

SB016

Cylinder Bore Finish

The never-ending demand for engine manufacturers to improve engine performance, engine life and fuel efficiency, while lowering engine weight and emissions, puts increased demands on the combustion chamber components of an engine. Higher revving engines mean higher piston and ring velocities, requiring lighter but stronger pistons and rings. Higher cylinder pressures require stronger and better designed pistons and rings. Reduced emissions has resulted in top rings much closer to the piston crown and EGR systems recirculating exhaust gases contaminated with combustion by-products. These have resulted in rings being exposed to higher temperatures and accelerated wear, which have required new ring materials, treatments and coatings. The demand for more efficient engines has resulted in reduced ring tensions, particularly on oil rings.

Most ring failures are the result of incorrect bore finish or incorrect running-in of the engine.

The engine reconditioner usually has no control over the running-in of the engine or the replacement ring design and quality, but has complete control over the cylinder bore size and finish. To maintain this control, engine reconditioners should *avoid using finished thin-wall liners if possible*. These liners are typically a slip fit (+ or - 0.025 mm interference), which means the profile of and heat transfer from the finished bore is completely dependent on the condition of the parent bore. Late model engines typically have stainless steel or ductile iron top rings, which are either chrome or moly-chrome faced, ductile iron second rings and chrome faced steel or ductile iron oil control rings. The top and second rings in quality replacement ring sets have been pre-lapped in the factory to aid bedding-in.

The function of the top ring is to control the escape of cylinder pressure and combustion gases past the piston, while the oil control ring regulates the amount of engine oil left on the cylinder bores for lubrication. The second (and sometimes third) ring does a 80 - 20 split between oil control and compression control. It is more an oil control ring than a compression ring. The ability of the rings to perform their designed functions is largely determined by three factors:

- Bore ovality/roundness (mm)
- Bore taper (mm)
- Bore finish - roughness (Ra, Rk, Rpk, Rvk)

Bore ovality and taper are mainly controlled by the quality of the boring and honing equipment and the skill of the operator. However, there can be significant effects from fitting and tensioning the main caps and bolts and the correct use of torque plates. The most important of the factors is almost certainly bore finish, as typically measured by Ra. Ra is defined as the arithmetic average of the deviation of the surface irregularities from the mean depth and is measured in either μm (micrometers) or μ (microns). It is measured in millionths of an inch (μ - microns) or millionths of a meter (μm - micrometers), where $1 \mu\text{m} = 39.4 \mu$. A special device for measuring roughness is required. The bore finish is determined by taking three readings per bore and then averaging the results. The probe should have a maximum tip radius of $5 \mu\text{m}$ (200μ), a trace length (L) of 5.00 mm (0.200") and a wave cutoff (λ_c) of 0.8 mm (0.030").

An ideal commercial bore finish will have the following properties:

- Uniform crosshatch in both directions.
- Clean-cut, not sharp and free of torn and folded metal.
- Microfinish of 0.25 - 0.75 μmRa (10 - 30 μRa), depending on ring coating and bore hardness.
- Crosshatch angle (to the horizontal) of 15° - 25° .
- Free of burnish or glaze.
- Free of embedded particles.
- Plateau honed with 50 - 75% surface area.

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Guidelines for Bore Preparation and Finish Using an Automatic Honing Machine with Silicone Carbide Honing Stones.

First stage boring for all rings: Bore to within 0.075 mm (0.003") of the finished bore size. The last cut should be no bigger than 0.125 mm (0.005"). The radius of the cutting tip should be approximately 0.5 mm (0.020"). The finish will be approximately 2.4 - 3.2 µmRa (95 - 125 µRa).

First stage honing for all rings: Hone to within 0.075 mm (0.003") of the finished bore size. This can be done with a #70 grit honing stone. The finish will be approximately 2.15 - 2.65 µmRa (85 - 105 µRa).

Second stage honing for Moly inlay rings: Hone to within 0.025 mm (0.001") of the finished bore size. This can be done with a #220 grit honing stone and should give a bore finish of 0.75 - 0.91 µmRa (30 - 36 µRa).

Final stage honing for Chrome faced or Cast Iron rings: Hone to finished bore size. This can be done with a #220 grit honing stone and should give a bore finish of 0.75 - 0.91 µmRa (30 - 36 µRa).

Final stage honing Moly inlay rings: Hone to finished bore size. This can be done with a #280 grit honing stone and should give a bore finish of 0.50 - 0.63 µmRa (20 - 25 µRa).

Plateau honing: 6 to 10 strokes with the stone pressure backed off will achieve a plateau. This can be done with the final stage honing stones or with special plateau honing stones. This can give a bore finish of 0.30 - 0.60 µmRa (12 - 24 µRa).

IMPORTANT NOTE

1. Always follow the engine manufacturer's recommendations for bore finish.
2. Harder block materials may require a slightly finer bore finish.
3. Irrespective of the stones used to obtain the finished bore size and finish, the most critical factor is the final bore roughness. This assumes all the other conditions of the bore preparation and honing pattern are correct.

Bore Preparation and Finish Check List

- Fit the main caps and tension the main cap bolts.
- Fit a torque plate, using the old head gasket and head bolts spaced up to give the correct depth into the block threads. Use the correct tension sequence and tension.
- Check the block is correctly mounted in the boring or honing machine.
- Boring or honing operations as specified.
- Ensure the cylinders are bored/honed in the correct sequence (e.g., 2-4-1-3 or 2-4-6-1-3-5) to eliminate bore distortion due to heat build-up.
- Ensure the bore and stones are continuously flooded with a good quality, clean (filtered) honing fluid.
- Hone with a firm cutting pressure (50 - 120 psi).
- Plateau hone.
- Wash bores with hot, soapy water and a stiff, nonmetallic bristle brush.
- Wipe bores with a white bore wipe to confirm they are clean.
- If bores are clean, dry and then oil to prevent rust.

Reference to Sunnen Stone Numbers

Approx. Finish	Grit Size	CK/CV Automatic Stone Number
2.15 - 2.65 µmRa (85 - 105 µRa)	70	EHU-133
0.75 - 0.91 µmRa (30 - 36 µRa)	220	JHU-525
0.50 - 0.63 µmRa (20 - 25 µRa)	280	JHU-623
0.18 - 0.35 µmRa (7 - 14 µRa)	400	JHU-818