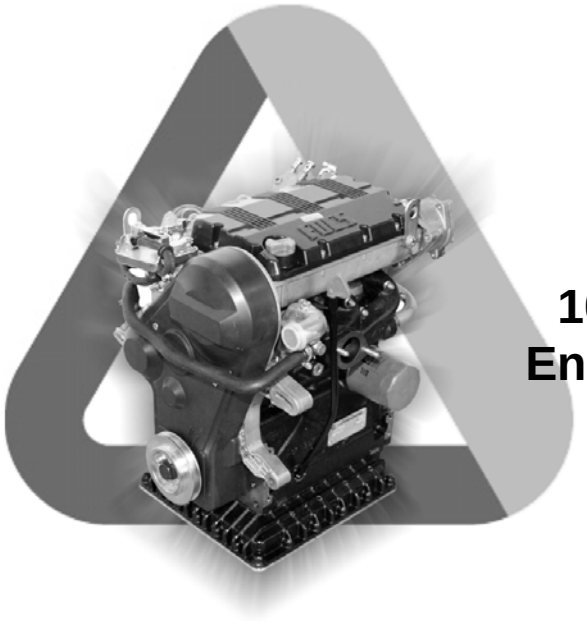
WORKSHOP MANUAL

1003 FOCS Engine Series

cod. 1-5302-858

UNI EN ISO 9001 - cert. n° 0446
ISO/TS 16949 - cert. n° 3792

LOMBARDINI SERVICE
A KOHLER COMPANY



1003 FOCS Engine Series

PREFACE

- Every attempt has been made to present within this service manual, accurate and up to date technical information.
  However, development on the **LOMBARDINI** series is continuous.
  Therefore, the information within this manual is subject to change without notice and without obligation.

- The information contained within this service manual is the sole property of **LOMBARDINI**.
  As such, no reproduction or replication in whole or part is allowed without the express written permission of **LOMBARDINI**.

Information presented within this manual assumes the following:

1 - The person or people performing service work on **LOMBARDINI** series engines is properly trained and equipped to safely and professionally perform the subject operation;

2 - The person or people performing service work on **LOMBARDINI** series engines possesses adequate hand and **LOMBARDINI** special tools to safely and professionally perform the subject service operation;

3 - The person or people performing service work on **LOMBARDINI** 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 **LOMBARDINI** 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.

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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
CUSE/ATLO	1-5302-858	51199	**1**	**0**	31.10.2008	31.10.2008	

This manual contains pertinent information regarding the repair of LOMBARDINI water-cooled, indirect injection Diesel engines type **LDW 1003**: updated October 31st, 2008.

CHAPTER INDEX

WARRANTY CERTIFICATE

- The products manufactured by **LOMBARDINI** S.r.l. 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** S.r.l. 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** S.r.l. directly or through its authorized network will repair and/or replace free of charge any own part or component that, upon examination by **LOMBARDINI** S.r.l. or by an authorized **LOMBARDINI** S.r.l. 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 S.r.l. warranty obligations here above described will be cancelled if:

- **LOMBARDINI** S.r.l. engines are not correctly installed and as a consequence the correct functional parameters are not respected and altered.
- **LOMBARDINI** S.r.l. 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** S.r.l. has been tampered with or removed.
- Spare parts used are not original **LOMBARDINI** S.r.l..
- 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** S.r.l..
- 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** S.r.l. 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** S.r.l. service agents.

GENERAL SERVICE MANUAL NOTES

1 - Use only genuine **LOMBARDINI** S.r.l. repair parts.
Failure to use genuine **LOMBARDINI** S.r.l. parts could result in sub-standard performance and low longevity.

2 - All data presented are in metric format. That is, dimensions are presented in millimeters (mm), torque is presented in Newton-meters (Nm), weight is presented in kilograms (Kg), volume is presented in liters or cubic centimeters (cc) and pressure is presented in barometric units (bar).

GLOSSARY AND TERMINOLOGY

For clarity, here are the definitions of a number of terms used recurrently in the manual.

- **Cylinder number one:** is the flywheel side piston .
- **Rotation direction:** anticlockwise «viewed from the flywheel side of the engine».

SAFETY AND WARNING DECALS

- Important remarks and features of the text are highlighted using symbols, which are explained below:

Danger – Attention

This indicates situations of grave danger which, if ignored, may seriously threaten the health and safety of individuals.

Caution – Warning

This indicates that it is necessary to take proper precautions to prevent any risk to the health and safety of individuals and avoid financial damage.

Important

This indicates particularly important technical information that should not be ignored.

SAFETY REGULATIONS

– **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.
– 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.

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.
– A number of procedures must be carried out with the aid of equipment and tools that simplify and improve the timing of operations.
– 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.

TROUBLE SHOOTING

THE ENGINE MUST BE STOPPED IMMEDIATELY WHEN:

1) - The engine rpms suddenly increase and decrease;
2) - A sudden and unusual noise is heard;
3) - The colour of the exhaust fumes suddenly darkens;
4) - The oil pressure indicator light turns on while running.

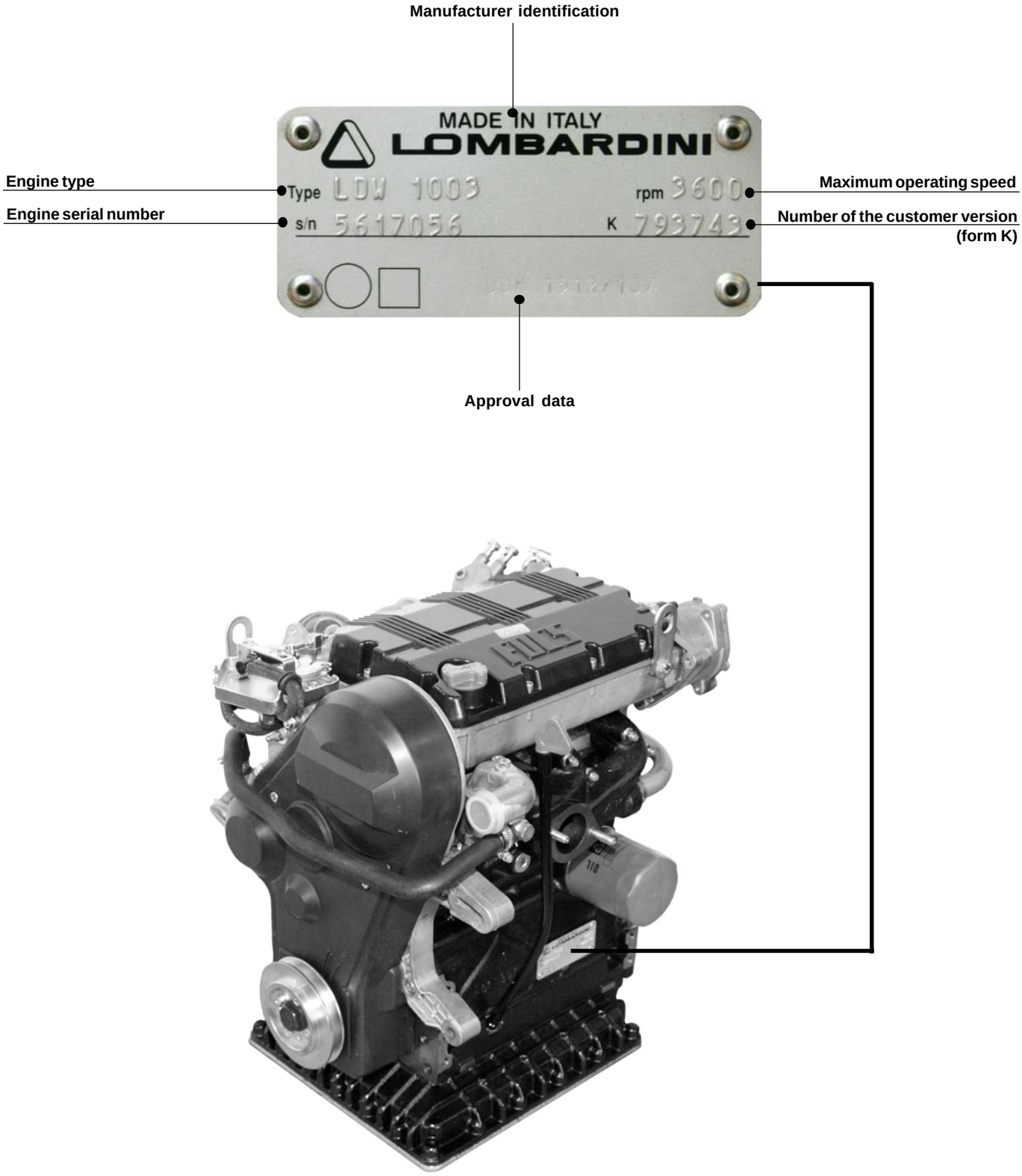
TABLE OF LIKELY ANOMALIES AND THEIR SYMPTOMS

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	Oil preassure too low	Oil level increase	Excessive oil consumption	Oil and fuel dripping from the exhaust	Engine overheats	Inadequate performance	High noise level
FUEL CIRCUIT	Clogged fuel pipes	■	■	■	■								■	
	Clogged fuel filter	■	■	■	■								■	
	Air or water in the fuel circuit	■	■	■	■		■						■	
	Tank cap breather blocked	■	■	■	■								■	
	Faulty fuel pump	■	■	■	■				■				■	
	Lack of fuel	■	■											
ELECTRIC SYSTEM	Glow plug fuse burned	■												
	Faulty glow plug control relay	■												
	Flat battery	■												
	Unclear or mistaken cable connection	■												
	Faulty starter switch	■												
	Faulty starting motor	■												
	Faulty glow plugs	■					■							
MAINTENANCE	Clogged air filter	■	■	■	■	■				■			■	
	Prolonged operation at idle						■			■	■			
	Incomplete run-in						■			■			■	
	Overloaded engine	■	■	■		■				■		■		
SETTINGS REPAIRS	Excessive valve clearances												■	■
	Absence of valve clearances	■												
	Incorrect speed governor leverages	■			■								■	
	Speed governor spring broken or disengaged		■	■										
	Idle low		■		■	■				■	■			
	Worn out or stuck rings	■					■			■	■	■	■	
	Worn out cylinders	■					■			■	■	■	■	
	Worn out valve guides						■			■	■	■	■	
	Bad valve seal	■				■				■	■	■	■	
	Bearing shells of bearing cap - piston rod - rocker worn out							■		■		■	■	■
	E.G.R. valve blocked open					■								
	Governor leverages not running	■	■	■	■									
	Cylinder head gasket damaged	■							■	■		■	■	■
	Faulty timing system	■												■
	Supplementary starter spring broken or disengaged	■												

POSSIBLE CAUSE		TROUBLE												
		Engine does not start	Engine starts but stops	No acceleration	Non-uniform speed	Black smoke	White smoke	Oil preassure too low	Oil level increase	Excessive oil consumption	Oil and fuel dripping from the exhaust	Engine overheats	Inadequate performance	High noise level
LUBRICATION CIRCUIT	High oil level				■		■			■		■	■	
	Low oil level					■		■				■	■	
	Dirty or blocked pressure regulation valve Worn oil pump					■		■				■	■	
	Air to the oil suction hose					■		■				■	■	
	Faulty manometer or pressure switch					■		■				■	■	
	Oil in sump suction hose blocked							■						
	Oil in sump drainage pipe blocked					■		■				■	■	
	Faulty spray nozzles (Turbo engines only)											■	■	
						■				■		■	■	
INJECTION	Damaged injector	■			■	■	■				■	■	■	■
	Damaged injection pump valve	■			■		■					■	■	■
	Incorrectly calibrated injector				■	■	■					■	■	
	Worn or damaged pumping element	■			■	■			■			■	■	■
	Incorrect injection pump delivery setting (delivery equalisation)			■	■	■						■	■	■
	Hardened pump/injector control rod	■	■	■	■								■	
	Cracked or broken pre-combustion chamber	■			■	■						■	■	■
	Incorrect adjustment of the injection systems (delivery equalisation advance)	■		■	■	■	■					■	■	■
COOLING CIRCUIT	Insufficient refrigerant fluid											■		
	Defective fan, radiator, or radiator cap											■		
	Defective thermostatic valve						■					■		
	Loss of refrigerant fluid from the radiator, hoses, engine crankshaft or water pump.											■		
	Inside of radiator or coolant lines obstructed.											■		
	Defective or worn water pump											■		
	Alternator fan drive belt loose or torn											■		
	Heat exchange surface of the radiator clogged											■		

MANUFACTURER AND ENGINE IDENTIFICATION

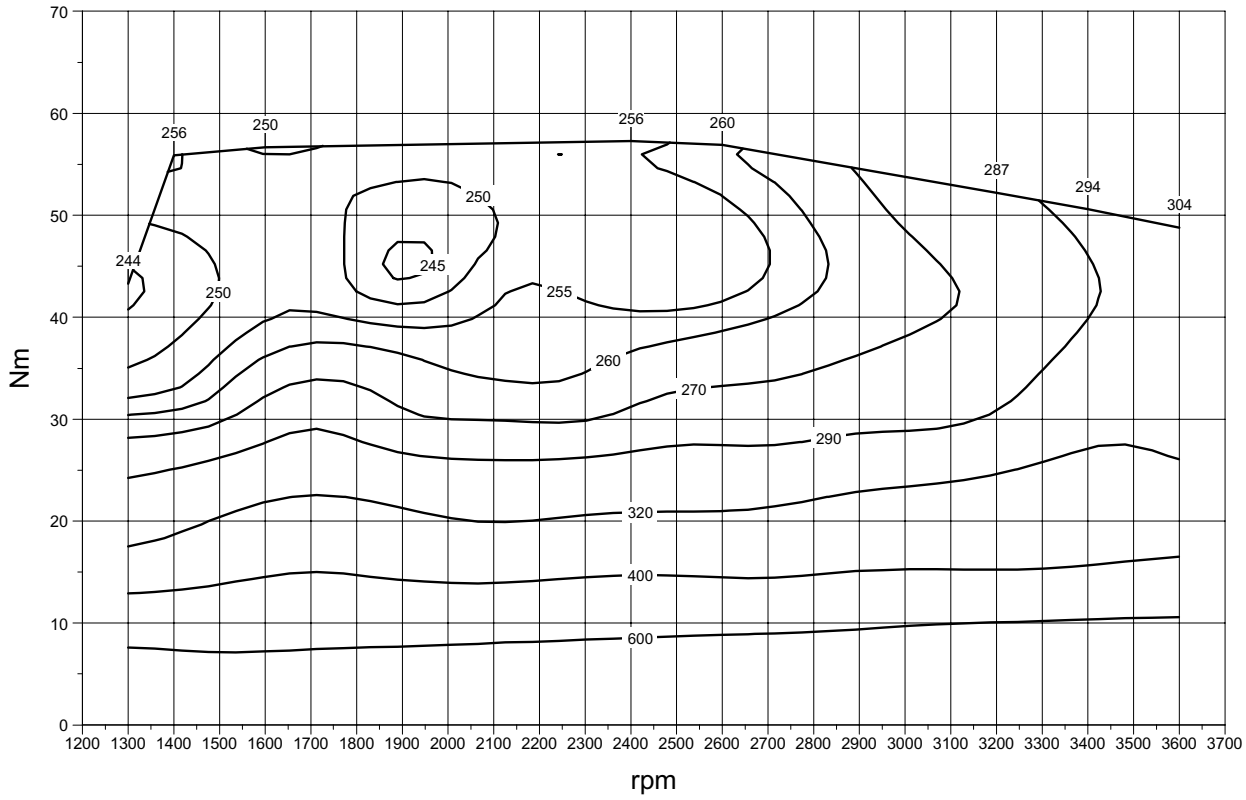


ENGINE TYPE			LDW 1003
Cylinders		N°	3
Bore		mm	75
Stroke		mm	77.6
Displacements		Cm³	1028
Compression rate			22,8:1
Rpm			3600
Maximum power	N 80/1269/CEE-ISO 1585-DIN 70020		19
Maximum torque		Nm	58
		RPM	@ 2200
Specific fuel consumption**		g/KWh	300
Oil consumption **		Kg/h	0,013
Dry weight of engine		Kg	87
Combustion air volume at 3600 Rpm		l./1'	1850
Cooling air volume at 3600 Rpm		m³/min	63
Axial load allowed on crankshaft (both directions)		Kg.	300
Max tilt	Instant operation (up to 1 min)	**α**	35°
	Intermittent operation (up to 30 min)	**α**	25°

** At max. power

PERFORMANCE DIAGRAMS

LDW 1003



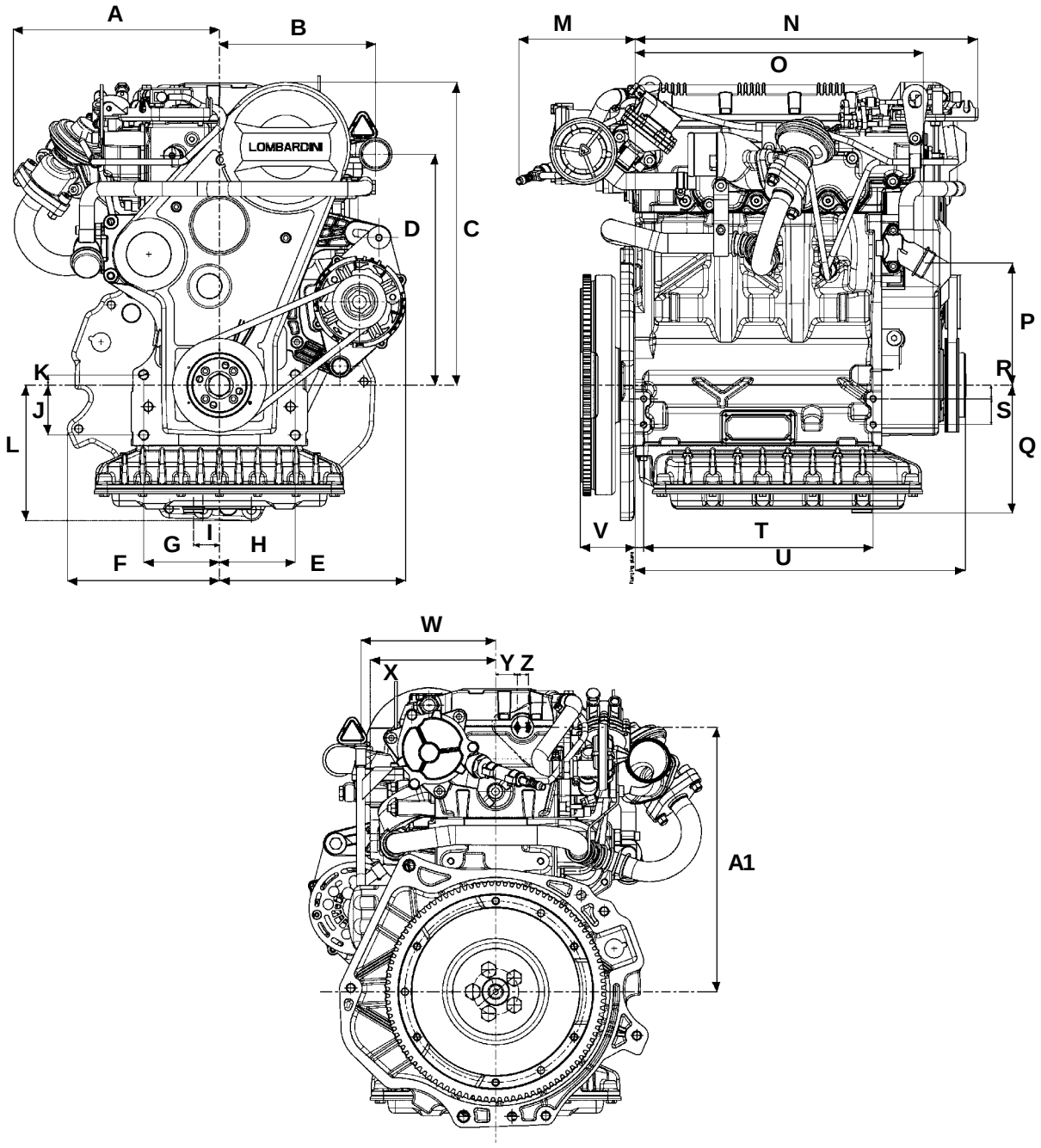
N (80/1269/CEE - ISO 1585 - DIN 70020)
AUTOMOTIVE RATING: intermittent operation with variable speed and variable load.

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.

Important
Non-approval by Lombardini for any modifications releases the company from any damages incurred by the engine.

TECHNICAL SPECIFICATIONS



DIMENSIONS (mm)					
A	239,1	**J**	58	**S**	30
B	181,2	**K**	12	**T**	266
C	351,7	**L**	157,4	**U**	383
D	268,1	**M**	135	**V**	63,5
E	216	**N**	397,7	**W**	155,8
F	176,3	**O**	334,5	**X**	145,2
G	88	**P**	141,9	**Y**	25
H	86	**Q**	148,7	**Z**	13
I	30	**R**	16	**A1**	306,1

ROUTINE ENGINE MAINTENANCE

Important

Non compliance with the instructions provided in the chart entails risk of technical damages to the machine and/or the system. Carry out maintenance regularly (after predefined number of km, or within the time intervals scheduled). Continue the periodical maintenance after 100,000 km by starting from 7,500 km.

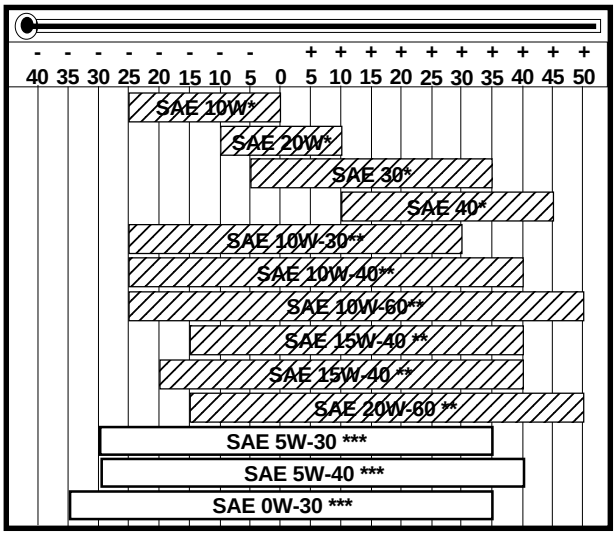
ORDINARY MAINTENANCE

	(x 1000 Km)	FREQUENCY x KM															
		1	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
			(6)	1	1,5	2	2,5	3	3,5	4	4,5	5	5,5	6	6,5	7	7,5
OPERATION	**COMPONENT**																
CLEANING	Radiator fins	EVERY 10.000 Km															
CHECK	Valve and rocker arms clearance			■		■		■		■		■		■		■	
	Engine oil	EVERY 3.500 Km															
	Solenoid valve operation			■		■		■		■		■		■		■	
	Fuel pipes and connections	■		■		■		■		■		■		■		■	
	Coolant	■	EVERY 3.500 Km														
	Alternator belt	■		■		■		■		■		■		■		■	
	Timing belt	EVERY 50.000 Km															
REPLACEMENT	Air filter element	EVERY 10.000 Km															
	Engine oil	■	EVERY 10.000 Km														
	Oil filter	■	EVERY 10.000 Km														
	Fuel filter				■			■			■			■			■
	Coolant					■				■				■			
	Alternator belt				■			■			■			■			■
	Timing belt	EVERY 100.000 km (or when disassembling)															
	Fuel pipe	EVERY 4 years															

LUBRICANT

SAE Classification

In the SAE classification, oils differ on the basis of their viscosity, and no other qualitative characteristic is taken into account.
The first number refers to the viscosity when the engine is cold (symbol W = winter), while the second considers viscosity with the engine at régime.
The criteria for choosing must consider, during winter, the lowest outside temperature to which the engine will be subject and the highest functioning temperature during summer.
Single-degree oils are normally used when the running temperature varies scarcely.
Multi-degree oil is less sensitive to temperature changes.



SAE- Grade

** Mineral base*
*** Semi-synthetic base*
**** Synthetic base*

International specifications

They define testing performances and procedures that the lubricants need to successfully respond to in several engine testing and laboratory analysis so as to be considered qualified and in conformity to the regulations set for each lubrication kind.
A.P.I : (American Petroleum Institute)
MIL : Engine oil U.S. military specifications released for logistic reasons
ACEA : European Automobile Manufacturers Association
Tables shown on this page are of useful reference when buying a kind of oil.
Codes are usually printed-out on the oil container and the understanding of their meaning is useful for comparing different brands and choosing the kind with the right characteristics.
Usually a specification showing a following letter or number is preferable to one with a preceding letter or number.
An SF oil, for instance, is more performing than a SE oil but less performing than a SG one.

ACEA Regualtions - ACEA Sequences

LIGHT DUTY DIESEL ENGINES

B1 = Low-viscosity, for frictions reduction
B2 = Standard
B3 = High performances (indirect injection)
B4 = High quality (direct injection)

HEAVY DUTY DIESEL ENGINES

E1 = OBSOLETE

E2 = Standard
E3 = Heavy conditions (Euro 1 - Euro 2 engines)
E4 = Heavy conditions (Euro 1 - Euro 2 - Euro 3 engines)
E5 = High performances in heavy conditions (Euro 1 - Euro 2 - Euro 3 engines)

API / MIL Sequences

	DIESEL								PETROL							
API	CH-4	CG-4	CF-4	CF-2	CF	CE	CD	CC	SC	SD	SE	SF	SG	SH	SJ	SL
MIL					L- 46152 D / E											

CURRENT / OBSOLETE

PRESCRIBED LUBRICANT

AGIP SINT 2000 5 W 40	specifications	**API SJ / CF 4 ACEA A3-96 B3-96 MIL - L-46152 D/E**

In the countries where AGIP products are not available, use oil API CF/SH for Diesel engines or oil corresponding to the military specification MIL-L-2104 C/46152 D.

OIL CAPACITY		LDW 1003	
OIL VOLUME (OIL FILTER INCLUDED)	Litres	max	**4,1**
		min	**3,1**
OIL VOLUME (WITHOUT OIL FILTER)	Litres	max	**4,0**
		min	**3,0**

Danger – Attention

- **The engine may be damaged if operated with insufficient lube oil. It is also dangerous to supply too much lube oil to the engine because a sudden increase in engine rpm could be caused by its combustion.**
- **Use proper lube oil preserve your engine. Good quality or poor quality of the lubricating oil has an affect on engine performance and life.**
- **If inferior oil is used, or if your engine oil is not changed regularly, the risk of piston seizure, piston ring sticking, and accelerated wear of the cylinder liner, bearing and other moving components increases significantly.**
- **Always use oil with the right viscosity for the ambient temperature in which your engine is being operated.**

Danger – Attention

- **The used engine oil can cause skin-cancer if kept frequently in contact for prolonged periods.**
- **If contact with oil cannot be avoided, wash carefully your hands with water and soap as soon as possible.**
- **Do not disperse the oil in the ambient, as it has a high pollution power.**

COOLANT

Danger – Attention

- **The fluid coolant circuit is pressurized. Inspections must only be made when the engine has cooled and even in this case, the radiator or expansion chamber plug must be unscrewed with the utmost caution.**
- **If an electric fan is installed, do not approach a hot engine since the fan itself could start up even when the engine is at a standstill.**
- **Coolant fluid is polluting, it must therefore be disposed of in the correct way. Do not litter.**

The anti-freeze protection liquid (AGIP ANTIFREEZE SPEZIAL) must be used mixed with water, preferably decalcified. The freezing point of the cooling mixture depends on the product concentration in water, it is therefore recommended to use a 50% diluted mixture which guarantees a certain degree of optimal protection. As well as lowering the freezing point, the permanent liquid also raises the boiling point.

Coolant refueling

ENGINE TYPE	LDW 1003
CAPACITY (Litres) Without radiator	1,30

For information concerning the capacity of Lombardini radiators, please contact Lombardini directly.
The total volume for refilling the cooling liquid varies according to the type of engine and radiator.

FUEL RECOMMENDATIONS

Purchase diesel fuel in small quantities and store in clean, approved containers. Clean fuel prevents the diesel fuel injectors and pumps from clogging. Do not overfill the fuel tank.
Leave room for the fuel to expand. Immediately clean up any spillage during refueling.

Never store diesel fuel in galvanized containers; diesel fuel and the galvanized coating react chemically to each other, producing flaking that quickly clogs filters or causes fuel pump or injector failure.

High sulfur content in fuel may cause engine wear. In those countries where diesel has a high sufur content, its is advisable to lubricate the engine with a high alkaline oil or alternatively to replace the lubricating oil recommended by the manufacturer more frequently. The regions in which diesel normally has a low sulfur content are Europe, North America, and Australia.

PRESCRIBED LUBRICANT	
Fuel with low sulphur content	**API CF4 - CG4**
Fuel with high sulphur content	**API CF**

FUEL TYPE

For best results, use only clean, fresh, commercial-grade diesel fuel. Diesel fuels that satisfy the following specifications are suitable for use in this engine: ASTM D-975 - 1D or 2D, EN590, or equivalent.

FUELS FOR LOW TEMPERATURES

It is possible to run the engine at temperatures below 0°C using special winter fuels. These fuels reduce the formation of paraffin in diesel at low temperatures. If paraffin forms in the diesel, the fuel filter becomes blocked interrupting the flow of fuel.

Fuel can be:
- Summer up to 0°C
- Winter up to -10°C
- Alpine up to -20°C
- Arctic up to -30°C

BIODIESEL FUEL

Fuels containing less than 20% methyl ester or B20, are suitable for use in this engine. Biodiesel fuels meeting the specification of BQ-9000 or equivalent are recommended. DO NOT use vegetable oil as a biofuel for this engine.
Any failures resulting from the use of fuels other than recommended will not be warranted.

EMISSION CONTROL INFORMATION

LOW SULFUR FUEL OR ULTRA LOW SULFUR FUEL ONLY

EPA /CARB emission label must be attached near the fuel inlet.

AVIATION FUEL

Aviation fuels suitable for use in this engine include JP5, JP4, JP8 and, JET-A (if 5 percent oil is added).

RECOMMENDATIONS FOR DISASSEMBLING AND ASSEMBLING

Important

To locate specific topics, the reader should refer to the index.

