CHAPTER 26

ENGINE BLOCKS

OBJECTIVES

After studying Chapter 26, the reader will be able to:

1. Prepare for Engine Repair (A1) ASE certification test content area "C" (Engine Block Diagnosis and Repair).
2. Describe the types of engine blocks and how they are manufactured.
3. List the machining operations required on most engine blocks.
4. List the steps necessary to prepare an engine block for assembly.

KEY TERMS

Bedplate (p. 501)
Block Deck (p. 502)
Bores (p. 500)
Compacted Graphite Iron (CGI) (p. 501)
Cooling Jacket (p. 502)
Core Plugs (p. 500)
Crosshatch Finish (p. 510)
Decking the Block (p. 506)
Dry Cylinder Sleeve (p. 501)
Fiber Reinforced Matrix (FRM) (p. 502)
Freeze Plugs (p. 500)
Frost Plugs (p. 500)
Grit Size (p. 511)
Monoblock (p. 500)
Oil Gallery (p. 503)
Oil Gallery Plugs (p. 503)
Plateau Honing (p. 509)
Saddles (p. 505)
Sleeving (p. 508)
Wet Cylinder Sleeve (p. 501)

ENGINE BLOCKS

The engine block, which is the supporting structure for the entire engine, is made from gray cast iron or from cast or die-cast aluminum alloy. The gray color is a result of the 3% carbon in the form of graphite in the cast iron. The liquid cast iron is poured into a mold. The carbon in the cast iron allows for easy machining, often without coolant. The graphite in the cast iron also has lubricating properties. Newer blocks use thinner walls to reduce weight. Cast iron is strong for its weight and usually is magnetic. All other engine parts are mounted on or in the block. This large casting supports the crankshaft and camshaft and holds all the parts in alignment. Blocks are often of the **monoblock** design, which means that the cylinder, water jacket, main bearing supports (saddles), and oil passages are all cast as one structure for strength and quietness. Large-diameter holes in the block casting form the cylinders to guide the pistons. The cylinder holes are called **bores** because they are made by a machining process called boring. Combustion pressure loads are carried from the head to the crankshaft bearings through the block structure. The block has webs, walls, and drilled passages to contain the coolant and lubricating oil and to keep them separated from each other. See Figure 26-1.

Mounting pads or lugs on the block transfer the engine torque reaction to the vehicle frame through attached engine mounts. A large mounting surface at the rear of the engine block is used for fastening a bell housing or transmission.

The cylinder head(s) attaches to the block. The attaching joints are sealed so that they do not leak. Gaskets are used in the joints to take up differences that are created by machining irregularities and that result from different pressures and temperatures.

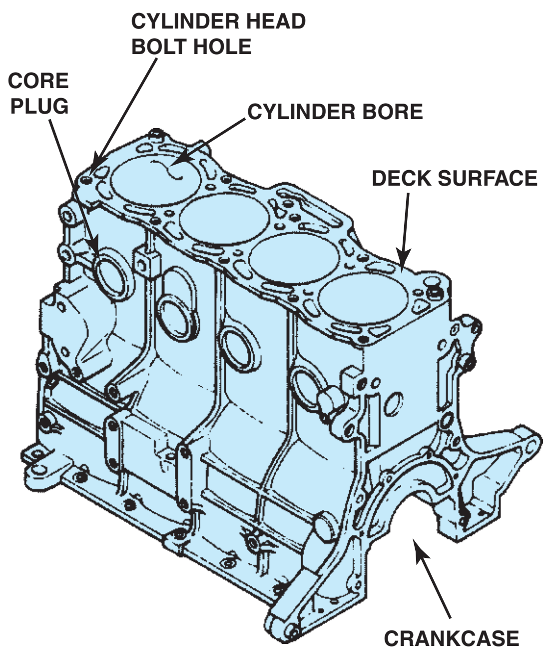


FIGURE 26-1 The cylinder block usually extends from the oil pan rails at the bottom to the deck surface at the top.

Block Manufacturing

Cast-iron cylinder block casting technology continues to be improved. The trend is to make blocks with larger cores, using fewer individual pieces. Oil-sand cores are forms that shape the internal openings and passages in the engine block. Before casting, the cores are supported within a core box. The core box also has a liner to shape the outside of the block. Special alloy cast iron is poured into the box. It flows between the cores and the core box liner. As the cast iron cools, the core breaks up. When the cast iron has hardened, it is removed from the core box, and the pieces of sand core are removed through the openings in the block by vigorously shaking the casting. These openings in the block are plugged with **core plugs.** Core plugs are also called **freeze plugs** or **frost plugs.** Although the name seems to mean that the plugs would be pushed outward if the coolant in the passages were to freeze, they seldom work this way. See Figure 26-2.

One way to keep the engine weight as low as possible is to make the block with minimum wall thickness. The cast iron used with thin-wall casting techniques has higher nickel content and is harder than the cast iron previously used. Engine designers have used foundry techniques to make engines lightweight by making the cast-iron block walls and bulkheads only as heavy as necessary to support their required loads.

Aluminum Blocks

Aluminum is used for some cylinder blocks and is nonmagnetic and lightweight. See Figure 26-3 for an example of a core used to sand-cast an aluminum block.

FIGURE 26-2 An expansion plug is used to block the opening in the cylinder head or block the holes where the core sand was removed after the part was cast.

FREQUENTLY ASKED QUESTION

WHAT IS COMPACTED GRAPHITE IRON?

Compacted graphite iron (CGI) has increased strength, ductility, toughness, and stiffness compared to gray iron. If no magnesium is added, the iron will form gray iron when cooled, with the graphite present in flake form. If a very small amount of magnesium is added to more and more of the sulfur and oxygen in the molten solution, the shape of the graphite begins to change to compacted graphite forms. Compacted graphite iron is used for bedplates and many diesel engine blocks. It has higher strength, stiffness, and toughness than gray iron. The enhanced strength has been shown to permit reduced weight while still reducing noise vibration and harshness.

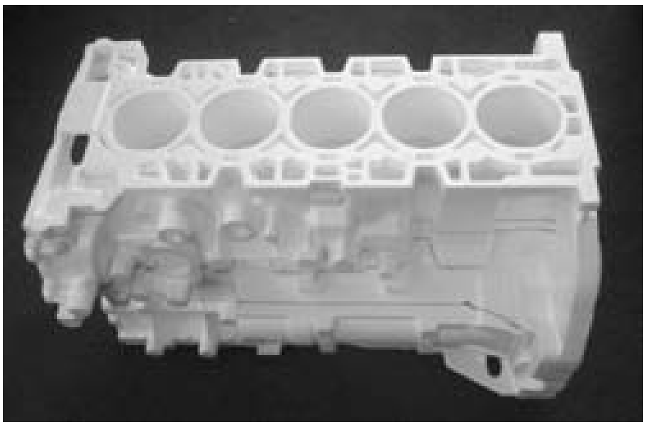


FIGURE 26-3 A Styrofoam casting mold used to make the five cylinder engine blocks for the Chevrolet Colorado and the Hummer H3. The brown lines are glue used to hold the various parts together. Sand is packed around the mold and molten aluminum is poured into the sand, which instantly vaporizes the Styrofoam. The aluminum then flows and fills the area of the mold.

Aluminum blocks may have one of several different types of cylinder walls:

- Cast-aluminum blocks may have steel cylinder liners (Saturn, Northstar, and Ford modular V-8s and V-6s). The cast-iron cylinder sleeves are either cast into the aluminum block during manufacturing or pressed into the aluminum block. These sleeves are not in contact with the coolant passages and are called **dry cylinder sleeves.** See Figure 26-4.
- Another aluminum block design has the block die-cast from silicon-aluminum alloy with no cylinder liners. Pistons with zinc-copper-hard iron coatings are used in these aluminum bores (some Porsche engines).

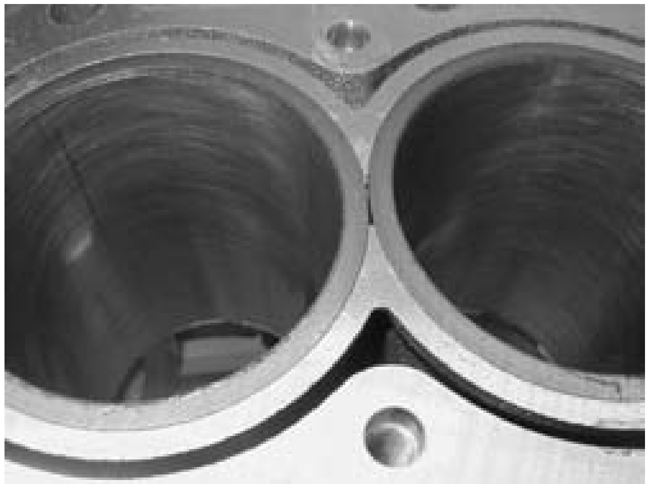


FIGURE 26-4 Cast-iron dry sleeves are used in aluminum blocks to provide a hard surface for the rings.

