31. Remove bolt and screw securing washer bottle filler neck. Remove filler neck.

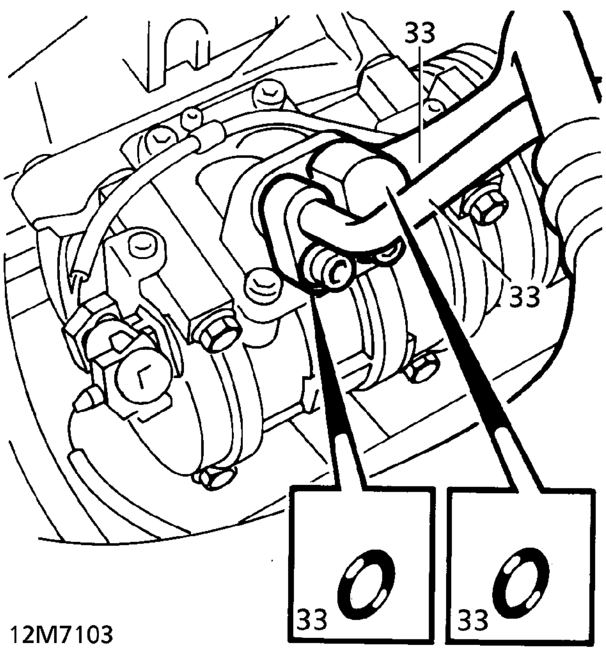


32. Disconnect 2 pipes from air conditioning condenser. Remove 'O' rings and discard.



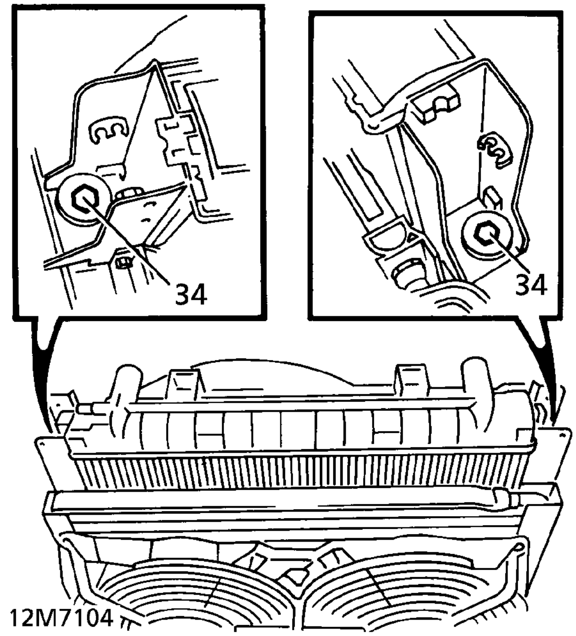
12M7102

33. Disconnect 2 pipes from air conditioning compressor. Remove 'O' rings and discard. Place pipes aside.



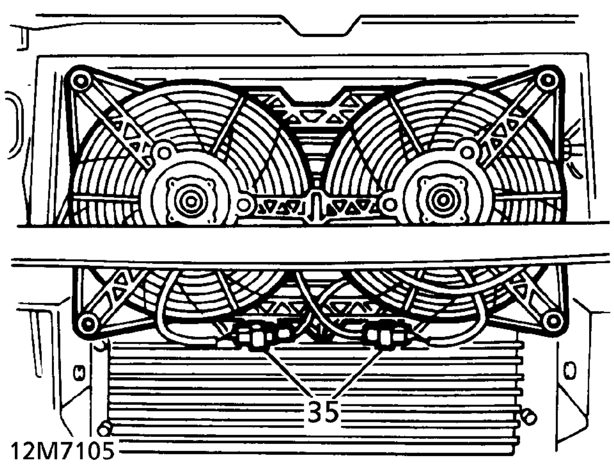
12M7103

34. Remove 2 nuts and bolts securing radiator mountings to chassis.



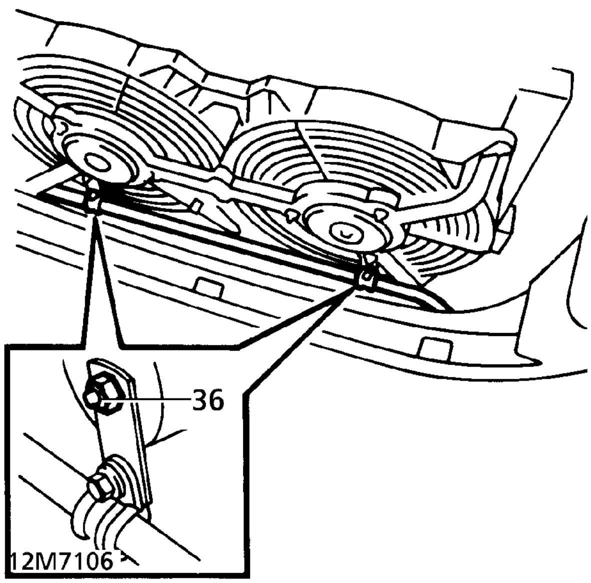
12M7104

35. Disconnect 2 condenser cooling fan multiplugs.



12M7105

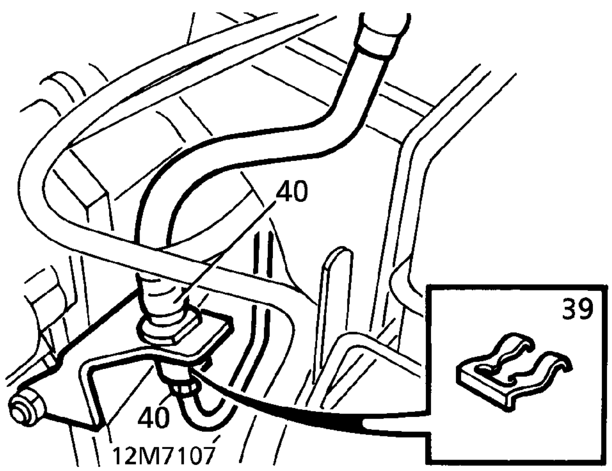
36. Remove 2 nuts securing air conditioning pipe to condenser fans. Release pipe.



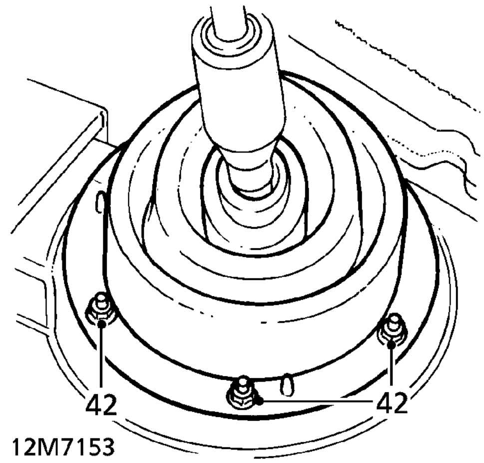
37. With assistance, remove radiator/condenser assembly.

Manual Vehicles:

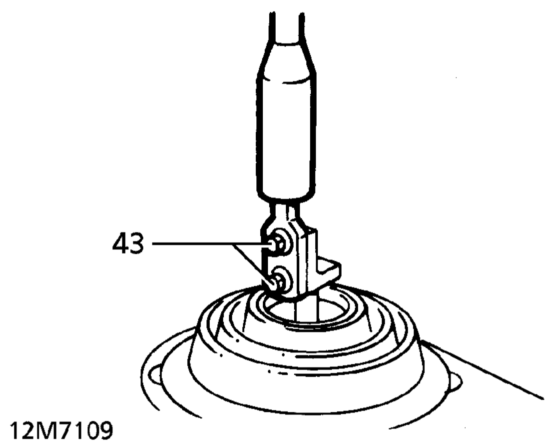
38. Clamp clutch flexible hose using approved brake hose clamp.



39. Remove clip securing flexible hose to gearbox bracket.
40. Disconnect clutch flexible hose at gearbox pipe. Position hose aside.
41. Remove centre console. ***See CHASSIS AND BODY, Repair.***
42. Remove 6 nuts securing gaiter ring. Remove ring and gaiter.



43. Remove 2 bolts securing gear lever. Remove lever.

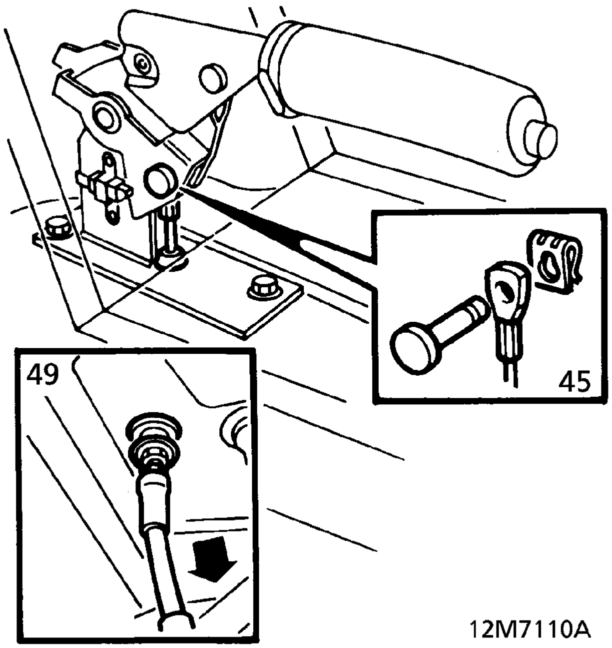


Automatic Vehicles:

44. Remove window switch pack. ***See ELECTRICAL, Repair.***

All Vehicles:

45. Release handbrake. Remove handbrake cable clevis pin.



12M7110A

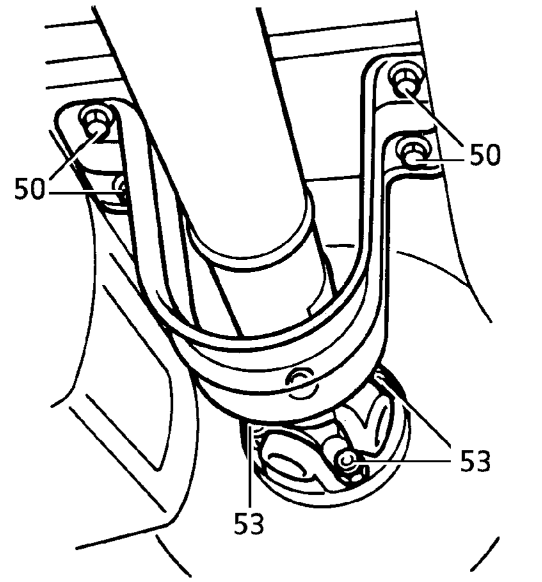
46. Raise lift. Drain gearbox, transfer box and engine fluids. ***See SECTION 10, Maintenance.***

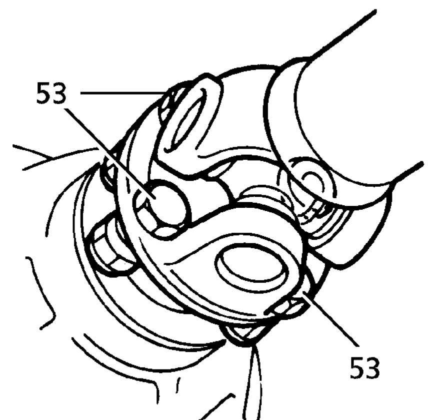
47. Using a transmission jack, support transmission under brake drum.

48. Remove chassis cross member. ***See CHASSIS AND BODY, Repair.***
Remove exhaust front pipe. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***

49. Release hand brake cable from grommet in tunnel.

50. Remove 4 bolts securing rear propeller shaft guard. Remove guard.





12M7111

51. Mark positions of propeller shafts and transfer box flanges to aid reassembly.

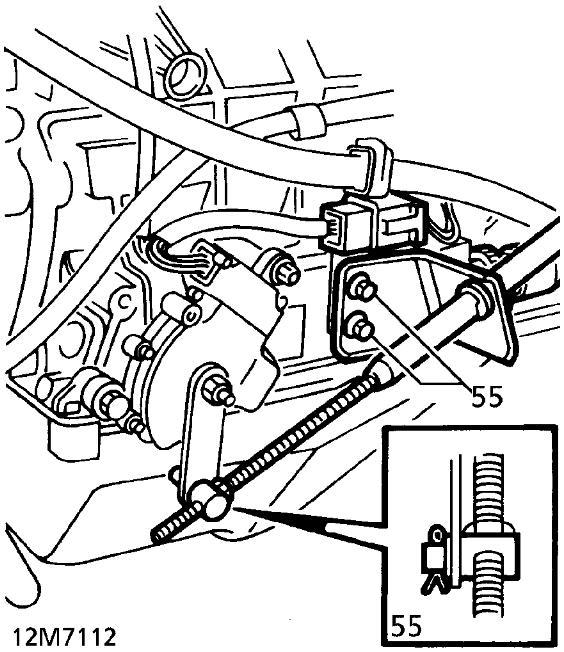
52. Raise one wheel on each axle to allow rotation of propeller shafts.

53. Remove 4 nuts from rear flange and 4 nuts and bolts from front flange. Disconnect propeller shafts. Tie aside.

54. Lower gearbox for access.

Automatic Vehicles:

55. Disconnect gear selector cable trunnion from gearbox lever. Remove 2 bolts securing selector cable abutment bracket to gearbox.
56. Place selector cable aside.

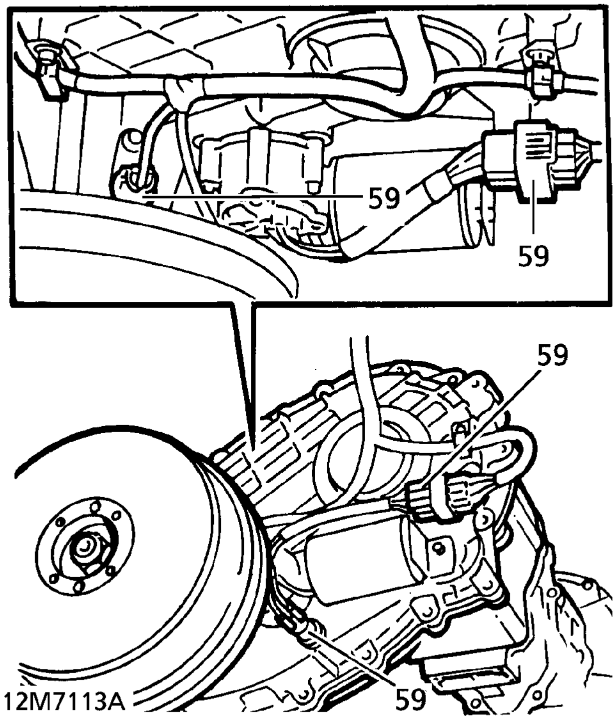


12M7112

57. Disconnect multiplugs from gear selection position switch and gearbox speed sensor.

All Vehicles:

58. Disconnect 2 Lucars from transfer box fluid temperature sensor.

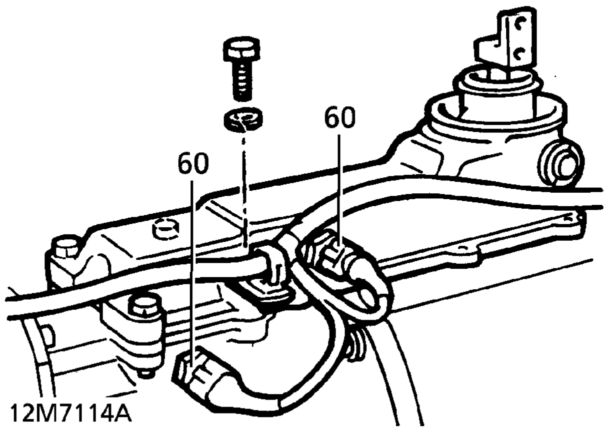


12M7113A

59. Disconnect multiplugs from High/Low motor and output shaft speed sensor.

Manual Vehicles:

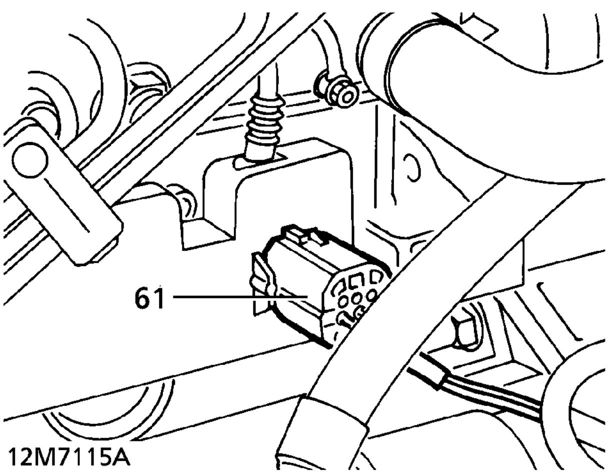
60. Disconnect multiplugs from reverse and neutral switches. Remove bolt securing harness bracket to gearbox. Release harness from clips on gearbox brackets.



12M7114A

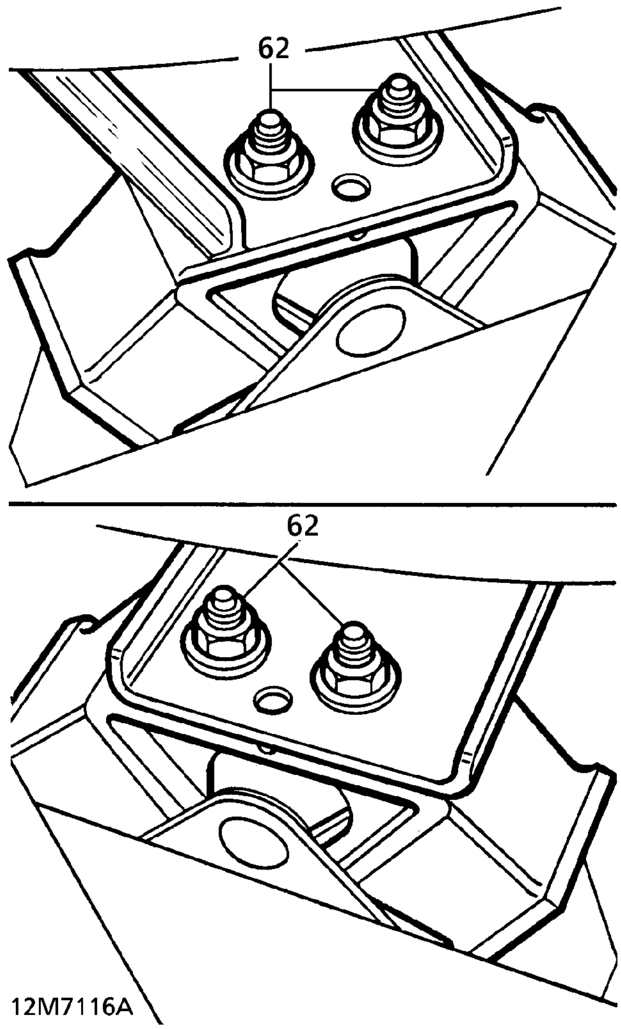
All Vehicles:

61. Disconnect engine harness to gearbox harness multiplug. Position harness aside.



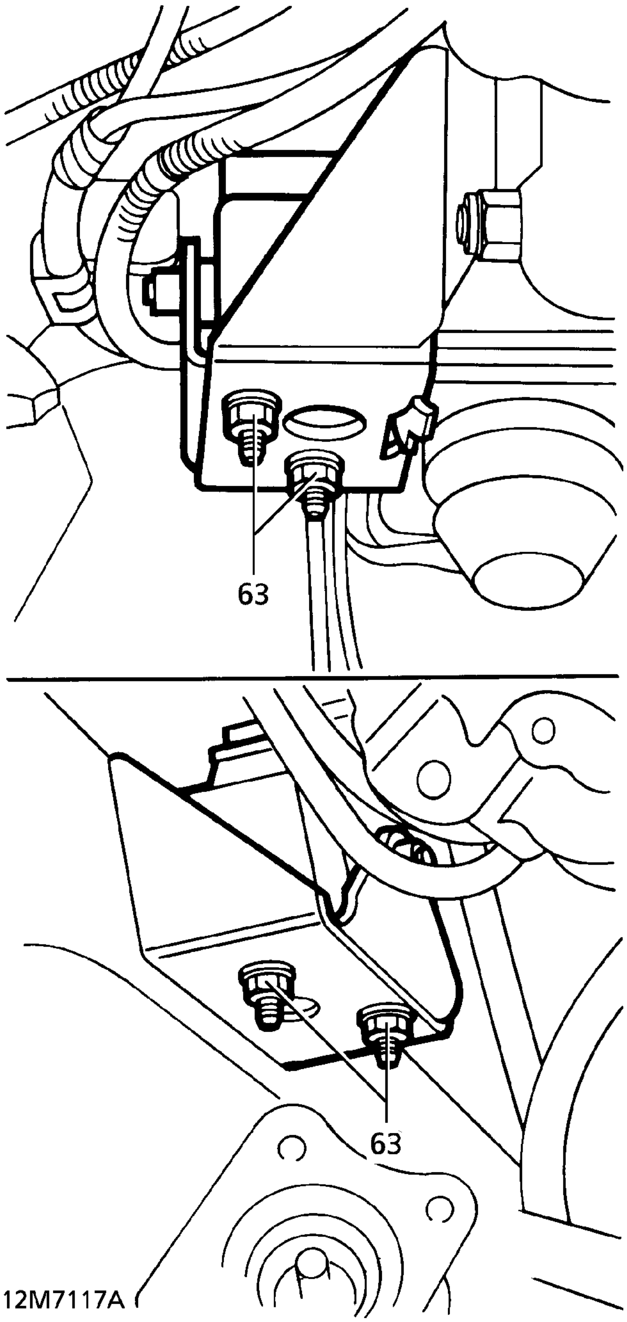
12M7115A

62. Remove 4 nuts securing each engine mount to engine bracket.

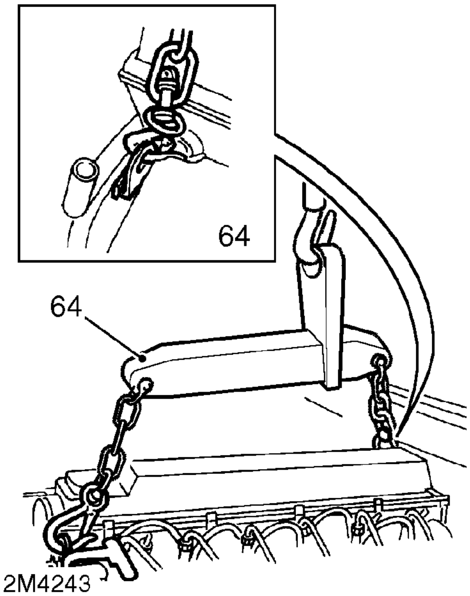


12M7116A

63. Remove 4 nuts securing each engine mount to chassis. Discard nuts.



12M7117A



12M4243

64. Fit lifting bracket to engine lifting eyes. Attach suitable hoist.
65. Raise engine slightly. Ensure that lifting bracket does not foul bulkhead. Remove both engine mountings.

NOTE: It may be necessary to lower gearbox support slightly during above operation.

66. Raise power unit and draw forward.
67. Lower support from transmission.

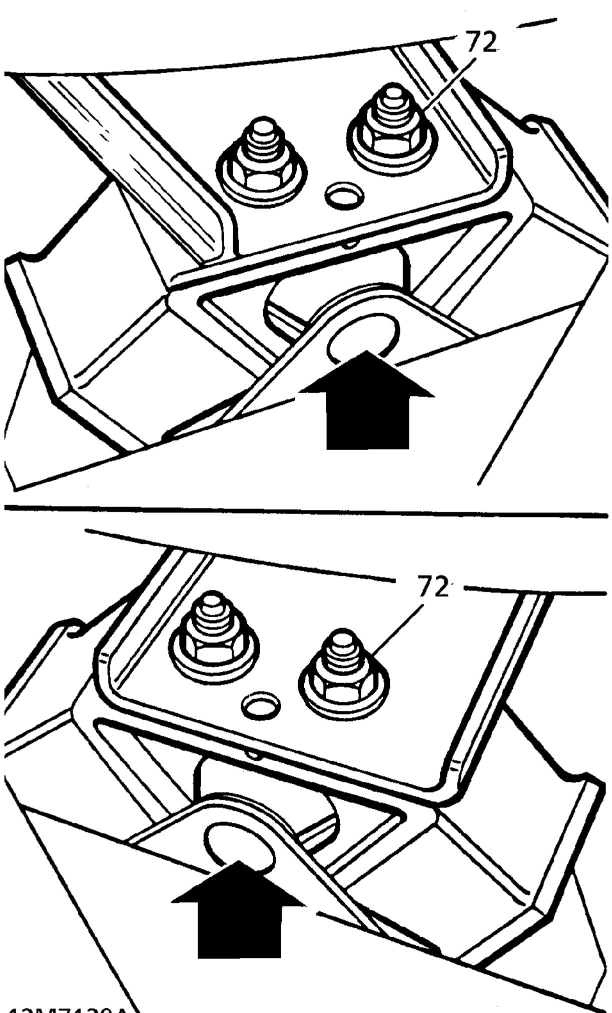
NOTE: Power unit must be tilted at an angle of approximately 45 degrees before it can be withdrawn from engine compartment.

68. Remove engine/transmission assembly.

Refit

69. Raise power unit. Guide into engine bay.
70. Position transmission jack beneath transmission brake drum.
71. With assistance, raise transmission and lower engine until engine mountings can be fitted.
72. Attach mountings to chassis with new flange nuts. Do not tighten at this stage.

CAUTION: Engine mountings must be fitted with centre bolt head facing outboard as shown.



12M7120A

73. Lower and guide engine onto mounting studs.
74. Attach engine to mountings with new flange nuts. Do not tighten at this stage.
75. Release lifting bracket from engine lifting eyes. Remove hoist.
76. Route gearbox harness. Secure with clips.
77. Connect multiplug to engine harness
78. Connect multiplugs to High/Low motor and output shaft speed sensor.

Manual Vehicles:

79. Secure gearbox harness bracket with bolt. Tighten to ***6 Nm (4 lbf.ft).***
80. Connect multiplugs to reverse and neutral switches.
81. Secure harness to gearbox bracket with clips.
82. Connect Lucars to transfer box fluid temperature sensor.
83. Raise transmission on jack.
84. Align harness bracket to gearbox.

Automatic Vehicles:

85. Connect multiplugs to gear selection position switch and gearbox speed sensor.
86. Position selector cable abutment bracket to gearbox. Secure with bolts.
87. Adjust gear selector cable. ***See AUTOMATIC GEARBOX, Adjustment.***

All Vehicles:

88. Raise one wheel on each axle to allow rotation of propeller shafts.
89. Position shafts to transfer box flanges. Align marks.
90. Secure propeller shaft flanges with nuts and bolts. Tighten to ***48 Nm (35 lbf.ft)***
91. Fit propeller shaft guard. Tighten bolts.
92. Guide hand brake cable through grommet in transmission tunnel.
93. Fit exhaust front pipe. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***
94. Fit chassis cross member. ***See CHASSIS AND BODY, Repair.***
95. Remove support from under transmission.
96. Tighten engine mounting nuts to ***45 Nm (33 lbf.ft)***
97. Lower lift.
98. Connect handbrake cable to lever, secure with clevis pin and clip.

Manual Vehicles:

99. Fit seal around gearbox remote housing to transmission tunnel aperture.
100. Fit gear lever bolts. Tighten to ***25 Nm. (18 lbf.ft)***
101. Fit gaiter and ring. Secure with nuts.
102. Fit centre console. ***See CHASSIS AND BODY, Repair.***

Automatic Vehicles:

103. Fit window switch pack. ***See ELECTRICAL, Repair.***

Manual Vehicles:

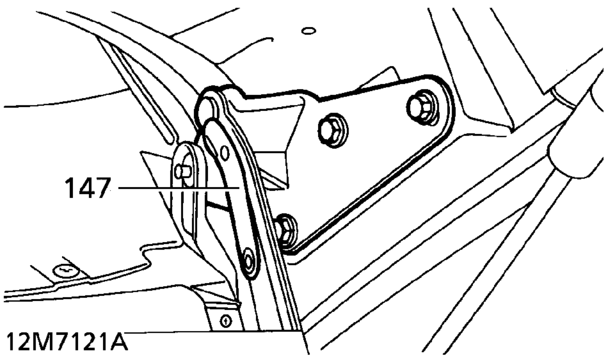
104. Connect clutch flexible hose. Remove hose clamp.
105. Secure flexible hose union to gearbox bracket with clip.
106. Bleed clutch hydraulic system. ***See CLUTCH, Repair.***

All Vehicles:

107. With assistance, position radiator/condenser assembly.
108. Connect multiplugs to condenser cooling fans.
109. Engage radiator in lower mounting rubbers. Secure with nuts and bolts.
110. Align air conditioning pipe to condenser fans. Secure with nuts.
111. Remove plugs from air conditioning compressor and pipes.
112. Fit new 'O' rings to compressor pipes. Lubricate 'O' rings with compressor oil. Connect to compressor.
113. Fit compressor connection bolts. Tighten to ***23 Nm (17 lbs.ft)***
114. Remove plugs from air conditioning condenser and pipes.
115. Fit new 'O' rings to condenser pipes. Lubricate 'O' rings with compressor oil. Secure pipes to condenser. Tighten to ***15 Nm (11 lbf.ft)***
116. Fit washer bottle filler neck. Secure with bolt and screw.
117. Remove plugs from power steering pump and pipes.
118. Using new sealing washers, secure feed pipe to power steering pump. Tighten to ***30 Nm (22 lbf.ft)***
119. Untie power steering reservoir from engine. Remove plugs. Connect return pipe. Secure return pipe to reservoir with clip.
120. Secure fog lamp breather hoses to clips on either side of radiator.
121. Connect heater hoses to engine coolant pipes. Secure with clips.
122. Connect coolant bleed hose to radiator. Secure with clip.
123. Connect bottom hose to radiator. Secure with clip.
124. Remove plugs from transmission oil cooler and pipes.
125. Lubricate pipes with transmission fluid, fit new 'O' rings. Connect to oil cooler. Tighten to ***30 Nm (22 lbf.ft)***
126. Replenish transmission fluids. ***See LUBRICANTS, FLUIDS AND CAPACITIES, Information.***
127. Fit engine oil cooler. ***See this section.***
128. Fit cooling fan. ***See COOLING SYSTEM, Repair.***
129. Evacuate and recharge air conditioning system. ***See AIR CONDITIONING, Adjustment.***
130. Refill cooling system. ***See COOLING SYSTEM, Repair.***
131. Refill engine oil. ***See LUBRICANTS, FLUIDS AND CAPACITIES, Information.***
132. Connect multiplugs to fuel heater and turbo boost sensor.
133. Connect fuel return hose to FIP. Secure with clip.
134. Using new 'O' rings, connect fuel feed hose to fuel heater/filter head.
135. Route engine harness along valance. Secure clip.
136. Connect engine harness multiplug to main harness. Secure earth terminal to valance stud.
137. Connect engine harness multiplug to base of fuse box.
138. Position fuse box. Secure with bolts.
139. Position earth lead to shock absorber turret. Secure with bolt.
140. Fit battery tray. Secure with bolts.
141. Fit starter feed wire to battery positive terminal clamp. Secure with nut.
142. Position engine harness to battery tray. Secure harness grommets.
143. Secure harness clamp to battery tray with screws.

144. Fit ECM. ***See FUEL SYSTEM, Repair.***
145. Fit inlet manifold. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***
146. Refit battery. ***See ELECTRICAL, Repair.***
147. With assistance, release bonnet stay clips. Engage bonnet struts.

CAUTION: Ensure bonnet stay clips are returned to their original positions as shown.



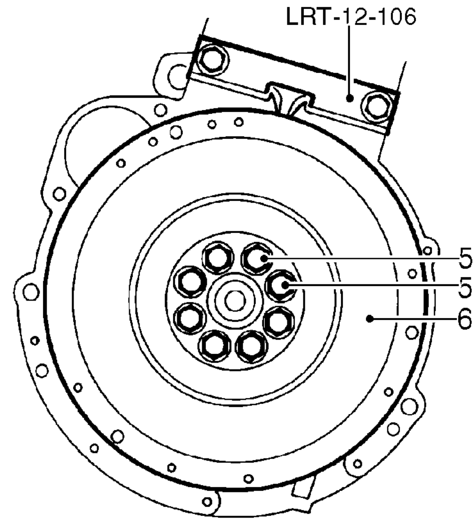
148. Start engine. Check for fuel, coolant and oil leaks.

FLYWHEEL/DRIVE PLATE

Service repair no - 12.53.07

Remove

1. Disconnect battery negative lead.
2. *Manual gearbox:* Remove clutch assembly. ***See CLUTCH, Repair.***
3. *Automatic gearbox:* Remove gearbox. ***See AUTOMATIC GEARBOX, Repair.***
4. Lock flywheel/drive plate using LRT-12-106.
5. Remove and discard 8 bolts securing flywheel/drive plate.
6. Remove flywheel/drive plate.



NOTE: Flywheel illustrated

Inspection

7. Inspect flywheel clutch face/drive plate for cracks, scores or overheating.
8. Inspect ring gear for worn, chipped or broken teeth.
9. Replace defective parts as necessary.

Refit

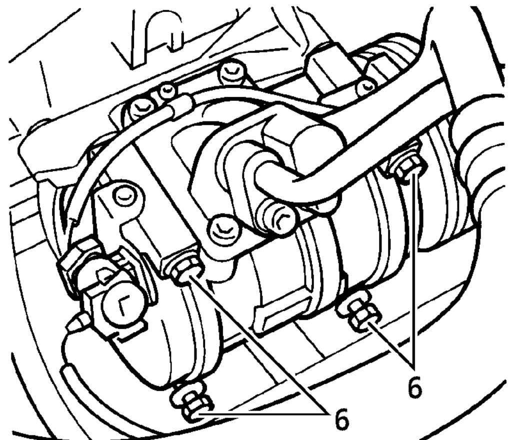
10. Ensure mating faces, dowel and dowel locations are clean.
11. Position flywheel/drive plate to crankshaft, locate dowel.
12. Secure flywheel/drive plate with new bolts. Tighten bolts to:
    Flywheel - ***105 Nm (77 lbf.ft)***
    Drive plate - ***120 Nm (88 lbf.ft)***
13. Manual gearbox: Fit clutch assembly. ***See CLUTCH, Repair.***
14. *Automatic gearbox:* Fit gearbox. ***See AUTOMATIC GEARBOX, Repair.***
15. Reconnect battery negative lead.

FRONT COVER GASKET

Service repair no - 12.65.04

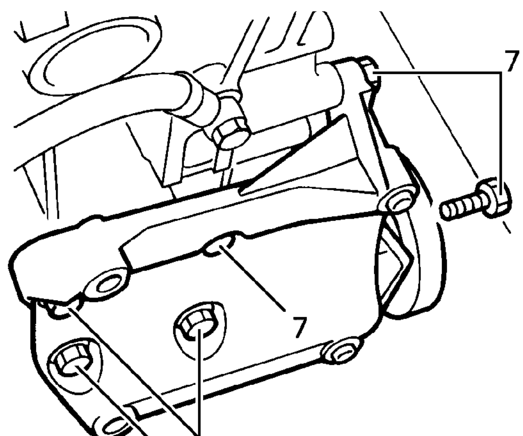
Remove

1. Disconnect battery negative lead.
2. Remove cylinder head gasket. ***See this section.***
3. Remove sump. ***See this section.***
4. Remove alternator. ***See ELECTRICAL, Repair.***
5. Remove crankshaft pulley. ***See this section.***



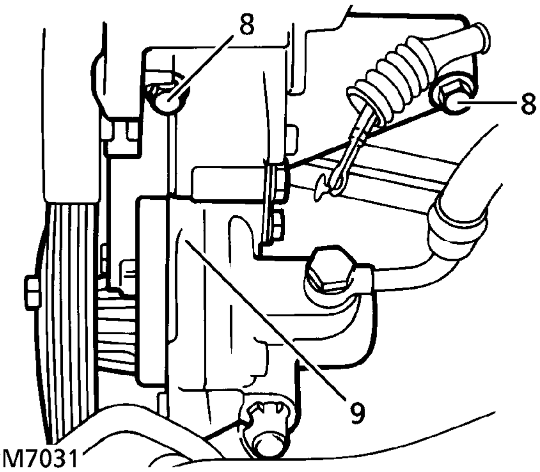
12M7029

6. Remove 4 bolts securing air conditioning compressor to bracket. Tie compressor aside.



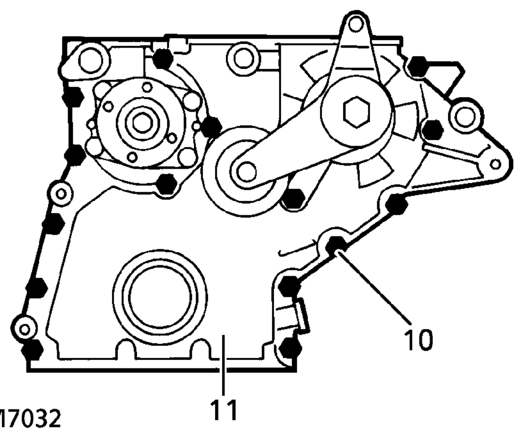
12M7030

7. Remove 6 bolts securing compressor bracket to cylinder block and front cover. Remove compressor bracket.



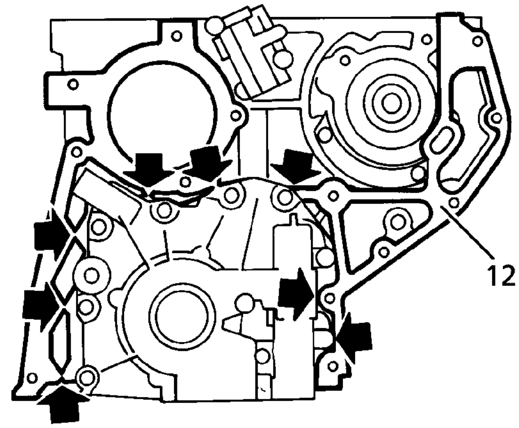
12M7031

8. Remove 2 bolts securing power steering pump bracket to front cover and cylinder block.
9. Release bracket/pump assembly. Tie aside.



12M7032

10. Remove 15 bolts securing front cover to cylinder block.
11. Remove front cover from 2 cylinder block ring dowels.



12M7033

12. Remove and discard gasket.

NOTE: Front cover gasket is integral with oil pump gasket. When removing front cover only, separate gaskets by cutting at points shown.

Refit

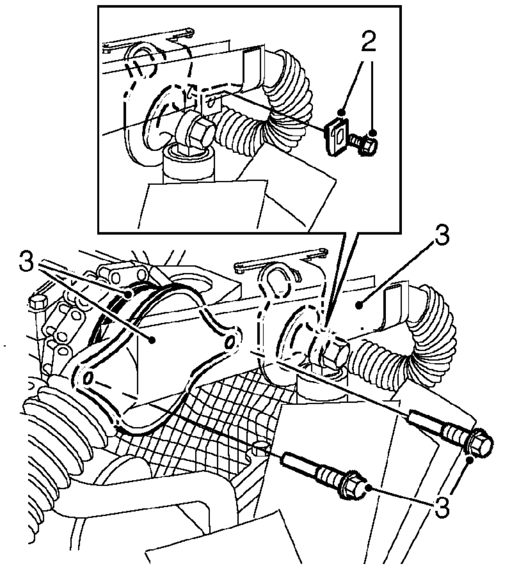
13. Ensure mating faces are clean.
14. Position new gasket on cylinder block.
15. Align front cover to cylinder block dowels. Secure with bolts. Tighten to ***10 Nm (7 lbf.ft)***
16. Position power steering pump on cylinder block dowel.
17. Secure steering pump bracket to front cover and cylinder block with bolts. Tighten to ***22 Nm (16 lbf.ft)***
18. Position air conditioning compressor bracket to cylinder block. Secure with bolts.
19. Position compressor on mounting bracket ring dowels. Secure with bolts.
20. Fit crankshaft pulley. ***See this section.***
21. Fit alternator. ***See ELECTRICAL, Repair.***
22. Fit sump. ***See this section.***
23. Fit cylinder head gasket. ***See this section.***
24. Reconnect battery negative lead.

CAMSHAFT

Service repair no - 12.13.02

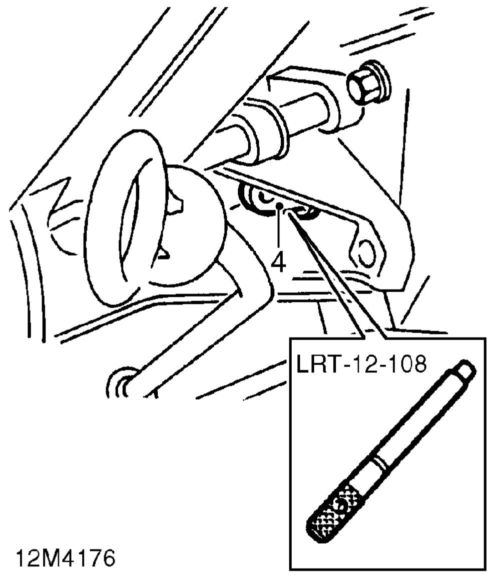
Remove

1. Remove camshaft cover. ***See this section.*** *Vehicles with EGR:* Remove EGR vacuum pump. ***See EMISSION CONTROL, Repair.***

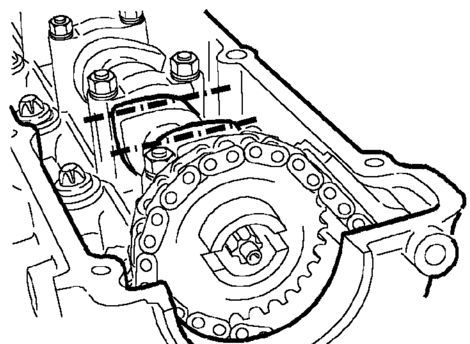


12M4175A

2. Remove bolt securing harness trunking, recover nut plate.
3. *Vehicles without EGR:* Remove 2 bolts securing camshaft front cover plate, remove cover plate; remove and discard 'O' ring. Lay harness trunking aside.
4. Remove plastic plug from flywheel/drive plate timing pin access hole.



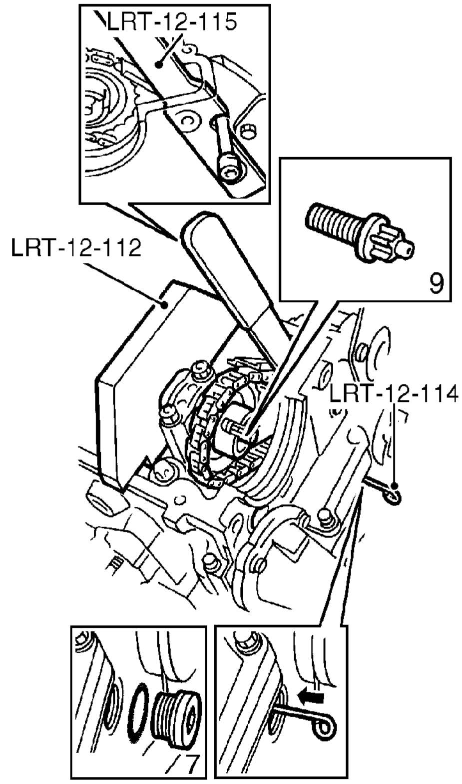
12M4176



12M4179

5. Rotate crankshaft clockwise until No.1 piston is at top dead centre (TDC) on its compression stroke. Insert timing pin LRT-12-108 into hole in flywheel/drive plate.

NOTE: TDC No. 1 is indicated when camshaft lobes of No. 1 cylinder are positioned as shown.



12M4177

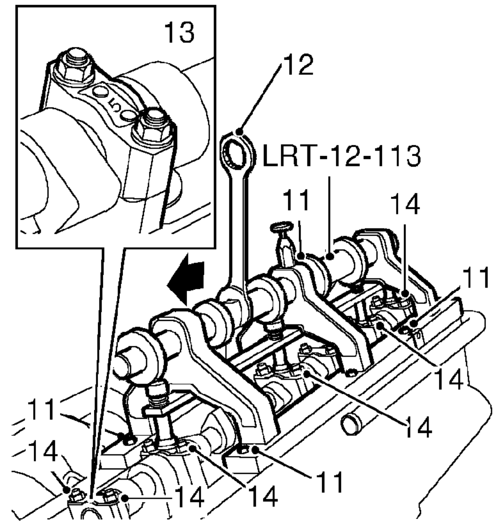
6. Fit camshaft holding tool LRT-12-112.
7. Remove timing chain tensioner access plug, remove and discard sealing washer.
8. Using tool LRT-12-115, retract timing chain tensioner and insert tensioner pin LRT-12-114 to retain tensioner plunger.

CAUTION: Ensure eye of tensioner pin LRT-12-114 is vertical not horizontal.

9. Remove bolt securing camshaft sprocket, remove sprocket.

NOTE: Do not discard bolt at this stage.

10. Remove camshaft holding tool LRT-12-112.



12M4178

11. Locate tool LRT-12-113 on cylinder head, secure with tool with camshaft cover bolts.
12. Rotate shaft of tool LRT-12-113 to load camshaft bearing caps.
13. Ensure camshaft bearing caps are suitably identified to their fitted positions.

NOTE: Caps should be numbered from 1 to 7 and are read from the front of the engine.

14. Remove nuts securing camshaft bearing caps.
15. Rotate shaft of tool LRT-12-113 until loading is removed from camshaft bearing caps, remove tool.
16. Remove camshaft bearing caps.
17. Remove camshaft.

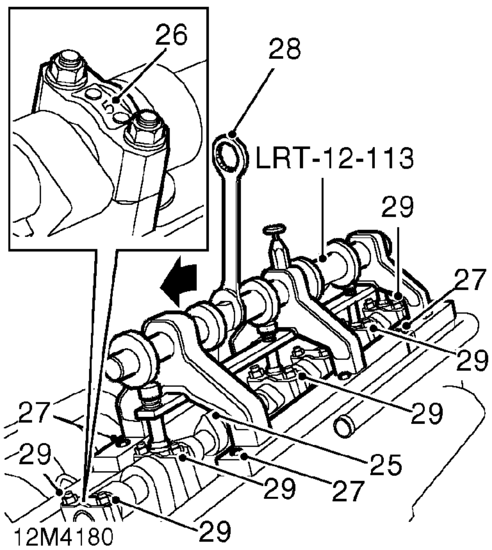
Inspection

18. Clean camshaft, bearing caps and journals in cylinder head.
19. Check cam lobes for signs of wear, pitting or scoring.
20. Check journals on camshaft, bearing caps and cylinder head for signs of wear, overheating and scoring.
21. Lubricate cam followers, camshaft bearing caps and journals with engine oil.
22. Clean sealant from threads of front cover plate bolt and bolt hole.

CAUTION: Do not use a tap.

Refit

23. Remove timing pin LRT-12-108 from flywheel/drive plate.
24. Rotate crankshaft **anti-clockwise** approximately 30° .

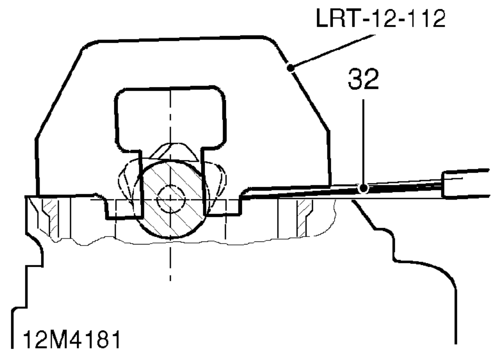


25. Fit camshaft with lobes of No.1 cylinder facing upwards.
26. Fit camshaft bearing caps ensuring No.1 cap is at front of engine and cap identification marks are on exhaust manifold side.
27. Locate tool LRT-12-113 on cylinder head, secure tool with camshaft cover bolts.
28. Rotate shaft of tool LRT-12-113 to load camshaft bearing caps.
29. Fit camshaft bearing cap nuts and tighten to:
M6 - ***10 Nm (7 lbf.ft)***
M7 - ***15 Nm (11 lbf/ft)***
M8 - ***20 Nm (15 lbf/ft)***
30. Rotate shaft of tool LRT-12-113 until loading is removed from camshaft bearing caps, remove tool.

CAUTION: The tappets expand when camshaft is removed. To avoid pistons contacting valves, observe the following wait times before rotating pistons back to top dead centre (TDC).
Above 20° C - 4 minutes
10° C to 20° C - 11 minutes
0° C to 10° C - 30 minutes
Below 0° C - 75 minutes

31. Rotate crankshaft clockwise until No.1 piston is at top dead centre (TDC) and timing pin LRT-12-108 can be inserted in flywheel/drive plate; fit camshaft holding tool LRT-12-112.

NOTE: If camshaft is not positioned correctly, rotate camshaft using spanner on cast hexagon until tool can be fitted.



32. *Engines with recorded mileage in excess of 20,000 km (12,500 miles):* Insert a 4.61 mm (0.18 in) thickness of feeler gauges between camshaft holding tool LRT-12-112 and inlet manifold side of cylinder head.
33. *All engines:* Fit camshaft sprocket.
34. Fit new camshaft sprocket bolt and tighten to:
Stage 1 - ***20 Nm (15 lbf.ft).***
Stage 2 - Further 35°

NOTE: Use angular torque wrench.

35. Using tool LRT-12-115, retract timing chain tensioner rail slightly and remove tensioner pin LRT-12-114.
36. Fit new sealing washer to timing chain tensioner access plug, fit plug and tighten to ***20 Nm (15 lbf.ft)*** .
37. Remove timing pin LRT-12-108 from flywheel/drive plate.
38. Fit plastic plug in timing pin access hole.

39. Apply STC 3373 sealant to camshaft front cover plate dowel bolt.
40. Lubricate new 'O' ring with engine oil.
41. Position harness trunking.
42. *Vehicles without EGR:* Fit 'O' ring and camshaft front cover plate, fit bolts and tighten to ***22 Nm (16 lbf.ft)*** .

CAUTION: Ensure dowel bolt passes through timing chain guide rail.

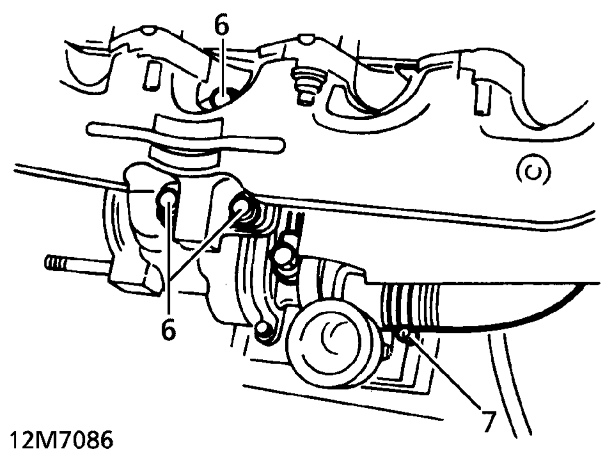
43. Position nut plate to bracket, fit and tighten harness trunking bolt.
44. Fit camshaft cover. ***See this section.***
45. *Vehicles with EGR:* Fit EGR vacuum pump. ***See EMISSION CONTROL, Repair.***

CYLINDER HEAD GASKET

Service repair no - 12.29.02

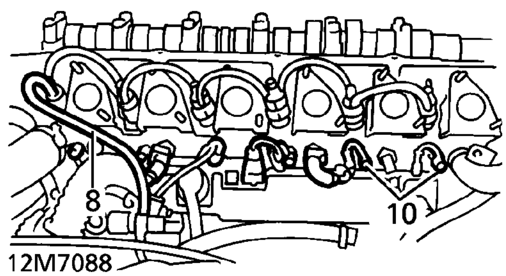
Remove

1. Disconnect battery negative lead.
2. Remove fan cowl. ***See COOLING SYSTEM, Repair.***
3. Remove high pressure fuel pipe assembly. ***See FUEL SYSTEM, Repair.***
4. Remove camshaft cover. ***See this section.***
5. *Vehicles with EGR:* Remove EGR vacuum pump. ***See EMISSION CONTROL, Repair.***
6. Remove exhaust manifold heat shield. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***
7. Remove 3 bolts securing turbocharger to exhaust manifold. Collect gasket and discard.



12M7086

8. Remove turbocharger intake hose. Plug turbocharger intake.

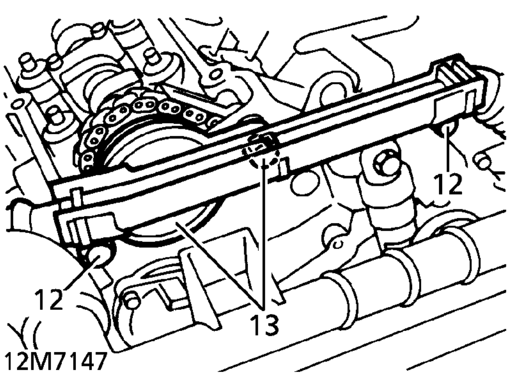


12M7088

9. Disconnect leak-off pipe from No. 1 injector. Plug injector and pipe.
10. Disconnect engine coolant temperature sensor (ECT) Sensor and temperature gauge sensor.
11. Disconnect leads from 6 glowplugs.
12. Disconnect No. 4 injector needle lift sensor.

Vehicles without EGR

13. Remove 2 bolts securing harness trunking to cylinder head. Tie trunking aside.



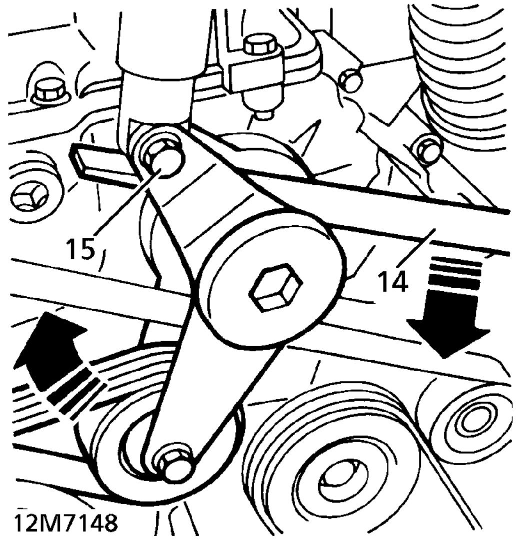
12M7147

14. Remove remaining bolt securing camshaft end cover. Remove cover. Discard 'O' ring.

NOTE: LH cover bolt also serves as retaining pin for timing chain guide rail.

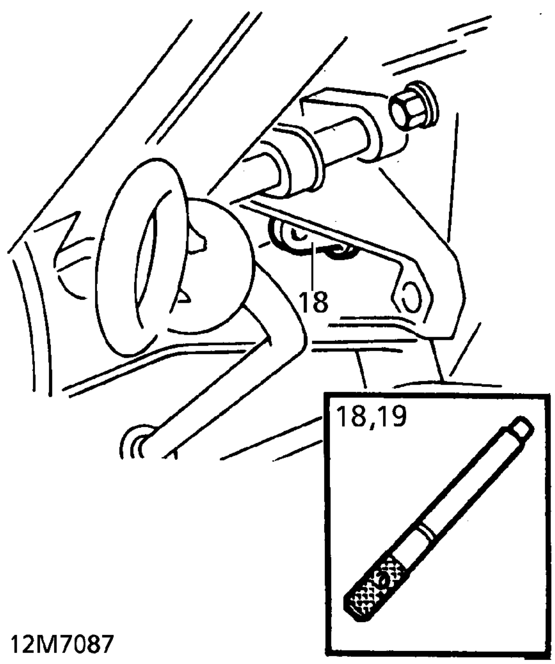
All vehicles

15. Release alternator belt tension using a suitable lever beneath tensioner damper as shown. Release drive belt from alternator pulley.



12M7148

16. Remove bolt securing damper to drive belt tensioner.
17. Release hoses from thermostat housing and cylinder head.
18. Disconnect heater hose from cylinder head.
19. Remove plastic plug from flywheel timing pin access hole. Insert timing pin LRT-12-108.

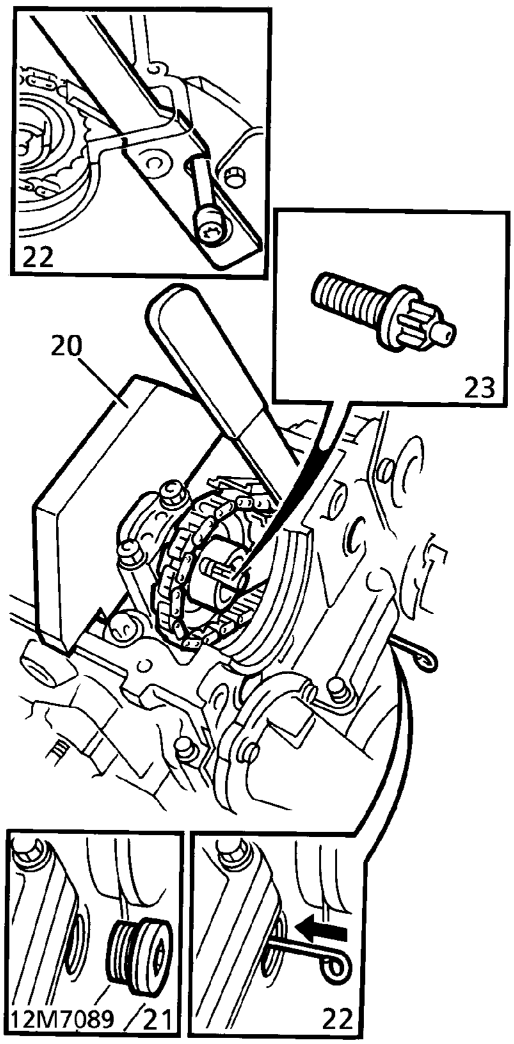


12M7087

20. Turn crankshaft clockwise until No. 1 piston is at Top Dead Centre (TDC) on its compression stroke. Locate timing pin into flywheel.

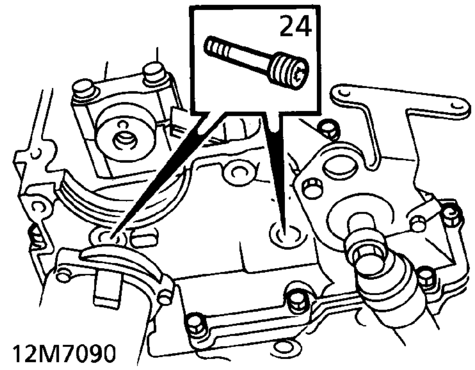
NOTE: TDC No. 1 indicated by camshaft lobes of No. 1 cylinder pointing upwards.

21. Fit camshaft holding tool LRT-12-112.
22. Remove timing chain tensioner access plug. Collect sealing washer and discard.
23. Using tool LRT-12-115, lever timing chain tensioner rail to slack position. Insert tool LRT-12-114 to retain tensioner plunger.



12M7089

24. Remove bolt securing camshaft sprocket. Remove sprocket.



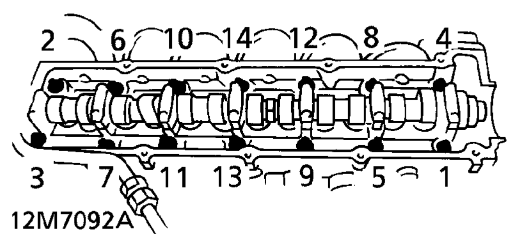
12M7090

25. Remove timing chain tensioner and guide rail pins. Remove 'O' rings and discard.
26. Remove timing chain tensioner rail.
27. Remove 5 bolts and 1 nut securing cylinder head to timing cover.
28. Remove camshaft holding tool.

CAUTION: Do not rotate camshaft.

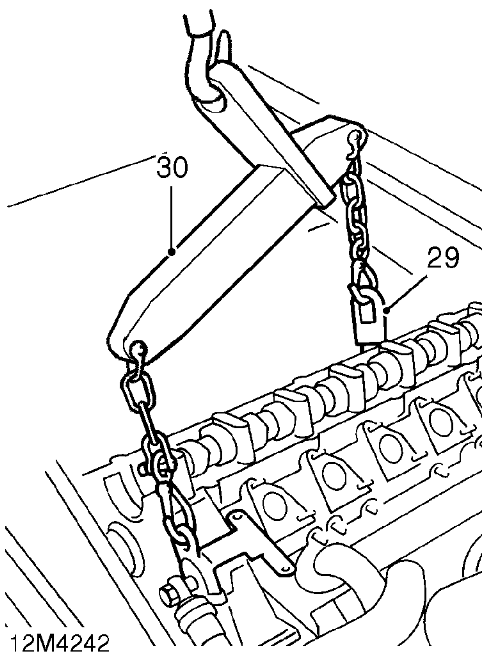
29. Using sequence shown, progressively slacken and remove 14 cylinder head bolts. Discard bolts.

NOTE: LH rear bolt cannot be removed due to proximity of bulkhead.



12M7092A

30. Attach suitable lifting eye to upper rear inlet manifold stud.



12M4242

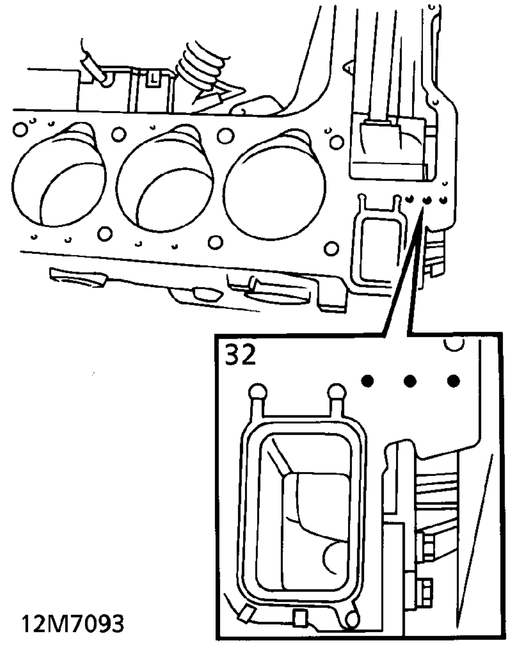
31. Attach hoist to lifting eyes. Remove cylinder head, remove and discard LH rear cylinder head bolt.

NOTE: 2 ring dowels locate cylinder head to block.

CAUTION: To avoid damaging timing chain guide, ensure cylinder head is lifted as squarely as possible.

32. Remove cylinder head gasket.

33. Check number of thickness identification holes before discarding gasket.

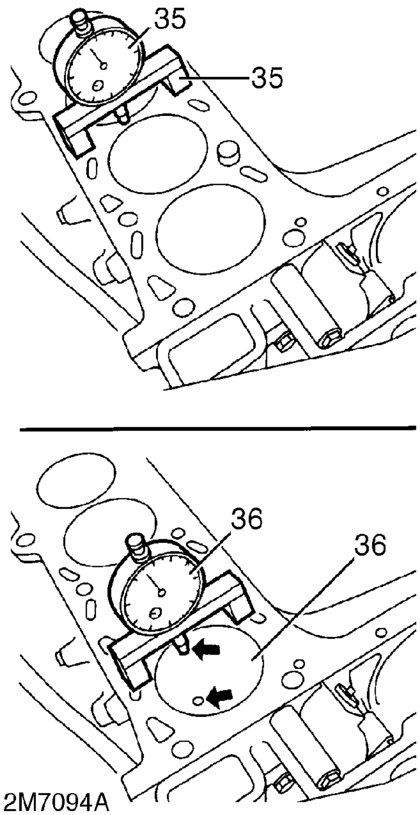


12M7093

CAUTION: Check cylinder head for warping, see Cylinder head warp check. If crankshaft, pistons or connecting rods have been renewed, new cylinder head gasket thickness must be determined using the following Piston Protrusion Check procedure. If above items have not been disturbed, continue at Refit using gasket with same thickness identification as original.

Piston Protrusion - Check

34. Ensure cylinder block face and piston crowns are clean.
35. Position a dial gauge with suitable base to cylinder block.



12M7094A

36. Preload and zero gauge on cylinder block face.
37. Move gauge onto piston crown. Measure protrusion of No. 1 piston in two positions as shown. Take average of readings. Record results.
38. Repeat protrusion check on piston No. 6.
39. Remove timing pin LRT-12-108 from flywheel.
40. Record protrusion of remaining pistons. Ensure that readings are taken at **exactly** TDC.

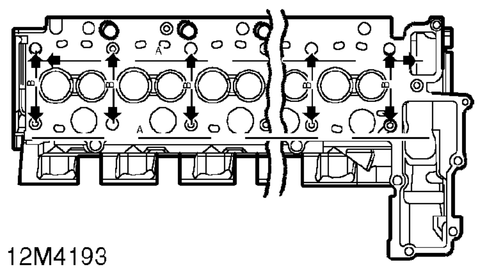
NOTE: Top Dead Centre must be located using dial gauge.

41. Calculate average piston protrusion to determine required gasket thickness:
Up to 0.76 mm = 2 identification holes
Over 0.76 mm = 3 identification holes

NOTE: If any piston protrudes more then 0.81mm, a gasket with 3 identification holes must be fitted.

Cylinder head warp - check

42. Remove all traces of carbon and gasket material from cylinder head.



12M4193

43. Using a straight edge and feeler gauges, check cylinder head for distortion along lines shown in illustration and compare with figures given:
Longitudinal warp **A** = 0.1 mm (0.004 in)
Lateral warp **B** = 0.05 mm (0.002 in)
44. Replace cylinder head if figures obtained exceed those given.

NOTE: Cylinder heads may not be refaced.

Refit

CAUTION: If crankshaft timing pin LRT-12-108 has been removed, ensure that FIP is on correct stroke, with dimple on FIP sprocket visible, before refitting pin.

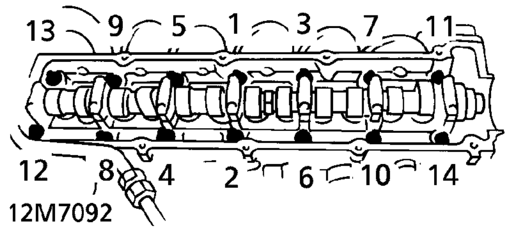
45. Ensure all mating faces are clean.
46. Check cylinder block ring dowels for condition and correct location.
47. Apply 1.5mm bead of Unipart sealant STC 3373 to joint lines of cylinder block and timing cover.
48. Fit cylinder head gasket of correct thickness.
49. Fit tool LRT-12-112 to ensure camshaft is in correct position. If necessary, turn camshaft using spanner on cast hexagon.

CAUTION: Do not turn camshaft if cylinder head is fitted to cylinder block.

NOTE: Fit a lightly oiled, new cylinder head bolt in LH rear location.

50. Position cylinder head on cylinder block. Ensure timing chain guide is not fouled and rear LH bolt enters bolt hole in cylinder block. Locate cylinder head on ring dowels.
51. Disconnect lifting chains. Remove lifting eye.
52. Lightly lubricate new cylinder head bolts. Fit bolts. Tighten, in sequence shown, in the following stages.
Stage 1 = 80 Nm (59 lbf.ft)
Stage 2 = Loosen by 180°
Stage 3 = 50 Nm (37 lbf.ft)
Stage 4 = Tighten 90°
Stage 5 = Tighten 90°
Stage 6 = Run engine for 25 minutes
Stage 7 = Stop engine, allow to cool
Stage 8 = Tighten 90°

NOTE: Tighten using angular torque wrench.



12M7092

53. Secure cylinder head to timing cover with bolts and nut.
M7 ***-15 Nm (11 lbf.ft)***
M8 ***-20 Nm (15 lbf.ft)***
54. Fit camshaft timing chain tensioner rail.
55. Using new 'O' rings, fit tensioner and guide rail pins.
56. Engage timing chain with camshaft sprocket. Position sprocket on camshaft.
57. Fit NEW camshaft sprocket bolt.

NOTE: Important; if engine has covered more than 20,000 km (12,500 miles), insert a feeler gauge of 4.61 mm (0.18 in) thickness between cylinder head face and inlet manifold side of LRT-12-112 prior to tightening bolt.

58. With LRT-12-112 fitted to camshaft, tighten camshaft sprocket bolt to ***20 Nm (15 lbf.ft).***
59. Using a suitable torque angle gauge, further tighten bolt by 35°.
60. Remove LRT-12-112.
61. Using tool LRT-12-115, lever tensioner rail to slack position. Remove LRT-12-114 from tensioner plunger.
62. Using a new sealing washer, refit access plug.

63. Remove LRT-12-108 from flywheel. Fit plastic plug.
64. Connect cooling hoses. Secure with clips.
65. Align damper to tensioner. Secure with bolt.
66. Lever tensioner to slack position. Engage drive belt over alternator pulley.

Vehicles without EGR

67. Using a new 'O' ring, fit camshaft end cover.

NOTE: Apply Loctite 577 sealant to threads of LH camshaft end cover bolt.

68. Align harness trunking to cylinder head. Secure camshaft end cover and harness trunking with bolts.

All Vehicles

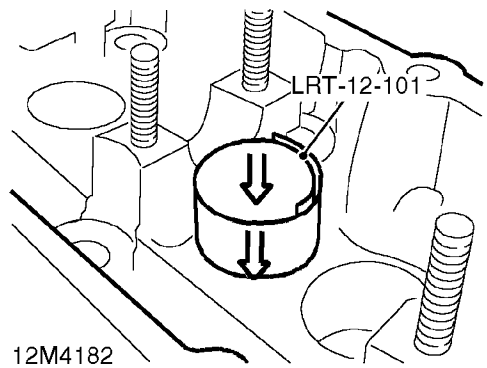
69. Connect No. 4 injector needle lift sensor.
70. Connect leads to glowplugs.
71. Connect ECT sensor and temperature gauge sensor.
72. Remove plugs. Connect leak-off pipe to No. 1 injector.
73. Remove plug, fit intake hose to turbocharger. Secure with clip.
74. Position new gasket on exhaust manifold. Fit turbocharger.
75. Secure with bolts. ***45 Nm (33 lbf.ft)***
76. Fit exhaust manifold heat shield. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***
77. Fit camshaft cover. ***See this section.***
78. *Vehicles with EGR:* Fit EGR vacuum pump. ***See EMISSION CONTROL, Repair.***
79. Fit high pressure fuel pipes. ***See FUEL SYSTEM, Repair.***
80. Fit fan cowl. ***See COOLING SYSTEM, Repair.***
81. Reconnect battery negative lead.

VALVES AND TAPPETS

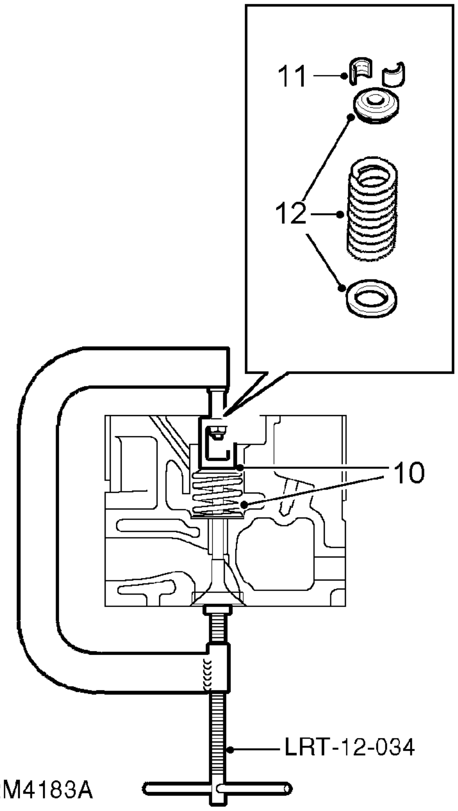
Service repair no - 12.29.59

Remove

1. Remove camshaft. ***See this section.***
2. Remove inlet manifold. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***
3. Remove exhaust manifold. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***
4. Remove injectors. ***See FUEL SYSTEM, Repair.***
5. Remove glow plugs. ***See FUEL SYSTEM, Repair.***
6. Remove cylinder head. ***See this section.***
7. Remove tappets and store in their fitted order.

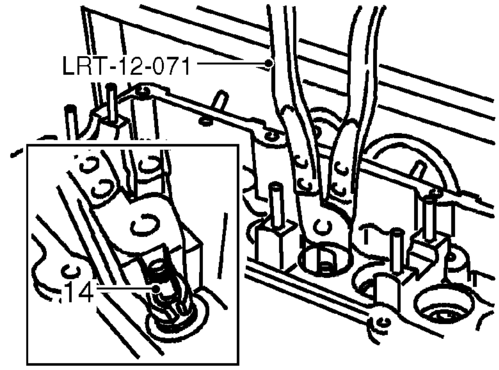


8. Insert protective sleeve LRT-12-101 in tappet bore.



12M4183A

9. Position tool LRT-12-034 on valve.
10. Compress valve spring.
11. Remove 2 collets using a stick magnet.
12. Release tool LRT-12-034, collect valve spring cup, valve spring and spring seat, discard valve spring.



12M4184

13. Remove valve stem oil seal using LRT-12-071, discard seal.
14. Remove valve.

CAUTION: Store valve components in their fitted order.

15. Repeat above procedures for remaining valves.
16. Clean all components.

Inspection

Valves

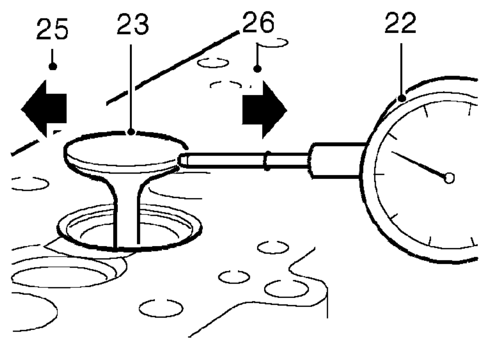
17. Remove carbon from valves, valve guides and seats.
18. Check valves for signs of burning, cracking and pitting of valve seats.
19. Check head diameter of each valve:
    Inlet = 36.0 mm (1.42 in)
    Exhaust = 31.0 mm (1.22 in)
20. Check stem diameter of each valve, half-way along stem and compare diameters with dimensions given to determine stem sizes of valves fitted and valve stem wear.
    Standard:
    Inlet = 6.97 mm (0.274 in)
    Service limit = 6.95 mm (0.273 in)
    Exhaust = 6.95 mm (0.273 in)
    Service limit = 6.93 mm (0.272 in)

    1st oversize:
    Inlet = 7.07 mm (0.28 in)
    Service limit = 7.05 mm (0.277 in)
    Exhaust = 7.06 mm (0.278 in)
    Service limit = 7.04 mm (0.27 in)

    2nd oversize:
    Inlet = 7.17 mm (0.282 in)
    Service limit = 7.15 mm (0.28 in)
    Exhaust = 7.16 mm (0.281 in)
    Service limit = 7.14 mm (0.279 in)
21. If valve stems are worn in excess of service limits, valves with next oversize stems must be fitted and valve guides reamed to correct size.

Valve guides

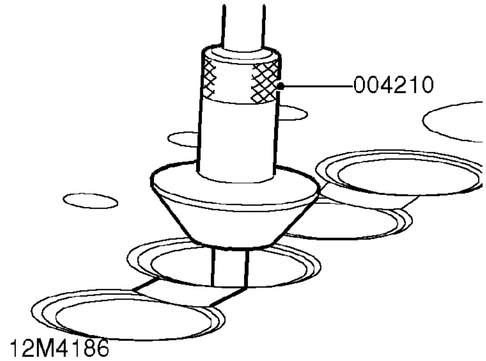
CAUTION: Prior to checking/reaming valve guides, check cylinder head for warping. *See Cylinder head gasket*.



12M4185

22. Position a suitable DTI to cylinder head adjacent to No.1 valve seat.
23. Insert a new valve with same stem diameter as the original in the valve guide.
24. Position end of valve stem flush with spring end of guide.
25. Move valve away from DTI, pre-load gauge and note pre-load reading.
26. Move valve towards DTI, note gauge reading and subtract pre-load from this figure. Compare final figure obtained with tilt figure:
    Valve tilt - inlet and exhaust = 0.5 mm (0.02 in).
27. If tilt figure exceeds above dimension, original valve must be replaced with next oversize valve and valve guide reamed to next oversize.
    Valve guide inside diameter - inlet and exhaust:
    Standard = 7.0 mm (0.275 in)
    For 1st oversize valve stem = 7.1 mm (0.28 in)
    For 2nd oversize valve stem = 7.2 mm (0.283 in)

NOTE: Valve guides may not be replaced.

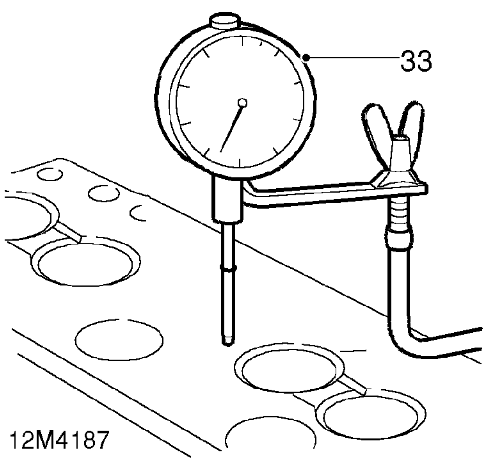


12M4186

28. Dry ream valve guides using BMW tool 004210 and appropriate size reamer from those supplied with tool.
29. Ream valve guide from combustion chamber side, rotate tool once only in a downwards direction; remove all traces of swarf on completion.

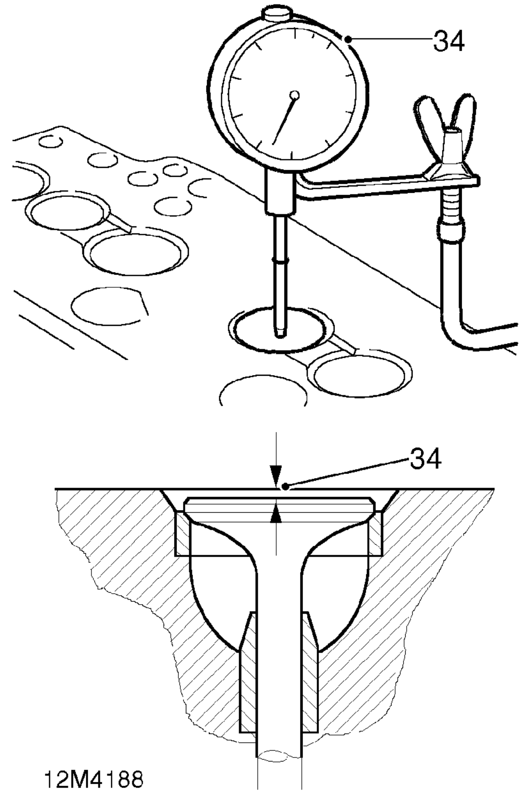
Check valve head stand-down

30. *Original valves:* Lap valves to their seats, remove all traces of grinding paste on completion.
31. *Replacement valves:* Do not lap valves to their seats.
32. Insert No.1 valve into its guide.



12M4187

33. Position suitable DTI to cylinder head, pre-load then zero gauge.



12M4188

34. Position DTI to centre of valve, measure valve head stand-down and compare with figures given:
Inlet = 0.65 to 0.85 mm (0.02 to 0.03 in)
Exhaust = 0.85 to 1.05 mm (0.03 to 0.04 in)
35. Replace any valve having stand-down in excess of figures given with a valve having an increased head thickness.
36. Refer to the following to determine thickness of valve head required ensuring that valves with correct size stem diameter are obtained.

NOTE: It will be necessary to re-cut valve seats when fitting valves with increased head thickness.

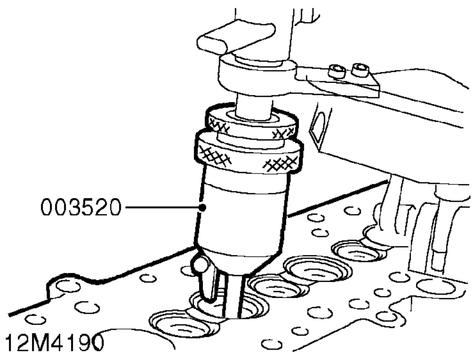
Standard valve stem diameter:
Head thickness increase - 0.25 mm (0.01 in)
Identification marks - RO

1st oversize valve stem:
Head thickness increase - 0.25 mm (0.01 in)
Identification marks - R1
Head thickness increase - 0.50 mm (0.02 in)
Identification marks - R2

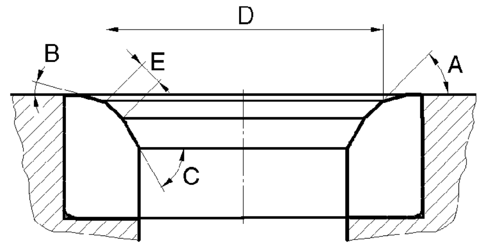
2nd oversize stem:
Head thickness increase - 0.50 mm (0.02 in)
Identification marks - R3

NOTE: Identification marks will be found adjacent to cotter grooves.

Valve seat - recut



37. Recut valve seats using BMW tool 003520.
Head thickness:
0.25 mm (0.01 in) - Increase depth by 0.25 mm (0.01 in)
0.50 mm (0.02 in) - Increase depth by 0.50 mm (0.02 in)

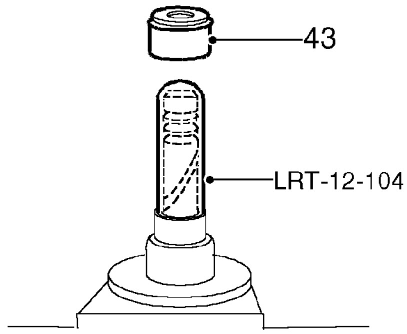


38. Use BMW tool 003580 to obtain specified valve seat dimensions:
Valve seat angle **A** = 45° ± 10'
Correction angle - outside **B** = 15°
Correction angle - inside **C** = 60°
Seat face outside diameter **D**:
Inlet valve = 35.5 mm (1.4 in)
Exhaust valve = 30.6 mm (1.2 in)
Valve seat width **E**:
Inlet valve = 1.75 to 2.25 mm (0.07 to 0.09 in)
Exhaust valve = 2.60 to 2.90 mm (0.10 to 0.11 in)
39. Remove all traces of swarf on completion.

CAUTION: Do not lap replacement valves to their seats.

Refit

40. Lubricate all components including valve guides and new valve stem oil seals with engine oil.
41. Insert protective sleeve LRT-12-101 in tappet bore.



12M4192

42. Fit protection sleeve LRT-12-104 on valve stem.
43. Fit new valve stem oil seal.

NOTE: Inlet valve stem oil seals are coloured RED whilst exhaust valve stem oil seals are coloured GREEN.

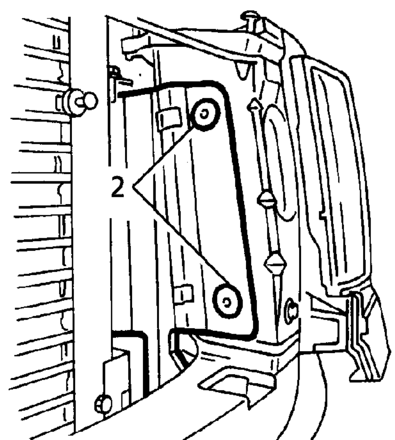
44. Press valve stem oil seal into position using tool LRT-12-071, remove protection sleeve LRT-12-104.
45. Fit valve spring seat, new valve spring and spring cup.
46. Compress valve spring using tool LRT-12-034, fit 2 collets.
47. Remove protection sleeve LRT-12-101.
48. Repeat procedures for remaining valves.
49. Lubricate tappet bores and tappets with engine oil, fit tappets to their original locations.
50. Fit cylinder head. ***See this section.***
51. Fit exhaust manifolds. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***
52. Fit glow plugs. ***See FUEL SYSTEM, Repair.***
53. Fit injectors. ***See FUEL SYSTEM, Repair.***
54. Fit inlet manifolds. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***
55. Fit camshaft. ***See this section.***

OIL COOLER

Service repair no - 12.60.68

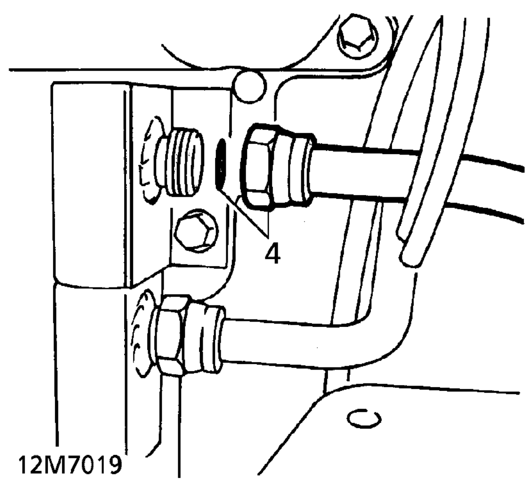
Remove

1. Remove intercooler. ***See FUEL SYSTEM, Repair.***
2. Remove 2 trim fixing studs securing LH deflector panel. Remove panel.



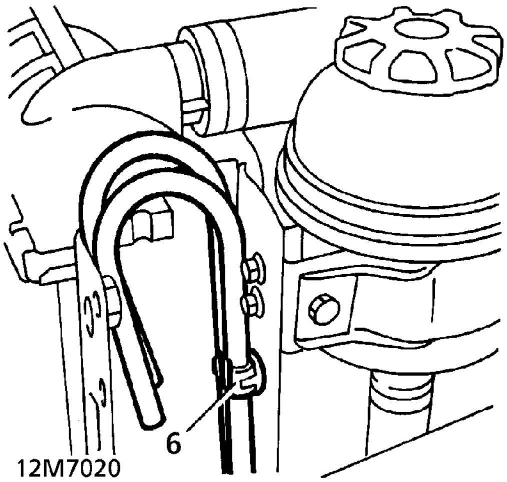
12M7018

3. Position container to catch oil spillage.
4. Disconnect oil cooler upper hose. Remove 'O' ring and discard.

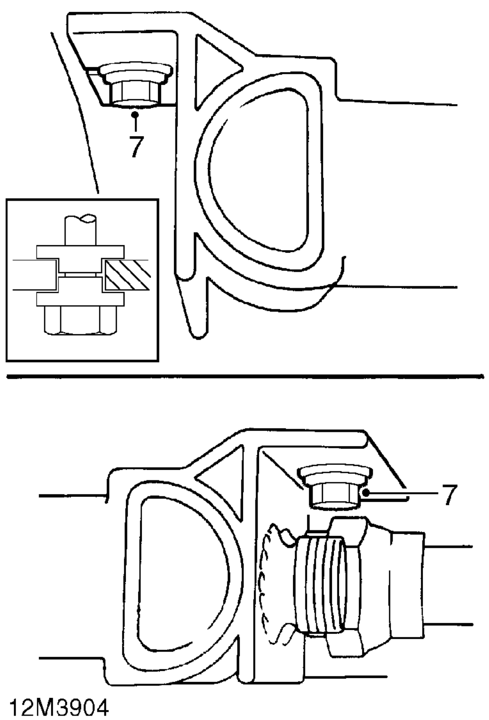


12M7019

5. Plug hose and cooler.
6. Release left hand fog lamp breather tubes from radiator bracket clips.

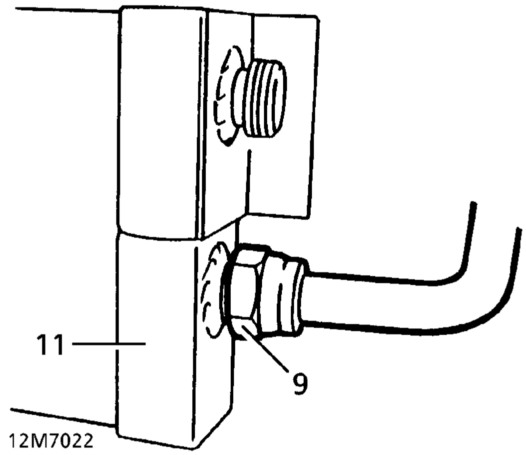


7. Remove 2 bolts securing oil cooler to radiator bracket.



CAUTION: The RH side of the oil cooler has a sliding mount which allows the cooler to expand and contact with changes in temperature. Incorrect tightening torque of the RH fixing will lead to cooler damage.

8. Raise oil cooler for access.
9. Disconnect lower hose. Remove 'O' ring and discard.



10. Plug hose and cooler.
11. Remove oil cooler.

Refit

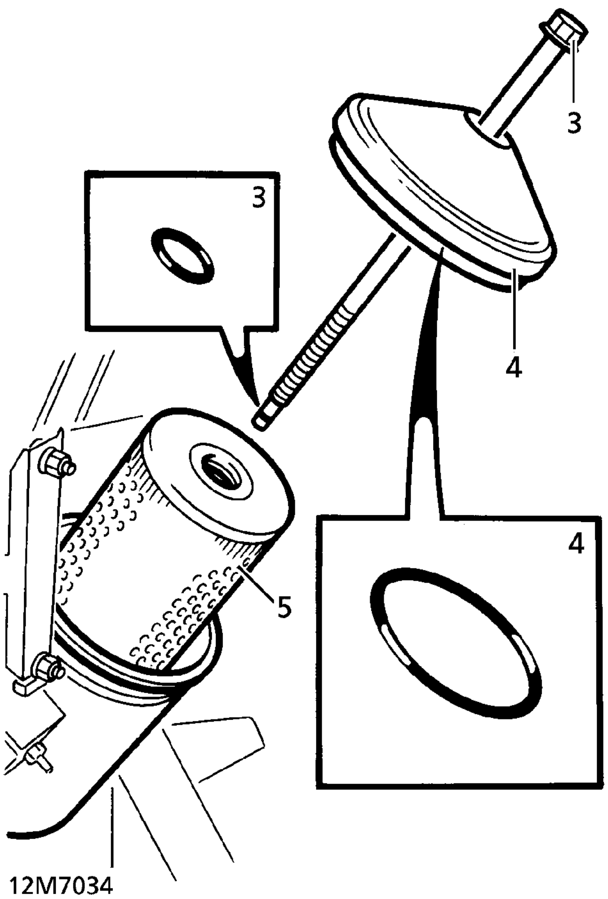
12. Position oil cooler. Remove plugs.
13. Using new 'O' ring, connect lower hose to oil cooler. Tighten to ***30 Nm (22 lbf.ft).***
14. Lower cooler to radiator bracket.
15. Apply Loctite 270 Stud Lock to threads of RH fixing.
16. Assemble spacers to fixing and secure fixing to radiator bracket, finger tight.
17. Engage slot in RH side of cooler to spacers.
18. RH fixing Tighten to ***5 Nm (4 lbf.ft).***
    LH fixing Tighten to ***25 Nm (19 lbf.ft).***
19. Using new 'O' ring, connect upper pipe to oil cooler. Tighten to ***30 Nm (22 lbf.ft)***
20. Remove container.
21. Secure fog lamp breather tubes to radiator bracket clips.
22. Fit deflector panel. Secure with studs.
23. Fit intercooler. ***See FUEL SYSTEM, Repair.***
24. Check engine oil level. Top-up if necessary.

OIL FILTER - UP TO 1998MY

Service repair no - 12.60.02

Remove

1. Drain engine oil. ***See SECTION 10, Maintenance.***
2. Position cloth beneath oil filter casing to catch spillage.
3. Remove bolt securing cover to filter casing. Collect 'O' ring and discard .
4. Remove cap. Collect 'O' ring and discard.
5. Remove filter element and discard.



12M7034

NOTE: Oil in filter casing will run back into sump once cover is removed.

Refit

6. Clean filter casing and cap.
7. Fit filter element.
8. Using new 'O' rings, position cap. Secure with bolt. Tighten to ***33 Nm (24 lbf.ft)***
9. Replenish engine oil. ***See LUBRICANTS, FLUIDS AND CAPACITIES, Information.***
10. Start engine. Run at 2500 rev/min until oil pressure warning light extinguishes.

NOTE: Oil pressure warning light will extinguish after approximately 5 seconds.

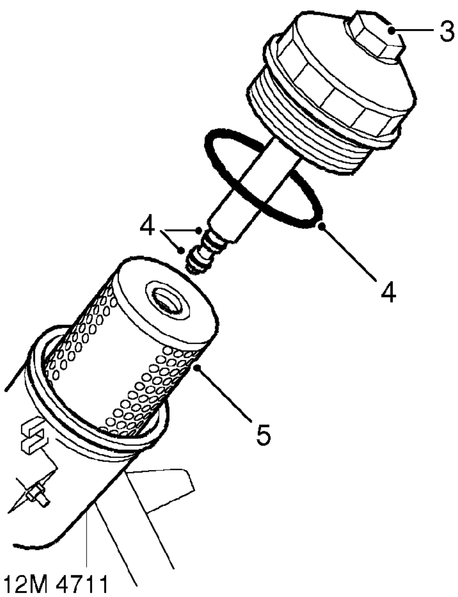
11. Stop engine. Recheck oil level.

OIL FILTER 1998MY ONWARDS

Service repair no - 12.60.02

Remove

1. Drain engine oil. ***See SECTION 10, Maintenance.***
2. Position cloth beneath oil filter casing to catch spillage.
3. Using a socket wrench, carefully loosen cap and allow oil to drain back into sump.
4. Remove cap and collect 3 'O' ring seals. Discard seals.
5. Remove filter element and discard.



12M 4711

Refit

6. Clean filter casing and cap.
7. Fit filter element.
8. Lubricate new 'O' ring seals using engine oil.
9. Fit cap and tighten to ***25 Nm (18 lbf.ft)***
10. Replenish engine oil. ***See LUBRICANTS, FLUIDS AND CAPACITIES, Information.***
11. Start engine. Run at 2500 rev/min until oil pressure warning light extinguishes.

NOTE: Oil pressure warning light will extinguish after approximately 5 seconds.

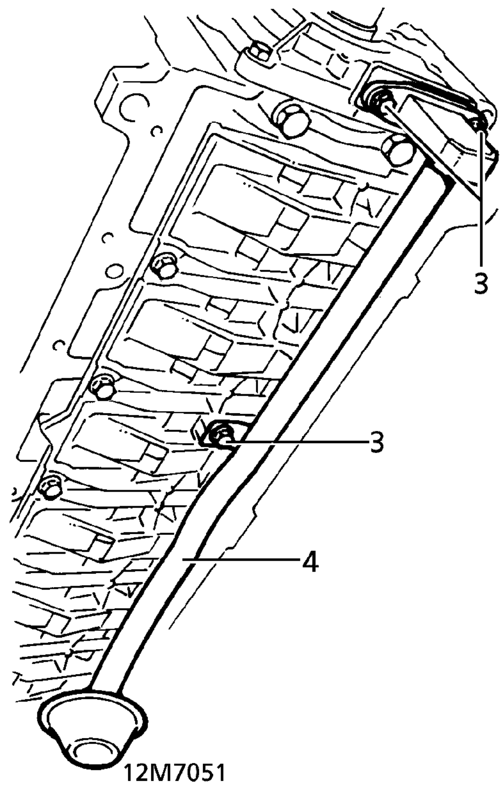
12. Stop engine. Recheck oil level.

OIL PUMP

Service repair no - 12.60.26

Remove

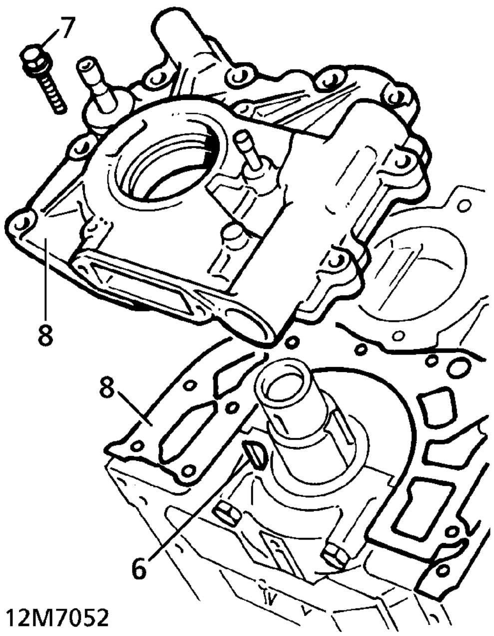
1. Remove timing chains and sprockets. ***See this section.***
2. Remove sump. ***See this section.***
3. Remove 3 bolts securing oil pick-up strainer to oil pump and deflector plate.



12M7051

4. Remove pick-up strainer. Collect gasket.

5. Remove lower chain guide.
6. Remove Woodruff key from crankshaft.

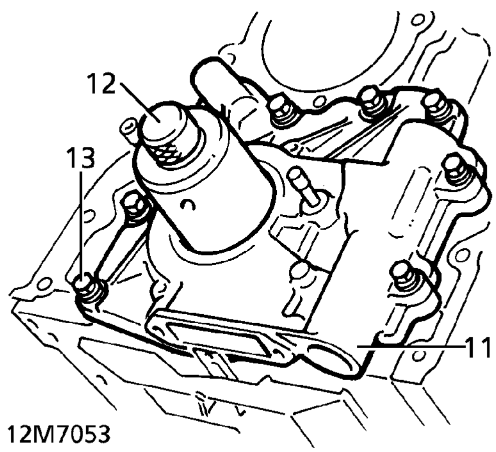


12M7052

7. Remove 8 bolts securing oil pump to cylinder block.
8. Remove pump. Collect gasket.

Refit

9. Ensure mating faces are clean.
10. Position new oil pump/front cover gasket to cylinder block.
11. Refit oil pump. Fit bolts, finger tight.
12. Fit tool LRT-12-116 over crankshaft. Tighten centre screw by hand to centralise oil pump.



12M7053

13. Tighten oil pump bolts to ***22 Nm (16 lbf.ft)***
14. Remove tool from crankshaft.
15. Fit woodruff key to crankshaft.
16. Fit lower chain guide.
17. Using a new gasket, position oil pick-up strainer. Secure with bolts. Tighten to ***10 Nm (7 lbf.ft)***
18. Fit timing chains and sprockets. ***See this section.***
19. Reconnect battery negative lead.

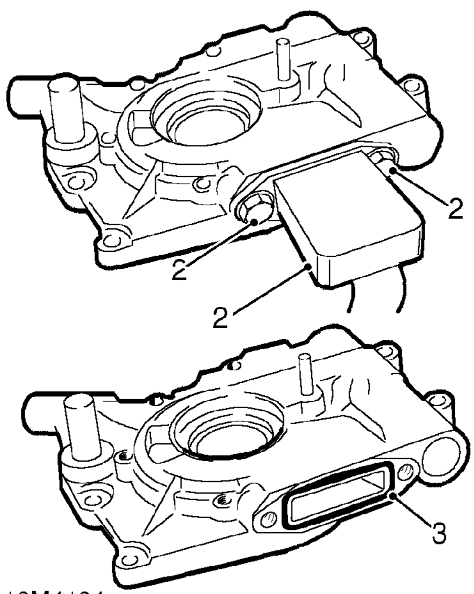
OIL PUMP AND OIL PRESSURE RELIEF VALVE - OVERHAUL

Service repair no - 12.60.32

1. Remove oil pump. ***See this section.***

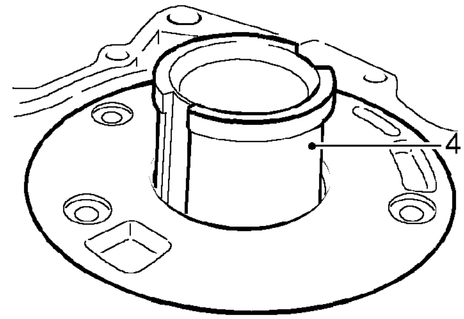
Oil pump

NOTE: Oil pump is only supplied as an assembly but the following dimensional checks checks may be carried out to determine serviceability.



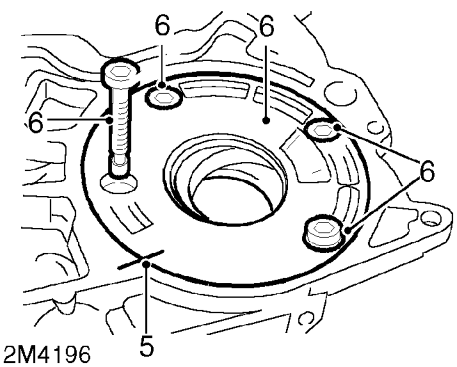
12M4194

2. *If fitted :* Remove 2 bolts securing oil pick-up pipe, remove pipe.
3. Remove and discard seal.



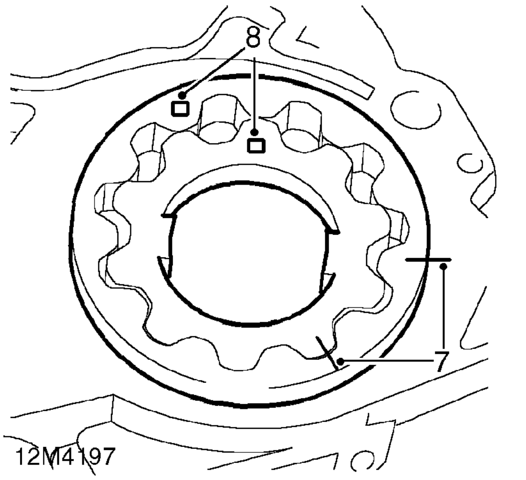
12M4195

4. Press flanged bush out from front of oil pump.

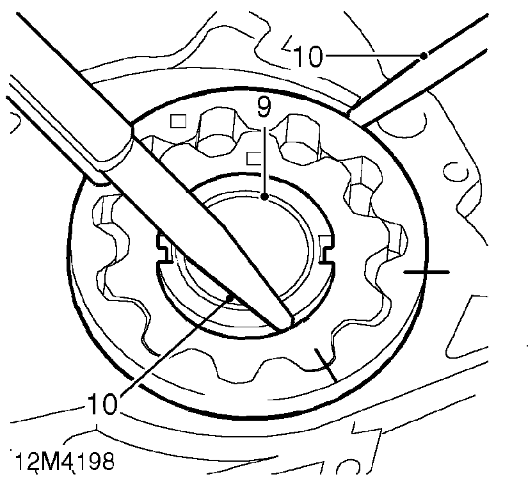


12M4196

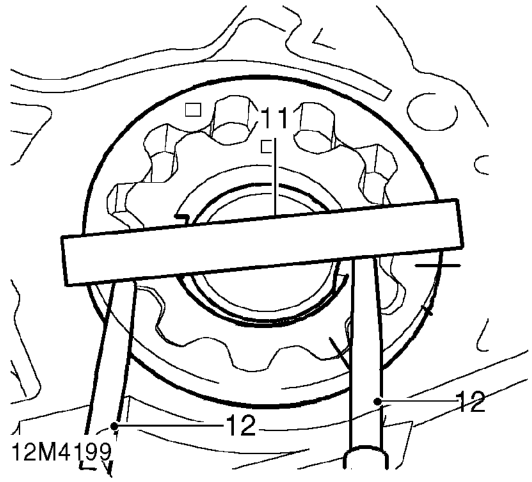
5. Make suitable alignment marks between cover plate and pump housing.
6. Noting fitted position of special screw, remove 4 screws securing cover plate, remove plate.



7. Make suitable alignment marks between inner and outer rotors and pump housing.
8. Clean rotors and recess in pump housing, fit rotors ensuring square identification marks face towards cover plate and reference marks are aligned.

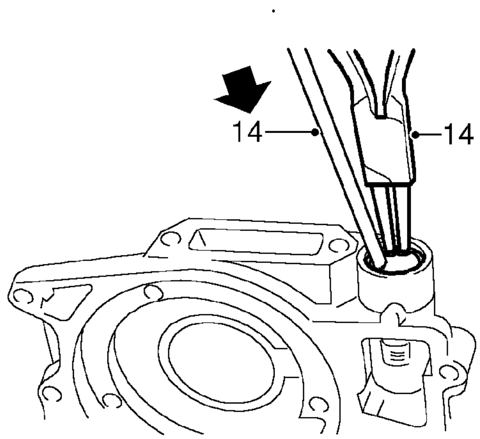


9. Insert flanged bush into inner rotor with flange on rotor side of pump.
10. Using feeler gauges, check clearance between outer rotor to pump body and inner rotor to flanged bush and compare with figures given:
    Outer rotor to pump housing = 0.4 mm (0.02 in) - maximum
    Inner rotor to flanged bush = 0.065 mm (0.003 in) - maximum



11. Remove flanged bush, position a straight edge across both rotors and the pump body.
12. Using feeler gauges inserted between straight edge and on each side of inner and outer rotors, measure axial clearance between rotors and pump body and compare with figures given:
    Outer rotor to pump body axial clearance = 0.070 mm (0.004 in) - maximum
    Inner rotor to pump body axial clearance = 0.065 mm (0.003 in) - maximum
13. If any of the clearances obtained exceed figures given, pump assembly must be replaced.

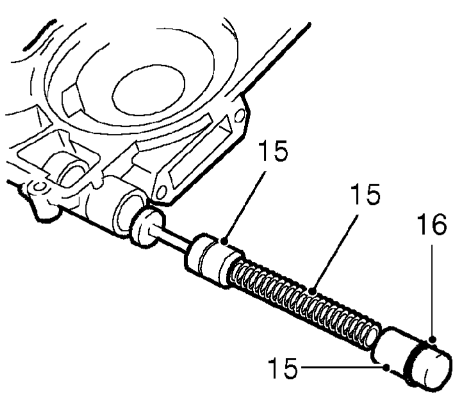
Oil pressure relief valve



12M4200

14. Using a suitable mandrel, depress sleeve and remove circlip.

WARNING: Sleeve is under strong spring pressure, suitable eye protection must be worn.



12M4201

15. Gradually release spring pressure, remove sleeve, spring and piston.
16. Remove and discard 'O' ring.
17. Clean all components, check piston, sleeve and relief valve bore for damage, scoring and signs of wear.
18. Check relief valve spring free length:
Free length = 84.1 mm (3.3 in)
19. Renew relief valve as an assembly.

Oil pump and oil pressure relief valve - assembling

20. Lubricate all components with engine oil.
21. Fit a new 'O' ring to sleeve.
22. Insert piston, spring and sleeve into relief valve bore, depress sleeve and fit circlip.

WARNING: Suitable eye protection must be worn.

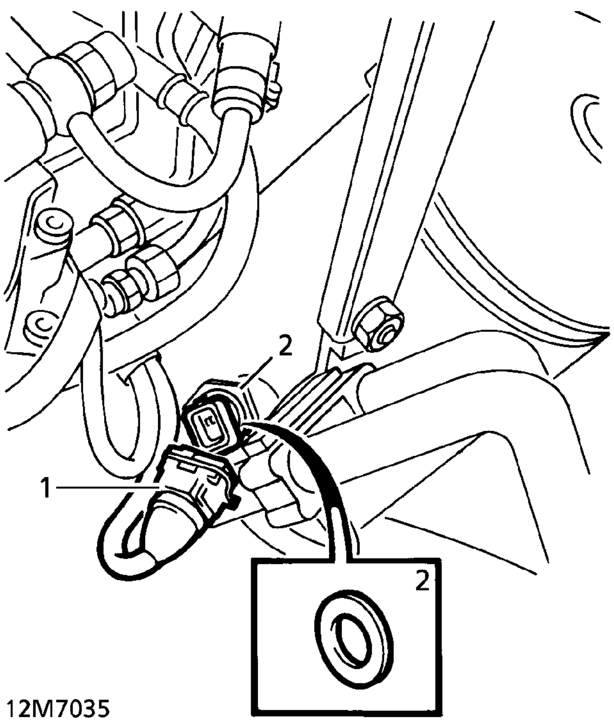
23. Check that circlip is correctly seated in groove.
24. Insert rotors into pump ensuring that square identification marks are toward cover.
25. Fit cover plate ensuring reference marks are aligned.
26. Fit 4 screws ensuring special screw is in its original location, tighten screws to ***20 Nm (15 lbf.ft).***
27. Fit flanged bush ensuring that flange is on cover plate side of pump.
28. Position new seal to oil pick-up pipe, fit pipe.
29. Fit 2 bolts and tighten to ***10 Nm (7 lbf.ft).***
30. Fit oil pump. ***See this section.***

OIL PRESSURE SWITCH

Service repair no - 12.60.50

Remove

1. Disconnect switch multiplug.
2. Remove switch. Collect sealing washer and discard.



12M7035

Refit

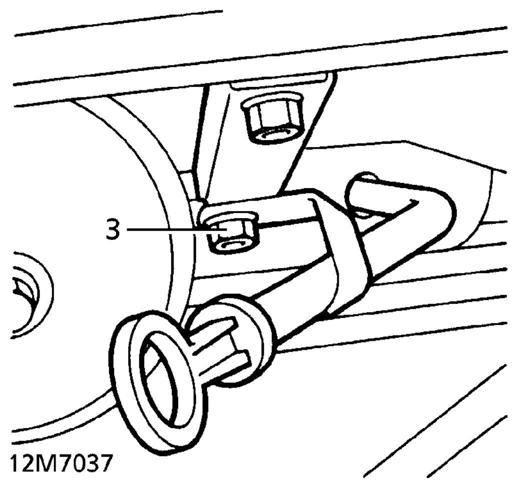
3. Ensure mating faces are clean.
4. Fit a new sealing washer, oil threads of switch and fit switch. Tighten to ***40 Nm (30 lbf.ft)***
5. Connect multiplug.

SUMP

Service repair no - 12.60.44

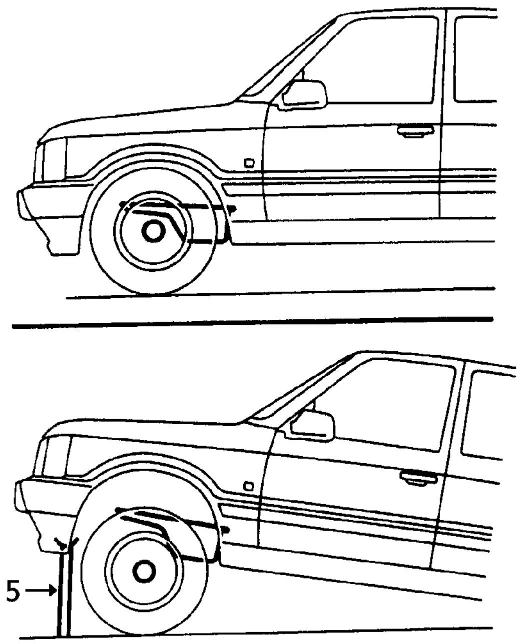
Remove

1. Raise vehicle on four post lift.
2. Disconnect battery negative lead.
3. Remove nut and bolt securing dipstick tube. Remove tube. Remove and discard 'O' ring.



12M7037

4. Raise lift.
5. Position support under chassis front cross member.

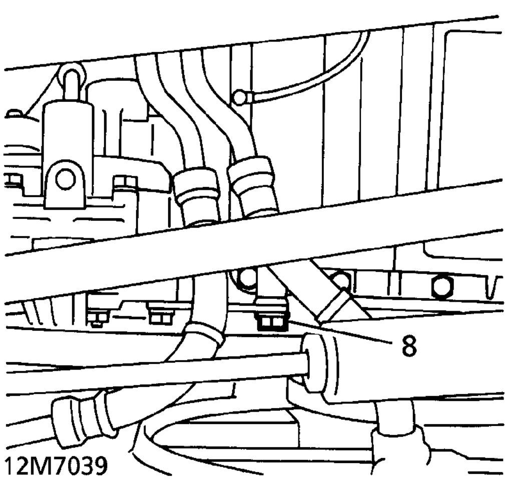


12M7038

6. Lower lift to give clearance between front axle and sump.

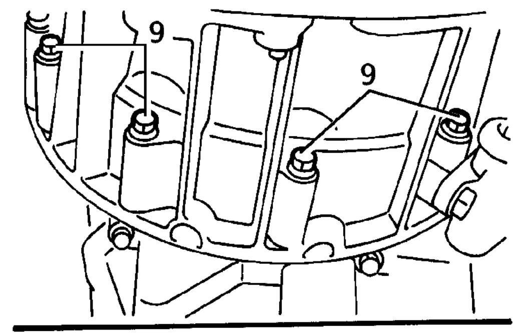
CAUTION: Do not lower axle from chassis if front shock absorbers are disconnected.

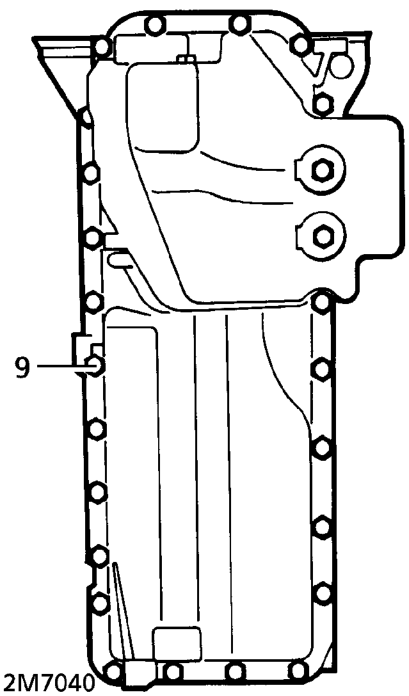
7. Drain oil from sump. Refit sump plug.
8. Remove bolt securing power steering pump bracket to sump.



12M7039

9. Remove 29 bolts securing sump. Remove sump and gasket.





12M7040

Refit

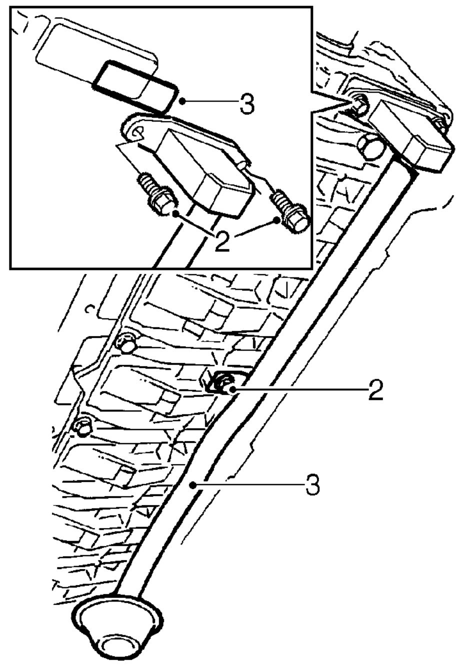
10. Ensure mating faces are clean.
11. Clean sump.
12. Fit gasket to sump. Fill front and rear openings in gasket with STC 3373 sealant.
13. Position sump to cylinder block.
14. Secure sump with bolts.
    M6 - ***10 Nm (7 lbf.ft)***
    M6 - ***12 Nm (9 lbf.ft)***
    M8 - ***20 Nm (15 lbf.ft)***
15. Tighten sump plug to:-
    M12 - ***25 Nm (18 lbf.ft)***
    M22 - ***60 Nm (44 lbf.ft)***
16. Position power steering pump bracket on sump. Secure with bolt.
17. Raise lift. Remove chassis support.
18. Lower lift.
19. Lubricate new dipstick tube 'O' ring with clean engine oil.
20. Fit 'O' ring to dipstick tube. Fit tube. Secure with nut and bolt.
21. Refill engine oil. ***See LUBRICANTS, FLUIDS AND CAPACITIES, Information.***
22. Reconnect battery negative lead.

BIG-END BEARINGS

Service repair no - 12.17.16

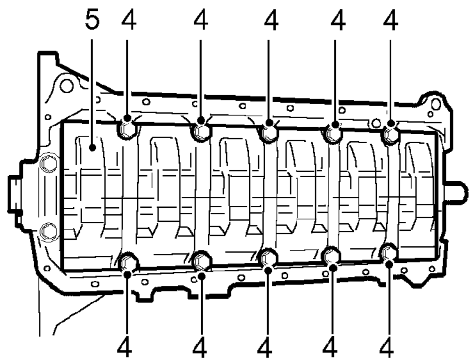
Remove

1. Remove sump. ***See this section.***



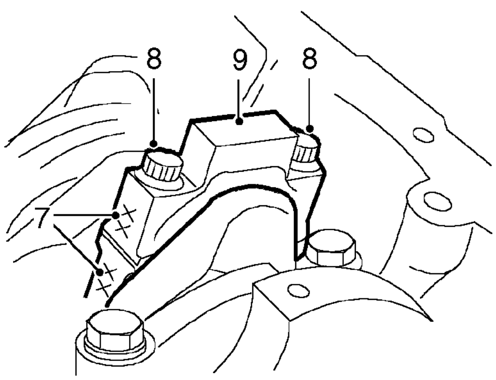
12M4202

2. Remove 3 bolts securing oil pick-up pipe.
3. Remove oil pick-up pipe, remove and discard seal.



12M4203

4. Progressively slacken then remove and discard 10 bolts securing reinforcing plate,
5. Remove reinforcing plate.
6. Carefully rotate crankshaft to gain access to connecting rod bolts.



12M4204

7. Ensure that connecting rods and big-end bearing caps are suitably identified to each other.
8. Remove big-end bearing cap bolts.

NOTE: Do not discard bolts at this stage.

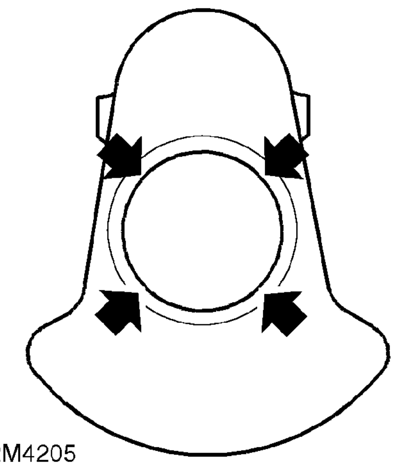
9. Remove big-end bearing caps, remove and discard big-end bearing shells.

CAUTION: Dowel located, do not tap bearing caps sideways.

10. Remove and discard big-end bearing shells from connecting rods.

CAUTION: Take care when carrying out above operation that piston does not contact valves. Keep big-end bearing caps and bolts in their fitted order.

Inspection



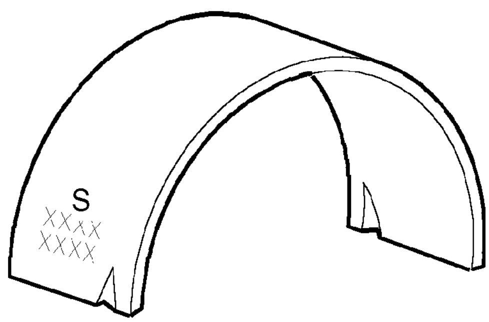
12M4205

11. Measure and record crankshaft big-end journal diameter, take 4 measurements at 90° intervals.

NOTE: There are 3 sizes of crankshaft big-end journals, Standard, Size 1 and Size 2. Crankshafts with either Standard or Size 1 journals may be ground to the next undersize and the appropriate oversize big-end bearing shells fitted.
Standard = 44.975 to 45.00 mm (1.770 to 1.771 in)
Size 1 - 0.25 (0.01 in) undersize = 44.725 to 44.75 mm (1.761 to 1.762 in)
Size 2 - 0.50 mm (0.02 in) undersize = 44.475 to 44.50 mm (1.751 to 1.752 in)

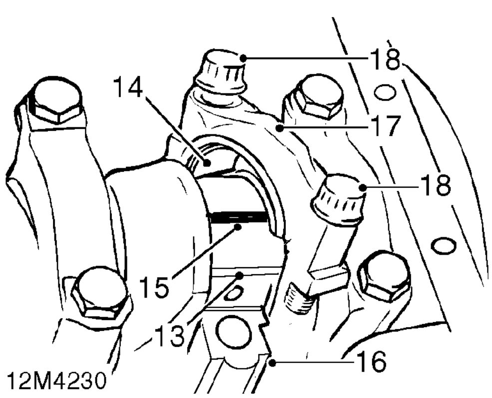
12. Repeat above procedures for remaining big-end journals.

Check big-end bearing clearances



12M4229

NOTE: Big-end bearing shells are available in 3 sizes - Standard, 0.25 (0.01 in) and 0.50 (0.02 in) oversize and are colour coded RED or BLUE. Additionally, the connecting rod bearing shell is of the 'sputter' type and can be identified by a letter S or a series of XXX on the outside of the shell. Sputter bearings must be fitted to the connecting rod.



12M4230

13. Fit a new RED colour coded big-end bearing shell of the appropriate size in connecting rod.

CAUTION: Ensure bearing shell is of the 'sputter' type.

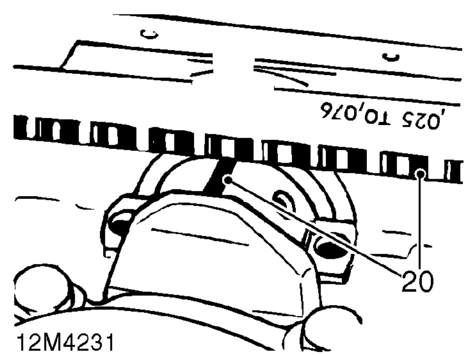
14. Fit a new BLUE colour coded big-end bearing shell of the appropriate size in the big-end bearing cap.

CAUTION: Do not fit a 'sputter' bearing to bearing cap.

15. Place a strip of Plastigage across crankshaft big-end journal.
16. Pull connecting rod on to journal.
17. Fit big-end bearing cap ensuring reference marks on connecting rod and cap are aligned.
18. Fit original big-end bearing cap bolts and tighten to:
    Stage 1 - ***5 Nm (4 lbf.ft)***
    Stage 2 - ***20 Nm (15 lbf.ft)***
    Stage 3 - Use angular torque wrench and tighten further 70°

CAUTION: Do not rotate crankshaft.

19. Remove big-end bearing cap.



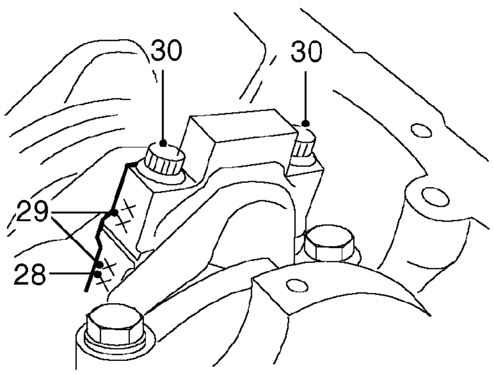
12M4231

20. Using scale provided, measure width of Plastigage on bearing journal and compare with bearing clearance:
    Big-end bearing clearance = 0.010 to 0.055 mm (0.0004 to 0.002 in)
21. If correct clearance cannot be obtained with bearing shells available, crankshaft journals must be ground to next undersize and the appropriate oversize big-end bearing shells fitted.

22. Retain selected bearing shell with connecting rod and bearing cap.
23. Remove all traces of Plastigage using an oily rag.
24. Repeat above procedures for remaining big-end bearings.
25. Discard original big-end bearing cap bolts.

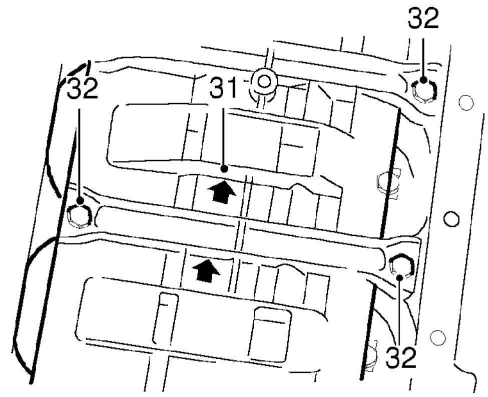
Refit

26. Lubricate crankshaft journals and selected big-end bearing shells with engine oil.
27. Fit selected big-end bearing shells to connecting rod and big-end bearing cap ensuring that 'sputter' bearing is fitted to connecting rod.



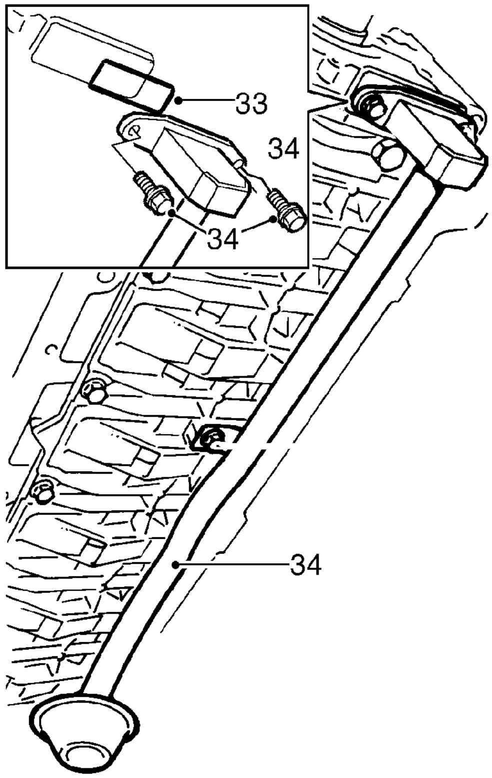
12M4232

28. Pull connecting rod down on to crankshaft journal.
29. Fit big-end bearing cap ensuring that reference marks on cap and rod are aligned.
30. Fit new big-end bearing cap bolts and tighten to:
Stage 1 - ***5 Nm (4 lbf.ft)***
Stage 2 - ***20 Nm (15 lbf.ft)***
Stage 3 - Use angular torque wrench and tighten further 70°.



12M4233

31. Position reinforcing plate to crankcase ensuring that arrows on plate are pointing towards front of engine.
32. Fit 10 new bolts and tighten from centre outwards to :
M4 - ***22 Nm (16 lbf.ft)***
M10 - ***43 Nm (32 lbf.ft)***



33. Position new seal to oil pump.
34. Fit oil pick-up pipe, fit 3 bolts and tighten to ***10 Nm (7 lbf.ft)***
35. Fit sump. ***See this section.***

PISTONS, CONNECTING RODS AND CYLINDER BORES

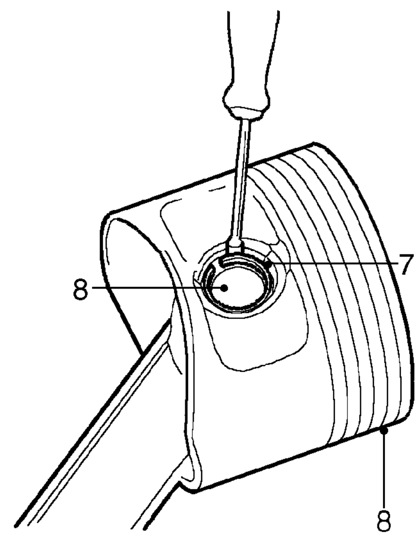
Service repair no - 12.17.03

Remove

1. Remove cylinder head. ***See this section.***
2. Remove big-end bearings. ***See this section.***
3. Push piston and connecting rod to top of cylinder bore, remove piston and connecting rod.
4. Suitably identify piston and connecting rod to its cylinder bore.
5. Repeat above procedure for remaining pistons and connecting rods.

Pistons and connecting rods - dismantling

6. Remove and discard piston rings.



7. Remove and discard snap rings retaining gudgeon pin.
8. Remove gudgeon pin, remove piston from connecting rod.

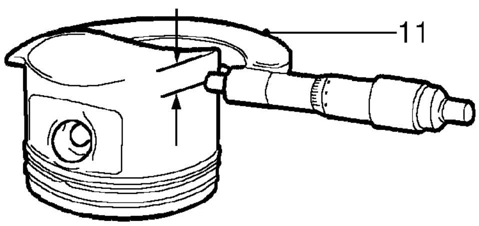
CAUTION: Keep each piston, gudgeon pin and connecting rod together as a set.

9. Remove carbon from piston crowns, and piston ring grooves.

CAUTION: Do not attempt to remove carbon or deposits from piston skirts as graphite coating will be destroyed.

Pistons - inspection

10. Check piston for signs of burning and skirt for scoring or damage.



12M4208

11. Measure and record piston diameter at a point 7.0 mm (0.27 in) from bottom of skirt and at right angles to gudgeon pin holes.

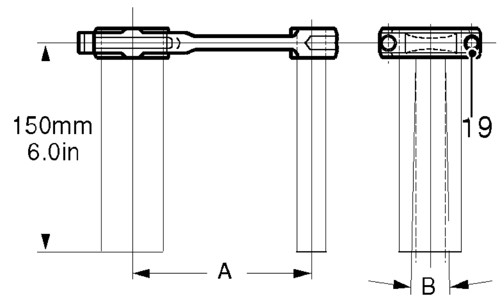
NOTE: Three sizes of piston may be fitted: Standard = 79.96 ± 0.009 mm (3.14 ± 0.0004 in)
Intermediate = 80.04 ± 0.009 mm (3.15 ± 0.0004 in)
1st oversize = 80.21 ± 0.009 mm (3.16 ± 0.0004 in)

12. Check gudgeon pin holes in piston for signs of ovality.
13. Repeat above procedures for remaining pistons.

Connecting rods - inspection

14. Check that oil feed passages are clear.
15. Check dowels in connecting rods and big-end bearing caps for security, replace as necessary.
16. Check gudgeon pin bush in connecting rod for wear:
    Gudgeon pin bush bore = 28.995 to 29.021 mm (1.142 to 1.143 in)
17. Replace worn bushes as necessary.

CAUTION: When fitting new bushes, ensure oil holes in bush and connecting rod are aligned.

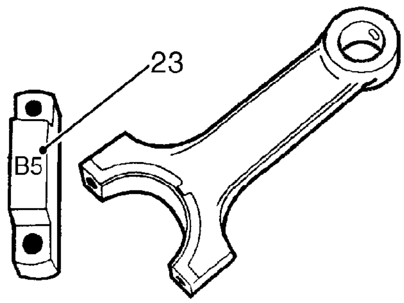


12M4210

18. Check connecting rods for distortion, fit a new BLUE colour coded 'sputter' big-end bearing shell to the connecting rod and a new RED colour coded shell to the big-end bearing cap.
19. Fit original big-end bearing cap bolts and tighten to ***5 Nm (4 lbf.ft).***
20. Check parallelism of connecting rods on both sides of rod.
    Maximum deviation **A** = 0.05 mm (0.002 in)

NOTE: Measurement must be taken approximately 150 mm (6.0 in) from centre line of rod:

21. Check for distortion on both sides of connecting rod:
    Maximum distortion **B** = 0.5 mm (0.02 in)
22. Repeat above procedures for remaining connecting rods.



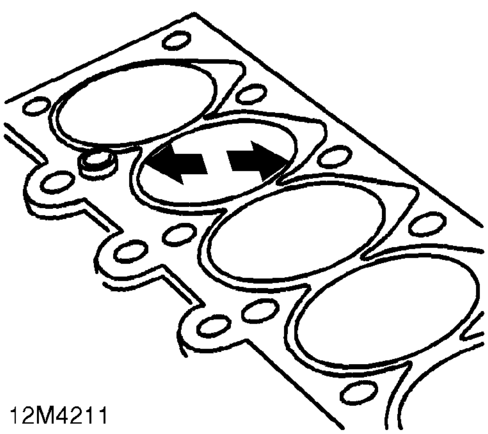
12M4235

23. Replace connecting rods as necessary, do not attempt to straighten distorted rods.

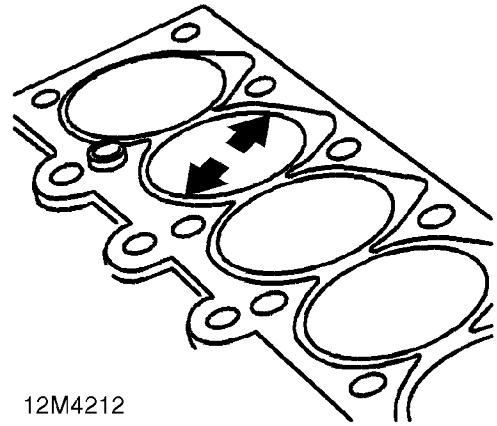
CAUTION: replacement connecting rods must be of the same weight classification, the classification is embossed on the main bearing caps.

Cylinder bores - inspection

24. De-glaze cylinder bores, check bores for scoring.
25. Remove all traces of cylinder head gasket and carbon deposits from cylinder block.


12M4211

26. Check and record cylinder bore diameter at bottom, centre and top of bore ensuring that measurements are taken at the angle shown.
27. Compare figures obtained with the following and determine cylinder bore size:
Standard = 80.00 to 80.04 mm (3.150 to 3.151 in)
Intermediate = 80.08 to 80.12 mm (3.153 to 3.154 in)
1st oversize = 80.25 to 80.29 mm (3.20 to 3.21 in)


12M4212

28. Repeat procedure at angle shown and from the 2 sets of measurements obtained, calculate cylinder bore ovality and taper:
Maximum ovality = 0.04 mm (0.002 in)
Maximum taper = 0.04 mm (0.002 in)
29. Compare piston diameter with cylinder bore size and determine piston to bore clearance:
Piston to bore clearance = 0.031 to 0.063 mm (0.0012 to 0.002 in)

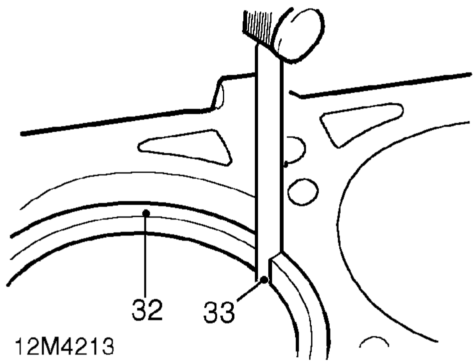
NOTE: For engines which have been 'run in,' the above clearance may be increased to 0.213 mm (0.008 in).

30. Standard and intermediate size cylinder bores which are worn in excess of limits given may be rebored to next oversize and the appropriate oversize pistons fitted.

Piston rings - check

CAUTION: Ensure that replacement piston rings are the correct size for the pistons to be fitted.

31. Lubricate cylinder bores and new piston rings with engine oil.

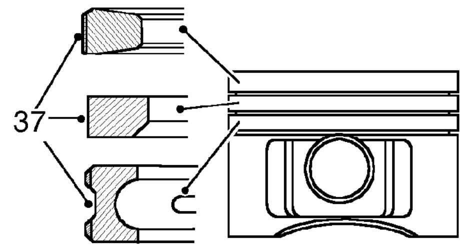


12M4213

32. Insert 1 set of piston rings in turn into No. 1 cylinder bore.
33. Check piston ring gaps using feeler gauges: Piston ring gap - 1st, 2nd and oil control rings = 0.2 to 0.4 mm (0.008 to 0.020 in)

CAUTION: If ring gaps are too wide, it will be necessary to rebore cylinder(s) to next size and fit appropriate size pistons and rings.

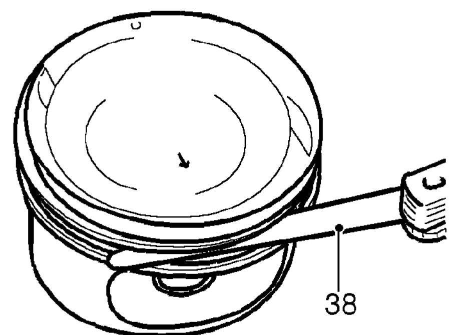
34. Suitably identify the piston rings with No.1 cylinder and retain with the piston and connecting rod for that cylinder.
35. Repeat above procedures for remaining cylinders.
36. Lubricate pistons and ring grooves with engine oil.



12M4214

37. Fit oil control, 2nd and 1st compression rings to piston.

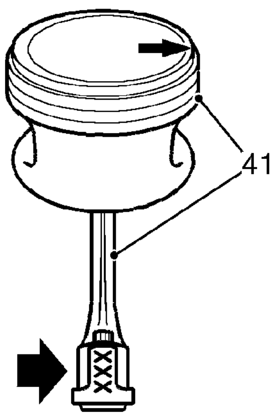
NOTE: 1st and 2nd rings are marked TOP.



12M4215

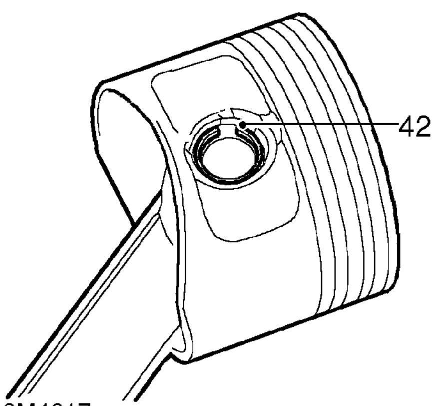
38. Using feeler gauges, measure clearance between piston ring groove and 2nd compression and oil control rings.
Ring to groove clearance:
1st compression - not checked
2nd compression = 0.040 to 0.072 mm (0.002 to0.004 in)
Oil control = 0.030 to 0.065 mm (0.001 to 0.003 in)
39. Check that 1st compression ring is free to move in groove.
40. Repeat above procedures for remaining pistons and rings.

Pistons and connecting rods - assembling



12M4216

41. Assemble each piston to its connecting rod ensuring that the number on the rod is positioned relative to the arrow on the piston crown as shown.



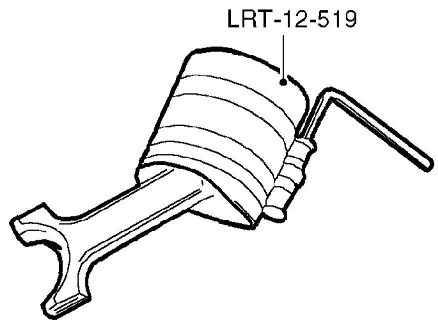
12M4217

42. Lubricate gudgeon pins and bushes with engine oil, fit pins and retain with new snap rings.

NOTE: Position snap ring gaps opposite recess in piston.

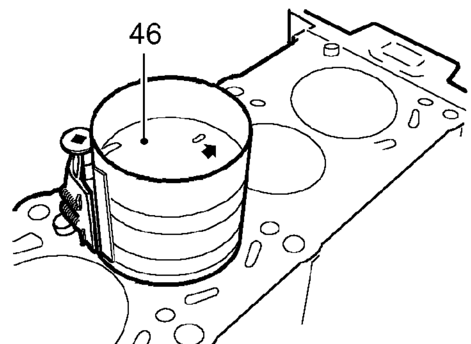
Pistons and connecting rods - refit

43. Lubricate pistons, rings and cylinder bores with engine oil.
44. Position piston ring gaps at 120° to each other ensuring that they are not over gudgeon pin.



12M4218

45. Compress piston rings using LRT-12-519.



12M4219

46. Fit each piston and connecting rod to its respective cylinder in turn ensuring that arrow on piston crown is pointing towards front of engine.

CAUTION: Fit pistons using hand pressure only.

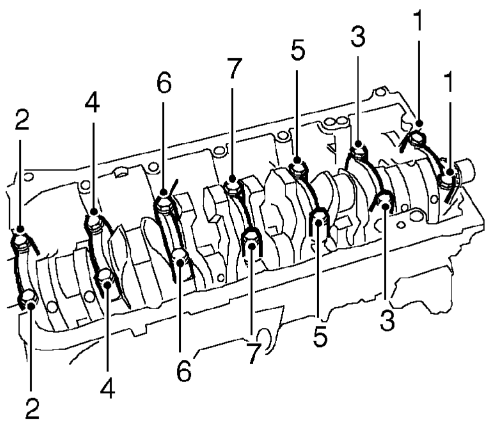
47. Fit big-end bearings. ***See this section.***
48. Fit cylinder head. ***See this section.***

CRANKSHAFT AND MAIN BEARINGS

Service repair no - 12.21.33/01

Remove

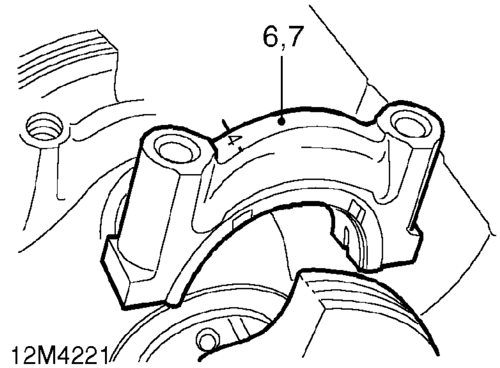
1. Remove engine and gearbox. ***See this section.***
2. Remove oil pump. ***See this section.***
3. Remove crankshaft rear oil seal. ***See this section.***
4. Remove pistons and connecting rods. ***See this section.***



12M4220

5. Using sequence shown, progressively slacken then remove main bearing cap bolts.

NOTE: Do not discard bolts at this stage.



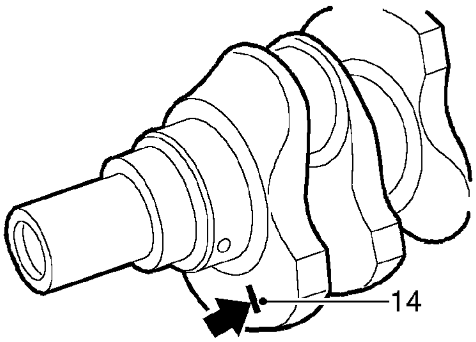
12M4221

6. Ensure that main bearing caps 1 to 5 are suitably identified on the exhaust manifold side of the engine.

NOTE: Main bearing caps 6 and 7 are not marked on production, ensure that they are suitably identified to their fitted positions. Bearing cap 6 carries the integral thrust/main bearing shell.

7. Remove main bearing caps.
8. Remove and discard main bearing shells from caps.
9. Lift out crankshaft.
10. Remove and discard main bearing shells from cylinder block.
11. Clean crankshaft, ensure all oilways are clear.
12. Clean main bearing caps and bearing shell locations in cylinder block; ensure bearing cap bolt holes are clean and dry.
13. Clean original bearing cap bolts and lightly oil threads.

Inspection



12M4222

14. Check front web of crankshaft to determine if main bearing journals have been ground undersize.
    No paint mark - Standard journals
    1 paint mark - Journals are 0.25 mm (0.01 in) undersize
    2 paint marks - Journals are 0.50 mm (0.02 in) undersize

NOTE: Each of the three main journal sizes has a triple colour classification which corresponds to the colour code of the main bearing cap shells, a colour code on the edge of the balance webs will indicate the actual size.

15. Measure and record main journal diameters and compare with the sizes given below. Take 4 measurements of each journal at 90° intervals to check for appropriate specified size and ovality.
    Standard:
    Yellow = 59.984 to 59.990 mm (2.3616 to 2.3618 in)
    Green = 59.977 to 59.983 mm (2.3612 to 2.3615 in)
    White = 59.971 to 59.976 mm (2.3610 to 2.3611 in)

    Undersize 1 - 0.25 mm (0.01 in):
    Yellow = 59.734 to 59.740 mm (3.3522 to 2.3526 in)
    Green = 59.727 to 59.733 mm (2.3514 to 2.3520 in)
    White = 59.721 to 50.726 mm (2.3512 to 2.3514 in)

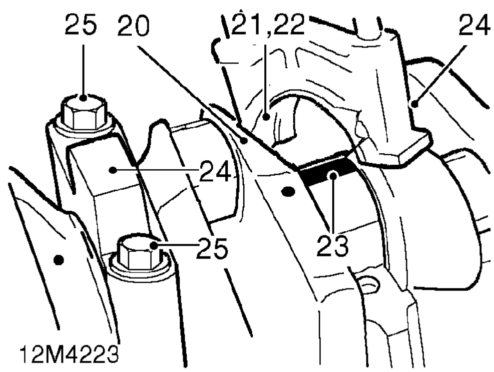
    Undersize 2 - 0.50 mm (0.02 in):
    Yellow = 59.484 to 59.490 mm (2.3418 to 2.3420 in)
    Green = 59.477 to 59.483 mm (2.3414 to 2.3417 in)
    White = 59.471 to 59.476 mm (2.3413 to 2.3415 in)
16. If standard or undersize 1 journals are found to be oval, the crankshaft may be ground to the next undersize.
17. If journals are worn below the original colour code size but ovality is within limits, then the next size main bearing shells should be fitted in the main bearing caps and cylinder block when carrying out the Plastigage check.

NOTE: If journals are worn below the lowest colour size for standard or undersize 1 journals, crankshaft may be ground to the next undersize. Ensure that paint stripe(s) to denote that grinding has been carried out are marked on the crankshaft front web.

Check crankshaft main bearing clearances

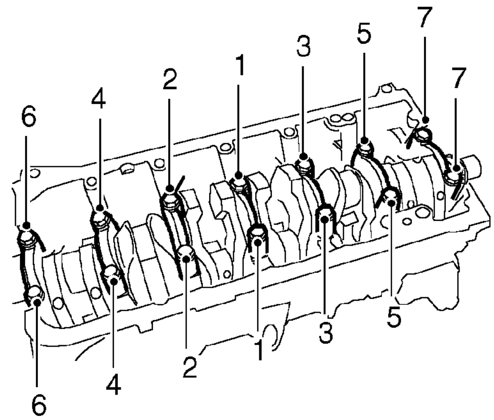
18. Fit new, appropriate size yellow main bearing shells in cylinder block at positions 1 to 5 and 7.
19. Fit new, appropriate yellow thrust/main bearing shell in cylinder block at position 6.

NOTE: Thrust portion of bearing shells fitted in cylinder block and main bearing cap should be the thinnest of the range available - *See crankshaft end-float - check.*



12M4223

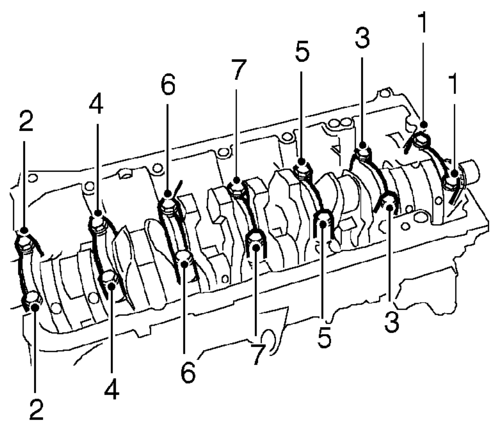
20. Position crankshaft in cylinder block.
21. Check colour coding on crankshaft webs and fit new, appropriate size main bearing shells of the same colour coding in main bearing caps numbers 1 to 5 and 7.
22. Fit new, appropriate size thrust/main bearing shell of the same colour coding in number 6 main bearing cap.
23. Place a strip of Plastigage across each main bearing journal.
24. Fit main bearing caps ensuring that identification marks are on exhaust manifold side of engine.
25. Fit original main bearing cap bolts.
26. Align main bearing caps to crankcase.



