WORK SHOP MANUAL

15 LD 500, series engines, p.no. 1-5302-637

15 LD 500

1st Edition

LOMBARDINI SERVICE

COMPILER TECCATI	REG. CODE	MODEL N°	DATE OF ISSUE	REVISION 00 DATE	ENDORSED	
	1-5302-637	51078	02-04	29.02.2004		1

FOREWORD

We have done all in our power to give up to date and accurate technical information in this manual. Lombardini engines are, however, constantly developing thus the data in this publication may be liable to modification without prior notice.

The information in this manual is the exclusive property of Lombardini. Neither partial nor total duplications or reprints are therefore permitted without the express authorization of Lombardini.

The information in this manual is given on the assumption that:

1 - the persons who service Lombardini engines have been adequately trained and outfitted to safely and professionally carry out the necessary tasks;

2 - the persons who service Lombardini engines possess the necessary skills and special Lombardini tools to safely and professionally carry out the necessary tasks;

3 - the persons who service Lombardini engines have read the specific information concerning the above mentioned Service operations and that they have clearly understood the operations required.

GENERAL SERVICE NOTES

1 - Only use genuine Lombardini spare parts. Use of spurious spares may lead to incorrect performance and shorten the life of the engines.
2 - The metric system is used to express all data, i.e. the dimensions are given in millimeters (mm), torque is expressed in Newton-meters (Nm), weight in kilograms (kg), volume in liters or cubic centimeters (cc) and pressure in barometric units (bar).

SERVICE

WARRANTY CERTIFICATE

The products manufactured by Lombardini Srl are warranted to be free from conformity defects for a period of 24 months from the date of delivery to the first end user.
For engines fitted to stationary equipment, working at constant load and at constant and/or slightly variable speed within the setting limits, the warranty covers a period up to a limit of 2000 working hours, if the above mentioned period (24 months) is not expired.
If no hour-meter is fitted , 12 working hours per calendar day will be considered.
For what concerns the parts subject to wear and deterioration (injection/feeding system, electrical system, cooling system, sealing parts, non-metallic pipes, belts) warranty covers a maximum limit of 2000 working hours, if the above mentioned period (24 months) is not expired.
For correct maintenance and replacement of these parts, it is necessary to follow the instructions reported in the documentation supplied with each engine.
To ensure the engine warranty is valid, the engine installation, considering the product technical features, must be carried out by qualified personnel only.
The list of the Lombardini authorized dealers is reported in the “Service” booklet, supplied with each engine.
Special applications involving considerable modifications to the cooling/lubricating system (for ex.: dry oil sump), filtering system, turbo-charged models, will require special written warranty agreements.
Within the above stated periods Lombardini Srl directly or through its authorized network will repair and/or replace free of charge any own part or component that, upon examination by Lombardini or by an authorized Lombardini agent, is found to be defective in conformity, workmanship or materials.
Any other responsibility/obligation for different expenses, damages and direct/indirect losses deriving from the engine use or from both the total or partial impossibility of use, is excluded.
The repair or replacement of any component will not extend or renew the warranty period.

Lombardini warranty obligations here above described will be cancelled if:

- Lombardini engines are not correctly installed and as a consequence the correct functional parameters are not respected and altered.
- Lombardini engines are not used according to the instructions reported in the “Use and Maintenance” booklet supplied with each engine.
- Any seal affixed to the engine by Lombardini has been tampered with or removed.
- Spare parts used are not original Lombardini.
- Feeding and injection systems are damaged by unauthorized or poor quality fuel types.
- Electrical system failure is due to components, connected to this system, which are not supplied or installed by Lombardini.
- Engines have been disassembled, repaired or altered by any part other than an authorized Lombardini agent.

Following expiration of the above stated warranty periods and working hours, Lombardini will have no further responsibility for warranty and will consider its here above mentioned obligations for warranty complete.
Any warranty request related to a non-conformity of the product must be addressed to the Lombardini Srl service agents.

INDEX

This manual contains pertinent information regarding the repair of LOMBARDINI air-cooled, indirect injection Diesel engines type **15LD500:** updated February 29, 2004.

INDEX

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	●									
MAINTE-NANCE	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 AND WARNING DECALS

DANGER

Failure to comply with the instructions could result in damage to persons and property

CAUTION

Failure to comply with the instructions could lead to technical damage to the machine and/or system

SAFETY INSTRUCTIONS

- Lombardini Engines are built to supply their performances in a safe and long-lasting way. To obtain these results, it is essential for users to comply with the servicing instructions given in the relative manual along with the safety recommendations listed below.
- The engine has been made according to a machine manufacturer's specifications and all actions required to meet the essential safety and health safeguarding requisites have been taken, as prescribed by the current laws in merit. All uses of the engine beyond those specifically established cannot therefore be considered as conforming to the use defined by Lombardini which thus declines all liability for any accidents deriving from such operations.
- The following indications are dedicated to the user of the machine in order to reduce or eliminate risks concerning engine operation in particular, along with the relative routine maintenance work.
- The user must read these instructions carefully and become familiar with the operations described. Failure to do this could lead to serious danger for his personal safety and health and that of any persons who may be in the vicinity of the machine.
- The engine may only be used or assembled on a machine by technicians who are adequately trained about its operation and the deriving dangers. This condition is also essential when it comes to routine and, above all, extraordinary maintenance operations which, in the latter case, must only be carried out by persons specifically trained by Lombardini and who work in compliance with the existing documentation.
- Variations to the functional parameters of the engine, adjustments to the fuel flow rate and rotation speed, removal of seals, demounting and refitting of parts not described in the operation and maintenance manual by unauthorized personnel shall relieve Lombardini from all and every liability for deriving accidents or for failure to comply with the laws in merit.
- On starting, make sure that the engine is as horizontal as possible, unless the machine specifications differ. In the case of manual start-ups, make sure that the relative actions can take place without the risk of hitting walls or dangerous objects, also considering the movements made by the operator. Pull-starting with a free cord (thus excluding self-winding starting only), is not permitted even in an emergency.
- Make sure that the machine is stable to prevent the risk of overturning.
- Become familiar with how to adjust the rotation speed and stop the engine.
- Never start the engine in a closed place or where there is insufficient ventilation. Combustion creates carbon monoxide, an odourless and highly poisonous gas. Lengthy stays in places where the engine freely exhausts this gas can lead to unconsciousness and death.

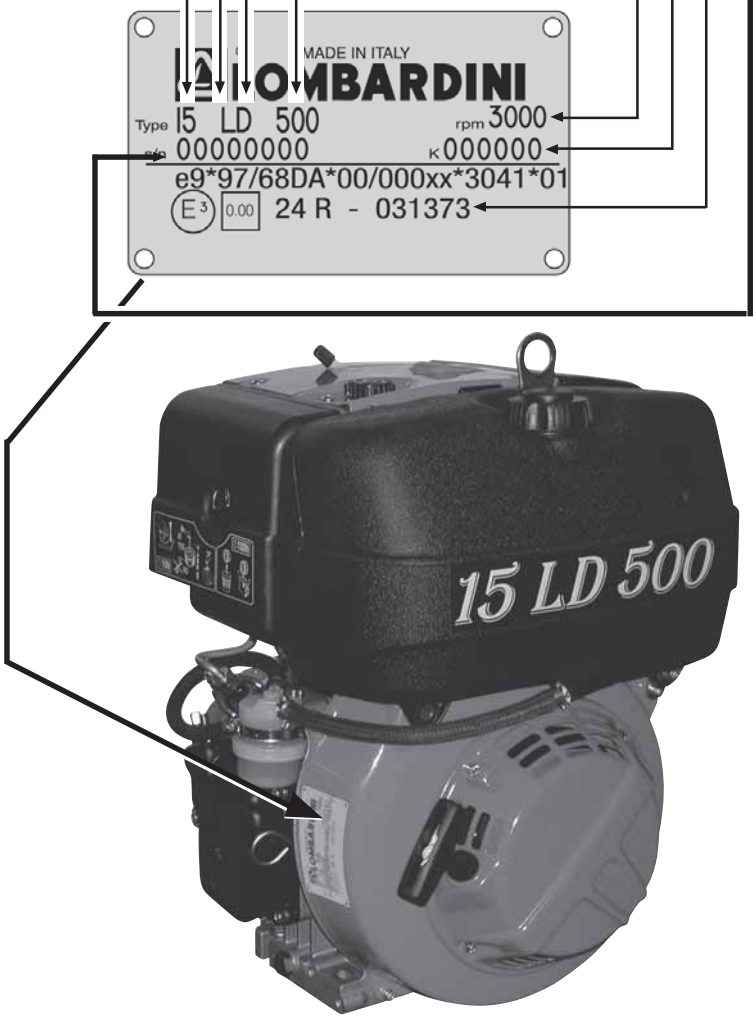
- The engine must not operate in places containing inflammable materials, in explosive atmospheres, where there is dust that can easily catch fire unles specific, adequate and clearly indicated precautions have been taken and have been certified for the machine.
- To prevent fire hazards, always keep the machine at least one meter from buildings or from other machinery.
- Children and animals must be kept at a due distance from operating machines in order to prevent hazards deriving from their operation.
- Fuel is inflammable. The tank must only be filled when the engine is off. Thoroughly dry any spilt fuel and move the fuel container away along with any rags soaked in fuel or oil. Make sure that no soundproofing panels made of porous material are soaked in fuel or oil. Make sure that the ground or floor on which the machine is standing has not soaked up any fuel or oil.
- Fully tighten the tank plug each time after refuelling. Do not fill the tank right to the top but leave an adequate space for the fuel to expand.
- Fuel vapour is highly toxic. Only refuel outdoors or in a well ventilated place.
- Do not smoke or use naked flames when refuelling.
- The engine must be started in compliance with the specific instructions in the operation manual of the engine and/or machine itself. Do not use auxiliary starting aids that were not installed on the original machine (e.g. Startpilot').
- Before starting, remove any tools that were used to service the engine and/or machine. Make sure that all guards have been refitted.
- During operation, the surface of the engine can become dangerously hot. Avoid touching the exhaust system in particular.
- Before proceeding with any operation on the engine, stop it and allow it to cool. Never carry out any operation whilst the engine is running.
- The coolant fluid circuit is under pressure. Never carry out any inspections until the engine has cooled and even in this case, only open the radiator plug or expansion chamber with the utmost caution, wearing protective garments and goggles. If there is an electric fan, do not approach the engine whilst it is still hot as the fan could also start operating when the engine is at a standstill. Only clean the coolant system when the engine is at a standstill.
- When cleaning the oil-cooled air filter, make sure that the old oil is disposed of in the correct way in order to safeguard the environment. The spongy filtering material in oil-cooled air filters must not be soaked in oil. The reservoir of the separator pre-filter must not be filled with oil.
- The oil must be drained whilst the engine is hot (oil T ~ 80°C). Particular care is required to prevent burns. Do not allow the oil to come into contact with the skin.
- Make sure that the drained oil, the oil filter and the oil it contains are disposed of in the correct way in order to safeguard the environment.
- Pay attention to the temperature of the oil filter when the filter itself is replaced.
- Only check, top up and change the coolant fluid when the engine is off and cold. Take care to prevent fluids containing nitrites from being mixed with others that do not contain these substances since "Nitrosamine", dangerous for the health, can form. The coolant fluid is polluting and must therefore be disposed of in the correct way to safeguard the environment.
- During operations that involve access to moving parts of the engine and/or removal of rotating guards, disconnect and insulate the positive wire of the battery to prevent accidental short-circuits and to stop the starter motor from being energized.
- Only check belt tension when the engine is off.
- Only use the eyebolts installed by Lombardini to move the engine. These lifting points are not suitable for the entire machine; in this case, the eyebolts installed by the manufacturer should be used.

