

Chapter 2 Part B

Engine removal and overhaul procedures

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Degrees of difficulty

Easy, suitable for novice with little experience 	Fairly easy, suitable for beginner with some experience 	Fairly difficult, suitable for competent DIY mechanic 	Difficult, suitable for experienced DIY mechanic 	Very difficult, suitable for expert DIY or professional 
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Specifications

General

Cylinder compression pressure @ 300 rpm, warm	
Standard	10.6 to 11.3 bar (150 to 160 psi)
High compression models	11.3 to 12.1 bar (160 to 170 psi)
Maximum variation between cylinders	0.8 bar (10 psi)
Oil pressure (engine warm)	
At idle	2.1 bar (30 psi) minimum
At 4000 rpm	4.9 bar (70 psi) minimum

Cylinder head

Resurfacing limit	0.25 mm (0.010 inch) maximum
Minimum thickness (see text)	
3.6 litre	129.6 mm (5.101 inches)
3.2 and 4.0 litre	129.7 mm (5.108 inches)

Valves and related components

Valve stem-to-guide clearance	0.038 to 0.076 mm (0.0015 to 0.0030 inch)
Valve springs, free length	40.13 mm (1.580 inches)
Valve lifter	
Diameter	33.34 to 33.35 mm (1.3126 to 1.3130 inches)
Lifter-to-bore clearance	0.02 to 0.05 mm (0.0008 to 0.0020 inch)

Crankshaft and connecting rods

Connecting rod journal	
Diameter	52.97 to 52.99 mm (2.0856 to 2.0861 inches)
Taper and out-of-round limits	0.008 mm (0.0003 inch) maximum
Bearing oil clearance	
3.6 litre	0.040 to 0.083 mm (0.0016 to 0.0033 inch)
3.2 and 4.0 litre	0.025 to 0.0068 mm (0.0010 to 0.0027 inch)
Connecting rod side clearance (endplay)	0.127 to 0.228 mm (0.005 to 0.009 inch)
Main bearing journal	
Diameter	76.217 to 76.233 mm (3.0007 to 3.0012 inches)
Taper and out-of-round limits	0.008 mm (0.0003 inch) maximum
Bearing oil clearance	0.040 to 0.083 mm (0.0016 to 0.0033 inch)
Crankshaft endplay (standard)	0.101 to 0.254 mm (0.004 to 0.010 inch)

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Engine block

Deck warpage limit	0.076 mm (0.003 inch)
Cylinder bore diameter	
Standard	
Size group A	90.990 to 91.003 mm (3.5823 to 3.5828 inches)
Size group B	91.005 to 91.018 mm (3.5829 to 3.5834 inches)
Oversize	
0.25 mm (0.010 inch) OS	91.259 to 91.272 mm (3.5929 to 3.5934 inches)
0.50 mm (0.020 inch) OS	91.513 to 91.526 mm (3.6029 to 3.6034 inches)

Pistons and rings

Piston-to-bore clearance	0.017 to 0.043 mm (0.0007 to 0.0017 inch)
Piston ring end gap	
No.1 (top) compression ring	0.40 to 0.66 mm (0.016 to 0.026 inch)
No.2 (middle) compression ring	0.40 to 0.66 mm (0.016 to 0.026 inch)
Oil ring	0.30 to 0.55 mm (0.012 to 0.022 inch)
Piston ring groove clearance	
No. 1 (top) compression ring	0.040 to 0.076 mm (0.0016 to 0.0030 inch)
No. 2 (middle) compression ring	0.040 to 0.076 mm (0.0016 to 0.0030 inch)

Torque wrench settings

	Nm	lbf ft
Main bearing cap bolts	136 to 142	100 to 105
Connecting rod cap nuts	50 to 60	37 to 44

* **Note:** Refer to Part A for additional torque specifications.

1 General information

Included in this portion of Chapter 2 are the general overhaul procedures for the cylinder head and internal engine components.

The information ranges from advice concerning preparation for an overhaul and the purchase of replacement parts to detailed, step-by-step procedures covering removal and refitting of internal engine components and the inspection of parts.

The following Sections have been written based on the assumption that the engine has been removed from the vehicle. For information concerning in-vehicle engine repair, as well as removal and refitting of the external components necessary for the overhaul, see Part A of this Chapter.

The Specifications included in this Part are only those necessary for the inspection and overhaul procedures which follow. Refer to Part A for additional Specifications.

service. Conversely, a neglected engine may require an overhaul very early in its life.

Excessive oil consumption is an indication that piston rings, valve seals and/or valve guides are in need of attention. Make sure that oil leaks aren't responsible before deciding that the rings and/or guides are bad. Perform a cylinder compression check to determine the extent of the work required (see Section 4). Also check the vacuum readings under various conditions (see Section 3).

Check the oil pressure with a gauge installed in place of the oil pressure sender unit (see illustrations) and compare it to this Chapter's Specifications. If it's extremely low, the bearings and/or oil pump are probably worn out.

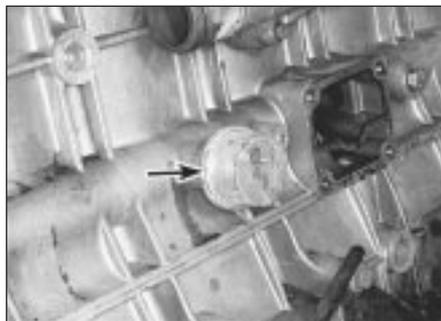
Loss of power, rough running, knocking or metallic engine noises, excessive valve train noise and high fuel consumption rates may also point to the need for an overhaul, especially if they're all present at the same time. If a complete tune-up doesn't remedy the situation, major mechanical work is the only solution.

An engine overhaul involves restoring the internal parts to the specifications of a new engine. During an overhaul, the piston rings are replaced and the cylinder walls are reconditioned (rebored and/or honed). If a rebore is done by an automotive machine workshop, new oversize pistons will also be installed. The main bearings, big-end bearings and camshaft bearings are generally replaced with new ones and, if necessary, the crankshaft may be reground to restore the journals. Generally, the valves are serviced as well, since they're usually in less-than-perfect condition at this point. While the engine is being overhauled, other components, such as the distributor, starter and alternator, can be rebuilt as well. The end result should be a like new engine that will give many trouble free miles. **Note:** *Critical cooling system components such as the hoses, drivebelts, thermostat and water pump should be replaced with new parts when an engine is overhauled. The radiator should be checked carefully to ensure that it isn't clogged or leaking (see Chapter 3). If you purchase a*

2 Engine overhaul - general information

It's not always easy to determine when, or if, an engine should be completely overhauled, as a number of factors must be considered.

High mileage is not necessarily an indication that an overhaul is needed, while low mileage doesn't preclude the need for an overhaul. Frequency of servicing is probably the most important consideration. An engine that's had regular and frequent oil and filter changes, as well as other required maintenance, will most likely give many thousands of miles of reliable



2.4a The oil pressure sender unit (arrowed) is located in the right front corner of the engine block, near the oil filter



2.4b The oil pressure can be checked by removing the sender unit and refitting a pressure gauge in its place

rebuilt engine or short block, some rebuilders will not warranty their engines unless the radiator has been professionally flushed. Also, we don't recommend overhauling the oil pump - always refit a new one when an engine is rebuilt.

Before beginning the engine overhaul, read through the entire procedure to familiarise yourself with the scope and requirements of the job. Overhauling an engine isn't difficult, but it is time-consuming. Plan on the vehicle being tied up for a minimum of two weeks, especially if parts must be taken to an automotive machine workshop for repair or reconditioning. Check on availability of parts and make sure that any necessary special tools and equipment are obtained in advance. Most work can be done with typical hand tools, although a number of precision measuring tools are required for inspecting parts to determine if they must be renewed. Often an automotive machine workshop will handle the inspection of parts and offer advice concerning reconditioning and renewal. **Note:** Always wait until the engine has been completely dismantled and all components, especially the engine block, have been inspected before deciding what service and repair operations must be performed by an automotive machine workshop. Since the engine block's condition will be the major factor to consider when determining whether to overhaul the original engine or buy a rebuilt one, never purchase parts or have machine work done on other components until the engine block has been thoroughly inspected. As a general rule, time is the primary cost of an overhaul, so it doesn't pay to refit worn or substandard parts.

If it turns out that a number of major components are beyond reconditioning, it may be cost effective to buy a factory-rebuilt engine from a Jaguar dealership.

As a final note, to ensure maximum life and minimum trouble from a rebuilt engine, everything must be assembled with care in a spotlessly-clean environment.

3 Vacuum gauge diagnostic checks



A vacuum gauge provides valuable information about what is going on in the engine at a low cost. You can check for worn rings or cylinder walls, leaking cylinder head or intake manifold gaskets, incorrect carburettor adjustments, restricted exhaust, stuck or burned valves, weak valve springs, improper ignition or valve timing and ignition problems.

Unfortunately, vacuum gauge readings are easy to misinterpret, so they should be used with other tests to confirm the diagnosis.

Both the absolute readings and the rate of needle movement are important for accurate interpretation. Most gauges measure vacuum



3.4 The vacuum gauge is easily attached to a port on the intake manifold, and can tell a lot about an engine's state of tune

in inches of mercury (in-Hg). As vacuum increases (or atmospheric pressure decreases), the reading will decrease. Also, for every 1000 foot increase in elevation above sea level; the gauge readings will decrease about one inch of mercury.

Connect the vacuum gauge directly to intake manifold vacuum, not to ported (above the throttle plate) vacuum (see illustration). Be sure no hoses are left disconnected during the test or false readings will result.

Before you begin the test, allow the engine to warm up completely. Block the wheels and set the handbrake. With the transmission in Park, start the engine and allow it to run at normal idle speed.



Warning: Carefully inspect the fan blades for cracks or damage before starting the engine. Keep your hands and the vacuum

tester clear of the fan and do not stand in front of the vehicle or in line with the fan when the engine is running.

Read the vacuum gauge; an average, healthy engine should normally produce between 17 and 22 inches of vacuum with a fairly steady needle.

Refer to the following vacuum gauge readings and what they indicate about the engines condition:

1 A low steady reading usually indicates a leaking gasket between the intake manifold and carburettor or throttle body, a leaky vacuum hose, late ignition timing or incorrect camshaft timing. Check ignition timing with a timing light and eliminate all other possible causes, utilising the tests provided in this Chapter before you remove the timing belt cover to check the timing marks.

2 If the reading is three to eight inches below normal and it fluctuates at that low reading, suspect an intake manifold gasket leak at an intake port or a faulty injector.

3 If the needle has regular drops of about two to four inches at a steady rate the valves are probably leaking. Perform a compression or leak-down test to confirm this.

4 An irregular drop or down-flick of the needle can be caused by a sticking valve or an ignition misfire. Perform a compression or leak-down test and read the spark plugs.

5 A rapid vibration of about four in-Hg vibration at idle combined with exhaust smoke indicates worn valve guides. Perform a leak-down test to confirm this. If the rapid vibration occurs with an increase in engine speed, check for a leaking intake manifold gasket or cylinder head gasket, weak valve springs, burned valves or ignition misfire.

