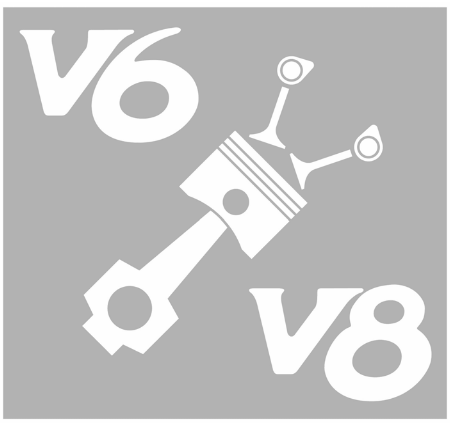
TRAINING PROGRAM

JAGUAR V6/V8 ENGINE REPAIR



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COURSE OBJECTIVES

- Describe the practical similarities and differences between Jaguar V6 and V8 engines
- Disassemble and reassemble V6 and V8 engine using Jaguar special tools and factory recommended procedures
- Inspect, measure and identify out of specification components
- Select needed service part sizes (bearing shells, pistons, shims)
- Set camshaft timing and adjust valve clearances
- Describe the function and advantages of variable valve timing

PROGRAM CONTENT

1. INTRODUCTION
2. GENERAL INFORMATION
3. ENGINE SERVICE GENERAL INFORMATION
4. JAGUAR V8 ENGINES
5. JAGUAR V6 ENGINES
6. WORKSHEETS - AJ26/27/28
7. WORKSHEETS - AJ33/34
8. WORKSHEETS - AJ60
9. WORKSHEETS - AJ61/62

DISCLAIMER

The illustrations, technical information, data and descriptive text in this publication, to the best of our knowledge, were correct at the time of going to print. The right to change specifications, equipment, procedures and maintenance instructions at any time without notice is reserved as part of our policy of continuous development and improvement.

No liability can be accepted for any inaccuracies or omissions in this publication, although every possible care has been taken to make it as complete and accurate as possible.

Jaguar Cars North America Service Training Department

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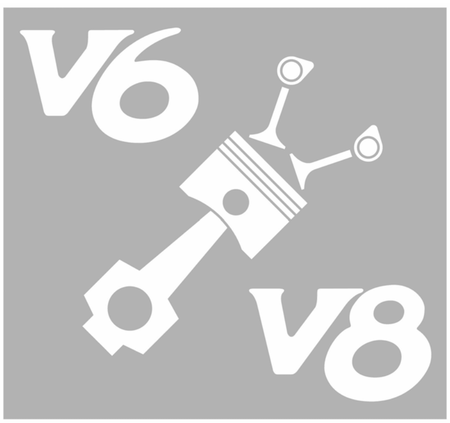

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COURSE CONTENT

Jaguar Service Training Course 168 covers the base engine components for the AJV8 and AJV6 engine families, and each of their variants:

- **AJV8**
  - AJ26 / AJ27 / AJ28
  - AJ33 / AJ34
- **AJV6**
  - AJ60
  - AJ61 / AJ62

The course will cover the basic engine hardware for both engine families, and detail the evolutionary changes to subsystems, where applicable.

The course will first review the common base engine integrity and specification measurements, and discuss the meaning of these measurements.

System Applicability

System applicability and variants are included in each section of this Student Guide.

Table 1 Jaguar V6/V8 Engine Evolution (1997–Onwards)

Vehicle	Model Year	Engine Configuration and Displacement	Comments
XJ and XK8	1997 - 98 N/A 1998 - 99 S/C	AJ26 4.0L V8 N/A and S/C	AJ26 Electronic throttle with mechanical guard
XK8 XJ8	1999 - 02 1999 - 03	AJ27 4.0L V8 N/A	AJ27 Electronic throttle with mechanical limp home mode, New continuous VVT, air assist, new CKP, O2, KS, MAF on N/A, new coils, top fed injectors
XJR XKR	2000 - 03 2000 - 02	AJ27 4.0L V8 S/C	S/C adopts AJ27 strategies
S-TYPE	2000 - 02	AJ28 4.0L V8 N/A AJ60 3.0L V6	New returnless fuel system, V6 with cylinder head temp sensor, AJ28 V8 new sensors, full authority throttle (no cable)
S-TYPE	2003 –	AJ33 4.2L V8 N/A AJ33 4.2L V8 S/C AJ62 3.0L V6	Increased V8 displacement, new VVT design, no air assist No CHT on V6, new VVT design
X-TYPE	2002 –	AJ61 2.5L V6 AJ61 3.0L V6	no CHT
XJ	2004 –	AJ33 4.2L V8 N/A AJ33 4.2L V8 S/C	C/O S-TYPE 2003MY
XK	2003 –	AJ34 4.2L V8 N/A AJ34 4.2L V8 S/C	modified AJ33 to package in XK

Table 2 Jaguar Model Year and Model Code Information

Model year	Model (Engineering Designation)
1998-2003	XJ Sedan Range (X308)
2004–Onwards	XJ Sedan Range (X350)
1997-2002	XK Range (X100)
2003–2004	XK Range (X103)
2005–Onwards	XK Range (X105)
2000–2002	S-TYPE (X200)
2003–2004	S-TYPE (X202)
2005–Onwards	S-TYPE (X204)
2002–2003	X-TYPE (X400)
2004–Onwards	X-TYPE (X404)

ACRONYMS AND ABBREVIATIONS

NOTE:

A large majority of these abbreviations conform to the standards of SAE J1930

- AACV — Air Assist Control Valve
- AAI — Air Assisted Injection
- ABS — Anti-lock Braking System
- A/C – Air Conditioning
- A/C CM Air Conditioning Control Module
- ACC — Adaptive Cruise Control
- APP sensor – Accelerator Pedal Position Sensor
- ASL — Automatic Speed Limiter
- B+ – Battery Voltage
- CAN – Controller Area Network
- CCV — Canister Close Valve
- CKP sensor – Crankshaft Position Sensor
- CHT sensor — Cylinder Head Temperature sensor
- CM — Control Module
- CMP sensor (A) 1 – Camshaft Position Sensor - RH Bank
- CMP sensor (B) 2 – Camshaft Position Sensor - LH Bank
- C/O — Carry Over
- CO — Carbon Monoxide
- CPU – Central Processing Unit
- D2B — Digital Data Bus
- DC — Direct Current
- DIN — Deutsche Industrie Normen
- DLC – Data Link Connector
- DPFE — Differential Pressure Feedback EGR
- DTC – Diagnostic Trouble Code
- DSC — Dynamic Stability Control
- ECATS — Enhanced Computer Active Technology Suspension
- ECM – Engine Control Module
- ECT sensor – Engine Coolant Temperature Sensor
- ECU — Electronic Control Unit
- EPROM — Erasable Programmable Read Only Memory
- EEPROM — Electrically Erasable Programmable Read Only Memory
- EFT sensor – Engine Fuel Temperature Sensor
- EGR – Exhaust Gas Recirculation
- EMS — Engine Management System
- EOT sensor – Engine Oil Temperature Sensor
- EVAP Canister Close Valve – Evaporative Emission Canister Close Valve
- FPDB — Front Power Distribution Box
- FEM – Front Electronic Control Module
- FTP — Federal Test Procedure
- FTP sensor – Fuel Tank Pressure Sensor
- FSC — Fail Safe Cooling strategy
- GEM – Generic Electronic Module
- HC — Hydrocarbons
- HO2 sensor 1/1 –Heated Oxygen Sensor - RH Bank/Upstream
- HO2 sensor 1/2 –Heated Oxygen Sensor - RH Bank/Downstream
- HO2 sensor 2/1 –Heated Oxygen Sensor - LH Bank/Upstream
- HO2 sensor 2/2 –Heated Oxygen Sensor - LH Bank/Downstream
- IAT sensor – Intake Air Temperature Sensor
- IC — Instrument Cluster
- IG – Ignition
- IMT Valve – Intake Manifold Tuning Valve (1 = top, 2 = bottom)
- IP sensor – Injection Pressure Sensor
- ISO — International Standards Organization
- JTIS — Jaguar Technical Information System
- KAM — Keep Alive Memory
- KS 1 – Knock Sensor RH bank

- KS 2 – Knock Sensor LH bank
- KTM — Key Transponder Module
- LED — Light Emitting Diode
- LEV — Low Emissions Vehicle
- LTFT — Long Term Fuel Trim
- MAF sensor – Mass Air Flow Sensor
- MIL — Malfunction Indicator Lamp
- N/A – Normally Aspirated
- NAS – North American Specification
- NTC – Negative Temperature Coefficient
- NOx — Oxides of Nitrogen
- OBD – On-Board Diagnostics
- O/C — Open Circuit
- ORVR — On-board Refuelling Vapor Recovery
- PATS — Passive Anti-Theft System
- PAD — Passenger Airbag Deactivation light
- PCB — Printed Circuit Board
- PJB — Passenger Junction Box
- PTEC — PowerTrain Electronic Control
- PPS – Pedal Position Sensor
- PCM – Powertrain Control Module
- PWM — Pulse Width Modulation
- RAM — Random Access Memory
- RCM — Restraints Control Module
- RCCM — Remote Climate Control Module
- RCCP — Rear Climate Control Panel
- REM – Rear Electronic Module
- ROM — Read Only Memory
- RHS — Right Hand Side
- RPDB — Rear Power Distribution Box
- ROW – Rest of the World Specification
- SAE — Society of Automotive Engineers
- S/C – Super Charged
- SCP – Standard Corporate Protocol Network
- STFT — Short Term Fuel Trim
- SWAS — Steering Wheel Angle Sensor
- TACM — Throttle Actuator Control Module
- TCM — Transmission Control Module
- TFT sensor – Transmission Fluid Temperature Sensor
- TLEV — Transitional Low Emission Vehicle
- TM – Throttle Motor
- TOT — Transmission Oil Temperature
- TP– Throttle Position
- ULEV — Ultra Low Emissions Vehicle
- VIS – Variable Intake System
- VSV — Vacuum Solenoid Valves
- VVT 1 – Variable Valve Timing solenoid valve - RH Bank
- VVT 2 – Variable Valve Timing solenoid valve - LH Bank
- WOT — Wide Open Throttle

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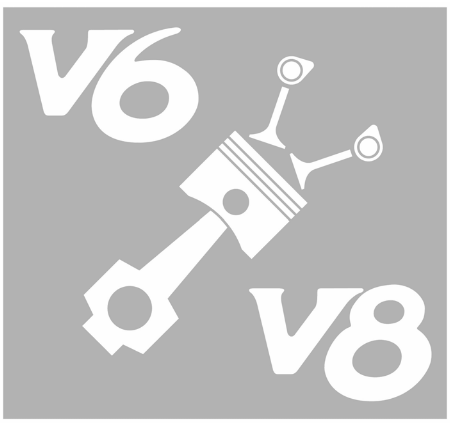

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ENGINE SERVICE

Best Practices — Servicing Aluminum Engines

Never use metal scrapers to remove residue. Metallic scrapers are capable of causing serious damage to aluminum and plastic surfaces in the form of scratches and depressions. The surface damage results in leaks. A plastic or wooden scraper is essential for carrying out these kinds of operations.

IMPORTANT: Never attempt to clean gasket surfaces using grinders, rotating steel brushes or tools with cutting edges. Prevent gasket residue from entering the engine by covering all engine orifices where possible. Be especially careful when installing components such as cylinder heads, intake manifolds, timing covers and oil pans as these are all critical areas with high potential for leakage.

ALWAYS replace used gaskets, regardless of condition or type of material. Observe the instruction in GTR. Gasket sealer is not required on all gaskets, and could be a detriment if used when not required. Some gaskets are pre-shaped meaning that the application of sealant could lead to excess height or local distortion in the gasket, with leaks as the ultimate results.

Long Term Wear Items

Over the life of an engine, some parts may wear beyond their operational specifications. Typical components which may require evaluation for replacement are:

- Engine Block — Cylinder bore size and roundness
- Cylinder Head — Sealing surface flatness and condition
- Bearings — Connecting rod and crank bearing clearance and condition
- Valve Shims — Clearance

The following measurement and inspection techniques can be used to ensure stock and replacement parts meet the specifications required for proper performance.

Wear Measurements — Cylinder Bore Out-of-Round

Measure the cylinder bore with an internal micrometer.

- Carry out the measurements in different directions and at different heights to determine if there is any out-of-roundness or tapering.
- If the measurement is out of the specified range then the block must be replaced.

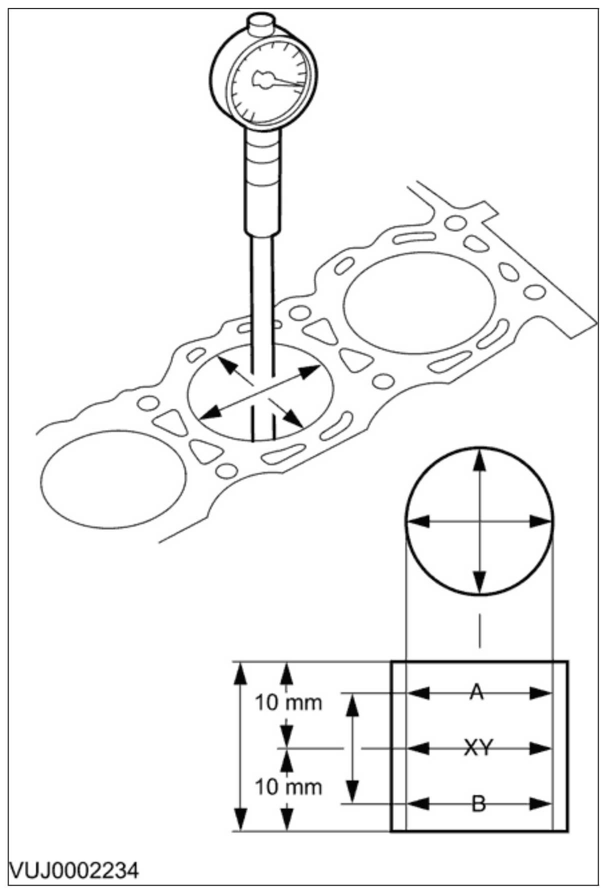


Fig. 1

Cylinder Head Distortion

- Measure the cylinder block/cylinder head distortion.
- Using the special tool, measure the mating face distortion.
- If the value is not to specification, replace the cylinder head.

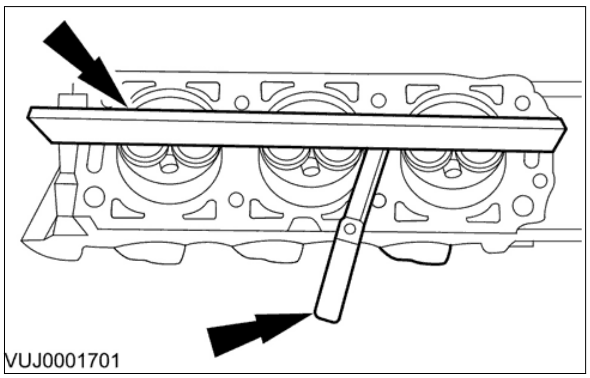


Fig. 2

Piston Inspection

Carry out a visual inspection.

- Clean the piston skirt, pin bush, ring grooves and crown and check for wear or cracks.
- If there are signs of wear on the piston skirt, check whether the connecting rod is twisted or bent.

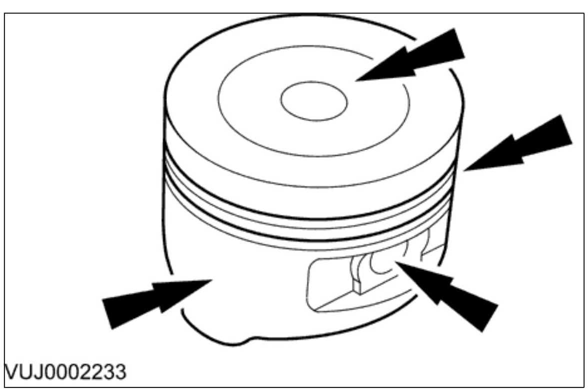


Fig. 3

Crankshaft End Play

Using the Dial Indicator Gauge with bolt on brackets, or a magnetic base on a large steel bolt head, measure the end play.

- Measure the end play by lifting the crankshaft using a lever.
- If the value is out of the specification, install new thrust bearing and half ring (washer) to take up the end float and repeat the measurement.

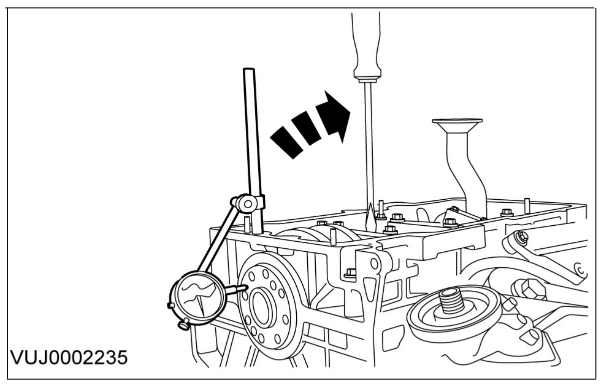


Fig. 4

Bearing Inspection

Inspect bearings for the following defects.

1. Cratering - fatigue failure
2. Spot polishing - incorrect seating.
3. Imbedded dirt - dirty engine oil.
4. Scratching - dirty engine oil.
5. Base exposed - poor lubrication.
6. Both edges worn - Crank journal damaged.
7. One edge worn - Crank journal tapered or bearing not seated.

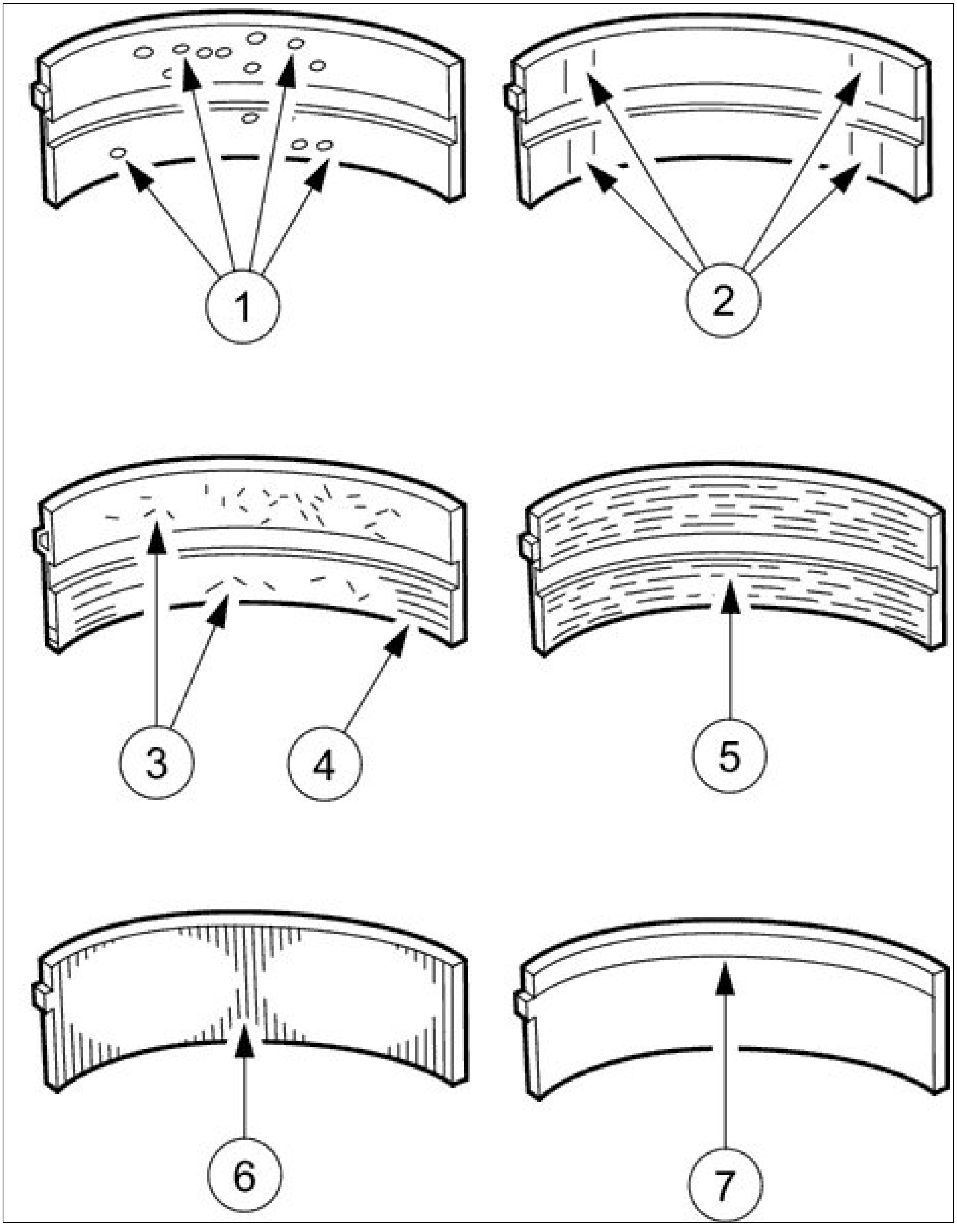


Fig. 5 Potential Bearing Defects

Connecting Rod and Crankshaft Main Bearing Journal Clearance

NOTE:

The bearing shells and journals must be free from engine oil and dirt. The measuring point should be near to the center.

- Insert the associated bearing shells, without lubrication, into the cylinder block.
- Insert the crankshaft, without lubrication, into the cylinder block.
- Position a strip of Plastigage, equal to the width of the bearing, on the bearing journal.

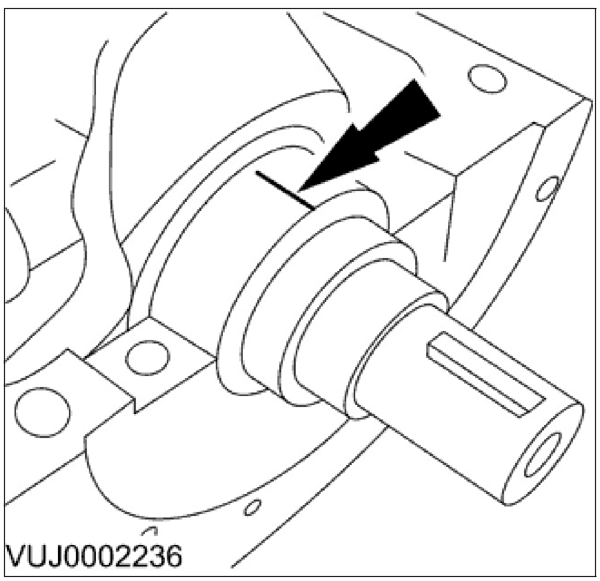


Fig. 6

NOTE:

Measure all the bearings at the same time.

- Carry out the measurement.
- Install the lower crankcase with bearing shells following the relevant tightening sequence.
- Remove the lower crankcase with bearing shells
- Compare the width of plastigage with the Plastigage scale.
- The value that is read off of the Plastigage scale is the actual bearing clearance
- If the measurement is out of the specified range, replace the bearing shells with the correct size to return the clearance to within specifications, and repeat the measurement.

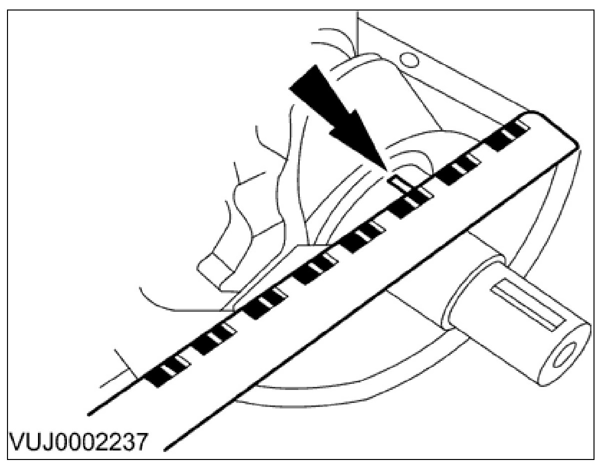


Fig. 7

Valve Clearance Check

Rotate the engine clockwise to position the camshaft lobe away from the shim surface.

Using the feeler gauge set, measure the clearance between the camshaft and the shim surface. Record and check the readings. Adjust the clearances as necessary. See example for calculating clearance and appropriate shim.

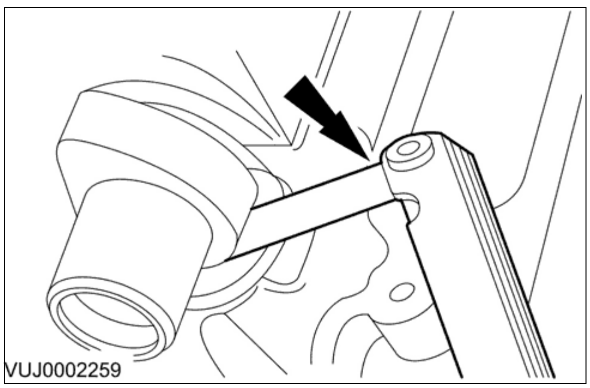


Fig. 8

Example Specification: 0.012 - 0.014 in.

Excessive clearance	
measured clearance	0.019 in.
plus the size of the existing shim	+0.100 in.
	0.119 in
less the specified clearance	- 0.013 in.
= required shim thickness	0.106 in
Insufficient clearance	
measured clearance	0.009 in.
plus the size of the existing shim	+0.106 in.
	0.115 in.
less the specified clearance	- 0.013 in.
= required shim thickness	0.102 in

Fig. 9 Valve Clearance Example

FAULT DIAGNOSTICS

Overview

Methods of Testing Engine to Diagnose the Condition and Areas of Concern

Examples of tests that can be carried out are:

- Compression Test
- Cylinder Leakage Test
- Vacuum Test

Before performing any of the above tests make sure that the ignition and fuel system are in good condition.

Compression Testing

The amount of compression generated in each cylinder has a great effect on the power output of an engine. Likewise, the amount of compression depends on how well the cylinder is sealed by the cylinder head gasket, piston rings, valves and the gasket. A leak at any of these points will result in a loss of compression and poor driveability. A compression test measures the compression in each individual cylinder. It also points out any significant pressure variations between all of the cylinders.

Understanding Compression Ratios

The compression ratio measures how much the volume of the cylinder is reduced by the piston as it travels from bottom dead center (BDC) to top dead center (TDC). When the piston is at TDC there is still a small volume between the piston top and the cylinder head. This space is known as the clearance volume. The compression ratio is simply the total volume of the cylinder divided by the clearance volume. For example, if the total cylinder volume is 500cc and the clearance volume is 50cc, the compression ratio is 500/50 = 10:1.

Assuming no other differences exist between two engines, the higher the compression ratio, the greater the engine torque and horsepower, and also the higher the peak temperature and peak pressure in the cylinder. The piston forces the air/fuel mixture into a smaller area, which increases the combustion pressure in the engine.

An engine with an 8:1 compression ratio has a compression pressure of approximately 150 PSI and a combustion pressure of 600 PSI; in comparison, and engine with a 7:1 compression ratio, has a compression pressure of about 125 PSI and a combustion pressure of 500 PSI.

Preparing for the Test

1. Run the engine until it reaches its normal operating temperature
2. Disconnect fuel pump relay - depressurise fuel system
3. Disconnect on-plug coils - label up for quick identification when refitting
4. Remove on-plug coils
5. Use compressed air to clean all dirt and other foreign matter out of the spark plug wells

   WARNING:

   SAFETY GLASSES MUST BE WORN

6. Remove spark plugs, examine and label from which cylinder each plug has been removed. AT THIS POINT YOU HAVE TO DECIDE WHETHER YOU ARE DOING A WET OR DRY TEST
7. For a wet test, see the heading 'Wet Compression Test' which follows. For a dry test, fit the gauge to the car. (MUST BE CAPABLE OF RECORDING THE REQUIRED FIGURE PLUS A SAFETY MARGIN)
8. Holding the throttle fully open, crank the engine keeping an eye on the compression gauge needle
9. Record the first and fourth gauge readings. The needle should rise steadily with each subsequent stroke
10. Open the vent valve to release the compression pressure
11. Repeat the procedure for the remaining cylinders

Interpreting Results of Dry Compression Test

- If any reading is low on the first stroke, but gradually gets higher without reaching the specified pressure, the piston rings are probably badly worn
- If any reading is low on the first stroke and gets only a little higher during subsequent strokes, the cause may be a sticking or burned out valve
- If the reading is equally low on two adjacent cylinders, the probable cause is a leaking head gasket
- If the total gauge reading is higher than specified, excessive carbon deposits in the combustion chamber are a likely cause
- Any cylinders that record a low pressure reading should be given a wet compression test

Wet Compression Test

- Squirt approximately 5cc of engine oil into the spark plug hole
- Turn the engine over several times to allow the oil to work its way down around the rings
- Connect the compression gauge to the cylinder and test as previously (paragraphs 7 to 11)

Interpreting Results

- If the readings are now normal or very close to normal, either the rings, pistons or cylinder bores require attention
- If the readings do not improve at all, then the leakage is probably at the valves or cylinder head gasket
- If there is a slight improvement then both of the above areas should be inspected

Cylinder Leakage Test

While the compression test gives a good indication of the amount of pressure in the cylinders, the leakage test provides a more accurate method of testing the engine condition. Even minute leaks in the valves, rings, or head gasket can be detected.

The leakage test also points out leaks around the exhaust and intake valves, leaks between cylinders, leaks into the water jacket and any other cause of compression loss.

Leakage Tester

The leakage tester contains a precision gauge for extremely accurate readings. Its scale ranges from zero to 100%; zero means that the cylinder is perfectly sealed, 100% indicates that it is not holding any air. To receive a reading as accurate as possible, the gauge should be calibrated before every test. To do this, first turn the control knob anticlockwise until it rotates freely. Connect a 70-200 PSI air supply to the testers air input fitting. Turn the knob until the gauge reads zero. Connect and disconnect a test adapter to the testers cylinder connection fitting. The gauge should rise to 100%, then return to zero; if not the control regulator knob must be adjusted.

Performing the Test

1. Check the coolant level - fill as required
2. Run the engine to normal operating temperature
3. Remove the on-plug coils and mark up respectively
4. Use compressed air to clean out all dirt and other matter from the spark plug wells

WARNING:

SAFETY GLASSES MUST BE WORN WHEN USING AIR LINES

5. Remove all the spark plugs, inspect and mark up respectively
6. Remove the crankcase breather pipe
7. Fit the adapter to the spark plug hole
8. Rotate the engine until that cylinder is at TDC using the crankshaft pulley nut in normal direction of rotation
9. Once that cylinder is at TDC, use the crank pulley tool to stop the crankshaft rotating
10. Connect air line to adaptor, allow air into cylinder, read gauge indicator needle
11. Record the results
12. Carry out the same procedure for the remaining cylinders

CAUTION:

Some sort of locking device must be used to stop unexpected crankshaft movement while performing this measurement.

Interpreting Results

All gauge readings taken should be approximately 20%. Any reading of 30% or more indicates a definite problem. Use a hydroscopic leak detector and the following guidelines to determine where the leak is and its cause:

- Air escaping from the exhaust pipe means that an exhaust valve is not sealing
- Air escaping through the inlet manifold means that an inlet valve is not sealing

- Air bubbles in the header tank indicate a crack in the block, porous head or a leaking head gasket
- Leakage from two adjacent cylinders might also indicate a cracked block, head or a leaking head gasket
- Crankcase leakage could mean worn piston rings or cylinder walls, or a cracked piston. If the engine is relatively new, the problem could just be that the piston rings are not sealing

In many cases it is useful to compare results of compression and cylinder leaking tests in order to best analyse difficult or unusual mechanical engine problems. For example, an older engine where the compression pressure is acceptable but has air escaping from the crankcase opening is showing signs of old age. High mileage engines typically suffer from excessive blow-by and poor fuel consumption, as well as heavy carbon deposits in the combustion chambers. These deposits can raise the compression readings, thus creating the impression that the engine is more mechanically sound than it is.

Low compression combined with minimal cylinder leakage usually indicates a valve timing problem. Although the valves are seating and sealing correctly, the valves are not opening and closing at the correct time in the engine cycle, causing lower than expected compression.

Vacuum Testing

An engine vacuum test is one of the quickest and easiest ways to test an engine. Since any piston driven engine is basically a combination vacuum pump and heat exchanger, it is the higher pressure on the outside of the cylinders that cause air to be pushed into the cylinders. When an engine loses the ability to create this pressure differential, its performance suffers.

CAUTION:

Like compression and leakage tests, vacuum testing alone should not be used to locate the exact source of a problem. Always perform it as part of a series of diagnostic tests.

The vacuum gauge reads in increments of inches of mercury (inHg) or millimeters of mercury (mmHg) and has a range of zero to 30 inHg or zero to 1000 mmHg.

The 'normal' range on a petrol engine is 18-20 "Hg (450-500 mmHg), with most of today's emission controlled cars falling into the lower end of this scale.

It is important to keep in mind that all vacuum gauge readings depend on altitude: for every 1000ft (305m) above sea level, the reading will fall by 1inHg (25mmHg), so consider sea level when taking a reading.

Performing the Idle Test

1. Use a length of hose to connect the vacuum gauge to a non-restricted port on the inlet manifold. The hose should be at least 3 feet (1 metre) long in order to dampen any vibrations from the needle
2. In some cases, it may be necessary to further dampen the needle by clamping the hose, slightly restricting its passageway
3. Run the engine to normal operating temperature
4. With the engine at idle, with the transmission in Neutral or Park, and no accessory loads (such as Air Conditioning) the needle should be constant between 18-20inHg (450-500mmHg)

Cranking Vacuum Test

1. Run engine to normal operating temperature
2. Depresurise the fuel system and disable ignition system
3. Crank the engine - note the vacuum reading. An engine in good condition should produce at least 5 inHg (125mmHg) of vacuum
4. If the reading is less check the inlet manifold for leaks or a split vacuum pipe

Exhaust System Test

The following procedure compares vacuum reading that occur in a specific condition to the values found in the Idle Test. The comparison assumes that the Idle Test was already performed and that the values recorded did not indicate a problem.

1. Run the engine to normal operating temperature
2. Accelerate the engine slowly. After it reaches 2000rpm, note the reading on the gauge; it should drop a little, then rise sharply
3. Close the throttle quickly. The needle should return to the normal idle reading as quickly as it rose
4. If the needle gives a normal reading at idle speed, and at 2000rpm drops to near zero, and rises to a below normal reading, there is a restriction in the exhaust system
5. Drive the car until it reaches the speed where the engine loses power. The gauge reading should be approximately the same each time a power loss occurs with the needle dropping towards zero. The greater the restriction, the closer to zero the needle will drop

Vacuum Testing for Loss of Compression

A vacuum gauge can be used to test for compression loss due to leakage around the pistons. This test should not be performed unless normal readings were produced on all previous vacuum tests.

1. Make sure that the oil is in good condition
2. Connect vacuum gauge
3. Quickly accelerate the engine to 2000 rpm, then close the throttle fast
4. As the throttle closes, the needle should rise 5 inches Hg or more above the normal reading. An increase of less than 5inHg (125mmHg) means there is a compression loss around the pistons, rings, or cylinder walls

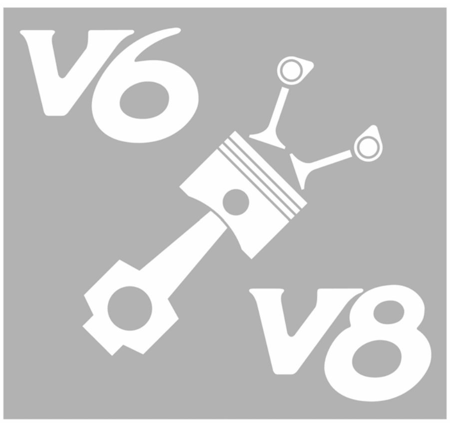
Vacuum Gauge Readings — Summary

1. NORMAL READING: Needle between 51–74 kPa (15–22 in-Hg) and holding steady.
2. NORMAL READING DURING RAPID ACCELERATION: When the engine is rapidly accelerated, the vacuum gauge will drop to a low, but not zero, reading. When the throttle is then suddenly released, the needle will snap back up to a reading higher than the normal idle reading.
3. NORMAL FOR LARGE OVERLAP CAMSHAFTS: The gauge will read as low as 51 kPa (15 in-Hg) but will be relatively steady. Some oscillation is normal.
4. WORN RINGS OR FUEL DILUTED OIL: When the engine is accelerated, the needle drops all the way to 0 kPa (0 in-Hg). Upon deceleration, the needle runs slightly above 74 kPa (22 in-Hg).
5. STICKING VALVES: When the needle remains steady at a normal vacuum, but occasionally flicks (sharp fast movement) down and back about 13 kPa (4 in-Hg), one or more valves may be sticking intermittently.
6. BURNED OR BENT VALVES: A regular, evenly spaced, down scale flicking can mean one or more valves are not seating correctly.
7. POOR VALVE SEATING: A small but regular downscale (less vacuum) flicking can mean one or more valves are not seating correctly.

8. WORN VALVE GUIDES: When the needle oscillates over about a 13 kPa (4 in-Hg) range at idle speed, the valve guides could be worn. As engine speed increases, the needle will become steady if the guides are responsible for the oscillation.
9. WEAK VALVE SPRINGS: When the needle oscillation becomes more violent as the engine speed is increased, weak valve springs are indicated. The reading at idle could be relatively steady, but still indicate the high rpm symptoms.
10. LATE VALVE TIMING: A steady but low reading could be caused by late valve timing.
11. IGNITION TIMING RETARDED: Similar to late valve timing, retarded timing will produce a steady but somewhat low reading.
12. INSUFFICIENT SPARK PLUG GAP: When the spark plug gap is too close, a regular, small pulsation of the needle can occur.
13. INTAKE “VACUUM” LEAK: A low, steady reading can be caused by an intake manifold or throttle body gasket leak. This symptom would be accompanied by an indicated lean condition, typically on both engine banks.
14. BLOWN HEAD GASKET: A regular drop of fair magnitude can be cause by a blown head gasket or warped cylinder head.
15. RESTRICTED EXHAUST SYSTEM: When the engine is first started and is idled, the reading may be normal. As the engine rpm is increased, the back pressure caused by a clogged muffler, kinked tailpipe, or melted catalyst will cause the needle to slowly drop to 0 kPa (0 in-Hg). The needle then may slowly rise.

TRAINING PROGRAM

JAGUAR V6/V8 ENGINE REPAIR



PUBLICATION CODE – 168

INTRODUCTION

AJV8 Base Engine

- The cylinder block is an 'Enclosed Vee' design, meaning that the cylinder banks are reinforce by ribs connecting the tops of each bank
- Crank bearing caps are incorporated into a single piece Bedplate design
- 110 volt block heaters are available as an option

The AJV8 is a compact, lightweight eight-cylinder engine. Its water-cooled cylinders are arranged in a 90-degree Vee configuration and its four-throw crankshaft is supported by five main bearings.

Each of the two cylinder head assemblies incorporates twin camshafts, chain-driven by the crankshaft. The camshafts activate four valves per cylinder via direct acting mechanical bucket tappets.

Table 3 V8 Engine History

MY and MODEL	ENGINE	FEATURE
97MY XK	AJ26 4.0L	Throttle housing with vacuum unit Throttle cable (mechanical guard) Center fed injectors
98MY XJ	AJ26 4.0L and 4.0L S/C	N/A as 97MY XK - new oil pump for all variants S/C - no VVT, dished pistons, new head gaskets, new inlet cam sprockets
99MY XJ 00MY XK	AJ26 4.0L	S/C fitted to XJR S/C fitted to XKR

MY and MODEL	ENGINE	FEATURE
99MY XJ / XK	AJ27 4.0L N/A only	New inlet manifold with air assist, new throttle housing with full authority throttle, continually variable valve timing (helical gear) new camshafts, pistons and lubrication system, new engine sensors - four lobe camshaft sensor ring on N/A versions and one lobe sensor on S/C versions AJ26 S/C - takes some AJ27 mechanical components to commonize parts in production
2000MY S-TYPE	AJ28	New inlet manifold, throttle centrally mounted, new electronic throttle, continually variable valve timing, air assist, new engine sensors (PTEC system), new returnless fuel system, five lobe camshaft sensor ring, modified sump and oil cooler, modified front end ancillary drive belt and components.
2001MY XJ / XK	AJ27	Dry steel cylinder liners in all variants Multi-layer steel head gasket
2002MY XJ / XK & S-TYPE	AJ27 /AJ28 Hybrid	Crank pin diameter reduced from 56mm to 53mm Con-rod changed to match new crank New inverted tooth primary chain and sprocket New oil pump
2003MY S-TYPE	AJ33 4.2 N/A, S/C	Modified cylinder block, Structural changes to the bedplate Engine id now in two positions in lieu of three Displacement increased by new crankshaft, New pistons (forged on the S/C with oil cooling), New connecting rods, New cylinder heads New camshaft covers, Modified front cover, Carry over inverted tooth primary chain and sprockets, New oil pump, New vane type VVT unit, New Denso EMS

MY and MODEL	ENGINE	FEATURE
2003MY XK	AJ34	Redesigned intake and throttle position for vehicle packaging, Hybrid AJ27 oil pan
2004MY XJ	AJ33 4.2L N/A 4.2L S/C	4.2 - as per S-TYPE 4.2 engine

Overview - AJ26 (97MY)

The AJ26 was an all new 90° V8 liquid cooled engine that gives refined and effortless performance. Constructed in aluminum alloy, the AJV8 introduced several innovative design features new to Jaguar engines, the most notable of these being:

- A bedplate
- Nikasil coated cylinder bores (iron liners fitted from 2001MY)
- Fracture split connecting rods
- Variable valve timing
- Aluminum alloy valve lifters
- Electronic throttle control

The AJ26 4.0 liter engine introduced the AJV8, the first of a new family of Jaguar engines. Designed to give excellent performance, refinement, economy and low vibration levels it conforms to the LEV emission requirements. Weighing only 200 kilograms (441lb), the engine is shorter by 300 mm (12 inches) than the AJ16 4.0 liter engine. Compression ratio is 10.75:1, with four valves per cylinder.

The cylinder heads, block and bedplate are all cast aluminum. Cylinders had electro-plated, Nikasil bores which reduce piston friction, improve warm-up and oil retention. A variable valve timing system was introduced to improve both low and high-speed engine performance, as well as improved idle quality. The valve gear is chain driven for durability. Low valve overlap improves engine idle speed and low residual fuel levels which improves combustion and reduces hydrocarbon emissions. The inlet manifold is a one-piece, plastic moulding with integral fuel rails connecting to the eight side feed fuel injectors. Air flow into the engine is via an electric throttle assembly.

Movement of the throttle is controlled by sensors in the throttle assembly through the ECM. The engine has a low volume, high velocity, cooling system which achieves a very fast warm-up with reduced and even metal temperatures in the combustion chamber and increased bore temperatures.

The generator, A/C pump, and PAS pump are mounted to the cylinder block on rigid cradle supports. Accessory drive is from a single, 7-ribbed vee belt. Hydraulic engine mounts minimize noise and vibration.

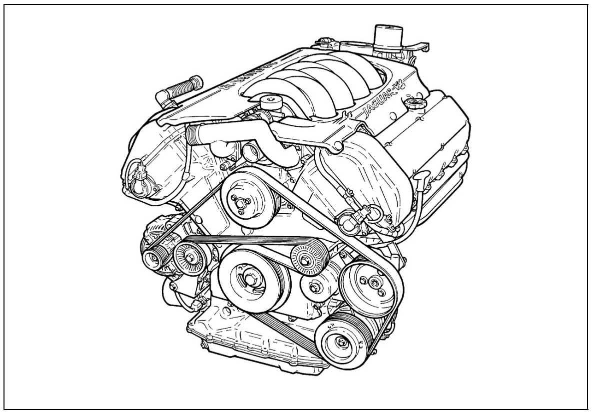


Fig. 10 BASIC ENGINE

Overview - AJ27 (99MY)

The AJ27 engine was a development of the AJ26 unit fitted to the XJ8 Sedan and XK sports cars and is in Normally Aspirated (N/A) form only: some of the mechanical changes are, however, applied to the Supercharged (S/C) engine to rationalize production.

Continuous improvement actions and the introduction of new features required a number of detail changes:

- Continuously variable inlet valve timing (VVT): the VVT mechanism is different to the two position, AJ26 system. Design changes associated with the new continuously variable system were made to the camshaft, cam position sensors, pistons and lubrication system. Since these changes were specific to VVT, they were not incorporated into the S/C engine.
- Air assisted fuel injection: this N/A only feature required changes to the fuel charging system and intake manifold
- Full authority electronic throttle control with cable operation and (limp home) mode: the main effects of this feature are enhanced EMS control and the deletion of cruise control hardware
- Engine sensors: some engine sensors have been replaced by improved or more cost effective types and additional sensors are fitted
- A number of changes are made to engine components to reduce weight, improve efficiency and help production cost effectiveness.

Overview - AJ28 (2000MY)

The AJ28 engine is a variant of the 4.0L 90° V8 units and fitted to the S-TYPE (X200). 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 AJV6 engine.

Features of the AJ28 engine are:

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

AJ33, 34 (2003MY)

The 4.2L engines were first seen in the 2003MY S-TYPE as designed and developed by Jaguar engineers at Whitely. The engines are manufactured and assembled at the Bridgend Engine Plant in Wales.

The AJ33 and 34 in essence are the same base engine and differ in how they are dressed for each vehicle line. The new AJV8 4.2 liter (AJ33) engine is an upgraded and stroked version of the Jaguar AJV8 4.0 liter engine. The 4.2 liter engine produces better performance, economy and greater refinement than its 4.0 liter predecessors.

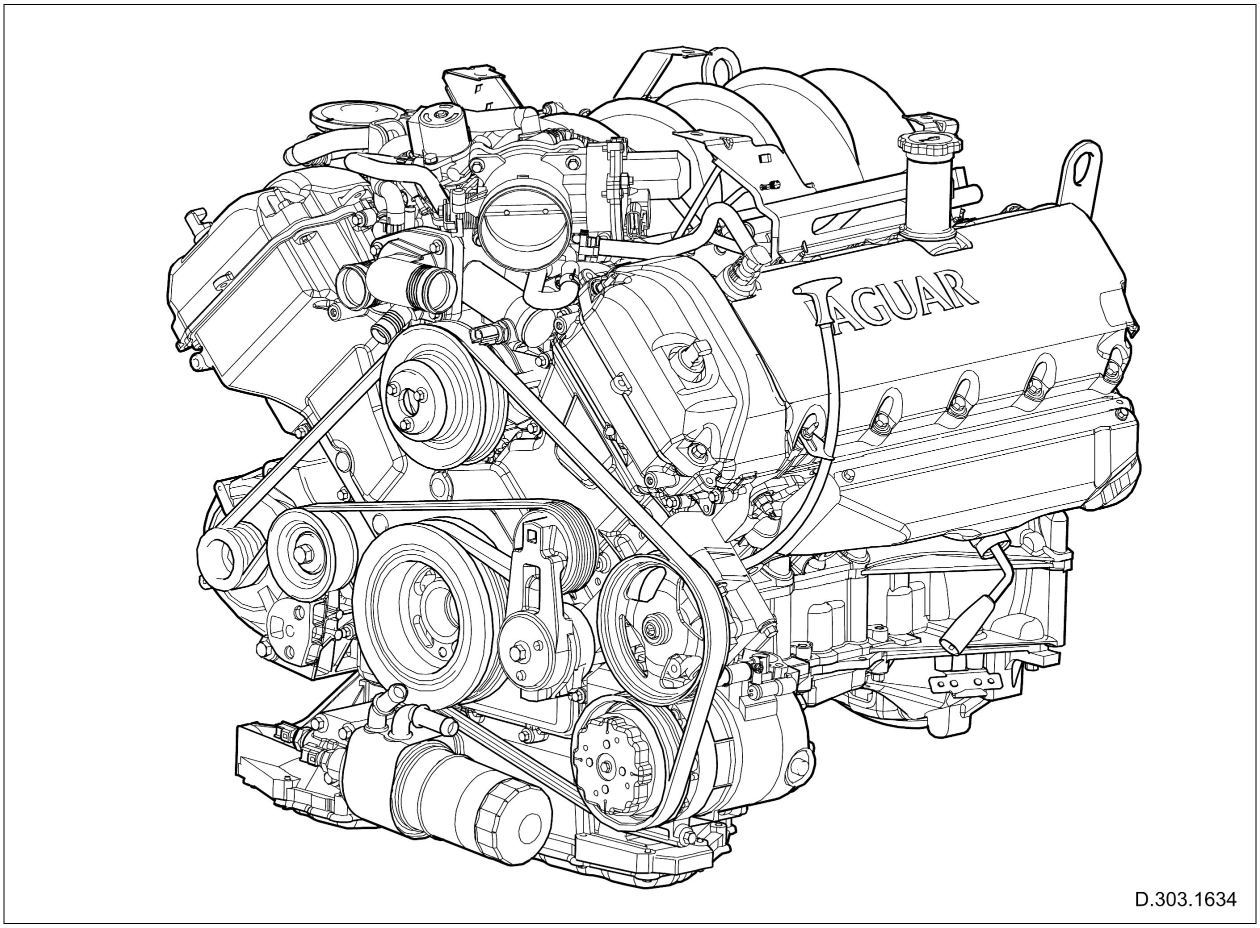


Fig. 11 AJ33 Naturally Aspisrated (N/A)

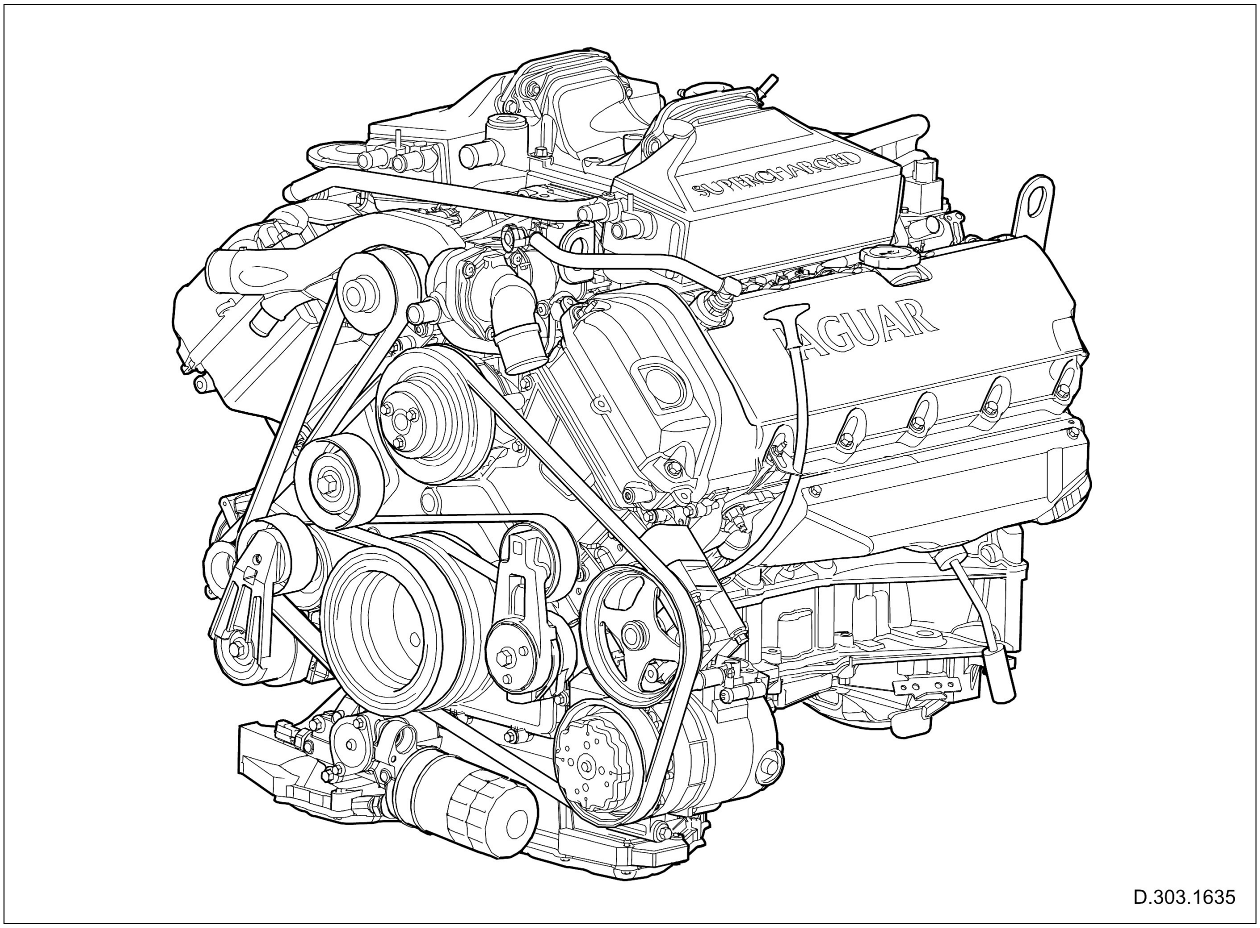


Fig. 12 AJ33 Supercharged (S/C)

ENGINE COMPONENTS

Cylinder Block

The AJ26 cylinder block is an “enclosed V” design, which provides an inherently rigid structure with low vibration levels. Nikasil (a composition of nickel and silicon) coated cylinder bores provide good friction, heat-transfer and piston noise levels. A low volume coolant jacket improves warm-up times and piston noise levels; the longitudinal flow design of the jacket, with a single cylinder head coolant transfer port in each bank, improves rigidity and head gasket sealing.

The engine number is stamped on the block at the Bridgend Assembly Plant and follows the usual format.

For the AJ27, there were no functional changes to the cylinder block on this engine. However, additional PAS and A/C compressor mounting bosses were provided for future use and to commonize production. Starting August 2000 production, dry steel cylinder liners were fitted to the block to improve robustness to sulfur contamination.

All engines built with serial numbers 000818-1043 higher were fitted with steel liners.

The AJ33 cylinder block design was enhanced to increase stiffness and reduce any noise vibration generated by the engine.

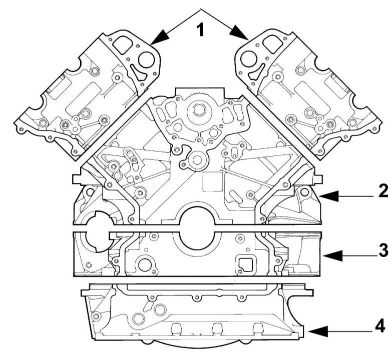


Fig. 13 ENGINE STRUCTURE

1. Cylinder Head
2. Cylinder Block
3. Bedplate
4. Structural Sump

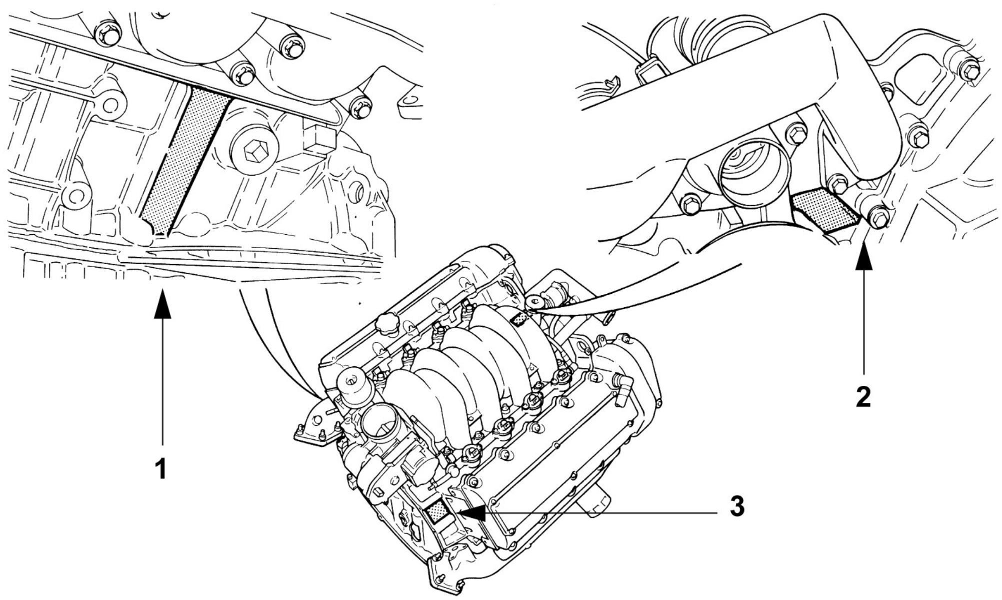


Fig. 14 ENGINE DATA LOCATIONS

1. ENGINE TECHNICAL DATA:
   Main bearing journal diameters
   Connecting rod journal diameters
   Cylinder bore diameters
   Main bearing bore diameters
2. ENGINE SERIAL NUMBER
3. EMISSIONS CODE

NOTE:

Engine serial number location was moved to the rear of the block, coincident with changing from Nikasil to steel lined. All blocks with serial number 0008181043 and later are steel lined.

Table 4 Engine serial number example: 9704051158

97	04	05	1158
year	month	day	time

Crankshaft Code: *LJDEH*BBBB*

Table 5 LJDEH: Main bearing crankshaft journal diameter

Diameter Code	**L**	**J**	**D**	**E**	**H**
Journal Number	1	2	3	4	5

Main bearing journal orientation: #1 — front; #5 — rear

Table 6 BBBB: Connecting rod journal diameter

Diameter Code	**B**	**B**	**B**	**B**
Journal #	1	2	3	4

Connecting rod journal orientation:

#1 — front; #4 — rear

Block Code: *22112222*SSRRR*

Table 7 22112222: Cylinder bore diameter

Diameter grade	**2**	**2**	**1**	**1**	**2**	**2**	**2**	**2**
Cylinder #	B1	B2	B3	B4	A4	A3	A2	A1

Cylinder bore orientation:

'B' bank — left side; #1 — front

Table 8 SSRRR: Main bearing bore inside diameter

Diameter Code	**S**	**S**	**R**	**R**	**R**
Bearing #	1	2	3	4	5

Main bearing bore orientation:

#1 — front; #5 — rear

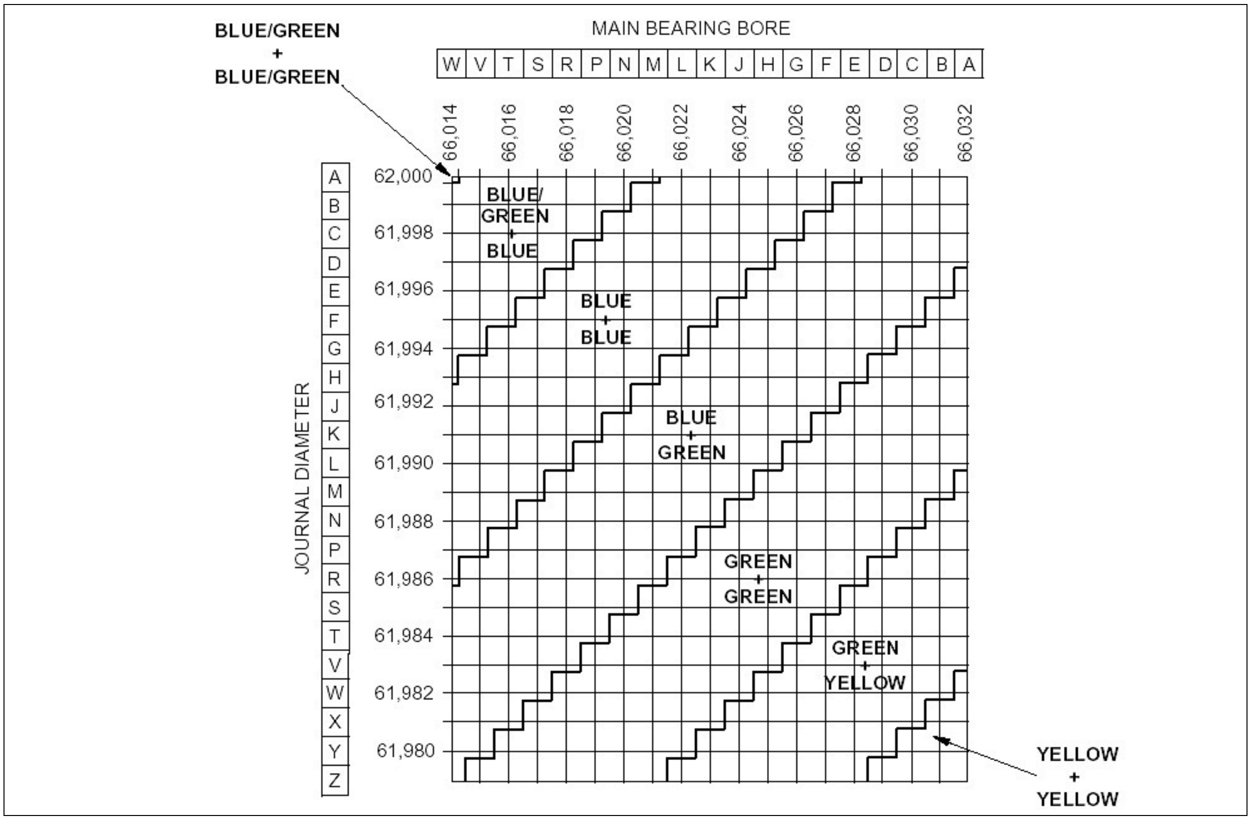


Fig. 15 AJ27/28 Main bearing selection chart

Table 9 AJ27/28 Main bearing bore inside diameter codes

Code	Diameter: mm	(in.)	Code	Diameter: mm	(in.)
A	66.032	2.59969	L	66.022	2.59929
B	66.031	2.59965	M	66.021	2.59925
C	66.030	2.59961	N	66.020	2.59921
D	66.029	2.59957	P	66.019	2.59917
E	66.028	2.59953	R	66.018	2.59913
F	66.027	2.59949	S	66.017	2.59909
G	66.026	2.59945	T	66.016	2.59906
H	66.025	2.59941	V	66.015	2.59902
J	66.024	2.59937	W	66.014	2.59898
K	66.023	2.59933			

Table 10 AJ27 / 28 Main bearing crankshaft journal codes

Code	Diameter: mm	(in.)	Code	Diameter: mm	(in.)
A	62.000	2.44094	M	61.989	2.44051
B	61.999	2.44091	N	61.988	2.44047
C	61.998	2.44087	P	61.987	2.44043
D	61.997	2.44083	R	61.986	2.44039
E	61.996	2.44079	S	61.985	2.44035
F	61.995	2.44075	T	61.984	2.44031
G	61.994	2.44071	V	61.983	2.44028
H	61.993	2.44067	W	61.982	2.44024
J	61.992	2.44063	X	61.981	2.44020
K	61.991	2.44059	Y	61.980	2.44016
L	61.990	2.44055	Z	61.979	2.44012

Table 11 Connecting rod journal diameter codes

Code	Diameter: mm	(in.)
A	56.000 – 55.994	2.20472 — 2.20449
B	55.994 — 55.988	2.20449 — 2.20425
C	55.988 — 55.982	2.20425 — 2.20402

CRANK PIN DIAMETER	BEARING GRADE COLOUR	PART NUMBER
from 52.982 up to and including 52.988	YELLOW	−6211−BCA
from 52.988 up to and including 52.994	GREEN	−6211−BBA
from 52.994 up to and including 53.000	BLUE	−6211−BAA

Note: # in part number may be any letter.

Table 12 Piston / cylinder bore grades

Code	Diameter: mm	(in.)
1	85.973 — 85.987	3.38476 — 3.38531
2	85.983 — 85.997	3.38516 — 3.38571
3	85.993 — 86.007	3.38555 — 3.38610

NOTE:

Piston and cylinder bore grade must match

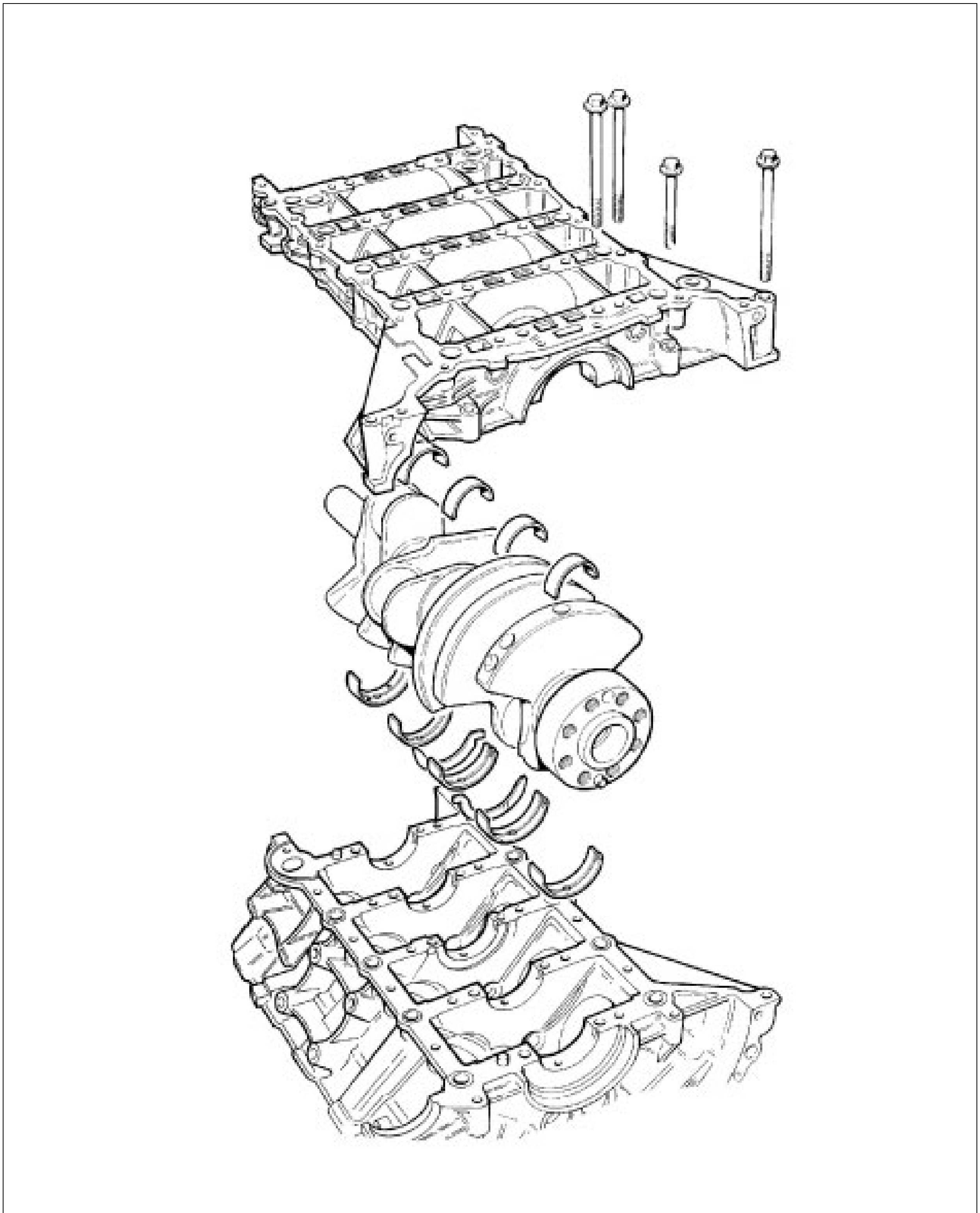


Fig. 16 CYLINDER BLOCK, CRANKSHAFT AND BEDPLATE

Bedplate — AJ26 through AJ34

The bedplate is a structural casting bolted to the bottom of the cylinder block to retain the crankshaft. The use of a bedplate further improves rigidity. Iron inserts, cast into the main bearing supports of the bedplate, minimize main bearing clearance changes due to heat expansion.

Two hollow dowels align the bedplate with the cylinder block.

Beads of sealant seal the joint between the bedplate and the cylinder block.

Structural enhancements were made to the AJ33 bedplate to compliment the stiffened engine block design.

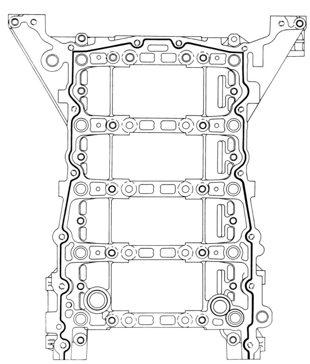


Fig. 17 BEDPLATE

Crankshaft — AJ26 through AJ28

Six counter-balance weights ensure good vibration levels from the four throw, five bearing crankshaft. Manufactured in cast iron, the crankshaft also has undercut and rolled fillets for improved strength.

The main bearings are aluminum/tin split plain bearings. An oil groove in the top half of each bearing transfers oil into the crankshaft for lubrication of the connecting rod bearings. A thrust washer is installed each side of the top half of the centre main bearing.

The crankshaft rear oil seal is a press fit in the bedplate to cylinder block interface.

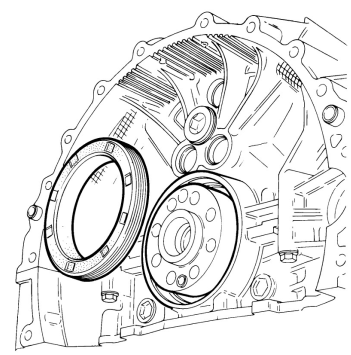


Fig. 18 CRANKSHAFT REAR OIL SEAL

Crankshaft AJ33, 34

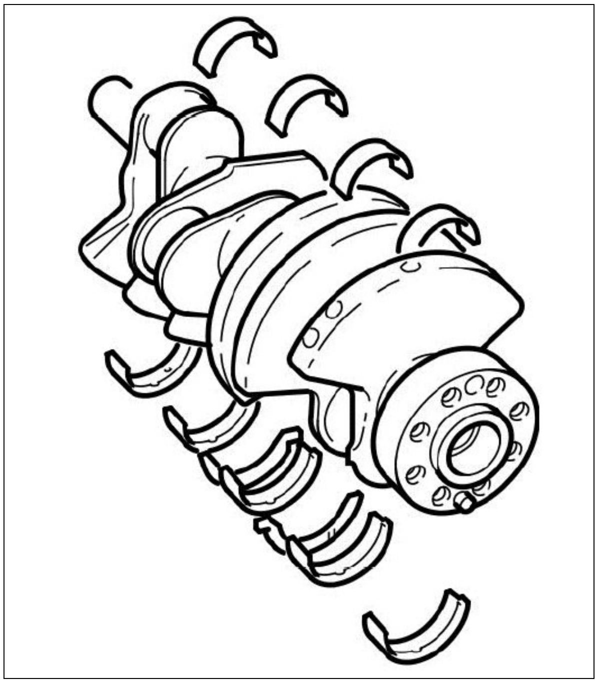


Fig. 19

- The stroke has been increased to achieve the 4.2 liter displacement.
- The crankshaft is manufactured in Spheroidal Graphite (SG) cast iron.
- The crankshaft pin journal diameters have been reduced to fit within existing cylinder block constraints.

Connecting Rods and Pistons

The connecting rods are manufactured in sinter forged steel. The bearing caps are produced by fracturing the opposing sides of the connecting rod at the bearing horizontal centre-line. As well as being easier to manufacture, when re-assembled the fractured surfaces interlock to form a strong seamless joint. The cylinder position is etched on adjoining sides of the joint to identify matching connecting rods and bearing caps. The connecting rod bearings are lead/bronze split plain bearings.

The AJ26 pistons are of the open ended skirt design with flat upper surfaces to reduce heat absorption. Three piston rings, two compression and one oil control, are installed on each piston. Each piston is installed on a wrist pin located in a lead/bronze bushing in the connecting rod.

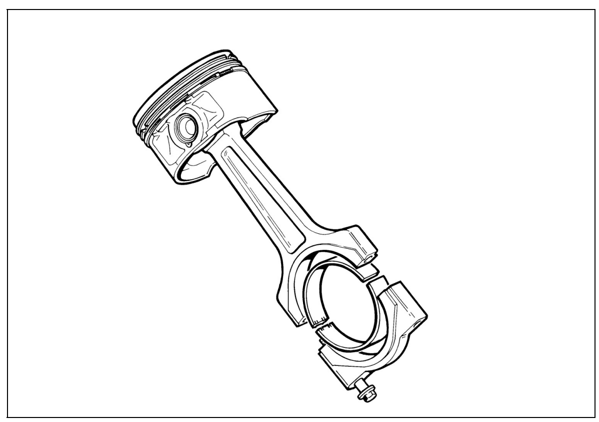


Fig. 20 CONNECTING ROD AND PISTON

S/C — Forged Pistons

The increased output of the supercharged engine increases the mechanical and thermal stresses on the pistons. Forging the pistons from a single billet of aluminum alloy produces a mechanically stronger piston.

AJ27 Pistons

Modified pistons are fitted to the N/A 4.0L engine to allow for the increased timing advance of the new VVT system. The piston crown has cut-outs to provide extra clearance for the inlet valves which, at full advance, open approximately 8° earlier BTDC compared to the AJ26 engine. Four cut-outs are used to enable a common piston to be fitted in both engine banks.

On the S/C engines, small dimensional changes have been made to the piston crown profile.

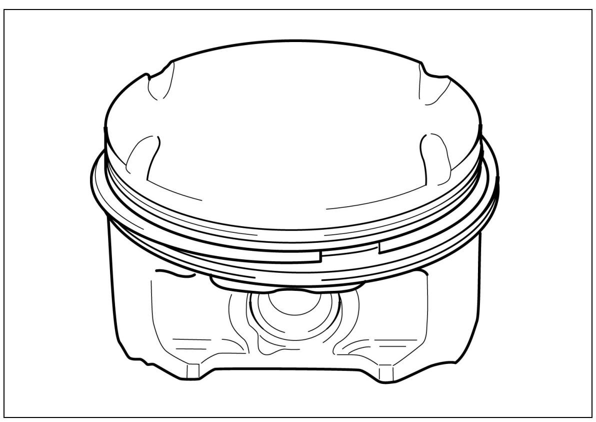


Fig. 21 4.0L N/A PISTON

Connecting Rods and Pistons AJ33 and 34

- The AJ33 range has new pistons for all engine variants
- The connecting rods are fracture split sinter forgings with a 22mm internal diameter small end bush for supercharger durability, and a 21mm internal diameter small end bush for normally aspirated applications
- The small end bush has a 'X' style oil groove for optimized bearing surface area
- The piston for the normally aspirated application is lightweight with reduced crown height design with new piston ring pack for increased combustion gas pressure and temperature performance
- The supercharger piston is forged aluminum with an ultra compact three piece oil control ring, same as the naturally aspirated three piece oil control ring

An additional feature of the AJ33 S/C engine is the application of cooling jets, one for each piston. Directing a jet of engine oil onto the underside of the piston crown helps to cool the piston and minimize distortion.