MODEL NUMBER

Displacement (cc)
Diesel
LOMBARDINI
Engine group number

ENGINE IDENTIFICATION

R.P.M.
Customer's code
Approval code
Engine Serial Number



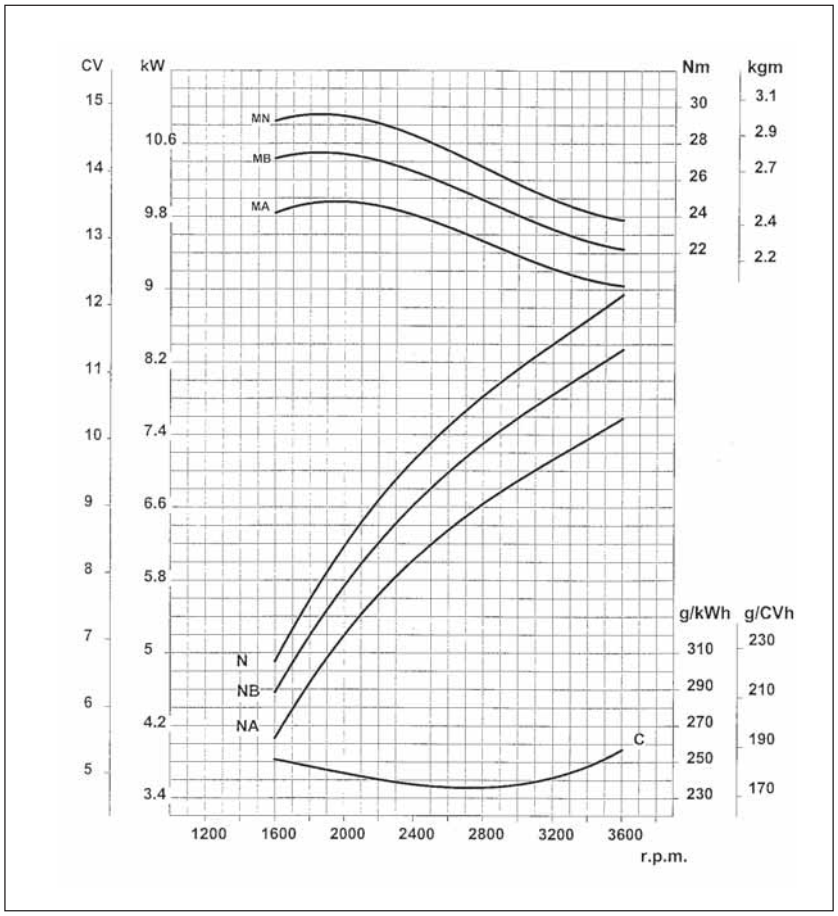
CHARACTERISTICS

ENGINE TYPE			15 LD 500
Number of cylinders		N.	1
Bore		mm	87
Stroke		mm	85
Swept volume		cm³	505
Compression ratio			19:1
Power kW (HP)	N 80/1269/CEE-ISO 1585		9 (12.24)
	NB ISO 3046 - 1 IFN		8.4 (11.42)
	NA ISO 3046 - 1 ICXN		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

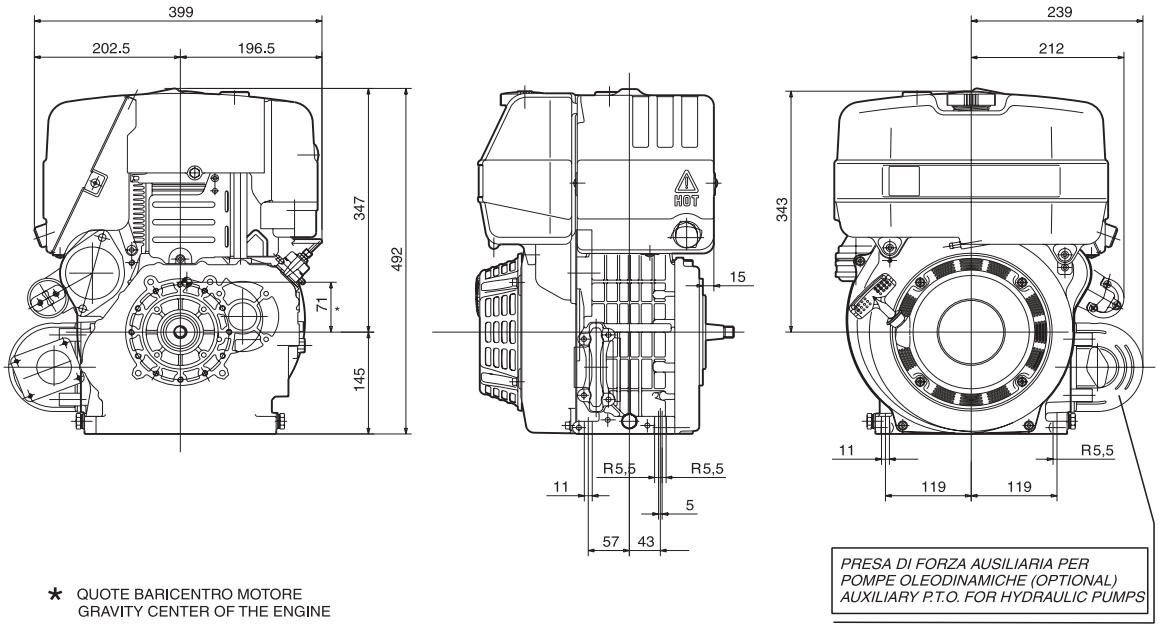
15 LD 500



N (80/1269/EEC - ISO 1585)	**AUTOMOTIVE RATING** : Intermittent operation with variable speed and variable load.
NB (ISO 3046 - 1 IFN)	**RATING WITH NO OWERLOAD CAPABILITY:** continuos ligth duty operation with constant speed and variable load.
NA (ISO 3046 - 1 ICXN)	**CONTINUOS RATING WITH OVERLOAD CAPABILITY:** continuos heavy duty with constant speed and constant load.
MN	**Torque** at **N** power.
MB	**Torque** at **NB** power.
MA	**Torque** at **NA** power.
C	Specific fuel consumption at **NB** power.

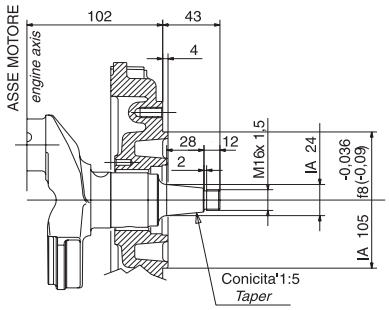
The above power values refer to an engine fitted with air cleaner and standard muffler, after testing and at the environmental conditions of 20°C and 1 bar.
Max. power tolerance is 5%.
Power decreases by approximately 1% every 100 m di altitude and by 2% every 5°C above 25°C.

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

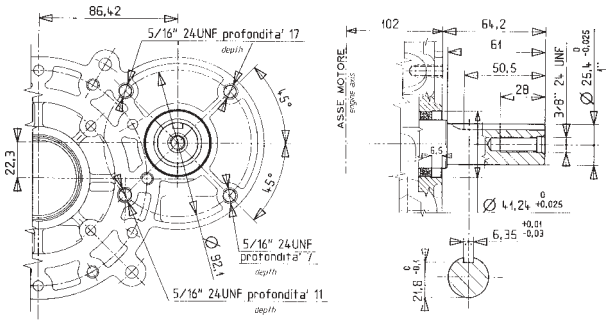


* QUOTE BARICENTRO MOTORE
GRAVITY CENTER OF THE ENGINE

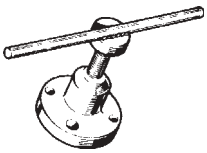
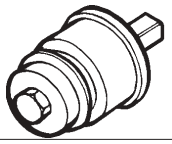
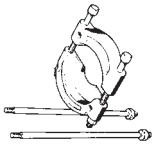
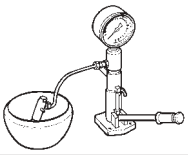
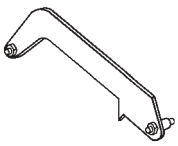
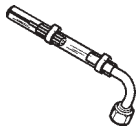
PRESA DI FORZA STANDARD CON SENSO DI ROTAZIONE SINISTRO
STANDARD P.T.O. WITH ANTICLOCKWISE DIRECTION OF ROTATION



PRESA DI FORZA SU ALBERO A CAMME OPZIONALE CON SENSO DI ROTAZIONE DESTRO
OPTIONAL P.T.O. ON CAMSHAFT WITH CLOCKWISE DIRECTION OF ROTATION



Note: Dimensions in mm

TOOL	CODE	DESCRIPTION
	**00365R0020**	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

MANUTENANCE

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

VIII MAINTENANCE - RECOMMENDED OIL TYPE - REFILLING

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.

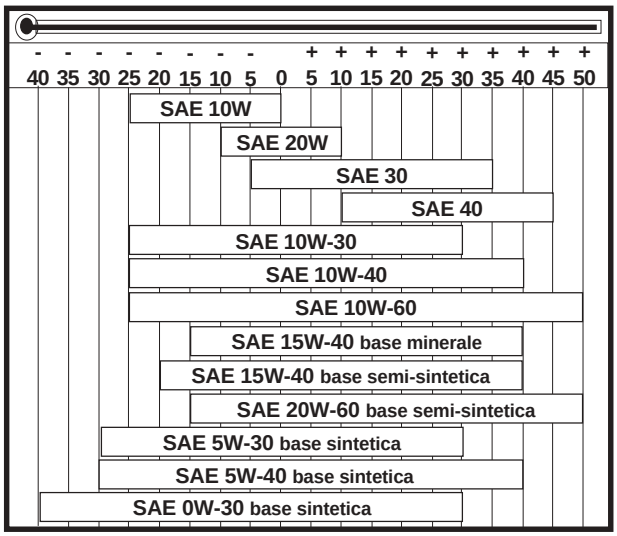
RECOMMENDED OIL

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.**

GRADE



ACEA SEQUENCES

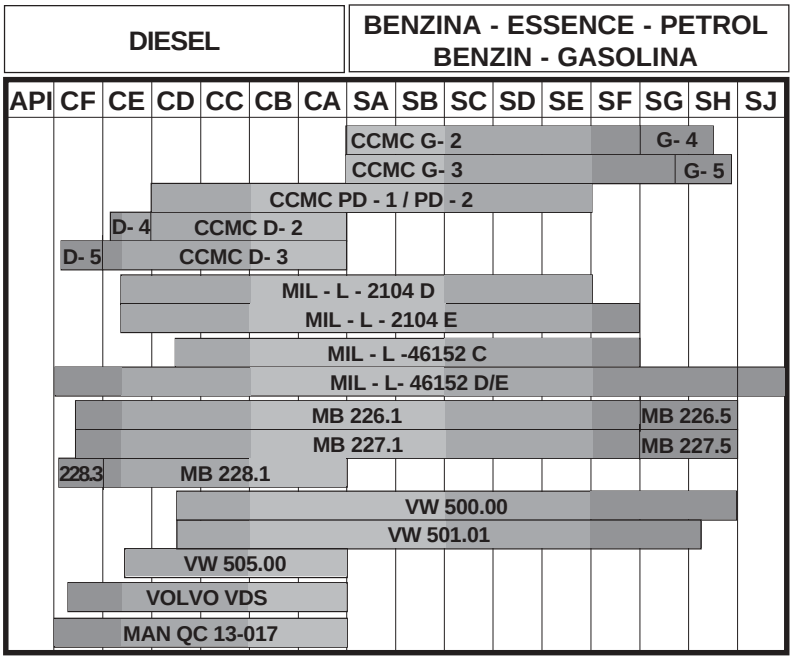
A = Gasoline (Petrol)
B = Light Diesel fuels
E = Heavy Diesel fuels

