WORKSHOP MANUAL

Focs series engines, code 1-5302-351

LDW 502
LDW 602
LDW 903
LDW 1204
LDW 1204/T

LDW 702
LDW 1003
LDW 1404

5st Edition

LOMBARDINI
intermotor SLANZI
SERVICE

LOMBARDINI

FOREWORD

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

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

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

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

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

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

GENERAL SERVICE NOTES

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

LOMBARDINI
intermotor SLANZI
SERVICE

WARRANTY CERTIFICATE

Engine manufactured by Lombardini S.r.l., are warranted to be free of defects in workmanship or materials for 12 months from the date of delivery to the first purchaser or non more than two (2) years from date of engine delivery to the Original Equipment Manufacturer as defined by Lombardini invoicing, whichever occurs firsts, except as defined below.

Stationary applications, working at constant speed and/or slightly variable speeds, are excluded from the above terms. Stationary/fixed speed applications will be warranted to be free of material/workmanship defects for a maximum operational period of 1000 hours or 12months from the date of first purchase, whichever occurs first. The two (2) year limitation from date of Lombardini invoice will remain intact as described above.

Modification of Lombardini products by the Original Equipement Manufacturer or the end user with respect to cooling systems, filtration systems, induction systems, exhaust systems, lubrication system, fuel system, fuel system settings, etc., will require special written warranty agreements. A test certificate/approval by the R&D/ Application engineering department of Lombardini or associated Lombardini companies concerning modified Lombardini products will entitle Warranty as defined above. Warranty will not be granted on any modified Lombardini product without special written approval by Lombardini.

Within the above stated periods Lombardini will replace and/or repair, at the option of Lombardini, any part or component that, upon examination by Lombardini or an authorized Lombardini agent, is found to be defective in 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 replacemnt of any component will not extend or renew the warranty period. Direct labor required to make repairs or to replace components found to be defective in materials or workmanship will be completed at no cost to the end user. Lombardini in not responsible however for indirect costs of removing/installing the engine assembly. Further, Lombardini is not responsible for the costs of transportation of the machine or components requiring repair or for service supplies such as lubricating oils and filters.

Lombardini Warranty obligations will be cancelled if:

- Lombardini engines are applied to a given machine causing working engine parameters outside Lombardini application guidelines.
- Lombardini engines are not serviced and maintained according to the "USE and MAINTENANCE" booklet.
- Any seal affixed to the engine by Lombardini has been tampered with or removed.
- Engines have been disassembled, repaired or altered by any party other than an authorized Lombardini agent.
- Spare parts used are not original Lombardini.
- Fuel injection system/component failures caused by the use of unauthorized fuel types or poor quality fuels are not covered under the Lombardini warranty policy.
- Electrical system failures due to the modification of Lombardini supplied harnesses, modification of Lombardini supplied control panels, OEM/end user supplied/installed relays, controls, etc. are not covered under warranty.

Following expiration of the above stated warranty period(s) and limitations, Lombardini will have no further responsibility for warranty and will consider our obligation for warranty complete.

The above warranty certificate will be in effect starting July 1, 1993 and cancels/replaces any and all explicit or implicit warranty policies on the part of Lombardini. The above warranty conditions can from this date forward be modified only in writing.

INDEX

This manual contains pertinent information regarding the repair of LOMBARDINI water-cooled, indirect injection Diesel engines type **LDW 502-602-903-1204-124/T** and **LDW 702-1003-1404:** updated November 15, 1999.

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NOTE

TROUBLESHOOTING CHART- LDW FOCS SERIES

POSSIBLE CAUSE	SYMPTOM													
	Engine will not crank	Engine does not start	Engine starts, but stops	Poor acceleration	Unsteady RPM	Black smoke	White smoke	Blue smoke	Low oil pressure	Oil level rising	Excessive oil consumption	Wet exhaust	Overheating	Engine knocks
Low fuel level		▪	▪		▪									
Fuel supply/ return lines clogged		▪	▪	▪	▪									
Clogged fuel tank vent			▪		▪									
Fuel pump faulty		▪	▪							▪				
Fuel entrained with air		▪	▪	▪	▪									
Unit injector(s) faulty/ worn		▪		▪	▪	▪	▪			▪		▪		
Unit injector settings incorrect		▪		▪		▪	▪					▪	▪	▪
Injection pump rack sticking		▪		▪	▪									
Oil level too high				▪	▪	▪		▪				▪	▪	▪
Improper oil viscosity											▪	▪	▪	
Oil diluted by fuel									▪	▪	▪	▪	▪	
Oil pressure relief valve faulty									▪					
Oil pick-up tube clogged									▪					
Oil pump air entrained at pick-up tube									▪					
Glow plugs faulty		▪					▪							
Glow plug controller faulty		▪												
Glow plug relay inoperable		▪												
Starter defective	▪													
Battery voltage too low	▪													
Battery / battery cable connections corroded	▪													
Key switch defective	▪													
Air filter clogged		▪		▪	▪	▪					▪	▪	▪	
Excessive idle / light load operation							▪	▪			▪	▪		
Incomplete engine run-in								▪			▪	▪		
Engine overloaded		▪	▪	▪	▪	▪					▪		▪	
Excessive parasitic load	▪	▪				▪								
Valve lash insufficient / excessive		▪					▪	▪						▪
Injection timing out of spec- advanced		▪					▪	▪			▪			▪
Injection timing out of spec- retarded		▪		▪		▪								
Governor linkage adjustment incorrect		▪	▪	▪	▪									
Governor spring fatigued or defective		▪		▪	▪									
Idle rpm too low		▪	▪											
Piston rings worn or stuck		▪					▪	▪			▪	▪		
Piston worn or damaged		▪					▪	▪			▪	▪	▪	▪
Cylinders worn or damaged		▪					▪	▪			▪	▪	▪	▪
Valves / valve guides worn		▪					▪	▪			▪	▪		
Valves sticking		▪	▪	▪	▪		▪				▪	▪		
Bearings (main / rod) worn									▪				▪	▪
Governor / governor linkage malfunction		▪	▪	▪	▪	▪								
Cylinder head gasket damaged		▪					▪						▪	
Thermostat stuck or malfunctioning													▪	
Engine seized	▪													
Radiator clogged (external or internal)													▪	
Coolant pump faulty													▪	
Turbocharger faulty				▪	▪	▪		▪			▪	▪	▪	

SAFETY AND WARNING DECALS

DANGER

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

CAUTION

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

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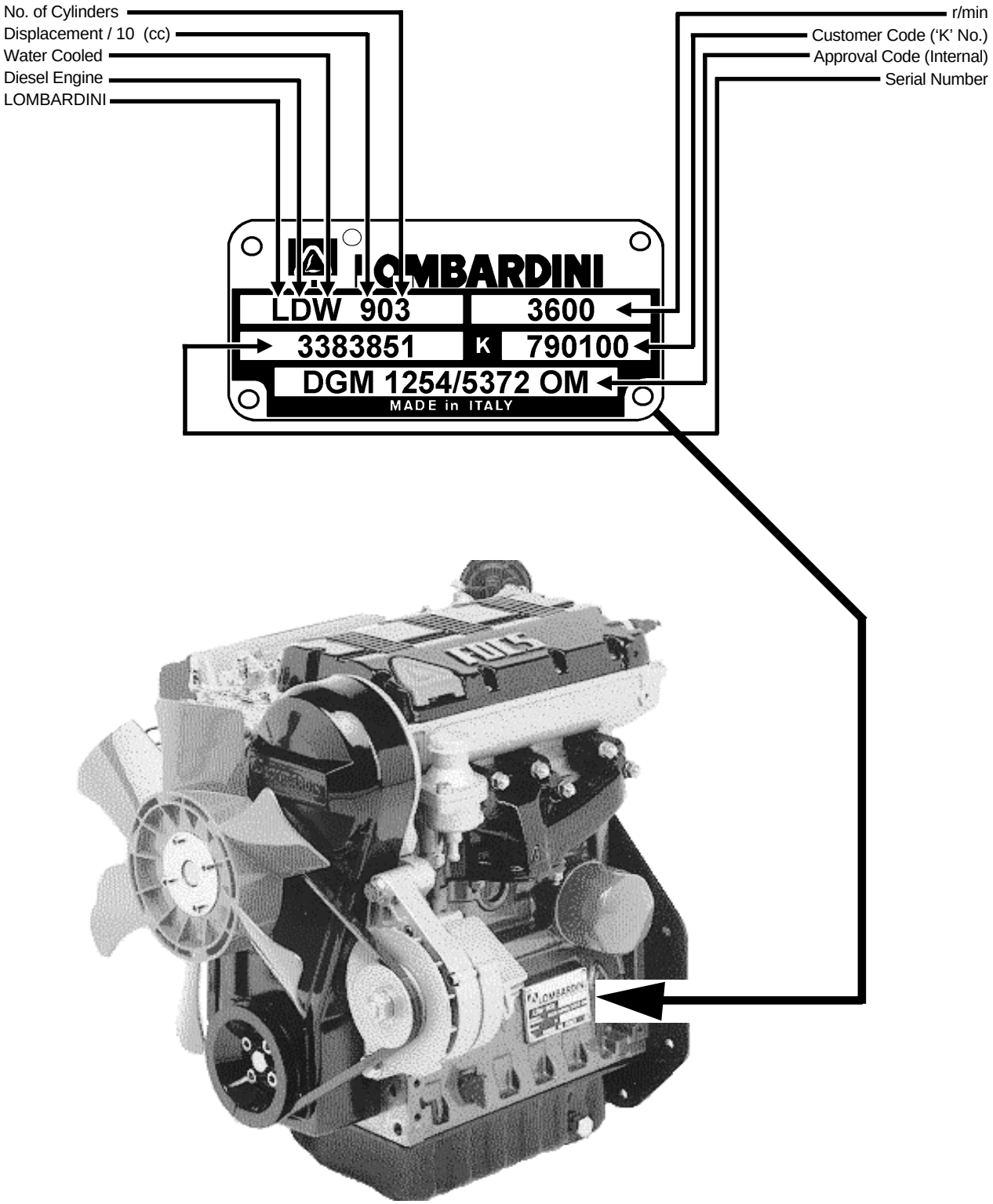
SAFETY INSTRUCTIONS

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

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

All pertinent information needed for engine identification and spare parts ordering can be accessed from the engine data plate. Additionally, the maximum engine speed, “K’ number and approval codes are included on the engine data plate. The location of the data plate, as shown below, is identical for all LOMBARDINI LDW-FOCS industrial engines. Please supply the engine data plate information to your Authorized LOMBARDINI Distributor or Dealer when ordering replacement parts or when making technical inquiries.



COMPILER TECDATI	REG. CODE	MODEL N°	DATE OF ISSUE	REVISION 04	DATE	ENDORSED
	1-5302-351	50563	04.90		15.11.99	

POWER RATINGS FOR LDW-FOCS GENSET SPEC DIESEL ENGINES

CONTINUOUS (NA) RATING- kW

ENGINE MODEL	1500 r/min	1800 r/min	3000 r/min	3600 r/min
LDW 602	4.5	5.4	9.0	9.9
LDW 903	6.7	8.1	14.0	14.9
LDW 1204	9.0	10.8	18.9	19.9
LDW 1204/T	11.7	14.0	24.8	25.8
LDW 702	5.0	5.9	9.9	10.6
LDW 1003	7.7	9.0	14.9	16.3
LDW 1404	9.9	11.7	19.8	22.8

NOTE: THE ABOVE RATINGS ARE FLYWHEEL OUTPUT, NOT ELECTRICAL GENSET OUTPUT

INTERMITTENT (NB) RATING- kW

ENGINE MODEL	1500 r/min	1800 r/min	3000 r/min	3600 r/min
LDW 602	5.0	6.0	10.0	11.0
LDW 903	7.5	9.0	15.5	16.5
LDW 1204	10.0	12.0	21.0	22.0
LDW 1204/T	13.0	15.5	27.5	28.5
LDW 702	5.5	6.5	11.0	11.7
LDW 1003	8.5	10.0	16.5	18
LDW 1404	11.0	13.0	22.0	25

NOTE: THE ABOVE RATINGS ARE FLYWHEEL OUTPUT, NOT ELECTRICAL GENSET OUTPUT

POWER RATING STANDARDS

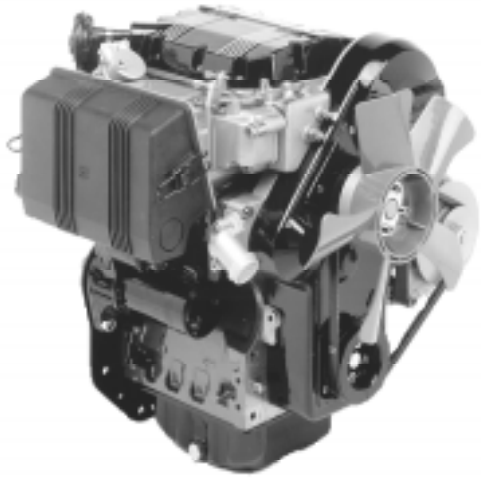
NB- ISO 3046/1-IFN - Maximum intermittent rating with no overload capacity; operation with constant speed and variable load.
NA- ISO 3046/1-ICXN- Continuous rating with 10% intermittent overload allowed; operation with constant speed and constant load.
Standard Rating Conditions: 25°C, 100kPa Total Barometric Pressure, 30% Relative Humidity.
Standard Production Power Tolerance = +/- 5%
Standard/ General Derations: 2% per 5°C increase in temperature over 25°C; 1% per 100m over mean sea level

LDW FOCS SERIES- TECHNICAL SPECIFICATIONS AND CAPACITIES					
TECHNICAL SPECIFICATIONS	**LDW 502**	**LDW 602**	**LDW 903**	**LDW 1204**	**LDW 1204/T**
No. of Cylinders	2	2	3	4	4
Firing Order	1-2	1-2	1-3-2	1-3-4-2	1-3-4-2
Cylinder Bore (mm)	72	72	72	72	72
Cylinder Stroke (mm)	62	75	75	75	75
Displacement (cc)	505	611	916	1222	1222
Aspiration Type	Natural	Natural	Natural	Natural	Turbo
Compression Ratio	22.8:1	22.8:1	22.8:1	22.8:1	22.8:1
RPM- maximum	3600	3600	3600	3600	3600
Power- (N)- ISO 1585- KW(CV)-@3600 r/min	9.8(13.4)	11.8(16.0)	17.2(23.4)	24.4(33.2)	31.0(42.0)
Power- (Nb)- ISO 3046-1 IFN- KW(CV)-@3600 r/min	9.1(12.4)	10.3(14.0)	15.6(21.2)	22.0(30.0)	28.5(38.7)
Power- (Na)- ISO 3046-1 ICXN- KW(CV)-@3600 r/min	8.2(11.2)	9.2(12.5)	13.7(18.6)	19.9(27.0)	25.8(35.0)
Torque(MAX)/rpm @Nb output, (Nm)	28.7/2400	34.5/2200	53.5/2000	75.1/2200	98/2400
Maximum Torque Available @ N0. 3 PTO (Nm)	37/1800	37/1800	37/1800	37/1800	37/1800
Fuel Consumption (Nb)@3600 rpm- (g/KWh)	326	282	300	290	305
Oil Consumption (Na)- (Kg/hr)	0.007	0.007	0.012	0.017	0.019
Dry Weight- (Kg)	60	65	85	96	101
Inclination (max)- (30 seconds)	35°	35°	35°	35°	35°
Inclination (max)- (60 seconds)	30°	30°	30°	30°	30°
Inclination (continuous)- APPLICATION DEPENDENT	****	****	****	****	****
Axial Load (max) on Crankshaft (both directions)- (Kg)	300	300	300	300	300
Radial (side) Load - APPLICATION DEPENDENT	****	****	****	****	****

**** - CONTACT LOMBARDINI APPLICATION ENGINEERING DEPARTMENT FOR DETAILS

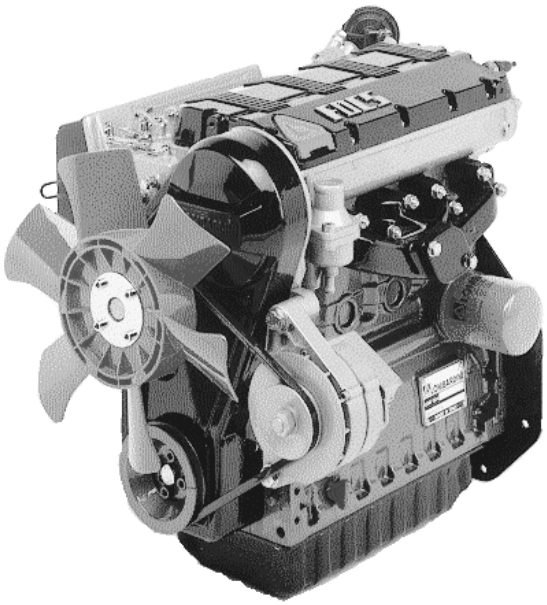
FLUID CAPACITIES (STANDARD)					
Oil Capacity (including oil filter)- (liters)	1.6	1.6	2.4	3.2	4.3
Oil Capacity (less oil filter)- (liters)	1.5	1.5	2.3	3.0	4.1
Coolant Capacity (including std. radiator)- (liters)	2.3	4.0	4.9	6.0	7.5
Coolant Capacity (engine only)- (liters)	0.8	0.9	1.3	1.8	2.0
Fuel Tank-standard (OPTIONAL)- (liters)	4.3	4.3	10.0	15.0	15.0

NOTE: The above cooling system capacities (including radiator) assume that the radiator fitted to your Lombardini FOCS series diesel engine is the standard Lombardini radiator. Different OEM machines may or may not be fitted with a standard Lombardini radiator. Always refer to your equipment documentation for capacity details.

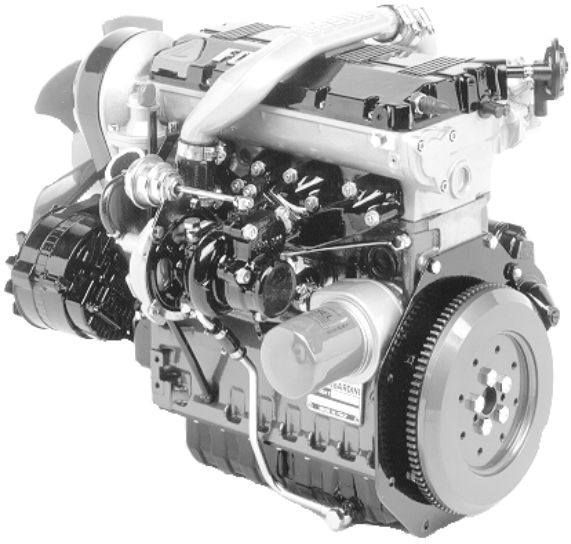


LDW 502/602

LDW 903



LDW 1204



LDW 1204/T

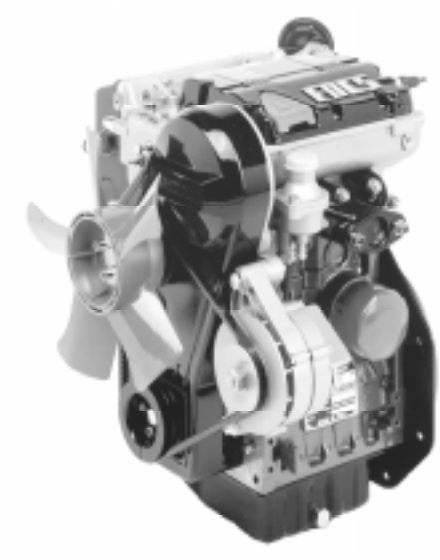
LDW FOCS SERIES- TECHNICAL SPECIFICATIONS AND CAPACITIES			
TECHNICAL SPECIFICATIONS	**LDW 702**	**LDW 1003**	**LDW 1404**
No. of Cylinders	2	3	4
Firing Order	1-2	1-3-2	1-3-4-2
Cylinder Bore (mm)	75	75	75
Cylinder Stroke (mm)	77.6	77.6	77.6
Displacement (cc)	686	1028	1372
Aspiration Type	Natural	Natural	Natural
Compression Ratio	22.8:1	22.8:1	22.8:1
RPM- maximum	3600	3600	3600
Power- (N)- ISO 1585- KW(CV)-@3600 r/min	13(17.7)	20(27.2)	27.2(36.7)
Power- (Nb)- ISO 3046-1 IFN- KW(CV)-@3600 r/min	11.7(16)	18(24.5)	25(34)
Power- (Na)- ISO 3046-1 ICXN- KW(CV)-@3600 r/min	10.6(14.4)	16.3(22.2)	22.8(31)
Torque(MAX)/rpm @Nb output, (Nm)	40/2200	59/2200	82.5/2200
Maximum Torque Available @ N0. 3 PTO (Nm)	37/1800	37/1800	37/1800
Fuel Consumption (Nb)@3600 rpm- (g/KWh)	320	300	325
Oil Consumption (Na)- (Kg/hr)	0.009	0.013	0.019
Dry Weight- (Kg)	66	87	98
Inclination (max)- (30 seconds)	35°	35°	35°
Inclination (max)- (60 seconds)	30°	30°	30°
Inclination (continuous)- APPLICATION DEPENDENT	****	****	****
Axial Load (max) on Crankshaft (both directions)- (Kg)	300	300	300
Radial (side) Load - APPLICATION DEPENDENT	****	****	****

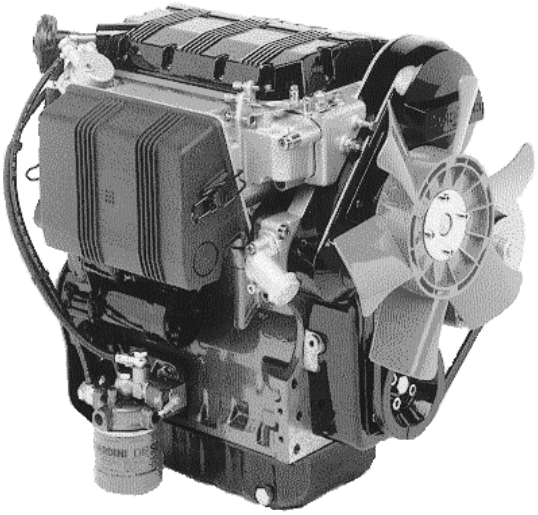
**** - CONTACT LOMBARDINI APPLICATION ENGINEERING DEPARTMENT FOR DETAILS

FLUID CAPACITIES (STANDARD)			
Oil Capacity (including oil filter)- (liters)	1.6	2.4	3.2
Oil Capacity (less oil filter)- (liters)	1.5	2.3	3.0
Coolant Capacity (including std. radiator)- (liters)	2.3	4.9	6.0
Coolant Capacity (engine only)- (liters)	0.9	1.3	1.7
Fuel Tank-standard (OPTIONAL)- (liters)	4.3	4.3	10.0

NOTE: The above cooling system capacities (including radiator) assume that the radiator fitted to your Lombardini FOCS series diesel engine is the standard Lombardini radiator. Different OEM machines may or may not be fitted with a standard Lombardini radiator. Always refer to your equipment documentation for capacity details.