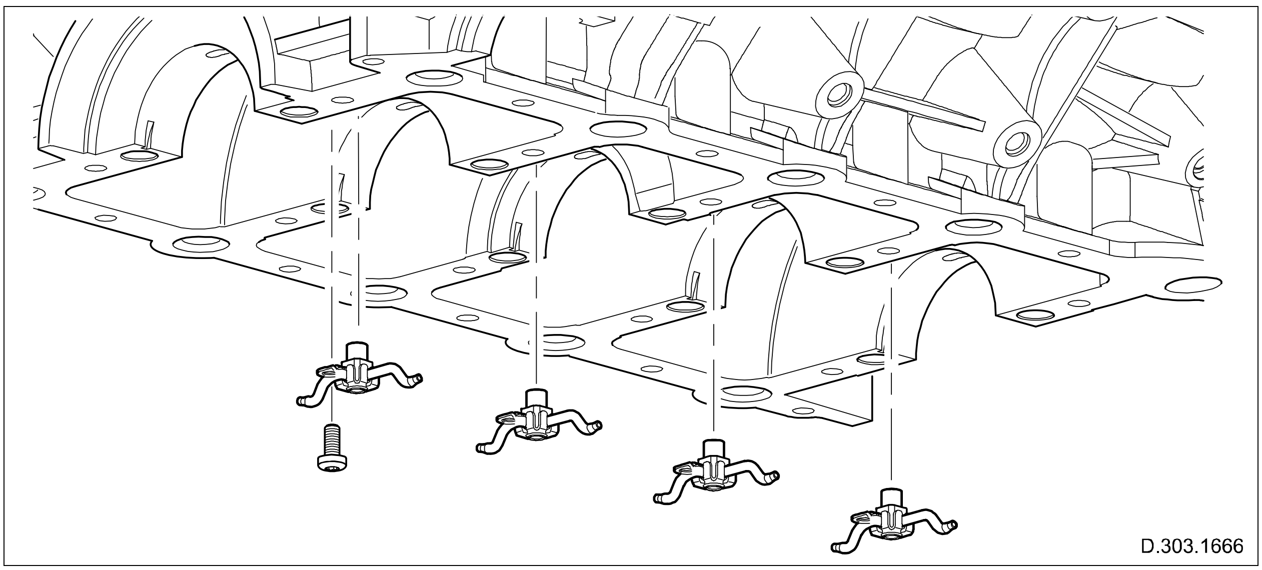


Fig. 22 Piston cooling jets

Starter and Drive Plate

The engine starter motor is installed at the rear left side of the engine, at the cylinder block to bedplate split line.

The starter drive plate is attached to the rear of the crankshaft. A timing disc, for the engine speed sensor, is spot welded to the front face of the drive plate, requiring the drive plate have a single orientation. A dowel pin aligns the drive plate correctly to the crankshaft.

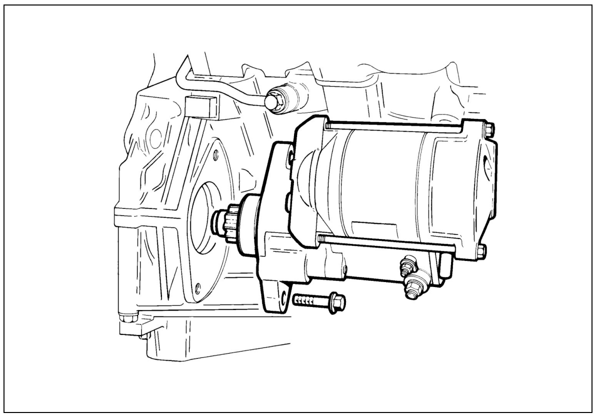


Fig. 23 STARTER MOTOR

Transmission Drive Plate- AJ33 and 34

To achieve commonality across the V8 engine range, longer bolts are used to fix the drive plate to the crankshaft. To accommodate the extra length, a spacer (arrowed) is welded to the transmission side of the drive plate. Locating the drive plate to the crankshaft is improved by the use of a stepped dowel which replaces the previous parallel dowel.

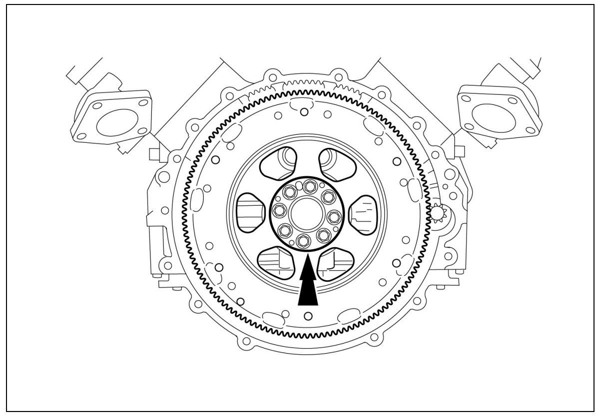


Fig. 24 TRANSMISSION DRIVE PLATE

Cylinder Heads — AJ26, AJ27, and AJ28

The cylinder heads are unique to each cylinder bank. Deep seated bolts, to reduce distortion, secure the cylinder heads to the cylinder block. Two hollow dowels align each cylinder head with the cylinder block.

The cylinder head gaskets consist of a silicon beaded composite gasket with metal eyelets for the cylinder bores. The normally aspirated head gaskets are mild steel; the supercharged eyelets are stainless steel.

An engine lifting eye is cast into the front of each cylinder head (the rear lifting eyes, one on each cylinder head, are bolt-on tools).

14 mm spark plugs, one per cylinder, locate in recesses down the centre-line of each cylinder head.

For the AJ27, the introduction of the air assisted fuel injection system introduced a conical spray pattern a change from the twin spray pattern of the AJ26. To reduce wall wetting, the inlet port divider walls are re-profiled.

Each cylinder head incorporates dual overhead camshafts operating four valves per cylinder via solid aluminum alloy valve tappets. Steel shims in the top of the valve tappets enable adjustment of valve clearances.

The lightweight valve gear provides good economy and noise levels. Valve head diameters are 31 mm for the exhaust and 35 mm for the intake. All valves have 5 mm diameter stems supported in sintered metal seats and guide inserts. Collets, valve collars and spring seats locate single valve springs on both intake and exhaust valves. Valve stem seals are integrated into the spring seats.

Cylinder Heads — AJ33 and AJ34

- The cylinder heads are unique to each cylinder bank
- Two hollow dowels align each cylinder head with the cylinder block
- The new thinner cylinder head gaskets are of a multi-layer steel construction (MLS)
- Each cylinder head still incorporates dual overhead camshafts operating four valves per cylinder
- The valve seats are changed to a three angle profile (more rounded) to improve gas flow
- Lightened valve gear reduces engine friction and noise levels
- Valve head diameter and stem diameter remains unchanged
- The inlet ports have been reworked to achieve improved volumetric efficiency
- All engine variants employ a camshaft sensor per inlet camshaft
- There have been changes to the combustion chamber design, with the inclusion of squish areas around the valves, to improve economy and emissions
- The engine lift eye, which had been cast as part of the cylinder head has been replaced by a drilled and tapped hole to accept a steel lifting bracket

Camshafts

The camshafts are manufactured in chilled cast iron. Five aluminum alloy caps retain each camshaft. Location numbers, 0 to 4 for the intake camshaft and 5 to 9 for the exhaust camshaft, are marked on the outer faces of the caps. A flat, machined near the front of each camshaft, enables the camshafts to be locked during the valve timing procedure.

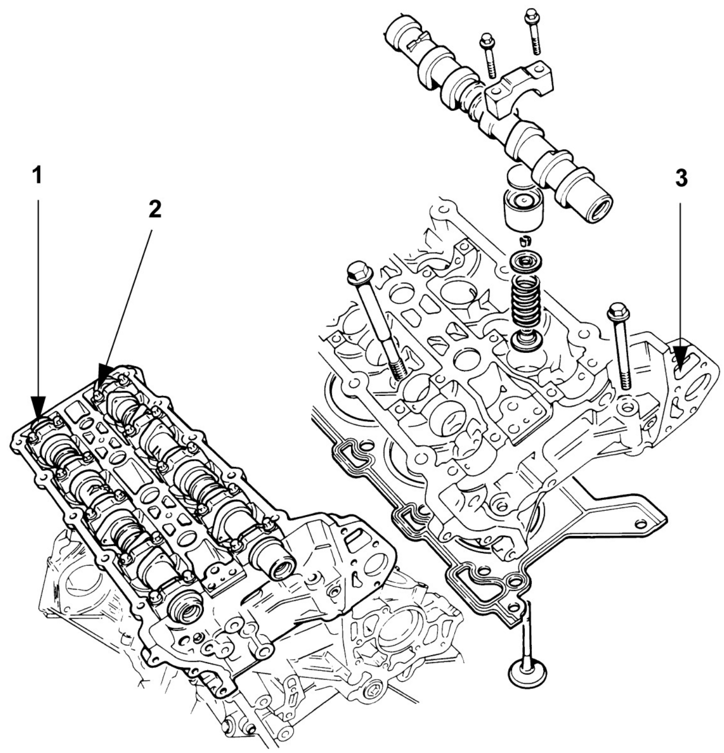


Fig. 25 'A' BANK CYLINDER HEAD

1. Exhaust Camshaft
2. Intake Camshaft
3. Lifting Eye

A mid year design change in 1999 led to all engines having modified secondary chain tensioner pivots. The S/C engines had new sprockets to mate with the modified nose on the inlet camshaft.

VVT — AJ26 N/A

The variable valve timing system improves low and high speed engine performance, engine idle quality and exhaust emissions. It is a two position system that only advances or retards the intake camshafts with 30° of crankshaft movement between fully retarded and advanced positions.

Engine oil pressure operates the system under the control of the ECM.

For each intake camshaft there is a valve timing unit, a bush carrier assembly and a valve timing solenoid.

Variable Valve Timing Operation — AJ26

The valve timing unit turns the intake camshaft in relation to the primary chain to advance and retard the timing.

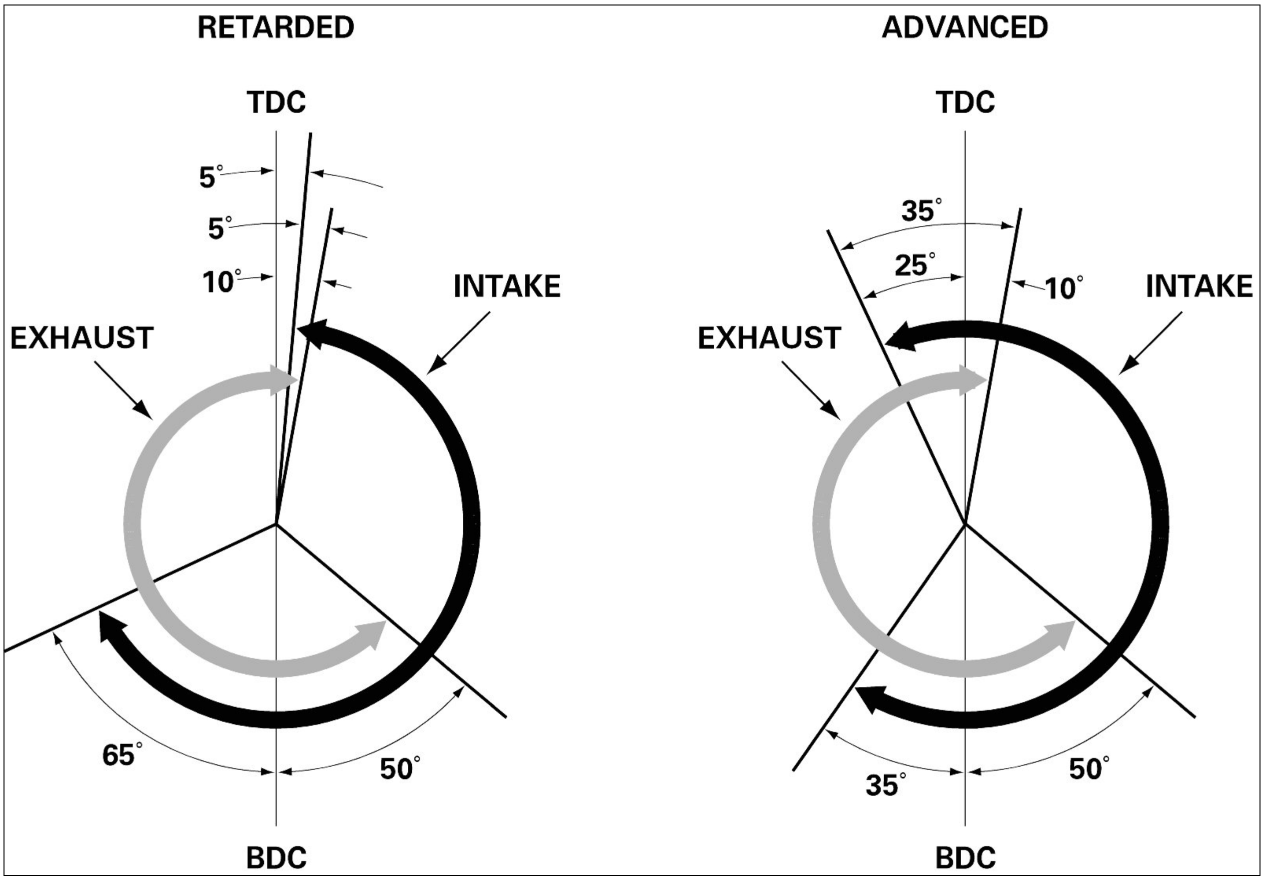


Fig. 26 VARIABLE VALVE TIMING – AJ26 (CRANKSHAFT ROTATION SHOWN)

The unit consists of a body and sprocket assembly separated from an inner sleeve by a ring piston and two ring gears.

A bolt secures the inner sleeve to the camshaft. The ring gears engage in opposing helical splines on the body and sprocket assembly and on the inner sleeve.

The ring gears transmit the drive from the body and sprocket assembly to the inner sleeve and, when moved axially, turn the inner sleeve in relation to the body and sprocket assembly.

Engine oil pressure moves the ring gears and piston to turn the inner sleeve in the advanced timing direction. A return spring moves the ring gears and piston to turn the inner sleeve in the retarded timing direction.

Additional springs absorb backlash to reduce noise and wear. The springs between the ring gears absorb rotational backlash. The spring between the inner sleeve and the end of the body and sprocket assembly absorbs axial backlash.

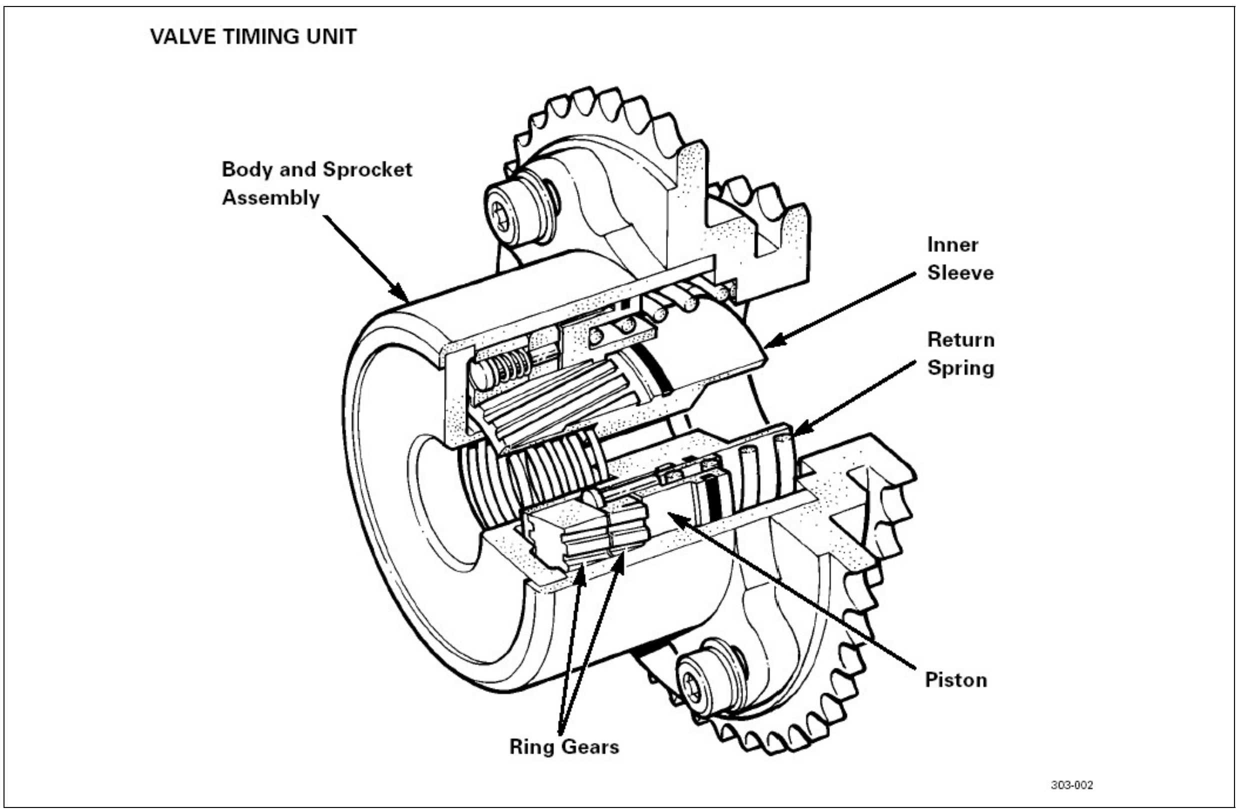


Fig. 27 VALVE TIMING UNIT – AJ26

Variable Valve Timing Actuation

System response times are 1.0 second maximum for advancing and 0.7 second maximum for retarding.

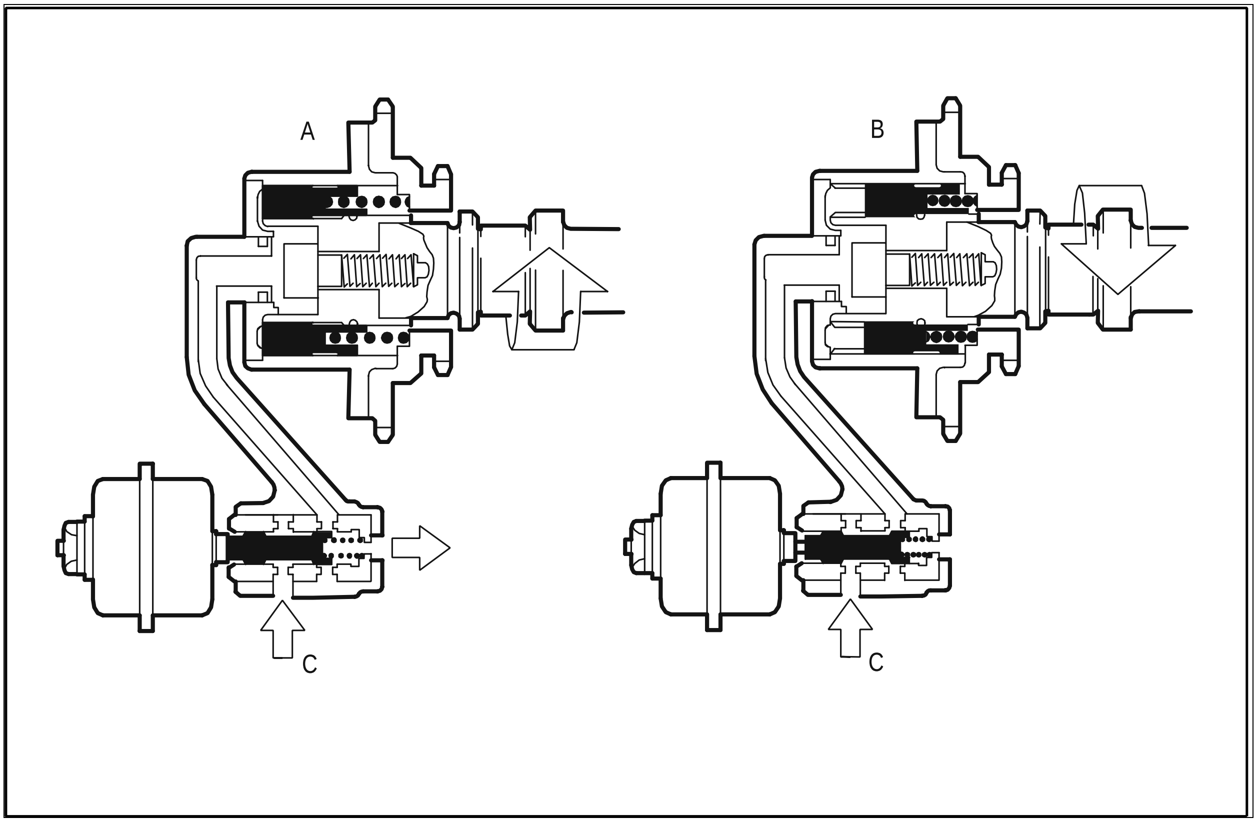


Fig. 28 VARIABLE VALVE TIMING ACTUATION

A. Retarded
B. Advanced
C. Engine Oil Pressure

While the valve timing is in the retarded mode, the ECM produces a periodic lubrication pulse. This momentarily energises the valve timing solenoids to allow a spurt of oil into the valve timing units. The lubrication pulse occurs once every 5 minutes.

NOTE:

With the vehicle stationary and the hood open, operation of the valve timing solenoids may be audible when the lubrication pulse occurs at engine idle speed.

Bush Carrier

The bush carriers contain oil passages that link the engine oil supply to the valve timing unit.

The integral shuttle valve, connected to the valve timing solenoid and biased by a coil spring, controls the flow of oil through the passages.

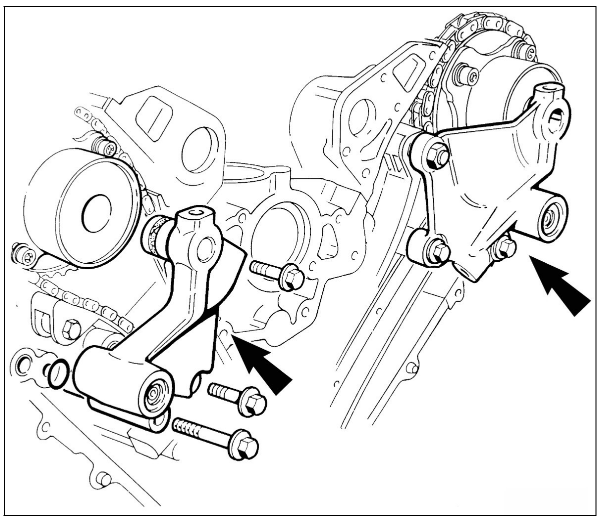


Fig. 29 BUSH CARRIERS – AJ26

Valve Timing Solenoid

The valve timing solenoid positions the shuttle valve in the bush carrier. A plunger on the solenoid extends a minimum of 6.8 mm (0.28 in.) when the solenoid is energized and retracts when the solenoid is de-energized.

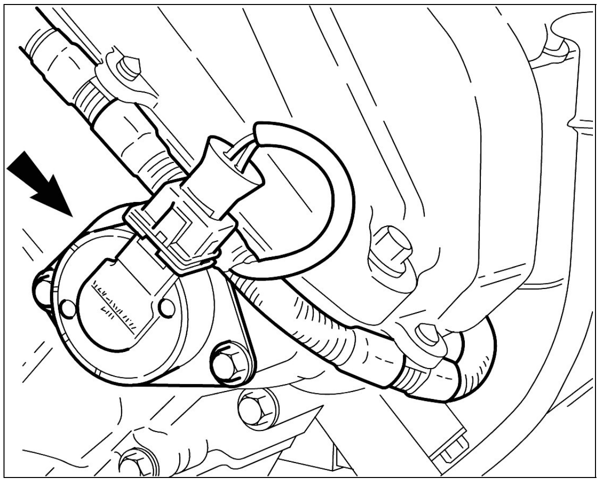


Fig. 30 VALVE TIMING SOLENOID – AJ26

Valve Timing Solenoid Operation

When the valve timing solenoids are de-energised, the coil springs in the bush carriers position the shuttle valves to connect the valve timing units to drain. In the valve timing units, the return springs hold the ring pistons and gears in the retarded position.

When the valve timing solenoids are energised, the solenoid plungers position the shuttle valves to direct engine oil to the valve timing units. In the valve timing units, the oil pressure overcomes the force of the return springs and moves the gears and ring pistons to the advanced position.

Continuously Variable Valve Timing Overview— AJ27

The variable valve timing (VVT) system is a further development of the system used on the AJ26 engine where the engine management system (EMS) selects one of two possible inlet cam positions relative to crankshaft angle. The new linear VVT system provides continuously variable inlet valve timing over a crankshaft range of $48° \pm 2°$. Depending on driver demand, engine speed/load conditions and EMS requirements, the inlet valve timing is advanced or retarded to the optimum angle within this range. Compared to the two position system, inlet valve opening is advanced by an extra 8°, providing greater overlap and increasing the internal EGR effect (exhaust gases mixing with air in the inlet port).

The linear VVT system provides a number of advantages:

- Improves internal EGR, further reducing NOx emissions and eliminating the need for an external EGR system
- optimizes torque over the engine speed range without the compromise of the two position system: note that specified torque and power figures are unchanged
- Improves idle quality: the inlet valve opens 10° later, reducing valve overlap and thus the internal EGR effect (undesirable at idle speed)
- Faster VVT response time
- VVT operates at lower oil pressure.

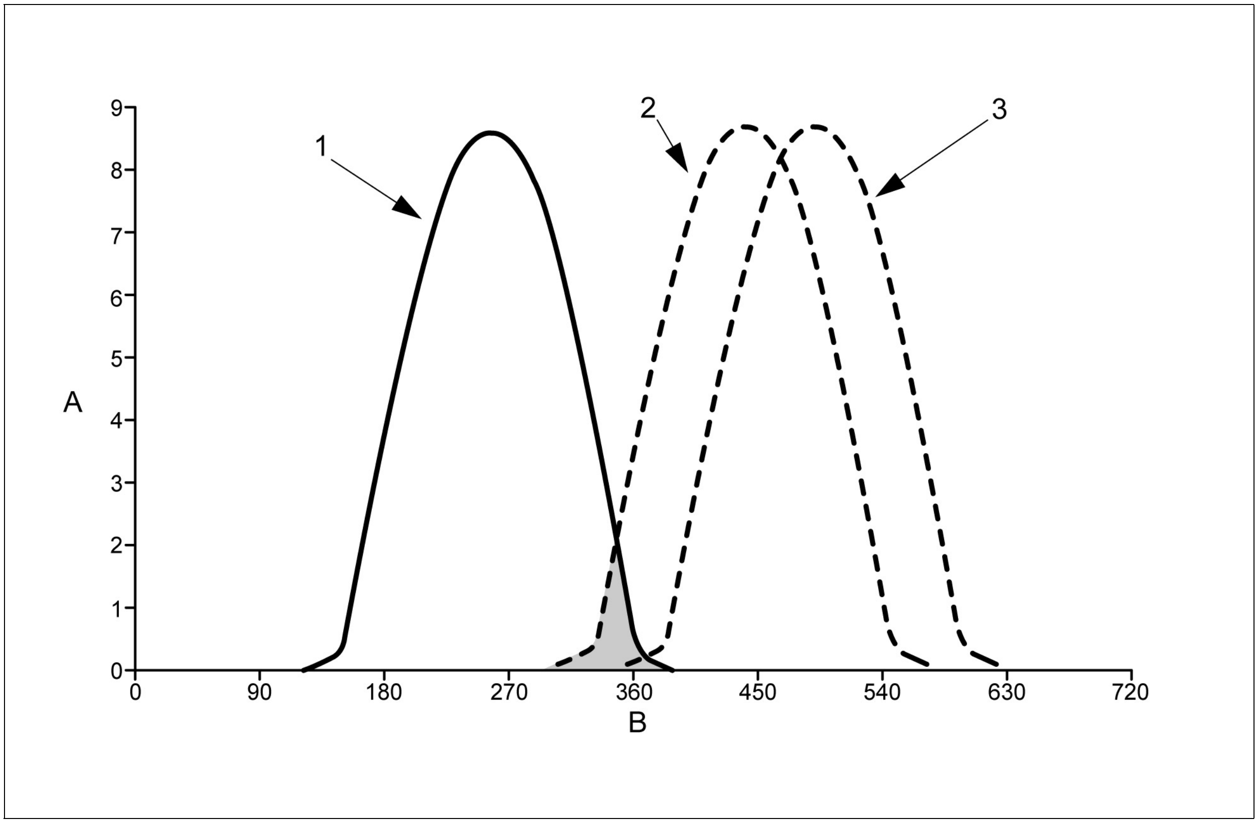


Fig. 31 VARIABLE VALVE TIMING

Table 13

A	Valve Lift (mm).	B	Crank Angle (degrees).
1	Exhaust.	2	Inlet Maximum Advance.
3	Inlet Maximum Retard.		

VVT Components

Each cylinder bank has a VVT unit, bush carrier and solenoid operated oil control valve which are all unique to the linear VVT system. The VVT unit consists of an integral control mechanism with bolted on drive sprockets, the complete assembly being non-serviceable. The unit is fixed to the front end of the inlet camshaft via a hollow bolt and rotates about the oil feed bush on the bush carrier casting. The bush carrier is aligned to the cylinder head by two hollow spring dowels and secured by three bolts.

The oil control valve fits into the bush carrier to which it is secured by a single screw.

The solenoid connector at the top of the valve protrudes through a hole in the camshaft cover. The cover must first be removed to take out the valve.

Engine oil enters the lower oil-way in the bush carrier (via a filter) and is forced up through the oil control valve shuttle spools to either the advance or retard oil-way and through the bush to the VVT unit. Oil is also returned from the VVT unit via these oil-ways and the control valve shuttle spools, exiting through the bush carrier drain holes.

Note that only the bush carriers are left and right handed.

Variable Valve Timing Unit

The VVT unit transmits a fixed drive via the secondary chain to the exhaust camshaft. The inlet camshaft is driven from the body of the unit via internal helical splines: when commanded from the EMS this mechanism rotates the inlet camshaft relative to the body/sprocket assembly to advance or retard the valve timing.

The VVT unit has three main parts: the body/sprocket assembly, an inner sleeve bolted axially to the nose of the camshaft and a drive ring/piston assembly located between the body and inner sleeve and coupled to both via helical splines.

The basic operation is similar to that of the two position unit: oil pressure applied in the advance chamber forces the drive ring/piston assembly to move inwards along its axis while rotating clockwise on the helical body splines. Since the drive ring is also helical geared to the inner sleeve but with opposite angled splines, the inner sleeve is made to rotate in the same direction, turning the camshaft.

The use of opposing helical gears (the angle is more acute than in the two position unit) produces a relatively large angular rotation for a small axial movement, thus keeping the VVT unit to a compact size. Note that the inner sleeve does not move axially.

To move back to a retard position, oil pressure is switched to the retard chamber and the piston and rotational movements are reversed. The use of oil pressure to move the piston in both directions eliminates the need for a return spring for VVT operation (as in the two position system).

However, a lighter pressure spring is fitted in the retard chamber to assist the piston assembly to revert to the fully retarded position with the engine stopped. Note that rotating the engine backwards from the stopped position will cause the VVT unit body to move relative to the camshaft, advancing the timing. To avoid the possibility of incorrect timing being set after any associated service work, reference must be made to JTIS for the correct procedures.

Due to the use of bi-directional oil pressure actuation and light spring pressure, a much lower oil pressure is required to advance the VVT unit, making its operation more consistent at high oil temperatures/low engine speed. Also, response times to move in the advance direction are reduced by approximately 50% compared with the two position actuator.

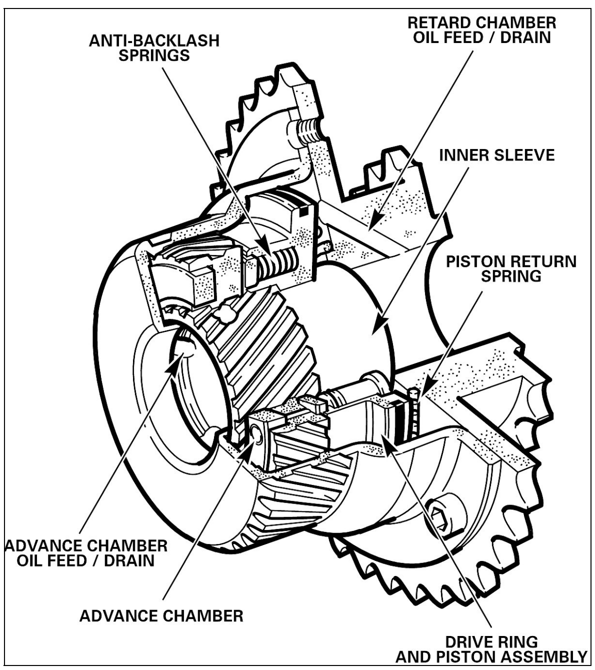


Fig. 32 LINEAR VVT UNIT – AJ27

VVT Oil Control

(see VVT oil control diagram)

Engine oil is supplied to the VVT unit via the bush carrier and is switched to either the advance or retard side of the moving piston assembly by the oil control valve. The oil control valve consists of a four spool shuttle valve directly operated by a solenoid plunger and fitted with a return spring. It is a non-serviceable component.

To fully advance the cams, the solenoid is energised pushing the shuttle valve down. This action causes the incoming oil feed to be directed through the lower oil-way in the bush carrier and into the advance oil chamber where it pushes on the piston/drive ring assembly. As the piston moves in the advance direction (towards the camshaft), oil is forced out of the retard chamber through oil-ways in the sprocket unit, camshaft, hollow fixing bolt, bush carrier and the shuttle valve from which it drains into the engine.

To move to the fully retarded position, the solenoid is de-energised, the return spring holds the shuttle valve in its upper position and the oil flow is directed through the bush carrier upper oil-way into the VVT unit. Oil is channelled through the hollow VVT fixing bolt and via oil-ways in the camshaft and sprocket unit to the retard chamber where it acts on the moveable piston/drive ring assembly. As the piston moves, oil is forced from the advance chamber back through the shuttle valve to the engine.

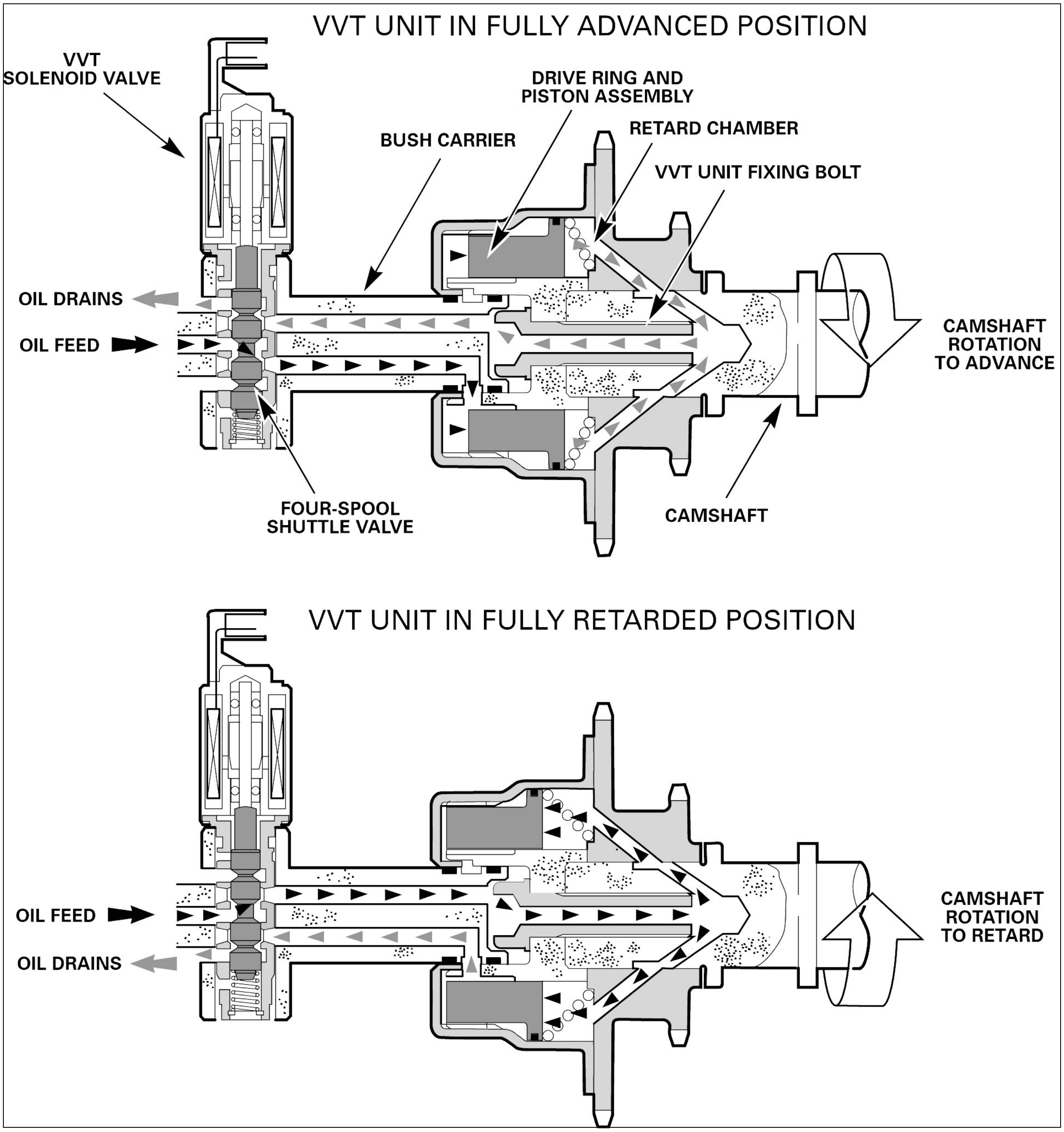


Fig. 33 LINEAR VVT OIL CONTROL – AJ27

VVT Design Overview— AJ33

Faster engine response at all speeds is available due to inlet camshaft timing that is continuously varied according to demands and conditions.

Although principle function of this VVT system is the same as that used on the V8 (AJ27) engine, the internal operating components of this VVT unit are different. Instead of a helical gear construction, this VVT unit uses a vane device to control the camshaft angle. The system operates over a 48 degrees and is advanced or retarded to the optimum angle within this range.

This system also has the added benefits of operating at a lower oil pressure and with a faster response time.

VVT Components

The VVT unit is a hydraulic actuator mounted on the end of the intake camshaft, which advances or retards the intake camshaft timing and thereby alters the camshaft to crankshaft phasing. The oil control solenoid, controlled by the ECM, routes oil pressure to either the advance or retard chambers located either side of the three vanes interspersed within the machined housing of the unit.

The actual position of the intake camshaft is monitored by the camshaft position sensor, which transmits signals to the ECM.

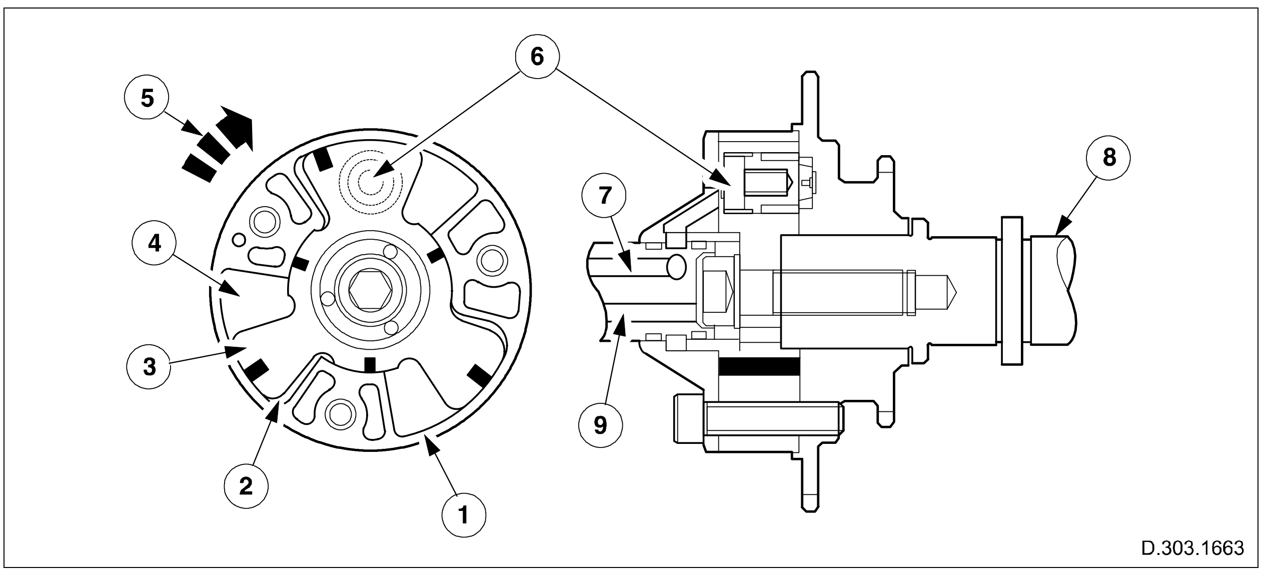


Fig. 34 VVT unit — AJ33/AJ34

1. Vane unit
2. Advance chamber
3. Vane shaft
4. Retard chamber
5. Rotation direction
6. Stopper pin
7. Advance chamber oil-channel
8. Intake camshaft
9. Retard chamber oil-channel

Timing Gear

Single row primary and secondary chains drive the camshafts of each cylinder bank. The primary chains transmit the drive from two sprockets on the crankshaft to variable valve timing units on the intake camshafts. The secondary chains transmit the drive from the variable valve timing units to sprockets on the exhaust camshafts.

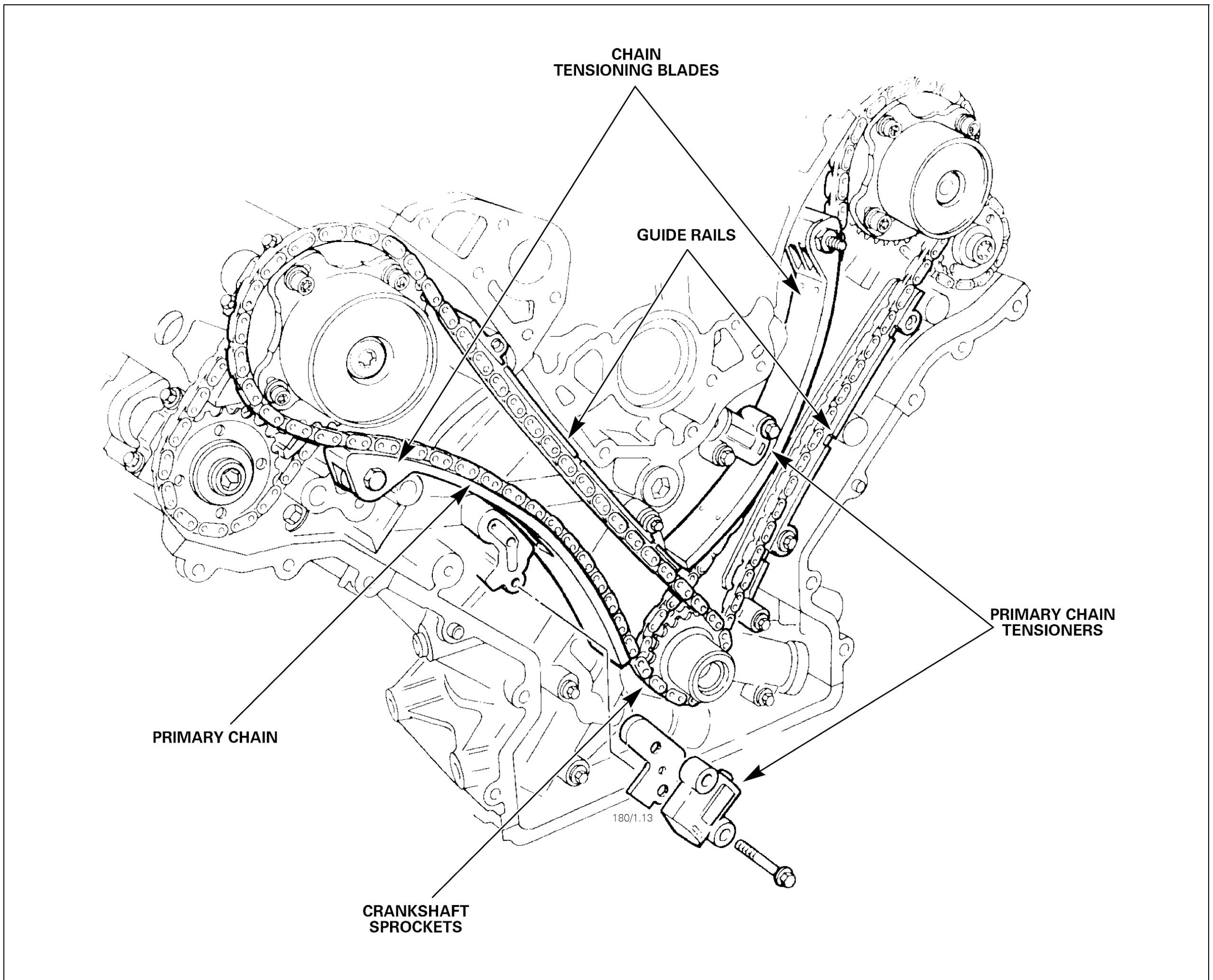


Fig. 35 TIMING GEAR — AJ27 shown

A key locates the two drive sprockets on the crankshaft. The crankshaft's torsional vibration damper retains the sprockets in position.

Unlike the drive sprockets, neither the variable valve timing units nor the exhaust camshaft sprockets are keyed to their respective camshafts. They also are not press fit to the camshafts. Instead, the sprockets are fixed to the camshafts clamping force produced by the valve timing unit/sprocket securing bolt.

Each chain has an hydraulic tensioner operated by engine oil. The primary chain tensioners act on pivoting flexible tensioner blades. The secondary chain tensioners act directly on the chains. Guide rails are installed on the drive side of the primary chains.

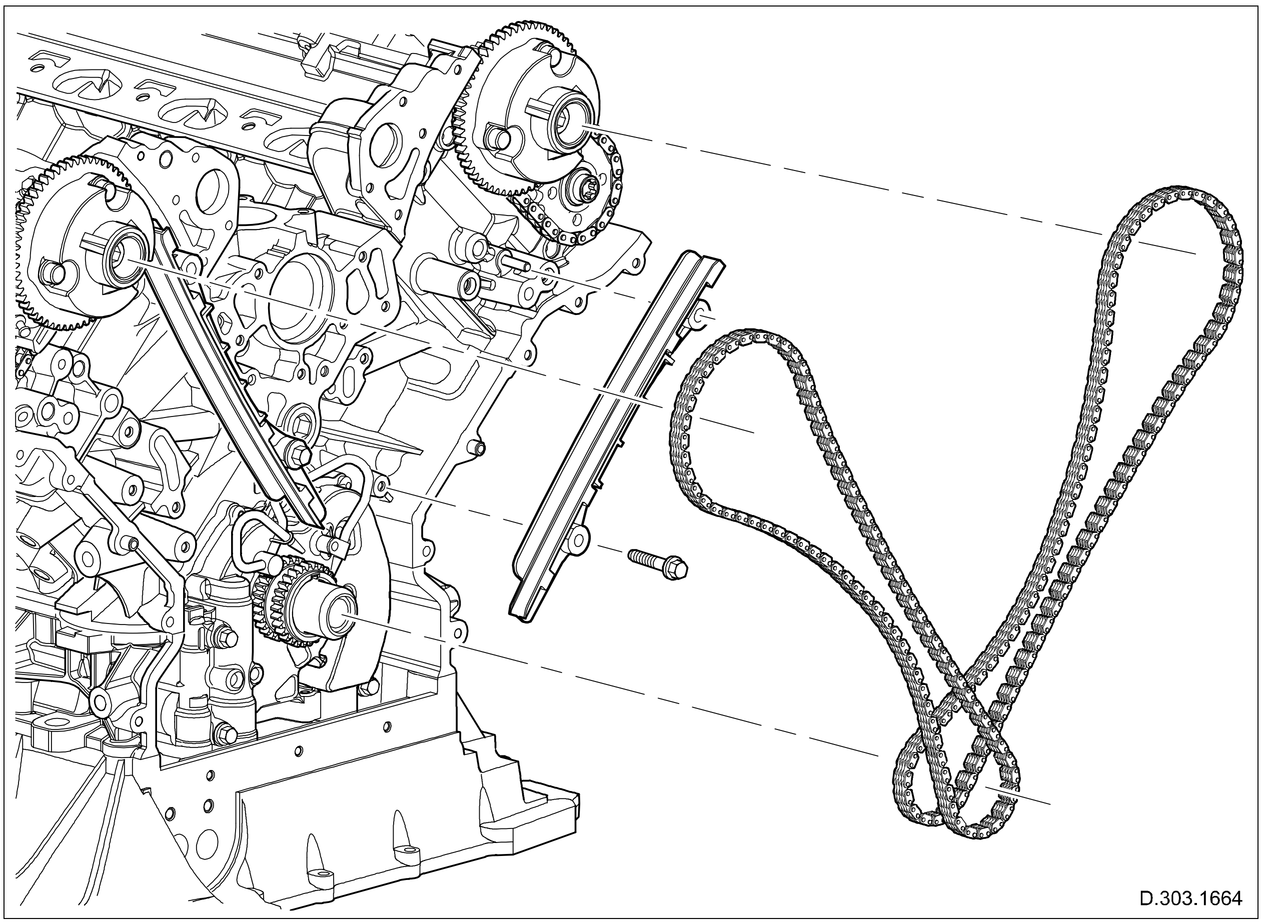


Fig. 36 Primary chain — AJ33 shown

Two major enhancements were introduced on the AJ33: the addition of oil jets for the tensioner guides, and an inverted tooth chain in place of the conventional timing chain.

Engine Oil Temperature

Engine oil properties and temperature can affect the ability of the VVT mechanism to follow demand changes to the cam phase angle. At very low oil temperatures, movement of the VVT mechanism is sluggish due to increased viscosity and at high temperatures the reduced viscosity may impair operation if the oil pressure is too low.

To maintain satisfactory VVT performance, an increased capacity oil pump is now fitted to all engines and an EOT sensor to N/A engines. The VVT system is normally under closed loop control except in extreme temperature conditions such as cold starts at well below 0°C. At extremely high oil temperatures, the EMS may limit the amount of VVT advance to prevent the engine stalling when returning to idle speed. This could otherwise occur because of the slow response of the VVT unit to follow a rapid demand for speed reduction. Excessive cam advance at very light loads produces high levels of internal EGR which may result in unstable combustion or misfires.

On-board Diagnostics

The diagnostic system is monitored for any registered OBDII fault codes for the cam sensors, VVT oil control valve solenoids and relevant sensors (IAT, ECT, MAF, TP); if a fault is detected, VVT control is disabled, causing the inlet timing to revert to the fully retarded state.

Camshaft Position Sensor

The AJ26 has a single camshaft position (CMP) sensor located on the face of the LH cylinder head (B bank).

For the AJ27, a CMP sensor location hole is provided in the RH cylinder head on all engines in addition to the existing location in the LH bank. New type CMP sensors are fitted to both banks of the 4.0L N/A and S/C engines.

Camshaft Position Sensor Rings

The AJ26 engines, both N/A and S/C, use a single tooth ring on the left bank camshaft only.

Starting with the AJ27, a four tooth sensor ring is fitted to the inlet camshaft of both cylinder banks on both the 4.0L N/A and S/C engines. The sensor ring is a keyed pressed fit into the rear end of the camshaft.

The AJ28 engine using the PTEC engine management system uses a five lobe sensor ring and the AJ33 engines using the Denso engine management use a four lobe sensor ring.

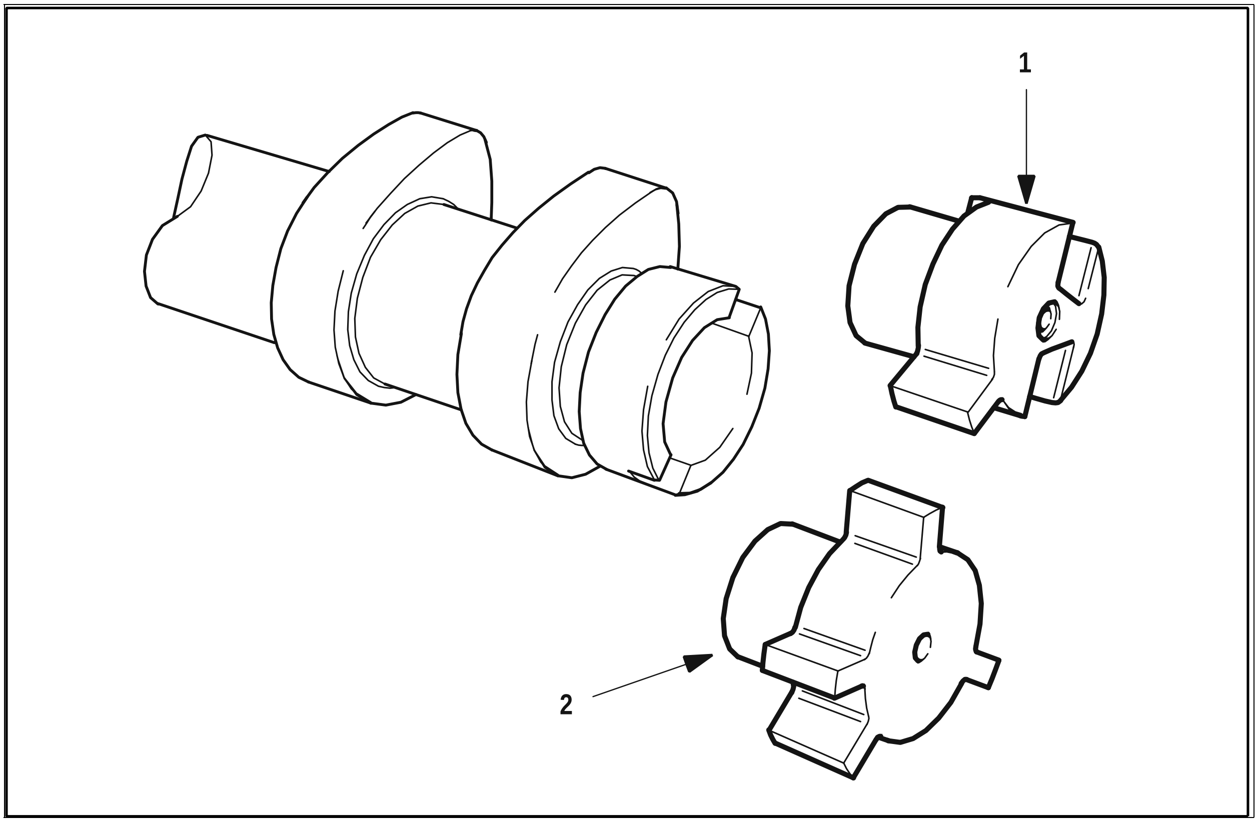


Fig. 37 CAMSHAFT POSITION SENSOR RING

1. AJ26 Sensor Ring
2. AJ27 N/A and S/C Sensor Ring

Cam covers

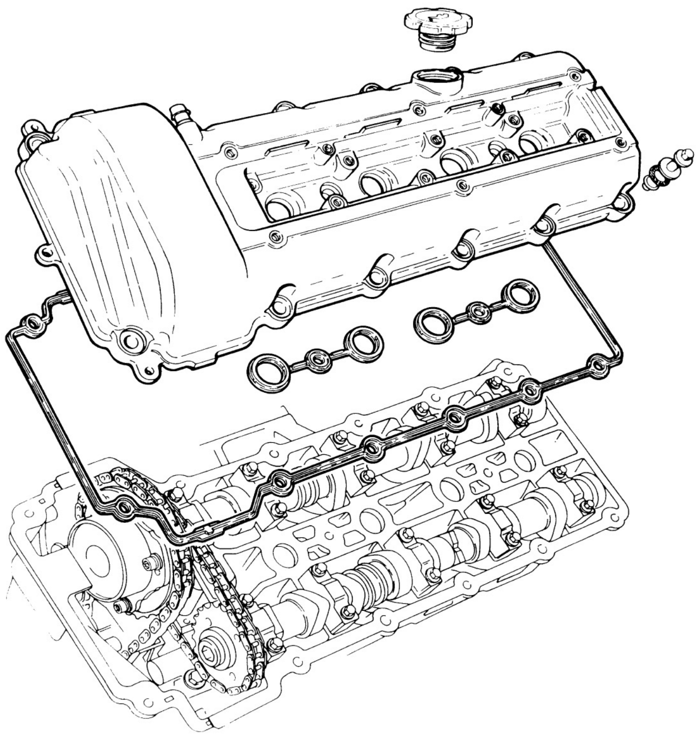


Fig. 38 'B' BANK CAMSHAFT COVER

The AJ26 camshaft covers are manufactured from a thermoset plastic, which allows for a lightweight, and acoustically damped design. The A bank camshaft cover incorporates an outlet for the full load engine breather. The B bank camshaft cover incorporates the engine oil filler cap and an outlet for the part load engine breather. Identical oil separators are incorporated below the breather outlet in each cover.

High Flourine Content (HFC) Silicone in-groove gaskets seal the joints between the camshaft covers and the cylinder heads. Together with spacers and seals on the camshaft cover fasteners, they also isolate the covers from direct contact with the cylinder heads, to reduce noise.

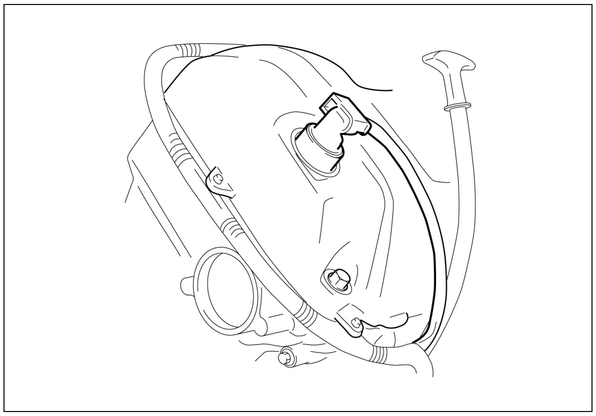


Fig. 39 AJ27 CAM COVER

For the AJ27, the plastic cam covers are modified for the new type VVT oil control valve which projects upwards from each cylinder bank. The top of the valve protrudes through a hole in the cam cover to enable connection to the engine harness. On the S/C engines without VVT, the new covers are used but the hole is moulded closed.

Camshaft cover AJ33

The camshaft covers are manufactured from Thermoplastic
The 'A' bank camshaft cover incorporates an outlet for the PCV (positive crankcase ventilation) for the engine breather system
The 'B' bank camshaft cover incorporates the engine oil filler cap (an oil fill tube is only fitted to N/A applications) and an outlet for the fresh air engine breather
There are oil separators and NVH baffles incorporated in each camshaft cover
An AEM (ethylene acrylate material) in-groove gaskets seal the joints between the camshaft covers and cylinder head
The camshaft covers have been re-designed to allow for sealing around the coils and better drainage of water away from the coil area
New 'stick' type ignition coils now supersede the conventional windings on top of the coil assembly (modifications have been made to the coils to allow for ease of removal)

Front cover

Starting with the AJ26, the aluminum alloy timing cover accommodates the crankshaft front oil seal (a PTFE lip seal) and the two variable valve timing solenoids. Silicon rubber in-groove gaskets seal the joint between the timing cover and the front face of the engine.

On the AJ27 engine the solenoid oil control valves for the VVT system were relocated from the front of the engine and the access holes in the timing covers were blanked off.

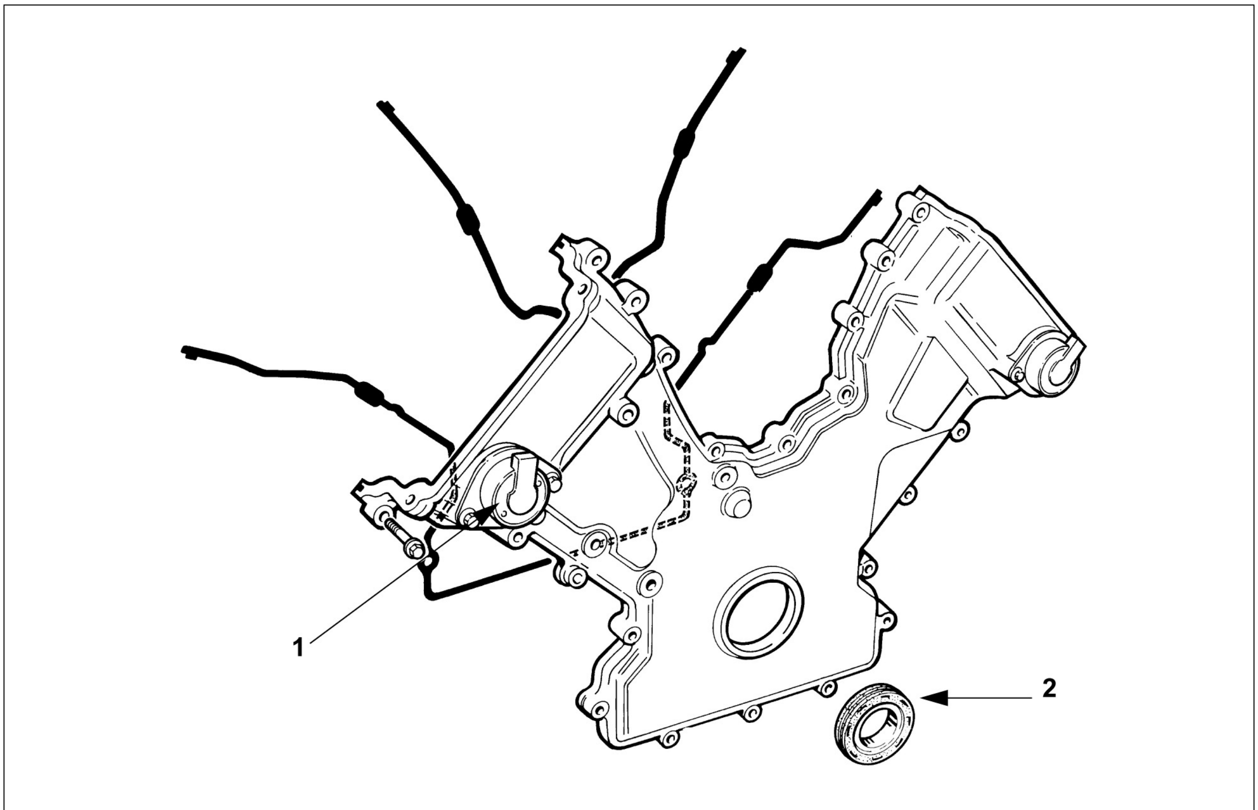


Fig. 40 TIMING COVER

1. Variable Valve Timing Solenoid
2. Crankshaft Front Oil Seal

Front cover AJ33

The aluminum alloy timing cover has been designed to suit the supercharged application
The timing cover accommodates the front crankshaft oil seal (a PTFE lip seal)

The new Poly-Acrylic in-groove gasket seals the joint between the timing cover and the front face of the engine
There have been internal ribbing changes to the timing cover, to accommodate the new oil pump

Exhaust Manifold

The thin-wall cast iron manifolds are unique for each cylinder bank. On engines with EGR, the A bank manifold has a connection for the transfer pipe.

Spacers on the securing bolts allow the manifolds to expand and retract with changes of temperature while maintaining the clamping loads.

Heat shields are integrated into the exhaust manifold gaskets.

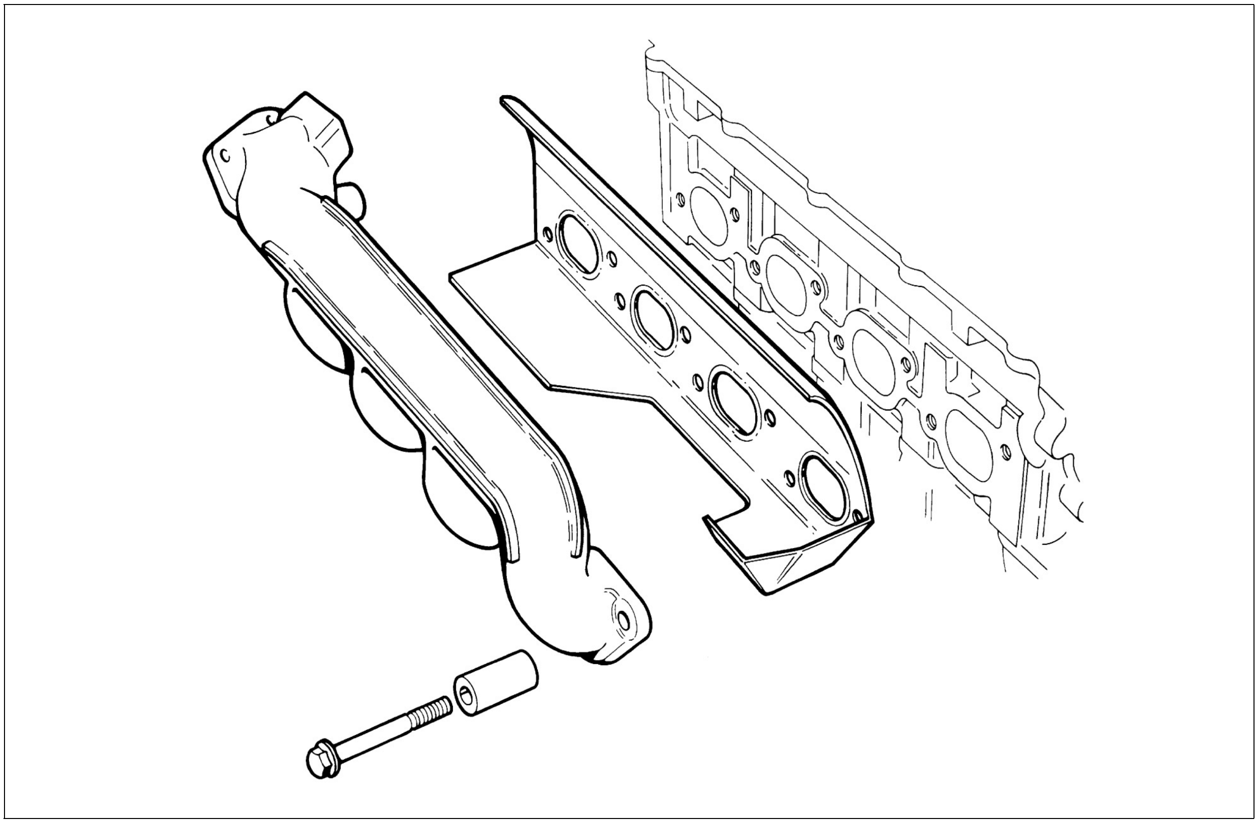


Fig. 41 EXHAUST MANIFOLD

Exhaust manifold AJ33/34 N/A

Tuning the primary length of the exhaust manifolds and pairing the manifold branches of complimentary cylinders helps to improve volumetric efficiency and ultimately, engine performance.

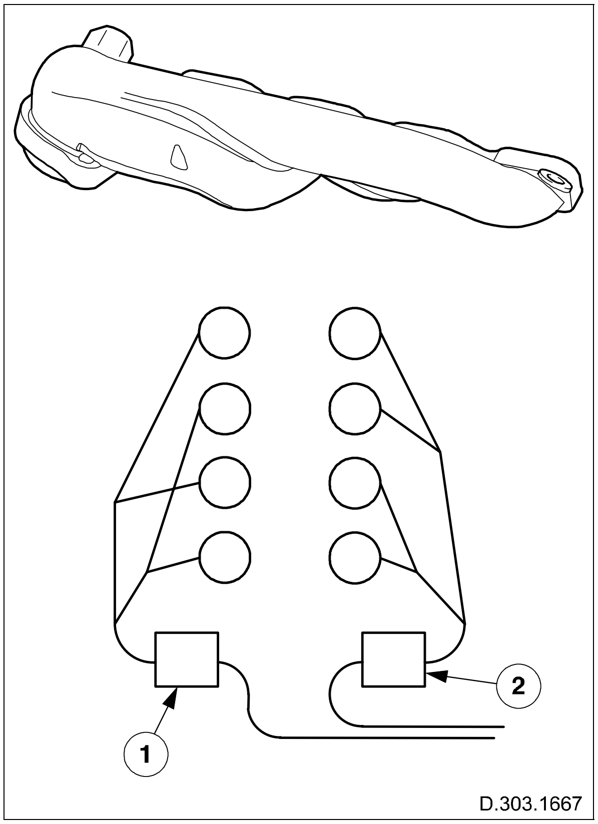


Fig. 42 Branched exhaust manifold - N/A engines

1. Catalytic converter left-hand
2. Catalytic converter right-hand

Air induction system

Air Intake System — AJ26

Filtered air from the vehicle's intake ducting is metered by the electronic throttle then directed through the induction elbow into the intake manifold.

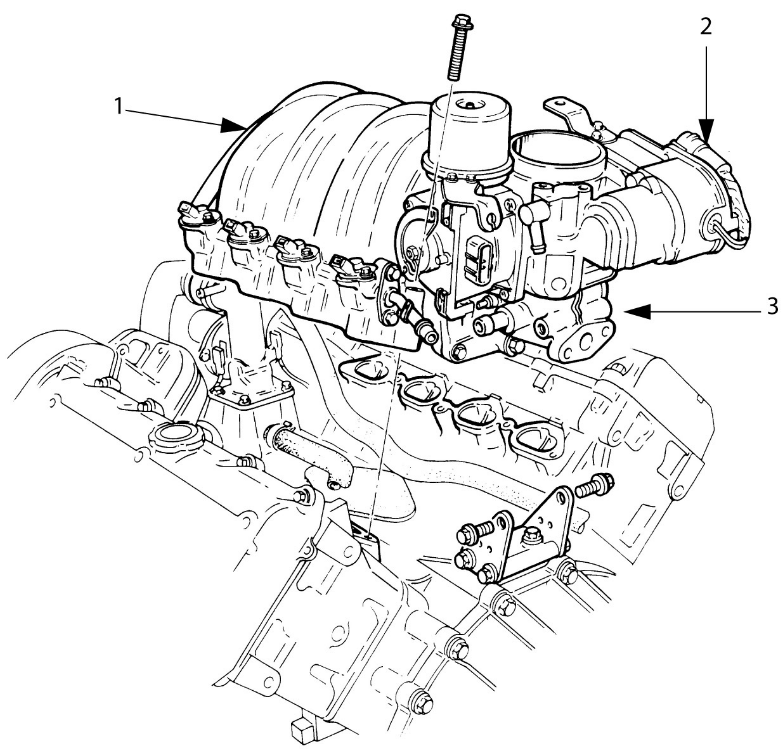


Fig. 43 AIR INTAKE SYSTEM — AJ26

1. Intake Manifold.
2. Electronic Throttle.
3. Induction Elbow.

Air Induction System — AJ27

Induction Manifold — AJ27

The induction manifold is modified to suit the new air assisted injectors and air feed system. Integral tubular air rails are located on each side of the manifold and fed at the centre point from detachable hoses.

The fuel injectors are seated directly into the air rails and fuel is supplied to the top of the injector (top fed) from separate fuel feed rails bolted to the manifold.

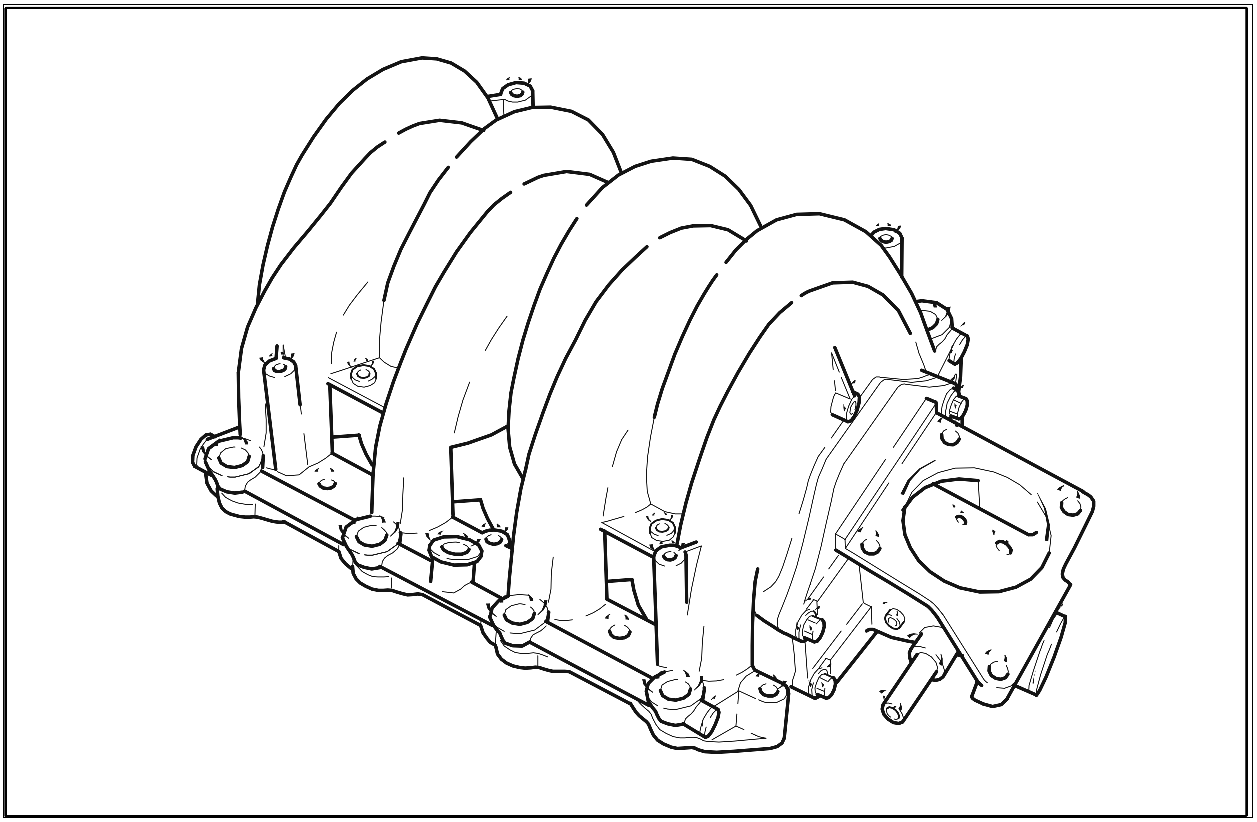


Fig. 44 INDUCTION MANIFOLD (AJ27)

Air Intake

The intake ducting and air cleaner are modified to clear the new VVT oil control valve which protrudes through the top of the cam cover.

Induction Elbow

The induction elbow has relocated fixing holes to accept the new throttle body.

EGR AND CRANKCASE VENTILATION

Exhaust gas recirculation (EGR)

The EGR system is controlled by the engine management system and consists of an EGR valve and a transfer pipe.

The EGR valve is a four pole stepper motor installed on the rear of the induction elbow. the valve is cooled by coolant return from the electronic throttle.

The transfer pipe connects the right hand exhaust manifold to the EGR valve.

EGR was introduced on the first AJ26 N/A, and quickly eliminated. EGR was brought back for the S/C version of the AJ26. A new EGR valve was fitted to all AJ27 S/C engines together with a modified gas feed pipe and reshaped coolant pipes. An increased amount of exhaust gas is recirculated to further reduce emissions. Due to stricter emission standards, the AJ33/34 N/A engines were equipped since launch with EGR.

