SHORT BLOCKS

8

OBJECTIVES

◆ List the parts that make up a short block and briefly describe their operation. ◆ Describe the major service and rebuilding procedures performed on cylinder blocks. ◆ Explain crankshaft construction, inspection, and rebuilding procedures. ◆ Explain the function of engine bearings, flywheels, and harmonic balancers. ◆ Explain the common service and assembly techniques used in connecting rod and piston servicing. ◆ Explain the purpose and design of the different types of piston rings. ◆ Describe the procedure for installing pistons in their cylinder bores.

An engine is made up of many parts, each with its own purpose and service procedure. When there is a major engine failure, shops either rebuild or replace the engine. Most often the **short block** is repaired or replaced as an assembly. A **long block** is basically a short block with cylinder heads.

A basic short block assembly consists of a cylinder block, crankshaft, crankshaft bearings, connecting rods, pistons and rings, and oil galley and core plugs (Figure 8–1). Parts that are related to the short block but not necessarily included are the engine's flywheel and **harmonic balancer**. A short block may also include the engine's camshaft and timing gear. These, however, are discussed in a later chapter.

CYLINDER BLOCK

The cylinder block makes up the lower section of the engine. It houses the areas where compression, ignition, and combustion of the air/fuel mixture take place (Figure 8–2). The upper section of the engine, known as the cylinder head, bolts on top of the cylinder block. In addition to covering the tops of th cylinder block bores, the head forms part of the combustion chamber and often contains the valve train components.

The cylinder block (Figure 8–3) is normally one piece, cast, and machined so all the parts contained in it fit properly. Blocks may be cast from several different materials: iron, aluminum, or possibly, in the future, plastic.

The word **cast** refers to how the block is made. To cast is to form molten metal into a particular shape by pouring or pressing it into a mold. This molded piece must then undergo a number of machining operations to make sure all the working surfaces are smooth and

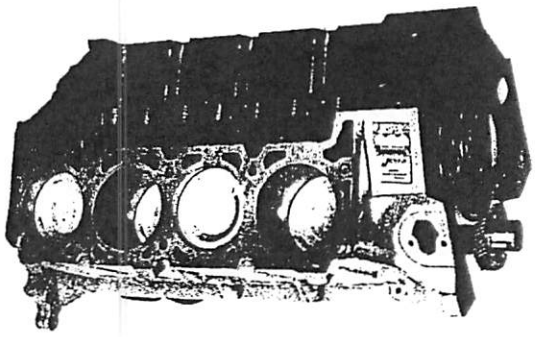


FIGURE 8–1 Basic short block assembly. *Courtesy of Jasper Engine and Transmission Exchange, Inc.*

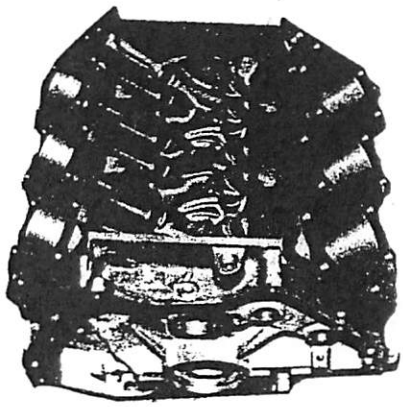
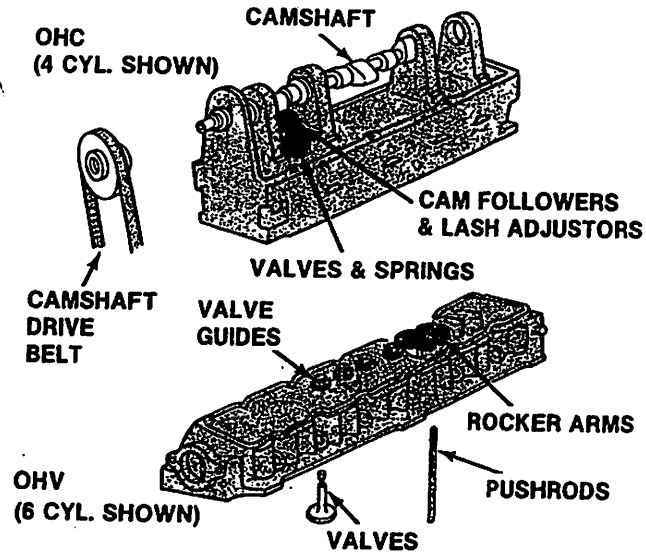
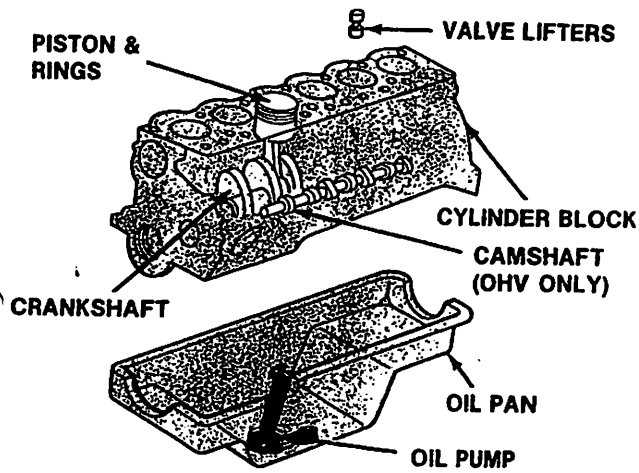


FIGURE 8–2 V-6 cylinder block.



TYPICAL HEADS



TYPICAL BLOCK (6 CYL. SHOWN)

FIGURE 8–3 An engine can be divided into two main assemblies: the engine or cylinder block and the cylinder head. *Courtesy of Ford Motor Company*

true. The top of the block must be perfectly smooth because the cylinder head will later be attached at this point. The base or bottom of the block must also be machined because the oil pan attaches here. All block sealing areas are also machined. The cylinder bores must be smooth and have the correct diameter to accept the pistons.

The main bearing area of the block must be align bored to a diameter that will accept the crankshaft. Camshaft bearing surfaces must also be bored. The word **bore** means to drill or machine a hole. Align boring is a series of holes in a straight line.

