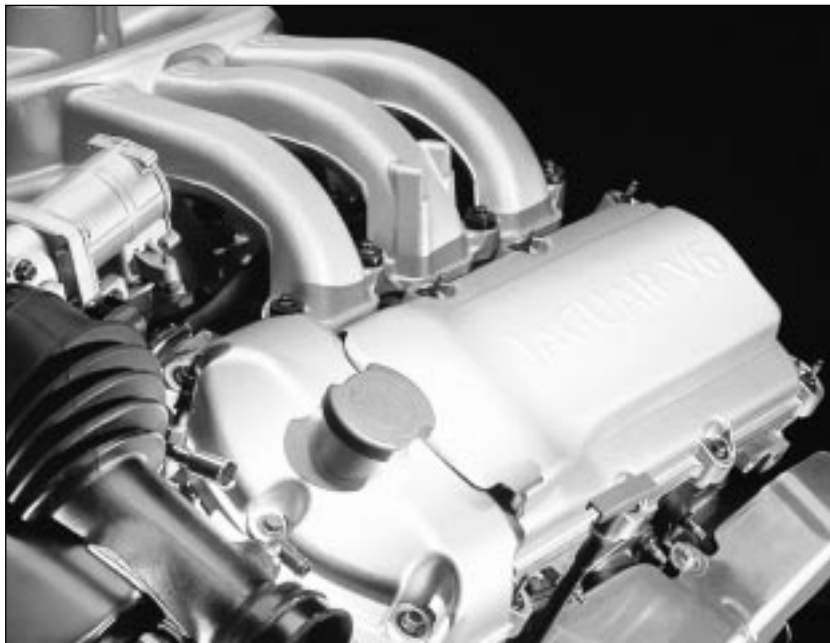




Technical Guide



Jaguar S-TYPE Sports Sedan Powertrain Introduction



BY APPOINTMENT TO
HER MAJESTY QUEEN ELIZABETH II
MANUFACTURERS OF DAIMLER AND JAGUAR CARS
JAGUAR CARS LIMITED COVENTRY



BY APPOINTMENT TO
HER MAJESTY QUEEN ELIZABETH
THE QUEEN MOTHER
MANUFACTURERS OF DAIMLER AND JAGUAR CARS
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HIS ROYAL HIGHNESS THE PRINCE OF WALES
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JAGUAR CARS LIMITED COVENTRY



Technical Guide

Jaguar S-TYPE Sports Sedan Powertrain Introduction

This Technical Guide introduces the engines and transmissions for the new S-TYPE sports sedan. It is intended to give Jaguar Dealer workshop personnel an overview of their construction and operation, and is for information purposes only.

The contents of this Technical Guide must not be used as a reference source for servicing procedures; all servicing must be carried out in accordance with the appropriate JTIS disc.

This Technical Guide will not be updated. While every effort is made to ensure accuracy, changes may occur between going to press and the equipment being introduced to the market. Once the equipment is in service, details of changes can be obtained from Service Bulletins and revisions to the JTIS disc.

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The following abbreviations are used in this document:

Abbreviation	Description
AAC	air assisted (injection) control valve
AAI	air assisted injection
ABDC	after bottom dead centre
A/C	air conditioning
AH	amp-hour
API	American Petroleum Institute
APP	accelerator pedal position (sensor)
ATDC	after top dead centre
bank 1	A bank
bank 2	B bank
BBDC	before bottom dead centre
BTDC	before top dead centre
°C	degree Celsius
CHT	cylinder head temperature (sensor)
CKP	crankshaft position (sensor)
CMP	camshaft position (sensor)
ECT	engine coolant temperature (sensor)
EFT	engine fuel temperature (sensor)
EGR	exhaust gas recirculation
EMS	engine management system
EOP	engine oil pressure (sensor)
EOT	engine oil temperature (sensor)
EVAP	evaporative emission
°F	degrees Fahrenheit
HO2	heated oxygen (sensor)
Hz	Hertz (cycles per second)
IAT	intake air temperature (sensor)
IMT	intake manifold tuning (valve)
IP	injector pressure (sensor)
JTIS	Jaguar Technical Information System
KS	knock sensor (sensor)
LH	lefthand
MAF	mass air flow (sensor)
N/A	normally aspirated
NAS	North American specification
OBDII	on-board diagnostics stage 2
PAS	power assisted steering
PCM	powertrain control module
PCV	positive crankcase ventilation
PWM	pulse width modulated
RH	righthand
RPM	revolutions per minute
SAE	Society of Automotive Engineers (USA)
SCP	standard corporate protocol
TAC	throttle actuator control (module)
TP	throttle position (sensor)
VVT	variable valve timing
W	watts

The new S-TYPE sports sedan has an in-line powertrain and rear wheel drive configuration and is available with either a 3 Litre V6 or a 4 Litre V8 engine, both normally aspirated. The V6 engine, designated AJ-V6 is new to the Jaguar range and provides expected Jaguar levels of performance with smooth power delivery, economy and excellent torque characteristics across the engine speed/load range. The engine is of a lightweight but rigid design with particular attention paid to minimising noise and vibration. A major innovation is the use of a variable geometry air intake manifold, which is controlled, via valves, by the engine management system and produces optimised volumetric efficiency at all engine speeds. Two stage variable valve timing is also fitted and both systems are optimised together to achieve the wide torque delivery at all engine speeds.

The V8 engine, designated AJ28, is a development of the now established engine fitted to the successful XK Series sports and XJ Series sedan and incorporates the latest modifications fitted to the AJ27 variant, in particular the continuously variable valve timing system and air assisted fuel injection.

Both the V6 and V8 engines are fitted with a new, common, electronic throttle which does not require a mechanical cable. Another new feature, also common to both engines, is the use of a returnless fuel system to reduce the formation of fuel vapour (evaporative emissions).

A new 5-speed automatic transmission is fitted (with slight differences) to both engines. In certain markets only, an optional 5-speed manual transmission, with new self-adjusting clutch, is available for the V6 engine only.

Both engines and the automatic transmission are controlled by a completely new powertrain control system.

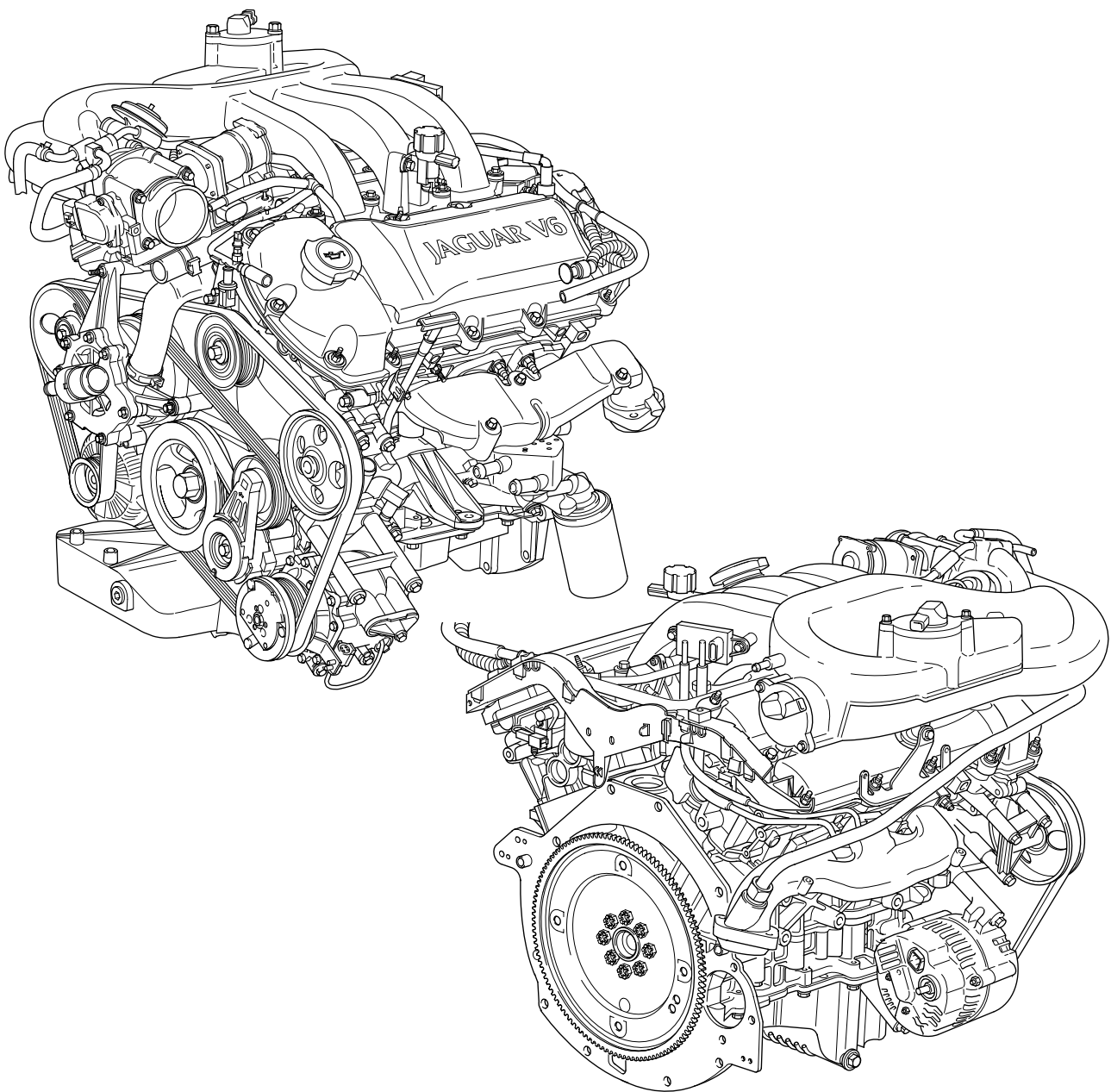
Introduction

The AJ-V6 is a water cooled six cylinder engine configured as two banks of cylinders in a 60° V formation. Valve operation is via chain driven double overhead camshafts on each cylinder bank. The engine is naturally aspirated but with a unique air intake system which significantly improves power output. Lightweight materials are used extensively but the structural design is such as to maintain a strong rigid assembly.

The main features of the power unit are:

- three stage variable geometry intake manifold
- electronic throttle with cable-less operation
- two position variable valve timing
- returnless fuel system
- fail safe cooling system

AJ-V6 ENGINE



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Engine Specifications

Configuration	60° V6
Displacement	2967 cc (181 cu. in)
Bore	89.0 mm (3.504 in)
Stroke	79.5 mm (3.130 in)
Compression ratio	10.5 :1
Cylinder head	2 overhead camshafts per bank, 4 valve per cylinder
Firing order	1-4-2-5-3-6
Maximum power	DIN - 179 kW (240 BHP) at 6800 RPM EEC - 175 kW (238 PS) at 6800 RPM
Maximum torque	DIN - 300 Nm (221 lbft) at 4500 RPM EEC - 293 Nm (216 lbft) at 4500 RPM
Oil specification	see below
Oil volume	5.7 Litres (6 quarts)
Coolant specification	see page 35
Coolant volume	10.4 Litres (11 quarts)
Weight	174 kg (384 lbs)

Oil Specification

All markets except the USA and Canada

Engine oil for all markets except the USA and Canada must be to API specification SJ/ACEA A1 or A3.

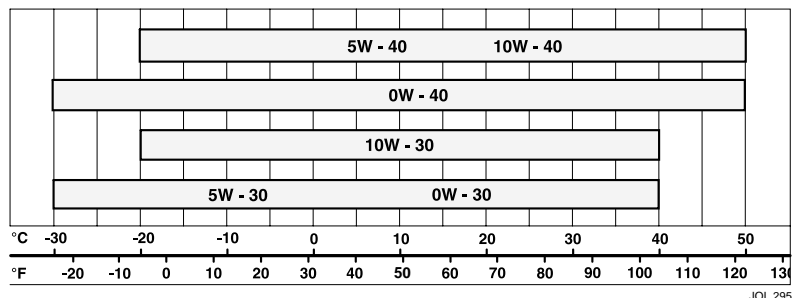
The recommended SAE viscosity for different ranges of ambient temperature are shown in table 1.

USA/Canada

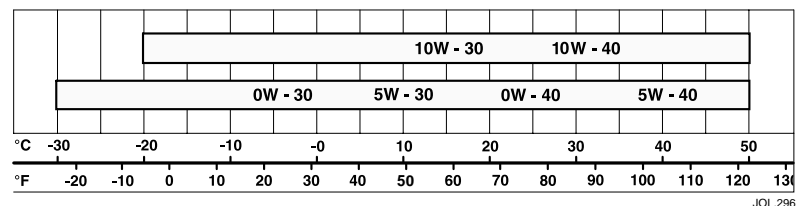
Engine oil for USA and Canada must be to API specification SJ/ILSAC GF-2.

The recommended SAE viscosity for different ranges of ambient temperature are shown in table 2. For maximum economy and in most climate conditions, SAE 5W/30 is to be preferred but SAE 10W/30 or 15W/40 are acceptable in moderate to hot climates.

SAE/TEMPERATURE TABLE 1



SAE/TEMPERATURE TABLE 2



Basic Engine

Engine Structure

Basic engine construction is similar to the V8 in that a structural bedplate is used which bolts to the cylinder block to provide a very strong housing for the crankshaft, minimising vibration. Both units are of cast aluminium alloy and are accurately aligned together by the use of eight hollow dowels.

The cylinder block is fitted with dry cast iron liners.

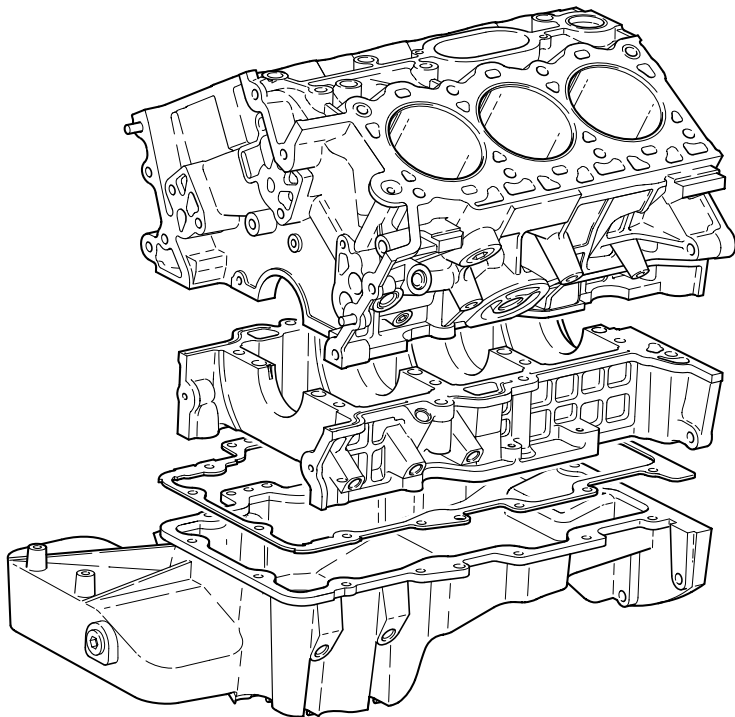
The oil sump is an aluminium alloy casting which combines a sump body and oil pan in a single structural component. The sump mounts to the bedplate via an aluminium gasket incorporating a silicone rubber seal.

Engine Identification Data

An engine identification code tag is located on the bank 2 side of the front cover assembly.

Mains bearing selection codes are located at the rear of the cylinder block and on the rear face of the crankshaft flange. The two codes are compared using reference data provided in the JTIS service information to identify the correct bearing.

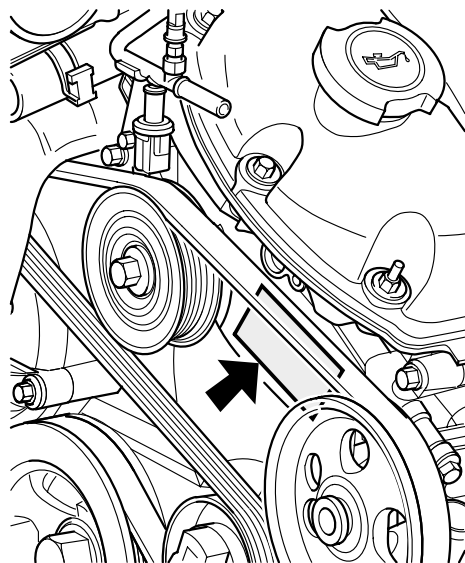
ENGINE STRUCTURE



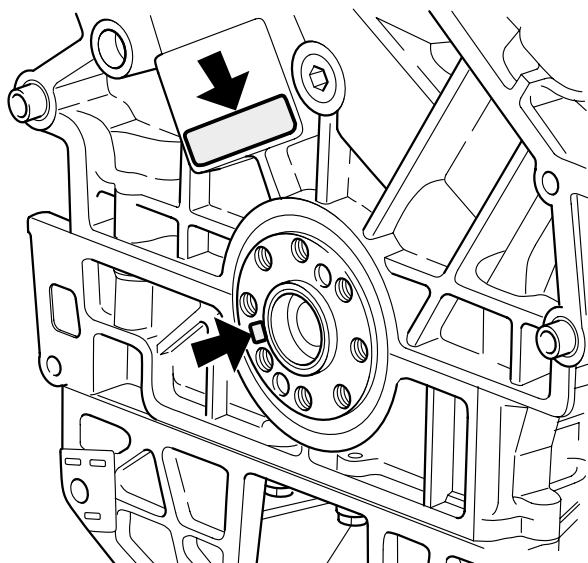
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ENGINE DATA LOCATIONS

Engine identification code



Mains bearing selection codes



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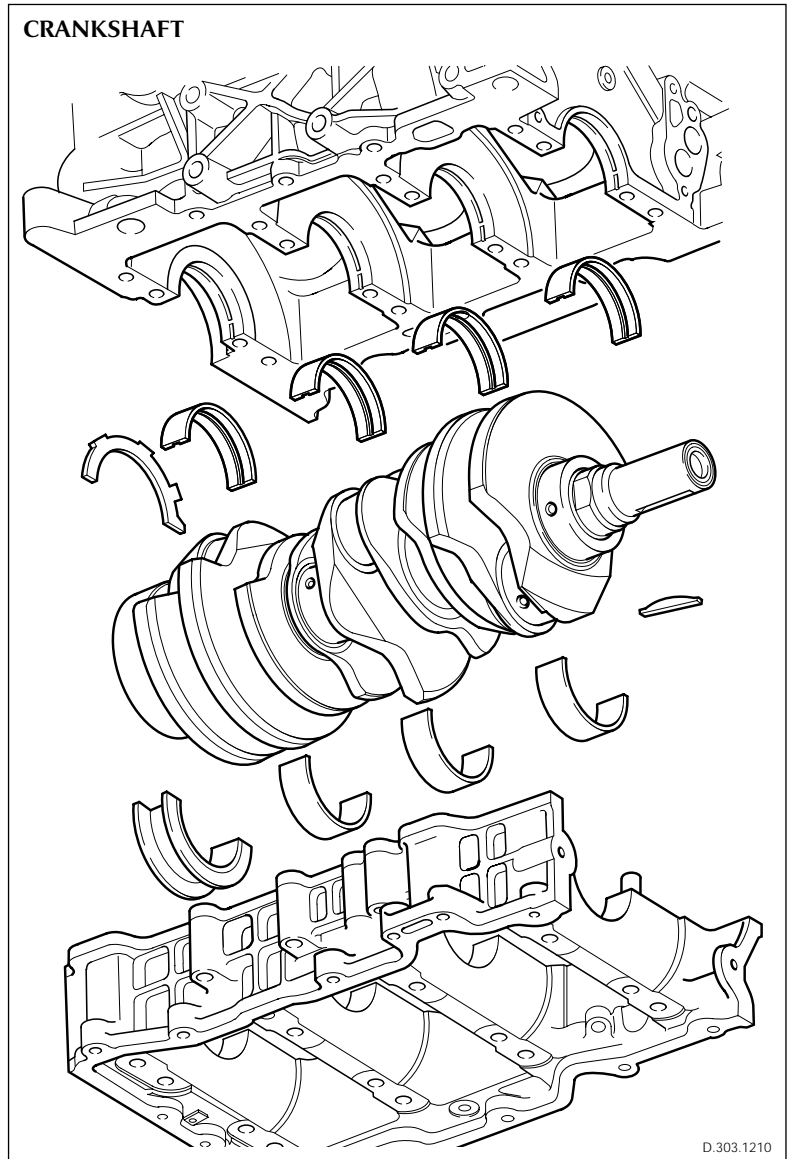
Crankshaft

The forged steel crankshaft runs in four aluminium/tin main bearings with the lower bearing shells supported in cast iron inserts in the bedplate. Fore and aft location of the shaft is set by the rear bearing assembly which consists of an upper shell and thrust half washer and a lower, flanged, thrust bearing shell. A keyway locates the crankshaft timing sprockets, timing pulse ring and crankshaft damper to the crankshaft.

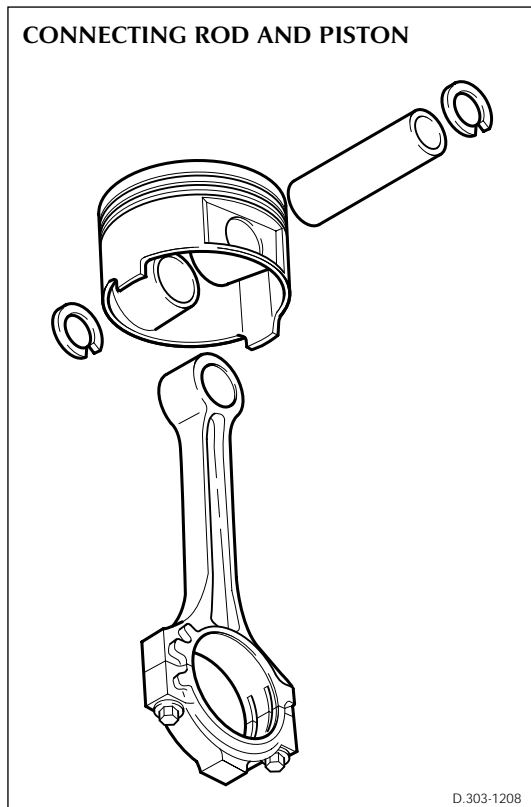
Connecting Rods and Pistons

The connecting rods are manufactured from sintered iron. The bearing caps are produced by the fracture split method (as used on the V8 engines) to provide a strong, accurately mated assembly. Bearing shells are of aluminium/tin alloy.

The pistons are made of aluminium alloy with valve cut-outs in the piston crown to allow for the extra inlet timing advance of the VVT system. Four cut outs are provided to enable a common piston to be used in each engine bank. The piston is fitted with two compression rings and an oil control ring assembly.



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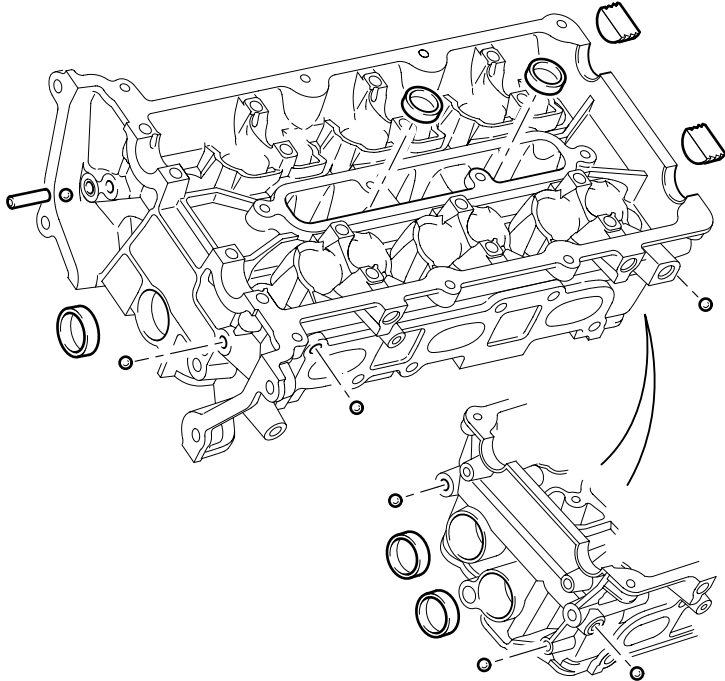
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Cylinder Head Assembly

Cylinder Head

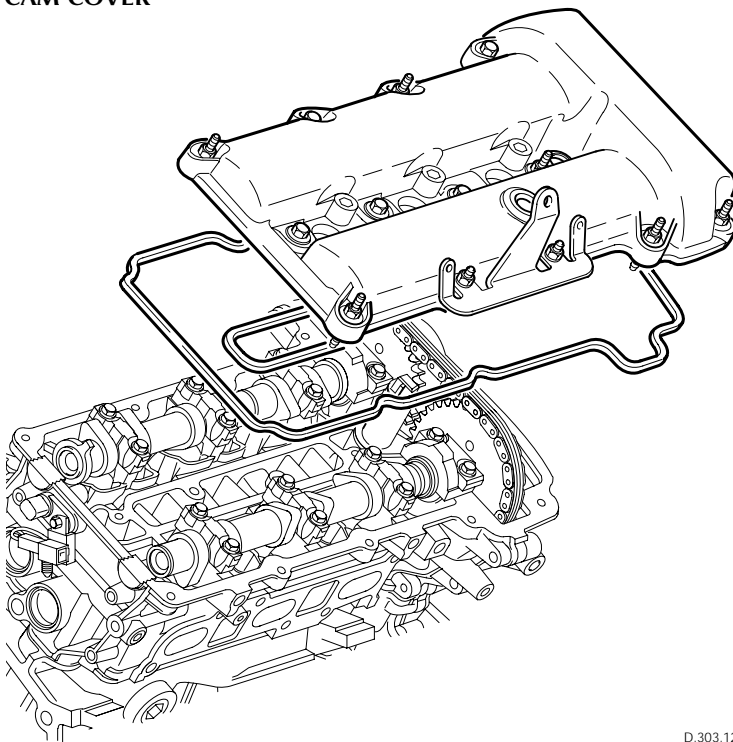
The aluminium alloy cylinder heads have square squish combustion chambers with four valve ports and a central spark plug. Each head is aligned to the cylinder block via two split hollow dowels and sealed with a composite stainless steel gasket. Steel balls (10.11mm diameter) are used to plug the external bores of the oilway drillings and cup plugs are fitted to the water jacket openings. Two half round aluminium cap inserts are fitted via a sealant at the rear of the head.

CYLINDER HEAD



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CAM COVER



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Cam Cover

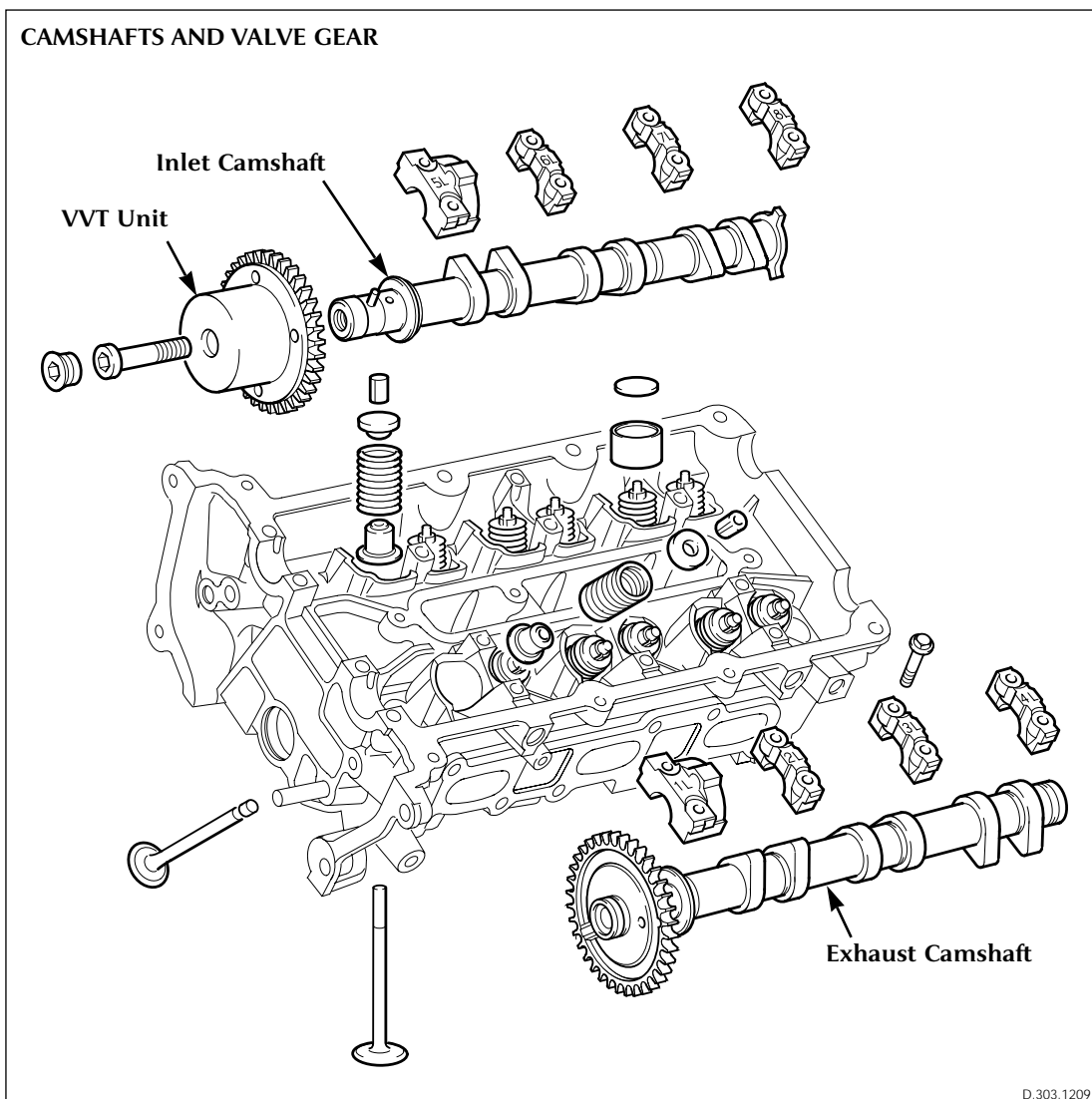
The cylinder heads are fitted with lightweight polyester cam covers, (bank 2 is silver colored) with silicone seals, to save weight and reduce airborne noise. A central aperture allows access to the coil on plug units and a second hole has a grommet through which the VVT oil control valve protrudes. The oil filler hole is in the LH cover.

Camshafts and Valve Gear

The basic camshaft consists of individual machined cam lobes, thrust washer and end plug assembled on a steel tube. The exhaust camshafts also have a pressed on drive sprocket, forming a single camshaft assembly. On the inlet camshaft the drive sprocket is fixed to the VVT unit which is removable but the rear end of the camshaft is fitted with a pressed on multi-tooth sensor ring. Each camshaft is supported in four bearings with the front (thrust) bearing cap having a special oilway for the VVT unit (see VVT section): on the exhaust camshaft this oilway is redundant. The bearing caps are made of aluminium.

The cams actuate the valves via direct acting mechanical bucket tappets made of lightweight aluminium with phosphate coated cast iron shims

mounted on top. The valve components are of lightweight design with 5.5mm valve stems.



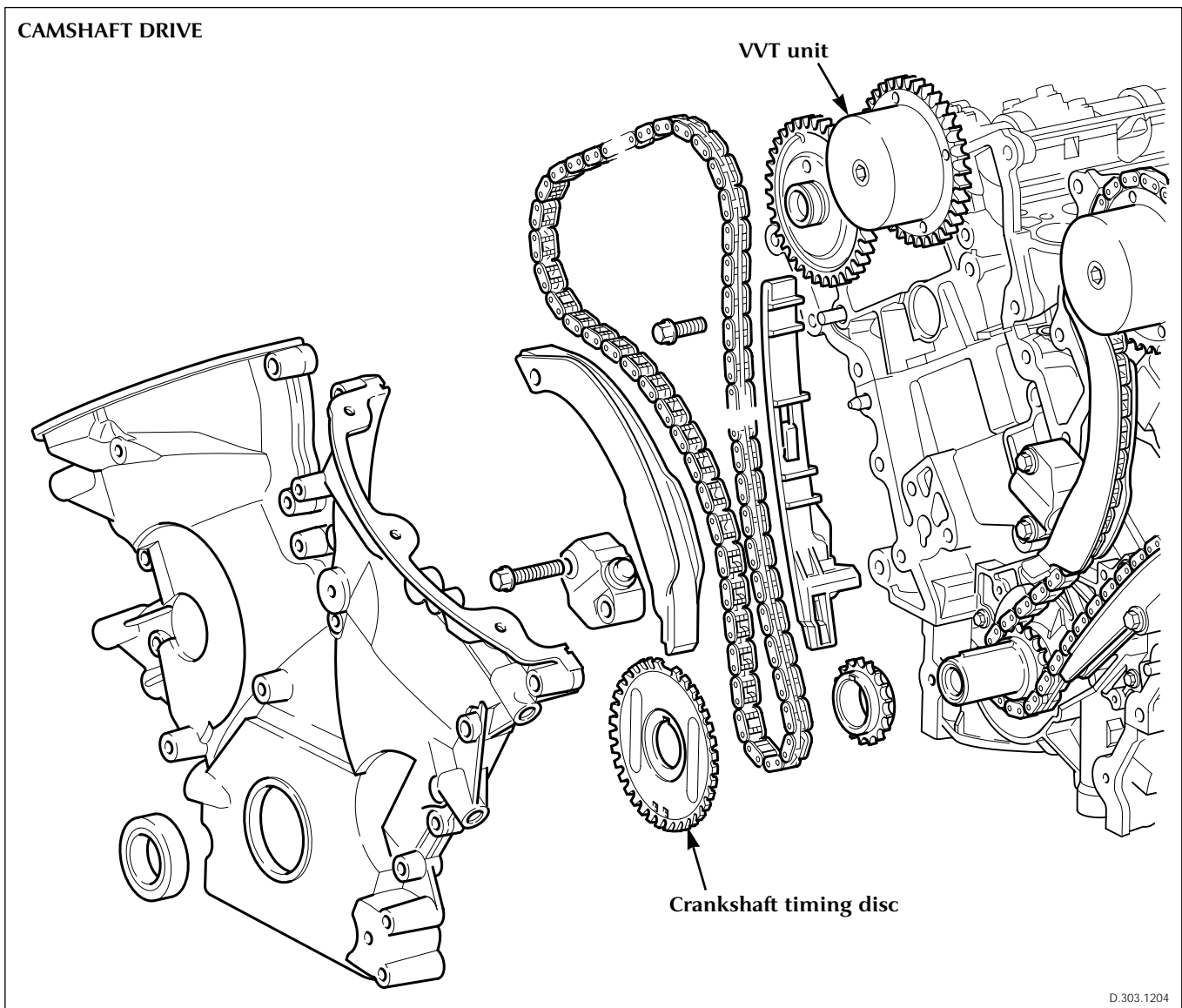
Camshaft Drive

Two timing chains are used, one for each cylinder bank and driven by separate sprockets keyed to the crankshaft. The chains are of the silent-type, with a multiple link construction and sprocket engagement on one side only.