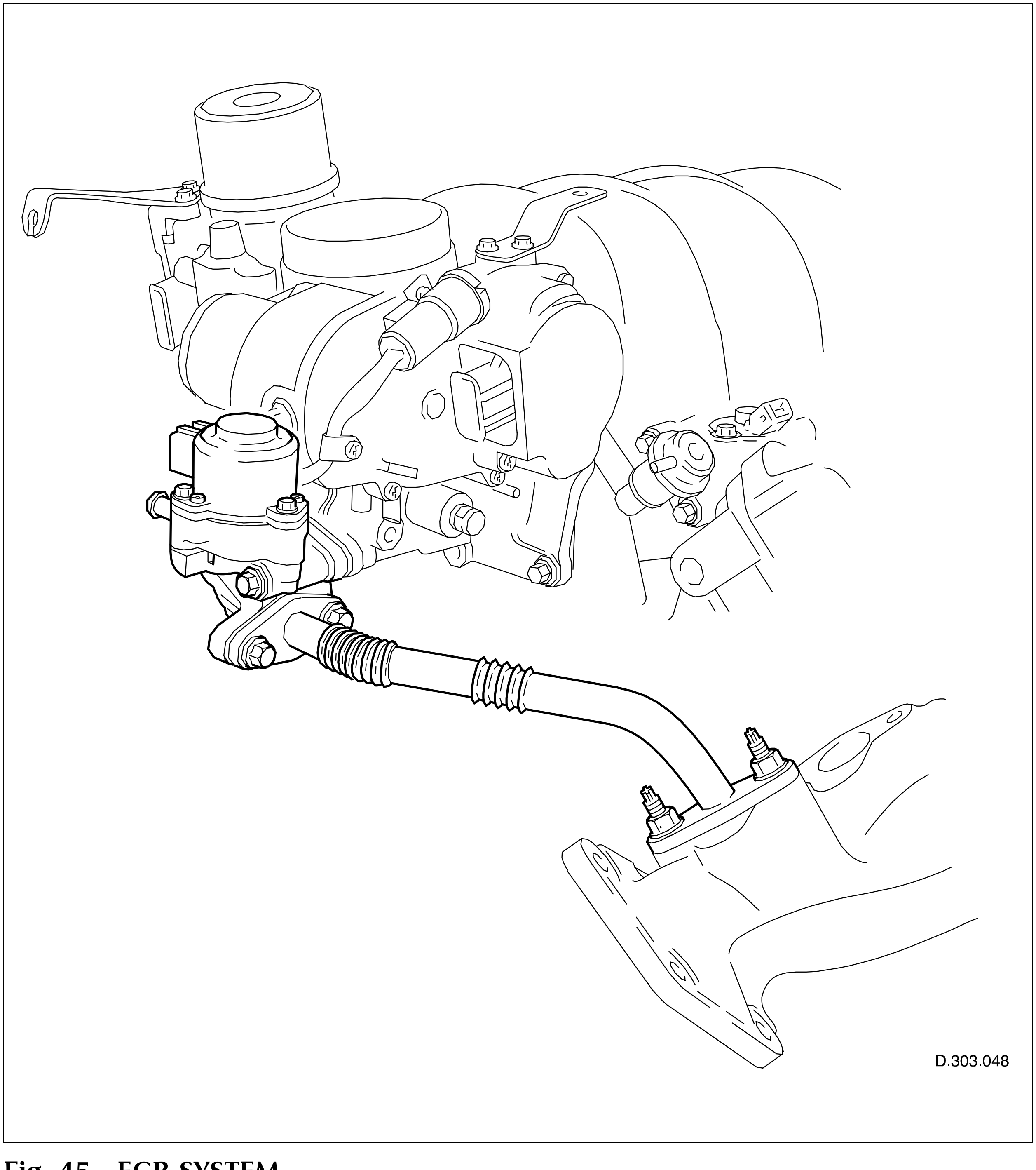


Fig. 45 EGR SYSTEM

Part Load / Full Load Breather — AJ26

The engine is ventilated through a part load and a full load breather.

The part load breather is a flexible plastic hose connected between the oil separator in the 'B' bank camshaft cover and the induction elbow. A restrictor from the oil separator outlet prevents reverse flow.

The full load breather is a flexible plastic hose connected between the oil separator in 'A' bank camshaft cover and the air duct.

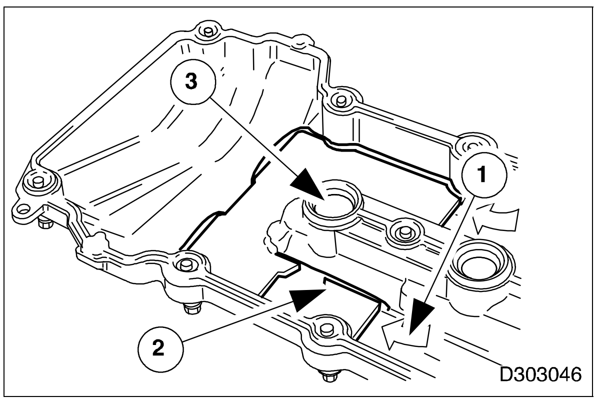


Fig. 46 SEPARATOR

A. Inlet
B. separator gauze
C. spark plug access seal

The ends of the hoses incorporate quick release connectors. The oil separators consist of wire gauze packed into an open ended enclosure below the breather outlet.

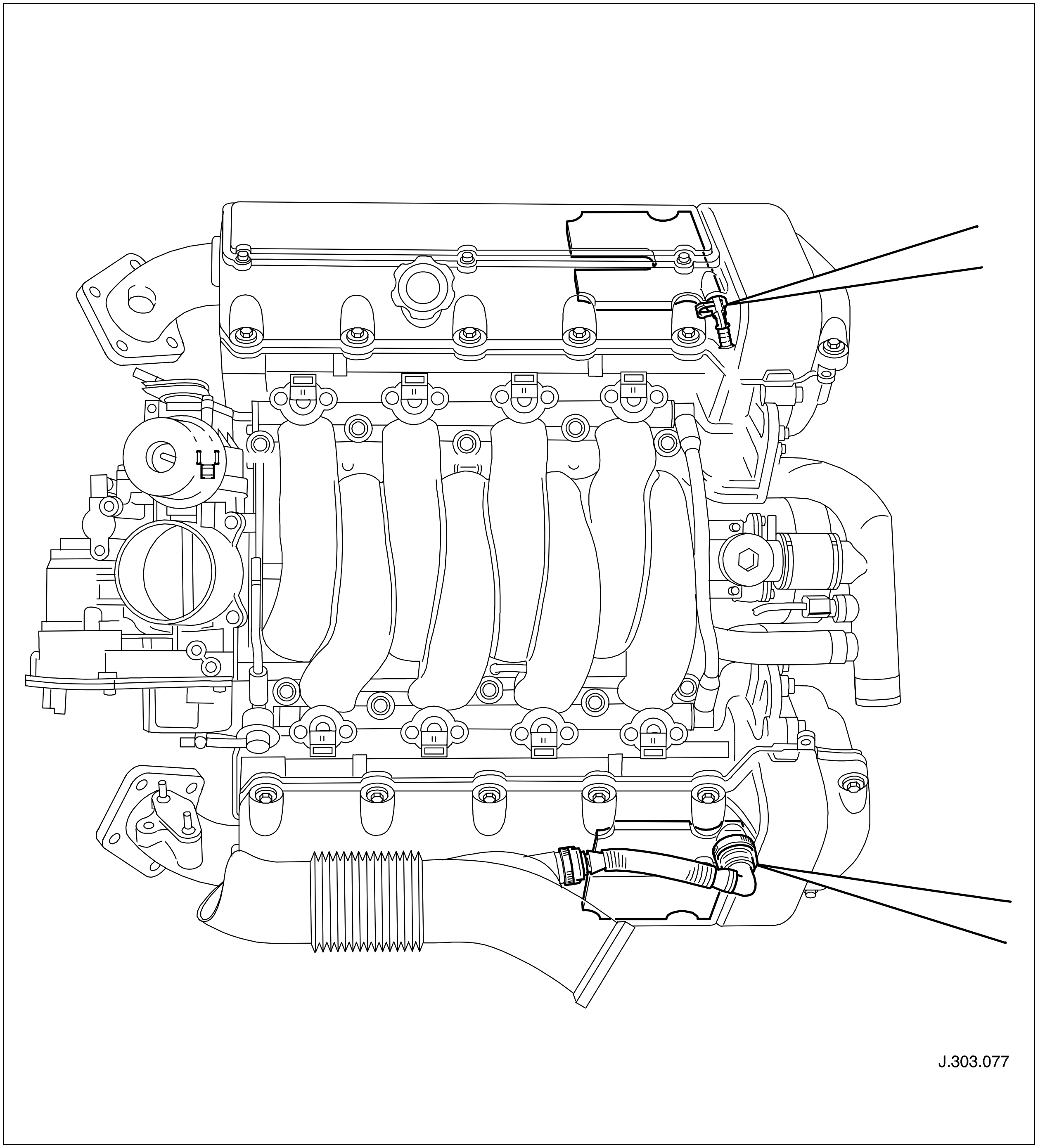


Fig. 47 BREATHER LOCATION (AJ26 shown)

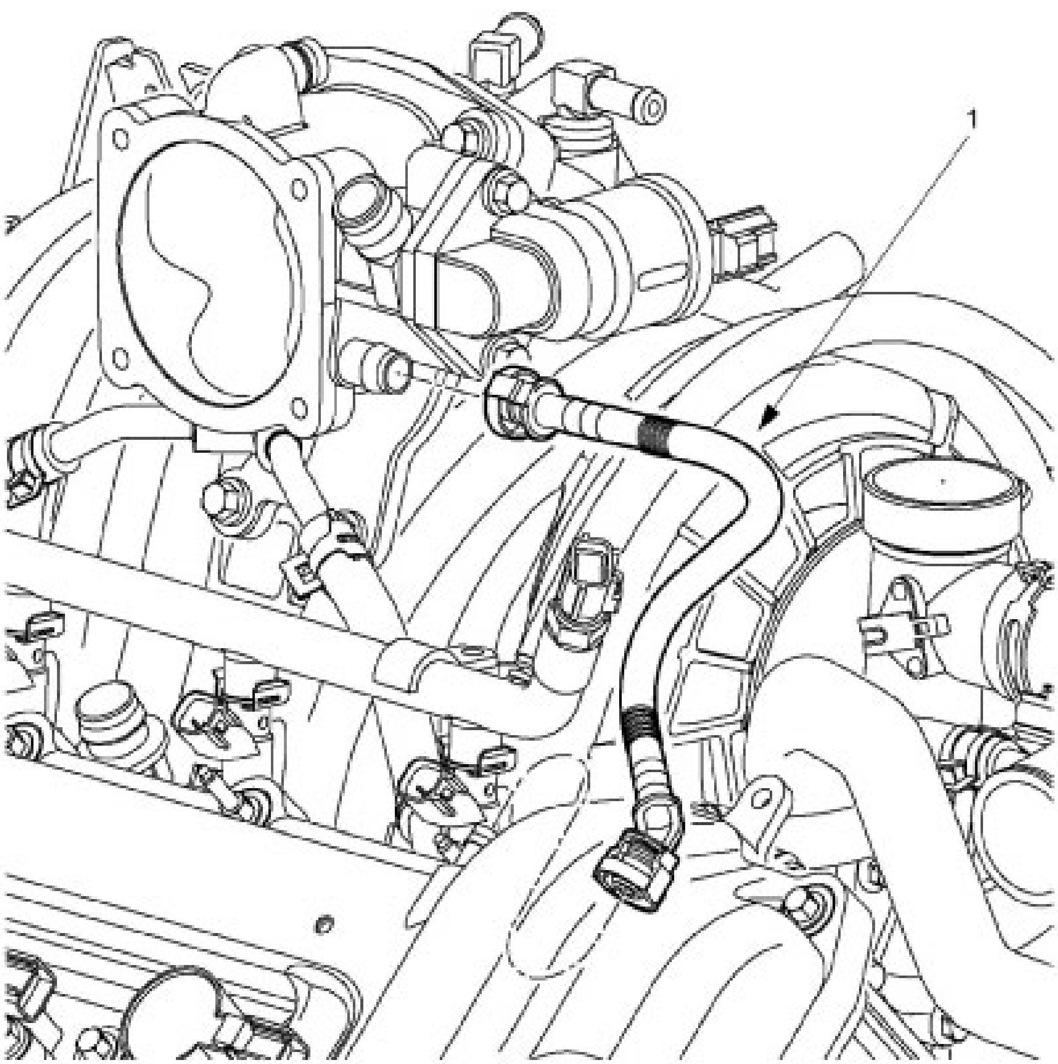


Fig. 48 PART LOAD BREATHER HOSE INSTALLATION (AJ28 shown)

1. Part Load Breather Hose

Positive Crankcase Ventilation (PCV) — AJ33

The AJ33 camshaft cover was modified and made from thermoplastic. the 'A' bank camshaft cover incorporates an outlet for the PCV valve for the engine breather system.

Crankcase ventilation is achieved by the use of a PCV valve mounted on the right hand camshaft cover and connected to the throttle housing.

The fresh air breather being connected to the intake zip tube.

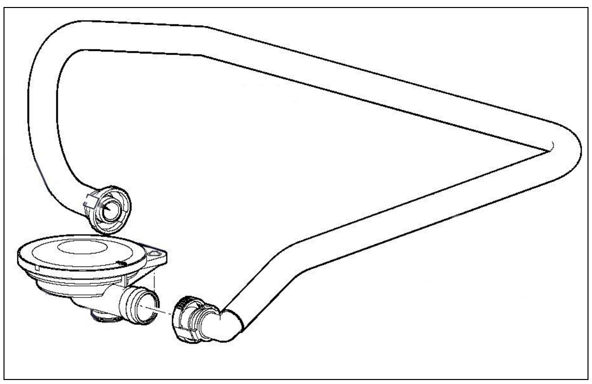


Fig. 49 Positive crankcase ventilation valve (PCV) part throttle

LUBRICATION AND COOLING

Sump

The sump consists of an aluminum alloy structural sump bolted to the bedplate, and a pressed steel oil pan bolted to the structural sump. A windage tray attached to the top of the structural sump isolates the oil pan from the disturbed air produced by the rotation of the crankshaft, to prevent oil aeration and improve oil drainage. A rubber plug at the rear of the structural sump seals the port that provides access to the torque converter securing bolts. The engine oil drain plug is located at the front right corner of the oil pan.

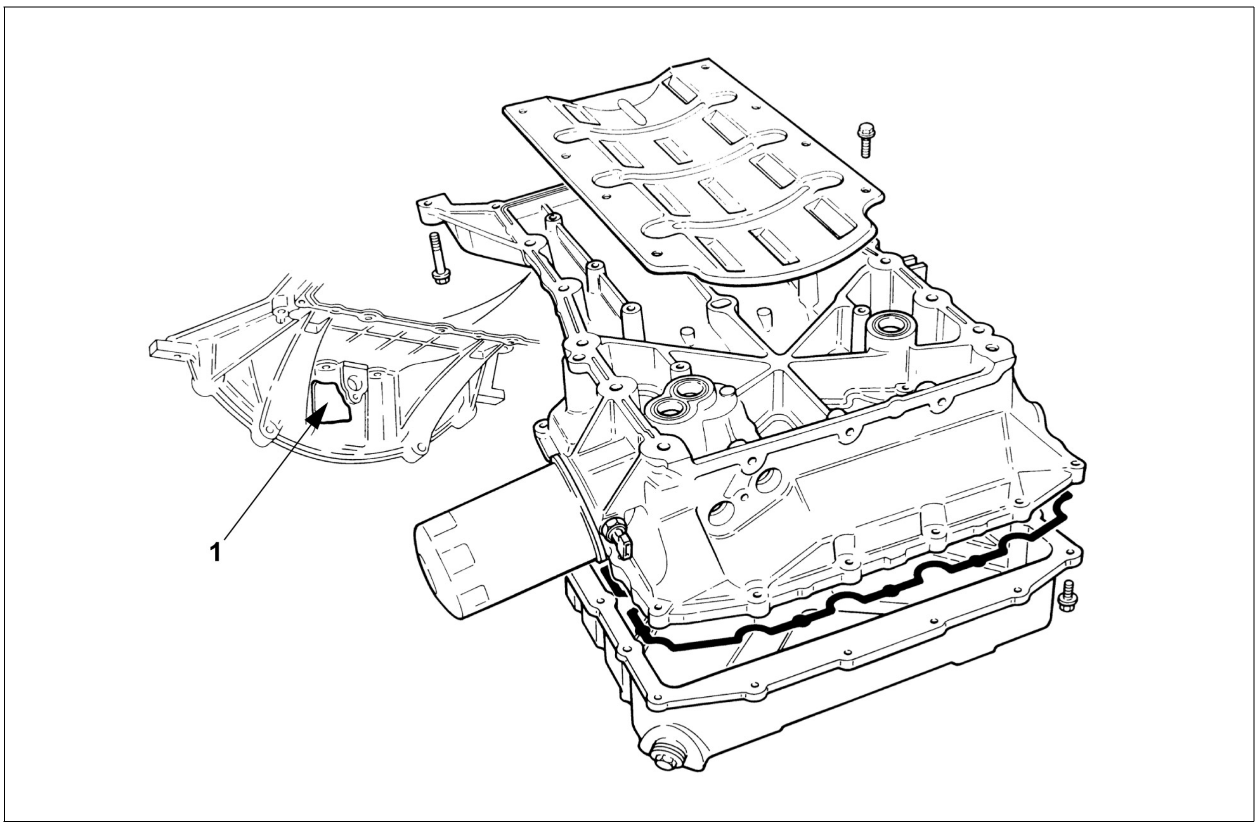


Fig. 50 STRUCTURAL SUMP AND OIL PAN

1. Torque Converter Access

A silicon rubber in-groove gasket seals the joint between the oil pan and the structural sump; a bead of sealant seals the joint between the structural sump and the bedplate.

The sump and oil pan have changed through development of the engine from AJ26 to AJ34.

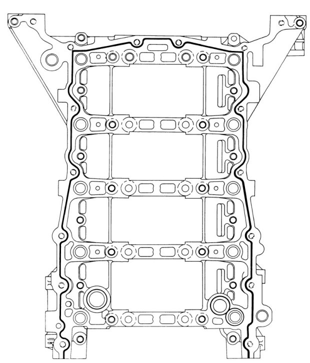


Fig. 51 SEALANT TRACK ON STRUCTURAL SUMP

Engine Lubrication

Oil is drawn from the reservoir in the oil pan and pressurized by the oil pump. The output from the oil pump is then filtered and distributed through internal oil passages. Where an oil cooler is fitted, the oil is cooled before entering the filter.

All moving parts are lubricated by pressure or splash oil. Pressurized oil is also provided for operation of the variable valve timing units and the timing gear chain tensioners.

The oil returns to the oil pan under gravity. Large drain holes through the cylinder heads and cylinder block ensure the quick return of the oil, reducing the volume of oil required and enabling an accurate check of the contents soon after the engine stops.

System replenishment is through the oil filler cap on B bank camshaft cover. With the exception of the pump and level gauge, all oil system components are installed on the structural sump.

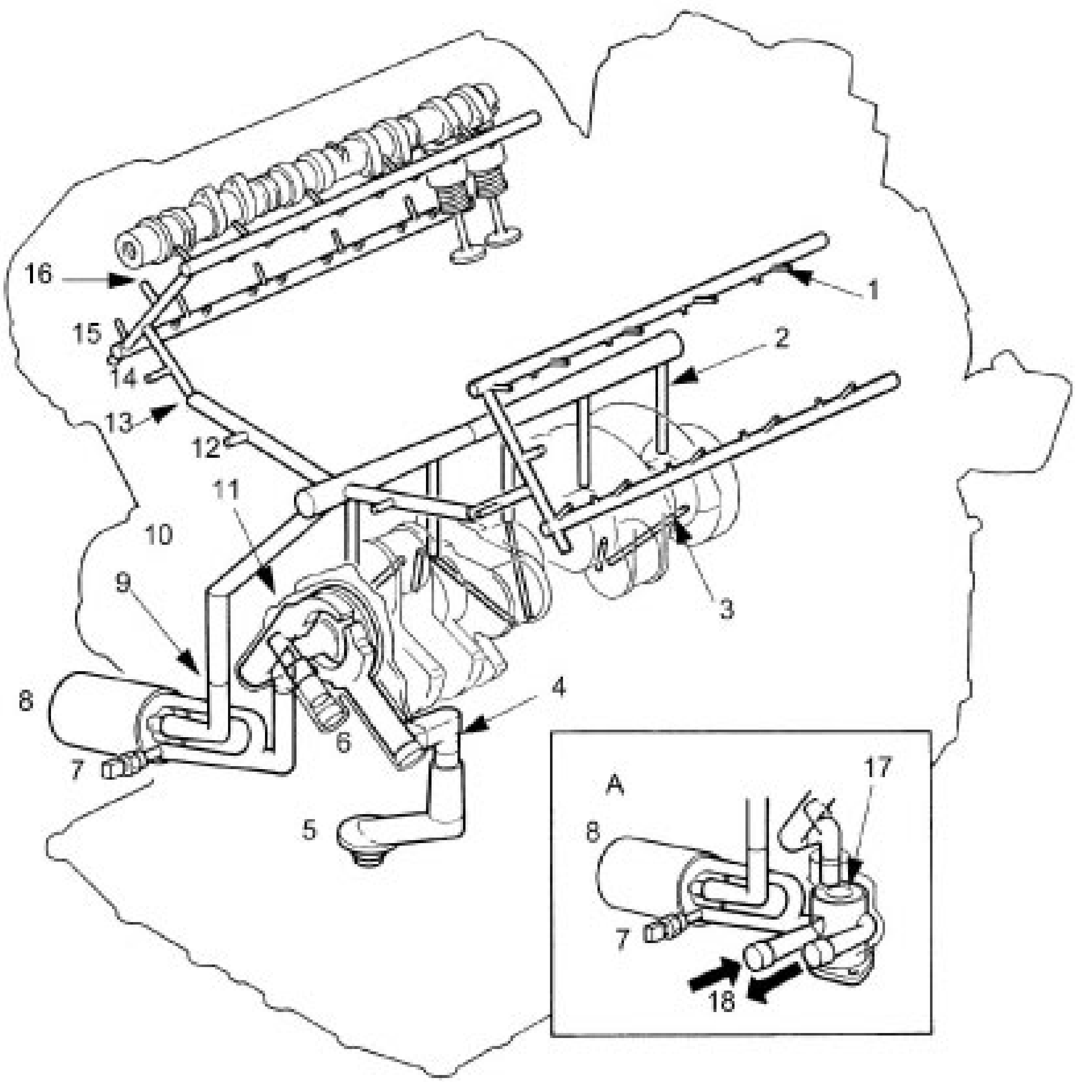


Fig. 52 LUBRICATION SYSTEM

Table 14

A	Oil Cooler Variant		
1	Valve Lifter Supply	2	Main Bearing Supply
3	Connecting Rod Bearing Supply	4	Bedplate/Cylinder Block Interface
5	Oil Pick-up	6	Pressure Relief Valve
7	Oil Pressure Switch	8	Oil Filter
9	Structural Sump/Bedplate Interface	10	Bedplate/Cylinder Block Interface
11	Oil Pump	12	Primary Chain Tensioner Supply
13	Cylinder Block/Cylinder Head Interface	14	Variable Valve Timing Supply
15	Camshaft Bearing Supply	16	Secondary Chain Tensioner Supply
17	Oil Diverter Valve (Oil Cooler Vehicles Only)	18	Oil Cooler Supply and Return

Oil Pickup

The molded plastic oil pickup is immersed in the oil reservoir to provide a supply to the oil pump during all normal vehicle attitudes. The castle shaped inlet allows the supply to be maintained even if the sump pan is deformed such that the pickup inlet bottoms out on the pan. A mesh screen in the inlet prevents debris from entering the oil system.

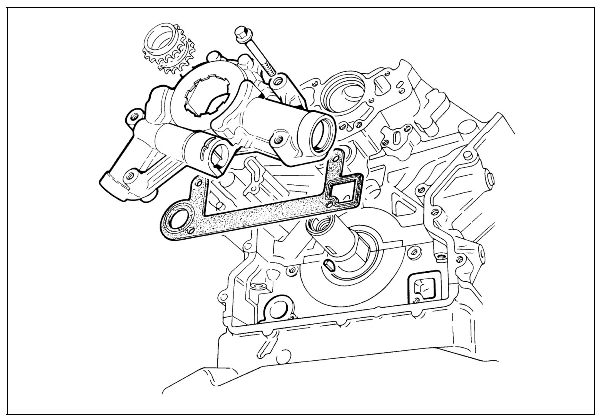


Fig. 53 OIL PUMP

Oil Pump AJ26/AJ27

The oil pump is installed on the crankshaft at the front of the engine. The pump inlet and outlet ports align with oil passages in the bedplate. A rubber coated metal gasket seals the pump to bedplate interface. The pumping element is an eccentric rotor, which is directly driven by flats on the crankshaft. An integral pressure relief valve regulates pump outlet pressure at 4.5 bar (66 PSI).

Oil Pump AJ33

An improved oil pump was introduced to aid the lubrication system for faster VVT response

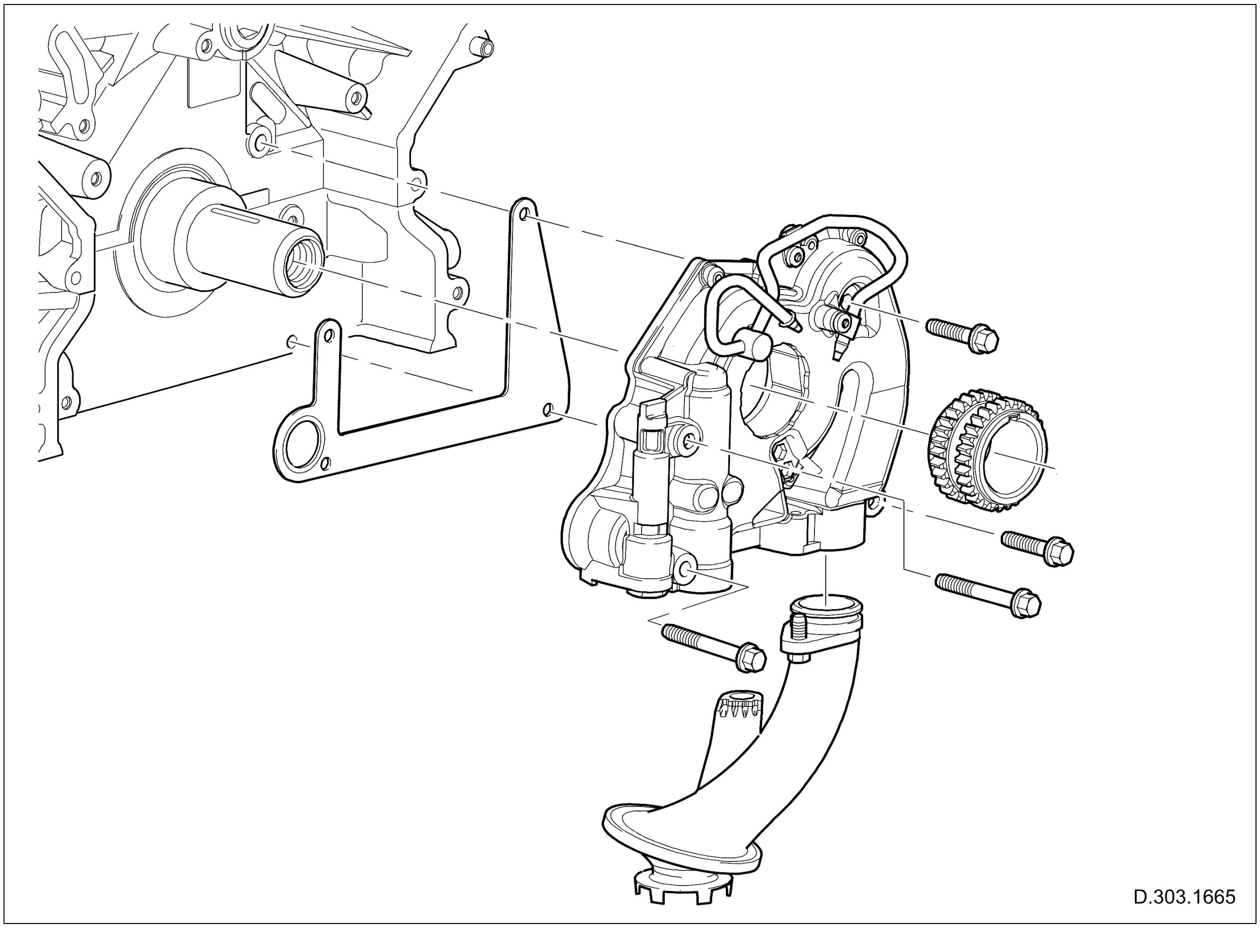


Fig. 54 Oil Pump AJ33, 34

Oil Filter

The oil filter is a replaceable canister installed on an adapter. An internal bypass facility permits full flow bypass if the filter is blocked.

Oil Pressure Switch

The oil pressure switch connects a ground input to the instrument cluster when oil pressure is present. The switch operates at a pressure of 0.15 to 0.41 bar (2.2 to 6.0 PSI).

Oil Level Gauge

The oil level gauge locates midway along the left side of the oil pan, supported in a tube installed in the bedplate. Two holes in the end of the gauge indicate the minimum and maximum oil levels. There is a difference of approximately 1 liter between the two levels.

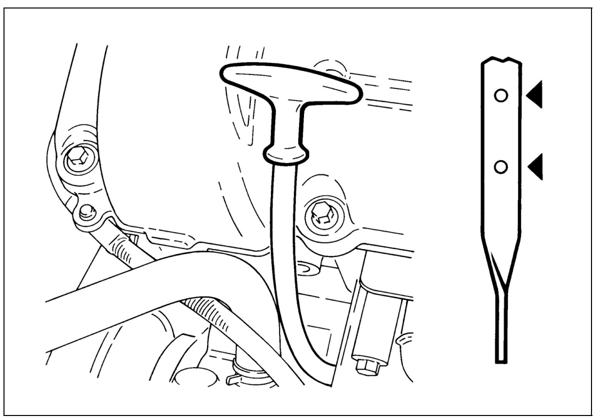


Fig. 55 OIL LEVEL GAUGE

Oil Diverter Valve (Oil Cooler Vehicles Only)

The oil diverter valve is installed in the passage from the pump outlet to the filter inlet. The valve is thermostatically operated and at higher temperatures diverts the oil through the vehicle mounted oil cooler. The valve begins to open between 103 and 107 °C, and is fully open, diverting 100% of the oil, at 119 °C.

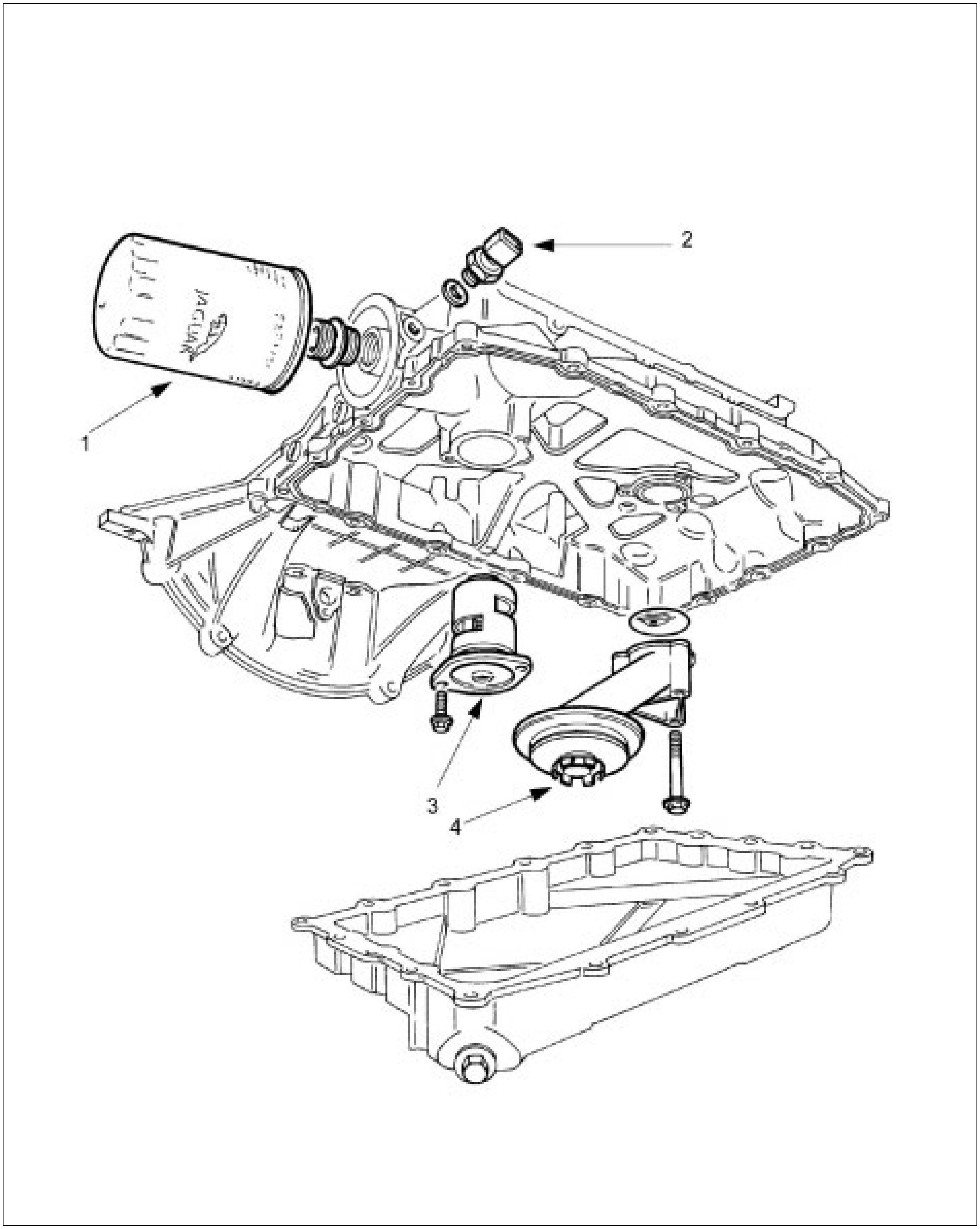


Fig. 56   OIL SYSTEM COMPONENTS ON STRUCTURAL SUMP

1. Filter
2. Pressure Switch
3. Diverter Valve
4. Pick-up

Oil Cooling

The external oil cooler is no longer fitted to normally aspirated engines but is retained on the supercharged models. The oil diverter valve is therefore not required on normally aspirated models.

Oil Temperature Sensor — AJ27 and later

The introduction of a fully oil controlled VVT system requires continuous monitoring of the oil temperature by the EMS. The sump is modified to accept an engine oil temperature (EOT) sensor which is fitted near the oil filter, immediately above the pressure sensor.

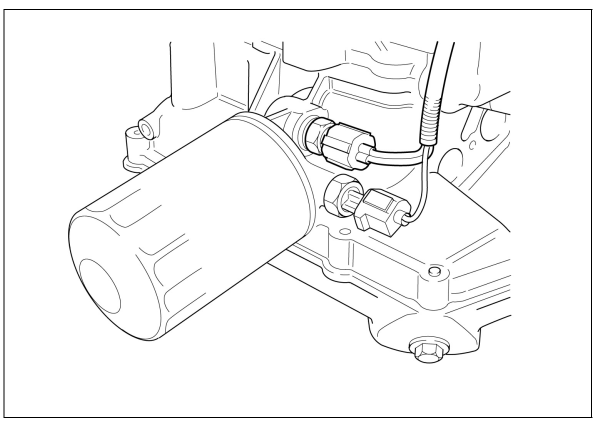


Fig. 57 AJ27 N/A ENGINES

Engine cooling

AJ26 Cooling System Overview

The cooling system is a low volume, high velocity system with good warm-up and temperature profile characteristics.

From the pump, the coolant flows into each bank of the cylinder block. In each bank, 50% of the coolant cools the cylinder bores and 50% is diverted through a bypass gallery. At the rear of the banks the two flows mix and enter the cylinder heads. The coolant then flows forwards to the outlet ports. When the thermostat is closed, the coolant returns directly to the pump through the bypass on the thermostat housing. When the thermostat is open, the coolant returns to the pump via the vehicle's radiator.

A coolant drain plug is installed on the rear left side of the cylinder block. On vehicles with the cold climate package, the cylinder block heater replaces the drain plug.

NOTE:

Coolant is drained from the right bank of the cylinder block by removing the coolant pipe behind the starter motor.

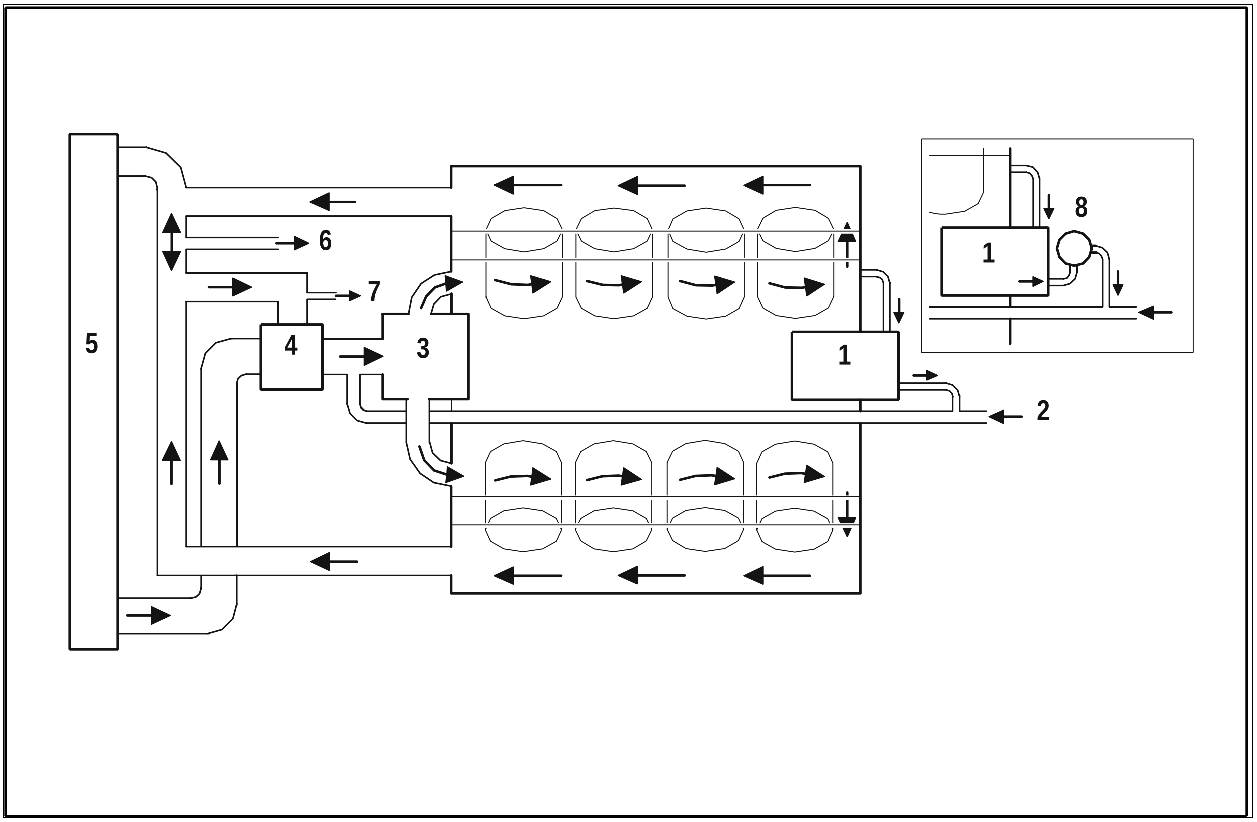


Fig. 58 COOLING SYSTEM DIAGRAM AJ26

1. Electronic Throttle
2. A/C Heater Return
3. Coolant Pump
4. Thermostat Housing
5. Vehicle Radiator (Reference)
6. A/C Heater Supply
7. Bleed Outlet
8. EGR Valve (Where Fitted)

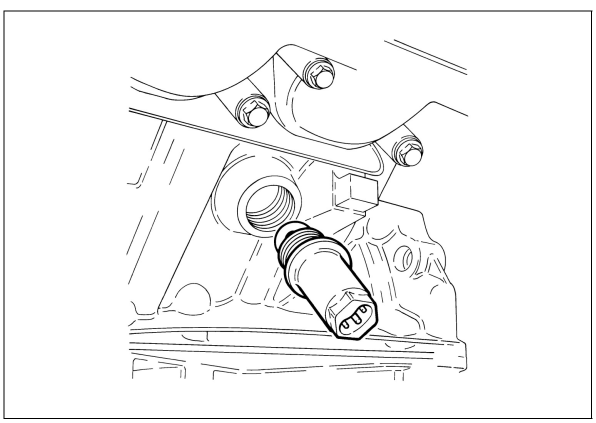


Fig. 59 CYLINDER BLOCK DRAIN/HEATER

Cooling System — AJ33, 34

- Changes have been made to the thermostat housing and pipe work
- The cooling system is a low volume, high velocity system with good warm up and temperature profile characteristics

The coolant flows from the pump into each bank of the cylinder block. At the rear of the banks the two flows mix and enter the cylinder heads. The coolant then flows forwards to the outlet ports, returning via a bypass pipe to the pump when the thermostat is closed, and returning to the pump via the vehicle radiator when the thermostat is open.

There is a drain plug for the coolant on the left side of the cylinder block. On vehicles with the cold climate package, the cylinder block heater replaces the drain plug.

NOTE:

Coolant can be drained from the right hand bank by removing the coolant plug above the starter motor.

The thermostat is installed between the two cylinder banks above the coolant pump. On normally aspirated engines the thermostat which will start to open at 86 °C - 90 °C and will be fully open at 102 °C is housed in a plastic casing.

On the supercharged variants the thermostat is held in an aluminum housing. It will start to open between 82 °C and 86 °C and will be fully open at 98 °C.

A duct in the cylinder block connects the thermostat-housing outlet to the pump inlet. The fill point has been deleted. Supply and return hoses for the air conditioning heater matrix are installed at the front of the engine.

A connection on the thermostat housing provides the coolant supply for the EGR valve and the electronic throttle. The outlet from the electronic throttle connects to a stub pipe at the back of the cylinder block Vee.

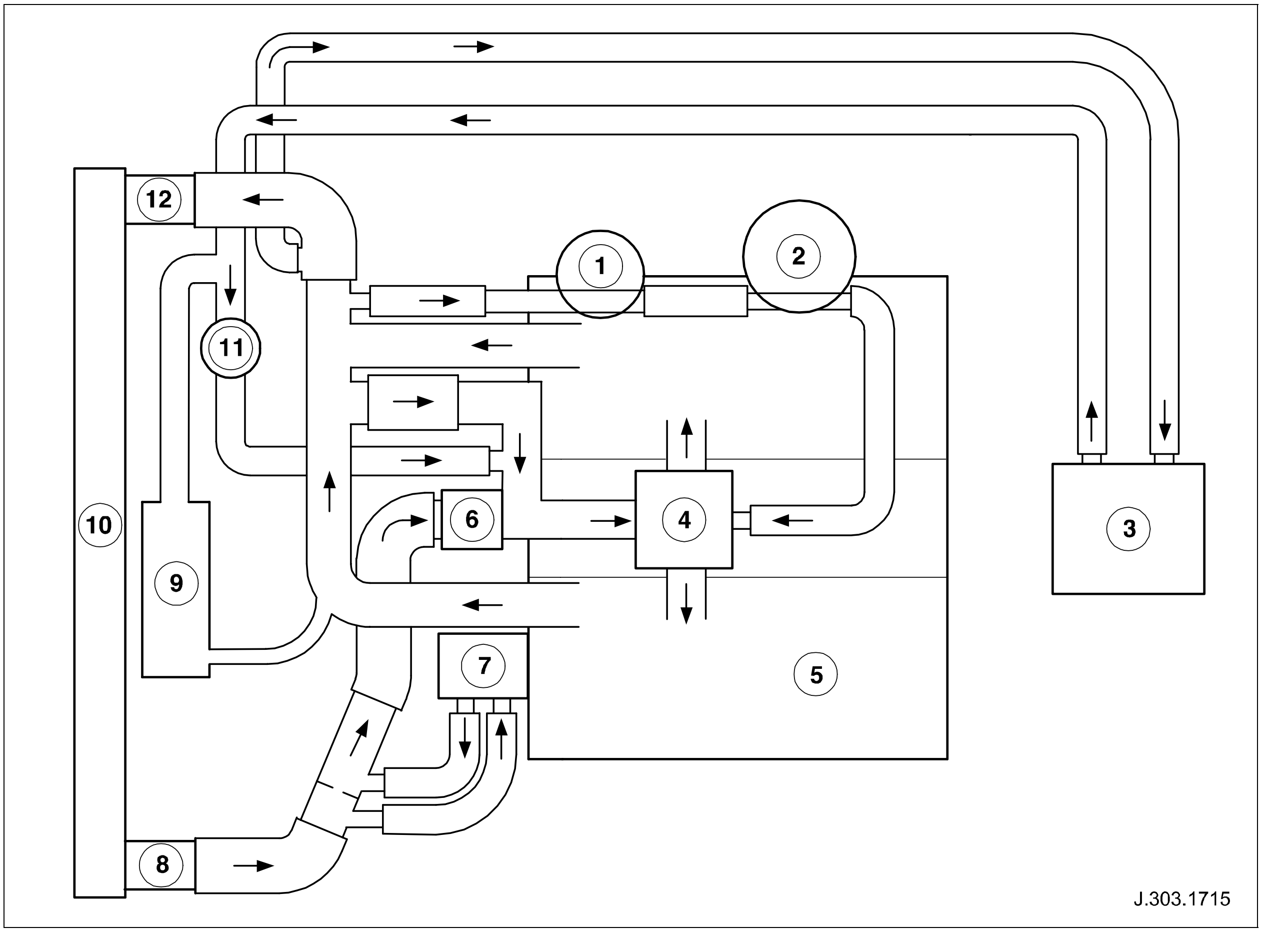


Fig. 60 V8 coolant flow diagram (N/A)

1. EGR Valve
2. Throttle body
3. Heater core
4. Coolant pump
5. Engine
6. Thermostat
7. Engine oil cooler
8. Bottom hose
9. Coolant expansion tank
10. Radiator
11. Auxiliary coolant flow pump
12. Top hose

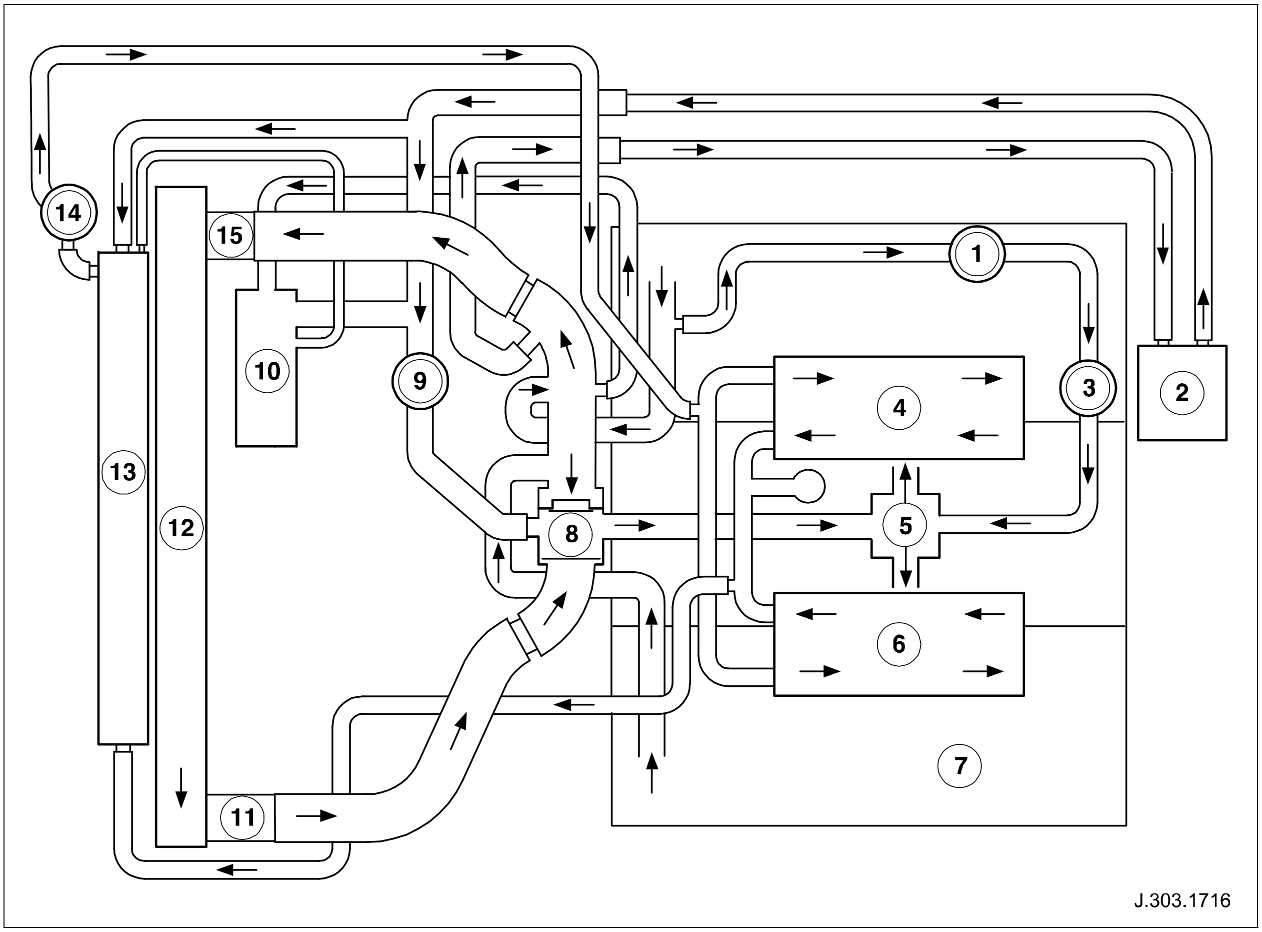


Fig. 61 V8 coolant flow diagram (S/C)

1. EGR Valve
2. Heater core
3. Throttle body
4. Charge air cooler (bank 1)
5. Coolant pump
6. Charge air cooler (bank 2)
7. Engine
8. Thermostat
9. Auxiliary coolant flow pump
10. Coolant expansion tank
11. Bottom hose
12. Radiator
13. SC Radiator
14. SC coolant pump
15. Top hose

Coolant Pump

The coolant pump is installed between the two cylinder banks, on the front face of the cylinder block. The pumping element is a shrouded plastic impeller. Coolant escapes from seal breather holes in the housing if the pump's bearing seal fails.

An O-ring and an edge bonded rubber/aluminum alloy gasket seal the pump to cylinder block interface. The O-ring seals the inlet port from the thermostat. The gasket seals the outlet ports into the cylinder banks.

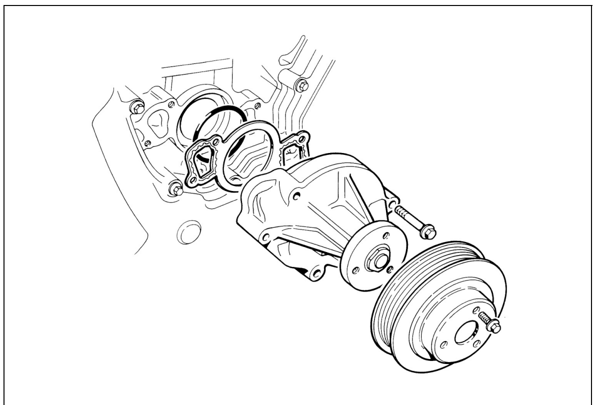


Fig. 62 COOLANT PUMP

Thermostat Housing

The plastic thermostat housing is installed between the two cylinder banks, immediately above the coolant pump. The thermostat controls the flow of coolant through the radiator. It starts to open at 80 to 84 °C and is fully open at 96 °C.

A duct in the cylinder block connects the thermostat housing outlet to the pump inlet. A stub pipe connects the duct to the air conditioning heater matrix return line.

An in-groove gasket seals the joint between the thermostat housing and the cylinder block.

In addition to containing the thermostat, the plastic thermostat housing incorporates connections for the bleed, bypass and radiator bottom hoses. The bleed outlet vents any air in the system into the vehicle's coolant reservoir.

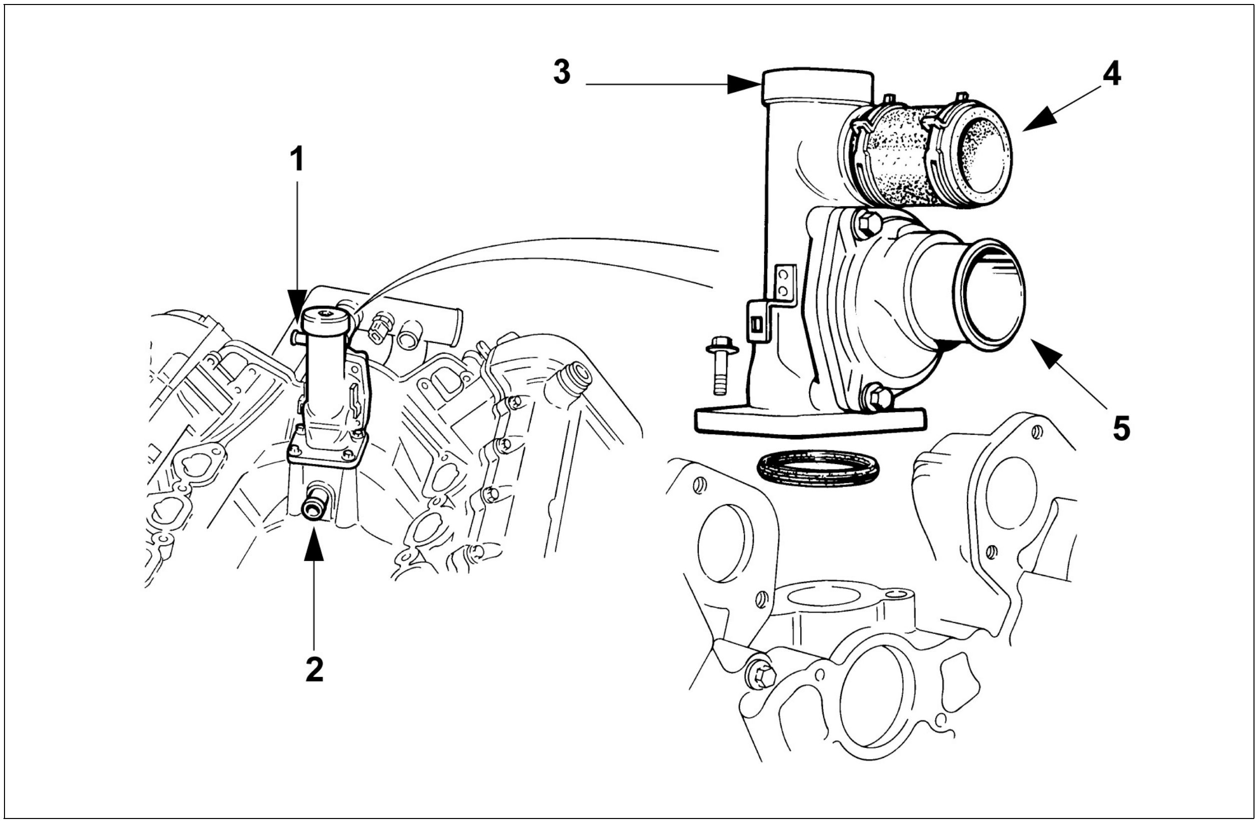


Fig. 63 THERMOSTAT HOUSING

1. Bleed
2. A/C Heater Return
3. Cap
4. By-pass
5. From Radiator

The cap of the thermostat housing is removable, to allow air out of the system when filling from empty.

CAUTION:

Use the correct torque (marked on the cap) when reinstalling the cap, or the cap and thermostat housing could be damaged.

Coolant Hoses

Supply and return hoses for the air conditioning heater matrix are installed between the cylinder banks. A connection at the rear of 'A' bank provides the coolant supply for the electronic throttle and the EGR valve (where fitted). The outlet from the electronic throttle connects to the return hose of the air conditioning heater matrix.

Table 15

A	Engines WITH EGR
B	Engines without EGR
C	A/C Heater Matrix

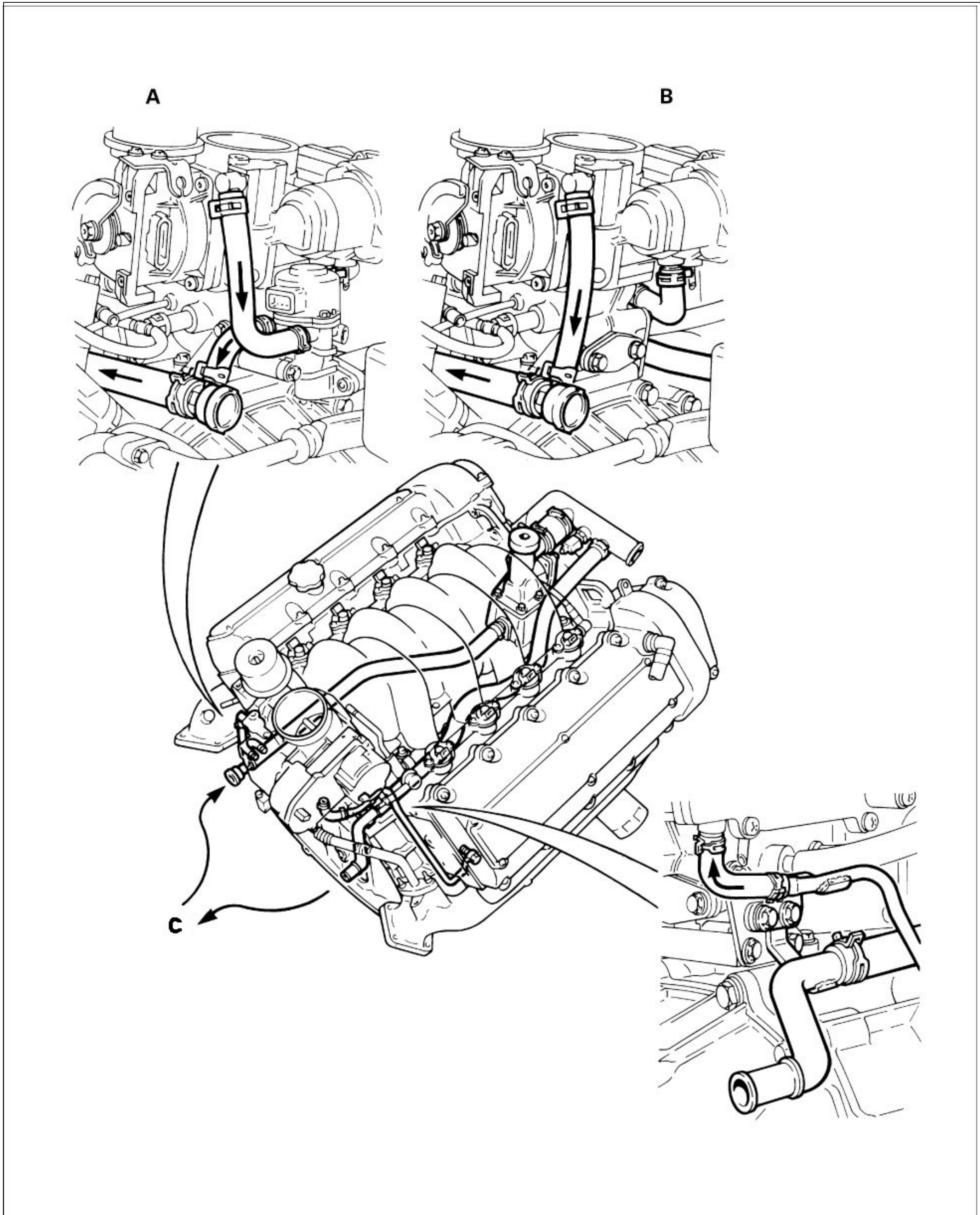


Fig. 64 COOLANT HOSES — With and without EGR

Coolant Outlet Duct

The plastic coolant outlet duct connects to the outlet port of each cylinder head to provide a common connection point for the radiator top hose. It also incorporates connections for the coolant temperature sensor, the supply to the air conditioning heater matrix, and the bypass flow to the thermostat housing.

An in-groove gasket seals each of the joints between the outlet duct and the cylinder heads.

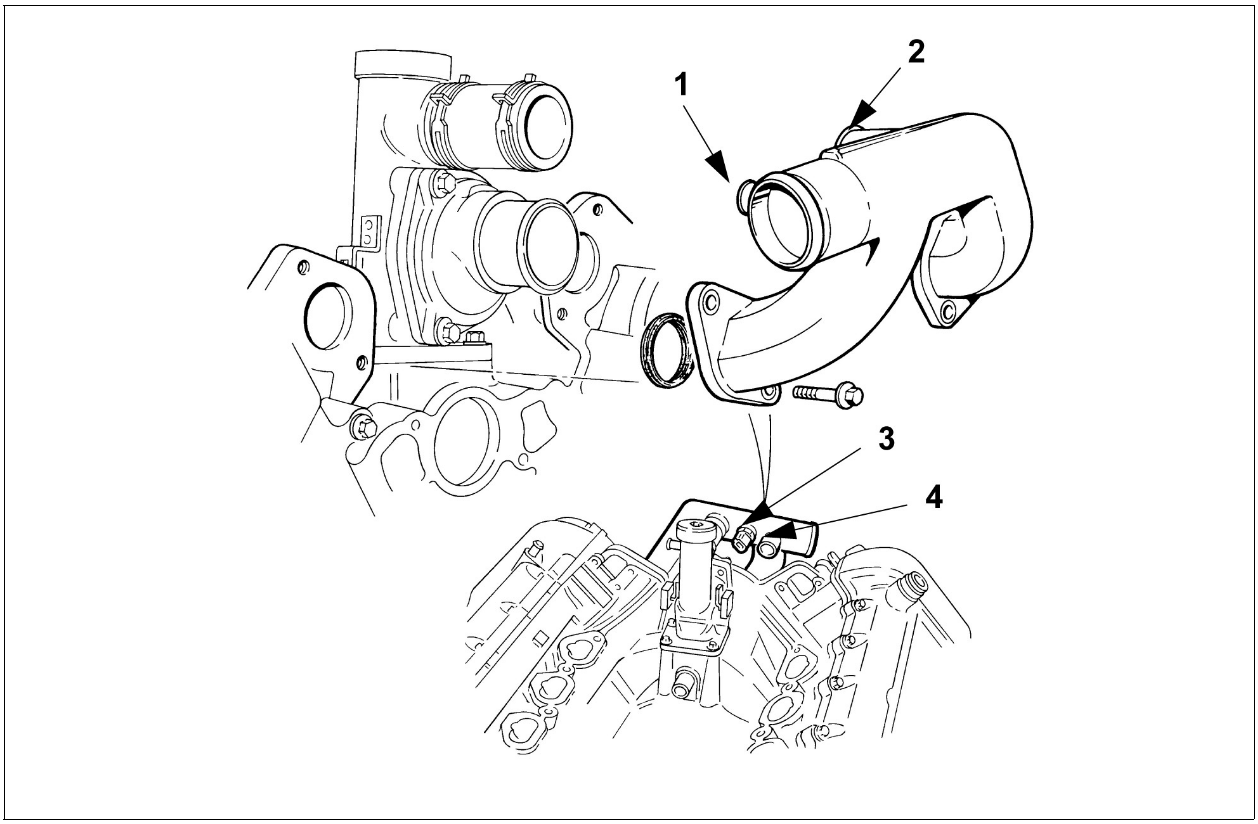


Fig. 65 COOLANT OUTLET DUCT — N/A Only

1. To Radiator
2. By-pass
3. ECT Sensor
4. A/C Heater Supply

Table 16 Cooling system specifications

Cooling data	
Type	Sealed pressurized
	Low volume – high velocity
Pump type	Enclosed impeller mechanically driven
Pressure	1.0 Bar
	14.5 PSI
Coolant type	E2F2-19549-AA
Percentage mix	50% water
	50% coolant
Coolant	
Boiling point	128 deg C
Service interval	5 years
	150,000 miles
	250,000 Km

Cooling system filling and bleeding S/C engines

- Remove the supercharger coolant fill plug (discard the sealing washer)
- Fill the system through this fill port
- Switch the ignition on. Allow the coolant pump to run and top up the coolant through the fill port
- Switch off the ignition and install the fill plug
- Start and run the engine
- Set the heating system to MAX heat and the blowers to MAX speed And the air distribution to instrument panel registers
- Allow the engine to run until hot air is emitted from the instrument panel registers
- Ensure the level is correct

Cooling system filling and bleeding N/A engines

- Fill the system at the header tank
- Switch the ignition on and start the engine
- Run the engine at between 1500 and 2000 rpm until the cooling fans operate
- Set the heating system to MAX heat and the blowers to MAX speed And the air distribution to instrument panel registers
- Allow the engine to run until hot air is emitted from the instrument panel registers
- Ensure the level is correct

Cooling system filling and bleeding S-TYPE
Left hand drive vehicles

- Remove the engine fill cap
- Open the heater air bleed located next to the expansion tank
- Fill the cooling system at the engine fill point and refit the cap
- Leave the engine air bleed open
- Start the engine and set the heater to a temperature of 29 °C / 90 °F
- Close the heater air bleed when a steady stream of coolant flows during engine idle
- Allow the engine to idle for five minutes, adding coolant to the expansion tank to maintain the COLD FILL MAX level
- Open the heater air bleed to release any trapped air. Close the heater air bleed
- Increase the engine speed to 2000 RPM for between three and five minutes or until the heater is blowing hot air

ACCESSORY DRIVES

Overview

All engine accessories are rigidly mounted to improve refinement.

Accessory mounting brackets on the left and right sides of the engine support the A/C compressor, power steering pump and the generator respectively.

Dowels between the accessory mounting brackets and the engine ensure the accessory pulleys are accurately aligned with the accessory drive belt.

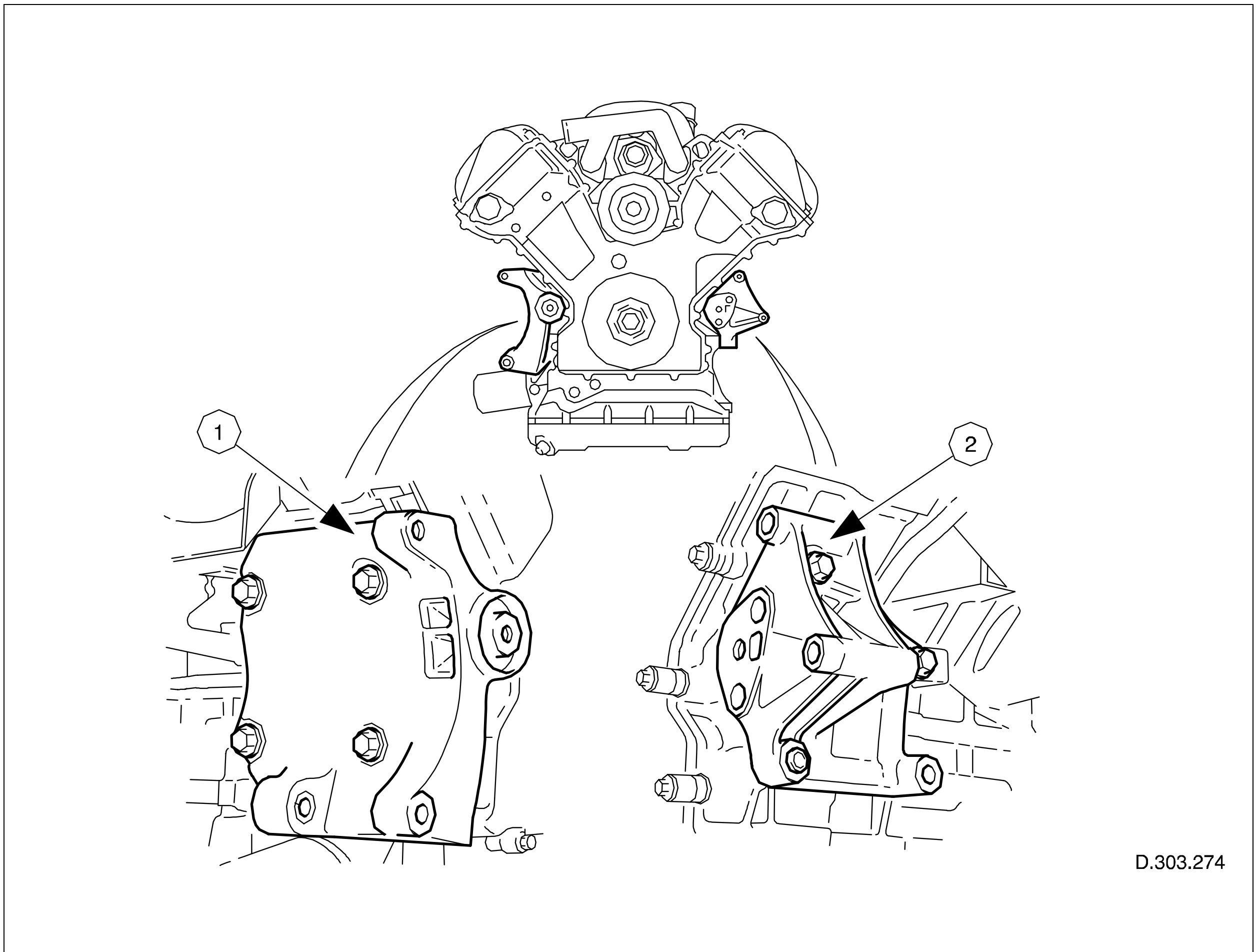


Fig. 66 ENGINE BRACKETS

A single multi-ribbed belt drives all the engine mounted accessories. The torsional vibration damper on the front of the crankshaft drives the belt. An automatic tensioner, located on the left accessory mounting bracket, keeps the belt at the correct tension. An idler pulley on the right accessory mounting bracket increases the wrap angle around the generator.

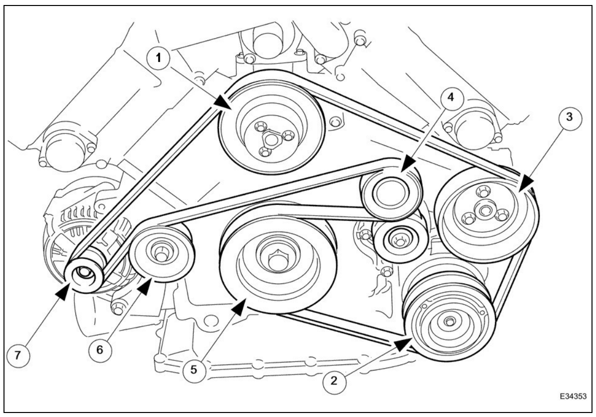


Fig. 67 ACCESSORY DRIVE — AJ26 & AJ27

1. Water pump pulley
2. A/C compressor
3. Power steering pulley
4. Tensioner
5. Crankshaft pulley
6. Idler pulley
7. Generator pulley

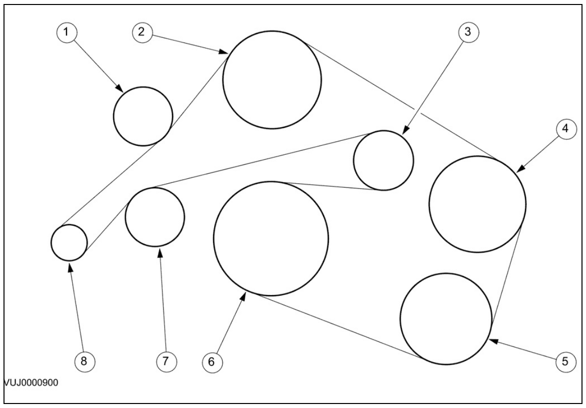


Fig. 68 ACCESSORY DRIVE — AJ28

1. Idler pulley
2. Water pump
3. Tensioner
4. Power steering pulley
5. A/C compressor
6. Crankshaft pulley
7. Idler pulley
8. Generator pulley

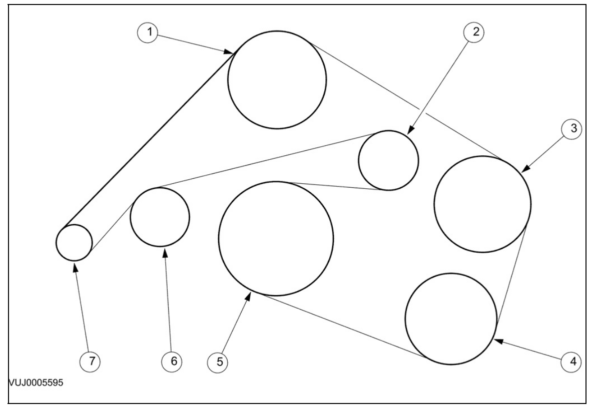


Fig. 69 ACCESSORY DRIVE — AJ33 & AJ34

1. Water pump pulley
2. Tensioner
3. Power steering pulley
4. A/C compressor
5. Crankshaft pulley
6. Idler pulley
7. Generator pulley

The torsional vibration damper incorporates compressed rubber between its inner and outer diameters to absorb vibration and shock loads. The automatic tensioner consists of an idler pulley on the end of a spring loaded pivot arm. The pivot arm can be turned counterclockwise (viewed from the front of the engine) for removal and installation of the belt. A belt wear indicator is incorporated on the rear of the pivot arm.

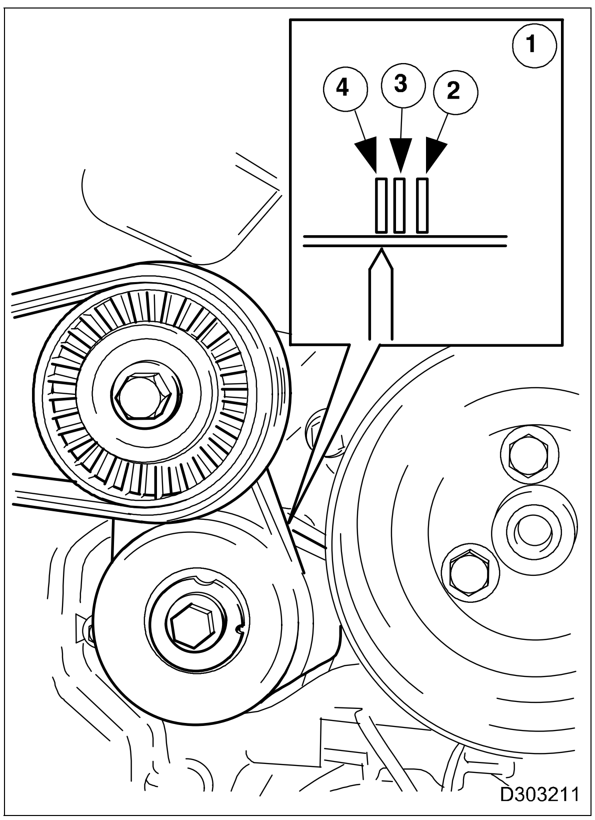


Fig. 70 Wear indicator

1. Wear indicator
2. Replace belt
3. New belt maximum length
4. New belt minimum length

A new belt with revised material composition was introduced at S/C AJ26 for the XKR accessory drive but not for the supercharger drive. All AJ27 series vehicles were made of a new material and are identified by larger white part numbers and Jaguar logos (the base drive belt also has a red band).