6 A slight fluctuation, say one inch up and down, may mean ignition problems. Check all the usual tune-up items and, if necessary, run the engine on an ignition analyser.

7 If there is a large fluctuation, perform a compression or leak-down test to look for a weak or dead cylinder or a blown cylinder head gasket.

8 If the needle moves slowly through a wide range, check for a clogged PCV system, incorrect idle fuel mixture, throttle body or intake manifold gasket leaks.

9 Check for a slow return after revving the engine by quickly snapping the throttle open until the engine reaches about 2,500 rpm and let it shut. Normally the reading should drop to near zero, rise above normal idle reading (about 5 in.-Hg over) and then return to the previous idle reading. If the vacuum returns slowly and doesn't peak when the throttle is snapped shut, the rings may be worn. If there is a long delay, look for a restricted exhaust system (often the silencer or catalytic converter). An easy way to check this is to temporarily disconnect the exhaust ahead of the suspected part and redo the test.

4 Cylinder compression check



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1 A compression check will tell you what mechanical condition the upper end (pistons, rings, valves, cylinder head gasket) of your engine is in. Specifically, it can tell you if the compression is down due to leakage caused by worn piston rings, defective valves and seats or a blown cylinder head gasket. **Note:** The engine must be at normal operating temperature and the battery must be fully charged for this check.

2 Begin by cleaning the area around the spark plugs before you remove them (compressed air should be used, if available, otherwise a small brush or even a bicycle tyre pump will work). The idea is to prevent dirt from getting into the cylinders as the compression check is being done.

3 Remove all of the spark plugs from the engine (see Chapter 1).

4 Block the throttle wide open.

5 Detach the coil wire from the centre of the distributor cap and ground it on the engine block. Use a jumper wire with alligator clips on each end to ensure a good earth. Also, remove the fuel pump relay (see Chapter 4) to disable the fuel pump during the compression test.



4.6 A compression gauge with a threaded fitting for the spark plug hole is preferred over the type that requires hand pressure to maintain the seal - be sure to block open the throttle valve as far as possible during the compression check!

6 Refit the compression gauge in the spark plug hole (see illustration).

7 Crank the engine over at least seven compression strokes and watch the gauge. The compression should build up quickly in a healthy engine. Low compression on the first stroke, followed by gradually increasing pressure on successive strokes, indicates worn piston rings. A low compression reading on the first stroke, which doesn't build up during successive strokes, indicates leaking valves or a blown cylinder head gasket (a cracked cylinder head could also be the cause). Deposits on the undersides of the valve heads can also cause low compression. Record the highest gauge reading obtained.

8 Repeat the procedure for the remaining cylinders and compare the results to this Chapter's Specifications.

9 Add some engine oil (about three squirts from a plunger-type oil can) to each cylinder, through the spark plug hole, and repeat the test.

10 If the compression increases after the oil is added, the piston rings are definitely worn. If the compression doesn't increase significantly, the leakage is occurring at the valves or cylinder head gasket. Leakage past the valves may be caused by burned valve seats and/or faces or warped, cracked or bent valves.

11 If two adjacent cylinders have equally low compression, there's a strong possibility that the cylinder head gasket between them is blown. The appearance of coolant in the combustion chambers or the crankcase would verify this condition.

12 If one cylinder is 20 percent lower than the others, and the engine has a slightly rough idle, a worn exhaust lobe on the camshaft could be the cause.

13 If the compression is unusually high, the combustion chambers are probably coated with carbon deposits. If that's the case, the cylinder head(s) should be removed and decarbonised.

14 If compression is way down or varies greatly between cylinders, it would be a good

idea to have a leak-down test performed by an automotive repair workshop. This test will pinpoint exactly where the leakage is occurring and how severe it is.

5 Engine removal - methods and precautions

If you've decided that an engine must be removed for overhaul or major repair work, several preliminary steps should be taken.

Locating a suitable place to work is extremely important. Adequate work space, along with storage space for the vehicle, will be needed. If a workshop or garage isn't available, at the very least a flat, level, clean work surface made of concrete or asphalt is required.

Cleaning the engine compartment and engine before beginning the removal procedure will help keep tools clean and organised.

An engine hoist or A-frame will also be necessary. Make sure the equipment is rated in excess of the combined weight of the engine and transmission. Safety is of primary importance, considering the potential hazards involved in lifting the engine out of the vehicle.

If the engine is being removed by a novice, a helper should be available. Advice and aid from someone more experienced would also be helpful. There are many instances when one person cannot simultaneously perform all of the operations required when lifting the engine out of the vehicle.

Plan the operation ahead of time. Arrange for or obtain all of the tools and equipment you'll need prior to beginning the job. Some of the equipment necessary to perform engine removal and refitting safely and with relative ease are (in addition to an engine hoist) a heavy duty trolley jack, complete sets of spanners and sockets as described in the front of this manual, wooden blocks and plenty of rags and cleaning solvent for mopping up spilled oil, coolant and petrol. If the hoist must be rented, make sure that you arrange for it in advance and perform all of the operations possible without it beforehand. This will save you money and time.

Plan for the vehicle to be out of use for quite a while. A machine workshop will be required to perform some of the work which the do-it-yourselfer can't accomplish without special equipment. These shops often have a busy schedule, so it would be a good idea to consult them before removing the engine in order to accurately estimate the amount of time required to rebuild or repair components that may need work.

Always be extremely careful when removing and refitting the engine. Serious injury can result from careless actions. Plan ahead, take your time and a job of this nature, although major, can be accomplished successfully.

6 Engine - removal and refitting



Note: Read through the entire Section before beginning this procedure. It is recommended to remove the engine and transmission from the top as a unit, then separate the engine from the transmission on the workshop floor. If the transmission is not being serviced, it is possible to leave the transmission in the vehicle and remove the engine from the top by itself, by removing the crankshaft damper and tilting up the front end of the engine for clearance, but access to the upper bellhousing bolts is only practical when the rear transmission mount and driveshaft have been removed and the transmission is angled down with a trolley jack.

Removal

1 Relieve the fuel system pressure (see Chapter 4).

2 Disconnect the battery negative cable.

Caution: If the stereo in your vehicle is equipped with an anti-theft system, make sure you have the correct activation code before disconnecting the battery.

3 Place protective covers on the wings and cowl and remove the bonnet (see Chapter 11).

4 Remove the battery and battery tray.

5 Remove the air cleaner assembly (see Chapter 4).

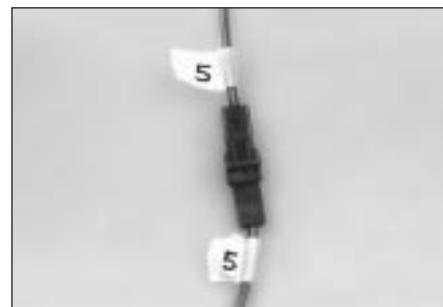
6 Raise the vehicle and support it securely on axle stands. Drain the cooling system and engine oil and remove the drivebelts (see Chapter 1).

7 Clearly label, then disconnect all vacuum lines, coolant and emissions hoses, wiring harness connectors and earth straps. Masking tape and/or a touch up paint applicator work well for marking items (see illustration). Take instant photos or sketch the locations of components and brackets.

8 Remove the cooling fan(s) and radiator (see Chapter 3).

9 Disconnect the heater hoses.

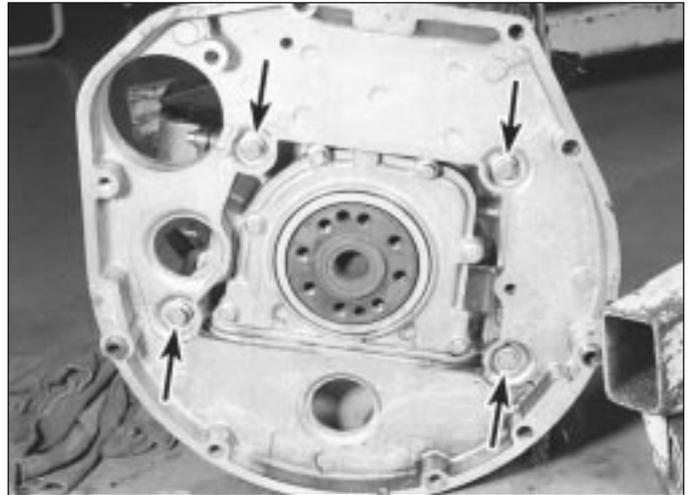
10 Release the residual fuel pressure in the tank by removing the petrol cap, then detach the fuel lines connecting the engine to the chassis (see Chapter 4). Plug or cap all open fittings.



6.7 Label both ends of each wire and hose before disconnecting it



6.20 Lift the engine high enough to clear the vehicle, tilting it up at the front to clear the front crossmember, then move it away and lower the hoist



6.21 With the engine on the floor but still supported by the hoist, remove the four large bolts (arrowed) and pull off the transmission adapter plate

11 Disconnect the throttle linkage, transmission linkage (and dipstick tube) and speed control cable, if equipped, from the engine (see Chapters 4 and 7).

12 Refer to Part A of this Chapter and remove the intake and exhaust manifolds.

13 Unbolt the power steering pump (see Chapter 10). Tie the pump aside without disconnecting the hoses. Refer to Part A for removal of the hydraulic pump (if equipped) from the timing chain cover.

14 On air-conditioned models, unbolt the compressor and set it aside. Do not disconnect the refrigerant hoses. **Note:** *Wire the compressor out of the way with a coat hanger, don't let the compressor hang on the hoses.*

15 Refer to Part A of this Chapter and remove the drivebelts, water pump pulley and crankshaft pulley.

16 Attach a lifting sling to the engine. Position a hoist and connect the sling to it. Take up the slack until there is slight tension on the hoist.

17 With a trolley jack and piece of wood supporting the bottom of the transmission sump, refer to Chapter 8 and remove the driveshaft and rear transmission mount.



Warning: *Do not place any part of your body under the engine/transmission when it's supported only by a hoist or other lifting device.*

18 With the hoist taking the weight of the engine, unbolt the engine mounts (see Part A of this Chapter).

19 Recheck to be sure nothing is still connecting the engine or transmission to the vehicle. Disconnect and label anything still remaining.

20 Slowly lift the engine/transmission out of the vehicle (see illustration). It may be necessary to pry the mounts away from the frame brackets.

21 Move the engine away from the vehicle and carefully lower the hoist until the engine/transmission can be set on the floor. Refer to Chapter 7 and remove the transmission and converter. Refer to Part A of this Chapter for removal of the flywheel. With the flywheel removed, remove the four large bolts and the transmission adapter plate from the engine (see illustration).

22 Refer to Part A of this Chapter for removal of the rear main seal retainer plate from the back of the engine, then lift the engine to a position where it can be attached to a sturdy engine stand.

Refitting

23 Check the engine/transmission mounts. If they're worn or damaged, renew them.

24 Attach the hoist and remove the engine from the stand. Refer to Part A of this Chapter and renew the rear main seal and retainer plate, then reattach the transmission adapter plate and refer to Chapter 7 for mounting the converter and transmission.

25 Carefully lower the engine into the vehicle with the hoist. An assistant is helpful to guide the engine clear of accessories in the engine compartment as the engine is lowered into place.

