WORKSHOP MANUAL

SP 420 series engines

cod. 1-5302-579_ 5° ed.

SP 420

RUGGERINI DIESEL

REGISTRATION OF MODIFICATIONS TO THE DOCUMENT

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

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PREFACE

- Every attempt has been made to present within this service manual, accurate and up to date technical information.
  However, development on the **RUGGERINI** series is continuos.
  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 persons performing service work on **RUGGERINI** series engines is properly trained and equipped to safely and professionally perform the subject operation;
2 - The person or persons performing service work on **RUGGERINI** series engines possesses adequate hand and **LOMBARDINI** special tools to safely and professionally perform the subject service operation;
3 - The person or persons performing service work on **RUGGERINI** 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 **RUGGERINI** 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.

This manual contains the most important information for the repair of RUGGERINI air cooled, direct injection Diesel engines type **SP 420.** This information is current up to 07.30.2007.

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SP 420
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WARRANTY CERTIFICATE

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

- Engines are not correctly installed and as a consequence the correct functional parameters are not respected and altered.
- 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 the Manufacturer has been tampered with or removed.
- Spare parts used are not original from Manufacturer.
- 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 the Manufacturer.
- Engines have been disassembled, repaired or altered by any part other than an authorized **RUGGERINI** Motori agent.

- Following expiration of the above stated warranty periods and working hours, **LOMBARDINI** will have no further responsibility for warranty and will consider its here above mentioned obligations for warranty complete.

- Any warranty request related to non-conformity of the product must be addressed to the **RUGGERINI** Motori service agents.

GENERAL SERVICE MANUAL NOTES

1 - Use only genuine Ruggerini repair parts.
Failure to use genuine Ruggerini 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 timing belt 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

- **RUGGERINI** 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 **RUGGERINI** 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 **RUGGERINI** 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.

POSSIBLE CAUSES AND 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.

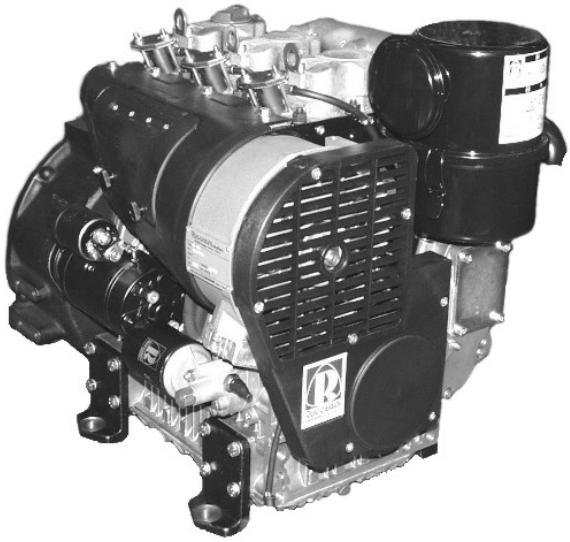
TABLE OF LIKELY ANOMALIES AND THEIR SYMPTOMS

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	Too low oil pressure	Overheats	Inadequate performance	Excessive oil consumption	High noise level
FUEL CIRCUIT	Obstructed fuel line	■	■		■					■		
	Fuel filter clogged	■	■	■	■					■		
	Air or water leaks in fuel system	■	■	■	■					■		
	The tank cap vent hole is clogged	■	■									
	No fuel	■	■		■							
ELECTRIC SYSTEM	Discharged battery	■										
	Cable connection uncertain or incorrect	■										
	Faulty starting switch	■										
	Faulty starting motor	■										
MAINTENANCE	Clogged air filter			■	■	■				■		
	Excessive idle operation						■				■	
	Incomplete run-in						■				■	
	Overloaded engine			■	■	■			■	■	■	■
	Non-conforming engine oil										■	
SETTINGS REPAIRS	Incorrect governor linkage adjustment				■							
	Governor spring broken or unhooked		■	■	■							
	Low idle speed		■									
	Rings worn or sticking	■			■		■		■	■	■	
	Worn cylinder	■			■		■		■	■	■	
	Worn main con rod-rocker arm bearings				■			■	■	■	■	
	Badly sealed intake valve	■							■	■	■	
	Head tightening nuts loose	■										■
	Damaged cylinder head gasket								■	■	■	■
	Excessive valve-rocker arm clearance									■		■
	No clearance between valves and rocker arms	■										
	Valves sticking											■
	Defective timing system											■
	Bent rods			■	■	■			■	■		■

POSSIBLE CAUSE		TROUBLE										
		Engine does not start	Engine starts but stops	No acceleration	Non-uniform speed	Black smoke	White smoke	Too low oil pressure	Overheats	Inadequate performance	Excessive oil consumption	High noise level
INJECTION	Damaged injector	■				■	■			■		■
	Injection pump valve damaged	■										
	Injector not adjusted	■										
	Faulty fuel feeding pump	■	■	■	■					■		
	Hardened pump control rod			■	■							
	Broken or loose supplementary start-up spring	■										
	Worn or damaged pumping element				■	■				■		
	Incorrect tuning of injection components (delivery balancing advance)	■	■		■	■			■	■		
	Extra fuel control level sticking					■						
LUBRICATION CIRCUIT	Oil level too high				■		■		■		■	
	Oil level low								■			
	Oil pressure valve blocked or dirty							■				
	Oil pressure regulator not adjusted							■				
	Worm oil pump								■			
	Oil sump suction line clogged								■			
	Faulty pressure gauge or pressure switch							■				
	Blocked draining pipe							■				
COOLING CIRCUIT	Worn or broken blower belt								■			
	Cooling circuit clogged								■			

MANUFACTURER AND MOTOR IDENTIFICATION DATA



Name plate for EPA rules applied on rocker- arm cap

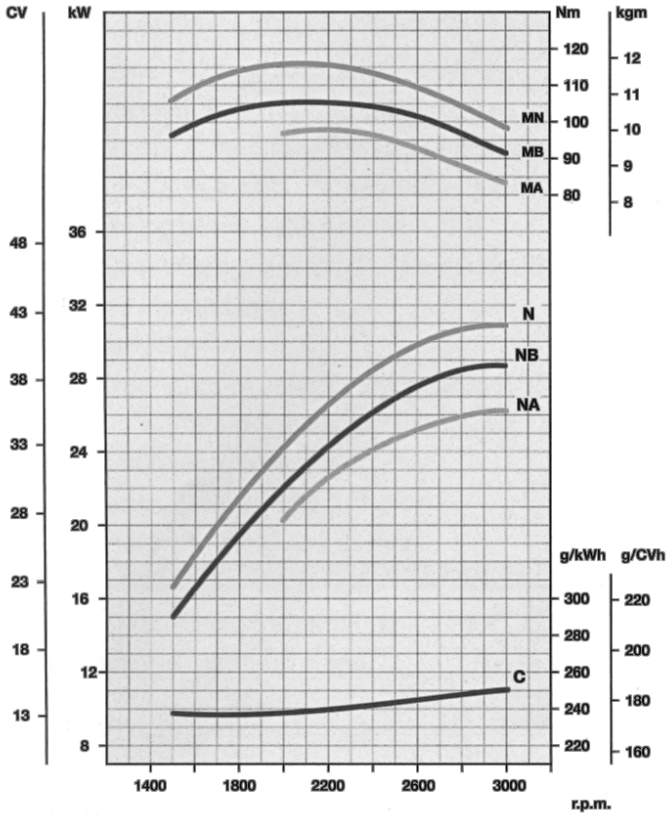
TECHINICAL SPECIFICATIONS

ENGINE TYPE			SP 420
Number of cylinders		N.	3
Bore		mm	95
Stroke		mm	88
Displacement		Cm³	1870
Compression ratio			17:1 - 20:1❐
R.P.M.			3000
Power kW/HP	N (80/1269/CEE) ISO 1585	kW/CV	30,8/42
	NB ISO 3046 IFN	kW/CV	28,6/39
	NA ISO 3046 ICXN	kW/CV	26,3/35,8
Max. torque		Nm/kgm	114,5/11,7 @2000
Max. torque at 3rd p.t.o. at 3200 r.p.m.		kW/CV	13/17,7
Max. torque at 4th p.t.o. at 3200 r.p.m.		kW/CV	7,98/10,8
Specific fuel consumption *		g/CV.h - g/kW.h	184/250
Tank capacity		l.	15
Oil consumption **		kg/h	0,017
Oil sump capacity		l.	5
Dry weight		kg	170
Combustion air volume at 3000 r.p.m.		l./min'	2400
Cooling air volume at 3000 r.p.m.		l./min'	38000
Max. permissible driving shaft axial load in both directions		kg	300
Max. inclination	momentary	α	35°
	lasting up to 1 h.	α	25°
	permanent	α	****
Firing Order			1 - 3 - 2

❐ Only for 97/68 CE and EPA approved engines
* Referred to max. NB power
** At NA power
*** Depending on the application

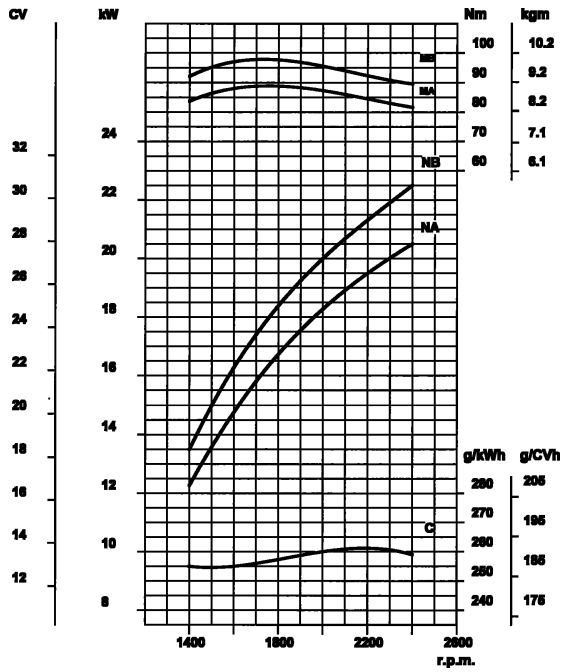
PERFORMANCE DIAGRAMS

SP 420 Standard @ 3000 r.p.m.

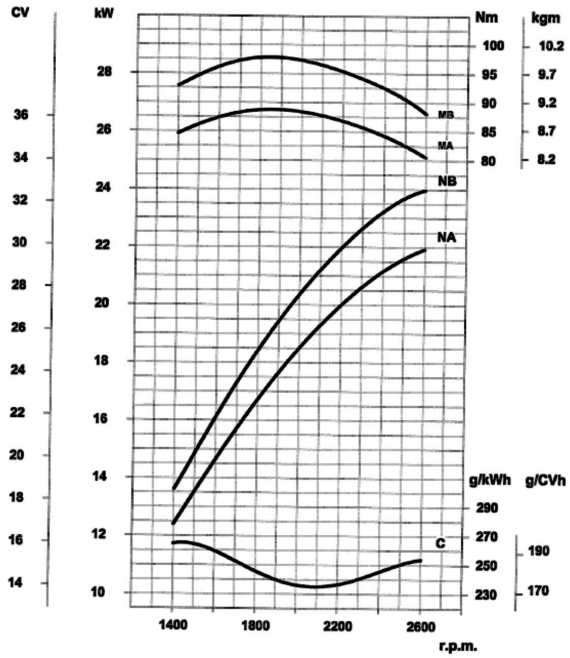


SP 420 EPA

@ 2400 r.p.m.



@ 2600 r.p.m.



N (80/1269/EEC - ISO 1585) - AUTOMOTIVE RATING: Intermittent operation with variable speed and variable load.
NB (ISO 3046 - 1 IFN) - RATING WITH NO OWERLOAD CAPABILITY: continuos ligth duty operation with constant speed and variable load.
NA (ISO 3046 - 1 ICXN) - CONTINUOS RATING WITH OVERLOAD CAPABILITY: continuos heavy duty with constant speed and constant load.

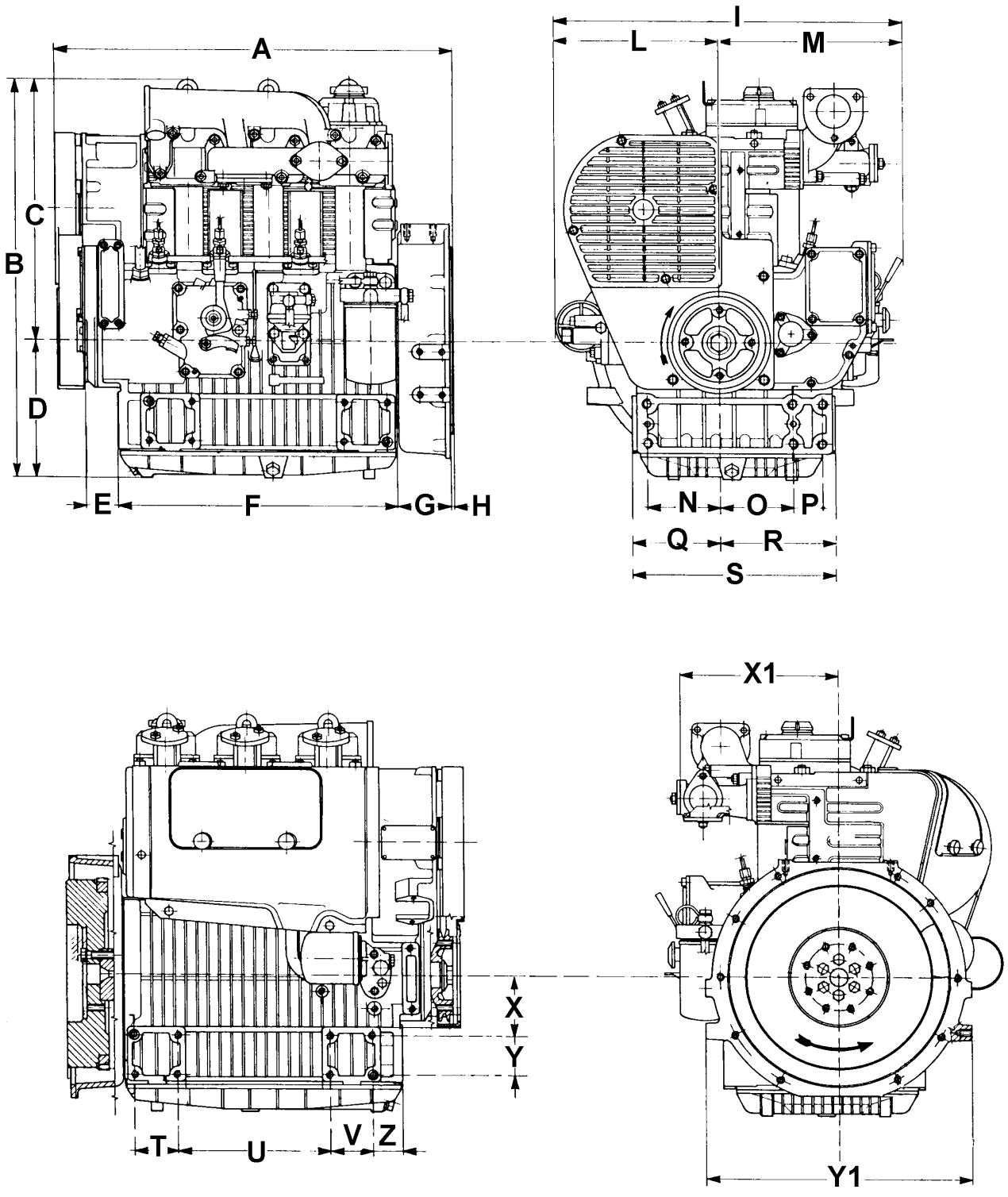
MN Torque at **N** power.
MB (NB curve)
MA (NA curve).
C Specific fuel consumption at **NB** power.

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

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

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

OVERALL DIMENSIONS



DIMENSIONI mm - MESURES mm - DIMENSION mm - EINBAUMAßE mm - DIMENSIONE mm - DIMEN0ÇÕES (mm)																
A	601	**D**	212	**G**	82	**L**	247	**O**	110	**R**	173	**U**	230	**X**	94	**X1**	237
B	612	**E**	47	**H**	4	**M**	278	**P**	45	**S**	305	**V**	65	**Y**	60	**Y1**	400
C	400	**F**	421	**I**	525	**N**	110	**Q**	132	**T**	65	**Z**	46				

Note : Dimensions shown in mm

ROUTINE ENGINE MAINTENANCE

Important

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

EXTRAORDINARY MAINTENANCE

AFTER THE FIRST 50 WORKING HOURS	Engine oilreplacement.	Oil filter replacement.

ORDINARY MAINTENANCE

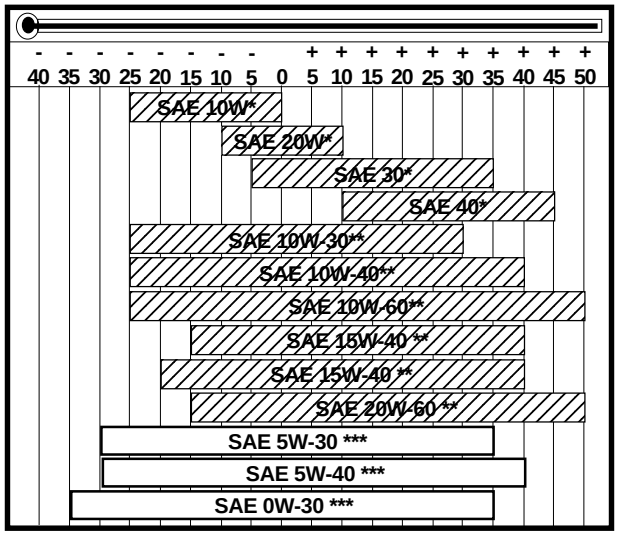
OPERATION DESCRIPTION		FREQUENCY x HOURS							
			10	125	250	500	1000	2500	5000
CHECK	LEVEL ENGINE LUBRICANT		■						
	DRY AIR CLEANER	(***)	■						
	OIL BATH AIR CLEANER		■						
	BLOWER BELT TENSION			■					
	VALVE/ROCKER ARMS CLEARANCE ADJUSTMENT					■			
	SETTING AND INJECTORS CLEANING					■			
	FUEL PIPES		■						
	RUBBER INTAKE HOSE (AIR FILTER – INTAKE MANIFOLD)				■				
	ENGINE OIL RADIATOR CLEANING (IN THE APPLICATIONS WHERE IT IS PRESENT)							■	
	FUEL TANK CLEANING						■		
	COOLING SYSTEM CLEANING				■				
REPLACEMENT	ENGINE LUBRICANT	(*)			■				
	OIL FILTER	(*)			■				
	FUEL FILTER	(*)			■				
	BLOWER BELT	(**)				■			
	FUEL PIPES						■		
	RUBBER INTAKE HOSE (AIR FILTER – INTAKE MANIFOLD)	(**)					■		
	DRY AIR CLEANER EXTERNAL CARTRIDGE	(***)	AFTER 6 CHECKS WITH CLEANING						
	DRY AIR CLEANER INTERNAL CARTRIDGE	(***)	AFTER 3 CHECKS WITH CLEANING						
OVERHAUL INSPECTION	PARTIAL OVERHAUL							■	
	TOTAL OVERHAUL								■

(*) - In case of low use: every year.
(**) - In case of low use: every 2 years.
(***) - The period of time that must elapse before cleaning or replacing the filter element depends on the environment in which the engine operates. The air filter must be cleaned and replaced more frequently in very dusty conditions.

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 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

PETROL

A1 = Low-viscosity, for frictions reduction
A2 = Standard
A3 = High performances

LIGHT DUTY DIESEL ENGINES

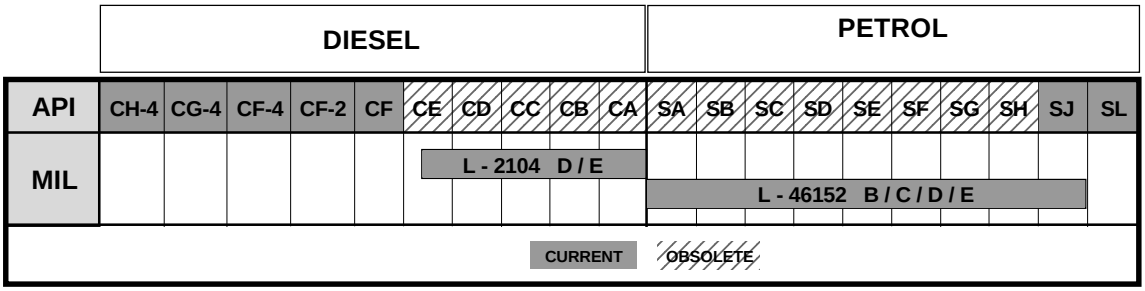
B1 = Low-viscosity, for frictions reduction
B2 = Standard
B3 = High performances (indirect injection)
B4 = High quality (direct injection)

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



PRESCRIBED LUBRICANT

AGIP SUPERDIESEL MULTIGRADE 15W40	specifications	**API CF 4 ACEA B2 - E2 MIL - L-2104 D/E**

In the countries where AGIP products are not available, use oil API SJ/CF for Diesel engines or oil corresponding to the military specification MIL-L-2104 D/E.
For a temperature of -10°C an oil with a **5W40** viscosity is recommended. For a temperature of -15°C an oil with a **0W30** viscosity is recommended.

SP 420 ENGINES OIL CAPACITY		
OIL VOLUME AT MAX LEVEL (OIL FILTER INCLUDED)	Litres	**5,5**
OIL VOLUME AT MAX LEVEL (WITHOUT OIL FILTER)	Litres	**5**

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.**

FUEL SPECIFICATIONS

Danger – Attention

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

To achieve optimum performance of the engine, use good quality fuel with certain characteristics:

Cetane number (minimum 51): indicates the ignition quality.
A fuel with a low cetane number may cause problems when starting from cold and have a negative effect on combustion.

Viscosity (2.0/4.5 centistokes at 40°C): this is the resistance to flow and performance may decline if not within the limits.

Density (0.835/0.855 Kg/litre): a low density reduces the power of the engine, and density that is too high increases performance and opacity of the exhaust

Distillation (85% at 350°): this is an indication of the mixture of different hydrocarbons in the fuel.
A high ratio of light hydrocarbons may have a negative effect on combustion.

Sulphur (maximum 0.05% of the weight): high sulphur content may cause engine wear.
In those countries where diesel has a high sulphur content, it is advisable to lubricate the engine with a high alkaline oil or alternatively to replace the lubricating oil recommended by the manufacturer more frequently.

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

The countries in which diesel normally has a low sulphur content are: Europe, North America and Australia.

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**

For all fuel types, the cetane number cannot be lower than 51.

Aviation kerosene and RME fuels (biofuels)

The only Aviation fuels that may be used in this engine are: JP5, JP4, JP8 and JET-A if 5% oil is added.
For more information on Aviation fuels and Biofuels (RME, RSME) please contact the Lombardini applications department.

Capacities standard fuel tank	Litres	**15**
As for filters, tanks and special crankcases please refer to RUGGERINI instructions.		

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RECOMMENDATIONS FOR DISASSEMBLING AND ASSEMBLING

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

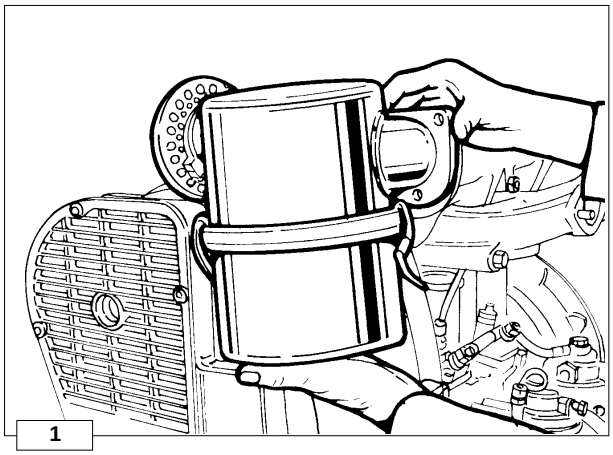
- Besides disassembly and reassembly operations this chapter also includes checking and setting specifications, dimensions, repair and operating instructions.
- Always use original RUGGERINI spare parts for proper repair operations.
- The operator must wash, clean and dry components and assemblies before 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.

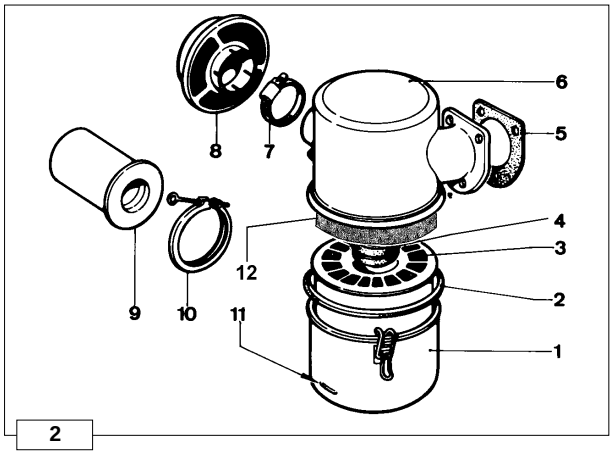

1

Oil-bath air cleaner

Danger – Attention
Do not blow the paper filter element with compressed air to clean.

Caution – Warning
Check gaskets and replace as necessary.
Check that flange welds are free of defective spots.

❍ When reassembling, tighten the fastening nuts of the air filter to the intake manifold to 25 Nm.



2

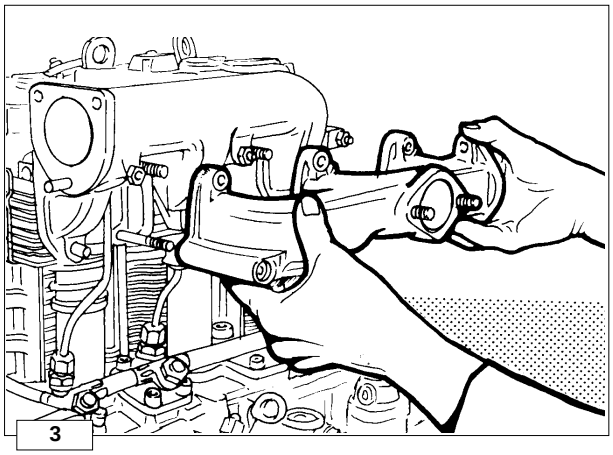
Oil-bath air cleaner components

Caution – Warning
Replace if irreparably clogged.

1 Bowl
2 External seal ring
3 Lower filtering element
4 Internal seal ring
5 Gasket
6 Cover
7 Cover clamp
8 Cap
9 Centrifugal pre-filter
10 Centrifugal pre-filter clamp
11 Oil level mark
12 Upper filtering element (polyurethan sponge)

Note: Thoroughly clean the lower tank and the metal filter element using diesel fuel then blow compressed air into them.
The upper filter element in polyurethane foam is cleaned by washing it in soapy water; after washing, dry completely using compressed air.

➲ After cleaning refill the engine oil tank up to the indicated level.
See page 17 for the maintenance or replacement instructions.

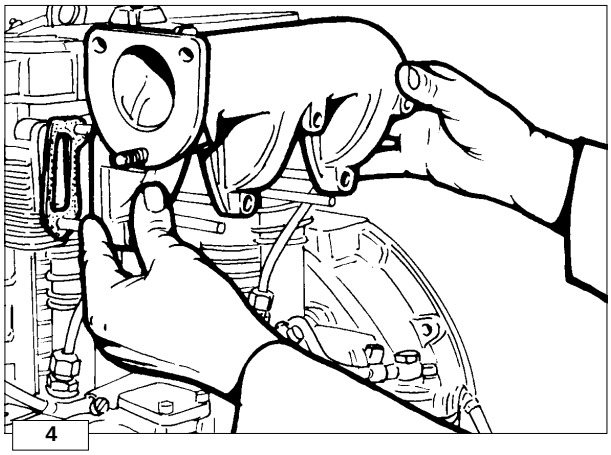

3

Exhaust manifold

Danger – Attention
Allow the exhaust manifold to cool before demounting it in order to prevent scorching and burns.

Make sure that the inside is properly clean and is free from cracks or breakage.
Always replace the seals between the manifold and the exhaust pipes.

❍ When assembling, tighten the nuts in sequence and gradually before the final torque to 20 Nm.



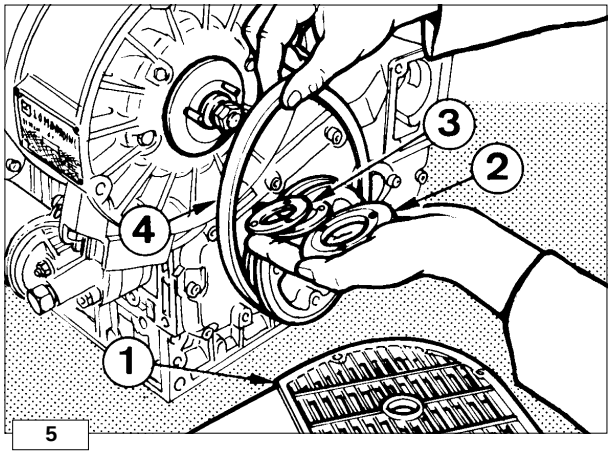
4

Intake manifold

Before reassembling the manifold check the levelness of the flanges.
Always replace the seals between the manifold and the intake pipes.

❍ Tighten the nuts gradually to 25 Nm.

Note: In case of low temperature starting we can supply a manifold with provision for a glow plug for air preheating.



5

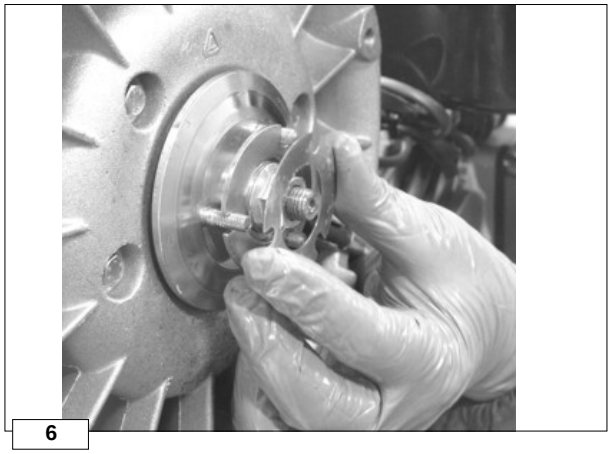
Blower belt alternator

Components:

1 Guard
2 Pulley
3 Spacers
4 'V'-belt

Unscrew the fastening screws of the belt guard and remove it, then take out the nuts on the three stud bolts on the half-pulley.
Remove the V belt and check for wear.

➲ See page 17 for periodic maintenance details.

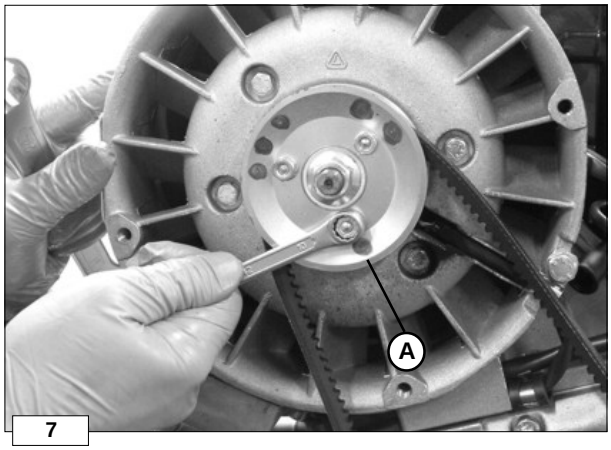


6

Belt tension adjustment

Danger – Attention
Check the belt tension only when the engine is not running

The belt tension is adjusted by adding (to reduce tension) or removing (to increase tension) spacers between the half-pulleys.
Spacers are available in thicknesses of 0.5, 1 and 2 mm.

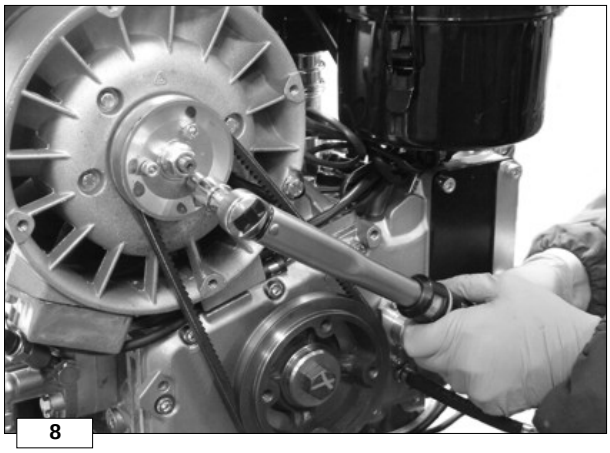


7

Half-pulley - Reassembly

Important
The three stop nuts of the half-pulley should never be tightened simultaneously.

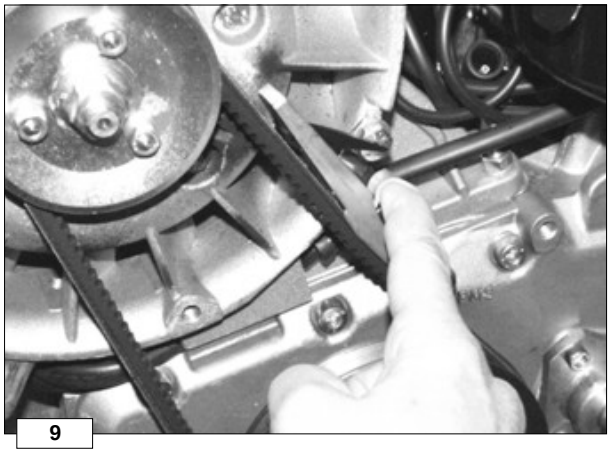
Turn the pulley so that, whenever you tighten a nut, this is in the position indicated **A** in the figure 7.
Tightening should be carried out gradually.


8

Blower belt alternator - Reassembly

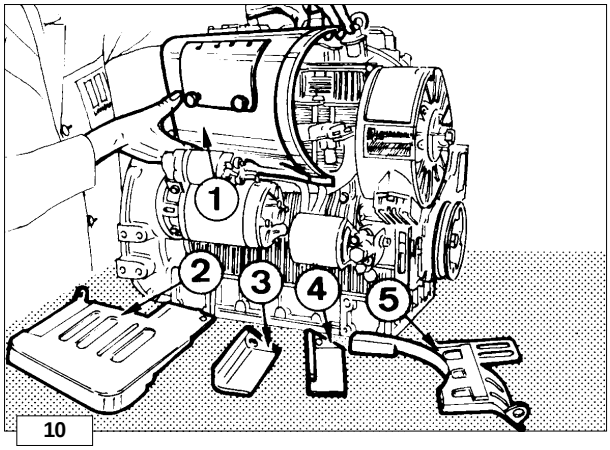
❍ The half-pulley fastening nuts must be tightened using the torque wrench to a final torque of 10 Nm.

Again during this phase the nut must be in position **A** when tightened as in fig. 7 – page 22.


9

Tension check

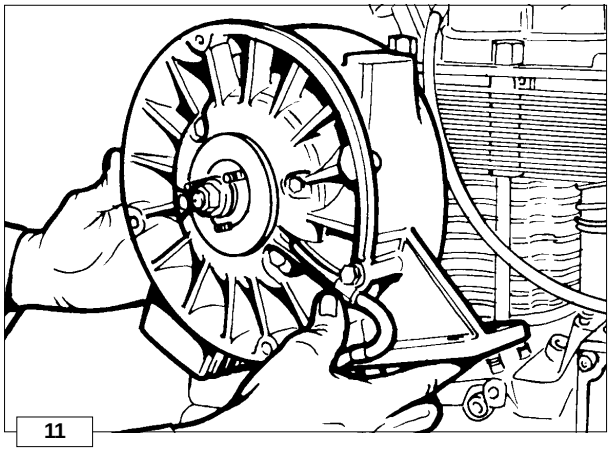
A 4 Kg load located halfway between the pulleys should cause the belt to bend 5 ÷ 15 mm.
The correct belt tension can also be checked with special tools that are available on sale.



10

Air shroud and baffles - Disassembly

The air shroud **1** and the baffles **2**, **3**, **4**, **5** are shaped in such a way as to direct the flow of air onto the cylinders in order to cool them.
As the shroud is completely covered in noise-absorbent material, it also has the function of reducing the amount of noise generated by the blower fan and vibrations.


11

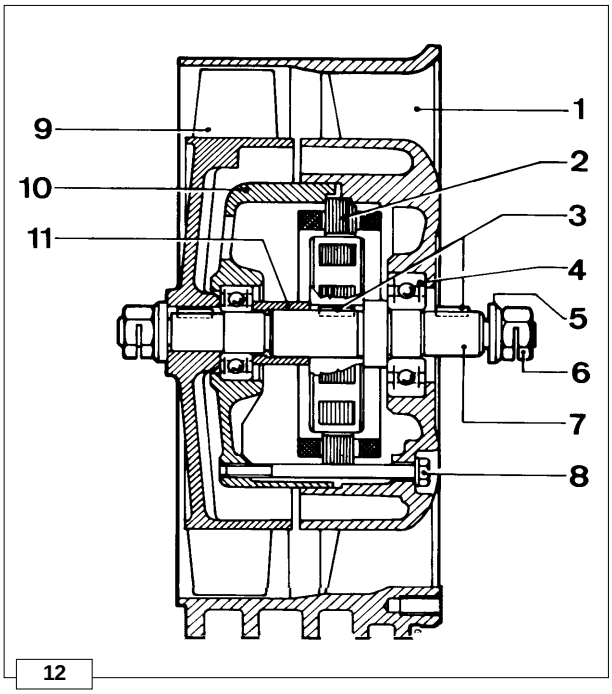
Blower assembly

Danger – Attention

Before demounting the cooling fan, disconnect the positive battery cable to prevent accidental short-circuits which could consequently energize the starter motor.

The plate and tension regulator are fixed to the outside of the blower fan stator.
A 14 A or 21 A alternator is housed inside the stator.

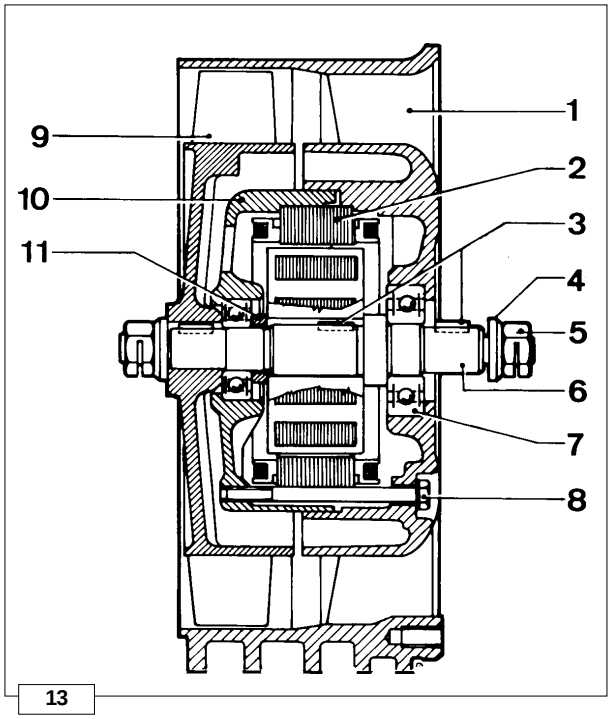
➲ See page 60 - 61 for the alternator technical data.
➲ See page 13 for the cooling air volume.