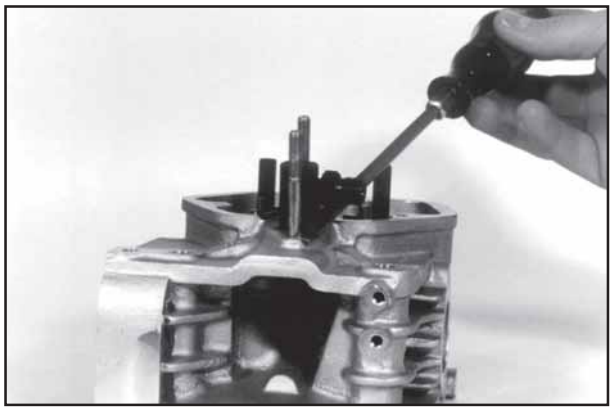
Required levels :

A1-96
A2-96
A3-96

B1-96
B2-96
B3-96

E1-96
E2-96
E3-96



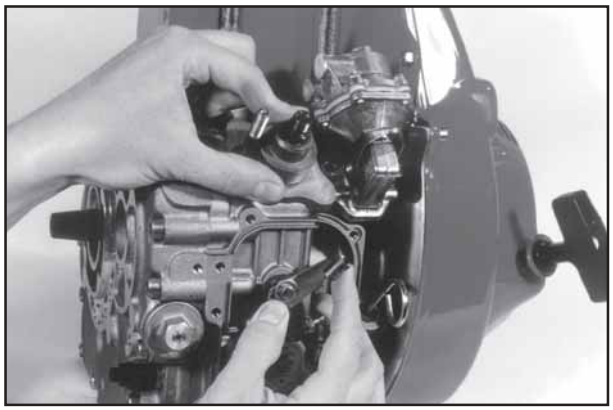


1

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 LOMBARDINI 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

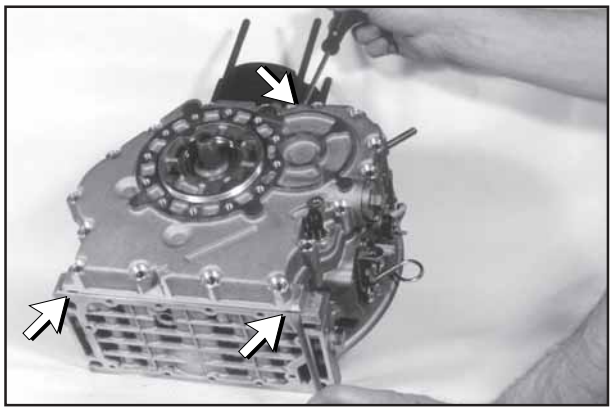
Remove the fuel tank, the air conveyor and flywheel nut.

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.

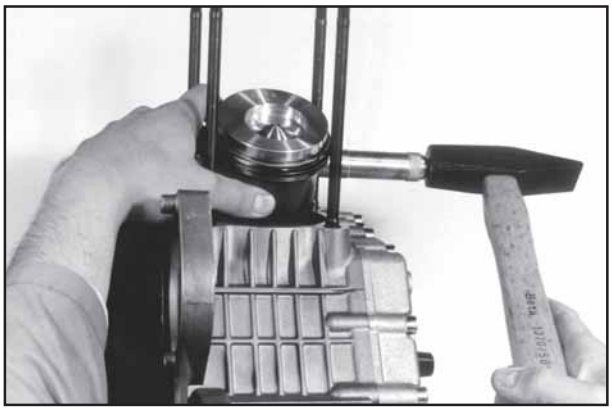


4

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.

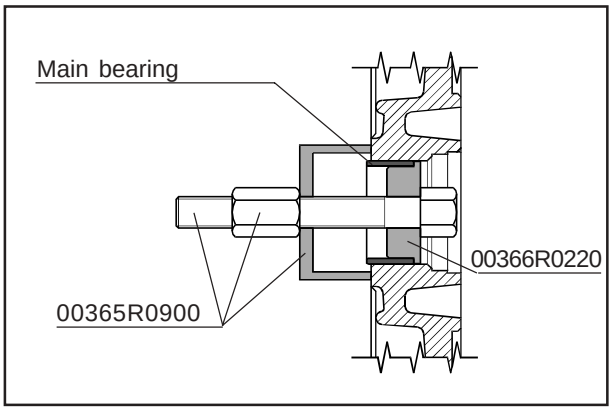
Warning: to prevent damage to the main bearings, it is advisable to demount the cover from the timing system side with the engine cold.



5

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

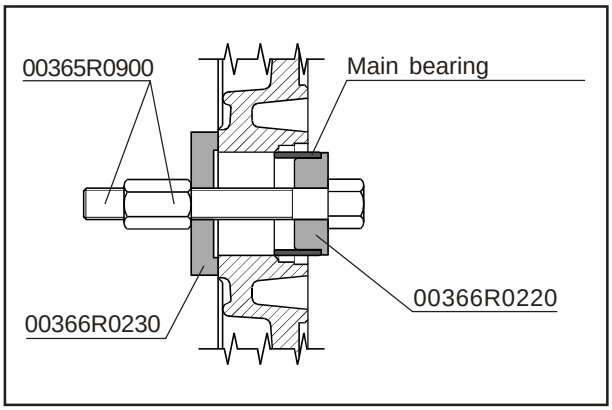
! Warning: do not demount the head when hot or the retention surfaces could be damaged.



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.

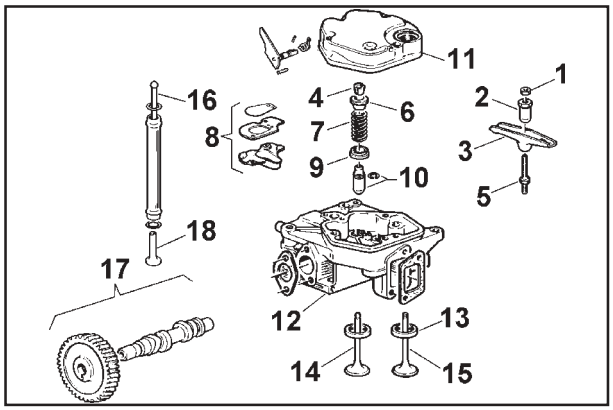


7

! **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).



8

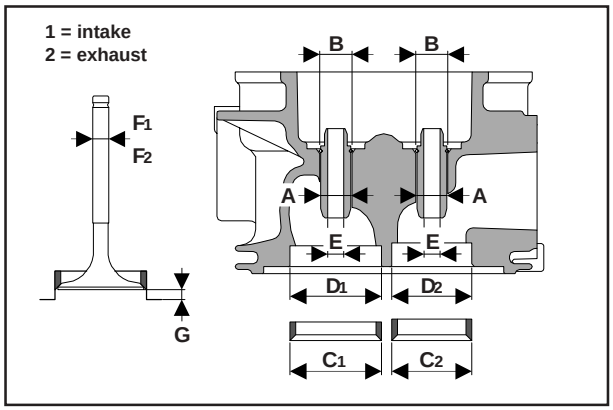
Head

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.



9

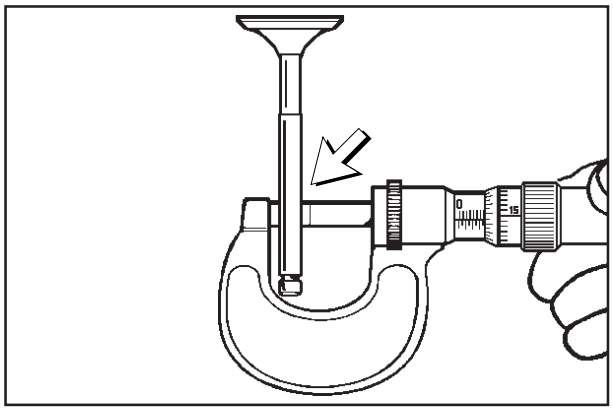
! Do not demount the head when hot to avoid deformations.

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 ÷ 6,955	0,8 ÷ 1

(*) with guide mounted. **measurements in mm**



10

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).

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).

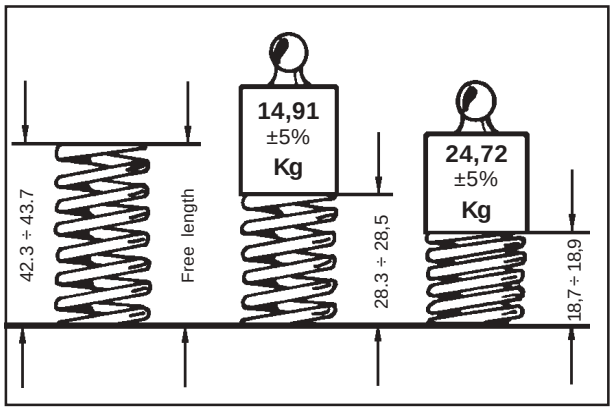
! **Warning:** when the valve embedding values are lower than those prescribed, the valves could interfere with the piston.

12

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.

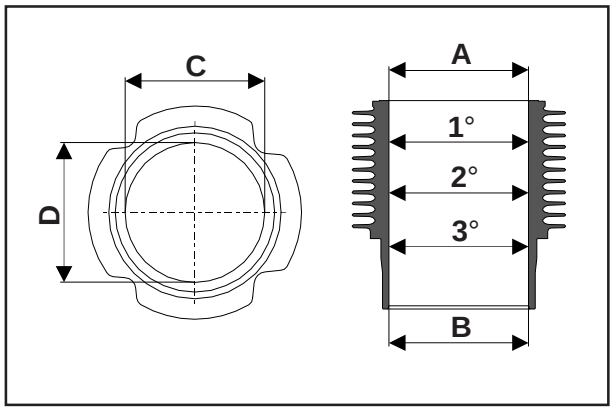
If there are air leaks in the form of bubbles between the housing and valve, demount the valve and grind-in again.



13

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.



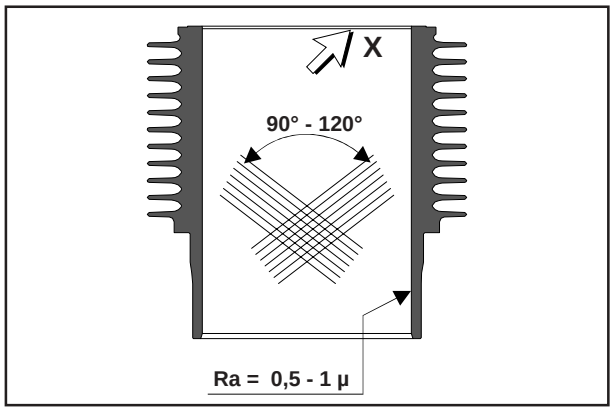
14

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:

Ø 87 ÷ 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.

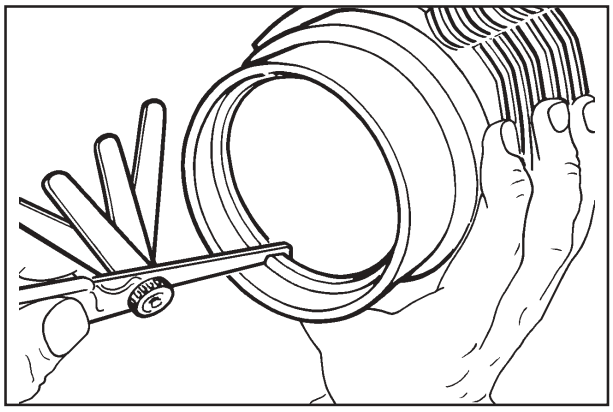


15

! 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.