Each chain has a hydraulic tensioner, fed from the engine oil supply, which acts on a pivoted tensioner arm with side flanges. Fixed guides bear on the drive side of the chains and are unique to each side.

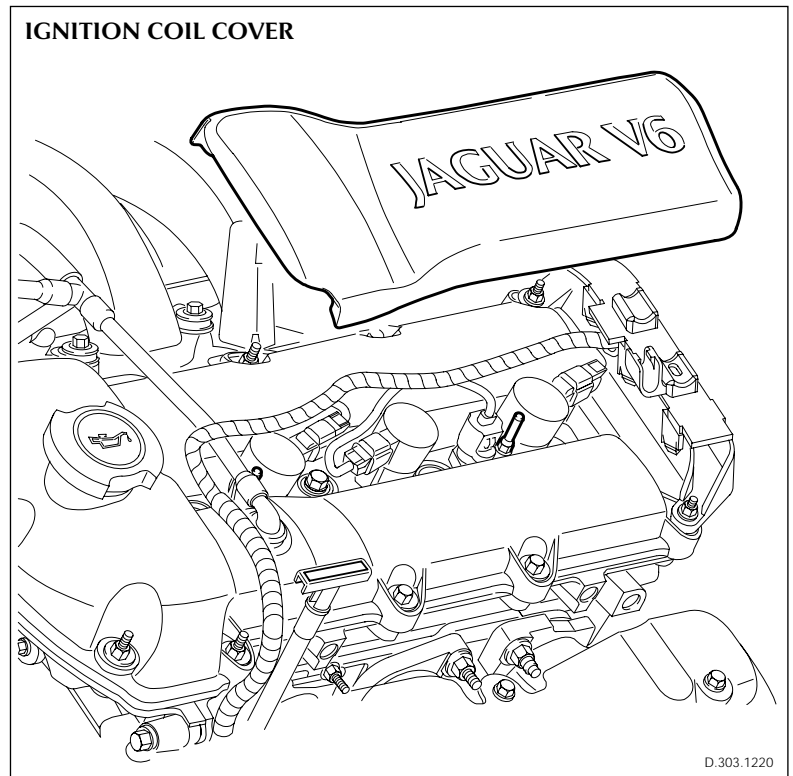
A single piece aluminium alloy front cover is aligned to the cylinder block by two dowels and

encloses the timing gear. The crankshaft front oil seal fits into the front cover and the inner lip bears on the crankshaft damper.

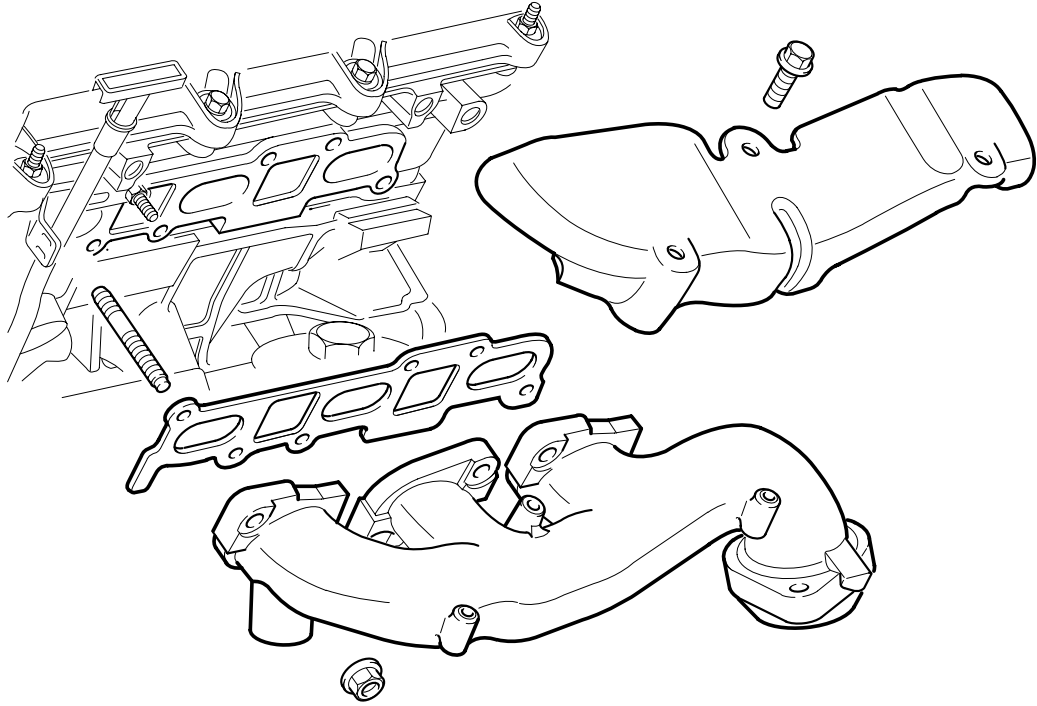


Ignition Coil Cover

A plastic ignition coil cover, embossed with 'JAGUAR V6', is fitted to engine bank 2 only. The cover is attached via two push fit studs on the camshaft cover.

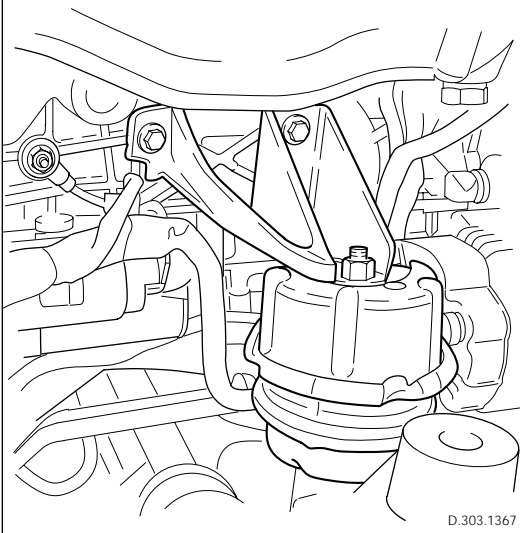


EXHAUST MANIFOLD AND HEATSHIELD



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ENGINE MOUNTING



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Exhaust Manifold

The exhaust manifolds are of cast iron with a threaded hole in the bank 1 manifold for the EGR pipe or blanking plug (if EGR not fitted). Each manifold is fitted with a heat shield constructed of a fibre compound sandwiched between an aluminium coated carbon steel shell.

Engine Mountings

The engine is supported at each side on hydramounts fitted between the aluminium alloy engine brackets and the No 2 front cross member. The hydramounts are similar to those on the XJ and XK Series and have an integral heat shield and anti-separation restraint.

Lubrication System

Oil Distribution

(see illustration on page 14)

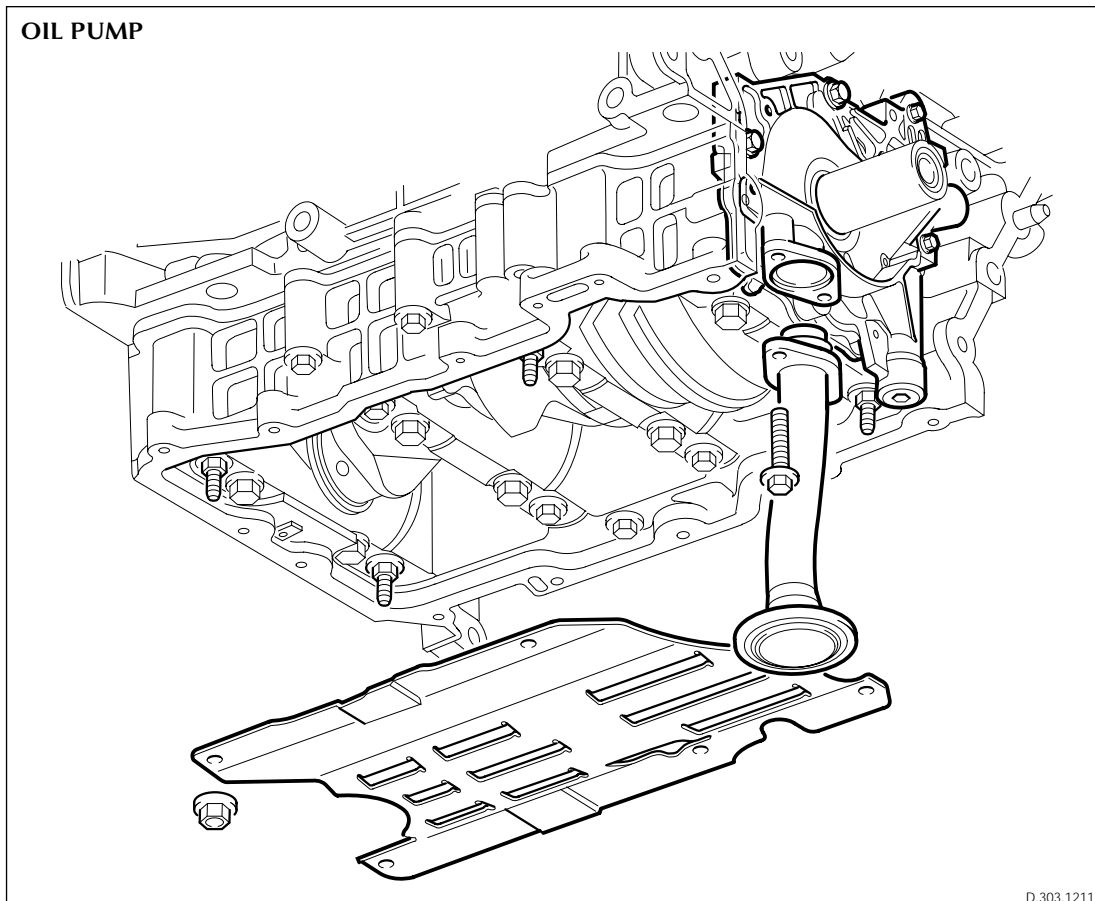
Oil distribution within the block and cylinder heads is similar to that of the V8 engine, the main differences being in the filter and cooler arrangement and the method of supplying the VVT system.

Oil is drawn from the sump through the strainer by the crankshaft driven pump, passes through the externally mounted filter and oil cooler and returns to the block. Distribution is via the main gallery and crankshaft oilways to the lower crankcase components and via branch feeds to the chain tensioners and then cylinder head components. Extra oilways in the cylinder heads provide a built-in feed for the VVT components (see VVT section).

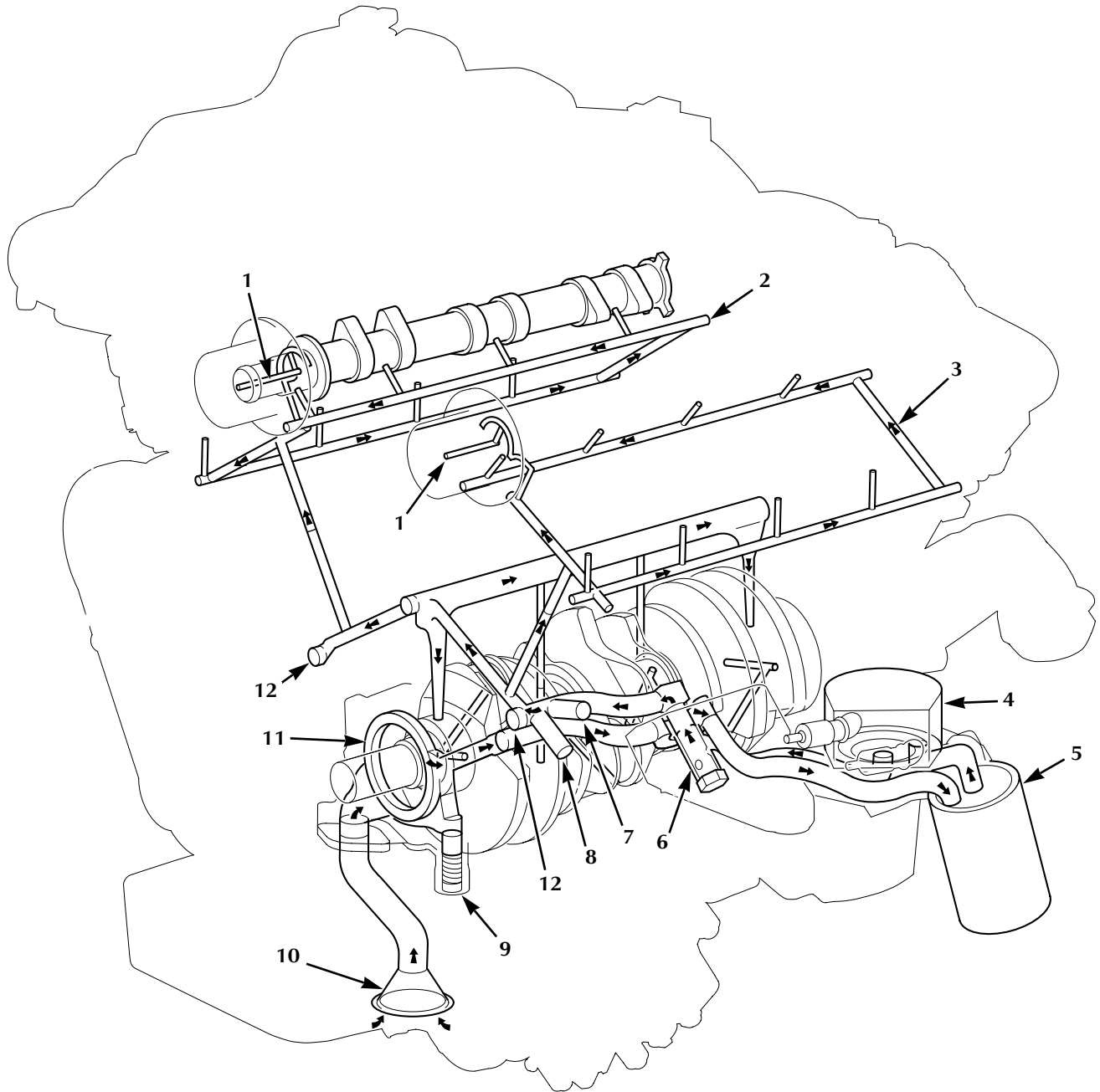
is located in the lower LH side of the pump. An oil pick-up tube and strainer is bolted to the pump inlet and projects directly down to the sump. Oil foaming is reduced by the windage tray bolted to the underside of the bedplate.

Oil Pump

The oil pump is of the inner/outer rotor type with the directly driven inner rotor located via flats on the crankshaft and the body of the pump bolted to the cylinder block. The oil pressure relief valve



ENGINE OIL SUPPLY



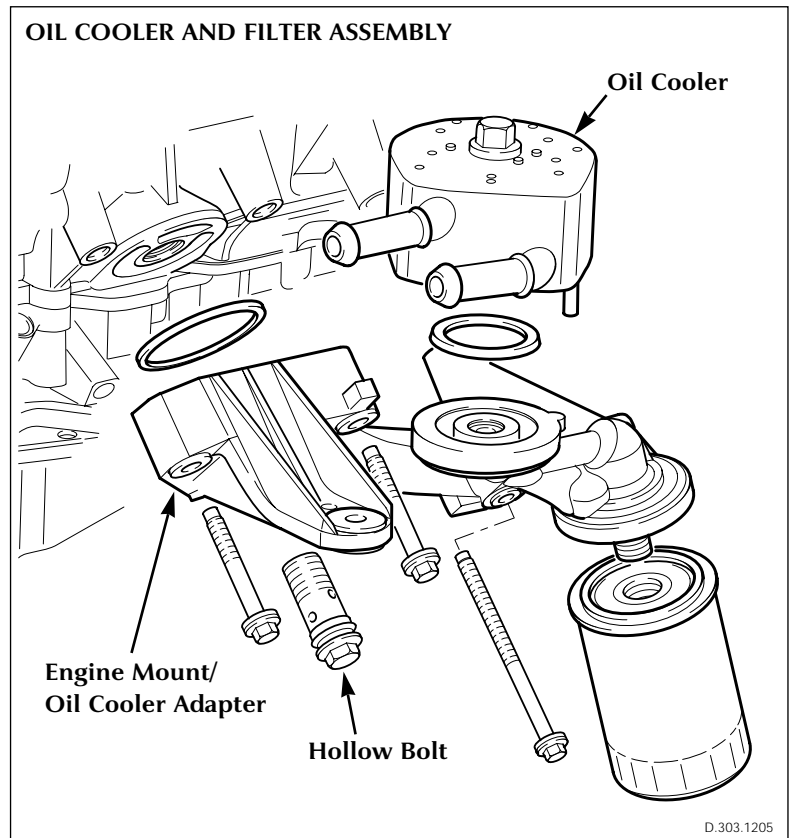
- | | |
|------------------------------|-------------------------------------|
| 1. VVT oil feed | 7. Oil pressure switch |
| 2. Bank 1 camshaft oil feeds | 8. EOT sensor |
| 3. Bank 2 camshaft oil feeds | 9. Oil pressure relief valve |
| 4. Oil cooler | 10. Oil strainer |
| 5. Oil filter | 11. Oil pump |
| 6. Oil filter adaptor | 12. Timing chain tensioner oil feed |

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Oil Cooler and Filter Mounting

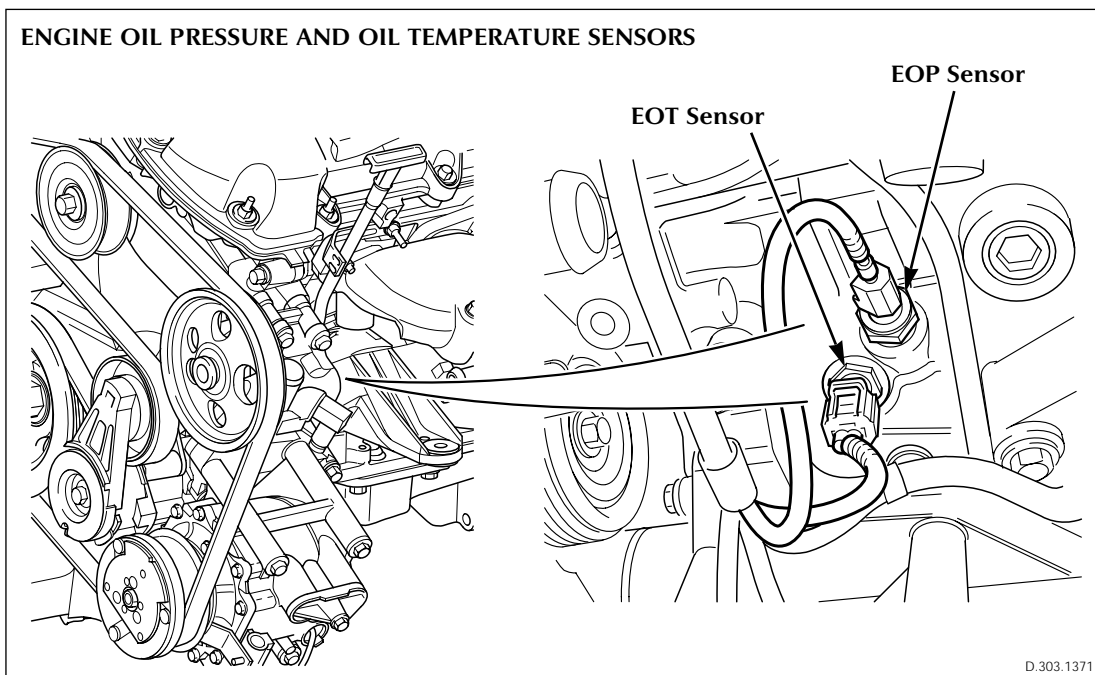
The oil filter and oil cooler are mounted slightly away from the cylinder block on an aluminium alloy adaptor which is an integral extension of the LH engine mount. The oil filter is a replaceable canister screw on type and the cooler is fixed by a single through bolt to the adaptor. Both components are connected to the cylinder block through internal oilways in the adaptor casting and via an interfacing filter mounting in the block. A hollow bolt passes through the adaptor/engine mount and screws into the centre channel of the block filter mounting to provide the oil return from the cooler to the cylinder block.

The adaptor mounted oil cooler is an oil to water heat exchanger and the coolant matrix is connected via hoses into the main coolant system at the radiator bottom hose (see Cooling System).



Engine Oil Pressure (EOP) and Oil Temperature (EOT) Sensors

EOP and EOT sensors are fitted on the LH side of the cylinder block in the return feed from the oil cooler. The oil temperature is monitored to provide data for the VVT system.



Crankcase Ventilation

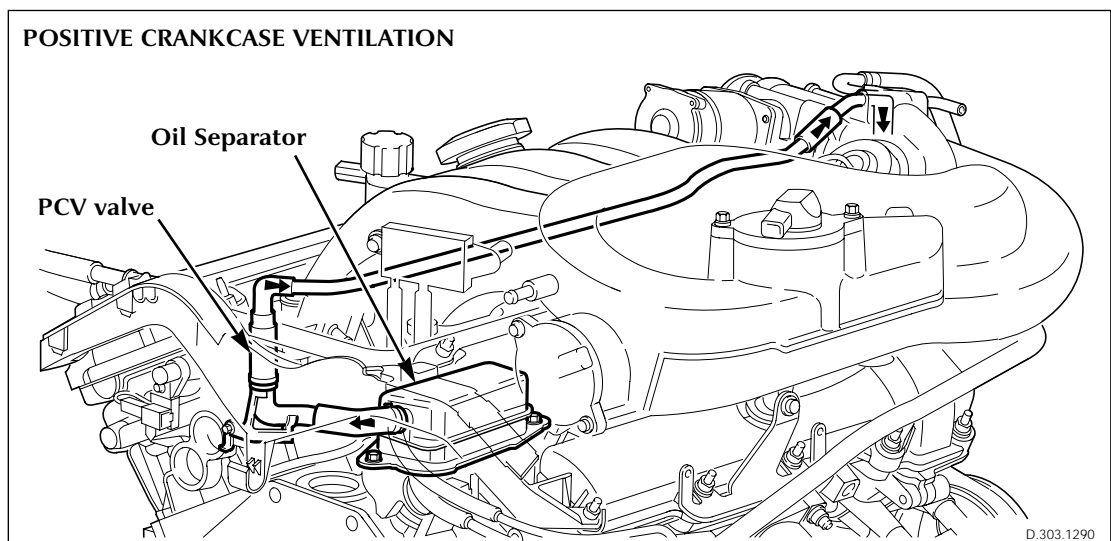
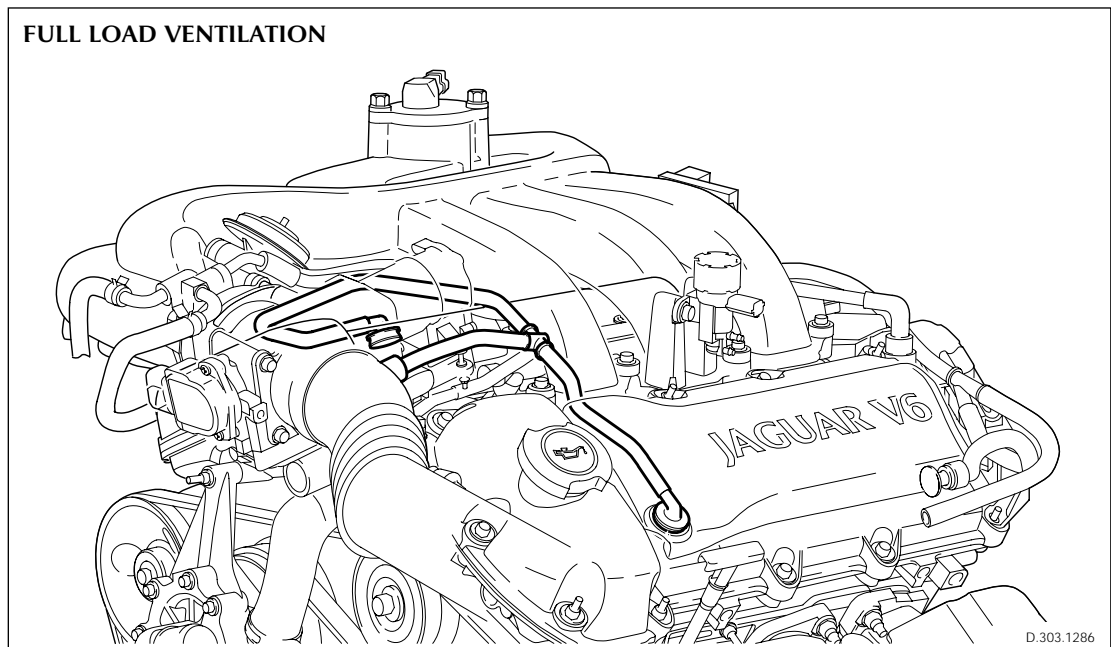
Full Load Ventilation

Breather outlets on each cam cover are connected via hoses and a Tee junction to the intake duct to provide full load crankcase ventilation.

Positive Crankcase Ventilation

Under closed or near closed throttle conditions, engine breathing is mainly via the positive crankcase ventilation (PCV) system. An oil separator is bolted to the top of the engine block between the cylinder banks and has an outlet connected to the intake manifold via an in-line PCV valve and hoses. The PCV valve has a spring

loaded plunger which opens under the intake vacuum created at low throttle openings. When the PCV valve is open, crankcase gases are drawn through the separator, depositing oil droplets on an internal baffle for return to the sump. The PCV inlet tube to the manifold is heated by the engine cooling system.



Exhaust Gas Re-circulation (EGR)

Operation

The EGR system is only fitted to vehicles in NAS markets and comprises the following components:

- EGR vacuum regulator valve
- EGR valve
- differential pressure feedback EGR sensor
- exhaust gas feedback pipe with internal orifice

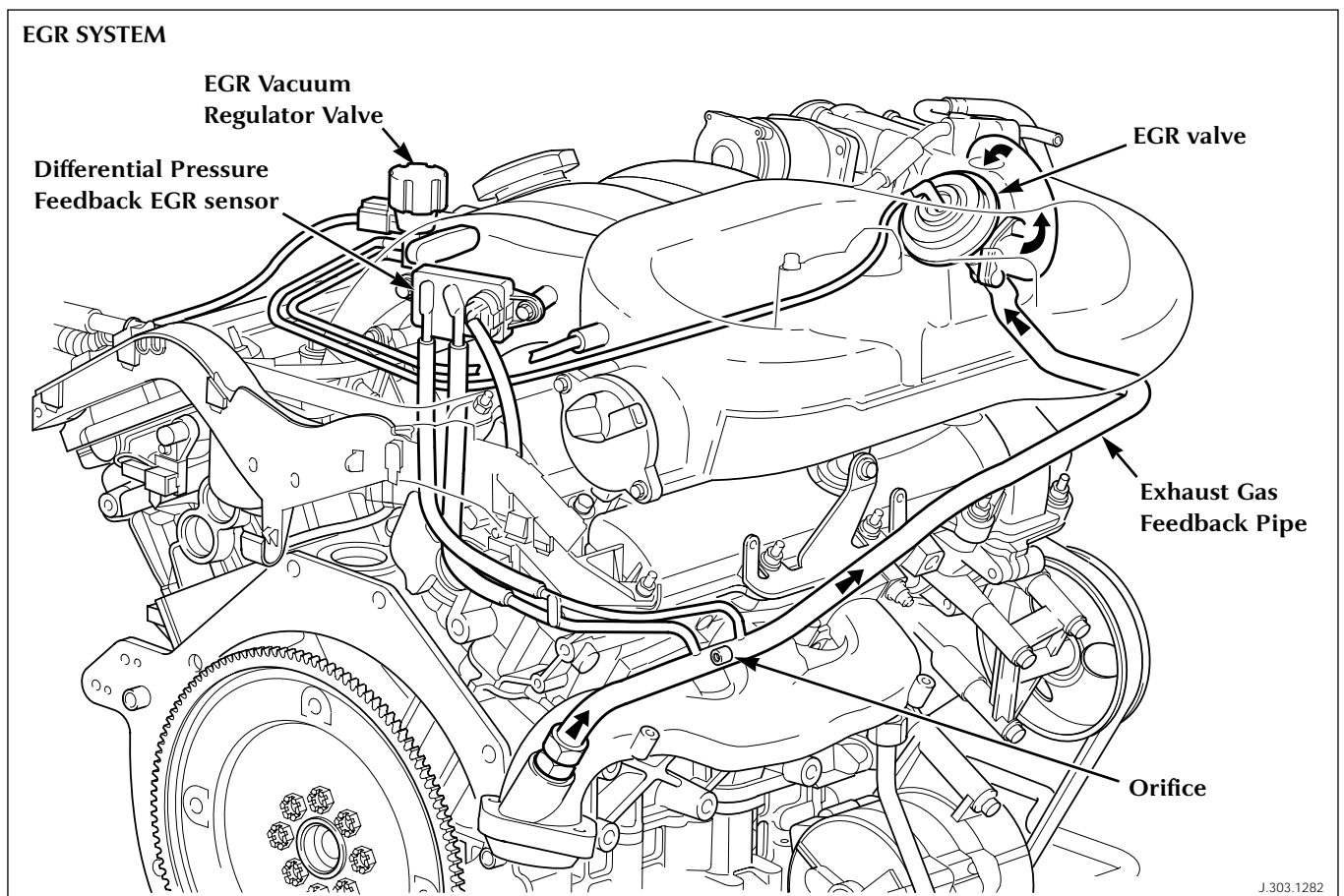
Exhaust gas is re-circulated back to the engine intake in proportion to a measured pressure differential in the feedback pipe. The amount of gas re-circulated varies primarily with engine speed and load but is also modified by the EMS to allow for other factors, eg coolant temperature, and also to achieve optimum emissions and fuel economy.

The re-circulated exhaust gas is taken from the A bank exhaust manifold and fed into the engine via the EGR valve. The feedback pipe contains an internal tube with a small diameter orifice that creates a pressure differential in the feedback pipe. Two small pipes, connected to the feedback

pipe each side of the orifice, transmit the pressure differential to the differential pressure feedback EGR sensor.

The sensor consists of a transducer (a vacuum operated variable capacitor) and a processing circuit which convert the input pressure/vacuum value to a corresponding analogue voltage which is sent to the PCM. The differential pressure feedback EGR sensor has a linear response and the variations in exhaust pressure produce outputs in the approximate range 1V- 3.5V dc.

The EGR vacuum regulator valve and the EGR valve comprise the actuating components of the control loop. The EGR vacuum regulator valve has a vacuum input from the manifold distribution pipes, a vacuum output to the EGR valve and receives a pulse width modulated (PWM) signal from the PCM. The PWM signal switches the vacuum control output to the EGR valve according to input demand from the differential pressure feedback EGR sensor or in response to override conditions determined by the engine management system. The EGR valve is a vacuum operated



J.303.1282

diaphragm valve with no electrical connections which opens the EGR feed pipe to the induction manifold under the EGR vacuum regulator control.

Where the EGR system is not fitted, a blanking plate seals the manifold in place of the EGR valve.

Control Conditions

EGR operates over most of the engine speed/load range but is disabled by the engine management system under certain conditions:

- during engine cranking
- until normal operating temperature is reached
- when the diagnostic system registers a failure which affects the EGR system (eg a faulty sensor)
- during idling to avoid unstable or erratic running
- during wide open throttle operation
- when traction control is operative.

While the main control loop is based on feedback from the differential pressure feedback EGR sensor, the EGR rate is also modified by other engine conditions; coolant, ambient and air charge temperatures, barometric pressure, VVT cam position and air charge mass. Note also that the EGR rate increases gradually after it is enabled on each drive cycle.

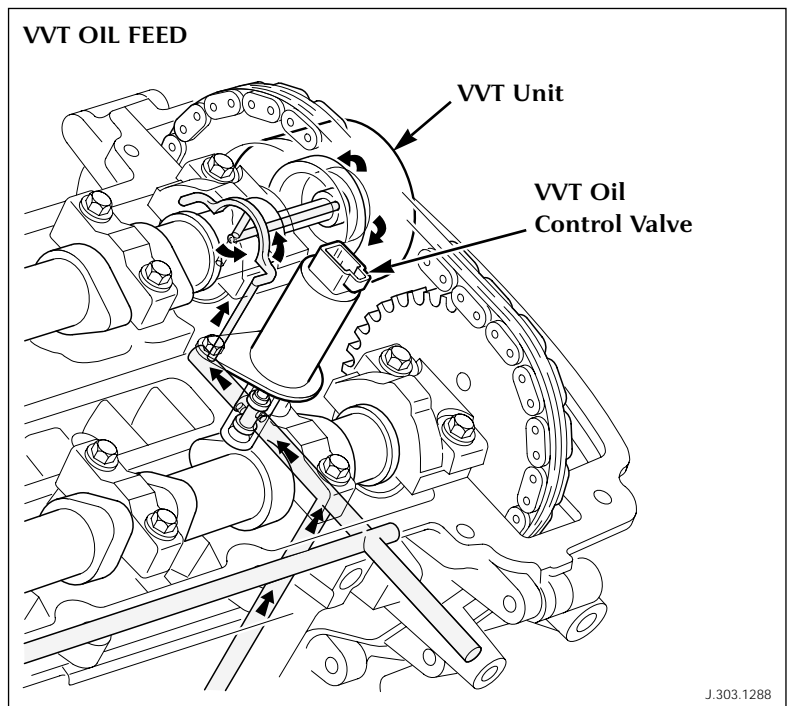
Variable Valve Timing (VVT)

A VVT system is used to allow the phasing of the inlet valve opening to be changed relative to the fixed timing of the exhaust valves. Two positions are used, 30° apart, with the advanced position occurring at 30° BTDC and overlapping with the exhaust opening. The system is similar to that previously used on the AJ26 V8 engine but uses different components and a different oil feed arrangement.

The operating regime is controlled by the engine management system in conjunction with the variable geometry induction system so as to optimise torque characteristics over the engine speed/load range. The engine torque curve with VVT operating points is shown in the section on the Variable Intake System. The VVT system also provides increased amounts of 'internal' EGR under certain speed/load operating conditions.