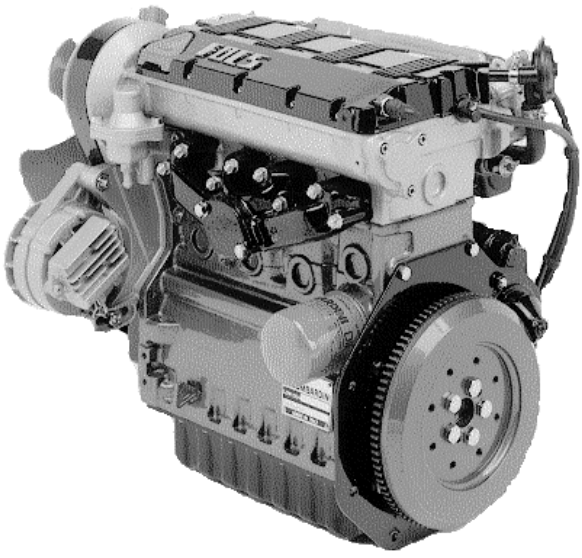
LDW 702





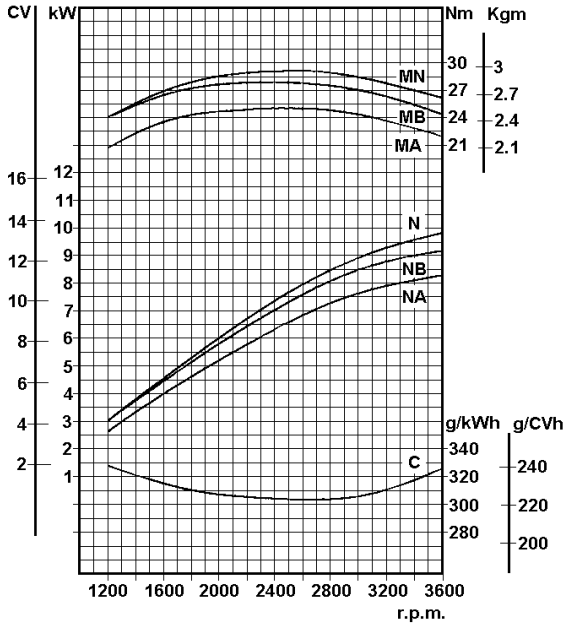
LDW 1003

LDW 1404

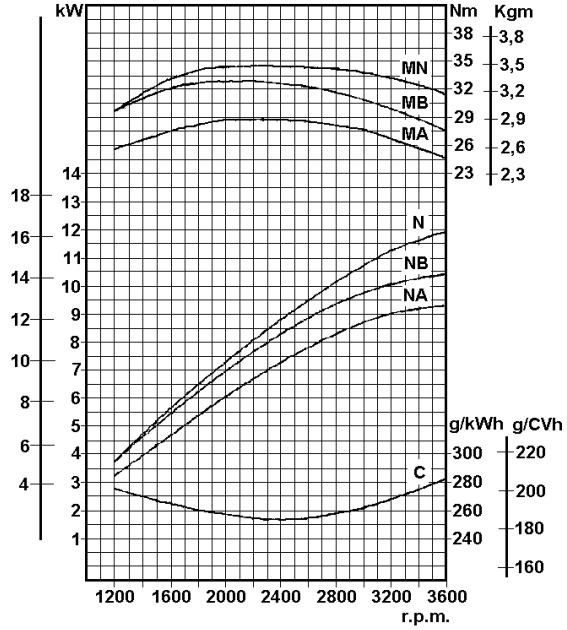


POWER, TORQUE AND SPECIFIC FUEL CONSUMPTION CURVES
LDW 502 FOCS, LDW 602 FOCS, LDW 903 FOCS

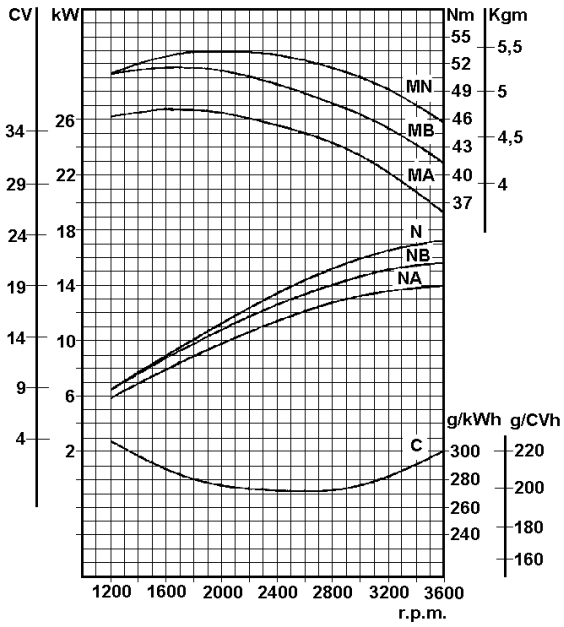
LDW 502



LDW 602



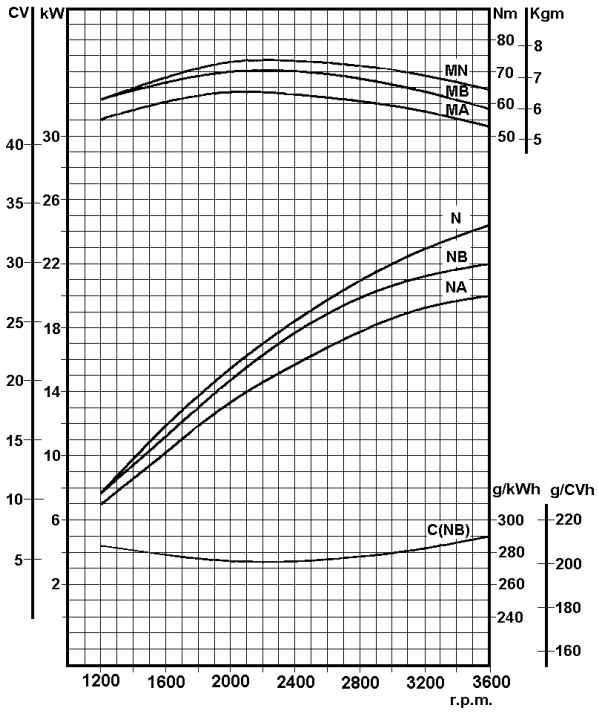
LDW 903



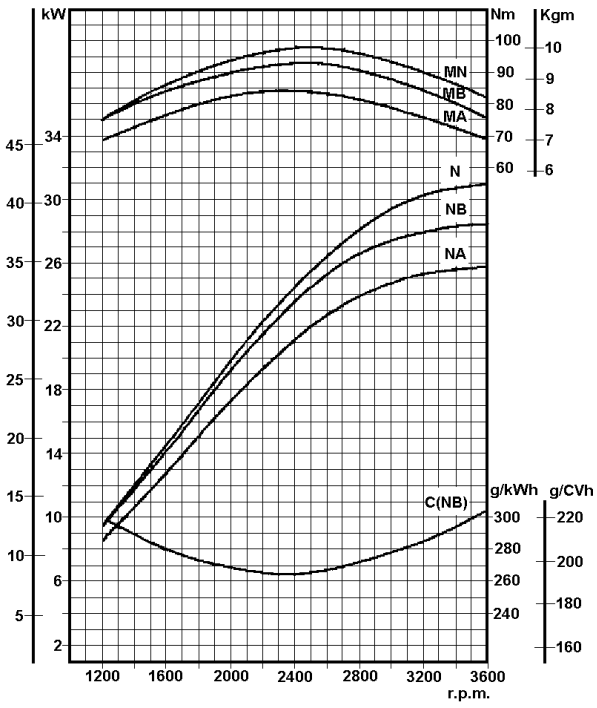
N - 80/1269/CEE- ISO 1585, Gross automotive rating- intermittent operation with variable speed and variable load.
NB- ISO 3046/1-IFN - Maximum intermittent rating with no overload capacity; operation with constant speed and variable load.
NA- ISO 3046/1-ICXN- Continuous rating with 10% intermittent overload allowed; operation with constant speed and constant load.
M(X)- Torque at N, NB and NA ratings respectively.
C- Specific fuel consumption at NB rating.
Standard Rating Conditions: 25°C, 100kPa Total Barometric Pressure, 30% Relative Humidity.
Standard Production Power Tolerance = +/- 5%
Standard/ General Derations: 2% per 5°C increase in temperature over 25°C; 1% per 100m over mean sea level

POWER, TORQUE AND SPECIFIC FUEL CONSUMPTION CURVES
LDW 1204 FOCS and LDW 1204/T FOCS

LDW 1204



LDW 1204/T



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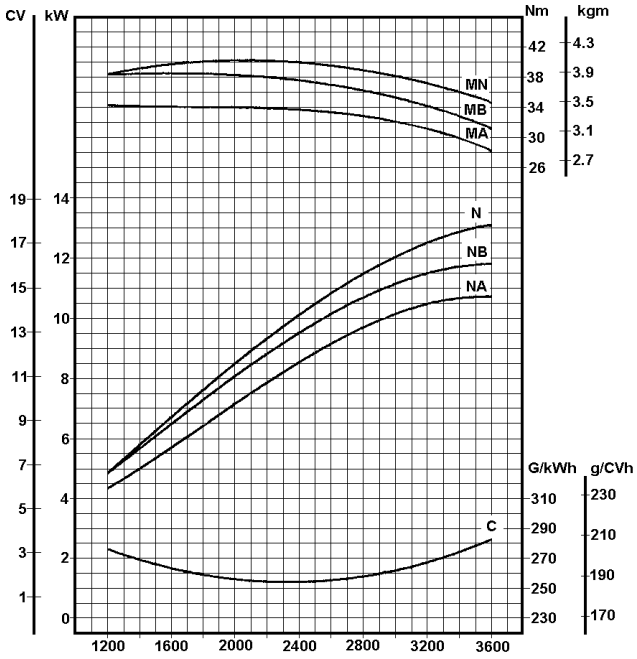
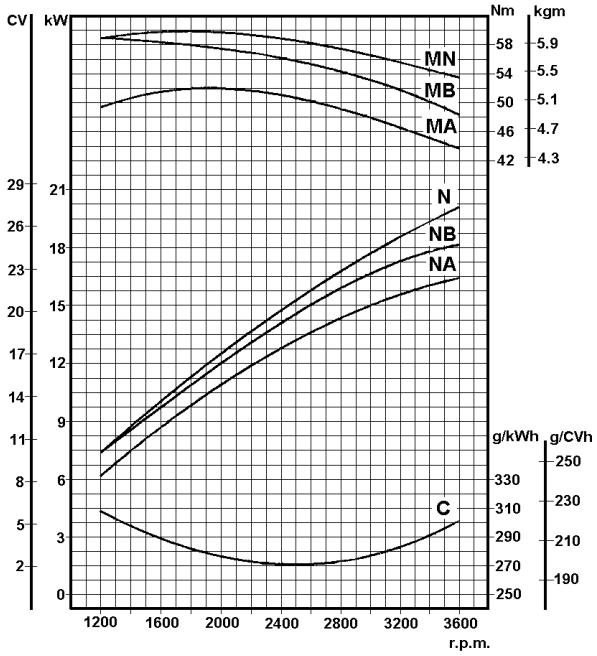
Standard Rating Conditions: 25°C, 100kPa Total Barometric Pressure, 30% Relative Humidity.
Standard Production Power Tolerance = +/- 5%
Standard/ General Derations: 2% per 5°C increase in temperature over 25°C; 1% per 100m over mean sea level

POWER, TORQUE AND SPECIFIC FUEL CONSUMPTION CURVES
LDW 702 FOCS, LDW 1003 FOCS, LDW 1404 FOCS

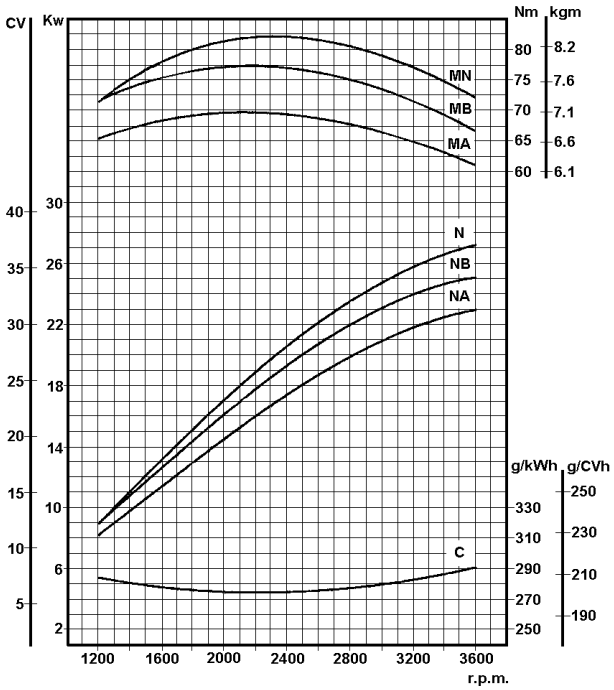
LDW 702



LDW 1003



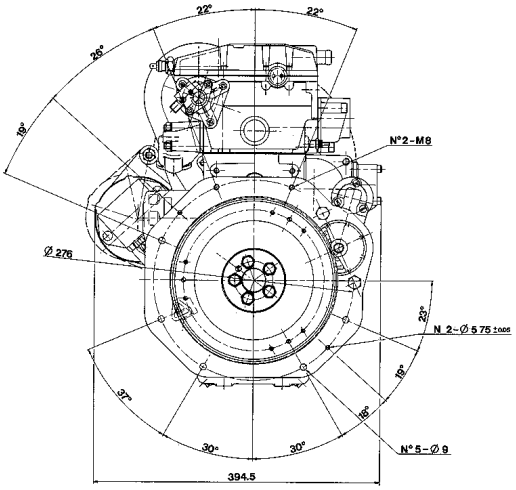
LDW 1404

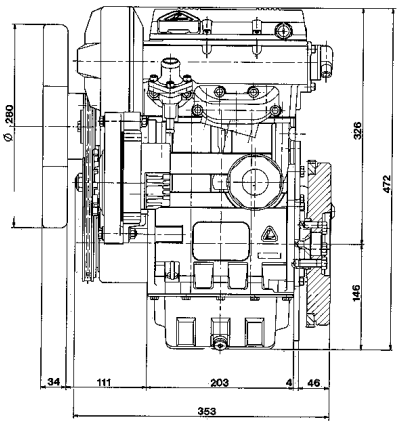


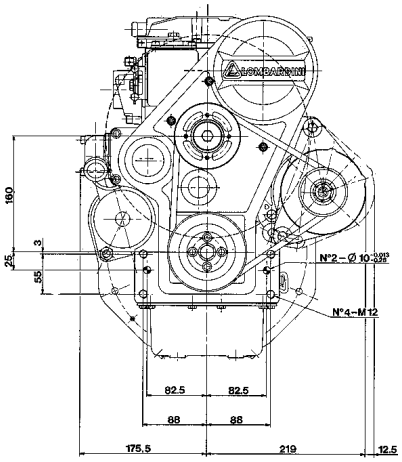
N - 80/1269/CEE- ISO 1585, Gross automotive rating- intermittent operation with variable speed and variable load.
NB- ISO 3046/1-IFN - Maximum intermittent rating with no overload capacity; operation with constant speed and variable load.
NA- ISO 3046/1-ICXN- Continuous rating with 10% intermittent overload allowed; operation with constant speed and constant load.
M(X)- Torque at N, NB and NA ratings respectively.
C- Specific fuel consumption at NB rating.
Standard Rating Conditions: 25°C, 100kPa Total Barometric Pressure, 30% Relative Humidity.
Standard Production Power Tolerance = +/- 5%
Standard/ General Derations: 2% per 5°C increase in temperature over 25°C; 1% per 100m over mean sea level