The plastic idler and tensioner pulleys on the accessory drive are replaced by steel pulleys.

NOTE:

The new type belts must not be used with the plastic pulleys.

Supercharger belt

The drive belt for the supercharger passes immediately in front of the accessory drive belt. Therefore, before any work can be done on the accessory drive belt and associated components, the supercharger drive belt must first be removed.

Belt inspection

The drive belt should be inspected at every routine service for excessive wear and damage. A drive belt which displays symptoms of cracking may be perfectly fit for further service.

Should cracking be detected, serviceability may be assessed using the following guidelines:

- Fifteen cracks per rib over a 100mm length of drive belt is acceptable
- Sections of belt missing from any rib is not acceptable and the drive belt must be renewed

TECHNICAL SPECIFICATIONS

Table 17

FEATURES	S-TYPE V8 (X200)	S-TYPE V8 (X202)	S-TYPE R (X202) (4.2 SC)
Configuration	90° V8	90° V8	90° V8
Displacement	3966cc	4196cc	4196cc
Bore/Stroke	86/86mm	86/90.3mm	86/90.3mm
Compression ratio	10.75:1	11:1	9.1:1
Cylinder head	– 2 overhead camshafts per bank, 4 valve per cylinder	– 2 overhead camshafts per bank, 4 valve per cylinder	– 2 overhead camshafts per bank, 4 valve per cylinder
Firing order	(1)1: (2)1: (1)4: (1)2: (2)2: (1)3: (2)3 (2)4	–1-2–7-3-4-5-6-8	–1-2–7-3-4-5-6-8
Maximum power (DIN values)	281 BHP /209 kW / 284 PS at 6100 RPM	300 BHP /224 kW /304 PS at 6000 RPM	400 BHP /298 kW /406 PS at 6100 RPM
Maximum torque (DIN values)	390 Nm /287 lb ft at 4300 RPM	420 Nm /310 lb ft at 4100 RPM	553 Nm /408 lb ft at 3500 RPM
Valve clearance (cold)	Intake 0.18 – 0.22 mm		
	Exhaust 0.23 – 0.27 mm		

Table 18 Engine Specifications XJ

FEATURE	XJ 98-03 (4.0)	XJ 98-03 (4.0 SC)	XJ 04 onwards (4.2)	XJ 04onwards (4.2 SC)
Configuration	– 90° V8	– 90° V8	– 90° V8	– 90° V8
Displacement	–3996cc	–3996cc	– 4196cc	– 4196cc
Bore/Stroke	86/86mm	86/86mm	86/90.3mm	86/90.3mm
Compression ratio	–10.75:1	– 8.9:1	–11.01:1	9.1:1
Cylinder head	– 2 overhead camshafts per bank, 4 valve per cylinder	– 2 overhead camshafts per bank, 4 valve per cylinder	– 2 overhead camshafts per bank, 4 valve per cylinder	– 2 overhead camshafts per bank, 4 valve per cylinder
Firing order	(1) 1: (2)1: (1)4: (1)2: (2)2: (1)3: (2)3: (2)4		1–2–7–3–4–5–6–8	
Maximum power (DIN values)	290 BHP /216 kW / 294 PS at 6100 RPM	370 BHP /276 kW / 375 PS at 6150 RPM	300 BHP /224 kW /304 PS at 6000 RPM	400 BHP /298 kW 406 PS at 6100 RPM
Maximum torque (DIN values)	393 Nm /290 lb ft at 4250 RPM	525 Nm /387 lb ft at 3600 RPM	420 Nm /310 lb ft at 4100 RPM	553 Nm /408 lb ft at 3500 RPM
Valve clearance (cold)	Intake 0.18 – 0.22 mm			
	Exhaust 0.23 — 0.27 mm			

Table 19 Engine Specifications XK

FEATURE	XK 97–02 (4.0)	XK 97–02 (4.0 SC)	XK 03 onwards (4.2)	XK 03 onwards (4.2 SC)
Configuration	– 90° V8	– 90° V8	– 90° V8	– 90° V8
Displacement	–3996cc	–3996cc	– 4196cc	–4196cc
Bore/Stroke	86/86mm	86/86mm	86/90.3mm	86/90.3mm
Compression ratio	–10.75:1	–8.9:1	–11:1	–9.1:1
Cylinder head	– 2 overhead camshafts per bank, 4 valve per cylinder	– 2 overhead camshafts per bank, 4 valve per cylinder	– 2 overhead camshafts per bank, 4 valve per cylinder	– 2 overhead camshafts per bank, 4 valve per cylinder
Firing order	(1)1: (2)1: (1)4: (1)2: (2)2: (1)3: (2)3 (2)4		–1-2–7-3-4-5-6-8	
Maximum power (DIN values)	290 BHP /216 kW / 294 PS at 6100 RPM	370 BHP /276 kW / 375 PS at 6150 RPM	300 BHP /224 kW / 304 PS at 6000 RPM	400 BHP /298 kW /406 PS at 6100 RPM
Maximum torque (DIN values)	393 Nm /290 lb ft at 4250 RPM	525 Nm /387 lb ft at 3600 RPM	420 Nm /310lb ft at 4100 RPM	553 Nm /408 lb ft at 3500 RPM
Valve clearance (cold)	Intake 0.18 – 0.22 mm			
	Exhaust 0.23 – 0.27 mm			

Table 20 AJV8 Service Specifications

Additional specifications	
AJ27 Main bearing clearance acceptable range	0.022 - 0.0475 mm
AJ33 Main bearing clearance acceptance range	0.022 - 0.040 mm
AJV8 Connecting rod bearing clearance range	0.033 - 0.058 mm
AJV8 Crankshaft endplay	0.027 - 0.070 mm
AJV8 Valve spring free length (min)	45.45 mm

Additional specifications	
Tappet type	aluminum inverted bucket with top mounted shim
Camshafts	Chilled cast iron
Number of bearings	Five
Crankshaft	Spheroidal Graphite cast iron
Number of main bearings	Five
Number of Big-end bearings	Eight
Balance	15 gram/cm to be corrected by drilling up to 7 holes in front and rear balance webs Connecting rods Powder sinter forged steel fracture split
Pistons	Die cast aluminum alloy Fully floating gudgeon pin
Piston rings	Change of rings took place on AJ33 engines
Top	Barrel faced molybdenum plasma sprayed compression ring
Middle	Napier taper compression ring
Bottom	Bottom Two piece spring assisted oil control ring
Compression pressure	180 PSI (12 Bar)
Lubrication system	
Oil	WSS – M2C913 – B
Oil specification	API SJ
	ACEA A1, A2, A3
Oil capacity non cooler	6.5 liters
with oil cooler	7.3 liters
Oil diverter opening temp start	105 deg C
fully open	119 deg C
Oil pump	Lobed rotor type pump
Maximum oil flow	45 l/min
	10 gallons/min
Maximum oil pressure	6.8 Bar
	98.6 PSI

Additional specifications	
Relief valve set	4.5 Bar
	65.25 PSI
Oil pressure @ 3000 rpm	3.8 Bar
	55.1 PSI
Oil pressure @ idle	0.7 Bar
	10.15 PSI
Oil pressure switch operates	0.15–0.41 Bar
	2.17–6 Bar
Oil filter	Full flow paper type
Tightening torque	12–17 Nm
Working (normal) pressure	0.7 Bar
	10.15 PSI
Nominal paper area	1760 cm^2
Dipstick minimum – maximum	1 liter
Primary timing chain	Single roller chain endless riveted 106 links (Inverted tooth at 2002 running change)
Secondary timing chain	Single roller chain endless riveted 44 links

The cylinder head warpage specification for the AJV8 engines is:

- 0.05 mm – 150x150
- 0.02 mm – 25x25
- 0.08 mm — Overall

NOTE:

The flatness is called out in patches. The 150x150 refers to a 150mm x 150mm square patch. In any 150x150 patch on the deck face, the flatness must be less than 0.05mm. Similar for the 25mm x 25mm patch.

Table 21 Service requirements

Component	Change interval
Oil and filter change	10,000 miles (16,000 km)
Air filter element change	30,00 miles (48,000 km)
Spark plug change	70,000 miles (112,000 km)
Unleaded fuel	NGK type PFR5G-13E. All N/A and S/C Engines
Leaded fuel	NGK type BKR5E-13. All N/A and S/C Engines
Spark plugs changed to Iridium with the 4.2 engines	100,000 miles (160,000 km)
Front auxiliary drive belt	150,000 miles (240,000 km)

Lubricants, Fluids, Sealers and Adhesives

Table 22

Specifications	
Engine oil, SAE 5W-30	– WSS-M2C-913 - B
Engine assembly lubricant	– SQM-2C9003 AA EP90
Sealant	– WSS M4G 320-A3
Spark plug grease	– 'Neverseeze' ESE M12 A4A

Table 23

Capacities	
Engine oil, service fill with filter change	– 6.0 – 7.0 liters dependant on VIN
Coolant	– 10 to 13.3 liters dependant on engine and vehicle

For Technical data and torque specifications refer to latest Workshop Manual in GTR : Powertrain, General Information and Specifications 303-01A.

Oil Specification

NAS Markets Engine oil for the NAS markets must be to specification API SJ/EC and ILSAC GF-2.

5W30 oil is the preferred oil and Jaguar recommends Castrol.

Table 24

Engine Numbering V8
Example engine number – 0108232319
01 – 2001
08 – August
23 – Day
2319 – Time
Suffix numbers:
AA = Normally aspirated 4.2
SA = Supercharged 4.2
JA = 3.5 liter
FA = Non oil cooled NAS

Emission Specifications

This code is stamped at the vehicle assembly plants, either Browns Lane or Castle Bromwhich, when the engine has arrived from Bridgend. It is located on right-hand side of the engine block behind A bank cylinder head; it consists of 2 letters.

Table 25

Example of emission code CA
C =
A = Body to be fitted to
Emission spec C = XK8 (X100) Five specs available: A = No oil cooler USA, Canada, Mexico, Taiwan C = No oil cooler Brazil, Argentina, Australia, Chile, Cyprus, E. Europe, Hong Kong, Israel, Malaysia, Morocco, Singapore, Thailand, New Zealand, Sri Lanka, Indonesia Panama, Paraguay, South Korea (option Middle East, Russia)D =No oil cooler China, Middle East, Russia, Vietnam, South AfricaE =Oil cooler EEC, Norway, Slovenia, SwitzerlandJ =No oil cooler Japan

The engine serial number is located on the front of the block on the right-hand side.

Table 26

	970215 1354		
97	02	15	1354
Year	Month	Date	Time

Special tools

The table below lists the service tools required for the AJV8 engine. These are in addition to the tools already in use on 6 and 12 cylinder engines, some of which can also be used on the AJV8.

Table 27

Global Tool №	Description
303-530	Camshaft setting/locking tool
303-531	Crankshaft setting/locking peg
303-645	Crankshaft setting/locking peg
303-532	Timing chain tensioner tool
303-533	Timing chain wedges (2 each)
303-534	Dummy main bearing caps (5 each)
303-535	Bore protector – connecting rod installation
303-536	Engine rear lifting brackets (1 pair)
303-537	Engine stand mounting brackets (1 pair)
303-538	Crankshaft rear oil seal remover/replace
303-539	Fuel injector remover
303-540	Valve lifter hold-down tool
303-590	Fan nozzle air gun
303-751	Crankshaft front oil seal remover
303-750	Crankshaft front oil seal replace
303-139-05	Valve seat 5 mm pilot cutter tools) (for use with existing MS 76 valve seat cutter tools)
303-191 (02)	Crankshaft locking tool and adapter
303-588	Remover, crankshaft damper
303-D055	Strap

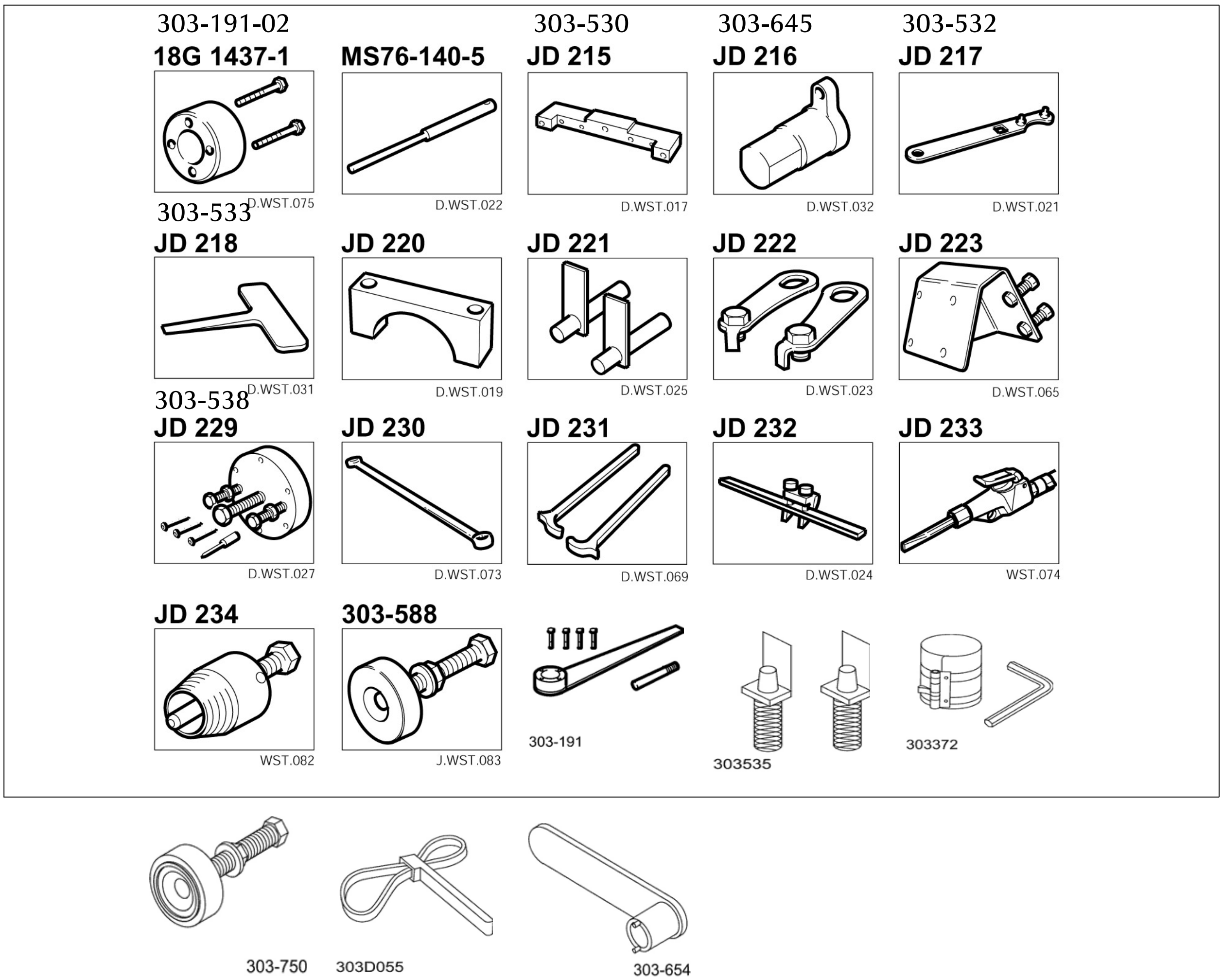
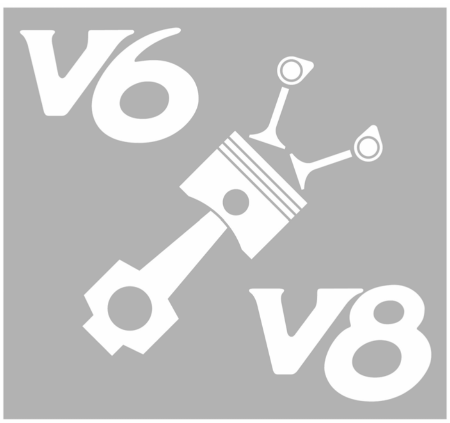


Fig. 71 AJV8 SPECIAL TOOLS

TRAINING PROGRAM

JAGUAR V6/V8 ENGINE REPAIR



PUBLICATION CODE – 168

INTRODUCTION

All variants of the Jaguar V6 engine are built at the Cleveland Engine Plant in Cleveland, Ohio. The 2.5 and 3.0 liter 24 valve V6 engines have four overhead camshafts and are driven by two timing chains.

The engine incorporates electronic engine management with distributorless ignition system and sequential electronic fuel injection.

It also has two catalytic converters in the exhaust system which includes two oxygen sensors and two catalytic monitor sensors.

Table 28 AJV6 Engine History

MY and MODEL	ENGINE	FEATURE
2000MY S-TYPE	AJ60 3.0L	Aluminum block and bedplate design with 60° V angle Dry cast iron liners cast in place Two position variable valve timing Helical gear VVT unit Two Intake Manifold Tuning valves for improved volumetric efficiency Drive by Wire Electronic Throttle PTEC Engine Management System
2002MY X-TYPE	AJ61 2.5L AJ61 3.0L	Continuously variable cam timing with increased range of authority Vane style VVT mechanism for faster response Camshaft-driven water pump New intake manifold with two intake manifold tuning valves Denso Engine Management System
2003MY S-TYPE	AJ62 3.0L	Rear Wheel Drive application of the AJ61 engine Intake manifold from AJ60 still used Denso Engine Management System

ENGINE COMPONENTS

Engine Identification Data

An engine identification code tag is located on the front cover assembly, and stamped on the left hand side of the block.

Main 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 to identify the correct bearing.

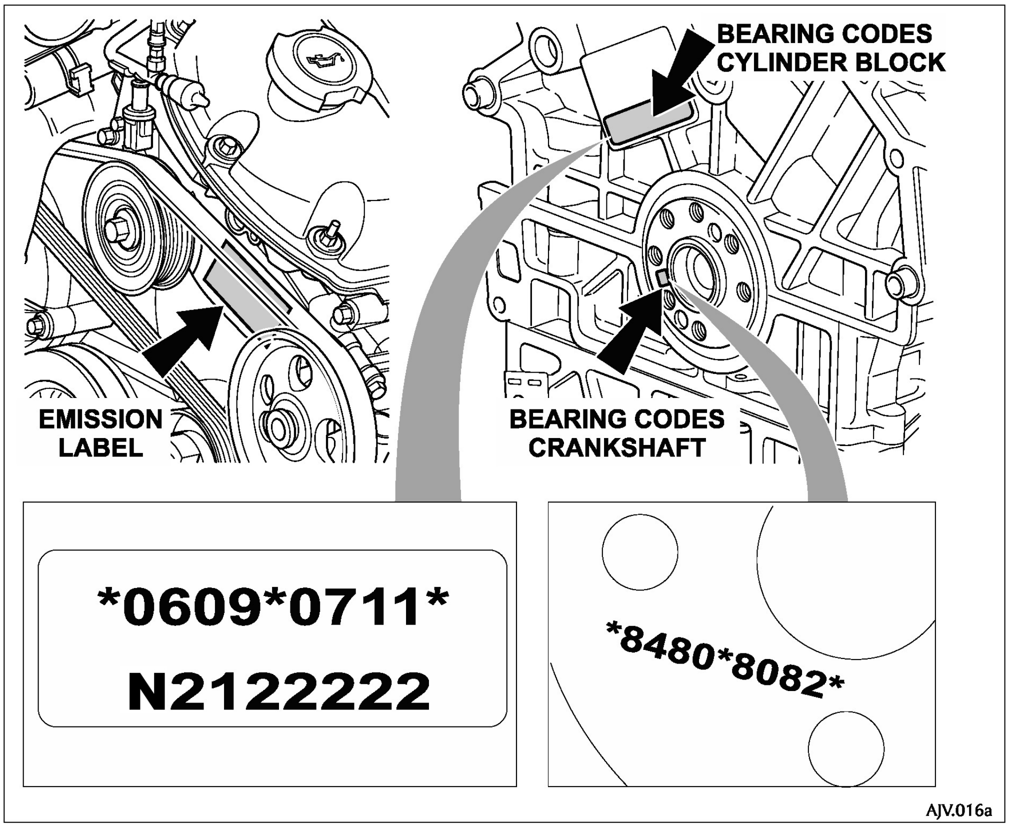


Fig. 72 ENGINE DATA LOCATIONS

N2122222 : AJ60 piston selection chart based on cylinder bore code

Cylinder Bore Code	**N2**	**1**	**2**	**2**	**2**	**2**	**2**
Cylinder Number	Cylinder Block Machining Line	4	5	6	1	2	3

N2122222 : AJ61/62 piston selection chart based on cylinder bore code

Cylinder Bore Code	**N2**	**1**	**2**	**2**	**2**	**2**	**2**
Cylinder Number	Cylinder Block Machining Line	2	4	6	1	3	5

BLOCK CODE

CRANKSHAFT CODE	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22
92	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2
91	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2
90	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2
89	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2
88	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2
87	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2
86	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
85	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
84	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3
83	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3
82	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3
81	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3
80	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3
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69	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
68	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

Fig. 73 AJV6 Crank bearing selection chart

Crankshaft Code: *8580*8082*

Table 29 *8580*8082*: Main bearing crankshaft journal diameter

Diameter Code	**85**	**80**	**80**	**82**
Journal Number	1	2	3	4

Main bearing crankshaft journal orientation: #1 — Front; #4 — rear

Table 30 *0609*0711*: Main bearing bore diameter

Diameter Code	**06**	**09**	**07**	**11**
Journal Number	1	2	3	4

Main bearing journal orientation: #1 — Front; #4 — rear

Table 31 Engine Part Number Breakdown

Model Year	Engine Assembly Part	Iteration
1G (1 = 2001)	762	AA (followed by AB)

Table 32 Engine Application Chart

Engine Code	Vehicle	Trans	EGR	Oil Cooler	Heat Shield
AJ60					
9G-762–	2000 X200	Auto	Yes	Yes	LH
9G/1G-766-	2000 –02 X200	Auto	No	Yes	LH-RH
1G-767–	2002 X200	Manual	No	Yes	LH-RH
AJ61					
1G-730–	2002 X400	Auto	No	Yes	No
1G-731–	2002 X400	Manual	No	Yes	No
4G-430–	2004 X404 2.5L	Auto	No	Yes	No
4G-431–	2004 X404 2.5L	Manual	No	Yes	No
4G-730–	2004 X404 3.0L	Auto	No	Yes	No
4G-731–	2004 X404 3.0L	Manual	No	Yes	No
AJ62					
3G-762–	2003 X202	Auto	No	No	LH-RH
3G-767–	2003 X202	Manual	No	Yes	LH-RH
4G-762–	2004 X202	Auto	No	No	LH-RH
4G-767–	2004 X202	Manual	No	Yes	LH-RH

Engine Structure

Basic engine construction is similar to the V8 in that a structural bedplate is used. The bedplate bolts to the cylinder block to provide a very strong housing for the crankshaft, minimizing vibration. Both the block and bedplate are of cast aluminum alloy and are accurately aligned together by the use of eight hollow dowels. The cylinder block is fitted with dry cast iron liners.

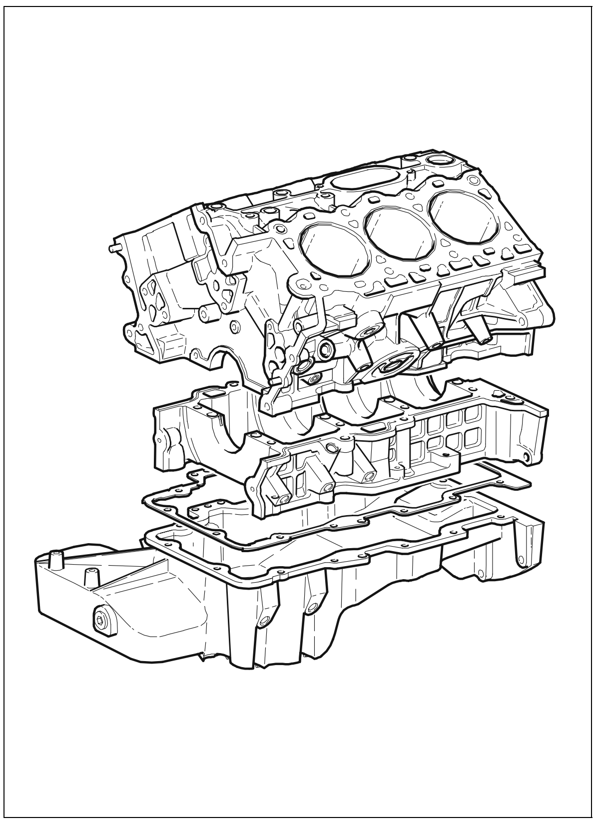


Fig. 74 ENGINE STRUCTURE (AJ60 shown)

The 2.5 liter capacity is achieved by reducing the 3.0 liter's 89mm bore size to 81.6mm.

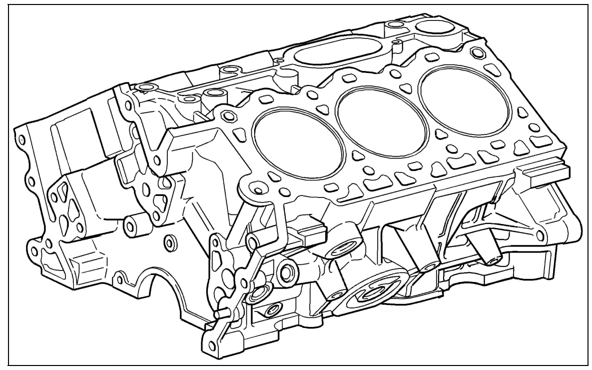


Fig. 75 ENGINE BLOCK (AJ61 2.5 liter shown)

Oil Sump

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

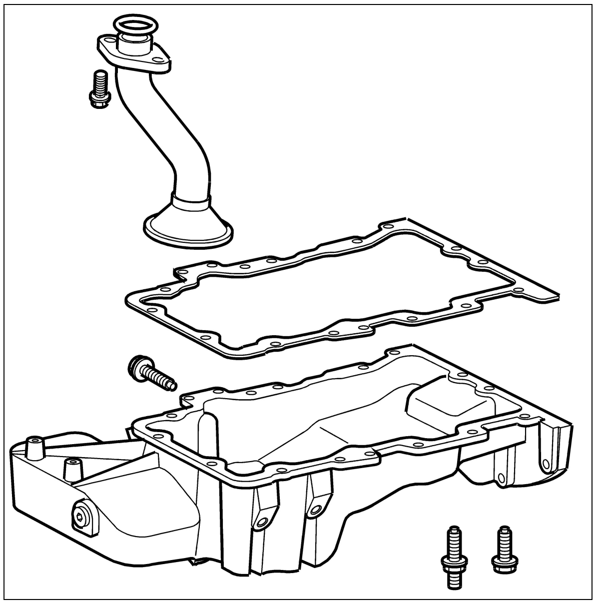


Fig. 76 AJ60 Oil Sump Assembly

Crankshaft

The forged steel crankshaft runs in four aluminum/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.

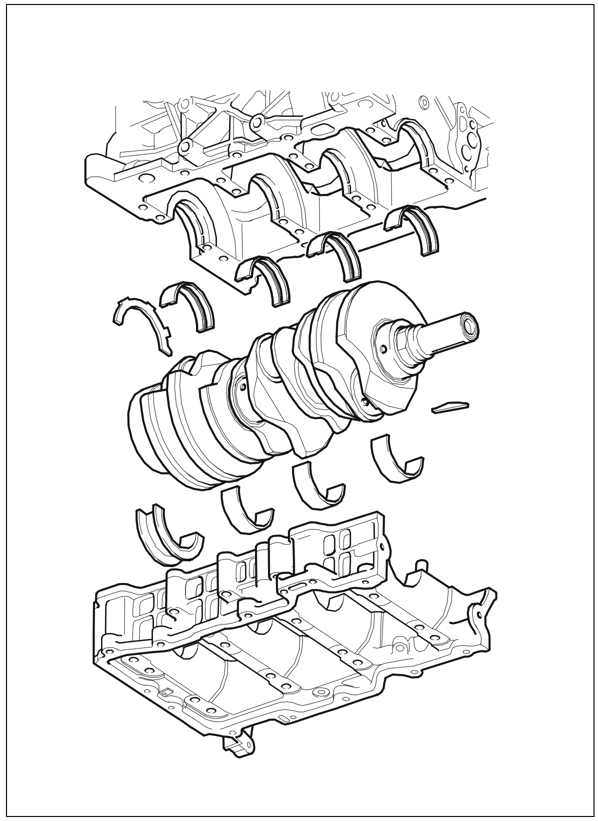


Fig. 77 CRANKSHAFT

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 aluminum/tin alloy.

The pistons are made of aluminum 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.

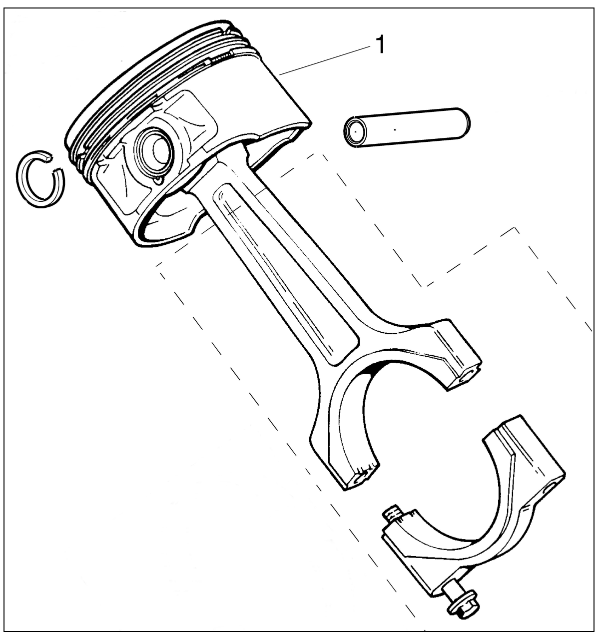


Fig. 78 Piston & Connecting rod assembly (S-TYPE)

1. Piston & connecting rod assembly

Cylinder Head

The aluminum 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.

Aluminum balls (10.11mm diameter) or Avdale plugs are used to plug the external bores of the oil-way drillings and threaded core plugs are fitted to the water jacket openings. Two half round aluminum cap inserts are fitted via a sealant at the rear of the head.

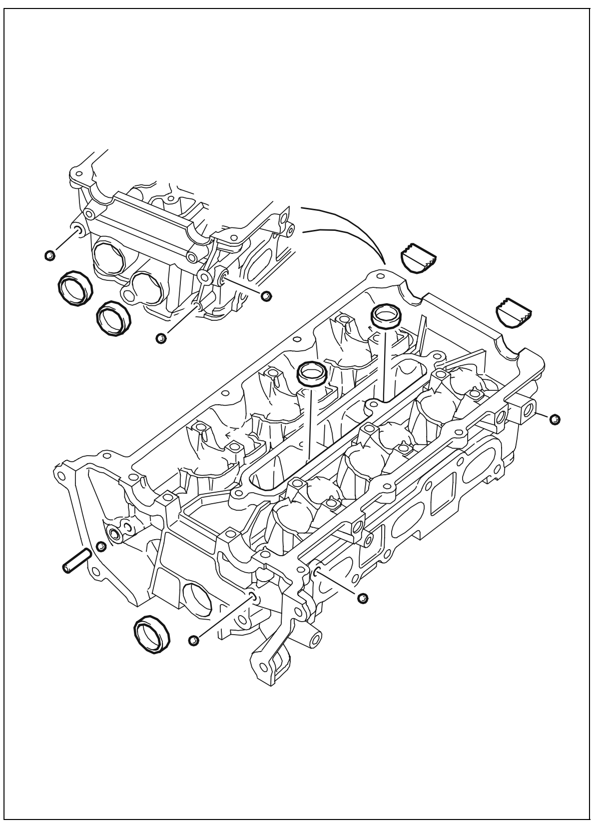


Fig. 79 CYLINDER HEAD (AJ60 shown)

The AJ61 and AJ62 heads were modified to accommodate the new linear VVT units. In addition, the 2.5 liter engine has new cylinder heads with smaller valves to accommodate the smaller bore cylinder block and VVT system and new head gaskets. X-TYPE (AJ61) cylinder heads provide a mounting for the camshaft driven water pump.

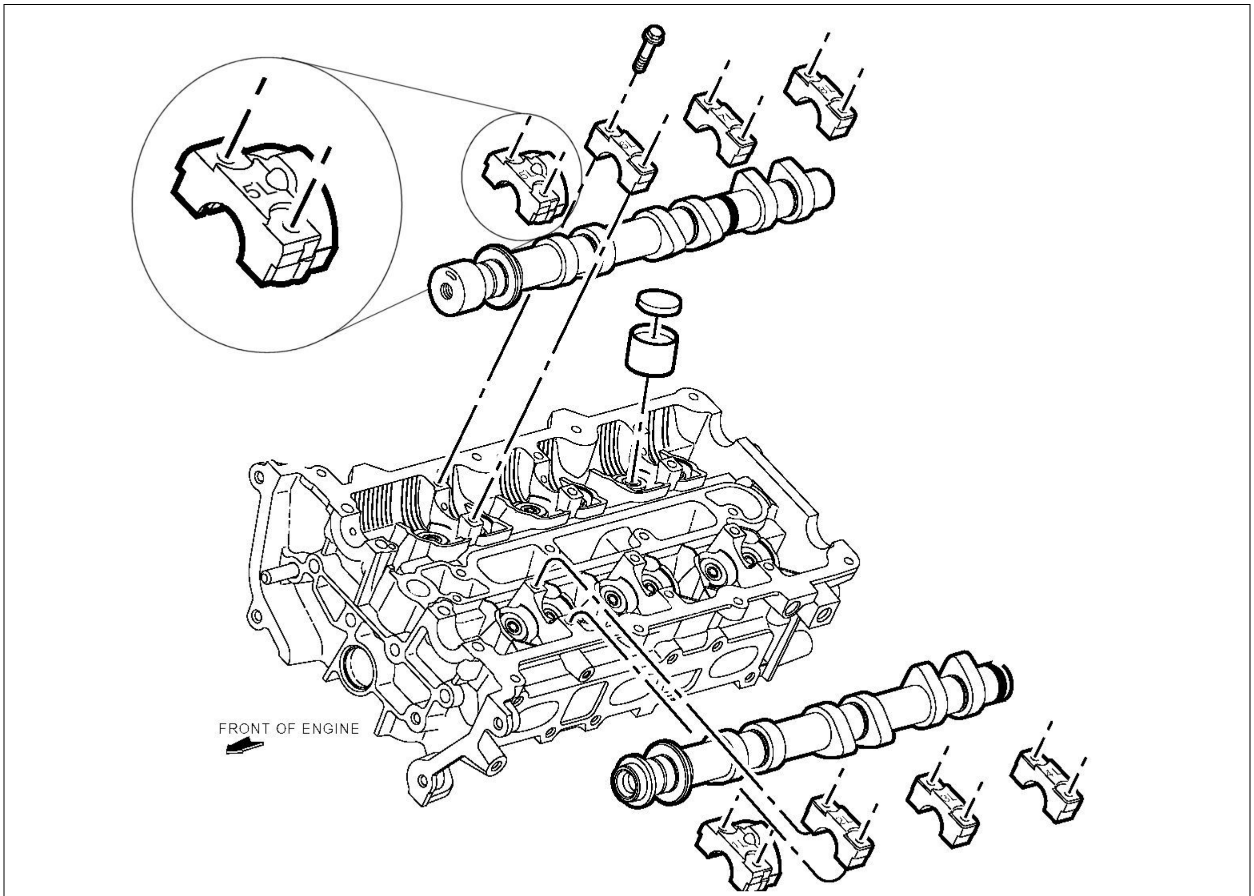


Fig. 80

Camshafts and Valve Gear (AJ60 S-TYPE only)

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. The rear end of the intake 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 oil-way for the VVT unit. On the exhaust camshaft this oil-way is redundant. The bearing caps are made of aluminum.

The cams actuate the valves via direct acting mechanical bucket tappets made of lightweight aluminum with phosphate coated cast iron shims mounted on top. The valve components are of lightweight design with 5.5mm valve stems.

Camshafts (AJ61 onwards)

Cast iron camshafts with steel tappets were introduced as a running change on X200 AJ60 engines and is now fully utilized on all the V6 range. This change of component material increases durability by reducing friction wear.

Note: Do not mix cast iron and steel tappets. Incorrect application of either tappet type will cause rapid wear of the valvetrain components.

Variable Valve Timing (VVT) Two stage

A VVT system fitted to the AJ60 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 optimize 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.

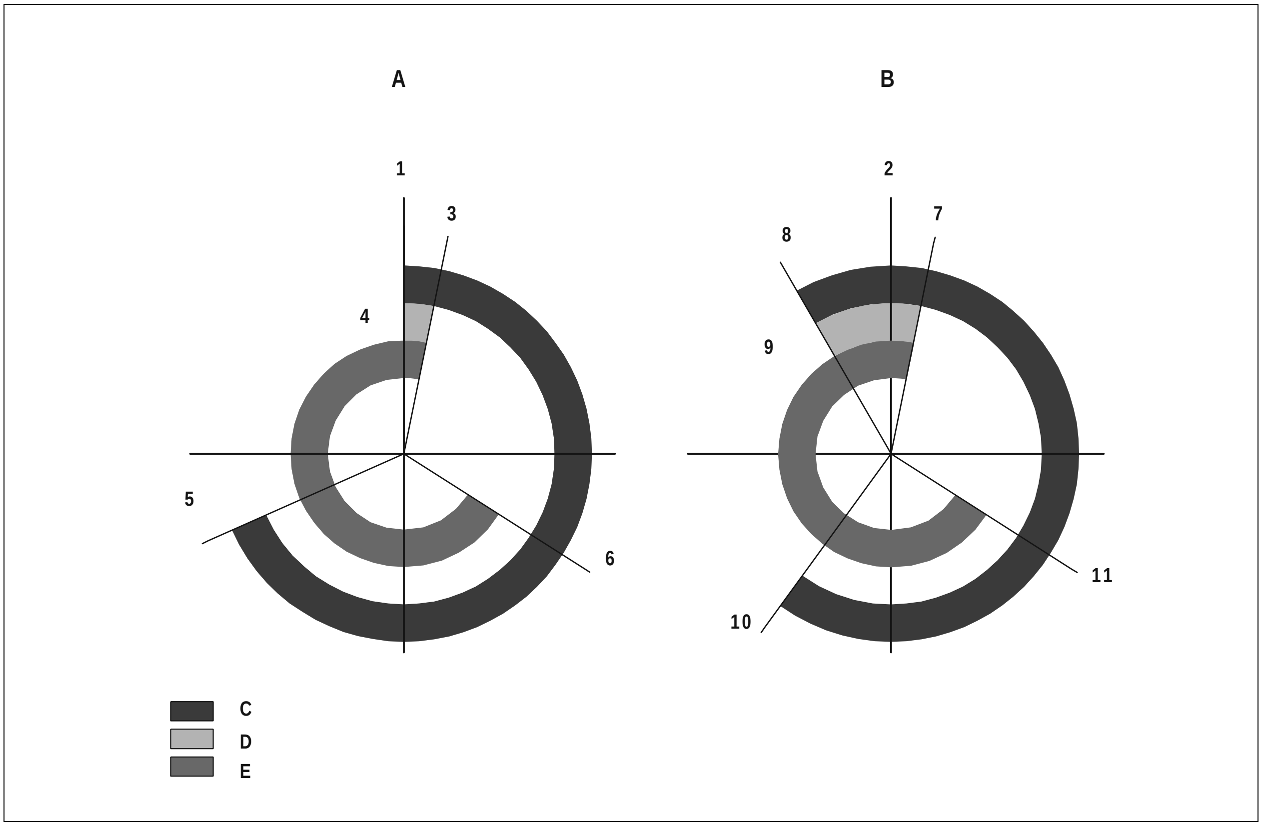


Fig. 81 VVT TIMING DIAGRAM (CRANKSHAFT DEGREES)

Table 33

A	Inlet Camshaft Retarded	B	Inlet Camshaft Advanced
C	Inlet Camshaft	D	Valve Overlap
E	Exhaust Camshaft		
1	Inlet opens TDC	2	TDC
3	Exhaust closes 11.5° ATDC	4	11.5° Overlap
5	Inlet closes 66° ABDC	6	Exhaust opens 57.5° BBDC
7	Exhaust closes 11.5° ATDC	8	Inlet opens 30° BTDC
9	41.5° Overlap	10	Inlet closes 36° BTDC
11	Exhaust opens 57.5° BBDC		

VVT Oil Feed

On the AJ60 variants the VVT / sprocket unit is fixed on the nose of the inlet camshaft via a locating pin and hollow bolt. The VVT / sprocket assembly is driven directly by the timing chain.

Unlike the two position VVT systems on the early V8 engines, the oil feed to each VVT unit is supplied via fixed oil-ways 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 (camshaft side) face of the VVT unit for any residual oil which has seeped past the piston.

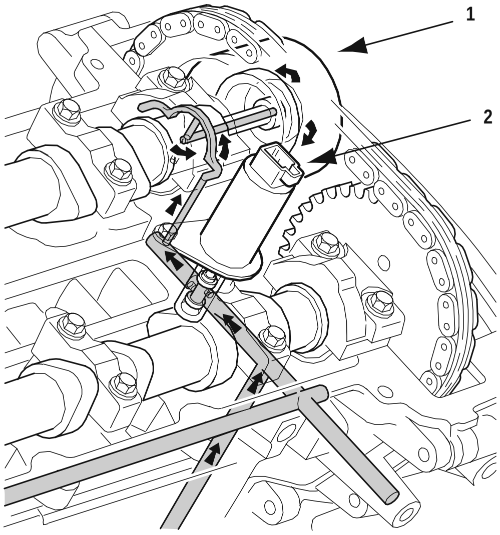


Fig. 82 VVT OIL FEED (AJ60)

1. VVT Unit
2. VVT Oil Control Valve

VVT Operation — AJ60

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 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.

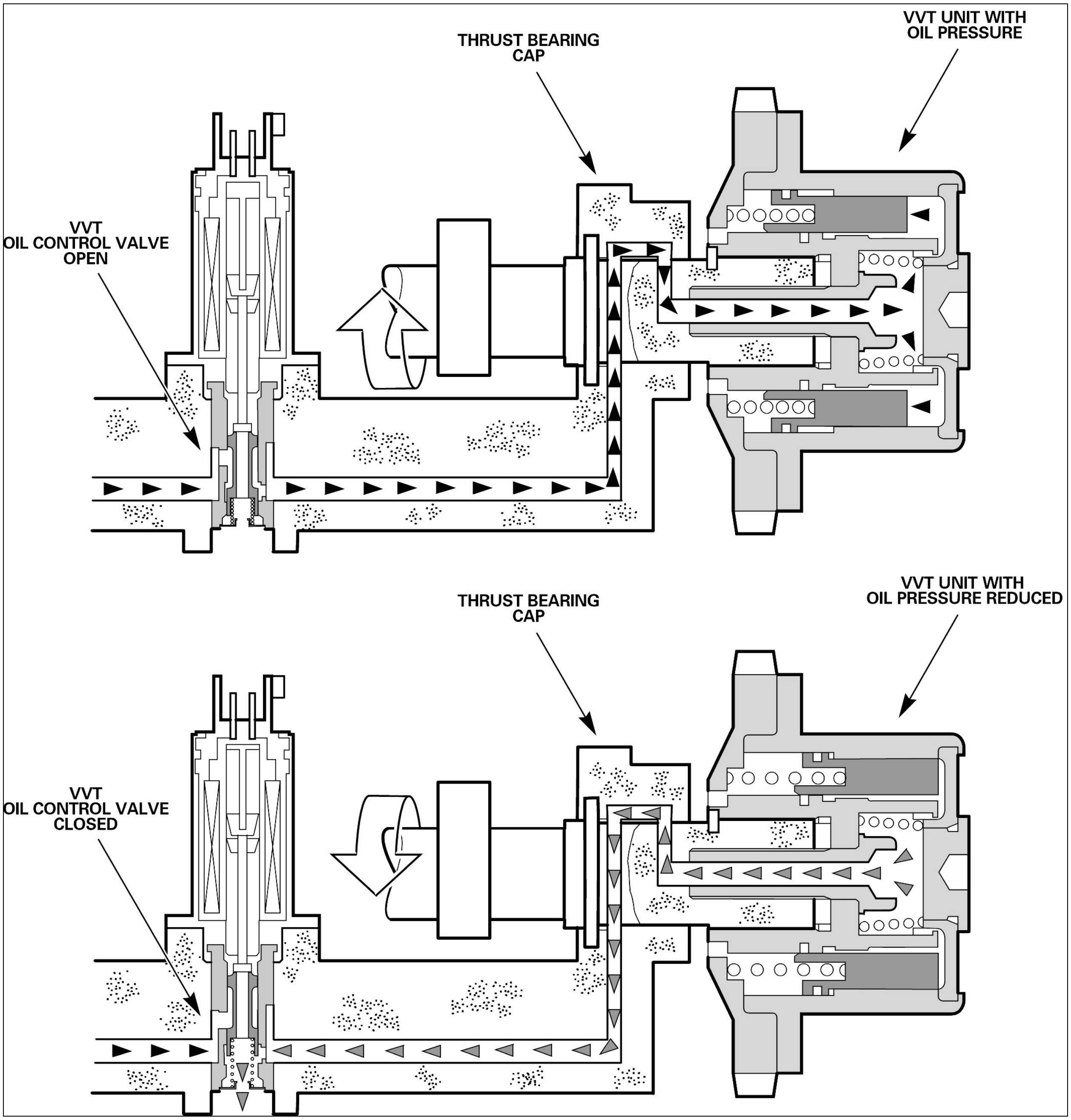


Fig. 83 TWO-STAGE VVT OPERATION – AJ60

Linear VVT System — AJ61/AJ62

The VVT system introduced on the AJ61 provides continuously variable inlet valve timing over a crankshaft range of 30°.

Depending on driver demand, engine speed/load conditions and powertrain control requirements, the inlet valve timing is advanced or retarded to the optimum angle within this range.

The linear VVT system provides a number of advantages:

- Improves internal EGR, further reducing NOx (Oxides of nitrogen) emissions and eliminating the need for an external EGR system
- optimizes torque over the engine speed range without the compromise of the two position system: note that specified torque and power figures are unchanged
- Improves idle quality: the inlet valve opens 10° later, reducing valve overlap and thus the internal EGR effect (undesirable at idle speed)
- Faster VVT response time

Linear VVT Components

Each cylinder bank has a VVT unit, bush carrier and solenoid operated oil control valve which are all unique to the linear VVT system. The VVT unit consists of an integral control mechanism with bolted on drive sprockets, the complete assembly being non serviceable. The unit is fixed to the front end of the inlet camshaft via a hollow bolt and rotates about the oil feed bush which is part of the bush carrier attached between the head and front cover.

The oil valve no longer mounts directly to the head, but fits into the bush carrier to which it is secured by a single screw. The solenoid connector at the top of the valve protrudes through a hole in the camshaft cover but the cover must first be removed to take out the valve.

Engine oil enters the lower oil-way in the bush carrier (via a filter) and is forced up through the oil control valve shuttle spools to either the advance or retard oil-way and through the bush to the VVT unit. Oil is also returned from the VVT unit via these oil-ways and the control valve shuttle spools, exiting through the bush carrier drain holes.

Note that only the bush carriers are left and right handed.

Linear VVT operation

Although the principle function of the VVT is the same as that used on the AJ27 V8 engine the internal operating components of this VVT are different. Instead of a helical gear construction the unit uses a vane device to control the camshaft angle.

The VVT unit is driven by the timing chain and rotates relative to the exhaust camshaft sprocket. When the ECM requests the camshaft timing advance, the oil control solenoid is energised moving the shuttle valve to a relevant position to allow the engine oil pressure, via a filter, into the VVT unit's advance chamber. When the camshaft timing is requested to retard, the shuttle valve moves position to allow oil pressure to exit the advance chamber, while simultaneously routing the oil pressure into the retard chambers.

When directed by the ECM the VVT unit will be set to the optimal position between full advance and retard for a particular engine speed and load. This is achieved by the ECM rapidly pulsing the energising signal to the oil control solenoid. Due to this rapid pulsing the shuttle valve assumes a position between the limits of it's travel and is continuously controlled by the ECM to maintain the requested camshaft angle. The actual position of the inlet camshaft is monitored by the camshaft position sensors which transmits signals to the ECM.

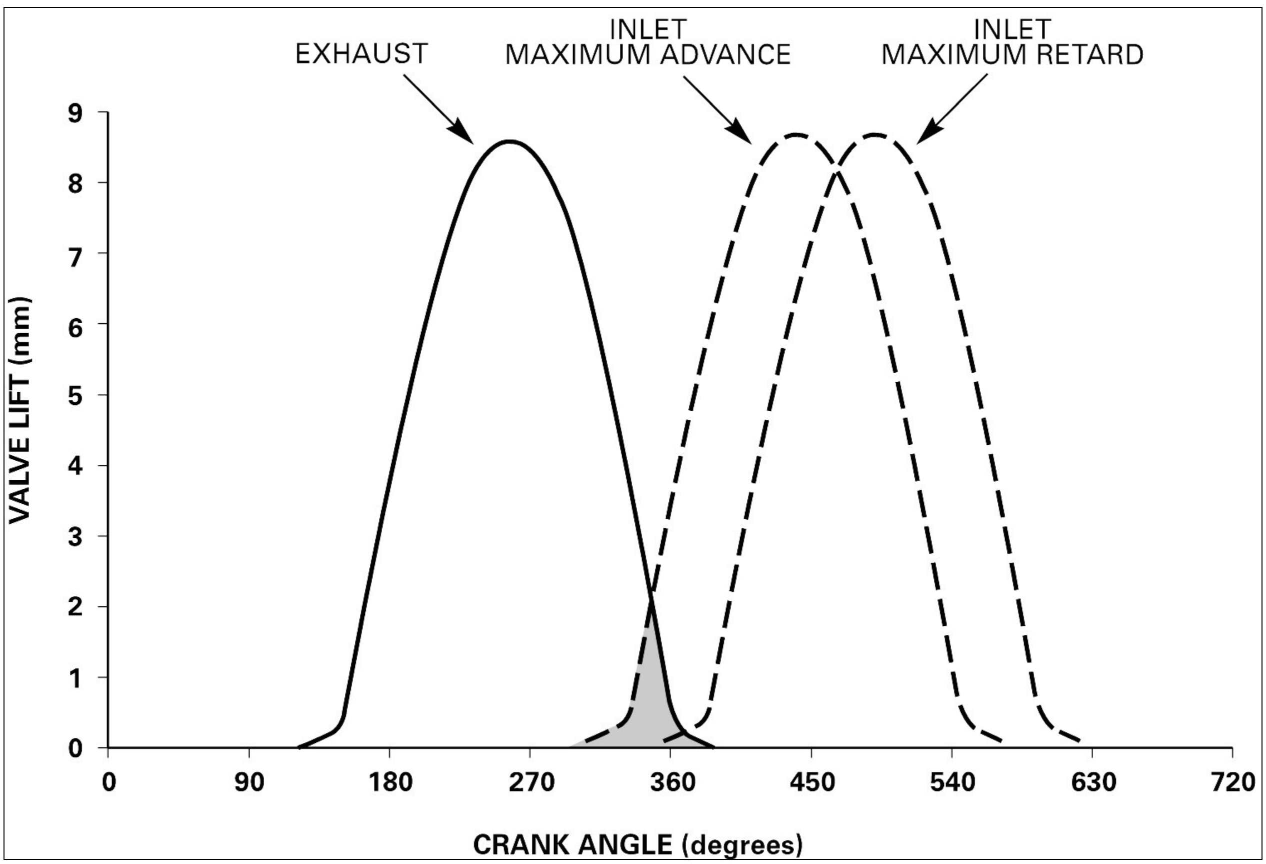


Fig. 84 LINEAR VVT

VVT & Engine oil temperature

Engine oil properties and temperature can affect the ability of the VVT mechanism to follow demand changes to the cam phase angle.

At very low oil temperatures, movement of the VVT mechanism is sluggish due to the increased viscosity and at high temperatures the reduced viscosity may impair operation if the oil pressure is too low.

The VVT system is normally under closed loop control except in extreme temperature conditions such as cold starts below 0°C (32°F).

At extremely high oil temperatures, the ECM may limit the amount of VVT advance to prevent the engine stalling when returning to idle speed. This could occur because of the slow response of the VVT unit to follow a rapid demand for speed reduction.

Excessive cam advance at very light loads produces high levels of internal EGR which may result in unstable combustion or misfires.

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 aluminum 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.

On the AJ61 the engine front cover is designed to accommodate the transverse engine mountings and VVT system, and a new design has been employed on the AJ62 to accept the new VVT system as well.

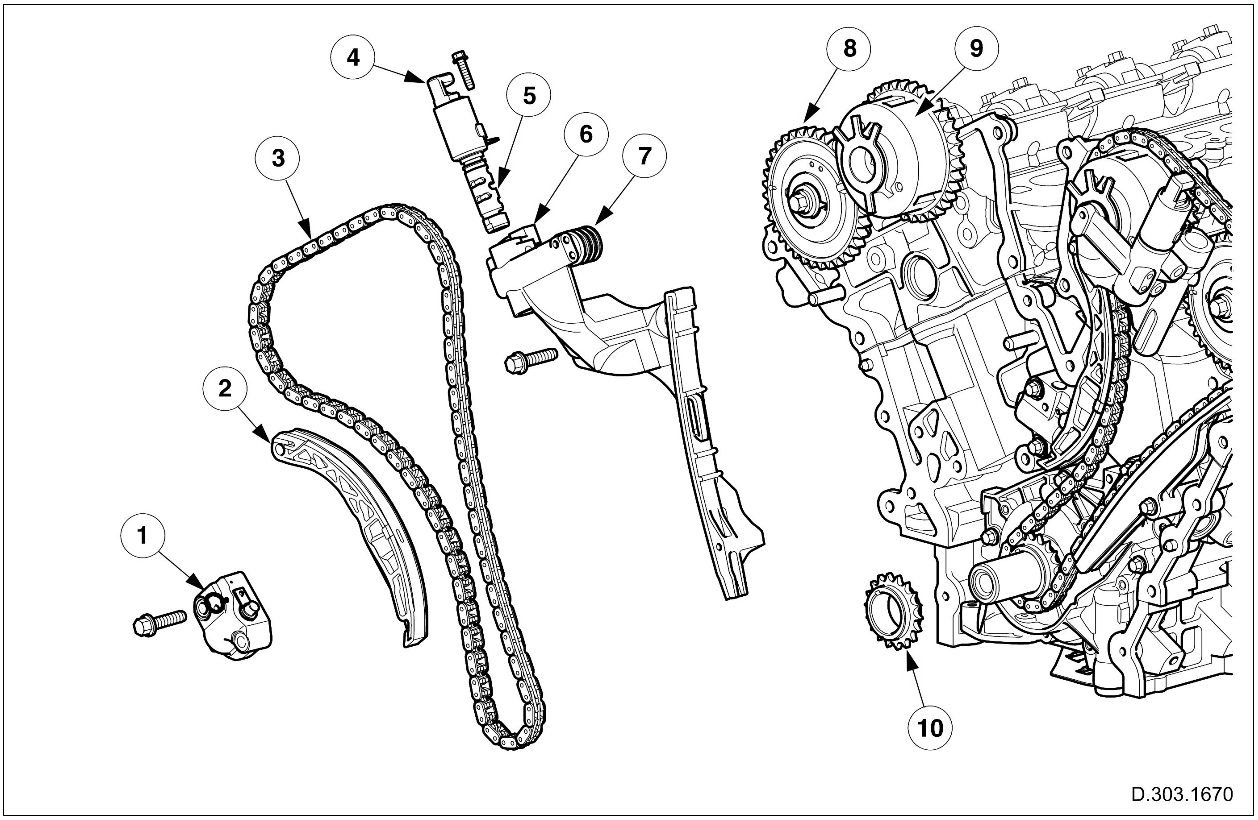


Fig. 85 CAMSHAFT DRIVE

1. Tensioner
2. Tensioner arm
3. Timing chain
4. Oil control solenoid
5. Shuttle valve
6. Bush carrier
7. Oil feed bush
8. Exhaust camshaft sprocket
9. VVT unit
10. Crankshaft sprocket

Ignition Pulse Ring

The ignition pulse ring, or reluctor wheel, has 35 teeth spaced at 10 degree intervals, with one missing tooth.

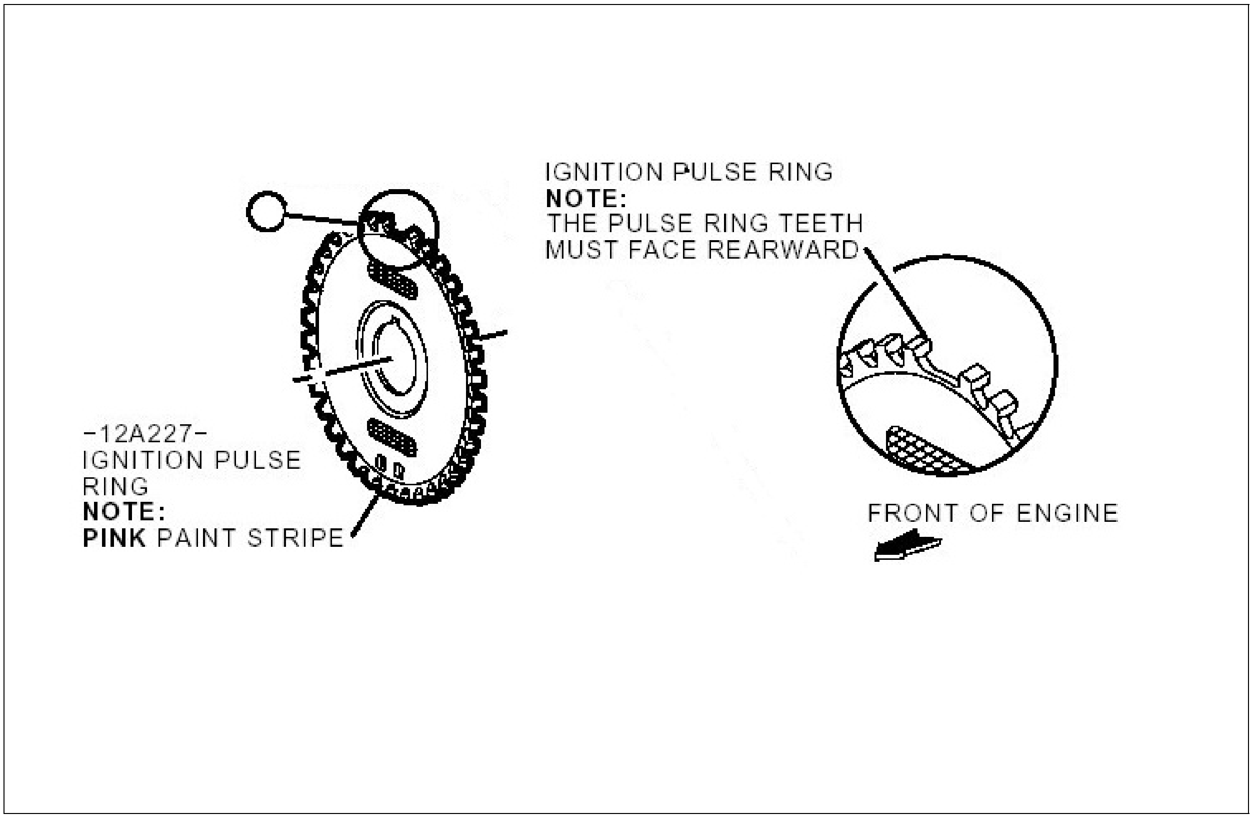


Fig. 86 AJ60 Ignition Pulse Ring — Teeth Face Rearward

On AJ60 engines, the missing tooth lines up with the keyway, and the teeth face the timing chains.

The pulse ring was changed for the AJ61 and AJ62 in two ways: the teeth now face the front of the engine, and the ring now has a second keyway for use on the 2.0L V6 that is used outside North America.

NOTE:

The correct keyway always lines up with the missing tooth on AJ60, AJ61, and AJ62 for North American applications.

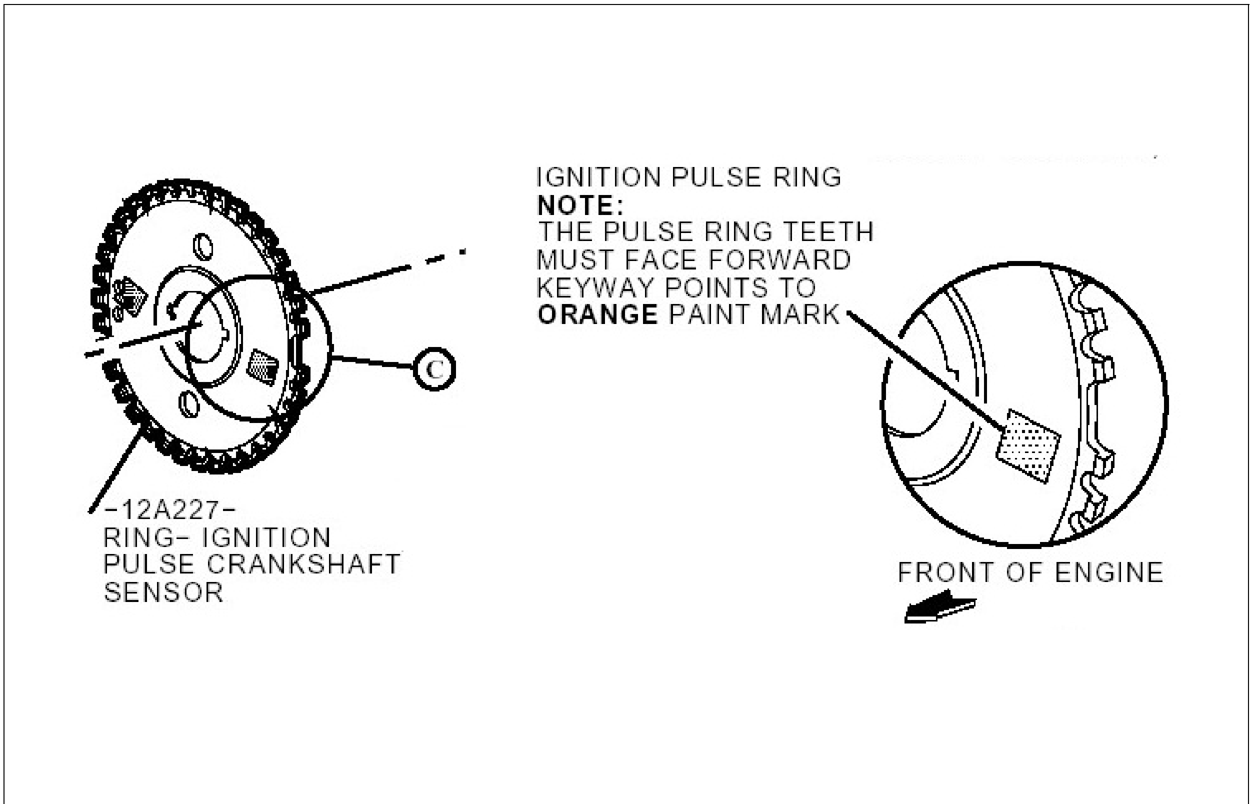


Fig. 87 AJ61 / AJ62 Ignition Pulse Ring — Teeth Face Forward

Camshaft Cover

The cylinder heads are fitted with lightweight polyester or magnesium cam covers, (left hand bank on AJ61 is colored silver) with silicone seals. These materials save weight and reduce airborne noise as compared to aluminum and steel.

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.

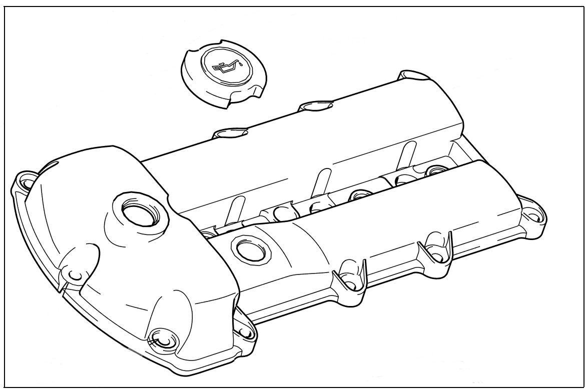


Fig. 88 Camshaft cover

Exhaust Manifold

The AJ60 and AJ62 exhaust manifolds are of cast iron with a threaded hole in the right hand bank manifold for the EGR pipe or blanking plug (if EGR not fitted). Each manifold is fitted with a heat shield constructed of a fiber compound sandwiched between an aluminum coated carbon steel shell.

On the AJ61 the exhaust manifolds were designed to accommodate the transverse engine configuration. Also, the front manifold is fabricated and the rear manifold is cast manufactured.

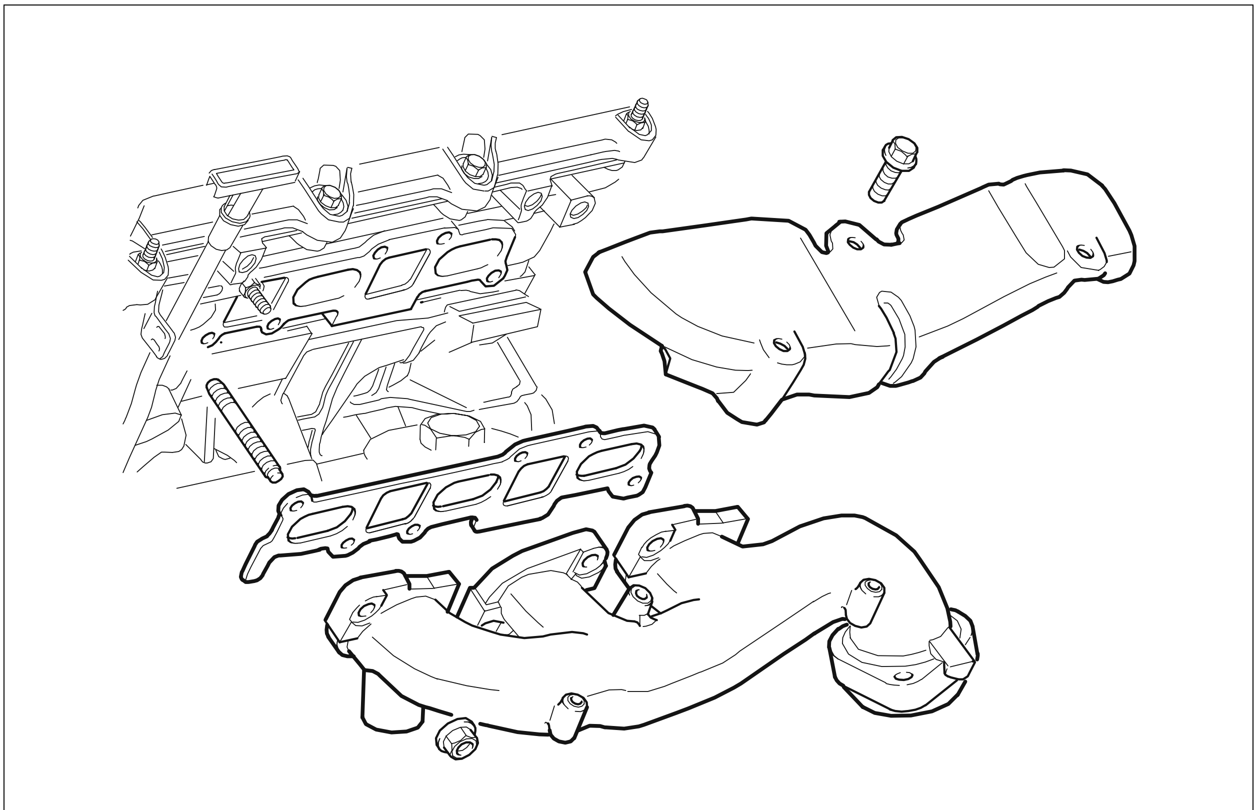


Fig. 89 EXHAUST MANIFOLD AND HEATSHIELD

S-TYPE Engine Mountings

The engine is supported at each side on hydro-mounts fitted between the aluminum alloy engine brackets and the front cross member. The hydro-mounts are similar to those on the XJ and XK Series and have an integral heat shield and anti-separation restraint.

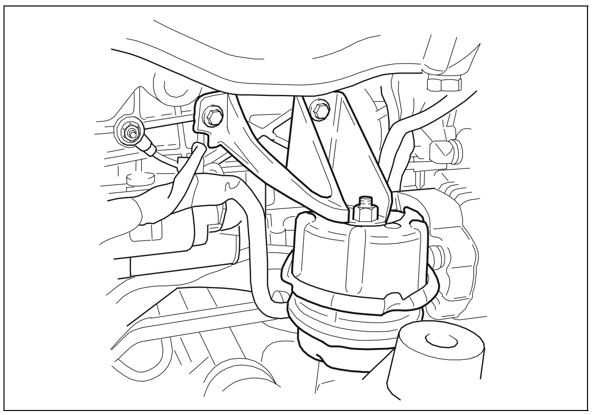


Fig. 90 S-TYPE ENGINE MOUNTING

X-TYPE Engine Mountings

The engine mountings used on the X-TYPE are designed to accommodate the transverse engine configuration. The hydromount and transaxle mountings provide optimum ride performance, and noise, vibration and harshness (NVH) damping.

The torque roll restrictor controls powertrain stability while also providing optimum NVH damping.

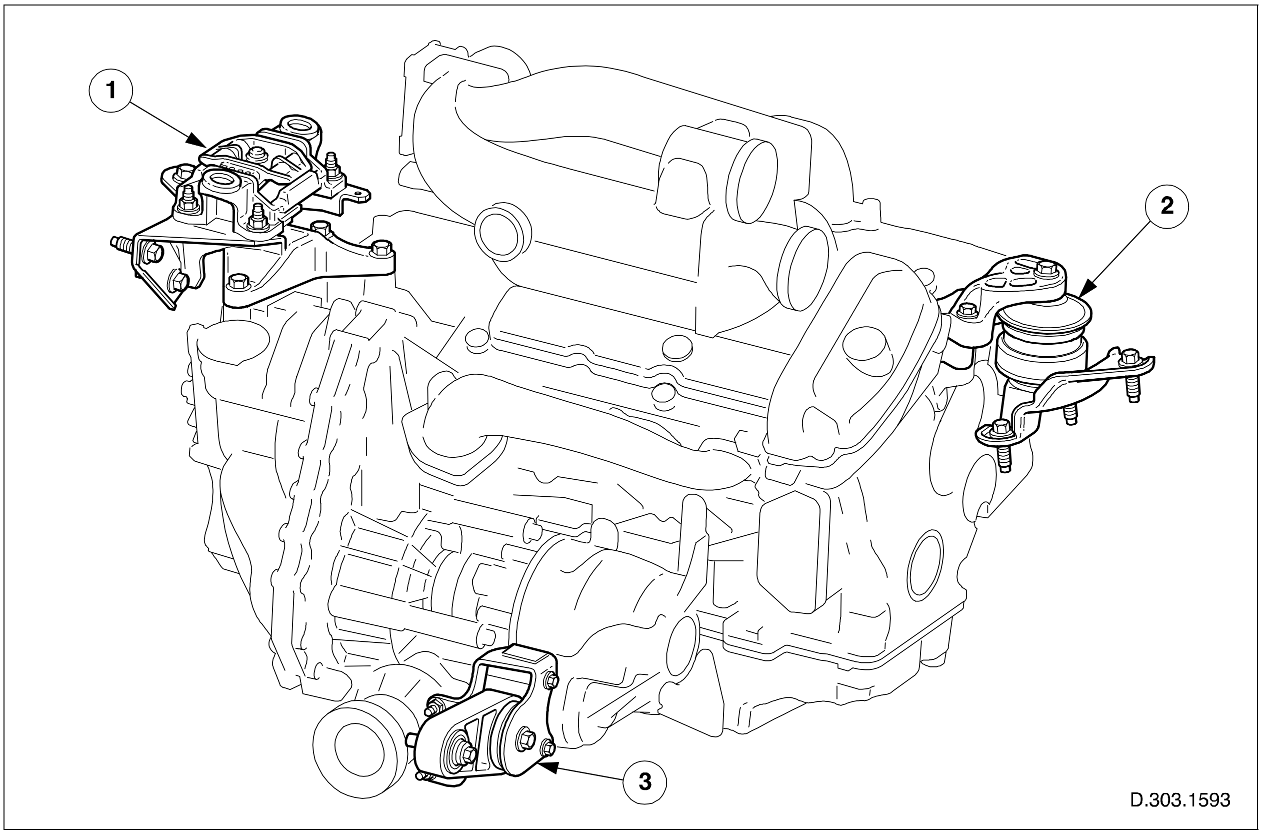


Fig. 91 X-TYPE ENGINE MOUNTINGS

1. Transaxle mount
2. Hydromount
3. Torque roll restrictor

Air Intake

The air induction system consists of the intake ducting and air cleaner, the throttle body, tuned manifold assembly and lower manifold.

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.

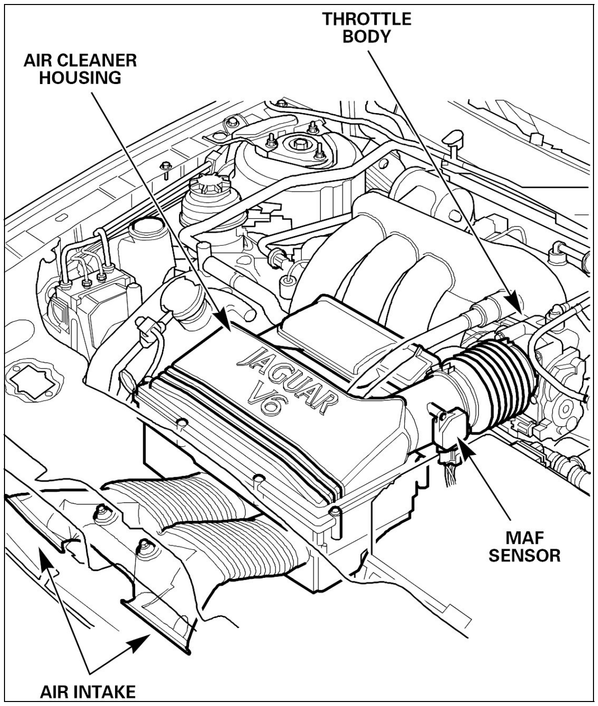


Fig. 92 X-TYPE V6 AIR INTAKE

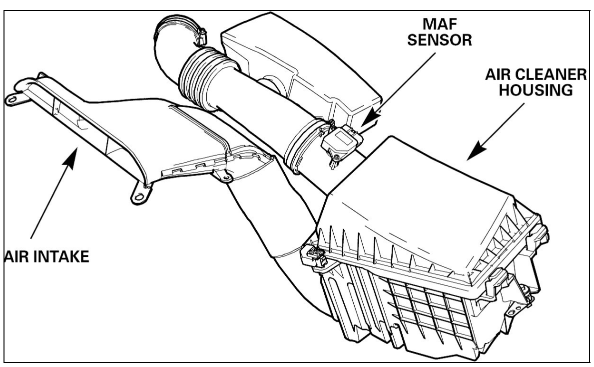


Fig. 93 2003MY S-TYPE V6 AIR INTAKE

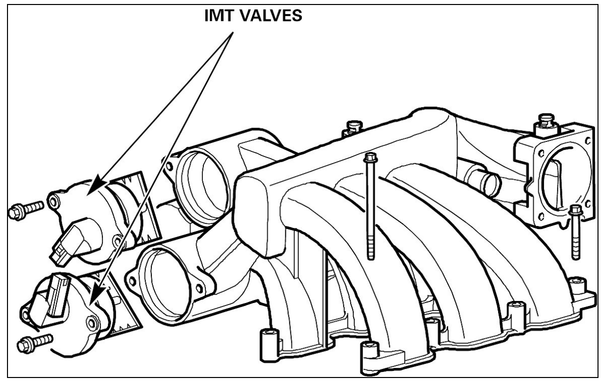


Fig. 94 X—TYPE INTAKE MANIFOLD

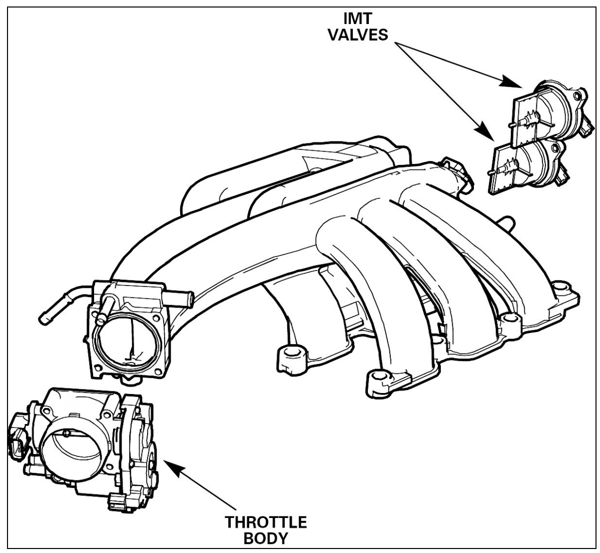


Fig. 95 2003MY S-TYPE V6 INTAKE MANIFOLD

Variable Intake System

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

Construction

The induction manifold is a single piece aluminum 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

The two IMT valves (A & B) are set to one of the following combinations (changing the resonant frequency of the intake system):

With both valves closed, there is no communication between the upper and lower plenum chambers.