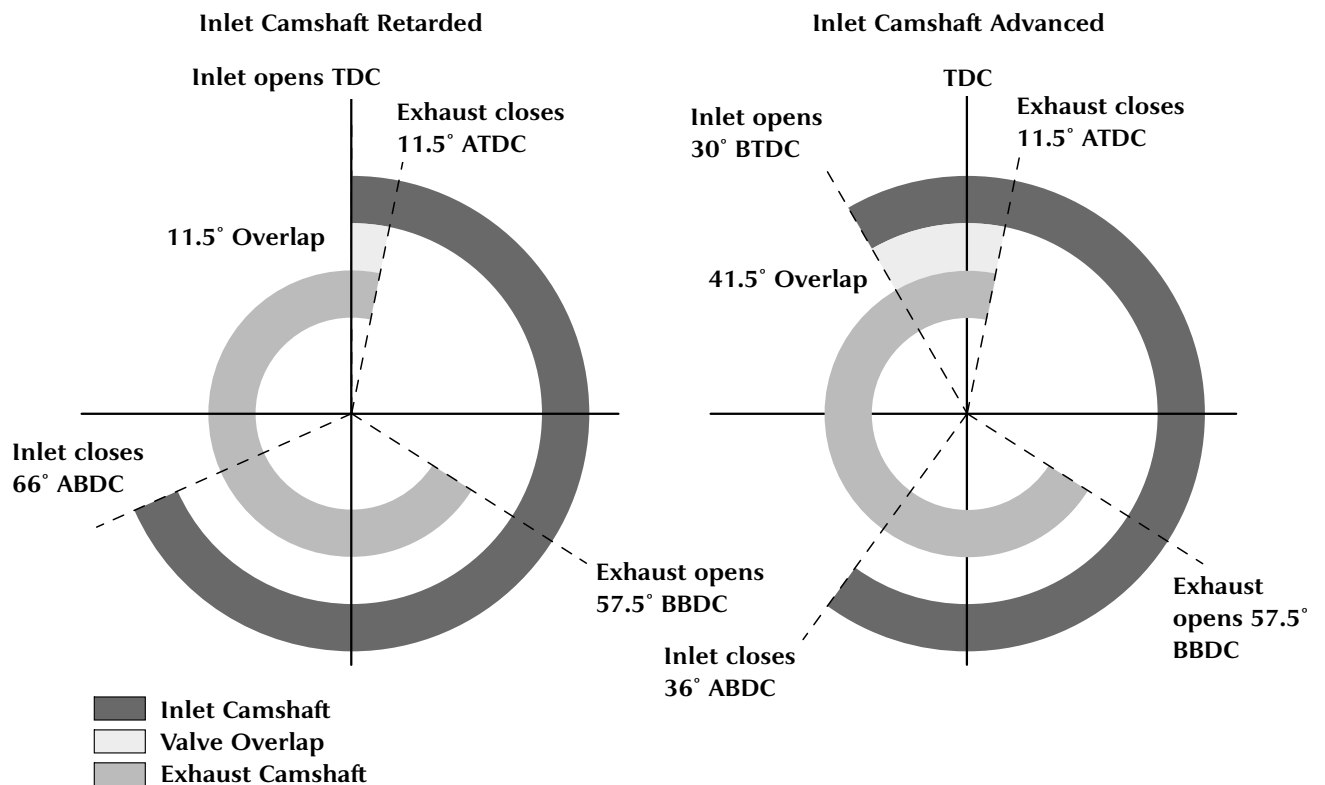
VVT Oil Feed

The VVT/sprocket unit is fixed on the nose of the inlet camshaft via a locating pin and hollow bolt and is driven directly by the timing chain. Unlike the VVT systems on the V8 engines, the oil feed



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VVT TIMING DIAGRAM



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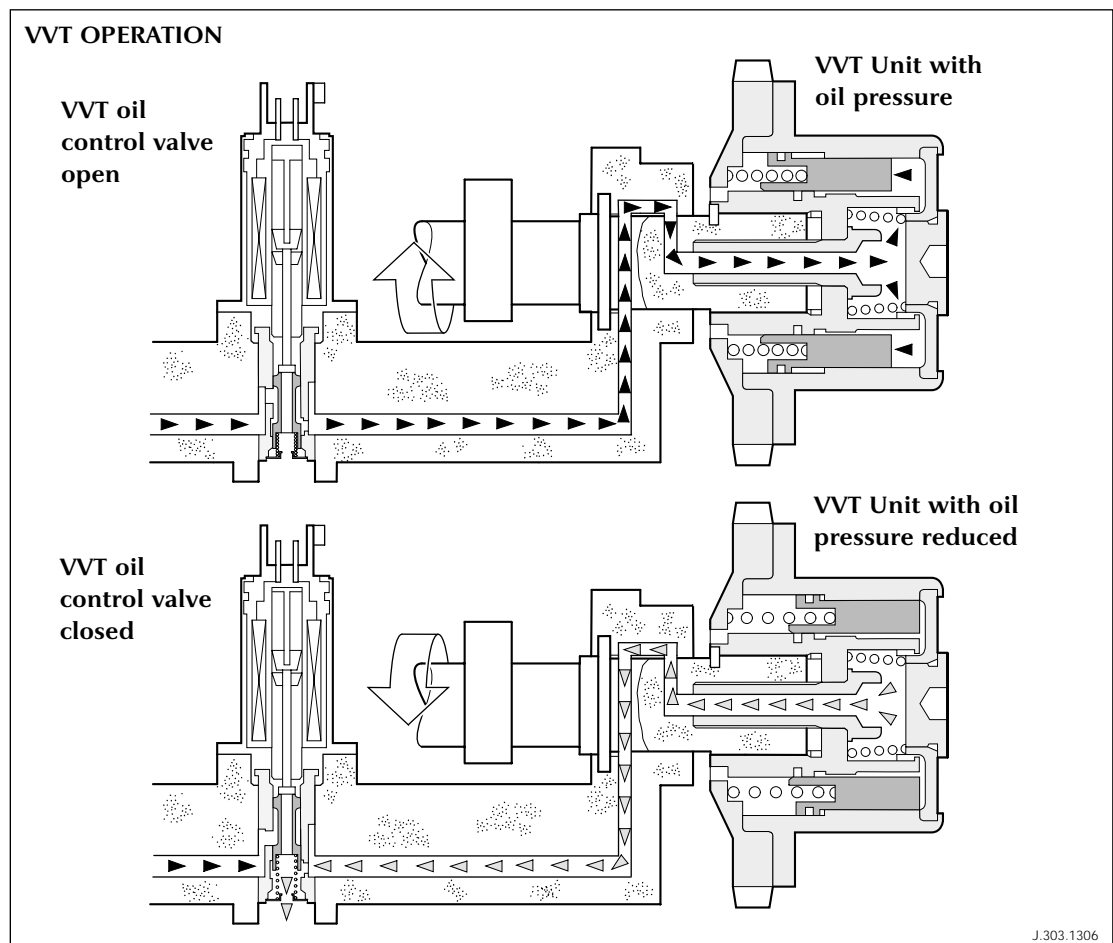
to each VVT unit is supplied via fixed oilways in the cylinder head and not through a separate bush carrier. This arrangement requires a feed through the camshaft side of the VVT unit from the main cylinder head supply. The oil feed is controlled by the VVT oil control valve, a solenoid operated shuttle valve, which is bolted directly to the cylinder head. From the oil control valve, the flow is via the thrust bearing cap, through drillings in the camshaft and then through the hollow fixing bolt which secures the VVT unit. Drain holes are provided at the rear (camside) face of the VVT unit for any residual oil which has seeped past the piston.

fully retarded position.

The oil control valve is controlled by a 300Hz PWM signal from the PCM which sets it to either the fully open or fully closed position.

Operation

Operation is similar to that of the two stage V8 VVT system. With the oil control valve open, oil pressure on the helical drive piston is increased, rotating the cams to the advanced position. When the valve closes, oil pressure reduces and the return spring pushes the piston back to the



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Air Induction System

Air Intake

The air induction system consists of the intake ducting and air cleaner, the throttle body, tuned manifold assembly and lower manifold (see Fuel System).

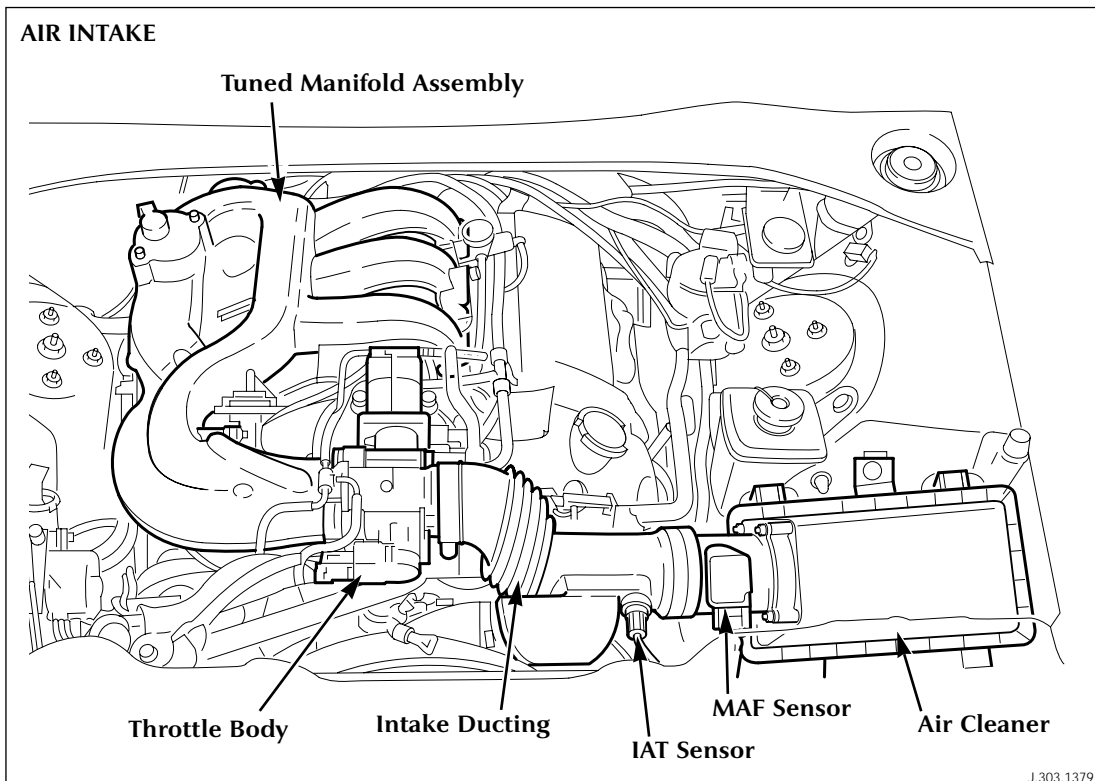
The air cleaner connects to the throttle body via a lateral mounted intake pipe with resonator box. A separate duct, housing the MAF sensor, fits between the air cleaner and resonator pipe. The IAT sensor is located in the intake resonator pipe.

range, the manifold geometry can be set to three different configurations, each of which maximises the tuning effect over different parts of the range. This variable geometry is achieved by the use of two gate valves, the intake manifold tuning (IMT) valves, which are controlled by the engine management system.

Variable Intake System

(see illustration on page 23)

The induction manifold is specially designed to optimise torque across the engine speed/load range. The air charge enters the induction manifold from the throttle body and passes through a plenum chamber for distribution to the cylinders via the manifold runners. The function of the plenum chamber is to provide a resonance (or maximising) effect such that large pulses of charge air are produced which will arrive at the inlet ports at the correct time for induction into the cylinders. This ram charging action is only effective over a restricted speed/load range for a particular plenum chamber volume and geometry. To extend the effect over the whole engine speed



Construction

The induction manifold is a single piece aluminium alloy casting which mounts to the cylinder head induction ports via the lower manifold assembly. The plenum chamber is split into upper and lower compartments with two connecting holes and each compartment is fitted with an IMT valve.

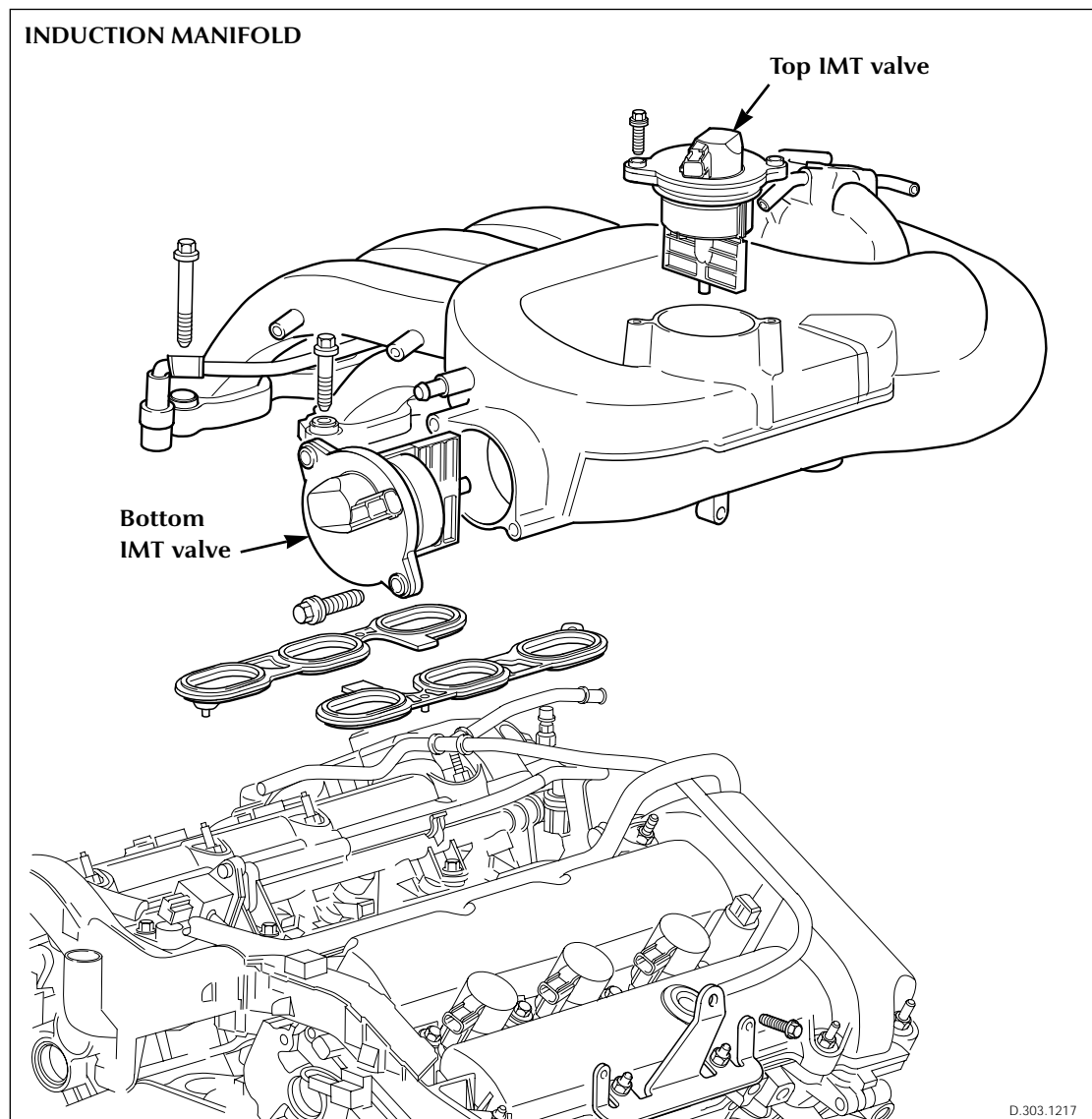
The IMT valves are identical, solenoid operated, with a gate or paddle which rotates through 90° between open and closed positions. The valves can only be set to either of these two positions.

IMT Valve Operation

(see illustration on page 23)

The two IMT valves are set to one of the following combinations:

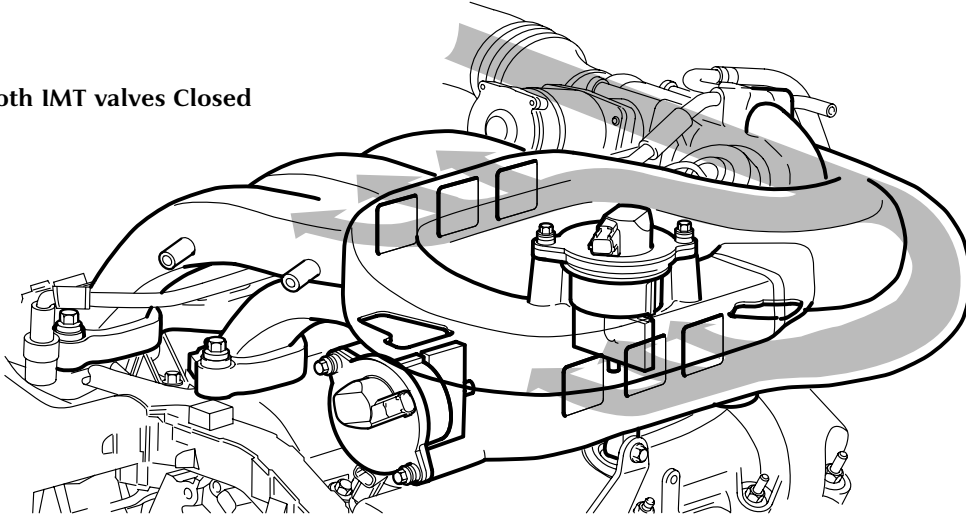
- With both valves closed, there is no communication between the upper and lower plenum chambers and the ram charge effect is not present
- With the top valve open and the bottom valve closed, the upper and lower plenum chambers are linked via the front connecting hole allowing pressure waves to be communicated and creating the ram charge effect.
- With both valves open, a second link is opened between the upper and lower



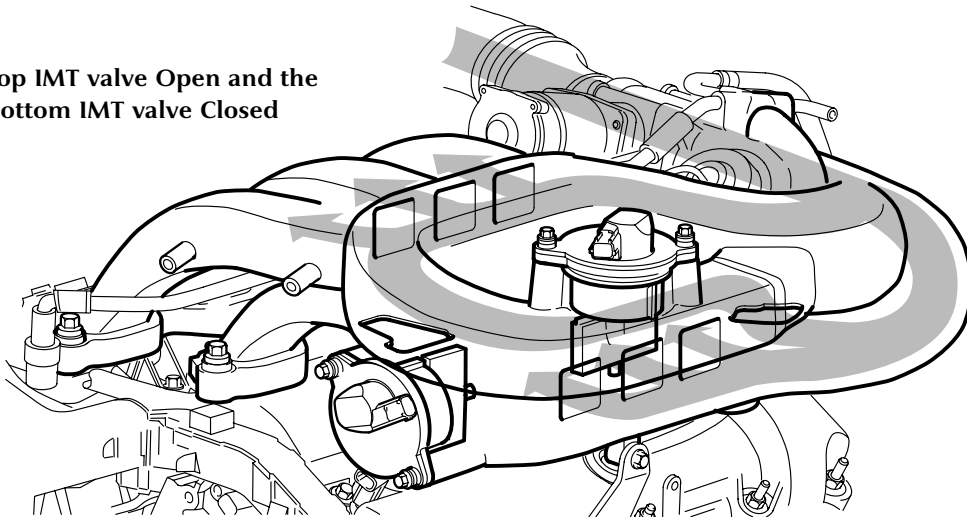
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VARIABLE INTAKE SYSTEM

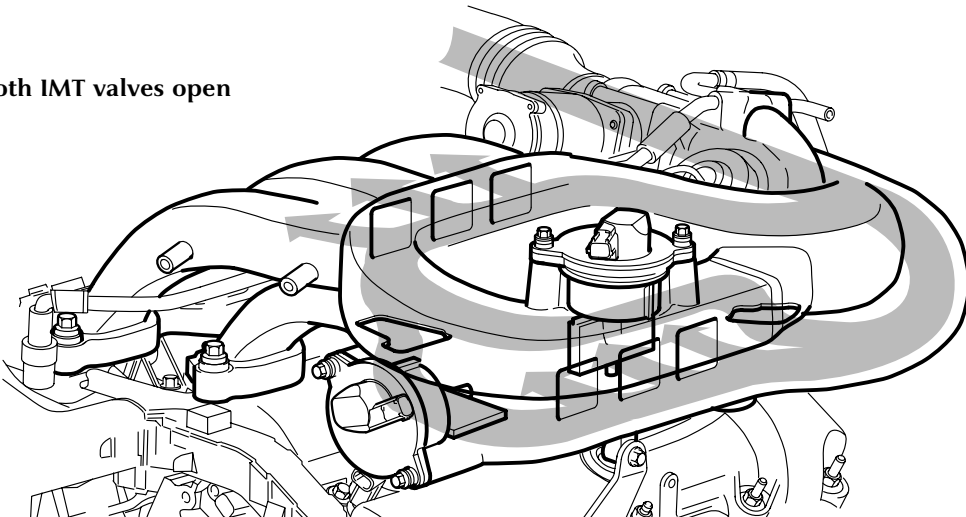
Both IMT valves Closed



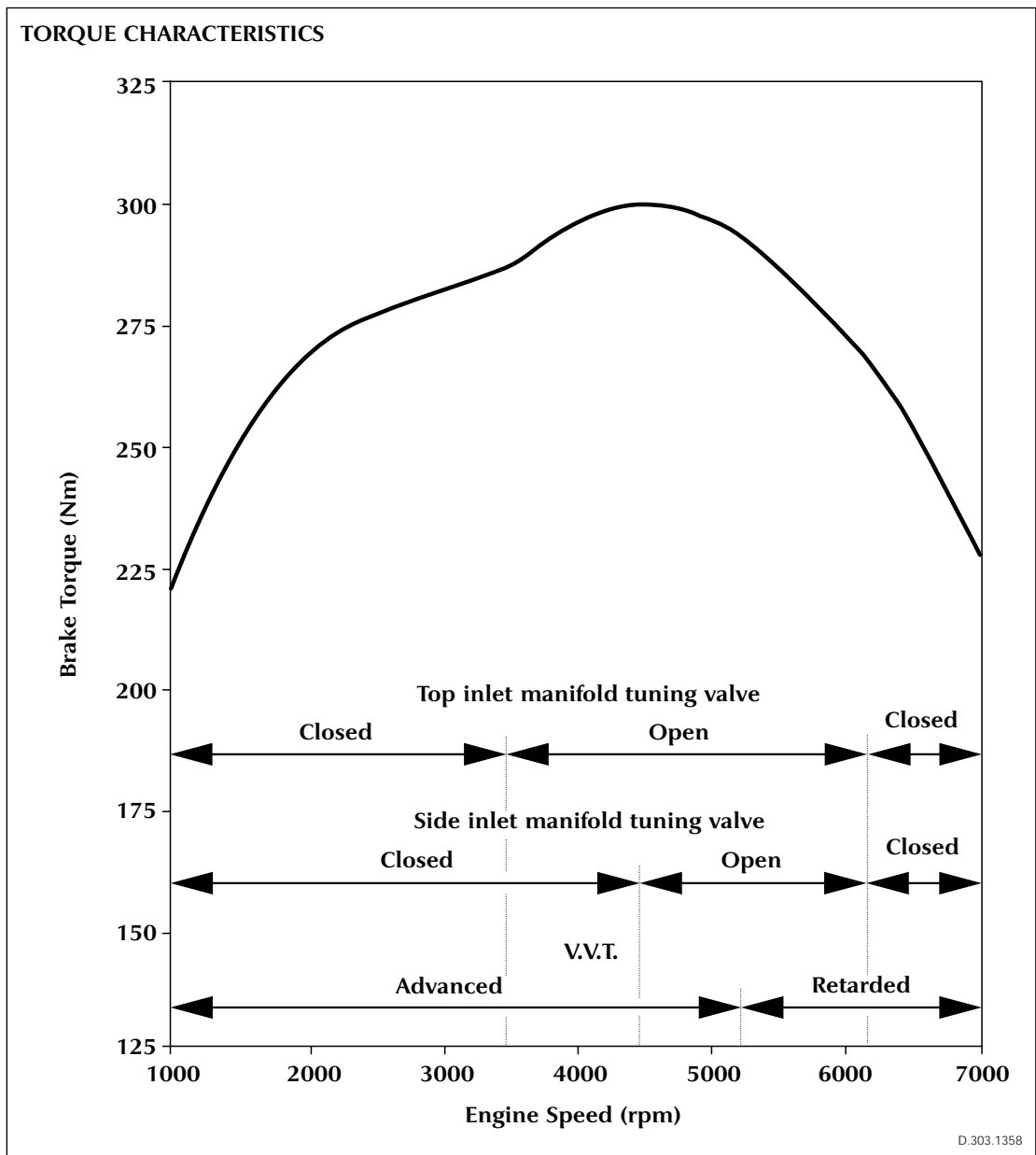
Top IMT valve Open and the Bottom IMT valve Closed



Both IMT valves open



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chambers via the rear connecting hole, further increasing the ram effect via the rear connecting hole.

System Performance

The valve open/close combinations across the engine speed range have been selected in conjunction with the VVT system to provide an optimised torque curve. Referring to the graph, it can be seen that there are five states that the IMT valves and VVT can adopt throughout the engine speed range.

Throttle Control System

Introduction

A fully electronically controlled throttle is fitted, requiring no mechanical connection between the accelerator pedal and throttle body. The driver operates a normal foot pedal and a transducer on the pedal shaft converts the mechanical rotation to electrical signals which are sent to the powertrain control module (PCM) to indicate driver demand. Signals requesting the desired throttle plate angle are sent from the PCM to an electronic module on the throttle assembly, the throttle actuator control (TAC) module, which provides closed loop control of the motorised throttle plate. The actual angle of the throttle plate is indicated to the PCM by the throttle position (TP) sensor.

The throttle assembly is mechanically simpler than those used on previous Jaguar vehicles, consisting essentially of a motor driven throttle plate with no other actuators or vacuum devices (eg cruise control).

Operation is designed to be transparent to the driver with a total delay of less than 70ms between pedal actuation and throttle movement.

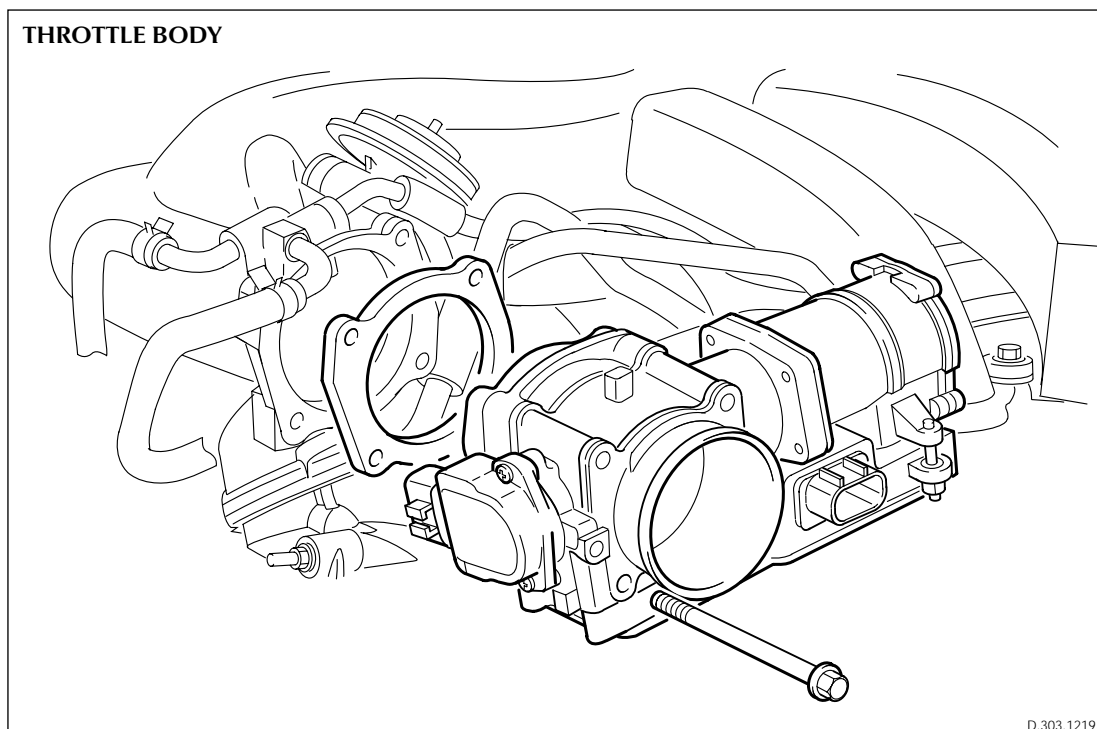
Control Components

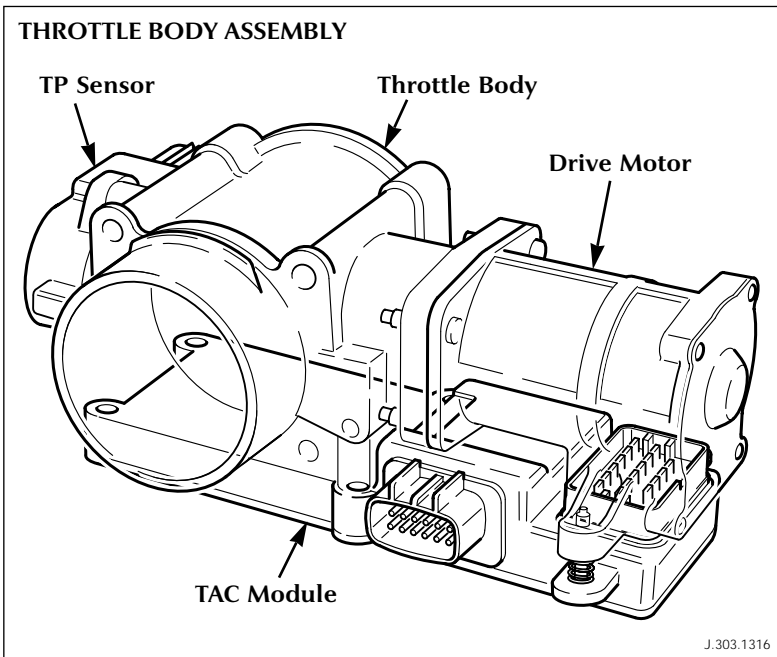
Throttle Assembly

The electronic throttle assembly consists of four component sub-assemblies:

- throttle body
- drive motor unit
- throttle actuator control (TAC) module
- throttle position (TP) sensor

The throttle body is an aluminium casting with a 70mm air intake bore, housing a shaft with brass throttle plate, rotating in ball bearings, and with a spur gear and return spring fitted to the drive end. A stop screw against the spur gear is pre-adjusted and sealed on assembly to set the throttle mechanical closed position and a second stop prevents the throttle plate from being driven beyond the full throttle position. The internal tooth spur gear is driven directly from the motor shaft which is offset to the throttle shaft. The motor drive unit is an integral assembly containing the motor, an inductive position encoder and the mating connector to the TAC module. Should the motor fail, the return spring will move the throttle plate to the closed position. The TAC module consists of a printed circuit board enclosed within an aluminium module with

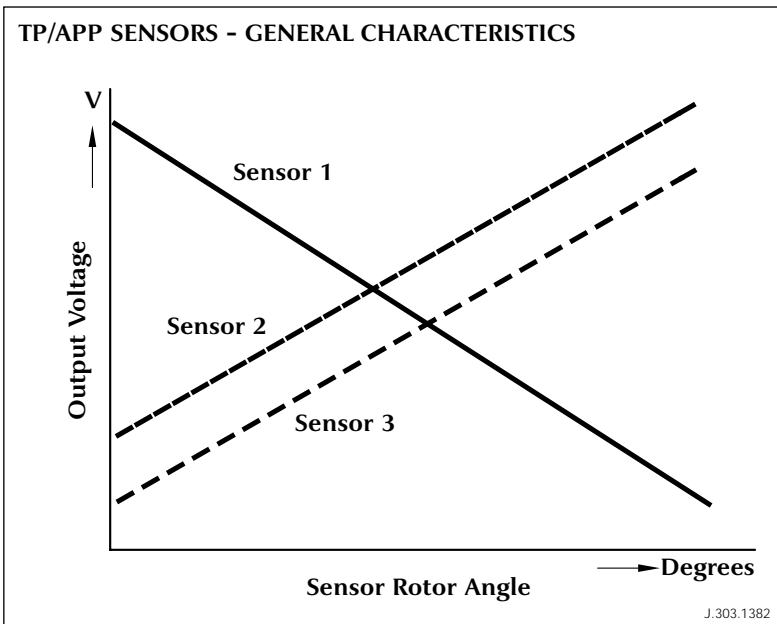




two fixed external connectors. The TAC module is mounted on the underside of the throttle body and drive motor unit with its upper connector plugged directly into a fixed recessed connector on the drive motor. The front connector provides the main control interface with the PCM. Note that the motor unit and the TAC module are electronically calibrated together on initial manufacture (the TAC module 'learns' the motor characteristics) and must not be individually replaced. The throttle assembly as a whole is not a serviceable item except for the TP sensor. Two stub pipes at the rear of the throttle body are connected via hoses into the engine cooling system to provide throttle de-icing.

Throttle Position (TP) Sensor

The TP sensor is bolted to the non drive end of the throttle body and is rotated directly (1:1) by the blade ended throttle shaft. It has three non-contacting, Hall effect, sensing elements which are supplied from the PCM by two separate 5V reference and signal return lines. Each sensor provides an independent analogue output to the PCM. For additional security, each sensor element has a unique rotational angle to output voltage characteristic (see Figure); the three outputs are compared by the PCM for the expected values for a particular throttle angle. This arrangement identifies a sensor or wiring fault including a short circuit between outputs.



Accelerator Pedal Position (APP)

Sensor

The APP sensor is driven directly by the pedal pivot shaft and is connected via the wiring harness to the powertrain control module (PCM). The sensor is a single assembly comprising three rotary, carbon track potentiometers with contacting wipers. Each potentiometer has a discrete 5V reference/return supplied from the PCM and provides an independent analogue output voltage to the PCM. As described for the TP sensor, the characteristics of the three potentiometers (angle/output voltage) differ so as to provide unique identification to the PCM. Note that while the TP and APP sensor characteristics, as shown, have a general similarity, actual values of voltage, slope and angular range for each type of sensor is different.

Further system redundancy is provided by the use of two pedal return springs.