- 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 proper repair operations.
- The operator must wash, clean and dry components and assemblies before installing them.
- The operator must make sure that the contact surfaces are intact, lubricate the coupling parts and protect those that are prone to oxidation.
- Before any intervention, the operator should lay out all equipment and tools in such a way as to enable him to carry out operations correctly and safely.
- For safety and convenience, you are advised to place the engine on a special rotating stand for engine overhauls.
- Before proceeding with operations, make sure that appropriate safety conditions are in place, in order to safeguard the operator and any persons involved.
- In order to fix assemblies and/or components securely, the operator must tighten the fastening parts in a criss-cross or alternating pattern.
- Assemblies and/or components with a specific tightening torque must initially be fastened at a level lower than the assigned value, and then subsequently tightened to the final torque.

RECOMMENDATIONS FOR OVERHAULS AND TUNING

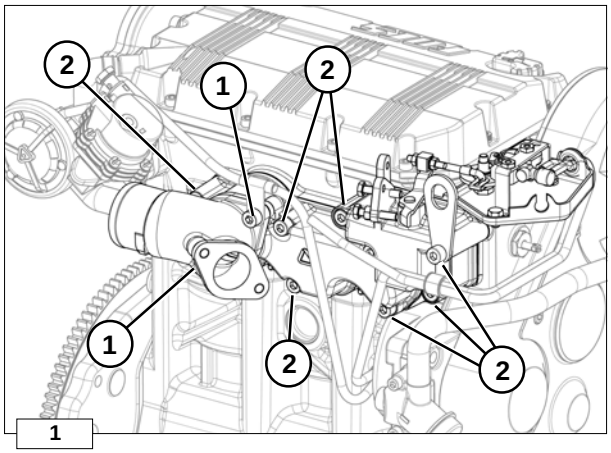
Important

To locate specific topics, the reader should refer to the index.

- Before any intervention, the operator should lay out all equipment and tools in such a way as to enable him to carry out operations correctly and safely.
- The operator must comply with the specific measures described in order to avoid errors that might cause damage to the engine.
- Before carrying out any operation, clean the assemblies and/or components thoroughly and eliminate any deposits or residual material.
- Wash the components with special detergent and do not use steam or hot water.
- Do not use flammable products (petrol, diesel, etc.) to degrease or wash components. Use special products.
- Dry all washed surfaces and components thoroughly with a jet of air or special cloths before reassembling them.
- Apply a layer of lubricant over all surfaces to protect them against oxidation.
- Check all components for intactness, wear and tear, seizure, cracks and/or faults to be sure that the engine is in good working condition.
- Some mechanical parts must be replaced *en bloc*, together with their coupled parts (e.g. valve guide/valve etc.) as specified in the spare parts catalogue.

Danger - Attention

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

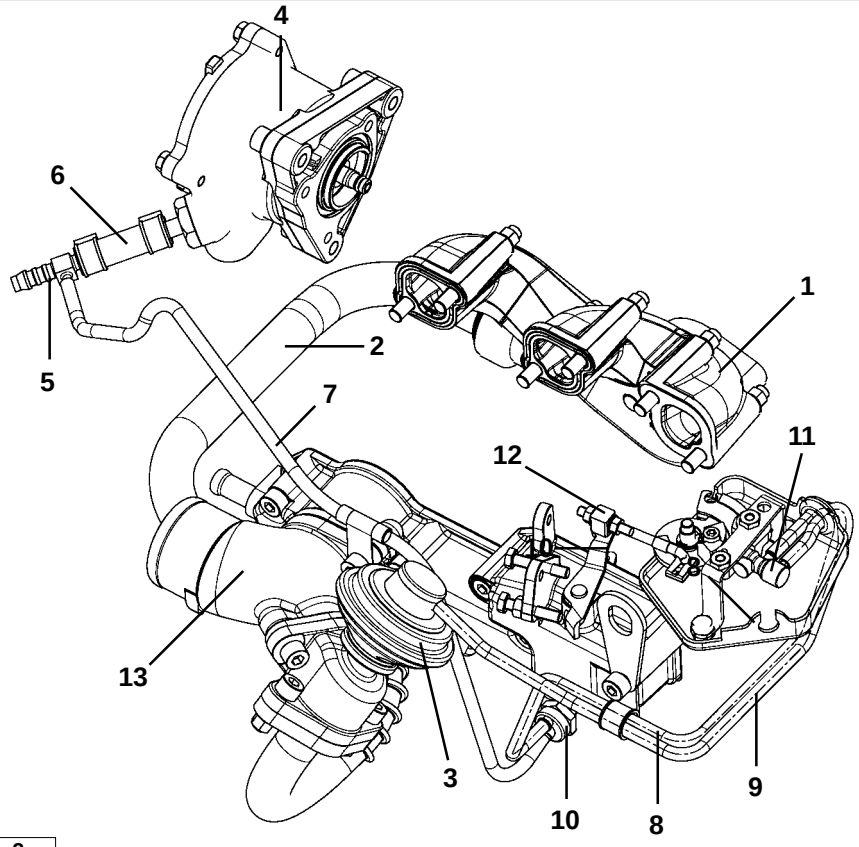


1

Intake manifold – Remote air filter

- Unscrew the the fastening screws **1** that fix the intake duct to the intake manifold unit.
- Unscrew the two fastening screws **2** of the intake manifold from the engine crankcase.
- Disassemble the inlet manifold by disengaging the hook of the min/max cylinder from the manifold.

E.G.R. CIRCUIT



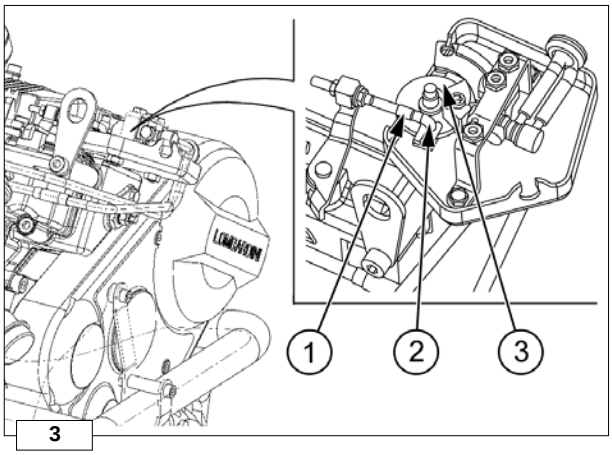
2

Components:

1. Exhaust manifold
2. E.G.R. Pipe
3. E.G.R. Valve
4. Vacuum pump
5. Three way union
6. Vacuum pump pipe
7. Thermovalve – vacuum pump connection pipe
8. Vacuum valve – thermovalve connection pipe
9. Vacuum valve - E.G.R. connection pipe
10. Thermovalve
11. Vacuum valve
12. ON-OFF sensor control cam
13. Intake duct

Operation

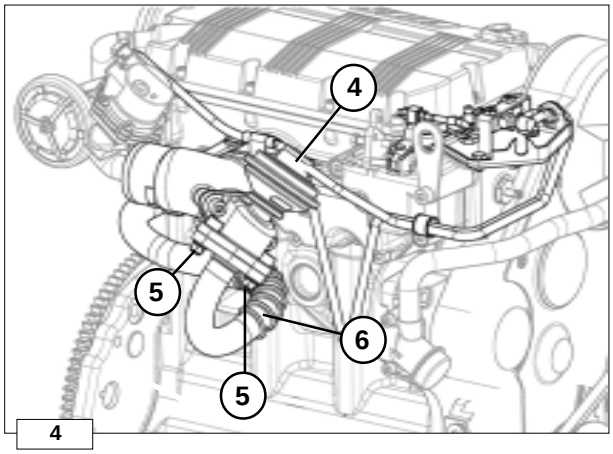
The main function of the E.G.R. (Exhaust Gas Recirculation) system is the reduction in emission of NOx (nitrogen oxides), gases harmful to people and the environment, via lowering the combustion temperature.
The system takes a certain quantity of exhaust gas from the exhaust manifold **1** (fig. 2) via the E.G.R. pipe **2** to the E.G.R. valve **3**.
This valve is opened by the vacuum (created in pipes **6**, **7**, **8** and **9** by vacuum pump **4**; fig. 2) only when:
a) thermovalve **10** placed in contact with the engine refrigerant fluid reaches a temperature of 40 °C;
b) the on-off sensor control cam **12** opens the vacuum valve **11** at a determined accelerator position.
Once the E.G.R. valve is opened, the exhaust gas enters the intake manifold **13** via the intake flange.
The same logic controls the closure of the E.G.R. valve.



3

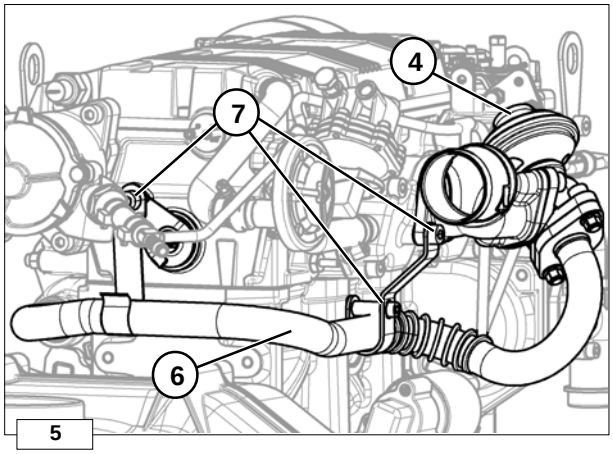
E.G.R. Circuit
Disassembly:

- Disengage the control rod catch **1** with a screwdriver from the accelerator control rod **2** (fig. 3).
- Disconnect the accelerator control rod from the accelerator control lever **3** (fig. 3).



4

- Disconnect the thermovalve – vacuum pump connection pipes (**7**, fig. 2) and vacuum valve – thermovalve connection pipe (**8**, fig. 2) from the thermovalve (**10**, fig.2).
- Unscrew the two fastening screws **5** that fix the E.G.R. pipe **6** to the E.G.R. valve **4** (fig. 4).



5

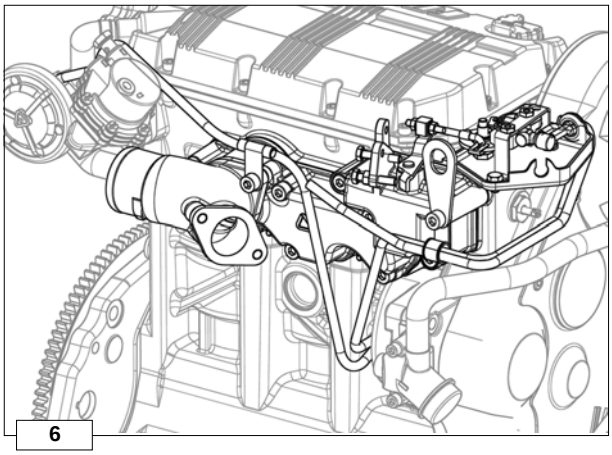
- Remove the intake manifold. See "Intake manifold – Remote air filter" on page 23 (Figure 1).
- Unscrew the fastening screws of the E.G.R. pipe support bracket **7** (fig. 5) from the engine crankcase and disengage the E.G.R. pipe from the exhaust manifold.

Reassembly:

When reassembling pay attention to the repositioning of the gaskets and to the precise connection of the pipes (**6**, **7**, **8**, **9**, fig. 2).
These pipes should be carefully fitted on the appropriate connections.

❍ Tighten the screws to specified torque, see "Table of tightening torques for the main components" on page 80.

➲ For the calibration of the E.G.R. system see "E.G.R. calibration" on page 77.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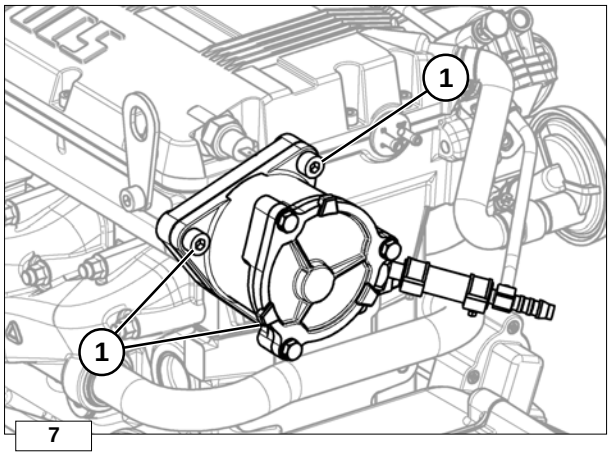
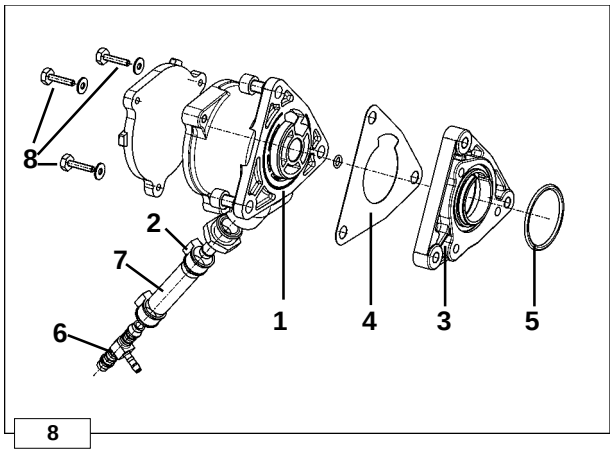


7

Vacuum pump and vacuum pump flange

Unscrew the three fastening screws **1** that fix the vacuum pump to the flange and remove the vacuum pump.
Unscrew the fastening screws that fix the flange to the engine crankcase and remove it.

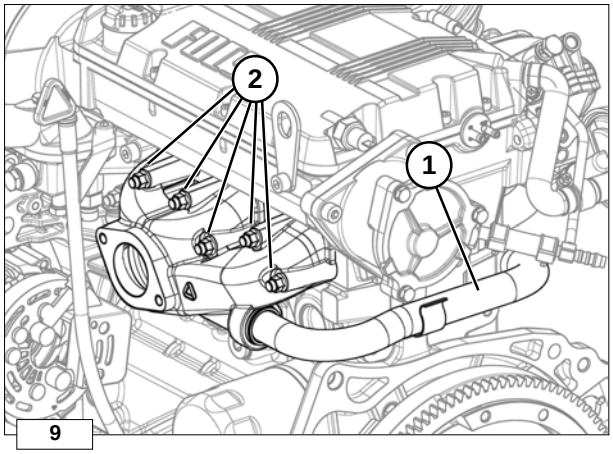


8

Components:

1. Vacuum pump
2. Clic clamp 86-50
3. Vacuum pump flange
4. Vacuum pump gasket-
5. O-ring
6. Three-way union for vacuum pump
7. Vacuum pump pipe
8. Screw

❍ When reassembling, tighten the screws **8** that fix the flange to the cylinder head to the specified torque of 10 Nm.



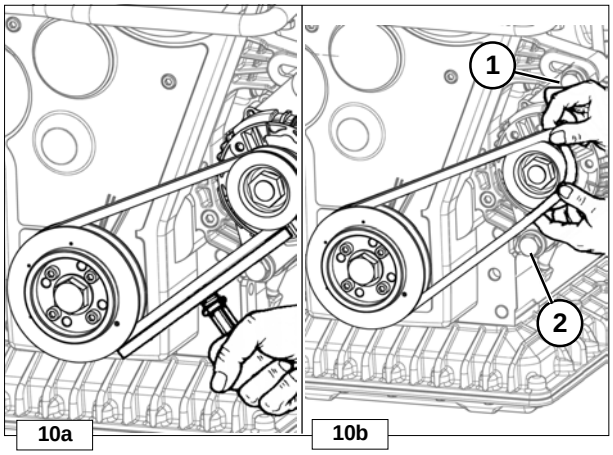
9

Exhaust manifold - engines with EGR

Remove the E.G.R. pipe **1**.
Unscrew the locking nuts **2** and remove the exhaust manifold and the seal.

Note: When reassembling the exhaust manifold, check that the inside is properly clean and free from cracks or breaks.
Note: Replace the gasket each time the manifold is reassembled.

❍ Tighten the nuts at the prescribed torque of 25 Nm.



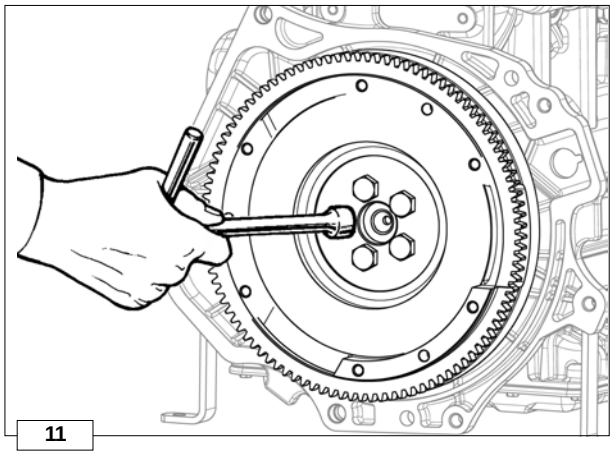
10a 10b

Alternator/Cooling fan belt drive

Danger - Attention
Check the belt tension only with the engine off.

Tension adjustment.
Loosen screws **1** and **2**.
Adjust the belt tension so that a 100N force at the midpoint of the belt center (as shown) results in a 10-15mm deflection.

➲ See page 18 for periodic maintenance details.



11

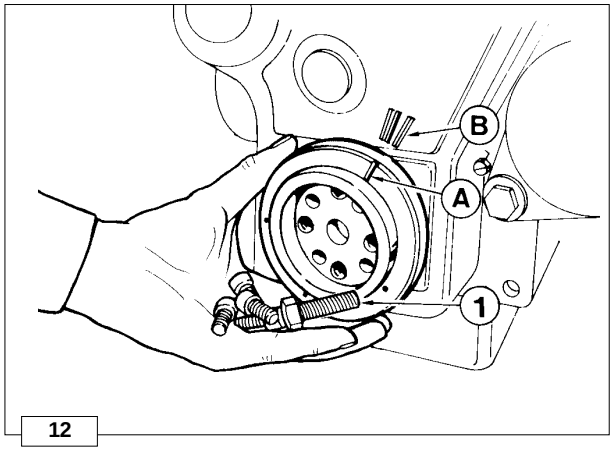
Flywheel

Danger - Attention

During dismounting be particularly careful not to let the flywheel fall, as this can be very dangerous for the operator.
Use protective goggles while removing the starter ring gear.

Unscrew the screws that fasten it to the crankshaft.
In order to replace the ring gear, it is necessary to disassemble the flywheel.
Cut the ring gear in several places using a chisel and remove it.
Heat the new ring gear uniformly and keep it at a temperature of 300°C for 15÷20 minutes.
Insert the ring gear into its seat and place it carefully on the rim of the flywheel.
eave to the ring gear to cool gently before reassembling the flywheel.

❍ When refitting tighten the screws at 80 Nm.



12

Driving pulley

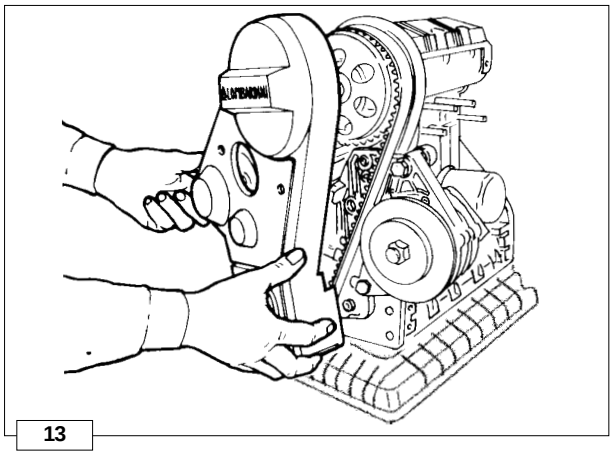
Important

To loosen or screw in screw 1 at the set torque you must always stop the crankshaft and not other parts of the engine.

Lock the crankshaft.
Remove the pulley, after having unscrewed central screw **1** and proceed with the four lateral screws.
The central bolt **1** is left-handed.

❍ When reassembling, apply some Moly-slip antiseizure compound on the screw thread and tighten at 360 Nm.

Note: When pulley reference mark **A** aligns with the timing cover reference mark **B**, the flywheel side piston is at TDC.

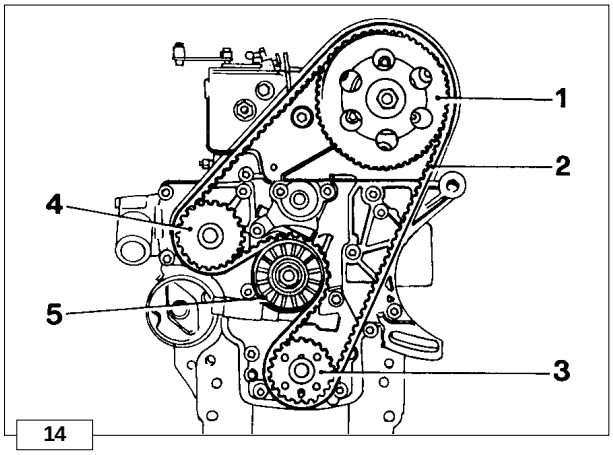

13

Timing belt cover

Loosen the five screws and remove the cover.

❍ When rifitting tighten the screws at a torque of 10 Nm.

Check the peripheral rubber sealing gasket and the two dust-protection rings of the two pulleys, if mounted.

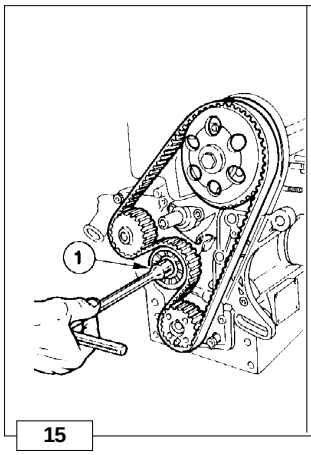


14

Timing belt / Timing pulley arrangement

Components:

1 Camshaft pulley
2 Timing belt
3 Crankshaft pulley
4 Coolant pump pulley
5 Belt tensioner pulley



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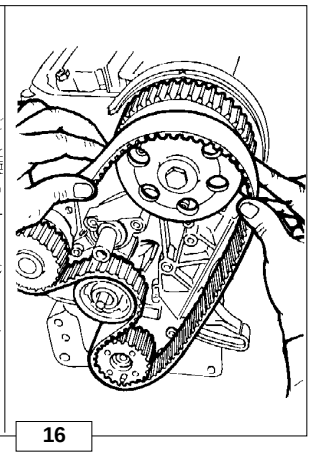

16

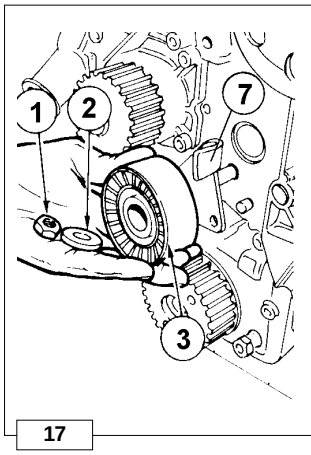
Timing belt removal

Important
When you remove the distributor belt replace it even if its prescribed operation time has not expired yet.

Danger – Attention
Always check that the positive pole of the battery is insulated.

Remove the belt tensioner **1**.
Remove the timing belt off the timing pulley.

➲ For assembly see fig. 22÷25.



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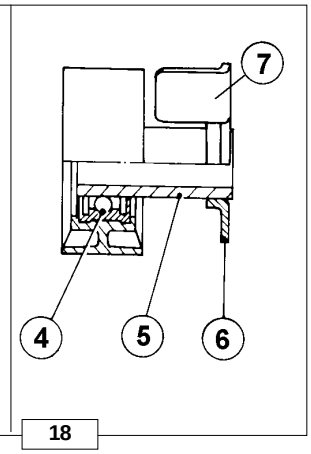
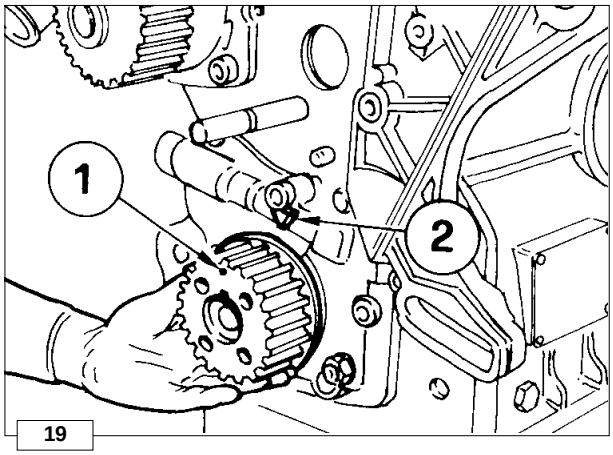


18

Tightening pulley

Components:

1 Nut
2 Washer
3 Pulley
4 Bearing
5 Shaft/Support
6 Mounting plate
7 Tensioning lever

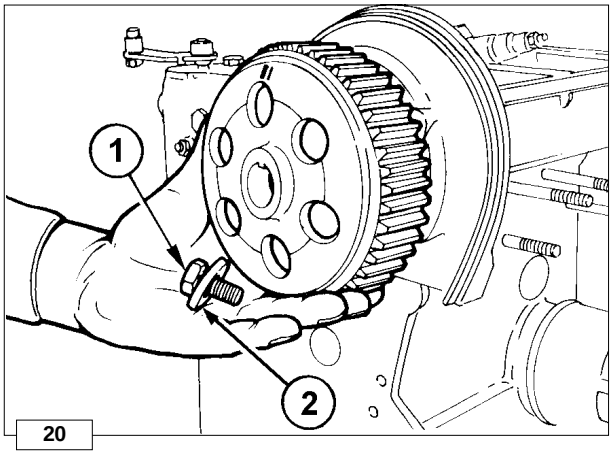


19

Crankshaft timing pulley

Al rimontaggio fare attenzione che la chiavetta rimanga inserita nella propria sede.

***Note*:** Reference mark **1** on the crankshaft timing pulley and reference mark **2** on the oil pump housing are timing marks. When aligned, No. 1 piston (flywheel side) is at TDC.



20

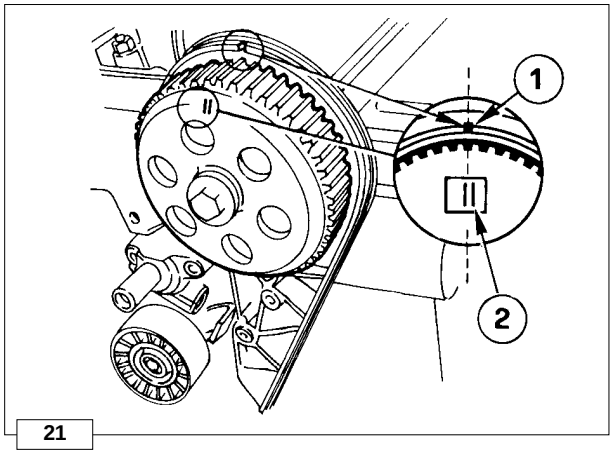
CAMSHAFT TIMING PULLEY

Camshaft timing pulley - Disassembly/Assembly

Unscrew screw **1** and remove the pulley. No extractor is needed.

❍ When refitting tighten the screw at a torque of 80 Nm.

***Note*:** Assess any wear caused by the lip of the seal ring on the pulley tang.

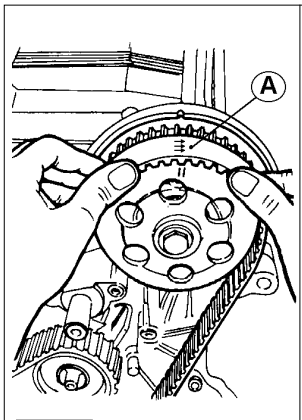


21

Camshaft timing pulley - Reference marks

1 Timing reference mark on cylinder head.
2 Timing system reference on the pulley.

Align references **1** and **2** as shown in the figure to set the correct timing.



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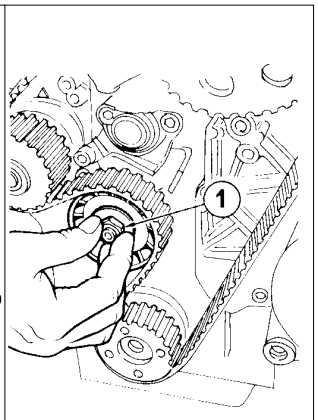


23

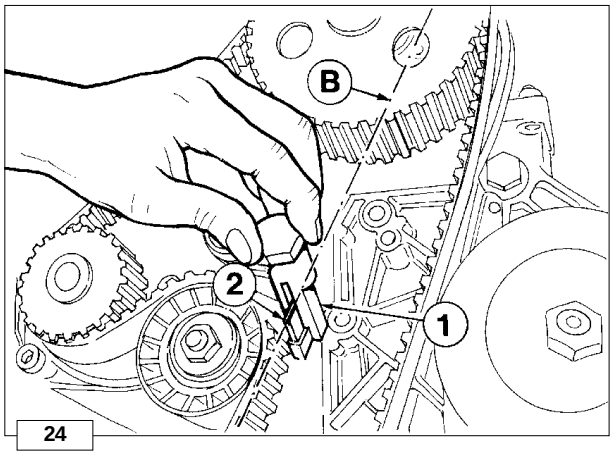
CAMSHAFT TIMING

Camshaft timing - Belt Reassembly

Important

Remove the distributor toothed belt from its protective wrapping only when mounting it.

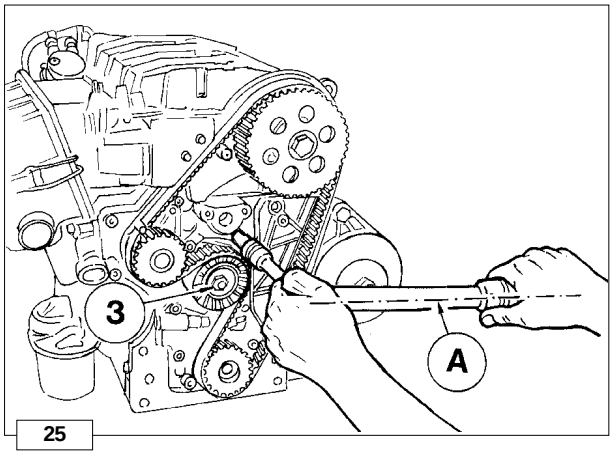
Insert the belt as in figure 22 taking account of the direction of the arrows **A** impressed on it (direction of rotation).
Tighten the nut **1** by hand until the belt tightener rests on surface of the crankcase.
Start by mounting the camshaft pulley belt, then mount crankshaft's pulley.
Do not mount driven belts.



