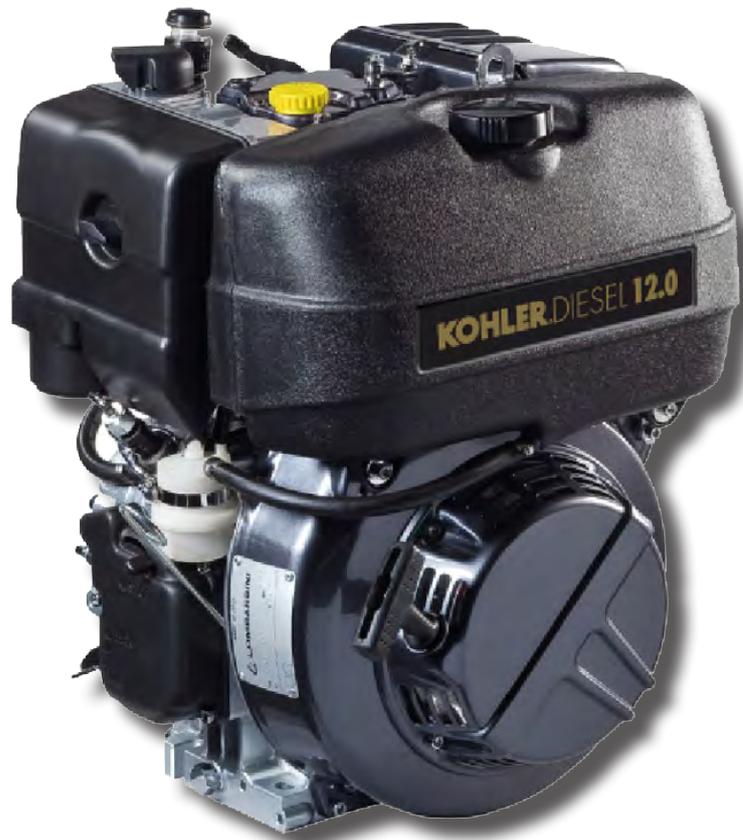


KOHLER® KD 500



KOHLER
ENGINES

REGISTRATION OF MODIFICATIONS TO THE DOCUMENT

Any modifications to this document must be registered by the drafting body, by completing the following table.

Drafting body	Document code	Model N°	Edition	Revision	Issue date	Review date	Endorsed
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KD 500

PREFACE

- Every attempt has been made to present within this service manual, accurate and up to date technical information. However, development on the **KOHLER** series is continuous. Therefore, the information within this manual is subject to change without notice and without obligation. The materials used by **KOHLER** to construct the engine's components undergo strict quality controls and the engine's assembly guarantees reliability and long life. The engine has been built to the machine manufacturer's specifications, and it was its responsibility to adopt all the measures needed to meet the essential health and safety requirements as provided for by the laws in force; use of the engine for uses other than the one defined shall not be considered as compliant with the use intended by **KOHLER**, who therefore refuses all responsibility for any injury arising from such an operation.
 - The information contained within this service manual is the sole property of **KOHLER**. As such, no reproduction or replication in whole or part is allowed without the express written permission of **KOHLER**.
- Information presented within this manual assumes the following:
- 1 - The person or people performing service work on **KOHLER** series engines is properly trained and equipped to safely and professionally perform the subject operation;
 - 2 - The person or people performing service work on **KOHLER** series engines possesses adequate hand and **KOHLER** special tools to safely and professionally perform the subject service operation;
 - 3 - The person or people performing service work on **KOHLER** series engines has read the pertinent information regarding the subject service operations and fully understands the operation at hand.
- This manual was written by the manufacturer to provide technical and operating information to authorised **KOHLER** after-sales service centres to carry out assembly, disassembly, overhauling, replacement and tuning operations.
 - As well as employing good operating techniques and observing the right timing for operations, operators must read the information very carefully and comply with it scrupulously.
 - Time spent reading this information will help to prevent health and safety risks and financial damage. Written information is accompanied by illustrations in order to facilitate your understanding of every step of the operating phases.

LIMITED 3 YEAR KOHLER[®] DIESEL ENGINE WARRANTY

Kohler Co. warrants to the original retail consumer that each new KOHLER Diesel engine sold by Kohler Co. will be free from manufacturing defects in materials or workmanship in normal service for a period of three (3) years or 2000 hours whichever occurs first from the date of purchase, provided it is operated and maintained in accordance with Kohler Co.'s instructions and manuals. If no hour meter is installed as original equipment then 8 hours of use per day and 5 days per week will be used to calculate hours used.

Our obligation under this warranty is expressly limited, at our option, to the replacement or repair at Kohler Co., Kohler, Wisconsin 53044, or at a service facility designated by us of such parts as inspection shall disclose to have been defective.

This warranty does not apply to defects caused by unreasonable use, including faulty repairs by others and failure to provide reasonable and necessary maintenance.

The following items are not covered by this warranty:

Engine accessories such as fuel tanks, clutches, transmissions, power-drive assemblies and batteries, unless supplied or installed by Kohler Co. These are subject to the warranties, if any, of their manufacturers.

KOHLER CO. AND/OR THE SELLER SHALL NOT BE LIABLE FOR SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES OF ANY KIND, including but not limited to labor costs or transportation charges in connection with the repair or replacement of defective parts.

IMPLIED OR STATUTORY WARRANTIES, INCLUDING WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, ARE EXPRESSLY LIMITED TO THE DURATION OF THIS WRITTEN WARRANTY. We make no other express warranty, nor is any one authorized to make any on our behalf.

Some states do not allow limitations on how long an implied warranty lasts, or the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

This warranty gives you specific legal rights, and you may also have other rights, which vary from state to state.

To obtain warranty service

Purchaser must bring the engine to an authorized Kohler service facility. To locate the nearest facility, visit our website, www.kohlerengines.com, and use the locator function, consult your Yellow Pages or telephone 1-800-544-2444.

ENGINE DIVISION, KOHLER CO., KOHLER, WISCONSIN 53044

**CALIFORNIA EMISSION CONTROL WARRANTY STATEMENT
YOUR WARRANTY RIGHTS AND OBLIGATIONS**

The California Air Resources Board and Kohler Co. are pleased to explain the **emission control system warranty** on your 2012 engine. In California, new heavy-duty off-road engines must be designed, built and equipped to meet the State's stringent anti-smog standards. Kohler Co. must warrant the emission control system on your engine for the time period listed below provided there has been no abuse, neglect or improper maintenance of your engine.

Your emission control system may include parts such as the fuel-injection system and the air induction system. Also included may be hoses, connectors and other emission related assemblies.

Where a warrantable condition exists, Kohler Co. will repair your heavy-duty off-road engine at no cost to you including diagnosis, parts and labor.

MANUFACTURER'S WARRANTY COVERAGE:

Your off-road, diesel engine emission control system is covered under warranty for a period of five (5) years or 3,000 hours, whichever occurs first, beginning on the date the engine or equipment is delivered to an ultimate purchaser for all constant speed engines with maximum power $19 \leq kW < 37$ and rated speed less than 3,000 rpm, all variable speed engines with maximum power $19 \leq kW < 37$, and all variable or constant speed engines with maximum power greater than 37 kW. Your off-road, diesel engine emission control system on variable or constant-speed engines with maximum power less than 19 kW, and for constant speed engines with maximum power $19 \leq kW < 37$ and rated speed equal to or greater than 3,000 rpm is covered under warranty for a period of two (2) years or 1,500 hours, whichever occurs first. If any emission related part on your engine is defective, the part will be repaired or replaced by Kohler Co.

OWNER'S WARRANTY RESPONSIBILITIES:

As the heavy-duty off-road engine owner, you are responsible for the performance of the **required maintenance listed in your Kohler Co. owner's manual**. Kohler Co. recommends that you retain all receipts covering maintenance on your heavy-duty off-road engine, but Kohler Co. cannot deny warranty solely for the lack of receipts or for your failure to ensure the performance of all recommended scheduled maintenance.

As the heavy-duty off-road engine owner, you should however be aware that Kohler Co. may deny you warranty coverage if your heavy-duty off-road engine or emission control related component has failed due to abuse, neglect, improper maintenance or unapproved modifications.

Your engine is designed to operate on commercial diesel fuel (No. 1 or No. 2 low sulfur or ultra low sulfur diesel fuel) only. Use of any other fuel may result in your engine no longer operating in compliance with California's emissions requirements.

You are responsible for initiating the warranty process. The Air Resources Board suggests that you present your heavy-duty off-road engine to a Kohler Co. dealer as soon as a problem exists. The warranty repairs should be completed by the dealer as expeditiously as possible.

Please review the document titled, "Kohler Co. Federal and California Emission Control Systems Limited Warranty Off-Road Diesel Engines", for complete details of your heavy-duty off-road engine warranty. If you have any questions regarding your warranty rights and responsibilities or the location of the nearest Kohler Co. authorized service location, you should contact Kohler Co. at 1-800-544-2444 or access our website at www.kohlerengines.com.

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POSSIBLE CAUSES AND TROUBLE SHOOTING

The following table contains the possible causes of some failures which may occur during operation. Always perform these simple checks before removing or replacing any part.

POSSIBLE CAUSE		TROUBLE									
		Engine does not start	Engine starts but stops	No acceleration	Non-uniform speed	Black smoke	White smoke	Too low oil pressure	Increase oil level	Excessive oil consumption	Oil and fuel dripping from exhaust
FUEL CIRCUIT	Clogged pipes										
	Clogged fuel filter										
	Air inside fuel circuit										
	Clogged tank breather hole										
	Faulty fuel pump										
	Injector jammed										
	Jammed injection pump delivery valve										
	Wrong injector setting										
	Excessive plunger blow-by										
	Jammed injection pump delivery control										
	Wrong injection pump setting										
LUBRICATION	Oil level too high										
	Jammed pressure relief valve										
	Worn oil pump										
	Air inside oil suction pipe										
	Faulty pressure gauge or switch										
	Clogged oil suction pipe										
ELECTRIC SYSTEM	Battery discharged										
	Wrong or inefficient cable connection										
	Defective ignition switch										
	Defective starter motor										
MAINTENANCE	Clogged air filter										
	Excessive idle operation										
	Incomplete running-in										
	Engine overloaded										
SETTINGS/REPAIRS	Advanced injection										
	Delayed injection										
	Incorrect governor linkage adjustment										
	Broken or loose governor spring										
	Idle speed too low										
	Worn or jammed piston rings										
	Worn or scored cylinders										
	Worn valve guides										
	Jammed valves										
	Worn bearings										
	Governor linkage not free to slide										
	Drive shaft not free to slide										
	Damaged cylinder head gasket										

SAFETY REGULATIONS

GENERAL NOTES

- **Kohler** engines are built to provide safe and longlasting performances, but in order to obtain these results it is essential that the maintenance requirements described in the manual are observed along with the following safety recommendations.
- The engine has been built to the specifications of a machine manufacturer, and it is his responsibility to ensure that all necessary action is taken to meet the essential and legally prescribed health and safety requirements. Any use of the machine other than that described cannot be considered as complying with its intended purpose as specified by **Kohler**, which therefore declines all responsibility for accidents caused by such operations.
- The following instructions are intended for the user of the machine in order to reduce or eliminate risks, especially those concerning the operation and standard maintenance of the engine.
- The user should read these instructions carefully and get to know the operations described. By not doing so he may place at risk his own health and safety and that of anyone else in the vicinity of the machine.
- The engine may be used or mounted on a machine only by personnel suitably trained in its operation and aware of the dangers involved. This is particularly true for standard and, above all, special maintenance work. For special maintenance contact personnel trained specifically by **Kohler**. This work should be carried out in accordance with existing literature.
- **Kohler** declines all responsibility for accidents or for failure to comply with the requirements of law if changes are made to the engine's functional parameters or to the fuel flow rate adjustments and speed of rotation, if seals are removed, or if parts not described in the operating and maintenance manual are removed and reassembled by unauthorized personnel.



WARNING

- In addition to all other machine specifications, ensure that the engine is in a near horizontal position when starting. If starting manually, ensure that the necessary operations can be performed without any risk of striking against walls or dangerous objects. Rope starting (except for recoil rope starting) is not permitted even in emergencies.
- Check that the machine is stable so that there is no risk of it overturning.
- Get to know the engine speed adjustment and machine stop operations.
- Do not start the machine in closed or poorly ventilated environments. The internal combustion process generates carbon monoxide, an odourless and highly toxic gas, so spending too long a time in an environment where the engine discharges its exhaust products freely can lead to loss of consciousness and even death.
- The engine may not be used in environments containing flammable materials, explosive atmospheres or easily combustible powders, unless adequate and specific precautions have been taken and are clearly stated and certified for the machine.
- To prevent the risk of fire, keep the machine at a distance of at least one metre from buildings or other machines.

- Children and animals must be kept at a sufficient distance from the machine to prevent any danger resulting from its operation.
- Fuel is flammable, so the tank must be filled only when the engine is turned off. Dry carefully any fuel that may have spilled, remove the fuel container and any cloths soaked in fuel or oil, check that any sound-absorbing panels made of porous material are not soaked with fuel or oil, and make sure that the ground on which the machine is located has not absorbed fuel or oil.
- Before starting, remove any tools that have been used for carrying out maintenance work to the engine and/or the machine and check that any guards removed have been replaced. In cold climates it is possible to mix kerosene with the diesel fuel to make the engine easier to start. The liquids must be mixed in the tank by pouring in first the kerosene and then the diesel fuel. Consult **Kohler** technical office for mixture proportions. Petrol may not be used because of the risk of it forming flammable vapours.
- During operation the surface of the engine reaches temperatures that may be dangerous. Avoid in particular all contact with the exhaust system.
- The liquid cooling circuit is under pressure. Do not carry out any checks before the engine has cooled down, and even then open the radiator cap or the expansion tank cautiously. Wear protective clothing and glasses. If there is an electric fan, do not approach the engine while it is still hot as the fan may come on even when the engine is not running. Clean the cooling system with the engine turned off.
- While cleaning the oil bath air filter, check that the oil is disposed of in such a way as not to harm the environment. Any filtering sponges in the oil bath air filter should not be soaked with oil. The cyclone pre-filter cup must not be filled with oil.
- Since the oil must be emptied out while the engine is still hot (approx. 80°C), particular care should be taken in order to avoid burns. In any case make sure that oil does not come into contact with your skin because of the health hazards involved.
- Fuel vapours are highly toxic, so fill up only in the open air or in well ventilated environments.
- During operations which involve access to moving parts of the engine and/or removal of the rotary guards, disconnect and insulate the positive cable of the battery so as to prevent accidental short circuits and activation of the starter motor.
- Check the belt tension only when the engine is turned off.



IMPORTANT

- To start the engine follow the specific instructions provided in the engine and/or machine operating manual. Do not use auxiliary starting devices not originally installed on the machine (e.g. Startpilot systems which utilise ether etc.)
- Before carrying out any work on the engine, turn it off and allow it to cool down. Do not perform any operation while the engine is running.
- Check that the discharged oil, the oil filter and the oil contained in the oil filter are disposed of in such a way as not to harm the environment.
- Close the fuel tank filler cap carefully after each filling operation. Do not fill the tank right up to the top, but leave sufficient space to allow for any expansion of the fuel.
- Do not smoke or use naked flames while filling.

- . Take care when removing the oil filter as it may be hot.
- . The operations of checking, filling up and replacing the cooling liquid must be carried out with the engine turned off and cold. Take particular care if liquids containing nitrites are mixed with others not containing these compounds as this may give rise to the formation of nitrosamines which are a health hazard. The cooling liquid is polluting, so dispose of in a manner that does not damage the environment.
- . In order to move the engine simultaneously use the eyebolts fitted for this purpose by **Kohler**. These lifting points are however not suitable for the entire machine, so in this case use the eyebolts fitted by the manufacturer.

GENERAL SAFETY DURING OPERATING PHASES

- The procedures contained in this manual have been tested and selected by the manufacturer's technical experts, and hence are to be recognised as authorised operating methods.
- Some tools are normal workshop ones, while others are special tools designed by the Manufacturer of the engine.
- All tools must be in good working condition so that engine components are not damaged and that operations are carried out properly and safely.
- It is important to wear the personal safety devices prescribed by work safety laws and also by the standards of this manual.
- Holes must be lined up methodically and with the aid of suitable equipment. Do not use your fingers to carry out this operation to avoid the risk of amputation.
- Some phases may require the assistance of more than one operator. If so, it is important to inform and train them regarding the type of activity they will be performing in order to prevent risks to the health and safety of all persons involved.
- Do not use flammable liquids (petrol, diesel, etc.) to degrease or wash components. Use special products.
- Use the oils and greases recommended by the manufacturer. Do not mix different brands or combine oils with different characteristics.
- Discontinue use of the engine if any irregularities arise, particularly in the case of unusual vibrations.
- Do not tamper with any devices to alter the level of performance guaranteed by the manufacturer.

SAFETY AND ENVIRONMENTAL IMPACT

Every organisation has a duty to implement procedures to identify, assess and monitor the influence of its own activities (products, services, etc.) on the environment.

Procedures for identifying the extent of the impact on the environment must consider the following factors:

- Liquid waste;
- Waste management;
- Soil contamination;
- Atmospheric emissions;
- Use of raw materials and natural resources;
- Regulations and directives regarding environmental impact.

In order to minimise the impact on the environment, the manufacturer now provides a number of indications to be followed by all persons handling the engine, for any reason, during its expected lifetime.

- All packaging components must be disposed of in accordance with the laws of the country in which disposal is taking place.
- Keep the fuel and engine control systems and the exhaust pipes in efficient working order to limit environmental and noise pollution.
- When discontinuing use of the engine, select all components according to their chemical characteristics and dispose of them separately.

California Proposition 65 WARNING

Engine exhaust from this product contains chemicals known to the State of California to cause cancer, birth defects, or other reproductive harm.