12

Blower assembly components with 14 A alternator

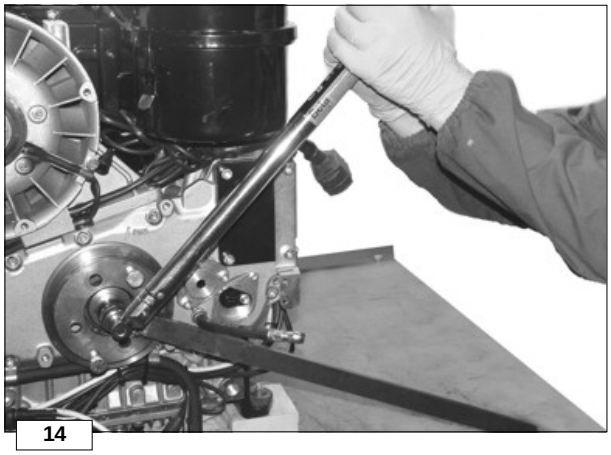
1 Housing
2 14 A alternator
3 Key
4 Ball bearing
5 Washer
6 Nut
7 Shaft
8 Bolt
9 Fan
10 14 A alternator bell
11 Spacer



13

Blower assembly components with 21 A alternator

1 Housing
2 21 A alternator
3 Key
4 Washer
5 Nut
6 Shaft
7 Bearing
8 Bolt
9 Fan
10 21 A alternator bell
11 Spacer

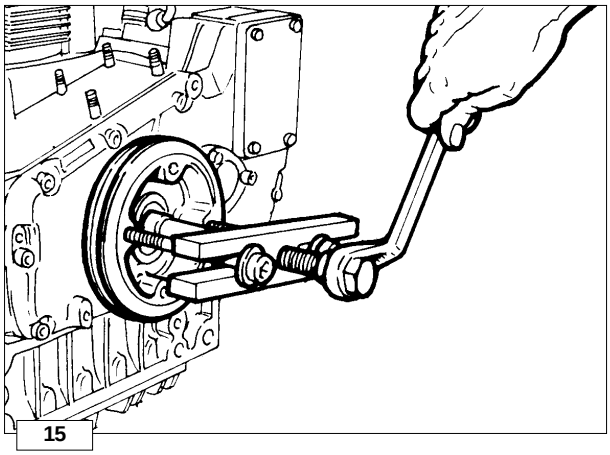


14

Blower control pulley - Disassembly

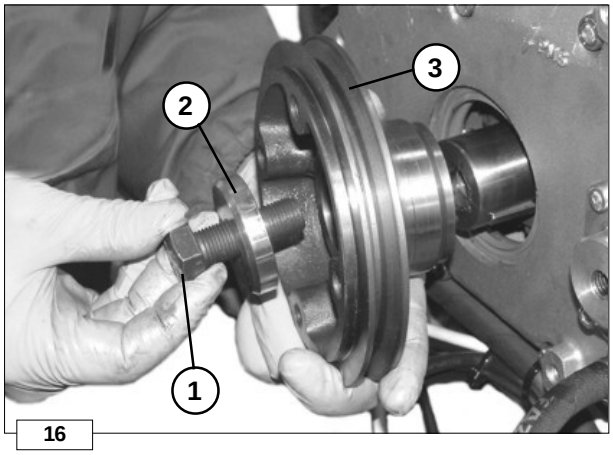
The blower control pulley is installed on and is driven by the crankshaft.
To disassemble the pulley unscrew the left-handed bolt (clockwise) after blocking the crankshaft.

❍ When reassembling, tighten the bolt using a torque wrench to a torque of 300 Nm.


15

Crankshaft pulley

Remove the pulley using extractor serial no. 1460.200.

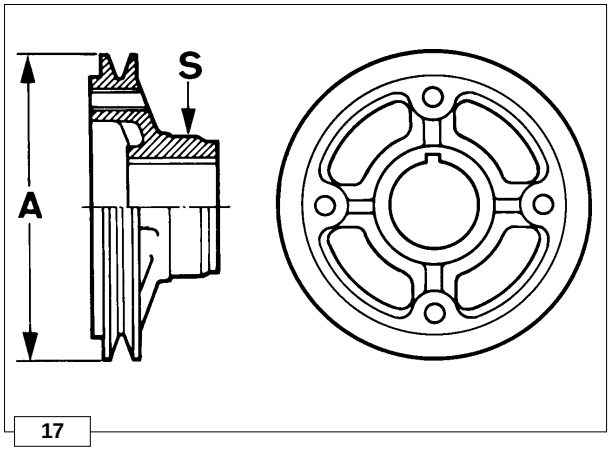


16

Components:

1 Left-handed bolt
2 Washer
3 Blower control pulley

Note: It is only possible to check crankshaft axial clearance after tightening the pulley.



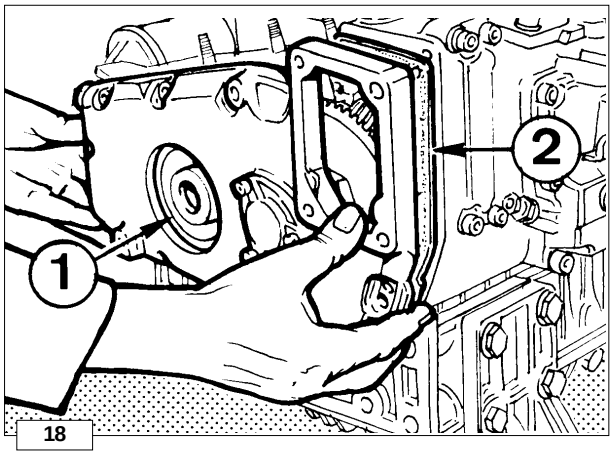
17

Blower control pulley diameter

There are three pulleys with different diameters **A** which take account of engine settings:

A = 142 mm	(from 2401 to 3000 r.p.m.)
$\mathbf{A_1}$ = 147 mm	(from 2001 to 2400 r.p.m.)
$\mathbf{A_2}$ = 163 mm	(from 1500 to 1800 r.p.m.)

Check **S** surface in contact with oil seal ring and, if necessary, rub with a fine grain emery cloth.



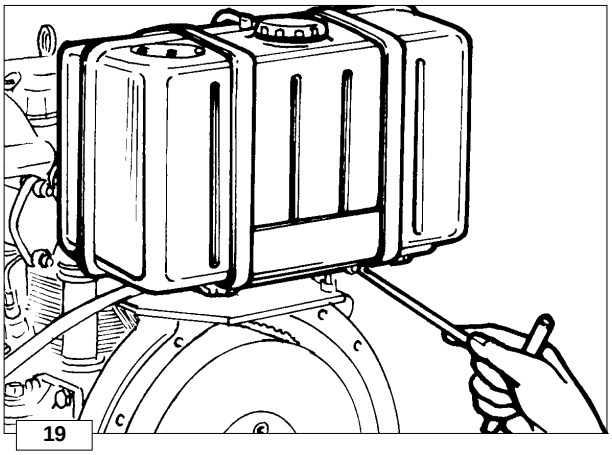
18

Timing cover

Loosen the screws and remove the cover.

❍ When refitting tighten screws at 25 Nm.

Check oil seal ring **1** and replace if warped, hardened or worn-out. Replace gasket **2**.

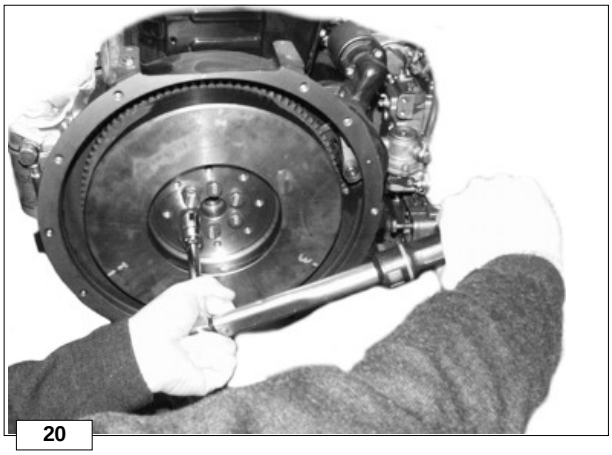

19

Tank

Danger – Attention

Do not smoke or use naked flames during the demounting operations as these could cause explosions or fire outbreaks.
Fuel fumes are highly toxic. Only carry out the operations outdoors or in a well ventilated place.
Keep your face well away from the filler cap or you could inhale harmful fumes. Dispose of fuel in the correct way as it is highly polluting. Do not litter.

Remove fuel filter and loosen clamp screws.
Completely empty the tank and check that no impurities are found inside.
Check that cap breather is not clogged.


20

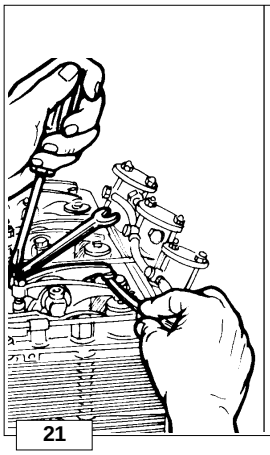
Flywheel

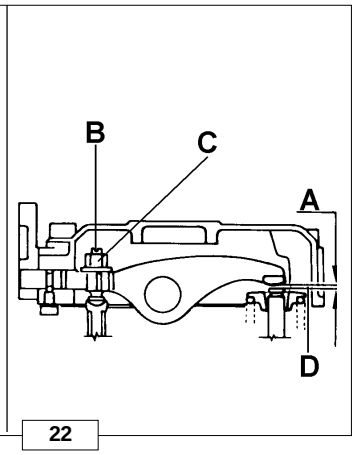
Danger – Attention

During the demounting phases, pay particular attention to prevent the flywheel from dropping as this could seriously injure the operator.
Wear protective goggles when removing the flywheel ring.

Remove the bolts which attach the flywheel to the crankshaft.
To replace starter ring gear heat it up to 300°C for 15 ÷ 20 minutes. Drive it onto the flywheei caretully checking that it perfectly fits into its seat.
Let it cool down slowly.

❍ When reassembling gradually tighten the fastening screws to 140 Nm on the crankshaft using a torque wrench.


21



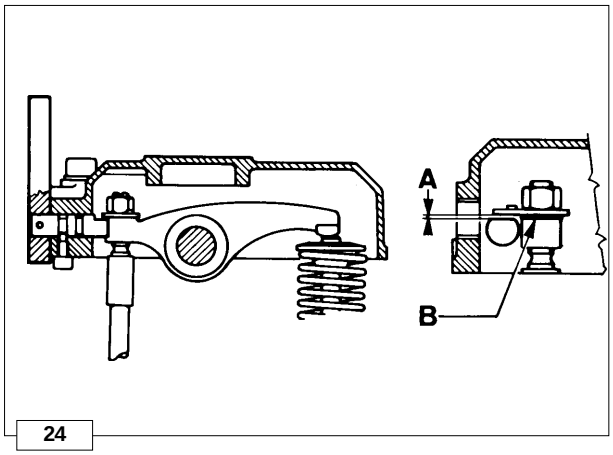
22

Valve / rocker arm clearance

Caution – Warning

Make settings when the engine is cold.

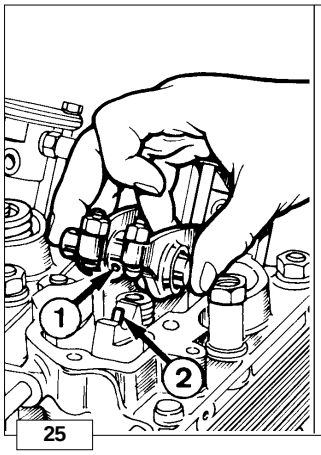
Remove the rocker arm covers and make sure the seals are intact, otherwise replace them. Bring the cylinder piston that is to be adjusted to the compression top dead centre.
Loosen the fastening nut **C**, insert the thickness gauge **D** between the rocker arm and the top of the valve stem, then, using a cross-head screwdriver turn the adjusting screw **B** to set clearance.
Tighten the fastening screw **C** and check valve clearance **A** again to ensure that it is between 0,15 and 0,2 mm for intake and 0,3 ÷ 0,35 mm for exhaust.
❍ When refitting tighten cover screws to 20 Nm.
If necessary place a 0,30 or 0,40 mm shim at **B**.



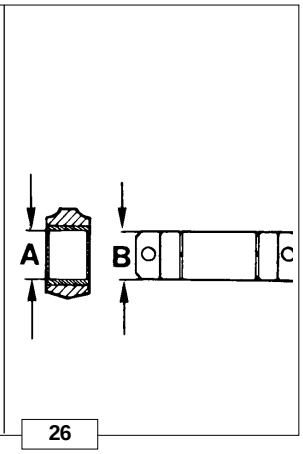
24

Compression release (optional)

Bring piston to top dead center on the compressìon stroke.
Unscrew rocker arm cover side plug and measure clearance **A** should be 0,30 ÷ 0,40 mm.



25



26

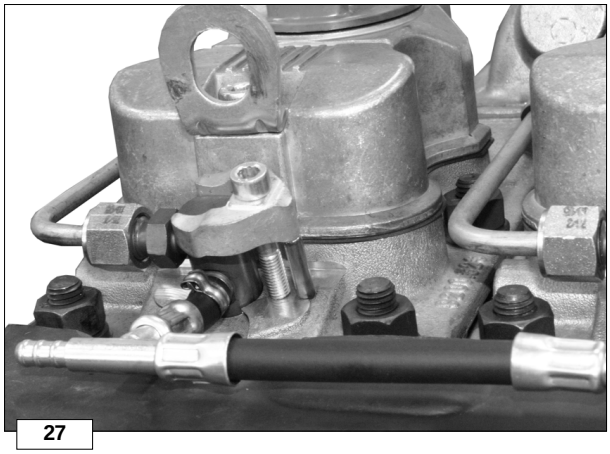
Rocker arm assembly

Components: **1** Rocker arm axle lubrication hole
2 Lubrication tube

Ref.	Dimensions
A	18.032 ÷ 18.050 mm
B	17.989 ÷ 18.000 mm

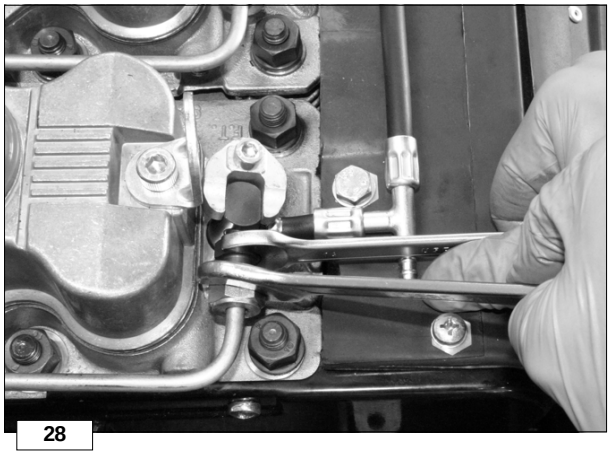
Replace the axle and the rocker arm if clearance (**A-B**) is greater than 0,135 mm.
When refitting check that lubrication tube **2** perfectly fits into centering bore **1**.

❍ Tighten screws at 25 Nm.

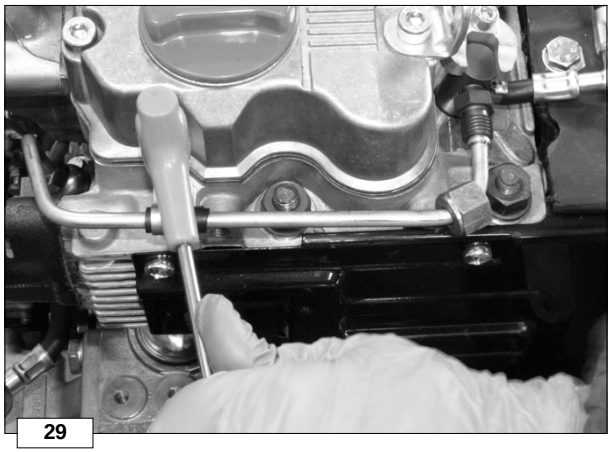

27

Disassembling size P injector

The injector is attached to the cylinder head via a forked bracket.

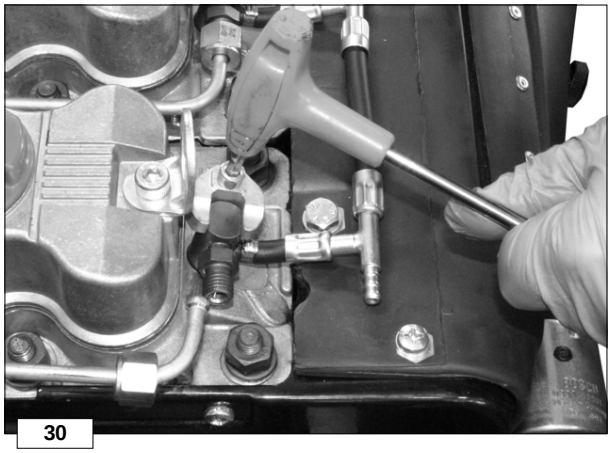

28

To release the injector union from the high-pressure pipe, use two box wrenches (14 and 17 mm).



29

Unscrew the screw fastening the clamp of the high-pressure pipe using a 4 mm hexagon screwdriver.

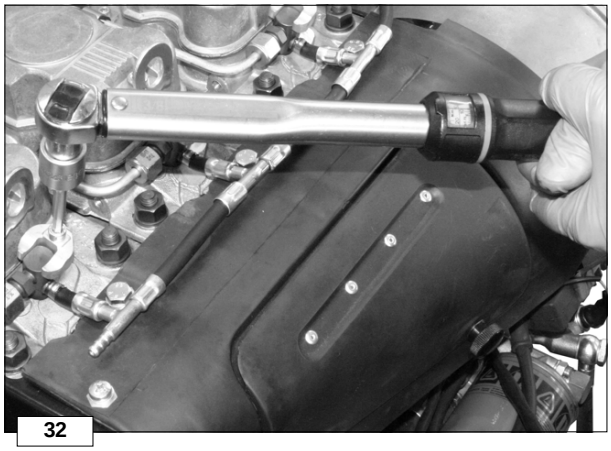


30

Remove the forked bracket fixing the injector to the cylinder head using a 5 mm hexagon screwdriver (see photo 29 - 30).

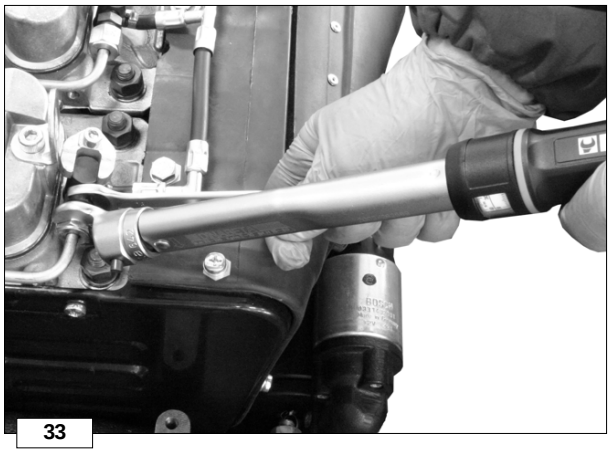
31

These operations are necessary when checking injector calibration or when replacing it.

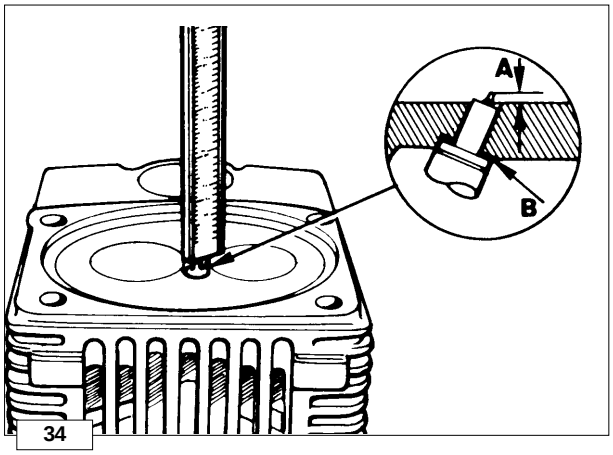


32

❍ The fixing bracket screws must be tightened to 10 Nm using a torque wrench.


33

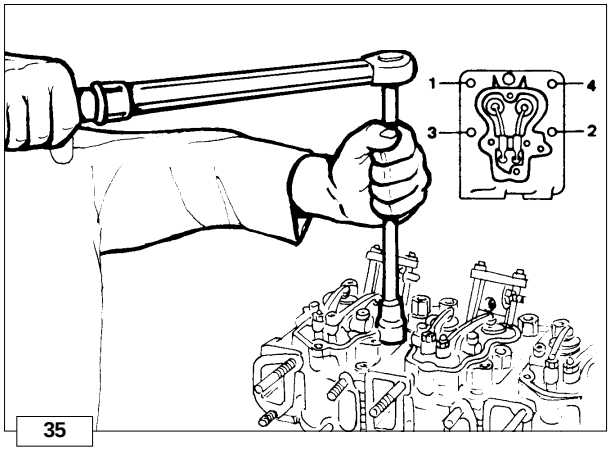
❍ The high-pressure pipe union must be tightened to the injector union to 20 ÷ 25 Nm using a torque wrench.



34

Injector protrusion

It is only possible to check injector protrusion with the cylinder head disassembled.
The end of the nozzle must be 3 ÷ 3,5 mm with respect to the head surface **A**.
Protrusion is adjusted by adding or removing copper seals **B** which are supplied at a thickness of 0,5 and 1 mm.



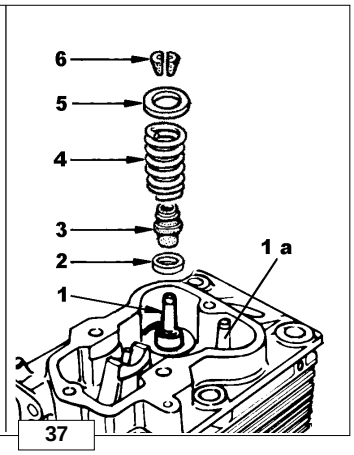
35

Cylinder Head

Caution – Warning
Do not demount or remount while hot as this could lead to deformations.

If the head surface is distorted, grind it by removing up to 0.3 mm thickness. When reassembling, before tightening, make sure that the rocker arm lubrication hose is firmly lodged into holes. The cylinder heads must be tightened with the exhaust or intake manifold mounted to keep them lined up. Always replace the copper seal between the cylinder head and the cylinder that determines clearance volume; see page 34 for the choice of thickness. See page 32 for how to mount the spring on the tappet rod protection pipe.
❍ The cylinder head fastening nuts must be tightened gradually to 55 Nm and in the sequence **1**, **2**, **3**, **4**; see fig. 35.

36



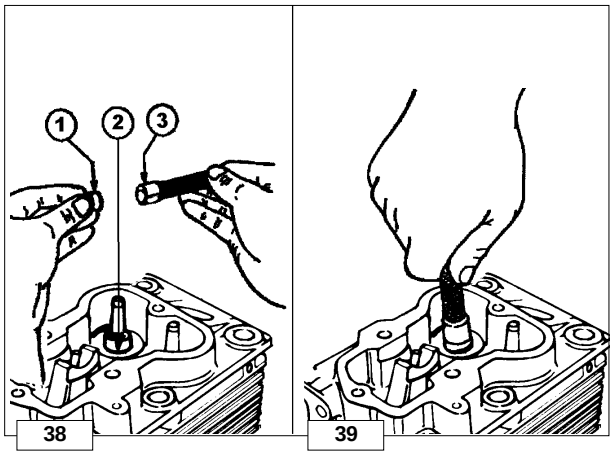
37

Valves

Components:

1 Intake valve
1a Exhaust valve
2 Lower spring collar
3 Valve stem sealing ring
4 Spring
5 Upper spring collar
6 Three-groove half collets

Te remove half collets firmly press down the special tool 1460 - 113 as shown in the figure 36.



38

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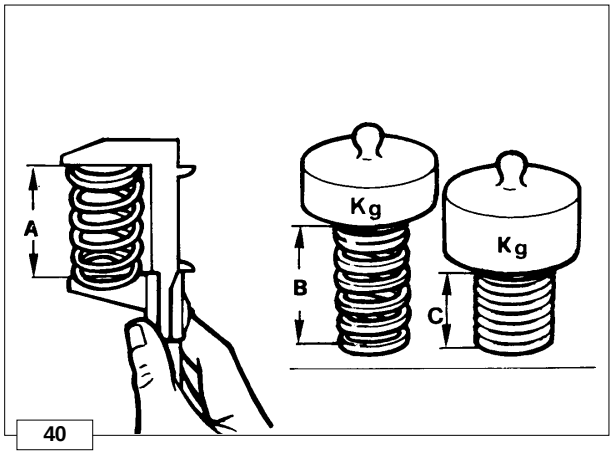
Valve stem sealing rings - Reassembly

Lubricate the inside of the sealing ring with Molikote BR2 Plus and insert them all the way onto the guides using tool 1460 – 108.
To prevent deformation of the sealing ring **1** as it is inserted onto the valve guide **2** insert it onto tool **3**.
Lubricate valve stem with the same type of grease; insert the valves into the guides rotating them particularly as they enter the sealing ring.

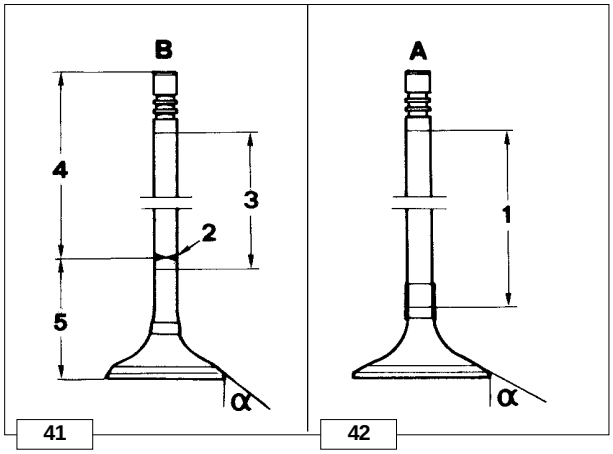


40

Valve springs

Measure free length with a gauge.
Using a spring tester check that the spring length under two different loads corresponds to the values below:

Free length **A** = 52 mm
Length **B** compressed by a 21 Kg weight = 34.8 mm
Length **C** compressed by a 32 Kg weight = 25.8 mm.



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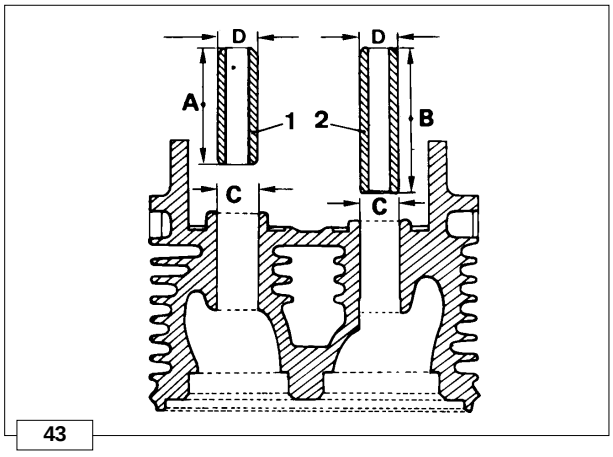
Valve material

Intake valves A
- Material: X 45 Cr Si 9 - 3 UNI EN 10090
1 = Chromium-plated portion
α = 45°15' ÷ 45°25'

Exhaust valve B
Shaft and head are made of 2 different materials.
2 = Welded portion
3 = Chromium-plated portion
4 = Portion made of X 45 Cr Si 9 - 3 UNI EN 10090
5 = Portion made of X 53 Cr Mn Ni N 21 - 9 UNI EN 10090
α = 45°15' ÷ 45°25'



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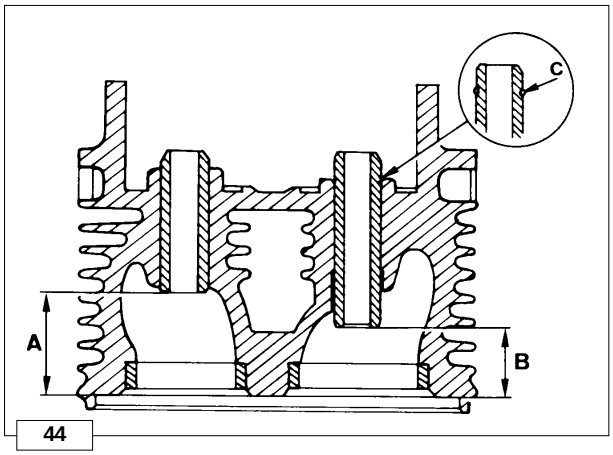
Valve guides and cylinder head housings

Intake and exhaust valve guides are both made of phosphoric cast iron.
Components: **1** = Exhaust valve guide
2 = Intake valve guide

Ref.	Dimensions (mm)
A	42,00
B	48,00
C	14,000 ÷ 14,018
D	14,045 ÷ 14,056

Valve guides with outside diameter increased by 0,5 mm are also available; in such cases valve guide bore **C** should also be increased by 0,5 mm.



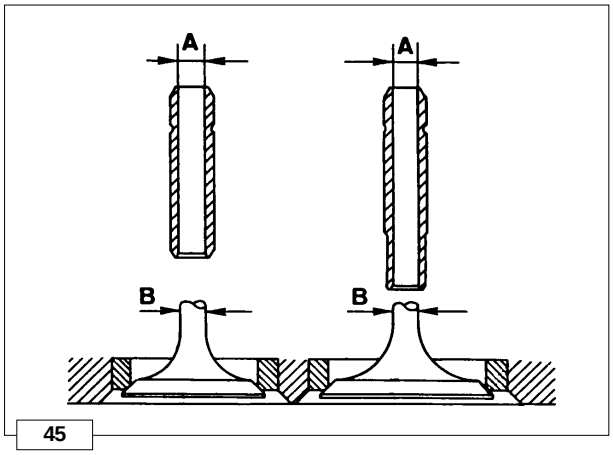
44

Valve guide insertion

Heat cylinder head up to 160 ÷ 180°C.
Thread guides considering the **A** e **B** distances from the head plane.

Ref.	Dimensions (mm)
A	30,80 ÷ 31,20
B	24,80 ÷ 25,20

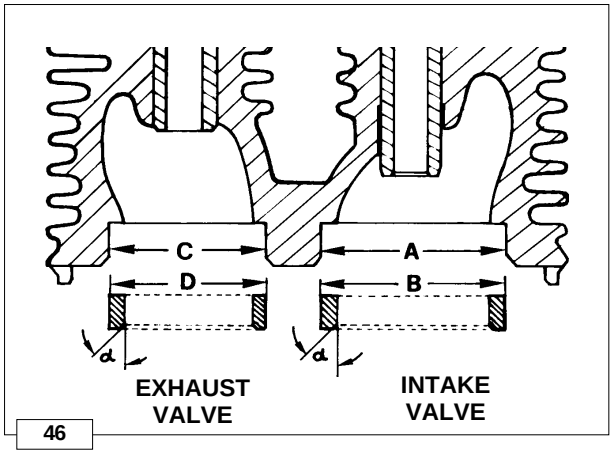
Note: If the guides are supplied with the housing for the lock ring **C**, insert the ring, then drive the guides until the lock ring is stopped without worrying about **A** and **B**.



45

Dimensions and clearance between guides and valves

Ref.	Dimensions (mm)	Clearance (mm)	Limit value (mm)
A	8,025÷8,040	0,025÷0,055	1,15
B	7,985÷8,000		



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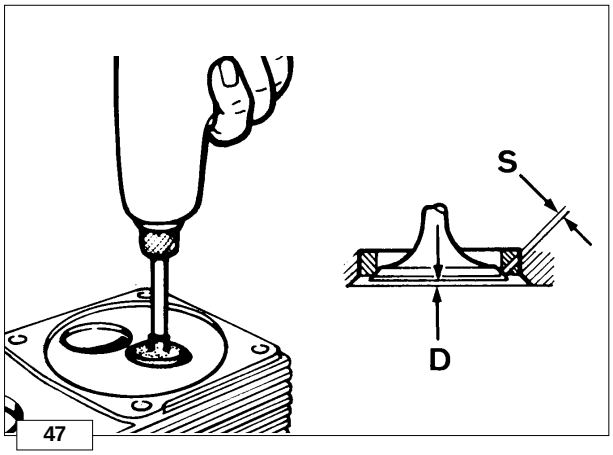
Valve seats and housings

Ref.	Dimensions (mm)
A	40,000÷40,016
B	40,120÷40,140
C	34,000÷34,016
D	34,120÷34,140



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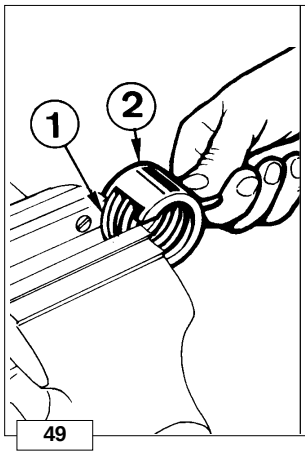
Valve seat lapping

After cutting, lap valve seats with fine emery paste in oil suspension. The sealing surface **S** should not exceed 2 mm.

Valve recess after grinding

Ref.	Dimensions (mm)	Limit value (mm)
D	0,75÷1,25	1,65



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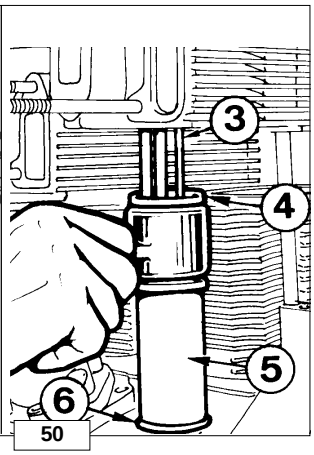


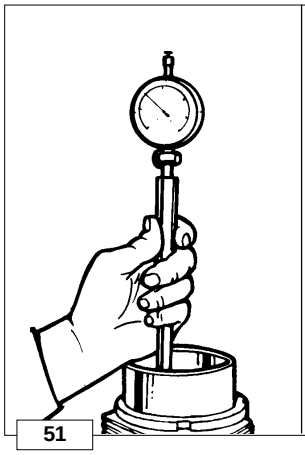
50

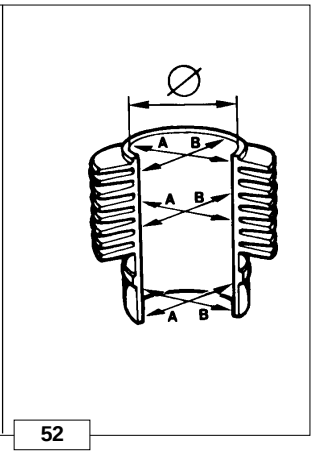
Pushrod tube spring fitting

Components:

1 Spring
2 Tool Part No 1460-009
3 Rocker arm lubrication tube
4 Gasket
5 Pushrod tube
6 Gasket

To mount the spring **1** on the tappet rod protection pipe **5** insert it into the tool **2** with the help of a vice.
Make sure that the rocker arm lubrication hose **3** and the seals **4** and **6** are fully in place.


51



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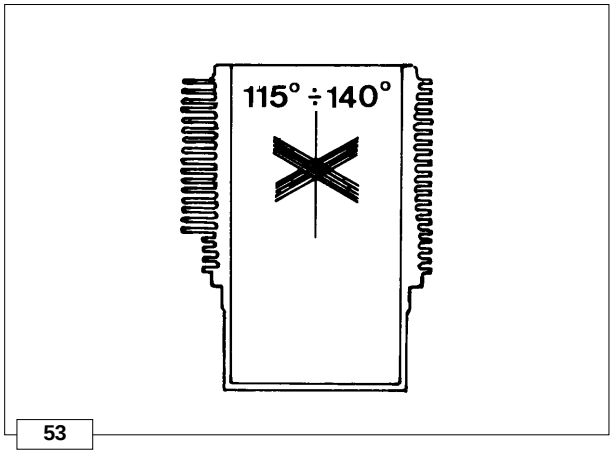
Cylinder

Measure diameter sìze between two diametrically opposed points at three different heights.

Ø Cylinder
95,00 ÷ 95.03 mm

In case wear exceeds 0,10 mm, bore the cylinder and fit oversize piston and rings.
In case of less wear replace piston rings only.



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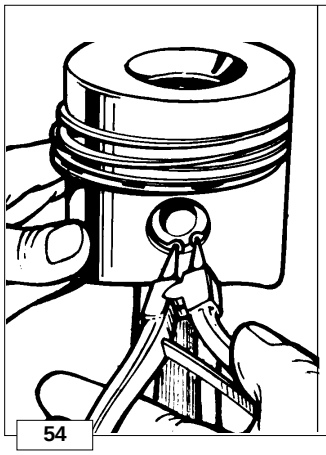
Checks and cyiinder roughness

The cylinder should show no blowholes or porosities.
Seal both ends of cylinder and pressurize with compressed air at 4 bar for 30 sec.
Fins must be intact.
Cross hatch pattern must range between 115° ÷ 140°: they must be uniform and clear in both directions.
Average roughness should range between 0,5 and 1 µm.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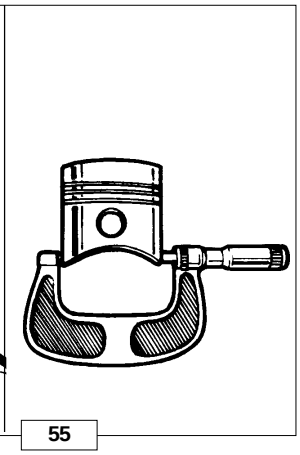

55

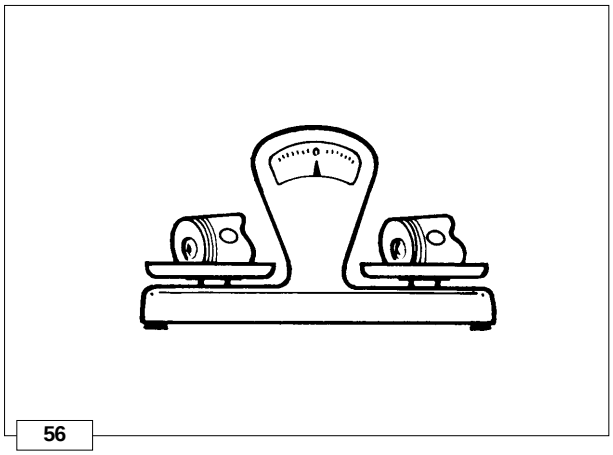
Piston

Remove the Sieger stop rings and extract the pin.
After removing the snap rings from the piston, clean the grooves if necessary.
Measure the diameter at 2 mm from the base using an external micrometer.

Ø Piston
94,92 ÷ 94,95 mm

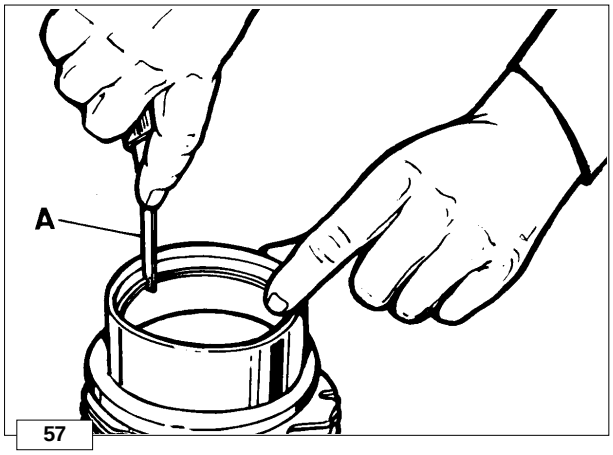
Replace the piston and the snap rings if the diameter of the wear is greater than 0,05 mm of the minimum value prescribed.

Note: Oversize pistons of 0,5 and 1,0 mm are available.


56

Piston weight

Weigh pistons when replacing them in order to avoid unbalance. The difference in weight should not exceed 6 g.



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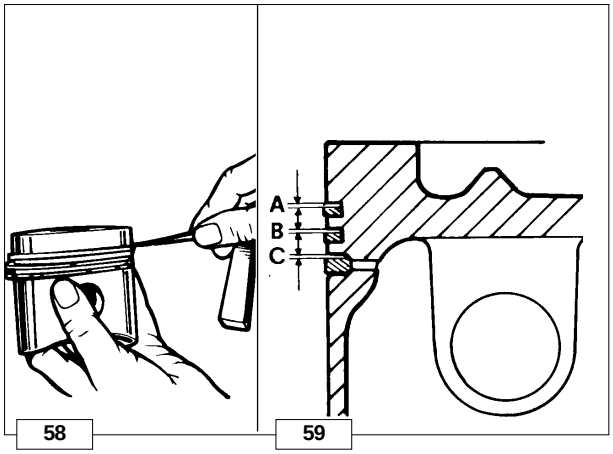
Metal snap rings - End gaps

Insert the snap rings in the lower part of the cylinder, then measure the distance between the tips.