Cast-iron blocks offer great strength and controlled rpage due to heat. With the increased concern for improved gasoline mileage however, car manufacturers are trying to make the vehicle lighter. One way to do this is to reduce the weight of the block. Aluminum is used for this purpose because it is a very light metal. Certain materials are added to the metal before it is poured into the mold. These materials are used to make the aluminum stronger and less likely to warp from the heat of combustion. Aluminum blocks normally have a sleeve or steel liner placed in them to serve as cylinder walls. Steel liners are placed in the mold before the metal is poured. After the metal is poured, the steel liner cannot be removed.

Lubrication and Cooling

The cylinder block contains a series of oil passages that allows engine oil from the oil pan to be pumped through the block and crankshaft and onto the cylinder head. The oil lubricates, cools, and cleans engine components (Figure 8–4).

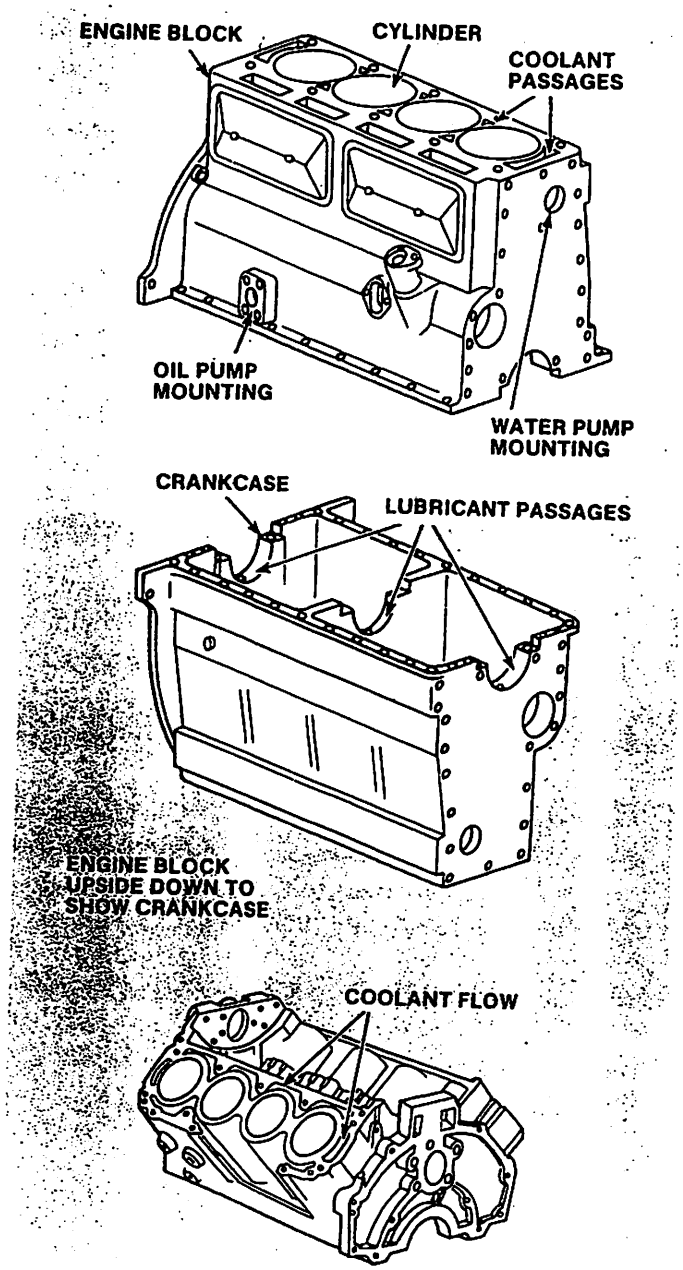


FIGURE 8–4 Oil and coolant passages in in-line and V-type engine blocks.

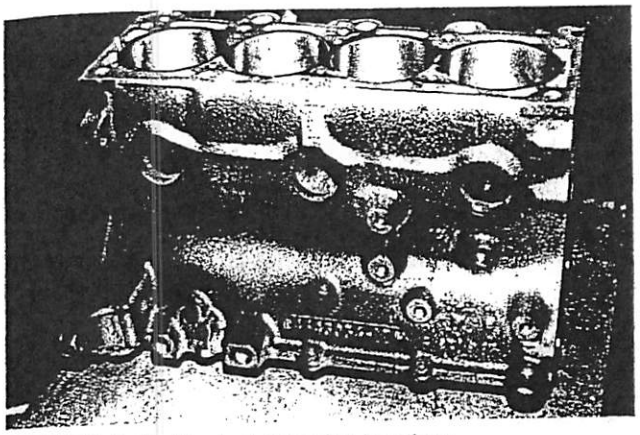


FIGURE 8–5 Typical core plug locations

Because engines are not 100 percent efficient, some of the heat they generate is absorbed by the block and cylinder heads. This absorbed heat is wasted power and must be removed from the engine parts before it damages the engine. This is the job of the cooling system. Water jackets are cast in the cylinder block around the cylinder bores. As shown in Figure 8–4, coolant circulates through these jackets to transfer heat away from these areas.

Core Plugs

All cast-iron cylinder blocks use **core plugs**. These are also called freeze-out or expansion plugs. During the manufacturing process, sand cores are used. These cores are partly broken and dissolved when the hot metal is poured into the mold. However, holes have to be placed in the block to get the sand out of the internal passageways. These are called core holes. The holes are machined and core plugs are placed into these holes to seal them (Figure 8–5).

Core plugs are made of soft metal. They can also protect the block from cracking. If the coolant in the block freezes, it will expand, putting an extreme amount of pressure on the passages inside the block. This pressure can easily crack the block. When the coolant freezes, the core plugs may pop out to allow the coolant to expand before the block cracks.

Cylinder Sleeves

Some automobile manufacturers use **cylinder sleeves** (Figure 8–6). Rather than casting the cylinder bores directly into the block, they insert a machined sleeve after the block has been machined. The purpose of using a sleeve is that if the cylinder is damaged, the sleeve can be removed and replaced rather easily. Cylinders without sleeves must be bored out to remove any damage. After boring, larger pistons are needed or standard-sized sleeves are added.

There are two types of sleeves: wet and dry. Both types are pressed into the block. The dry sleeve is supported from top to bottom by the block. The wet sleeve is supported only at the top and bottom. Coolant touches the center part of the sleeve.

