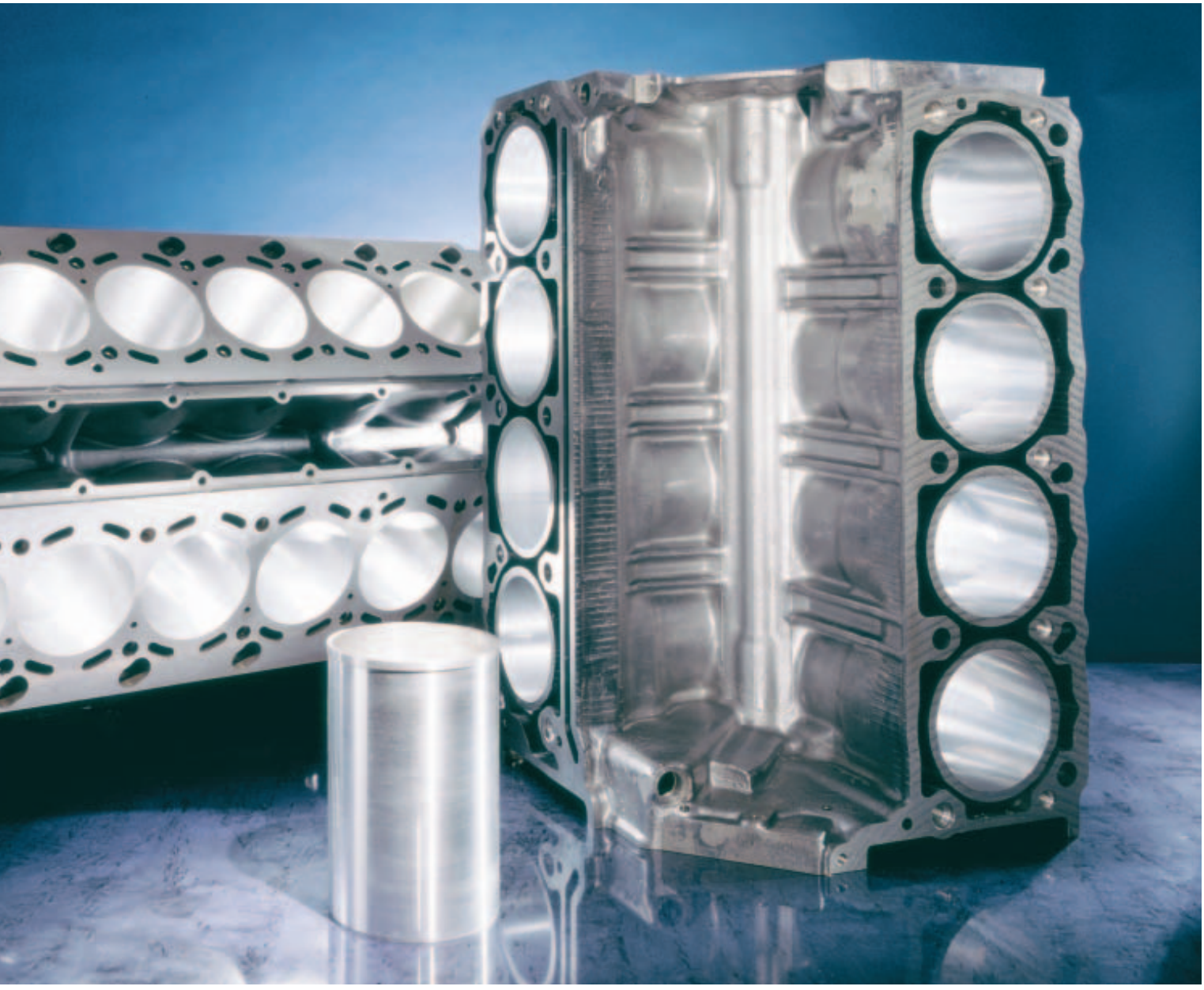
Reconditioning of Aluminium Engines



Contents

1.1 Reasons for using aluminium engine blocks

It has always been a challenge for engine designers to make, besides cylinder heads and pistons, the entire cylinder block from aluminium without additional cylinder liners or surface reinforcements. Besides a favourable running behaviour due to weight reduction, it is especially the heat balance which can be controlled much more easily because the thermal conductivity of aluminium is about 4 times higher. The engine warms up more quickly and uniformly. So the weight savings are not limited to the cylinder block weight but a reduction of the cooling water volume is also possible because of the better thermal conductivity and heat radiation of the cylinder block.

1.2 Known brands of aluminium alloys for cylinder blocks

KOLBENSCHMIDT	MAHLE
Alusil	Silumal
Galnikal	Nikasil
Chrome cylinder	Cromal
Lokasil (KS patent)	

1.3 Vehicles/engines with aluminium cylinder blocks

GALNIKAL / NIKASIL

BMW
- 2.0 Litre 6 cylinders
- 2.5 Litre 6 cylinders M52
- 2.8 Litre 6 cylinders M52
- 3.0 Litre V8
- 4.0 Litre V8
- Motorbike 100 K

JAGUAR
- V 8

ALUSIL / SILUMAL

MERCEDES-BENZ
- 3.8 Litre before 8.81
- 3.8 Litre after 8.81
- 4.2 Litre
- 5.0 / 5.6 Litre
- 6.0 Litre