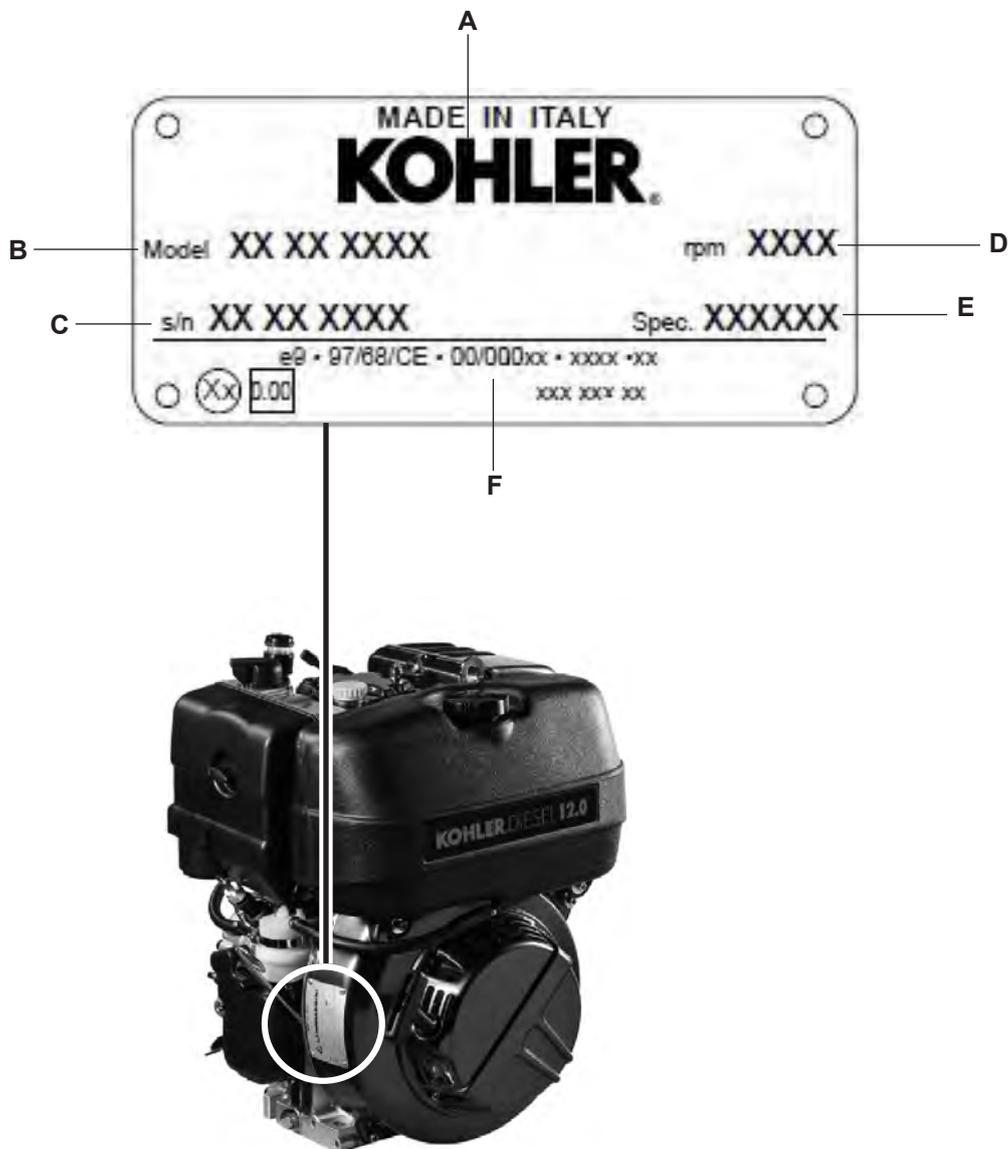
The identification plate shown in the figure can be found directly on the engine.

It contains the following information:

- A) Manufacturer's identity
- B) Engine type
- C) Engine serial number
- D) Maximum operating speed
- E) Number of the customer version (form K)
- F) Approval data

Approval data

The approval reference directives EC are on the engine plate (F).

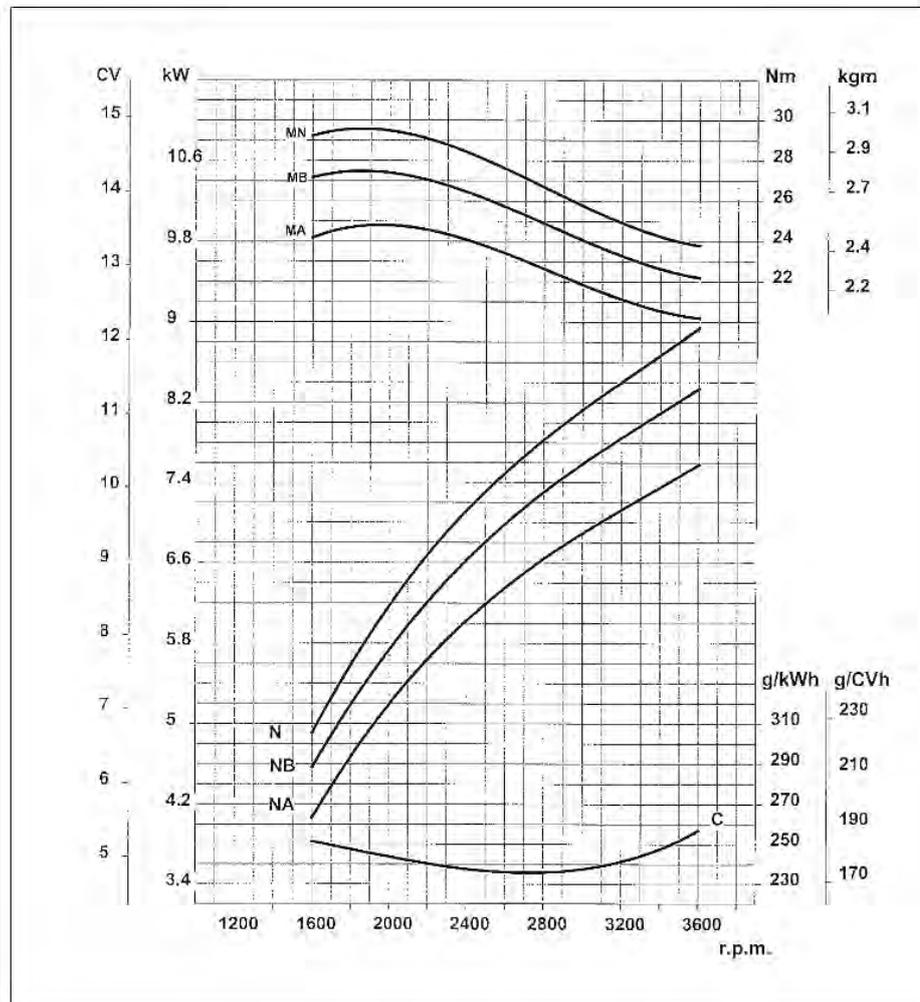


ENGINE TYPE		KD 500
Number of cylinders		N° 1
Bore		mm 87
Stroke		mm 85
Swept volume		Cm ³ 505
Compression ratio		19:1
Power kW	N 80/1269/CEE-ISO 1585 9 (12.24)	9 (12,24)
	(HP) NB ISO 3046 - 1 IFN 8.4 (11.42)	8,4 (11,42)
	NA ISO 3046 - 1 ICXN 7.6 (10.34)	7,6 (10,34)
Crankshaft PTO ratio		rpm 3600
Camshaft PTO ratio		rpm 3000
Crankshaft main PTO rotation		left*
Camshaft main PTO rotation		right*
Max. torque		Nm (@ rpm) 31 (2000)
Fuel consumption (@ max. torque)		g/kWh 250
Oil consumption		kg/h 0,0055
Capacity of standard oil sump		lt 1,5
Recommended battery 12V in standard start conditions		Ah - A 50Ah-255A DIN
Recommended battery 12V in heavy-duty start conditions		Ah - A 60Ah-300A DIN
Dry weight		kg 48
Combustion air volume		l/min 800
Cooling air volume		l/min 8700
Max. permissible driving shaft axial: on crankshaft main PTO: continuous (instantaneous)		kg 120 (300)
Max. inclination	Flywheel site: continuous (instantaneous)	30° (35°)
	Power take off site: continuous (instantaneous)	35° (45°)
	Bank angle right side: continuous (instantaneous)	30° (40°)
	Bank angle left side: continuous (instantaneous)	30° (45°)

* Viewed the engine from main P.T.O.

CHARACTERISTICS POWER, TORQUE AND SPECIFIC FUEL CONSUMPTION CURVES

KD 500



N (80/1269/EEC - ISO 1585)

NB (ISO 3046 - 1 IFN)

NA (ISO 3046 - 1 ICXN)

MN

MB

MA

C

AUTOMOTIVE RATING : Intermittent operation with variable speed and variable load.

RATING WITH NO OVERLOAD CAPABILITY: continuous light duty operation with constant speed and variable load.

CONTINUOUS RATING WITH OVERLOAD CAPABILITY: continuous heavy duty with constant speed and constant load.

Torque at N power.

Torque at NB power.

Torque at NA power.

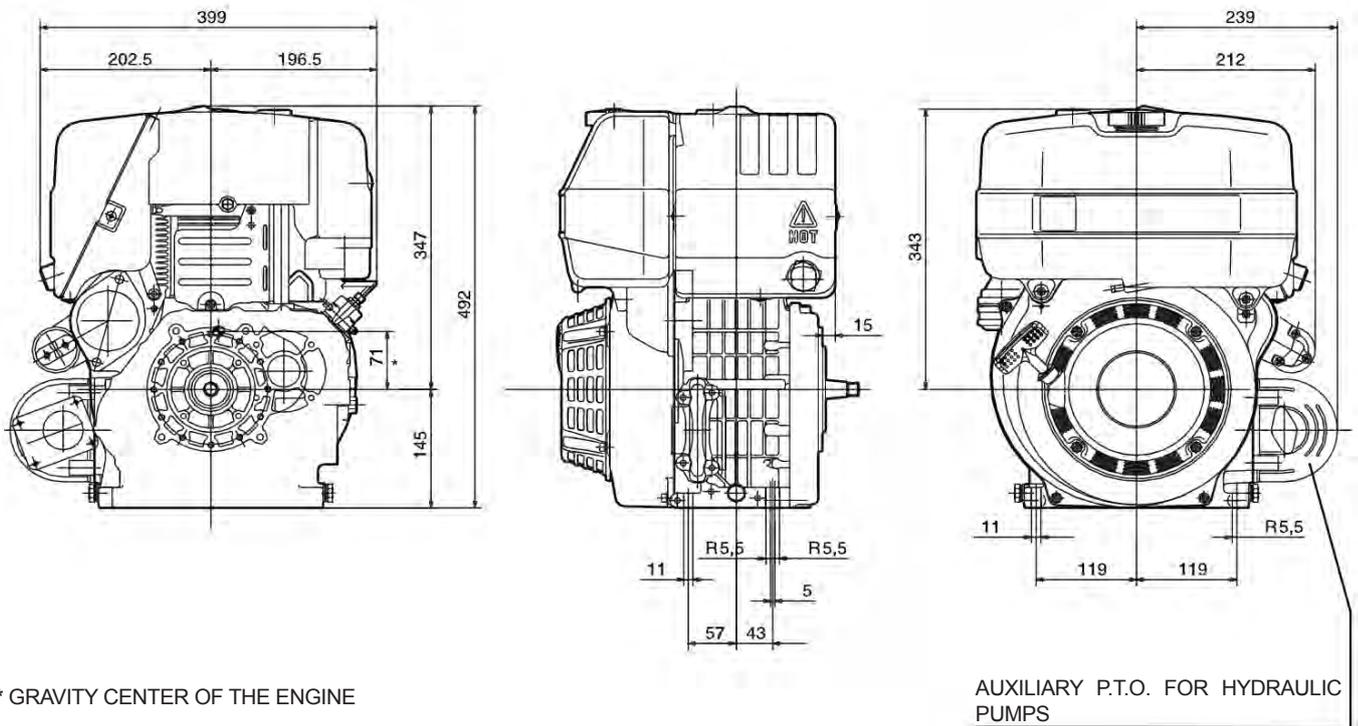
Specific fuel consumption at NB power.

The above power values refer to an engine fitted with air cleaner and standard muffler, after testing and at the environmental conditions of 20°C and 1 bar.

Max. power tolerance is 5%.

Power decreases by approximately 1% every 100 m di altitude and by 2% every 5°C above 25°C.

Note: Consult **KOHLER** for power, torque curves and specific consumptions at rates differing from those given above.

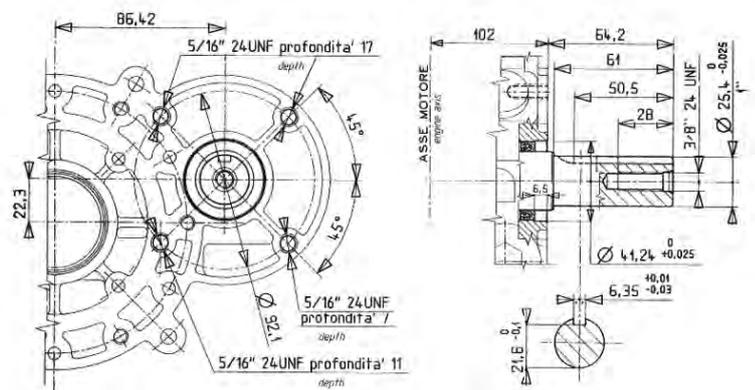
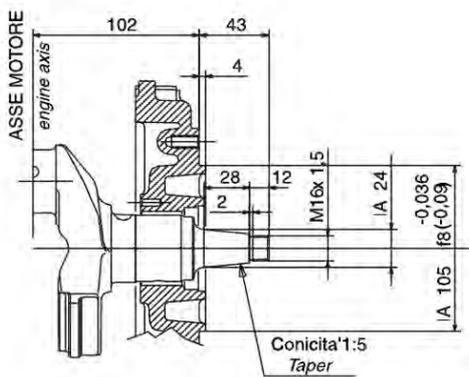


* GRAVITY CENTER OF THE ENGINE

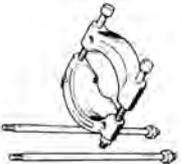
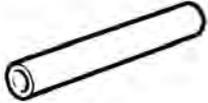
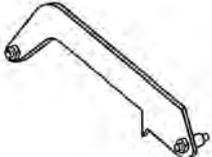
AUXILIARY P.T.O. FOR HYDRAULIC PUMPS

STANDARD P.T.O. WITH ANTICLOCKWISE DIRECTION OF ROTATION

OPTIONAL P.T.O. ON CAMSHAFT WITH CLOCKWISE DIRECTION OF ROTATION



Note: Dimensions in mm

TOOL	CODE	DESCRIPTION
	00365R0020	Failure Flywheel puller
	00365R0900	Tool to mount and demount main bearings
	00366R0220	Plug to mount and demount main bearings
	00366R0230	Sleeve to insert main bearings
	00365R0770	Piston mounting tool
	00365R0100	Crankshaft gear puller
	00366R0210	Punch to insert By-pass valve
	00365R0430	Injector test bench
	00366R0240	Tool to stagger injection lead
	00365R0940	Capillary tube for injection lead



Failure to carry out the operations described in the table may lead to technical damage to the machine and/or system

MAINTENANCE

OPERATION	INTERVAL (HOURS)					
	10	50 ⁽¹⁾	250 ⁽²⁾	500 ⁽³⁾	2500	5000
SUMP OIL LEVEL CHECK	●					
OIL BATH AIR CLEANER CLEANING	●					
DRY AIR CLEANER CHECKING	●					
OIL CARTER REPLACEMENT (4)		●	●			
OIL FILTER REPLACEMENT		●		●		
FUEL FILTER REPLACEMENT				●		
COOLING FINS CLEANING				●		
SETTING ROCKER ARMS CLEARANCE				●		
SETTING AND INJECTORS CLEANING				●		
OVERALL INSPECTION PARTIAL					●	
OVERALL INSPECTION COMPLETE						●

(1) After the first 50 working hours

(2) In case of low use: every 6 months

(3) In case of low use: every 12 months

(4) If you are using oil of a quality lower than the recommended one then you will have to replace it every 150 hours

The maintenance operations listed above refer to an engine operating in normal conditions (temperature, degree of humidity, dust in the working environment). They may vary significantly according to the type of use.



To avoid explosions or fire outbreaks, do not smoke or use naked flames during the operations. Fuel vapours are highly toxic. Only carry out the operations outdoors or in a well ventilated place. Keep your face well away from the plug to prevent harmful vapours from being inhaled. Dispose of fuel in the correct way and do not litter as it is highly polluting.

FUEL

When refuelling, it is advisable to use a funnel to prevent fuel from spilling out. The fuel should also be filtered to prevent dust or dirt from entering the tank.

Use the same type of diesel fuel as used in cars. Use of other types of fuel could damage the engine. The cetane rating of the fuel must be higher than 45 to prevent difficult starting. Do not use dirty diesel fuel or mixtures of diesel fuel and water since this would cause serious engine faults.

The capacity of the standard tank is: lt. 5,0



The engine could be damaged if allowed to operate with insufficient oil. It is also dangerous to add too much oil as its combustion could sharply increase the rotation speed.

Use a suitable oil in order to protect the engine.

The lubrication oil influences the performances and life of the engine in an incredible way.

The risk of piston seizure, jammed piston rings and rapid wear of the cylinder liner, the bearings and all moving parts increases if oil whose characteristics differ from the recommended type is used, or if the oil is not regularly changed.

All this notably reduces engine life.

Oil viscosity must suit the ambient temperature in which the engine operates.



Old oil can cause skin cancer if repeatedly left in contact with the skin and for long periods of time. If contact with the oil is inevitable, you are advised to thoroughly wash your hands with soap and water as soon as possible.

Appropriate protective gloves etc should be wore during this operation.

Old oil is highly polluting and must be disposed of in the correct way. Do not litter.

RECOMMENDED OIL

AGIP SINT 2000 5W40 specification API SJ/CF ACEA A3-96 B3-96 MIL-L-46152 D/E.

ESSO ULTRA 10W40 specification API SJ/CF ACEA A3-96 MIL-L-46152 D/E.

In countries where AGIP and ESSO products are not available, use API SJ/CF oil for gasoline-fuelled engines or oil that complies with military specification MIL-L-46152 D/E.

OIL SUPPLY (liters) Standard oil sump

filter included 1,5 l.