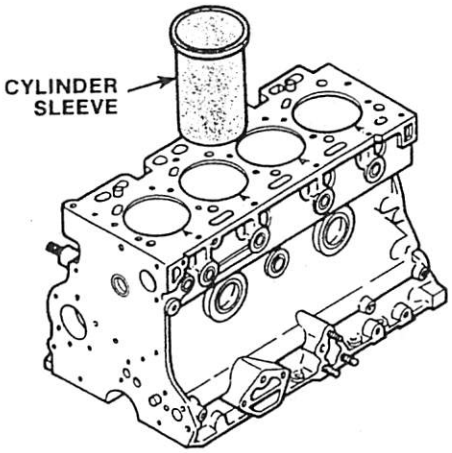


FIGURE 8–6 A cylinder sleeve is fitted into the bore to serve as a wear surface for the piston rings.

CYLINDER BLOCK RECONDITIONING

Before any reconditioning or rebuilding work is started, threaded holes should be cleaned with the correct size tap to remove any and all burrs or dirt to allow for proper bolt torquing (Figure 8–7). Use a bottoming tap in any blind holes. **Chamfering** or counterboring will eliminate thread pulls and jagged edges. All burrs and casting slag should be removed from inside the block with a high-speed grinder.

Deck Flatness

The top of the engine block where the cylinder head mounts, is called the **deck**. To check deck warpage, use a precision straightedge and feeler gauge (Figure 8–8) to measure the deck in each direction. With the straightedge positioned diagonally across the deck, the amount of warpage is determined by the size of feeler gauge that fits into the gap between the deck and the straightedge.

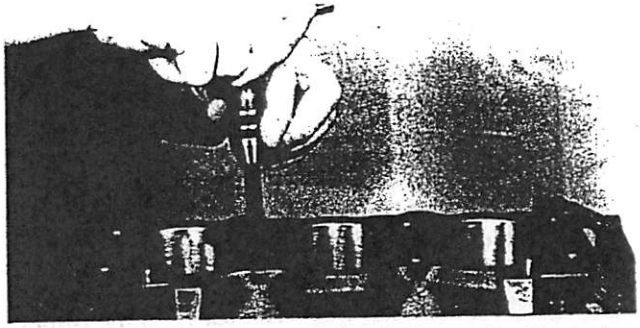


FIGURE 8–7 All threaded bores in the engine block should be cleaned with the correct size tap. *Courtesy of Perfect Circle/Dana*

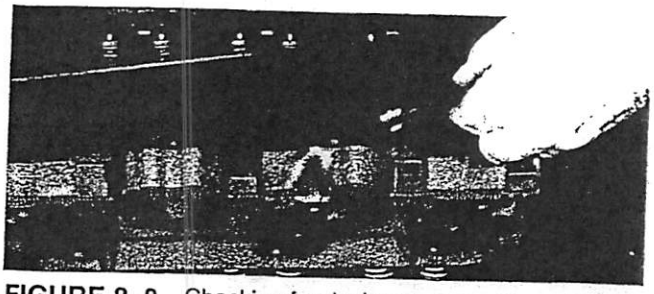


FIGURE 8–8 Checking for deck warpage with a straightedge and feeler gauge.

SHOP TALK

Instead of using a straightedge and feeler gauge, many technicians prefer to check for warpage with an arbor and gauge. Roll the dial indicator along the arbor and across the surface of the block. It can also be used to check a cylinder head for warpage (Figure 8–9). ■

Some engines have special sealing surface flatness requirements. Always refer to the manufacturer's specifications. If specifications are not available, use 0.003 inch per 6 inches, and no more than 0.006-inch maximum on any length. In most cases if the block has more than one deck surface (such as a V-type engine), each deck should be machined to the same height. This allows for uniform compression and manifold alignment. If the gasket surface of the block is warped and not corrected, valve seat distortion will occur when the head is tightened to the block. Coolant and combustion leakage can also occur.

Two other reasons a technician might elect to resurface are to blend the sleeves into the deck surface after sleeving or to obtain uniform cylinder length for performance or blueprint work. Blocks can be refinished by broaching, milling, or grinding. Any of these methods is acceptable as long as the proper surface finish is obtained.

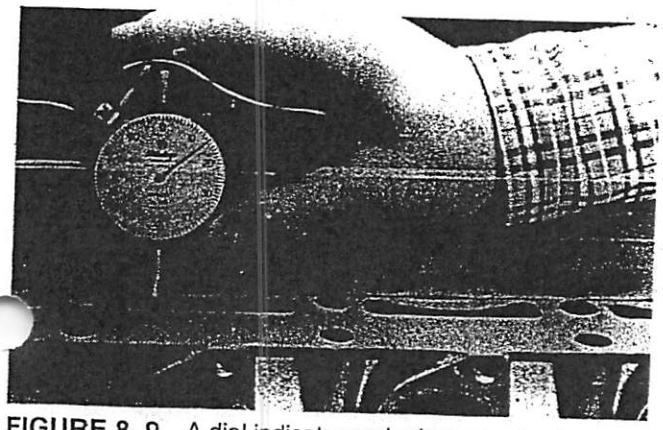


FIGURE 8–9 A dial indicator and arbor can also be used to check for deck warpage. *Courtesy of Goodson Shop Supplies*

Cylinder Walls

Inspect the cylinder walls for scoring, roughness, or other signs of wear. Ring and cylinder wall wear can be accelerated by an abrasive environment. Abrasive particles that get between mated moving parts grind away at the adjoining surfaces and remove material from the parts. Abrasive particles can include metallic debris in the engine, which is a result of wear and nonmetallic dirt particles that entered the engine during operation or maintenance. The source of contamination should be located and corrected to avoid a recurrence of the problem.

CUSTOMER CARE

If the cause of an engine problem is customer neglect, inform the customer of this. Do so in an understanding way. Never make the customer feel stupid. ■

Piston ring, piston, and cylinder wall damage can also be caused by scuffing and scoring. Grooves cut in these parts act as passages for oil to bypass the rings and enter the combustion chamber. Scuffing and scoring occur when the oil film on the cylinder wall is ruptured, allowing metal-to-metal contact of the piston and rings on the cylinder wall. The heat generated causes momentary welding of the contacting parts. The reciprocating movement of the piston breaks these welds, cutting grooves in the ring faces, piston skirt, and cylinder wall. Cooling system hot spots, oil contamination, and fuel wash are significant causes of this problem.