12M4224

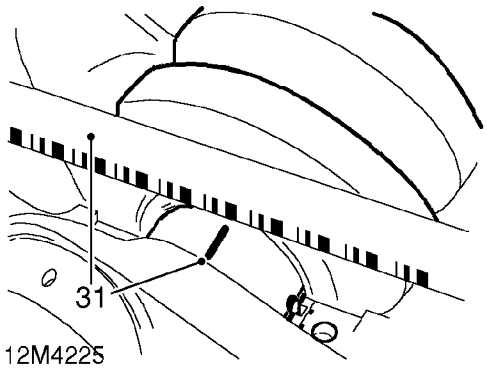
27. Using sequence shown, tighten main bearing cap bolts to ***20 Nm (15 lbf.ft).***
28. Using a suitable angular torque wrench, tighten bolts in sequence a further 50°

CAUTION: Do not rotate crankshaft.



12M4220

29. Using sequence shown, progressively slacken then remove main bearing cap bolts.
30. Remove main bearing caps and shells.



12M4225

31. Using scale provided, measure width of Plastigage on each main bearing journal and compare with specified bearing clearances:
Main bearing clearance = 0.020 to 0.058 mm (0.001 to 0.002 in)

32. If clearances are incorrect, select alternative main bearing cap shell(s) from the range available and repeat check.

NOTE: If colour coding of selected bearing shell(s) differs from colour marked on adjacent crankshaft web, ensure correct colour is marked on web on completion.

33. Remove all traces of Plastigage using an oily rag.

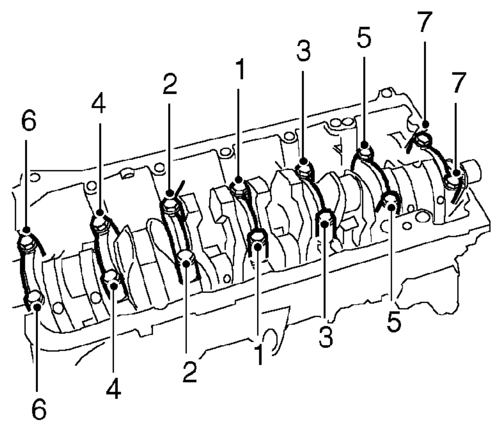
34. Fit selected main bearing shells to main bearing caps.

35. Remove crankshaft, lubricate journals and main bearing shells with engine oil.

Crankshaft end float - check

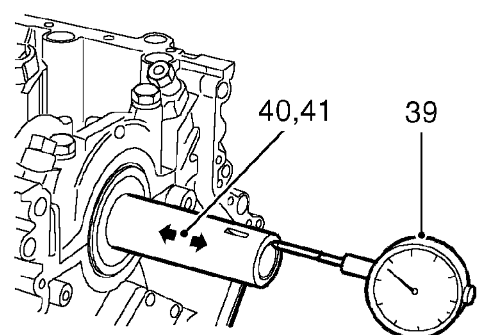
36. Fit crankshaft, fit main bearing caps ensuring that reference marks are on exhaust manifold side of engine.

37. Align main bearing caps to crankcase.



12M4224

38. Fit original main bearing cap bolts and tighten in sequence shown to ***20 Nm (15 lbf.ft)*** then using an angular torque wrench, tighten in sequence a further 50° .



12M4226

39. Position a suitable DTI to front of crankshaft.

40. Move crankshaft fully rearwards and zero gauge.

41. Move crankshaft fully forwards and note end-float reading on gauge.
Crankshaft end-float = 0.080 to 0.163 mm (0.003 to 0.006 in)

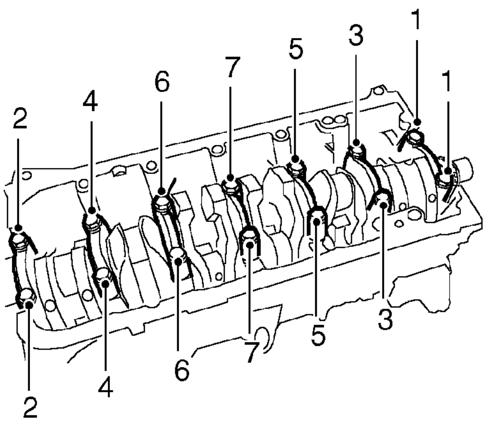
Crankshaft end-float incorrect:

42. Remove crankshaft.
43. Select combined thrust/main bearing shells from the range available to give correct end-float ensuring that correct colour coding/size of bearing shell is maintained.

NOTE: Each of the thrust/main bearing shell sizes has three widths of shell available:
Standard = 25.0 mm (0.94 in)
Size 1 = 25.2 mm (0.992 in)
Size 2 = 25.4 mm (1.00 in)

44. Fit selected thrust/main bearing shells in cylinder block and main bearing caps.
45. Fit crankshaft and main bearing caps ensuring that identification marks are on exhaust manifold side of engine and repeat check as necessary until end-float is correct.
46. Discard original main bearing cap bolts on completion.

Crankshaft end-float correct:

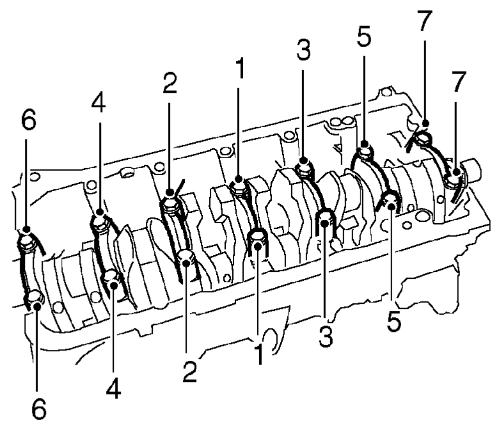


12M4220

47. Using sequence shown, progressively slacken then remove main bearing cap bolts; discard bolts.

Refit

48. Lightly oil threads of new main bearing cap bolts.
49. Fit main bearing cap bolts, align main bearing caps to crankcase.



12M4224

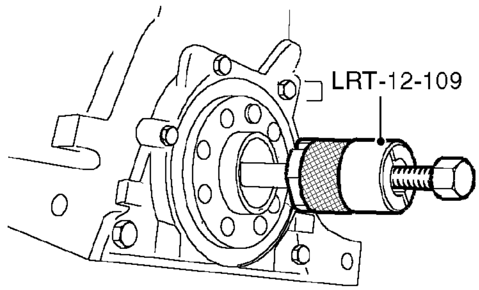
50. Tighten main bearing cap bolts in sequence shown using the following procedure:
Stage 1 - Tighten in sequence shown to ***20 Nm (15 lbf.ft).***
Stage 2 - Slacken bolts on number 6 main bearing cap.
Stage 3 - Using a hide mallet, strike each end of crankshaft to centralise thrust/main bearing shells.
Stage 4 - Tighten number 6 main bearing cap bolts to ***20 Nm (15 lbf.ft)***
Stage 5 - Using an angular torque wrench, tighten all main bearing cap bolts in sequence a further 50° .
51. Fit pistons and connecting rods. ***See this section.***
52. Fit crankshaft rear oil seal. ***See this section.***
53. Fit oil pump. ***See this section.***
54. Fit engine and gearbox. ***See this section.***

CRANKSHAFT SPIGOT BEARING

Service repair no - 12.21.45/01

Remove

1. Remove flywheel/drive plate. ***See this section.***

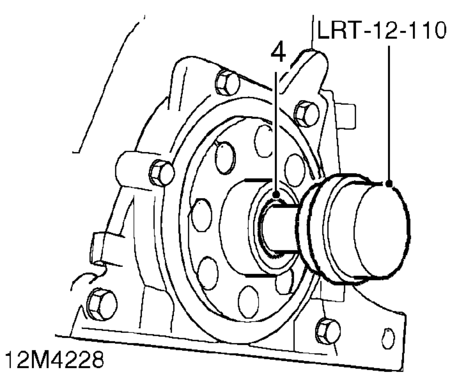


12M4227

2. Remove spigot bearing using LRT-12-109, discard bearing.

Refit

3. Clean spigot bearing recess in crankshaft.



12M4228

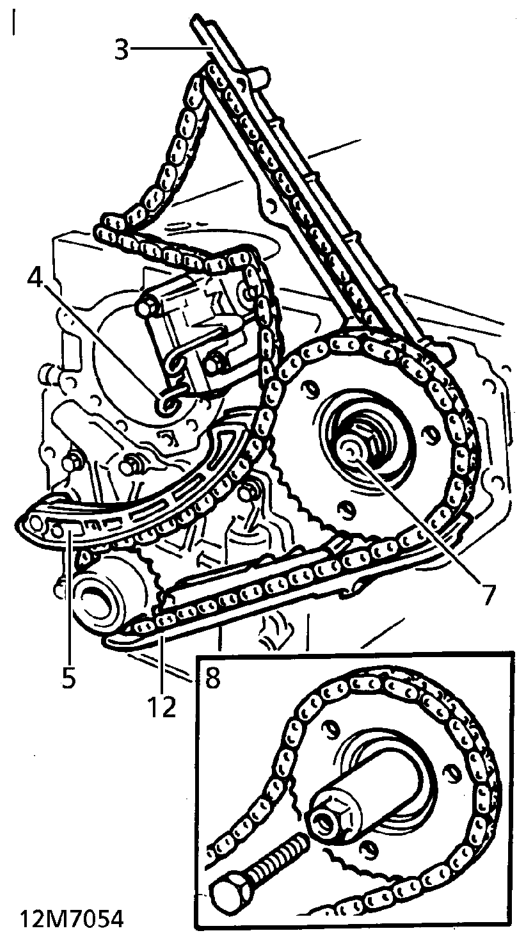
4. Position new spigot bearing to crankshaft.
5. Drift bearing fully into crankshaft using LRT-12-110.
6. Fit flywheel/drive plate. ***See this section.***

TIMING CHAINS AND SPROCKETS

Service repair no - 12.65.12

Remove

1. Disconnect battery negative lead.
2. Remove front cover. ***See this section.***
3. Remove upper timing chain guide rail.



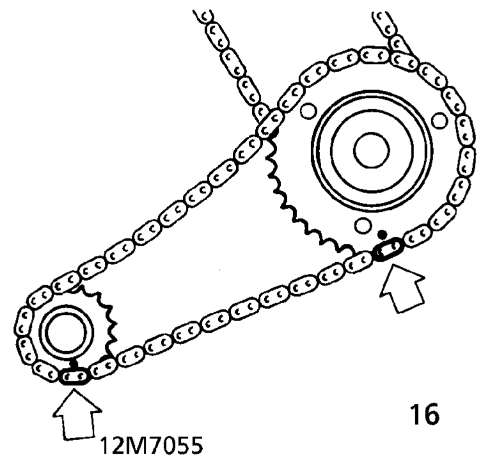
12M7054

4. Using a suitable lever, retract lower chain tensioner plunger. Insert retaining pin LRT-12-114.
5. Remove lower timing chain tensioner rail.
6. Ensure timing pin LRT-12-108 is still located in flywheel.

7. Remove nut from Fuel Injection Pump (FIP) sprocket.
8. Remove centre bolt from tool LRT-12-119. Screw body of tool onto FIP sprocket.
9. Fit centre bolt to tool. Pull sprocket from FIP.
10. Withdraw sprockets and chains as an assembly.
11. Remove tool from FIP sprocket.
12. Remove lower timing chain guide rail.

Refit

13. Ensure mating faces are clean.
14. Lubricate timing chains with clean engine oil.
15. Fit lower chain guide.
16. Assemble sprockets to lower timing chain. Ensure dimples on sprockets align with chain 'bright' links.



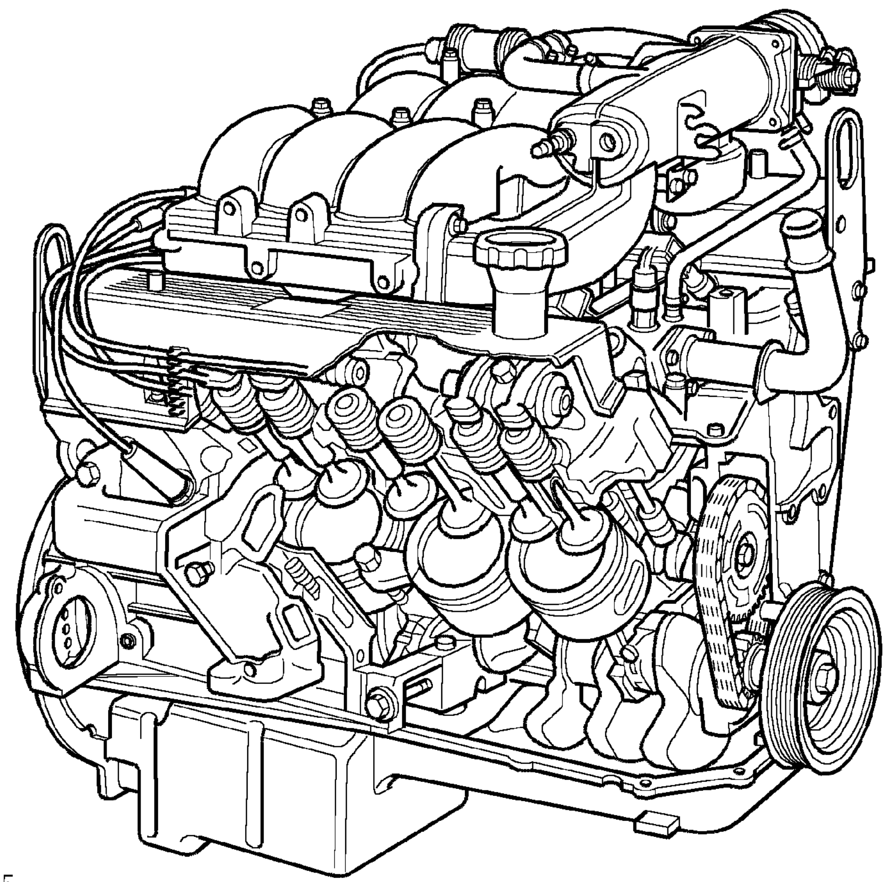
17. Engage upper timing chain over rear sprocket.
18. Engage sprockets over crankshaft and FIP shaft. Ensure sprockets/bright links remain aligned.

NOTE: Align FIP shaft to sprocket keyways using tool LRT-12-118 prior to fully engaging sprockets.

19. Secure FIP sprocket with nut. Tighten to ***50 Nm (37 lbf.ft)***
20. Fit lower timing chain tensioner rail.
21. Depress tensioner plunger using a suitable lever. Remove retaining pin LRT-12-114.
22. Fit upper timing chain guide rail.
23. Refit front cover. ***See this section.***
24. Check and adjust fuel injection pump timing. ***See FUEL SYSTEM, Adjustment.***
25. Reconnect battery negative lead.

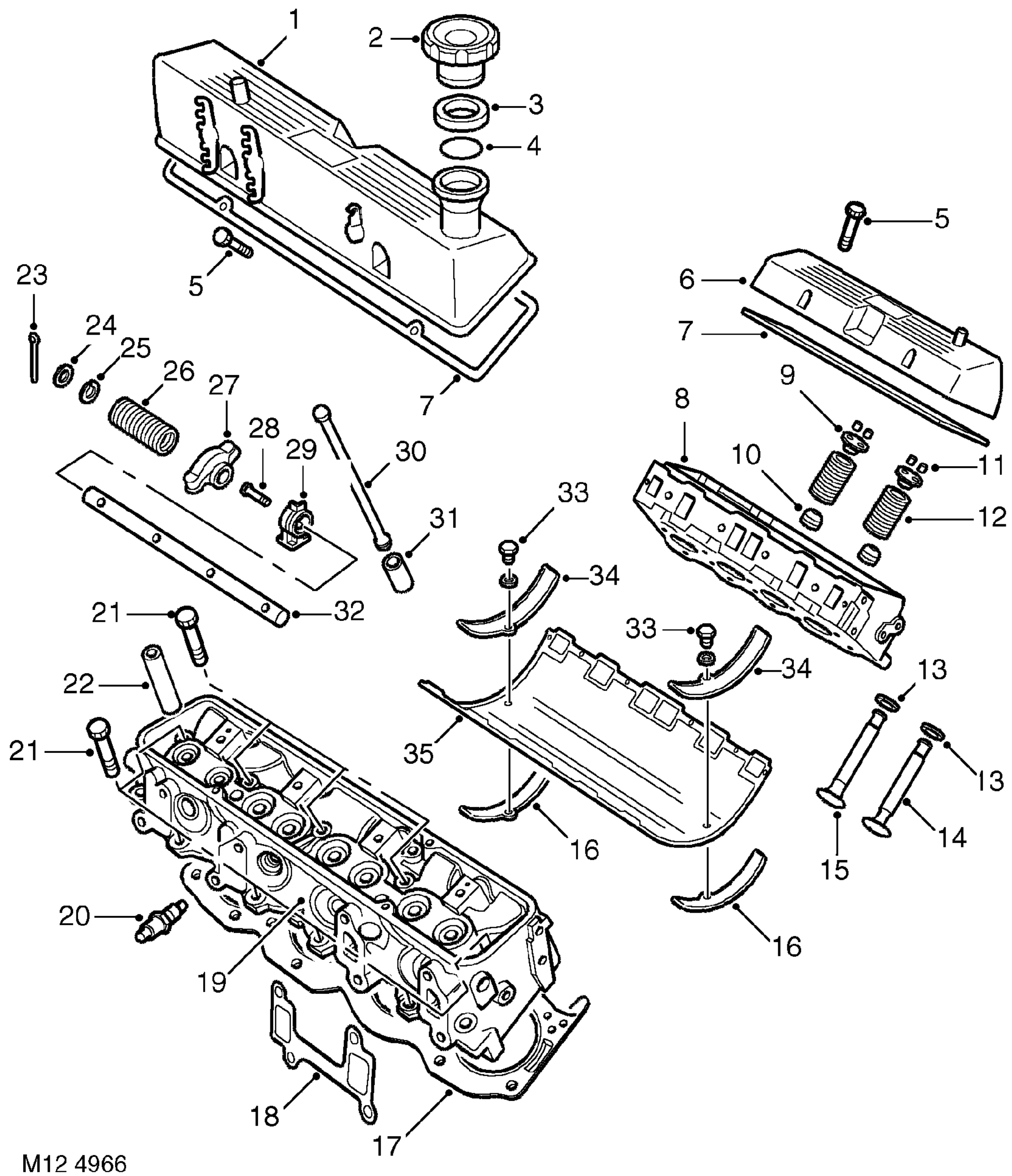
CONTENTS

V8 ENGINE - from 99MY



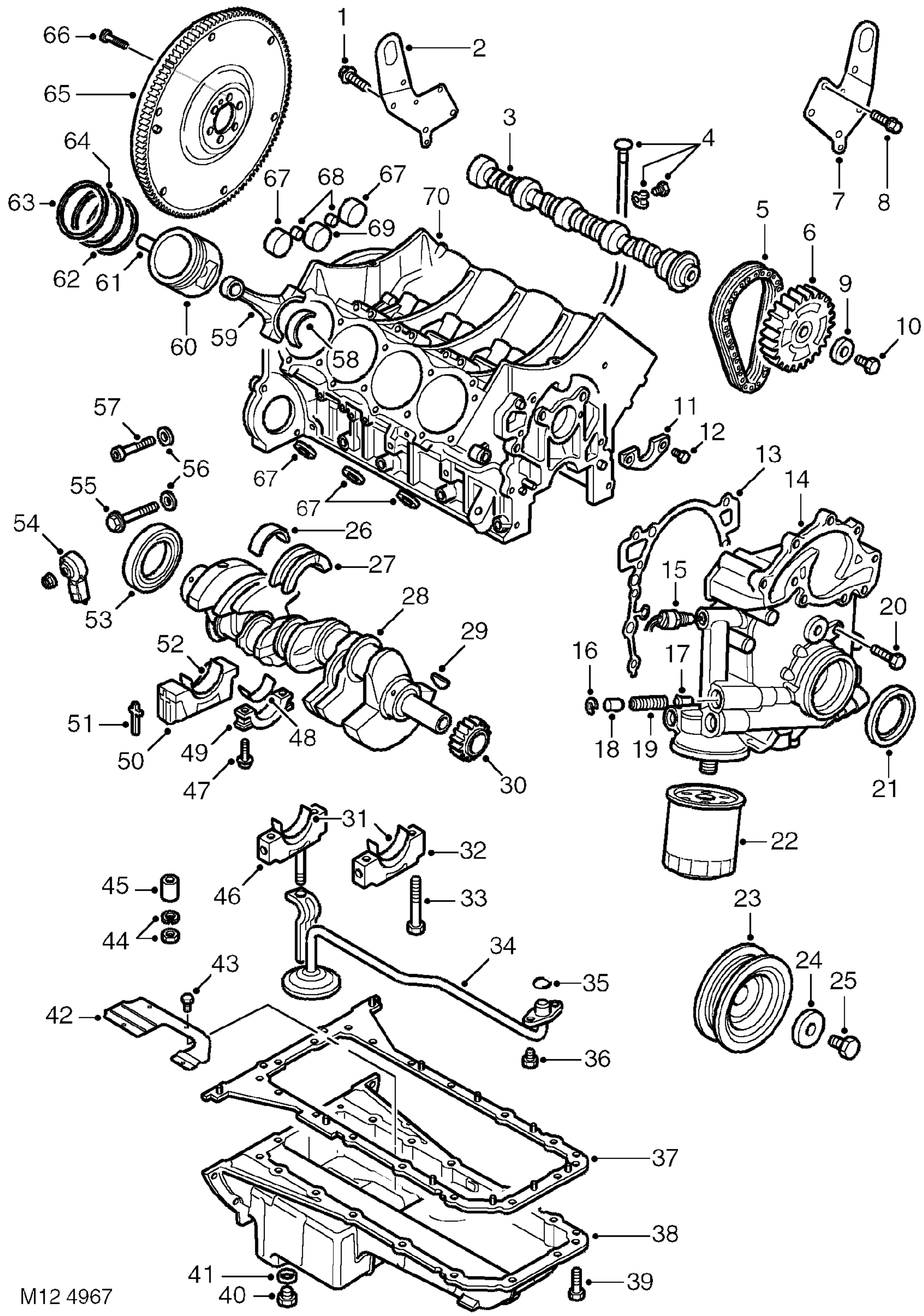
M12 4965

CYLINDER HEAD COMPONENTS - from 99MY



1. Rocker cover - right hand
2. Engine oil filler cap
3. Oil filler dust cap seal
4. 'O' ring - oil filler cap
5. Bolt - rocker cover (4 off; 2 x short, 2 x long)
6. Rocker cover - left hand
7. Gasket - rocker cover
8. Cylinder head - left hand
9. Valve spring cap (16 off)
10. Valve stem oil seals (16 off)
11. Collets (16 pairs)
12. Valve spring (16 off)
13. Valve seat insert (16 off)
14. Exhaust valve (8 off)
15. Inlet valve (8 off)
16. Seal - inlet manifold gasket (2 off)
17. Gasket - cylinder head (2 off)
18. Gasket - exhaust manifold
19. Cylinder head - right hand
20. Spark plug (8 off)
21. Bolt - cylinder head (3 x long & 7 x short per cylinder head)
22. Valve guide (16 off)
23. Split pin (4 off)
24. Washers - plain (4 off)
25. Washers - spring (4 off)
26. Spring - rocker shaft (6 off)
27. Rocker arm
28. Pedestal bolt
29. Pedestal
30. Push rod
31. Hydraulic tappet
32. Rocker shaft
33. Screw/washer - inlet manifold gasket clamp (2 off)
34. Clamp - inlet manifold gasket (2 off)
35. Gasket - inlet manifold

CYLINDER BLOCK COMPONENTS - from 99MY



1. Bolt - Rear lifting eye (2 off)
2. Rear lifting eye
3. Camshaft
4. Dipstick, dipstick tube, clamp and bolt
5. Timing chain
6. Camshaft sprocket
7. Front lifting eye
8. Bolt - Front lifting eye (2 off)
9. Washer
10. Bolt - camshaft timing gear
11. Thrust plate - camshaft end-float
12. Bolt - camshaft thrust plate
13. Gasket - front cover
14. Front cover
15. Oil pressure switch
16. Circlip
17. Plunger - oil pressure relief valve
18. Plug - oil pressure relief valve
19. Spring - oil pressure relief valve
20. Bolt
21. Crankshaft front oil seal
22. Oil filter element
23. Crankshaft front pulley
24. Washer
25. Bolt - crankshaft front pulley
26. Upper main bearing seal
27. Upper centre main bearing shell and thrust washer
28. Crankshaft
29. Woodruff key
30. Crankshaft timing gear
31. Lower main bearing shells
32. Numbers 1, 2 and 3 main bearings
33. Bolt - main bearing caps
34. Oil pick-up pipe and strainer
35. 'O' ring
36. Screw - oil pick-up pipe (2 off)
37. Gasket - sump
38. Sump
39. Bolt - sump
40. Oil sump drain plug
41. Sealing washer
42. Baffle plate - oil sump
43. Screws - baffle plate (4 off)
44. Stiffener and nut - oil pick-up pipe to main bearing cap
45. Spacer - oil pick-up pipe to main bearing cap
46. Number 4 main bearing cap
47. Bolt - connecting rod big-end bearing cap
48. Connecting rod big-end bearing shell - lower
49. Connecting rod big-end bearing cap
50. Number 5 - rear main bearing cap
51. Cruciform seal - rear main bearing cap
52. Number 5 - rear main bearing seal
53. Crankshaft rear oil seal
54. Crankshaft knock sensor
55. Side bolt - main bearing cap
56. Dowty washers
57. Side Allen bolt - main bearing cap
58. Connecting rod big-end bearing shell - upper
59. Connecting rod
60. Piston
61. Gudgeon pin
62. Oil control ring
63. Top compression ring
64. 2nd compression ring
65. Flywheel / drive plate and starter ring gear
66. Bolt - flywheel / drive plate
67. Core plugs
68. Tappet oil gallery plugs (2 off)
69. Plug - Camshaft rear bore
70. Cylinder block

DESCRIPTION - up to 99MY

For description and operation of V8 engine before 99MY, refer to 4.0/4.6 V8 Engine Overhaul Manual.

DESCRIPTION - from 99MY

General

The V8 petrol engine is an eight cylinder, water cooled unit having two banks of four cylinders positioned at 90 degrees to each other. The engine comprises five main castings - two cylinder heads, cylinder block, front cover and the oil sump, all of which are manufactured from aluminium alloy. The engine is available in 4.0 litre and 4.6 litre versions and each type can be supplied as high compression or low compression variants, dependent on market requirements.

Cylinder heads

The cylinder heads are fitted with replaceable valve guides and valve seat inserts with the combustion chambers formed in the head. Each cylinder head is sealed to the cylinder block with a multi-layer gasket. The exhaust manifolds are bolted to the outside of each cylinder head whilst the inlet manifolds are located in the centre of the 'Vee' and are bolted to the inside face of each head. Inlet and exhaust manifolds are sealed to the cylinder heads by means of gaskets.

Each cylinder has a single inlet and exhaust valve. The exhaust valves are of the 'carbon break' type, a recess on the valve stem prevents a build-up of carbon in the valve guide by dislodging particles of carbon as the valve stem moves up and down the guide. Inlet and exhaust valve stem oil seals are fitted at the top of each valve guide. Valve operation is by means of rocker arms, push rods and hydraulic tappets. Each of the rocker arms is located on a rocker shaft which is supported by means of pedestals bolted to the cylinder heads. A spring, positioned on either side of each rocker arm, maintains the correct relative position of the arm to its valve stem. The rocker arms are operated directly by the push rods which pass through drillings in the cylinder heads and cylinder block. The bottom end of each push rod locates in a hydraulic tappet operated by the single, chain driven camshaft.

The rocker covers are bolted to the cylinder heads and are sealed to the heads by a rubber gasket. Stub pipes for crankcase ventilation hose connections are fitted to each rocker cover, the pipe in the right hand rocker cover incorporates an oil separator. The engine oil filler cap is situated in the right hand cover.

Cylinder block and camshaft

The cylinder block is fitted with cast iron cylinder liners which are shrink-fitted and locate on stops in the block. The camshaft is positioned in the centre of the cylinder block and runs in one-piece bearing shells which are line bored after fitting. Camshaft end-float is controlled by a thrust plate bolted to the front of the cylinder block. A timing gear, chain driven by the crankshaft timing gear is bolted to the front of the camshaft.

Crankshaft and main bearings

The crankshaft is carried in five main bearings. The upper main bearing shell locations are an integral part of the cylinder block casting. The lower main bearing caps are bolted to the cylinder block on either side of the upper bearing shell locations with an additional bolt being inserted into each cap from either side of the cylinder block. The rear main bearing cap carries the crankshaft rear oil seal and is sealed to the cylinder block by means of cruciform shaped seals in each side of the cap. Number four main bearing cap carries the stud fixing for the oil pick-up pipe. Lower main bearing shells are plain whilst the upper shells have an oil feed hole and are grooved. Crankshaft end-float is controlled by the thrust faces of the upper centre shell. The crankshaft timing gear is located on the front of the crankshaft by means of a Woodruff key which is also used to drive the gear type oil pump. The drive plate incorporates the crankshaft position sensor reluctor ring, and the assembly is dowel located and bolted to the crankshaft.

Front cover

The front cover is bolted to the front of the cylinder block and is sealed to the block with a gasket. The disposable, full-flow oil filter canister is screwed to the front cover, which also carries the oil pressure switch, oil pressure relief valve and crankshaft front oil seal. The gear type oil pump is integral with the front cover which also has an internal oilway to direct oil from the oil cooler to the filter.

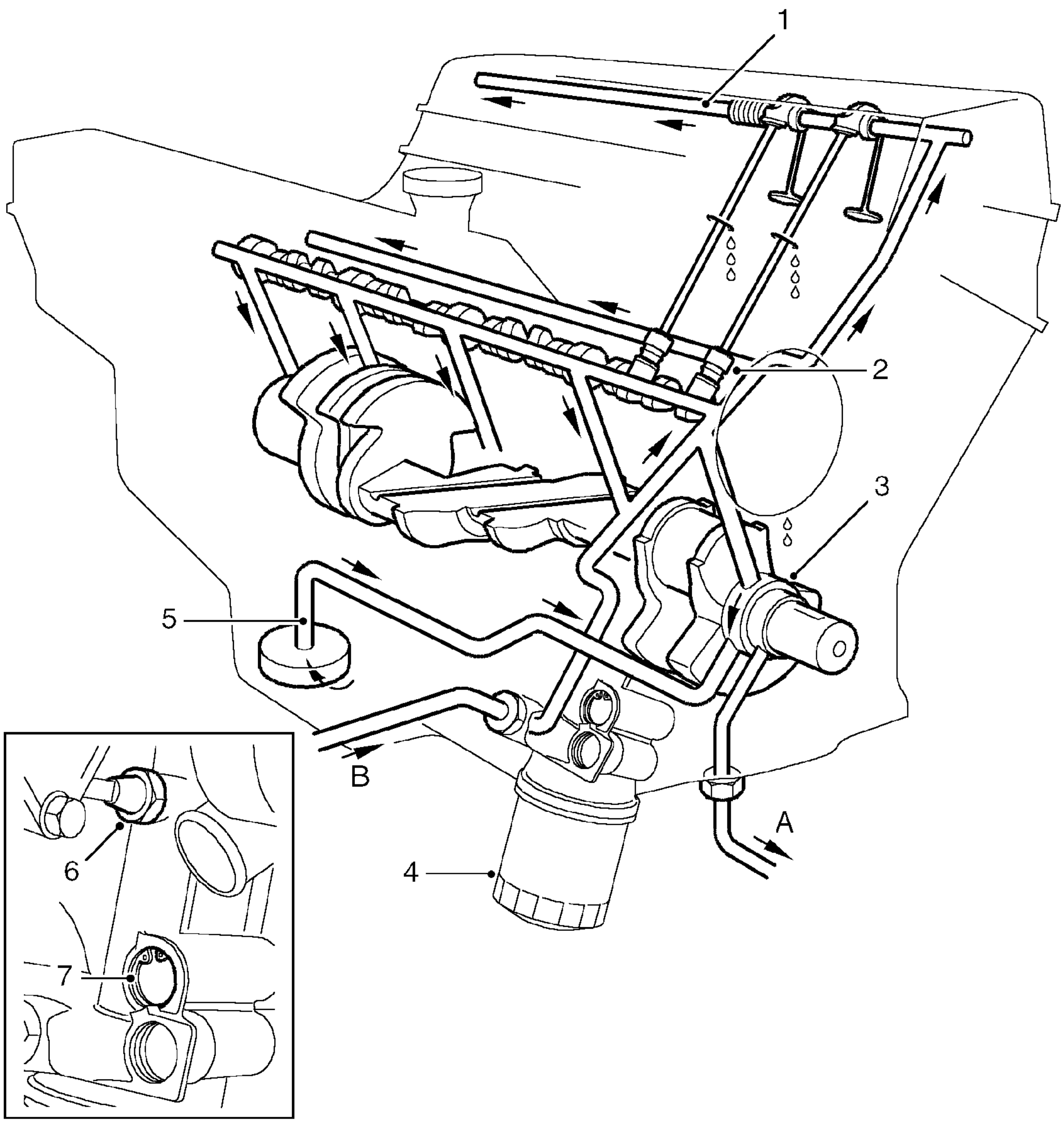
Oil sump

The oil sump is bolted to the bottom of the cylinder block and the front cover and is sealed to both components with a one-piece gasket. A removable baffle to prevent oil surge is fitted in the sump. The oil pick-up pipe and strainer assembly is positioned within the sump. The assembly is attached at the pick-up end to a stud screwed into number four main bearing cap and at the delivery end to the oil pump. The oil drain plug is located in the bottom of the sump and is sealed with a washer.

Pistons and connecting rods

Each of the aluminium alloy pistons has two compression rings and an oil control ring. The pistons are secured to the connecting rods by semi-floating gudgeon pins. Each gudgeon pin is offset by 0.5 mm (0.02 in). The top of each piston is recessed, the depth of recess determining the compression ratio of the engine. Plain big-end bearing shells are fitted to each connecting rod and cap.

Lubrication



M12 4968

1. Rocker shaft assembly
2. Hydraulic tappet
3. Oil pump
4. Oil filter element
5. Oil pick-up pipe and strainer
6. Oil pressure switch
7. Oil pressure relief valve

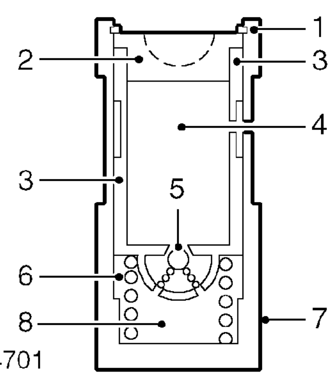
A. - to oil cooler
B. - from oil cooler

Oil is drawn from the sump through a strainer and into the oil pump via the oil pick-up pipe. Pressurised oil from the pump passes through the oil cooler mounted in front of the radiator and returns to the full-flow oil filter element. Oil from the filter passes into the main oil gallery and through internal drillings to the crankshaft where it is directed to each main bearing and to the big-end bearings via numbers 1, 3 and 5 main bearings. Excess oil pressure is relieved by the oil pressure relief valve. An internal drilling in the cylinder block directs oil to the camshaft where it passes through further internal drillings to the hydraulic tappets, camshaft bearing journals and rocker shafts. Lubrication to the pistons, small ends and cylinder bores is by oil grooves machined in the connecting rods and by splash.

Oil pressure switch

The oil pressure warning light switch registers low oil pressure in the main oil gallery on the outflow side of the filter. Whilst the engine is running and oil pressure is correct, the switch is open. When the ignition is switched on or if oil pressure drops below the pressure setting of the switch, the switch closes and the low oil pressure warning lamp located in the instrument pack will illuminate.

Hydraulic tappets



M12 4701

1. Clip
2. Pushrod seat
3. Inner sleeve
4. Upper chamber
5. Non-return ball valve
6. Spring
7. Outer sleeve
8. Lower chamber

The hydraulic tappet provides maintenance free, quiet operation of the valves. This is achieved by utilizing engine oil pressure to eliminate the clearance between the rocker arms and valve stems. When the valve is closed, engine oil pressure present in the upper chamber, passes through the non-return ball valve and into the lower chamber. When the cam begins to lift the outer sleeve, the resistance of the valve spring, felt through the push rod and seat, causes the tappet inner sleeve to move downwards inside the outer sleeve. This downwards movement closes the non-return ball valve and increases the pressure in the lower chamber sufficiently to ensure that the valve is fully opened by the push rod. As the tappet moves off the peak of the cam, the non-return ball valve opens thereby allowing the pressure in both chambers to equalize. This ensures that the valve will be fully closed when the tappet is on the back of the cam.

Crankcase ventilation

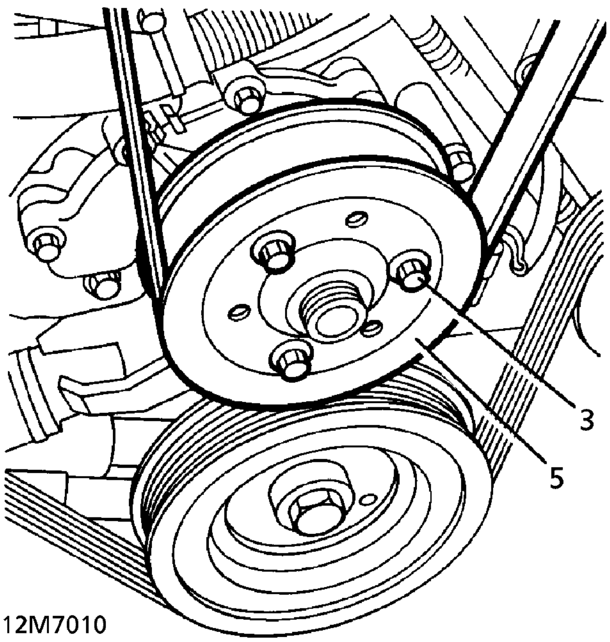
A positive crankcase ventilation system is used to vent crankcase gases to the air induction system. Gases are drawn from the left hand rocker cover to a tapping in the throttle body. An oil separator is incorporated in the hose connection stub pipe in the right hand rocker cover, gases from this connection are drawn to a tapping in the inlet manifold.

CRANKSHAFT PULLEY AND FRONT COVER OIL SEAL - up to 99MY

Service repair no - 12.21.01 - Crankshaft Pulley
Service repair no - 12.21.14 - Front Cover Oil Seal

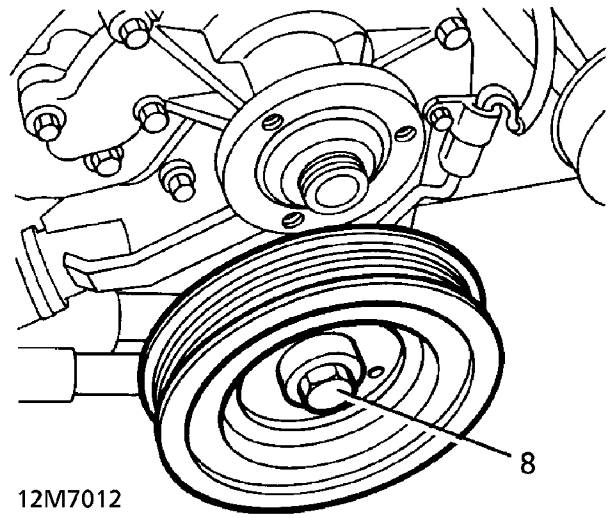
Remove

1. Disconnect battery negative lead.
2. Remove cooling fan. ***See COOLING SYSTEM, Repair.***



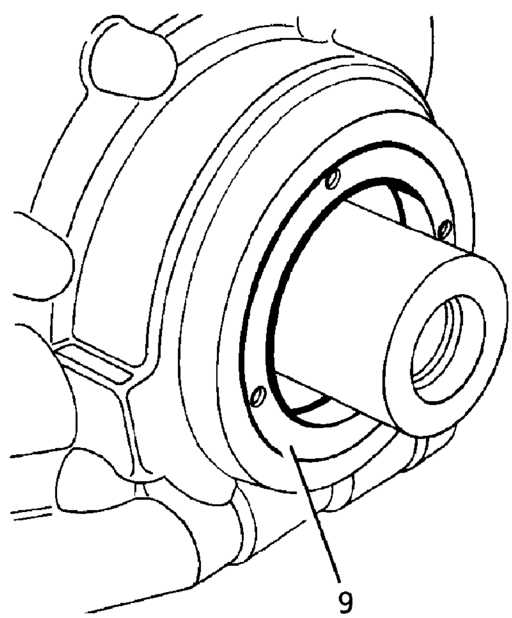
12M7010

3. Slacken 3 water pump pulley securing bolts.
4. Remove alternator drive belt.
5. Remove water pump pulley bolts. Remove pulley.
6. Raise vehicle on four post lift.Remove acoustic cover if applicable. ***See CHASSIS AND BODY, Repair.***
7. Secure LRT-12-080 to crankshaft pulley with 4 bolts.



12M7012

8. Remove crankshaft pulley bolt. Collect pulley and tool.



12M7013

9. Using LRT-12-088, remove oil seal from front cover.

CAUTION: Do not damage front cover.

Refit

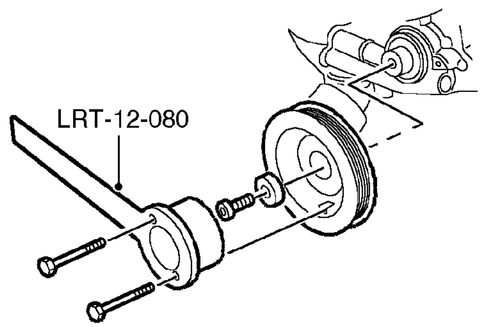
10. Clean seal register and crankshaft pulley.
11. Lubricate outer face of seal.
12. Using LRT-12-089, fit seal to cover.
13. Lubricate oil seal lip. Fit crankshaft pulley.
14. Refit crankshaft pulley bolt. Tighten to ***270 Nm (200 lbf.ft)***
15. Ensure mating faces between flywheel access cover and gearbox are clean.
16. Lower vehicle.
17. Ensure mating faces between water pump pulley and pump are clean.
18. Refit water pump pulley. Tighten to ***22 Nm (16 lbf.ft)***
19. Refit alternator drive belt.
20. Refit cooling fan. ***See COOLING SYSTEM, Repair.***
21. Reconnect battery negative lead.

CRANKSHAFT PULLEY AND FRONT COVER OIL SEAL - from 99MY

Service repair no - 12.21.01 Crankshaft pulley
Service repair no - 12.21.14 Front cover oil seal

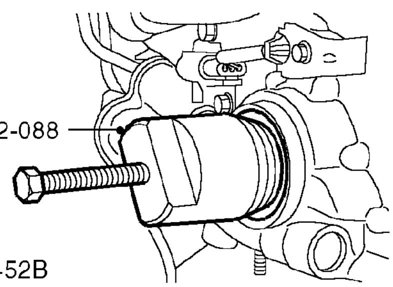
Remove

1. Remove auxiliary drive belt. ***See ELECTRICAL, Repair.***



M12 4445A

2. Secure LRT-12-080 to crankshaft pulley with 2 bolts.
3. Remove crankshaft pulley bolt.
4. Remove crankshaft pulley.

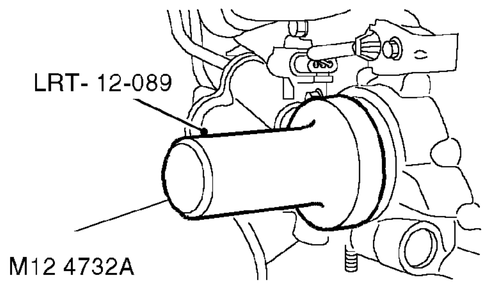


M12 4452B

5. Using LRT-12-088, remove oil seal from front cover.

Refit

6. Clean seal register in front cover and crankshaft pulley.



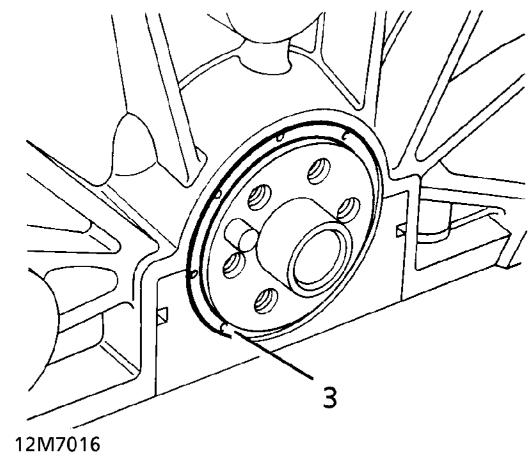
7. Lubricate outer face of seal and fit seal to front cover using LRT-12-089
8. Fit crankshaft pulley and tighten bolt to ***270 Nm (200 lbf.ft.).***
9. Remove LRT-12-080 from crankshaft pulley.
10. Fit auxiliary drive belt. ***See ELECTRICAL, Repair.***

CRANKSHAFT REAR OIL SEAL

Service repair no - 12.21.20

Remove

1. **Manual Vehicles:** Remove flywheel. ***See this section.***
2. **Automatic Vehicles:** Remove drive plate. ***See this section.***

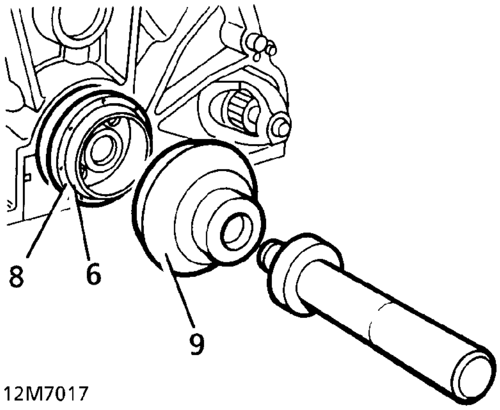


3. Remove oil seal from location.

CAUTION: Do not damage seal location or running surface on crankshaft.

Refit

4. Ensure both seal location and running surface on crankshaft are clean.
5. Ensure mating faces of flywheel and crankshaft are clean.
6. Lubricate seal guide LRT-12-095 with clean engine oil. Position over crankshaft boss.



12M7017

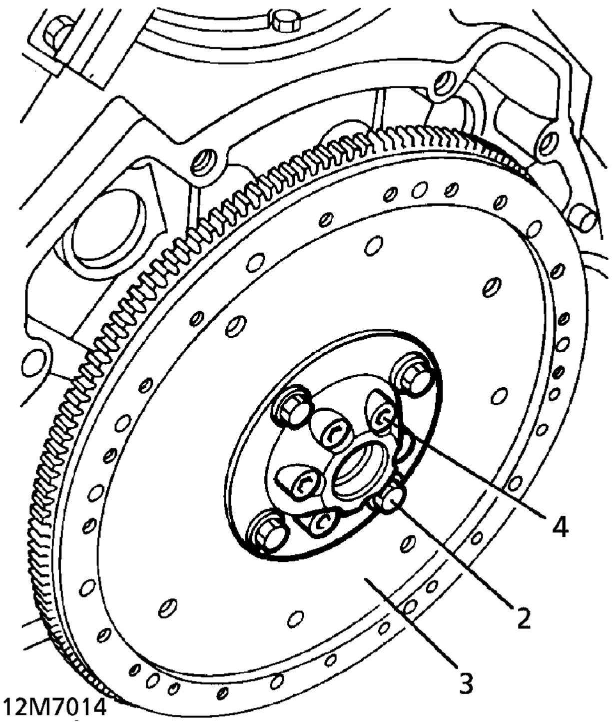
7. Lubricate oil seal lip.
8. Position seal squarely. Remove guide.
9. Drift seal into location using LRT-12-091.
10. **Manual Vehicles:** Fit flywheel. ***See this section.***
11. **Automatic Vehicles:** Fit drive plate. ***See this section.***

DRIVE PLATE - AUTOMATIC - up to 99MY

Service repair no - 12.53.13

Remove

1. Remove automatic gearbox and torque converter. ***See AUTOMATIC GEARBOX, Repair.***



12M7014

2. Remove 4 clamp ring bolts. Collect clamp ring.
3. Remove flexible drive plate/starter ring gear assembly from hub aligner.
4. Remove 6 screws from hub aligner. Remove hub aligner from crankshaft. Collect spacer.
5. Check drive plate for distortion or cracks. Check starter ring gear for chipped or broken teeth. If either component shows signs of damage, fit a new assembly.

Refit

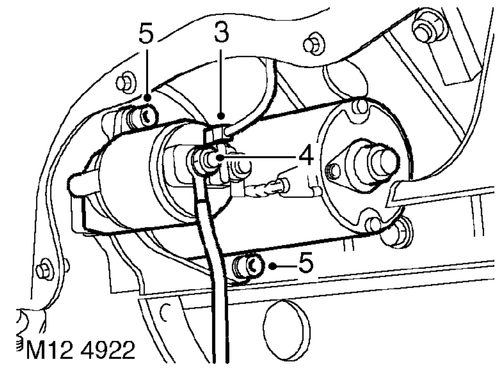
6. Ensure all mating surfaces are clean.
7. Fit spacer and hub aligner to crankshaft.
8. Fit hub aligner screws. Tighten to ***85 Nm (63 lbf.ft)***
9. Fit drive plate and clamp ring.
10. Fit clamp ring bolts. Tighten to ***45 Nm (33 lbf.ft)***
11. Fit automatic gearbox and converter assembly. ***See AUTOMATIC GEARBOX, Repair.***

DRIVE PLATE - AUTOMATIC - from 99MY

Service repair no - 12.53.13

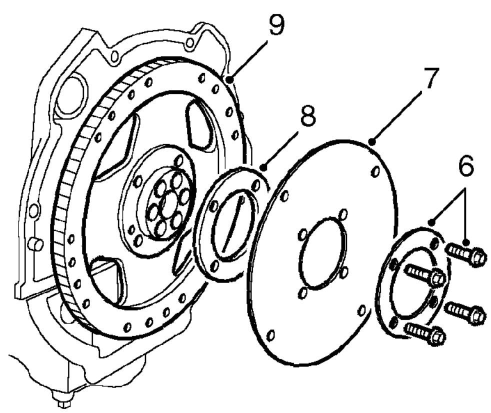
Remove

1. Remove gearbox. ***See AUTOMATIC GEARBOX, Repair.***
2. Remove CKP sensor. ***See FUEL SYSTEM, Repair.***



M12 4922

3. Remove Lucar from starter solenoid.
4. Remove nut securing battery lead to starter solenoid and disconnect lead.
5. Remove 2 Allen screws securing starter motor and remove starter motor.



M12 4923

6. Remove 4 bolts securing drive plate clamp ring and remove ring.
7. Remove drive plate from hub.
8. Remove spacer.
9. Remove starter ring gear.

Refit

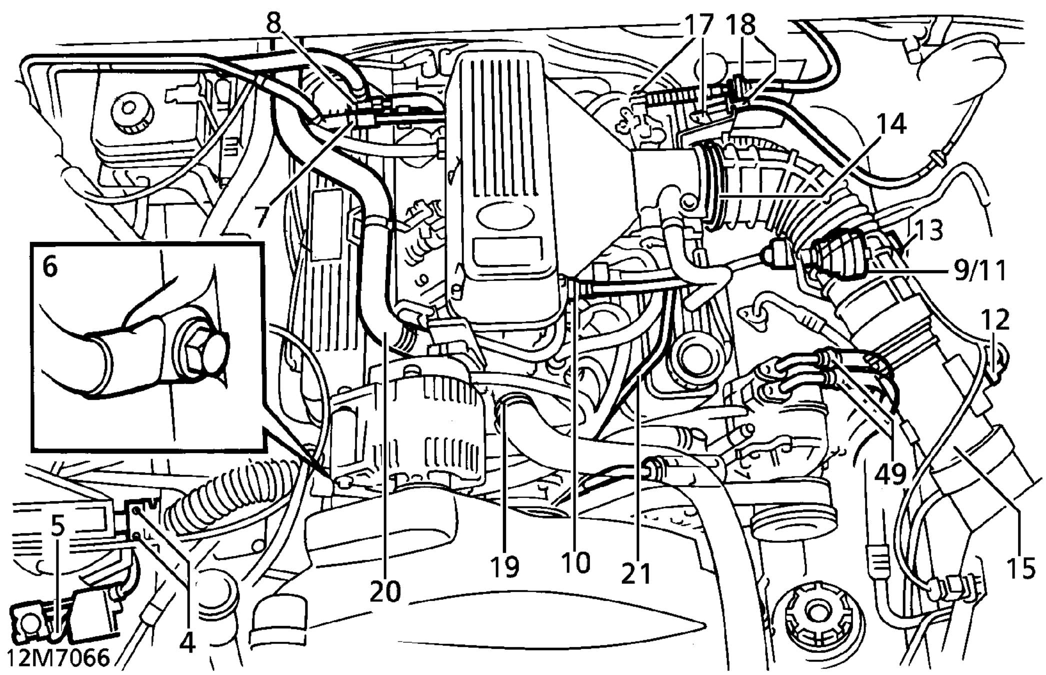
10. Clean starter ring gear and hub, clean dowel and dowel hole.
11. Fit starter ring gear to hub.
12. Clean spacer, clamp ring and mating face on hub.
13. Clean drive plate and check for cracks and distortion.
14. Fit spacer to hub, fit drive plate and clamp ring. Tighten bolts to ***45 Nm (33 lbf.ft).***
15. Clean starter motor and mating face.
16. Fit starter motor and tighten Allen screws to ***45 Nm (33 lbf.ft).***
17. Connect battery lead to starter solenoid and secure with nut.
18. Connect lucar to starter solenoid.
19. Fit CKP sensor. ***See FUEL SYSTEM, Repair.***
20. Fit gearbox. ***See AUTOMATIC GEARBOX, Repair.***

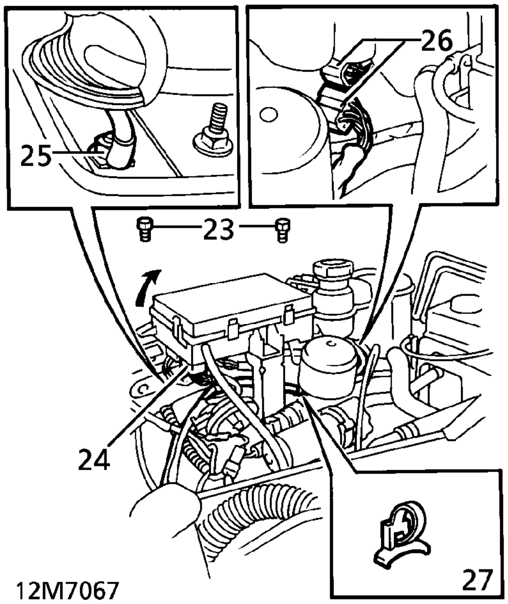
ENGINE AND GEARBOX - up to 99MY

Service repair no - 12.37.01/99

Remove

1. Position vehicle on four post lift.
2. Remove battery. ***See ELECTRICAL, Repair.***
3. Remove ECM. ***See FUEL SYSTEM, Repair.***
4. Remove 2 screws securing engine harness clamp to battery tray. Collect clamp.
5. Release starter feed wire from battery terminal clamp.
6. Release earth lead from alternator bracket.
7. Release fuel return hose clip. Release fuel return hose from regulator connecting pipe.
8. Release fuel feed pipe from fuel rail.
9. Disconnect multiplug from purge valve.
10. Release purge hose from ram pipe housing.
11. Remove purge valve securing bolt from shock absorber turret. Place valve aside.
12. Disconnect multiplug from air flow meter.
13. Release harness from intake hose.
14. Slacken clip securing intake hose to plenum chamber.
15. Remove intake hose/air flow meter assembly.
16. Position harness across engine.
17. Disconnect throttle and cruise control cables from throttle linkage.
18. Release cables from abutment bracket.
19. Disconnect top hose from inlet manifold.
20. Disconnect heater hose from inlet manifold. Release hose from clip. Place hose aside.
21. Disconnect coolant hose from plenum chamber water jacket. Release hose from 2 clips. Place hose aside on valance.
22. Remove 4 bolts securing battery tray. Remove battery tray.

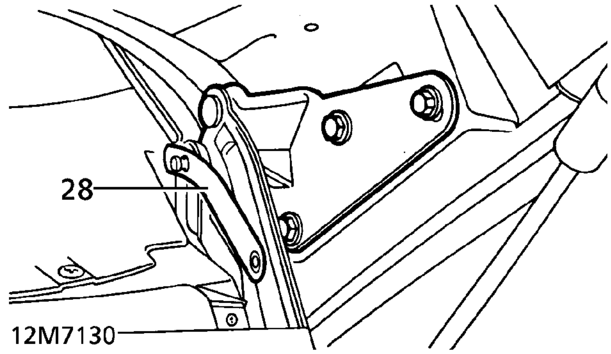




12M7067

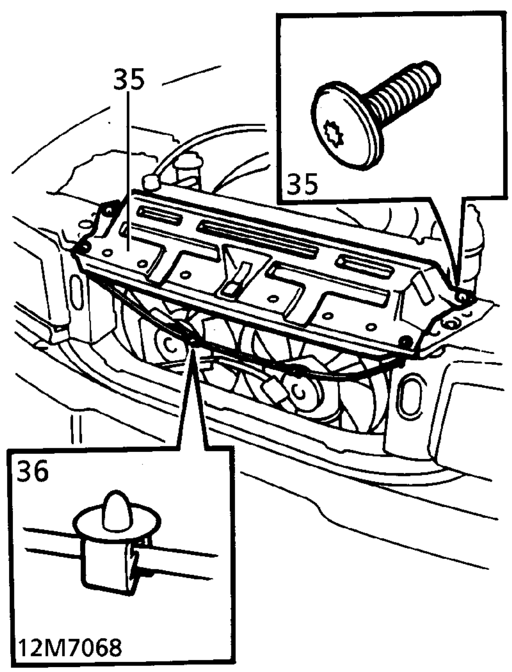
23. Remove 2 bolts securing fuse box. Pivot fuse box for access.
24. Disconnect engine harness multiplug from base of fuse box.
25. Release earth wire from valance stud.
26. Disconnect 2 engine harness multiplugs from main harness.
27. Release engine harness clip from valance. Tie harness aside over engine.
28. With assistance, release bonnet struts from body locations. Retain bonnet in vertical position using stay clips.

WARNING: Only open the bonnet to the vertical position with the vehicle on a horizontal surface in the workshop. This position is not intended to be used outdoors where the bonnet could be affected by winds.



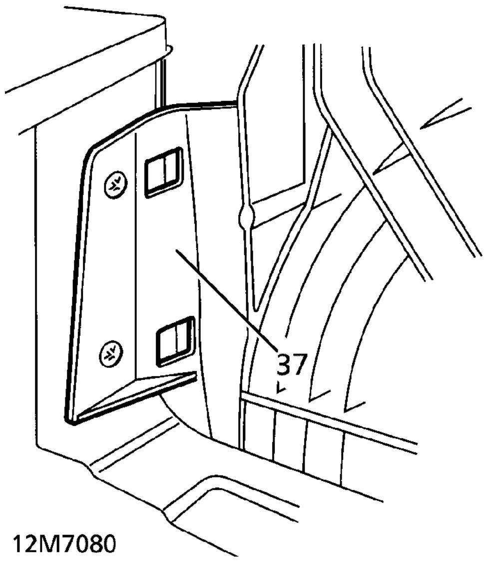
12M7130

29. Depressurise fuel system. ***See FUEL SYSTEM, Repair.***
30. Remove air cleaner. ***See FUEL SYSTEM, Repair.***
31. Drain cooling system. ***See COOLING SYSTEM, Repair.***
32. Discharge air conditioning system. ***See AIR CONDITIONING, Adjustment.***
33. Remove cooling fan and viscous coupling. ***See COOLING SYSTEM, Repair.***
34. Remove front grille. ***See CHASSIS AND BODY, Repair.***
35. Remove 4 bolts securing bonnet platform.



12M7068

36. Release straps securing bonnet release cable to platform. Remove platform.
37. Remove 2 studs securing each radiator air deflector. Remove both deflectors.

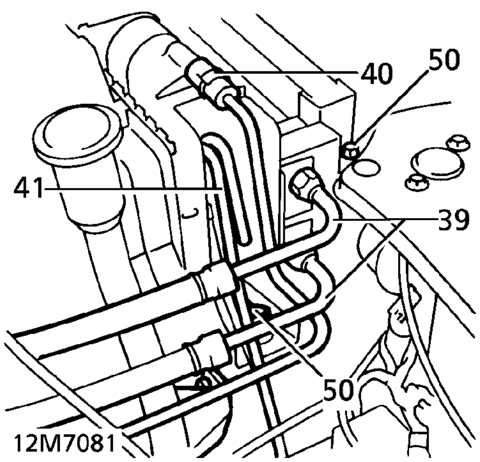


12M7080

38. Remove bolt and screw securing washer bottle filler neck. Remove filler neck.

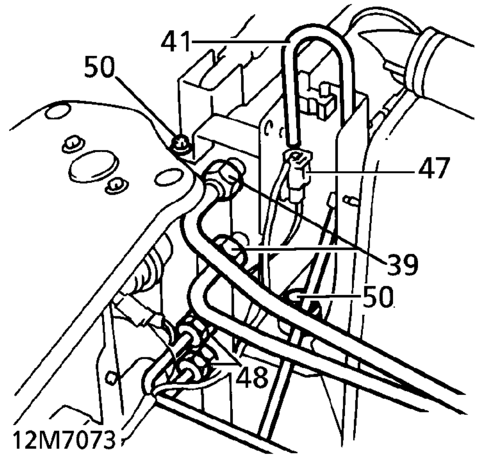
CAUTION: Where pipes are disconnected, plug pipes and ports to prevent ingress of dirt.

39. Disconnect engine and gearbox oil coolers. Remove ’O’ rings and discard. Tie pipes aside on engine.



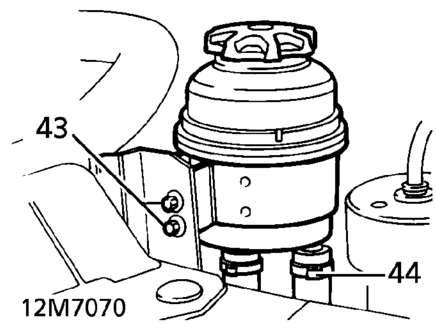
12M7081

40. Disconnect coolant bleed hose from radiator.



12M7073

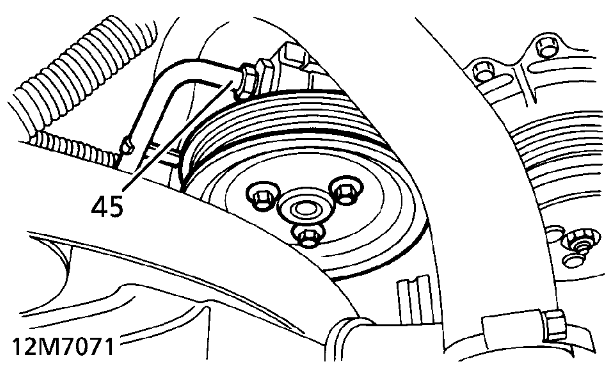
41. Release 2 fog lamp breather hoses from clips on either side of radiator.
42. Disconnect 3 coolant hoses from thermostat housing.
43. Remove 2 bolts securing power steering fluid reservoir to radiator.



12M7070

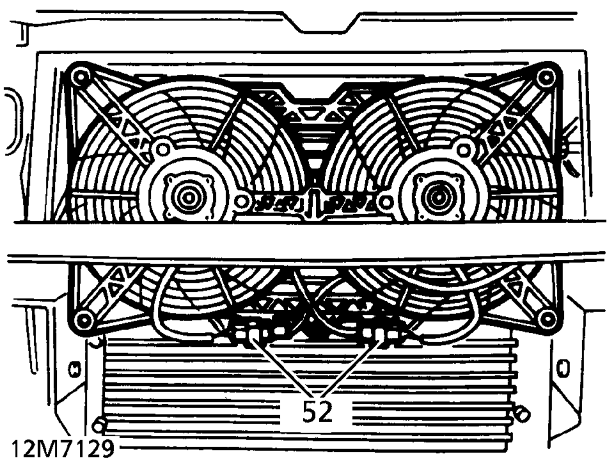
NOTE: Position container beneath power steering reservoir to catch spillage.

44. Disconnect return pipe from reservoir. Tie reservoir aside to engine.
45. Disconnect feed pipe from power steering pump. Remove ’O’ rings and discard.



12M7071

46. Release feed pipe clip from bracket. Place pipe aside.
47. Disconnect multiplug from gearbox oil temperature sensor.
48. Disconnect 2 pipes from air conditioning condenser. Remove 'O' rings and discard.
49. Disconnect 2 pipes from air conditioning compressor. Remove 'O' rings and discard. Place pipes aside.
50. Remove 2 nuts and bolts securing radiator mountings to chassis.
51. With assistance, raise radiator assembly for access to condenser cooling fan connections.



52. Disconnect 2 condenser cooling fan multiplugs.
53. With assistance, remove radiator/condenser/oil cooler assembly.

Manual Vehicles:

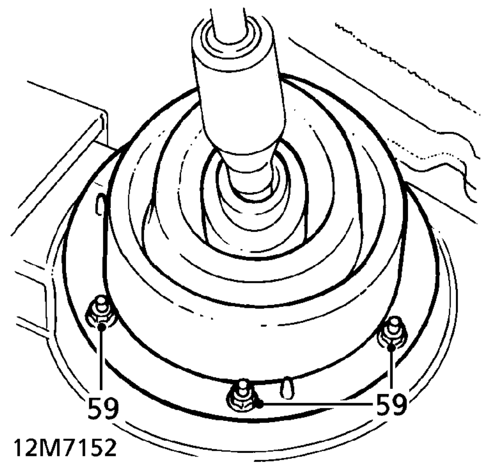
54. Clamp clutch flexible hose using an approved brake hose clamp.
55. Remove clip securing flexible hose to gearbox bracket.
56. Disconnect clutch flexible hose at gearbox pipe. Position hose aside.

Automatic Vehicles:

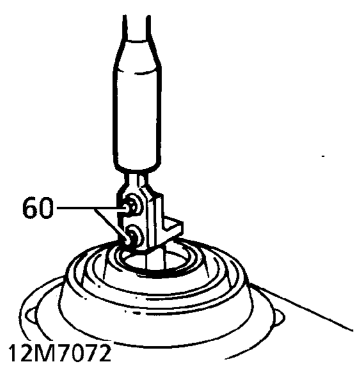
57. Remove window switch pack. ***See ELECTRICAL, Repair.***

Manual Vehicles:

58. Remove centre console. ***See CHASSIS AND BODY, Repair.***
59. Remove 6 nuts securing gaiter ring. Remove ring and gaiter.

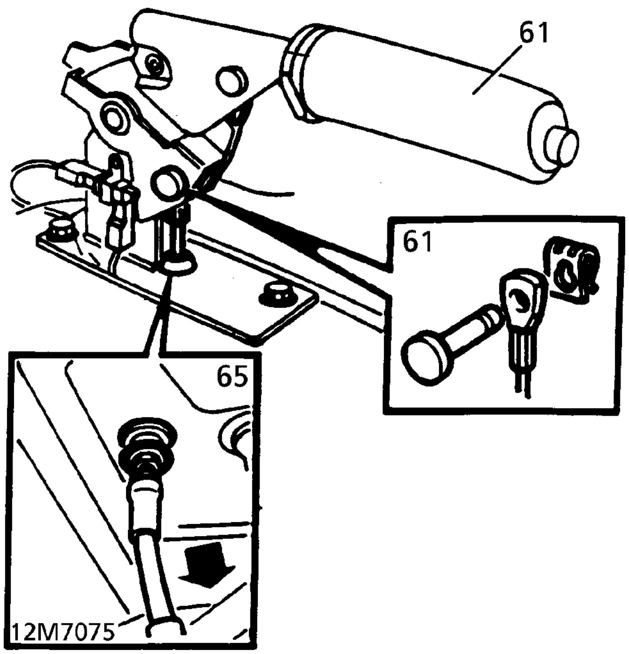


60. Remove 2 bolts securing gear lever. Remove lever.

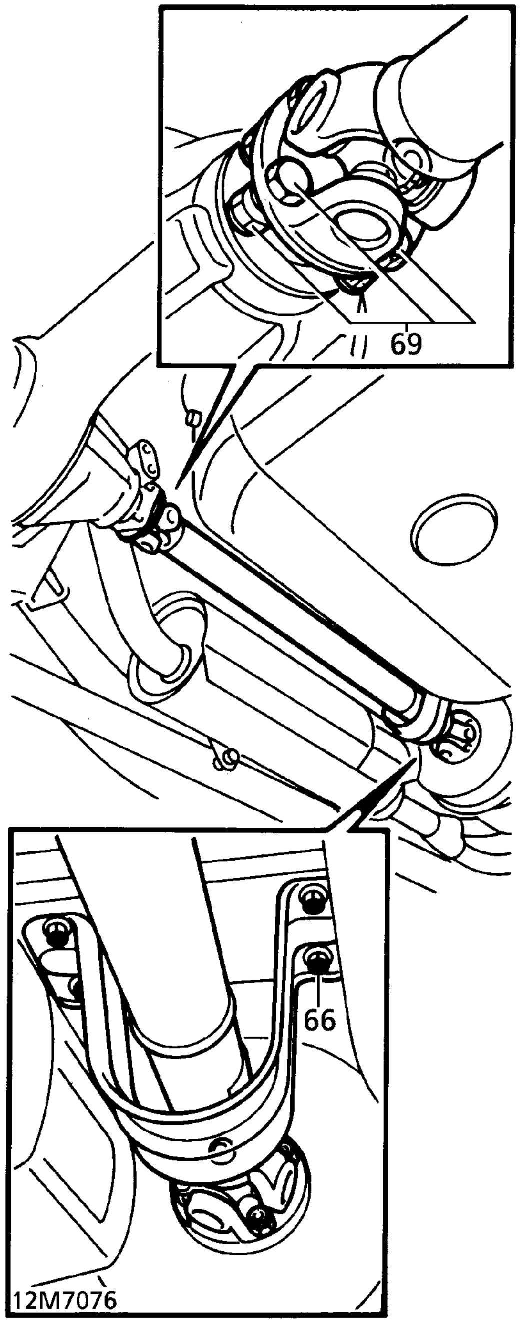


All Vehicles:

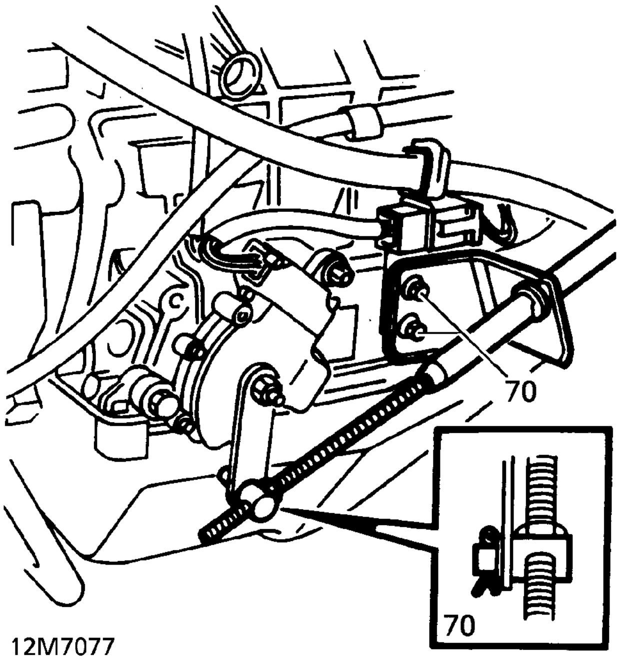
61. Release handbrake. Release handbrake cable clevis pin.



62. Raise lift. Drain gearbox, transfer box and engine fluids. ***See SECTION 10, Maintenance.***
63. Using a transmission jack, support transmission under brake drum.
64. Remove exhaust front pipe. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***
65. Release hand brake cable from grommet in tunnel.
66. Remove 4 bolts securing rear propeller shaft guard. Remove guard.

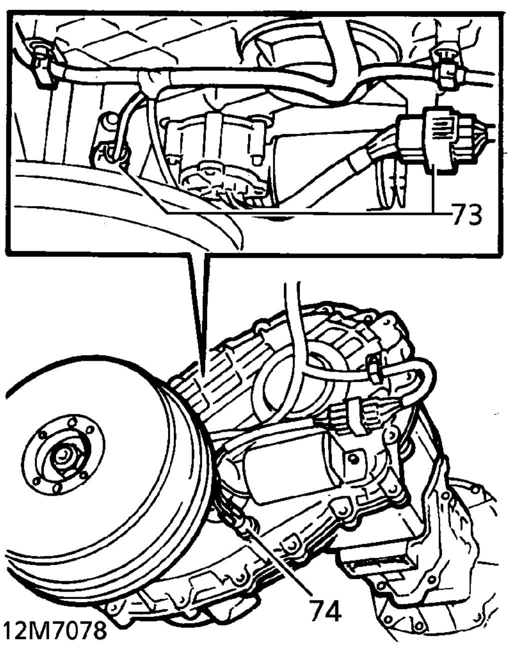


67. Mark transfer box and propeller shaft flanges to aid reassembly.
68. Raise one wheel on each axle to allow rotation of propeller shafts.
69. Remove 4 nuts and bolts from each flange. Disconnect propeller shafts. Tie aside.
70. **Automatic Vehicles:** Disconnect gear selector cable trunnion from gearbox lever. Remove 2 bolts securing selector cable abutment bracket to gearbox. Place selector cable aside.



12M7077

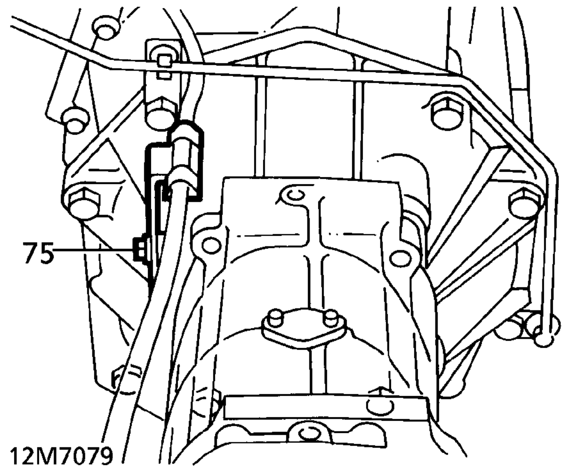
71. Lower gearbox for access.
72. Disconnect 2 Lucars from transfer box fluid temperature sensor.



12M7078

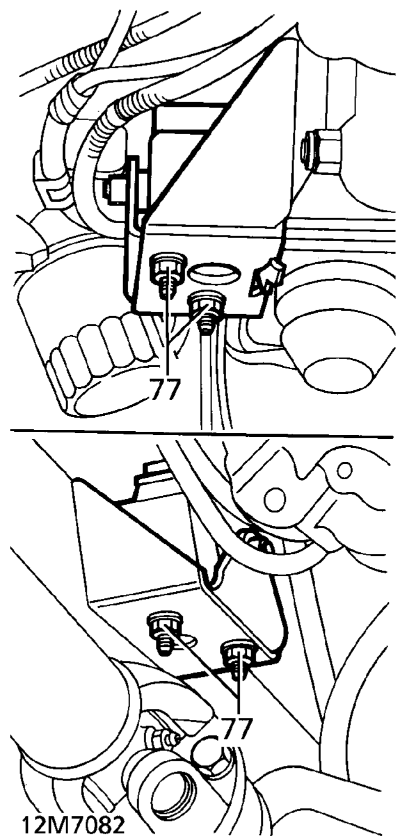
73. Disconnect multiplugs from High/Low motor and output shaft speed sensor.
74. **Automatic Vehicles:** Disconnect multiplugs from gear selection position switch and gearbox speed sensor.

75. **Manual Vehicles:** Disconnect multiplugs from reverse and neutral switches. Remove bolt securing harness bracket to gearbox. Release harness from clips on gearbox brackets.



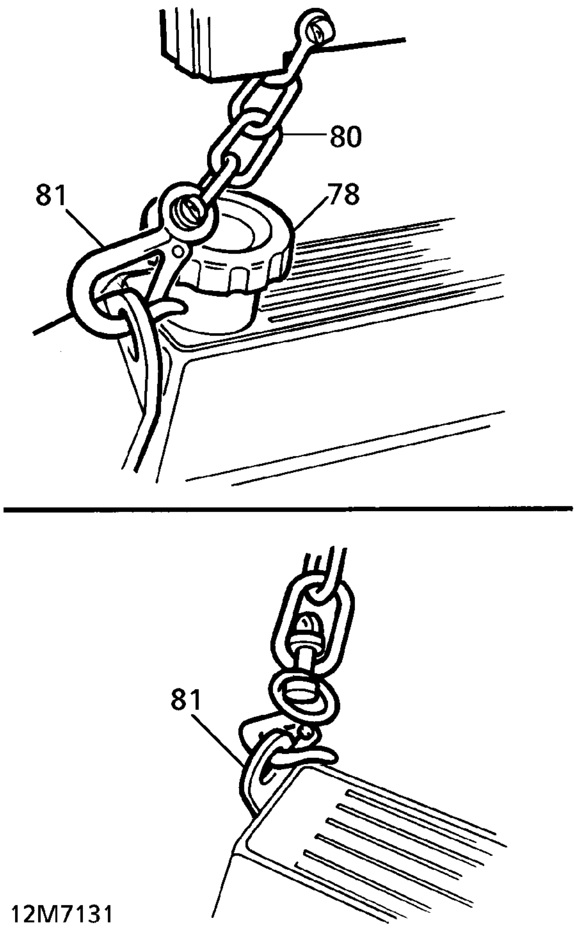
12M7079

76. Disconnect engine harness to gearbox harness multiplug. Position harness aside.
77. Remove 4 nuts securing each engine mount to chassis and engine brackets. Discard nuts.



12M7082

78. Remove oil filler cap.
79. Place cloth over plenum chamber to protect from damage during lifting.
80. Shorten front chain of lifting bracket to 2 links as shown.



12M7131

81. Fit lifting bracket to engine lifting eyes. Attach suitable hoist.
82. Raise engine slightly. Ensure that lifting bracket does not foul bulkhead. Remove both engine mountings.

NOTE: It may be necessary to lower gearbox support slightly during above operation.

83. Raise power unit and draw forward. Lower support from transmission.

NOTE: Power unit must be tilted at an angle of approximately 45 degrees before it can be withdrawn from engine compartment.

84. Remove engine/transmission assembly.

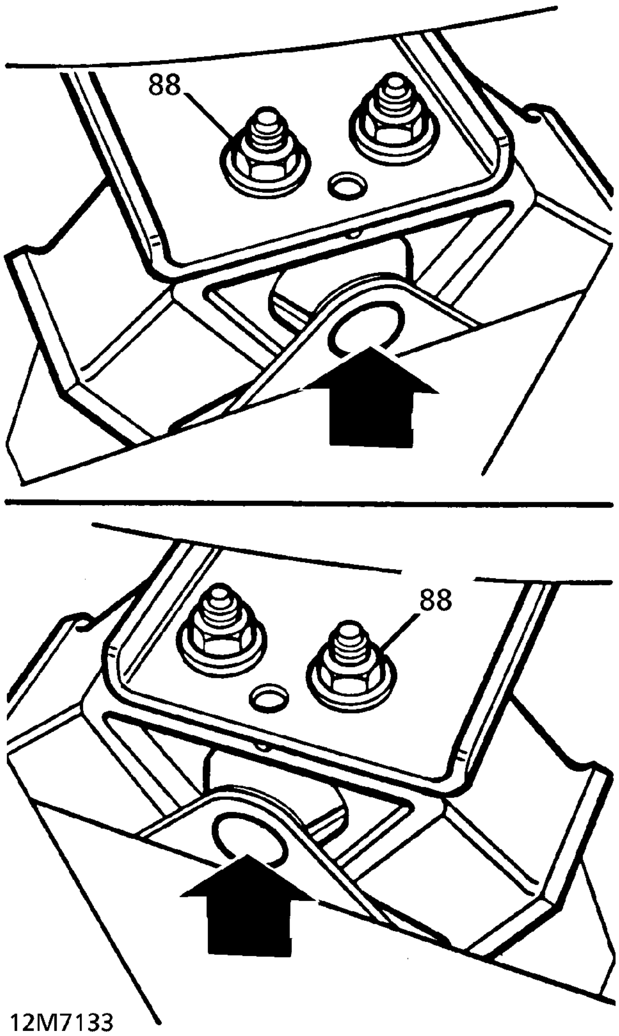
Refit

85. Raise power unit. Guide into engine bay.
86. Position transmission jack beneath transmission brake drum.
87. With assistance, raise transmission and lower engine until engine mountings can be fitted.

CAUTION: Ensure all under body wax is removed from mating surfaces of fixings before fitting.

88. Attach mountings to chassis with new flange nuts. Do not tighten at this stage.

⚠ **CAUTION: Engine mountings must be fitted with centre bolt head facing outboard as shown.**



12M7133

89. Lower and guide engine onto mounting studs.
90. Attach engine to mountings with new flange nuts. Do not tighten at this stage.
91. Release lifting bracket from engine lifting eyes. Remove hoist.
92. Route gearbox harness. Secure with clips.
93. Connect multiplug to engine harness.
94. Connect multiplugs to High/Low motor and output shaft speed sensor.

Manual Vehicles:

95. Secure gearbox harness bracket with bolt. Tighten to ***6 Nm (4 lbf.ft).***
96. Connect multiplugs to reverse and neutral switches.
97. Secure harness to gearbox bracket with clips.

Automatic Vehicles:

98. Connect multiplugs to gear selection position switch and gearbox speed sensor.
99. Position selector cable abutment bracket to gearbox. Secure with bolts.
100. Adjust gear selector cable. ***See AUTOMATIC GEARBOX, Adjustment.***

All Vehicles:

101. Connect Lucars to transfer box fluid temperature sensor.
102. Raise gearbox on transmission jack.
103. Align harness bracket to gearbox.
104. Raise one wheel on each axle to allow rotation of propeller shafts.
105. Position shafts to transfer box flanges. Align marks.
106. Secure propeller shaft flanges with nuts and bolts. Tighten to ***48 Nm (35 lbf.ft)***
107. Fit propeller shaft guard. Tighten bolts.
108. Guide hand brake cable through grommet in transmission tunnel.
109. Fit exhaust front pipe and chassis cross member. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***
110. Remove support from under transmission.
111. Tighten engine mounting nuts to ***45 Nm (33 lbf.ft)***

112. Lower lift.
113. Connect handbrake cable to lever, secure with clevis pin and clip.

Manual Vehicles:

114. Fit seal around gearbox remote housing to transmission tunnel aperture.
115. Position gear lever. Secure with bolts. Tighten to ***25 Nm (18 lbf.ft)***
116. Fit gaiter and ring. Secure with bolts.
117. Fit centre console. ***See CHASSIS AND BODY, Repair.***
118. Connect clutch flexible hose. Remove hose clamp.
119. Secure flexible hose union to gearbox bracket with clip.
120. Bleed clutch hydraulic system. ***See CLUTCH, Repair.***

Automatic Vehicles:

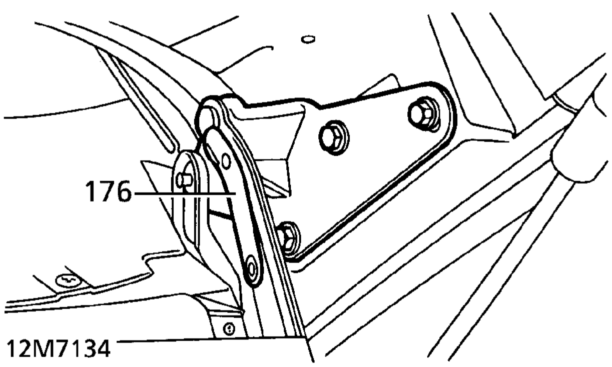
121. Fit window switch pack. ***See ELECTRICAL, Repair.***

All Vehicles:

122. With assistance, position radiator/condenser/oil cooler assembly.
123. Connect multiplugs to condenser cooling fans.
124. Engage radiator in lower mounting rubbers. Secure with nuts and bolts.
125. Remove plugs from air conditioning compressor and pipes.
126. Fit new 'O' rings to compressor pipes. Lubricate 'O' rings with compressor oil. Connect to compressor.
127. Fit compressor connection bolts. Tighten to ***23 Nm (17 lbf.ft)***
128. Remove plugs from air conditioning condenser and pipes.
129. Fit new 'O' rings to condenser pipes. Lubricate 'O' rings with compressor oil. Secure pipes to condenser. Tighten to ***15 Nm (11 lbf.ft)***
130. Connect gearbox oil temperature multiplug.
131. Remove plugs from power steering pump and pipes.
132. Fit new 'O' rings to power steering pipes. Lubricate 'O' rings with power steering fluid. Secure to power steering pump. Tighten to ***16 Nm (12 lbf.ft)***
133. Untie power steering reservoir from engine. Remove plugs. Connect return pipe. Secure return pipe to reservoir with clip.
134. Position reservoir to radiator. Secure with bolts.
135. Secure fog lamp breather hoses to clips on either side of radiator.
136. Route plenum chamber hose along front of engine. Secure in clips.
137. Connect hose to plenum chamber water jacket. Secure with clip.
138. Connect coolant hoses to radiator, thermostat housing and inlet manifold. Secure hoses with clips.
139. Remove plugs from oil coolers and pipes.
140. Lubricate pipes with clean fluid. Fit new 'O' rings. Connect to oil coolers. Tighten to ***30 Nm (22 lbf.ft)***
141. Fit washer bottle filler neck. Secure with bolt and screw.
142. Fit radiator deflector panels. Secure with studs.
143. Position bonnet platform. Secure bonnet release cable to platform with clips.
144. Secure bonnet platform with bolts.
145. Fit front grille. ***See CHASSIS AND BODY, Repair.***
146. Fit cooling fan and viscous coupling. ***See COOLING SYSTEM, Repair.***
147. Evacuate and recharge air conditioning system. ***See AIR CONDITIONING, Adjustment.***
148. Refill cooling system. ***See COOLING SYSTEM, Repair.***
149. Replenish transmission fluids. ***See LUBRICANTS, FLUIDS AND CAPACITIES, Information.***
150. Replenish engine oil. ***See LUBRICANTS, FLUIDS AND CAPACITIES, Information.***
151. Fit oil filler cap.
152. Route engine harness along valance. Secure clip.
153. Connect engine harness multiplugs to main harness. Secure earth terminal to valance stud.
154. Connect engine harness multiplug to base of fuse box.
155. Position fuse box. Secure with bolts.
156. Position earth lead to alternator bracket. Secure with bolt.
157. Fit battery tray. Secure with bolts.
158. Fit starter feed wire to battery positive terminal clamp. Secure with nut.
159. Position engine harness to battery tray. Secure harness grommets.
160. Secure harness clamp to battery tray with screws.

161. Fit ECM. ***See FUEL SYSTEM, Repair.***
162. Fit throttle and cruise control cables to abutment bracket. Secure cruise control cable with 'C' clip.
163. Position cable trunnions to throttle linkage. Secure with clevis and split pins.
164. Adjust throttle cable free-play. ***See FUEL SYSTEM, Adjustment.***
165. Adjust cruise control cable. ***See CRUISE CONTROL, Adjustment.***
166. Fit intake hose and air flow meter assembly to plenum chamber. Secure with clip. Connect multiplug to air flow meter.
167. Connect multiplug to purge valve.
168. Position purge valve on shock absorber turret. Secure with bolt.
169. Connect purge hose to ram pipe housing.
170. Secure harness to clip on intake hose.
171. Fit air cleaner. ***See FUEL SYSTEM, Repair.***
172. Remove plugs from fuel hoses and fuel rail connections.
173. Connect fuel feed pipe to fuel rail. Tighten to ***16 Nm (12 lbf.ft)***
174. Connect return hose to pressure regulator pipe. Secure with clip.
175. Refit battery. ***See ELECTRICAL, Repair.***
176. With assistance, release bonnet stay clips. Engage bonnet struts.

CAUTION: Ensure bonnet stay clips are returned to their original positions as shown.



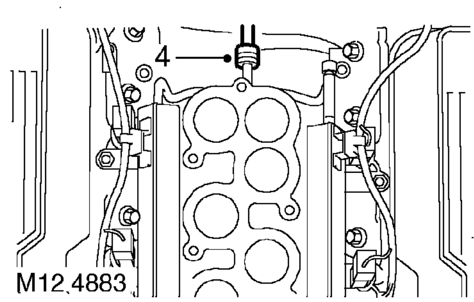
177. Start engine. Check for fuel, coolant and oil leaks.

ENGINE AND ANCILLARIES - from 99MY

Service repair no - 12.41.01.99

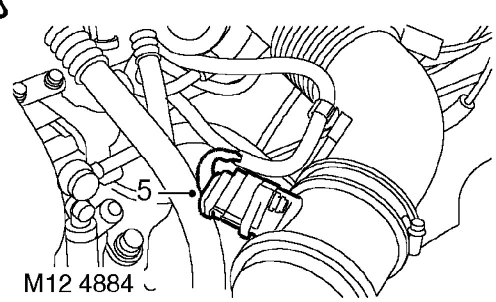
Remove

1. Drain engine oil and remove oil filter.
2. Remove radiator. ***See COOLING SYSTEM, Repair.***
3. Remove ignition coils. ***See FUEL SYSTEM, Repair.***

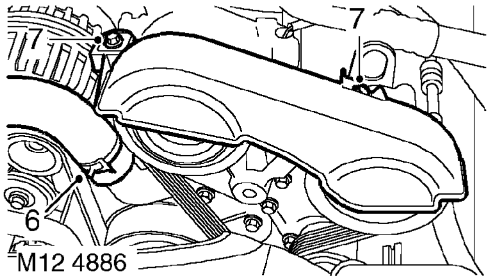


4. Position absorbent material to catch any fuel spillage and disconnect fuel pipe from rail.

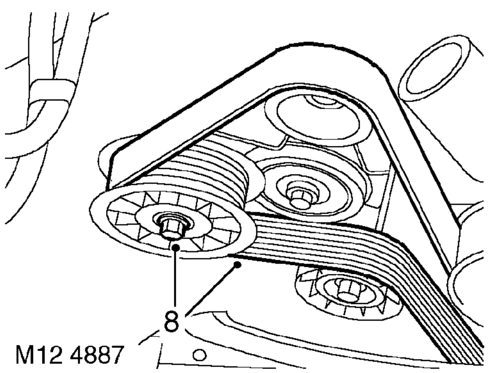
CAUTION: Plug the connections.



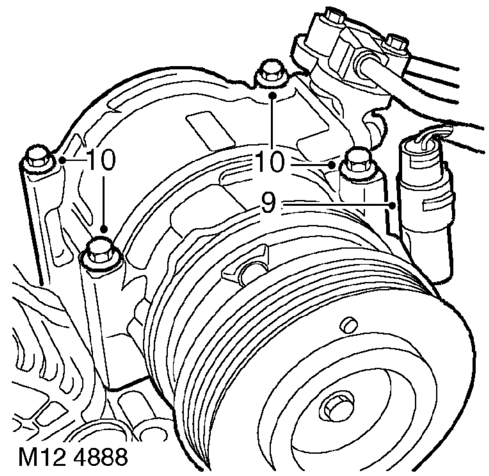
5. Disconnect MAF sensor multiplug.



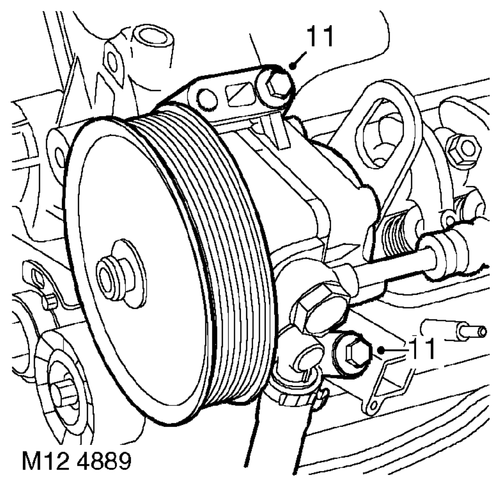
6. Release clip and remove top hose from adaptor on inlet manifold.
7. Remove 2 bolts securing auxiliary drive belt cover, remove cover and collect spacers.



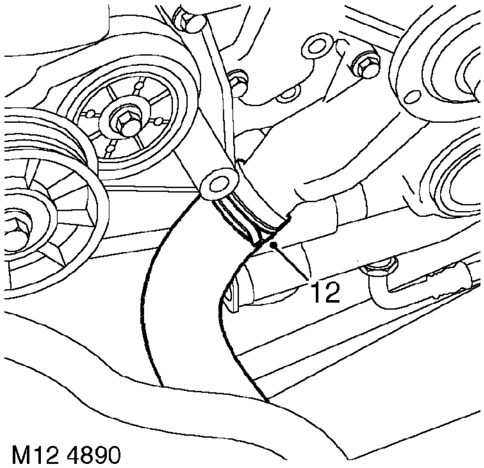
8. Using a 15 mm spanner, release auxiliary drive belt tension and remove drive belt.



9. Disconnect A/C compressor multiplug.
10. Remove 4 bolts securing A/C compressor, release compressor and tie aside.

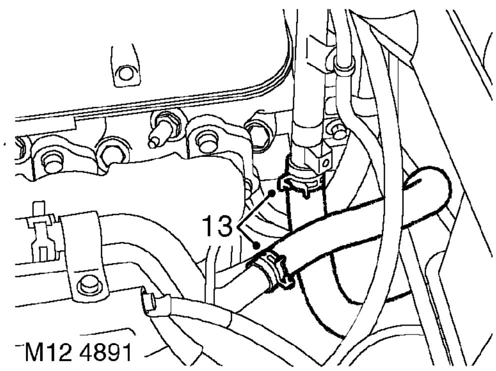


11. Remove 2 bolts securing PAS pump to mounting bracket, release pump and tie pump aside.



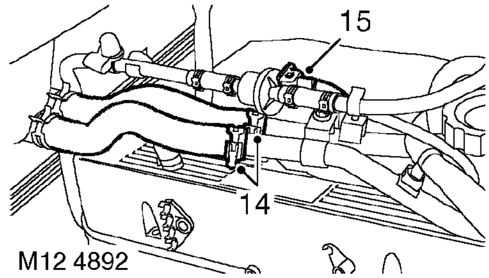
M12 4890

12. Release clip and disconnect coolant hose from water pump.



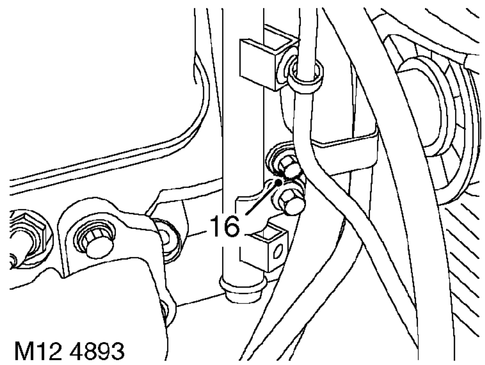
M12 4891

13. Release 2 clips securing coolant hoses to coolant rails, release hoses and remove hoses and thermostat housing.



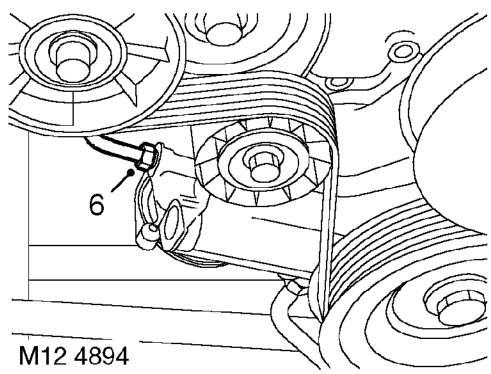
M12 4892

14. Release 2 clips securing heater hoses to coolant rails and disconnect hoses from rails.
15. Disconnect multiplug from purge valve and position EVAP pipe aside.



M12 4893

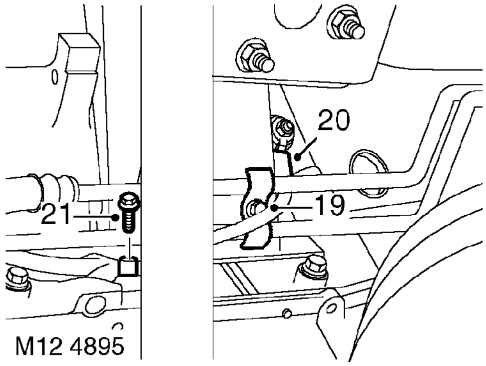
16. Remove bolt securing engine oil cooler return pipe to alternator mounting bracket.



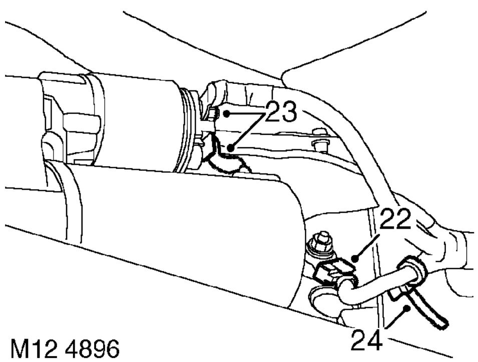
M12 4894

17. Loosen engine oil cooler feed and return pipe unions from oil pump.
18. Release feed and return pipes, remove and discard 'O' rings.

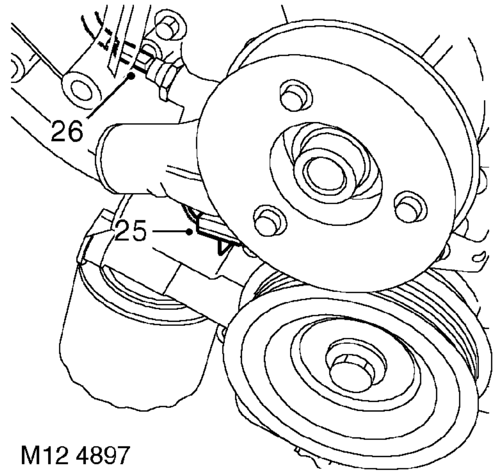
CAUTION: Plug the connections.



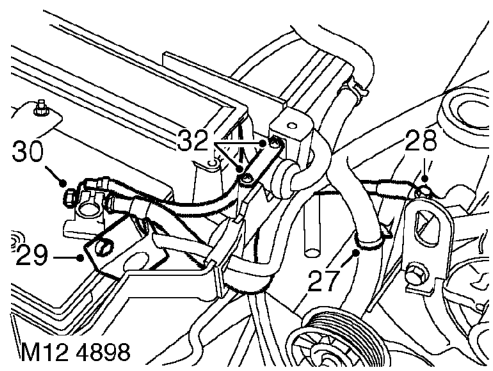
19. Remove bolt securing gearbox fluid cooler pipes clamp to engine LH mounting bracket and remove clamp and spacer.
20. Disconnect multiplug from LH KS.
21. Remove bolt securing harness 'P' clip to cylinder block.



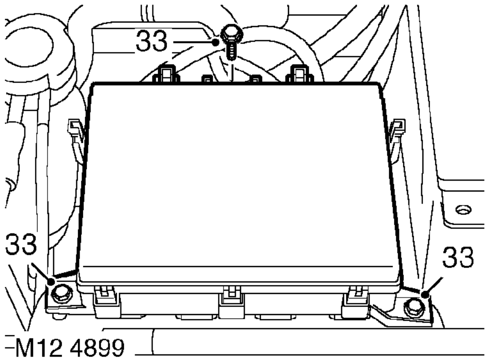
22. Disconnect multiplug from RH KS.
23. Remove nut securing battery lead to starter solenoid, release lead and disconnect lucar from solenoid.
24. Release clip securing harness to engine RH mounting bracket.



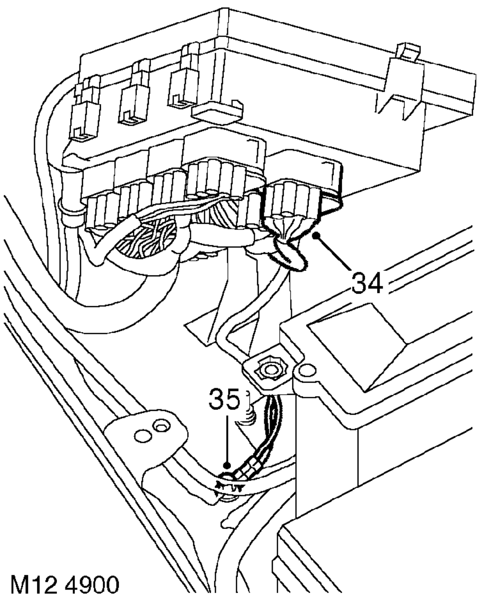
25. Disconnect multiplug from CMP sensor.
26. Disconnect Lucar from oil pressure switch.



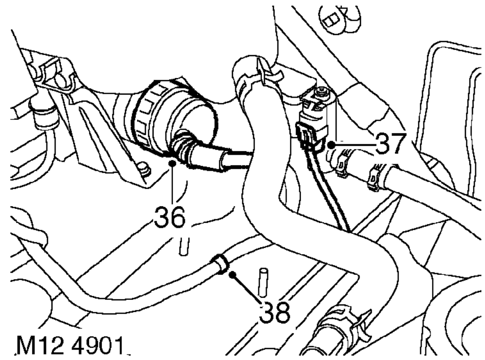
27. Release clip securing harness to coolant rail.
28. Remove bolt securing engine earth lead and position lead aside.
29. Release cover from battery positive terminal.
30. Remove nut securing positive lead to battery terminal, release fuse box feed lead, and disconnect positive lead from battery terminal.
31. Release positive lead from battery carrier.
32. Remove 2 screws and remove harness clamp from battery carrier.



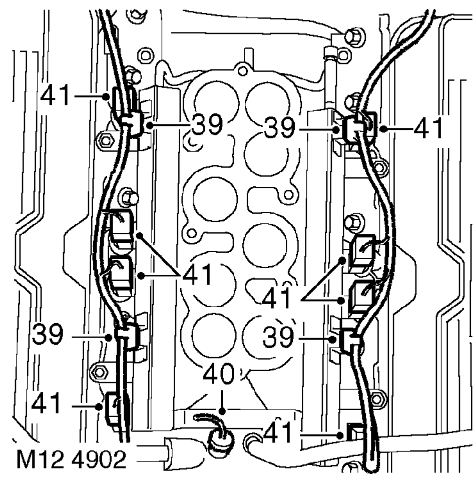
33. Remove 3 bolts securing under bonnet fuse box.



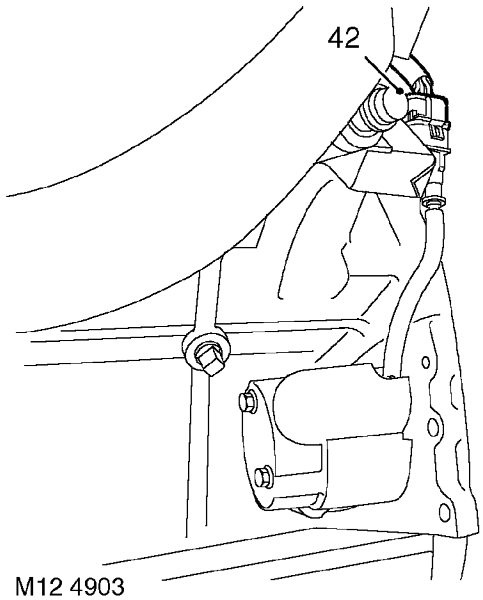
34. Disconnect engine harness multiplug from fuse box.
35. Remove nut and disconnect 2 earth leads from RH wing valance.



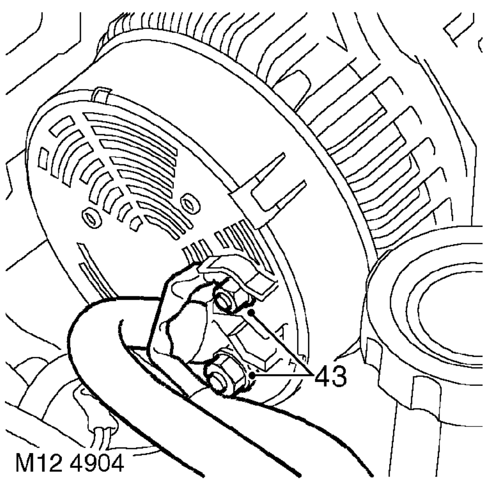
36. Disconnect engine harness multiplug from main harness.
37. Disconnect multiplug from Canister Vent Solenoid (CVS) unit.
38. Release clip securing harness to RH wing valance.



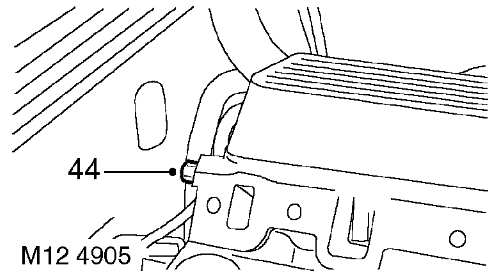
39. Release harness clips from fuel rail and heater coolant pipe.
40. Disconnect multiplug from ECT sensor.
41. Disconnect multiplugs from fuel injectors.



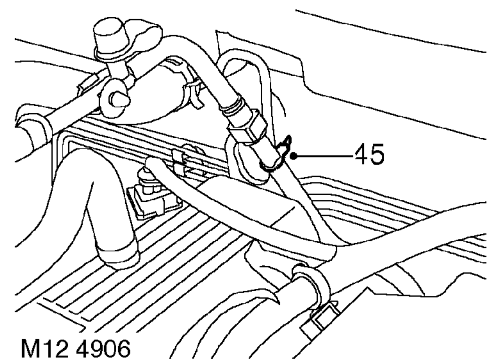
42. Disconnect multiplug from CKP sensor.



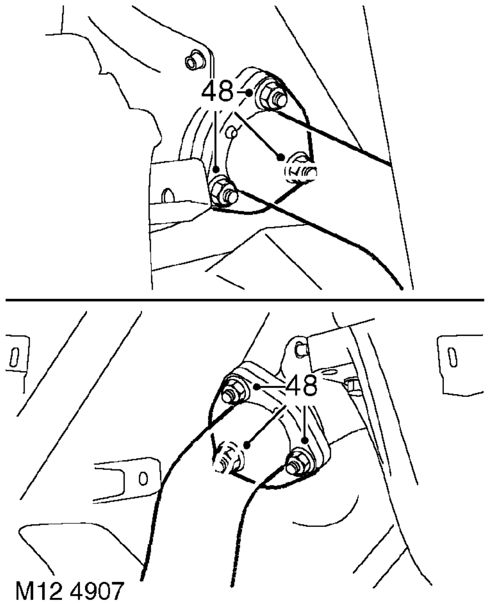
43. Remove 2 nuts securing engine harness to alternator.



44. Remove bolt securing engine harness 'P' clip to rear of LH cylinder head.

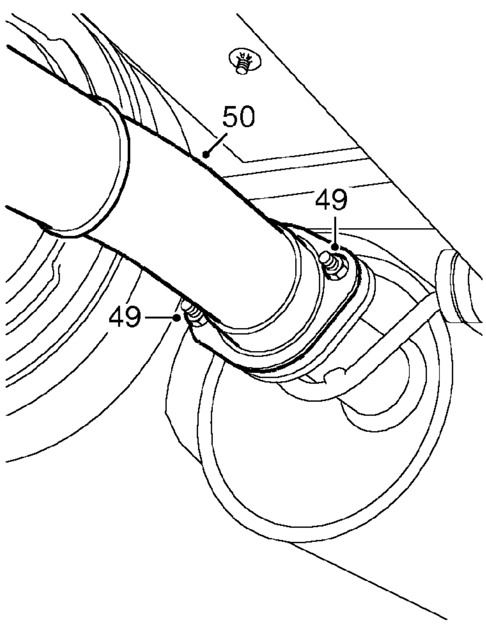


45. Remove cable tie securing purge pipe to engine rear lifting eye.
46. Move harness clear of engine.
47. Raise vehicle on ramp.

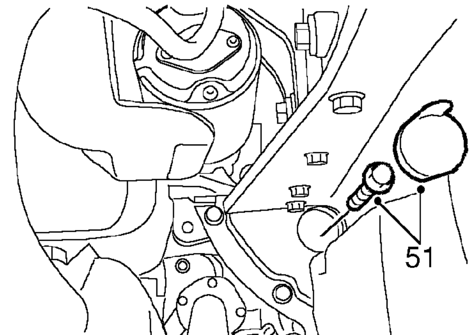


M12 4907

48. Remove 6 nuts securing exhaust front pipes to exhaust manifolds and collect gaskets.

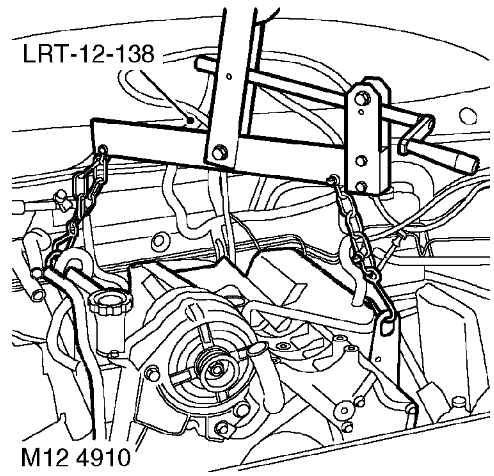


49. Remove 2 nuts securing exhaust front pipe to intermediate pipe.
50. Release exhaust front pipe from intermediate pipe.



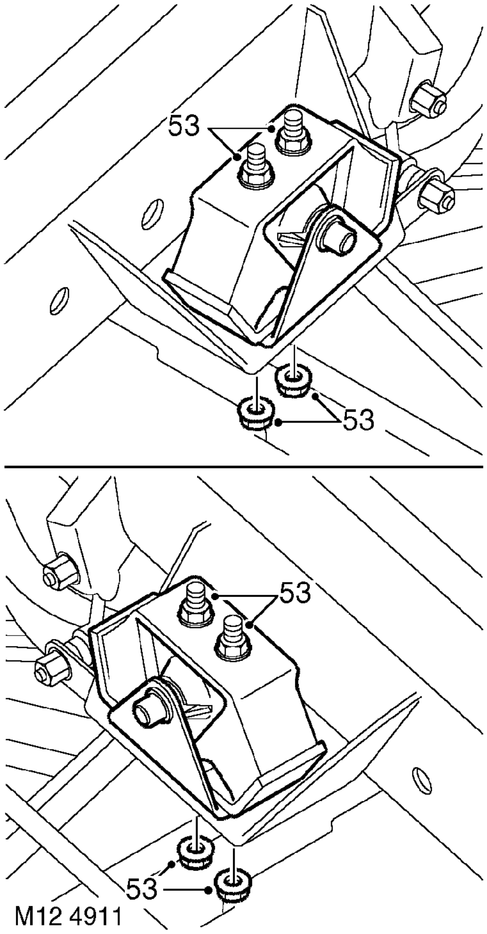
M12 4909

51. Remove access plug and remove 4 bolts securing torque converter to drive plate.



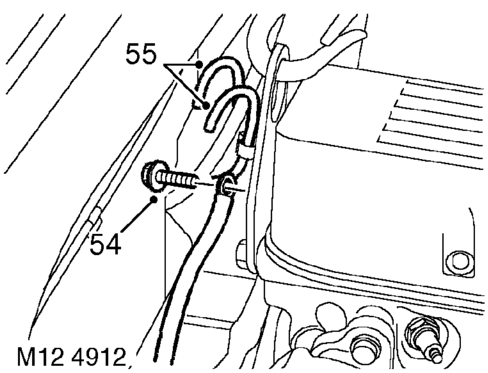
M12 4910

52. Using hoist and LRT-12-138 connected to engine lifting eyes provided, support engine weight.



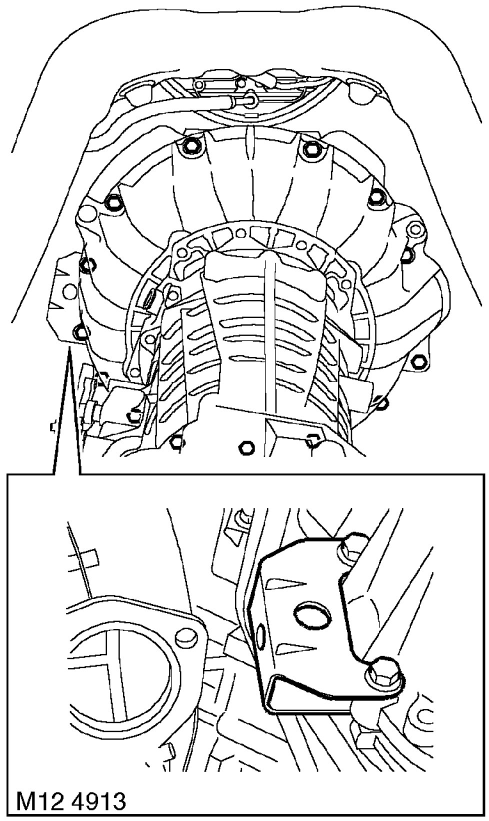
M12 4911

53. Remove 8 nuts securing engine mountings, raise engine and remove engine mountings.



M12 4912

54. Remove bolt securing earth strap to RH cylinder head.
55. Release 3 breather hoses from RH lifting eye.


M12 4913

56. Remove 12 bolts securing engine to gearbox and remove crash bracket.
57. Support gearbox on a jack.
58. Remove 2 remaining bolts securing engine to gearbox and with assistance, remove engine from gearbox dowels and remove engine from engine bay.
59. Care must be taken when releasing engine from dowels to ensure torque convertor remains fully engaged with gearbox.

Refit

60. Clean mating faces of engine and gearbox, dowel and dowel holes.
61. Ensure drive plate and convertor mating faces are clean.

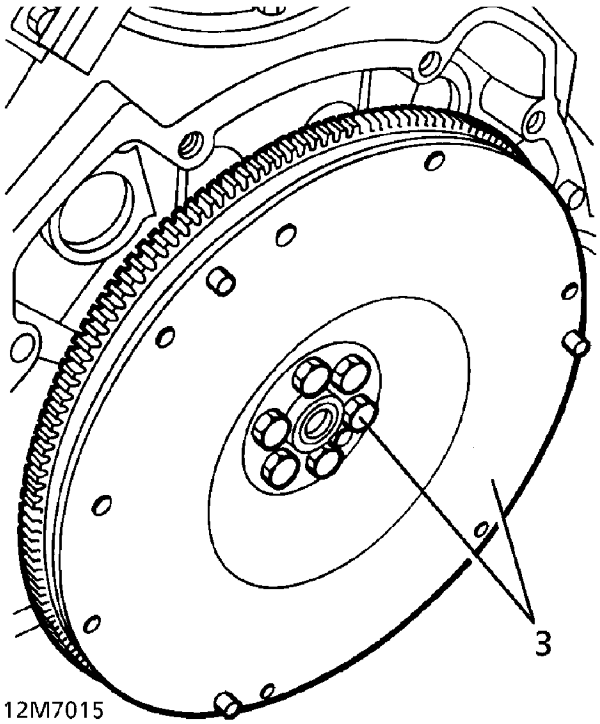
62. With assistance position engine in engine bay, align to gearbox and locate on dowels.
63. Fit crash bracket to gearbox flange and fit and tighten engine to gearbox bolts to ***45 Nm (33 lbf.ft).***
64. Lower and remove support from gearbox.
65. Fit breather hoses to clip on engine RH lifting eye.
66. Position earth strap to RH cylinder head and secure with bolt.
67. Fit engine mountings, lower engine onto mountings and tighten nuts to ***45 Nm (33 lbf.ft).***
68. Lower lifting equipment and remove from engine.
69. Align torque converter and drive plate. Fit bolts and tighten to ***50 Nm (37 lbf.ft).***
70. Fit access plug.
71. Ensure mating face of exhaust front pipe , intermediate pipe and exhaust manifolds are clean.
72. Use new gaskets, fit front pipe to exhaust manifolds and tighten nuts to ***30 Nm (22 lbf.ft).***
73. Fit intermediate pipe to front pipe, align clamp and tighten nuts to ***25 Nm (18 lbf.ft).***
74. Secure purge pipe to rear engine lift eye with cable tie.
75. Fit bolt to secure harness 'P' clip to LH cylinder head.
76. Connect harness to alternator and tighten B + terminal nut to ***18 Nm (13 lbf.ft)*** *and D + terminal nut to* ***5 Nm (3.5 lbf.ft).***
77. Connect multiplug to CKP sensor.
78. Connect multiplugs to fuel injectors and ECT sensor.
79. Fit harness clips to fuel rail and heater coolant pipe.
80. Connect multiplug to Canister Vent Solenoid (CVS) unit.
81. Connect engine harness multiplug to main harness.
82. Connect earth leads to stud on RH wing valance and tighten nut to ***10 Nm (7 lbf.ft).***
83. Connect engine harness multiplug to fuse box.
84. Secure harness clip to RH wing valance.
85. Fit bolts to secure fuse box.
86. Fit harness clamp to battery carrier and secure with screws.
87. Fit battery positive lead to battery carrier and connect cable to battery terminal. Connect fuse box positive feed to terminal clamp bolt and secure with nut. Fit terminal cover.
88. Fit engine earth lead to alternator bracket and tighten bolt to ***20 Nm (15 lbf.ft).***
89. Secure harness to coolant rail.
90. Connect Lucar to oil pressure switch.
91. Connect multiplug to CMP sensor.
92. Connect battery lead to starter solenoid and tighten nut to ***18 Nm (13 lbf.ft).***
93. Connect Lucar to starter solenoid.
94. Connect multiplug to RH KS and secure harness clip to engine RH mounting bracket.
95. Connect multiplug to LH KS, align harness 'P' clip to cylinder block and tighten bolt to ***20 Nm (15 lbf.ft).***
96. Align gearbox oil cooler pipes, fit spacer and clamp and tighten bolt to ***18 Nm (13 lbf.ft).***
97. Ensure engine oil cooler pipe unions are clean. Fit new 'O' rings, connect pipes to oil pump and tighten unions to ***15 Nm (11 lbf.ft).***
98. Align engine oil cooler return pipe to alternator mounting bracket and secure with bolt.
99. Align EVAP pipe and connect multiplug to purge valve.
100. Connect and secure heater hoses to coolant rails.
101. Fit thermostat housing and hose assembly. Connect and secure hoses to coolant rails.
102. Connect and secure coolant hose to water pump.
103. Ensure PAS pump and mating face is clean . Fit PAS pump to mounting bracket and tighten bolts to ***22 Nm (16 lbf.ft).***
104. Ensure compressor and mating face is clean. Fit compressor to mounting bracket and tighten bolts to ***22 Nm (16 lbf.ft).***
105. Connect multiplug to compressor.
106. Ensure auxiliary drive belt pulley grooves are clean and free from damage.
107. Fit new drive belt to pulleys, and ensure belt is correctly aligned in pulley grooves.
108. With assistance, hold tensioner fully clockwise and fit drive belt to remaining pulley.
109. Fit auxiliary drive belt cover and spacers and tighten bolts to ***18 Nm (13 lbf.ft).***
110. Connect and secure coolant top hose to adaptor on inlet manifold.
111. Connect multiplug to MAF sensor.
112. Ensure connection is clean and connect fuel pipe to fuel rail.
113. Fit ignition coils. ***See FUEL SYSTEM, Repair.***
114. Fit radiator. ***See COOLING SYSTEM, Repair.***
115. Fit engine oil filter and fill engine with engine oil. ***See LUBRICANTS, FLUIDS AND CAPACITIES, Information.***
116. Check and if necessary top up gearbox oil.

FLYWHEEL

Service repair no - 12.53.07

Remove

1. Remove clutch assembly. ***See CLUTCH, Repair.***
2. Rotate flywheel until location dowel is opposite starter motor.
3. Remove 6 flywheel securing bolts. Remove flywheel.



4. Inspect flywheel clutch face for cracks, scores or overheating.
5. Inspect ring gear for worn, chipped or broken teeth.

Refit

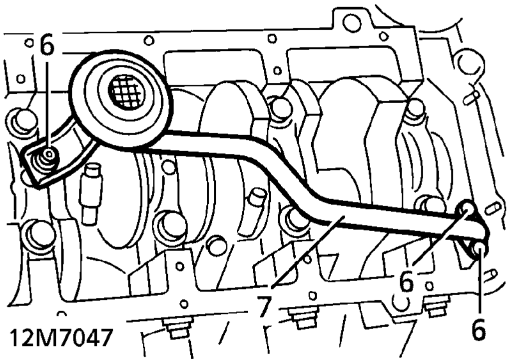
6. Ensure mating surfaces, dowel and dowel locations in both flywheel and crankshaft are clean.
7. Offer flywheel up to crankshaft. Locate on dowel.
8. Refit flywheel bolts. Tighten to ***80 Nm (59 lbf.ft)***
9. Refit clutch assembly. ***See CLUTCH, Repair.***

FRONT COVER GASKET AND OIL PUMP - up to 99MY

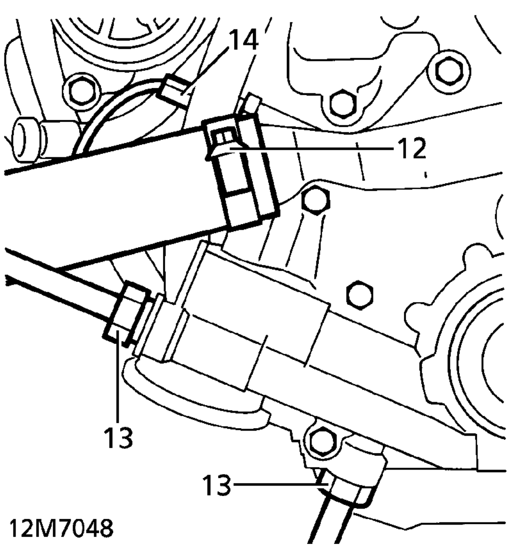
Service repair no - 12.65.04 - Front Cover Gasket
Service repair no - 12.60.26 - Oil Pump

Remove

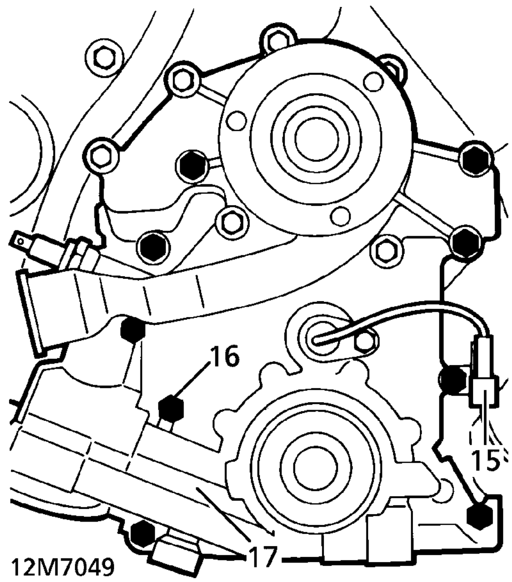
1. Raise vehicle on four post lift.
2. Disconnect battery negative lead.
3. Raise lift.
4. Drain cooling system. ***See COOLING SYSTEM, Repair.***
5. Remove oil sump. ***See this section.***
6. Remove 2 bolts and nut securing oil pick up strainer.



7. Remove strainer and 'O' ring.
8. Remove oil filter. ***See SECTION 10, Maintenance.***
9. Remove stand from under front cross member. Lower vehicle.
10. Remove crankshaft pulley. ***See this section.***
11. Remove auxiliary drive belt tensioner.
12. Slacken bottom hose clip. Remove hose from water pump.



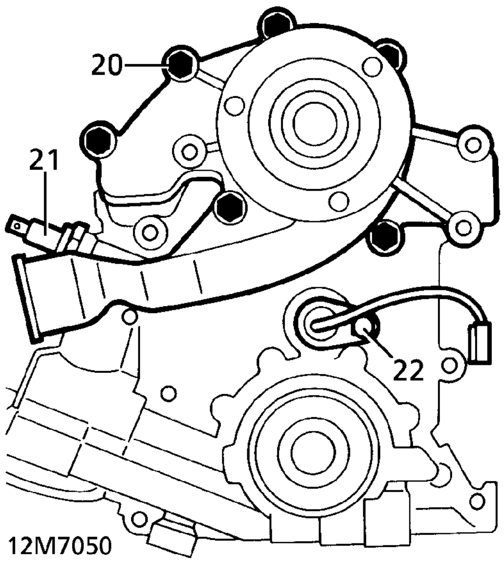
13. Disconnect oil cooler hoses from front cover. Plug hoses and connections.
14. Disconnect Lucar from oil pressure switch.
15. Disconnect multiplug from camshaft sensor.



16. Remove 9 bolts securing front cover.
17. Release cover from 2 dowels. Remove cover.
18. Remove gasket.
19. Remove seal from cover.

Do not carry out further dismantling if component is removed for access only.

20. Remove 6 remaining bolts securing water pump to cover. Remove water pump and gasket.

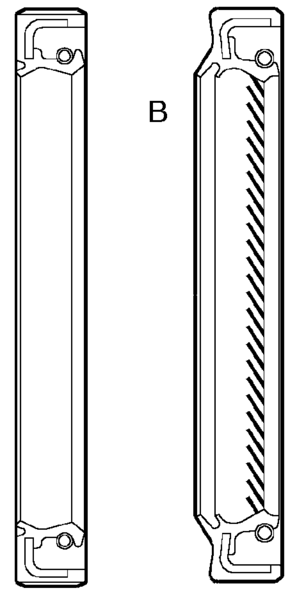


12M7050

21. Remove oil pressure switch.
22. Remove bolt securing camshaft sensor. Remove sensor from front cover.
23. Ensure mating faces of camshaft sensor and front cover are clean.
24. Refit sensor.
25. Refit sensor bolt. Tighten to ***8 Nm (6 lbf.ft)***
26. Ensure thread of oil pressure switch is clean.
27. Refit switch to front cover. Tighten to ***15 Nm (11 lbf.ft)***
28. Ensure water pump, its mating face, dowel and dowel hole are clean.
29. Refit water pump and new gasket.
30. Refit water pump bolts. Tighten to ***22 Nm (16 lbf.ft)***

Refit

31. Ensure cover, its mating face, dowels and dowel holes are clean.
32. Ensure crankshaft and oil pump mating faces are clean.
33. Ensure oil seal register in cover is clean.



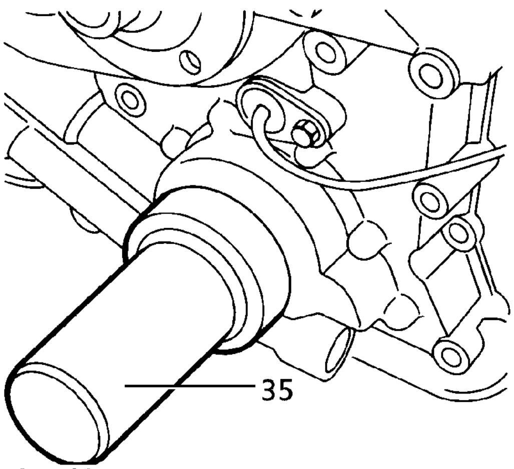
12M3678

A- Early type seal
B- Later type seal - use as replacement for all covers

34. Lubricate new front cover oil seal with Shell Retinax LX grease ensuring that space between seal lips is filled with grease.

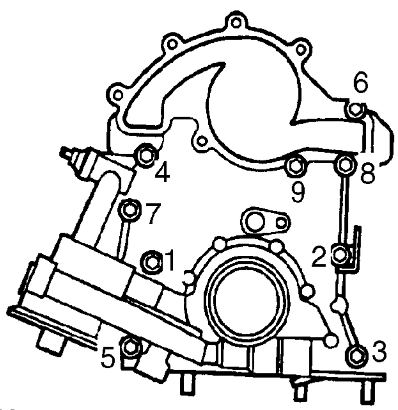
CAUTION: Do not use any other type of grease.

35. Using LRT-12-089, fit seal to cover.



12M7085

36. Fit alignment tool LRT-12-090 to end of crankshaft.
37. Position front cover gasket on engine.
38. Position front cover on engine, align pump drive gear with key in crankshaft. Fit cover onto dowels.



12M1398

39. Refit front cover bolts, tighten in sequence shown to ***22 Nm (16 lbf.ft).***
40. Align camshaft sensor multiplug bracket. Refit bolts. Tighten to ***22 Nm (16 lbf.ft)***
41. Connect camshaft sensor multiplug. Connect Lucar to oil pressure switch terminal.
42. Remove plugs from oil cooler hoses and cover.

CAUTION: Over tightening of oil cooler hose unions can crack front cover.

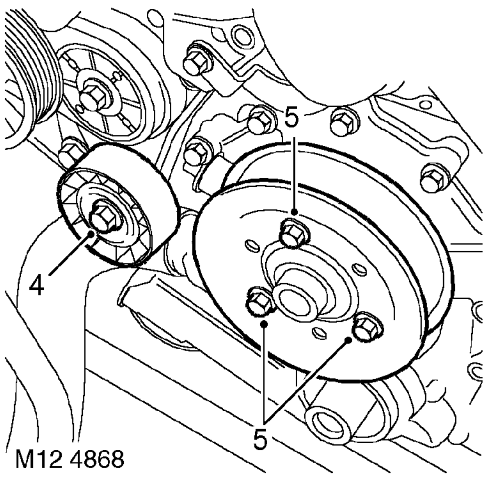
43. Fit new 'O' ring seals, reconnect hoses to cover. Tighten to ***15 Nm (11 lbf.ft)***
44. Reposition engine harness under auxiliary drive belt tensioner.
45. Refit tensioner and bolt. Tighten to ***50 Nm (37 lbf.ft)***
46. Refit bottom hose to water pump. Tighten clip.
47. Fit engine oil filter. ***See SECTION 10, Maintenance.***
48. Refit crankshaft pulley. ***See this section.***
49. Ensure oil pick up strainer is clean.
50. Refit strainer and new 'O' ring to engine.
51. Refit strainer bolts. Tighten to ***8 Nm (6 lbf.ft)***
52. Refit strainer nut to main bearing cap. Tighten to ***25 Nm (18 lbf.ft)***
53. Refit sump. ***See this section.***
54. Refill cooling system. ***See COOLING SYSTEM, Repair.***
55. Reconnect battery negative lead.

GASKET - FRONT COVER - from 99MY

Service repair no - 12.65.04

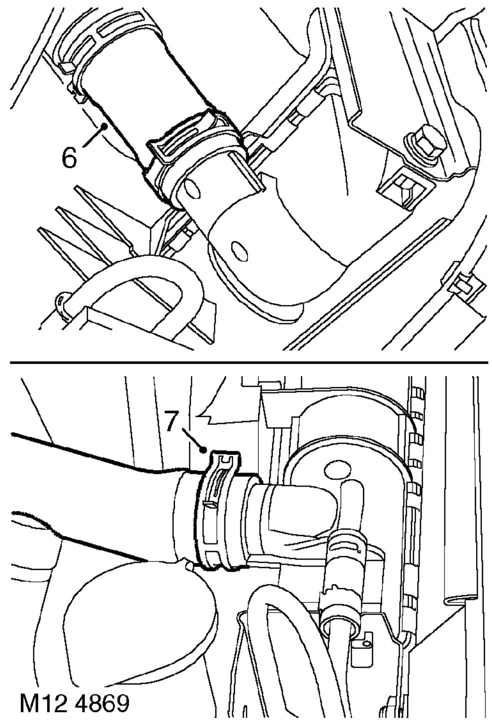
Remove

1. Remove oil pick-up strainer. ***See this section.***
2. Remove front cover oil seal. ***See this section.***
3. Drain cooling system. ***See COOLING SYSTEM, Repair.***



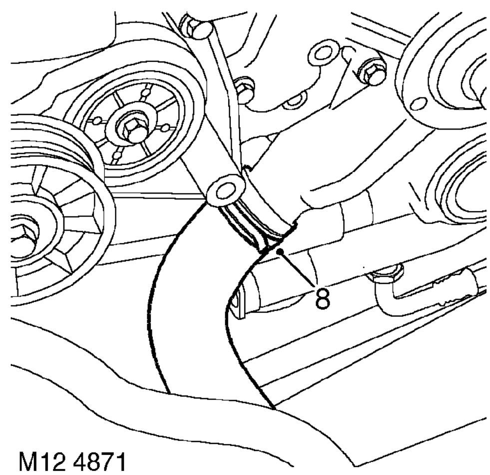
M12 4868

4. Remove bolt securing auxiliary belt jockey pulley and remove pulley.
5. Remove 3 bolts securing water pump pulley and remove pulley.



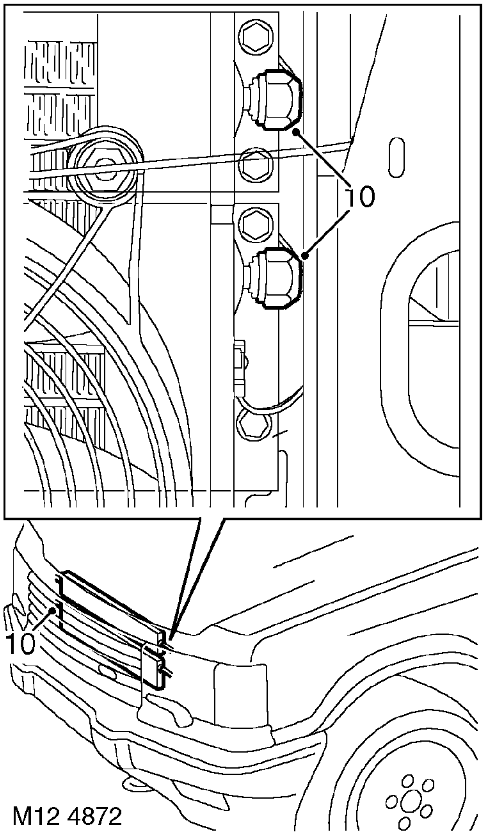
M12 4869

6. Release clip and disconnect bottom hose from radiator.
7. Release clip and disconnect top hose from radiator.



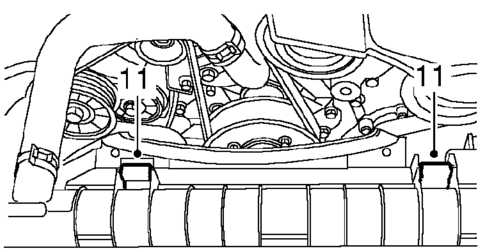
M12 4871

8. Release clip and disconnect coolant hose from water pump.
9. Release thermostat housing from radiator cowl and move hoses clear of front cover.



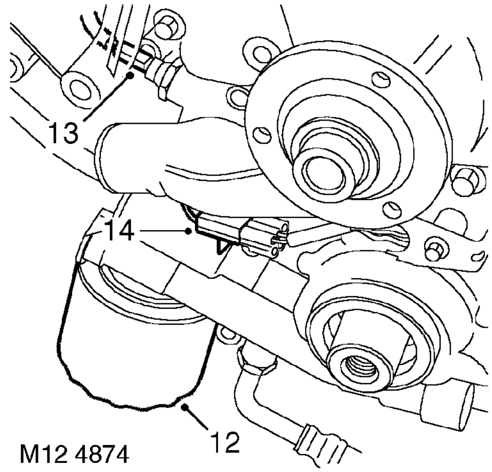
M12 4872

10. Position cloth to collect spillage and loosen both gearbox fluid cooler pipe unions and engine oil cooler inlet pipe union.



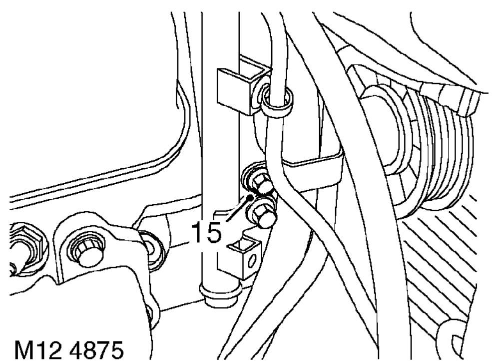
M12 4873

11. Remove 2 clips securing radiator cowl and remove cowl.



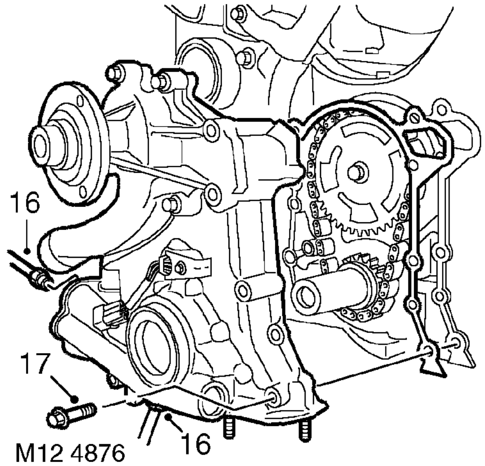
M12 4874

12. Remove engine oil filter.
13. Disconnect Lucar from oil pressure switch.
14. Disconnect multiplug from CMP sensor.



M12 4875

15. Remove bolt securing engine oil cooler return pipe to alternator bracket.



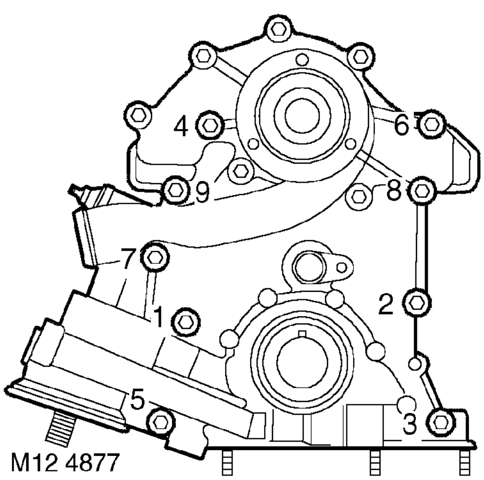
16. Loosen unions and disconnect oil cooler feed and return pipes from front cover , remove and discard 'O' rings.

CAUTION: Plug the connections.

17. Remove 9 bolts securing front gear cover and remove cover. Remove and discard gasket.

Refit

18. Clean mating faces of front cover and cylinder block. Clean dowels and dowel holes.
19. Fit new gasket onto dowels in cylinder block.



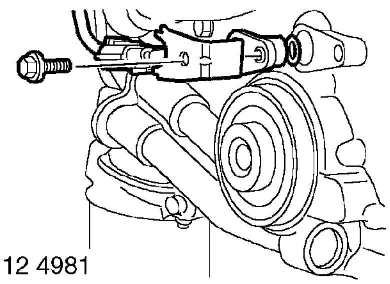
20. Fit front cover to cylinder block and tighten bolts in sequence shown to ***22 Nm (16 lbf.ft).*** *Ensure CMP sensor multiplug bracket is secured by bolt.*
21. Fit new 'O' rings to oil cooler pipes, connect pipes to front cover and tighten unions to ***15 Nm (11 lbf.ft).***
22. Fit bolt securing oil cooler return pipe to alternator mounting bracket.
23. Connect Lucar to oil pressure switch.
24. Connect multiplug to CMP sensor.
25. Ensure oil filter seal and mating face on front cover is clean.
26. Lubricate seal with clean engine oil and fit engine oil filter.
27. Fit radiator cowl and secure with clips.
28. Fit oil cooler pipes into recesses in radiator cowl and tighten pipe unions to ***30 Nm (22 lbf.ft).***
29. Fit thermostat housing to radiator cowl.
30. Connect bottom coolant hose to radiator and secure with clip.
31. Connect hose to water pump and secure with clip.
32. Connect top hose to radiator and secure with clip.
33. Ensure mating faces of water pump pulley and drive flange are clean, fit pulley and tighten bolts to ***22 Nm (16 lbf.ft).***
34. Fit auxiliary belt jockey pulley and tighten bolt to ***50 Nm (37 lbf.ft).***
35. Fit front cover oil seal. ***See this section.***
36. Fit oil pick-up strainer. ***See this section.***
37. Refill cooling system. ***See COOLING SYSTEM, Repair.***

FRONT COVER AND OIL PUMP ASSEMBLY

Service repair no - 12.60.26

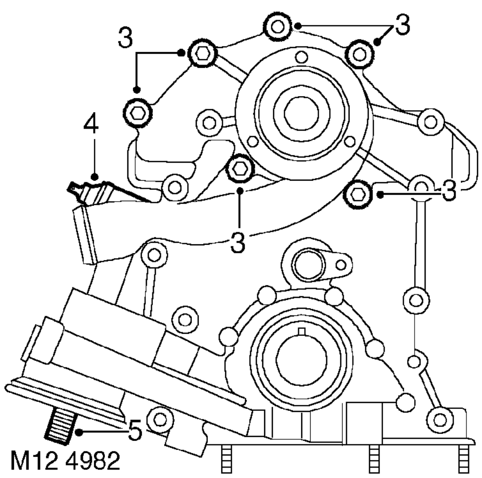
Remove

1. Remove front cover gasket *See this section.*



M12 4981

2. Remove bolt securing CMP sensor, remove clamp and sensor. Discard 'O' ring.



M12 4982

3. Remove 6 bolts securing water pump, remove pump and discard gasket.
4. Remove oil pressure switch and discard 'O' ring.
5. Remove oil filter cartridge. *See this section.*

Refit

6. Ensure oil filter cartridge adaptor thread is clean and apply Loctite 577 sealant to thread.
7. Ensure oil pressure switch and mating face is clean.
8. Fit new 'O' ring and tighten switch to ***15 Nm (11 lbf.ft).***
9. Clean water pump and mating face.
10. Use a new gasket and fit water pump. Tighten bolts securing water pump to ***22 Nm (16 lbf.ft).***
11. Ensure CMP sensor is clean, fit new 'O' ring and fit sensor to cover.
12. Fit clamp to CMP sensor and tighten bolt to ***8 Nm (6 lbf.ft).***
13. Fit front cover gasket. *See this section.*

ENGINE MOUNTINGS - up to 99MY

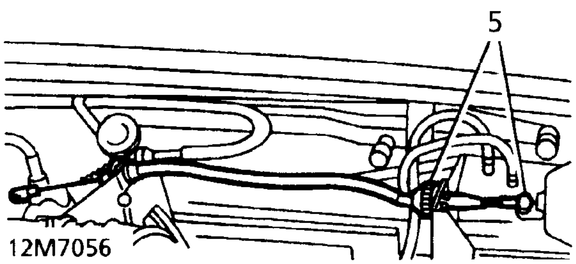
Service repair no - 12.45.01 - LH
Service repair no - 12.45.02 - RH

Remove

1. Disconnect battery negative lead.
2. With assistance, release bonnet struts from body locations. Retain bonnet in vertical position using stay clips.

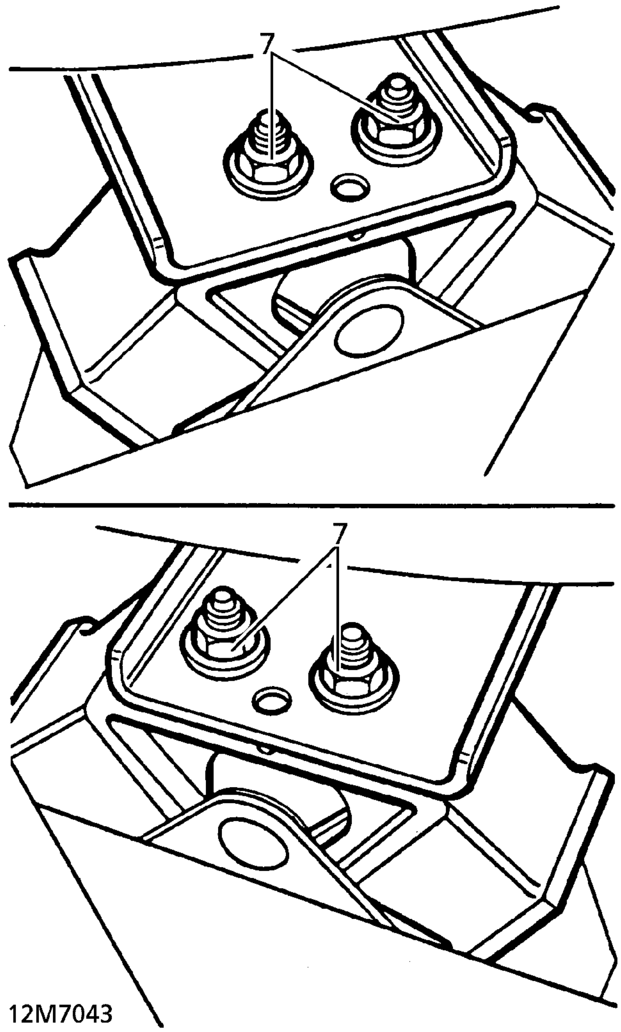
WARNING: Only open the bonnet to the vertical position with the vehicle on a horizontal surface in the workshop. This position is not intended to be used outdoors where the bonnet could be affected by winds.

3. **Right Hand Mounting Only:** Fit lifting eye to alternator bracket.
4. **RHD - Right Hand Mounting Only:** Remove steering column intermediate shaft. ***See STEERING, Repair.***
5. **Left Hand Mounting Only:** To prevent strain on cruise control cable, disconnect from abutment and actuator diaphragm.