Control and Operation

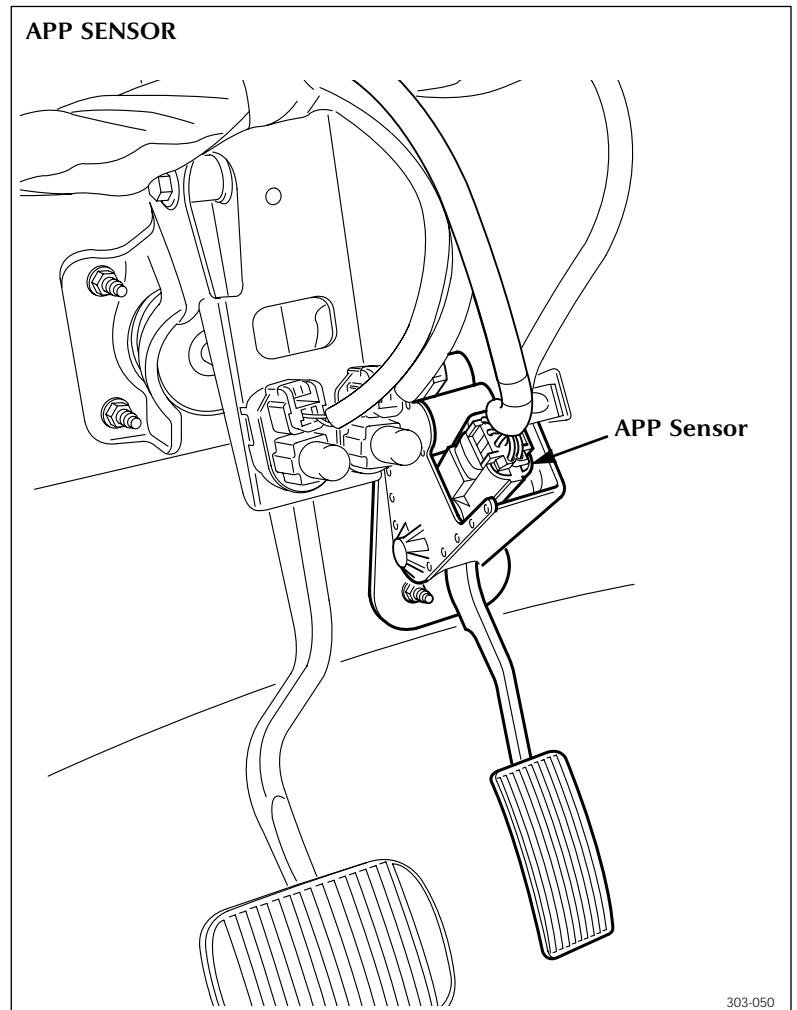
Drive Motor Control

The PCM does not drive the throttle motor directly but sends duplicated control signals to the TAC module indicating the desired throttle plate angle. Both signals are pulse width modulated (PWM) at 256Hz with an increase in duty cycle indicating a corresponding (linear) increase in desired throttle angle (ie towards full throttle). Separate interface circuits within the PCM and TAC module provide additional signal redundancy. In response to PCM demand, the TAC module processes the demand signals and generates the current drive to the dual winding motor. An inductive position encoder on the motor shaft generates feedback signals to the TAC module, providing closed loop motor control and enabling the TAC module to maintain the desired angle. Actual throttle plate angle is measured by the TP sensor.

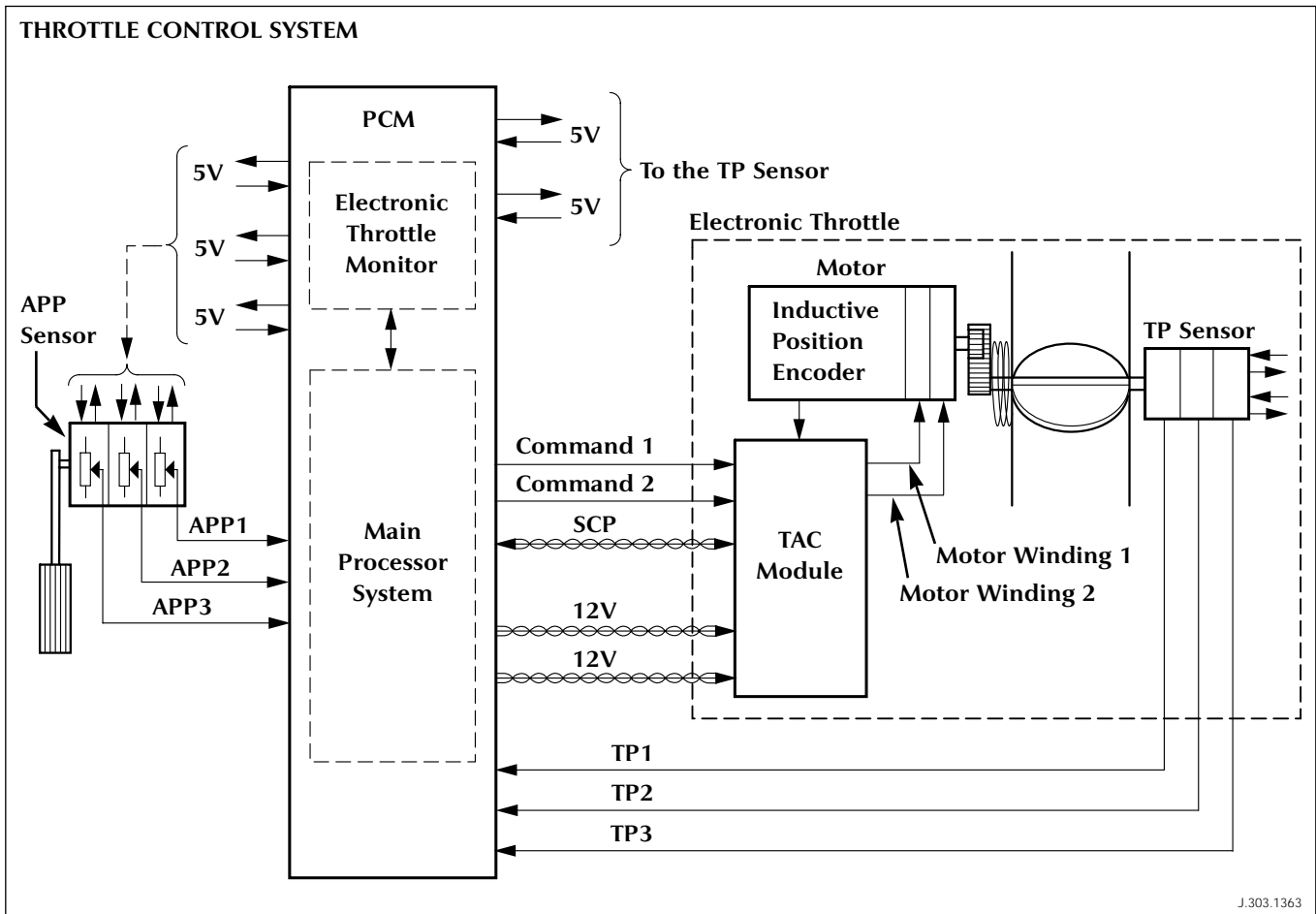
The TAC module has two separate feeds from the vehicle 12V and ground supply, each feed (12V and ground) being a twisted pair to reduce noise pick up.

The TAC module also performs self diagnostic checks:

- the two PWM control signals are compared for validity
- the ability of the TAC module to set the requested throttle angle is monitored



- operation of the motor drive circuit is checked
 - a failed throttle return spring can be detected
 - failure of one or both motor windings can be detected
 - the output of the inductive position encoder is checked for out of range signals or failure
- Diagnostic information from the TAC module is communicated to the PCM over the twisted pair SCP link.



System Monitoring

Within the PCM, operation of the overall throttle control system (main processor logic and software) is itself monitored by a separate, independent microprocessor, the electronic throttle monitor. Communication is maintained between the two processors but if it is lost or if faults are detected by the monitor (eg throttle angle greater than demanded), the monitor processor may call for a restricted operating mode such as cruise cancellation or a forced idle condition or engine shutdown.

- Limp home mode in which a high idle speed is set, with no accelerator pedal response, to allow the vehicle to creep: the RED warning light and FAIL SAFE ENGINE MODE message are activated: this mode is set by, eg the loss of two or more sensors.
- Engine shutdown due to serious throttle malfunction.

Failure Modes

There are four failure modes:

- Loss of redundancy eg a failure of one sensor output: this type of fault causes the AMBER warning light to illuminate and FAIL SAFE ENGINE MODE to be displayed on the message centre (the engine remains fully functional).
- Cruise inhibit.

Fuel System

Returnless Fuel System

The returnless fuel system is a one way system which delivers fuel to the engine without the requirement for fuel to be returned to the tank. When a return line is used, the effects of fuel pressurisation, de-pressurisation and engine heat on the returning fuel causes extra vapour to be generated in the tank. With increasing regulatory controls on evaporative emissions, this is an undesirable condition and elimination of a fuel return line provides significant benefits.

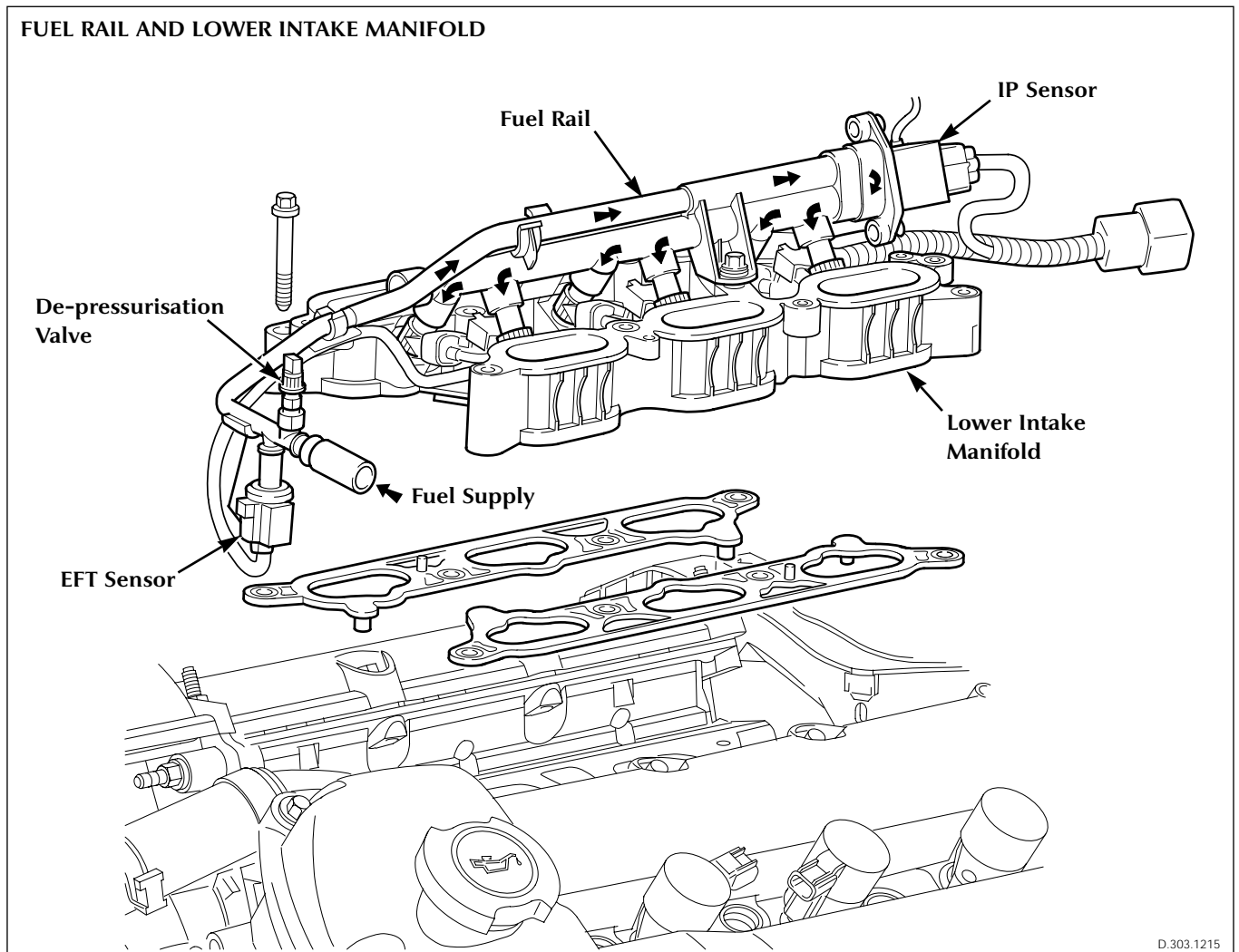
The in-tank fuel pump supplies fuel and regulates pressure to the injectors under control of the PCM and the rear electronic module (REM) and a pressure regulator is not therefore required on the engine fuel rail. To provide feedback for closed loop control, an injector pressure (IP) sensor on the fuel rail detects the pressure differential

between the fuel and the intake manifold and the engine fuel temperature (EFT) sensor monitors fuel temperature. Analogue signals from both sensors are sent to the PCM to indicate the pressure of the fuel and to detect whether it has reached the vapourisation point. In response to the sensor inputs and driver or load demands, the PCM requests the pump system to vary the fuel flow; in particular, fuel pressure will always be increased to avoid vapour formation and to maintain flow through the injectors.

Fuel pump control is further described in the 'S-TYPE Introduction' Technical Guide.

Fuel Rail and Lower Intake Manifold

The fuel injectors are seated in two lower intake manifolds, made of a lightweight plastic composite material, which are fitted between the



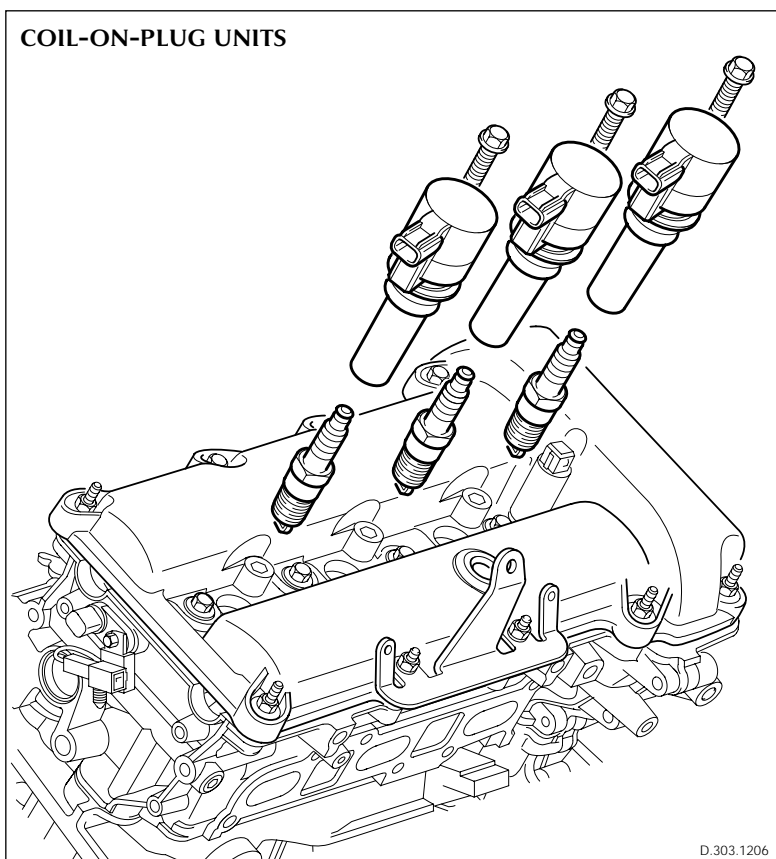
cylinder heads and the upper intake manifold assembly.

The injectors are of the top fed, split spray type and are supplied from a common fuel rail assembly which bolts to the lower manifold. The integral fuel rail consists of an upper delivery pipe and a lower pipe with six takeoff feeds for the injectors. The IP sensor is bolted to a flange at the junction of the two pipes and has an electrical connection to the fuel rail harness and a vacuum feed from the intake manifold. A steel cross-over pipe provides the coupling to the vehicle mounted fuel line and also carries the EFT sensor, on a bracket, and the de-pressurisation valve. The cross-over pipe is connected to the fuel rail via a semi-rigid length of pipe.

All fuel injectors and sensors use a common electrical harness with a single multi-way connection to the main engine harness.

Ignition System

Six coil-on-plug ignition units fit directly on to the spark plugs. The ignition units are driven by the PCM and do not contain integral amplifiers.



Engine Cooling

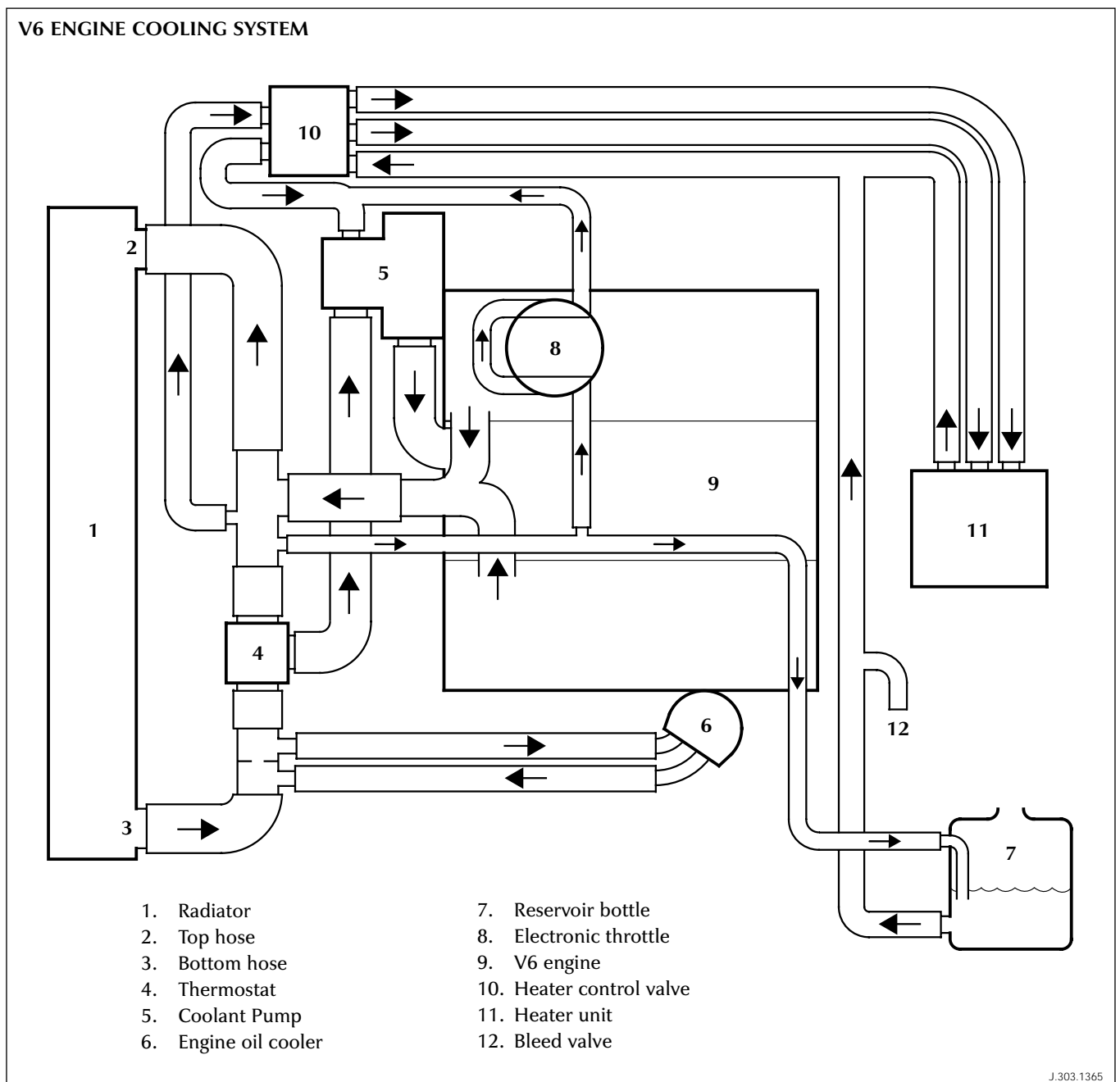
Cooling System

Engine cooling is via a conventional re-circulation system between the engine assembly and front mounted coolant to air radiator. Coolant flow is from the front of the engine, dividing to pass around each bank of cylinders towards the rear and then flowing forward through the cylinder heads. The coolant from the engine returns to the top RH side of the radiator, by-pass circuit and also provides the hot input feed to the cabin

heater system. The bottom hose feeds coolant from the radiator via the thermostat to the coolant pump and also provides the cooling circuit for the oil. A differential pressure orifice in the bottom hose causes a flow through the engine mounted oil cooler.

A coolant reservoir system (or de-gas system) is used which is similar to previous (pre 1998MY) vehicles.

The reservoir bottle is mounted at the rear left



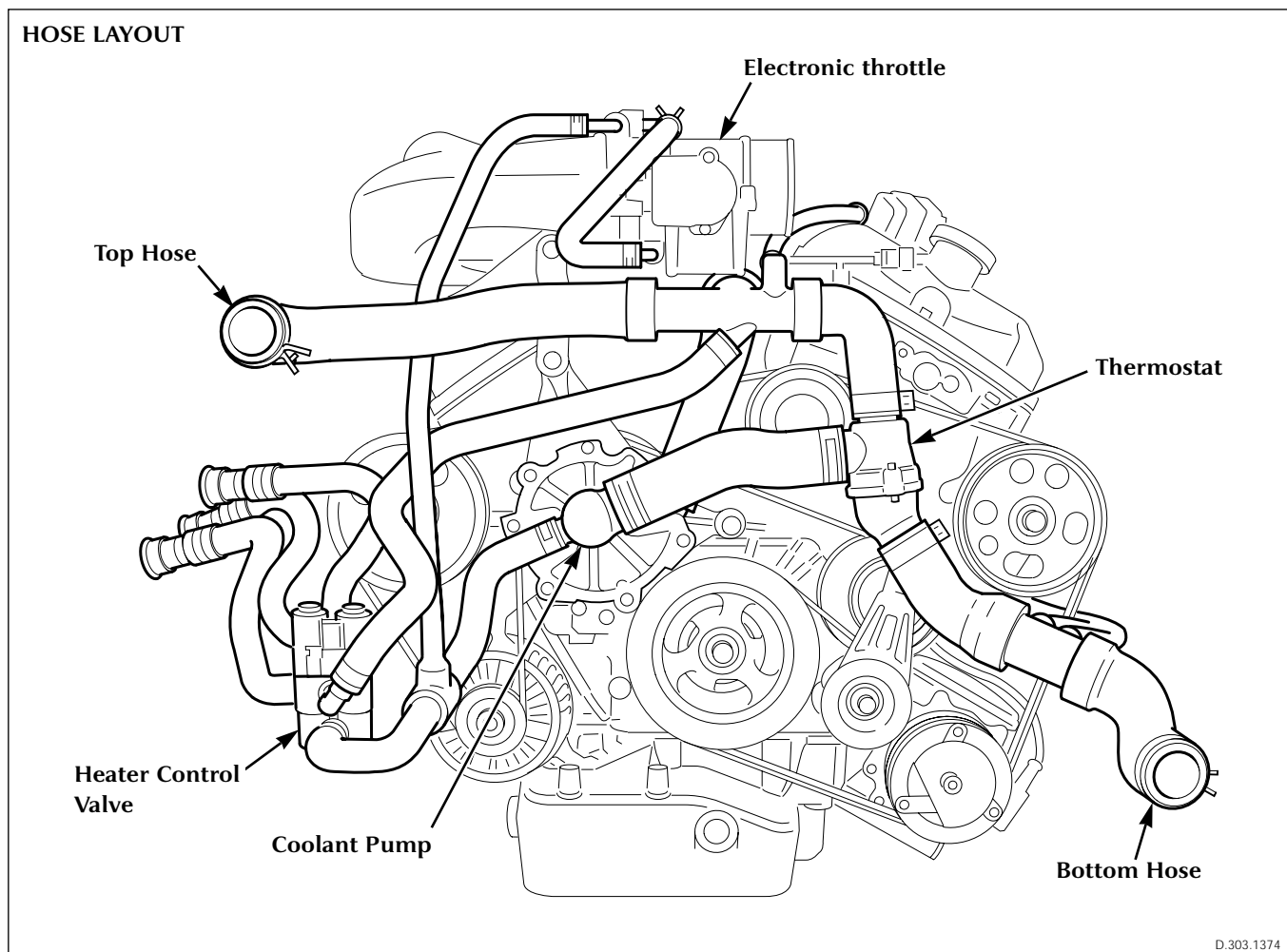
(LHD vehicles) or rear right (RHD) of the engine bay and in the LHD location has a bleed valve on the return pipe running across the bulkhead. The pipe layout is shown in the 'S-TYPE Introduction' Technical Guide. A dip tube within the bottle ensures that coolant is drawn back into the engine when it cools down.

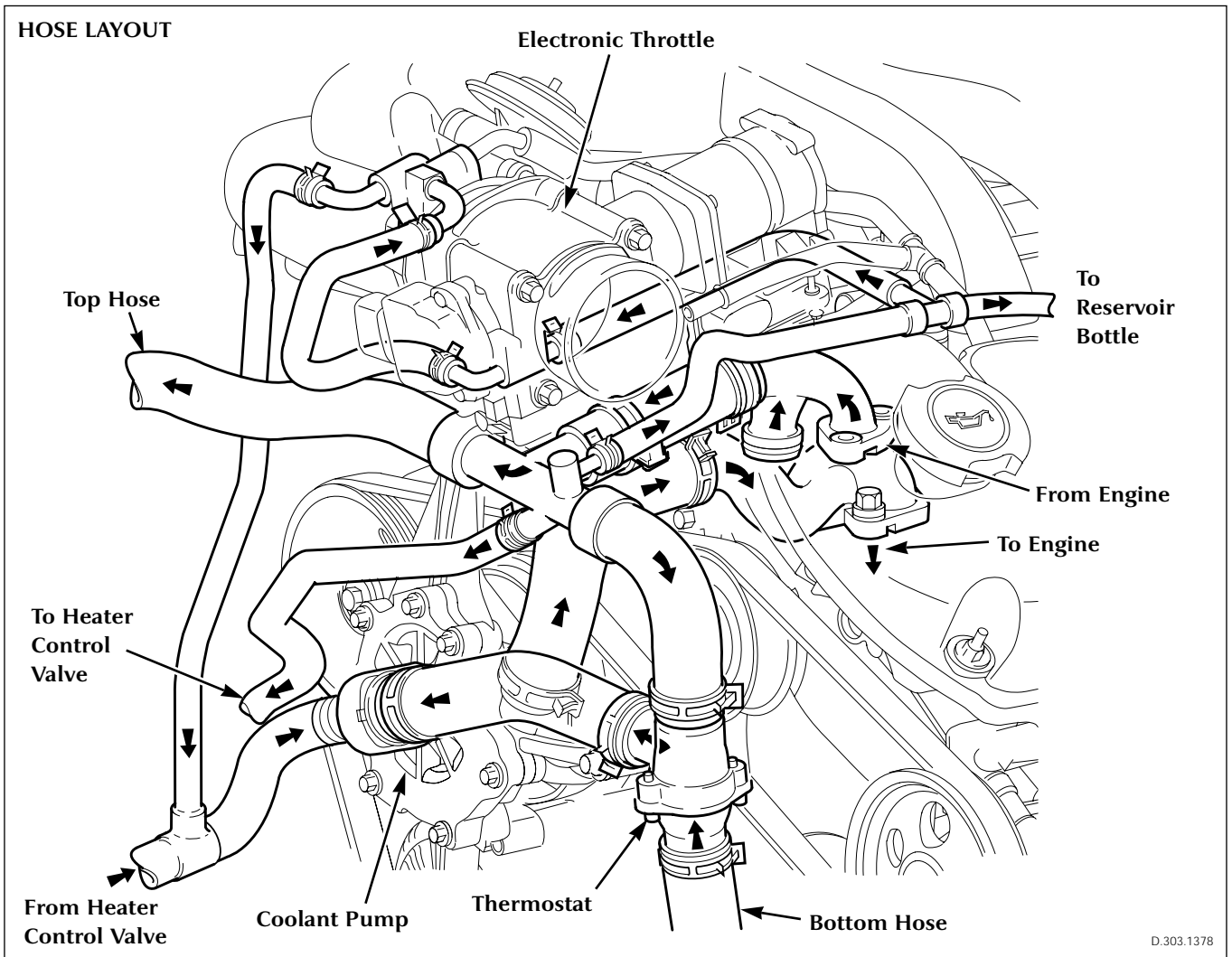
A subsidiary circuit provides a series coolant feed through the lower throttle body and top of the intake manifold inlet. This is necessary to prevent ice forming at low ambient temperatures at the base of the throttle body and also in the positive crankcase ventilation (PCV) port.

Hoses and Connectors

Coolant ducting consists of flexible hoses, aluminium tubing and plastic tubing with injection moulded rubber to plastic joints. All coolant hose clamps are of the spring band type and are glued to the hose with a pull off clip for

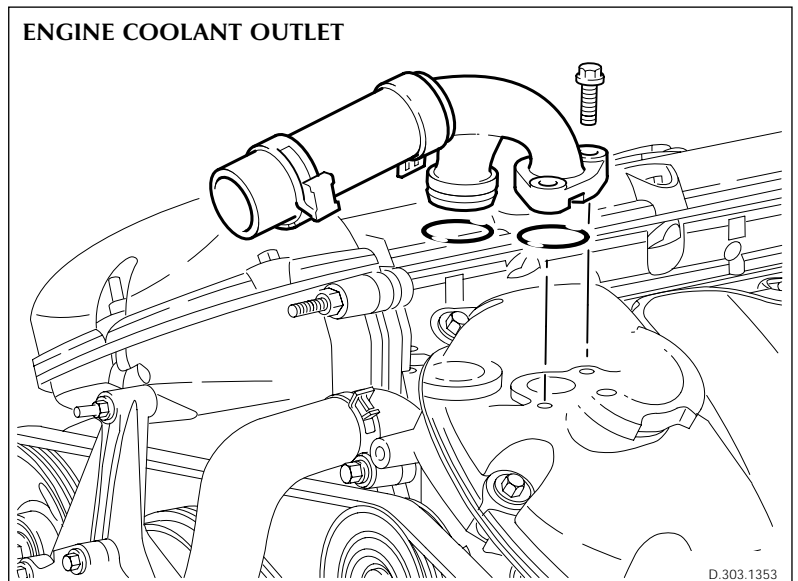
fitting. The thermostat is enclosed in an aluminium casting which is a separate component supported by hose connections.



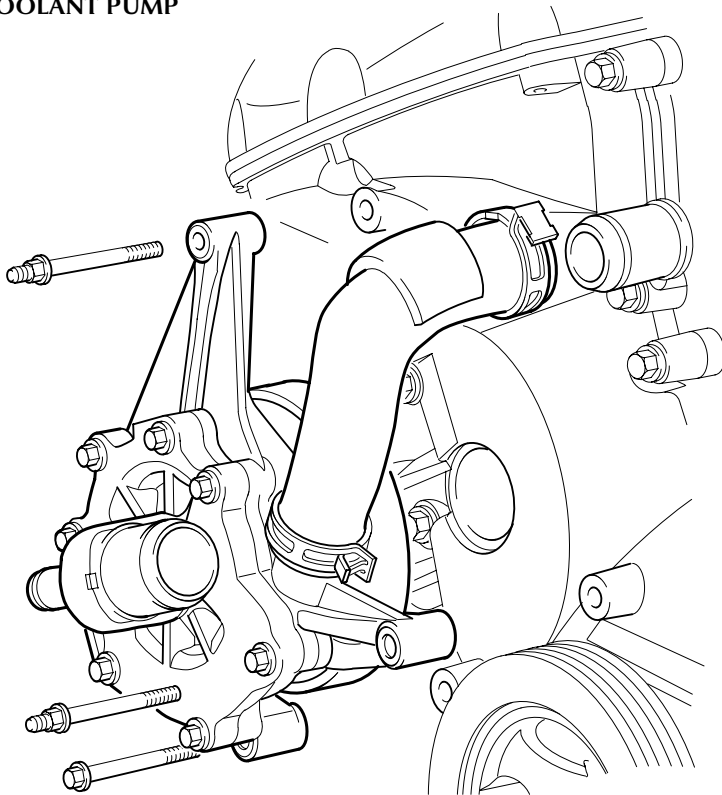


Engine Coolant Outlet

A cast aluminium outlet junction bolts to both cylinder heads to provide a single return flow to the radiator top hose assembly.



COOLANT PUMP



Coolant Pump

The coolant pump is fitted via three bolts to the engine front cover. The pulley is mounted in-board of the pump assembly, between the pump and front cover, and has a smooth surface which is driven from the outer, non ribbed side of the drive belt.

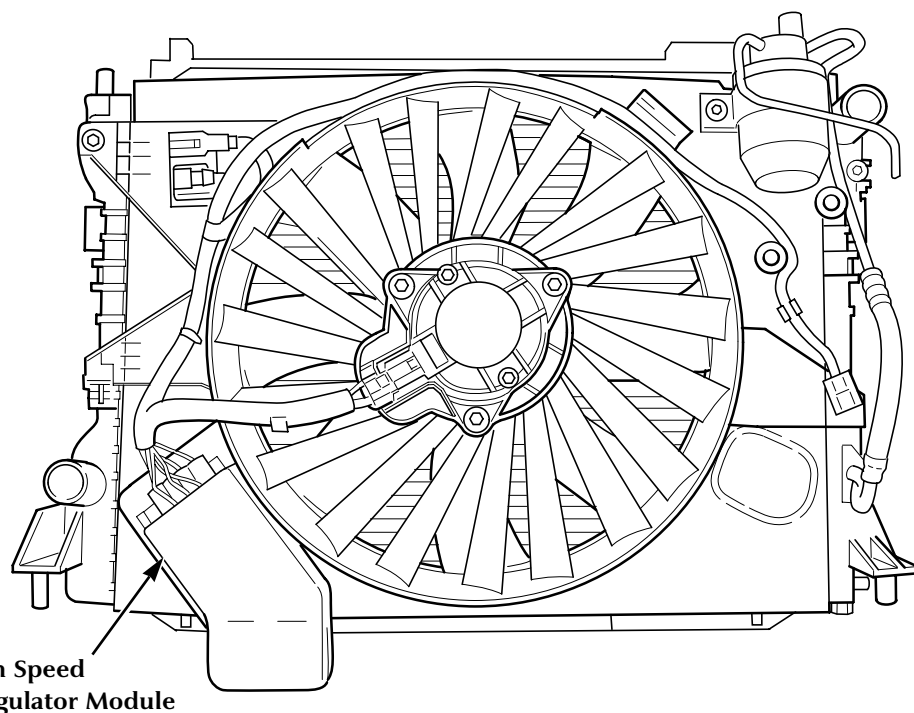
Coolant returns from the radiator and cabin heater system are connected via hoses to inlets on the front of the pump assembly. The outlet from the pump is connected to the engine block via a hose and a tubular casting bolted to the top front of the block between the cylinders.