GENERAL ENGINEERING DRAWINGS- LDW 502 FOCS, LDW 602 FOCS, LDW 903 FOCS

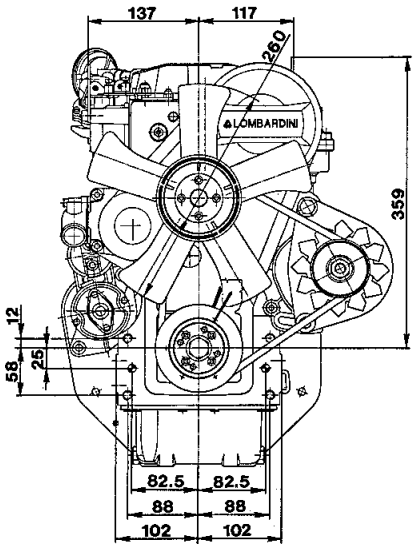
LDW 502

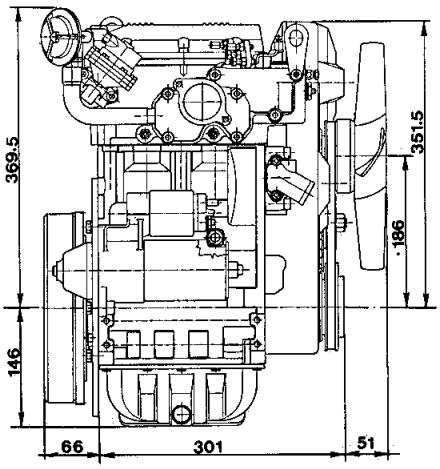


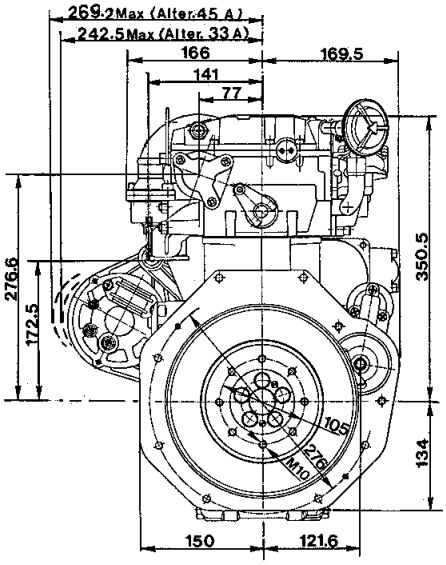




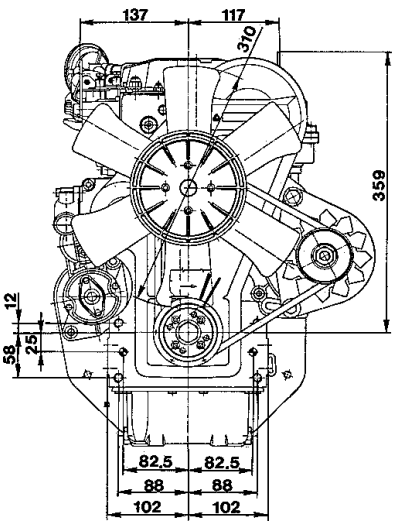
LDW 602

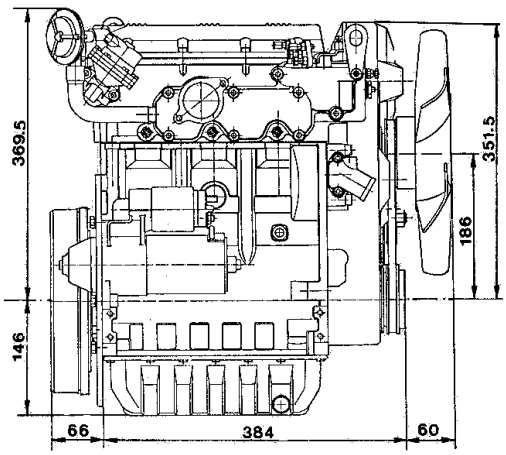


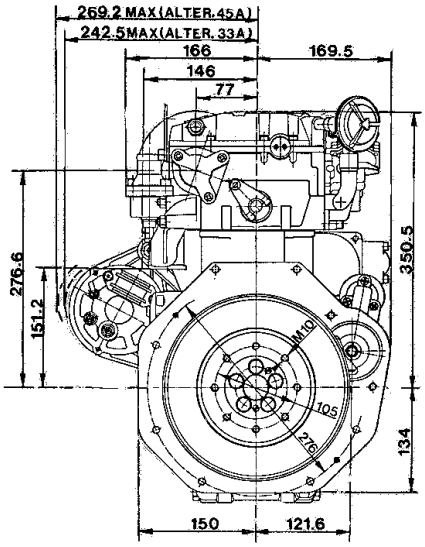




LDW 903

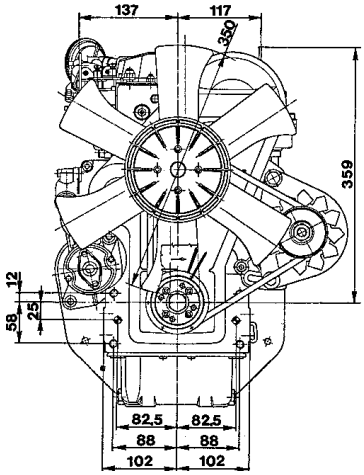


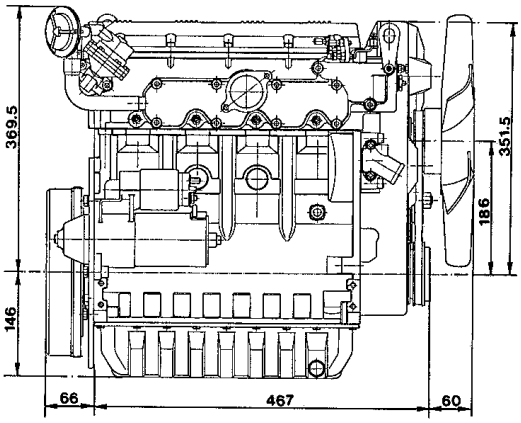


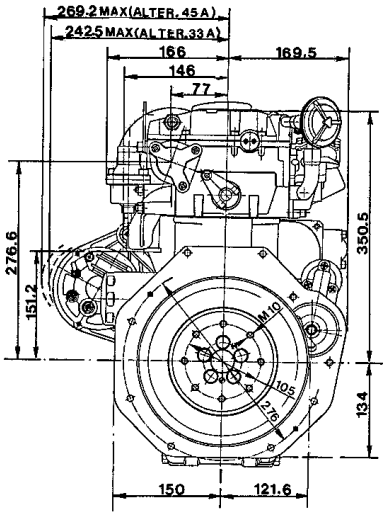


GENERAL ENGINEERING DRAWINGS- LDW 1204 FOCS, LDW 1204/T FOCS

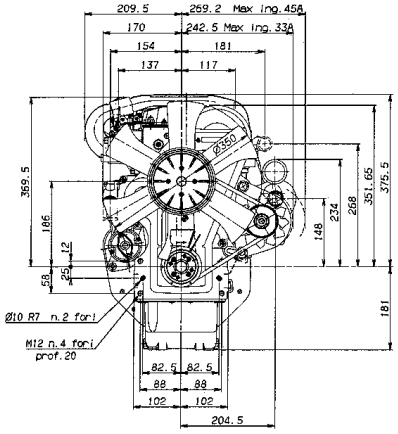
LDW 1204

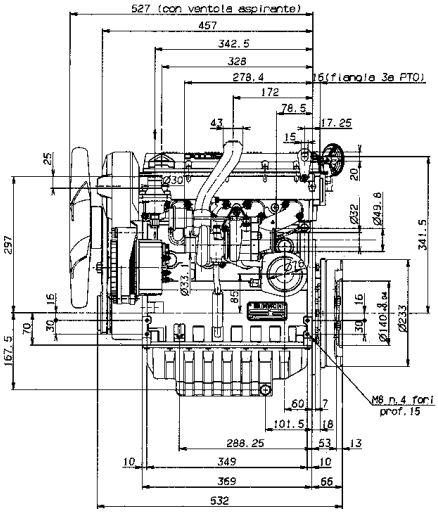


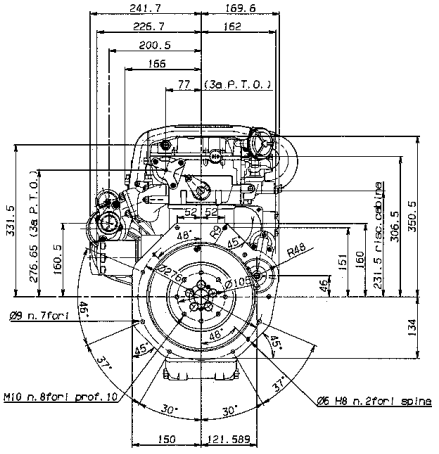




LDW 1204/T

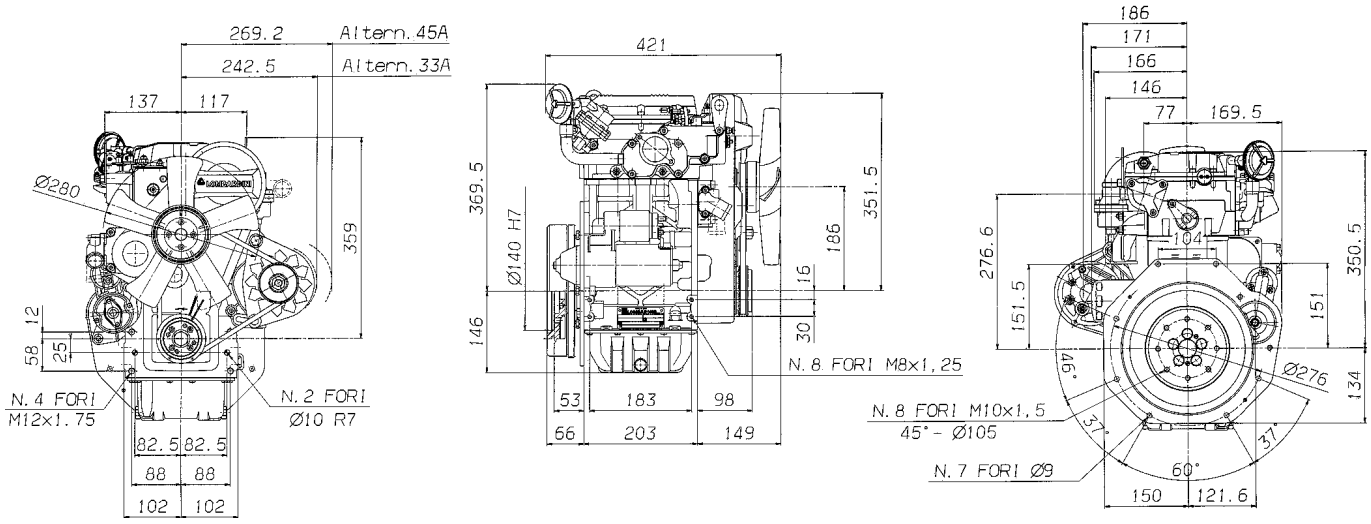




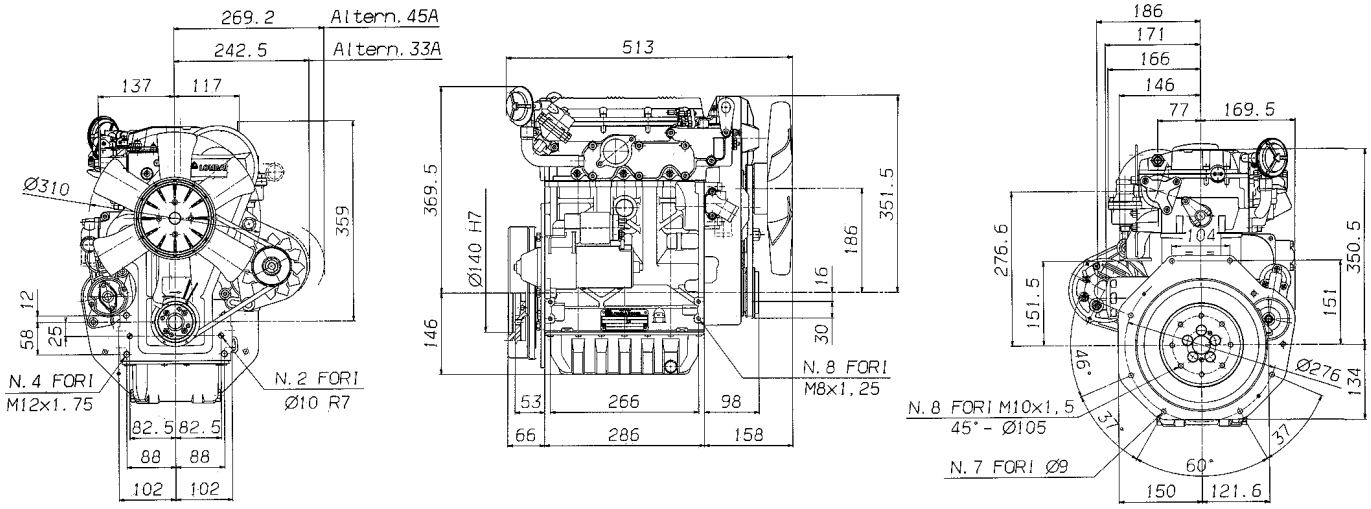


GENERAL ENGINEERING DRAWINGS- LDW 702 FOCS, LDW 1003 FOCS, LDW 1404 FOCS

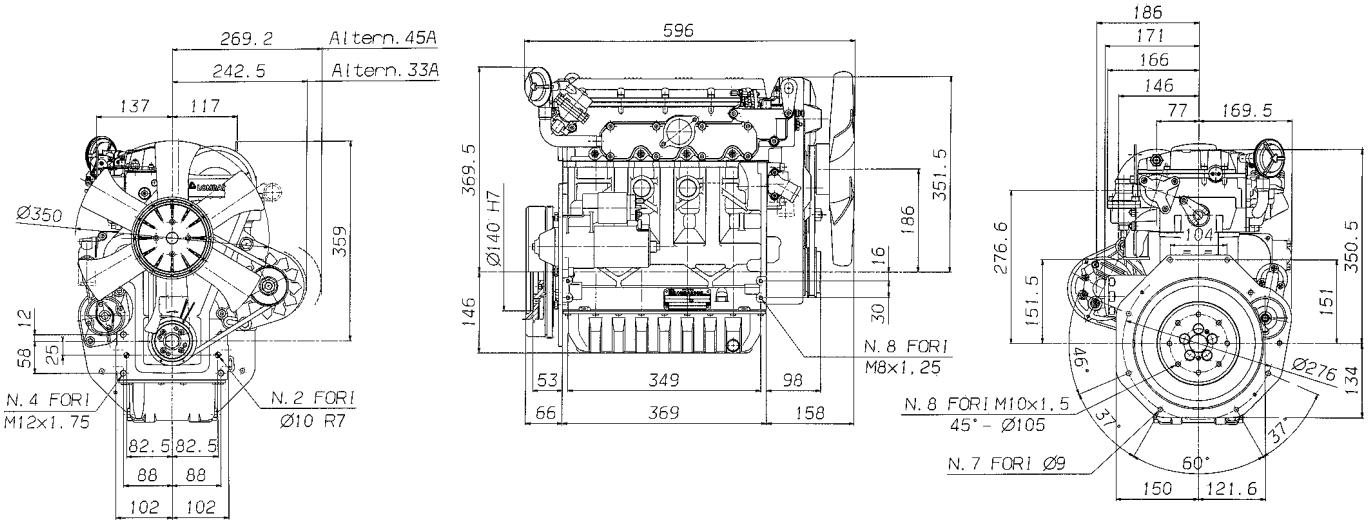
LDW 702



LDW 1003



LDW 1404



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

LDW- FOCS SERIES MAINTENANCE SCHEDULE

MAINTENANCE OPERATION	MAINTENANCE INTERVAL						
	10 hours or DAILY	50 hours	125 hours	250 hours	500 hours	1000 hours	2500 hours
OIL LEVEL CHECK (D)	▪						
COOLANT LEVEL CHECK (D)	▪						
FAN/ ALTERNATOR BELT INSPECTION (•)	▪						
AIR FILTER ELEMENT CHECK (DRY TYPE) (*)	see note						
AIR FILTER CHECK (OIL BATH TYPE) (**)	▪						
RADIATOR CORE INSPECTION (⦿)	▪						
FLUID LEAK INSPECTION- GENERAL (•)	▪						
SAFETY GUARD INSPECTION (•)	▪						
OIL REPLACEMENT- INITIAL ONLY-(see RECOMMENDED OIL TYPE)		▪					
OIL FILTER REPLACEMENT - INITIAL ONLY		▪					
OIL REPLACEMENT- (see RECOMMENDED OIL TYPE)			▪				
OIL FILTER REPLACEMENT				▪			
FUEL FILTER REPLACEMENT				▪			
COOLANT HOSE INSPECTION				▪			
FAN/ ALTERNATOR BELT TENSION ADJUSTMENT				▪			
VALVE ADJUSTMENT					▪		
FAN/ ALTERNATOR BELT REPLACEMENT					▪		
FUEL INJECTION SYSTEM ADJUSTMENT					▪		
CLEAN FUEL TANK (⦿)						▪	
COOLANT REPLACEMENT (***)						▪	
REPLACE TIMING BELT							▪

(D) Add fluid(s) as required
(•) After inspection, adjust, repair or replace as required
(⦿) Clean as often as required
(*) Replace air filter after air filter restriction switch indication or one(1) year. Lombardini does not recommend the removal of air filter elements for purposes of inspection.
(**) Service oil bath filter element (upper and lower) as required. Replace reservoir oil as required. NOTE: In dusty conditions, service the oil bath air filter every four(4) hours.
(***) Replace coolant every 1000 hours or 2 years

NOTES: 1. USE ONLY GENUINE LOMBARDINI REPLACEMENT PARTS.
2. USE ONLY LOMBARDINI APPROVED FLUIDS.

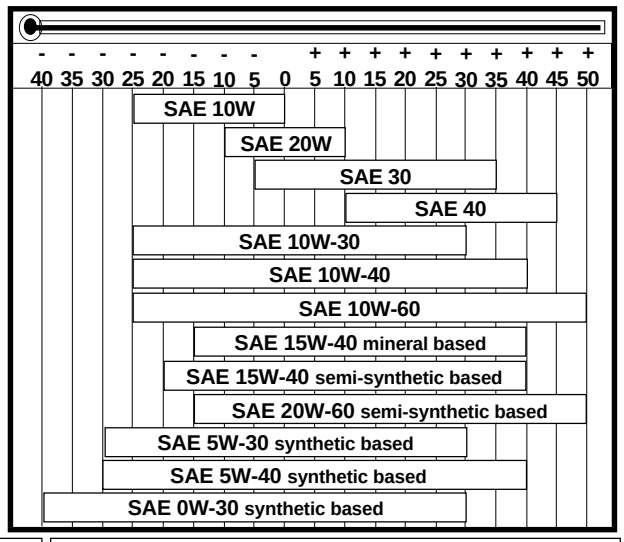
The engine could be damaged if allowed to operate with insufficient oil. It is also dangerous to add too much oil as its combustion could sharply increase the rotation speed.
Use a suitable oil in order to protect the engine.
The lubrication oil influences the performances and life of the engine in an incredible way.
Use of an inferior quality oil or failure to regularly change the oil will increase the risk of piston seizure, may make the compression rings 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.
Oil viscosity must suit the ambient temperature in which the engine operates.

Old oil can cause skin cancer if repeatedly left in contact with the skin and for long periods of time. If contact with the oil is inevitable, you are advised to thoroughly wash your hands with soap and water as soon as possible.
Appropriate protective gloves etc should be wore during this operation.
Old oil is highly polluting and must be disposed of in the correct way. Do not litter.

RECOMMENDED OIL

AGIP SINT 2000 5W40 specification API SJ/CF ACEA A3-96 B3-96 MIL-L-46152 D/E.
ESSO ULTRA 10W40 specification API SJ/CF ACEA A3-96 MIL-L-46152 D/E.
In countries where AGIP and ESSO products are not available, use API SJ/CF oil for gasoline-fuelled engines or oil that complies with military specification MIL-L-46152 D/E.

GRADE



OIL SUPPLY (liters) 502 - 602 - 702
Standard oil sump
filter included 1.6
filter excluded 1.5

OIL SUPPLY (liters) 903 - 1003
Standard oil sump
filter included 2.4
filter excluded 2.3

OIL SUPPLY (liters) 1204 -1404
Standard oil sump
filter included 3.2
filter excluded 3.0

OIL SUPPLY (liters) 1204/T
Standard oil sump
filter included 4.3
filter excluded 4.1

ACEA SEQUENCES

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

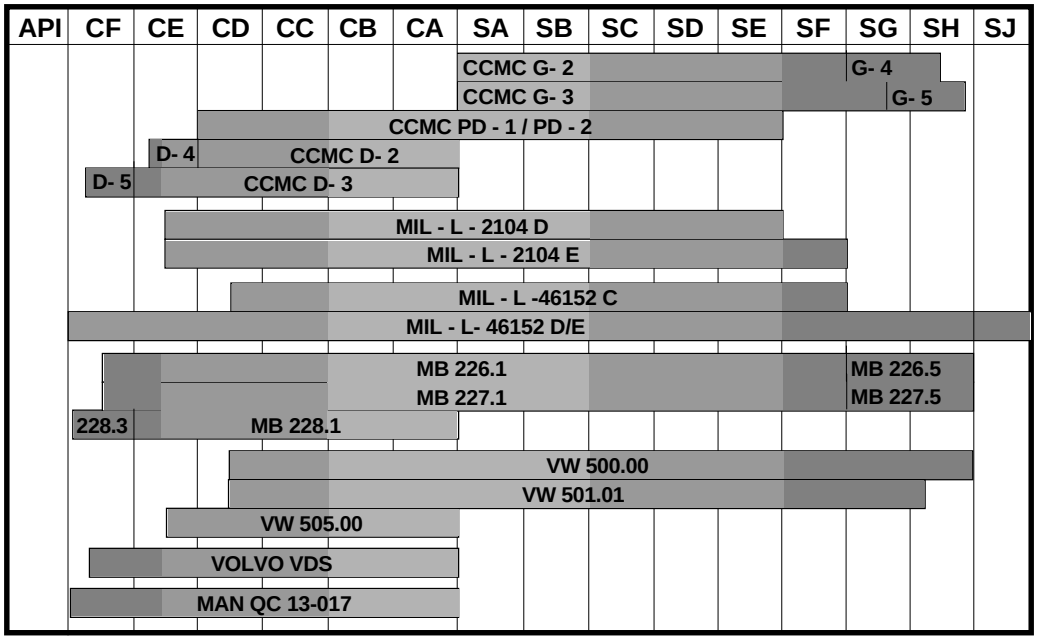
Required levels :

A1-96
A2-96
A3-96

B1-96
B2-96
B3-96

E1-96
E2-96
E3-96

DIESEL	BENZINA - ESSENCE - PETROL BENZIN - GASOLINA -



DIESEL FUEL SPECIFICATIONS

Diesel fuel must be clean, fresh, meet Lombardini fuel specifications and be sourced from a known and reputable supplier. Clean, fresh and properly specified diesel fuel will provide assurances of maximum engine performance and maximum fuel injection system longevity. The use of out-of-spec, dirty or questionable quality diesel fuel will result in engine performance and start ability problems as well as reductions in engine and fuel injection system life.

Lombardini diesel engines are designed to operate on No. 2 diesel fuel. However, some geographical areas, by virtue of cold winter temperatures, change the diesel fuel supply depot to No. 1 diesel fuel in winter months. No. 2 diesel fuel provides maximum viscosity and lubricity but can have “waxing” problems at lower temperature. Lombardini expressly recommends the use of No. 2 diesel fuels when temperatures are above -10°C (14°F). Lombardini recommends that No. 1 diesel fuel be used when temperatures are at or below -10°C (14°F). Lombardini allows the use of either EPA- High Sulfur, off-highway diesel fuel or EPA- Low Sulfur, on-highway fuel for non-CARB certified engines. CARB certified engines must consume only EPA- low sulfur diesel fuels conforming to EPA 40 CFR 86-113-94. For general non-CARB certified engines, Lombardini highly recommends that either low sulfur or high sulfur fuel be used on a continuous basis. Mixing the usage of low sulfur and high sulfur fuels can cause complications within the fuel injection system and thus is not recommended.

Lombardini does not recommend the use of “heating oil”, blended fuel/ waste engine oil, or low grade diesel fuel of any kind. The use of aviation fuels- JP4, JP5 or JP8 must be approved on an application basis and is not recommended for broad range commercial applications.