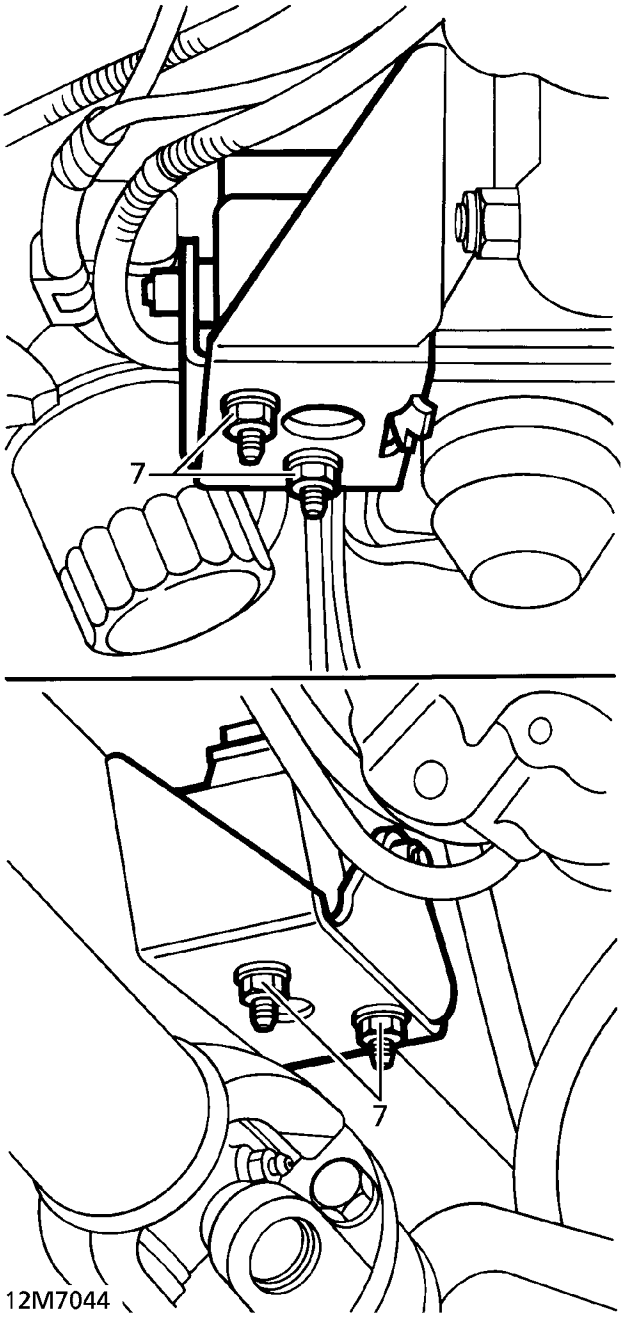
12M7056

6. Raise vehicle on four post lift.



12M7043

7. Remove 4 nuts securing mounting to chassis and engine. Discard nuts.



12M7044

8. Connect hoist to lifting eye. Raise relevant side of engine.

CAUTION: Raise engine by minimum necessary to remove mounting. Ensure ignition coils do not foul bulkhead.

9. Remove engine mounting.

Refit

10. Fit engine mounting. Ensure domed head of centre bolt faces toward chassis.
11. Align mounting studs. Lower engine. Disconnect hoist.
12. Fit new engine mounting flange nuts. Tighten to ***45 Nm (33 lbf.ft)***
13. Lower vehicle.
14. **Left Hand Mounting Only:** Connect cruise control cable to abutment bracket and actuator diaphragm.
15. Adjust cable free-play if necessary. ***See CRUISE CONTROL, Adjustment.***
16. **RHD - Right Hand Mounting Only:** Fit steering column intermediate shaft. ***See STEERING, Repair.***
17. **Right Hand Mounting Only:** Remove lifting eye from alternator bracket.
18. With assistance, release bonnet stay clips. Engage bonnet struts.

CAUTION: Ensure bonnet stay clips are returned to their original positions as shown.

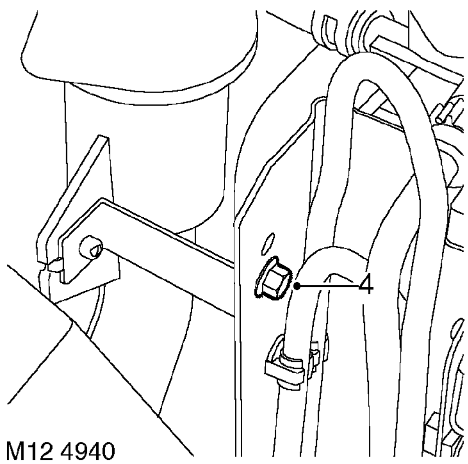
19. Reconnect battery negative lead.

ENGINE MOUNTINGS - from 99MY

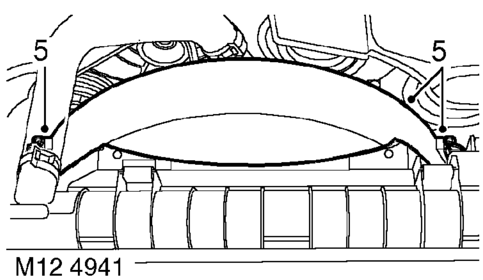
Service repair no - 12.45.11 - LH
Service repair no - 12.45.12 - RH

Remove

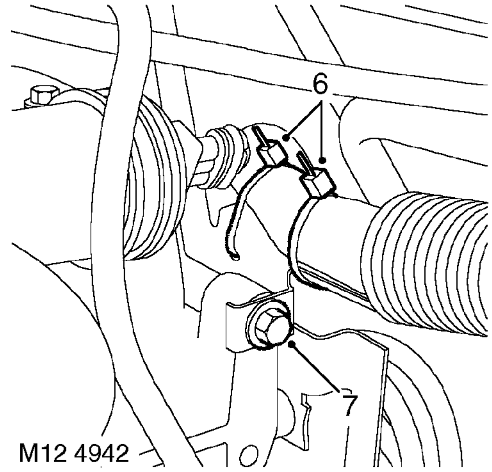
1. With assistance, release bonnet struts and retain bonnet in vertical position with stay clips.
2. Release fixings and remove battery cover.
3. Disconnect battery earth lead.



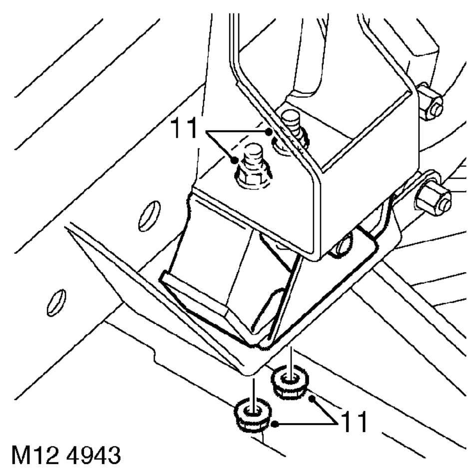
4. Remove bolt securing screen washer filler tube.



5. Release 2 clips and remove cooling fan cowl.



6. Remove ties securing harness to support bracket at rear of engine and move harness clear of bracket.
7. Remove bolt securing harness support bracket and remove bracket.
8. **Right hand engine mounting:** Fit suitable lifting eye to alternator fixing bolt.
9. **RHD - Right hand engine mounting:** Remove steering column intermediate shaft. ***See STEERING, Repair.***
10. Raise vehicle on 4 post ramp.



11. Remove and discard 4 nuts securing engine mounting.
12. Connect hoist to lifting eye and raise relevant side of engine.
13. Remove engine mounting.

Refit

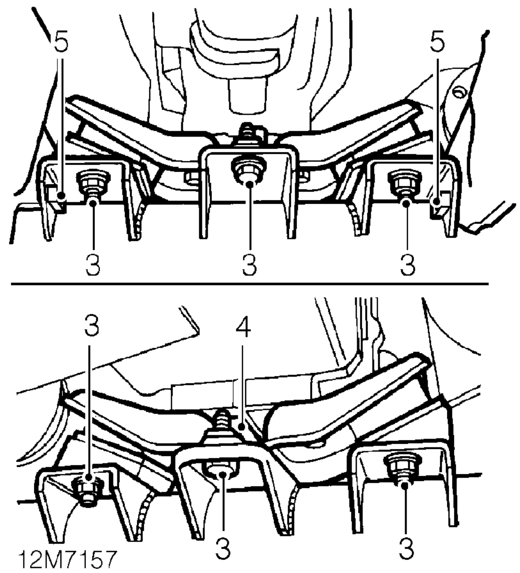
14. Fit engine mounting. Ensure domed head of centre bolt faces towards chassis.
15. Carefully lower engine onto mounting and disconnect hoist.
16. Fit new engine mounting nuts and tighten to ***45 Nm (33 lbf.ft).***
17. Lower vehicle.
18. **RHD - Right hand engine mounting:** Fit steering column intermediate shaft ***See STEERING, Repair.***
19. **Right hand mounting:** Remove lifting eye from alternator fixing bolt.
20. Fit harness support bracket and secure with bolt.
21. Lay harness onto bracket and secure with cable ties.
22. Fit cooling fan cowl and secure with clips.
23. Fit bolt to secure screen washer reservoir filler tube.
24. Connect battery earth lead.
25. Fit battery cover and secure with fixings.
26. With assistance, release bonnet stay clips and engage bonnet struts.

REAR ENGINE MOUNTING

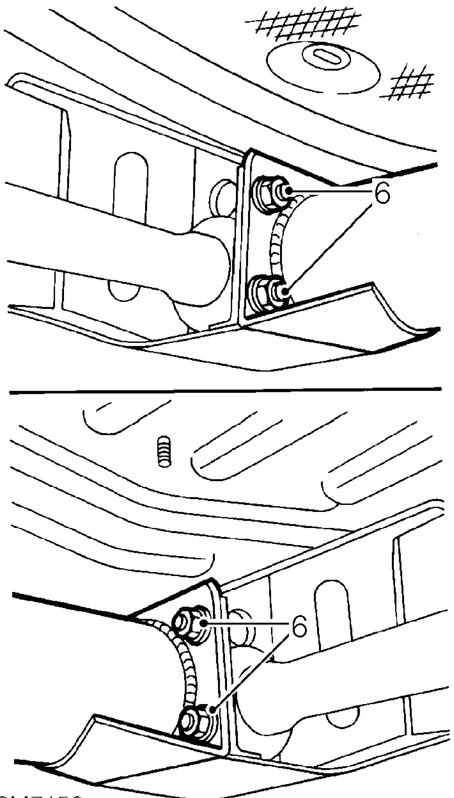
Service repair no - 12.45.08

Remove

1. Raise vehicle on 4 post ramp.
2. Support transmission using a suitable stand.

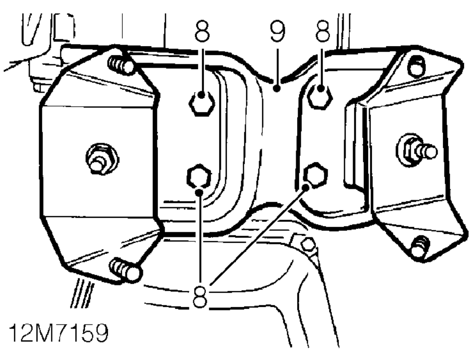


3. Remove 4 nuts and 2 bolts securing mounting to crossmember and discard nuts.
4. Remove transmission snubber bar.
5. If applicable, remove 2 bolts securing rear of gearbox side acoustic covers to crossmember.



12M7158

6. Remove 3 of 4 nuts and bolts securing each side of crossmember to chassis.
7. With assistance, remove remaining bolt securing crossmember and remove crossmember.



12M7159

8. Remove 4 bolts securing mounting to gearbox.
9. Remove mounting assembly.

Refit

CAUTION: Ensure all under body wax is removed from mating surfaces of fixings before fitting.

10. Fit mounting to gearbox, fit bolts and tighten to ***45 Nm (33 lbf.ft)***
11. Using assistance, fit crossmember to chassis.
12. Fit nuts and bolts and tighten to ***45 Nm (33 lbf.ft)***
13. Fit transmission snubber bar.
14. Fit NEW flange nuts and bolts securing transmission mount to crossmember and tighten to ***45 Nm (33 lbf.ft)***
15. Remove transmission stand.
16. If applicable, align rear of side acoustic covers to crossmember and secure with bolts.

OIL FILTER

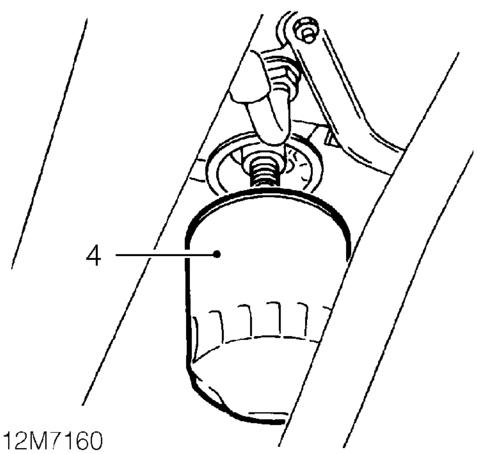
Service repair no - 12.60.04

Remove

1. Raise front of vehicle.

WARNING: Support on safety stands.

2. Remove engine acoustic cover (if applicable). ***See CHASSIS AND BODY, Repair.***
3. Position drain tray to catch spillage.



12M7160

4. Remove oil filter cartridge.

Refit

5. Clean mating face of oil pump.
6. Lubricate oil filter seal with clean engine oil.
7. Fit oil filter and tighten until rubber seal contacts machined face. Tighten a further half turn by hand.

CAUTION: DO NOT overtighten oil filter.

8. Run engine to allow oil to fill filter.
9. Stop engine, check and top up oil level. ***See LUBRICANTS, FLUIDS AND CAPACITIES, Information.***
10. Fit engine acoustic cover (if applicable). ***See CHASSIS AND BODY, Repair.***
11. Remove stand(s) and lower vehicle.

OIL COOLER

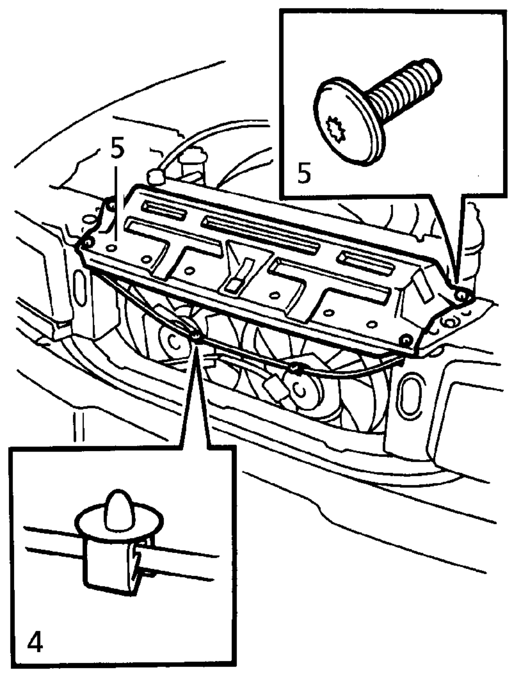
Service repair no - 12.60.68

Remove

1. Disconnect battery negative lead.
2. Raise the vehicle.

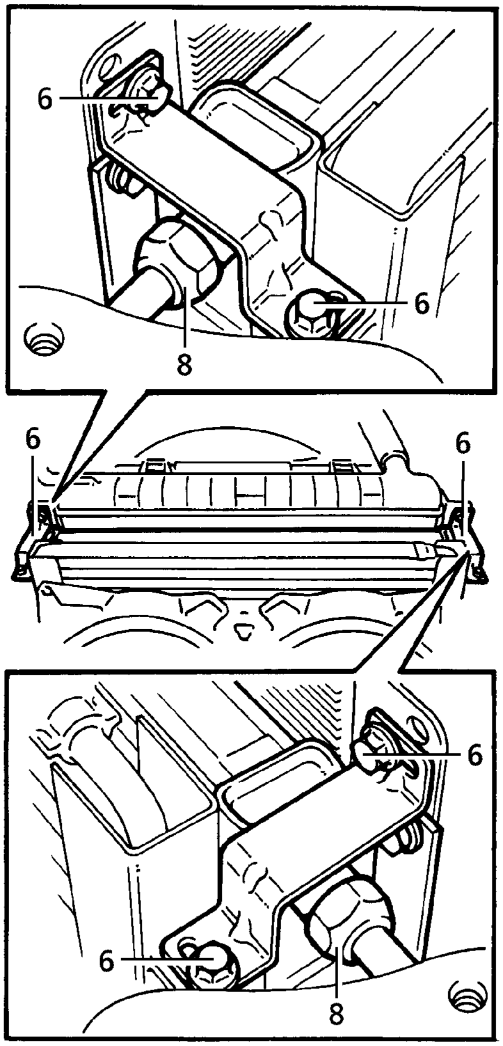
WARNING: Support on safety stands.

3. Remove front grille. ***See CHASSIS AND BODY, Repair.***
4. Release 2 clips securing bonnet release cable to bonnet platform.



12M7057

5. Remove 4 bolts securing bonnet platform. Remove platform.
6. Remove 4 bolts from condenser mounting brackets. Collect 2 brackets.



12M7058

7. Position container to catch oil spillage.
8. Disconnect pipes from oil cooler. Remove 'O' rings and discard.
9. Remove 2 bolts securing oil cooler to radiator bracket.
10. Remove oil cooler.

Refit

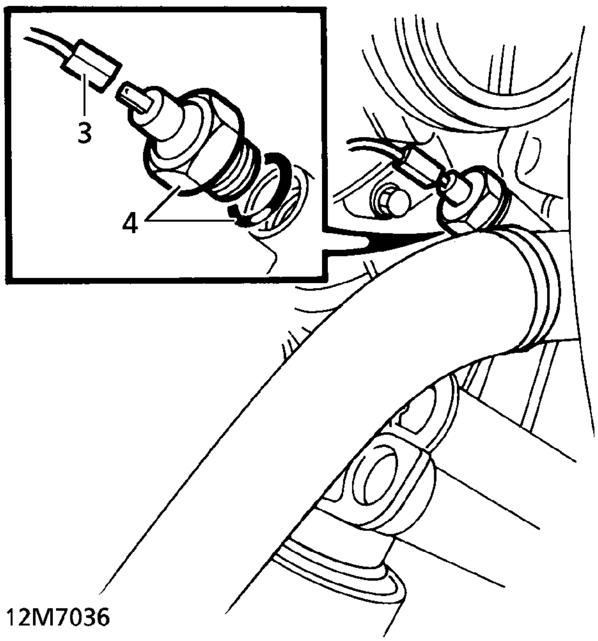
11. Position oil cooler to radiator bracket. Secure with bolts.
12. Using new 'O' rings, connect pipes to oil cooler. Tighten unions to ***30 Nm (22 lbf.ft)***
13. Remove container.
14. Position condenser brackets. Secure with bolts.
15. Fit bonnet platform. Secure with bolts.
16. Secure release cable to bonnet platform with clips.
17. Fit front grille. ***See CHASSIS AND BODY, Repair.***
18. Remove safety stands. Lower vehicle.
19. Reconnect battery negative lead.
20. Check engine oil level. Top-up if necessary.

OIL PRESSURE SWITCH - up to 99MY

Service repair no - 12.60.50

Remove

1. Disconnect battery negative lead.
   Remove cooling fan. ***See COOLING SYSTEM, Repair.***
2. Remove alternator drive belt tensioner. ***See ELECTRICAL, Repair.***
3. Disconnect Lucar from oil pressure switch.
4. Remove switch and discard 'O' ring.



12M7036

Refit

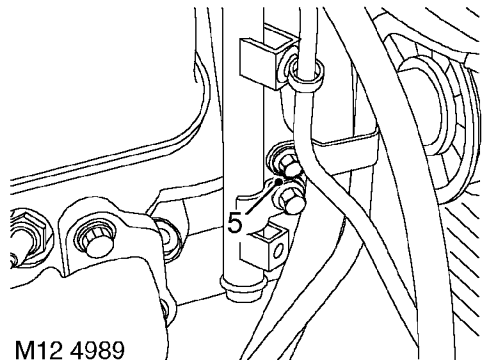
5. Ensure switch thread and seating in front cover are clean.
6. Lubricate new 'O' ring with clean engine oil. Fit to switch.
7. Fit switch. Tighten to ***15 Nm (11 lbf.ft)***
8. Refit alternator drive belt tensioner. ***See ELECTRICAL, Repair.***
9. Fit cooling fan. ***See COOLING SYSTEM, Repair.***
10. Reconnect battery negative lead.

OIL PRESSURE SWITCH - from 99MY

Service repair no - 12.60.50

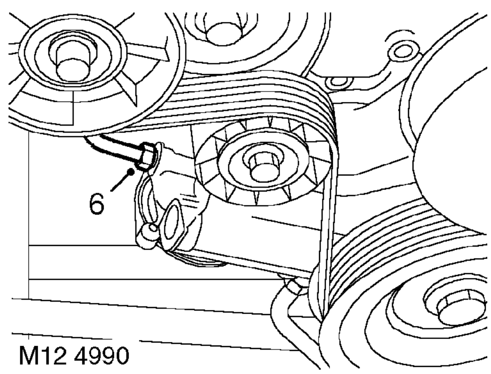
Remove

1. Release fixings and remove battery cover.
2. Disconnect battery earth lead.
3. Raise vehicle on 4 post ramp.
4. Remove oil filter. ***See this section.***



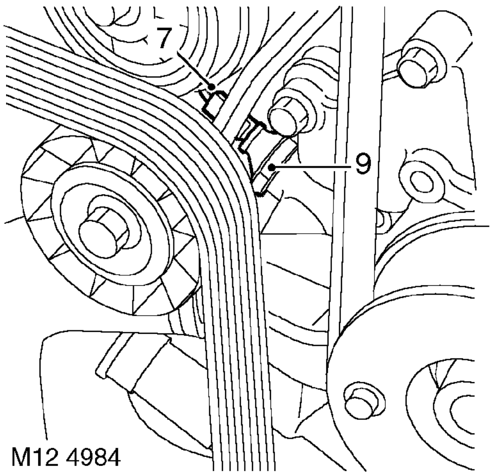
M12 4989

5. Remove bolt securing engine oil cooler return pipe to alternator support bracket.



M12 4990

6. Loosen union and remove oil cooler return pipe.



7. Disconnect Lucar from oil pressure switch.
8. Position container below switch to catch oil spillage.
9. Remove oil pressure switch and discard 'O' ring.

Refit

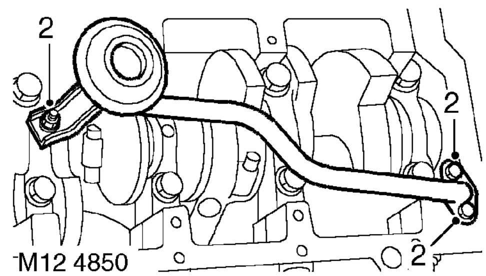
10. Clean oil pressure switch threads.
11. Fit new 'O' ring to switch.
12. Fit oil pressure switch and tighten to ***15 Nm (11 lbf.ft).***
13. Connect Lucar.
14. Ensure oil cooler return pipe union is clean and fit new 'O' ring to pipe.
15. Align oil cooler return pipe to alternator support bracket and fit but do not tighten bolt at this stage.
16. Tighten oil cooler return pipe union to ***15 Nm (11 lbf.ft).***
17. Tighten bolt securing oil cooler return pipe to alternator support bracket.
18. Fit oil filter. ***See this section.***
19. Connect battery earth lead.
20. Fit battery cover and secure with fixings.
21. Top up engine oil.

STRAINER - OIL PICK-UP

Service repair no - 12.60.20

Remove

1. Remove sump gasket. ***See this section.***



2. Remove 2 bolts and 1 nut securing oil pick-up strainer.
3. Remove oil pick-up strainer.
4. Collect spacer from stud.
5. Remove and discard 'O'ring.

Refit

6. Clean oil pick-up strainer and 'O' ring recess.
7. Lubricate and fit new 'O' ring.
8. Locate spacer on stud.
9. Position oil pick-up strainer, fit and tighten, bolts to ***10 Nm (7 lbf.ft)*** *and, nut to* ***22 Nm (17 lbf.ft).***
10. Fit new sump gasket. ***See this section.***

ROCKER COVER GASKET - up to 99MY

Service repair no - 12.29.39 - Gaskets - Pair
Service repair no - 12.29.40 - LH Cover Gasket
Service repair no - 12.29.41 - RH Cover Gasket

Remove

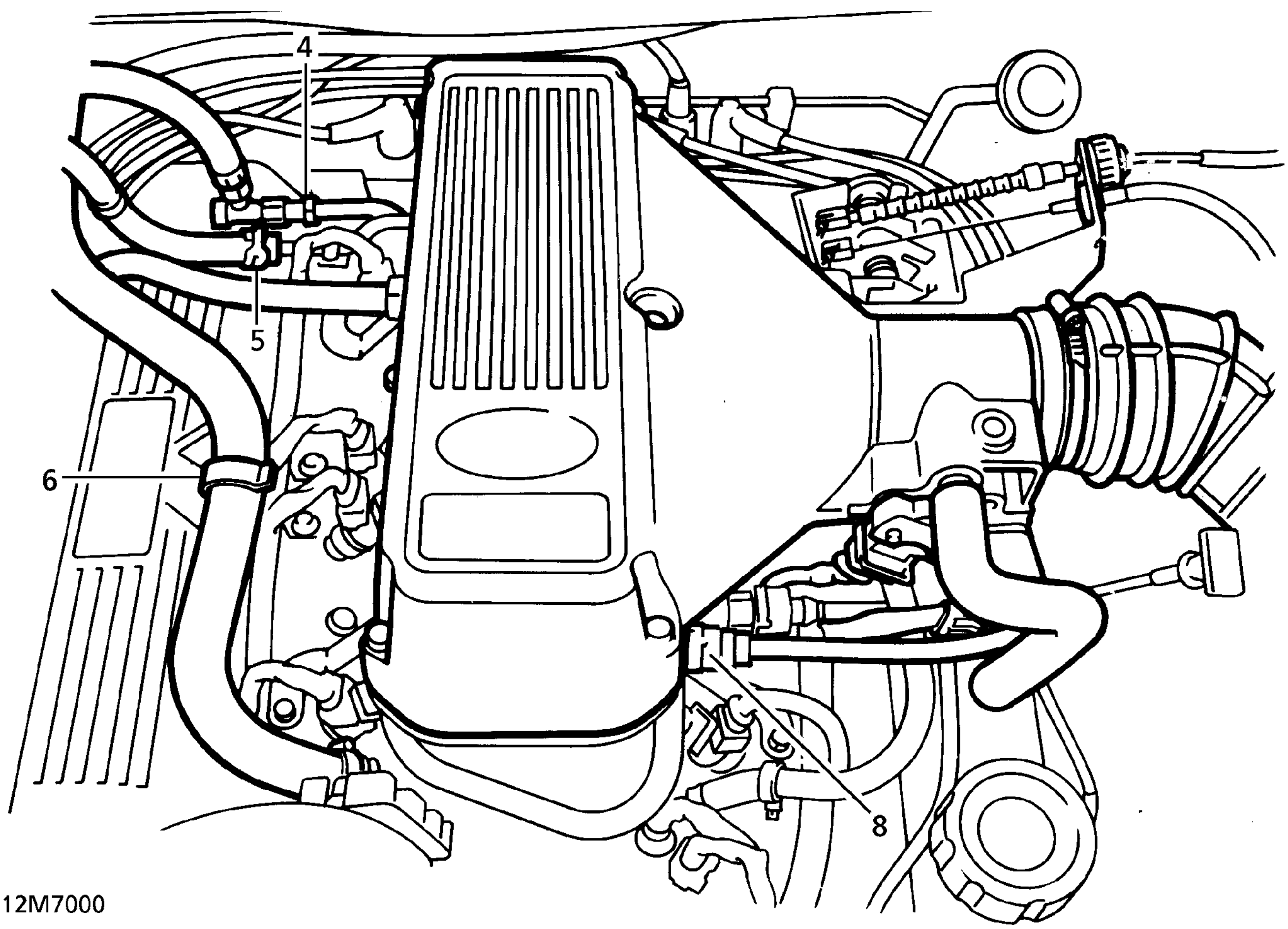
1. Disconnect battery negative lead.
2. Disconnect crankcase breather hose from cover.

NOTE: Instructions 3,4,5 & 6 apply to *RH Cover Only.*

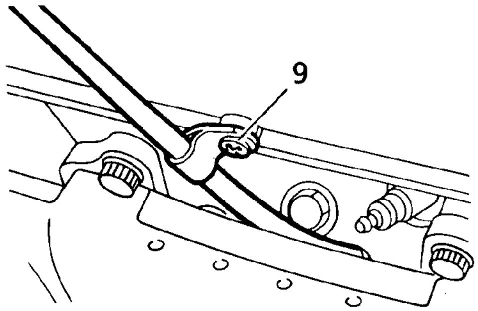
3. Depressurise fuel system. ***See FUEL SYSTEM, Repair.***
4. Remove fuel feed pipe from fuel rail.
5. Release fuel pressure regulator return pipe from clip.
6. Release heater hose from clip on inlet manifold.

NOTE: Instructions 7,8 & 9 apply to *LH Cover Only.*

7. Release plenum chamber. Place aside for access. ***See FUEL SYSTEM, Repair.***
8. Release purge hose from ram pipe housing. Place hose aside.

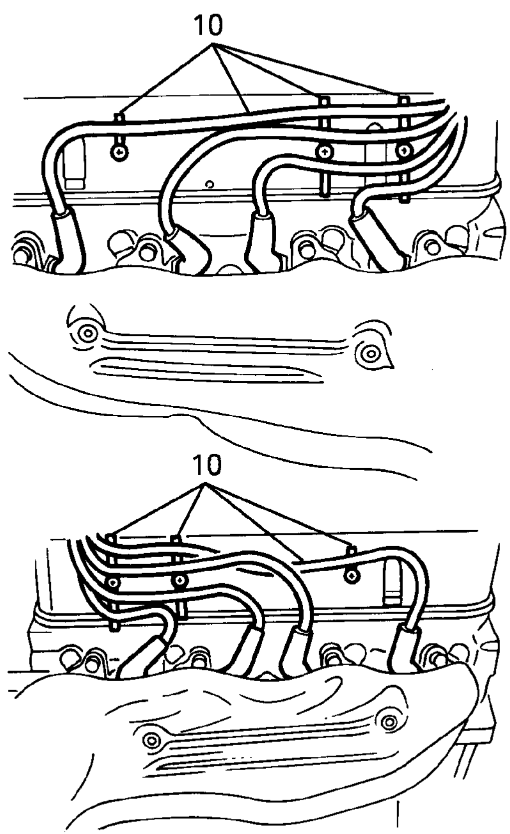


12M7000



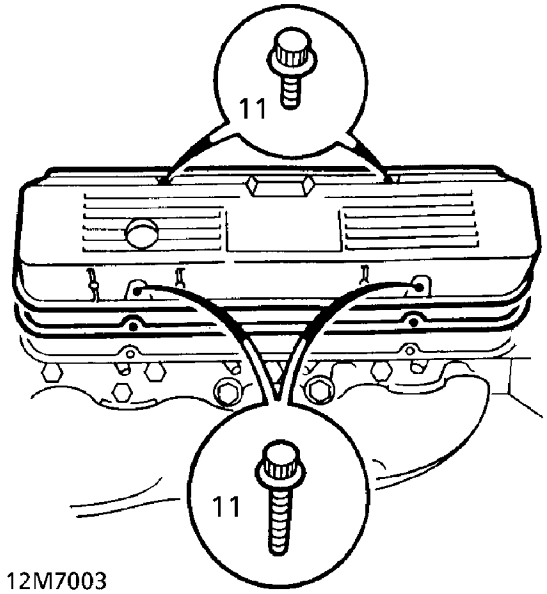
12M7001

9. Remove screw securing dipstick tube to rocker cover.
10. Remove H.T. leads from spark plugs and guide clips on rocker covers.



12M7002

11. Remove 4 bolts securing rocker cover to cylinder head.



12M7003

12. Remove rocker cover.
13. Remove and discard rocker cover gasket.

Refit

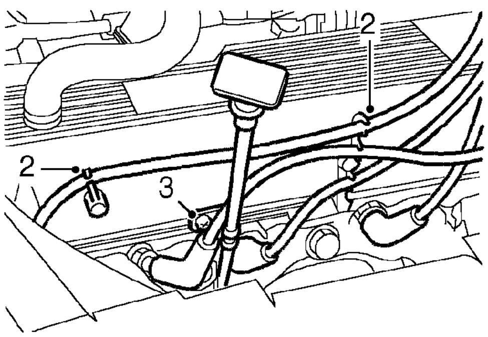
14. Clean mating faces between rocker cover and cylinder head.
15. Refit rocker cover to cylinder head using a new gasket.
16. Fit rocker cover bolts and tighten by diagonal selection to :
    Stage 1 - ***4 Nm (3 lbf.ft)***
    Stage 2 - ***8 Nm (6 lbf.ft)***
    Stage 3 - Re-torque to ***8 Nm (6 lbf.ft)***
17. Refit H.T. leads to spark plugs. Secure leads to rocker cover clips.
18. Align dipstick tube. Secure to rocker cover with screw.
19. Reconnect purge hose to ram pipe housing.
20. Refit plenum chamber. ***See FUEL SYSTEM, Repair.***
21. Secure heater hose to clip on inlet manifold.
22. Secure fuel pressure regulator return pipe in clip.
23. Reconnect fuel feed pipe to fuel rail.
24. Reconnect breather hose to rocker cover.
25. Reconnect battery negative lead.

ROCKER COVER GASKET (LH) - from 99MY

Service repair no - 12.29.40

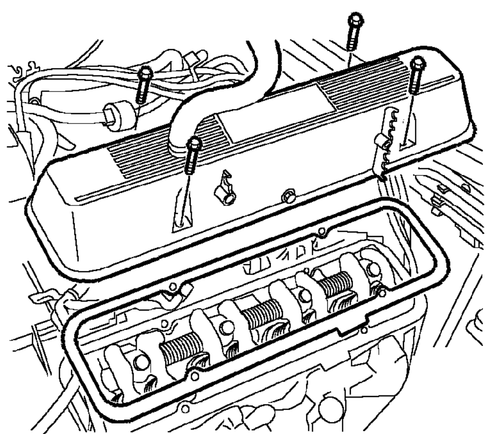
Remove

1. Remove upper inlet manifold gasket ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***



M12 4867

2. Release HT leads from clips on rocker cover.
3. Remove screw securing dip stick tube.



M12 4343

4. Remove and discard 4 bolts securing rocker cover.
5. Remove rocker cover and gasket.

Refit

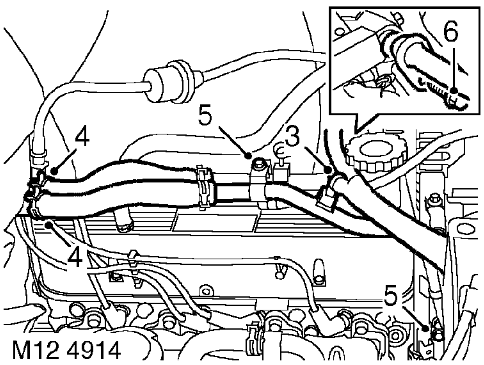
6. Clean mating faces of rocker cover and cylinder head.
7. Position new gasket on cylinder head.
8. Locate rocker cover on gasket and install securing bolts.
9. Ensure gasket outer rim is correctly located around periphery of rocker cover, then tighten bolts in diagonally opposite sequence to:
   Stage 1 - ***3 Nm (2.2 lbf.ft).***
   Stage 2 - ***7 Nm (5.2 lbf.ft).***
10. Fit and tighten screw securing dip stick tube.
11. Fit plug leads to clips on rocker cover.
12. Fit upper inlet manifold gasket. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***

ROCKER COVER GASKET (RH) - from 99MY

Service repair no - 12.29.41

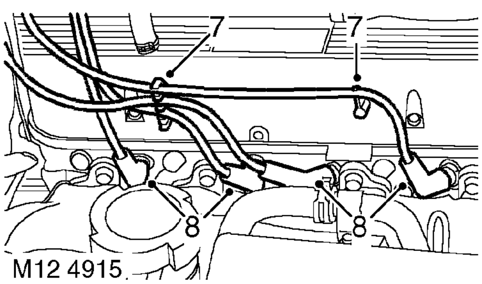
Remove

1. Drain cooling system. ***See COOLING SYSTEM, Repair.***
2. Remove upper inlet manifold gasket. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***



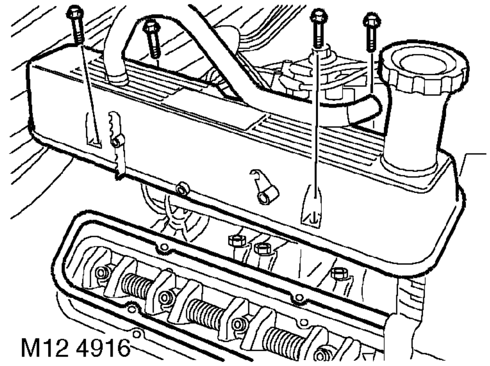
M12 4914

3. Release engine harness clip from coolant rail and move harness clear of rocker cover.
4. Release clips and disconnect coolant hoses from heater.
5. Remove 2 bolts securing coolant rails and move outer rail clear of rocker cover.
6. Remove bolt securing inner coolant rail to inlet manifold, remove rail and discard 'O' ring.
7. Release HT leads from clips on rocker cover.



M12 4915

8. Disconnect HT leads from spark plugs and move clear of rocker cover.



M12 4916

9. Remove and discard 4 bolts securing rocker cover.
10. Remove rocker cover and gasket.

Refit

11. Clean mating faces of rocker cover and cylinder head.
12. Position new gasket on cylinder head.
13. Locate rocker cover on gasket and install securing bolts.
14. Ensure gasket outer rim is correctly located around periphery of rocker cover, then tighten bolts in diagonally opposite sequence to:
    Stage 1 - ***3 Nm (2.2 lbf.ft).***
    Stage 2 - ***7 Nm (5.2 lbf.ft).***
15. Connect HT leads to spark plugs and fit leads to clips on rocker cover.
16. Clean coolant rail 'O' ring recess.
17. Lubricate and fit new 'O' ring to coolant rail, fit rail to inlet manifold and tighten bolt to ***22 Nm (16 lbf.ft).***
18. Align outer coolant rail and fit and tighten bolts.
19. Connect coolant hoses to heater and secure with clips.
20. Reposition engine harness and secure with clip to coolant rail.
21. Fit upper inlet manifold gasket. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***
22. Refill cooling system. ***See COOLING SYSTEM, Repair.***

ROCKER SHAFT - OVERHAUL

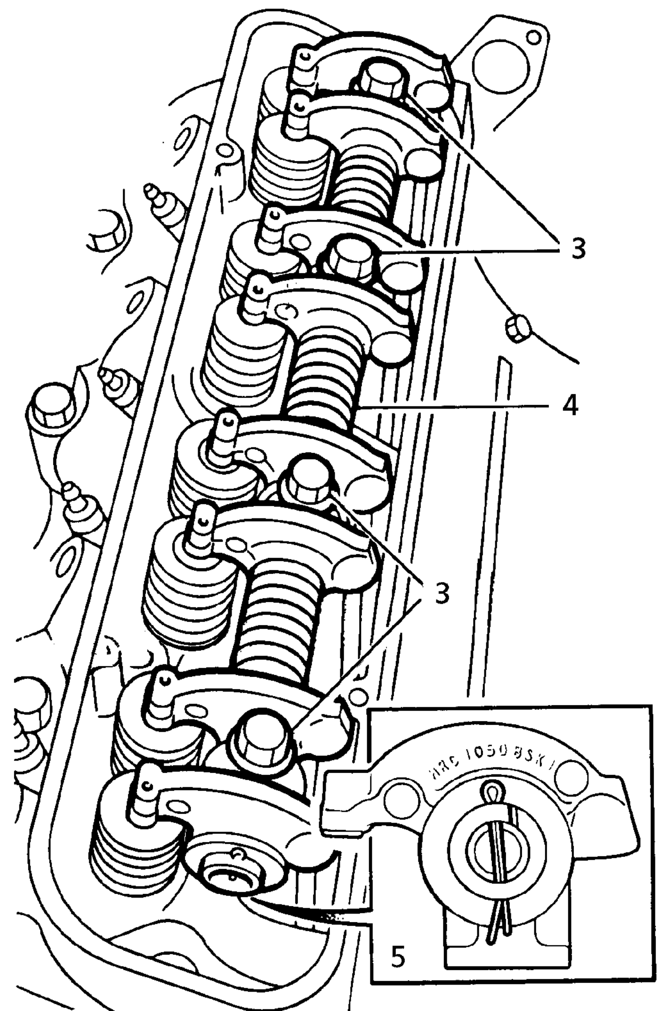
Service repair no - 12.29.49 - LH Shaft
Service repair no - 12.29.50 - RH Shaft
Service repair no - 12.29.55 - Both Shafts

Remove

1. Disconnect battery negative lead.
2. Remove relevant rocker cover. ***See this section.***

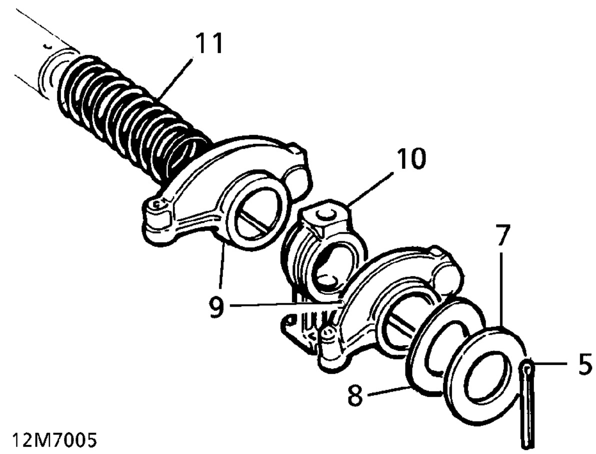
NOTE: If both shafts are to be removed, identify each assembly to ensure refitment on original cylinder bank.

3. Remove 4 bolts securing rocker shaft assembly.



12M7004

4. Remove rocker shaft assembly. Ensure pushrods remain seated in tappets.
Do not carry out further dismantling if component is removed for access only.
5. Remove and discard split pin from one end of rocker shaft.



12M7005

6. Remove the following components:

NOTE: Retain components in correct sequence for re-assembly.

7. Plain washer.
8. Wave washer.
9. Rocker arms.
10. Rocker pillars.
11. Springs.
12. Clean all components.
13. Inspect all components for wear.
14. Inspect rocker shaft and bores in rocker arms. If excessively worn or scored, fit new components.
15. Replace all weak or broken springs.
16. Lubricate all moving parts with clean engine oil.
17. Re-assemble rocker shafts. Ensure that components are returned to their original positions, use new split pins to retain components.
18. Ensure shaft identification groove is positioned at one o'clock, with pushrod locations of rocker arms to the right.

CAUTION: Oil feed restriction will result if rocker shafts are incorrectly assembled.

Refit

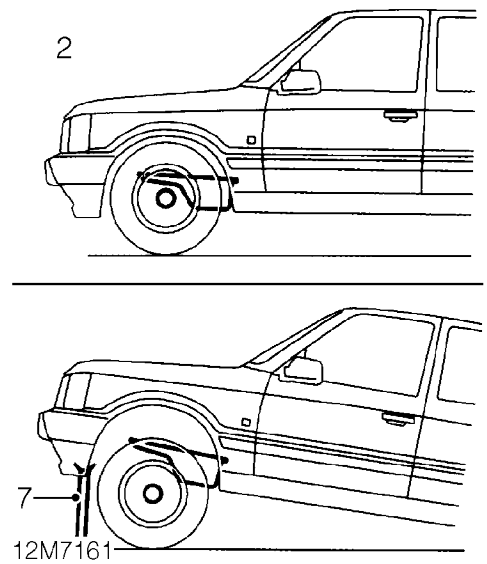
19. Refit rocker shaft to original cylinder bank.
20. Engage push-rods in rocker arm locations.
21. Refit rocker shaft securing bolts. Tighten working from centre outwards to ***38 Nm (28 lbf.ft).***
22. Refit rocker cover. ***See this section.***
23. Reconnect battery negative lead.

SUMP - up to 99MY

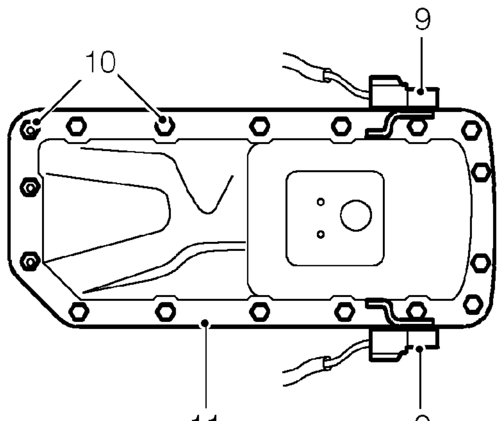
Service repair no - 12.60.44

Remove

1. Disconnect battery earth lead.



2. Raise vehicle on 4 post ramp.
3. Remove engine acoustic cover (if applicable). ***See CHASSIS AND BODY, Repair.***
4. Remove gearbox acoustic cover (if applicable). ***See CHASSIS AND BODY, Repair.***
5. Remove engine oil dip stick.
6. Drain engine oil from sump. Refit sump plug.
7. Position support under chassis front crossmember.
8. Lower ramp to give clearance between front axle and sump.

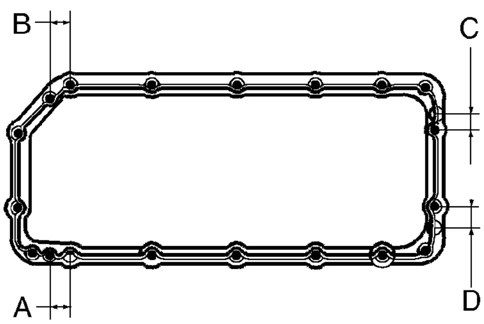


12M7162

9. Release 2 heated oxygen sensor multiplugs from sump brackets.
10. Remove 3 nuts and 14 bolts securing sump to cylinder block.
11. Remove sump.

Refit

12. Clean sealant from mating faces of sump and cylinder block.

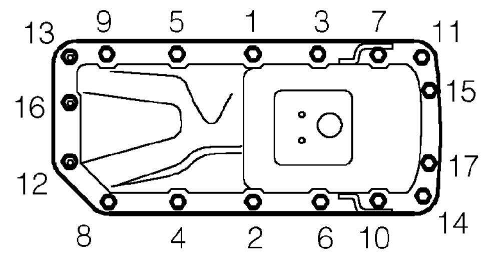


12M4239

13. Apply a bead of Hylosil type 101 or 106 sealant to joint face of sump as shown.
    Bead width - areas A, B, C and D = 12 mm (0.5 in)
    Bead width - remaining areas = 5 mm (0.20 in)
    Bead length - areas A and B = 32 mm (1.23 in)
    Bead length - remaining areas = 19 mm (0.75 in)

CAUTION: Do not spread sealant bead. Sump must be fitted immediately after applying sealant bead.

14. Position sump to cylinder block taking care not to disturb sealant bead.



12M7163

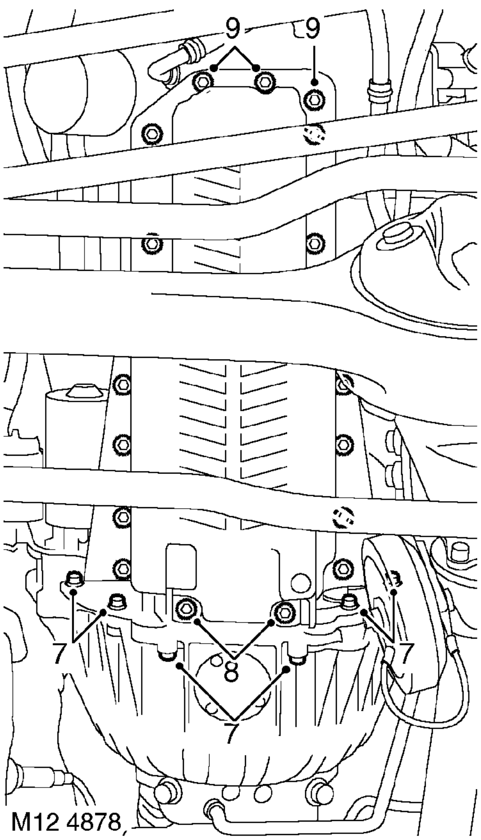
15. Fit nuts and bolts securing sump to cylinder block and tighten in the sequence shown to ***23 Nm (17 lbf.ft)*** .
16. Fit sump plug and tighten to ***45 Nm (33 lbf.ft).***
17. Engage oxygen sensor multiplugs to sump brackets.
18. Fit engine acoustic cover (if applicable). ***See CHASSIS AND BODY, Repair.***
19. Fit gearbox acoustic cover (if applicable). ***See CHASSIS AND BODY, Repair.***
20. Raise ramp and remove support.
21. Lower vehicle.
22. Fill engine oil. ***See LUBRICANTS, FLUIDS AND CAPACITIES, Information.***
23. Fit dip stick.

SUMP GASKET - from 99MY

Service repair no - 12.60.38

Remove

1. Release fixings and remove battery cover.
2. Disconnect battery earth lead.
3. Remove dipstick.
4. Raise vehicle on ramp
5. Drain engine oil. ***See LUBRICANTS, FLUIDS AND CAPACITIES, Information.***
6. Raise front of vehicle under body to increase clearance between engine and front axle.

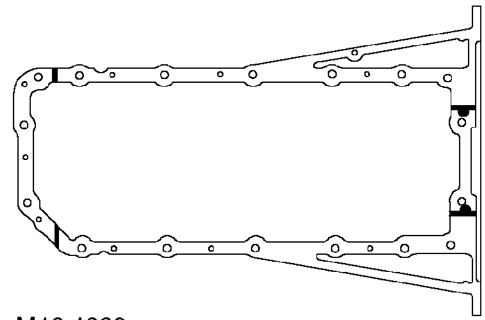


M12 4878

7. Remove 2 forward facing and 4 rearward facing bolts securing sump to bell housing.
8. Remove 2 bolts in sump recess.
9. Remove 3 nuts securing front of sump.
10. Remove 12 bolts securing sump flange to engine.
11. Manoeuvre sump over front axle and remove sump.
12. Discard sump gasket.

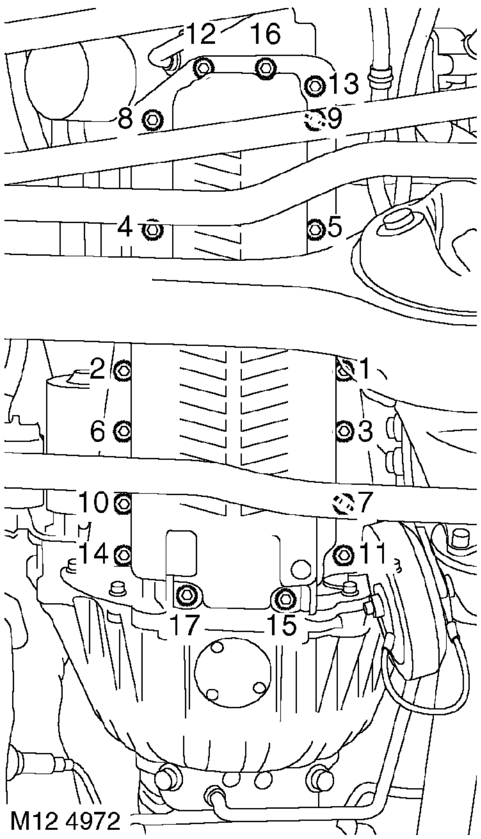
Refit

13. Clean all traces of RTV sealant from sump and sump mating faces using a wide, flat-bladed implement or solvent.



M12 4669

14. Apply a bead of RTV sealant 5mm wide across the cylinder block to front cover joint and across the cylinder block to rear main bearing joint. Apply a globule of RTV to cover end of cruciform seal, (see illustration).
15. Fit new gasket to sump, ensuring that locating tags are correctly positioned.



16. Fit sump and tighten sump bolts and nuts in sequence illustrated to ***23 Nm (17 lbf.ft).***
17. Fit and tighten bolts securing sump to bell housing to ***45 Nm (33 lbf.ft).***
18. Lower vehicle.
19. Refill engine oil and fit dip stick.
20. Connect battery earth lead.
21. Fit battery cover and secure with fixings.

TAPPETS - ENGINE SET

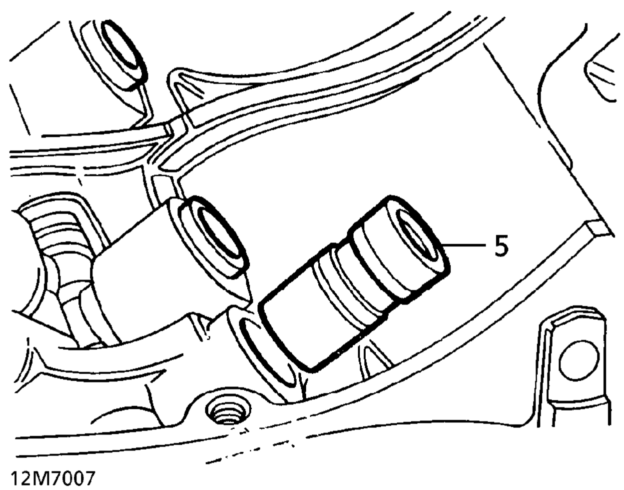
Service repair no - 12.29.57

Remove

1. Disconnect battery negative lead.
2. Remove inlet manifold gasket. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***
3. Remove both rocker shaft assemblies. ***See this section.***

NOTE: Identify each rocker shaft assembly to ensure refitment on original cylinder bank.

4. Remove pushrods, retain in fitted order.
5. Remove tappets.



NOTE: If tappets are to be refitted, retain with respective pushrods.

6. Clean tappets.
7. Check for even, circular wear patterns on camshaft contact area.

NOTE: If contact area is pitted, or square wear patterns have developed, renew tappets. Inspect camshaft lobes for excessive wear.

8. Inspect tappet body for excessive wear or scoring.

NOTE: If scoring or deep wear patterns extend up to oil feed area, replace tappet.

9. Inspect pushrod seats in tappets. If surface is rough or pitted, replace tappet.
10. Clean and inspect tappet bores in engine block.
11. Ensure that tappets rotate freely in their respective bores.
12. Inspect pushrods for straightness.
13. Inspect pushrod contact surfaces. If surfaces are rough or pitted, replace pushrod.
14. Inspect pushrod seats in valve rocker arms. If surfaces are rough or pitted, replace rocker arm.

Refit

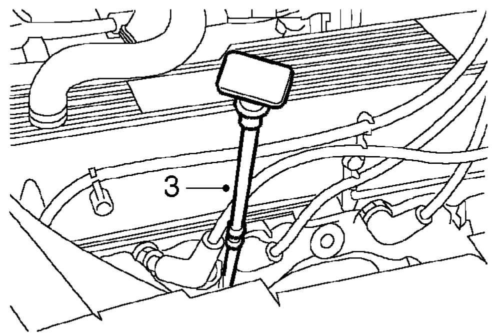
15. Immerse tappets in clean engine oil.
16. Lubricate tappet bores with clean engine oil.
17. Refit tappets in removed order.
18. Refit pushrods in removed order.
19. Refit rocker shaft assemblies. ***See this section.***
20. Refit inlet manifold gasket. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***
21. Reconnect battery negative lead.

CYLINDER HEAD GASKET (LH) - from 99MY

Service repair no - 12.29.02

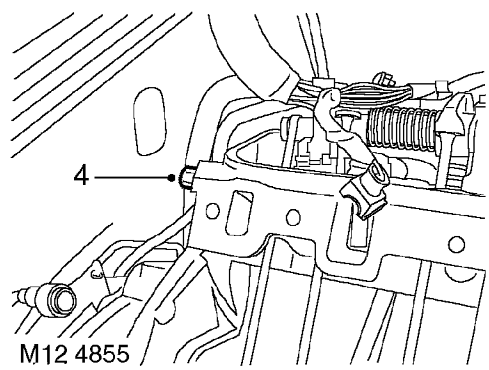
Remove

1. Remove inlet manifold gasket ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***
2. Remove exhaust manifold gasket ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***



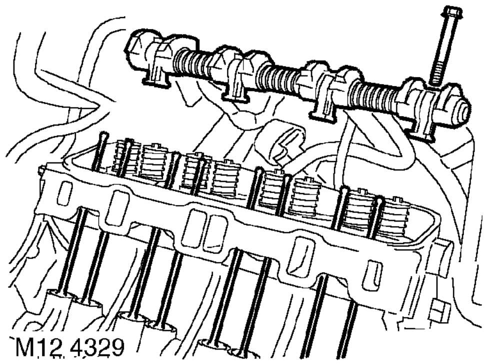
M12 4879

3. Remove dipstick and dipstick tube. Remove four screws securing rocker cover and remove rocker cover.



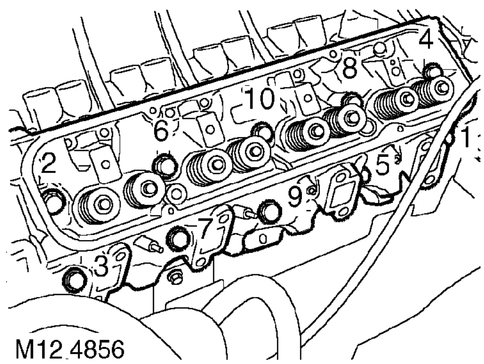
M12 4855

4. Remove bolt securing engine harness to rear of cylinder head.

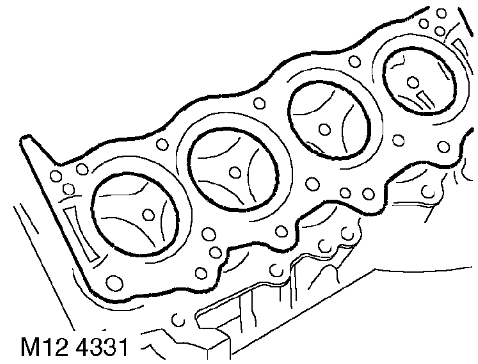


5. Progressively remove 4 bolts securing rocker shaft and remove rocker shaft.
6. Remove push rods.

NOTE: Store push rods in their fitted order.



7. In the sequence shown remove 10 bolts securing the cylinder head to block.
8. Remove cylinder head.



9. Remove cylinder head gasket.

Refit

10. Clean mating faces of cylinder block and head using suitable gasket removal spray and a plastic scraper, ensure that bolt holes in block are clean and dry.

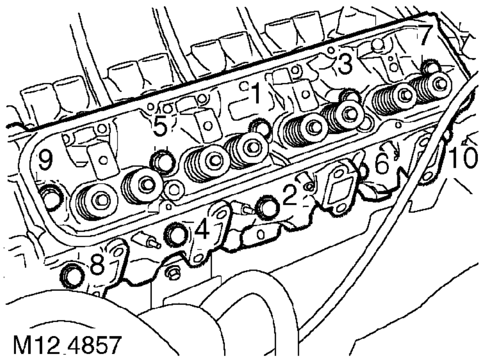
CAUTION: Do not use metal scraper or machined surfaces may be damaged.

11. Check head and block faces for warping and pitting.
12. Fit cylinder head gasket with the word TOP uppermost.

NOTE: Gasket must be fitted dry.

13. Carefully fit cylinder head and locate on dowels.
14. Lightly lubricate new cylinder head bolt threads with clean engine oil.

NOTE: **Long bolts: 1, 3, 5.**



15. Fit bolts and tighten in the sequence shown to ***20 Nm (15 lbf.ft)*** *then* ***90 °*** *, then a further* ***90 °*** *.*
16. Clean push rods.
17. Lubricate ends of push rods with clean engine oil.
18. Fit push rods in their removed order.
19. Clean base of rocker pillars and mating faces on cylinder head.
20. Clean contact surface on rockers, valves and push rods.
21. Lubricate contact surfaces and rocker shaft with clean engine oil.
22. Fit rocker shaft assembly and engage push rods.
23. Tighten rocker shaft securing bolts progressively to ***38 Nm (28 lbf.ft).***
24. Fit and tighten engine harness bolt to ***20 Nm (15 lbf.ft).***
25. Refit rocker cover.
26. Ensure dipstick tube and mating face on cylinder block is clean.
27. Apply Loctite 638 to end of dipstick tube and fit tube and dipstick to cylinder block.
28. Fit exhaust manifold. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***
29. Fit inlet manifold gasket. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***

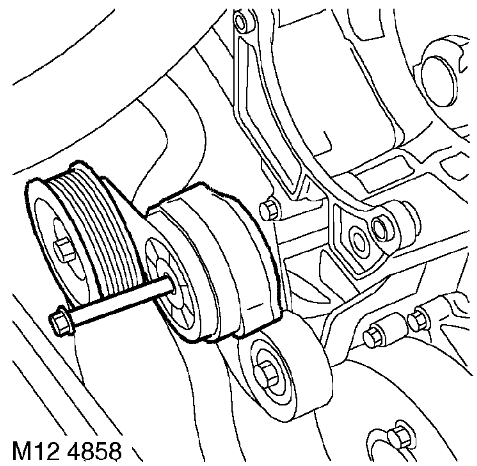
CYLINDER HEAD GASKET (RH) - from 99MY

Service repair no - 12.29.03

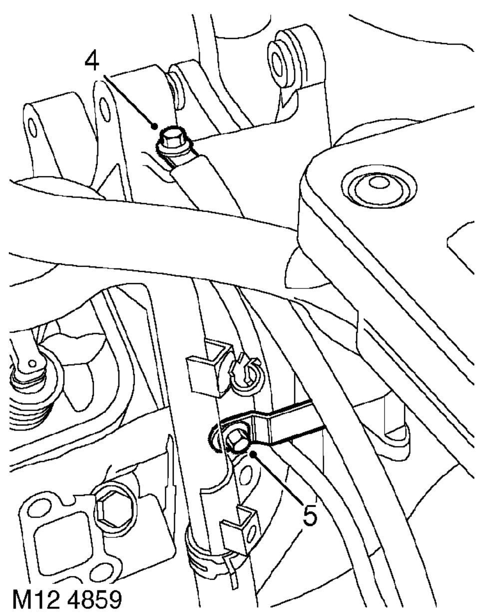
Remove

1. Remove inlet manifold gasket. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***
2. Remove RH exhaust manifold gasket. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***

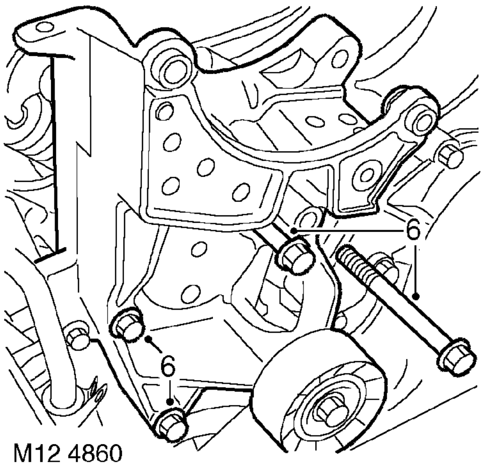
NOTE: RHD models: Exhaust manifold will remain captive in engine bay but clear of cylinder head.



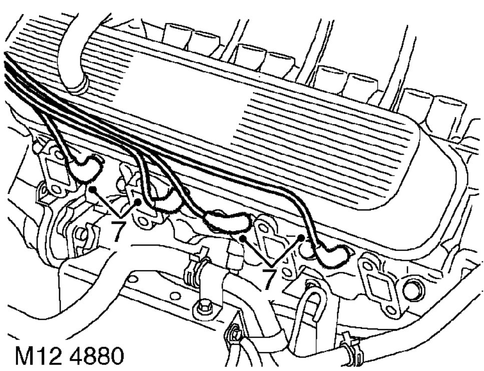
3. Remove bolt securing auxiliary drive belt tensioner and remove tensioner.



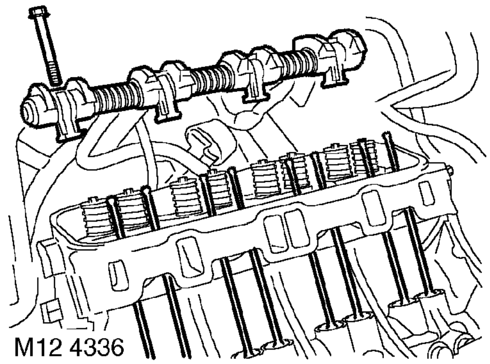
4. Remove bolt securing engine earth lead.
5. Remove bolt securing engine oil cooler pipe to alternator mounting bracket.



6. Remove 4 bolts securing alternator mounting bracket and remove bracket.

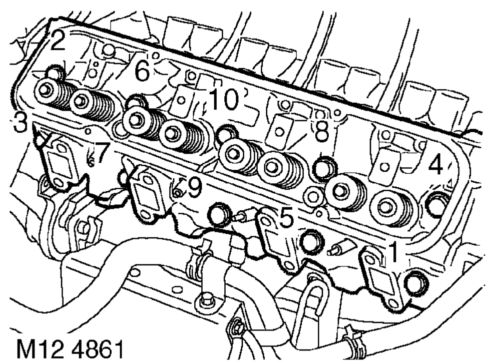


7. Disconnect HT leads from spark plugs.
8. Remove rocker cover.

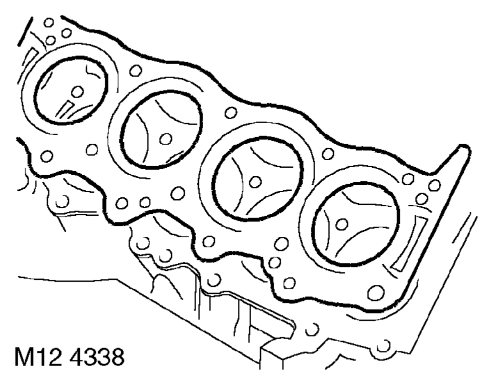


9. Progressively remove 4 bolts securing the rocker shaft and remove rocker shaft assembly.
10. Remove push rods.

NOTE: Store push rods in their fitted order.



11. In the sequence shown remove 10 bolts securing the cylinder head.
12. Remove cylinder head.



13. Remove cylinder head gasket.

Refit

14. Use a suitable gasket removal spray and plastic scraper to clean cylinder head and cylinder block mating faces. Ensure bolt holes are left clean and dry.

CAUTION: Do not use metal scraper or machined surfaces may be damaged.

15. Check head and block faces for warping and pitting.
16. Fit cylinder head gasket with the word TOP uppermost.

NOTE: Gasket must be fitted dry.

17. Carefully fit cylinder head and locate on dowels.
18. Lightly lubricate new cylinder head bolt threads with clean engine oil.

NOTE: Long bolts: 1, 3, 5. short bolts: 2, 4, 6, 7, 8, 9, 10.

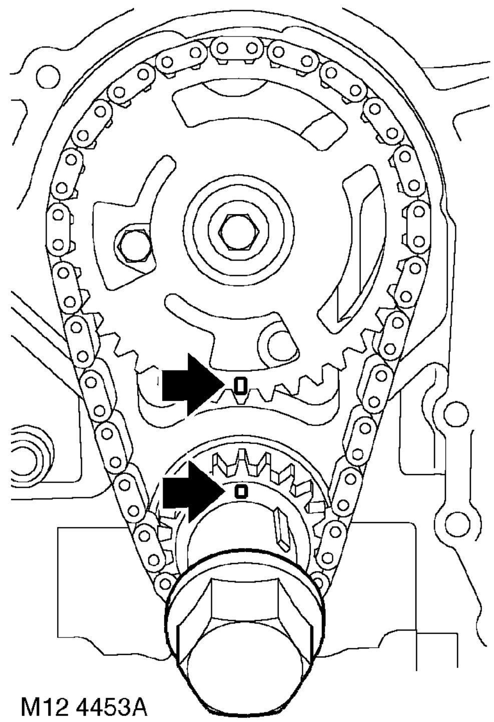
19. Fit bolts and tighten in the sequence shown to ***20 Nm (15 lbf.ft)*** *then* ***90*** *°, then a further* ***90*** *°.*
20. Clean push rods.
21. Lubricate ends of push rods with clean engine oil.
22. Fit push rods in their removed order.
23. Clean base of rocker pillars and mating face on cylinder head.
24. Clean contact surface on rockers, valves and push rods.
25. Lubricate contact surface and rocker shaft with clean engine oil.
26. Fit rocker shaft assembly and engage push rods. Tighten bolts progressively to ***38 Nm (28 lbf.ft).***
27. Fit rocker cover.
28. Position alternator mounting bracket, fit and tighten bolts to ***40 Nm (30 lbf.ft).***
29. Position engine harness, align oil cooler pipe and secure with bolt.
30. Position auxiliary drive belt tensioner, fit bolt and tighten to ***45 Nm (33 lbf.ft).***
31. Position engine earth lead, fit bolt and tighten to ***22 Nm (16 lbf.ft).***
32. Connect HT leads to spark plugs.
33. Fit exhaust manifold gasket. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***
34. Fit inlet manifold gasket. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***
35. Remove stand(s) and lower vehicle.

TIMING CHAIN AND GEARS - from 99MY

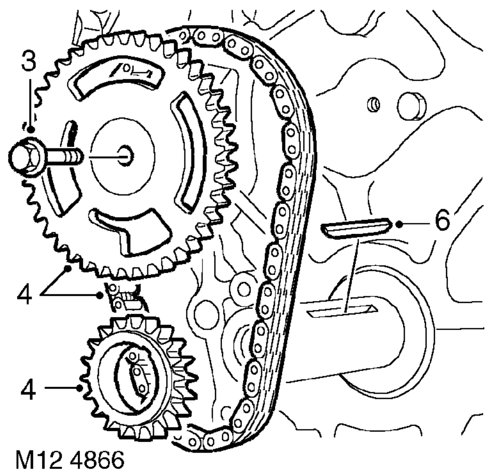
Service repair no - 12.65.12

Remove

1. Remove front cover gasket. ***See this section.***


M12 4453A

2. Fit crankshaft pulley bolt and rotate engine to align timing marks. Remove crankshaft pulley bolt.



M12 4866

3. Restrain camshaft gear and remove gear retaining bolt.
4. Remove camshaft drive chain and gears as an assembly.
5. Remove gears from chain.
6. If necessary remove key from crankshaft.

Refit

7. Clean timing chain, gears and gear locations.
8. Fit key to crankshaft.
9. Temporarily fit gears to camshaft and crankshaft. If necessary, rotate shafts to align timing marks.

NOTE: When aligned correctly, the timing marks will face each other: the crankshaft gear with its timing mark at twelve 0'clock position and the camshaft with its timing mark at six 0'clock position.

10. Remove gears from shafts and fit to timing chain.
11. With timing marks aligned, fit timing chain and gears as an assembly.
12. Restrain the camshaft gear and tighten retaining bolt to ***50 Nm (37 lbf.ft).***
13. Fit front cover gasket ***See this section.***
14. Reconnect battery negative lead.

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17 - EMISSION CONTROL

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EMISSION CONTROL - BMW DIESEL

Crankcase Ventilation Control

The purpose of the crankcase ventilation system is to ensure that any gases entering the inside of the engine are redirected into the air intake and do not accumulate in the engine.

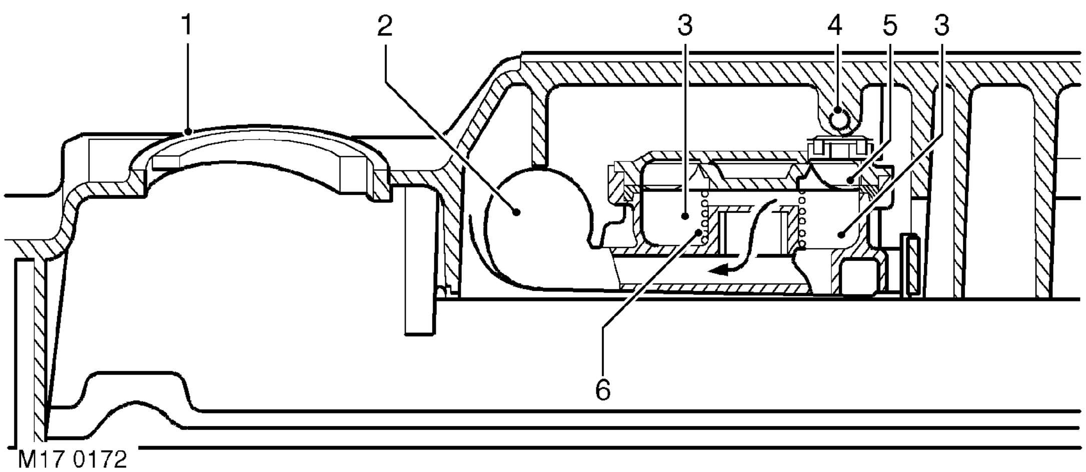
Vehicles without EGR

The camshaft cover is connected via a pipe to the air intake duct to the turbocharger. When the engine is running, gases are drawn from the crankcase and the camshaft cover into the air intake duct due to the pressure difference between the air induction into the turbocharger and the inside of the engine.

As the gases are drawn into the camshaft cover, they pass through a wire mesh filter which separates oil from the gases. A Mann Hummel type valve is located in the pipe to the intake duct. The valve allows crankcase ventilation at low engine speeds but closes at high engine speeds to prevent excessive crankcase depression.

Vehicles with EGR

The Mann Hummel type valve is no longer used and the camshaft cover is fitted with a pressure regulating valve. The valve is located in the front of the cover and is connected by a pipe to the air intake duct. The purpose of the regulating valve is to maintain a constant vacuum of 20 mbar inside the engine crankcase, improving crankcase ventilation under all operating conditions.

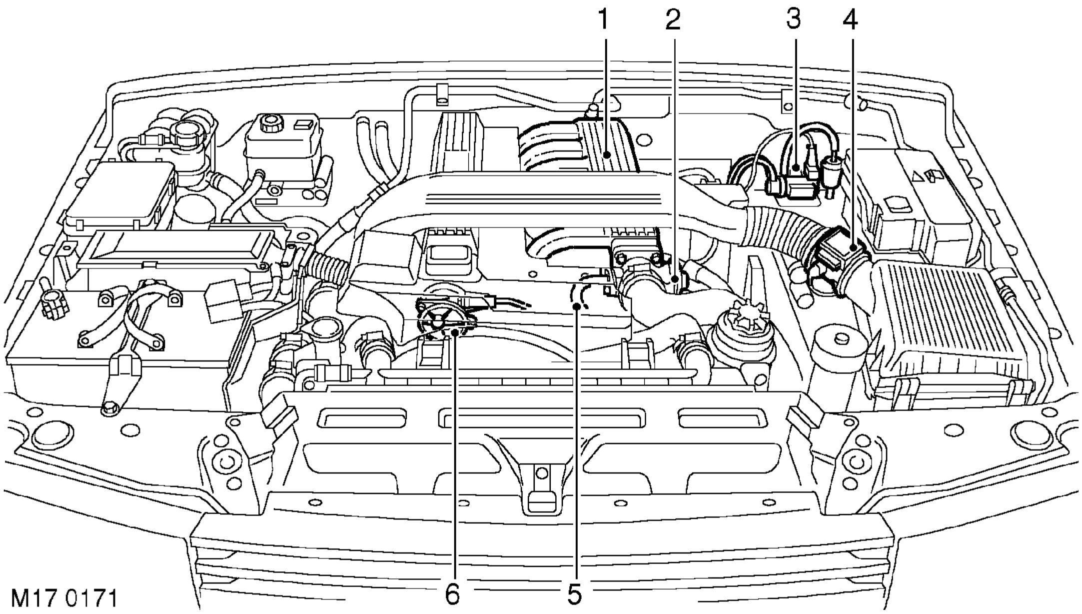


1. Camshaft cover
2. Blow-by pipe
3. Internal engine pressure
4. Atmospheric vent
5. Membrane
6. Spring

The pressure regulating valve comprises a membrane held in the open position by a spring. The membrane and spring are subject to engine crankcase pressure and intake manifold depression on one side and atmospheric pressure on the other side. When crankcase pressure rises, gases are drawn from the engine past the open membrane and into the air intake manifold by the intake manifold depression.

When the intake manifold depression exceeds the crankcase pressure, the membrane moves against the spring pressure and engine crankcase pressure. This causes the membrane to lower and cover the port, preventing excessive depression in the crankcase.

Exhaust Gas Recirculation (EGR)



Component location

1. Intake Manifold
2. EGR Valve
3. EGR Modulator Valve
4. Mass Air Flow (MAF) Sensor
5. Pipe - Exhaust Manifold to EGR Valve
6. Vacuum Pump - EGR System

During certain running conditions, the EGR system directs exhaust gases into the intake manifold to be used in the combustion process. The principal affect of this is to reduce combustion temperatures by reducing the amount of oxygen fed into the combustion chamber, which in turn reduces Oxides of Nitrogen (NO_X) emissions. Up to 50% of the intake air can be replaced by exhaust gas.

Recirculating too much exhaust gas can result in higher emissions of soot, HC and CO due to insufficient air. The precise quantity of recirculated gas is controlled by the ECM to ensure that optimum conditions are maintained.

The ECM controls an EGR modulator valve mounted on the LH inner wing. This valve, when modulated, opens an EGR valve on the inlet manifold and directs exhaust gases into the inlet manifold. The EGR modulator valve controls the supply of vacuum from a vacuum pump located at the front of the cylinder head.

Exhaust gases are fed from a metal pipe on the exhaust manifold to the EGR valve on the inlet manifold. The pipe is secured at each end by a flanged connection secured by two bolts.

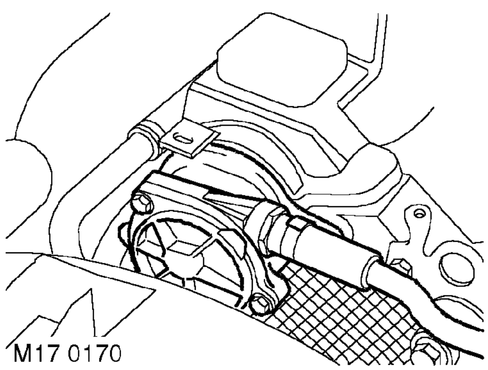
In operation, the ECM monitors engine conditions and signals the EGR modulator to supply a vacuum to the EGR valve.

The EGR valve opens allowing exhaust gases to be drawn into the air intake manifold. The exhaust gas replaces a proportion of the air drawn into the intake manifold. Less air flows through the MAF sensor which consequently requires a lower electrical current to maintain its temperature. The change of current is read by the ECM which calculates the amount of exhaust gas being recirculated.

The mapping in the ECM monitors the MAF sensor current changes and alters the signal current supplied to the EGR modulator, varying the vacuum to operate the EGR valve. In this way, the ECM controls the amount of exhaust gas recirculated to maintain the engine at its optimum operating parameters.

The EGR system does not operate when starting the engine, at engine overrun or when the engine is at full load. The ECM may also prevent EGR system operation if the electrical signal from the MAF sensor is insufficient or if a given speed or injection volume is exceeded.

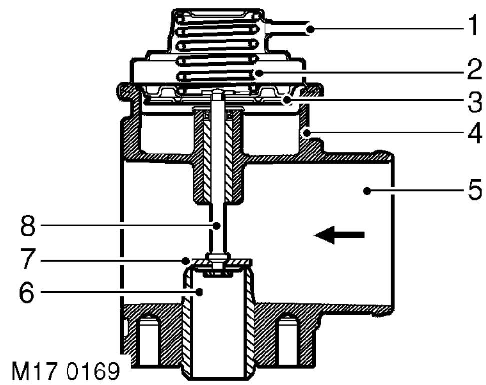
Vacuum pump



The vacuum pump is located at the front of the engine on the cylinder head. The pump is sealed to the cylinder head with a sealing ring and secured with two bolts.

The pump is driven from the camshaft via two drive dogs which engage with corresponding slots in the end of the camshaft. Engine oil is supplied through a nozzle in the end of the camshaft gear to lubricate the vacuum pump. The pump is connected to the EGR modulator valve via a pipe and hose.

EGR Valve



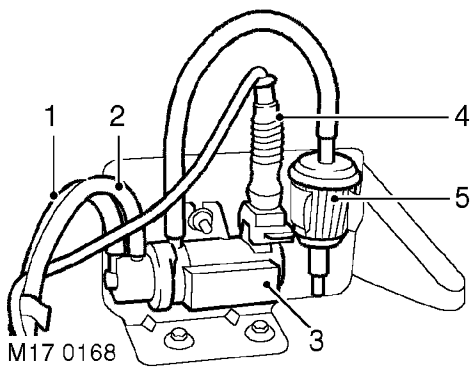
1. Vacuum connection
2. Spring
3. Diaphragm
4. Housing
5. Air inlet connection
6. EGR pipe connection
7. Seal
8. Rod

The EGR valve is located on the forward end of the intake manifold. The valve is sealed to the manifold with an O-ring and secured with four bolts. The EGR valve comprises a diaphragm, housing and valve.

The EGR valve is mounted on an aluminium housing which also provides for the connection of the air intake hose from the intercooler. The valve is positioned opposite the exhaust gas pipe intake connection. The valve is connected to the diaphragm by a rod and is held in the closed position by a spring.

Vacuum supplied by the EGR modulator valve acts on the diaphragm, overcoming the spring pressure and pulling the valve open up to 2.5 mm (0.1 in.). This exposes the exhaust gas pipe connection and allows gases to be drawn into the intake manifold. When the vacuum is removed the diaphragm moves under spring pressure, closing the valve and sealing the EGR pipe inlet with a seal on the valve. The extent to which the valve opens is controlled by the vacuum level supplied from the EGR modulator, which in turn is controlled by the ECM.

EGR Modulator valve



1. Vacuum pipe to EGR valve
2. Vacuum pipe from vacuum pump
3. Modulator valve
4. Electrical connector
5. Air filter

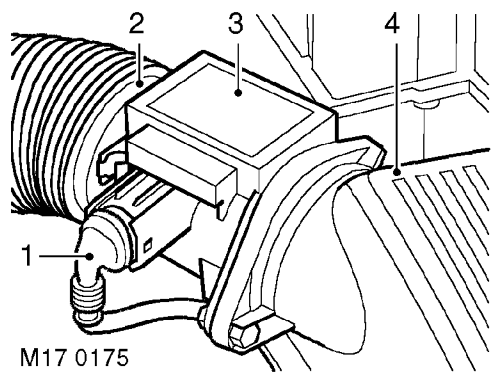
The EGR modulator valve is located in the engine compartment on the left inner wing near the bulkhead.

The EGR modulator is vacuum operated through a solenoid valve. When the ECM determines that EGR should take place, the solenoid valve is modulated and vacuum, supplied from the vacuum pump, opens the EGR valve. When EGR is not required, the ECM switches the control solenoid to close the vacuum to the EGR valve.

The modulator valve receives full vacuum from the pump and is also subjected to atmospheric pressure supplied from an air filter attached to the side of the EGR modulator valve. The vacuum and atmospheric pressure are mixed inside the modulator valve by electrical actuation of the solenoid creating a controlled vacuum.

Failure of the EGR modulator valve may result in a reduction of engine performance and the EGR may shut down or operate at full EGR.

Mass Air Flow (MAF) Sensor



1. Electrical connector
2. Air cleaner outlet pipe
3. MAF sensor
4. Air cleaner housing

The MAF sensor, located in the air cleaner outlet pipe, monitors the amount of air being drawn into the intake manifold. This data is used by the ECM to calculate the injected fuel volume, the intake air temperature and the rate of EGR.

The MAF sensor is a hot film sensor which has a heated surface maintained by an electrical current at a constant temperature. With cool air flowing past the sensor, the volume of air drawn into the intake manifold is measured by the electrical current required to keep the temperature of the hot film sensor constant.

EMISSION CONTROL - LAND ROVER V8

Engine design has evolved in order to minimise the emission of harmful by-products. Emission control systems are fitted to Land Rover vehicles which are designed to maintain the emission levels within the legal limits pertaining for the specified market.

Despite the utilisation of specialised emission control equipment, it is still necessary to ensure that the engine is correctly maintained and is in good mechanical order so that it operates at its optimal condition. In particular, ignition timing has an effect on the production of HC and NO_x emissions, with the harmful emissions rising as the ignition timing is advanced.

CAUTION: In many countries it is against the law for a vehicle owner or an unauthorised dealer to modify or tamper with emission control equipment. In some cases, the vehicle owner and/or the dealer may even be liable for prosecution.

The engine management ECM is fundamental for controlling the emission control systems. In addition to controlling normal operation, the system complies with On Board Diagnostic (OBD) system strategies. The system monitors and reports on faults detected with ignition, fuelling and exhaust systems which cause an excessive increase in tailpipe emissions. This includes component failures, engine misfires, catalyst damage, catalyst efficiency, fuel evaporative loss and exhaust leaks.

When an emission relevant fault is determined, the fault condition is stored in the ECM memory. For NAS vehicles, the MIL warning lamp on the instrument pack will be illuminated when the fault is confirmed. Confirmation of a fault condition occurs if the fault is found to be present during the driving cycle subsequent to the one when the fault was first detected. ***See FUEL SYSTEM, Description and operation.***

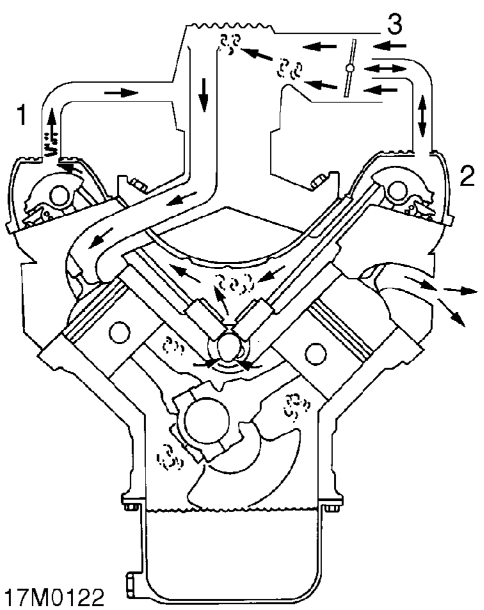
The following types of supplementary control system are used to reduce harmful emissions released into the atmosphere from the vehicle:

- **Crankcase emission control -** also known as blow-by gas emissions from the engine crankcase.
- **Exhaust emission control -** to limit the undesirable by-products of combustion.
- **Fuel vapour evaporative loss control -** to restrict the emission of fuel through evaporation from the fuel system.
- **Fuel leak detection system (NAS only) -** an on board diagnostic (OBD) test to check the evaporative emission system for the presence of fuel evaporation leaks from the fuel tank to the purge valve.
- **Secondary air injection system (NAS only) -** to reduce emissions experienced during cold starting of the engine.

Crankcase ventilation system

The concentration of hydrocarbons in the crankcase of an engine is much greater than that in the vehicle's exhaust system. In order to prevent the emission of these hydrocarbons into the atmosphere, crankcase emission control systems are employed and are a standard legal requirement.

The crankcase ventilation system is an integral part of the air supply to the engine combustion chambers and it is often overlooked when diagnosing problems associated with engine performance. A blocked ventilation pipe, filter or excessive air leak into the inlet system through a damaged pipe or leaking gasket can affect the air:fuel mixture, performance and economy of the engine. Periodically check the ventilation hoses are not cracked and that they are securely fitted to form airtight connections at their relevant ports.



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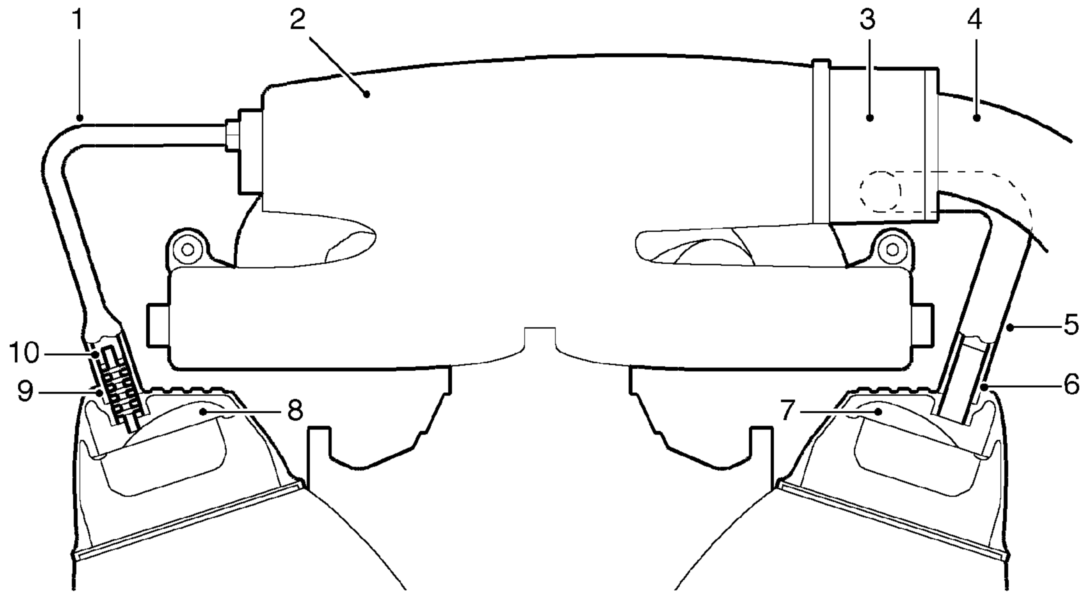
The purpose of the crankcase ventilation system is to ensure that any noxious gas generated in the engine crankcase is rendered harmless by burning them in the combustion chambers. Burning the crankcase vapours in a controlled manner decreases the HC pollutants that could be emitted and helps to prevent the development of sludge in the engine oil as well as increasing fuel economy.

When the engine is running in cruise conditions, or at idle, manifold pressure is low and the majority of gasses are drawn into the inlet manifold through an oil/vapour separator (1), located in the RH rocker cover. At the same time, filtered air is drawn from the throttle body (3) into the engine via the LH rocker cover (2). The oil/vapour separator serves to prevent oil mist being drawn into the engine.

During periods of driving at Wide Open Throttle (WOT), pressure at either side of the throttle disc equalizes (manifold depression collapses). The larger ventilation opening (3), positioned in the fast moving stream of intake air, now offers more 'pull' than the small opening (1) in the RH rocker cover, and the flow of ventilation reverses. Gases are drawn from the LH rocker cover into the throttle body (3).

Crankcase ventilation system - from 99MY



M17 0160

1. Hose - RH rocker cover to inlet manifold
2. Inlet manifold
3. Throttle body
4. Air intake
5. Hose - LH rocker cover to inlet manifold
6. LH rocker cover breather tube (without oil separator)
7. LH rocker cover baffle
8. RH rocker cover baffle
9. RH rocker cover breather tube
10. Oil separator (integral with breather tube)

A spiral oil separator is located in the stub pipe to the ventilation hose on the right hand cylinder rocker cover, where oil is separated and returned to the cylinder head. The rubber ventilation hose from the right hand rocker cover is routed to a port on the right hand side of the inlet manifold plenum chamber, where the returned gases mix with the fresh inlet air passing through the throttle butterfly valve. The stub pipe on the left hand rocker cover does not contain an oil separator, and the ventilation hose is routed to the throttle body housing at the air inlet side of the butterfly valve. The ventilation hoses are attached to the stub pipe by metal band clamps.

Oil laden noxious gas in the engine crankcase is drawn through the spiral oil separator. The mass of fresh air which is drawn in from the atmospheric side of the throttle butterfly to mix with the returned crankcase gas depends on the throttle position and the engine speed.

Exhaust emission control.

The fuel injection system provides accurately metered quantities of fuel to the combustion chambers to ensure the most efficient air to fuel ratio under all operating conditions. A further improvement to combustion is made by measuring the oxygen content of the exhaust gases to enable the quantity of fuel injected to be varied in accordance with the prevailing engine operation and ambient conditions; any unsatisfactory composition of the exhaust gas is then corrected by adjustments made to the fuelling by the ECM.

The main components of the exhaust emission system are two catalytic converters which are an integral part of the front exhaust pipe assembly. The catalytic converters are included in the system to reduce the emission, to atmosphere, of carbon monoxide (CO), oxides of nitrogen (NO_x), and hydrocarbons (HC). The active constituents of the converters are platinum (Pt), palladium (PD) and rhodium (Rh). **Catalytic converters for NAS low emission vehicles (LEVs) from 2000MY have active constituents of palladium and rhodium only).** The correct functioning of the converters is dependent upon close control of the oxygen concentration in the exhaust gas entering the catalysts.

The basic control loop comprises the engine (controlled system), the heated oxygen sensors (measuring elements), the engine management ECM (control) and the injectors and ignition (actuators). Other factors also influence the calculations of the ECM, such as air flow, air intake temperature and throttle position. Additionally, special driving conditions are compensated for such as starting, acceleration, deceleration, overrun and full load. ***See FUEL SYSTEM, Description and operation.***

The reliability of the ignition system is critical for efficient catalytic converter operation, since misfiring will lead to irreparable damage of the catalytic converter due to the overheating that occurs when unburned combustion gases are burnt inside it.

⚠ **CAUTION: If the engine is misfiring, it should be shut down immediately and the cause rectified. Failure to do so will result in irreparable damage to the catalytic converter.**

⚠ **CAUTION: Ensure the exhaust system is free from leaks. Exhaust leaks upstream of the catalytic converter could cause internal damage to the catalytic converter.**

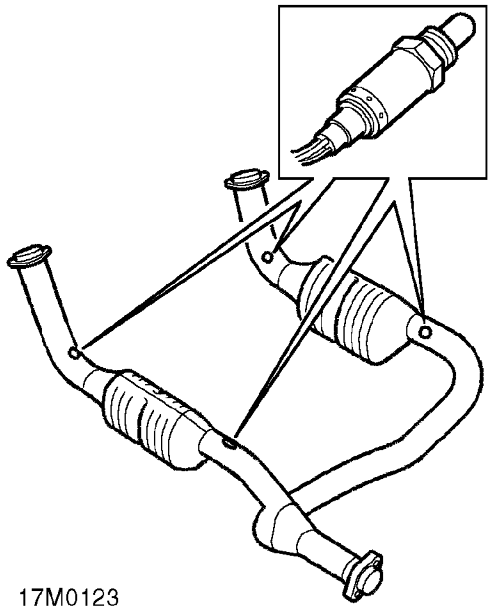
⚠ **CAUTION: Serious damage to the engine may occur if a lower octane number fuel than that which is recommended is used.**

⚠ **CAUTION: Only unleaded fuel must be used on vehicles fitted with catalytic converters; serious damage to the catalytic converter and oxygen sensors will occur if leaded fuel is used. A reminder label is adhered to the inside of the fuel filler flap. As a further safeguard, the filler neck is designed to accommodate only unleaded fuel pump nozzles.**

The oxygen content of the exhaust gas is signalled to the Engine Control Module (ECM) by two Heated Oxygen Sensors (HO2S) located in the exhaust front pipes, upstream of each catalytic converter. The ECM can then make an appropriate adjustment to the fuel supply to correct the composition of the exhaust gases.

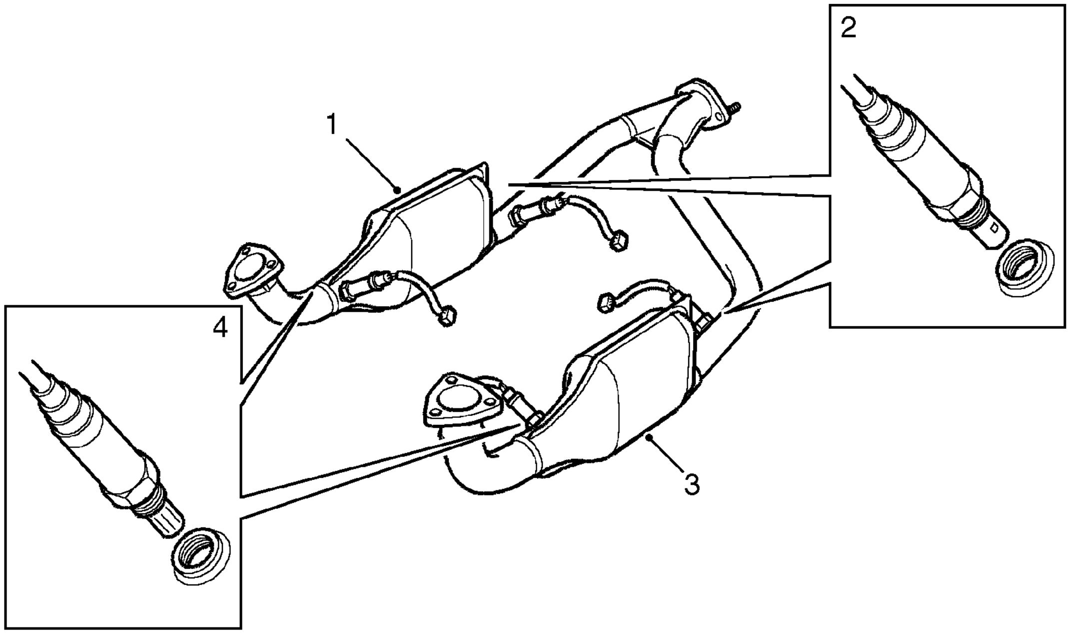
North American Specification (NAS) vehicles have additional Heated Oxygen Sensors, positioned downstream of each catalytic converter. The ECM uses the signals from these sensors to determine whether the catalysts are working efficiently.

HO_2S sensors and exhaust system - up to 99MY



Detail of front pipe showing location of oxygen sensors. Only NAS vehicles have four sensors, Rest of World vehicles have two sensors, one mounted upstream (towards the exhaust manifold) of each catalytic converter.

HO_2S sensors and exhaust system - from 99MY



M17 0187

1. RH catalytic converter
2. Heated oxygen (HO_2S) sensors - post-catalytic converter (2 off - NAS only).
3. LH catalytic converter
4. Heated oxygen (HO_2S) sensors - pre-catalytic converter (2 off).

The oxygen content of the exhaust gas is monitored by heated oxygen (HO_2S) sensors using either a four sensor (NAS only) or two sensor setup, dependent on market destination and legislative requirements. Signals from the HO_2S sensors are input to the engine management ECM, which correspond to the level of oxygen detected in the exhaust gas. From ECM analysis of the data, necessary changes to the air:fuel mixture and ignition timing can be made to bring the emission levels back within acceptable limits under all operating conditions.

Changes to the air:fuel ratio are needed when the engine is operating under particular conditions such as cold starting, idle, cruise, full throttle or high altitude. In order to maintain an optimum air:fuel ratio for differing conditions, the engine management control system uses sensors to determine data which enable it to select the ideal ratio by increasing or decreasing the air to fuel ratio.

NOTE: Some markets do not legislate for closed loop fuelling control and in this instance no heated oxygen sensors will be fitted to the exhaust system.

On open loop systems, improved fuel economy can be arranged by increasing the quantity of air to fuel to create a lean mixture during part-throttle conditions. On closed loop systems, lean running conditions are not implemented as the system automatically optimises the air:fuel ratio to the stoichiometric ideal.

A higher proportion of fuel can be supplied to create a rich mixture during idle and full-throttle operation. Rich running at wide open throttle (WOT) is used for improved performance and high load to keep the exhaust temperature down and protect the catalysts and exhaust valves.

The voltage of the HO_2S sensors at the stoichiometric point is 450 to 500mV. The voltage decreases to between 100 and 500 mV if there is an increase in oxygen content(i.e. lean mixture). The voltage increases to between 500 and 1000mV if there is a decrease in oxygen content, signifying a rich mixture.

The HO_2S sensor needs to operate at high temperatures in order to function correctly (350°C (662°F)). To achieve this, the sensors have integral heater elements, controlled by a pulse width modulated (PWM) signal from the ECM. The heater element warms the sensor's ceramic layer from the inside so that the sensor is hot enough for operation. The heater elements are supplied with current immediately following engine start and are ready for closed loop control within 20 to 30 seconds (longer at cold ambient temperatures less than 0°C (32°F)). Heating is also necessary during low load conditions when the temperature of the exhaust gases is insufficient to maintain the required sensor temperatures. The maximum tip temperature is 930°C (1706°F).

A non-functioning heater element will delay the sensor's readiness for closed loop control and influences emissions. A diagnostic routine is utilised to measure both sensor heater current and the heater supply voltage so its resistance can be calculated. The function is active once per drive cycle, as long as the heater has been switched on for a pre-defined period and the current has stabilised. The PWM duty cycle is carefully controlled to prevent thermal shock to cold sensors.

The heated oxygen sensors age with mileage, causing an increase in the response time to switch from rich to lean and lean to rich. This increase in response time influences the closed loop control and leads to progressively increased emissions. The response time of the pre-catalytic converter sensors are monitored by measuring the period of rich to lean and lean to rich switching. The ECM monitors the switching time, and if the threshold period is exceeded, the fault will be detected and stored in the ECM as a fault code (the MIL light will be illuminated on NAS vehicles). NAS vehicle engine calibration uses downstream sensors to compensate for aged upstream sensors, thereby maintaining low emissions.

Diagnosis of electrical faults is continuously monitored for both the pre-catalytic converter sensors and the post-catalytic converter sensors (NAS only). This is achieved by checking the signal against maximum and minimum thresholds for open and short circuit conditions. For NAS vehicles, if the pre- and post-catalytic sensors are inadvertently transposed, the lambda signals will go to maximum but opposite extremes and the system will automatically revert to open loop fuelling. The additional sensors for NAS vehicles provide mandatory monitoring of catalyst conversion efficiency and long term fuelling adaptations.

Failure of the closed loop control of the exhaust emission system may be attributable to one of the failure modes indicated below:

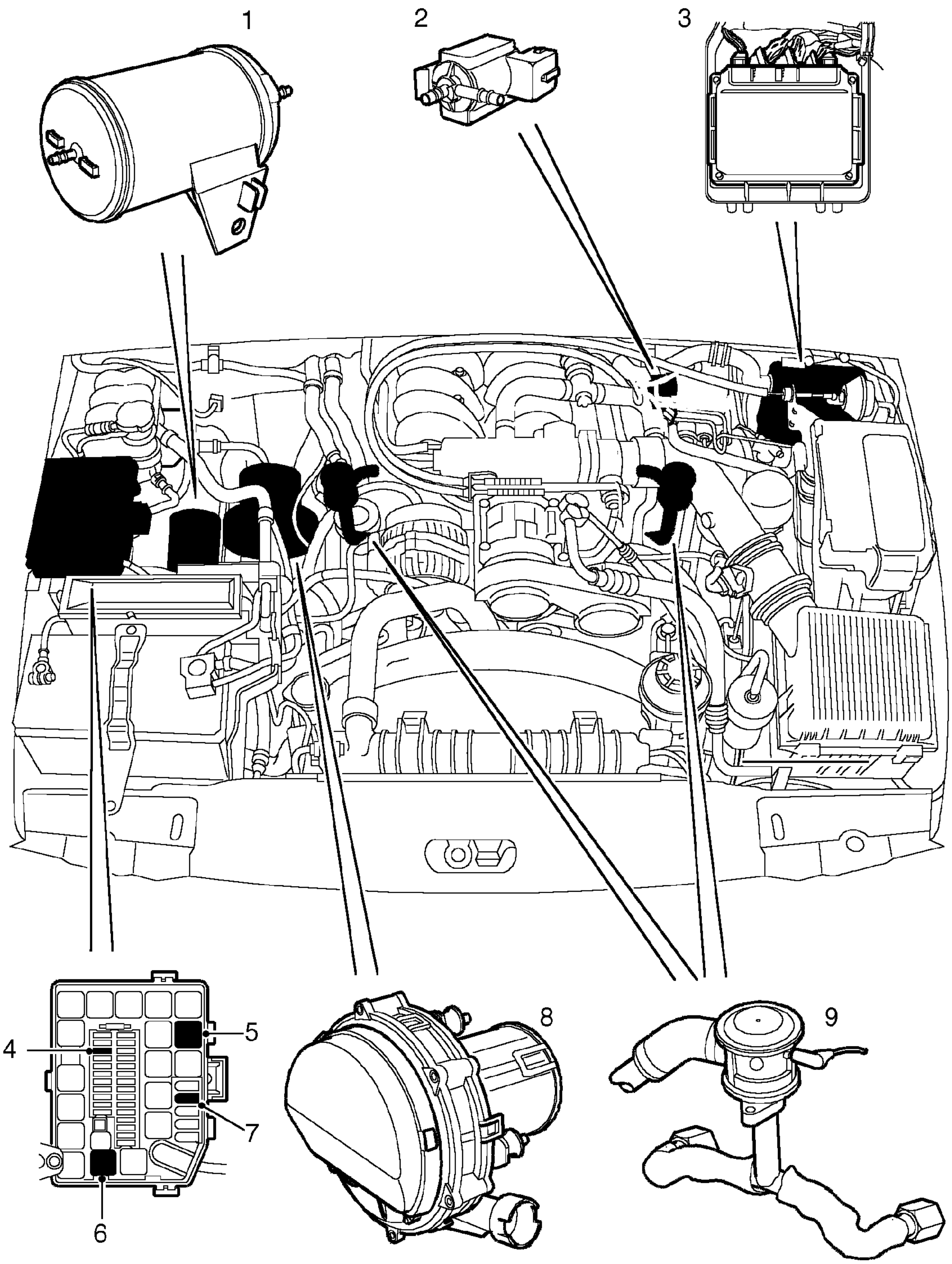
- Mechanical fitting and integrity of the sensor.
- Sensor open circuit / disconnected.
- Short circuit to vehicle supply or ground.
- Lambda ratio outside operating band.
- Crossed sensors.
- Contamination from leaded fuel or other sources.
- Change in sensor characteristic.
- Harness damage.
- Air leak into exhaust system (cracked pipe / weld or loose fixings).

System failure will be indicated by the following symptoms:

- MIL light on (NAS only).
- Default to open-loop fuelling for the defective cylinder bank.
- If sensors are crossed, engine will run normally after initial start and then become progressively unstable with one bank going to its maximum rich clamp and the other bank going to its maximum lean clamp - the system will then revert to open-loop fuelling.
- High CO reading.
- Strong smell of H_2S (rotten eggs).
- Excessive emissions.

See FUEL SYSTEM, Description and operation.

SECONDARY AIR INJECTION SYSTEM - COMPONENT LOCATION



1. Vacuum reservoir
2. SAI vacuum solenoid valve
3. Engine Control Module (ECM)
4. Fuse 26 - Engine Compartment Fusebox
5. Main relay - Engine Compartment Fusebox
6. SAI pump relay - Engine Compartment Fusebox
7. Fuselink 2 - Engine Compartment Fusebox
8. Secondary Air Injection (SAI) pump
9. SAI control valves (2 off)

Secondary air injection system - description

The secondary air injection (SAI) system comprises the following components:

- Secondary air injection pump
- SAI vacuum solenoid valve
- SAI control valves (2 off, 1 for each bank of cylinders)
- SAI pump relay
- Vacuum reservoir
- Vacuum harness and pipes

The SAI system is used to limit the emission of carbon monoxide (CO) and hydrocarbons (HCs) that are prevalent in the exhaust during cold starting of a spark ignition engine.

The concentration of hydrocarbons experienced during cold starting at low temperatures are particularly high until the engine and catalytic converter reach normal operating temperature. The lower the cold start temperature, the greater the prevalence of hydrocarbons emitted from the engine.

There are several reasons for the increase of HC emissions at low cold start temperatures, including the tendancy for fuel to be deposited on the cylinder walls, which is then displaced during the piston cycle and expunged during the exhaust stroke. As the engine warms up through operation, the cylinder walls no longer retain a film of fuel and most of the hydrocarbons will be burnt off during the combustion process.

The SAI pump is used to provide a supply of air into the exhaust ports in the cylinder head, onto the back of the exhaust valves, during the cold start period. The hot unburnt fuel particles leaving the combustion chamber mix with the air injected into the exhaust ports and immediately combust. This subsequent combustion of the unburnt and partially burnt CO and HC particles help to reduce the emission of these pollutants from the exhaust system. The additional heat generated in the exhaust manifold also provides rapid heating of the exhaust system catalytic converters. The additional oxygen which is delivered to the catalytic converters also generate an exothermic reaction which causes the catalytic converters to 'light off' quickly.

The catalytic converters only start to provide effective treatment of emission pollutants when they reach an operating temperature of approximately 250°C (482°F) and need to be between temperatures of 400°C (752°F) and 800°C (1472°F) for optimum efficiency. Consequently, the heat produced by the secondary air injection "afterburning", reduces the time delay before the catalysts reach an efficient operating temperature.

The engine control module (ECM) checks the engine coolant temperature when the engine is started, and if it is below 55°C (131°F), the SAI pump is started. Secondary air injection will remain operational for a period controlled by the ECM and is dependent on the starting temperature of the engine. This varies from approximately 95 seconds for a start temperature of 8°C (46°F) to 30 seconds for a start temperature of 55°C (131°F). The SAI pump operation can be cut short due to excessive engine speed or load.

Air from the SAI pump is supplied to the SAI control valves via pipework and an intermediate T-piece which splits the air flow evenly to each bank.

At the same time the SAI pump is started, the ECM operates a SAI vacuum solenoid valve, which opens to allow vacuum from the vacuum reservoir to be applied to the vacuum operated SAI control valves on each side of the engine. When the vacuum is applied to the SAI control valves, they open simultaneously to allow the air from the SAI pump through to the exhaust ports. Secondary air is injected into the inner most exhaust ports on each bank.

When the ECM breaks the ground circuit to de-energise the SAI vacuum solenoid valve, the vacuum supply to the SAI control valves is cut off and the valves close to prevent further air being injected into the exhaust manifold. At the same time as the SAI vacuum solenoid valve is closed, the ECM opens the ground circuit to the SAI pump relay, to stop the SAI pump.

A vacuum reservoir is included in the vacuum line between the intake manifold and the SAI vacuum solenoid valve. This prevents changes in vacuum pressure from the intake manifold being passed on to cause fluctuations of the SAI vacuum solenoid valve. The vacuum reservoir contains a one way valve and ensures a constant vacuum is available for the SAI solenoid valve operation. This is particularly important when the vehicle is at high altitude.

Secondary air injection system - operation

When the engine is started, the engine control module (ECM) checks the engine coolant temperature and if it is below 55°C (131°F), the ECM grounds the electrical connection to the coil of the SAI pump relay.

The Main and Secondary Air Injection (SAI) pump relays are located in the engine compartment fusebox. A 12V battery supply is fed to the contacts of the SAI pump relay via fuselink 2. When the ECM completes the earth path, the coil energises and closes the contacts of the SAI pump relay to supply 12V to the SAI pump. The SAI pump starts to operate, and will continue to do so until the ECM switches off the earth connection to the coil of the SAI pump relay.

An earth connection from the Main relay coil is connected to the ECM. When the ECM completes the earth path, the coil energises and closes the contacts of the Main relay. When the contacts of the Main relay are closed, a 12V battery supply is fed to the SAI vacuum solenoid valve via fuse 26 in the engine compartment fusebox. The ECM grounds the electrical connection to the SAI vacuum solenoid valve at the same time as it switches on the SAI pump motor.

The SAI pump remains operational for a period determined by the ECM and depends on the starting temperature of the engine, or for a maximum operation period determined by the ECM if the target engine coolant temperature has not been reached in the usual time.

When the SAI vacuum solenoid valve is energised, a vacuum is provided to the operation control ports on both of the vacuum operated SAI control valves at the exhaust manifolds. The control vacuum is sourced from the intake manifold depression and routed to the SAI control valves via a vacuum reservoir and the SAI vacuum solenoid valve.

The vacuum reservoir is included in the vacuum supply circuit to prevent vacuum fluctuations caused by changes in the intake manifold depression affecting the smooth operation of the SAI control valves.

When a vacuum is applied to the control ports of the SAI control valves, the valves open to allow pressurised air from the SAI pump to pass through to the exhaust ports in the cylinder heads for combustion.

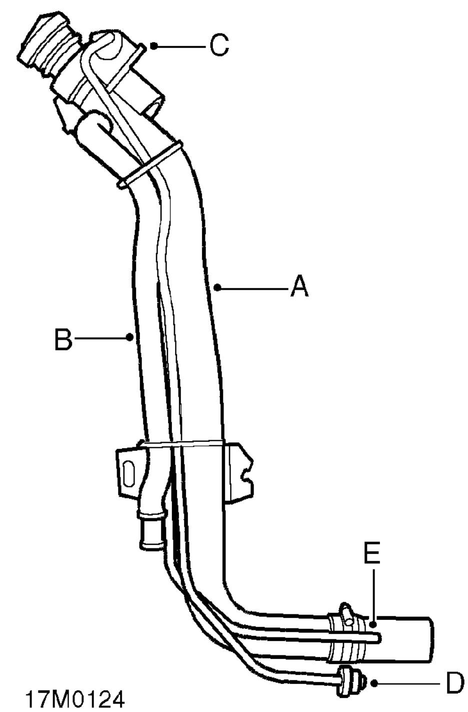
When the ECM has determined that the SAI pump has operated for the desired duration, it switches off the earth paths to the SAI pump relay and the SAI vacuum solenoid valve. With the SAI vacuum solenoid valve de-energised, the valve closes, cutting off the vacuum supply to the SAI control valves. The SAI control valves close immediately and completely to prevent any further pressurised air from the SAI pump entering the exhaust manifolds.

The engine coolant temperature sensor incurs a time lag in respect of detecting a change in temperature and the SAI pump automatically enters a 'soak period' between operations to prevent the SAI pump overheating. The ECM also compares the switch off and start up temperatures, to determine whether it is necessary to operate the SAI pump. This prevents the pump running repeatedly and overheating on repeat starts.

Other factors which may prevent or stop SAI pump operation include the prevailing engine speed/load conditions.

Evaporative emission control system - pre advanced EVAPS.

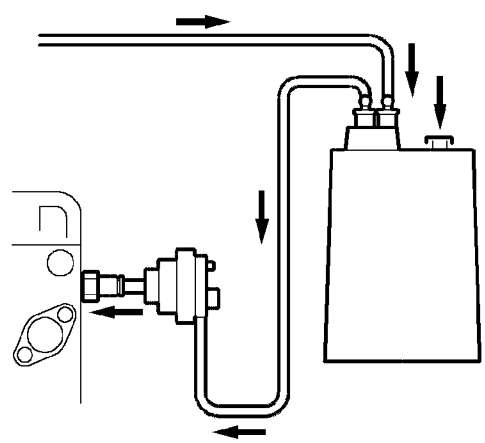
The system is designed to prevent harmful fuel vapour escaping to the atmosphere. The system comprises a vapour separator (C) and a two way valve (D), both located on the fuel filler neck (A), an Evaporative Emissions (EVAP) canister and an EVAP canister purge valve.



17M0124

A Fuel filler neck
B External fill breather pipe
C Fuel/vapour separator
D Two way valve - fuel vapour to EVAP canister
E Fuel vapour from fuel tank

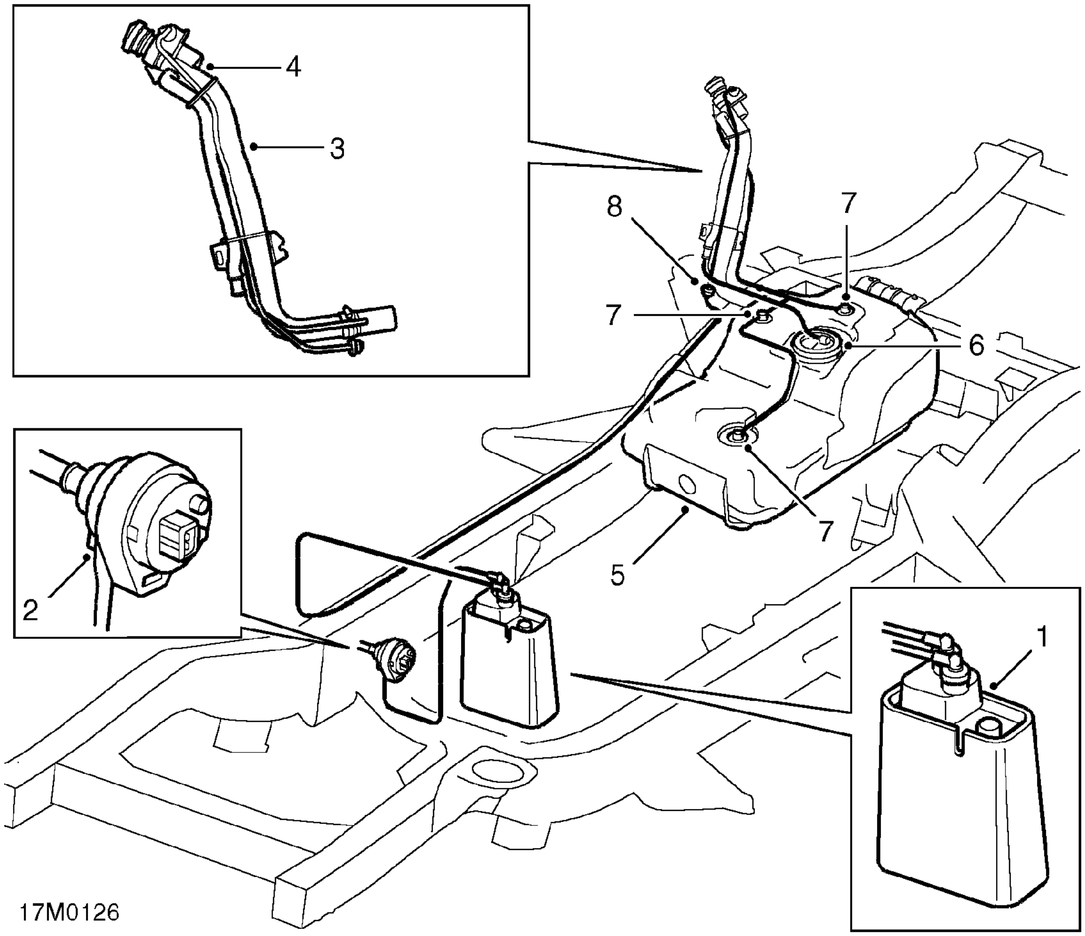
During conditions of high ambient temperatures, fuel in the tank vapourises, and pressure rises. Fuel vapour enters the vapour separator and any liquid fuel runs back to the tank. Three roll over valves (ROVs) are fitted in the fuel tank vapour lines. These valves prevent liquid fuel entering the vapour separator if the vehicle rolls over. When pressure rises above 5 to 7 kPa (0.7 to 1.0 lbf/in^2), the two way valve opens and allows fuel vapour to flow to the EVAP canister where it is stored in the canister's activated charcoal element. When the correct engine operating conditions are met, the Engine Control Module (ECM) opens the EVAP canister purge valve and vapour is drawn from the canister, into the plenum chamber to be burned in the engine. Fresh air is drawn into the canister through a vent to take up the volume of displaced vapour. If the two way valve should fail, or the main vapour line becomes blocked, excess pressure is vented to atmosphere through a valve in the fuel filler cap. Similarly, the cap vent valve will open to prevent the tank collapsing if excessive vacuum is present.



17M0125

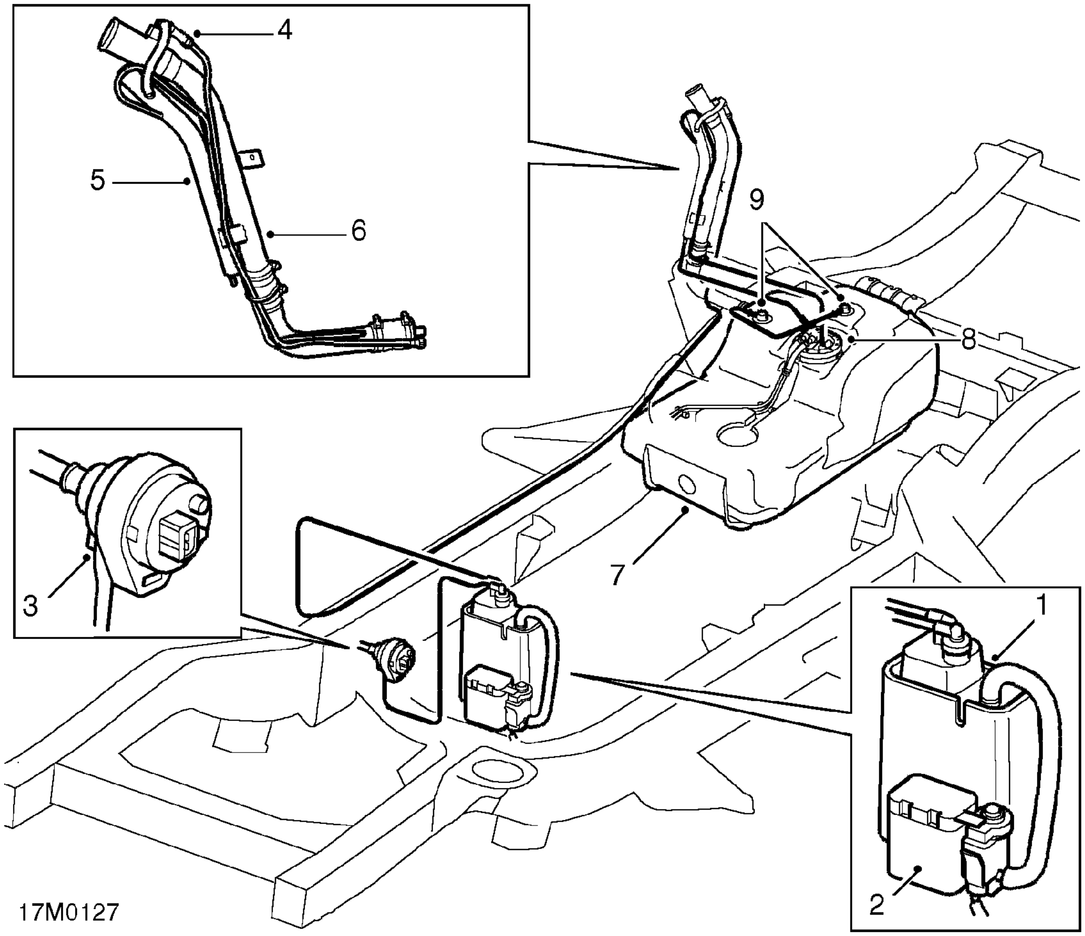
When the temperature of fuel in the tank reduces, pressure also reduces and vapour must be drawn back into the tank. When tank pressure drops into vacuum, the two way valve opens, allowing fuel vapour to be drawn out of the EVAP canister into the fuel tank. Again, fresh air is drawn into the canister to take up the displaced volume.

EVAPORATIVE CONTROL SYSTEM - PRE ADVANCED EVAPS



1. EVAP canister
2. EVAP canister purge valve
3. Fuel filler neck assembly
4. Fuel/vapour separator
5. Fuel tank
6. Fuel pump and gauge sender unit
7. Roll over valves
8. Two way valve

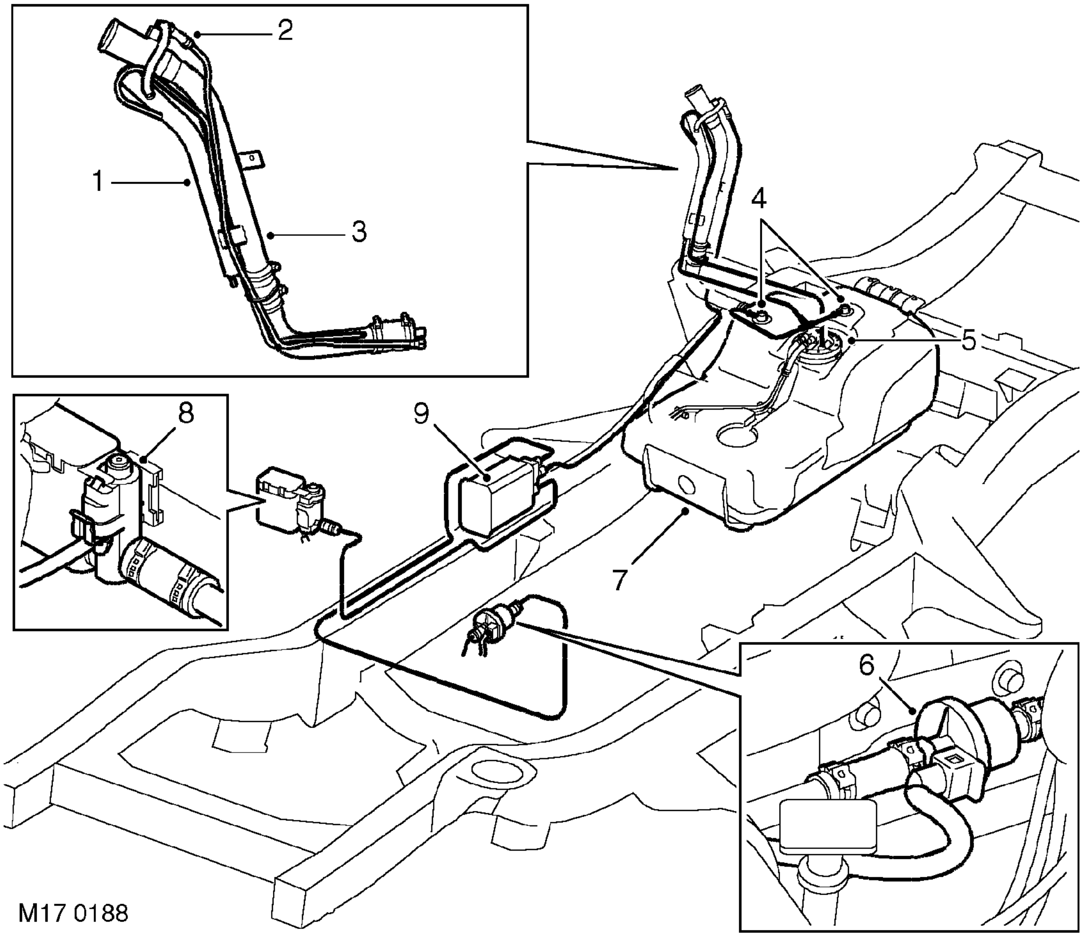
EVAPORATIVE EMISSION CONTROL SYSTEM - ADVANCED EVAPS (up to 99MY)



Component location

1. EVAP canister
2. EVAP canister vent solenoid (ECVS)
3. EVAP canister purge valve
4. Anti-trickle fill valve
5. Liquid/vapour separator
6. Fuel filler neck assembly
7. Fuel tank
8. Fuel pump and gauge sender unit, incorporating fuel tank pressure sensor
9. Roll over valves

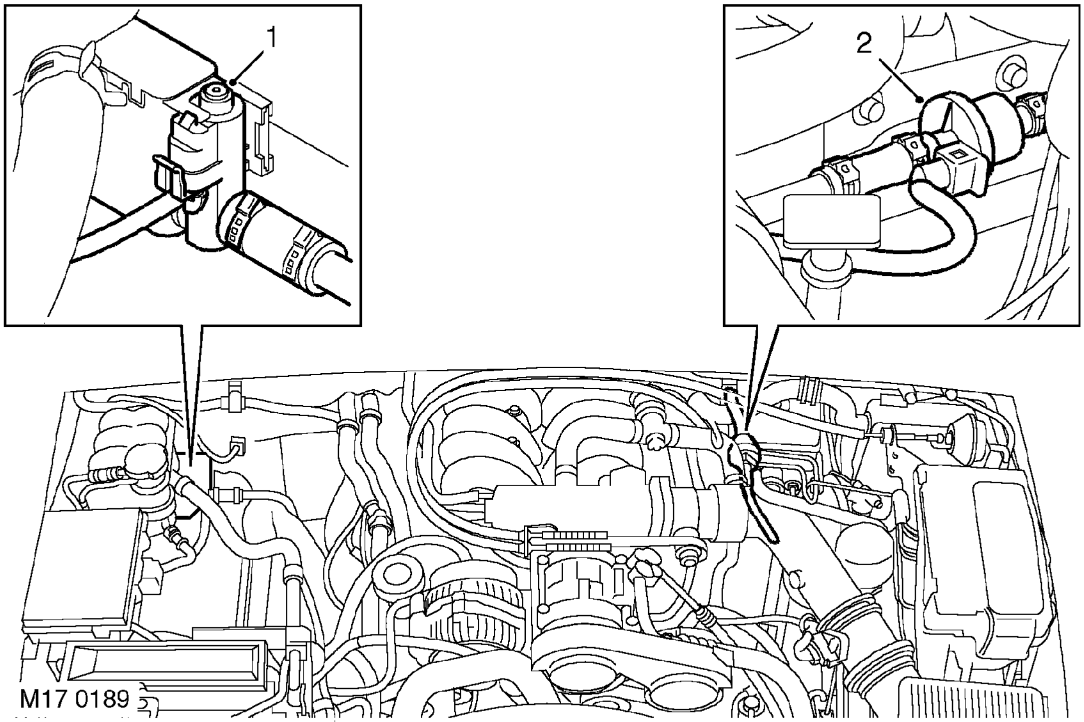
EVAPORATIVE EMISSION CONTROL SYSTEM - ADVANCED EVAPS (from 99MY)



Component location

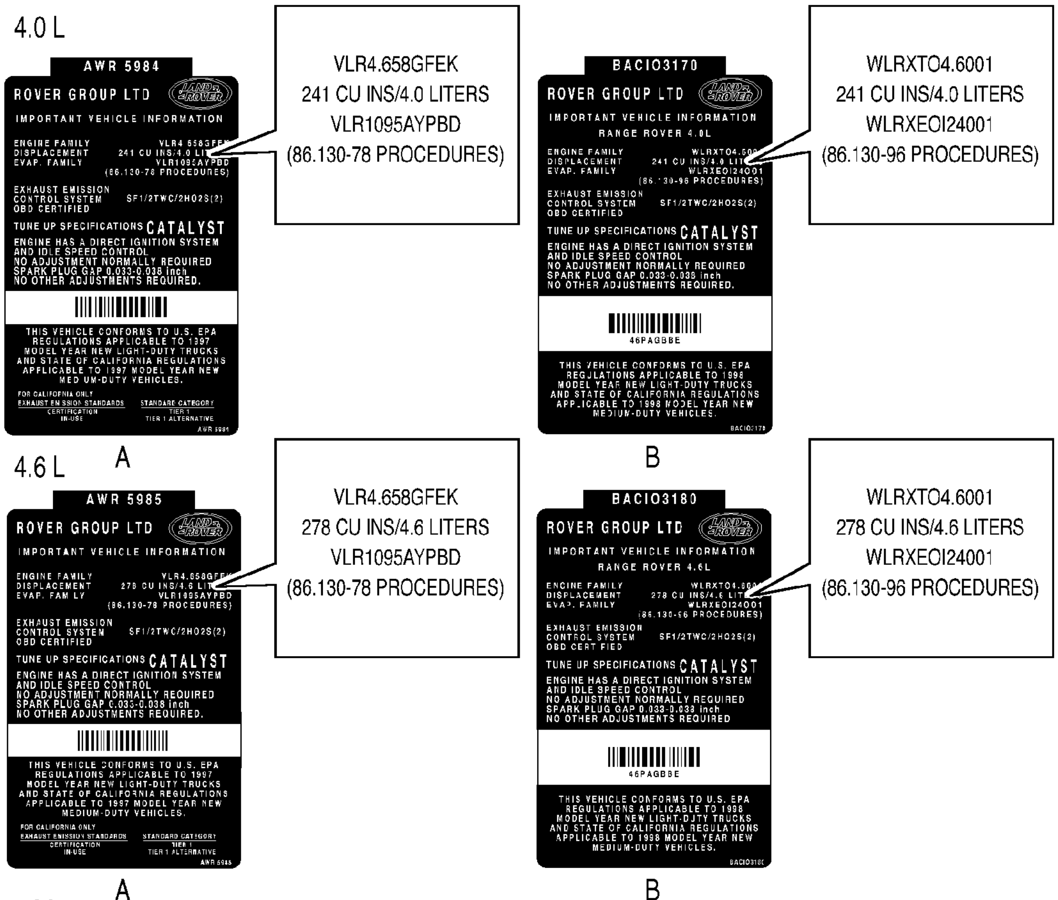
1. Liquid/vapour separator
2. Anti-trickle fill valve
3. Fuel filler neck assembly
4. Roll over valves
5. Fuel pump and gauge sender unit, incorporating fuel tank pressure sensor (NAS only)
6. EVAP canister purge valve
7. Fuel tank
8. Canister vent solenoid (CVS) unit
9. EVAP canister

99MY component location continued:



1. Canister Vent Solenoid (CVS) unit - (NAS only)
2. Purge valve

Identification



17M0129

The system was introduced on all North American specification vehicles from 1998 Model Year. Advanced EVAP vehicles can be recognised by the information contained in the **EVAP. FAMILY** entry on the underbonnet Emission label (mounted on the bonnet lock platform).

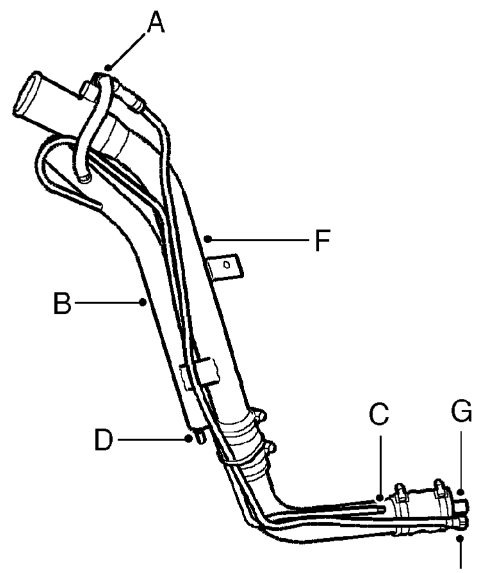
A - Vehicles without advanced EVAPS
VLR1095AYPBD

B - Vehicles with advanced EVAPS
WLRXEO124001

Evaporative emission control system - Advanced EVAPS.

The evaporation emission control system is used to reduce the level of hydrocarbons emitted into the atmosphere from the fuel system. The system comprises a vapour separator (B) and an anti-trickle valve (A), both located on the fuel filler neck (F), an Evaporative Emissions (EVAP) canister and an EVAP canister purge valve. A Canister vent solenoid (CVS) unit is mounted in front of the EVAP canister on vehicles up to 99MY. On vehicles from 99MY the CVS unit is mounted near the bulkhead on the RHS of the engine bay. The CVS unit is used by the ECM to control fresh air supply to the canister.

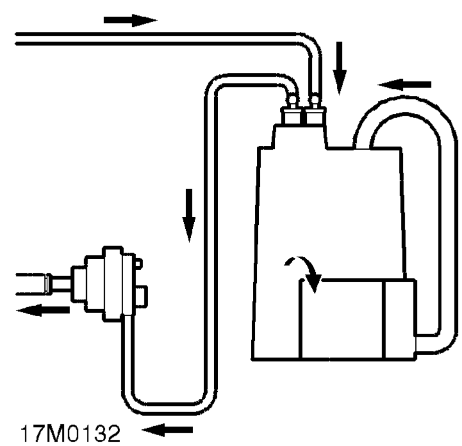
On NAS vehicles, the fuel pump and gauge sender unit incorporates a pressure sensor which is used by the ECM, in conjunction with the CVS unit, to determine the presence of leaks which may cause vapour to escape. This system is added for compliance with OBD measures.



17M0128

A Anti-trickle fill valve
B Liquid/Vapour Separator
C Vent line to pressure sensor
D From fuel tank to liquid/vapour separator
E From EVAP canister to anti-trickle fill valve
F Fuel filler neck assembly
G Internal fill breather hose

During conditions of high ambient temperatures, fuel in the tank vapourises, and pressure rises. Fuel vapour enters the vapour separator and any liquid fuel runs back to the tank. Two roll over valves are fitted in the fuel tank vapour lines. These valves prevent liquid fuel entering the vapour separator if the vehicle rolls over. The advanced EVAPS system has no two way valve, so vapour is free to flow to the EVAP canister, where it is stored in the canister's activated charcoal element. When the correct engine operating conditions are met, the Engine Control Module (ECM) opens the EVAP canister purge valve and vapour is drawn from the canister, into the plenum chamber to be burned in the engine. Fresh air is drawn into the canister through the EVAP canister vent solenoid to take up the volume of displaced vapour. During normal operating conditions, and when the engine is switched off, the vent solenoid remains open and the fuel tank is free to breath through the EVAP canister. If the vent solenoid should fail, or the main vapour line becomes blocked, excess pressure is vented to atmosphere through a valve in the fuel filler cap. Similarly, the cap vent valve will open to prevent the tank collapsing if excessive vacuum is present.



17M0132

When the temperature of fuel in the tank reduces, pressure also reduces and vapour must be drawn back into the tank. Fresh air is drawn into the canister, through the open vent solenoid, to take up the displaced volume.

An anti-trickle fill valve is fitted to the filler neck in the line between the tank and EVAP canister. The function of this valve is to prevent the user overfilling the tank by trickling fuel into the neck, thereby preserving the vapour space in the tank to allow for fuel expansion during hot weather.

The valve creates a blockage in the vent line during the fuel filling process. The valve is operated by the action of inserting the fuel filler gun. With the valve in the closed position, air displaced during filling exits the tank only through the internal fill breather. When the fuel level reaches the level of the fill breather, the filler neck fills with fuel, shutting off the filler gun.

The breather ports from the EVAP canister are located high up in the engine bay (CVS unit on NAS vehicles, snorkel tubes on ROW vehicles), to prevent water ingress during vehicle wading.

The advanced evaporative loss control system used on NAS vehicles is similar to the standard system, but also includes a CVS unit and an in-tank pressure sensor to monitor the pressure build-up for determining whether leaks are present.

The function of the CVS unit is to block the atmospheric vent side of the EVAP canister to enable the ECM to carry out the EVAP system leak check. The leak check is only carried out when the vehicle is stationary and the engine is running at idle speed. The test uses the natural rate of fuel evaporation and engine manifold depression. Failure of the leak check will result in illumination of the Malfunction Indicator Lamp (MIL).

The fuel evaporation leak detection is included as part of the On-Board Diagnostics (OBD) strategy and checks for leaks greater than 1mm (0.04 in.) in diameter. During checking, the vent and purge lines are closed for a reference check on system pressure to be determined. Then the purge valve is opened, exposing the fuel tank and vent lines to engine vacuum. The ECM then checks the signal from the fuel tank pressure sensor for any pressure increase (i.e loss of vacuum) which would indicate a leakage.

Any fuel evaporation system leaks which occur between the output of the purge valve and the connection to the inlet manifold cannot be determined using this test, but this type of fault will be detected through the fuelling adaption diagnostics.

EXHAUST EMISSION CONTROL COMPONENTS - (from 99MY)

Catalytic converters

The catalytic converters are located in each of the front pipes from the exhaust manifolds. The catalytic converter's housings are fabricated from stainless steel and are fully welded at all joints. Each catalytic converter contains two elements of an extruded ceramic substrate which is formed into a honeycomb of small cells with a density of 62 cells / cm^2. The ceramic element is coated with a special surface treatment called 'washcoat' which increases the surface area of the catalyst element by approximately 7000 times. A coating is applied to the washcoat which contains the precious elements Platinum (Pt), Palladium (PD) and Rhodium(Rh) in the following relative concentrations: **1 Pt : 21.6 PD : 1 Rh**.

The metallic coating of platinum and palladium oxidize the carbon monoxide and hydrocarbons and convert them into water (H_2O) and carbon dioxide (CO_2). The coating of rhodium removes the oxygen from nitrogen oxide (NO_x) and converts it into nitrogen (N_2).

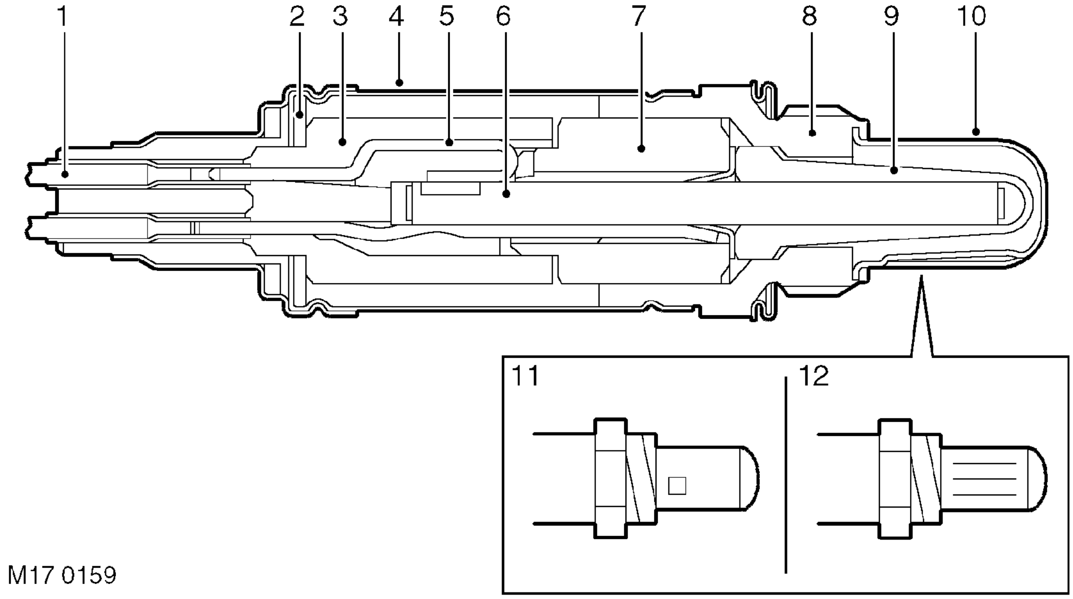
NOTE: Catalytic converters for NAS low emission vehicles (LEVS) from 2000MY have active constituents of Palladium and Rhodium only. The proportion of active constituents are 14 PD: 1 Rh, and the Palladium coating is used to oxidise the carbon monoxide and hydrocarbons in the exhaust gas.

CAUTION: Catalytic converters contain ceramic material which is very fragile. Avoid heavy impacts on the converter casing.

CAUTION: Serious damage to the catalytic converter will occur if leaded fuel or a lower octane number fuel than recommended is used. The fuel tank filler neck is designed to accomodate only unleaded fuel pump nozzles.

WARNING: To prevent personal injury from a hot exhaust system, do not attempt to disconnect any components until the exhaust system has cooled down.

Heated oxygen (HO_2S) sensors



1. Connection cable
2. Disc spring
3. Ceramic support tube
4. Protective sleeve
5. Clamp connection for heating element
6. Heating element
7. Contact element
8. Sensor housing
9. Active sensor ceramic
10. Protective tube
11. Post-catalytic converter sensor (NAS spec. only)
12. Pre-catalytic converter sensor

The heated oxygen sensor is an integral part of the exhaust emission control system and is used in conjunction with the catalytic converters and the engine management control ECM to ensure that the air:fuel mixture ratio stays around the stoichiometric ideal, where the catalytic converters are most effective. Combinations of four (NAS only) or two heated oxygen sensors are used in the exhaust system, dependent on market legislation.

The heated oxygen sensors are screwed into threaded mountings welded into the front exhaust pipes at suitable locations. They are used to detect the level of residual oxygen in the exhaust gas to provide an instantaneous indication of whether combustion is complete. By positioning sensors in the stream of exhaust gases from each separate bank of the exhaust manifold, the engine management system is better able to control the fuelling requirements on each bank independently of the other. This facilitates much closer control of the air:fuel ratio and optimises catalytic converter efficiency.

CAUTION: HO_2S sensors are easily damaged by dropping, excessive heat or contamination. Care must be taken not to damage the sensor tip or housing.

The HO_2S sensors consist of a ceramic body (Galvanic cell) which is practically a pure oxygen-ion conductor made from a mixed oxide of zirconium and yttrium. The ceramic is then coated with gas-permeable platinum, which when heated to a sufficiently high temperature (above 350°C) generates a voltage which is proportional to the oxygen content in the exhaust gas stream.

The sensor is protected by an outer tube with a restricted flow opening to prevent the sensor's ceramic from being cooled by low temperature gases at start up. The pre-catalytic sensors are identified by three slots in the protective tube, whereas the post-catalytic sensors have four square indentations and a hole in the end of the protective tube (NAS only). The post-catalytic sensors have improved signal quality, but a slower response rate. **It is important not to confuse the sensor signal pins; the signal pins are gold plated, whilst the heater supply pins are tinned, mixing them up will cause contamination and adversely affect system performance.**

The HO_2S sensors should be treated with extreme care, since the ceramic material within them can be easily cracked if they are dropped, banged or over-torqued. The sensors should be torqued to the recommended values indicated in the repair procedures. Apply anti-seize compound to the sensor's threads when refitting.

WARNING: Some types of anti-seize compound used in service are a potential health hazard. Avoid skin contact.

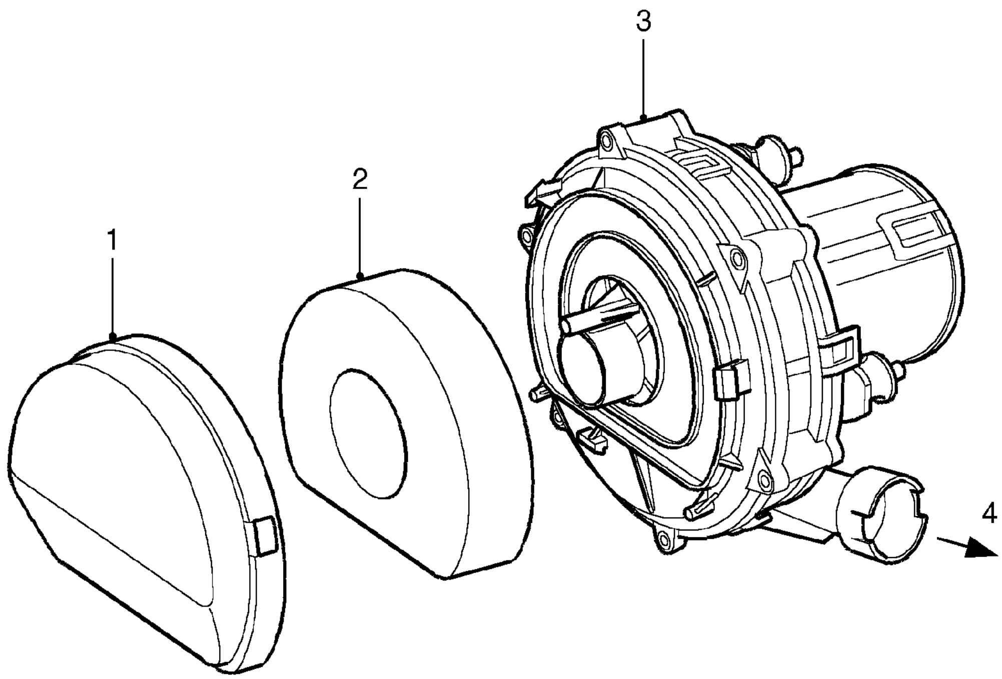
WARNING: To prevent personal injury from a hot exhaust system, do not attempt to disconnect any components until the exhaust system has cooled down.

CAUTION: Do not allow anti-seize compound to come into contact with the tip of the sensor or enter the exhaust system.

NOTE: A new HO_2S sensor is supplied with pre-treated anti-seize compound.

SECONDARY AIR INJECTION SYSTEM COMPONENTS

Secondary air injection (SAI) pump



M17 0214

1. SAI pump cover
2. Foam filter
3. SAI pump
4. Pressurised air to exhaust manifolds

The SAI pump is attached to a bracket at the RH side of the engine compartment. The pump is electrically powered from a 12V battery supply via a dedicated relay and supplies approximately 35 kg/hr of air when the vehicle is at idle in Neutral / Park on a start from 20°C (68°F).