Radiator and Cooling Fan Assembly

The engine radiator is one component of the cooling pack assembly which also includes the PAS and transmission heat exchangers and the A/C condenser. The cooling pack assembly and the PAS and A/C systems are described in the 'S-TYPE Introduction' Technical Guide and transmission cooling is described elsewhere in this Guide.

The radiator consists of an aluminium core, 26mm in thickness, with crimped on plastic end tanks. A single electrical cooling fan and a fan

RADIATOR AND FAN SHROUD ASSEMBLY



Fan Speed
Regulator Module

speed regulator module are fixed to the glass filled nylon fan shroud assembly which is mounted on the rear of the radiator end tanks via two lower slots and pegs, two upper screws and two clips at the bottom of the radiator. The A/C system receiver drier bottle is also mounted on the fan shroud assembly - see the 'S-TYPE Introduction' Technical Guide.

The 500W fan motor drives a glass filled nylon impeller over a continuously variable speed range from 300RPM to 2900RPM and is controlled by a regulator module mounted at the lower LH side of the fan shroud. Since the fan speed regulator module provides power drive to the fan, it has a finned heat sink outer casing and is enclosed within a cooling duct. The ducting extends forwards below the cooling pack to receive an inflow of air.

The radiator drain is located on the RH end tank.

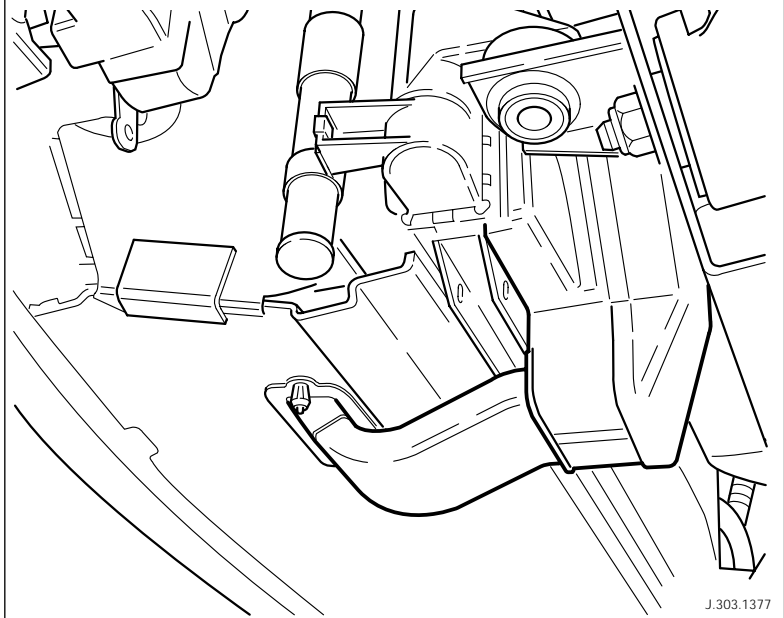
Coolant

A new type of anti-freeze fluid is used for the coolant mixture. This product is a conventional ethylene glycol based fluid but with new organic corrosion inhibitors instead of the silicate, nitrite and other additives which are normally used. These new corrosion inhibitors do not form a deposit on the inner surfaces of the coolant system and therefore provide improved heat transfer (more efficient cooling), better component protection and an extended coolant life due to the low rate of depletion of the additives. The recommended coolant change is every five years or 250,000km (150,000miles).

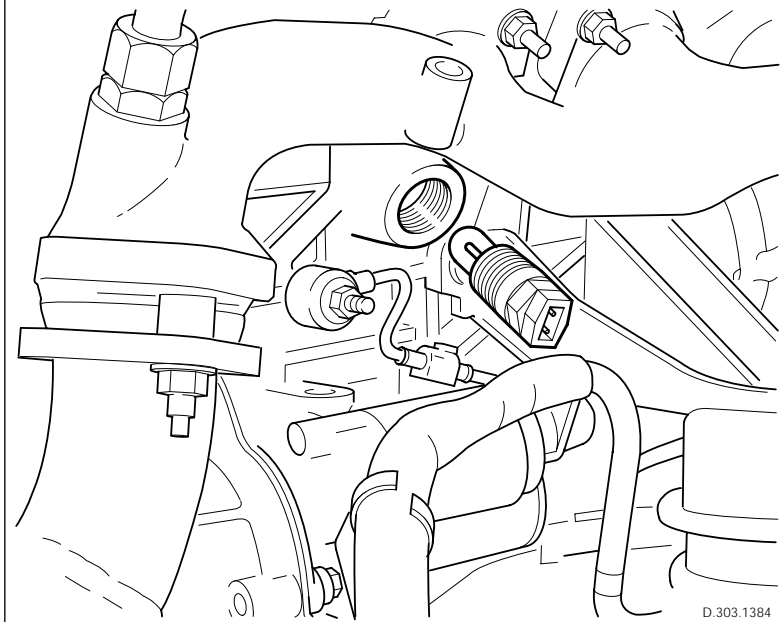
Engine Block Heater

For markets subject to very low temperatures, an engine coolant heater, for connection to an external mains electrical supply, is screwed into the RH side of the cylinder block adjacent to the knock sensor. Two heaters are available, a 400W 115V unit with a two pin connector and a 600W 230V unit with flying lead.

FAN SPEED REGULATOR MODULE COOLING DUCT



ENGINE BLOCK HEATER



Fail Safe Cooling System

A unique feature of the V6 engine is the use of a fail safe cooling strategy, controlled by the EMS, in the event of coolant loss leading to rising engine temperatures. The principle of the strategy involves switching off one or more fuel injectors to inhibit combustion and reduce heat, thus allowing the flow of ambient intake air to further cool the selected cylinders. By cycling the selected cylinders, ie switching different injectors off for a period and in a sequence determined by EMS parameters, overall engine temperature can be controlled sufficiently to allow the vehicle to be driven, at reduced power, for a short distance. Throughout the malfunction period, instrument panel messages and warnings advise the driver of the current status of the cooling system as described below.

Driver Indication and EMS Action

The fail safe strategy moves through different stages depending on engine temperature:

- Temperatures below 122° C (250° F) are within the normal range. At high temperatures below this level the temperature gauge pointer enters the red zone.
- If the temperature rises to between 122° C - 127° C (250° F to 260° F) no action is taken by the EMS which affects engine running but the following indications appear:

Temperature gauge	pointer in red zone
Message Centre	HIGH ENGINE TEMPERATURE
Warning light	TEMP
Priority light	red
Audible indicator	single chime sounded

- If the temperature rises to 127° C (260° F) or above, the fail safe strategy operates. At 127° C (260° F), the EMS will cut out one cylinder (the selected cylinder is varied) and as the temperature continues to rise, this will increase to a maximum of three cylinders cut (with cylinder cycling). The following indications are given:

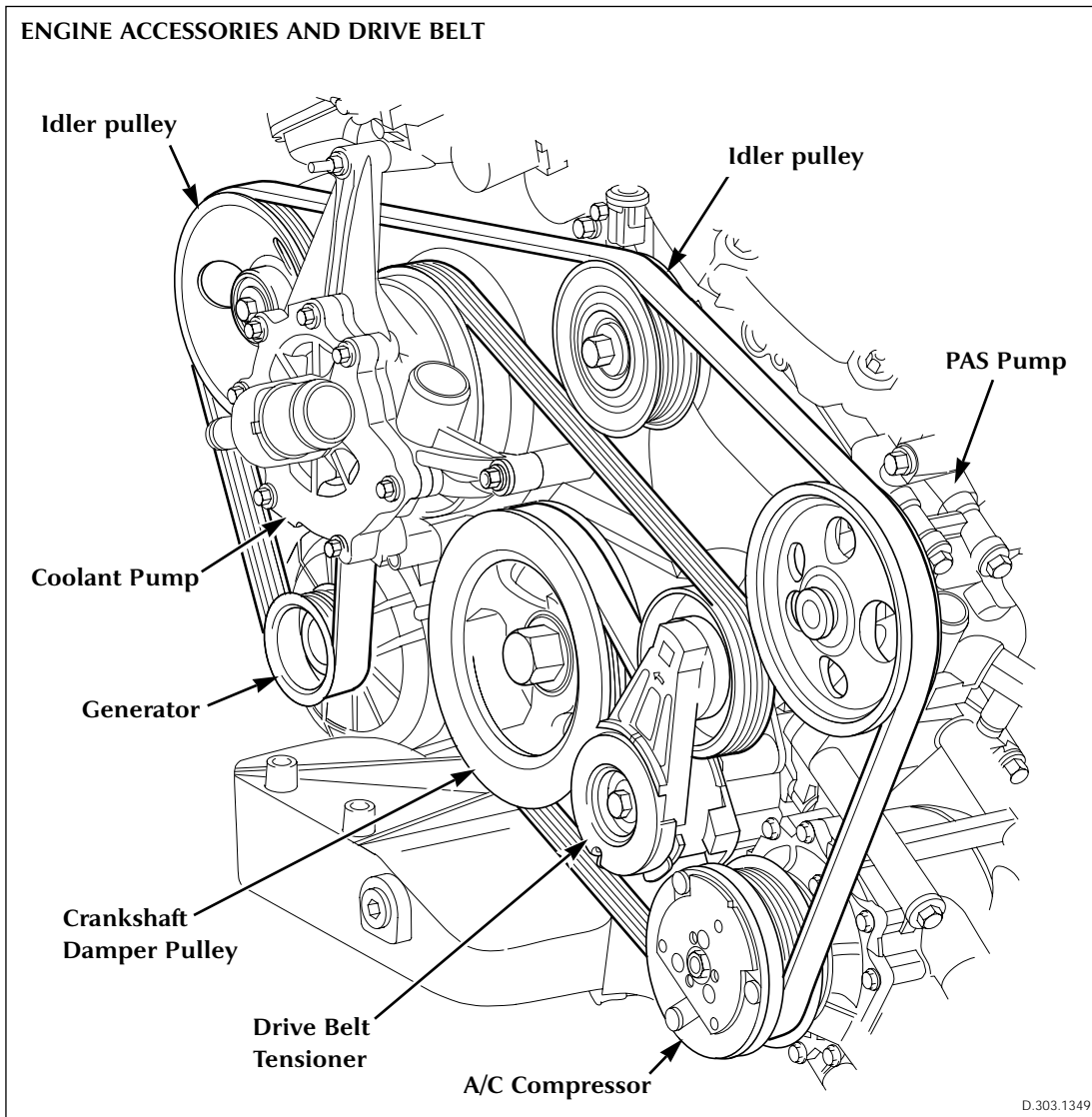
Temperature gauge	pointer in red zone
Message Centre	ENGINE POWER REDUCED
Warning light	TEMP
Priority light	red
Audible indicator	three chimes sounded

- At 166° C (300° F) or above, the fail safe strategy continues as described but the following indications are given:

Temperature gauge	pointer in red zone
Message Centre	PULL OFF ROAD SAFELY alternates with TURN OFF IGNITION
Warning light	TEMP flashes
Priority light	red
Audible indicator	five chimes sounded

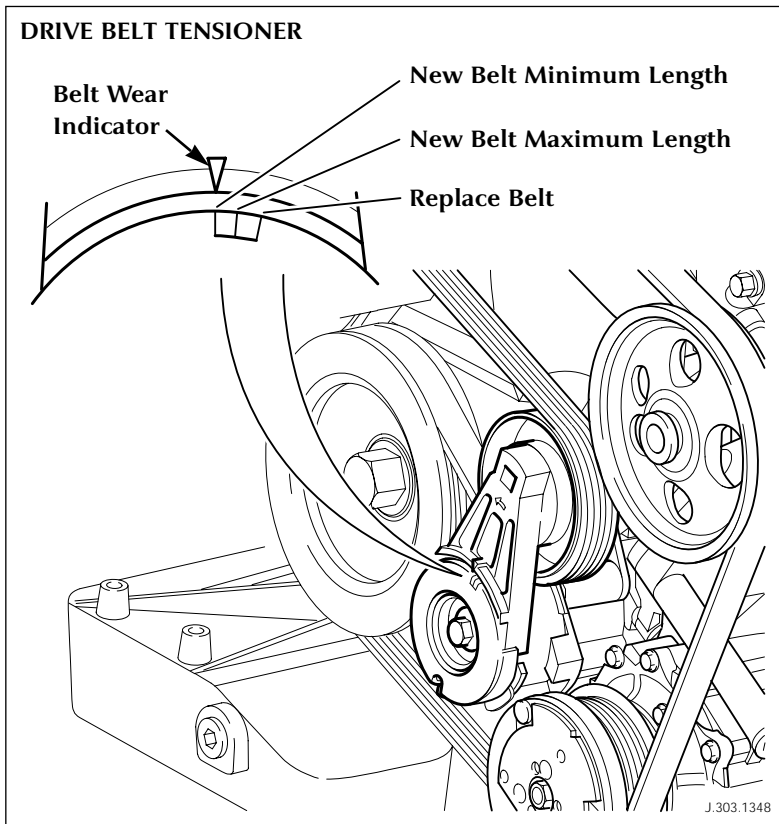
- EMS shuts the engine down.

Front End Accessories Drive



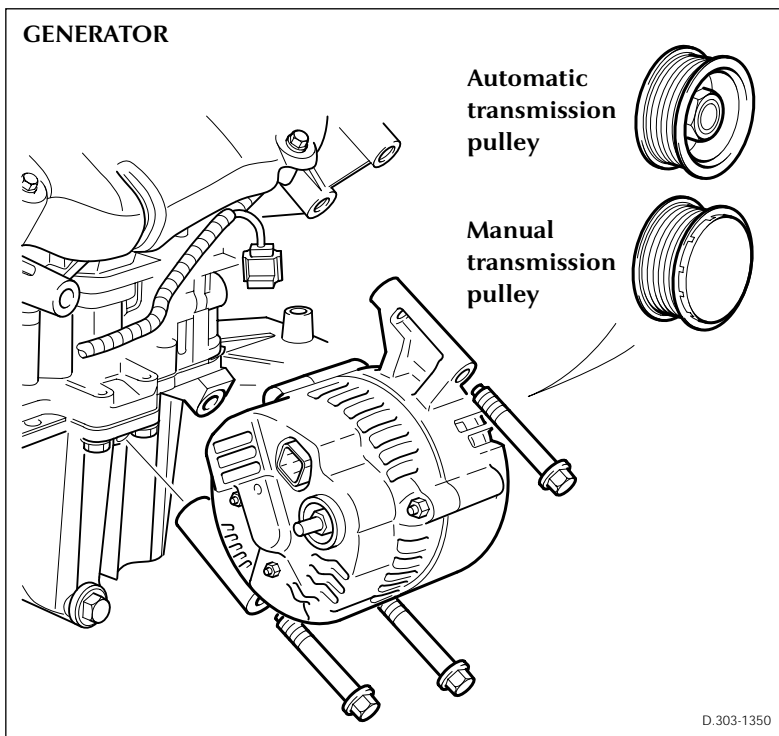
Drive Belt

A single six ribbed belt is driven from the crankshaft damper pulley to drive the coolant pump, generator, PAS pump and A/C pump. The drive belt run is guided via two idler pulleys and an automatic belt tensioner.



Drive Belt Tensioner

The drive belt tensioner is a similar type to that fitted to the V8 engines. An index on the tensioned arm rotates with wear against three markings on the tensioner spring cap which indicate the minimum and maximum lengths for a new belt and the point at which the belt must be replaced.



Generator

The 120AH generator is fitted with a special casing to enable it to be bolted directly to the engine via three fixing points.

On the manual transmission vehicles, sudden deceleration may result in generator momentum driving the belt against the engine which is slowing down, with possible effects on the life of the drive belt. The generator pulley fitted to the manual transmission vehicle incorporates a clutch mechanism which allows it to freewheel in the reverse drive (anti-clockwise) direction. Note that a special tool is required to remove the pulley.

To improve generator control on all engine/transmission variants, the generator now has a four pin connector to provide two new sensing signals:

- pin S is directly connected to the battery to provide voltage feedback to the regulator
- the regulator senses field current and produces a PWM signal from pin FR to the PCM to indicate the generator duty cycle.

Idler Pulleys

Two idler pulleys are used, one fixed by a single bolt to the front cover and a second (see illustration) fixed via a mounting bracket to the upper RH side of the cylinder head and front cover.

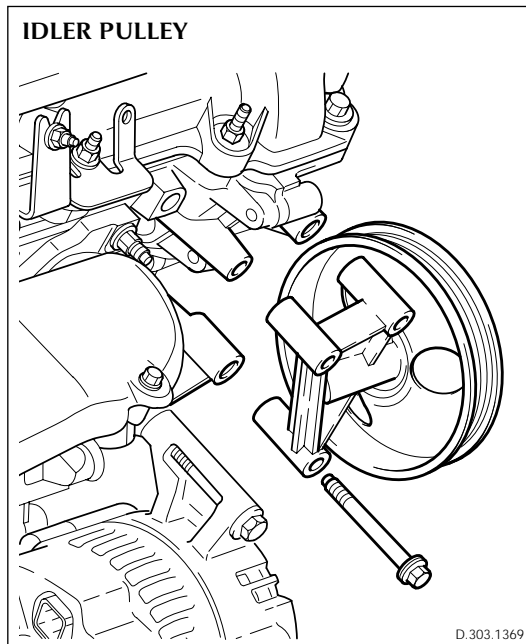
PAS Pump

The PAS pump is fixed by a single bolt to the LH cylinder head and by two bolts to the front cover. The pulley is constructed of lightweight phenolic material.

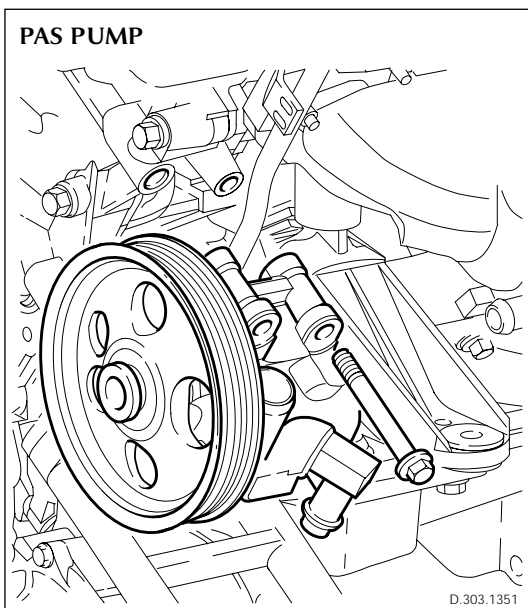
Air Conditioning Compressor

The A/C compressor is mounted on the lower LH side of the engine and is secured by two bolts to a bracket fixed to the bedplate and by two lower bolts directly to the oil sump.

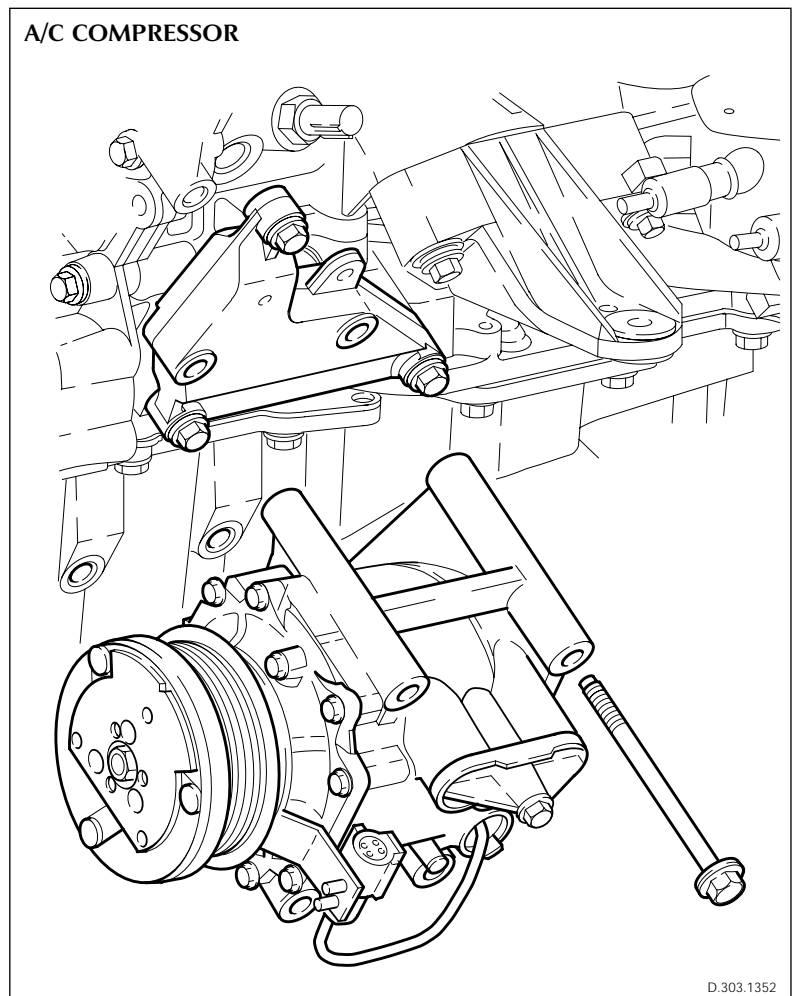
IDLER PULLEY



PAS PUMP



A/C COMPRESSOR



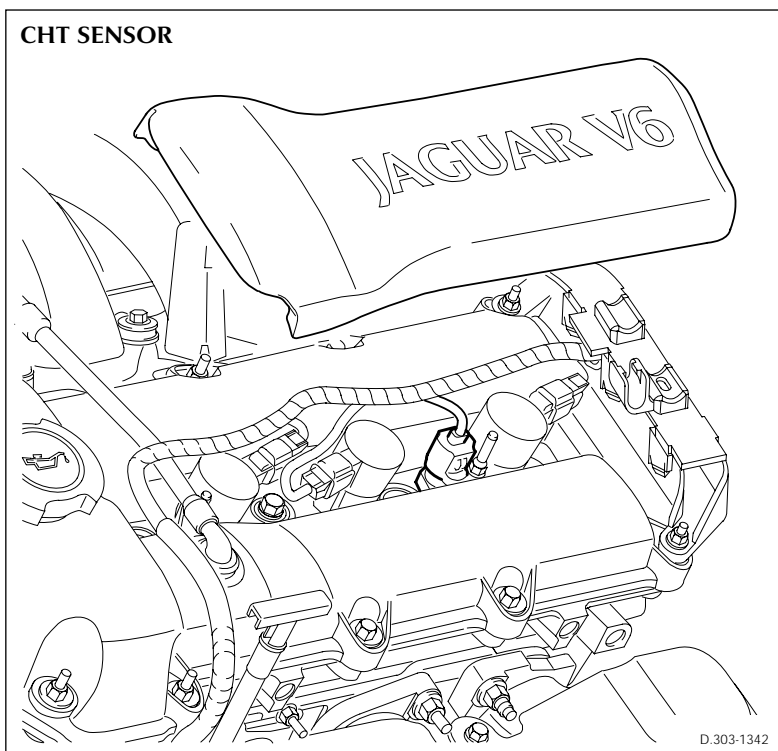
Engine Management Sensors

Engine management sensors and actuators (but not off engine sensors) are summarised in the illustration on page 41 and are also described below or in the relevant section (VVT, fuel system, throttle, tuned manifold).

The engine management system is described in a separate section.

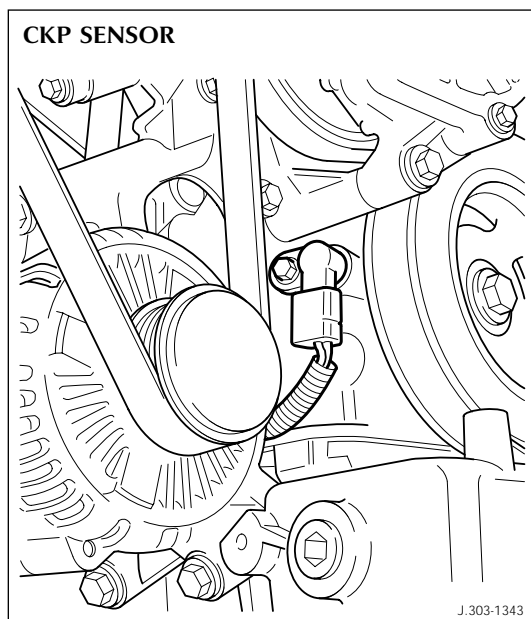
Key to illustration on page 41:

1. Throttle motor
2. TP sensor
3. IAT sensor
4. MAF sensor
5. Top IMT valve
6. Bottom IMT valve
7. EFT sensor
8. IP sensor
9. Fuel injectors
10. Coil-on-plug units
11. VVT shuttle valve
12. CMP sensor
13. CHT sensor
14. KS sensors
15. EOT sensor
16. CKP sensor
17. HO2 sensors
18. HO2 sensors (catalyst monitors)



Cylinder Head Temperature (CHT) Sensor

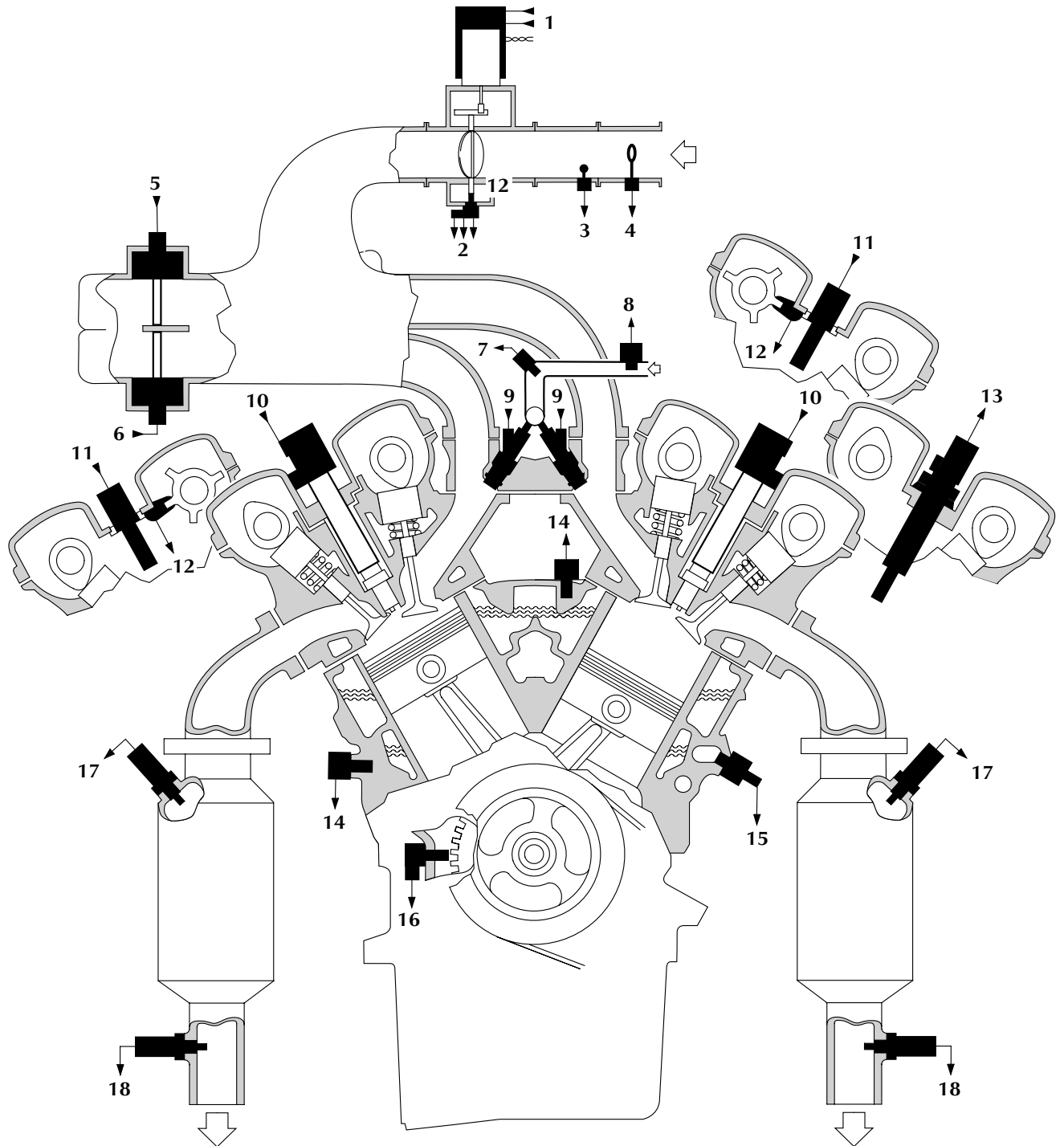
The single CHT sensor is located between the two rear coil-on-plug units in the bank 2 cylinder head. The sensor directly monitors the metal temperature of the cylinder head. This method of engine heat sensing is used in place of a conventional coolant temperature sensor to enable the fail safe cooling strategy to operate. The use of a metal temperature sensor allows cylinder head temperature to be measured even if coolant has been lost unlike an ECT sensor which would produce inaccurate temperature indications, eg measuring steam temperature.



Crankshaft Position (CKP) Sensor

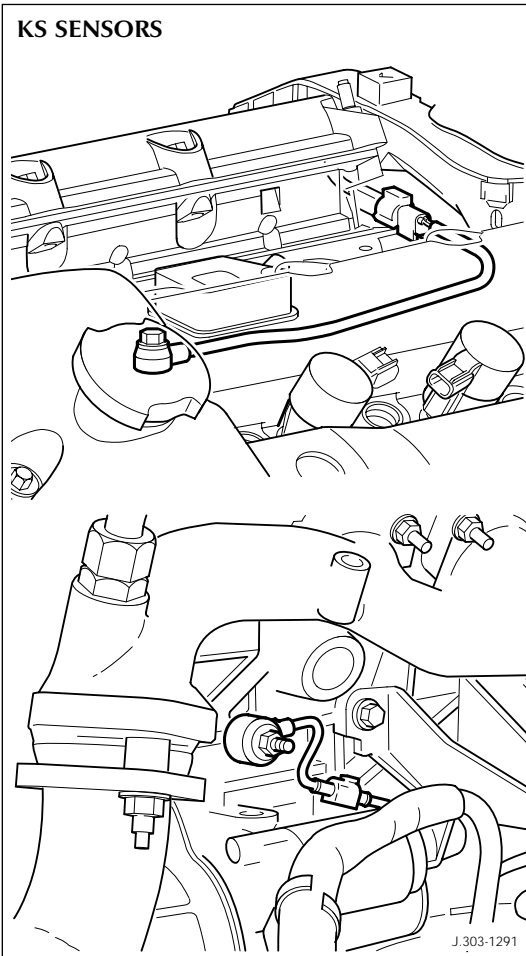
Crankshaft position and rotational speed are sensed from a steel timing ring keyed to the front end of the crankshaft immediately behind the front cover. The timing ring has 36-1 teeth, ie one missing tooth, which are angled slightly forward and bent at rightangles to provide a sensing area for the inductive sensor. The sensor is positioned in the front cover, to the side of the crankshaft damper, at approximately 20° to the plane of the timing ring.

ENGINE MANAGEMENT SCHEMATIC



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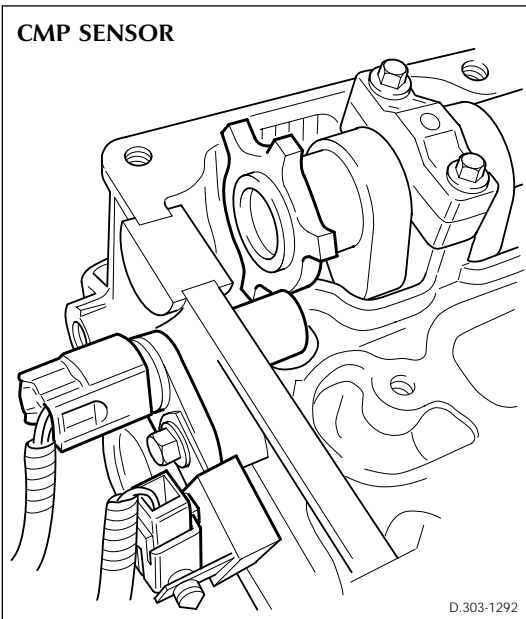
KS SENSORS



Knock (KS) Sensors

Two 'donut' type knock sensors are fitted, in asymmetrical positions. The bank 2 sensor is located on top of the block near the oil separator and the bank 1 sensor is fixed on the RH side of the block above the starter motor.

CMP SENSOR



Camshaft Position (CMP) Sensors

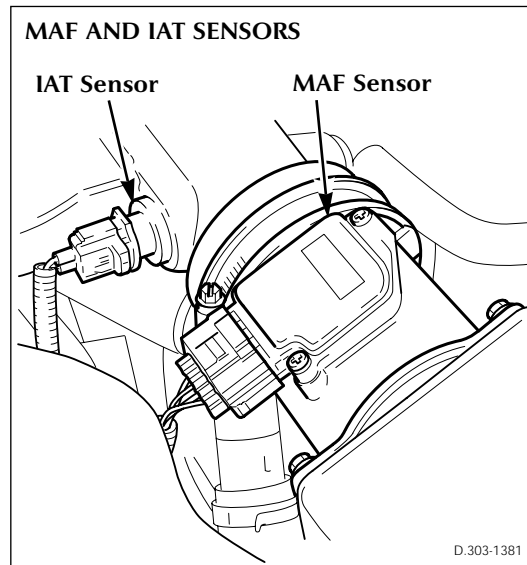
Each inlet camshaft has a four tooth sensor ring pressed on to the rear end of the camshaft with the inductive sensor projecting through a hole in the cylinder head behind and in line with the sensor ring teeth. The use of a four tooth ring enables the sensor to provide increased feedback (position indication of each cylinder).