26 Refit the engine mount bolts and tighten them securely. Raise the back of the transmission with the trolley jack and reattach the transmission mount, driveshaft and shift linkage.

27 Refit the remaining components and fasteners in the reverse order of removal.

28 Add coolant, oil, power steering and transmission fluids as needed (see Chapter 1).

29 Run the engine and check for proper operation and leaks. Shut off the engine and recheck the fluid levels.

7 Engine rebuilding alternatives

The do-it-yourselfer is faced with a number of options when performing an engine overhaul. The decision to renew the engine block, piston/connecting rod assemblies and crankshaft depends on a number of factors, with the number one consideration being the condition of the engine block. Other considerations are cost, access to machine workshop facilities, parts availability, time required to complete the project and the extent of prior mechanical experience on the part of the do-it-yourselfer.

Some of the rebuilding alternatives include:

Individual parts - If the inspection procedures reveal that the engine block and most engine components are in reusable condition, purchasing individual parts may be the most economical alternative. The engine block, cylinder head, crankshaft, and piston/connecting rod assemblies should all be inspected carefully. Even if the engine block shows little wear, the cylinder bores should be surface honed.

Short block - A short block consists of an engine block with a crankshaft and piston/connecting rod assemblies already installed. All new bearings are incorporated and all clearances will be correct. The existing camshafts, valve train components, cylinder head and external parts can be bolted to the short block with little or no machine workshop work necessary.

Long block - A long block consists of a short block plus an oil pump, sump, cylinder head, valve cover, camshaft and valve train components, timing sprockets and chain or gears and timing cover. All components are installed with new bearings, seals and gaskets

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incorporated throughout. The refitting of manifolds and external parts is all that's necessary. Engines in this rebuilt form are available from Jaguar dealers, and some independent rebuilders.

Give careful thought to which alternative is best for you and discuss the situation with local automotive machine shops, auto parts dealers and experienced rebuilders before ordering or purchasing replacement parts.

8 Engine overhaul - dismantling sequence

1 It's much easier to dismantle and work on the engine if it's mounted on a portable engine stand. A stand can often be rented quite cheaply from an equipment rental yard. Before the engine is mounted on a stand, the driveplate and rear oil seal retainer should be removed from the engine.

2 If a stand isn't available, it's possible to dismantle the engine with it blocked up on the floor. Be extra careful not to tip or drop the engine when working without a stand.

3 If you're going to obtain a rebuilt engine, all external components must come off first, to be transferred to the replacement engine, just as they will if you're doing a complete engine overhaul yourself. These include:

- Alternator and brackets
- Emissions control components
- Distributor, spark plug leads and spark plugs
- Thermostat and housing cover
- Water pump
- EFI components
- Intake/exhaust manifolds
- Oil filter
- Engine mounts
- Driveplate
- Transmission adapter plate

Note: When removing the external components from the engine, pay close attention to details that may be helpful or important during refitting. Note the installed position of gaskets, seals, spacers, pins, brackets, washers, bolts and other small items.

4 If you're obtaining a short block, which consists of the engine block, crankshaft, pistons and connecting rods all assembled, then the cylinder head, sump and oil pump will have to be removed as well from your engine so that your short-block can be turned in to the rebuilder as a core. See *Engine rebuilding alternatives* for additional information regarding the different possibilities to be considered.

5 If you're planning a complete overhaul, the engine must be dismantled and the internal components removed in the following order:

- Intake and exhaust manifolds
- Valve cover
- Upper timing chain and camshaft sprockets

- Camshafts
- Timing chain cover
- Cylinder head
- Sump
- Oil pump
- Piston/connecting rod assemblies
- Crankshaft rear oil seal retainer
- Crankshaft and main bearings

6 Before beginning the dismantling and overhaul procedures, make sure the following items are available. Also, refer to Section 21 for a list of tools and materials needed for engine reassembly.

- Common hand tools
- Small cardboard boxes or plastic bags for storing parts
- Gasket scraper
- Ridge reamer
- Micrometers
- Telescoping gauges
- Dial indicator set
- Valve spring compressor
- Cylinder surfacing hone
- Piston ring groove-cleaning tool
- Electric drill motor
- Tap and die set
- Wire brushes
- Oil gallery brushes
- Cleaning solvent

Special Jaguar tools

- Engine lifting brackets (18G 1465)
- Timing damper simulator (18E 1436)
- Camshaft TDC tool (18G 1433)

9 Cylinder head - dismantling

Note: New and rebuilt cylinder heads are available from Jaguar and some independent rebuilders. Due to the fact that some specialised tools are necessary for the dismantling and inspection procedures, and replacement parts may not be readily available, it may be more practical and economical for the home mechanic to purchase a replacement cylinder head rather than taking the time to dismantle, inspect and recondition the original.



9.2 A small plastic bag, with an appropriate label, can be used to store the valve train components so they can be kept together and reinstalled in the correct guide

1 Cylinder head dismantling involves removal of the intake and exhaust valves and related components. It's assumed that the lifters and camshafts have already been removed (see Part A as needed).

2 Before the valves are removed, arrange to label and store them, along with their related components, so they can be kept separate and reinstalled in the same valve guides they are removed from (see illustration).

3 Compress the springs on the first valve with a spring compressor and remove the keepers (see illustration). Carefully release the valve spring compressor and remove the retainer, the spring and the spring seat (if used). **Note:** If your spring compressor does not have an end (such as the one shown) with cut-outs on the side, an adapter is available to use with a standard spring compressor.

Caution: Be very careful not to nick or otherwise damage the lifter bores when compressing the valve springs.

4 Pull the valve out of the cylinder head, then remove the oil seal from the guide. If the valve binds in the guide (won't pull through), push it back into the cylinder head and deburr the area around the keeper groove with a fine file or whetstone.

5 Repeat the procedure for the remaining valves. Remember to keep all the parts for each valve together so they can be reinstalled in the same locations.

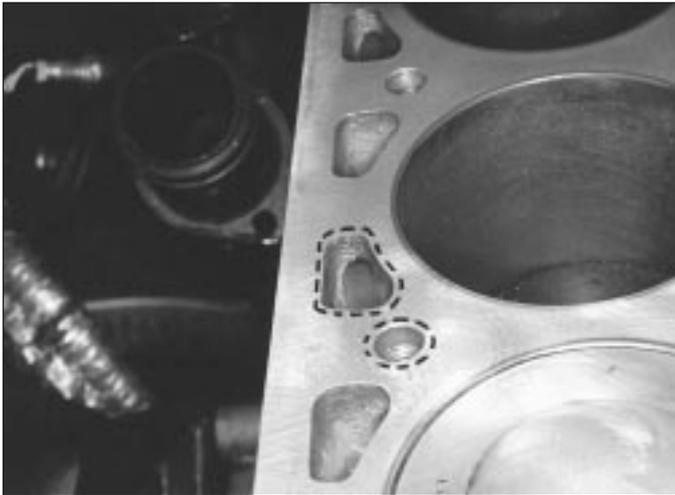
6 Once the valves and related components have been removed and stored in an organised manner, the cylinder head should be thoroughly cleaned and inspected. If a complete engine overhaul is being done, finish the engine dismantling procedures before beginning the cylinder head cleaning and inspection process.

10 Cylinder head - cleaning and inspection

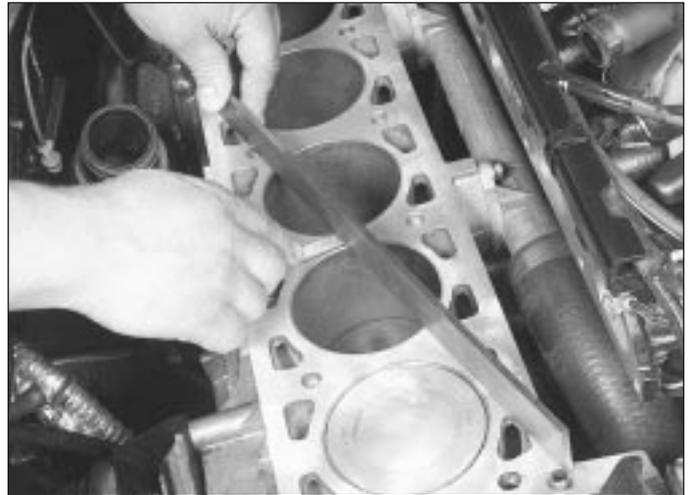
1 Thorough cleaning of the cylinder head(s) and related valve train components, followed by a detailed inspection, will enable you to decide how much valve service work must be



9.3 Compress the spring until the keepers can be removed with a small magnetic screwdriver or needle-nose pliers - use a valve spring compressor with an adapter (arrowed) to remove the keepers



10.12 Place the new head gasket on the engine block, and trace around the water passages and bolt holes - make sure there is no erosion of the aluminium beyond these lines



10.13 Check the cylinder head and engine block gasket surfaces for warpage by trying to slip a feeler gauge under a precision straightedge (see the Specifications for the maximum warpage allowed and use a feeler gauge of that thickness) - check both the cylinder head and engine block (shown)

done during the engine overhaul. **Note:** *If the engine was severely overheated, the cylinder head is probably warped* (see paragraph 12).

Cleaning

2 Scrape all traces of old gasket material and sealing compound off the cylinder head gasket, intake manifold and exhaust manifold sealing surfaces. Be very careful not to gouge the cylinder head. Special gasket-removal solvents that soften gaskets and make removal much easier are available at car accessory outlets.

3 Remove all built up scale from the coolant passages.

4 Run a stiff wire brush through the various holes to remove deposits that may have formed in them. If there are heavy deposits in the water passages, the bare head should be professionally cleaned at a machine workshop.

5 Run an appropriate-size tap into each of the threaded holes to remove corrosion and any thread sealant that may be present. If compressed air is available, use it to clear the holes of debris produced by this operation.



Warning: *Wear eye protection when using compressed air!*

6 Clean the exhaust and intake manifold stud threads with a wire brush.

7 Clean the cylinder head with solvent and dry it thoroughly. Compressed air will speed the drying process and ensure that all holes and recessed areas are clean. **Note:** *Decarbonising chemicals are available and may prove very useful when cleaning cylinder heads and valve train components. They are very caustic and should be used with caution. Be sure to follow the instructions on the container.*

8 Clean the lifters with solvent and dry them

thoroughly. Compressed air will speed the drying process and can be used to clean out the oil passages. Don't mix them up during cleaning - keep them in a box with numbered compartments.

9 Clean all the valve springs, spring seats, keepers and retainers with solvent and dry them thoroughly. Work on the components from one valve at a time to avoid mixing up the parts.

10 Scrape off any heavy deposits that may have formed on the valves, then use a motorised wire brush to remove deposits from the valve heads and stems. Again, make sure that the valves don't get mixed up.

Inspection

Note: *Be sure to perform all of the following inspection procedures before concluding that machine workshop work is required. Make a list of the items that need attention. The inspection procedures for the lifters and camshafts, can be found in Part A.*

Cylinder head

11 Inspect the cylinder head very carefully for cracks, evidence of coolant leakage and other damage. If cracks are found, check with an automotive machine workshop concerning repair. If repair isn't possible, a new cylinder head should be obtained.