ACEA SEQUENCES

A = Gasoline (Petrol)

B = Light Diesel fuels

E = Heavy Diesel fuels

Required levels :

A1-96

A2-96

A3-96

B1-96

B2-96

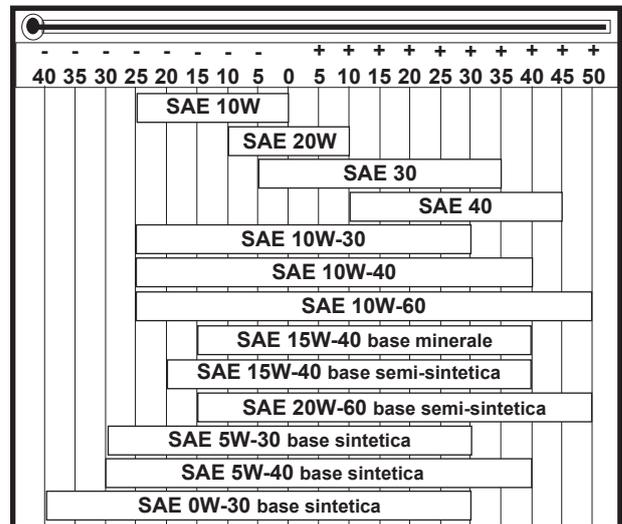
B3-96

E1-96

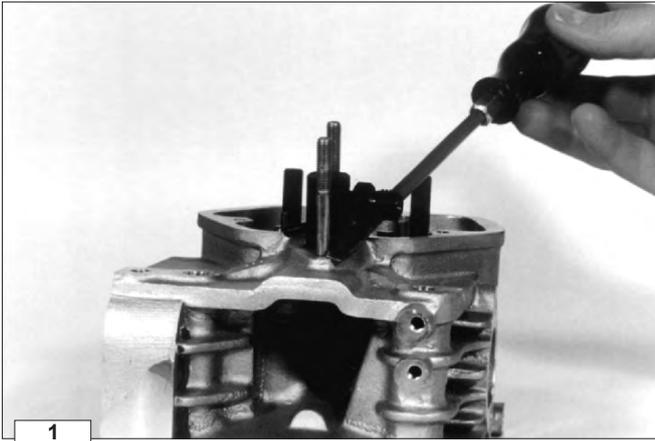
E2-96

E3-96

GRADE



DIESEL							BENZINA - ESSENCE - PETROL BENZIN - GASOLINA								
API	CF	CE	CD	CC	CB	CA	SA	SB	SC	SD	SE	SF	SG	SH	SJ
							CCMC G-2							G-4	
							CCMC G-3							G-5	
							CCMC PD - 1 / PD - 2								
			D-4	CCMC D-2											
			D-5	CCMC D-3											
							MIL - L - 2104 D								
							MIL - L - 2104 E								
							MIL - L - 46152 C								
							MIL - L - 46152 D/E								
							MB 226.1							MB 226.5	
							MB 227.1							MB 227.5	
			228.3	MB 228.1											
							VW 500.00								
							VW 501.01								
							VW 505.00								
							VOLVO VDS								
							MAN QC 13-017								



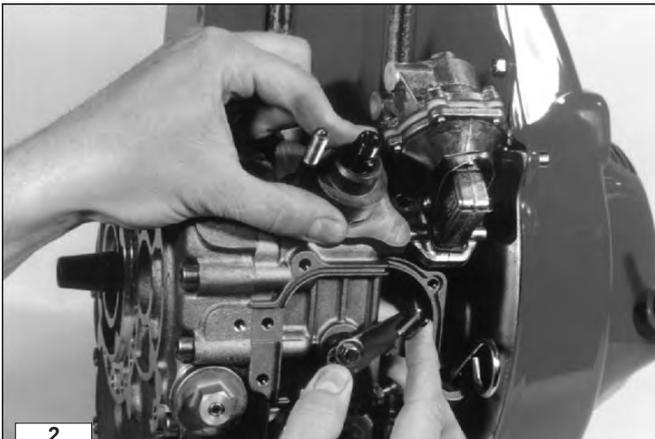
1



During repair operations, when using compressed air, wear eye **protection**.

DISASSEMBLY AND REASSEMBLY

Besides disassembly and reassembly operations this chapter also includes checking and setting specifications, dimensions, repair and operating instructions. Always use original KOHLER spare parts for repair operations.



2

Removing the injector

Slacken off the fuel delivery pipe, remove the fixing bracket and take out the tube.

Remove the injector by levering it out with a screwdriver, as indicated in fig. 1.

Removing the injection pump

Mark the position of the injection pump in relation to the engine casing (if this has not already been done).

Remove the injection tube and take out the fuel pipes.

The pump can only be removed when the stop lever has been turned to the stop position. To do this, the pump must be pressed towards the housing as shown in fig. 2.



3

Flywheel extraction

Remove the fuel tank, the air conveyor and flywheel nut. Use extractor cod. **00365R0020**, as shown in figure 3.

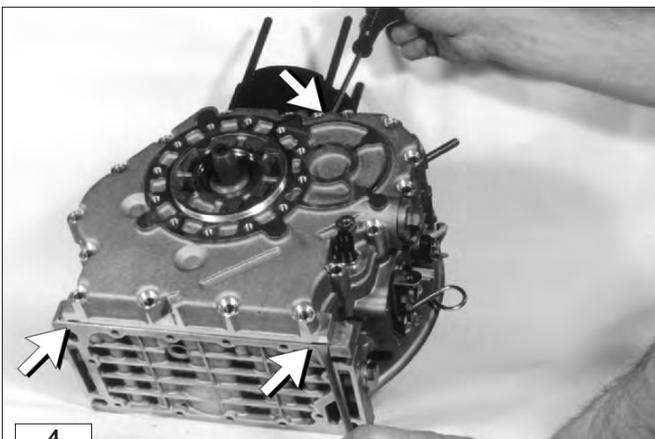


During the demounting phases, pay particular attention to prevent the flywheel from dropping as this could seriously injure the operator.

Wear protective goggles when removing the flywheel ring.



IMPORTANT: Do not tap the end of the extractor when removing the flywheel.



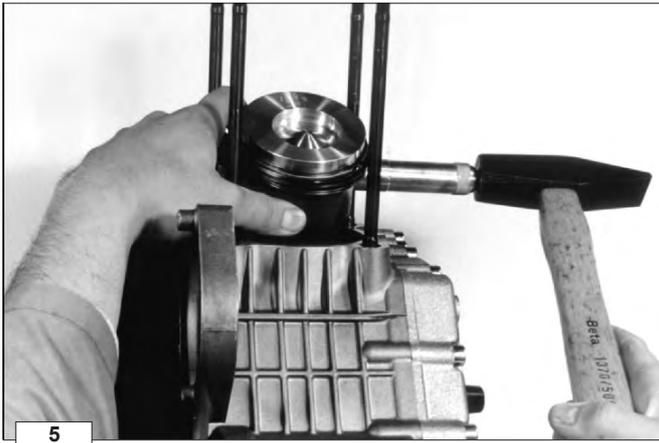
4

Removing the cover on the timing system side

Slacken off the screws around the perimeter of the cover on the timing system side. Split the cover from the engine casing by levering with a screwdriver in the points indicated in fig. 4.



Warning: to prevent damage to the main bearings, it is advisable to demount the cover from the timing system side with the engine cold.



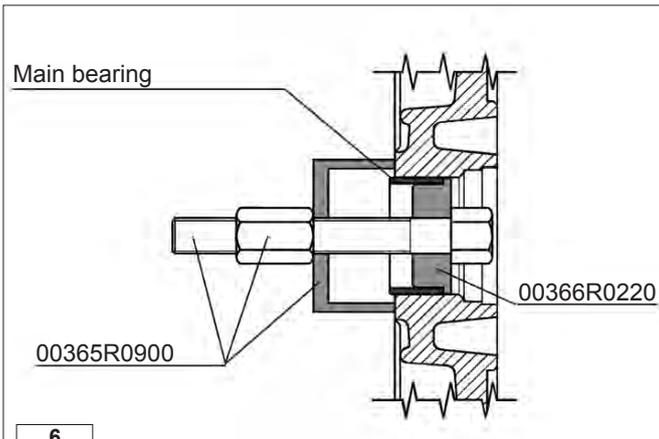
5

Demounting the piston

Take out the piston pin as shown in fig. 5.



Warning: do not demount the head when hot or the retention surfaces could be damaged.



6

Demounting and remounting the main bearings

Use tool code **00365R0900** and plug code **00366R0220** (fig. 6) to demount the main bearings from the engine casing and cover on the timing system side.

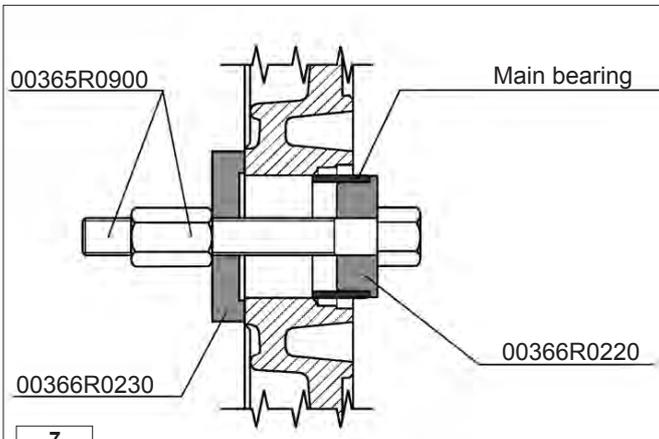
To fit the main bearing back into the engine casing, use tool code **00365R0900** with plug code **00366R0220** and sleeve code **00366R0230** side A (fig. 7).

To mount the main bearing on the cover on the timing system side, use tool code **00365R0900** with plug code **00366R0220** and sleeve code **00366R0230** side B (fig. 7).

During the assembly operations, make sure that the bearing holes match the oil ducts by making reference marks with a felt-tip pen.

Make sure that the reference mark on the bearing edge points towards:

- the casing interior
- the outer part of the timing system cover.



7



WARNING

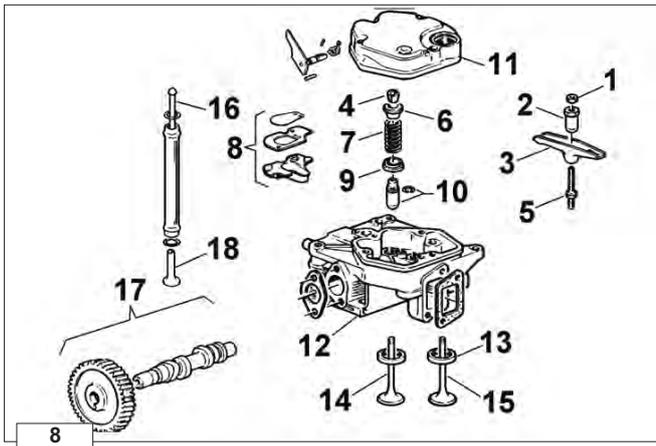
Proceed with the following inspections after assembly:

Cover on timing system side

The main bearing must project 1.7 to 2 mm in relation to the bearing surface of the bull ring (inner side of cover).

Engine casing

The main bearing must be flush with the bearing surface of the shimming ring (inner side of casing).



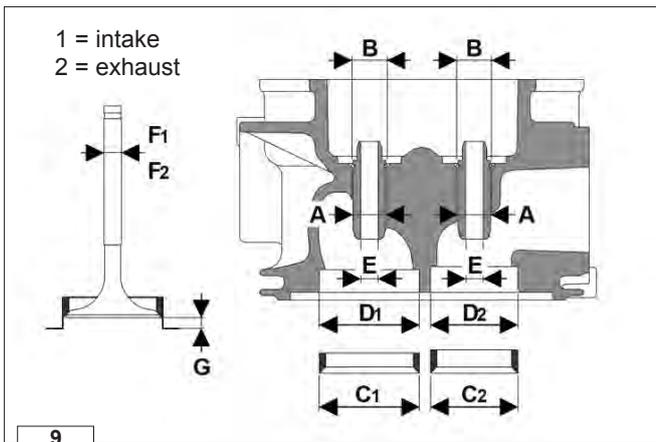
Head

Parts indicated in fig. 8.

1. Nut - 2. Nut with ball - 3. Rocker arm - 4. Cotters - 5. Rocker arm stud - 6. Upper cap - 7. Spring - 8. Air-relief valve - 9. Lower cap - 10. Valve guide - 11. Rocker arm cover - 12. Head - 13. Valve housing - 14. Exhaust valve - 15. Intake valve - 16. Rocker arm rod - 17. Camshaft - 18. Tappets.

The head is made of aluminium with valve guides and housings in faced cast iron. Remove any carbon deposits from the head and check the cylinder bearing surface. Level it off to a depth of no more than 0.3 mm if deformed.

The head must not be cracked or deformed. If such faults are discovered, replace the part after consulting the spare parts catalogue.



! Do not demount the head when hot to avoid deformations.

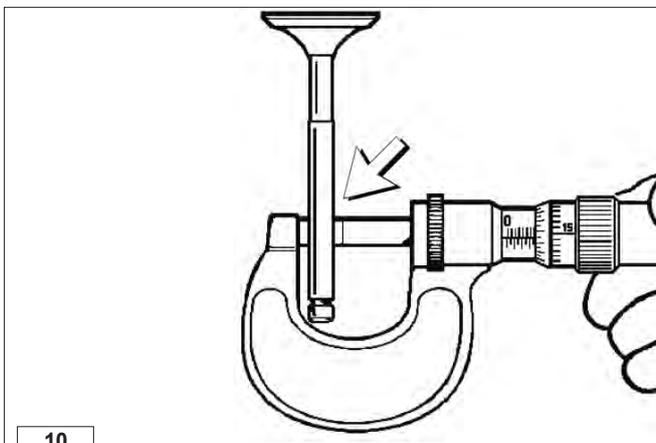
Valves - Guides - Housings

Clean the valves with a metal brush and replace them if the tops are deformed, cracked or worn (fig. 9).

ØA	ØB	ØC1	ØC2	ØD1	ØD2	ØE(*)	ØF1	ØF2	G
13 ± 13,01	13,025 ± 13,037	40,13 ± 40,145	35,13 ± 35,145	40 ± 40,025	35 ± 35,025	7 ± 7,01	6,96 ± 6,97	6,945 ± 6,995	0,8 ± 1

(*) with guide mounted.

measurements in mm



Check the dimensions of the valve stem (fig. 10) and the play between the guide and valve. Ream the guide to the dimensions indicated in the table. Change the guide and valve if the play exceeds 0.1 mm.

The valve housings will always need to be ground when new guides are mounted. Valve guides oversized on the outside by 0.10 mm are available.

After the engine has been used for a lengthy period of time, valve knocking in their housings at high temperatures will harden the housing tracks and make manual milling difficult to carry out.

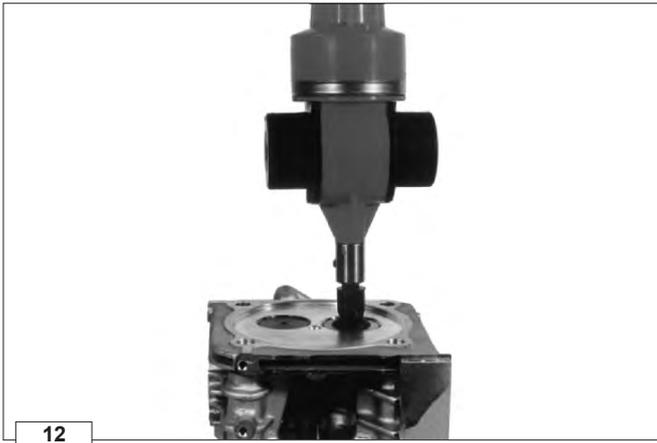
When this happens, remove the hardened surface layer with a grinder at 45° (Fig. 11).

The valve retention track will widen when the valve housing is machined. Final adaptation of the valve in the housing must be carried out by smearing fine grain lapping compound in the housing and turning the valve with a light pressure and with an alternate movement until the surfaces bed perfectly (fig. 12).

Comply with the valve embedding values as indicated in the table (G, fig. 9).

! Warning: when the valve embedding values are lower than those prescribed, the valves could interfere with the piston.





Grinding-in must always be carried out when new valves or housings are mounted. Valve housings oversized on the outside by 0.5 mm are available. Thoroughly wash the valve and housing with petroleum or gasoline to eliminate lapping paste residues or swarf. Proceed in the following way to make sure that the valve and seat are tight:

1. Mount the valve on the head with cap string and cotters (see fig. 8)
2. Overturn the head and pour a few drops of diesel fuel or oil on to the edge of the valve top
3. Blow compressed air into the head duct. Plug the edges of the duct itself to prevent air escaping.

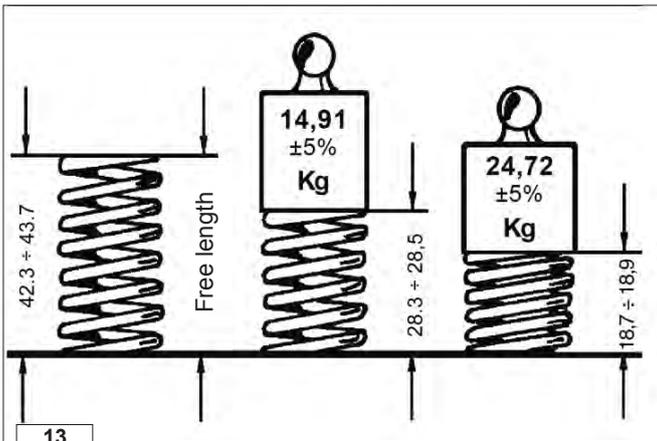
If there are air leaks in the form of bubbles between the housing and valve, demount the valve and grind-in again.

Valve springs

Check the length of the spring as indicated in fig. 13 to identify any yielding. Replace the springs if the values are different.

Rocker arms

Make sure that there are no evident signs of wear on the contacting surfaces. Replace the parts if necessary.



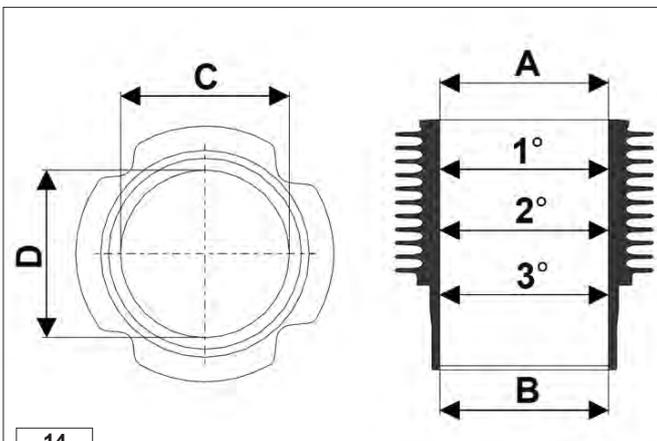
Cylinder

In special cast iron with integral liner. Use a bore gauge to check the two internal diameters (C-D) perpendicular to each other and at different heights (fig. 14). Maximum tolerated taper error (A-B) and ovality error (C-D): 0.06 mm.