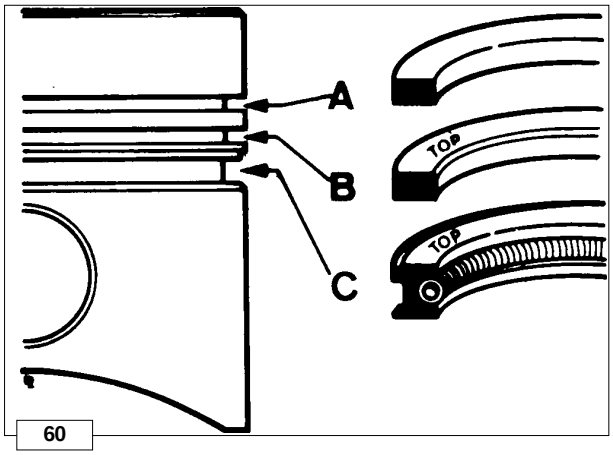
			Limit value
1°	Compression snap ring (chrome-plated)	0,40 ÷ 0,65 mm	1 mm
2°	Snap ring (conical internal torsional)		
3°	Ring (oil scraper)	0,25 ÷ 0,50 mm	



58 59

Metal snap rings - Piston grooves

Ref.	Dimensions (mm)	Limit value (mm)
A	0,07 ÷ 0,11	0,20
B	0,05 ÷ 0,09	0,16
C	0,04 ÷ 0,08	0,15



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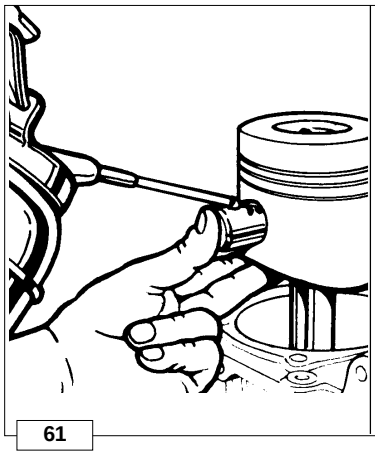
Metal snap rings - Fitting sequence

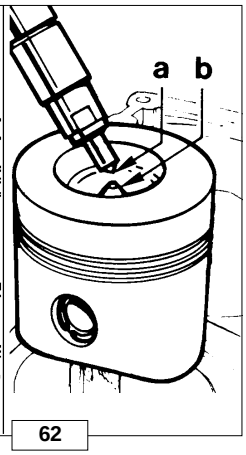
A = Compression snap ring (chrome-plated)
B = Snap ring (conical internal torsional)
C = Ring (oil scraper)

Note: before inserting the piston in the cylinder, rotate snap rings so that cuts are misaligned by 120° from one to the next.

Important
Assemble the segments with TOP facing the piston crown.



61



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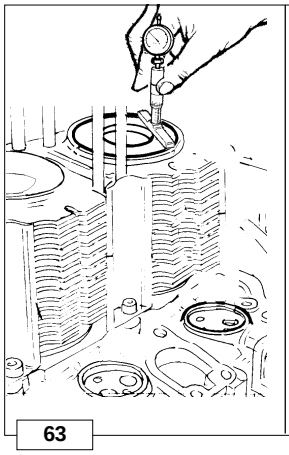
Piston - Refitting

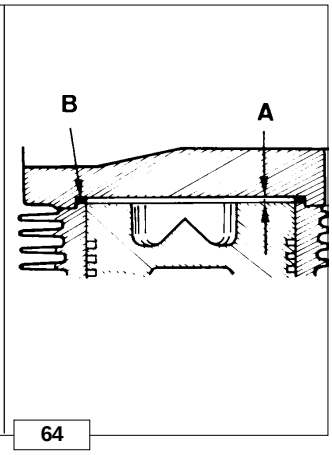
Caution – Warning

Lubricate the following parts with oil before mounting: the piston pin, the piston, the cylinder and the big-end bearing

Connect piston to connecting rod in a way that the combustion chamber center **b** is under nozzle tip **a**.
Lubricate piston pin and introduce it into the piston by exerting pressure with your thumb.
Check that both circlips are well inside their seats.



63



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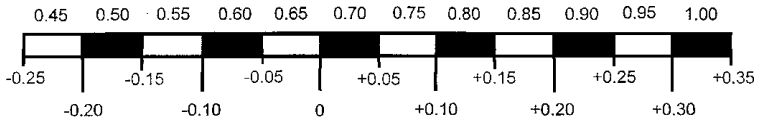
Piston clearance

A = Clearance volume is 0,65 ÷ 0,7 mm for size **S** injectors and 0,55 ÷ 0,6 mm for size **P** injectors
B = Copper seal with various thicknesses

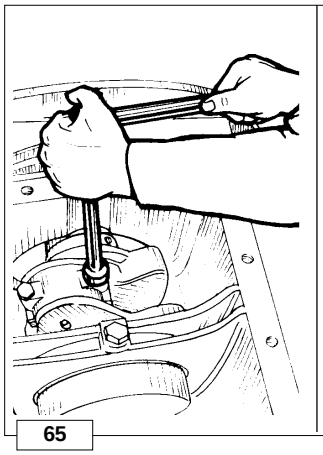
The piston crown in the **TDC** (top dead centre) position may vary, and extend or be short of the upper surface of the cylinder.
Use a dial indicator to measure the positive or negative difference between the two surfaces (piston crown and upper cylinder surface) and use a suitable thickness copper gasket **B** for the cylinder head to adjust the clearance volume **A** between the cylinder head and the piston crown, and which must be between 0,65 and 0,7 mm for size S injectors and 0,55 ÷ 0,6 mm for size **P** injectors.

The table below shows how to choose the most suitable cylinder head copper seal according to the position of the piston in relation to the upper surface of the cylinder.

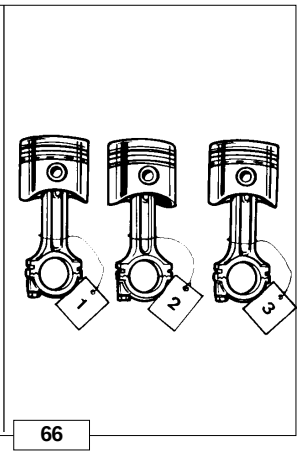
Seal thickness



Position



65



66

Connecting rod

Caution – Warning

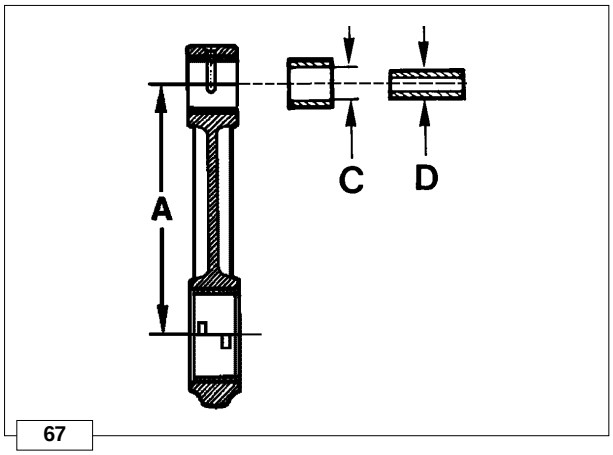
When remounting the big-end bearings, remember to thoroughly clean the parts and generously lubricate them to prevent seizure when the engine is started up for the first time

Remove the oil sump and internal oil filter.
Remove connecting rocis and check as follows.

Important

All connecting rod/piston units should be fitted back into the corresponding cylinders; mark them to avoid mistakes.

➲ See page 35 fig. 71 for specifications as to the tightening of the connecting rod big end bearing.

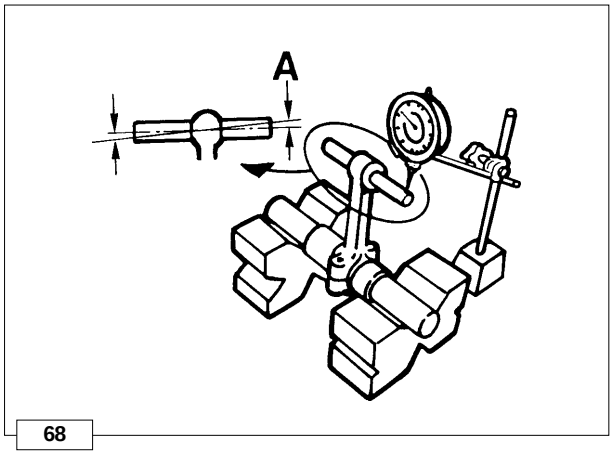


67

Connecting rod small end bearing and pin

Ref.	Dimensions (mm)	Clearance (C - D) (mm)	Limit value (C - D) (mm)
A	141,95÷142,05		
C	25,020÷25,030	0,020÷0,035	0,070
D	24,995÷25,000		

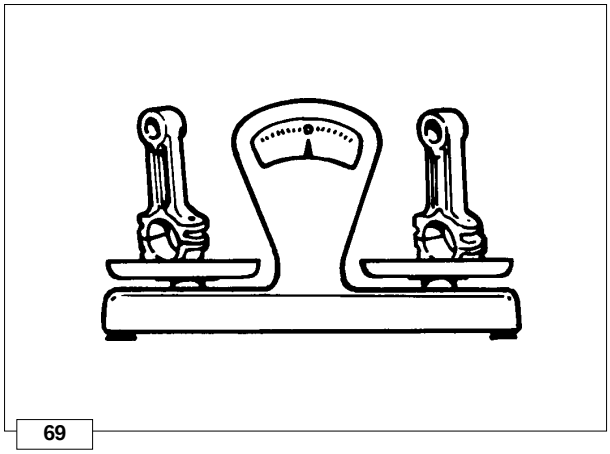
* with driven and machined bearing.
When refitting the bearing of the connecting rod small end, as you drive in, make sure that the lubrication hole on the connecting rod coincides with the hole on the bearing.



68

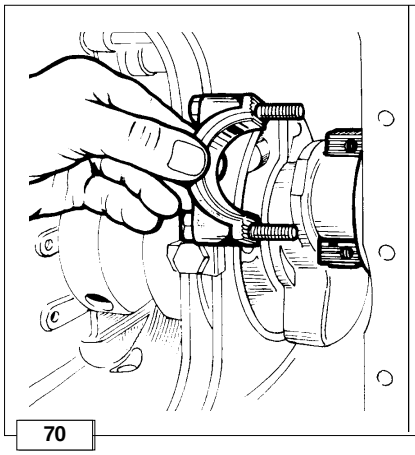
Connecting rod alignment

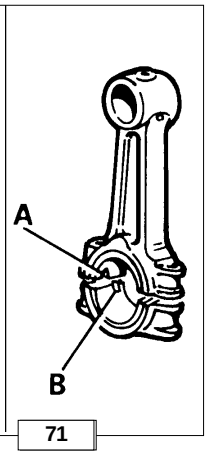
Check alignment of small end and big end bearing bores using fitted mandrels; axial mis-alignment **A** = 0,02 mm; maximum limit 0,05 mm.
Moderale warpage may be corrected by gradually working with a press.


69

Connecting rod weight

Weight connecting rods when replacing them in order to avoid unbalance.
The difference in weight should not exceed 10 g.


70



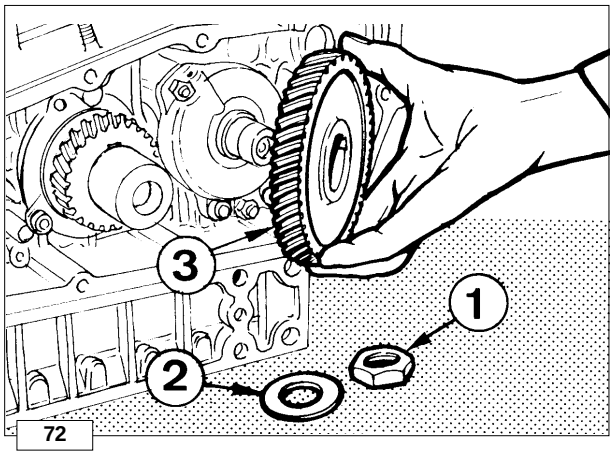
71

Connecting rod big end bearing

Both centering notches **A** and **B** must be on the same side when refitting.

❍ Tighten bolts at 40 Nm.

➲ See page 39 for dimensions.



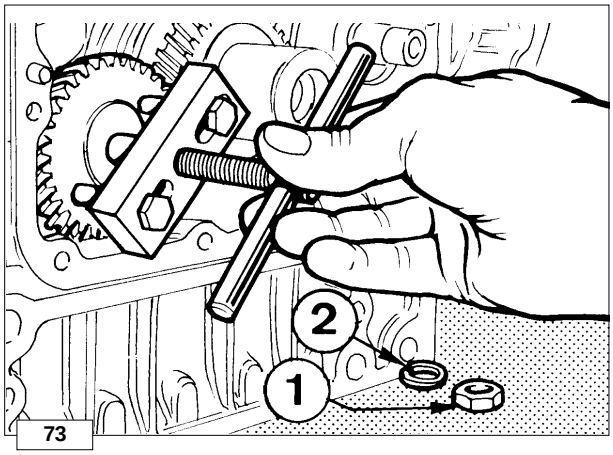
72

Camshaft gear

Remove nut **1** and washer **2**. Then remove camshaft gear **3**.
The cylindrical type of coupling makes gear removal easier since no puller is required.

❍ Tighten nut **1** at 25 Nm.

➲ See Page 42 for timing.

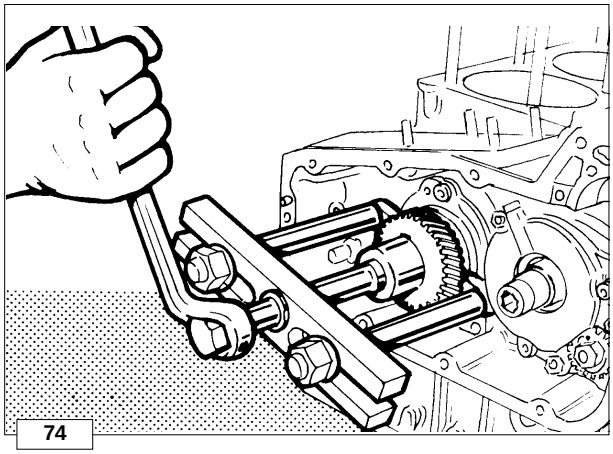


73

Oil pump gear

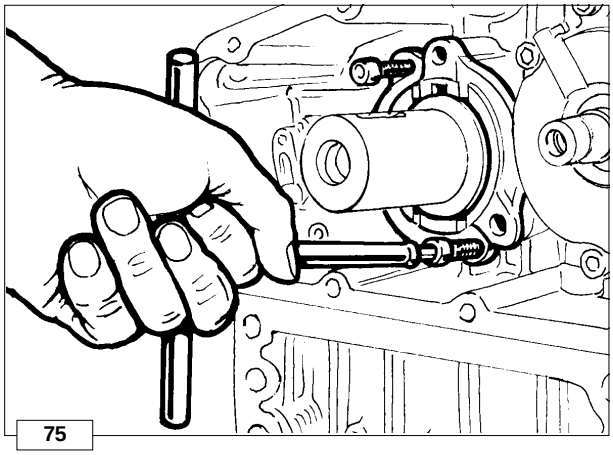
Remove nut **1** and washer **2**. Then remove oil pump gear using a puller with two M 8x1,25 bolts (length: 60 mm).

❍ Tighten the nut at 35 Nm.


74

Timing gear

The timing gear can be easily pulled out thanks to the cylindrical type of coupling.
However, if resistance is felt use a bearing puller.

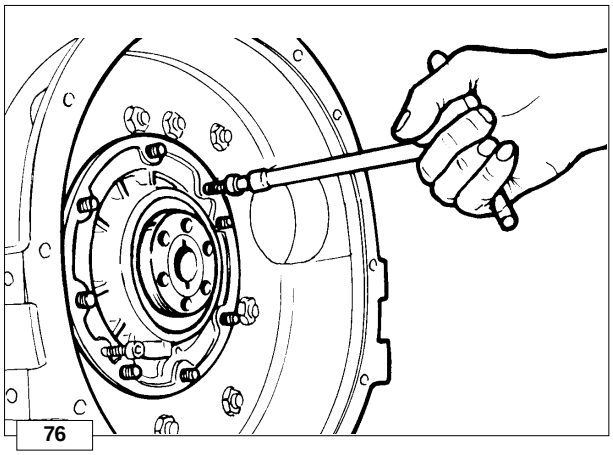

75

Main bearing support, gear side

Remove crankshaft key and thrust bearing.
Loosen the three fixing bolts and remove the main bearing support on gear side using two M 8x1,25 screws with fully threaded length of 60 mm.

***Note**:* To avoid distortion it is not recommended to repiace the bearing bushing.
Complete assemblies of bushing and support are available in standard, 0,25 and 0,50 mm undersíze configurations as spare parts.

❍ When refitting tighten screws at 25 Nm.

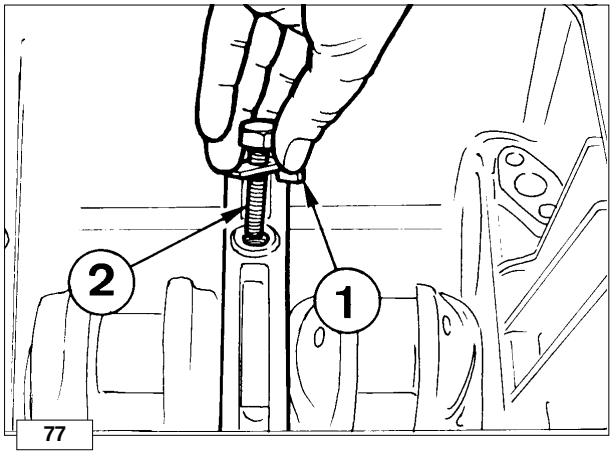

76

Main bearing support, flywheel side

Loosen nuts and extract main bearing support using two M 8x1.25 screws with fully threaded length of 40 mm.
Check oil seal ring and replace if warped, hardened or worn-out.

❍ When refitting tighten nuts at 25 Nm.

➲ See Page 40 for dimensions.

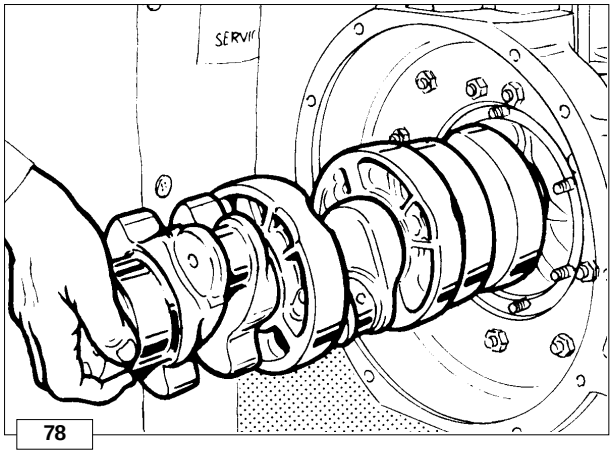


77

CRANKSHAFT

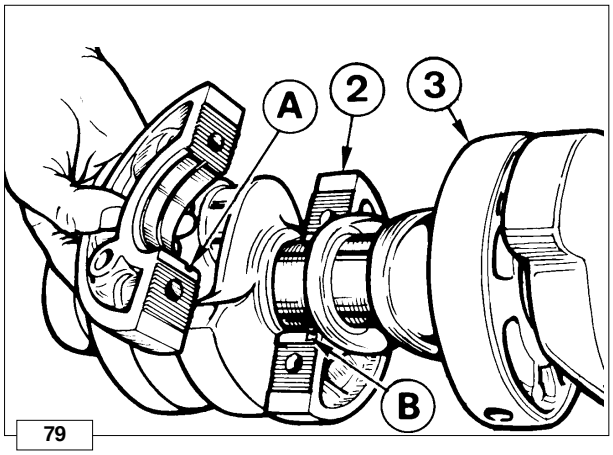
Center main bearing support, locating bolts

Before removing the crankshaft, straighten the safety stop **1** and unscrew the bolts **2** of the central main bearings.


78

Crankshaft removal

To pull out the crankshaft tap lightly on the gear side end using a copperheaded hammer.
When refitting align center main bearing supports so that the locating bolt holes coincide with the crankcase holes.

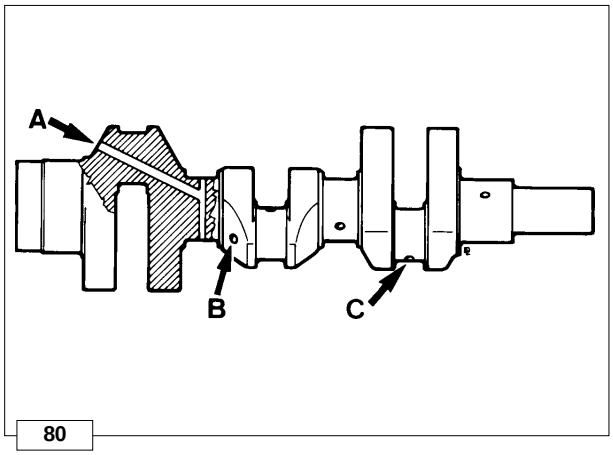


79

Crankshaft center main bearing supports

Main bearing supports **2** and **3** have a different diameter size (see page 40 for dimensions).
When refitting, both centering notches **A** and **B** must be located on the same side.

❍ Tighten screws at 30 Nm.



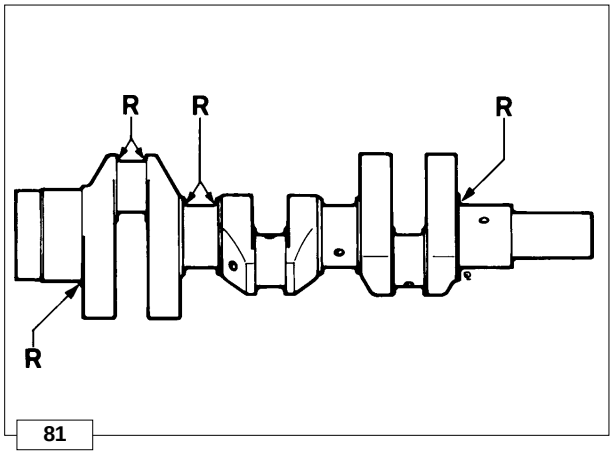
80

Crankshaft lubrication ducts

Important

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

Remove the caps, clean ducts **A**, **B** and **C** using a drill bit with the same diameter and blow with compressed air.
After cleaning, replace the new caps in their seats and make sure they are sealed.

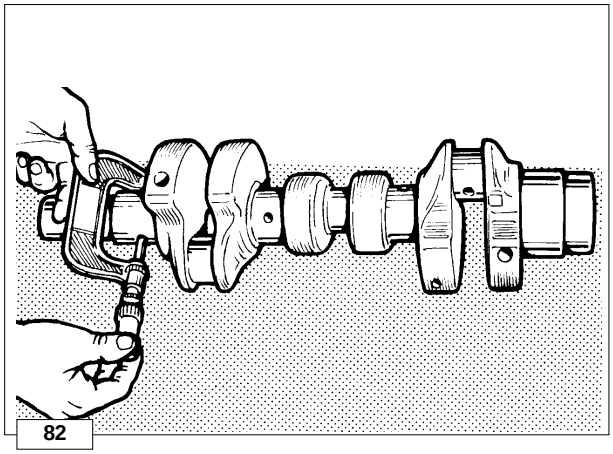


81

Crankshaft journal radius

The radius **R** connecting journal to shoulders is 2,8 ÷ 3,2 mm.

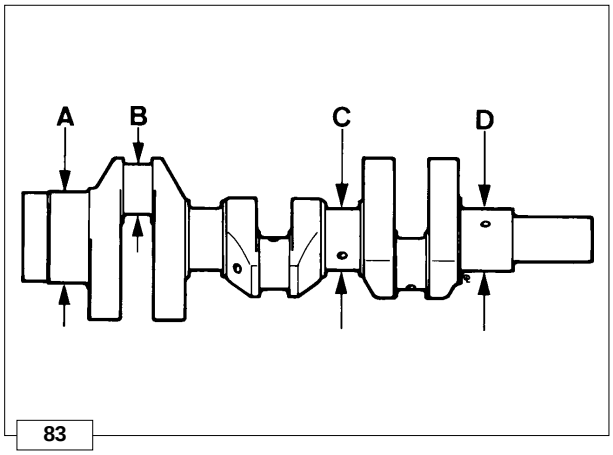
Note: When grinding main journals or crank pins restore the **R** value to original specification.



82

Checking main journals and crank pins

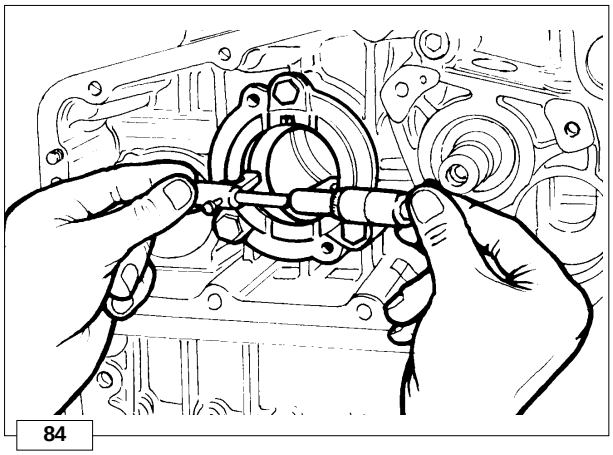
Use an outside micrometer gauge.



83

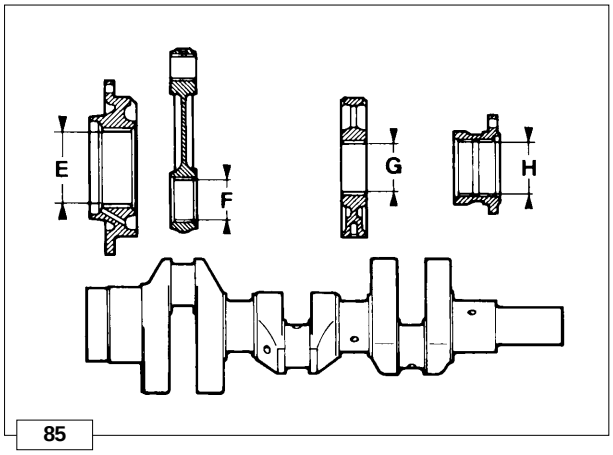
Main journal and crank pin diameter

Ref.	Dimensions (mm)
A	80,781÷80,800
B	45,500÷45,516
C	55,350÷55,370
D	54,931÷54,950


84

Diameter of main bearings

Use an inside micrometer to measure the inside.



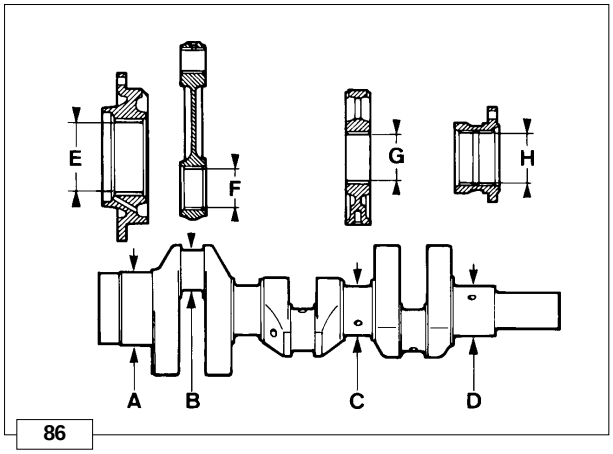
85

Main bearing and connecting rod big end bearing inside diameter

Ref.	Dimensions (mm)
E	80,870 ÷ 80,890
F	45,548 ÷ 45,578
G	55,430 ÷ 55,460
H	55,000 ÷ 55,020

The above dimensions refer to driven in or tightened bearings.

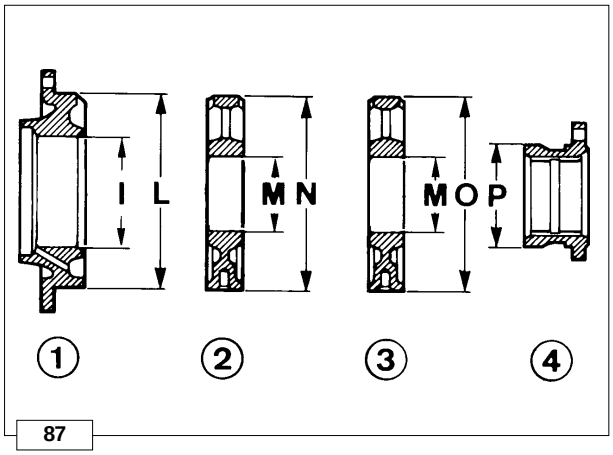
Note: Both main bearings and connecting rod big end bearings are available with inside diameter size measuring 0,25 and 0,50 less than the standard version.



86

Clearance between main journals/crank pins and connecting rod bearings

Ref.	Dimensions (mm)	Limit value (mm)
E-A	0,070÷0,109	0,195
F-B	0,032÷0,078	0,150
G-C	0,060÷0,110	0,195
H-D	0,050÷0,089	0,180



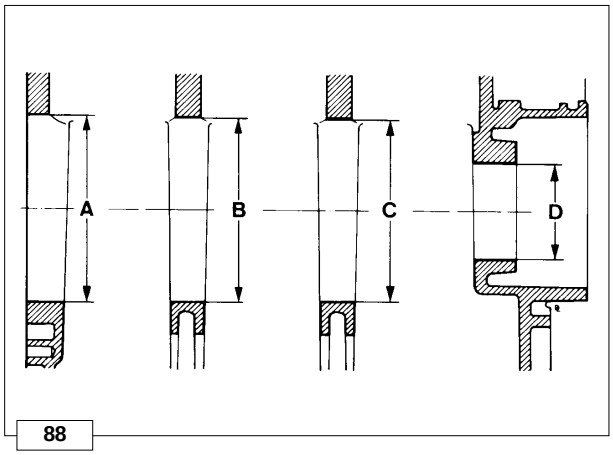
87

Main bearing supports

1 Flywheei side
2 1st central
3 2nd central
4 Gear side

Ref.	Dimensions (mm)
I	85,785 ÷ 85,815
L	152,000 ÷ 152,020
M	60,000 ÷ 60,020
N	150,000 ÷ 150,020 *
O	148,000 ÷ 148,020 *
P	77,990 ÷ 78,010

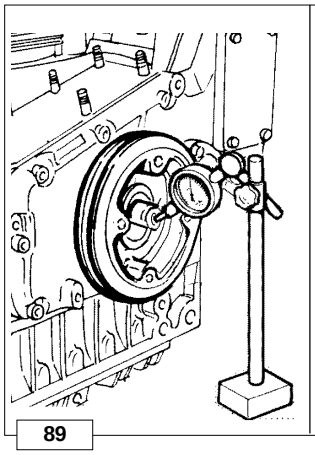
* with tightened bearing



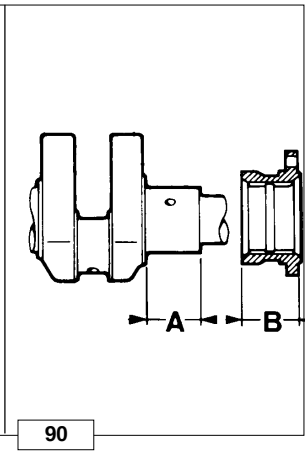
88

Main bearing housings

Ref.	Dimensions (mm)
A	150,000÷150,020
B	152,000÷152,020
C	148,000÷148,020
D	78,000÷78,020



89

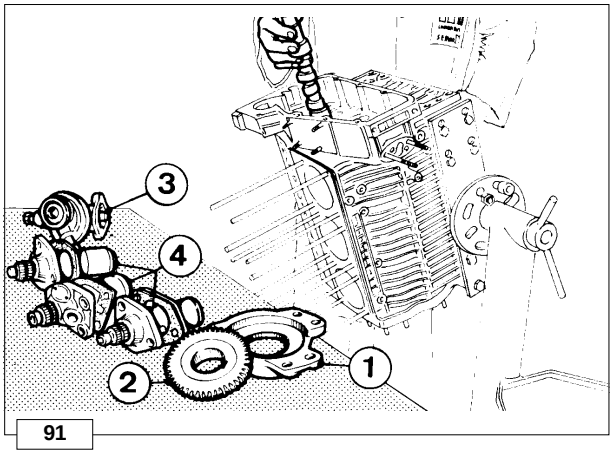


90

Crankshaft end play

Ref.	Dimensions (mm)
A	48,200 ÷ 48,250
B	47,950 ÷ 48,000

Check crankshaft end play after refitting the crankshaft pulley and tightening its nut at 300 Nm; the crankshaft end play is equal to 0,20 ÷ 0,30 mm and is not adjustable. If this value cannot be obtained check **A** and **B**, and possibly replace the parts whose size is inadequate.

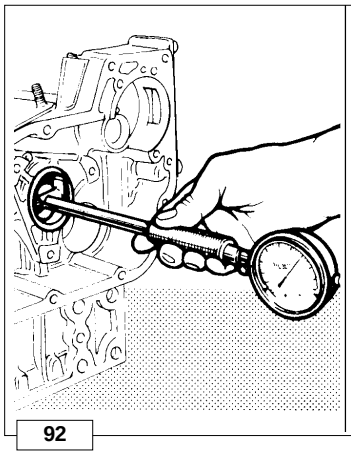


91

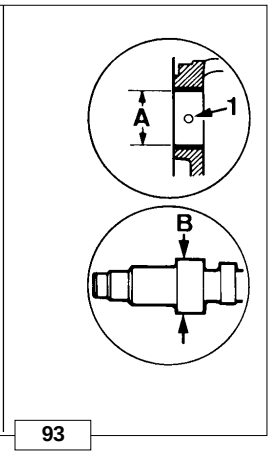
CAMSHAFT

Camshaft removal

To pull out the camshaft simply remove bell **1**, gear **2**, fuel feeding pump **3**, injection pumps **4** and tilt the engine; in this position the cam followers is not in contact with the camshaft thus making its removal possible.



92

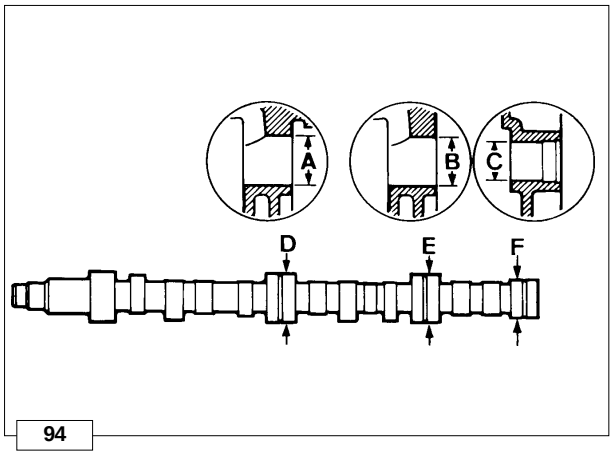


93

How to measure camshaft bearing and journal inside diameter

Ref.	Dimensions (mm)	Clearance (mm)	Limit value (mm)
A	44,000÷44,025	0,040÷0,085	0,170
B	43,940÷43,960		

Measure **A** using an internal dial indicator and **B** with an external micrometer.
When repiacing the bearing make the lubrication hole **1** match with the corresponding crankcase bore.

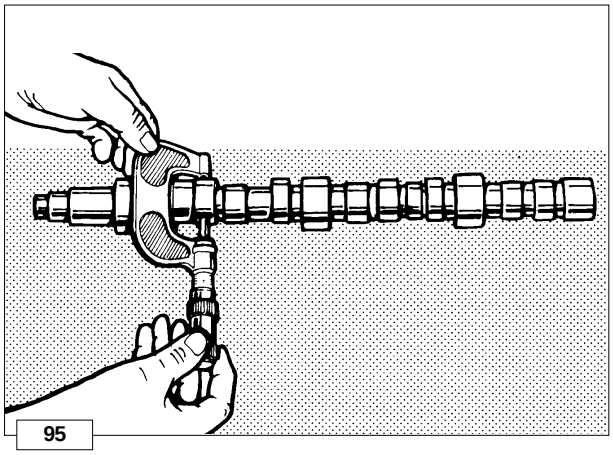


94

Dimensions of camshaft journals and housings

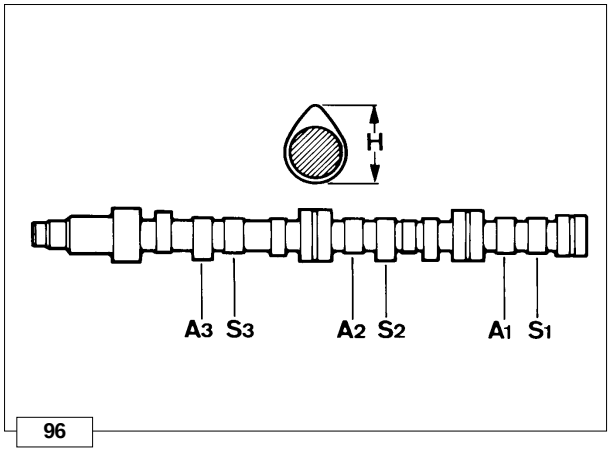
Ref.	Dimensions (mm)
A	42,000÷42,025
B	41,000÷41,025
C	33,200÷33,220
D	41,940÷41,960
E	40,940÷40,960
F	33,140÷33,160

Ref.	Clearance (mm)	Limit value (mm)
A-D	0,040÷0,085	0,170
B-E		
C-F	0,040÷0,080	0,160


95

Checking intake/exhaust cam height

Use an outside micrometer gauge to measure camshaft lobe height.



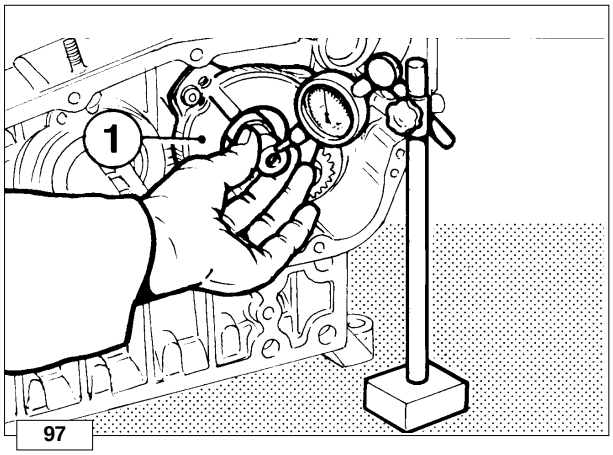
96

Intake/exhaust cam height

A1= 1st cylinder intake cam
S1 = 1st cylinder exhaust cam
A2 = 2nd cylinder intake cam
S2 = 2nd cylinder exhaust cam
A3 = 3rd cylinder intake cam
S3 = 3rd cylinder exhaust cam
H = 33,65 ÷ 33,55 for engines EPA 97/68 CE

Exhaust and intake cams feature the same height **H**.
Replace camshaft if **H** is 0.1 mm below the given value.

Note: Engine SP 420, in the slow speed version (1500÷2000 r.p.m.) features a camshaft with **H** = 33.765÷33.865 mm.



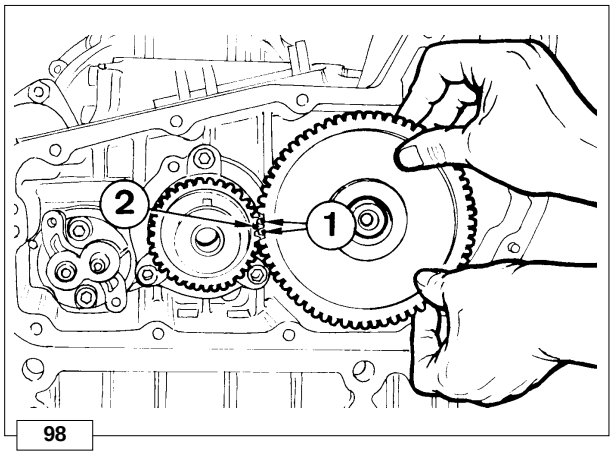
97

Camshaft end play

Check camshaft end play after removing cylinder head, injection pump and fuel feed pump from the engine.

❍ Check that the three cover **1** screws are tightened at 25 Nm.

Place the dial gauge on the camshaft gear outer part; push and pull same gear as required.
Camshaft end play should be 0,15 ÷ 0,30 mm.

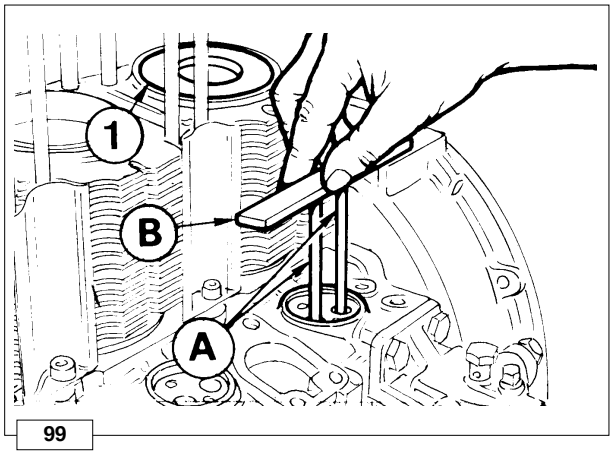


98

Camshaft timing

Fit camshaft gear by making timing mark **2** coincide with timing marks **1**.

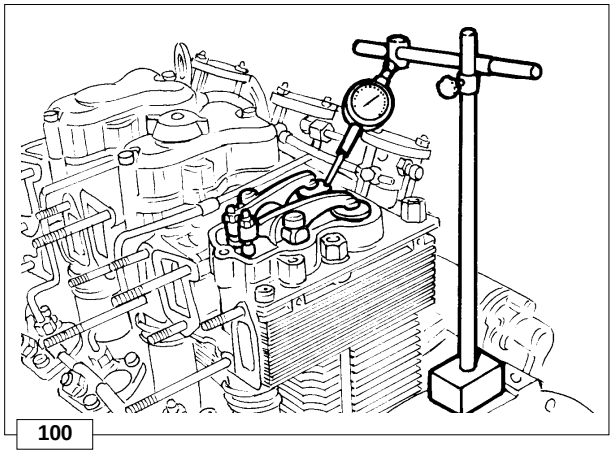
❍ Tighten camshaft bolt at 250 Nm.