EPA FUEL SPECIFICATIONS (No. 2 DIESEL FUEL):

	ASTM TEST	EPA 40CFR 86.113-90 (OFF-HIGHWAY FUEL)	EPA 40CFR 86.113-94 (ON-HIGHWAY FUEL)
CETANE NUMBER	D613	42-50	40-48
DISTILLATION RANGE			
BP	D86	340-400°F (171.1-204.4°C)	340-400°F (171.1-204.4°C)
10% point	D86	400-460°F (204.4-237.8°C)	400-460°F (204.4-237.8°C)
50% point	D86	470-540°F (243.3-282.2°C)	470-540°F (243.3-282.2°C)
90% point	D86	550-610°F (287.8-321.1°C)	560-630°F (287.8-321.1°C)
EP	D86	580-660°F (304.4-348.9°C)	610-690°F (304.4-348.9°C)
GRAVITY (API)	D287	33-37	33-37
TOTAL SULFUR (pct.)	D129 D2622	0.2-0.5	0.03-0.05
HYDROCARBONS			
AROMATICS (min. pct.)	D1319	27	27
PARAFFINS, OLEFINS, NAPHTHENES (pct.)	D1319	73	73
FLASHPOINT	D93	130°F (54.4°C)	130°F (54.4°C)
VISCOSITY (CSt)	D445	2.0-3.2	2.0-3.2

NOTE: BY LAW, EPA 40CFR 86.113-90 FUEL MUST BE DYED RED.

FUEL QUALITY/ STORAGE:
No. 1 and No. 2 Diesel fuel degrades with time. No. 2 diesel fuel has a storage life of approximately one(1) year. No. 1 diesel fuel has a maximum storage life of two(2) years. Further, storage of diesel fuel in contaminated storage tanks can lead to excessive impurities within the stored fuel. As such, aged or contaminated diesel fuel should not be consumed by Lombardini diesel engines. Aside from the specifications listed above, fuel measured to have total insolubles > 1mg/100mg, organic matter > 1mg/100ml or rust/mineral matter > 2mg/ml should not be consumed by Lombardini diesel engines.

ANTI-FREEZE / COOLANT SPECIFICATIONS/ DETAILS- FOCS SERIES

Ethylene Glycol based Anti-freeze / coolant usage is required for all Lombardini LDW-FOCS series engines. Never operate a LDW-FOCS engine with the cooling system filled with water only. The purpose of the anti-freeze/coolant is three-fold. First the anti-freeze/coolant mixture prevents or reduces the potential for corrosion within the cooling system. Secondly, the anti-freeze/ coolant increases the boiling point of the cooling fluid, reducing the potential for localized boiling within the engine and engine overheat in general. Lastly, the anti-freeze/coolant reduces the freezing point of the engine coolant, thereby reducing or preventing potential engine damage caused by freezing.

Many different brands and types of anti-freeze are available in the market. Some anti-freeze/coolants are designed exclusively for automotive type cooling systems with aluminum cooling system components. Other anti-freeze/coolants are designed exclusively for use within heavy-duty, predominately cast iron cooling systems and require that the coolant solution be “charged” with a Supplemental Coolant Additive (SCA). Other anti-freeze solutions are designed for long life and are sometimes designated “permanent”.

Lombardini recommends only those anti-freeze/coolants which are ethylene glycol based and designed to protect aluminum coolant components- thus, automotive anti-freeze/coolant. Long life anti-freeze/coolants may be used so long as the anti-freeze/coolant is changed at least every two(2) years as is required by the Lombardini maintenance schedule. Lombardini does not recommend the use of low silicate heavy duty anti-freeze/coolants which may or may not require the use of SCA’s. The following provides guidelines for the selection of acceptable anti-freeze/coolants for LDW-FOCS series diesel engines.

ANTI-FREEZE/COOLANT CONCENTRATION

Lombardini recommends that the minimum anti-freeze/coolant concentration be 30% when mixed with distilled water. Concentrations below 30% will not provide adequate corrosion protection. Lombardini further recommends that the maximum allowable anti-freeze/coolant concentration be 60% when mixed with distilled water. Concentrations of anti-freeze/coolant in excess of 60% provide no appreciable additional freeze protection and can actually reduce the heat rejection capability of the cooling system. As such, Lombardini recommends that an anti-freeze / coolant mixture of 50% anti-freeze/coolant and 50% distilled water be used for most general applications. In general terms the freezing points of anti-freeze/coolant solutions (ethylene glycol based) with respect to concentration is 30%/ -15°C(5°F); 40%/ -24°C(-12°F); 50%/ -37°C(-34°F); 60%/ -52°C(-62°F). Please refer to the details regarding freezing points as supplied from your anti-freeze/coolant supplier for more exact information.

WATER SPECIFICATIONS

Lombardini recommends that the engine cooling fluid solution be made up of the ethylene glycol based anti-freeze/coolant and distilled water. Further, we realize that the use of distilled water is not always practical. The quality of the base water does play a large role in the overall chemical composition of the coolant solution and the corrosion prevention characteristics of the solution. As such, tap water may be used as long as the water meets the following specifications with reference to SAE j1941:

PROPERTY	SPECIFICATION	TEST METHOD
Total Solids (max.)	340ppm	ASTM D1888
Total Hardness (max. $CaCO_3$)	170ppm	ASTM D1126
Chloride (max.)	40ppm	ASTM D512
Sulfate (max. SO_4)	100ppm	ASTM D516
pH	5.5-9.0	ASTM 1293

ANTI-FREEZE COOLANT MINIMUM RECOMMENDATIONS/ SPECIFICATIONS

Lombardini recommends that only automotive type anti-freeze/coolants be used in LDW-FOCS series diesel engines. These anti-freeze/coolants are typically “High Silicate” , although not always, and are designed to prevent corrosion in cooling systems with aluminum components. The chosen coolant should meet or exceed ASTM 3306 and SAE j1034. Further, the chosen anti-freeze/coolant should pass ASTM D4340, ASTM D1384 and ASTM D2570 corrosion tests as detailed within SAE j1034.

NOTE: Many brands/ products meet the specifications presented above and may be used within Lombardini LDW-FOCS series diesel engines. The engine owner is responsible for determining the suitability of any given anti-freeze/coolant to the minimum specifications provided. Failure to follow the above coolant guidelines may impact the engine warranty.

DRIVING TORQUES FOR STANDARD SCREWS

DENOMINATION						
Diameter x pitch (mm)	R ³ 800 N/mm²		R ³ 1000 N/mm²		R ³ 1200 N/mm²	
	Nm	Kgm	Nm	Kgm	Nm	Kgm
4x0.70	3.6	0.37	5.1	0.52	6	0.62
5x0.80	7	0.72	9.9	1.01	11.9	1.22
6x1.00	12	1.23	17	1.73	20.4	2.08
7x1.00	19.8	2.02	27.8	2.84	33	3.40
8x1.25	29.6	3.02	41.6	4.25	50	5.10
9x1.25	38	3.88	53.4	5.45	64.2	6.55
10x1.50	52.5	5.36	73.8	7.54	88.7	9.05
13x1.75	89	9.09	125	12.80	150	15.30
14x2.00	135	13.80	190	19.40	228	23.30
16x2.00	205	21.00	289	29.50	347	35.40
18x2.50	257	26.30	362	37.00	435	44.40
20x2.50	358	36.60	504	51.50	605	61.80
22x2.50	435	44.40	611	62.40	734	74.90
24x3.00	557	56.90	784	80.00	940	96.00

SEALANT and THREAD LOCK LOCATIONS/ DETAILS

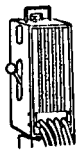
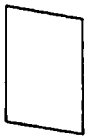
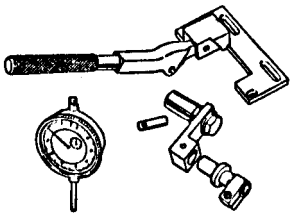
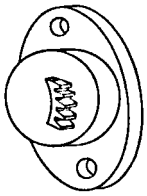
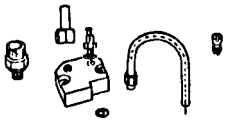
LOCATION	DETAIL	SEALANT / THREAD LOCK (LOCTITE BRAND)
Valve / Rocker Cover	12mm Crankcase Vent Tube	638
Oil Filter Nipple	M20x1.5 Hollow Nipple	601
Camshaft Bearing Retainer Bolts	M6	270
Timing Belt Idler Stud to Crankcase	M10	601
Crankcase	M12x1.5 Plug	242
Cylinder Head	18mm Plug	510
Cylinder Head	M6x1.0 Stud	601
Crankcase and Cylinder Head	Welch Plugs (30mm)	510

CRITICAL TORQUE SPECIFICATIONS			
POSITION/ LOCATION	Page No. Ref.	Diameter/ Pitch (mm)	TORQUE (Nm)
Injection Pump Control Rod (Rack Adjustment)	78	M3 (special)	1.1
Injection Pump Control Rod to Unit Injector Rack Bolt	34	M3 (special)	1.2
Fuel Rail	34	M4x0.7	4
Connecting Rod (***)	44	M8x1.00	40
Piston Cooling Jet (LDW 1204/T)		M8X1.5	12
Glow Plugs		M12x1.25	25
Valve / Rocker Cover	33	M6x1.00	9
Main Bearing Cap	47	M10	60
Oil Pan	40	M6	10
Camshaft Roller Bearing Retainer		M6	10
Glow Plug Wire Nut		M5x0.8	5
Timing Belt Idler	28	M10	40
Stop Lever Nut		M8x1.25	8
Unit Injector Retainer Nut	30	M8	20 (*)
Rocker Arm Support	35	M10	40
Fuel Pump Eccentric	34	M10x1.25	80
Oil Seal Support (Flywheel Side)		M6	12
Pre-chamber Ring Nut	40	M30x1.5	(**)
Governor Fork Pivot		M6x1.00	7
Crankshaft Pulley (V)	26	M16x1.5 (Left Hand)	360
Camshaft Timing Pulley	27	M10x1.25	80
Oil Pressure Switch		M12x1.5	25
Oil Pan Plug		M12x1.5	40
Cylinder Head	46	SEE MANUAL FOR DETAILS	
Flywheel	26	M10x1.5	80

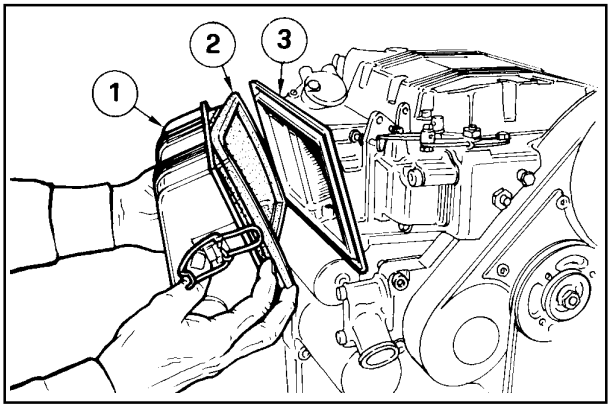
(*) Torque the unit injector retaining nuts alternately in 5 Nm steps

(**) Torque the pre-chamber ring nut to 100 Nm first, then torque to 180 Nm.

(***) Torque aluminum connecting rods to 35 Nm.

SPECIAL TOOLS	DESCRIPTION	PART No.
	Fuel delivery equalization tool. Allows the adjustment of individual unit injector fuel delivery.	7107-1460-090
	Pre-chamber removal tool.	7107-1460-030
	Static timing tool	7107-1460-024
	Main bearing cap lateral seal installation tool.	7107-1460-053
	Unit injector ring nut tool.	7107-1460-029
	Pre-chamber ring nut tool.	7107-1460-027
	Pre-chamber index.	7107-1460-031
	Union for static timing adjustment/ testing.	7107-1460-028
	Valve guide seal installation tool.	7107-1460-047
	T.D.C. determination fixture.	7107-1460-048
	Timing Belt tension tool.	7107-1460-049
	Flywheel/ Ring gear engine locking tool.	7107-1460-051
	Static timing kit for “low pressure” testing/ adjustment.	7107-1460-074 7107-1460-056 (See pg. 55 for details)

WARNING: Always exercise extreme care when performing engine service work. Refer to and understand the safety guidelines presented on page 3. Additionally, some engine components have sharp edges which could cause cuts if not handled properly. Wear hand protection. Further, some engine components are heavy. As such, wear foot protection to protect from accidental drops of engine components. Always use proper form and procedures when lifting engine components. Ask for help or assistance if in doubt concerning the lifting or manipulation of the engine or engine components. The use of compressed air is required for some operations. Compressed air can be dangerous. Do not direct compressed air towards yourself or others. Do not allow bearings to spin while drying with compressed air. The use of cleaning solvents is also required for certain service operations. When “SOLVENT” is recommended, a commercially available, low-toxicity, degreasing solvent such as “SAFETY-KLEEN” should be used. Wear hand and eye protection and avoid direct contact with solvents.



DRY TYPE AIR FILTER- STANDARD ENGINE MOUNTED

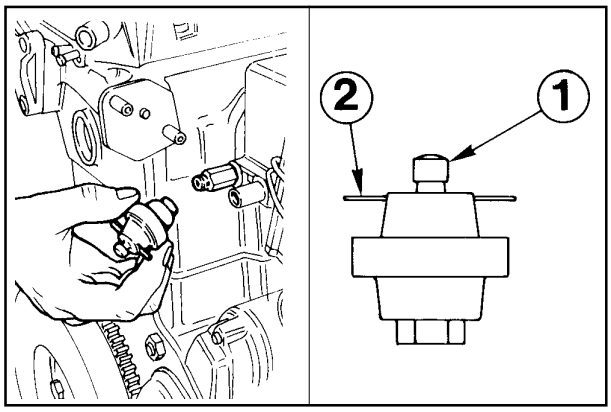
Components:

1	Cover
2	Filter Element
3	Support

Air Filter Specifications:

Filtration Level	13-14 micron
Filtration Area	4470 cm^2- 502, 602, 702, 903, 1003
Filtration Area	7150 cm^2- 1204, 1404

INSPECTION: Inspect the air filter cover for cracks, heat damage or warpage. Replace as required.

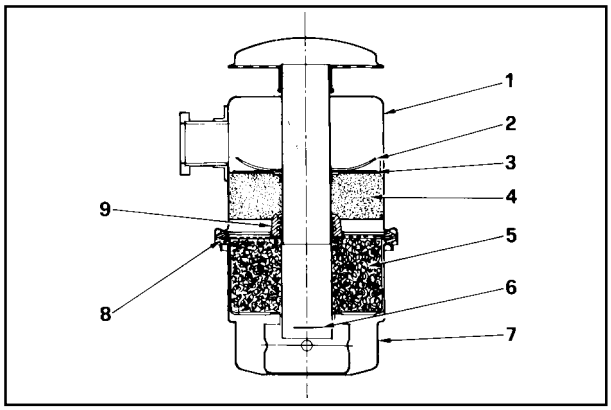


AIR RESTRICTION SWITCH

LDW FOCS diesel engines that are supplied with engine mounted, panel type air filters as shown above, are fitted with an air filter restriction switch. The purpose of the air restriction switch is to signal the engine operator, via a lamp or otherwise, of a high air filter restriction condition. The electrical connections for the signal is provided at (2) as shown. Following a signal from the restriction switch, the switch must be reset. Reset the switch by pushing button (1) until the button latches. The restriction switch is set to 600/650 mm-H_2O.
After the restriction signal, the air filter should be replaced at once. Do not clean the air filter element. Operation in a high restriction condition could cause excessive oil consumption, low power output, engine overheating and potentially engine damage.

Components:

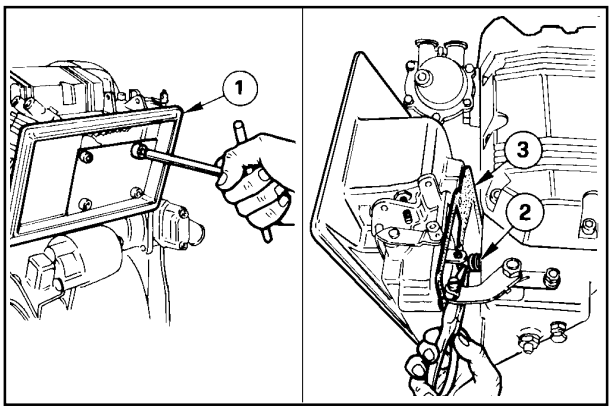
1	Reset Button
2	.25” Tab Connection



OIL BATH AIR FILTER

1	Upper Housing	6	Oil level reference mark (on 7)
2	Diaphragm Seat	7	Reservoir bowl
3	Diaphragm	8	Outer seal ring
4	Polyurethane upper element	9	Inner seal ring
5	Metal wool lower element		

Service Instructions: Check the sealing rings regularly. Replace the sealing rings if hardening or damage is noted. Inspect the air filter housing and bowl- replace if damaged. Carefully clean the reservoir bowl and both elements with clean diesel fuel. Blow the lower element dry with compressed air. Dry the upper element by squeezing out excess diesel fuel, then drying with suitable cloths. Fill the reservoir with clean engine oil to the reference mark. DO NOT OVERFILL.

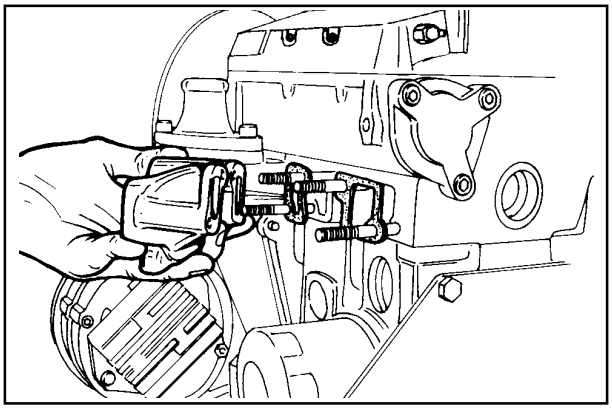


AIR FILTER SUPPORT- (INTAKE MANIFOLD)

REMOVAL: Disassemble the air filter cover and air filter element. Loosen the crankcase ventilation hose (see page 29) and pull the hose from the air filter support. Remove all bolts that secure the air filter support (1) to the cylinder head. Carefully pull the air filter support from the cylinder head. Using suitable pliers, release the governor spring (2) from the air filter support assembly.

INSPECTION: Carefully clean the gasket (3) from the air filter support and the cylinder head. Clean the air filter support with solvent. Dry with compressed air. Inspect the air filter support for cracks or warpage. Replace as required.

INSTALLATION: Using a new gasket, install the air filter support by reversing the procedure detailed above. Torque the air filter support in three(3) steps to 29.6 Nm.

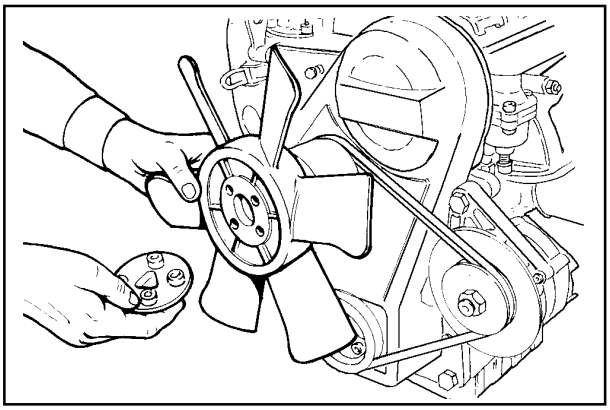


EXHAUST MANIFOLD

REMOVAL: Disconnect the equipment exhaust system. Remove the nuts that affix the exhaust manifold to the cylinder head.

INSPECTION: Carefully clean all gasket material form the exhaust manifold and the cylinder head. Remove all carbon deposits. Check the exhaust manifold mounting flange for warpage and flatness. Inspect the exhaust manifold for cracks and heat stress. Replace as necessary.

INSTALLATION: Using new gaskets, install the exhaust manifold to the cylinder head by reversing the removal procedure. Torque the exhaust manifold nuts to 24.5 Nm.

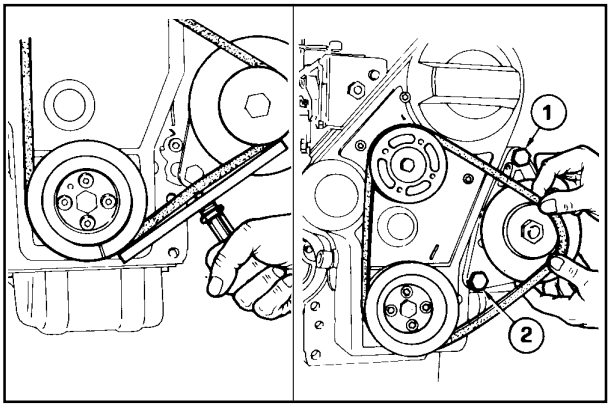


COOLING FAN

REMOVAL: Loosen and remove the four(4) bolts and the stress plate attaching the cooling fan to the cooling fan support.

INSPECTION: Inspect the entire cooling fan for cracks, stress damage, indications of contact with the shroud and brittleness. Replace the cooling fan if ANY damage is noted.

INSTALLATION: Install the stress plate and bolts. Torque the bolts to 20.0 Nm.

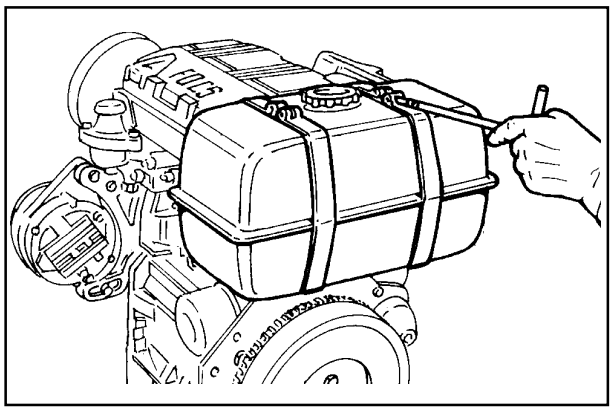


ALTERNATOR / COOLING FAN DRIVE BELT

REMOVAL: Loosen bolts (1) and (2). Pivot the alternator so that the belt can be removed. Remove the belt.

