To maximize engine performance, many builders check to see if the lifter bores are in the same plane as the camshaft. Most production engines are within 0.10° (0.25 mm) and will perform perfectly for many years.

If the lifter bores do need realignment, you’ll need a special fixture and tooling for boring the holes oversize and fitting bronze sleeves into the block. Sleeves are made from cast iron or a bronze alloy. They should be press-fit with a quality anaerobic compound. Machining of the sleeve may be required to obtain the correct size bore.

Connecting Rods

In Chapter 2, we looked at the different types of connecting rods currently used in passenger car and truck engines. Early connecting rods were designed for engines that generated 20-40 horsepower and had to cope with compression ratios no greater than 6:1. These museum pieces were wear-looking by today’s standards. They utilized journal bearings — much like Babbitt poured into a form placed around the connecting rod (Figure 2.46). To fit the rod to the crankshaft, the rod bearing was bored to fit the crank pin.

Figure 9.64 A precision gage is used to check the housing bore for twist, out-of-round, and taper.

Today’s connecting rods strain under 3,000+ horsepower in passenger cars. Regardless of a vehicle’s use, the connecting rods must be free of defects, straight and true. Misalignment can cause rubbing of the piston skirts on the cylinders and cause edge-loading on the bearing by the crankshaft. Both problems will result in early engine failures. Measurement of the rod for twist, bend, and center-to-center distances are made with sophisticated rod alignment machines.

The rod is considered acceptable if the parting edge location does not entirely clean up during the reconditioning process. This small area allows a small pool of oil to form and provides increased oil wedge lubrication. To promote this same effect, some bearing manufacturers make a Delta-wall bearing where the edges of the insert are thinned. By thinning the edges you promote the formation of the oil pool.

Connecting rods stretch, slightly, at the parting line during extreme operating conditions. The housing bore pulls in towards the journal, while the center-to-center length increases. Over long periods of time, the housing bore is forced out-of-round to a point that it never returns to a round shape.

Rods having gone to metal (housing bore making physical contact with the crankshaft) must be inspected very closely during the non-destructive testing (NDT) process. Metal build-up on the flanged housing bore interior should be removed with a file before reconditioning. It is imperative that these rods be resized before returning them to service. Should cracks or fractures be found during NDT, replace the rod without hesitation.

Figure 9.66 This small displacement engine produces over 450 Hp @ 9,800 Rpm. (Courtesy, Lancs.)

In most rebuilding cases, you will remove 0.003" (0.08 mm) from each mating surface (.006" (0.15 mm total)). This cuts the effective rod length by only 0.003" (0.08 mm), not 0.006" (0.15 mm). This amount of reduced center-to-center distance does not disrupt the compression ratio significantly and does not compromise piston-to-deck clearance, even when the deck is resurfaced. Most deck resurfacing procedures remove 0.003" (0.08 mm) to 0.006" (0.15 mm).

Most connecting rods use bolts and nuts to clamp the rod and cap together. Some rods use bolts only. In either case, the bolts must be removed before machining can occur. To remove them, you may need a press and disassembly fixture. Engines with torque-to-yield (TTY) bolts have a press fit pin retainer system. A press-fit retaining pin is used on most engines. It is important to measure the pin bore for side-to-side twist. Out-of-round is what we call the condition when one measurement location is larger than another 90° away. A limited amount of out-of-round is acceptable.

In Chapter 7, we looked at how the connecting rod was measured for concentricity with a pre-ision gage and found that the rod was measured from the 12 o’clock to the 6 o’clock locations, and then again at the 2 o’clock, and 8 o’clock positions. The area from the 2 o’clock to 8 o’clock locations and the 3 o’clock to 9 o’clock positions will experience the most out-of-round condition.

Figure 9.67 A rod with replaceable pin bushings.

On those rods fitted with float-pin bushings, bronze bushings are used to support the pin. There are two methods used for their repair. Fit an oversize pin to the rod and piston, or remove, replace and fit a new pin bushing for the same (stock) size pin.

The housing and pin bores must be perpendicular to one another. Misalignment can cause rubbing of the piston skirts on the cylinders and cause edge-loading on the bearing by the crankshaft. Both problems will result in early engine failures. Measurement of the rod for twist, bend, and center-to-center distances are made with sophisticated rod alignment machines.