24

Camshaft timing - Belt tightening tool

Position belt preload tool 7107-1460-049 **1** over the timing belt idler adjustment ear **2**.
See "Camshaft timing - Belt Tightening and Fastening".



25

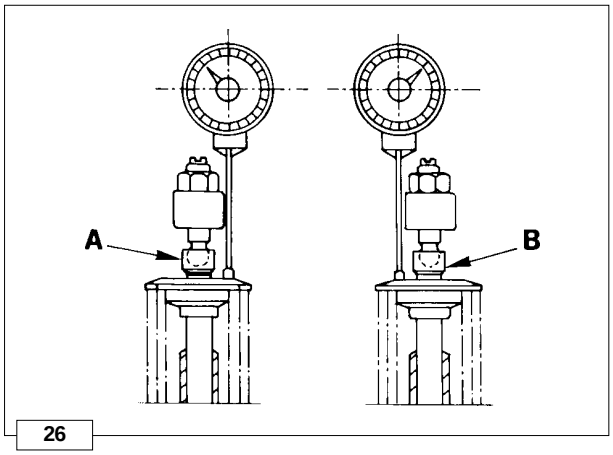
Camshaft timing - Belt Tightening and Fastening

Insert the torque wrench in the suitable tool so that the **A** axis of the key fig. 25 is at 90° to the **B** axis of the tool in fig. 24.
Tighten in clockwise direction at 20 Nm.

❍ Maintaining the belt tension, tighten nut **3** with another torque wrench at 40 Nm, after having remounted the drive pulley.

Rotate the crankshaft a few times and check that the tension is as described above.

The check must be carried out with the appropriate Nippon Denso tension measuring instrument (halfway along the longest section of the belt), the value for a cold engine must be 15±2 Kg.

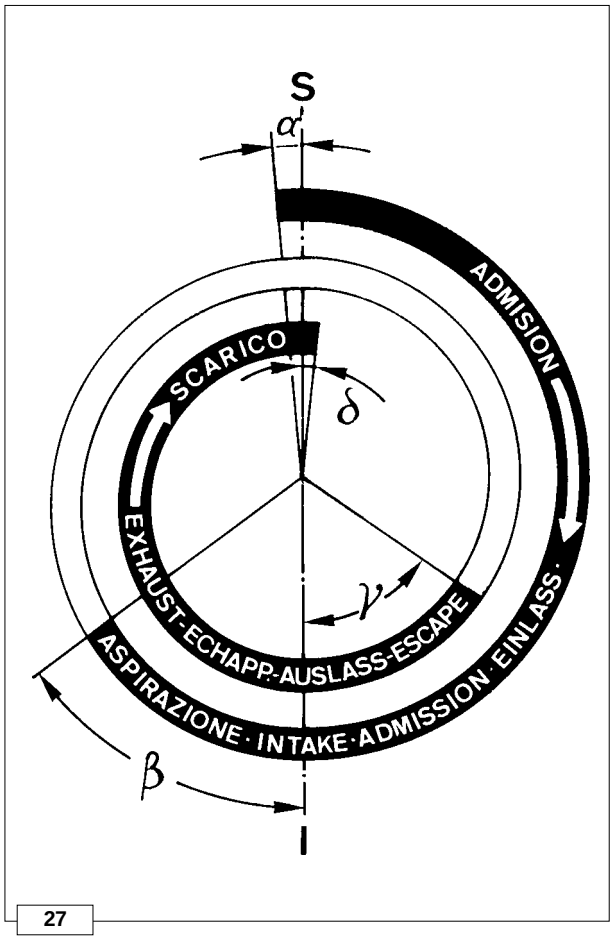


26

Valve timing check

A = Intake valve
B = Exhaust valve

Rotate the engine in the normal direction of rotation until the No. 1 piston (flywheel side) approaches TDC- compression stroke
Check the balance of intake and exhaust valves **A** and **B** placing the two micrometers testers on the valve collars.



27

Valve timing - Angles

The angle values are determined by turning the driving shaft clockwise.

S = Piston at top dead centre
I = Piston at bottom dead centre

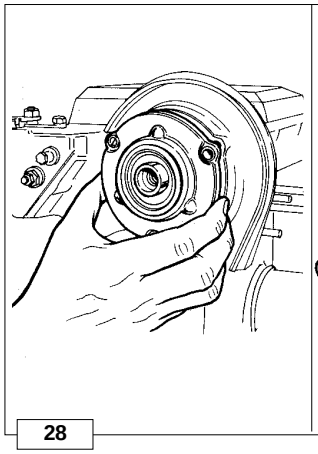
α = Intake valve open
β = Intake valve closed
γ = Exhaust valve open
δ = Exhaust valve closed

Timing angles for operating purposes (valve clearance = 0.25 mm)

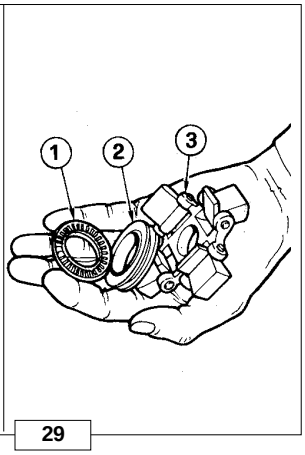
α = 16° before **S**
β = 36° after **I**
γ = 36° before **I**
δ = 16° after **S**

Timing angles for checking puposes (valve clearance = 2 mm)

α = 21° after **S**
β = closes in **I**
γ = 2° after **I**
δ = 20° before **S**



28



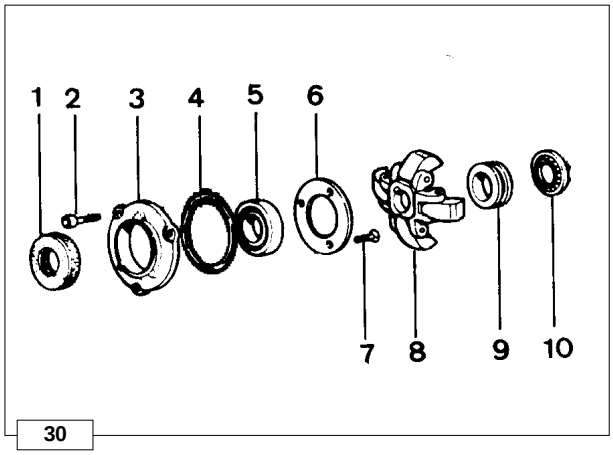
29

SPEED GOVERNOR

The weight-type mechanical governor, is driven directly by the camshaft and is housed with the cylinder head.

Components:

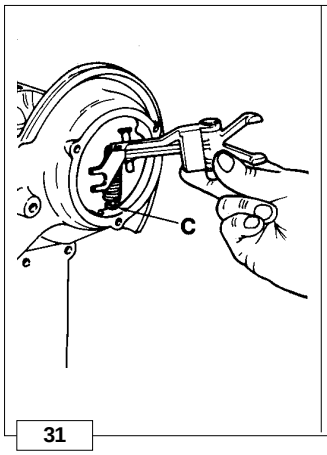
1 Thrust washer
2 Spool
3 Flyweight assembly



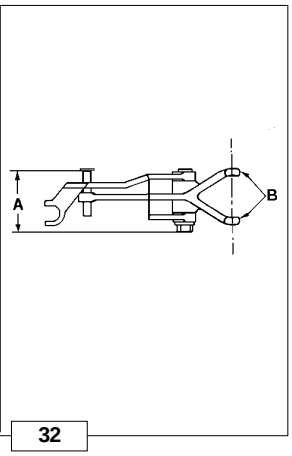
30

Speed governor components

1 Oil seal
2 Screw
3 Support
4 O-Ring
5 Bearing
6 Retainer
7 Screw
8 Flyweight assembly
9 Spool
10 Thrust washer



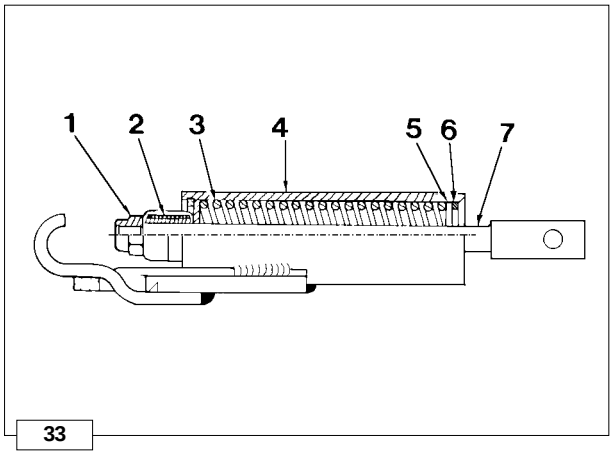
31



32

Governor springs

Unscrew the pin that attaches it to the cylinder head.
To remove it as shown in the figure it is necessary to dismount the camshaft. It could also be removed from the accelerator box side by unscrewing the torque gearing device.
Before reassembling it, check value **A** (45 to 46 mm) and the parallelism of the two levels **B** that must not exceed 0.05 mm.



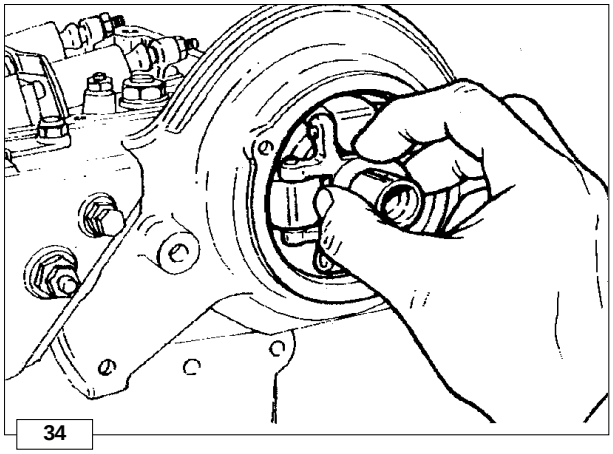
33

Speed governor - Limiting speed governor

With applications for the automotive sector the regulator spring (**C**, fig. 31) is replaced by a device (plunger barrel) that only enables a constant speed at the minimum and maximum rpm rating.

Components:

1 Nut
2 Idle speed spring
3 Max. speed spring
4 Case
5 Register
6 Spring ring
7 Actuation rod


34

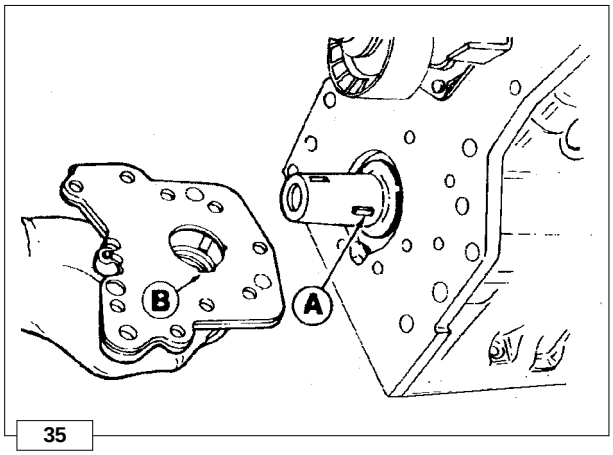
Speed governor - Reassembly

Caution – Warning
While reassembling, check the integrity of the components and check that they operate correctly.
Bad operation of the speed governor can cause serious damage to the engine and to people being near to it.

Remount in reverse order to Fig. 30.
When inserting the bearing in the camshaft, do it so that the four blocks enter opened, so that they can receive the hose and close over it.
Check the integrity of the sealing rings of the cover.

❍ Tighten the three screws at a torque of 10 Nm.

Note: With the speed governor mounted the camshaft axial clearance should be zero.



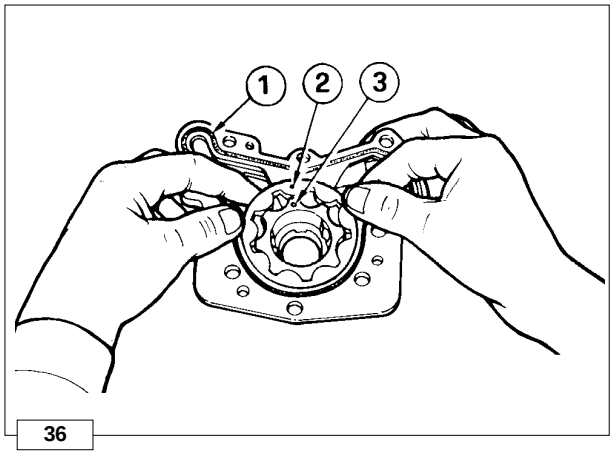
35

OIL PUMP

Oil pump - disassembly

The FOCS oil pump is supplied as an assembly. Lombardini therefore recommends that the oil pump be handled as an assembly from a service standpoint
Lombardini does not recommend that the oil pump be disassembled, then reassembled for purposes of installation on the engine except during emergency situations.

Rotate the crankshaft until the crankshaft timing pulley keyway is vertical as shown. Remove the oil pump assembly retaining bolts. When the crankshaft timing pulley keyway is vertical, the oil pump drive keyway **A** will be at 3:00 o'clock allowing removal of the oil pump assembly via relief **B**.



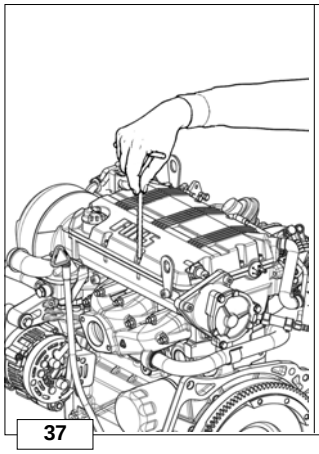
36

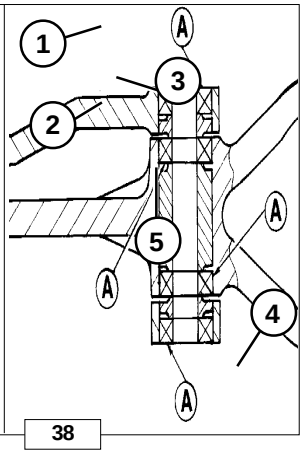
Oil pump - Reassembly

The pump rotors should be coupled on the same side, see references **2** and **3**.
Replace the O-ring **1**.

❍ Tighten the fastening screws to the crankcase at 25 Nm and those of the plate at 10 Nm.

➲ See page 55 for technical details.


37



38

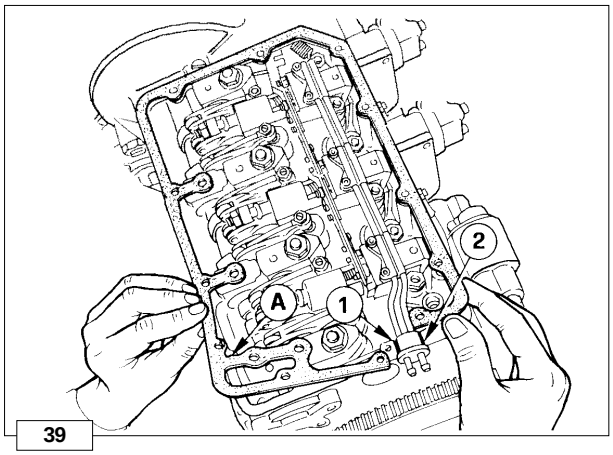
ROCKER ARM COVER

The engine control components are all on the cylinder head.
The cover contains part of the lubrication duct of the camshaft and of the rocker arms, as well as part of the engine vent system.

Components:

1 Oil preassure switch
2 Camshaft lubrification port
3 Rocker arm lubrification port
4 Oil exhaust hose from sump vent system
5 Air valve with oil decanting wire gauze

Note: During remounting be careful with oil exhaust hose **4** that needs to be properly inserted into its housing on the cylinder head.

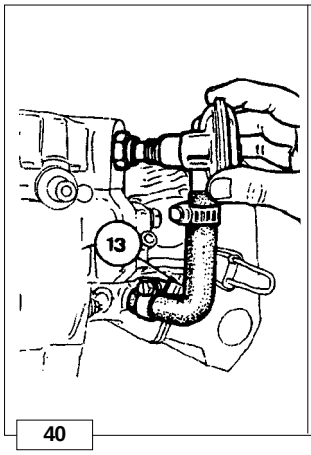


39

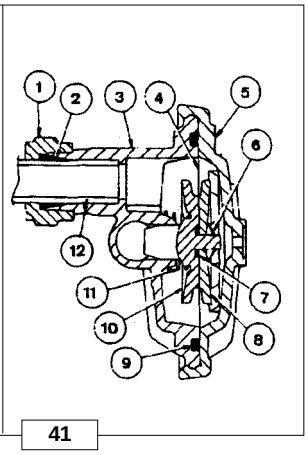
Rocker arm cover gasket

The rocker arm cover gasket **A** ensures the seal of the lubrication circuit for the camshaft and rocker arm shaft.
Always replace it and mount it with especial care above all in zones **1** and **2** where, for greater safety, it is advisable to apply a few drops of silicon sealant.

❍ Tighten the rocker arm cover screws at a torque of 9 Nm.



40



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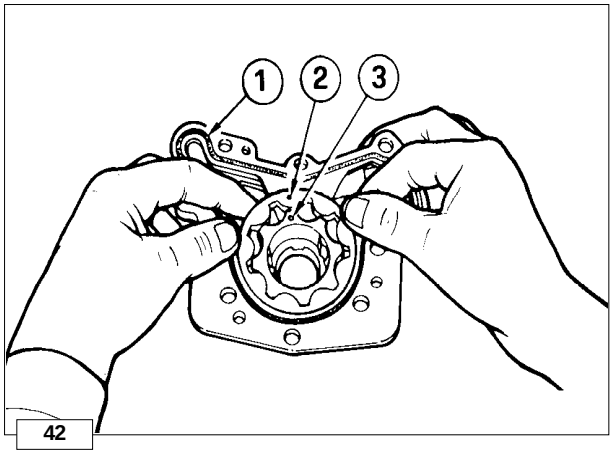
Crankcase vacuum regulator valve

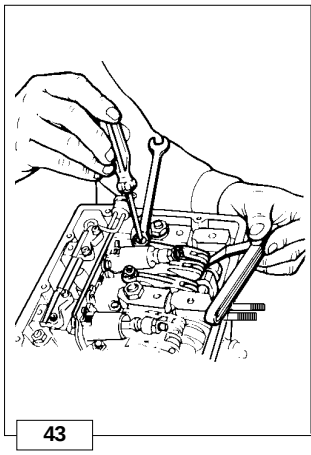
Components:

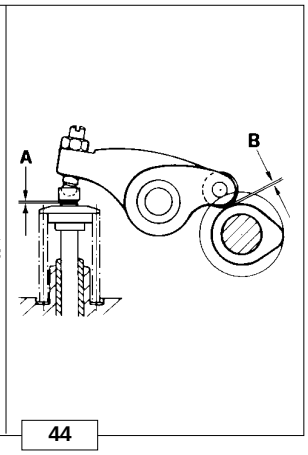
1 Gland Nut
2 Bushing
3 Body
4 Diaphragm
5 Cap / Cover
6 Clip / Lock
7 O-Ring
8 Washer
9 O-Ring
10 Valve
11 Spring
12 Tube
13 Hose



42

The vacuum relief valve is an engine safety device.
Its function is that of limiting the vacuum whenever it tends to increase.
Without this, should the air filter be clogged, the oil contained in the carter may be sucked back into intake manifold causing the condition for engine runaway.


43

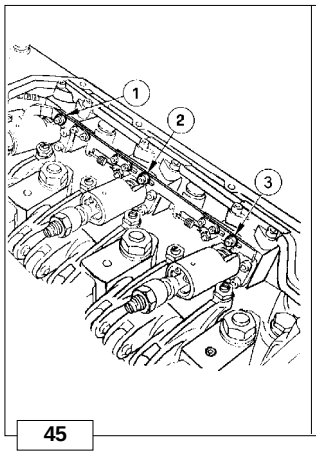


44

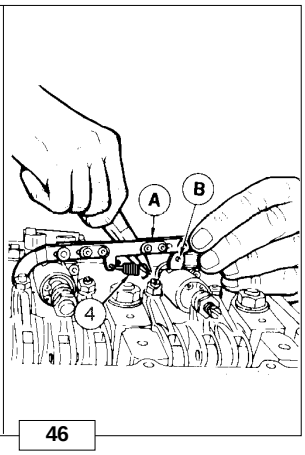
Valve / Rocker arm clearance

Important
Setting should be performed when the engine is cold.

Bring each cylinder piston to top dead center on the compression stroke and set clearance **A** at 0,20 mm for both the intake and exhaust valves.
For greater convenience, clearance check **B** is accepted. In this case the value is 0.15 mm.



45

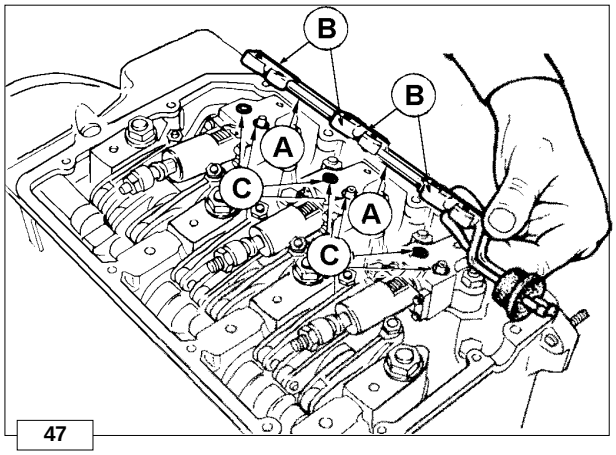


46

Injection pump control rod

The injection pump control rod will link injectors to the engine governor.
Screws **1** and **2** are pivoted on the delivery control lever of each pump/injector **B**, unscrew the screws and remove spring **3**.
When refitting tighten the screws **1** and **2** at a torque of 1,1 Nm and make sure that they stop on lever **B** of each pump/injector and not on rod **A**.

➲ To carry out the delivery equalisation of the injection pumps see page 67.
➲ To carry out the timing of the injection pumps and speed governor see page 74.

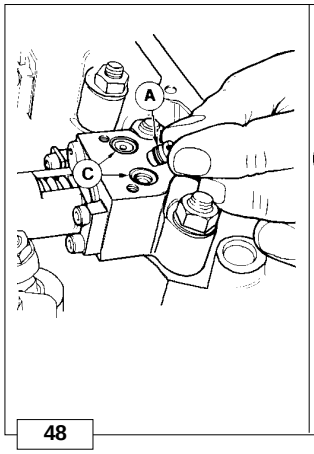


47

Fuel rail

When removing the fuel feeding pumps **A**, with the rail holders **B**, pay attention that the sealing O-rings **C** remain in their seats.

❍ When refitting tighten the rail holder screws at a torque of 4 Nm.



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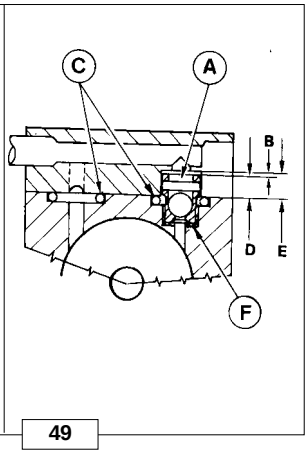

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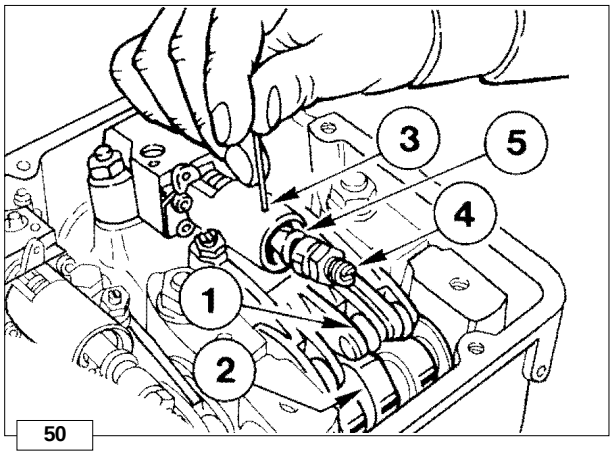
Pump/injector unit - non-return valve

Non-return valve **A** immediately stops the engine whenever the stop is activated.

Dimensions (mm):

LDW 1003		
B	**D**	**E**
0,5÷1,15	5,95÷6,5	7,0÷7,1

Note: If the value of **B** is not achieved, the two rings **C** are not subject to enough compression to ensure the seal; any fuel loss would contaminate the lubrication oil and consequently damage the engine, **F** = metal gasket.

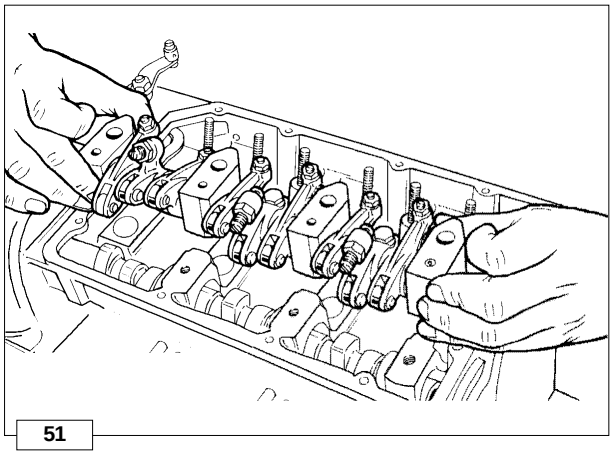


50

Pump/injector unit - Disassembly

When the removal (but not replacement) of a unit injector is required the following procedure may be used to avoid the need for other adjustments:
Rotate the crankshaft until the unit injector cam lobe **2** forces the cam follower **1** to the highest position, then insert a suitable sized (hardened) pin into the hole **3** and rotate the crankshaft until the cam follower **1** is at the lowest position. In this way the injection advance regulator **4** remains calibrated.

Note: If you dismount more than one pump/injector unit, make sure to reinstall them in the appropriate housing (with relative drive rod **5**); before mounting lubricate the drive rod at its two ends with MOLYSLIP, AS COMPOUND 40 type.


51

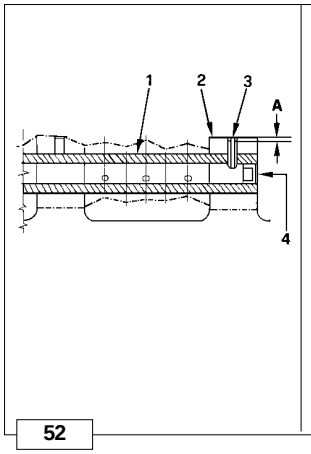
Rocker arm assembly

Remove the nuts attaching the rocker arm assembly to the cylinder head.

❍ When refitting tighten the nuts at a torque of 40 Nm.

The pin, that is hollow inside to allow lubrication, is closed at its ends by two caps.

Note: The rocker arm assembly may be removed without removal of the unit injectors.



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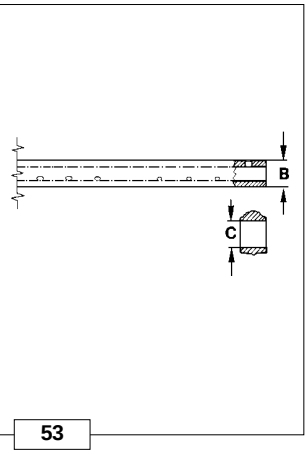


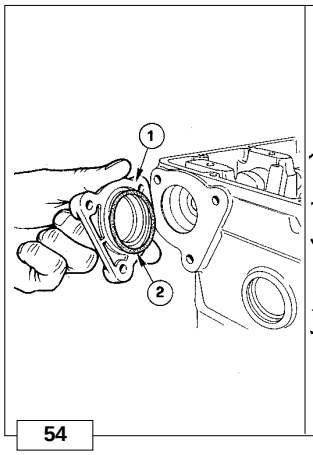
53

Rocker arm pivot, dismounting and remounting

To remove pivot **1** from the support **2** it's necessary to drill out pin **3** using a 4mm drill bit.
On remounting insert a new pin and reinsert it in bearing surface **A** (0 to 1 mm).
Check the rod's state of wear and tear (diam. **B**) and that of the rocker arm holes (diam. **C**).
Remove the closing caps **4** at the end and carefully clean inside.

Dimensions (mm):

	mm	C-B	C-B limit value
A	0 ÷ 1,00		
B	17,989 ÷ 18,000	0,015 ÷ 0,041	0,090
C	18,015 ÷ 18,030		



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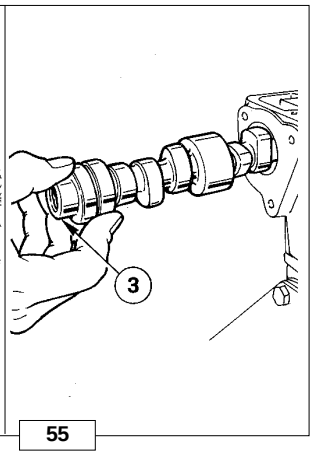


55

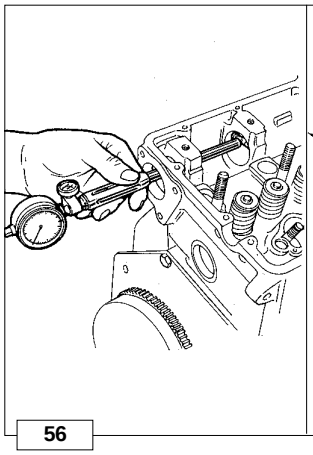
CAMSHAFT

Camshaft, disassembly

Loosen the screws and remove the cover **1**.
Check gasket ring **2** for integrity.
Remove the drive rod from the fuel pump.
Gently remove the camshaft, slight rotations may be required to avoid binding the camshaft lobes against the camshaft bearing surface bores.

Note: The lift pump drive eccentric **3** is included on the flywheel end of the camshaft and fixed with a screw.

❍ In case of replacement tighten the eccentric screw at a torque of 80 Nm.