Intake Air Temperature (IAT) Sensor

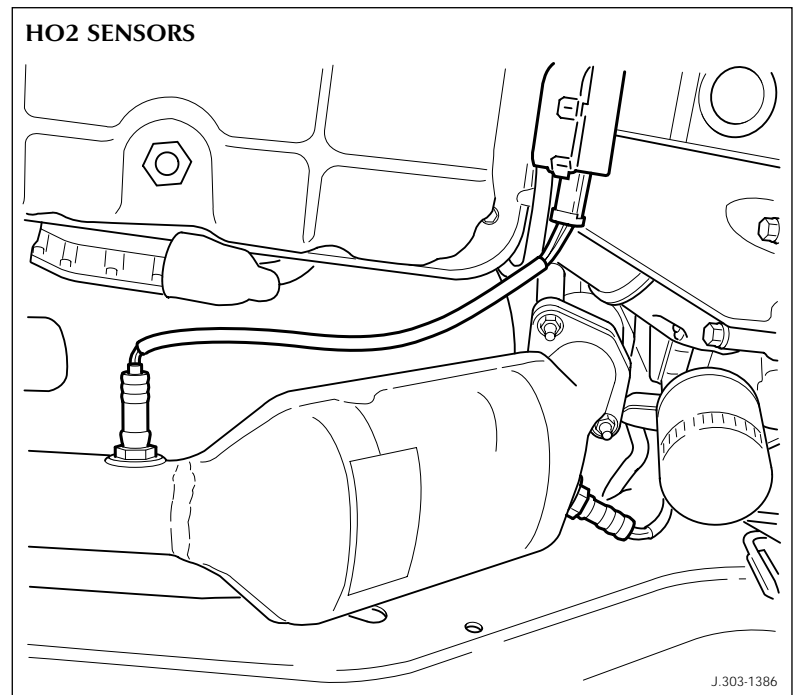
The IAT sensor is a conventional thermistor type device which is a push fit in the intake resonator duct.

Mass Air Flow (MAF) Sensor

The MAF sensor is an integral assembly consisting of a hot wire sensor unit and air duct and is non-serviceable. The assembly is fitted between the air cleaner and intake resonator tube.

**Heated Oxygen (HO2) Sensors**

HO2 sensors are fitted in both the upstream and downstream positions on the catalytic converters. Both sensors are standard types with a step response at the stoichiometric (lambda) air/fuel value. The upstream sensors provide the feedback for stoichiometric fuelling control and the downstream sensors monitor catalyst efficiency and also provide long term fuelling adaptation trim.



Introduction

The AJ28 engine is a variant of the 4.0L 90° V8 units fitted to the XJ and XK range of vehicles. The AJ28 shares some of the changes incorporated in the current AJ27 engine: both engines are derived from the original AJ26 unit. A number of features are unique to the AJ28 or are shared with the AJ-V6 engine also described in this publication.

Features of the AJ28 engine are:

- Continuously variable inlet valve timing over a $48^{\circ} \pm 2^{\circ}$ crank angle: as fitted to the AJ27 engine
- Full authority cable-less electronic throttle control: as fitted to the AJ-V6 engine
- Air assisted fuel injection: similar to system used on the AJ27 engine
- Unique induction manifold with centrally mounted throttle body
- Returnless fuel system: similar to AJ-V6 engine
- Twin wall exhaust manifold
- Engine management system as used on the AJ-V6
- New sensors
- Modified sump and oil cooler
- Modified front end ancillary drive and components

Engine Specification

Maximum power	DIN - 209 kW (281 BHP) at 6100 RPM EEC - 203 kW (276 PS) at 6100 RPM
Maximum torque	DIN - 390 Nm (287 lbft) at 4300 RPM EEC - 278 Nm (279 lbft) at 4300 RPM

Oil Specification

All markets except the USA and Canada

Engine oil for all markets except the USA and Canada must be to API specification S/ACEA A1 or A3.

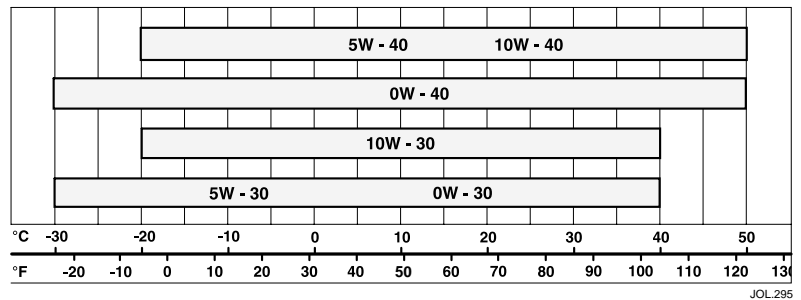
The recommended SAE viscosity for different ranges of ambient temperature are shown in table 1.

USA/Canada

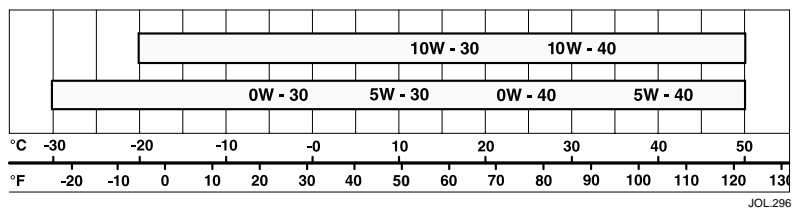
Engine oil for USA and Canada must be to API specification S/ILSAC GF-2.

The recommended SAE viscosity for different ranges of ambient temperature are shown in table 2. For maximum economy and in most climate conditions, SAE 5W/30 is to be preferred but SAE 10W/30 or 15W/40 are acceptable in moderate to hot climates.

SAE/TEMPERATURE TABLE 1



SAE/TEMPERATURE TABLE 2



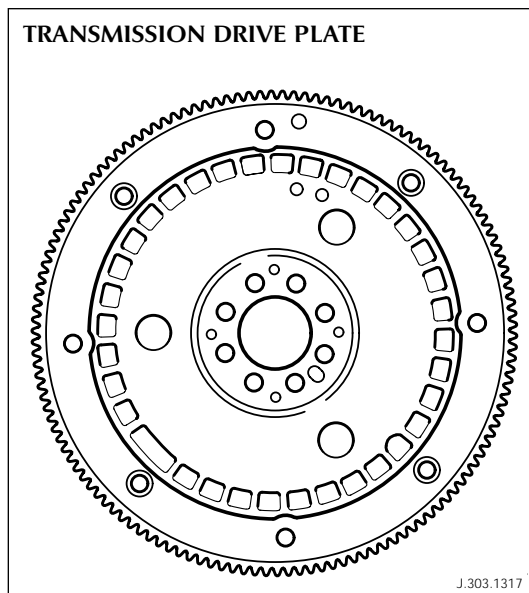
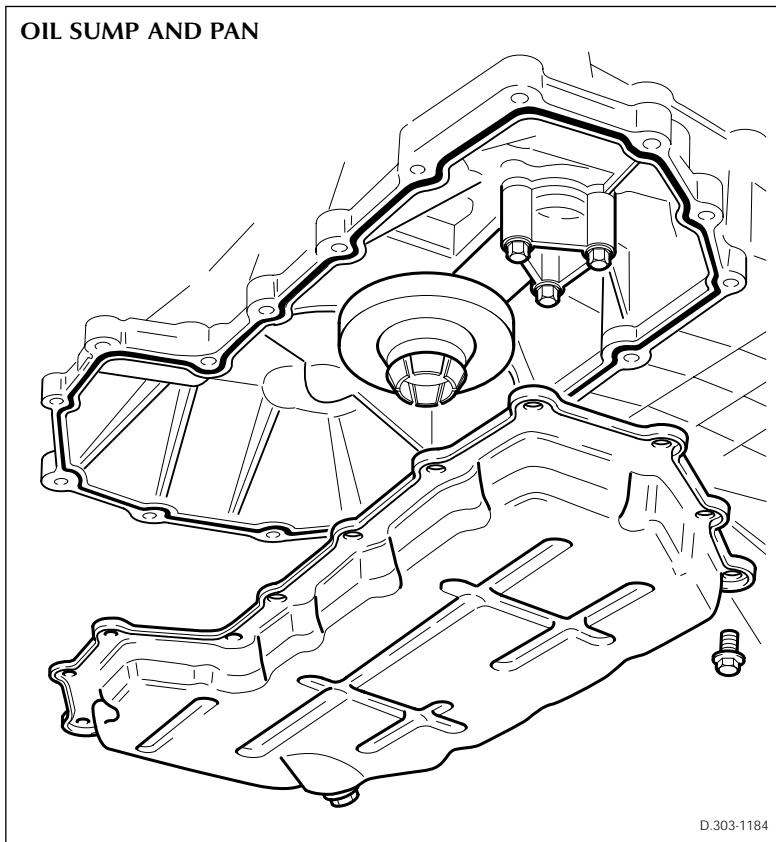
Basic Engine

Bottom End

Changes to the cylinder block, connecting rods and pistons which were introduced for the AJ27 N/A engine are also applicable to the AJ28 unit and are described in the 'XK and XJ series 1999 MY update' Technical Guide.

Oil Sump Body and Pan

A revised oil sump body and sump pan are necessary to accommodate the V8 engine in the S-TYPE model but the sump capacity is unchanged.



Transmission Drive Plate

The transmission drive plate is similar to AJ27 but is fixed with eight bolts to an adaptor plate on the torque converter (see Transmission sections). The crankshaft sensor ring is fitted to the engine side of the drive plate as for the previous V8 engines.

Cylinder Head

The cylinder head incorporates the modifications first introduced for the AJ27 engine except for the camshaft sensor ring and cam cover.

Camshaft Sensor Ring

Cam position sensing is similar to that used on the AJ27 engine, except that the sensor ring fitted to each inlet camshaft has five triggering teeth.

Camshaft Covers

To improve accessibility, an extension tube is fitted to the oil filler hole on the bank 2 cam cover. Due to the position of the throttle and air intake ducting, the part load breather outlet is taken from bank 1 cam cover and the full load breather outlet from bank 2 (the reverse of AJ27).

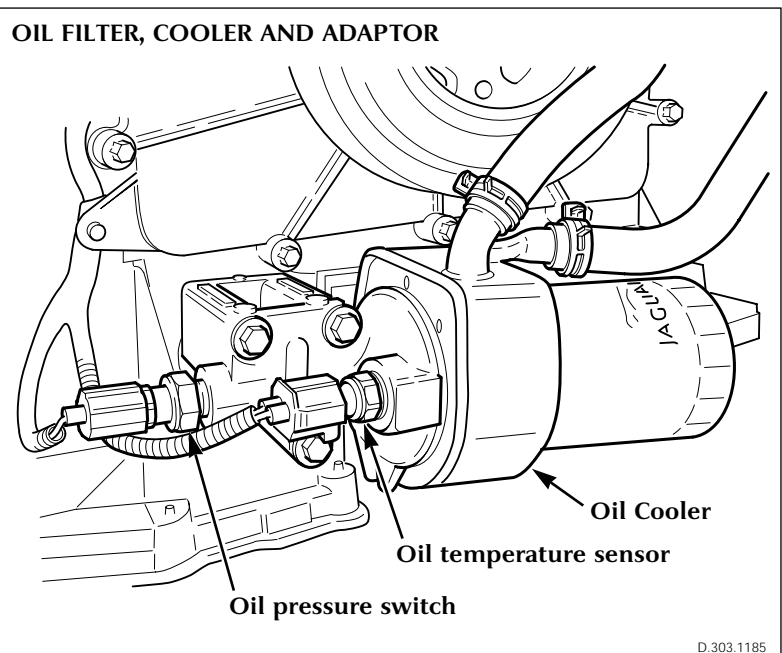
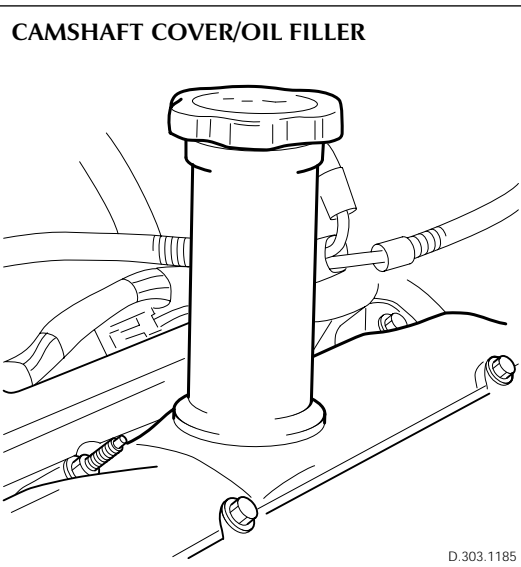
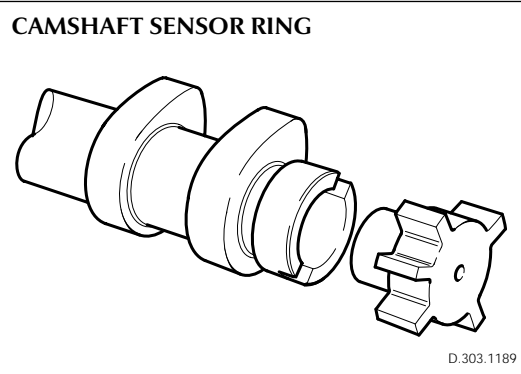
Front Cover

The front cover is modified from the AJ27 to include a mounting boss for a new idler pulley (see Front End Accessories Drive).

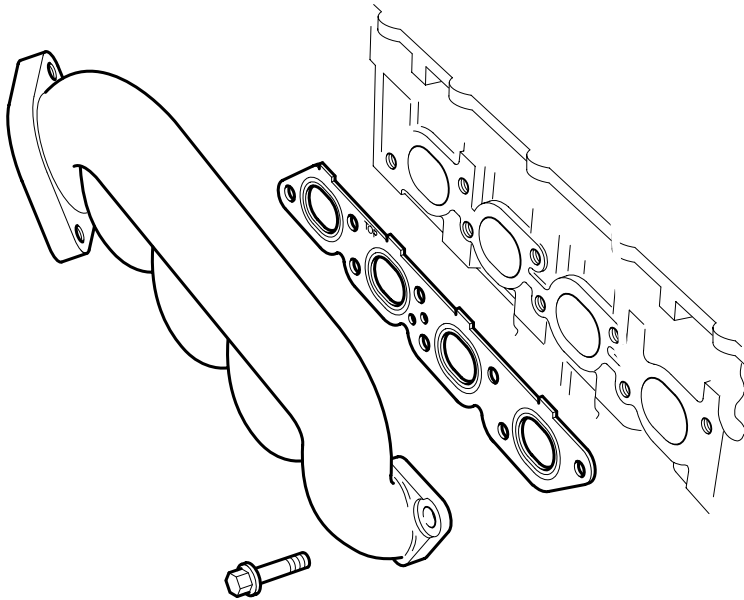
Lubrication

The lubrication system includes the updated oil pump (for the linear VVT system) and the same oil temperature sensor as fitted to the AJ27 engine. The oil sump and pan are modified as described on page 46.

The external oil system components are located laterally across the front of the sump body and consist of an oil filter, oil cooler and oil filter head assembly. The oil cooler is an oil to water heat exchanger similar to the V6 oil cooler and the cooler matrix is also connected via hoses to a circulator orifice in the radiator bottom hose (see Cooling System). The oil filter screws on to the cooler which connects to the sump body through an adaptor, the oil filter head assembly.



EXHAUST MANIFOLD



J.303.1318

Exhaust Manifold

The exhaust manifolds have a double wall construction and are manufactured from austenitic stainless steel. The double wall construction has a number of advantages:

- it provides a significant reduction in the external heat generated and therefore improves underhood thermal management
- a heat shield is not required
- the durability of the manifold is increased (eg less likely to crack)
- by retaining heat, the insulation effect provides a slight improvement in the time to catalyst light-off.

The manifold couples to the catalytic converter via a spherical joint which requires no gasket or sealant.

Cooling System

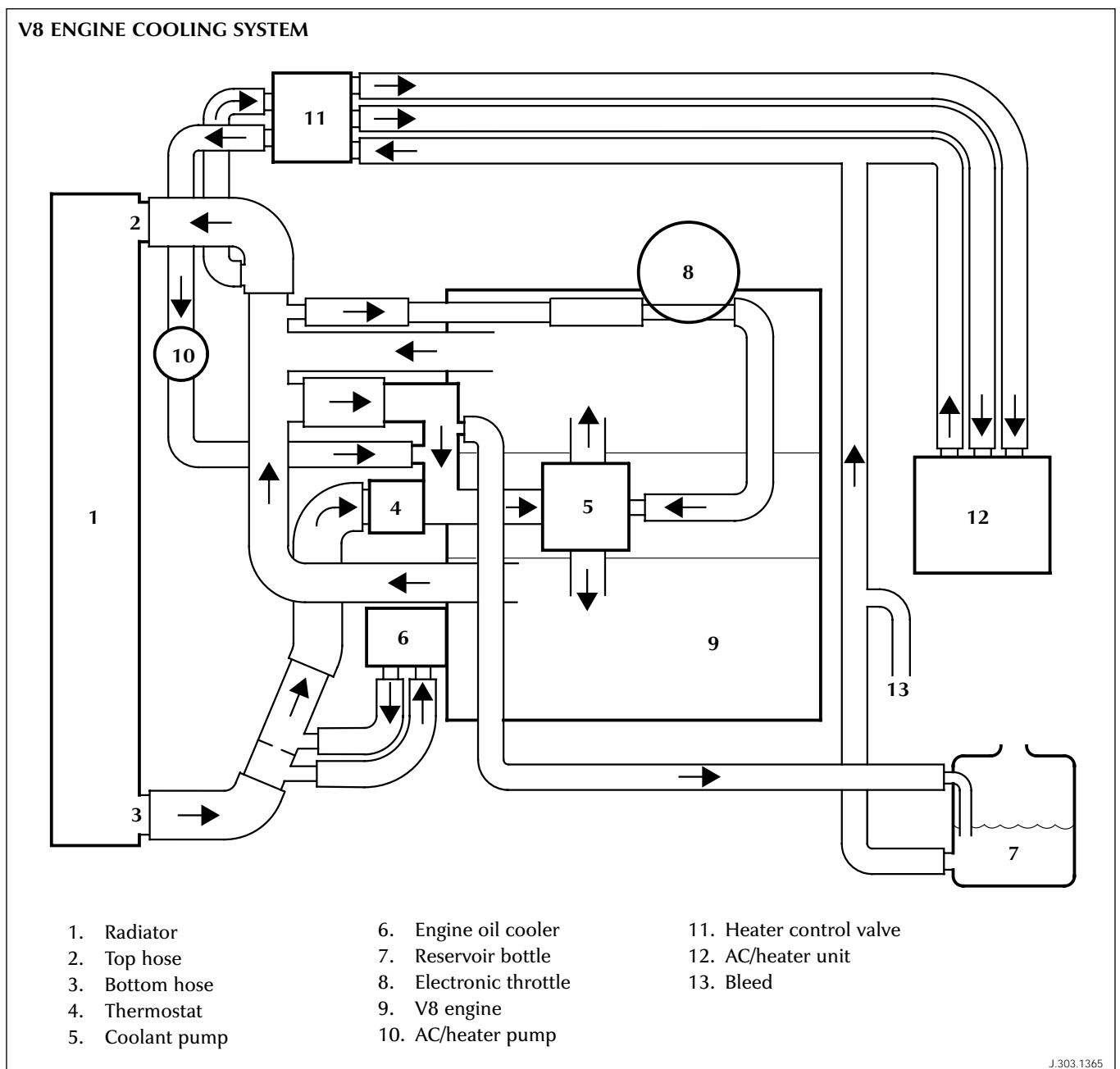
The AJ28 engine retains the same basic cooling system as the previous V8 engines but shares the radiator, fan shroud assembly, de-gas circuit and bottom hose oil cooler circulator features with the V6. The coolant specified for the V6 is also applicable to the V8 engine.

Particular features of the AJ28 cooling system are:

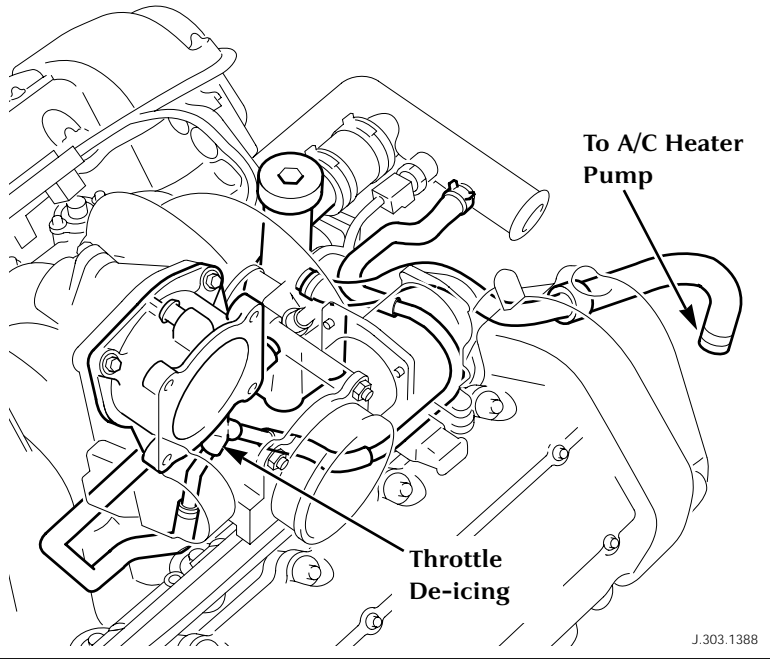
- The thermostat is located in the engine mounted housing as in previous V8 engines.
- The thermostat housing is modified with an extra stub pipe for the new heater return

hose.

- The throttle adaptor is heated from the main cooling system to provide throttle de-icing.
- Both heater hoses, feed and return, are now routed forward to the heater control valve.
- An electric pump is fitted in the heater coolant circuit ('S-TYPE Introduction' Technical Guide).
- The coolant reservoir (de-gas bottle) is fitted with a level sensor which provides a low level warning on the instrument panel message



COOLING SYSTEM HOSES - TOP

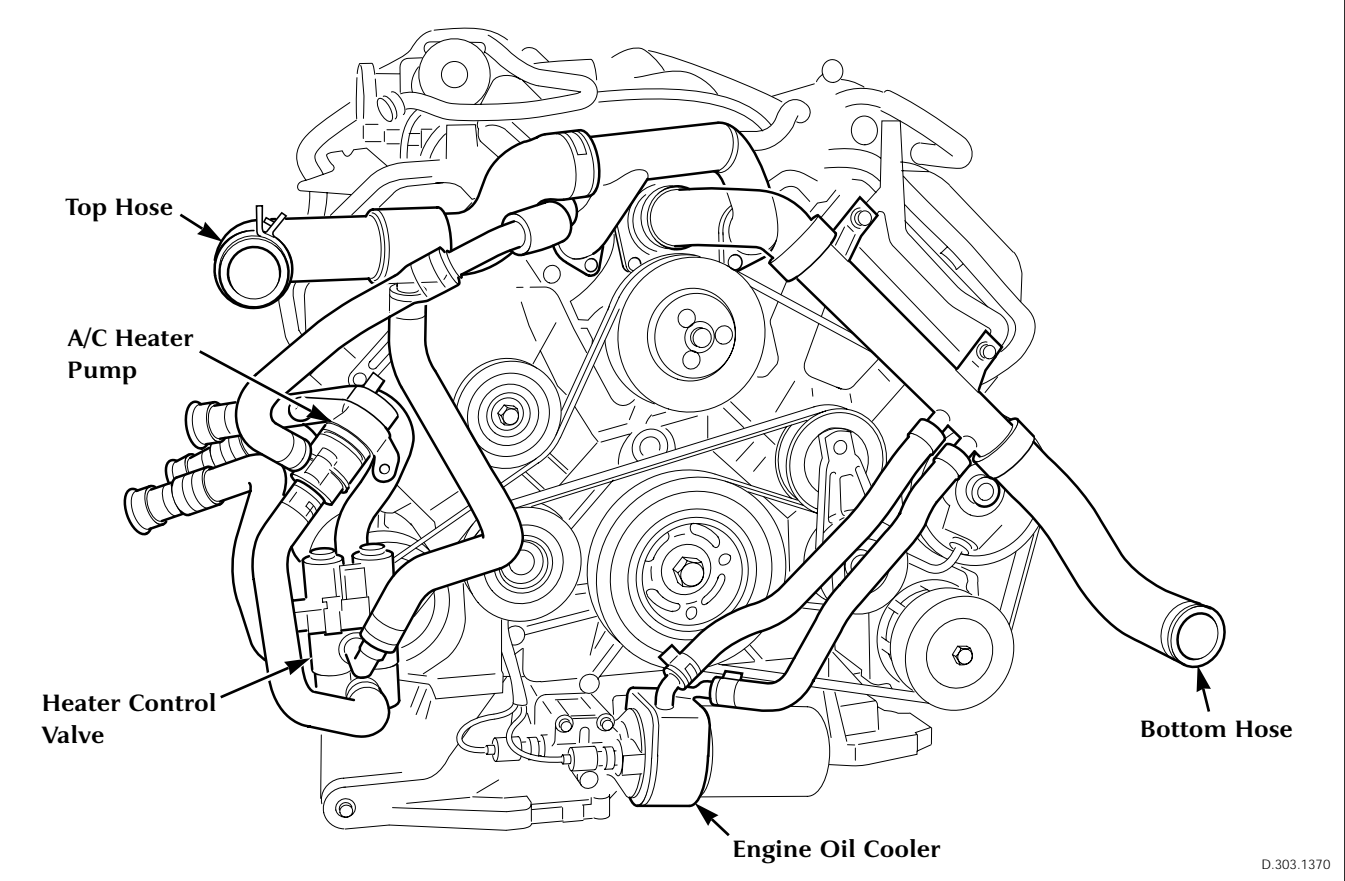


- centre if the coolant level drops.
- The fail safe cooling strategy described for the V6 is not applicable to the AJ28 engine.

Cooling System Hoses

The cooling system hoses are constructed of the same materials and have the same type of fittings as the V6 engine.

COOLING SYSTEM HOSES - FRONT



Air Induction System

Charge air is supplied to the cylinders via an air cleaner, induction tube, throttle body, throttle body adaptor and induction manifold.

The throttle body and system operation is identical to that of the V6 engine.

Induction Manifold

(see illustration on page 52)

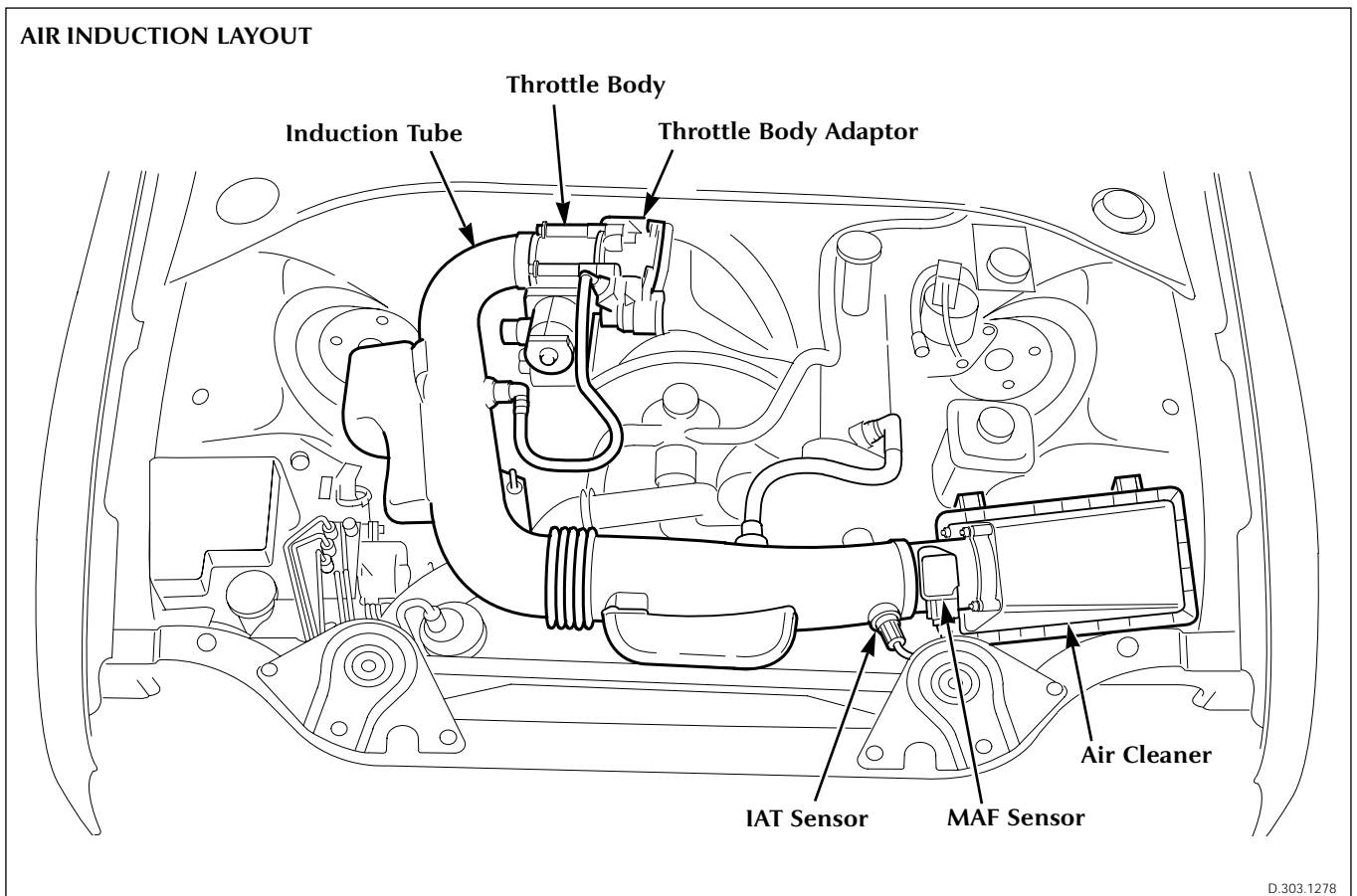
To accommodate the V8 engine in the S-TYPE model, the throttle body is re-located and now supplies charge air via an inlet at the top centre of the induction manifold. The manifold is manufactured from a plastic material and has an integral injector air supply tube on each side with holes for the fuel injectors, but as on the AJ27 engine, the fuel feed pipes are not incorporated into the manifold (see Fuel System). Two stub pipes at the top of the manifold provide vacuum connections for the vacuum hose and the brake servo hose.

A polypropylene covered foam noise isolation pad fits between the manifold assembly and the block.

Throttle Adaptor

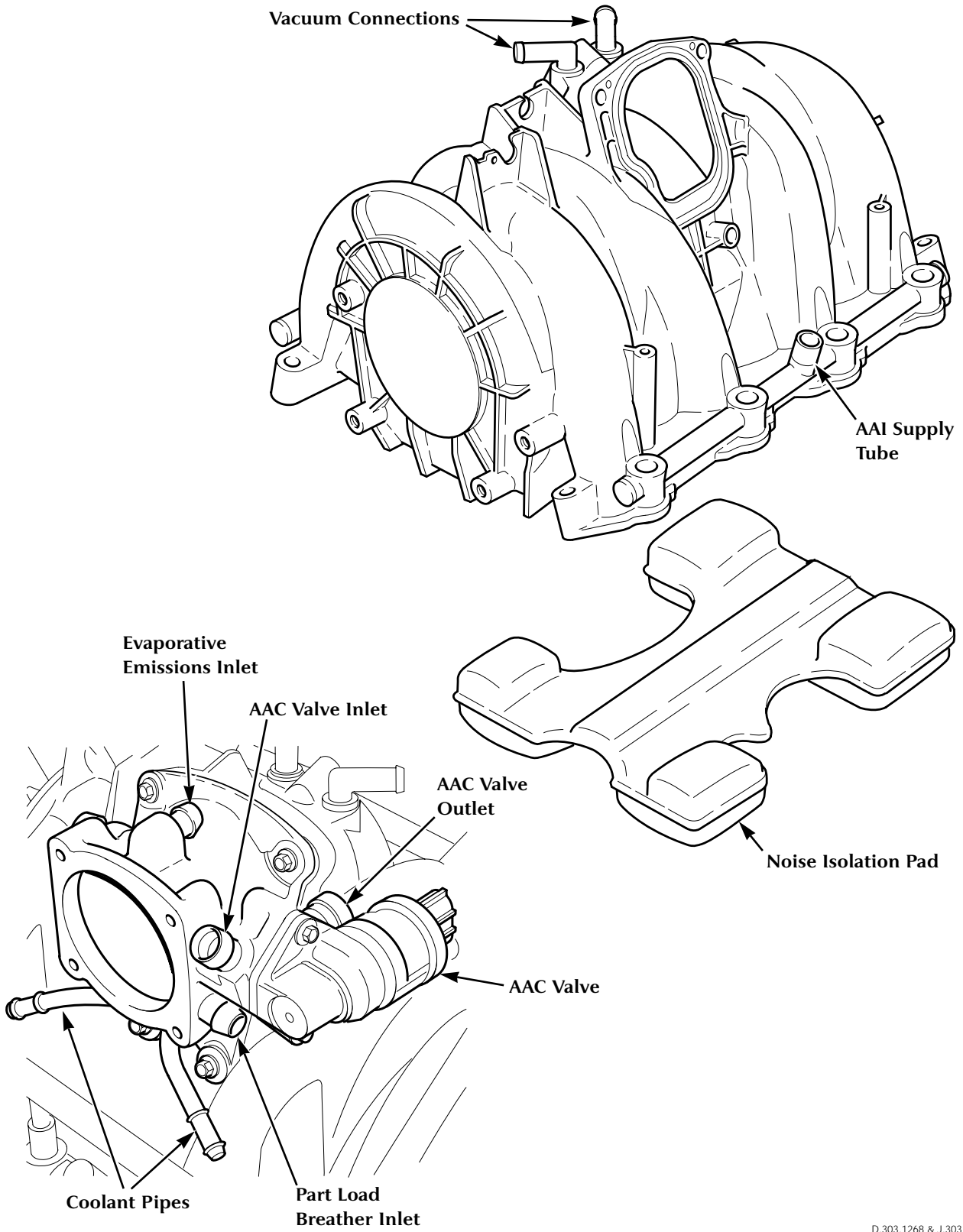
The throttle body is mounted to the induction manifold via a cast aluminium adaptor. The throttle body adaptor provides input ports for the evaporative emissions (top stub) and part load breather (lower side stub) and also mounts the air assisted injection control (AAC) valve. Input and output ports for the side mounted AAC valve are an integral part of the adaptor casting (the ports do not connect to the induction airstream).