A problem affecting the newer thin-wall engines is block distortion. Out-of-round cylinders break the face seal between the rings and cylinder wall permitting the passage of oil into the combustion chamber (Figure 8–10).

The cylinder heads and main bearing caps induce stresses in the block. These stresses must be duplicated when the cylinders are being bored, particularly if the block is of the thin-wall design. To accomplish

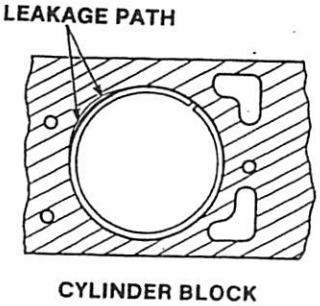


FIGURE 8–10 Checking for oil leakage past the piston rings.

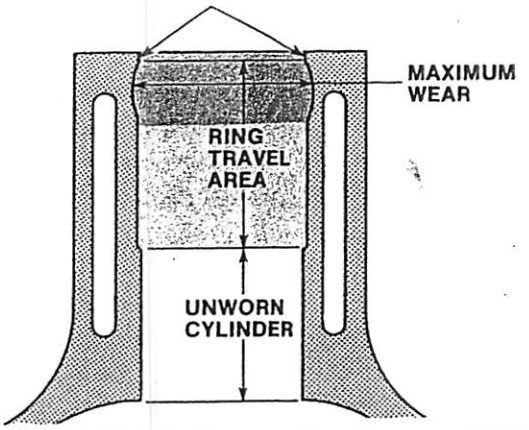


FIGURE 8–11 Cross section of a worn cylinder.

this, the main bearing caps should be installed and torqued to specifications. Torque or deck plates should be bolted to the block to simulate the weight and structure of the cylinder heads so the bores will be round when the engine is assembled. Failure to follow these steps can result in block distortion, which causes oil consumption.

Cylinder Bore Inspection

Normally cylinder bore wear is not uniform (Figure 8–11). The maximum amount of wear occurs at the top of the ring travel area. Pressure on the top ring is at a peak and lubrication at a minimum when the piston is at the top of its stroke. Shallow depressions form at the top of the cylinder on the thrust faces, giving the cylinder an oval shape at the top. A ridge of unworn material will remain above the upper limit of ring travel. Below the ring travel area, wear is negligible because only the piston skirt contacts the cylinder wall (Figure 8–12).

There are several requirements for a properly reconditioned cylinder. It must be the correct diameter, have no taper or out-of-roundness, and the surface finish must be such that the piston rings will seat to form a seal that will control oil and minimize blowby.

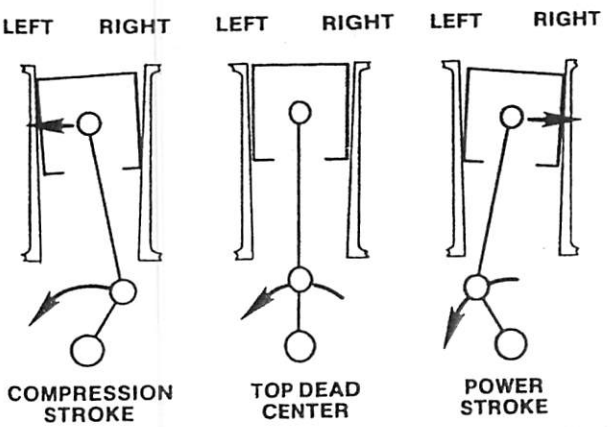


FIGURE 8–12 When piston slap occurs, the cylinder bore wears most at the top.

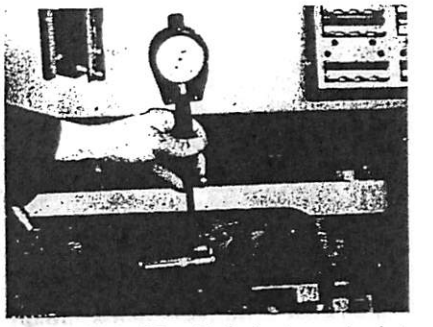


FIGURE 8–13 Cylinder taper is determined by measuring the diameter of the bore at the top of ring travel and comparing it to the diameter at the bottom of ring travel. *Courtesy of Goodson Shop Supplies*

Taper is the difference in diameter between the cylinder bore at the bottom of the hole and the bore at the top of the hole, just below the ridge (Figure 8–13). Subtracting the smaller diameter from the larger one gives the cylinder taper. Some taper is permissible, but normally not more than 0.006 inch. If taper is less than 0.006 inch, it is possible to get by with just a re-ring job as opposed to reboring.

Cylinder out-of-roundness is the difference of the cylinder's diameter when measured parallel with the crank and perpendicular to the crank (Figure 8–14). Out-of-roundness is measured at the top of the cylinder just below the ridge. Typically the maximum allowable out-of-roundness is 0.0015 inch. Normally a cylinder bore is checked for out-of-roundness with a dial bore gauge. However, a telescoping gauge (Figure 8–15) can also be used.

Cylinder Bore Surface Finish

The surface finish on a properly prepared cylinder wall acts as a reservoir for oil to lubricate the piston rings and prevent piston and ring scuffing primarily during break-in. Piston ring faces can be damaged and experience premature wear if the cylinder wall is too rough. A surface that is too smooth will not allow

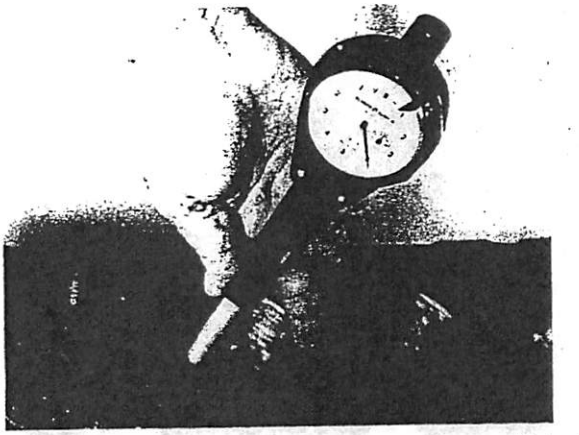


FIGURE 8–14 Measuring out-of-roundness with a dial bore gauge. *Courtesy of Atlas Engineering and Manufacturing, Inc.*

