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Metrological Dimensions in the Repair of Internal Combustion Engine Cylinders

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Abstract: This article describes in detail information about the manufacture and repair of parts of internal combustion engines, ensuring metrological dimensions at the required level, types of measurements, means and rules for their use.

Keywords: Measurement, tool, machine tool, deviation, metrology, machine tool, interval, sleeve, piston, cylinder, diameter, chamfer.

Automotive internal combustion engines have their cylinder blocks enlarged to specified repair dimensions and then honed or first ground and then honed. After that, it is completed with pistons of the appropriate diameter according to the size group.

For the bushings of car engine blocks, one repair size is specified, increased by 0.7 mm (in some cases by 0.5 mm). For all car engines, there are basically three repair sizes with 0.5 mm intervals.

Cylinders of engines with non-replaceable liners are overhauled after all repair sizes have been used (after the cylinder diameter has increased by 1.5 mm), liners are restored, and then machined to normal dimensions. After that, repeating the cycle of their repair, in which the repair dimensions of the pistons can be used one after the other.

Cylinders (sleeves) are expanded on vertical diamond milling machines with VK-2 or VK-ZM hard alloy plate cutters. Cylinders of automobile engines can also be reamed on mobile boring machines, which are mounted on the upper plane of the cylinder block.

The clearance between the piston and the cylinder is the difference between the inner diameter of the cylinder and the outer diameter of the piston. Therefore, by measuring the inner diameter of the cylinder and the outer diameter of the piston (Fig. 1), they are divided into 3 groups (B, S and M) and the corresponding sizes are selected (Table 1).

Table 1. Size group of the piston and cylinder liner on the D-244 engine

Marking of the group	Sleeve diameter, mm	Diameter of piston skirt, mm
B	$110^{+0,06}_{+0,04}$	$110^{-0,10}_{-0,12}$
S	$110^{+0,04}_{+0,02}$	$110^{-0,12}_{-0,14}$
M	$110^{+0,02}$	$110^{-0,14}_{-0,16}$

Pistons and bushings installed on the engine must be of the same size group.

The piston pin is classified into two size groups according to the outside diameter, the diameter of the seat where the piston pin sits and the inside diameter of the connecting rod bush. Those in the group are marked with paint (black and yellow), the mark is placed on the inner surface of the finger, near the piston seat and on the elbow of the connecting rod (Table 2).

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When expanding blocks of car engines (displacement engines), the distance between the axes of the cylinders is maintained and their perpendicular position relative to the axis of the crankshaft is observed. The surface of the oil sump that is connected to the cylinder block and the chamfer taken from the upper edge of the cylinder, as well as the unbent part of the upper part of the cylinder, serve as the base surface when installing the block. When expanding the cylinder liners, the upper and lower mounting strips are taken as a basis.

Table 2. Size groups of the piston rod, piston rod seat and connecting rod bushing on the D-244 engine

Designation by color	Finger diameter, mm	Diameter of connecting rod bushing, mm	Diameter of the finger slot on the piston, mm
Black	$38^{-0,004}$	$38^{+0,031}_{+0,025}$	$38^{-0,008}_{-0,014}$
Yellow	$38^{-0,004}_{-0,008}$	$38^{+0,025}_{+0,019}$	$38^{-0,014}_{-0,020}$

Cylinders are expanded in special vertical-direction machines of type 278N and 279N. In this case, the sleeves are expanded with the help of special devices. Before flaring, the diameters of all cylinders, especially the diameters at the working area of the upper piston holes, are measured and the nearest repair size for flaring of the cylinder is determined. The cutter mounting size is determined by the following formula:

$$P = \frac{Д_Ц + Д_Г - К}{2}$$

Here, P is the opening size of the micrometer, mm; Дц - cylinder diameter, mm; Дг - diameter of the chisel head, mm; K = 0.05...0.07 mm, allowance for expansion (honing).

The cutter is adjusted to the calculated size. Then the cutting mode is selected and the rotation frequency of the machine spindle is calculated:

$$n = \frac{60000 \times V}{\pi \times Д_Ц}$$

where V is the received cut, speed, m/sec.

According to the passport of the machine, the closest rotation frequency of the spindle is selected. The cylinder is expanded in one pass along its entire length. The rest of the cylinders of the block are expanded exactly to the size of the repair. The conicity and ovality of the flared cylinders should be no more than 0.04...0.05 mm along the entire length, and the roughness of the surface should be Pa = 2.5...1.25 μm.

Expanded sleeves and cylinders are processed intermittently by honing. Honing is carried out on special vertical lathes of type 3833M.

When expanding the sleeves, an allowance of 0.06...0.12 mm (0.04...0.10 mm for the cylinders of automobile engines) is left for expansion (honeying).

Bringing the cylinders to exact size and removing fine shavings with abrasive brushes to create a smooth surface is called honing.

Cylinders are sized on vertical honing machines, and in the absence of such machines, on vertical boring machines. Abrasive brushes are attached to a special head. The head is hingedly connected to the spindle of the machine and receives rotational and reciprocating motion from it.

One of the sizing heads used in practice is shown in Figure 11.9. Abrasive brushes 2 are worn on handles 3. The handles have angular grooves into which two cones 4 are inserted and fixed with a screw 5. The cones are bolted and cannot rotate. Therefore, when the screw 5 rotates, they move in the direction of the axis, as a result of which the handles 3 on which the brushes 2 are installed move radially. Thus, by turning the screw, it is possible to set the brush to the appropriate size or push them during work. The handles are always clamped to the cones by means of springs 1 and 6.

In order to give the cylinders the correct geometric shape, the abrasive brushes should protrude approximately 1/5 ... 1/3 of their length on both sides of the cylinder during honing. If the brushes protrude too much from the cylinder, the diameter of its middle part is smaller than the diameter of the outer part, if it does not protrude enough, it expands and the cylinder takes the shape of a barrel.

During honing, coolant (kerosene or a mixture of 80...90% kerosene with machine oil or lubricating oil) is continuously fed into the cylinder. The liquid not only cools the cylinder walls, but also washes away abrasive particles and small debris from them and the brushes.

Cylinders are not honed unless they are reamed or reamed. If the inner diameter of the repair bushing of the car engine does not differ more than 0.15 mm from the nominal size, it is honed to the first repair size (p) increased by 0.20 mm from the nominal size without expanding it.

The inner diameter of the sleeve (cylinder) should be within the tolerance specified for the size. The ovality and taper of the sleeve is allowed to be 0.03 mm at most. The cleanliness of the cylinder surface should not be less than 9 class. This is checked by comparison with purity standards for cast iron or checked with a profilometer. The offset of the upper and lower drive shafts against the inner surface of the machine bushings should not exceed 0.1 mm (places where the difference of the wall is clearly noticeable are marked). The variation of the wall is checked with an indicator in a special device or with a tool designed for checking rods and it is recommended to use it.

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