Cylinder diameter:

$\text{Ø } 87 \div 87,020$

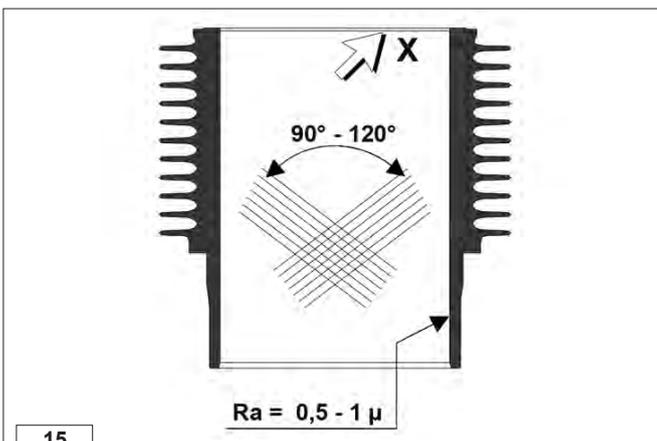
If the diameter of the cylinder does not exceed said values or if there are slight surface scores on the cylinder, it will be sufficient to change the piston rings.

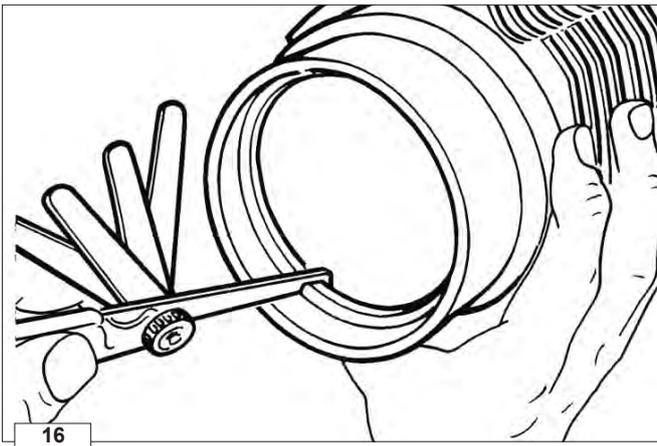


! Do not manually hone the cylinder bore surfaces with emery cloth or other means.

The cross-hatch pattern should be at an angle of 90°±120°; lines should be uniform and clear in both directions (fig. 15). Average roughness must range between 0.5 mm 1 µm. The cylinder surface which comes into contact with piston rings should be machined with the plateau method.

Replace the cylinder and piston if there is a ridge in zone "X" fig. 15 of the cylinder and if tapering and ovality exceed the previously given values.





Piston rings - Piston - Pin

To gauge the wear on the piston rings, put them into the cylinder from the bottom side and measure the distance between the free ends (fig. 16), which must be:

Piston ring	Fitting mm	Max. wear mm
Compression	0,30 ÷ 0,50	0,80
Oil scrapper	0,25 ÷ 0,50	0,80

Make sure that the piston rings slide smoothly in the slots and use a thickness gauge to check the play between the slot and ring (fig. 17). Replace the piston and rings if the play exceeds:

Piston ring	Max. wear mm
1st Compression	A = 0,22
2nd Compression	B = 0,19
3rd Oil scrapper	C = 0,16

! WARNING: it is advisable to replace the piston rings whenever the piston is demounted.

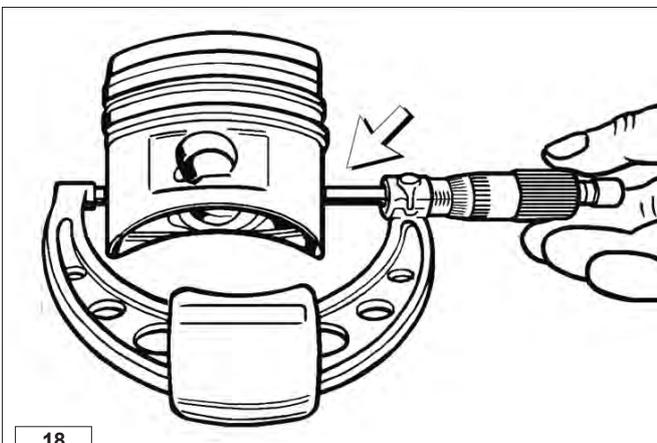
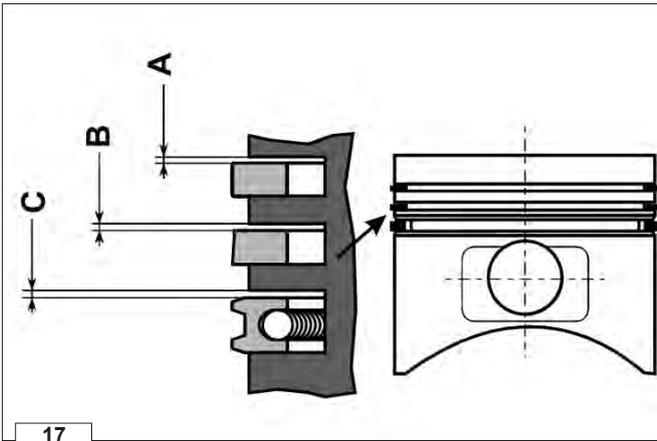
Checking the piston diameter: the diameter of the piston must be measured at a distance from the base (fig. 18) of approximately 11 mm.

Ø 86,915 ÷ 86,835

Check the play between cylinder and piston. Replace the parts if play exceeds 0.150 mm.

Play between pin and piston mm:

Pin Ø mm	Assy.clearance mm	Max. wear mm
21,997 ÷ 22,002	0,003 ÷ 0,013	0,040



Connecting rod

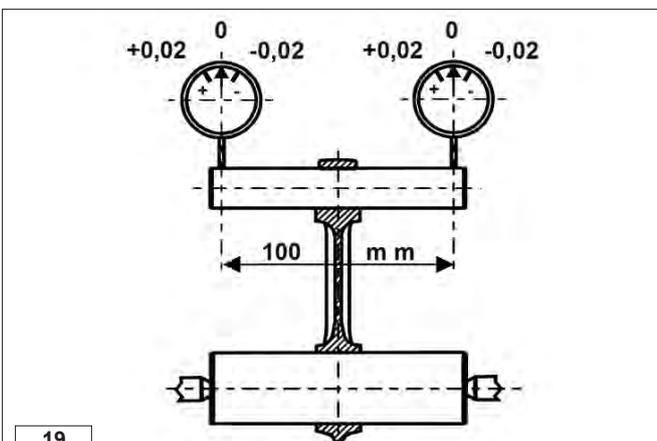
Coupling between the small end hole of the connecting rod and pin is made without a bearing.

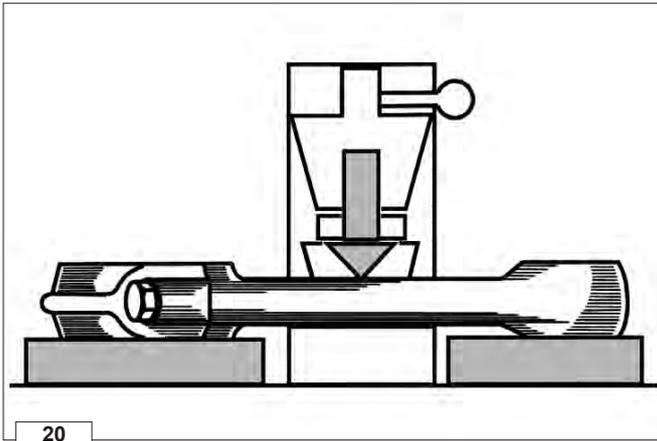
Play between connecting rod small end and pin mm:

Pin Ø mm	Assy.clearance mm	Max. wear mm
21,997 ÷ 22,002	0,023 ÷ 0,038	0,070

Check connecting rod axes parallelism in the following way:

1. Insert the pin into the small end hole of the connecting rod and a calibrated plug into the big end (with the bearing mounted).
2. Rest the plug on two prisms arranged on a surface plate or between two centers (fig. 19).
3. Use a centesimal comparator to check that the difference between the readings made at the ends of the pin does not exceed **0.02 mm**. square up the connecting rod if the deformation is greater (**max. 0.05 mm**).





The operation is carried out by applying a calibrated pressure to the convex side in the middle of the connecting rod stem set on surface plates (fig. 20).

Crankshaft

It is advisable to check the condition of the crankshaft whenever the engine is demounted and particularly when cylinders and pistons must be replaced following wear due to dust having been intaken.

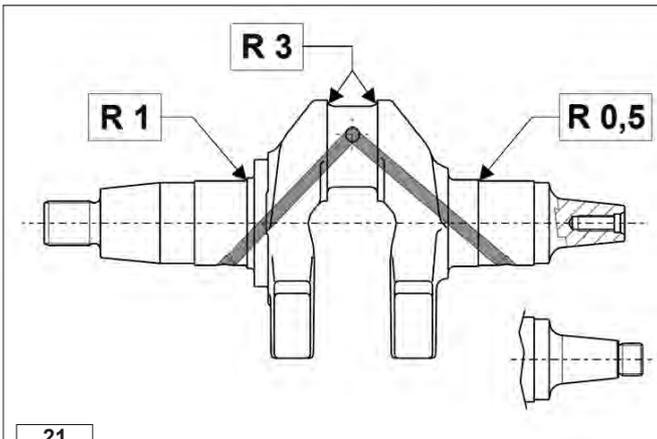
Thoroughly clean inside the oil ducts using a shaped metal point. If there are heavily caked incrustations, immerse the crankshaft into a bath of petroleum or gasoline before proceeding with the scraping operation (fig. 21).

When the crankshaft is perfectly clean, check with a micrometer to ascertain wear and main journal ovality in the two perpendicular positions (fig. 22).

Grind the shaft if the wear exceeds the values in the table by 0.08 mm or more.

Dimensions	STD mm	-0,25 mm
A C	41,97 ÷ 41,99	41,72 ÷ 41,74
B	39,98 ÷ 40	39,73 ÷ 39,75

NOTE: crankshaft grinding operations of more than 0.25 mm should not be carried out.

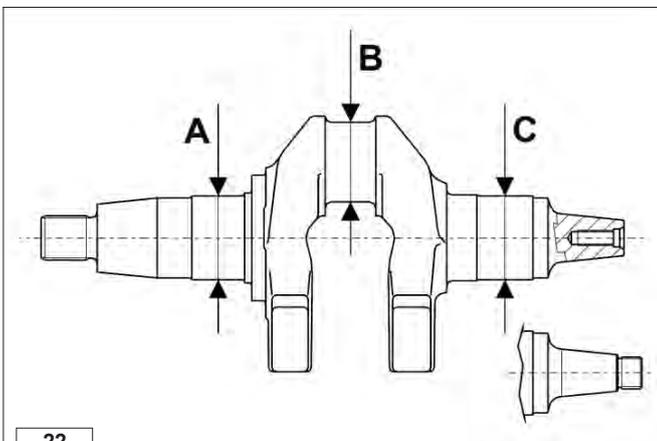


Undersized bearings can be mounted without any reaming work required.

! **WARNING:** do not remove material from the main journal shims during the grinding operation as this would alter crankshaft float. Also make sure that the grinder radii correspond to those indicated in fig. 21 to prevent fracture sections from initiating on the shaft.

Oil retention rings

Make sure that the rings have not hardened in the retention lip and that there is no sign of breakage or wear.



Lubrication circuit

Lubrication of the main bearings and connecting rod big end is the forced type with a rotor oil pump.

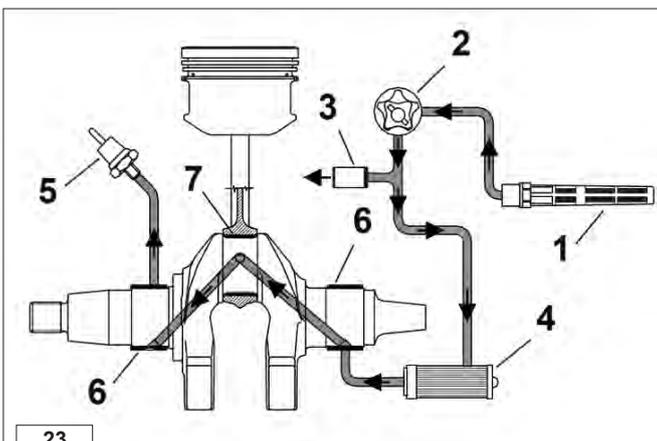
Excessive pressure in the oil circuit is prevented by the by-pass valve (3, fig. 23).

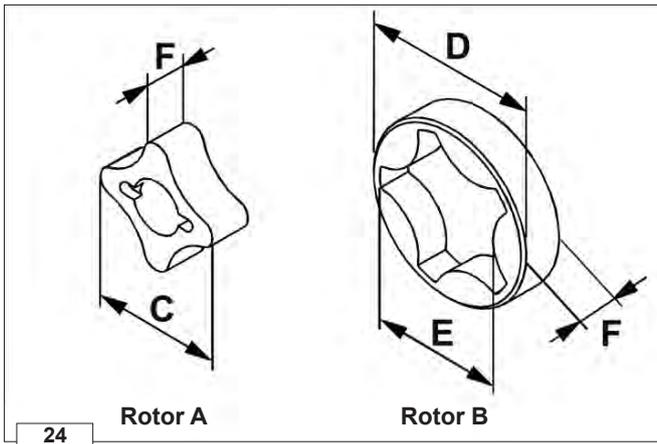
All the other parts are splash lubricated.

Oil vapours are eliminated from inside the casing by a diaphragm mounted in the rocker arm cover.

Illustration in fig. 23:

- 1. Internal intake oil filter in casing
- 2. Oil pump
- 3. By-pass valve
- 4. Engine oil filter
- 5. Pressure switch
- 6. Main bearing
- 7. Big end bearing.





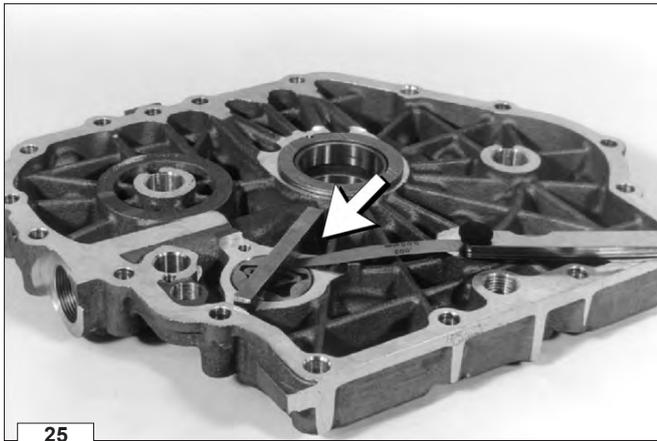
Checking the oil pump

Make sure that the oil pump cover is in a good condition. After demounting, examine the rotors and replace them if their lobes or centerings are damaged. To check the degree of pump wear, measure the dimensions of **rotor A** and **rotor B** (fig. 24) and compare them with the values in the following table:

OIL PUMP ROTOR DIMENSIONS AND PLAY

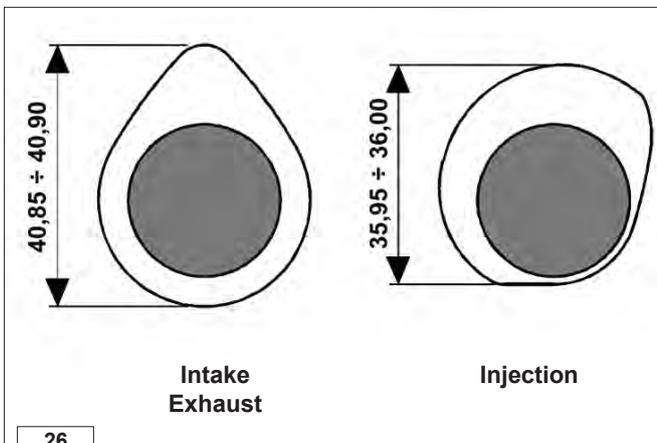
Measurement	Dimensions mm	Max. wear mm
C	∅ 25,97 ÷ 25,99	∅ 25,92
D	∅ 34,96 ÷ 34,99	∅ 34,87
E	26,205 ÷ 26,27	26,31
F	7,97 ÷ 7,99	7,93

The entire pump must be replaced if the wear is greater.



The coupling play between the external oil pump rotor and the housing on the cover of the timing system is:

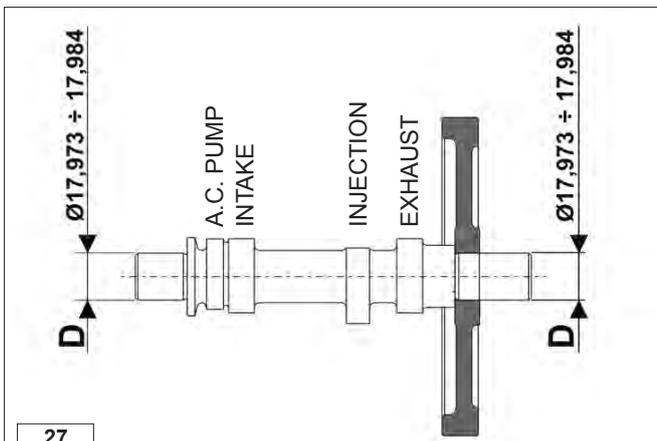
Fitting mm	Max. wear mm
0,16 ÷ 0,215	0,345



Make sure that the oil pump recess in relation to the surface of the timing system cover (fig. 25) is between :

Fitting mm	Max. wear mm
0,03 ÷ 0,07	0,11

Make sure that there are no impurities in the by-pass valve on the cover on the timing system side by unscrewing the inspection plug near the fuel flow limiter.

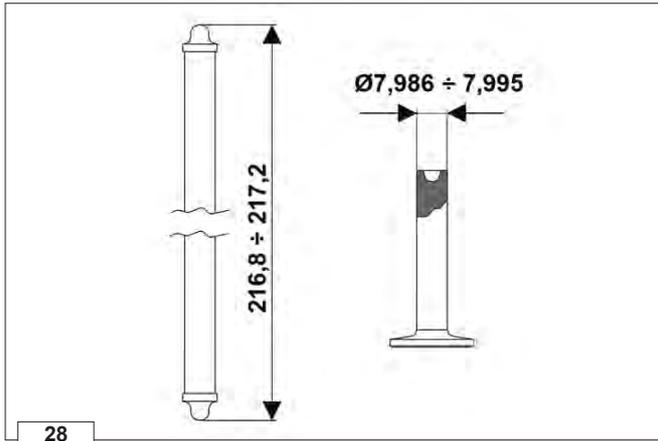


Camshaft

Make sure that the cams and bearing pins are not scored or worn.

Check the dimensions as indicated in fig. 26. Check the dimensions of the camshaft pins (D, fig. 27) and the corresponding housings in the casing and cover on the timing system side. The max. constructional play is 0.032 to 0.061 mm.

! **WARNING:** replace the shaft if the wear on the cams or pins exceeds:
0.1 mm (injection cams and pins)
0.3 mm (intake and exhaust cams).