With the top valve (A) open and the bottom valve (B) closed, the upper and lower plenum chambers are linked via the front connecting hole allowing pressure waves to be communicated.

With both valves open, a second link is opened between the upper and lower chambers via the rear connecting hole.

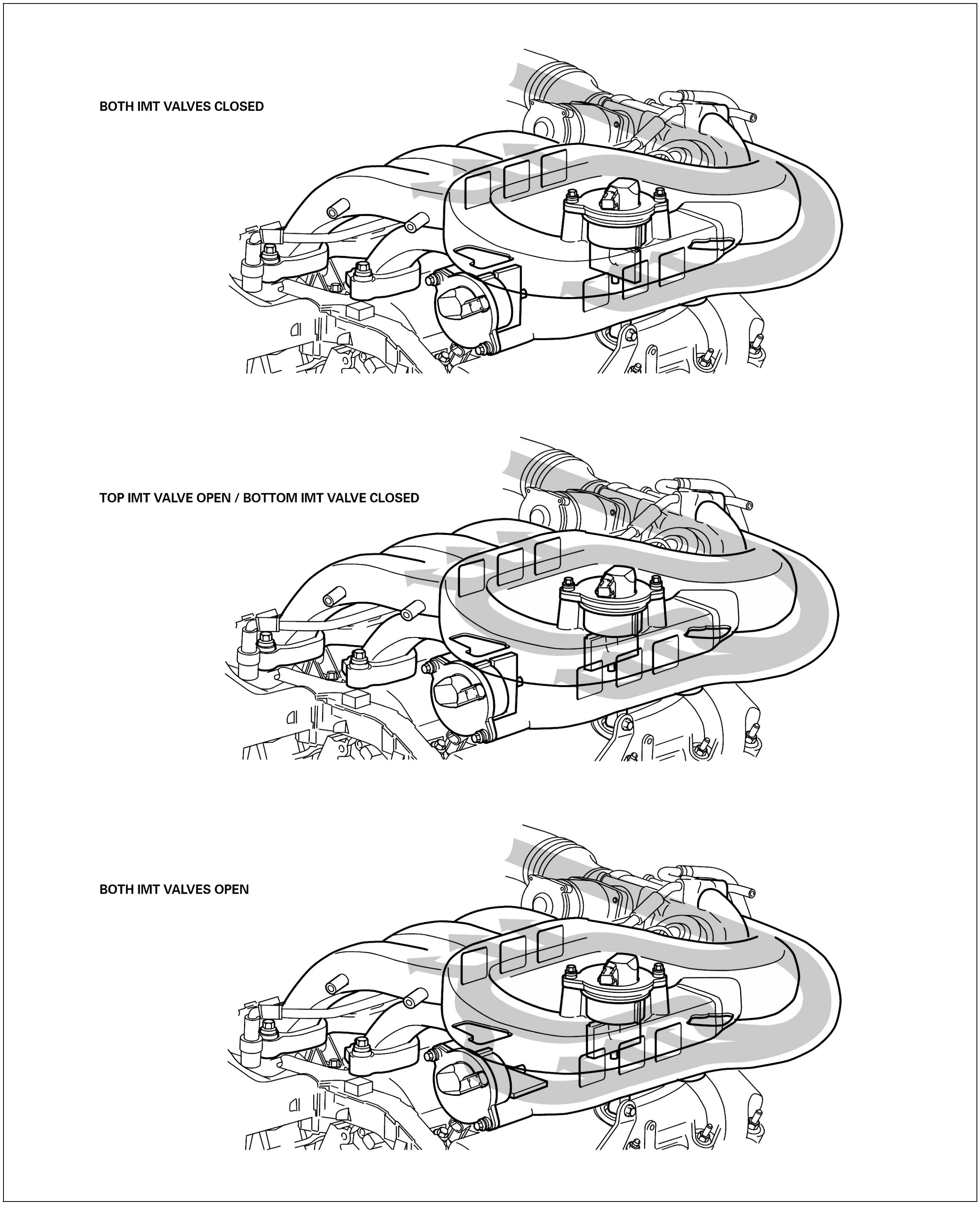


Fig. 96 INDUCTION MANIFOLD (AJ60 shown)

System Performance

The valve open/close combinations across the engine speed range have been selected in conjunction with the VVT system to provide an optimized 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.

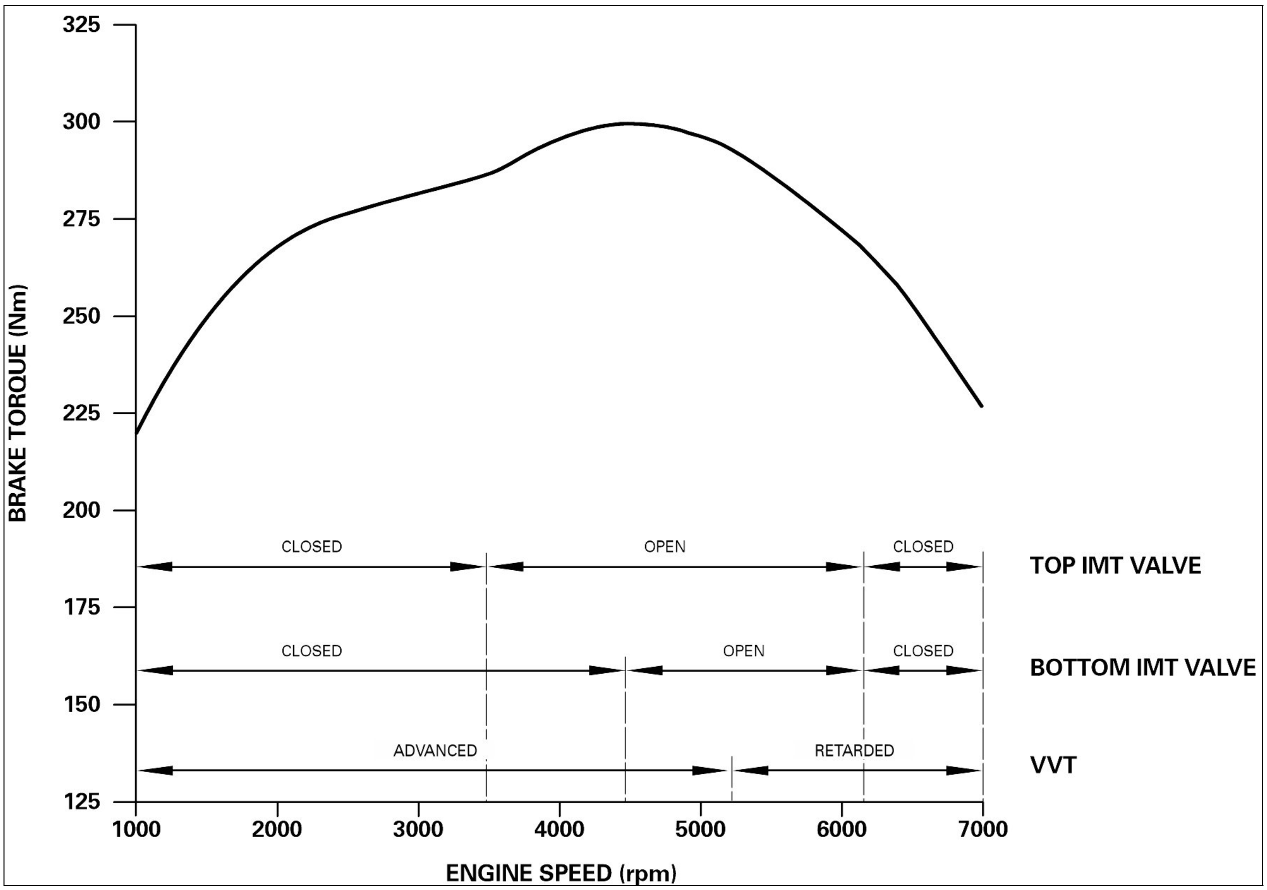


Fig. 97 ENGINE TORQUE CHARACTERISTICS

LUBRICATION AND COOLING

Lubrication System

Oil Distribution

Oil distribution within the block and cylinder head is similar to that of the V8 engine. The main differences are 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 and passes through the externally mounted filter and oil cooler and returns to the block. Distribution is via the main gallery and crankshaft oil-ways to the lower crankcase components and via branch feeds to the chain tensioners and then cylinder head components. Extra oil-ways in the cylinder heads provide a built-in feed for the VVT components on the AJ60 engines and supply through a spider arrangement on the AJ61 and 62.

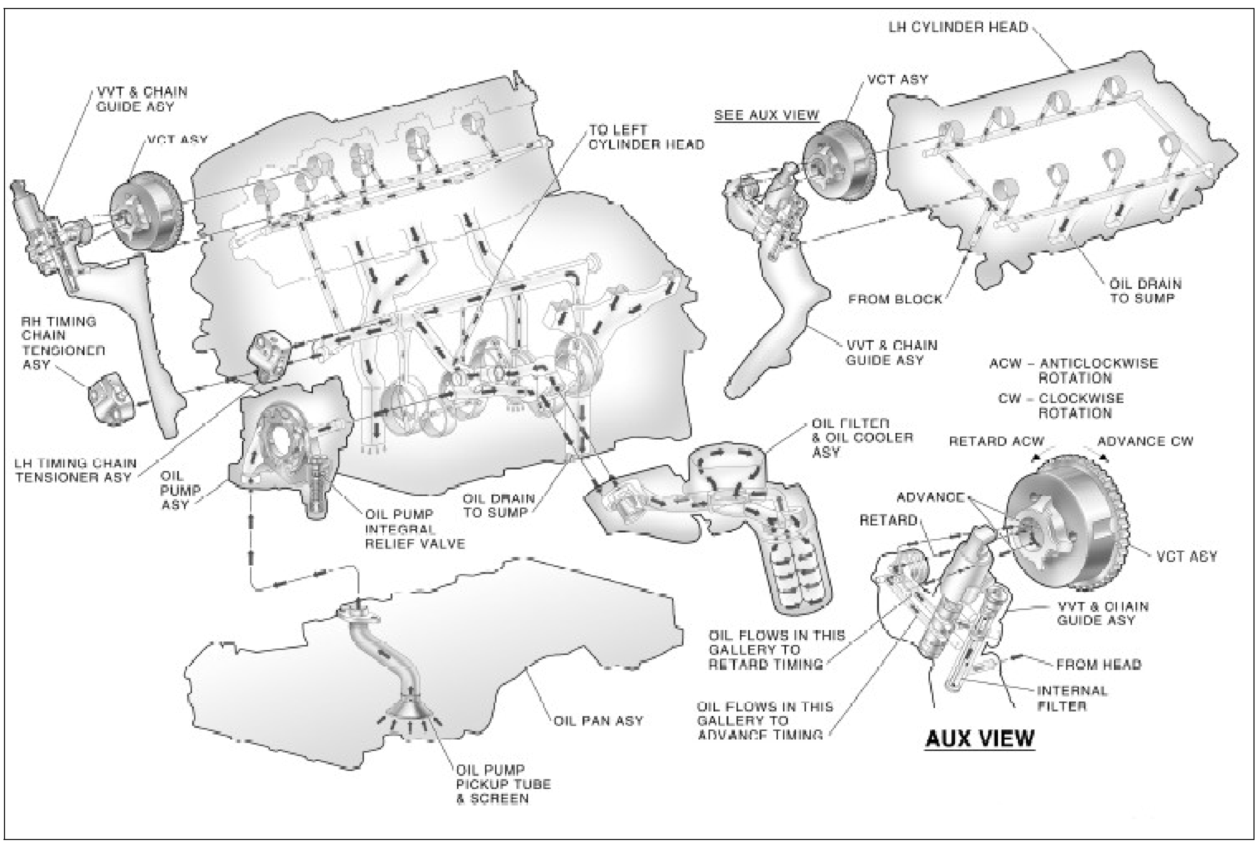


Fig. 98

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 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.

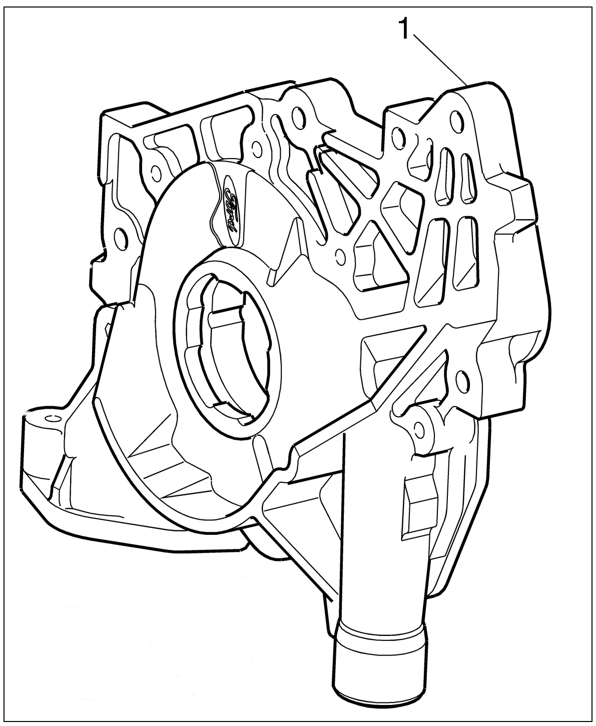


Fig. 99 OIL PUMP S-TYPE

Oil Cooler and Filter Mounting (AJ60)

The oil filter and oil cooler are remote mounted on an adapter which also incorporates an engine mount. The oil filter is a replaceable canister screw on type. The oil cooler is fixed to the bracket by a single through bolt to the adaptor. Oil flows from both components to the cylinder block through internal oil-ways in the adaptor casting and via an interfacing filter mounting in the block. A hollow bolt (B) 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.

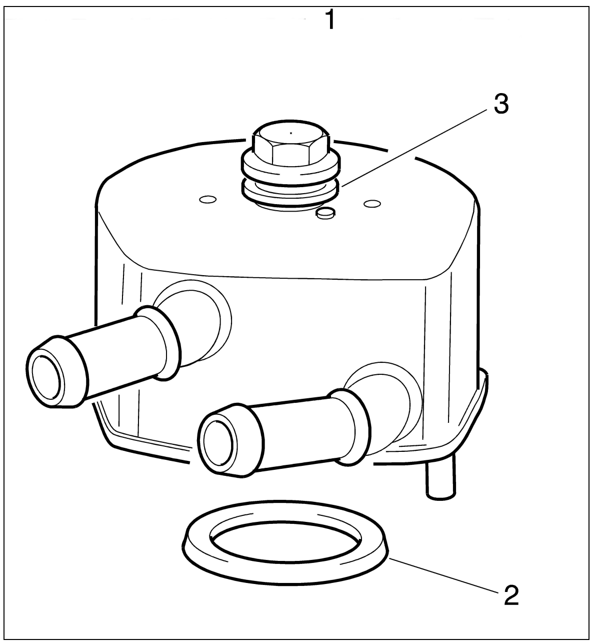


Fig. 100 Oil Cooler (2000–2002 S-TYPE)

1. Oil Cooler
2. Sealing ring
3. Sealing washer

The 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.

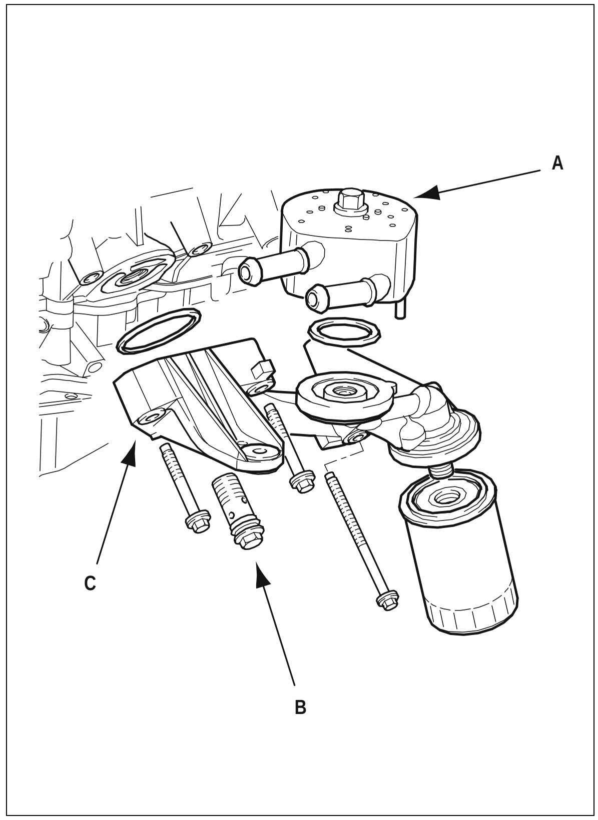


Fig. 101 OIL COOLER AND FILTER ASSEMBLY (2000 MY S-TYPE Shown)

a. Oil cooler
b. Hollow mounting bolt
c. aluminum adaptor and engine mounting

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

EOP (A) and EOT (B) 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.

Below 5°C (40°F) EOT there is no VVT operation.

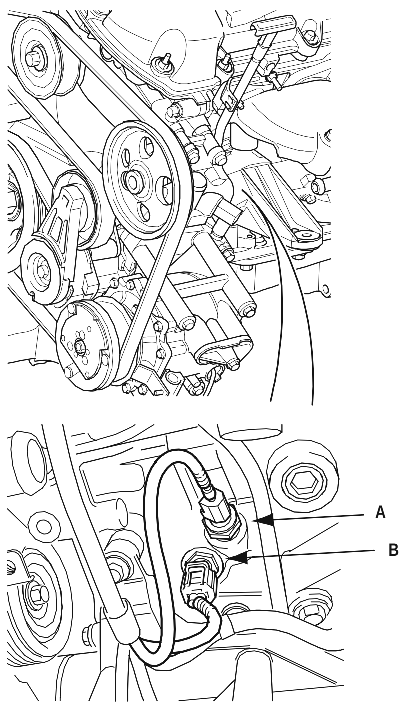


Fig. 102 ENGINE OIL PRESSURE AND OIL TEMPERATURE SENSORS

WARNING:

Recommended engine oil - an oil of 5W-30 viscosity meeting Jaguars specification WSS M2C913 - A or B is preferred. Where this is not possible oil meeting API SJ / EC and ACEA A1 98 or A3 98 may be used. Synthetic oil meeting the above specification may be used in both V6 and V8 engines.

Engine Cooling

S-TYPE cooling system

Engine cooling is via a conventional re-circulation system between the engine assembly and front mounted coolant to air radiator. It is a sealed, high pressure system, which has an expansion resevoir to account for thermal expansion and to help purge air trapped within the system.

Coolant flow is from the front of the engine, dividing to pass through the cooling jackets of 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.

The reservoir bottle is mounted at the rear left of the engine bay and has a bleed valve on the return pipe running across the bulkhead. 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.

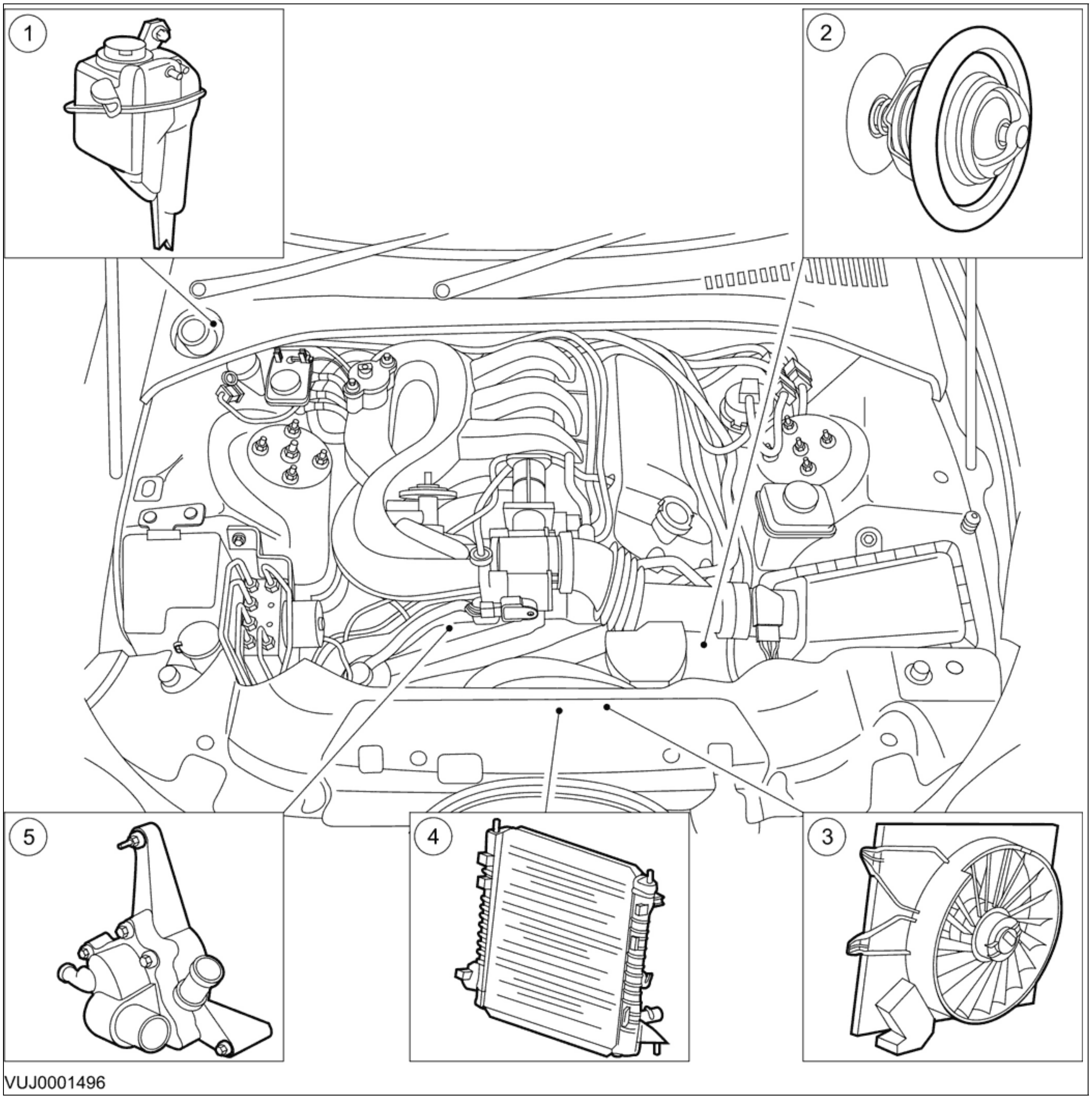


Fig. 103 2000–2002 S-TYPE Cooling System Components

1. Coolant expansion tank
2. Thermostat
3. Electric fan
4. Radiator
5. Water pump

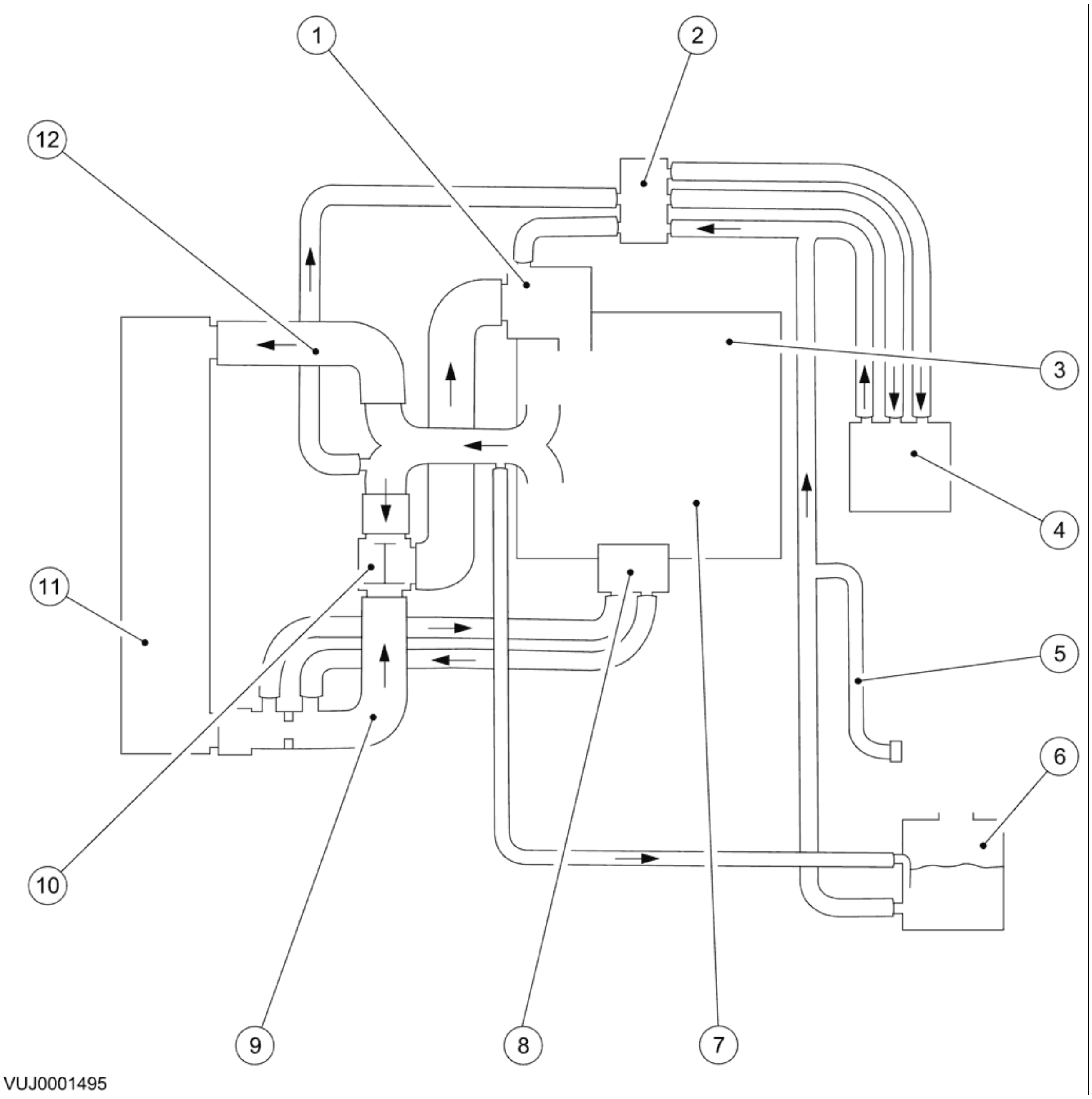


Fig. 104 Cooling flow diagram (2000MY S-TYPE)

1. Water pump
2. Water control valve
3. Engine bank (right-hand)
4. Heater
5. Manual bleed tube (left-hand drive only)
6. Expansion tank
7. Engine bank (right-hand)
8. Engine oil cooler
9. Bottom hose
10. Thermostat
11. Radiator
12. Top hose

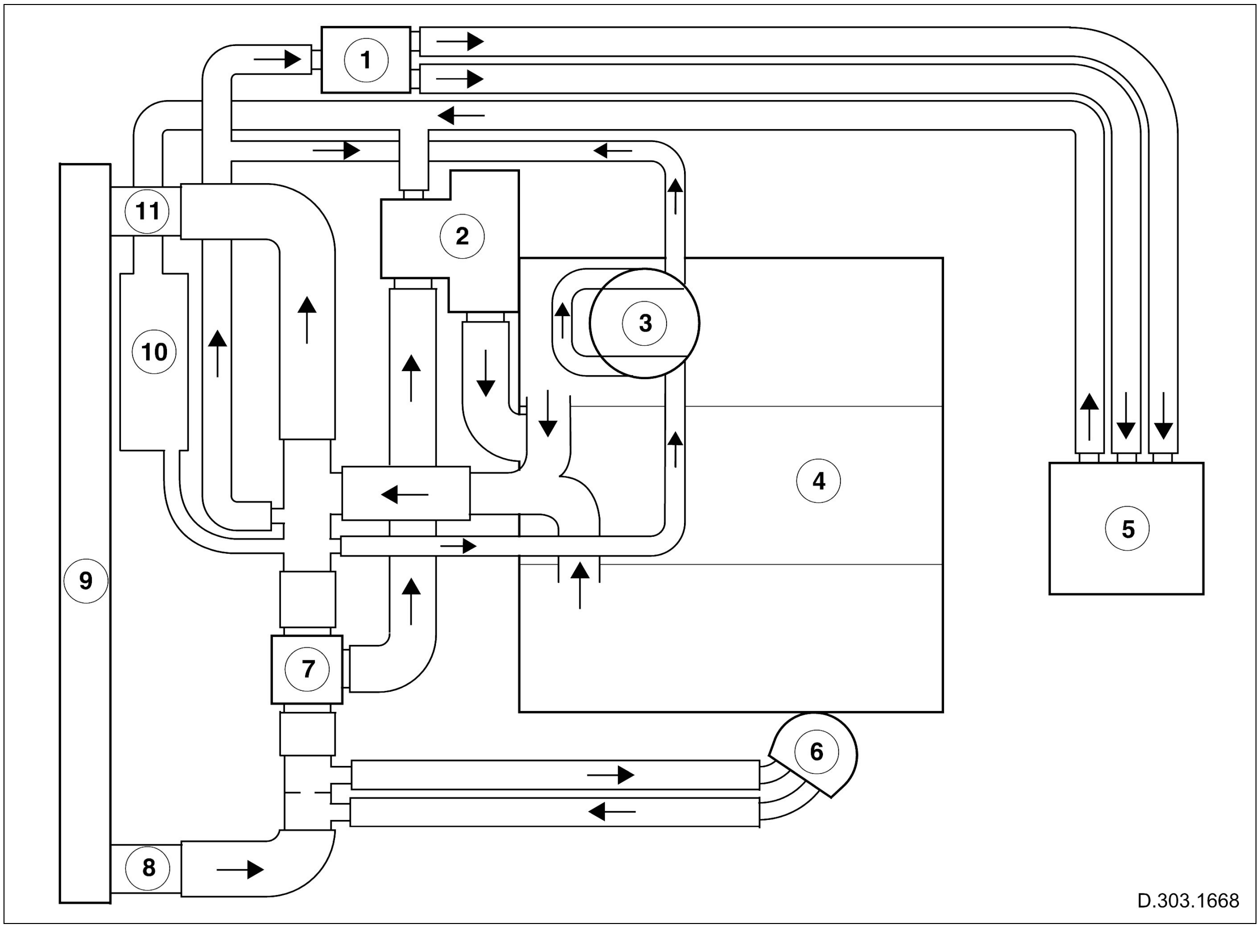


Fig. 105 Cooling flow diagram (2003MY S-TYPE)

1. Dual coolant flow valve
2. Coolant pump
3. Throttle body
4. Engine
5. Heater core
6. Engine oil cooler
7. Thermostat
8. Bottom hose
9. Radiator
10. Coolant expansion tank
11. Top hose

X-TYPE cooling system

The cooling system is a low volume, high velocity system with good warm-up characteristics. The thermostat which controls the system's coolant flow is located in a housing in the upper coolant hose.

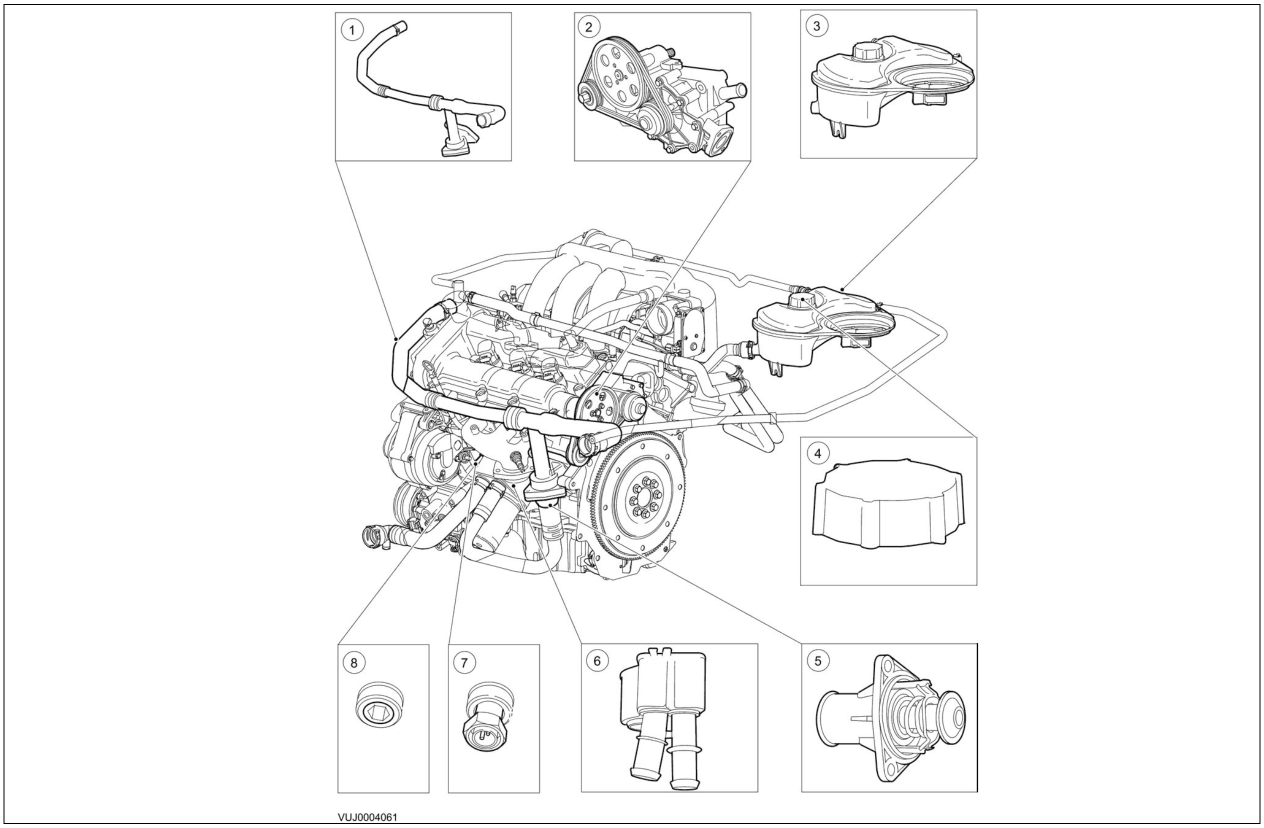


Fig. 106 X-TYPE Cooling System Components

1. Upper coolant hose
2. Water pump
3. Coolant expansion tank
4. Coolant pressure cap
5. Thermostat
6. Engine oil cooler
7. Engine block heater (option)
8. Engine block drain plug

When the engine is cold and the thermostat is closed, coolant travels from the coolant pump, circulates through the engine and returns directly to the pump via the upper coolant hose. The coolant flow to the heater core located in the climate control assembly is on a parallel circuit and is unaffected by the thermostat position.

As the engine warms-up and the thermostat opens, coolant is then directed from the engine, through the radiator and engine oil cooler via the lower hose before returning to the coolant pump.

A continuous vent to the coolant expansion tank from the engine radiator, via the bypass hoses, ensures continuous de-aeration of the coolant system. There are no manual bleed points on the system

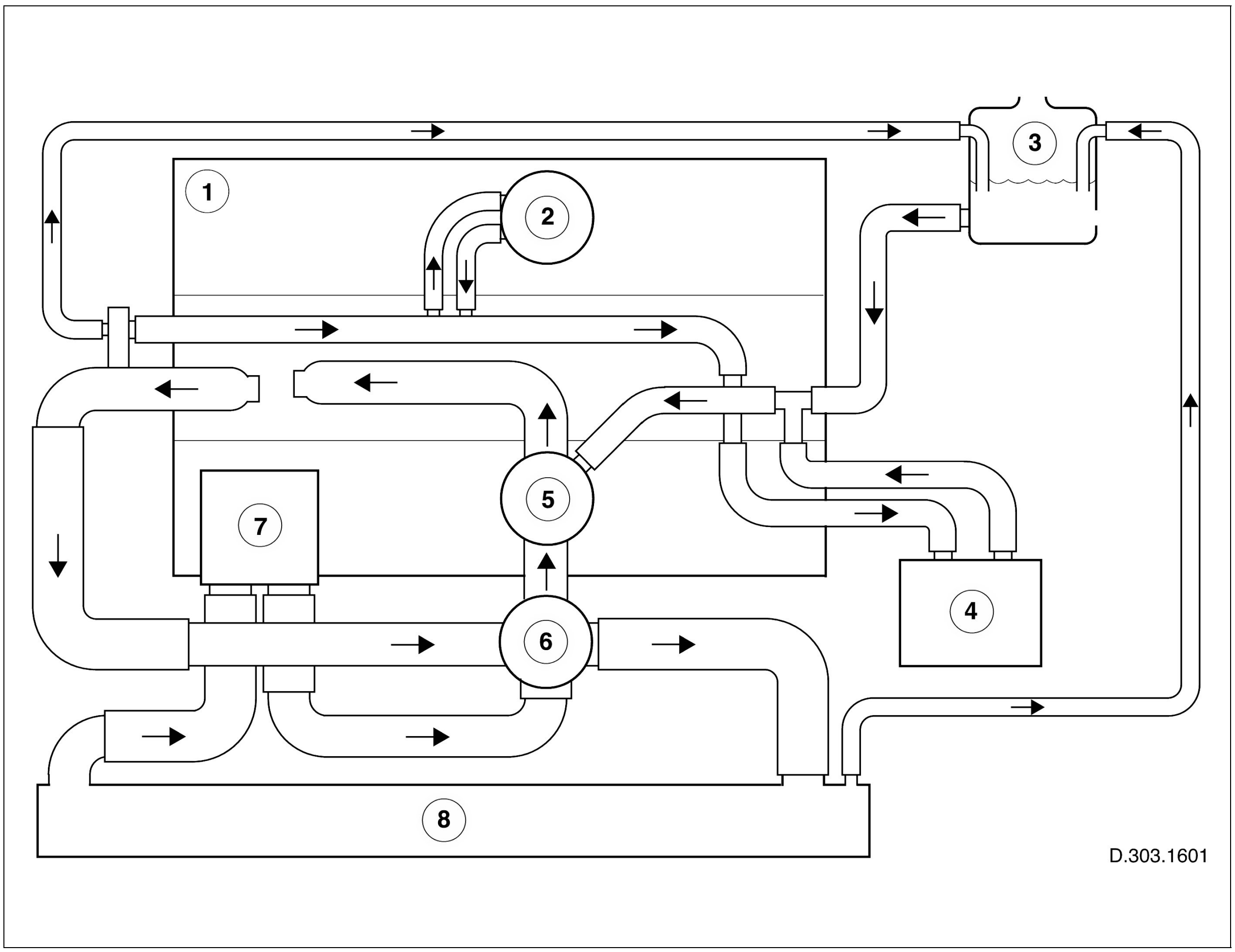


Fig. 107 X-TYPE cooling system

1. Engine
2. Throttle Body
3. Expansion Tank
4. Heater core
5. Coolant pump
6. Thermostat
7. Engine oil cooler
8. Radiator

Hoses

Coolant ducting consists of flexible hoses, aluminum 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.

On the AJ60 and AJ62, the thermostat is enclosed in a stand alone, aluminum casting, which is supported solely by hose connections. The thermostat for the AJ61 (X-TYPE) is located in a plastic housing mounted on a hose leading directly to the water pump.

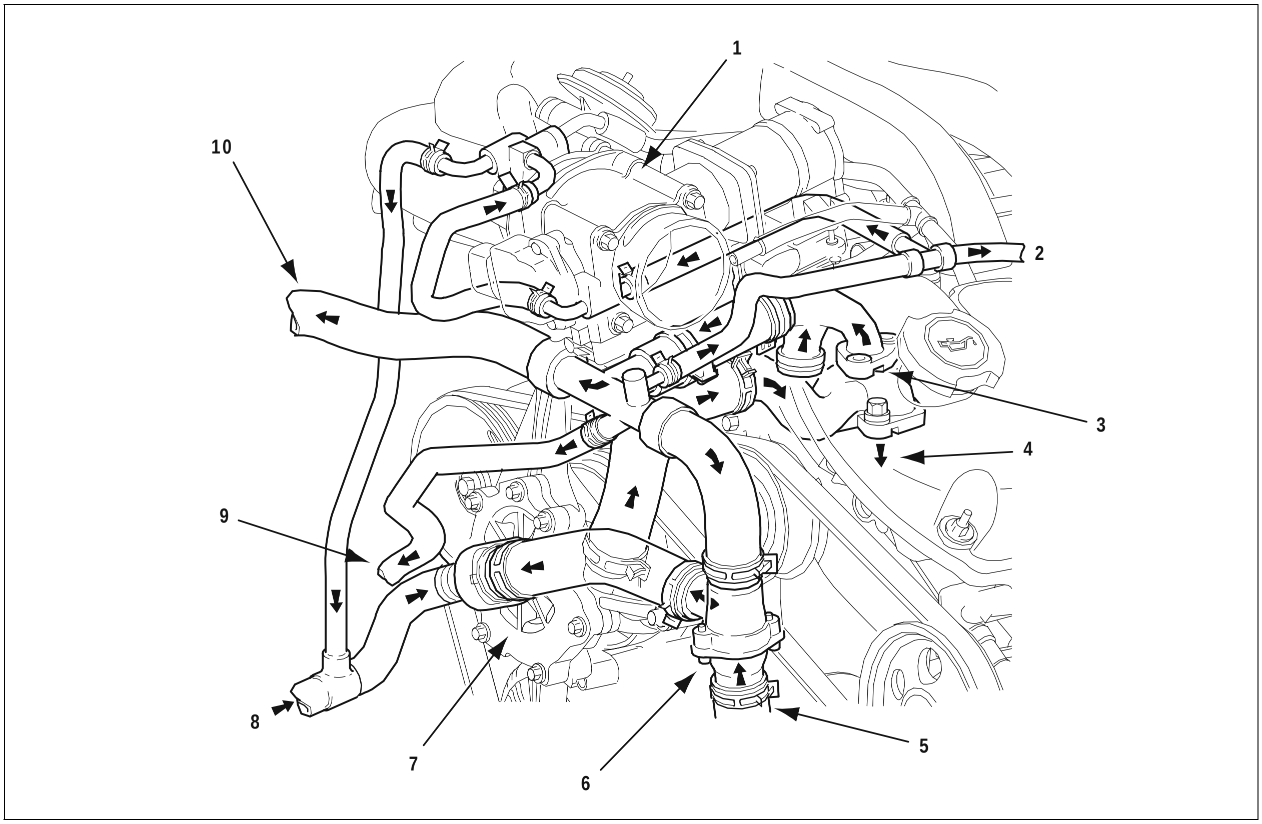


Fig. 108 HOSE LAYOUT (AJ60)

1. Electronic Throttle
2. To Reservoir Bottle
3. From Engine
4. To Engine
5. Bottom Hose
6. Thermostat
7. Coolant Pump
8. From Heater Control Valve
9. To Heater Control Valve
10. Top Hose

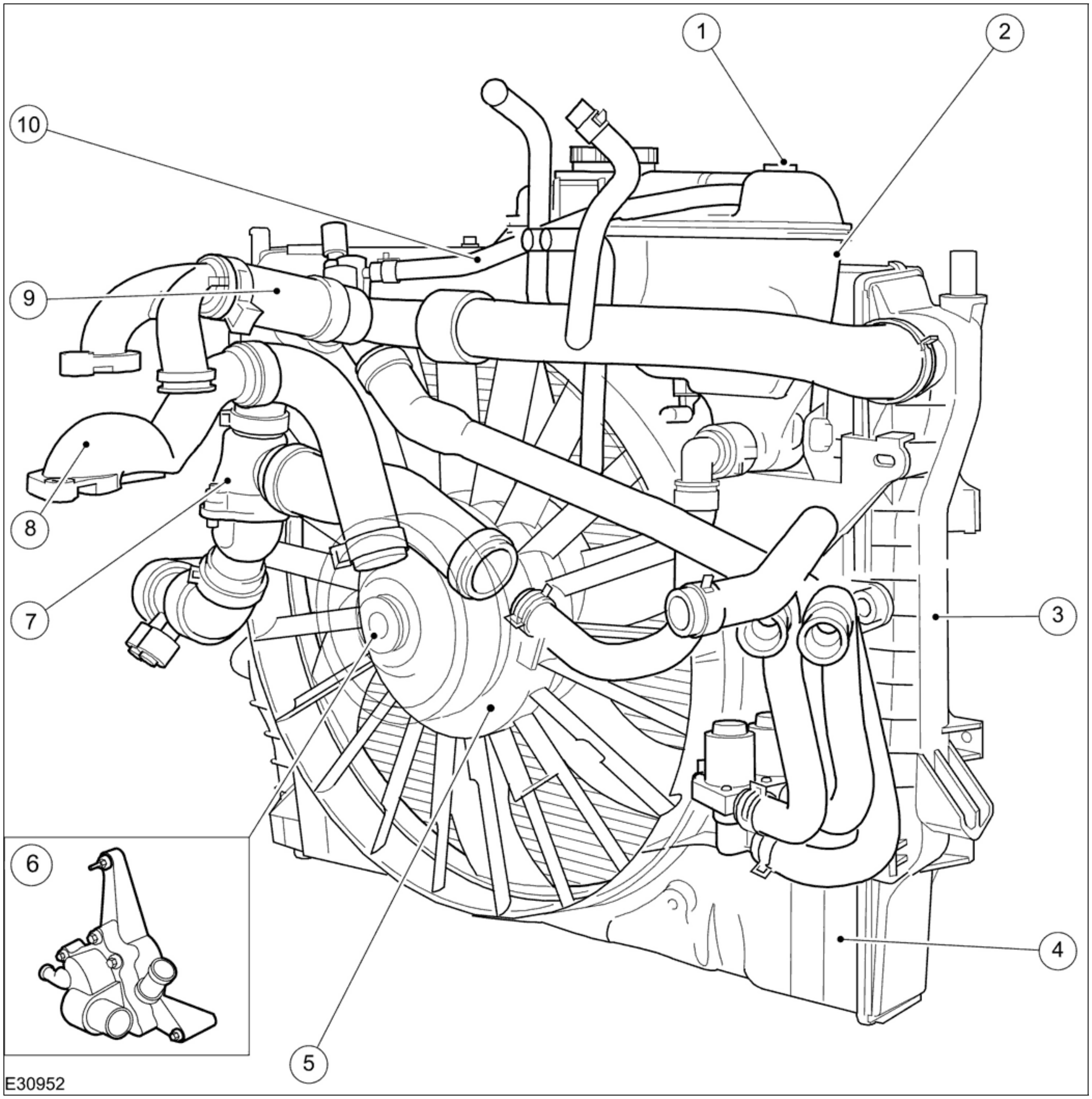


Fig. 109 Hose layout (2003 S-TYPE)

1. Bleed screw
2. Coolant expansion tank
3. Radiator
4. Radiator shroud
5. Cooling fan motor
6. Water pump
7. Thermostat housing
8. Engine coolant inlet
9. Engine coolant outlet
10. Vent hose

Coolant Pump (AJ60 and AJ62)

The coolant pump is fitted via three bolts to the engine front cover. The pulley is mounted inboard 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.

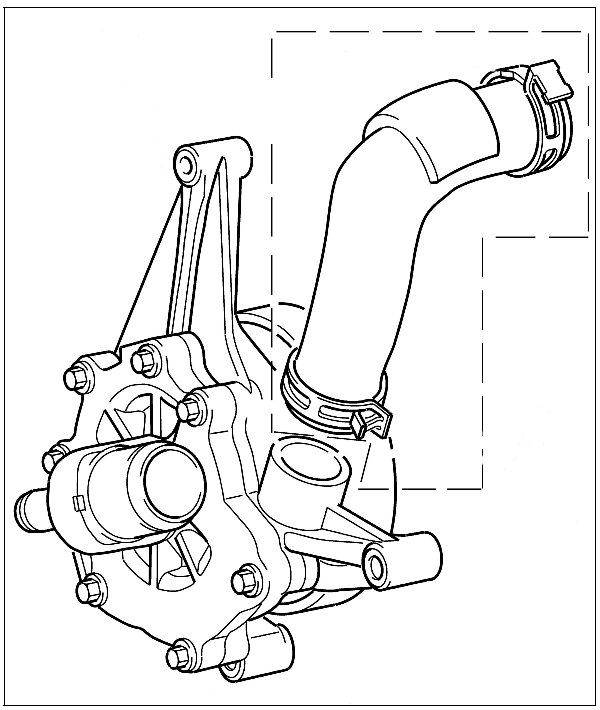


Fig. 110 Coolant Pump S-TYPE

Coolant Pump (AJ61)

The coolant pump assembly is located at the rear of the engine and consists of a three pulley drive-system. The centre pulley, which is driven by the exhaust camshaft, transmits the drive to the coolant pump via the drive-belt.

Drive belt tension is maintained by an automatic drive belt tensioner.

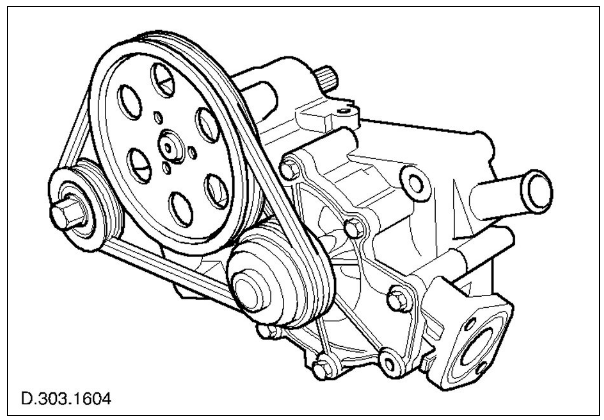


Fig. 111 X-TYPE coolant pump

Radiator and Cooling Fan Assembly — X200

The engine radiator is one component of the cooling pack assembly which also includes the power steering (ps) and transmission heat exchangers and the A/C condenser.

The radiator consists of an aluminum core with crimped on plastic end tanks. A single electrical cooling fan (twin fan motor assembly on AJ61) and a fan speed regulator module (AJ60 only) are fixed to the glass filled nylon fan shroud assembly. The complete shroud assembly 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 fan motor drives the impeller over a continuously variable speed range from 300 RPM to 2900 RPM and is controlled by a regulator module as commanded by the ECM. Since the fan speed regulator module provides power to the fan, it has a finned heat sink outer casing and is enclosed within a cooling duct.

The ACCM also controls the fan speed after the ignition has been turned off to provide an extended period of engine cooling as required to protect the engine. The ACCM calculates cooling fan run time based on coolant temperature information from the ECM immediately before shutdown.

Airflow seals located around the edge of the radiator have a significant effect on performance of the cooling and air conditioning system by preventing uncontrolled air from entering the assembly.

The radiator drain is located on the RH end tank on the X200 and in the radiator lower hose on X400.

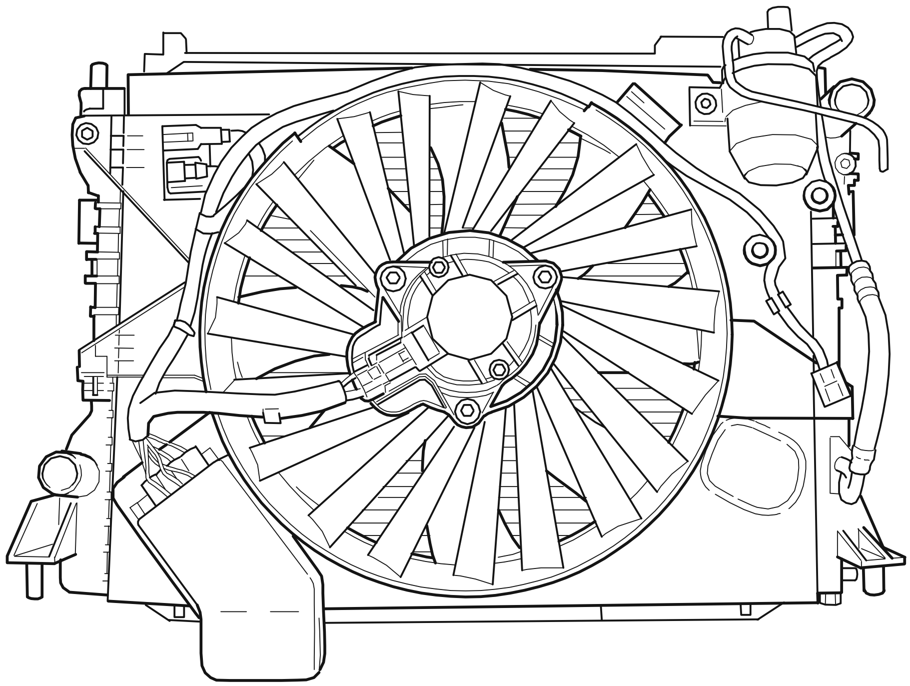


Fig. 112 RADIATOR AND FAN SHROUD ASSEMBLY (X400)

Coolant

A new type of anti-freeze fluid is used for the coolant mixture of the AJV6, commonly known as Organic Acid Technology (OAT). 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. Conventional anti-freeze is not compatible with OAT coolant, and should never be used to top off the

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 150,000 miles (250,000km).

Engine Block Heater

For vehicles subject to very low temperatures, a 400W 115V engine coolant heater is available as an option. Requiring connection to an external mains electrical supply, the heater element is screwed into the RH side of the cylinder block adjacent to the knock sensor.

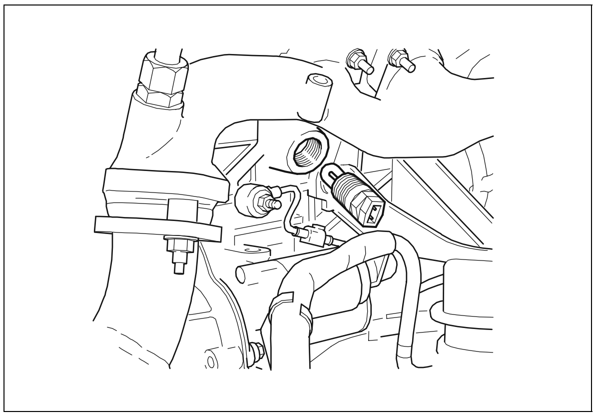


Fig. 113 ENGINE BLOCK HEATER

Cylinder Head Temperature (CHT) Sensor (AJ60 only)

The CHT sensor, located between the two rear coil-on-plug units in the left hand cylinder head, is a thermistor which has a negative temperature coefficient (NTC).

The sensor directly monitors the metal temperature of the cylinder head. This method of engine heat sensing is used in place of an engine coolant temperature sensor to enable the V6 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.

Cylinder head temperature is determined by the PCM by the change in the sensor resistance. The PCM applies 5 volts to the sensor and monitors the voltage across the pins to detect the varying resistance.

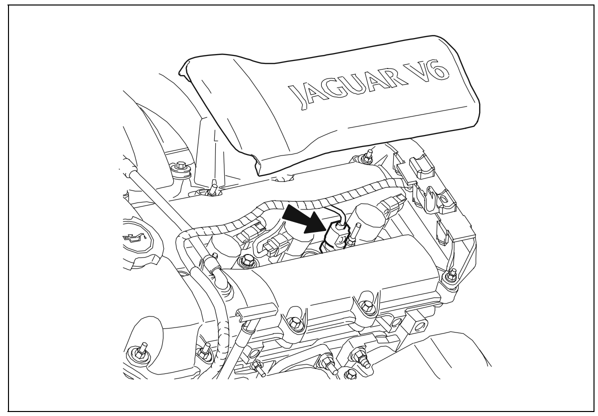


Fig. 114 CHT SENSOR

Cooling system filling and bleeding

For each model always refer to JTIS for the correct procedures. There are differences for each variant which are highlighted here.

Fill the cooling system up to the MAX mark on the coolant expansion tank using a 50% mixture of Jaguar premium cooling system fluid or equivalent, meeting Jaguar specification ESE-M97B44–A and 50% distilled water.

X-TYPE

- Start and run the engine at 2000 rpm until the cooling fans operate
- Stop the engine and allow to cool for two minutes
- Loosely install a pipe clamp to the heater inlet and return hoses
- Start and run the engine at 2000 rpm
- With the engine at 2000 rpm, fully clamp the outlet and then the inlet hose
- Continue to run the engine for a further two minutes.
- Switch off the engine and remove the clamps
- When cool ensure the level is up to the MAX mark on the expansion tank

2000–2002MY S-TYPE

- Open the engine air bleed located on the engine crossover pipe
- Open the heater air bleed located on the expansion tank
- Fill the expansion tank until the coolant flows from the engine air bleed screw and the expansion tank is full
- Close the engine air bleed screw
- Install the expansion tank cap
- Leave the heater air bleed open
- Start the engine and set the heater to 29°C/90°F temperature
- Close the heater air bleed when a steady stream of coolant flows during idle
- Allow the engine to idle for five minutes, adding coolant to the expansion tank to maintain the cold fill MAX level
- Open the heater air bleed to release any trapped air, close the heater air bleed
- Increase the engine speed to 1500 rpm for between three and five minutes or until the heater is blowing hot air

2003MY S-TYPE

- Remove the coolant expansion tank bleed screw
- Fill the cooling system up to the MAX mark on the expansion tank
- Install the coolant expansion tank pressure cap
- Start and run the engine
- Set the heating system to MAX heat, the blower motor to MAX speed and the air distribution to instrument panel registers
- Allow the engine to run until hot air is emitted from the registers, while observing the engine temperature gauge
- Switch off the engine
- When cool, check the cooling system is filled to the MAX mark

CRANKCASE VENTILATION AND EGR

Crankcase Ventilation

Positive Crankcase Ventilation

Under closed or near closed throttle conditions, crankcase breathing is mainly via the positive crankcase ventilation (PCV) system.

An oil separator (A) is bolted to the top of the engine block between the cylinder banks. A PCV valve is suspended between the seperator and the intake manifold via connecting hoses.

The PCV valve (B) 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.

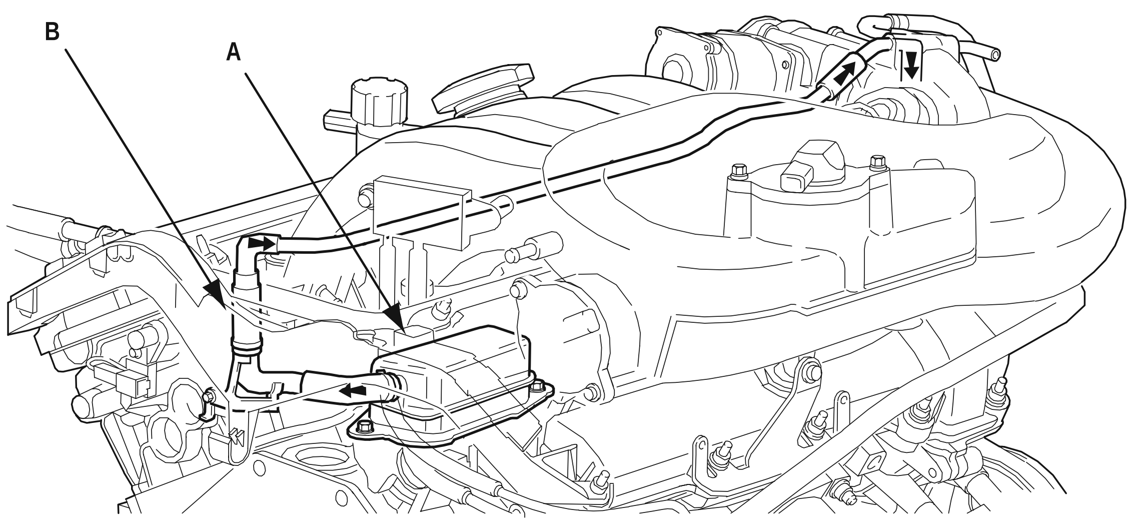


Fig. 115 POSITIVE CRANKCASE VENTILATION (AJ60 Shown)

The positive crankcase ventilation valve was repositioned on the AJ61 and AJ62 into the left hand camshaft cover.

Full Load Ventilation (AJ60 engine)

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

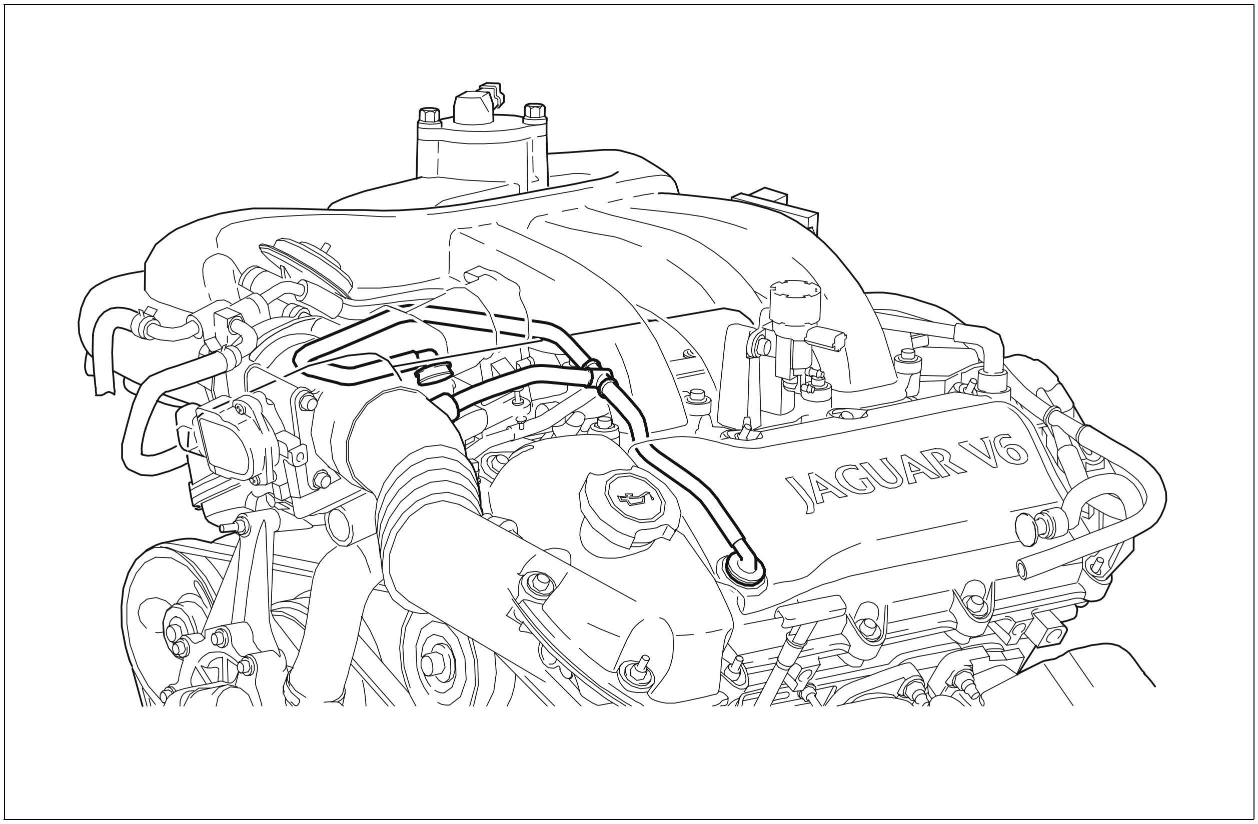


Fig. 116 FULL LOAD VENTILATION (AJ60)

Exhaust Gas Recirculation (EGR)

Operation

The EGR system is only fitted to early production X200 vehicles, and eliminated partway into the 2001 MY.

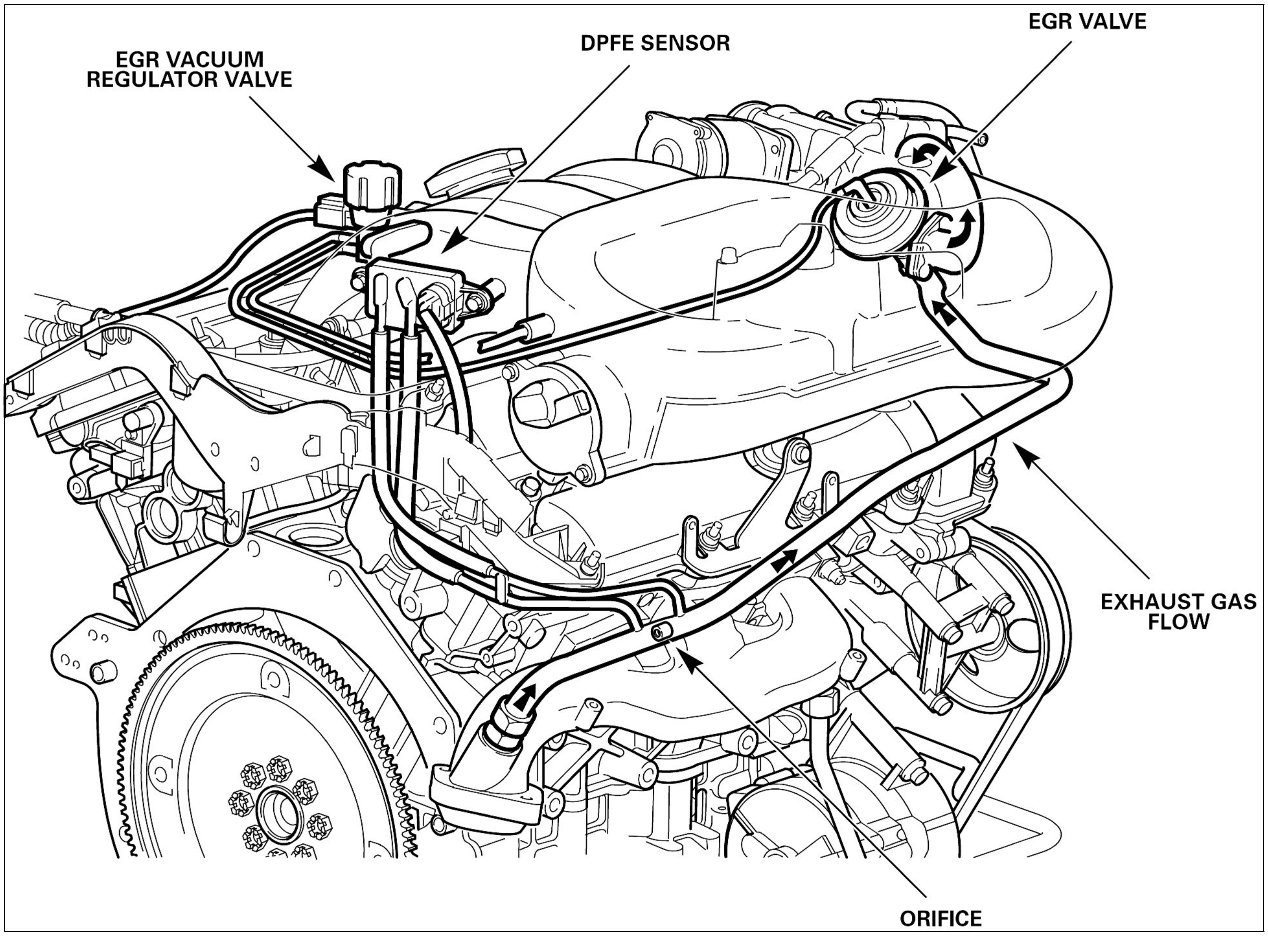


Fig. 117 EGR SYSTEM (V6)

Exhaust gas is recirculated back to the engine intake at a flow rate predetermined by the EMS.

The amount of gas recirculated varies primarily with engine speed and load but is also modified by the EMS to allow for other factors such as coolant temperature and inlet air temperature. The EGR flow rate is optimized to reduce NOx generation and also to achieve maximum fuel economy.

The recirculated exhaust gas is taken from the right hand 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 converts 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 to the sensed pressure drop across the orifice, producing outputs in the approximate range 1V-3.5V dc.

The EGR control system is comprised of the EGR vacuum regulator valve and the mechanical EGR valve. The EGR vacuum regulator valve has a vacuum input from the intake manifold, a vent to ambient air (via a foam filter), a vacuum output to the EGR valve and a pulse width modulated (PWM) signal from the PCM. The PWM signal controls power to a solenoid, which then balances the vacuum control output and vent to the EGR valve diaphragm.

The EGR valve is a vacuum operated diaphragm valve with no electrical connections. As vacuum is applied to the EGR valve, the vacuum opens the EGR feed pipe to the induction manifold, allowing the exhaust gas to flow from the exhaust manifold to the intake manifold.

The PCM then uses the feedback signal from the differential feedback EGR sensor to adjust the PWM signal to the vacuum regulator valve to get the desired amount of EGR flow.

On engines where an 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 (e.g. a faulty sensor)
- During idling to avoid unstable or erratic running
- During wide open throttle operation
- When traction control is operative.

ACCESSORY DRIVES

Drive Belts

On the AJ60 engine 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.

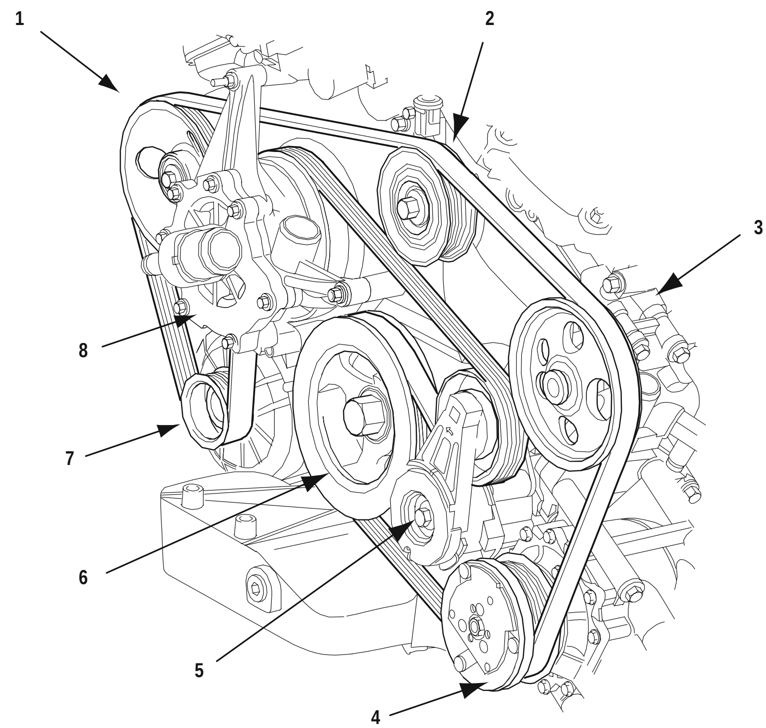


Fig. 118 ENGINE ACCESSORIES AND DRIVE BELT (AJ60 S-TYPE)

1. Idler pulley
2. Idler pulley
3. PAS Pump
4. A/C Compressor
5. Drive Belt Tensioner
6. Crankshaft Damper Pulley
7. Generator
8. Coolant Pump

The front end accessory drive belt fitted to X-TYPE (AJ61) has been reconfigured to make the arrangement more compact. This has also been achieved by mounting the coolant pump at the rear of the engine.

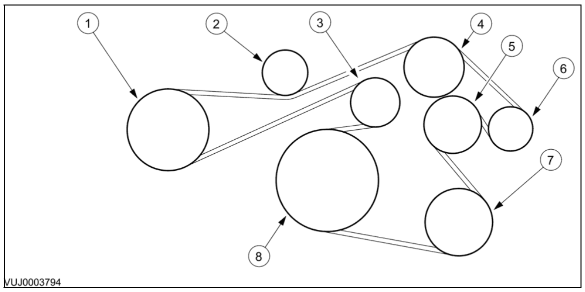


Fig. 119 X-TYPE belt routing

1. Power steering pump pulley
2. Belt idler pulley
3. Belt tensioner
4. Belt idler pulley
5. Belt idler pulley
6. Generator pulley
7. Air conditioning pump pulley
8. Crankshaft pulley

On the 2003MY S-TYPE a new single drive belt driven by the engine is used to drive the engine's auxiliaries, including a new air conditioning compressor. To achieve the required routing, the belt runs around two idler pulleys and a belt tensioner.