Throttle de-icing is achieved by a coolant feed through the base of the adaptor instead of the throttle body itself as on the V6 engine (see cooling section).

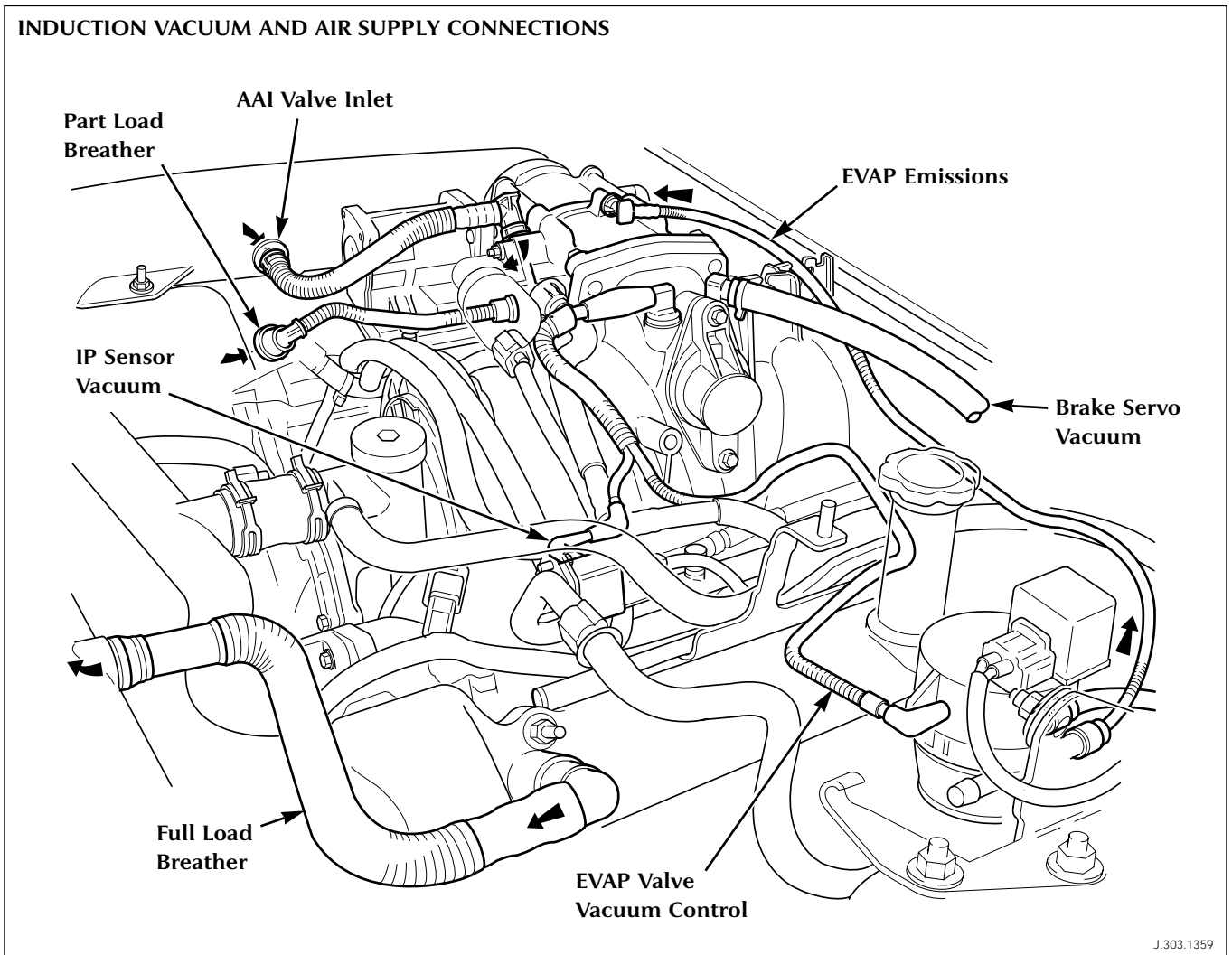


D.303.1278

INDUCTION MANIFOLD AND THROTTLE ADAPTOR



D.303.1268 & J.303.1251



Induction and Vacuum System

Emission and vacuum connections to the induction system are shown in the illustration above.

Variable Valve Timing (VVT)

The inlet valve timing gear is fitted with the same continuously VVT system as is used on the AJ27 engine. Operation is as described in the 'XJ and XK Series 1999MY Update' Technical Guide, with the following variations:

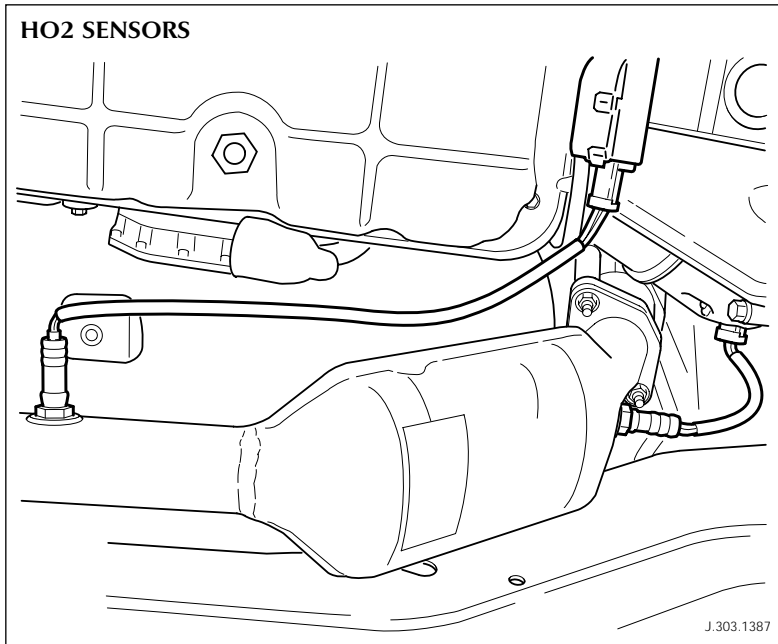
- engine management system
- PWM solenoid control frequency is 300Hz
- the use of five toothed sensor rings for cam position feedback

Note that the use of this VVT system eliminates the need for external EGR components.

Engine Management Sensors

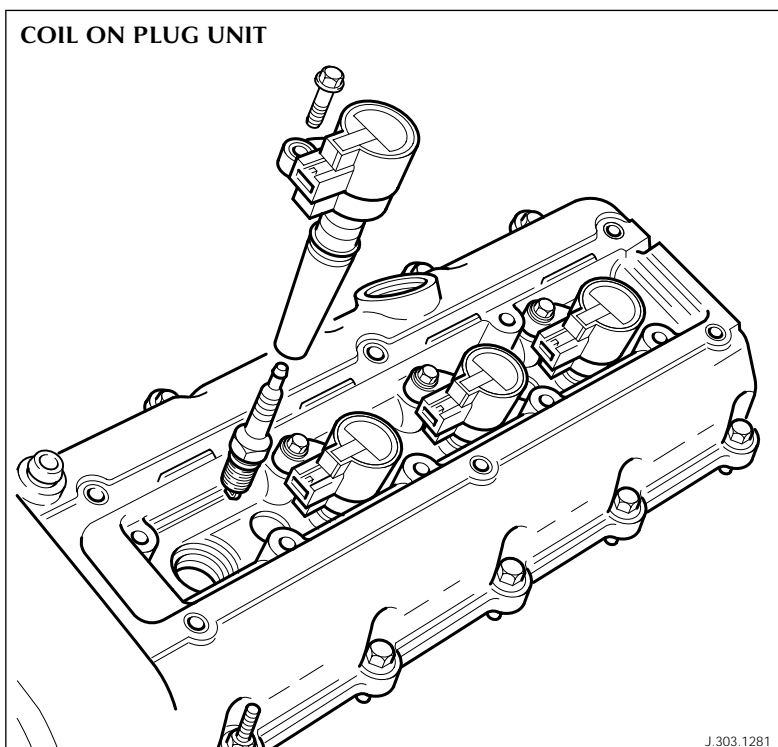
The configuration of the AJ28 engine management sensors is changed from the previous V8 variants:

- New components unique to AJ28 engine are the MAF sensor and engine fuel temperature (EFT) sensor.
- Components in common with the V6 engine are the IAT sensor, KS sensors, injector pressure (IP) sensor, engine oil temperature (EOT) sensor and HO2 sensors.
- The crankshaft (CKP) and camshaft (CMP) sensors are the same as those fitted to the AJ27 engine.



Heated Oxygen (HO2) Sensors

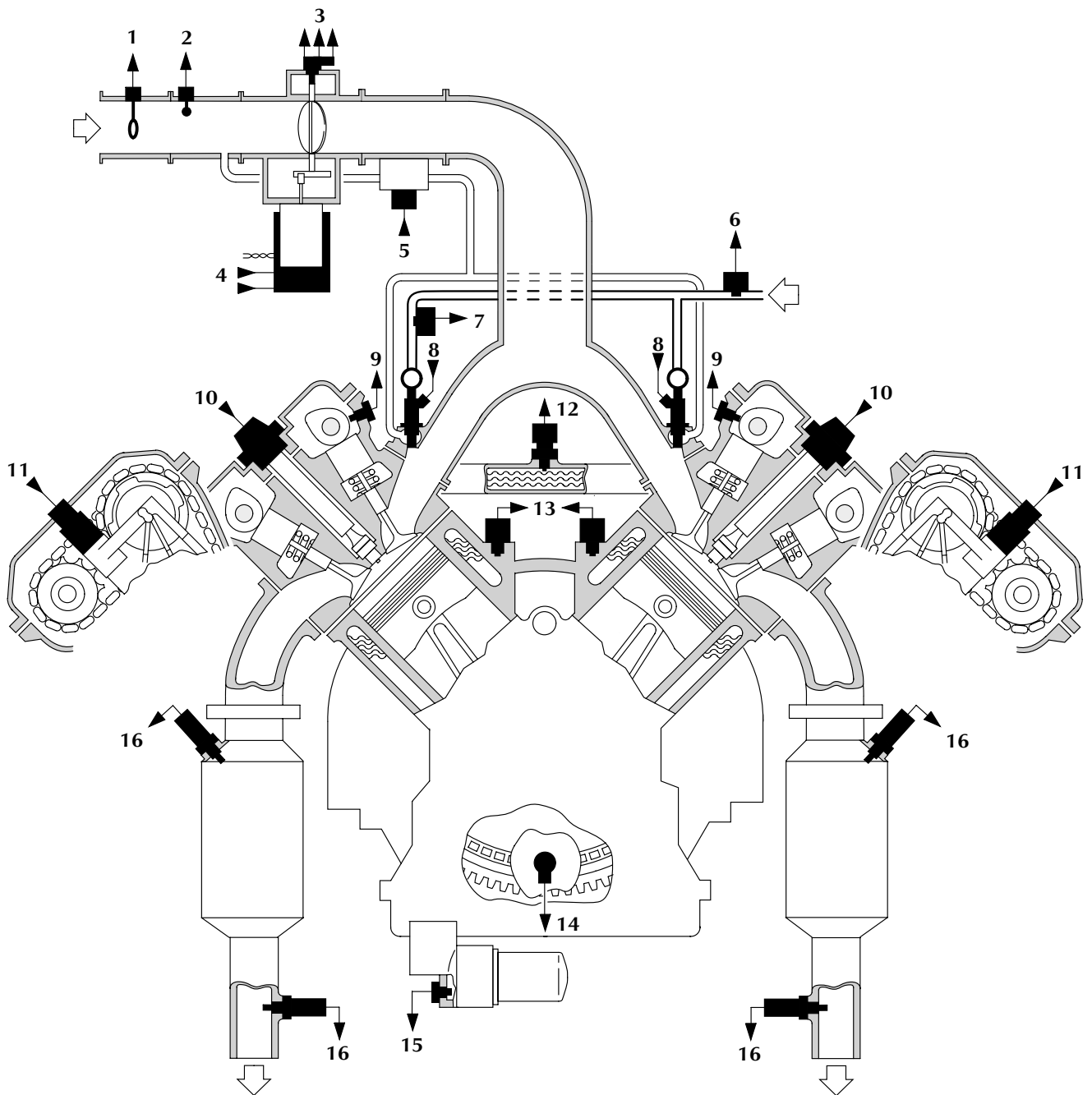
Upstream and downstream HO2 sensors are fitted and are of the type used on the V6 engine (the linear type sensor is not used).



Ignition System

The coil-on-plug ignition modules are specific to the AJ28 engine and are triggered directly from the PCM. Double electrode platinum plugs are fitted.

ENGINE MANAGEMENT SCHEMATIC



Key :

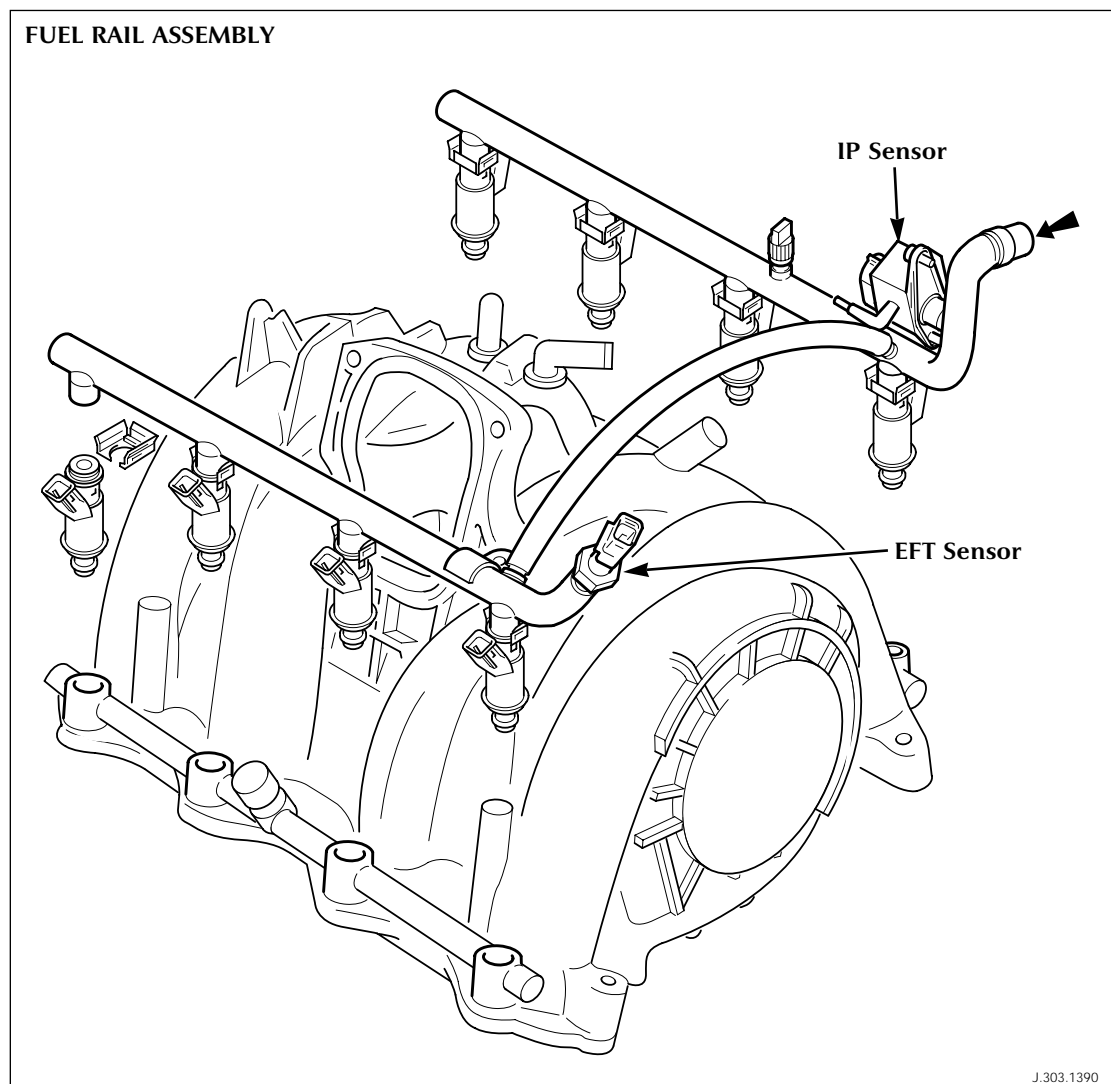
- | | | |
|-------------------|------------------------|-----------------|
| 1. MAF sensor | 7. EFT sensor | 13. KS sensors |
| 2. IAT sensor | 8. Fuel injectors | 14. CKP sensor |
| 3. TP sensor | 9. CMP sensor | 15. EOT sensor |
| 4. Throttle motor | 10. Coil-on-plug units | 16. HO2 sensors |
| 5. AAC valve | 11. VVT shuttle valve | |
| 6. IP sensor | 12. ECT sensor | |

J.303-1287

Fuel Injection

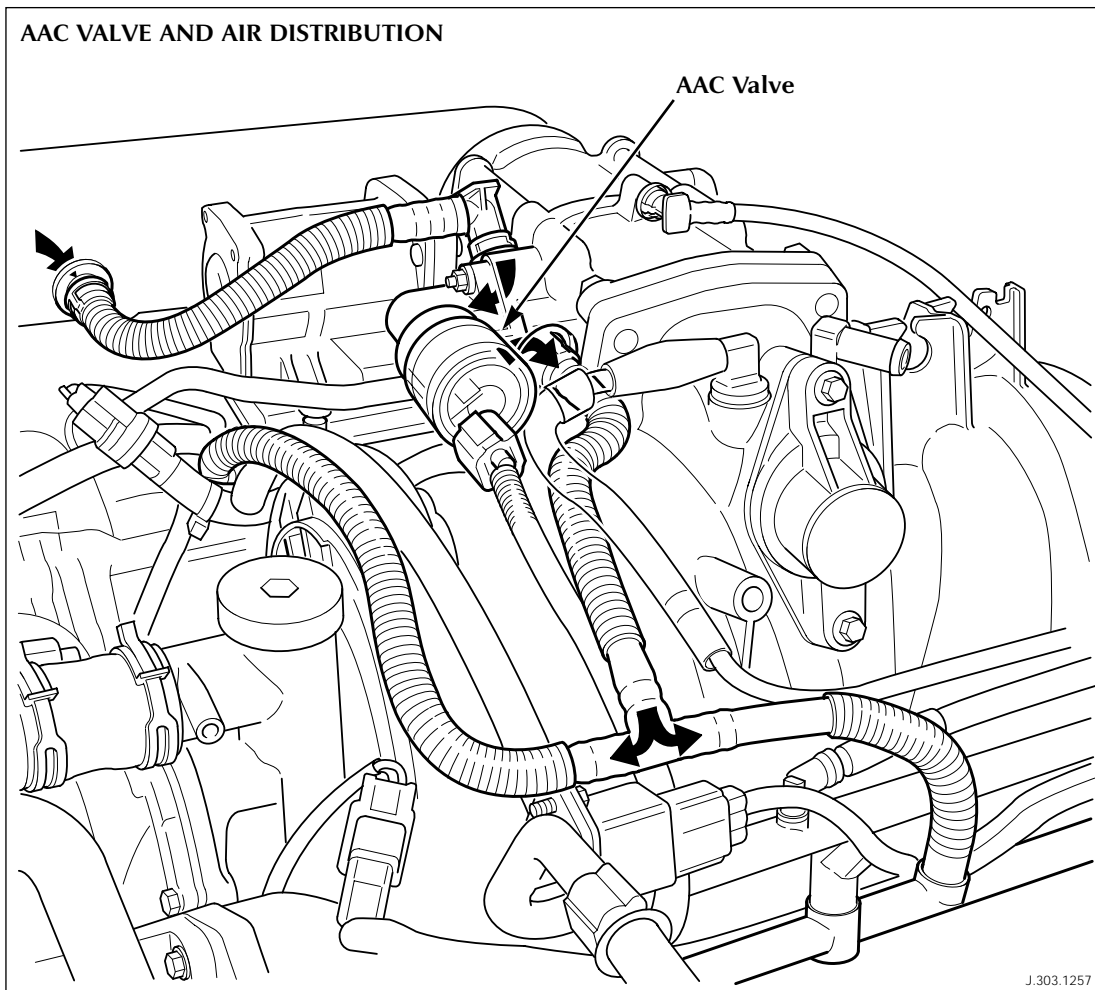
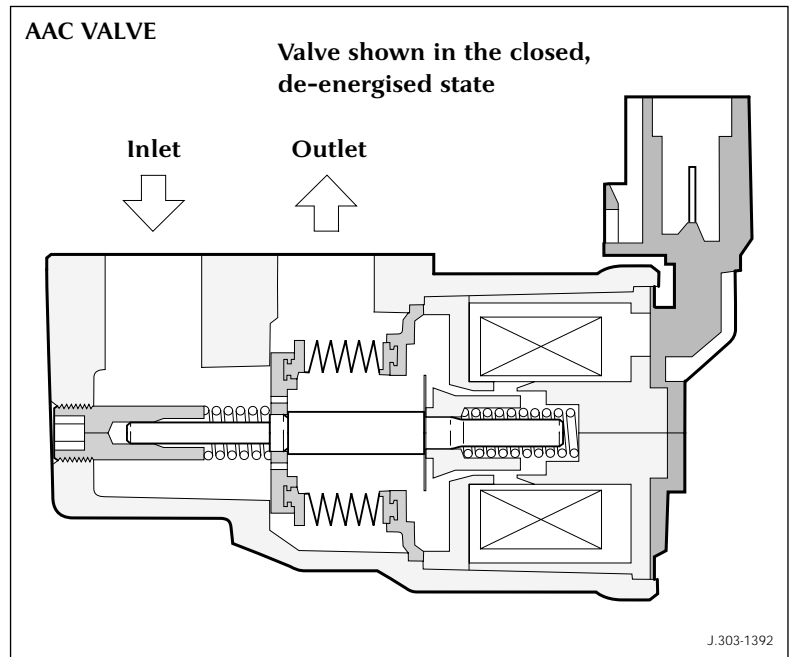
Returnless Fuel System

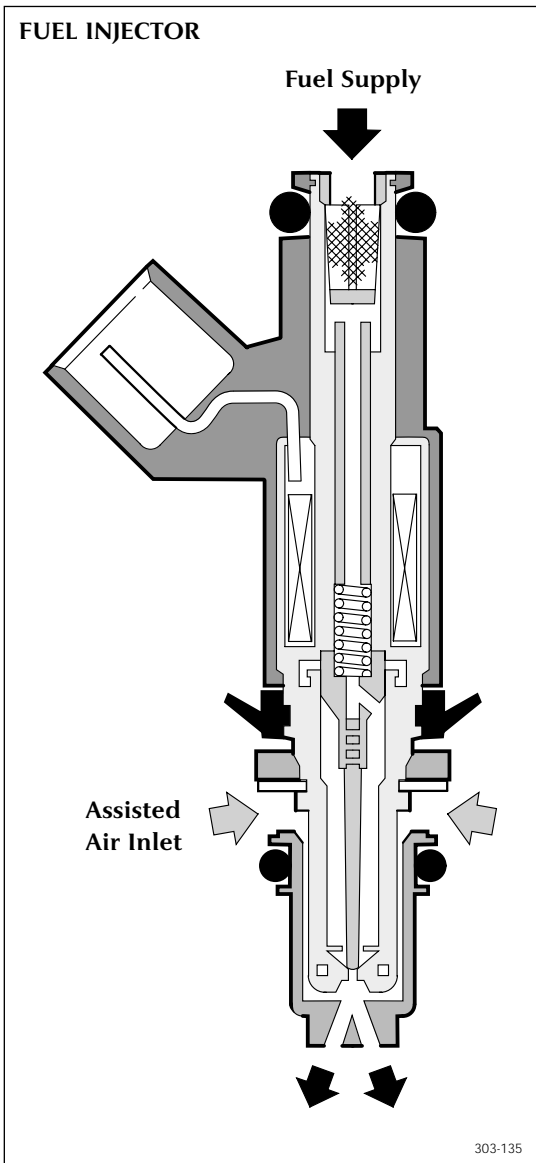
The function and operation of the returnless fuel system is the same as that fitted to the V6 engine but with different fuel pipework to suit the V8 layout. The air assisted, top fed, fuel injectors are supplied from two separate rails joined by an interconnecting cross-over pipe (similar to AJ27) with a single common feed from the fuel tank. The fuel rail assembly is removeable. An engine fuel temperature (EFT) sensor and injector pressure (IP) sensor provide feedback to the PCM to control the fuel pump flow rate (see 'S-TYPE Introduction' Technical Guide). Note that the EFT sensor is not in direct contact with the fuel ('dry' type sonser).



Air Assisted Injection

The air assisted injection system is very similar to the AJ27 system, with a solenoid valve controlling an air supply to the fuel injector nozzles. The AJ28 engine uses a different type of injector and air assist control AAC valve. The AAC valve bolts to the side of the throttle adaptor which provides an inlet port connection from the intake resonator duct via a hose and an outlet port to the air rails. The injectors are located in the air rails which are integral with the manifold.





Fuel Injectors

The type of fuel injector used operates in a similar way to the type fitted to the AJ27 engine but has a different shroud arrangement at the nozzle to provide the air/fuel mixing.

Front End Accessories Drive

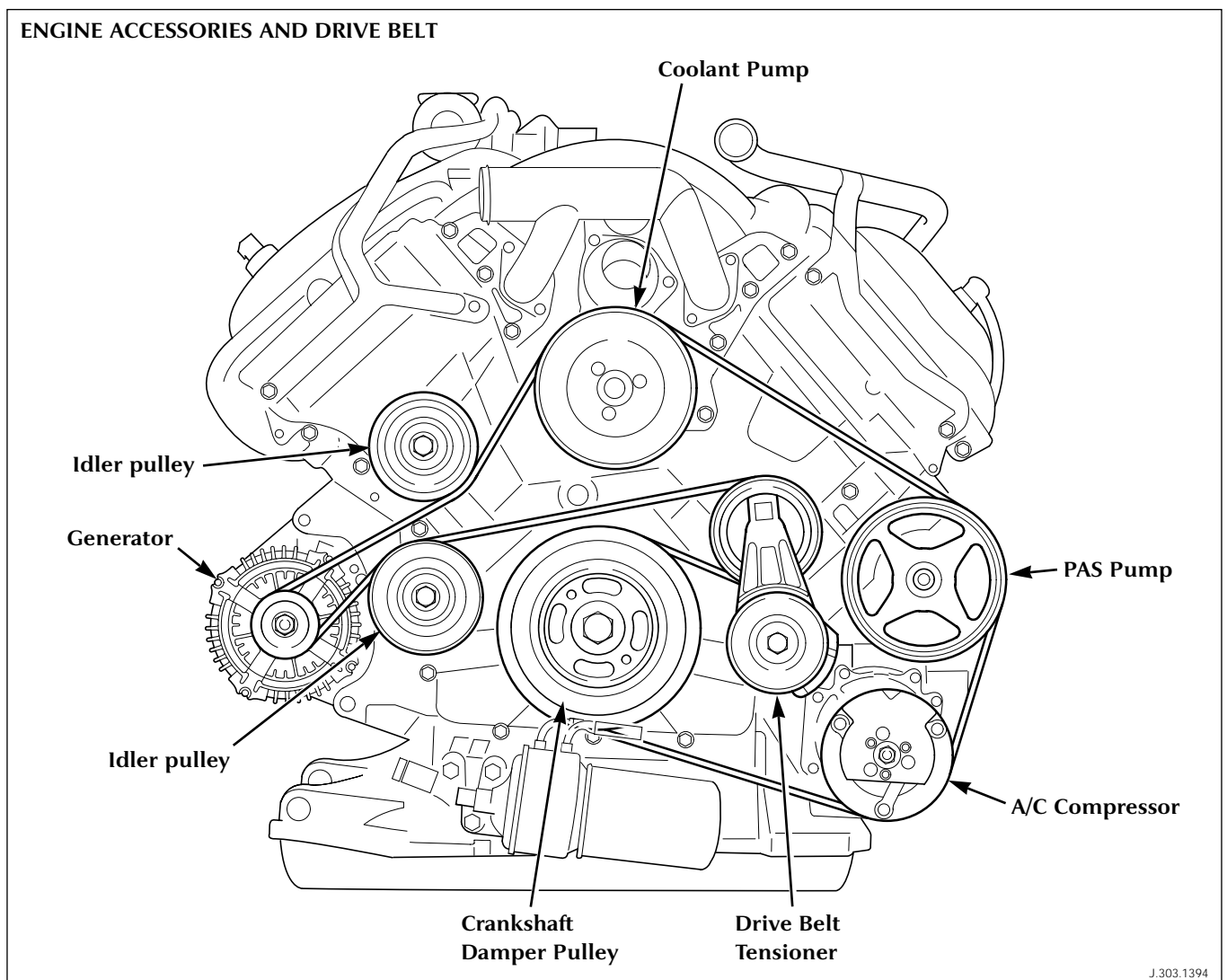
The front end accessories drive has a modified belt run, new type ancillaries and modified mounting brackets. The belt is changed to a 6-ribbed type and all pulleys are changed to suit.

Idler Pulleys and Tensioner

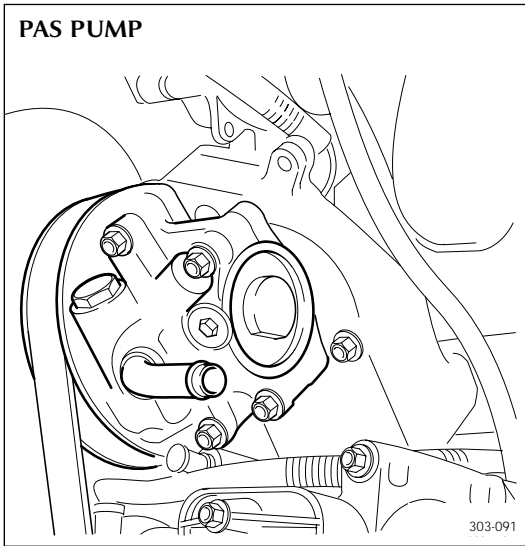
Two idler pulleys are used, the lower one mounted on the generator bracket and a new idler which screws directly into the engine front cover. The tensioner is mounted on the PAS pump support bracket.

Generator

The generator is electrically identical to the unit fitted to the V6 engine but with a different outer casing which allows it to be mounted via a similar (not identical) bracket to the AJ27 unit.



PAS PUMP

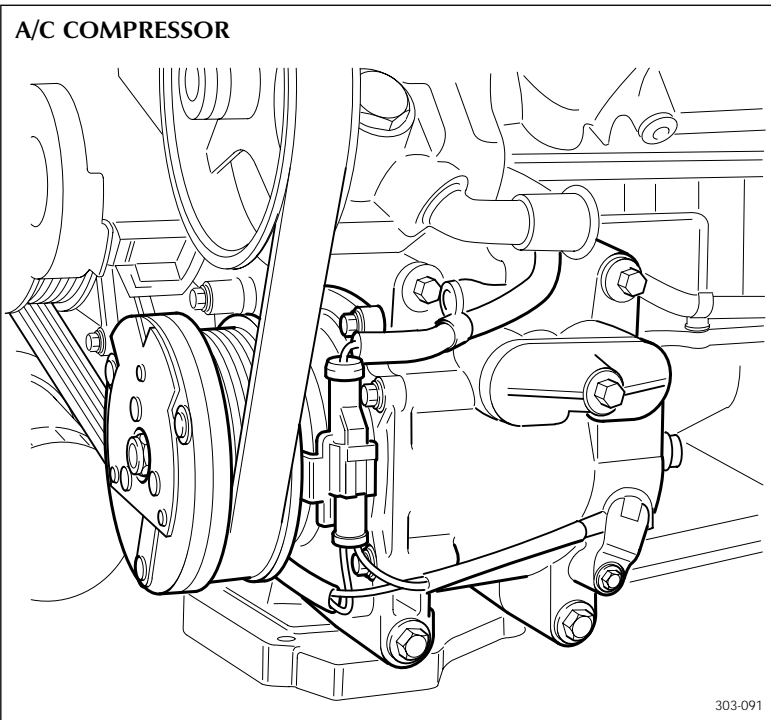


303-091

PAS Pump

A new type of PAS pump/pulley assembly and mounting bracket are fitted.

A/C COMPRESSOR



303-091

A/C Compressor

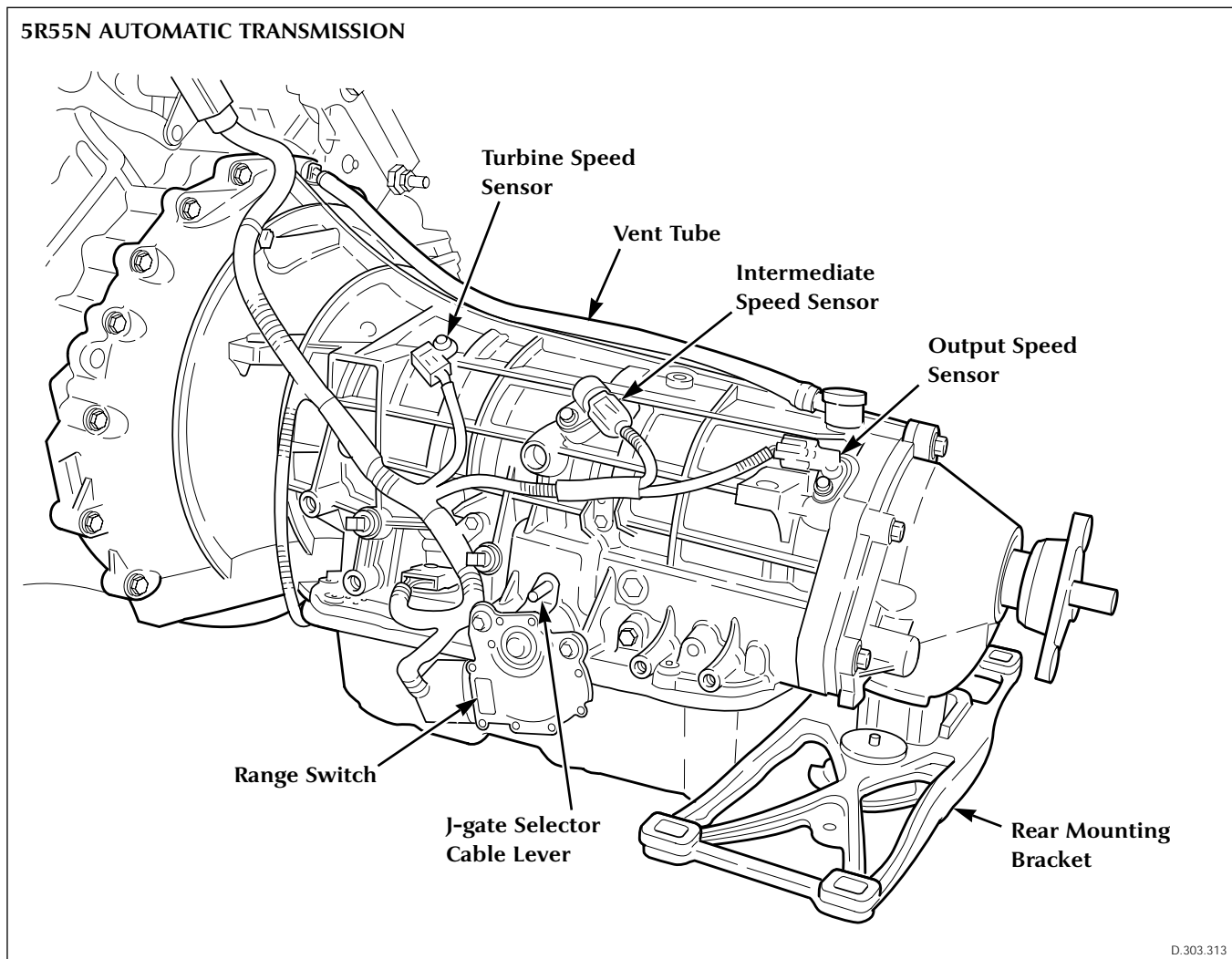
A new type A/C compressor is fitted. The unit is attached via an upper mounting bracket to the block and directly to the bedplate by lower bolts.