PORSCHE
- 928
- 928 S
- 944

BMW
- 750 i
- 3.5 Litre V8
- 4.4 Litre V8

AUDI
- V8 4.2 Litre
- V6 2.8 Litre

LOKASIL

PORSCHE
- Boxster

1.4 Design details

Alusil:
- Alusil base material is expensive and difficult to machine due to the high silicon content
- Boring the cylinder block is possible
- Oversized pistons are available
- Pistons in Alusil blocks are coated with iron and tin

Galnikal:
- Galnikal base material is cheaper than Alusil and easier to machine due to its substantially lower silicon content
- The cylinder bore is nickel coated
- Boring the cylinder block is not possible because of the nickel coat !
- Oversized pistons are not available

Chromium cylinders:
- As Galnikal
- but: the cylinder bore is chromium coated

Lokasil / KS patent:
- Lokasil base material costs less than Alusil and is easier to process.
- Preforms, which are special prefabricated liners from Lokasil with a high silicon content of 20 - 27 %, are cast into the cylinder bore
- Oversized pistons are available
- Boring of the cylinder block is possible

1.5 Composite materials for cylinder liners. Aluminium/cast iron

KOLBENSCHMIDT	MAHLE
Alfin cylinder	Biral cylinder
Alfin cast into cylinder	Outer cylinder wall surface rough

1.6 Use of Cr-coated piston rings

KOLBENSCHMIDT	MAHLE	Cr piston rings
Alfin cylinder	Biral cylinder	possible
Alusil	Silumal	possible
Galnikal	Nikasil	not possible
Chrome cylinder	Cromal	not possible

1.7 KS cylinder liners for Alusil engines

Manufacturer/engine	KS Art.No.	Flange diameter (mm)	Flange height(mm)	Outside diameter (mm)	Inside diameter (mm)	Length (mm)
MB 3.8 Litre before 8.81	89 321 190	97.50	4.70	95.50	91.00	134.70
MB 3.8 Litre after 8.81	89 189 190	93.50	4.70	91.50	87.00	134.70
MB 4.2 Litre	89 321 190	97.50	4.70	95.50	91.00	134.70
MB 5.0/5.6 Litre	89 190 190	102.00	4.70	100.00	95.50	155.70
MB M120 12 Cyl.	89 418 190	94.50	4.70	92.50	88.00	131.55
PORSCHE 928S 1984-1986 Diameter 97mm	89 190 190	102.00	4.70	100.00	95.50	155.70
PORSCHE 928 from1985 Diameter 100 mm	89 327 190 reduce to block height	107.00	4.70	105.00	99.50	145.00
PORSCHE 944	89 327 190	107.00	4.70	105.00	99,50	145,00
BMW M70 12 Cylinder	89 400 190	89.00	4.70	87.00	83.00	126.50
ALUSIL raw casting	89 397 190 on request	—	—	110.00	90.00	160.00

2.1 Preparatory machining of the cylinder block (Fig. 1)

Tighten the bearing cap applying the torque specified by the engine manufacturer. Next, clamp the cylinder block onto the boring machine, align it roughly and than fasten it. Swivel the cylinder block and set it to the final machining position by fine alignment.
The semi-finished Alusil cylinder liners offered by KS are manufactured to a high degree of accuracy. The outside diameter tolerance is 0.03 mm max.
In order to achieve an exact bore, the following work sequences are recommended for preparing the bore to accommodate Alusil liners:

1st stage: Pre-boring with a material removal of 7/10 mm max.
2nd stage: Finish boring with a material removal of 5/10 mm max.

Then the flange support is turned to a diameter “B” to a depth of “C” (values see Table 1, page 9).
In order to avoid the risk of liner flange cracking, care should be taken to ensure that the support surface of the liner flange is exactly perpendicular to the cylinder bore.
The diameters for the respective engine types can also be found listed in Table 1. As dry cylinder liners have extremely thin walls, they may be subject to dimensional changes in unstressed condition, such as oval deformation, but when installed, after the shrinking process, they will again revert to the cylindrical shape of the base bore. Subsequently, the top edge of the cylinder bore is to be provided with a chamfer of 0.5 + 0.1 mm x 45°.

Figure 1

2.2 Installation of the Alusil cylinder liner

2.2.1 Installation with dry ice (Fig. 2)

A relatively simple method is to use CO_2 (carbon dioxide) filled into riser-type pressure bottles. Physical principle: when the gas flows out, dry ice is forming due to the sudden strong expansion. The dry ice may be collected in an insulated container. This insulated container should meet the necessary demands on insulation and strength. The cylinder liner may be cooled down to about -80°C with the dry ice.

Figure 2

2.2.2 Installation with liquid nitrogen (Fig. 3)

The cylinder liner is placed in liquid nitrogen and reaches a temperature of -180° C. Liquid nitrogen may be obtained from the local gas dealer.

Figure 3

2.2.3 Preheating of the cylinder block (Fig. 4)

A heating oven with appropriate dimensions is ideal for heating up the cylinder block. The cylinder block remains in the preheated oven for about 20 - 30 minutes.
If the installation is done with dry ice, it is essential to preheat the cylinder block to a temperature of 160° C. It is not absolutely necessary to preheat the cylinder block if the installation work is done with liquefied nitrogen. However, if there is a possibility, we would recommend about 100 - 120°C.
A temperature difference between cylinder block and liner of about 200°C is necessary to ensure safe installation.