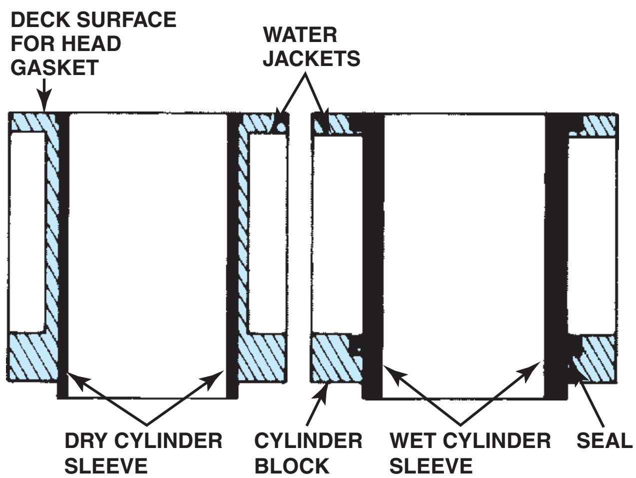


FIGURE 26-5 A dry sleeve is supported by the surrounding cylinder block. A wet sleeve must be thicker to be able to withstand combustion pressures without total support from the block.

- Some engines have die-cast aluminum blocks with replaceable cast-iron cylinder sleeves. The sleeves are sealed at the block deck and at their base. Coolant flows around the cylinder sleeve, so this type of sleeve is called a **wet cylinder sleeve** (Cadillac 4.1, 4.5, and 4.9 L V-8 engines). See Figure 26-5.

Cast-iron main bearing caps are used with aluminum blocks to give the required strength.

Bedplate Design Blocks

A **bedplate** is a structural member that attaches to the bottom of the block and supports the crankshaft. Under the bedplate

FREQUENTLY ASKED QUESTION

WHAT ARE FRM-LINED CYLINDERS?

Fiber reinforced matrix (FRM) is used to strengthen cylinder walls in some Honda/Acura engines. FRM is a ceramic material similar to that used to construct the insulators of spark plugs. The lightweight material has excellent wear resistance and good heat transfer properties making it ideal for use as a cylinder material. FRM inserts are placed in the mold and the engine block is cast over them. The inserts are rough and can easily adhere to the engine block. The inserts are then bored and honed to form the finished cylinders. FRM blocks were first used in a production engine on the Honda S2000 and are also used on the turbocharged Acura RDX sport utility vehicle.

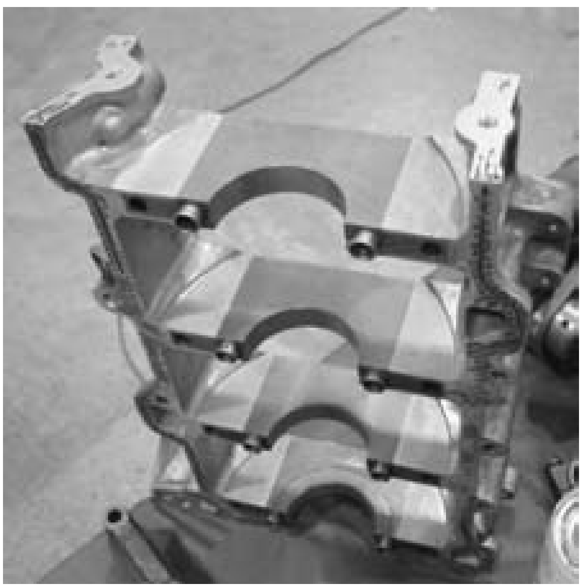


FIGURE 26-6 A bedplate is a structural part of the engine that is attached between the block and the oil pan and supports the crankshaft.

is the oil pan, which in most cases is also part of the structure and support for the block assembly. See Figure 26-6.

Casting Numbers

Whenever an engine part such as a block is cast, a number is put into the mold to identify the casting. These casting numbers can be used to check dimensions such as the cubic inch displacement and other information, such as year of manufacture. Sometimes changes are made to the mold, yet the casting number is not changed. Most often the casting number is the best piece of identifying information that the service technician can use.

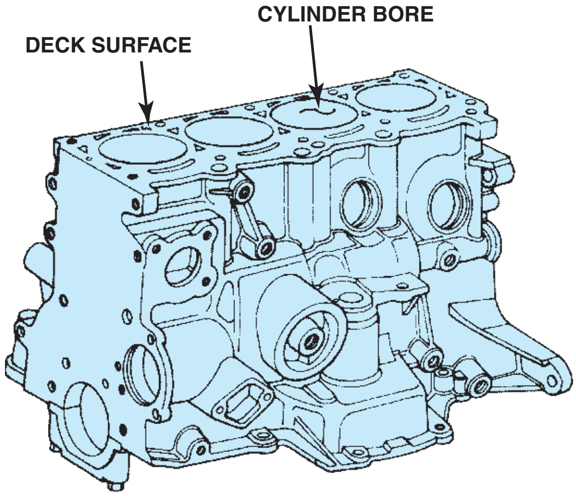


FIGURE 26-7 The deck is the machined top surface of the block. Note all of the passages and holes that are part of the typical block.

Block Deck

The cylinder head is fastened to the top surface of the block. This surface is called the **block deck.** The deck has a smooth surface to seal *against* the head gasket. Bolt holes are positioned around the cylinders to form an even holding pattern. Four, five, or six head bolts are used around each cylinder in automobile engines. These bolt holes go into reinforced areas within the block that carry the combustion pressure load to the main bearing bulkheads. Additional holes in the block are used to transfer coolant and oil, as seen in Figure 26-7.

Cooling Passages

Cylinders are surrounded by cooling passages. These coolant passages around the cylinders are often called the **cooling jacket.** In most skirtless cylinder designs, the cooling passages extend nearly to the bottom of the cylinder. In extended skirt cylinder designs, the cooling passages are limited to the upper portion of the cylinder.

Some engines are built with *Siamese cylinder bores* where the cylinder walls are cast together without a water jacket (passage) between the cylinders. While this design improves the strength of the block and adds stability to the cylinder bores, it can reduce the cooling around the cylinders.

FIGURE 26-8 Cutaway of a Chevrolet V-8 block showing all of the internal passages.

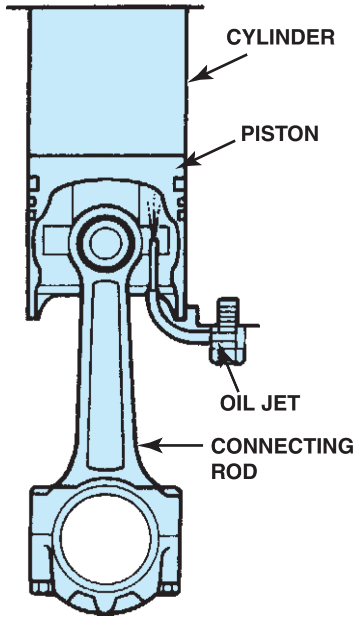


FIGURE 26-9 Oil jets are often used in some turbocharged, and many diesel, engines to cool the pistons.

FREQUENTLY ASKED QUESTION

WHAT IS AN OIL JET?

Some turbocharged gasoline engines and many diesel engines have an oil jet that directs a shot of oil directly to the underside of the piston crown. See Figure 26-9.

The spray of oil not only lubricates, but helps reduce piston temperatures. Combustion chamber temperatures are always higher in turbocharged and diesel engines.

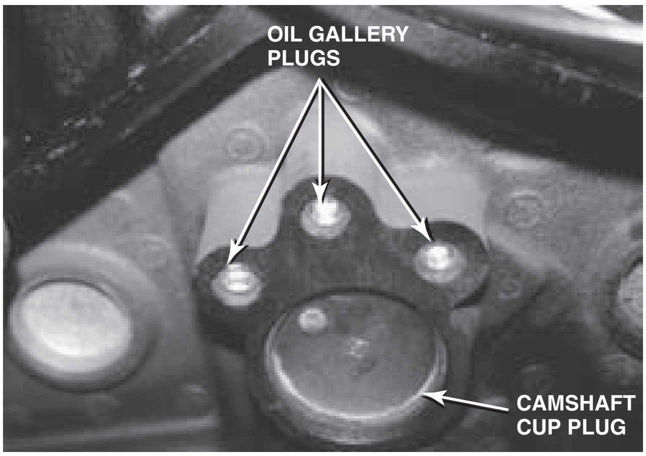


FIGURE 26-10 Typical oil gallery plugs on the rear of a Chevrolet small-block V-8 engine.

Figure 26-8 is a typical V-8 engine cutaway that shows the coolant jackets and some of the lubrication holes.

Lubricating Passages

An engine block has many oil holes that carry lubricating oil to the required locations. During manufacture, all oil holes, called the **oil gallery,** are drilled from outside the block. When a curved passage is needed, intersecting drilled holes are used. In some engines, plugs are placed in the oil holes to direct oil to another point before it comes back to the original hole, on the opposite side of the plug. After oil holes are drilled, the unneeded open ends may be capped by pipe plugs, steel balls, or cup-type soft plugs, often called **oil gallery plugs.** These end plugs in the oil passages can be a source of oil leakage in operating engines. See Figure 26-10.