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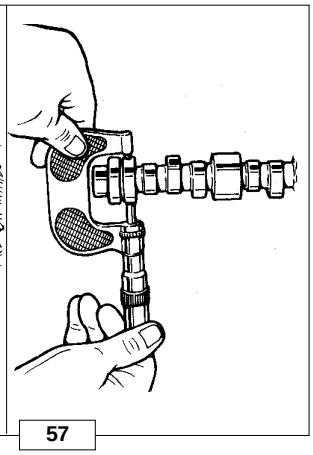

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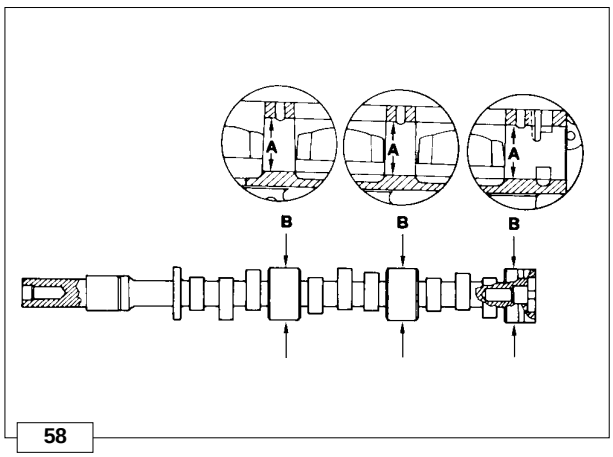
Camshaft, journal and housing measurement

Use an inside micrometer gauge for housing diameters and an outside micrometer gauge for journal diameters.



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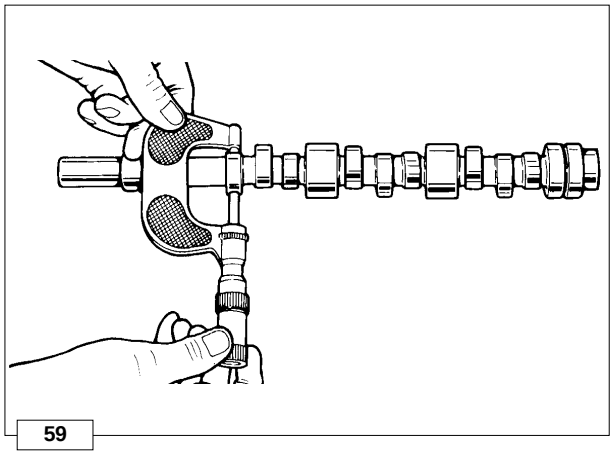
Camshaft journals and housings - Dimensions (mm)

A	B	A-B	A-B limit value
37,035 ÷ 37,060	36,975 ÷ 37,000	0,035 ÷ 0,085	0,170



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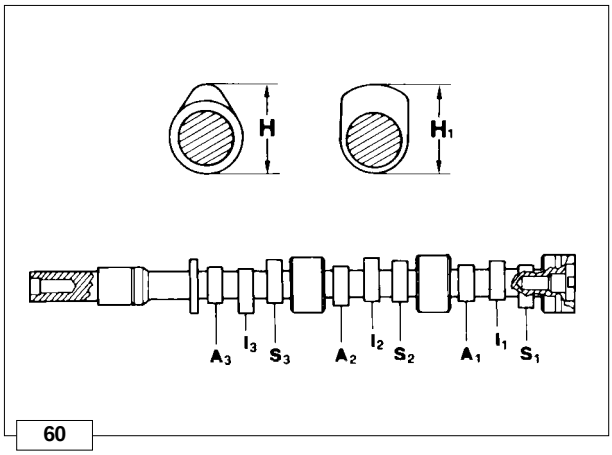
Camshaft lobe measurement

Use an outside micrometer gauge.



60

Intake, exhaust, injection camshaft lobe height

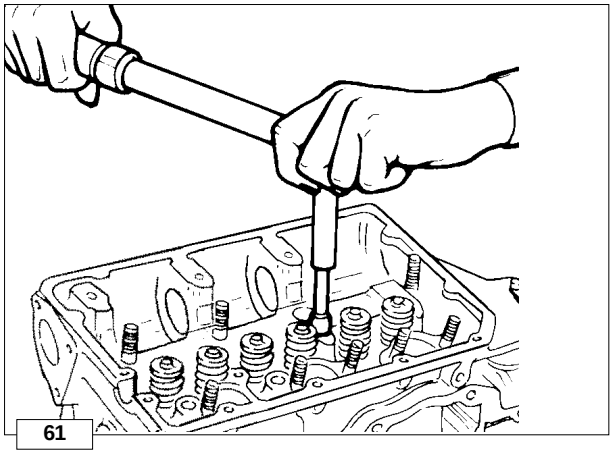
A1 = 1st cylinder intake camshaft lobe
A2 = 2nd cylinder intake camshaft lobe
A3 = 3rd cylinder intake camshaft lobe

I1 = 1st cylinder injection camshaft lobe
I2 = 2nd cylinder injection camshaft lobe
I3 = 3rd cylinder injection camshaft lobe

S1 = 1st cylinder exhaust camshaft lobe
S2 = 1st cylinder exhaust camshaft lobe
S3 = 1st cylinder exhaust camshaft lobe

H = 29,598÷29,650 mm (intake/exhaust camshaft lobe height)
H1 = 28,948÷29,000 mm (injection camshaft lobe height)

If wears on the cams exceeds by 0.1 mm the minimum value given **H** and **H1**, replace the crankshaft.

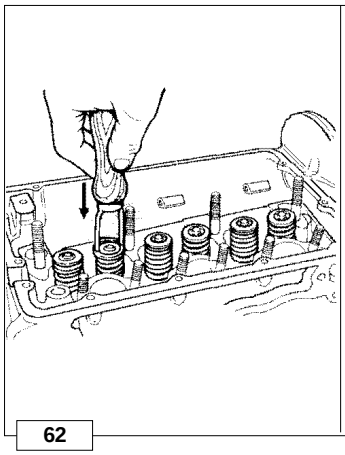

61

Cylinder head, removal

Important
Do not remove the cylinder head when hot to avoid deformation.

If cylinder head is deformed by more than 0.10 mm, level it off by removing a maximum of 0.20 mm.

➲ For the cylinder head tightening procedure see page 45.



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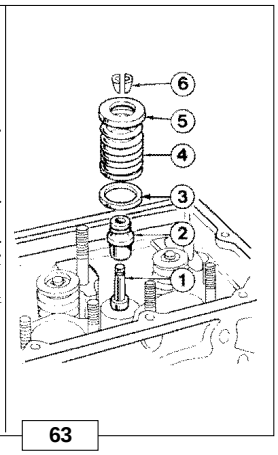

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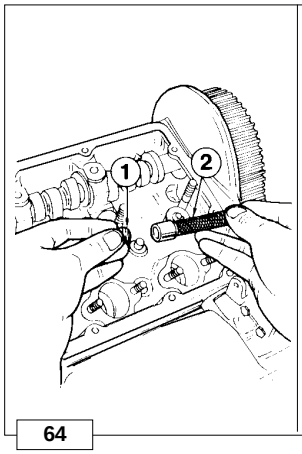
VALVES

To remove the valves it is necessary to remove the collets; place a spacer under the valve head, press strongly on the spring cap as shown in the picture.

Components:

1 Valve stem
2 Valve stem seal ring
3 Spring seat
4 Spring
5 Spring cap
6 Collets



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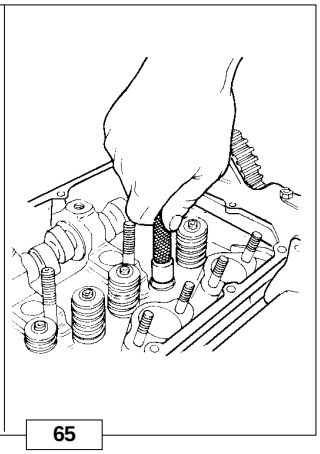
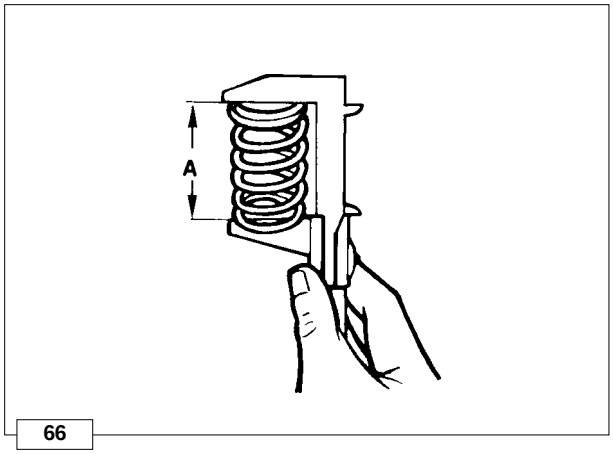


65

Valve stem sealing rings - Reassembly

To prevent deformation of the sealing ring **1** as it is inserted onto the valve guide, insert it onto tool "7107-1460-047" **2** (after lubricating the sealing ring) and proceed as shown int the picture ensuring that gasket **1** is completely fitted.



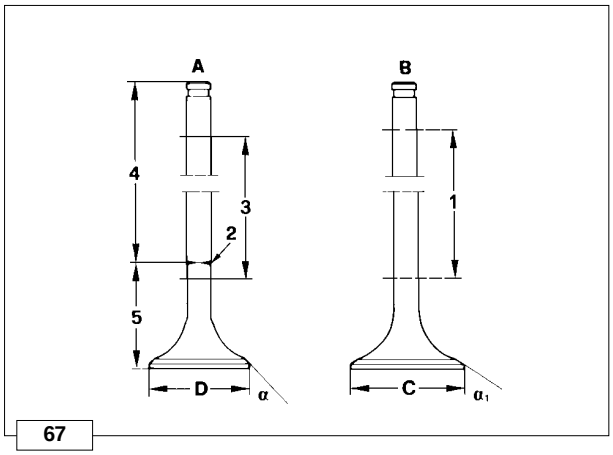
66

Valve springs

Measure free height with a gauge.

Free height **A** = 46 mm.

Note: If the free height **A** is less than 43,5 mm replace the spring.



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Valve, specifications

Exhaust valve A
Shaft and head are made of 2 different materials.

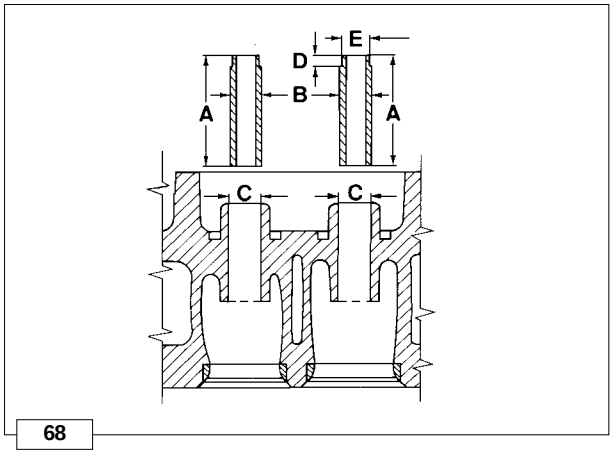
2 Welded joint
3 Chromium-plated joint
4 Portion made of: ..... X 45 Cr Si 8 UNI 3992
5 Portion made of: ..... X 70 Cr Mn NI N 216 UNI 3992

D	30,20	α = 45° 30' ÷ 45° 45'

Intake valve B
Material: X 45 Cr Si 8 UNI 3992

1 = Chromium-plated joint

C	34,40	α_1 = 60° 30' ÷ 60° 45'



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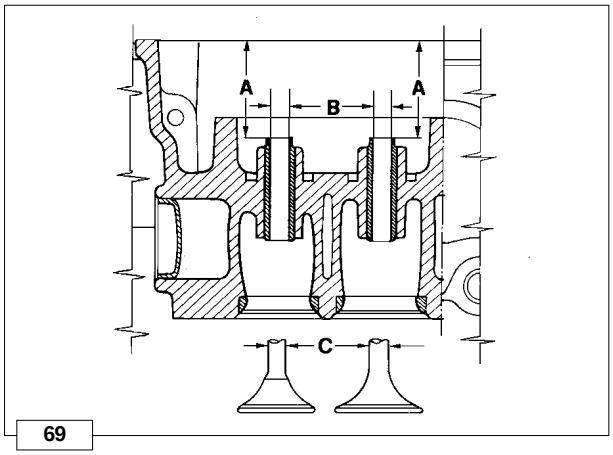
Valve guides and valve guide housings

Both intake and exhasut valve guides are identical dimensionally and are made from phosphoric gray iron with a pearlitic matrix:

Dimensions (mm):

A	B	C	D	E
36,4÷36,6	11,045÷11,054	11,000÷11,018	5,80÷6,20	9,75÷9,85

Note: Valve guides are supplied in finished form, <u>further machining is prohibited</u>.
Valve guides with outside diameter **B** increased by 0.5 mm. are available.



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Valve guide insertion

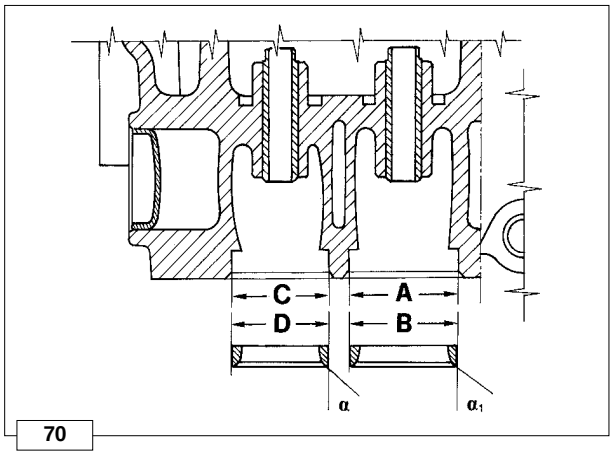
Fit the guides with a punch taking account of value A in relation to the cylinder head surface.

Dimensions (mm):

A	B	C
39,5 ÷ 40,0	7,005 ÷ 7,020	6,960 ÷ 6,990

Clearance (mm):

(**B-C**) = 0,015÷0,050 (**B- C**) limite usura = 0,10



70

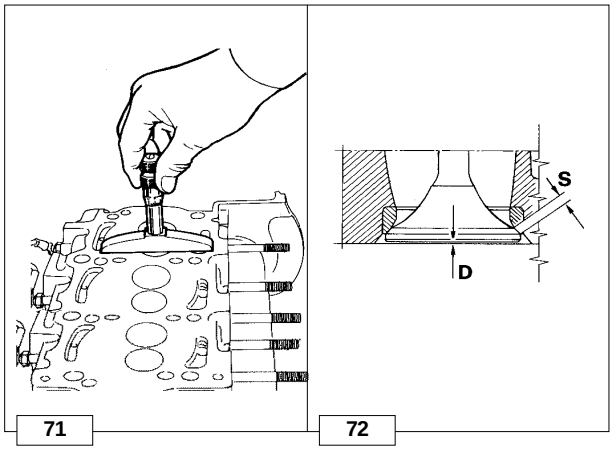
Valve seats and housings -

Dimensions (mm)

	mm	α	α1
A	35,220÷35,245	44° 53' ÷ 45°	59° 53' ÷ 60°
B	35,306÷35,315		
C	31,220÷31,241		
D	31,308÷31,316		

Press valve seats into the housings

Note: Valve seatsare supplied in finished form, <u>further machining is prohibited</u>.



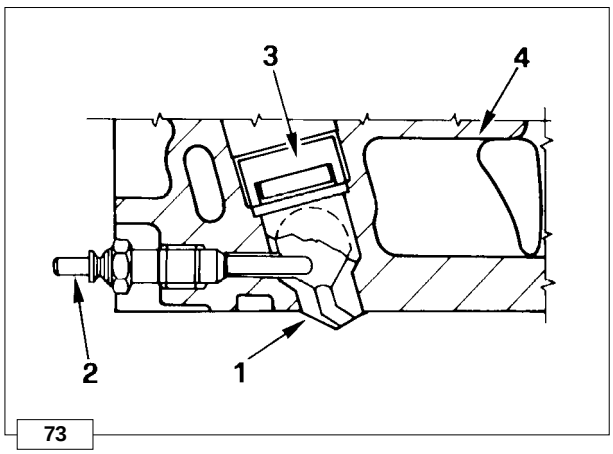
71 72

Valve recess and seat sealing width

Dimensions (mm):

	mm	***Limit value***
D	0,7÷1,0	1,3
S	1,6	2,0

Grind valve seats with fine emery paste.
After grinding check the valve recess **D** relative to the cylinder head surface and the seat sealing width **S**.



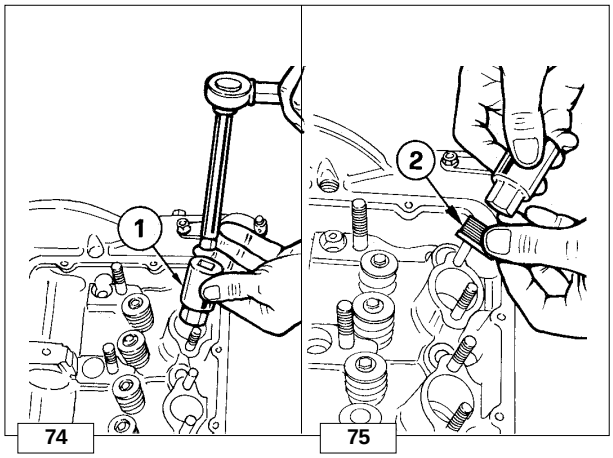
73

PRE-COMBUSTION CHAMBER

Components:

1 Pre-combustion chamber
2 Pre-heating glow plug
3 Pre-combustion chamber ring nut
4 Cylinder head

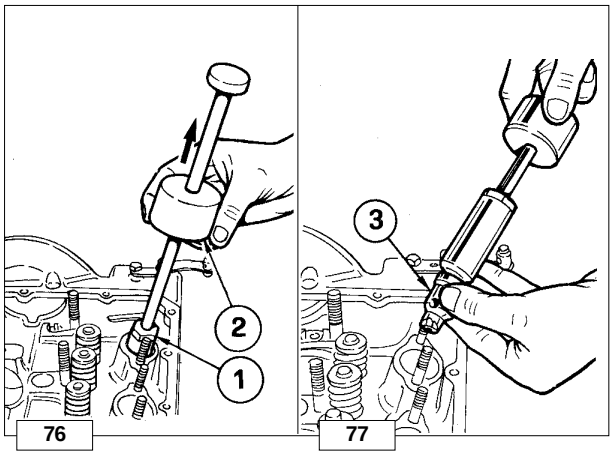
The pre-combustion chamber does not normally require removal or service, if service is necessary follow the procedure described below.



74 75

Pre-combustion chamber ring nut removal

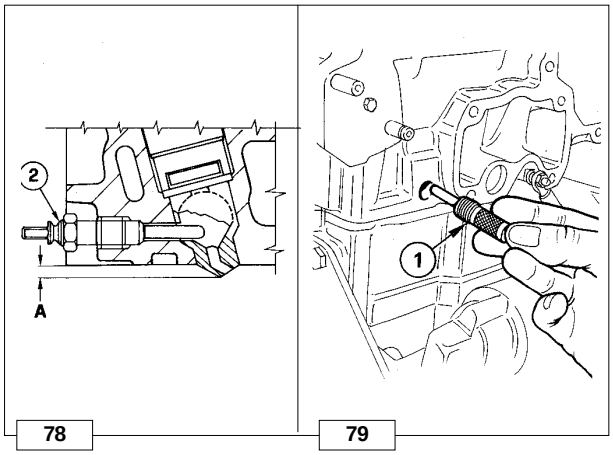
The pre-combustion chamber is fixed to the cylinder head by a ring nut, so before removing the pre-combustion chamber it is necessary to unscrew the pre-combustion chamber ring nut.
Use the special tool "7107-1460-027" **1** to romve the ring nut **2**.



76 77

Pre-combustion chamber, removal

Before proceeding with removing the pre-combustion chamber it is necessary to remove the pre-heating glow plug.
Screw special tool "7107-1460-030" **1** into the pre-combustion chamber.
Carefully, but sharply, slide the slide hammer **2** up the special tool shaft until contact is made with end of the tool. The hammer effect of the special tool will extract the pre-combustion chamber **3**.



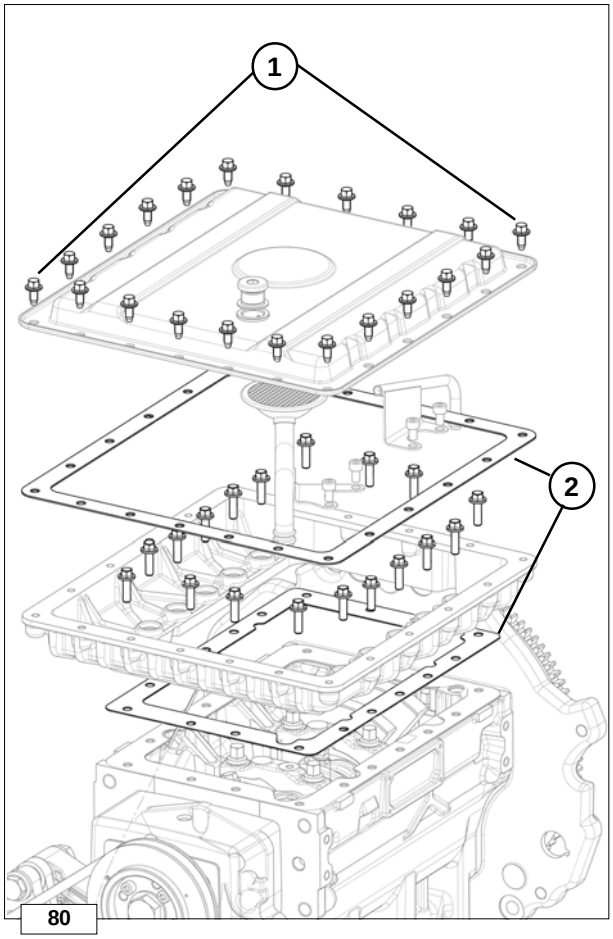
78 79

Pre-combustion chamber, installation

The pre-combustion chamber has a hole on the side where the pre-heating glow plug **2** must be inserted.
When re-fitting introduce the the new pre-combustion chamber into the cylinder head so that the side hole of the pre-combustion chamber aligns with the glow-plug hole.
To make sure that both the holes align appropriately use tool "7107-1460-031" **1** inserting it into the glow-plug hole.

❍ Tighten the ring nut twice:
1st tighten at a torque of 100 Nm,
2nd tighten at a torque of 180 Nm.

Chack that clearance **A** is 3,56÷4,04 mm.



80

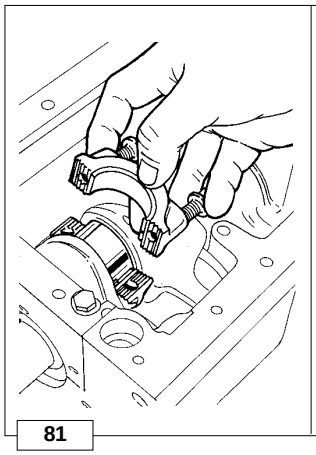
Oil pan, removal

Danger - Attention
- **The used engine oil can cause skin-cancer if kept frequently in contact for prolonged periods.**
- **If contact with oil cannot be avoided, wash carefully your hands with water and soap as soon as possible.**
- **Do not disperse the oil in the ambient, as it has a high pollution power.**

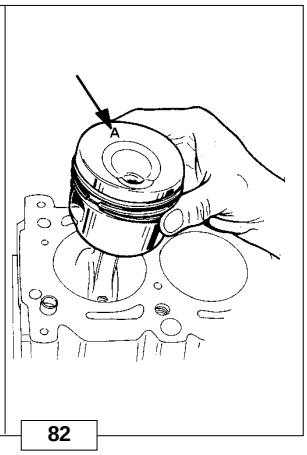
Remove the fixing screws **1**.
When reassembling, replace the seals **2**.

❍ Tighten the screws at a torque of 10 Nm.

Before starting the engine make sure that:
1) the oil drain plug is tightened correctly
2) the engine has been refilled with the prescribed quantity of oil (see page 20).



81

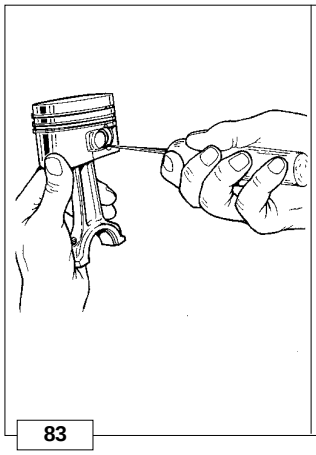


82

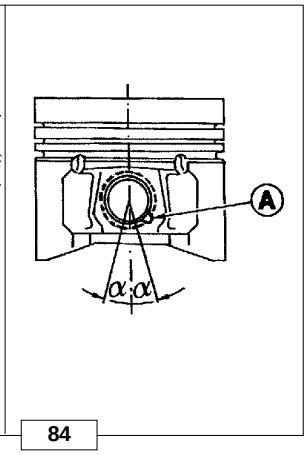
PISTON

Remove the connecting rod big end cap.
Remove the piston-connecting rod assembly.

Note: The combustion chamber is a Ricardo type.



83

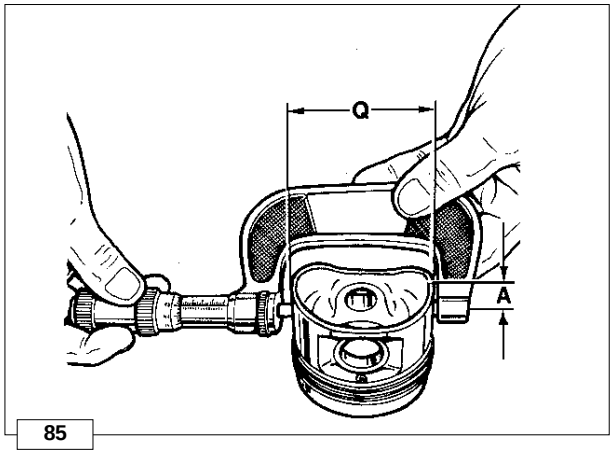


84

Stop pin rings, dismounting and remounting

Extract the ring inserting a pointed tool in hollow **A**.

On remounting, insert rings with the points turned downwards inside the corners (α = 15°).



85

Piston, disassembly and inspection

Remove the stop rings and remove the pin (see fig. 83).
Remove the piston rings and clean the slot.
Measure diameter **Q** at height **A** from the base of skirt (**A** = 9 mm).
If the diameter is worn more than the 0.05 mm minimum given value, replace piston and rings.

Note: The provided oversize elements are of 0.50 mm and 1.00 mm

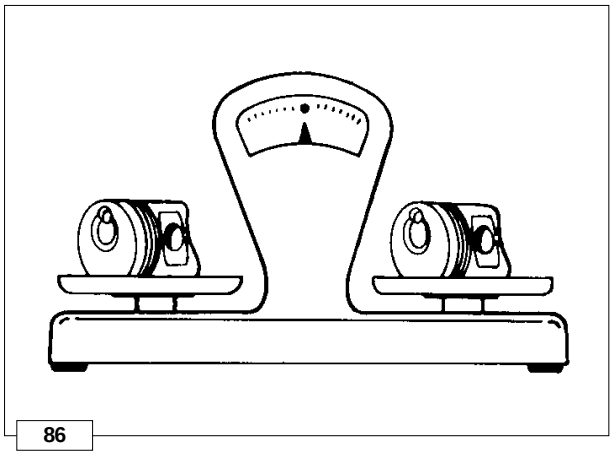
Piston, class

The pistons are subdivided according to their diameters into categories: **A**, **B**, **C**. These references, are shown on the top of the piston (see fig. 82).

Class	Ø Cylinder - mm	Ø Piston - mm	Clearance - mm
A	74,990÷75,000	74,930÷74,940	0,050÷0,070
B	75,000÷75,010	74,940÷74,950	
C	75,010÷75,020	74,950÷74,960	

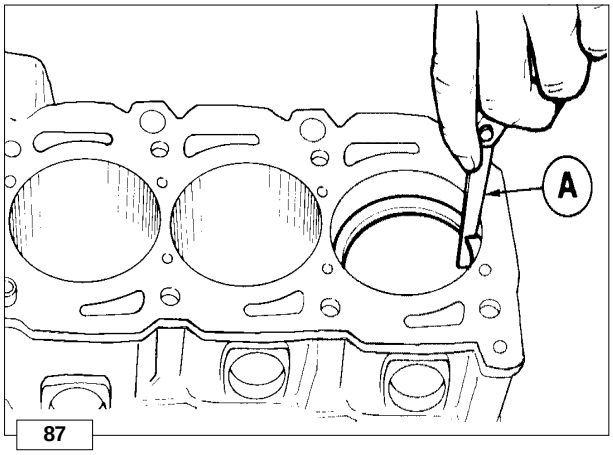
Piston supply:

Pistons at the nominal diameter are only supplied in category **A**.
Pistons oversized by 0.50 and 1.00 mm are supplied with reference to the increased level on the piston crown: Ø 75.5 – 76.0 .


86

Piston, weight

Weigh pistons when replacing them in order to avoid unbalance. The difference in weight should not exceed 4 g.

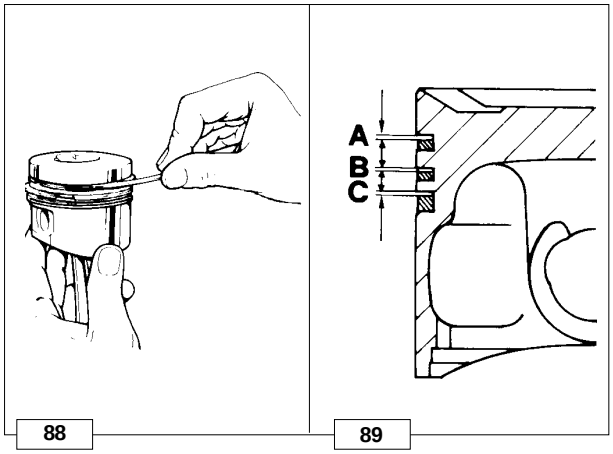


87

Piston rings - End gaps (mm)

Place piston rings squarely into the unworn part of the lower cylinder and measure the end gap **A**.