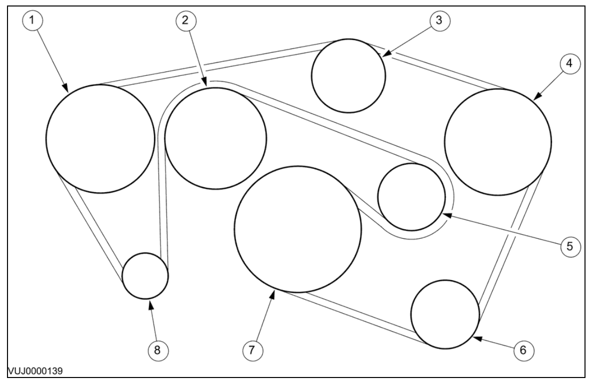


Fig. 120 2003MY S-TYPE belt routing

1. Accessory drive belt idler pulley
2. Water pump pulley
3. Accessory drive belt idler pulley
4. Power steering pump pulley
5. Accessory drive belt tensioner
6. Air conditioning compressor pulley
7. Crankshaft pulley
8. Generator pulley

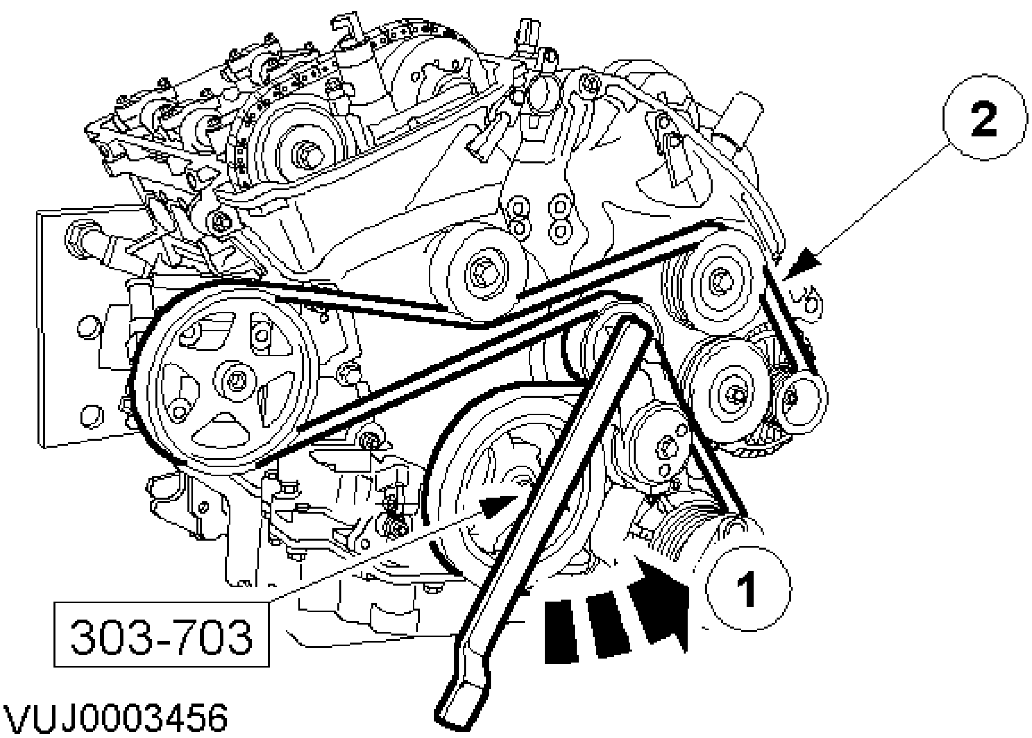


Fig. 121 Belt removal

Idler Pulleys

Two idler pulleys are used. One is fixed by a single bolt to the front cover and a second fixed via a mounting bracket to the upper RH side of the cylinder head and front cover.

PAS Pump

- On the 2000MY early S-TYPE the pump was supplied by Visteon and fixed by two bolts to the front cover and one to the cylinder head. The pulley was a lightweight phenolic material
- The X-TYPE pump is supplied by ZF and has a four bolt fixing to the right hand side of the front cover and a steel pulley
- The 2003MY S-TYPE pump is also supplied by ZF with a three bolt fixing and steel pulley

Air Conditioning Compressor

The A/C compressor on X-TYPE 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. On the S-TYPE the compressor is mounted with four bolts two to the sump and two to a block mounted bracket.

Drive Belt Tensioner

The drive belt tensioneron the 2000–2002MY S-TYPE 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 (A) and maximum (B) lengths for a new belt and the point at which the belt must be replaced (C).

On the X-TYPE and 2003–onwards S-TYPE, the accessory drive belt tensioner consists of an idler pulley which is free to rotate on a bearing, located at the end of a spring-loaded pivot arm. The pivot arm can be turned counter-clockwise (viewed from the front of the engine) for accessory drive belt removal and installation. The accessory drive belt wear indicators are incorporated on the bottom of the accessory drive belt tensioner. When the indicators are aligned the accessory drive belt requires replacing.

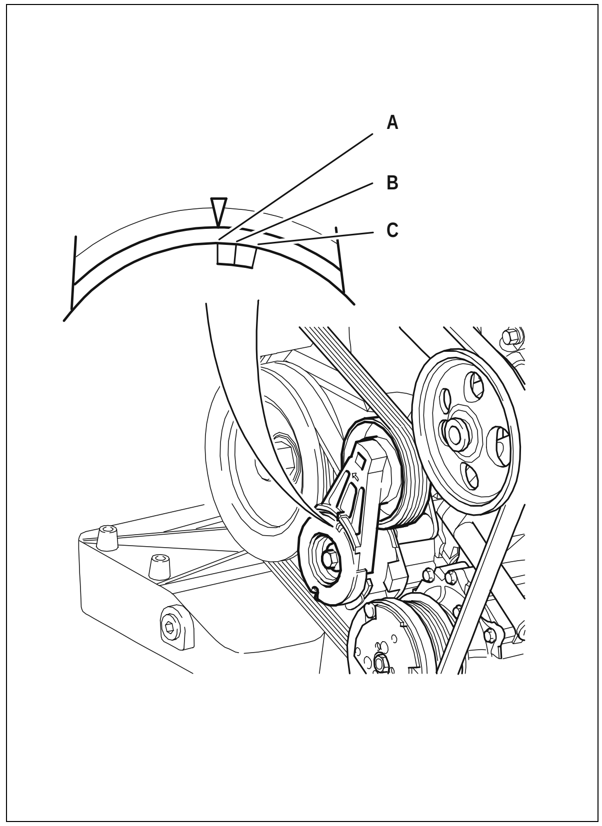


Fig. 122 DRIVE BELT TENSIONER 2000–2002MY S-TYPE

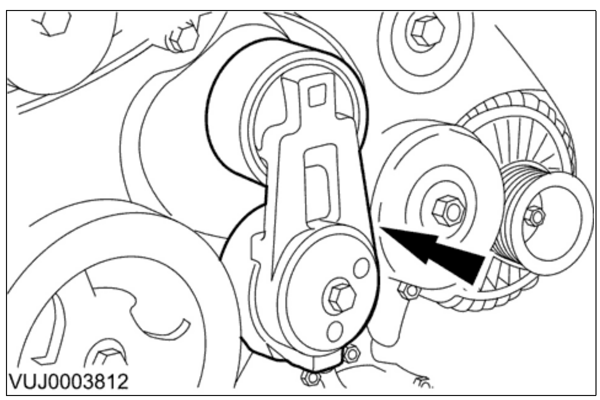


Fig. 123 DRIVE BELT TENSIONER X-TYPE

Generator

The generator on S-TYPE is fitted with a special casing to enable it to be bolted directly to the engine via three fixing points. On X-TYPE the generator is mounted with two bolts axially.

On all 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 vehicles incorporates a clutch mechanism which allows it to freewheel in the reverse drive (anti-clockwise) direction.

To improve generator control on all engine/transmission variants, the generator 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.

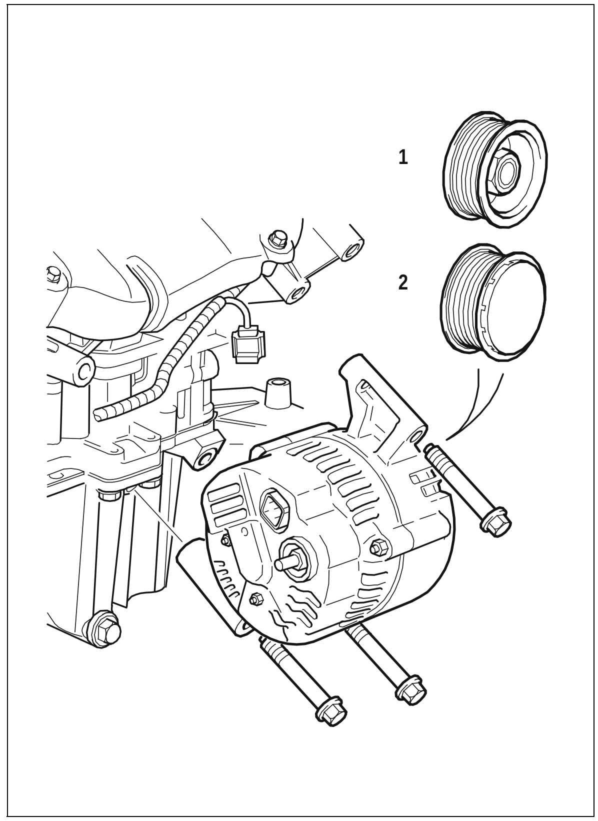


Fig. 124 GENERATOR (S-TYPE)

1. Automatic Transmission Pulley
2. Manual Transmission Pulley

SPECIFICATIONS

General Specifications

Table 34

FEATURE	S-TYPE 3.0l	X-TYPE 3.0l	X-TYPE 2.5l
Configuration	– 60° V6	– 60° V6	– 60° V6
Displacement	– 2967cc	–2967cc	– 2495cc
Bore/Stroke	89/79.5mm	89/79.5mm	81.65/79.5mm
Compression ratio	– 10.5:1	– 10.5:1	–10.31:1
Cylinder head	– 2 overhead camshafts per bank, 4 valve per cylinder	– 2 overhead camshafts per bank, 4 valve per cylinder	– 2 overhead camshafts per bank, 4 valve per cylinder
Firing order	– 1-4-2-5-3-6	–1-2–3-4-5-6	–1-2–3-4-5-6
Maximum power (DIN values)	240 BHP /179 kW / 243 PS at 6800 RPM	231 BHP /172 kW / 234 PS at 6800 RPM	194 BHP /145 kW / 197 PS at 6800 RPM
Maximum torque (DIN values)	300 Nm /221 lb ft at 4500 RPM	284 Nm /210 lb ft at 3000 RPM	244 Nm /180 lb ft at 3000 RPM
Valve clearance (cold)	Intake 0.175 – 0.225 mm		
	Exhaust 0.325 – 0.375 mm		

Table 35 Engine codes S-TYPE 3.0 Liter (2003 MY ONWARDS)

ENGINE CODE	EMISSIONS	TRANS	EGR	OIL COOLER
3G-762–	LEV	AUTO	NO	NO

Table 36 Engine codes X-TYPE 2.5 Liter

ENGINE CODE	EMISSIONS	TRANS	EGR	OIL COOLER
1G-430	LEV	AUTO	NO	YES
1G-431	LEV	MANUAL	NO	YES

Table 37 Engine codes X-TYPE 3.0 Liter

ENGINE CODE	EMISSIONS	TRANS	EGR	OIL COOLER
1G-730	LEV	AUTO	NO	YES
1G-731	LEV	MANUAL	NO	YES

V6 WEAR SPECIFICATIONS

- Crankshaft end play to be within (0.100–0.250mm)
- Valve guide inner diameter (mm) 5.514 - 5.544
- Intake valve effective length (mm) 90.93 - 90.13
- Exhaust valve effective length (mm) 89.88 - 89.68
- Valve stem to guide clearance intake - diametral (mm) 0.067 - 0.022
- Valve stem to guide clearance exhaust - dimetral (mm) 0.080 - 0.035
- Valve head diameter intake (mm) 35.15 - 34.85
- Valve head diameter exhaust (mm) 30.15 - 29.85
- Intake valve face angle degree 45.75°
- Exhaust valve face angle degree 45.25°
- Valve stem diameter intake (mm) 5.492 - 5.471
- Valve stem diameter exhaust (mm) 5.479 - 5.464
- Valve spring min free length (mm) 44.2
- Valve spring installed height (mm) 33.41
- Camshaft lobe lift intake (mm) 9.367
- Camshaft lobe lift exhaust (mm) 9.461
- Camshaft end play (mm) 0.150 - 0.070
- Camshaft journal to cylinder head bearing surface clearance diametral (mm) 0.076 - 0.025
- Camshaft journal diameter standard runout limit (mm) 0.040
- Camshaft journal diameter standard out of round (mm) 0.013

- **Main Bearing Clearance:** (0.026–0.042mm) at crown
- **Connecting Rod Bearing Clearance:** (0.035-0.065mm) at crown
- Connecting rod to crankshaft side clearance (0.10–0.30mm)
- Compression ring end gap upper (0.10–0.25mm), lower (0.27–0.42mm)
- Oil ring segment end gap (0.15–0.65mm)

The cylinder head warpage specification for the AJV6 engines is:

- 0.05 mm – 150x150
- 0.025 mm – 25x25
- 0.12 mm — Overall

NOTE:

The flatness is called out in patches. The 150x150 refers to a 150mm x 150mm square patch. In any 150x150 patch on the deck face, the flatness must be less than 0.05mm. Similar for the 25mm x 25mm patch.

Table 38 Piston & Connecting Rod Assy, Bearings and Rod Cap Assembly

LITER	GRADE	CYL. BLOCK BORE DIA. (mm)	PISTON DIA. (mm)
3.0	1	89.000–89.010	88.990–89.010
3.0	2	89.010–89.020	88.998–89.22
3.0	3	88.990–89.000	89.010–89.030
2.5	7	81.640–81.650	81.630–81.650
2.5	8	81.651–81.660	81.638–81.662
2.5	9	81.661–81.670	81.650–81.670

V6
Main Bearing Ordering Chart

Bearing Number	Top Bearing Part Number	Bottom Bearing Part Number
1	C2S 23247	C2S 23250
2	C2S 23248	C2S 23251
3	C2S 23249	C2S 23252
Thrust Bearing 1	C2S 12612	C2S 23253
Thrust Bearing 2	C2S 12612	C2S 23254
Thrust Bearing 3	C2S 12612	C2S 23254

Lubricants, Fluids, Sealers and Adhesives

Table 39

Specifications	
Engine oil, SAE 5W-30	– WSS-M2C-912A
Engine assembly lubricant	– SQM-2C9003 AA EP90
Sealant	– WSS M4G 320-A3
Spark plug grease	– 'Antiseize' ESE M12 A4A

Table 40

Capacities	
Engine oil, service fill with filter change	– 5.5 to 6.5 liters dependant on VIN
Coolant	– 10 to 10.5 liters

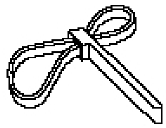
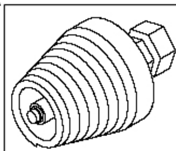
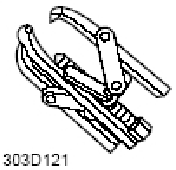
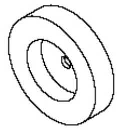
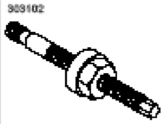
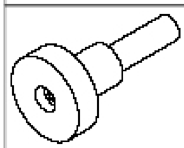
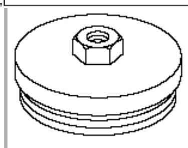
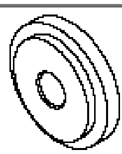
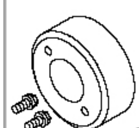
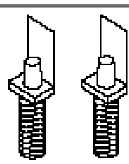
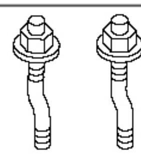
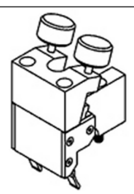
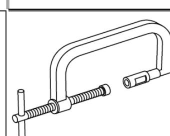
NOTE:

To signify the oil-fill change to S-TYPE V6 engines during 2000MY, a new style oil-level gauge was introduced. The new style gauge can be recognized by a loop handle opposed to the old T-bar design. The oil fill mark on the oil- level gauge was also altered by 14 mm. The change was implemented at approximate VIN L37178.

For Technical data and torque specifications refer to latest Workshop Manual in GTR : Powertrain, General Information and Specifications 303-01A.

CAUTION:

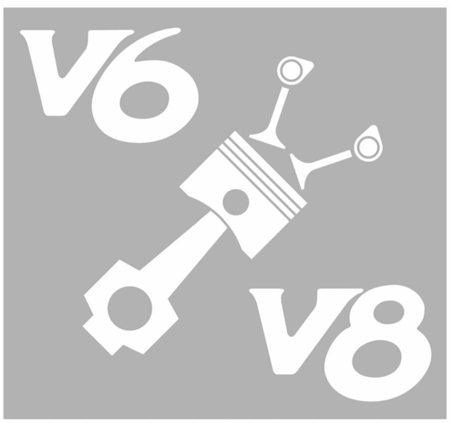
V6 engine oil specification : Synthetic oil meeting the following specification may be used - API SL and ILSAC GF-3.

 303D055	Wrench strap-universal 303-D055	 303-700	Crankshaft Front Seal Remover 303-700
 303D121	Crankshaft Pulley Remover 303-D121	 303-542	Crankshaft Front Seal Installer 303-542
303102  303102	Crankshaft Pulley Installer 303-102	 303-335	Crankshaft Front Seal Installer 303-335
 303D12101	Trust Pad 303-D121-01	 303566	Crankshaft Rear Seal Remover 303-566
 303-335/2	Crankshaft pulley installer 303-335/2	 303178	Crankshaft Rear Seal Installer 303-178
 303535	Cylinder Bore Protector 303-535	 303384	Crankshaft Rear Seal Installer Adapter Bolts 303-384
	Tappet Tool 303-717	 303252	Valve Spring Compressor 303-252

AJV6 SPECIAL TOOLS

TRAINING PROGRAM

JAGUAR V6/V8 ENGINE REPAIR



PUBLICATION CODE – 168

JAGUAR

Student___________________________________ Date____________

168
AJ27 / AJ28 Engines

Directions:
- Complete each step in sequence, following your workshop manual reference book. Fill in all blanks.
- When you reach an INSTRUCTOR CHECKPOINT, call your instructor who will examine your work and issue further instructions. **Do not** continue past an INSTRUCTOR CHECKPOINT unless instructed.
- Ask your instructor for assistance if needed.

1. Locate and record the following engine codes:
   (*Refer to your student guide for locations and definitions)*

   Engine Number: ____

   Crankshaft Main Bearing Journal Codes: 1 _____ 2_____ 3_____ 4_____ 5_____

   Crankshaft Connecting Rod Journal Codes: 1 _____ 2_____ 3_____ 4_____

   Cylinder Bore / Piston Grade Codes:

   B Bank: 1 _____ 2_____ 3_____ 4_____

   A Bank: 1 _____ 2_____ 3_____ 4_____

   Crankshaft Main Bearing Bore Codes: 1 _____ 2_____ 3_____ 4_____ 5_____

2. Following the procedures documented in your workshop manual, remove the ignition coil covers, coils, spark plugs, intake manifold assembly and harnesses.

3. Remove the exhaust manifolds.
   What is the exhaust manifold bolt grade? ________________________________

4. Remove the coolant outlet pipe.

5. Remove the thermostat housing assembly.

6. Remove the camshaft covers and inspect the sealing surface.
   How many places on the cylinder head show traces of sealant application?______

7. Set the engine at 45° ATDC cylinder 1A.
   What special tools are required? ________________--________________

INSTRUCTOR CHECK POINT 1 ____

8. Check the camshaft timing and remove special tool 303-645.

9. What is the acceptable range for intake and exhaust valve clearance:

Intake Max.	**Intake Min.**	**Exhaust Max.**	**Exhaust Min.**
__________	__________	____________	___________

10. Measure and record the existing valve clearances.

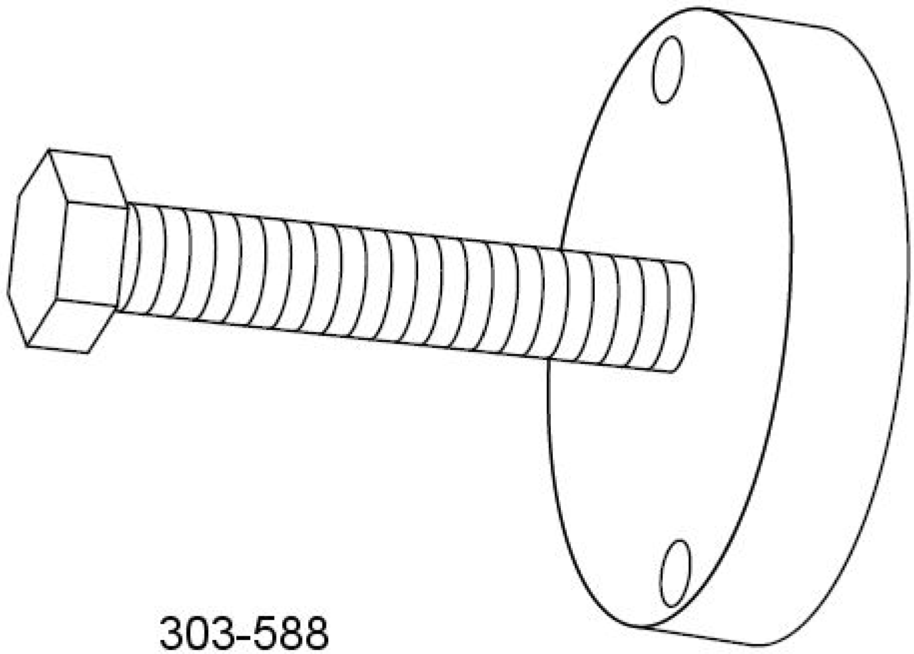
Cylinder	**Intake Front**	**Intake Rear**	**Exhaust Front**	**Exhaust Rear**
Cyl. A1	__________	__________	____________	___________
Cyl. A2	__________	__________	____________	___________
Cyl. A3	__________	__________	____________	___________
Cyl. A4	__________	__________	____________	___________
Cyl. B1	__________	__________	____________	___________
Cyl. B2	__________	__________	____________	___________
Cyl. B3	__________	__________	____________	___________
Cyl. B4	__________	__________	____________	___________

11. Remove the drivebelt. Remove the driveshaft damper bolt.

What special tools are required to hold the crankshaft?_______--__________

12. Remove the crankshaft vibration damper using special tool 303-588.

    Note the locking cone which retains the damper.



303-588

13. Remove the crankshaft front oil seal.

    What special tools are required? ____________________________________

14. Remove the coolant pump and engine front cover.

15. Prepare to remove the camshaft assemblies by setting the engine to 45 deg ATDC cylinder 1, bank 1.

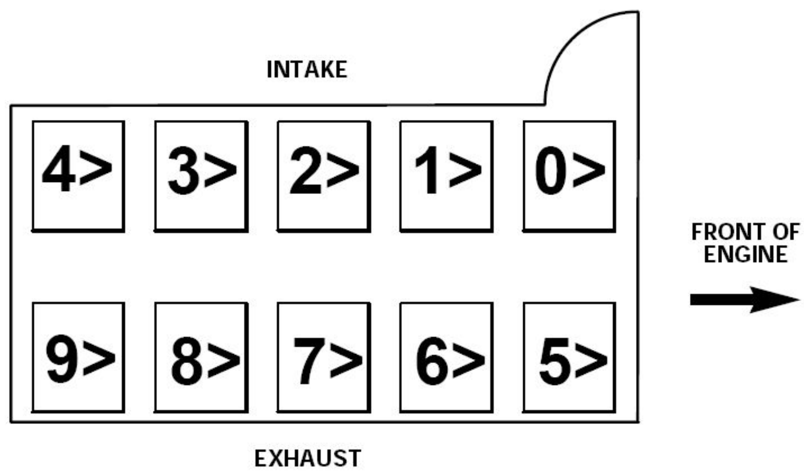
    What special tools are required to align the camshafts and crankshaft?

    ___________-__________ AND ___________-__________

16. Remove timing gears, camshaft sprockets, chain tensioners, guides and blades.

17. Remove the camshafts bearing caps, noting markings for each location on the chart:

CAMSHAFT BEARING CAP MARKINGS ('A' BANK SHOWN)



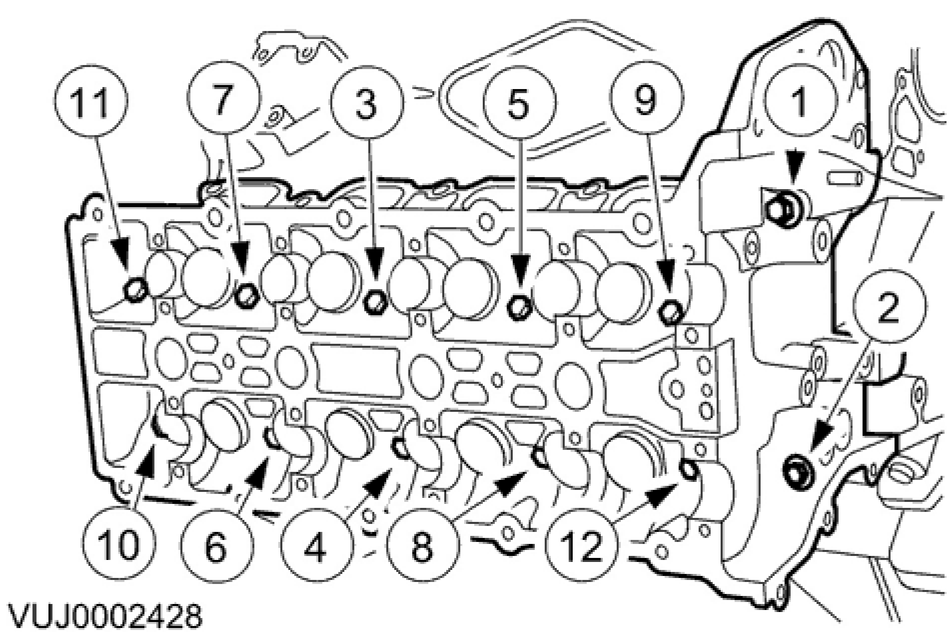
Are the camshaft bearing caps all correctly marked?

NOTE: Keep camshaft and camshaft bearing caps with their respective cylinder heads!

How can the intake camshafts be quickly identified? ____________________________

____

18. Remove the cylinder heads using the following cylinder head removal torque sequence:



19. Remove the oil pump.

20. Remove the oil pan.

21. Remove the oil pickup assembly.

22. Remove the structural pump.

23. Following the procedure specified in the 'Generic Engine Procedures' section of your reference book, measure and record existing crankshaft end float. Write in the allowed specifications:

Min. allowable end float: ___________ **Max. allowable end float:___________**

Existing crankshaft end float: ____

INSTRUCTOR CHECK POINT 2 ____

24. Remove drive plate AFTER removing special tool 303-645. Do NOT use 303-645 to hold the crankshaft while removing the drive plate.

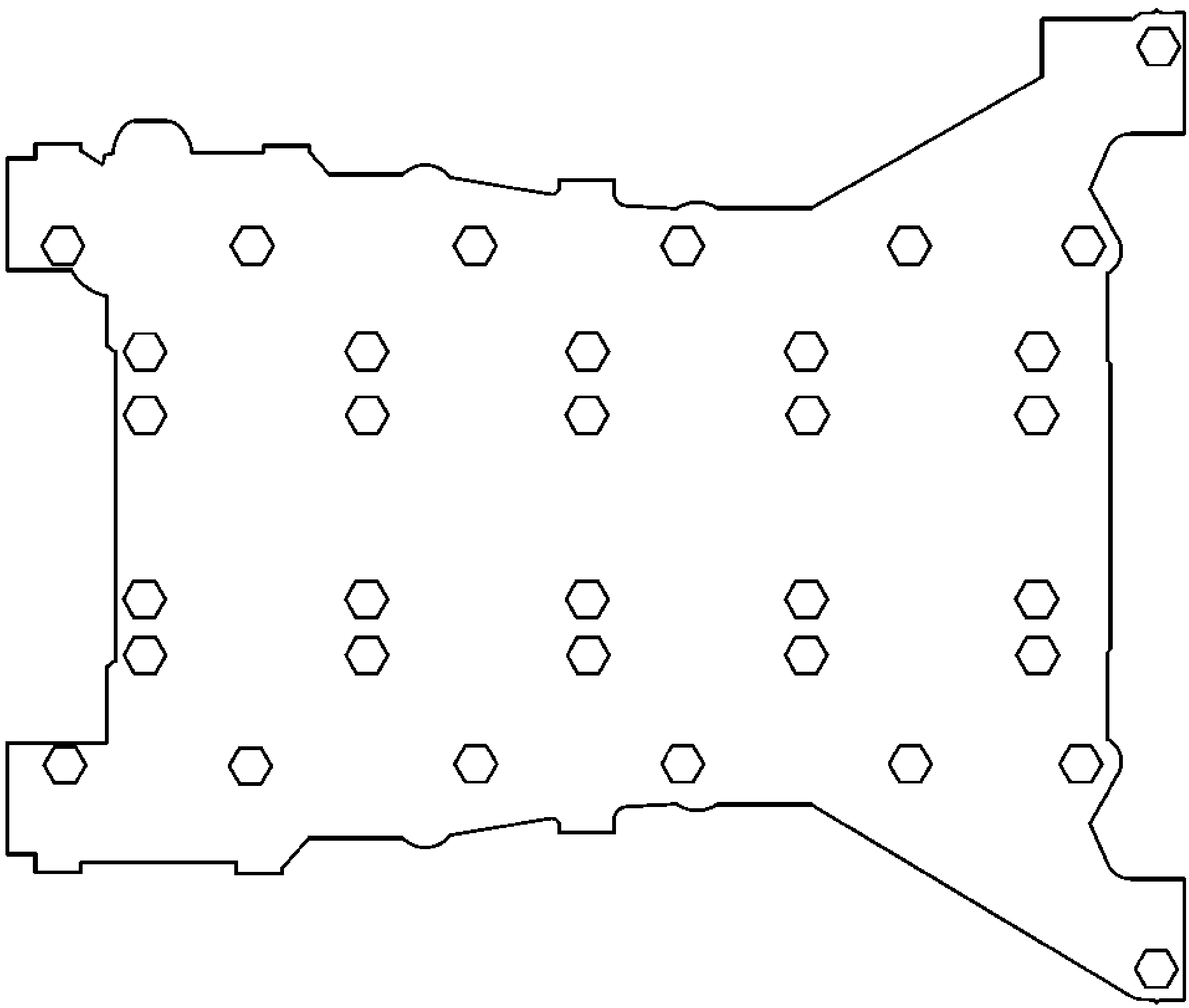
25. Remove the rear crankshaft oil seal using the procedure 303-01B-9 for Rear Main Seal found in the reference manual, and tool 303-538.

26. Remove the bed plate.

Where are the bed plate / cylinder block separation lugs located? ________________

____

27. **Write in the bedplate removal torque sequence:**



28. Observe the connecting rod and piston assembly orientation.

What position on the crankshaft journals are the connecting rods?

A bank connecting rods: Front of journal________ Rear of journal_________

B bank connecting rods: Front of journal________ Rear of journal_________

29. Remove the connecting rod and piston assemblies.

What special tools are required? ____

30. Identify and record connecting rod / piston assembly markings.

Cyl.	**Rod Matching number**	**Rod thick flange direction (Front or Rear)**	**Wrist pin offset direction (Intake or Exhaust)**	**Piston direction arrow (Front or Rear)**
A1				
A2				
A3				
A4				
B1				
B2				
B3				
B4				

INSTRUCTOR CHECK POINT 3 ____

31. Remove crankshaft.

    NOTE: Be careful of bearing surfaces.

32. Measure and record crankshaft journal diameters.

Crankshaft journal	Diameter
Main bearing number 1	______________
Main bearing number 2	______________
Main bearing number 3	______________
Main bearing number 4	______________
Main bearing number 5	______________
Connecting rod journal cyls. 1	______________
Connecting rod journal cyls. 2	______________
Connecting rod journal cyls. 3	______________
Connecting rod journal cyls. 4	______________

INSTRUCTOR CHECK POINT 4 ______________________________

33. Prepare to select main bearing and connecting rod bearings by copying bearing codes recorded in step 1 of this worksheet.

Crankshaft Main Bearing Journal Codes: 1 _____ 2_____ 3_____ 4_____ 5_____

Crankshaft Main Bearing Bore Codes: 1 _____ 2_____ 3_____ 4_____ 5_____

34. Using the bearing selection chart found in your course book, record selected bearing color codes.

Crankshaft journal	Bearing color (top)	Bearing color (Bottom)
Main bearing number 1	____________________	____________________
Main bearing number 2	____________________	____________________
Main bearing number 3	____________________	____________________
Main bearing number 4	____________________	____________________
Main bearing number 5	____________________	____________________
Connecting rod bearings cyls. 1	____________________	
Connecting rod bearings cyls. 2	____________________	
Connecting rod bearings cyls. 3	____________________	
Connecting rod bearings cyls. 4	____________________	

35. Install bearings in block.

Which main bearings fit to the block? ____

36. **What is the allowed range for crankshaft main bearing oil clearance?**

Min. allowable clearance: ________________ Max. allowable clearance:___________

37. Using the Plastigage procedure 303-00-11 documented in the 'Generic Procedures' section of your reference book, measure and record main bearing oil clearances.

Crankshaft journal	Oil clearance
Main bearing journal number 1	_____________________________
Main bearing journal number 2	_____________________________
Main bearing journal number 3	_____________________________
Main bearing journal number 4	_____________________________
Main bearing journal number 5	_____________________________

38. **What is the allowed range for piston-to-cylinder clearance?**

Min. allowable clearance: ___________ Max. allowable clearance:___________

39. **Measure and record diameter of piston B1** _____________________________

40. **Measure and record diameter of cylinder B1** _____________________________

What is the piston-to-cylinder clearance? _____________________________

41. **What is the allowed range for connecting rod bearing clearance?**

Min. allowable clearance: __________ **Max. allowable clearance:__________**

42. Measure and record connecting rod bearing oil clearances at each connecting rod.

Crankshaft journal	Oil clearances
Number 1 connecting rod journals	______________________________
Number 2 connecting rod journals	______________________________
Number 3 connecting rod journals	______________________________
Number 4 connecting rod journals	______________________________
Number 5 connecting rod journals	______________________________
Number 6 connecting rod journals	______________________________
Number 7 connecting rod journals	______________________________
Number 8 connecting rod journals	______________________________

INSTRUCTOR CHECK POINT 5 ____

43. Apply 4 drops of EP90 to each con rod bearing, and install piston / connecting rod assemblies.

Which direction should the arrow on the piston face? ____________________________

What is the connecting rod assembly direction?

A bank: ____

B bank: ____

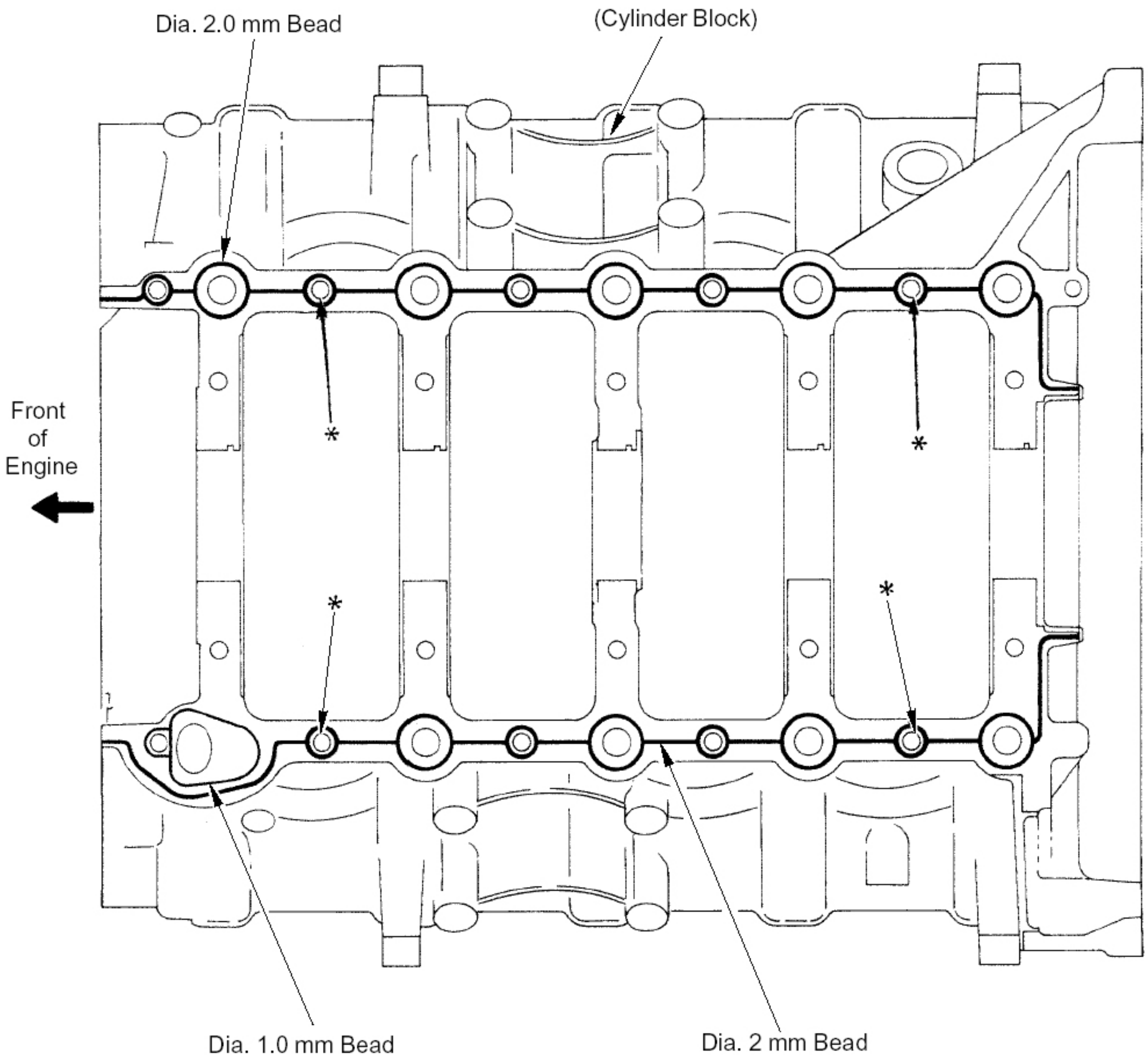
What special tools are required to protect the cylinder bores during piston assembly installation? ___________-__________

What is the rod torque specification? ____

Which bolts must not be reused? ____

44. Prepare to assemble the bed plate to the block by applying a bead of RTV sealant to the block, as shown in the diagram. Do NOT continue until your instructor has signed off within the 20 minute cure window.

NOTE: * Joint must be closed and peripheral bolts marked by - * snugged down to a torque of 7-9 Nm within 7 minutes of starting to apply sealant. All bolts must be tightened to the relevant procedure and Crankshaft Rear Seal fitted within 20 minutes of starting to apply sealant.

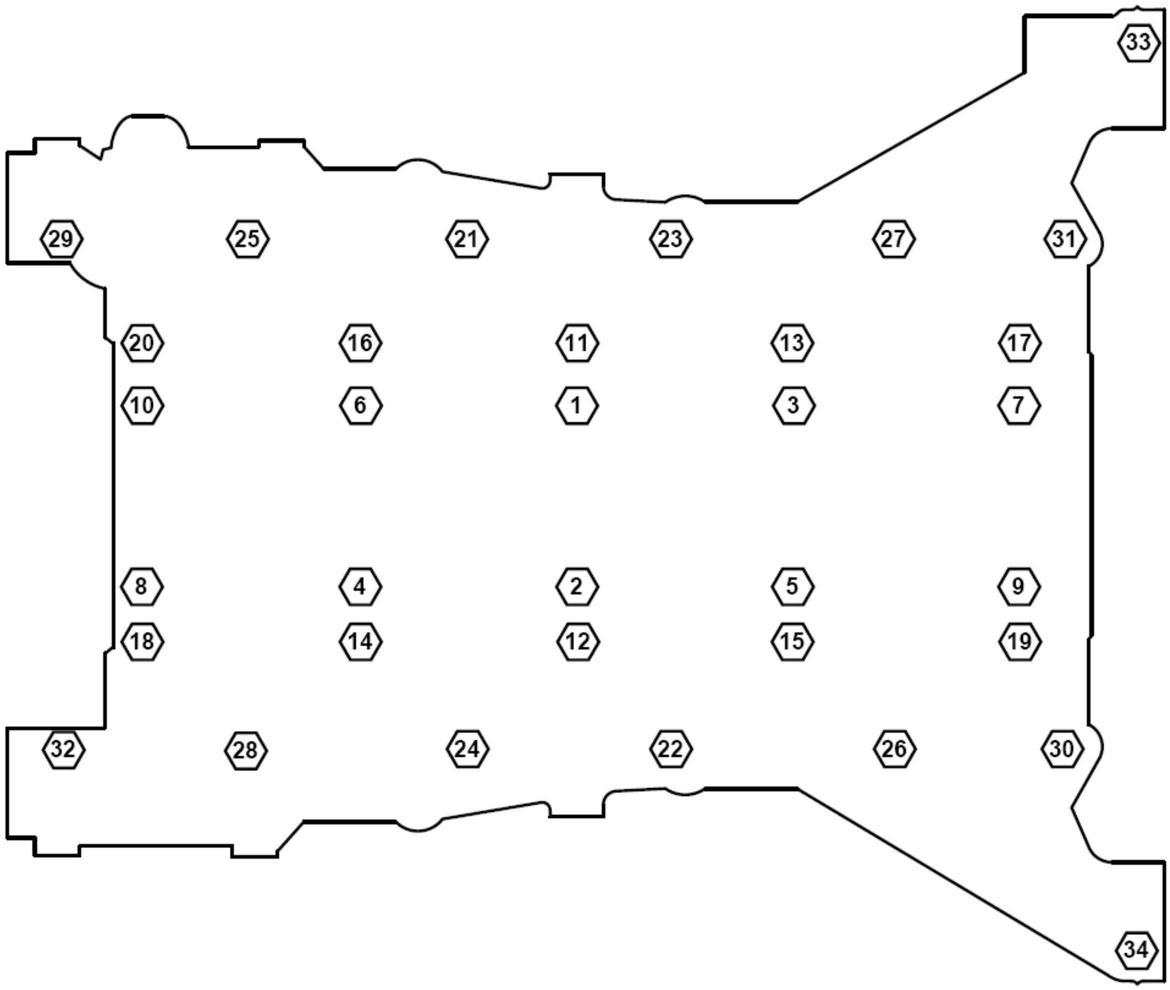


INSTRUCTOR CHECK POINT 6 ____

45. Apply 2 drops of EP90 to each crankshaft bearing shell. Assemble block, crankshaft bearings, thrust washer and bed plate.

NOTE: Install new bedplate bolts in all locations.

Write in the bed plate torque specifications.



Step 1 – Bolts 21 to 32 torque to ____________________________

Step 2 – Bolts 33 to 34 torque to ____________________________

Step 3 – Bolts 1 to 10 torque to ____________________________

Step 4 – Bolts 11 to 20 torque to ____________________________

Step 5 – Bolts 1 to 10 torque to ____________________________

Step 6 – Bolts 11 to 20 torque to ____________________________

Step 7 – Bolts 21 to 32 torque to ____________________________

Step 8 – Bolts 33 to 34 torque to ____________________________

46. Measure and record crankshaft end float and the rotate the crankshaft. The end float procedure can be found in the 'Generic Procedures' section of your reference book. Write in the allowed specifications:

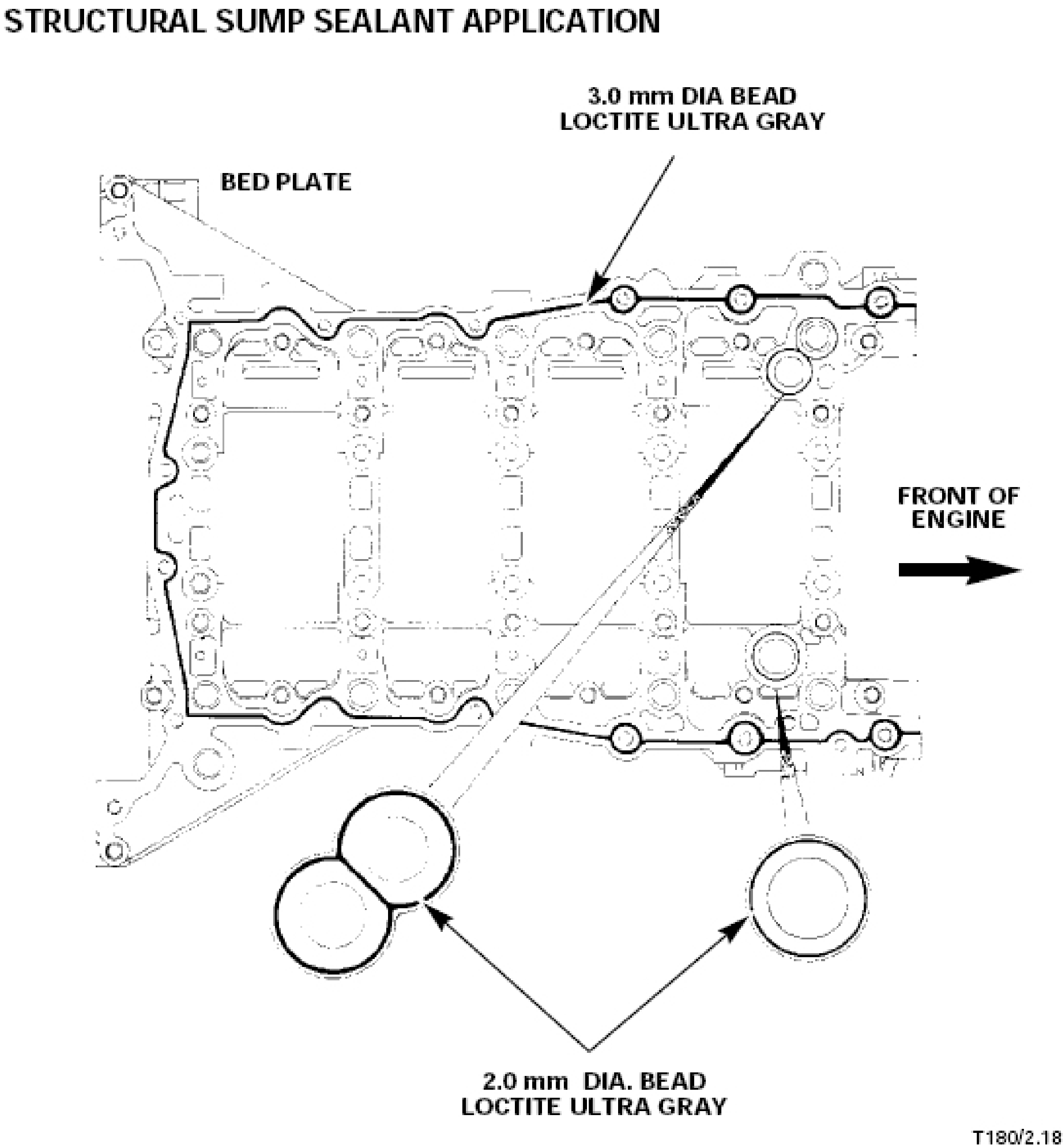
Min. allowable end float: ___________ **Max. allowable end float:___________**

Crankshaft end float measurement: ___________________________

Does the crankshaft turn smoothly? ___________________________

INSTRUCTOR CHECK POINT 7 ____

47. Apply RTV. **Do NOT continue** until your instructor has signed off within the 20 minute cure window.



INSTRUCTOR CHECK POINT 8 ____

48. Assemble and install the structural sump.

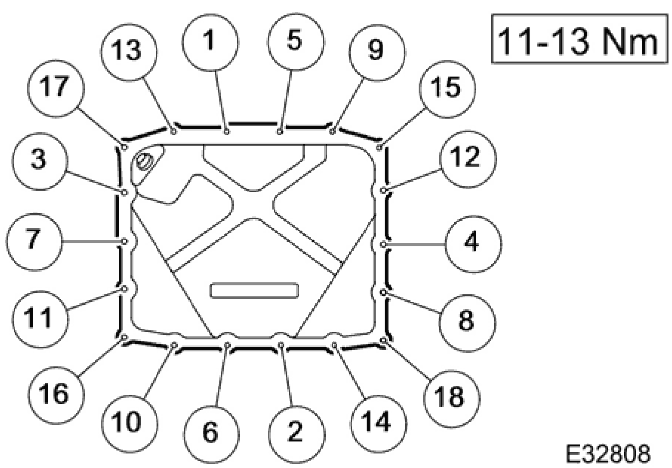
49. If supercharged, apply Vaseline to a new diverter valve o-ring and install the oil diverter valve.

50. Install oil pump and rear oil seal.

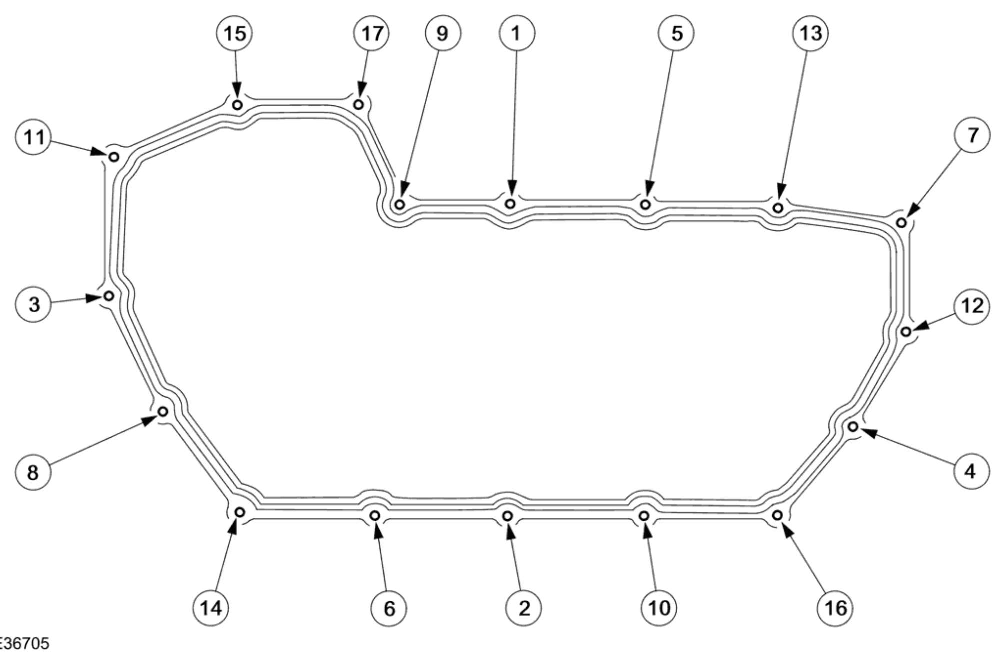
What special tools are required? ________________________________

51. Install oil pan. Follow the torque sequence shown below:

AJ26/AJ27 Upper Oil Pan



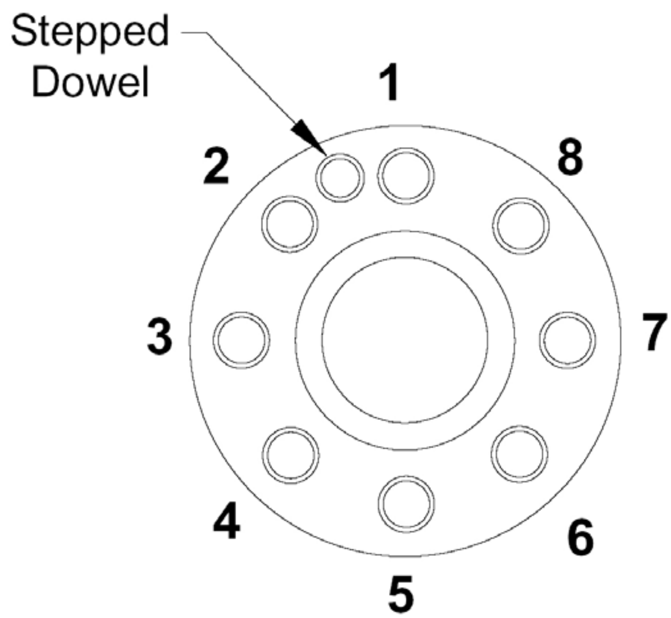
AJ28 Upper Oil Pan



52. Install drive plate using the following torque sequence:

Step 1: Tighten bolts to 14 - 16 Nm in order 1, 5, 3, 7, 2, 6, 4, 8

Step 2: Tighten bolts to 95 – 125 Nm in order 1, 5, 3, 7, 2, 6, 4, 8



End view of crankshaft
bolt numbering

INSTRUCTOR CHECK POINT 8 ____

53. Remove one intake and one exhaust valve.

What is the maximum valve spring free length specification? ________________

What is the existing valve spring measurement? ______________________

54. Inspect and reassemble cylinder heads.

List any head problems found with the cylinder heads. ______________________

____

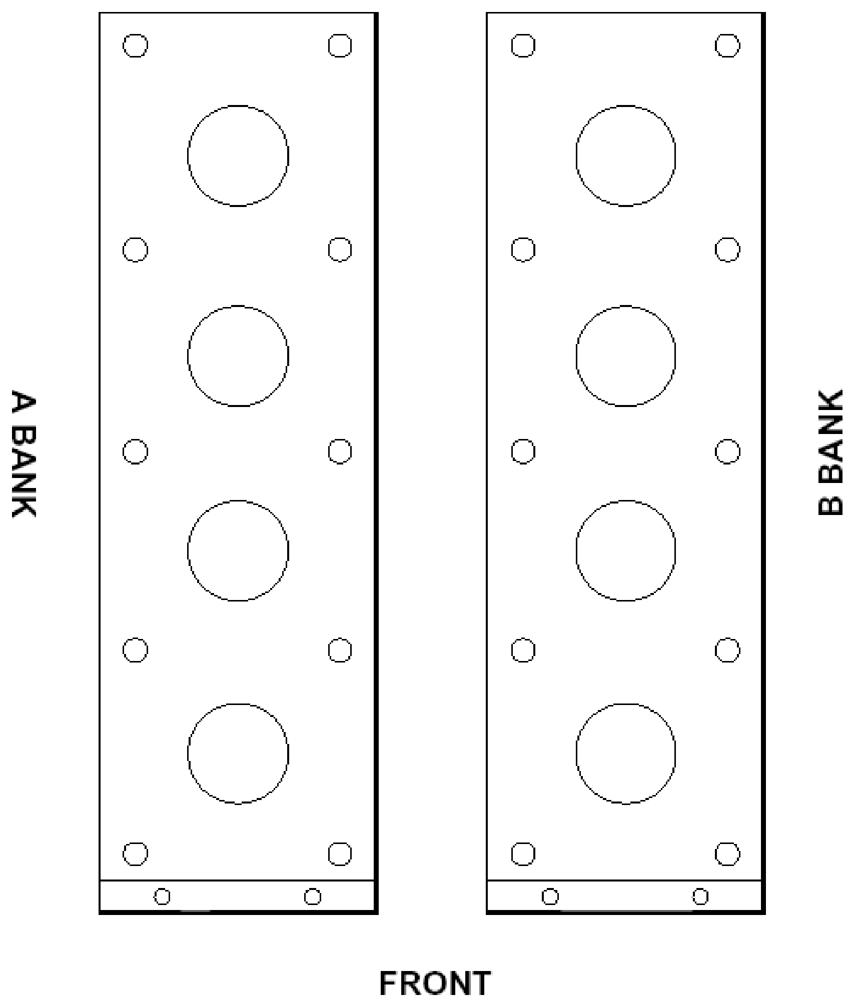
What is the difference between head gaskets for NA and SC engines?

____

55. Install cylinder heads.

Note: Do not re-use cylinder head bolts.

Write in the cylinder head torque sequence:



56. Inspect and install valve gear and camshafts. Use the camshaft procedure from the 'In Vehicle Repair' section of your reference guide for detailed assembly instructions.

What is the crankshaft position before camshaft installation?____________________

Apply EP90 lubricant on the following components before assembly:

- Valve lifters
- Valve adjusting shims
- Camshaft lobes
- Camshaft lower bearings
- Camshaft bearing cap

57. Install secondary tensioners.

What is the installed position of the chain tensioners?

Bank	**Check the correct installation position**	
A bank	**Piston up _____**	**Piston down _____**
B bank	**Piston up _____**	**Piston down _____**

58. Install primary chain guide rails, tensioners and blades.

INSTRUCTOR CHECK POINT 9 ____

59. Install chain and sprocket assemblies.

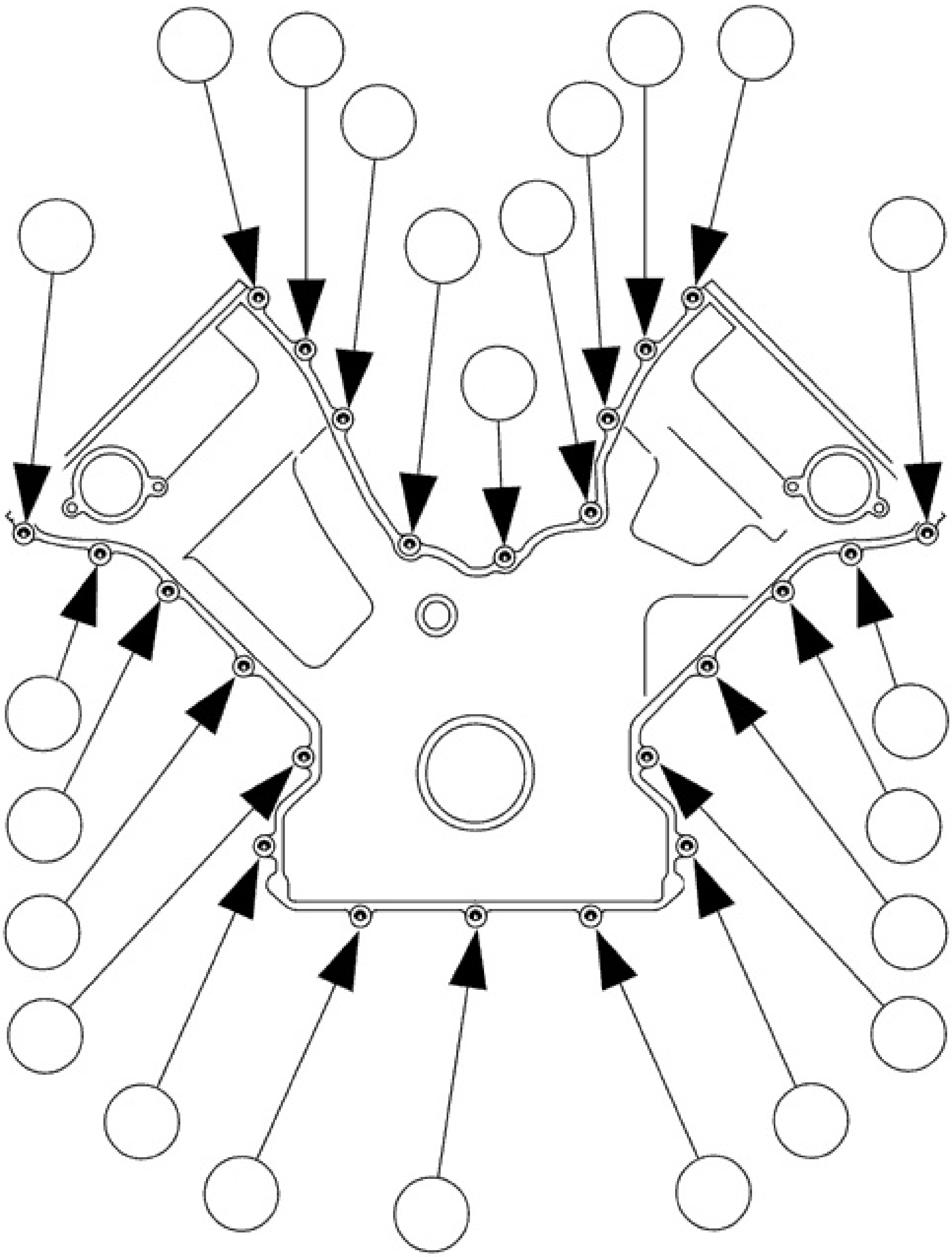
60. Time camshafts.

61. Install bush carriers

INSTRUCTOR CHECK POINT 10 ____

62. Install timing cover.

Write in the timing cover torque sequence



63. Copy the accepted valve clearance ranges from step 9 of this worksheet:

Intake Max.	Intake Min.	Exhaust Max.	Exhaust Min.
________	________	__________	_________

64. Rotate engine assembly at least three times. Measure and record valve clearances.

Cyl.	Intake Front	Intake Rear	Exhaust Front	Exhaust Rear
A1				
A2				
A3				
A4				
B1				
B2				
B3				
B4				

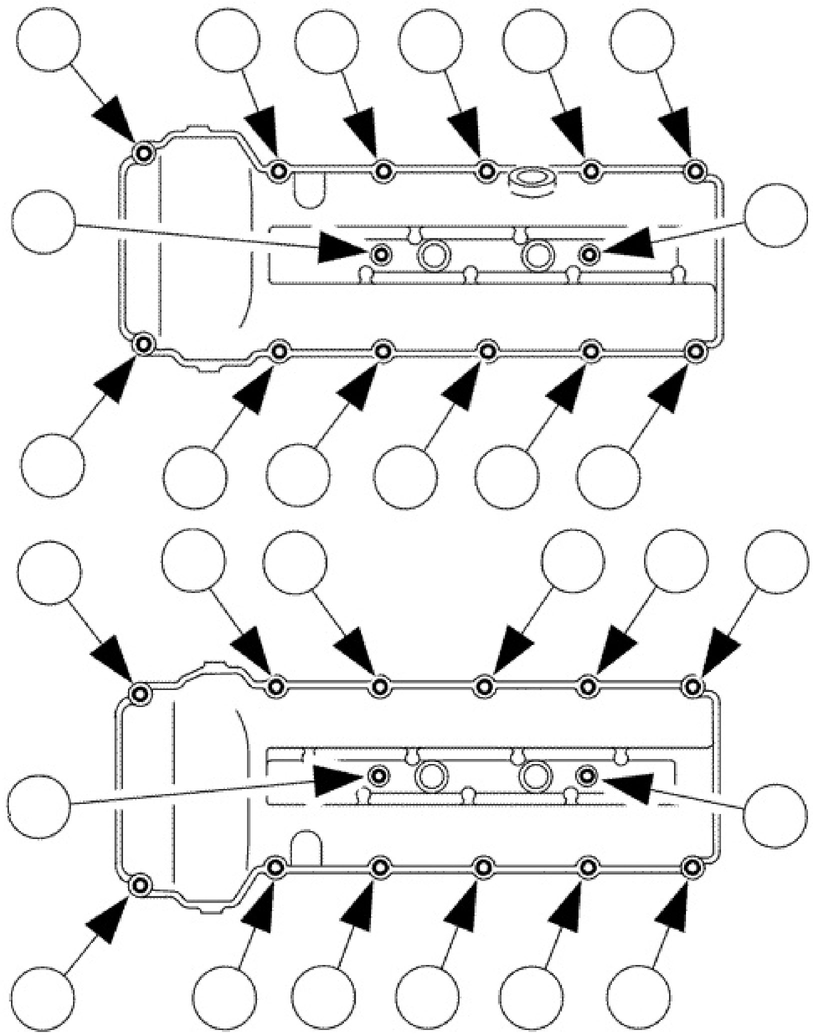
If valve clearances required readjustment, adjust, rotate engine at least three times and remeasure clearances. Record final valve clearances.

Cyl.	Intake Front	Intake Rear	Exhaust Front	Exhaust Rear
A1				
A2				
A3				
A4				
B1				
B2				
B3				
B4				

INSTRUCTOR CHECK POINT 11____

65. Install camshaft covers, spark plugs and coils.

Write in the camshaft cover torque sequence.



66. Install coolant pump, thermostat housing and outlet pipes.

67. Install intake and exhaust manifold assemblies.

68. Continue to assemble the engine in the order outlined in the workshop manual. Notify your instructor for the final checkpoint when complete.

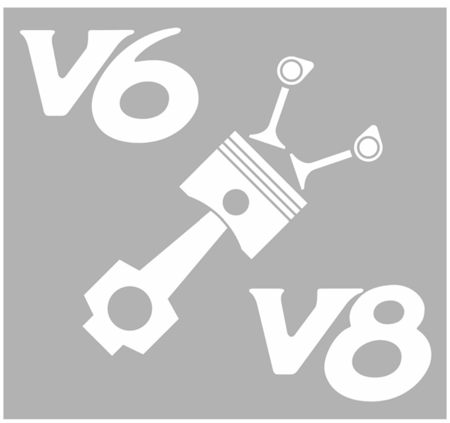
INSTRUCTOR CHECK POINT 12 ____

If your instructor signed off on checkpoint 12, then:

Congratulations – you have completed the assembly of the AJ27/28 engine.

TRAINING PROGRAM

JAGUAR V6/V8 ENGINE REPAIR



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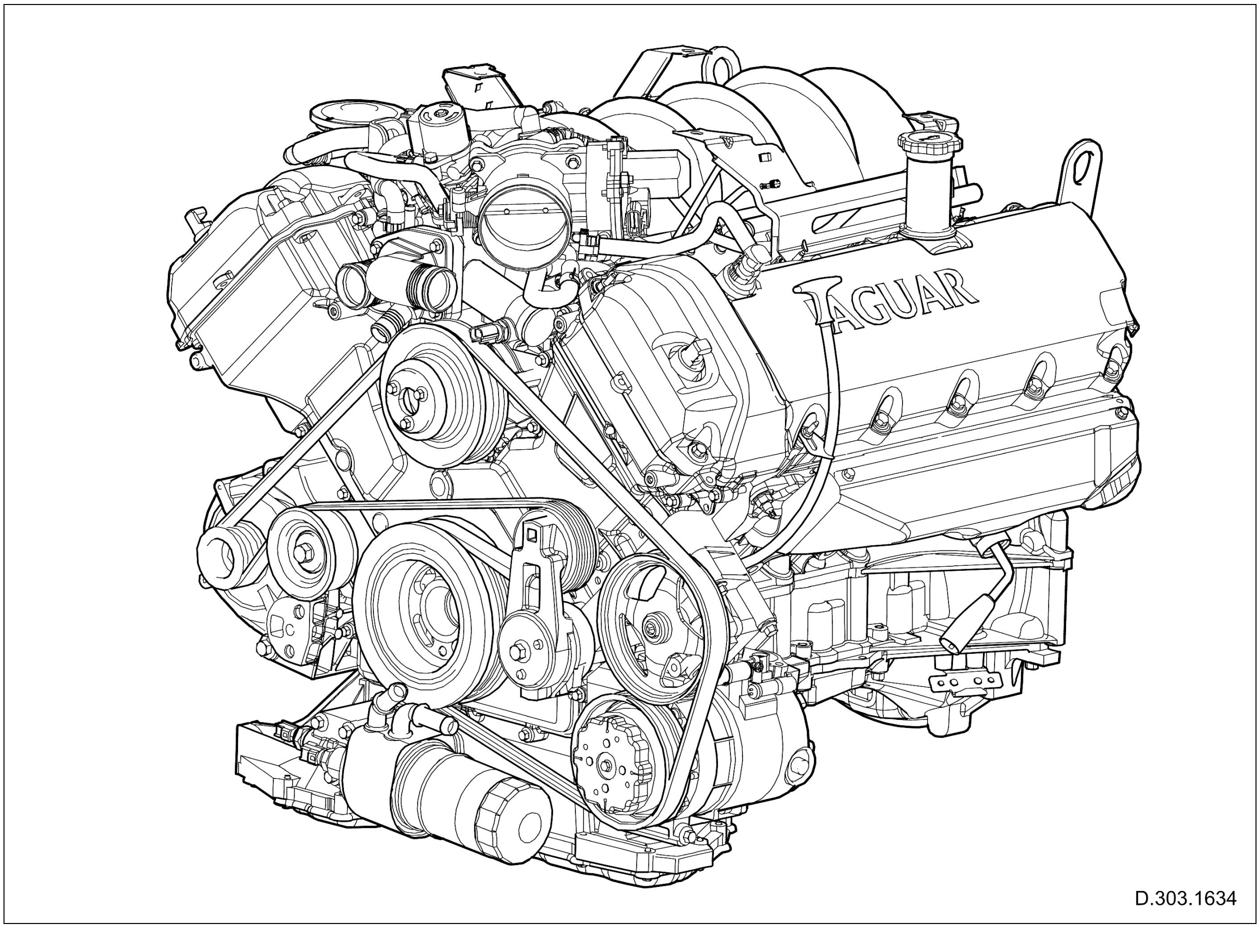


Fig. 130 AJ33

Student______________________________________ Date_____________

168
AJ33 / AJ34 Engines

Directions:
- Complete each step in sequence, following your workshop manual reference book. Fill in all blanks.
- When you reach an INSTRUCTOR CHECKPOINT, call your instructor who will examine your work and issue further instructions. **Do not** continue past an INSTRUCTOR CHECKPOINT unless instructed.
- Ask your instructor for assistance if needed.

1. Locate and record the following engine codes:

   (*Refer to your student guide for locations and definitions)*

   Engine Number: ____

   Crankshaft Main Bearing Journal Codes: 1 _____ 2_____ 3_____ 4_____ 5_____

   Crankshaft Connecting Rod Journal Codes: 1 _____ 2_____ 3_____ 4_____

   Cylinder Bore / Piston Grade Codes:

   Bank 2: 1 _____ 2_____ 3_____ 4_____

   Bank 1: 1 _____ 2_____ 3_____ 4_____

   Crankshaft Main Bearing Bore Codes: 1 _____ 2_____ 3_____ 4_____ 5_____

2. Following the procedures documented in your workshop manual, remove:

   - Ignition coil covers, coils, spark plugs, intake manifold assembly and harnesses
   - Exhaust manifolds
   - Coolant outlet pipe and thermostat housing assembly
   - Drive belt and water pump

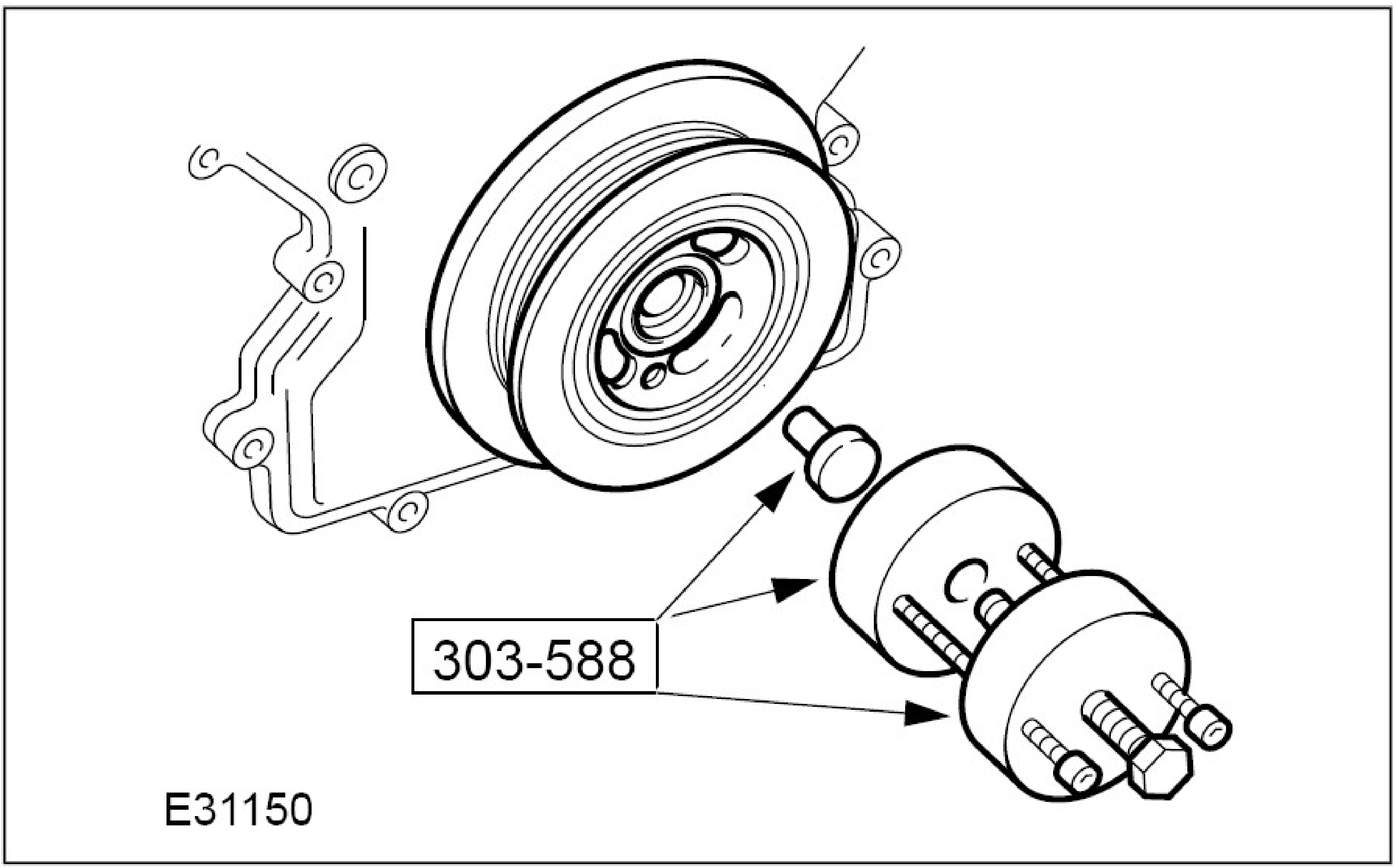
NOTE: *Throughout the workshop manual, Bank 1 is sometimes referenced as the 'Right Bank' or as 'A Bank', and Bank 2 may be referenced as the 'Left Bank' or 'B Bank'. References to the right and left bank will always be from the perspective of the driver's seat, as if looking at the engine from inside the car.*

3. Remove the driveshaft damper bolt.

What special tools are required to hold the crankshaft?

____________________________and____________________________

4. Remove the crankshaft vibration damper using special tool 303-588.



INSTRUCTOR CHECK POINT 1 ____

5. Set the engine at 45° ATDC cylinder 1.

   What special tools are required? ____

6. Remove the camshaft covers and inspect the sealing surface.

   How many places on the cylinder head show traces of sealant application? __________

7. Check the camshaft timing and remove special tool 303-645.

8. What is the acceptable range for intake and exhaust valve clearance:

Intake Max.	**Intake Min.**	**Exhaust Max.**	**Exhaust Min.**
__________	__________	____________	___________

9. Following the technique explained in the 'General Procedures' section of your AJ33 engine workshop manual (section 303-01B-02), measure and record the existing valve clearances.

Cylinder	**Intake Front**	**Intake Rear**	**Exhaust Front**	**Exhaust Rear**
Cyl. 1	__________	__________	____________	___________
Cyl. 3	__________	__________	____________	___________
Cyl. 5	__________	__________	____________	___________
Cyl. 7	__________	__________	____________	___________
Cyl. 2	__________	__________	____________	___________
Cyl. 4	__________	__________	____________	___________
Cyl. 6	__________	__________	____________	___________
Cyl. 8	__________	__________	____________	___________

10. Following the procedure shown in the 'In-Vehicle Repair' section of your reference book, remove the crankshaft front oil seal.

    What special tools are required? ___________________________________

11. Remove the engine front cover.

12. Prepare to remove the camshaft assemblies by setting the engine to 45 deg ATDC cylinder 1, bank 1 and re-install special tool 303-645.