Air is drawn into the pump through vents in its front cover and is then passed through a foam filter to remove particulates before air injection. The air is delivered to the exhaust manifold on each side of the engine through a combination of plastic and metal pipes.

The air delivery pipe is a flexible plastic type, and is connected to the air pump outlet via a plastic quick-fit connector. The other end of the flexible plastic pipe connects to the fixed metal pipework via a short rubber hose. The metal delivery pipe has a fabricated T-piece included where the air is split for delivery to each exhaust manifold via the vacuum operated SAI control valves.

The pipes from the T-piece to each of the SAI control valves are approximately the same length, so that the pressure and mass of the air delivered to each bank will be equal. The ends of the pipes are connected to the inlet port of each SAI control valve through short rubber hose connections.

The T-piece is mounted at the rear of the engine (by the ignition coils) and features a welded mounting bracket which is fixed to the engine by two studs and nuts.

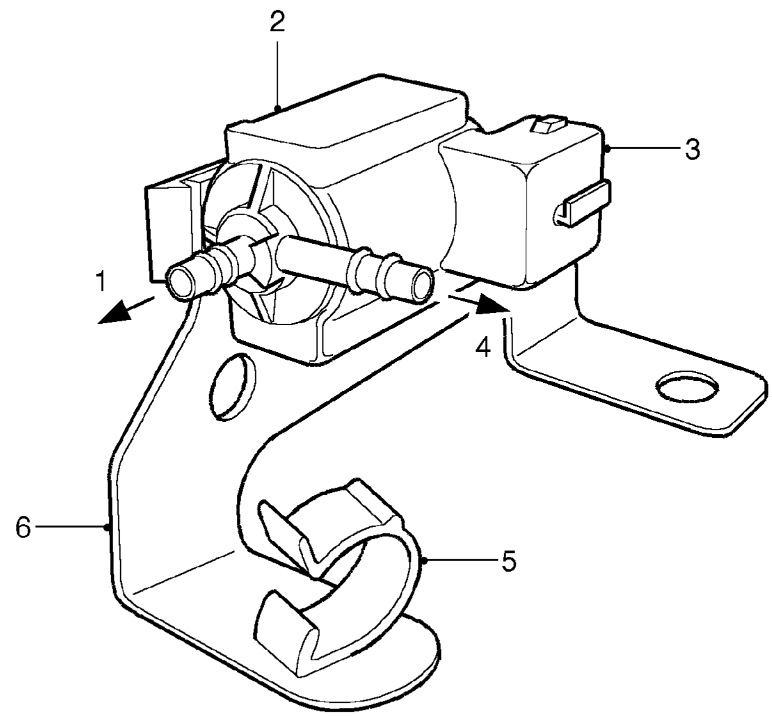
The foam filter in the air intake of the SAI pump provides noise reduction and protects the pump from damage due to particulate contamination. In addition, the pump is fitted on rubber mountings to help prevent noise generated by pump operation from being transmitted through the vehicle body into the passenger compartment.

The SAI pump has an integral thermal cut-out switch, to stop pump operation when the pump overheats. The pump automatically enters a 'soak period' between operations, to allow the pump motor a cooling off period.

Secondary air injection (SAI) pump relay

The secondary air injection pump relay is located in the engine compartment fusebox. The engine control module (ECM) is used to control the operation of the SAI pump via the SAI pump relay. Power to the SAI relay contacts is via fuselink 2 which is located in the engine compartment fusebox.

Secondary air injection (SAI) vacuum solenoid valve



M17 0215

1. Vacuum port to intake manifold (via vacuum reservoir)
2. SAI vacuum solenoid valve
3. Electrical connector
4. Vacuum port to vacuum operated SAI control valves
5. Purge valve clip
6. Mounting bracket

The SAI vacuum solenoid valve is located at the rear LH side of the engine, mounted on a bracket with the EVAP system purge valve and electrically controlled by the ECM.

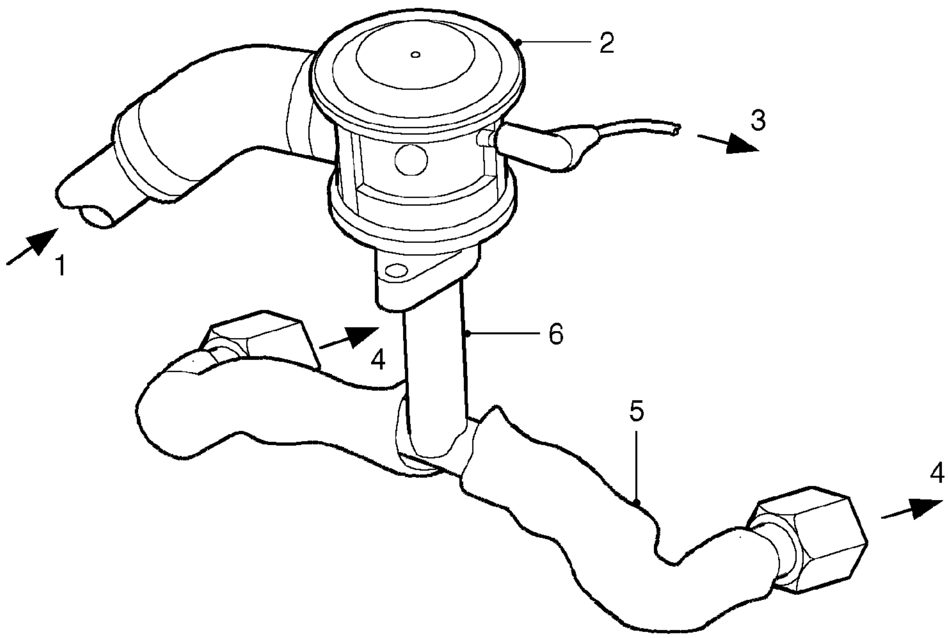
Vacuum to the SAI vacuum solenoid valve is provided from the intake manifold depression via a vacuum reservoir. A small bore vacuum hose with rubber elbow connections at each end provides the vacuum route between the vacuum reservoir and SAI vacuum solenoid valve. A similar hose with a larger size elbow connector, connects the SAI vacuum solenoid valve to the SAI control valves on each side of the engine via an intermediate connection. The SAI vacuum solenoid valve port to the SAI control valves is located at a right angle to the port to the vacuum reservoir.

The intermediate connection in the vacuum supply line splits the vacuum equally between the two SAI control valves and is located midpoint in front of the inlet manifold. All vacuum hose lines are protected by flexible plastic sleeving.

Electrical connection to the SAI vacuum solenoid valve is via a 2-pin connector. A 12V electrical power supply to the valve is provided via the Main relay and Fuse 26 in the engine compartment fusebox. The ground connection is via the ECM which controls the SAI vacuum solenoid valve operation. **Note that the harness connector to the SAI solenoid valve is grey, and must not be confused with the harness connector to the EVAP system purge valve which is black.**

The ECM switches on the SAI vacuum solenoid valve at the same time as initiating SAI pump operation. When the SAI vacuum solenoid valve is open, a steady vacuum supply is allowed through to open the two vacuum operated SAI control valves. When the ECM breaks the earth path to the SAI vacuum solenoid valve, the valve closes and immediately shuts off the vacuum supply to the two SAI control valves at the same time as SAI pump operation is terminated.

SAI control valves



M17 0216

1. Pressurised air from SAI pump
2. Vacuum operated SAI control valve
3. Vacuum hose from SAI vacuum solenoid valve
4. Pressurised air to exhaust manifold
5. Protective heat sleeving
6. Air delivery pipe to exhaust manifold

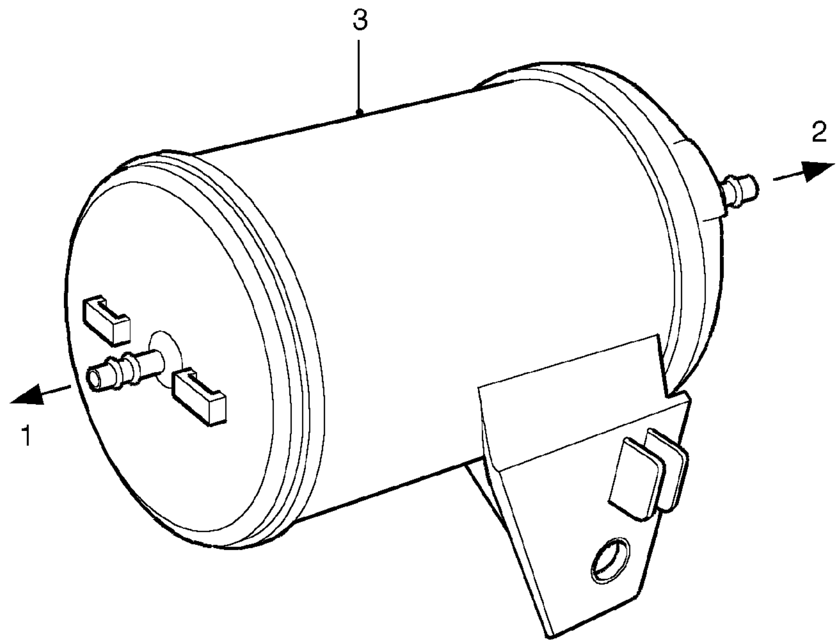
The SAI control valves are located on brackets at each side of the engine.

The air injection supply pipes connect to a large bore port on the side of each SAI control valve via a short rubber connection hose. A small bore vacuum port is located on each SAI control valve at the opposite side to the air injection supply port. The vacuum supply to each vacuum operated SAI control valve is through small bore nylon hoses from the SAI vacuum solenoid valve. An intermediate connector is included in the vacuum supply line to split the vacuum applied to each SAI control valve, so that both valves open and close simultaneously.

When a vacuum is applied to the SAI control valves, the valve opens to allow the pressurised air from the SAI pump through to the exhaust manifolds. The injection air is output from each SAI control valve through a port in the bottom of each unit. A metal pipe connects between the output port of each SAI control valve and each exhaust manifold via an intermediate T-piece. The T-piece splits the pressurised air delivered to ports at the outer side of the two centre exhaust ports on each cylinder head. The pipes between the T-piece and the exhaust manifold are enclosed in thermal sleeving to protect the surrounding components from the very high heat of the exhaust gas, particularly at high engine speeds and loads.

When the SAI vacuum solenoid valve is de-energised, the vacuum supply line opens to atmosphere, this causes the vacuum operated valves to close automatically and completely to prevent further air injection.

Vacuum reservoir



M17 0218

1. Vacuum port to SAI vacuum solenoid valve
2. Vacuum port to intake manifold (one-way valve end)
3. Vacuum reservoir

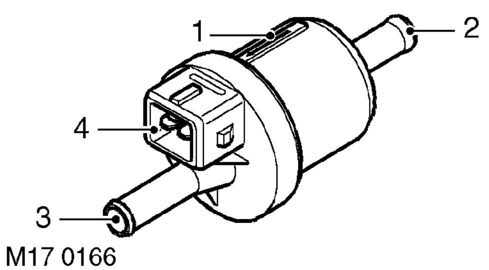
A vacuum reservoir is included in the vacuum supply line between the intake manifold and the SAI vacuum solenoid valve. The vacuum reservoir contains a one-way valve, to stop depression leaking back towards the intake manifold side. The reservoir holds a constant vacuum so that the SAI control valves open instantaneously as soon as the SAI vacuum solenoid valve is energised.

The vacuum reservoir is a plastic canister construction located on the SAI pump bracket at the RH side of the engine compartment. It is important to ensure the reservoir is fitted in the correct orientation, and the correct vacuum hoses are attached to their corresponding ports. The one-way valve end of the reservoir is the cap end which connects to the inlet manifold.

A small bore nylon hose is used to connect the one-way valve end of the vacuum reservoir to a port on the RH side of the inlet manifold. A further small bore nylon hose connects between the other port on the vacuum reservoir and a port on the front of the SAI vacuum solenoid valve.

EVAPORATIVE EMISSION SYSTEM CONTROL COMPONENTS - (from 99MY)

Purge valve



1. Direction of flow indicator
2. Inlet port - from EVAP canister
3. Outlet port - to inlet manifold
4. Harness connector

The EVAP canister purge valve is located in the engine bay at the LH side of the engine intake manifold. On NAS vehicles with secondary air injection, the purge valve is fixed to a metal bracket together with the SAI vacuum solenoid valve; the purge valve is fixed to the bracket by two plastic clips.

The outlet side of the purge valve is connected to a stub pipe on the back of the inlet manifold plenum chamber (through a combination of rubber and nylon pipes). The connector to the plenum chamber stub pipe is a quick-release type, plastic 90°female elbow. A short hose/pipe is connected between the inlet side of the purge valve and a service port.

The purge valve has a plastic housing, and a directional arrow is moulded onto the side of the casing to indicate the direction of flow. The head of the arrow points to the outlet side of the valve which connects to the plenum chamber.

A service port is connected in line between the EVAP canister and the inlet side of the purge valve and is rated at 1 psi maximum regulated pressure. The service port must be mounted horizontally and is located close to the bulkhead at the rear left hand side of the engine bay.

The service port is used for pressure testing using specialist nitrogen test equipment for localising the source of leaks. A pipe/hose from the inlet side of the service port connects to a quick-fit connector that mates to the purge pipe leading to the EVAP canister beneath the vehicle.

Purge valve operation is controlled by the engine control module (ECM). The purge valve has a two-pin electrical connector which links to the ECM via the engine harness. **Note that the harness connector to the SAI solenoid valve is grey, and must not be confused with the harness connector to the EVAP system purge valve which is black.**

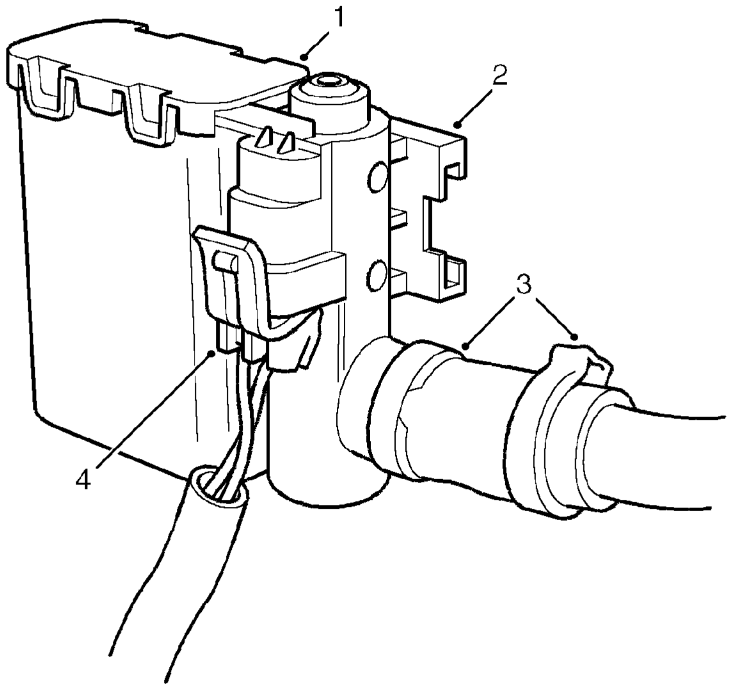
One pin of the connector is the power supply source and the other is the switched earth from the ECM (pulse width modulated (PWM) signal) which is used to control the purge valve operation time.

When the purge valve is earthed by the ECM, the valve opens to allow hydrocarbons stored in the EVAP canister to be purged to the engine inlet manifold for combustion.

If the purge valve breaks or becomes stuck in the open or closed position, the EVAP system will cease to function and there are no default measures available. The ECM will store the fault in memory and illuminate the MIL warning lamp. If the purge valve is stuck in the open position, a rich air:fuel mixture is likely to result at the intake manifold, this could cause the engine to misfire and fuelling adaptions will change. The following failure modes are possible:

- Sticking valve
- Valve blocked
- Connector or harness wiring fault (open or short circuit)
- Valve stuck open

Canister Vent Solenoid (CVS) unit - (NAS only)



M17 0165

1. CVS unit
2. Mounting bracket
3. Spring clips to pipe from EVAP canister
4. Harness connector

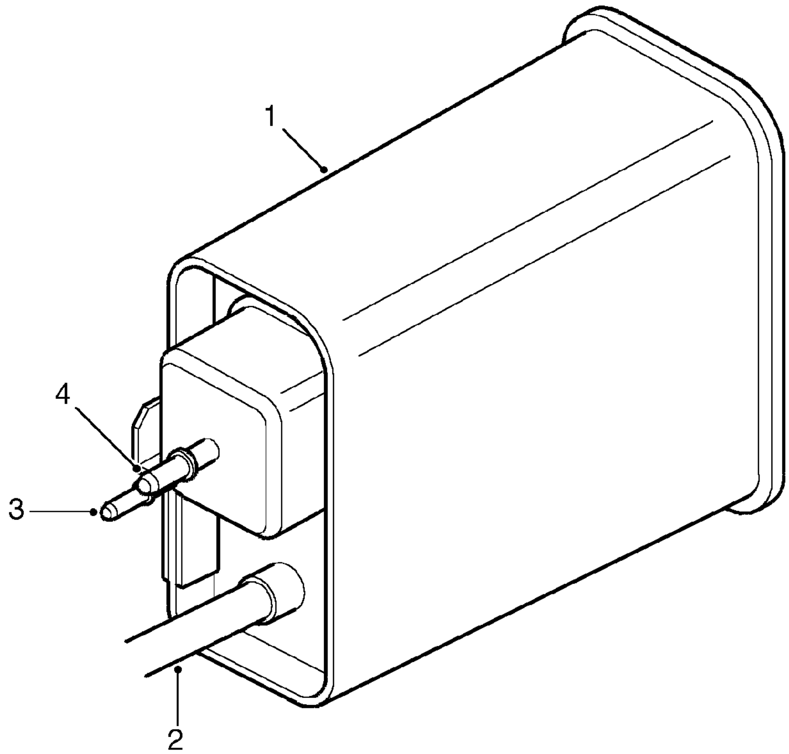
The CVS unit is mounted at the rear right hand side of the engine bay on a slide-on bracket. The vent pipe from the EVAP canister is connected to a stub pipe on the CVS unit via a short rubber hose. The rubber hose is connected to the CVS unit and plastic pipe by two metal band clips. A two-pin connector links to the engine management ECM via the engine harness for solenoid control. One wire is for the voltage feed, the other is the valve drive line to the ECM. The solenoid is operated when the ECM grounds the circuit.

The valve is normally open, allowing any build up of air pressure within the evaporation system to escape, whilst retaining the environmentally harmful hydrocarbons in the EVAP canister.

When the ECM is required to run a fuel evaporation system test, the CVS valve is energised and closes to seal the system. The ECM is then able to measure the pressure in the EVAP system using the fuel tank pressure sensor. The ECM performs electrical integrity checks on the CVS valve to determine wiring or power supply faults. The ECM can also detect a valve blockage if the signal from the fuel tank pressure sensor indicates a depressurising fuel tank while the CVS valve should be open to atmosphere. The following failure modes are possible:

- Connector or wiring harness fault (open or short circuit)
- Valve stuck open or shut
- Valve blocked

EVAP canister



M17 0164

1. EVAP canister
2. Port to breather tube (CVS unit on NAS vehicles)
3. Port - vent line from fuel tank
4. Port - purge line

The EVAP canister is mounted on a bracket which is fitted beneath the vehicle on the RH side of the chassis. The ports of the EVAP canister face towards the rear of the vehicle. Each EVAP canister port has a moulded inscription next to it for identification of the 'purge', 'tank' and 'air' connections.

The NAS and ROW EVAP canisters are of similar appearance, but use charcoal of different consistency. The ROW vehicles use granular charcoal of 11 bwc (butane working capacity) and NAS vehicles use pelletised charcoal with a higher absorption capacity of 15 bwc. All canisters are of rectangular shape and have purge foam retention.

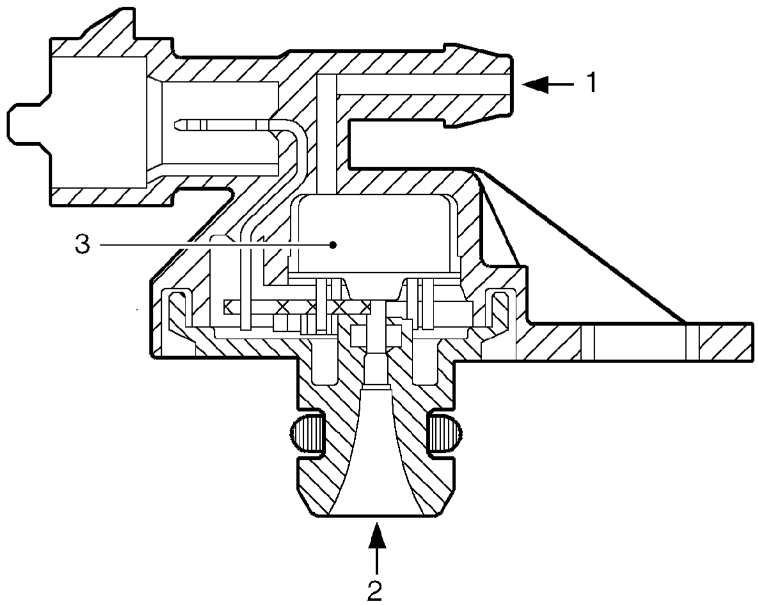
The vent line from the fuel tank to the EVAP canister connects to the vent port on the canister by means of a straight quick-fit connector. The vent line terminates in a quick-fit connector at the fuel filler.

The nylon pipe to atmosphere connects to a port on the EVAP canister via a short rubber hose secured with metal band clips. The atmosphere end of the pipe terminates in a quick-fit connector to the pipe leading to the CVS unit on NAS vehicles and a snorkel tube situated behind the engine at the bulkhead on ROW vehicles. The bore of the nylon breather pipe used on NAS vehicles is larger than that used on ROW vehicles.

The purge line from the EVAP canister is connected to the inlet manifold plenum after the throttle body via a purge valve and service port. The pipe between the EVAP canister and the purge valve is routed over the transmission and into the LH side of the engine bay. The pipe clips to the purge port on the EVAP canister by means of an elbowed quick-fit connector and the connection is covered by a rubber seal which is held in position on the port stub pipe.

The pipes are clipped at various points along the pipe runs and tied together with tie straps at suitable points along the runs.

Fuel tank pressure sensor - (NAS only)



M17 0167

1. Ambient pressure
2. Tank pressure
3. Sensor cell

A fuel tank pressure sensor is fitted to NAS vehicles with advanced EVAPS, it is used by the ECM during an EVAP system leak test, in accordance with the on board diagnostics (OBD) strategy.

The fuel tank pressure sensor is located in the top flange of the fuel tank sender/ fuel pump module and is a non-serviceable item (i.e. if the sensor becomes defective, the entire fuel tank sender unit must be replaced). The fuel tank pressure sensor connector is accessible through the fuel pump access hatch in the rear floor of the vehicle.

The pressure sensor is basically a piezo-resistive sensor element with associated circuitry for signal amplification and temperature compensation. The active surface is exposed to ambient pressure by an opening in the cap and by the reference port. It is protected from humidity by a silicon gel. The tank pressure is fed up to a pressure port at the rear side of the diaphragm.

Fuel evaporation leaks are diagnosed by the ECM monitoring the sensor for a drop in vacuum pressure during test conditions. The EVAP system is sealed by the CVS valve and purge valve after a vacuum has been set up in the system from the intake manifold while the purge valve is open and the CVS valve is closed.

If any holes or leaks are present at the evaporation system joints, the vacuum pressure will gradually drop and this change in pressure will be detected by the fuel tank pressure sensor. The system is sensitive enough to detect leaks down to 1mm (0.04 in.) in diameter.

The fuel tank pressure sensor is part of the NAS OBD system, a component failure will not be noticed by the driver, but if the ECM detects a fault, it will be stored in the diagnostic memory and the MIL light will be illuminated on the instrument pack. Possible failures are listed below:

- Damaged or blocked sensor
- Harness/connector faulty
- Sensor earthing problem
- Open circuit
- Short circuit to battery voltage
- Short circuit to ground
- ECM fault

Fuel vapour separator

The fuel vapour separator is located under the right rear wheel arch next to the filler neck and protected by the wheel arch lining. The connections to the separator unit are quick release devices at the end of the flexible hoses which connect the fuel tank to the inlet side of the separator and the outlet of the separator to the evaporation vent line.

TESTING EVAPORATIVE EMISSION CONTROL - PRE ADVANCED EVAPS

The following pressure test procedure is intended to provide a method for ensuring that the system does not leak excessively and will effectively control evaporative emissions.

Equipment required.

Nitrogen cylinder (compressed air may be used to pressure the system when there has NEVER been fuel present in the fuel or evaporative control systems).

Water manometer 0 - 100 cm (0 - 30" H_2O or more).

Pipework and a "T" piece.

Method.

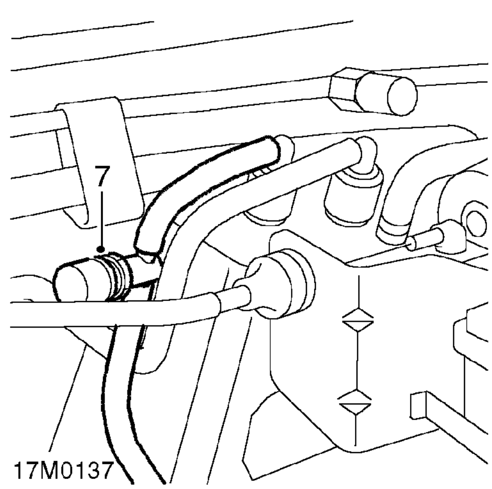
1. Ensure that there is at least two gallons of fuel in the petrol tank unless there has never been any fuel in the system.
2. Disconnect, at the EVAP canister, the pipe to the fuel tank vapour separator.
3. Connect this pipe to the nitrogen cylinder and the water manometer using the "T" piece.
4. Pressurize the system to between 67.3 and 70.0 cm (26.5 and 27.5 inches) of water, allow the reading to stabilize, then turn off the nitrogen supply.
5. Measure the pressure drop within a period of 2 minutes 30 seconds. If the drop is greater than 6.3 cm (2.5 inches) of water the system has failed the test. Note that a fully sealed system will show a slight increase in pressure.
6. Should the system fail the test, maintain the pressure in the system and apply a soap solution round all the joints and connections until bubbles appear to reveal the source of the leak.
7. Repeat the test and if successful, dismantle the test equipment and reconnect the pipe to the EVAP canister.

LEAK DETECTION PROCEDURE - ADVANCED EVAPS

1. Connect TestBook to the vehicle and confirm that the fault code(s) displayed relate to an EVAP system fault.
2. Examine components in fuel and EVAP system for damage or poorly connected joints.
3. Repair or replace components to rectify any faults found, then reset the Malfunction Indicator Lamp (MIL) using TestBook.
4. Carry out Drive Cycle, ***See this section.***
5. Using TestBook confirm that the Evaporative Loss Control (ELC) Inspection and Maintenance (IM) flag has cleared. This procedure should confirm that the ELC test was carried out during the drive cycle and that the fault was cured.
6. If the IM flag is still shown, use TestBook to interrogate the engine management system to ascertain which of the following situations exists:

- If a fault code is shown, then further investigation is required, proceed to the next step.
- If the IM flag is still shown, but no faults are indicated the conditions for the ELC check have not been met and the drive cycle must be repeated.

7. Connect the EVAP Diagnostic Station to the service port and carry out the procedures given in the operating instructions supplied with the equipment.



8. Rectify faults indicated by the EVAP Diagnostic Station and return to step 4.

DRIVE CYCLES - up to 99MY

1. Switch on ignition for 30 seconds.
2. Ensure that coolant temperature is less than 30 °C (86 °F).
3. Start engine and allow to idle for 2 minutes.
4. Perform 2 light accelerations 0 to 35 mph (0 to 56 km/h) with light pedal pressure.
5. Perform 2 medium accelerations 0 to 45 mph (0 to 72 km/h) with moderate pedal pressure.
6. Perform 2 hard accelerations 0 to 55 mph (0 to 88 km/h) with heavy pedal pressure.
7. Cruise at 60 mph (96 km/h) for 5 minutes.
8. Cruise at 50 mph (80 km/h) for 5 minutes.
9. Cruise at 35 mph (56 km/h) for 5 minutes.
10. Allow engine to idle for 2 minutes.
11. Connect TestBook and check for fault codes.

DRIVE CYCLES - from 99MY

The following are the Testbook drive cycles

Drive cycle A:

1. Switch on the ignition for 30 seconds.
2. Ensure engine coolant temperature is less than 60°C (140°F).
3. Start the engine and allow to idle for 2 minutes.
4. Connect Testbook and check for fault codes.

Drive cycle B:

1. Switch ignition on for 30 seconds.
2. Ensure engine coolant temperature is less than 60°C (140°F).
3. Start the engine and allow to idle for 2 minutes.
4. Perform two light accelerations (0 to 35 mph) (0 to 60 km/h) with light pedal pressure).
5. Perform two medium accelerations (0 to 45 mph) (0 to 70 km/h) with moderate pedal pressure).
6. Perform two hard accelerations (0 to 55 mph) (0 to 90 km/h) with heavy pedal pressure).
7. Allow engine to idle for two minutes.
8. Connect Testbook and check for fault codes.

Drive cycle C1 (vehicles without advanced EVAPS):

1. Switch ignition on for 30 seconds.
2. Ensure engine coolant temperature is less than 60°C (140°F).
3. Start the engine and allow to idle for 2 minutes.
4. Perform two light accelerations (0 to 35 mph) (0 to 60 km/h) with light pedal pressure).
5. Perform two medium accelerations (0 to 45 mph) (0 to 70 km/h) with moderate pedal pressure).
6. Perform two hard accelerations (0 to 55 mph) (0 to 90 km/h) with heavy pedal pressure).
7. Cruise at 60 mph (100 km/h) for 5 minutes.
8. Cruise at 50 mph (80 km/h) for 5 minutes.
9. Allow engine to idle for 2 minutes.
10. Connect Testbook and check for fault codes.

Drive cycle C2 (vehicles with advanced EVAPS):

1. Switch ignition on for 30 seconds.
2. Ensure engine coolant temperature is less than 60°C (140°F).
3. Start the engine and allow to idle for 2 minutes.
4. Perform two light accelerations (0 to 35 mph) (0 to 60 km/h) with light pedal pressure).
5. Perform two medium accelerations (0 to 45 mph) (0 to 70 km/h) with moderate pedal pressure).
6. Perform two hard accelerations (0 to 55 mph) (0 to 90 km/h) with heavy pedal pressure).
7. Cruise at 60 mph (100 km/h) for 8 minutes.
8. Cruise at 50 mph (80 km/h) for 3 minutes.
9. Allow engine to idle for 3 minutes.
10. Connect Testbook and check for fault codes.

NOTE: The following areas have an associated readiness test which must be flagged as complete, before a problem resolution can be verified:

- *Catalytic converter fault;*
- *Evaporative loss system fault;*
- *HO_2S sensor fault;*
- *HO_2S sensor heater fault.*

When carrying out a drive cycle C to determine a fault in the above areas, select the readiness test icon to verify that the test has been flagged as complete.

Drive cycle D:

1. Switch ignition on for 30 seconds.
2. Ensure engine coolant temperature is less than 35°C (95°F).
3. Start the engine and allow to idle for 2 minutes.
4. Perform two light accelerations (0 to 35 mph) (0 to 60 km/h) with light pedal pressure).
5. Perform two medium accelerations (0 to 45 mph) (0 to 70 km/h) with moderate pedal pressure).
6. Perform two hard accelerations (0 to 55 mph) (0 to 90 km/h) with heavy pedal pressure).
7. Cruise at 60 mph (100 km/h) for 5 minutes.
8. Cruise at 50 mph (80 km/h) for 5 minutes.
9. Cruise at 35 mph (60 km/h) for 5 minutes.
10. Allow engine to idle for 2 minutes.
11. Connect Testbook and check for fault codes.

Drive cycle E:

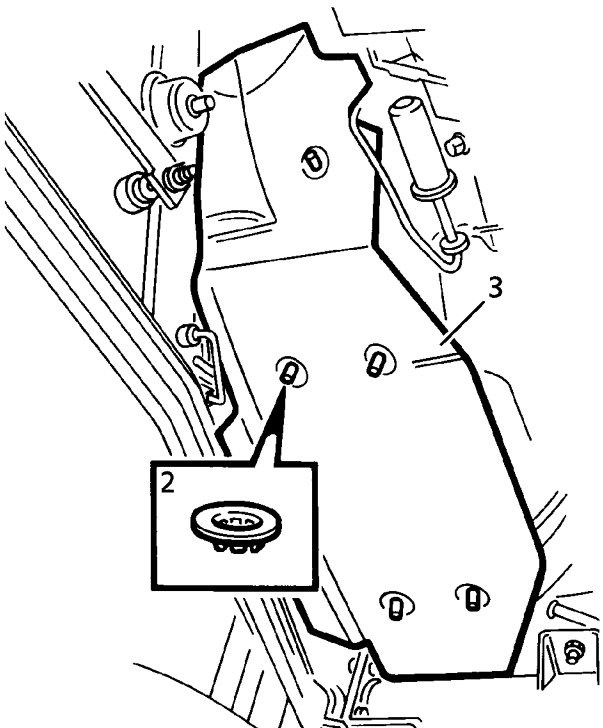
1. Ensure the fuel tank is more than a quarter full.
2. Carry out drive cycle A.
3. Switch off ignition.
4. Leave vehicle undisturbed for 20 minutes.
5. Switch on ignition.
6. Connect Testbook and check for fault codes.

CATALYST HEAT SHIELDS

Service repair no - 17.50.05

Remove

1. Remove exhaust front pipe. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***
2. Remove 5 retaining washers securing heat shield to floor pan studs.



17M7002

3. Remove heat shield. Discard retaining washers.

Refit

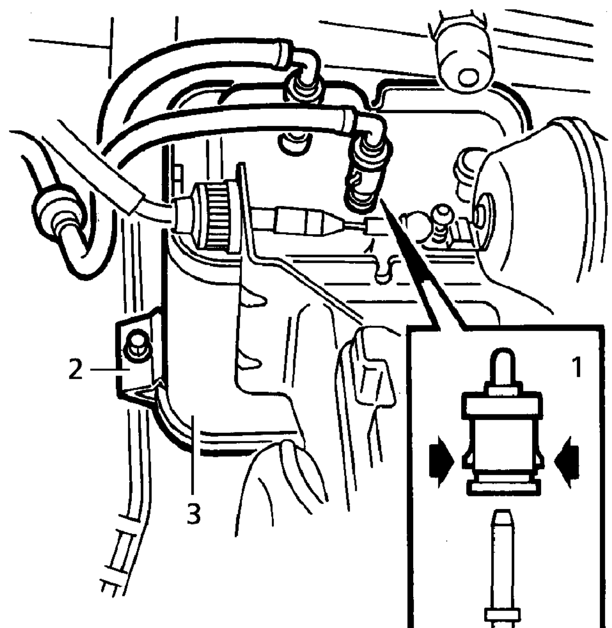
4. Reverse removal procedure.

EVAP CANISTER - PRE-ADVANCED EVAPS

Service repair no - 17.15.13

Remove

1. Disconnect fuel tank vapour and purge valve hoses from canister.
2. Remove bolt and clamp plate securing canister to mounting plate.
3. Remove EVAP canister.



17M7000

Refit

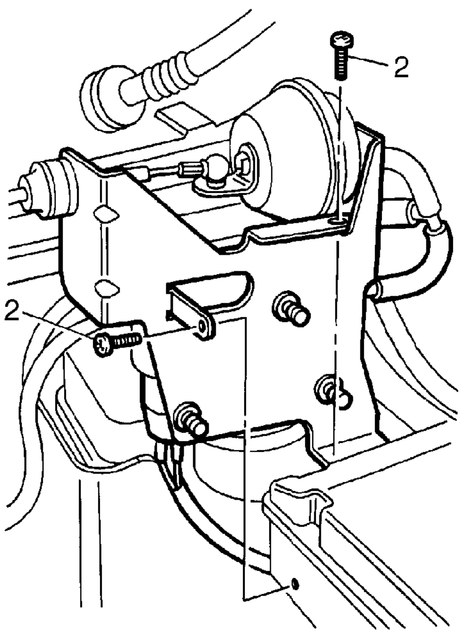
4. Reverse removal procedure.

EVAP CANISTER - ADVANCED EVAPS (up to 99MY)

Service repair no - 17.15.13

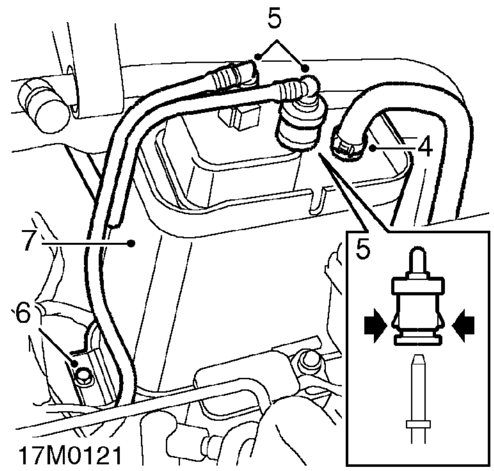
Remove

1. Disconnect battery earth lead.



17M0120

2. Remove 2 screws securing cruise control actuator bracket to suspension control box.
3. Position cruise control actuator assembly aside.



17M0121

4. Release clip securing vent solenoid hose to cannister and disconnect hose.
5. Release vent and purge quickfit connectors from canister.
6. Remove bolt securing canister to mounting bracket and collect clamp plate.
7. Remove canister.

Refit

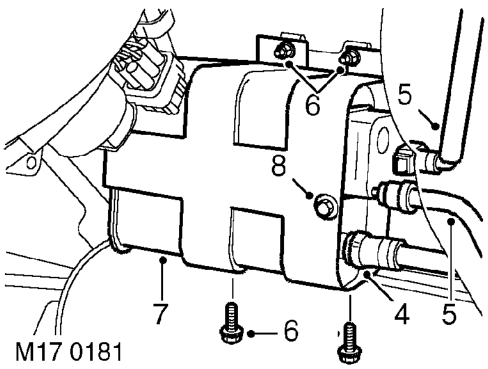
8. Position canister to mounting bracket.
9. Position clamp plate and secure canister to bracket with bolt.
10. Connect purge and vent hoses to cannister, ensuring that quickfit connectors correctly engage.
11. Connect vent solenoid hose to canister and secure clip.
12. Align cruise control actuator bracket to suspension control box and secure with screws.
13. Connect battery earth lead.

EVAP CANISTER - from 99MY

Service repair no - 17.15.13

Remove

1. Release fixings and remove battery cover.
2. Disconnect battery earth lead.
3. Raise vehicle on lift.



M17 0181

4. Release clip and disconnect air hose from canister.
5. Release and remove purge and tank pipes from canister.
6. Remove 2 nuts and 2 bolts securing EVAP canister to chassis.
7. Remove EVAP canister.
8. Remove bolt securing bracket to canister and remove canister.

CAUTION: Plug the connections.

Refit

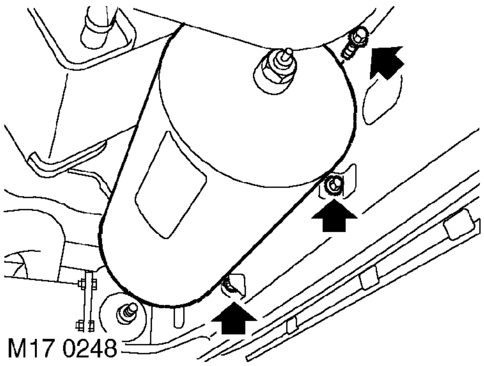
9. Fit bracket to canister and secure with bolt.
10. Fit canister to chassis and secure with nuts and bolts.
11. Ensure all connections are clean.
12. Connect purge and tank pipes to canister.
13. Connect air hose to canister and secure hose with clip.
14. Lower vehicle.
15. Connect battery earth lead.
16. Fit battery cover and secure with fixings.

EVAP CANISTER - LEVS

Service repair no - 17.15.13

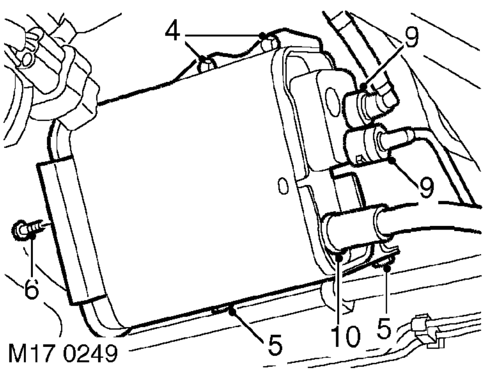
Remove

1. Raise vehicle on 4 post ramp.



M17 0248

2. Remove 3 bolts securing air suspension reservoir to mounting brackets.
3. Release air suspension reservoir and carefully move aside.



M17 0249

4. Remove 2 bolts securing EVAP canister mounting bracket to body.
5. Remove 2 nuts securing EVAP canister mounting bracket to body.
6. Remove bolt securing EVAP canister to mounting bracket. Collect nut and mounting bracket.
7. Remove mounting bracket.
8. Position cloth to absorb any fuel spillage.
9. Release purge and tank vent pipes from EVAP canister.
10. Remove clip securing CVS valve pipe to EVAP canister.
11. Release pipe from EVAP canister and remove canister.

CAUTION: Plug the connections.

Refit

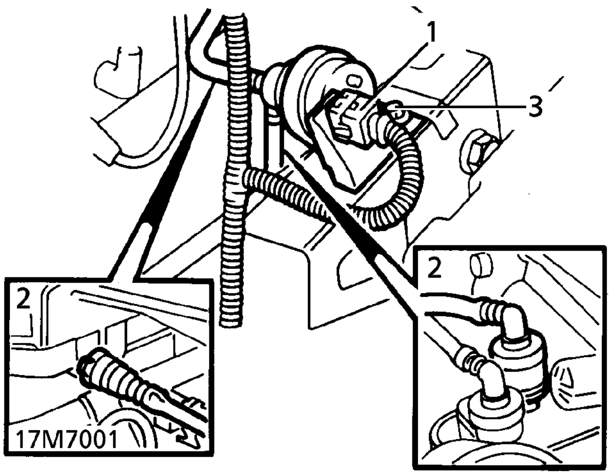
12. Remove plugs and ensure all connections are clean.
13. Connect CVS valve pipe to EVAP canister and secure with clip.
14. Connect purge and tank vent pipes to EVAP canister.
15. Position mounting bracket to EVAP canister and secure with bolt.
16. Position mounting bracket to body and secure with nuts.
17. Fit and tighten bolts securing mounting bracket to body.
18. Lower vehicle.

PURGE VALVE - up to 97MY

Service repair no - 17.15.39

Remove

1. Disconnect multiplug from purge valve.
2. Disconnect hoses from EVAP canister and ram pipe housing.
3. Remove bolt securing valve to shock absorber turret. Remove purge valve.



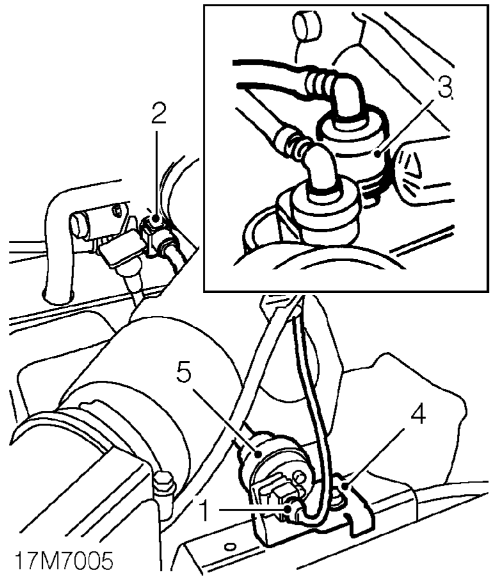
Refit

4. Reverse removal procedure.

PURGE VALVE - 97MY to 99MY

Service repair no - 17.15.39

Remove



1. Disconnect multiplug from purge valve.
2. Depress quick release connector tabs and disconnect hose from throttle housing.
3. Depress quick release connector tabs and disconnect hose from EVAP canister.
4. Remove bolt securing purge valve to shock absorber turret.
5. Remove purge valve.

Refit

6. Position purge valve to shock absorber turret.
7. Fit and tighten bolt securing purge valve to shock absorber turret.
8. Clean hose connections.
9. Connect hoses to EVAP canister and throttle housing.

NOTE: Ensure connections are correctly engaged by gently pulling hose connections.

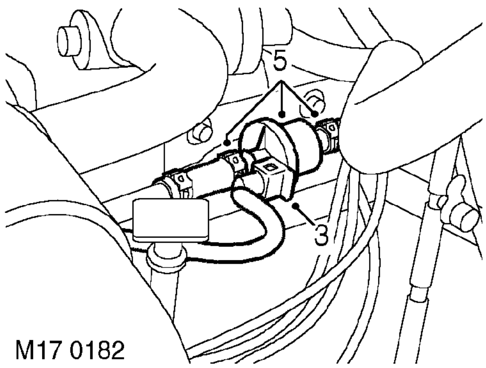
10. Connect multiplug to purge valve.

PURGE VALVE - from 99MY

Service repair no - 17.15.39

Remove

1. Release fixings and remove battery cover.
2. Disconnect battery earth lead.



M17 0182

3. Disconnect multiplug from purge control valve.
4. Release purge control valve and hoses from clips.
5. Disconnect hoses from purge control valve and remove valve.

CAUTION: Plug the connections.

Refit

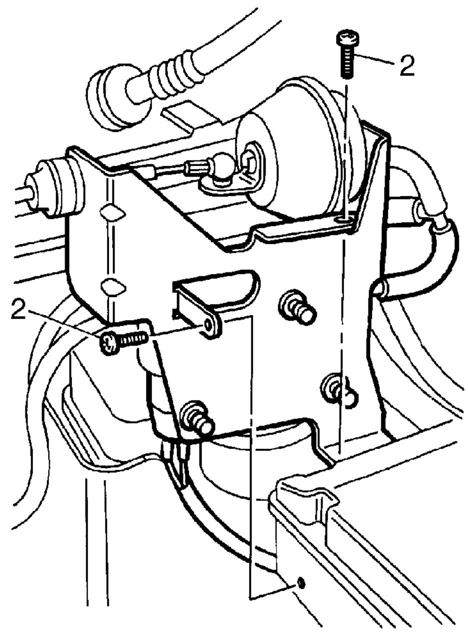
6. Position purge control valve, connect hoses and secure with clips.
7. Fit purge control valve and hoses to clips.
8. Connect multiplug to purge control valve.
9. Connect battery earth lead.
10. Fit battery cover and secure with fixings.

EVAP CANISTER VENT SOLENOID - up to 99MY

Service repair no - 17.15.47

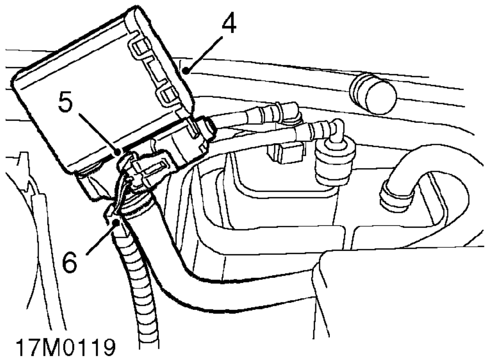
Remove

1. Disconnect battery earth lead.



17M0120

2. Remove 2 screws securing cruise control actuator bracket to suspension control box.
3. Position cruise control actuator assembly aside.



4. Release vent solenoid from EVAP canister bracket for access to hose clip and connector.
5. Disconnect multiplug from vent solenoid.
6. Release clip and remove vent solenoid from hose.

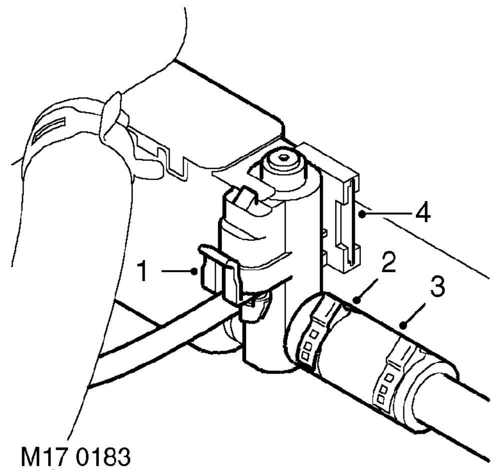
Refit

7. Fit vent solenoid to hose and secure hose clip.
8. Connect multiplug to vent solenoid.
9. Position vent solenoid to bracket and engage clip.
10. Align cruise control actuator bracket to suspension control box and secure with screws.
11. Connect battery earth lead.

EVAP CANISTER VENT SOLENOID - from 99MY

Service repair no - 17.15.47

Remove



1. Disconnect multiplug from vent solenoid.
2. Remove clip securing hose to vent solenoid.
3. Disconnect hose from vent solenoid.

CAUTION: Plug the connections.

4. Release clip and remove vent solenoid from bracket.

Refit

5. Fit vent solenoid to bracket.
6. Connect hose to vent solenoid.
7. Fit clip to secure hose to vent solenoid.
8. Connect multiplug to vent solenoid.

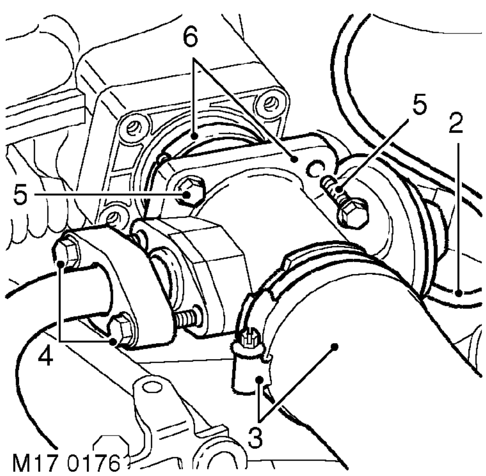
EXHAUST GAS RECIRCULATION (EGR) VALVE - DIESEL

Service repair no - 17.45.01

Remove

1. Disconnect battery negative terminal.
2. Disconnect vacuum hose from EGR valve.
3. Slacken clip and disconnect intercooler hose from EGR valve.
4. Remove 2 bolts securing EGR pipe to EGR valve.
5. Remove 4 bolts securing EGR valve to intake manifold.
6. Remove EGR valve and collect seal from intake manifold.

CAUTION: Care must be taken when extracting seal to ensure recess in intake manifold is not damaged.



7. Clean sealing faces of manifold, EGR valve and EGR pipe.

Refit

8. Fit new seal to intake manifold recess.
9. Position EGR valve to intake manifold and secure with bolts. Tighten bolts to ***10 Nm (7 lbf.in).***
10. Engage EGR pipe to valve, align flange and secure with bolts. Tighten bolts to ***22 Nm (16 lbf.in).***
11. Connect intercooler hose to EGR valve and secure with clip.
12. Connect vacuum hose to EGR valve.
13. Connect battery negative terminal.

MODULATOR VALVE - EGR

Service repair no - 17.45.04

Remove

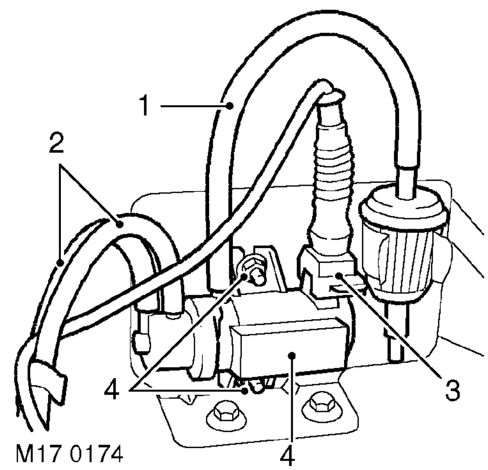
1. Disconnect vent hose from solenoid valve.

NOTE: Record hose positions to aid connection.

2. Disconnect EGR valve and vacuum pump hoses from solenoid valve.

CAUTION: Plug the connections.

3. Disconnect multiplug from solenoid valve.
4. Remove 2 nuts securing solenoid valve to mounting and remove valve.



Refit

5. Fit solenoid valve to mounting and secure with nuts.
6. Connect multiplug to valve.
7. Connect vent hose and vacuum hoses to solenoid valve.

VACUUM PUMP - EGR SYSTEM

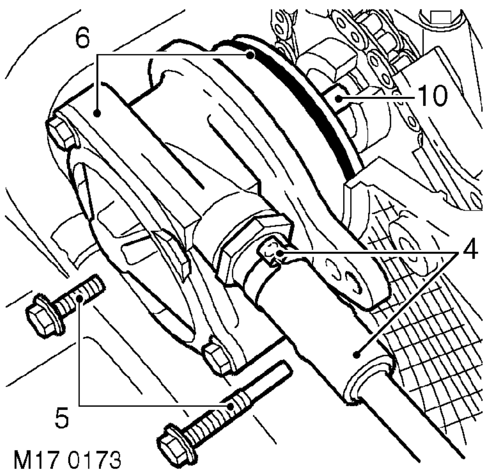
Service repair no - 17.45.30

Remove

1. Disconnect battery negative terminal.
2. Remove camshaft cover. ***See ENGINE, Repair.***
3. Position harness trunking aside.
4. Release clip and disconnect pipe from vacuum pump.
5. Remove 2 bolts securing vacuum pump.

NOTE: Dowel bolt is used to secure inlet manifold side of vacuum pump.

6. Remove vacuum pump and discard 'O' ring seal.



M17 0173

7. Clean sealing faces of vacuum pump and cylinder head.

Refit

8. Fit new 'O' ring seal to vacuum pump.
9. Apply STC 3373 to threads of dowel bolt.
10. Position vacuum pump and engage drive dog with camshaft slot.
11. Secure vacuum pump with bolts. Tighten to ***22 Nm (16 lbf.ft).***

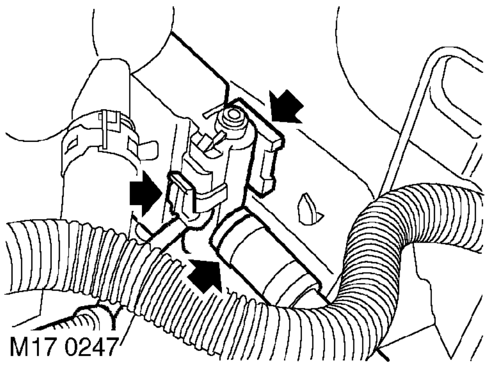
CAUTION: Ensure that dowel bolt passes through timing chain guide rail bolt.

12. Connect pipe to vacuum pump and secure with clip.
13. Align harness trunking.
14. Fit camshaft cover. ***See ENGINE, Repair.***
15. Connect battery negative terminal.

SOLENOID - EVAP CANNISTER VENT VALVE (CVS)

Service repair no - 17.15.47

Remove



1. Disconnect multiplug from CVS unit.
2. Remove clip securing hose to CVS unit.
3. Disconnect hose from CVS unit.

CAUTION: Plug the connections.

4. Remove CVS unit from bracket.

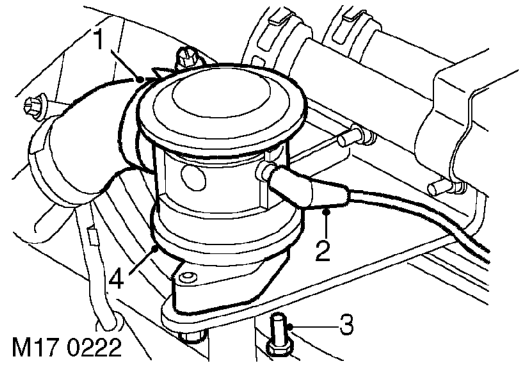
Refit

5. Fit CVS unit to bracket.
6. Connect hose to CVS unit.
7. Fit clip to secure hose to CVS unit.
8. Connect multiplug to CVS unit.

CONTROL VALVE - SECONDARY AIR INJECTION (SAI)

Service repair no - 17.25.02

Remove



1. Release clip and disconnect air hose from valve.
2. Disconnect vacuum hose from valve.
3. Remove 2 bolts securing valve to air manifold.
4. Remove valve and discard gasket.

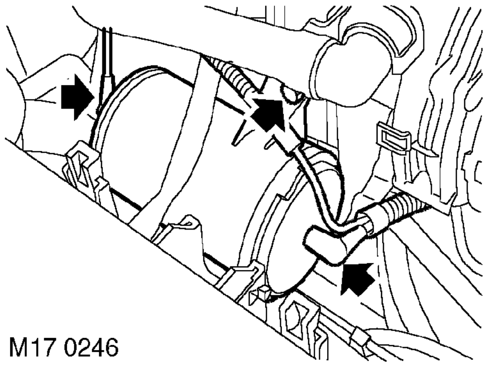
Refit

5. Clean air valve and mating face on manifold.
6. Fit new gasket and fit valve. Tighten bolts to ***10 Nm (7 lbf.ft)*** .
7. Connect vacuum hose.
8. Connect air hose and secure with clip.

RESERVOIR - VACUUM - SECONDARY AIR INJECTION (SAI)

Service repair no - 17.25.04

Remove



M17 0246

1. Disconnect 2 vacuum hoses from reservoir.
2. Remove bolt securing reservoir to mounting bracket and collect reservoir.

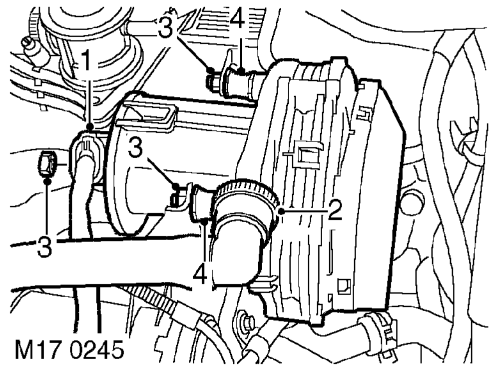
Refit

3. Position reservoir to mounting bracket and tighten bolt to ***10 Nm (7 lbf.ft)*** .
4. Connect vacuum hoses to reservoir.

PUMP - SECONDARY AIR INJECTION (SAI)

Service repair no - 17.25.07

Remove



M17 0245

1. Disconnect multiplug from air pump.
2. Release clip and disconnect air hose from air pump.
3. Remove 3 nuts securing air pump to mounting bracket and remove pump.
4. Remove 3 mountings from air pump.

Refit

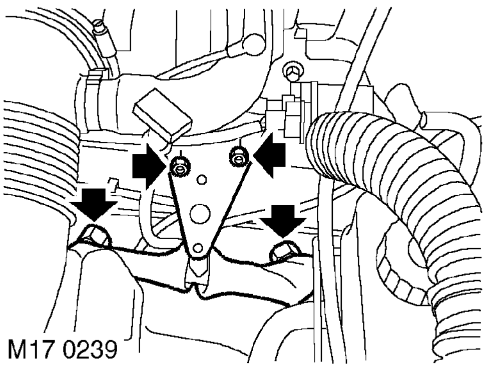
5. Fit mountings to air pump and tighten to ***10 Nm (7 lbf.ft)*** .
6. Fit air pump to mounting bracket and tighten nuts to ***10 Nm (7 lbf.ft)*** .
7. Connect air hose and secure with clip.
8. Connect multiplug to air pump.

AIR MANIFOLD - LH - SECONDARY AIR INJECTION (SAI)

Service repair no - 17.25.17

Remove

1. Remove SAI control valve. ***See this section.***



2. Loosen 2 union nuts securing air manifold to cylinder head adaptors.
3. Remove 2 nuts securing air manifold bracket to inlet manifold.
4. Remove air manifold.

Refit

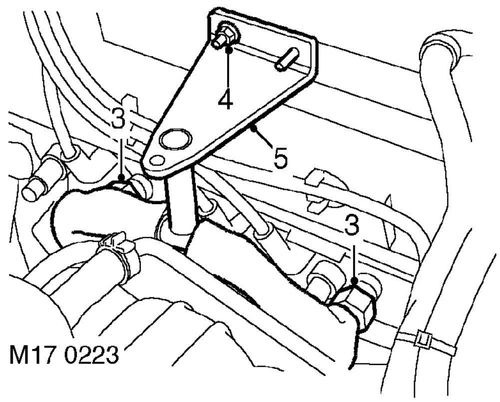
5. Clean air manifold and cylinder head adaptors.
6. Fit air manifold and start union nuts.
7. Fit nuts securing air manifold to inlet manifold.
8. Tighten air manifold unions to ***25 Nm (18 lbf.ft)*** .
9. Fit SAI control valve. ***See this section.***

AIR MANIFOLD - RH - SECONDARY AIR INJECTION (SAI)

Service repair no - 17.25.18

Remove

1. Remove SAI control valve. ***See this section.***
2. Remove heater feed and return pipes. ***See HEATING AND VENTILATION, Repair.***



3. Loosen 2 union nuts securing air manifold to cylinder head adaptors.
4. Remove nut securing air manifold bracket to inlet manifold.
5. Remove air manifold.

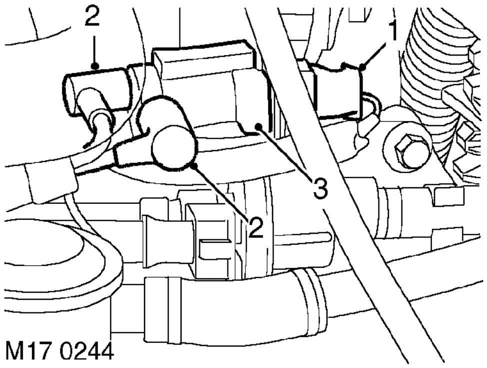
Refit

6. Clean air manifold and cylinder head adaptors.
7. Fit air manifold and start union nuts.
8. Fit nut securing air manifold to inlet manifold.
9. Tighten air manifold unions to ***25 Nm*** .
10. Fit heater return and feed pipes. ***See HEATING AND VENTILATION, Repair.***
11. Fit SAI control valve. ***See this section.***

SOLENOID - VACUUM - SECONDARY AIR INJECTION (SAI)

Service repair no - 17.25.47

Remove



M17 0244

1. Release multiplug from solenoid.
2. Disconnect 2 vacuum hoses from solenoid.
3. Release solenoid from mounting bracket and remove.

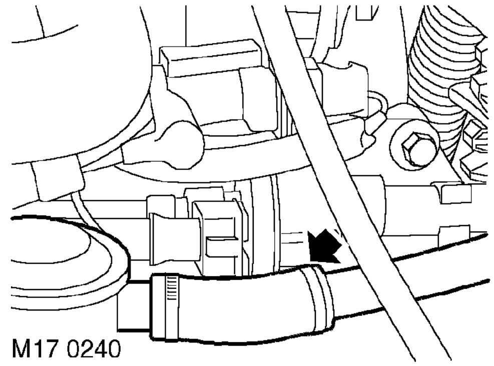
Refit

4. Secure solenoid to mounting bracket.
5. Connect vacuum hoses and multiplug to solenoid.

PIPE - SECONDARY AIR INJECTION (SAI)

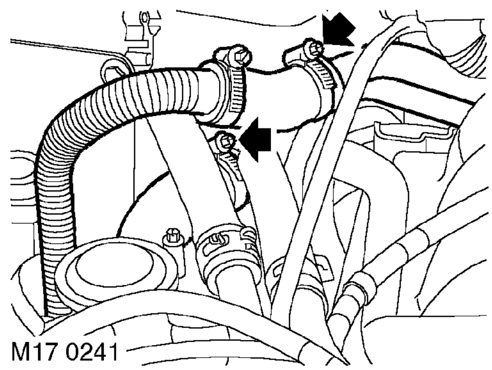
Service repair no - 17.25.59

Remove



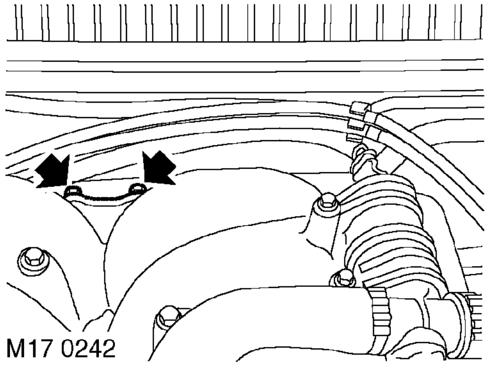
M17 0240

1. Loosen clip securing RH SAI control valve hose to air injection pipe.
2. Release hose from air injection pipe.

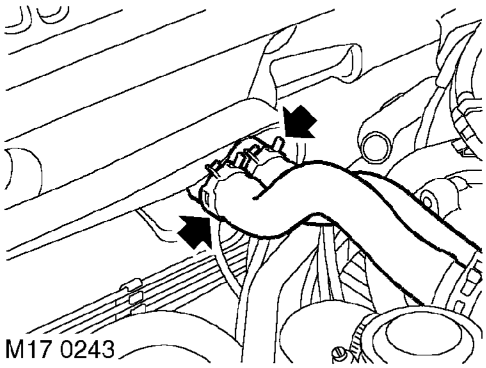


M17 0241

3. Loosen clip securing SAI pump hose to air injection pipe.
4. Release hose from air injection pipe.
5. Loosen clip securing LH SAI control valve hose to air injection pipe.
6. Release hose from air injection pipe.



7. Remove 2 nuts securing air injection pipe to air intake plenum.



8. Position drain tin to collect any coolant spillage.
9. Release clips securing heater hoses to heater.
10. Release hoses from heater.
11. Remove air injection pipe.

Refit

12. Fit air injection pipe to rear of air intake plenum and tighten nuts.
13. Connect heater hoses to heater and secure with clips.
14. Connect SAI pump hose to air injection pipe and secure with clip.
15. Connect LH and RH SAI control valve hoses to air injection pipe and secure with clips.
16. Remove drain tin.
17. Top up engine coolant.

19 - FUEL SYSTEM

CONTENTS

Page

BMW DIESEL

DESCRIPTION AND OPERATION

ADJUSTMENT

REPAIR

DESCRIPTION

Operation of the engine is monitored and controlled by a Digital Diesel Electronics (DDE) system. The DDE system electronically regulates injection timing and fuel delivery rate under all operating conditions.

The system comprises:

- An engine control module
- Output devices
- Input devices
- An injection pump

Engine Control Module (ECM)

The 55-pin engine control module (ECM) is located under the bonnet, in a compartment of the battery tray. It consists of an input section, two microprocessors, No. 1 and No. 2, and an output section. The microprocessors receive input signals from the various input devices and calculate the necessary response to the output devices. Calculations are based on fixed, pre-programmed data. Data is manipulated within function blocks:

Microprocessor function blocks

The following function blocks are provided in microprocessor 1:

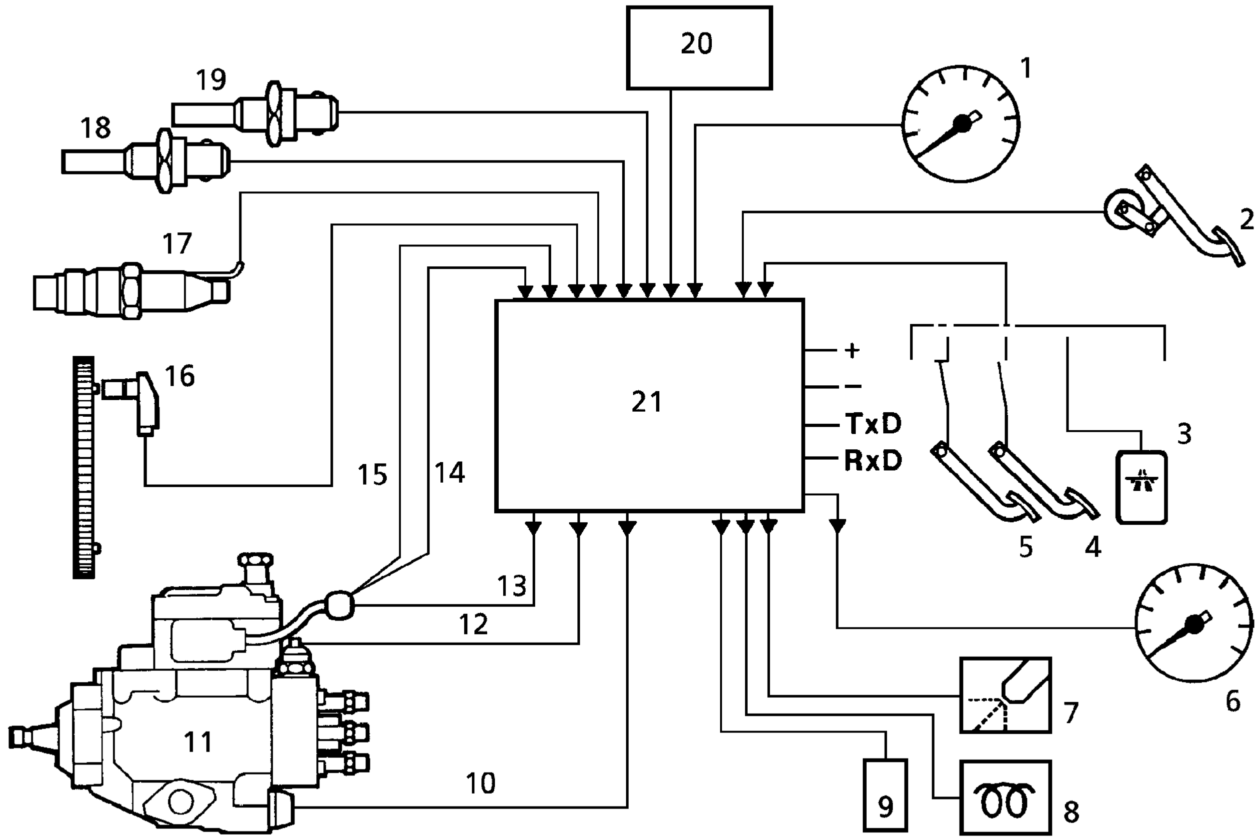
- Injection timing (start of injection) control
- Output of self-diagnosis results

The following function blocks are provided in microprocessor 2:

- Injection quantity control with special start quantity control and full load quantity limitation
- Engine speed control
- Running stability control and vibration damping
- Exhaust emission limitation and overheating protection
- Cruise control

Fault diagnosis

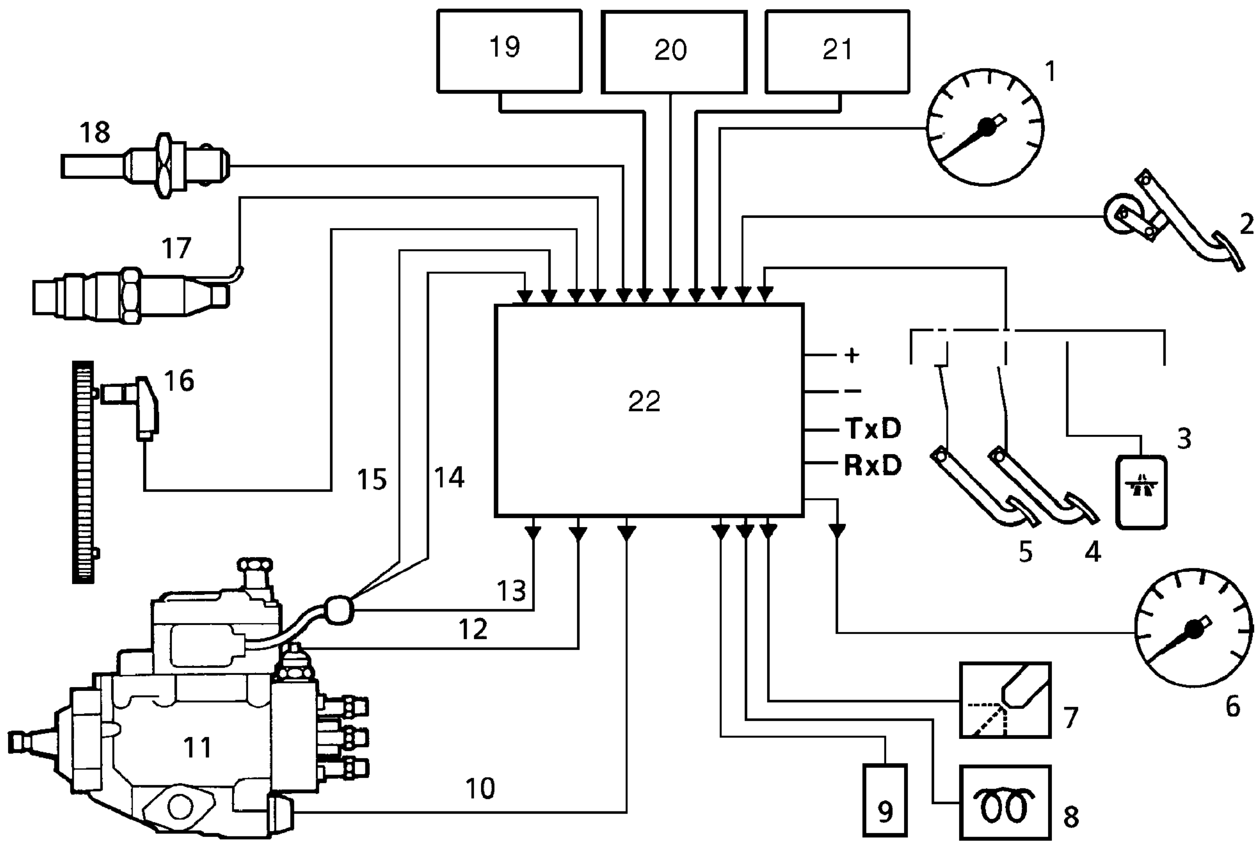
Operating faults are registered by the ECM and held within a defect code memory. TestBook connected into the diagnostic socket beneath the fascia, can be used to interrogate the ECM for stored faults and perform diagnostic routines. The ECM is also connected to a warning lamp on the instrument panel.



18M7013A

Fuel system inputs/outputs - Vehicles without EGR

1. Vehicle speed signal
2. Throttle position sensor - linked to accelerator pedal
3. Cruise control selector (optional)
4. Brake switch
5. Clutch switch
6. Engine speed signal
7. Diagnostic lamp
8. Glow plug lamp
9. Heater time relay
10. Injection timing device
11. Fuel injection pump
12. Stop solenoid
13. Quantity servo control unit
14. Quantity servo control unit potentiometer
15. Fuel temperature sensor
16. Crankshaft position sensor
17. Start of injection sensor
18. Coolant temperature sensor
19. Intake air temperature sensor
20. Manifold absolute pressure sensor
21. Engine Control Module (ECM)



M18 0286

Fuel system inputs/outputs - Vehicles with EGR

1. Vehicle speed signal
2. Throttle position sensor - linked to accelerator pedal
3. Cruise control selector (optional)
4. Brake switch
5. Clutch switch
6. Engine speed signal
7. Diagnostic lamp
8. Glow plug lamp
9. Heater time relay
10. Injection timing device
11. Fuel injection pump
12. Stop solenoid
13. Quantity servo control unit
14. Quantity servo control unit potentiometer
15. Fuel temperature sensor
16. Crankshaft position sensor
17. Start of injection sensor
18. Coolant temperature sensor
19. Manifold Absolute Pressure (MAP) sensor
20. Mass Air Flow (MAF) sensor
21. EGR Modulator valve
22. Engine Control Module (ECM)

Input devices

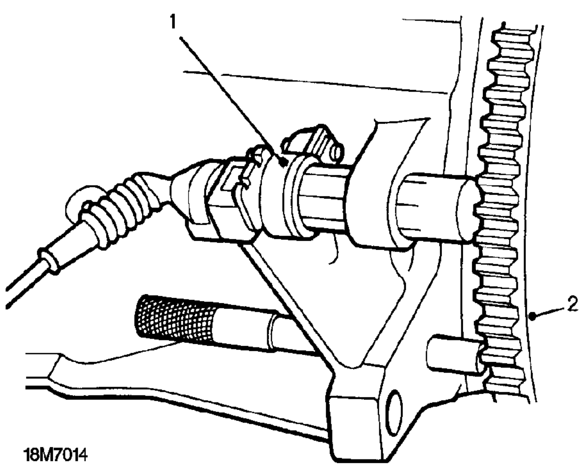
Input devices of the DDE system comprise the following:

Crankshaft position sensor
Start of injection sensor
Fuel temperature sensor
Coolant temperature sensor
Intake air temperature sensor
Manifold absolute pressure sensor
Vehicle speed signal
Throttle position sensor
Servo unit potentiometer (drive potentiometer) on quantity servo control unit
Clutch switch
Brake switches
Cruise control selector (if fitted)

Crankshaft position sensor (CKP sensor)

Attached to the flywheel of the engine are six position pins. These are equally spaced around the crankshaft circumference at 60 degree intervals.

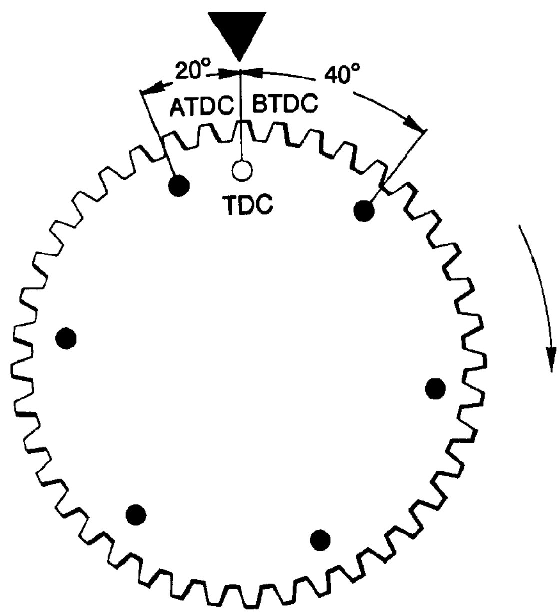
To determine engine speed and crankshaft position, an inductive CKP sensor is mounted on the crankcase adjacent to the flywheel. The CKP sensor consists of a body containing a coil and a permanent magnet which provides a magnetic field. The CKP sensor is situated so that an air gap exists between it and the position pins. Air gap distance is critical for correct operation.



18M7014

1. Sensor
2. Flywheel

As the flywheel rotates, position pins pass the CKP sensor and disturb the magnetic field, inducing voltage pulses in the coil. The pulses are transmitted to the ECM.
When the flywheel rotates one complete revolution, six pulses are transmitted to the ECM. The ECM determines engine speed by calculating how many pulses occur within a given time. The output from the CKP sensor is also used, in conjunction with the start of injection sensor, to determine and control ignition timing.



18M7015A

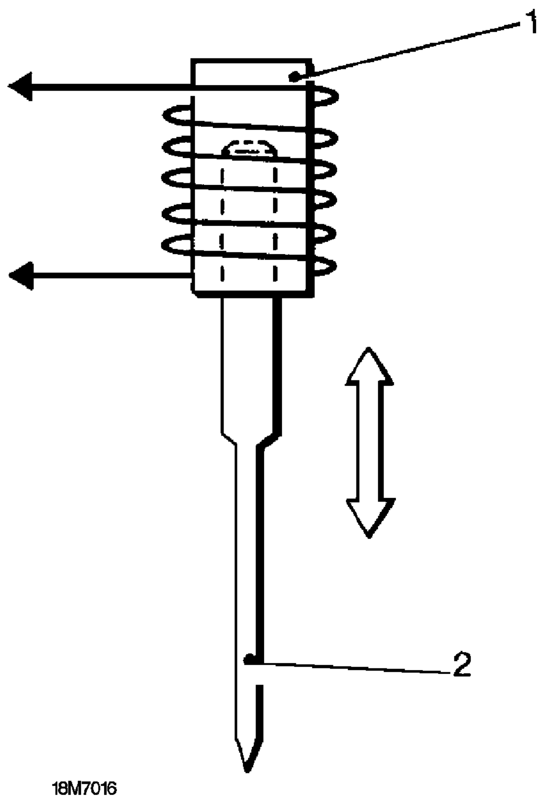
The flywheel position pins are spaced so that at TDC, one pin is 40 degrees before TDC while the other is 20 degrees after TDC as shown. To determine which pulse represents 40 degrees before, or 20 degrees after TDC, the control unit requires additional information from the start of injection sensor.

Start of injection sensor

The start of fuel injection is registered by this sensor which is incorporated in No 4 injector.

The sensor consists of a coil which surrounds the shaft of an extended injection needle.The coil is fed a DC supply from the ECM which produces a magnetic field.

When the needle is moved under the influence of fuel pressure, the magnetic field is disturbed which induces an AC voltage in the coil. The induced voltage is registered in the ECM as a reference point for the start of injection.



1. Coil
2. Injector needle

The ECM uses the input signals from the start of injection sensor, together with signals from the crankshaft position sensor, to detect the actual start of injection angle. The detected actual value is adjusted by the ECM to a nominal value via the injection timing solenoid.

Fuel temperature sensor

Fuel temperature is monitored by a sensor located in the fuel injection pump. This sensor is of the negative temperature coefficient (NTC) type, designed to reduce its resistance with increasing temperature.

When the system is operating, the ECM regularly checks the sensor resistance. As fuel density varies with temperature, the information received is used to calculate the correct quantity of fuel to inject.

Engine coolant temperature sensor (ECT sensor)

The temperature of the engine coolant is monitored by a ECT sensor located on the cylinder head.

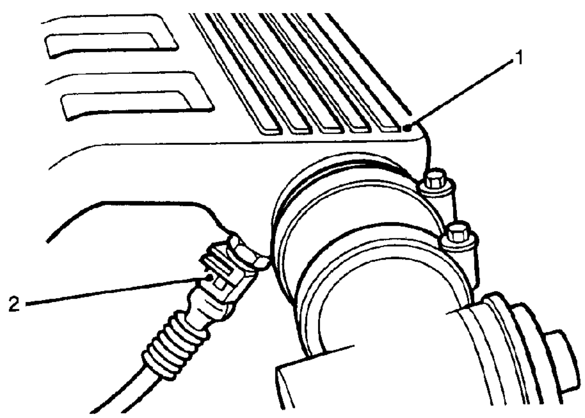
The ECT sensor is of the NTC type and is similar in operation to the fuel temperature sensor previously described.

The ECM uses this information to adjust the basic injection timing and quantity values for all operating conditions.

Intake air temperature sensor (IAT sensor) - Vehicles without EGR

Intake air temperature is monitored by a IAT sensor in the intake manifold. The IAT sensor is of the NTC type and is similar in operation to the fuel temperature sensor previously described.

The ECM uses the information received from the IAT sensor, in conjunction with the manifold absolute pressure sensor, to determine the volume of air being be drawn in to the engine.



18M7017

1. Intake manifold
2. IAT sensor

EGR Modulator valve - Vehicles with EGR

The EGR modulator valve is located in the engine compartment on the left inner wing near the bulkhead. The EGR modulator valve is used to control the EGR valve and is controlled by the ECM. ***See EMISSION CONTROL, Description and operation.***

Manifold absolute pressure sensor (MAP sensor)

Inlet air pressure is monitored by a silicon diaphragm type sensor mounted on top of the fuel filter and connected, via a pressure tube to the intake manifold. The MAP sensor is connected electrically to the ECM.

When inlet air pressure changes, pressure in the detection chamber causes the diaphragms to deflect. This alters the length of each resistor, changing their resistance value. The change is detected by electronics within the MAP sensor which varies the output voltage. This is converted to a pressure reading in the ECM.

Manifold absolute pressure, when linked to inlet air temperature, gives an accurate measurement of the charge volume. The ECM adjusts fuelling as necessary.

Mass air flow sensor (MAF sensor) - Vehicles with EGR

The MAF sensor is located in the air inlet pipe from the air cleaner and is connected electrically to the ECM. The sensor replaces the Air Intake Temperature (IAT) sensor previously used on Pre-EGR vehicles.

The MAF sensor comprises a hot film sensor which has a heated surface maintained by an electrical current at a constant temperature. With cool air flowing past the sensor, the volume of air drawn into the intake manifold is measured by the electrical current required to keep the temperature of the hot film sensor constant.

The MAF sensor records the amount of incoming air being drawn into the engine. The ECM uses this information to control the Exhaust Gas Recirculation (EGR) process. ***See EMISSION CONTROL, Description and operation.***

Vehicle speed signal

Vehicle speed is monitored by the ECM from the ABS ECU.

The ECM uses vehicle speed data when adjusting idle stabilisation, cruise control and fuel delivery.

Throttle position sensor (TP sensor)

The position, selected by the driver, of the accelerator pedal is signalled to the ECM by the TP sensor. This is linked, mechanically to the pedal and electrically to the ECM.

The sender consists of a thick film TP sensor together with a sender switch (9 degree switch). With the accelerator pedal at rest the switch is open. When the pedal is moved past the 9 degree position the switch closes.

When the ignition is switched ON, pedal position is signalled to the ECM. Pedal movement causes voltage through the TP sensor to vary and the ECM uses this to measure:

- Required engine speed
- Rate of acceleration
- Rate of deceleration

The ECM calculates the rate of change of the voltage signal in a positive (accelerate) or negative (decelerate) direction. From this, acceleration enrichment, deceleration fuel metering or overrun fuel cut-off can be carried out by the system.

The sender switch is used together with the voltage from the TP sensor to check the operation of the circuit. When the pedal is moved, the switch signals a logic input to the ECM. The ECM then checks the voltage signal from the TP sensor. This voltage is compared with a pre-programmed value to check that the TP sensor is working correctly.

Servo unit potentiometer (drive potentiometer) on quantity servo control unit

This potentiometer signals a voltage to the ECM. The voltage value is used to calculate the position of the control spool in the injection pump quantity servo control unit - See description of this item.

Clutch switch

A switch fitted at the clutch pedal position is connected to the ECM.

The switch detects when the clutch is depressed. This input is used to deactivate the cruise control and various driveability strategies.

Brake switch

The brake pedal is fitted with a twin contact switch which provides two outputs. Both outputs send signals to the ECM. Both signals are used by the system to test the operation of the brake circuit, and to deactivate the cruise control.

Output devices

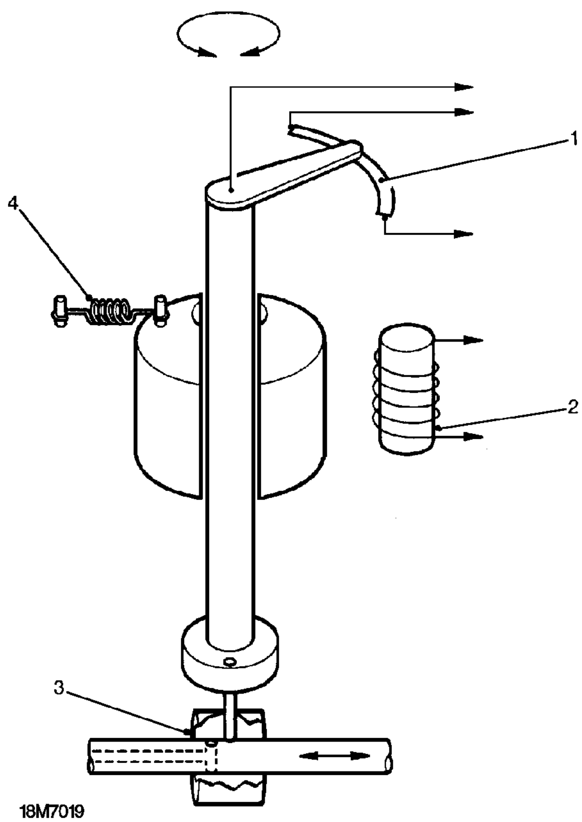
Output devices of the DDE system comprise the following:

Quantity servo control unit
Stop solenoid
Injection timing device
Heater time relay
Diagnosis and preheater lamps
Fuel consumption indicator in instrument pack

Quantity servo control unit

The servo is used to accurately control the amount of fuel delivered to the injectors. It is housed within the fuel injection pump. ***See Injection pump.***

The unit consists of a rotary magnet mounted on an eccentric shaft; the shaft engages with the control spool of the pump. The rotary magnet is fitted with a return spring and moves under the influence of a control coil. The magnet rotates through an arc of about 60 degrees which moves the control spool from zero to maximum fuel delivery position. The eccentric shaft engages with the control spool at one end, while the opposite end operates a rotary potentiometer.



1. Rotary potentiometer
2. Control coil
3. Control spool
4. Return spring

When the control coil is energised the rotary magnet and eccentric shaft move against spring pressure. Rotary movement of the eccentric shaft is converted into linear movement of the control spool. This allows more fuel to be delivered to the injectors.

When the control coil is de-energised the return spring causes the rotary magnet and eccentric shaft to resume their original position. The control spool is moved to the zero position.

The control unit accurately controls the position of the control spool to achieve the desired engine performance.

Stop solenoid

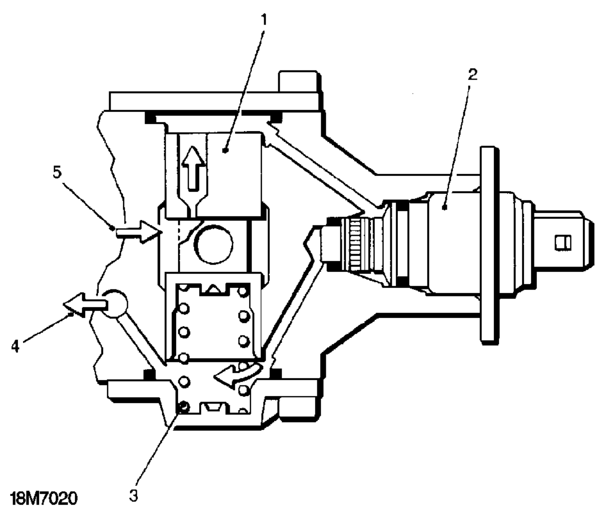
This is a solenoid operated valve located on the high pressure section of the injection pump. When the ignition is switched ON it receives voltage supply and the valve opens allowing fuel to flow.

When the ignition is switched OFF the valve closes and the fuel supply is cut.

Injection timing device

This injection timing device is housed within the fuel injection pump. It consists of a spring-loaded plunger and a solenoid. The spring loaded plunger moves under the influence of pump working pressure. The solenoid is controlled by a pulsed frequency signal from the control unit.

When the pump is operating the solenoid regulates the speed dependent, internal pump pressure into working pressure. This moves the plunger against spring tension.



1. Plunger
2. Solenoid
3. Spring
4. Pump feed pressure
5. Pump internal pressure

Injection is retarded with an energised solenoid and the resultant pressure drop. The beginning of injection is advanced with a de-energised solenoid and the resultant pressure rise.

Heater time relay

Glow plug preheating time is regulated by the heater timer relay in the heating time control unit. This connects to the glow plugs in the cylinder head and to the ECM.

The control unit monitors and operates the glow plugs; operating time for the glow plugs is dependent on engine temperature.

Fuel injection pump (FIP)

The FIP is of the vane-type and is chain driven from the front end of the crankshaft. Fuel delivery from the FIP to the injectors is regulated by the movement of a control spool. Movement of the control spool increases or decreases the fuel delivery rate to meet engine operating requirements.

The FIP houses the following items that either send signals to the ECM, or responds to signals sent from the ECM:

Fuel quantity servo unit

Moves the control spool to regulate the amount of fuel delivered to injectors.

Servo unit potentiometer

Used by the control unit to calculate the position of the control spool.

Injection timing device

Regulates pump speed dependent on internal pump pressure.

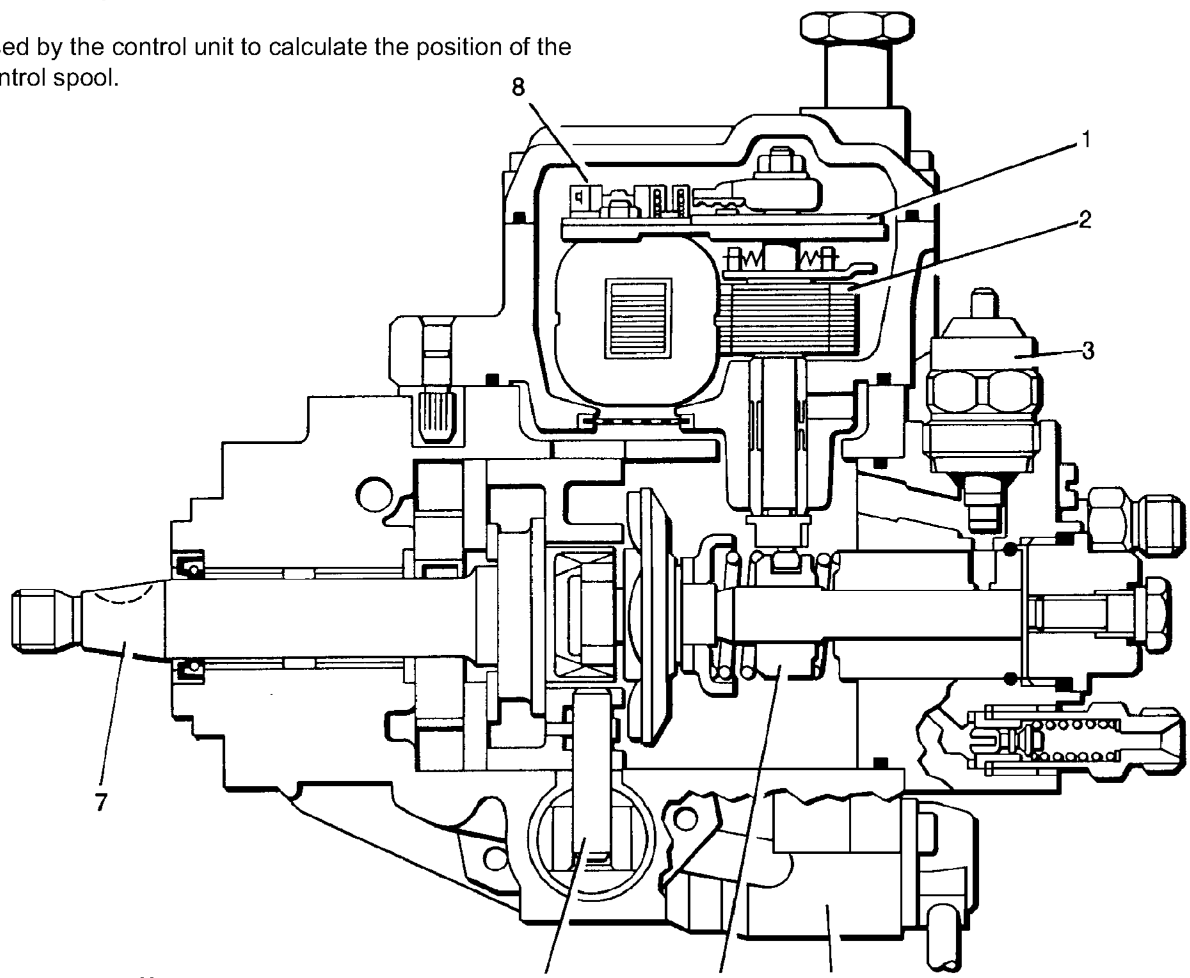
Fuel temperature sensor

Monitors fuel temperature.

Stop solenoid

Cuts fuel delivery to the injectors when de-energised.

These items have been previously described in this section - ***See Input devices or Output devices*** as applicable.



18M7021

1. Rotary potentiometer
2. Quantity control servo unit
3. Stop solenoid
4. Injection timing device solenoid valve
5. Control spool
6. Timing device plunger
7. Drive shaft
8. Fuel temperature sensor

OPERATION

General

The digital diesel electronics system (DDE) facilitates exact control of injection quantity and injection timing under all operating conditions. As a result, fuel consumption and exhaust emissions are kept to a minimum.

Malfunctions

If a fault occurs in any of the following circuits: manifold absolute pressure sensor, fuel temperature sensor or coolant temperature sensor, the ECM will provide substitute values. In the case of a faulty throttle position sensor, start of injection sensor or injection timing device, the engine will run at a reduced performance level.

If the servo unit potentiometer or servo unit fails, the injection system is deactivated. The engine shuts down as a result.

Injection timing (Start of Injection) control

The start of injection is controlled by the injection timing device in the injection pump. A solenoid valve modulates the internal pump pressure on one side of the system so that a defined start of injection is set. When no power is applied, the solenoid valve is closed, resulting in advanced injection timing (start of injection).

Injection quantity control

Injection quantity control is achieved by the quantity servo control unit in the injection pump. The servo acts on the pump control spool to vary the effective stroke of the pump piston (injection quantity). The position of the control spool is signalled back via the servo potentiometer to the ECM. The ECM compares the actual value with the nominal value and, if necessary, adjustment is carried out until the nominal injection quantity value is achieved. The servo control unit is set to zero delivery when no power is applied.

Start control

To determine the quantity of fuel to inject during starting, the ECM uses signals from the coolant temperature sensor, fuel temperature sensor, crankshaft position sensor and throttle position sensor.

Engine speed control

After starting, an idle speed control function cuts in after a certain engine speed threshold has been exceeded. This is calculated by the ECM dependent on the coolant temperature and the active loads. The idle speed can be adjusted by means of TestBook.

The maximum engine speed is limited by the ECM by reducing the injection quantity.

Running stability control and jolt damping

The running stability control system is used for engine speed stabilization when idling. Controlled injection quantity correction counteracts the irregularities which occur in the individual cylinders as the result of dispersion of the injected fuel quantity.

In the case of spontaneous change in the position of the accelerator pedal or a sudden change in the driving resistance, vibrations occur which, in conjunction with the control frequency of the injection hydraulics, can result in jolts and jerks.

On the basis of segment-by-segment angle evaluation in the input sequence, the engine speed signals provide the information which is used for corrective control (rotation irregularities) in the quantity servo control unit. The prerequisite for this function is the input of the vehicle speed signal.

Exhaust emission limitation and overheating protection

At high ambient air temperatures and at increasing altitude, the full load quantity is reduced in order to limit exhaust emission. The full load fuel quantity is also reduced when the permissible water temperature is exceeded in the high speed range.

Cruise control

The required driving statuses: acceleration or resume driving speed can be set or selected using the steering wheel switches. These functions are active with a vehicle speed of more than 40 km/h (25 mph).

Air conditioning compressor cut-out

The ECM switches off the air conditioning compressor during driving conditions demanding high torque requirements (starting off, accelerating). The compressor is also cut-out at high water temperatures (more than 110°C) in order to protect the engine.

Self-diagnosis

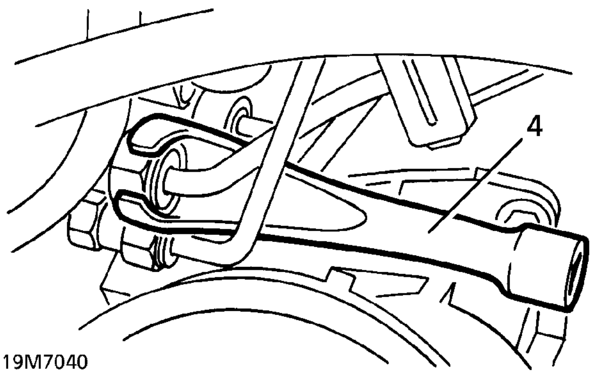
The task of the self-diagnosis function is to detect malfunctions in the DDE system and to make available substitute values and emergency programs. The ECM stores a record of faults, including intermittent faults which can be interrogated using TestBook.

FUEL INJECTION PUMP TIMING - CHECK AND ADJUST

Service repair no - 19.30.01

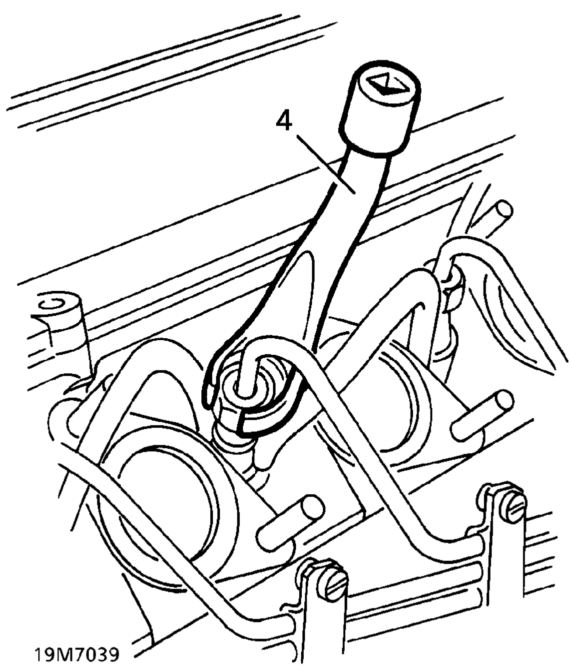
Check

1. Disconnect battery negative lead.
2. Remove intake manifold. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***
3. Remove cooling fan cowl. ***See COOLING SYSTEM, Repair.***



19M7040

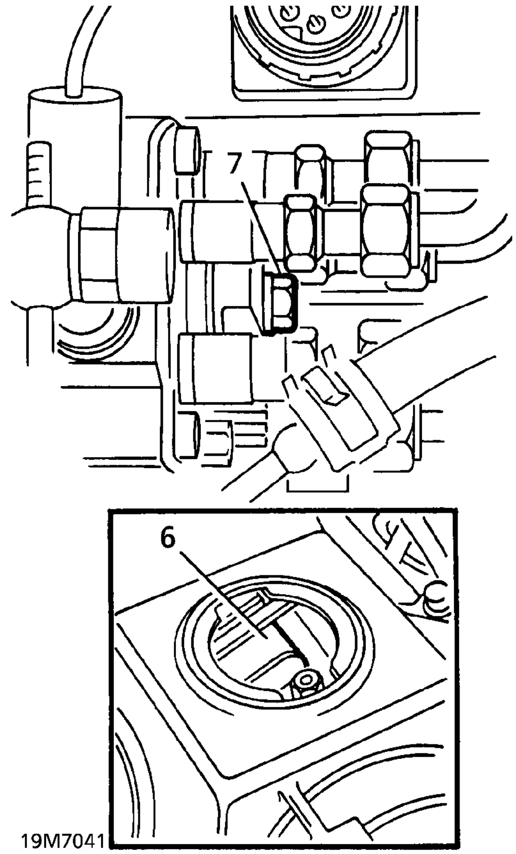
4. Loosen high pressure pipe unions at injectors and Fuel Injection Pump (FIP) using LRT-12-117.



19M7039

CAUTION: Hold delivery valves against rotation as pipe unions are loosened.

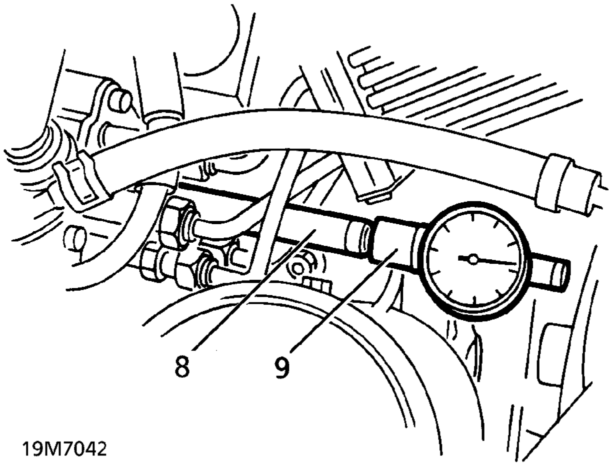
5. Remove oil filler cap.
6. Observe No. 1 camshaft lobe. Turn engine clockwise until lobe points vertically upwards.



19M7041

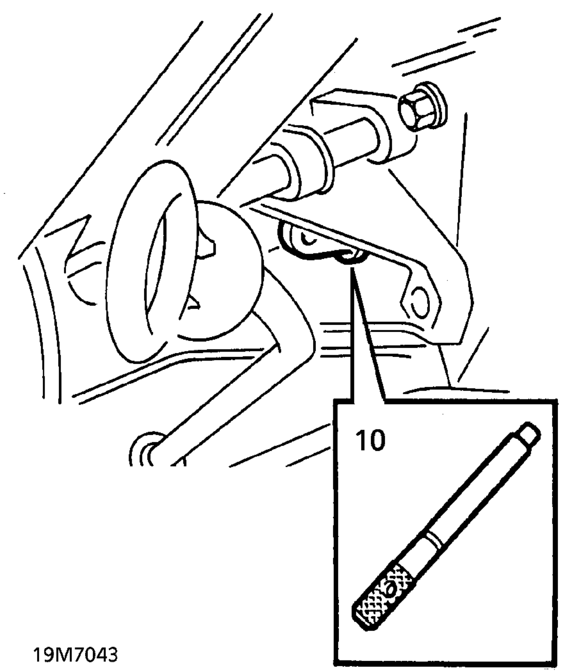
NOTE: This indicates that the engine is approximately 90° Before Top Dead Centre (BTDC) with No. 1 cylinder on its compression stroke.

7. Remove bolt from timing access hole in FIP. Collect sealing washer.



19M7042

8. Fit injection pump timing gauge holder LRT-12-121 into access hole.
9. Fit dial gauge and preload by approximately 2 mm. Secure dial gauge in holder.



19M7043

10. Remove plastic plug from flywheel timing pin access hole. Insert timing pin LRT-12-108.
11. Rotate engine slowly clockwise until dial gauge needle reaches its lowest point. Zero gauge.
12. Continue turning crankshaft in a clockwise direction until timing pin locates into flywheel.

Check reading:
Engines with less than
20,000 km = 0.95 mm $\pm$0.02 mm (0.4 $\pm$0.001 in)
Engines with more than
20,000 km = 0.90 mm $\pm$0.02 mm (0.035 $\pm$ 0.001 in)

If in tolerance, continue at **Assemble.**
If out of tolerance, carry out adjustment as follows:

Adjust

13. Slacken 2 flange nuts and 1 support bolt securing FIP.

CAUTION: Slacken flange nuts by minimum amount. Timing chain tension will deflect pump if bolts are over loose, leading to false readings.

14. Rotate pump on mounting until correct reading is achieved.

NOTE: Ensure final movement of pump head is made towards the engine.

CAUTION: If final movement of pump head is away from engine, backlash will be left in pump mechanism, leading to false readings.

15. Tighten pump flange nuts to ***22 Nm (16 lbf.ft)***
16. Remove flywheel timing pin.
17. Repeat from operation 6 to verify timing.
18. Refit plastic plug to flywheel timing pin hole.
19. Tighten rear support bolt to ***22 Nm (16 lbf.ft)***

Assemble

20. Remove dial gauge and holder.
21. Fit bolt to FIP timing access hole, use a new sealing washer if necessary. Tighten to ***25 Nm (18 lbf.ft)***
22. Using LRT-12-117, tighten high pressure pipe unions on injection pump to ***20 Nm (15 lbf.ft). Do not tighten pipes at injectors.***

CAUTION: Hold delivery valves against rotation as pipe unions are tightened.

23. Fit oil filler cap.
24. Fit cooling fan cowl. ***See COOLING SYSTEM, Repair.***
25. Fit intake manifold. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***
26. Reconnect battery negative lead.
27. With assistance, crank engine. As fuel emerges at injector connections, secure each pipe union using tool LRT-12-117. Tighten to ***20 Nm (15 lbf.ft)***

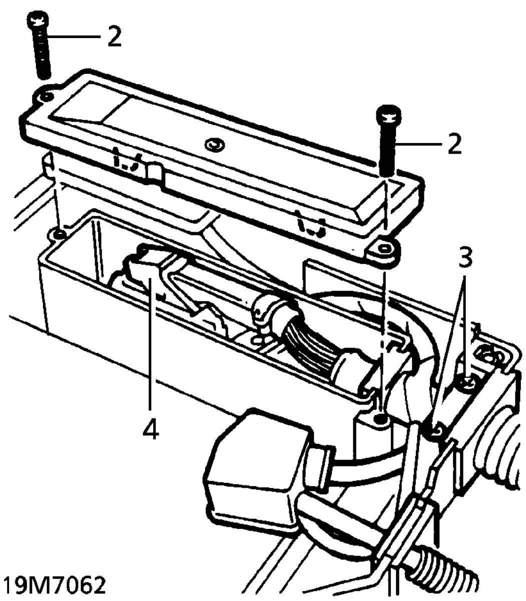
WARNING: Engine will start during high pressure pipe bleeding procedure.

GLOW PLUG CONTROL UNIT

Service repair no - 19.60.33

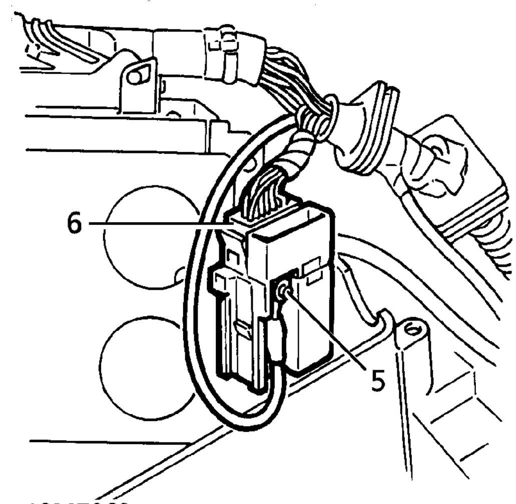
Remove

1. Disconnect battery negative lead.
2. Remove 2 screws securing ECM housing cover. Remove cover.



19M7062

3. Remove 2 harness clamp screws. Remove harness clamp.
4. Lift ECM and control unit from housing.
5. Remove nut securing battery cable to control unit. Release cable.



19M7063

6. Disconnect multiplug. Remove control unit.

Refit

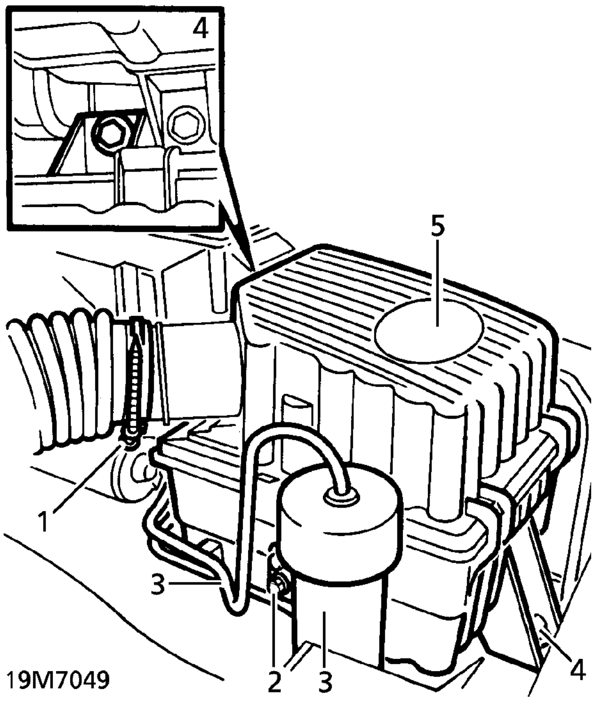
7. Reverse removal procedure.

AIR CLEANER ASSEMBLY

Service repair no - 19.10.01

Remove

1. Release intake hose from air cleaner.



19M7049

2. Remove bolt securing air suspension dryer to air cleaner.
3. Release dryer pipes from air cleaner. Position dryer aside.
4. Remove 2 bolts securing air cleaner to valance.
5. Release air cleaner lug from valance grommet. Remove air cleaner.
6. If necessary, remove seal.

Refit

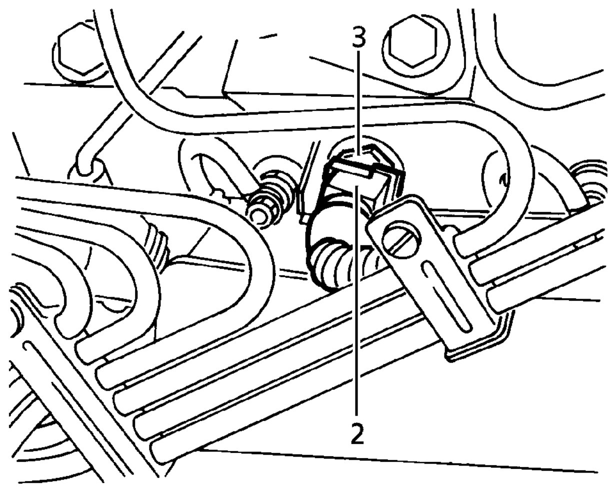
7. If removed, refit seal to air cleaner.
8. Position air cleaner assembly. Engage lug to valance grommet. Secure with bolts.
9. Position air suspension dryer to air cleaner. Secure with bolt. Tighten to ***8 Nm (6 lbf.ft)***
10. Engage dryer pipes to clips.
11. Connect intake hose to air cleaner. Secure with clip.

ENGINE COOLANT TEMPERATURE SENSOR (ECT SENSOR)

Service repair no - 18.30.10

Remove

1. Partially drain cooling system. ***See COOLING SYSTEM, Repair.***
2. Disconnect ECT sensor multiplug.
3. Remove ECT sensor. Collect sealing washer and discard.



18M7009

Refit

4. Ensure mating faces are clean.
5. Using a new sealing washer, fit ECT sensor. Tighten to ***18 Nm (13 lbf.ft)***
6. Connect multiplug to ECT sensor.
7. Refill cooling system. ***See COOLING SYSTEM, Repair.***
8. Run engine to normal operating temperature. Check for leaks around ECT sensor.

CRANKSHAFT POSITION SENSOR (CKP SENSOR)

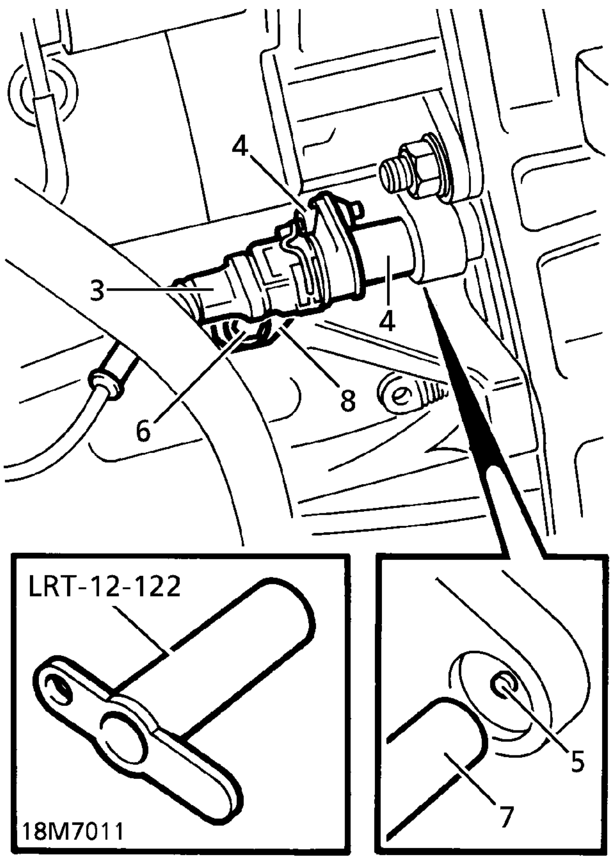
Service repair no - 18.30.12

Remove

1. Disconnect battery negative lead.
2. Remove cooling fan cowl. ***See COOLING SYSTEM, Repair.***

NOTE: Cowl removed to give access to crankshaft pulley for manual cranking of engine.

3. Disconnect CKP sensor multiplug.



4. Remove bolt securing CKP sensor to bracket. Remove CKP sensor.

CKP Sensor Bracket - Adjust

CAUTION: CKP Sensor bracket must be correctly positioned. CKP sensor damage or failure will result from mis-aligned bracket.

5. Rotate crankshaft until flywheel TDC pole is central to CKP sensor aperture.

NOTE: Use mirror and lamp to view flywheel poles.

6. Slacken bolt securing CKP sensor bracket to cylinder block.
7. Position LRT-12-122 to CKP sensor bracket. Secure with bolt.
8. Push CKP sensor bracket rearwards until tool contacts flywheel pole.

NOTE: Tool positions bracket allowing for correct air gap between CKP sensor nose and flywheel poles.

9. Tighten bolt securing bracket to cylinder block.
10. Remove bolt securing tool to bracket. Remove tool.

Refit

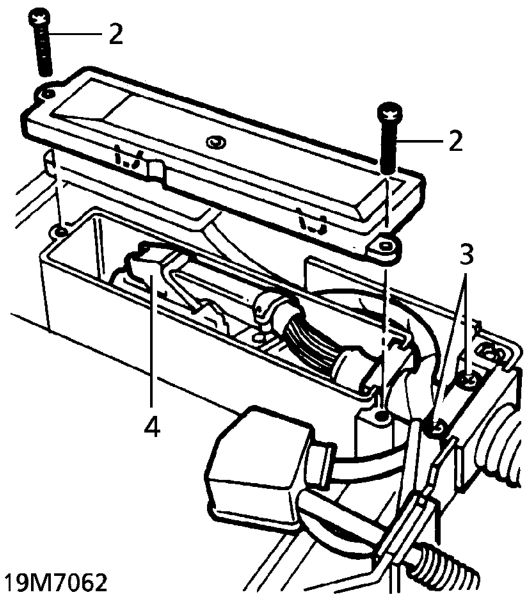
11. Fit CKP sensor to bracket. Secure with bolt. Tighten to ***Max 8 Nm (6 lbf.ft)***
12. Connect CKP sensor multiplug.
13. Fit cooling fan cowl. ***See COOLING SYSTEM, Repair.***
14. Reconnect battery negative lead.

ENGINE CONTROL MODULE (ECM)

Service repair no - 18.30.03

Remove

1. Disconnect battery negative lead.
2. Remove 2 screws securing ECM housing cover. Remove cover



19M7062

3. Slacken 2 harness clamp screws.
4. Lift ECM slightly for access. Disconnect multiplug.
5. Remove ECM from housing.
6. Remove carrier plate from ECM.

Refit

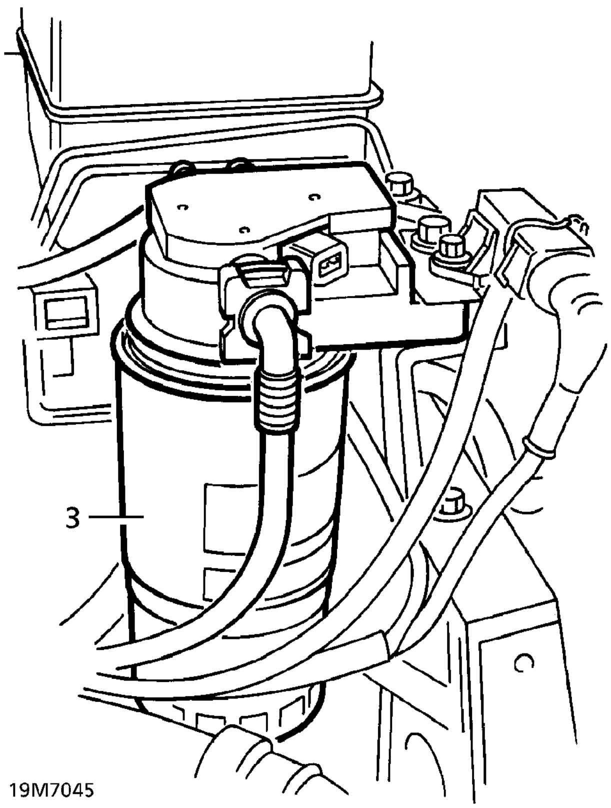
7. Reverse removal procedure.

FUEL FILTER

Service repair no - 19.25.07

Remove

1. Disconnect battery negative lead.
2. Position container beneath fuel filter to catch spillage.



19M7045

3. Remove filter using strap wrench.

Refit

4. Ensure mating faces are clean.
5. Lubricate seal on new filter with clean diesel fuel.
6. Fit filter to filter head. Tighten securely by hand.
7. Remove container.
8. Slacken fuel feed union at fuel injection pump using LRT-12-117.

NOTE: Position cloth over feed union to catch any fuel spillage.

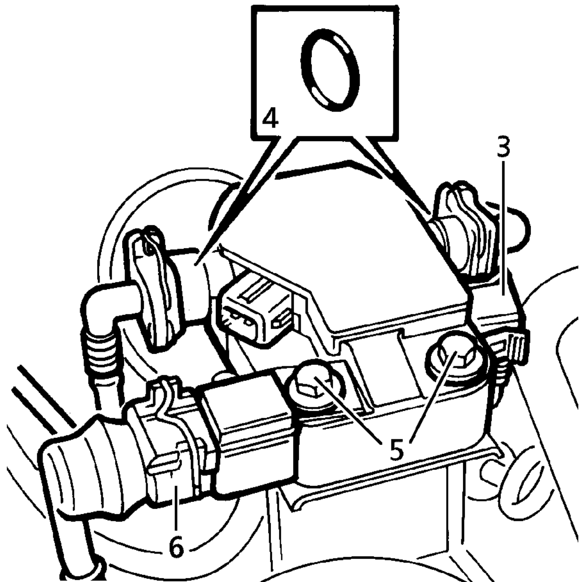
9. Reconnect battery negative lead.
10. With assistance, turn on ignition switch to operate fuel lift pump.
11. When all air is bled from filter, secure feed pipe at injection pump. Tighten to ***14 Nm (10 lbf.ft)***

FUEL HEATER/FILTER HEAD

Service repair no - 19.25.20

Remove

1. Disconnect battery negative lead.
2. Remove fuel filter. ***See this section.***



19M7044

3. Disconnect multiplug from fuel heater.
4. Disconnect fuel lines from filter head. Remove 2 'O' rings from each connection and discard.

NOTE: Fuel line connections are of quick release type. Press retainer, pull fuel line to remove.

5. Remove 2 bolts securing fuel heater to bracket.
6. Position Manifold Absolute Pressure (MAP) sensor aside. Remove fuel heater.

Refit

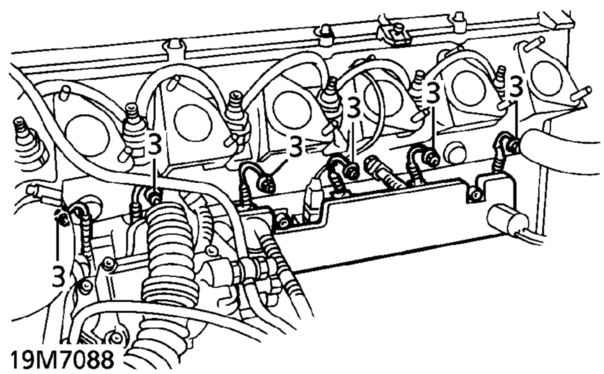
7. Align fuel heater to bracket. Position MAP sensor.
8. Secure fuel heater and MAP sensor to bracket with bolts.
9. Fit new 'O' rings to fuel connections. Lubricate with diesel fuel.
10. Connect fuel lines and multiplug to fuel heater.
11. Fit fuel filter. ***See this section.***
12. Reconnect battery negative lead.

GLOW PLUGS

Service repair no - 19.60.31

Remove

1. Disconnect battery negative lead.
2. Remove injector high pressure pipe assembly. ***See this section.***
3. Remove nuts and disconnect feed wires from glow plugs.
4. Using a deep 12 mm socket, remove glow plugs.



19M7088

Refit

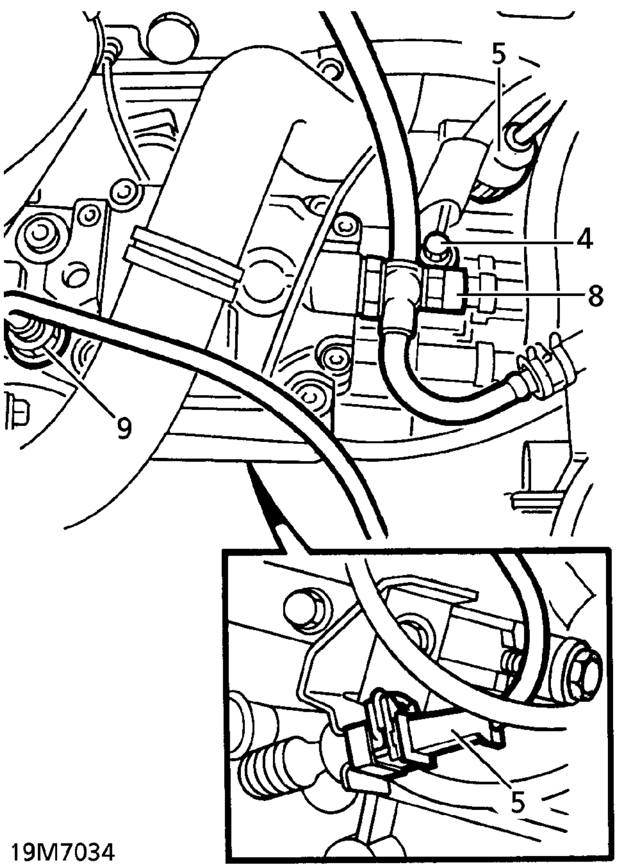
5. Ensure glow plug threads and locations in cylinder head are clean.
6. Fit glow plugs. Tighten to ***20Nm (15lbf.ft).***
7. Connect feed wires and tighten nuts to ***4Nm (3lbf.ft).***
8. Fit injector pipe assembly. ***See this section.***
9. Reconnect battery negative lead.

FUEL INJECTION PUMP (FIP)

Service repair no - 19.30.07

Remove

1. Disconnect battery negative lead.
2. Remove high pressure pipes. ***See this section.***
3. Remove cooling fan cowl. ***See COOLING SYSTEM, Repair.***
4. Disconnect lead from stop solenoid terminal.

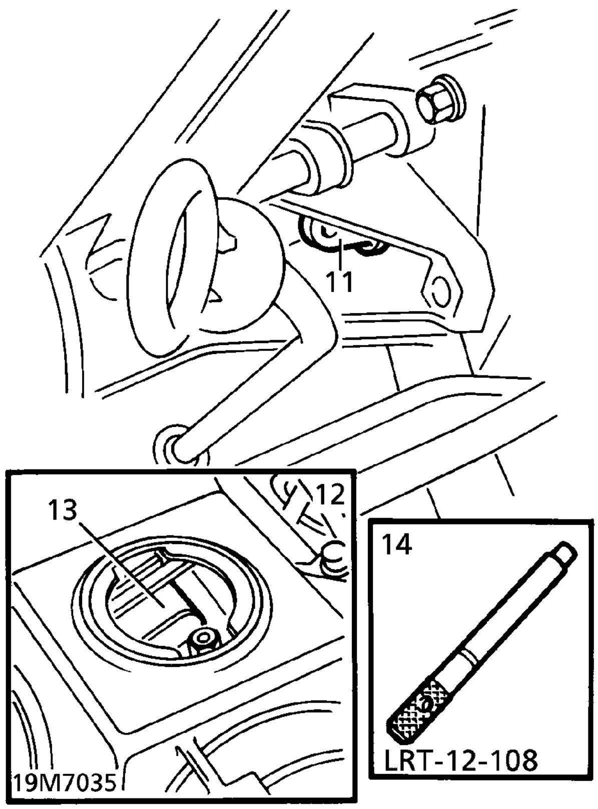


19M7034

5. Disconnect FIP harness multiplug.
6. Disconnect oil pressure switch.
7. Disconnect FIP cycle valve multiplug.

NOTE: Position cloth beneath FIP to catch fuel spillage.

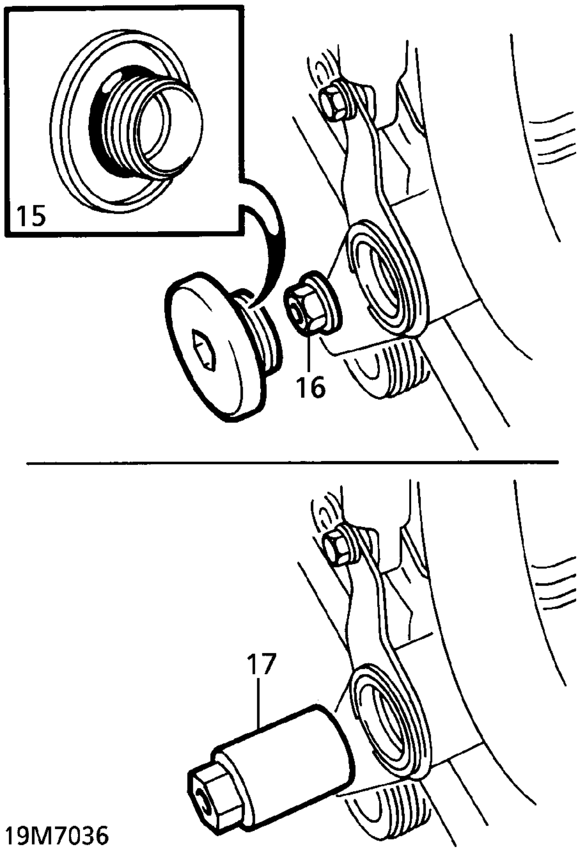
8. Disconnect fuel return pipe. Collect sealing washers.
9. Using tool LRT-12-117, disconnect fuel feed pipe at FIP.
10. Plug pipes and connections.
11. Remove plastic plug from flywheel timing pin access hole.



12. Remove oil filler cap. Observe No. 1 camshaft lobe.
13. Rotate crankshaft clockwise until camshaft lobe points towards inlet side of engine.
14. Insert timing pin LRT-12-108 into access hole. Locate into flywheel timing hole.

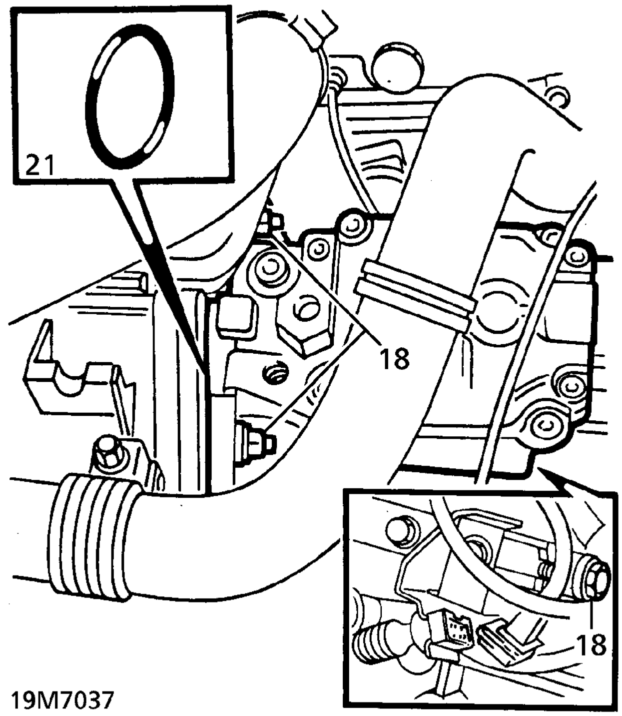
NOTE: No. 1 Piston is now at Top Dead Centre (TDC) on its compression stroke.

15. Remove end cap from auxiliary belt tensioner fulcrum. Collect 'O' ring and discard.



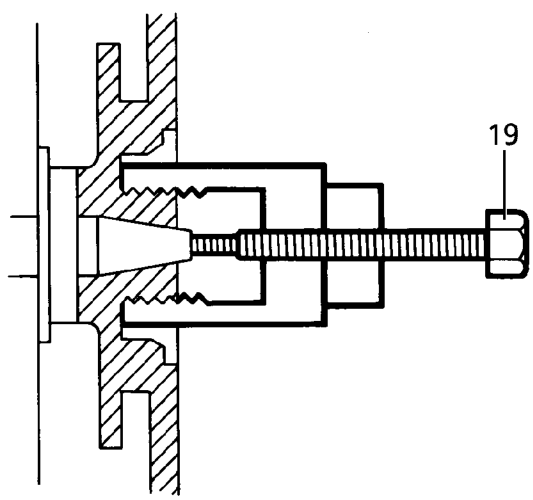
19M7036

16. Remove nut from FIP sprocket.
17. Remove centre bolt from LRT-12-119. Screw body of tool onto FIP sprocket to retain sprocket in position when pump is removed.
18. Remove 2 flange nuts and 1 support bolt securing FIP to timing case.



19M7037

19. Fit centre bolt to LRT-12-119. Press FIP from sprocket.



19M7038

20. Remove FIP from timing case.
21. Remove FIP. Collect 'O' ring and discard.
22. Remove centre bolt from LRT-12-119.

CAUTION: If body of tool is removed, FIP sprocket will drop into timing case.

Refit

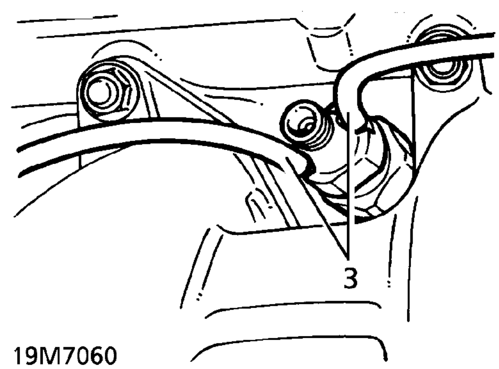
23. Ensure mating faces are clean.
24. Ensure Woodruff key on FIP drive shaft aligns with sprocket keyway. If necessary, turn pump shaft using tool LRT-12-118.
25. Fit new 'O' ring. Position pump to timing case.
26. Secure pump to timing case with nuts and bolts. Do not tighten at this stage.
27. Remove body of LRT-12-119 from injection pump sprocket.
28. Fit nut to injection pump shaft. Tighten to ***50 Nm (37 lbf.ft)***
29. Using a new 'O' ring, fit end cap to auxiliary belt tensioner fulcrum.
30. Adjust injection timing. ***See Adjustment.***
31. Remove plugs from FIP connections and pipes.
32. Connect fuel feed pipe to FIP using LRT-12-117. Tighten to ***14 Nm (10 lbf.ft)***
33. Using new sealing washers, connect fuel return pipe. Tighten to ***25 Nm (18 lbf.ft)***
34. Connect FIP harness and cycle valve multiplugs.
35. Connect oil pressure switch.
36. Connect lead to stop solenoid terminal.
37. Fit cooling fan cowl. ***See COOLING SYSTEM, Repair.***
38. Fit high pressure pipes. ***See this section.***
39. Reconnect battery negative lead.

FUEL INJECTORS

Service repair no - 19.60.10 - Injectors - each
Service repair no - 19.60.12 - Injectors - set

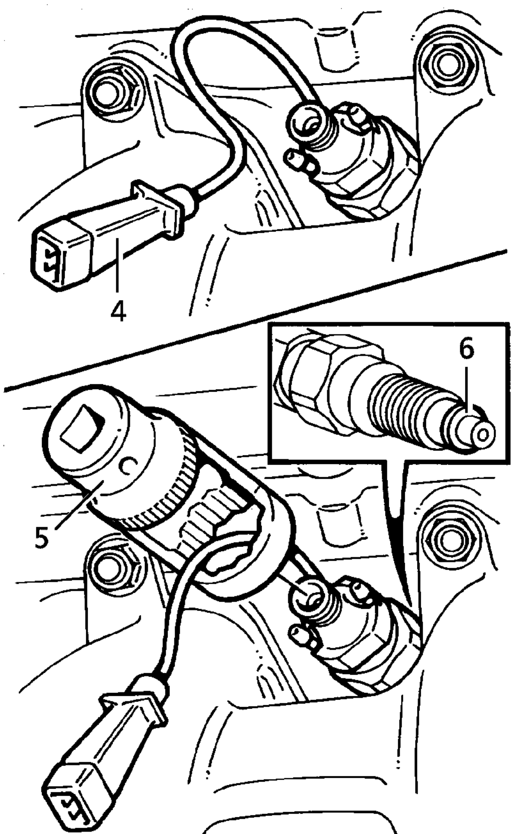
Remove

1. Disconnect battery negative lead.
2. Remove high pressure pipes. ***See this section.***
3. Disconnect leak-off pipes from injector. Plug connections.



19M7060

4. **No. 4 injector only:** Disconnect needle lift sensor multiplug.



5. Remove injector using tool LRT-12-120.

NOTE: Special tool has cut-out for needle lift sensor multiplug. Thread flylead through tool. Ensure lead and connector are not damaged during injector removal or refitting.

6. Collect sealing washer and discard.

Refit

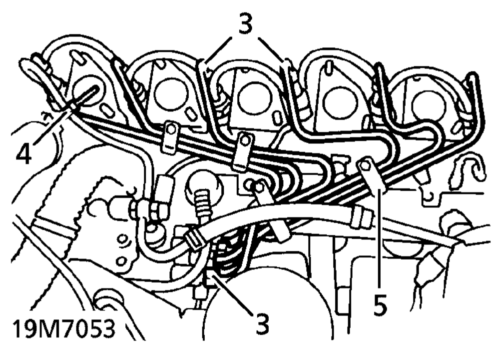
7. Ensure injector nozzle and cylinder head bore are clean.
8. Apply anti-seize compound to injector threads.
9. Position injector with new sealing washer to cylinder head. Using LRT-12-120. Tighten to ***65 Nm (48 lbf.ft)***
10. **No. 4 injector only:** Connect needle lift sensor multiplug.
11. Remove plugs. Connect leak-off pipes.
12. Fit high pressure pipe assembly. ***See this section.***
13. Reconnect battery negative lead.

HIGH PRESSURE PIPES

Service repair no - 19.60.14

Remove

1. Disconnect battery negative lead.
2. Remove inlet manifold. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***
3. Using LRT-12-117, disconnect high pressure pipes at Fuel Injection Pump (FIP) and injectors.



CAUTION: Hold delivery valves against rotation as pipe unions are loosened.

4. Remove clip securing leak-off pipe to No. 1 high pressure pipe.
5. Remove high pressure pipe assembly.
6. Plug high pressure pipes and connections.

Refit

7. Ensure all pipes and connections are clean,
8. Remove plugs. Position pipe assembly.
9. Using LRT-12-117, secure high pressure pipes to injection pump. Tighten to ***22 Nm (16 lbf.ft)***

CAUTION: Hold delivery valves against rotation as pipe unions are tightened.

10. Connect pipes to injectors. Do not tighten.
11. Secure leak-off pipe to No. 1 high pressure pipe with clip.
12. Fit inlet manifold. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***
13. Reconnect battery negative lead.
14. With assistance, crank engine. As fuel emerges at injector connections, secure each pipe union using tool LRT-12-117. Tighten to ***22 Nm (16 lbf.ft)***

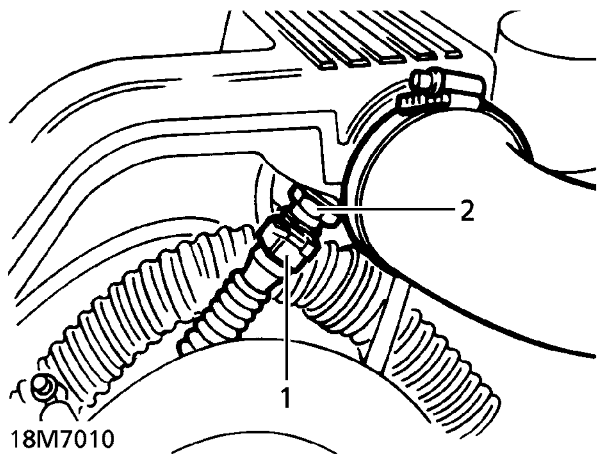
CAUTION: Engine will start during high pressure pipe bleeding procedure.

INTAKE AIR TEMPERATURE SENSOR (IAT SENSOR) - VEHICLES WITHOUT EGR

Service repair no - 18.30.09

Remove

1. Disconnect multiplug.
2. Remove sensor from intake manifold. Discard sealing washer.



Refit

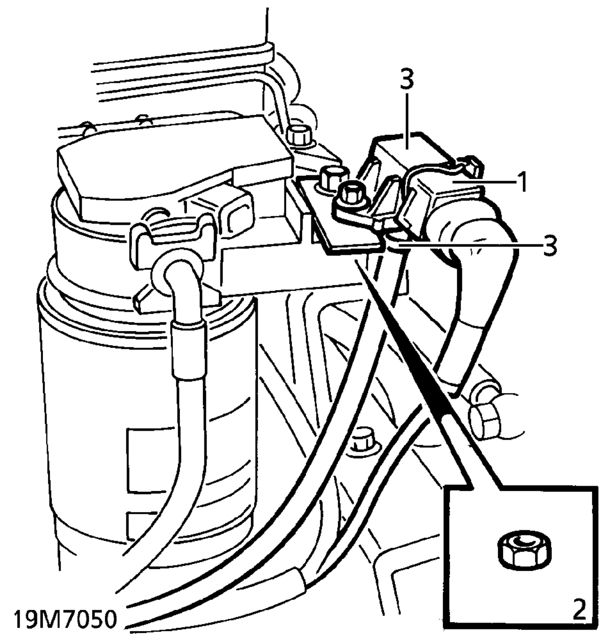
3. Ensure mating faces are clean.
4. Using a new sealing washer, fit sensor to intake manifold. Tighten to ***14 Nm (10 lbf.ft)***
5. Connect multiplug.

MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR

Service repair no - 19.42.34

Remove

1. Disconnect multiplug from sensor.
2. Remove nut and bolt. Release sensor from bracket.
3. Release clip. Remove sensor from hose.



Refit

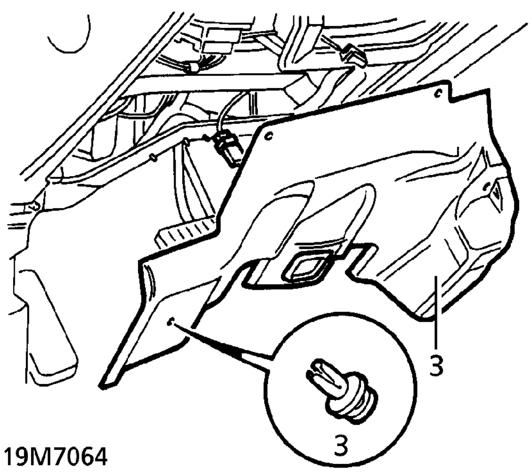
4. Reverse removal procedure.

THROTTLE POSITION SENSOR (TP SENSOR)

Service repair no - 19.22.49

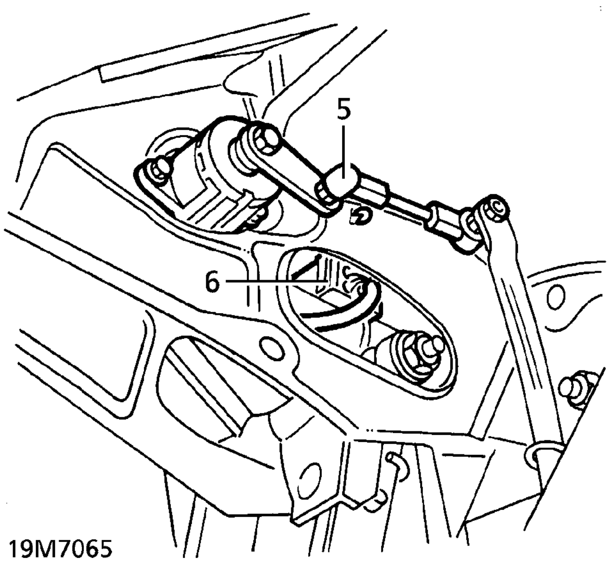
Remove

1. Disconnect battery negative lead.
2. Remove drivers side fascia closing panel. ***See CHASSIS AND BODY, Repair.***
3. Remove 3 scrivet fasteners securing lower closing panel. Release panel to gain access to blower motor ducting.



19M7064

4. Release ducting from blower motor housing and heater. Remove blower motor ducting.
5. Release linkage from ball joint on TP sensor lever.



19M7065

6. Disconnect multiplug.
7. Remove 2 bolts securing TP sensor to pedal box.
8. Release TP sensor harness from pedal box. Remove TP sensor.

Refit

9. Position TP sensor. Route harness correctly over pedal box.
10. Secure TP sensor with bolts. Tighten to ***5 Nm (4 lbf.ft)***
11. Connect linkage to TP sensor lever ball joint.
12. Connect multiplug.
13. Fit blower ducting. Engage to heater and blower motor housing.
14. Align lower closing panel. Secure with scrivet fasteners.
15. Fit drivers side fascia closing panel. ***See CHASSIS AND BODY, Repair.***
16. Reconnect battery negative lead.

TURBOCHARGER

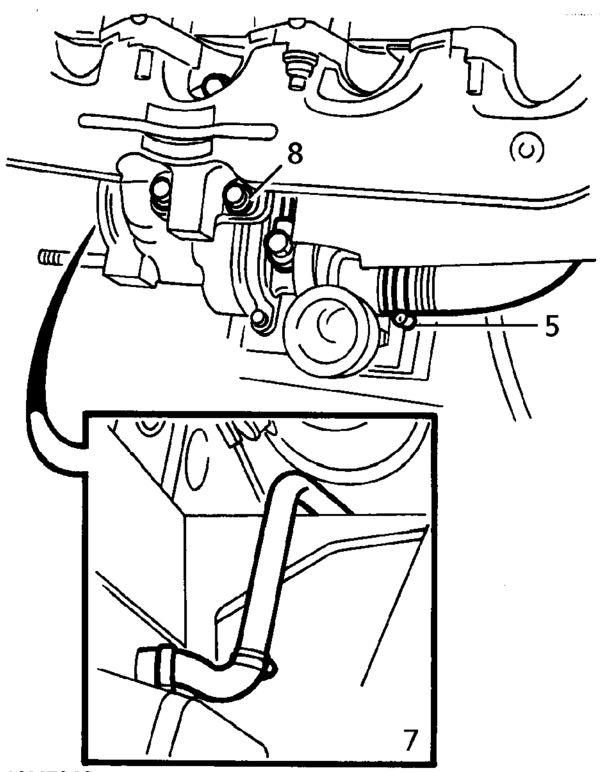
Service repair no - 19.42.01

Remove

1. Disconnect battery negative lead.
2. Raise the vehicle.

WARNING: Support on safety stands.

3. Remove exhaust system front pipe. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***
4. Remove heat shield. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***
5. Disconnect intake hose from turbocharger.



19M7046

6. Disconnect oil feed pipe from turbocharger. Collect sealing washers and discard.
7. Disconnect oil drain hose from turbocharger.
8. Remove 3 bolts securing turbocharger to exhaust manifold.
9. Remove turbocharger. Collect gasket and discard.

NOTE: Plug all connections to prevent ingress of dirt.