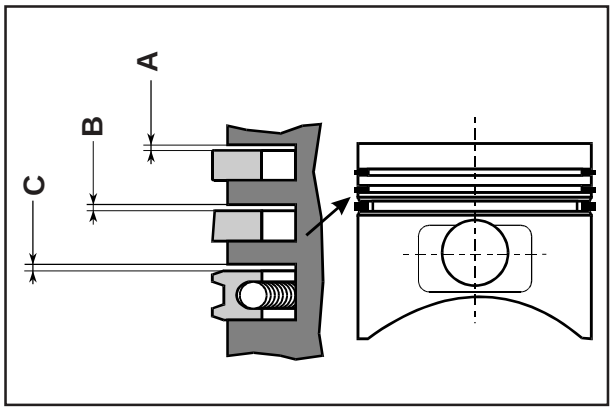
16

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:



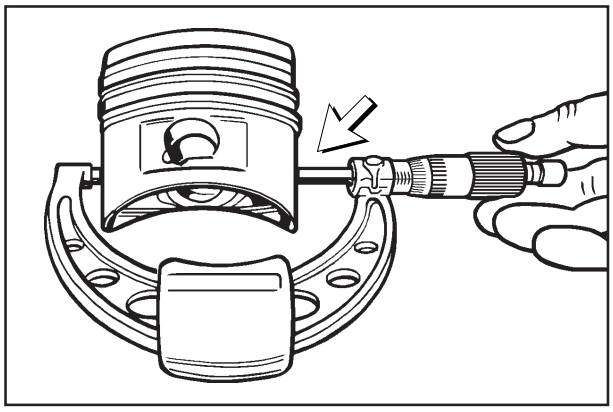
17

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



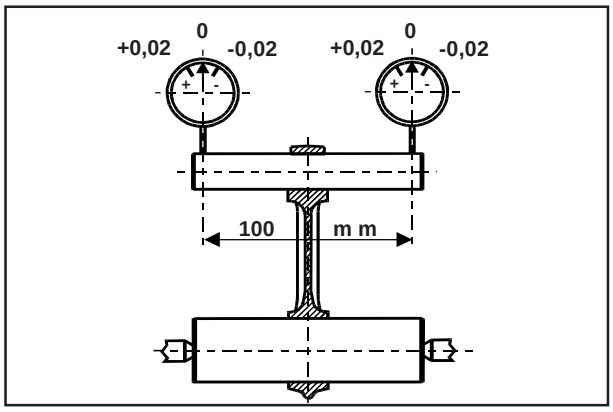
18

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:

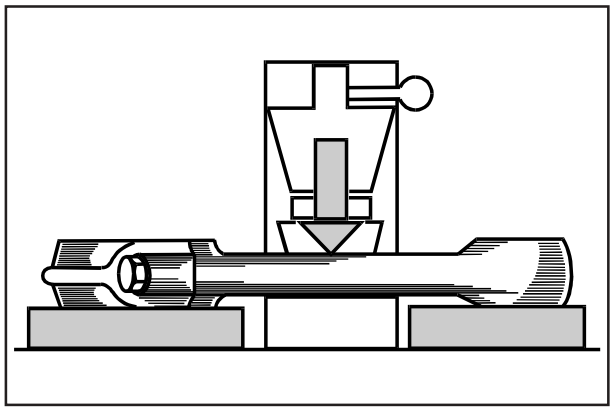


19

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)**.



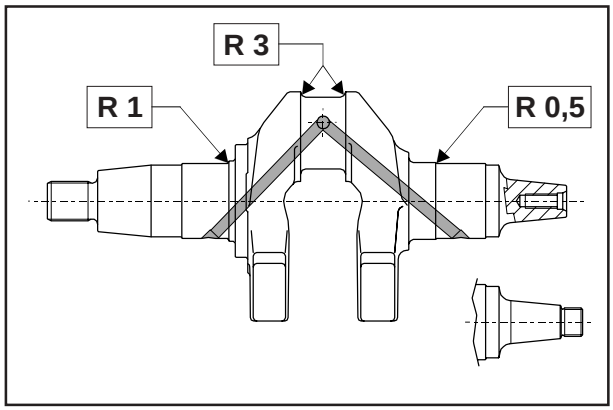
20

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).

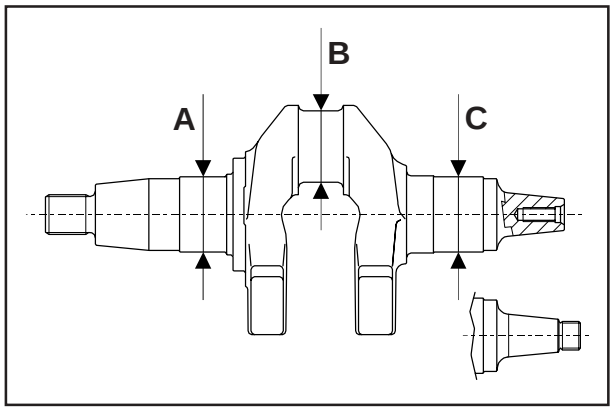


21

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.



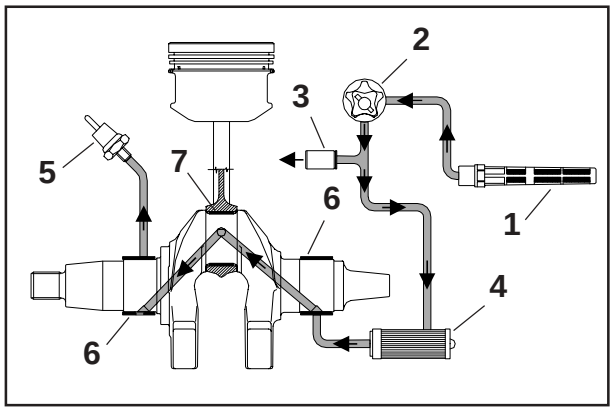
22

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.

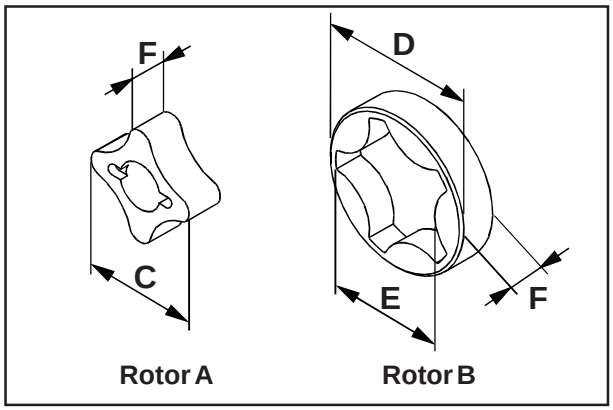


23

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.



24

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:

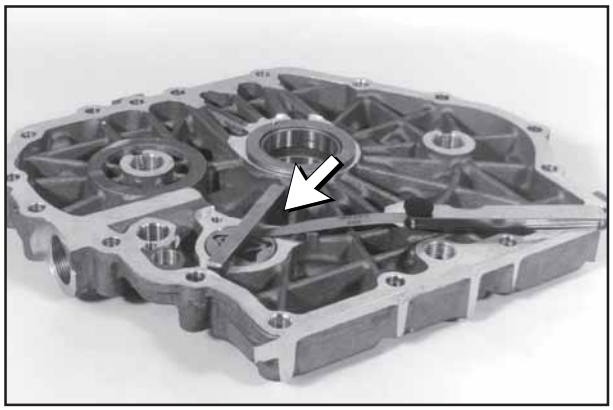
OIL PUMP ROTOR DIMENSIONS AND PLAY

Measurement	Dimensions mm	Max. wear mm
C	Ø 25,97 ÷ 25,99	Ø 25,92
D	Ø 34,96 ÷ 34,99	Ø 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

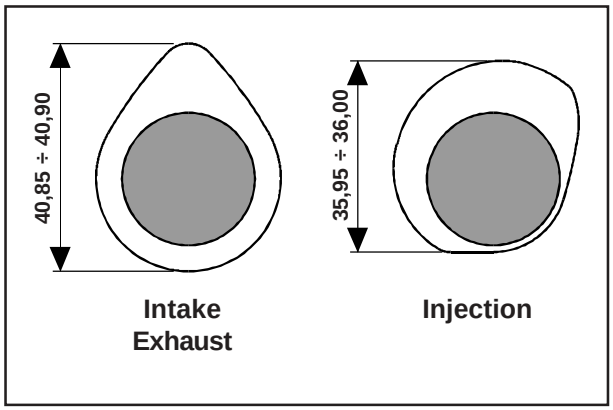


25

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.



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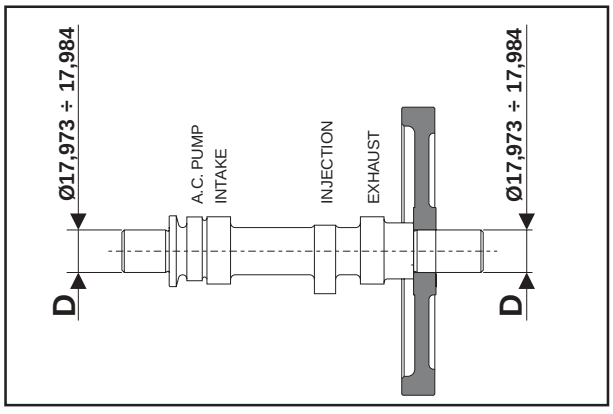


27

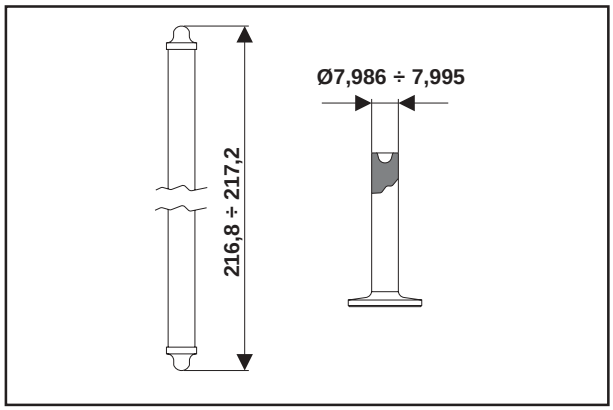
Camshaft

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. xonstructional 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).

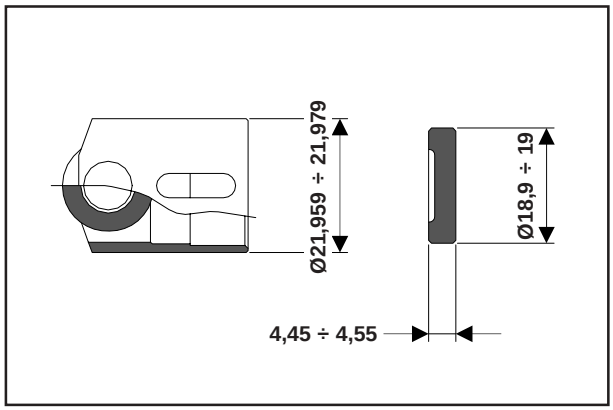


28

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
0,005 ÷ 0,029	0,10

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



29

Injection pump tappets and pads
Replace the parts if the wear on their surfaces exceeds 0.1 mm (fig. 29).