Figure 4

2.2.4 Fitting the cylinder liner (Fig. 5)

Installing the cylinder liner is absolutely unproblematic. By cooling the cylinder liner, its diameter will decrease by about 0.1 mm whereas by preheating of the cylinder block, the base bore will become enlarged by about 0.25 mm, so that when fitting the liner, there will be a clearance of about 0.35 mm. However, the Alusil cylinder liner should be installed relatively quickly because this is a cylinder liner of extremely thin walls and aluminium is a very good heat conductor.

Figure 5

2.3 Planing of the cylinder block (Fig. 6)

After aligning, the cylinder block is planed. The material removal should be 0.1 mm in order to ensure a perfectly plane surface.

Figure 6

2.4 Prehoning, finish honing, polishing (Fig. 7)

Honing should be done using a Sunnen honing machine. For the first 3 honing phases (prehoning, finish honing, polishing), different honing stones are to be applied. The type of tool used (honing stones, honing oil) and the machine adjustments are important for efficient machining and may differ from engine type to engine type. The respective values can be read from the various tables provided.

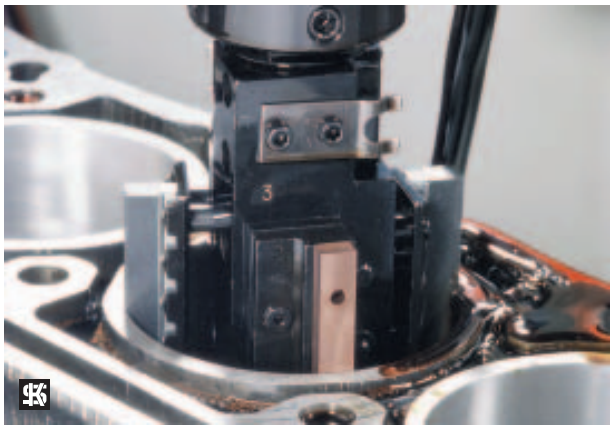


Figure 7

2.5 Silicon lapping (Figs. 8 and 9)

The fourth and last machining phase is silicon lapping. In this process, the honing stones are replaced by felt pads. The cylinder bore and the felt pads are coated with silicon polishing paste. Honing oil is not used. The felt pads and the silicon paste do not effect a measurable material removal.

Figure 8

With this machining step, the silicon crystals in the cylinder block are exposed, which leads to a more durable and wear-resistant cylinder surface.

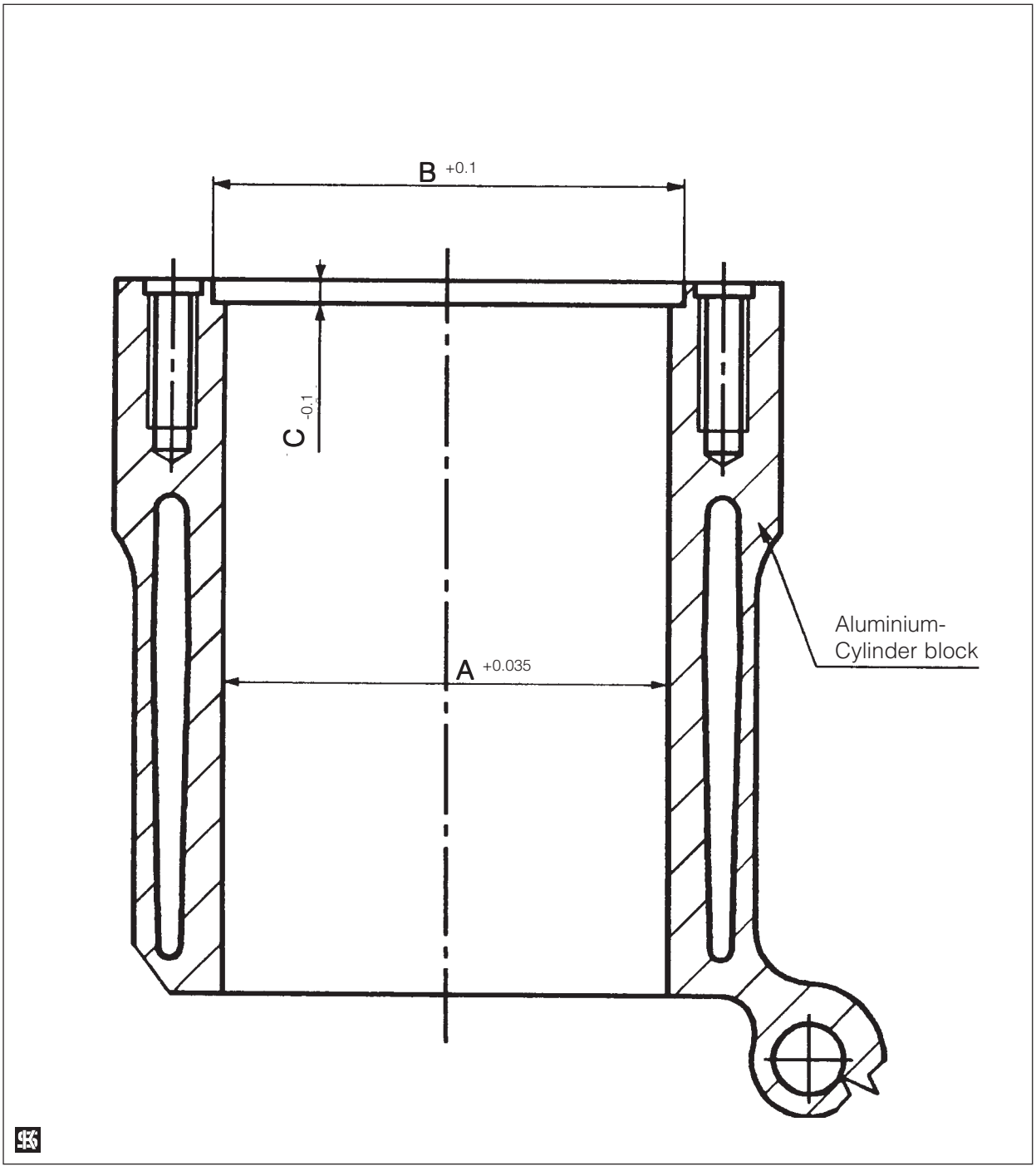
Figure 9

An additional long lifetime can be expected from an aluminium cylinder block reconditioned in this way (Fig.10).