Main Bearing Caps

The main bearing caps are cast or manufactured from sintered or billeted materials, separately from the block. They are machined and then installed on the block for a final bore finishing operation. With caps installed, the main bearing bores and cam bearing bores are machined to the correct size and alignment. On some engines, these bores are honed to a very fine finish and exact size. Main bearing caps are not interchangeable or reversible, because they are individually finished in place. Main bearing caps may have cast numbers

TECH TIP

WHAT DOES LHD MEAN?

The abbreviation LHD means *left-hand dipstick,* which is commonly used by rebuilders and remanufacturers in their literature in describing Chevrolet small-block V-8 engines. Before about 1980, most small-block Chevrolet V-8s used an oil dipstick pad on the left side (driver's side) of the engine block. Starting in about 1980, when oxygen sensors were first used on this engine, the dipstick was relocated to the right side of the block.

Therefore, to be assured of ordering or delivering the correct engine, knowing the dipstick location is critical. An LHD block cannot be used with the exhaust manifold setup that includes the oxygen sensor without major refitting or the installing of a different style of oil pan that includes a provision for an oil dipstick. Engine blocks with the dipstick pad cast on the right side are, therefore, coded as right-hand dipstick (RHD) engines.

NOTE: Some blocks cast around the year 1980 are cast with both right- and left-hand oil dipstick pads, but only one is drilled for the dipstick tube. See Figure 26-11.

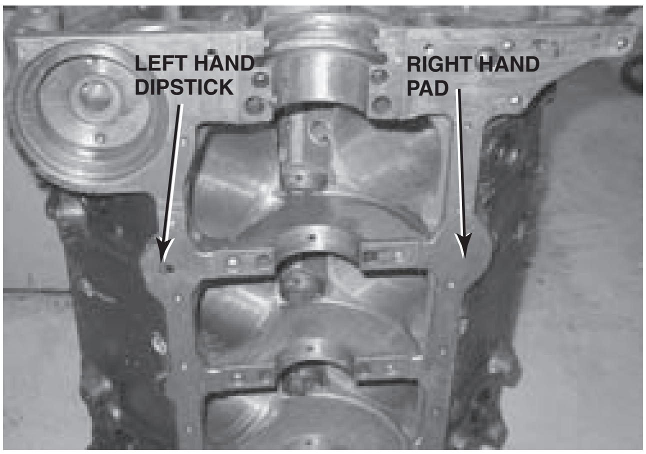


FIGURE 26-11 Small-block Chevrolet block. Note the left-hand dipstick hole and a pad cast for a right-hand dipstick.

indicating their position on the block. If not, they should be marked.

Standard production engines usually use two bolts to hold the main bearing cap in place. See Figure 26-12.

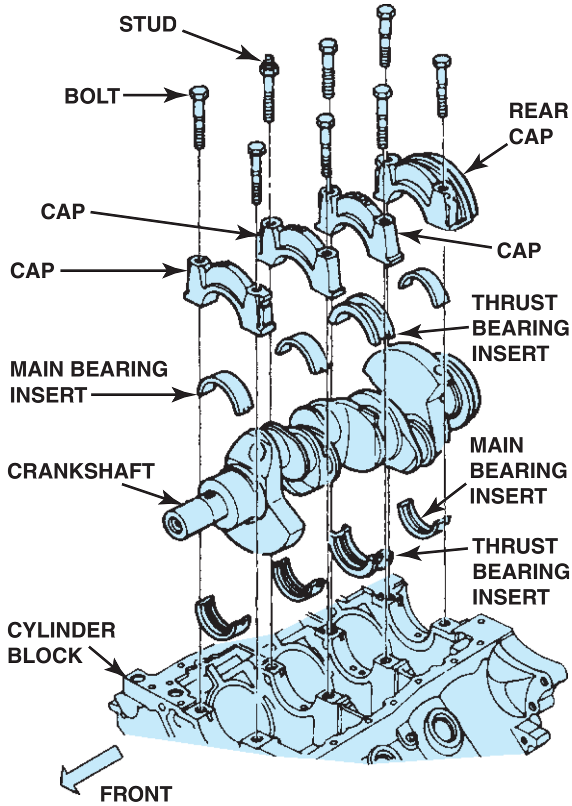


FIGURE 26-12 Two-bolt main bearing caps provide adequate bottom end strength for most engines.

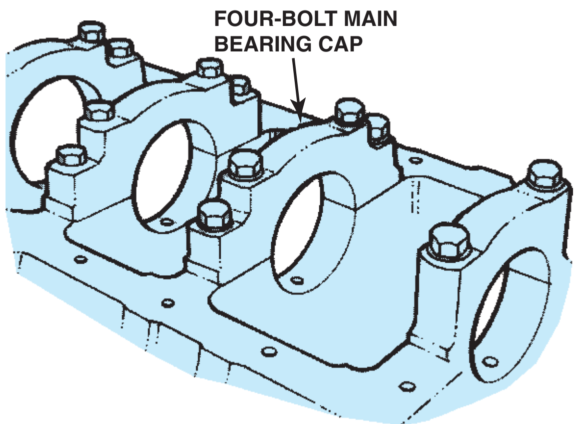


FIGURE 26-13 High-performance and truck engines often use four-bolt main bearing caps for greater durability.

Heavy-duty and high-performance engines often use additional main bearing support bolts. A four-bolt, and even six-bolt, main cap can be of a cross-bolted design in a deep skirt block or of a parallel design in a shallow skirt block. See Figures 26-13 and 26-14. Expansion force of the combustion chamber gases will try to push the head off the top and the crankshaft off the bottom of the block. The engine is held

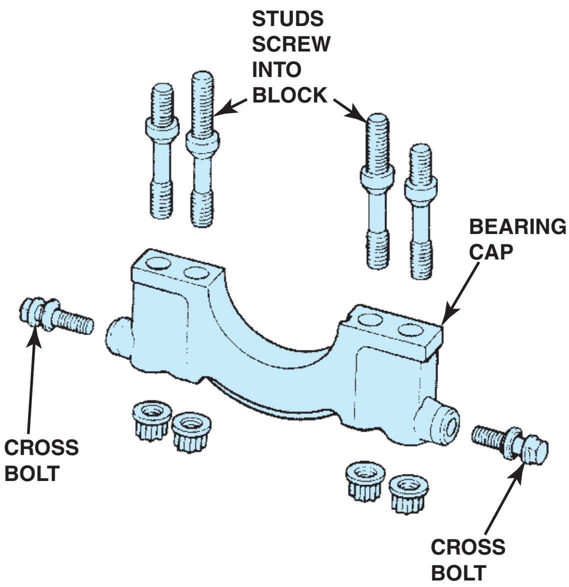


FIGURE 26-14 Some engines add to the strength of a four-bolt main bearing cap by also using cross bolts through the bolt on the sides of the main bearing caps.

together with the head bolts and main bearing cap bolts screwed into bolt bosses and ribs in the block. The extra bolts on the main bearing cap help to support the crankshaft when there are high combustion pressures and mechanical loads, especially during high-engine speed operation.

ENGINE BLOCK SERVICE

The engine block is the foundation of the engine. All parts of the block must be of the correct size and they must be aligned. The parts must also have the proper finishes if the engine is to function dependably for a normal service life. Blueprinting is the reconditioning of all the critical surfaces and dimensions so that the block is actually like new.

After a thorough cleaning, the block should be inspected for cracks or other flaws before machine work begins. If the block is in serviceable condition, the block should be prepared in the following sequence:

Operation 1 Align boring or honing main bearing saddles and caps

Operation 2 Machining the block deck surface parallel to the crankshaft

Operation 3 Cylinder boring and honing

Main Bearing Housing Bore Alignment

The main bearing journals of a straight crankshaft are in alignment. If the main bearing housing bores in the block are not

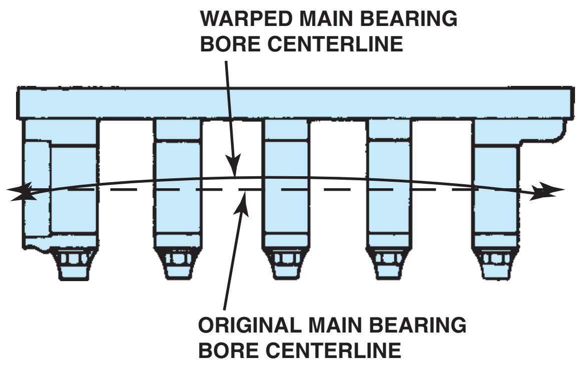


FIGURE 26-15 The main bearing bores of a warped block usually bend into a bowed shape. The greatest distortion is in the center bores.