99

Valve timing without considering timing marks

Locate piston **1** (on flywheeI side) at the top dead center. Position two small cylinders **A** of the same height onto the tappets.
Rotate camshaft stopping when cylinder **1** tappets are in overlap position (intake open, exhaust closed).
By means of ruler **B** check that tappets are at the same height.

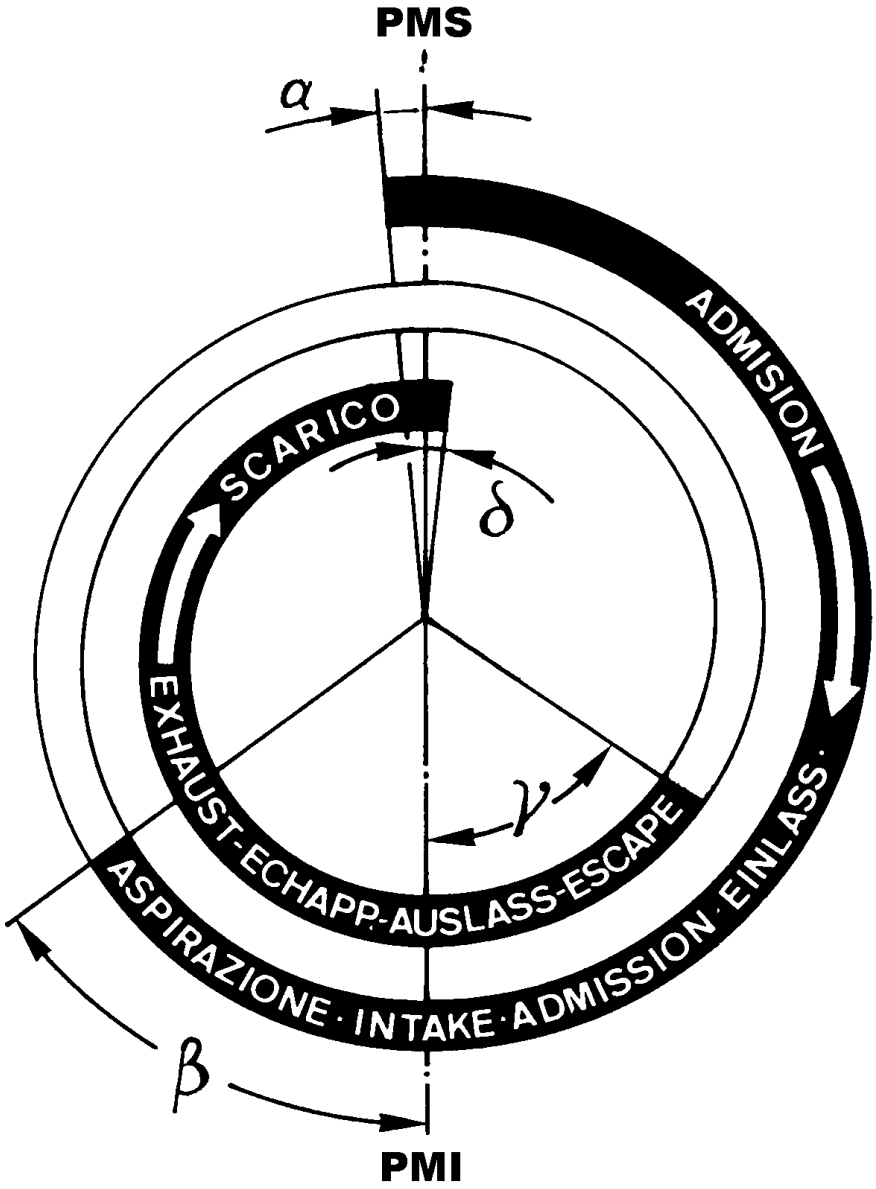


100

Valve timing check

Check using an index plate suitable for reading angles, integral with the crankshaft. Readings are taken in degrees.
Set valve clearance at 0,65 ÷ 0,70 mm (after checking restore the value al 0,15 ÷ 0,20 mm). Set dial gauge on intake valve to a zero value; by rotating the driving shaft according to its direction of rotation you can measure α (intake valve opening advance referred to top dead centre **PMS**) and **ß** (intake valve closing delay referred to bottom **1** dead centre).

Follow the same procedure for exhaust valves checking γ (exhaust valve opening advance) and δ (exhaust valve closing delay).

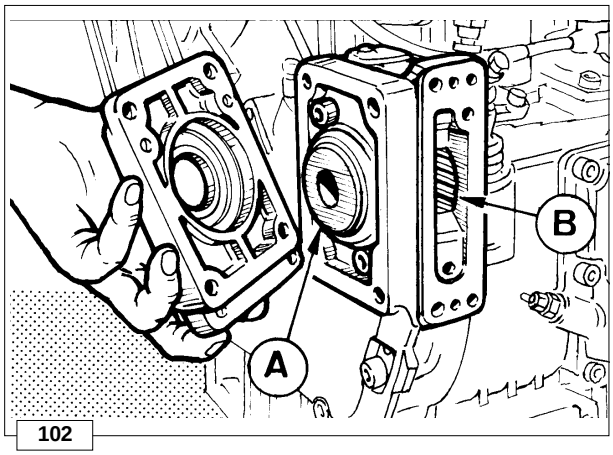


Legend

S = piston at top dead center
I = piston at bottom dead center
α = intake valve open
β = intake valve closed
γ = exhaust valve open
δ = exhaust valve closed

Value expressed in degrees of the timing angles. (valves clearance = 0.65 ÷ 0.70 mm)

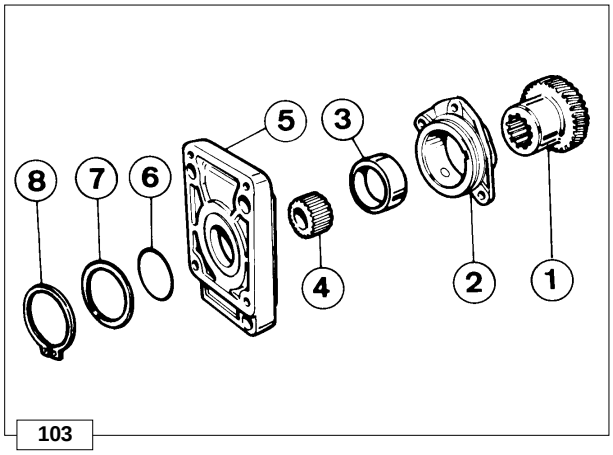
α	=	open 2°	before P.M.S.
β	=	close 34°	after P.M.I.
γ	=	open 34°	before P.M.I.
δ	=	close 2°	after P.M.S.



102

Hydraulic pump p.t.o. group 1

A hydraulic pump of group 1 or 2 can be installed on the gear side **A**, 3rd p.t.o.
A group 1 hydraulic pump can be installed at the 4th p.t.o. **B**.



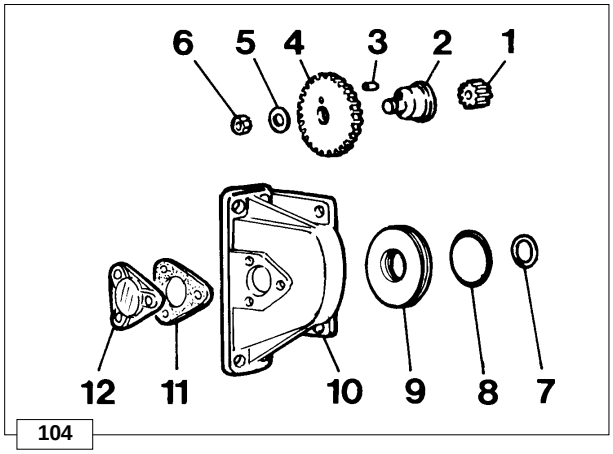
103

Hydraulic pump 3rd p.t.o., group 2

Components:

1 Gear
2 Gear support
3 Bearing
4 Drive
5 Flange
6 Washer
7 Seal ring
8 Circlip

A max torque of 39,6 Nm can be obtained from this p.t.o.



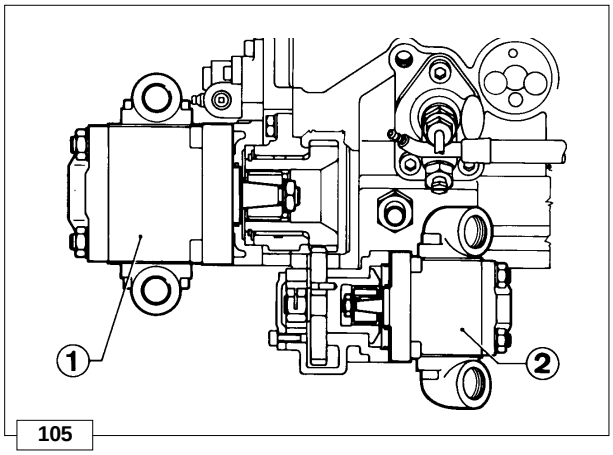
104

Hydraulic pump 4th p.t.o., group 1

Components:

1 Drive
2 Control shaft
3 Pin
4 Gear
5 Washer
6 Nut
7 Seal ring
8 Seal ring
9 Centering ring
10 Bracket
11 Gasket
12 Cover

A max. torque of 243 Nm can be obtained from this p.t.o.

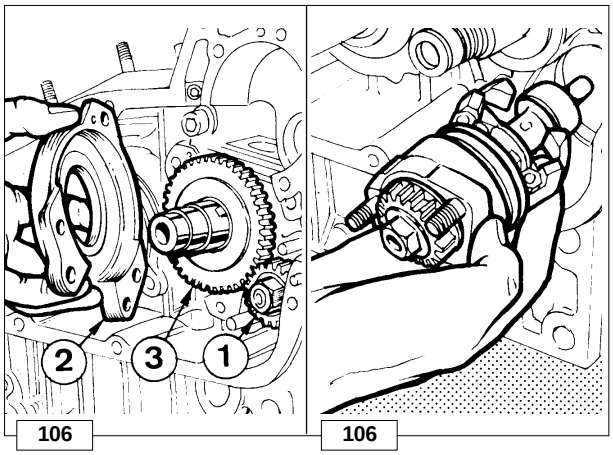


105

Use of 3rd and 4th p.t.o.

1 Hydraulic pump, group 2, mounted at 3rd p.t.o.
2 Hydraulic pump, group 1, mounted at 4th p.t.o.

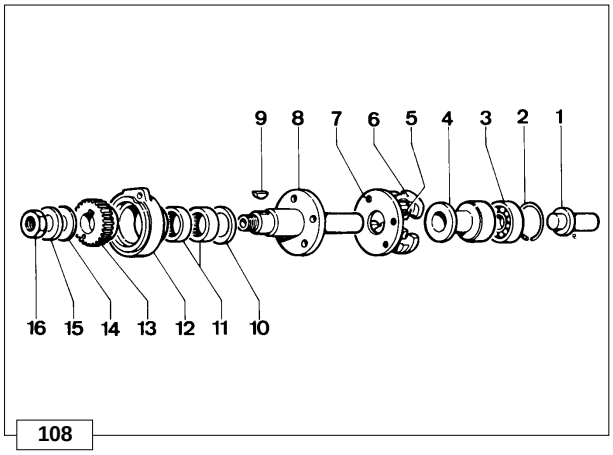
Total power obtainable from 3rd and 4th plo. is 13 kW (17.7 HP).
Ratio for both p.t.o. compared to the engine r.p.m. is 1:1 for 4th PTO is 1 : 1,067 for 3th PTO.



106

Mechanical speed governor

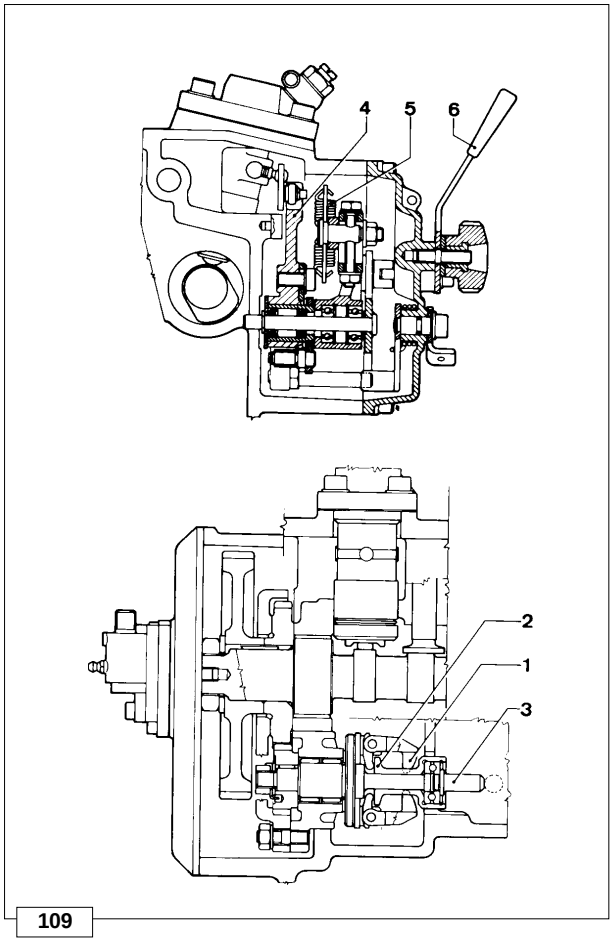
The governor (with centrifugal weights) is housed inside the crankcase and is controlled by a camshaft gear.
To remove speed governor **1** remove camshaft bell **2** and speed governor control gear **3**.



108

Mechanical speed governor components (standard)

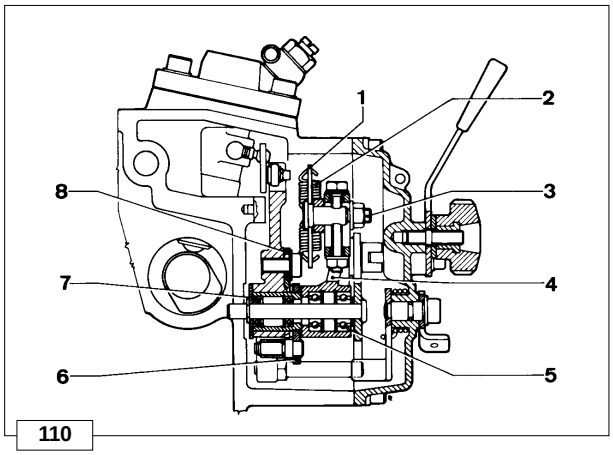
1 Drive rod
2 Stop ring
3 Bearing
4 Washer
5 Pin
6 Weights
7 Weight support
8 Shaft
9 Key
10 Thrust washer
11 Bearings
12 Shaft support
13 Gear
14 Spring washer
15 Flat washer
16 Nut



109

Mechanical speed governor operation (standard)

Weights **1** are moved to the periphery by the centrifugal force and thus axially shift the washer **2** and the drive rod **3** which, by means of a linkage, move injection pump control lever **4**.
The governor springs **5** placed under tension by the accelerator control lever **6** offset the weights **1** centrifugal force.
Balance between the two forces keeps speed at an almost constant level in spite of load variations.

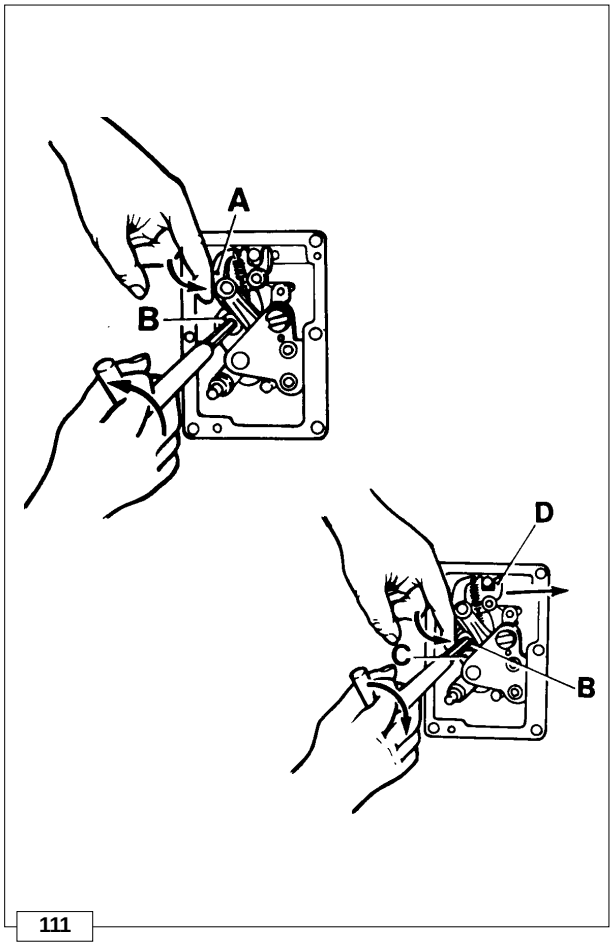


110

Mechanical speed governor components for special generating sets

1 Spring anchoring rocker arm
2 Governor springs
3 Journal
4 Governor control lever
5 Governor control lever ball bearing
6 Lever
7 Bearing
8 Plate

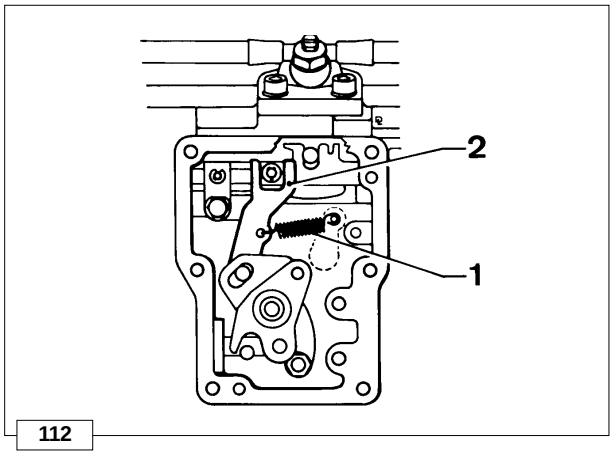
Note: Two types of governor springs **2** are available: one for full speed regulation at 1500 r.p.m. and the other for full speed regulation at 1800 r.p.m.; in this case governor weights are heavier.



111

Mechanical speed governor setting

Lift finkage **A**.
Loosen screw **B**.
Push lever **C** to the right and check that speed governor weights are closed.
Shift injection pump delivery control yoke **D** to the right (for maximum delivery).
Tighten screw **B**.



112

Spring for extra fuel supply at starting

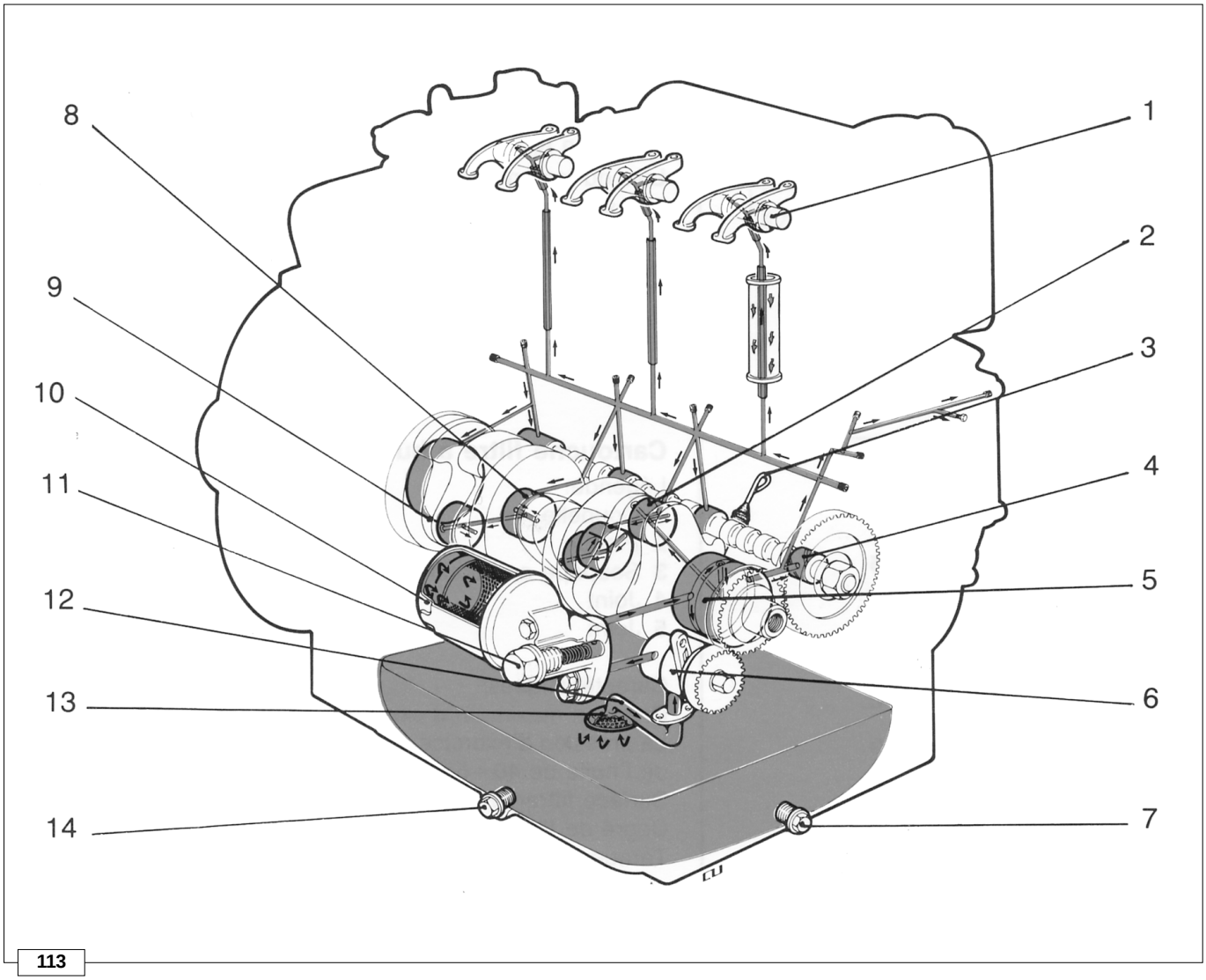
The device is operated automatically: when the engine is stopped spring **1** acts on injection pump control yoke **2** providing maximum fuel delivery, until the speed governor starts operating.

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

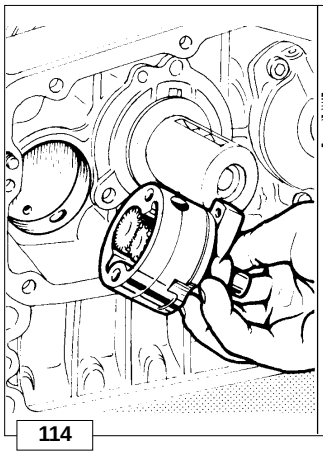
Old engine oil can cause skin cancer if repeatedly left in contact with the skin and for long periods of time.
If contact with the oil is unavoidable, you are advised to wash your hands with soap and water as soon as possible.
Dispose of old oil in the correct way as it is highly polluting.

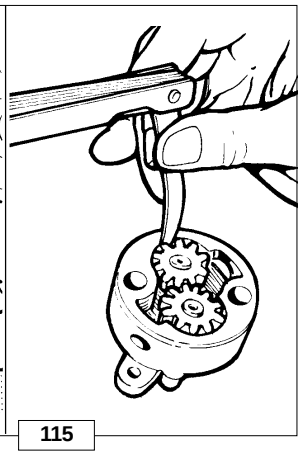


113

Components:

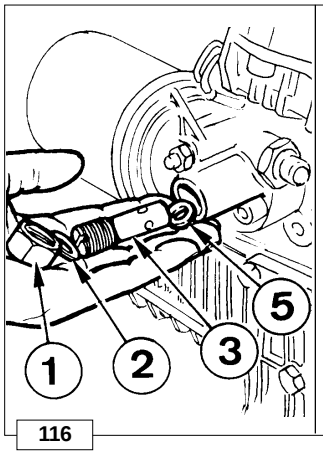
1) Rocker arm shaft
2) Connecting rod big end bearìng
3) Oil dipstick
4) Camshaft
5) Crankshaft journal
6) Oil pump
7) Drain plug
8) Crankshaft main journal
9) Crankshaft
10) Cartridge filter
11) Oil pressure relief valves
12) Pump intake pipe
13) Internal strainer
14) Drain plug


114

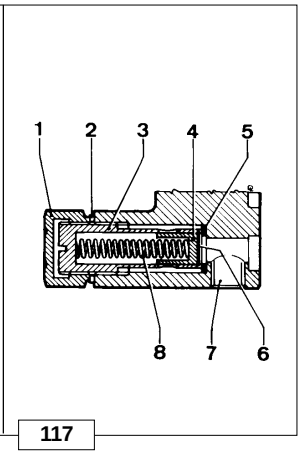

115

Oil pump

Check that gear teeth are intact and that clearance between gear edge and pump body is 0,041 ÷ 0,053 mm with limit value 0,10 mm. Furthermore check that control shaft is tree to rotate with end float of 0,040 ÷ 0,090 mm with limit value of 0,170 mm.
Oil pump delivery at 3000 r.p.m. is 18 liters/min.



116



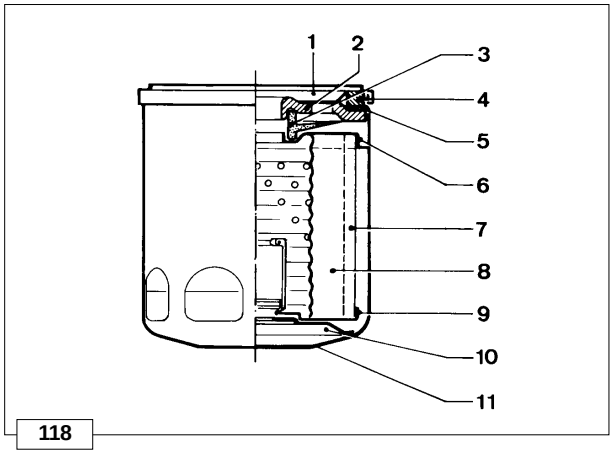
117

Oil pressure relief valve

Components:

1 Plug
2 Copper gasket
3 Bushing
4 Piston
5 Rubber gasket
6 Ring
7 Hole for pressure switch connection
8 Spring

Note: Blow-by at an oil temperature of 40 ÷ 50°C and pressure of 3 bar should be less than 1 l/min.
When refitting screw bushing **3** so that it touches gasket **5**.
Do not tighten excessively since gasket **5** might break causing an oil pressure drop in the system.



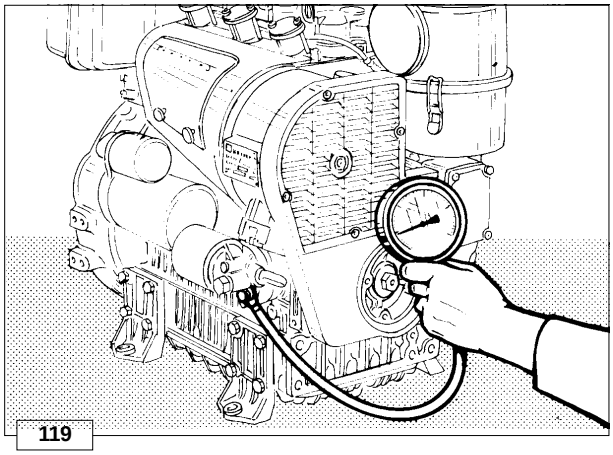
118

Oil filter cartridge

Components:
1 Retainer
2 Plate
3 Valve
4 Gasket
5 Gasket
6 Upper cover
7 Blade
8 Filtering element
9 Assembly
10 Belleville washer
11 Tank

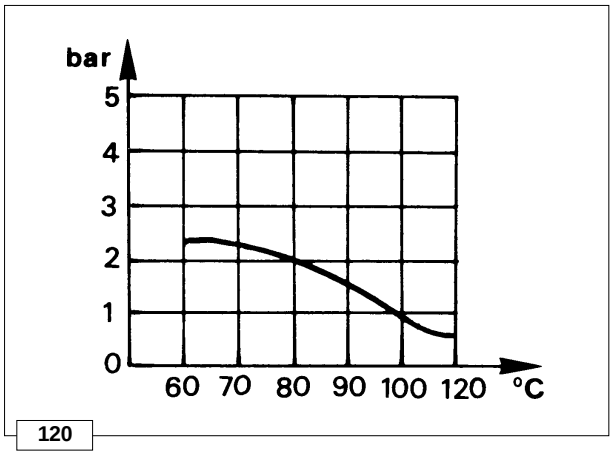
Characteristics:

Max. working pressure ..... 13 bar
Filtering area ..... 955 cm^2
Type of filtration ..... 20 µm
By-pass valve opening pressure ..... 1,4 ÷ 1,8 bar.


119

Oil pressure check

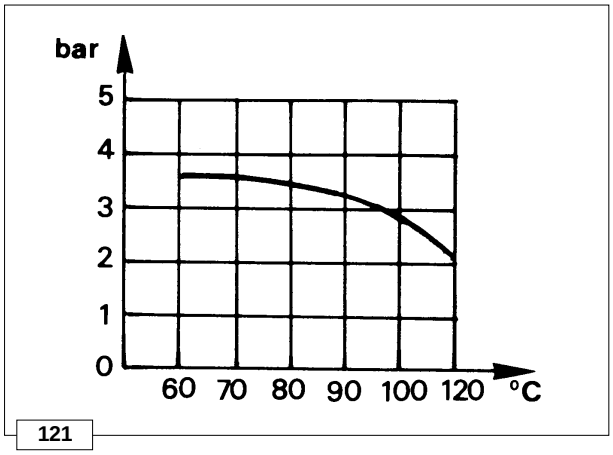
Once the engine is fitted fill with oil and fuel, connect a 10 bar pressure gauge to the oil filter fitting.
Start the engine and check pressure as a function of the oil temperature (see page. 49).



120

Oil pressure curve at idling speed

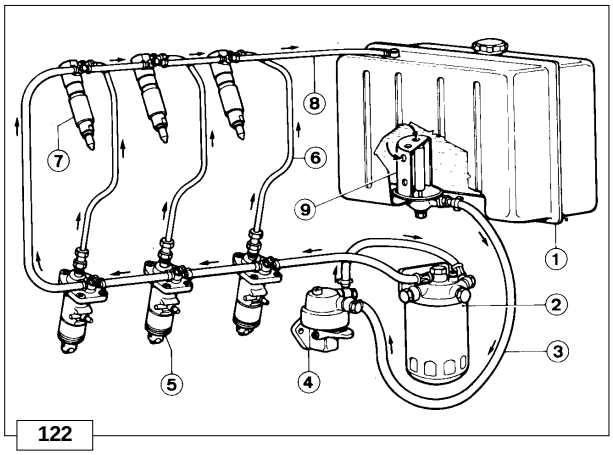
The curve is obtained at the oil filter level with constant engine speed of 1200 r.p.m. in no-load conditions and at a room temperature of + 25°C.
Pressure is given in bar and temperature in centigrades.



121

Oil pressure curve at full speed

The curve is obtained at the oil filter level with engine working al 3000 r.p.m. al the N power. Room temperature is +25°C.
Lube oil peak temperature should be below 120°C for engines without oil cooler and below 110°C for engines with oil cooler.
Pressure is given in bar and temperature in centigrades.

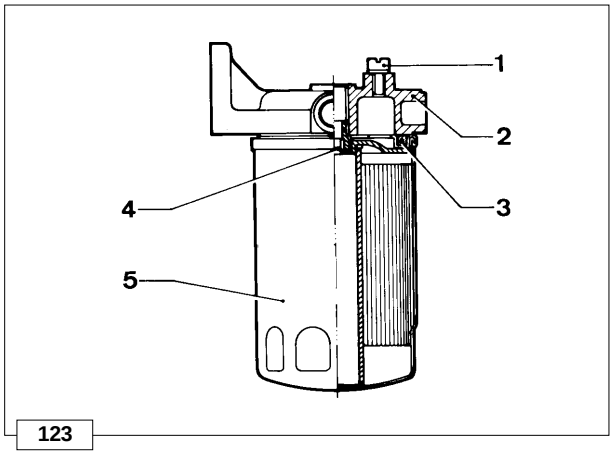


122

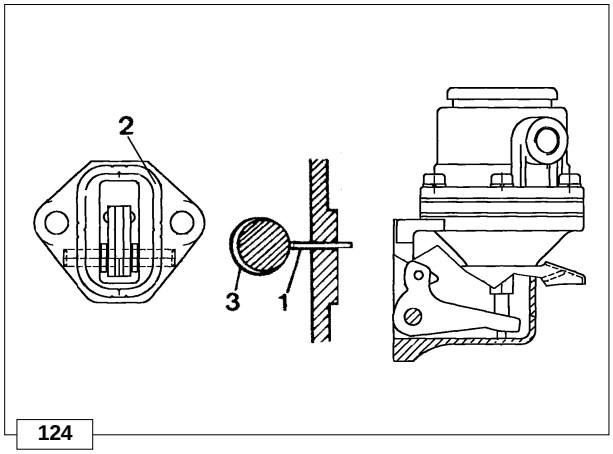
Fuel feeding/injection circuit

Components:

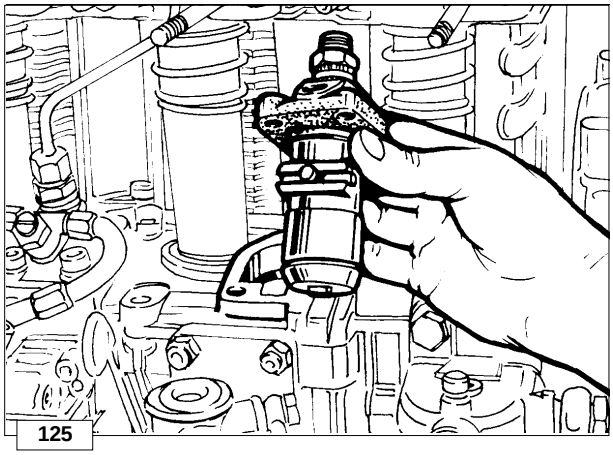
1 Tank
2 Filter
3 Fuel feeding tube
4 Fuel feeding pump
5 Injection pump
6 Injection line
7 Injector
8 Injector leak off line and self bleeding system
9 Bowl



123



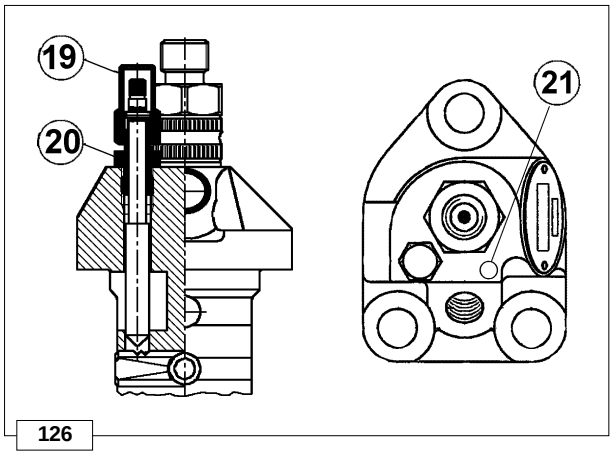
124



125

Injection pump

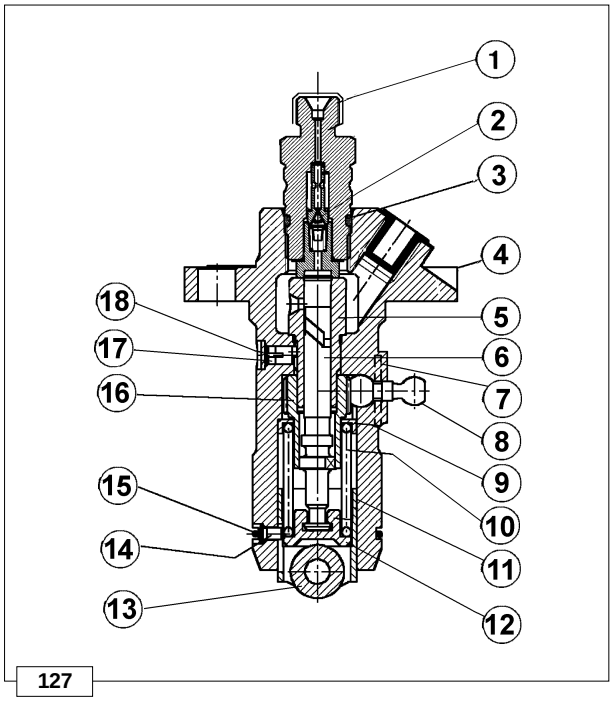
The Bosch injection system consists of three pumps each feeding one cylinder.
The pumps mounted on the crankcase, corresponding to their proper cylinder, are directly operated by the camshaft.



126

19 Threaded plug
20 Adjustment rod locking device
21 Area in which the pump delivery class is stamped

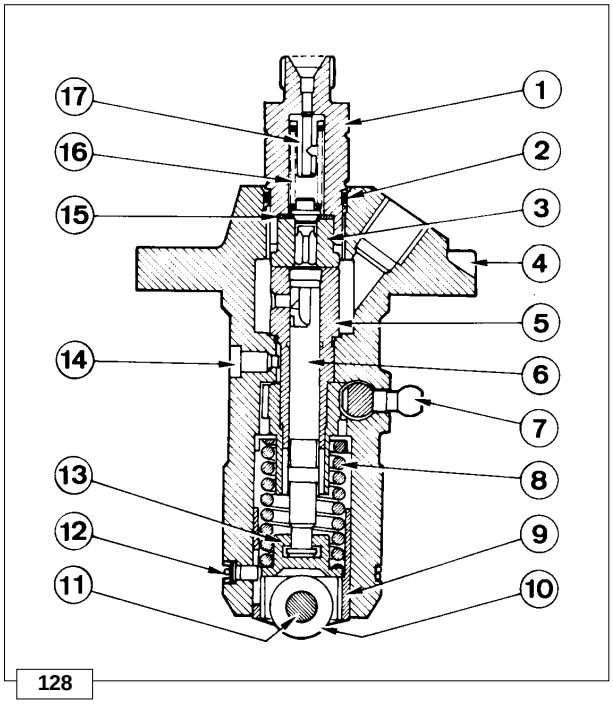
In this engine the injection pumps are preset by the manufacturer who supplies them stamped with alphabetical classes (A, Ax, B, Bx, C, Cx or D) for standard and 97/68 EC engines, while for EPA2 engines the classes are numerical (5, 6, 7, 8, 9, 10, 11, 12, 13 and 14).
The adjustment rod is locked via the bayonet device.