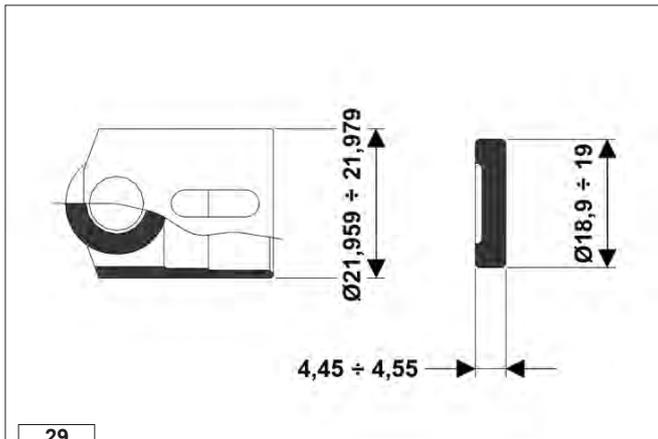
Tapets and rocker arms

Make sure that there is no wear, scoring or signs of seizure on the surfaces of the tappets (fig. 28). Replace the parts if necessary.

Tapet and housing coupling play:

Fitting mm	Max. wear mm
0,16 ÷ 0,215	0,345

The rods must be straight with ball shaped surfaces at the ends and in good conditions (fig. 28).



Injection pump tappets and pads

Replace the parts if the wear on their surfaces exceeds 0.1 mm (fig. 29).

Coupling play between the tappet and relative housing in the crankcase:

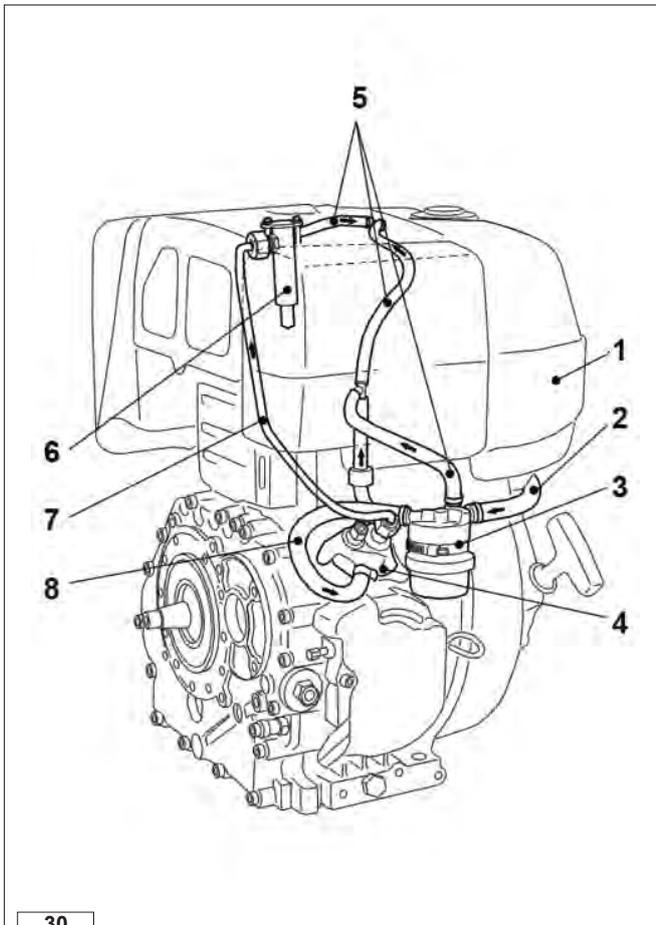
Fitting mm	Max. wear mm
0,021 ÷ 0,059	0,10

Fuel pump (optional)

Check the projection of the AC pump rod in relation to the engine casing surface with the canshaft eccentric in the non-operative position.

Rod length mm	Wear limit mm	Rod projection mm
53,0 ÷ 53,2	0,3	1,45 ÷ 2,05

WARNING: the rod projection cannot be adjusted.



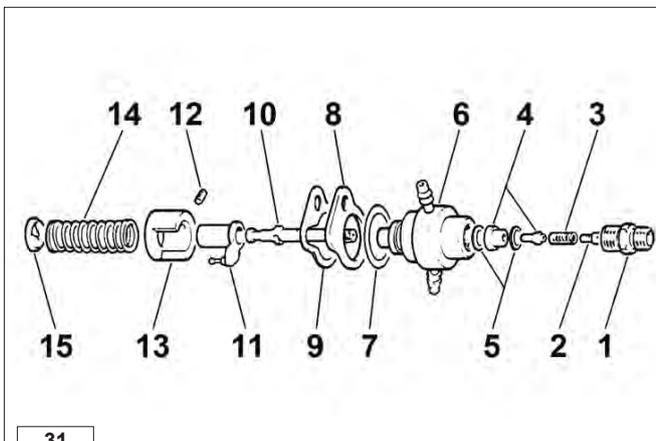
30

Fuel circuit

Fuel supply is the gravitational type. An AC pump can be mounted on request. Air bleeding is automatic.

Illustration in fig. 30:

1. Fuel tank - 2. Fuel pipe - 3. Fuel filter - 4. Injection pump - 5. Fuel return pipe - 6. Injector - 7. Injection pipe - 8. Fuel pipe.

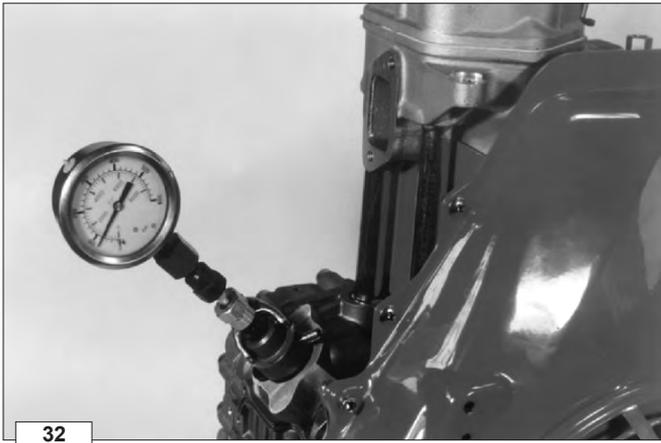


31

Injection pump

Illustration in fig. 31:

1. Delivery union - 2. Filler - 3. Valve spring - 4. Delivery valve - 5. Washers - 6. Monobloc pump casing - 7. Adjuster seal - 8. Flange - 9. Pump seal - 10. Plunger - 11. Adjuster sleeve - 12. Plug - 13. Adjuster block - 14. Spring - 15. Lower cap



Checking the injection pump before demounting the injection pump, make sure that the plunger unit, enbloc pump casing and valve are pressure tight by proceeding in the following way:

1. Connect a pressure gauge with scale up to **600 Kg/cm²** to the fuel delivery pipe (fig. 32).
2. Set the regulating sleeve (fig. 33) to the average delivery position.
3. Slowly turn the flywheel to make the plunger make one compression stroke.
4. Read the indication on the pressure gauge. If it is lower than **300 Kg/cm²**, the complete pump must be changed.

During the test, the pressure gauge needle will show a progressive pressure increase until reaching a maximum value, after which it will drop sharply back and stop at a lower pressure value. Replace the valve if the pressure drop is more than **50 Kg/cm²** and continues to slowly drop lower.

The pressure must drop from **200 Kg/cm²** to **150 Kg/cm²** in not less than **7 sec.**

Injection pump calibration (fig. 34)

When the adjuster sleeve is **10.5 mm** from the stop position and the pump spins at **1,500 rpm**, the amount of fuel for **1,000 deliveries** must be between:

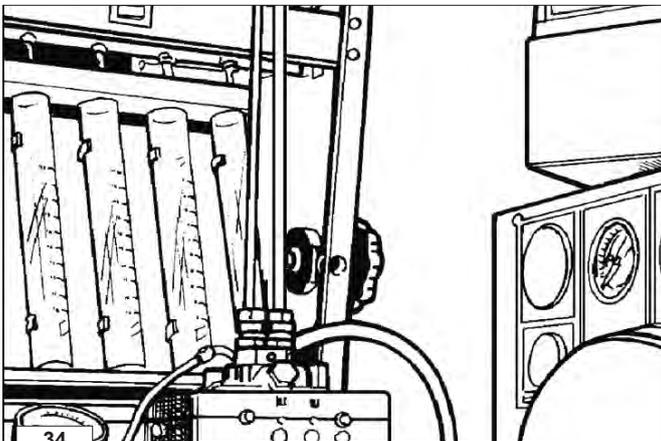
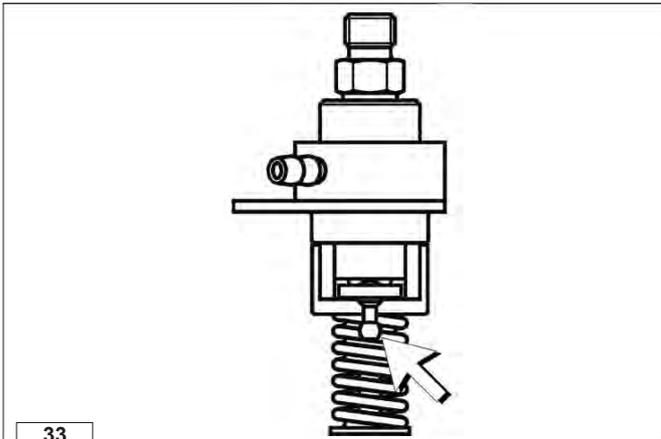
$$25,5 \div 29 \text{ cc}$$

Replace the pump if the values differ.

WARNING:

Check to make sure that plunger travel with the injection cams in the non-operative position (BDC) at the start of delivery is:

$$25,5 \div 29 \text{ cc}$$



Injection pump assembly (fig. 36)

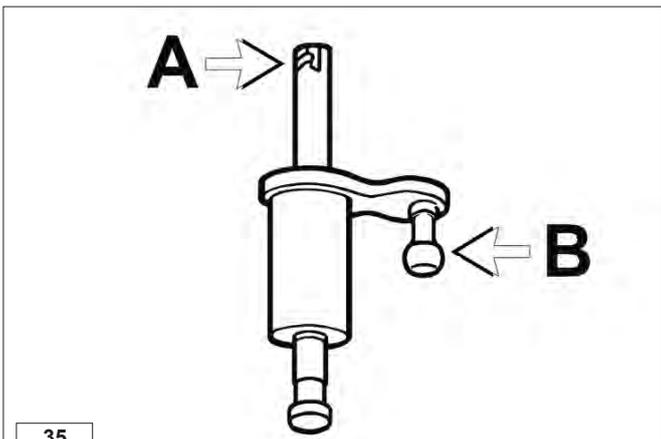
If the injection pump must be demounted, use an electric pen to mark the adjuster block (M) with the enbloc pump casing (A) and loosen the plug (N) after having heated it to make the Loctite easier to release.

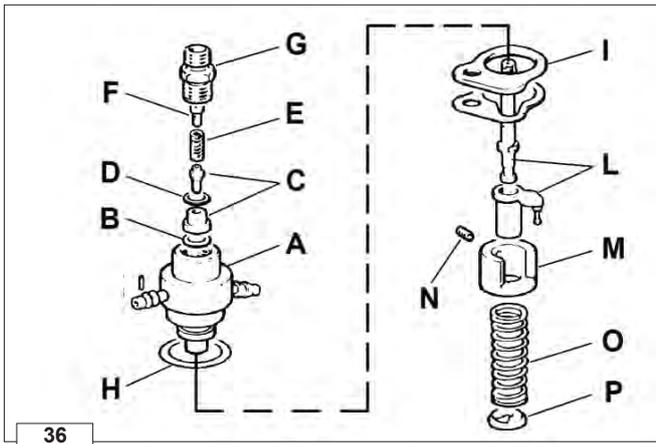
Comply with the following instructions when remounting the parts:

1. Fit the washer (B), the delivery valve (C), the washer (D), the alve spring (E), the filler (F) into the enbloc pump casing (A) and torque the delivery union (G) to a value of:

$$4,3 \div 5,4 \text{ kgm (} 42,5 \div 52,5 \text{ Nm)}$$

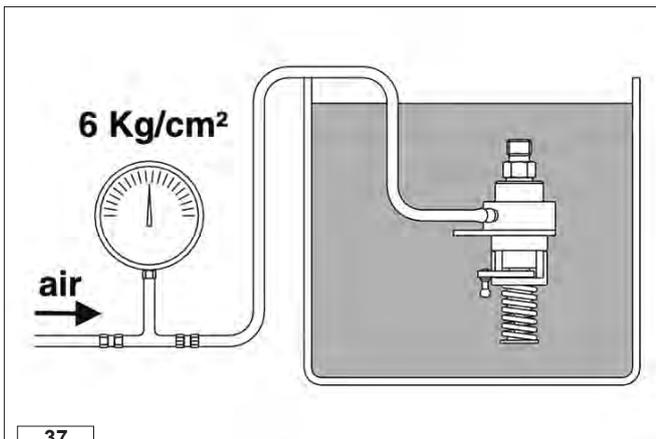
2. Insert the adjuster seal (H).
3. Insert the flange (I).
4. Insert the plunger with helical profile (A, fig. 35) into the inner housing of the adjuster sleeve from the side opposite the sleeve pin (B, fig. 35).





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5. Insert the adjuster sleeve unit and plunger (L) into the pump casing (A), making sure that the helical profile is directed on a level with the return union with ball.
6. Fit in the adjuster block (M), matching the reference marks applied during the demounting phase.
7. Tighten the plug (N) to a 0.5 to 0.6 Nm torque, locking it in place with Loctite 290.
8. Insert the spring (O) and lower cap (P).
9. Compress the tappets in the various operating positions to check that the adjuster sleeve (L) slides perfectly. Resistance or jamming will make the engine to hunt during operation.



37

Leak test

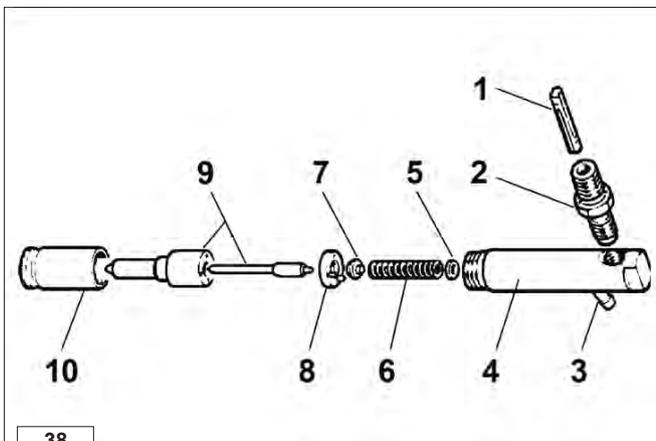
Plug the fuel return union and let air in through the fuelling union at a pressure of **6 Kg/cm²**. Fully immerse the pump in a receptacle containing diesel fuel for about 50 - 60 seconds (fig. 37) and make sure that no bubbles appear.

NOTE: the position of the pump adjuster sleeve is of no importance for this test.

Injector

Details of fig. 38:

1. Filter - 2. Fuel inlet union - 3. Fuel return union - 4. Nozzle holder - 5. Calibration washer - 6. Spring - 7. Pressure rod - 8. Spacer - 9. Nozzle - 10. Ring nut.



38

Injector inspection and calibration

1. Clean the nozzle holes with a thin steel wire (fig. 39) with the following diameters:

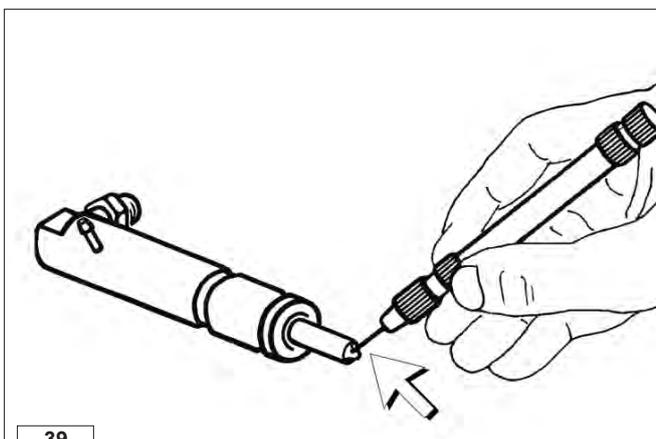
Diameter of steel wire (mm)	Number of holes	Diameter of holes (mm)
0,24	5	0,25

2. Mount the injector on the test bench (code **00365R0430**, fig. 40). Disconnect the pressure gauge and rapidly operate the lever. The nozzle must make the characteristic "trilling" sound and inject with a good atomizing action.

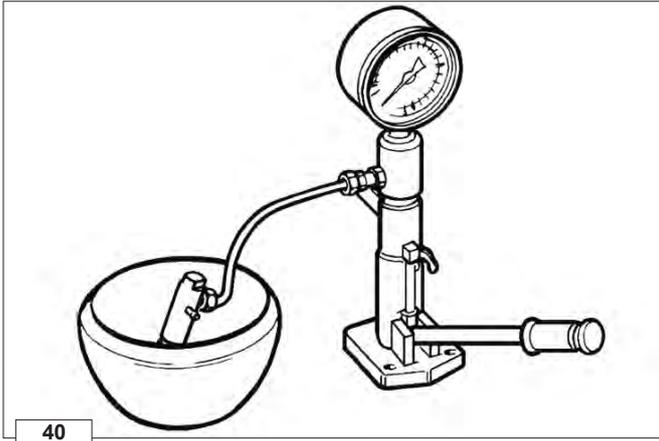
3. Connect the pressure gauge. Slowly depress the level in a continuous way until injection occurs. The injector needle must "open" at the pressure of 230 to 238 bar. Vary the washer shims (N° 5 fig. 38) to calibrate in the correct way.

4. **Leak test:** operate the test bench lever until the gauge pointer is 20 Kg/cm² below the injection pressure value. Nozzle tightness is good if no fuel comes out within 10 sec.

5. **Checking for leaks on the nozzle return phase:** operate the test bench lever until the gauge pointer is 20 Kg/cm² below the injection pressure value. Release the lever and

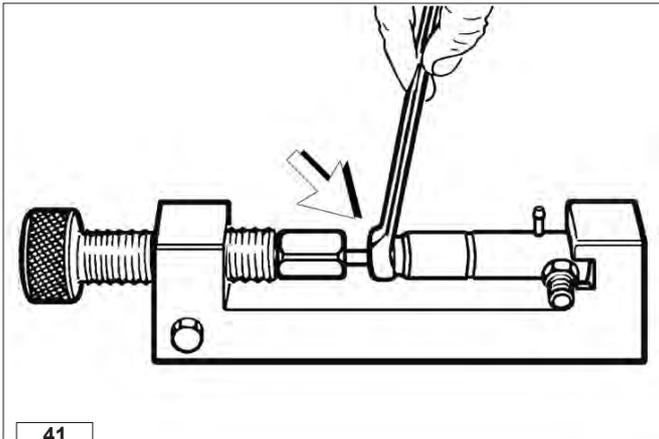


39



heck the time it takes to drop. The pressure must drop to 150 to 100 Kg/cm² within 6 to 40 seconds.