12 A common problem on aluminium engines is erosion of the cylinder head or engine block coolant passages due to improper sealing. Using a new cylinder head gasket held against the cylinder head, trace the bolt holes and coolant passage outlines in pencil on the cylinder head. Use the gasket to trace the same on the top of the engine block (see illustration). If the top of the engine block has eroded *outside* of the pattern around the

water passages or cylinder head bolt holes, the engine block must be renewed; the manufacturer doesn't recommend resurfacing it. If the cylinder head has eroded outside of the water passage holes but the erosion is *away from* the combustion chamber, the eroded area can be built up with metal-impregnated epoxy and machined flat again.

13 Using a straightedge and feeler gauge, check the cylinder head gasket mating surface (on the engine block and cylinder head) for warpage (see illustration). If the warpage exceeds the limit found in this Chapter's Specifications, it can be resurfaced at an automotive machine workshop, but no more than 0.010-inch of material should be removed. If the cylinder head had been overheated, take it to the machinist for inspection before proceeding further. It's possible that the overheating could have annealed (softened) the aluminium of the cylinder head, making it unsuitable for machine work. In this case, a new cylinder head is required.

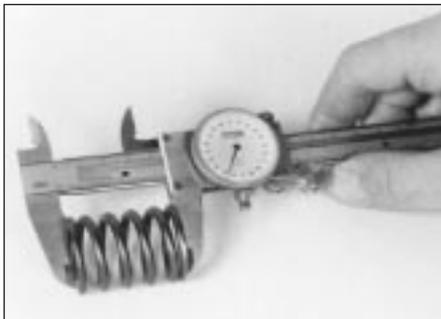
Note 1: *To check if a cylinder head has been machined previously, measure the height between the cylinder head gasket surface and the valve cover mounting surface with a large micrometer or vernier caliper and compare with Specifications.*

Note 2: *Jaguar aluminium cylinder heads require precision machine work. It is best to find a machine workshop that has considerable experience in servicing Jaguar cylinder heads.*

14 Examine the valve seats in each of the combustion chambers. If they're pitted, cracked or burned, the cylinder head will require valve service that's beyond the scope of the home mechanic.



10.15 Use a small dial bore gauge to determine the inside diameter of the valve guides - subtract the valve stem diameter to determine the stem-to-guide clearance



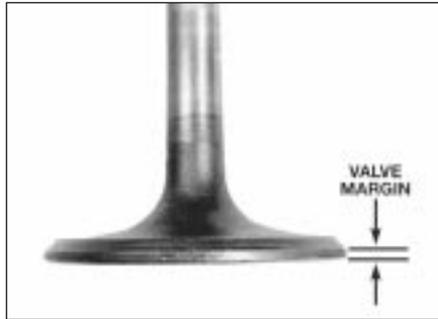
10.18 Measure the free length of each valve spring with a dial or vernier caliper

15 Check the valve stem-to-guide clearance with a small hole gauge and micrometer, or a small dial bore gauge (see illustration). Also, check the valve stem deflection with a dial indicator attached securely to the cylinder head. The valve must be in the guide and approximately 1/16-inch off the seat. The total valve stem movement indicated by the gauge needle must be noted, then divided by two to obtain the actual clearance value. If it exceeds the stem-to-guide clearance limit found in this Chapter's Specifications, the valve guides should be renewed. After this is done, if there's still some doubt regarding the condition of the valve guides they should be checked by an automotive machine workshop (the cost should be minimal).

Valves

16 Carefully inspect each valve face for uneven wear, deformation, cracks, pits and burned areas. Check the valve stem for scuffing and galling and the neck for cracks. Rotate the valve and check for any obvious indication that it's bent. Look for pits and excessive wear on the end of the stem. The presence of any of these conditions indicates the need for valve service by an automotive machine workshop.

17 Measure the margin width on each valve (see illustration). Any valve with a margin narrower than 1/32-inch will have to be replaced with a new valve.



10.17 The margin width on each valve must be as specified (if no margin exists, the valve cannot be re-used)



10.19 Check each valve spring for squareness

Valve components

18 Check each valve spring for wear (on the ends) and pits. Measure the free length and compare it to this Chapter's Specifications (see illustration). Any springs that are shorter than specified have sagged and should not be re-used. The tension of all springs should be pressure checked with a special fixture before deciding that they're suitable for use in a rebuilt engine (take the springs to an automotive machine workshop for this check).

Note: If any valve springs are found broken on 1988 or 1989 engines, all springs should be replaced with the improved springs used in 1990 (after VIN 9EPCLA120245) and later engines. They are identified with a white stripe. If your engine has springs with white-stripes, they have already been replaced, and only broken ones need be replaced.

19 Stand each spring on a flat surface and check it for squareness (see illustration). If any of the springs are distorted or sagged, renew all of the springs.

20 Check the spring retainers and keepers for obvious wear and cracks. Any questionable parts should be renewed, as extensive damage will occur if they fail during engine operation.

21 If the inspection process indicates that the valve components are in generally poor condition and worn beyond the limits specified, which is usually the case in an engine that's being overhauled, reassemble the valves in the cylinder head and refer to Section 11 for valve servicing recommendations.

11 Valves - servicing



1 Because of the complex nature of the job and the special tools and equipment needed, servicing of the valves, the valve seats and the valve guides, commonly known as a valve job, should be done by a professional.

2 The home mechanic can remove and dismantle the cylinder head(s), do the initial cleaning and inspection, then reassemble and deliver them to a dealer service department or an automotive machine workshop for the actual service work. Doing the inspection will enable you to see what condition the cylinder head(s) and valvetrain components are in and will ensure that you know what work and new parts are required when dealing with an automotive machine workshop.

3 The dealer service department, or automotive machine workshop, will remove the valves and springs, will recondition or renew the valves and valve seats, recondition the valve guides, check and renew the valve springs, spring retainers and keepers (as necessary), replace the valve seals with new ones, reassemble the valve components and make sure the installed spring height is correct. The cylinder head gasket surface will also be resurfaced if it's warped.

4 After the valve job has been performed by a professional, the cylinder head(s) will be in like new condition. When the cylinder heads are returned, be sure to clean them again before refitting on the engine to remove any metal particles and abrasive grit that may still be present from the valve service or cylinder head resurfacing operations. Use compressed air, if available, to blow out all the oil holes and passages.

12 Cylinder head - reassembly



1 Regardless of whether or not the cylinder head was sent to an automotive machine workshop for valve servicing, make sure it's clean before beginning reassembly. Renew the cylinder head rear plate gasket any time that the engine is overhauled or the cylinder head is reconditioned (see Part A of this Chapter for renewal procedure).

2 If the cylinder head was sent out for valve servicing, the valves and related components will already be in place. Begin the reassembly procedure with paragraph 8.

3 Refit new seals on each of the valve guides. Gently push each valve seal into place until it's seated on the guide.

Caution: Don't hammer on the valve seals once they're seated or you may damage them. Don't twist or cock the seals during refitting or they won't seat properly on the valve stems.

HAYNES
HINT



The keepers are easier to fit if a small amount of grease is applied to keep them in place

13 Pistons/connecting rods - removal



Note : Prior to removing the piston/connecting rod assemblies, remove the cylinder head(s), the sump and the oil pump transfer tubes by referring to Chapter 2A.

1 Use your fingernail to feel if a ridge has formed at the upper limit of ring travel (about 1/4-inch down from the top of each cylinder). If carbon deposits or cylinder wear have produced ridges, they must be completely removed with a special tool (see illustration). Follow the manufacturer's instructions provided with the tool. Failure to remove the ridges before attempting to remove the piston/connecting rod assemblies may result in piston damage.

2 After the cylinder ridges have been removed, turn the engine upside-down so the crankshaft is facing up. Remove the screws and the front and rear baffle plates from the bottom of the engine block (see illustration).

3 Before the connecting rods are removed, check the endplay with a feeler gauge. Slide the blade between the first connecting rod and the crankshaft throw until the play is removed (see illustration). The endplay is equal to the thickness of the feeler gauge(s). If the endplay exceeds the specified service limit, new connecting rods will be required. If

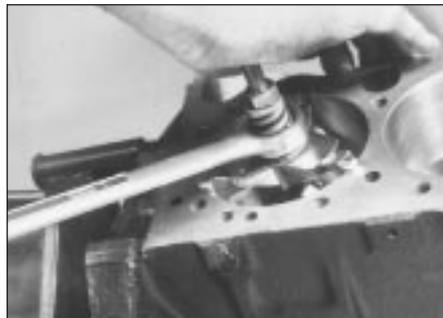
new rods (or a new crankshaft) are installed, the endplay may fall under the service limit (if it does, the rods will have to be machined to restore it - consult an automotive machine workshop for advice if necessary). Repeat the procedure for the remaining connecting rods.

4 Check the connecting rods and caps for identification marks. If they aren't plainly marked, use a small centre punch to make the appropriate number of indentations on each rod and cap (1, 2, 3, etc., depending on the cylinder they're associated with) (see illustration).

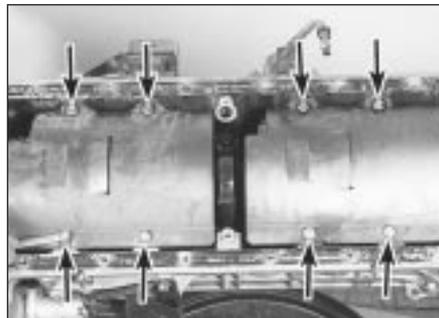
5 Loosen each of the connecting rod cap nuts 1/2-turn at a time until they can be removed by hand. Remove the number one connecting rod cap and bearing insert. Don't drop the bearing insert out of the cap. **Note:** These engines use special connecting rod and main bearing cap bolts that are designed to be used one time only. They can be used during Plastigage checks, but must be replaced with new bolts when the engine is finally reassembled.

6 Slip a short length of plastic or rubber hose over each connecting rod cap bolt to protect the crankshaft journal and cylinder wall as the piston is removed (see illustration).

7 Remove the bearing insert and push the connecting rod/piston assembly out through the top of the engine. Use a wooden hammer handle to push on the upper bearing surface in the connecting rod. If resistance is felt, double-check to make sure that all of the ridge was removed from the cylinder.



13.1 A ridge reamer is required to remove the ridge from the top of each cylinder - do this before removing the pistons!



13.2 Remove the screws (arrowed) and remove the front and rear baffle plates



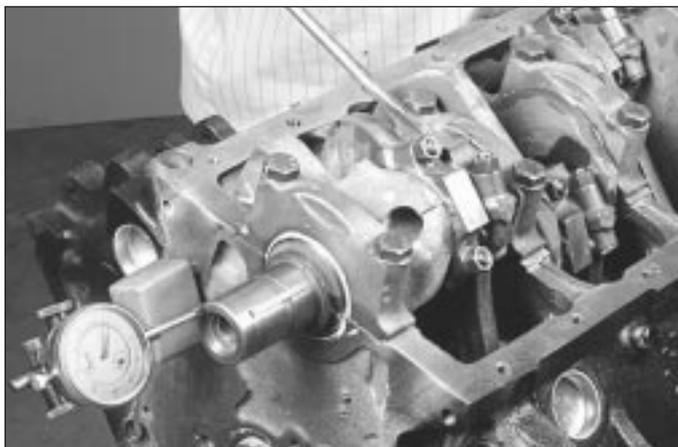
13.3 Check the connecting rod side clearance with a feeler gauge as shown



13.4 The connecting rods and caps should be marked by cylinder number - if they aren't, mark them with a centre punch to avoid confusion during reassembly



13.6 To prevent damage to the crankshaft journals and cylinder walls, slip sections of hose over the connecting rod bolts before removing the pistons



14.1 Checking crankshaft endplay with a dial indicator



14.3 Checking crankshaft endplay with a feeler gauge

8 Repeat the procedure for the remaining cylinders. **Note:** Turn the crankshaft as needed to position the piston/connecting rod assembly to be removed close to parallel with the cylinder bore - i.e. don't try to drive it out while at a large angle to the bore.