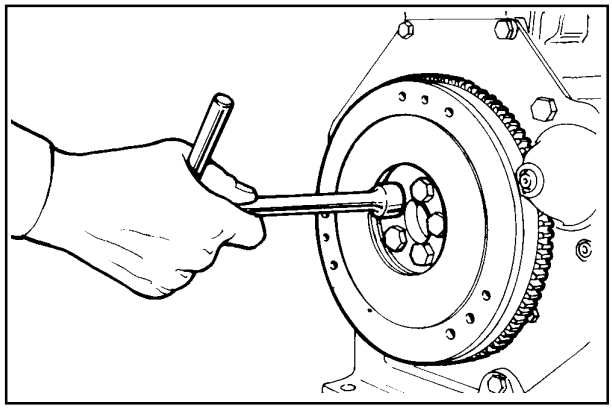
INSPECTION: Inspect the belt for brittleness, cracks and general appearance. Replace the belt if any irregularities are noted.

INSTALLATION / ADJUSTMENT: Install the belt over the cooling fan support, crankshaft pulley and alternator pulley. Pivot the alternator, thus tensioning the belt. Adjust the belt tension so that a 100N force at the midpoint of the belt center (as shown) results in a 10-15mm deflection. Tighten bolts (1) and (2). DO NOT OVER TIGHTEN THE BELT.



FUEL TANK - (OPTIONAL ACCESSORY)

A fuel tank may be fitted the the LDW-FOCS engine as shown on an optional basis. Any fuel tank whether engine mounted or not must be maintained. Extreme care must be taken to make sure that only high quality, clean and properly specified fuel is consumed by the LDW-FOCS engine. In general terms, service the engine fuel tank as follows: Carefully drain all fuel from the tank in a suitable container. Inspect the fuel cap to make sure that the vent is open and that a good seal is present at the fill neck. Replace the fuel cap as necessary. Flush the fuel tank to remove all scale, rust and impurities. After cleaning, fill the fuel tank with sufficient fuel to allow a thorough rinsing. Drain the rinse fuel from the tank. Dispose of the drained and rinse fuel according to local and national laws. Replace the fuel tank if adequate cleanliness cannot be attained. Always replace the engine fuel filter following fuel tank service and prior to initial start-up.



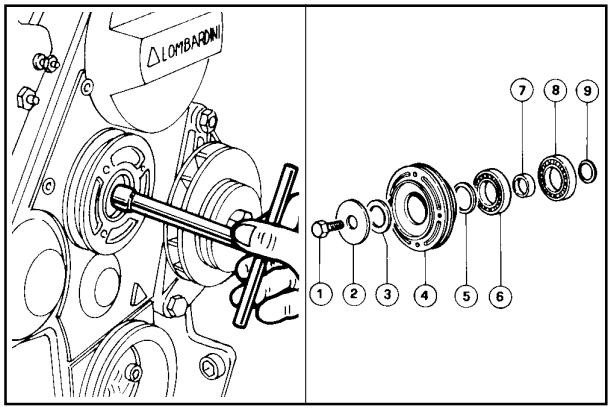
FLYWHEEL / RING GEAR

REMOVAL: Remove the engine starter. (See page 63 for warnings). Install the flywheel fixture tool 1460-051 in place of the starter. Remove the flywheel bolts. WARNING: The flywheel is heavy. Do not remove the final flywheel bolt until the flywheel is secured from accidentally falling.

INSPECTION: Clean the flywheel and flywheel bolts in solvent. Dry with compressed air. Inspect the flywheel for cracks, indications of loose operation and general damage. Inspect the ring gear for damaged teeth. Replace as required. Clean the crankshaft flywheel pilot as required.

RING GEAR REPLACEMENT: Secure the engine flywheel in a soft jawed vise. Carefully drive the ring gear from the flywheel. Remove the flywheel from the vise and lie on a secure flat surface- ring gear side up. Heat the new ring gear to 300°C for 20 minutes in a suitable oven. Using insulated hand protection and suitable hooks, place the heated ring gear on the flywheel ring gear pilot. Tap the ring gear down onto the seat as required. Allow to completely cool.

INSTALLATION: Carefully place the flywheel onto the crankshaft. Align the dowel index. Install the flywheel bolts and torque to 80Nm.



COOLING FAN SUPPORT

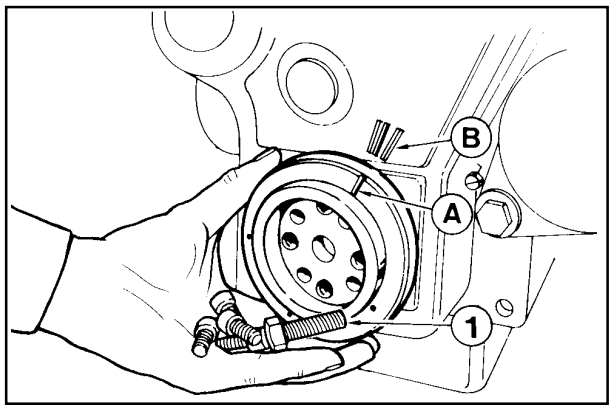
REMOVAL: Remove the center bolt (1) and slide the fan support assembly from the engine.

Components:

1	Bolt	4	Pulley	7	Spacer
2	Washer	5	Snap Ring	8	Bearing
3	Spacer	6	Bearing	9	Snap Ring

INSPECTION: Disassemble the support assembly. Clean all components. Inspect the pulley for wear. Inspect the bearings for wear. Replace as required.

INSTALLATION: Install the support assembly onto the engine. Using Locktite 270 on bolt (1), torque to 25 Nm.



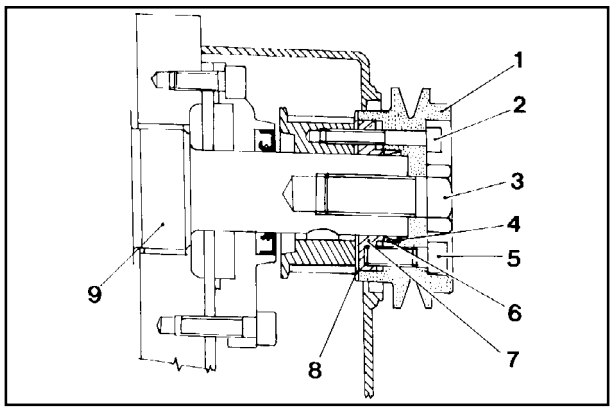
CRANKSHAFT PULLEY

REMOVAL: Secure the engine from rotation by removing the engine starter (see warnings on page 62) and installing the fixture tool 1460-051. Remove the four(4) M6 bolts, then remove the center bolt (1). **NOTE: THE CENTER BOLT(1) IS LEFT-HANDED.**

INSPECTION: Clean the pulley removing all oil residue and dirt. Inspect the pulley for cracks, warpage and V-groove wear or damage. Replace as required.

INSTALLATION: Align the crankshaft pulley with the index pin on the crankshaft. Hand tighten the M6 bolts. Using Locktite on the center bolt thread, torque the center bolt to 360 Nm. Torque the M6 bolts to 12 Nm.

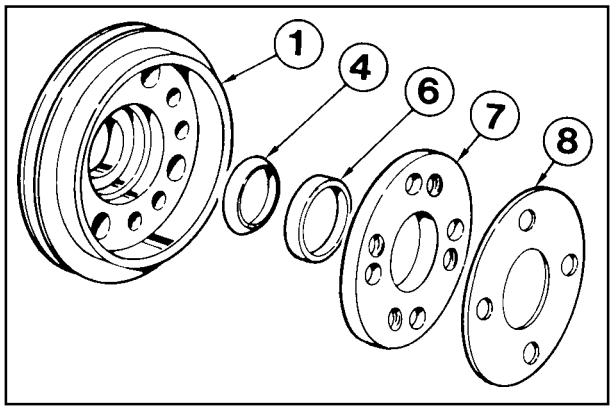
NOTE: When pulley reference mark (A) aligns with the timing cover reference mark (B), the flywheel side piston is at TDC.



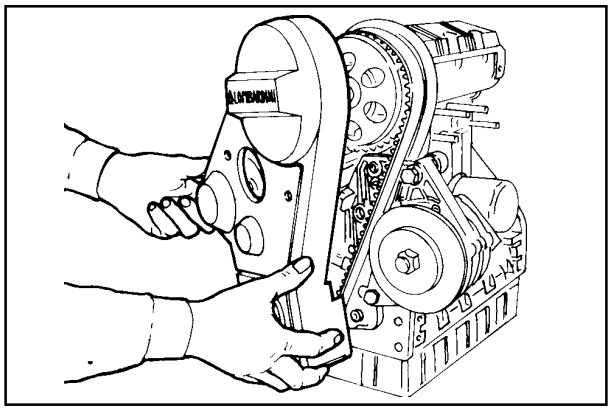
No. 2 PTO (CRANKSHAFT PULLEY) with "RINGFEDER"- LDW 1204, LDW 1204/T, LDW 1404

The maximum allowable power to be taken from the LDW 1204 and LDW 1204/T and LDW 1404 standard No. 2 PTO is 75% of the speed specific output (see page 10). In order provide 100% of the available power, a "RINGFEDER" coupling must be fitted to the engine.
Components:

1	Pulley- Special	4	RINGFEDER Internal Ring	7	Spacer Flange
2	M6 Bolt	5	M8 Bolt	8	Shoulder Plate
3	M16x1.5 Bolt	6	RINGFEDER External Ring	9	Crankshaft



INSTALLATION: Clean the crankshaft of all nicks, rust, dirt and oil. Clean all components of the RINGFEDER in solvent and dry with compressed air. Saturate all RINGFEDER components with clean engine oil. Lock the engine by removing the engine starter and installing the 1460-051 fixture (see page 62 for warnings). With reference to the diagram at the left, insert into pulley (1) -internal ring (4), external ring (6) and flange (7). The protruding portion of flange (7) must be oriented toward the external ring (6). Install the plate (8) onto the crankshaft. Install the (1), (4), (6), (7) subassembly onto the crankshaft. Loosely install the M6 bolts(2) through the pulley assembly, through the plate (8) and into the crankshaft timing pulley. Install the M8 bolts (5) loosely.
Torque (crossing pattern) the M6 bolts (2) to 10 Nm.
Torque the M16 bolt (3) to 360 Nm. (Note: Left Hand thread.)
Torque (crossing pattern) the M8 bolts (5) to 15 Nm.
Torque (crossing pattern) the M8 bolts (5) to 35 Nm.
Torque (crossing pattern) the M8 bolts (5) to 35 Nm (confirmation step).

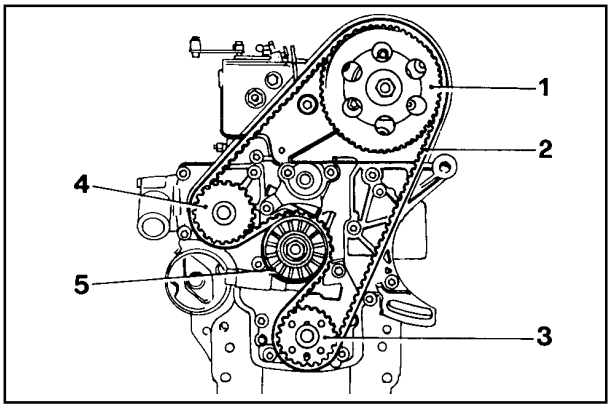


TIMING BELT COVER

REMOVAL: Remove and note position of the five(5) allen head screws attaching the timing cover to the engine. The attachment screws are of differing lengths.

INSPECTION: Clean the cover (inside and out) with a solvent soaked rag. DO NOT SOAK THE TIMING COVER IN SOLVENT. Inspect the cover for cracks and warpage. For engines equipped with a sealed timing cover, inspect the integrity of the exterior perimeter seal and the condition of the lip seals at the fan support and crankshaft pulley. Replace the cover and/or seals as required.

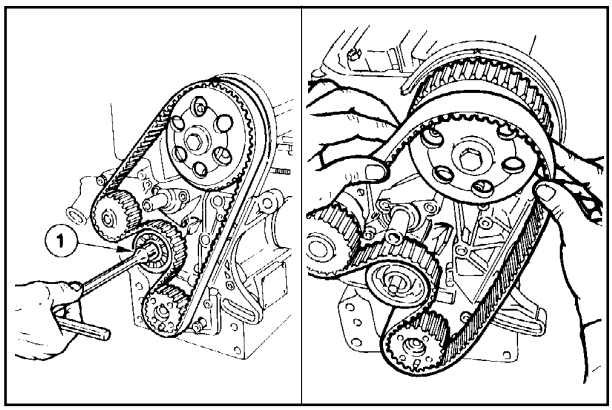
INSTALLATION: Fit the timing cover to the engine. Install the five(5) allen head screws in the exact location as removed. Torque the screws to 10 Nm.



TIMING BELT / TIMING PULLEY ARRANGEMENT

COMPONENT IDENTIFICATION:

1	Camshaft Pulley
2	Timing Belt
3	Crankshaft Pulley
4	Coolant Pump Pulley
5	Belt Tensioner Pulley

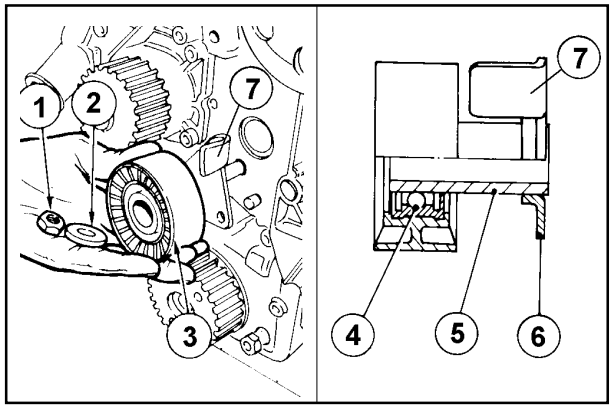


TIMING BELT REMOVAL

REMOVAL: Loosen nut (1). Slide the timing belt off of the pulleys.

NOTE 1.: Timing belt refitting can be greatly simplified if the engine is rotated until the timing marks align prior to removing the timing belt.

NOTE 2.: Discard the timing belt after removal irrespective of operational hours. Timing belts take a “set” during operation and subsequent reinstallations will not allow replacement in the identical position as prior.



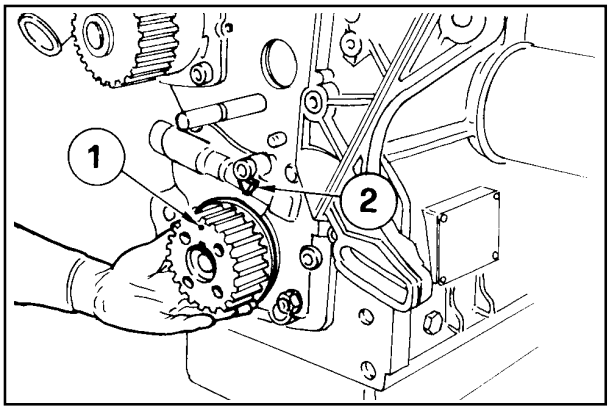
IDLER PULLEY

REMOVAL: Remove nut (1) and washer (2). Remove the idler pulley assembly from the engine.

INSPECTION: Inspect the pulley idler surface for chips, wear, degradation, etc. Check the bearing for radial run-out and smooth operation. Replace the bearing, pulley or assembly as required.

Components:

1	Nut	4	Bearing
2	Washer	5	Shaft/ Support
3	Pulley	6	Mounting Plate



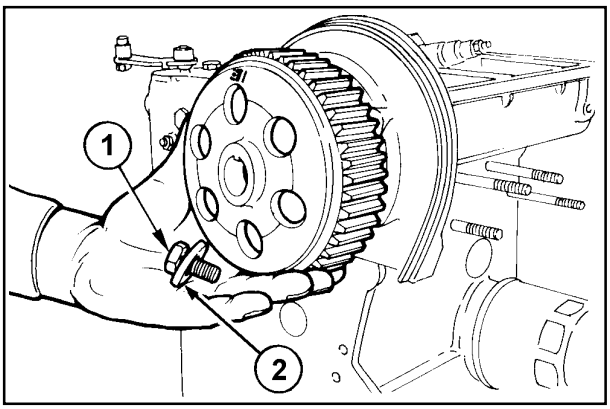
CRANKSHAFT TIMING PULLEY

REMOVAL: Slide pulley from the crankshaft.

INSPECTION: Clean the pulley in solvent. Dry with compressed air. Inspect the pulley for chips, tooth profile wear and cracks. Inspect the keyway for fretting or indications of loose operation. Inspect the crankshaft for signs of fretting at the keyway. Inspect the key condition. Replace components as required. Remove all rust and deposits from the crankshaft.

INSTALLATION: Slide the clean timing pulley onto the crankshaft aligning the keyway in the pulley with the key on the crankshaft.

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

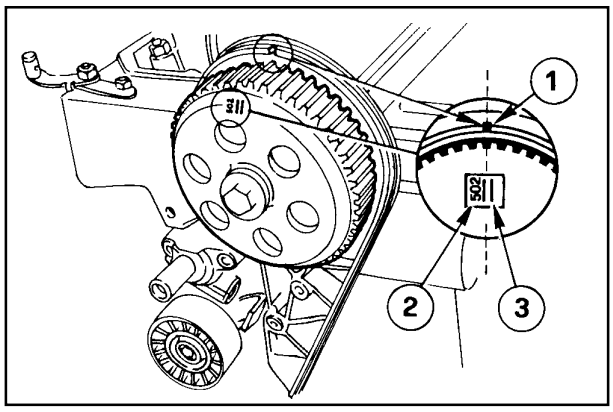


CAMSHAFT TIMING PULLEY

REMOVAL: Loosen and remove bolt(1) and washer(2). Slide the camshaft pulley from the camshaft.

INSPECTION: Clean the pulley in solvent. Dry with compressed air. Inspect the pulley for chips, tooth profile wear and cracks. Inspect the keyway for fretting or indications of loose operation. Inspect the seal race on the backside of the pulley for excessive grooving, erosion or roughness. Replace as required.

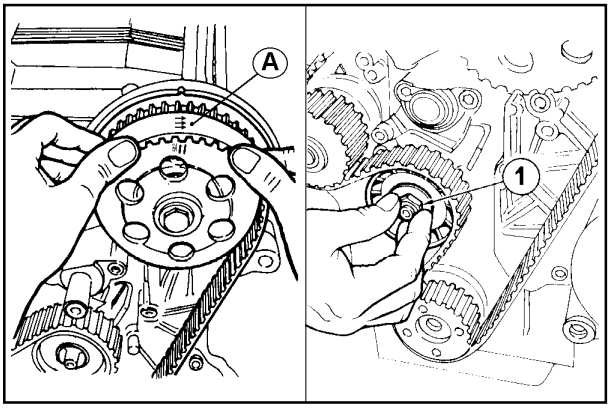
INSTALLATION: Coat the seal race of the camshaft pulley with clean engine oil. Install the camshaft pulley onto the camshaft taking care not to damage the camshaft seal. Install the washer (2) onto the bolt (1). Torque the camshaft retaining bolt to 80 Nm.



TIMING PULLEY - REFERENCE MARKS

All LDW-FOCS engines (502, 602, 903, 1204 and 1204/T) utilize the same camshaft timing pulley. The cam timing of the LDW 502 however, differs from the other LDW-FOCS engines. Carefully review the diagram to the left and the chart below to assure the correct timing marks are used with respect to the engine model.

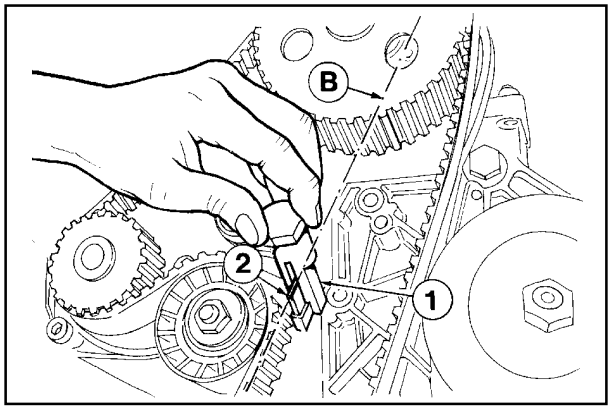
1	Timing Reference Mark on Cylinder Head.
2	Camshaft Pulley Timing Mark- LDW 502 Only.
3	Camshaft Pulley Timing Mark- LDW602,702,903,1003,1204,1404 and 1204/T



TIMING BELT INSTALLATION- TIMING PROCEDURE

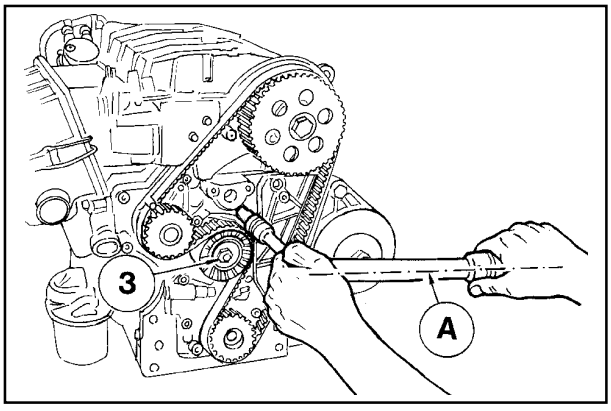
With reference to the Crankshaft Timing Pulley section on the previous page, align the crankshaft timing pulley mark with the TDC reference mark on the oil pump housing. Align the camshaft timing pulley with the timing reference mark as detailed above.