Figure 10

2.6 Tables

Table 1: Machining dimensions for installing KS Alusil cylinder liners



Vehicle	KS Art.No.	Dimension A (mm)	Dimension B (mm)	Dimension C (mm)
MB 3.8 l before 8/81	89 321 190	95.50	97.50	4.50
MB 3.8 l after 8/81	89 189 190	91.50	93.50	4.50
MB 4.2 l	89 321 190	95.50	97.50	4.50
MB 5.0 l and 5.6 l	89 190 190	100.00	102.00	4.50

Table 2: MERCEDES-BENZ 3.8 Litre engine 2. Series with Sunnen CK- 10/CV- 616

	Rouging to Ø	Finishing to Ø	Polishing to Ø	Silicon lapping to Ø
Cylinder Ø std. 88.00 mm Cylinder oversize 88.50 mm	88.40 mm	88.48 mm	88.50 mm	88.50 mm
Cylinder length 135 mm				
Honing head type	CK-3000 or CK 2600	dto.	dto.	dto.
Stroke length setting	70 mm	70 mm	70 mm	70 mm
Setting on machine	140 mm	140 mm	140 mm	120 mm
RPM	125 CK / CV	125 CK / CV	125 CK / CV	185 CK / 230 CV
SPM	49 CK / 57 CV	49 CK / 57 CV	49 CK / 57 CV	73 CK / 80 CV
Feed setting	5	4	3	2
Top stone overstroke	15 mm	15 mm	15 mm	2 mm
Roughing stone	C 30- J55			
Finishing stone		C 30-J84		
Polishing stone			C30- C03- 81	
Felt pads				C30- F85
Load meter %	30 - 40	30 - 40	20 - 30	20 - 30
Material removal approx.	0.07 mm	0.03 mm	0.01 mm	approx. 15 strokes
Feed wheel setting	10 lines	10 lines	10 lines	60 sec. running time
Roughness Rt.	approx.7-8 my	approx. 2 my	approx.0.6 - 0,8 my	approx. 1-2 my

Table 3: MERCEDES-BENZ 4.2 and 3.8 litre engine with Sunnen CK- 10/CV- 616

	Roughing to Ø	Finishing to Ø	Polishing to Ø	Silicon lapping to Ø
Cylinder Ø Std. 92.00 mm Cylinder oversize 92.50 mm	92.40 mm	92.48 mm	92.50 mm	92.50 mm
Cylinder length 135 mm				
Honing head type	CK-3000 or CK 2600	dto.	dto.	dto.
Stroke length setting	70 mm	70 mm	70 mm	70 mm
Setting on machine	140 mm	140 mm	140 mm	120 mm
RPM	125 CK / CV	125 CK / CV	125 CK / CV	185 CK / 230 CV
SPM	49 CK / 57 CV	49 CK / 57 CV	49 CK / 57 CV	73 CK / 80 CV
Feed setting	5	4	3	2
Top stone overstroke	15 mm	15 mm	15 mm	2 mm
Roughing stone	C 30- J55			
Finishing stone		C 30-J84		
Polishing stone			C30- C03- 81	
Felt pads				C30- F85
Load meter %	30 - 40	30 - 40	20- 30	20- 30
Material removal approx.	0.07 mm	0.03 mm	0.01 mm	approx. 15 strokes
Feed wheel setting	10 lines	10 lines	10 lines	60 sec. running time
Roughness Rt.	approx. 7-8 my	approx. 2 my	approx. 0.6 - 0.8 my	approx. 1-2 my

Table 4: MERCEDES-BENZ 5.0 and 5.6 litre engine with Sunnen CK- 10/CV- 616

	Roughing to Ø	Finishing to Ø	Polishing to Ø	Silicon lapping to Ø
Cylinder Ø Std.96.50 mm Cylinder oversize 97.00 mm	96.90 mm	96.98 mm	97.00 mm	97.00 mm
Cylinder length 155 mm				
Honing head type	CK-3000 or CK 2600	dto.	dto.	dto.
Stroke length setting	70 mm	70 mm	70 mm	70 mm
Setting on machine	160 mm	160 mm	160 mm	140 mm
RPM	125 CK / CV	125 CK / CV	125 CK / CV	185 CK/230 CV
SPM	49 CK/57 CV	49 CK / 57 CV	49 CK/57 CV	73 CK / 80 CV
Feed setting	5	4	3	2
Top stone overstroke	15 mm	15 mm	15 mm	2 mm
Roughing stone	C 30- J55			
Finishing stone		C 30-J84		
Polishing stone			C30- C03- 81	
Felt pads				C30- F85
Load meter %	30 - 40	30 - 40	20- 30	20- 30
Material removal approx.	0.07 mm	0.03 mm	0.01 mm	approx. 15 strokes
Feed wheel setting	10 lines	10 lines	10 lines	60 sec. running time
Roughness Rt.	approx. 7-8 my	approx. 2 my	approx. 0.6 - 0.8 my	approx. 1-2 my