127

Injection pump only for EPA engines

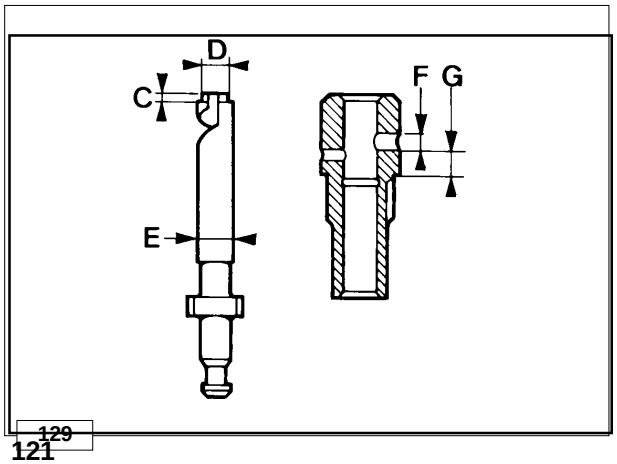
1 Delivery union
2 PRV valve
3 O-Ring
4 Pump housing
5 Pumping piston
6 Pumpung plunger
7 Elastic pin
8 Rack rod
9 Superior retainer
10 Spring tappet
11 Tappet body
12 Inferior retainer
13 Roller
14 Journal guide tappet
15 Elastic pin
16 Adjustment hose
17 Plunger stop pin
18 Cap



128

Injection pump only for standard and 97/68 Ce engines

1 Delivery union
2 Rubber ring
3 Delivery valve
4 Pump housing
5 Piston
6 Plunger
7 Rack rod
8 Spring
9 Tappet body
10 Roller
11 Journal
12 Pin
13 Spring retainer
14 Eccentric
15 Copper gasket
16 Spring
17 Filler

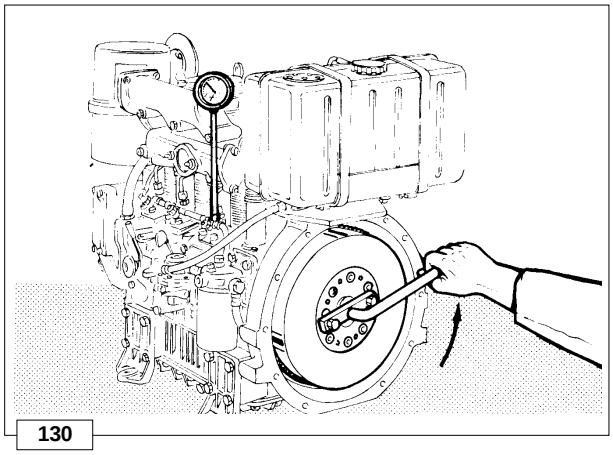


129

121

Plunger

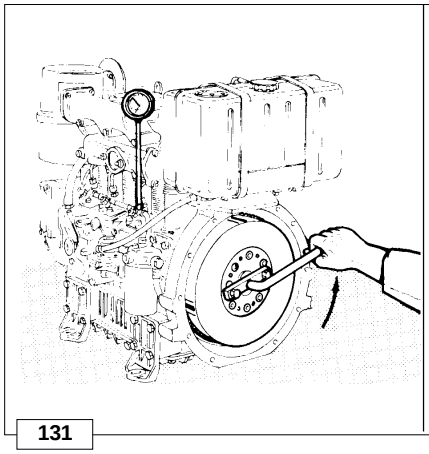
Ref.	Dimensions (mm)
C	1,000 ÷ 1,100 mm
D	7,445 ÷ 7,455 mm
E	7,500 mm
F	3,000 ÷ 3,025 mm
G	7,225 ÷ 7,275 mm



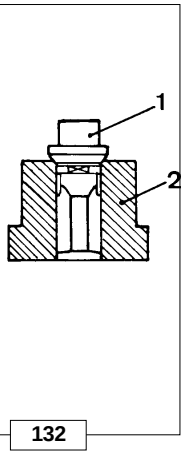
130

How to check plunger and barrel for internal leakage

This operation is only diagnostic since pressure changes depend on the pumping speed.
Connect the delivery union with a 600 bar pressure gauge with safety valve.
Adjust rack rod at half-stroke.
Turn flywheel according to its direction so that the plunger puts the circuit under pressure.
Replace plunger if the displayed pressure is below 300 bar.
Repeat the same operation for the other plungers.



131



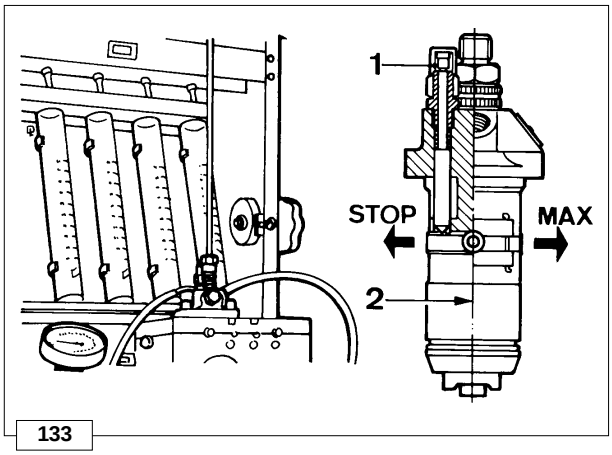
132

How to check injection pump delivery valve sealing

Components:

1 Valve
2 Seat

Adjust pump rack at half-stroke.
Turn flywheel according to its direction of rotation so that the plunger puts the circuit under pressure.
During this operation the displayed pressure will gradually reach a peak followed by a sudden drop which corresponds to valve closing. Pressure drop should be 30 ÷ 50 bar.
Replace the valve if pressure drop is below this value.
Repeat the same operation for the other two pumps.



133

Test data for injection pump delivery at the test bench for standard and 97 / 68 CE engines

1 Rack rod lock to be removed after pump fitting to the engine
2 Injection pump axis

Test data:

Control rod max. force (N)	Rod stroke from pump axis (mm) + towards max - towards stop	Camshaft r.p.m.	Delivery mm^3/stroke
0,45	- 2	500	3 ÷ 4 stamped A 4 ÷ 5 stamped Ax 5 ÷ 6 stamped B 6 ÷ 7 stamped Bx 7 ÷ 8 stamped C 8 ÷ 9 stamped Cx 9 ÷ 10 stamped D
	- 2	1500	27,5 ÷ 30,5
	max	150	90 ÷ 100

The above test data refer to pump with plunger dia. of 7,500 mm.

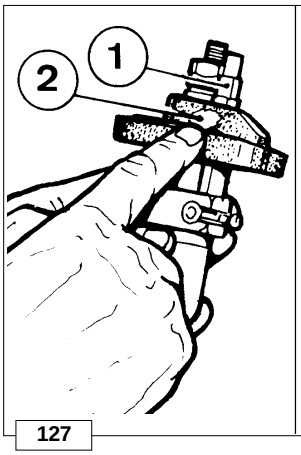
Test data for injection pump delivery at the test bench only for EPA engines

Test data:

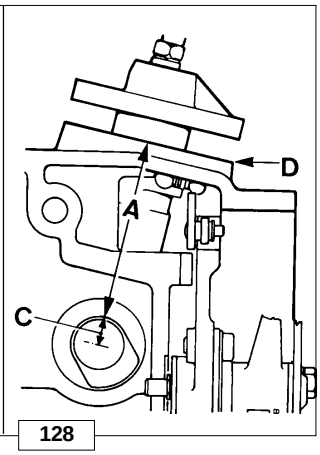
Control rod max. force (N)	Rod stroke from pump axis (mm) + towards max - towards stop	Camshaft r.p.m.	Delivery mm^3/stroke
0,45	0	500	3 ÷ 4 stamped A 4 ÷ 5 stamped Ax 5 ÷ 6 stamped B 6 ÷ 7 stamped Bx 7 ÷ 8 stamped C 8 ÷ 9 stamped Cx 9 ÷ 10 stamped D
	0	1500	38 ÷ 40
	max	150	90 ÷ 100

The pump class is indicated by the full delivery value ***** at 1 mm^3/ stroke from 5 to 14.
Plunger diameter size: 7,500 mm.

Note: All pumps are tested and set in order to obtain the same delivery at full speed.
After the tests carried out at idle speed pumps are subdivided into classes marked with references in letters or numbers. These reference marks are very clearly stamped on the upper pump body.
If replacing, make sure that the new pumps have the same references (letters or numbers) as the previous ones.



127



128

Injection pump replacement

1 Rack rod lock
2 Reference mark pump class

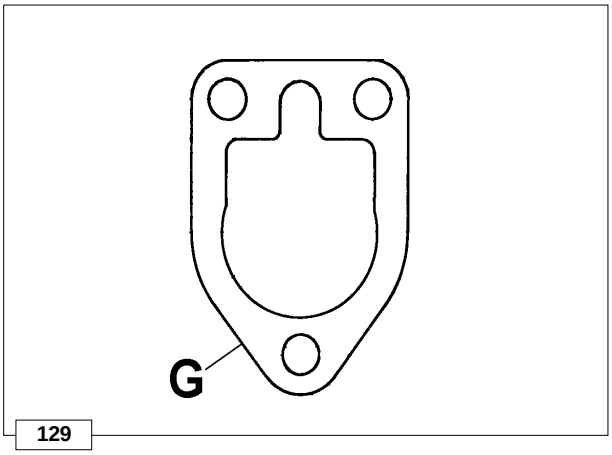
A = 82.80 mm
C = Injection cam radius
D = Injection pump support

Important

Whe replacing this type of injection pump check that the new one has a same reference mark as the old one.
The reference marks of injection pumps must be the same.

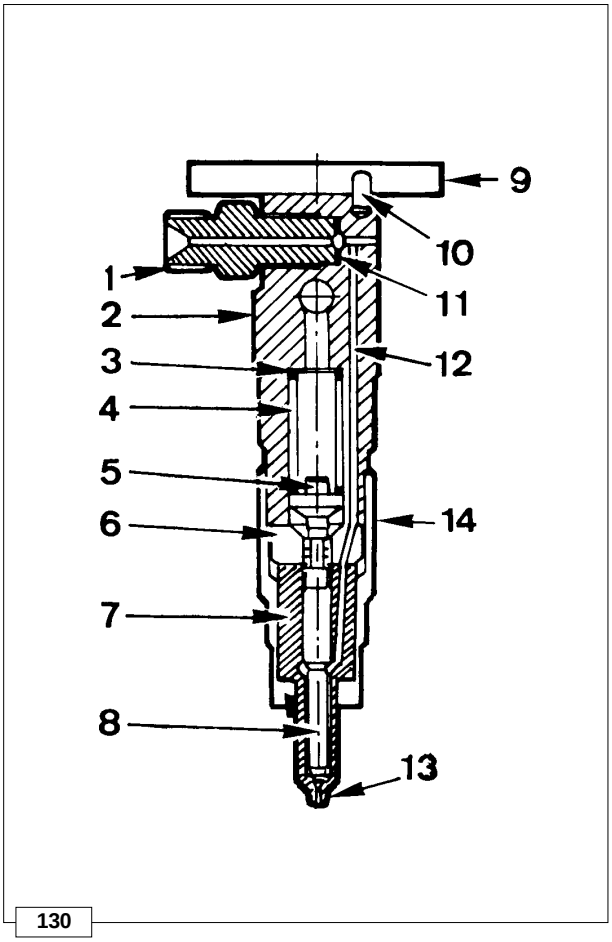
Replace as follows:

❍ Fit pump into the crankcase and tighten screws at 25 Nm.



129

Remove lock **1** and check that rack rod is free to move.
If pump removal is required fit lock **1** to its original position: the rack rod centre should coincide with the pump axis (see fig. 126).
When replacing the crankcase or the camshaft preserve the same distance **A** between **D**, injection pump support, and **C**, injection cam radius; add shims **G** on **D** to obtain the right **A** value if required.
Seals **G** are supplied with different thicknesses: 0,05 – 0,1 – 0,3 and 0,5 mm.

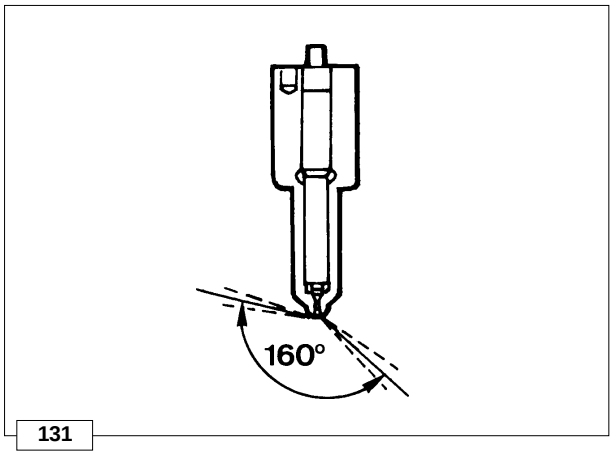


130

Size S injector

Components:

1 Intake fitting
2 Nozzle holder
3 Shim
4 Spring
5 Pressure rod
6 Intermediate flange
7 Nozzle
8 Needle valve
9 Fixing flange
10 Taper pin
11 Gasket
12 System duct
13 Sump
14 Cup



131

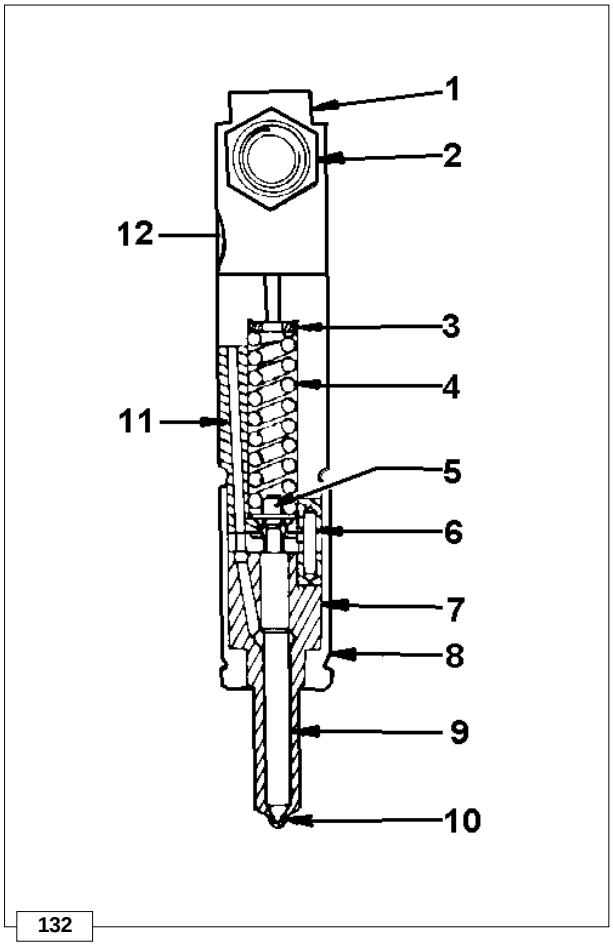
Size S nozzle

Features:

Hole number and diameter ..... 4x0,28 mm
Jet angles ..... 160°
Needle valve elevation ..... 0,20 ÷ 0,22 mm
Hole length ..... 0,7 mm
Sump diameter and length ..... 1x1,5 mm

Clean nozzle tip with a brass brush.
Check that holes are not obstructed using a mandrel with steel wìre with 0,28 mm diam.

❍ When refitting tighten ring nut at 70 Nm.



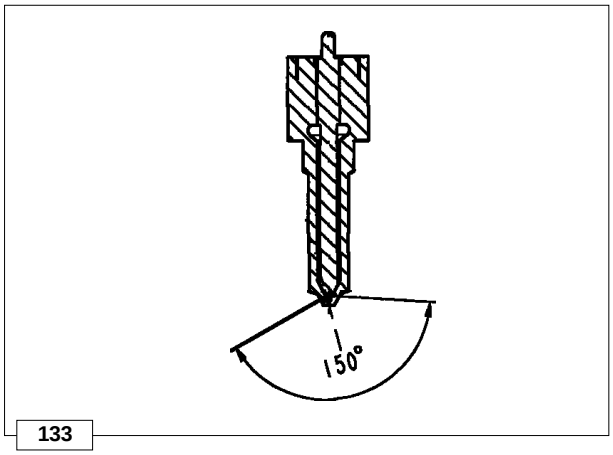
132

Size P injector

Components:

1 Injector housing
2 Intake fitting
3 Shim
4 Spring
5 Pressure rod
6 Taper pin
7 Nozzle
8 Cup
9 Needle valve
10 Sump
11 System duct
12 Overflow pipe

❍ When refitting tighten ring **8** nut at 50 Nm.



133

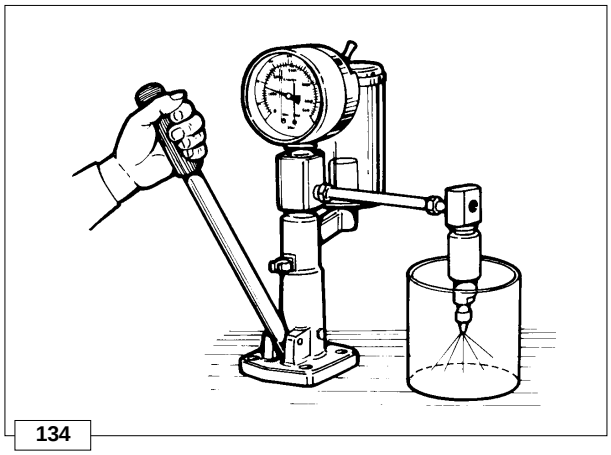
Size P nozzle

Features:

Hole number and diameter ..... 5 x 0,23 mm.
Jet angles ..... 150°.
Needle valve elevation ..... 0,200 ÷ 0,205 mm
Hole length ..... 1 mm
Sump diameter and length ..... 2 x 2,5 mm

Clean nozzle tip with a brass brush.
Check that holes are not obstructed using a mandrel with steel wìre with 0,23 mm diam.

❍ When refitting tighten ring nut at 55 ÷ 65 Nm.

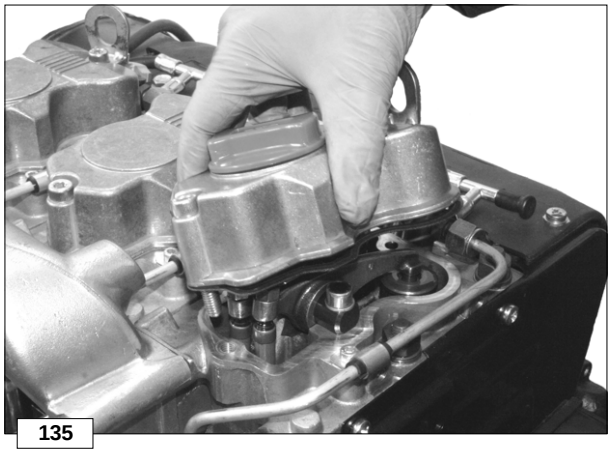


134

Injector setting

Connect injector to high pression pump and check that setting pressure is 210 ÷ 220 bar for size S injector and 245 ÷ 255 bar for size P injector.
To change injector setting replace the shim over the spring.
When replacing the spring, setting should be performed at a 10 bar greater pressure to allow for bedding during operation.
Check needle valve sealing by slowly moving hand pump until approximately 180 bar.
Replace nozzle in case of dripping (only for size S injectors).

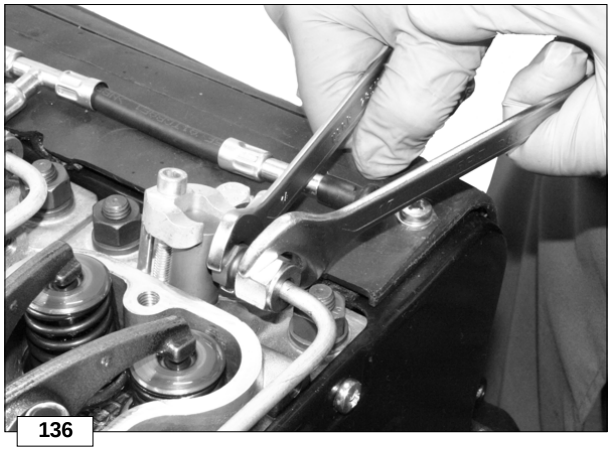
17°



135

(Static) Injection timing

Remove the rocker arm cover.

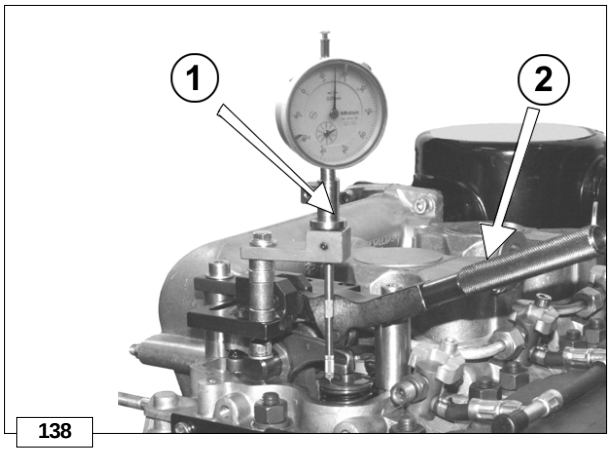


136

Use a 14 mm box wrench to lock the injector union and a 17 mm box wrench to loosen the union of the injector pump high-pressure pipe.

137

Use a 19 mm box wrench to lock the injection pump union and a 17 mm box wrench to loosen the union of the injector pump high-pressure pipe.

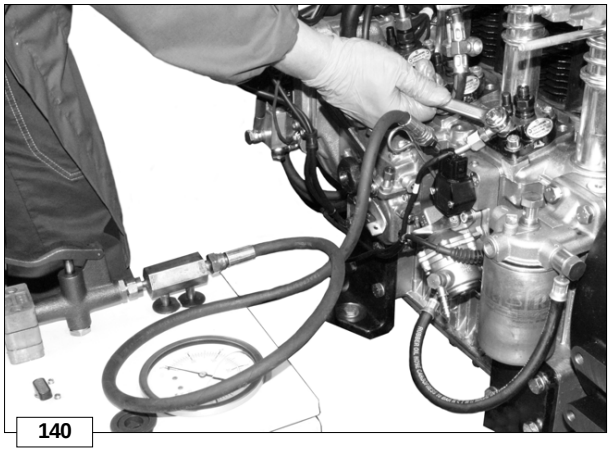


138

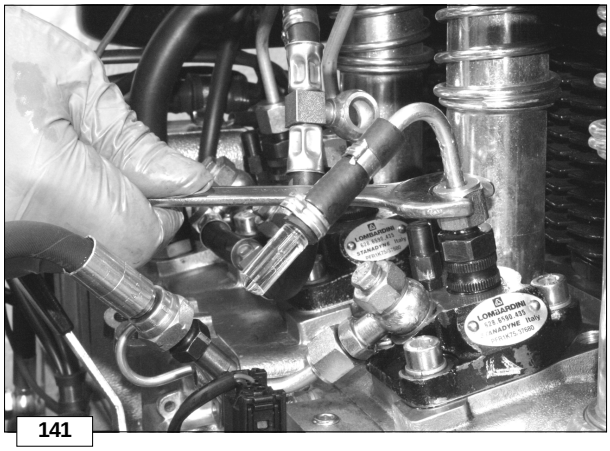
Assemble tool serial no. 1460 - 266 made up of lever **2** serial no. 1460 - 275, of a dial indicator **1** serial no. 1460 - 274 inserted in a dial indicator holder serial no. 1460 - 270.
The function of lever **2** is to reduce the effort required against the resistance of the spring when the valve lowers and comes into contact with the piston crown near the top dead centre.
The dial indicator tracer **1** rests against the upper spring bearing ring of the valve.
To sum up, as pressure is placed on lever **2** the valve goes into contact with the piston since the dial indicator **1** is applied to the valve, allowing to know precisely every movement of the piston from and towards the **TDC**, which is very important for the following operation.

139

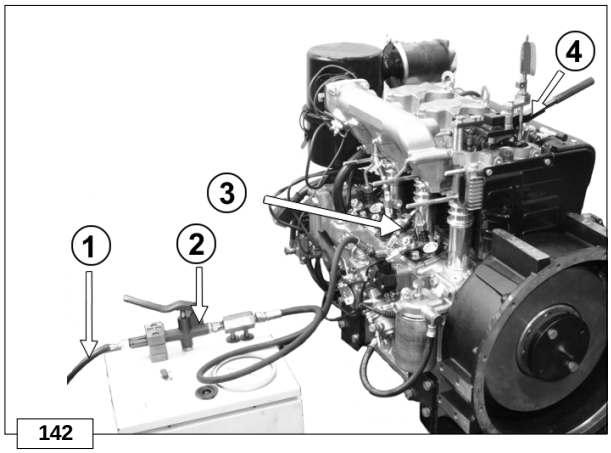
Unscrew the fuel supply union for the injection pump of the cylinder which is to be worked on.


140

To the injection pump connect the high-pressure pump serial no. 1460 - 273 supplied by a tank whose fuel level is at least 100 mm above the injection pump.


141

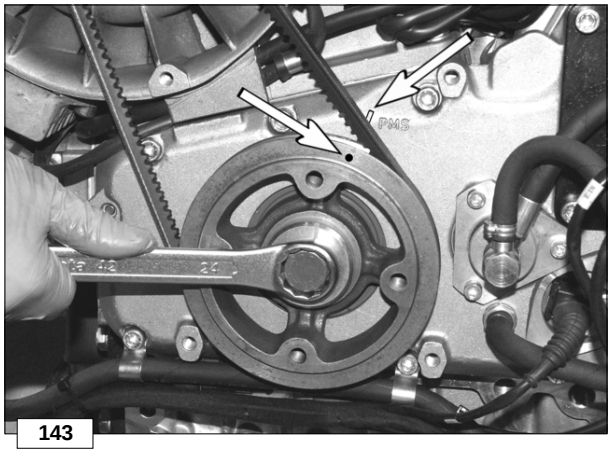
Insert the capillary tester serial no. 1460 - 024 onto the injection pump union where the high-pressure pipe is usually connected from the pump to the injector.



142

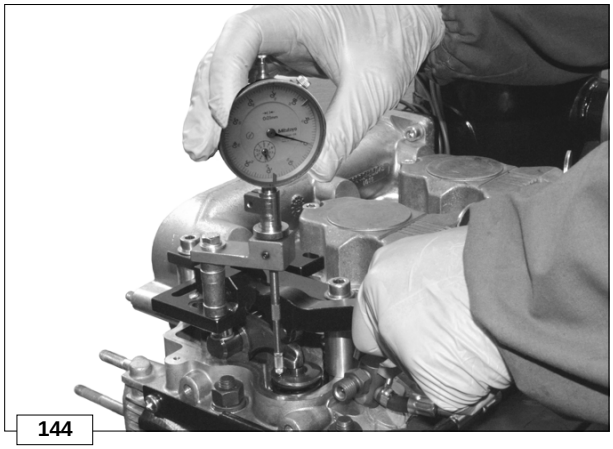
Components:

1 Fuel supply pipe from the tank
2 High-pressure pipe
3 Capillary tester
4 Valve-lowering lever with dial indicator showing piston movement

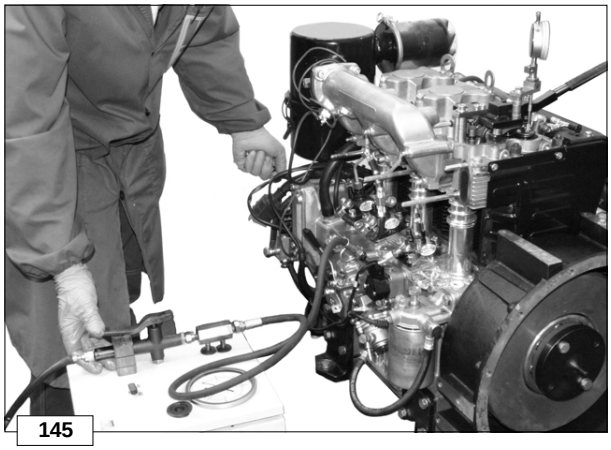


143

Rotate the crankshaft clockwise on the timing belt side and position the relevant cylinder piston at top dead centre.


144

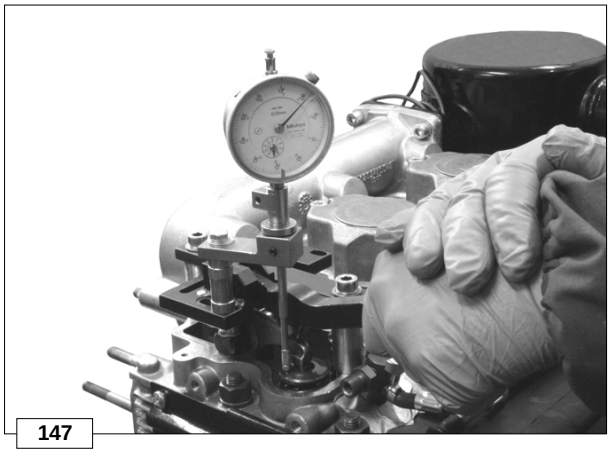
Press the lever to bring the valve into contact with the piston crown.
By joggling back and forth clockwise and anticlockwise, find the dead centre via the dial indicator and then reset to zero.


145

Rotate the crankshaft anticlockwise until diesel starts to flow out from the capillary when the high-pressure lever is pressed.
Change direction of rotation of the crankshaft to clockwise from the timing belt side.
Press the high-pressure lever and rotate the crankshaft until fuel stops flowing from the capillary.

146

The capillary tube shows when the fuel is flowing out, thanks to its small transparent slot.


147

After finding the delivery start point (when fuel stops flowing from the capillary), press the lever and use the dial indicator to check how many millimetres the piston has moved from the top dead centre.
Check static injection advance using the conversion table from millimetres to degrees.
If it is necessary to change static advance add the seals **G** in figure 129 (to delay) or remove the seals **G** in figure 129 (to advance) from between the injection pump surface and the crankcase surface.
The same operation must be performed for each cylinder.

Table static advance values for engines with P size injectors

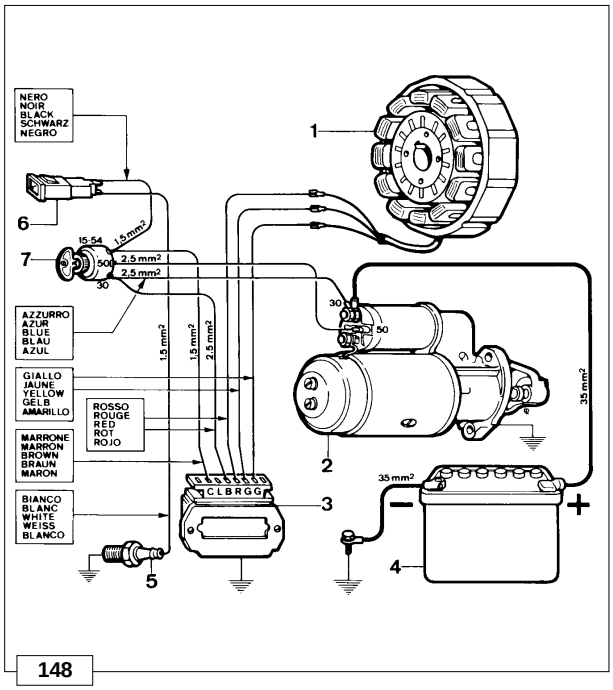
	R.p.m.	α	Piston lowering (mm)
97-68 CE	2400	9° ± 1°	8° –> 0,56 9° –> 0,71 10° –> 0,87
	2500÷2800	8° ± 1°	7° –> 0,43 8° –> 0,56 9° –> 0,71
	3000	9° ± 1°	8° –> 0,56 9° –> 0,71 10° –> 0,87
EPA	2400÷2800	5° ± 1°	4° –> 0,14 5° –> 0,22 6° –> 0,32

Table static advance values for engines with S size injectors

R.p.m.	α	Piston lowering (mm)
1500÷2200	14° ±1°	13° –> 1,47 14° –> 1,71 15° –> 1,96
2201÷3000	16° ±1°	15° –> 1,47 16° –> 1,71 17° –> 1,96

Conversion table from degrees into millimetres

α	mm
0°	0,00
1°	0,01
2°	0,04
3°	0,08
4°	0,14
5°	0,22
6°	0,32
7°	0,43
8°	0,56
9°	0,71
10°	0,87
11°	1,06
12°	1,26
13°	1,47
14°	1,71
15°	1,96
16°	2,22
17°	2,51
18°	2,81
19°	3,12
20°	3,45



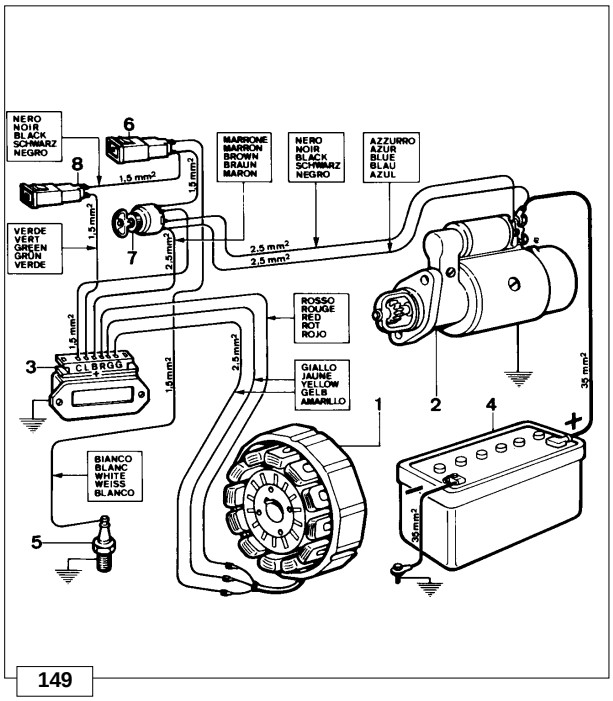
148

Standard electric equipment

Electric starting layout without battery charging light

Components:

1 Alternator
2 Starting motor
3 Voltage regulator
4 Battery
5 Pressure switch
6 Oil pressure warning light
7 Key switch



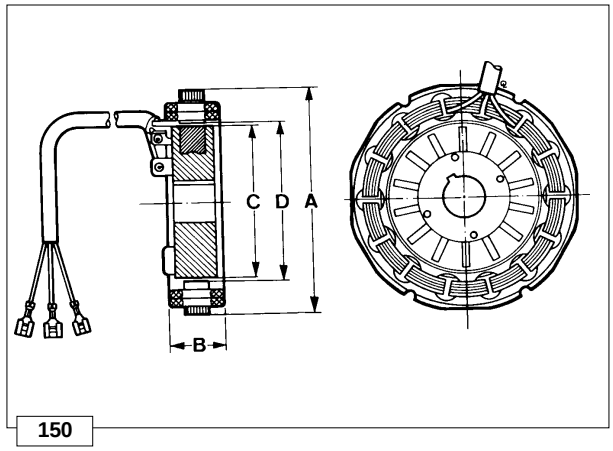
149

Electrical starting layout with battery charging light

Components:

1 Alternator
2 Starting motor
3 Voltage regulator
4 Battery
5 Pressure switch
6 Oil pressure warning light
7 Key switch
8 Battery charging light

Note: Battery, which is not supplied by Ruggerini, should feature a 12V voltage.
When choosing battery capacity please consider environmental conditions: 66 Ah are recommended down to -10°C and 88 Ah are recommended below -15°C; in any case do not use a battery with greater capacity than 110 Ah.



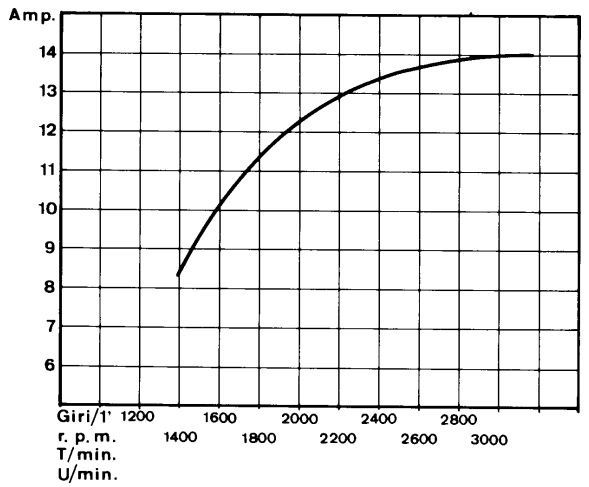
150

12,5 V, 14 A Alternator

Features a fixed armature winding, housed in the bell inside the blower stator. The rotating permanent magnet inductor is located in the fan spindle. See page 24.

Ref.	Dimensions (mm)
A	111,701 ÷ 111,788
B	31,000 ÷ 33,500
C	76,226 ÷ 76,300
D	77,400 ÷ 77,474

Note: Clearance between armature winding and inductor (air gap) should be 0,55 ÷ 0,63 mm.

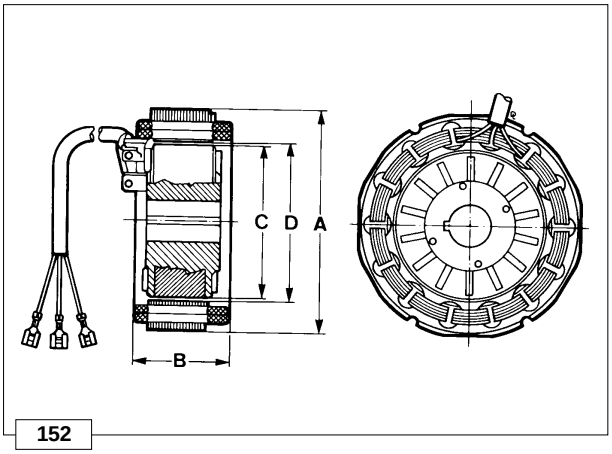


151

Alternator battery charger curve (12.5 V, 14A)

The curve was obtained at room temperature of + 25°C with 12.5V battery voltage.

Note: The r.p.m. shown in the table refers to the engine.



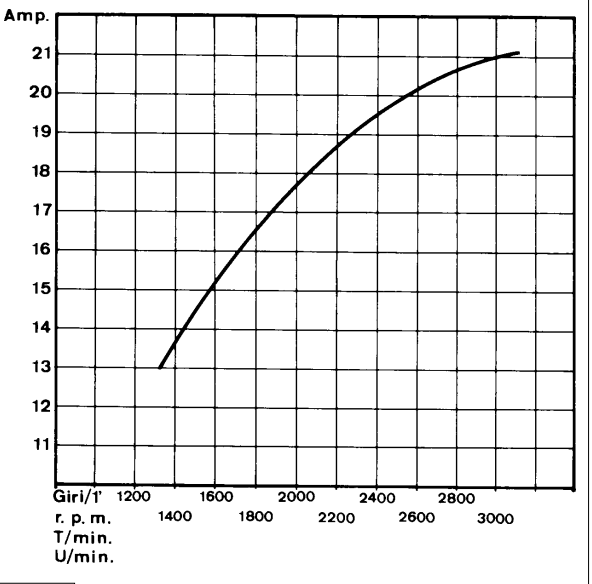
152

12 V, 21 A Alternator

Features a fixed armature winding housed in the bell inside the blower stator.The rotating permanent magnet inductor is located in the fan spindle. See page 24.

Ref.	Dimensions (mm)
A	111,701 ÷ 111,788
B	49,500 ÷ 52,000
C	76,226 ÷ 76,300
D	77,400 ÷ 77,474

Note: Clearance between armature winding and inductor (air gap) should be 0,47 ÷ 0,63 mm.

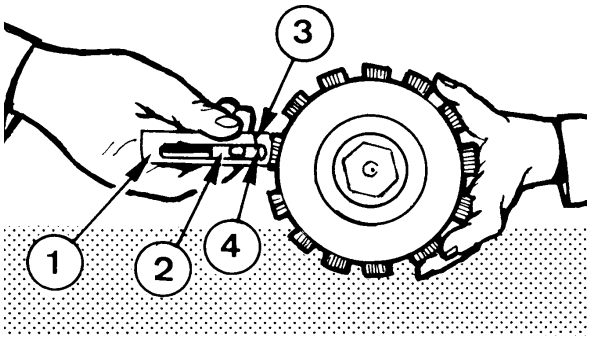


153

Alternator battery charger curve (12 V, 21 A)

The curve was obtained at room temperature of + 25°C with 12.5V battery voltage.

Note: The r.p.m. shown in the table refers to the engine.



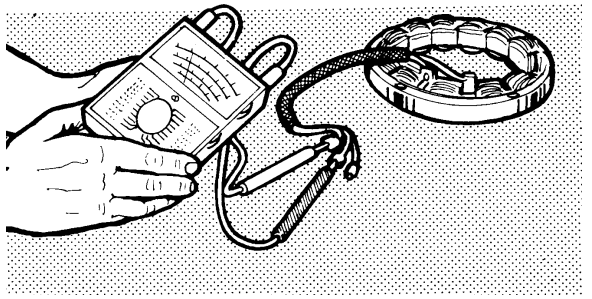
154

Magnetization checking tool (Part No. 7000-9727-001)

Components:

1 Casing
2 Slider
3 Casing reference line
4 Slider reference line

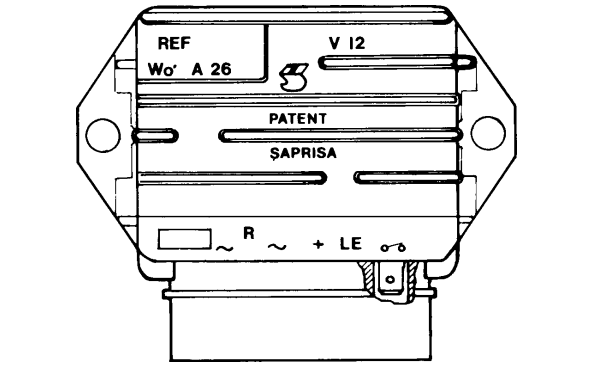
Rest the tool end horizontally onto the magnetic poles.
Hold sfider so that its reference line coincides with the casing reference line.
Release slider: if no attraction occurs the rotor is demagnetized; therefore replace alternator.



155

Checking for cable continuity

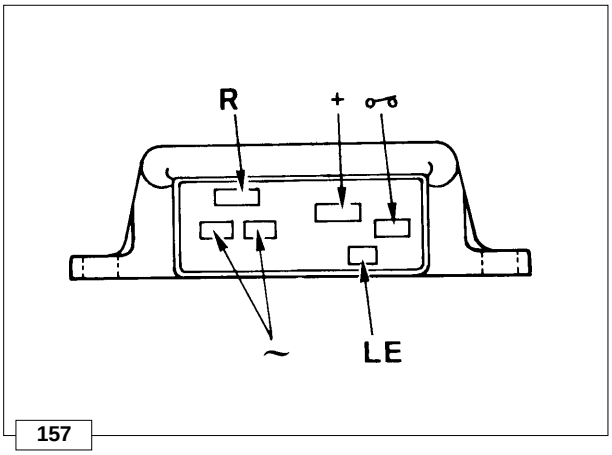
Check that stator windings have no unsoldered connections, burnt areas or grounded wires.
Using an ohmmeter check for continuity between the red cable and the two yellow ones.
Furthermore, check that they are insulated from the ground.