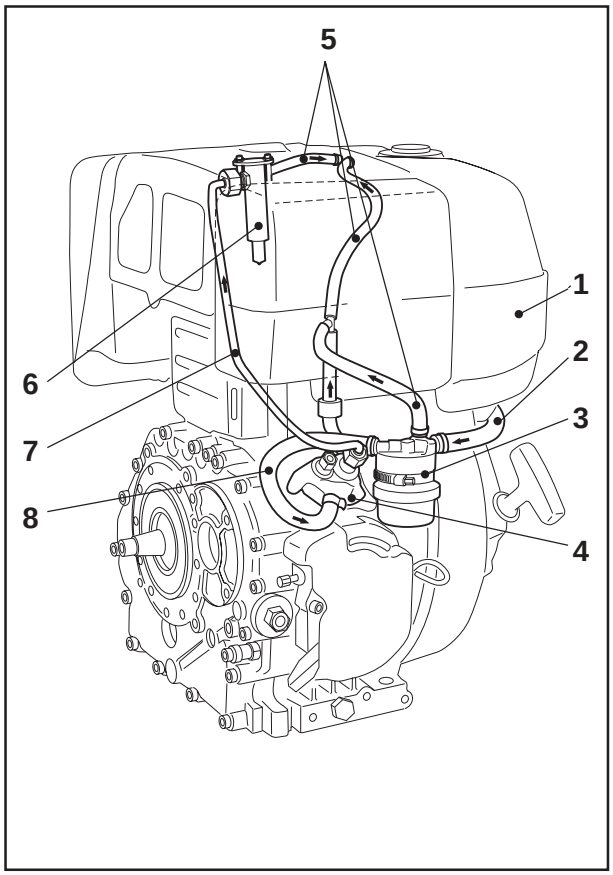
Coupling play between the tappet and relative housing in the crankcase:

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.



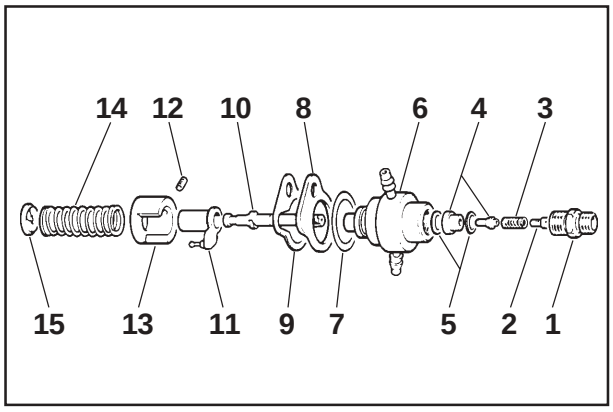
30

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.

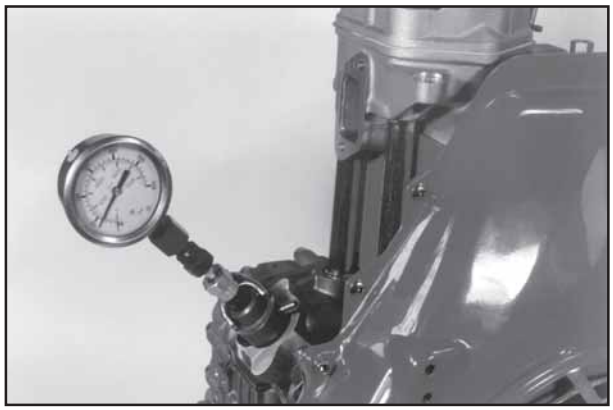


31

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



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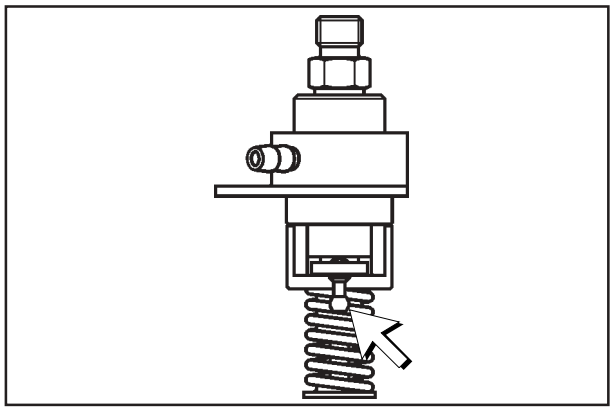

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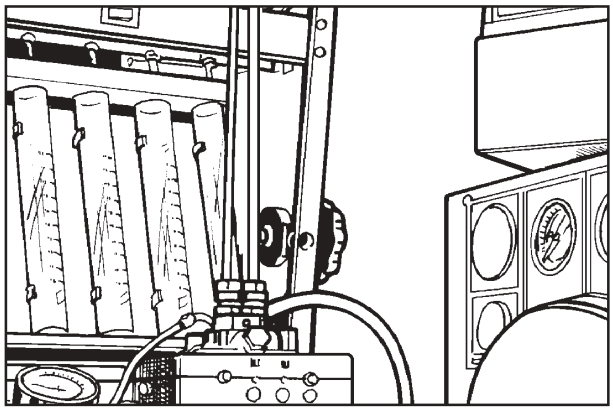
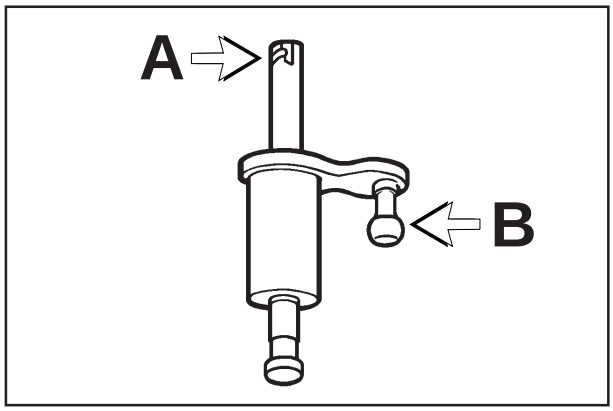


34



35

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 that **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 ÷ 29 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:

4,0 ÷ 4,1 mm

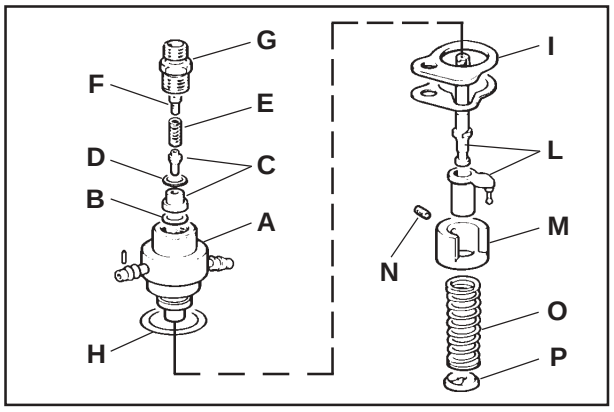
Injection pump assembly (fig. 36)
If the injection pump must be demounted, use an electric pen to mark the adjuster block (M) with the enbloc pump casing (A) and loosen the plug (N) after having heated it to make the Loctite easier to release.

Comply with the following instructions when remounting the parts:

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

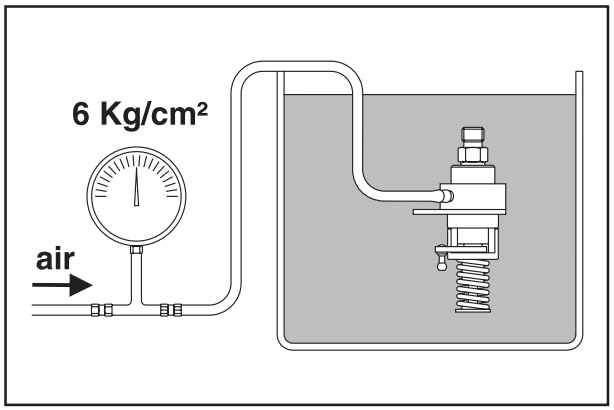
4,3 ÷ 5,4 kgm (42,5 ÷ 52,5 Nm)

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



36

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

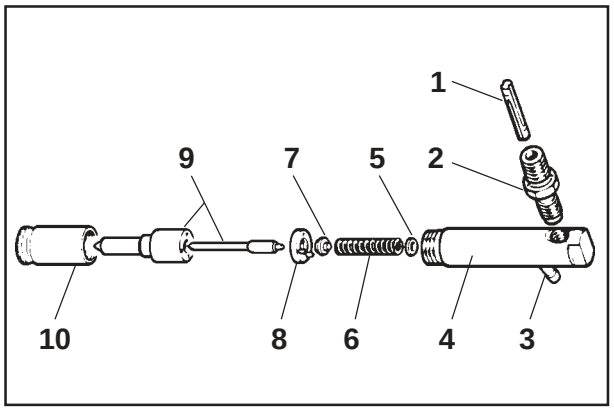
Plug the fuel return union and let air in through the fuelling union at a pressure of **6 Kg/cm²**. Fully immerse the pump in a receptacle containing diesel fuel for about 50 - 60 seconds (fig. 37) and make sure that no bubbles appear.

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.



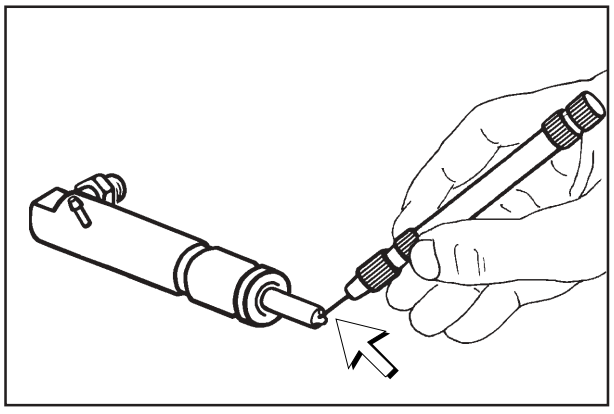
38

Injector inspection and calibration

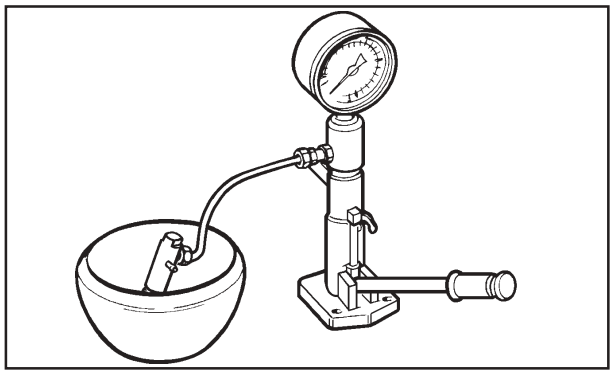
1. Clean the nozzle holes with a thin steel wire (fig. 39) with the following diameters:

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



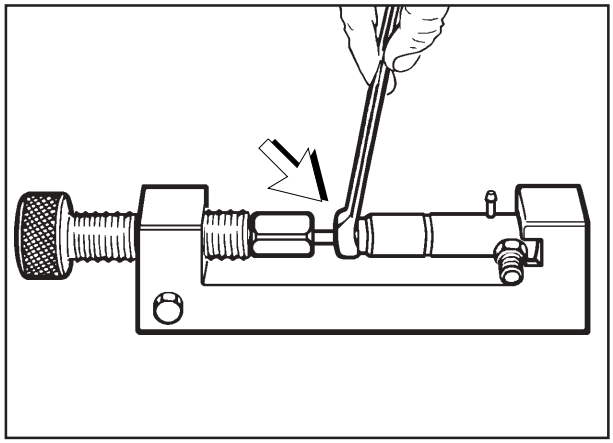
39



40

check the time it takes to drop. The pressure must drop to 150 to 100 Kg/cm² withinn 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.