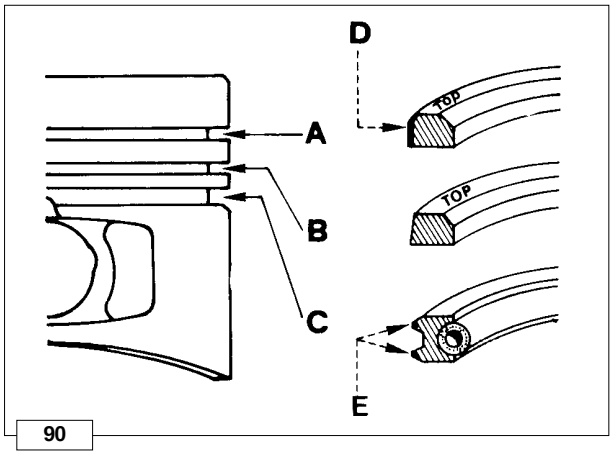
Piston ring	A	limit value
1°	0,25÷0,45	1.0
2°	0,25÷0.45	
3°	0,20÷0,45	


88

89

Piston ring, Clearance between grooves (mm)

A	0,090÷0,125
B	0.050÷0,085
C	0,040÷0,075

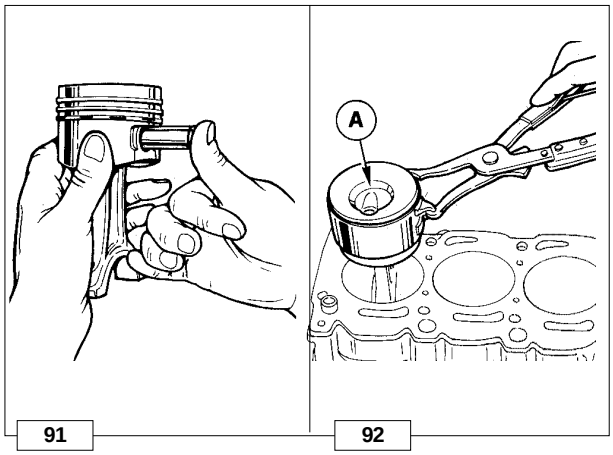


90

Piston ring, mounting order

A = 1° ring (internal tapered and torsional)
B = 2° ring (internal tapered and torsional)
C = 3° Oil control ring
D = Chrome-plated area
E = Chrome-plated area

Note: When there is writing on the surface of a piston ring, mount that surface with face upward.



91 92

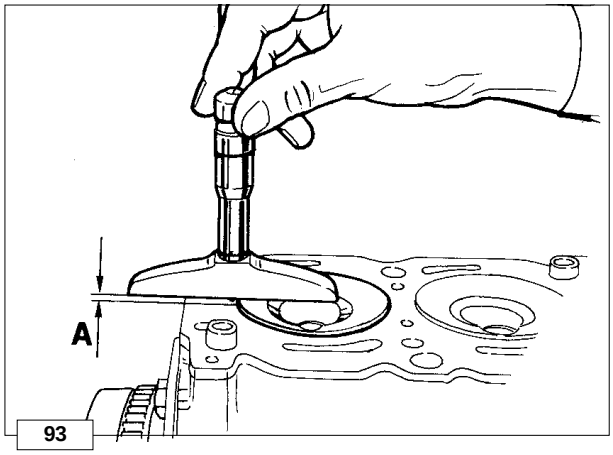
Piston, assembly

Important

Before re-mounting lubrificate the piston pin, piston, cylinder and conncecting rod big end bearing.

Couple the piston to the connecting rod inserting the pin, after lubricating it, just via thumb pressure.
Insert the two pin stop rings and check that they are properly housed in their seats (see fig. 84).
Using piston ring compression pliers, introduce the piston into the cylinder so that combustion chamber **A** is directly under the precombustion chamber parallel to the head.
Couple the piston/connecting rod to the crankshaft.

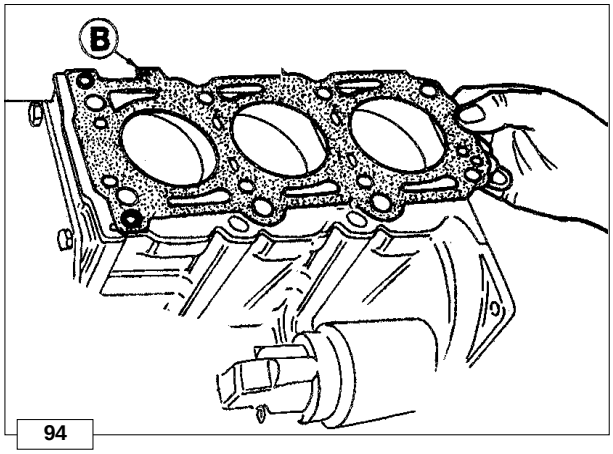
➲ For tightening the head/connecting rod see fig. 97.



93

Piston clearance

Determinare the value **A** of each piston using a dial indicator to measure the difference between the two surfaces (piston crown and upper cylinder surface).
To determine the piston clearance and, by consequence, which copper gaske is most suitable it is necessary to consider the **A** value of the piston that projects furthest.



94

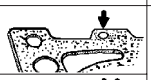
Head gasket

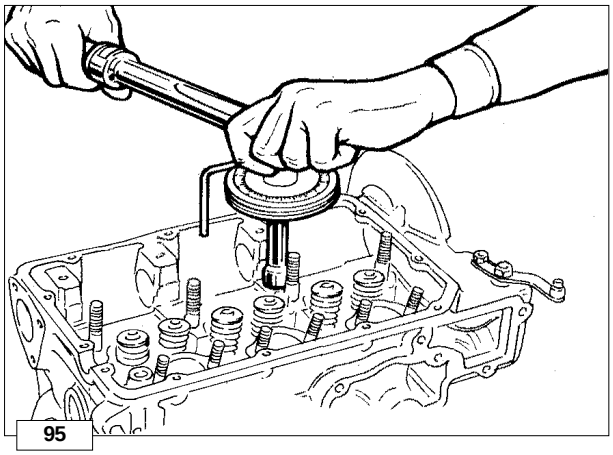
Important

Remove the cylinder head gasket seal from its protective covering only when you are going to mount it.

The gasket thickness is identified by the number of notches located in point **B**.

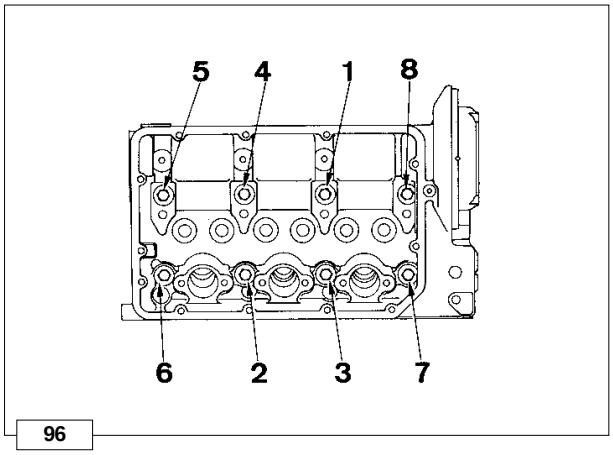
Choose the appropriate gasket considering that each **A** value on the table corresponds to a gasket with: one hole, two holes, three holes.
The **A** value relates to figure 93.
Each time you dismount the head you must replace the gasket.

A (mm)	N° of holes	Piston clearance
0.82÷0.91	1 hole 	0.54÷0.63
0.92÷1.01	2 holes 	
1.02÷1.10	3 holes 	0.55÷0.63


95

Cylinder head assembly

Use a torque wrench equipped with a device for angular tightening.
Measure the length of each screw (normal length = 89.5÷90.5 mm).
Replace it if it exceeds 92 mm.
Proceed as follows.



96

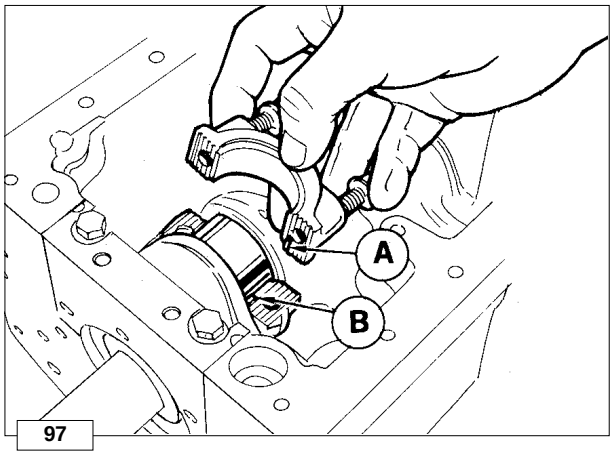
Cylinder head tightening procedure

Important

Once the head has been correctly tightened, it should not be retightened except if it is disassembled again.

Following the numerical order shown in the diagram, the bolts must be tightened in three phases:

1st phase = 50 Nm
2nd phase = Rotate the wrench 90° in a clockwise direction.
3rd phase = Rotate the wrench again 90° in a clockwise direction.



97

CONNECTING ROD

Caution – Warning

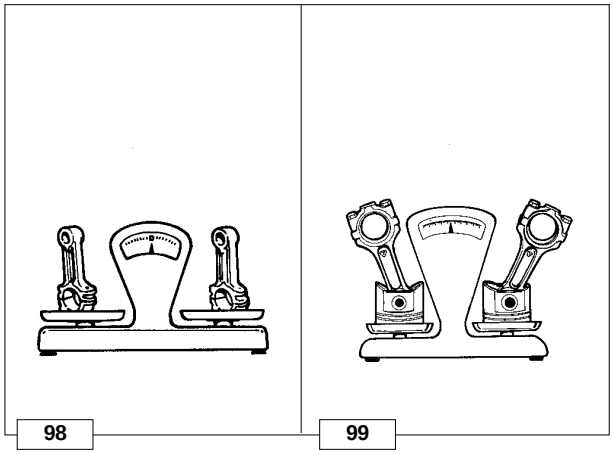
While reassembling the big end bearings, we suggest cleaning all parts thoroughly, as well as proper greasing in order to avoid risks of seizure at the first start.

Big end bearing

After connecting rod from crankshaft disconnection, check the following.
While reassembling, be sure the two centring notches **A** an **B** are on the same side.

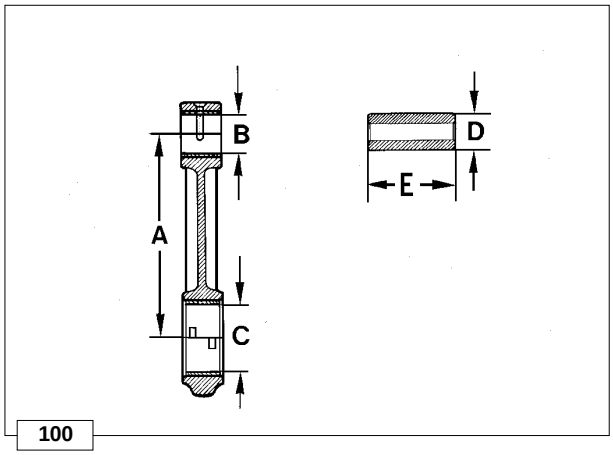
❍ Tighten the connecting rod big end cap screws simultaneously at a torque of 40 Nm.

Note: The big end bearing is supplied both at the nominal value and undersized by 0.25 and 0.50 mm.


98 99

Connecting rod, weight

Weigh connecting rods when replacing them in order to avoid unbalance.
The difference in weight should not exceed 10 g.
The difference in weight of the pre-assembled connecting rod, piston and pin must not exceed 14 g.



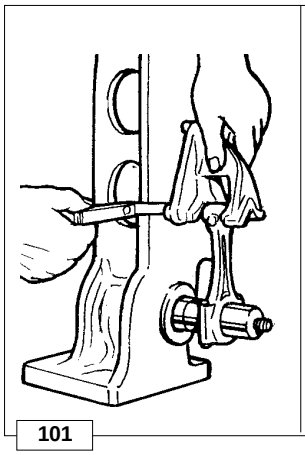
100

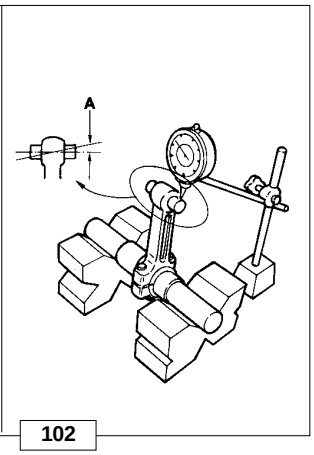
Connecting rod with bearings and pin

Dimensions (mm):

B = 20,015÷20,025
C = 40,021÷40,050 ..... (bearing tightened at 40 Nm)
D = 19,996÷20,000
E = 54,000÷55,100
(B-D) = 0,015÷0,039 **(B-D)** limit value = 0,060

Note: When driving the small end bearing make sure both oilholes are aligned.

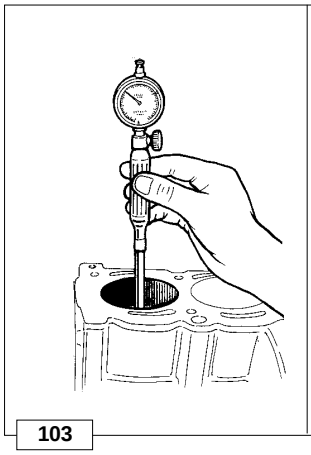

101

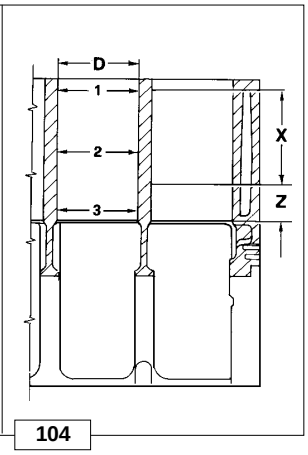


102

Connecting rod alignment

Using a gauge on a comparison plan, check the axial alignment by placing the connecting rod on a V-blocks as shown.
Maximum Axial Mis-alignment = 0,015mm, Limit =0,030mm.
Minor mis-alignment may be corrected by skillfully and gradually working the connecting rod between centers on a press.


103

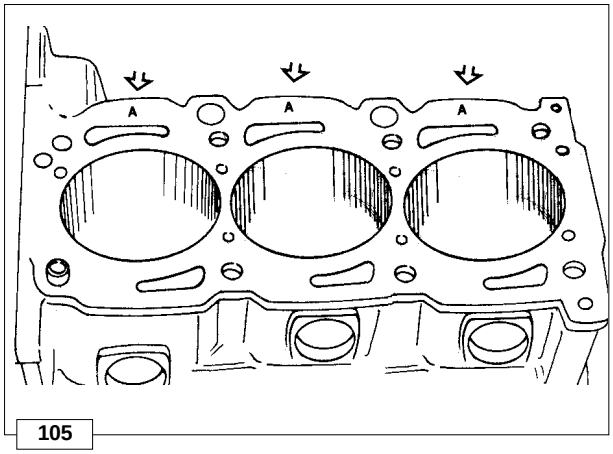


104

CYLINDERS

Reset the dial gauge with a calibrated ring: check the diameter **D** in points **1**, **2** and **3**; repeat the same operation rotating the dial gauge by 90° at the same heights.
Check any wear in zone **X** where the piston rings operate and if it is greater than the 0.05 mm max limit given adjust the cylinder to the next increased value.

75.000 mm max limit.

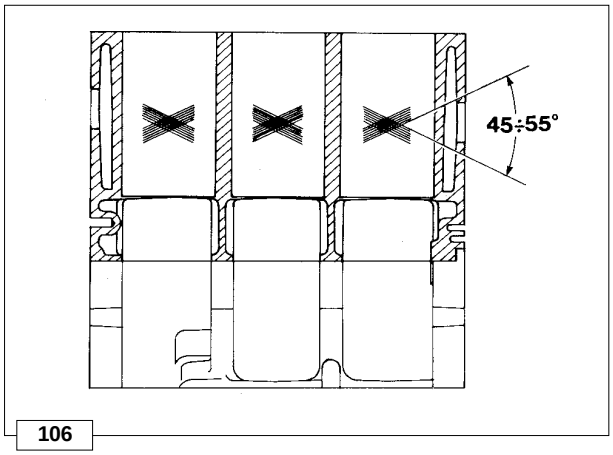


105

Cylinder, class

The pistons (**A**, **B**, **C**) locations are shown on the piston crown while those for the cylinders are found on the crankcase in the points shown by the arrows, see picture.

Note: The cylinders are not to be changed.

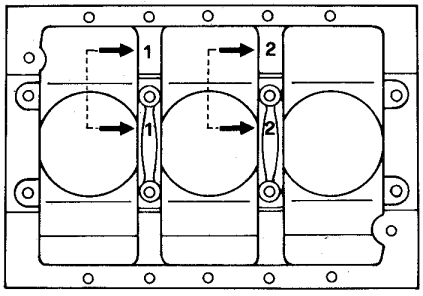


106

Cylinder roughness

Caution – Warning
Do not treat the cylinder's internal surfaces with an emery cloth.

The angle of the crossed processing marks must be between 45° and 55°. These must be uniform and distinct in both directions.
Average roughness must be between 0.5 and 1 µm.
The whole surface of the cylinder affected by contact with the piston rings must be rendered with the plateau method.

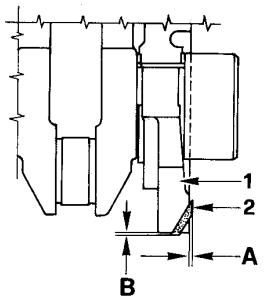


107

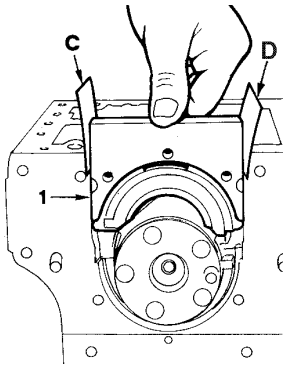
Central main bearing caps

The central support caps are marked with locations that can be numbers as in the diagram or dots.
The same locations are given on the crankcase.
Couple the caps with the same references and on the same side. In any case locate the bearing's two centring notches that are to be found on the same side.

❍ Tighten the screws simultaneously at a torque of 60 Nm.



108



109

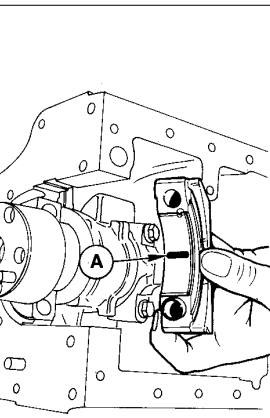
Rear and forward main bearing caps

Important
Before the final tightening and after it, using a ground bar, check the coplanarity of the horizontal and vertical levels.

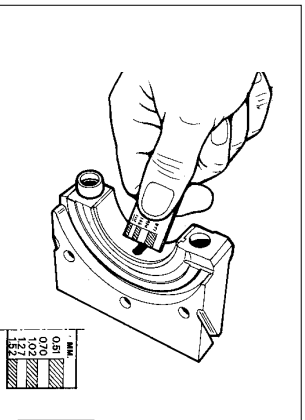
On remounting the rear main bearing cap **1** replace the lateral rubber gaskets **2**, keeping in mind that projections **A** and **B** of the support must be 0,5÷1,0 mm; cut off any exceeding portions.
Do the same with the front bearing cap.
Before reintroducing the bearings in the crankcase, place between their surfaces two plates **C** and **D** - 0.1 mm thick - se.no.7107-1460-053.

❍ Tighten the screws at a torque of 60 Nm.

Note: It is advisable to apply a few drops of silicon sealant on the surface of the gasket slot **2**.



110



111

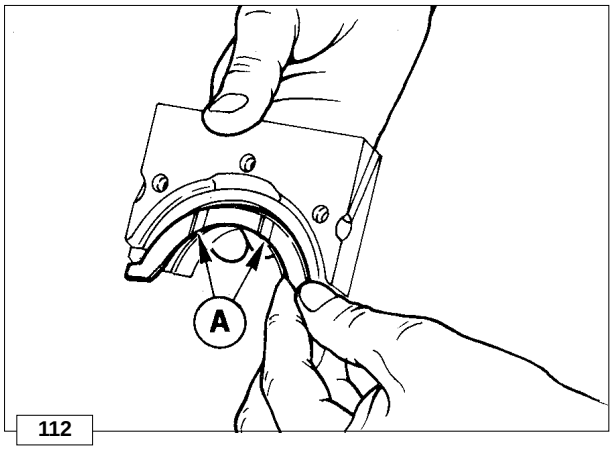
Check the clearances between the bearings and the journal

Use the "Perfect Circle Plastigage" type calibrated wire **A** and put it at the centre of the bearing with a bit of grease.

❍ Tighten the screws at a torque of 60 Nm.

Find out the clearance value checking the wire's compression with the appropriate graduated scale supplied in the same pack and available on the market.

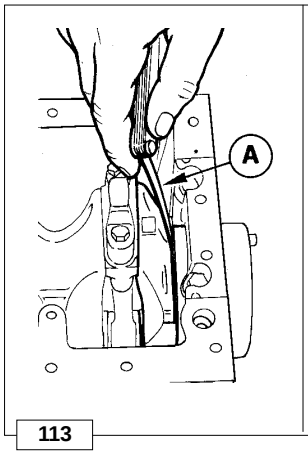
➲ For clearance values between the journals, connecting rod pin and the relevant bearings see page 51.



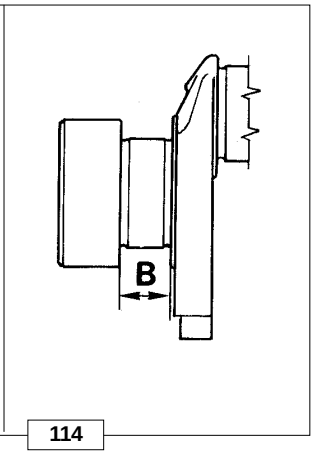
112

Shoulder half rings

So as to keep them in their seats during assembly, put a bit of grease.
The half-rings must be assembled with the slots **A** as in the figure.
Thickness of half-rings is equal to 2.31÷2.36 mm.
They are supplied as spare parts as increased thickness 0.1 and 0.2 mm, see below.



113



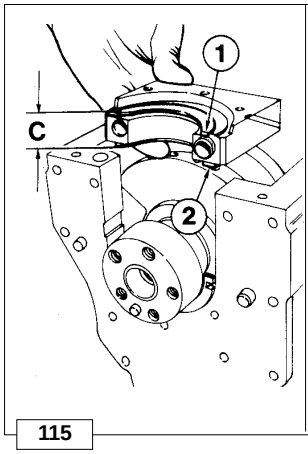
114

Crankshaft axial clearance

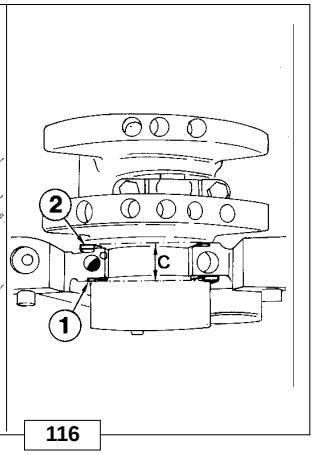
After tightening the main bearings measure the axial clearance **A** between the crankshaft flywheel side shoulder and the main bearing half rings.

Ref.	*Clearance*	*Limit value*
A mm	0,130÷0,313	0,5
B mm	23,05÷23,10	23,50

If the clearance is not within the given value check value **B**.
If need be, fit oversized half rings, see below.



115



116

Shoulder half rings, oversized elements

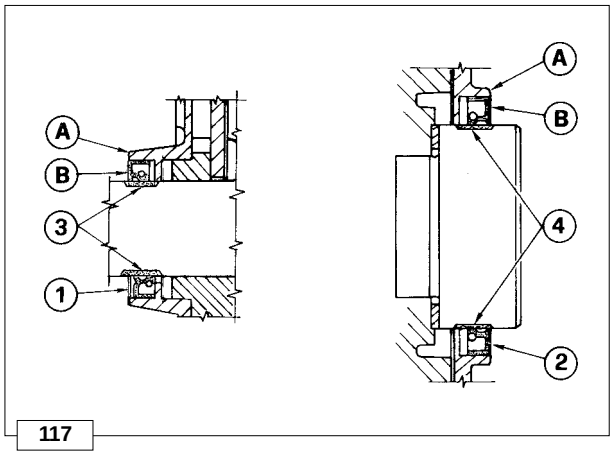
Dimensions (mm):

	C	B**	A*
Std	22,787÷22,920	23,050÷23,100	0,130÷0,313
1ª	22,987÷23,120	23,250÷23,300	
2ª	3,087÷23,220	23,350÷23,400	
3ª	23,187÷23,320	23,450÷23,500	

* **A** of Fig. 113.
** **B** of Fig. 114.

Grinding **B** as per relevant table, you can mount the following half rings:

1st Oversized element Half rings **1** and **2** + 0.10 mm on both sides of the bearing
2nd Oversized element Half rings **1** and **2** + 0.10 mm on one side of the support and + 0.20 mm on the other side.
3rd Oversized element Half rings **1** and **2** + 0.20 mm on both sides of the bearing.



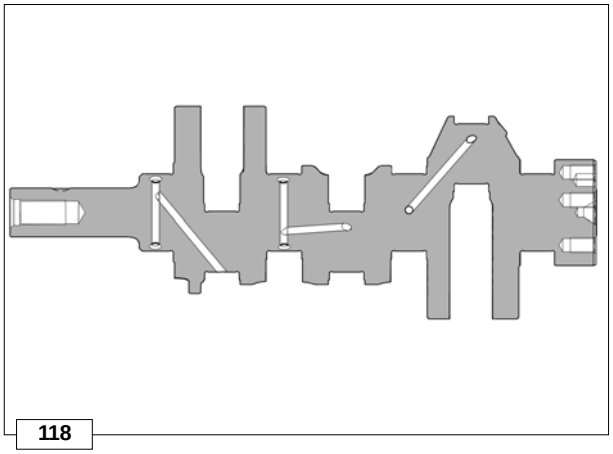
117

Crankshaft front and back oil seal rings

The front oil seal ring **1** inserted into the oil pump cover and the back one **2**, in the flywheel side flange.
If warped, hardened, or cracked, replace them.

For the replacement:
- Carefully clean the housing
- Keep the ring immersed in engine oil for about half an hour.
- Drive it into its housing with a buffer exercising a uniform pressure on the whole front surface. Be sure that the two surfaces **A** and **B** meet on the same level.
- Refill the interior hollow with grease and lubricate the seal lip with thickened oil.

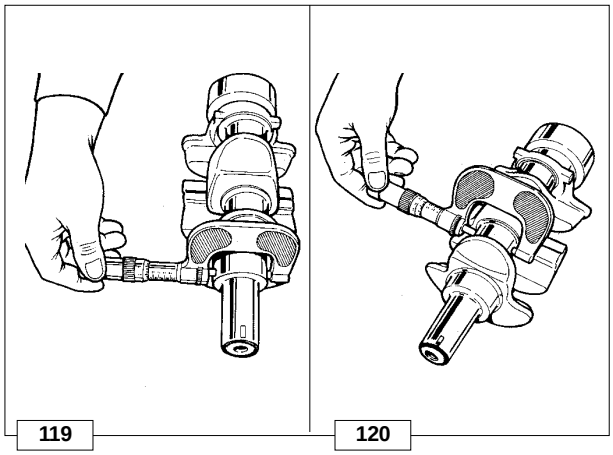
Note: Before major engine overhaul, in case of oil leakage in the seal area of rings **3** and **4**, you can remedy this by replacing the rings and pushing them about 2 mm deeper with respect to the previous ones.
If the rings are black it means zones **3** and **4** of the crankshaft are tempered. In this case it is necessary to remount a ring of the same colour.
If the rings are brown it means that zones **3** and **4** of the crankshaft are not tempered. In this case it is necessary to remount brown coloured rings.


118

Crankshaft, lubrication lines

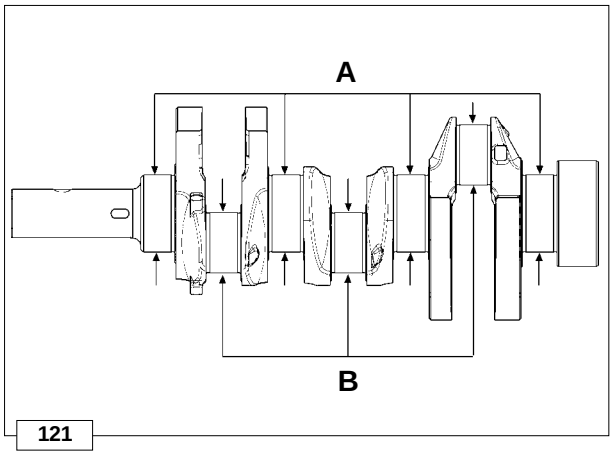
Caution – Warning
During repairs, when compressed air is used it is important to wear protective goggles.

Put the crankshaft in a bath of crude oil.
Use compressed air to clean the inside of the lines.
Reposition the new caps in their seating and check the seal.


119 120

Crankshaft, check journals and crank

Use a micrometer for the outsides.

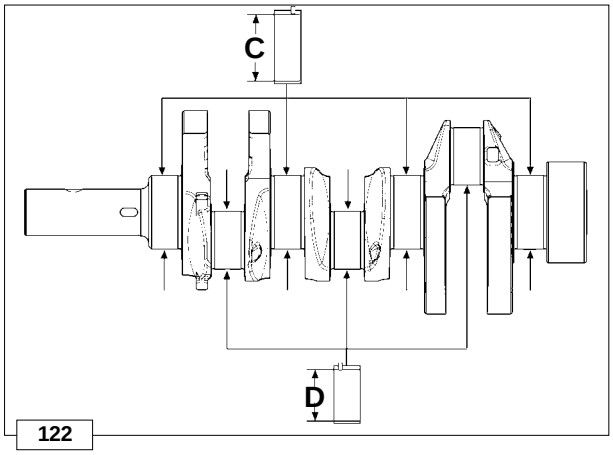


121

Journal and connecting rod pins diameters

Dimensions (mm):

Ref.	Tolerance	Limit value
A (mm)	50,981÷51,000	50,900
B (mm)	39,984÷40.000	39,900



122

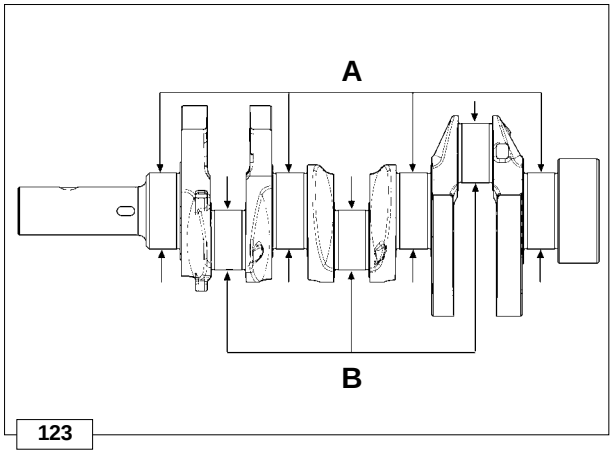
Main bearings and connecting rod big ends diameters

Dimensions (mm):

Ref.	Tolerance	Limit value
C (mm)	51,023÷51,059	51,098
D (mm)	40,021÷40,050	40,100

The dimensions given refer to tightened bearings.