Loosen the timing belt idler pulley (see page 24). Orient the new timing belt with the directional marks(A) as shown. Install the timing belt onto the engine routing the timing belt over the crankshaft pulley, over the camshaft pulley, over the coolant pump pulley and finally around the idler. Push the timing belt against the back of the crankshaft pulley and align the timing belt on all other pulleys. Pivot the timing belt idler by hand and slightly tension the belt. Hand tighten the tensioner nut, then loosen the nut by 1/2 turn.



TIMING BELT TENSIONING PROCEDURE- SETUP

Position belt preload tool 1460-049 (1) over the timing belt idler adjustment ear (2). The tool should be oriented so that parallelism with axis (B) is attained.

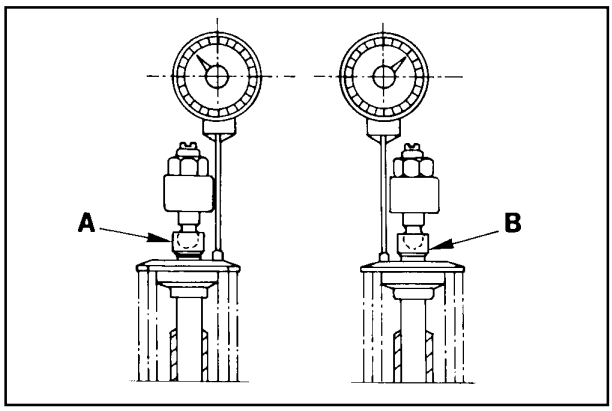


TIMING BELT TENSION PROCEDURE

Position a torque wrench as shown, engaging the 1460-049 tension tool. The torque wrench axis (A) should be 90° from axis (B) as shown above. Tension the belt by applying a torque of 30 Nm. While holding the torque at 20 Nm, tighten the idler nut (3) securely. Torque nut (3) to 40 Nm.

Rotate the engine in the normal direction of rotation (CW when viewed from fan end of engine) three(3) complete revolutions to allow the timing belt to “seat” and to align perfectly.

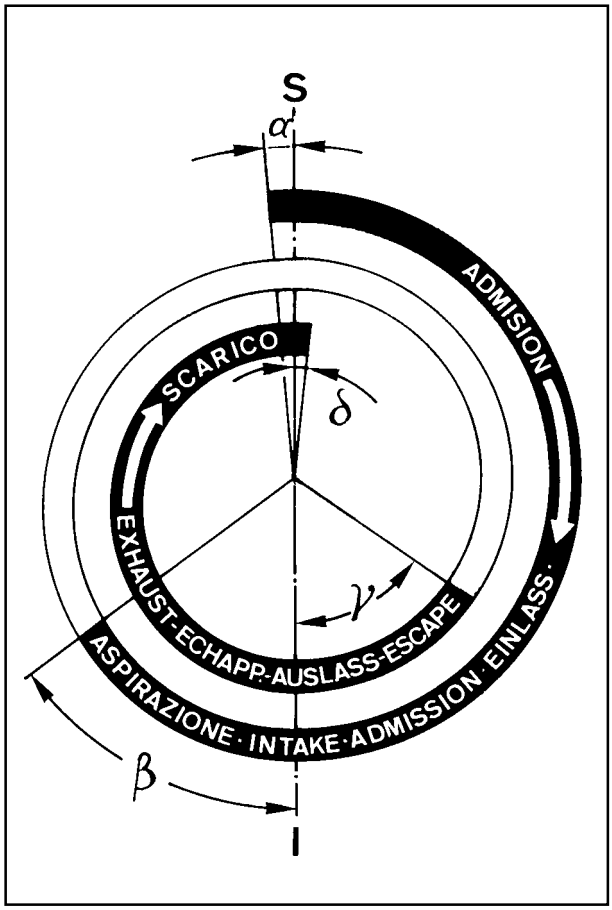
Repeat the above procedure two(2) times, including rotating the engine to allow complete and confident tensioning.



VALVE TIMING CONFIRMATION

A Intake Valve
B Exhaust Valve

Rotate the engine in the normal direction of rotation until the No. 1 piston (flywheel side) approaches TDC- compression stroke. Setup dial indicators on the intake and exhaust valve caps as shown. Locate the dial indicators so that the full valve travel will be indicated by needle movement. Rotate the engine (normal direction) until the valves are on “rocking point”. Rocking point is defined as the condition at which any small movement of the crankshaft results in opposing valve movements. That is, a movement of the crankshaft CW with result in one valve tending to open and the other valve tending to close. Further, a movement of the crankshaft CCW will result in the opposite valve behavior. Position the crankshaft so that both valves are at the highest point possible with reference to the dial indicator movements- thus TDC. Zero the dial indicators. Rotate the engine 360° so that the engine is at TDC- exhaust stroke. Check the valve timing angles as detailed below.



VALVE TIMING ANGLES

With the engine setup as above and positioned at TDC- exhaust stroke as determined above, fit the engine crankshaft with a suitable “degree wheel” and pointer. Set the pointer to 0°. Adjust valve clearance to 0.25mm at the camshaft to rocker arm roller interface. Zero the dial indicators. Rotate the engine clockwise (when facing the crankshaft pulley end of the engine) and check conformance to the chart to the left and the data below.

S = TDC (Top Dead Center)
I = BDC (Bottom Dead Center)

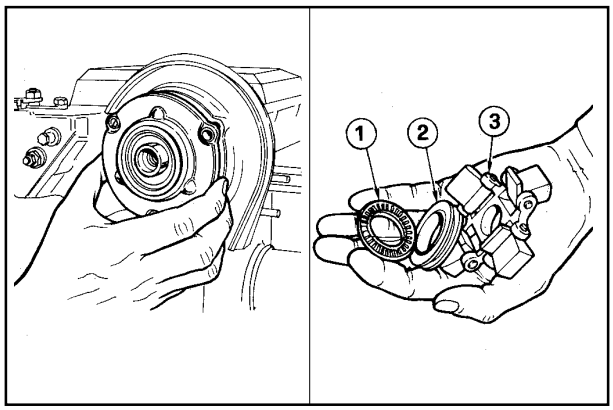
a = Intake Valve Opening Angle
b = Intake Valve Closing Angle
g = Exhaust Valve Opening Angle
d = Exhaust Valve Closing Angle

LDW 502, 602, 903 and 1204:

a = 16° BTDC
b = 36° ABDC
g = 36° BBDC
d = 16° ATDC

LDW 1204/ T

a = 10° BTDC
b = 42° ABDC
g = 56° BBDC
d = 16° ATDC

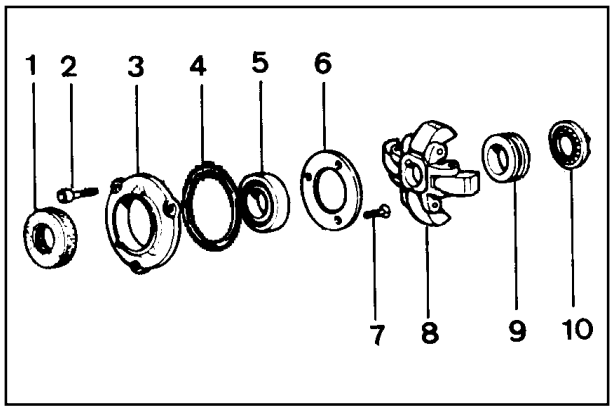


SPEED GOVERNOR

The FOCS speed governor is driven by the camshaft and is housed within the cylinder head. Access to the speed governor is gained by removing the camshaft front support as shown. Disassemble the front camshaft support by first loosening and removing three(3) securing bolts holding the camshaft support to the cylinder head, then pulling the support from the cylinder head. Following removal of the camshaft support, the governor assembly may be removed from the engine.

Components (Speed Governor)
(see figure directly at left)

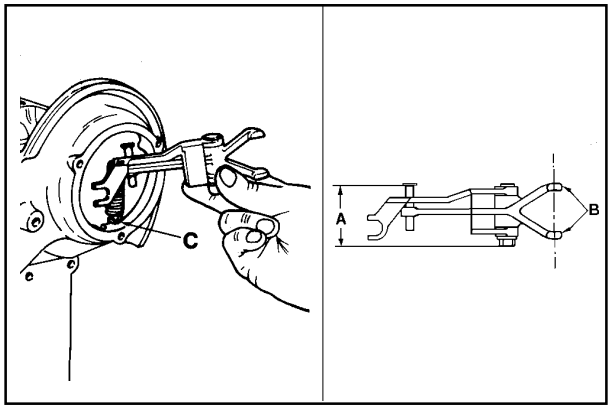
1	Thrust Washer
2	Spool
3	Flyweight Assy.



Components (Governor / Camshaft Support Assembly)

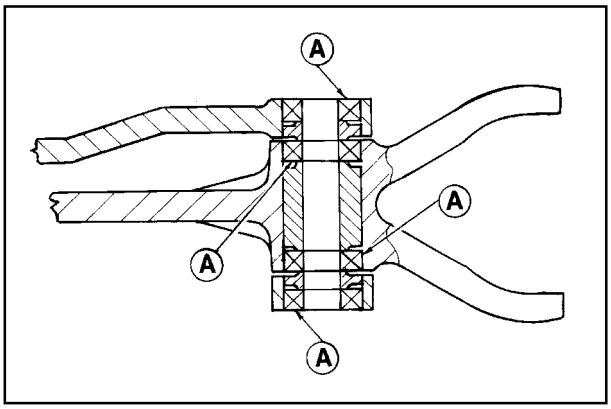
1	Oil Seal	5	Bearing	9	Spool
2	Bolt	6	Retainer	10	Thrust Bearing
3	Support	7	Bolt		
4	O-Ring	8	Flyweight Assy.		

NOTE: The flyweight assembly has four(4) weights up to 4000 r/min and two(2) weights over 4000 r/min. Further, the flyweight mass is reduced by 25% for limiting speed governors.
INSPECTION: Remove the bearing(5) from the support by removing the bolts(7) and retainer(6). Clean the camshaft support and governor components in solvent then blow dry with compressed air. Inspect the spool(3) (thrust surfaces and internal bushing), thrust bearing(10), bearing(5) and flyweights(8) for wear. Replace as required.



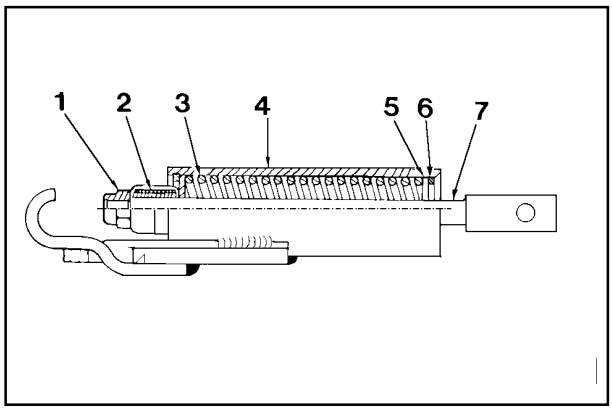
GOVERNOR FORK
After removal of the intake manifold/ air filter support (page 20) and the governor/ camshaft support assembly, remove the governor fork pivot pin (not shown) located on top of the cylinder head in the area of the governor. Remove the fork assembly as shown making sure that the governor spring(C) does not drop off. Clean the fork assembly in solvent and dry using compressed air. Inspect the for wear at points(B) and make sure that the contact areas at points(B) are parallel within 0.05mm. Replace the fork if the contact points(B) show evidence of flat spots or if the assembly does not operate freely and smoothly. Check dimension(A) to make sure that the distance is 45/46mm.

GOVERNOR SPRINGS
Governor springs are fitted within FOCS series engines as a function of the intended operating speed. Springs are available in the following ranges: 3600 r/min, 3000 r/min, 2400-2600 r/min, 1800 r/min and 1500 r/min. Additionally, a special spring is available for the limiting speed governor.



PRECISION SPEED GOVERNOR -(GENSETS)
FOCS engines ordered and specified for genset applications at 1500 or 1800 r/min are supplied with a modified governor fork assembly with respect to standard. The governor fork for genset applications utilizes qty(4) bearings as shown at (A). The additional bearings reduce friction, there by providing better governor regulation at 1500 or 1800 r/min.

INSPECTION: Clean the governor fork assembly using solvent. Dry with compressed air. Inspect the fork wear surfaces and actuating pin height as described above for the standard fork assembly. Test the fork assembly for smooth operation. Replace as required. Coat with clean engine oil before installation.

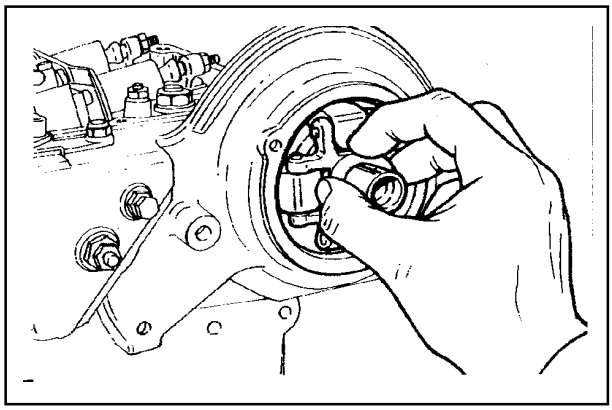


LIMITING SPEED GOVERNOR

Applications requiring true operator “foot” control, such as vehicles, are specified with a limiting speed or “MIN-MAX” governor. The limiting speed governor spring is designed as a singular unit but comprises two(2) separate springs- an idle spring and a high speed spring. The spring assemblies are speed specific and are identified by color code as detailed below.

Components			
1	Nut- Adjustment	5	Register
2	Idle Spring	6	Seat- Elastomeric
3	High Speed Spring	7	Actuation Rod
4	Case		

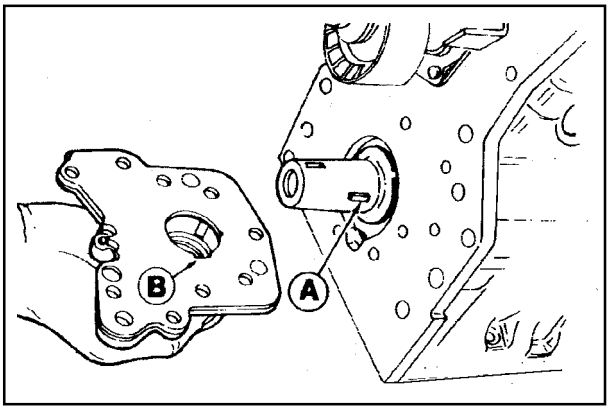
Ref. Color	Speed
red	3000
(none)	3200
black	3600
orange	3750
white	4200
brown	4500
green	4300



SPEED GOVERNOR REASSEMBLY

Install the governor fork assembly (with governor spring). After coating with oil, install the governor fork pivot bolt (use new -o-ring on pivot bolt). Torque the pivot bolt to 7 Nm. With reference to the previous page (Governor / Camshaft Support Assembly), install the governor assembly using a new O-Ring(4) and Seal(1). Coat all components with clean engine oil. Subassemble the camshaft support by installing the bearing(5), retainer(6) and bolts(7). Torque the retainer bolts(7) to 10 Nm. Install the governor assembly onto the camshaft as shown in the diagram, beginning with the thrust bearing(10), then the spool(9), then the flyweight assembly(8), making sure that the needle bearing side of the thrust bearing faces the spool. Install the camshaft support. Torque the camshaft support bolts to 10 Nm.

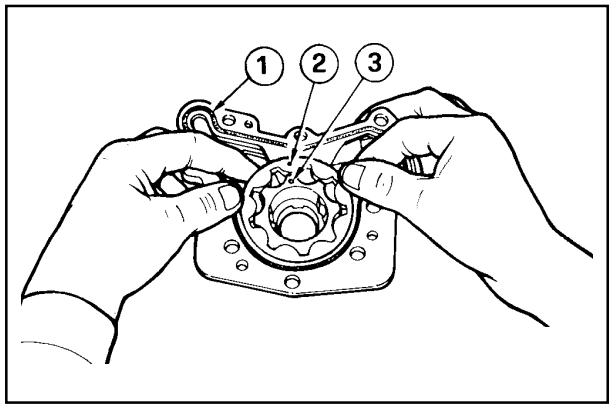
NOTE: After assembly, check the camshaft end play. If end play is noted, replace the camshaft support bearing.



OIL PUMP ASSEMBLY

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

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

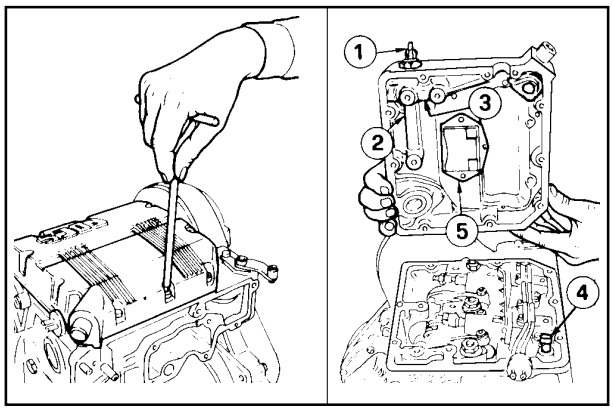


OIL PUMP INSPECTION:

Tear down analysis and failure analysis regarding the FOCS oil pump is facilitated by removing the oil pump back plate. Cleanliness is very important. Do not wipe the oil pump housing or rotors with a rag. Clean the oil pump rotor and housing using clean solvent. Dry with compressed air. When reassembling the oil pump, coat all components with clean engine oil and align timing marks(2) and (3). Replace O-ring(1) before installing the back plate. Torque the back plate bolts to 10 Nm. Replace the crankshaft oil seal if any indication of seal degradation or wear is noted (see page 45).

OIL PUMP ASSEMBLY TO THE ENGINE:

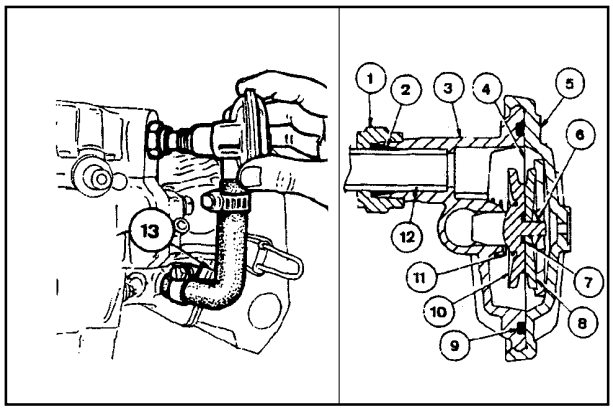
Thoroughly clean the crankshaft to remove dirt, rust and residue. Coat the oil seal with clean engine oil. Install the oil pump assembly onto the crankshaft taking care not to damage the crankshaft oil seal. Torque the oil pump retaining



VALVE / ROCKER COVER: All critical engine adjustments require the removal of the valve/ rocker cover. Remove the valve / rocker cover by removing the crankcase vacuum regulator valve (see below), removing the retaining bolts, then lifting the valve / rocker cover assembly.The engine crankcase breather system is integrally contained by the valve / rocker cover. Additionally, the valve / rocker cover facilitates oil pressure measurement and camshaft/ rocker arm lubrication via oil ports.
Components:

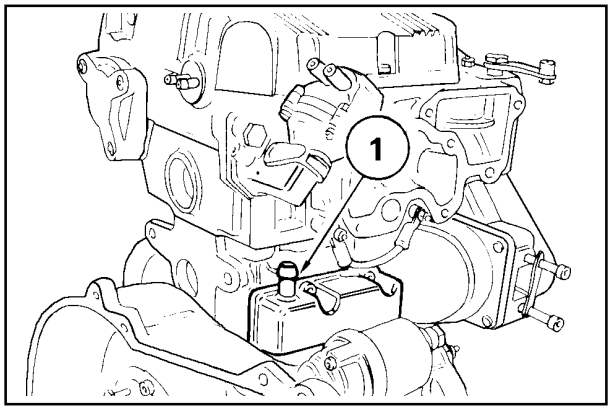
1	Oil Pressure Switch	4	Boot/ Tube for oil return to the Oil Sump
2	Camshaft Lubrication Port	5	Crankcase Ventilation Chamber
3	Rocker Arm Lubrication Port		

INSPECTION / CLEANING: Inspect the valve/ rocker cover for clogged oil ports, varnish deposits, cracks and lack of parallelism at the mounting flange. Remove boot(4) ,clean in solvent and dry (COMPLETELY) with compressed air. Replace the boot (4) if swelling, cracking or degradation is noted.