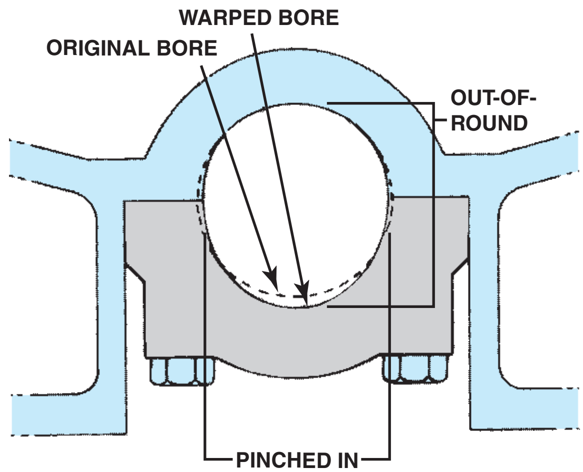


FIGURE 26-16 When the main bearing caps bow downward, they also pinch in at the parting line.

in alignment, the crankshaft will bend as it rotates. This will lead to premature bearing failure and it could lead to a broken crankshaft. The original stress in the block casting is gradually relieved as the block is used. Some slight warpage may occur as the stress is relieved. In addition, the continued pounding caused by combustion will usually cause some stretch in the main bearing caps. See Figure 26-15.

The main bearing bores gradually bow from the cylinder head and elongate vertically. This means that the bearing bore becomes smaller at the centerline as the block distorts, pinching the bore inward at the sides. See Figure 26-16.

The first step in determining the condition of the main bearing bores is to determine if the bore alignment in the block is straight. These bores are called the **saddles.** A precision ground straightedge and a feeler gauge are used to determine the amount of warpage. The amount of variation along the entire length of the block should not exceed 0.0015 inch (0.038 mm).

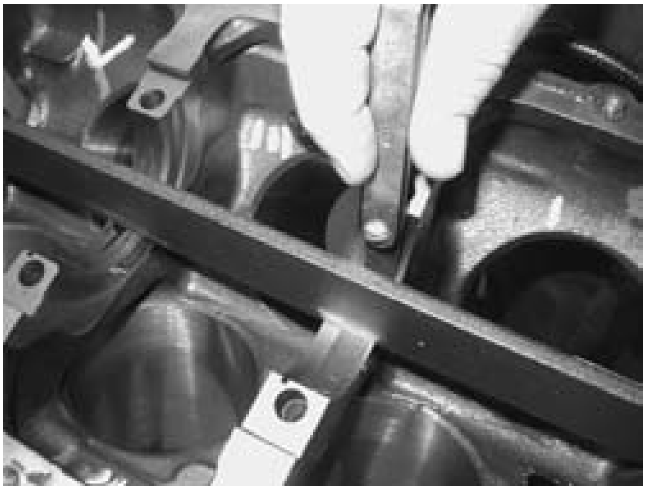


FIGURE 26-17 The main bearing bores can be checked using a precision straightedge and a feeler gauge.

CAUTION: When performing this measurement, be sure that the block is resting on a flat surface. If the engine is mounted to an engine stand, the weight of the block on the unsupported end can cause an error in the measurement of the main bearing bores and saddle alignment.

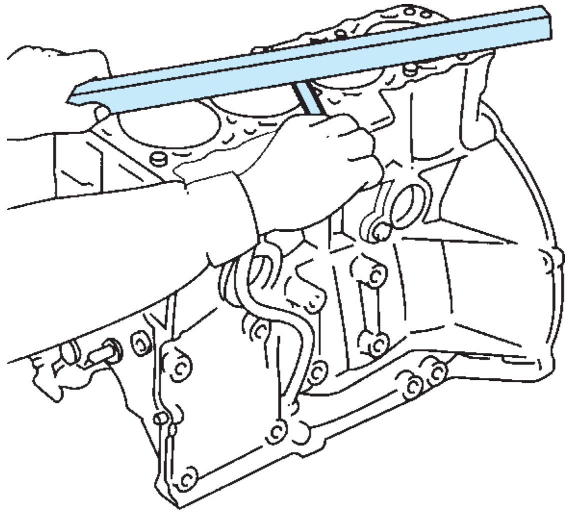
If the block saddles exceed one-and-a-half thousandth of an inch distortion, then align honing is required to restore the block. If the block saddles are straight, the bores should be measured to be sure that the bearing caps are not distorted. The bearing caps should be installed and the retaining bolts tightened to the specified torque before measuring the main bearing bores.

Using a telescoping gauge, measure each bore in at least two directions. Check the service information for the specified main bearing bore diameter. The bearing bore should vary by more than one-half of a thousandth of an inch or 0.0005 inch (0.0127 mm). See Figure 26-17.

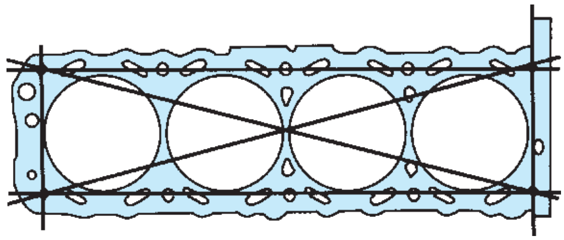
A dial bore gauge is often used to measure the main bearing bore. Set up the dial bore gauge in the fixture with the necessary extensions to achieve the nominal main bearing bore diameter. Check the service information for the specified main bearing bore diameter and determine the exact middle of the range.

Machining the Deck Surface of the Block

An engine should have the same combustion chamber size in each cylinder. For this to occur, each piston must come up an equal distance from the block deck. The connecting rods are attached to the rod bearing journals of the crankshaft. Pistons are attached to the connecting rods. As the crankshaft rotates, the pistons come to the top of the stroke. When all parts are sized equally, all the pistons will come up to the same level. This can only happen if the block deck is parallel to the main bearing bores. See Figure 26-18.



(a)



(b)

FIGURE 26-18 (a) Checking the flatness of the block deck surface using a straightedge and a feeler gauge. (b) To be sure that the top of the block is flat, check the block in six locations as shown.

The block deck must be resurfaced in a surfacing machine that can control the amount of metal removed when it is necessary to match the size of the combustion chambers. This procedure is called **decking the block.** The block is set up on a bar located in the main bearing saddles, or set up on the oil pan rails of the block. The bar is parallel to the direction of cutting head movement. The block is leveled sideways, and then the deck is resurfaced in the same manner as the head is resurfaced. Figure 26-19 shows a block deck being resurfaced by grinding.

The surface finish should be 60 to 100 Ra (65 to 110 RMS) for cast iron and 50 to 60 Ra (55 to 65 RMS) for aluminum block decks to be assured of a proper head gasket surface. The surface finish is determined by the type of grinding stone used, as well as the speed and coolant used in the finishing operation.

FIGURE 26-19 Grinding the deck surface of the block.

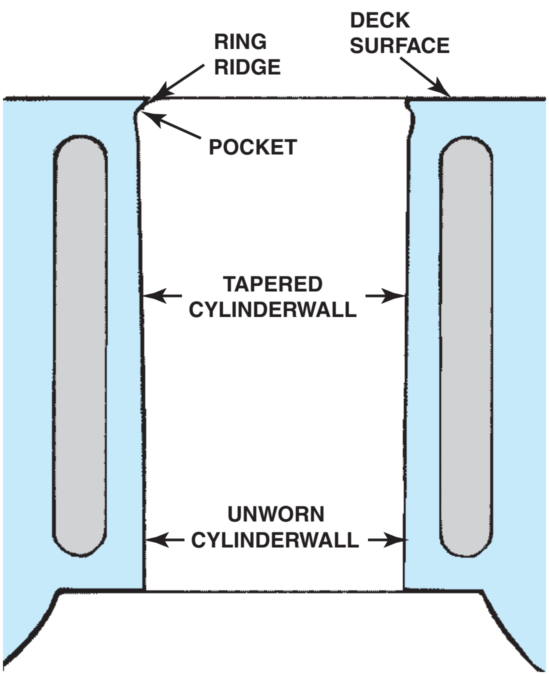


FIGURE 26-20 Cylinders wear in a taper, with most of the wear occurring at the top of the cylinder where the greatest amount of heat is created. The ridge is formed because this very top part of the cylinder is not worn by the rings.

Cylinder Boring

Cylinders should be measured across the engine (perpendicular to the crankshaft), where the greatest wear occurs. Most wear will be found just below the ridge, and the least amount of wear will occur below the lowest ring travel. See Figure 26-20. The cylinder should be checked for out-of-round and taper. See Figure 26-21.

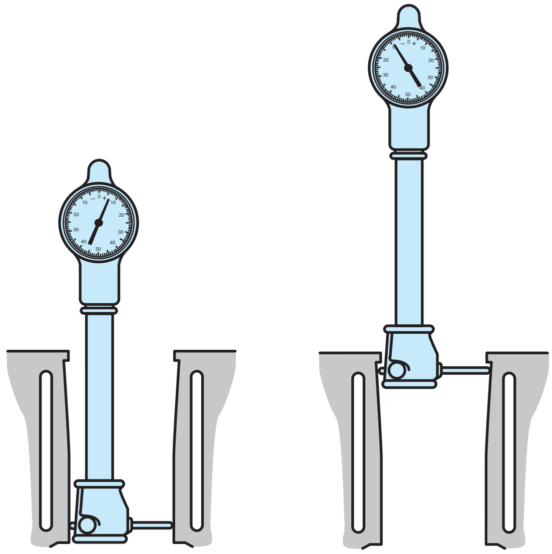


FIGURE 26-21 Using a dial bore gauge to measure the bore diameter at the top just below the ridge and at the bottom below the ring travel. Take the measurements in line with the crankshaft and then repeat the measurements at right angles to the centerline of the block in each cylinder.