➲ For tightening torque see figures 97.



123

Clearances between the bearings and corresponding pins

See figures. 110 ÷ 111.

Dimensions (mm):

Ref.	Clearance	Limit value
C-A (mm)	0,023÷0,078	0,200
D-B (mm)	0,021÷0,066	0,130

Nota: Both for crankshaft bearings and for connecting rod big end bearings internal diameter are undersized by 0.25 and 0.50 mm.

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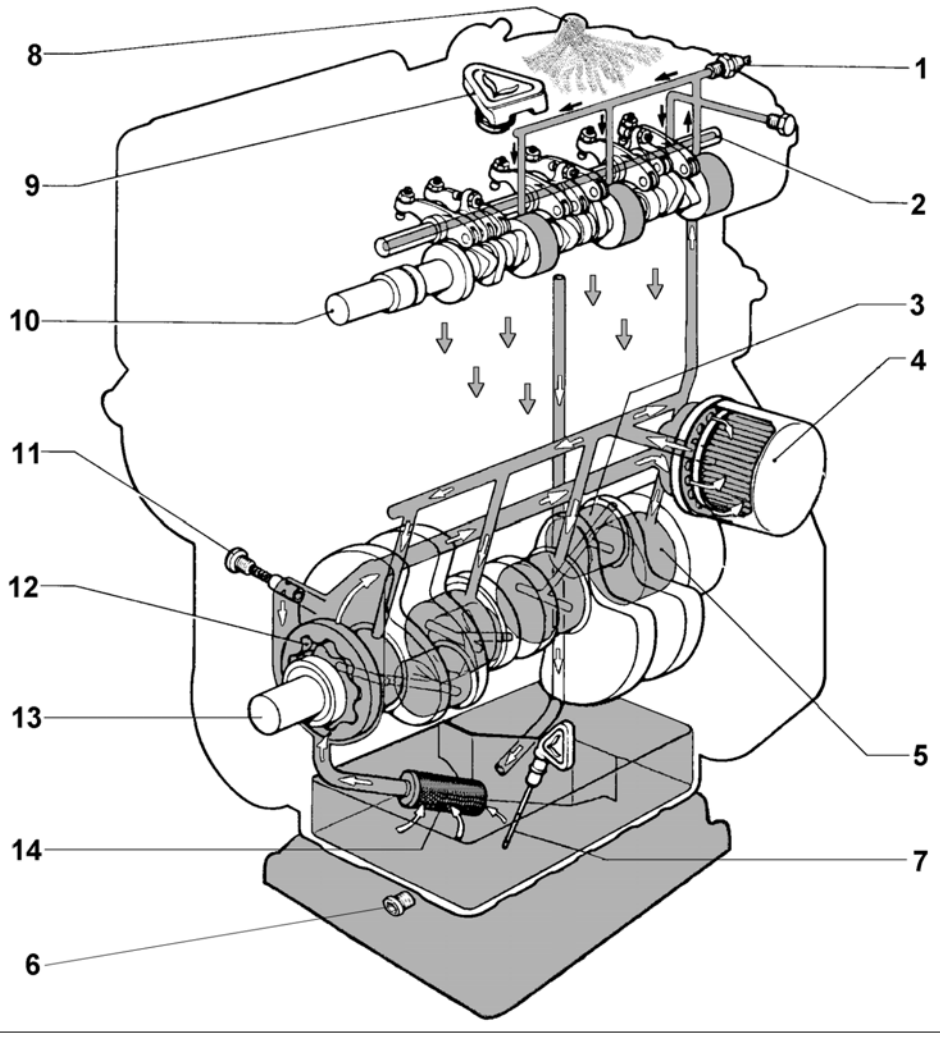
Danger – Attention

- **The engine can be damaged if allowed to operate with insufficient oil. It is also dangerous to add too much oil because its combustion may lead to a sharp increase in the rotation speed.**
- **Use suitable oil in order to protect the engine. Nothing more than lubrication oil can influence the performances and life of an engine.**
- **Use of an inferior quality oil or failure to regularly change the oil will increase the risk of piston seizure, will cause the piston rings to jam and will lead to rapid wear on the cylinder liner, the bearings and all other moving parts. Engine life will also be notably reduced.**
- **The oil viscosity must suit the ambient temperature in which the engine operates.**

Danger – Attention

- **Old engine oil can cause skin cancer if repeatedly left in contact with the skin and for long periods of time. Wear protective gloves to avoid touching used oil.**
- **If contact with the oil is unavoidable, you are advised to wash your hands with soap and water as soon as possible. Dispose of old oil in the correct way as it is highly polluting.**

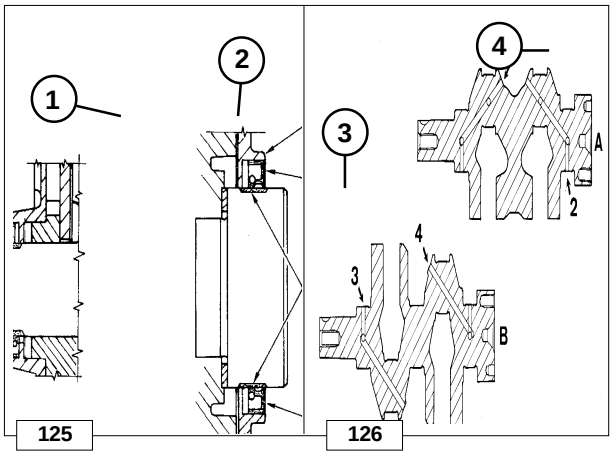
LUBRIFICATION CIRCUIT



124

Components:

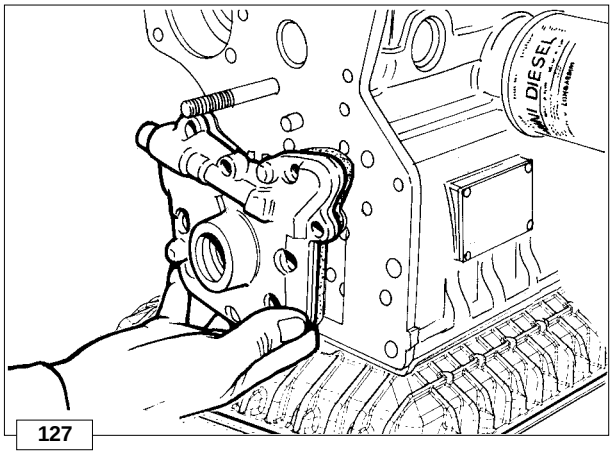
1 Pressure gauge
2 Rocker shaft
3 Connecting rod pin
4 Oil filter cartridge
5 Journal
6 Oil drain plug
7 Oil dipstick
8 Bleed
9 Oil filler cap
10 Camshaft
11 Oil pressure regulating valve
12 Oil pump
13 Crankshaft
14 Oil suction filter



Internal oil filter and oil sump return pipe

Clean with petrol the internal oil filter **1** and oil sump return pipe **2**, blow also some compressed air.
Replace sealing rings **3** and **4**.

❍ Tighten oil drain plug at a torque of 40 Nm.



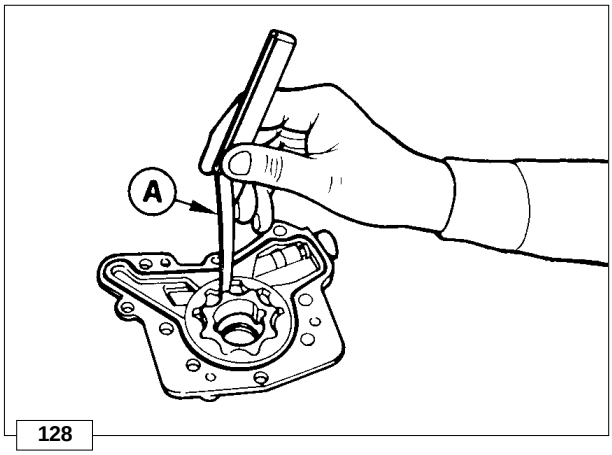
Oil pump

Oil pump delivery test at 1000 revs per minute with an oil temperature of 120°C.

Delivery (l/1')	Pressure (bar)
4÷4,3	3÷3,5

Delivery test at 3600 rpm with an oil temperature of 120°C.

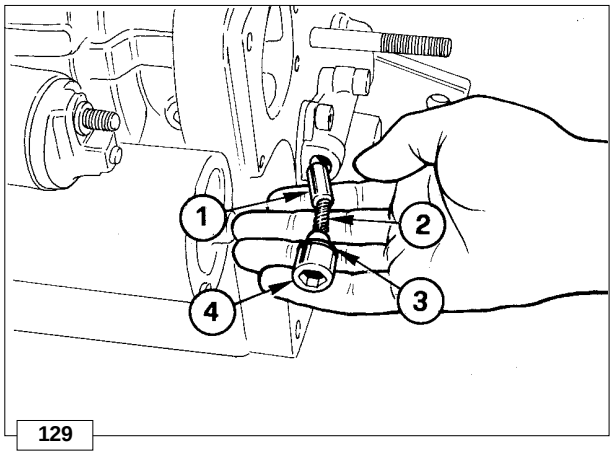
Delivery (l/1')	Pressure (bar)
19,3	4÷4,5



Oil pump, clearance between rotors

Measure the clearance **A** between teeth as in figure; the maximum value is 0.171 mm.
Clearance wear limit should be 0.250 mm.

➲ See page 32 for assembly and disassembly.



129

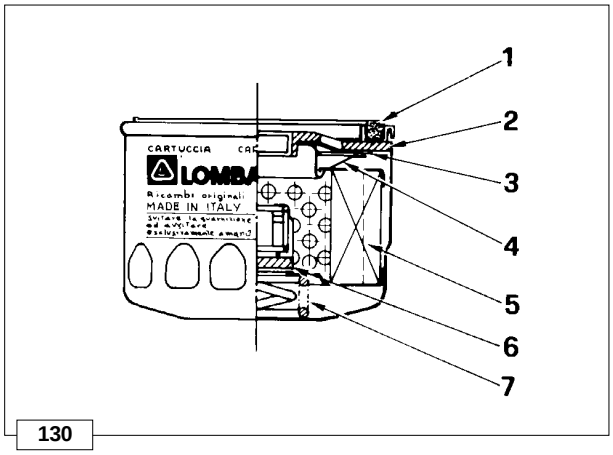
Oil pressure regulating valve

Components:

1 Valve
2 Spring
3 Gasket
4 Screw cap

Spring length = 27.50÷27.75 mm
Blow the valve's seating with compressed air and carefully clean all the components before remounting them.

Nota: The valve begins to open at a pressure of 4.5÷5.5 bar.



130

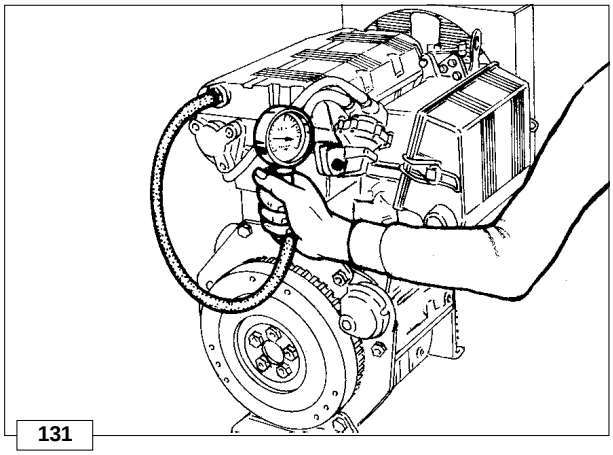
Oil filter cartridge

Components:

1 Gasket
2 Plate
3 Rubber element
4 Spring
5 Filtering element
6 By-pass valve
7 Spring

Characteristics:

Maximum operating pressure: ..... 7 bar
Maximum bursting pressure: ..... 20 bar
Degree of filtration: ..... 15 **µ**
By-pass valve calibration: ..... 1,5÷1,7 bar
Total filtration surface: ..... 730 cm^2



131

Oil pressure check

Once remounted fill the engine with oil, fuel and coolant.
Remove the pressure switch, fit a union and connect a 10 bar pressure gauge.
Start the engine and check how pressure is affected by oil temperature.

Nota*:* With a maximum operating temperature of 120°C at 900 rpm the oil pressure must not be less than 1 bar.

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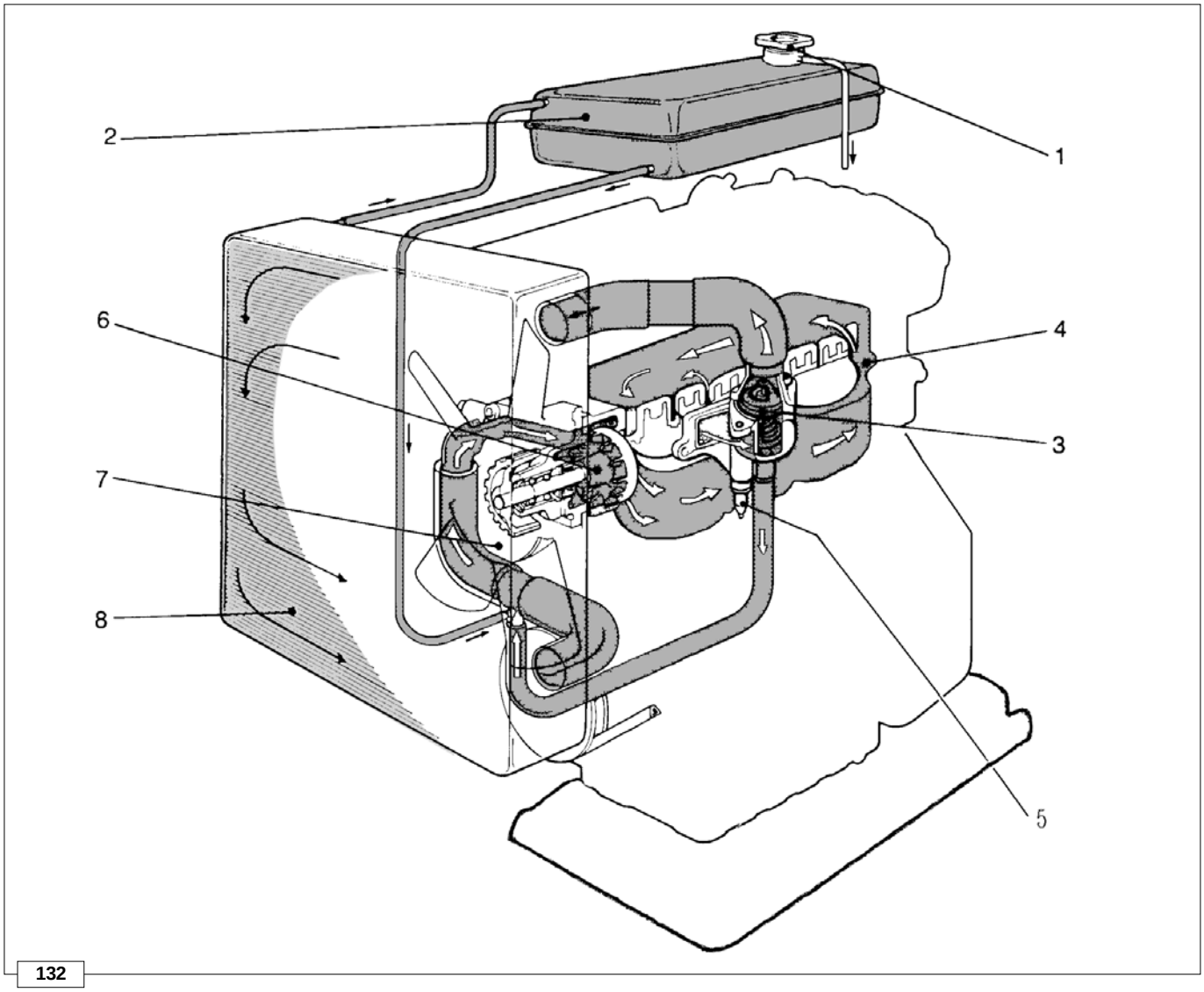
Danger – Attention

- **The coolant circuit is pressurised. Do not check it before the engine has cooled down and, also in that case, open the radiator cap or expansion tank plug with caution.**
- **When there is an electric fan do not approach a hot engine because it could also come on with the engine off.**
- **The liquid coolant is a pollutant and therefore must be disposed of with care according to environmental provisions.**

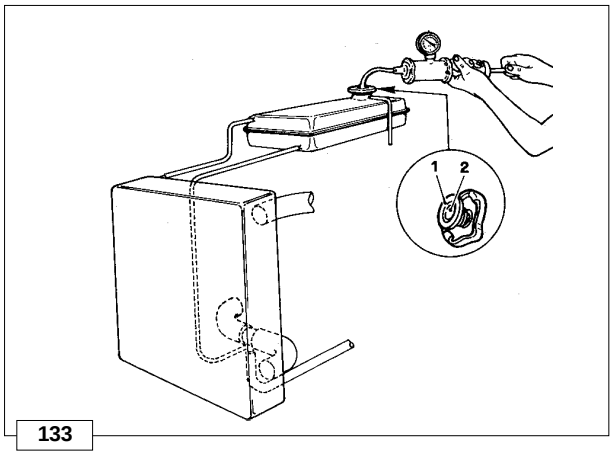
COOLANT CIRCUIT



132

Components:

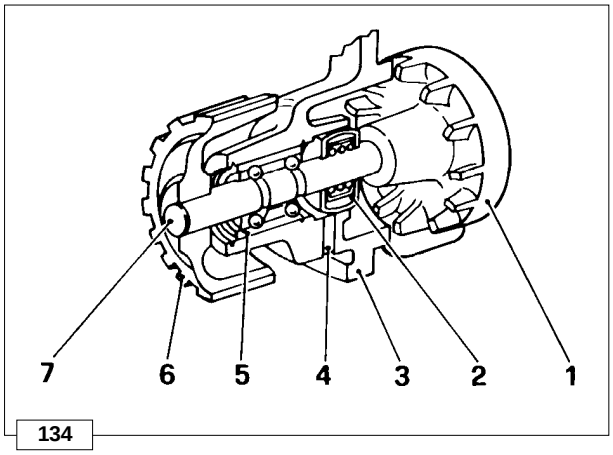
1 Coolant filler plug
2 Compensating tank
3 Thermostatic valve
4 Cylinder block
5 Thermostat for liquid temperature indicator
6 Circulation pump
7 Fan
8 Radiator



133

Radiator and compensation, check and seal tank cap.

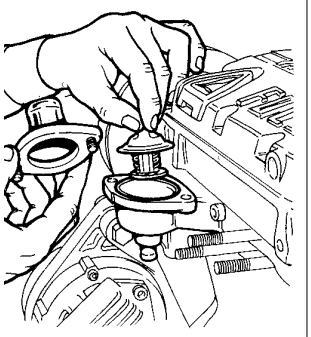
Remove the cap from compensation tank cap and check that the liquid is at the correct level.
Replace the cap with a new one provided with hand air pump socket.
Compress air at a pressure of 1 bar for about two minutes.
Check that there are no drips in the radiator.
The tank cap is supplied with a vacuum relief valve **1** and an overpressure valve **2**.
Overpressure valve opening pressure of 0.7 bar.



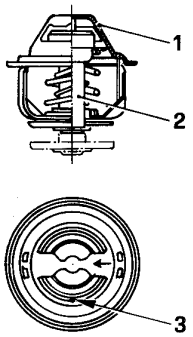
134

Coolant circulation pump, components

1 Rotor
2 Front seal gasket
3 Pump casing
4 Exhaust hole
5 Bearing
6 Pulley
7 Shaft



135



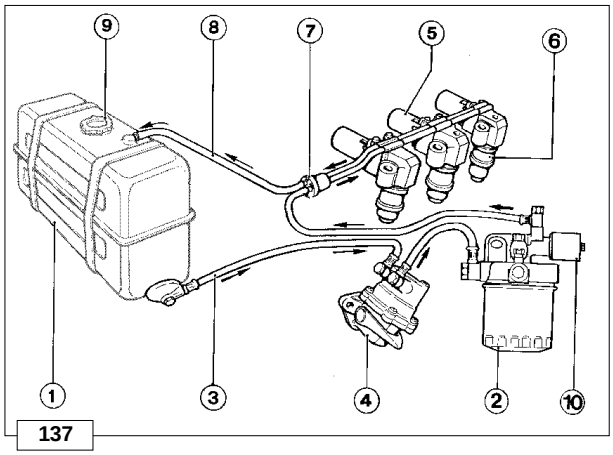
136

Thermostatic valve

1 - Stainless steel or brass casing
2 - Wax bulb
3 - Air relief hole

Characteristics:

Opening temperature: ..... 83°÷87°C
Max stroke at: ..... 94°C = 7 mm
Liquid recycling: ..... 30÷80 l/h.



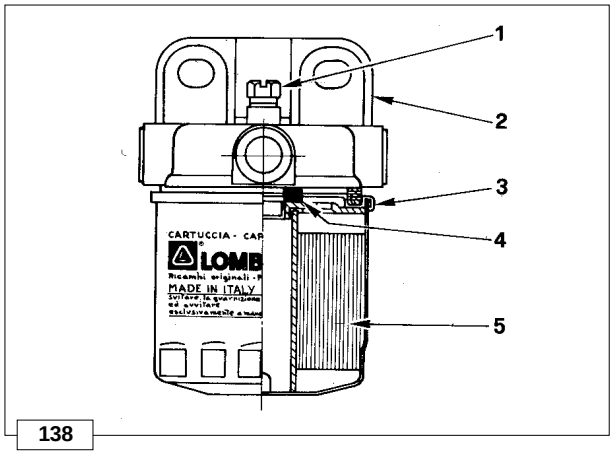
137

Fuel feeding / injection circuit

Components:

1 Fuel Tank
2 Fuel filter
3 Fuel feeding tube
4 Fuel lift pump
5 Injection pump
6 Injector
7 Fuel rail passage rubber joint
8 Injector exhaust pipe
9 Fuel tank cap
10 Solenoid valve

Note: The tank complete with filter is supplied on request.



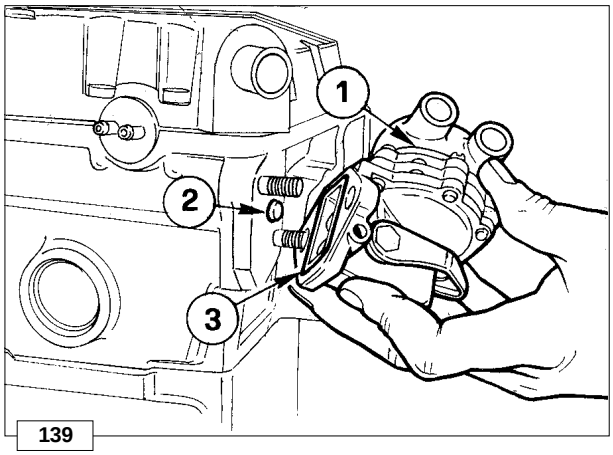
138

Fuel filter detached from the tank (on request)

1 Air relief valve
2 Bearing
3 Cartridge
4 Rubber element
5 Filtering element

Cartridge characteristics:
Filtering paper: ..... PF 905
Filtering surface: ..... 2400 cm^2
Degree of filtration: ..... 2÷3 **µ**
Maximum operating pressure: ..... 4 bar

➲ See page 18 for periodic maintenance details.



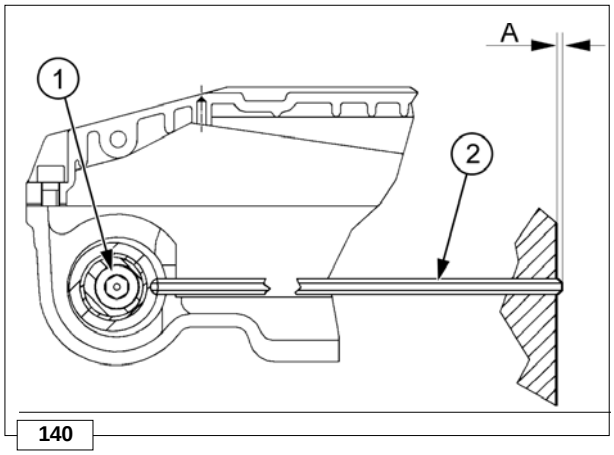
139

Fuel lift pump

Components:
1 Fuel lift pump
2 Push rod
3 Seal ring

The fuel pump is membrane type. It is driven by camshaft cam via a drive rod.
It is equipped with an external manual fuel lever.

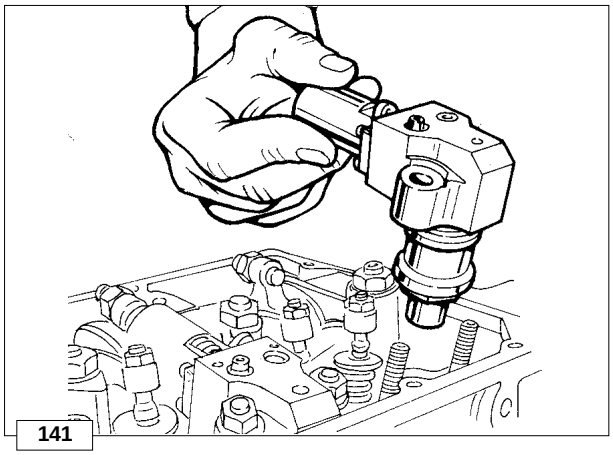
Characteristics:
With the control cam at 1500 rpm the delivery rate is 75 l/hours and the self-adjusting pressure is at 0.55 to 0.65 bar.



140

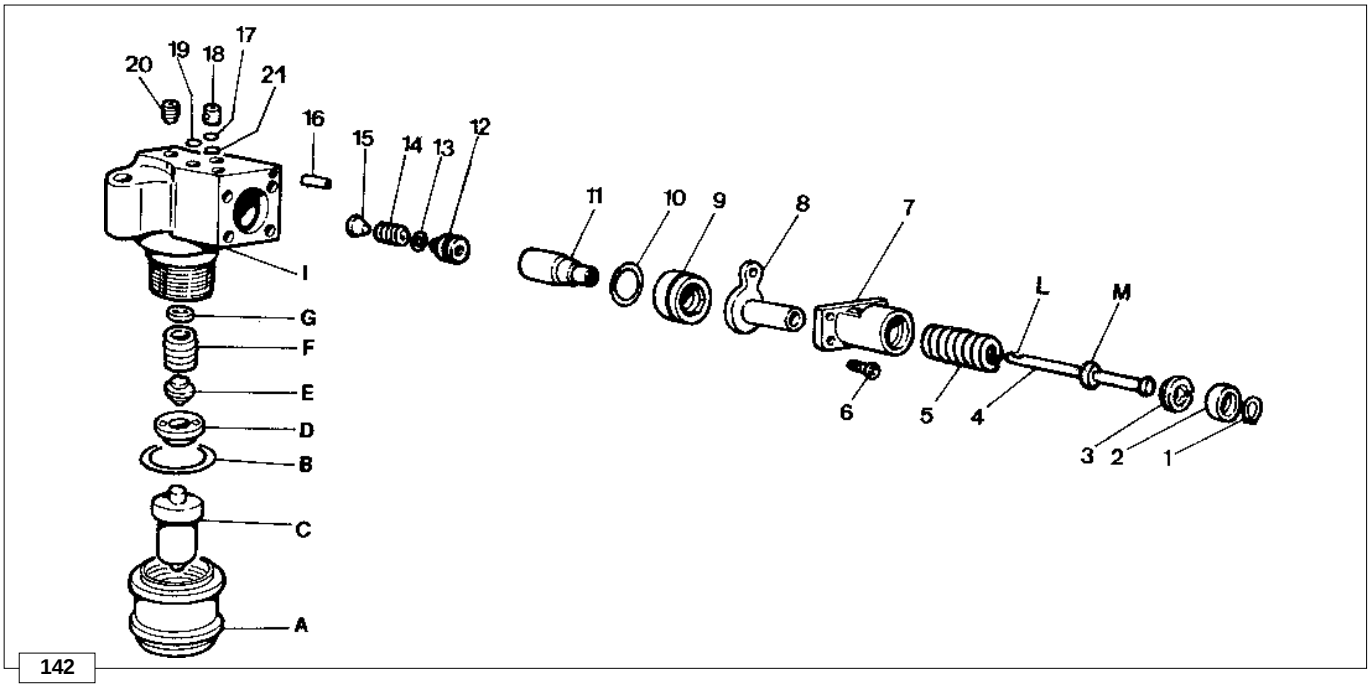
Fuel pump drive rod projection - Assembly

Rotate the timing shaft so that the eccentric is on the base radius and the drive rod is in place in its spherical seat in the control bush.
The projection **A** of the drive rod **2** from the head level should be 2÷2.5 mm.
The check should be carried out with cam **1** at rest, as shown in the figure.
Tighten the two fuel pump fastening nuts at 24 Nm.
Check the length of the drive rod and if it is not the right size, replace it.
Drive rod length = 153.15÷153.35 mm.


141

Pump/injector unit

Designed by LOMBARDINI, the pump/injector is exclusive to FOCS series engines.
The injection system includes three identical pumps/injector units, each one of which feeds a cylinder.