Refit

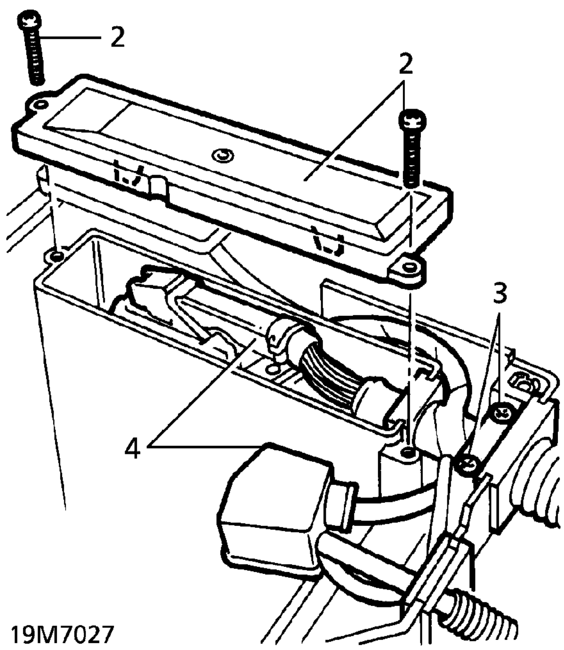
10. Ensure all mating faces are clean.
11. Remove plugs. Position new gasket on manifold. Position turbocharger.
12. Secure turbocharger with bolts. Tighten to ***45 Nm (33 lbf.ft)***
13. Connect oil drain hose to turbocharger. Secure with clip.
14. Position oil feed pipe with new washers. Secure with banjo bolt. Tighten to ***25 Nm (18 lbf.ft)***
15. Connect intake hose to turbocharger. Secure with clip.
16. Fit exhaust system front pipe. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***
17. Fit heat shield. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***
18. Remove safety stands. Lower vehicle.
19. Reconnect battery negative lead.

INTERCOOLER

Service repair no - 19.42.15

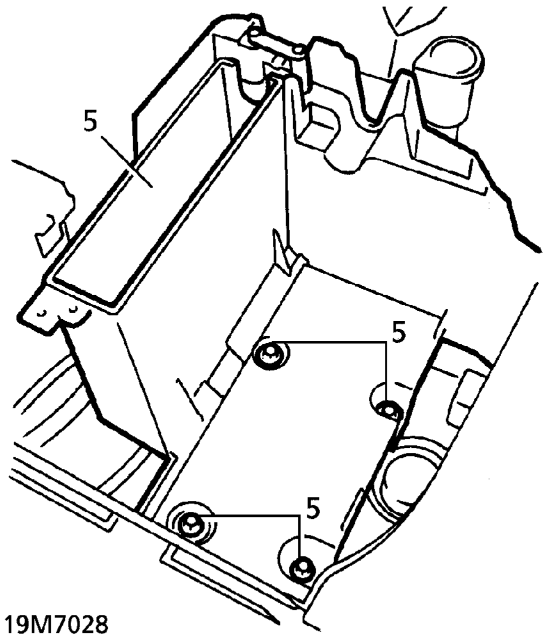
Remove

1. Remove battery. ***See ELECTRICAL, Repair.***



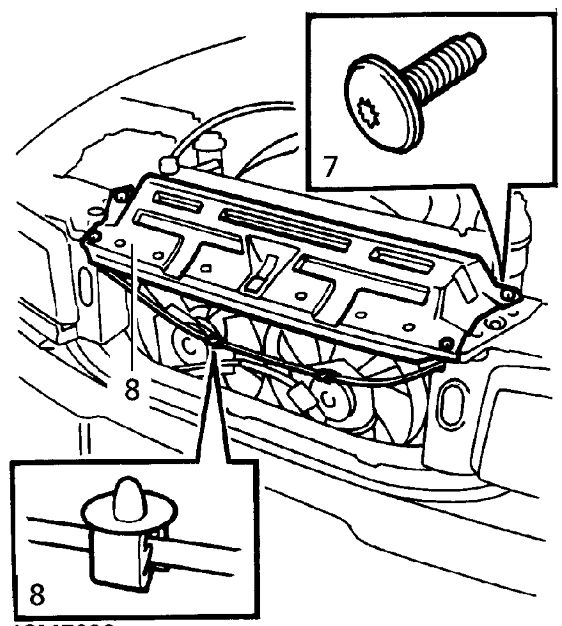
19M7027

2. Remove 2 screws securing fuel ECM cover. Remove cover.
3. Remove 2 screws securing ECM harness clamp. Remove clamp.
4. Remove ECM from battery box. Position ECM and battery harness aside.



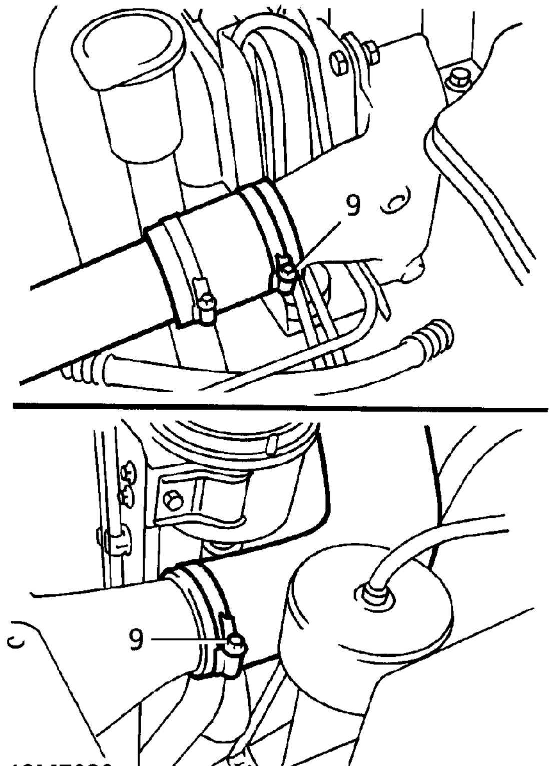
19M7028

5. Remove 4 bolts securing battery box. Remove battery box.
6. Remove front grille. ***See CHASSIS AND BODY, Repair.***
7. Remove 4 bolts securing bonnet platform.



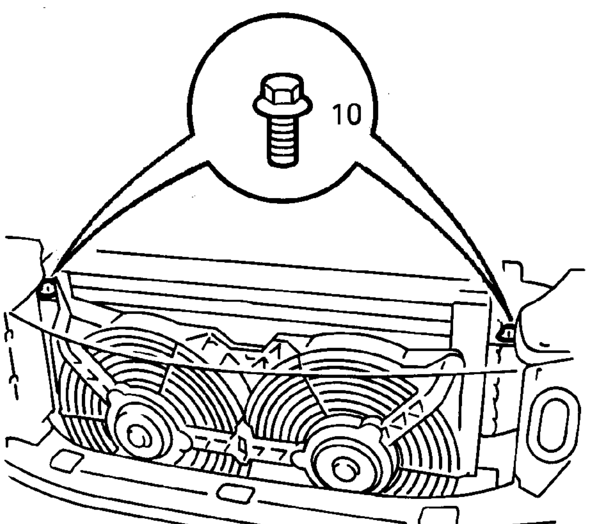
19M7029

8. Release bonnet release cable clips from platform. Remove platform.



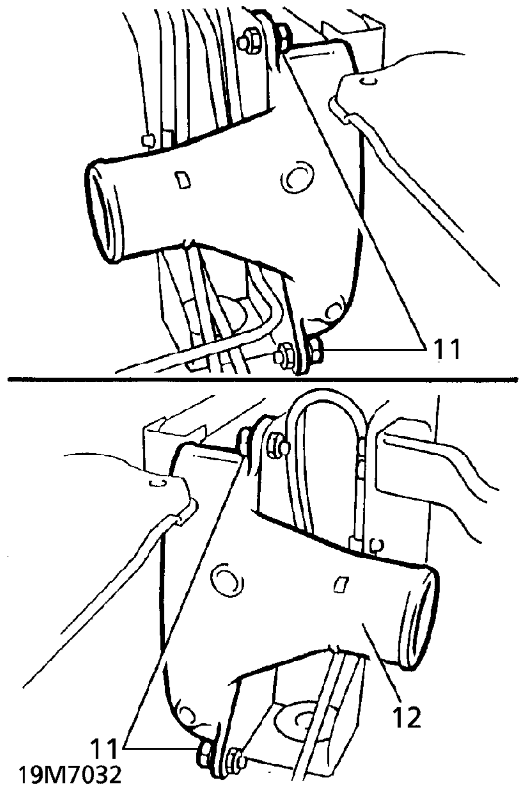
19M7030

9. Disconnect hoses from intercooler.



19M7031

10. Remove 2 bolts securing intercooler to air conditioning condenser.
11. Remove 4 bolts securing intercooler to radiator bracket.



19M7032

12. Remove intercooler.

Refit

13. Reverse removal procedure.

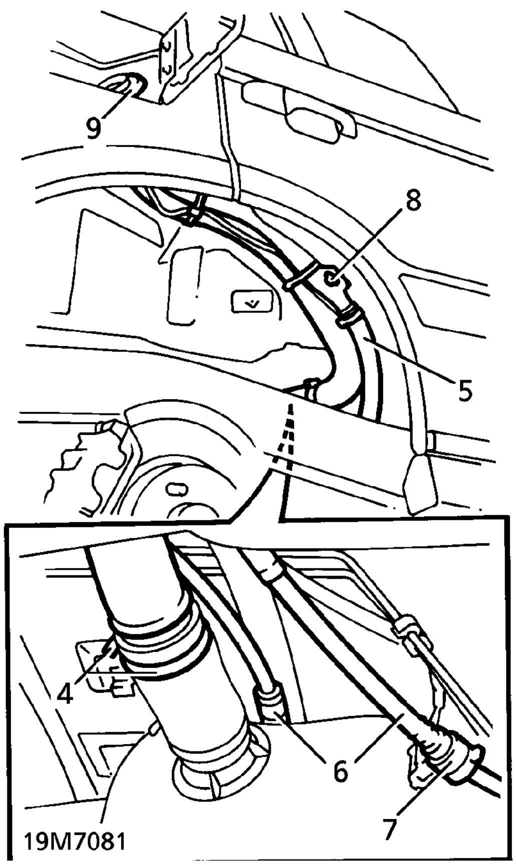
FILLER NECK ASSEMBLY

Service repair no - 19.55.07

WARNING: If fuel tank is full, fuel level will be above filler neck aperture in the tank. If gauge indicates over 75%, drain a minimum 10 litres of fuel from tank.

Remove

1. Disconnect battery negative lead.
2. Remove rear wheel arch liner. *__See CHASSIS AND BODY, Repair.__*
3. Remove fuel filler cap.
4. Slacken clips securing hoses to filler neck.



5. Release fill breather hose from filler neck.
6. **Petrol Models Only:** Disconnect fuel tank and charcoal canister hoses from vapour separator.
7. **Diesel Models Only:** Release cap from quick release connector. Disconnect breather hose.
8. Remove nut securing filler neck to wheel arch.
9. Release filler neck from fuel tank hose and grommet in body aperture.
10. Remove filler neck assembly.

Refit

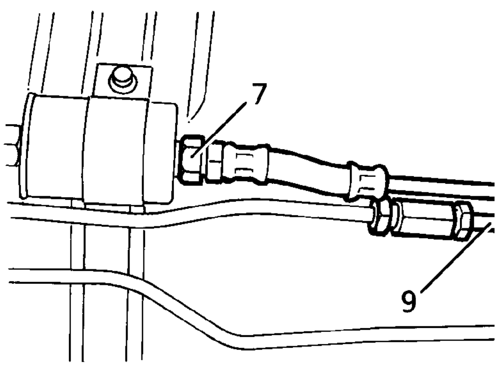
11. Apply liquid soap to grommet and mating surface of filler neck.
12. Reverse removal procedure.

FUEL TANK, PUMP AND GAUGE SENDER UNIT

Service repair no - 19.55.01 - Fuel Tank
Service repair no - 19.45.08 - Fuel Pump
Service repair no - 88.25.32 - Fuel gauge Tank Unit

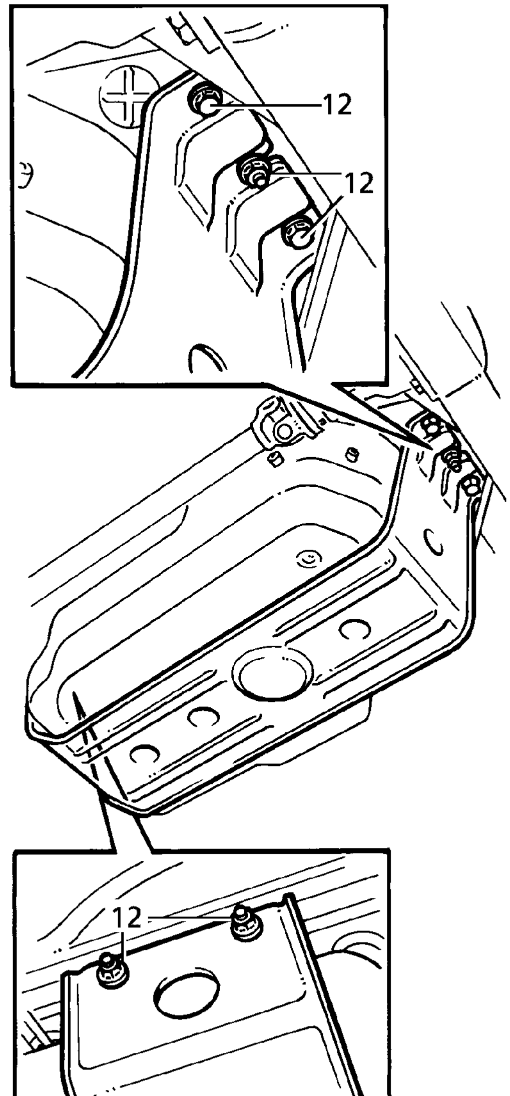
Remove

1. Disconnect battery negative lead.
2. **Petrol Models Only:** Depressurise fuel system. ***See this section.***
3. Remove contents of fuel tank into an approved closed container.
4. Remove fuel filler neck. ***See this section.***
5. Raise vehicle on four post lift.
6. Position container beneath fuel filter to catch spillage.
7. **Petrol Models Only:** Disconnect feed pipe from fuel filter.
8. **Diesel Models Only:** Disconnect feed pipe at connection, forward of fuel tank.



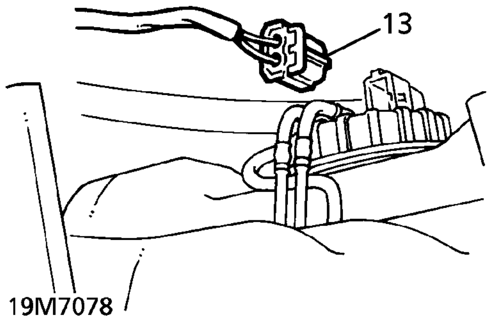
19M7076

9. Disconnect return pipe, forward of tank.
10. Plug pipes and connections.
11. Support tank with jack.
12. Remove 3 nuts and 2 bolts securing tank cradle to floor pan.



19M7077

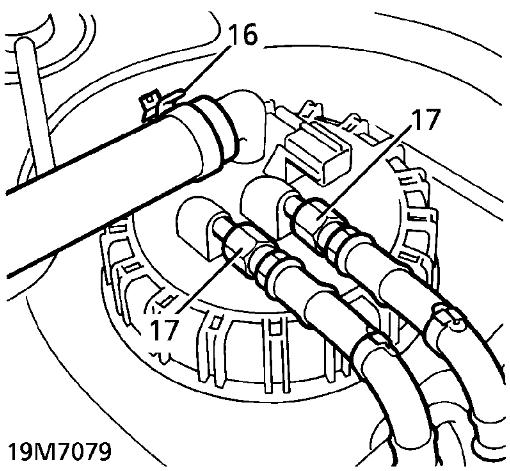
13. Lower tank by 150mm. Disconnect multiplug from fuel tank unit.



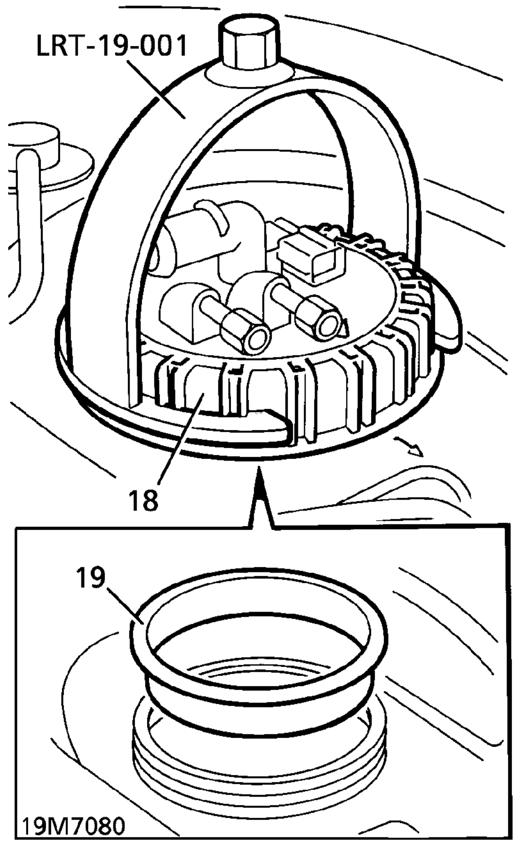
14. Lower tank assembly. Remove from jack.
Do not carry out further dismantling if component is removed for access only.

Disassemble

15. Remove tank from cradle.
16. Slacken clip. Remove fill breather pipe from tank unit.



17. Disconnect feed and return pipes from tank unit. Remove each pipe from 2 fuel tank clips.
18. Remove tank unit retaining ring using LRT-19-001. Remove assembly from tank.



WARNING: A quantity of fuel will be retained in the unit, care must be taken to avoid excessive spillage during removal.

19. Remove tank unit sealing rubber and discard.

Reassemble

20. Fit new sealing rubber.
21. Fit tank unit. Align location marks.
22. Fit retaining ring using LRT-19-001.
23. Connect fuel feed and return pipes to tank unit. Tighten to ***16 Nm (12 lbf.ft)***
24. Secure pipes to fuel tank clips.
25. Position fill breather pipe to tank unit. Secure with clip.
26. Position tank in cradle.

Refit

27. Raise fuel tank assembly on jack until multiplug can be connected to tank unit.
28. Raise tank. Align cradle mounting points. Secure with nuts and bolts.
29. Remove plugs from pipes and connections.
30. **Petrol Models Only:** Using new 'O' ring, connect fuel spill return pipe. Tighten to ***16 Nm (12 lbf.ft)***
31. **Petrol Models Only:** Using new 'O' ring, connect fuel feed pipe to filter. Tighten to ***20 Nm (15 lbf.ft)***
32. **Diesel Models Only:** Connect fuel feed and return pipes.
33. Lower vehicle.
34. Refit fuel filler neck. ***See this section.***
35. Refill fuel tank.
36. Reconnect battery negative lead.

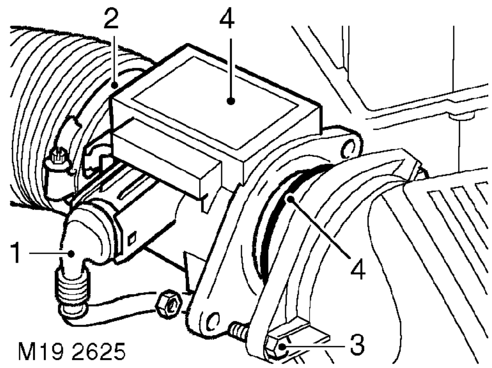
MASS AIR FLOW (MAF) SENSOR - DIESEL WITH EGR

Service repair no - 19.22.25

Remove

1. Disconnect multiplug from MAF sensor.
2. Slacken clip and disconnect intake hose from MAF sensor.
3. Remove 2 bolts securing MAF sensor to air cleaner.
4. Remove MAF sensor and collect 'O' ring seal.

NOTE: Discard 'O' ring seal.



Refit

5. Position new 'O' ring seal to MAF sensor.
6. Engage MAF sensor to air cleaner and secure with bolts. Tighten bolts to ***10Nm (7 lbf.in).***
7. Connect intake hose and secure with clip.
8. Connect multiplug to MAF sensor.

DUCTING - AIR INTAKE - DIESEL WITH EGR

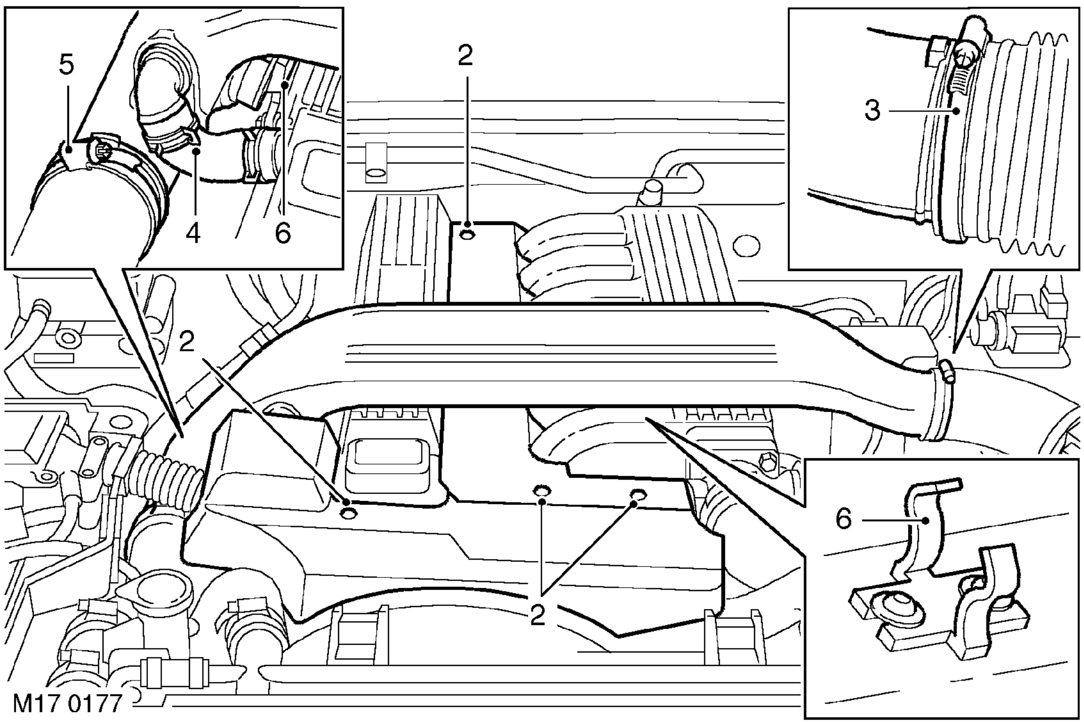
Service repair no - 19.10.27

Remove

1. Disconnect battery negative terminal.
2. Remove 4 bolts securing injector cover and remove cover.
3. Slacken clip securing intake hose to intake ducting and disconnect hose.
4. Release clip securing breather hose to intake ducting.
5. Slacken clip securing intake duct to turbo duct.
6. Carefully release intake duct from clips on intake manifold and camshaft cover.

CAUTION: Care must be taken to ensure clips do not become damaged.

7. Disengage duct from breather hose and turbo duct. Remove intake duct assembly.



Refit

8. Position intake duct. Engage turbo duct and breather hose.
9. Carefully engage intake duct clips to camshaft cover and inlet manifold locations.

CAUTION: Ensure that manifold clips are correctly engaged before pushing duct downwards or clips may be damaged.

10. Connect intake hose to intake duct.
11. Secure clips on intake turbo duct, intake hose and breather hose.
12. Position injector cover and secure with bolts. Tighten bolts to Tighten to ***10 Nm (7 lbf.in).***
13. Connect battery negative terminal.

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LAND ROVER V8

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ENGINE MANAGEMENT SYSTEM - up to 99MY

Description

The V8 engine for models prior to 99MY is controlled by a Sagem GEMS engine management system. The ECM uses sensors to determine ambient conditions and operating data and uses this data and the information stored in an internal memory map to control the electronic ignition and fuel injection. The system features idle speed control, fault monitoring, security immobilisation and engine load management functions. GEMS can be interrogated via the diagnostic socket to access fault codes and other diagnostic information using Testbook.

The engine management system (EMS) maintains optimum engine performance over the entire operating range. The correct amount of fuel is metered into each cylinder inlet tract and the ignition timing is adjusted at each spark plug.

The system is controlled by the engine control module (ECM) which receives data from sensors located on and around the engine. From this information it provides the correct fuel requirements and ignition timing at all engine loads and speeds.

The fuel injection system uses a hot wire mass air flow (MAF) sensor to calculate the quantity of air flowing into the engine.

The ignition system does not use a distributor. It is a direct ignition system (DIS), using four double ended coils. The circuit to each coil is completed by switching inside the ECM.

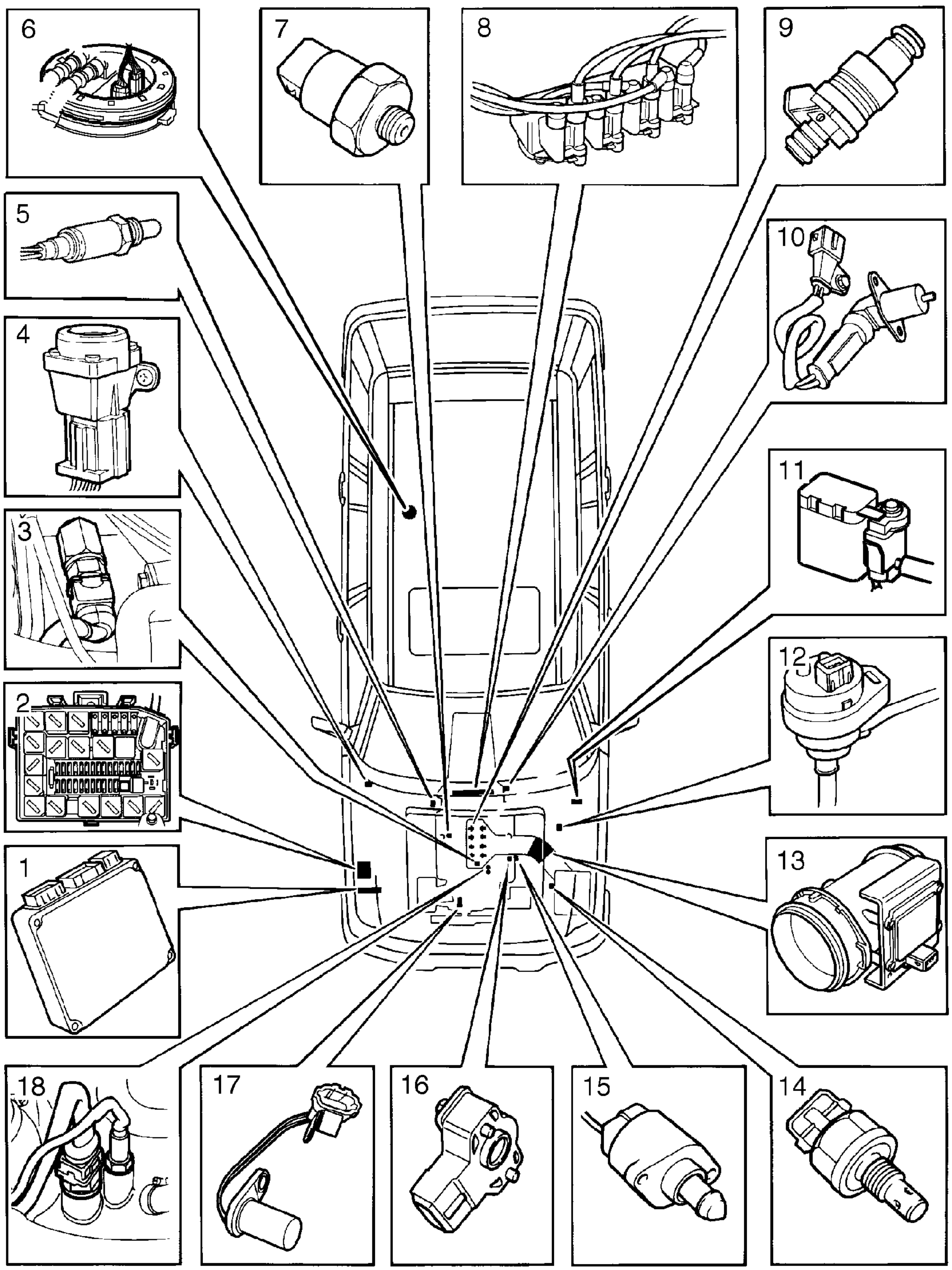
The on-board diagnostic system detects any faults which may occur within the EMS. Fault diagnosis includes failure of any EMS sensors and actuators, emissions related items, fuel supply and exhaust systems.

The system incorporates certain default strategies to enable the vehicle to be driven in case of sensor failure. This may mean that a fault is not detected by the driver. The fault is indicated by illumination of the malfunction indicator light (MIL) on North American specification vehicles.

A further feature of the system is 'robust immobilisation', fitted to European specification vehicles. Upon arming the alarm, the EMS ECM disables the injectors and the Body electrical Control Module (BeCM) inhibits the crank relay (the vehicle cannot be started until the alarm is disarmed).

CAUTION: System sensor connectors can be contaminated by oil or coolant when disconnected during repair or testing. Use a suitable cap to prevent dirt or fluid ingress.

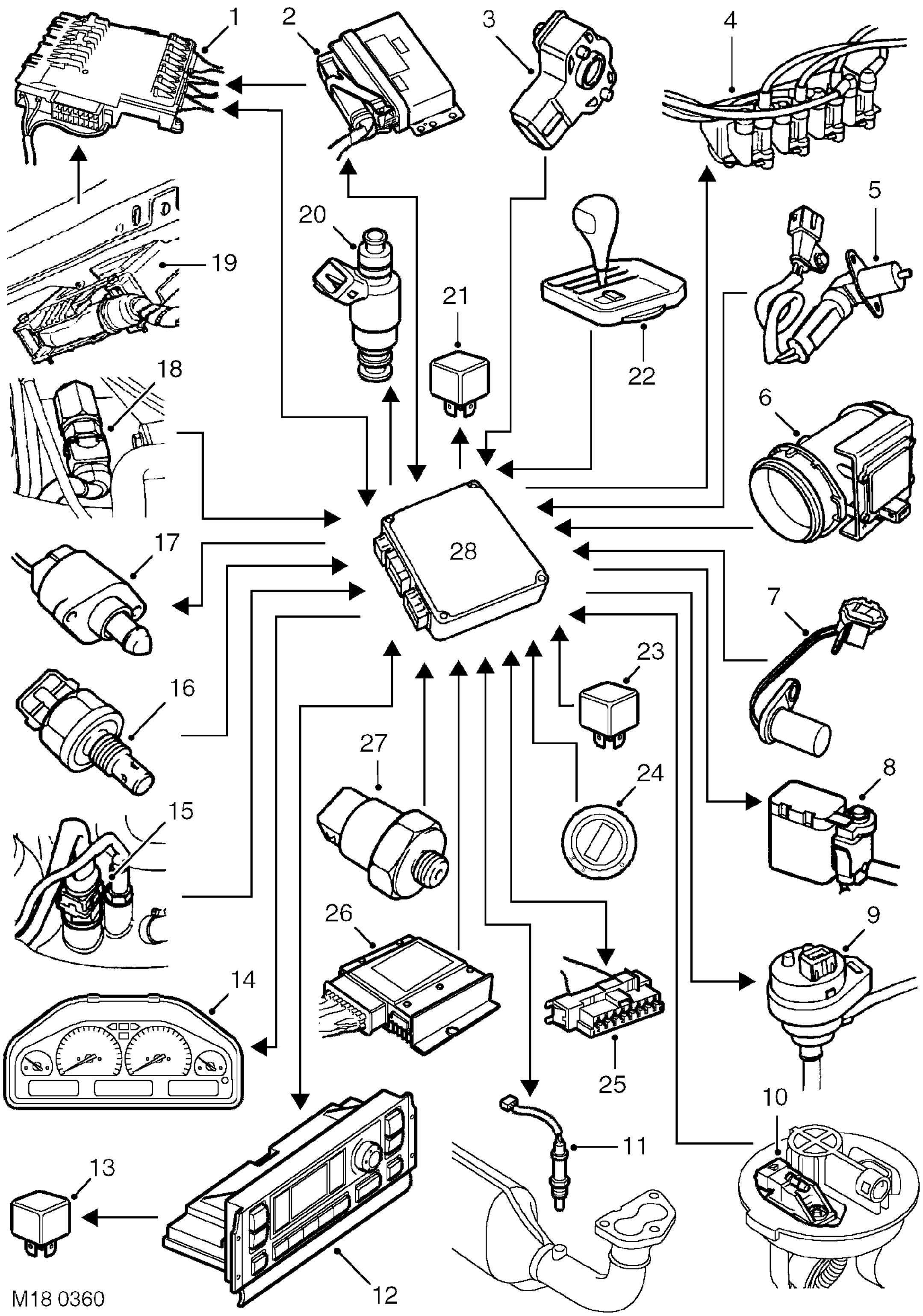
ENGINE MANAGEMENT SYSTEM COMPONENT LOCATION - up to 99MY



18M0257

1. Engine Control Module (ECM)
2. Relays in underbonnet fuse/relay box
   - Main relay
   - Ignition relay
   - Starter motor relay
   - Fuel pump relay
3. Engine Fuel Temperature (EFT) sensor
4. Inertia Fuel Shut-off (IFS) switch
5. Heated Oxygen Sensor (HO_2S)
6. Fuel pump and gauge sensor (Advanced EVAPS unit also incorporates tank pressure sensor)
7. Knock Sensors (KS) (2 off)
8. Ignition coils
9. Fuel injectors
10. Crankshaft position (CKP) sensor (early type shown)
11. EVAP Canister Vent Solenoid (ECVS) - Advanced EVAPS only
12. EVAP canister purge valve
13. Mass air flow (MAF) sensor
14. Intake Air Temperature (IAT) sensor
15. Idle Air Control (IAC) Valve
16. Throttle Position (TP) sensor
17. Camshaft Position (CMP) sensor
18. Engine coolant temperature (ECT) sensor

ENGINE MANAGEMENT SYSTEM SCHEMATIC - up to 99MY



1. Body electrical Control Module (BeCM)- (Inputs and Outputs)
   - Engine speed signal - (Output)
   - Engine immobilisation security signal - (Input)
   - Road speed signal - (Input from ABS ECU via BeCM)
   - Check engine / Service engine soon (NAS) warning lamp - (Output)
   - Fuel level signal - (Input)
2. Electronic Automatic Transmission (EAT) ECU - (Inputs and Outputs)
   - Engine torque signal - (Output)
   - Throttle angle signal - (Output)
   - Ignition retard - (Input)
   - Engine speed signal - (Output via BeCM)
3. Throttle Position (TP) sensor - (Input)
4. Ignition coils (4 off) - (Output)
5. Crankshaft speed and position (CKP) sensor - (Input)
6. Mass air flow (MAF) sensor - (Input)
7. Camshaft position (CMP) sensor - (Input)
8. Canister vent solenoid (CVS) unit - (Output- NAS Advanced EVAPs system only)
9. Purge valve - (Output)
10. Fuel tank pressure sensor - (Input - NAS Advanced EVAPs system only)
11. HO_2S sensors (0, 2 or 4 off dependent on market legislation)
    - (Input signal and HO_2S sensor heater supply output)
12. HEVAC unit - (Inputs and Outputs)
    - Air Con Request - (Output)
    - Air Con Grant - (Output)
    - Condenser Fan Request - (Input)
    - Heated Front Screen - (Input via BeCM for idle speed compensation)
13. Condenser Fan Relay - (Output)
14. Instrument pack - (Fuel used signal output)
15. Engine coolant temperature (ECT) sensor - (Input)
16. Intake air temperature (IAT) sensor - (Input)
17. Idle Air Control Valve (IACV) - (Output)
18. Fuel temperature sensor - (Input)
19. ABS ECU (Rough road signal) - (Input via BeCM)
20. Fuel injectors (8 off) - (Output)
21. Fuel pump relay - (Output)
22. Park / Neutral Switch - (Input)
23. Main power relay - (Input)
24. Ignition supply (Ignition sense) - (Input)
25. Diagnostic connector - (bi-directional)
26. Transfer box ECU - (MIL request input)
27. Knock (KS) sensors (2 off) - (Input)

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ENGINE MANAGEMENT SYSTEM - from 99MY

Description

The V8 engine for models from 99MY is controlled by a Bosch Motronic 5.2.1 engine management system. The ECM uses sensors to determine ambient conditions and operating data and uses this data and the information stored in an internal memory map to control the electronic ignition and fuel injection. The system features:

- Idle speed control (ISC)
- Adherance to regulatory emissions standards
- Adherance to OBDII legislation for NAS vehicles
- Security immobilisation
- Fuelling quantity
- Exhaust emission control using HO_2S sensors and closed loop fuelling
- Knock control
- Ignition timing
- Interfaces with other electronic systems including Electronic Automatic Transmission (EAT) ECU, Transfer Box ECU, ABS ECU, BeCM and instrument pack.

The engine management system controls the engine fuelling by providing full sequential injection to all cylinders. Ignition is controlled by a direct ignition system which is provided by two quad ignition coils operating on the wasted spark principle.

Sensors used in the engine management system include:

- Mass air flow sensor - to determine the mass of air entering the engine
- Throttle position sensor - to detect the current throttle angle
- Coolant temperature sensor - to detect current engine coolant temperature
- Exhaust gas sensors (HO_2S) sensors - to determine the exhaust emission levels

The ECM software program processes these signals and determines what actions to implement based on these signals and the internal mapped data settings.

The on-board diagnostic system detects any faults which may occur within the EMS. The system monitors and reports on any ignition, fuelling or exhaust faults which cause an excessive increase in emissions. Fault diagnosis includes failure of any EMS sensors and actuators, as well as misfire, catalyst damage, catalyst efficiency, fuel evaporative loss control and exhaust leaks.

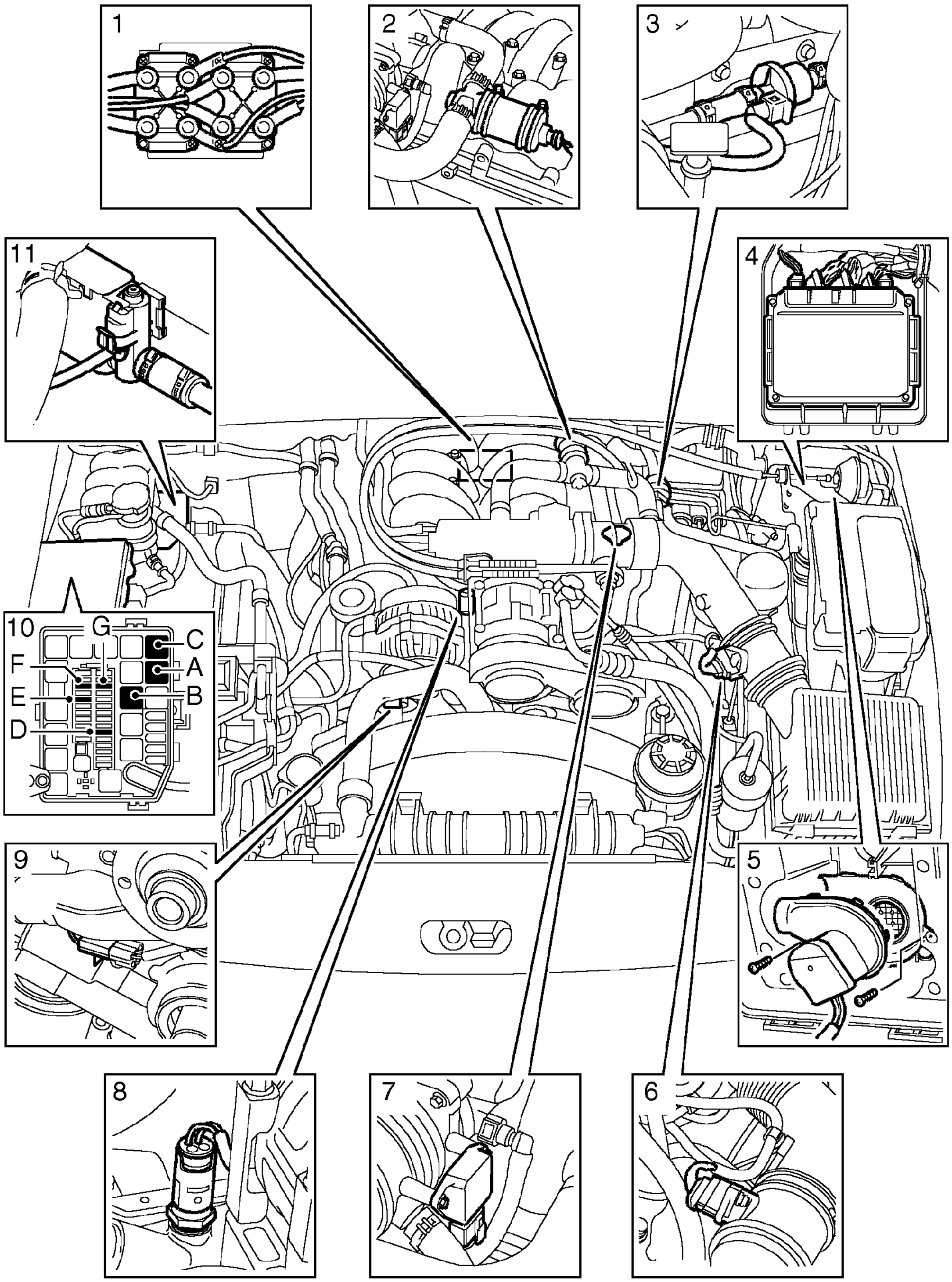
The system incorporates certain default strategies to enable the vehicle to be driven in case of sensor failure. This may mean that a fault is not detected by the driver. The fault is indicated by illumination of the malfunction indicator lamp (MIL) on North American specification vehicles.

The ECM also communicates with the EAT ECU using a CAN data link for the transmission of OBD information.

A further feature of the system is 'robust immobilisation', (fitted to vehicles in most markets). Upon arming the alarm, the EMS ECM disables the injectors and the Body electrical Control Module (BeCM) inhibits the crank relay (the vehicle cannot be started until the alarm is disarmed).

CAUTION: System sensor connectors can be contaminated by oil or coolant when disconnected during repair or testing. Use a suitable cap to prevent dirt or fluid ingress.

ENGINE MANAGEMENT SYSTEM COMPONENT LOCATION - from 99MY

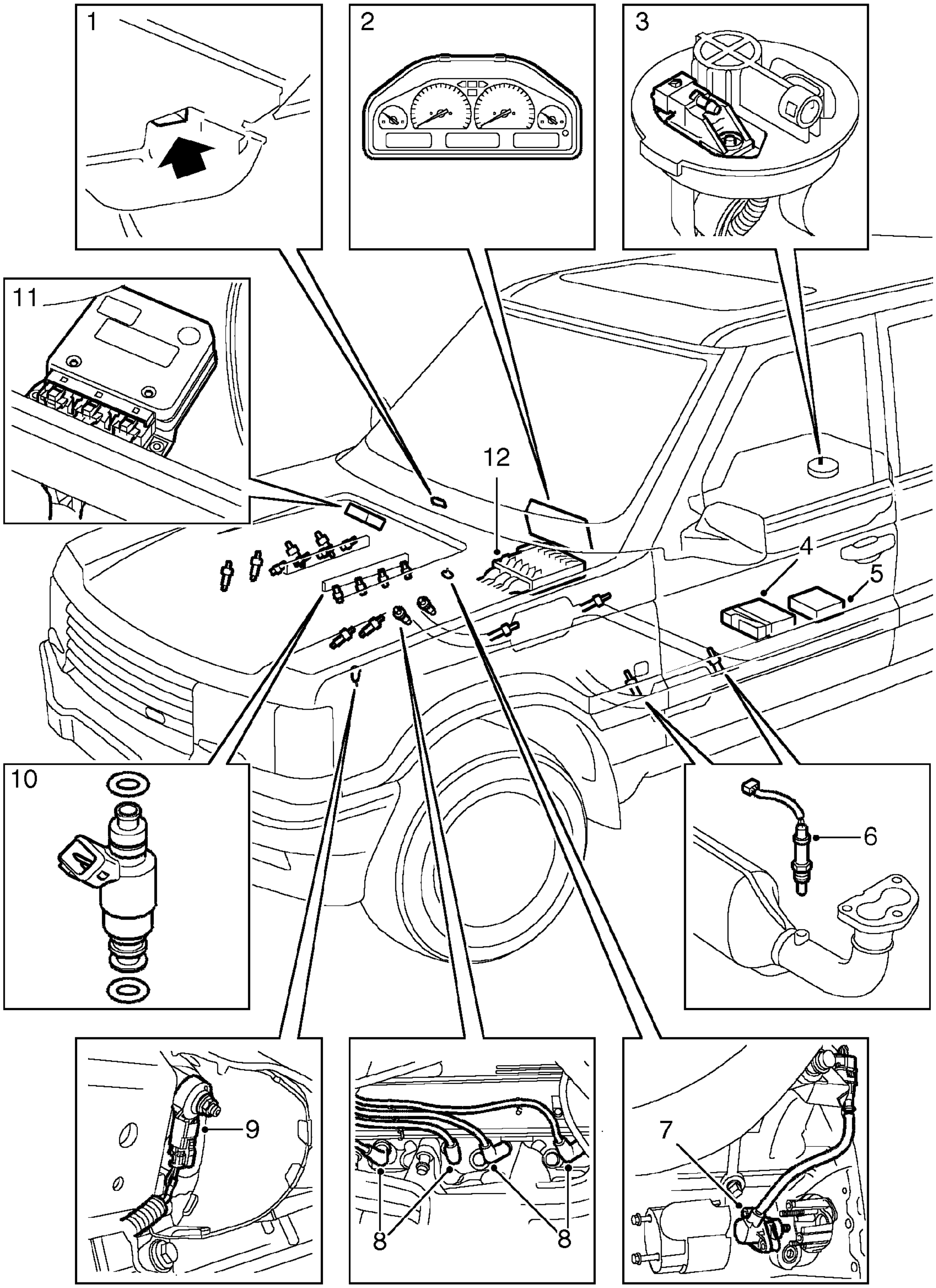


M18 0358

1. Ignition coils
2. Idle Air Control Valve (IACV)
3. Purge valve
4. Engine Control Module (ECM)
5. "E-box" cooling fan
6. MAF Sensor & IAT Sensor
7. Throttle Position Sensor
8. Engine Coolant Temperature (ECT) Sensor
9. Camshaft Position (CMP) Sensor
10. Engine Compartment Relay and Fusebox
    A - Main Relay
    B - Ignition Relay
    C - Air Conditioning On/Off Relay
    D - Battery supply fuse (30A)
    E - Ignition relay supply fuse (30A)
    F - Main relay output fuse (20A)
    G - Main relay output fuse (30A)
11. Canister Vent Solenoid (CVS) Valve

NOTE: For component locations of secondary air injection system components fitted to NAS vehicles from 2000MY, refer to the EMISSION CONTROL section of this manual.

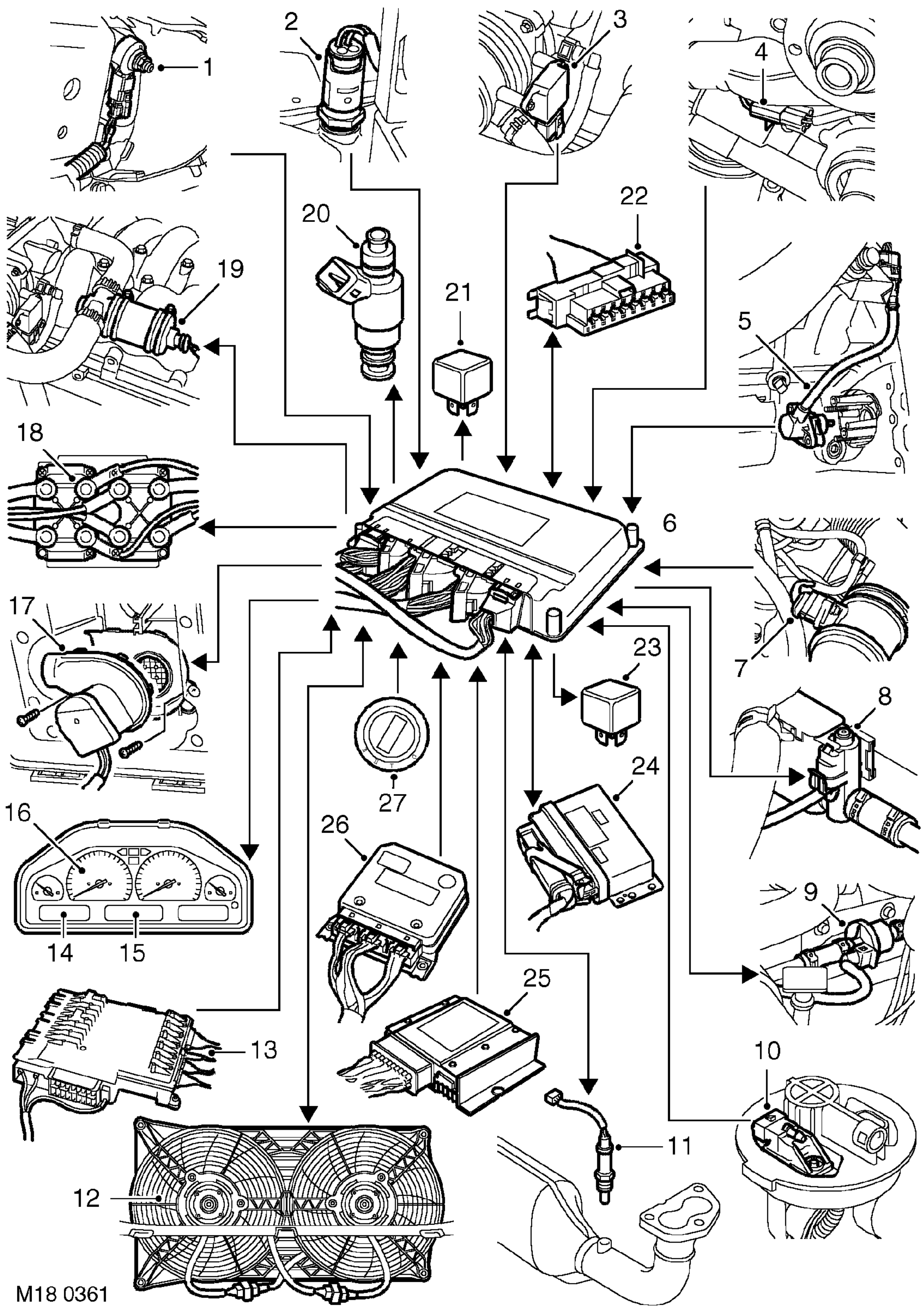
ENGINE MANAGEMENT SYSTEM COMPONENT LOCATION - from 99MY (Continued)



M18 0359

1. Diagnostic connector
2. Instrument pack
   - Check engine / Service engine soon (NAS only) warning lamp
   - Tachometer
   - Fuel used
3. Fuel tank pressure sensor
4. Electronic Automatic Transmission (EAT) ECU
5. Transfer Box ECU
6. HO_2S sensors
7. Crankshaft position sensor
8. Spark plugs and HT leads
9. Knock sensor
10. Fuel injectors
11. ABS ECU
12. Body electronic Control Module (BeCM)

ENGINE MANAGEMENT SYSTEM SCHEMATIC - from 99MY



ECM engine interface inputs:

1. Knock sensor (2 off)
2. Engine coolant temperature (ECT) sensor
3. Throttle position (TP) sensor
4. Camshaft position (CMP) sensor
5. Crankshaft speed and position sensor
6. Engine control module (ECM)
7. Mass air flow (MAF) / Inlet air temperature (IAT) sensor

Fuel system:

8. Canister vent solenoid (CVS) valve (output)
9. Purge valve (output)
10. Fuel tank pressure sensor (input)

Emissions:

11. Heated oxygen sensors (0, 2 or 4 dependent on market destination)
 - HO_2S sensor signal inputs
 - HO_2S sensor heater supply outputs

Air Conditioning System:

12. - Air conditioning compressor (output)
 - Air conditioning condenser fan relay (output)
 - Air conditioning request (input)
 - Condenser fan request (input)

BeCM:

13. BeCM
 - Immobilisation signal (input)
 - Fuel tank level signal (input)

Instrument pack:

14. Check Engine / Service Engine Soon (NAS) warning lamp (output)
15. Fuel used signal - display (output)
16. Tachometer (output)

E-box:

17. E-box cooling fan control (output)

ECM engine interface outputs:

18. Ignition coils (4 off)
19. Idle air control (IAC) actuator
20. Fuel injectors (8 off)
21. Fuel pump relay

Diagnostics:

22. Diagnostic connector (bi-directional)

Power supply:

23. Main relay (input)

Electronic Control Unit interfaces:

24. Electronic Automatic Transmission (EAT) ECU (via bi-directional CAN link)
25. Transfer Box ECU (MIL request)
26. ABS ECU (Rough road signal)

Ignition switched power supply:

27. Ignition switch - position II (input)

NOTE: Additional components for secondary air injection are fitted to some NAS vehicles from 2000MY, refer to the EMISSION CONTROL section in this manual for details.

COMPONENT DESCRIPTIONS - up to 99MY

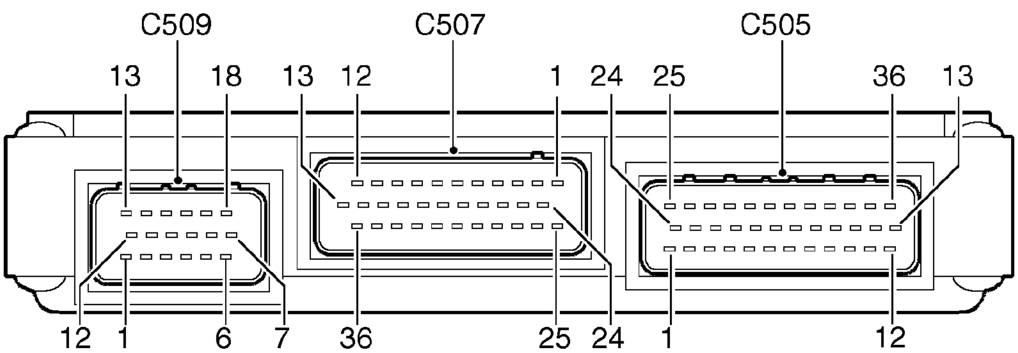
Engine Control Module (ECM) - (up to 99MY)

The engine control module (ECM) prior to 99MY is a GEMS (Generic Engine Management System), it is located in a plastic moulded box behind the battery in the engine compartment.

The ECM has various sensors fitted to the engine to allow it to monitor engine condition. The ECM processes these signals and decides what actions to carry out to maintain driveability, after comparing the information from these signals to mapped data within its memory.

Input / Output

The black plastic case which houses the ECM protects it from sources of contamination including heat. The ECM itself is contained in a cast aluminium case. The ECM has 3 independent connectors totalling 90 pins, of which up to 66 are used, dependent on market variations.



M18 0364

C509:18-pin black connector
C507:36-pin red connector
C505:36-pin black connector

18-pin black connector (C509):

This connector is used primarily for ECM power and earth connections.

NOTE: Voltages and other measurements given are approximations only. Actual values will depend on particular specification and will be affected by accuracy and calibration of the measurement tool used and impedances caused by harness wiring etc.

ECM pin details for Connector C509:

Pin No.	Description	Input/Output	Voltage
1	Coil driver - Cylinders 5 & 8	Output	0 - 12V
2	Not used	-	-
3	Not used	-	-
4	Throttle Position Sensor	Output	5V supply
5	ECM to chassis ground	Ground	0V
6	Not used	-	-
7	Main relay supply	Input	0 - 12V
8	Ignition sense	Input	0 - 12V
9	ECM to chassis ground	Ground	0V
10	ECM to chassis ground	Ground	0V
11	Crankshaft (CKP) sensor -ve	Ground	0V
12	Crankshaft (CKP) sensor +ve	Analogue input	18V (average) at 480Hz
13	Coil driver - Cylinders 2 & 3	Output	0 - 12V
14	Coil driver - Cylinders 1 & 6	Output	0 - 12V
15	Coil driver - Cylinders 4 & 7	Output	0 - 12V
16	ECM to chassis ground	Ground	0V
17	Main relay control	Output	switched to ground
18	Not used	-	-

36-pin red connector (C507):

This connector is used primarily for sensor inputs to the ECM.

NOTE: Voltages and other measurements given are approximations only. Actual values will depend on particular specification and will be affected by accuracy and calibration of the measurement tool used and impedances caused by harness wiring etc.

ECM pin details for Connector C507:

Pin No.	Description	Input/Output	Voltage
1	Rough road detected	Input	0 -12V
2	Camshaft position (CMP) sensor	Input (2 pulses per engine revolution)	12V (average)
3	Not used	-	-
4	Transfer box (Low range detected)	Input	0 - 12V
5	Not used	-	-
6	Not used	-	-
7	Fuel level	Input (out of range and validity check only)	0 - 12V
8	HO_2S Bank B Upstream	Input	0V (Rich) - 5V (Lean)
9	Not used	-	-
10	Knock sensor ground	Ground	0V
11	Knock sensor A	Input	Voltage signal proportional to level of knock detected
12	Knock sensor B	Input	Voltage signal proportional to level of knock detected
13	Air temperature sensor	Input	1 k-ohm to 1.3 k-ohm at 40°C (140°F)
14	Coolant temperature sensor	Input	4.7V at -30°C (-22°F) to 0.25V at 130°C (266°F); 2.0V at 40°C (104°F)
15	Throttle position sensor	Input	0 to 5V (0.6V at idle; 4.5V typical max.)
16	Mass air flow (MAF) Sensor	Analogue input	0 to 5V (1.4V at idle)
17	HO_2S sensor Bank A Downstream	Input	0V (Rich) - 5V (Lean)

ECM pin details for Connector C507 continued:

Pin No.	Description	Input/Output	Units
18	Park / Neutral Switch	Input	0V (Park/Neutral) - 12V (Drive)
19	Not used	-	-
20	Diagnostic 'L' Line	Bi-directional	Serial 0 - 12V
21	Heated front windshield	Output	0V or 12V
22	Not used	-	-
23	Diagnostic 'K' Line	Bi-directional	Serial 0 - 12V
24	Not used	-	-
25	Not used	-	-
26	Immobilization	Input	Serial 0 - 12V (366 baud)
27	Vehicle speed	Input	PWM 0 - 12V (8000 pulses / mile)
28	A/C request	Output	0V or 12V
29	Condenser cooling fan request	Input	0V or 12V
30	Fuel Pressure sensor (from 97.5 MY)	Input	1 k-ohm to 1.3 k-ohm at 40°C (140°F)
31	Ignition Retard Request (EAT ECU)	Input	12V PWM
32	HO_2S sensor	Ground	0V
33	HO_2S sensor Bank B Downstream	Input	0V (Rich) - 5V (Lean)
34	HO_2S sensor Bank A Upstream	Input	0V (Rich) - 5V (Lean)
35	Fuel temperature sensor	Input	1 k-ohm to 1.3 k-ohm at 40°C (140°F)
36	Sensor ground	Ground	0V

36-pin black connector (C505):

This connector is used primarily for outputs to actuators and sensors driven by the ECM.

NOTE: Voltages and other measurements given are approximations only. Actual values will depend on particular specification and will be affected by accuracy and calibration of the measurement tool used and impedances caused by harness wiring etc.

ECM pin details for Connector C505:

Pin No.	Description	Input/Output	Units
1	A/C grant	Output	0V or 12V
2	Fuel used	Output	Serial 0 - 12V (12000 pulses per litre)
3	Condenser cooling fan	Output drive	Switch to ground
4	Not used	-	-
5	Not used	-	-
6	Canister vent solenoid (from 97.5 MY)	Output	0 - 12V
7	Not used	-	-
8	Not used	-	-
9	Not used	-	-
10	Not used	-	-
11	Injector - Cylinder 3	Output	0 - 12V
12	Not used	-	-
13	Injector - Cylinder 1	Output	0 - 12V
14	Not used	-	-
15	IACV-D Stepper motor	Output	stepped by sequentially changing voltage polarity
16	IACV-B Stepper motor	Output	stepped by sequentially changing voltage polarity
17	Injector - Cylinder 6	Output	0 - 12V
18	Injector - Cylinder 8	Output	0 - 12V
19	Purge valve	Output	0 - 12V (100 Hz)
20	Not used	-	-

ECM pin details for Connector C505 continued:

Pin No.	Description	Input/Output	Voltage
21	HO_2S sensor Upstream - Heater supply	Output	Heater resistance = 5.7 ohms
22	Malfunction Indicator Lamp (MIL)	Output drive	Switch to ground
23	Engine speed output	Output	12V square wave (4 pulses per revolution)
24	Fuel pump relay	Output drive	Switch to ground
25	Not used	-	-
26	Not used	-	-
27	Throttle position	Analogue input	0 - 5V (1.4V at idle)
28	HO_2S sensor Upstream - Heater supply	Output	Heater resistance = 5.7 ohms
29	Engine torque	Output	12V PWM
30	Injector - Cylinder 4	Output	0 - 12V
31	Not used	-	-
32	Injector - Cylinder 7	Output	0 - 12V
33	Injector - Cylinder 5	Output	0 - 12V
34	IACV-C Stepper motor	Output	stepped by sequentially changing voltage polarity
35	IACV-A Stepper motor	Output	stepped by sequentially changing voltage polarity
36	Injector - Cylinder 2	Output	0 - 12V

Crankshaft position (CKP) sensor - (up to 99MY)

The crankshaft position sensor is the most important sensor on the engine. It is located in the left hand side of the flywheel housing and uses a different thickness of spacer for manual and automatic gearboxes. The signal it produces informs the ECM:
- the engine is turning
- how fast the engine is turning
- which stage the engine is at in the cycle

As there is no default strategy, failure of the CKP sensor will result in the engine failing to start. The fault is indicated by illumination of the malfunction indicator light (MIL) on North American specification vehicles.

The output signal from the CKP sensor is obtained from the magnetic path being made and broken as the reluctor ring teeth pass the sensor tip. The reluctor ring has 35 teeth and one missing tooth spaced at 10°intervals. The missing tooth is positioned at 20°after TDC.

Fault codes:

- **P0335 -**Crankshaft sensor circuit fault - no signal
- **P0336 -**Crankshaft sensor generating poor quality signal

Camshaft position (CMP) sensor - (up to 99MY)

The camshaft sensor is located in the engine front cover, between the belt pulleys. It is a Hall Effect device which produces four pulses for every two revolutions of the engine. The signal is used for two purposes, injector timing corrections for fully sequential fuelling and active knock control. The CMP sensor signal pulses are generated from four gaps on the cam wheel, one gap is smaller than the other three, consequently one of the pulses is longer than the others.

If the camshaft sensor fails, default operation is to continue normal ignition timing. The fuel injectors will be actuated sequentially, timing the injection with respect to top dead centre. Injection will either be correct or one revolution out of synchronisation. The fault is not easily detected by the driver. The fault is indicated by illumination of the malfunction indicator light (MIL) on North American specification vehicles.

Fault codes:

- **P0340 -** Camshaft sensor circuit fault or signal timing different from crankshaft sensor signal.

NOTE: It is physically possible to interchange the camshaft gear wheel fitted to pre-99MY and post-99MY vehicles. However, because the GEMS and Motronic systems are incompatible, an incorrect camshaft signal will be received by the ECM and a P0340 fault code will result.

Mass air flow (MAF) sensor - (up to 99MY)

The 'hot wire' type mass air flow sensor is mounted rigidly to the air filter and is connected by flexible hose to the plenum chamber inlet. The MAF sensor is a hot wire anenometer. The main sensing element of the sensor is a heated wire, positioned in the stream of intake air. Changes in intake air flow changes the temperature, and hence resistance, of the wire. The ECM measures this change in resistance and calculates the amount of air flowing into the engine.

As there is no default strategy, failure will result in the engine starting, and dying when it reaches 550 rev/min, when the ECM detects no MAF sensor signal. The fault is indicated by illumination of the malfunction indicator light (MIL) on North American specification vehicles.

Intake Air Temperature (IAT) sensor - (up to 99MY)

The IAT sensor is another resistive sensor, located in the body of the air cleaner. The sensor resistance varies with changes in air temperature. The signal from the IAT sensor is used to retard the ignition timing if the air temperature rises above 55°C. If the sensor is disconnected or failure occurs, a default value will be used by the system. The default value selected will represent nominal operating conditions. The fault may not be evident to the driver, there may be slight power loss in high ambient temperatures. The fault is indicated by illumination of the malfunction indicator light (MIL) on North American specification vehicles.

Throttle Position (TP) sensor - (up to 99MY)

The throttle position sensor is mounted on the throttle body in line with the throttle plate shaft. The sensor is a variable resistor, the signal from which (0 - 5V) informs the ECM of the actual position of the throttle disc and the rate of change of throttle position. This information is used by the ECM for regulation of acceleration enrichment fuelling. Sensor failure will adversely affect the acceleration performance. The closed throttle voltage is continuously monitored and updated when engine conditions indicate that the throttle is closed.

The GEMS ECM performs a throttle potentiometer range check by cross checking with the measured air flow. If the two values do not correlate and fuelling feedback indicates that fuelling and therefore airflow is correct, the potentiometer is assumed to have failed. In the event that a fault is detected, GEMS supplies a default value dependent on air flow.

The throttle angle is also supplied to the gearbox ECM, the loss of this signal will result in poor gear change quality and loss of kickdown.

WARNING: If the throttle potentiometer is changed, it is necessary to reset the closed throttle voltage.

Fault codes:

- **P0121 -** Throttle potentiometer signal inconsistent with MAF, IACV, air temperature and engine rpm.
- **P0122 -** Throttle potentiometer circuit low input
- **P0123 -** Throttle potentiometer circuit high input

Engine Coolant Temperature (ECT) sensor - (up to 99MY)

The sensor is located at the top front of the engine, to the right of the alternator and in front of the plenum chamber.

The sensor comprises a temperature dependant resistive metal strip. The resistance of the strip varies considerably with coolant temperature, i.e. from 28K ohms at - 30°C to 90 ohms at 130°C. At 85°C the resistance is 300 ohms. The ECT sensor signal is vital to engine running, as the correct fuelling is dependant upon engine temperature i.e. richer mixture at low temperatures.

If the sensor is disconnected or failure occurs, a default value will be supplied to the system. The initial default value selected will be based on the value of the air intake temperature. This will increase to a nominal warmed up value over a given time, programmed for each default value. The fault may not be evident to the driver, there may be a hot restart problem. The fault is indicated by illumination of the malfunction indicator light (MIL) on North American specification vehicles.

Fault codes:

- **P0116 -** Coolant temperature sensor - falling temperature fault
- **P0117 -** Coolant temperature sensor circuit low range fault
- **P0118 -** Coolant temperature sensor circuit high range fault
- **P0125 -** Coolant temperature sensor - no warm-up fault

Engine Fuel Temperature (EFT) sensor - (up to 99MY)

The EFT sensor is located on the fuel rail by cylinders 3 and 5. The sensor measures the temperature of the rail rather than the fuel. The resistance varies with changes in temperature. The signal is used to increase the injection pulse time when undergoing hot restarts. When the fuel is hot, vapourisation can occur in the fuel rail and bubbles form in the injectors. Increasing the pulse time helps flush the fuel vapour away. An EFT sensor fault may not be evident to the driver, there may be a hot restart problem. The fault is indicated by illumination of the malfunction indicator light (MIL) on North American specification vehicles.

Fault codes:

- **P0181 -** Fuel temperature sensor fault - reading invalid compared with water temperature
- **P0182 -** Fuel temperature sensor circuit low range fault
- **P0183 -** Fuel temperature sensor circuit high range fault

Knock Sensors (KS) - up to 99MY

The knock sensor produces an output voltage which is proportional to mechanical vibration caused by the engine. A sensor is located in each cylinder bank between 2/4 and 3/5 cylinders. The ECM calculates if the engine is knocking by taking camshaft and crankshaft sensor signals to determine the position of the engine in the combustion cycle.

The ECM can also work out exactly which cylinder is knocking and progressively retards the ignition on that particular cylinder until the knock disappears. It then advances the ignition to find the optimum ignition timing for that cylinder.

The ECM can simultaneously adjust the timing of each cylinder for knock. It is possible that all eight cylinders could have different advance angles at the same time. If the camshaft sensor fails, the knock control will be disabled.

Fault codes:

- **P0331 -** Continuous knock on bank B
- **P0332 -** Knock background noise low, bank B
- **P0333 -** Knock background noise high, bank B
- **P0326 -** Continuous knock on bank A
- **P0327 -** Knock background noise low, bank A
- **P0328 -** Knock background noise high, bank A

Ignition coils - up to 99MY

The electronic ignition system uses four double ended coils. The ignition coils are mounted on a bracket fitted to the rear of the engine. The circuit to each coil is completed by switching within the ECM, allowing each coil to charge. When the ECM determines the correct ignition point, it switches off current supply to the coil which in turn causes the magnetic field around the coil's primary winding to collapse, inducing ht voltage in the secondary winding and in the iron core of the coil. High tension voltage, of different polarities, is produced at either end of the coil's core and is transmitted to two cylinders simultaneously, one on compression stroke, the other on exhaust stroke. This is called the wasted spark principle.

Note that coil 1 feeds cylinders 1 and 6, coil 2 feeds cylinders 5 and 8, coil 3 feeds cylinders 4 and 7, and coil 4 feeds cylinders 2 and 3. The resistance of the spark plug in the compression cylinder is higher than that in the exhaust cylinder and hence more spark energy is dissipated in the compression cylinder. Coil failure will result in a lack of ignition, resulting in a misfire in the related cylinders. The fault is indicated by illumination of the malfunction indicator light (MIL) on North American specification vehicles.

Fuel injectors - (up to 99MY)

A multiport Sequential Fuel Injection (SFI) system is used which utilises one injector per cylinder. Each injector comprises a small solenoid which is activated by the ECM to allow a metered quantity of fuel to pass into the combustion chamber. Due to the pressure in the fuel rail and the shape of the injector orifice, the fuel is injected into the cylinder in a fine spray which aids combustion. In the unlikely event of total injector failure or leakage which will cause a rich mixture, a misfire will occur in the affected cylinder. The fault is indicated by illumination of the malfunction indicator light (MIL) on North American specification vehicles.

Fault codes:

- **P0201 -** Injector circuit fault, cylinder 1
- **P0202 -** Injector circuit fault, cylinder 2
- **P0203 -** Injector circuit fault, cylinder 3
- **P0204 -** Injector circuit fault, cylinder 4
- **P0205 -** Injector circuit fault, cylinder 5
- **P0206 -** Injector circuit fault, cylinder 6
- **P0207 -** Injector circuit fault, cylinder 7
- **P0208 -** Injector circuit fault, cylinder 8
- **P1201 -** Injector circuit open or ground short, cylinder 1
- **P1202 -** Injector circuit open or ground short, cylinder 2
- **P1203 -** Injector circuit open or ground short, cylinder 3
- **P1204 -** Injector circuit open or ground short, cylinder 4
- **P1205 -** Injector circuit open or ground short, cylinder 5
- **P1206 -** Injector circuit open or ground short, cylinder 6
- **P1207 -** Injector circuit open or ground short, cylinder 7
- **P1208 -** Injector circuit open or ground short, cylinder 8

⚠ **CAUTION: The injectors are extremely sensitive, they must not be dropped or contaminated.**

⚠ **CAUTION: When assembling the injector to the fuel rail, only use clean engine oil to aid assembly. DO NOT use petroleum jelly or other forms of grease, as this will contaminate the injector.**

The injectors can be checked using a multimeter to test the resistance values:

- Injector resistance at 20°C = 16.2 ohms ± 0.5 ohms

Idle Air Control (IAC) valve - up to 99MY

The idle speed control stepper motor is located on the side of the inlet manifold. Idle speed is controlled by the stepper motor, which comprises two coils, mounted to the throttle housing. When energised in the correct sequence, the coils move a plunger which opens or closes the throttle bypass valve controlling the quantity of idle air. The stepper motor controls idle speed by moving the plunger a set distance called a step. Fully open is 200 steps (180 steps for vehicles up to 97MY) and fully closed 0 steps. Failure of the stepper motor will result in low or high idle speed, poor idle, engine stall or non start. If the number of recorded steps changes beyond a set threshold (opening or closing) without a corresponding change in airflow, then a fault code will be stored. The GEMS diagnostics also check for short circuit conditions during normal stepper operation and open circuit during power down. Detected faults are indicated by illumination of the malfunction indicator light (MIL) on North American specification vehicles.

The stepper motor coil resistance is 53 ohms ± 2 ohms.

CAUTION: The pintle must not be moved by force.

Fault codes:

- **P0506 -** Low idle speed
- **P0507 -** High idle speed
- **P1508 -** IACV stepper motor open circuit
- **P1509 -** IACV stepper motor short circuit

Heated Oxygen Sensor (HO_2S) - up to 99MY

The heated oxygen sensors consist of a titanium metal sensor surrounded by a gas permeable ceramic coating. Oxygen in the exhaust gas diffuses through the ceramic coating on the sensor, and reacts with the titanium wire altering the resistance of the wire. From this resistance change the ECM calculates the amount of oxygen in the exhaust gas. The injected fuel quantity is then adjusted to achieve the correct air:fuel ratio, thus reducing the emissions of carbon monoxide (CO), hydrocarbons (HC), and oxides of nitrogen (NO_x). Two HO_2S sensors are fitted, one in each exhaust front pipe and positioned in front of the catalytic convertor. On North American specification vehicles, an additional HO_2S sensor is fitted behind each catalytic converter. These additional sensors are used to monitor the operating efficiency of the catalysts. Note that if the wiring to these sensors is crossed, the vehicle will start and idle correctly until the sensors reach operating temperature. Then the ECM will read the signals from them and send one bank of cylinders very rich and the other very weak. The engine will misfire, have a rough idle and emit black smoke, with possible catalyst damage.

The oxygen sensors are heated to ensure rapid warm up and continued operation when the exhaust temperature may be below the working temperature of the sensor. Both the upstream sensor heaters and the downstream sensor heaters are connected in parallel. The heaters are directly driven from the GEMS ECM by a pulse width modulated (PWM) signal to enable temperature control of the heater to be achieved. When the sensor is powered up, the duty ratio of the PWM signal to the heater is started low and then increased over a period of approximately 30 seconds. This is to ensure the sensor is not heated up too quickly, which might cause the ceramic interior of the sensor to crack. The duty ratio of the heater signal may be altered during normal operation to maintain sensor temperature.

In the event of sensor failure, the system will default to 'open loop' operation. Fuelling will be calculated using signals from the remaining ECM inputs.

On North American Specification vehicles, a fault with any of the HO_2S sensors is indicated by illumination of the malfunction indicator light (MIL). ECM diagnostics also use the Heated Oxygen Sensors to detect catalyst damage, misfire and fuel system faults.

CAUTION: Although robust within the vehicle environment, Heated Oxygen Sensors are easily damaged by dropping, excessive heat and contamination. Care must be exercised when working on the exhaust system not to damage the sensor housing or tip.

Fault codes:

- **P0130 -** Oxygen sensor circuit slow response, upstream sensor bank A
- **P0136 -** Oxygen sensor circuit slow response, upstream sensor bank A
- **P0150 -** Oxygen sensor circuit slow response, upstream sensor bank B
- **P0156 -** Oxygen sensor circuit slow response, upstream sensor bank B
- **P0131 -** Oxygen sensor circuit low voltage, upstream sensor bank A
- **P0151 -** Oxygen sensor circuit low voltage, upstream sensor bank B
- **P0137 -** Oxygen sensor circuit low voltage, downstream sensor bank A
- **P0157 -** Oxygen sensor circuit low voltage, downstream sensor bank B
- **P0132 -** Oxygen sensor circuit high voltage, upstream sensor bank A
- **P0152 -** Oxygen sensor circuit high voltage, upstream sensor bank B
- **P0138 -** Oxygen sensor circuit high voltage, downstream sensor bank A
- **P0158 -** Oxygen sensor circuit high voltage, downstream sensor bank B
- **P0133 -** Oxygen sensor circuit slow response, upstream sensor bank A
- **P0153 -** Oxygen sensor circuit slow response, upstream sensor bank B
- **P0139 -** Oxygen sensor circuit slow response, downstream sensor bank A
- **P0159 -** Oxygen sensor circuit slow response, downstream sensor bank B
- **P1138 -** Oxygen sensor problem with switching lean, sensor(s) for bank A
- **P1158 -** Oxygen sensor problem with switching lean, sensor(s) for bank B
- **P1137 -** Oxygen sensor problem with switching rich, sensor(s) for bank A
- **P1157 -** Oxygen sensor problem with switching rich, sensor(s) for bank B
- **P1139 -** Oxygen sensor circuit switching period too long bank A
- **P1159 -** Oxygen sensor circuit switching period too long bank B
- **P1171 -** System too lean bank A and bank B
- **P1172 -** System too rich bank A and bank B
- **P0171 -** System too lean bank A
- **P0174 -** System too lean bank B
- **P0172 -** System too rich bank A
- **P0175 -** System too rich bank B
- **P1185 -** Oxygen sensor heater circuit open circuit, upstream sensors
- **P1186 -** Oxygen sensor heater circuit short circuit, upstream sensors
- **P1187 -** Oxygen sensor heater circuit inferred open circuit, upstream sensors
- **P1188 -** Oxygen sensor heater circuit high resistance, upstream sensors
- **P1189 -** Oxygen sensor heater circuit inferred low resistance, upstream sensors
- **P1190 -** Oxygen sensor heater circuit low resistance, upstream sensors

- **P1191 -** Oxygen sensor heater circuit open circuit, downstream sensors
- **P1192 -** Oxygen sensor heater circuit short circuit, downstream sensors
- **P1193 -** Oxygen sensor heater circuit inferred open circuit, downstream sensors
- **P1194 -** Oxygen sensor heater circuit high resistance, downstream sensors
- **P1195 -** Oxygen sensor heater circuit inferred low resistance, downstream sensors
- **P1196 -** Oxygen sensor heater circuit low resistance, downstream sensors
- **P0420 -** Catalyst efficiency is low, bank A
- **P0430 -** Catalyst efficiency is low, bank B

Fuel pressure regulator - (up to 99MY only)

The fuel pressure regulator is a mechanical device controlled by manifold depression and is mounted at the rear of the engine in the fuel rail. The regulator ensures that fuel pressure is maintained at a constant pressure difference to that in the inlet manifold. As manifold depression increases, the regulated fuel pressure is reduced in direct proportion. When pressure exceeds the regulator setting, excess fuel is spill returned to the fuel tank swirl pot which contains the fuel pick up strainer.

Failure of the regulator will result in a rich mixture at idle but normal at full load, or a rich mixture resulting in engine flooding, or a weak mixture. Although the fault will not illuminate the MIL, faults caused by the failure may be indicated.

Accumulator - (up to 99MY only)

Certain derivatives have an accumulator fitted into the feed line connection at the fuel rail. The purpose of this device is to damp out pulsations in the fuel system caused by the normal opening and closing of the injectors. These pulsations, called injector knock, may otherwise be detected inside the vehicle.

Relays - (up to 99MY)

The engine management system employs four relays, which are all located in the main under bonnet fusebox.

Main Relay:

The main relay supplies the power feed to the ECM to feed the fuel injectors (8 amps)and air flow meter (4 amps). This relay is controlled by the GEMS ECM which has a second power feed. This enables the ECM to remain powered up after ignition is switched off. During this 'ECM power down routine' the ECM records all temperature readings and powers the stepper motor to the cold start position. Failure of this relay will result in the engine management ECM not being powered up, resulting in engine not starting due to absence of fuel and ignition.

Starter Motor Relay:

The starter motor relay is ignition key controlled and activated with the key in position 3 only. Releasing the key after cranking cuts supply to the relay and switches off the starter motor. Failure of this relay will result in the starter motor not working.

Ignition Relay:

The ignition relay supplies the power feed to the coils (6.5 amps), purge valve (1 amp, non-continuous) and heating elements of the HO_2S sensors (8 amps, non-continuous). The relay is ignition key controlled, when the key is turned off, supply to the coils is immediately cut. Failure of this relay will result in no ignition.

Ignition switch sense:

This is used to initiate the power up and power down routines within GEMS. The input is supplied from the ignition relay. When the ignition is turned on, the ignition relay is energised and the GEMS ECM starts its power up routines and turns on the ECM main relay, the main power to GEMS and its associated system components. When the ignition is turned off, GEMS will usually maintain its powered up state for several seconds (up to 20 minutes in extreme cases when cooling fans are required) while it initiates its power down routine. On completion of the power down routine, the ECM main relay is turned off.

Fuel Pump Relay:

The fuel pump relay is fed from the ignition relay and controlled by the ECM. The relay is activated in ignition key position 2 to prime the fuel system for a period of time controlled by the ECM. Failure of this relay will result in no fuel pressure.

Advanced Evaporative Emissions System - 98MY to 99MY (NAS only)

The Advanced evaporative emissions system is included on NAS vehicles from 98MY in compliance with OBD strategies. The system has the capability of detecting holes in the fuel system down to 1 mm (0.04 in.). The leak tests are performed by the ECM, allowing the tank to be depressurised and measuring the pressure over a period of time.

See EMISSION CONTROL, Description and operation.

Fault codes:

- **P1440 -** Purge valve stuck open.
- **P0442 -** Evaporative loss control system - small leak
- **P0448 -** Evaporative loss control system - major leak
- **P0496 -** Evaporative loss control system - major leak
- **P0446 -** Purge canister closure valve information
- **P1447 -** Purge canister closure valve - poor performance

Fuel Tank Pressure Sensor

This sensor is used on NAS vehicles with advanced evaporative emissions systems. The sensor is located in the fuel tank sender unit and is not a serviceable item. The GEMS ECM checks for any fuel system leaks through joints and holes, by measuring the pressure drop after the vent seal valve is shut. The diagnostic system performs out of range and validity checks.

The following failure modes are possible:

- Connector or harness open circuit
- Sensor earthing problem
- Blocked sensor

Certain failure modes may cause the 5V supply voltage which is shared with the throttle position sensor to be reduced to less than 1V.

Fault codes:

- **P0451 -** Fuel tank pressure sensor poor performance fault
- **P0452 -** Fuel tank pressure sensor low range fault
- **P0453 -** Fuel tank pressure sensor high range fault

See EMISSION CONTROL, Description and operation.

EVAP Canister Purge Valve

The purge valve is controlled by the GEMS ECM and allows hydrocarbons stored in the EVAP canister to be purged to the engine inlet manifold for burning. Electrical circuit integrity and system flow checks are performed.

If a purge valve breaks or becomes stuck, the purge system will cease to function, and there is no default operation measures. GEMS will store the fault if the correct monitoring conditions have been achieved (45 seconds after 15 minutes running). If a valve is stuck open, the engine may misfire and the fuelling adaptions will change.

The following failure modes are possible:

- Sticking valve
- Valve blocked
- Connector or harness wiring fault (open or short circuit)
- Valve stuck open

Fault codes:

- **P0441 -** Purge valve flow fault
- **P0443 -** Purge valve open or short circuit

See EMISSION CONTROL, Description and operation.

EVAP Canister Vent Solenoid (CVS) Valve

The CVS unit is located at the left hand side of the engine bay. The vent seal valve is normally open. When the GEMS ECM is required to run a fuel system test, the vent valve is closed to seal the system. The ECM is then able to measure the pressure in the fuel system using the fuel tank pressure sensor. Electrical integrity checks are performed on the CVS valve and a valve blockage can be determined from a depressurising fuel tank.

The following failure modes are possible:

- Connector or harness wiring fault (open or short circuit)
- Valve stuck open or shut
- Valve blocked

See EMISSION CONTROL, Description and operation.

Inertia Fuel Shut-off (IFS) Switch

The inertia switch isolates the power supply to the fuel pump in the event of sudden deceleration, as encountered during an accident. The inertia switch is located in the right hand side footwell behind an access flap. It is reset by depressing the central plunger at the top of the switch.

Electronic Automatic Gearbox Interface - up to 99MY

Engine Torque Signal

The engine torque signal is calculated by the GEMS ECM and output to the gearbox ECU in a 12 volt PWM signal format. Warm up status of GEMS is passed on start-up for OBDII purposes.

Throttle Angle Signal

The throttle signal is output by the GEMS ECM to the gearbox ECU in a 12 volt PWM signal format. The signal is used to calculate when a gear change is necessary. If a fault occurs with this signal, then the gearbox ECU assumes a default throttle angle. The signal is also used to indicate engine temperature at starting.

Ignition Retard (Torque Reduction)

The gearbox ECU calculates the optimum shift point and in order to produce a smooth gear change, sends a torque reduction signal to the GEMS ECM which retards the ignition so reducing the engine torque to allow a smooth shift.

Engine Speed Signal

The engine speed signal is output to the gearbox ECU via the Body electronic control module (BeCM). The signal comprises a 12 volt square wave with 4 pulses for every engine revolution.

The following fault modes are possible:

- Harness wiring or connector faulty
- Power up problems
- Faulty gearbox ECU

Fault codes:

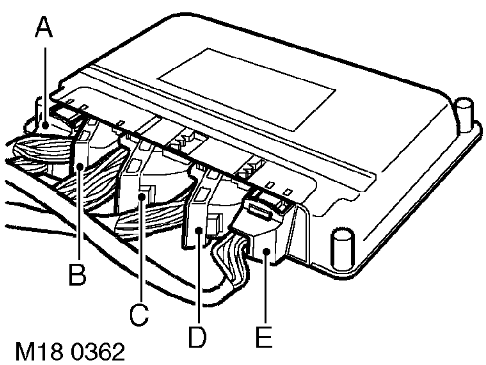
- **P1775 -** Gearbox has signalled a fault condition to the ECM
- **P1776 -** Gearbox ignition retard request duration fault
- **P1777 -** Gearbox ignition retard request line fault

See AUTOMATIC GEARBOX, Description and operation.

COMPONENT DESCRIPTIONS - from 99MY

Engine Control Module (ECM) - (from 99MY)

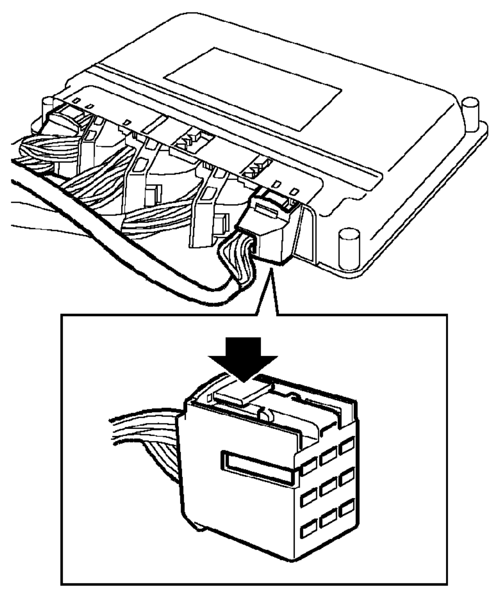
From 99MY the Engine Control Module (ECM) is a Bosch Motronic 5.2.1. which is mounted in a plastic "E-box" located on the LH side of the engine bay bulkhead. The ECM is cooled by a dedicated fan, which supplies cabin air into the plastic E-box to provide a suitable temperature environment for the ECM. The working temperature of the ECM is monitored by an internal temperature sensor.



M18 0362

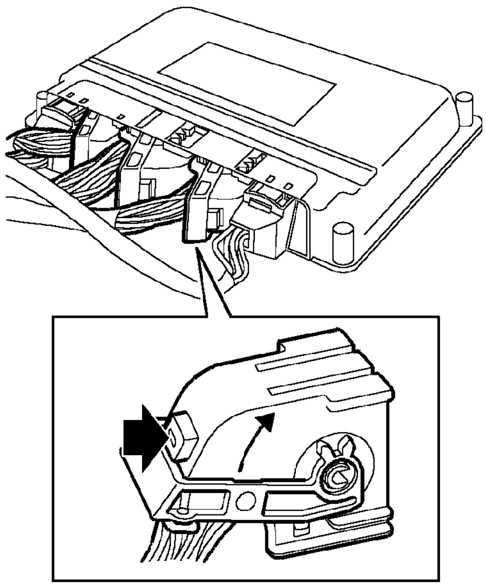
A. 9-pin connector (C0634)
B. 24-pin connector (C0635)
C. 52-pin connector (C0636)
D. 40-pin connector (C0637)
E. 9-pin connector (C0638)

The E-box is a moulded black plastic case which houses the ECM and protects it from sources of contamination. The ECM itself is contained in a cast aluminium case. The ECM has 5 independent connectors totalling 134 pins, of which up to 79 are used, dependent on market variations. The ECM and connectors can be accessed by positioning the cruise control pneumatic actuator and pump assembly aside, lifting the two plastic clips at the top of the e-box and pulling the E-box lid upwards and out. The ECM is held in position in the lid of the box by two plastic brackets. The ECM connectors have to be disengaged sequentially to release them from the unit. Similarly, when the connectors are reconnected to the ECM, the correct sequence must be observed.



M18 0367

Connectors C0634 and C0638 are square type and have release buttons on their front face which have to be pressed to enable them to be removed.



M18 0366

Connectors C0635, C0636 and C0637 are angled and have release buttons located on the top face. The release buttons have to be pressed and the locking levers pulled back to enable the connectors to be disconnected from the ECM. Each of the connectors have two integral blocks, one grey and one black, which can be removed from the connector housing to enable access to the back of the plugs. Block removal is achieved by pressing the locking tags and sliding the connector blocks outwards.

The E-box lid has two location tags on the bottom edge which have to be aligned with the corresponding holes in the E-box case before clipping the top of the lid into position. Care should be taken not to trap any wires when closing the E-box lid.

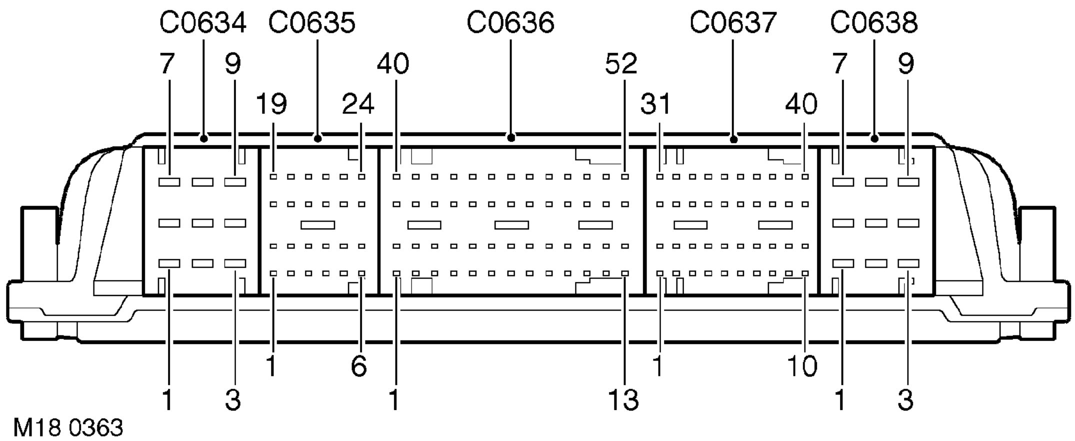
The ECM uses a 'flash' electronic erasable programmable read only memory (EEPROM). This enables the ECM to be externally configured, to ensure that the ECM can be updated with any new information; this also allows the ECM to be configured as many times as is necessary to meet changing specifications and legislation.

The ECM memorises the positions of the crankshaft and the camshaft when the engine has stopped via the CKP and CMP sensors. This allows immediate sequential fuel injection and ignition timing during cranking. This information is lost if battery voltage is too low (i.e. flat battery). So the facility will be disabled for the first engine start after battery reconnection.

The ECM has various sensors fitted to the engine to allow it to monitor engine condition. The ECM processes these signals and decides what actions to carry out to maintain driveability, after comparing the information from these signals to mapped data within its memory.

CAUTION: Do not connect test probes connected to battery positive supply to any ground pins on the ECM. THIS MAY DESTROY THE ECM.

Input / Output



C0634: 9-pin connector
C0635: 24-pin connector
C0636: 52-pin connector
C0637: 40-pin connector
C0638: 9-pin connector

Connector 1 (C0634):

This connector contains 9 pins and is used primarily for ECM power input and earth. The ECM requires a permanent battery supply, if this permanent feed is lost i.e. the battery discharges or is disconnected, the ECM will lose its adapted values and its Diagnostic Trouble Codes (DTC). These adapted values are a vital part of the engine management's rolling adaptive strategy. Without an adaptive strategy, driveability, performance, emission control and fuel consumption are adversely affected. The ECM can be affected by high voltage inputs, so care must be taken when removing and replacing the ECM.

ECM pin details for Connector C0634:

Pin No.	Description	Input/Output	Voltage
1	Ignition position "II"	Input	12V
2	Not used	-	-
3	Not used	-	-
4	Chassis ground	Ground	0V
5	Fuel injector ground	Ground	0V
6	Power stage ground	Ground	0V
7	Battery supply	Input	12V
8	Main relay switched supply	Input switched	0 - 12V
9	Not used	-	-

Connector 2 (C0635):

This connector contains 24 pins and is primarily used for the Heated Oxygen (HO_2S) Sensor's control and earth. An output to a heater circuit in each HO_2S sensor is also required; this is to assist in heating the tip of the sensors to enable closed loop fuelling to be implemented quickly after cold starting.

ECM pin details for Connector C0635:

Pin No.	Description	Input/Output	Voltage
1	HO_2S sensor heater RH bank - downstream	Output drive	PWM 12 - 0V
2	Not used	-	-
3	Not used	-	-
4	Not used	-	-
5	Not used	-	-
6	Not used	-	-
7	HO_2S sensor heater LH bank - downstream	Output drive	PWM 12 - 0V
8	HO_2S sensor RH bank - downstream	Ground signal	0V
9	HO_2S sensor LH bank - upstream	Ground signal	0V
10	HO_2S sensor RH bank - upstream	Ground signal	0V
11	HO_2S sensor LH bank - downstream	Ground signal	0V
12	Not used	-	-
13	HO_2S sensor heater RH bank - upstream	Output drive	PWM 12 - 0V
14	HO_2S sensor RH bank - downstream	Input signal	Analogue 0 - 5V
15	HO_2S sensor LH bank - upstream	Input signal	Analogue 0 - 5V
16	HO_2S sensor RH bank - upstream	Input signal	Analogue 0 - 5V
17	HO_2S sensor LH bank - downstream	Input signal	Analogue 0 - 5V
18	Fuel pump relay	Output drive	Switch to ground
19	HO_2S sensor heater LH bank - upstream	Output drive	PWM 12 - 0V
20	Not used	-	-
21	Not used	-	-
22	Not used	-	-
23	Main relay output	Output drive	Switch to ground
24	Not used	-	-

Connector 3 (C0636):

This connector contains 52 pins and is used for most sensor and actuator inputs and outputs. Sensor and actuator control is vital to ensure that the ECM maintains adaptive strategy.

ECM pin details for Connector C0636:

Pin No.	Description	Input/Output	Voltage
1	Fuel injector cylinder number 2	Output drive	Switch to ground
2	Fuel injector cylinder number 5	Output drive	Switch to ground
3	Purge valve drive	Output signal	PWM 12 - 0V
4	SAI vacuum solenoid valve (NAS vehicles from 2000MY only)	Output drive	Switch to ground
5	Not used	-	-
6	Fuel tank pressure sensor (NAS vehicles with Advanced EVAPS only)	Ground	0V
7	MAF sensor 5V supply	Output, reference	5V
8	Not used	-	-
9	MAF sensor earth	Ground	0V
10	Throttle pot sensor 5V supply	Output reference	5V
11	Not used	-	-
12	Not used	-	-
13	Not used	-	-
14	Fuel injector cylinder number 7	Output drive	Switch to ground
15	Fuel injector cylinder number 6	Output drive	Switch to ground
16	SAI pump relay (NAS vehicles from 2000MY only)	Output drive	Switch to ground
17	Camshaft (CMP) sensor screen	Ground	0V
18	Not used	-	-
19	Not used	-	-
20	Camshaft (CMP) sensor signal	Input signal	Digital switch 0 - 12V
21	Coolant temperature (ECT) sensor	Ground	0V
22	Coolant temperature (ECT) sensor signal	Input signal	Analogue 0 - 5V
23	MAF sensor signal	Input signal	Analogue 0 - 5V
24	Throttle potentiometer signal	Input signal	Analogue 0 - 5V

ECM pin details for Connector C0636 continued:

Pin No.	Description	Input/Output	Voltage
25	Throttle potentiometer	Ground	0V
26	Not used	-	-
27	Fuel injector cylinder number 3	Output drive	Switch to ground
28	Fuel injector cylinder number 8	Output drive	Switch to ground
29	Not used	-	-
30	Canister vent solenoid (CVS) shut-off valve (NAS vehicles with Advanced EVAPs only)	Output drive	Switch to ground
31	Air conditioner condenser fan drive	Output drive	Switch to ground
32	Crankshaft (CKP) sensor signal	Input signal	Analogue 0 - 300V pk.
33	Not used	-	-
34	Intake air temperature (IAT) sensor	Input signal	Analogue 0 - 5V
35	Knock sensor RH bank	Ground	0V
36	Knock sensor RH bank	Input signal	Analogue 0V
37	Not used	-	-
38	Not used	-	-
39	Not used	-	-
40	Fuel injector cylinder number 4	Output drive	Switch to ground
41	Fuel injector cylinder number 1	Output drive	Switch to ground
42	Idle speed actuator open	Output signal	PWM 12 - 0V
43	Idle speed actuator close	Output signal	PWM 12 - 0V
44	Instrument Pack - Coolant sensor output	Output signal	PWM 0 - 12V
45	Crankshaft position (CKP) sensor screen ground	Ground	0V
46	Crankshaft position (CKP) sensor reference ground	Ground	0V
47	Not used	-	-
48	Knock sensor LH bank	Ground	0V

ECM pin details for Connector C0636 continued:

Pin No.	Description	Input/Output	Voltage
49	Knock sensor LH bank	Input signal	Analogue 0V
50	Not used	-	-
51	Not used	-	-
52	Not used	-	-

Connector 4 (C0637):

This connector contains 40 pins and facilitates the use of Testbook via the Diagnostic connector. Also contained in this connector is the Malfunction Indicator Lamp (MIL), this instrument panel lamp informs the driver of concerns within the engine management system.

ECM pin details for Connector C0637:

Pin No.	Description	Input/Output	Voltage
1	Not used	-	-
2	Not used	-	-
3	Not used	-	-
4	Not used	-	-
5	Not used	-	-
6	Not used	-	-
7	Not used	-	-
8	Low fuel level	Input signal	Active high
9	Fuel tank pressure sensor (NAS vehicles with Advanced EVAPs only)	Output reference	5V
10	ECM E-box cooling fan	Output drive	Switch to ground
11	Not used	-	-
12	BeCM Low fuel level signal	Ground	12V - 0V (when fuel level low)
13	Not used	-	-
14	Fuel tank pressure sensor (NAS vehicles with Advanced EVAPs only)	Input signal	Analogue 0 - 5V
15	Not used	-	-
16	Air conditioning compressor	Input signal	Active low
17	Engine speed output	Output signal	PWM 0 - 5V
18	Not used	-	-

ECM pin details for Connector C0637 continued:

Pin No.	Description	Input/Output	Voltage
19	Not used	-	-
20	MIL "ON"	Output drive	Switch to ground
21	Not used	-	-
22	Road speed sensor	Input signal	PWM 0 - 12V
23	Not used	-	-
24	Not used	-	-
25	Not used	-	-
26	Not used	-	-
27	Not used	-	-
28	Not used	-	-
29	Air con compressor relay	Output drive	Switch to ground
30	Not used	-	-
31	Not used	-	-
32	Diagnostic K-line	Bi-directional	Serial 0 - 12V
33	Immobiliser serial W link	Input signal	Serial 0 - 12V
34	Rough road signal	Input signal	PWM 0 -12V
35	Not used	-	-
36	CAN bus ’high line’	Bi-directional	5 - 2.5V
37	CAN bus ’low-line’	Bi-directional	0 - 2.5V
38	Air conditioning stand by relay	Input signal	Active low
39	Not used	-	-
40	Not used	-	-

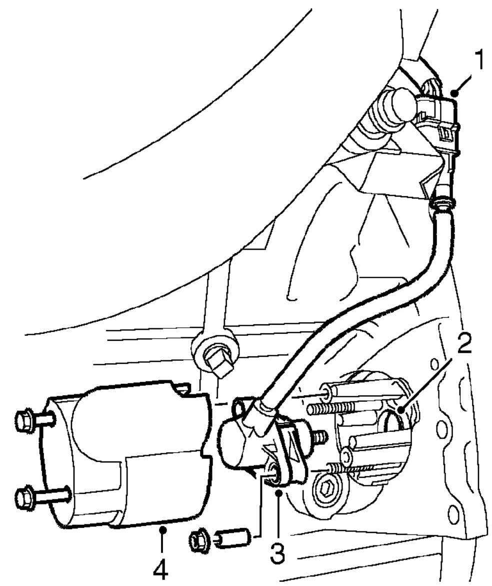
Connector 5 (C0638):

This connector contains 9 pins and is used to control the ignition system. The ignition coils are supplied with power and a switching earth completes the circuit.

ECM pin details for Connector C0638:

Pin No.	Description	Input/Output	Voltage
1	Not used	-	-
2	Ignition coil cylinders 2+3	Output drive	Switch to ground
3	Not used	-	-
4	Not used	-	-
5	Ignition screen	Ground	0V
6	Ignition coil cylinders 4 + 7	Output drive	Switch to ground
7	Ignition coil cylinders 1 + 6	Output drive	Switch to ground
8	Ignition coil cylinders 5 + 8	Output drive	Switch to ground
9	Not used	-	-

Crankshaft speed and position (CKP) sensor - (from 99MY)



1. Multiplug
2. Aperture to reluctor ring
3. CKP sensor
4. Heatshield

The CKP sensor is located at the lower, rear LH side of the engine below cylinder number 7. The CKP sensor is protected by a heatshield which is attached to the rear flange of the engine block by two M5 bolts. The CKP sensor itself is located on two studs and fixed in position by two M5 nuts and 18mm spacers. The sensor has a flying lead which terminates in a 3-pin multiplug that connects to the engine harness and is mounted to a bracket to the rear of the left hand cylinder head.

The tip of the CKP sensor protrudes through an aperture in the engine block rear flange, adjacent to the outer circumference of the flywheel. A 60-tooth reluctor ring is included on the flywheel which provides the reference signal to the crankshaft position sensor.

The ECM uses the signal produced at the CKP sensor to determine the position of the crankshaft to enable accurate ignition and fuel injection timing. The ECM also determines the engine speed at any particular instance through analysis of the frequency of fluctuations induced in the CKP sensor as the teeth of the reluctor ring pass by the sensor tip.

The CKP sensor is a variable reluctance sensor, and contains a permanent magnet and soft iron core surrounded by a copper winding. As the reluctor ring passes by the sensor tip it causes a voltage to be induced in the sensor, consequently the CKP sensor does not need a power supply for operation. The signal wires of the CKP sensor are surrounded by a grounded screen to prevent noise being induced in the signal wires and causing a spurious interference signal being passed to the ECM.

NOTE: When fitting a CKP sensor, ensure no ferrous metal has been attracted to it by its magnet. Ensure the sensor pin is straight and undamaged.

The reluctor ring teeth are spaced at 6° intervals and are 3° wide. Two of the reluctor ring teeth are removed, to provide a reference mark which indicates when the crankshaft is at 60°BTDC for number 1 cylinder. The remaining 58 teeth cause an AC voltage to be induced in the sensor pick-up, with the amplitude of the signal increasing with rising engine speed. The voltage generated is an analogue signal capable of peak amplitude voltages of up to 300V.

The distance of the tip from the top of the reluctor ring teeth is important as the amplitude of the detected signal will be reduced in proportion to an increase in the gap between the sensor tip and the top of the reluctor ring teeth. If the air gap becomes too wide, the CKP signal could become too weak and possible misfires could occur. Spacers are included in the CKP sensor kit which are used to ensure the correct gap between the sensor tip and reluctor ring teeth.

The ECM uses the falling edge of the signal waveform as its reference for each reluctor ring tooth. Consequently, if the input signal wire and reference ground wire are inadvertently reversed, the ECM will react by providing a 3° advance in ignition timing.

If the crankshaft sensor fails, the engine will stop and fail to restart. There is no back-up strategy or limp home facility programmed into the ECM. If a fault occurs whilst the engine is running, the engine will stall and a fault code will be stored in ECM memory. If the fault develops while the engine is not running, the engine may not be capable of starting and no fault code will be available. In this case, the MIL light will still be illuminated.

In the event of a CKP sensor signal failure, the following symptoms may be observed:

- Engine cranks but fails to start
- MIL remains on at all times
- Engine misfires (CKP incorrectly fitted)
- Engine runs roughly or stalls (CKP incorrectly fitted)
- Tachometer fails to work
- Flywheel adaption reset -- ferrous contamination

Possible causes of CKP sensor failure include the following:

- CKP sensor not fitted correctly (or assembly loose)
- Incorrect length spacers fitted
- Sensor/wiring open or short circuit
- Sensor bent or damaged by reluctor ring
- Water ingress at sensor connector
- ECM unable to detect the software reference point.
- Ferrous contamination of crank sensor pin/reluctor.

Whenever a new CKP sensor is fitted or the flywheel is removed, the adaptive values have to be reset using Testbook.

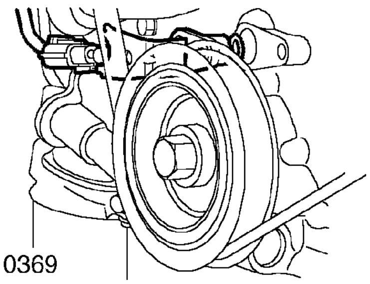
Should a malfunction of the component occur, the following fault codes may be evident and can be retrieved by Testbook:

- **P0335 -** (reference mark is outside search window with engine speed above 500 rev/min for more than 2 revolutions.
- **P0336 -** (incorrect number of teeth detected $\pm$ 1 tooth between reference marks with engine speed above 500 rev/min.

In addition to crankshaft position, the ECM also uses the CKP sensor signal to determine engine speed. The ECM shares the engine speed information with the electronic automatic transmission (EAT) ECU by transmitting the data via the CAN link. Engine speed output is also provided to the instrument pack (tachometer), for which the output signal is scaled down to 4 pulses per crankshaft revolution.

The ECM also has a quick start facility, where the position of the crankshaft and camshaft are memorised when the engine is stopped. This stored information is used to facilitate immediate sequential fuelling during cranking.

Camshaft Position (CMP) sensor - (from 99MY)



The CMP sensor is located at the front of the engine block, above and behind the crankshaft pulley. The sensor is clamped into position by means of a single bolt. An 'O'ring is used to seal the interface between the sensor and the aperture in the engine front cover.

The sensor has three wires which terminate in a multiplug secured to a bracket on the left of the crankshaft pulley. A short link lead is used to connect the sensor to the engine harness. The wires to the sensor have the following functions:

- Power supply from engine compartment fusebox
- Camshaft input signal to ECM
- Screen to chassis ground connection

The CMP sensor is a Hall effect sensor which produces four pulses for every two engine revolutions. The sensing element is positioned less than 2mm from the side of the camshaft gear wheel. The camshaft gear wheel has four slots machined at 90°intervals which allows the identification of four cylinder positions every camshaft revolution. Cylinder recognition is used to enable sequential fuel injection and knock control and is also used for diagnostic purposes. The slots in the camshaft gear wheel are shaped to provide unequal timing pulses for determining TDC on No.1 cylinder. The camshaft and crankshaft drives must also be correctly aligned, since the ECM uses the crankshaft "missing teeth" marker to determine crankshaft and camshaft position and provide a reference mark which is 60°BTDC on No.1 cylinder.

The CMP sensor uses the Hall effect to act as a magnetic switch for switching battery voltage on or off depending on the position of the camshaft gear wheel in relationship to the sensor. This results in a square wave input between 0 and 12V at the ECM input pin.

Symptoms of a CMP sensor failure include the following:

- Ignition timing reverts to default values from ECM memory with loss of cylinder correction.
- Loss of active knock control and diagnostics.
- Loss of cylinder identification for misfire diagnostics.
- Loss of quick synchronisation of crankshaft and camshaft for cranking/start up.
- Fuel injection could be 360°out of phase at engine restart.
- Front HO_2S sensor ageing period diagnostic could become disabled (NAS only).

The cause of CMP sensor failure may be attributable to one of the following conditions:

- Sensor open circuit.
- Sensor signal line short circuit to vehicle battery supply.
- Sensor signal line or voltage supply line short circuit to vehicle ground.
- Incorrect fitting of the sensor.
- Excessive camshaft gear wheel tolerance.
- Excessive camshaft endfloat.
- Camshaft and crankshaft misalignment.
- Speed signal correlation with CKP sensor signal.
- Cam wheel magnetised / residual magnetism.

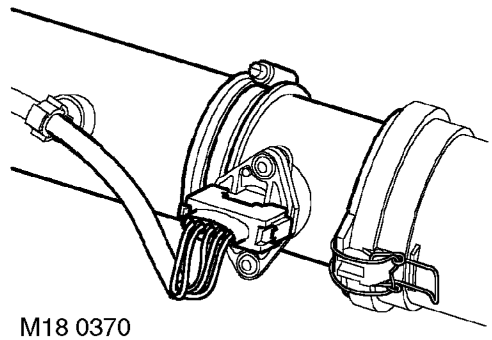
Should a malfunction of the component occur the following fault codes may be evident and can be retrieved by Testbook:

- **P0340 -** (Signal open & short circuit to vehicle supply or ground).

The fault condition has to be detected for more than 100 cam pulses (25 revolutions) when the engine speed is greater than 500 rev/min.

NOTE: It is physically possible to interchange the camshaft gear wheel fitted to pre-99MY and post-99MY vehicles. However, because the GEMS and Motronic systems are incompatible, an incorrect camshaft signal will be received by the ECM and a P0340 fault code will result.

Mass Air Flow (MAF) and Intake Air Temperature (IAT) sensor - (from 99MY)



M18 0370

The MAF/IAT sensor is located at the RHS of the engine compartment, in the air intake duct between the air filter housing and the inlet manifold. The complete assembly forms part of the air intake tube, but the sensor itself is attached by two torx screws and can be removed from the intake tube if necessary.

The upper section of the intake tube containing the MAF/IAT sensor is embossed with an arrow indicating the direction of air flow, always ensure the unit is fitted in the correct orientation.

CAUTION: Take care handling the sensor unit, it should not be dropped or roughly handled, ensure that the unit remains free of contamination.

The sensor has a five pin connector which connects to the ECM via the engine harness. The connector has silver plated terminals for low current signals and corrosion protection. The harness is clipped to prevent vibration of the terminals.

MAF SENSOR

The Mass Air Flow sensor utilises a "hot film" element contained in the air intake tube to monitor the mass flow of the air stream being drawn into the engine. The MAF sensor contains two sensing elements, one element is controlled at ambient temperature (e.g. 25°C (77°F), while the other is heated to 200°C (360°F) above the ambient temperature (e.g. 225°C (437°F)).

When the intake air passes the heated element, it cools it down, so lowering the resistance of the hot film element. In order to maintain the same temperature, the circuit to the heated element has to supply more current. The change in current causes a corresponding change in potential difference to be detected in the monitoring circuit. This change is supplied to the ECM as a voltage between 0 and 5V, where it is processed by the ECM's internal mapping to interpret the data as a measure of the mass of air flow.

The measured air mass flow is used by the ECM to determine the fuel quantity to be injected in order to maintain the stoichiometric air:fuel mixture for optimum engine performance and low emissions.

The MAF sensor receives a power supply via the engine compartment fusebox, and a 5V reference signal from the ECM. The MAF sensor and the IAT sensor share a common ground connection and each provide a separate signal input to the ECM.

CAUTION: Do not apply 12 V directly to the 5 V supply terminal, this will destroy the internal circuitry. The connector terminals are silver plated - avoid probing with multimeter test leads.

If the MAF sensor fails, the ECM implements a backup strategy which is based on throttle angle, air temperature and engine speed. A MAF sensor failure may result in the following symptoms being experienced:

- The engine rpm may relapse slightly during driving and then recover.
- Difficulty in starting and/or frequent stalling of engine.
- Poor throttle response
- Degraded engine performance.
- Emissions control and idle speed control inoperative.
- MAF sensor signal offset.

A MAF sensor failure is likely to occur for the following reasons:

- Sensor open circuit of voltage supply, signal or ground lines.
- Short circuit of signal line to vehicle supply or ground.
- Contaminated / damaged sensor element.
- Air leak after the MAF sensor.
- Inlet air restriction.
- Poor connection or resistance in wiring harness causing signal offset.

If the MAF sensor should fail, the following fault codes will be generated by the ECM diagnostics, which can be retrieved by Testbook:

- **P0102 -** (MAF signal less than the speed dependent minimum threshold).
- **P0103 -** (MAF signal greater than the speed dependent maximum threshold).

Intake-air density varies with temperature, the ECM needs to be aware of these changes so that corrective calculations can be incorporated into the ECM's fuelling and ignition timing strategies. The intake air temperature value is also used by the ECM as a reference when implementing compensation for an ECT failure.

IAT SENSOR

The intake air temperature sensor utilises a thermistor with a negative temperature co-efficient (as temperature rises, thermistor resistance decreases). The change in resistance causes a change in input voltage at the ECM. The ECM converts the voltage value it receives to provide an indication of the temperature of the inlet air.

If the IAT sensor fails, the ECM substitutes a default value for air temperature of 45°C (113°F). An IAT sensor failure may result in the following symptoms being experienced:

- Catalyst monitoring affected due to exhaust temperature model.
- Warm-up ignition angle affected.
- ISC speed adaption disabled
- ISC actuator blocked test disabled
- Fuelling adaptions disabled.
- Condenser fan hot restart inhibited

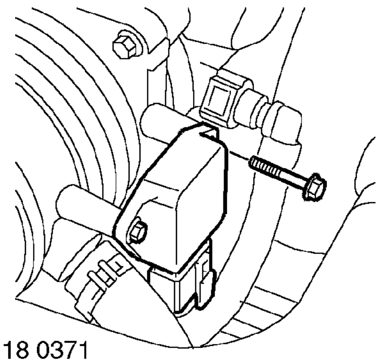
An IAT sensor failure is likely to occur for the following reasons:

- Sensor open circuit.
- Sensor signal line short circuit to vehicle 12V supply or ground.
- Damaged sensor element
- Bad connection or increased resistance in wiring harness.

If the IAT sensor should fail, the following fault codes will be generated by the ECM diagnostics, which can be retrieved by Testbook:

- **P0112 -** (air temperature signal is less than the minimum threshold - after a sufficient time (more than three minutes) for exhaust warm-up has been allowed).
- **P0113 -** (air temperature signal greater than the maximum threshold).

Throttle Position (TP) sensor - (from 99MY)



M18 0371

The TP sensor is located on the rear of the throttle body assembly in the engine compartment and fixed to its mounting studs by two screws.

The TP sensor is a potentiometer having a resistance track that is connected to a stabilized 5V supply at one end of its track and ground at the other end of the track. The potentiometer wiper arm is connected to the throttle plate assembly and provides a signal to the ECM which is an analogue voltage between 0.3V (closed throttle) and 4.5V (wide open throttle), corresponding to the throttle valve angle. The TP sensor connector terminals are gold plated for good conductivity and corrosion resistance; care should be exercised if it is necessary to probe the connector and sensor terminals.

The TP sensor enables the ECM to determine the throttle valve's position and angular velocity. The ECM uses the data from the throttle valve position for determining intake-air volume, which it uses for calculating the necessary fuel injection duration under various operating conditions. The data from the throttle valve's angular velocity is used mainly for acceleration/deceleration compensation. The ECM also uses closed throttle position for idle speed control in conjunction with road speed.

The TP sensor also supplies the ECM with information to enable the overrun fuel shut off strategy to be implemented. When the ECM receives closed throttle information from the TP sensor, it closes the injectors for the duration of the closed throttle time.

A software strategy within the ECM enables the closed throttle position to be learnt, so that the sensor can be fitted without the need for adjustment.

The throttle position signal is also supplied to the EAT ECU from the ECM using the CAN communication link. The EAT ECU uses the throttle position data to determine the correct point for gear shifts and acceleration kickdown.

If the TP sensor signal fails, the ECM uses a default value derived from engine load and speed. A TP sensor failure may result in the following symptoms being experienced:

- Poor throttle response and degraded engine performance
- Emission control failure.
- Closed loop idle speed control inoperative.
- Automatic gearbox kickdown inoperative.
- Incorrect altitude adaption
- MIL illuminated (NAS only)

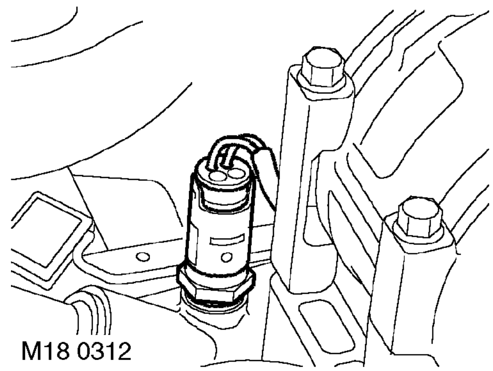
A TP sensor failure is likely to occur for the following reasons:

- Sensor open circuit
- Short circuit of signal line to vehicle supply, 5V supply or ground.
- Bad connection or increased resistance in wiring harness causing signal offset.
- Blocked air filter (load monitoring, ratio of the TP sensor to air flow).
- Restricted air inlet (load monitoring, ratio of the TP sensor to air flow).

If the TP sensor should fail, the following fault codes will be generated by the ECM diagnostics, which can be retrieved by Testbook:

- **P0101 -** (load monitoring, the ratio of throttle position to air flow).
- **P0122 -** (signal less than the minimum threshold).
- **P0123 -** (signal greater than the maximum threshold).

Engine Coolant Temperature (ECT) sensor - (from 99MY)



The ECT sensor is located at the top front of the engine, adjacent to the coolant outlet pipe. The sensor screws into a thread in the inlet manifold and incorporates a sealing ring between the faces of the sensor and manifold.

The ECT sensor multiplug has four wires; two are the signal and ground connections used by the ECM, the other two are used by the body control module (BeCM) for control of the temperature warning lamp operation on the instrument pack.

The sensor contains two thermistors with negative temperature co-efficients; as temperature increases, the thermistor's resistance decreases. The ECM receives a corresponding analogue input voltage between 0 and 5V.

NOTE: The temperature / resistance characteristics of the two thermistors differ, and so it is important to maintain the correct pin-outs.

The ECM uses the information received from the ECT sensor to make adjustments to the engine operating conditions. The ECM ensures a richer air:fuel mixture is available at lower block temperatures for good quality starts and smooth running. The mixture is then made leaner as the engine temperature rises to maintain low emissions and good performance.

For NAS vehicles with secondary air injection, the signal from the ECT sensor is monitored at engine start, to determine whether the conditions are cold enough to warrant secondary air injection to be employed. The ECT sensor is then monitored to switch off the secondary air injection when the required engine coolant temperature has been attained.

If the sensor fails, the ECM uses a substitute software routine that changes default value during warm up, based on the signal from the inlet air temperature sensor. When the software model reaches a coolant temperature of 60°C (140°F) the ECM implements a fixed default value of 85°C (185°F). The ECM coolant model also forms part of the diagnostics that is performed for detecting a temperature sensor fault, as well as open and short circuit tests.

Temperature	Voltage
-50°C	5V
-20°C	4.8V
10°C	4.2V
40°C	2.8V
70°C	1.4V
100°C	0.6V
130°C	0.2V

NOTE: All voltages listed are approximate.

A coolant temperature circuit failure may result in the following symptoms:

- Poor cold and warm/hot starting and driveability.
- Instrument pack temperature warning lamp will illuminate.
- MIL will be illuminated.
- Temperature gauge reads excessively hot or cold.
- Cooling fan will not run
- SAI pump will operate at engine start up even when engine is hot (NAS with secondary air injection system only).

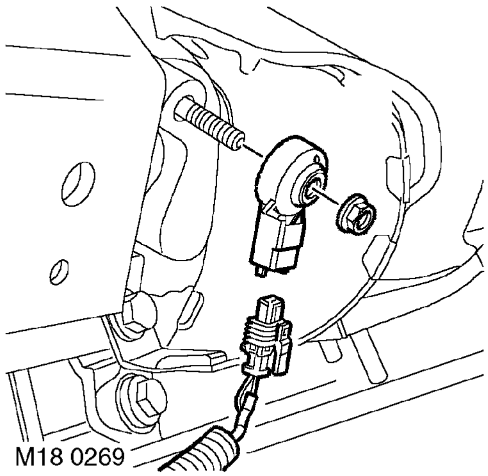
The ECT sensor can fail in the following ways, or supply an incorrect signal:

- Sensor open circuit.
- Short circuit to vehicle supply.
- Short circuit to earth.
- Incorrect mechanical fitting.
- Signal fixed above 40°C (140°F) will not be detected.
- Signal fixed below 40°C (140°F) not detected.

Should a malfunction of the component occur, the following fault codes may be evident and can be retrieved by Testbook:

- **P0116 -** (Signal differs too much from temperature model for longer than 2.54s)
- **P0117 -** (Open circuit or short circuit to battery supply)
- **P0118 -** (Short circuit to ground)

Knock Sensors (KS) - from 99MY



The ECM utilises active knock control, which serves to prevent engine damage through pre-ignition or detonation. Knock control is effective under all operating conditions, enabling the engine to operate without additional safety margins.

Two knock sensors are used, one mounted each side of the cylinder block between the two centre cylinders of each bank. Each sensor has two wires; a signal wire providing input to the ECM and a ground (screen). Each of the sensors monitor the 'knock' from four cylinders (Cylinder No's: 1, 3, 5 & 7 and Cylinder No's: 2, 4, 6 & 8).

CAUTION: The connector and sensor terminals are gold plated to provide good conductivity and resistance to corrosion and high temperatures. Be careful not to damage terminals if probing with test equipment.

The knock sensors consist of piezo-ceramic crystals that oscillate to create a voltage signal. During pre-ignition, the frequency of crystal oscillation increases which alters the signal output to the ECM.

The signal is processed by comparing it to signal profiles contained in memory which indicate a pre-ignition condition. If pre-ignition conditions are evident, the ECM retards the ignition on that cylinder for a number of cycles. The ignition timing gradually reverts to its original setting.

The ignition system is calibrated to run on 95 RON Premium fuel for optimum fuel economy and performance characteristics. The system can also function satisfactorily with 91 RON Regular fuel. If the vehicle is refuelled with a lower grade of fuel some audible detonation may be heard until the system adaptions are complete for the new fuel grade.

If a knock sensor should fail, the following symptoms may be observed:

- Possible rough running
- Reduction in engine performance

A knock sensor failure is likely to occur for the following reasons:

- Sensor open circuit
- Short circuit to vehicle supply or ground
- Faulty component
- Loose sensor - incorrectly torqued

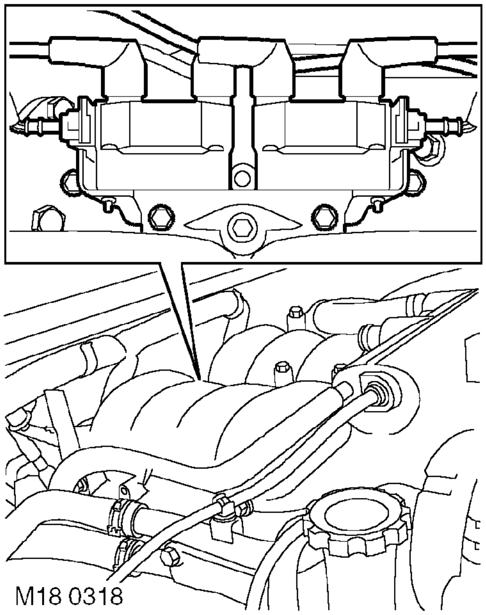
If knock control is disabled, a default "safe ignition map" is used.

If a knock sensor should fail, the following fault codes will be generated by the ECM diagnostics, which can be retrieved by Testbook:

- **P0327 -** (LH bank signal less than the threshold value determined from the ECM model above 2200 rpm)
- **P0328 -** (LH bank signal greater than the threshold value determined from the ECM model above 2200 rpm)
- **P0332 -** (RH bank signal less than the threshold value determined from the ECM model above 2200 rpm)
- **P0333 -** (RH bank signal greater than the threshold value determined from the ECM model above 2200 rpm)

Noise induced on the battery supply line could be misinterpreted as a knock signal and cause a maximum knock fault. A maximum fault could be caused by a short circuit to the battery supply or in the case of extreme mechanical engine noise / piston slap. A minimum fault is usually due to an open circuit.

Ignition coils


M18 0318

The electronic ignition system is fitted with two quad coils which are directly driven by the ECM. The ignition coils are mounted on a bracket fitted to the rear of the engine. The circuit to each coil is completed by switching within the ECM, allowing each coil to charge. When the ECM determines the correct ignition point, it switches off current supply to the coil which in turn causes the magnetic field around the coil's primary winding to collapse, inducing ht voltage in the secondary winding and in the iron core of the coil. High tension voltage, of different polarities, is produced at either end of the coil's core and is transmitted to two cylinders simultaneously, one on compression stroke, the other on exhaust stroke. This is called the wasted spark principle.

Note that coil 1 feeds cylinders 1 and 6, coil 2 feeds cylinders 5 and 8, coil 3 feeds cylinders 4 and 7, and coil 4 feeds cylinders 2 and 3. The resistance of the spark plug in the compression cylinder is higher than that in the exhaust cylinder and hence more spark energy is dissipated in the compression cylinder. Coil failure will result in a lack of ignition, resulting in a misfire in the related cylinders. The fault is indicated by illumination of the malfunction indicator light (MIL) on North American specification vehicles.

The positive supply to the coils is fed via a common fuse and ignition relay located in the engine compartment fusebox. Each coil supply feed has an RFI suppression capacitor fitted adjacent to the coil mounting bracket. The ignition primary wires are screened to suppress the emission of radio frequency interference, with the screens being grounded at a connection on the ECM.

WARNING: The ignition coils operate at very high voltages, do not attempt repair operations and procedures on the ignition high tension / secondary system when the engine is running.

The ECM calculates the dwell timing from battery voltage and engine speed data to ensure sufficient secondary (spark) energy is always available without excessive primary current flow, thus avoiding overheating or damage to the ignition coils.

The spark timing for each individual cylinder is calculated by the ECM using an internal memory map under consideration of the following inputs:

- Engine speed
- Engine load
- Engine temperature
- Knock control
- Automatic gearbox shift control
- Idle speed control

The nominal value for a warm engine at idle is 12°BTDC

CAUTION: Avoid running the engine if there is a possibility of the secondary (ht) becoming open circuit. This condition could damage the ignition power stages and / or the ignition coils through excessive energy being reflected back into the primary circuit.

NOTE: Testbook is not able to perform diagnostics to the primary power stage coils. Ignition related faults are monitored indirectly via the misfire detection system and its fault codes (NAS vehicles only).

Resistance measurements of the primary and secondary sides of the ignition coils can be performed using a suitable multimeter. Default values are:

- Nominal primary coil resistance (up to 99MY) = 0.8 ohms
- Nominal primary coil resistance (from 99MY) = 0.5 ohms ± 0.05 ohms at 20°C (68°F)
- Nominal secondary coil resistance = 13.3 k-ohms ± 1.3 k-ohms at 20°C (68°F)

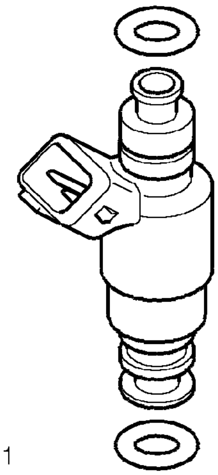
If an ignition coil should fail, the following symptoms may be observed:

- Engine will not start - loss of spark
- Engine misfire on specific cylinders

An ignition coil failure is likely to occur for the following reasons:

- Connector or harness fault
- Coil open circuit
- Short circuit to vehicle battery supply or ground
- Faulty component

Fuel injectors - from 99MY



M17 0191

The fuel injectors are located beneath the air inlet manifold. They utilise an electrical solenoid which lifts an injector needle off its seat to allow fuel injection to take place. The fuel injectors provide excellent fuel atomisation in the lower portion of the inlet manifold, the air:fuel mixture is then drawn into the cylinders to provide optimum combustion characteristics and excellent driveability.

A fuel pressure test point is provided by means of a Schrader valve positioned between the rear of the engine and the bulkhead, above the coil packs.

There are eight fuel injectors, one per cylinder which the ECM operates sequentially. All the injectors are fed from a common fuel rail as part of the returnless fuel system. Fuel pressure is maintained at a constant 3.5 bar (52 $lbf.in^2$) by a regulator that is integral with the fuel pump.

CAUTION: The injectors are extremely sensitive, they must not be dropped or contaminated.

CAUTION: When assembling the injector to the fuel rail, only use clean engine oil to aid assembly. DO NOT use petroleum jelly or other forms of grease, as this will contaminate the injector.

The injectors can be checked using a multimeter to test the resistance values:

- Injector resistance at 20°C = 14.5 ohms ± 0.7 ohms

If an injector should fail, the following symptoms may be observed:

- Rough running
- Difficult starting
- Engine misfire
- Possible catalyst damage
- High emissions
- Fuelling and idle speed control adaptations disabled

A fuel injector failure is likely to occur for the following reasons:

- Actuator open circuit
- Short circuit to vehicle 12V supply or ground
- Blocked or restricted injector
- Low fuel pressure

If a fuel injector should fail, the following fault codes will be generated by the ECM diagnostics, which can be retrieved by Testbook:

Injector 1

- **P0201 -** Open circuit
- **P0261 -** Short circuit to ground
- **P0262 -** Short circuit to battery supply

Injector 2

- **P0202 -** Open circuit
- **P0264 -** Short circuit to ground
- **P0265 -** Short circuit to battery supply

Injector 3

- **P0203 -** Open circuit
- **P0267 -** Short circuit to ground
- **P0268 -** Short circuit to battery supply

Injector 4

- **P0204 -** Open circuit
- **P0270 -** Short circuit to ground
- **P0271 -** Short circuit to battery supply

Injector 5

- **P0205 -** Open circuit
- **P0273 -** Short circuit to ground
- **P0274 -** Short circuit to battery supply

Injector 6

- **P0206 -** Open circuit
- **P0276 -** Short circuit to ground
- **P0277 -** Short circuit to battery supply

Injector 7

- **P0207 -** Open circuit
- **P0279 -** Short circuit to ground
- **P0280 -** Short circuit to battery supply

Injector 8

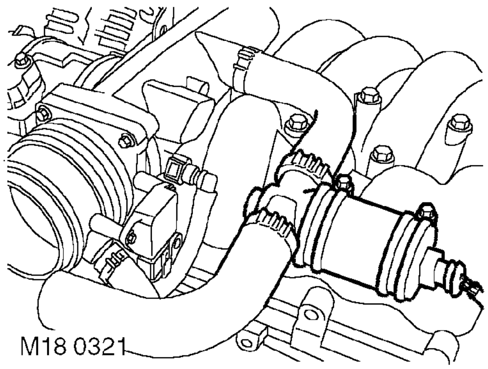
- **P0208 -** Open circuit
- **P0282 -** Short circuit to ground
- **P0283 -** Short circuit to battery supply

All injectors

- **P0170 -** High leak rate detection
- **P0300 to P0308 -** Misfire detected excess emissions - blocked or restricted injector
- **P0300 to P0308 -** Misfire detected catalyst damage - blocked or restricted injector

Specific P-code number depends on which cylinder(s) is experiencing the fault.

Idle Air Control Valve (IACV) - from 99MY



The idle air control valve is positioned at the top rear of the engine, on the side of the air inlet pipe. The unit is clamped to the inlet manifold by two bolts passing through 'P' clips.

A grey three-pin connector is provided at the back of the unit. One wire supplies the voltage feed from the engine compartment fusebox, while the other two wires carry the valve positioning control signals.

The IACV is used to make adjustments to optimise the engine idle speed under all operating conditions. Engine load at idle will vary in reaction to a combination of conditions and influences such as engine friction, water pump , air conditioning, altitude etc. The IACV utilises closed loop control to compensate for the changing conditions by regulating the air flow into the engine.

The IACV utilises two electromagnetic coils which use opposing PWM signals to control the positioning of a rotary valve. The rotary valve position determines how much air is allowed to flow through the bypass route.

CAUTION: Do not try to forcibly set the valve position, the actuator cannot be serviced. In the event of failure the IACV must be replaced as a unit.

If one of the electrical circuits supplying the PWM signals fails, the ECM switches off the other circuit to prevent the valve from biasing towards a maximum or minimum setting. Under these conditions, a default position for the valve is provided by a permanent magnet, which sets the valve position to maintain the idle speed at a fixed value of approximately 1200 rpm with no load applied.

During cold start conditions, the idle speed is held at 1200 rpm in neutral for 20 seconds. Ignition timing is retarded as a catalyst heating strategy.

If the IACV should fail, the following symptoms may be observed:

- Either low or high idle speed
- Engine stalls
- Difficult starting
- Raised idle speed in default condition.

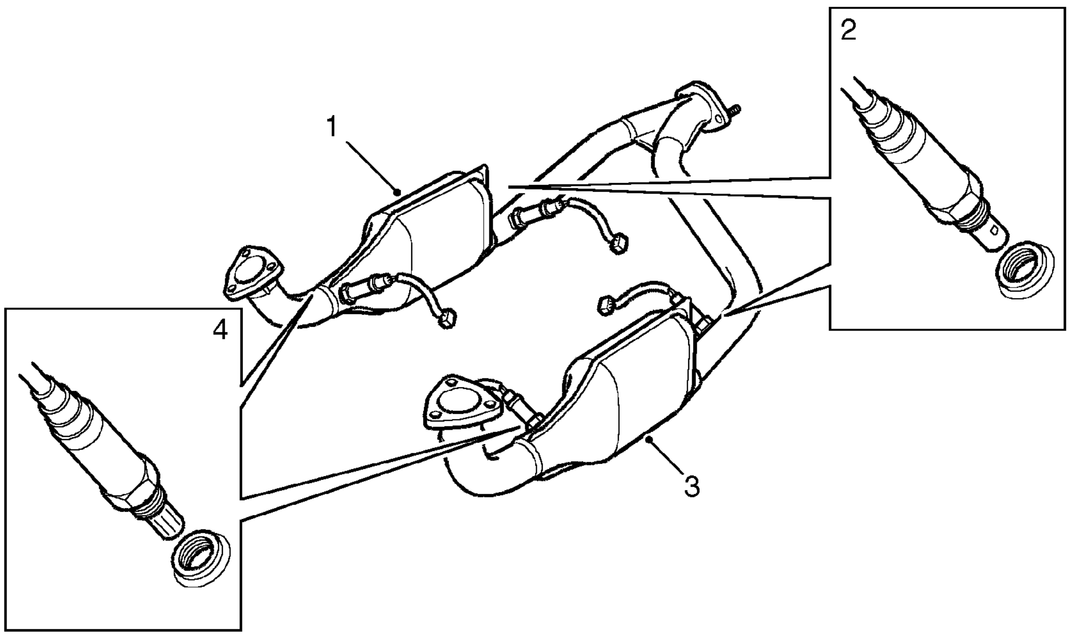
An IACV failure is likely to occur for the following reasons:

- Rotary valve seized
- Faulty actuator
- Connector or harness fault
- Intake system air leak
- Actuator port or hoses blocked, restricted or crimped

If the IACV should fail, the following fault codes will be generated by the ECM diagnostics, which can be retrieved by Testbook:

- **P0505 -** Blocked IACV valve - rpm error high or low
- **P1510 -** Short circuit to battery supply - opening winding
- **P1513 -** Short circuit to ground - opening winding
- **P1514 -** Open circuit - opening winding
- **P1553 -** Short circuit to battery supply - closing windings
- **P1552 -** Short circuit to ground - closing winding
- **P1551 -** Open circuit - closing winding

Heated Oxygen Sensors (HO_2S) - from 99MY



M17 0187

1. RH catalytic converter
2. Heated oxygen sensors - post-catalytic converters (2 off - NAS only)
3. LH catalytic converter
4. Heated oxygen sensors - pre-catalytic converters (2 off)

The number of heated oxygen (HO_2S) sensors fitted to a vehicle is dependent on the particular market requirements:

- 4 - HO_2S sensors (NAS vehicles)
- 2 - HO_2S (UK, European, Australia & Japan vehicles)
- 0 - HO_2S (Gulf & ROW vehicles)

The HO_2S sensors monitor the level of oxygen in the exhaust gases and the resulting data is used by the ECM to control the air:fuel mixture to provide the most efficient mix under all operating conditions. By positioning a sensor in the stream of exhaust gases from each bank of cylinders of the V8 engine enables the ECM to control the fuelling on each bank independently. This allows the ECM to provide more accurate control of the air:fuel ratio and monitor catalytic converter efficiency.

Two upstream sensors are utilised in markets where closed loop fuelling is the only mandatory requirement. For markets where closed loop fuelling control is not mandatory, HO_2S sensors are not included.

NAS vehicles utilise four HO_2S sensors, one upstream of each catalyst and one downstream of each catalyst. This arrangement is used to monitor catalytic converter efficiency and so determine when a catalyst is no longer working effectively. Obtaining catalytic converter efficiency data is a mandatory requirement of the ECM OBD strategy. The downstream sensors also provide for long term fuelling adaptions.

The basic closed control loop comprises the engine (controlled system), the heated oxygen sensors (measuring elements) and the engine management ECM (control) and the injectors and ignition (actuators). Although other factors also influence the calculations of the ECM, such as air flow, air intake temperature and throttle position. Additionally, special driving conditions are compensated for such as starting, acceleration and full load.

From cold start the ECM runs an open loop strategy, which is kept in place until the sensor's working temperature has been reached.

The heated oxygen sensors age with mileage, which will cause an increase in their response time for switching from rich to lean and lean to rich. The increase in response time influences the closed loop control and leads to progressively increased emissions. If the response rate is diagnosed to be exceeding a preset threshold, an error code will be stored in the ECM and the MIL warning lamp will be illuminated (NAS only).

The heated oxygen sensor is protected by an outer tube with a restricted flow opening to prevent the sensor's ceramics from being cooled by low temperature exhaust gases at start up. The pre-catalytic sensors are identified by three slots in the protective tube, whereas the post-catalytic sensors have four square indentations and a hole in the end of the protective tube (NAS only).

NOTE: The maximum working temperature of the tip of the HO_2S sensor is 930 °C (1706°F); temperatures higher than this will damage the sensor.

The heater elements are controlled by a PWM signal from the ECM. The heater elements are operated immediately following engine start and also during low load conditions when the temperature of the exhaust gases is insufficient to maintain the required sensor temperatures. The heater element warms the sensor's ceramic layer from the inside so that the sensor is hot enough for operation. After start up, the sensors are ready for closed loop control within about 20 to 30 seconds.

If the heater element fails, the ECM will not allow closed loop fuelling to be implemented until the sensor has achieved the required temperature. A diagnostic routine is utilised to measure both sensor heater current and the heater supply voltage, so its resistance can be calculated. The function is active once per drive cycle, as long as the heater has been switched on for a pre-defined period and the current has stabilised. The PWM duty cycle is carefully controlled to prevent thermal shock to cold sensors.

The pre-catalytic and post-catalytic converters are not interchangeable, and although it is possible to mount them in transposed positions, their harness connections are of different gender and colour:

- Upstream sensors have orange connectors.
- Downstream sensors have grey connectors.

It is important not to confuse the sensor signal pins; the signal pins are gold plated, whilst the heater supply pins are tinned, mixing them up will cause contamination and effect system performance with time.

NOTE: Sensor voltage is most easily monitored using "Testbook".

If a heated oxygen sensor should fail, the following symptoms may be observed:

- Default to open loop fuelling on the catalyst bank with the failed sensor.
- If sensor get crossed, the engine will run normally after the initial start, but then become progressively unstable. One bank will clamp at the maximum rich level, and the other bank will clamp at maximum lean. The system will then revert to open loop fuelling.
- High CO reading
- Excess emissions
- Strong smell of hydrogen sulphide (H_2S) until the ECM defaults to open loop fuelling
- MIL lamp illuminated (NAS only)

A heated oxygen sensor failure is likely to occur for the following reasons:

- Damaged or incorrectly fitted sensor
- Sensor open circuit or disconnected
- Short circuit to vehicle supply or ground
- Stoichiometric ratio outside the correct operating band
- Contamination from leaded fuel or other sources
- Change in sensor characteristics - Chemical Shift Down (CSD)
- Sensors from LH and RH banks crossed
- Air leak into exhaust system (cracked pipe / weld or loose fixings)

Diagnosis of electrical faults is continually monitored by the ECM in both the upstream sensors and downstream sensors (NAS only). The sensor signal is checked against stored minimum and maximum threshold values equating to short and open circuit conditions.

If an HO_2S sensor should fail, the following fault codes will be generated by the ECM diagnostics, which can be retrieved by Testbook:

- **P1129 -** Front heated oxygen sensors transposed

Upstream sensor LH bank - electrical (NAS only)

- **P0130 -** Stoichiometric ratio outside operating band
- **P0132 -** Short circuit to battery supply
- **P0134 -** Open circuit

Downstream sensor LH bank - electrical

- **P0136 -** Stoichiometric ratio outside operating band
- **P0137 -** Short circuit to battery supply
- **P0138 -** Short circuit to ground or chemical shift down
- **P0140 -** Open circuit

Upstream sensor RH bank - electrical (NAS only)

- **P0150 -** Stoichiometric ratio outside operating band
- **P0152 -** Short circuit to battery supply
- **P0154 -** Open circuit

Downstream sensor RH bank - electrical

- **P0156 -** Stoichiometric ratio outside operating band
- **P0157 -** Short circuit to ground
- **P0158 -** Short circuit to battery voltage
- **P0160 -** Open circuit

Upstream sensors aged (NAS only)

- **P0133 -** Upstream sensor aged - Period time too short LH bank
- **P0133 -** Upstream sensor aged - Period time too long LH bank
- **P0153 -** Upstream sensor aged - Period time too short RH bank
- **P0153 -** Upstream sensor aged - Period time too long RH bank
- **P1170 -** Upstream sensor aged - ATV adaption too lean LH bank
- **P1170 -** Upstream sensor aged - ATV adaption too rich LH bank
- **P1173 -** Upstream sensor aged - ATV adaption too lean RH bank
- **P1173 -** Upstream sensor aged - ATV adaption too rich RH bank

Sensor Heater faults

- **P0135 -** Upstream heater LH bank - Short circuit (NAS only)
- **P0135 -** Upstream heater LH bank - Open circuit (NAS only)
- **P0141 -** Downstream heater LH bank - Short circuit
- **P0141 -** Downstream heater LH bank - Open circuit
- **P0155 -** Upstream heater RH bank - Short circuit (NAS only)
- **P0155 -** Upstream heater RH bank - Open circuit (NAS only)
- **P0161 -** Downstream heater LH bank - Short circuit
- **P0161 -** Downstream heater LH bank - Open circuit

A diagnostic routine is used to measure both sensor heater current and the heater supply voltage so its resistance can be calculated. The function is active once per drive cycle as long as the heater has been switched on for a pre-defined period and the current has stabilised. The PWM duty cycle is carefully controlled to prevent thermal shock to cold sensors.

On NAS vehicles, the catalysts are monitored to determine emission pollutant conversion efficiency; the following fault codes will be generated by the ECM diagnostics, which can be retrieved by Testbook:

- **P0420 -** Catalyst efficiency deteriorated LH bank
- **P0430 -** Catalyst efficiency deteriorated RH bank

See EMISSION CONTROL, Description and operation.

Fuel pump relay - from 99MY

The fuel pump relay is fitted in the engine compartment fusebox which is situated at the front right hand side of the engine compartment. The relay is a four-pin normally open type, encapsulated in a yellow plastic housing.

The fuel supplied to the injectors from the in-tank fuel pump is controlled by the ECM via the fuel pump relay. During engine cranking, the fuel pump relay is activated by the ECM allowing the fuel system to be pressurised to 3.5 bar (52 $lbf.in^2$). The pump relay is then deactivated until engine start has been achieved.

Battery voltage is supplied via the engine compartment fusebox and relay activation is achieved by ground path switching through the ECM.

If the fuel pump relay should fail, the following symptoms may be observed:

- Engine stalls or will not start
- No fuel pressure at the fuel injectors

A fuel pump relay failure is likely to occur for the following reasons:

- Relay drive open circuit
- Short circuit to vehicle supply or ground
- Component failure

If the fuel pump relay should fail, the following fault codes will be generated by the ECM diagnostics, which can be retrieved by Testbook:

- **P1230 -** Fuel pump relay open circuit - not the fuel pump itself
- **P1231 -** Fuel pump relay short circuit to battery supply - not the fuel pump itself
- **P1232 -** Fuel pump relay short circuit to ground - not the fuel pump itself

Advanced Evaporative Emissions System - from 99MY (NAS only)

The Bosch Motronic 5.2.1 ECM includes control for the evaporative emissions system components, its purpose is to minimise the evaporative loss of fuel vapour from the fuel system to the atmosphere. This is achieved by venting the system through an EVAP canister filled with vapour absorbing charcoal. The charcoal acts like a sponge and stores the vapour until the canister is purged under the control of the ECM.

Fuel vapour is stored in the activated charcoal canister for retention when the vehicle is not operating. When the vehicle is operating, fuel vapour is drawn from the canister into the engine via a purge control valve. The vapour is then delivered to the intake plenum chamber to be supplied to the engine cylinders where it is burned in the combustion process.

See EMISSION CONTROL, Description and operation.

Fuel Filling

During fuel filling, the fuel vapour displaced from the fuel tank is allowed to escape to atmosphere; valves within the fuel filler prevent any vapour escaping through the EVAP canister as this can adversely effect the fuel cut-off height. Only fuel vapour generated whilst driving is prevented from escaping to atmosphere by absorption into the EVAP canister. The fuel filler shuts off to leave the tank approximately 10% empty to ensure the roll over valves (ROVs) are always above the fuel level and so vapour can escape to the EVAP canister and the tank can breathe. The back pressures normally generated during fuel filling are too low to open the pressure relief valve, but vapour pressures accumulated during driving are higher and can open the pressure relief valve. Should the vehicle be overturned, the ROVs shut off to prevent any fuel spillage.