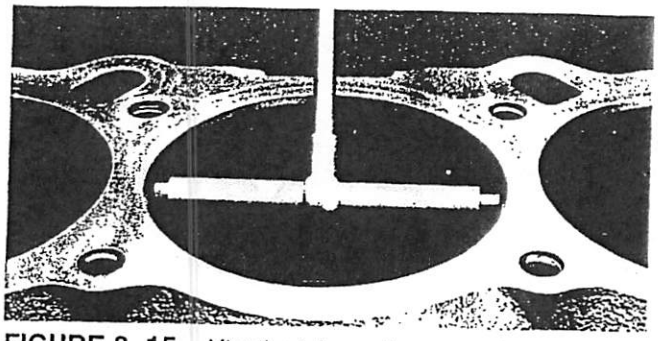


FIGURE 8–15 After the telescoping gauge has been expanded to fit the bore, it is measured with a micrometer. *Courtesy of Perfect Circle/Dana*

the rings to seat properly. Obtaining the correct cylinder wall finish is important. The finish should allow for good sealing and oil control.

CYLINDER DEGLAZING If the inspection and measurements of the cylinder wall show that surface conditions, taper, and out-of-roundness are within acceptable limits, the cylinder walls only need to be deglazed. Combustion heat, engine oil, and piston movement combine to form a thin residue on the cylinder walls that is commonly called **glaze**.

CAUTION:

Always wear eye protection when operating deglazing, honing, or boring equipment. ■

The two most common types of glaze breakers are shown in Figure 8–16. With either type, use an abrasive with about 220 or 280 grit. The driver end of the glaze breaker is installed in a slow-moving electric drill that operates at 300 to 500 rpm or in a

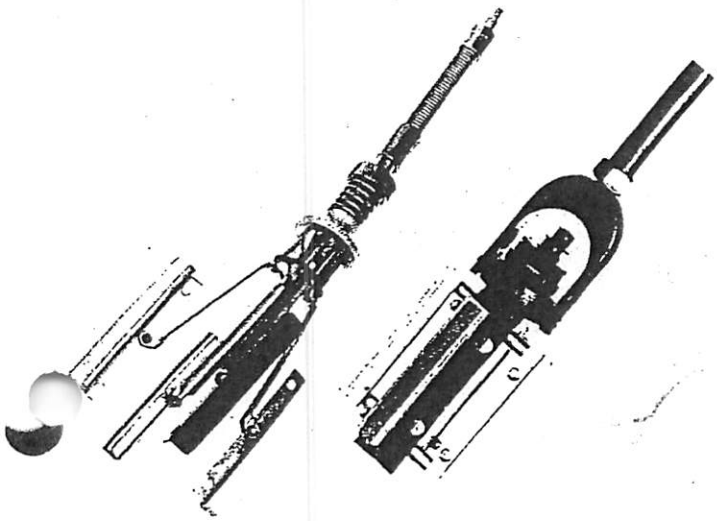


FIGURE 8–16 Two types of glaze breakers. *Courtesy of K-Line Industries*

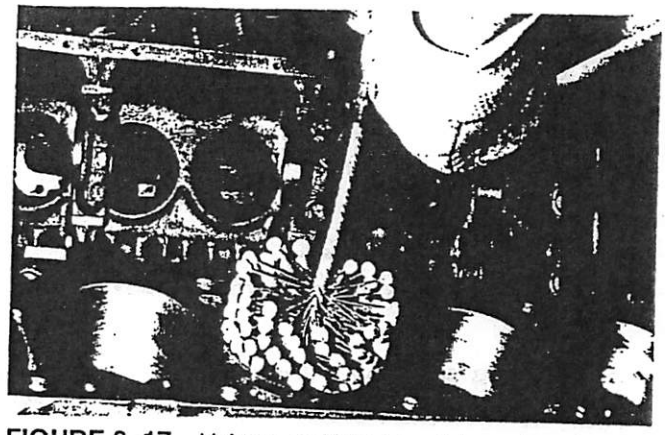


FIGURE 8–17 Using a resilient-based, hone-type brush, commonly called a ball hone.

FIGURE 8–18 After honing, clean with soapy water and a soft, lint-free cloth. *Courtesy of TRW, Inc.*

honing machine. Various sizes of resilient-based hone-type brushes are available for honing and deglazing (Figure 8–17).

Deglazing residue and metal fragments adhering to the cylinder walls are abrasive and will quickly damage the rings, pistons, and cylinders if not removed. Using plenty of hot, soapy water, a stiff bristle brush, and a soft, lint-free cloth is the best way to clean the residue (Figure 8–18). Then rinse the block with clear water and dry thoroughly. Lightly coat all machined areas of the engine with clean, light engine oil to prevent rust. Cylinder cleanliness can be checked by wiping them with a clean white cloth after oiling. The cylinder walls can be considered free of abrasive residue when the cloth remains clean.

SHOP TALK

If the cylinders have varnish deposits, they can be swabbed with lacquer thinner to remove the varnish. Should the cylinders be lightly scuffed or scratched, light honing is recommended. Also, remember to adhere to the engine manufacturer's instructions. ■

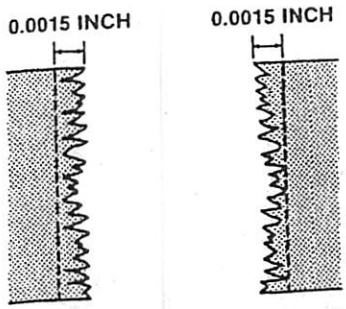
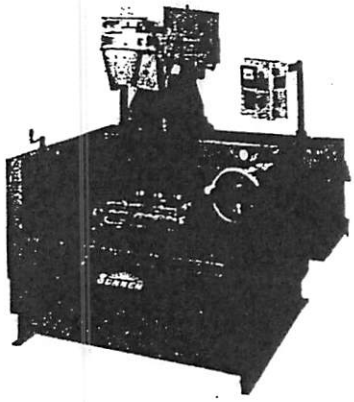


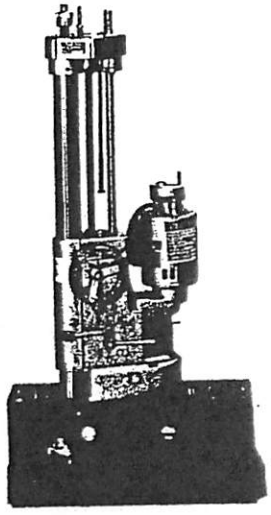
FIGURE 8–19 Typical bore pattern created by a boring bar.