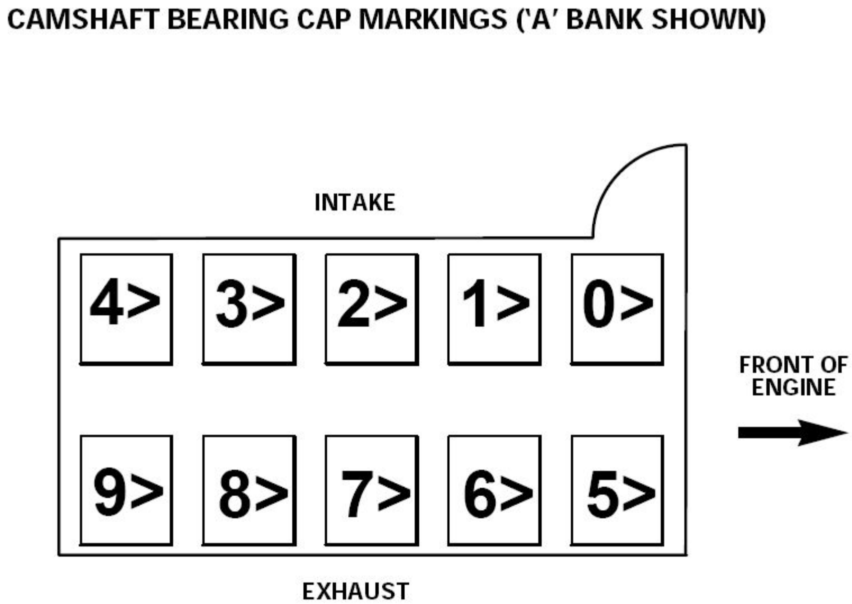
13. Remove the bank 1 and bank 2 VVT oil control unit housings.

14. Install special tool _________-__________ on both banks to properly align the camshafts for timing gear removal.

15. Remove primary chain tensioners, guides and timing chains in the order explained in your workshop manual.

16. Remove the secondary timing chain tensioner retaining bolts, and then remove the camshaft and crankshaft sprockets. Be sure to keep the right and left side assemblies identified and organized so that they can be reinstalled on the correct side.

17. Remove the camshaft bearing caps, noting markings for each location on the chart:



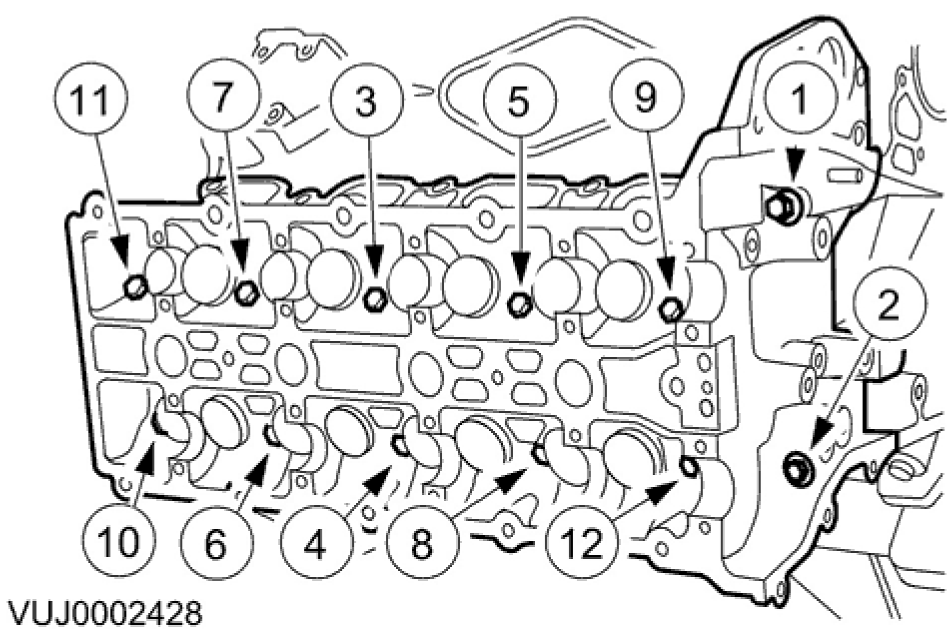
Are the camshaft bearing caps all correctly marked?

NOTE: Keep camshaft and camshaft bearing caps with their respective cylinder heads!

How can the intake camshafts be quickly identified? ____________________________

____

Remove the cylinder heads using the following cylinder head removal torque sequence:



18. Remove drive plate AFTER removing special tool 303-645. Do NOT use 303-645 to hold the crankshaft while removing the drive plate.

19. Remove the rear crankshaft oil seal using the procedure 303-01B-9 for Rear Main Seal found in the reference manual, and tool 303-538.

20. Remove the lower oil pan, strainer (pickup assembly), and upper oil pan.

21. Remove the oil pump.

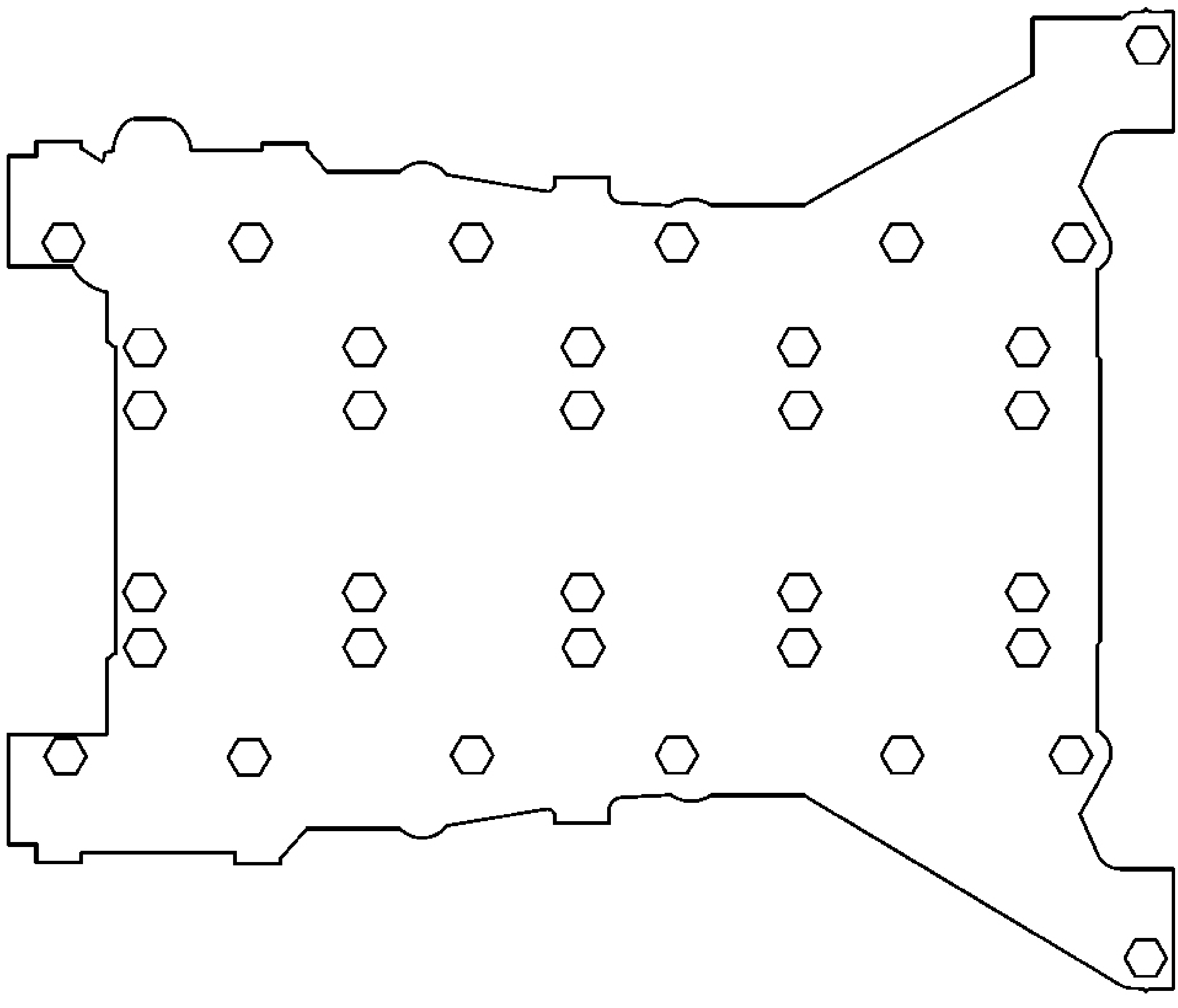
22. Following the procedure specified in the 'Generic Engine Procedures' section of your reference book, measure and record existing crankshaft end float. Write in the allowed specifications:

Min. allowable end float: ___________ **Max. allowable end float:___________**

Existing crankshaft end float: ____

INSTRUCTOR CHECK POINT 2 ____

23. What is the bedplate removal torque sequence?



24. Remove the bed plate and install special tool 303-534.

Where are the bed plate-to-cylinder block separation lugs located? ______________

____

25. Observe the connecting rod and piston assembly orientation.

In which location on the crankshaft journals are the connecting rods?

Bank 1 connecting rods: Front of journal __________ Rear of journal __________

Bank 2 connecting rods: Front of journal __________ Rear of journal __________

26. Remove the connecting rod and piston assemblies.

What special tools are required? ____

27. Identify and record connecting rod / piston assembly markings.

Cyl.	Rod Matching number	Rod thick flange direction (Front or Rear)	Wrist pin offset direction (Intake or Exhaust)	Piston direction arrow (Front or Rear)
1				
3				
5				
7				
2				
4				
6				
8				

INSTRUCTOR CHECK POINT 3 ____

28. Remove crankshaft.

NOTE: Be careful of bearing surfaces while handling the crankshaft.

29. Measure and record crankshaft journal diameters.

Crankshaft journal	Diameter
Main bearing number 1	____________________
Main bearing number 2	____________________
Main bearing number 3	____________________
Main bearing number 4	____________________
Main bearing number 5	____________________
Connecting rod journal cyls. 2/1	____________________
Connecting rod journal cyls. 4/3	____________________
Connecting rod journal cyls. 6/5	____________________
Connecting rod journal cyls. 7/8	____________________

INSTRUCTOR CHECK POINT 4 ______________________________

30. Copy the technical data recorded in step 1 of this worksheet :

Crankshaft Main Bearing Journal Codes: 1 _____ 2_____ 3_____ 4_____ 5_____

Crankshaft Connecting Rod Journal Codes: 1 _____ 2_____ 3_____ 4_____

Crankshaft Main Bearing Bore Codes: 1 _____ 2_____ 3_____ 4_____ 5_____

31. Using the technical data from above and referencing the bearing selection chart shown in the beginning of your student guide, select main bearings and connecting rod bearings. Record selected color codes, as indicated on the selection chart.

Crankshaft journal	Bearing color (top)	Bearing color (Bottom)
Main bearing number 1	____________________	____________________
Main bearing number 2	____________________	____________________
Main bearing number 3	____________________	____________________
Main bearing number 4	____________________	____________________
Main bearing number 5	____________________	____________________
Connecting rod bearings cyl.s 2/1	____________________	
Connecting rod bearings cyl.s 4/3	____________________	
Connecting rod bearings cyl.s 6/5	____________________	
Connecting rod bearings cyl.s 8/7	____________________	

32. Install bearings in block.

Which main bearings fit to the block? ____

33. What is the allowed range for crankshaft main bearing oil clearance?

Min. allowable clearance: ________________ Max. allowable clearance:___________

34. Using the Plastigage procedure 303-00-11 documented in the 'Generic Procedures' section of your reference book, measure and record main bearing oil clearances.

Crankshaft journal	Oil clearance
Main bearing journal number 1	______________________________
Main bearing journal number 2	______________________________
Main bearing journal number 3	______________________________
Main bearing journal number 4	______________________________
Main bearing journal number 5	______________________________

35. What is the allowed range for piston-to-cylinder clearance?

Min. allowable clearance: ___________ Max. allowable clearance:___________

36. Measure and record diameter of piston 2 ______________________

37. Measure and record diameter of cylinder 2 ______________________

What is the piston-to-cylinder clearance? ___________________________

38. What is the allowed range for connecting rod bearing oil clearance?

Min. allowable clearance: __________ Max. allowable clearance:__________

39. Measure and record connecting rod bearing oil clearances for each connecting rod.

Crankshaft journal	Oil clearances
Cylinder 1 connecting rod	______________________________
Cylinder 2 connecting rod	______________________________
Cylinder 3 connecting rod	______________________________
Cylinder 4 connecting rod	______________________________
Cylinder 5 connecting rod	______________________________
Cylinder 6 connecting rod	______________________________
Cylinder 7 connecting rod	______________________________
Cylinder 8 connecting rod	______________________________

40. Apply 4 drops of EP90 to each con rod bearing, and install piston / connecting rod assemblies.

Which direction should the arrow on the piston face? ____________________________

(If the arrow marking is lost, the piston grade number should always face the front of the engine)

What is the connecting rod assembly direction?

Bank 1: ____

Bank 2: ____

What special tools are required to protect the cylinder bores during piston assembly installation? ____

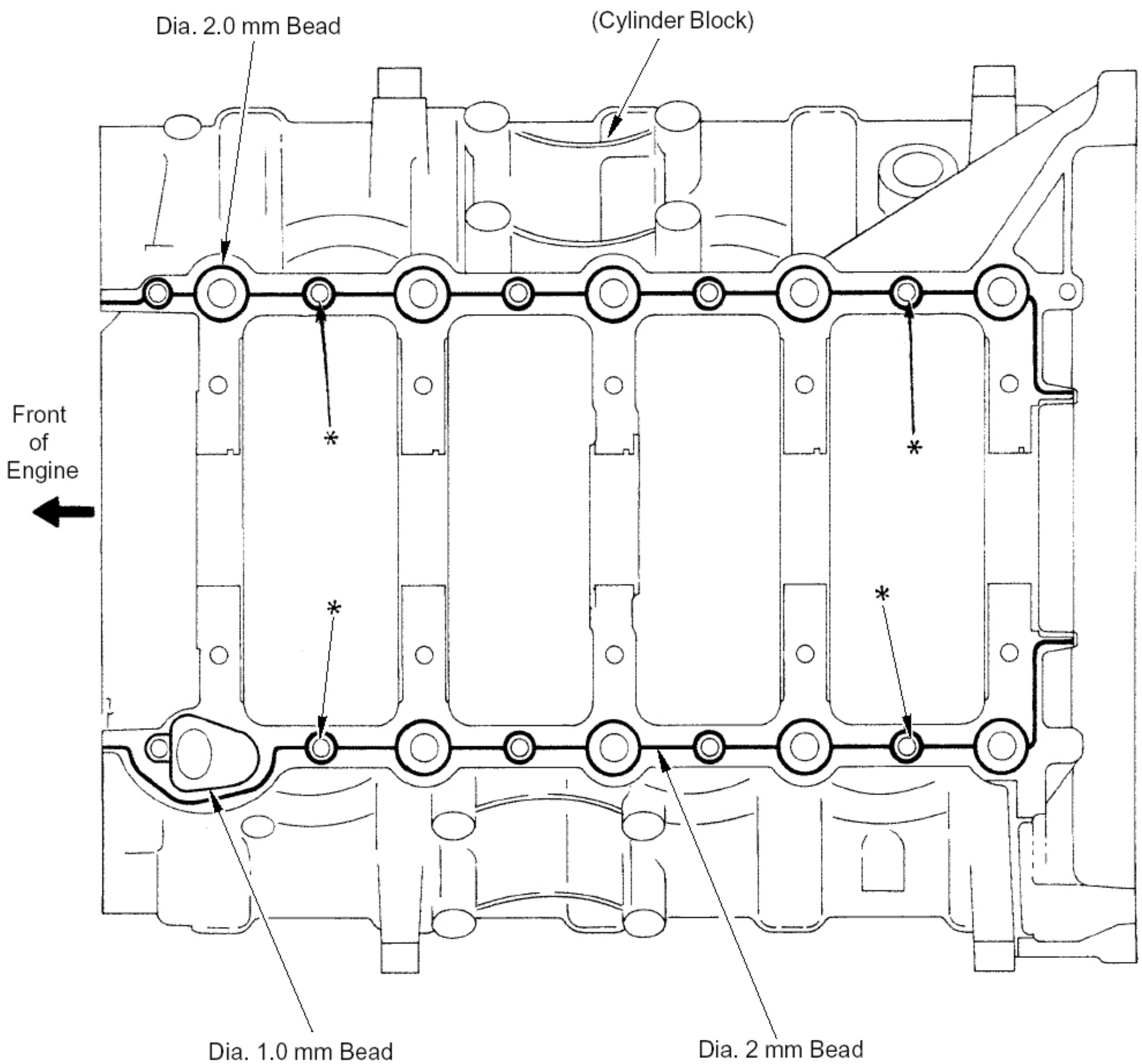
What is the rod torque specification? ____

Which bolts must not be reused? ____

INSTRUCTOR CHECK POINT 5 ____

41. Prepare to assemble the bed plate to the block by applying a bead of RTV sealant to the block, as shown in the diagram. **Do NOT continue** until your instructor has signed off within the 20 minute cure window.

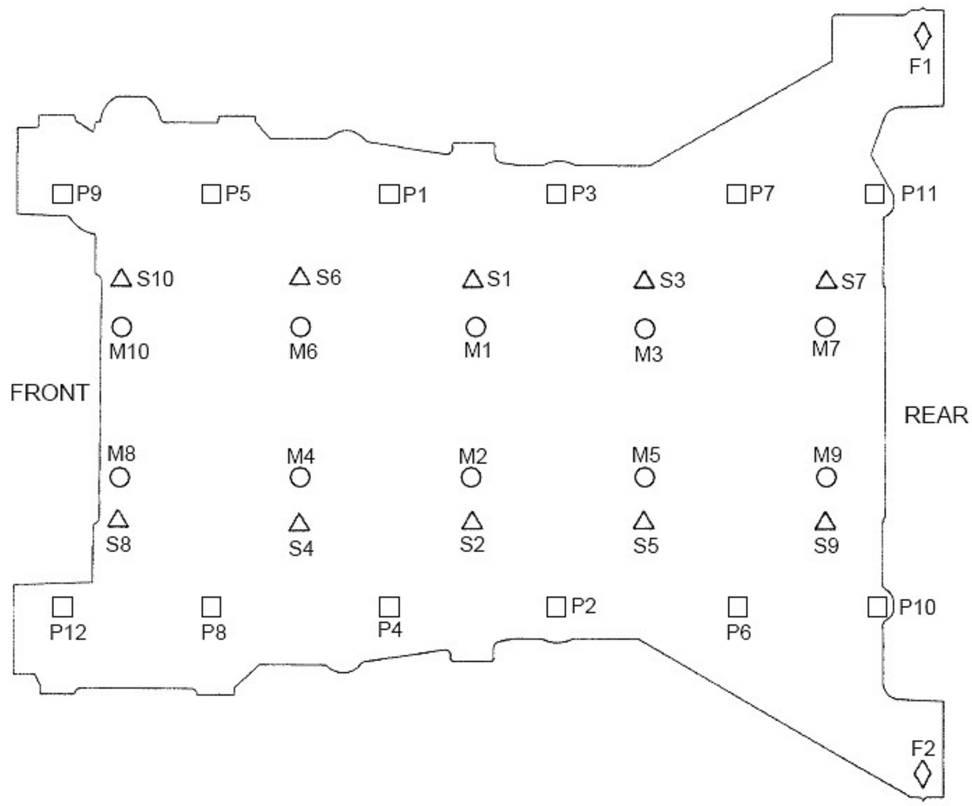
NOTE: * Joint must be closed and peripheral bolts marked by ' * ' snugged down to a torque of 7-9 Nm within 7 minutes of starting to apply sealant.. All bolts must be tightened to the relevant procedure and the Crankshaft Rear Seal fitted within 20 minutes of starting to apply sealant.



INSTRUCTOR CHECK POINT 6 ____

42. Apply 2 drops of EP90 to each crankshaft bearing shell. Assemble block, crankshaft bearings, thrust washer and bed plate.

NOTE: Install new bedplate bolts in all locations.



Write in the bed plate torque specifications.

Step 1 – "P" bolts torque to ______________________________

Step 2 – "F" bolts torque to ______________________________

Step 3 – "M" bolts torque to ______________________________

Step 4 – "S" bolts torque to ______________________________

Step 5 – "M" bolts torque to ______________________________

Step 6 – "S" bolts torque to ______________________________

Step 7 – "P" bolts torque to ______________________________

Step 8 – "F" bolts torque to ______________________________

43. Measure and record crankshaft end float and then rotate the crankshaft. The end float procedure can be found in the 'Generic Procedures' section of your reference book. Write in the allowed specifications:

Min. allowable end float: ___________ **Max. allowable end float:___________**

Crankshaft end float measurement: _____________________

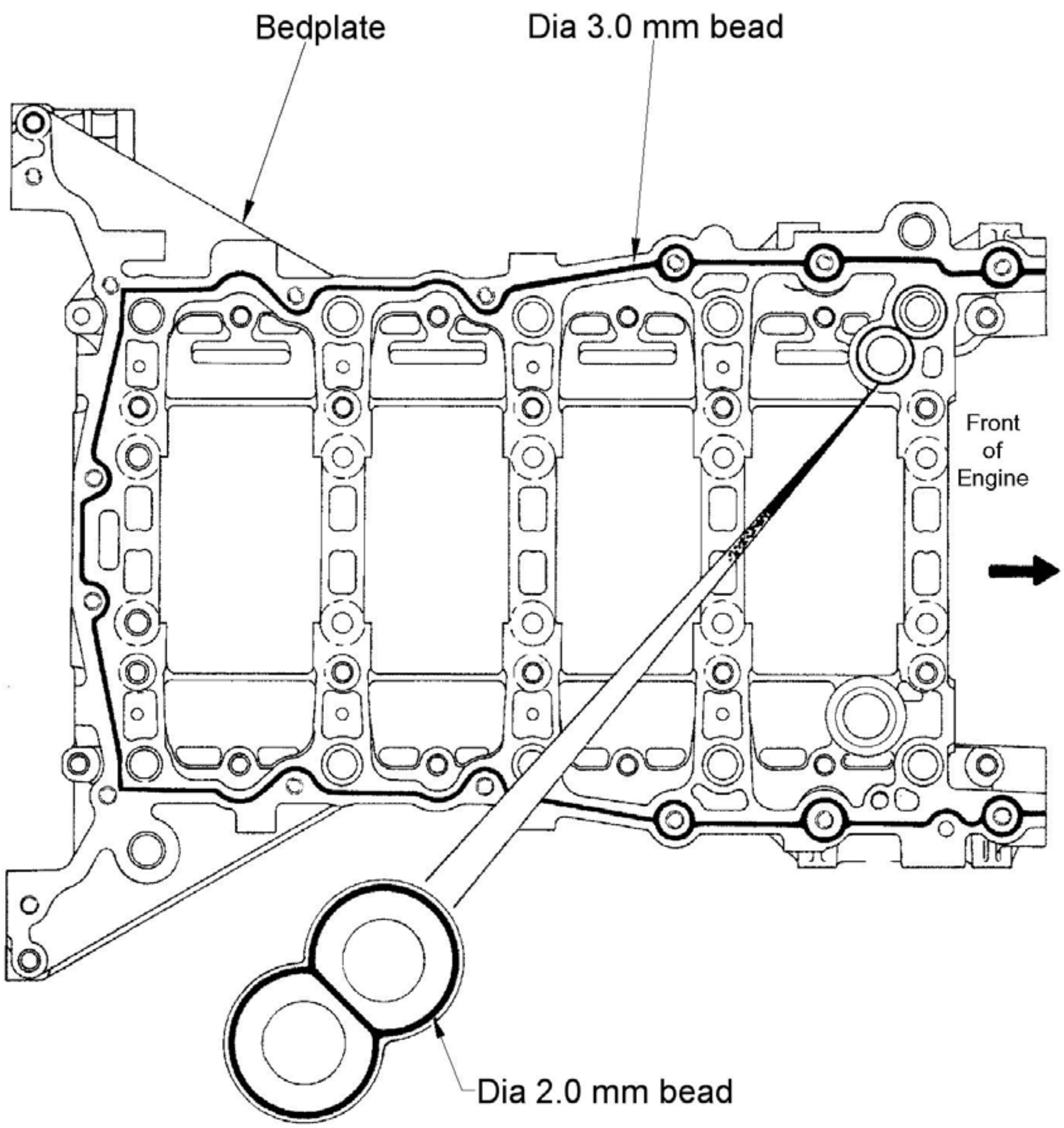
Does the crankshaft turn smoothly? _____________________

INSTRUCTOR CHECK POINT 7 ____

44. Install rear oil seal. What special tool is required? ________________________

45. Install the oil pump.

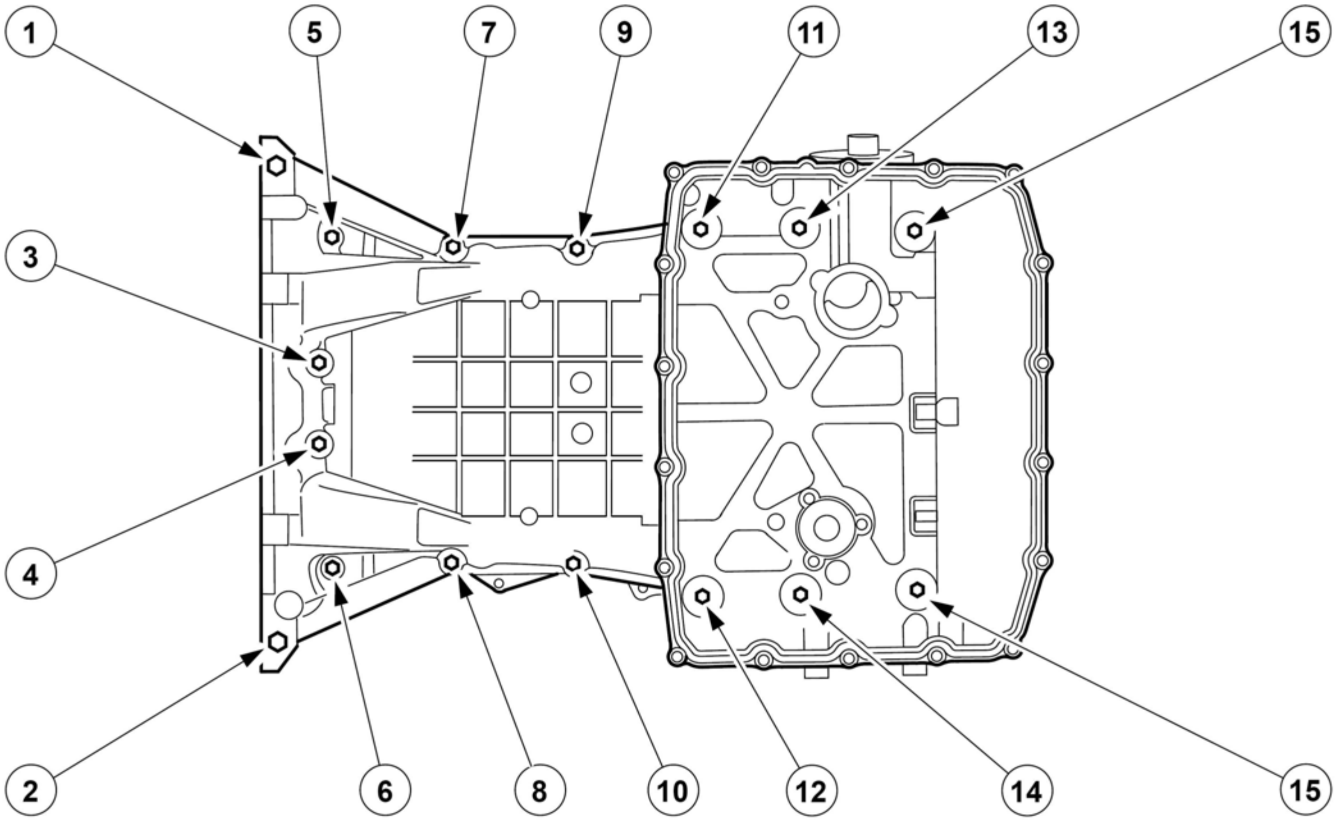
46. Apply RTV as shown below Do NOT continue until your instructor has signed off within the 20 minute cure window.



INSTRUCTOR CHECK POINT 8 ____

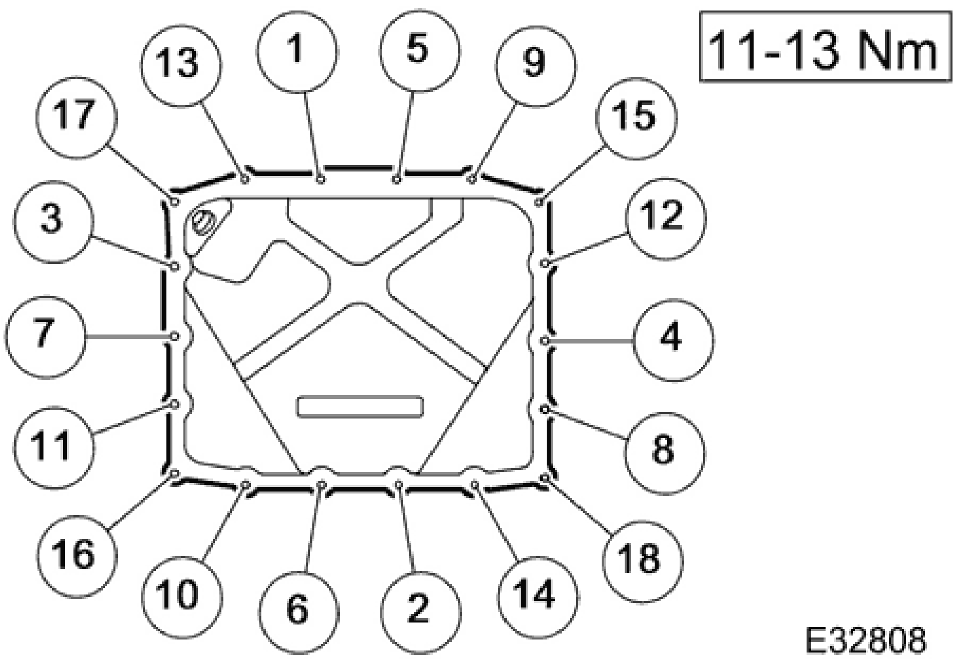
47. Install a new oil pickup tube o-ring seal and pickup tube (oil strainer).

48. Torque the structural sump (upper oil pan) bolts to 21 NM. The following torque sequence is recommended:

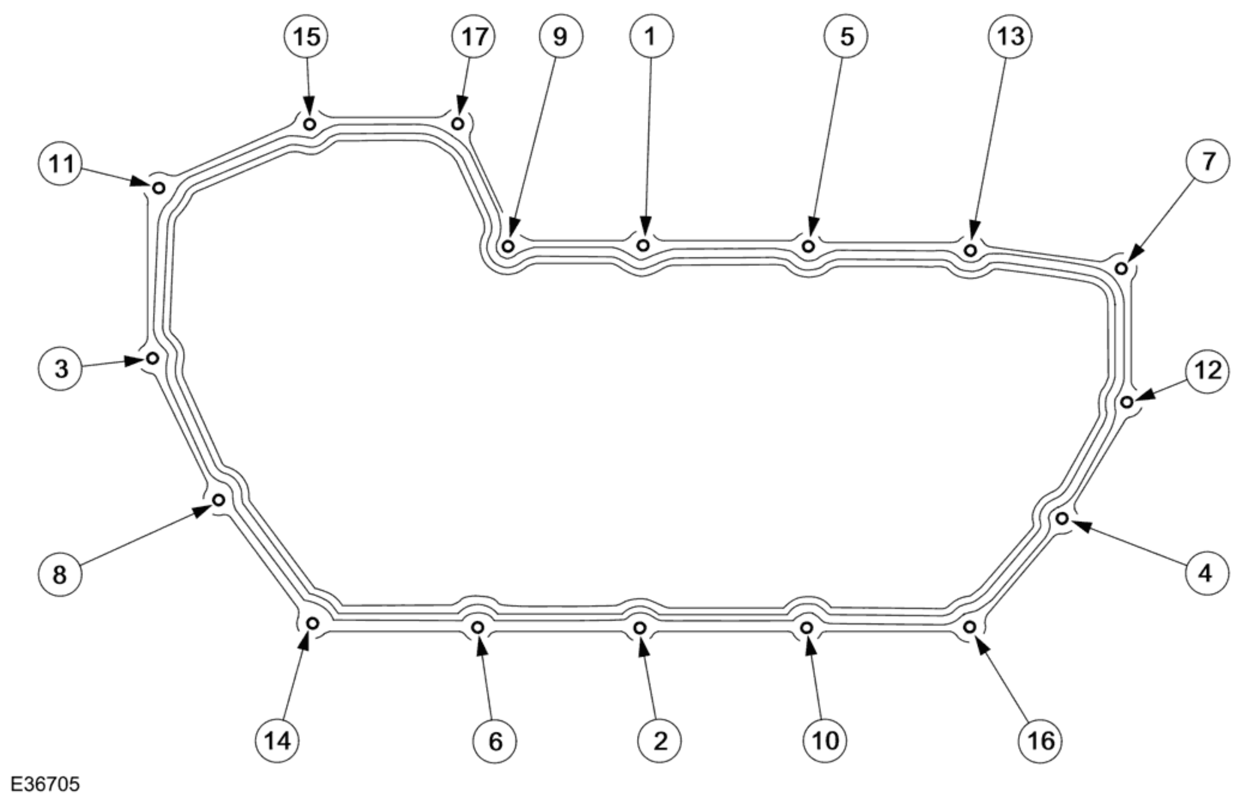


49. Install the upper oil pan. Follow the torque sequence shown below:

AJ34 Upper Oil Pan



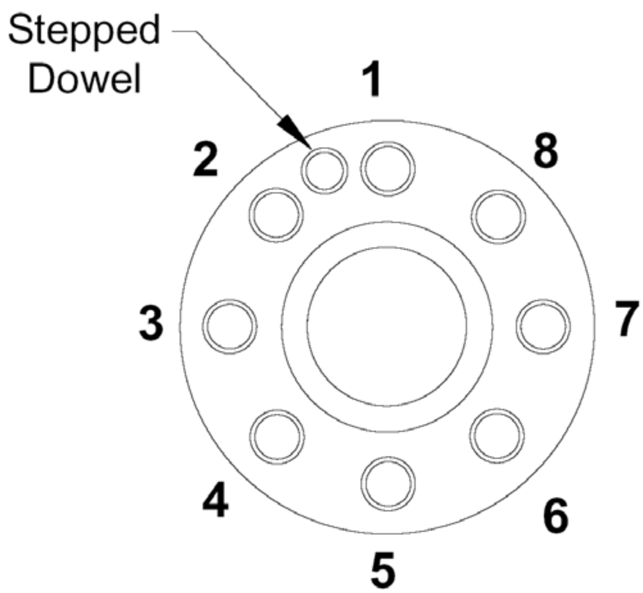
AJ33 Upper Oil Pan



50. Install drive plate using the following torque sequence:

Step 1: Tighten bolts to 14 - 16 Nm in order 1, 5, 3, 7, 2, 6, 4, 8

Step 2: Tighten bolts to 95 – 125 Nm in order 1, 5, 3, 7, 2, 6, 4, 8



End view of crankshaft bolt numbering

INSTRUCTOR CHECK POINT 9 ____

51. Remove one intake and one exhaust valve.

What is the maximum valve spring free length specification? ______________________

What is the existing valve spring measurement? __________________________________

52. Inspect and reassemble cylinder heads.

List any head problems found with the cylinder heads. _______________________

____

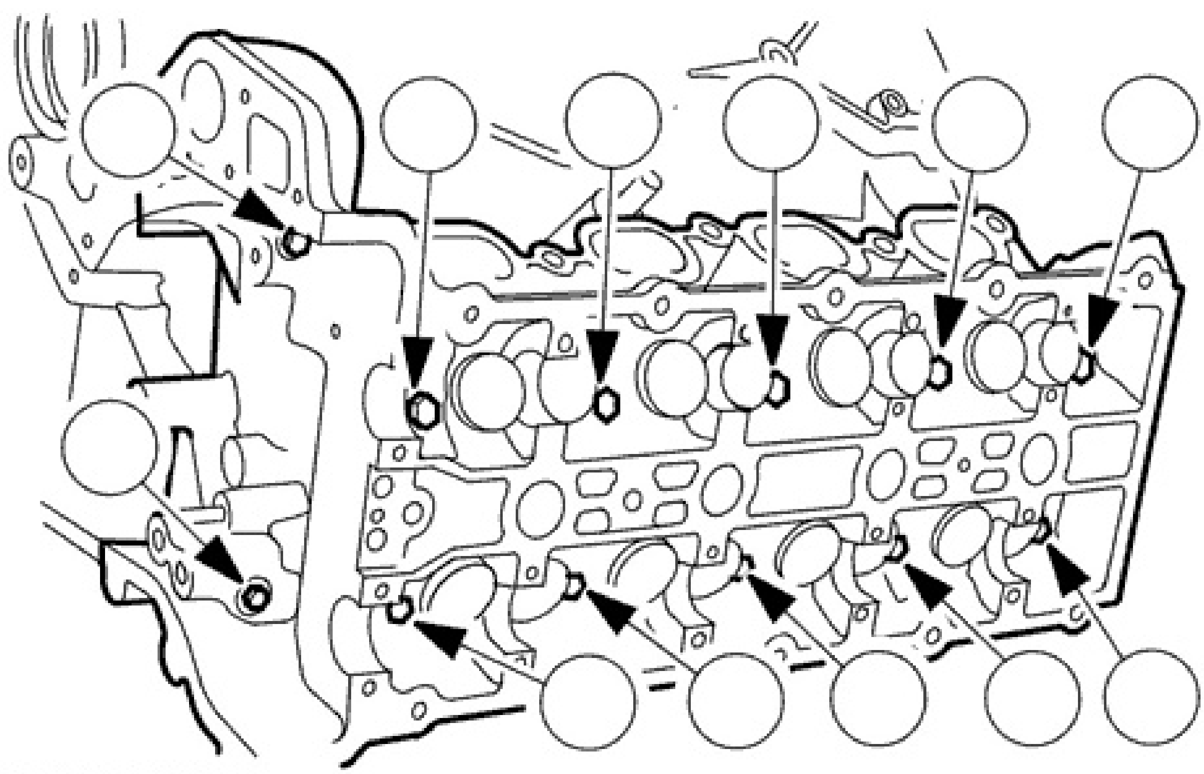
What is the difference between head gaskets for NA and SC engines? _________

____

53. Install cylinder heads.

Note: Do not re-use cylinder head bolts.

Write in the cylinder head torque sequence:



VUJ0002452

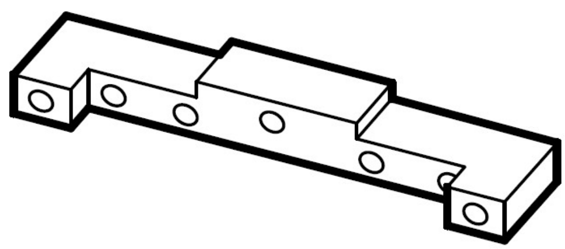
54. Set the engine at 45° ATDC cylinder 1, and install special tool 303-645.

55. Inspect and install valve gear and camshafts. Continue using the "AJ33 Engine Assembly" section of your reference guide for detailed assembly instructions.

Apply EP90 lubricant on the following components before assembly:

- Valve lifters
- Valve adjusting shims
- Camshaft lobes
- Camshaft lower bearings
- Camshaft bearing caps

56. Orient camshafts on both banks with special tool 303-530:



57. Install secondary tensioners.

What is the installed position of the chain tensioners?

Bank	**Check the correct installation position**	
Bank 1	Piston pointing up _____	Piston pointing down _____
Bank 2	Piston pointing up _____	Piston pointing down _____

58. Install primary chain guides and tensioners.

INSTRUCTOR CHECK POINT 10 ____

59. Following the procedure defined in the Engine Assembly section for the AJ33/34, install chain and sprocket assemblies.

60. Time camshafts.

61. Install bush carrier assemblies.

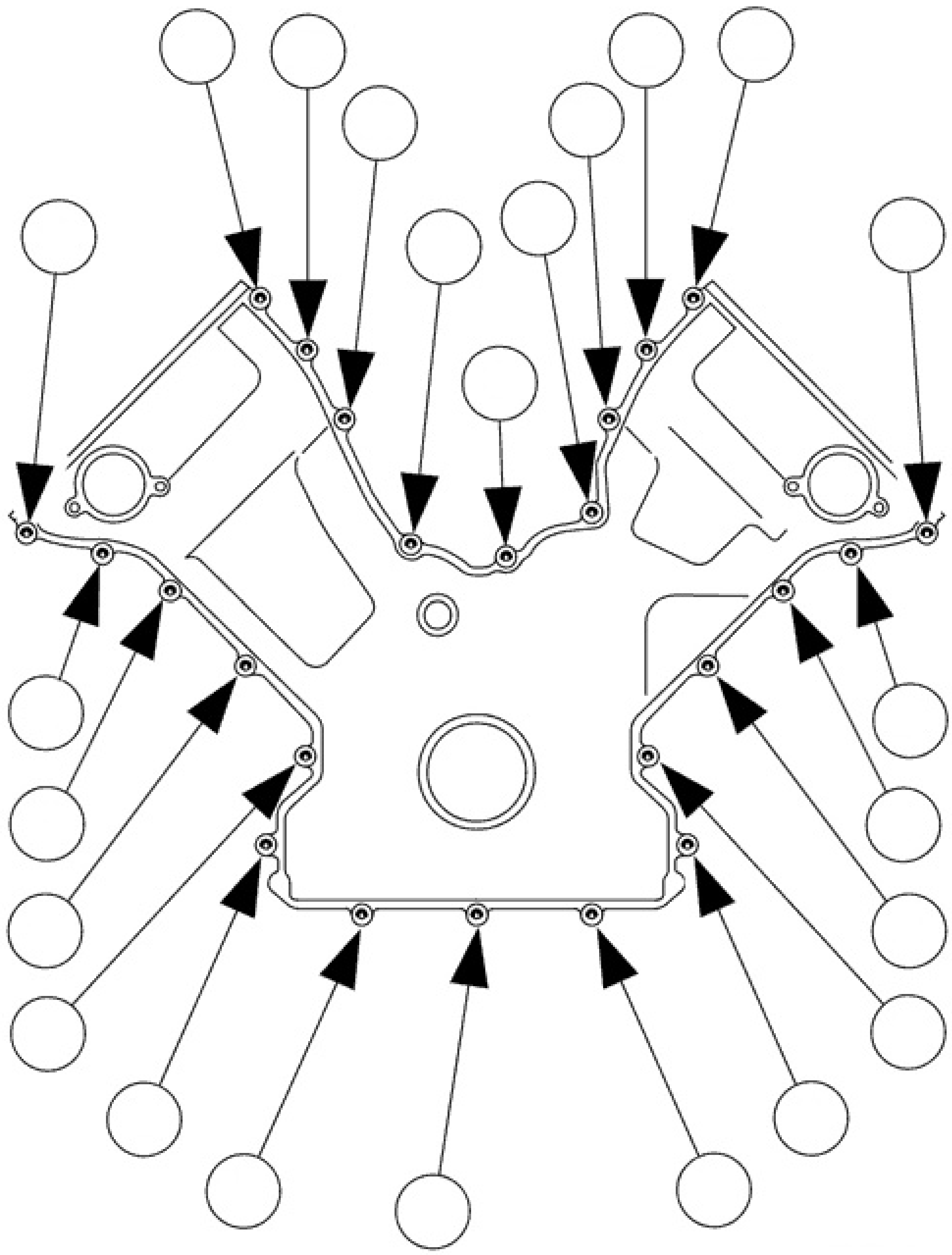
    What bush carrier components must always be replaced when re-installing bush carriers?

    ____

INSTRUCTOR CHECK POINT 11 ____

62. Apply RTV sealant where appropriate, and install timing cover.

Write in the timing cover torque sequence and mark the (8) locations that RTV must be applied:



63. Copy the accepted valve clearance ranges from step 9 of this worksheet:

Intake Max.	Intake Min.	Exhaust Max.	Exhaust Min.
________	________	________	________

64. Rotate engine assembly at least three times. Measure and record valve clearances.

Cyl.	Intake Front	Intake Rear	Exhaust Front	Exhaust Rear
1	________	________	________	________
3	________	________	________	________
5	________	________	________	________
7	________	________	________	________
2	________	________	________	________
4	________	________	________	________
6	________	________	________	________
8	________	________	________	________

If valve clearances required readjustment, adjust, rotate engine at least three times and remeasure clearances. Record final valve clearances.

Cyl.	Intake Front	Intake Rear	Exhaust Front	Exhaust Rear
1	________	________	________	________
3	________	________	________	________
5	________	________	________	________
7	________	________	________	________
2	________	________	________	________
4	________	________	________	________
6	________	________	________	________
8	________	________	________	________

INSTRUCTOR CHECK POINT 12 ____

65. Install a new crankshaft front seal.

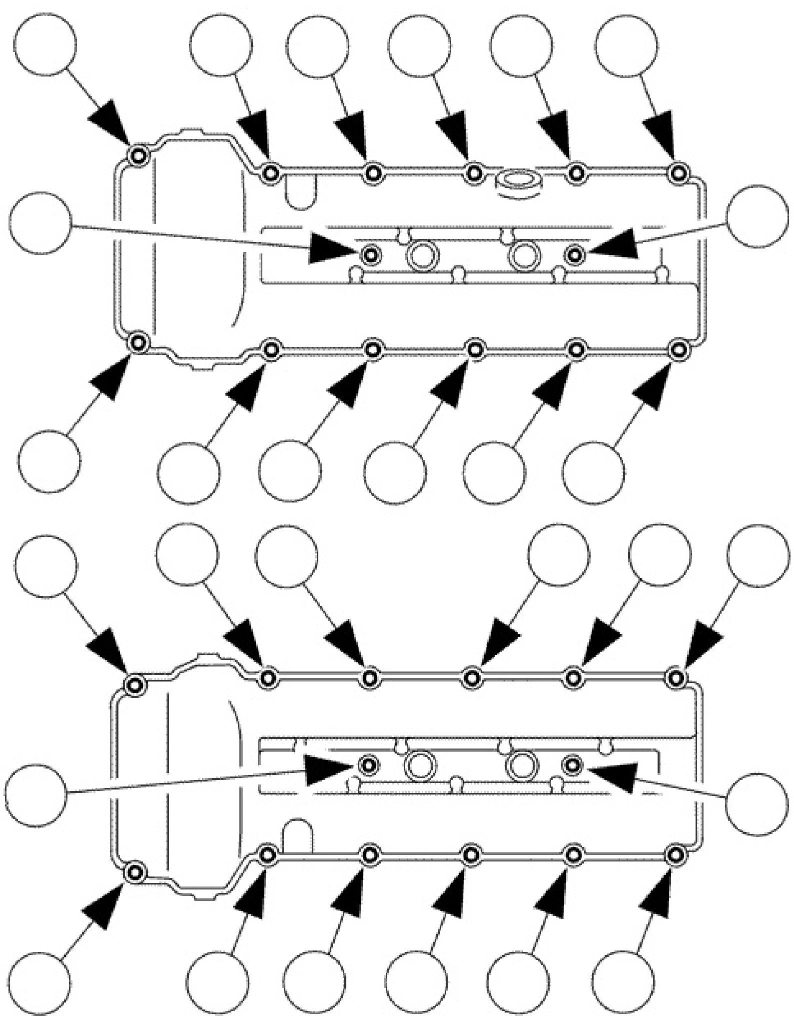
What special tool is used to install the front seal? __________-__________

66. Install the crankshaft pulley, locking ring and retaining bolt AFTER removing special tool 303-645. Do NOT use 303-645 to hold the crankshaft while tightening the crankshaft pulley retaining bolt.

What is the torque specification for the crankshaft pulley retaining bolt? _____

67. Apply silicone gasket sealant where appropriate, and install camshaft covers.

Write in the camshaft cover torque sequence and mark the sealant locations.



68. Install spark plugs, ignition coils and camshaft sensor, following the order and methods explained in the "AJ33 Engine Assembly" section of your workshop manual.

69. Install coolant pump, thermostat housing and outlet pipes.

70. Install intake and exhaust manifold assemblies.

71. Continue to assemble the engine in the order outlined in the workshop manual. Notify your instructor for the final checkpoint when complete.

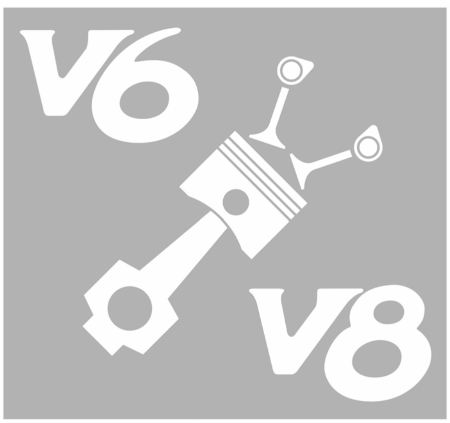
INSTRUCTOR CHECK POINT 13 ____

If your instructor signed off on checkpoint 13, then: Congratulations – you have completed the assembly of the AJ33 or AJ34 engine.

JAGUAR

TRAINING PROGRAM

JAGUAR V6/V8 ENGINE REPAIR



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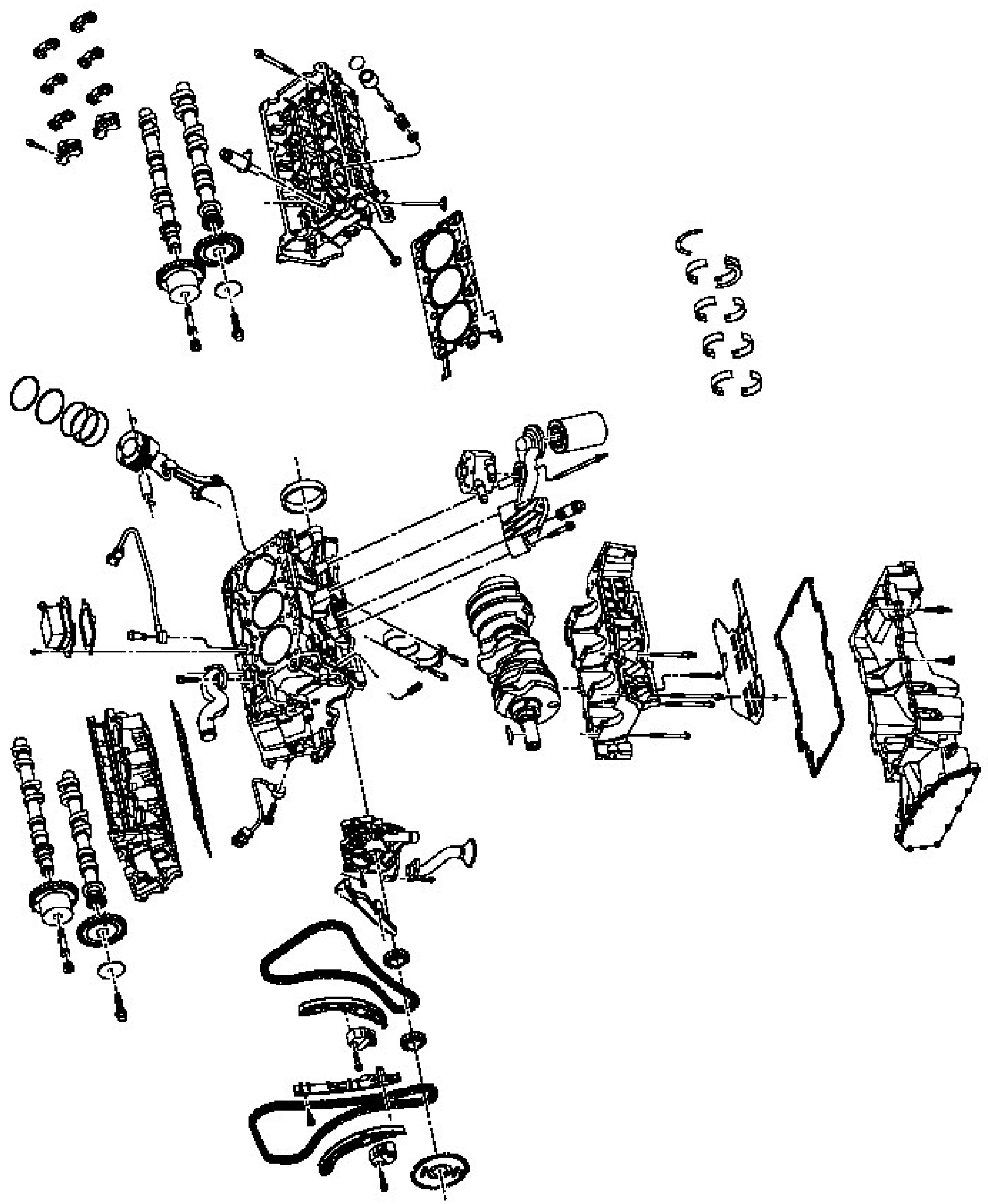

Fig. 136 AJV6 Exploded View

Student__________________________________ Date____________

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AJ60 Engine

Directions:
- Complete each step in sequence, following your workshop manual reference book. Fill in all blanks.
- When you reach an INSTRUCTOR CHECKPOINT, call your instructor who will examine your work and issue further instructions. **Do not** continue past an INSTRUCTOR CHECKPOINT unless instructed.
- Ask your instructor for assistance if needed.

1. Locate and record the following engine data codes:
   (*Refer to your student guide for locations and definitions)*

   Engine Serial Number: ____

   Emissions ID label (Engine Part Number): ________________________________

2. Following the disassembly procedures documented in your workshop manual, remove the upper and lower intake manifold assemblies and injector harness.

3. Continue disassembly by removing, in the order shown in your workshop manual, the following:
   - Serpentine belt, idler and tensioner pulley assemblies
   - Ignition coils and camshaft covers
   - Water pump, power steering pump, and A/C compressor
   - Belt tensioner, Bank 2 idler pulley and generator
   - Exhaust manifolds

NOTE: *Throughout the workshop manual, Bank 1 is sometimes referenced as the 'Right Bank', and Bank 2 may be referenced as the 'Left Bank'. References to the right and left bank will always be from the perspective of the drivers seat, as if looking at the engine from inside the car.*

4. Remove the flex plate.

5. Locate and record the following engine codes:

   (*Refer to your student guide for locations and definitions)*

Crankshaft Main Bearing Journal Codes: **1 _____ 2_____ 3_____ 4_____**

Cylinder Block Main Bearing Journal Codes: **1 _____ 2_____ 3_____ 4_____**

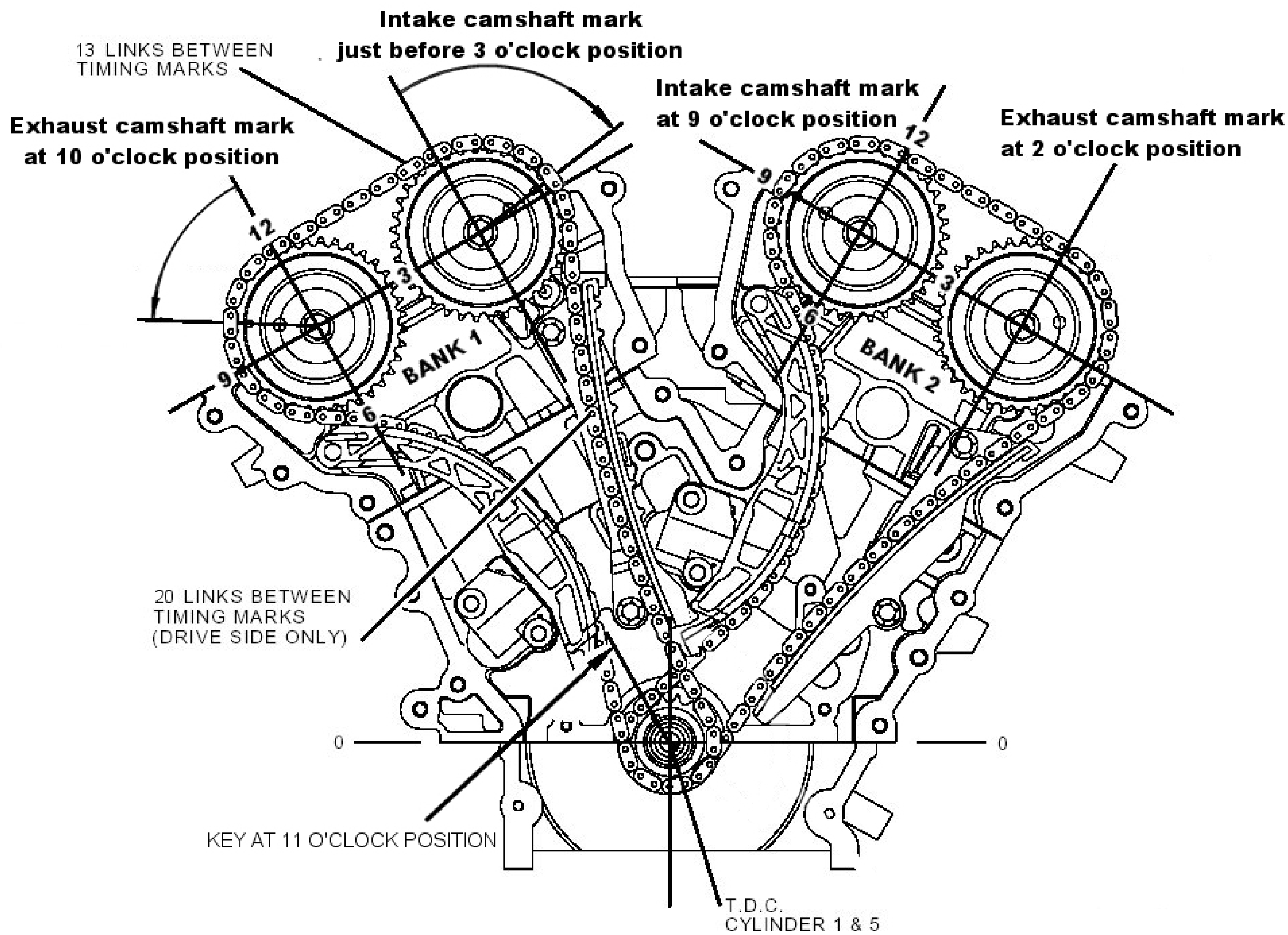
Cylinder Bore / Piston Grade Codes:

Bank 1: **1 _____ 2_____ 3_____**

Bank 2: **1 _____ 2_____ 3_____**

INSTRUCTOR CHECK POINT 1 ____

6. Remove the vibration dampener.
7. Remove the front timing case cover oil seal (front seal) using special tool 303-700.
8. Remove oil pan and timing case cover.
9. Prepare to remove the bank 1 camshaft assembly by setting the bank 1 exhaust camshaft timing mark to the 10 o'clock position. Verify that the crank key is at the 11 o'clock position.



INSTRUCTOR CHECK POINT 2 ____

10. Observe the bank 1 camshaft sprocket markings on both the front and back of the camshafts.

At what clock position is the front bank 1 exhaust cam mark? ___________

At what clock position is the front bank 1 intake cam mark? ___________

11. Verify that **ALL** bank 1 intake and exhaust valves are closed. If they are not, check that the bank 1 exhaust camshaft timing mark is at the 10 o'clock position, as shown in step 9.

12. Remove the bank 1 (right bank) tensioner, guide, and timing chain.

13. Verify that **ALL** bank 2 (left bank) intake and exhaust valves are closed.

14. Remove the bank 2 (left bank) tensioner, guide, and timing chain.

15. Note the camshaft bearing cap codes and remove.

Bank 1

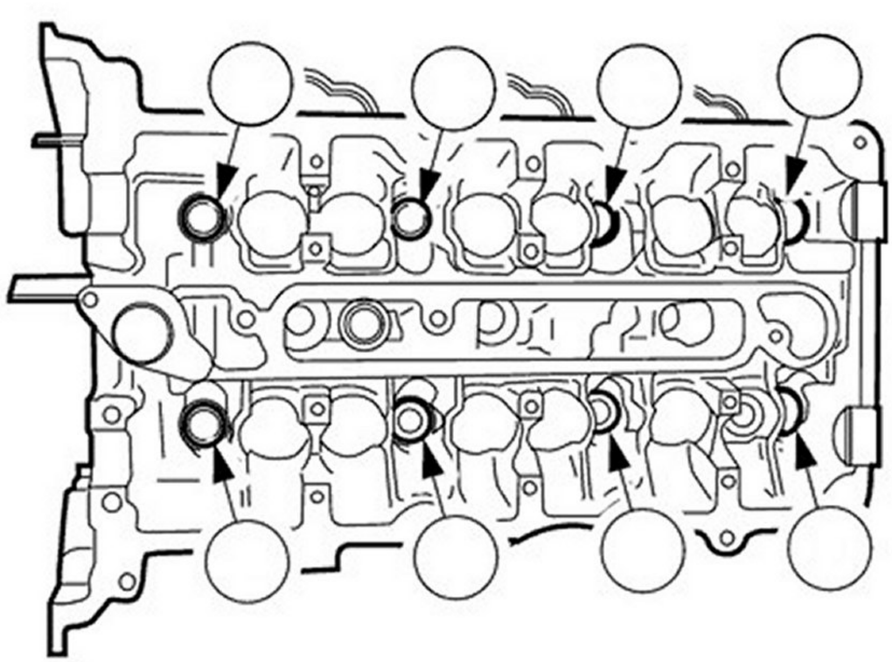
	Cap 1 (Front)	Cap 2	Cap 3	Cap 4 (Rear)
Exhaust	__________	__________	__________	__________
Intake	__________	__________	__________	__________

Bank 2

	Cap 1 (Front)	Cap 2	Cap 3	Cap 4 (Rear)
Intake	__________	__________	__________	__________
Exhaust	__________	__________	__________	__________

NOTE: *Keep camshafts and camshaft bearing caps with their respective cylinder heads.*

16. Remove the bank 1 cylinder head retaining bolts and fill in the appropriate removal sequence.



17. Remove the bank 1 cylinder head.

18. De-torque the bank 2 cylinder head retaining bolts and remove the bank 2 cylinder head.

INSTRUCTOR CHECK POINT 3 ____

19. Remove the engine oil separator and coolant housing.

20. Remove the oil intake (pickup tube) and pan baffle.

21. Remove the oil pump.

22. Remove the rear main oil seal.

What tool must be used to remove the seal? ________ _________

NOTE: Special tool 204-269 must also be used with this tool.

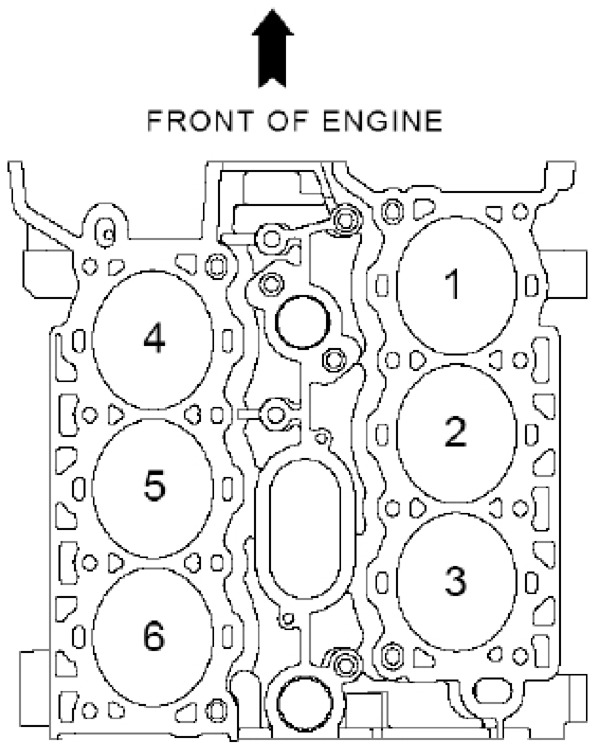
23. Following the procedure specified in the 'Generic Engine Procedures' section of your reference book, measure and record existing crankshaft end float. Make sure it is within the specification of 0.100 to 0.250 mm.

    Crankshaft end float value: _________________ mm

24. Note the orientation of each piston/con rod assembly. Label piston tops with appropriate cylinder number so that they may be identified, 1-6, to be put back into the original location.

    Sketch below:

25. Remove all piston assemblies:



26. Identify and record connecting rod / piston assembly markings.

Cyl.	Wrist pin offset direction (Intake or Exhaust)	Piston direction arrow (Front or Rear)
1	______________________	______________________
2	______________________	______________________
3	______________________	______________________
4	______________________	______________________
5	______________________	______________________
6	______________________	______________________

27. Remove the bedplate.
28. Remove crankshaft.

NOTE: *Be careful of bearing surfaces.*

29. Inspect cylinder block, cylinder bores, bedplate and sump. Record any problems found:

____

____

30. **What is the allowed range for piston-to-cylinder clearance?**

Min. allowable clearance: ___________ **Max. allowable clearance:___________**

31. Measure cylinder 1 piston clearance by measuring the piston diameter and the cylinder 1 bore diameter. Use a bore gauge, NOT internal micrometers, to measure the bore diameter.

Cyl. 1 bore dia. _________________

- Cyl. 1 piston dia. -________________

= Piston clearance ________________**mm**

32. What is the allowed range for piston ring end gap?

Min. allowable end gap: ___________ **Max. allowable end gap:___________**

33. Using the sample piston ring provided by your instructor, measure piston ring end gap per the procedure listed in the 'general procedures' section of the AJ60 Engine Systems workshop manual.

Piston Ring End Gap: _______________ mm

34. Measure and record the thickness of the existing crankshaft thrust washer:

Thrust Washer thickness: _______________ mm

35. Measure and record crankshaft journal diameters.

Crankshaft journal	Diameter
Main bearing number 1	
Main bearing number 2	
Main bearing number 3	
Main bearing number 4	

Connecting rod journal cyl. 1 ______________________________

Connecting rod journal cyl. 2 ______________________________

Connecting rod journal cyl. 3 ______________________________

Connecting rod journal cyl. 4 ______________________________

Connecting rod journal cyl. 5 ______________________________

Connecting rod journal cyl. 6 ______________________________

INSTRUCTOR CHECK POINT 4 ____

36. Prepare to select main bearings by copying bearing data recorded in step 1 of this worksheet:

Crankshaft Main Bearing Journal Codes: **1 _____ 2_____ 3_____ 4_____**

Cylinder Block Main Bearing Journal Codes: **1 _____ 2_____ 3_____ 4_____**

37. Based on the selection chart shown in your course material, select main bearings and record selected bearing codes.

Crankshaft journal	Bearing code
Main bearing number 1	____________________
Main bearing number 2	____________________
Main bearing number 3	____________________
Main bearing number 4	____________________

38. Install main bearing shells into the block.

Which main bearing halves fit to the block? _______________________________________

39. **What is the allowed range for crankshaft main bearing oil clearance?**

Min. allowable clearance: ___________ Max. allowable clearance:___________

40. Using the Plastigage procedure 303-00-11 documented in the 'Generic Procedures' section of your reference book, measure and record main bearing oil clearances.

Crankshaft journal	Oil clearance
Main bearing journal number 1	
Main bearing journal number 2	
Main bearing journal number 3	
Main bearing journal number 4	

41. **What is the allowed range for connecting rod bearing oil clearance?**

Min. allowable clearance: ___________ **Max. allowable clearance:___________**

42. Measure and record connecting rod bearing oil clearances at each connecting rod journal.

Connecting rod journal	Oil clearances
Number 1 connecting rod journals	________________________________
Number 2 connecting rod journals	________________________________
Number 3 connecting rod journals	________________________________
Number 4 connecting rod journals	________________________________
Number 5 connecting rod journals	________________________________
Number 6 connecting rod journals	________________________________

INSTRUCTOR CHECK POINT 5 ____

43. Apply 4 drops of EP90 to each con rod bearing, and install piston / connecting rod assemblies

Which direction should the piston markings face? ______________________________

Bank 1: ____

Bank 2: ____

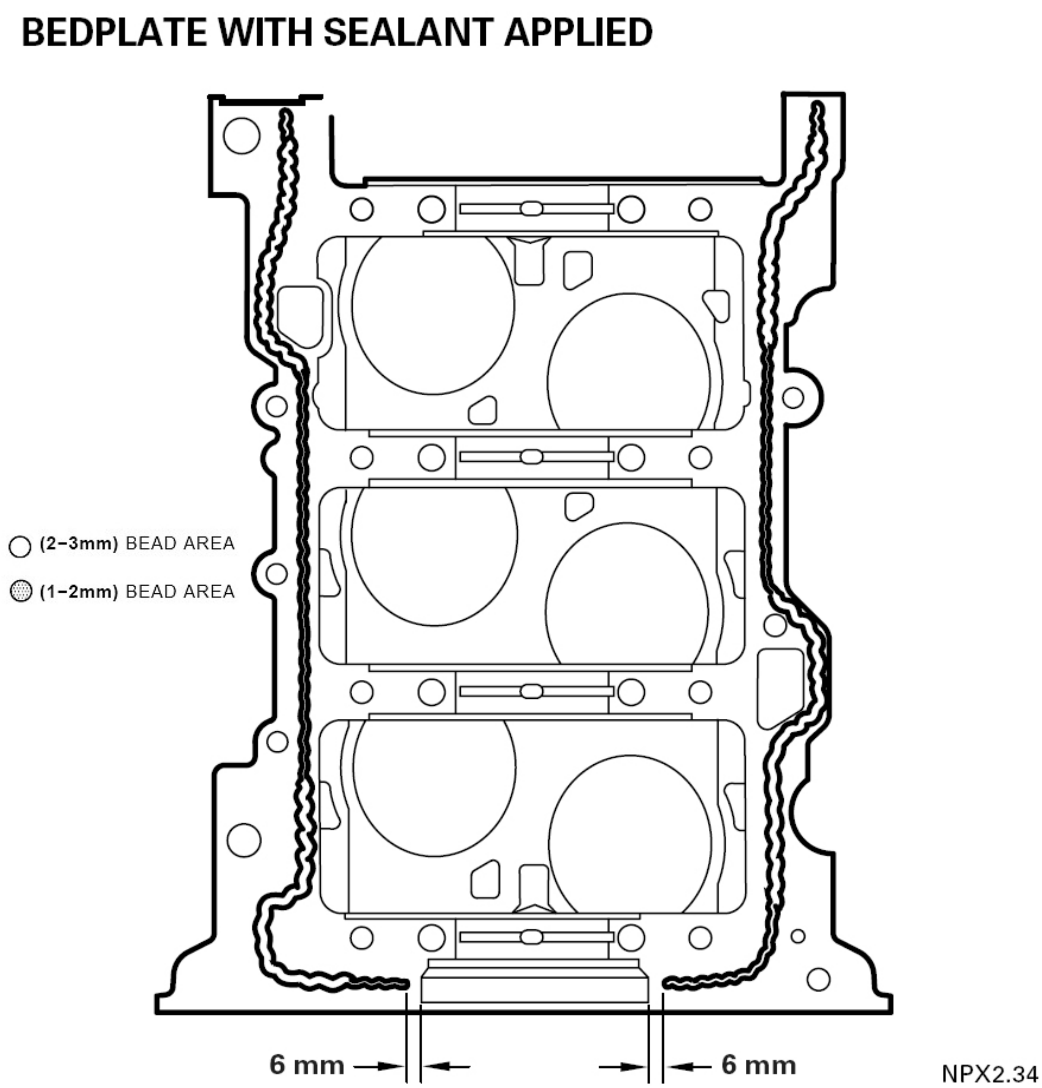
What special tools are required to protect the cylinder bores during piston assembly installation? ____

What is the rod torque specification? ____________________________________

Which bolts must not be reused? ______________________________________

44. Prepare to assemble the bed plate to the block by applying a bead of RTV sealant to the block, as shown in the diagram. Do NOT continue until your instructor has signed off within the 20 minute cure window.

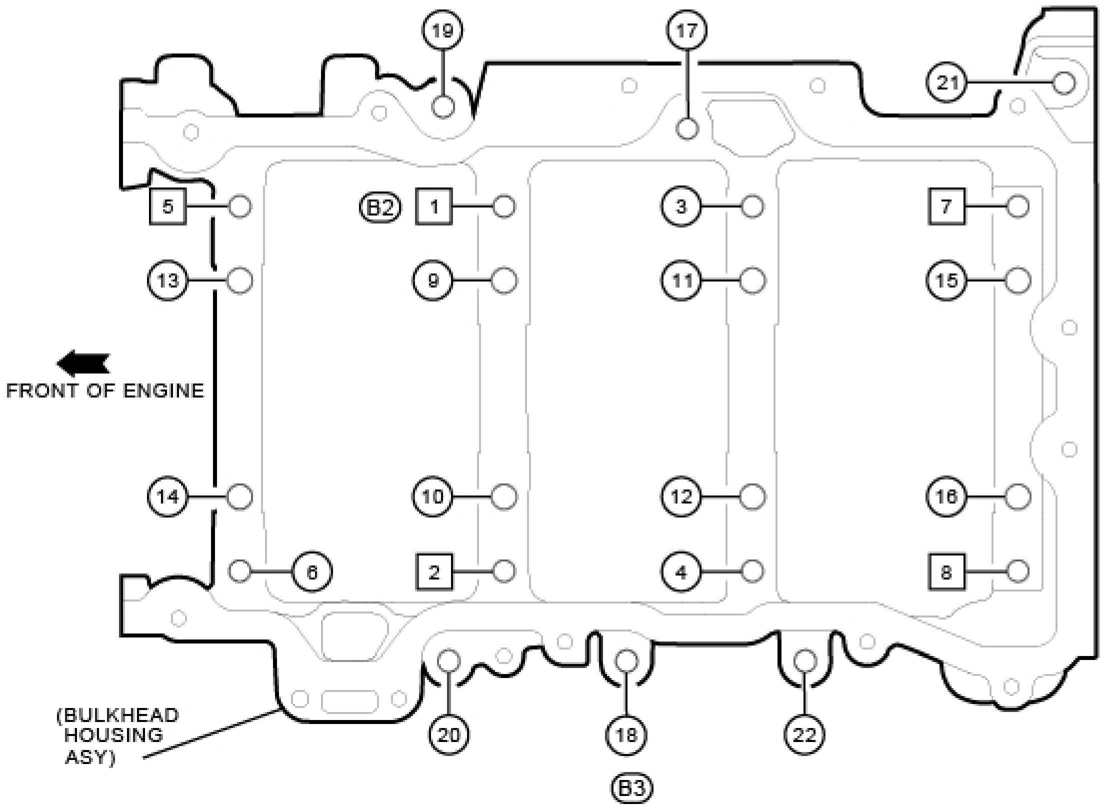
NOTE: * Joint must be closed and peripheral bolts marked by - * snugged down to a torque of 7-9 Nm within 7 minutes of starting to apply sealant.
* All bolts must be tightened to the relevant procedure and Crankshaft Rear Seal fitted within 20 minutes of starting to apply sealant.