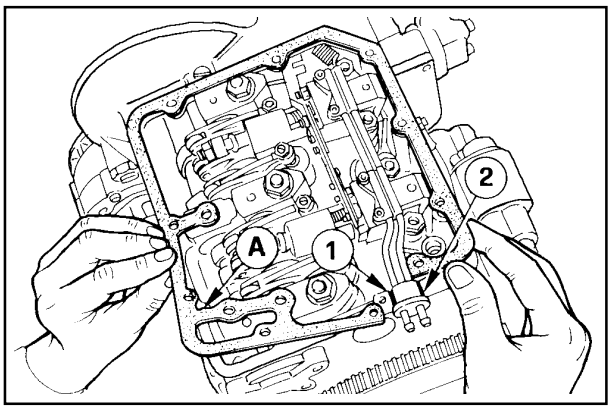
CRANKCASE VACUUM REGULATOR VALVE (602, 702, 903, 1003, 1204, 1204/T, 1404)
The LDW-FOCS crankcase breather system is closed loop design. Therefore, all crankcase vapors are induced into the intake manifold and consumed by the engine. As such, a crankcase vacuum regulator is required so that in conditions of high air filter restriction, excessive oil is prevented from entering the engine potentially causing speed regulation problems.
Components:

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



CRANKCASE BREATHER - LDW 502

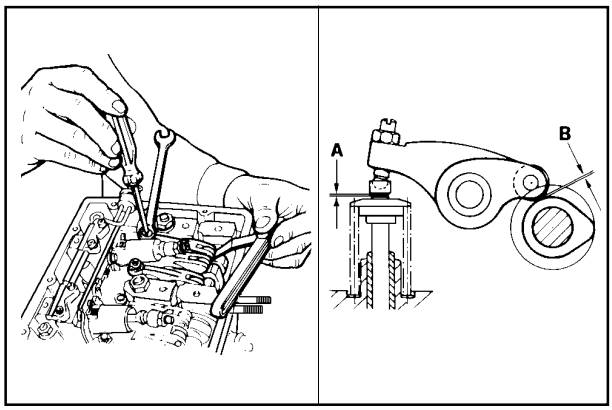
The crankcase breather system of the LDW 502 is not integral with the valve/ rocker cover as described above. The LDW 502 breather system includes a breather assembly(1), which includes a vapor separation, condensate drain and vacuum regulator. A hose (not shown) connects the breather assembly to the intake manifold.



VALVE / ROCKER COVER GASKET

The FOCS valve/ rocker cover gasket (A) is a critical part of the lubricating system. Always replace the valve / rocker cover gasket when reinstalling the valve / rocker cover.

Thoroughly clean all gasket material from the cylinder head and valve / rocker cover. Place a small bead of RTV Silicone at positions (1) and (2). Install the valve / rocker cover gently, inserting the drain boot (see top diagram, No. 4) into the cylinder head. Torque the valve / rocker cover bolts to 9 Nm.



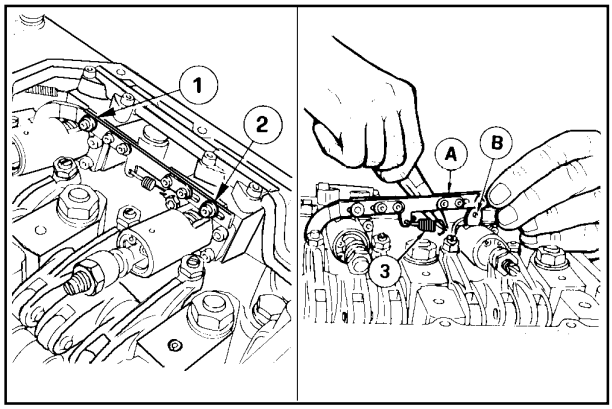
VALVE ADJUSTMENT

Valve adjustments should be performed on a cold engine. Remove the engine valve / rocker cover. Rotate the engine to TDC-compression stroke before adjusting the valves on each respective cylinder.

Loosen the adjustment lock nut and adjust the clearance at (A) to 0.20mm or 0.15mm at (B) for both intake and exhaust valves.

While holding the adjustment screw with a suitable screwdriver, tighten the adjustment lock nut. Re-check the valve clearance and re-adjust as required. Repeat the procedure for each cylinder.

After adjusting the valves, replace the valve / rocker cover using a new gasket and following the instructions from the previous page.



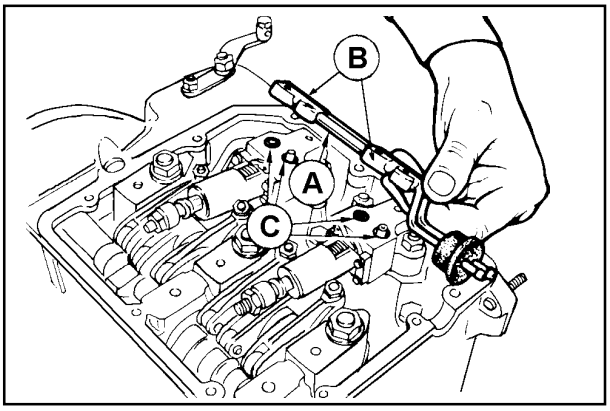
INJECTION PUMP CONTROL ROD

Depending on the engine model, the injection pump control rod will link two(2), three(3), or four(4) injectors to the engine governor.

REMOVAL: Carefully remove spring(3). Carefully remove bolts (1),(2) at point (B) of each unit injector. Do not loosen the bolts at (A). NOTE: Each unit injector has a pivot bolt identical to bolts (1),(2). For purposes of illustration, a LDW 602 engine is shown, thus, two(2) pivot bolts. Disengage the control rod from the unit injectors and the governor fork. Remove the control rod.

INSPECTION: Clean the control rod with solvent and dry with compressed air. Inspect the actuation slot at the the point the control rod attaches to the governor for wear, bending, galling, etc. Inspect the control rod for bending or general degradation. Replace as required.

INSTALLATION: Install the control rod by reversing the removal procedure detailed above. Coat the control rod with clean engine oil. Torque bolts (1), (2) to 1.1 Nm. NOTE: Adjustment of the control rod is covered on page 74.



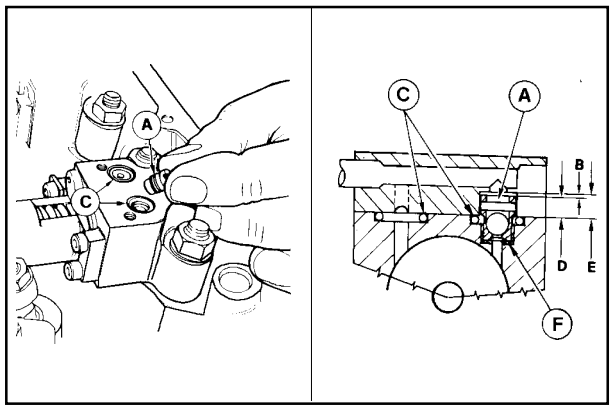
FUEL RAIL

Fuel supply to the unit injectors and the return of excess fuel from the unit injectors to the fuel tank is facilitated by the fuel rail.

REMOVAL: Remove the supply and return lines from the end of the fuel rail. Remove the bolts securing the fuel rail to the unit injectors (two(2) bolts per unit injector). Carefully lift fuel rail (A) from the unit injectors making sure that the sealing O-rings (C) do not fall into the engine.

INSPECTION: Clean the fuel rail in clean diesel fuel. Inspect the fuel rail for welded joint fatigue or cracks, degradation and flatness at the O-ring joint. Inspect the fuel rail grommet joint (located at the fuel rail / cylinder head interface on the rear of the cylinder head). Replace the grommet if brittleness or evidence of oil leakage is evident. Replace the fuel rail as required.

INSTALLATION: Remove all O-rings(C) and clean the seats of all O-rings. Replace the O-rings(C). Lightly coat the grommet seat on the cylinder head with RTV silicone. Carefully lower the fuel rail onto the unit injectors. Torque the retaining bolts to 4 Nm. WARNING: Do not use any type of sealing compound at the O-ring joints.

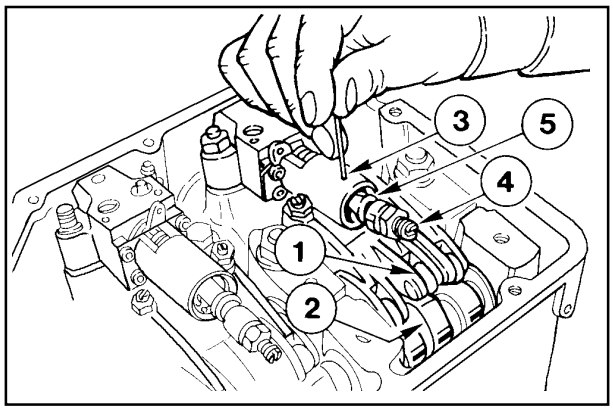


UNIT INJECTOR CHECK VALVE

The unit injector check valve(A) allows an instantaneous engine shutdown via a simple fuel shut-off valve. With reference to the unit injector identification chart on page 55, remove the unit injector check valve. Please note that unit injector reference no.'s 231-2, 235-2 and 272-o are equipped with push-in check valves, while all other unit injector reference no's are equipped with screw-in check valves.

INSPECTION: Inspect the check valves for general condition, indication of loose operation within the unit injectors, loose or damaged check valve balls/retaining pins and erosion. Replace as required. Reassemble the check valves into the unit injectors. Measure the and confirm the following dimensions as shown on the diagram: B= 1,0/1,85mm; D= 5.5/6.0mm; E= 7.0/7.1mm (502-602-903-1204) and B= 0.5/1.15mm; D= 5.95/6.5mm; E=7.0/7.1mm. Special spacer washers are available to increase the height of the check valve to specifications.

NOTE: The sealing of the fuel rail and check valves is critical to prevent fuel from entering the oil sump. The sealing mechanisms are O-rings (C). If in doubt, always replace the O-rings.



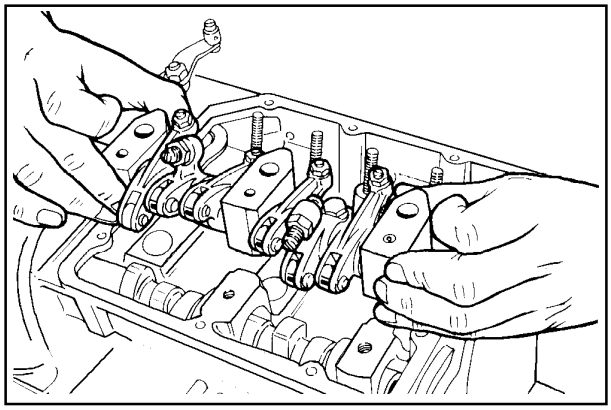
UNIT INJECTOR REMOVAL / INSTALLATION

Unit injectors may require removal for either service on the unit injector, or for purposes of allowing other service operations. If unit injector service is required, a static timing and fuel delivery equalization procedure will be required (see FUEL SYSTEM).

If unit injector service is not required, the following procedure may be used to allow unit injector removal and replacement without the need for other adjustments.

1. Remove the valve/rocker cover(page 29).
2. Remove the control rod(page 30).
3. Remove the fuel rail(page 30).
4. Label all injectors with respect to cylinder number.
5. DO NOT LOOSEN THE UNIT INJECTOR ADJUSTMENT SCREW(4).
6. Rotate the engine until the unit injector cam lobe(2) forces the cam follower (1) to the highest position.
7. Insert a suitable sized (hardened) pin into the hole (3).
8. Rotate the engine until the cam follower(1) is at the lowest position.
9. Loosen and remove the two(2) M8 unit injector retainer nuts and washers.
10. Remove the unit injector from the cylinder head while making sure that the push rod(5) does not fall into the engine. Set aside the “labeled” unit injector, keeping the push rod(5) from each cylinder with the respective unit injector.

ASSEMBLY: Inspect the unit injector O-rings for damage and replace as required. Using a new fire ring (see page 59), reassemble the unit injectors and unit injector push rods into the exact cylinder from with they were removed. Install the unit injectors using a procedure reverse from the removal procedure. Torque the unit injector retaining nuts in 5 Nm steps to 20 Nm.

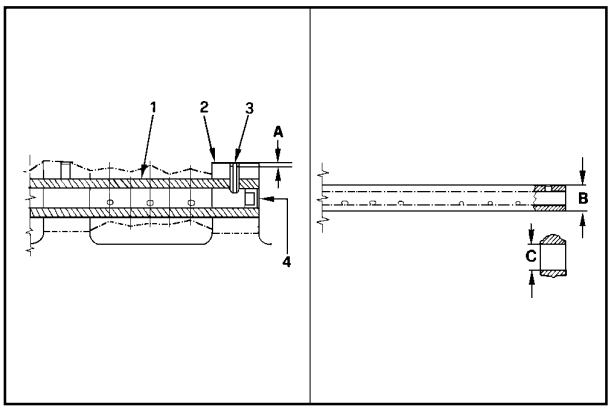


ROCKER ARM ASSEMBLY

NOTE: The rocker arm assembly may be removed without removal of the unit injectors. If unit injector removal is not required, follow steps 1, 5, 6, 7 and 8. Upon reinstallation of the rocker arm assembly, follow steps 8, 7, 6, 5 and 1 as detailed above.

REMOVAL: Remove the nuts and washers attaching the rocker arm assembly to the cylinder head. Lift the rocker arm assembly from the engine as shown in the diagram. Take measures to insure that the unit injector push rods do not fall into the engine when lifting the rocker arm assembly.

INSPECTION: Clean the rocker arm assembly in solvent and dry with compressed air. Inspect the rocker arm to valve stem contact areas, inspect the unit injector actuation balls, inspect the rocker arms for signs of looseness or galling and fractures. If complete disassembly and dimensional analysis of the rocker arm assembly is required or desired, refer to the lower diagram.



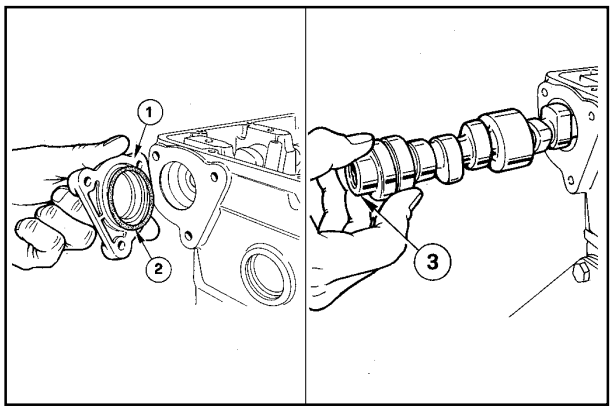
DISASSEMBLY: Label all rocker arms so that the rocker arms may be reinstalled in the same position. Using a 4mm drill bit and a suitable drill and vise, drill out the pin(3). Remove the support blocks(2) and the rocker arms. Remove plug (4) and thoroughly clean shaft (1). with solvent.

SPECIFICATIONS

A 0-1.00mm
B 17.989/18.000mm
C 18.015/18.030

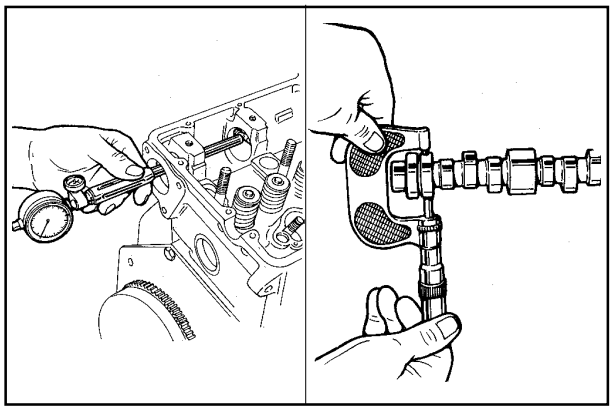
C-B = 0.015/0.041mm (USEABLE Limit= 0.090mm)

INSTALLATION: Reassemble the rocker arm assembly installing the rocker arms in identical positions as removed (if reused), coating all components with clean engine oil. Reassemble the rocker arm assembly onto the engine taking



CAMSHAFT REMOVAL/ REPLACEMENT

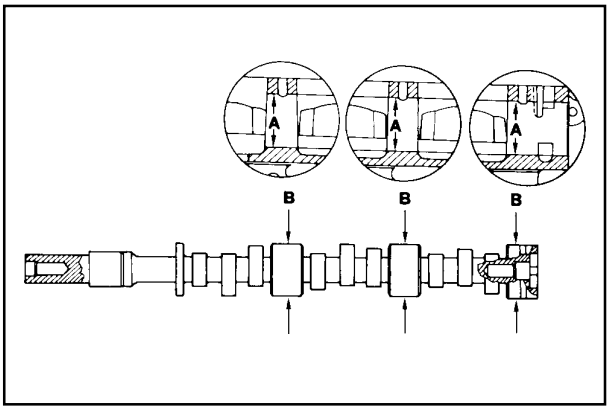
PREPARATION: Remove the rocker arm assembly, remove the camshaft end cover(1), remove the camshaft timing pulley, remove the governor assembly, remove the fuel lift pump, remove the fuel lift pump push rod.
REMOVAL: Gently and slowly, slide the camshaft toward the flywheel end of the engine. Slight rotation(s) may be required to prevent binding of the camshaft lobes against the camshaft bearing surface bores.
INSPECTION: Clean the camshaft with solvent and dry with compressed air. Inspect all lobes and journals for wear, seizure, pitting, etc. Refer to the data presented in the following for dimensional analysis of the camshaft. Replace the camshaft as required.
INSTALLATION: Liberally oil the cylinder head camshaft supprt bores and the camshaft journals. Install the camshaft into the cylinder head, gently rotating the camshaft as required to allow installation. Replace O-ring(2) and replace the camshaft cover(1).



NOTE: The flywheel end of the camshaft includes a bolt-on eccentric(3) for purposes of lift pump drive. Torque the eccentric(3) to 80 Nm.

CAMSHAFT JOURNAL / SUPPORT MEASUREMENT

After thoroughly cleaning the camshaft and cylinder head bores, measure the critical diameters with calibrated micrometers as shown.

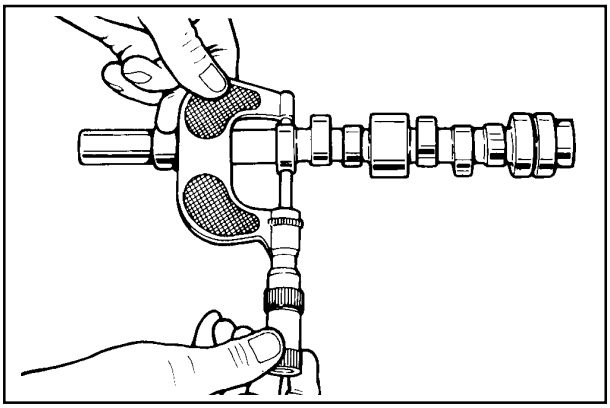


CAMSHAFT JOURNAL / SUPPORT BORE SPECIFICATIONS

A 37.035/37.060mm
B 36.975/37.000mm

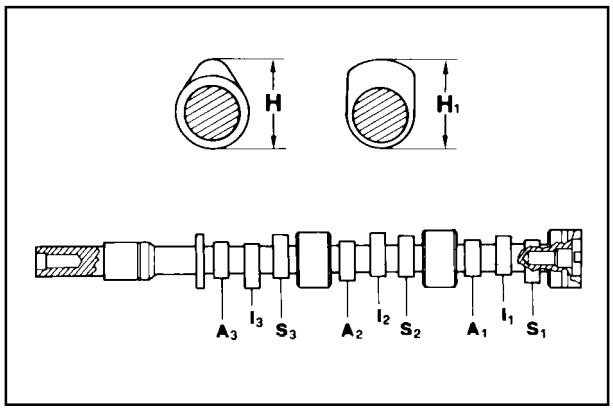
A-B= 0.035/0.085mm (USEABLE Limit= 0.170mm)

NOTE: The camshaft journal and cylinder head camshaft bore dimensions are identical for all LDW-FOCS series engines- LDW 502, LDW 602, LDW 702, LDW 903, LDW 1003, LDW 1204, LDW 1404, LDW 1204/T.



CAMSHAFT LOBE MEASUREMENT PROCEDURE

After thoroughly cleaning the camshaft, measure the camshaft lobes from the circle base to the top of the lobe (maximum possible dimension) using a calibrated micrometer.



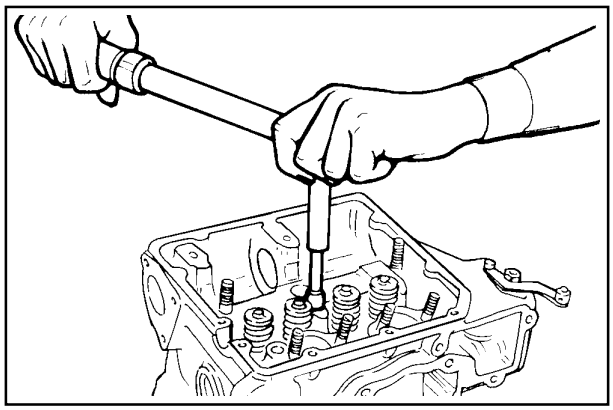
CAMSHAFT LOBE SPECIFICATIONS

NOTE: The camshaft shown in the figure is reflective of a LDW 903. However, the cam lobes are identical for the LDW 502, LDW 602, LDW 903 and LDW 1204 diesel engines. The cam lobes are slightly different for the LDW 1204/T as is shown in the data below.