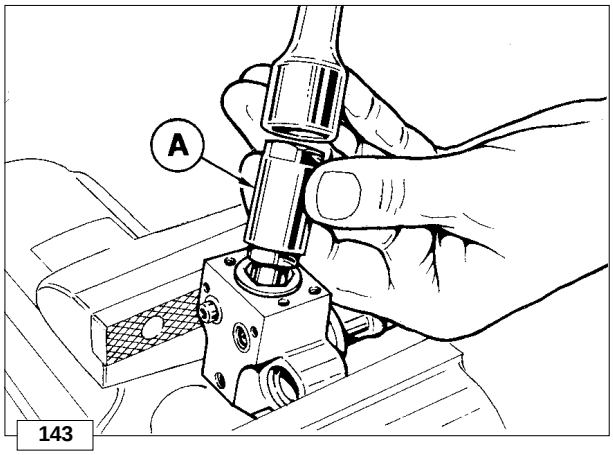
142

Pump/injector unit, components

1 Seeger ring
2 Tappet
3 Stop plate
4 Plunger
5 Spring
6 Screw
7 Bearing
8 Lever
9 Ring nut
10 Plunger guide O-ring
11 Cylinder
12 Delivery valve
13 Gasket
14 Spring
15 Filler
16 Pin
17 O-ring
18 Non-return valve
19 O-ring
20 Cap screw (old type)
21 Metal gasket (new type)

A Ring nut
B O-ring
C Nozzle
D Spacer
E Pressure rod
F Spring
G Spacer
I Casing
L Control spiral
M Plunger guide

❍ When remounting the injector tighten ring nut A at 70 Nm

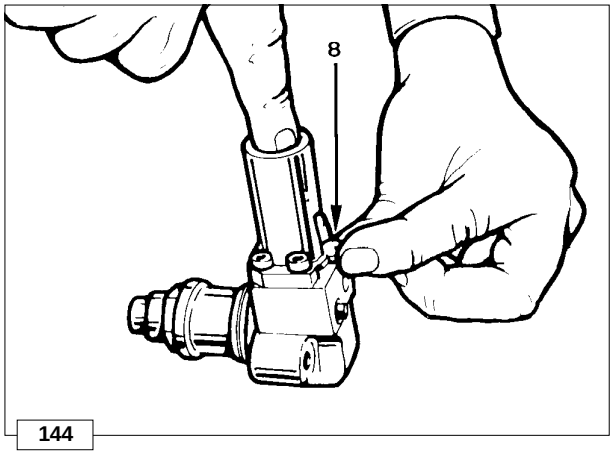


143

Plunger barrel ring nut assembly/disassembly

To disassemble ring nut **9** (fig. 142) , use the suitable wrench **A** se.no. 7107-1460-029

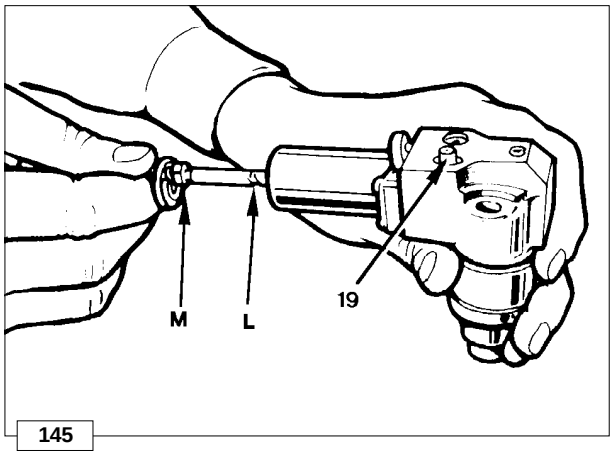
❍ When refitting tighten it a torque of 34 Nm.



144

Injection pump assembly/disassembly

Disassemble the unit following the progressive order of fig. 142.
Reassemble following the same steps in reverse order.
During reassembly, turn the plunger spiral **L** towards the non-return valve **19**, as follows.

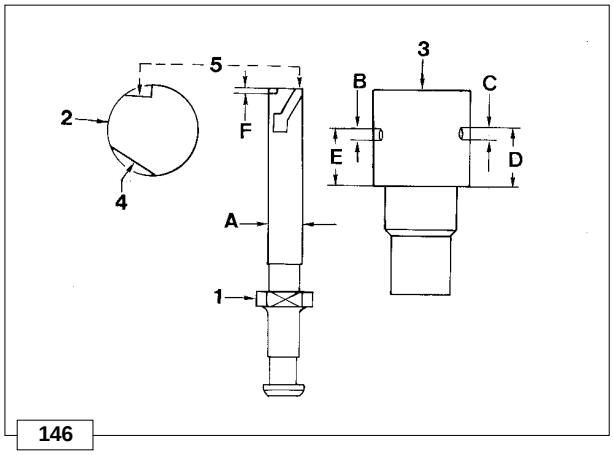


145

Plunger injection pump reassembly

To be able to insert the plunger in its barrel press with a finger and at the same time slowly rotate lever **8** (fig. 144) until guide **M** of the plunger (fig. 145) enters the lever seating.

Note: If by mistake the plunger is mounted with the spiral in the wrong direction the pump won't function (there is no danger that the engine runs away).

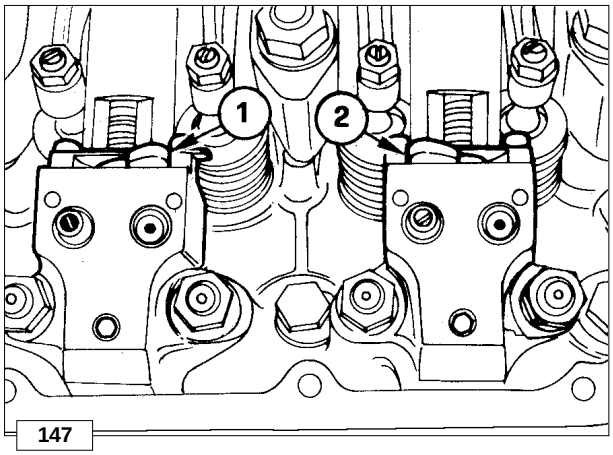


146

Pumping element

1 Plunger
2 Upper plunger section
3 Plunger barrel
4 Delay notch
5 Control slot

INJECTION PUMP	Dimensions					
	A	B	C	D	E	F
6590.290	6.5	1.50 ÷ 1.55	1.50 ÷ 1.53	9.965 ÷ 10.035	9.565 ÷ 9.635	0.9



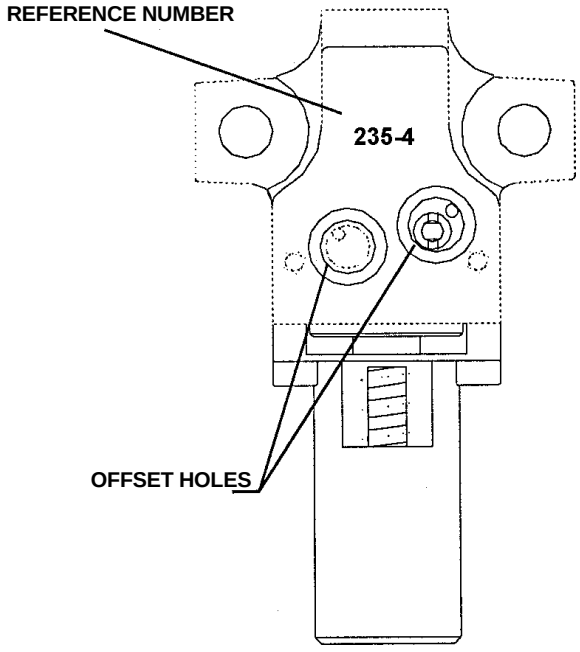
147

Pump/injector unit se.no. 6590.290 control data.

1 Delivery control lever on stop position.
2 Delivery control lever on maximum delivery position.
start position

Rod stroke form max delivery position (mm)	Rpm (*)	mm³/stroke
9,5	3600	19÷23
9,5	1200	15÷24
start position	300	35÷38

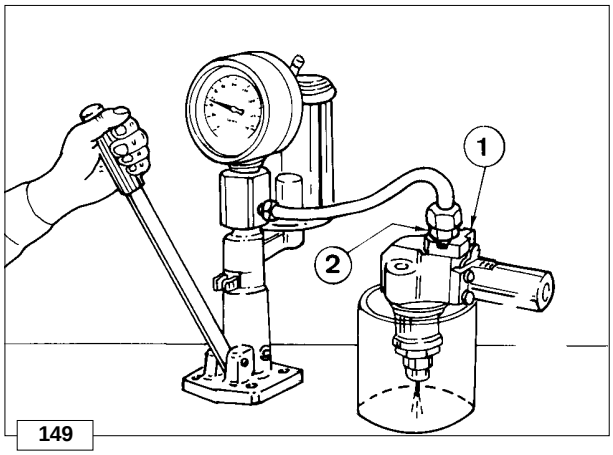
Injector setting pressure: 140÷155 bar
* Rpm rating is that of the crankshaft.



CURRENT PUMP INJECTOR

148

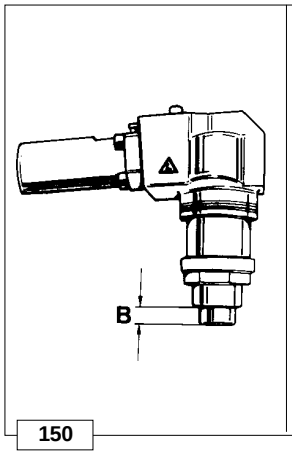
REFERENCE N°	CODE N°	INJECTION ADVANCE VALUE	SPECIAL TOOLS
235-4	6590.290	13° ÷ 14° > 3600 g/min	ADVANCE / INJECTOR SETTING ..... 1460.074 T.D.C. 1460.048



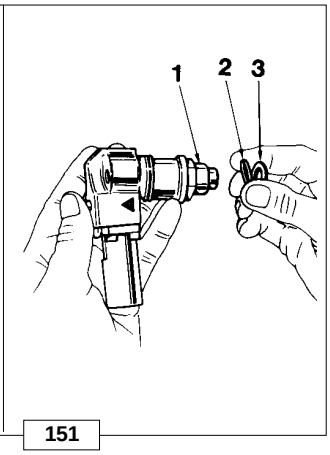
149

Setting of injector

Remove the non-return valve leaving its metal gasket and fit a cap screw in its place, that is part of tooling 7107-1460-074.
Mount then head **1** and coupling **2**.
Then connect a hand pump as shown in the picture.
The pressure setting must be 140÷155 mm bar.



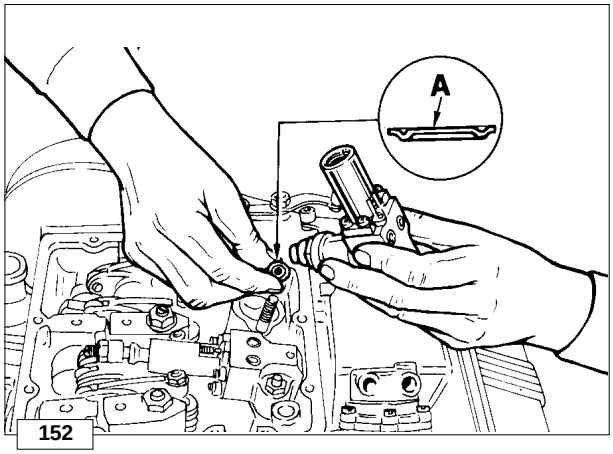
150



151

Injector, nozzle projection

To avoid excessive compression of the spark arrester **A** (fig. 152), check projection **B** of the nozzle (fig. 150).
B = 6.80÷7.05 mm.
If this measure is larger put spacer **2** between ring nut **1** and copper gasket **3**.
0.25 mm thick spacers are available.



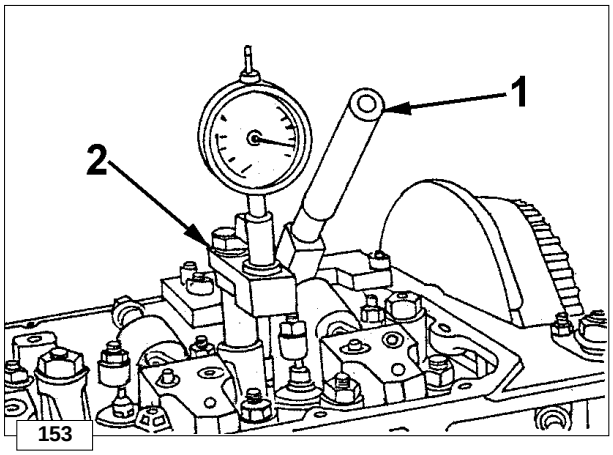
152

Injector, spark arrester

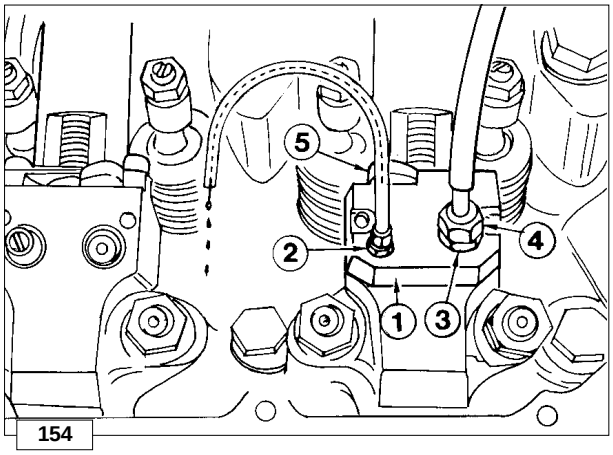
Every time you remove the pump/injector you must replace the spark arrester, the copper gasket, the oil O-ring, as well as the 2 fuel O-rings.
Insert the spark arrester in the injector housing with surface **A** pointing upwards.

❍ Tighten simultaneously both nuts that fasten it to the head at 20 Nm.
For engines with the injectors fixed with self-locking nuts, tighten the nuts at 23 Nm.

➲ See page 18 for periodic maintenance details.



153



154

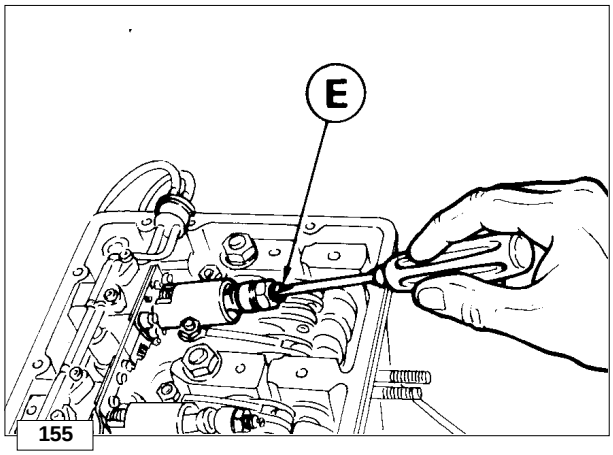
Injection advance control and regulation

- Dismount the rocker arm cover (see page 32).
- Position the device on the head, in contact with cylinder no. 1.
- Mount the dial gauge on the valve controlled by tool ref. 1460.048.
- Via lever **1** of the tool, open the valve until it comes into contact with the piston.
- Then rotate the crankshaft until the TDC is read in the dial gauge. Then reset the hundredths.
- Remove the fuel pipes.
- Remove the O-ring in contact with the non-return valve and replace it with the appropriate gasket - equipment component part ref. 1460.074. Once the check has been completed, remove the gasket and refit the O-ring.
  Connect tool 1460.074 on pump **1**. This will automatically position the control lever to the maximum delivery. The tool is provided with **3÷4** couplings for connection to a tank that must be not lower than 30 cm from the pumps level. Coupling **2** is equipped with a plastic pipe **5** with internal drip collecting wire.
- Put cylinder 1 under compression and open the tank tap. Fuel diesel will start to flow out from coupling **2**.
- Slowly rotate the engine towards TDC 1 until the diesel fuel stops leaking out.
- At this point with lever **1** (of fig. 153) move again the valve until it touches the piston and read on the dial gauge how many hundredths are missing from the previously reset value (TDC).
- To convert hundredths into degrees, consult the table below.
- Repeat the operation on the other cylinders.

α	(mm)
18°	2.468
17°	2.205
16°	1.956
15°	1.721
14°	1.501
13°	1.296
12°	1.105
11°	0.930
10°	0.769
9°	0.623
8°	0.493
7°	0.378
6°	0.277

Injection advance

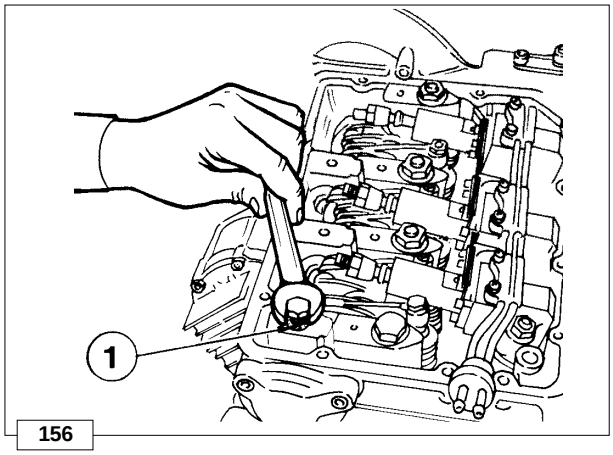
Code	Reference n°	Rpm	α
6590-290	235-4	> 3600	13°÷15°



155

Static injection advance tuning

If the injection advance value found does not correspond to the previously described value, adjust the screw **E** and repeat the test.
Rotating screw **E** by ½ turn will change the injection advance by 5°.
If turned clockwise, injection is advanced.
In the opposite direction, injection is delayed.



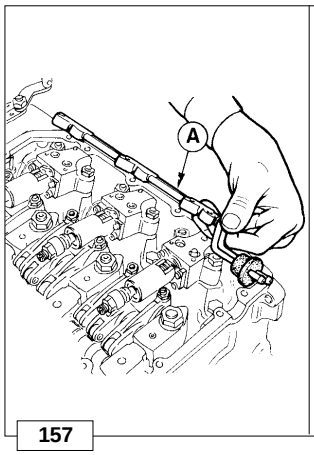
156

Preliminary steps to pump/injector unit delivery balancing test

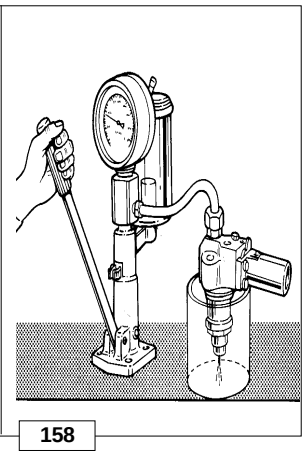
Closing the oilhole

To perform this test you must remove the rocker arms cover and close hole **1** with an M 8x1.25 or M 10x1.5 screw (on latest model engines) not longer than 8 mm. Also remove the copper gasket.
If the camshaft and rocker arms are dry, lubricate them with engine oil.

Note: If you only want to check the nozzle it is not necessary to balance the deliveries; provided that when you dismount the rod you do not loosen adjusting screws **1** and **2** (fig. 160).

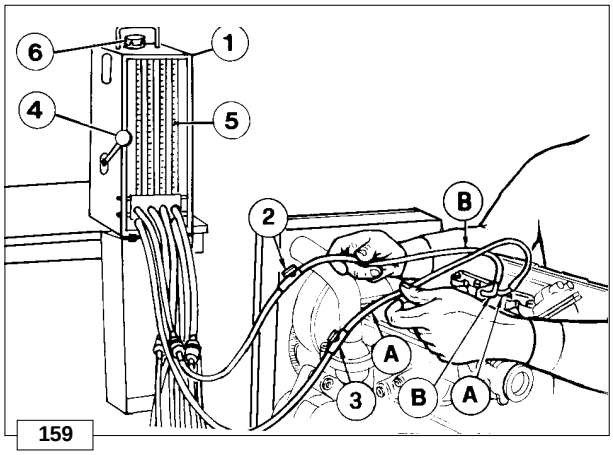


157


158

Test head B assembly

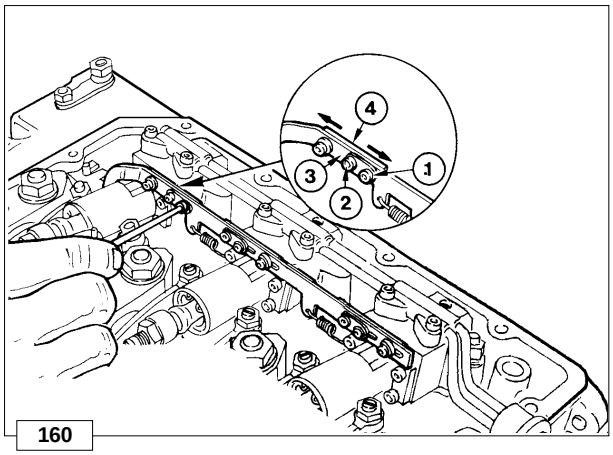
Remove fuel pipe **A** and mount one test head **B** in its place per pump/injector.
The test heads complete with pipes are supplied together with instrument ref. 7104-1460-069.



159

Instrument connection

Place the instrument **1**, se.no. 7104-1460-127 at least 20 cm above the pump/injector level.
Connect pipe **A** (outlet from every instrument test piece) with pipe **A** (inlet of every pump/injector) and pipe **B** (return to the instrument) with pipe **B** (outlet from the pump/injector).
Open tap **2** and **3** of each pipe and fill the instrument with diesel.
Start the engine and bring it to 1500 rpm idle running.
Close the fuel supply to the engine from the instrument's tank using lever **4** and after 1 minute observe the levels in the test piece.
If a level goes down more than the others it is necessary to decrease the delivery of the corresponding pump (see below) and vice versa to increase the delivery if the level increases.



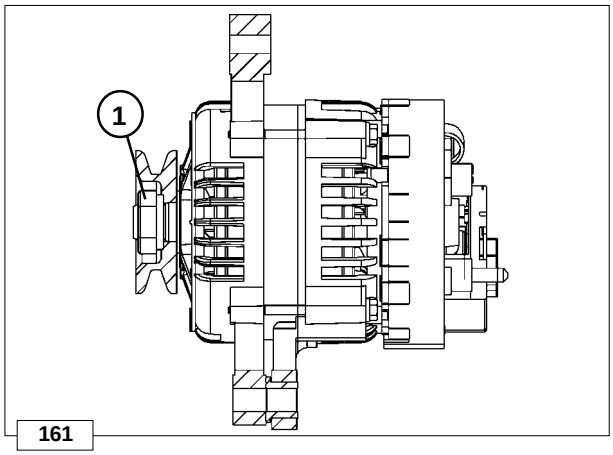
160

Injection pumps delivery balancing

In case the balancing error read on the test pieces is greater than 2 cm^3/min, then injection pumps deliveries should be adjusted.
Plate **4** and rod **3** are blocked by screws **1** and **2**. Loosen them.
Move plate **4** rightwards with respect to rod **3** if you want to increase delivery.
If moved leftwards delivery decreases. Make very small movements with the plate.

❍ Tighten screws **1** and **2** at a torque of 1,1 Nm.

Note: Each time a pump/injector is replaced it is necessary to balance the deliveries.

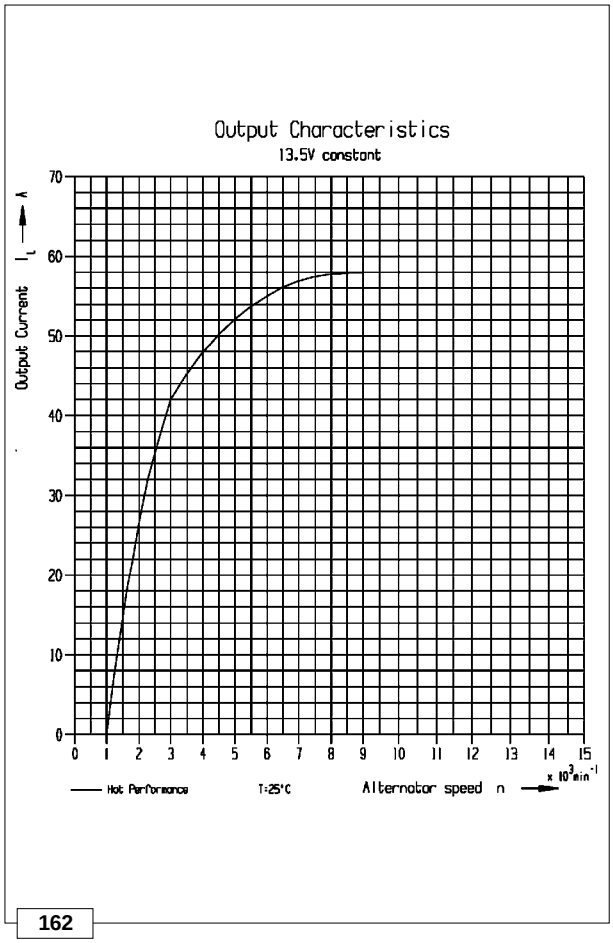


161

Alternator, 14V 33A

Nominal voltage 12V
Nominal current output 55A
Maximum Rpm ..... 18.000 giri/1'
Rotation (viewed at puley end): Clockwise

❍ Tighten nut **1** at a torque of 60÷70Nm.

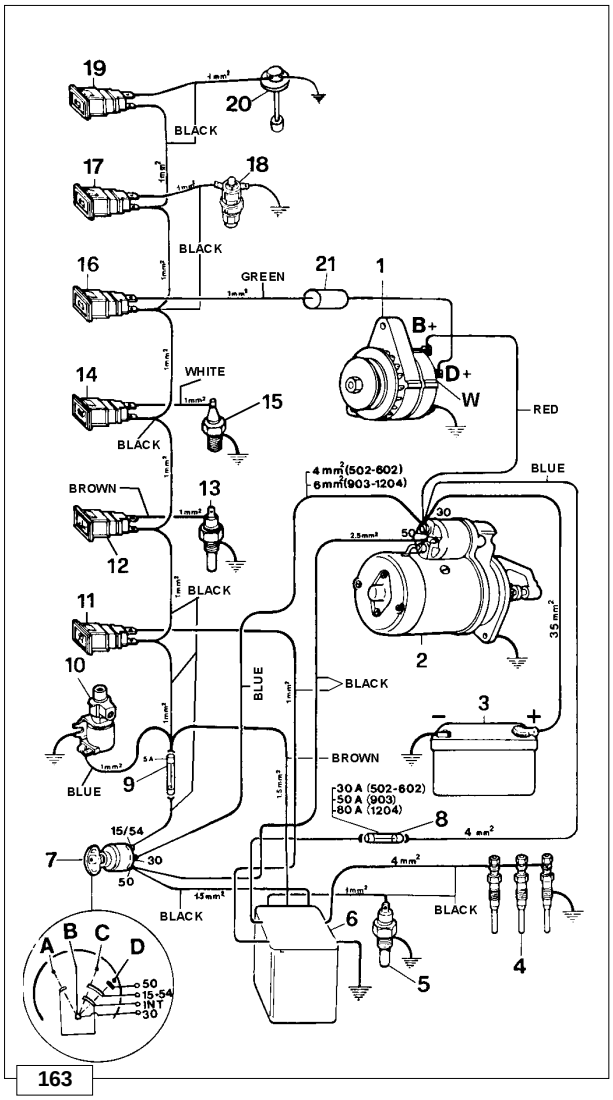


162

Alternator, 14V 33A - Performance Curve

The curve was obtained at room temperature of +25°C with 13,5 V battery voltage.

Note: The rpm shown on the table are referred to the alternator. Engine rpm/alternator rpm ratio, with driving pulley diameter 105 mm = 1:1,79.



163

Electric starting layout (12V) with alternator 14V 33A

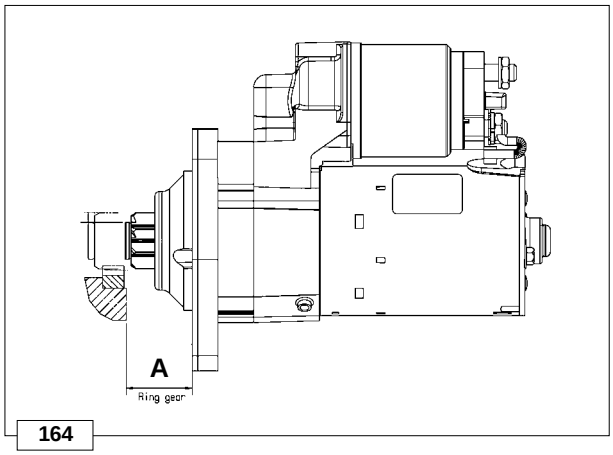
1 Alternator
2 Starter Motor
3 Battery
4 Glow Plugs
5 Coolant temperature thermistor
6 Glow Plug Controller / Timer
7 Key Switch
8 System Fuse, 50 A
9 Fuse (Accessory)- 5A
10 Fuel Solenoid Valve
11 Glow Plug Indicator Lamp
12 Coolant High Temperature Lamp
13 Coolant High Temperature Switch
14 Oil Pressure (Low) Lamp
15 Oil Pressure Switch
16 Alternator Charging Lamp
17 Air Filter High Restriction Indicator Lamp
18 Air Filter Restriction Switch
19 Low Fuel Level Lamp
20 Low Fuel Level Switch
21 Diode

A Accessory Position
B Off Position
C On Position
D Starting Position

➲ For electrical connections of the pre-heating gear case, see figure 170.

Note: Battery **3** not supplied by LOMBARDINI.
For assembly we recommend a battery with the following characteristics, see table below.

Starter motor class (epicyclic type) Kw	Normal starting conditions		Heavy-duty starting conditions (max allowed)	
	Capacity K20 - Ah	Rapid discharge intensity (DIN Standards at -18° C) A	Capacity K20 - Ah	Rapid discharge intensity (DIN Standards at -18° C) A
1,6	66	310	88	330



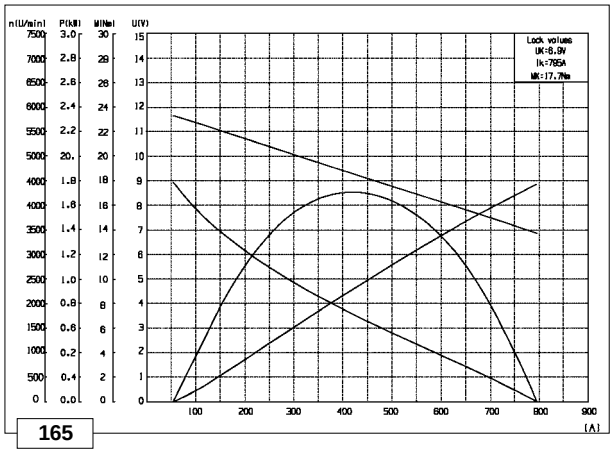
164

STARTER MOTOR - Bosch DW 12V 1,1 KW

Rotation: Clockwise

A = 17,5÷19,5 mm
(distance from starter mounting flange to ring gear face)

Note: Please refer to your local BOSCH distributor for service parts, repair criterion and warranty service.

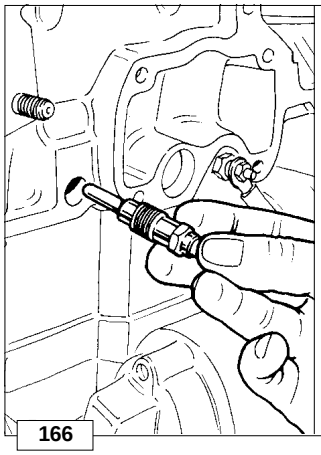


165

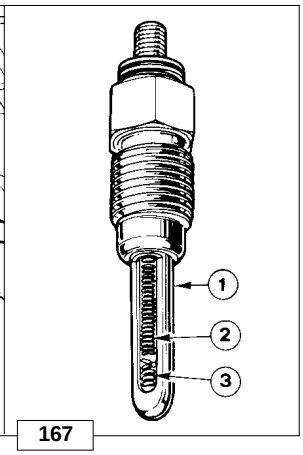
Starter motor, Bosch DW 12V 1,1 KW - Performance Curve

The curve was obtained at room temperature of -20°C with a fully charged 66Ah battery.