- replace the nozzle if it drops in less than 6 seconds.
- if it takes longer than 40 seconds to drop, make sure that there are no carbon deposits in the nozzle and that the return holes are not clogged.



Demounting and remounting

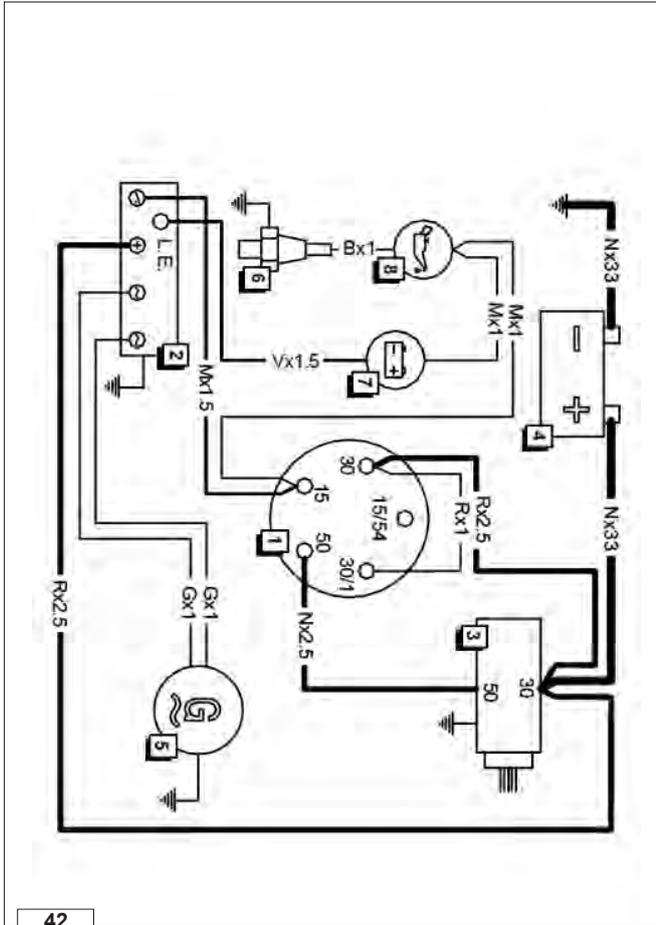
Loosen the ring nut that fixes the nozzle using a torque wrench and as device like the one shown in fig. 41 which relieves the pressure exercised by the spring on the ring nut.

1. Visual inspection: make sure that the needle housing is not deformed or excessively rough. The nozzle body must not show signs of wear or damage. The holes must be free from carbon residues.

2. Smoothness test: the nozzle needle, which will have been previously immersed in impurity-free fuel, should be inserted into the body of the nozzle. Noz extract it by up to a third of the guide length, holding the nozzle in a vertical position. The needle must drop back into its housing thanks to its actual weight alone.

Remount the injection in compliance with the order indicated in fig. 38. Make sure that the plugs and centering pins on the spacer (N° 8 fig. 38) match the relative holes in the housings. Tighten the ring nut that fixes the nozzle to a value of:

4,6 ÷ 5,6 kgm (45 ÷ 55 Nm)



42

Characteristics of the system

Starter motor: lh rotation direction (pinion side), 12V voltage rating, power 1.1 kW.

Internal alternator: 12V - 280W

Voltage regulator: electronic, with controlled diodes and indicator connection for battery recharger

Recommended battery:

In standard start conditions: 12V - 50Ah/255 A DIN
 In heavy-duty start conditions: 12V - 60Ah/300 A DIN

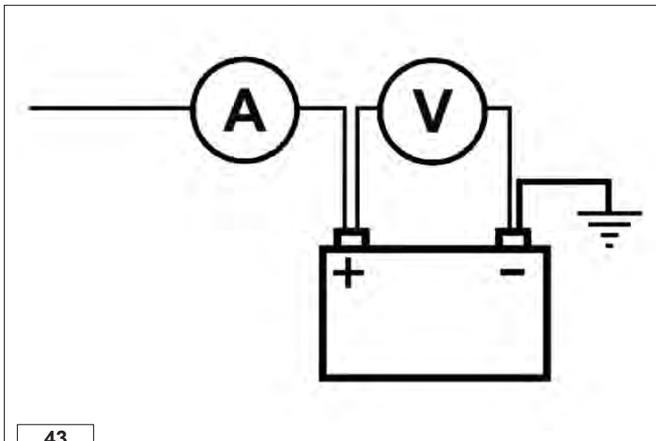
Optional accessories: control strip with remote control switch and OIL ALARM plant.

Illustration in fig. 42:

1. Ignition key - 2. Voltage regulator - 3. Starter motor - 4. Battery - 5. Alternator - 6. Pressure switch - 7. Low battery charge indicator - 8. Low oil pressure indicator.

CABLES: Colour x Section mm²

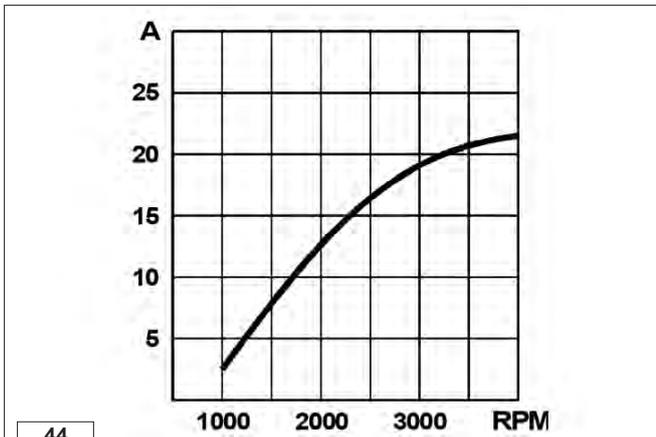
CABLE COLOURS: B= white
 M= brown
 N= black
 R= red
 V= green



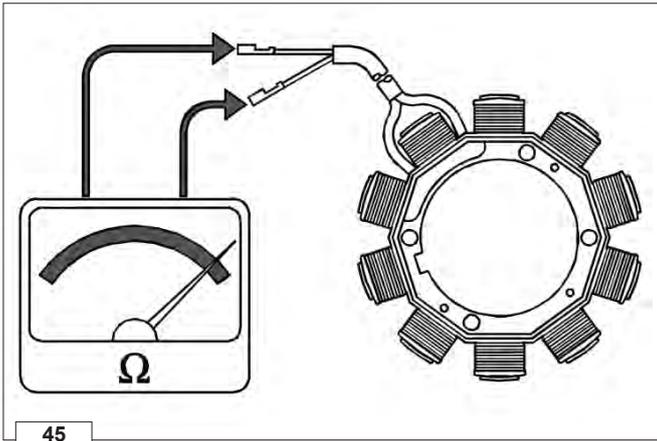
43

Checking the system

1. make sure that the connections between the regulator and alternator are correct and in good conditions
2. detach the wire from the remote control switch from the terminal and fit on a d.c. amperemeter (A, fig. 43)
3. connect a d.c. voltmeter to the battery terminals (V, fig. 43)
4. make a few no-load starts or introduce a **80-100W** lamp load at the battery lugs to keep the battery voltage below **13V**.
5. accelerate the engine to a **3000 rpm** rate. The current indicated on the amperemeter must correspond to the values in fig. 44.
6. disconnect the load (if any) and keep the engine at the above mentioned rate for a few minutes. The battery voltage must progressively increase until reaching about **14.2 V**. Meanwhile, the charge voltage must drop to a minimum value of about **2A**, with a speed determined by the battery charge condition.
7. if charge current is missing or is less than the given values, check the alternator and replace the voltage regulator if necessary.



44



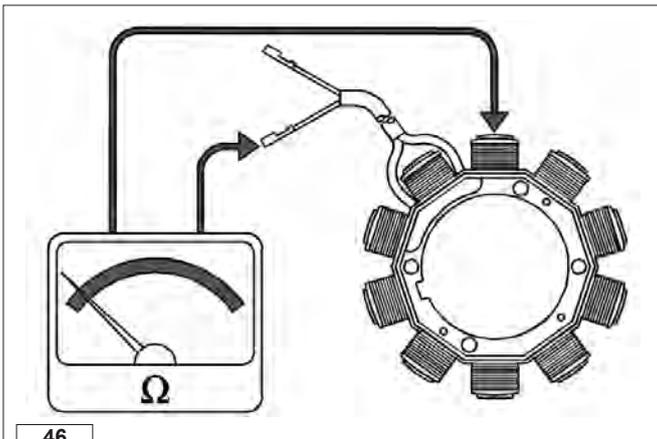
45

Checking the alternator

With the engine at a standstill, disconnect the alternator wires from the regulator and check:

1. using an ohmmeter, that the windings (fig. 45, null resistance) and the insulation between wires and ground (fig. 46, infinite resistance) are unbroken. Replace the stator if interruptions are discovered;
2. with a voltmeter, the voltage between the two yellow wires (fig. 47). Accelerate the engine to **3000 rpm**. The voltage must be **33V**.

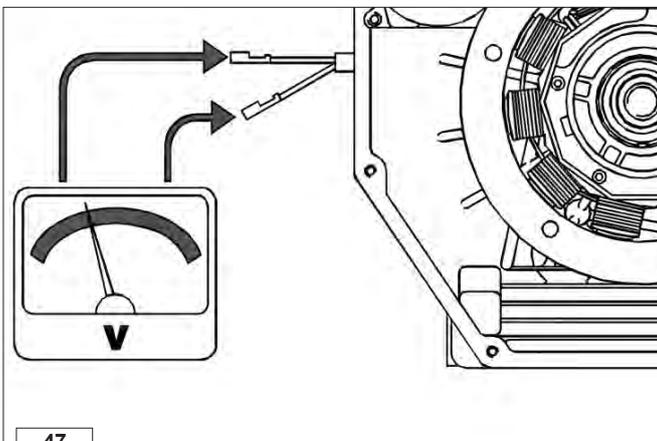
If the values are more than 10V less than this, it means that the rotor is demagnetized and that the alternator must be replaced.



46

Warning:

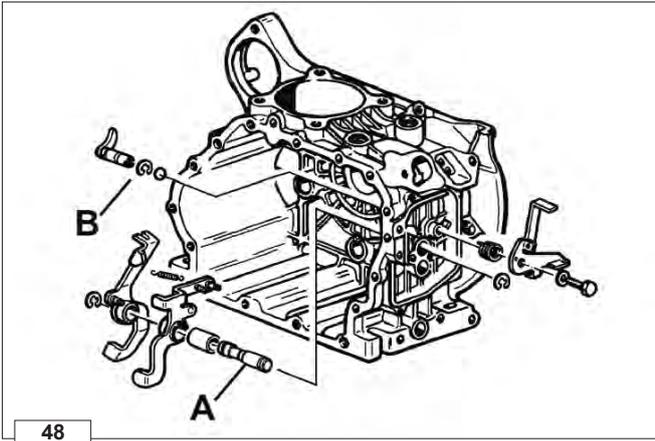
1. the alternator does not deliver current when the yellow cables are isolated
2. the alternator burns out if the yellow wires are grounded
3. the regulator may be damaged if the ground connection or electrical connections are made in a slapdash way.
4. the alternator and regulator will immediately burn out if the battery connections are inverted.



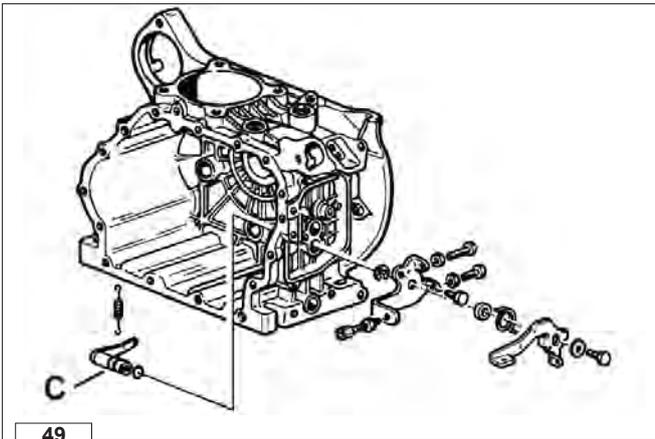
47

Ring gear

Make sure that the teeth of the crown wheel are not worn or damaged. Heat the starting ring gear to a temperature of 200-250 °C before fitting it on to the flywheel .



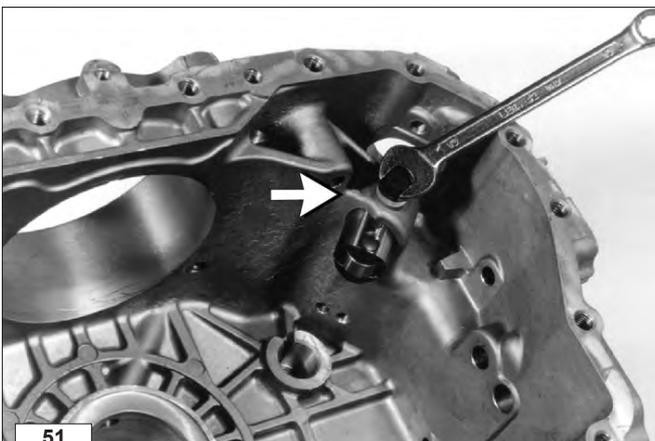
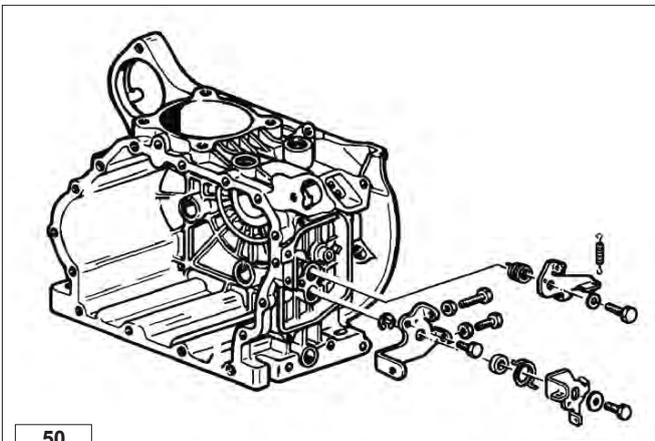
! The instructions refer to engines updated at the time of publication. Check the technical circulars for any modifications.
 Thoroughly clean the parts before remounting them.
 Lubricate the moving parts to prevent seizures when the engine is first started.
 Replace the seals whenever the parts are remounted.
 Use torque wrenches to tighten to the correct values.



Preparing the engine block

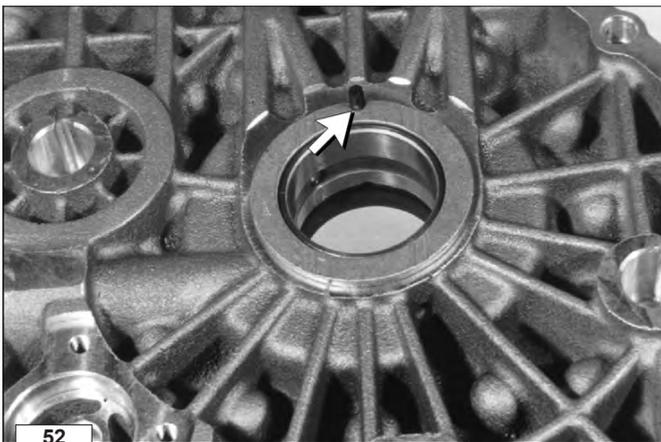
Remove all traces of sealant or impurities from the bearing surfaces with a copper plate or lapping stone, then proceed in the following way:

1. Fit on the oil drain plugs without tightening them too much (max. 2 Kgm) to prevent damage to the threads.
2. Mount the main bearing as indicated at page 18.
3. Fit the benzing ring on to the pin of the regulator levers (fig. 48 - **A**); apply Loctite 648 to the zone where the pin touches the engine casing.
 Insert the stop lever (fig. 48 - **B**), the accelerator lever (fig. 49 - **C**) and complete the assembly operations in compliance with the sequencies indicated in figures 48 and 49.
4. Comply with the sequence indicated in fig. 50 for the "motorstop" version.



Injection pump tappets

Insert the tappet into the injection pump housing in the engine casing.
 Fit the screw into the guide as shown in fig. 51.

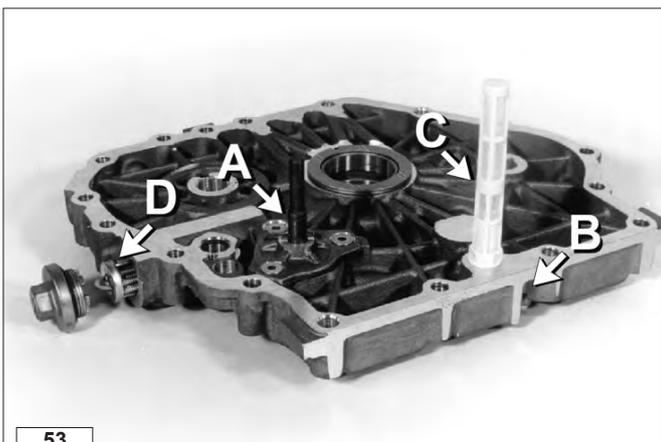


Timing system cover pre-assembly

Prepare the cover of the timing system in the following way:

1. Mount the main bearing as indicated at page 18.
2. Fit in the pin and drive shaft bearing ring (fig 52).
3. Mount the oil pump rotors as described at page 23. Insert the plug and driving pin as shown in fig. 53 - **A**. Fix the oil pump cover in place by tightening the screws to the following torque value:

0,8 ÷ 1,0 kgm (7,8 ÷ 9,8 Nm)

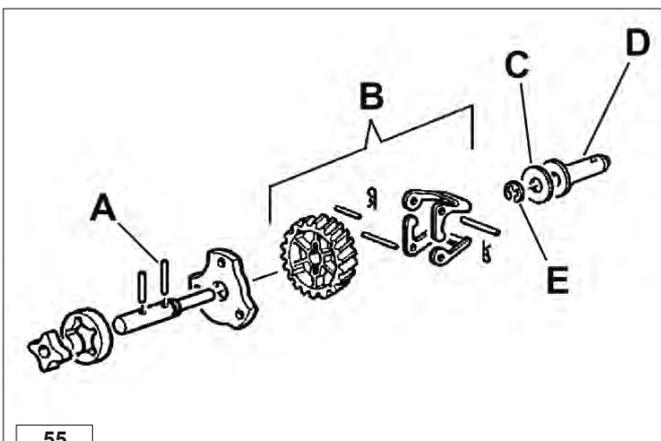


4. Insert the by-pass valve using tool code **00366R0210** (fig. 54); mount the by-pass check screw with Loctite 648; mount the bypass valve inspection plug on the outside of the cover on the timing system side.
5. Fit the retainer cap on the oil intake duct at the base of the cover on the timing system side, using Loctite 648 (fig. 53 - **B**).
6. Tighten the internal oil filter (fig. 53 - **C**).
7. Fit on the engine oil filter and relative plug including the O-Ring (fig 53 - **D**).
8. Mount the rpm governor, in compliance with the alphabetical sequence given in fig. 55.