156

Voltage regulator

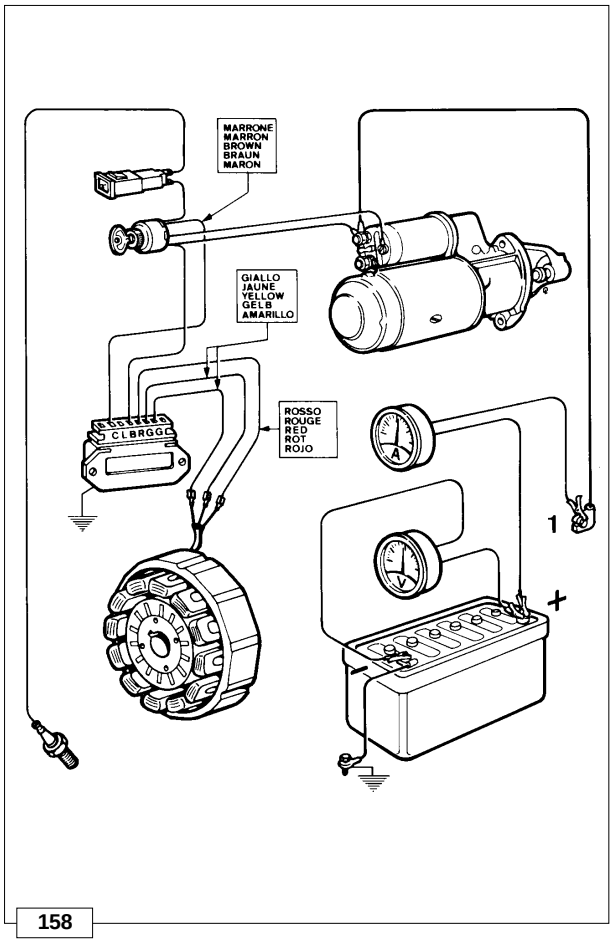
Supplied by SAPRISA : Voltage 12 V, max. current 26A.



157

To avoid wrong connections 3 different sizes are supplied.

Ref.	Connection size (mm)	
	Width	Thickness
~	6.25	0.8
R	9.50	1.12
+	9.50	1.12
LE	4.75	0.5
O O	6.25	0.8



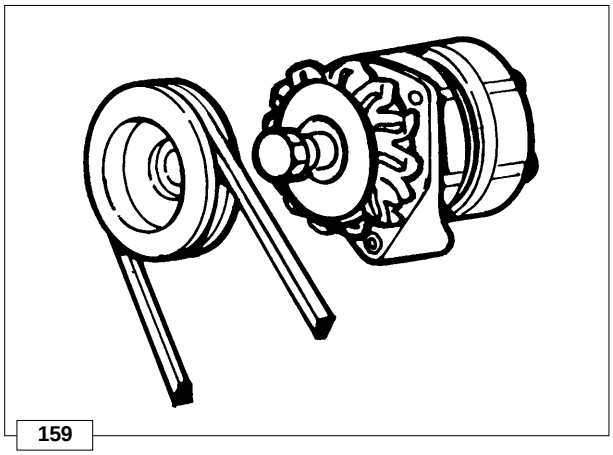
158

How to check voltage regulator for proper operation

Check that connections correspond to the layout.
Disconnect the terminal from the battery positive poie.
Connect a d.c. voltmeter between the two battery poles.
Fit an ammeter between the positive pole and the corresponding cable **1** terminal.
The ammeter should be suitabie for reading the required value (14 or 21 A) and for withstanding the starting motor peak absorption (400 ÷ 450 A).
Start a couple of times until battery voltage drops below 13 V.
When battery voltage reaches 14,5 V the ammeter current suddeniy drops down to almost zero.
Replace regulator if recharge current is zero with voltage below 14 V.

Important

When the engine is running do not disconnect battery cables or remove the key from the control panel.
Keep regulator away from heat sources since temperatures above 75°C mmght damage it.
No electric welding on engíne or application.

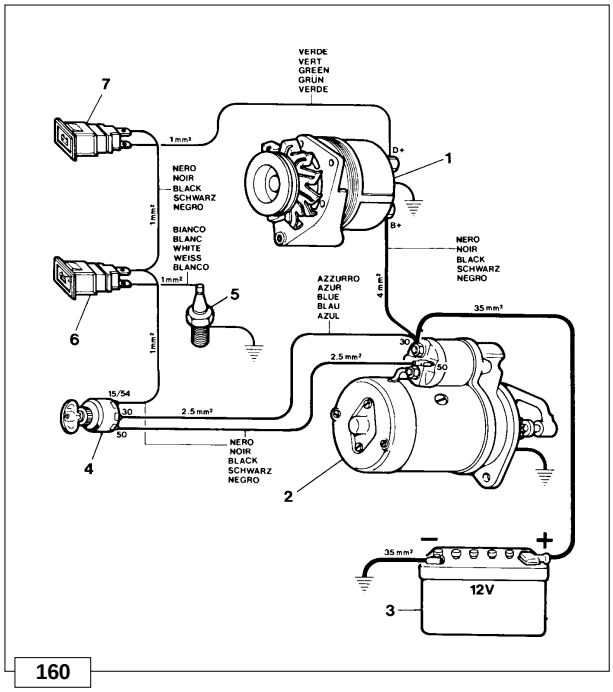


159

Alternator type Bosch G1 14 V, 33 A

The alternator is ot the claw-pole rotor type with built-in voltage reguiator.
The rotating motion is conveyed by the engine through a 'V' belt and sheave.

Features: 12V rated voltage. Max. current 33A at 7000 alternator r.p.m.
RH direction of rotation.

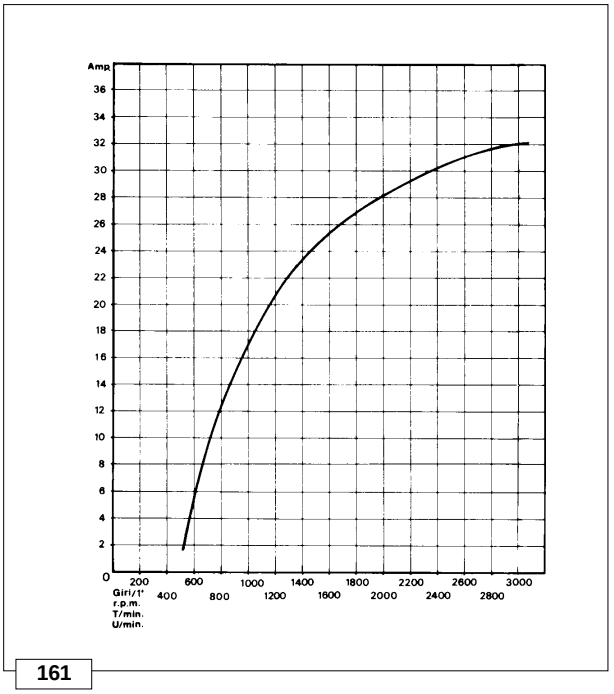


160

Alternator type Bosch Gil 14 V, 33 A layout

Components:

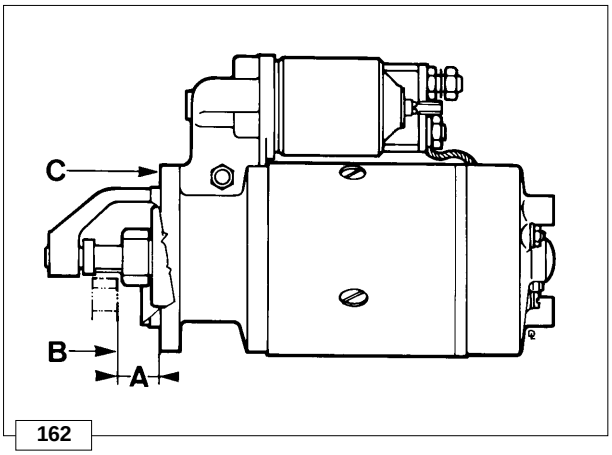
1 Alternator
2 Starting motor
3 Battery
4 Key switch
5 Pressure switch
6 Oil pressure warning light
7 Battery charging light



161

14 V, 33 A Bosch G1 alternator battery charger curve

The curve was obtained at room temperature of +25°C.
Battery terminal voltage is 12.5 V.
The r.p.m. shown on the table refers to the engine.



162

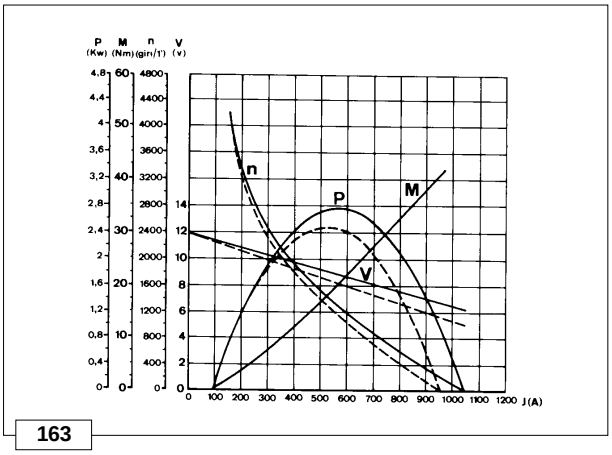
Starting motor type Bosch JF (R) 12 V, class 2.5

RH direction of rotation

A = 23 ÷ 24 mm
B = Ring gear plane
C = Flange plane

Vorsicht - Warnung
The flywheel should not project from ring gear plane B.

Note: Apply to Bosch Service Centers for any type of repair.

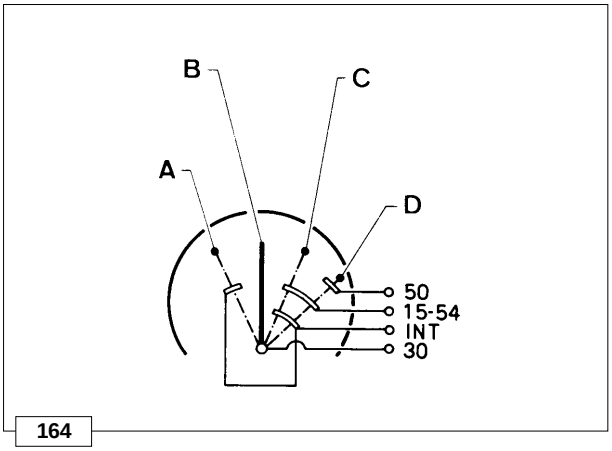


163

Characteristic curves for starting motor type Bosch JF (R) 12 V

Curves were obtained at room temperature of + 20°C with 88 Ah bat-
teries.

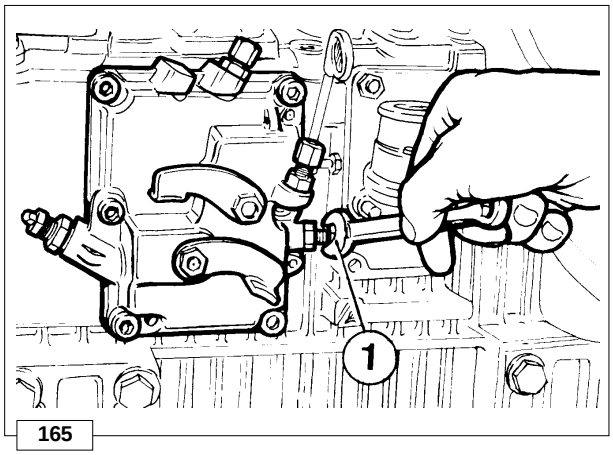
V = Motor terminal voltage in Volt
P = Power in kW
C = Torque in N/m
N = Motor speed in r.p.m.
J (A) = Absorbed current in Ampere



164

Starting motor layout

A = Parking lights
B = Stop
C = Run
D = Start

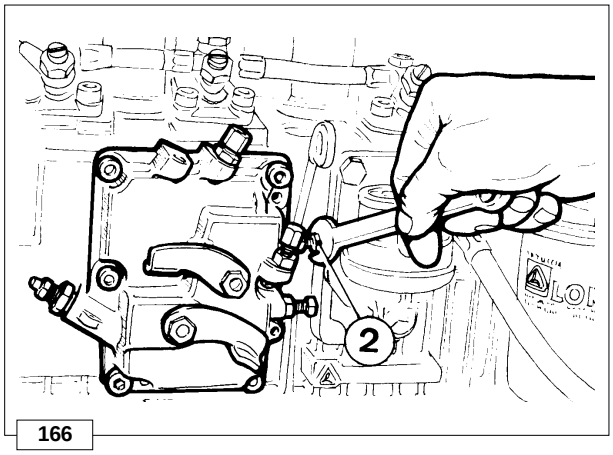


165

Settings

1 - Idling speed setting in no-load conditions (standard)

After filling with oil and fuel, start the engine and let it warm up for 10 minutes. Adjust idling speed at 800 ÷ 900 r.p.m. by turning setscrew **1**; then tighten lock nut.

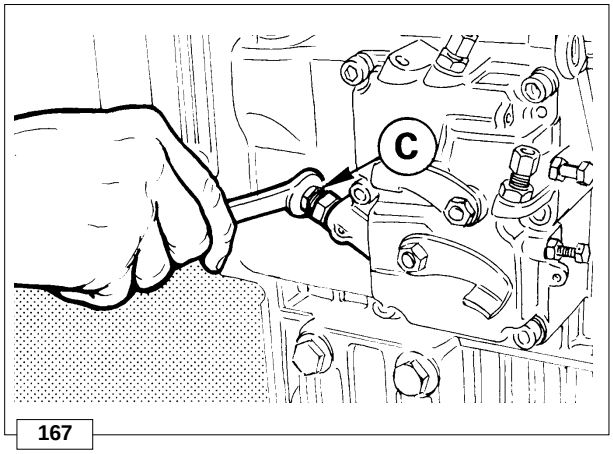


166

2 - Full speed setting in no-load conditions (standard)

After setting idle speed turn screw **2** and set full speed in no-load conditions at 3200 r.p.m.; then tighten lock nut.

Note: When the engine reaches the pre-set power full speed stabilizes at 3000 r.p.m.

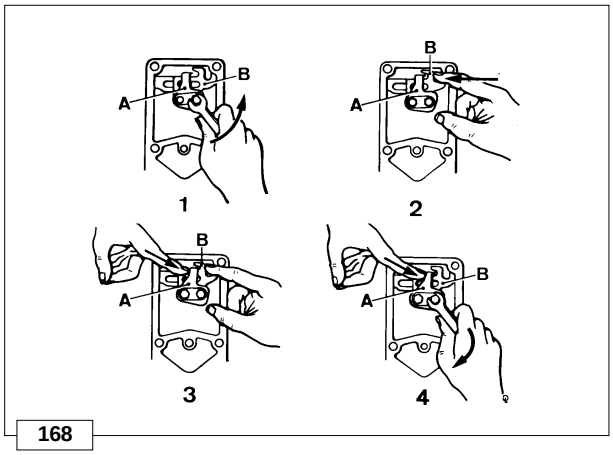


167

Injection pump delivery setting

This setting should be performed at the torque dynamometer.
If not, setting is only approximate.
The following steps are required:
Loosen delivery limiting device **C** by 5 turns.
Bring engine to full speed in no-load conditions i.e. 3200 r.p.m..
Tighten limiting device until the engine shows a drop in r.p.m..
Unscrew limiting device **C** by 1½ turn. Tighten lock nut.

Note: If the engine, under full load, generates too much smoke tighten **C**; if no smoke is observed at the exhaust and the engine cannot reach its full power unscrew **C**.



168

Stop setting

Remove fuel feeding pump and cover.

1) Loosen both bolts fixing plate **A**.
2) Push injection pump **B** control rod to the right and keep it in this position.
3) Push plate **A** to the right until it touches rod **B** and stop.
4) Release rod **B** and push plate **A** to the right so that rod **B** has a stroke of 1 mm.
Tighten both bolts.

Note: Under these conditions no damage can be caused to the injection pump rack rod stops by sudden impacts due to the available control solenoids.

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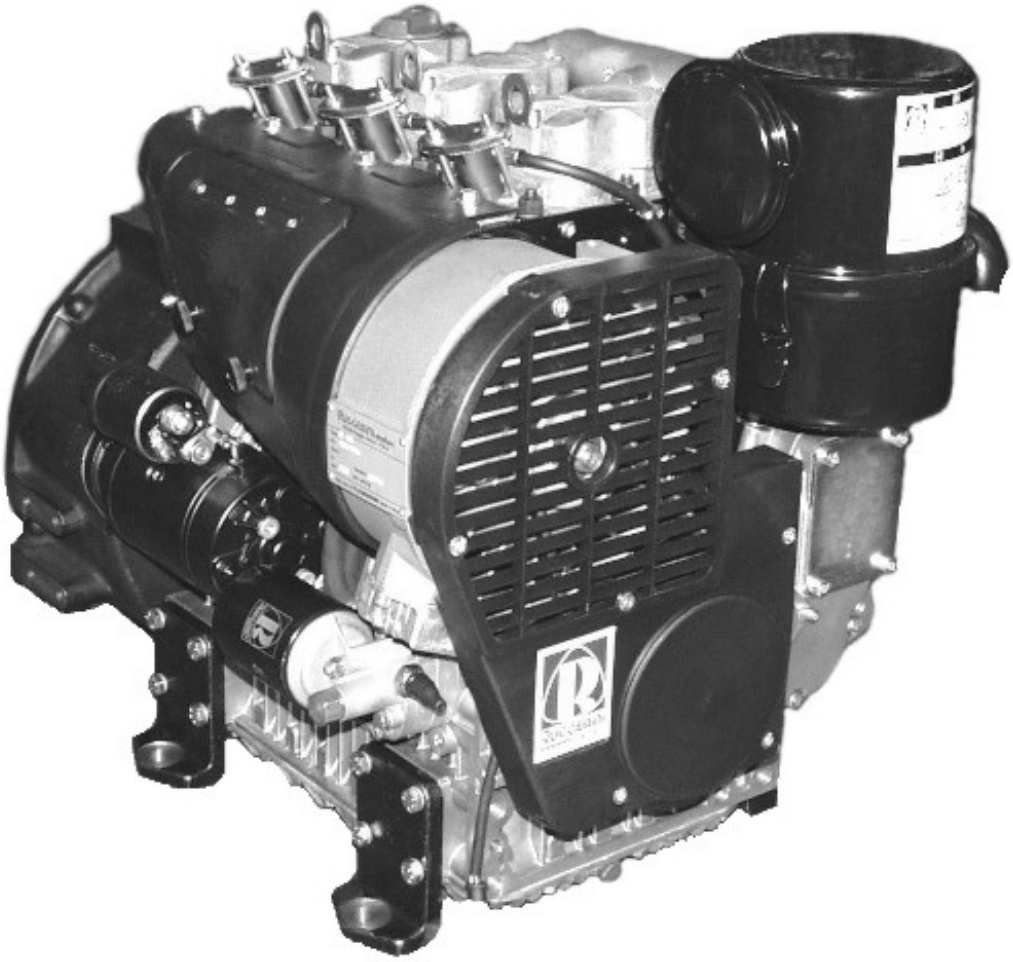
SP 420

ENGINE

with advance variator



INJECTION TIMING DEVICE OPERATION

In order to meet EPA tier 2 limits, the engine SP 420 has been equipped with a variable injection timing device.
The system consists of an electro–hydraulic actuated mechanical device, that allows changing the injection timing by rotating the camshaft against its driving gear.
The change takes place using the oil whose pressure is regulated by a pair of electric valves, which allow a rotation between 0 and 4.5°. The maximum variation of the injection timing is 4.5° (camshaft degrees).
Oil is taken from the engine oil circuit and its pressure acts on a sort of hydraulic piston that moves from one side to the other. The hydraulic plunger is attached on the inside by means of a straight groove and on the outside via a spiral-shaped groove. Thus movement from left to right (or vice versa) causes rotation from the driving gear and the camshaft.
In other words, the plunger translates and, at the same time, rotates and thus varying the angular position of camshaft that is connected to it.
The gear timing variation is managed by an ECU which receives electric signals from two speed sensors, the temperature sensor and the load sensor, which reads the position of the injection pump control.
The ECU memory contains the maps of the injection timing variation strategies.

Fig. A_1. Injection timing device: in "Resting position"

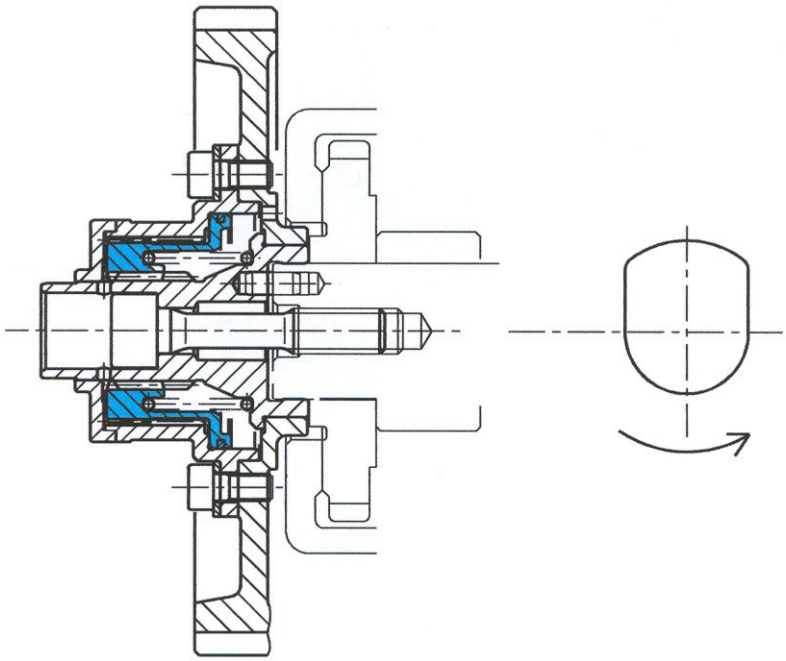


Fig. A_2. Injection timing device: during actuation of an advance (max value 4.5°).
The oil (yellow) goes into the system and moves the plunger (blue) that activates the camshaft anticlockwise.

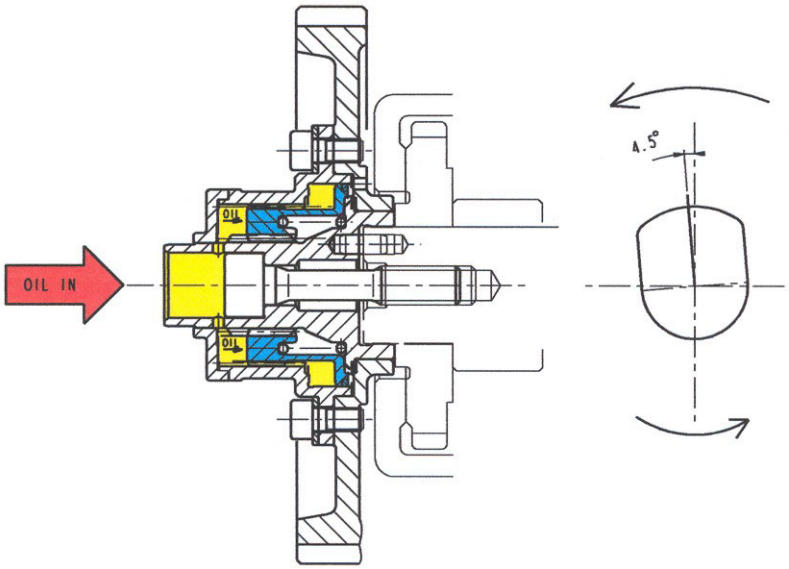
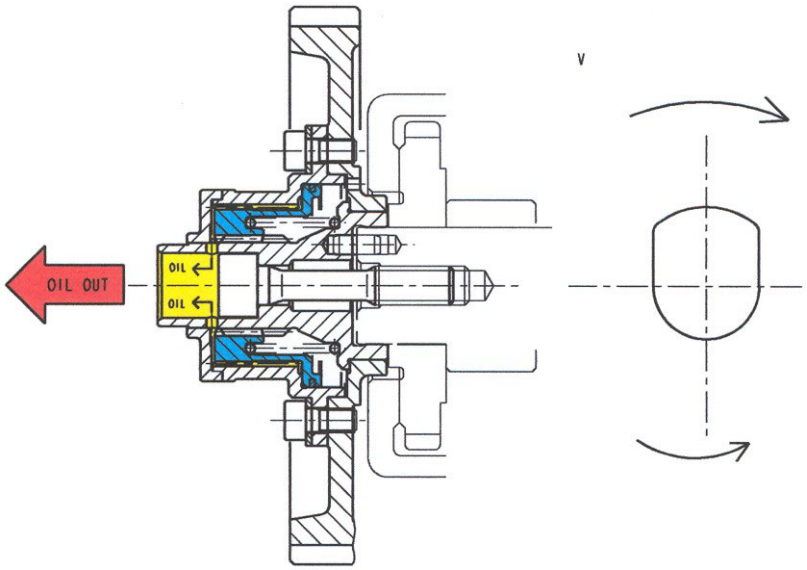
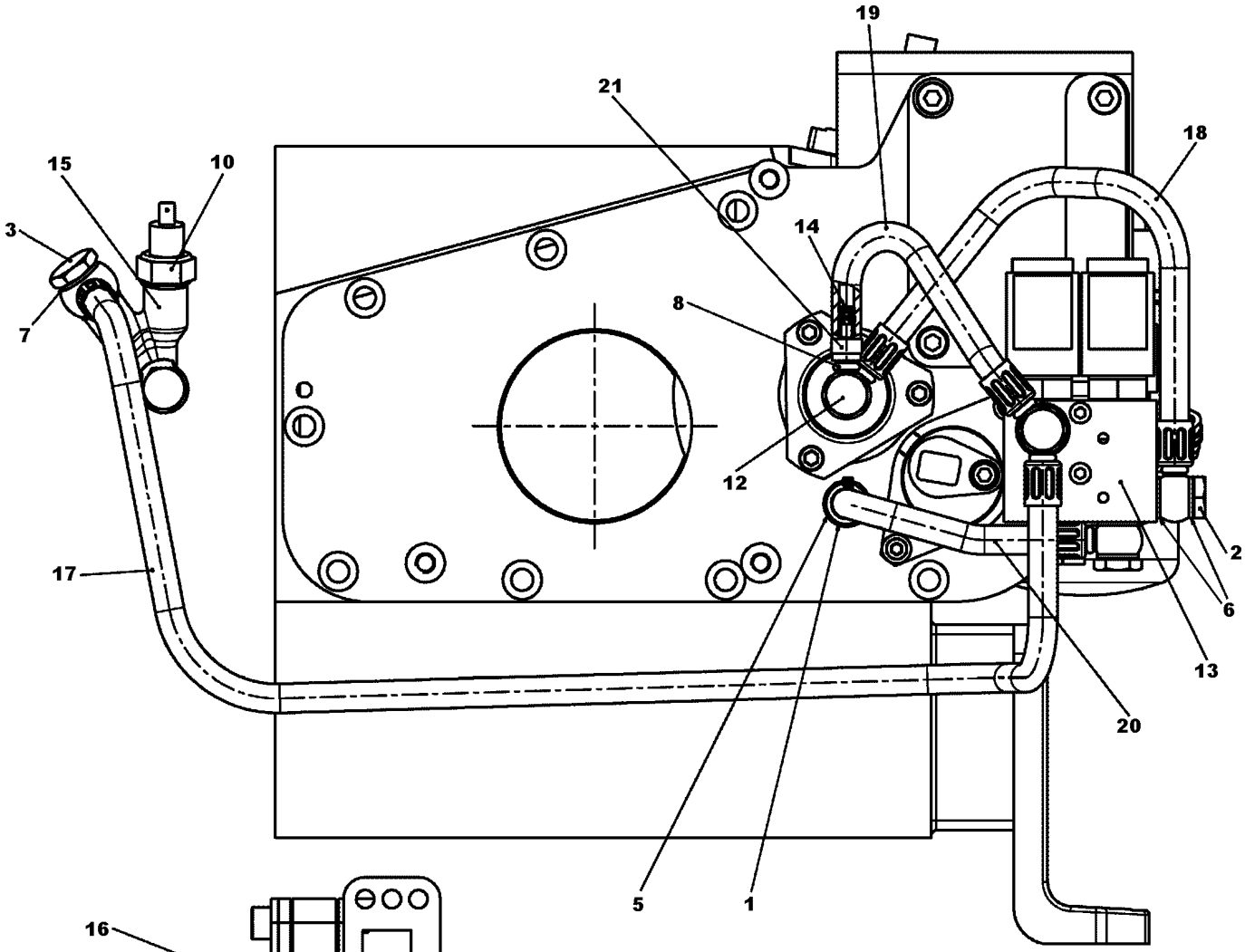


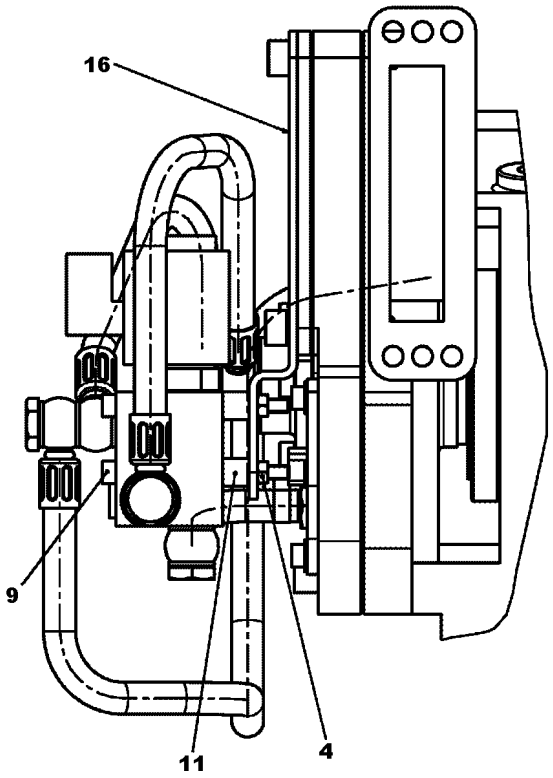
Fig. A_3. Injection timing device: moving from actuation of an advance to resting position.
The oil (yellow) goes out and releases the spring to move the plunger (blue), which in turn activates the camshaft clockwise.



Our system is able to actuate any intermediate advance, regulating the oil pressure. When the set level is reached, the oil exerts the right force to compress the spring at the right height to move the plunger appropriately, thus achieving the required rotation (angular advance).

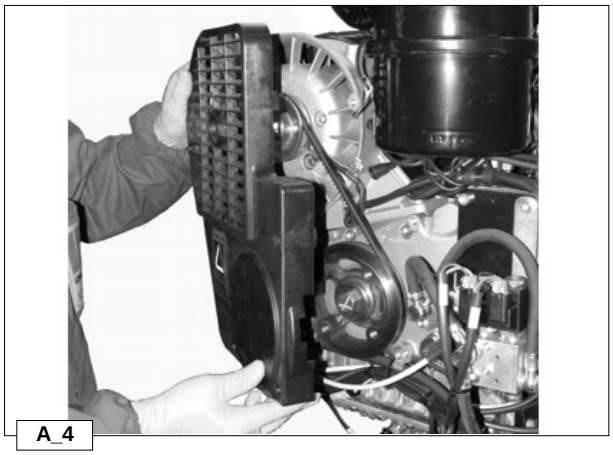
Solenoid valve assembly diagram



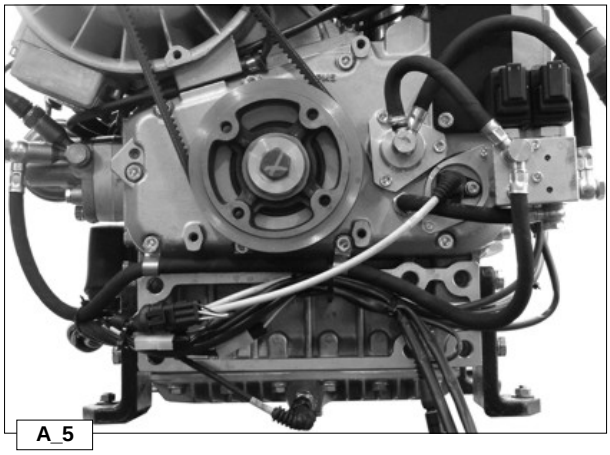


COMPONENTS TABLE

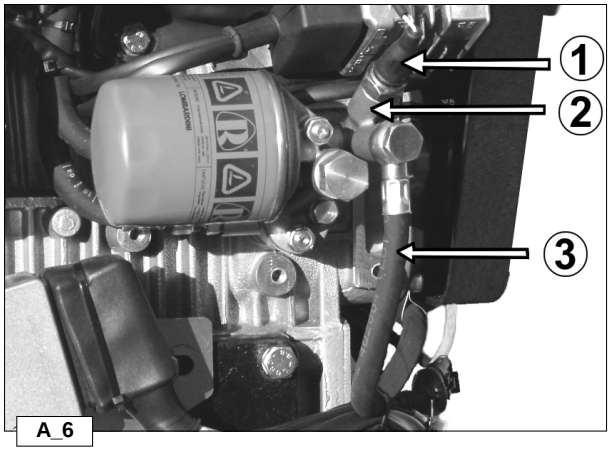
1	Cylindrical 1/4" gas union
2	Union bolt M 12x1.5
3	Connection screw M 14x1.5
4	Nut M 5
5	Copper seal 13.5x19x2
6	Seal
7	Seal 14x19x1.5
8	Adjustable union d. 12
9	Screw TCEI M 5x65
10	Pressure switch
11	Spacer
12	Bolt for two adjustable unions M 12x1.5
13	OilSistem solenoid valve block
14	Variator lubrication jet
15	Pressure switch union
16	Solenoid valve block support
17	Solenoid valve block oil filter pipe
18	Variator oil loading pipe
19	Variator oil bypass pipe
20	Variator oil draining pipe
21	"OTECO clic 66" clamp


A_4

After loosening the screws, remove the alternator belt guard.


A_5

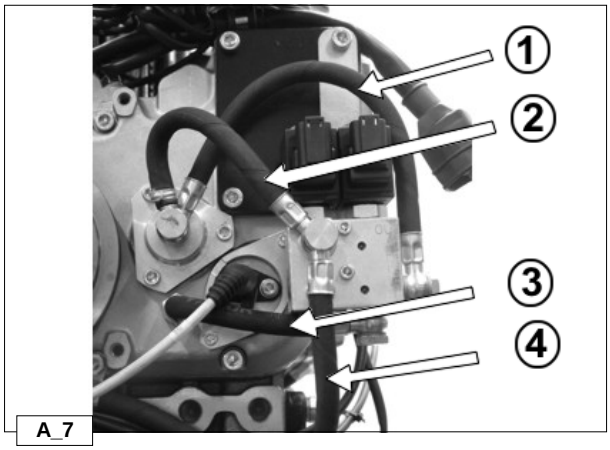
Overall view of variator speed sensor and hydraulic circuit.



A_6

Components:

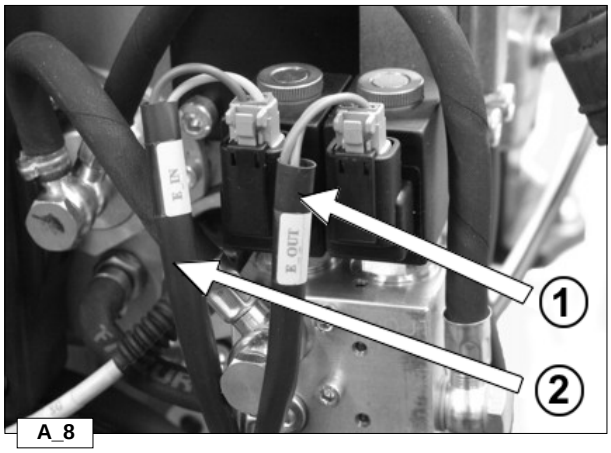
1 Pressure switch
2 Pressure switch union
3 Solenoid valve block oil filter pipe



A_7

Components:

1 Variator oil loading pipe
2 Variator oil bypass pipe
3 Variator oil draining pipe
4 Solenoid valve block oil filter pipe



A_8

Components:

1 Variator load solenoid valve
2 Variator unload solenoid valve

Important
Do not invert cables during reassembly.

A_9

To remove connectors, press the stop tabs and draw upwards.

A_10

➲ Refer to page 78 to identify the pipes.

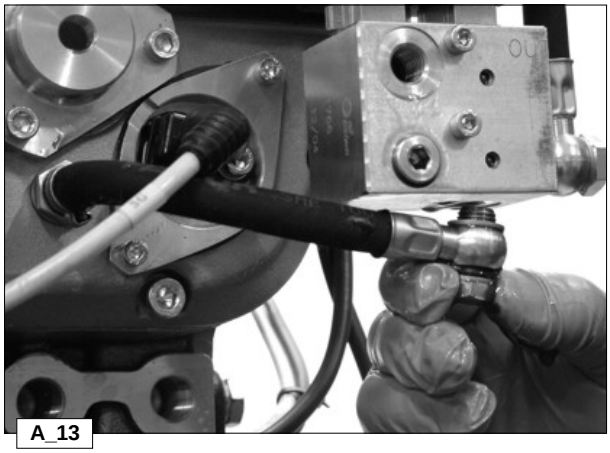
Loosen the union screw of pipes **17** and **19**.

A_11

On the opposite end of the block of pipe **19** is the variator lubrication jet attached to the pipe by a click clamp.

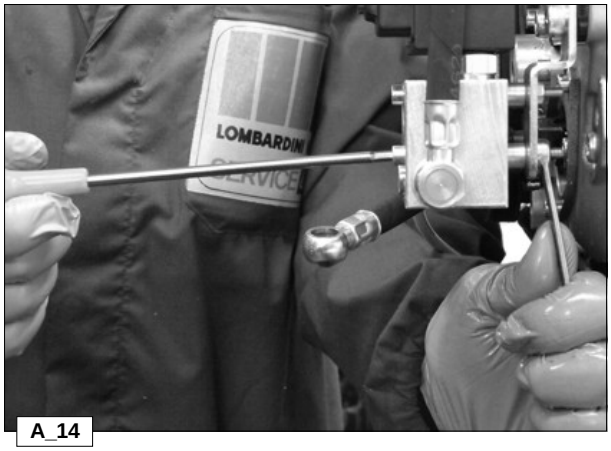
A_12

Variator lubrication jet complete with banjo union.



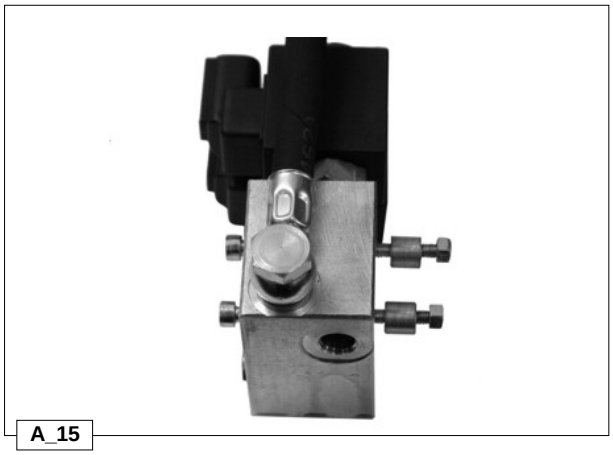
A_13

Unscrew the union of variator oil discharge pipe **20**.