9 After removal, reassemble the connecting rod caps and bearing inserts in their respective connecting rods and refit the cap nuts/bolts finger tight. Leaving the old bearing inserts in place until reassembly will help prevent the big-end bearing surfaces from being accidentally nicked or gouged.

10 Don't separate the pistons from the connecting rods (see Section 18 for additional information).

2 Push the crankshaft all the way to the rear and zero the dial indicator. Next, pry the crankshaft to the front as far as possible and check the reading on the dial indicator. The distance that it moves is the endplay. If it's greater than that specified in this Chapter's Specifications, check the crankshaft thrust surfaces for wear. If no wear is evident, new thrust washers should correct the endplay.

3 If a dial indicator isn't available, feeler gauges can be used. Gently pry or push the crankshaft all the way to the front of the engine. Slip feeler gauges between the crankshaft and the front face of the number 4 (thrust) main bearing to determine the clearance (see illustration).

4 Check the main bearing caps to see if they're marked to indicate their locations. They should be numbered consecutively from the front of the engine to the rear. If they aren't, mark them with number stamping dies or a centre punch. Main bearing caps generally have a cast-in arrow, which points to the front of the engine. Loosen the main bearing cap bolts 1/4-turn at a time each, starting at the ends and working toward the centre, until they can be removed by hand.

5 The main bearing caps are numbered on the right side with corresponding numbers stamped into the sump rail on the same side (see illustration). Gently tap the caps with a

soft-face hammer, then separate them from the engine block. If necessary, use the bolts as levers to remove the main bearing caps. Try not to drop the bearing inserts if they come out with the caps. **Note:** The number four main bearing is the thrust bearing and is not numbered.

6 Carefully lift the crankshaft out of the engine. It may be a good idea to have an assistant available, since the crankshaft is quite heavy. With the bearing inserts in place in the engine block and main bearing caps, return the main bearing caps to their respective locations on the engine block and tighten the bolts finger tight.

14 Crankshaft - removal



Note: The rear main oil seal and retainer must be removed from the engine block before proceeding with crankshaft removal (see Part A of this Chapter).

1 Before the crankshaft is removed, check the endplay. Mount a dial indicator to the front of the engine with the stem in line with, and just touching, the end of the crankshaft (see illustration).



14.5 The right side of each main bearing cap is stamped with a number (left arrow) that corresponds to the stamped number on the pan rail (right arrow)



15.1a A hammer and a large punch can be used to knock the core plugs sideways in their bores

15 Engine block - cleaning



Caution: The core plugs (also known as freeze or soft plugs) may be difficult or impossible to retrieve if they're driven completely into the engine block coolant passages.

1 Using the blunt end of a punch, tap in on the outer edge of the core plug to turn the plug sideways in the bore. Then using pliers, pull the core plug from the engine block (see illustrations).



15.1b Pull the core plugs from the engine block with pliers



15.8 All bolt holes in the engine block - particularly the main bearing cap and cylinder head bolt holes - should be cleaned and restored with a tap (remove debris from holes after this is done)

2 Using a gasket scraper, remove all traces of gasket material from the engine block. Be very careful not to nick or gouge the gasket sealing surfaces.

3 Remove the main bearing caps and separate the bearing inserts from the caps and the engine block. Tag the bearings, indicating which cylinder they were removed from and whether they were in the cap or the engine block, then set them aside.

4 Remove all of the threaded oil gallery plugs from the engine block. The plugs are usually very tight - they may have to be drilled out and the holes retapped. Use new plugs when the engine is reassembled.

5 If the engine is extremely dirty, it should be taken to an automotive machine workshop to be steam cleaned or hot tanked.

6 After the engine block is returned, clean all oil holes and oil galleries one more time. Brushes specifically designed for this purpose are available at most car accessory outlets. Flush the passages with warm water until the water runs clear, dry the engine block thoroughly and wipe all machined surfaces with a light, rust preventive oil. If you have access to compressed air, use it to speed the drying process and to blow out all the oil holes and galleries.



15.10 A large socket on an extension can be used to drive the new core plugs into the bores



Warning: Wear eye protection when using compressed air!

7 If the engine block isn't extremely dirty or sludged up, you can do an adequate cleaning job with hot soapy water and a stiff brush. Take plenty of time and do a thorough job. Regardless of the cleaning method used, be sure to clean all oil holes and galleries very thoroughly, dry the engine block completely and coat all machined surfaces with light oil.

8 The threaded holes in the engine block must be clean to ensure accurate torque readings during reassembly. Run the proper size tap into each of the holes to remove rust, corrosion, thread sealant or sludge and restore damaged threads (see illustration). If possible, use compressed air to clear the holes of debris produced by this operation.

9 Refit the main bearing caps and tighten the bolts finger tight.

10 After coating the sealing surfaces of the new core plugs with suitable sealant, refit them in the engine block (see illustration). Make sure they're driven in straight and seated properly or leakage could result. Special tools are available for this purpose, but a large socket, with an outside diameter that will just slip into the core plug, a 1/2-inch

drive extension and a hammer will work just as well.

11 Apply non-hardening sealant (such as Permatex no. 2 or Teflon pipe sealant) to the new oil gallery plugs and thread them into the holes in the engine block. Make sure they're tightened securely.

12 If the engine isn't going to be reassembled right away, cover it with a large plastic trash bag to keep it clean.

16 Engine block - inspection



1 Before the engine block is inspected, it should be cleaned as described in Section 15.

2 Visually check the engine block for cracks, rust and corrosion (see illustration 10.12). Look for stripped threads in the threaded holes. It's also a good idea to have the engine block checked for hidden cracks by an automotive machine workshop that has the special equipment to do this type of work, especially if the vehicle had a history of overheating or using coolant. If defects are found, have the engine block repaired, if possible, or renewed. If the top of the engine block has been eroded by coolant leakage and the erosion is near the cylinder bores, the engine block must be renewed.

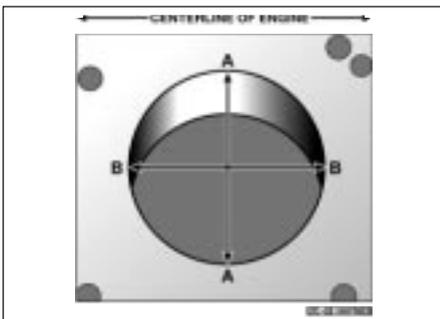
3 Check the cylinder bores for scuffing and scoring.

4 Check the cylinders for taper and out-of-round conditions as follows (see illustrations):

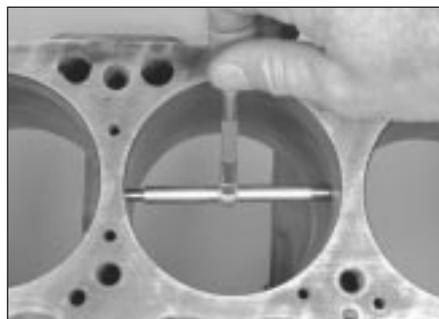
5 Measure the diameter of each cylinder at the top (just under the ridge area), centre and bottom of the cylinder bore, parallel to the crankshaft axis.

6 Next, measure each cylinder's diameter at the same three locations perpendicular to the crankshaft axis.

7 The taper of each cylinder is the difference between the bore diameter at the top of the cylinder and the diameter at the bottom. The out-of-round specification of the cylinder bore



16.4a Measure the diameter of each cylinder at 90° to engine centreline (A), and parallel to engine centreline (B) - out-of-round is the difference between A and B; taper is the difference between A and B at the top of the cylinder and A and B at the bottom of the cylinder



16.4b The ability to "feel" when the telescoping gauge is at the correct point will be developed over time, so work slowly and repeat the check until you're satisfied that the bore measurement is accurate



16.4c The gauge is then measured with a micrometer to determine the bore size

is the difference between the parallel and perpendicular readings. Compare your results to this Chapter's Specifications.

8 If the cylinder walls are badly scuffed or scored, or if they're out-of-round or tapered beyond the limits given in this Chapter's Specifications, have the engine block rebored and honed at an automotive machine workshop. If a rebores is done, oversize pistons and rings will be required.

9 Using a precision straightedge and feeler gauge, check the engine block deck (the surface that mates with the cylinder head) for distortion (see illustration 10.13). If it's distorted beyond the specified limit, it can be resurfaced by an automotive machine workshop.

10 If the cylinders are in reasonably good condition and not worn to the outside of the limits, and if the piston-to-cylinder clearances can be maintained properly, then they don't have to be rebored. Honing is all that's necessary (refer to Section 17).

17 Cylinder honing



1 Prior to engine reassembly, the cylinder bores must be honed so the new piston rings will seat correctly and provide the best possible combustion chamber seal. **Note:** If you don't have the tools or don't want to tackle the honing operation, most automotive machine shops will do it for a reasonable fee.

2 Before honing the cylinders, refit the main bearing caps (without bearing inserts) and tighten the bolts to the specified torque.

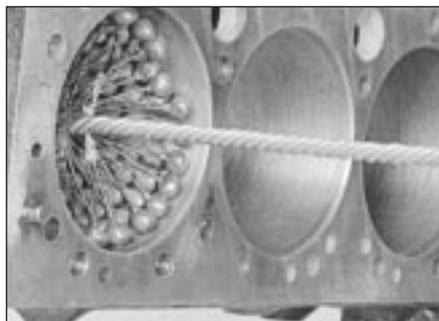
3 Two types of cylinder hones are commonly available - the flex hone or "bottle brush" type and the more traditional surfacing hone with spring-loaded stones. Both will do the job, but for the less-experienced mechanic the "bottle brush" hone will probably be easier to use. You'll also need some paraffin or honing oil, rags and a variable-speed electric drill motor. The drill motor should be operated at a steady, slow speed. Proceed as follows:

- a) Mount the hone in the drill motor, compress the stones and slip it into the first cylinder (see illustration).



Warning: Be sure to wear safety goggles or a face shield!

- b) Lubricate the cylinder with plenty of honing oil, turn on the drill and move the hone up-and-down in the cylinder at a pace that will produce a fine crosshatch pattern on the cylinder walls. Ideally, the crosshatch lines should intersect at approximately a 60° angle (see illustration). Be sure to use plenty of lubricant and don't take off any more material than is absolutely necessary to produce the desired finish. **Note:** Piston ring manufacturers may specify a smaller



17.3a A "bottle brush" hone will produce better results if you have never done cylinder honing before

crosshatch angle than the traditional 60° - read and follow any instructions included with the new rings.