Introduction

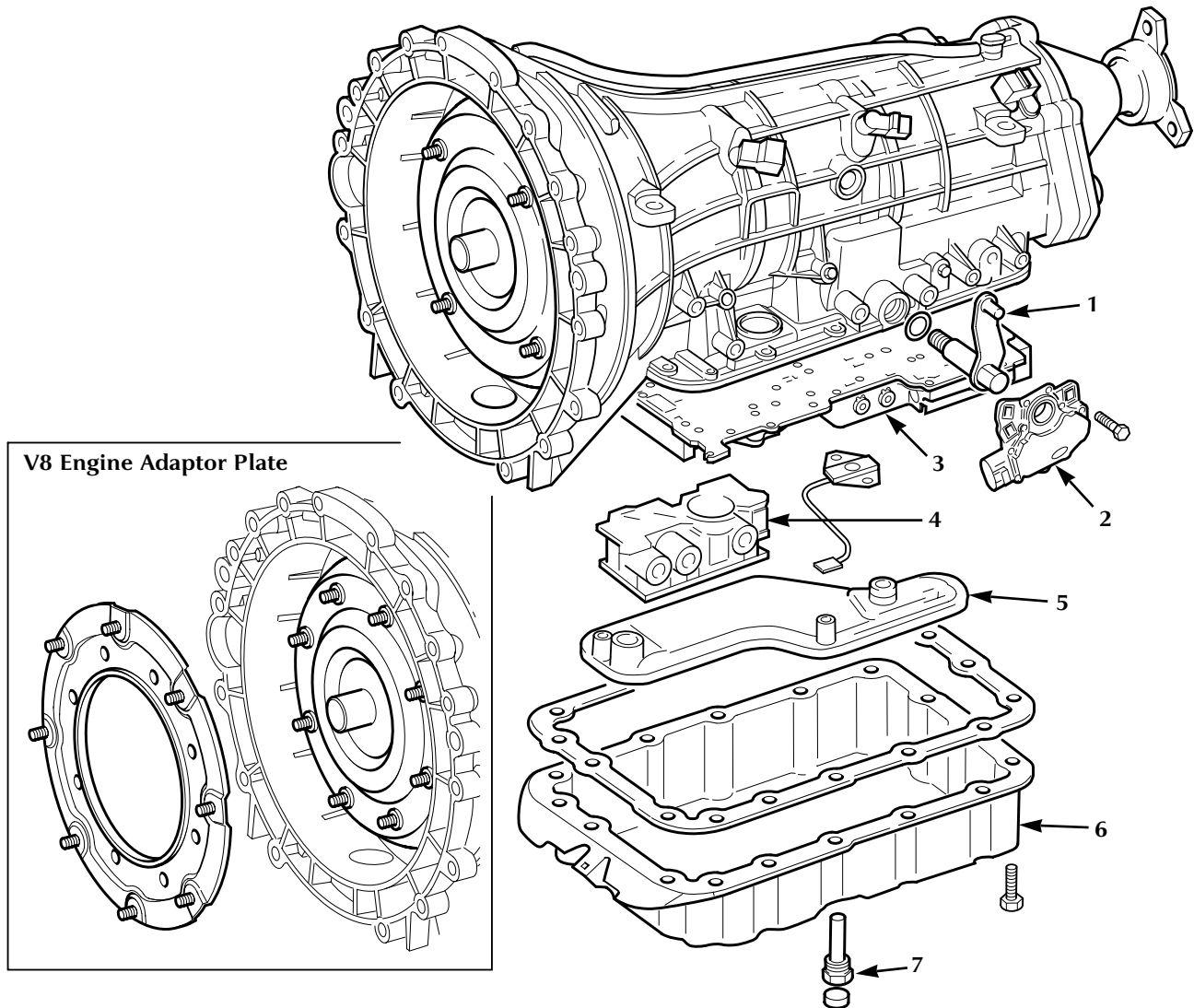
The 5R55N type 5-speed automatic transmission is fitted to both the V6 and V8 engines. The transmission is controlled electronically by the powertrain control module (PCM) without the use of a dedicated control module. Normal P, R, N, D drive functions plus manual selection of 4th, 3th and 2nd gears are provided by a Jaguar style 'J' gate (not the same as XJ and XK Series - see 'S-TYPE Introduction' Technical Guide). Sports mode and traction assistance are selected at the 'J' gate.

Specification

Transmission weight with fluid:	90 kg (198 lbs)					
Oil type:	Mercon V semi-synthetic (not compatible with other fluids)					
Oil capacity:	9 Litres (9.5 quarts) - new 5 Litres (5.3 quarts) - after draining					
Oil Fill/change:	Filled for life, no top up required (no dipstick)					
Gear ratios:	1st	2nd	3rd	4th	5th	Rev
	3.24 : 1	2.44 : 1	1.55 : 1	1 : 1	0.75 : 1	3.07 : 1



5R55N AUTOMATIC TRANSMISSION



- | | |
|--------------------------------|--------------------|
| 1. J-gate selector cable lever | 5. Filter assembly |
| 2. Range switch | 6. Sump |
| 3. Control Module | 7. Drain plug |
| 4. Solenoid block assembly | |

D.307.321

Construction and Operation

The transmission housing consists of a one piece die cast aluminium case with re-inforcement ribs to minimise noise, vibration, and harshness (NVH). To allow for the different physical size of the engines, there are two transmission variants with different overall lengths and bell housings to match the respective engines, the V8 variant being shorter. Different torque converters are necessary and the V8 variant is also fitted with an adaptor

plate to mate the torque converter to the larger diameter drive plate on the V8 engine.

The main features of the transmission unit are :

- torque converter with a twin friction face lock-up clutch and torsional damper
- geartrain consisting of three epicyclic gearsets
- shift elements consisting of multi-plate clutches, brakes and one way clutches
- control actuators: four shift solenoids, three variable force solenoids and a PWM

controlled solenoid are mounted on an integral, replaceable, control module

- three speed sensors mounted on the external casing: turbine speed sensor, intermediate speed sensor and output speed sensor
- an oil temperature sensor is fitted inside the transmission.

The gear select lever is connected via a Bowden cable to an operating lever on the left side of the transmission casing. A digital rotary switch, the transmission range switch, fits over the shaft of the operating lever and is fixed by two bolts to the transmission casing. Selection of a particular drive function generates a 4 bit binary coded signal which is transmitted directly to the PCM over a four wire parallel interface. As on the XK and XJ Series, lateral movement of the gear select lever across the gate, D to 4 or 4 to D, operates a switch which indicates the selected function to the PCM (the Bowden cable is not actuated laterally).

The PCM directly controls the transmission actuators as a response to driver demand, engine requirements and according to the selected shift mode. Gear selection is controlled by commands to the four shift solenoids. If, during gear selection, the relative speeds monitored by the speed sensors are not as expected, the PCM varies the analogue signal to the variable force solenoids to increase/decrease the clutch pressure (closed loop control). Increased engagement times due to ageing are also controlled by adaptive shift

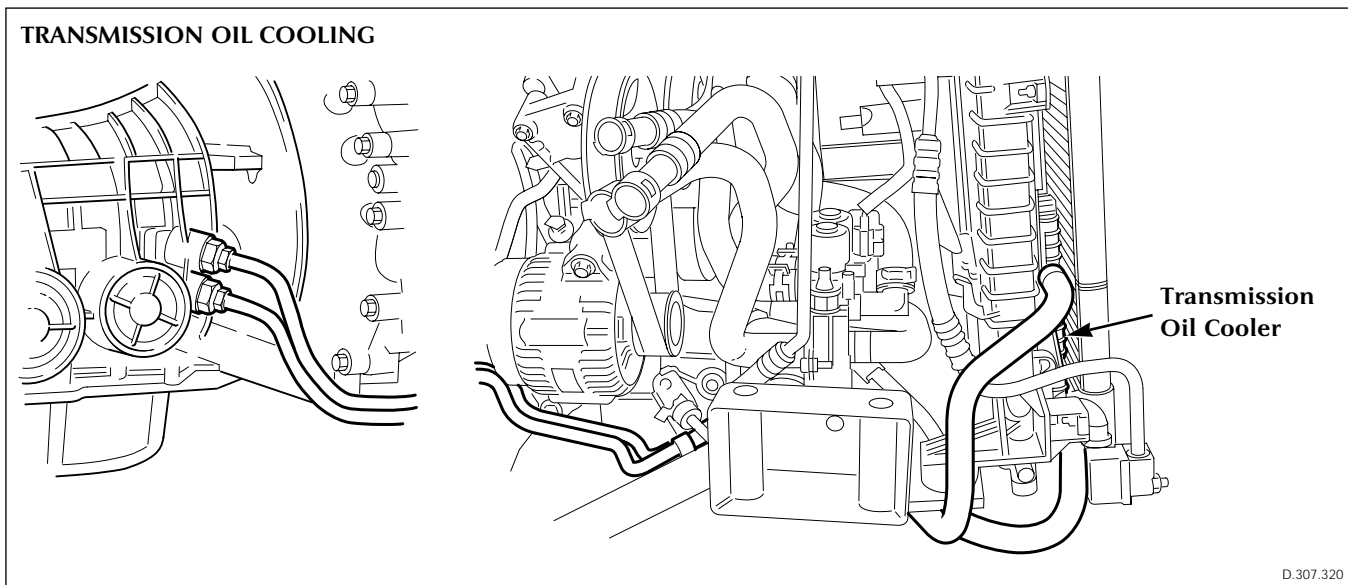
pressure.

Apart from the sports mode and traction mode selected by the driver, there are pre-programmed modes selected by the PCM in response to sensed driving conditions :

- increased load such as gradients and trailer towing
- cruise control
- hot mode: strategies including clutch lock up are applied to reduce heat.

Transmission Oil Cooler

The transmission fluid is cooled externally by a dedicated oil to air radiator which is mounted in the integral cooling pack between the engine radiator and A/C condenser and below the PAS cooler.



Introduction

In European markets only, manual transmission is fitted as standard on the V6 entry S-TYPE model and as an option on the V6 high specification model. Manual transmission is not available for the V8 variant. The manual transmission is a 5 speed Getrag 221 unit with the following features:

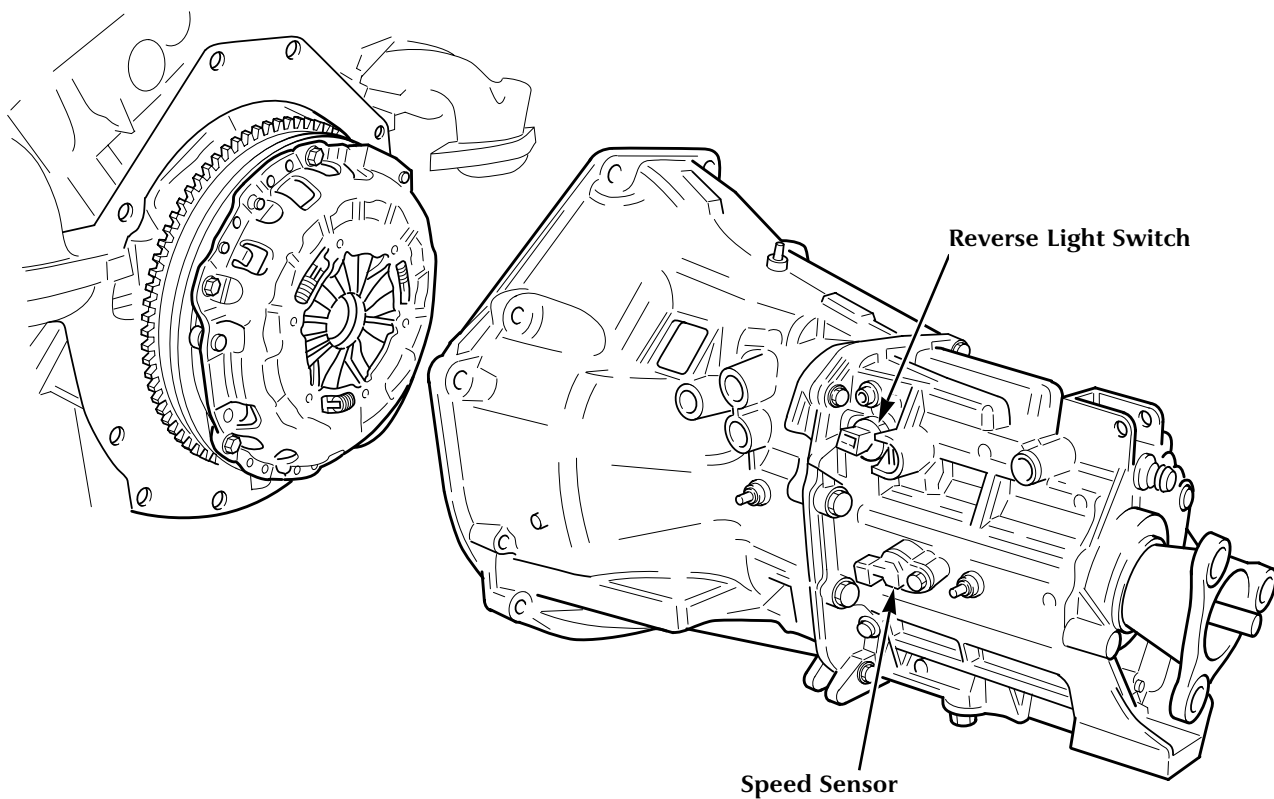
- direct gearing (1:1) on 5th gear (it is normally on 4th) reduces losses
- twin synchronising cones on 1st and 2nd gears provide a smoother change
- four plane shift gate (R-1-3-5) with 'knock-over' protection on the Reverse position.

A reverse light switch and speed sensor are fitted on the LH side of the gearbox. The speed sensor monitors output shaft speed to provide an input to the PCM in addition to the signals received from the road wheel speed sensors.

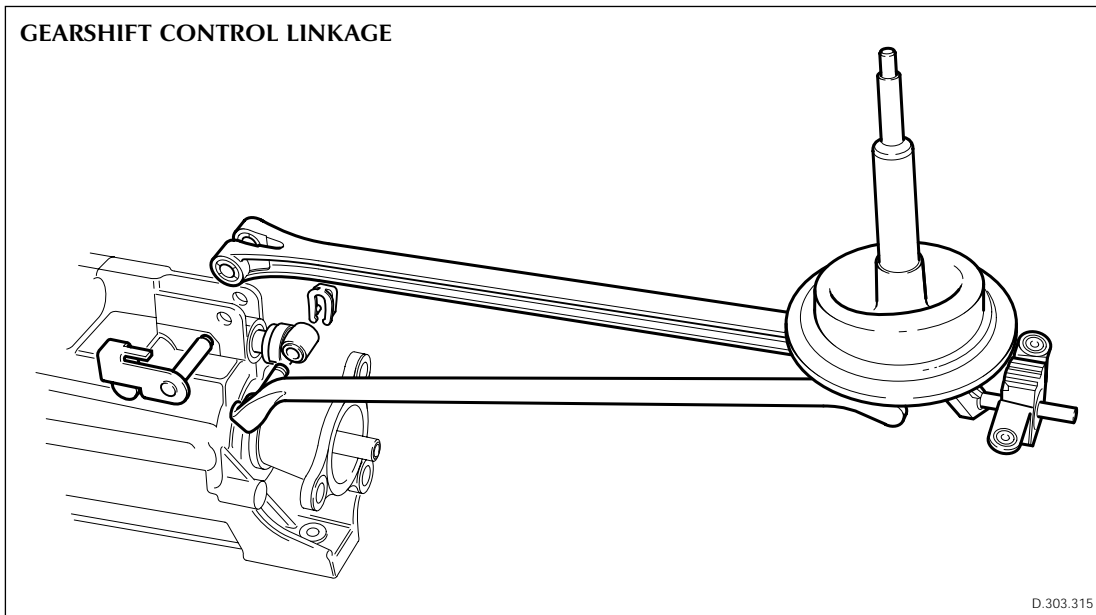
Specification:

Gear ratios:	1st	2nd	3rd	4th	5th	Reverse
	4.23 : 1	2.52 : 1	1.67 : 1	1.22 : 1	1 : 1	4.14 : 1
Weight:	33 kg (72 lbs)					
Oil specification:	ESSOD21065					
Oil change interval:	60,000 miles (96,000 km)					

MANUAL TRANSMISSION, CLUTCH ASSEMBLY AND DUAL MASS FLYWHEEL



D.307.312



Gear Selector Control

The gear selector mechanism is designed to give a smooth positive action. The lever assembly is mounted via a bracket to the floor, not the transmission. Further isolation is provided by the use of low friction bushes and tuned shift mechanism compliance.

Flywheel and Clutch

The clutch system is based on the established principle of a single driven plate and diaphragm spring hydraulically actuated from the clutch pedal but incorporates the following special features:

- dual mass flywheel
- self adjusting clutch
- concentric slave cylinder.

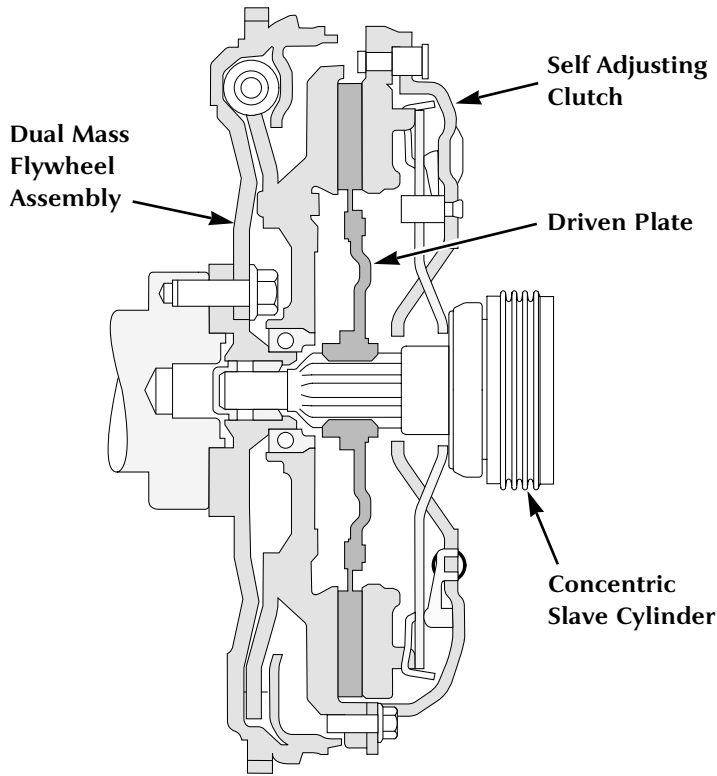
Flywheel

While the use of a dual mass flywheel is not new to Jaguar, the model described here incorporates the latest refinements in the technology. Relative rotational movement between the primary and secondary flywheel masses via the damper system is greater than on previous vehicles, giving further improvements in torsional vibration isolation (engine irregularities) and reducing stresses on the crankshaft and drivetrain. Steel pressings rather than castings are used to reduce the weight of the assembly. The flywheel assembly is not a serviceable item but the bearing can be released for servicing.

Self Adjusting Clutch

The self adjusting clutch is an innovative feature which improves operation and driver comfort by enabling a constant pedal pressure to be applied as the friction faces wear, unlike conventional types of clutch which require increasing pressure with wear.

DUAL MASS FLYWHEEL AND CLUTCH ASSEMBLY

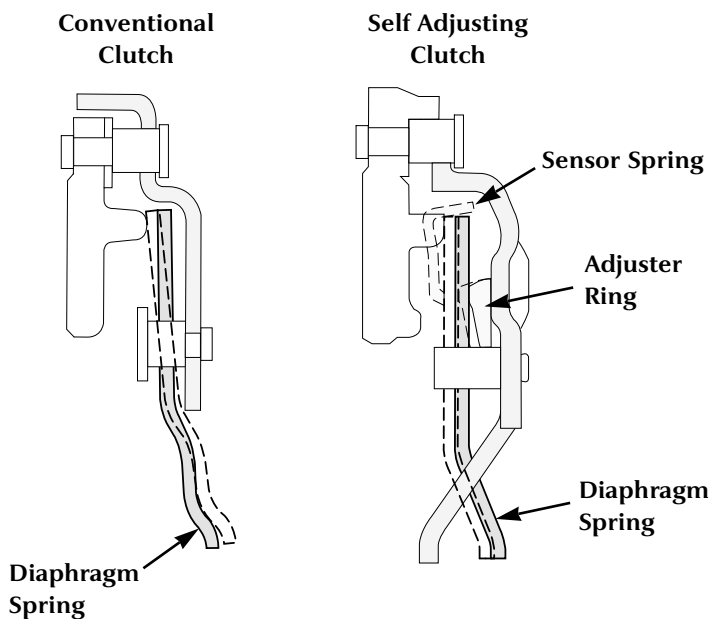


J.307.318

With a conventional clutch, increased lining wear causes the angle of the actuating diaphragm spring to change as the pressure plate moves axially towards the engine, requiring a greater force to operate the clutch (diaphragm actuating force varies with diaphragm angle). The self adjusting clutch eliminates the problem by allowing the diaphragm spring to follow the axial movement of the pressure plate thus maintaining the diaphragm spring at the same angle throughout the life of the clutch. As well as maintaining a constant pedal pressure, the clamp force on the pressure plate also remains constant with wear.

The operation is shown in the diagram. The diaphragm spring is not fixed at its rotation point like the conventional system but pivots between a sensor spring and an adjuster ring. The sensor spring provides a counter force which is just sufficient to retain the diaphragm spring axially against the cover via the adjuster ring and during normal actuation of the clutch. As the linings wear, the tendency of the diaphragm angle to change causes an increase in the actuation force required to operate the clutch. When this increased effort exceeds the counter force of the sensor spring, the diaphragm spring moves axially towards the pressure plate until the original angle is restored. At this point the actuation force required drops to the level of the opposing sensor spring force, restoring equilibrium with the diaphragm spring at its new location.

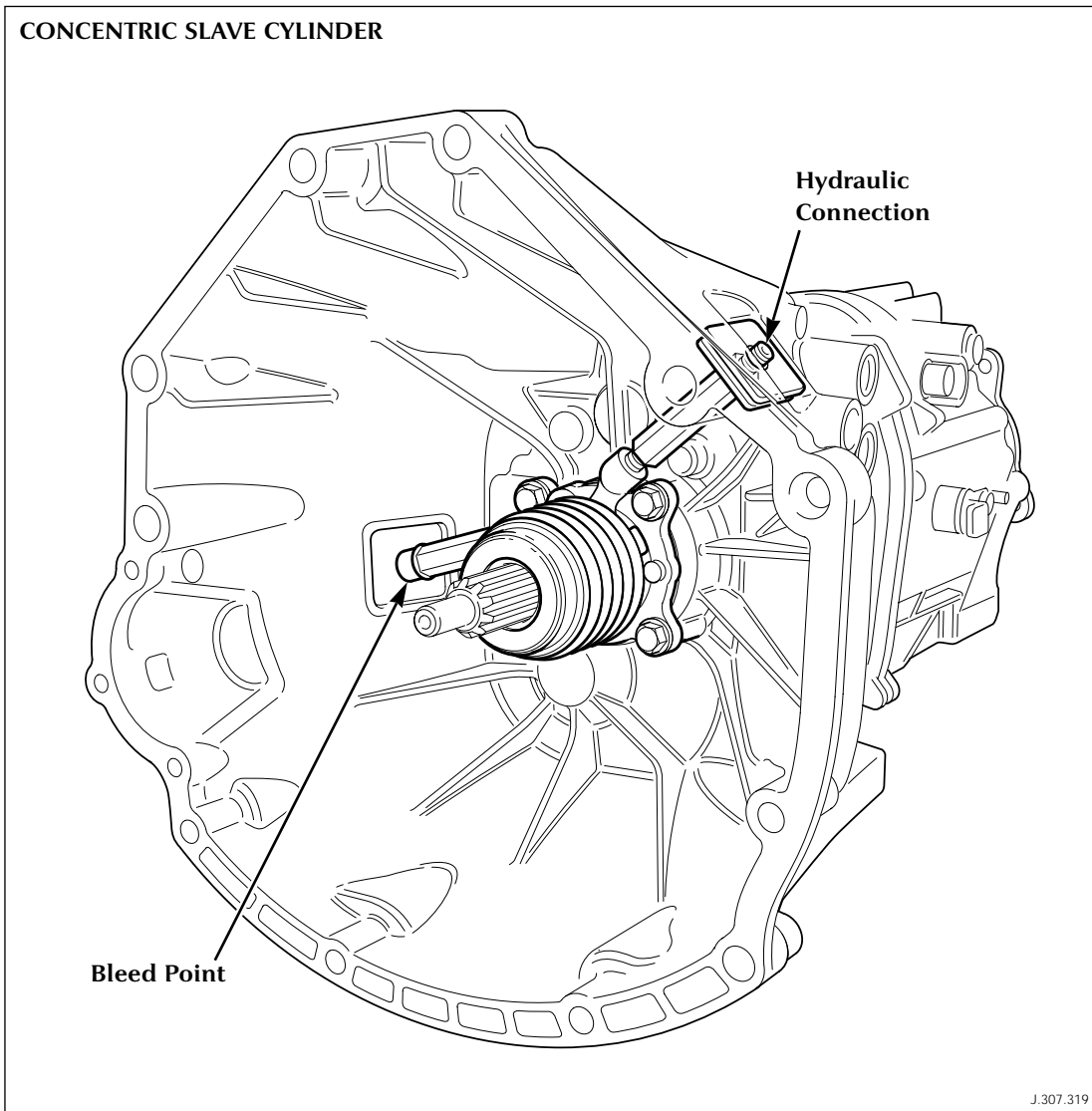
OPERATION OF SELF ADJUSTING CLUTCH



J.307.319

During the axial movement of the diaphragm spring, the increased distance between the spring and cover is taken up by the adjuster ring. This ring has fifteen raised segments, each having a ramp profile which fits into a corresponding shape in the clutch cover. When the diaphragm spring moves axially for wear compensation, three pre-loaded coil springs in the clutch cover cause the adjuster ring to rotate, moving up the ramps and taking up the extra distance between the diaphragm spring and clutch cover.

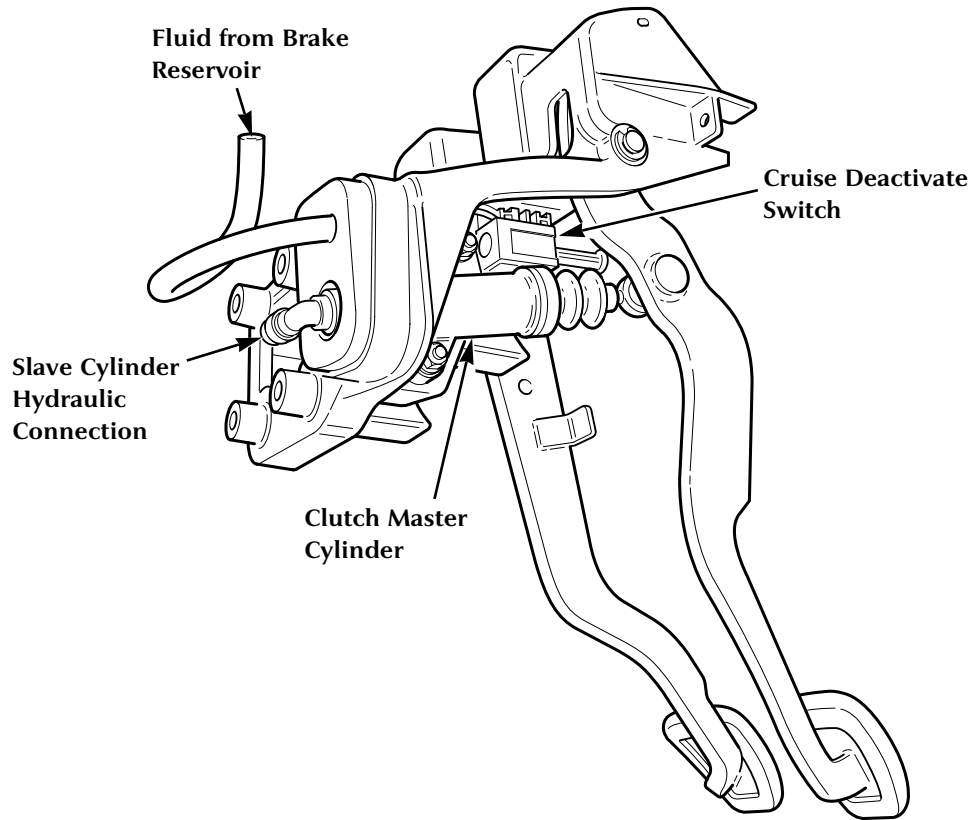
Note that, in operation, the adjuster ring rotates in a clockwise direction, as viewed from the transmission. If a worn driven plate is replaced in service and the clutch cover assembly is to be re-used, the adjuster ring must be rotated back to its pre-loaded position (see JTIS service instructions).



Concentric Hydraulic Cylinder

The clutch diaphragm spring is operated directly by a slave hydraulic cylinder located concentrically about the transmission input shaft. This system eliminates the need for a release lever mechanism and improves operating efficiency.

CLUTCH PEDAL ASSEMBLY



D.307.316

Clutch Pedal Assembly

The clutch pedal is mounted on a combined assembly with the brake pedal. The clutch master cylinder is directly actuated by the pedal and shares a common reservoir with the brake system. An assist spring is fitted to the clutch pedal to reduce the actuation load.

Operation of the pedal when in cruise control mode activates a switch which cancels this mode.

Introduction

All powertrain and associated management functions are controlled from a single unit, the powertrain control module (PCM). These functions are as follows:

- overall monitoring and control of performance, fuel economy, emissions, driveability and safety
- receives and processes direct inputs from engine, transmission, fuel system and ancillary systems sensors
- provides direct control of actuator devices
- communicates with other modules via the SCP bus (eg to obtain wheel speed information)
- provides system diagnostics to conform to OBDII requirements.

Powertrain Control Module (PCM)

The basic PCM is common to the V6 and V8 engines but with unique programming to suit the respective engine characteristics and some differences in the interface circuits for the different sensors and actuators.

The PCM is located below the LH or RH mounted A/C evaporator/blower unit and has a single connector panel which protrudes through the forward bulkhead into the engine bay.

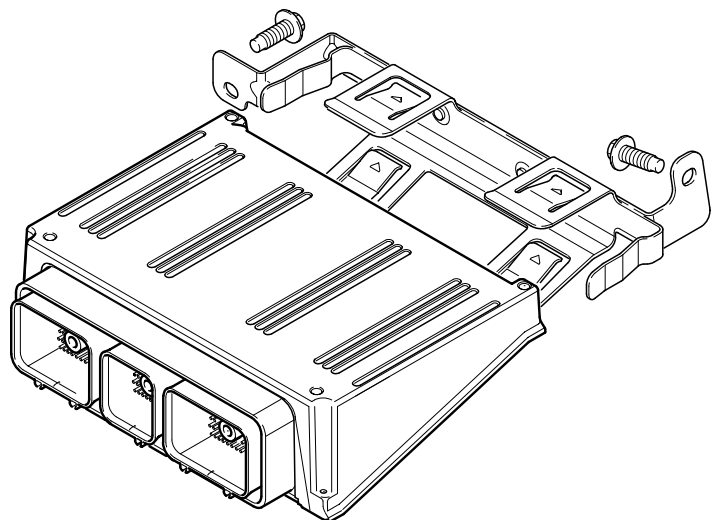
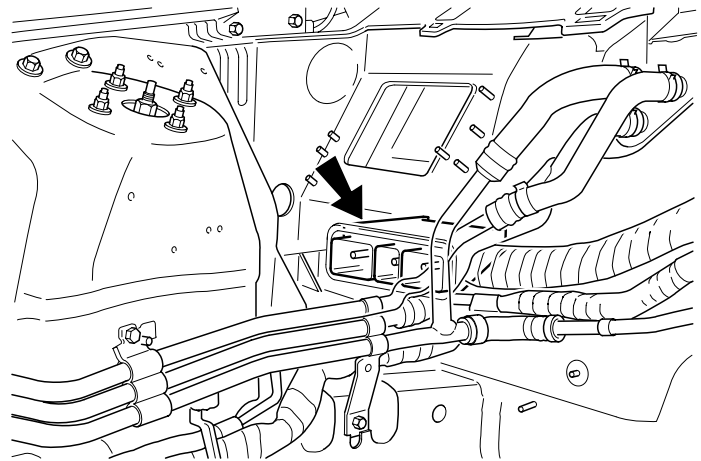
The PCM has three connectors:

- a 60 pin connector which provides the interfacing with the engine wiring harness: carries engine mounted sensor inputs and output control signals
- a 32 pin connector which carries the transmission sensing and control signals and also the rear HO2 sensor inputs
- a 58 pin connector which carries non engine mounted sensor and actuator signals and provides the PCM link to the SCP bus.

Powertrain Sub-Systems

Brief descriptions of PCM control of new subsystems are given in the relevant engine and transmission sections (electronic throttle, returnless fuel etc).

POWERTRAIN CONTROL MODULE



J.303.1393