Table 5: PORSCHE 928 engine with Sunnen CK- 10/CV- 616

	Roughing to Ø	Finishing to Ø	Polishing to Ø	Silicon lapping to Ø
Cylinder Ø std. 95.00 mm Cylinder oversize 95.50 mm	95.40 mm	95.48 mm	95.50 mm	95.50 mm
Cylinder length 140 mm				
Honing head type	CK-3000 or CK 2600	dto.	dto.	dto.
Stroke length setting	70 mm	70 mm	70 mm	70 mm
Setting on machine	160 mm	160 mm	160 mm	125 mm
RPM	125 CK / CV	125 CK / CV	125 CK / CV	185 CK/230 CV
SPM	49CK/57CV	49 CK/57 CV	49 CK/57 CV	73 CK/80 CV
Feed setting	5	4	3	2
Top stone overstroke	25 mm	25 mm	25 mm	2 mm
Roughing stone	C30- J55			
Finishing stone		C30- J84		
Polishing stone			C30- C03- 81	
Felt pads				C30- F85
Load meter%	30- 40	30- 40	20- 30	20- 30
Material removal approx.	0.07 mm	0.03 mm	0.01 mm	approx. 15 strokes
Feed wheel setting	10 lines	10 lines	10 lines	60 sec. running time
Roughness Rt.	approx. 7- 8 my	approx. 2 my	approx. 0.6 - 0.8 my	approx. 1- 2 my

Table 6: PORSCHE 928 S Engine with Sunnen CK- 10/CV- 616

	Roughing to Ø	Finishing to Ø	Polishing to Ø	Silicon lapping to Ø
Cylinder Ø std. 97.00 mm Cylinder oversize 97.50 mm	97.40 mm	97.48 mm	97.50 mm	97.50 mm
Cylinder length 140 mm				
Honing head type	CK-3000 or CK 2600	dto.	dto.	dto.
Stroke length setting	70 mm	70 mm	70 mm	70 mm
Setting on machine	160 mm	160 mm	160 mm	125 mm
RPM	125 CK / CV	125 CK / CV	125 CK / CV	185 CK/230 CV
SPM	49 CK/57 CV	49 CK/57 CV	49 CK/57 CV	73 CK/80 CV
Feed setting	5	4	3	2
Top stone overstroke	25 mm	25 mm	25 mm	2 mm
Roughing stone	C30- J55			
Finishing stone		C30- J84		
Polishing stone			C30- C03- 81	
Felt pads				C30- F85
Load meter %	30- 40	30- 40	20- 30	20- 30
Material removal approx.	0.07 mm	0.03 mm	0.01 mm	approx.15 strokes
Feed wheel setting	10 lines	10 lines	10 lines	60 sec. running time
Roughness Rt.	approx. 7- 8 my	approx. 2 my	approx. 0.6 - 0.8 my	approx. 1- 2 my

Table 7: PORSCHE 944 engine with Sunnen CK- 10/CV- 616

	Roughing to Ø	Finishing to Ø	Polishing to Ø	Silicon lapping to Ø
Cylinder Ø std.100.00 mm Cylinder oversize 100.50 mm	100.40 mm	100.48 mm	100.50 mm	100.50 mm
Cylinder length 145 mm				
Honing head type	CK-3000 or CK 2600	dto.	dto.	dto.
Stroke length setting	70 mm	70 mm	70 mm	70 mm
Setting on machine	160 mm	160 mm	160 mm	125 mm
RPM	125 CK / CV	125 CK / CV	125 CK / CV	185 CK/230 CV
SPM	49 CK/57 CV	49 CK/57 CV	49 CK/57 CV	73 CK/80 CV
Feed setting	5	4	3	2
Top stone overstroke	21 mm	21 mm	21 mm	2 mm
Roughing stone	C30- J55			
Finishing stone		C30- J84		
Polishing stone			C30- C03- 81	
Felt pads				C30- F85
Load meter %	30- 40	30- 40	20- 30	20- 30
Material removal approx.	0.07 mm	0.03 mm	0.01 mm	approx.15 strokes
Feed wheel setting	10 lines	10 lines	10 lines	60 sec. running time
Roughness Rt.	approx. 7- 8 my	approx. 2 my	approx. 0.6 - 0.8 my	approx. 1- 2 my

Table 8: BMW 750 i engine type M 70 V- 12 with Sunnen CK- 10/CV- 616

	Roughing to Ø	Finishing to Ø	Polishing to Ø	Silicon lapping to Ø
Cylinder Ø Std. 84.00 mm Cylinder oversize 84.25 mm	84.15	84.23 mm	84.25 mm	84.25 mm
Cylinder length 125 mm				
Honing head type	CK-3000 or CK 2600	dto.	dto.	dto.
Stroke length setting	70 mm	70 mm	70 mm	70 mm
Setting on machine	125 mm	125 mm	125 mm	105 mm
RPM	125 CK / CV	125 CK / CV	125 CK / CV	185 CK/230 CV
SPM	49 CK/57 CV	49 CK/57 CV	49 CK/57 CV	73 CK/80 CV
Feed setting	5	4	3	2
Top stone overstroke	15 mm	15 mm	15 mm	2 mm
Roughing stone	C30- J55			
Finishing stone		C30- J84		
Polishing stone			C30- C03- 81	
Felt pads				C30- F85
Load meter %	30- 40	30- 40	20- 30	20- 30
Material removal approx.	0.07 mm	0.03 mm	0.01 mm	approx.15 strokes
Feed wheel setting	10 lines	10 lines	10 lines	60 sec. running time
Roughness Rt.	approx. 7- 8 my	approx. 2 my	approx. 0.6 - 0.8 my	approx. 1- 2 my