- c) Don't withdraw the hone from the cylinder while it's running. Instead, shut off the drill and continue moving the hone up-and-down in the cylinder until it comes to a complete stop, then compress the stones and withdraw the hone. If you're using a "bottle brush" type hone, stop the drill motor, then turn the chuck in the normal direction of rotation while withdrawing the hone from the cylinder.
- d) Wipe the oil out of the cylinder and repeat the procedure for the remaining cylinders.

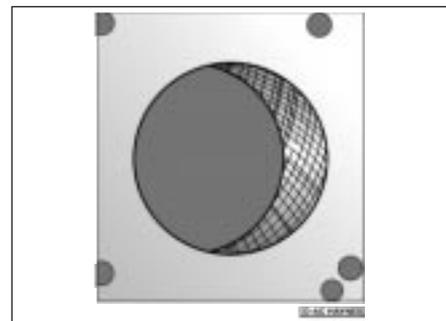
4 After the honing job is complete, chamfer the top edges of the cylinder bores with a small file so the rings won't catch when the pistons are installed. Be very careful not to nick the cylinder walls with the end of the file.

5 The entire engine block must be washed again very thoroughly with warm, soapy water to remove all traces of the abrasive grit produced during the honing operation. **Note:** The bores can be considered clean when a lint-free white cloth - dampened with clean engine oil - used to wipe them out doesn't pick up any more honing residue, which will show up as grey areas on the cloth. Be sure to run a brush through all oil holes and galleries and flush them with running water.

6 After rinsing, dry the engine block and apply a coat of light rust preventive oil to all machined surfaces. Wrap the engine block in a plastic bag to keep it clean and set it aside until reassembly.



18.4a The piston ring grooves can be cleaned with a special tool, as shown . . .



17.3b The cylinder hone should leave a smooth, crosshatch pattern with the lines intersecting at approximately a 60° angle

18 Pistons/connecting rods - inspection



1 Before the inspection process can be carried out, the piston/connecting rod assemblies must be cleaned and the original piston rings removed from the pistons. **Note:** Always use new piston rings when the engine is reassembled.

2 Using a piston ring refitting tool, carefully remove the rings from the pistons. Be careful not to nick or gouge the pistons in the process.

3 Scrape all traces of carbon from the top of the piston. A hand-held wire brush or a piece of fine emery cloth can be used once the majority of the deposits have been scraped away. Do not, under any circumstances, use a wire brush mounted in a drill motor to remove deposits from the pistons. The piston material is soft and may be eroded away by the wire brush.

4 Use a piston ring groove-cleaning tool to remove carbon deposits from the ring grooves. If a tool isn't available, a piece broken off the old ring will do the job. Be very careful to remove only the carbon deposits - don't remove any metal and do not nick or scratch the sides of the ring grooves (see illustrations).

5 Once the deposits have been removed, clean the piston/connecting rod assemblies with solvent and dry them with compressed air (if available). Make sure the oil return holes



18.4b . . . or a section of a broken ring



18.10 Check the ring groove clearance with a feeler gauge at several points around the groove



18.11 Measure the piston diameter at a 90° angle to the piston pin, at the bottom of the piston pin area - a precision caliper may be used if a micrometer isn't available



19.5 Measure the diameter of each crankshaft journal at several points to detect taper and out-of-round conditions

in the back sides of the ring grooves and the oil hole in the lower end of each rod are clear.

6 If the pistons and cylinder walls aren't damaged or worn excessively, and if the engine block is not rebored, new pistons won't be necessary. Normal piston wear appears as even vertical wear on the piston thrust surfaces and slight looseness of the top ring in its groove. New piston rings, however, should always be used when an engine is rebuilt.

7 Carefully inspect each piston for cracks around the skirt, at the pin bosses and at the ring lands.

Caution: *Some early 1988 3.6 litre engines (before engine no. 9D 121113) have incorrectly-stamped pistons. On these, the word FRONT is actually stamped on the rear of the pistons. Correct pistons will have the cast arrows on the inside of the skirt to your left when facing the word FRONT.*

8 Look for scoring and scuffing on the thrust faces of the skirt, holes in the piston crown and burned areas at the edge of the crown. If the skirt is scored or scuffed, the engine may have been suffering from overheating and/or abnormal combustion, which caused excessively high operating temperatures. The cooling and lubrication systems should be checked thoroughly. A hole in the piston crown is an indication that abnormal combustion (pre-ignition) was occurring. Burned areas at the edge of the piston crown are usually evidence of spark knock (detonation). If any of the above problems exist, the causes must be corrected or the damage will occur again. The causes may include intake air leaks, incorrect air/fuel mixture, incorrect ignition timing and EGR system malfunctions.

9 Corrosion of the piston, in the form of small pits, indicates that coolant is leaking into the combustion chamber and/or the crankcase. Again, the cause must be corrected or the problem may persist in the rebuilt engine.

10 Measure the piston ring groove clearance by laying a new piston ring in each ring groove and slipping a feeler gauge in beside it (see illustration). Check the clearance at three or four locations around each groove. Be sure to

use the correct ring for each groove - they are different. If the clearance is greater than that listed in this Chapter's Specifications, new pistons will have to be used.

11 Check the piston-to-bore clearance by measuring the bore (see Section 16) and the piston diameter. Make sure the pistons and bores are correctly matched. Measure the piston across the skirt, at a 90° angle to the piston pin (see illustration). Subtract the piston diameter from the bore diameter to obtain the clearance. If it's greater than specified, the engine block will have to be rebored and new pistons and rings installed.

12 Check the piston-to-rod clearance by twisting the piston and rod in opposite directions. Any noticeable play indicates excessive wear, which must be corrected.

13 If the pistons must be removed from the connecting rods for any reason, the rods should be taken to an automotive machine workshop, to be checked for bend and twist, since automotive machine shops have special equipment for this purpose.

14 Check the connecting rods for cracks and other damage. Temporarily remove the rod caps, lift out the old bearing inserts, wipe the connecting rod and cap bearing surfaces clean and inspect them for nicks, gouges and scratches. After checking the connecting rods, renew the old bearings, slip the caps into place and tighten the nuts finger tight.

Note: *If the engine is being rebuilt because of a connecting rod knock, be sure to refit new rods.*

19 Crankshaft - inspection



1 Clean the crankshaft with solvent and dry it with compressed air (if available). Be sure to clean the oil holes with a stiff brush and flush them with solvent.

2 Check the main and connecting rod bearing journals for uneven wear, scoring, pits and cracks.

3 Remove all burrs from the crankshaft oil holes with a stone, file or scraper.

4 Check the remainder of the crankshaft for cracks and other damage. It should be magnafluxed to reveal hidden cracks - an automotive machine workshop will handle the procedure.

5 Using a micrometer, measure the diameter of the main and connecting rod journals and compare the results to this Chapter's Specifications (see illustration). By measuring the diameter at a number of points around each journal's circumference, you'll be able to determine whether or not the journal is out-of-round. Take the measurement at each end of the journal, near the crank throws, to determine if the journal is tapered. Crankshaft runout should be checked also, but large V-blocks and a dial indicator are needed to do it correctly. If you don't have the equipment, have a machine workshop check the runout.

6 If the crankshaft journals are damaged, tapered, out-of-round or worn beyond the limits given in the Specifications, have the crankshaft reground by an automotive machine workshop. Be sure to use the correct size bearing inserts if the crankshaft is reconditioned.

7 Check the oil seal journals at each end of the crankshaft for wear and damage. If the seal has worn a groove in the journal, or if it's nicked or scratched, the new seal may leak when the engine is reassembled. In some cases, an automotive machine workshop may be able to repair the journal by pressing on a thin sleeve. If repair isn't feasible, a new or different crankshaft should be installed.

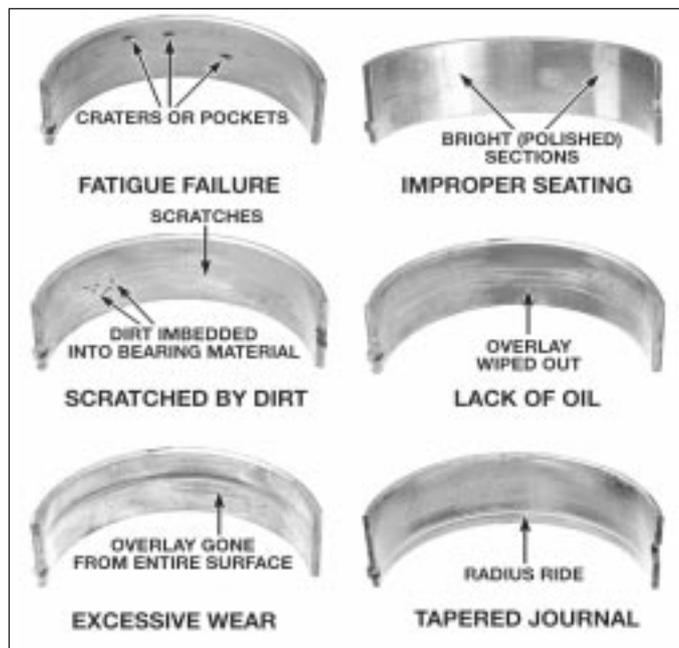
8 Refer to Section 20 and examine the main and big-end bearing inserts.

20 Main and big-end bearings - inspection and selection

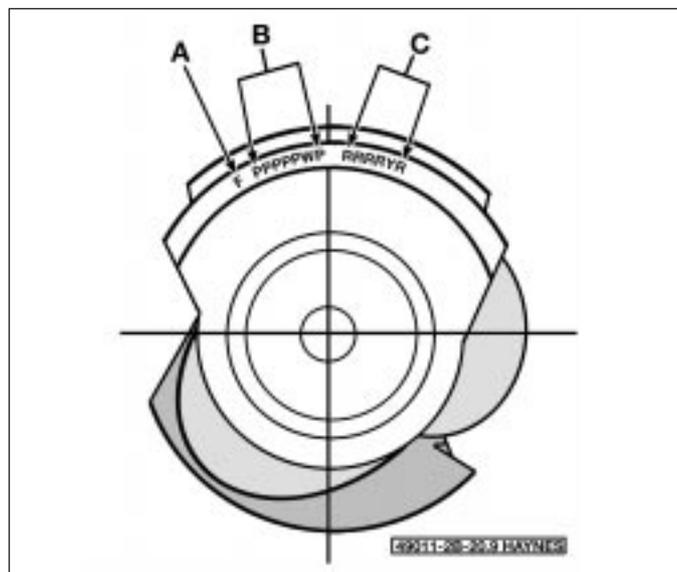


Inspection

1 Even though the main and big-end bearings should be replaced with new ones during the engine overhaul, the old bearings should be retained for close examination, as they may



20.1 When inspecting the main and big-end bearings, look for these problems



20.9 Later model 4.0 litre engines have graded journals and bearings, with the markings indicated on the front throw of the crankshaft - "A" indicates the front of the engine, "B" indicates the codes for the main journals/bearings, and "C" indicates the connecting rod journal grades

reveal valuable information about the condition of the engine (see illustration).