Most cylinders are serviceable if:

- Maximum of 0.003 inch (0.076 millimeter) out-of-round
- No more than 0.005 inch (0.127 millimeter) taper
- Have no deep scratches in the cylinder wall

NOTE: **Always check the specifications for the engine being surfaced. For example, the General Motors 5.7 L, LS-1, V-8 has a maximum out-of-round of only 0.0003 (3/10 of one thousandths of an inch). Normally this specification is about three times that dimension or about 0.001 inch.**

The most effective way to correct excessive cylinder out-of-round, taper, or scoring is to *rebore* the cylinder. The rebored cylinder requires the use of a new, oversize piston.

The maximum bore oversize is determined by two things: the cylinder wall thickness and the size of the available oversize pistons. If in doubt as to the amount of overbore that is possible without causing structural weakness, an ultrasonic test should be performed on the block to determine the thickness of the cylinder walls. All cylinders should be tested. Variation in cylinder wall thickness occurs because of core shifting (moving) during the casting of the block. For best results, cylinders should be rebored to the smallest size possible.

NOTE: **The pistons that will be used should always be in hand *before* the cylinders are rebored. The cylinders are then bored and honed to match the exact size of the pistons.**

FREQUENTLY ASKED QUESTION

HOW DO I DETERMINE WHAT OVERSIZE BORE IS NEEDED?

An easy way to calculate oversize piston size is to determine the amount of taper, double it, and add 0.010 inch (Taper × 2 + 0.010 in. = OS piston). Common oversize measurements include 0.020 inch, 0.030 inch, 0.040 inch, and 0.060 inch. Use caution when boring for an oversize measurement larger than 0.030 inch.

The cylinder must be perpendicular to the crankshaft for normal bearing and piston life. If the block deck has been aligned with the crankshaft, it can be used to align the cylinders. Portable cylinder boring bars are clamped to the block deck. Heavy-duty production boring machines support the block on the main bearing bores.

Main bearing caps should be torqued in place when cylinders are being rebored. In precision boring, a torque plate is also bolted on in place of the cylinder head while boring cylinders. In this way, distortion is kept to a minimum. The general procedure used for reboring cylinders is to set the boring bar up so that it is perpendicular to the crankshaft. It must be located over the center of the cylinder. The cylinder center is found by installing centering pins in the bar. The bar is lowered so that the centering pins are located near the bottom of the cylinder, where the least wear has occurred. This locates the boring bar over the original cylinder center. Once the boring bar is centered, the boring machine is clamped in place to hold it securely. This will allow the cylinder to be rebored on the original centerline, regardless of the amount of cylinder wear. A sharp, properly ground cutting tool is installed and adjusted to the desired dimension. Rough cuts remove a great deal of metal on each pass of the cutting tool. The rough cut is followed by a fine cut that produces a much smoother and more accurate finish. Different-shaped tool bits are used for rough and finish boring. The last cut is made to produce a diameter that is at least 0.002 inch (0.05 millimeter) smaller than the required diameter. See Figure 26-22.

FIGURE 26-22 A cylinder boring machine is to enlarge cylinder bore diameter so a replacement oversize piston can be used to restore a worn engine to useful service or to increase the displacement of the engine in an attempt to increase power output.

Sleeving the Cylinder

Sometimes, cylinders have a gouge so deep that it will not clean up when the cylinder is rebored to the maximum size. This could happen if the piston pin moved endways and rubbed on the cylinder wall. Cylinder blocks with deep gouges can be salvaged by **sleeving** the cylinder. This is done by boring the cylinder to a dimension that is greatly oversize to almost match the outside diameter of the cylinder sleeve. The sleeve is pressed into the rebored block, then the center of the sleeve is bored to the diameter required by the piston. The cylinder can be sized to use a standard-size piston when it is sleeved. See Figure 26-23.

FIGURE 26-23 A dry cylinder sleeve can also be installed in a cast-iron block to repair a worn or cracked cylinder.

Cylinder Honing

It is important to have the proper surface finish on the cylinder wall for the rings to seat against. Some ring manufacturers

FIGURE 26-24 An assortment of ball-type deglazing hones. This type of hone does not straighten wavy cylinder walls.

recommend breaking the hard surface glaze on the cylinder wall with a hone before installing new piston rings. Honing the cylinder removes the fractured metal that is created by boring. The cylinder wall should be honed to straighten the cylinder when the wall is wavy or scuffed. If honing is being done with the crankshaft remaining in the block, the crankshaft should be protected to keep honing chips from getting on the shaft.

Two types of hones are used for cylinder service.

- A *deglazing hone* removes the hard surface glaze remaining in the cylinder. It is a flexible hone that follows the shape of the cylinder wall, even when the wall is wavy. It cannot be used to straighten the cylinder. A brush-type (ball-type) deglazing hone is shown in Figure 26-24.
- A *sizing hone* can be used to straighten the cylinder and to provide a suitable surface for the piston rings. The cylinders must be honed a minimum of 0.002 inch (0.050 mm) after boring to cut below the rough surface and provide an adequate finish. Honing leaves a plateau surface that can support the oil film for the rings and piston skirt. This plateau surface is achieved by first using a coarse stone followed by a smooth stone to achieve the desired surface. The process of using a coarse and fine stone is called **plateau honing.** See Figure 26-25.

  The honing stones are held in a rigid fixture with an expanding mechanism to control the size of the hone. The sizing hone can be used to straighten the cylinder taper by honing the lower cylinder diameter more than the upper diameter. As it rotates, the sizing hone only cuts the high spots so that cylinder out-of-round is also reduced. The cylinder wall surface finish is about the same when the cylinder is refinished with either type of hone. See Figure 26-26.

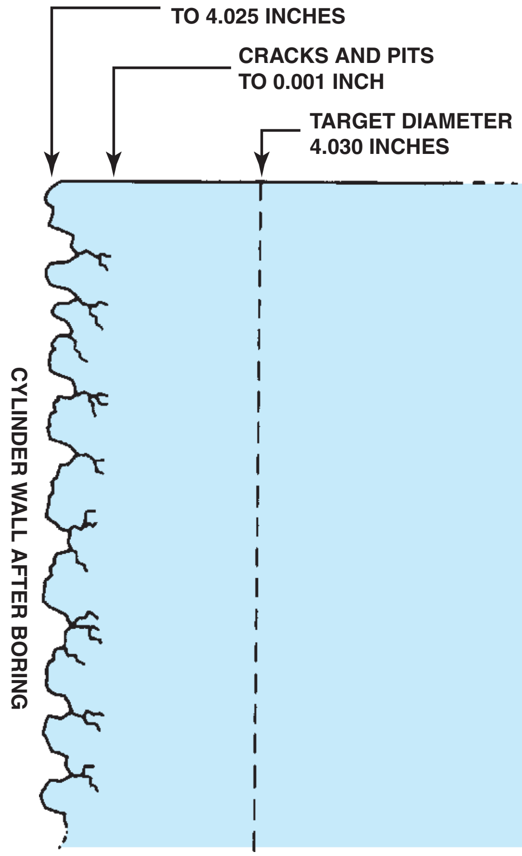


FIGURE 26-25 After boring, the cylinder surface is rough, pitted, and fractured to a depth of about 0.001 inch.

TECH TIP

ALWAYS USE TORQUE PLATES

Torque plates are thick metal plates that are bolted to the cylinder block to duplicate the forces on the block that occur when the cylinder head is installed. Even though not all machine shops use torque plates during the boring operation, the use of torque plates during the final dimensional honing operation is very beneficial. Without torque plates, cylinders can become out-of-round (up to 0.003 inch) and distorted when the cylinder heads are installed and torqued down. Even though the use of torque plates does not eliminate all distortion, their use helps to ensure a truer cylinder dimension. See Figure 26-27.