Fuel Tank Venting

Fuel vapour generated from within the fuel tank as the fuel heats up is stored in the tank until the pressure exceeds the operating pressure of the two-way valve. When the two-way valve opens, the fuel vapour passes along the vent line from the fuel tank via the fuel tank vapour separator to the evaporation inlet port of the EVAP canister.

Liquid fuel must not be allowed to contaminate the charcoal in the EVAP canister. To prevent this, the fuel vapour separator fitted to the fuel filler neck allows fuel to drain back into the tank. As the fuel vapour cools, it condenses and is allowed to flow back into the fuel tank from the vent line by way of the two-way valve.

The EVAP canister contains charcoal pellets which absorbs and stores the fuel vapour from the fuel tank while the engine is not running. When the canister is not being purged, the fuel vapour remains in the canister and clean air exits the canister via the air inlet port.

ECM Purge Control

The engine management ECM controls the output signals to the purge valve and the canister vent solenoid (CVS) valve, and receives an input from the fuel tank pressure sensor. The system will not work properly if there is a leakage or clogging within the system, or if the purge valve cannot be controlled.

When the engine is running, the ECM decides when conditions are correct for the vapour to be purged from the canister and opens the canister purge valve. This connects a manifold vacuum line to the canister and fuel vapour containing the hydrocarbons is drawn from the canister's charcoal element to be burned in the engine. Clean air is drawn into the canister through the air inlet port to fill the displaced volume of vapour.

The purge valve remains closed below preset coolant and engine speed values to protect the engine tune and catalytic converter performance. If the EVAP canister was purged during cold running or at idling speed the additional enrichment in the fuel mixture would delay the catalytic converter light off time and cause erratic idle. When the purge valve is opened, fuel vapour from the EVAP canister is drawn into the plenum chamber downside of the throttle housing, to be delivered to the combustion chambers for burning.

The purge valve is opened and closed in accordance with a PWM signal supplied from the ECM. Possible failure modes associated with the purge valve failure are listed below:

- Valve drive open circuit
- Short circuit to vehicle supply or ground
- Purge valve or pipework blocked or restricted
- Purge valve stuck open
- Pipework joints leaking or disconnected.

Possible symptoms associated with purge valve or associated pipework failure is listed below:

- Engine may stall on return to idle if purge valve is stuck open
- Poor idling quality if the purge valve is stuck open
- Fuelling adaptions forced excessively lean if the EVAP canister is clear and the purge valve is stuck open.
- Fuelling adaptions forced excessively rich if the EVAP canister is saturated and the purge valve is stuck open.
- Saturation of the EVAP canister if the purge valve is stuck closed.

To maintain driveability and effective emission control, purging control must be closely controlled by the ECM, as a 1% concentration of fuel vapour from the EVAP canister in the air intake may shift the air:fuel ratio by as much as 20%. The ECM must purge the fuel vapour from the EVAP canister at regular intervals as its storage capacity is limited and an excessive build-up of fuel pressure in the system could increase the likelihood of vapour leaks. Canister purging is cycled with the fuelling adaption as both cannot be active at the same time. The ECM alters the PWM signal to the purge valve to control the rate of purging of the canister to maintain the optimum stoichiometric air:fuel mixture for the engine.

See EMISSION CONTROL, Description and operation.

Leak Test

The evaporative emission system used on NAS vehicles includes a fuel pressure sensor and a canister vent solenoid (CVS) valve. The system is capable of detecting holes in the fuel system down to 1 mm (0.04 in.).

The test is carried out in three parts:

First the purge valve and the CVS valve closes off the storage system and the vent pressure increases due to the fuel vapour pressure level in the tank. If the pressure level is greater than the acceptable limit, the test will abort because a false leak test response will result. In part two of the test, the purge valve is opened (preferably with the engine idling) and the fuel tank pressure will decrease due to purge operation. In part three of the test, the leak measurement test is performed. The pressure response of the tests determines the level of the leak, and if greater than the limit on two consecutive tests, the ECM stores the fault in diagnostic memory and the MIL light on the instrument pack is illuminated. The test is only carried out at idle with the vehicle stationary. Following the test, the system returns to normal purge operation after the CVS valve opens. The in-tank pressure sensor monitors the pressure build-up to determine whether leaks are present.

Possible reasons for a test failure are listed below:

- Fuel filler not tightened or cap missing
- Sensor or actuator open circuit
- Short circuit to vehicle supply or ground
- Either purge or CVS valve stuck open
- Either purge or CVS valve stuck closed or blocked pipe
- Piping broken or not connected
- Loose or leaking connection

If the piping is broken forward of the purge valve or is not connected, the engine may run rough and fuelling adaptions will drift. The fault will not be detected by the test, but by the engine management ECM detecting that the fuelling adaption is suspended. The evaluation of the leakage is dependent on the differential pressure between the fuel tank and the ambient atmospheric pressure. The diagnostic test is disabled at altitudes above 2,800 metres (9,500 ft).

The fuel tank pressure sensor is included as part of the OBD system. A failure of the fuel tank pressure sensor will not be noticed by the driver, but if the ECM detects a fault, it will be stored in the diagnostic memory and the MIL warning lamp will be illuminated on the instrument pack

Possible fuel tank pressure sensor failures are listed below:

- Damaged sensor
- Harness wiring or connector faulty
- Open circuit
- Short circuit to battery voltage or ground
- ECM fault

Possible symptoms of a fuel tank pressure sensor failure are listed below:

- Fuel tank pressure sensor poor performance
- Fuel tank pressure sensor low range fault
- Fuel tank pressure sensor high range fault

Fault codes associated with the evaporative emission control system are listed below:

- **P0171 -** Multiplication fuelling adaption (Max.) exceeded lean limit - LH bank
- **P0172 -** Multiplication fuelling adaption (Min.) exceeded lean limit - LH bank
- **P0174 -** Multiplication fuelling adaption (Max.) exceeded lean limit - RH bank
- **P0175 -** Multiplication fuelling adaption (Min.) exceeded lean limit - RH bank
- **P0171 -** Additive fuelling adaption (Max.) exceeded lean limit - LH bank
- **P0172 -** Additive fuelling adaption (Min.) exceeded lean limit - LH bank
- **P0174 -** Additive fuelling adaption (Max.) exceeded lean limit - RH bank
- **P0175 -** Additive fuelling adaption (Min.) exceeded lean limit - RH bank
- **P0440 -** Purge valve not sealing
- **P0442 -** Small leak within system
- **P0443 -** Purge valve power stage short circuit to battery voltage
- **P0444 -** Purge valve power stage open circuit
- **P0445 -** Purge valve power stage short circuit to ground
- **P0445 -** Large leak within system
- **P0446 -** CVS valve / filter / pipe blocked
- **P0447 -** CVS valve open circuit
- **P0448 -** CVS valve short circuit to ground
- **P0449 -** CVS valve short circuit to battery voltage
- **P0451 -** Fuel tank pressure signal stuck high within range
- **P0452 -** Fuel tank pressure signal short circuit to battery voltage (out of range - high)
- **P0453 -** Fuel tank pressure sensor signal short circuit to ground or open circuit (out of range - low)

Secondary air injection system (NAS only from 2000MY)

Refer to EMISSION CONTROL section for description of the secondary air injection system components.

Inertia Fuel Shut-off (IFS) Switch

The inertia switch isolates the power supply to the fuel pump in the event of sudden deceleration, as encountered during an accident. The inertia switch is located in the right hand side footwell behind an access flap. It is reset by depressing the central plunger at the top of the switch.

E-box Cooling Fan control - from 99MY only

The cooling fan is utilised to provide a cool temperature environment for the Bosch Motronic 5.2.1 ECM in the under bonnet mounted E-box. The fan provides cabin air into the E-box and operation is controlled by the ECM. The ECM contains an internal temperature sensor which it uses to determine when cooling fan operation is necessary.

Spark plugs - from 99MY

The spark plugs are platinum tipped on both centre and earth electrodes to provide a long maintenance free life and exceptional cold starting performance.

CAUTION: Do not clean the spark plugs or attempt to reset the spark plug gap.

CAUTION: If the wrong specification spark plugs are used, the misfire detection system is likely to malfunction and corresponding error codes will be stored in the ECM diagnostic memory. Only use the recommended spark plugs.

In the event of a spark plug failure, a misfire on a specific cylinder may be observed.

A spark plug failure may occur for the following reasons:

- Connector or wiring fault
- Faulty plug (e.g. wrong gap, damaged electrodes etc.)
- Incorrect spark plugs fitted
- Breakdown of high tension lead causing tracking to chassis earth

High tension (ht) leads

The ht leads are routed from the ignition coils at the back of the engine to four spark plugs on each bank of the engine block.

An ht lead failure will result in a misfire condition on a specific cylinder.

An ht lead failure may occur for the following reasons:

- Connector / wiring fault
- Faulty lead causing spark tracking to chassis earth
- Damage to ht lead during gearbox removal

Electronic Automatic Gearbox Interface - from 99MY

The ECM communicates with the EAT ECU via a Controller Area Network (CAN). This is used for the gearshift torque interface and as a means for transmitting OBD information between the two control units. The EAT ECU passes OBD data and requests to the ECM which controls the storage of diagnostics data and MIL activation. Unlike the GEMS ECM, the Bosch M5.2.1 does not store gearbox faults. The MIL activation request can be checked with Testbook.

The CAN network is a high speed serial interface operating at 500 k-baud. The system is a differential bus using a twisted pair. If either or both wires of the twisted pair CAN bus is open or short circuited, a CAN time out fault will occur and the EAT ECU defaults to third gear.

See AUTOMATIC GEARBOX, Description and operation.

Transfer Box ECU (MIL input) - from 99MY (NAS only)

The input from the transfer box ECU to the ECM indicates that there is an OBD relevant error detected within the transfer box ECU and requests activation of the MIL. In addition, the ECM carries out an integrity check on the signal following an "ignition ON" condition.

See TRANSFER BOX, Description and operation.

Engine Speed Output - from 99MY

The ECM supplies engine speed information to various vehicle systems (instrument pack etc.). The system uses an output frequency of 4 pulses per engine revolution.

HeVAC system interface - from 99MY

The diagnostics for the condenser fans and A/C grant signal is disabled and so it is not possible to detect open and short circuit conditions on these lines.

The condenser fans can be switched on by either the HeVAC ECU or the engine management ECM (to assist engine cooling) or by the fan control logic.

See HEATING AND VENTILATION, Description and operation.

See AIR CONDITIONING, Description and operation.

Fuel used signal - from 99MY

This output is required to provide fuel consumption information to the trip computer.

Fuel level input - from 99MY

This input is required by the ECM as part of the misfire detection strategy, in order to record a "low fuel" situation was present when misfire was detected and logged as a fault. The signal is received as an analogue signal from the fuel tank sender unit.

Fuel Level State	Sender Resistance	Fuel Level Signal Voltage
Full	19 ohm	1.00 V
Empty	270 ohm	3.16 V
Low Fuel Lamp ON threshold	above 175 ohm	2.77 V
Low Fuel Lamp OFF threshold	less than 117 ohm	2.40 V

FUEL TANK - DRAIN

Service repair no - 19.55.02

WARNING: Fuel must be drained through the tank fill stub, with the filler neck removed. In some circumstances, the fuel level could be above the level of the stub. If the fuel gauge indicates more than 75% full prior to draining, a minimum of 10 litres of fuel must first be removed through the fuel return line as detailed below.

WARNING: The fuel tank must be completely drained before it is removed.

WARNING: Petrol/gasoline vapour is highly flammable and in confined spaces is also explosive and toxic. Always have a fire extinguisher containing FOAM, CO_2 GAS or POWDER close to hand when handling or draining fuel. See 01 Introduction.

CAUTION: Before disconnecting any part of the fuel system, it is imperative that all dust, dirt and debris is removed from around components to prevent ingress of foreign matter into the fuel system.

WARNING: Follow manufacturer's instructions for connection and safe use of equipment.

NOTE: Assuming the fuel tank is FULL, drain the following quantities:

Renew fuel pump = COMPLETE DRAIN

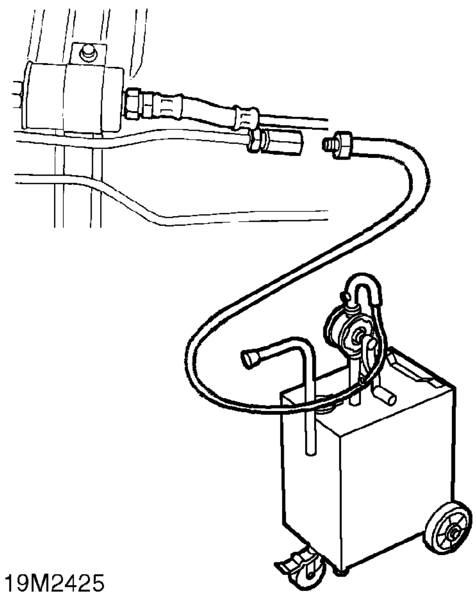
Renew fuel filler neck = 10 litres (2.6 US Gallons)

Renew Fuel Tank = COMPLETE DRAIN

1. Depressurise fuel system. ***See Repair.***
2. Disconnect battery earth lead.

Fuel gauge indicated over 75% full:

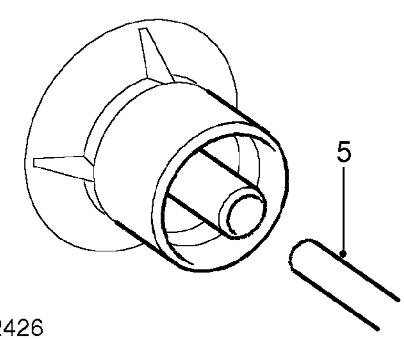
3. Using a bowser, with a suitable hose connection into the fuel return line, either at the fuel rail, or at the under floor connection, forward of the fuel tank, drain a minimum 10 litres (2.6 US Gallons) from fuel tank.



19M2425

Fuel level at least 10 litres (2.6 US gallons) from full:

4. Remove fuel filler neck. ***See Repair.***
5. Using a suitable length of plastic tube, inserted through the fuel tank fill stub, drain contents of tank into a closed container.



19M2426

6. Fit filler neck. ***See Repair.***
7. Connect battery earth lead.

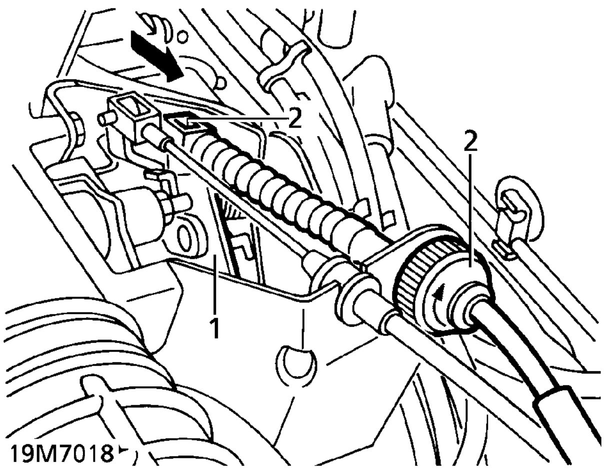
THROTTLE CABLE - up to 99MY

Service repair no - 19.20.05

Adjust

NOTE: Accurate setting of this cable is critical to correct operation of automatic transmission.

1. Ensure throttle lever is against stop in closed position.

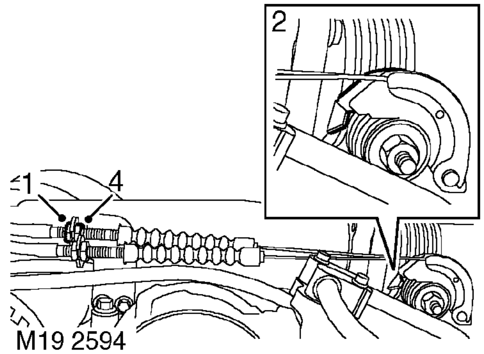


2. Rotate thumb-wheel clockwise until all slack is removed from cable. (Throttle lever is about to lift from stop)
3. Back off thumb-wheel anti-clockwise by one quarter of a turn.
4. Check cruise control cable adjustment.
5. If necessary, adjust cruise control cable. ***See CRUISE CONTROL, Adjustment.***

THROTTLE CABLE - from 99MY

Service repair no - 19.20.05

Adjust



1. Loosen outer cable locknuts.
2. Adjust the rear locknut until it is in contact with the back of the abutment bracket and the throttle lever is in contact with the inner driven lever.
3. Ensure that the driven lever remains in contact with the throttle stop screw, (throttle closed).
4. Tighten cable front nut to lock cable to abutment bracket and tighten lock nut.

ENGINE TUNING - up to 99MY

Service repair no - 19.22.13

The position of the Idle Air Control (IAC) valve can be checked using TestBook and adjusted if necessary through the by-pass screw in the plenum chamber. The bypass screw is covered by a tamper proof plug which can be extracted using a self tapping screw.

Vehicles in certain markets are not fitted with oxygen sensors or active catalytic converters. Certain specification vehicles may have active catalytic converters fitted, but do not use oxygen sensors. This is referred to as an open loop catalyst system. All vehicles without oxygen sensors must have the exhaust CO content checked periodically using an approved CO meter and adjusted if necessary using TestBook.

On vehicles with open loop catalyst systems, exhaust CO content must be checked upstream of the catalyst, **NOT at the tailpipe**.

Preliminary Checks

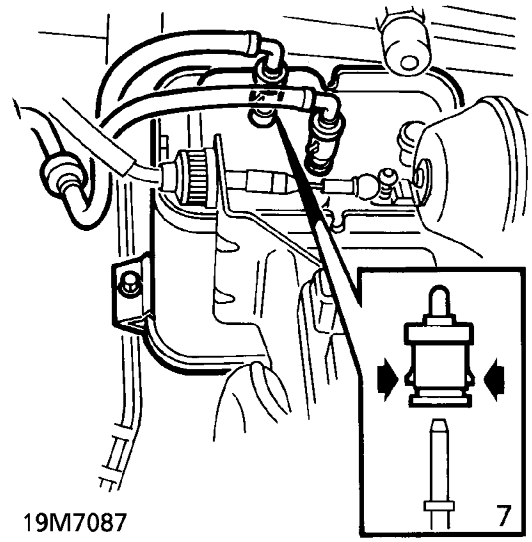
1. Ensure that air filter and fuel filter elements are in a serviceable condition.
2. Check air intake system, including vacuum pipes and hoses for correct routing and freedom from leaks and restriction.
3. Electrical connections must be secure and leads correctly routed.
4. Check ignition system integrity using an approved Engine Analyser.

Procedure

Vehicles without oxygen sensors:

5. Ensure exhaust gas analyser is warmed and calibrated ready for use.
6. **Non catalyst vehicles:** Connect exhaust gas analyser to tailpipe.
7. Disconnect purge valve pipe at charcoal canister.

CAUTION: Do not disconnect purge valve electrical multiplug.



19M7087

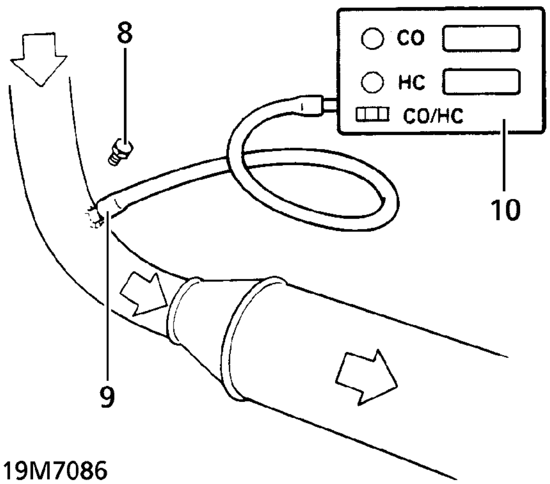
Open loop catalyst vehicles:

8. Remove blanking plug from RH exhaust front pipe, forward of the catalyst.
9. Fit sampling pipe and tighten securely.

CAUTION: Air leaks at the sampling pipe will cause incorrect readings.

10. Connect exhaust gas analyser to sampling pipe.

NOTE: When refitting the blanking plug apply nickel based grease to the thread.



19M7086

All vehicles:

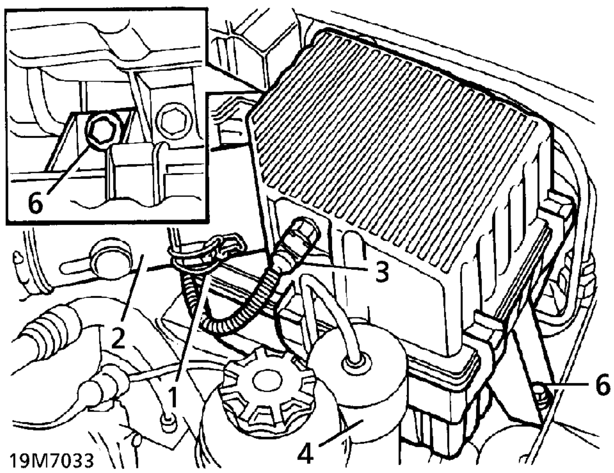
11. Ensure air conditioning and all electrical loads are off. Vehicle must be in neutral or park with air suspension in kneel and disabled.
12. Carry out tuning or base idle setting procedure as applicable using TestBook.

AIR CLEANER ASSEMBLY - up to 97MY

Service repair no - 19.10.01

Remove

1. Release 2 clips securing air flow meter to air cleaner.
2. Release air flow meter. Remove 'O' ring and discard.
3. Disconnect intake air temperature sensor.



4. Remove bolt securing air suspension dryer to air cleaner.
5. Release dryer pipes from 2 clips. Position dryer aside.
6. Remove 2 bolts securing air cleaner to valance.
7. Release air cleaner lug from valance grommet. Remove air cleaner.
8. If necessary, remove intake air temperature sensor.
9. Remove seal.

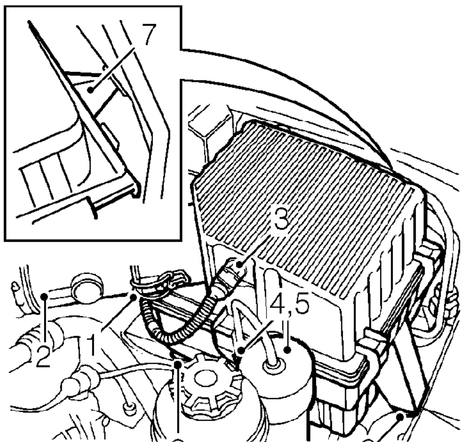
Refit

10. If removed, refit intake air temperature sensor with seal to air cleaner. Tighten to ***8 Nm (6 lbf.ft)***
11. Position air cleaner assembly. Engage lug to valance grommet. Secure with bolts.
12. Position air suspension dryer to air cleaner. Secure with bolt. Tighten to ***8 Nm (6 lbf.ft)***
13. Engage dryer pipes to clips.
14. Connect multiplug to intake air temperature sensor.
15. Fit new 'O' ring to air flow meter.
16. Secure air flow meter to air cleaner with clips.

AIR CLEANER ASSEMBLY - from 97MY

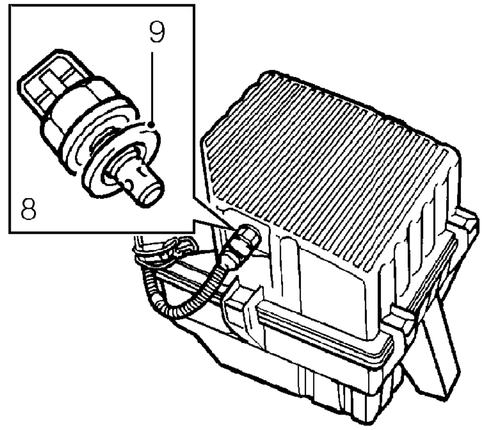
Service repair no - 19.10.01

Remove



19M7094

1. Release 2 clips securing mass air flow (MAF) meter to air cleaner.
2. Release MAF meter from air cleaner. Remove and discard 'O' ring from MAF sensor.
3. Disconnect multiplug from air temperature sensor.
4. Remove bolt securing air suspension air dryer to air cleaner.
5. Release air dryer from air cleaner and position aside.
6. Release air cleaner from 2 valance grommets.
7. Remove air cleaner from inner wing grommet. ***Do not carry out further dismantling if component is removed for access only.***



19M7095

8. Remove air temperature sensor from air cleaner.
9. Remove and discard air temperature sensor seal.
10. Fit new seal to air cleaner.
11. Fit air temperature sensor to air cleaner and tighten to ***8 Nm (6 lbf.ft)***

Refit

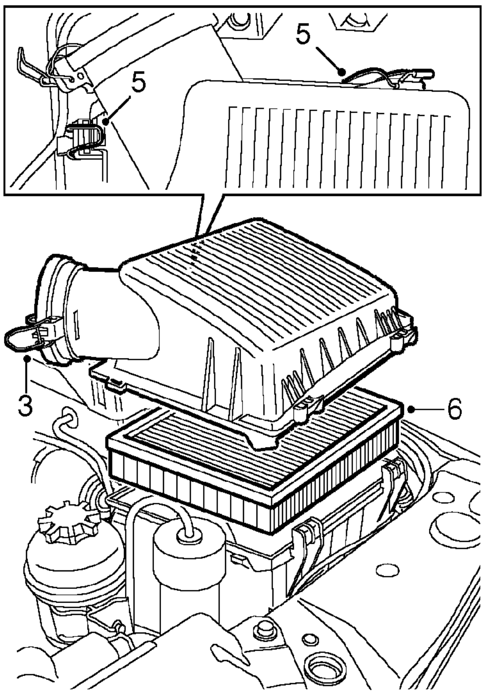
12. Fit air cleaner lugs to inner wing and valance grommets. Ensure lugs are fully engaged to grommets.
13. Position air dryer to air cleaner, fit bolt and tighten to ***8 Nm (6 lbf.ft)***
14. Connect multiplug to air temperature sensor.
15. Fit new 'O' ring seal to MAF meter.
16. Engage MAF meter to air cleaner and secure with clips.

ELEMENT - AIR CLEANER - from 99MY

Service repair no - 19.10.10

Remove

1. Release 3 fixings and remove battery cover.
2. Disconnect battery earth lead.



M19 2633

3. Release 2 clips securing air flow meter to air cleaner assembly.
4. Release air flow meter and position aside.
5. Release 2 clips securing air cleaner top cover and remove cover.
6. Remove air cleaner element.

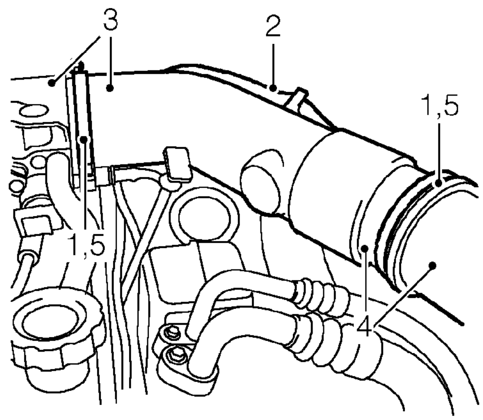
Refit

7. Clean inside of air cleaner case and cover.
8. Fit new air cleaner element.
9. Fit air cleaner cover and secure with clips.
10. Connect air flow meter to air cleaner assembly and secure with clips.
11. Connect battery earth lead.
12. Fit battery cover and secure with fixings.

AIR INTAKE HOSE - up to 99MY

Service repair no - 19.10.17

Remove



19M7089

1. Loosen 2 clips securing intake hose to plenum chamber and mass air flow sensor.
2. Release harness from intake hose clip.
3. Release intake hose from plenum chamber.
4. Remove intake hose from mass air flow sensor.
5. Remove 2 clips from intake hose.

Refit

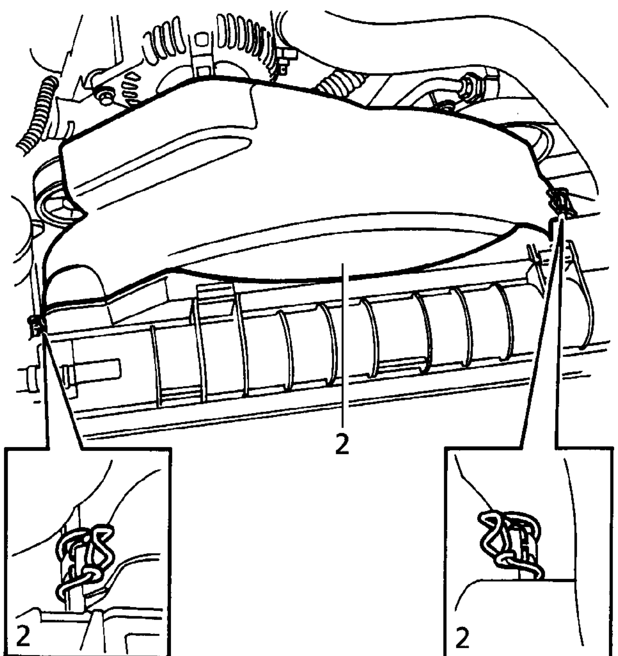
6. Fit clips to intake hose.
7. Fit intake hose to mass air flow sensor.
8. Connect intake hose to plenum chamber.
9. Tighten clips securing intake hose to plenum and MAF sensor.
10. Engage harness to intake hose clip.

CAMSHAFT POSITION (CMP) SENSOR - up to 99MY

Service repair no - 18.30.24

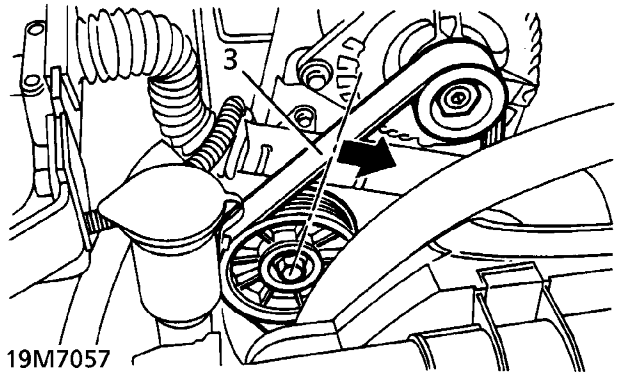
Remove

1. Disconnect battery negative lead.
2. Release 2 clips securing upper fan cowl. Remove cowl.



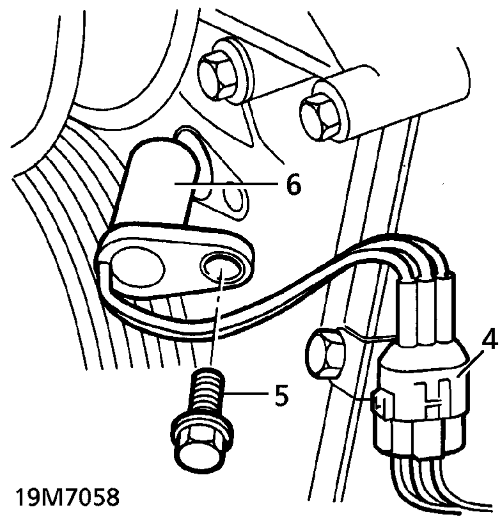
19M7056

3. Release tension from auxiliary belt. Remove belt from crankshaft pulley.



19M7057

4. Release CMP sensor connector from bracket. Disconnect multiplug.



19M7058

5. Remove bolt securing CMP sensor to front cover.
6. Remove CMP sensor.

Refit

7. Ensure mating surfaces are clean.
8. Engage CMP sensor in front cover location. Secure with bolt. Tighten to ***8 Nm (6 lbf.ft)***
9. Secure CMP sensor connector to bracket. Connect multiplug.
10. Turn auxiliary belt tensioner. Refit belt to crankshaft pulley.
11. Fit upper fan cowl. Secure with clips.
12. Reconnect battery negative lead.

CAMSHAFT POSITION (CMP) SENSOR - from 99MY

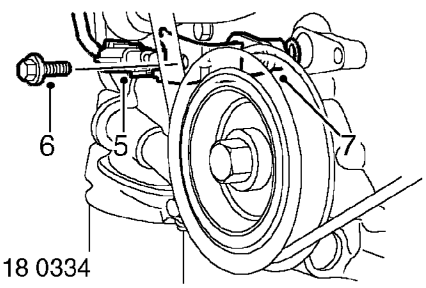
Service repair no - 18.30.24

Remove

1. Release fixings and remove battery cover.
2. Disconnect battery earth lead.
3. Raise front of vehicle.

WARNING: Support on safety stands.

4. Disconnect engine harness from CMP sensor.



M18 0334

5. Disconnect CMP sensor multiplug from bracket.
6. Remove bolt from clamp securing CMP sensor to front cover.
7. Remove clamp and sensor. Discard 'O' ring from CMP sensor.

Refit

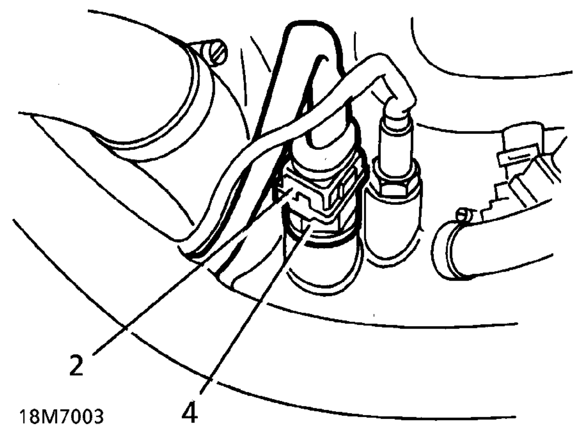
8. Ensure CMP sensor is clean, fit new 'O' ring and sensor to cover.
9. Fit clamp to CMP sensor and tighten bolt to ***8 Nm (6 lbf.ft).***
10. Fit sensor multiplug to bracket and connect engine harness to multiplug.
11. Lower vehicle.
12. Connect battery earth lead.
13. Fit battery cover and secure with fixings.

ENGINE COOLANT TEMPERATURE (ECT) SENSOR - up to 99MY

Service repair no - 18.30.10

Remove

1. Partially drain cooling system. ***See COOLING SYSTEM, Repair.***
2. Disconnect ECT sensor multiplug.
3. Position rag around ECT sensor to catch spillage.
4. Remove ECT sensor. Collect and discard copper washer.



18M7003

Refit

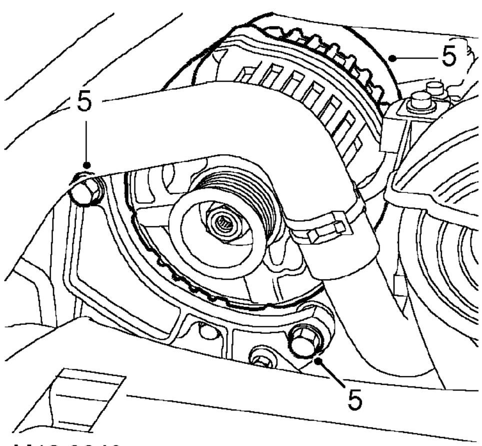
5. Ensure ECT sensor seat in manifold is clean.
6. Coat sensor threads with Loctite 577 and fit a new copper washer.
7. Fit ECT sensor. Tighten to ***20 Nm (15 lbf.ft).***
8. Connect multiplug to ECT sensor.
9. Refill cooling system. ***See COOLING SYSTEM, Repair.***
10. Run engine to normal operating temperature. Check for leaks around ECT sensor.

ENGINE COOLANT TEMPERATURE (ECT) SENSOR - from 99MY

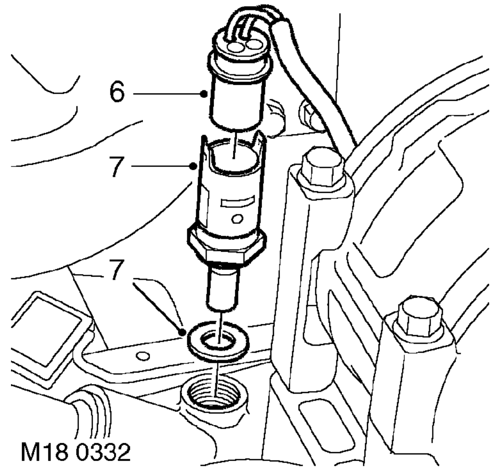
Service repair no - 18.30.10

Remove

1. Release fixings and remove battery cover.
2. Disconnect battery earth lead.
3. Drain sufficient coolant to ensure no spillage during removal of ECT sensor. ***See COOLING SYSTEM, Repair.***
4. Remove alternator drive belt. ***See ELECTRICAL, Repair.***



5. Remove 2 bolts securing alternator, release alternator from support bracket and position aside.



6. Disconnect multiplug from ECT sensor.
7. Remove sensor from inlet manifold and discard sealing washer.

Refit

8. Clean sealant from threads in manifold.
9. Apply Loctite 577 to sensor threads.
10. Fit new sealing washer to coolant sensor and tighten sensor to ***10 Nm (8 lbf. ft).*** Connect multiplug.
11. Position alternator, fit bolts and tighten to ***45 Nm (33 lbf.ft).***
12. Fit alternator drive belt. ***See ELECTRICAL, Repair.***
13. Top up cooling system. ***See COOLING SYSTEM, Repair.***
14. Connect battery earth lead.
15. Fit battery cover and secure with fixings.

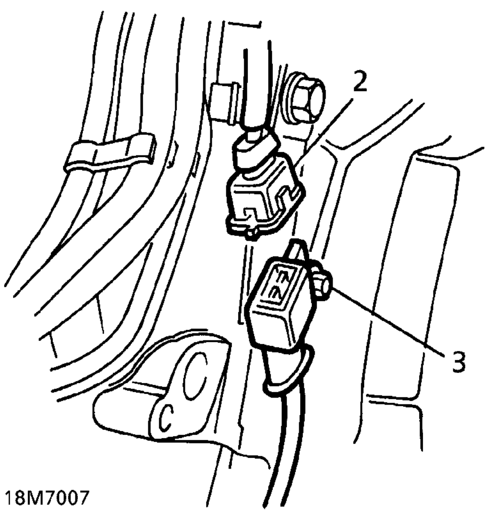
CRANKSHAFT POSITION (CKP) SENSOR - up to 97MY

Service repair no - 18.30.12

Remove

CAUTION: 4.6 litre automatic vehicles have a spacer fitted to the engine speed sensor.

1. Disconnect battery negative lead.
2. Disconnect multiplug from CKP sensor fly-lead.
3. Remove bolt securing CKP sensor connector to bracket.

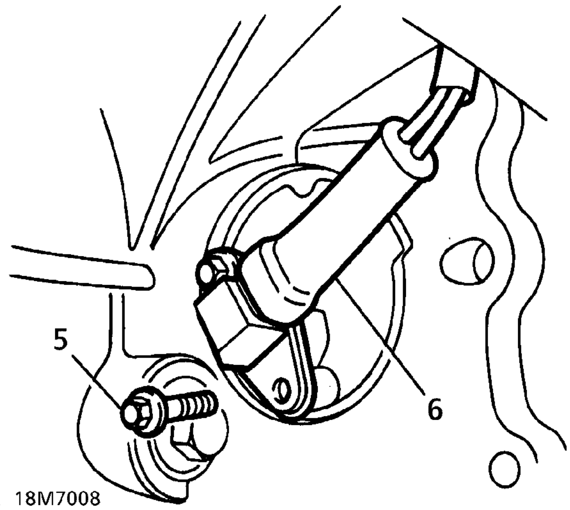


18M7007

4. Raise the vehicle.

WARNING: Support on safety stands.

5. Remove 2 bolts securing CKP sensor to cylinder block adaptor plate.



18M7008

6. Remove CKP sensor.
7. **4.6 litre Automatic Only:** Collect spacer from sensor.

Refit

8. **4.6 litre Automatic Only:** Fit spacer to CKP sensor.
9. Fit CKP sensor to adaptor plate. Secure with bolts. Tighten to ***6 Nm (4 lbf.ft)***
10. Remove safety stands. Lower vehicle.
11. Secure CKP sensor connector to bracket with bolt.
12. Connect CKP sensor multiplug.
13. Reconnect battery negative lead.

CRANKSHAFT POSITION (CKP) SENSOR - 97MY to 99MY

Service repair no - 18.30.12

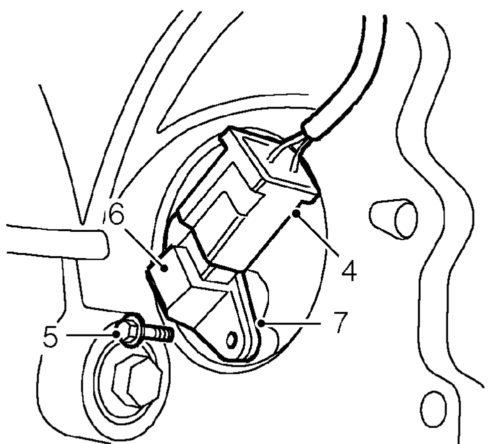
CAUTION: System sensor connectors can be contaminated by oil or coolant when disconnected during repair or testing. Use a suitable cap to prevent dirt or fluid ingress.

Remove

1. Disconnect battery earth lead.
2. Raise front of vehicle.

WARNING: Support on safety stands.

3. Remove gearbox LH acoustic cover. ***See CHASSIS AND BODY, Repair.***



18M7027

4. Disconnect multiplug from CKP sensor.
5. Remove bolt securing CKP sensor to cylinder block adaptor plate.
6. Remove CKP sensor.
7. Collect spacer from sensor.

Refit

8. Fit spacer to CKP sensor.
9. Fit CKP sensor to adaptor plate.
10. Fit bolt securing sensor to adaptor plate and tighten to ***6 Nm (4 lbf.ft)***
11. Connect multiplug to CKP sensor.
12. Fit gearbox LH acoustic cover. ***See CHASSIS AND BODY, Repair.***
13. Remove stand(s) and lower vehicle.

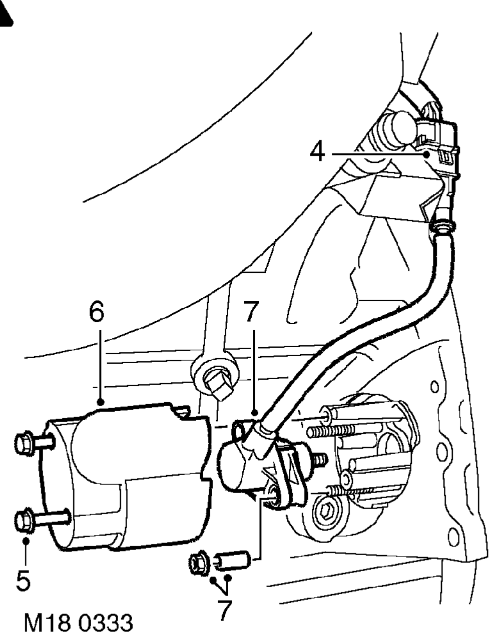
CRANKSHAFT POSITION (CKP) SENSOR - from 99MY

Service repair no - 18.30.12

Remove

1. Release fixings and remove battery cover.
2. Disconnect battery earth lead.
3. Raise front of vehicle.

WARNING: Support on safety stands.



M18 0333

4. Release CKP sensor multiplug from bracket and disconnect multiplug from engine harness.
5. Remove 2 bolts securing CKP sensor heat shield.
6. Remove heat shield.
7. Remove 2 nuts securing CKP sensor, remove 2 spacers, sensor and sensor mounting.

Refit

8. Ensure all components are clean.
9. Fit sensor mounting, CKP sensor, 2 spacers and tighten sensor retaining nuts to ***6 Nm (5 lbf.ft).***
10. Fit CKP sensor heat shield and secure with bolts.
11. Connect sensor multiplug to engine harness and fit multiplug to bracket.
12. Remove stand(s) and lower vehicle.
13. Connect battery earth lead.
14. Fit and secure battery cover.

FUEL SYSTEM - DEPRESSURISE

WARNING: Fuel pressure of up to 2.5 bar will be present in the system, even if the engine has not been run for some time. Always depressurise the system before disconnecting any components in the fuel feed line (between fuel pump and pressure regulator). The spilling of fuel is unavoidable during this operation. Ensure that all necessary precautions are taken to prevent fire and explosion.

NOTE: Fuel pressure can be relieved at fuel rail feed union or fuel filter unions.

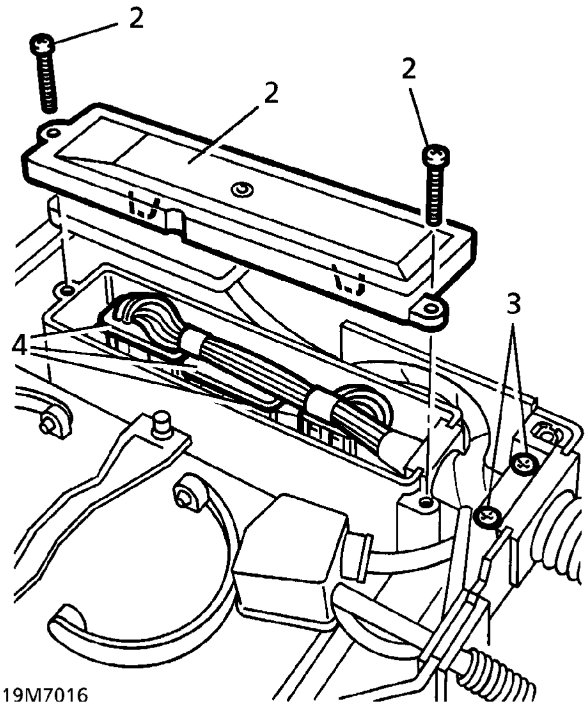
1. Position cloth around relevant union to protect against fuel spray.
2. Carefully slacken union.
3. Tighten union to correct torque once pressure has relieved.

ENGINE CONTROL MODULE (ECM) - up to 99MY

Service repair no - 18.30.01

Remove

1. Disconnect battery negative lead.



19M7016

2. Remove 2 screws securing ECM housing cover. Remove cover
3. Slacken 2 harness clamp screws.
4. Lift ECM slightly for access. Disconnect 3 multiplugs.
5. Remove ECM from housing.
6. Remove carrier plate from ECM.

Refit

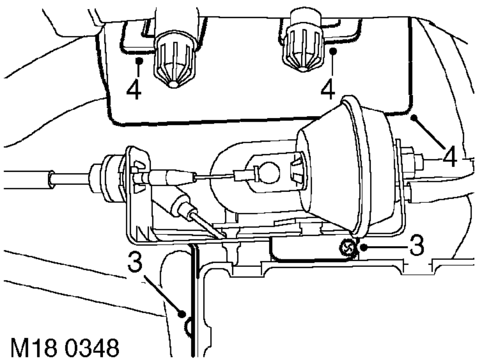
7. Reverse removal procedure.

ENGINE CONTROL MODULE (ECM) - from 99MY

Service repair no - 18.30.01

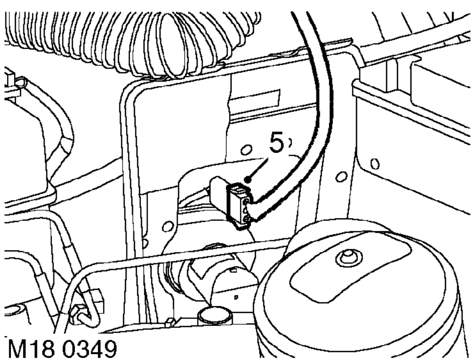
Remove

1. Release fixings and remove battery cover.
2. Disconnect battery earth lead.



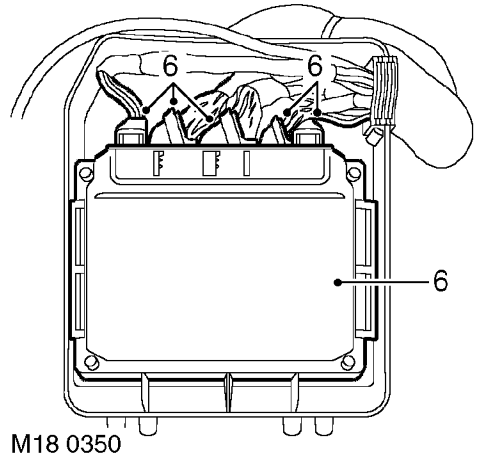
M18 0348

3. Remove 2 screws securing cruise control assembly to EAS housing cover and position aside.
4. Release 2 fixings securing ECM housing cover and release cover.



M18 0349

5. Disconnect ECM cooling fan multiplug.



M18 0350

6. Release ECM from housing cover, disconnect multiplugs and remove ECM.

Refit

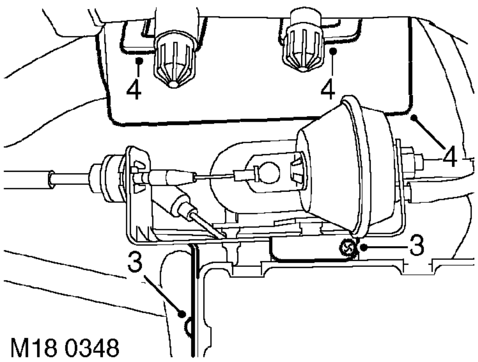
7. Position ECM and connect multiplugs.
8. Fit ECM to housing cover and connect ECM cooling fan multiplug.
9. Fit ECM housing cover to main housing and secure with fixings.
10. Position cruise control assembly to EAS housing cover and secure with screws.
11. Connect battery earth lead.
12. Fit battery cover and secure with fixings.

FAN - ECM COOLING - from 99MY

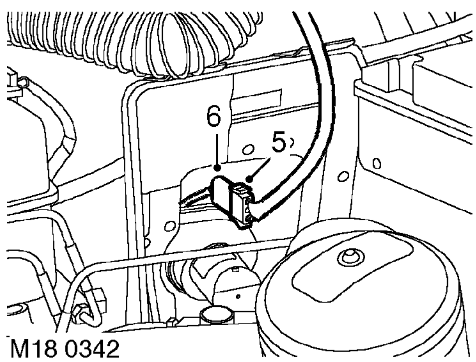
Service repair no - 18.30.80

Remove

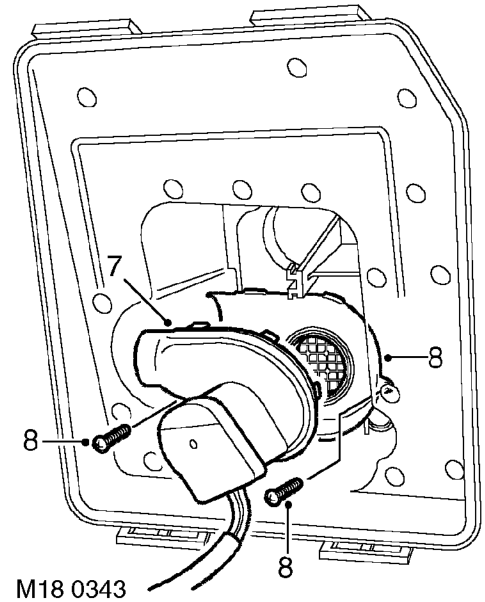
1. Release fixings and remove battery cover.
2. Disconnect battery earth lead.



3. Remove 2 screws securing cruise control assembly to EAS housing cover and position aside.
4. Release 2 fixings securing ECM housing cover and release cover.



5. Disconnect ECM cooling fan multiplug and position ECM housing cover aside.
6. Release ECM cooling fan multiplug from bracket.



7. Release ECM cooling fan from cooling fan cowl and remove cooling fan.
8. Remove 2 screws securing cooling fan cowl to ECM housing and remove cowl.

Refit

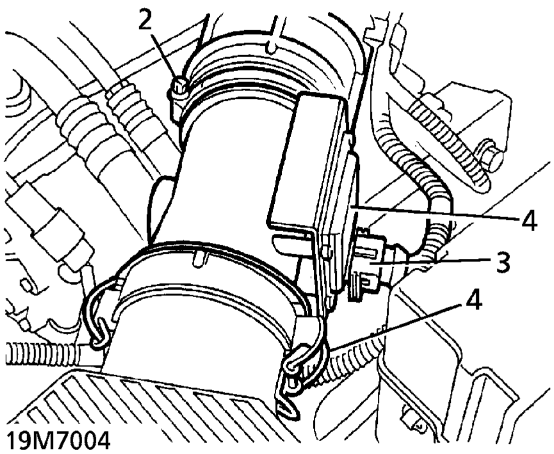
9. Remove cooling fan cowl from new cooling fan.
10. Fit cooling fan cowl to ECM housing and secure with screws.
11. Fit cooling fan to cooling fan cowl and fit multiplug to bracket.
12. Position ECM housing cover and connect ECM cooling fan multiplug.
13. Fit ECM housing cover to main housing and secure with fixings.
14. Position cruise control assembly to EAS housing cover and secure with screws.
15. Connect battery earth lead.
16. Fit battery cover and secure with fixings.

MASS AIR FLOW (MAF) SENSOR - up to 99MY

Service repair no - 19.22.25

Remove

1. Disconnect battery negative lead.
2. Loosen hose clip. Release intake hose from MAF sensor.
3. Disconnect multiplug from MAF sensor.
4. Release 2 clips and remove MAF sensor from air cleaner.



5. Collect 'O' ring seal.

Refit

6. Ensure mating faces of air cleaner, MAF sensor and intake hose are clean.
7. Fit 'O' ring to MAF sensor.
8. Fit MAF Sensor to air cleaner. Secure with clips.
9. Connect multiplug to MAF sensor.
10. Connect intake hose. Secure with clip.

CAUTION: Failure to connect intake hose securely will allow unmetered air to enter the engine, causing running problems.

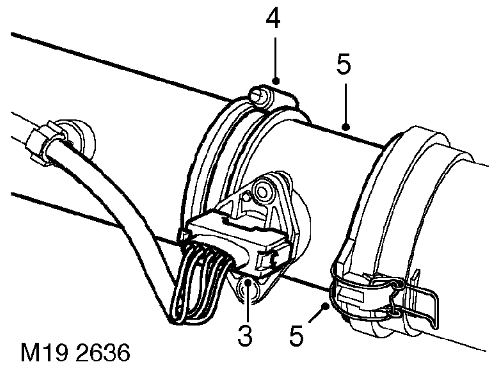
11. Reconnect battery negative lead.

MASS AIR FLOW (MAF) SENSOR - from 99MY

Service repair no - 19.22.25

Remove

1. Release fixings and remove battery cover.
2. Disconnect battery earth lead.



3. Disconnect multiplug from MAF sensor.
4. Loosen clip screw and release air intake hose from MAF sensor.
5. Release 2 clips and remove sensor from air cleaner.

Refit

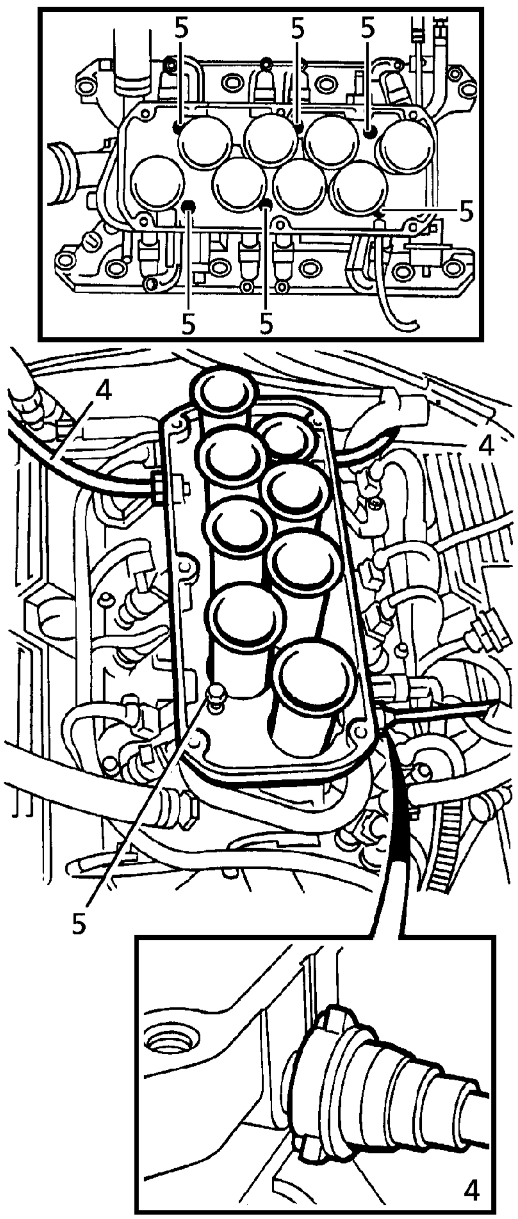
6. Position sensor to air cleaner and secure clips.
7. Position air intake hose and tighten clip screw.
8. Connect multiplug.
9. Connect battery earth lead.
10. Fit battery cover and secure with fixings.

FUEL RAIL AND INJECTORS - up to 99MY

Service repair no - 19.60.04 - Fuel Rail
Service repair no - 19.60.12 - Injectors

Remove

1. Disconnect battery negative lead.
2. Depressurise fuel system. ***See this section.***
3. Release plenum chamber and place aside. ***See this section.***
4. Release purge hose, crankcase breather hose and pressure regulator vacuum hose from ram housing.



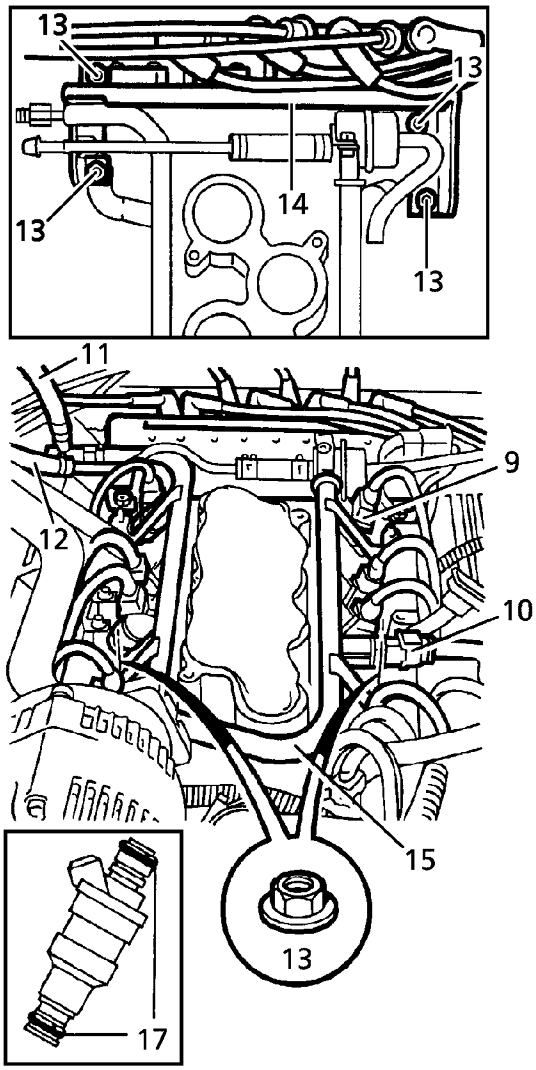
19M7000

5. Remove 6 bolts securing ram housing to inlet manifold.
6. Place small packing block on inlet manifold. Lever between packing block and ram pipe housing to break seal.

CAUTION: Do not lever against fuel rail.

7. Remove ram housing from 2 dowels.
8. Place cloth over inlet manifold to prevent ingress of debris.

9. Disconnect 8 injector multiplugs.

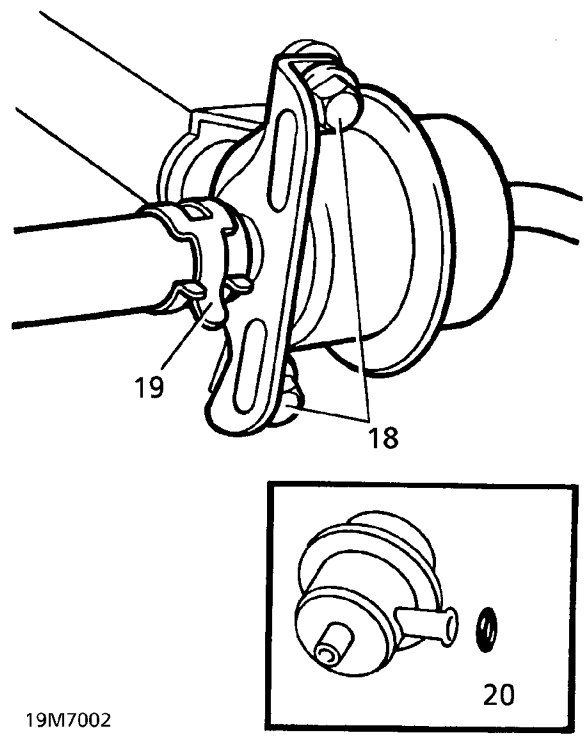


19M7001

10. Disconnect fuel temperature sensor multiplug.
11. Disconnect fuel feed hose from fuel rail.
12. Disconnect fuel return hose from pressure regulator pipe.

NOTE: Advanced EVAPS vehicles have a threaded connection to the return hose.

13. Remove 6 nuts securing fuel rail and ignition coil bracket to inlet manifold.
14. Release ignition coil bracket from inlet manifold studs. Place aside.
15. Release injectors from inlet manifold and remove fuel rail assembly.
    Do not carry out further dismantling if component is removed for access only.
16. Remove 8 clips securing injectors to fuel rail. Remove injectors.



19M7002

17. Remove 2 'O' rings from each injector and discard.
18. Remove 2 screws securing fuel pressure regulator to fuel rail.
19. Release return pipe from clip. Remove pressure regulator assembly.
20. Remove 'O' ring from fuel pressure regulator and discard.

Refit

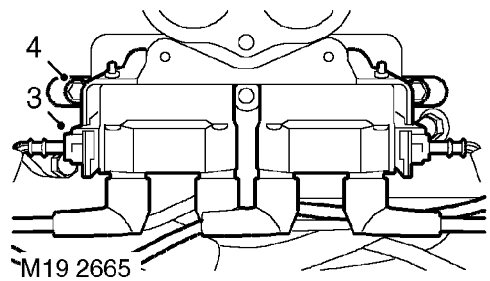
21. Ensure mating surfaces between inlet manifold and ram pipe housing are clean.
22. Ensure all locations in fuel rail and inlet manifold are clean.
23. Fit new 'O' rings to injectors and fuel pressure regulator.
24. Lubricate 'O' rings with silicone grease.
25. Fit fuel pressure regulator to fuel rail. Secure with bolts. Tighten to ***10 Nm (7 lbf.ft)***
26. Engage regulator return pipe in clip.
27. Fit injectors to fuel rail. Secure with clips.
28. Position fuel rail to inlet manifold. Engage injectors, one bank at a time.
29. Position ignition coil bracket on inlet manifold studs.
30. Secure ignition coil bracket and fuel rail to inlet manifold with nuts. Tighten to ***8 Nm (6 lbf.ft)***
31. Connect return hose to pressure regulator pipe. Secure with clip.
32. Connect fuel feed pipe to fuel rail. Tighten union to ***16 Nm (12 lbf.ft)***
33. Connect multiplugs to fuel injectors and fuel temperature sensor.
34. Remove cloth from inlet manifold.
35. Apply a thin, uniform coating of Loctite 577 sealant to mating face of inlet manifold.
36. Fit ram pipe housing to inlet manifold. Secure with bolts. Tighten to ***24 Nm (18 lbf.ft)***
37. Connect purge hose, crankcase breather hose and pressure regulator vacuum hose to ram pipe housing.
38. Fit plenum chamber. ***See this section.***
39. Reconnect battery negative lead.
40. Start engine. Check for leaks around fuel rail and injectors.

FUEL RAIL AND INJECTORS - from 99MY

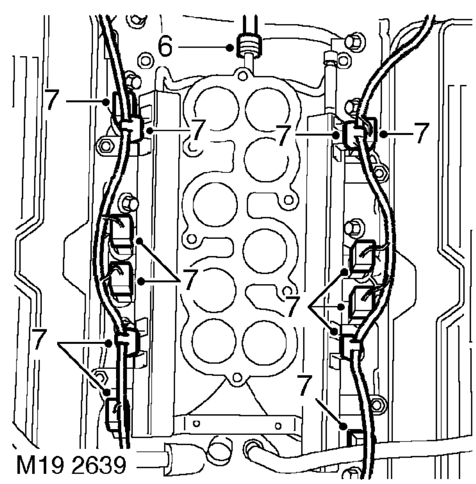
Service repair no - 19.60.04 - Fuel Rail
Service repair no - 19.60.12 - Injectors

Remove

1. Remove upper inlet manifold gasket. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***
2. Release HT leads from clips on rocker covers and from spark plugs.



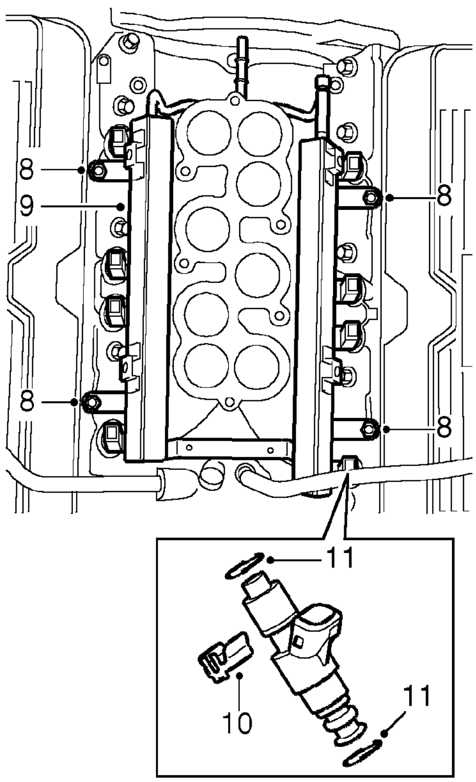
3. Disconnect multiplugs from coils.
4. Remove 2 lower coil fixing bolts and remove coil assembly.
5. Position absorbent cloth beneath fuel pipe to catch spillage.



6. Disconnect fuel feed hose from fuel rail

CAUTION: Plug the connections.

7. Release injector harness clips from fuel rail and disconnect injector multiplugs.



M19 2641

8. Remove 4 bolts securing fuel rail to inlet manifold.
9. Release injectors from inlet manifold and remove fuel rail and injectors.
10. Release spring clips securing injectors to fuel rail and remove fuel injectors.
11. Remove and discard 2 'O' rings from each injector.
12. Fit protective caps to each end of injectors.

Refit

13. Clean injectors and recesses in fuel rail and inlet manifold.
14. Lubricate new 'O' rings with silicone grease and fit to each end of injectors.
15. Fit injectors to fuel rail.
16. Secure injectors to fuel rail with spring clips.
17. Position fuel rail assembly and push-fit each injector into inlet manifold.
18. Fit bolts securing fuel rail to inlet manifold and tighten to ***9 Nm (6 lbf.ft).***
19. Connect fuel feed hose to fuel rail.
20. Connect injector harness multiplugs and secure to fuel rail.
21. Carefully position coil assembly, fit 2 lower fixing bolts but do not tighten at this stage.
22. Connect multiplugs to coils.
23. Fit HT leads to spark plugs and clips on rocker covers.
24. Fit upper inlet manifold gasket. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***

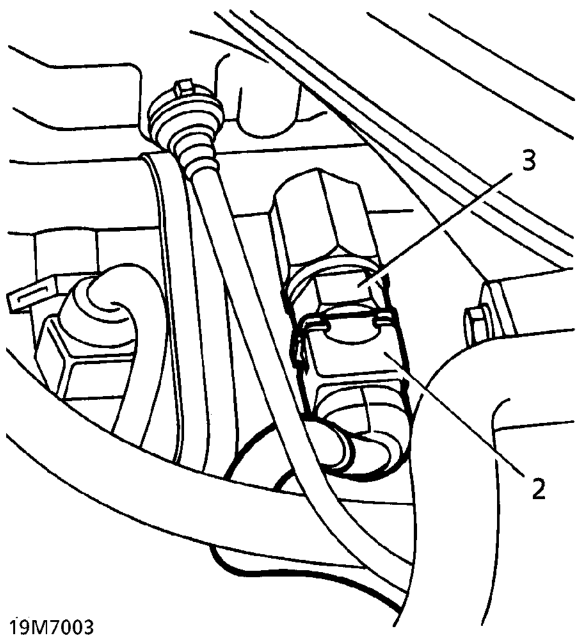
ENGINE FUEL TEMPERATURE (EFT) SENSOR

Service repair no - 19.22.08

Remove

NOTE: Because fuel leakage will not occur when sensor is removed, it is not necessary to depressurise the fuel system for this operation.

1. Disconnect battery negative lead.
2. Disconnect multiplug from fuel temperature sensor.
3. Remove sensor from fuel rail.



Refit

4. Ensure sensor and location in fuel rail are clean.
5. Fit sensor. Tighten to ***17 Nm (13 lbf.ft)***
6. Connect multiplug.
7. Reconnect battery negative lead.

HEATED OXYGEN SENSOR (HO_2S)- FRONT (up to 99MY) AND REAR

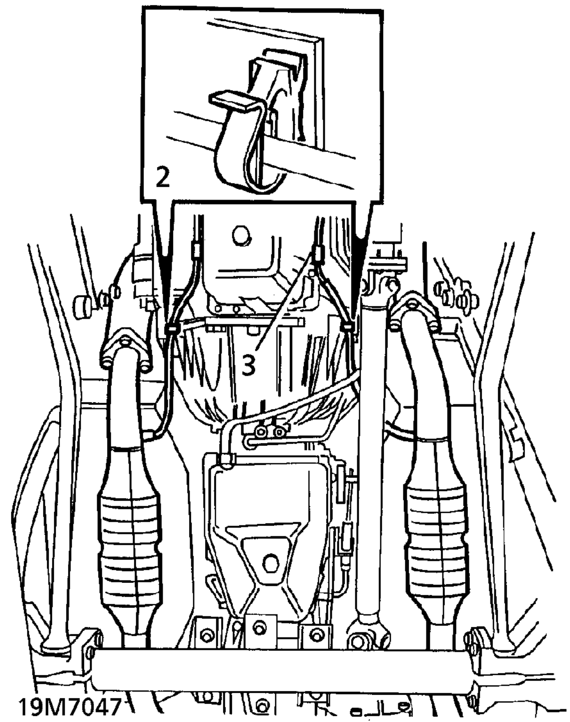
Service repair no - 19.22.16 - Front
Service repair no - 19.22.17 - Rear (NAS Spec. only)

Remove

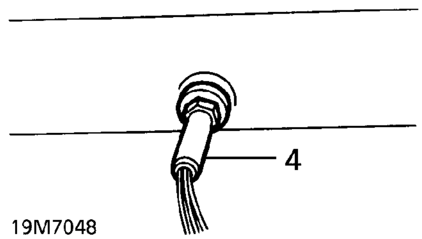
1. Raise the vehicle.

WARNING: Support on safety stands.

2. Remove clip securing HO_2S lead.



3. Release HO_2S multiplug from bracket on sump or transfer gearbox. Disconnect multiplug from engine harness.



CAUTION: Although robust within the vehicle environment, HO_2S sensors are easily damaged by dropping, excessive heat and contamination. Care must be exercised when working on the exhaust system not to damage the sensor housing or tip.

4. Remove sensor from exhaust front pipe. Remove sealing washer and discard.

Refit

5. Ensure mating faces are clean.

NOTE: New HO_2S is supplied pre-treated with anti-seize compound.

6. If refitting existing HO_2S, coat threads with anti-seize compound.

CAUTION: Do not allow anti-seize compound to come into contact with HO_2S nose or enter exhaust system.

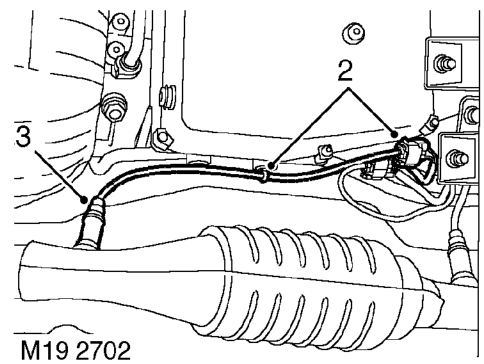
7. Position HO_2S with new sealing washer on exhaust pipe. Tighten to ***20 Nm (15 lbf.ft)***
8. Connect multiplug to engine harness. Secure to bracket.
9. Secure lead in clip.
10. Remove stands. Lower vehicle.

HEATED OXYGEN SENSOR (HO2S) - FRONT - from 99MY

Service repair no - 19.22.16

Remove

1. Raise vehicle on ramp.



2. Release HO_2S harness from clip if fitted, and disconnect HO_2S multiplug.
3. Remove HO_2S from exhaust front pipe.

Refit

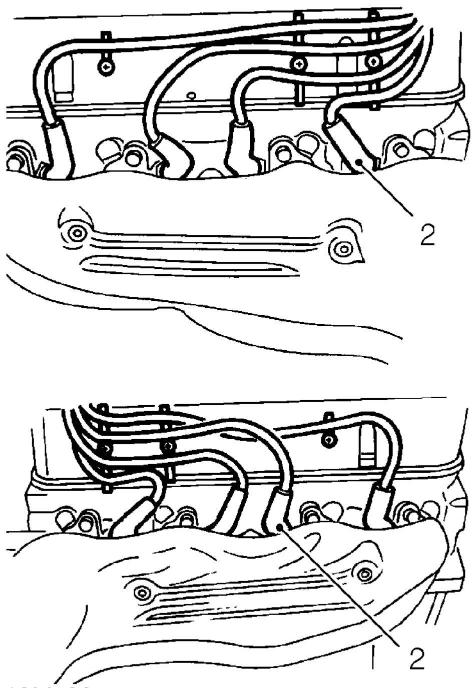
4. If refitting existing HO_2S apply anti-seize compound to threads.
5. Fit new sealing washer to HO_2S.
6. Fit HO2S and tighten to ***45 Nm (33 lbf.ft).***
7. Connect HO_2S multiplug and secure harness to clip.
8. Lower vehicle.

SPARK PLUGS

Service repair no - 18.20.02

Remove

1. Remove air intake hose. ***See this section.***



18M7025

2. Disconnect 8 h.t. leads from spark plugs.

CAUTION: To avoid damage to h.t. leads, disconnect them by pulling the rubber boot NOT the lead.

3. Remove 8 spark plugs and washers from cylinder heads.

Refit

CAUTION: Take care not to cross-thread spark plugs when fitting as costly damage to the cylinder head will result. It is essential that correct type of spark plug is fitted. Incorrect grade of spark plugs may lead to piston overheating and engine failure.

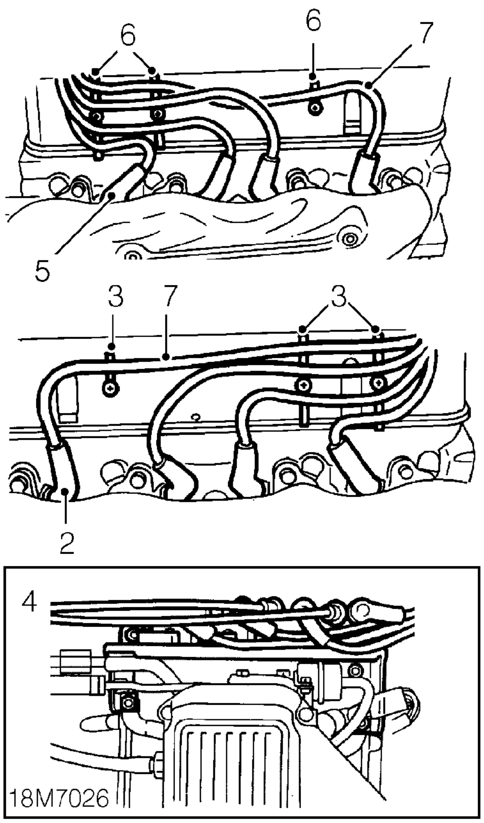
4. Ensure spark plug gaps are between 0.89 - 1.01 mm and set gap if necessary.
5. Fit spark plugs to cylinder heads and tighten to ***20 Nm (15 lbf.ft)***
6. Connect h.t. leads to spark plugs.
7. Fit air intake hose. ***See this section.***

H.T. LEADS

Service repair no - 18.20.11

Remove

1. Remove air intake hose. ***See this section.***



2. Disconnect 4 h.t. leads from LH cylinder head spark plugs.

CAUTION: To avoid damage to h.t. leads, disconnect them by pulling on the rubber boot, NOT the lead.

3. Release h.t. leads from 8 camshaft cover clips.
4. Disconnect 8 h.t. leads from ignition coils.
5. Disconnect 4 h.t. leads from RH cylinder head spark plugs.
6. Release h.t. leads from 8 camshaft cover clips.
7. Remove 8 h.t. leads
8. Remove 4 clips securing h.t. leads to each other.

Refit

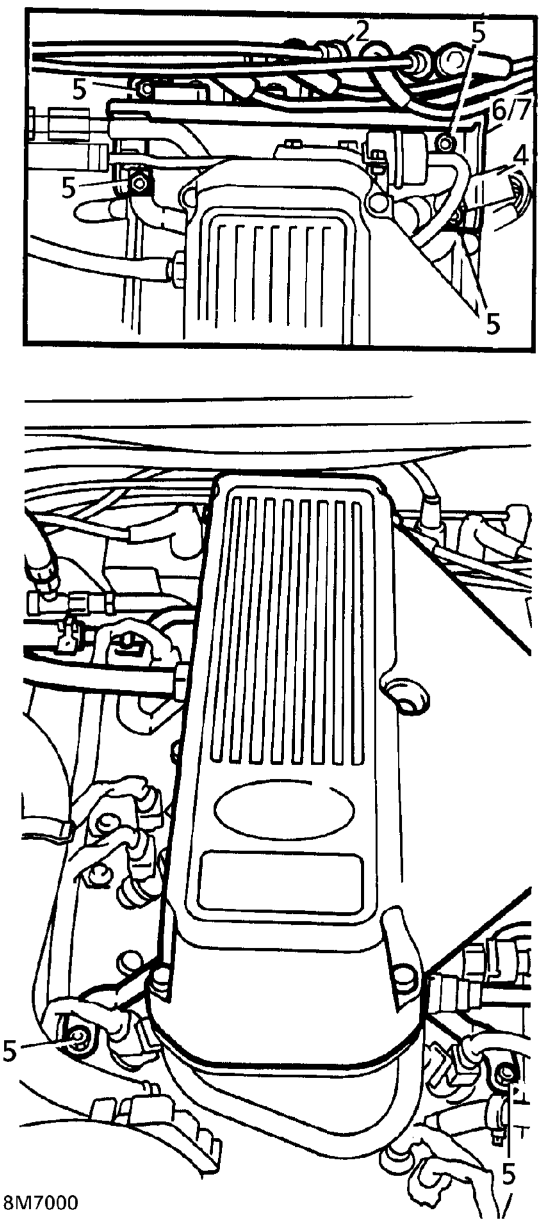
9. Position h.t. leads and connect to ignition coils.
10. Connect h.t. leads to spark plugs.
11. Engage h.t. leads to camshaft cover clips.
12. Fit clips securing h.t. leads to each other.

IGNITION COILS - up to 99MY

Service repair no - 18.20.45 - Set
Service repair no - 18.20.43 - Each
Service repair no - 18.20.44 - Extra - Each

Remove

1. Disconnect battery negative lead.
2. Disconnect H.T. leads from ignition coils. Note positions of leads.
3. Place H.T. leads aside.

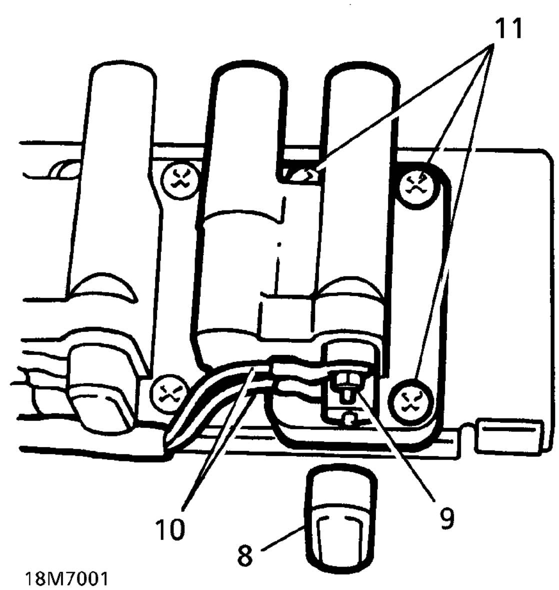


18M7000

4. Disconnect ignition coil multiplug.
5. Remove 6 nuts securing fuel rail and ignition coil bracket to inlet manifold.
6. Lift fuel rail slightly for access. Release ignition coil bracket from inlet manifold studs.

CAUTION: Do not completely withdraw injectors from fitted locations.

7. Remove ignition coils assembly.
8. Remove terminal cover.



18M7001

9. Remove 2 nuts securing wires to coil terminals.
10. Remove wires from terminals. Note wire positions.
11. Remove 3 screws securing ignition coil to bracket. Remove coil.

Refit

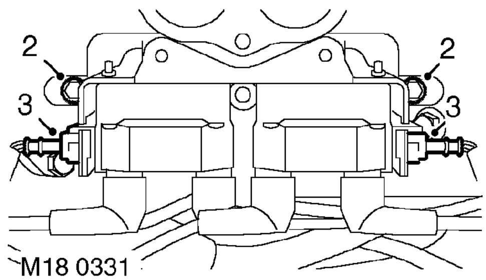
12. Fit ignition coil to bracket. Secure with screws.
13. Connect wires to terminals. Secure with nuts.
14. Fit terminal cover.
15. Position ignition coil bracket on inlet manifold studs.
16. Secure fuel rail and ignition coil bracket with nuts. Tighten to ***8 Nm (6 lbf.ft)***
17. Connect multiplug.
18. Connect H.T. leads to respective coil towers.
19. Reconnect battery negative lead.

IGNITION COILS - from 99MY

Service repair no - 18.20.45

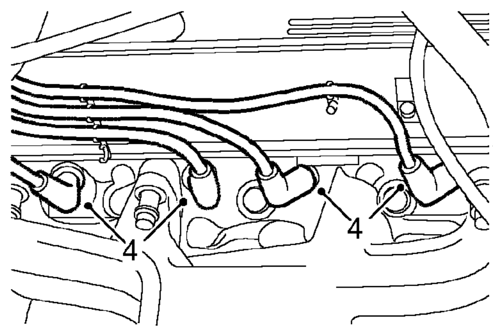
Remove

1. Remove upper inlet manifold gasket. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***



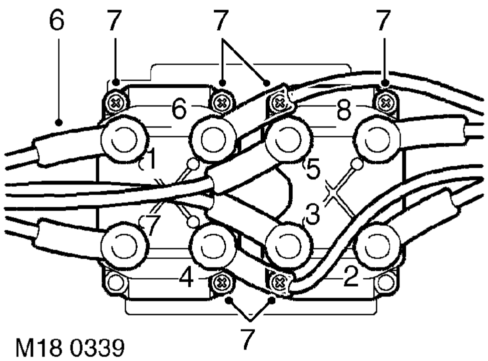
M18 0331

2. Remove 2 lower coil fixing bolts.
3. Disconnect multiplugs from coils.



M18 0351

4. Release HT leads from rocker covers and disconnect HT leads from plugs.
5. Carefully manoeuvre coil assembly from between engine and bulkhead.



M18 0339

6. Noting their fitted position disconnect HT leads from coils.
7. Remove 6 screws securing coils to support bracket and remove coils.

Refit

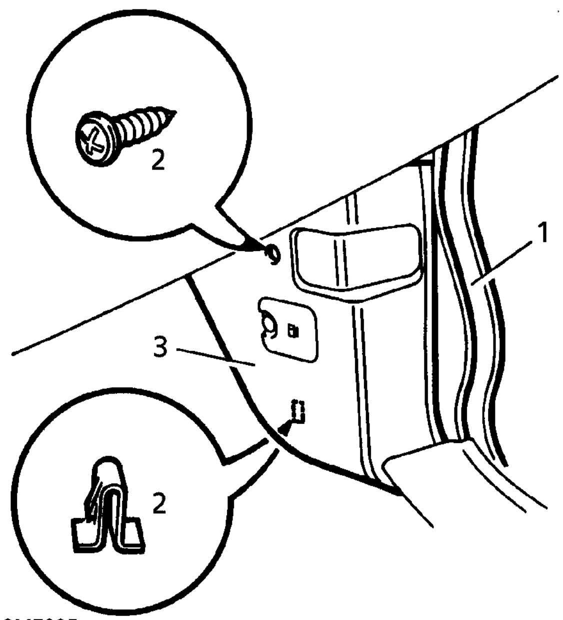
8. Position coils to support bracket, fit and tighten screws.
9. Connect HT leads to coils ensuring they are in the correct position.
10. Carefully position coil assembly between engine and bulkhead.
11. Connect HT leads to plugs and secure HT leads to rocker covers.
12. Connect multiplugs to coils.
13. Fit 2 lower coil fixing bolts but do not tighten at this stage.
14. Fit upper inlet manifold gasket. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***

INERTIA FUEL SHUT OFF (IFS) SWITCH

Service repair no - 19.22.09

Remove

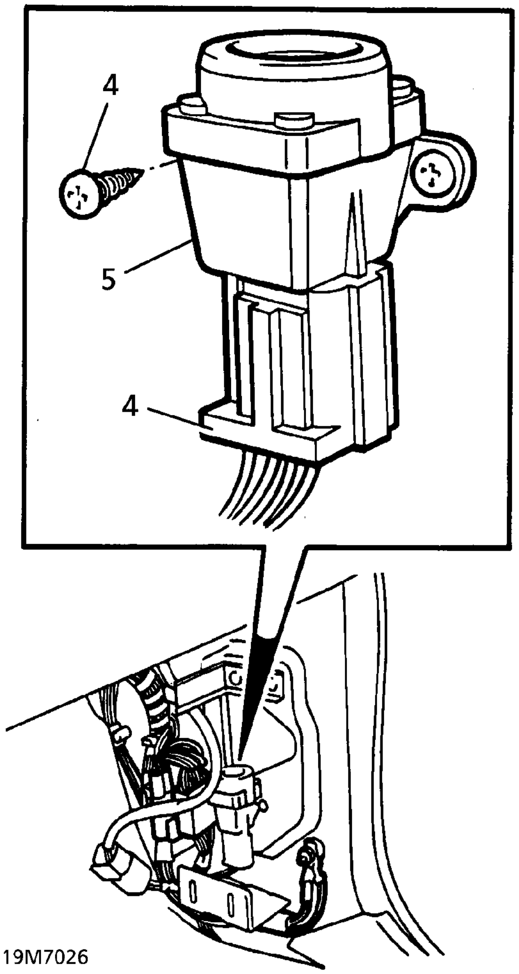
1. Release 300mm of door seal from base of RH 'A' post.



19M7025

2. Remove 'A' post lower finisher securing screw. Remove finisher from sprag clip.
3. Remove RH lower 'A' post finisher.

4. Disconnect multiplug. Remove 2 screws securing IFS switch to 'A' post.
5. Remove IFS switch.



19M7026

Refit

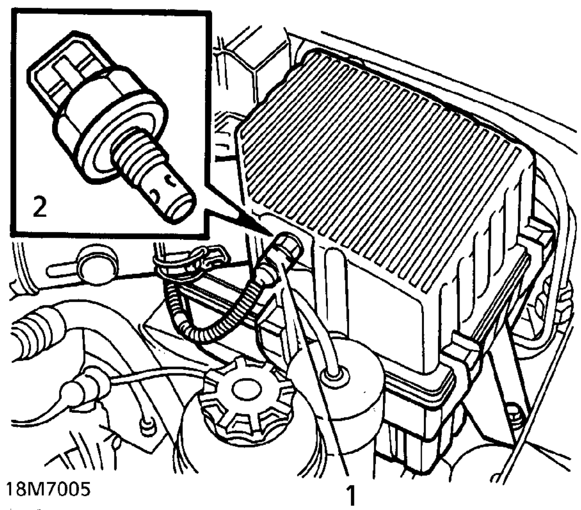
6. Reverse removal procedure.

INTAKE AIR TEMPERATURE (IAT) SENSOR

Service repair no - 18.30.09

Remove

1. Disconnect multiplug from IAT sensor.
2. Remove IAT sensor from air cleaner.



18M7005

Refit

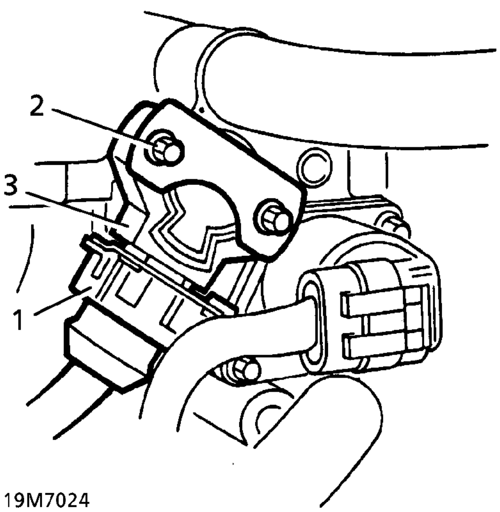
3. Fit IAT sensor. Tighten to ***8 Nm (6 lbf.ft)***
4. Connect multiplug.

THROTTLE POSITION (TP) SENSOR - up to 99MY

Service repair no - 19.22.49

Remove

1. Disconnect multiplug from TP sensor.
2. Remove 2 bolts securing TP sensor. Collect clamp plate.
3. Remove TP sensor.



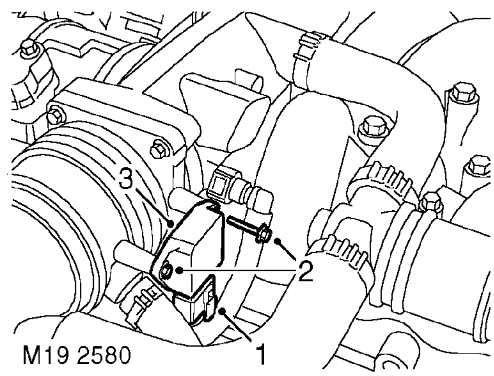
Refit

4. Fit TP sensor. Ensure drive engages correctly with throttle spindle.
5. Position clamp plate. Secure TP sensor with bolts. Tighten to ***2 Nm (1.5 lbf.ft)***
6. Connect multiplug.

THROTTLE POSITION (TP) SENSOR - from 99MY

Service repair no - 19.22.49

Remove



1. Disconnect TP sensor multiplug.
2. Remove 2 bolts securing TP sensor to throttle body.
3. Remove TP sensor and discard 'O' ring.

Refit

4. Clean TP sensor and throttle body mating faces.
5. Using a new 'O' ring, position TP sensor, fit bolts and tighten to ***2.2 Nm (1.5 lbf.ft).***
6. Connect TP sensor multiplug.
7. If fitting new TP sensor, connect Testbook to check for correct operation.

KNOCK SENSOR (KS) - up to 99MY

Service repair no - 18.30.28 - Sensor - LH
Service repair no - 18.30.30 - Sensor - RH

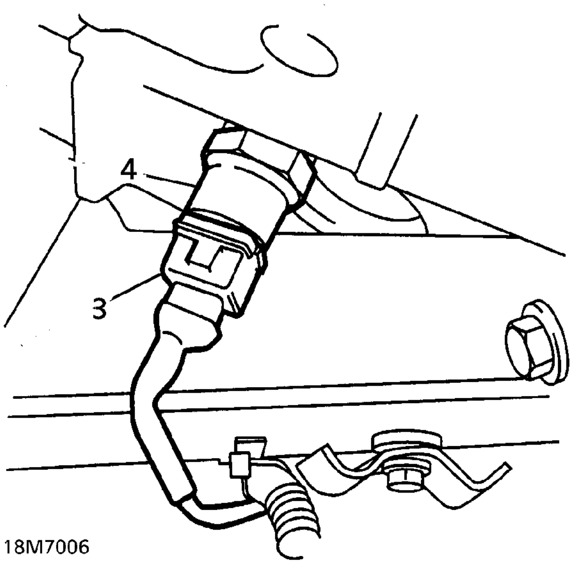
CAUTION: Due to the sensitivity of the sensors, do not apply tape or sealant to sensor threads.

Remove

1. Raise the vehicle.

WARNING: Support on safety stands.

2. **RH Sensor Only:** Remove starter motor. ***See ELECTRICAL, Repair.***
3. Disconnect sensor multiplug.
4. Remove sensor from cylinder block.



18M7006

Refit

5. Ensure sensor location in cylinder block is clean.
6. Fit sensor. Tighten to ***16 Nm (12 lbf.ft)***

CAUTION: Failure to tighten sensor to correct torque will result in malfunction or sensor damage.

7. Connect sensor multiplug.
8. **RH Sensor Only:** Fit starter motor. ***See ELECTRICAL, Repair.***
9. Remove safety stands. Lower vehicle.

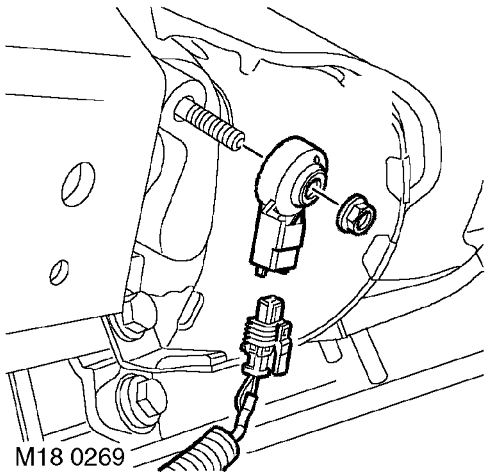
KNOCK SENSOR (KS) - from 99MY

Service repair no - 18.30.28 - Sensor - LH
Service repair no - 18.30.30 - Sensor - RH

Remove

1. Release fixings and remove battery cover.
2. Disconnect battery earth lead.
3. Raise front of vehicle.

WARNING: Support on safety stands.



4. Disconnect multiplug from KS.
5. Remove nut securing KS to cylinder block and remove KS.

Refit

6. Clean mating faces of KS and block.
7. Fit KS to block and tighten nut to ***22 Nm (17 lbf.ft).***
8. Connect multiplug to KS.
9. Remove stand(s) and lower vehicle.
10. Connect battery earth lead.
11. Fit and secure battery cover.

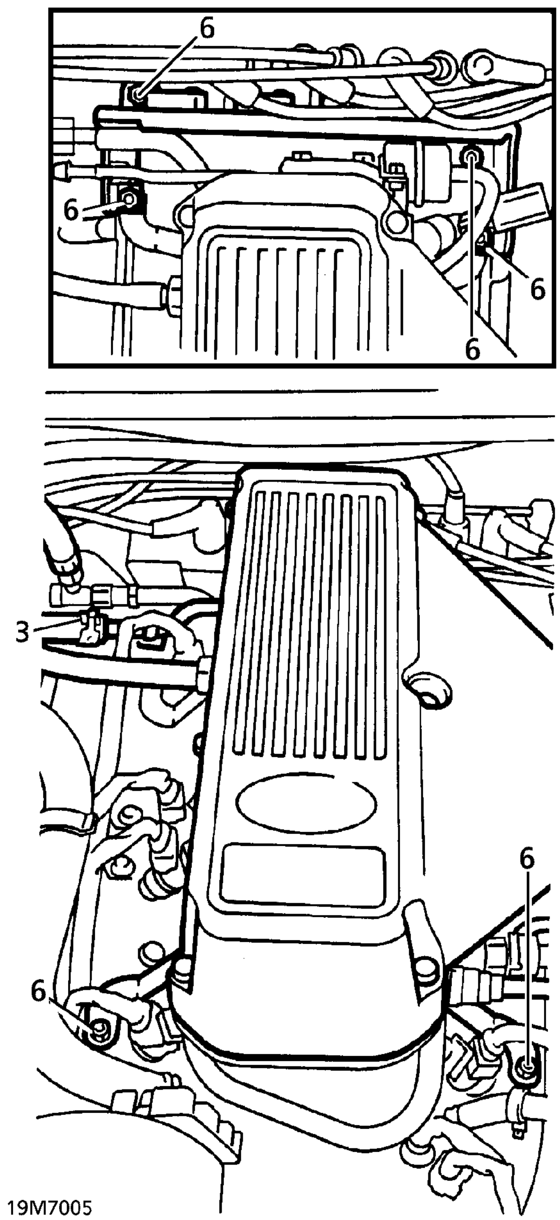
FUEL PRESSURE REGULATOR

Service repair no - 19.45.06

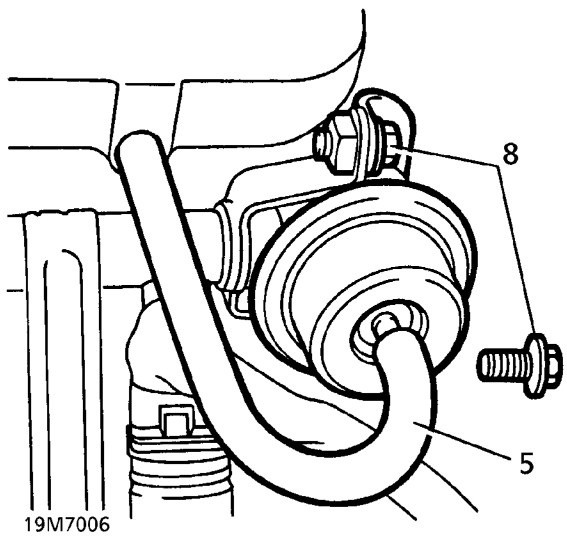
Remove

1. Disconnect battery negative lead.
2. Depressurise fuel system. ***See this section.***
3. Release fuel return pipe clip. Remove fuel return pipe from regulator connecting pipe.

NOTE: Advanced EVAPS vehicles have a threaded connection to the return hose.



4. Release regulator connecting pipe from clip.
5. Disconnect vacuum hose from fuel pressure regulator.

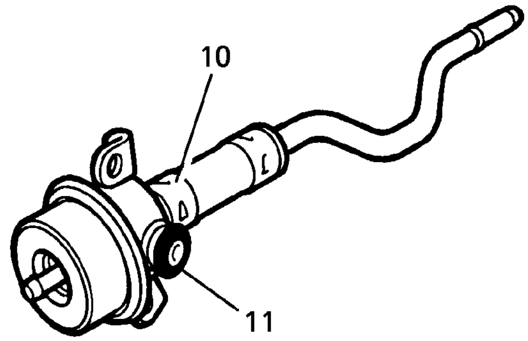


19M7006

6. Remove 6 nuts securing fuel rail and ignition coil bracket to inlet manifold.
7. Lift fuel rail slightly for access. Release ignition coil bracket from inlet manifold studs. Place aside.

CAUTION: Do not completely withdraw injectors from fitted locations.

8. Remove bolts securing fuel pressure regulator to fuel rail.
9. Remove fuel pressure regulator assembly.
10. Release connecting pipe and hose assembly from regulator.



19M7007

11. Remove 'O' ring and spacer ring from fuel pressure regulator. Discard 'O' ring.

Refit

12. Ensure locations on fuel pressure regulator and fuel rail are clean.
13. Fit new spacer ring and 'O' ring to fuel pressure regulator. Lubricate 'O' ring with silicone grease.
14. Fit connecting pipe assembly to fuel pressure regulator. Secure clip.
15. Fit pressure regulator assembly to fuel rail. Secure with bolts. Tighten to ***10 Nm (7 lbf.ft)***
16. Secure regulator connecting pipe in clip.
17. Align ignition coil bracket to inlet manifold studs.
18. Secure ignition coil bracket and fuel rail to inlet manifold with nuts. Tighten to ***8 Nm (6 lbf.ft)***
19. Connect return pipe to regulator connecting pipe. Secure with clip.

NOTE: Advanced EVAPS vehicles have a threaded connection to the return hose.

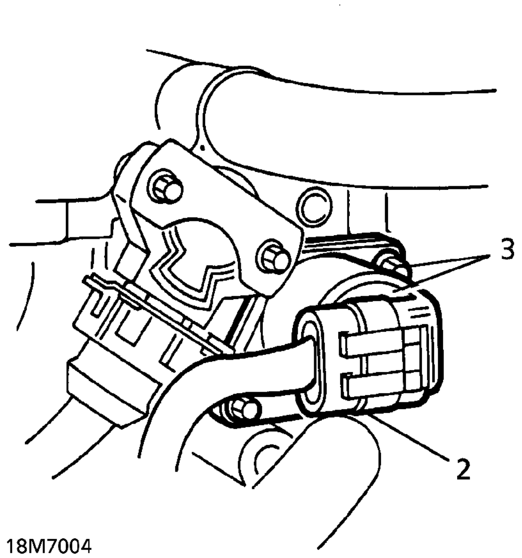
20. Connect vacuum hose to fuel pressure regulator.
21. Reconnect battery negative lead.
22. Start engine. Check for leaks around fuel pressure regulator, fuel feed and fuel return unions.

IDLE AIR CONTROL (IAC) VALVE - up to 99MY

Service repair no - 19.22.54

Remove

1. Disconnect battery negative lead.
2. Disconnect IAC multiplug.
3. Remove 2 bolts, remove IAC. Discard gasket.



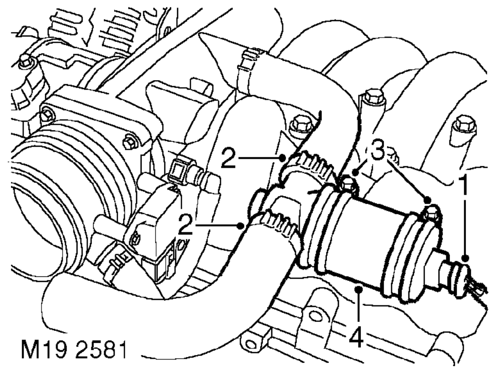
Refit

4. Ensure all mating faces are clean.
5. Using a new gasket, fit IAC. Secure with bolts. Tighten to ***2.3 Nm (2 lbf.ft)***
6. Connect multiplug.
7. Reconnect battery negative lead.

IDLE AIR CONTROL (IAC) VALVE - from 99MY

Service repair no - 19.22.54

Remove



1. Disconnect IAC valve multiplug.
2. Release and remove 2 clips securing air hoses and release hoses.
3. Remove 2 screws securing IAC valve to inlet manifold.
4. Collect IAC valve clamps and remove IAC valve.

Refit

5. Position IAC valve, locate clamps, fit screws and tighten to ***8.5 Nm (6 lbf.ft).***
6. Position air hoses and secure clips.
7. Connect IAC valve multiplug.
8. Connect Testbook to clear any fault codes.

PLENUM CHAMBER - up to 97MY

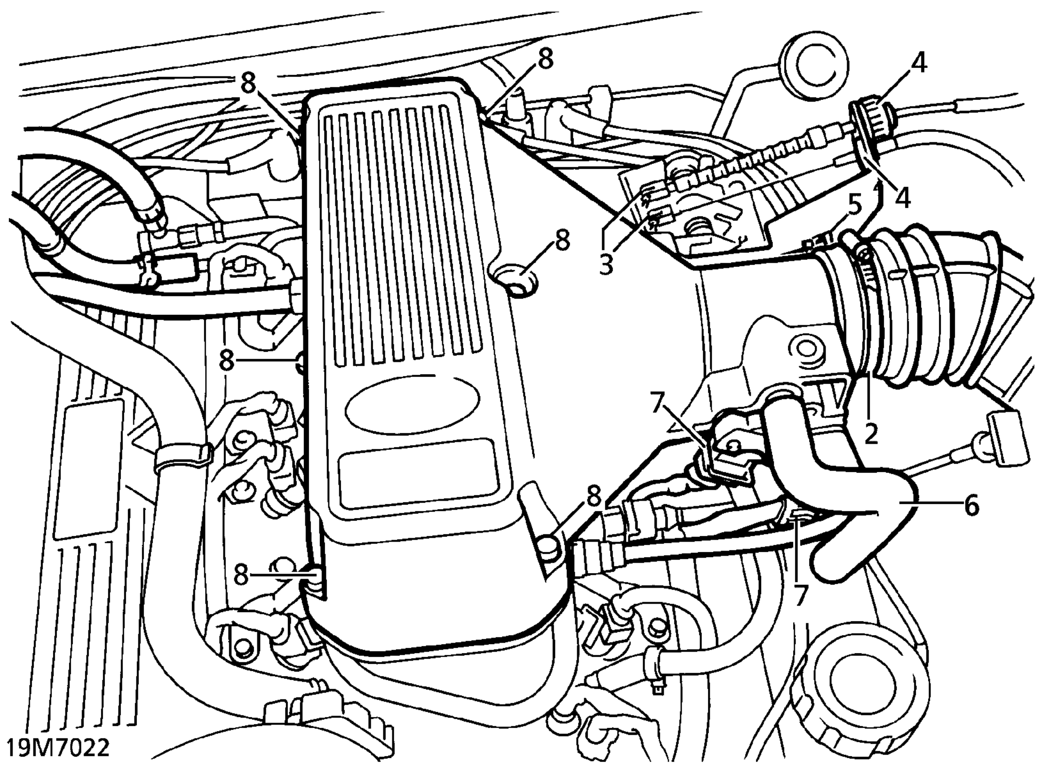
Service repair no - 19.22.46

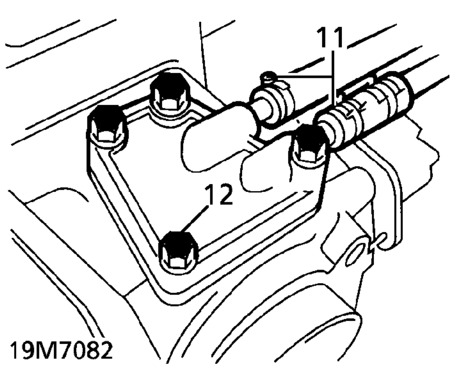
Remove

1. Disconnect battery negative lead.
2. Slacken clip securing intake hose to plenum chamber. Release hose.
3. Remove throttle and cruise control cables from throttle linkage.
4. Remove throttle and cruise control cable from abutment bracket.
5. Release harness clip from throttle linkage bracket.
6. Disconnect breather hose from plenum chamber.
7. Disconnect multiplugs from idle air control (IAC) and throttle position sensor (TP Sensor).
8. Remove 6 bolts securing plenum chamber. Remove plenum chamber from ram pipe housing.
9. Place cloth over ram pipes to prevent ingress of foreign matter.

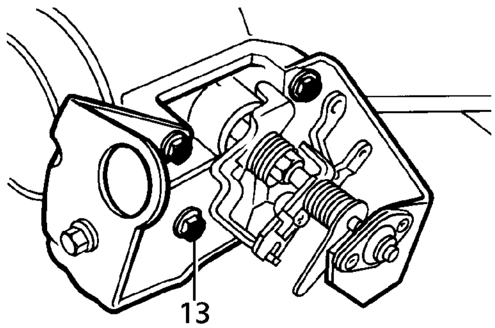
Do not carry out further dismantling if component is removed for access only.

10. Clamp coolant hoses with an approved hose clamp.
11. Disconnect coolant hoses from water jacket. Remove plenum chamber.
12. Remove 4 bolts securing water jacket to plenum chamber. Remove water jacket. Remove gasket and discard.



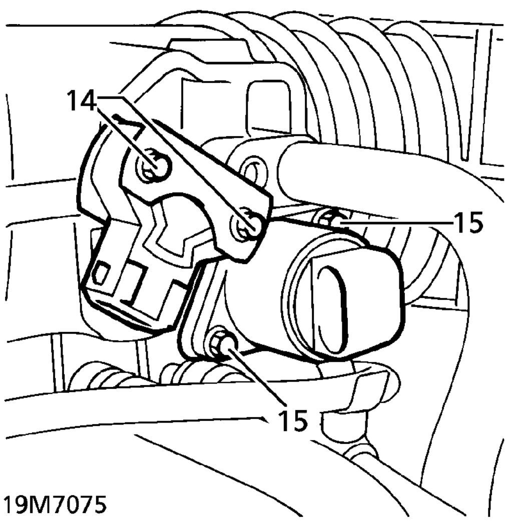


13. Remove 3 bolts securing throttle linkage bracket to plenum chamber. Remove bracket. Collect return spring.



19M7083

14. Remove 2 bolts securing TP sensor. Collect clamp plate. Remove TP sensor.



19M7075

15. Remove 2 bolts securing IAC. Remove motor. Remove gasket and discard.

Refit

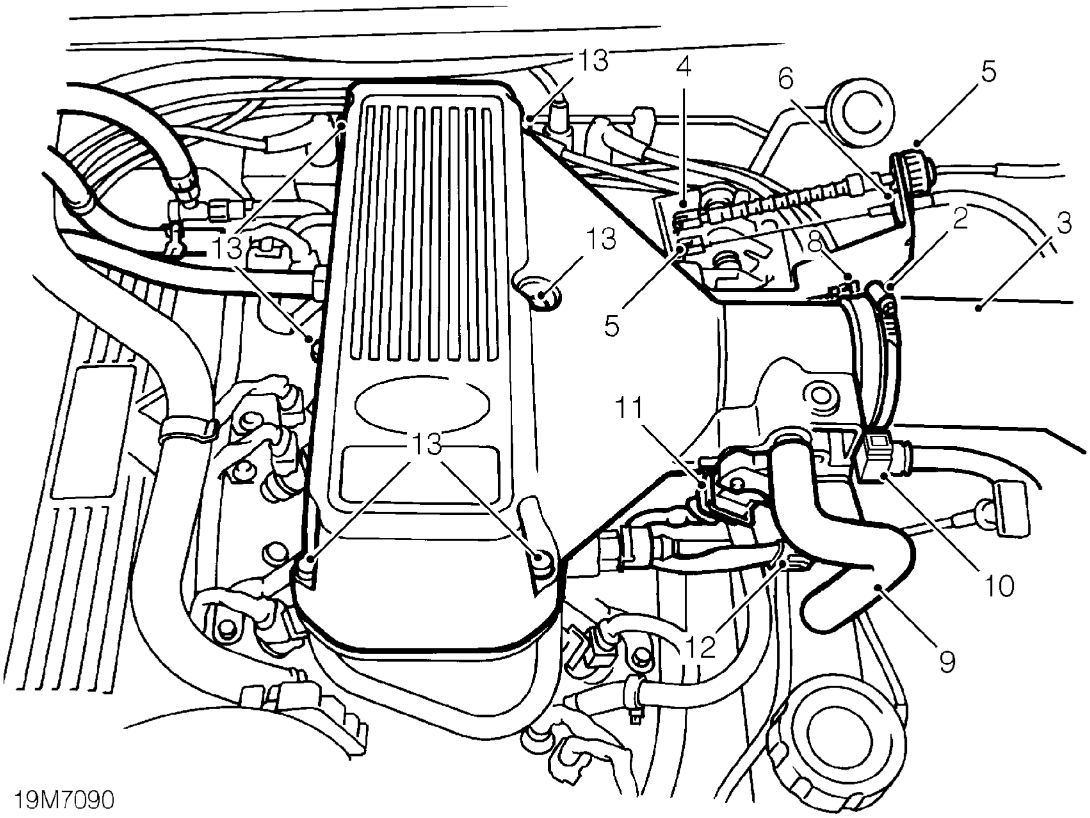
16. Ensure all mating surfaces are clean.
17. Fit TP sensor. Ensure drive engages correctly with throttle spindle.
18. Position clamp plate. Secure TP sensor with bolts. Tighten to ***2 Nm (2 lbf.ft)***
19. Using a new gasket, fit IAC. Secure with bolts. Tighten to ***2.3 Nm (1.8 lbf.ft)***
20. Ensure mating faces of water jacket and plenum chamber are clean.
21. Using a new gasket, fit water jacket. Secure with bolts. Tighten to ***13 Nm (10 lbf.ft)***
22. Position throttle linkage bracket, fit and engage return spring.
23. Secure linkage bracket to plenum chamber with bolts. Tighten to ***8 Nm (6 lbf.ft)***
24. Ensure mating faces of plenum chamber and ram pipe housing are clean.
25. Position plenum chamber. Connect coolant hoses to water jacket. Secure with clips.
26. Remove clamp from coolant pipes.
27. Apply a thin, uniform coating of Loctite 577 sealant to sealing face of plenum chamber.
28. Fit plenum chamber.
29. Fit plenum chamber bolts. Tighten to ***24 Nm (18 lbf.ft)***
30. Connect multiplugs to TP sensor and IAC.
31. Connect breather hose to plenum chamber.
32. Secure harness clip to throttle linkage bracket.
33. Engage throttle cable and cruise control cable to abutment. Secure cruise control cable with 'C' clip.
34. Align cables to throttle linkage. Fit clevis pins. Secure clevis pins with split pins.
35. Adjust throttle cable. ***See Adjustment.***
36. Connect intake hose. Secure with clip.
37. Reconnect battery negative lead.
38. Top up cooling system.
39. Check base idle speed. Adjust if necessary.

If 4.6 ***See ENGINE TUNING DATA, Information.***
If 4.0 ***See ENGINE TUNING DATA, Information.***

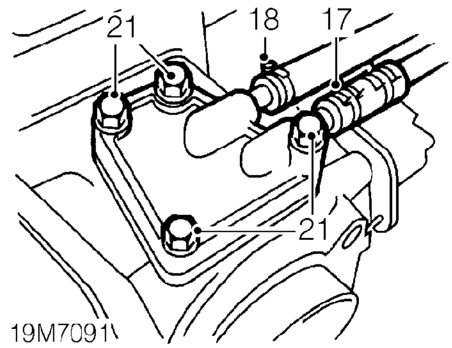
PLENUM CHAMBER - 97MY to 99MY

Service repair no - 19.22.46

Remove



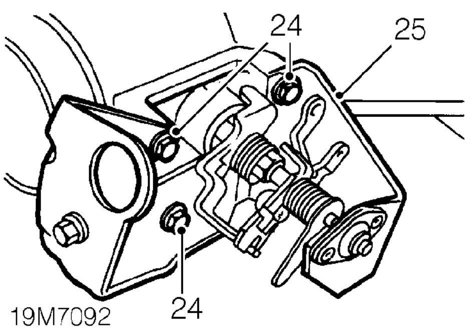
1. Remove battery cover and disconnect battery.
2. Loosen clip securing air intake hose to plenum chamber.
3. Disconnect air intake hose from plenum chamber.
4. Remove split pin and clevis pin securing throttle cable to throttle linkage.
5. Remove split pin and clevis pin securing cruise control cable to throttle linkage and release cable adjuster from abutment bracket.
6. Remove 'C' clip securing cruise control cable abutment to bracket and position cable aside.
7. Release clip securing throttle cable abutment to bracket and position cable aside.
8. Release clip securing harness to cable abutment bracket and position aside.
9. Disconnect breather hose from plenum chamber.
10. Release clip and disconnect purge hose from plenum chamber.
11. Disconnect multiplug from throttle potentiometer.
12. Disconnect multiplug from stepper motor.
13. Remove 6 bolts securing plenum chamber to ram housing.
14. Release plenum chamber from ram housing.
15. Fit hose clamp to 2 plenum chamber coolant hoses.
16. Position cloth to catch spillage.



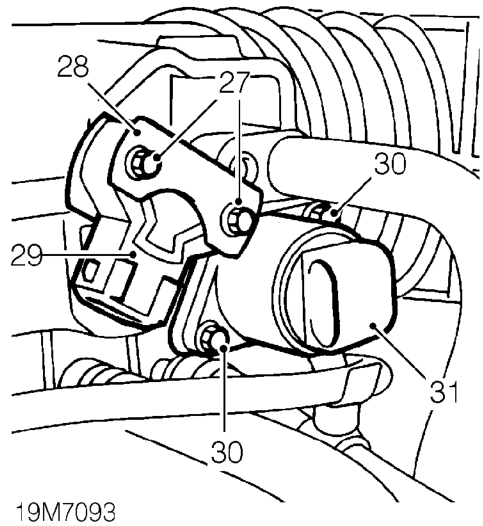
17. Release clip securing coolant hose to plenum water jacket and disconnect hose.
18. Loosen clip securing coolant hose to plenum water jacket and disconnect hose.
19. Remove plenum chamber assembly.
20. Place clean cloth over intake pipes to prevent dirt ingress.

Do not carry out further dismantling if component is removed for access only.

21. Remove 4 bolts securing water jacket to plenum chamber.
22. Remove water jacket and sealing gasket.
23. Position throttle linkage to gain access to bolt.



24. Remove 3 bolts securing throttle linkage to plenum chamber.
25. Remove throttle linkage and bracket.
26. Collect spring.



27. Remove 2 bolts securing throttle potentiometer to plenum chamber.
28. Collect clamp plate.
29. Remove throttle potentiometer.
30. Remove 2 bolts securing stepper motor to plenum chamber.
31. Remove stepper motor and collect gasket.
32. Position throttle linkage bracket and spring to plenum chamber.
33. Engage spring to linkage.
34. Fit bolts securing throttle linkage to plenum and tighten to ***8 Nm (6 lbf.ft)***
35. Clean mating faces of throttle potentiometer and stepper motor.
36. Fit throttle potentiometer, ensuring spindle is correctly engaged.
37. Fit retaining plate and bolts and tighten to ***2 N. (1.5 lbf.ft)***
38. Fit NEW stepper motor gasket to plenum chamber.
39. Fit stepper motor.
40. Fit bolts securing stepper motor to plenum chamber and tighten to ***2 Nm (1.5 lbf.ft)***
41. Clean mating faces of water jacket and plenum chamber.
42. Fit NEW water jacket gasket to plenum chamber.
43. Fit water jacket to plenum chamber.
44. Fit bolts securing water jacket to plenum chamber and tighten to ***13 Nm (10 lbf.ft)***

Refit

45. Clean mating faces of plenum chamber and ram housing.
46. Connect coolant hose to water jacket and secure with clip.
47. Connect second coolant hose to water jacket and secure with clip.
48. Remove hose clamps.
49. Apply a thin, uniform coating of Loctite 577 sealant to mating face of plenum chamber.
50. Fit plenum chamber to ram housing.
51. Fit bolts securing plenum chamber to ram housing and tighten to ***24 Nm (18 lbf.ft)***
52. Connect multiplugs to stepper motor and throttle potentiometer.
53. Connect purge hose to plenum chamber. Ensure connector is securely mated.
54. Connect breather hose to plenum chamber.
55. Position harness to throttle linkage bracket and secure clip.
56. Engage throttle cable abutment clip to bracket.
57. Align throttle cable to throttle linkage, fit clevis pin and split pin.
58. Position cruise control cable abutment to bracket and secure with 'C' clip.
59. Align cruise control cable to throttle linkage, fit clevis pin and split pin.
60. Adjust throttle cable. ***See Adjustment.***
61. Connect air intake hose to plenum chamber and secure with clip.
62. Connect battery and fit cover.
63. Top up cooling system.
64. Check base idle speed. Adjust if necessary.

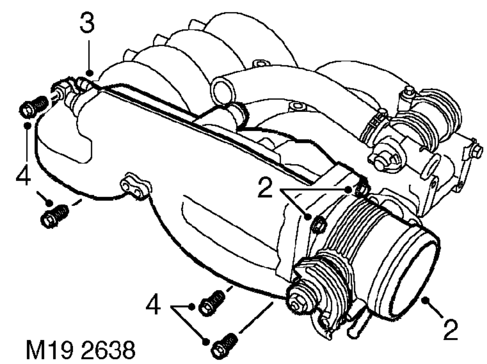
If 4.6 ***See ENGINE TUNING DATA, Information.***
If 4.0 ***See ENGINE TUNING DATA, Information.***

PLENUM CHAMBER - from 99MY

Service repair no - 19.22.46

Remove

1. Remove upper inlet manifold gasket. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***



2. Remove 4 bolts securing throttle body to plenum chamber, remove throttle body and collect gasket.
3. Remove breather hose adaptor.
4. Remove 4 bolts securing plenum chamber to upper manifold and remove plenum chamber.
5. Collect plenum chamber gaskets.

Refit

6. Clean plenum chamber and upper manifold mating faces.
7. Using new gaskets, position plenum chamber, fit bolts and tighten to ***22 Nm (16 lbf.ft).***
8. Fit and tighten breather adaptor to ***6 Nm (4.5 lbf.ft).***
9. Clean plenum chamber and throttle body mating faces.
10. Using a new gasket, position throttle body, fit bolts and tighten to ***9 Nm (6 lbf.ft).***
11. Fit upper inlet manifold gasket. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***

FUEL FILTER

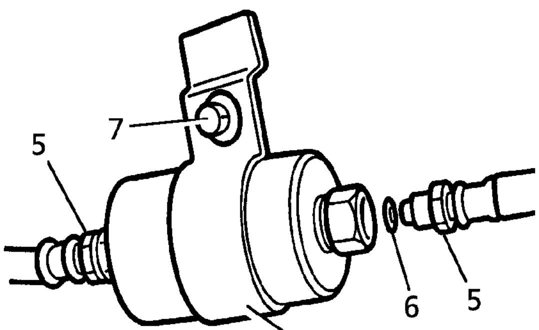
Service repair no - 19.25.02

Remove

1. Disconnect battery negative lead.
2. Depressurise fuel system. ***See this section.***
3. Raise the vehicle.

WARNING: Support on safety stands.

4. Position container beneath fuel filter to catch spillage.
5. Disconnect fuel hoses from filter.



6. Remove 'O' rings and discard.
7. Remove bolt securing filter and strap assembly. Remove assembly.

Refit

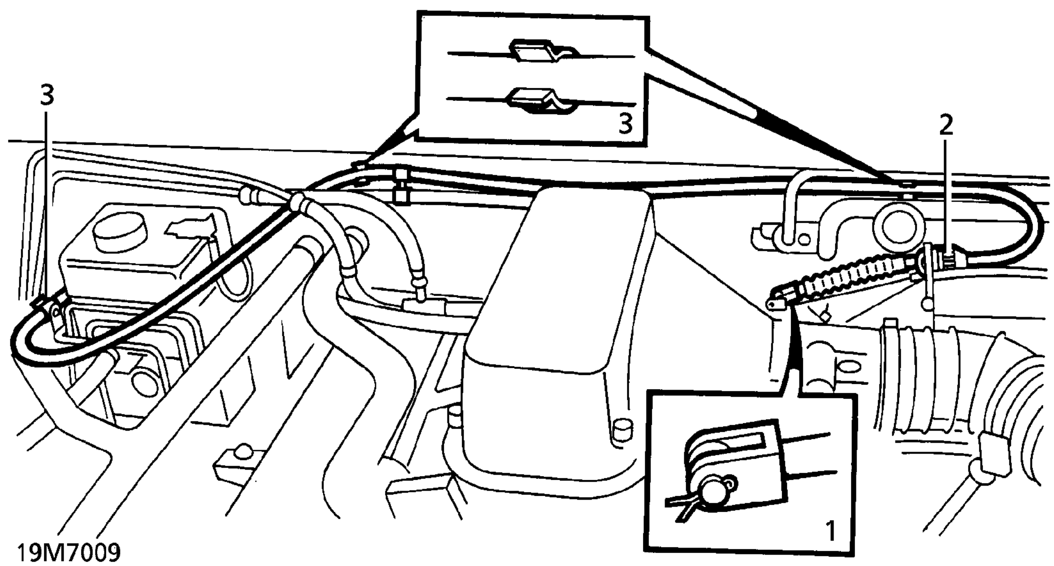
8. Transfer strap to new fuel filter.
9. Position filter and strap assembly to floor pan. Ensure that flow arrow points toward front of vehicle.
10. Secure filter strap with bolt.
11. Using new 'O' rings, connect fuel hoses to filter. Tighten to ***20 Nm (15 lbf.ft)***
12. Remove container beneath filter.
13. Remove safety stands. Lower vehicle.
14. Reconnect battery negative lead.

THROTTLE CABLE - up to 99MY

Service repair no - 19.20.06

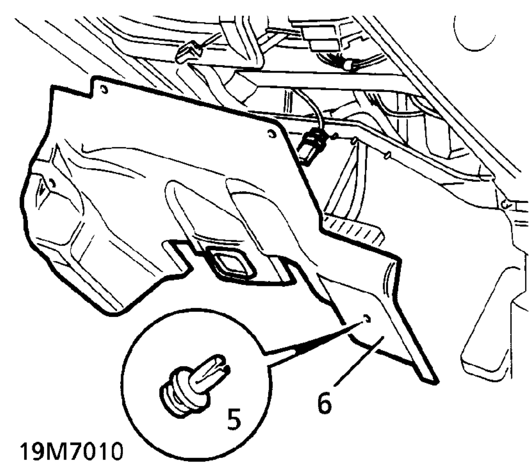
Remove

1. Remove split pin and clevis pin securing cable to throttle linkage.



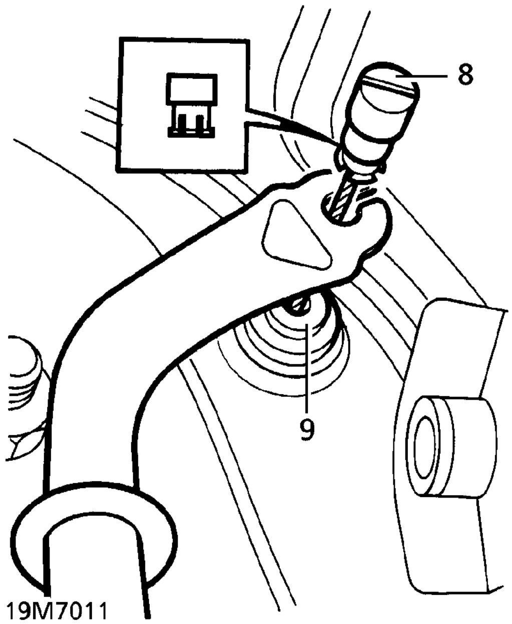
19M7009

2. Release cable adjuster from abutment bracket.
3. Release cable from 3 clips along bulkhead and single clip on brake booster bracket.
4. Remove driver's side fascia closing panel. ***See CHASSIS AND BODY, Repair.***
5. Remove 3 scrivet fasteners securing lower closing panel.
6. Release panel for access to blower motor ducting.



19M7010

7. Release ducting from blower motor housing and heater. Remove blower motor ducting.
8. Release cable from throttle pedal.
9. Release cable outer from bulkhead location. Remove throttle cable assembly.



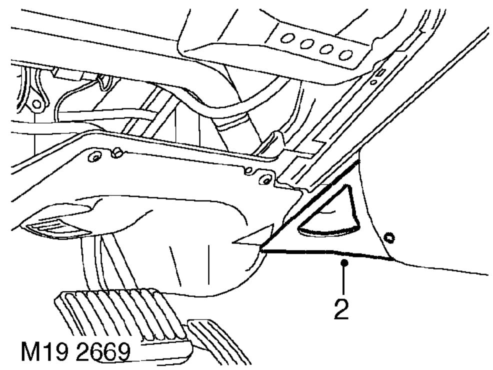
Refit

10. Lubricate bulkhead end of outer cable with liquid soap to aid fitment.
11. Fully engage cable outer into bulkhead location. Connect cable to throttle pedal.
12. Position blower ducting. Engage onto heater and blower motor housing locations.
13. Position lower closing panel. Secure with scrivet fasteners.
14. Fit driver's side fascia closing panel. ***See CHASSIS AND BODY, Repair.***
15. Route cable along bulkhead. Secure to clips
16. Engage cable adjuster to abutment bracket.
17. Align cable trunnion to throttle linkage. Secure with clevis pin and split pin.
18. Check and adjust throttle cable free-play. ***See Adjustment.***

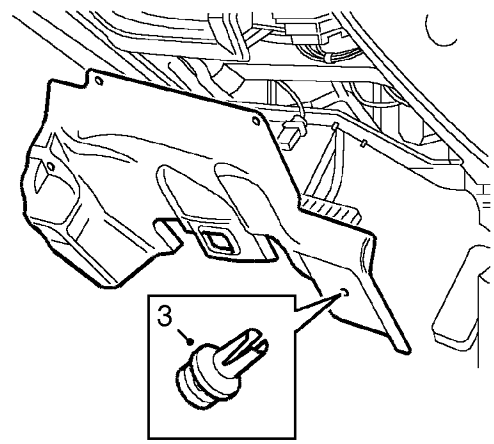
THROTTLE CABLE - from 99MY

Service repair no - 19.20.06

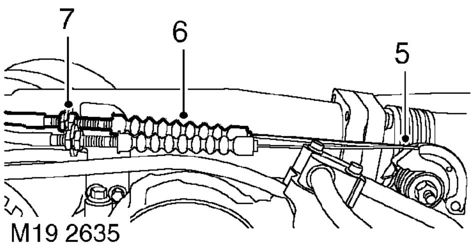
1. Remove closing panel from fascia. ***See CHASSIS AND BODY, Repair.***



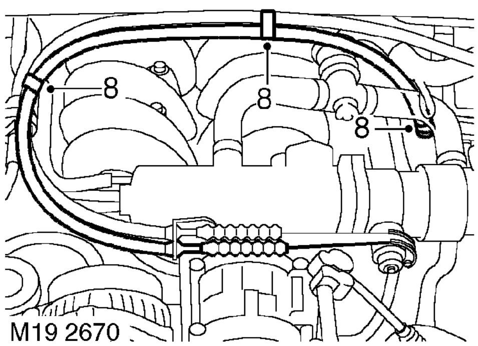
2. Remove screw and remove heater outlet duct.



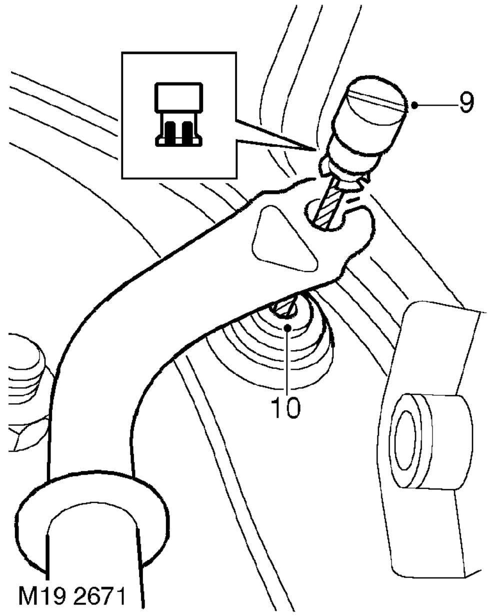
3. Remove 4 scrivets and remove access panel from fascia.
4. Release and remove heater air duct for access to throttle pedal lever.



5. Disconnect inner cable from throttle cam.
6. Release cable gaiter.
7. Loosen locknuts and disconnect throttle cable from abutment bracket.



8. Release throttle cable from 3 clips.



9. Release and disconnect inner cable from throttle lever.
10. Release throttle cable from bulkhead and remove from vehicle.

Refit

11. Apply liquid soap to bulkhead end of outer cable.
12. Fit throttle cable to bulkhead, connect and secure inner cable to pedal lever.
13. Fit throttle cable to abutment bracket and connect inner cable to throttle cam.
14. Fit throttle cable to clips.
15. Adjust throttle cable. ***See Adjustment.***
16. Secure gaiter to outer cable.
17. Refit heater air duct.
18. Fit closing panel and secure with scrivets.
19. Fit heater outlet duct and secure with screw.
20. Fit closing panel to fascia. ***See CHASSIS AND BODY, Repair.***

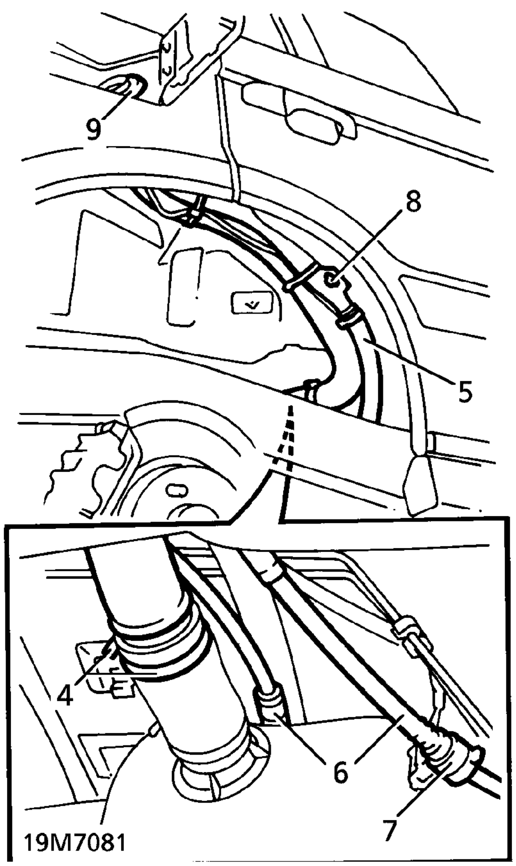
FILLER NECK ASSEMBLY - PRE-ADVANCED EVAPS

Service repair no - 19.55.07

WARNING: If fuel tank is full, fuel level will be above filler neck aperture in the tank. If gauge indicates over 75%, drain a minimum of 10 litres of fuel from tank.

Remove

1. Disconnect battery negative lead.
2. Remove rear wheel arch liner. ***See CHASSIS AND BODY, Repair.***
3. Remove fuel filler cap.
4. Slacken clips securing hoses to filler neck.



5. Release fill breather hose from filler neck.
6. **Petrol Models Only:** Disconnect fuel tank and charcoal canister hoses from vapour separator.
7. **Diesel Models Only:** Release cap from quick release connector. Disconnect breather hose.
8. Remove nut securing filler neck to wheel arch.
9. Release filler neck from fuel tank hose and grommet in body aperture.
10. Remove filler neck assembly.

Refit

11. Apply liquid soap to grommet and mating surface of filler neck.
12. Reverse removal procedure.

FUEL FILLER NECK - ADVANCED EVAPS

Service repair no - 19.55.07

Remove

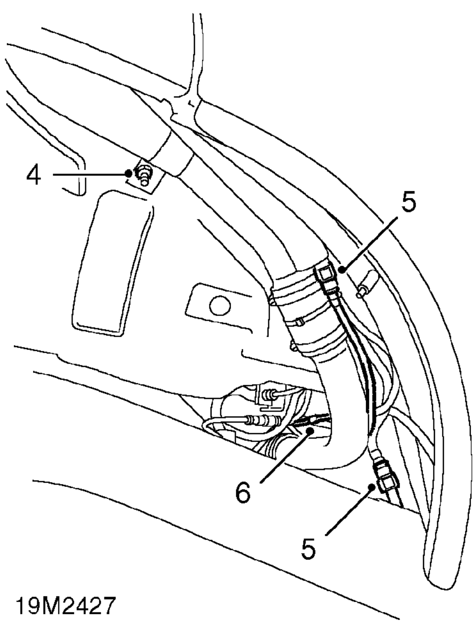
WARNING: Ensure that fuel handling precautions given in 01 - Introduction are strictly adhered to when carrying out following instructions.

WARNING: If the fuel tank is full, the fuel level may be close to the filler neck aperture. If gauge indicates over 75%, drain a minimum of 10 litres (2.6 US Gallons) from fuel tank. ***See Adjustment.***

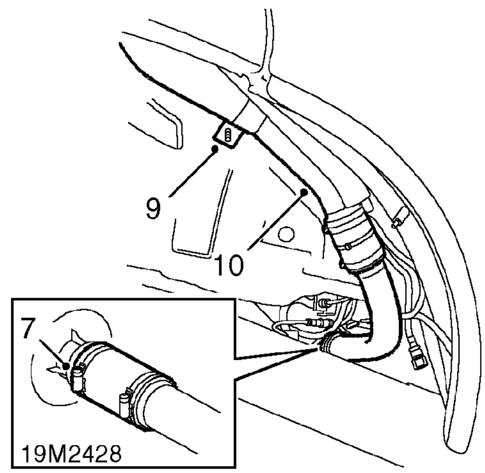
CAUTION: before disconnecting any part of the system, it is imperative that all dust, dirt and debris is removed from around components to prevent ingress of foreign matter into fuel system.

Remove

1. Open fuel filler flap and remove filler cap.
2. Disconnect battery earth lead.
3. Remove RH rear wheel arch liner. ***See CHASSIS AND BODY, Repair.***
4. Remove nut securing filler neck bracket to stud.
5. Disconnect vent line quickfit connectors at fuel/vapour separator and under body connection.
6. Disconnect pressure sensor breather pipe connection.



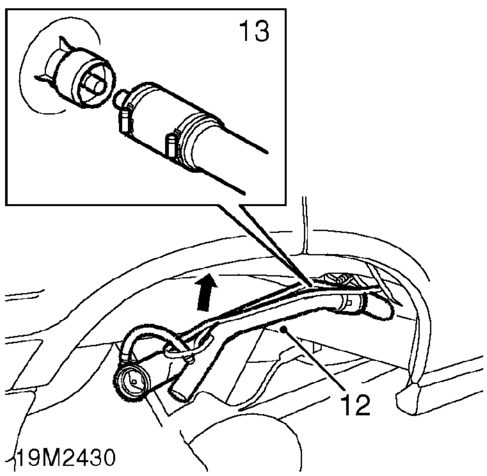
7. Remove shear cap from clip securing neck assembly to tank.
8. Slacken clip securing neck assembly to tank.
9. Release filler neck bracket from body stud. Push filler neck down then forwards to release from aperture grommet.
10. Remove filler neck assembly.



Refit

CAUTION: Hose clips used on the filler neck of advanced EVAPS vehicles have a special 'shear' cap to ensure the correct tightening torque is achieved. Always use NEW clips of the correct type.

11. Loosely position new clip to filler neck hose.
12. Position filler neck assembly to fuel tank stub, rotated anti-clockwise as shown.
13. Engage internal breather hose to fuel tank inner stub.



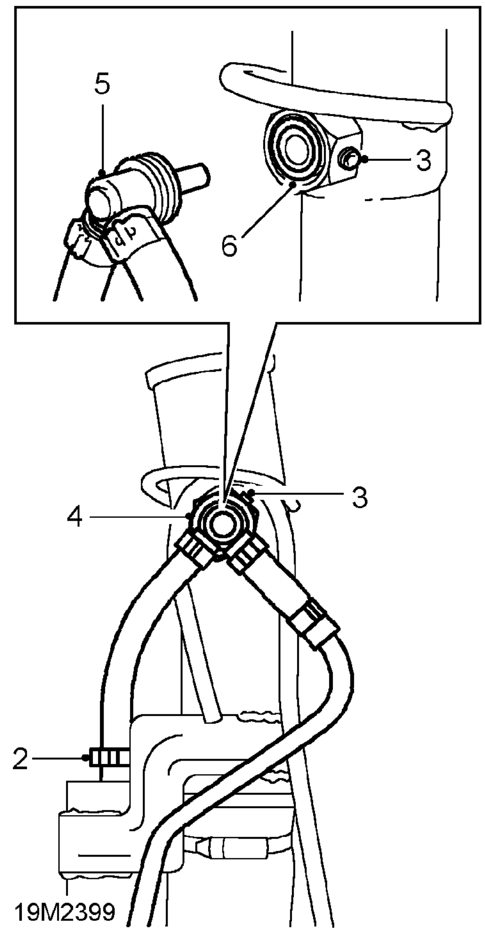
14. Engage filler neck hose with fuel tank stub.
15. Manoeuvre filler neck into position and engage with grommet.
16. Engage filler neck bracket with body stud and secure with nut.
17. Tighten clip securing hose to fuel tank stub until cap shears off.
18. Connect vent lines to fuel/vapour separator and under floor connection, ensuring that quickfit connections fully engage.
19. Connect pressure sensor breather line.
20. Replenish fuel if necessary.
21. Fit filler cap and tighten in accordance with instructions.
22. Close filler flap.
23. Connect battery earth lead.

ANTI-TRICKLE FILL VALVE - ADVANCED EVAPS

Service repair no - 19.55.31

Remove

1. Remove the fuel filler neck. ***See this section.***



2. Release the cobra clip securing the hose to the liquid/vapour separator and disconnect the hose.
3. Loosen the grub screw on the valve nut, two complete turns.
4. Loosen the valve nut completely.

NOTE: The nut is held captive by the stub pipe on the filler neck.

5. Carefully remove the valve and hose assembly from the filler neck

Refit

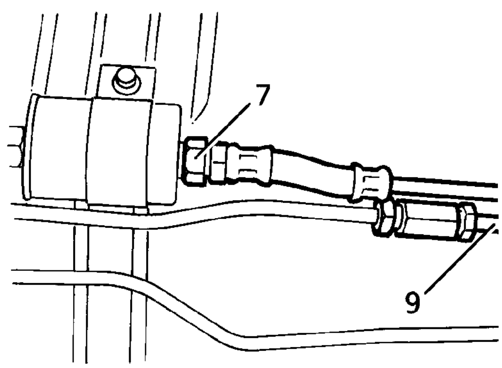
6. Fit a new 'O' ring to the recess in the stub pipe.
7. Fit the valve and hose assembly to the filler neck stub pipe, ensuring that the 'O' ring is fitted around the body of the valve as it is pushed into the filler neck stub pipe.
8. Hand tighten the nut, then tighten to ***3 Nm***
9. Tighten the grub screw to ***2 Nm***
10. Connect the hose to the liquid/vapour separator and secure with the cobra clip.
11. Fit the fuel filler neck. ***See this section.***

FUEL TANK, PUMP AND GAUGE SENDER UNIT - PRE-ADVANCED EVAPS

Service repair no - 19.55.01 - Fuel Tank
Service repair no - 19.45.08 - Fuel Pump
Service repair no - 88.25.32 - Fuel gauge Tank Unit

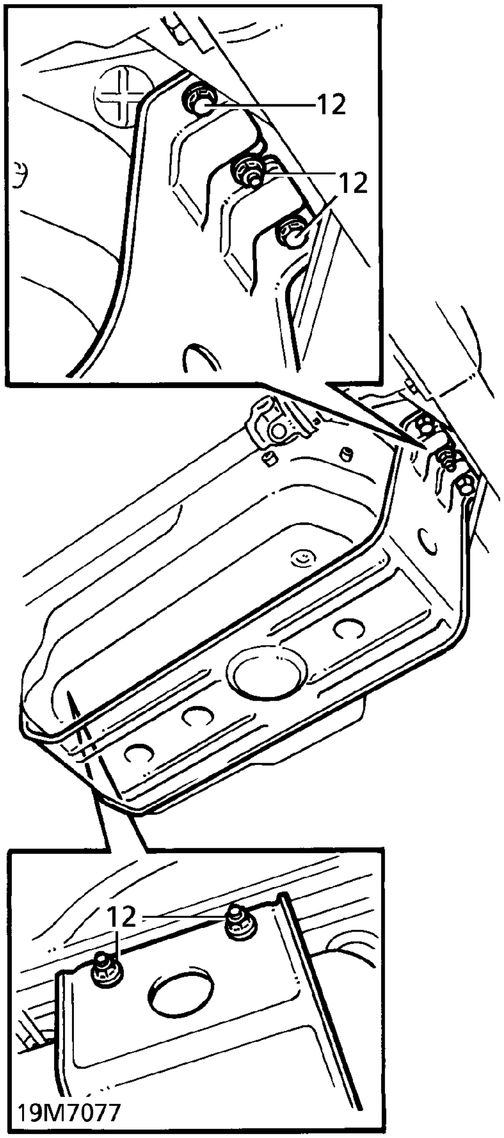
Remove

1. Disconnect battery negative lead.
2. **Petrol Models Only:** Depressurise fuel system. ***See this section.***
3. Remove contents of fuel tank into an approved closed container.
4. Remove fuel filler neck. ***See this section.***
5. Raise vehicle on four post lift.
6. Position container beneath fuel filter to catch spillage.
7. **Petrol Models Only:** Disconnect feed pipe from fuel filter.
8. **Diesel Models Only:** Disconnect feed pipe at connection, forward of fuel tank.

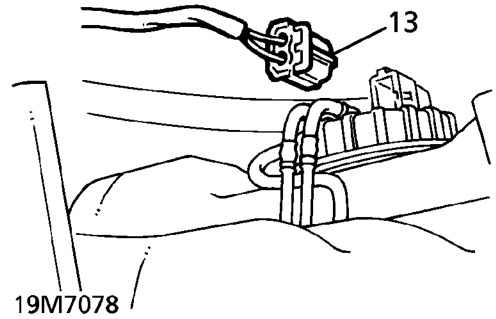


19M7076

9. Disconnect return pipe, forward of tank.
10. Plug pipes and connections.
11. Support tank with jack.
12. Remove 3 nuts and 2 bolts securing tank cradle to floor pan.



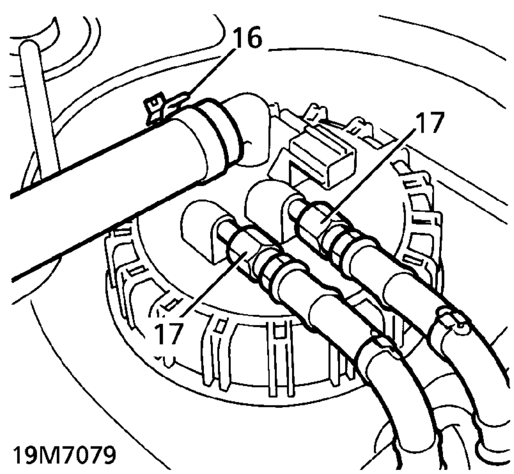
13. Lower tank by 150mm. Disconnect multiplug from fuel tank unit.



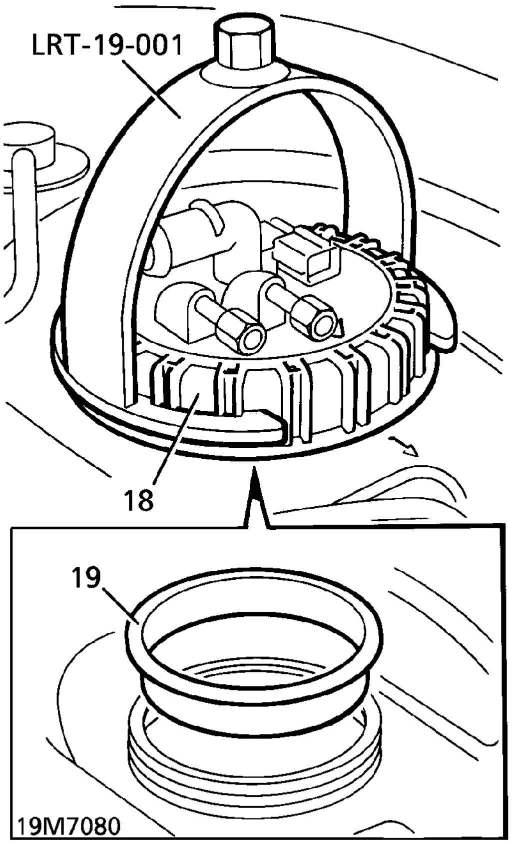
14. Lower tank assembly. Remove from jack. ***Do not carry out further dismantling if component is removed for access only.***

Disassemble

15. Remove tank from cradle.
16. Slacken clip. Remove fill breather pipe from tank unit.



17. Disconnect feed and return pipes from tank unit. Remove each pipe from 2 fuel tank clips.
18. Remove tank unit retaining ring using LRT-19-001. Remove assembly from tank.