INSTRUCTOR CHECK POINT 6 ____

45. Assemble block, crankshaft bearings, thrust washer and bed plate. Fill in the correct torque sequence:

BULKHEAD HOUSING FASTENERS



	HOLE NO.	FASTENER	DESCRIPTION
B3	○ 18-19-20-21-22	W701554 (10mm HEX)	M8 X 1.25 X 75 BOLT & WASHER PILOT
	○ 3-4-6-17	F43E-6345-CB (13mm HEX)	M8 X 1.25 X 94 BOLT HEX FLNG HD PILOT
	○ 9-10-11-12 13-14-15 16	F43E-6345-DC (13mm HEX)	M10 X 1.5 X 103.2 BOLT HEX FLNG HD PILOT
B2	□ 1-2-5-7-8	F43E-6K258-CB (13mm HEX)	M8 X 1.25 X 94 – M6 X 1 X 17 STUD BOLT HEX FLNG HD PILOT

46. Measure and record crankshaft end float. The end float procedure can be found in the 'Generic Procedures' section of your reference book. Write in the allowed specifications:

Min. allowable end float: ___________ **Max. allowable end float:**___________

Crankshaft end float measurement: __________________________

47. Rotate the crankshaft.

Does the crankshaft turn smoothly? _______________________

48. Install rear oil seal.

What special tools are required? ________________________________

49. Lubricate a new pickup tube O ring with Vaseline before installing pickup tube.

50. Install oil pump, oil pan baffle and oil pickup tube.

Which nuts must not be reused? ____

51. Install engine oil separator and water inlet tube.

INSTRUCTOR CHECK POINT 6 ____

52. Remove one intake and one exhaust valve.

What is the maximum valve spring free length specification? ___________________

What is the existing valve spring measurement? ______________________________

Note that the valve spring seat and the stem seal are integrated into a single component.

53. Inspect and reassemble cylinder heads (valves, valve springs, etc).

List any head problems found with the cylinder heads. ________________________

____

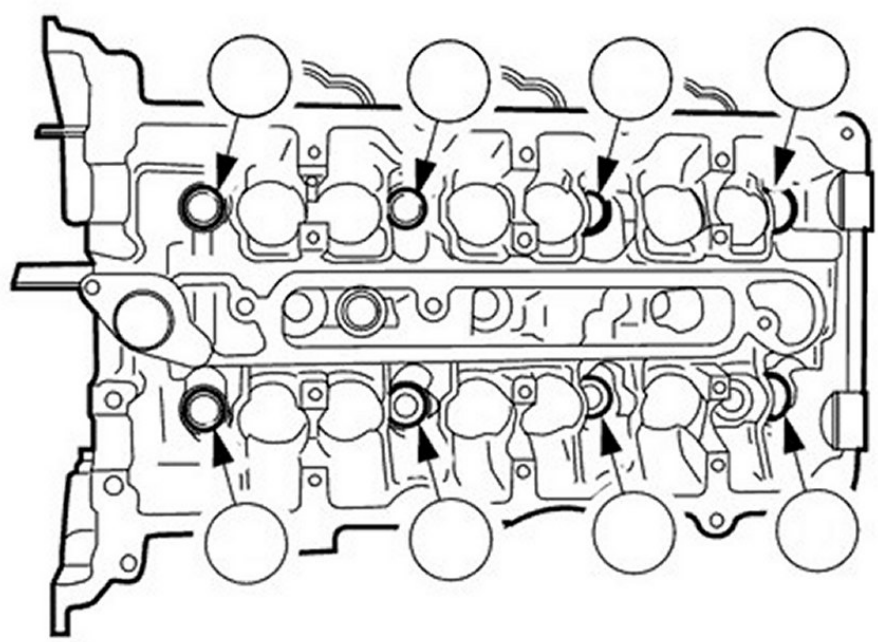
54. Position the crankshaft, in preparation to install the cylinder heads.

What is the proper orientation? (hint – follow your workshop manual) ___________

55. Install cylinder head gaskets and cylinder heads, carefully following the workshop manual torque process.

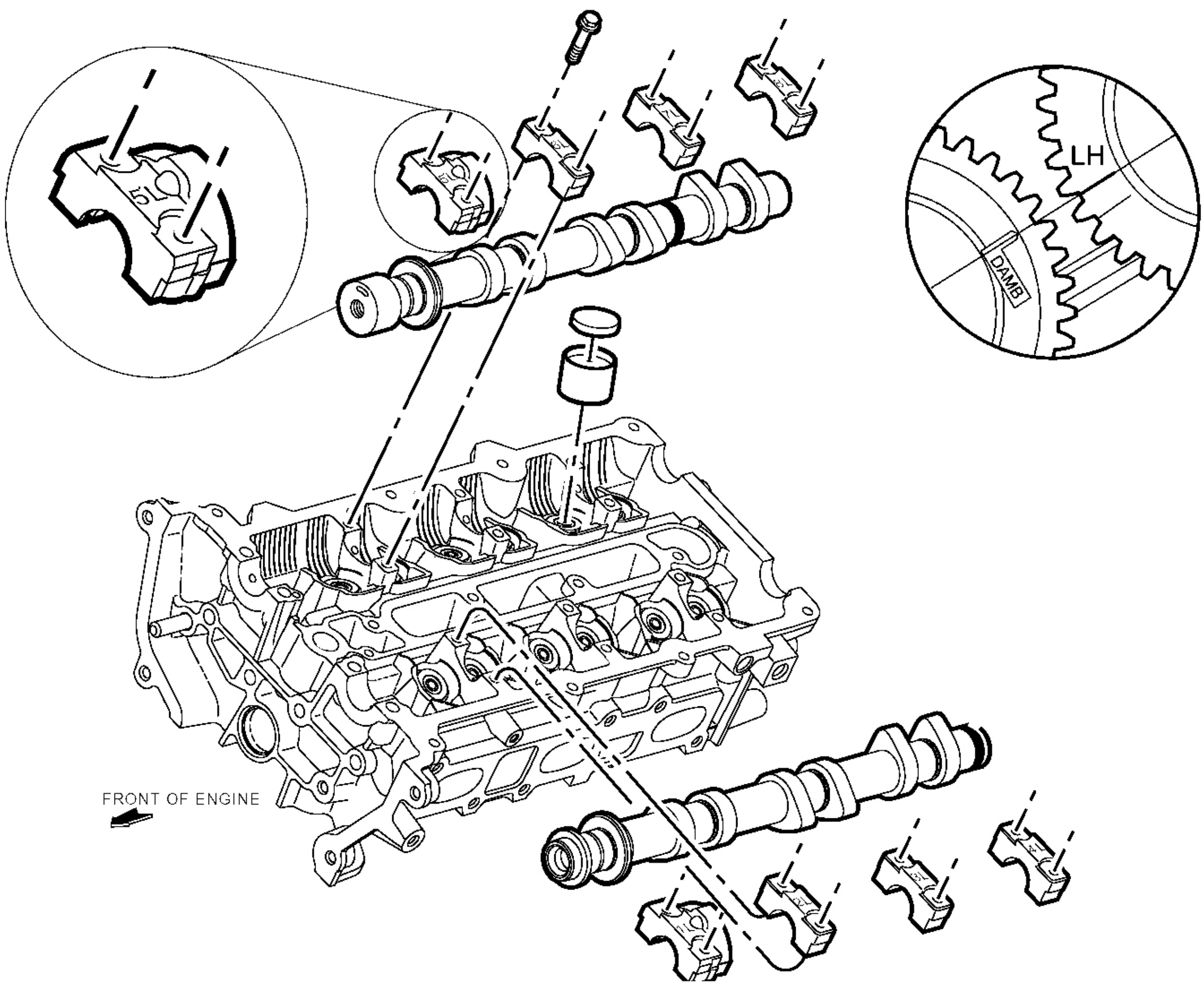
Head bolts must not be reused.

Write in the cylinder head torque sequence:



56. Inspect and install the Bank 2 valve gear and camshafts. **Use the camshaft procedure from the 'In Vehicle Repair' section of your reference guide for detailed assembly instructions.**

NOTE: Before installing the camshaft bearing caps, orient the camshafts with the markings on the **BACK** of the camshaft sprockets as shown below (right side of illustration). Be sure that the bearing caps are oriented correctly, as they are not symmetric, top to bottom.



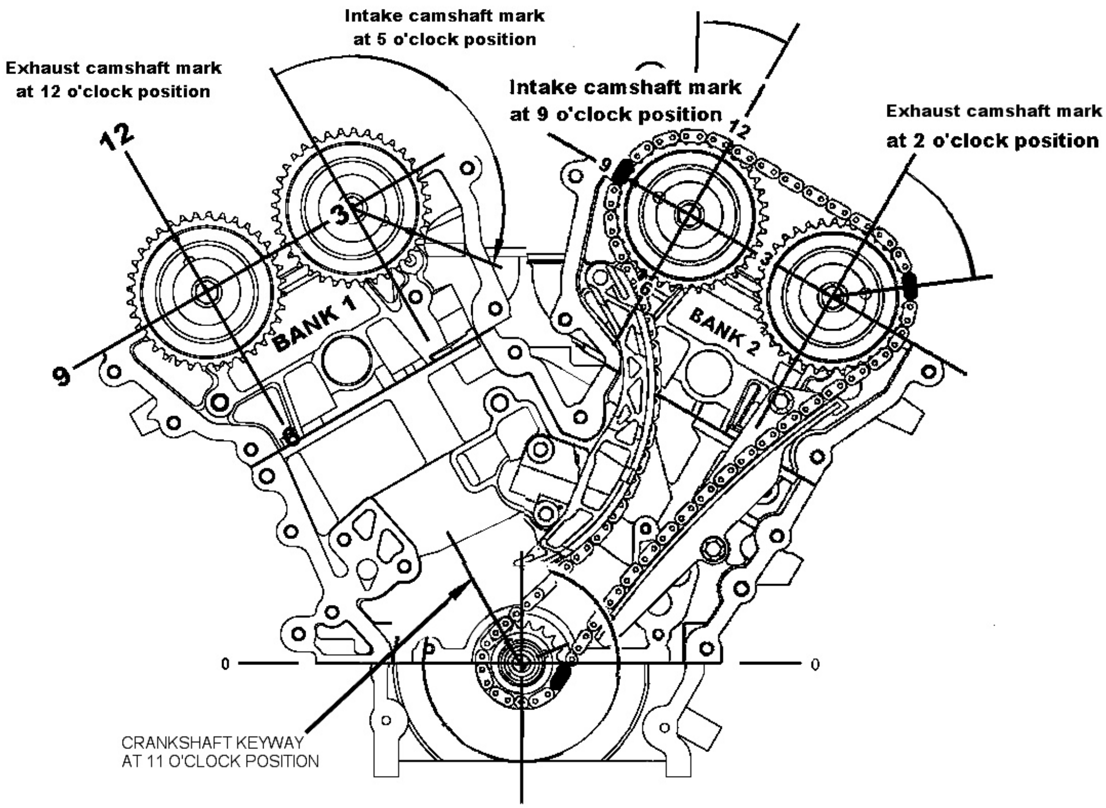
57. Install chain guides and tensioners for bank 2.

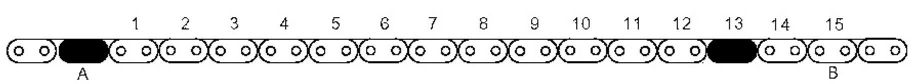
58. Install the bank 2 timing chain and align proper timing:

NOTE:
COPPER LINKS AT (A), (B) & (C) POSITIONS

NOTE:
YELLOW MARKS ON LINK AT (C) POSITION ONLY

1. BE SURE LH CAM DRIVE TENSIONER PIN IS PULLED BEFORE ROTATING CRANK.
2. ROTATE CRANKSHAFT **CLOCKWISE**
3. INSTALL RH CAM DRIVE COMPONENTS.





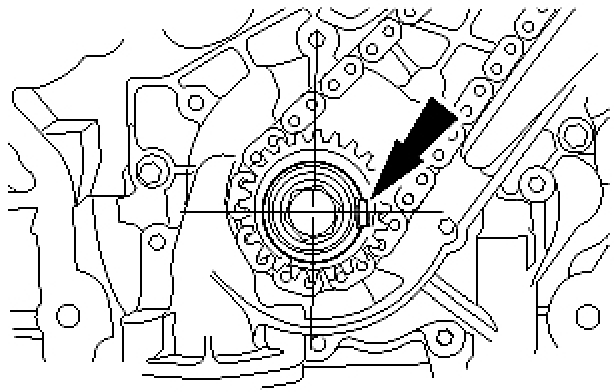
NOTE:
1. COUNT WHOLE LINKS CLOCKWISE STARTING WITH THE LINK IMMEDIATELY TO THE RIGHT OF LINK (A) (COPPER LINK) & INCLUDE THE NEXT (COPPER) LINK (B) IN THE TOTAL TO ACHIEVE **13 LINKS.**

2. COUNT WHOLE LINKS CLOCKWISE STARTING WITH THE LINK IMMEDIATELY TO THE RIGHT OF LINK (B) (COPPER LINK) & INCLUDE THE NEXT (COPPER) LINK (C) IN THE TOTAL TO ACHIEVE **20 LINKS.**

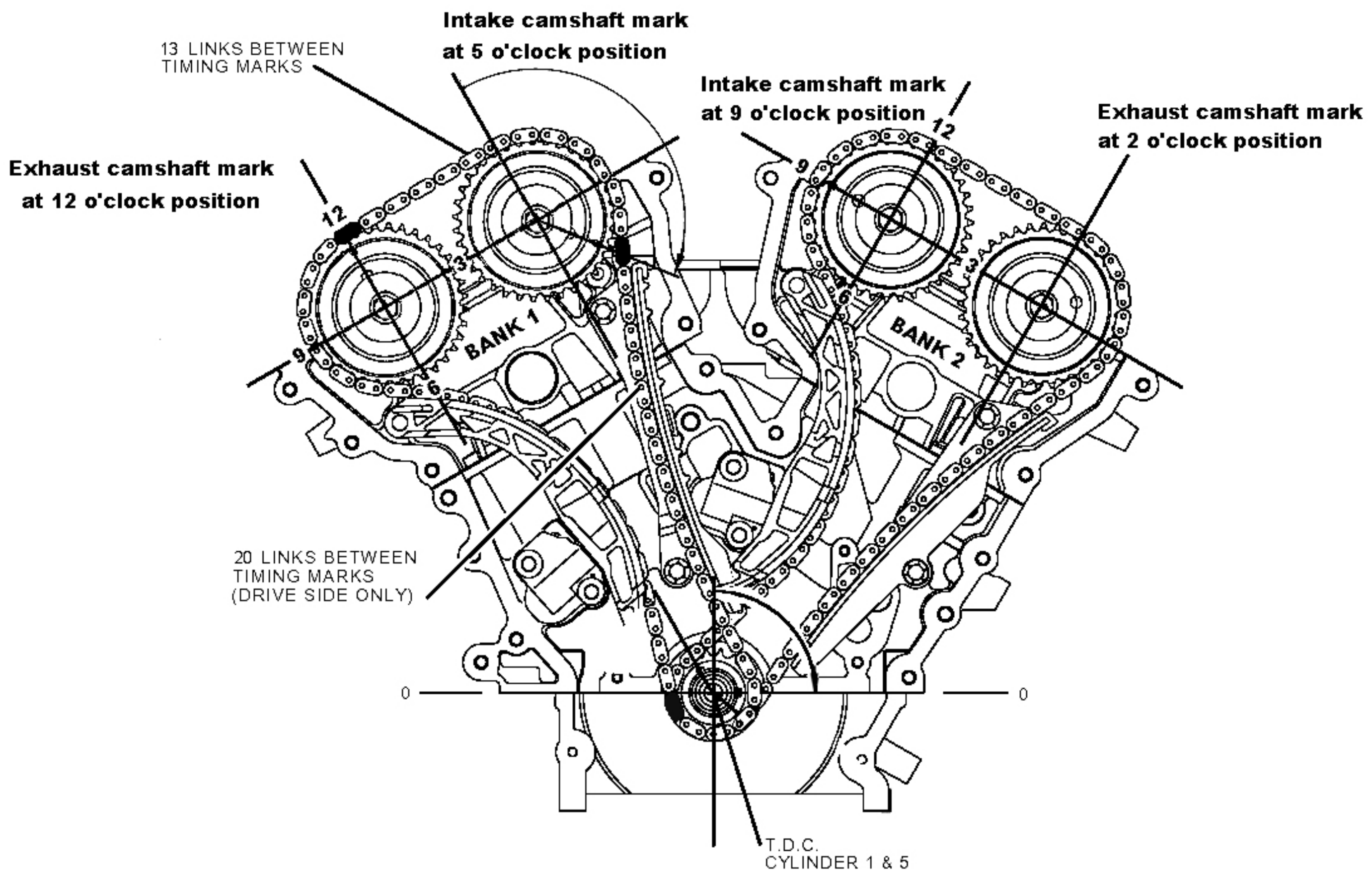
INSTRUCTOR CHECK POINT 7 ______________________________

59. Continue using the procedure shown in the "In Vehicle Repair" section of your reference book. Install the bank 1 camshafts, using the marks on the **front** of the camshaft sprockets to determine proper orientation **before** installing bearing caps.

60. Rotate the crankshaft clockwise until the crankshaft keyway is at the 3 o'clock position.



61. Install bank 1 chain guides, tensioner and chain.



62. Adjust and verify camshaft for the specified timing.

INSTRUCTOR CHECK POINT 8 ____

63. **Install the crankshaft position sensor pulse wheel – Which way do the teeth face?**

64. Install the VVT solenoids. Install the timing cover and front seal.

NOTE: Be sure to apply sealant to the keyway, as noted in the 'In-vehicle repair' section of the workshop manual. Failure to do so may result in an oil leak.

65. What is the acceptable range for intake and exhaust valve clearance:

Intake Max.	**Intake Min.**	**Exhaust Max.**	**Exhaust Min.**
________	________	__________	_________

66. Measure and record valve clearances.

Cyl.	**Intake Front**	**Intake Rear**	**Exhaust Front**	**Exhaust Rear**
1				
2				
3				
4				
5				
6				

If valve clearances required readjustment, adjust, rotate engine at least three times and re-measure clearances. Record final valve clearances.

Cyl**.**	**Intake Front**	**Intake Rear**	**Exhaust Front**	**Exhaust Rear**
1				
2				
3				
4				
5				
6				

INSTRUCTOR CHECK POINT 9____

67. Install the oil pan.
68. Continue following the workshop manual, and install camshaft covers, EOP, EOT and CHT sensors.
69. Install exhaust manifolds and oil level indicator tube.
70. Install waterpump and coolant hose assembly.
71. Install the accessory drive belt tensioner and accessory drive belt idler.

    What is the torque specification for the tensioner bolt? ______________________________
72. Continue to assemble the engine in the order outlined in the workshop manual. Notify your instructor for the final checkpoint when complete.

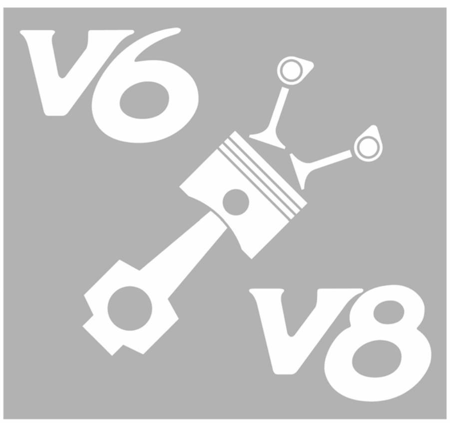
INSTRUCTOR CHECK POINT 10 ____

If your instructor signed off on checkpoint 11, then: Congratulations – you have completed the assembly of the AJ60 engine.

JAGUAR

TRAINING PROGRAM

JAGUAR V6/V8 ENGINE REPAIR



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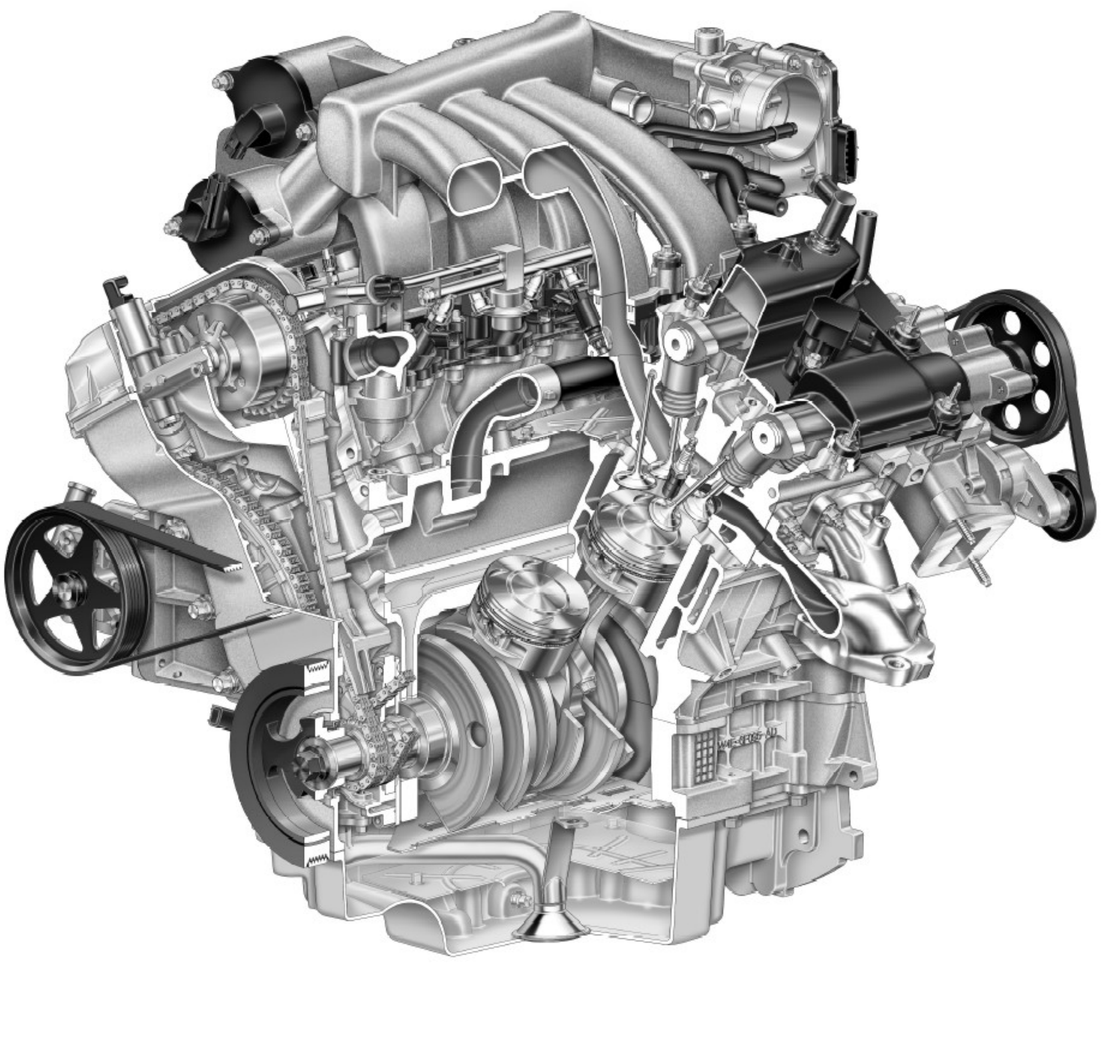

JAGUAR

Student__________________________________ Date____________

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AJ61/AJ62 Engine

Directions:

- Complete each step in sequence, following your workshop manual reference book. Fill in all blanks.
- When you reach an INSTRUCTOR CHECKPOINT, call your instructor who will examine your work and issue further instructions. **Do not** continue past an INSTRUCTOR CHECKPOINT unless instructed.
- Ask your instructor for assistance if needed.

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1. Locate and record the following engine data codes:
   (*Refer to your student guide for locations and definitions)*

   Engine Serial Number: ____

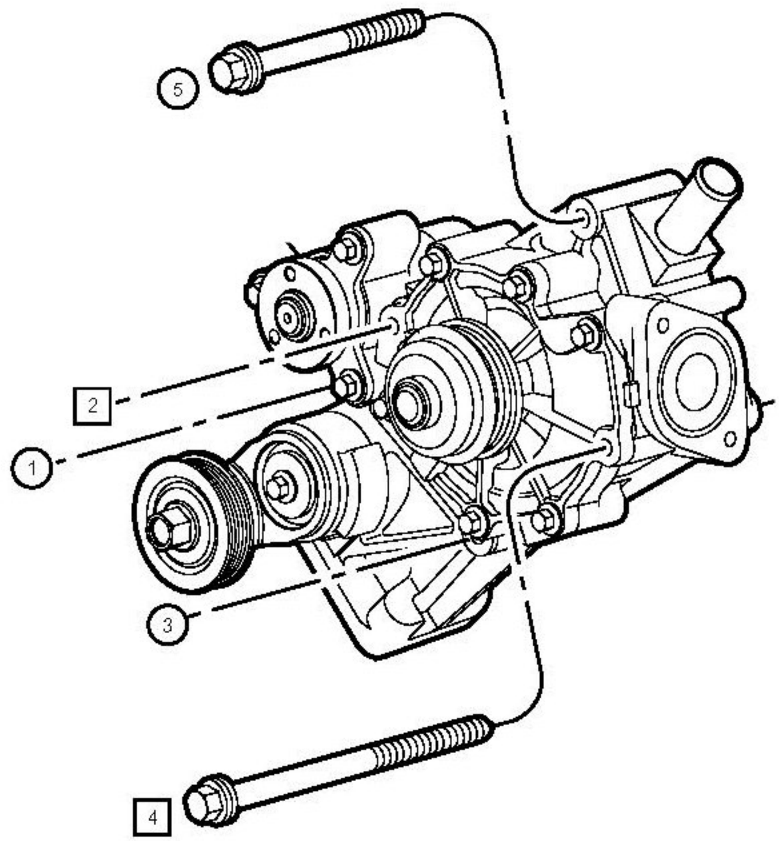
   Emissions ID label (Engine Part Number): _________________________________

2. Following the disassembly procedures documented in your workshop manual, remove the upper and lower intake manifold assemblies and injector harness.

3. Continue disassembly by removing, in the order shown in your workshop manual, the following:
   - Serpentine belt, idler and tensioner pulley assemblies
   - Ignition coils and camshaft covers

NOTE: *Throughout the workshop manual, Bank 1 is sometimes referenced as the 'Right Bank', and Bank 2 may be referenced as the 'Left Bank'. References to the right and left bank will always be from the perspective of the drivers seat, as if looking at the engine from inside the car.*

4. On the AJ62, remove the water pump as shown in the reference book. On the AJ61, remove the water pump belt and the (5) bolts retaining the water pump assembly to the head, as shown in the illustration below:



5. Continuing to follow the workshop manual disassembly procedure, remove:
   - power steering pump and A/C compressor
   - Belt tensioner, Bank 2 idler pulley and generator
   - Exhaust manifolds

6. Remove the flex plate.

7. Locate and record the following engine codes:

   (*Refer to your student guide for locations and definitions)*

Crankshaft Main Bearing Journal Codes: **1 _____ 2_____ 3_____ 4_____**

Cylinder Block Main Bearing Journal Codes: **1 _____ 2_____ 3_____ 4_____**

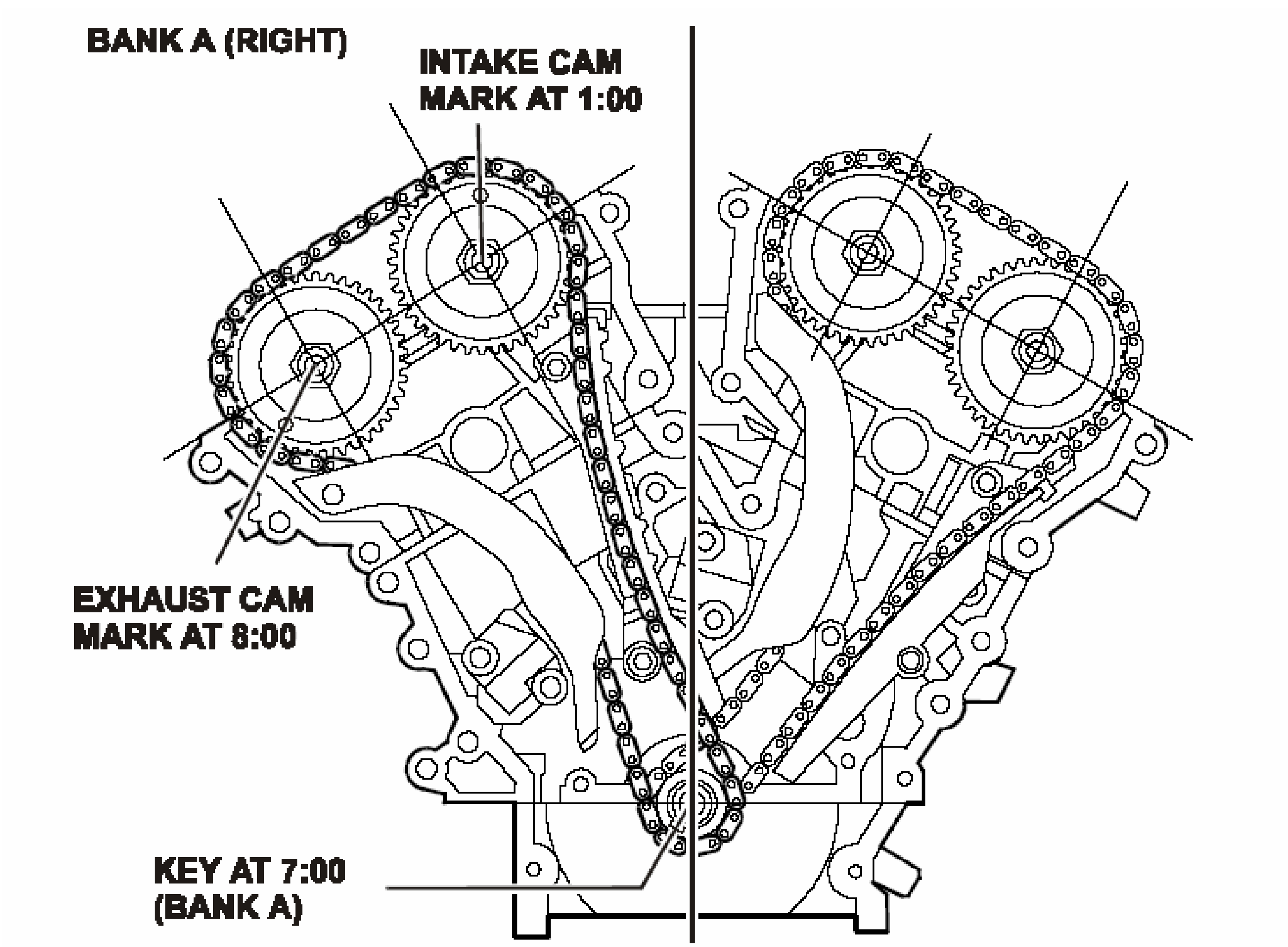
Cylinder Bore / Piston Grade Codes:

Bank 1: **1 _____ 2_____ 3_____**

Bank 2: **1 _____ 2_____ 3_____**

INSTRUCTOR CHECK POINT 1 ____

8. Remove the vibration dampener.
9. Remove the front timing case cover oil seal (front seal) using special tool 303-700.
10. Remove oil pan and valve covers.
11. Remove the front timing case cover.
12. Prepare to remove the bank 1 camshaft assembly by setting the bank 1 intake camshaft to the 1 o'clock position relative to the head orientation (almost straight up and down). Verify that the crank key is set to the 7 o'clock position. Be sure that all bank 1 valves are closed.



INSTRUCTOR CHECK POINT 2 ______________________________

13. Observe the bank 1 camshaft sprocket markings on the front of the camshafts.

    At what clock position is the bank 1 exhaust cam mark? _________________

    At what clock position is the bank 1 intake cam mark? _________________

14. Carefully following the 'Engine Disassembly' workshop manual procedure, remove the right hand (bank 1) tensioner, guide, and timing chain. Note that the bush carrier is part of the guide assembly.

15. Rotate the crankshaft until the crankshaft keyway is at the 11 o'clock position.

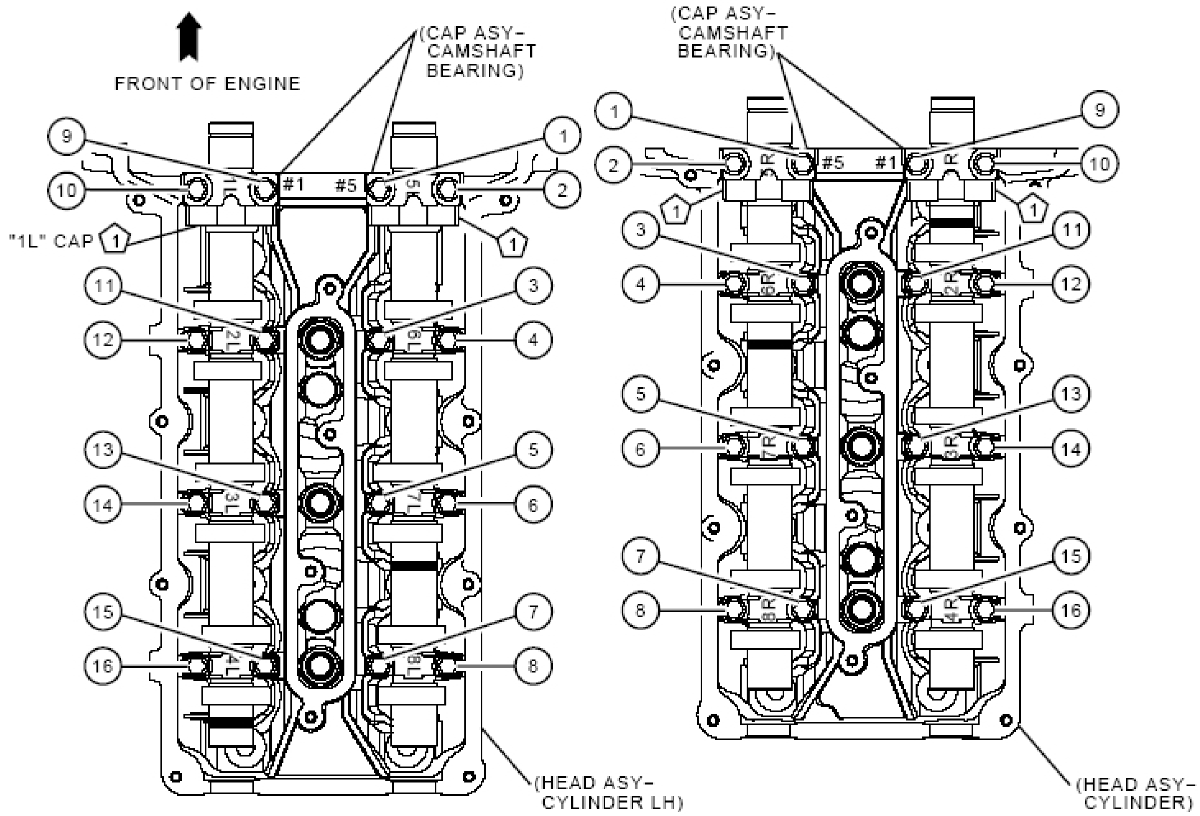
    At what clock position is the bank 2 exhaust cam mark? _________________

    At what clock position is the bank 2 intake cam mark? _________________

16. VERIFY that all bank 2 valves are closed. If they are not, rotate the crankshaft clockwise one revolution, such that the crankshaft keyway is at the 11 o'clock position.

17. Remove the left hand (bank 2) tensioner, guide, and timing chain.

18. Note the camshaft bearing cap codes AND code orientation, and then remove the bearing caps in the order of highest to lowest number shown below.



Bank 1	**Cap 1 (Front)**	**Cap 2**	**Cap 3**	**Cap 4 (Rear)**
Exhaust	________	________	________	________
Intake	________	________	________	________

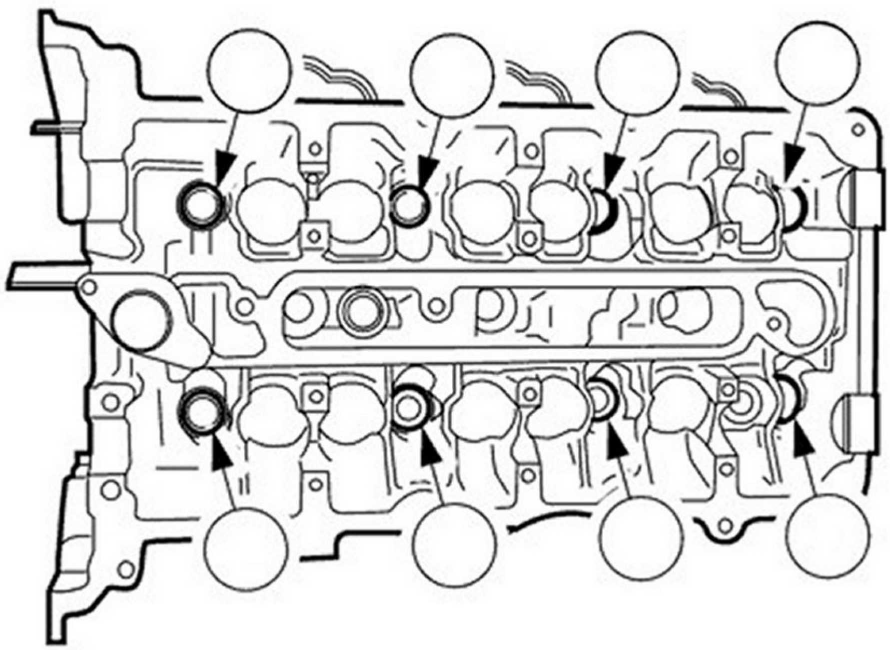
Bank 2	**Cap 1 (Front)**	**Cap 2**	**Cap 3**	**Cap 4 (Rear)**
Intake	________	________	________	________
Exhaust	________	________	________	________

19. Remove the camshafts and note their positions.

NOTE: *Keep camshafts and camshaft bearing caps with their respective cylinder heads.*

20. Remove the engine coolant (thermostat) housing and crossover tubes.

21. Remove the bank 1 cylinder head retaining bolts and fill in the appropriate removal sequence.



22. Remove the bank 1 cylinder head.

23. De-torque the bank 2 cylinder head retaining bolts and remove the bank 2 cylinder head.

INSTRUCTOR CHECK POINT 3 ____

24. Remove the oil pickup (pump tube) and pan baffle.

25. Remove the oil pump.

26. Remove the rear main oil seal, using the procedure shown in the 'In Vehicle Repair' section of your workshop manual. This procedure is not necessary for full engine disassembly, but allows practice of correct seal replacement.

What tool must be used to remove the seal?___________-__________

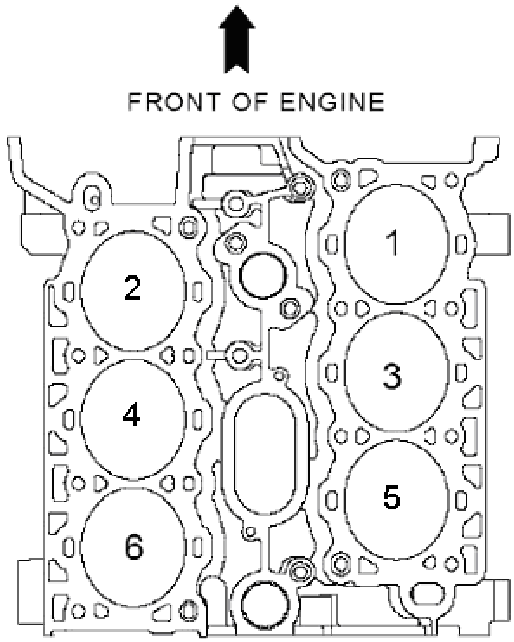
27. Following the procedure specified in the 'Generic Engine Procedures' section of your reference book, measure and record existing crankshaft end float. Make sure it is within the specification of 0.100 to 0.250 mm

Crankshaft end float value: _________________ mm

28. Note the orientation of each piston/con rod assembly. Label the top of each piston with the appropriate cylinder number, 1-6, so it can be put back into the original location.

29. **Sketch below:**

30. Remove all piston assemblies:



31. Identify and record connecting rod / piston assembly markings.

Cyl.	Wrist pin offset direction (Intake or Exhaust)	Piston direction arrow (Front or Rear)
1	______________	______________
2	______________	______________
3	______________	______________
4	______________	______________
5	______________	______________
6	______________	______________

32. Remove the bedplate.

33. Remove crankshaft.

    NOTE: *Be careful of bearing surfaces.*

34. Inspect cylinder block, cylinder bores, bedplate and sump. Record any problems found:

____

____

35. What is the allowed range for piston-to-cylinder clearance?

Min. allowable clearance: __________ **Max. allowable clearance:__________**

36. Measure cylinder 1 piston clearance by measuring the piston diameter and the cylinder 1 bore diameter. Use a bore gauge, NOT internal micrometers, to measure the bore diameter.

Cyl. 1 bore dia.	________________
- Cyl. 1 piston dia.	**-** ________________
= Piston clearance	________________**mm**

37. What is the allowed range for piston ring end gap?

Min. allowable end gap: ___________ Max. allowable end gap:___________

38. Using the sample piston ring provided by your instructor, measure piston ring end gap per the procedure listed in the 'general procedures' section of the AJ61 Engine Systems workshop manual.

Piston Ring End Gap: _______________ mm

39. Measure and record the thickness of the existing crankshaft thrust washer:

Thrust Washer thickness: _______________ mm

40. Measure the crankshaft and record crankshaft journal diameters.

Crankshaft journal	Diameter
Main bearing number 1	______________________
Main bearing number 2	______________________
Main bearing number 3	______________________
Main bearing number 4	______________________
Connecting rod journal cyl. 1	______________________
Connecting rod journal cyl. 2	______________________
Connecting rod journal cyl. 3	______________________
Connecting rod journal cyl. 4	______________________
Connecting rod journal cyl. 5	______________________
Connecting rod journal cyl. 6	______________________

INSTRUCTOR CHECK POINT 4 ______________________________________

41. Prepare to select main bearings by copying bearing data recorded in step 1 of this worksheet:

Crankshaft Main Bearing Journal Codes: **1 _____ 2_____ 3_____ 4_____**

Cylinder Block Main Bearing Journal Codes: **1 _____ 2_____ 3_____ 4_____**

42. Based on the selection chart shown in your course material, select main bearings and record selected bearing codes.

Crankshaft journal	Bearing code
Main bearing number 1	____________________
Main bearing number 2	____________________
Main bearing number 3	____________________
Main bearing number 4	____________________

43. Install main bearing shells into the block.

Which main bearing halves fit to the block? _______________________________________

44. What is the allowed range for main crankshaft bearing clearance?

Min. allowable clearance: __________ Max. allowable clearance:__________

45. Using the Plastigage procedure 303-00-11 documented in the 'Generic Procedures' section of your reference book, measure and record main bearing oil clearances.

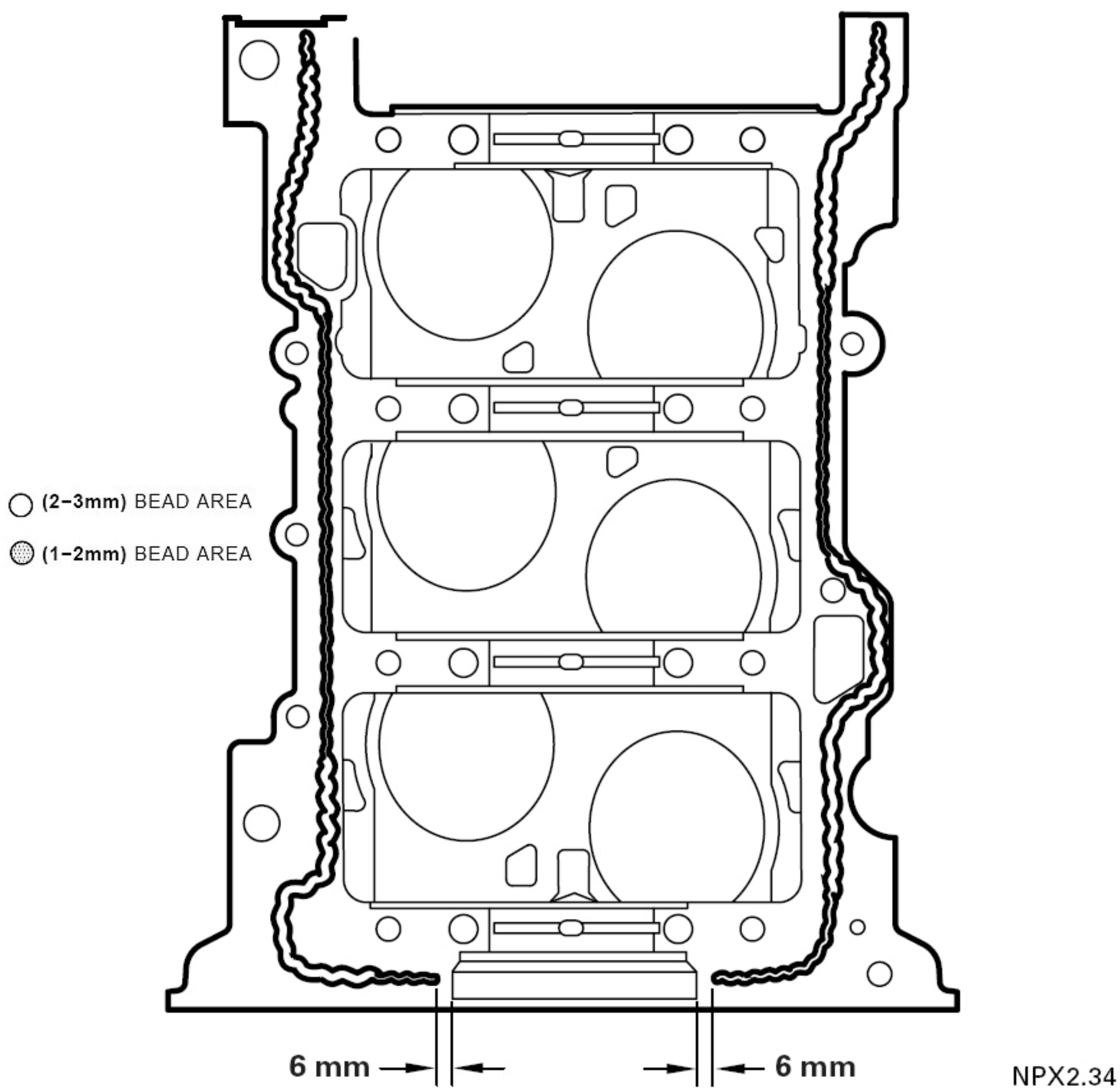
Crankshaft journal	Oil clearance
Main bearing journal number 1	____________________________
Main bearing journal number 2	____________________________
Main bearing journal number 3	____________________________
Main bearing journal number 4	____________________________

46. Prepare to assemble the bed plate to the block by applying a bead of RTV sealant to the block, as shown in the diagram. Do NOT continue until your instructor has signed off within the 20 minute cure window.

NOTE: * Joint must be closed and peripheral bolts marked by - * snugged down to a torque of 7-9 Nm within 7 minutes of starting to apply sealant.

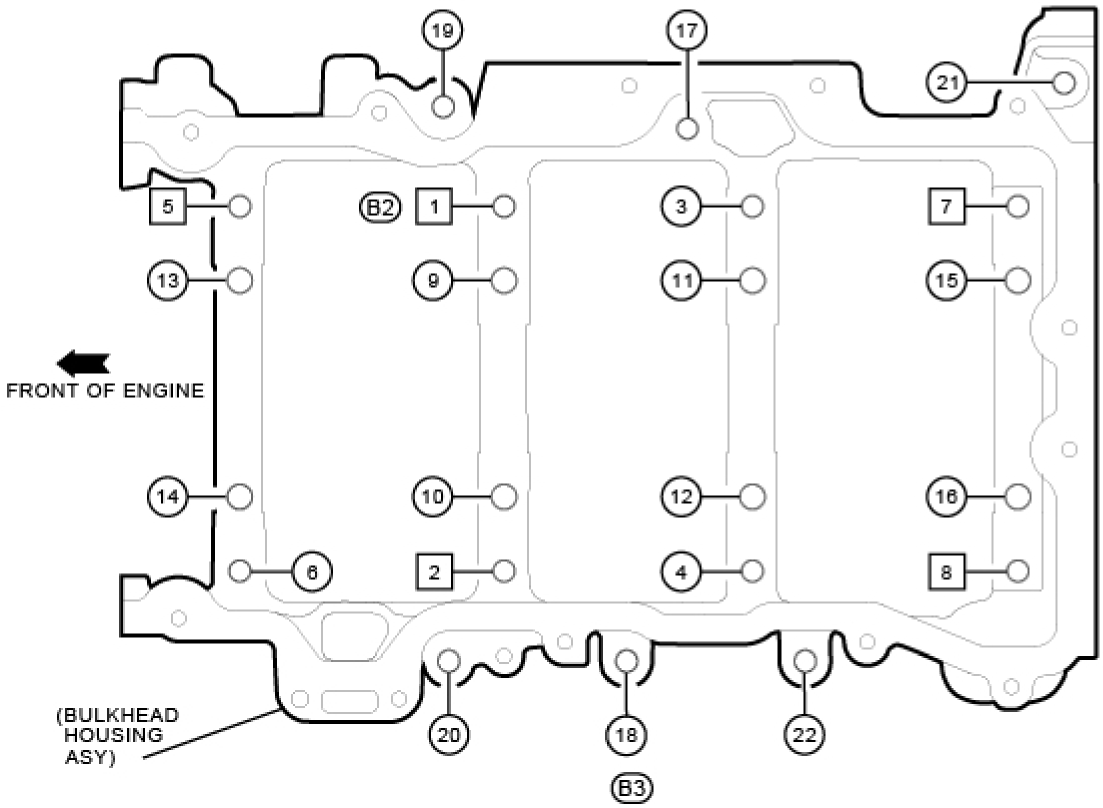
* All bolts must be tightened to the relevant procedure and Crankshaft Rear Seal fitted within 20 minutes of starting to apply sealant.

BEDPLATE WITH SEALANT APPLIED



47. Assemble block, crankshaft bearings, thrust washer and bed plate. Fill in the correct torque sequence:

BULKHEAD HOUSING FASTENERS



HOLE NO.	FASTENER	DESCRIPTION
(B3) ○ 18-19-20-21-22	W701554 (10mm HEX)	M8 X 1.25 X 75 BOLT & WASHER PILOT
○ 3-4-6-17	F43E-6345-CB (13mm HEX)	M8 X 1.25 X 94 BOLT HEX FLNG HD PILOT
○ 9-10-11-12 13-14-15 16	F43E-6345-DC (13mm HEX)	M10 X 1.5 X 103.2 BOLT HEX FLNG HD PILOT
(B2) □ 1-2-5-7-8	F43E-6K258-CB (13mm HEX)	M8 X 1.25 X 94 – M6 X 1 X 17 STUD BOLT HEX FLNG HD PILOT

48. Measure and record crankshaft end float. The end float procedure can be found in the 'Generic Procedures' section of your reference book. Make sure it is within the specification of 0.100 to 0.250 mm

Crankshaft end float measurement: ____________________________

49. Rotate the crankshaft.

Does the crankshaft turn smoothly? ____________________________

50. Install rear oil seal.

What special tools are required? ____________________________

51. What is the allowed range for connecting rod bearing clearance?

Min. allowable clearance: __________ **Max. allowable clearance:__________**

52. Measure and record connecting rod bearing oil clearances at each connecting rod journal.

Crankshaft journal	Oil clearances
Number 1 connecting rod journal	______________________________
Number 2 connecting rod journal	______________________________
Number 3 connecting rod journal	______________________________
Number 4 connecting rod journal	______________________________
Number 5 connecting rod journal	______________________________
Number 6 connecting rod journal	______________________________

INSTRUCTOR CHECK POINT 5 ____

53. Apply 4 drops of EP90 to each con rod bearing, and install piston / connecting rod assemblies

Which direction should the piston marking ______________________________

Bank 1: ______________________________

Bank 2: ______________________________

What special tools are required to protect the cylinder bores during piston assembly installation? ______________________________

What is the rod torque specification? ______________________________

Which bolts must not be reused? ______________________________

54. Lubricate the pickup tube O ring with Vaseline.

55. Install oil pump, oil pan baffle and oil pickup tube.

NOTE: Oil pan baffle nuts are torque-to-yield, and must not be reused.

56. Install water inlet tube.

INSTRUCTOR CHECK POINT 6 ____

57. Remove one intake and one exhaust valve.

What is the maximum valve spring free length specification? ________________

What is the existing valve spring measurement? ___________________________

Note that the valve seat and the valve stem seal are a single piece.

58. Inspect and reassemble cylinder heads (valves, valve springs, etc).

List any head problems found with the cylinder heads. _________________________

____

59. Position the crankshaft, in preparation to install the cylinder heads.

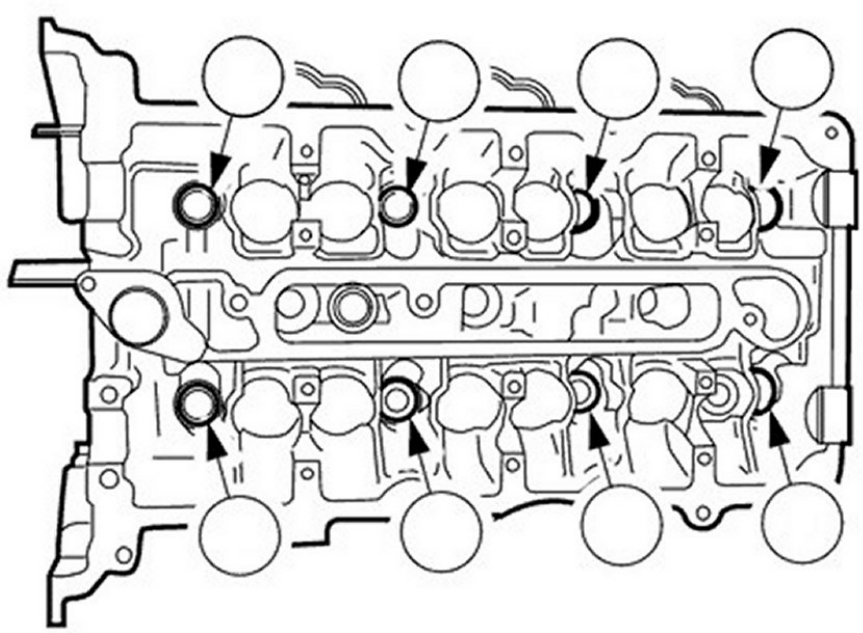
At what clock position is the crankshaft key? (hint – follow your workshop manual)

________________ o'clock

60. Install new cylinder head gaskets and cylinder heads, carefully following the workshop manual torque process.

NOTE: Head bolts must not be reused.

Write in the cylinder head torque sequence:

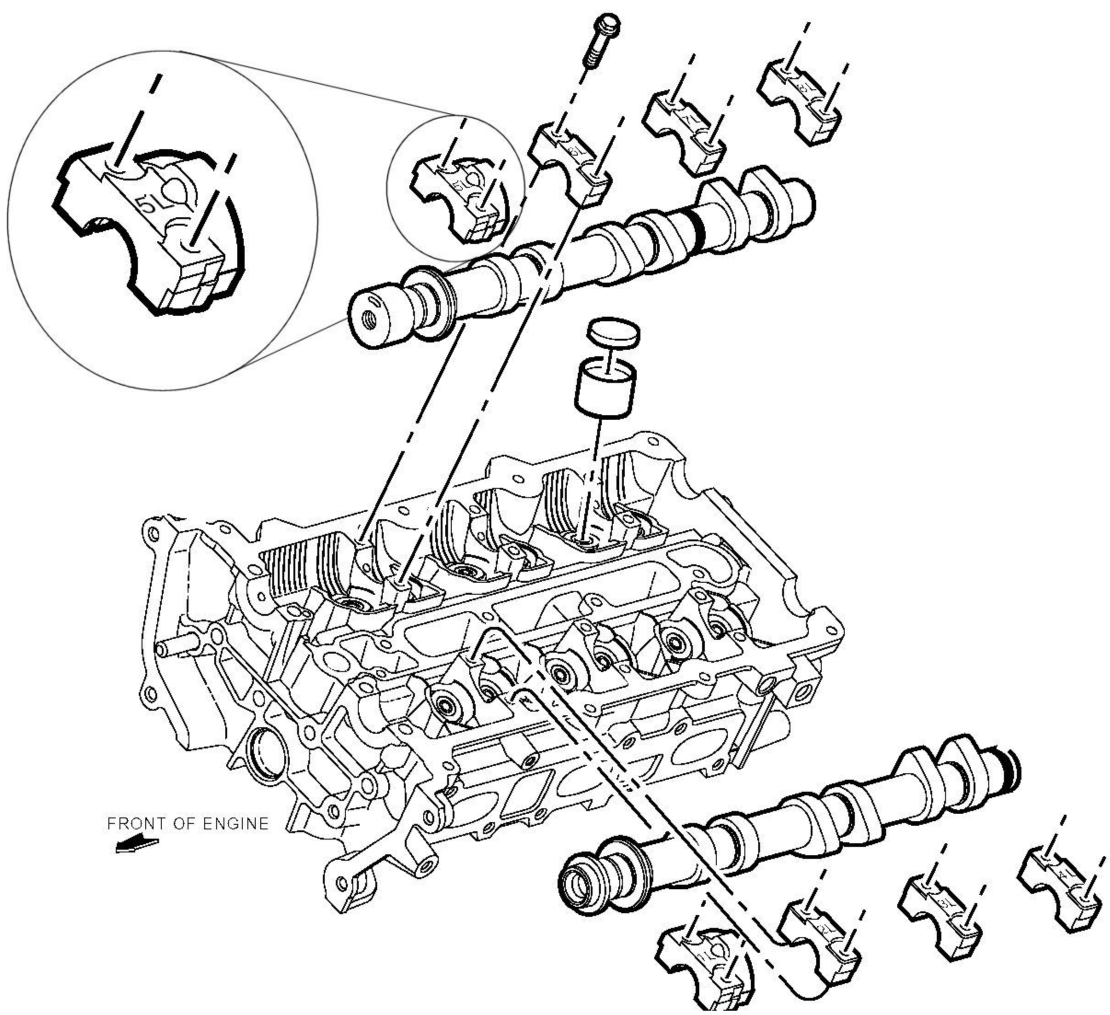


61. Apply EP90 lubricant on the following components before assembly: Valve lifters, Valve adjusting shims, Camshaft lobes, Camshaft lower bearings, Camshaft bearing caps.

62. Inspect and install the Bank 2 valve gear and camshafts. Use the camshaft procedure from the assembly' section of your reference guide for detailed assembly instructions, following proper torque sequence.

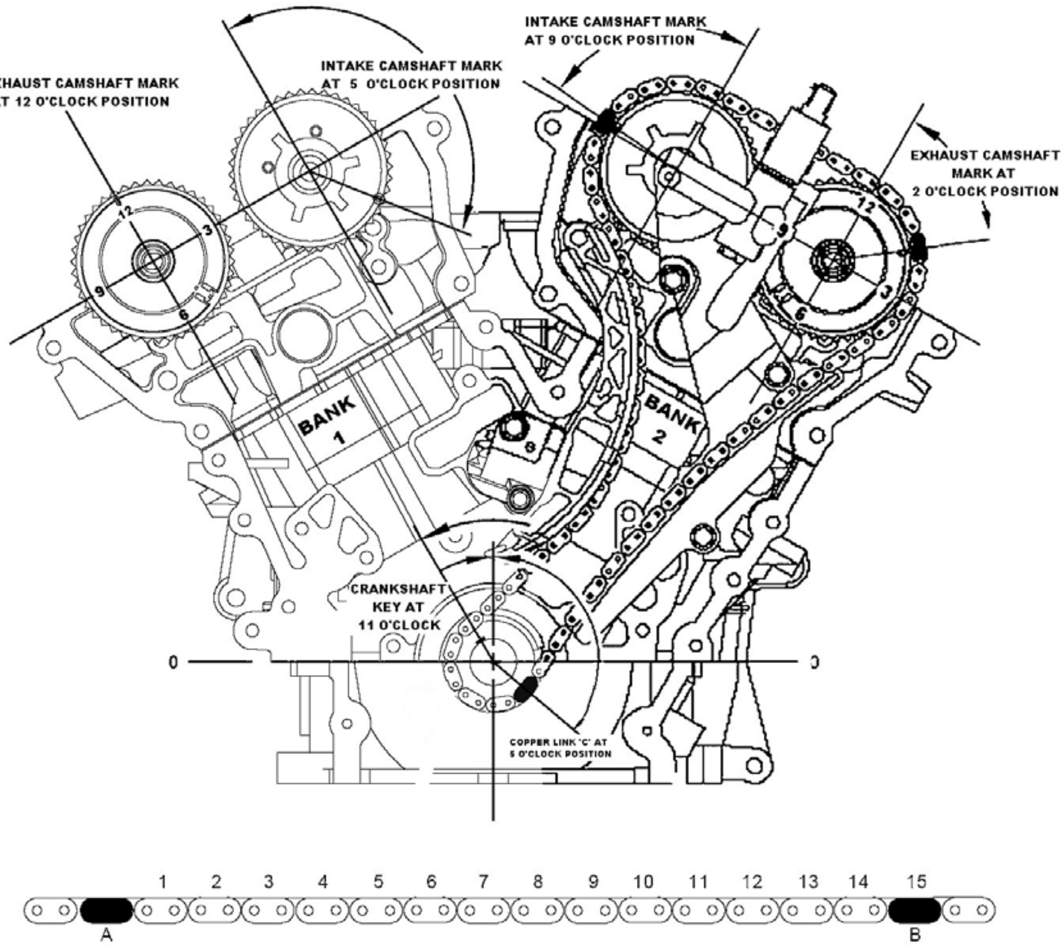
NOTE: Before installing the camshaft bearing caps, orient the camshafts such that all valves will be closed once the bearing caps are secured.

Be sure that the bearing caps are oriented correctly, as they are not symmetric, top to bottom.



63. Install chain guides, bush carrier and tensioner for bank 2.

64. Install the bank 2 timing chain and align proper timing:



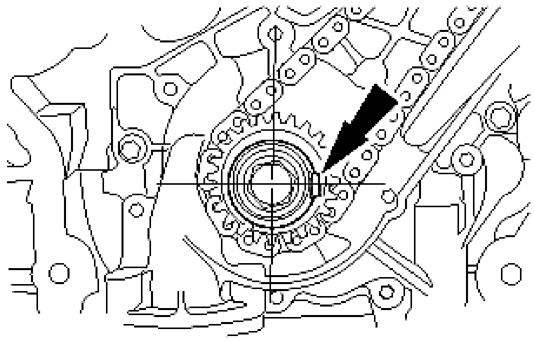
NOTE:

1. COUNT WHOLE LINKS CLOCKWISE STARTING WITH THE LINK IMMEDIATELY TO THE LEFT OF LINK (A) (COPPER LINK) & INCLUDE THE NEXT (COPPER) LINK (B) IN THE TOTAL TO ACHIEVE **15 LINKS.**

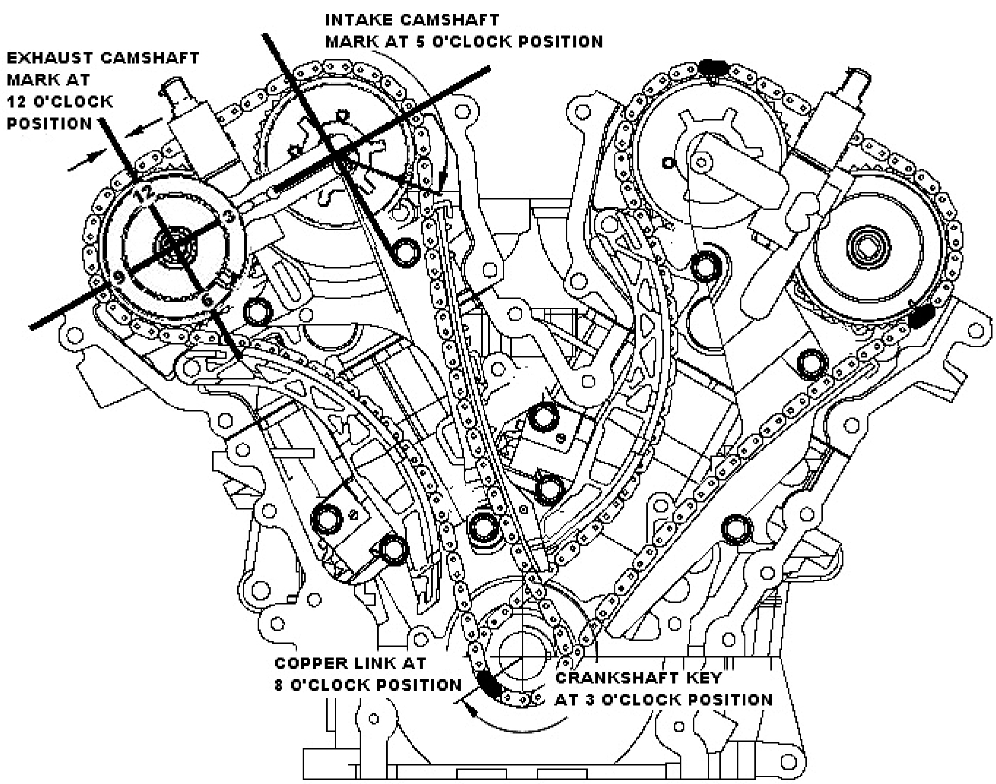
2. COUNT WHOLE LINKS CLOCKWISE STARTING WITH THE LINK IMMEDIATELY TO THE LEFT OF LINK (B) (COPPER LINK) & INCLUDE THE NEXT (COPPER) LINK (C) IN THE TOTAL TO ACHIEVE **24 LINKS.**

INSTRUCTOR CHECK POINT 7 ____

65. Position the crankshaft keyway to the 3 o'clock position in preparation to install the bank 1 camshafts as shown below:



66. Install the bank 1 camshafts, using the marks on the **front** of the camshaft sprockets to determine proper orientation **before** installing bearing caps.



67. Install bank 1 chain guides, bush carrier, tensioner, and chain. Adjust and verify camshaft for the specified timing.

INSTRUCTOR CHECK POINT 8 ____

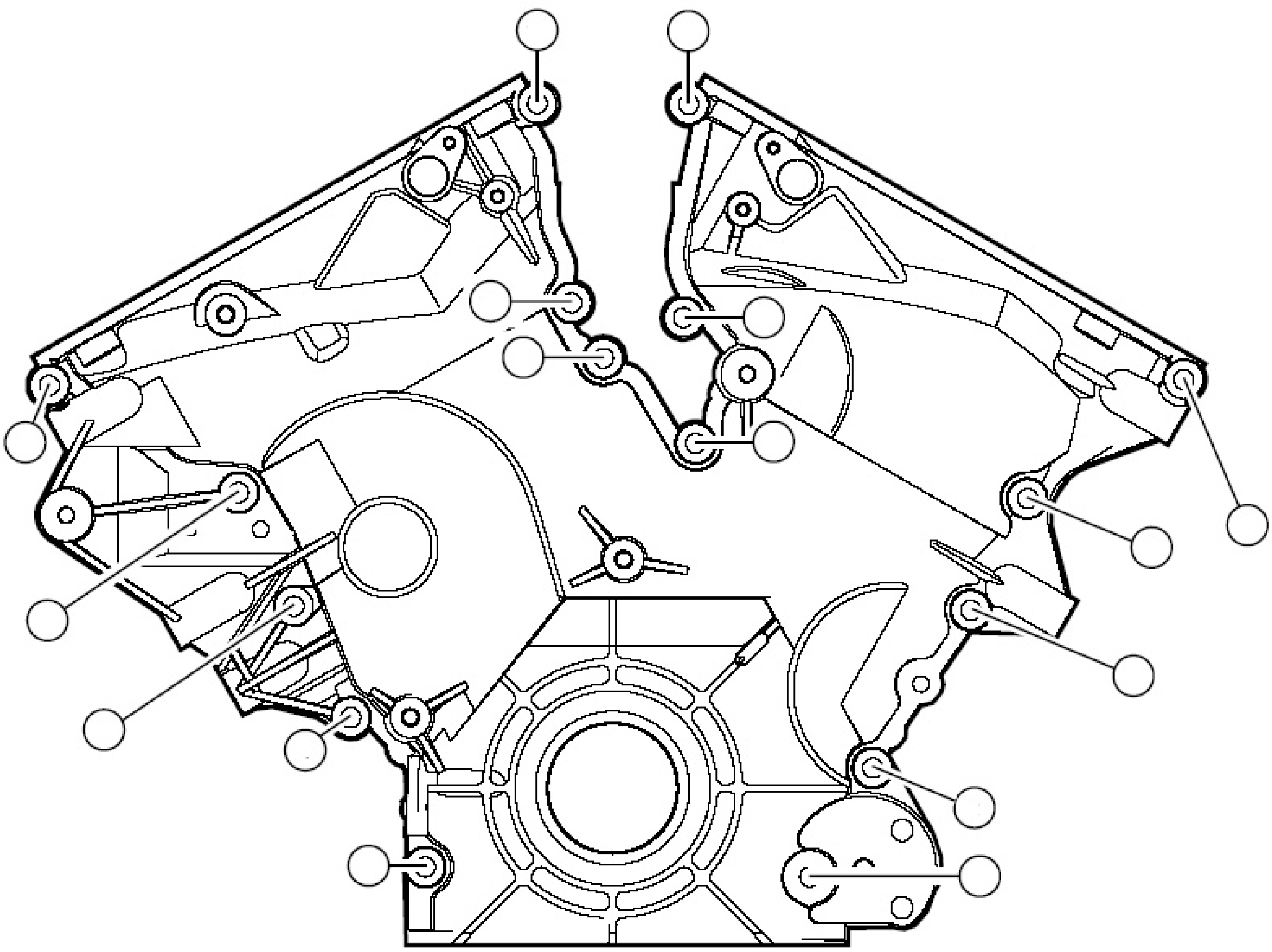
68. Install the crankshaft position sensor pulse wheel.

Which keyway is used for AJ61? ________________________________

Which keyway is used for AJ62? ________________________________

Do the teeth face the front or rear of the engine? ________________

69. Install the timing cover. Fill in the appropriate torque sequence, and mark the proper location for sealant application.



70. Install the front seal following the process described in the 'In-vehicle repair' section of your workshop manual.

NOTE: Be sure to apply sealant to the keyway, as noted in the 'In-vehicle repair' section of the workshop manual. Failure to do so may result in an oil leak.

71. Install vibration damper, using special tools 303-335/1 and 303-335/2. Do NOT use 303-542, as shown in the 'In-vehicle repair' section of the workshop manual.

72. What is the acceptable range for intake and exhaust valve clearance:

Intake Max.	Intake Min.	Exhaust Max.	Exhaust Min.
____________	____________	____________	____________

73. Measure and record valve clearances.

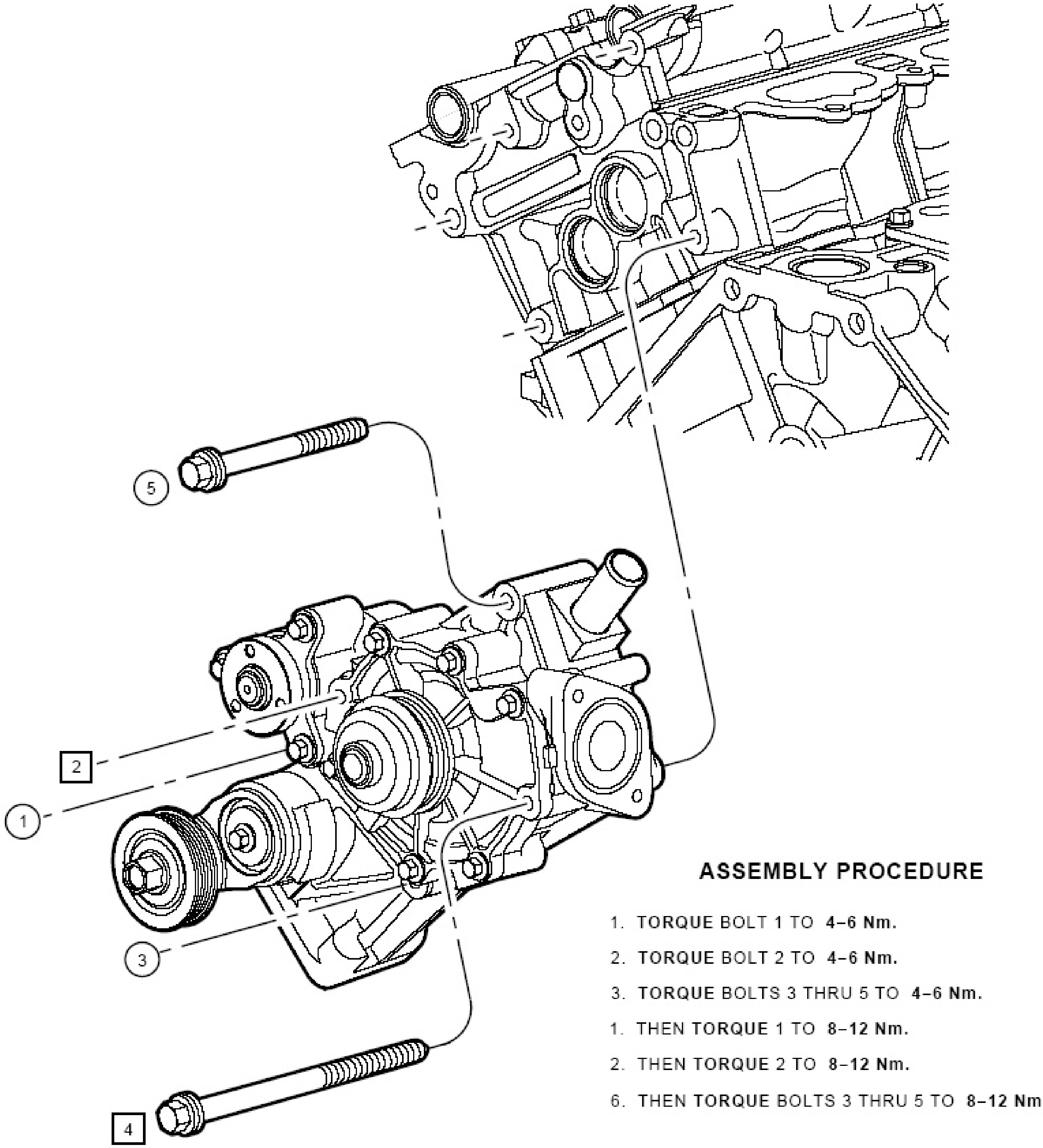
Cyl.	Intake Front	Intake Rear	Exhaust Front	Exhaust Rear
1				
2				
3				
4				
5				
6				

If valve clearances required readjustment, adjust, rotate engine at least three times and re-measure clearances. Record final valve clearances.

Cyl.	Intake Front	Intake Rear	Exhaust Front	Exhaust Rear
1				
2				
3				
4				
5				
6				

INSTRUCTOR CHECK POINT 9____

74. On AJ61, install the water pump assembly, following the torque sequence shown below:



75. Install the oil pan.

76. Continue following the workshop manual, and install camshaft covers, EOP, EOT and CHT sensors.

77. Install exhaust manifolds and oil level indicator tube.

78. Install waterpump (AJ62) and coolant hose assembly.

79. Install the accessory drive belt tensioner and accessory drive belt idler.

What is the torque specification for the tensioner bolt? ______________________

80. Continue to assemble the engine in the order outlined in the workshop manual. Notify your instructor for the final checkpoint when complete.

INSTRUCTOR CHECK POINT 10 ____

If your instructor signed off on checkpoint 11, then: Congratulations – you have completed the assembly of the AJ61 or AJ62 engine.