U = Starter Motor Voltag
n = Armature r/min
I = Absorbed Amperage
P = Starter Output Power (KW)
M = Starter Output Torque (Nm)



166



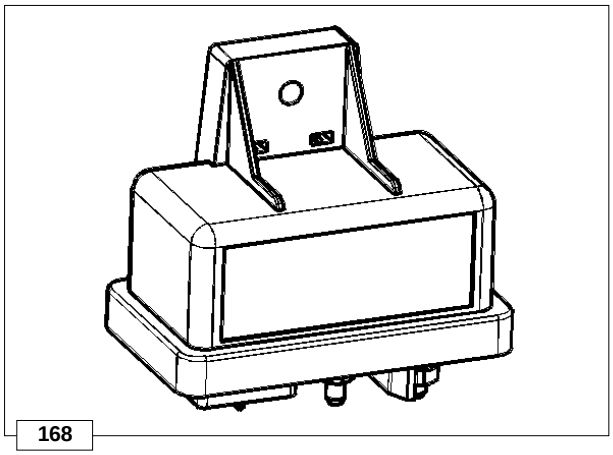
167

Pre-heating glow plug

Characteristics:
Nominal voltage 12,5V
Current absorption ..... 12A÷14A after 5 seconds
Sheath surface temperature ..... 850°C after 5 seconds.

Components:
1 Sheath
2 Primary Heating Coil
3 Secondary Heating Coil

❍ When remounting tighten at a torque of 20 Nm.

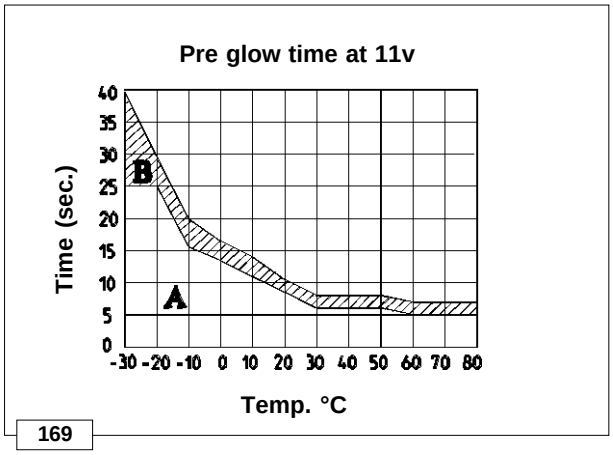


168

Pre-heating plug control unit with coolant temperature sensor

To avoid white smoke immediately following start-up post-heat for about 180 seconds, see table

Thermistor input		Glow-plug heat time (sec.)	
Resistance (ohm)	Coolant temp. °C	Pre-heat	Post-heat
11860	-30	30÷40	170÷190
7000	-20	25÷30	
4270	-10	16÷20	
2400	0	13÷18	
1000	+20	7÷11	
540	+40	6÷8	



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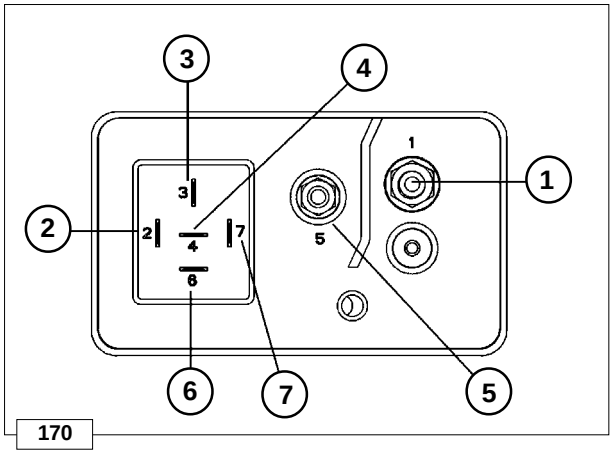
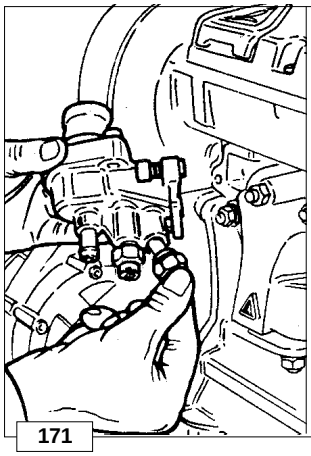


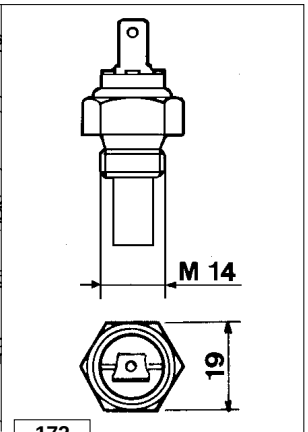
170

Wiring diagram for pre-heating gear case

1 6 mm² cable to "30" terminal of key-switch
2 1,5 mm² cable to ground
3 1,5 mm² cable to "15/54" terminal of key-switch
4 2,5 mm² cable to "50" terminal of key-switch
5 6 mm² cable to glowplugs
6 1 mm² cable to glowplugs warning light (max.2w)
7 1 mm² cable to water temperature transducer



171



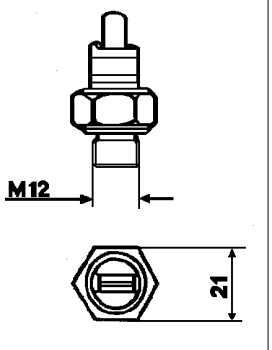
172

Temperature sensor for control unit

In engines fitted with the above-mentioned type of control unit, the introduction of the glow plugs depends on a temperature sensor that varies preheating temperature in relation to the coolant temperature.

Characteristics:

Temperature range ..... -30 ÷ +50°C
Voltage range ..... 6÷24 V
Temperature max. ..... 150°C
Max. tightening torque. ..... 30 Nm.



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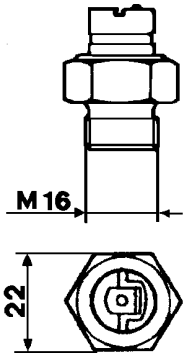


174

Oil pressure switch (Fig. 174)

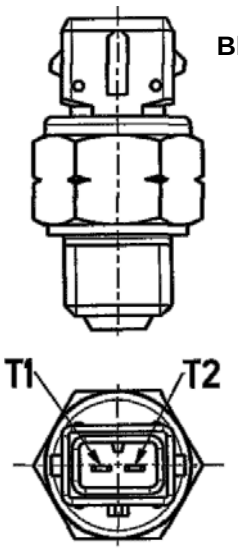
Characteristics:
Opening pressure: 0,15÷0,45 bar.

❍ Tightening torque 25 Nm.

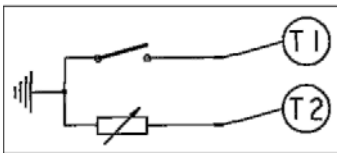
Coolant high temperature lamp sensor (Fig. 175)

Characteristics:
Circuit ..... single pole
Voltage range ..... 6÷24 V
Max. Power Absorption ..... 3 W
Closing temperature ..... 107÷113°C

❍ Tightening torque 25 Nm.



Electric System



175

Pre-heating water temperature thermistor and Water temperature indicator thermal contact

Thermistor features		
Temperature (°C)	**Resistance (Ohm)**	**Resistance (Ohm)**
60	552	639
70	402	470
80	296	349
90	222	264
100	169	204
110	130	158

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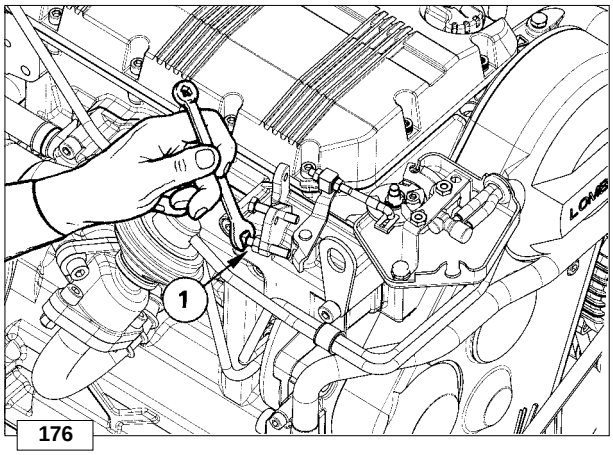


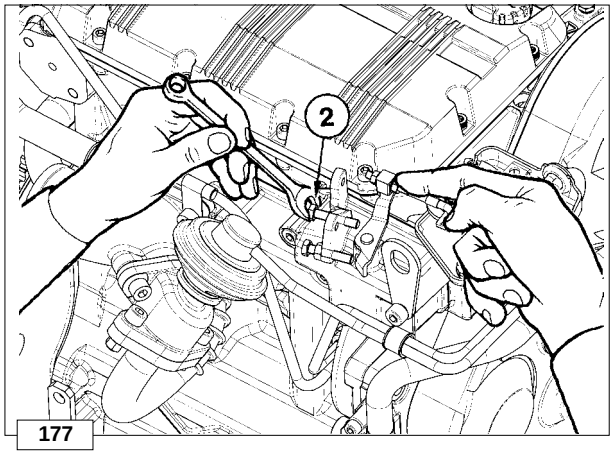
176

SPEED SETTINGS

Setting the idle minimum (standard)

After filling the engine with oil, fuel and coolant, start it and let it warm up for 10 minutes.
Turn the screw **1** to adjust the idle speed at 850 to 900 rpm.
Tighten then the locknut.

Note: If you loosen screw **1** speed decreases. To the opposite direction speed increases.

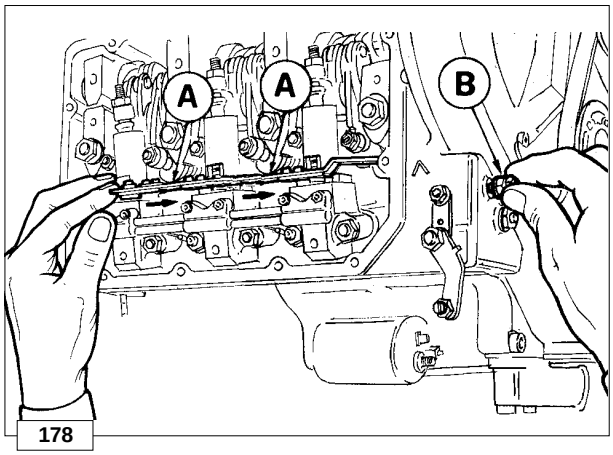


177

Setting the idle maximum (standard)

After setting the idle speed turn screw **2** and regulate the idle maximum at 3800 rpm.
Block then the locknut.
When the engine reaches its setting power, the maximum rpm will stabilise at 3600 rpm.

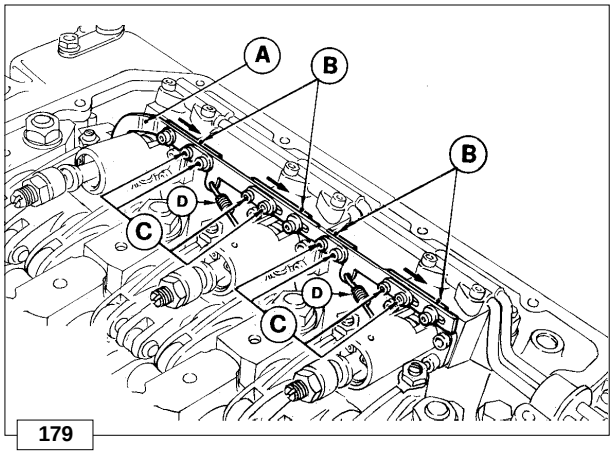
Note: If you loosen screw **2** speed increases.
To the opposite direction speed decreases.



178

Setting the stop

Remove the rocker arms cover and completely unloosen screw **B**.
Push rod **A** to the right and keep it in this position; see figure.
Tighten screw **B** until it touches rod **A**.
Release rod **A** and tighten again screw **B** by a 0.5÷1.0 turn.
Tighten the lock nut.

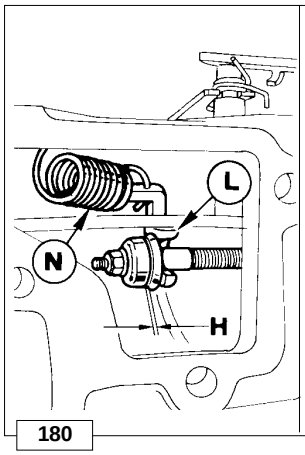


179

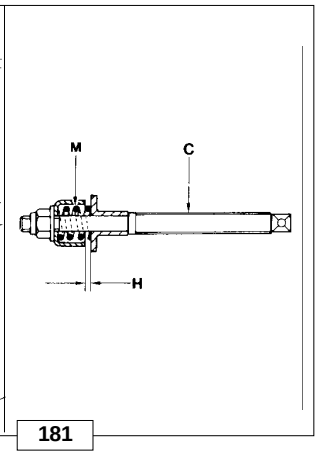
Pump/injector unit timing with speed governor

- Loosen the screws **C** of each pump/injector unit.
- If it is not connected, connect spring **D** to rod **A** (with this operation the speed governor blocks are closed).
- Move plates **B** of each pump/injector unit rightwards; see figure (with this operation the pumps/injector unit are at their maximum delivery).
- Tighten screws **C** at 1.1 Nm. Re-balance the deliveries.

Note: Spring **D** is the start-up fuel supplement spring: with the engine stopped pull rod **A** to the right by bringing the pump/ injector unit delivery to the maximum value, until the speed governor comes into operation with the engine running



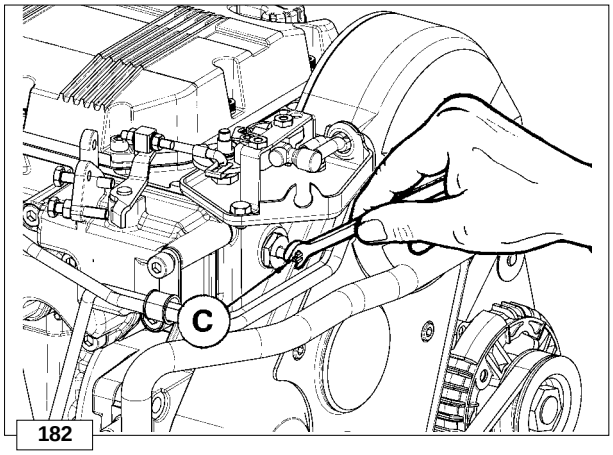
180



181

Injection pump flow limiter and engine torque gearing device

Flow limiter **C** has the function of limiting the injection pump's maximum delivery.
The same mechanism acts also as a torque gearing device. Indeed, under torque, spring **N** operating lever **L** overcomes the resistance of spring **M** located in the plunger barrel.
The stroke **H** that the torque gearing device allows to be carried out by lever **L**, will increase the injection pump delivery and the torque will hit its maximum value.



182

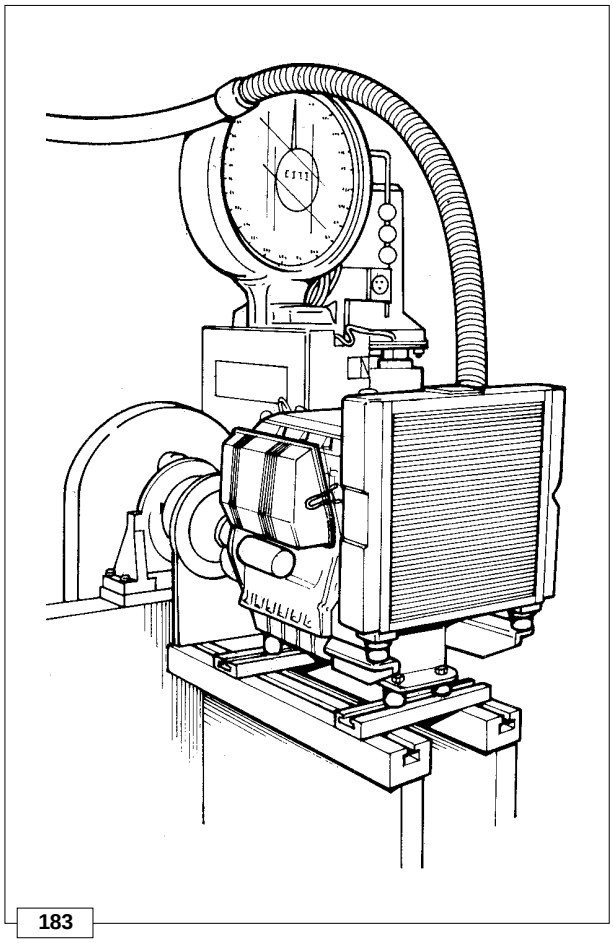
PUMP INJECTION DELIVERY SETTING

Pump injection delivery standard setting without dynamometric brake

This adjustment must be performed with the dynamometric braked engine.
Without this the regulation is approximate.
In this case proceed as follows:

- Unlock the maximum flow limiter lock nut.
- Fully screw in flow limiter **C**.
- Run the engine to the maximum speed, that is 3800 rpm.
- Loosen flow limiter **C** until the engine revs start to decrease.
- Screw flow limiter **C** by 2.5 turns.
- Tighten the lock nut.

Note: If the engine under maximum load emits too much smoke unscrew **C**. Tighten **C** if at this load there is no smoke and if the engine does not reach its maximum power.



183

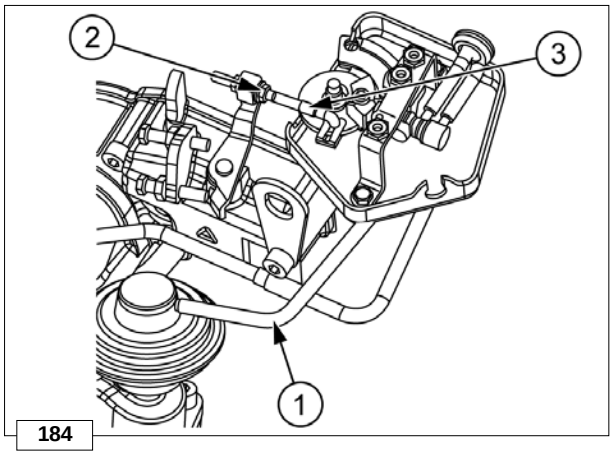
Pump/injector unit delivery setting with braked engine

1) Run the engine to the maximum speed.
2) Screw flow limiter **C** (see fig. 182).
3) Load the engine up to the power and number of revs required by the application's manufacturer.
4) Check that consumption is within the values allowed for in the settings table (see below).
If consumption is not within the given figures, it is necessary to change the balance conditions shown to the brake, altering the load and the speed governor. Redo the consumption check on the stabilised engine.
5) Unscrew limiter **C** until the engine rpm start to decrease. Lock the limiter using the lock nut.
6) Completely release the brake and check the rpm at which the engine stabilises.
The performance of the speed governor must meet the class required by the application's manufacturer.
7) Stop the engine.
8) Recheck the valve clearance with the engine cold.

Required settings (as most commonly applies)

* Refers to power curve **N** (see pages 16) and after run-in.

Engine	Rpm	Power* (N curve)	Specific fuel consumption	
		Kw	Time (sec) per 100 cm^3	g/Kwh
1003	2200	13	57÷53	258÷264
	3600	19	54÷55	289÷294



184

E.G.R. calibration

Mount a T-branch on vacuum valve - E.G.R. valve connection pipe **1**, and connect it to a vacuum pressure gauge with 1 bar bottom scale so as to be able to read the degree of vacuum within the pipe.

Note: It is also possible to use a mercury column, 1 metre long, since the maximum suction pressure exerted by the vacuum pump is 720 mmHg.

Adjust the position of the accelerator lever via the regulator block, so that the internal adjusting nut **2**, is about 5 mm from the end of the thread.

Accelerate the engine up to 3.600 rpm (with valve closed: this means that the value showed on the vacuum pressure gauge or on the mercury column should be 0.
In case it is different from zero, adjust the regulator block nuts to move it, in relation to the rod **3**, in the direction that goes from the flywheel to the timing.

With the brake at a braking curve N=constant, “load” the engine slowing it down to 2.800 rpm.

Acting on the accelerator look for the E.G.R. valve closing point (pressure of the vacuum pressure gauge or mercury gauge equal to zero).

Note: Pay attention to determine the precise closing point: by slightly accelerating the engine the vacuum value in the E.G.R. operation pipe should immediately increase.

Measure the engine consumption in order to calculate the mm3/stroke value.

If the calculated value is less than 18.8 mm^3/stroke, adjust the adjusting nut making it closer to the end of the rod **3** to “increase the calibration”.

When the required value of 18.8 mm^3/stroke has been reached (and a power of around 7 KW) tighten the adjusting nuts.

ENGINE STORAGE

- When the engines are not for more than 6 months, they have to be protected performing the operations described in the following pages.

- If the engine is not to be used for extensive periods, check the storage area conditions and the type of packaging and make sure that these are suitable for correct storage.
  If necessary, cover the engine with a proper protective sheet.
- Avoid storing the engine in direct contact with the ground, in environments that are humid and exposed to bad weather, near high voltage electric lines, etc.

Important

If, after the first 6 months, the engine is still not used, it is necessary to carry out a further measure to extend the protection period (see “Protective treatment”).

PROTECTIVE TREATMENT

1 - Pour in the engine housing AGIP RUSTIA C protective oil up to the maximum level.
2 - Fill up with fuel containing 10% AGIP RUSTIA NT.
3 - Make sure that the coolant is up to the maximum level.
4 - Start the engine and keep it idle at minimum speed for some minutes.
5 - Bring the engine to ¾ of the maximum speed for 5÷10 minutes.
6 - Turn off the engine.
7 - Empty out completely the fuel tank.
8 - Spray SAE 10W on the exhaust and intake manifolds.
9 - Seal the exhaust and intake ducts to prevent foreign bodies from entering.
10 - Thoroughly clean all external parts of the engine using suitable products.
11 - Treat non-painted parts with protective products (AGIP RUSTIA NT).
12 - Loosen the alternator/fan belt.
13 - Cover the engine with a proper protective sheet.

Caution - Warning

In countries in which AGIP products are not available, find an equivalent product (with specifications: MIL-L-21260C).

Important

Maximum every 24 months of inactivity, the engine must be started up by repeating all "Engine Storage" operations.

PREPARING THE ENGINE FOR OPERATION AFTER PROTECTIVE TREATMENT

After the storage period and before starting up the engine and preparing it for operation, you need to perform certain operations to ensure maximal efficiency conditions.

1 - Remove the protective sheet.
2 - Remove any sealing devices from the exhaust and intake ducts.
3 - Use a cloth soaked in degreasing product to remove the protective treatment from the external parts.
5 - Inject lubricating oil (no more than 2 cm3) into the intake ducts.
6 - Adjust the alternator/fan belt tension.
7 - Turn the engine manually to check the correct movement and smoothness of the mechanical parts.
8 - Refill the tank with fresh fuel.
9 - Make sure that the oil and the coolant are up to the maximum level.
10 - Start the engine and after some minutes bring it to ¾ of the maximum speed for 5-10 minutes.
11 - Turn off the engine.
12 - Remove the oil drain plug (see “Oil replacement”) and discharge the AGIP RUSTIA NT protective oil while the engine is hot.
13 - Pour new oil (see "Table of lubricants") up to the maximum level.
14 - Replace the filters (air, oil, fuel) with original spare parts.
15 - Empty the cooling circuit completely and pour in the new coolant up to the maximum level.

Caution - Warning

Over time, a number of engine components and lubricants lose their properties, so it is important considering whether they need replacing, also based on age (see Replacement table).

Important

Maximum every 24 months of inactivity, the engine must be started up by repeating all "Engine Storage" operations.

TABLE OF TIGHTENING TORQUES FOR THE MAIN COMPONENTS				
POSITION	**Riference (figure and page n°)**	**Diam. & pitch (mm)**	**Torque (Nm)**	**Sealant**
Injection pump control rod	45÷46 - p. 34	M 3 spec.	1,1	
Connecting rod ****	97 - p. 46	8x1	40	
Glow-plugs	166÷167 - p. 70	12x1,25	20	
Oil filter cartridge (M 20x1,5 union)		20X1,5	15	270
Camshaft bearing (M 6 screws)		6	10	270
Rocker arm cover	39 - p. 33	6x1	9	638
Main bearing caps	107÷111 - p. 48	M 10	60	
Oil pan	80 - p. 41	M 6	10	Silicon 7091
Camshaft bearing support screw	34 - p. 31	M 6	10	
Glow-plug cable nuts		5x0,8	5	
Fuel lift pump nuts	140 - p. 60	8x1,5	24	
Belt tensioner nut	25 - p. 29	M 10	40	
External Stop control lever nut		8x1,25	8	
Pump/injector unit fixing nut	152 - p. 64	M 8	20*	
Rocker arm assembly support nut	51 - p. 35	M 10	40	
Fuel pump cam				
Flywheel side oil seal ring flange		M 6	12	
Pre-combustion chamber ring nut	73÷79 - p. 40÷41	30x1,5	**	
Vacuum pump fixing screws	7÷8 - p. 25	10x1,25	50	270
Belt tensioner		10	15	242
Crankcase		12x1,5		
Speed governor lever screw		6x1	7	
Driving pulley	12 - p. 26	16x1,5 sin.	360	
Camshaft timing pulley	20 - p. 28	10x1,25	80	
Oil pressure switch	173 - p. 72	12x1,5	25	
Oil drain plug	125÷126 - p. 55	12x1,5	40	242
Cylinder headù	95÷96 - p. 45	18	***	
Injection pipe	47 - p. 34	TCEI 4x1,5	4	
Flywheel	11 - p. 26	10x1,5	80	

* Tighten the two nuts that fasten each pump/injector unit at the same time. For engines with the injectors fixed with self-locking nuts, tighten the nuts at 23 Nm.

** Tighten these in two phases: the first phase at 100 Nm, the second phase at 180 Nm. See page 40-41, figures 73-79.

*** See page 45

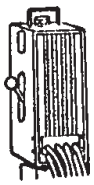
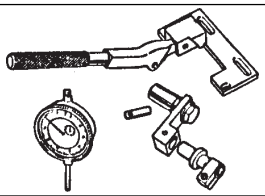
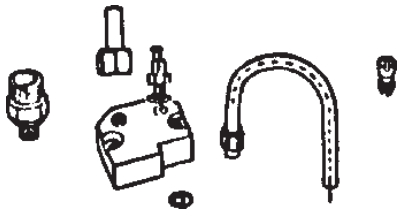
**** Aluminium connecting rod with 35 Nm tightening torque.

Table of tightening torques for standard screws (coarse thread)

Resistance class (R)								
Quality/ Dimensions	 4.6	 4.8	 5.6	 5.8	 6.8	 8.8	 10.9	 12.9
Diameter	R>400N/mm²		R>500N/mm²		R>600N/mm²	R>800N/mm²	R>1000N/mm²	R>1200N/mm²
	Nm	Nm	Nm	Nm	Nm	Nm	Nm	Nm
M3	0,5	0,7	0,6	0,9	1	1,4	1,9	2,3
M4	1,1	1,5	1,4	1,8	2,2	2,9	4,1	4,9
M5	2,3	3	2,8	3,8	4,5	6	8,5	10
M6	3,8	5	4,7	6,3	7,5	10	14	17
M8	9,4	13	12	16	19	25	35	41
M10	18	25	23	31	37	49	69	83
M12	32	43	40	54	65	86	120	145
M14	51	68	63	84	101	135	190	230
M16	79	105	98	131	158	210	295	355
M18	109	145	135	181	218	290	405	485
M20	154	205	193	256	308	410	580	690
M22	206	275	260	344	413	550	780	930
M24	266	355	333	444	533	710	1000	1200
M27	394	525	500	656	788	1050	1500	1800
M30	544	725	680	906	1088	1450	2000	2400

Table of tightening torques for standard screws (fine thread)

Resistance class (R)								
Quality/ Dimensions	 4.6	 4.8	 5.6	 5.8	 6.8	 8.8	 10.9	 12.9
Diameter	R>400N/mm²		R>500N/mm²		R>600N/mm²	R>800N/mm²	R>1000N/mm²	R>1200N/mm²
	Nm	Nm	Nm	Nm	Nm	Nm	Nm	Nm
M 8x1	10	14	13	17	20	27	38	45
M 10x1	21	28	26	35	42	56	79	95
M 10x1,25	20	26	24	33	39	52	73	88
M 12x1,25	36	48	45	59	71	95	135	160
M 12x1,5	38	45	42	56	68	90	125	150
M 14x1,5	56	75	70	94	113	150	210	250
M 16x1,5	84	113	105	141	169	225	315	380
M 18x1,5	122	163	153	203	244	325	460	550
M 18x2	117	157	147	196	235	313	440	530
M 20x1,5	173	230	213	288	345	460	640	770
M 20x2	164	218	204	273	327	436	615	740
M 22x1,5	229	305	287	381	458	610	860	1050
M 24x2	293	390	367	488	585	780	1100	1300
M 27x2	431	575	533	719	863	1150	1600	1950
M 30x2	600	800	750	1000	1200	1600	2250	2700

SPECIAL TOOLS	DESCIPTION	PART N°.
	Injection pumps delivery balancing instrument	7107-1460-127
	Precombustion chamber extractor	7107-1460-030
	Sheet metal for insertion of main bearings in the crankcase	7107-1460-053
	Ring nut wrench for fastening pump/injector pumping element	7107-1460-029
	Precombustion chamber wrench	7107-1460-027
	Precombustion chamber adjusting rod	7107-1460-031
	Device for mounting valve guide gasket, intake and exhaust side	7107-1460-047
	Valve lowering device for injection advance control	7107-1460-048
	Timing belt tightening tool	7107-1460-049
	Tool for injection advance control and setting of injector for pump/injector unit: se.no. 6590-290	7107-1460-074

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1003 FOCS Engine Series

cod. 1-5302-858

LOMBARDINI SERVICE
A KOHLER COMPANY

UNI EN ISO 9001 - cert. n° 0446
ISO/TS 16949 - cert. n° 3792

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