A_14

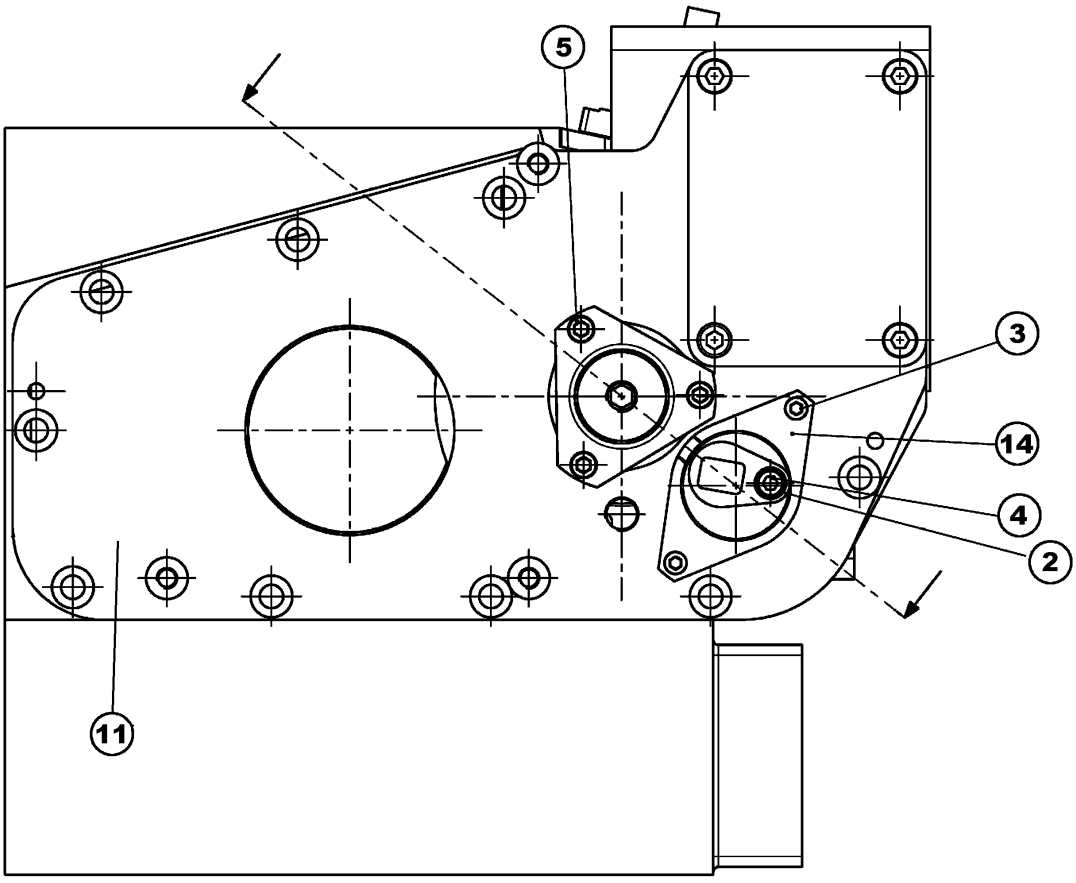
To remove the solenoid valve block from the support bracket, unscrew the two screws M 5.

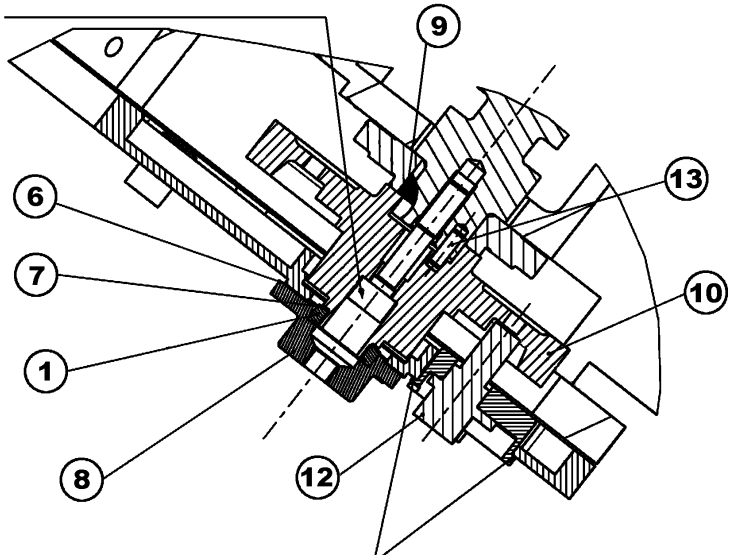


A_15

View of the unassembled solenoid valve block with two spacers between the block and the bracket.

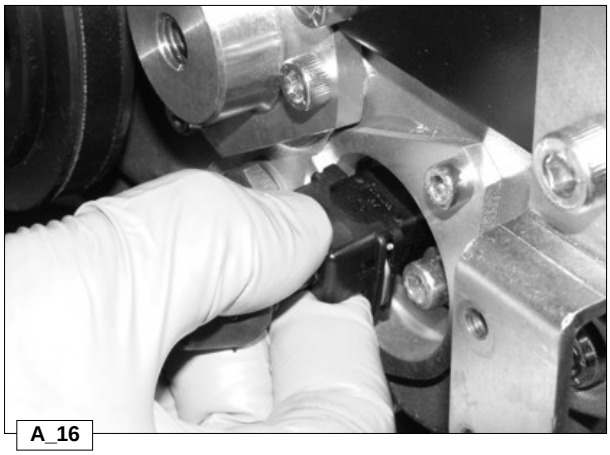
Speed sensor and variator assembly diagram





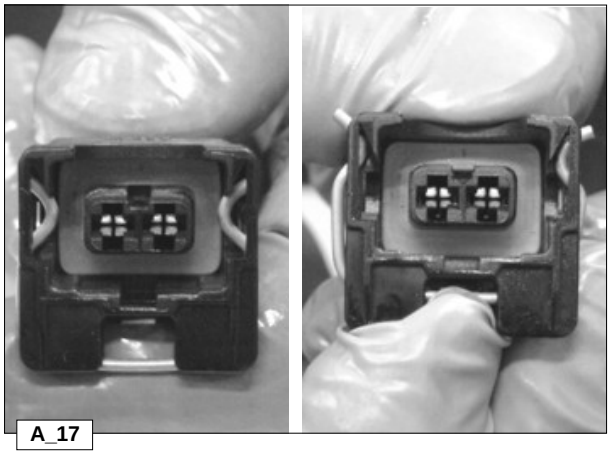
COMPONENTS TABLE

1	Oil seal ring 20x30x7
2	Washer 6x12xSp1
3	Screw TCEI M 5x10
4	Screw TCEI UNI 5931 M 6x10
5	Screw TCEI UNI 5931 M 6x14
6	Lid seal (rev. counter)
7	Oil seal support ring
8	Variator oil bush
9	Special tab for variator
10	Advance variator device
11	Timing cover side cover for variator
12	Speed and phase sensors
13	Cylindrical pin 5x16
14	Speed sensor support

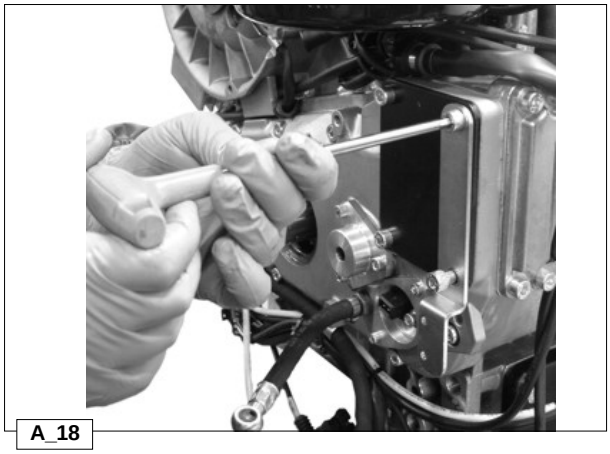


A_16

To remove the speed sensor cable connector press the spring as shown in figures **A_16** and **A_17** and draw upwards.

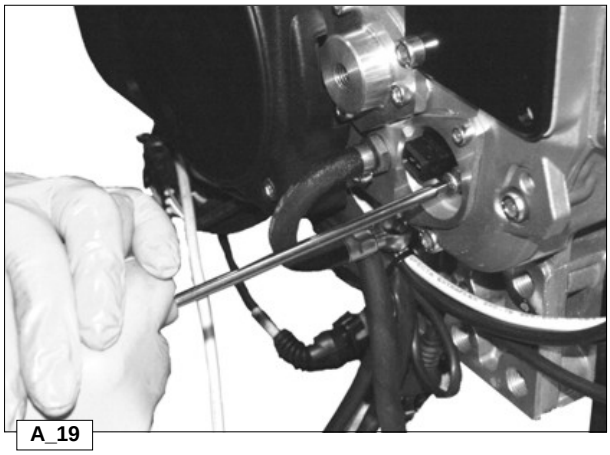


A_17



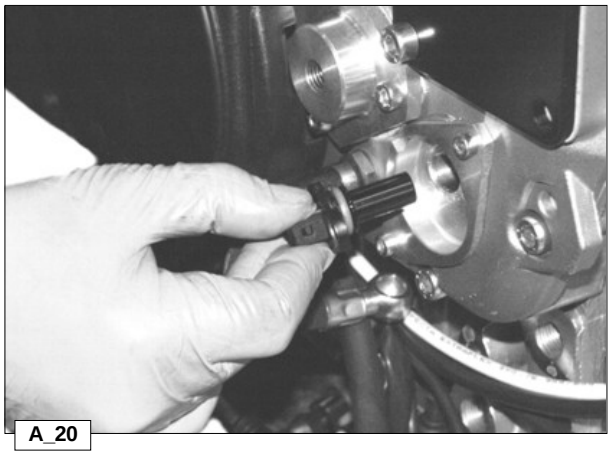
A_18

Loosen the two screws M8 to disassemble the solenoid valve support bracket.



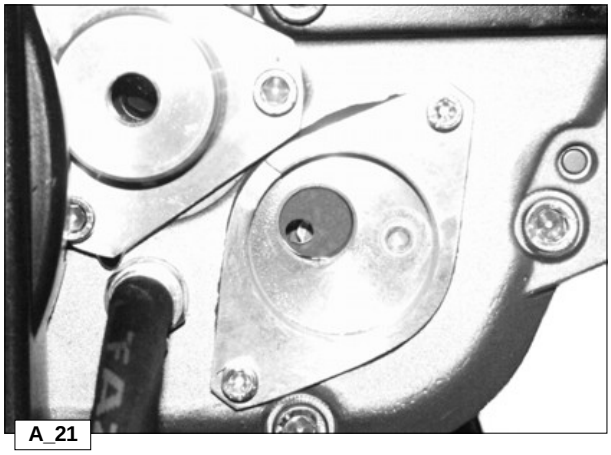
A_19

Loosen screw M6 to remove the speed sensor from its support.



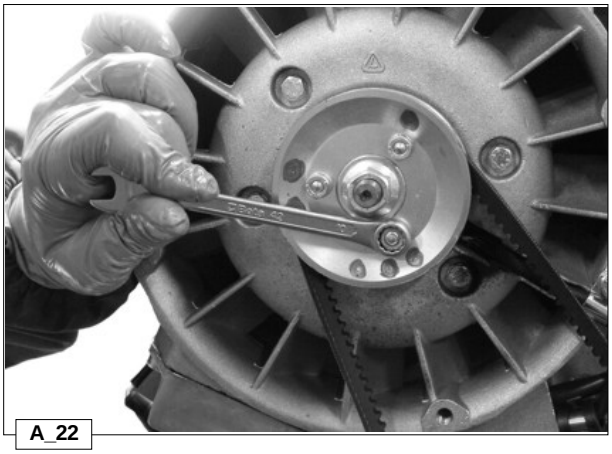
A_20

Draw he speed sensor outwards, being careful not to damage the rubber seal ring.



A_21

View of speed sensor housing.

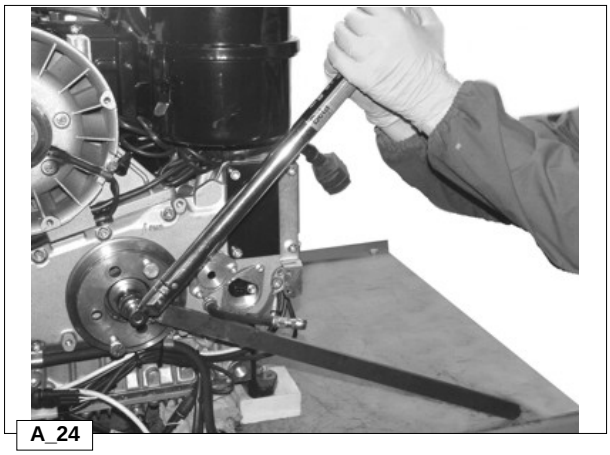


A_22

Blower belt alternator - Disassembly

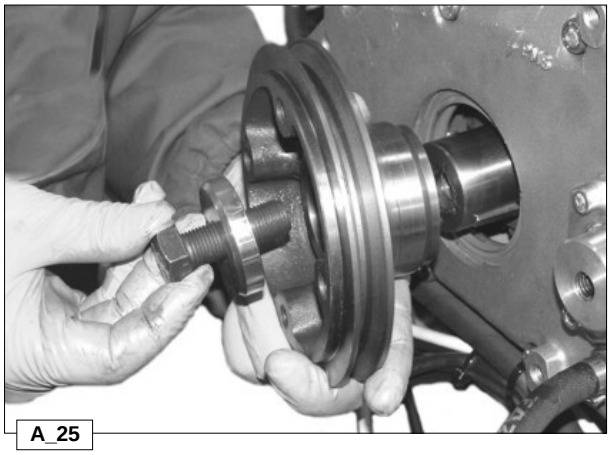
➲ See page 22 - 23.

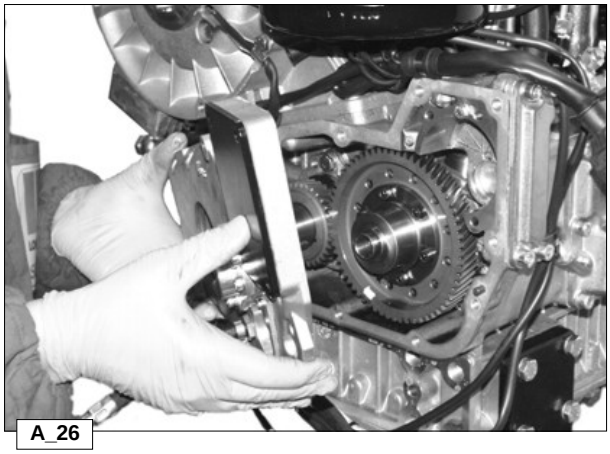
A_23


A_24

Blower control pulley - Disassembly

➲ See page 24 - 25.

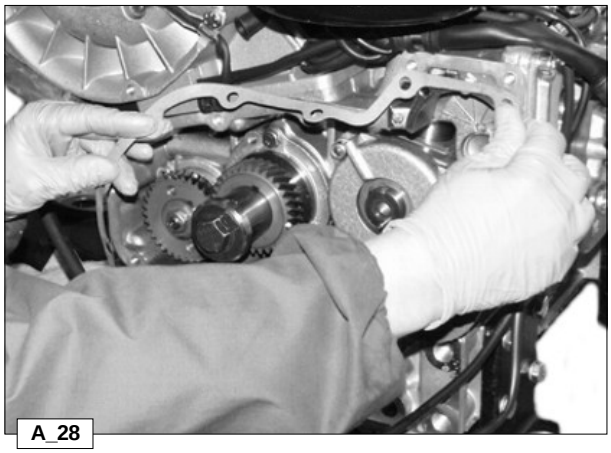

A_25


A_26

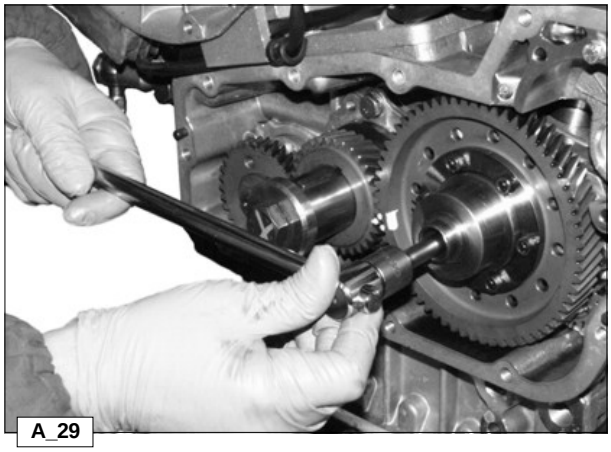
After loosening the screws, remove the timing cover.

A_27

Pay attention to the oil seal support ring when disassembling the timing cover.


A_28

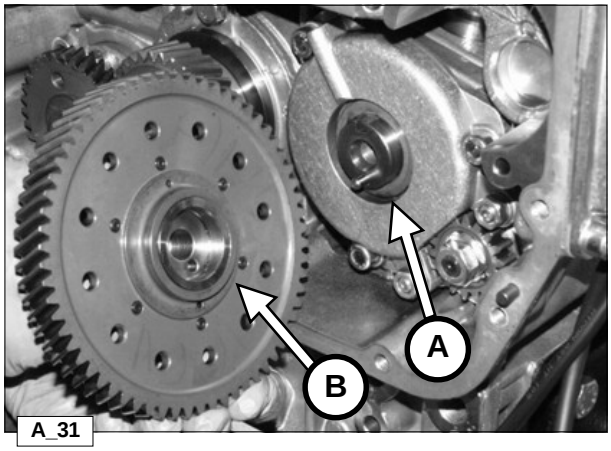
Remove the timing cover seal.


A_29

Unscrew screws M10 on the variator to the camshaft.

A_30

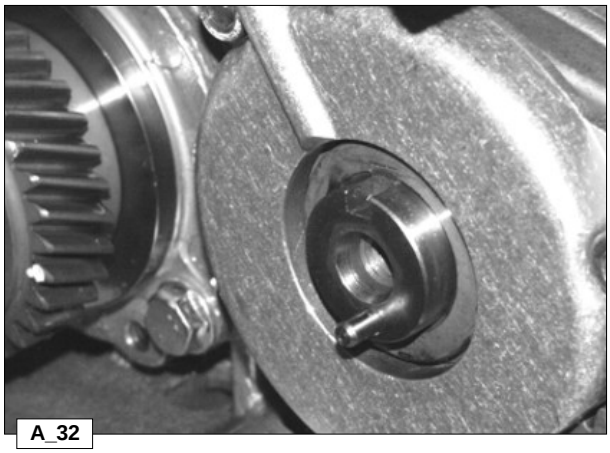
Remove screw M10.



A_31

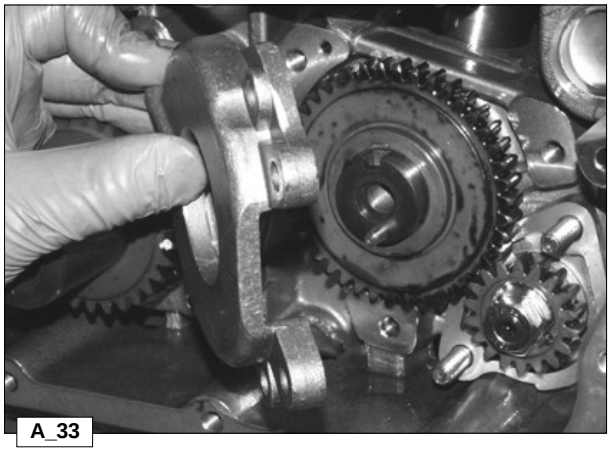
Remove the variator.
The figure shows the camshaft pin for correct variator timing.

A Cylindrical pin Ø 5x16
B Pin housing



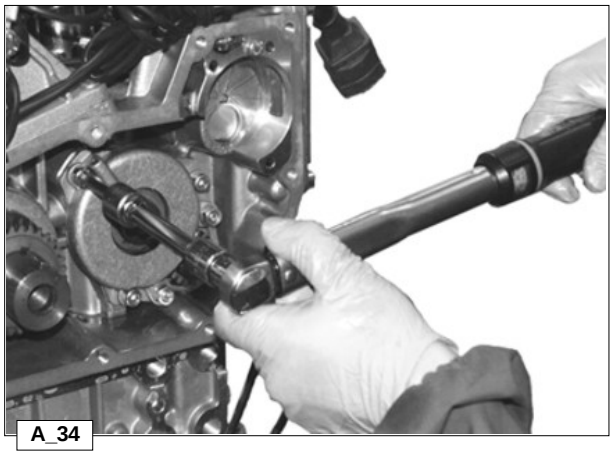
A_32

View of the camshaft ends with pin inserted.



A_33

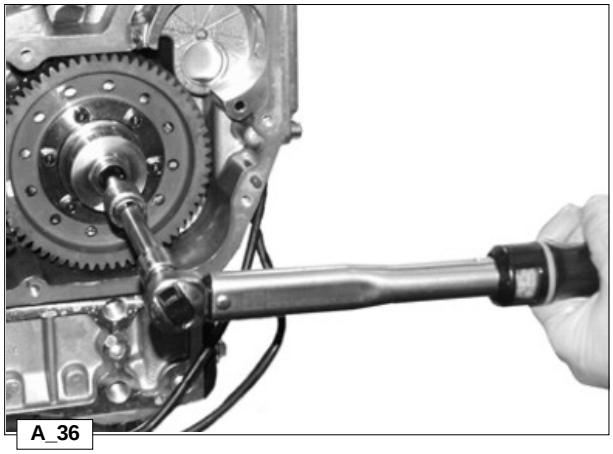
Remove the shoulder housing of the idle gear that drives the speed governor.


A_34

❍ After refitting the housing tighten the screws to 20 Nm using a torque wrench.

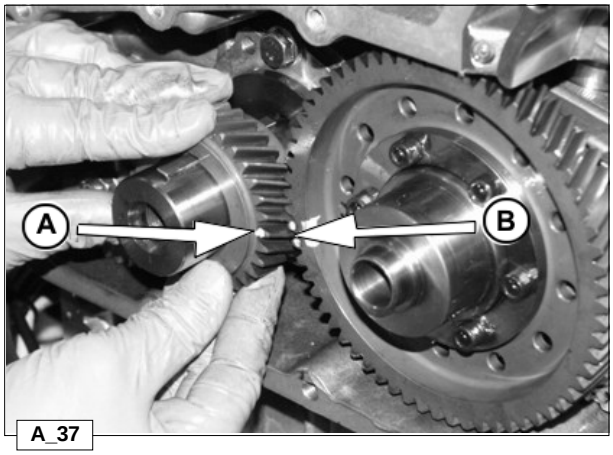
A_35

Remove the distribution control gear from the crankshaft.


A_36

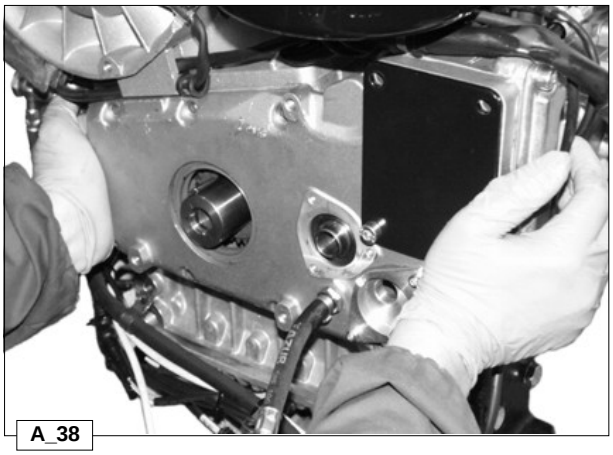
Assemble the variator onto the end of the camshaft taking care to properly insert the timing pin into place and ensuring that the variator comes into contact with the surface of the speed governor idle gear.

❍ Tighten screw M10 to 65 Nm using a torque wrench.

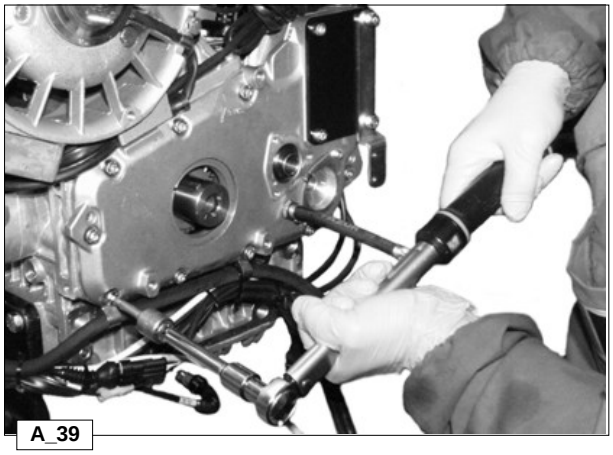


A_37

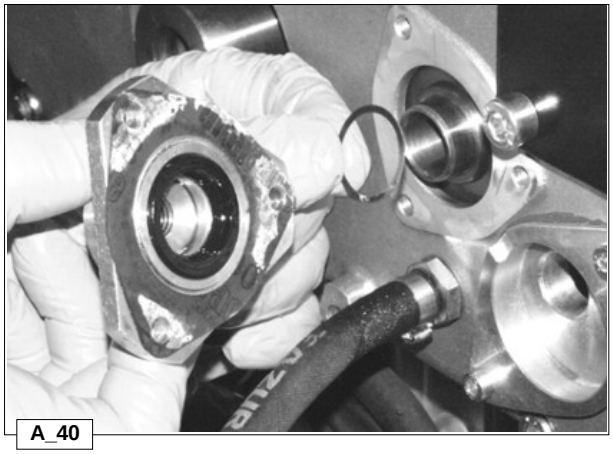
Assemble the timing control gear onto the crankshaft so that reference mark **A** is lined up with the two reference marks **B** on the idle gear installed on the camshaft.


A_38

Replace the timing cover, placing a new seal and lining up with the two centring pins.

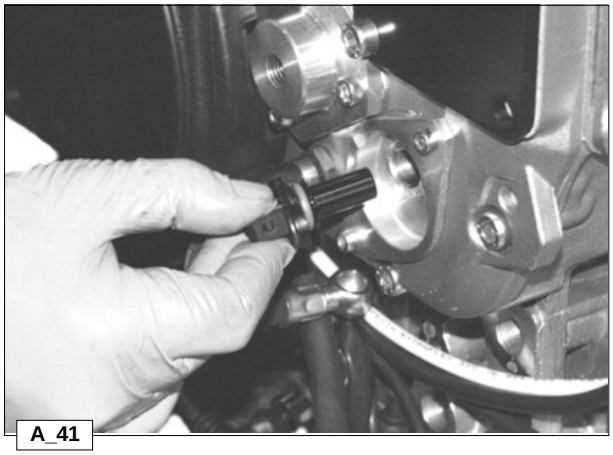

A_39

❍ Tighten the screws to a 25 Nm torque.

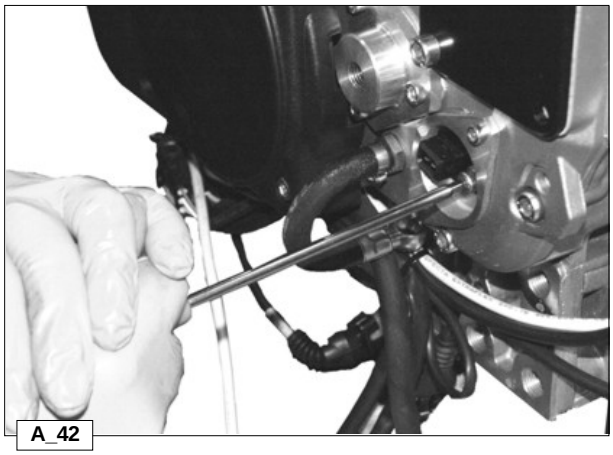

A_40

Refit the oil feed bushing to the variator, placing the oil seal support ring in between.
Replace the seal.

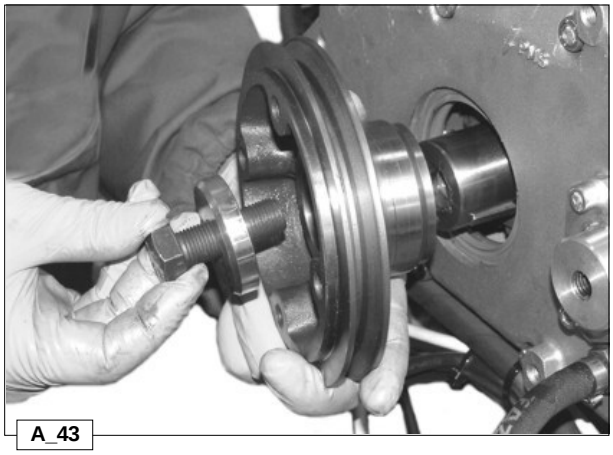
❍ Tighten the three screws M6 to an 8 Nm torque.


A_41

Replace the speed sensor taking care not to damage the O-ring.

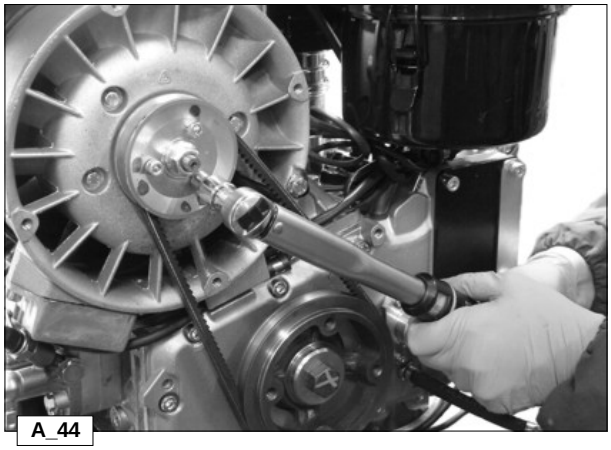

A_42

❍ Attach the sensor using screw M6 to a torque of 8 Nm.

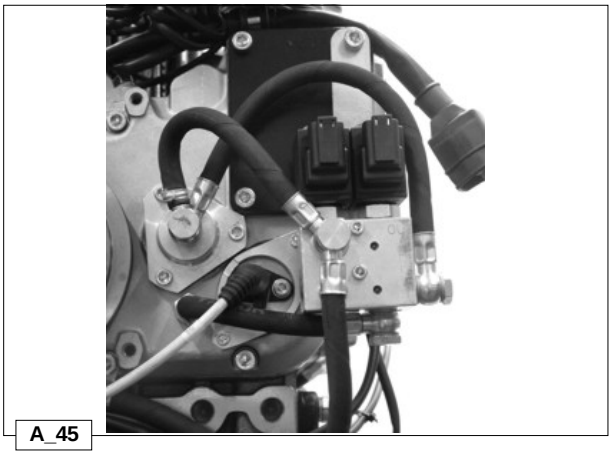

A_43

Reassemble the blower control pulley onto the crankshaft.

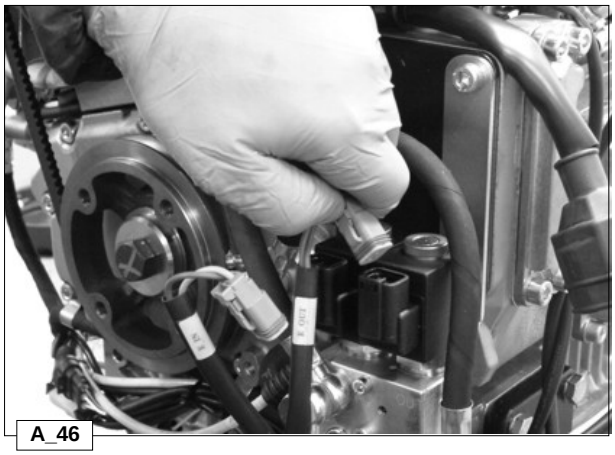
❍ Tighten the left-handed fastening bolts to torque of 300 Nm.


A_44

➲ Replace and check the belt tension (see page 22-23).

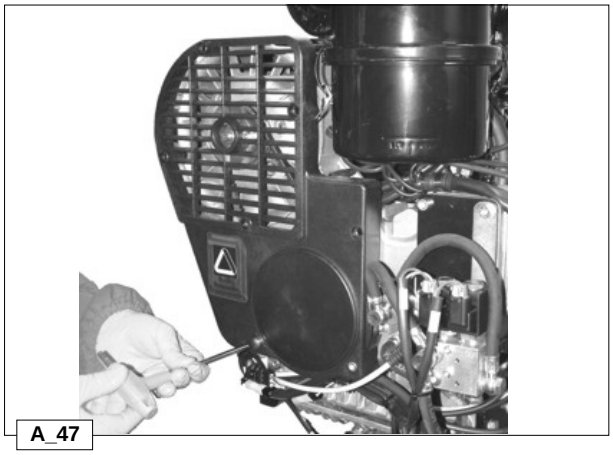

A_45

Replace the variator circuit oil pipes. If in doubt consult the diagram on page 78.



A_46

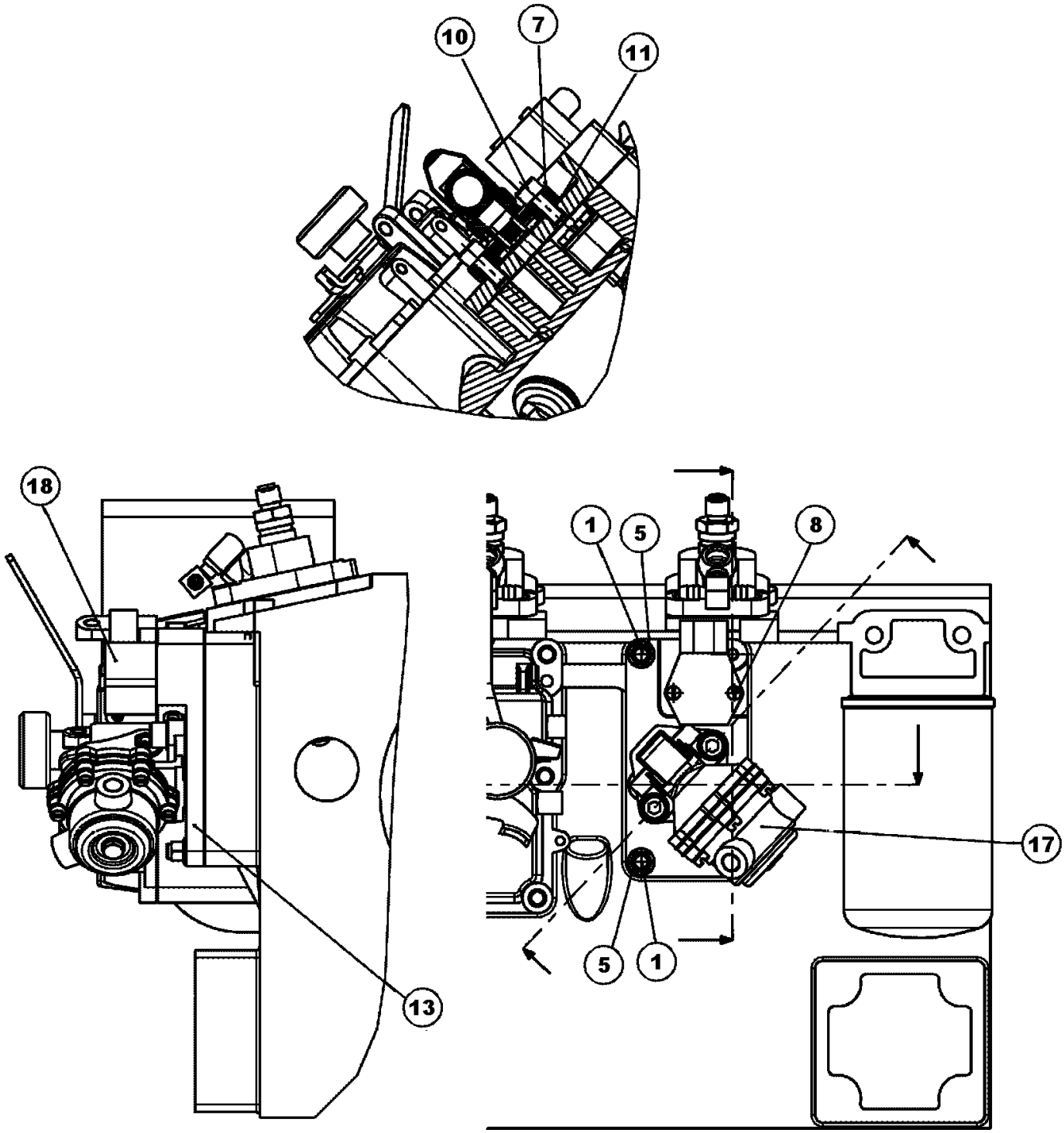
Insert the solenoid valve connectors following the references (**IN** and **OUT**) shown on the cables and on the solenoid valve block.

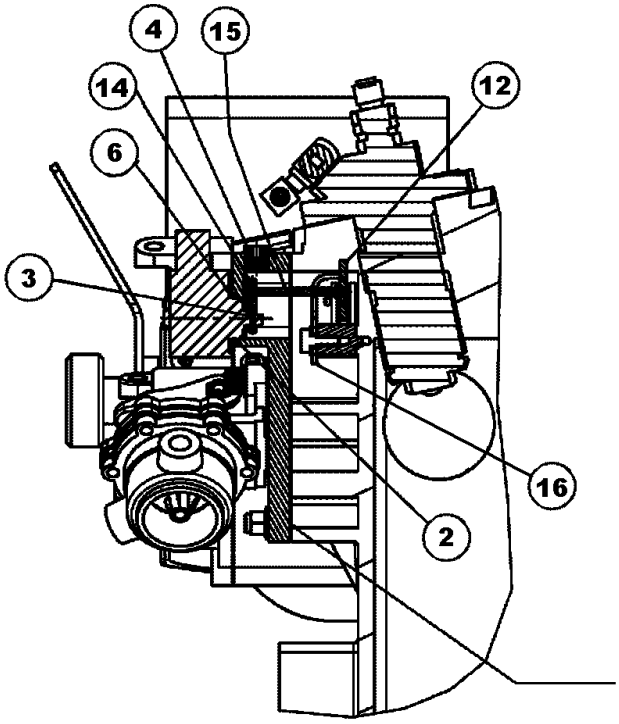


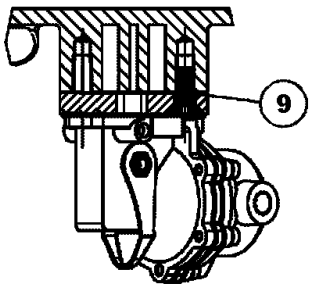
A_47

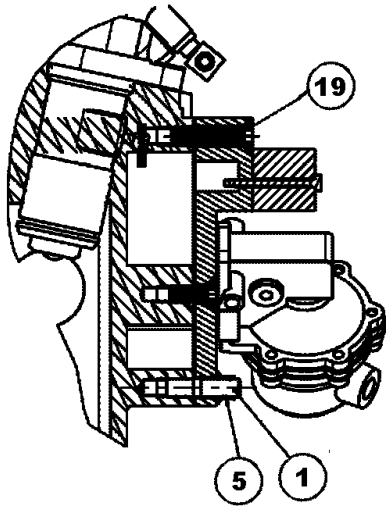
❍ Replace the built guard and tighten to 15 Nm.