WARNING: A quantity of fuel will be retained in the unit, care must be taken to avoid excessive spillage during removal.

19. Remove tank unit sealing rubber and discard.

Reassemble

20. Fit new sealing rubber.
21. Fit tank unit. Align location marks.
22. Fit retaining ring using LRT-19-001.
23. Connect fuel feed and return pipes to tank unit. Tighten to ***16 Nm (12 lbf.ft)***
24. Secure pipes to fuel tank clips.
25. Position fill breather pipe to tank unit. Secure with clip.
26. Position tank in cradle.

Refit

27. Raise fuel tank assembly on jack until multiplug can be connected to tank unit.
28. Raise tank. Align cradle mounting points. Secure with nuts and bolts.
29. Remove plugs from pipes and connections.
30. **Petrol Models Only:** Using new 'O' ring, connect fuel spill return pipe. Tighten to ***16 Nm (12 lbf.ft)***
31. **Petrol Models Only:** Using new 'O' ring, connect fuel feed pipe to filter. Tighten to ***20 Nm (15 lbf.ft)***
32. **Diesel Models Only:** Connect fuel feed and return pipes.
33. Lower vehicle.
34. Refit fuel filler neck. ***See this section.***
35. Refill fuel tank.
36. Reconnect battery negative lead.

FUEL TANK, PUMP AND GAUGE SENDER UNIT - ADVANCED EVAPS

Service repair no - 19.55.01 - Fuel Tank
Service repair no - 19.45.08 - Fuel Pump
Service repair no - 88.25.32 - Fuel Gauge Tank Unit

Remove

WARNING: Ensure that fuel handling precautions given in 01 - Introduction are strictly adhered to when carrying out following instructions.

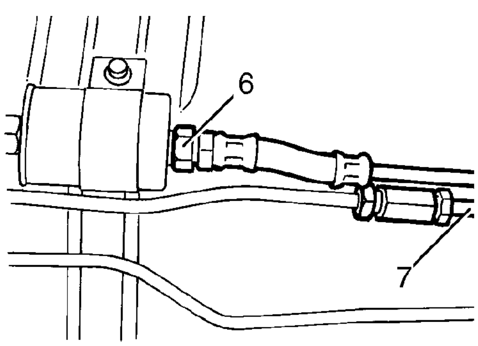
CAUTION: before disconnecting any part of the system, it is imperative that all dust, dirt and debris is removed from around components to prevent ingress of foreign matter into fuel system.

Remove

1. Raise vehicle on 4 post ramp.
2. Disconnect battery earth lead.
3. Depressurise fuel system. ***See this section.***
4. Drain fuel tank completely. ***See this section.***

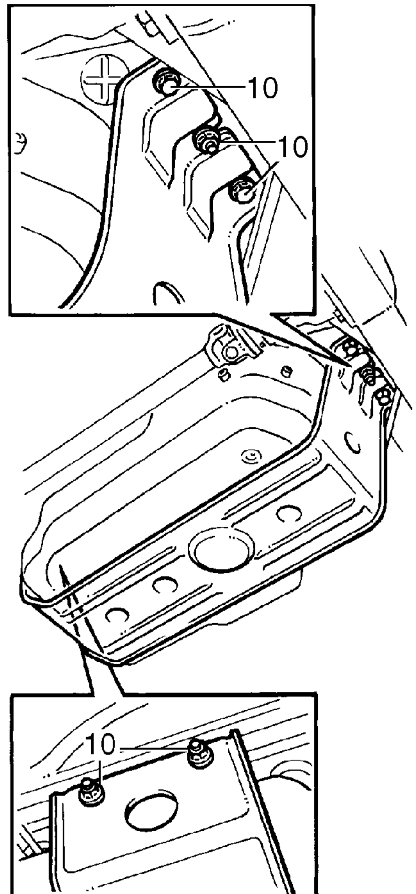
NOTE: Fuel tank draining includes removal of fuel filler neck.

5. Position container beneath fuel filter to catch spillage.
6. Disconnect fuel feed pipe at rear of filter.
7. Disconnect fuel return pipe.



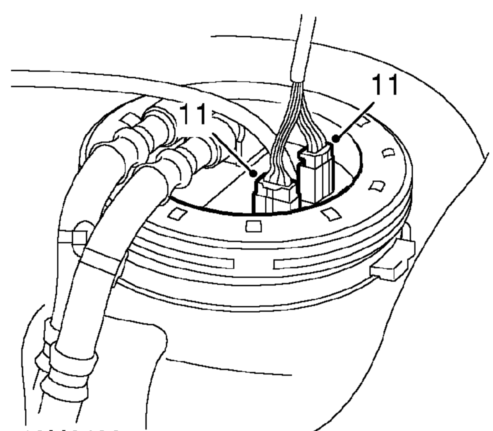
19M2420

8. Remove and discard 'O' rings. Plug all pipes and connections.
9. Support tank with jack.
10. Remove 3 nuts and 2 bolts securing tank cradle to floor pan.



19M2421

11. Lower tank by 150mm (6in) and disconnect 2 multiplugs from tank unit.

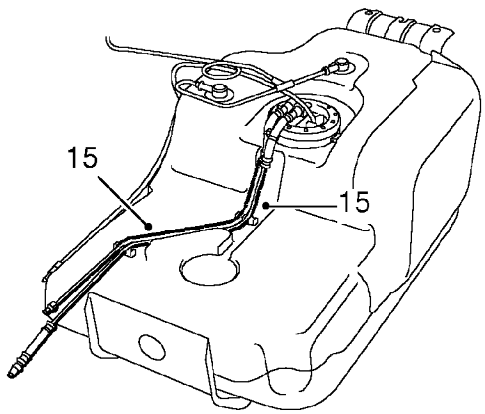


19M2422

12. Lower tank assembly and remove from jack.

Disassemble

13. Remove tank from cradle.
14. Disconnect and remove breather hose from pressure sensor.
15. Disconnect feed and return pipes at tank unit and remove pipes.



19M2423

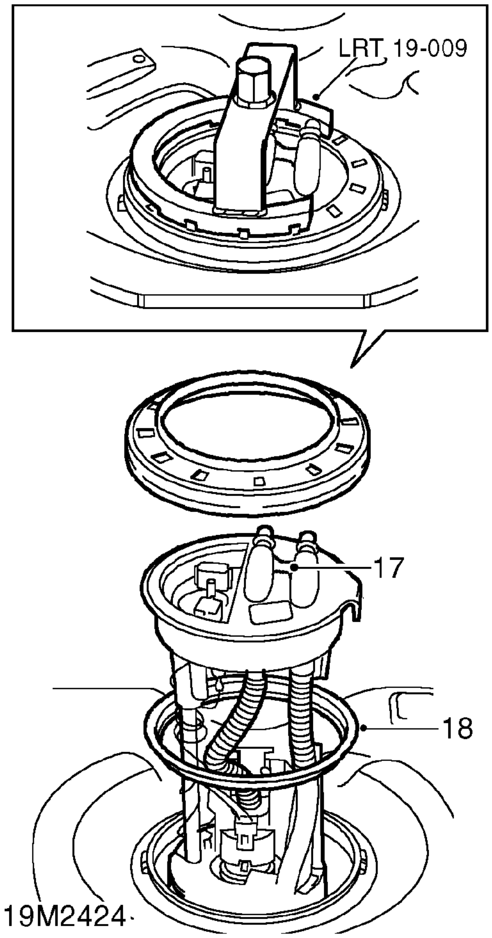
16. Remove tank unit locking ring using LRT-19-009.

WARNING: A quantity of fuel will be retained in the unit. Care must be taken to avoid excessive spillage during removal.

17. Remove tank unit using the lifting eye provided.

CAUTION: Do not lift the unit using the feed and return stubs as this may damage the stubs.

18. Remove tank unit sealing rubber and discard.



19M2424

Reassemble

19. Fit new sealing rubber to tank unit.
20. Carefully fit tank unit and align aperture tab.
21. Tighten retaining ring to ***35Nm (26lbf.ft)*** using tool LRT-19-009.
22. Fit fuel pipes and engage to tank clips.
23. Fit breather hose to pressure sensor.
24. Position tank in cradle.
25. Position tank assembly to jack.

Refit

26. Raise fuel tank assembly on jack until multiplugs can be connected.
27. Connect multiplugs to tank unit.
28. Raise tank and align to mountings. Secure tank with nuts and bolts.
29. Remove plugs from pipes and connections.
30. Connect and tighten fuel feed and return unions using new 'O' rings.
31. Lower vehicle.
32. Fit fuel filler neck. ***See this section.***
33. Refill fuel tank.
34. Connect battery earth lead.

FUEL TANK FILLER CAP - ADVANCED EVAPS

Service repair no - 19.55.08

Remove

1. Open filler flap.
2. Remove nut securing retaining strap to body.

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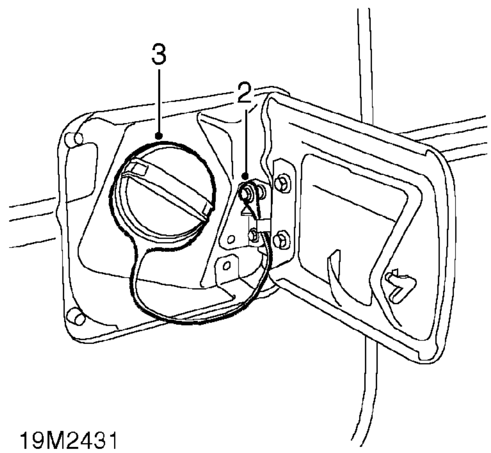


19M2431

3. Remove cap.

Refit

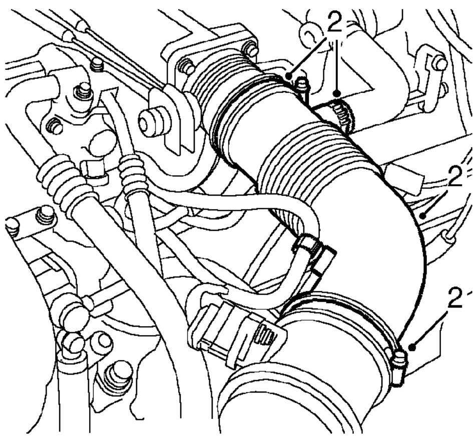
4. Fit cap, ensuring that it is tightened in accordance with instruction label.
5. Position cap retaining strap to stud and secure with nut.
6. Close fuel filler flap.

THROTTLE BODY - from 99MY

Service repair no - 19.22.45

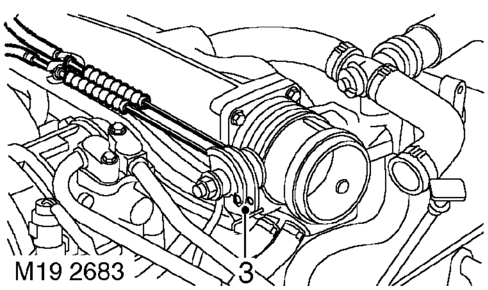
Remove

1. Drain sufficient coolant to allow for removal of throttle body.



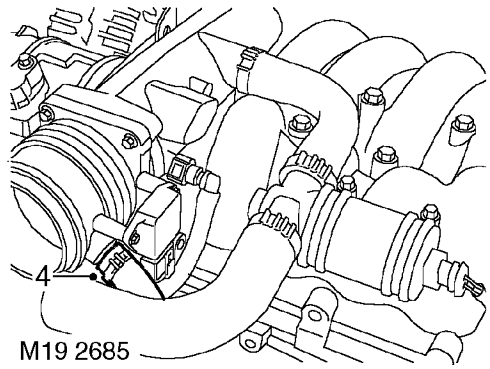
M19 2637

2. Loosen 3 clips securing air intake hose, release air intake hose and position aside.



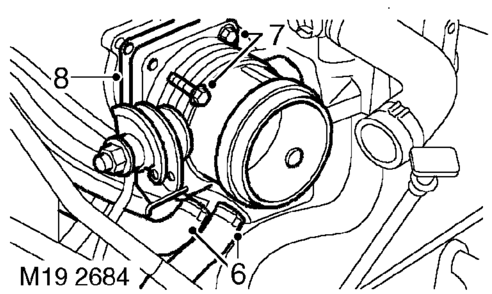
M19 2683

3. Disconnect throttle and cruise control cables from throttle body cams.



M19 2685

4. Loosen clip securing breather hose and release hose.
5. Remove TP sensor. ***See this section.***



M19 2684

6. Release 2 clips securing coolant hoses to throttle body and release hoses.
7. Remove 4 bolts securing throttle body to plenum chamber and remove throttle body.
8. Remove and discard gasket.

Refit

9. Clean plenum chamber and throttle body mating faces.
10. Using a new gasket, position throttle body, fit bolts and tighten to ***9 Nm (7 lbf.ft).***
11. Fit coolant hoses and secure clips.
12. Fit breather hose and secure clip.
13. Fit TP sensor. ***See this section.***
14. Connect throttle and cruise control cables.
15. Position air intake hose and secure clips.
16. Refill cooling system.

CONTENTS

Page

DESCRIPTION - V8

The cruise control system consists of electro-mechanical devices and comprises of the following components.

Electronic Control Unit (ECU)

The microprocessor based ECU evaluates the signals received from the driver controls, BeCM (vehicle speed signal), brake pedal switch and clutch pedal switch on manual vehicles. The ECU activates a vacuum pump as required. The ECU has a memory function to store desired cruise speed. The memory is cleared when power to the cruise ECU is cut, i.e. when the main cruise control switch is turned off.

Driver operated switches

The driver controls cruise operation from 3 switches. The main cruise control switch is located on the centre switch pack and activates the cruise control system. 2 further switches are located in the steering wheel. 'Set/+' informs the ECU of the required cruise speed. 'Res' temporarily switches cruise control off but retains the previously set cruise speed. Pressing 'Res' a second time resumes the previously selected cruise speed.

Vehicle speed signal

The cruise control ECU receives a road speed signal from the BeCM, which in turn receives the signal from the ABS ECU. The cruise control ECU compares the road speed signal with the required cruise speed and adjusts the output to the vacuum pump as necessary. Cruise control will not operate below the low speed threshold of 28 mph or above the high speed threshold of 125 mph.

Brake pedal switch

The vehicle utilised 2 brake pedal switches, mounted on the pedal box. One switch is normally closed with the brake pedal released while the other is normally open. The normally closed switch also incorporates a vent valve to rapidly deplete actuator vacuum when cruise control is disengaged. When the brake pedal is pressed, the signal from each brake switch is monitored by the cruise control ECU which switches the vacuum pump off.

Clutch pedal switch

The clutch pedal switch is located on the pedal box and is identical to the previously described brake pedal switch with vent valve.

Vacuum pump

When cruise control is active and cruise ECU inputs are acceptable, the ECU energises the vacuum pump motor. The vacuum pump creates a vacuum in the actuator which operates the throttle linkage. When the required speed has been achieved, the ECU switches off the vacuum pump. The ECU also controls a dump valve which allows system vacuum to vent to atmosphere.

Actuator

The actuator provides the servo mechanical link between the cruise control system and the throttle linkage.

Neutral lock-out - automatic vehicles

Cruise control is disengaged when neutral or park is selected in the main gearbox. The cruise control ECU receives a signal from the BeCM.

Engine overspeed - manual vehicles

Cruise control is disengaged if the engine speed exceeds 5000 rpm. The cruise control ECU receives the engine speed signal from the BeCM.

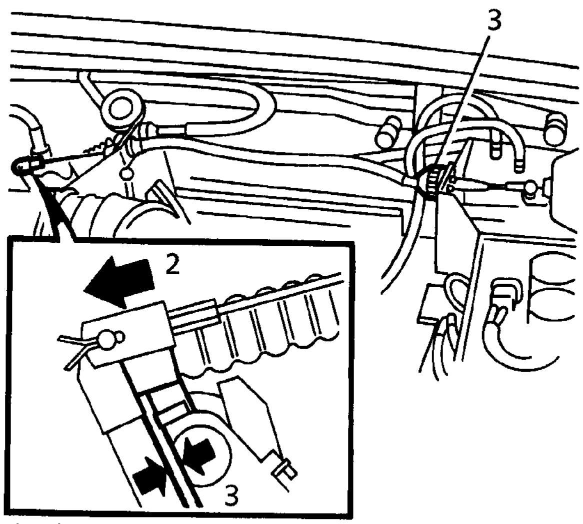
DESCRIPTION - DIESEL

Diesel vehicles utilise the electronic diesel control (EDC) system for cruise control. As the EDC has complete control of the fuelling system, the only additional inputs required for cruise control are, driver controls, vehicle speed, brake and clutch signals. The individual components are as previously described by V8 vehicles.

CABLE - CRUISE CONTROL - ADJUST - UP TO 99MY

Service repair no - 19.75.09

1. Ensure throttle cable is adjusted correctly. ***See this section.***
2. Using light finger pressure only, push cruise control lever towards plenum chamber to remove all free play from cruise control cable.



19M7014

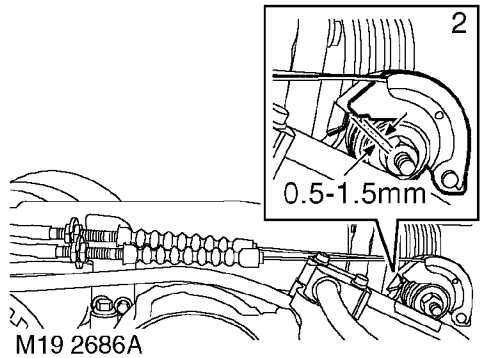
3. Adjust cable outer length by turning plastic thumb screw to achieve a clearance of between 0.5 mm and 1.5 mm.

CABLE - CRUISE CONTROL - ADJUST - FROM 99MY

Service repair no - 19.75.11

Check

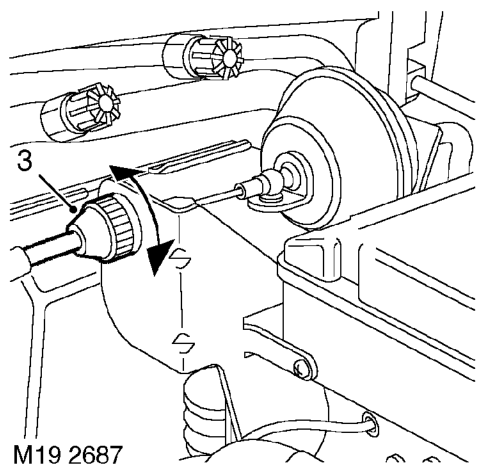
1. Ensure that the throttle cable is correctly adjusted. ***See this section.***



M19 2686A

2. Check for a 0.5 - 1.5mm gap between cruise control cable cam and throttle cable driven lever.

Adjust



M19 2687

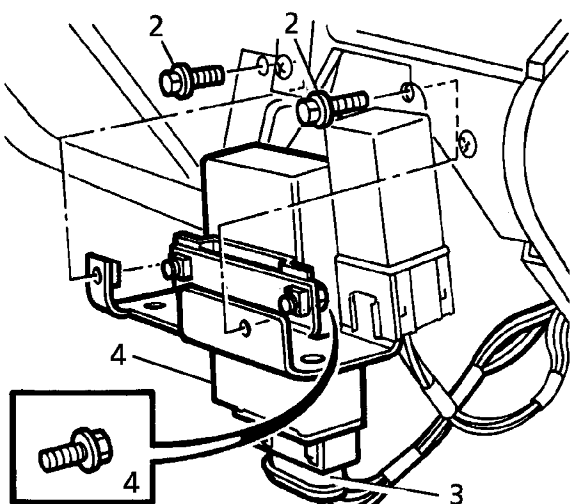
3. Rotate cruise control cable adjusting nut to give a 0.5 - 1.5mm gap between the cruise control cable cam and throttle cable driven lever.

CRUISE CONTROL ECU

Service repair no - 19.75.49

Remove

1. Remove fascia closing panel. ***See CHASSIS AND BODY, Repair.***
2. Remove 2 bolts securing ECU bracket to fascia. Release bracket to gain access to fixings.
3. Disconnect multiplug from ECU.
4. Remove 2 bolts securing ECU. Remove ECU.



19M7015

Refit

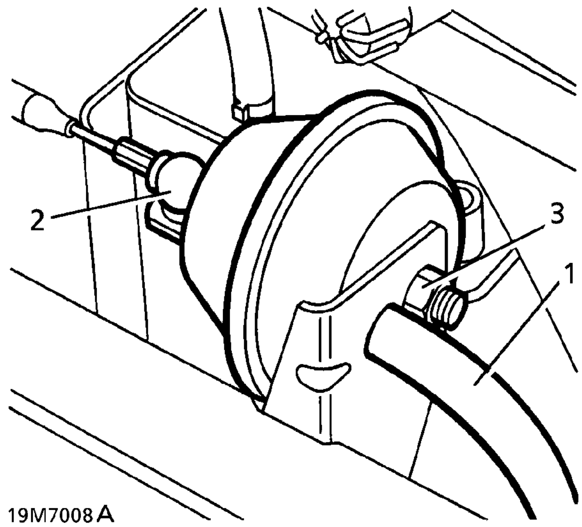
5. Reverse removal procedure.

CRUISE CONTROL ACTUATOR

Service repair no - 19.75.05

Remove

1. Disconnect vacuum hose from actuator.
2. Disconnect control cable from ball joint on actuator diaphragm.
3. Remove nut securing actuator to bracket. Remove actuator.



19M7008A

Refit

4. Position actuator to bracket. Secure with nut.
5. Connect vacuum hose. Secure cable to actuator ball joint.
6. Adjust cruise control cable. ***See CRUISE CONTROL, Adjustment.***

SET AND RESUME SWITCHES - CRUISE CONTROL

Service repair no - 19.75.36 - Set Switch
Service repair no - 19.75.37 - Resume Switch

Remove

1. Remove steering wheel switch pack assembly. ***See ELECTRICAL, Repair.***

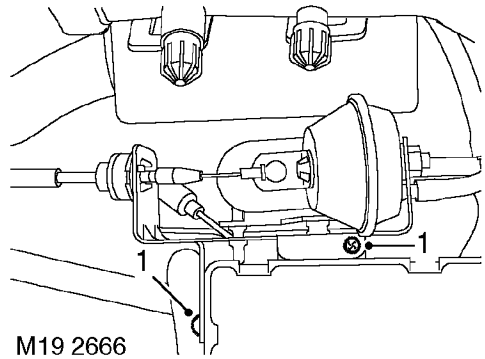
Refit

2. Reverse removal procedure.

CRUISE CONTROL - VACUUM CONTROL UNIT

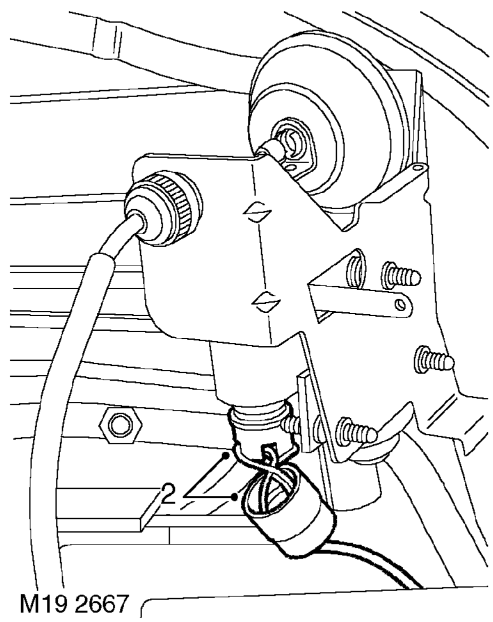
Service repair no - 19.75.06

Remove



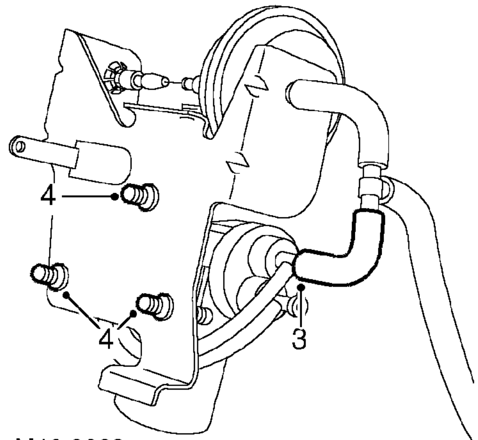
M19 2666

1. Remove 2 screws securing actuator bracket.



M19 2667

2. Release cover and disconnect multiplug from vacuum control unit.



M19 2668

3. Remove vacuum hose from control unit.
4. Release 3 rubber mountings and remove control unit.
5. Remove 3 rubber mountings from control unit.

Refit

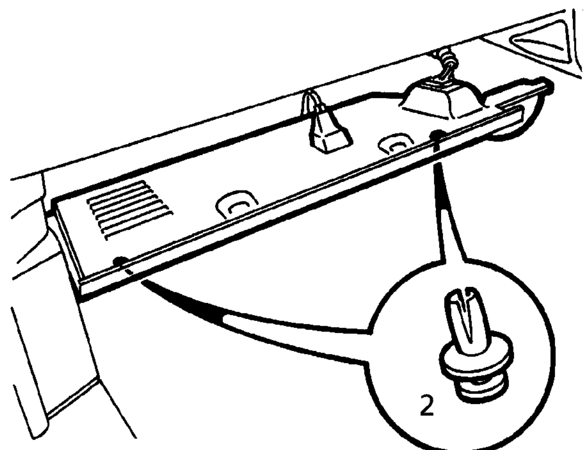
6. Fit rubber mountings to control unit.
7. Position control unit and secure mountings.
8. Connect vacuum hose to control unit.
9. Connect multiplug and fit cover.
10. Position actuator bracket and secure with screws.

BRAKE AND CLUTCH PEDAL SWITCHES/VENT VALVES - CRUISE CONTROL

Service repair no - 19.75.34 - Clutch Switch
Service repair no - 19.75.35 - Brake Switch (not fitted to diesel variants)

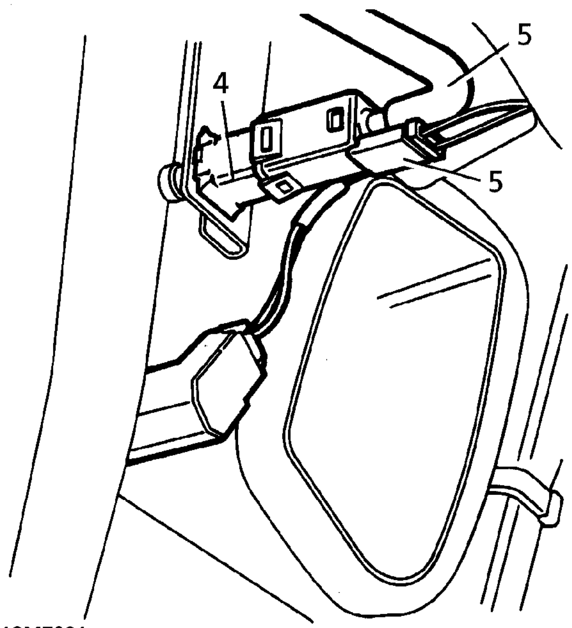
Remove

1. Remove drivers side fascia closing panel. ***See CHASSIS AND BODY, Repair.***
2. Remove 3 scrivet fasteners securing lower closing panel. Release panel to gain access to blower motor ducting.



19M7020

3. Release ducting from blower motor housing and heater. Remove blower motor ducting.
4. Release switch/vent valve from pedal bracket.



19M7021

5. Disconnect vacuum hose and multiplug from switch.

NOTE: Vacuum hose fitted to petrol variants only.

6. Remove switch/vent valve.

Refit

7. Reverse removal procedure.

NOTE: The switch/vent valve is factory set and does not require adjustment in service.

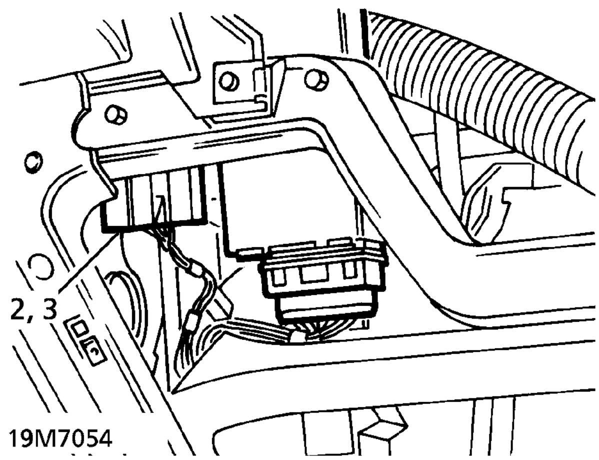
CRUISE CONTROL - SWITCH INVERTER/CONVERTER

Service repair no - 19.75.22

NOTE: Inverter is used on petrol, converter on diesel. Units are in same position and are visually similar. Illustration 19M7054 shows petrol condition, diesel vehicles do not have the cruise control ECU.

Remove

1. Remove fascia closing panel. ***See CHASSIS AND BODY, Repair.***
2. Release inverter/converter multiplug from bracket.



19M7054

3. Remove inverter/converter from multiplug.

Refit

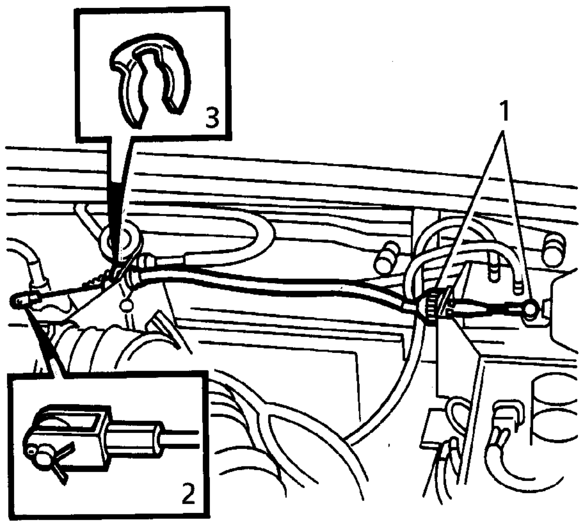
4. Reverse removal procedure.

CABLE - CRUISE CONTROL - UP TO 99MY

Service repair no - 19.75.10

Remove

1. Release cable from actuator. Disengage adjuster from actuator abutment bracket.
2. Remove split pin and clevis pin from cable trunnion.
3. Remove 'C' clip securing cable to abutment bracket. Remove cable.



19M7013A

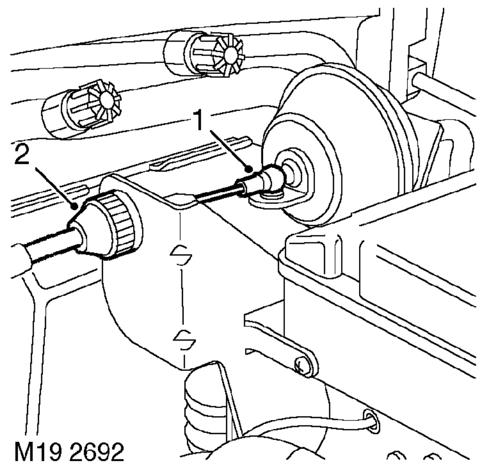
Refit

4. Position cable through abutment bracket. Secure with 'C' clip.
5. Position cable trunnion to throttle linkage. Secure with clevis pin and split pin.
6. Engage cable adjuster to actuator abutment bracket. Connect cable to actuator diaphragm.
7. Adjust cruise control cable. ***See CRUISE CONTROL, Adjustment.***

CABLE - CRUISE CONTROL - FROM 99MY

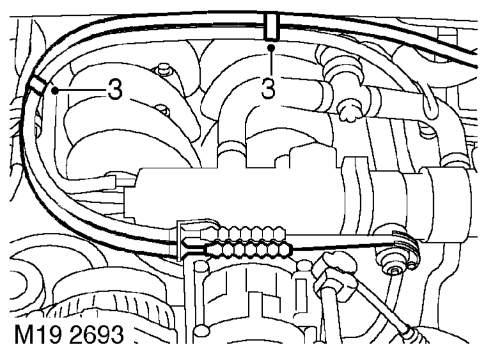
Service repair no - 19.75.10

Remove



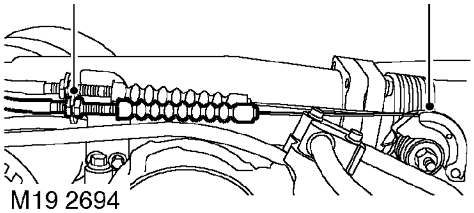
M19 2692

1. Disconnect inner cable from actuator.
2. Release cable from actuator mounting bracket.



M19 2693

3. Release cable from 2 support clips.



4. Loosen cable locknuts, release cable from abutment bracket.
5. Release inner cable from operating lever and remove cable.

Refit

6. Position cable and connect to operating lever.
7. Position cable to abutment bracket.
8. Fit cable to support clips.
9. Fit cable to actuator mounting bracket and connect inner cable to actuator.
10. Adjust cruise control cable. ***See Adjustment.***

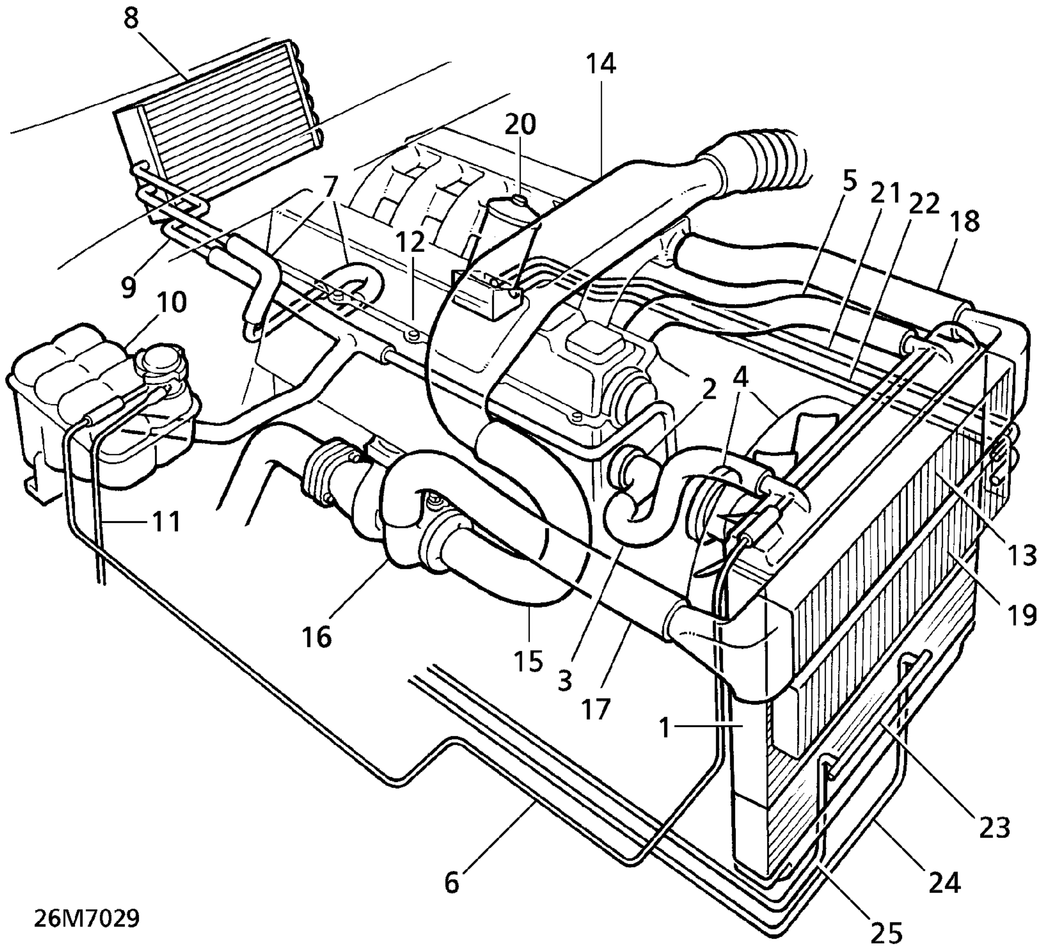
26 - COOLING SYSTEM

CONTENTS

DIESEL COOLING SYSTEM

The complete cooling system installed in vehicles with diesel engines incorporates four independent cooling functions:- Engine (coolant) cooling; Turbo (charge air) intercooling; Engine oil cooling; Gearbox oil cooling.

Both intercooler and engine oil cooler are mounted in front of the radiator while the gearbox oil cooler on manual vehicles is an integral part of the radiator. Pre-formed pipes/hoses are used to link the components within the separate systems, as shown in 26M7029.



26M7029

Engine cooling system

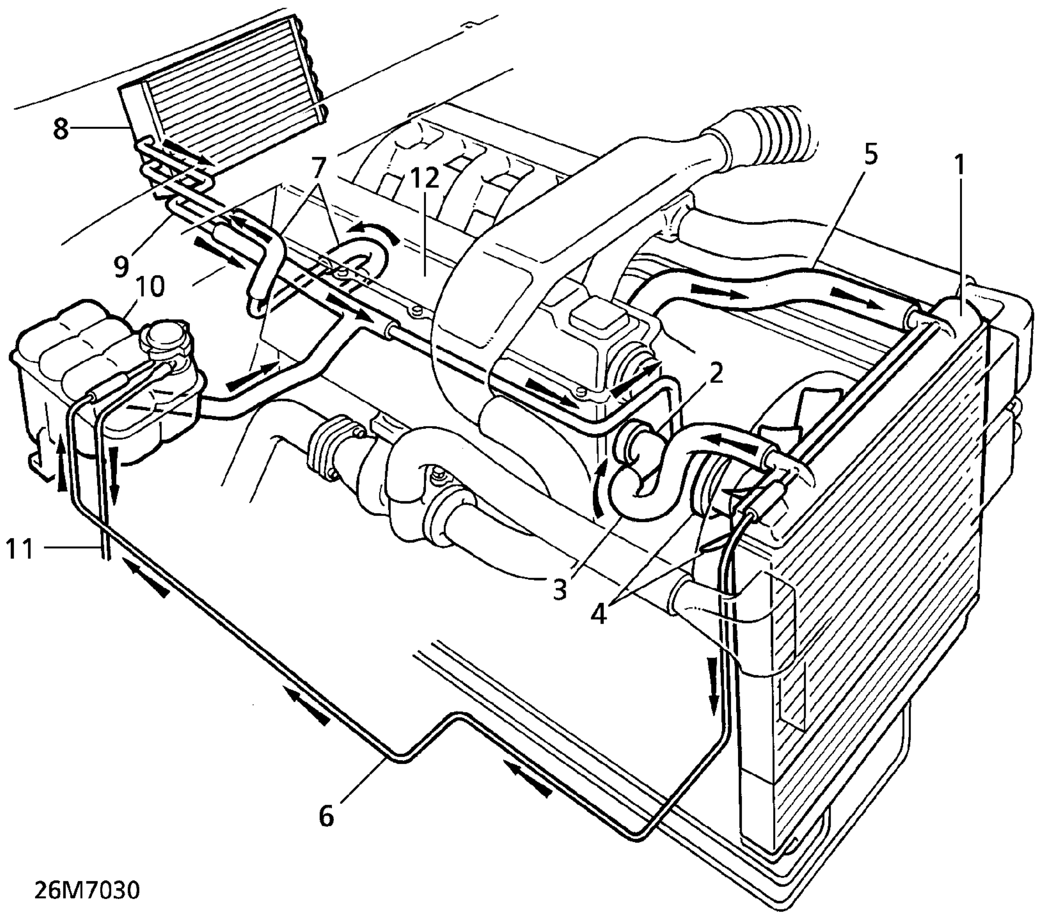
1. Radiator
2. Thermostat housing
3. Radiator return hose
4. Viscous fan and water pump
5. Radiator top hose
6. Radiator bleed pipe
7. Heater feed pipe
8. Heater matrix
9. Heater return pipe
10. Expansion tank
11. Overflow/breather pipe
12. Crankcase
13. Intercooler
14. Cross-over duct
15. Link hose
16. Turbocharger
17. Inlet pipe
18. Feed hose
19. Engine oil cooler
20. Oil filter
21. Feed pipe, engine oil cooler
22. Return pipe, engine oil cooler
23. Gearbox oil cooler (manual gearbox, oil cooler shown)
24. Feed pipe, gearbox oil cooler
25. Return pipe, gearbox oil cooler

ENGINE COOLING

Description

The 2.5 litre diesel engine uses a pressurized cooling system and a vertical flow, two row matrix radiator. An expansion tank, mounted on the RH side of the engine compartment, provides a fluid reservoir for the coolant system.

A belt driven centrifugal water pump, complete with viscous fan, is fitted to the engine front timing cover and pumps coolant to the engine crankcase and cylinder head. The thermostat housing, located at the front of the crankcase, see 26M7030, is fitted with a separate vent valve.



Engine cooling system

1. Radiator
2. Thermostat/housing
3. Radiator return hose
4. Viscous fan and water pump
5. Radiator top hose
6. Radiator bleed pipe
7. Heater feed pipe
8. Heater matrix
9. Heater return pipe
10. Expansion tank
11. Overflow/breather pipe
12. Crankcase

COOLANT CIRCULATION

Operation

When the engine is started from cold, the thermostat, integral in the housing (2), prevents any coolant circulation through the radiator by closing off the supply from the radiator. During the engine warm up, the water pump (4) pumps coolant around the cylinders in the crankcase (12) and through separate galleries to the cylinder head. At the rear LH side of the cylinder head, a proportion of the flow is diverted through a heater feed pipe (7). The heater feed pipe is connected to the heater matrix (8), which is housed in the distribution unit of the heating and ventilation system. This coolant is then carried, via the heater return pipe (9) back to the water pump. The remaining coolant flows through a bypass port at the front of the cylinder head back to the water pump to complete the cycle.

When normal engine running temperature is reached, the thermostat opens and a secondary valve closes the bypass port. With the thermostat open, coolant is circulated through the top hose (5) to the radiator. Coolant is drawn from the base of the radiator by the water pump. Coolant circulation through the crankcase and cylinder head to the heater matrix remains the same.

An integral bleed pipe (6), connects the top of the radiator to the expansion tank and aids bleeding of air from the coolant system. The expansion tank cap contains a pressure valve which allows excessive pressure and coolant to vent to the overflow pipe (11) if the system has been overfilled.

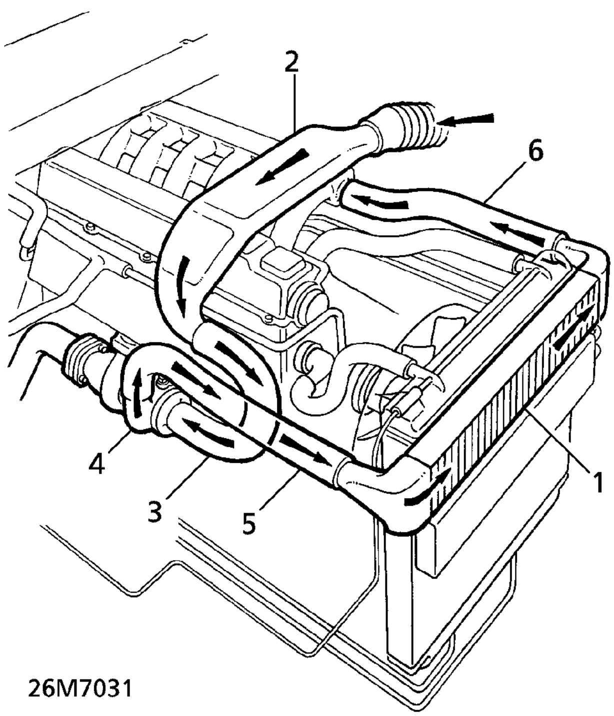
VISCOUS FAN

The viscous drive unit for the cooling fan on diesel engines work on the same principal as that fitted on V8 engines but is of slightly different size. ***See this section.***

INTERCOOLER

Description

The intercooler (1) is an aluminium heat exchanger, with integral side tanks, comprising a single row matrix incorporating fifteen internal cooling tubes. A cross-over duct (2) directs air from the air cleaner, through a link hose (3) to the turbocharger (4). Air is directed under pressure from the turbocharger to the intercooler via the pre-formed inlet pipe (5). The cooled air is fed to the inlet manifold through the feed hose (6), see 26M 7031.



26M7031

Intercooler

1. Intercooler
2. Cross-over duct
3. Link hose
4. Turbocharger
5. Inlet pipe
6. Feed hose

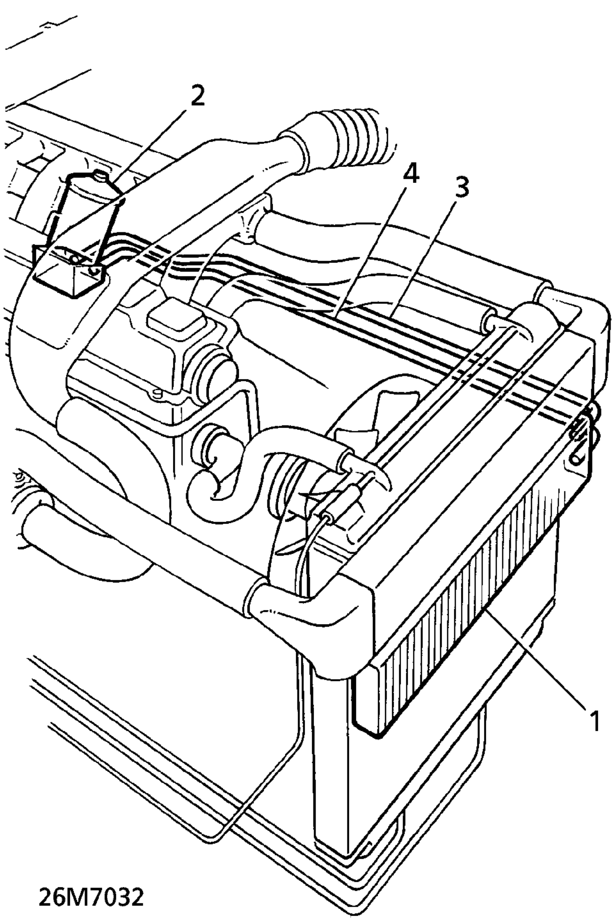
Operation

The 2.5 litre diesel has a high power output and is subject to high running temperatures. Compression in the turbocharger heats the air considerably, so that it expands. As a result the air charge mass per cylinder is reduced, having a negative effect on power output. The charge-air intercooler cools the air before it reaches the cylinders, thus increasing its density. This increases power output through increased mass of oxygen in the combustion process as well as maximising engine durability through maintaining lower piston and head temperatures.

ENGINE OIL COOLER

Description

The engine oil cooler is located in front of the radiator, below the intercooler, and comprises a two pass, single row matrix with twelve internal cooling tubes. Pre-formed feed and return pipes/hoses are used to link the oil filter housing and oil cooler, as shown in 26M7032.



26M7032

Engine oil cooler

1. Engine oil cooler
2. Oil filter
3. Feed pipe
4. Return pipe

Operation

When the engine reaches its normal operating temperature, oil, drawn through a steel strainer in the sump, is pumped under pressure from the filter housing (2) to the oil cooler (1) via the feed pipe (3). Ambient air, forced through the front grille of the vehicle and assisted by the pull of the viscous fan, is dispersed across the oil cooler. The cooled oil then passes through a return pipe (4) to the filter housing before being distributed by the oil pump to the various internal engine components.

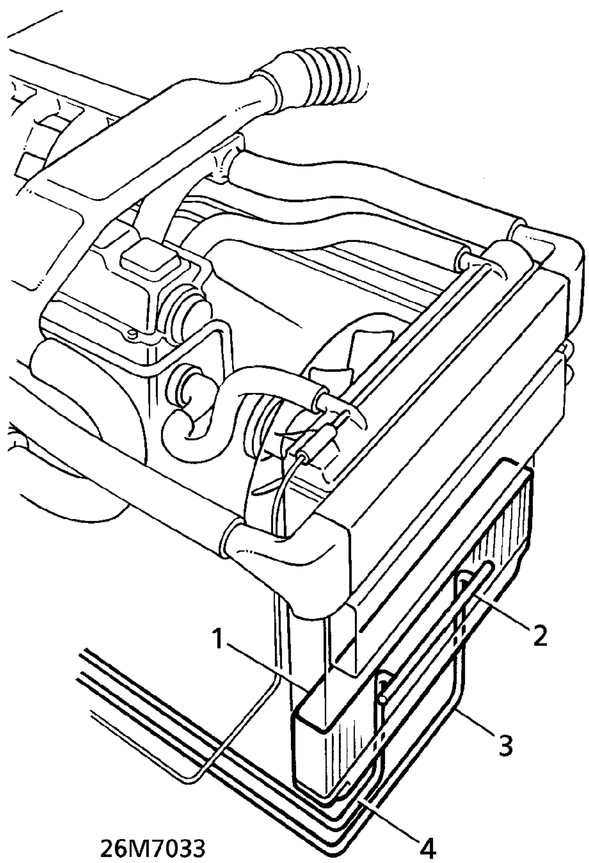
GEARBOX OIL COOLER - MANUAL

Description

The gearbox oil cooler on manual vehicles is an integral part of the radiator and is a brass concentric tube type. The cooler is immersed in a separate water tank at the base of the radiator. The inner core, which has its own water jacket within the cooling tube, carries the transmission oil via feed and return pipes, see 26M7033.

Operation

Oil is pumped under pressure from the gearbox through the feed pipe (3) into the tube (2) of the oil cooler tank. With a combination of water and ram air cooling, through the front grille of the vehicle and assisted by the pull of the viscous fan, the cooled transmission oil is routed back to the gearbox via the return pipe (4), to repeat the cycle.



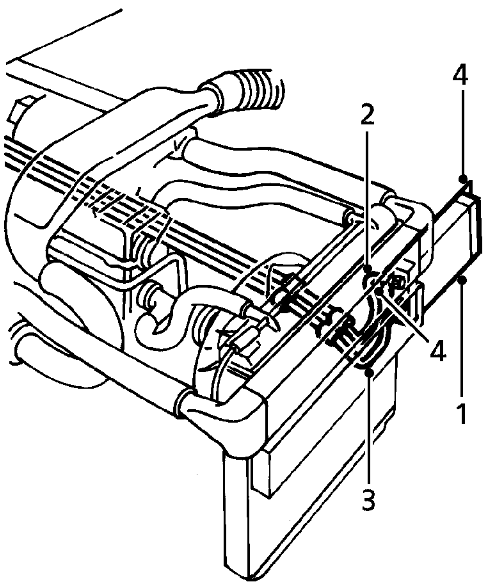
Gearbox oil cooler, manual transmission

1. Gearbox oil cooler tank
2. Coolant tube
3. Feed pipe, oil cooler
4. Return pipe, oil cooler

GEARBOX OIL COOLER - AUTOMATIC

Description

On diesel models with automatic transmission an independent oil cooler is used and is mounted on the LH side of the vehicle behind the front bumper. The oil cooler comprises a cast aluminium radiator, two pass, single row matrix with sixteen internal cooling tubes. Pre-formed feed and return pipes/hoses are used to link the automatic transmission and oil cooler.



26M7043

Gearbox oil cooler, automatic transmission

1. Gearbox oil cooler
2. Feed pipe, oil cooler
3. Return pipe, oil cooler
4. Mounting brackets

Operation

On automatic vehicles the coolant process relies on ram air only through an aperture in the LH side of the bumper moulding. Air is dispersed over the oil cooler, the cooled oil then being fed back,via the return pipe (3), to run parallel with the feed pipe to the LH side of the transmission.

COOLING SYSTEM FAULTS

This section covers mechanical faults that could occur in the complete cooling system :- 1 Engine (coolant) cooling; 2 Turbo intercooling; 3. Engine oil cooling; 4. Gearbox oil cooling.

Before conducting any visual checks within the separate systems and undertaking detailed diagnosis procedures. ***See Description and operation.***

1. ENGINE (COOLANT) COOLING SYSTEM

Symptom - Engine Overheating

POSSIBLE CAUSE	REMEDY
1. Engine coolant low.	1. Allow engine to cool. Top up expansion tank to correct level, with engine running at idle. Check cooling system for leaks and rectify if necessary.
2. Loose drive belt.	2. Check/renew drive belt tensioner or renew drive belt. ***See ELECTRICAL, Repair.***
3. Coolant in radiator frozen.	3. Slowly thaw and drain cooling system. ***See Repair.***
4. Air flow through radiator restricted or blocked.	4. Apply air pressure to engine side of radiator to clear obstruction. If mud or dirt is evident, carefully use a hose.
5. External leaks from water pump, engine gaskets, thermostat housing or pipe/hoses.	5. Check for visual causes and rectify.
6. Viscous fan not operating correctly or inoperative.	6. Renew viscous fan unit. ***See Repair.***
7. Thermostat seized in closed position.	7. Check radiator bottom hose for coolant flow through radiator. If cold a faulty thermostat is confirmed. Renew thermostat. ***See Repair.***

Symptom - Engine Overheating Continued

POSSIBLE CAUSE	REMEDY
8. Air in cooling system.	8. Check coolant level. Run engine at fast idle (approximately 2,000 rpm) with expansion tank cap off. Top up coolant level with engine at idle and refit expansion tank cap.
9. Air conditioning condenser fans not operating correctly or inoperative.	9. ***See AIR CONDITIONING, Fault diagnosis.***
10. Temperature gauge or sender unit giving inaccurate readings.	10. Refer to **TestBook** .
11. Coolant leakage across cylinder head gasket.	11. Carry out cylinder pressure test to determine if pressure is leaking into cooling system, causing over pressurising and loss of coolant. Renew cylinder head gasket.
12. Engine oil contamination of cooling system due to leaking.	12. Renew cylinder head gasket. ***See ENGINE, Repair.***
13. Coolant contamination of lubrication system.	13. Renew inlet manifold or front cover gaskets. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.*** or ***See ENGINE, Repair.***

Symptom - Engine Runs Cold

POSSIBLE CAUSE	REMEDY
1. Thermostat seized in open or partially open position.	1. Remove thermostat housing and check operation of thermostat. Renew, if necessary. ***See Repair.***
2. Temperature gauge or sender unit giving inaccurate readings.	2. Refer to **TestBook** .
3. Viscous fan not operating correctly.	3. Renew viscous fan unit. ***See Repair.***
4. Air conditioning condenser fans operating continuously.	4. Refer to **TestBook** .

2. TURBO INTERCOOLING SYSTEM

Symptom - Loss of Performance

POSSIBLE CAUSE	REMEDY
1. Cooling air flow through intercooler matrix restricted or blocked.	1. Apply air pressure to engine side of radiator to clear obstruction. If mud or dirt is evident, carefully use a hose.
2. Charge-air flow through intercooler matrix restricted.	2. Check for blocked air cleaner element and renew, if necessary. ***See SECTION 10, Maintenance.***
3. Blocked air cleaner.	3. Renew air cleaner element. ***See SECTION 10, Maintenance.***
4. Pipe/hose leaks in intercooler system.	4. Tighten all joint connections or renew components as necessary.
5. Turbocharger not operating correctly or inoperative.	5. Substitute parts and recheck. ***See FUEL SYSTEM, Repair.***
6. Customer fitted grille blind restricting cooling air flow.	6. Remove blind or advise accordingly.

3. ENGINE OIL COOLING SYSTEM

Symptom - Engine Oil Overheating

POSSIBLE CAUSE	REMEDY
1. Air flow through oil cooler matrix restricted or blocked.	1. Apply air pressure to engine side of radiator to clear obstruction. If mud or dirt is evident carefully use a hose.
2. Blocked or damaged oil cooler or pipe/hoses, restricting engine oil flow.	2. Check for visual damage and renew components where necessary.
3. Oil cooler relief valve seized in closed position.	3. Remove and check relief valve. Renew if necessary.

4. GEARBOX OIL COOLING SYSTEM

Symptom - Gearbox Oil Overheating

POSSIBLE CAUSE	REMEDY
1. Blocked or damaged oil cooler or pipe/hoses restricting gearbox oil flow.	1. Check for visual damage and renew components where necessary.
2. Leaking coolant from oil cooler water tank.	2. Remove radiator, inspect for source of leak and repair. ***See Repair.***
3. Vehicle being driven in wrong gear.	3. Advise owner/driver accordingly.

NOTE: Critical warning messages relating to the complete cooling system are displayed on the message centre of the instrument pack, should a fault occur in any of the separate systems.

COOLANT - DRAIN AND REFILL

Service repair no - 26.10.01

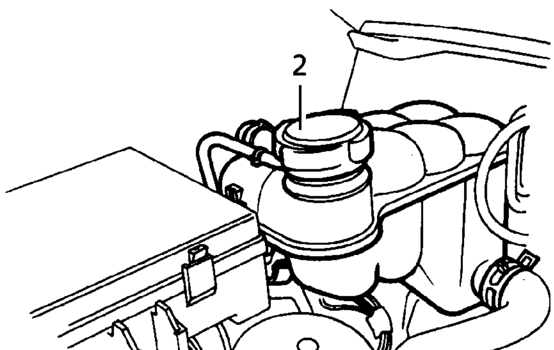
Drain

WARNING: Do not remove expansion tank filler cap when engine is hot. The cooling system is pressurised. Personal scalding could result.

1. Raise the vehicle.

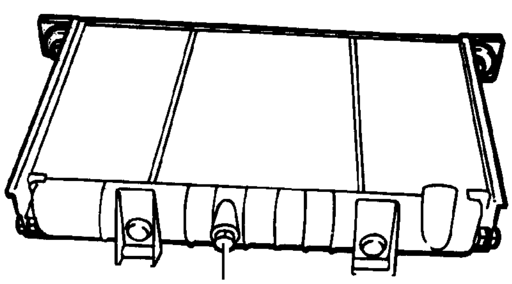
WARNING: Support on safety stands.

2. Remove expansion tank filler cap to assist draining.



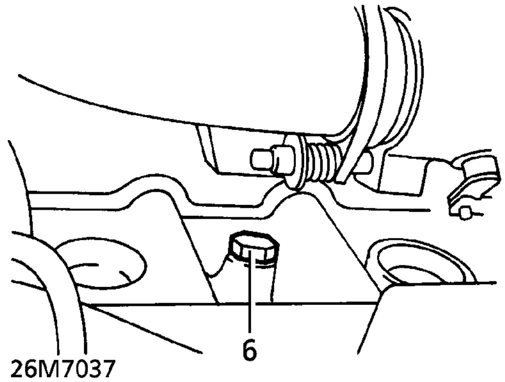
26M7038

3. Position container beneath radiator.
4. Remove plug from base of radiator. Allow coolant to drain.



26M7039

5. If system is only being partially drained, continue at **Refill.**
6. Reposition container. Remove cylinder block drain plug. Allow coolant to drain.

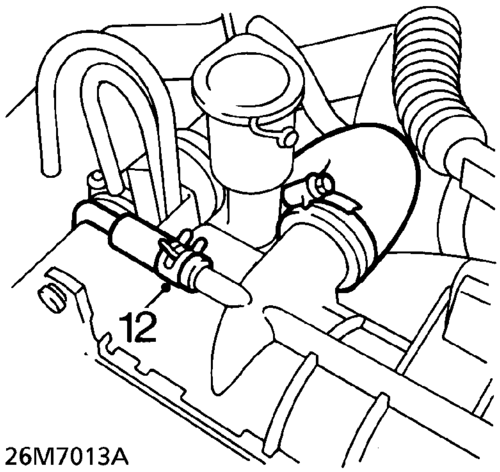


26M7037

7. Clean drain plug threads. Apply a coating of 'Loctite 577'. Refit plug to block. Tighten securely.

Refill

8. Ensure sufficient coolant solution is available. ***See LUBRICANTS, FLUIDS AND CAPACITIES, Information.***
9. Inspect radiator drain plug 'O' ring, renew if required.
10. Fit drain plug to radiator. Tighten to ***Max 6 Nm (4 lbf.ft)***
11. Remove safety stands. Lower vehicle.
12. Disconnect radiator bleed hose at the radiator.
13. Blow through hose to clear any residual coolant. Reconnect hose.
14. Fill expansion tank until coolant is level with base of neck.
15. Start engine, continue filling at expansion tank until coolant level stabilises at the 'COLD LEVEL' marking.
16. Run the engine until the thermostat opens (top hose becomes warm).
17. Stop engine, allow to cool.
18. Check coolant level, top-up as necessary.
19. Refit expansion tank filler cap.



RADIATOR

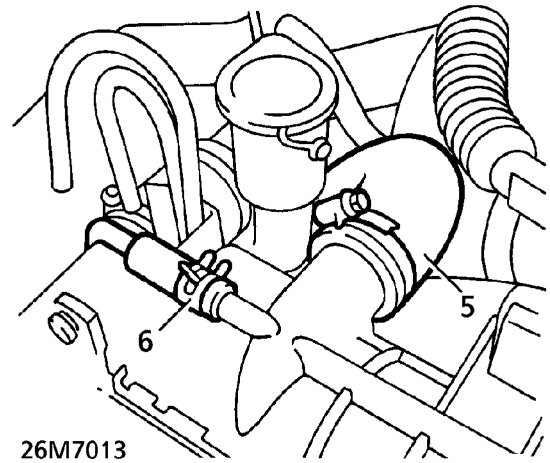
Service repair no - 26.40.04

Remove

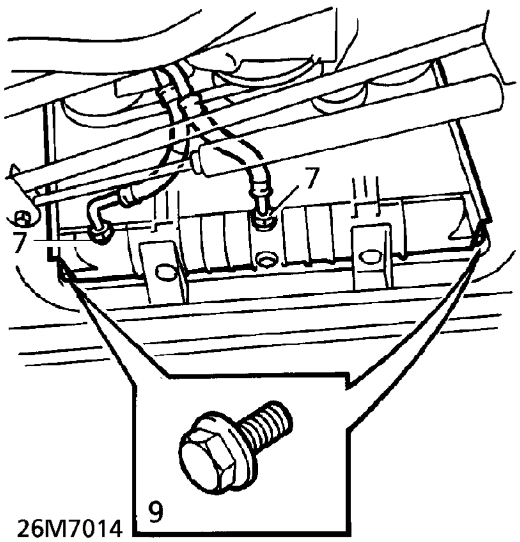
1. Disconnect battery negative lead.
2. Raise the vehicle.

WARNING: Support on safety stands.

3. Drain cooling system. ***See this section.***
4. Remove viscous coupling. ***See this section.***
5. Release bottom hose from radiator.
6. Release expansion tank hose from radiator.

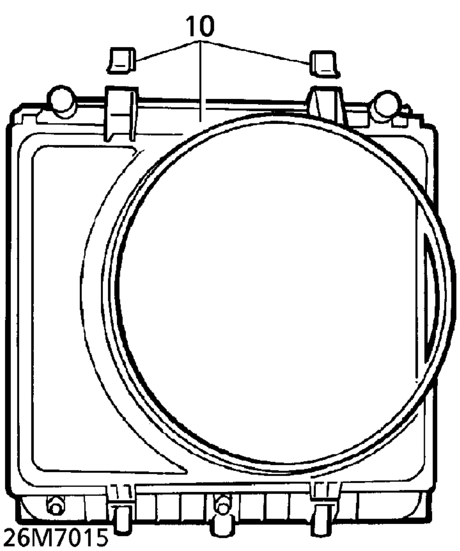


7. **Manual Vehicles:**Disconnect gearbox oil cooler pipes from radiator. Remove 'O' rings and discard.
8. **Manual Vehicles:**Plug oil cooler pipes and connections.
9. Remove 2 bolts securing radiator to bracket. Remove radiator assembly.



26M7014

10. If necessary, remove 2 clips securing cowl to radiator. Remove cowl.



26M7015

Refit

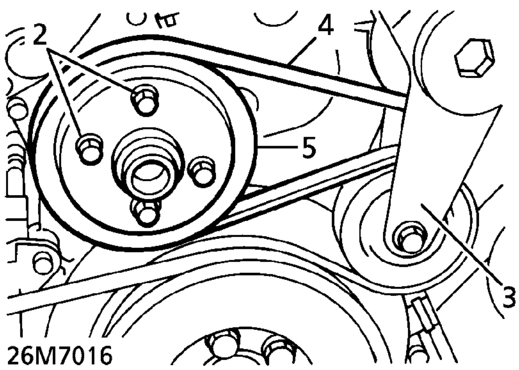
11. Ensure that lower mounting rubbers are positioned.
12. With assistance, position radiator. Engage mountings. Secure with bolts.
13. **Manual Vehicles:**Remove plugs from oil cooler pipes and connections.
14. **Manual Vehicles:**Using new 'O' rings, connect gearbox oil cooler pipes. Tighten to ***30 Nm (22 lbf.ft)***
15. Fit viscous coupling. ***See this section.***
16. Connect cooling hoses to radiator. Secure with clips.
17. Refill cooling system. ***See this section.***
18. Remove safety stands. Lower vehicle.
19. Reconnect battery negative lead.
20. **Manual Vehicles:**Top-up gearbox fluid. ***See SECTION 10, Maintenance.***

WATER PUMP

Service repair no - 26.50.01

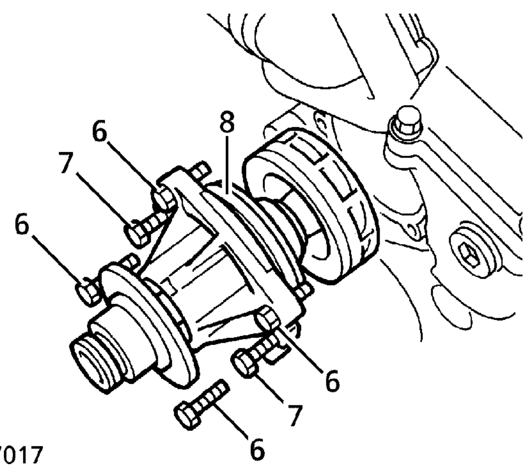
Remove

1. Remove radiator assembly. ***See this section.***
2. Slacken 4 water pump pulley bolts.



26M7016

3. Release tension from auxiliary drive belt.
4. Release belt from water pump pulley.
5. Remove pulley bolts. Remove pulley.
6. Remove 4 bolts securing water pump.



26M7017

7. Fit 2 M6 bolts into tapped holes of water pump. Extract pump.
8. Remove 'O' ring and extraction bolts.

Refit

9. Ensure mating faces are clean.
10. Lubricate 'O' ring with petroleum jelly. Fit to water pump.
11. Fit water pump. Secure with bolts. Tighten to ***10 Nm (7 lbf.ft)***
12. Fit water pump pulley. Secure with bolts. Tighten to ***10 Nm (7 lbf.ft)***
13. Rotate tensioner. Fit auxiliary drive belt.
14. Fit radiator assembly. ***See this section.***

VISCOUS COUPLING AND FAN ASSEMBLY

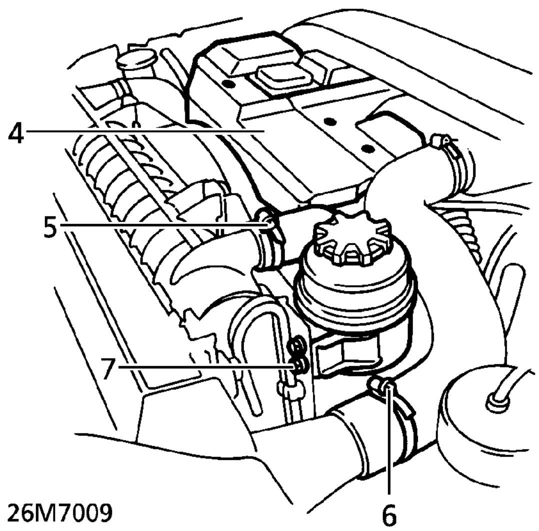
Service repair no - 26.25.19

Remove

1. Disconnect battery negative lead.
2. Raise the vehicle.

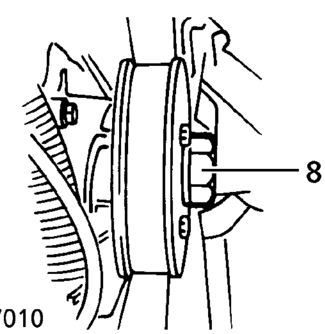
WARNING: Support on safety stands.

3. Drain cooling system. ***See this section.***
4. Remove 3 bolts securing upper fan cowl. Remove cowl.



26M7009

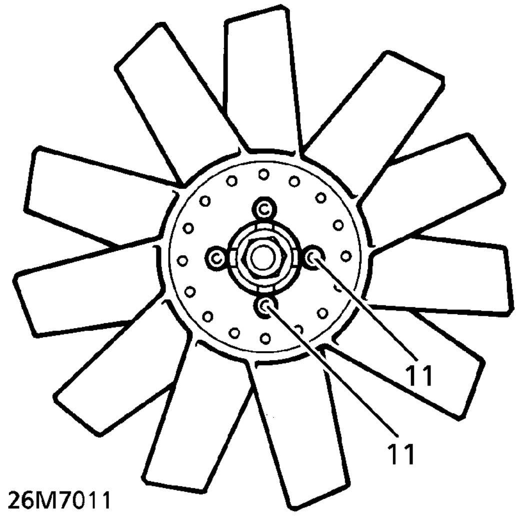
5. Release top hose from radiator. Position hose aside.
6. Release outlet hose from intercooler. Position hose aside.
7. Remove 2 bolts securing power steering reservoir to radiator bracket. Position reservoir aside.
8. Using special tools LRT-12-093 and LRT-12-094 unscrew viscous coupling.



26M7010

NOTE: Viscous coupling is fitted with a LH thread.

9. Remove viscous coupling assembly from LH side of radiator.
10. ***Do not carry out further dismantling if component is removed for access only.***
11. Remove 4 bolts securing fan to coupling. Remove coupling.



26M7011

Refit

12. Ensure mating faces are clean.
13. Fit fan to coupling. Secure with bolts. Tighten to ***10 Nm (7 lbf.ft)***
14. Position viscous coupling assembly.
15. Engage to pump. Using special tools LRT-12-093 and LRT-12-094. Tighten to ***40 Nm (29 lbf.ft)***
16. Connect hoses to intercooler and radiator. Secure with clips.
17. Position power steering fluid reservoir to radiator bracket. Secure with bolts.
18. Position upper fan cowl. Secure with bolts.
19. Refill cooling system. ***See this section.***
20. Remove safety stands. Lower vehicle.
21. Reconnect battery negative lead.

THERMOSTAT

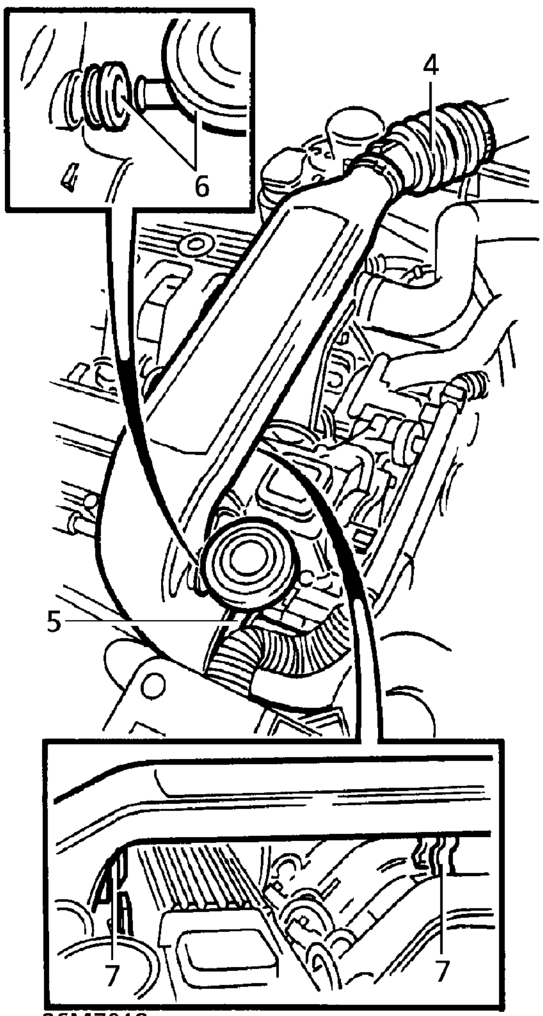
Service repair no - 26.45.01

Remove

1. Disconnect battery negative lead.
2. Raise the vehicle.

WARNING: Support on safety stands.

3. Remove cooling fan cowl. ***See this section.***
4. Release intake hose from ducting.

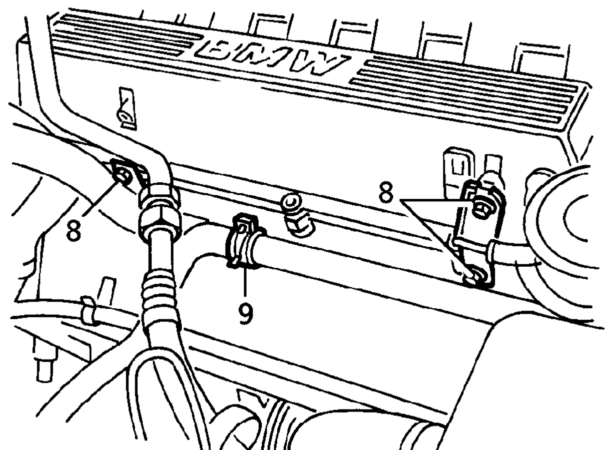


26M7018

5. Release turbocharger intake hose from ducting.
6. Release breather valve from intake ducting grommet.

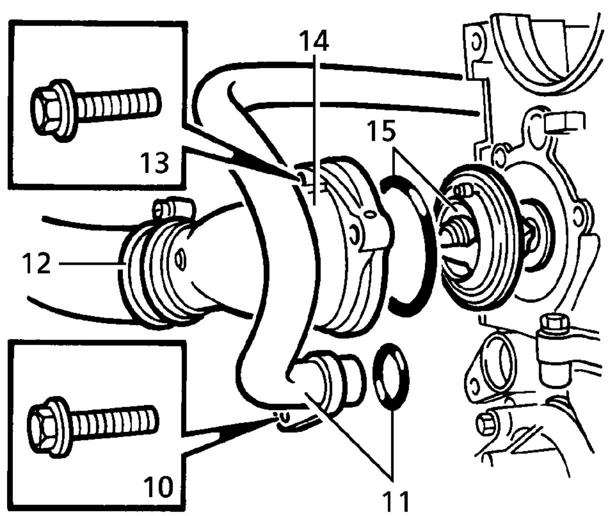
NOTE: Collect grommet. Refit to ducting.

7. Disengage 2 clips securing intake ducting. Remove ducting.
8. Remove 3 bolts securing intake ducting bracket and exhaust manifold heat shield to camshaft cover. Collect bracket.



26M7019

9. Disconnect heater hose from coolant connecting pipe.
10. Remove bolt securing coolant connecting pipe to engine front cover.

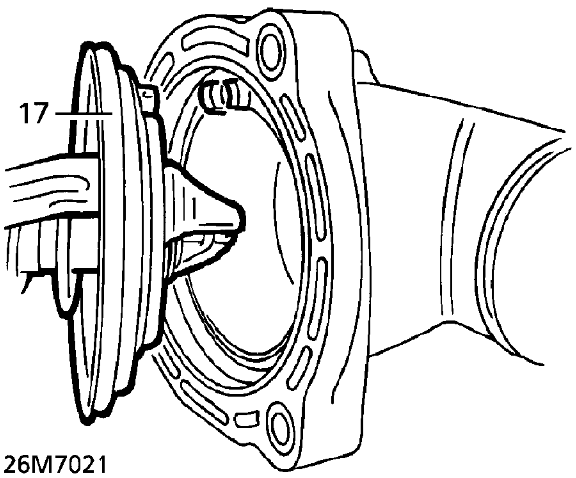


26M7020

11. Remove coolant pipe. Remove 'O' ring and discard.
12. Remove top hose from thermostat housing.
13. Remove 3 bolts securing thermostat housing to engine front cover.
14. Remove thermostat housing.
15. Collect thermostat. Remove 'O' ring and discard.

Refit

16. Lubricate new 'O' ring with clean coolant solution. Fit to thermostat.
17. Locate thermostat in housing.



26M7021

CAUTION: Ensure that ball valve is correctly located.

18. Position thermostat and housing assembly. Secure with bolts. Tighten to ***10 Nm (7 lbf.ft)***
19. Fit top hose to thermostat. Secure with clip.
20. Using a new 'O' ring, position coolant pipe. Engage to engine front cover.
21. Secure connecting pipe to front cover with bolt. Tighten to ***10 Nm (7 lbf.ft)***
22. Connect heater hose. Secure with clip.
23. Align exhaust manifold heat shield. Position intake ducting bracket.
24. Secure ducting bracket and heat shield with bolts.
25. Position intake ducting. Engage clips.
26. Engage breather valve into ducting grommet.
27. Connect ducting to turbocharger intake hose. Secure with clip.
28. Connect intake hose to ducting. Secure with clip.
29. Fit cooling fan cowl. ***See this section.***
30. Remove safety stands. Lower vehicle.
31. Reconnect battery negative lead.

COOLING FAN COWL

Service repair no - 26.25.11

Remove

1. Disconnect battery negative lead.
2. Raise the vehicle.

WARNING: Support on safety stands.

3. Remove viscous coupling and fan assembly. ***See this section.***
4. Disconnect bottom hose from radiator.
5. Remove 2 clips securing cowl to radiator.
6. Remove cooling fan cowl from radiator.

Refit

7. Reverse removal procedure.

26 - COOLING SYSTEM

CONTENTS

Page

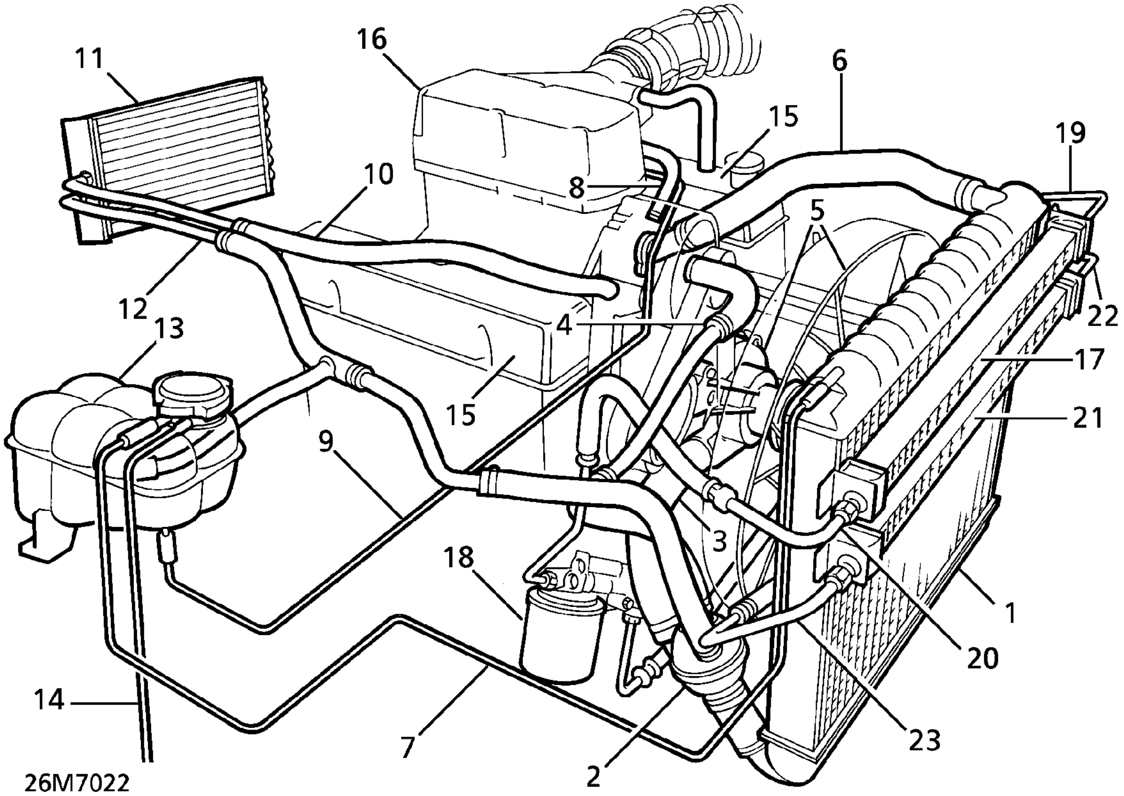
LAND ROVER V8

DESCRIPTION AND OPERATION

FAULT DIAGNOSIS

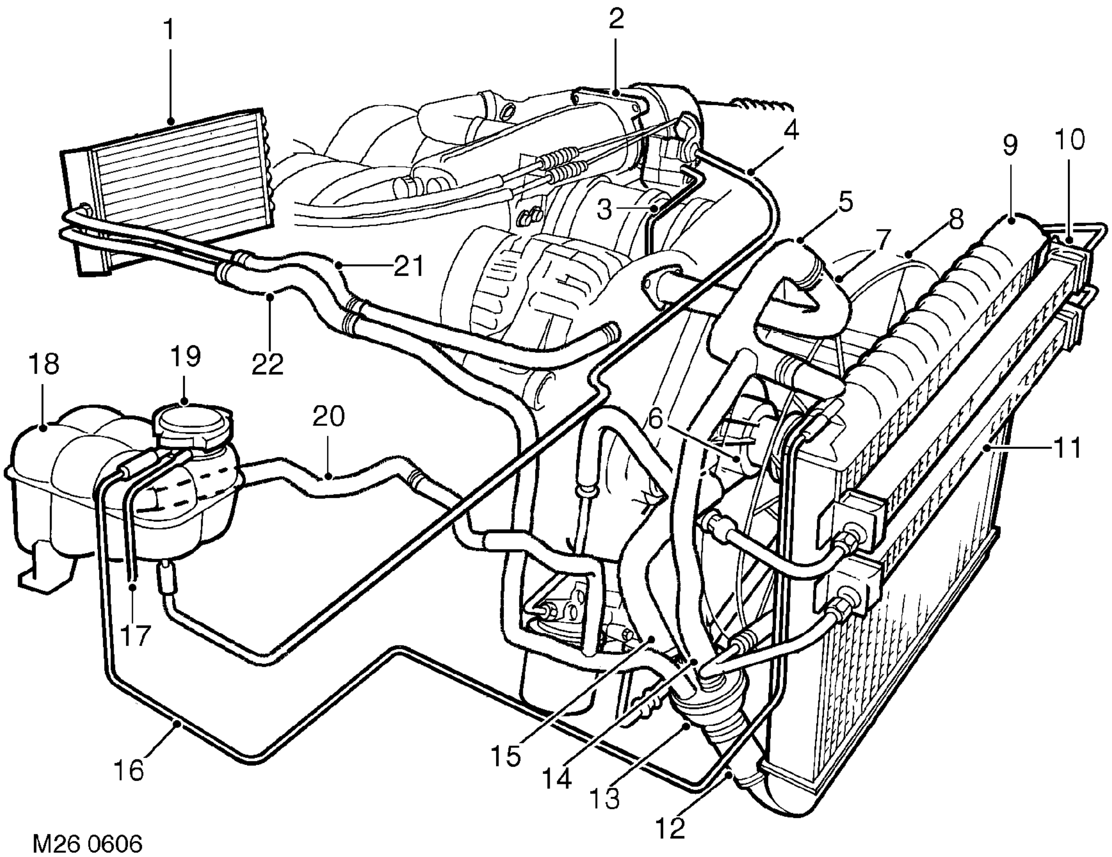
REPAIR

V8 cooling system component layout - up to 99MY



1. Radiator
2. Thermostat housing
3. Bottom hose
4. Bypass hose
5. Viscous fan and water pump
6. Radiator top hose
7. Radiator bleed pipe
8. Plenum chamber feed pipe
9. Plenum chamber bleed pipe
10. Heater feed hose
11. Heater matrix
12. Heater return hose
13. Expansion tank
14. Overflow/Breather pipe
15. Cylinder banks
16. Plenum chamber
17. Engine oil cooler
18. Engine oil filter
19. Feed pipe, engine oil cooler
20. Return pipe, engine oil cooler
21. Gearbox oil cooler
22. Feed pipe, gearbox oil cooler
23. Return pipe, gearbox oil cooler

V8 cooling system component layout - from 99MY



1. Heater matrix
2. Throttle housing
3. Throttle housing inlet hose
4. Throttle housing return pipe
5. Radiator top hose
6. Coolant pump
7. Manifold outlet pipe
8. Viscous fan
9. Radiator
10. Engine oil cooler
11. Gearbox oil cooler
12. Radiator bottom hose
13. Thermostat housing
14. By-pass hose
15. Coolant pump feed hose
16. Radiator bleed pipe
17. Overflow/breather pipe
18. Expansion tank
19. Pressure cap
20. Expansion hose
21. Heater inlet hose/pipe
22. Heater return hose/pipe

ENGINE COOLING - DESCRIPTION

General

The complete cooling system installed in vehicles with V8 engines incorporates three independent functions:- Engine (coolant) cooling; Engine oil cooling; Gearbox oil cooling.

Engine and gearbox oil coolers are mounted in front of the radiator and linked to their separate systems by pre-formed pipes and hoses.

The cooling system used on the V8 engine is a pressurised, by-pass type system which allows coolant to circulate around the engine block and heater matrix when the thermostat is closed. With coolant not passing through the radiator, faster heater warm-up is promoted which in turn improves passenger comfort.

A coolant pump is located in a housing at the front of the engine and is driven by a drive belt. The water pump is connected into the coolant passages cast into the cylinder block and pumps coolant from the radiator through the cylinder block and heater circuit.

A viscous fan is attached to the water pump drive pulley. The fan is secured by a left hand threaded nut to the pulley spindle. The fan draws air through the radiator to assist in cooling when the vehicle is stationary. The fan rotational speed is controlled relative to the running temperature of the engine by a thermostatic valve regulated by a bi-metallic coil.

The cooling system uses a 50/50 mix of anti-freeze and water.

Thermostat housing

A 'four way' thermostat housing, located at the bottom of the fan cowling behind the radiator, is used to link the main components within the engine cooling system. The four connections locate the radiator bottom hose, top hose, by-pass hose and coolant pump feed hose.

The plastic housing contains a wax element thermostat. The thermostat and housing are a sealed unit and cannot be replaced individually. The thermostat is used to maintain the coolant at the optimum temperature for efficient combustion and to aid engine warm-up.

The thermostat is closed at temperatures below approximately 80 °C (176 °F). When the coolant temperature reaches between 80 to 84 °C (176 to 183 °F) the thermostat starts to open and is fully open at approximately 96 °C (204 °F). In this condition the full flow of coolant is directed through the radiator.

Inlet manifold cooling connections

With the thermostat open, coolant leaves the cylinder block via an outlet pipe and top hose attached to the front of the inlet manifold. The top hose is connected to the top of the radiator.

Hot coolant from the cylinder block is also directed from the inlet manifold via pipes and hoses to the heater matrix. Coolant is circulated through the heater matrix at all times when the engine is running.

Plenum chamber - up to 99MY

The plenum chamber is heated with a supply of coolant from a supply pipe from the inlet manifold to a plate on the underside of the throttle on the plenum. The hot coolant prevents the air intake and throttle linkage from icing. A bleed pipe returns coolant from the plenum chamber to the expansion tank.

Throttle housing - from 99MY

A tapping from the inlet manifold supplies coolant to the throttle housing via a hose. The coolant circulates through a plate attached to the bottom of the throttle housing and is returned through a plastic bleed pipe to the expansion tank. The hot coolant heats the throttle housing preventing ice from forming.

ECT sensor and temperature gauge sender unit - up to 99MY

An Engine Coolant Temperature (ECT) sensor and a temperature gauge sender unit are located on the inlet manifold adjacent to the outlet pipe. The ECT sensor monitors coolant temperature emerging from the engine and sends signals relating to coolant temperature to the ECM for engine management. The temperature gauge sender unit operates the warning lamp and temperature gauge in the instrument pack. ***See FUEL SYSTEM - Engine Management, Description and operation.***

ECT sensor - from 99MY

An Engine Coolant Temperature (ECT) sensor is located on the inlet manifold adjacent to the outlet pipe. The ECT sensor monitors coolant temperature emerging from the engine and sends signals relating to coolant temperature to the ECM for engine management and to the instrument pack for temperature gauge operation. ***See FUEL SYSTEM - Engine Management, Description and operation.***

Expansion tank

The expansion tank is located in the engine compartment and attached to the right hand inner wing. The tank is made from moulded plastic and has a maximum coolant level when cold mark moulded on the side.

Excess coolant created by heat expansion is returned to the expansion tank from the bleed pipe at the top of the radiator. An outlet pipe is connected into the thermostat housing and replaces coolant displaced by heat expansion into the system when the engine is cool.

The tank is fitted with a sealed pressure cap. The cap contains a pressure relief valve which opens to allow excessive pressure and coolant to vent through the overflow pipe. The relief valve opens at a pressure of 1.4 bar (20 lbf.in) and above.

Heater matrix

The heater matrix is fitted in the distribution unit of the heating and ventilation system inside the passenger compartment. Two pipes pass through the bulkhead and provide coolant flow to and from the matrix.

The matrix is constructed from aluminium with two end tanks interconnected with tubes. Aluminium fins are located between the tubes and conduct heat away from the hot coolant flowing through the tubes. Air from the heater assembly is warmed as it passes through the matrix fins. The warm air is then distributed into the passenger compartment as required. ***See HEATING AND VENTILATION, Description and operation.***

Radiator

The radiator is located at the front of the vehicle. The vertical flow radiator is manufactured from aluminium with moulded plastic tanks at the top and bottom, interconnected with tubes. Aluminium fins are located between the tubes and conduct heat from the hot coolant flowing through the tubes, reducing the coolant temperature as it passes through the radiator. Air intake from the front of the vehicle when moving carries heat away from the fins. When the vehicle is stationary, the viscous fan draws air through the fins to prevent the engine from overheating.

Two connections at the top of the radiator provide for the attachment of the top hose and bleed pipe. A connection at the bottom of the radiator allows for the attachment of the bottom hose to the thermostat housing.

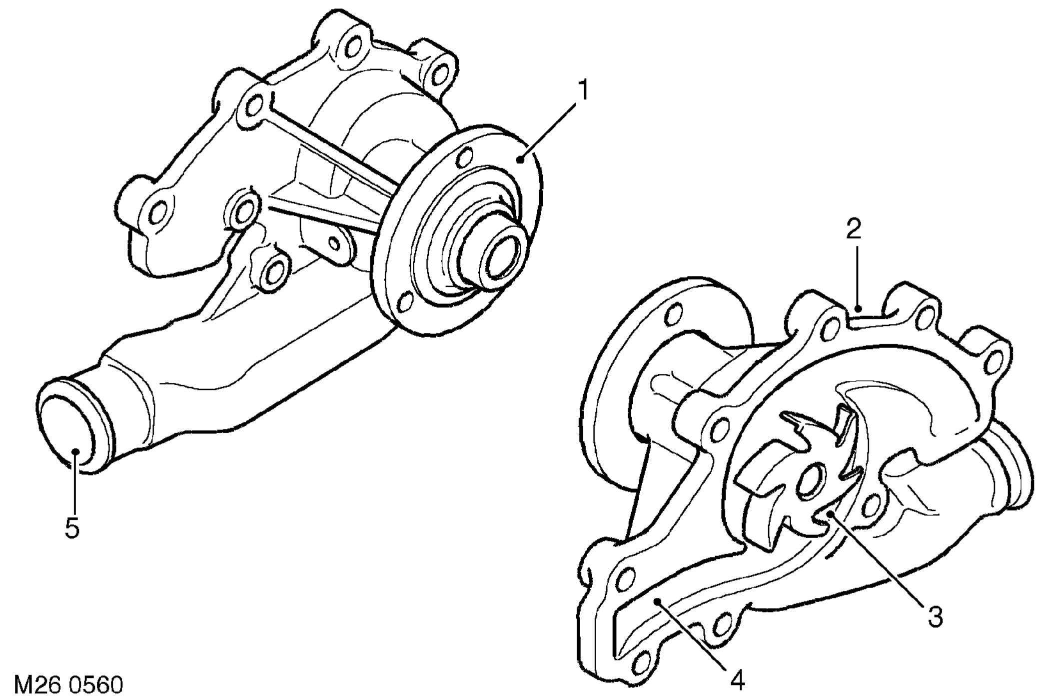
Two coolers are located in front of the cooling radiator. The upper cooler provides cooling of the engine oil and the lower cooler provides cooling for the gearbox oil.
See MANUAL GEARBOX, Description and operation.
See AUTOMATIC GEARBOX, Description and operation.
See ENGINE, Description and operation.

Pipes and hoses

The coolant circuit comprises flexible hoses and metal formed pipes which direct coolant into and out of the engine, radiator and heater matrix. Plastic pipes are used for the bleed and overflow pipes to the expansion tank.

A drain plug is fitted to each cylinder bank in the cylinder block. These are used to drain the block of coolant.

Coolant pump



1. Pulley flange
2. Body
3. Impeller
4. Gallery
5. Inlet connection

The coolant pump is attached to the front of the cylinder block with nine bolts and sealed between the pump housing and the cylinder block with a gasket. The pump comprises a shaft which passes through an alloy housing.

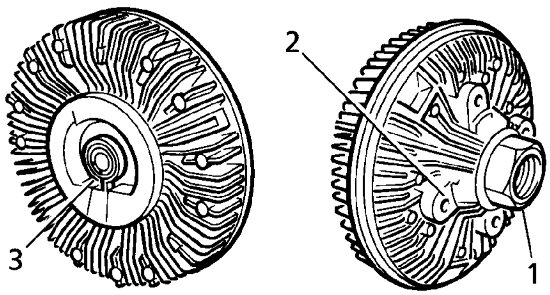
The outer end of the shaft has a flange which allows for the attachment of the pump drive pulley which is secured with three bolts. The drive pulley is driven by the grooved auxiliary drive belt and rotates at the same speed as the crankshaft. The inner end of the shaft is fitted with an impeller which draws coolant from the thermostat housing and circulates it through galleries in the cylinder block and through the heater matrix.

The shaft is supported on bearings in the housing which are packed with grease and sealed for life. A seal is positioned in the housing to further protect the bearings from the ingress of coolant. The seal is manufactured from a synthetic material which will allow for the expansion of the casing when hot coolant is present.

The cast alloy housing has a hose connection which provides the attachment for the coolant pump feed hose. The housing connects with galleries in the cylinder block and distributes coolant from the pump impeller into the galleries and water jackets.

Viscous fan

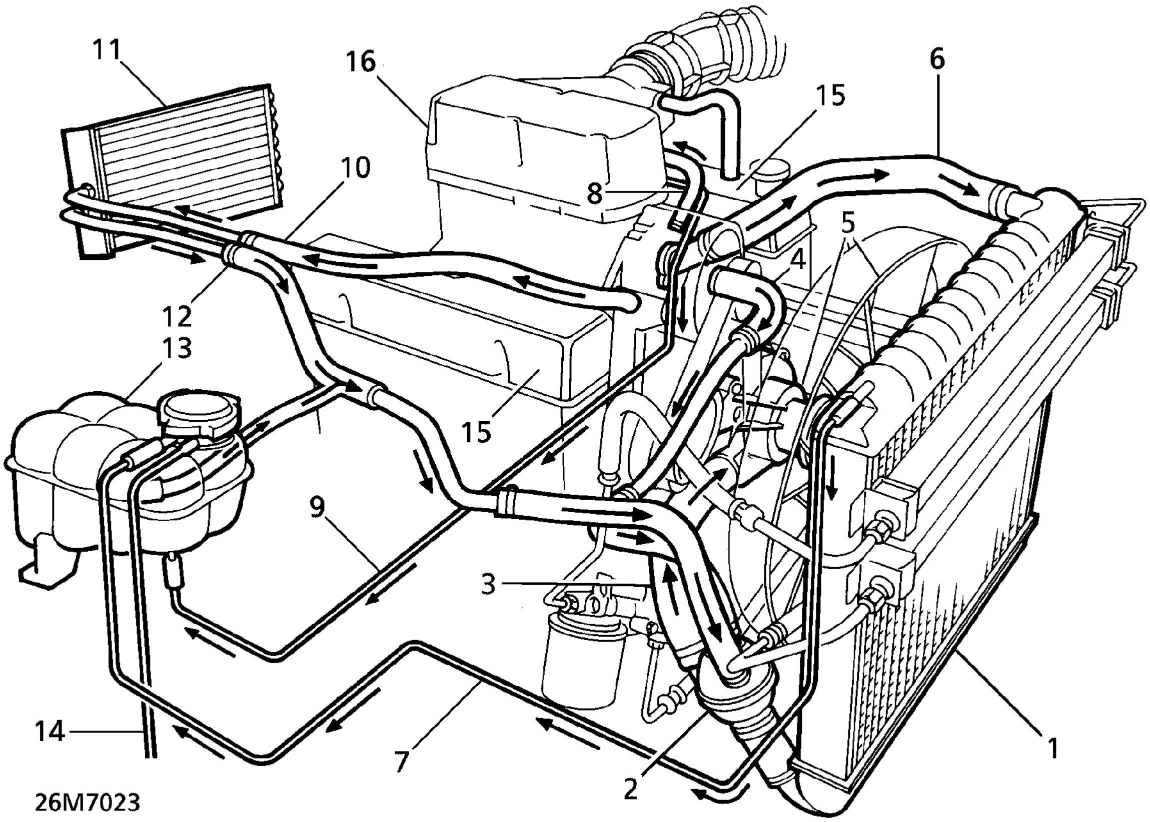
The viscous drive unit for the engine cooling fan provides a means of controlling the speed of the fan relative to the temperature of the engine. The viscous fan unit is a type of fluid coupling, which drives the fan blades by means of 'silicon fluid'.



26M7024

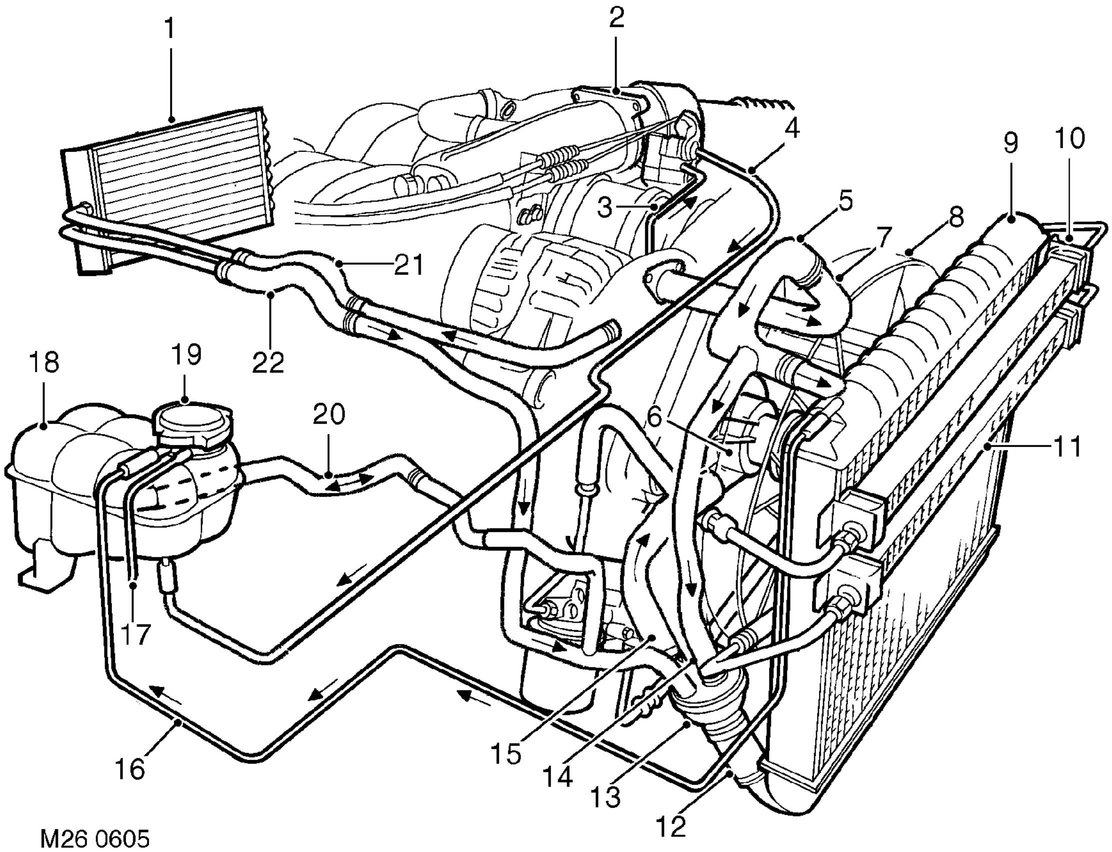
1. Input (drive) member
2. Output (driven) member
3. Sensing mechanism (bi-metal coil)

Cooling system coolant flow - up to 99MY



1. Radiator
2. Thermostat housing
3. Bottom hose
4. Bypass hose
5. Viscous fan and water pump
6. Radiator top hose
7. Radiator bleed pipe
8. Plenum chamber feed pipe
9. Plenum chamber bleed pipe
10. Heater feed hose
11. Heater matrix
12. Heater return hose
13. Expansion tank
14. Overflow/breather pipe
15. Cylinder banks
16. Plenum chamber

Cooling system coolant flow - from 99MY



1. Heater matrix
2. Throttle housing
3. Throttle housing inlet hose
4. Throttle housing return pipe
5. Radiator top hose
6. Coolant pump
7. Manifold outlet pipe
8. Viscous fan
9. Radiator
10. Engine oil cooler
11. Gearbox oil cooler
12. Radiator bottom hose
13. Thermostat housing
14. By-pass hose
15. Coolant pump feed hose
16. Radiator bleed pipe
17. Overflow/breather pipe
18. Expansion tank
19. Pressure cap
20. Expansion hose
21. Heater inlet hose/pipe
22. Heater return hose/pipe

ENGINE COOLING - OPERATION

Coolant flow

Engine warm up - up to 99MY

When the engine is started from cold, the thermostat, integral in the housing, prevents any coolant circulation through the radiator by closing off the supply from the radiator bottom hose.

During engine warm up, the water pump moves coolant around the cylinders to the rear of the engine block and along the galleries in both cylinder banks. At the rear of the cylinder block the coolant rises through a large port in both cylinder head/block joint faces to the inlet manifold.

From the manifold, the coolant flow is divided between the by-pass hose, the heater feed hose and the plenum chamber feed pipe. The heater feed hose supplies the heater matrix, located within the distribution unit of the heating and ventilation system. The coolant is then carried, via the heater return hose, back to the thermostat housing to complete the cycle.

The heater matrix acts as a heat exchanger reducing coolant temperature as it passes through the matrix. With the thermostat closed and coolant flowing around the by-pass circuit, the cooling system is operating at maximum heater performance.

The plenum chamber is heated by a flow of coolant through the feed pipe from the inlet manifold. A bleed pipe returns the coolant from the plenum chamber across the engine to the expansion tank.

Engine hot - up to 99MY

When normal engine running temperature is reached, the main valve of the thermostat opens and a secondary valve closes the bypass port. With the thermostat open, coolant is circulated through the top hose to the radiator.

The air flowing between the tubes cools the coolant as it passes through the radiator. A controlled flow of the lower temperature coolant is drawn from the base of the radiator, through the bottom hose, by the water pump and blended with hot coolant returning from the heater matrix. Coolant circulation through cylinder block and cylinder heads to the heater matrix and plenum chamber remains the same.

Coolant is drawn from the base of the radiator, through the bottom hose, by the water pump. Coolant circulation through the cylinder block and cylinder heads to the heater matrix and plenum chamber remains the same.

An integral bleed pipe connects the top of the radiator to the expansion tank and aids bleeding of air from the coolant system. The expansion tank cap contains a pressure valve which allows excessive pressure and coolant to vent to the overflow pipe if the system has been overfilled.

Engine warm up - from 99MY

When the engine is started from cold, the thermostat, integral in the housing, prevents any coolant circulation through the radiator by closing off the supply from the radiator bottom hose.

During engine warm up, the water pump moves coolant around the cylinders to the rear of the engine block and along the galleries in both cylinder banks. At the rear of the cylinder block the coolant rises through a large port in both cylinder head/block joint faces to the inlet manifold.

From the manifold, the coolant flow is divided between the outlet pipe and the top hose by-pass connection to the thermostat housing, the heater inlet pipe and hose and the throttle housing inlet hose.

The heater inlet pipe and hose supply the heater matrix, located within the distribution unit of the heating and ventilation system. The coolant is then carried, via the heater return hose and pipe, back to the thermostat housing to complete the cycle.

The heater matrix acts as a heat exchanger reducing coolant temperature as it passes through the matrix. With the thermostat closed and coolant flowing around the by-pass circuit, the cooling system is operating at maximum heater performance.

The throttle housing inlet hose allows coolant to flow from the inlet manifold to the plate attached to the bottom of the throttle housing. A return pipe directs coolant flow from the throttle housing to the expansion tank.

Engine hot - from 99MY

When normal engine running temperature is reached, the main valve of the thermostat opens and a secondary valve closes the bypass port from the top hose. With the thermostat open, coolant is circulated through the top hose to the radiator.

The air flowing between the tubes cools the coolant as it passes through the radiator. A controlled flow of the lower temperature coolant is drawn from the base of the radiator, through the bottom hose, by the water pump and blended with hot coolant returning from the heater matrix. Coolant circulation through the cylinder block and cylinder heads to the heater matrix and throttle housing remains the same.

A bleed pipe connects the top of the radiator to the expansion tank and aids bleeding of air from the coolant system. The expansion tank cap contains a pressure valve which allows excessive pressure and coolant to vent to the overflow pipe if the system has been overfilled.

Viscous fan

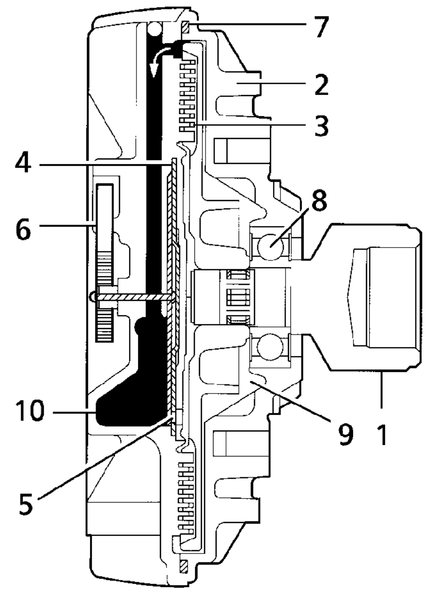
There are two main components of the viscous fan drive : An input (drive) member consisting of a threaded shaft passing through a bearing into the clutch plate and secured to the water pump. An output (driven) member comprises the main body to which the fan attaches, with the temperature sensing mechanism (bi-metal coil) and pump plates.

The fan drive only has to be engaged periodically, between 5% and 10% of the time during normal driving conditions, because usually the vehicle is cooled by ram air.

A bi-metal coil senses air temperature behind the radiator. When a pre-determined temperature is reached, the coil opens a valve which allows fluid to enter the drive area. Centrifugal force circulates the fluid to the annular drive area. There are two sets of annular grooves, one in the drive clutch and the other in the drive body, a specific clearance being provided between the two sets of grooves. When this clearance is filled with viscous fluid a shearing action, caused by the speed differential between the two drive components, transmits torque to the fan. The fluid is thrown to the outside of the unit by centrifugal force from where it is then re-circulated to the reservoir via the pump plate adjacent to the drive member.

If the engine speed is increased, the amount of slip will also increase to limit the maximum fan speed.

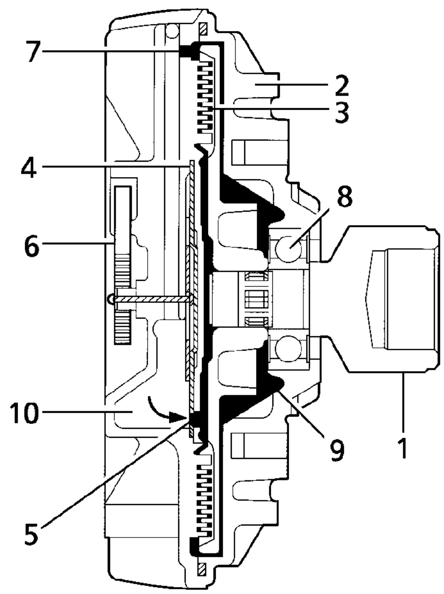
Viscous unit disengaged (engine at normal operating temperature)



26M7025

1. Input (drive) member
2. Output (driven) member
3. Running clearance
4. Pump plate
5. Valve (closed)
6. Sensing mechanism (bi-metal coil)
7. Fluid seal
8. Bearing,input member
9. Fluid chamber
10. Fluid reservoir

Viscous unit engaged (hot running temperature)



Bi-metal coil expanded, valve open.

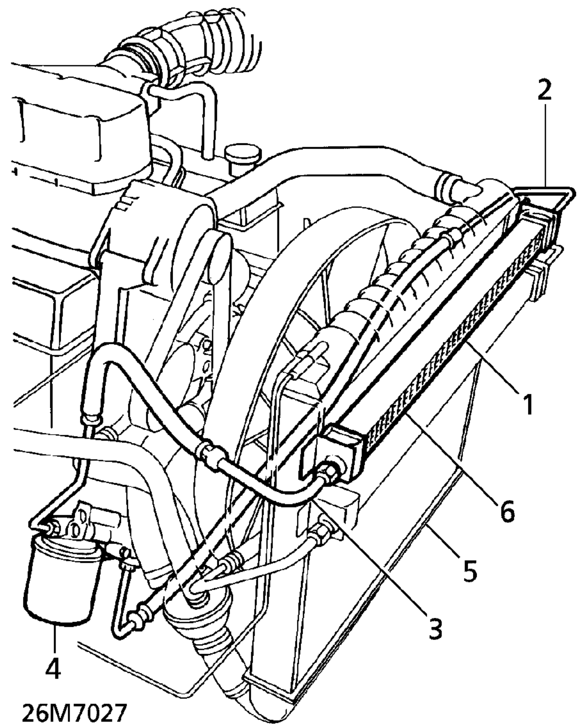
When the air temperature from the radiator drops sufficiently, the bi-metal coil closes the valve and prevents fluid entering the drive area, see 26M7026. The fluid that is in the drive area will gradually pump out into the reservoir and the fan will return to an idle condition.

Engine oil cooler

The engine oil cooler is located in front of the radiator above the gearbox oil cooler and comprises a single row matrix; on 4.0 litre models three internal cooling tubes are used; 4.6 litre models use a larger matrix incorporating six cooling tubes. Pre-formed feed and return pipes/hoses are used to link the cylinder block, oil filter and oil cooler. The oil cooler is mounted above the gearbox oil cooler, fixed to the radiator side frame.

Oil drawn through a steel gauze strainer in the sump, is pumped under pressure through the feed pipe into the oil cooler. Ambient air, forced through the front grille of the vehicle and assisted by the pull of the viscous fan, is dispersed across the oil cooler. The cooled oil then passes through the return pipe to the filter, before being distributed from the cylinder block to the various internal engine components.

Engine oil cooler - up to 99MY shown



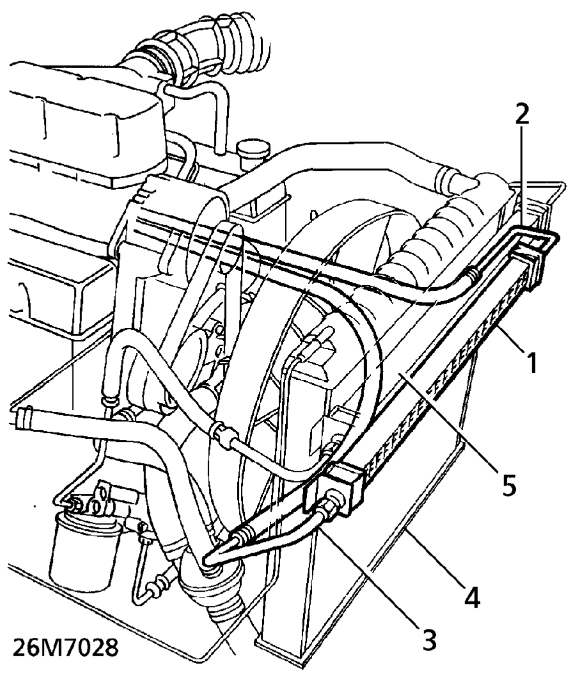
1. Engine oil cooler
2. Feed pipe
3. Return pipe
4. Oil filter
5. Radiator
6. Gearbox oil cooler

Gearbox oil cooler

The gearbox oil cooler is located below the engine oil cooler in front of the radiator and comprises a single row matrix. On vehicles fitted with manual gearboxes three internal cooling tubes are used, on vehicles with automatic transmission a larger matrix, incorporating twelve coolant tubes is fitted. Pre-formed feed and return pipes/hoses are used to link the gearbox and oil cooler.

Oil is pumped under pressure from the gearbox through the feed pipe into the oil cooler. Ambient air, forced through the front grille of the vehicle and assisted by the pull of the viscous fan, is dispersed over the oil cooler. The cooled oil then passes through the return pipe, which is routed under the engine to run parallel with the feed pipe back to the LH side of the gearbox.

Gearbox oil cooler - up to 99MY shown



1. Gearbox oil cooler
2. Feed pipe
3. Return pipe
4. Radiator
5. Engine oil cooler

COOLING SYSTEM FAULTS

This section covers mechanical faults that could occur in the complete cooling system :

1. Engine (coolant) cooling;
2. Engine oil cooling;
3. Gearbox oil cooling.

Before conducting any visual checks within the separate systems and undertaking detailed diagnosis procedures. ***See Description and operation.***

1. ENGINE (COOLANT) COOLING SYSTEM

Symptom - Engine Overheating

POSSIBLE CAUSE	REMEDY
1. Engine coolant low.	1. Allow engine to cool. Top up expansion tank to correct level, with engine running at idle. Check cooling system for leaks and rectify, if necessary.
2. Loose drive belt.	2. Check/renew drive belt tensioner or renew drive belt. ***See ELECTRICAL, Repair.***
3. Coolant in radiator frozen.	3. Slowly thaw and drain cooling system. ***See Repair.***
4. Air flow through radiator restricted or blocked.	4. Apply air pressure to engine side of radiator to clear obstruction. If mud or dirt is evident, carefully use a hose.
5. External leaks from water pump, engine gaskets, thermostat housing or pipe/hoses.	5. Check for visual causes and rectify.
6. Viscous fan not operating correctly or inoperative.	6. Renew viscous fan unit. ***See Repair.***
7. Thermostat seized in closed position.	7. Check radiator bottom hose for coolant flow through radiator. If cold a faulty thermostat is confirmed. Renew thermostat housing assembly. ***See Repair.***

Symptom - Engine Overheating, continued

POSSIBLE CAUSE	REMEDY
8. Air in cooling system.	8. Check coolant level. Run engine at fast idle (approximately 2,000 rpm) with expansion tank cap off. Top up coolant level with engine at idle and refit expansion tank cap.
9. Air conditioning condenser fans not operating correctly or inoperative.	9. ***See AIR CONDITIONING, Fault diagnosis.***
10. Temperature gauge or sender unit giving inaccurate readings.	10. Substitute parts and compare new readings.
11. Coolant leakage across cylinder head gasket.	11. Carry out cylinder pressure test to determine if pressure is leaking into cooling system, causing over pressurising and loss of coolant. Renew cylinder head gasket.
12. Engine oil contamination of cooling system due to leaking.	12. Renew cylinder head gasket. ***See ENGINE, Repair.***
13. Coolant contamination of lubrication system.	13. Renew inlet manifold or front cover gaskets. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.*** or ***See ENGINE, Repair.***

Symptom - Engine Runs Cold

POSSIBLE CAUSE	REMEDY
1. Thermostat seized in open or partially open position.	1. Remove thermostat housing and check operation of thermostat. Renew, if necessary. ***See Repair.***
2. Temperature gauge or sender unit giving inaccurate readings.	2. Substitute parts and compare new readings.
3. Viscous fan not operating correctly.	3. Renew viscous fan unit. ***See Repair.***
4. Air conditioning condenser fans operating continuously.	4. Refer to **TestBook** .

2. ENGINE OIL COOLING SYSTEM

Symptom - Engine Oil Overheating

POSSIBLE CAUSE	REMEDY
1. Air flow through oil cooler matrix restricted or blocked.	1. Apply air pressure to engine side of radiator to clear obstruction. If mud or dirt is evident, carefully use a hose.
2. Blocked or damaged oil cooler or pipe/hoses restricting engine oil flow.	2. Check for visual damage and renew components where necessary.
3. Oil cooler relief valve seized in closed position.	3. Remove and check relief valve. Renew, if necessary.

3. GEARBOX OIL COOLING SYSTEM

SYMPTOM - Gearbox Oil Overheating

POSSIBLE CAUSE	REMEDY
1. Air flow through oil cooler matrix restricted or blocked.	1. Apply air pressure to engine side of radiator to clear obstruction. If mud or dirt is evident, carefully use a hose.
2. Damaged oil cooler or pipe/hoses restricting gearbox oil flow.	2. Check for visual damage and renew components where necessary.
3. Vehicle being driven in wrong gear.	3. Advise owner/driver accordingly.

NOTE: Critical warning messages relating to the complete cooling system are displayed on the message centre in the lower section of the instrument pack, should a fault occur in any of the separate systems.

COOLANT - DRAIN AND REFILL

Service repair no - 26.10.01

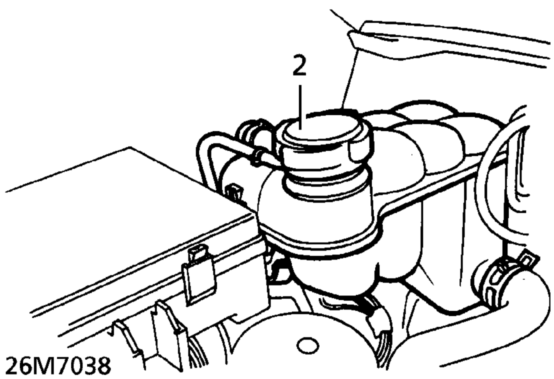
Drain

WARNING: Do not remove expansion tank filler cap when engine is hot. The cooling system is pressurised. Personal scalding could result.

1. Raise the vehicle.

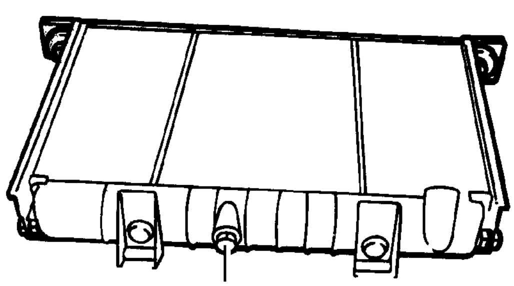
WARNING: Support on safety stands.

2. Remove expansion tank filler cap to assist draining.



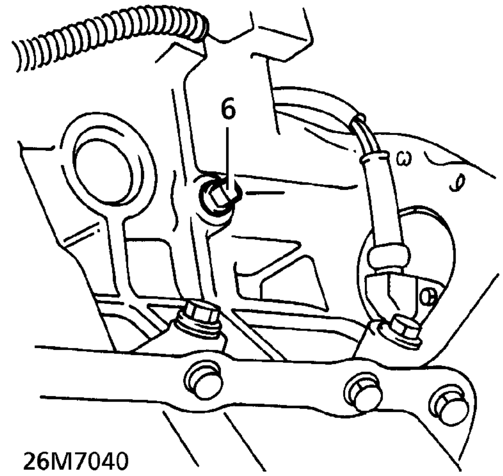
26M7038

3. Position container beneath radiator.
4. Remove plug from base of radiator. Allow coolant to drain.



26M7039

5. If system is only being partially drained, continue at **Refill.**
6. Reposition container. Remove LH cylinder block drain plug. Allow coolant to drain.



26M7040

NOTE: Do not remove RH cylinder block drain plug.

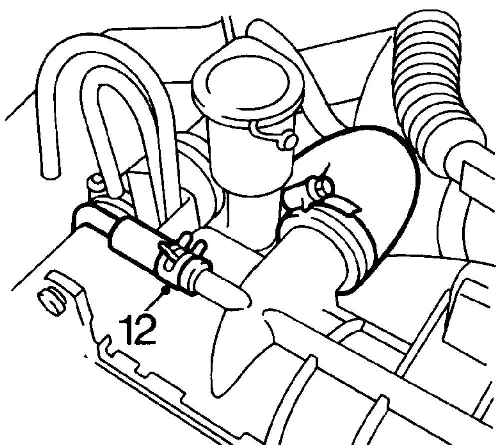
7. Clean drain plug threads. Apply a coating of 'Loctite 577'. Refit plug to block. Tighten securely.

Refill

8. Ensure sufficient coolant solution is available. ***See LUBRICANTS, FLUIDS AND CAPACITIES, Information.***
9. Inspect radiator drain plug 'O' ring, renew if required.
10. Fit drain plug to radiator. Tighten to ***Max 6 Nm (4 lbf.ft)***
11. Remove safety stands. Lower vehicle.
12. Disconnect radiator bleed hose at the radiator.
13. Blow through hose to clear any residual coolant. Reconnect hose.

CAUTION: If radiator bleed hose is not cleared of coolant, air may become trapped at top of radiator during refill, leading to subsequent engine overheating.

14. Fill expansion tank until coolant is level with base of neck.
15. Start engine, continue filling at expansion tank until coolant level stabilises at the 'COLD LEVEL' marking.
16. Run the engine until the thermostat opens (top hose becomes warm).
17. Stop engine, allow to cool.
18. Check coolant level, top-up as necessary.
19. Refit expansion tank filler cap.



26M7013A

RADIATOR

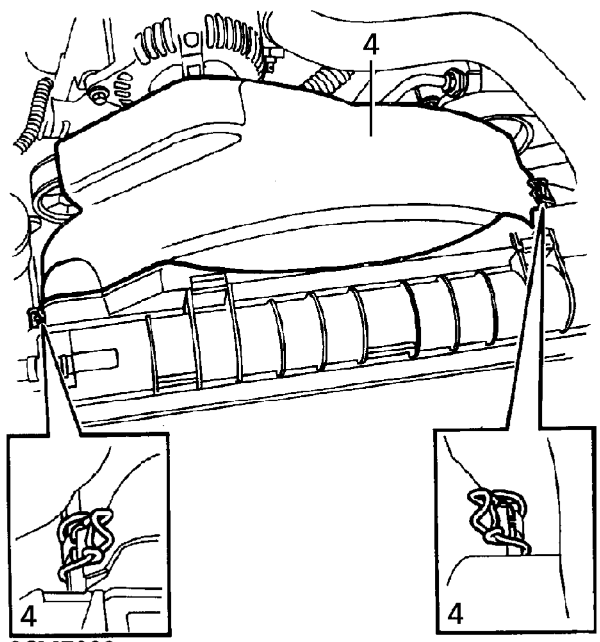
Service repair no - 26.40.04

Remove

1. Disconnect battery negative lead.
2. Raise the vehicle.

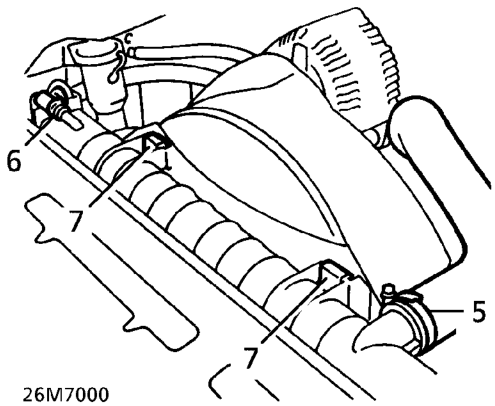
WARNING: Support on safety stands.

3. Drain cooling system. ***See this section.***
4. Release clips securing upper cooling fan cowl. Remove cowl.

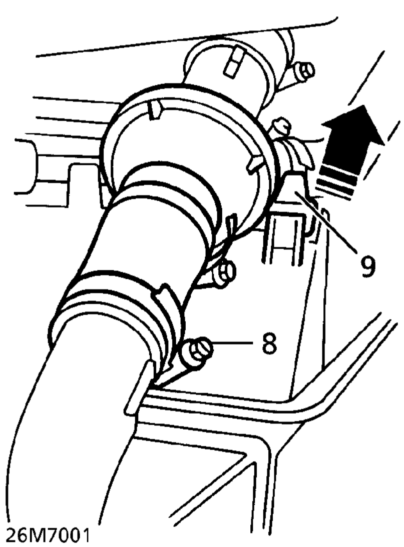


26M7008

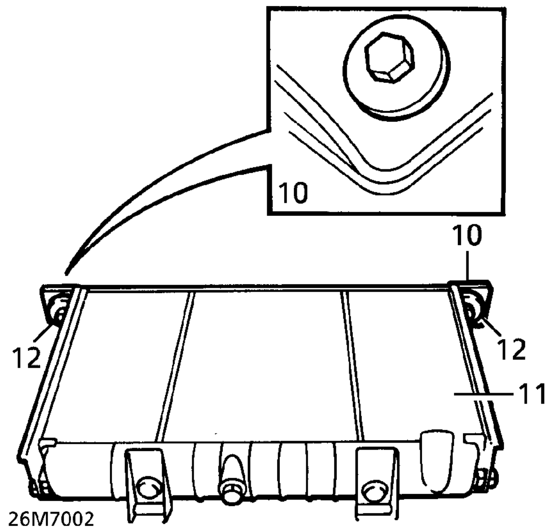
5. Release top hose from radiator.
6. Release expansion tank hose from radiator.



7. Remove clips securing radiator to cooling fan cowl.



8. Slacken bottom hose clips at radiator and thermostat housing.
9. Release thermostat housing from fan cowl. Remove bottom hose.
10. Remove 2 bolts securing radiator to mounting bracket.



11. Release radiator from upper and lower mountings.
12. Remove radiator. Collect lower mounting rubbers.

Refit

13. Reverse removal procedure.
14. Refill cooling system. ***See this section.***

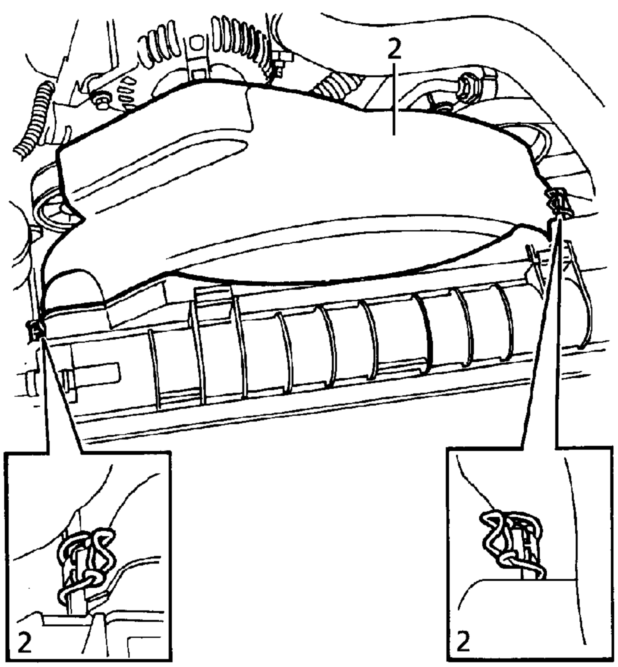
VISCOUS COUPLING AND FAN ASSEMBLY - UP TO 99MY

Service repair no - 26.25.19

Special tools:
LRT-12-093
LRT-12-094 - Viscous coupling removal

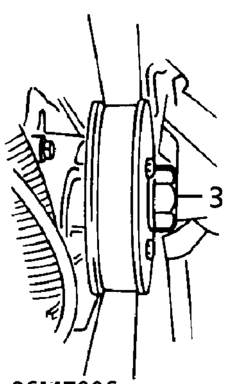
Remove

1. Disconnect battery negative lead.



26M7005

2. Release 2 clips securing cooling fan upper cowl. Remove cowl.

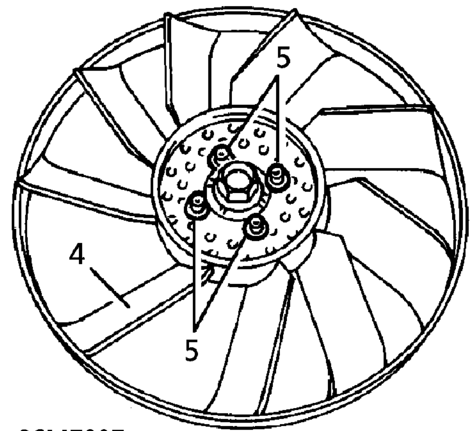


26M7006

3. Using LRT-12-093 and LRT-12-094 unscrew viscous coupling from water pump.

NOTE: Viscous coupling is secured with a RH thread.

4. Remove fan and coupling assembly.



26M7007

Do not carry out further dismantling if component is removed for access only.

5. Remove 4 bolts securing coupling to fan. Remove coupling.

Refit

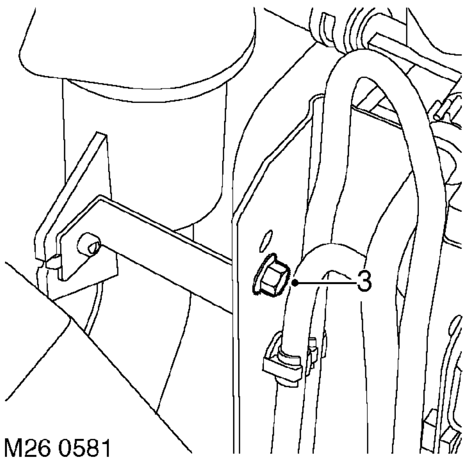
6. Ensure mating faces are clean.
7. Fit fan to coupling. Secure with bolts. Tighten to ***24 Nm (18 lbf.ft)***
8. Using LRT-12-093 and LRT-12-094, fit fan assembly to pump. Tighten to ***56 Nm (41 lbf.ft.)***
9. Fit cooling fan upper cowl. Secure with clips.
10. Reconnect battery negative lead.

VISCOUS COUPLING AND FAN ASSEMBLY - FROM 99MY

Service repair no - 26.25.19

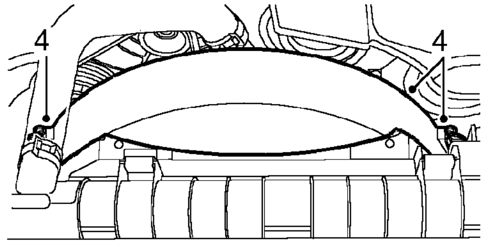
Remove

1. Release fixings and remove battery cover.
2. Disconnect battery earth lead.



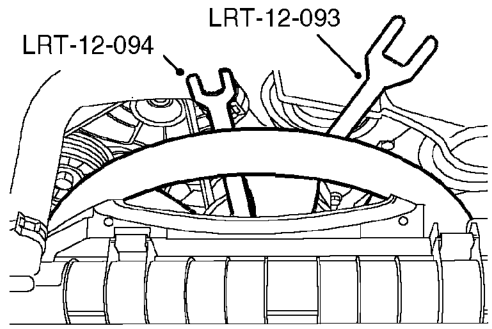
M26 0581

3. Remove bolt securing washer reservoir filler tube support bracket to radiator bracket.



M26 0582

4. Release 2 clips securing fan cowl and remove fan cowl.



M26 0583

5. Remove cooling fan using LRT-12-093 andLRT-12-094.

Refit

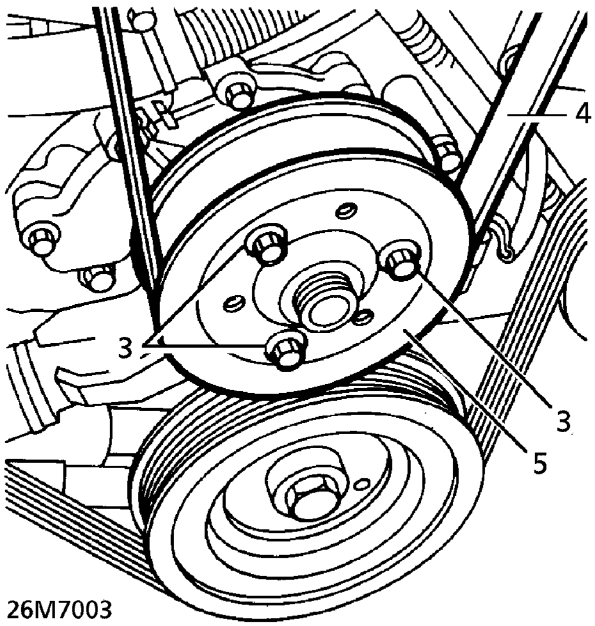
6. Position cooling fan and tighten using LRT-12-093 andLRT-12-094.
7. Fit fan cowl and secure with clips.
8. Align washer reservoir filler tube bracket and secure with bolt.
9. Connect battery earth lead.
10. Fit battery cover and secure with fixings.

WATER PUMP - UP TO 99MY

Service repair no - 26.50.01

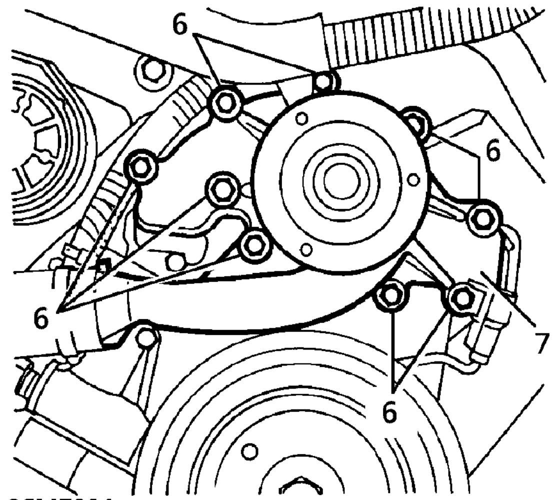
Remove

1. Drain cooling system. ***See this section.***
2. Remove cooling fan. ***See this section.***
3. Slacken water pump pulley bolts.



26M7003

4. Release tension from water pump drive belt. Remove belt.
5. Remove water pump pulley.



26M7004

6. Remove 9 bolts securing water pump.
7. Remove water pump and gasket.

Refit

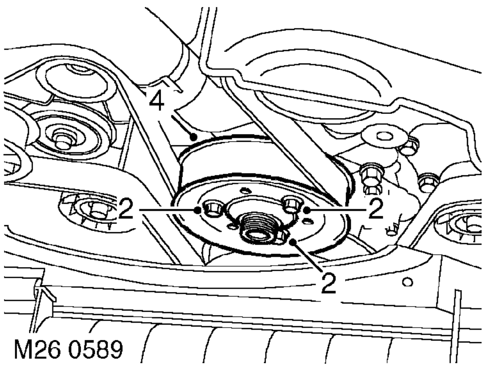
8. Ensure mating faces are clean.
9. Fit water pump with new gasket.
10. Position water pump. Secure with bolts. Tighten to ***22 Nm (16 lbf.ft)***
11. Fit water pump pulley. Secure with bolts. Tighten to ***22 Nm (16 lbf.ft)***
12. Fit water pump drive belt.
13. Fit cooling fan. ***See this section.***
14. Fill cooling system. ***See this section.***

WATER PUMP - FROM 99MY

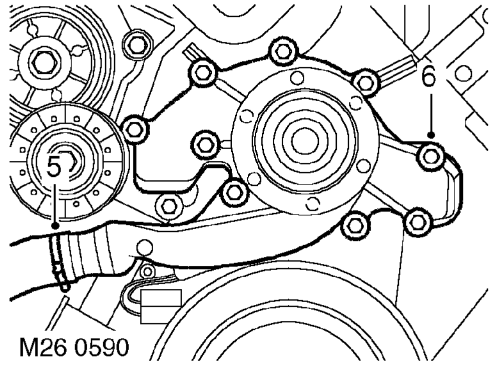
Service repair no - 26.50.01

Remove

1. Drain cooling system. ***See this section.***



2. Loosen 3 bolts securing water pump pulley to water pump.
3. Remove auxiliary drive belt. ***See ELECTRICAL, Repair.***
4. Remove 3 bolts securing pulley to water pump and remove pulley.



5. Release clip and disconnect coolant hose from water pump.
6. Remove 9 bolts securing water pump, remove water pump and discard gasket.

Refit

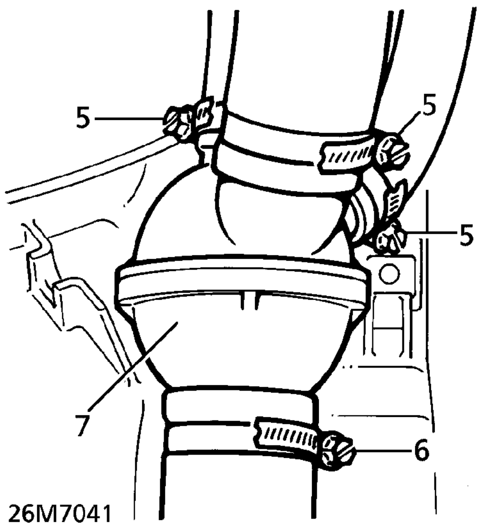
7. Clean water pump and mating face.
8. Fit new gasket and water pump, tighten bolts to ***24 Nm (18 lbf.ft).***
9. Connect coolant hose to water pump and secure with clip.
10. Ensure mating faces of water pump pulley and flange are clean, fit pulley and tighten bolts to ***22 Nm (17 lbf.ft).***
11. Fit auxiliary drive belt. ***See ELECTRICAL, Repair.***
12. Refill cooling system. ***See this section.***

THERMOSTAT - UP TO 99MY

Service repair no - 26.45.01

Remove

1. Disconnect battery earth lead.
2. Raise vehicle on 4 post ramp.
3. Remove engine acoustic cover (if applicable). ***See CHASSIS AND BODY, Repair.***
4. Drain cooling system. ***See this section.***



26M7041

5. Loosen 3 upper hose clips and disconnect 3 hoses from top of thermostat housing.
6. Loosen lower hose clip and disconnect hose from bottom of thermostat housing.
7. Release 2 clips securing thermostat to housing radiator cowl and remove thermostat housing.

Refit

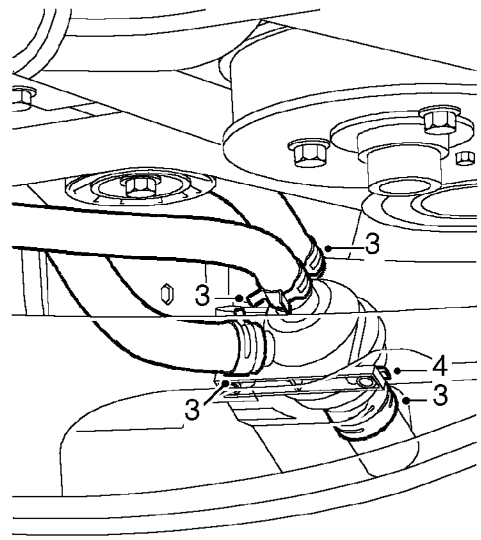
8. Position thermostat housing and connect to radiator hose.
9. Connect hoses to top of thermostat housing.
10. Tighten clips securing hoses to thermostat housing.
11. Engage thermostat housing to radiator cowl clips.
12. Fill coolant system. ***See this section.***
13. Fit engine acoustic cover (if applicable). ***See CHASSIS AND BODY, Repair.***

THERMOSTAT - FROM 99MY

Service repair no - 26.45.09

Remove

1. Drain cooling system. ***See this section.***
2. Remove cooling fan. ***See this section.***



M26 0588

3. Release 3 clips and disconnect coolant hoses from thermostat.
4. Release clip securing thermostat to fan cowl and remove thermostat.

Refit

5. Position thermostat and secure to cowl.
6. Fit hoses to thermostat and secure with clips.
7. Fit cooling fan. ***See this section.***
8. Fill cooling system. ***See this section.***

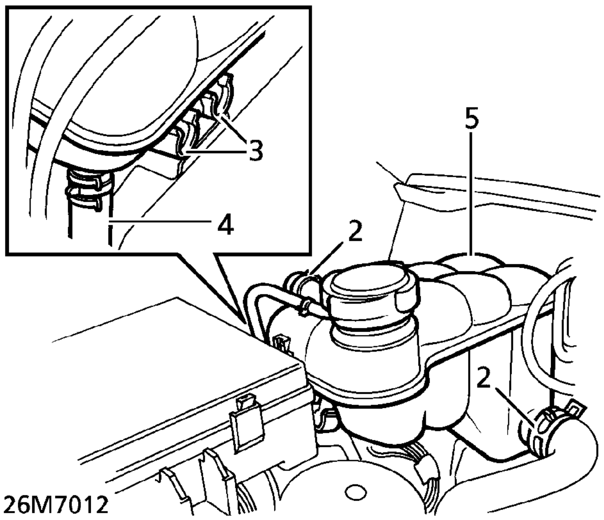
EXPANSION TANK

Service repair no - 26.15.01

NOTE: This operation covers all models

Remove

1. Position container to collect coolant spillage.
2. Disconnect heater hose and radiator bleed hose from expansion tank.



26M7012

3. Release expansion tank from clips.
4. **Petrol only:** Disconnect throttle housing coolant bleed hose from expansion tank.
5. Remove expansion tank.

Refit

6. Reverse removal procedure.
7. Check and top up cooling system.

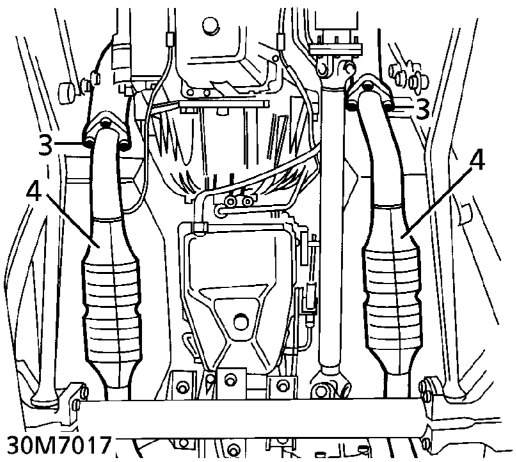
30 - MANIFOLD AND EXHAUST SYSTEM

CONTENTS

EXHAUST MANIFOLD GASKETS - V8 - UP TO 99MY

Service repair no - 30.15.16 - Right Hand
Service repair no - 30.15.17 - Left Hand

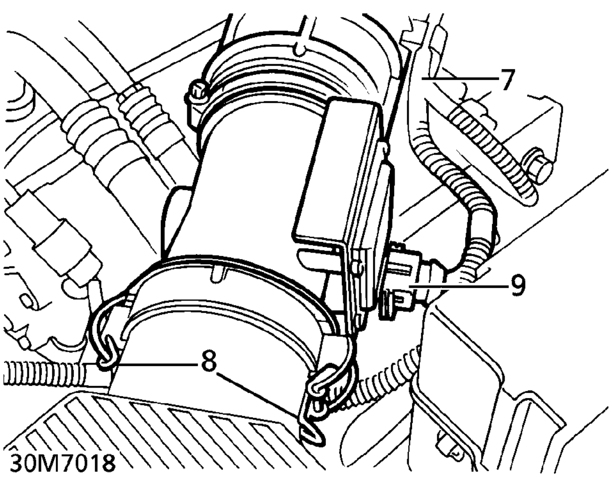
1. Disconnect battery negative lead.
2. Raise vehicle on four post lift.
3. Remove 3 nuts securing each front pipe flange to exhaust manifold.



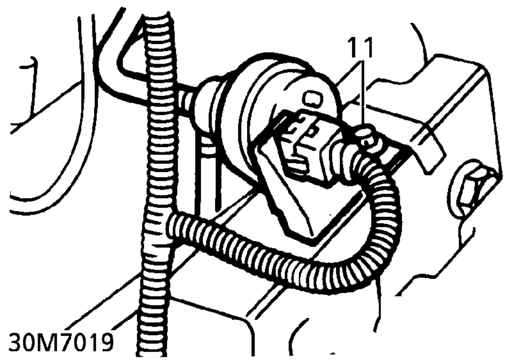
4. Release front pipe from exhaust manifolds. Collect gaskets.
5. Lower lift.

NOTE: Instructions 6 to 11 apply to *Left Hand Manifold Only*

6. Release intake hose from plenum chamber.

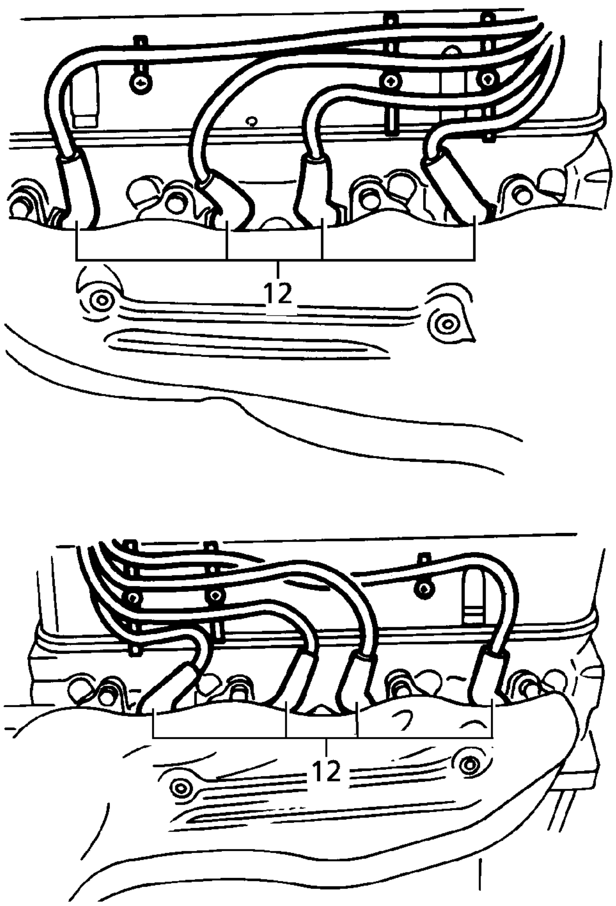


7. Release harness from intake hose clip.
8. Release 2 clips securing air flow meter to air cleaner. Release meter. Collect 'O' ring.
9. Disconnect multiplug from air flow meter. Remove meter.
10. Release purge hose from ram pipe housing.
11. Remove purge valve securing bolt from shock absorber turret. Place valve aside.