Figure 9.68 The electronic rod tester can check a rod for bend, twist, and center-to-centerpin location all at one setting.

In the following sections we will discuss the necessary steps, honing the bore, required to recondition the connecting rods for top performance.

Cap And Rod Cutting

All connecting rods have a parting line. The majority of these are flat surfaces machined onto the cap and rod sections. The edges must be straight and perpendicular to the sides of the rod. Cap misalignment can reduce clearance between the rod and crankshaft journal. The cutting process is not unlike the one used for the main bearing caps. The difference is that both the cap and the rod are machined. Each should have a minimum amount of material removed in the process.

Figure 9.69 These are the main components of a cap grinder.

Caution: Always measure the pin bore before the pin is installed. Excessive material in the pin bore will cause the pin to seize half way through during installation and cause the pin to become loose. Oversize pins are available for most applications to correct loose fitting or out-of-specification pins. In the majority of cases, press-fit pin bores do not require reconditioning. If a press-fit pin rod must be resized for an oversize piston, so to will the piston pin bore.
rod bolts will need to be torqued with an electronic torque wrench (ETW) to ensure their correct reinstallation.

**Straight, T&G, Serrated, And Broken Parting Edges**

There are four distinctive parting edges used to joint the cap to the rod. Straight edges are the most common; the tongue and groove (T&G) is more common to medium and heavy truck and industrial engines; the serrated edge is typically found in industrial engines; and the broken parting edge is now making its debut on powdered metal technology rods. All will require specialized reconditioning procedures, save the serrated and broken parting edge rods. Tange and serrations were used to ensure cap-to-rod alignment. This is very important to bearing longevity.

A phenomenon which will make its presence known within a very short while will be remanufactured connecting rods with oversize housing bores. In an effort to reduce remanufacturing costs and to be able to salvage certain rods (most notably, cracked parting edge and certain straight type), aftermarket parts suppliers are manufacturing oversize coated rod bearings. Typical oversizes are .002" (.05 mm) and .005" (.075 mm). The routine installation of these oversized bearings must be taken into account during the tear-down and initial inspection phase of the rebuild. Not identifying these rods could prove catastrophic and quite costly.

**Standard Rod And Cap Cutting Procedure:**

Refer to the section on cap cutting earlier in this chapter. Perform the following additional steps:

1. Remove the bolts from the rod, if so equipped,
2. Remove all burrs from sides and parting edge with a fine file. Wipe surfaces clean.
3. Position the gage rod in the set-up position.
4. Retract feed wheel slightly.
5. Move clamp table assembly into set-up position over rod gage.
6. Adjust clamp table assembly to accommodate connecting rod width.
7. Place rod in clamp assembly with side of cap against clamp table face; bearing tang grooves (both cap or rod) should face forward.
8. While holding rod firmly against set-up gage rod, tighten clamp handle. Note: If the cap or rod is not clamped tight enough, the grinding wheel will push it up and less stock will be removed than desired.
9. Swing the table assembly to position parting edge surface of the rod over the leading edge of the grinding wheel.
10. Start motor and advance feed wheel until light sparking is observed. Note setting on graduated scale.
11. Return rod to original set-up position and advance feed wheel according to the amounts of stock removal desired.

**Example:**

If .005" (.13 mm) is the desired reduction in the connecting rod's diameter, advance the feed wheel half this amount (.0025" (.064 mm)) on graduated scale to remove .001" (.025 mm) from the rod. If the cap removed .003" (.076 mm) from the cap, the .001" (.025 mm) removed from the rod is sufficient to ensure perfectly matched surfaces when reassembled. DO NOT remove more than .002" (.05 mm) per pass.

12. Advance feed wheel clockwise (CW) 1-1/2 divisions on the graduated scale. Each division is equal to .001" (.04 mm).
13. Swing the clamp table assembly back and forth across grinding wheel – grinding both parting edges of the rod – with a slow smooth, steady motion. Advance feed wheel another 1-1/2 divisions on graduated scale and continue grinding operation.
14. When sparking has stopped (spark-out), return clamp table assembly to set-up position and note graduated scale setting.
15. Remove rod and repeat for remaining rods and caps. DO NOT advance feed wheel; use same graduated scale settings as noted in Step 14 for all remaining rods and caps.
16. Clean rod bolt holes with a small brush to remove chips and debris.
17. Install new rod bolts.