9. Fit in the fuel flow limiter

10. Mount the oil retention ring as indicated on page 35 fig.66.





56

Removal and assembly of the drive shaft gear

The gear on the timing system side can only be replaced.

To demount it, use puller code **00365R0100** (fig. 56) or a puller available on the market.

To assemble, preheat the gear to a temperature of about 180 to 200 °C, fit it on the shaft, taking care to ensure that the chamfer points towards the internal part, and use the tang as a reference.



57

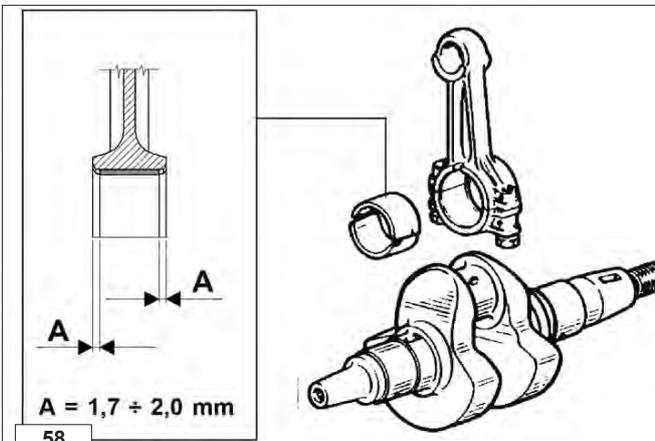
Drive shaft assembly (fig. 57)

Mount the drive shaft after having fixed the first shimming washer to the casing with Loctite 648 and after having inserted the needle bearing and the second shimming washer.

Connecting rod - drive shaft connection

After having fitted the bearings into the small end, connect the connecting rod to the crank pin as shown in fig. 58.

Mount the connecting rod cap with the reference numbers matching those on the rod.



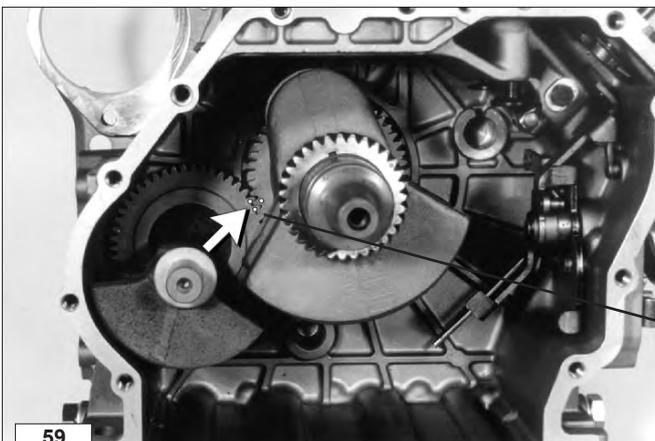
58



WARNING: mount the connecting rod half bearing with the positioning mark on the cap and that without positioning mark in the center of the rod, in compliance with the dimensions indicated in fig. 58.

Evenly tighten the connecting rod bolts to the following value:

3,8 ÷ 3,9 kgm (37,3 ÷ 38,2 Nm)

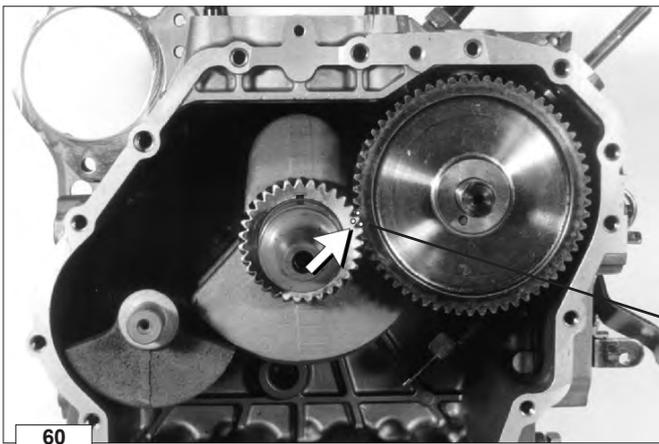


59

Counter-shaft

Insert the counter-shaft, matching the reference marks on the gears (fig. 59).



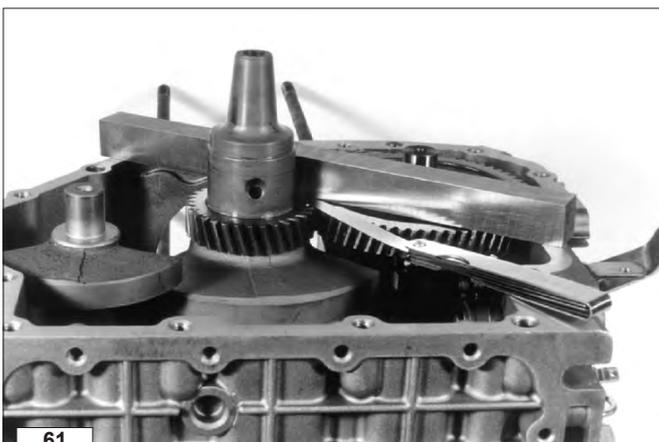


Camshaft

Insert the tappets into their housings on the casing. Mount the camshaft, matching the reference marks on the gears (fig.60).



60



Play adjustment
Crankshaft float:

Place a calibrated bar on the casing, on a level with the timing system cover retention surface and use a thickness gauge to check the distance between the gear and bar (fig. 61). Note down the value measured.

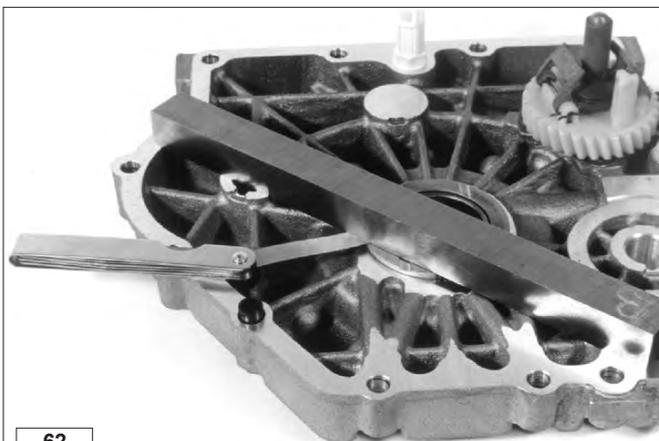
Place a calibrated bar on the cover of the timing system, on a level with the engine casing retention surface and use a thickness gauge to check the distance between the bearing ring and bar (fig. 62).

Note down the value measured.

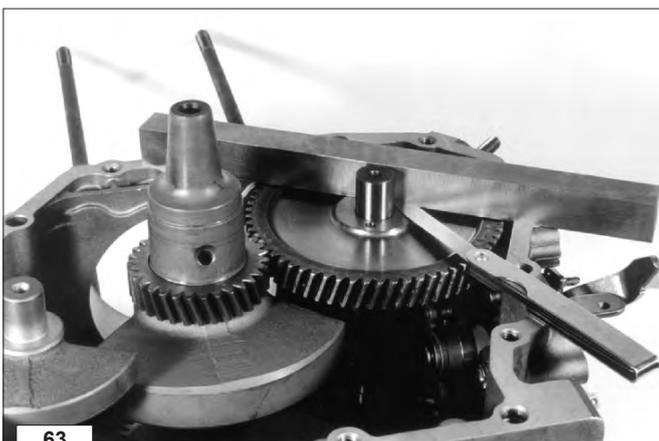
The sum of the two measured values must be within:

0,10 ÷ 0,30 mm

61



62

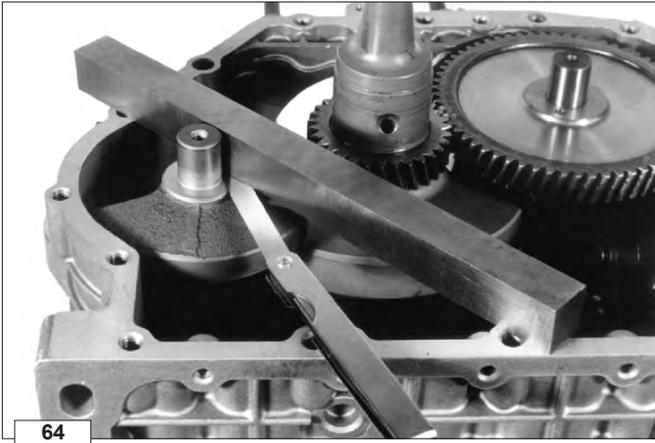


Camshaft float:

Place a calibrated bar on the casing, on a level with the timing system retention cover and use a thickness gauge to check the distance between the gear and bar (fig. 63). The value must be between:

0,10 ÷ 0,25 mm

63

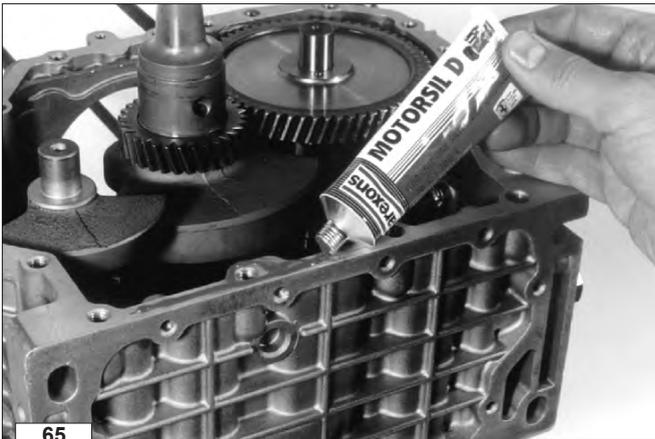


64

Counter-shaft float (optional):

Place a calibrated bar on a level with the timing system cover retention surface and use a thickness gauge to check the distance between the stop surface and bar (fig. 64). The measured value must be between:

0,10 ÷ 0,25 mm



65

Cover on timing system side

Spread liquid seal of the AREXON D 0036 MOTORASIL type on the retention surface of the timing system cover (fig.65).

Place the cover on the casing.

Insert the cover fixing screws, making sure that the five shorter ones (40 mm) are mounted in the top part of the cover. Tighten to the following torque value:

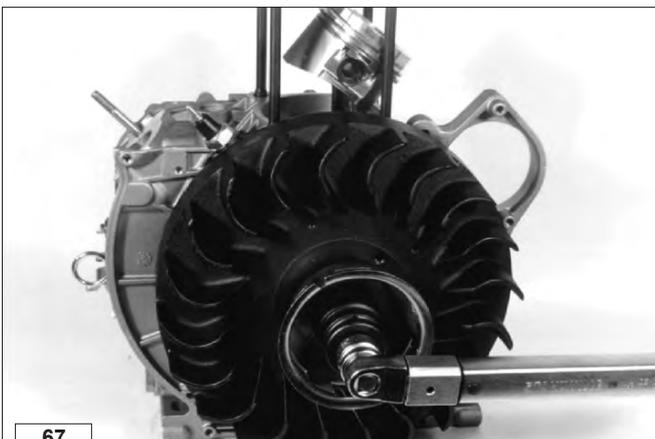
2,7 ÷ 2,8 kgm (26,5 ÷ 27,5 Nm)



66

Oil retention rings

1. Immerse the retention ring in oil for about 10 minutes.
2. Clean the housing and insert the ring with a plug, exercising an even pressure all over the surface (fig.66).

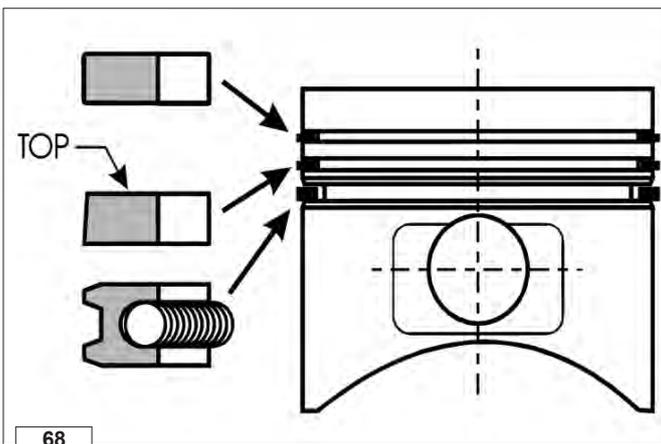


67

Flywheel

Block the flywheel (fig. 67) and torque the nut to value:

18 ÷ 20 kgm (176,5 ÷ 196,1 Nm)



Piston

- Mount the rings on the piston (fig. 68) in the following order:
1. chromium plated compression retention ring (stamped trademark pointing upwards)
 2. tapering retention ring (stamped word TOP pointing upwards)
 3. oil scraper ring (stamped trademark pointing upwards)

Position the piston so that the central axis of the combustion chamber is aligned with the injector (fig. 69). Connect the piston to the connecting rod, slightly pressing with the hand on the pin.

68



Cylinder

Insert the cylinder into the engine casing after having inserted the 0.3 mm thick seal.

before mounting, turn the rings through 120°, one in relation to the other, with the first compression ring pointing with its ends on a level with the pin axis.

There is a chamfer to allow ring insertion on the lower side of the cylinder. The operation is simplified by using a normal ring mounting tool code **00365R0770** as indicated in fig. 70.

Move the piston to TDC (top dead center) and check that the mark stamped on the flywheel corresponds to the reference pointer of the tool code **00366R0240** (fig. 75).

To obtain the correct clearance, use a head seal of adequate thickness:

1. check the piston projection as shown in fig. 71
2. Choose the seal as indicated in the following table

Measurement	Dimensions mm
0,00 ÷ 0,10	0,8
0,10 ÷ 0,20	0,9
0,20 ÷ 0,30	1,0
0,30 ÷ 0,40	1,1

NOTE: The distance between piston crown and the corresponding head surface must be:

0,7 ÷ 0,8 mm

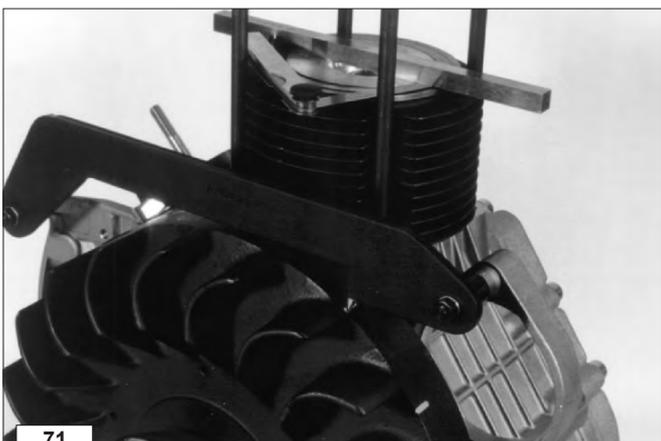


70

Head

Before fixing the head to the cylinder, fit the injector into its housing and, after having temporarily fixed it, check that the distance the nozzle projects from the surface of the head by (fig. 72):

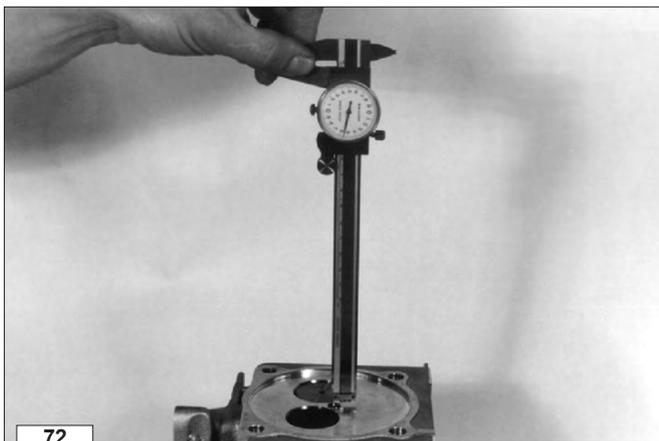
2,2 ÷ 2,7 mm



71

regulate by placing copper washers between the injector and the bearing surface on the head.

Consult page 19 and 20 for the relative inspections and overhauls.



72

Insert the rocker arm casings, the partition (A, fig. 74), the head seal and the head. Tighten the head fixing nuts evenly and alternately (fig. 73) to the following value:

4 kgm (39,2 Nm)

! NOTE: To prevent oil leaks, spread sealant (Motorsil) on the threads of the stud bolts and washer bearing surfaces in the rocker arm chamber before tightening the nuts.

Valve clearance

Adjust the clearance between valves and rocker arms in either a hot or cold condition, to the following values (fig. 74):

hot	0,20 mm (intake/exhaust)
cold	0,20 mm (intake/exhaust)



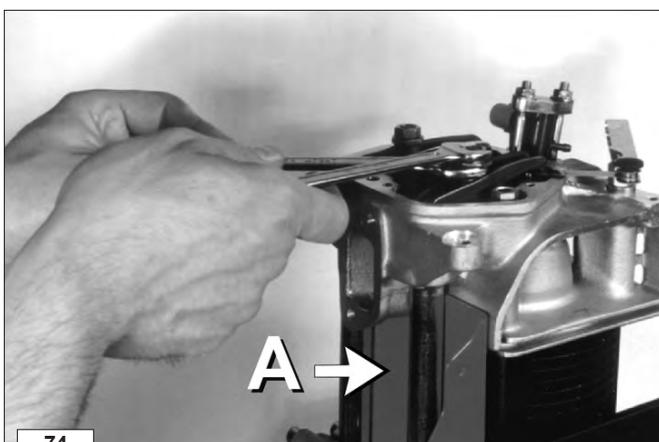
73

Since the automatic decompression device opens the exhaust valve near TDC, clearance must be adjusted during the expansion phase, a few degrees after TDC.