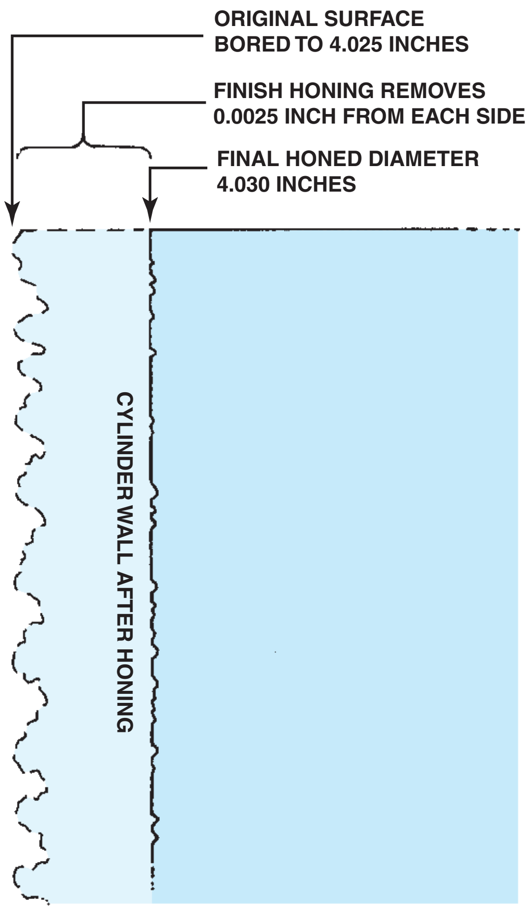


FIGURE 26-26 Honing enlarges the cylinder bore to the final size and leaves a plateau surface finish that retains oil.

FIGURE 26-27 A torque plate being used during a cylinder honing operation. The thick piece of metal is bolted to the block and simulates the forces exerted on the block by the head bolts when the cylinder head is attached.

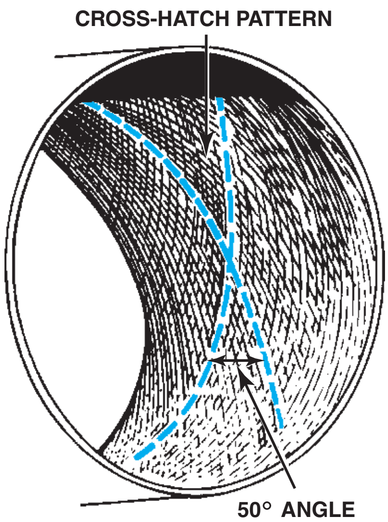


FIGURE 26-28 The crosshatched pattern holds oil to keep the rings from wearing excessively, and also keeps the rings against the cylinder wall for a gas-tight fit.

TECH TIP

BORE TO SIZE, HONE FOR CLEARANCE

Many engine rebuilders and remanufacturers bore the cylinders to the exact size of the oversize pistons that are to be used. After the block is bored to a standard oversize measurement, the cylinder is honed. The rigid hone stones, along with an experienced operator, can increase the bore size by 0.001 to 0.003 inch (1 to 3 thousandths of an inch) for the typical clearance needed between the piston and the cylinder walls.

For example:

Actual piston diameter = 4.028 in.
Bore diameter = 4.028 in.
Diameter after honing = 4.030 in.
Amount removed by honing = 0.002 in.

NOTE: The minimum amount recommended to be removed by honing is 0.002 inch to remove the fractured metal in the cylinder wall caused by boring.

The hone is stroked up and down in the cylinder as it rotates. This produces a **crosshatch finish** on the cylinder wall. A typical honed cylinder is pictured in Figure 26-28. The angle of the crosshatch should be between 20 and 60 degrees.

Higher angles are produced when the hone is stroked more rapidly in the cylinder.

Cylinder Surface Finish

The size of the abrasive particles in the grinding and honing stones controls the surface finish. The size of the abrasive is called the **grit size.** The abrasive is sifted through a screen mesh to sort out the grit size. A coarse-mesh screen has few wires in each square inch, so large pieces can fall through the screen. A fine-mesh screen has many wires in each square inch so that only small pieces can fall through. The screen is used to separate the different grit sizes. The grit size is the number of wires in each square inch of the mesh. A low-numbered grit has large pieces of abrasive material; a high-numbered grit has small pieces of abrasive material. The higher the grit number, the smoother the surface finish.

Grit Sizing Chart

Grit/Sieve Size	*Inches*	*Millimeters*
12	0.063	1.600
16	0.043	1.092
20	0.037	0.939
24	0.027	0.685
30	0.022	0.558
36	0.019	0.482
46	0.014	0.355
54	0.012	0.304
60	0.010	0.254
70	0.008	0.203
80	0.0065	0.165
90	0.0057	0.144
100	0.0048	0.121
120	0.0040	0.101
150	0.0035	0.088
180	0.0030	0.076
220	0.0025	0.063
240	0.0020	0.050

A given grit size will produce the same finish as long as the cutting pressure is constant. With the same grit size, light cutting pressure produces fine finishes, and heavy cutting pressure produces rough finishes.

The surface finish should match the surface required for the type of piston rings to be used. Typical grit and surface finish standards include the following:

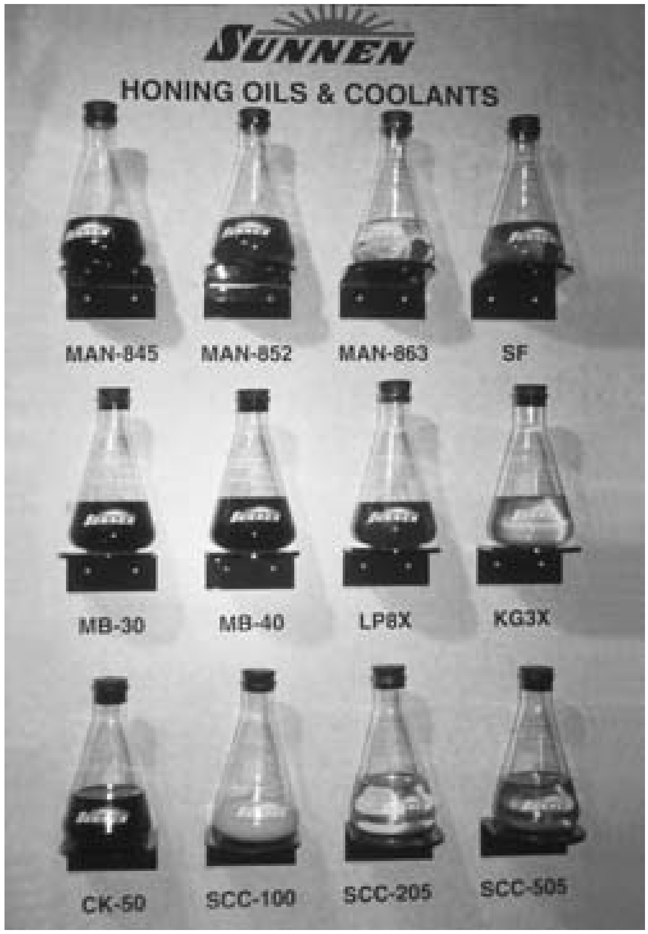


FIGURE 26-29 An assortment of the various honing oils and coolants available. Always use the correct oil or coolant as specified by the equipment manufacturer.

- Chrome—#180 grit (25 to 35 micro inches)
- Cast iron—#200 grit (20 to 30 micro inches)
- Moly—#220 grit (18 to 25 micro inches)

NOTE: The correct honing oil and/or coolant are critical to proper operation of the honing equipment and to the quality of the finished cylinders. See Figure 26-29 for the many different examples of honing oil and coolants that one equipment manufacturer has available.

The hone is placed in the cylinder. Before the drive motor is turned on, the hone is moved up and down in the cylinder to get the feel of the stroke length needed. The end of the hone should just break out of the cylinder bore on each end. The hone must *not* be pulled from the top of the cylinder while it is rotating. Also, it must not be pushed so low in the cylinder that it hits the main bearing web or crankshaft. The sizing hone is adjusted to give a solid drag at the lower end of the stroke. The hone drive motor is turned on and stroking begins immediately. Stroking continues until the sound of the drag is reduced. The hone drive motor is turned off while it is still stroking. Stroking is stopped as the rotation of the hone stops. After rotation stops, the hone is collapsed and removed from the cylinder. The cylinder is examined to check the bore size and finish of the wall. If more honing is needed, the cylinder is again coated with honing oil and the cylinder is honed again. The finished cylinder should be within 0.0005 inch (0.013 millimeter) on both out-of-round and taper measurements. See Figure 26-30.

See Figure 26-31a and b for an example of cylinder surface finish reading.

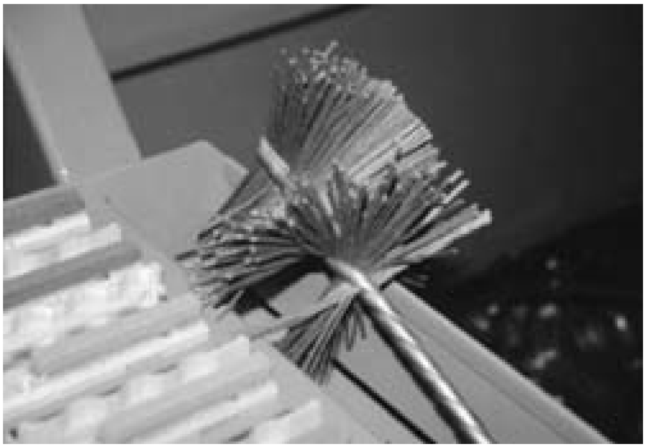


FIGURE 26-30 To achieve a finer surface finish, use a soft hone that is made from nylon bristles with impregnated abrasive. This hone is ideal for engines using low tension piston rings and provides a smooth surface that allows the rings to seal immediately.