The manufacturers of tongue and groove connecting rods provide clearance between the tongue and the bottom of the groove. If an amount exceeding this clearance is removed from the groove surface through excessive or repeated reconditioning, it will be necessary to grind the tongue to re-establish clearance. To grind tongue, place parting edge of gage rod so tongue surface DOES NOT rest in way of the grooves in the gage rod and place a shim under the groove surface approximately equal to
the thickness of the tongue. Clamp tightly, remove shim and grind as normal.

Steps used for the standard rod are the same as used for the alternate T&G rod with the following exception in Step 7:

7. Place cap in clamp assembly with groove surface of cap toward grinding wheel, and the tongue resting in one of the grooves in the gage rod. Also, pull the gage rod down away from the cap and rod to facilitate correct movement across the grinding wheel.

Opposite T&G Rod And Cap Cutting Procedure:

Opposed-type tongue and groove connecting rod rods have both tongue surfaces on either the cap or the rod and both groove surfaces on the opposite part.

The manufacturers of opposed tongue and groove connecting rods provide clearance between the tongue and the bottom of the groove. If an amount exceeding this clearance is removed from the groove surface through excessive or repeated reconditioning, it will be necessary to grind the tongue to re-establish clearance.

To grind tongue, place part in any of the grooves in the gage rod. Clamp tightly and grind as normal.

Housing Bore

The most common method used to recondition connecting rod housing bores is with a power-stroked horizontal honing machine. These machines very quickly produce a round and straight bore equal or better than original manufacturer's specifications. Interchangeable mandrels reduce set-up time and each connecting rod (CR-type) mandrel can vary in size approximately .001" (5.0 mm), plus they are available in sizes ranging from 1.450" (37.0 mm) to 3.300" (84 mm).

The connecting rod mandrel uses a double-wide stone arrangement, sometimes called a key-way mandrel. This increase in the stone surface area assures better alignment and faster material removal.

Make sure there is an adequate supply of honing oil whenever you use the hone. Honing oils are specially-blended to enhance the cutting action of the oil; also important to maintain the purity of the oil. Uncontaminated honing oil should be changed periodically.

Horizontal Honing Machines

Horizontal honing machines come in three configurations—manual, power-stroked, and computer automated (computer numerical control). The manual machine is just that: parts must be loaded and stroked back and forth on the mandrel by hand. The power-stroked machine is usually loaded by hand and the parts are power-stroked back and forth by the machine. The computer automated machine will generally have the parts loaded by hand unless a parts handling device is used.

On this machine, simply input the diameter and width of the rod, the machine then calculates spindle speed and stroke length.

Figure 8.71 A computer-automated honing machine uses sophisticated diamond abrasives to achieve maximum performance capacity, while achieving small tolerances of ±.000015" (0.00038 mm) accuracy.

Let's examine some of the capabilities of the manual horizontal honing machines. They can be used to size connecting rod housing and pin bores, small engine and motorcycle cylinder assemblies, and to fit steering kingpins, just to name a few. Any bored hole used for a bearing surface or alignment purposes can benefit greatly from honing. Closer tolerances can be maintained with greater ease and productivity.

Mandrels for honing machines come in a wide variety to accommodate even the most difficult bore size, type and shape. Fortunately, most bores found in automotive applications are through or spaced holes, meaning that the hone can pass all the way through. Tandem bores are those with two or more holes to be honed in the same plane. Such would be the case when fitting king pins. Blind holes do not allow the hone to pass all the way through, this would be the case with a brake master or clutch slave cylinder.

Common Bore Errors

Honing is an abrasive machining process, which is designed to improve the accuracy of cylindrical surfaces. It is characterized by: Large areas of abrasive contact; low cutting pressure; low velocity; floating part; and automatic centering of tool by expansion inside the bore.