Injection lead

To ensure the injection lead is accurately adjusted, it is advisable to define the shims to insert under the pump by measuring the dimension between the pump bearing surface and the tappet. Proceed in the following way:

1. turn the flywheel to the compression phase
2. insert the tappet pad into the housing in the engine block, pointing the exhaust side towards the tappet roller (see fig. 29 page 24)
3. align the dynamic lead punch mark (IP) on the flywheel with the reference mark of the tool code **00366R0240** (fig. 75)
4. using a depth gauge (fig. 76), measure the dimension between the injection pump bearing surface and the tappet pad.
5. subtract **51.6 mm** from the dimension measured on the gauge; the result represents the theoretic thickness of the seals to insert under the injection pump.

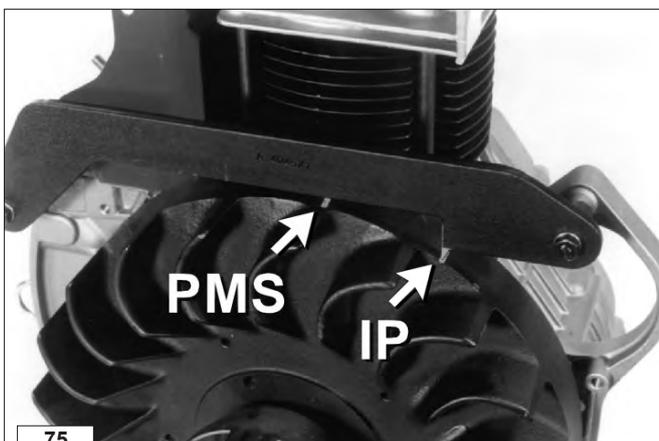


74

! NOTE: if the flywheel or a crank component is replaced, make sure that the punch mark on the flywheel (TDC, fig. 75) and the reference mark of the tool code **00366R0240**, match when the piston is at top dead center.

Lead values in degrees and millimeters on the flywheel:

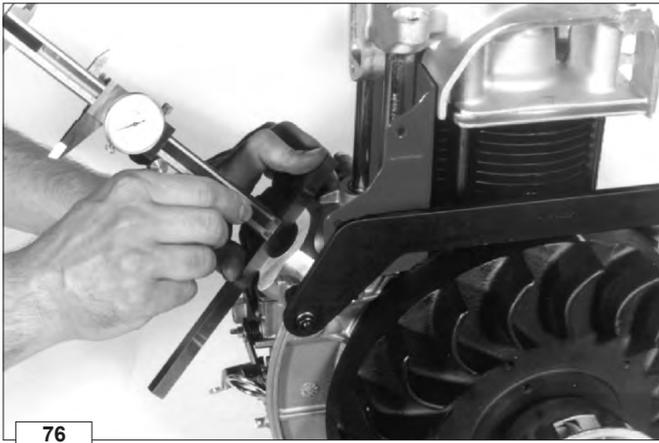
rpm	Lead IP
3000	18° (42,4 mm)
3600	23° (54,2 mm)



75

The punch marks on the flywheel indicate (fig. 75):

- TDC = top dead center
- IP = start of delivery



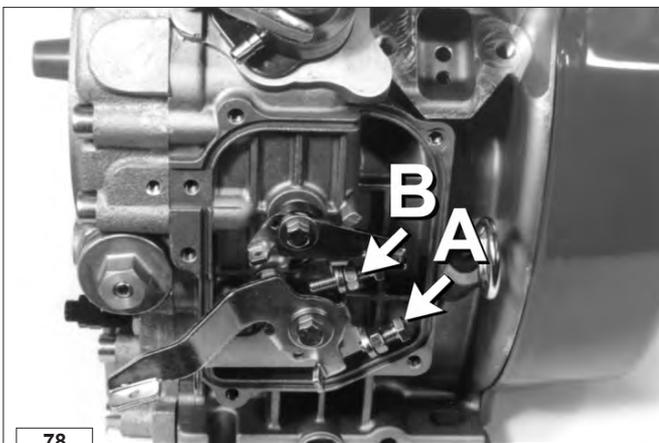
Mounting the injection pump on the engine

Lower the tappet in the innermost point of the engine by slightly turning the flywheel.

- Insert a seal of adequate thickness (see section "Injection lead" point 5, page 37).
- Turn the motor stop lever to the STOP position.
- Set the adjuster sleeve of the injection pump about one millimeter from the stop position on the adjuster block (fig. 77).
- Fit the injection pump into the engine block and, keeping it pressed down, fix it in place by tightening the nut that holds the relative bracket. (Match the marks made during the demounting phase, see section "Removing the injection pump" page 17)



! **Warning:** consult section "Braked engine test" page 39, if the position of the injection pump in relation to the casing was not marked during the demounting operations or if a new one must be installed.

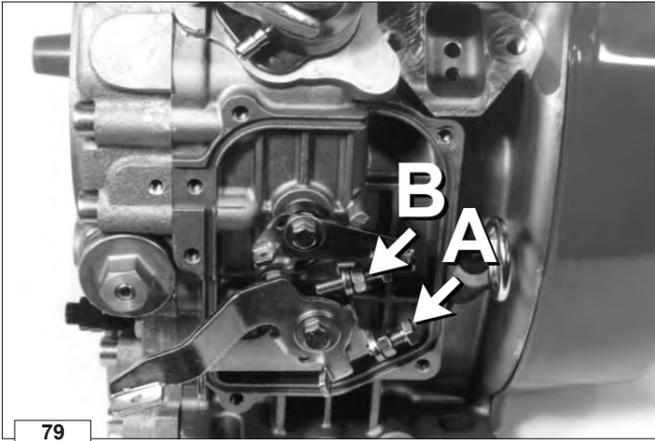


Injector and injector tube

Mount the injector on the head, inserting the copper retention seals (see section "Head" page 36).

Connect the injector to the pump with the injection pipe.

! **Warning:** always use two wrenches to slacken off or tighten injection pipes (fig. 78)



79

Rpm regulation

Fill the engine with oil and diesel fuel and allow it to warm up for 10 minutes.

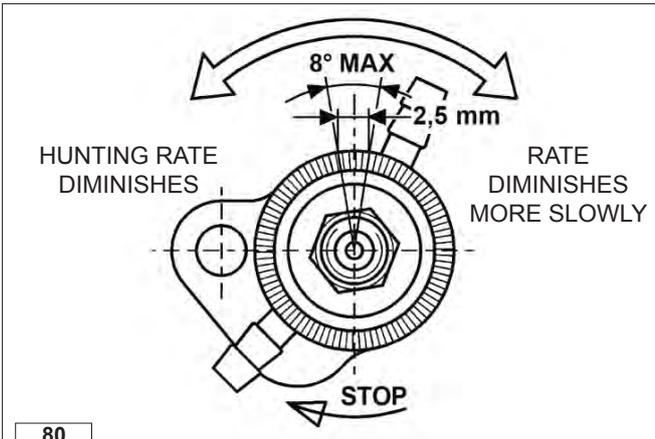
With the engine hot, adjust the idling rate (A, fig. 79) to **1,300 rpm** and the peak no-load rate (B, fig. 79) to:

- **3,150 rpm** for engines set at 3,000 rpm on load
- **3,750 rpm** for engines set at 3,600 rpm on load

Braked engine test

Carry out the following operations after having positioned the engine on the brake:

1. Start the engine and allow it to idle
2. Allow the engine to run in before checking the maximum power

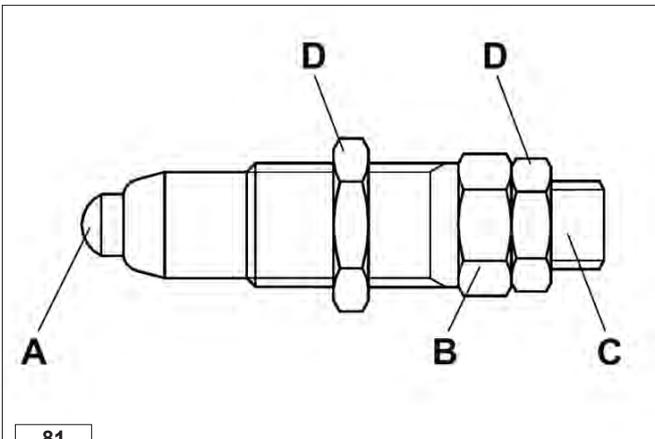


80

Running-in table

Time (min)	RPM	Load
5	2000	0
15	3000/3600	0
30	3000/3600	30%
30	3000/3600	50%
30	3000/3600	70%
5	3000/3600	100%

Consult the power curves in chapter 5.



81

There may be hunting problems, slowness or misfiring if the injection pump is changed. Correct these faults by turning the pump casing a few degrees in relation to the engine casing, following the directions indicated in fig. 80.

Fuel limiter.

The fuel limiter has a torque corrector device (fig. 81) that consists of the following parts:

- A) Torque corrector cap
- B) Maximum power flow rate adjuster
- C) Spring load adjuster
- D) Locking nuts

The adjustments can only be made to the exhaust brake. It is therefore inadvisable to tamper with the corrector adjuster (C fig. 81). The setting of adjuster B (fig. 81) can only be modified if work has been done on the injection pump or regulator, if the engine produces a lot of smoke or has insufficient power.

Storage

Prepare engines as follows for storage over 30 days

Temporary protection (1/6 months)

- Let engine run at idling speed in no-load conditions for 15 minutes.
- Fill crankcase with protection oil MIL-1-644-P9 and let engine run at 3/4 full speed for 5/10 minutes.
- When engine is warm empty oil pan and fill with standard new oil
- Remove fuel tube and empty the tank
- Remove fuel filter, replace cartridge if dirty and refit
- Carefully clean cylinder fins, heads and fan
- Seal all openings with tape.
- Remove injectors, pour a spoonful of oil type SAE 30 into the cylinders and rotate manually to distribute the oil. Refit injectors.
- Spray oil type SAE 10W into exhaust and intake manifolds, rocker arms, valves, tappet etc. Grease all unpainted parts.
- Loosen belt
- Wrap the engine in a plastic film.
- Store in a dry place, if possible not directly on the soil and far from high voltage electric lines.

Permanent protection (over 6 months)

- The following is recommended apart from the above instructions:
- For the lubrication and injection system as well as for moving parts use rustproof oil type MIL-L-21260 P10 grade 2, SAE 30 (Ex. ESSO RUST - BAN 623 - AGIP, RUSTIA C. SAE 30) Let the engine run with rustproof oil and drain any excess.
- Coat external unpainted surfaces with antirust type MIL-C- 16173D - grade 3 /Ex. ESSO RUST BAN 398 - AGIP, RUSTIA 100/F).

How to prepare the engine for operation

- Clean engine outside
- Remove protections and covers
- Remove antirust with an appropriate solvent or degreaser.
- Remove injector, fill with standard oil, turn crankshaft by a few revolutions, remove oil pan and drain the protective oil.

Couplings	Spiel (mm)	Grezen (mm)
Camshaft and plugs	0,032 ÷ 0,061	0,1
Compression ring opening	0,030 ÷ 0,050	0,8
Oil scraper ring opening	0,025 ÷ 0,050	0,8
Connecting rod and piston pin	0,023 ÷ 0,038	0,04
Injection pump tappets and housing	0,021 ÷ 0,059	0,1
Tappets and housing	0,005 ÷ 0,029	0,1
Pin and piston	0,003 ÷ 0,013	0,04
Intake guide and valve	0,030 ÷ 0,050	0,1
Exhaust guide and valve	0,045 ÷ 0,065	0,1

Adjustments	MIN (mm)	MAX (mm)
Camshaft float	0,1	0,25
Countershaft float	0,1	0,25
Crankshaft float	0,1	0,3
Connecting rod float	0,3	0,5
Valve clearance hot [cold]	0,15 (0,20)	0,15 (0,20)
Valve recessing	0,8	1
Injector projection	2,2	2,7
Piston projection	0,1	0,4

Tightening torques	kgm	(Nm)
	Timing system cover	2,7 ÷ 2,8
Injector ring nut	4,6 ÷ 5,6	45 ÷ 55
Injection tube unions	2 ÷ 2,5	19,6 ÷ 24,5
Injector bracket	0,8 ÷ 0,9	7,8 ÷ 8,8
Injection pump bracket	2	19,6
Head	4	39,2
Flywheel	18 ÷ 20	176,5 ÷ 196,1
Connecting rod	3,8 ÷ 3,9	37,3 ÷ 38,2

Standard screw tightening torques						
Denomination	 = 8.8 R ≥ 800 N/mm ²		 = R10 = 10.9 R ≥ 1000 N/mm ²		 = R12 = 12.9 R ≥ 1200 N/mm ²	
	Diameter x pitch mm	Nm	kgm	Nm	kgm	Nm
4 x 0,70	3,6	0,37	5,1	0,52	6	0,62
5 x 0,80	7	0,72	9,9	1,01	11,9	1,22
6 x 1,00	12	1,23	17	1,73	20,4	2,08
7 x 1,00	19,8	2,02	27,8	2,84	33	3,40
8 x 1,25	29,6	3,02	41,6	4,25	50	5,10
9 x 1,25	38	3,88	53,4	5,45	64,2	6,55
10 x 1,50	52,5	5,36	73,8	7,54	88,7	9,05
13 x 1,75	89	9,09	125	12,80	150	15,30
14 x 2,00	135	13,80	190	19,40	228	23,30
16 x 2,00	205	21,00	289	29,50	347	35,40
18 x 2,50	257	26,30	362	37,00	435	44,40
20 x 2,50	358	36,60	504	51,50	605	61,80
22 x 2,50	435	44,40	611	62,40	734	74,90
24 x 3,00	557	56,90	784	80,00	940	96,00

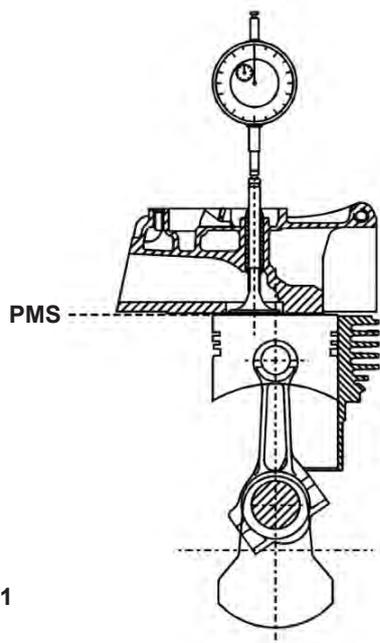


Fig. 1

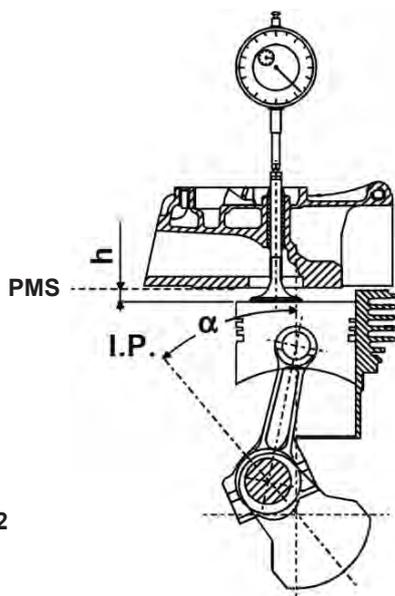


Fig. 2

TDC = top dead center

h = extent of piston lowering in relation to TDC.

α = angle corresponding to piston lowering in relation to T.D.C.

I.P. = start of delivery

SUGGESTIONS ON HOW TO TIME THE INJECTION PUMP WHEN THE LEAD PUNCH MARKS ON THE FLYWHEEL ARE DIFFICULT TO REACH.

(Consult chapter "Injection lead" on page 37 for a description of the conventional adjustment)

Proceed in the following way:

1. Remove the cover from the rocker arms.
2. Demount the recoil and turn the drive shaft to the valve regulation position.
(This operation is carried out by means of the flywheel nut, using a N° 32 socket wrench).
3. Demount the intake or exhaust rocker arm, the valve spring and caps.
4. Rest the valve top on the crown of the T.D.C. balanced piston (fig.1).
WARNING: The valve slips from its guide if the piston is lowered by turning the drive shaft more than 1/4 of a pipe wrench turn.
5. Position a comparator mounted on a magnetic pedestal or dummy injector and reset it on the valve stem (fig.1).
6. Slowly turn the drive shaft in an anti-clockwise direction and check the comparator to make sure that the piston drops about 5 mm in relation to TDC (dimension "h" - fig. 2).
7. Slowly turn the drive shaft in a clockwise direction and check the comparator to make sure that the piston rises by the values indicated in the following table, in relation to TDC (dimension "h" - fig. 2):

rpm	h	α
3000	2,735 mm	18°
3600	4,427 mm	23°

8. Remove the injection tube and mount the capillary tube code **00365R0940** on the injection pump delivery fitting (fig. 3).
9. Turn the accelerator lever to the MAX position and the stop lever to about half travel.
10. Turn the drive shaft anti-clockwise by no more than 1/4 of the pipe wrench turn.
11. Pressurize the circuit by turning the drive shaft several times in an alternate clockwise/anti-clockwise way until fuel splashes out of the calibrated hole of the capillary tube.
12. Turn the drive shaft and check the comparator to make sure that the piston drops about 10 mm in relation to TD. (dimension (quota "h" - fig. 2).
13. Shake the capillary tube until an air bubble forms inside it (fig. 3).
14. Turn the drive shaft in a clockwise direction very slowly and check the position of the air bubble in the capillary tube. A small movement of this bubble will indicate the exact lead position. This value must correspond to the one previously read on the comparator (see point 7). If this is not the case, add or remove seals to or from the injection pump according to the corrections indicated in the following table:

rpm	Lead IP
2,443 mm	17°
2,735 mm	18°
3,043 mm	19°
3,336 mm	20°
3,704 mm	21°
4,058 mm	22°
4,427 mm	23°
4,811 mm	24°

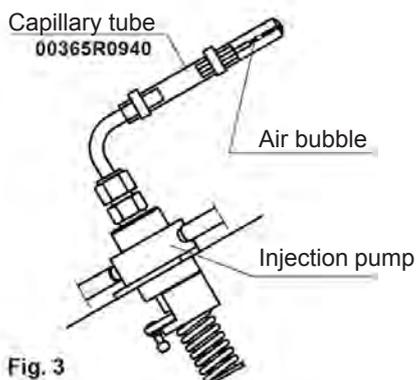


Fig. 3

Translated from the original manual in Italian language.

Data reported in this issue can be modified at any time by KOHLER.

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