2 Bearing failure occurs because of lack of lubrication, the presence of dirt or other foreign particles, overloading the engine and corrosion. Regardless of the cause of failure, it must be corrected before the engine is reassembled to prevent it from happening again.

3 When examining the bearings, remove them from the engine block, the main bearing caps, the connecting rods and the rod caps and lay them out on a clean surface in the same general position as their location in the engine. This will enable you to match any bearing problems with the corresponding crankshaft journal.

4 Dirt and other foreign particles get into the engine in a variety of ways. It may be left in the engine during assembly, or it may pass through filters or the PCV system. It may get into the oil, and from there into the bearings. Metal chips from machining operations and normal engine wear are often present. Abrasives are sometimes left in engine components after reconditioning, especially when parts are not thoroughly cleaned using the proper cleaning methods. Whatever the source, these foreign objects often end up embedded in the soft bearing material and are easily recognised. Large particles will not embed in the bearing and will score or gouge the bearing and journal. The best prevention for this cause of bearing failure is to clean all parts thoroughly and keep everything spotlessly clean during engine assembly. Frequent and regular engine oil and filter changes are also recommended.

5 Lack of lubrication (or lubrication breakdown) has a number of interrelated causes. Excessive heat (which thins the oil), overloading (which squeezes the oil from the bearing face) and oil leakage or throw off (from excessive bearing clearances, worn oil pump or high engine speeds) all contribute to lubrication breakdown. Blocked oil passages, which usually are the result of misaligned oil holes in a bearing shell, will also oil starve a bearing and destroy it. When lack of lubrication is the cause of bearing failure, the bearing material is wiped or extruded from the steel backing of the bearing. Temperatures may increase to the point where the steel backing turns blue from overheating.

6 Driving habits can have a definite effect on bearing life. Low speed operation in too high a gear (labouring the engine) puts extremely high loads on bearings, which tends to squeeze out the oil film. These loads cause the bearings to flex, which produces fine cracks in the bearing face (fatigue failure). Eventually the bearing material will loosen in pieces and tear away from the steel backing. Short trip driving leads to corrosion of bearings because insufficient engine heat is produced to drive off the condensed water and corrosive gases. These products collect in the engine oil, forming acid and sludge. As the oil is carried to the engine bearings, the acid attacks and corrodes the bearing material.

7 Incorrect bearing refitting during engine assembly will lead to bearing failure as well. Tight-fitting bearings leave insufficient bearing oil clearance, and this will lead to oil

starvation. Dirt or foreign particles trapped behind a bearing insert result in high spots on the bearing which lead to failure.

Selection

8 If the original bearings are worn or damaged, or if the oil clearances are incorrect (see Sections 23 or 25), the following procedures should be used to select the correct new bearings for engine reassembly. However, if the crankshaft has been reground, new undersize bearings must be installed - the following procedure should not be used if undersize bearings are required! The automotive machine workshop that reconditions the crankshaft will provide or help you select the correct-size bearings. Regardless of how the bearing sizes are determined, use the oil clearance, measured with Plastigage, as a guide to ensure the bearings are the right size.

9 If you need to use a STANDARD size main or big-end bearing, refit one that has the same number as the original bearing. **Note:** 4.0 litre engines after #164637 have sized crankshafts and bearings in three grades, indicated by colour and letter. The codes are stamped into the front throw of the crankshaft (see illustration). Match replacement bearings by the colour codes: pink (P), white (W) or green (G) for main bearings; red (R), yellow (Y) or blue (B) for the three grades of big-end bearings.

10 Remember, the oil clearance is the final judge when selecting new bearing sizes. If you have any questions or are unsure which bearings to use, get help from a dealer parts or service department.



22.3 When checking piston ring end gap, the ring must be square in the cylinder bore (this is done by pushing the ring down with the top of a piston as shown)



22.4 With the ring square in the cylinder, measure the end gap with a feeler gauge



22.5 If the end gap is too small, clamp a file in a vice and file the ring ends (from the outside in only) to enlarge the gap slightly

21 Engine overhaul - reassembly sequence

1 Before beginning engine reassembly, make sure you have all the necessary new parts, gaskets and seals as well as the following items on hand:

- Common hand tools
- A 1/2-inch drive torque wrench
- Piston ring refitting tool
- Piston ring compressor
- Short lengths of rubber or plastic hose to fit over connecting rod bolts
- Plastigauge
- Feeler gauges
- A fine-tooth file
- New engine oil
- Engine assembly lube or moly-base grease
- Gasket sealer
- Thread locking compound

Special Jaguar tools:

- Engine lifting brackets (18G 1465)
- Timing damper simulator (18E 1436)
- Camshaft TDC tool (18G 1433)

2 In order to save time and avoid problems, engine reassembly must be done in the following general order:

- Piston rings (Part B)
- Crankshaft and main bearings (Part B)
- Piston/connecting rod assemblies (Part B)
- Rear main (crankshaft) oil seal (Part B)
- Auxiliary shaft (Part A)
- Timing chains and sprockets (Part A)
- Oil pump (Part A)
- Timing chain cover (Part A)
- Cylinder head and lifters (Part A)
- Camshafts (Part A)
- Oil pick-up (Part A)
- Sump (Part A)
- Intake and exhaust manifolds (Part A)
- Valve cover (Part A)
- Flywheel/driveplate (Part A)

22 Piston rings - refitting

1 Before refitting the new piston rings, the ring end gaps must be checked. It's assumed that the piston ring groove clearance has been checked and verified correct (see Section 18).

2 Lay out the piston/connecting rod assemblies and the new ring sets so the ring sets will be matched with the same piston and cylinder during the end gap measurement and engine assembly.

3 Insert the top (number one) ring into the first cylinder and square it up with the cylinder walls by pushing it in with the top of the piston (see illustration). The ring should be near the bottom of the cylinder, at the lower limit of ring travel.

4 To measure the end gap, slip feeler gauges between the ends of the ring until a gauge equal to the gap width is found (see illustration). The feeler gauge should slide between the ring ends with a slight amount of drag. Compare the measurement to that found in this Chapter's Specifications. If the gap is larger or smaller than specified, double-check to make sure you have the correct rings before proceeding.

5 If the gap is too small, it must be enlarged or the ring ends may come in contact with each other during engine operation, which can cause serious damage to the engine. The end gap can be increased by filing the ring ends very carefully with a fine file. Mount the

file in a vice equipped with soft jaws, slip the ring over the file with the ends contacting the file face and slowly move the ring to remove material from the ends (see illustration).

Caution: When performing this operation, file only from the outside in, and after the correct gap is achieved, deburr the filed ends of the rings with a fine whetstone.

6 Excess end gap isn't critical unless it's greater than Specifications. Again, double-check to make sure you have the correct rings for your engine.

7 Repeat the procedure for each ring that will be installed in the first cylinder and for each ring in the remaining cylinders. Remember to keep rings, pistons and cylinders matched.

8 Once the ring end gaps have been checked/corrected, the rings can be installed on the pistons.

9 The oil control ring (lowest one on the piston) is usually installed first. It's composed of three separate components. Slip the spacer/expander into the groove (see illustration). If an anti-rotation tang is used, make sure it's inserted into the drilled hole in the ring groove. Next, refit the lower side rail. Don't use a piston ring refitting tool on the oil ring side rails, as they may be damaged. Instead, place one end of the side rail into the groove between the spacer/expander and the ring land, hold it firmly in place and slide a finger around the piston while pushing the rail into the groove (see illustrations). Next, refit the upper side rail in the same manner.

10 After the three oil ring components have been installed, check to make sure that both

2B



22.9a Refit the spacer/expander in the oil control ring groove



22.9b DO NOT use a piston ring refitting tool when refitting the oil ring side rails



22.12 Refit the compression rings with a ring expander - the mark must face up

the upper and lower side rails can be turned smoothly in the ring groove.

11 The number two (middle) ring is installed next. It's usually stamped with a mark which must face up, toward the top of the piston.

Note: Always follow the instructions on the ring package or box - different manufacturers may require different approaches. Do not mix up the top and middle rings, as they have different cross sections.

12 Use a piston ring refitting tool and make sure the ring's identification mark is facing the top of the piston, then slip the ring into the middle groove on the piston (see illustration). Don't expand the ring any more than necessary to slide it over the piston.

13 Refit the number one (top) ring in the same manner. Make sure the mark is facing up. Be careful not to confuse the number one and number two rings.

14 Repeat the procedure for the remaining pistons and rings.

23 Crankshaft - refitting and main bearing oil clearance check



1 Crankshaft refitting is the first major step in engine reassembly. It's assumed at this point that the engine block and crankshaft have been cleaned, inspected and repaired or reconditioned.

2 Position the engine with the bottom facing up.

3 Remove the main bearing cap bolts and lift out the caps. Lay the caps out in the proper order.

4 If they're still in place, remove the old bearing inserts from the engine block and the main bearing caps. Wipe the main bearing surfaces of the engine block and caps with a clean, lint free cloth. They must be kept spotlessly clean!

Main bearing oil clearance check

5 Clean the back sides of the new main bearing inserts and lay the bearing half with the oil groove in each main bearing saddle in



23.10 Lay the Plastigauge strips on the main bearing journals, parallel to the crankshaft centreline

the engine block. Lay the other bearing half from each bearing set in the corresponding main bearing cap. Make sure the tab on each bearing insert fits into the recess in the engine block or cap. Also, the oil holes in the block must line up with the oil holes in the bearing insert.

Caution: Do not hammer the bearings into place and don't nick or gouge the bearing faces. No lubrication should be used at this time.

6 The thrust bearings (washers) must be installed in the number four main bearing cap and saddle.

7 Clean the faces of the bearings in the engine block and the crankshaft main bearing journals with a clean, lint free cloth. Check or clean the oil holes in the crankshaft, as any dirt here can go only one way - straight through the new bearings.

8 Once you're certain the crankshaft is clean, carefully lay it in position in the main bearings. **9** Before the crankshaft can be permanently installed, the main bearing oil clearance must be checked.

10 Trim several pieces of the appropriate size Plastigauge (they must be slightly shorter than the width of the main bearings) and place one piece on each crankshaft main bearing journal, parallel with the journal axis (see illustration).

11 Clean the faces of the bearings in the caps and refit the caps in their respective positions (don't mix them up) with the arrows pointing toward the front of the engine. Don't disturb the Plastigauge. Apply a light coat of oil to the bolt threads and the undersides of the bolt heads, then refit them. **Note:** Use the old bolts for this step (save the new bolts for final refitting).

12 Tighten the main bearing cap bolts, in three steps, to the torque listed in this Chapter's Specifications. Don't rotate the crankshaft at any time during this operation!

13 Remove the bolts and carefully lift off the main bearing caps or cap assembly. Keep them in order. Don't disturb the Plastigauge or rotate the crankshaft. If any of the main bearing caps are difficult to remove, tap them gently from side-to-side with a soft-face hammer to loosen them.

14 Compare the width of the crushed Plastigauge on each journal to the scale printed on the Plastigauge envelope to obtain the main bearing oil clearance (see illustration). Check the Specifications to make sure it's correct.