There are ten common bore errors associated with machining, heat treating, or holding the part. These include: Out-of-round, bellmouth, waviness, undercut, burned; taper; boring marks; runner chatter, rainbow, and misalignment. Only honing can correct all ten.
somewhat more limited in size range. Most of the piston and pin honing units use an adapter to hold the mandrel in place on the machine. A truing sleeve is used for correcting taper, size and forming the correct radius on the mandrel. Truing sleeves should be replaced once they exceed .010" (0.25 mm) over the part size specification. In short, once truing sleeves are oversized by more than .016" (0.4 mm), get a new one.

We have already discussed stone compositions and their applications earlier in this chapter, however there are only four stones generally available for automotive applications. Roughting stones, -5, are used to remove large amounts of material from the bore. Medium finishing stones, -7, are used to provide a surface finish required for the majority of honing applications. The fine finishing stones, -13, are used for finish surface finishes. And, for steel applications there are, -14 stones. You should notice how the stones are listed as, -5 (rough), -7 (medium), -13 (finish), and -14 (finish).

**Honing Bore Honing Procedure:**

**Manual Honing Method:**

1. Select the appropriate honing stones.
   a. Determine the amount of stock to be removed and the number of operations required to get the part to proper size and surface finish. Many times a three-stone operation is the most economical — that is, deburring, fast stock removal, and fine finishing. If deburring is attempted with a stock removal stone, excessive stone wear will result. If stock removal is attempted with a deburring stone, honing time will be excessive.
   b. Use a harder stone to improve stone life.
   c. Use a softer stone to promote finer cutting.
   d. Use a coarse stone for fast stock removal and a fine stone for finishing. Always use the coarsest stone that will produce an acceptable surface finish.

2. Select the correct honing unit.  
   a. Depending upon your part configuration, select a honing unit type and size most suitable.

<table>
<thead>
<tr>
<th>Connecting Rod Diameter</th>
<th>Suggested Mandrel Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.80&quot;-1.792&quot; (45.78 mm)</td>
<td>CR-1490</td>
</tr>
<tr>
<td>1.750&quot;-1.700&quot; (44.31 mm)</td>
<td>CR-1720</td>
</tr>
<tr>
<td>1.600&quot;-1.575&quot; (41.60 mm)</td>
<td>CR-1960</td>
</tr>
<tr>
<td>2.000&quot;-2.000&quot; (50.80 mm)</td>
<td>CR-2100</td>
</tr>
<tr>
<td>2.300&quot;-2.200&quot; (58.42 mm)</td>
<td>CR-2300</td>
</tr>
<tr>
<td>2.500&quot;-2.300&quot; (63.50 mm)</td>
<td>CR-2500</td>
</tr>
<tr>
<td>2.750&quot;-2.650&quot; (69.85 mm)</td>
<td>CR-2700</td>
</tr>
<tr>
<td>3.000&quot;-3.000&quot; (76.20 mm)</td>
<td>CR-3000</td>
</tr>
</tbody>
</table>

Figure 9.76 Chart relating mandrel size to housing bore tunnel size.

3a. Turn the feed dial all the way anti-clockwise (CCW), then advance the unit about five turns clockwise (CW). Usually a quarter-turn, clockwise (CW) is required to seat the mandrel in the hone mandrel receiver.

3b. Push the eccentric sleeve out until it is free to rotate, and set arrow on sleeve to the correct size range as indicated on sides of mandrel body. Push eccentric sleeve back onto mandrel shank, engaging lock pin with notch in sleeve. Install mandrel into machine. Rotate set-screw until it is at 12 o’clock. Push the wedge out of the mandrel as far as it will go. Turn the mandrel until the sleeves are at the 3 o’clock position. Slide the mandrel into the spindle nose until it stops. Rotate the mandrel until it stops (about the 6 o’clock position). Tighten set-screw with hex key.

3c. Rotate the mandrel so that the guide shoes are facing upward; loosen the guide shoes with a 1/8" (3.18 mm) hex key.