Table 9: MERCEDES-BENZ V-12 6,0 Litre engine with Sunnen CK- 10/CV- 616

	Roughing to Ø	Finishing to Ø	Polishing to Ø	Silicon lapping to Ø
Cylinder Ø Std.89.00 mm Cylinder oversize 89.35 mm	89.25 mm	89.33 mm	89.35 mm	89.35 mm
Cylinder length 130 mm				
Honing head type	C-3000 or CK 2600	dto.	dto.	dto.
Stroke length setting	70 mm	70 mm	70 mm	70 mm
Setting on machine	135 mm	135 mm	135 mm	115 mm
RPM	125 CK / CV	125 CK / CV	125 CK / CV	185 CK/230 CV
SPM	49 CK/57 CV	49 CK/57 CV	49 CK/57 CV	73 CK/80 CV
Feed setting	5	4	3	2
Top stone overstroke	15 mm	15 mm	15 mm	2 mm
Roughing stone	C30- J55			
Finishing stone		C30- J84		
Polishing stone			C30- C03- 81	
Felt pads				C30- F85
Load meter %	30- 40	30- 40	20- 30	20- 30
Material removal approx.	0.07 mm	0.03 mm	0.01 mm	approx.15 strokes
Feed wheel setting	10 lines	10 lines	10 lines	60 sec. running time
Roughness Rt.	approx. 7- 8 my	approx. 2 my	approx. 0.6 - 0.8 my	approx. 1- 2 my

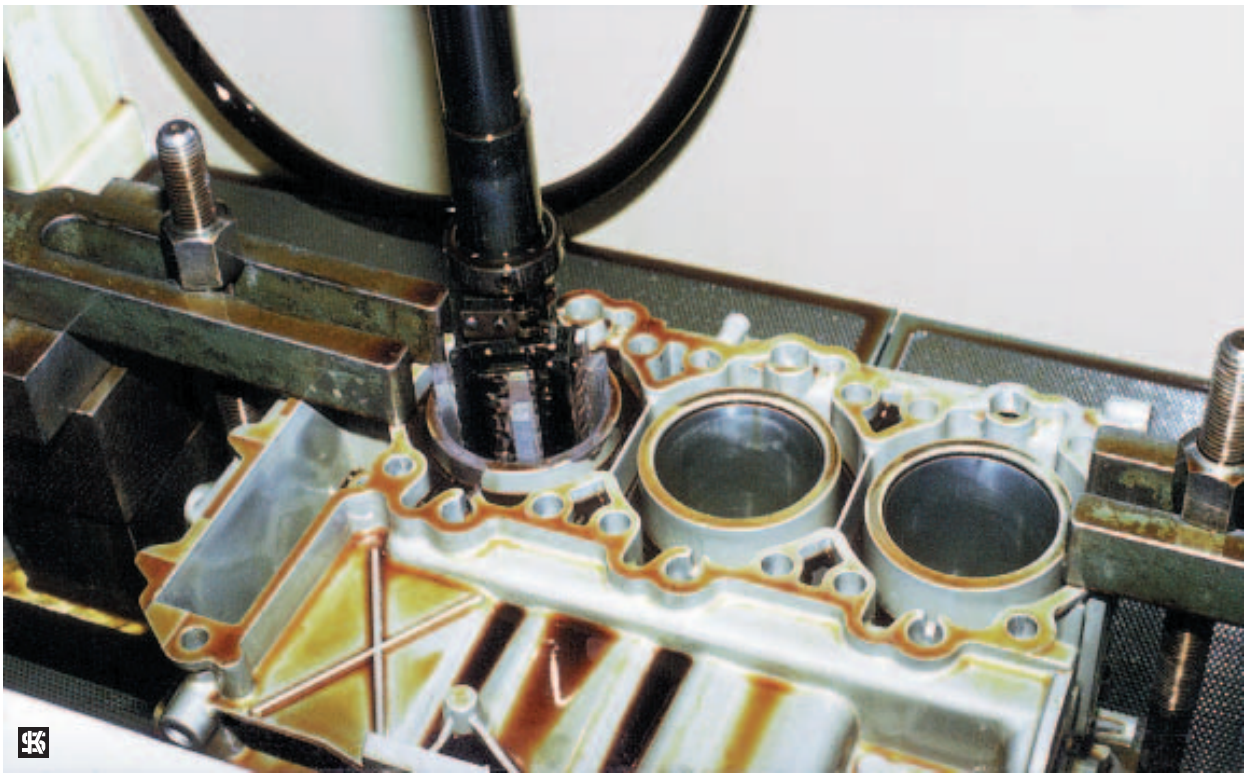
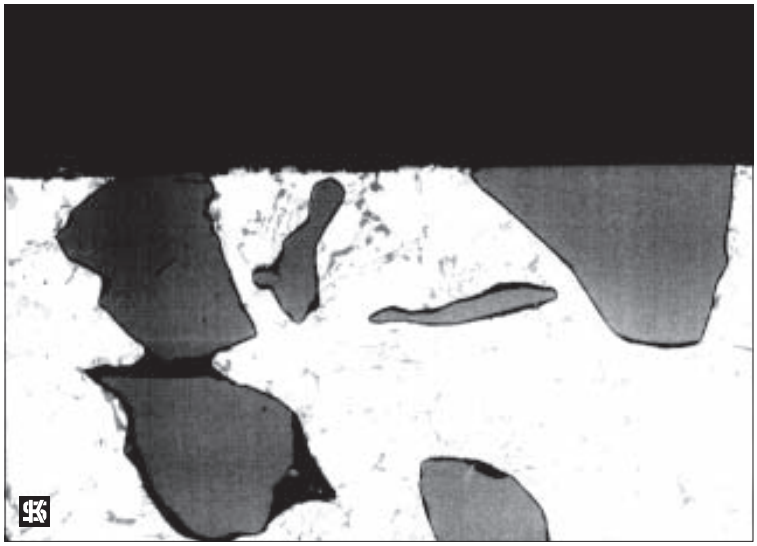
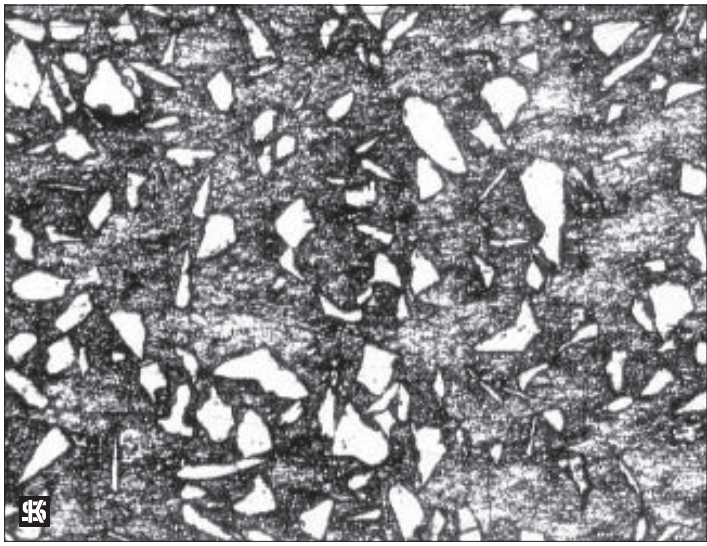