CYLINDER BORING When cylinder surfaces are badly worn or excessively scored or when a perfectly straight cylinder is desired, a **boring bar** is used to cut the cylinders for oversize pistons or sleeves. A boring bar leaves a pattern on the cylinder wall similar to uneven screw threads (Figure 8–19). This makes it necessary to hone the bore to the correct finish after it has been bored to the proper size. This size is determined by the size of the replacement pistons and rings.

As shown in Figure 8–20, there are two types of boring machines: (A) stationary and (B) portable.

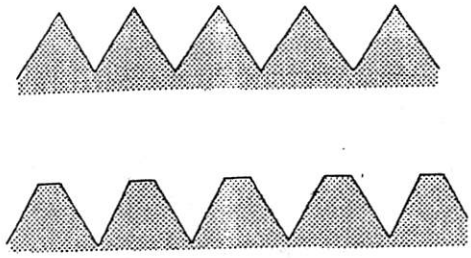


A



B

FIGURE 8–20 (A) Stationary and (B) portable boring machines. *Courtesy of Sunnen Products Company*



A

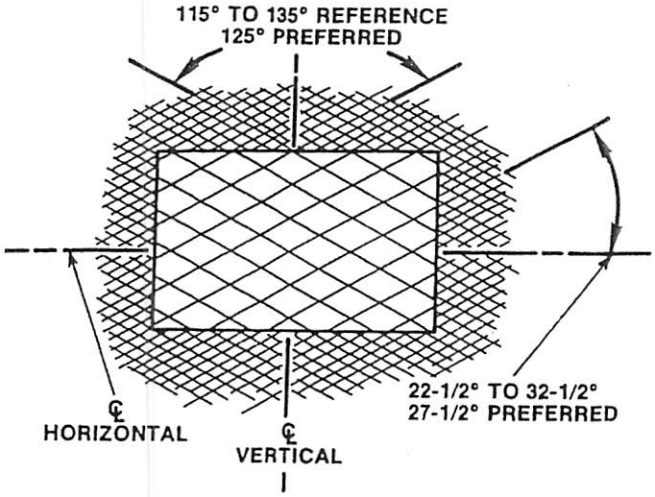
B

FIGURE 8–21 Comparison of (A) ridges and (B) plateaus on a honed cylinder surface.

CYLINDER HONING It is necessary to **hone** the cylinder after boring to obtain proper ring and cylinder seating. Normally a minimum of 0.003 inch needs to be removed from the bore to smooth the marks left by the boring bar's cutter. These marks can slow down the piston ring seating process, which will cause poor oil control, blowby, and a dissatisfied customer. Honing will leave the cylinder with the proper surface so it will distribute oil, serve as an oil reservoir, and provide a place for worn metal and abrasive particles. A proper finish will provide for flat areas or plateaus in the surface. These act as bearing surfaces on which an oil film can form to separate the rings from the wall (Figure 8–21).

A rigid hone usually consists of two stones mounted opposite each other on a holder with guide located at right angles between them (Figure 8–22). The hone rotates at a selected speed. It is also manually or automatically reciprocated within the cylinder bore. The stones have an outward pressure on them and they remove some metal from the bore as they rotate within it. Honing oil flows over the stones and onto the cylinder wall to control the temperature and flush out any metallic and abrasive residue. The proper stones should be selected to ensure the walls will have the correct surface finish. Honing stones are classified by grit size, although honing equipment manufacturers can also have their own designation. The lower the grit number, the coarser the stone.

FIGURE 8–22 Using a rigid hone. *Courtesy of Sealed Power Corporation*



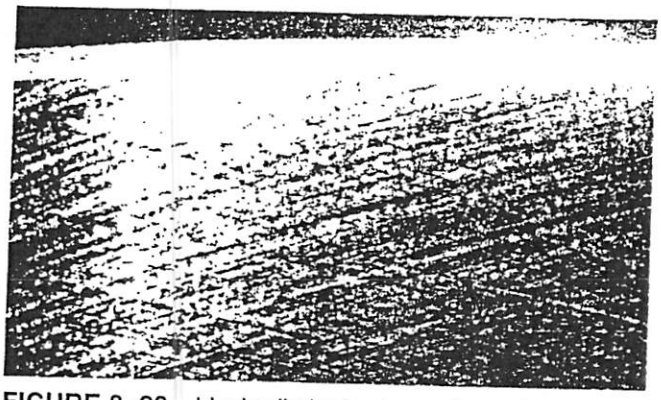


FIGURE 8–23 Ideal cylinder honing pattern. *Courtesy of Sealed Power Corporation*

A honing stone has thousands of tiny cutting edges that leave a multitude of crisscross grooves in the cylinder wall (Figure 8–23). These cutting edges continually break away from a properly operated hone to expose new, sharp cutting edges. Millions of tiny diamond-shaped areas are generated during the honing process, which serve as lubricant reservoirs to maintain the oil film on which the piston rings ride. Ideally, these grooves cross at 50 degree angles, although anything in the 20- to 60-degree range is acceptable.

Cylinder hone machines are available in manual and automatic models (Figure 8–24). The major advantage of the automatic type is that it allows the machine operator to dial in the exact crosshatch angle required in both the upper and lower stops of the bore.

Torquing plates are usually fastened to the cylinder block to equalize or prevent twist and distortion, while honing or boring a cylinder (Figure 8–25). When honing, be sure to keep a good flow of honing oil.