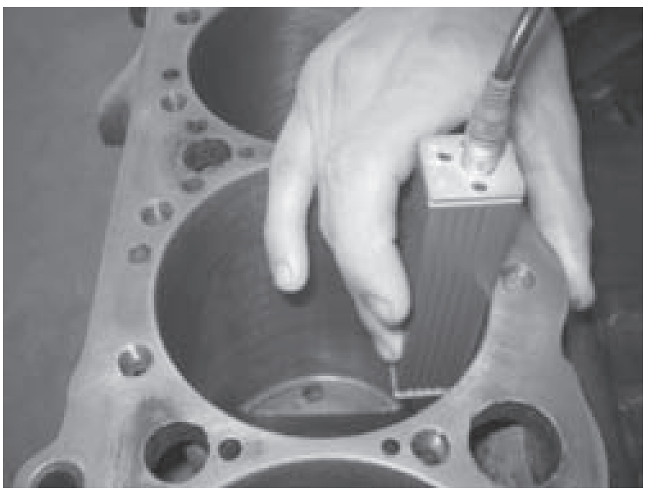
BLOCK CLEANING AND PREPARATION FOR ASSEMBLY

After the cylinders have been honed and before the block is cleaned, use a sandpaper cone to chamfer the top edge of the cylinder. Cleaning the honed cylinder wall is an important part of the honing process. If any grit remains on the cylinder wall, it will rapidly wear the piston rings. This wear will cause premature failure of the reconditioning job. Degreasing and decarbonizing procedures will only remove the honing oil. They will *not* remove the abrasive. The *best* way to clean the honed cylinders is to scrub the cylinder wall with a brush using a mixture of *soap* or *detergent* and *water*. The block is scrubbed until it is absolutely clean. This can be determined by wiping the cylinder wall with a clean cloth. The cloth will pick up no soil when the cylinder wall is clean.

Block Detailing

Before the engine block can be assembled, a final detailed cleaning should be performed.

1. All oil passages (galleries) should be cleaned by running a long bottle-type brush through all holes in the block.
2. All tapped holes should be chamfered and cleaned with the correct size of thread chaser to remove any dirt and burrs. See Figures 26-32 and 26-33.
3. Coat the newly cleaned block with fogging oil to prevent rust. Cover the block with a large plastic bag to keep out dirt until it is time to assemble the engine.



(a)

(b)

FIGURE 26-31 (a) The surface finish tool is being held against the cylinder wall. (b) The reading indicates the Ra roughness of the cylinder. More work is needed if moly piston rings are to be used.

FIGURE 26-32 Notice on this cutaway engine block that some of the head bolt holes do not extend too far into the block and dead end. Debris can accumulate at the bottom of these holes and it must be cleaned out before final assembly.

TECH TIP

INSTALL LIFTER BORE BUSHINGS

Lifter bores in a block can be out-of-square with the camshaft, resulting in premature camshaft wear and variations in the valve timing from cylinder to cylinder. To correct for this variation, the lifter bores are bored and reamed oversize using a fixture fastened to the block deck to ensure proper alignment. Bronze lifter bushings are then installed and finish honed to achieve the correct lifter-to-bore clearance. See Figure 26-34.

FIGURE 26-33 A thread chaser or bottoming tap should be used in all threaded holes before assembling the engine.

FIGURE 26-34 High-performance engine builders will often install bronze sleeves in the valve lifter bores.

CYLINDER MEASUREMENT AND HONING Step-by-Step

STEP 1 The tools and equipment needed to hone the cylinder include the service manual for engine block specifications and a dial bore gauge, along with a telescoping gauge and outside micrometer, to accurately measure the cylinder bore.

STEP 2 Start the honing process by carefully lowering the engine block into the cylinder hone bay. Use a nylon strap to support and hoist the block to avoid causing harm to the machined surfaces of the block that may occur if a metal chain is used.

STEP 3 Clamping the block to the holding fixture.

STEP 4 After the block has been securely attached to the holding fixture, the hone has to be adjusted for the bore diameter. The technician is gauging the shims for the honing head.

STEP 5 After gauging the honing head, the shims are installed in the honing head.

STEP 6 After the honing head has been shimmed, it is lowered into the cylinder.

CYLINDER MEASUREMENT AND HONING continued

STEP 7 After installing the honing head into the cylinder, the top limit of the stroke has to be set. Notice the safety shield is open.

STEP 8 When the marks align, the honing head is at the top of the stroke.

STEP 9 The next step in the cylinder honing process is to use a hook ruler to measure the length of the cylinder.

STEP 10 After determining the length of the cylinder, the stroke length is set.

STEP 11 Setting the "crown" for stock removal. This adjusts the pressure of the honing stone against the cylinder walls.

STEP 12 The honing operation is started after all adjustments and settings have been performed.

(continued)

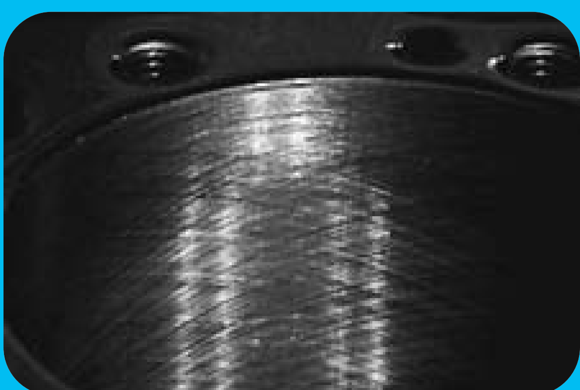
CYLINDER MEASUREMENT AND HONING continued

STEP 13 The crown may need adjustment for the correct honing pressure.

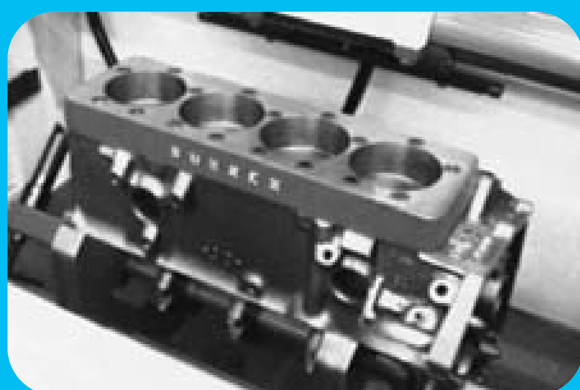
STEP 14 The bar graph indicates honing pressure. For a rough cut, the pressure should be set to 60% to 80% and to 20% to 40% for a finish cut.

STEP 15 After honing for a short time, it is important to check the cylinder for proper dimension using a dial bore gauge.

STEP 16 It is often necessary to change the amount of time the hone stays in a certain area. For example, a dwell button is pushed to achieve greater stock removal at the bottom of the cylinder.

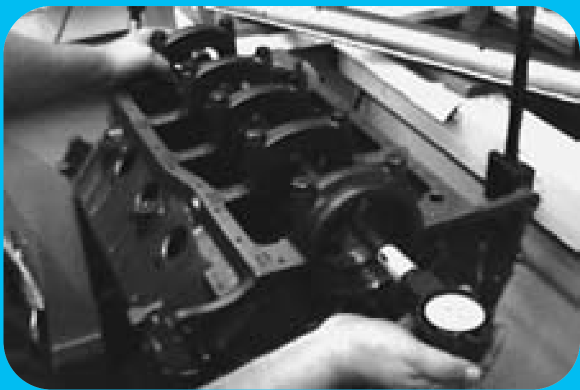


STEP 17 The finish cylinder hone should have the characteristic 60-degree crosshatch pattern as shown.

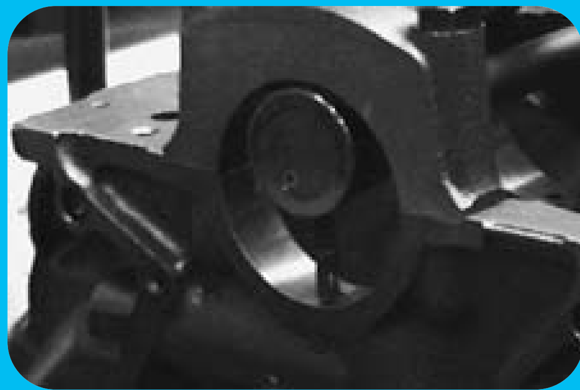


STEP 18 Finish honing should be performed using a torque plate. Using a finish honing stone results in a round cylinder with a plateau hone surface and correct surface finish.

MAIN BEARING HOUSING BORE ALIGN HONING Step-by-Step



STEP 1 Before align honing the main bearing bores, the main bearing caps are installed and torqued to factory specifications. A dial bore gauge is then used to determine the variation in diameter in the original housing bores.



STEP 2 The dial bore gauge is also used to check for taper and out-of-round of each bore.

STEP 3 The machinist wrote the variation in the bore housing on the rail of the block using a felt-tip marker for easy reference.