Figure 11 Reconditioning a Lokasil cylinder block
Engine: Porsche Boxster



Exposure of silicon crystals 500:1



Lokasil surface 100:1

Reconditioning is similar to Alusil, in the same sequence, but with changed machine setting in accordance with the following table.

Table 10: Porsche Boxster 6 cyl., 2480 cm³, bore 85.5 mm, stroke 72 mm with Sunnen CV-616

	Roughing to Ø	Finishing to Ø	Polishing to Ø	Silicon lapping to Ø
Cylinder Ø Std. 85.50 mm Cylinder oversize 86.00 mm	85.90 mm	85.98 mm	86.00 mm	86.00 mm
Cylinder length 130 mm				
Honing head type	-3000 or CK 2600	dto.	dto.	dto.
Stroke length setting	70 mm	70 mm	70 mm	70 mm
Setting on machine	145 mm	145 mm	145 mm	145 mm
RPM	170 CV	170 CV	125 CV	125 CV
SPM	80CV	80 CV	80 CV	80 CV
Feed setting	1	6	5	4
Top stone overstroke	15 mm	15 mm	15 mm	2 mm
Roughing stone	C30-J55			
Finishing stone		C30-J84		
Polishing stone			C30-C03-81	
Felt pads				C30-F85
Load meter %	30-40	10-20	10-20	10-20
Material removal approx.	0.07 mm	0.03 mm	0.01 mm	approx.15 Strokes
Feed wheel setting	10 lines	10 lines	10 lines	45 sec. running time
Roughness Rt.				approx. 3-4 my

For the cylinder blocks of Porsche Boxster 6 Cyl., Lokasil 2 is applied with a silicon content of 27 % (compared with Lokasil 1 with 20 % Si).
This material is more resistant to wear than Alusil on account of its higher silicon content. The cylinder wall is much thicker due to the preforms (see chapter 1, item 1.4) so that it exhibits a good dimensional stability.
The cylinder bore is continuous which makes machining much easier.

Specification for the Lokasil surface:

Roughness average Ra	0.15-0.35 my
Roughness height Rz	1.0-3.0 my
Peak height Rpk	0.40-0.70 my
Core roughness height Rk	0.20-0.60 my
Groove depth Rvk	0.10-0.70 my

KS Honing accessories:

KS Art.No.	Article	Sunnen No.
50 009 859	Silicon paste	AN-30
50 009 860	Honing stone set 2 roughing stones	C30-J55
50 009 861	Honing stone set 2 finishing stones	C30-J84
50 009 862	Honing stone set 2 polishing stones	C30-C03-81
50 009 863	Felt pad set 2 felt pads	C30-F85

Chapter 4: Reconditioning the threads for the cylinder head bolts

Engine overheating may lead to stripped threads in the cylinder head bolt holes in aluminium cylinder blocks. This thread damage can be repaired with the so-called Time Sert system. This system has a great benefit in that a small threaded bush locks itself into the aluminium cylinder block so that when the engine is dismantled again, the threaded insert is not turned out. This assumes a solid threaded bush made of steel which ensures simple installation and high endurance.
Internally and externally synchronous threads allow the application of these threaded bushes with low wall thicknesses.
Moreover, threaded bushes are self-locking and pressure tight so that the tensioning achieved when fitting prevents unscrewing and withstands any number of bolt fitting and removal operations.