Angular position sensor and AC pump assembly diagram





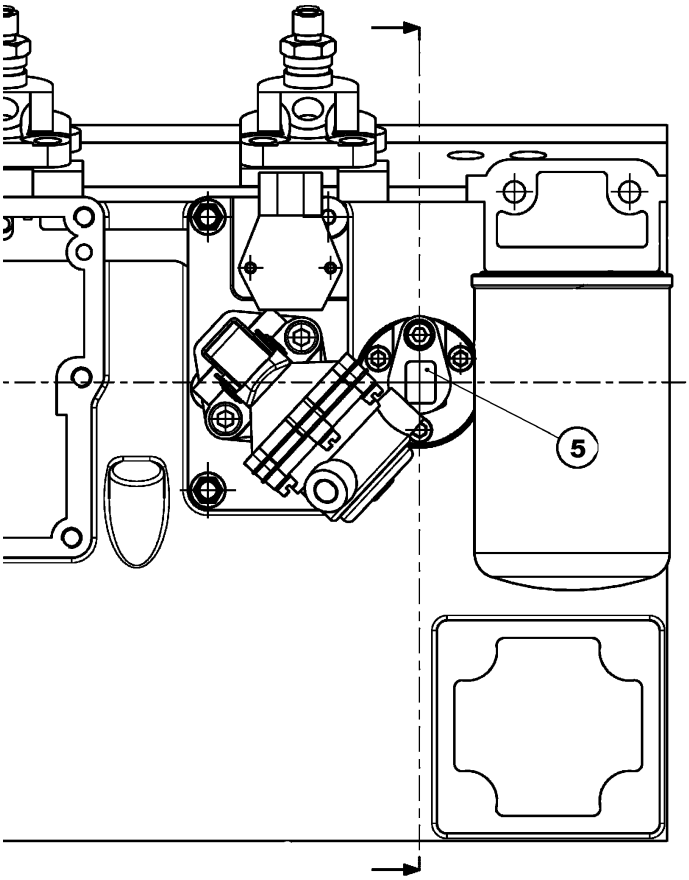


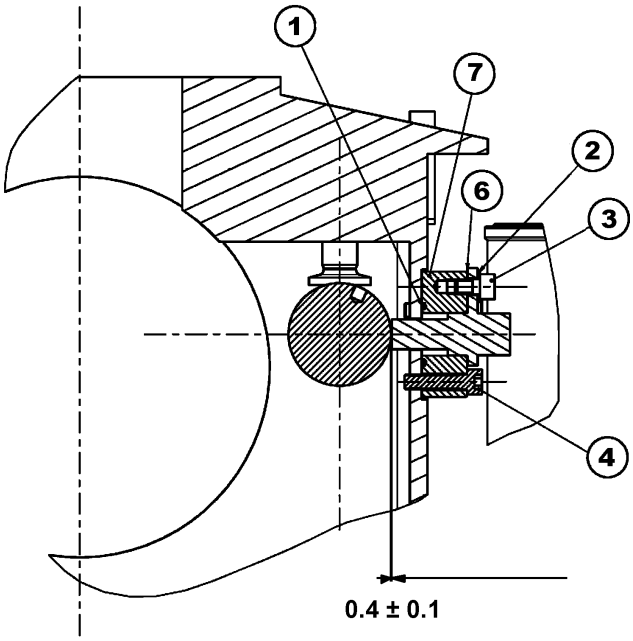


COMPONENTS TABLE

1	Stud bolt M8x20
2	Silicone O-ring
3	Snap pin 2x10
4	Conical screw STEI M 10x1.5
5	Self-locking flanged hex nut
6	Copper washer
7	Crinkled spring washer
8	Screw TCEI UNI 5931 M 4x35
9	Screw STEI M 8x20
10	Fuel supply pump
11	Screw TCEI M 8x18
12	Fuel supply pump seal
13	Sensor pump connection rod
14	AC pump and angular position sensor cover
15	Sensor control lever
16	Connecting pin between rod and sensor
17	Discharge stop plate
18	Angular position sensor
19	Flathead screw

Phase sensor assembly diagram

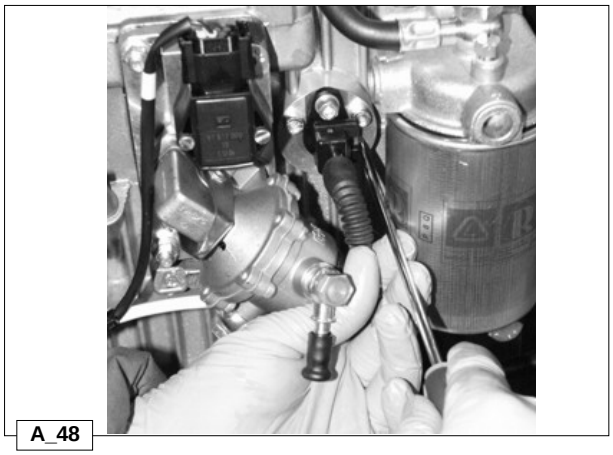




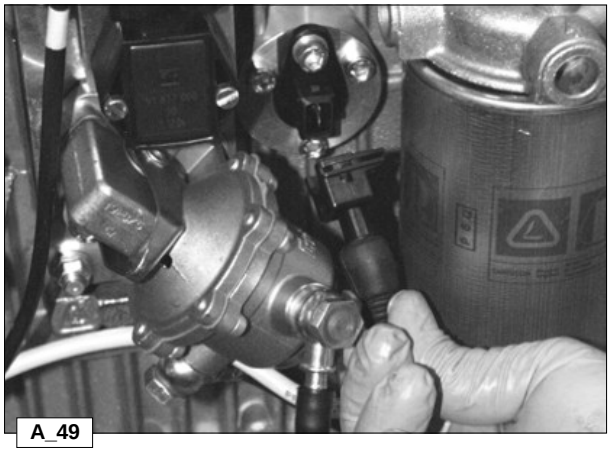
Adjust with 0.2 mm shims

COMPONENTS TABLE

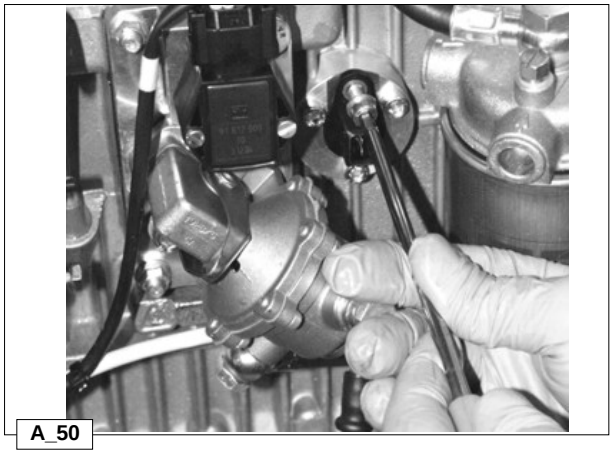
1 Silicone O-ring
2 Washer 6x12xSp1
3 Screw TCEI UNI 5931 M 6x10
4 Screw TCEI UNI 5931 M 6x25
5 Speed and phase sensors
6 Phase sensor air gap adjustment shim
7 Phase sensor support


A_48

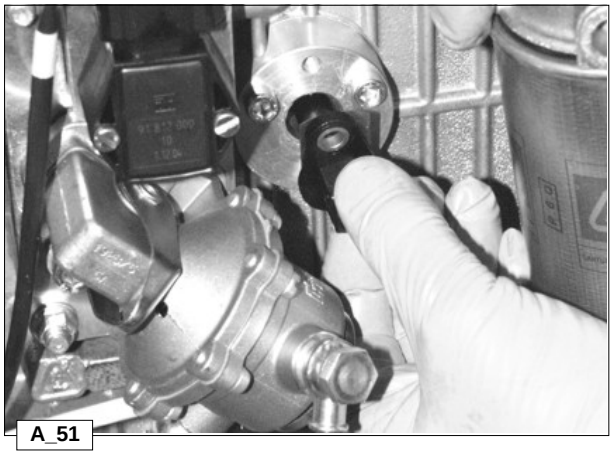
To assemble the phase sensor connector press the locking spring.


A_49

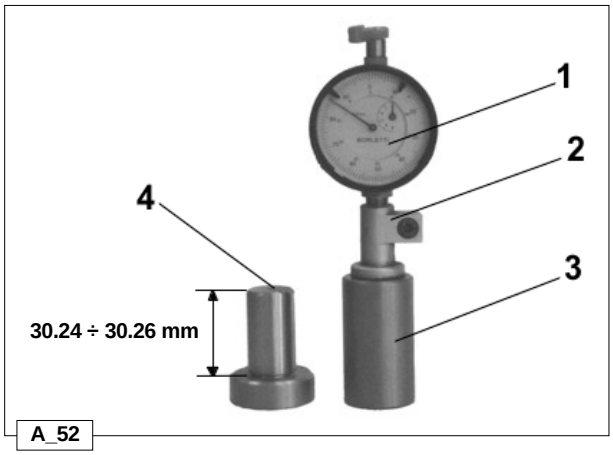
Remove the connector from the sensor.


A_50

❍ Loosen screw M6. When refitting, tighten to 8 Nm.


A_51

Remove the sensor from the support taking care not to damage the O-ring.



A_52

Components:

1 Dial indicator
2 Support for dial indicator
3 Sensor control gauge measurement: 30,24 ÷ 30,26 mm
4 Control master measurement: 30,24 ÷ 30,26 mm for sensor gauge

If replacing the phase sensor, check the length of the sensor pin using the tool in figure A_52.
Check by measuring the distance between magnetic end and the sensor support surface (30,24 ÷ 30,26 mm).

➲ The serial numbers of special tools are on page 103.

A_53

Resetting the dial indicator

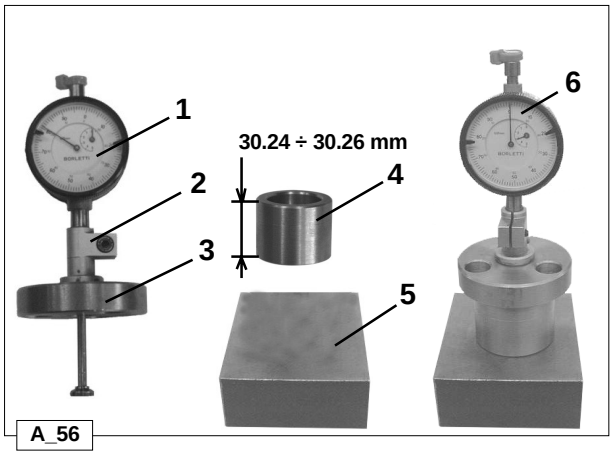
Assemble the dial indicator **1** onto support **2**.
Attach the support with the dial indicator to the gauge **3**.
Insert the master **4** into the gauge **3** and reset the dial indicator.

A_54

Sensor test

Remove the master **4** from the gauge **3**; insert the phase sensor and check that the sensor falls within tolerance measurements of 30,015 ÷ 30,035 mm.
See fig. A_53 -A_ 54.

A_55



A_56

Resetting the dial indicator

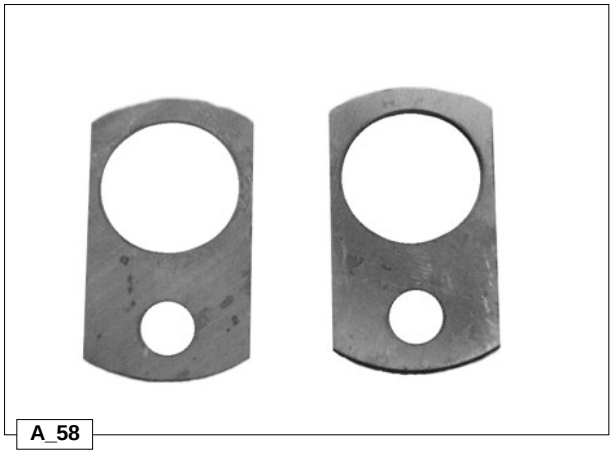
Components:
1 Dial indicator
2 Support for dial indicator
3 Camshaft sensor support surface control gauge
measurement: 30,24 ÷ 30,26 mm
4 Resetting master measure: 30,24 ÷ 30,26 mm for gauge
5 Resetting reference base
If replacing the sensor, camshaft or engine block via the tool see figure 56.
Make sure that the support surface of the sensor on the camshaft support measures 30,24 ÷ 30,26 mm. Assemble the dial indicator **1** in the support **2**. Insert the support **2** complete with dial indicator **1** into the gauge **3**. Set the master **4** and reset the dial indicator while resting on the base **5** as in **6**.

A_57

Measuring the depth between the sensor support and the camshaft

Insert the gauge complete with dial indicator onto the sensor support and attach using the three screws.
Make sure the measurements taken are within the specific tolerance limits 30.24 ÷ 30.26 mm.

❍ The three screws for the phase sensor support screws must be tightened to 8 Nm using a torque wrench.


A_58

Air gap adjustment

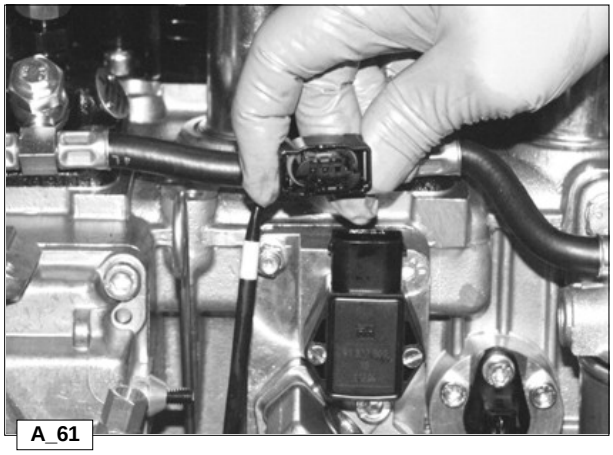
The air gap is adjusted using shims measuring 0,2 mm in thickness which are placed between the sensor surface and its support.
The air gap must be between 0,3 and 0,5 mm (see phase sensor assembly diagram page 94).
When adjusting the air gap with shims, it is important to consider any difference between the measurements taken (length of the sensor pin and depth between the sensor support surface and the camshaft) and specifications.

A_59

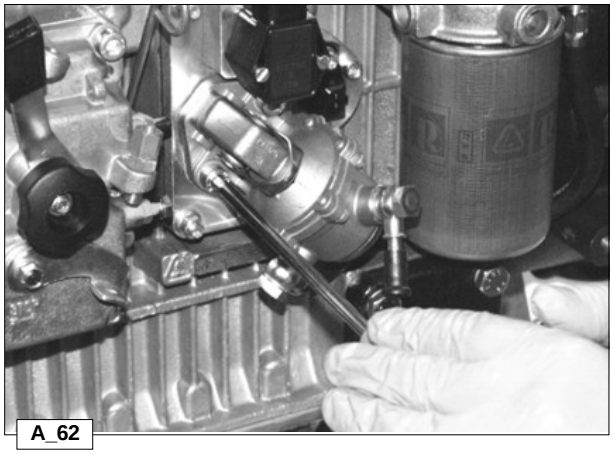
Example of where to insert the air gap adjustment shims.

A_60

Remove the connector from the position sensor on the injection pump control rod.



A_61



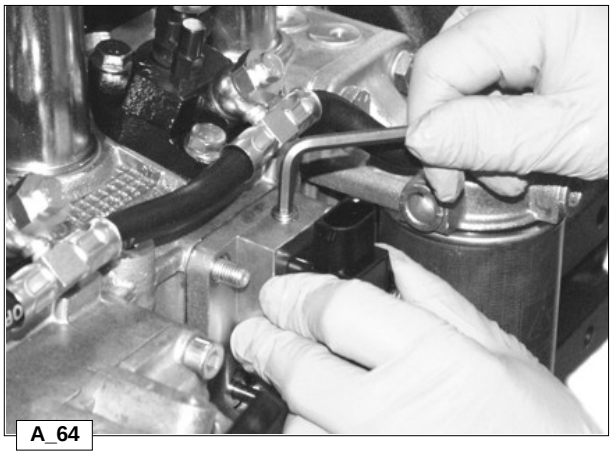
A_62

Unscrew the two screws to disassemble the fuel pump;

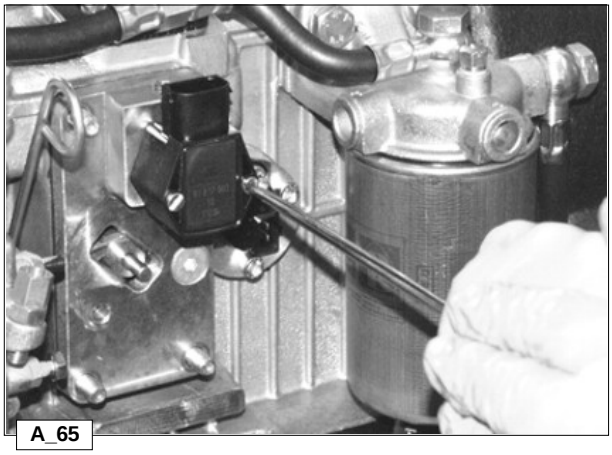
- when refitting, tighten the flathead screws, the nuts and hexagonal-head screws to 25 Nm.

A_63

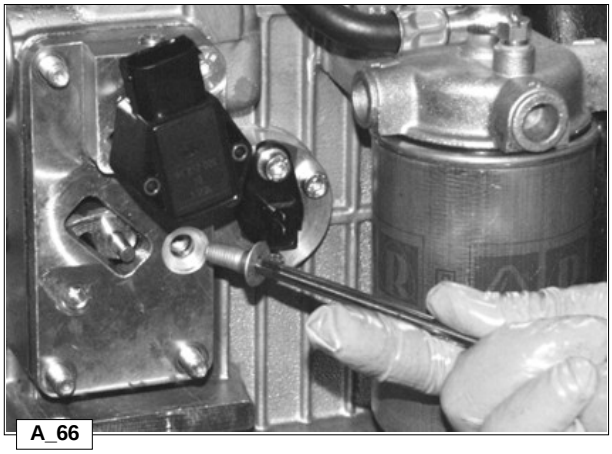
When reassembling, replace the sealing gasket.


A_64

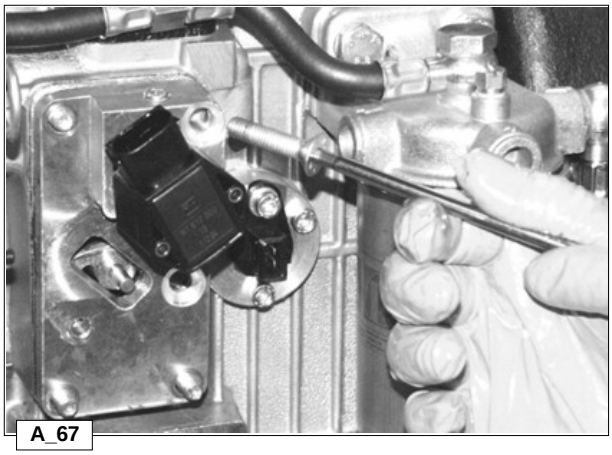
Remove the conical inspection plug.


A_65

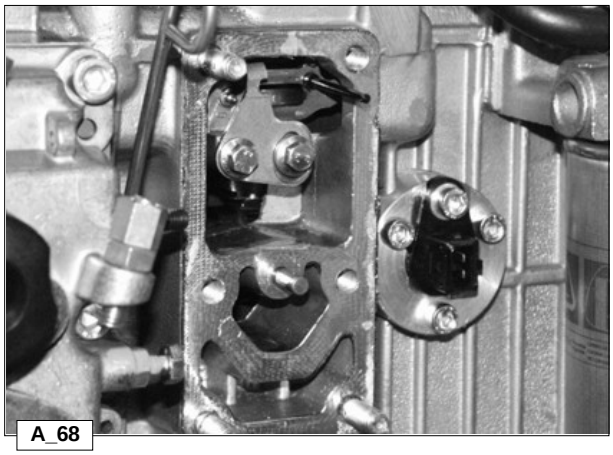
Unscrew the two screws to disassemble the injection pump rod position sensor.


A_66

Remove the three flanged nuts and the flathead screw.

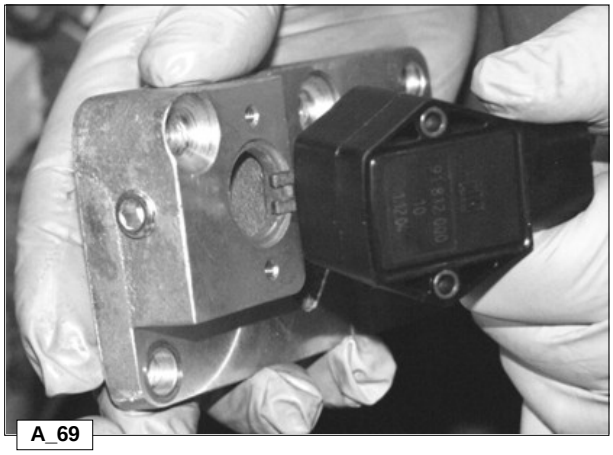

A_67

Unscrew the last screw (flathead) after rotating the sensor anticlockwise.



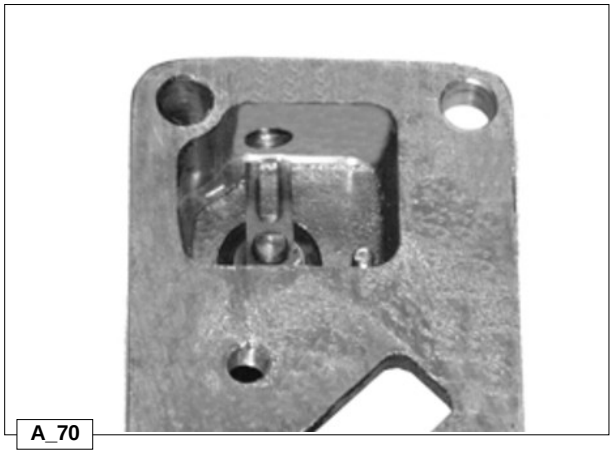
A_68

Remove the cover supporting the sensor and the fuel pump.



A_69

Rotate the position sensor shaft to direct the fork on the side opposite the connector.

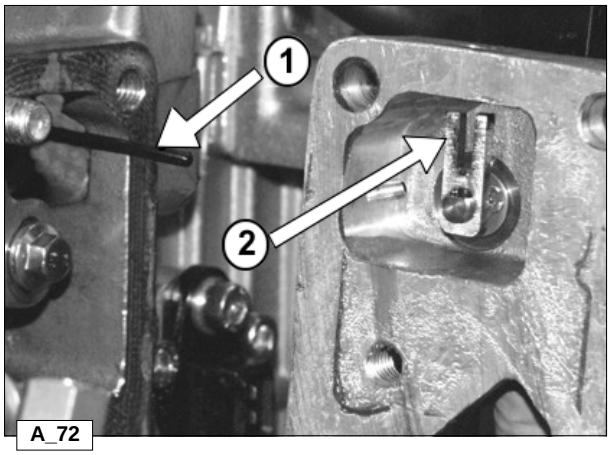


A_70

Insert the fork into the slot in the support.
Rotate the sensor body 180°, keeping the fork in the position shown in figure A _70.

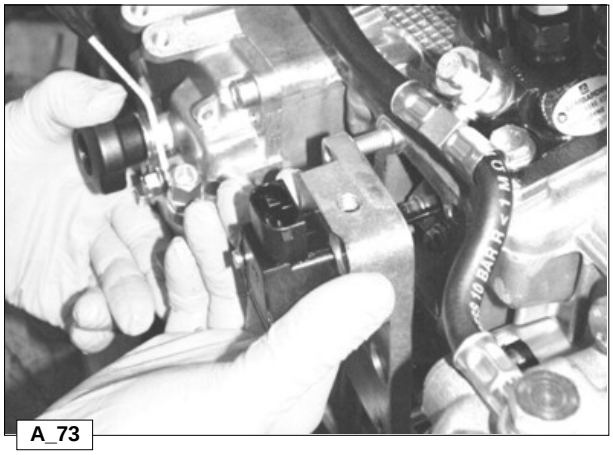
A_71

Tighten only one screw on the position sensor to keep it in the right position.

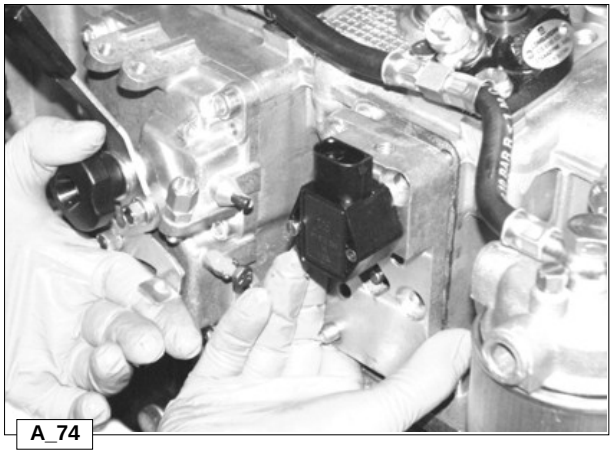


A_72

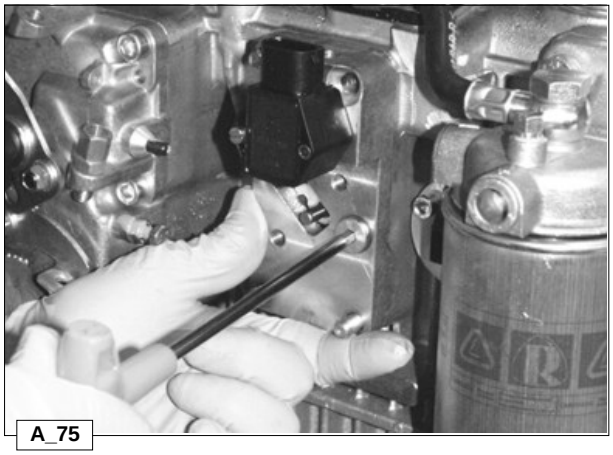
Set the cover against the crankcase so that the injection pump rod drive pin **1** is inserted between the two prongs of the fork **2**.


A_73

Look through the upper inspection hole on the cover to make sure that the pin **1** is correctly inserted into the fork **2**.

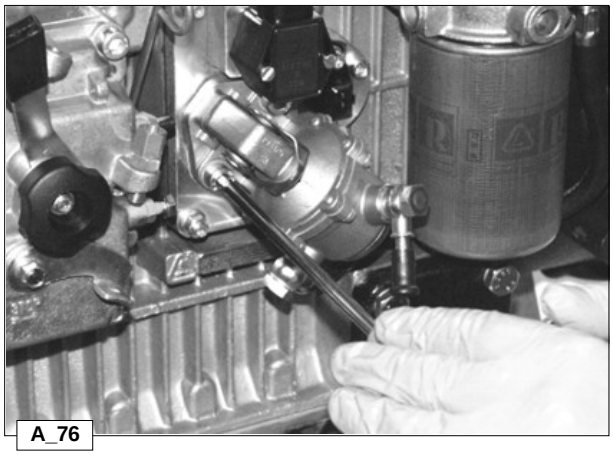

A_74

Operate the stop control lever repeatedly to make sure the system is running smoothly.


A_75

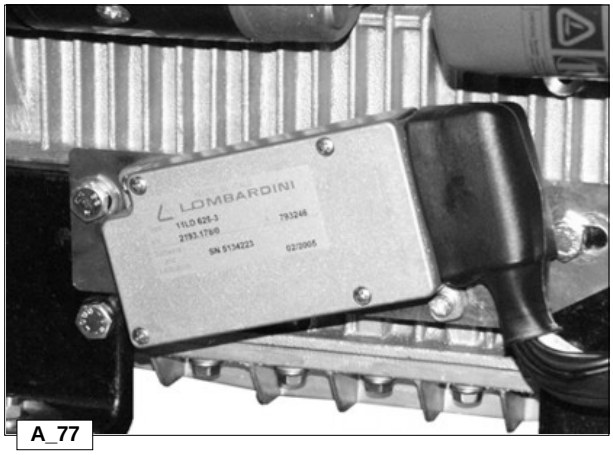
Replace the screws and nuts in the cover in the opposite order to when they were removed and

❍ tighten to 25 Nm.



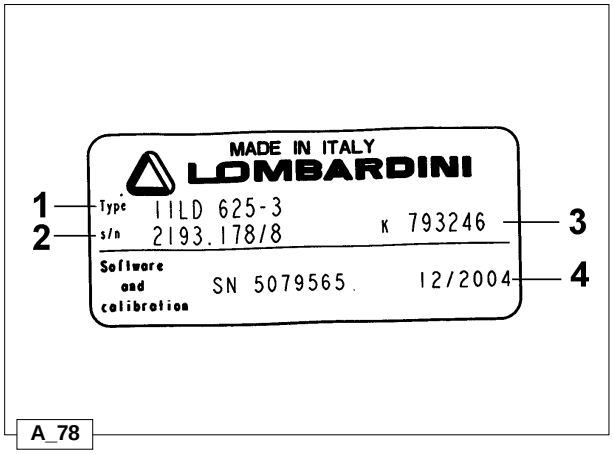
A_76

Refit the fuel pump after replacing the seal; tighten the screws to 25 Nm.



A_77

Correct assembly position of the control unit that runs the engine variator.



A_78

Example of adhesive plate on the control panel

1 Engine type
2 Control panel serial number
3 Version number (form **K**)
4 SN plus engine serial number plus date

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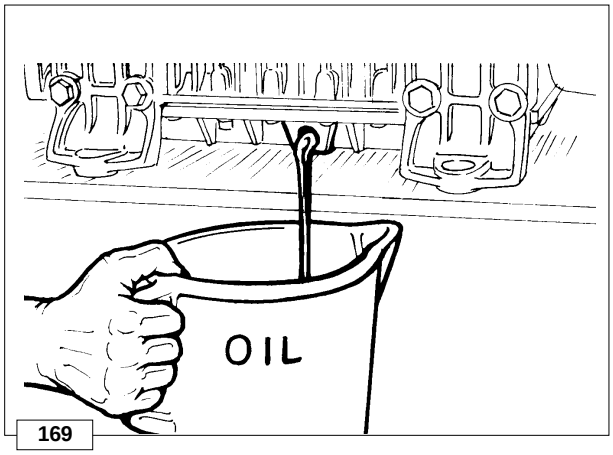
When the engines are not used for more than 3 months, they must be protected by the measures described below:

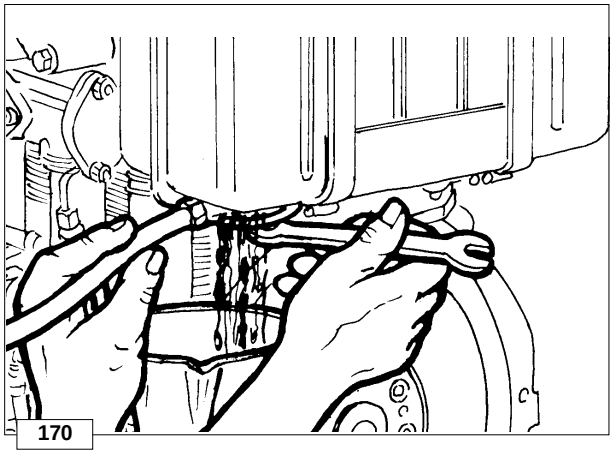
STORAGE



169

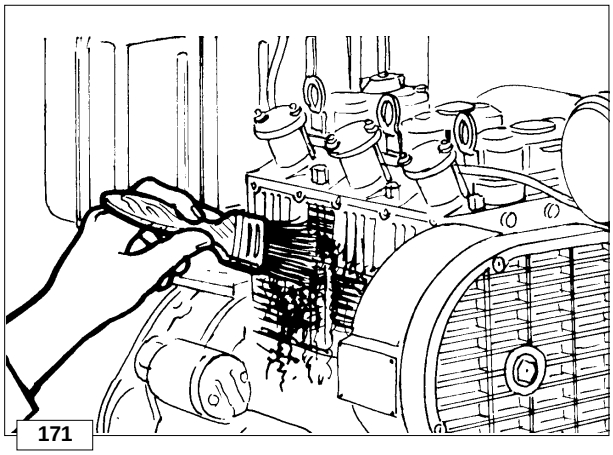
External engine protection:

- Start the engine and heat it.
- Remove the drain plug and let the oil flow completely.
- Replace the oil filter with a new one (screw manually the new filter).
- Clean the oil drain plug and after having assembled a new gasket, tighten it.
- Carry out the oil refilling to the upper level of the rod, using AGIP RUSTIA C (for Countries in which this product is not available find an equivalent product on the market).
- Start for about 10 minutes and verify any possible oil leakage, then stop the engine.


170

Injection systems protection:

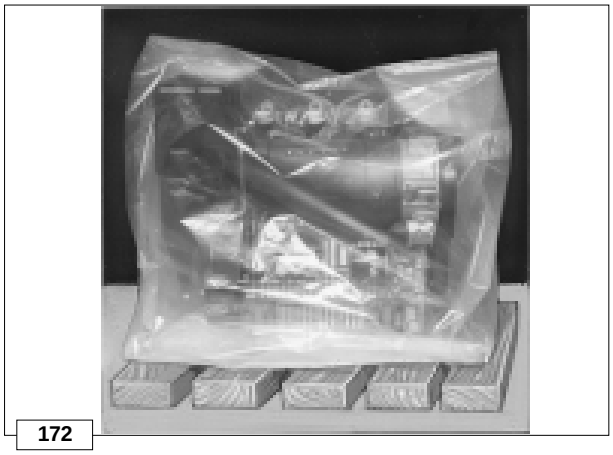
- Empty the fuel tank.
- Replace the fuel filter with a new one.
- Carry out the filling of fuel using 10% of AGIP RUSTIA NT special additives.
- After having performed the air bleeding, start the engine, verify any possible fuel leakage, then stop the engine.


171

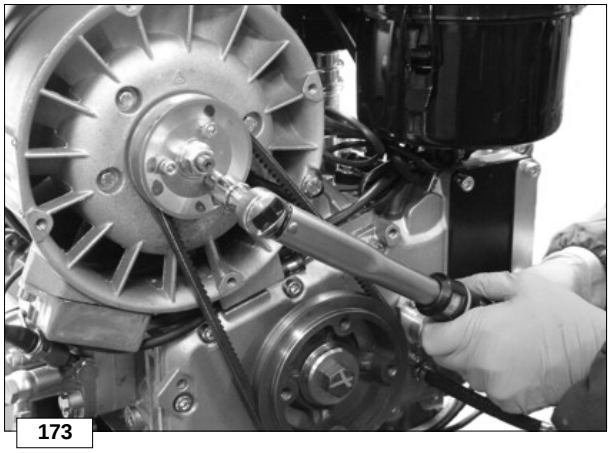
External engine protection:

- Clean carefully cylinder cooling system fins and the blowing fan.
- Loosen the drive belt of the blowing fan.
- Protect the external non-painted surfaces with AGIP RUSTIA 100/F.
- Seal with adhesive tape the intake and exhaust systems
- Coat the engine with a nylon or plastic sheet.
- Keep in a dry place. If possible not in direct contact with the ground and away from high voltage electric lines.

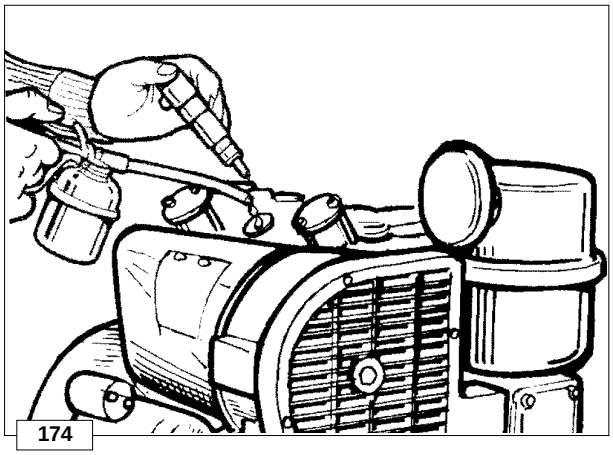
PROCEDURES TO BE CARRIED OUT BEFORE START THE ENGINE


172

- Remove all protections and coverings.
- Remove the rust preventer from the external part of the engine by means of adequate products (solvent or degreaser).
- Tension the blower timing belt.
- Disassemble the injectors and introduce, by means of a bowl, motor oil on the piston crown (no more than 2 cc for every cylinder).
- Remove valve covers and spray motor oil on the valves, then turn the crankshaft manually for a few revolutions.
- Start the engine and heat it for about 10 minutes.
- Remove the drain plug and let the protective oil flow completely.


173

- Reinsert the drain plug.
- Carry out motor oil refilling to the upper level of the rod using the oil recommended by the manufacturer for a normal engine operation.


174

MAIN TORQUE SPECIFICATIONS

COMPONENT	Diameter and pitch (mm)	Torque Kgm	Sealants
Tank bracket vibration dampers	8x1,25	25	Loctite 270
Connecting rod	8x1	40	
Injection pump delivery valve union	18x1,5	40	
Bell flywheel side	10x1,5	50	
Central support collar	8x1,25	25	
Intake manifold	8x1,25	25	
Exhaust manifold	8x1,25	25	
Air shroud	8x1,25	15	
Throttle control cover	8x1,25	25	
Rocker arm cover	8x1,25	20	
Timing cover	8x1,25	25	
Cover hydraulic pump flange 1P	8x1,25	25	
Oil pump casing	8x1,25	25	
Blower pulley nuts	6x1	10	
Oil pump nut or union	8x5	25	Loctite 270
Oil pump gear threading			Loctite 270
Tank bracket gasket			LoctiteIS 495
Air filter		25	
Oil filter	8x1,25	25	
Internal oil filter	8x1,25	25	
Hydraulic pump flange	8x1,25	25	
Nozzle cup		70	
Blower assembly	8x1,25	25	
Camshaft gear	24x2	250	
Oil pump gear	10x1,5	35	
Timing gear	10x1,5	40	
Injector (cylinder head fastening nuts for S size, screw for P size)		10	
Injection pump control lever	8x1,25	25	
Starting motor	10x1,5	45	
Oil radiator nipple	16x1,5	45	Loctite 270
Oil filter cartridge nipple	8x1,25	25	Loctite 270
Rocker arm pin	8x1,25	25	
Governor control external lever pin	8x1,25	10	
Stop control external lever pin	8x1,25	10	
Engine mounting foot	10x1,5	40	
Injector stud bolt	8x1,25	25	
Starter motor stud bolt	8x1,25	25	
Fuel feeding pump	8x1,25	25	
Blower housing stud	10x1,5	12	Loctite 270
Main bearing support fixing stud bolt, flywheel side	8	25	Loctite 270
Head stud	12	86	Loctite 270
Crankcase stud bolt	8x1,25	8-10	Loctite 270
Injection pump	8	25	Loctite 270

MAIN TORQUE SPECIFICATIONS

COMPONENT	Diameter and pitch (mm)	Torque Kgm	Sealants
Oil sump	10		Loctite 270
Belt guard	8x1,25	25	
Blower crankshaft pulley	16x1,5	250	
Fan pulley	12x1,5	40	
Fuel filter union	14x1,5	40	
Fuel pump union	10x1	12	
Radiator union	14x1,5	40	
Injector high pressure pipe union	12x1,5	20-25	
Speed governor support shaft	8x1,25	22	
Main bearing support, gear case side	8x1,25	25	
Main bearing support, flywheel side	8x1,25	25	
Center main bearing support	10x1,5	30	
Hydraulic pump gear support	8x1,25	25	
Governor control internal lever support	8x1,25	25	
Fuel tank bracket	8x1,25	25	
Drain plug	14x1,5	50	
Cylinder head	10x1,5	55	
Camshaft axle housing screws		25	
Flywheel	12x1,25	140	

USE OF SEALANTS ONLY FOR ENGINES WITH VARIATOR	
POSITION	**SEALANTS**
Pump cover C	Loctite 5205
Speed sensor support	Loctite 209079
Phase sensor support fastening screws	Loctite 242
Speed sensor support fastening screws	Loctite 242

Table of tightening torques for standard screws (coarse thread)

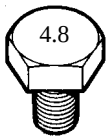
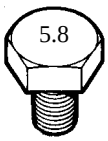
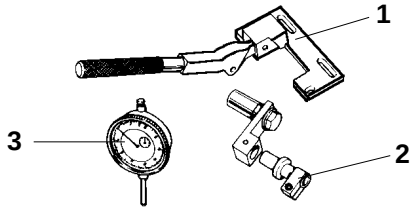
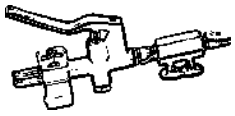
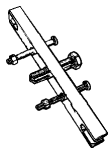
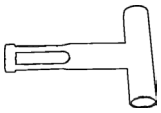
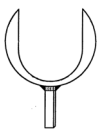
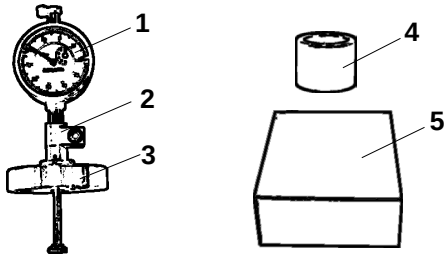
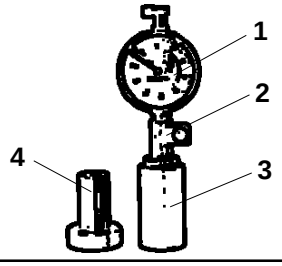
Quality/ Dimensions	Resistance class (R)							
	4.6	 4.8	5.6	 5.8	6.8	8.8	10.9	12.9
Diameter	R>400N/mm²		R>500N/mm²		R>600N/mm²	R>800N/mm²	R>1000N/mm²	R>1200N/mm²
	Nm	Nm	Nm	Nm	Nm	Nm	Nm	Nm
M3	0,5	0,7	0,6	0,9	1	1,4	1,9	2,3
M4	1,1	1,5	1,4	1,8	2,2	2,9	4,1	4,9
M5	2,3	3	2,8	3,8	4,5	6	8,5	10
M6	3,8	5	4,7	6,3	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)

Quality/ Dimensions	Resistance class (R)							
	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	DESCRIPTION	Part No.
	**1** Valve control lowering tool static injection advance **2** Dial indicator support **3** Dial indicator	**Overall:** 1460 - 266 **1** 1460 - 275 **2** 1460 - 270 **3** 1460 - 274
	High-pressure pump for static advance control.	1460 - 273
	Injection pump static injection advance tester	1460 - 024
	Tool for fitting valve stem seal ring	1460 - 108
	Blower control pulley extractor	1460 - 200
	Tool for assembling/removing valve half-collets	1460 - 113
	Tool for mounting the spring on the tappet rod protection pipe	1460 - 009
	Only for engines with advance variator: Tool for measuring air gap: **1** Dial indicator **2** Dial indicator support **3** Gauge **4** Master **5** Base	**Overall:** 1460 - 272 **1** 1460 - 274 **2** 1460 - 270 **3** 2003 - 021 **4** 1460 - 269 **5** 1460 - 268
	Only for engines with advance variator: Tool for checking phase sensor: **1** Dial indicator **2** Dial indicator support **3** Gauge **4** Master	**Overall:** 1460 - 271 **1** 1460 - 274 **2** 1460 - 270 **3** 2003 - 020 **4** 1460 - 267

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