Engines with cylinder walls too thin for boring, engines with oversize pistons, and engines with only one damaged cylinder can be reconditioned by sleeving. Sleeving involves boring the cylinder oversize, then installing a thin metal liner. The inside diameter

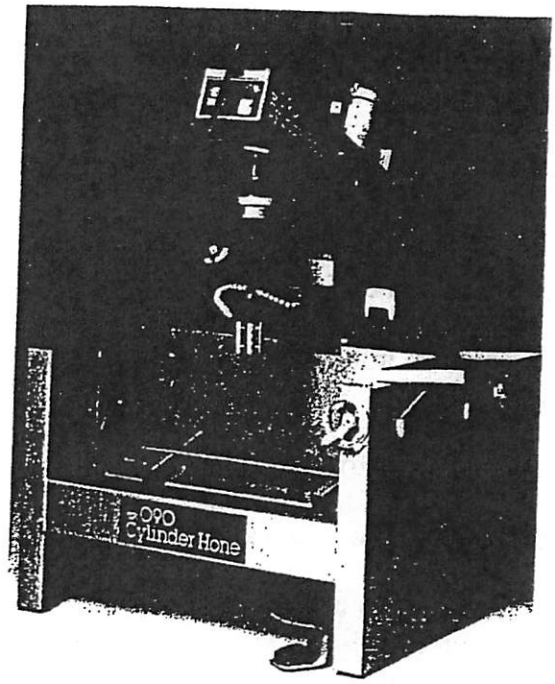


FIGURE 8–24 Automatic cylinder hone machine. *Courtesy of Kwik-Way Manufacturing Company*

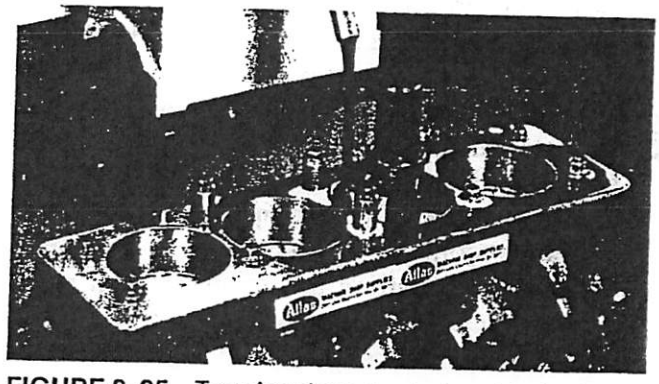


FIGURE 8–25 Torquing plates are fastened to the block during cylinder boring to prevent distortion. *Courtesy of Atlas Engineering and Manufacturing, Inc.*

of the sleeve is then bored, usually to the original or standard piston size. This procedure can be used in one or all of the engine's cylinders. Figure 8–26 shows two methods used to install a cylinder sleeve.

INSTALLING CORE PLUGS

Old core and oil galley plugs are normally removed and replaced as part of cylinder block reconditioning. To install new core or soft plugs in the block, always use a nonhardening gasket sealer and the proper installation tool (Figure 8–27). It is important that the proper size and type of plug is used. Check a service manual for the proper replacement numbers. Brass core plugs are often recommended because they will not rust.

Prior to installing a core plug, the plug bore should be inspected for any damage that would inter-

hole is used to supply oil for lubricating and cooling the piston skirt. When the rod is properly installed, the oil hole should be pointing to the major thrust area of the cylinder wall.

PISTON AND PISTON RINGS

The piston forms the lower portion of the combustion chamber. The force of the expanding air/fuel mixture at the time of ignition is exerted against the head or dome of the piston. This force then pushes the piston down in the cylinder. The force applied to the piston can be as high as 2-1/2 tons. Therefore, the piston must be very strong.

In the past, pistons were made primarily of cast iron or a mixture of iron and steel. They were strong, but also heavy. Due to advances in aluminum technology, most modern pistons are made of lighter-weight aluminum or aluminum alloys.

Hypereutectic pistons are cast from an aluminum alloy containing up to 20 percent silicon. The silicon adds exceptional strength and durability to the metal. Higher strength means thinner side walls can be used, reducing piston weight. Hypereutectic pistons are very scuff resistant and less prone to ring groove, skirt, and pin bore wear. They offer excellent heat resistance and reduce thermal expansion so they can be installed to tight tolerances. This improves cold sealing and reduces operating noise. Hypereutectic pistons are now OEM equipment on many engines and are recommended replacement equipment for engines with scuffing and/or detonation problems. Passenger cars and light trucks with turbochargers or high output or severe duty operation also benefit from hypereutectic pistons.

The top of the piston is called the **head** or **dome**. Just below the dome on the side of the piston is a series of grooves. The grooves are used to contain the piston rings. The high parts between the grooves are called **ring lands**. Below the grooves, as shown in Figure 8–61, there is a bore, or hole, which is used for the **piston pin**, sometimes called the **wrist pin**. This hole is not always centered in the piston. It can be offset to one side. Piston pin offset is toward the major thrust side of the piston, the side that will contact the cylinder wall during the power stroke. By offsetting the pin, piston slap caused by the piston changing direction in the cylinder is eliminated.

SHOP TALK

The term piston slap or bang is used to describe the noises made by the piston when it contacts the cylinder wall. This noise is usually heard only in older, high-mileage engines that have worn pistons or cylinder walls. The noise is most noticeable when the engine is cold or under a load. ■

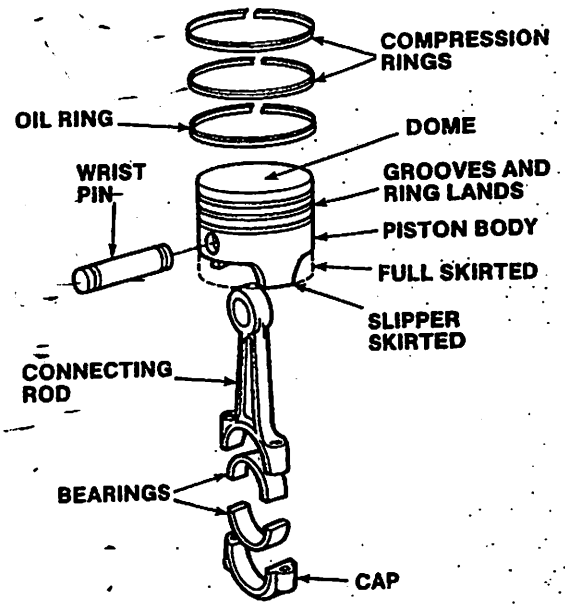


FIGURE 8–61 Piston and connecting rod assembly.