Figure 12

1st step - Boring

Figure 13 Drill a core hole with a drill or bore the old thread out

2nd step - Cutting the shank

Figure 14 The core hole is countersunk with a shank cutter (depth 2.5 mm).

3rd step - Tapping

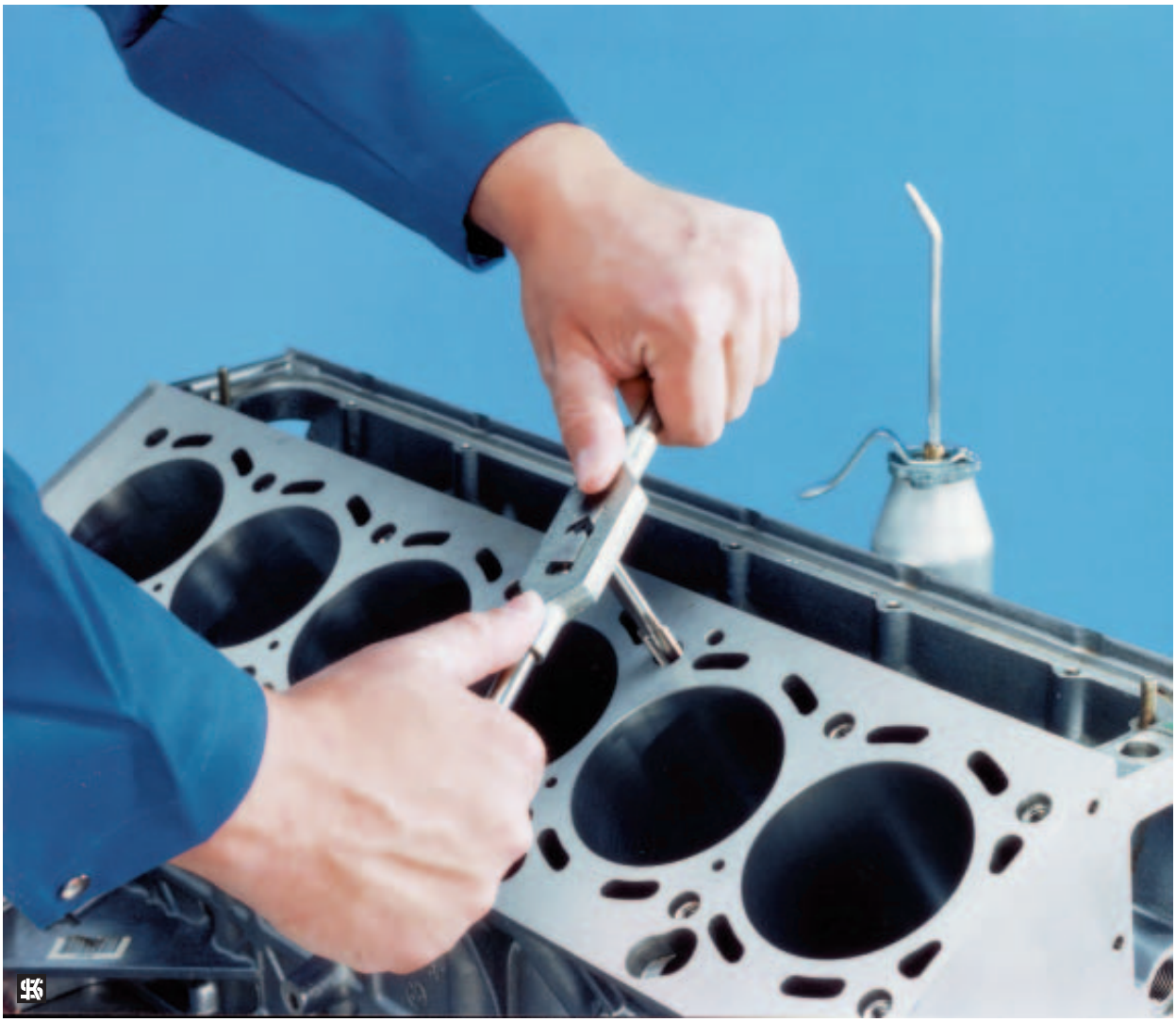


Figure 15 Cutting the thread with a tap

4th step - Blowing out

Figure 16 Important: Blow out chips and oil

5th step - Engaging the threads

Figure 17 Position threaded bush by hand and screw a few turns

6th step - Tightening

Figure 18

Using the tightening tool, turn in the threaded bush until it is flush with the surface. At increasing turning depth, more force has to be applied. Now the internal thread is fully shaped and at the same time the bush pressed into the base thread. Only after this operation can the tightening tool be easily turned back.

The job is complete.
A heavy duty, thin-walled and self-locking threaded bush is fitted.

Figure 19

Tools for threaded bushes

KS Art.No.	Article
50 009 871	Set: 1 shank cutter, 1 tap, 1 special drill, 1 tightening tool, 50 threaded bushes
50 009 872	50 threaded bushes M 10 x 1.5 (internal thread)

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Culatas

Filter
Filters
Filtres
Filtros

Riemen
Belts
Courroies
Correas

Öl- und Wasserpumpen
Oil Pumps and Water Pumps
Pompes à huile et à eau
Bombas de aceite y agua

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