15 If the clearance is not as specified, the bearing inserts may be the wrong size (which means different ones will be required - see Section 20). Before deciding that different inserts are needed, make sure that no dirt or oil was between the bearing inserts and the caps or engine block when the clearance was measured. If the Plastigauge is noticeably wider at one end than the other, the journal may be tapered (see Section 19).

16 Carefully scrape all traces of the Plastigauge material off the main bearing journals and/or the bearing faces. Don't nick or scratch the bearing faces.

Final crankshaft refitting

17 Carefully lift the crankshaft out of the engine. Clean the bearing faces in the engine block, then apply a thin, uniform layer of clean moly-base grease or engine assembly lube to each of the bearing surfaces. Coat the thrust washers as well.

18 Lubricate the crankshaft surfaces that contact the oil seals with moly-base grease, engine assembly lube or clean engine oil.

19 Make sure the crankshaft journals are clean, then lay the crankshaft back in place in the engine block. Clean the faces of the bearings in the main bearing caps, then apply lubricant to them. Refit the main bearing caps in their respective positions with the arrows pointing toward the front of the engine. **Note:** Be sure to refit the thrust washers (lubricated) with the number 4 main journal. The upper (block side) thrust washers can be rotated into position around the crankshaft with the crankshaft installed in the engine block, with the thrust washer grooves facing OUT. The lower thrust washers should be placed on the main bearing caps with their grooves OUT.

20 For the final assembly, use only new bolts, for both the main bearings and the



23.14 Compare the width of the crushed Plastigauge to the scale on the envelope to determine the main bearing oil clearance (always take the measurement at the widest point of the Plastigauge). Be sure to use the correct scale - imperial and metric scales are included

connecting rods. Apply a light coat of oil to the bolt threads and the under sides of the bolt heads, then refit them. Tighten all main bearing cap bolts to the torque listed in this Chapter's Specifications, starting in the centre and working out to the ends.

21 Rotate the crankshaft a number of times by hand to check for any obvious binding.

22 Check the crankshaft endplay with a feeler gauge or a dial indicator as described in Section 14. The endplay should be correct if the crankshaft thrust faces aren't worn or damaged and new thrust washers have been installed. **Note:** *If the end-play is too great, even with the new thrust bearings, oversized thrust bearings are available. There are two sizes, 0.005-inch and 0.010-inch oversize.*

23 Refit a new rear main oil seal, then bolt the retainer to the engine block (see Section 24).

24 Rear main oil seal refitting



1 The crankshaft must be installed first and the main bearing caps bolted in place, then the new seal should be installed in the retainer and the retainer bolted to the engine block.

2 Check the seal contact surface on the crankshaft very carefully for scratches and nicks that could damage the new seal lip and cause oil leaks. If the crankshaft is damaged, the only alternative is a new or different crankshaft.

3 Refer to Part A of this Chapter for refitting of the new rear seal, using the plastic alignment tool supplied with the engine overhaul gasket set.

25 Pistons/connecting rods - refitting and big-end bearing oil clearance check

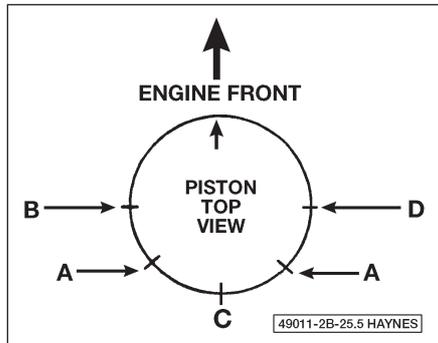


1 Before refitting the piston/connecting rod assemblies, the cylinder walls must be perfectly clean, the top edge of each cylinder must be chamfered, and the crankshaft must be in place.

2 Remove the cap from the end of the number one connecting rod (refer to the marks made during removal). Remove the original bearing inserts and wipe the bearing surfaces of the connecting rod and cap with a clean, lint-free cloth. They must be kept spotlessly clean.

Big-end bearing oil clearance check

3 Clean the back side of the new upper bearing insert, then lay it in place in the connecting rod. Make sure the tab on the bearing fits into the recess in the rod so the oil holes line up. Don't hammer the bearing insert into place and be very careful not to nick or gouge the bearing face. Don't lubricate the bearing at this time.



25.5 Stagger the ring end gaps around the piston as shown

- A Oil ring rail gaps
- B Second compression ring gap
- C Oil ring spacer gap
- D Top compression ring gap

4 Clean the back side of the other bearing insert and refit it in the rod cap. Again, make sure the tab on the bearing fits into the recess in the cap, and don't apply any lubricant. It's critically important that the mating surfaces of the bearing and connecting rod are perfectly clean and oil free when they're assembled.

5 Position the piston ring gaps at staggered intervals around the piston (see illustration).

6 Slip a section of plastic or rubber hose over each connecting rod cap bolt.

7 Lubricate the piston and rings with clean engine oil and attach a piston ring compressor to the piston. Leave the skirt protruding about 1/4-inch to guide the piston into the cylinder. The rings must be compressed until they're flush with the piston.

8 Rotate the crankshaft until the number one connecting rod journal is at BDC (bottom dead centre) and apply a coat of engine oil to the cylinder wall.

9 With the word FRONT (or the arrow) on top of the piston facing the front of the engine (see illustration), gently insert the piston/connecting rod assembly into the number one cylinder bore and rest the bottom edge of the ring compressor on the engine block.

10 Tap the top edge of the ring compressor to make sure it's contacting the engine block around its entire circumference.



25.11 The piston can be driven (gently) into the cylinder bore with the end of a wooden or plastic hammer handle



25.9 Pistons must be installed with the arrow (right arrow) or FRONT facing the front of the engine - left arrow indicates piston size letter

11 Gently tap on the top of the piston with the end of a wooden hammer handle (see illustration) while guiding the end of the connecting rod into place on the crankshaft journal. The piston rings may try to pop out of the ring compressor just before entering the cylinder bore, so keep some downward pressure on the ring compressor. Work slowly, and if any resistance is felt as the piston enters the cylinder, stop immediately. Find out what's hanging up and fix it before proceeding.

Caution: *Do not, for any reason, force the piston into the cylinder - you might break a ring and/or the piston.*

12 Once the piston/connecting rod assembly is installed, the big-end bearing oil clearance must be checked before the rod cap is permanently bolted in place.

13 Cut a piece of the appropriate size Plastigauge slightly shorter than the width of the big-end bearing and lay it in place on the number one connecting rod journal, parallel with the journal axis (see illustration).

14 Clean the connecting rod cap bearing face, remove the protective hoses from the connecting rod bolts and refit the rod cap. Make sure the mating mark on the cap is on the same side as the mark on the connecting rod. Check the cap to make sure the front mark is facing the timing chain of the engine.

15 Apply a light coat of oil to the under sides of the nuts, then refit and tighten them to the torque listed in this Chapter's Specifications,



25.13 Lay the Plastigauge strips on each big-end bearing journal, parallel to the crankshaft centreline



25.17 Measure the width of the crushed Plastigauge to determine the big-end bearing oil clearance

working up to it in three steps. **Note:** Use the old bolts for this step (save the new bolts for final refitting). Use a thin-wall socket to avoid erroneous torque readings that can result if the socket is wedged between the rod cap and nut. If the socket tends to wedge itself between the nut and the cap, lift up on it slightly until it no longer contacts the cap. Do not rotate the crankshaft at any time during this operation.

16 Remove the nuts and detach the rod cap, being careful not to disturb the Plastigauge.

17 Compare the width of the crushed Plastigauge to the scale printed on the envelope to obtain the oil clearance (see **illustration**). Compare it to this Chapter's Specifications to make sure the clearance is correct.

18 If the clearance is not as specified, the bearing inserts may be the wrong size (which means different ones will be required). Before deciding that different inserts are needed, make sure that no dirt or oil was between the bearing inserts and the connecting rod or cap when the clearance was measured. Also, recheck the journal diameter. If the Plastigauge was wider at one end than the other, the journal may be tapered (refer to Section 19).

Final connecting rod refitting

19 Carefully scrape all traces of the Plastigauge material off the rod journal and/or bearing face. Be very careful not to scratch

the bearing, use your fingernail or the edge of a credit card to remove the Plastigauge.

20 Make sure the bearing faces are perfectly clean, then apply a uniform layer of clean moly-base grease or engine assembly lube to both of them. You'll have to push the piston higher into the cylinder to expose the face of the bearing insert in the connecting rod, be sure to slip the protective hoses over the connecting rod bolts first.

21 At this time, remove the original connecting rod bolts/nuts and replace them with new bolts/nuts. They are of a design which requires they be used only once. The old ones are OK for Plastigauge checking, but for final assembly use only new connecting rod bolts/nuts. Refit the rod cap and tighten the nuts to the torque listed in this Chapter's Specifications. Again, work up to the torque in three steps.

22 Repeat the entire procedure for the remaining pistons/connecting rod assemblies.

23 The important points to remember are:

- a) Keep the back sides of the bearing inserts and the insides of the connecting rods and caps perfectly clean during assembly..
- b) Make sure you have the correct piston/connecting rod assembly for each cylinder.
- c) The dimple on the piston must face the front of the engine.
- d) Lubricate the cylinder walls with clean oil.
- e) Lubricate the bearing faces when refitting the rod caps after the oil clearance has been checked.

24 After all the piston/connecting rod assemblies have been properly installed, rotate the crankshaft a number of times by hand to check for any obvious binding.

25 As a final step, the connecting rod endplay must be checked. Refer to Section 13 for this procedure.

26 Compare the measured endplay to this Chapter's Specifications to make sure it's correct. If it was correct before dismantling and the original crankshaft and connecting rods were reinstalled, it should still be right. However, if new connecting rods or a new crankshaft were installed, the endplay may be

inadequate. If so, the connecting rods will have to be removed and taken to an automotive machine workshop for resizing.

26 Initial start-up and running-in after overhaul



Warning: Have a suitable fire extinguisher handy when starting the engine for the first time.

1 Once the engine has been installed in the vehicle, double-check the engine oil and coolant levels.

2 With the spark plugs out of the engine and the ignition system and fuel pump disabled, crank the engine until oil pressure registers on the gauge or the light goes out.

3 Refit the spark plugs, hook up the plug leads and restore the ignition system and fuel pump functions.

4 Start the engine. It may take a few moments for the fuel system to build up pressure, but the engine should start without a great deal of effort.

5 After the engine starts, it should be allowed to warm up to normal operating temperature. While the engine is warming up, make a thorough check for fuel, oil and coolant leaks.

6 Shut the engine off and recheck the engine oil and coolant levels.

7 Drive the vehicle to an area with no traffic, accelerate from 30 to 50 mph, then allow the vehicle to slow to 30 mph with the throttle closed. Repeat the procedure 10 or 12 times. This will load the piston rings and cause them to seat properly against the cylinder walls. Check again for oil and coolant leaks.

8 Drive the vehicle gently for the first 500 miles (no sustained high speeds) and keep a constant check on the oil level. It is not unusual for an engine to use oil during the running-in period.

9 At approximately 500 to 600 miles, change the oil and filter.

10 For the next few hundred miles, drive the vehicle normally. Do not pamper it or abuse it.

11 After 2000 miles, change the oil and filter again and consider the engine run-in.