To ensure that the piston is installed correctly and the offset is on the proper side, the top of the piston will have a mark. The most common mark is a notch, machined into the top edge of the piston. This mark must always face the timing chain end of the engine when the piston is installed. The base of the piston, the area below the piston pin, is called the piston skirt. The area from just below the bottom ring groove to the tip of the skirt is the piston thrust surface.

There are two basic types of piston skirts: the slipper type and the full skirt. The full skirt is used primarily in truck and commercial engines. The slipper type is used for automobile engines. The slipper type allows the piston enough thrust surface for normal operation and has the advantage of allowing the piston to be lighter. This design also cuts down on piston expansion because there is less material to hold heat.

When an engine is designed, piston expansion determines how much piston clearance will be needed in the cylinder bore. Too little clearance will cause the piston to bind at operating temperatures. Too much will cause piston slap. The normal piston clearance for an engine, using slipper skirted pistons, is about 0.001 to 0.002 inch. This clearance is measured cold between the piston skirt and the cylinder wall. The piston clearance also supplies a space for piston lubrication.

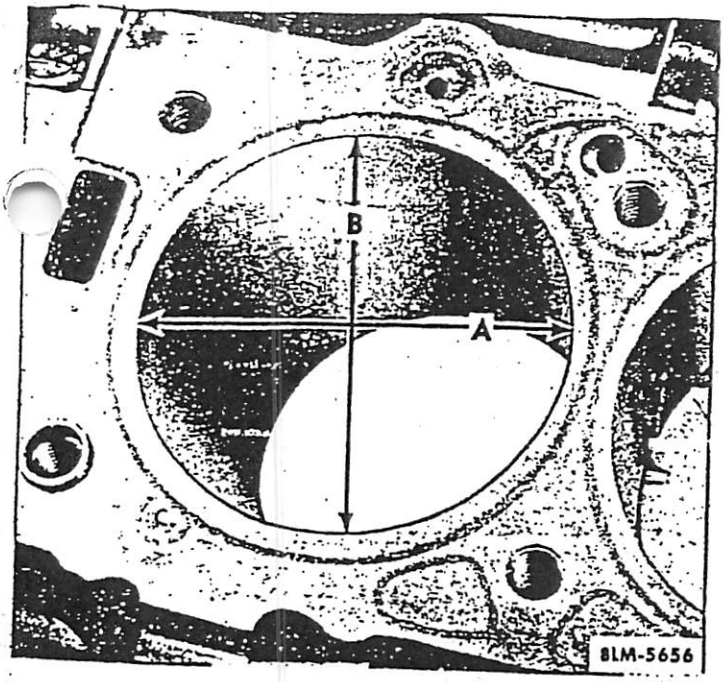
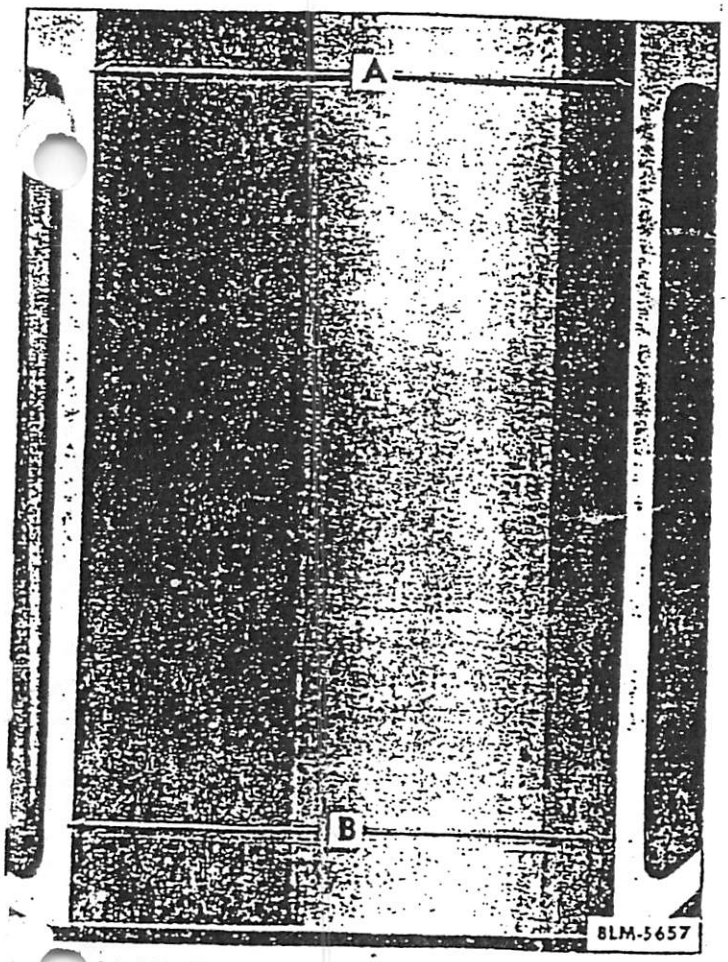


Fig. 6A-58—Measurement of Cylinder Bore—Out of Round

"Measuring Engine Cylinders"

Measure the diameter of the cylinder bore at the top of the piston ring travel at right angles to the centerline of the crankshaft (B). Record readings. Next, measure each bore so gauge position coincides with centerline or crankshaft(A) The difference between the readings is the out-of-round condition at the top of the cylinder bore. Repeat this same procedure at the bottom of the ring travel to check for out-of-round.



6A-59—Measurement of Cylinder Bore—Taper

The difference between the diameters measured at the top (A) and bottom (B) of the bore (at right angles to the centerline of the crankshaft) is the taper of the bore. See figure 6A-59.

If the cylinder bore wear does not exceed the limits of approx. 0.003 inch out-of-round; 0.005 inch taper new service piston rings will give satisfactory performance provided the piston is not damaged and piston to cylinder clearance is not excess Check the manufacturer's specs regarding taper and out-of-round.

However, if the wear exceeds the limits it will be necessary to rebore the cylinder or cylinders to within 0.0015 inch of the required oversize diameter. This will all enough stock for the final step of honing the bores so the exact clearance and surfa finish may be obtained for the selected oversize pistons.