4. Select and set spindle speed.

<table>
<thead>
<tr>
<th>Spindle Speed</th>
<th>SAE Size</th>
<th>ISO Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>Under 1,250</td>
<td>Under 12</td>
</tr>
<tr>
<td>500</td>
<td>1,250 - 1,625</td>
<td>52 - 41</td>
</tr>
<tr>
<td>400</td>
<td>1,625 - 2,000</td>
<td>41 - 81</td>
</tr>
<tr>
<td>500</td>
<td>2,000 - 2,500</td>
<td>51 - 84</td>
</tr>
<tr>
<td>250</td>
<td>2,500 - 3,250</td>
<td>64 - 85</td>
</tr>
<tr>
<td>200</td>
<td>Over 3,250</td>
<td>Over 83</td>
</tr>
</tbody>
</table>

Figure 9.77 Hone spindle speed chart.

5. Set the cutting pressure. Two separate cutting pressure controls are used to set light or heavy cutting pressures. Turning the controls clockwise (CW) increases cutting pressure. An initial setting of 2 or 2-1/2 is suggested for most connecting rods. Readjust as required to achieve desired cutting action.

Always set the heavy cutting pressure control to ZERO (0) when using the light cutting pressure control.
<table>
<thead>
<tr>
<th>SAE Bore Size</th>
<th>ISO Bore Size</th>
<th>Pressure Control Initial Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/16 in.</td>
<td>9.5 to 12.7</td>
<td>1</td>
</tr>
<tr>
<td>5/32 in.</td>
<td>12.7 to 20.4</td>
<td>1-1/2</td>
</tr>
<tr>
<td>1 in.</td>
<td>1 in.</td>
<td>2</td>
</tr>
</tbody>
</table>

6a. Align the rod over the torque support bar.

6b. Always hone two rods at a time if possible. Adjust the auxiliary work support. This will increase production and use less abrasive. Plus, the job will be easier to perform.

7. Position oil lines and adjust nozzles so that oil flow will enter both ends of the rod.

8. Set up precision gage by installing correct point set, centralizing gage with set-up ring, and setting size with a micrometer.

9. Check rod with precision gage to determine amount stock to be removed.


12. Start stroking and depress foot pedal slowly until it is all the way down. Be sure to stroke the rod across the entire surface of the stone. Approximately 1/4 to 1/3 of the honing bore should pass over the ends of the stone while stroking, otherwise cupping of the stones will result.

13. Observe the gage pointer. Once it has reached zero, remove and check the rod for size. The rod will not have .003" or .004" of stock removal because you will experience stone wear during the honing process. Once you have determined the amount of stone wear to achieve the desired dimension, turn the feed-up dial the corresponding amount and you should find that each rod will be within a few tenths of being on size. Refer to the section on power cylinder honing to refresh your memory on stone wear calculations.

Note: The rod size should increase by .001" per each in-and-out-stroke of the rod on the mandrel. If the gage needle does not increase .001" per stroke, the cutting pressure is insufficient. If the gage needle moves more than .0001" per stroke, the pressure is too much.

14. Remove rod from mandrel and check for size with precision gage.

15. Repeat process until rod is honed to size.

16. After the first rod has been honed to size, note the setting of the feed dial. Now put the next rod on the honing unit, and hone until the honing dial is on ZERO (0), with feed dial returned to its previous setting. Gage the rod and advance the feed dial if necessary to compensate for stone wear. Hone to ZERO again and note position of feed dial.

17. Repeat the procedure for additional rods in same set.

Because all rods are not the same size, the hone and honing unit will need to be adjusted for each new set of rods.

**Power-Stroking Method:**

1. Select the honing unit.
2. Insert the unit into the spindle.
3. Set-up the connecting rod fixture.
   a. Select and install face rings.
      (1) Select proper face rings. (Face-rings are stamped with part number and diameter range.)
      EXAMPLE: CRF-521***2.1-2.2
   b. Install face rings. Be sure mating surfaces are clean just prior to installation.
      (i) Install face rings on front and back plates. Tighten clamp knob finger tight for now.
   c. Set distance between face rings for proper rod width.
      (1) Install brass sleeves and spacing nuts.
      (2) Place cap or rod between spacing nuts on brass sleeve. NOTE: Brass sleeve is used
to protect threads on spacing studs.
(3) Adjust nuts on each of the three studs to just touch the rod or cap side faces.
(4) Replace front plate.
(5) Tighten front nuts and adjust spacing nuts so rod or cap has a very slight drag between spacing nuts and locking nuts.
4. Set stroke length equal to CR stone length 2-11/16" (68 mm).