41

Demounting and remounting

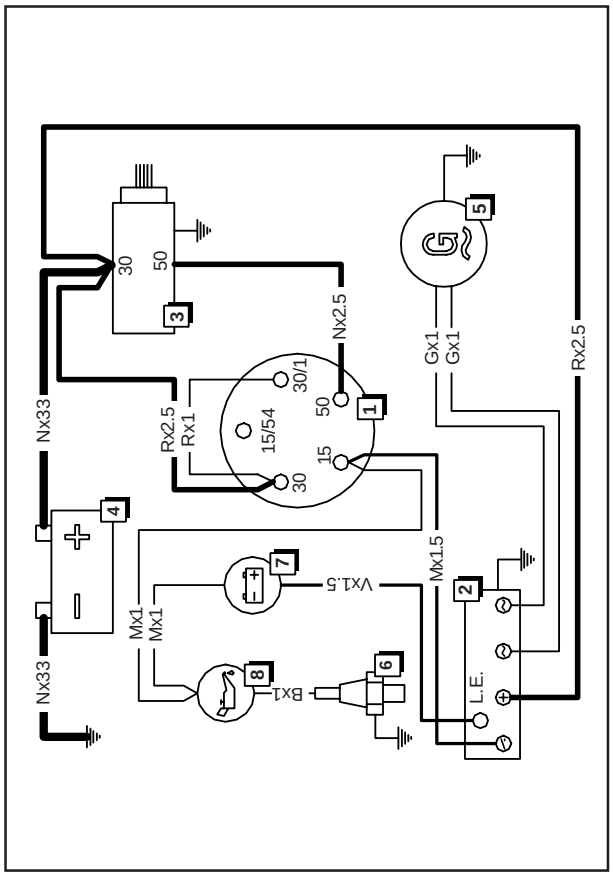
Loosen the ring nut that fixes the nozzle using a torque wrench and as device like the one shown in fig. 41 which relieves the pressure exercised by the spring on the ring nut.

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.

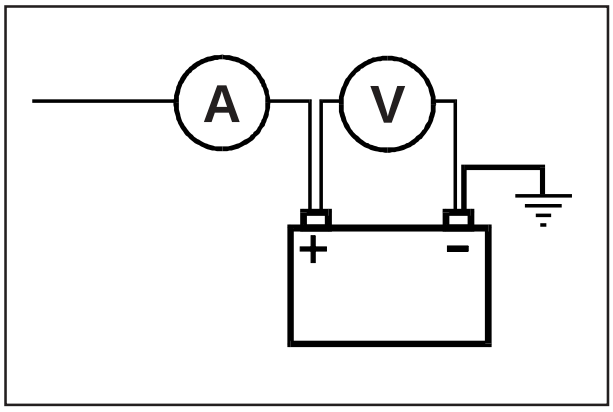
2. **Smoothness test**: the nozzle needle, which will have been previously immersed in impurity-free fuel, should be inserted into the body of the nozzle. Noz extract it by up to a third of the guide length, holding the nozzle in a vertical position. The needle must drop back into its housing thanks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

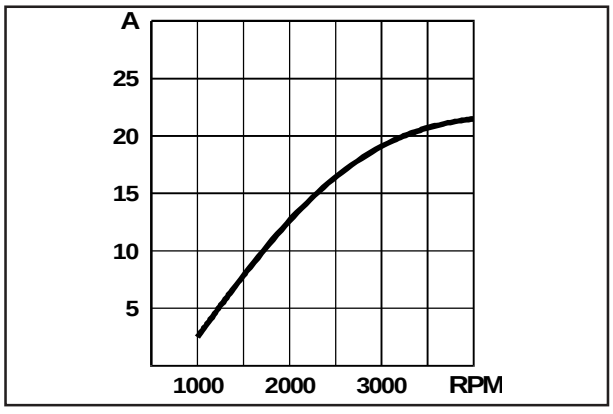
4,6 ÷ 5,6 kgm (45 ÷ 55 Nm)



42



43



44

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.

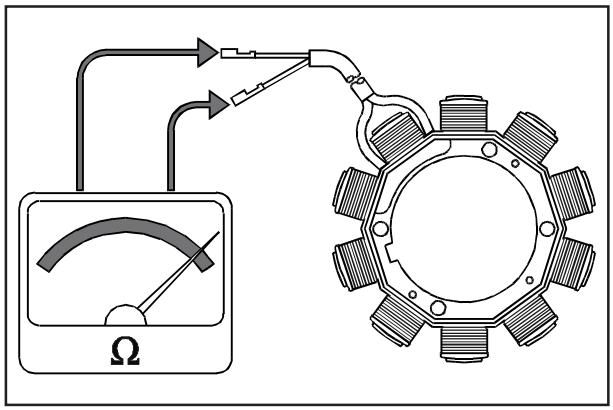
Illustration in fig. 42:
1. Ignition key - 2. Voltage regulator - 3. Starter motor - 4. Battery - 5. Alternator - 6. Pressure switch - 7. Low battery charge indicator - 8. Low oil pressure indicator.

CABLES: Colour x Section mm^2

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

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. amperometer (**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 amperometer 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.

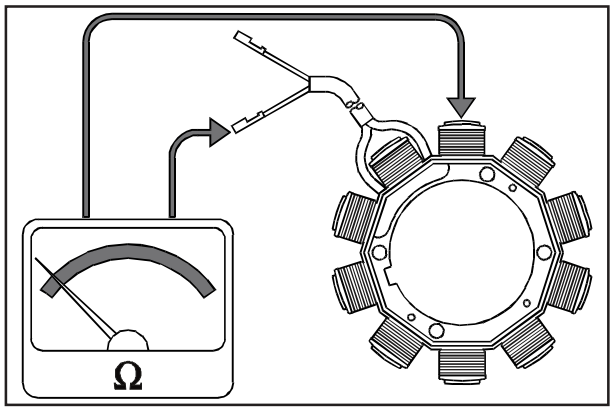


45

Checking the alternator

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

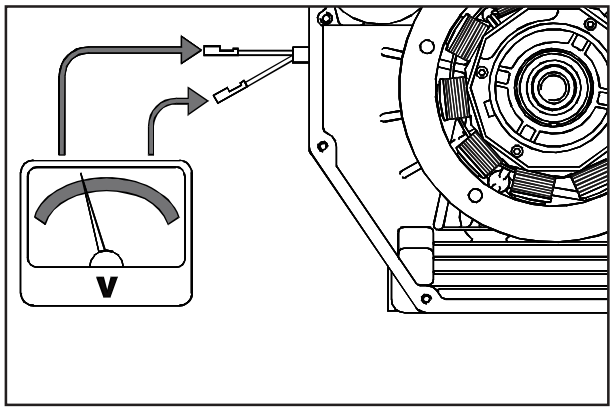
1. using an ohmmeter, that the windings (fig. 45, null resistance) and the insulation between wires and ground (fig. 46, infinite resistance) are unbroken. Replace the stator if interruptions are discovered;
2. with a voltmeter, the voltage between the two yellow wires (fig. 47). Accelerate the engine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

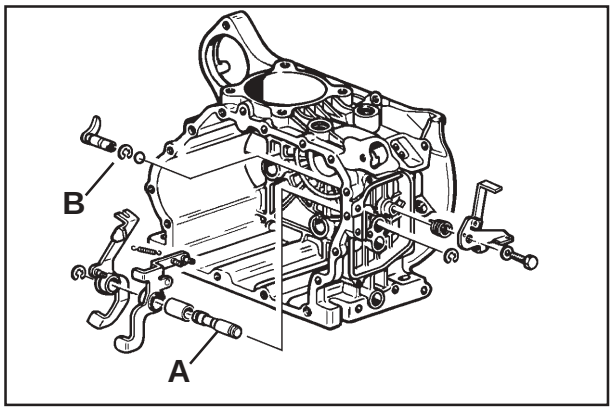
1. the alternator does not deliver current when the yellow cables are isolated
2. the alternator burns out if the yellow wires are grounded
3. the regulator may be damaged if the ground connection or electrical connections are made in a slapdash way.
4. the alternator and regulator will immediately burn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



47

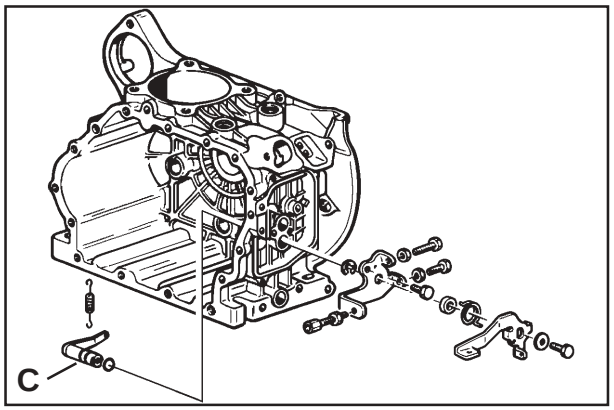
Ring gear

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 .



48

! 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.



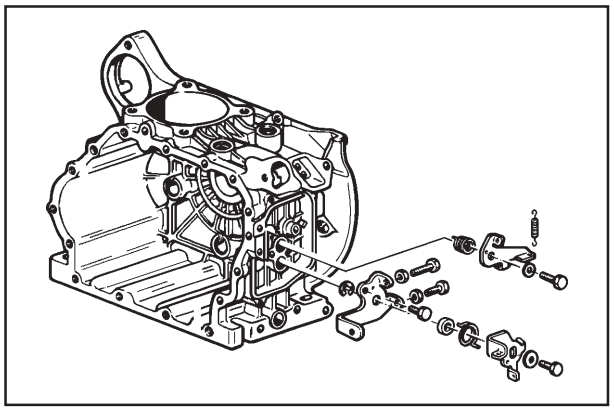
49

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.

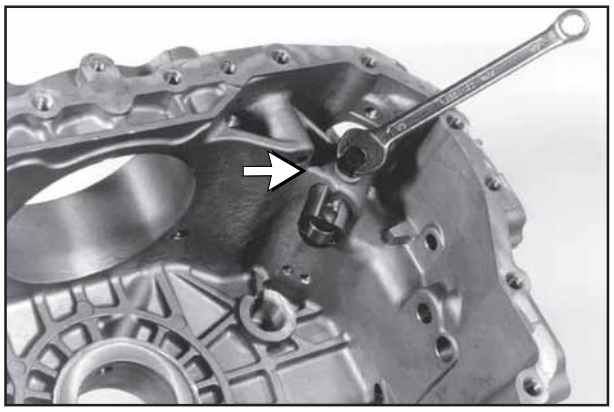
2. Mount the main bearing as indicated at page 18.

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.



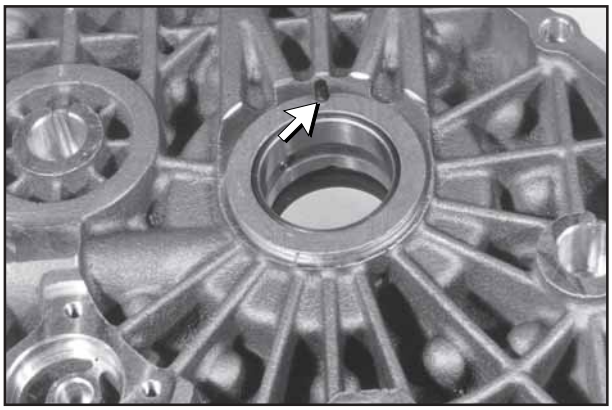
50

4. Comply with the sequence indicated in fig. 50 for the "motorstop" version.



51

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

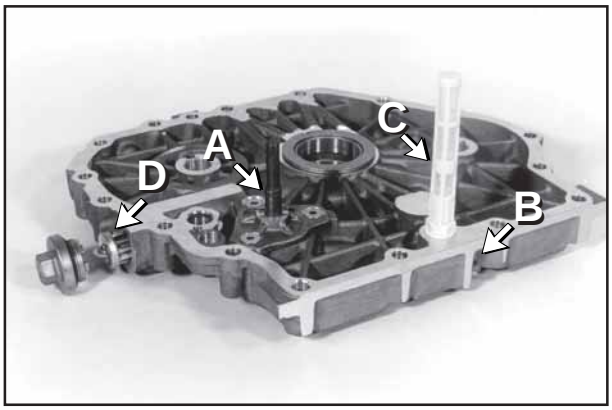


52

Timing system cover pre-assembly

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

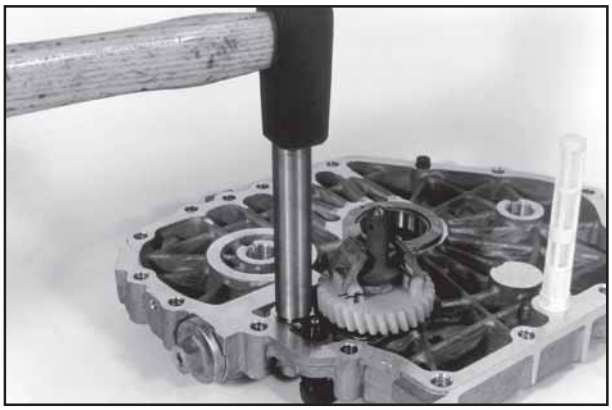
1. Mount the main bearing as indicated at page 18.
2. Fit in the pin and drive shaft bearing ring (fig 52).
3. Mount the oil pump rotors as described at page 23. Insert the plug and driving pin as shown in fig. 53-A. Fix the oil pump cover in place by tightening the screws to the following torque value:



53

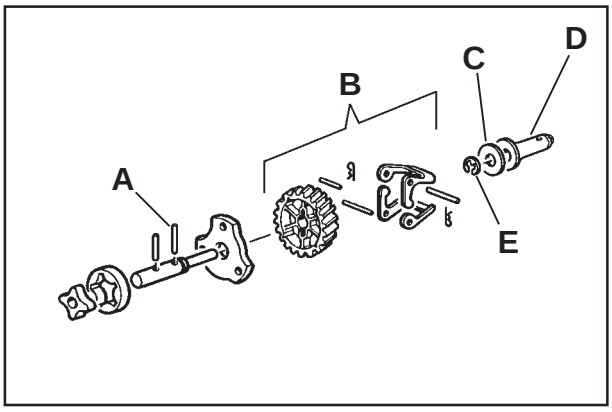
0,8 ÷ 1,0 kgm (7,8 ÷ 9,8 Nm)

4. Insert the by-pass valve using tool code **00366R0210** (fig. 54); mount the by-pass check screw with Loctite 648; mount the by-pass 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).



54

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.



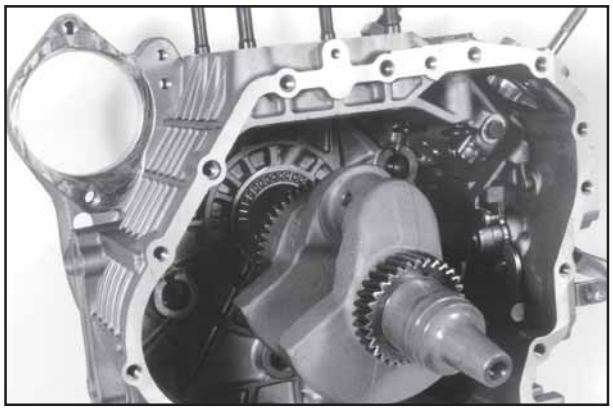
55

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.

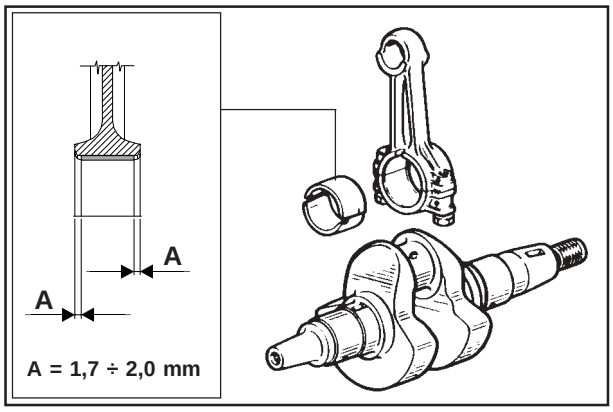
To assemble, preheat the gear to a temperature of about 180 to 200 °C, fit it on the shaft, taking care to ensure that the chamfer points towards the internal part, and use the tang as a reference.



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.

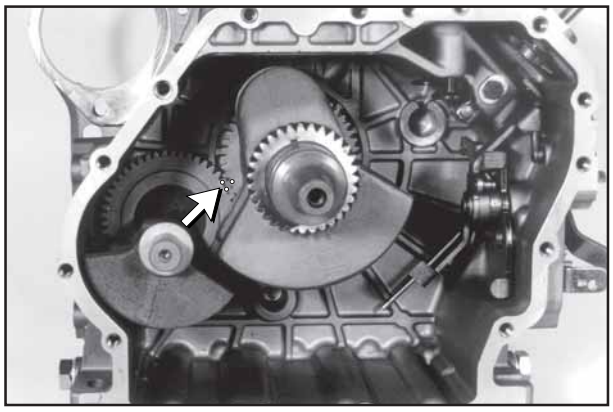


58

! 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.

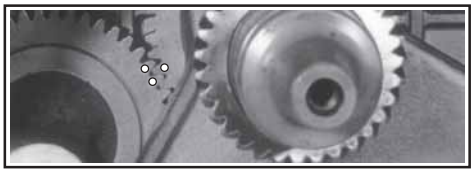
Evenly tighten the connecting rod bolts to the following value:

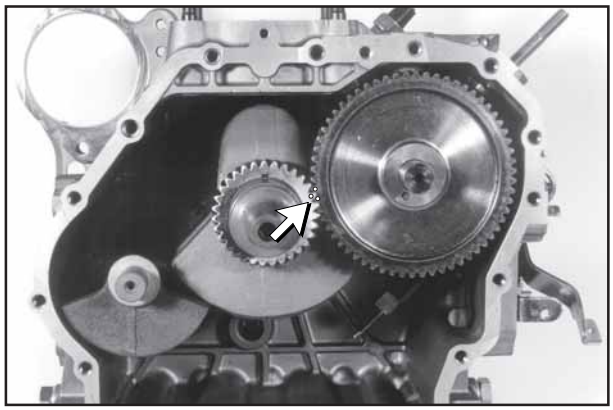
3,8 ÷ 3,9 kgm (37,3 ÷ 38,2 Nm)



59

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

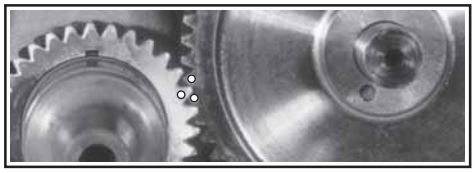


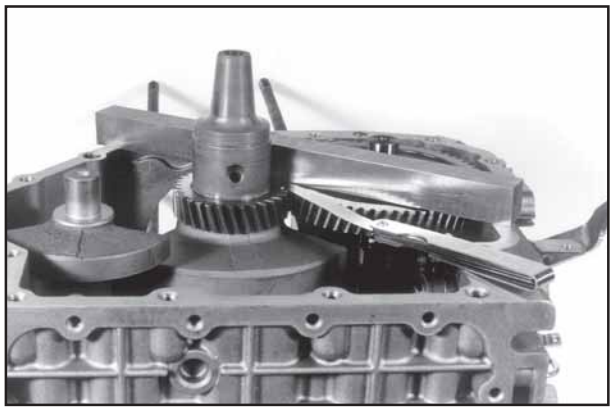


60

Camshaft

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





61

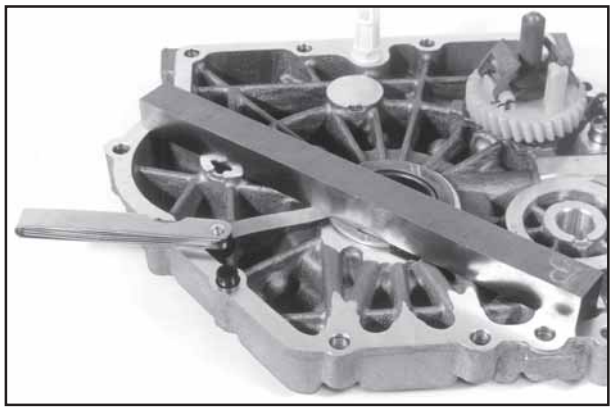
Play adjustment

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.

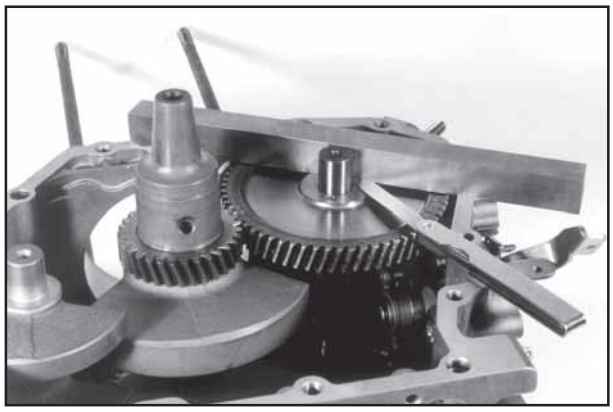
Place a calibrated bar on the cover of the timing system, on a level with the engine casing retention surface and use a thickness gauge to check the distance between the bearing ring and bar (fig. 62). Note down the value measured.

The sum of the two measured values must be within:



62

0,10 ÷ 0,30 mm

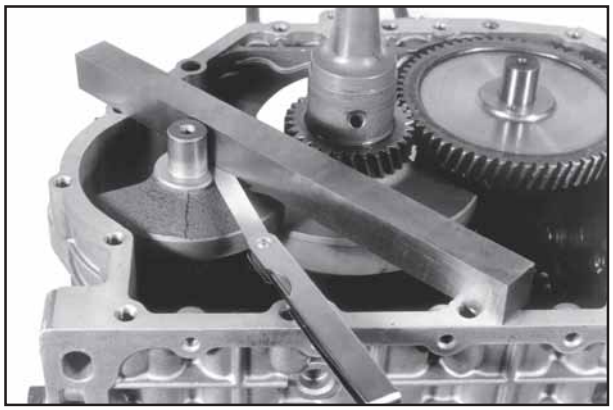


63

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



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

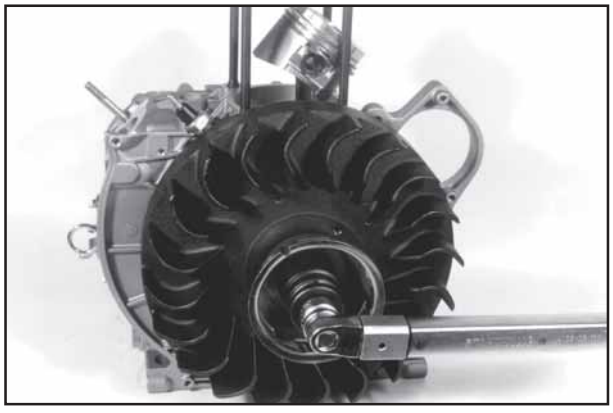
65

Cover on timing system side
Spread liquid seal of the AREXON D 0036 MOTORSIL 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

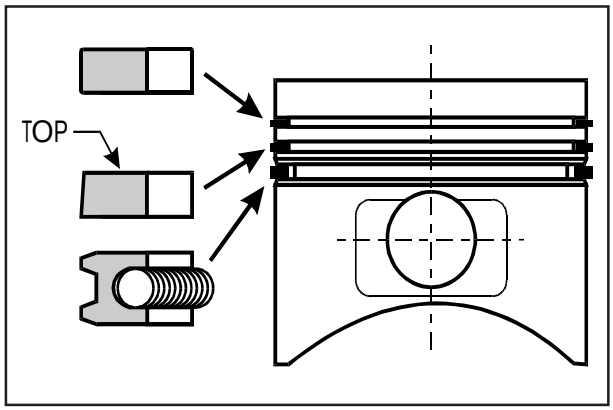
Oil retention rings
1. Immerse the retention ring in oil for about 10 minutes.
2. Clean the housing and insert the ring with a plug, exercising an even pressure all over the surface (fig.66).