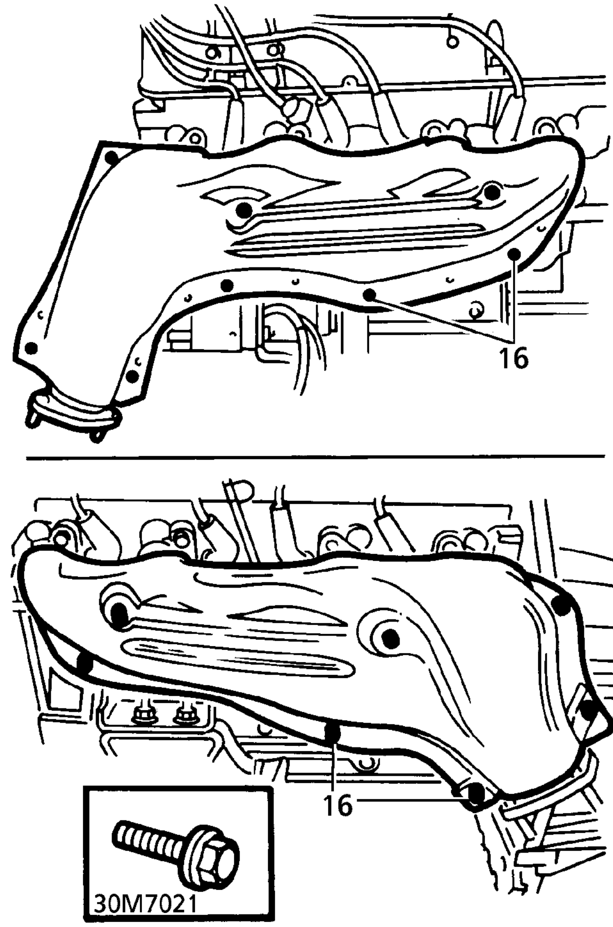


NOTE: Instructions 12,13 & 14 apply to *Right Hand Manifold Only.*

12. Release spark plug caps. Release H.T. leads from clips on rocker cover. Place leads aside.



30M7020



30M7021

13. Remove screw securing H.T. lead clip to rocker cover. Remove clip.

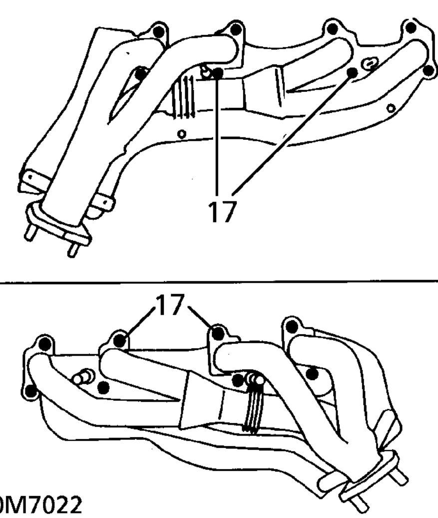
14. Unscrew RH shock absorber top mounting bolt to provide additional clearance for heat shield removal.

NOTE: Do not remove bolt.

15. Right Hand Drive - Right Hand Manifold Only. Remove intermediate steering shaft. ***See STEERING, Repair.***

16. Remove 8 bolts (RH manifold) or 7 bolts (LH manifold) securing outer heat shield to manifold. Remove heat shield.

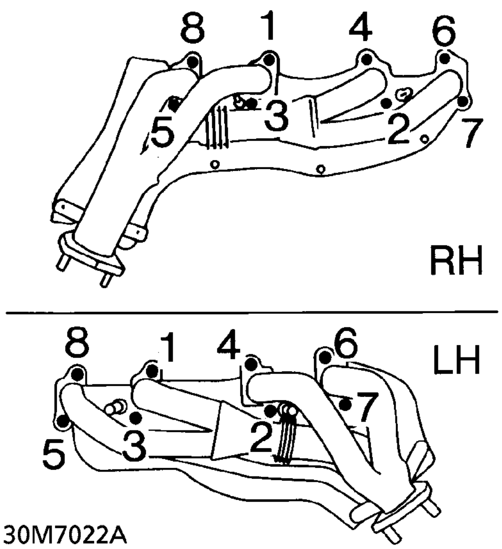
17. Remove 8 bolts securing exhaust manifold to cylinder head. Remove manifold. Collect gaskets.



30M7022

Refit

18. Ensure mating faces are clean.
19. Position manifold on cylinder head. Align new gaskets.
20. Secure manifold with bolts. Tighten to ***55 Nm (40 lbf.ft)*** in sequence shown.



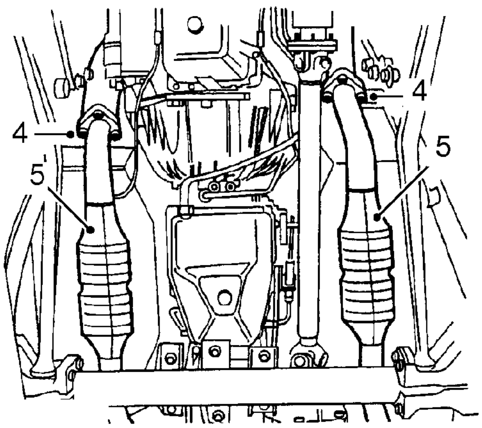
30M7022A

21. Fit outer heat shield. Secure with bolts. Tighten to ***8 Nm (6 lbf.ft)***
22. Position purge valve on shock absorber turret. Secure with bolt.
23. Connect purge hose to ram pipe housing.
24. Fit air flow meter/hose assembly to plenum chamber. Secure with clip.
25. Connect multiplug to air flow meter.
26. Fit 'O' ring to air flow meter. Secure meter to air cleaner with clips.
27. Engage harness in intake hose clip.
28. Tighten RH shock absorber top mounting bolt to ***85 Nm (63 lbf.ft)***
29. Position H.T. lead clip on rocker cover. Secure with screw.
30. Route H.T. leads. Secure in clips. Connect plug caps.
31. If removed, fit intermediate steering shaft. ***See STEERING, Repair.***
32. Raise lift.
33. Fit new gasket to front pipe. Position pipe to exhaust manifold. Secure with nuts. Tighten to ***50 Nm (37 lbf.ft)***
34. Reconnect battery negative lead.

EXHAUST MANIFOLD GASKETS - V8 - FROM 99MY

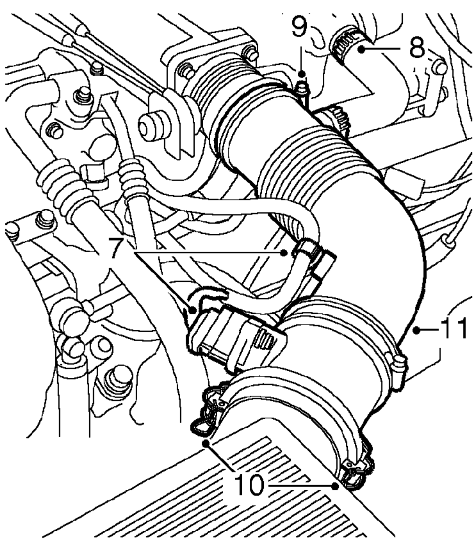
Service repair no - 30.15.16 - Right Hand
Service repair no - 30.15.17 - Left Hand

1. Release 3 fixings and remove battery cover.
2. Disconnect battery negative lead.
3. Raise vehicle on four post lift.



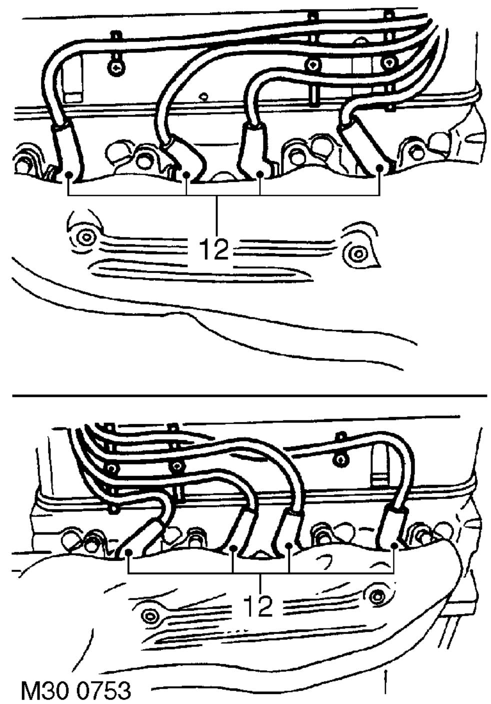
M30 0751

4. Remove 3 nuts securing each front pipe flange to exhaust manifold.
5. Release front pipe from exhaust manifold. Collect gaskets.
6. Lower lift.



M30 0752

7. Disconnect multiplug from MAF sensor and release harness from clip on air intake hose.
8. Release clip and disconnect hose from IAC valve.
9. Loosen clip and disconnect air intake hose from throttle body.
10. Release two clips securing MAF sensor to air cleaner.
11. Remove MAF sensor and hose assembly. Collect 'O' ring.



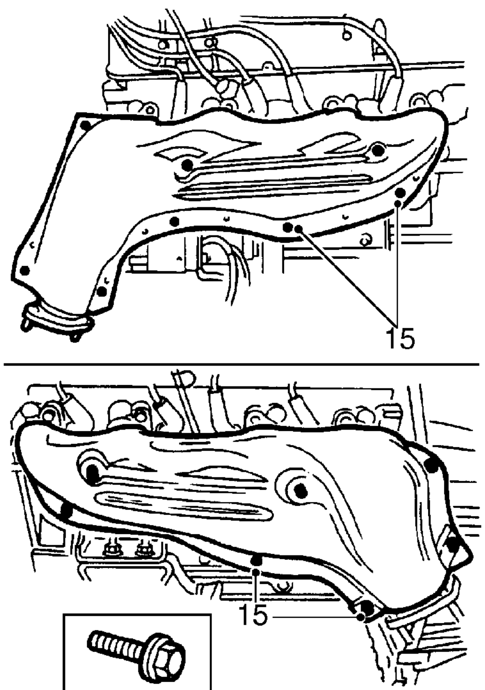
M30 0753

12. Release spark plug caps. Release H.T. leads from clips on rocker cover. Place leads aside.

13. **RH Manifold Only.** Loosen RH shock absorber top mounting bolt (to provide clearance for heat shield removal).

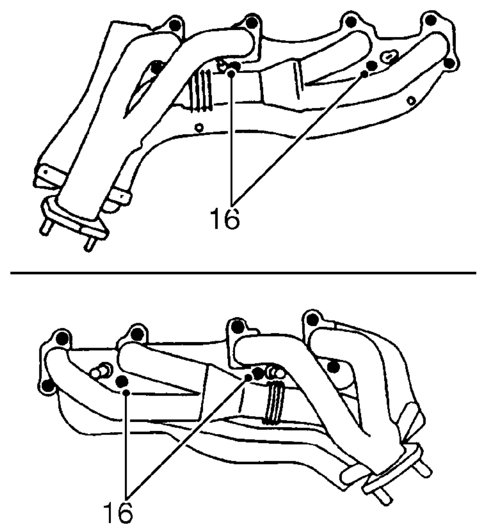
NOTE: Do not remove bolt.

14. **RHD, RH Manifold Only.** Remove steering column intermediate shaft. ***See STEERING, Repair.***



M30 0754

15. Remove 8 (RH exhaust manifold) or 7 (LH exhaust manifold) bolts securing outer heat shield to manifold. Remove heat shield.

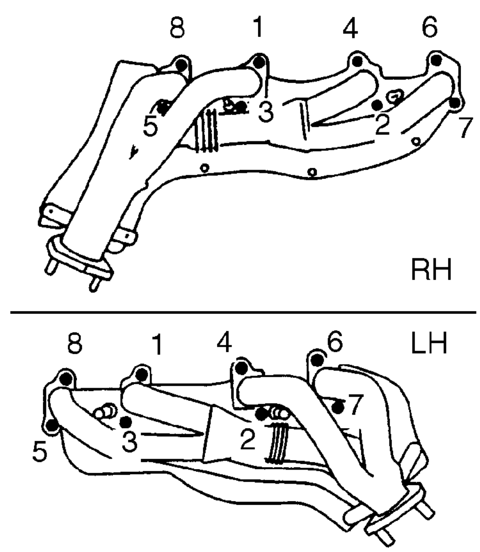


M30 0755

16. Remove 8 bolts securing exhaust manifold to cylinder head. Remove exhaust manifold and collect gaskets.

Refit

17. Ensure mating faces are clean.
18. Position manifold on cylinder head. Align new gaskets.



M30 0756

19. Secure manifold with bolts. Tighten to ***55 Nm (40 lbf.ft)*** in sequence shown.

20. Fit outer heat shield. Secure with bolts. Tighten to ***8 Nm (6 lbf.ft).***
21. Fit MAF sensor and hose assembly to throttle body. Secure with clip.
22. Fit 'O' ring to MAF sensor. Secure MAF sensor to air cleaner with clips.
23. Connect multiplug to MAF sensor. Engage harness in clip on air intake hose.
24. **RH Manifold Only.** Tighten RH shock absorber top mounting bolt to ***85 Nm (63 lbf.ft).***
25. Route H.T. leads. Secure in clips. Connect plug caps.
26. **RHD, RH Manifold Only.** Fit steering column intermediate shaft. ***See STEERING, Repair.***
27. Raise lift.
28. Fit new gasket to front pipe. Position pipe to exhaust manifold. Secure with nuts. Tighten to ***50 Nm (37 lbf.ft).***
29. Reconnect battery negative lead.
30. Fit battery cover and secure with fixings.

EXHAUST MANIFOLD GASKETS - DIESEL

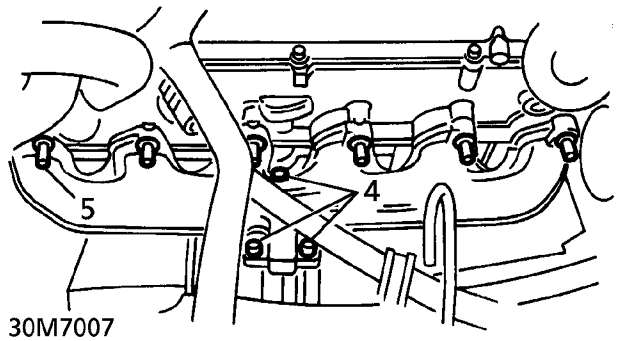
Service repair no - 30.15.12

Remove

1. Disconnect battery negative lead.
2. Raise the vehicle.

WARNING: Support on safety stands.

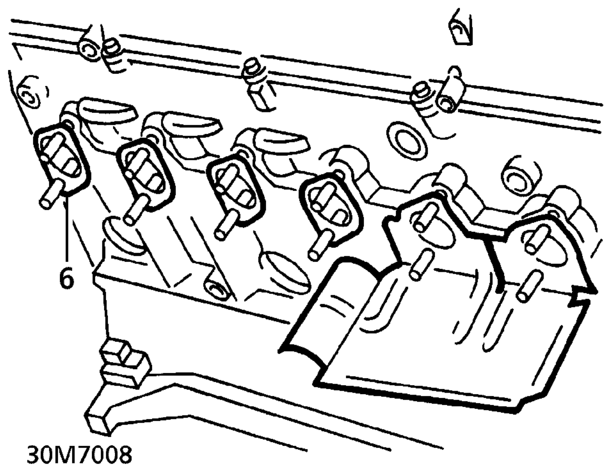
3. Remove heat shield. ***See this section.***
4. Remove 3 bolts securing turbocharger to exhaust manifold. Collect gasket and discard.



30M7007

5. Remove 12 nuts and flat washers securing exhaust manifold to cylinder head. *Vehicles with EGR:* Remove 2 bolts securing EGR pipe flange to manifold. Position pipe aside.

6. Remove exhaust manifold. Collect gaskets and discard.



30M7008

NOTE: The gasket fitted to No. 1 & 2 exhaust ports acts as a turbocharger heat shield.

Refit

7. Ensure mating faces are clean.
8. Position new gaskets and turbocharger heat shield to cylinder head studs. Ensure tabs face outwards.
9. Position exhaust manifold. Secure with nuts and flat washers. Working from centre outwards, progressively tighten to ***22 Nm (16 lbf.ft).***
10. *Vehicles with EGR:* Secure EGR pipe flange to manifold with bolts. Tighten to ***22 Nm (16 lbf.ft).***
11. Position turbocharger with new gasket to exhaust manifold. Secure with bolts. Tighten to ***45 Nm (33 lbf.ft).***
12. Fit heat shield. ***See this section.***
13. Remove safety stands. Lower vehicle.
14. Reconnect battery negative lead.

EXHAUST MANIFOLD HEAT SHIELD - DIESEL

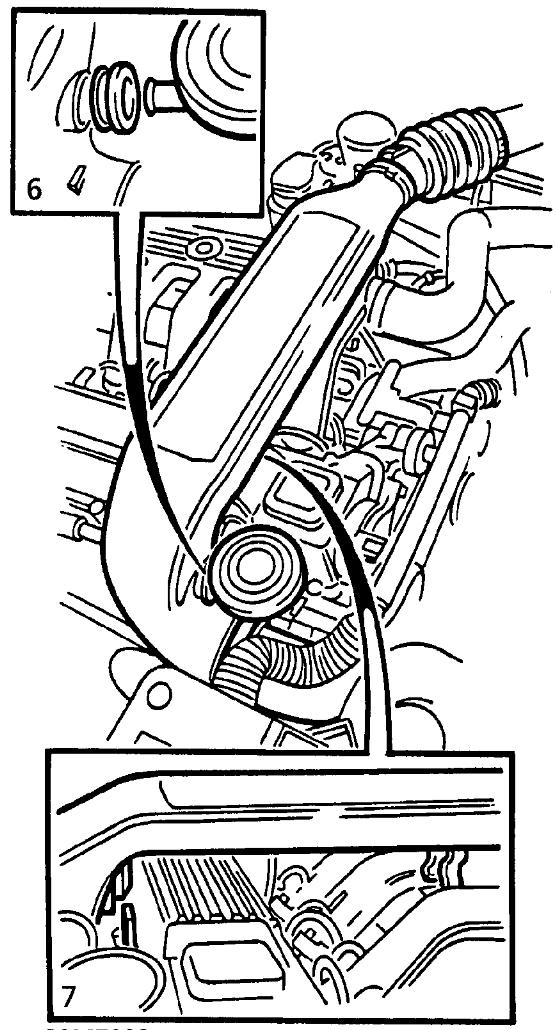
Service repair no - 30.15.09

Remove

1. Disconnect battery negative lead.
2. Raise the vehicle.

WARNING: Support on safety stands.

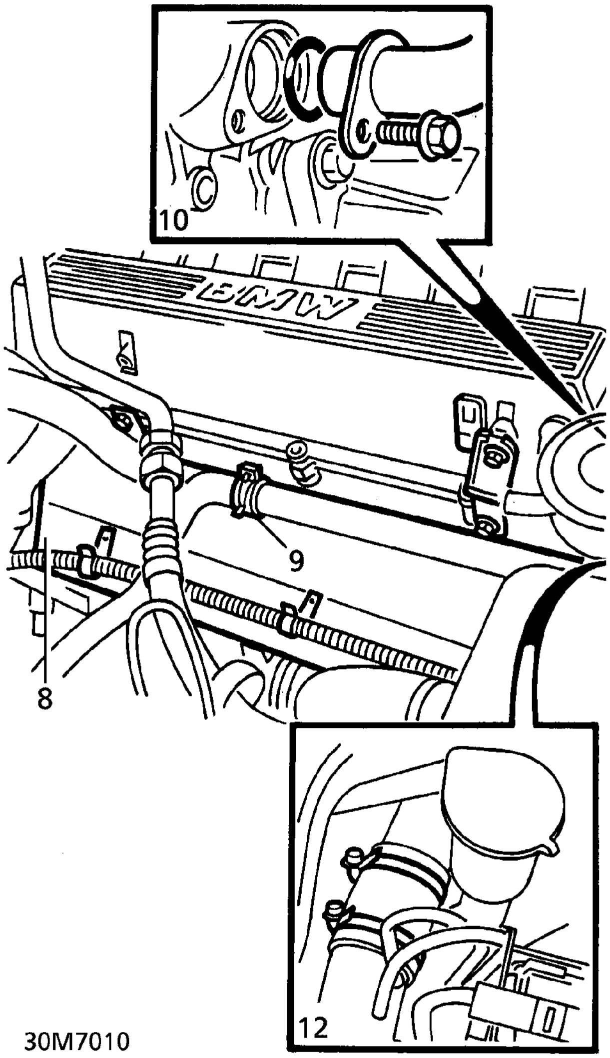
3. Remove cooling fan cowl. ***See COOLING SYSTEM, Repair.***
4. Release intake hose from ducting.
5. Release turbocharger intake hose from ducting.
6. Release breather valve from intake ducting grommet.



30M7009

NOTE: Collect grommet. Refit to ducting.

7. Disengage 2 clips securing intake ducting. Remove ducting.
8. Remove 3 bolts securing intake ducting bracket and exhaust manifold heat shield to camshaft cover. Collect bracket.



30M7010

9. Disconnect heater hose from coolant connecting pipe.
10. Remove bolt securing coolant connecting pipe to engine front cover.
11. Remove coolant pipe. Remove 'O' ring and discard.
12. Slacken clips securing turbocharger outlet hose to turbocharger and intercooler.
13. Remove turbocharger outlet hose assembly.
14. Release harness from 2 heat shield clips.
15. Remove heat shield.

Refit

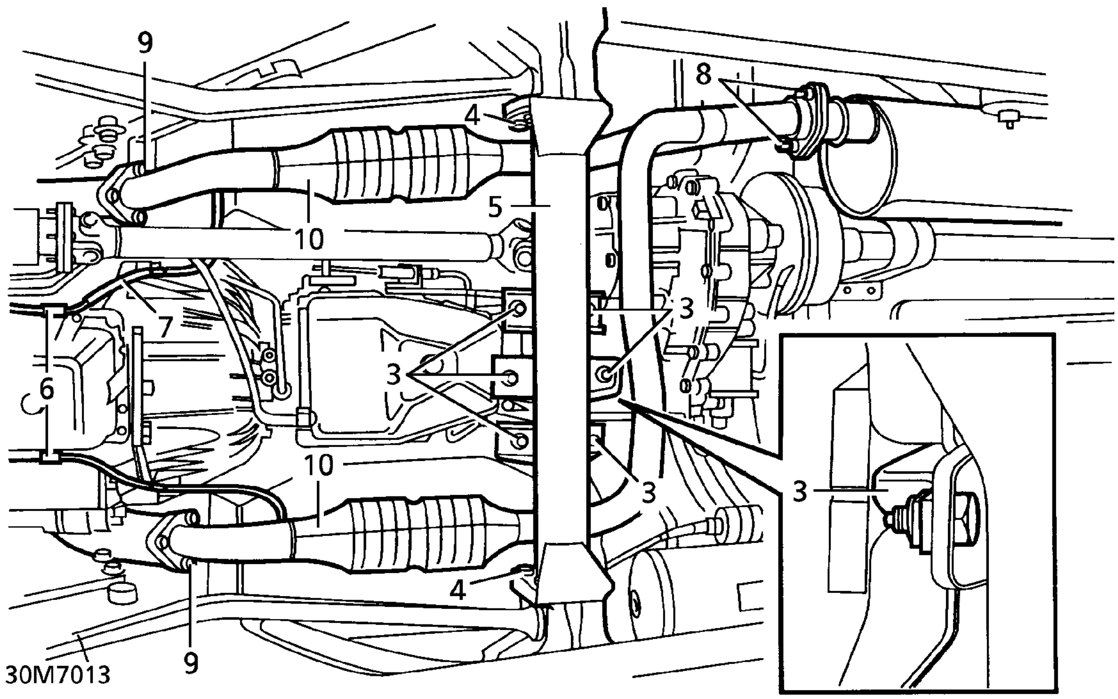
16. Position heat shield.
17. Secure harness to heat shield clips.
18. Position outlet hose to turbocharger and intercooler. Secure with clips.
19. Using a new 'O' ring, position coolant pipe. Engage to engine front cover.
20. Secure connecting pipe to front cover with bolt. Tighten to ***10 Nm (7 lbf.ft)***
21. Connect heater hose. Secure with clip.
22. Align exhaust manifold heat shield. Position intake ducting bracket.
23. Secure ducting bracket and heat shield with bolts.
24. Position intake ducting. Engage clips.
25. Engage breather valve into ducting grommet.
26. Connect ducting to turbocharger intake hose. Secure with clip.
27. Connect intake hose to ducting. Secure with clip.
28. Fit cooling fan cowl. ***See COOLING SYSTEM, Repair.***
29. Remove safety stands. Lower vehicle.
30. Reconnect battery negative lead.

EXHAUST FRONT PIPE - V8

Service repair no - 30.10.09

Remove

1. Raise vehicle on four post lift.
2. Support transmission with a suitable stand.



3. Remove 6 nuts securing transmission mount to crossmember. Remove snubber bar. Discard nuts.
4. Remove 3 of 4 nuts and bolts securing each side of crossmember to chassis.
5. With assistance, remove remaining bolt securing crossmember. Remove crossmember.
6. Disconnect heated oxygen sensor (HO2S) harnesses. Release multiplugs from sump brackets.
7. Remove cable tie securing L.H. HO2S harness to gearbox bracket.
8. Remove 2 nuts securing front pipe to intermediate pipe flanges.
9. Remove 6 nuts securing front pipe to exhaust manifold flanges.
10. Remove front pipe. Collect front pipe to manifold gaskets.
11. If necessary, remove HO2S. ***See FUEL SYSTEM, Repair.***

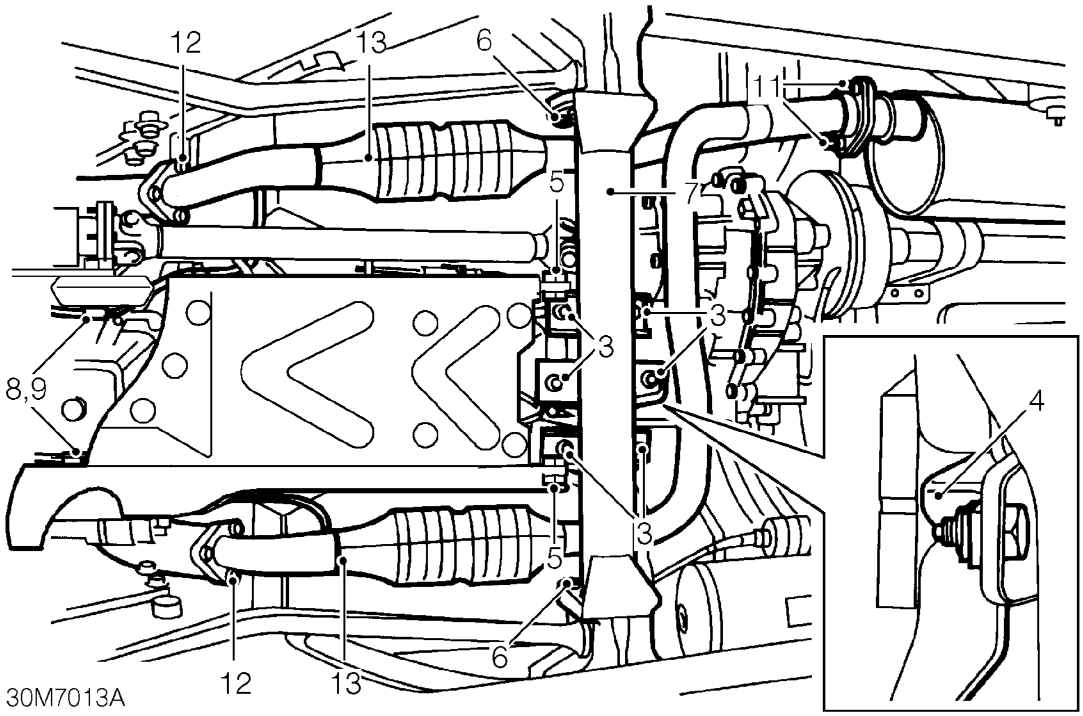
Refit

12. Ensure mating faces are clean.
13. If removed, fit HO2S. ***See FUEL SYSTEM, Repair.***
14. Position front pipe assembly with gaskets to manifolds. Secure with nuts. Tighten to ***50 Nm (37 lbf.ft)***
15. Secure front pipe to intermediate pipe flange with nuts. Tighten to ***25 Nm (18 lbf.ft)***
16. Secure LH HO2S harness to gearbox bracket with cable tie.
17. Connect HO2S harnesses. Secure multiplugs to sump brackets.
18. With assistance, position transmission crossmember on chassis. Secure with nuts and bolts. Tighten to ***45 Nm (33 lbf.ft)***
19. Fit snubber bar. Secure transmission mount to crossmember with new flange nuts. Tighten to ***45 Nm (33 lbf.ft)***
20. Remove support from transmission.
21. Lower vehicle.

EXHAUST FRONT PIPE - V8 - FROM 97MY UP TO 99MY

Service repair no - 30.10.09

Remove



1. Raise vehicle on 4 post ramp.
2. Support transmission using a suitable stand.
3. Remove 4 nuts and 2 bolts securing transmission mount to crossmember and discard nuts.
4. Remove transmission snubber bar.
5. Remove 2 bolts securing rear of side acoustic covers to crossmember.
6. Remove 3 of 4 nuts and bolts securing each side of crossmember to chassis.
7. With assistance, remove remaining bolt securing crossmember and remove crossmember.
8. Disconnect 2 oxygen sensor harness multiplugs from oxygen sensor flylead.
9. Release 2 oxygen sensor flylead multiplugs from brackets.
10. Release flyleads from 2 clips.
11. Remove 2 nuts securing front pipe to intermediate pipe flange.
12. Remove 6 nuts securing front pipe to exhaust manifold down pipe flanges
13. Using assistance, remove front pipe and collect 2 front pipe to manifold gaskets.

Do not carry out further dismantling if component is removed for access only.

14. Remove 2 heated oxygen sensors from front pipe and discard sealing washers.
15. Fit NEW sealing washers to heated oxygen sensors.
16. Fit heated oxygen sensors to front pipe and tighten to ***20 Nm (15 lbf.ft)***

Refit

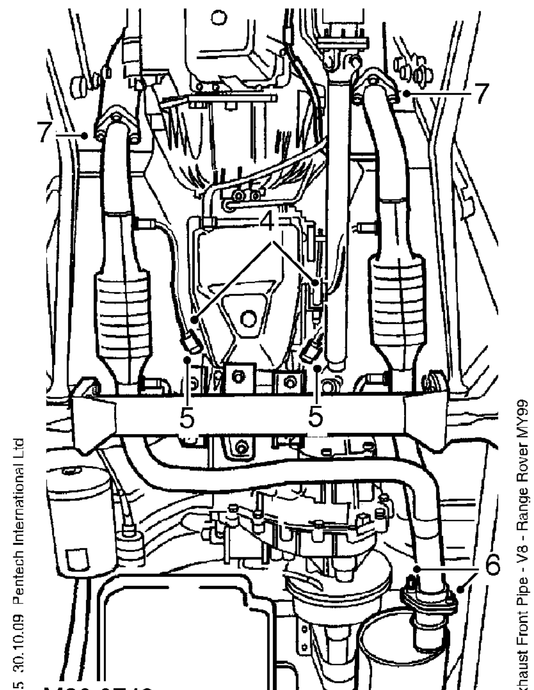
17. Ensure all mating faces are clean.
18. Using assistance, position front pipe and NEW gaskets to manifold.
19. Fit but do not tighten nuts securing front pipe to manifolds.
20. Align front pipe to intermediate pipe, fit nuts and tighten to ***25 Nm (18 lbf.ft)***
21. Tighten front pipe to manifold nuts to ***50 Nm (37 lbf.ft)***
22. Connect heated oxygen sensor multiplugs to brackets.
23. Connect oxygen sensor multiplugs.
24. Connect oxygen sensor fly leads to clips.
25. Using assistance, fit crossmember to chassis.
26. Fit nuts and bolts and tighten to ***45 Nm (33 lbf.ft)***
27. Fit transmission snubber bar.
28. Fit bolts and NEW flange nuts securing transmission mount to crossmember and tighten to ***45 Nm (33 lbf.ft)***
29. Remove transmission stand.
30. Align rear of side acoustic covers to crossmember and secure with threaded fasteners.

EXHAUST FRONT PIPE - V8 - FROM 99MY

Service repair no - 30.10.09

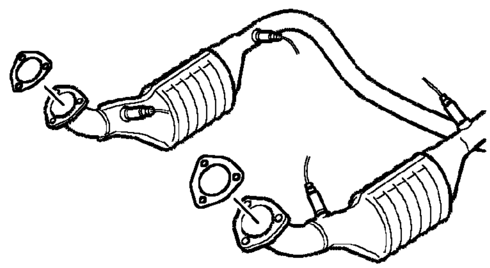
Remove

1. Release fixings and remove battery cover.
2. Disconnect battery earth lead.
3. Remove chassis crossmember. ***See CHASSIS AND BODY, Repair.***



M30 0748

4. Disconnect 2 front HO2S multiplugs and release RH HO2S harness from clip on sump.
5. Release 2 rear HO2S multiplugs from brackets, disconnect from harness and release harness from 2 clips.
6. Remove 2 nuts securing exhaust front pipe to intermediate flange.
7. Remove 6 nuts securing front exhaust pipe to exhaust manifold down pipe flanges.



M30 0749

8. With assistance, remove exhaust front pipe and collect 2 front pipe to manifold gaskets.
9. Remove 4 HO2S from exhaust manifold and discard sealing washers.

Refit

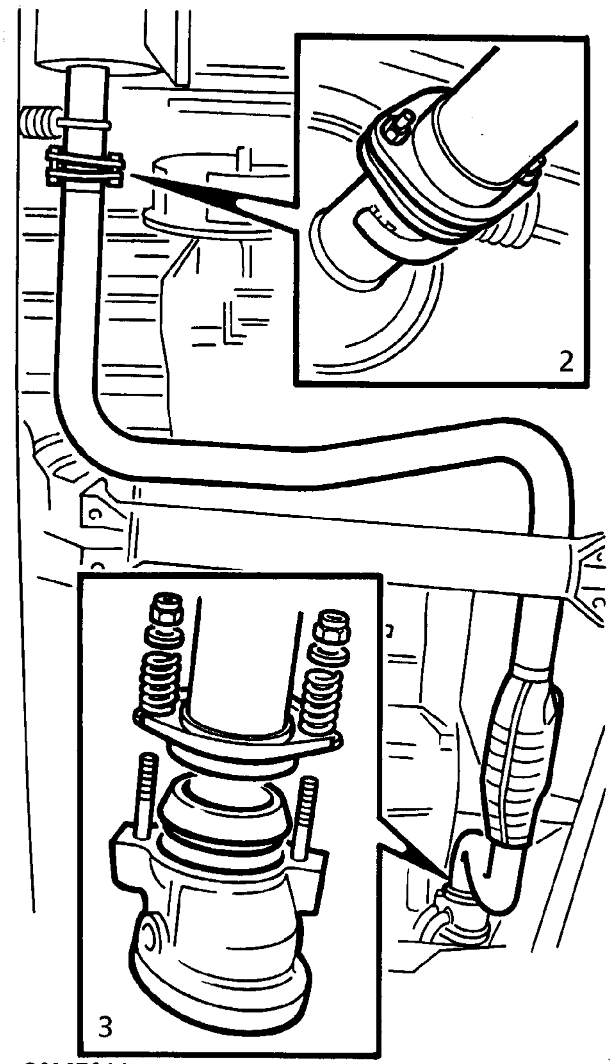
10. Clean mating faces of exhaust front pipe, manifolds and intermediate pipe.
11. Use new sealing washers and fit and tighten HO2S to ***20 Nm (15 lbf.ft).***
12. Use new flange gaskets and with assistance, fit exhaust front pipe to manifolds. Fit nuts but do not tighten at this stage.
13. Align intermediate pipe to front pipe and tighten clamp nuts to ***25 Nm (18 lbf.ft)***
14. Tighten front pipe to manifold nuts to ***50 Nm (37 lbf.ft).***
15. Connect HO2S multiplugs to harness and secure multiplugs to brackets.
16. Secure RH front and rear HO2S harness to clips.
17. Fit chassis crossmember. ***See CHASSIS AND BODY, Repair.***
18. Connect battery earth lead.
19. Fit battery cover and secure with fixings.

EXHAUST FRONT PIPE - DIESEL

Service repair no - 30.10.09

Remove

1. Raise vehicle on four post lift.
2. Remove 2 nuts and bolts securing front pipe to intermediate pipe flange.



30M7011

3. Remove 2 nuts securing front pipe flange to turbocharger oulet. Collect springs and flat washers.

4. With assistance, manoeuvre front pipe rearwards over chassis crossmember.
5. Remove front pipe.
6. Collect olive.

Refit

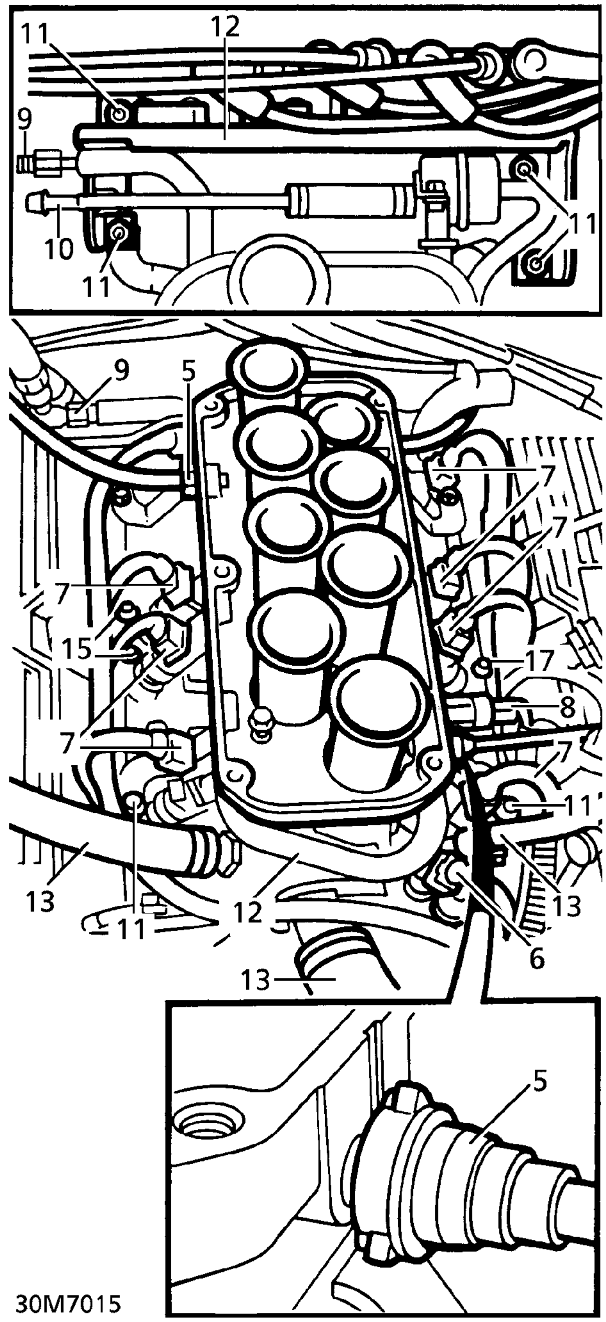
7. Ensure mating faces are clean.
8. With assistance, manoeuvre pipe forwards over chassis crossmember into position.
9. Position olive. Fit front pipe flange over turbocharger studs. Secure with nuts, springs and washers.
10. Tighten nuts to ***14 Nm (10 lbf.ft).*** Back off by 2.5 turns.
11. Position rear flange to intermediate pipe. Secure with nuts. Tighten to ***25 Nm (18 lbf.ft)***
12. Lower lift.

INLET MANIFOLD GASKET - V8 - UP TO 99MY

Service repair no - 30.15.08

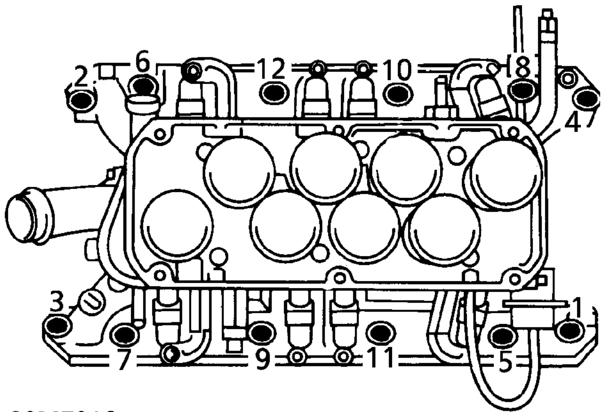
Remove

1. Depressurise fuel system. ***See FUEL SYSTEM, Repair.***
2. Drain cooling system. ***See COOLING SYSTEM, Repair.***
3. Remove alternator. ***See ELECTRICAL, Repair.***
4. Remove plenum chamber. ***See FUEL SYSTEM, Repair.***
5. Release purge and crankcase breather hoses from ram pipe housing.
6. Disconnect coolant temperature and temperature gauge sensors.
7. Disconnect 8 injector multiplugs.
8. Disconnect fuel temperature sensor multiplug.
9. Disconnect fuel feed hose from fuel rail.
10. Disconnect fuel return hose from pressure regulator pipe.
11. Remove 6 nuts securing fuel rail and ignition coil bracket to inlet manifold.
12. Lift fuel rail slightly for access. Release ignition coil bracket from inlet manifold studs. Place aside.
13. Disconnect coolant hoses from inlet manifold
14. Disconnect plenum chamber coolant hose from inlet manifold.
15. Remove 2 bolts securing harness to RH side of inlet manifold.
16. Place harness and heater hose aside.
17. Remove bolt securing harness to LH side of inlet manifold.



30M7015

18. Using sequence shown, remove 12 bolts securing inlet manifold to cylinder heads



30M7016

19. Remove inlet manifold assembly.
20. Remove bolts and clamps securing manifold gasket to cylinder block.
21. Remove inlet manifold gasket and discard.
22. Remove gasket seals and discard.

Refit

23. Ensure mating faces are clean.
24. Apply a thin bead of Loctite Superflex (black) sealant to 4 notches between cylinder head and block.
25. Position new gasket seals. Ensure ends engage correctly in notches.
26. Fit new inlet manifold gasket.
27. Position manifold gasket clamps. Fit bolts and tighten to ***0.7 Nm (0.5 lbf.ft)***.
28. With assistance to hold harness and ignition coils aside, position inlet manifold assembly.

NOTE: When fitting inlet manifold bolts, tighten in reverse of removal sequence.

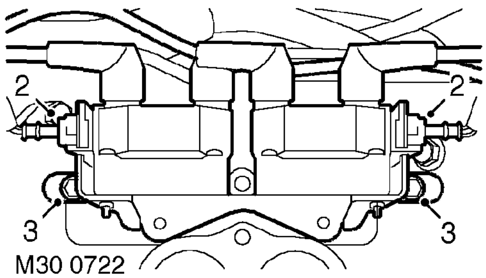
29. Fit inlet manifold bolts. Initially tighten to ***10 Nm (7 lbf.ft)***
30. Finally tighten bolts to ***50 Nm (37 lbf.ft).***
31. Tighten gasket clamp bolts to ***17 Nm (13 lbf.ft).***
32. Position RH injector harness and heater hose bracket on inlet manifold. Secure with bolts.
33. Fit plenum chamber coolant hose to inlet manifold. Secure with clip.
34. Connect 3 cooling hoses to inlet manifold. Secure with clips.
35. Position ignition coil bracket on inlet manifold studs. Secure with nuts. Tighten to ***8 Nm (6 lbf.ft).***
36. Connect fuel feed pipe to fuel rail. Tighten to ***16 Nm (12 lbf.ft).***
37. Connect return hose to pressure regulator pipe. Secure with clip.
38. Connect multiplugs to fuel injectors and fuel temperature sensor.
39. Connect coolant temperature sensor and temperature gauge sensor.
40. Connect purge and crankcase breather hose to ram pipe housing.
41. Fit plenum chamber. ***See FUEL SYSTEM, Repair.***
42. Refill cooling system. ***See COOLING SYSTEM, Repair.***
43. Fit alternator. ***See ELECTRICAL, Repair.***
44. Start engine. Check for leaks around fuel rail and injectors.

GASKET - INLET MANIFOLD - LOWER- FROM 99MY

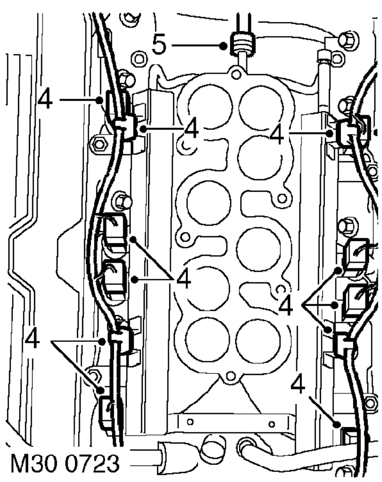
Service repair no - 30.15.08

Remove

1. Remove RH and LH rocker cover gaskets. ***See ENGINE, Repair.***



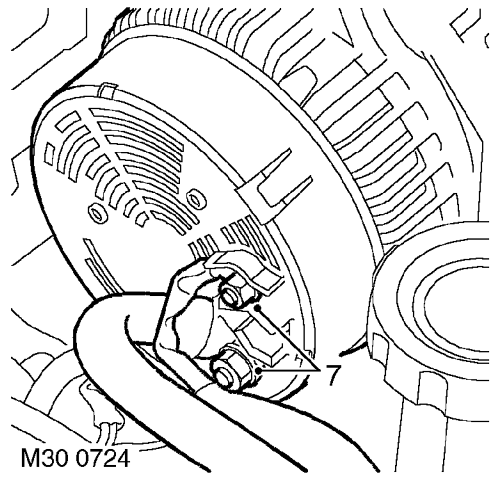
2. Disconnect multiplugs from coils.
3. Remove 2 bolts securing coils and remove coils.



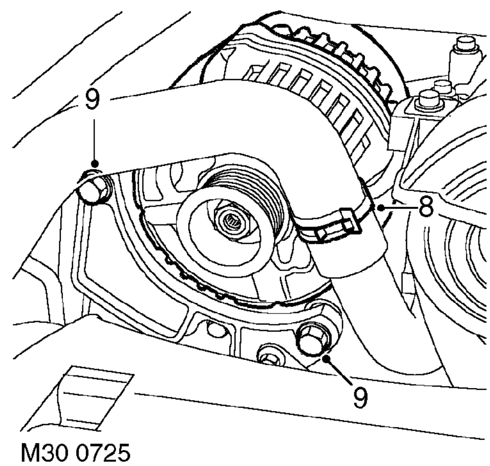
4. Release leads from fuel rails and disconnect LH and RH injector multiplugs.
5. Position absorbent cloth to catch any fuel spillage and disconnect fuel pipe.

CAUTION: Plug the connections.

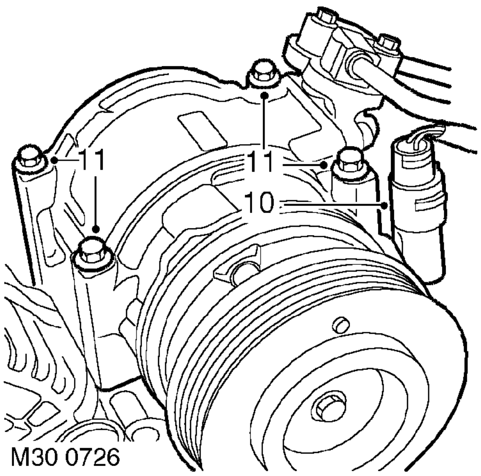
6. Remove auxiliary drive belt. ***See ELECTRICAL, Repair.***



7. Remove 2 nuts securing leads to alternator and release leads.

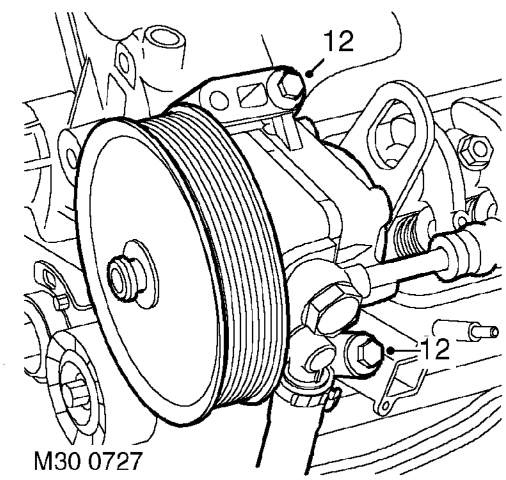


8. Release clip securing top hose to outlet pipe and release hose.
9. Remove 2 bolts securing alternator and remove alternator.



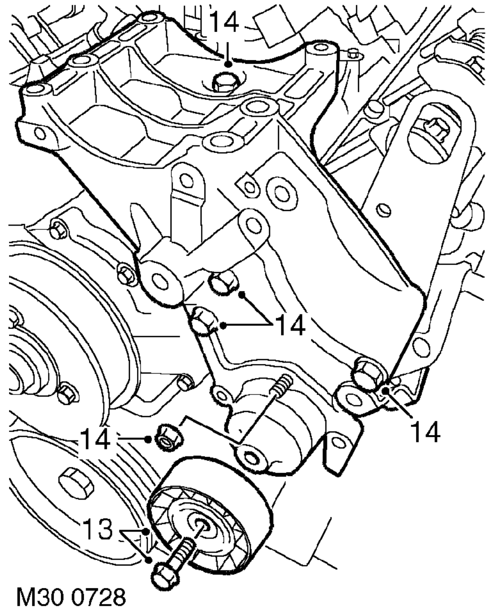
M30 0726

10. Disconnect multiplug from compressor.
11. Remove 4 bolts securing compressor to mounting bracket and position compressor aside.



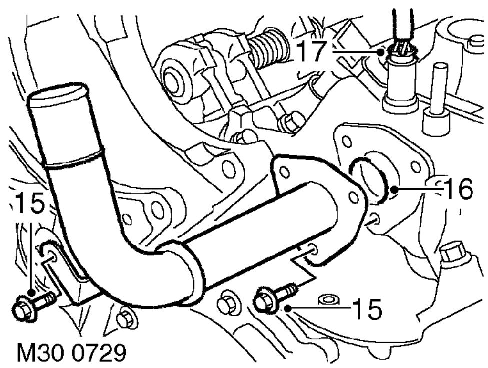
M30 0727

12. Remove 2 bolts securing PAS pump to mounting bracket and position aside.



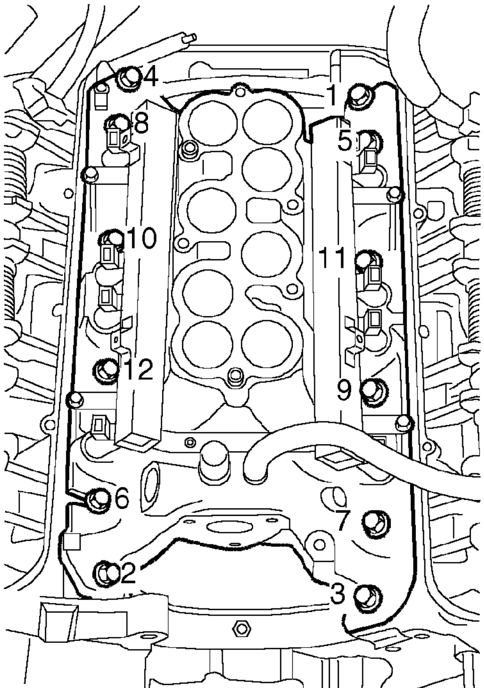
M30 0728

13. Remove bolt securing jockey pulley to mounting bracket and remove pulley.
14. Remove 4 bolts and one nut securing mounting bracket and remove mounting bracket .



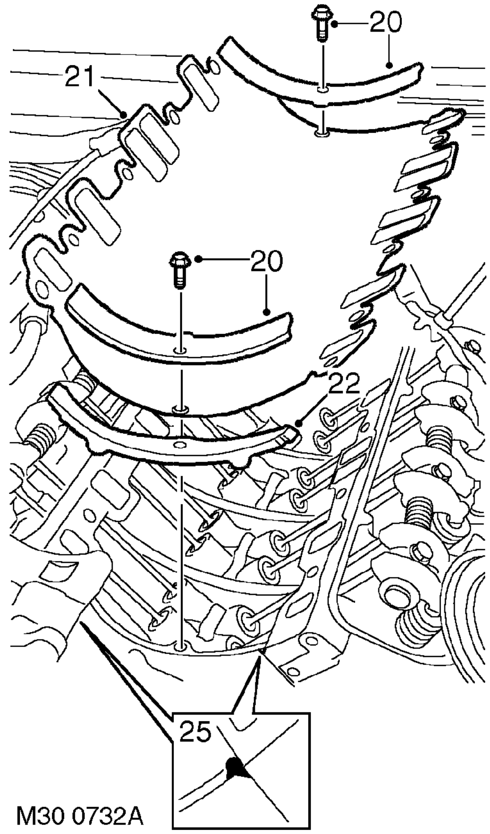
M30 0729

15. Remove 4 bolts securing top hose outlet pipe and remove outlet pipe.
16. Remove and discard 'O' ring.
17. Disconnect ECT sensor multiplug.



M30 0731

18. Using the sequence shown, remove 12 bolts securing inlet manifold.
19. Remove inlet manifold assembly.



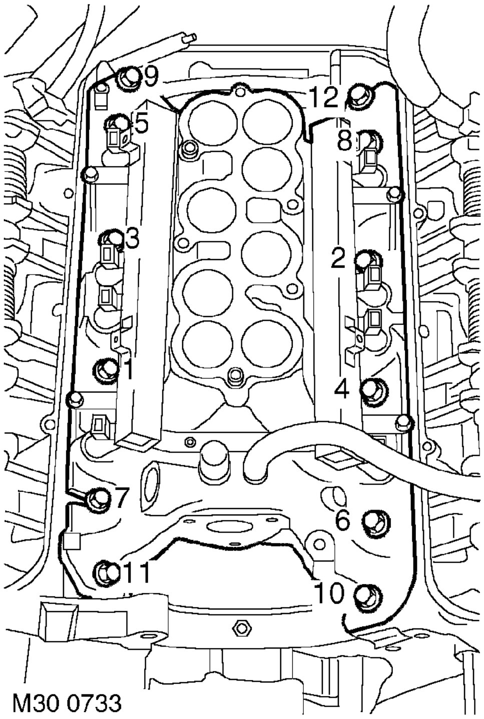
M30 0732A

20. Remove 2 bolts securing manifold gasket clamps and collect gasket clamps.
21. Remove inlet manifold gasket.
22. Remove gasket seals.

Refit

23. Clean RTV from head and block notches.
24. Clean mating faces of block, head and manifold.
25. Apply RTV silicone sealant in the four 'V' shaped notches between the ends of the cylinder head and the cylinder block joint.
26. Fit new gasket seals, ensure ends engage correctly in notches.
27. Fit new manifold gasket.
28. Position gasket clamps, fit bolts but do not tighten at this stage.
29. Position inlet manifold assembly.

NOTE: When fitting inlet manifold bolts, tighten in reverse of removal sequence.



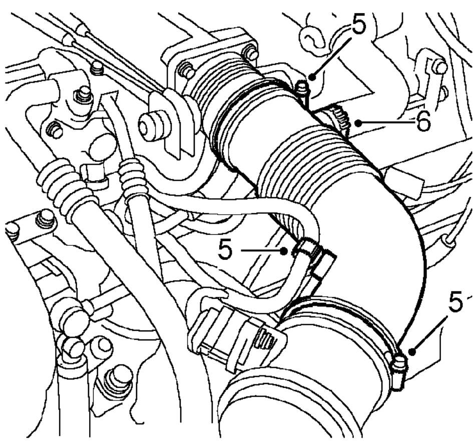
30. Fit manifold bolts and in the sequence shown tighten bolts initially to ***10 Nm (8 lbf.ft)***, then tighten to ***51 Nm (38 lbf.ft).***
31. Tighten gasket clamp bolts to ***18 Nm (14 lbf.ft).***
32. Connect fuel pipe.
33. Connect multiplug to ECT sensor.
34. Clean top hose outlet pipe mating faces.
35. Lubricate and fit new 'O' ring to outlet pipe.
36. Position outlet pipe, fit and tighten bolts to ***22 Nm (16 lbf.ft).***
37. Position mounting bracket, fit and tighten, bolts to***40 Nm (30 lbf.ft)***, and nut to ***10 Nm (7 lbf.ft).***
38. Fit jockey pulley and tighten bolt to ***50 Nm (37 lbf.ft).***
39. Clean PAS pump dowels and dowel holes.
40. Position PAS pump to mounting bracket, locate on dowels and fit and tighten bolts to ***40 Nm (30 lbf.ft).***
41. Clean compressor dowels and dowel holes.
42. Position compressor, locate on dowels and fit and tighten bolts to ***25 Nm (18 lbf.ft).***
43. Connect multiplug to compressor.
44. Position alternator, fit and tighten bolts to ***45 Nm (34 lbf.ft).***
45. Position top hose and secure clip.
46. Connect alternator cables, fit nuts and tighten B+ nut to ***18 Nm (13 lbf.ft)*** max and D+ nut to ***5 Nm (3.5 lbf.ft)*** max. B+ and D+ are marked on the rear of the alternator, adjacent ot each cable connector. Fit leads to alternator and tighten nuts.
47. Fit auxiliary drive belt. ***See ELECTRICAL, Repair.***
48. Connect injector multiplugs and secure leads to fuel rail.
49. Position coils and fit bolts but do not tighten at this stage.
50. Connect multiplugs to coils.
51. Fit rocker cover gaskets. ***See ENGINE, Repair.***

GASKET - INLET MANIFOLD - UPPER - FROM 99MY

Service repair no - 30.15.24

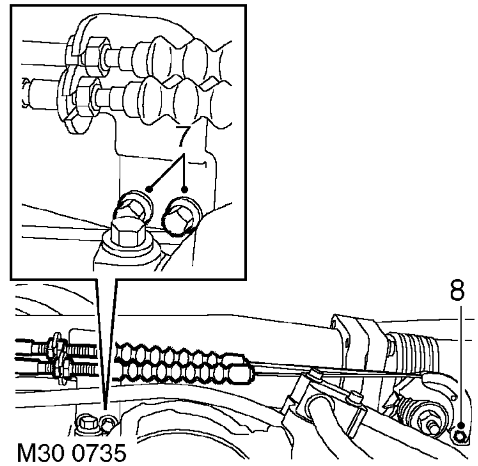
Remove

1. Release 3 fixings and remove battery cover.
2. Disconnect battery earth lead.
3. Remove gas struts from bonnet.
4. With assistance support bonnet on hinge extension arms.



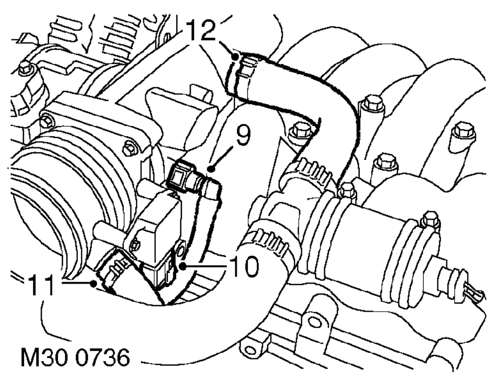
M30 0734

5. Loosen 2 clips securing air intake hose, release air intake hose and disconnect harness from clip on hose.
6. Release clip securing IAC hose to air intake hose and remove air intake hose.



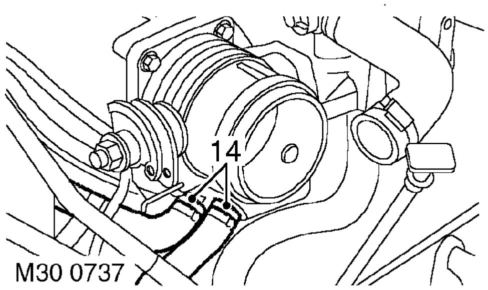
M30 0735

7. Remove 2 bolts securing abutment bracket to plenum chamber and position aside.
8. Release throttle and cruise control cables from clips and throttle cams and position aside.

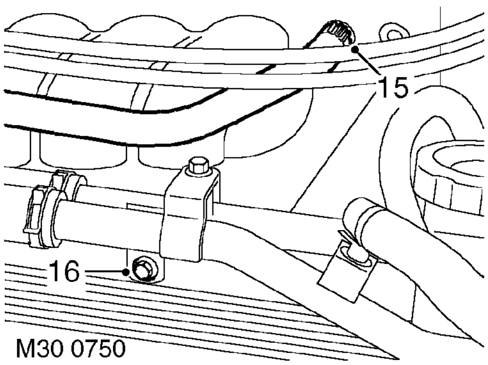


M30 0736

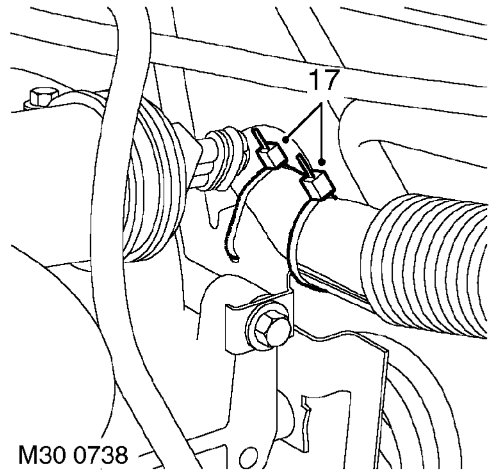
9. Disconnect EVAP pipe from plenum chamber and clip on upper manifold.
10. Disconnect multiplug from TP sensor.
11. Release clip securing breather hose to throttle body and release breather hose.
12. Release clip and disconnect IAC hose from plenum chamber.



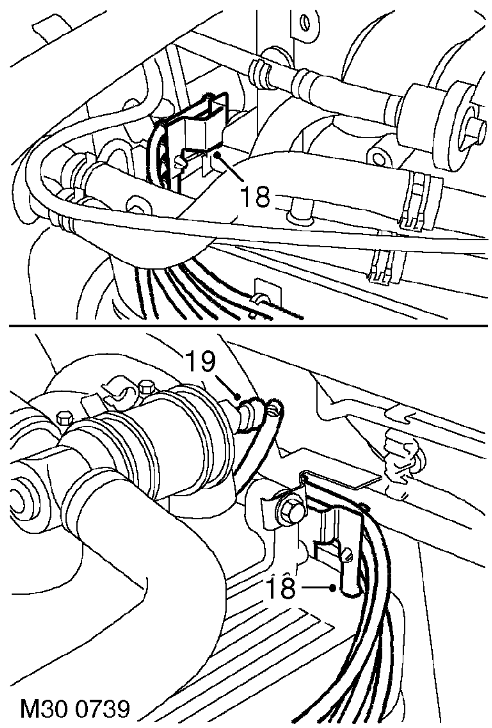
13. Position a container below throttle body to collect coolant.
14. Release clips securing coolant hoses to throttle body and release hoses.



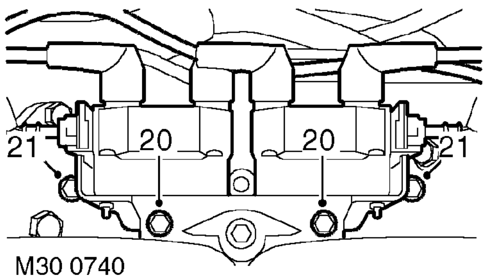
15. Release clip and disconnect engine breather hose from plenum chamber.
16. Remove bolt securing coolant rails.



17. Remove 2 cable ties securing engine harness to clip on upper manifold.

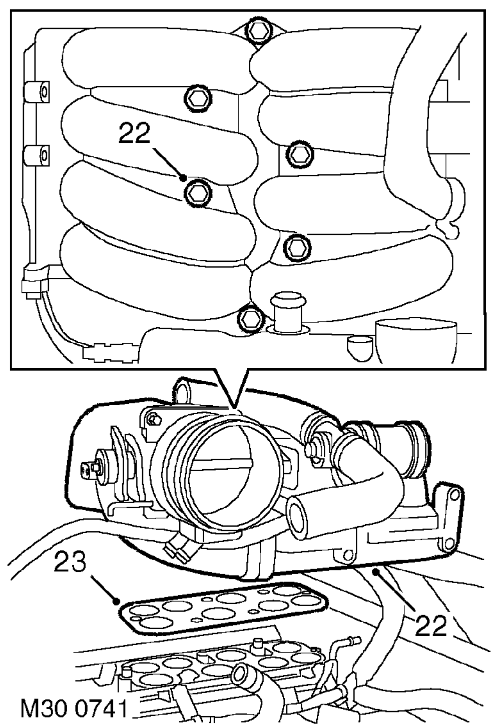


18. Release HT leads from clips on upper inlet manifold.
19. Disconnect multiplug from IAC valve.



M30 0740

20. Remove 2 bolts securing top of coils.
21. Loosen 2 bolts securing bottom of coils to block but do not remove bolts.



M30 0741

22. Remove 6 bolts securing upper manifold and remove upper manifold.
23. Collect upper manifold gasket.

Refit

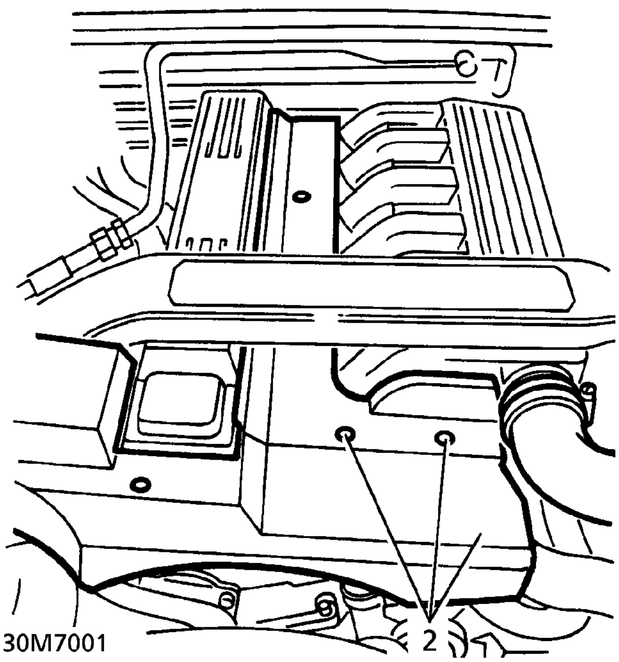
24. Clean inlet manifold and upper manifold mating faces, dowels and dowel holes.
25. Using a new gasket, position upper manifold. Fit bolts, and working in a diagonal sequence, tighten to ***22 Nm (16 lbf.ft).***
26. Fit 2 top bolts securing coils to manifold and tighten all coil fixing bolts to ***8 Nm (6 lbf.ft).***
27. Connect IAC valve multiplug.
28. Secure HT leads to upper manifold clips.
29. Connect multiplug to TP sensor.
30. Position engine harness in manifold clip and secure with new cable ties.
31. Fit and tighten coolant rail bolt to ***22 Nm (16 lbf.ft).***
32. Connect breather hose to plenum and secure with clip.
33. Connect IAC hose to plenum chamber and secure with clip.
34. Position coolant hoses to throttle body and secure hose clips.
35. Fit breather hose to throttle body and secure clip.
36. Connect multiplug to TP sensor.
37. Connect EVAP pipe to plenum chamber and clip on upper manifold.
38. Connect throttle and cruise control cables to clips and secure in throttle body cams.
39. Position abutment bracket to upper manifold, fit and tighten bolts.
40. Fit air intake hose, tighten 2 clips and connect harness to clip on hose.
41. Connect IAC hose to air intake hose and secure with clip.
42. Top-up cooling system.
43. Lower bonnet and connect gas struts.
44. Connect battery earth lead.
45. Fit battery cover and secure fixings.

INLET MANIFOLD GASKETS - DIESEL - VEHICLES WITHOUT EGR

Service repair no - 30.15.08

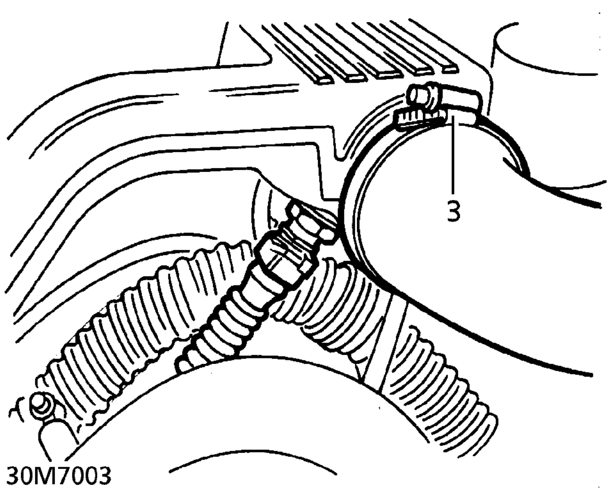
Remove

1. Disconnect battery negative lead.



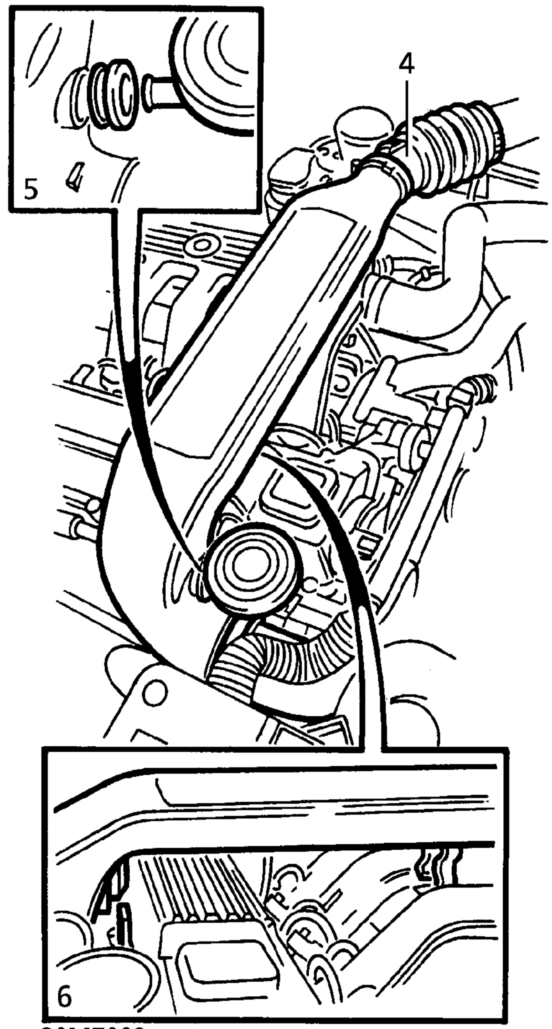
30M7001

2. Remove 4 screws securing injector covers. Remove covers.



30M7003

3. Release intake hose from ducting.
4. Release turbocharger intake hose from ducting.
5. Release breather valve from grommet in intake ducting.

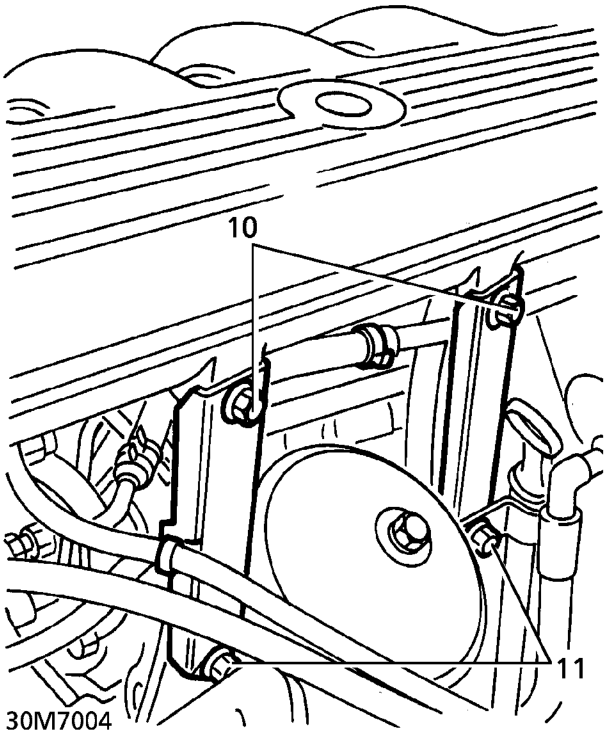


30M7002

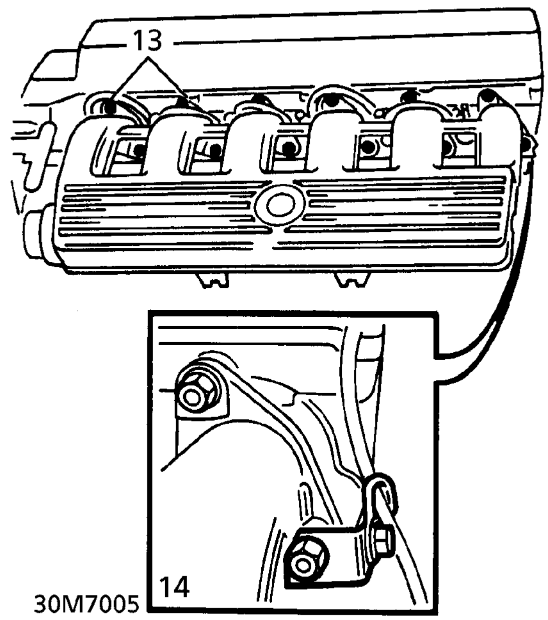
NOTE: Collect grommet. Refit to ducting.

6. Disengage 2 clips. Remove intake ducting.
7. Disconnect intake hose from manifold.
8. Disconnect multiplug from intake temperature sensor.
9. Release fuel return hose from inlet manifold clip.

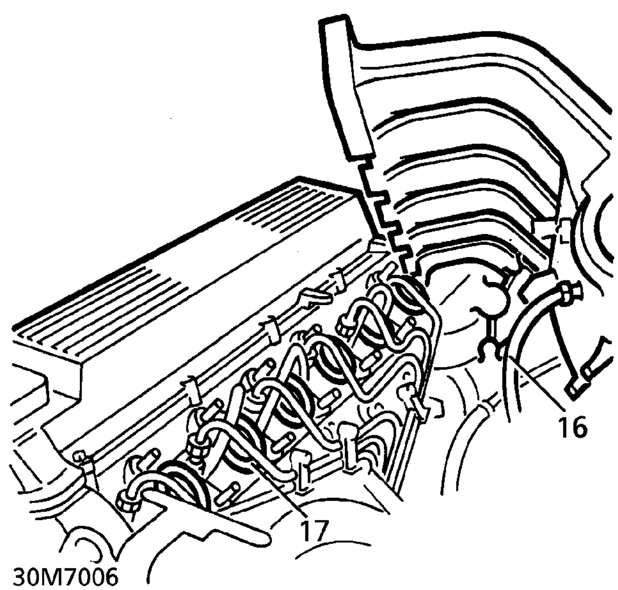
10. Remove 2 nuts and bolts securing stays to inlet manifold.



11. Slacken 2 nuts securing manifold stays to oil filter casing.
12. Release clip securing manifold pressure sensing pipe to stay.



13. Remove 12 nuts securing intake manifold to cylinder head.
14. Release gearbox breather hose bracket from rearmost manifold stud.
15. Release manifold from studs. Ensure that injector leak off pipes do not foul on manifold flanges.
16. Place manifold aside. Do not strain manifold pressure sensing hose.



17. Collect 6 inlet manifold gaskets.
18. Position cloth over inlet ports to prevent dirt ingress.

Refit

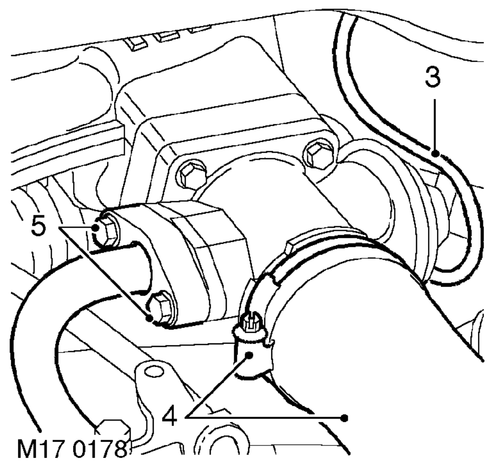
19. Ensure mating faces are clean.
20. Position intake manifold with gaskets on studs. Ensure injector leak off pipes are not fouled.
21. Position gearbox breather hose bracket on rearmost manifold stud.
22. Secure manifold with nuts. Progressively tighten to ***22 Nm (16 lbf.ft)***
23. Position manifold stays. Secure with nuts and bolts.
24. Secure manifold pressure sensing hose to stay with clip.
25. Connect multiplug to intake temperature sensor.
26. Engage fuel return hose into inlet manifold clip.
27. Connect intake hose. Secure with clip.
28. Position intake ducting. Engage clips.
29. Engage breather valve into ducting grommet.
30. Connect ducting to turbocharger intake hose. Secure with clip.
31. Connect intake hose to ducting. Secure with clip.
32. Fit injector covers. Secure with screws.
33. Reconnect battery negative lead.

INTAKE MANIFOLD GASKETS - DIESEL WITH EGR

Service repair no - 30.15.08

Remove

1. Disconnect battery negative terminal.
2. Remove air intake ducting. ***See this section.***
3. Disconnect vacuum hose from EGR valve.
4. Slacken clip and disconnect intercooler hose from EGR valve.
5. Remove 2 bolts securing EGR pipe to EGR valve.

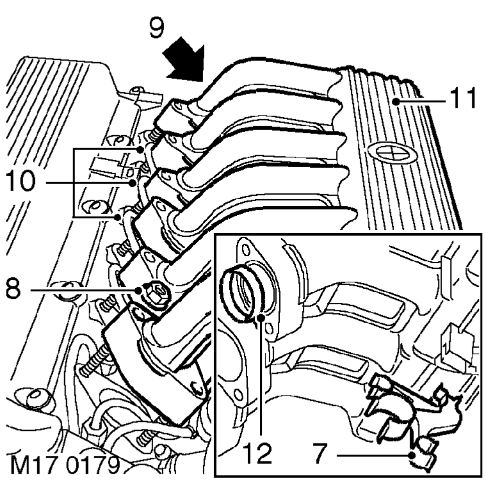


6. Disengage clip on underside of intake manifold. Release wiring harness and vacuum hoses.
7. Release fuel return hose and EGR vacuum pipe from clips on underside of manifold.
8. Remove 12 nuts securing intake manifold to cylinder head.
9. Release gearbox breather hoses from rearmost manifold stud.
10. Release manifold from from studs. Ensure that injector leak off pipes do not foul on manifold flanges.
11. Position manifold aside.

CAUTION: Ensure manifold pressure sensing hose is not strained.

12. Remove 6 seals from intake manifold ports.

CAUTION: Care must be taken when extracting seals to ensure recesses in intake manifold are not damaged.



M17 0179

13. Clean mating faces of intake manifold and cylinder head.
14. Position cloth over inlet ports to prevent dirt ingress.

Refit

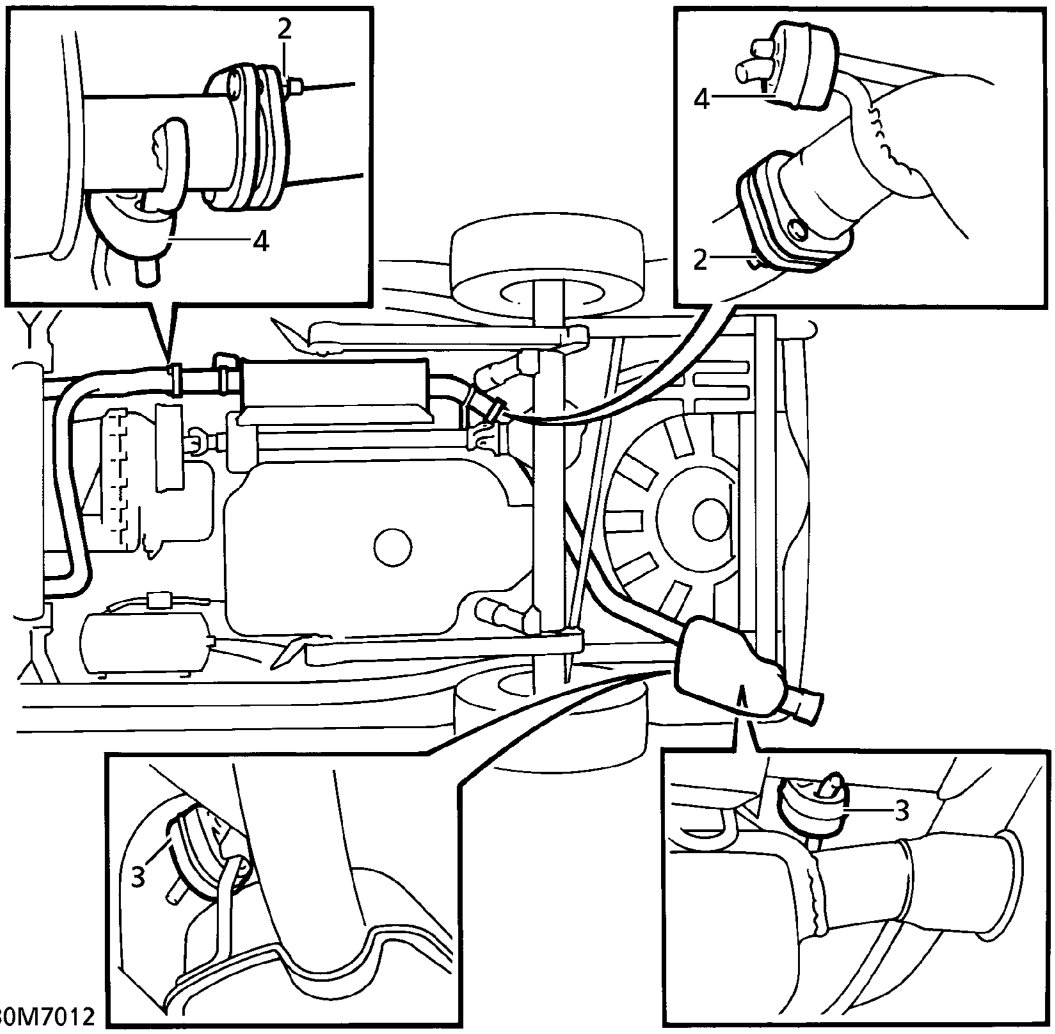
15. Fit new seals to recesses in intake manifold.
16. Position intake manifold to studs, ensuring that leak off pipes do not become trapped beneath flanges.
17. Position gearbox breather hose bracket to rearmost stud.
18. Secure manifold with nuts and progressively tighten to ***22Nm (16 lbf.in).***
19. Position and secure fuel return hose, harnesses and vacuum hoses to clips on underside of manifold.
20. Engage EGR pipe to valve, align flange and secure with bolts. Tighten bolts to ***22 Nm (16 lbf.in).***
21. Connect intercooler hose to EGR valve and secure with clip.
22. Connect vacuum hose to EGR valve.
23. Fit air intake ducting. ***See this section.***
24. Connect battery negative terminal.

INTERMEDIATE AND REAR PIPES

Service repair no - 30.10.11 - Intermediate Pipe
Service repair no - 30.10.22 - Rear Pipe

Remove

1. Raise vehicle on four post lift.
2. Remove 4 nuts securing intermediate pipe flanges to front and rear pipes.



30M7012

3. Release 2 mounting rubbers. Remove rear pipe.
4. With assistance, release 2 mounting rubbers. Remove intermediate pipe.

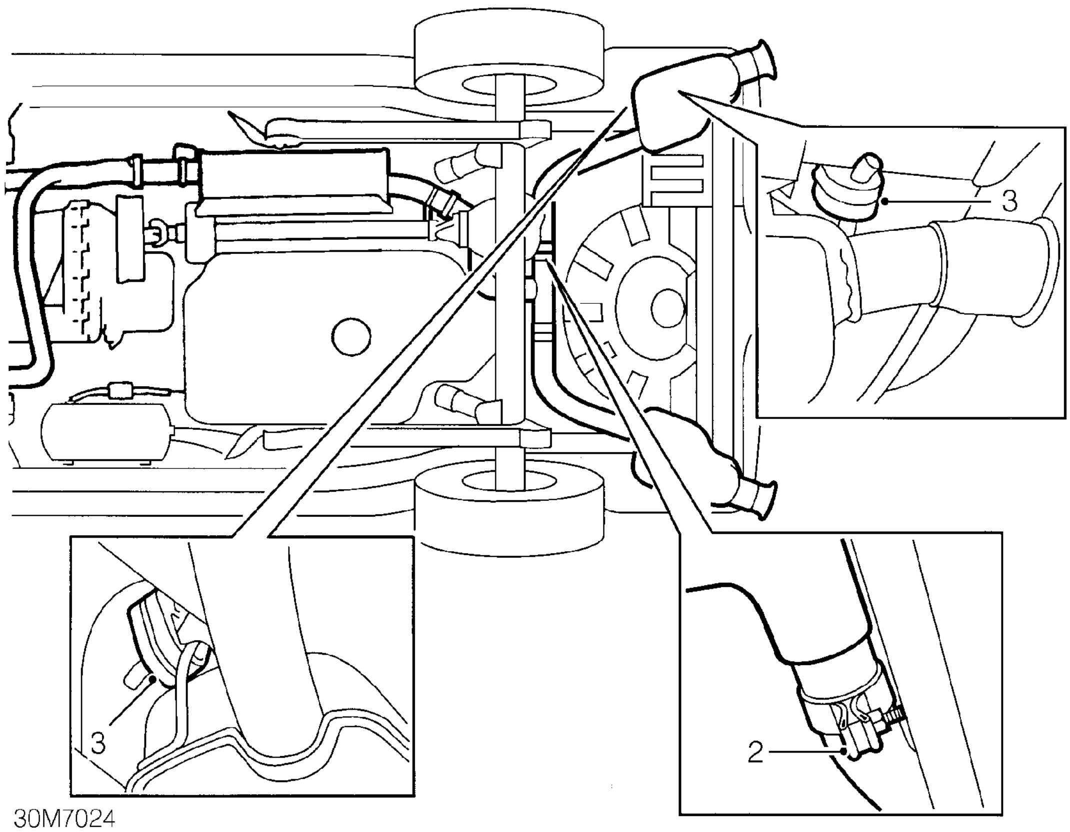
Refit

5. Ensure mating faces are clean.
6. With assistance, position intermediate pipe. Secure with mounting rubbers.
7. Position rear pipe. Secure with mounting rubbers.
8. Position intermediate pipe flanges. Secure with nuts. Tighten to ***25 Nm (18 lbf.ft).***

TAIL PIPE - LH - FROM 97MY

Service repair no - 30.10.22

Remove



30M7024

1. Raise vehicle on 4 post ramp.
2. Loosen clamp securing LH tail pipe to RH tail pipe.
3. Release LH tail pipe from 2 mounting rubbers.
4. Release LH tail pipe from RH tail pipe and remove tail pipe.

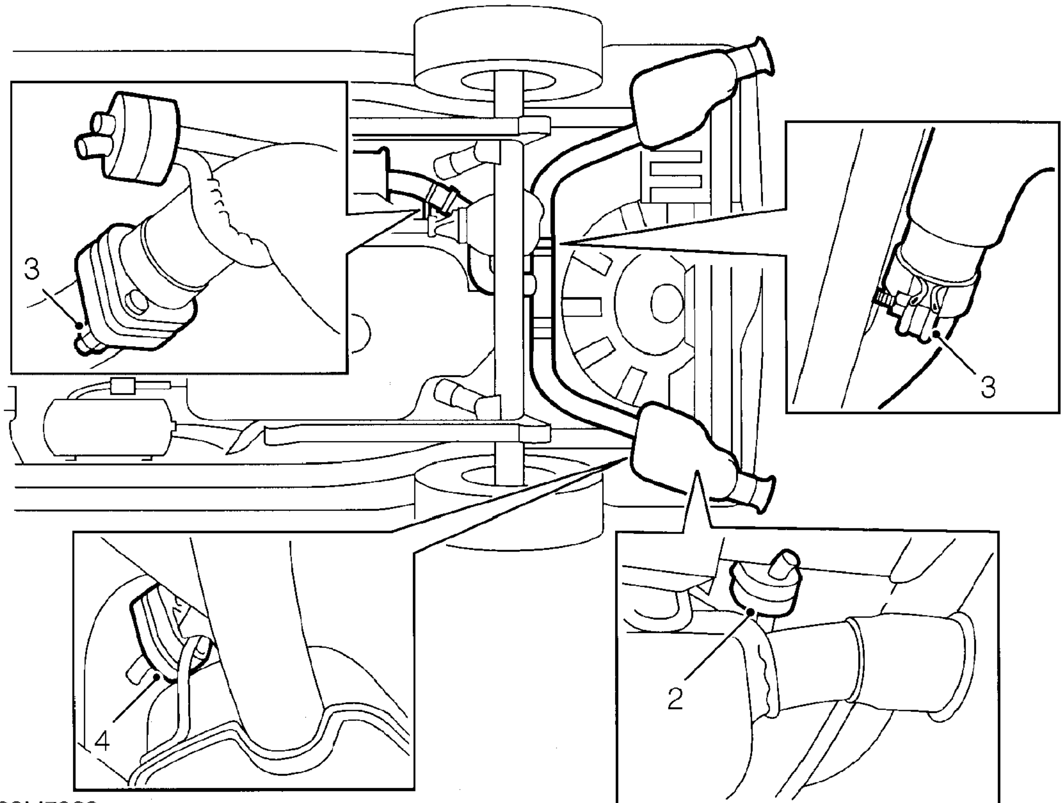
Refit

5. Clean tail pipe mating faces.
6. Position LH tail pipe to vehicle and fit to mounting rubbers.
7. Engage LH tail pipe to RH tail pipe and tighten clamp to ***65 Nm (48 lbf.ft)***

TAIL PIPE - RH - FROM 97MY

Service repair no - 30.10.52

Remove



30M7023

1. Raise vehicle on 4 post ramp.
2. Loosen clamp securing LH tail pipe to RH tail pipe.
3. Remove 2 nuts securing tail pipe flange to intermediate pipe flange.
4. Release RH tail pipe from 2 mounting rubbers.
5. With assistance, release RH tail pipe from LH tail pipe and remove tail pipe.

Refit

6. Clean tail pipe mating faces.
7. With assistance, position RH tail pipe to vehicle and fit to mounting rubbers.
8. Engage RH tail pipe to LH tail pipe.
9. Align tail pipe flange to intermediate pipe flange and fit nuts. Tighten nuts to ***25 Nm (18 lbf.ft)***
10. Tighten nut securing RH tail pipe to LH tail pipe to ***65 Nm (48 lbf.ft)*** .

33 - CLUTCH

CONTENTS

Page

REPAIR

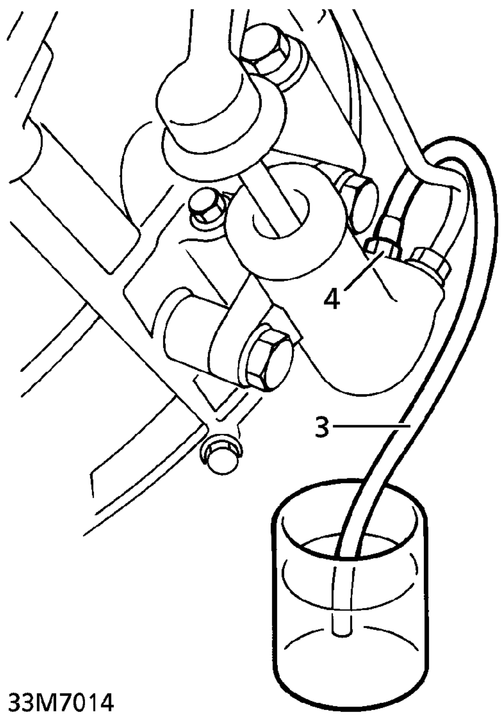
HYDRAULIC SYSTEM BLEED

Service repair no - 33.15.01

1. Top-up clutch master cylinder. ***See LUBRICANTS, FLUIDS AND CAPACITIES, Information.***

CAUTION: Do not allow brake fluid to contact painted surfaces. Paint damage will occur. If spilled, remove fluid. Wash area with clean warm water.

2. Clean area around slave cylinder bleed screw.
3. Connect bleed tube to bleed screw. Immerse free end of tube into container of brake fluid.



33M7014

4. Hold clutch pedal down. Slacken bleed screw.
5. Release clutch pedal, allow it to return unassisted. Depress pedal again.

CAUTION: Ensure master cylinder is topped up at frequent intervals. Use only fresh fluid.

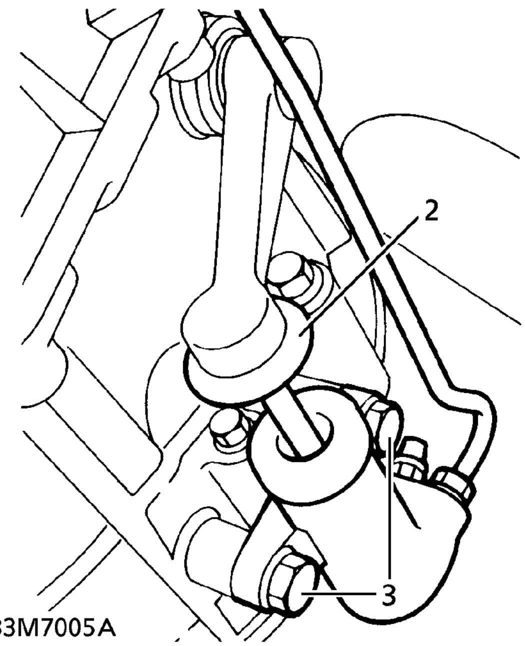
6. Repeat procedure until fluid issuing from bleed tube is free from air bubbles.
7. Tighten bleed screw. Remove bleed tube.
8. Top-up master cylinder.

CLUTCH ASSEMBLY - V8

Service repair no - 33.10.07

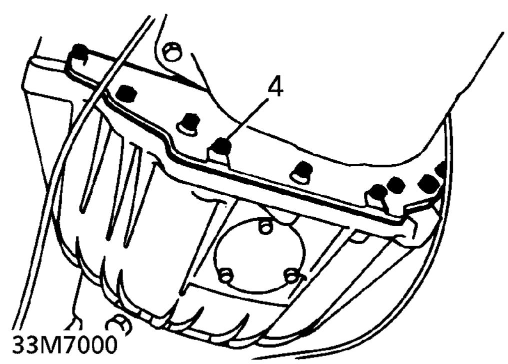
Remove

1. Remove gearbox assembly. ***See MANUAL GEARBOX, Repair.***
2. Release push rod gaiter from clutch lever.
3. Remove 2 bolts securing clutch slave cylinder. Tie cylinder aside.



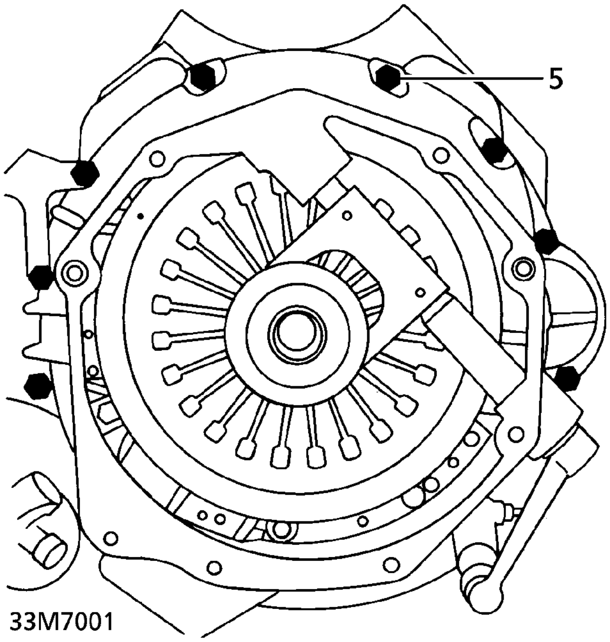
33M7005A

4. Remove 9 bolts securing flywheel access cover to clutch housing. Remove cover.



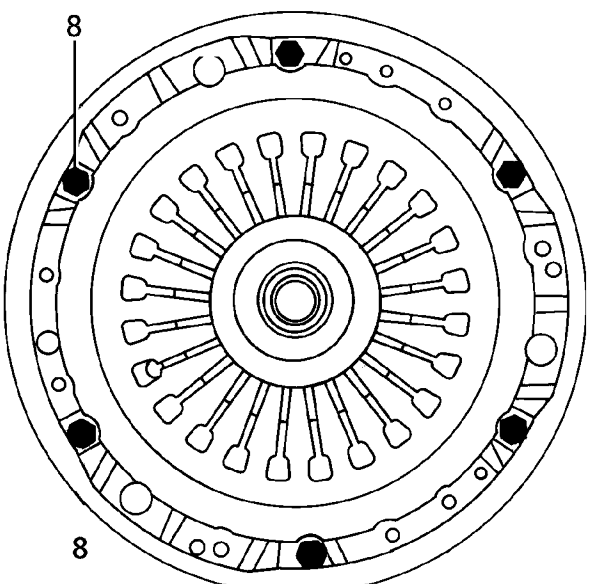
33M7000

5. Remove 8 bolts securing clutch housing. Disengage release lever from release bearing. Remove clutch housing.



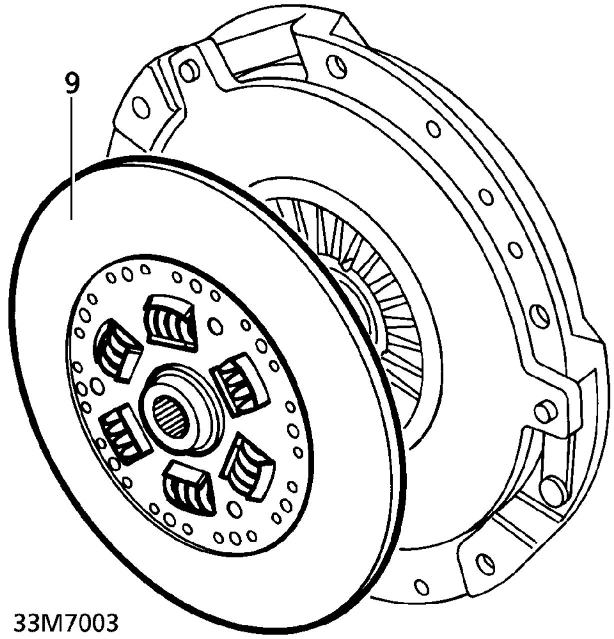
33M7001

6. If clutch cover is to be refitted, mark cover and flywheel to aid re-assembly.
7. Restrain flywheel.
8. Working diagonally, sequentially slacken 6 bolts securing clutch cover to flywheel. Remove bolts.



33M7002

9. Remove cover assembly. Collect friction plate.



33M7003

Check

10. Check linings of friction plate for excessive or uneven wear, burning or contamination.
11. Check splines of friction plate for excessive wear.
12. Check friction surface of cover for burning distortion or scoring.
13. Check fingers of cover for cracks and distortion.
14. Check release bearing for smooth operation.
15. Renew components as necessary.

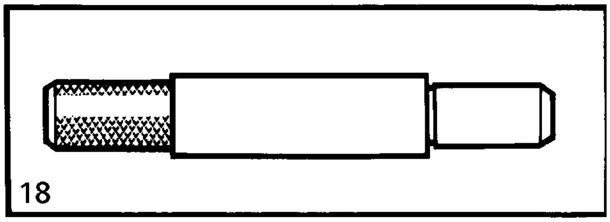
CAUTION: Bearing is packed with grease, do not wash in solvent.

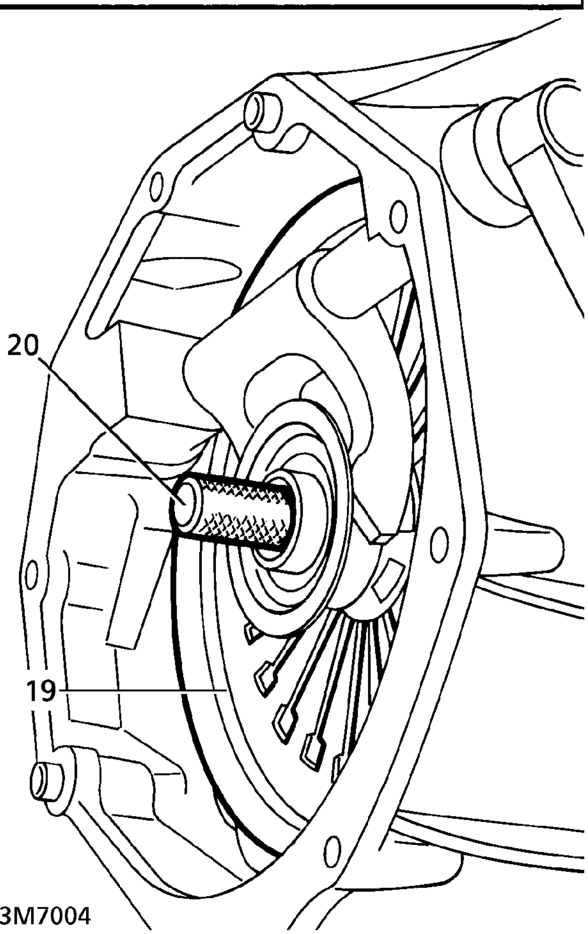
Refit

16. Ensure mating faces are clean.

NOTE: New friction plates are supplied with splines pre-greased.

17. If refitting existing friction plate, smear splines with 'Molycote FB180'.
18. Position friction plate on flywheel. Fit LRT-12-001 to align plate.


18



33M7004

19. Position cover. Locate on dowels.

NOTE: If original cover is refitted, align marks.

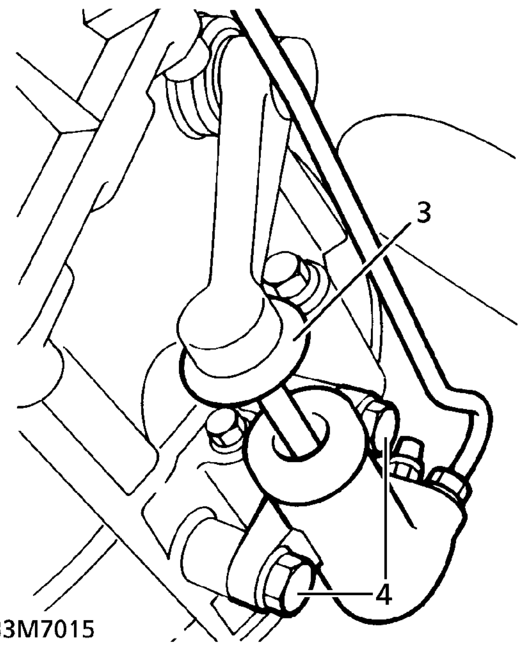
20. Secure cover with bolts. Tighten progressively, in a diagonal sequence to ***40 Nm (30 lbf.ft).*** Remove LRT-12-001.
21. Position clutch housing onto dowels. Ensure release fork engages with release bearing.
22. Secure clutch housing with bolts. Tighten to ***40 Nm (30 lbf.ft)***
23. Position flywheel access cover. Secure with bolts.
24. Smear release lever push rod socket with 'Molycote FB180'.
25. Position slave cylinder on clutch housing. Ensure pushrod is engaged with lever. Secure cylinder with bolts. Tighten to ***45 Nm (33 lbf.ft)***
26. Secure push rod gaiter to clutch lever.
27. Fit gearbox assembly. ***See MANUAL GEARBOX, Repair.***

CLUTCH ASSEMBLY - DIESEL

Service repair no - 33.10.07

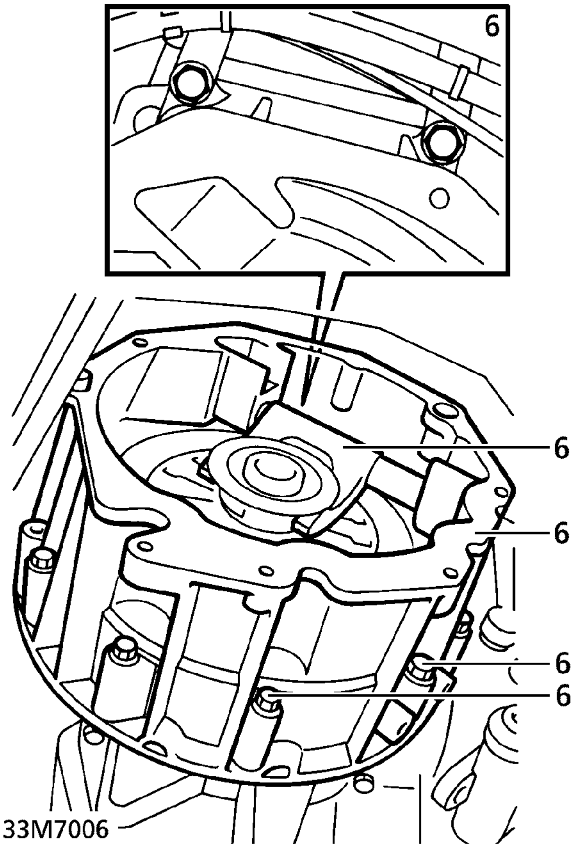
Remove

1. Remove gearbox assembly. ***See MANUAL GEARBOX, Repair.***
2. Remove starter motor. ***See ELECTRICAL, Repair.***
3. Release push rod gaiter from clutch lever.



33M7015

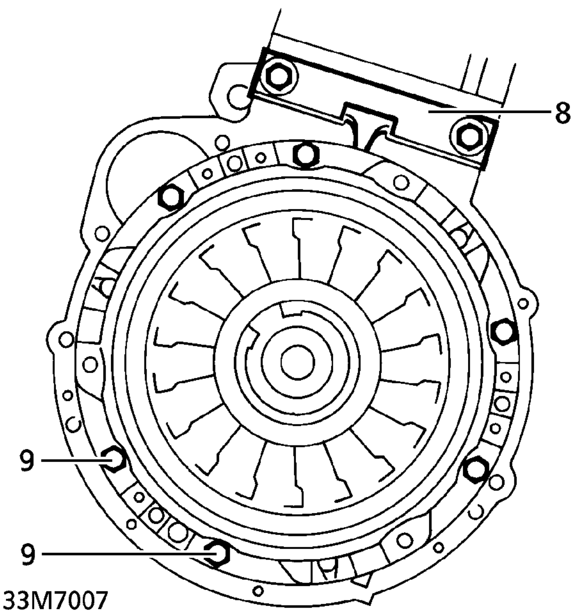
4. Remove 2 bolts securing clutch slave cylinder. Tie cylinder aside.
5. Release clutch fluid pipe from clips. Move pipe bracket clear of clutch housing.
6. Remove 7 remaining bolts securing clutch housing. Disengage release lever from release bearing. Remove clutch housing.



33M7006

NOTE: Spacer plate may become detached from dowels but remain captive behind flywheel.

7. If clutch cover is to be refitted, mark cover and flywheel to aid re-assembly.
8. Fit LRT-12-106 to flywheel. Secure tool to cylinder block with bolts.



33M7007

9. Working diagonally, sequentially slacken 6 bolts securing clutch cover to flywheel. Remove bolts.
10. Remove cover assembly. Collect friction plate.

Check

11. Check linings of friction plate for excessive or uneven wear, burning or contamination.
12. Check splines of friction plate for excessive wear.
13. Check friction surface of cover for burning, distortion or scoring.
14. Check fingers of cover for cracks and distortion.
15. Check release bearing for smooth operation.
16. Renew components as necessary.

CAUTION: Release bearing is packed with grease, do not wash in solvent.

Refit

17. Ensure mating faces are clean.

NOTE: New friction plates are supplied with splines pre-greased.

18. Smear friction plate splines with 'Molycote BR2'.
19. Position friction plate on flywheel. Fit LRT-12-123 to align plate.
20. Position cover, locate on dowels.

NOTE: If original cover is refitted, align marks.

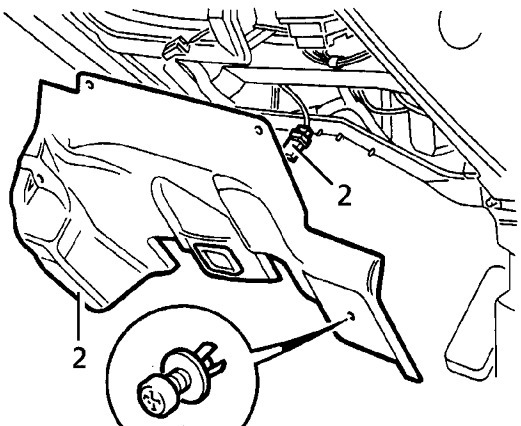
21. Secure cover with bolts. Tighten progressively, in a diagonal sequence, to:
    M8 8.8 - ***24 Nm (18 lbf.ft)***
    M8 10.9 - ***34 Nm (25 lbf.ft)***
22. Remove LRT-12-123 and LRT-12-106.
23. Position spacer plate onto dowels.
24. Position clutch housing onto dowels. Ensure release fork engages with release bearing.
25. Align clutch fluid pipe bracket and coolant pipe with clutch housing.
26. Secure clutch housing with bolts.
    M8 - Tighten to ***27 Nm (20 lbf .ft)***
    M10 - Tighten to ***51 Nm (38 lbf.ft)***
    M12 - Tighten to ***86 Nm (63 lbf.ft)***
27. Smear push rod socket of release lever with 'Molycote FB180'.
28. Position slave cylinder on clutch housing. Ensure push rod has engaged with lever. Secure cylinder with bolts. Tighten to ***45 Nm (33 lbf.ft)***
29. Secure push rod gaiter to clutch lever.
30. Secure fluid pipe to clips.
31. Fit starter motor. ***See ELECTRICAL, Repair.***
32. Fit gearbox assembly. ***See MANUAL GEARBOX, Repair.***

MASTER CYLINDER

Service repair no - 33.20.01

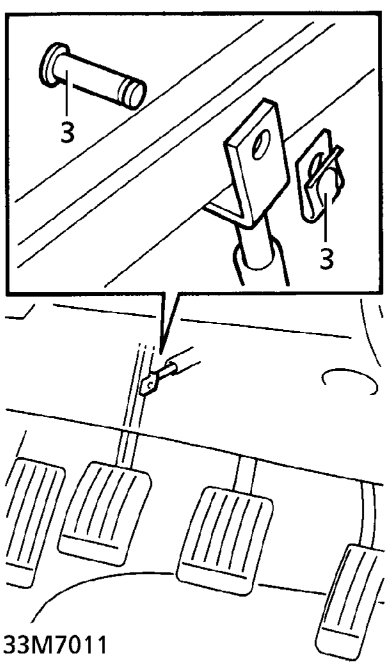
Remove

1. Remove fascia closing panel. ***See CHASSIS AND BODY, Repair.***
2. Remove 4 scrivets securing lower closing panel. Disconnect multiplug from footwell lamp. Remove panel.



33M7010

3. Remove spring clip and clevis pin from master cylinder push rod.

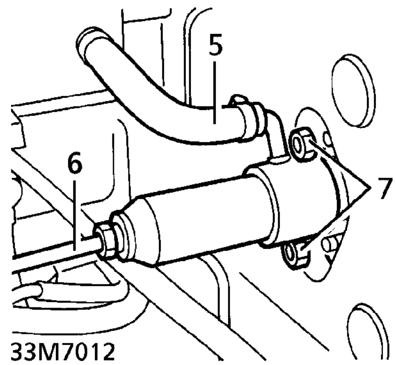


33M7011

4. Position cloth beneath master cylinder to absorb fluid spillage.

CAUTION: Do not allow brake fluid to contact painted surfaces. Paint damage will occur. If spilled, remove fluid. Wash area with clean warm water.

5. Disconnect reservoir hose from master cylinder. Plug hose and connection.



33M7012

6. Disconnect pressure pipe from master cylinder. Plug pipe and connection.
7. Remove 2 nuts securing master cylinder to bulkhead. Remove master cylinder.

Refit

8. Ensure mating faces are clean.
9. Reverse removal procedure.
10. Bleed clutch system. ***See this section.***

SLAVE CYLINDER

Service repair no - 33.35.01

Remove

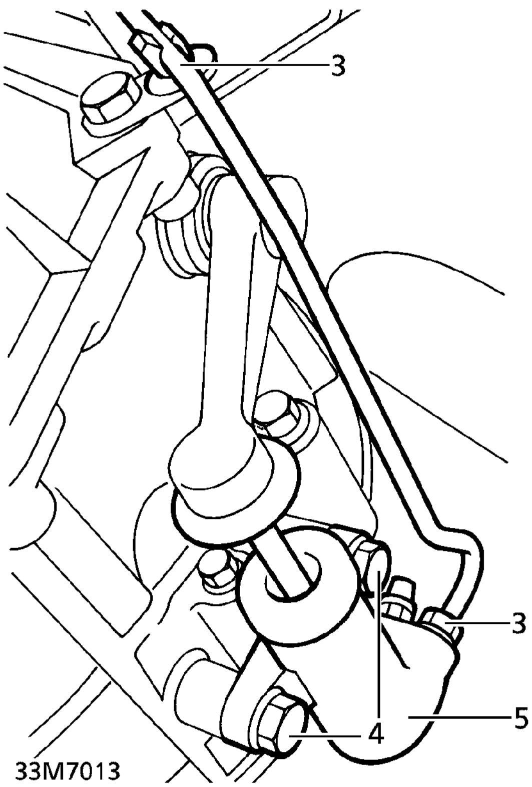
1. Raise the vehicle.

WARNING: Support on safety stands.

2. Position container to collect fluid spillage.

CAUTION: Do not allow brake fluid to contact painted surfaces. Paint damage will occur. If spilled, remove fluid. Wash area with clean warm water.

3. Disconnect fluid pipe. Release pipe from clip. Plug pipe and connection.



4. Remove 2 bolts securing cylinder.
5. Remove cylinder from clutch housing and push rod.

Refit

6. Ensure mating faces are clean.
7. Position cylinder to clutch housing and push rod. Secure with bolts. Tighten to ***45 Nm (33 lbf.ft)***
8. Remove plugs from pipe and cylinder. Connect pipe to cylinder. Tighten union.
9. Secure pipe to clip.
10. Bleed hydraulic system. ***See this section.***
11. Remove safety stands. Lower vehicle.

SLAVE CYLINDER - FROM 97MY

Service repair no - 33.35.01

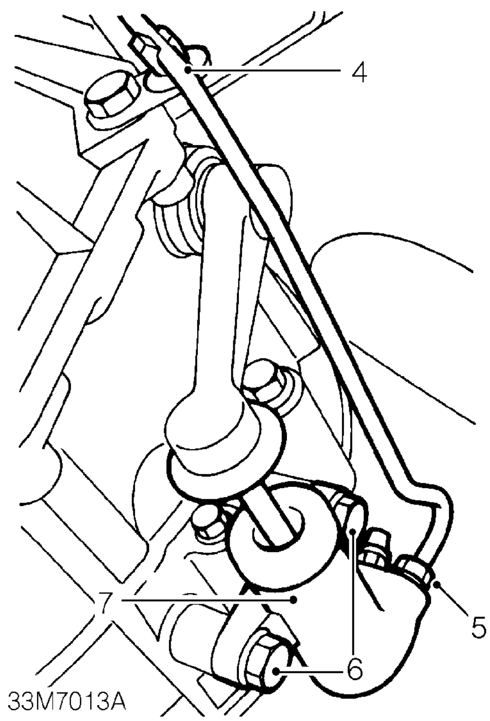
Remove

1. Raise front of vehicle.

WARNING: Support on safety stands.

2. Remove gearbox RH acoustic cover. ***See CHASSIS AND BODY, Repair.***
3. Position container to collect fluid spillage.

CAUTION: Do not allow brake fluid to contact painted surfaces. Paint damage will occur. Thoroughly clean spillages with clean, warm water.



4. Release pipe from clip.
5. Remove pipe union from slave cylinder.

CAUTION: Plug the connections.

6. Remove 2 bolts securing slave cylinder to clutch housing.
7. Remove slave cylinder from push rod.

Refit

8. Ensure mating surfaces of slave cylinder and clutch housing are clean.
9. Clean pushrod.
10. Fit slave cylinder to push rod and align to clutch housing.
11. Fit bolts securing slave cylinder to clutch housing and tighten to ***25 Nm (18lbf.ft)***
12. Remove plugs from slave cylinder and pipe union.
13. Clean pipe union and slave cylinder.
14. Connect and tighten pipe union to slave cylinder.
15. Secure pipe to clip.
16. Bleed clutch system. ***See this section.***
17. Fit gearbox RH acoustic cover. ***See CHASSIS AND BODY, Repair.***

CONTENTS

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R380 GEARBOX

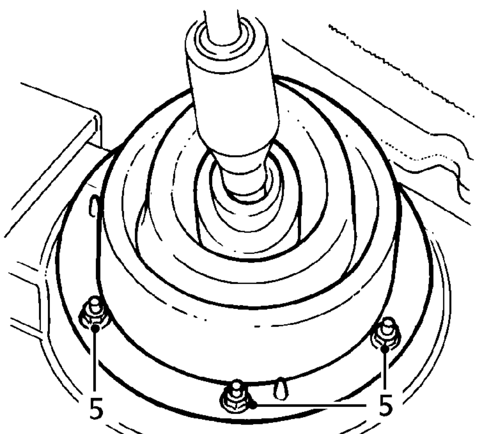
REPAIR

GEARBOX

Service repair no - 37.20.02 - Gearbox Renew
Service repair no - 37.20.02/99 - Gearbox Remove for Access

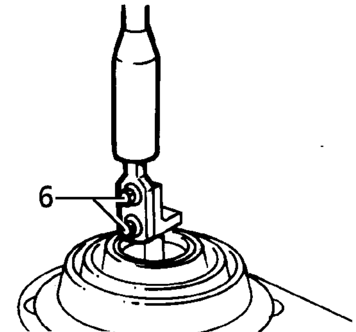
Remove

1. Raise vehicle on four post lift.
2. Disconnect battery negative lead.
3. **Petrol Vehicles:** Release 2 clips securing cooling fan cowling to radiator. Remove cowl.
4. Remove centre console. ***See CHASSIS AND BODY, Repair.***



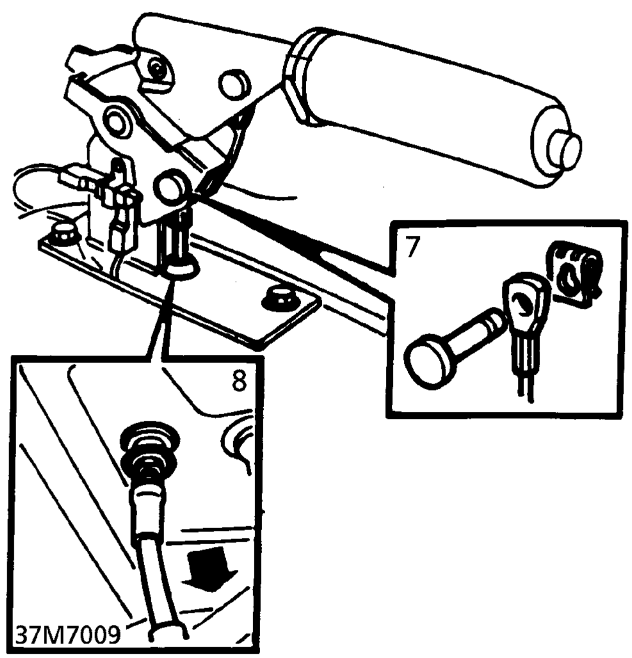
37M7021

5. Remove 6 nuts securing gaiter ring. Remove ring and gaiter



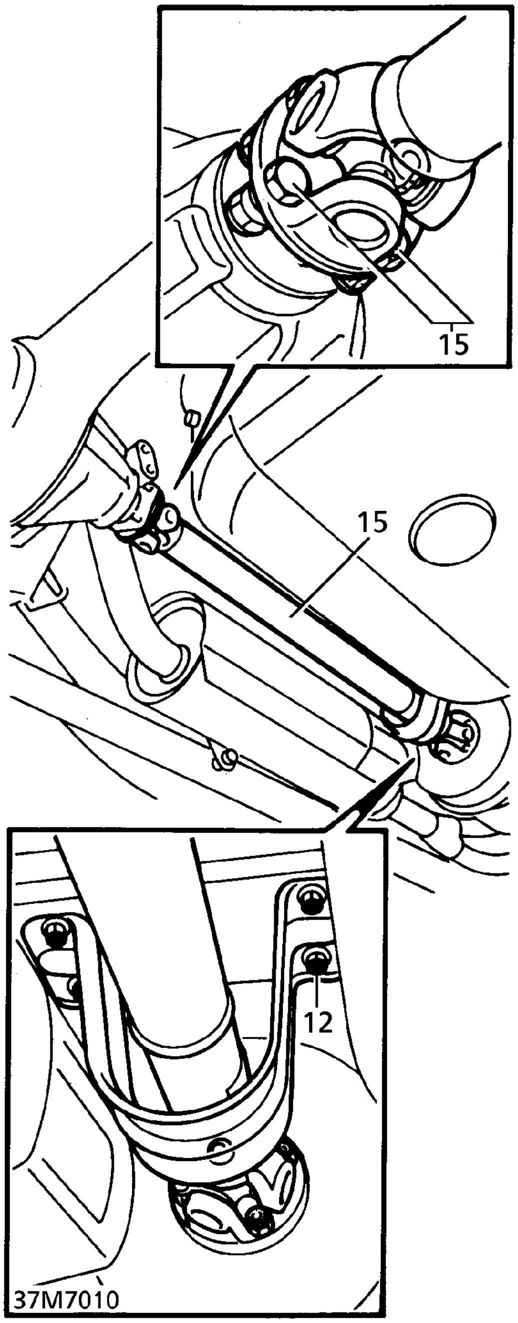
37M7008

6. Remove 2 bolts securing gear lever. Remove lever.
7. Remove handbrake cable clevis pin.
8. Release handbrake cable from grommet in tunnel. Refit cable grommet to tunnel.

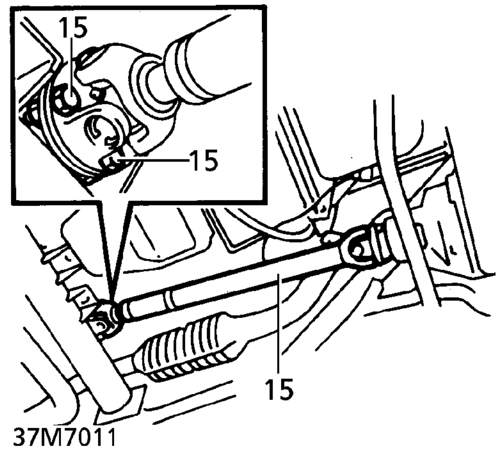


37M7009

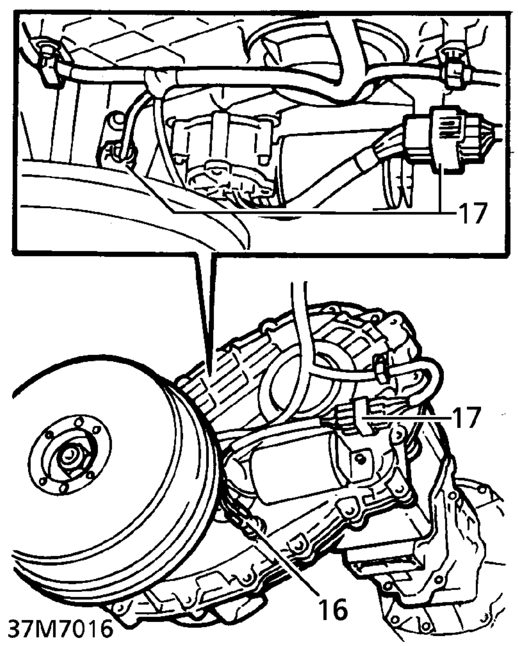
9. Raise lift. Drain gearbox and transfer box oil. ***See SECTION 10, Maintenance.***
10. Remove exhaust front pipe. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***
11. **Diesel Vehicles:** Remove chassis crossmember. ***See CHASSIS AND BODY, Repair.***
12. Remove 4 bolts securing rear propeller shaft guard. Remove guard.



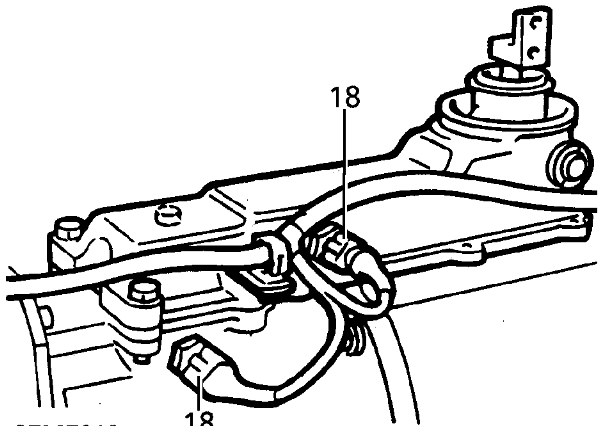
13. Mark transfer box and propeller shaft flanges to aid re-assembly.
14. Raise one wheel on each axle to allow rotation of propeller shafts.
15. Remove 4 nuts and bolts from each flange. Disconnect propeller shafts. Tie aside.



16. Disconnect 2 Lucars from transfer box oil temperature sensor.

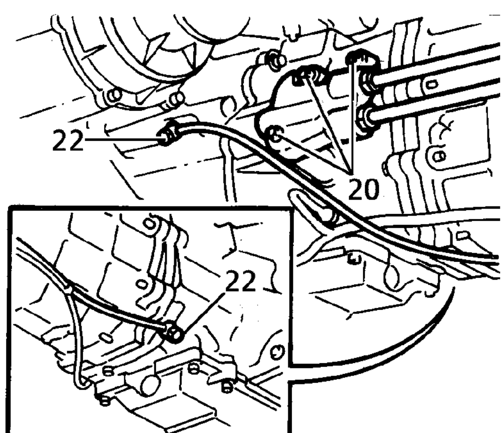


17. Disconnect multiplugs from high/low motor and output shaft speed sensor.



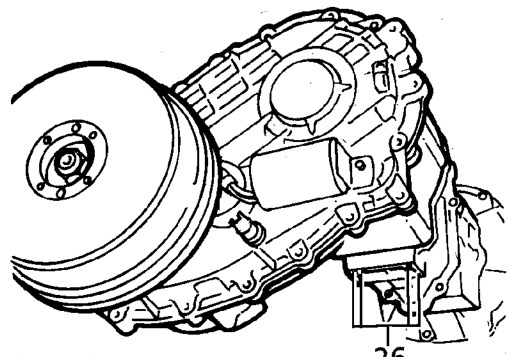
37M7012

18. Disconnect multiplugs from reverse and neutral switches.
19. Release harness from clips.
20. Remove 3 bolts securing oil cooler pipe adaptor to gearbox.
21. Release adaptor, collect 2 'O' rings and discard. Plug connections.



37M7013

22. Remove banjo bolts securing breather pipes to gearbox and transfer box.
23. Collect 2 sealing washers from each union and discard. Plug pipes and connections.
24. Tie breather and oil cooler pipes aside.
25. Position adaptor plate to transmission lift. Secure with bolts.

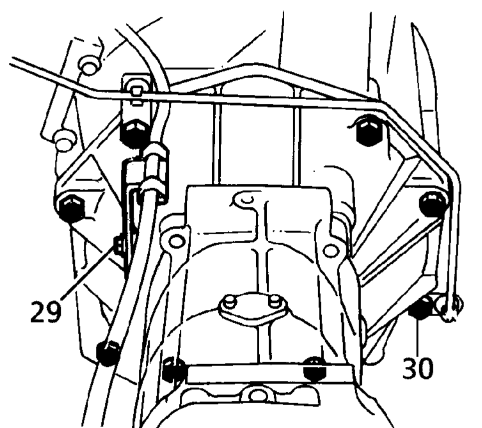


37M7014

26. Raise transmission lift into position. Secure adaptor plate to gearbox mounting bracket holes with 4 bolts.
27. Remove transmission stand.
28. Lower transmission for access.

CAUTION: Place a wooden block between axle case and sump to support engine.

29. Remove bolt securing harness bracket to gearbox.



37M7015

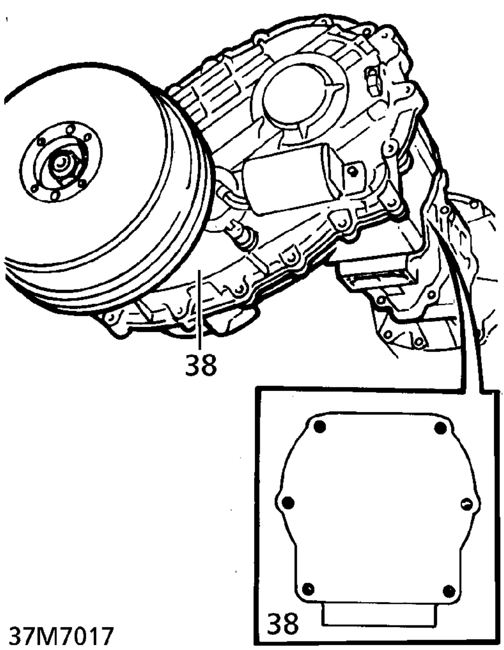
30. Remove 8 bolts securing gearbox to bell housing.

CAUTION: Do not allow the weight of the gearbox to be supported by the clutch.

31. With assistance, release gearbox from clutch plate splines.
32. Lower transmission assembly away from vehicle.
33. ***Do not carry out further dismantling if component is removed for access only.***
34. Attach lifting eyes to transmission.
35. Attach hoist to lifting eyes. Take weight of transmission.
36. Remove lift adaptor. Hoist transmission assembly onto bench.
37. Fit lifting eye to transmission brake drum. Raise gearbox on end.

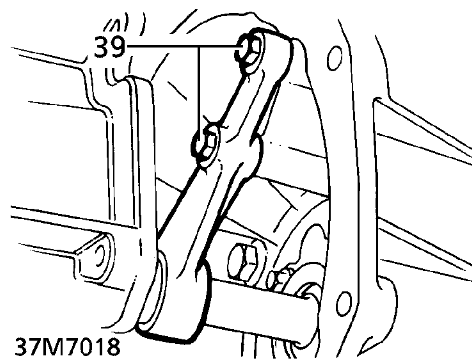
CAUTION: Position packers beneath bell housing extension to provide clearance for input shaft.

38. Remove 6 bolts securing transfer box to gearbox. Release from 2 ring dowels. Remove transfer box.



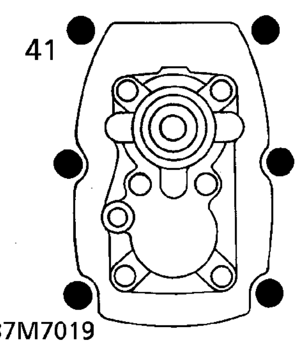
37M7017

39. Remove 2 bolts securing clutch release bearing spigot. Remove spigot.



37M7018

40. Lay gearbox on side. Position bell housing extension over edge of bench.
41. Remove 6 bolts securing bell housing extension. Release from 2 ring dowels. Remove from gearbox.



37M7019

42. Ensure mating faces are clean.
43. Clean release bearing spigot. Lightly coat running surface with grease. ***See LUBRICANTS, FLUIDS AND CAPACITIES, Information.***
44. Position bell housing extension to gearbox. Engage ring dowels. Secure with bolts. Tighten to ***45 Nm (33 lbf.ft)***
45. Position clutch release bearing spigot. Secure with bolts. Tighten to ***18 Nm (13 lbf.ft)***

46. Place gearbox on end. Position transfer box.
47. Engage transfer box to ring dowels. Secure to gearbox with bolts. Tighten to ***45 Nm (33 lbf.ft)***
48. Place transmission on side. Fit lifting eyes.
49. Raise transmission to lift adaptor. Secure to adaptor plate with bolts.
50. Detach hoist. Remove lifting eyes.

Refit

51. With assistance, depress clutch pedal. Align clutch friction plate with either: LRT-12-001 **Petrol models** or LRT-12-123 **Diesel models.**
52. Release clutch pedal. Remove aligning tool.
53. Select gear to aid input shaft alignment.
54. Position transmission to engine. Engage input shaft to friction plate splines.

CAUTION: Do not allow the weight of the gearbox to be supported by the clutch.

55. Engage bell housing ring dowels. Secure gearbox to bell housing with bolts. Tighten to ***45 Nm (33 lbf.ft)***

CAUTION: Ensure that gearbox is located on both dowels, or transmission damage may occur.

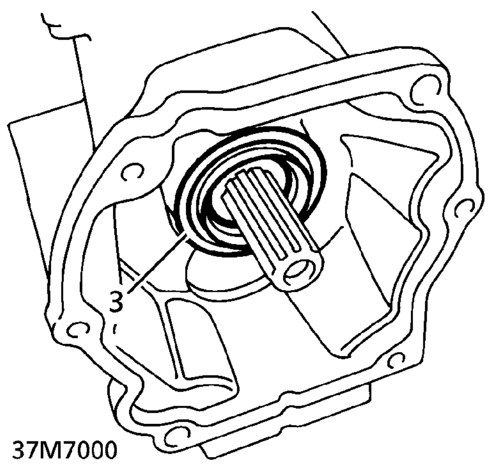
56. Select neutral.
57. Raise transmission. Support under brake drum with transmission jack.
58. Remove transmission lift adaptor. Remove lift.
59. Untie breather and oil cooler pipes.
60. Remove plugs from pipes pipes and connections.
61. Fit new 'O' rings to oil cooler pipe adaptor. Position adaptor to gearbox. Secure with bolts.
62. Fit new sealing washers to breather pipes. Position pipes. Secure with banjo bolts.
63. Position harness bracket to gearbox and secure with bolt.
64. Secure harness to clips.
65. Connect multiplugs to reverse and neutral switches.
66. Connect multiplugs to high/low motor and output shaft speed sensor.
67. Connect Lucar terminals to transfer box oil temperature sensor.
68. Raise one wheel on each axle to allow rotation of propeller shafts.
69. Position propeller shafts to transfer box flanges. Align marks.
70. Secure shafts with nuts and bolts. Tighten to ***48 Nm (35 lbf.ft)***
71. Fit rear propeller shaft guard. Secure with bolts.
72. Route handbrake cable through grommet in transmission tunnel.
73. **Diesel Vehicles.** Fit chassis cross member. ***See CHASSIS AND BODY, Repair.***
74. Fit exhaust front pipe. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***
75. Refill gearbox and transfer box fluids. ***See LUBRICANTS, FLUIDS AND CAPACITIES, Information.***
76. Fit seal around gearbox remote housing to transmission tunnel aperture.
77. Connect handbrake cable to lever. Secure with clevis pin and clip.
78. Position gear lever. Secure with bolts. Tighten to ***25 Nm (18 lbf.ft)***
79. Fit gaiter and ring. secure with nuts.
80. Fit centre console. ***See CHASSIS AND BODY, Repair.***
81. **Petrol Vehicles.** Position radiator cooling fan cowling. Secure with clips.
82. Reconnect battery negative lead.

OUTPUT SHAFT SEAL

Service repair no - 37.23.01

Remove

1. Disconnect battery negative lead.
2. Remove transfer box. ***See TRANSFER BOX, Repair.***
3. Lever seal from extension housing.



37M7000

CAUTION: Ensure seal location does not become damaged.

Refit

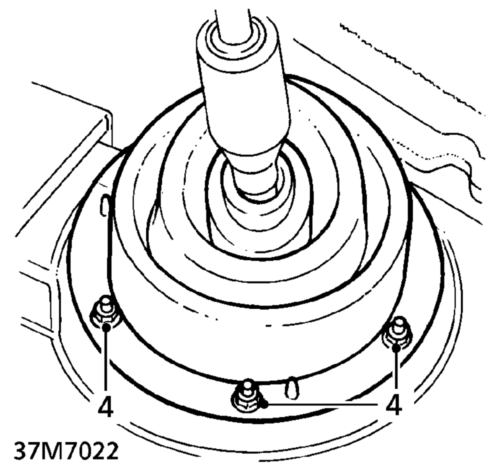
4. Ensure mating faces are clean.
5. Lubricate seal lip with transmission oil.
6. Using LRT-37-014, fit seal to extension housing.
7. Fit transfer box. ***See TRANSFER BOX, Repair.***
8. Reconnect battery negative lead.

SELECTOR REMOTE HOUSING

Service repair no - 37.16.29

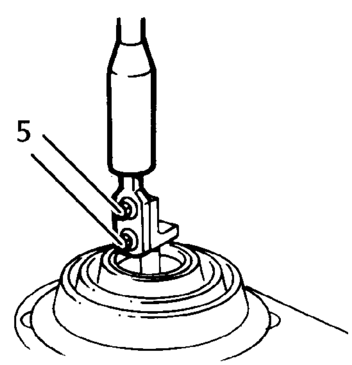
Remove

1. Raise vehicle on four post lift.
2. Disconnect battery negative lead.
3. Remove centre console. ***See CHASSIS AND BODY, Repair.***
4. Remove 6 nuts securing gaiter ring. Remove ring and gaiter.



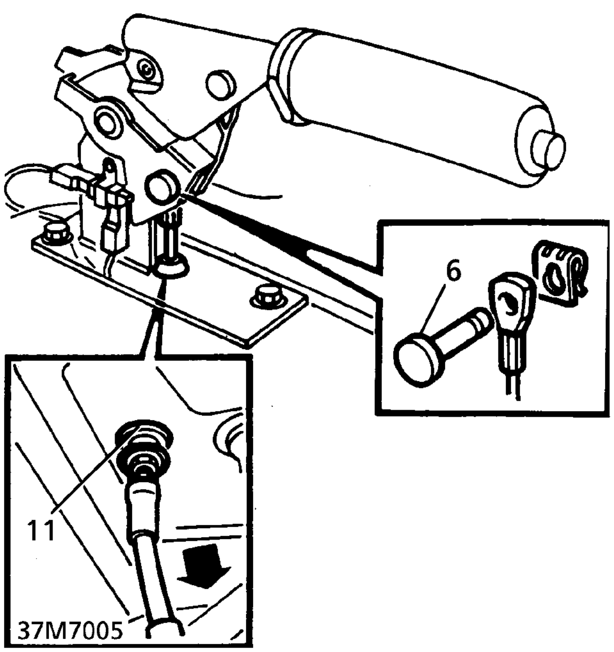
37M7022

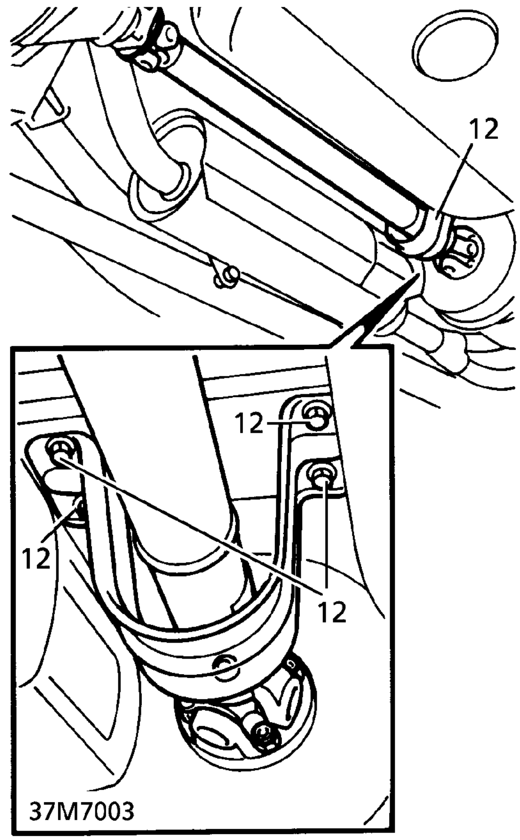
5. Remove 2 bolts securing gear lever. Remove lever.



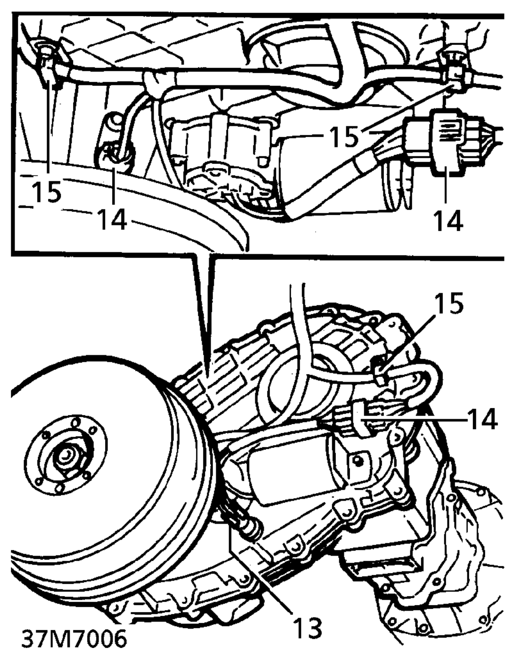
37M7002

6. Remove handbrake cable clevis pin.





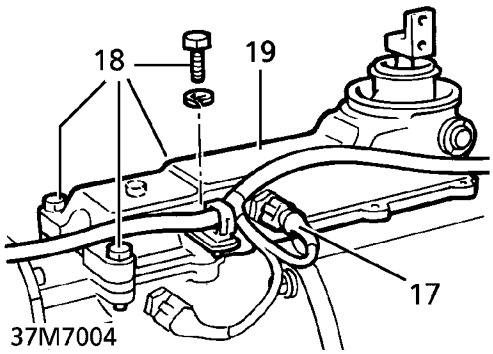
7. Raise lift.
8. Support gearbox using transmission jack.
9. Remove exhaust front pipe. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***
10. **Diesel Vehicles.** Remove chassis cross member. ***See CHASSIS AND BODY, Repair.***
11. Release hand brake cable from grommet in tunnel. Refit grommet to tunnel.
12. Remove 4 bolts securing propeller shaft guard. Remove guard.
13. Disconnect 2 Lucars from transfer box oil temperature sensor.



14. Disconnect multiplugs from High/Low motor and output shaft speed sensor.
15. Release harness from 2 clips on transfer gearbox brackets.
16. Lower gearbox for access.

CAUTION: Ensure engine does not foul bulkhead.

17. Disconnect neutral switch multiplug.



18. Remove 4 bolts securing remote housing to gearbox. Position harness bracket aside.
19. Remove selector remote housing from 2 location dowels.

Refit

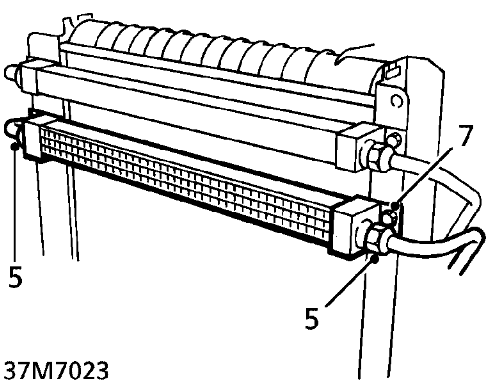
20. Ensure all mating faces are clean.
21. Apply a uniform bead of Hylogrip 2000 to sealing face of remote housing as shown.
22. Position remote housing. Engage remote spigot into selector yoke.
23. Engage housing to location dowels. Align harness bracket.
24. Secure remote housing with bolts. Tighten to ***25 Nm (18 lbf.ft)***
25. Connect neutral switch multiplug.
26. Connect multiplugs to High/Low motor and output shaft speed sensor.
27. Connect Lucars to transfer box fluid temperature sensor.
28. Secure harness in clips.
29. Position propeller shaft guard. Secure with bolts.
30. Route hand brake cable through grommet in transmission tunnel.
31. Fit exhaust front pipe. ***See MANIFOLD AND EXHAUST SYSTEM, Repair.***
32. **Diesel Vehicles.** Fit chassis cross member. ***See CHASSIS AND BODY, Repair.***
33. Remove jack. Lower lift.
34. Connect handbrake cable to lever. Secure with clevis pin and clip.
35. Fit seal around gearbox remote housing to transmission tunnel aperture.
36. Position gear lever. Secure with bolts. Tighten to ***25 Nm (18 lbf.ft)***
37. Fit gaiter and ring. Secure with nuts.
38. Fit centre console. ***See CHASSIS AND BODY, Repair.***
39. Reconnect battery negative lead.

FLUID COOLER - PETROL

Service repair no - 37.12.52

Remove

1. Disconnect battery negative lead.
2. Remove engine oil cooler. ***See ENGINE, Repair.***
3. Remove 4 trim studs securing air deflectors. Remove deflectors.
4. Position container to collect fluid spillage.
5. Unscrew fluid pipe union nuts. Collect 'O' rings and discard.



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6. Plug pipes and connections.
7. Remove 4 bolts securing cooler to radiator bracket.
8. Remove cooler.

Refit

9. Fit cooler.
10. Fit and tighten 4 bolts securing cooler to mounting bracket.
11. Remove plugs from cooler and pipes.
12. Ensure pipe unions are clean.
13. Lubricate new 'O' rings seals with clean fluid. Fit seals to pipes.
14. Connect pipes to cooler. Tighten to ***30 Nm (22 lbf.ft)***
15. Remove container.
16. Fit air deflectors and secure with studs.
17. Fit engine oil cooler. ***See ENGINE, Repair.***
18. Reconnect battery negative lead.
19. Top up gearbox fluid. ***See SECTION 10, Maintenance.***

FLUID COOLER - DIESEL

Service repair no - 37.12.52

Remove

1. Remove radiator. ***See COOLING SYSTEM, Repair.***

Refit

2. Reverse removal procedure.