STEP 4 After all main bearing bores have been measured and recorded, the main bearing caps are removed from the engine and placed on a cap grinder to remove material from the main bearing cap.

STEP 5 The cap is first placed flat and clamped tight into the vise and then the side of the cap is ground.

STEP 6 Grinding the side of the cap first ensures that the cap is clamped into the vise squarely.

(continued)

MAIN BEARING HOUSING BORE ALIGN HONING continued

STEP 7 After the side of the bearing cap is ground, it is then placed vertically in the vise with the machined surface of the main bearing cap against the flat surface of the holding fixture.

STEP 8 A small amount of material is ground from the mating surface of the main bearing cap. The amount removed should be the same for each cap.

STEP 9 The cap grinder is being adjusted for the amount of material to be removed from the main bearing cap.

STEP 10 The finished cap shows that the entire surface of the end of the cap has been ground. This procedure is repeated for all main bearing caps.

STEP 11 Before reassembling the bearing caps onto the engine block, use a file to remove any sharp edges from the saddle area that could interfere with the proper joining of the bearing caps in the block.

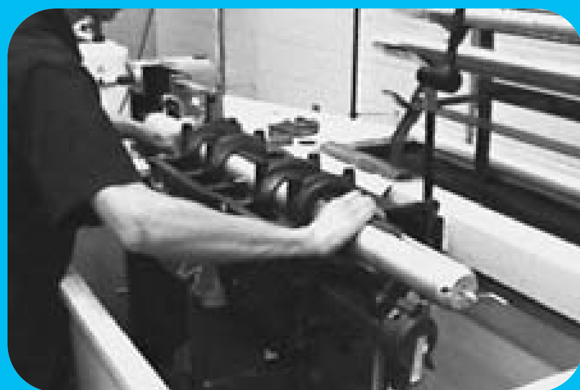
STEP 12 After the caps have been ground and before they are installed on the block, a file is used to remove any burrs from the sharp edges created by the grinding.

MAIN BEARING HOUSING BORE ALIGN HONING continued

STEP 13 To be sure that everything is clean, all oil passages are blown out using compressed air.

STEP 14 After everything has been deburred and cleaned, the main bearing caps are reinstalled onto the block and torqued to factory specifications.

STEP 15 The main bearing bores are again measured using a dial bore gauge to make sure that each is the same size. If necessary, a cap may have to be removed and additional material ground from the mating surface to achieve the proper diameter.

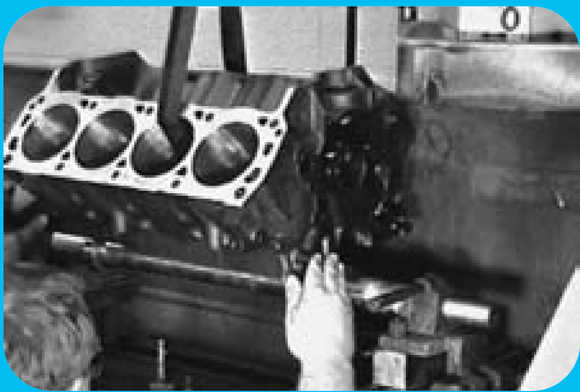


STEP 16 The aligned hone is now installed and adjusted for proper tension.

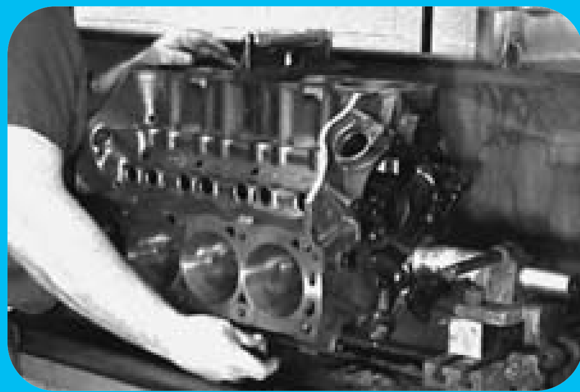
STEP 17 The main bearing bores are then honed round by using a large electric motor to drive the honing stones through the bores.

STEP 18 The dimension of the main bearing bores should be checked after performing the honing process.

DECKING A BLOCK Step-by-Step



STEP 1 Before the deck surface of the block can be machined, it has to be precisely located onto the surface mounts by aligning the main bearing bores on a 2-inch diameter ground shaft.



STEP 2 After attaching the main bearing caps over the pucks, the engine block is leveled by rotating the jack screw mechanism. Note the bubble level on the deck surface.

STEP 3 To determine the deck height, a depth micrometer is being used to measure the distance between the deck surface and the ground shaft.

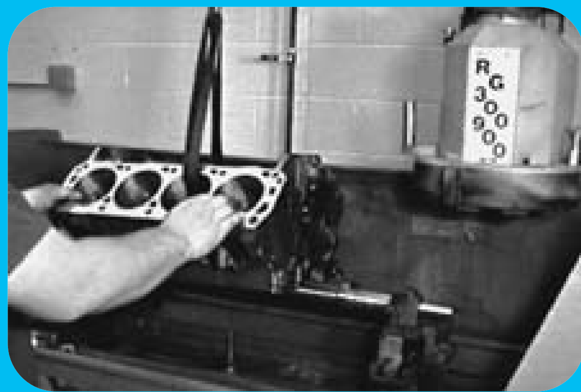
STEP 4 Because the supporting shaft is exactly 2 inches in diameter, the deck height is determined by adding 1 inch to the measurement obtained on the micrometer.

STEP 5 After the block has been securely attached, leveled, and measured, the deck surface can be ground. A typical pass across the deck surface will remove about 0.001 to 0.0015 inch.

STEP 6 It is wise to double-check the deck height especially if more than one cut is required to straighten the top of the block surface.

DECKING A BLOCK continued

STEP 7 A typical block may require 0.004 to 0.006 inches to be removed from the deck surface to eliminate any warpage or waviness.



STEP 8 After both deck surfaces have been machined and checked, the block can be removed from the attachment using an engine hoist equipped with a nylon strap to prevent damaging the machined surfaces of the block.

SUMMARY

1. Engine blocks are either cast iron or aluminum.
2. Cores are used inside a mold to form water jackets and cylinder bores. After the cast iron has cooled, the block is shaken, which breaks up the cores so that they fall out of openings in the side of the block. Core plugs are used to fill the holes.
3. The block deck is the surface to which the cylinder head attaches. This surface must be flat and true for proper engine operation.
4. The cylinder should be bored and/or honed to match the size of the pistons to be used.
5. All bolt holes should be chamfered and cleaned with a thread chaser before assembly.

REVIEW QUESTIONS

1. What does “decking the block” mean?
2. What is the purpose of core plugs?
3. What is the difference between deglazing and honing a cylinder?
4. What is the best method to use to clean an engine block after honing?

CHAPTER QUIZ

1. The block deck is the ______.
   - a. Bottom (pan rail) of the block
   - b. Top surface of the block
   - c. Valley surface of a V-type engine
   - d. Area where the engine mounts are attached to the block
2. The standard measurement for surface finish is the microinch. Which of the following is correct?
   - a. The rougher the surface, the higher the microinch finish measurement.
   - b. The smoother the surface, the higher the microinch finish measurement.
   - c. The rougher the surface, the lower the microinch finish measurement.
   - d. Both b and c.
3. What surface finish is needed to be achieved if moly piston rings are going to be used?
   - a. 35 to 45 micro inches
   - b. 28 to 30 micro inches
   - c. 18 to 25 micro inches
   - d. 10 to 15 micro inches
4. Cast iron has about how much carbon content?
   - a. 1%
   - b. 2%
   - c. 3%
   - d. 4+%
5. Engine blocks can be manufactured using which method(s)?
   - a. Sand-cast
   - b. Sand-cast or die-cut
   - c. Extruded cylinder
   - d. Machined from a solid piece of metal (either cast iron or aluminum)
6. A bedplate is located between the ______ and the ______.
   - a. Cylinder bores / water jacket
   - b. Cylinder head / block deck
   - c. Bottom of the block / oil pan
   - d. Block deck / cylinder bore
7. Siamese cylinder bores are ______.
   - a. Cylinders that do not have a coolant passage between them
   - b. Aluminum cylinders
   - c. Another name for cylinder liners
   - d. Cast-iron cylinders
8. An oil jet is commonly used on which type of engine?
   - a. Turbocharged/supercharged gas engines
   - b. Turbocharged diesel engines
   - c. Small displacement, high RPM engines
   - d. Both a and b
9. An engine block should be machined in which order?
   - a. Align honing, cylinder boring, block deck machining
   - b. Block decking, align honing, cylinder boring
   - c. Cylinder boring, align honing, block decking
   - d. Align honing, block decking, cylinder boring
10. After the engine block has been machined, it should be cleaned using ______.
    - a. Soap and water
    - b. SAE 10W-30 oil and a shop cloth
    - c. Brake cleaner sprayed to remove the cutting oil
    - d. Sprayed WD-40