5. Set stroke position.

5b. Rotate arm position knob until the space between the face rings is divided - half over the stone, half off the stone.
6. Set spindle speed.
7. Set stroke speed. Use 80 strokes per minute (SPM) for most passenger car and light truck rods in the 1.4"-2.6" (48-66 mm) diameter range. Use 55 SPM for large truck rods over 2.6" (66 mm) in diameter.
8. Position rod torque support arm.

9. Set cutting pressure to 2 to 2-1/2 for roughing and 1 to 1-1/2 for finishing.
10. Position oil lines and adjust oil flow.

(a) Loosen flat head clamp screw; move notched crank to pin A and tighten clamp screw.
(b) Loosen clamp on stroke length adjustment and rotate adjustment knob until index line coincides with red line 1-11/32" (34 mm) on B scale.
5a. Rotate gear box to put stroke at either extreme end.

11. Hone rods.
   a. Pull release handle toward you.
   b. Pull arm and connecting rod fixture away from the machine so fixture opening clears end of mandrel.
   c. Push release handle back.
   d. With motor off, rotate mandrel so the shoes are up and retract the stone all the way.
   e. Slide a rod that has been ground and torqued into fixture opening with rod beam facing up.
   f. Push fixture and arm toward the machine so rod will slide onto the mandrel. Push arm toward machine.
   g. With rod beam still facing up and HONE START indicator lamp OFF, depress the machine foot pedal and feed up stone until there is a reading (approximately 5) on the honing dial. Loosen shoe set screws and adjust mandrel shoes to the curvature of the rod by tapping rod shank lightly. Tighten shoe set screws (do not over-tighten). Note: This operation may require that the stroking arm is out of the way.
   h. Adjust stone feed-up until the hone dial indicates the amount of stock removal desired.
   i. With machine pedal still depressed, set feed marker at index line while holding feed dial.
   j. Release machine foot pedal.
   k. Push HONE START button and turn STROKE switch to POWER.
   l. Depress machine pedal slowly all the way to the floor.
   m. Slowly advance feed dial until feed marker reaches index line. Note: The sound of honing and the pull on the honing machine motor will indicate how fast dial can be advanced.
   n. Stop honing when dial reaches "0". Note: On the first rod, the honing dial needle may not leave the red line. If this happens, stop honing when feed marker reaches index line.
   o. Pull release handle toward you.
   p. Pull rod and fixture toward you.
   q. Push release handle toward machine.

r. Remove and gauge the connecting rod.
When center-to-center distances must be maintained, the housing bore is resized with the hone and the pin end is bored to size and length. Diesel engines require specific center-to-center lengths in order to maintain compression. The majority of diesel engines have removable pin bushings. This makes it possible to locate the pin, within reason, at a specific length from the crank pin. Lengths can be held to a plus/minus of .0005" (0.012 mm), or better.

The way the piston pin is held in the connecting rod will help you select the correct reconditioning process. Most engines use a press-fit pin—one in which the pin is pressed through the piston and into the rod. The pin is typically .0015" (0.038 mm) larger than the connecting rod pin hole. A force of 1500-2000 psi (10,500-13,700 kg) is required to press the pin into place. It is especially important to use an assembly lubricant when mounting press-fit pins. Typically, press-fit pins are assembled using a special heating device to enlarge the pin bore enough so that the pin will just slip in.

Press fit

Another process used to machine the rod housing tunnel is the boring procedure. As the term implies, the rods are bored to size, rather than honed. Realizing of the connecting rod with a boring machine is typically reserved for large industrial engines or engines where metal build-up is a result of a rod bearing insert failure. Otherwise, honing is the preferred choice for the big end of the rod. Where the rod boring machine is indispensable is where the center-to-center distance of the rod is concerned.

A second method of retaining piston pins (common in heavy-duty and performance engines) involves a pair of circular clips. These allow the pin to float in a bronze bushing located in the connecting rod. This arrangement is often called full-floating because the pin is not secured by the rod or piston.