67

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

18 ÷ 20 kgm (176,5 ÷ 196,1 Nm)



68

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.

69

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).

70

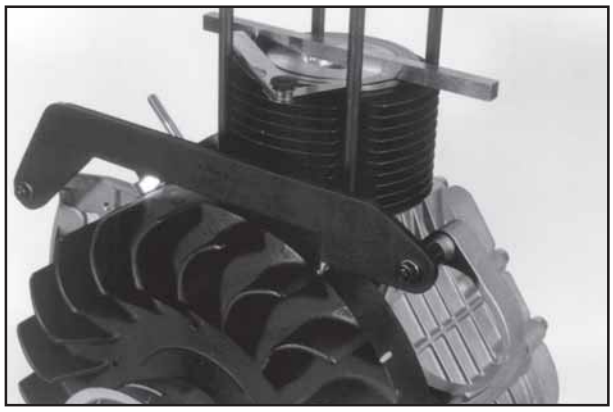
To obtain the correct clearance, use a head seal of adequate thickness:

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

Piston projection (mm)	Seal thickness (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



71

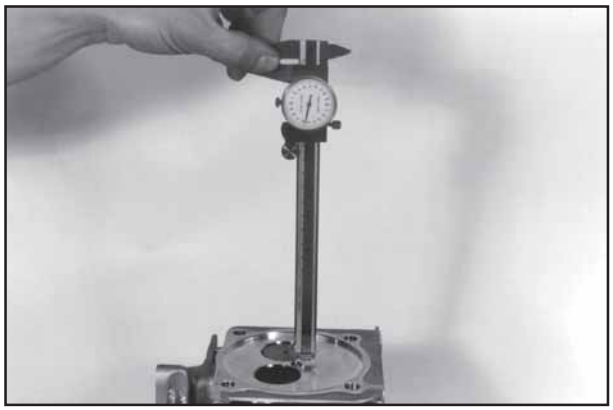
Head

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

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

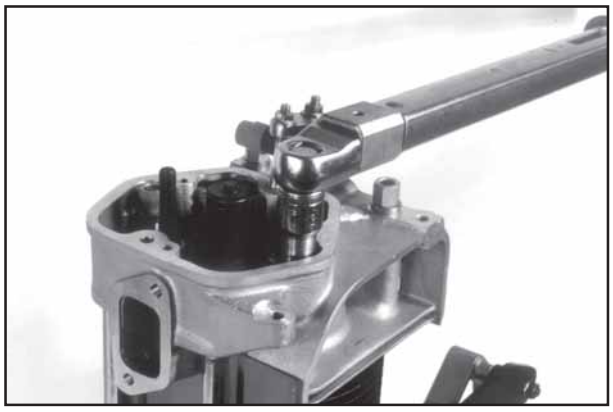
Insert the rocker arm casings, the partition (A, fig. 74), the head seal and the head. Tighten the head fixing nuts evenly and alternately (fig. 73) to the following value:

4 kgm (39,2 Nm)

! **NOTE:** To prevent oil leaks, apread 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):



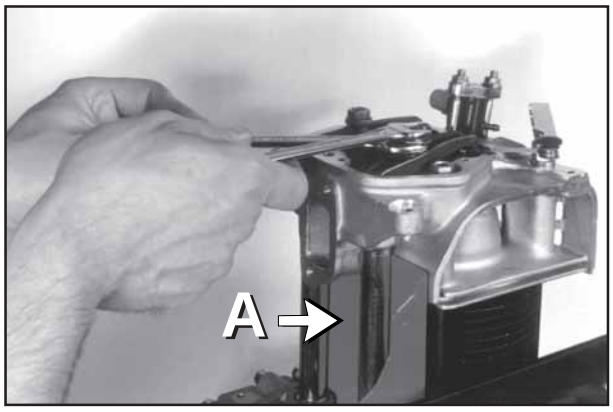
73

hot	0.15 mm (intake/exhaust)
cold	0.20 mm (intake/exhaust)

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

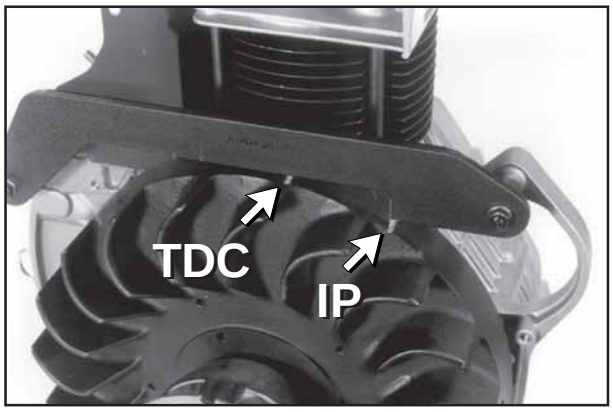
Injection lead

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:



74

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.



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! 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)

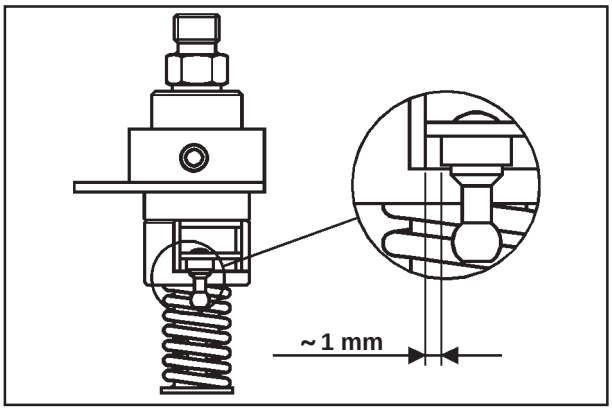
The punch marks on the flywheel indicate (fig. 75):

TDC = top dead center
IP = start of delivery

76

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)



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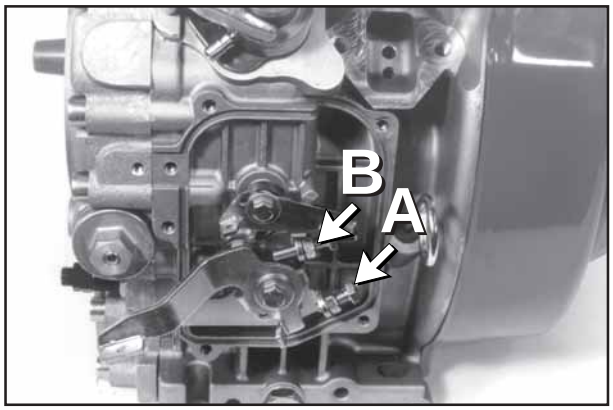
! **Warning:** consult section "*Braked engine test*" page 39, if the position of the injection pump in relation to the casing was not marked during the demounting operations or if a new one must be installed.

78

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)



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Rpm regulation

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

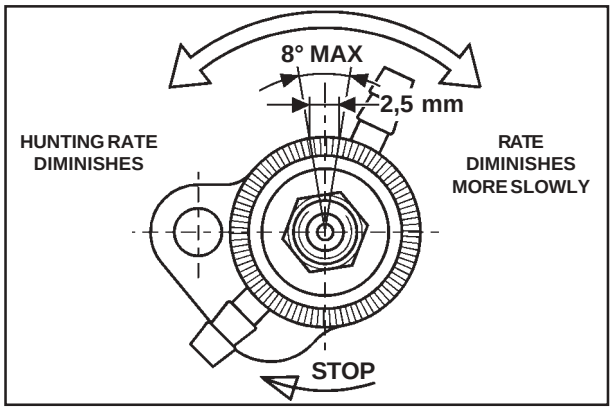
With the engine hot, adjust the idling rate (A, fig. 79) to **1,300 rpm** and the peak no-load rate (B, fig. 79) to:

- **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



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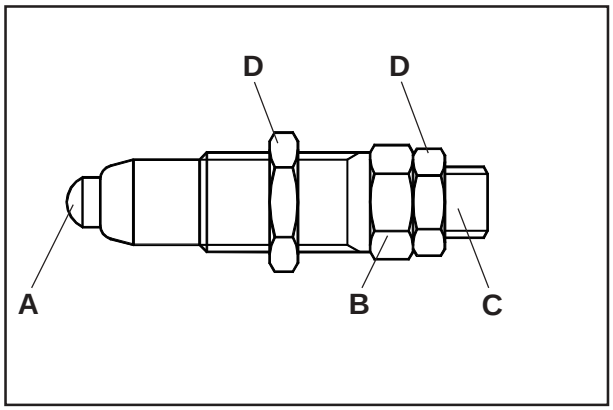
Running-in table

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.

XV STORAGE

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 manualy 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	0,30 ÷ 0,50	0,8
Oil scraper ring opening	0,25 ÷ 0,50	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

XVI QUICK REFERENCE CHARTS

Tightening torques	kgm	(Nm)
Timing system cover	2,7 ÷ 2,8	26,5 ÷ 27,5
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 **= 8.8** **R ≥ 800 N/mm²**		R10 **= R10 = 10.9** **R ≥ 1000 N/mm²**		R12 **= R12 = 12.9** **R ≥ 1200 N/mm²**	
Diameter x pitch **mm**	**Nm**	**kgm**	**Nm**	**kgm**	**Nm**	**kgm**
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

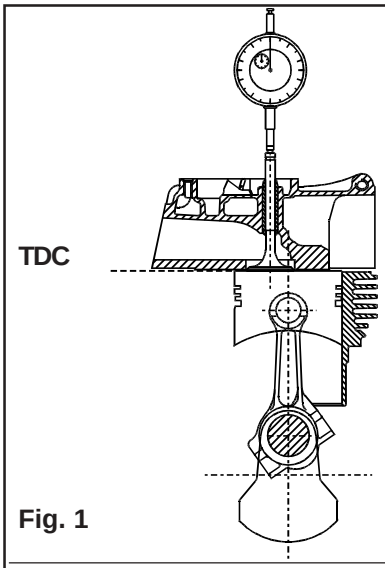


Fig. 1

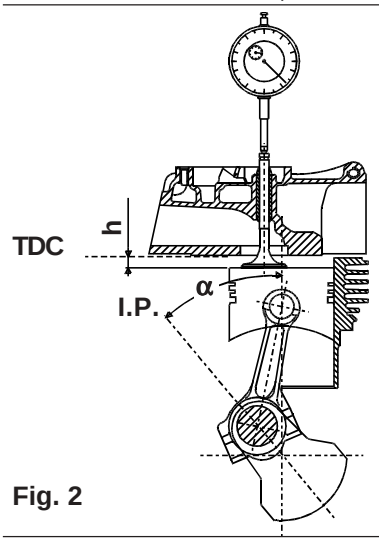


Fig. 2

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

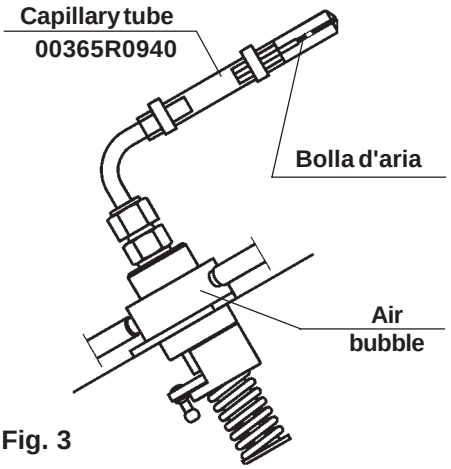


Fig. 3

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 fylwheel 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:

Comparative lead adjustment table

h	α
2,443 mm	17°
2,735 mm	18°
3,043 mm	19°
3,366 mm	20°
3,704 mm	21°
4,058 mm	22°
4,427 mm	23°
4,811 mm	24°

Seal thickness 0,10 mm = 0,8°

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