H- (502, 602, 903, 1204)= Valve Lobe (intake/ exhaust)= 29.598/ 29.650mm
H- 1204/T, Intake Lobe= 29.438/29.490mm
H- 1204/T, Exhaust Lobe= 29.778/29.830mm
H- USEABLE Limit (All Models)= Minimum Value minus(-) 0.1mm
H_1- Injection Lobe (All Models)= 28.948/29.00mm
H_1- Injection Lobe USEABLE Limit= 28.848mm

LOBE IDENTIFICATION:

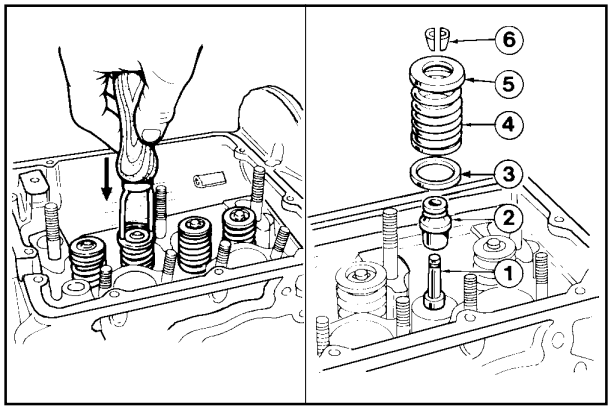
A1	No. 1 Intake	A2	No. 2 Intake	A3	No. 3 Intake
S1	No. 1 Exhaust	S2	No. 2 Exhaust	S3	No. 3 Exhaust
I1	No. 1 Injection	I2	No. 2 Injection	I3	No. 3 Injection



CYLINDER HEAD REMOVAL

Remove all cylinder head bolts, then lift the cylinder head from the crankcase. Do not pry excessively, lever or strike the cylinder head with a hammer in attempts to break the cylinder head loose from the head gasket. Do not damage the pre-combustion chambers during the handling process.

INSPECTION: Thoroughly clean the cylinder head in a non-caustic solvent. Dry with compressed air. Inspect for cracks and warpage. Check cylinder head warpage using a high quality straight edge and precision feeler gauges. Hold the straight edge on the cylinder head deck and check corner-to-corner and side to side in at least four(4) equidistant zones. The maximum allowable warpage is 0.10mm. If warpage exceeds 0.10mm, the cylinder head may be planed a maximum of 0.20mm. NOTE: Remove pre-combustion chambers before planing.

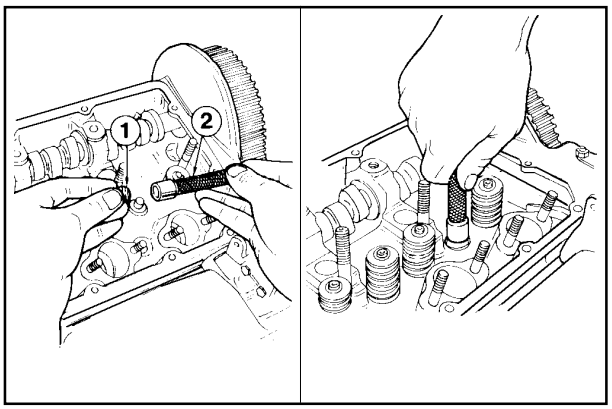


VALVE REMOVAL

Components:

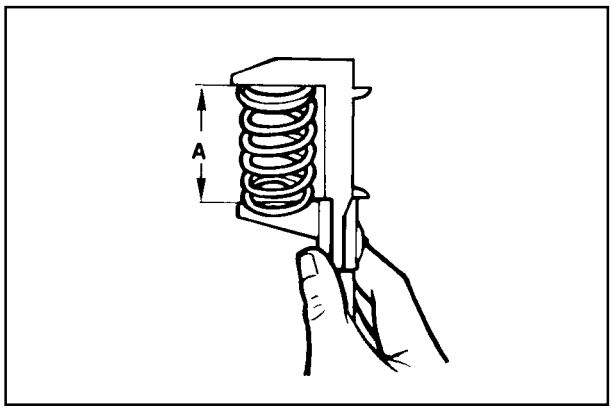
1	Valve Stem	3	Spring Seat	5	Spring Cap
2	Valve Seal	4	Spring	6	Collets

Place the cylinder head on suitable wood spacers so that the pre-chambers do not touch the top of the work bench when the cylinder head is oriented as shown. Using a suitable valve spring compression tool and acting on the spring cap(5), compress the valve springs so that the collets(6) can be removed while the spring is being held in the compressed state. WARNING: Valve springs can store a considerable amount of energy while under compression. Compress and hold valve springs under compression with care- wear suitable eye protection. After the collets are removed from all valves, turn the cylinder head 90° so that the cylinder head is resting on the intake or exhaust planes. Remove the valves. If valves are to be reused, label each valve according to cylinder number so that the valves can be reinstalled in the identical position as removed.



VALVE STEM SEAL INSTALLATION

Following cleaning of the cylinder head and machining or lapping of the valves/ valve seats, install the valves into the cylinder head. Using wooden spacers to prevent pre-chamber damage, orient the cylinder head as shown. Soak new valve stem seals in clean engine oil for five(5) minutes. Liberally lubricate the valve stems with clean engine oil. Using special tool 1460-047, place the valve stem seals in the end of the 1460-047 tool. Carefully push the valve stem onto the valve stem and over the valve guide. Do not force the seal or use a hammer to drive the seals into place. The hand force applied must be parallel to the valve

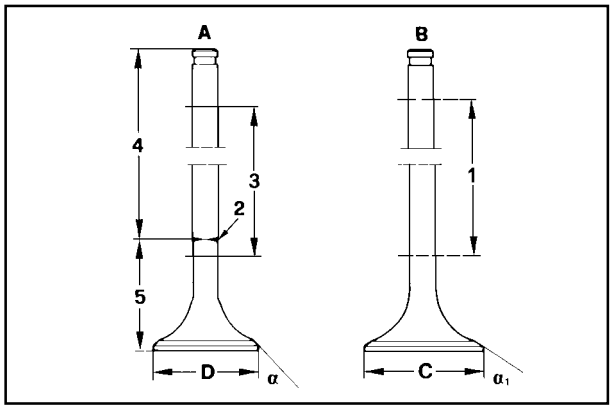


VALVE SPRINGS

INSPECTION:
Clean all valve springs in solvent and dry with compressed air. Inspect the springs for surface cracks and fractures. Orient the spring in normal direction of operation with one end of the spring resting on a flat surface. Make sure that both planes of the spring are parallel. If the springs seats are not parallel, discard the spring.

Measure the free height of the spring as shown in the diagram. The free height should be 45.6mm (nominal). If the free height is less than 43.5mm, discard the spring.

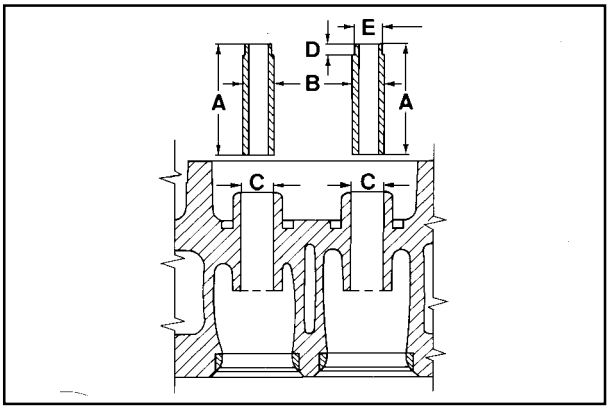
VALVE SPECIFICATIONS:



INTAKE VALVE: Base Material: X 45 Cr Si 8 UNI 3992
Zone 1 - Chrome Plated
C= 33.00mm (LDW 502-602-903-1204-1204/T)
C= 34.40mm (LDW 702-1003-1404)
a_1= 60° 30' / 60° 45'

EXHAUST VALVE: Zone 2 - Weld Joint
Zone 3- Chrome Plated
Zone 4- Base Material: X 45 Cr Si 8 UNI 3992
Zone 5- Base Material: X 70 Cr Mn NI N 216 UNI 3992
D= 29.00mm (LDW 502-602-903-1204-1204/T)
D= 30.20mm (LDW 702-1003-1404)
a= 45° 30' / 45° 45'

VALVE CLEANING: The face and lower shank of the valves may be power cleaned via an electric brush. DO NOT POWER BRUSH THE VALVE STEM!

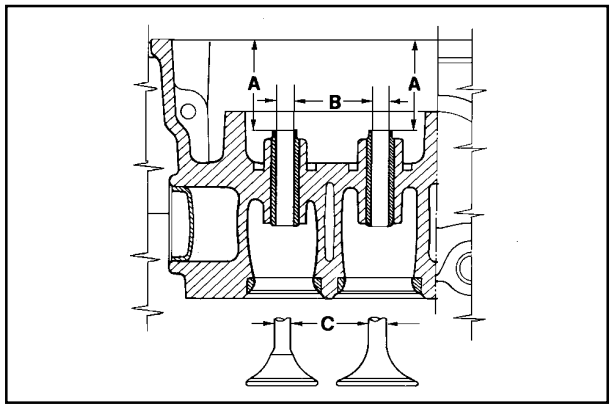


VALVE GUIDES / VALVE GUIDE BORE

Both intake and exhaust valve guides are identical dimensionally and are made from phosphoric gray iron with a pearlitic matrix. The dimensional specifications are as follows:

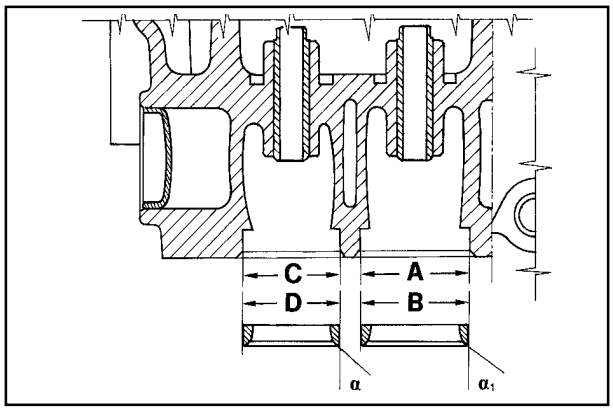
A 36.4/36.6mm
B 11.045/11.054mm
C 11.000/11.018mm
D 5.80/6.20mm
E 9.75/9.85mm

Valve guides are supplied in finished form. No further machining of standard valve guides is required or recommended. NOTE: 0.50mm oversized valves guides (OD) are available. If oversized valve guides are used, dimension (C) from above must be increased by 0.50mm.



VALVE GUIDE INSTALLATION GUIDELINES AND POST INSTALLATION VALVE/VALVE GUIDE SPECIFICATIONS
Lombardini does not provide installation tools for valve guides. Lombardini recommends that valve guide replacement be done by a suitable shop specializing in cylinder head work.

Whether newly installed or existing, the valve guides should conform to the following:
A 39.5/40.0mm
B 7.005/7.020mm
C 6.960/6.990mm
B-C= 0.015/0.050mm; USAGE Limit= 0.10mm



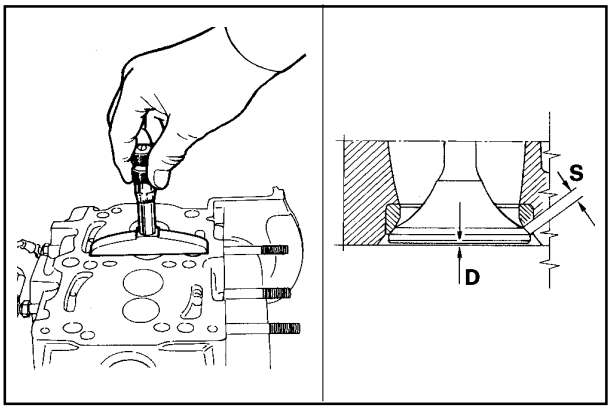
VALVE SEATS

Valve seats are supplied fully finished. No further machining of the valve seats is required or recommended except for a final lapping operation as part of valve installation. Lombardini does not provide installation tools for valve seats. Lombardini recommends that valve seat replacement be done by a suitable shop specializing in cylinder head work. Whether newly installed or existing, the valve seat to cylinder head interface must conform to the following:

For LDW 502-602-903-1204-1204/T

EXHAUST VALVE SEAT: A = 34.020 / 34.045mm
B = 34.106 / 34.115mm
a_1=59° 53' / 60°

INTAKE VALVE SEAT: C = 30.020 / 30.041mm
D = 30.108 / 30.116mm
a = 44° 53' / 45°



For LDW 702-1003-1404

EXHAUST VALVE SEAT: A = 35.220 / 35.245mm
B = 35.306 / 35.315mm
a_1=59° 53' / 60°

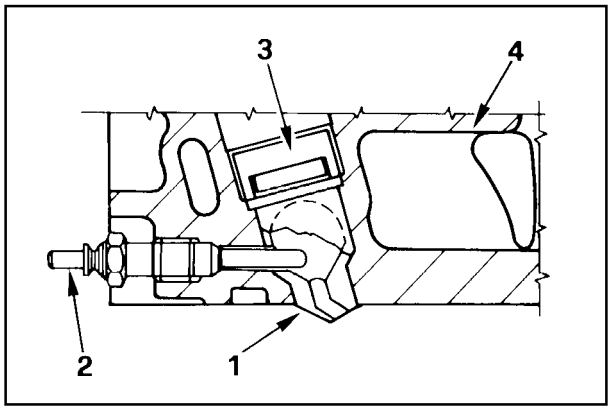
INTAKE VALVE SEAT: C = 31.220 / 31.241mm
D = 31.308 / 31.316mm
a = 44° 53' / 45°

VALVE RECESS and SEAT SEALING WIDTH

Invert the cylinder head as shown with the cylinder head resting on suitable supports. Install the valves, but not the valve springs. Lubricate the valve stems with clean engine oil and perform the final lapping on the valve to valve seat interface using 'fine' lapping compound. Wipe off all excess lapping compound. Remove each valve following lapping and measure the width of the sealing band (S) as shown by the gray lap line.

For LDW 502-602-903-1204-1204/T

SEALING WIDTH (S) = 1.6 / 1.7mm; USEABLE Limit= 2.0mm
VALVE RECESS (D) = 0.5 / 0.8mm; USEABLE Limit= 1.1mm



With the valve resting in the cylinder head, use a depth micrometer to determine the recess (D) that the valve face drops below the cylinder head deck.
If valve recess or valve sealing area does not meet the above specifications, replace the valves/ valve seats as required.

For LDW 702-1003-1404

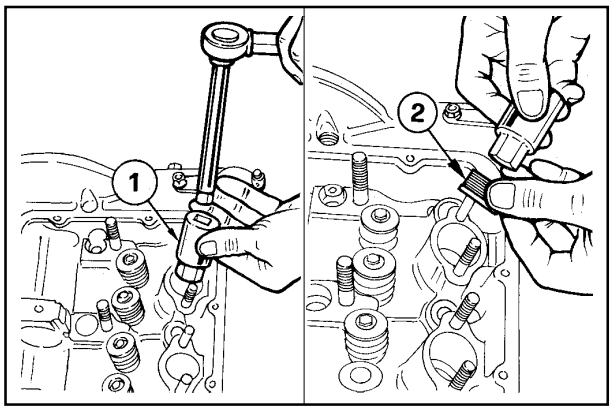
SEALING WIDTH (S) = 1.6mm; USEABLE Limit= 2.0mm
VALVE RECESS (D) = 0.7 / 1.0mm; USEABLE Limit= 1.3mm

PRE-COMBUSTION CHAMBER-OVERVIEW

Components of the Pre-combustion chamber configuration

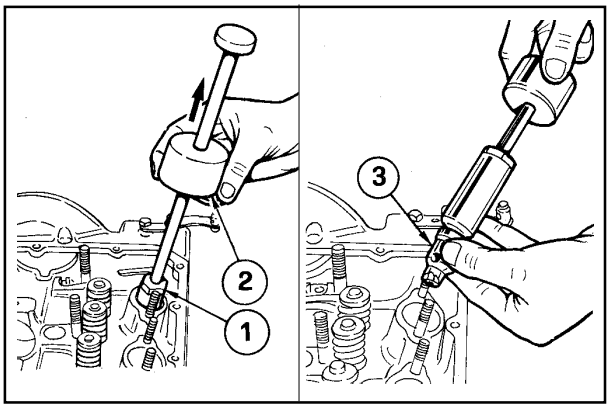
1 Pre-combustion Chamber
2 Glow Plug
3 Pre-combustion Chamber Ring Nut
4 Cylinder Head

NOTE: Pre-combustion chambers are identical for the LDW 602, LDW 903, LDW 1204 and LDW 1204/T. The LDW 502 has a slightly different design than the other FOCS models.



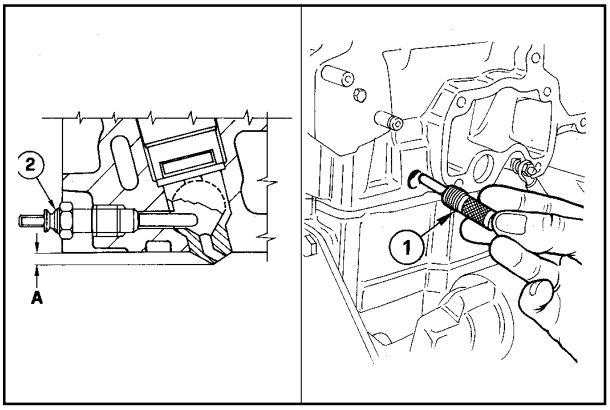
NOTE: THE PRE-COMBUSTION CHAMBER DOES NOT NORMALLY REQUIRE REMOVAL OR SERVICE AND SHOULD NOT BE DISTURBED UNLESS ABSOLUTELY NECESSARY. DO NOT REMOVE PRE-COMBUSTION CHAMBERS AS PART OF A NORMAL REBUILD OR VALVE JOB. FURTHER, LOMBARDINI RECOMMENDS THAT NEW PRE-COMBUSTION CHAMBERS BE INSTALLED IF REMOVAL OF THE EXISTING PRE-CHAMBERS IS REQUIRED. THE FOLLOWING PROCEDURES DETAIL PRE-CHAMBER REMOVAL AND INSTALLATION SHOULD SERVICE BE REQUIRED.

PRE-COMBUSTION CHAMBER RING NUT:
As shown in the diagram at the bottom of page 35, the pre-combustion chamber is secured to the cylinder head by a ring nut. The ring nut(2) may be removed by securing the cylinder head in a safe and suitable manner- resting on wooden blocks to protect the pre-combustion chambers, then using special tool 1460-027 and a breaker bar to loosen and remove the ring nut(2).



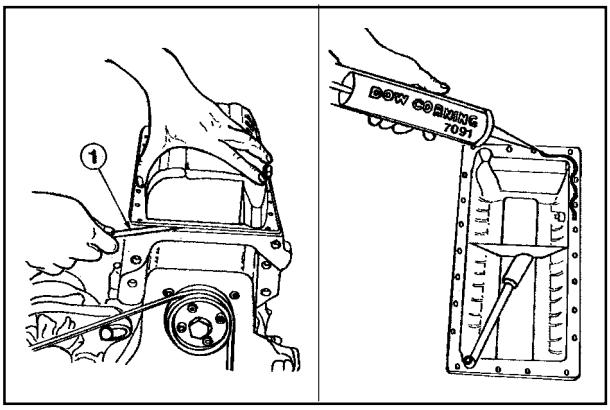
PRE-COMBUSTION CHAMBER REMOVAL
Remove the glow plug(s) from the cylinder head. Screw special tool 1460-030 into the pre-combustion chamber. Special tool 1460-030 is comprised of shaft/end (1) and slide hammer(2). Make sure that the shaft/end (1) portion of the special tool is completely screwed into the pre-combustion chamber. Carefully, but sharply, slide the slide hammer(2) up the special tool shaft until contact is made with the end of the tool. The hammer effect of the special tool will extract the pre-combustion chamber. Following extraction of the pre-combustion chamber, unscrew the pre-combustion chamber(3) from the special tool.

WARNING: SPECIAL TOOL 1460-030 IS AN IMPACT DEVICE. EYE PROTECTION SHOULD BE WORN DURING OPERATION. GREAT CARE SHOULD BE TAKEN TO PREVENT THE PINCHING OF YOUR HAND OR FINGERS AS THE SLIDE HAMMER IMPACTS THE TOP OF THE TOOL.

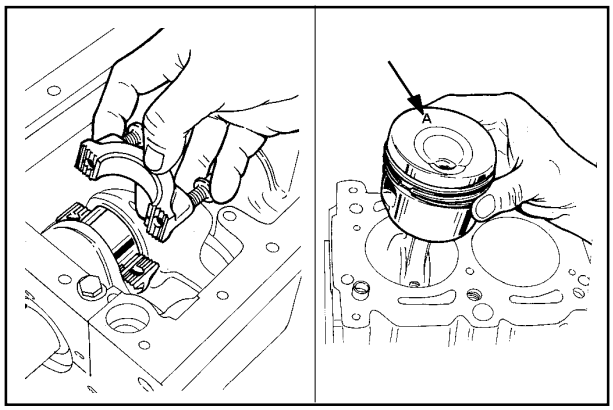


PRE-COMBUSTION CHAMBER INSTALLATION:
Carefully clean all carbon from the pre-combustion chamber pocket in the cylinder head. Do not use sharp edges or abrasive means to clean the pre-combustion chamber pocket. Non-caustic solvents may be used to assist in carbon removal.
Introduce a new pre-combustion chamber into the cylinder head so that the side hole of the pre-combustion chamber approximately aligns with the glow plug hole (see diagram at left). Screw the pre-chamber alignment tool 1460-031 fully into the glow plug threaded hole, through the pre-chamber side hole. Using the pre-combustion chamber ring nut tool- 1460-027 as shown above, install and tighten the pre-combustion chamber ring nut. Torque the ring nut in two(2) steps- 100 Nm, then 180 Nm.
Reinstall the glow plug. Torque the glow plug to 25 Nm.

OIL PAN REMOVAL / INSTALLATION

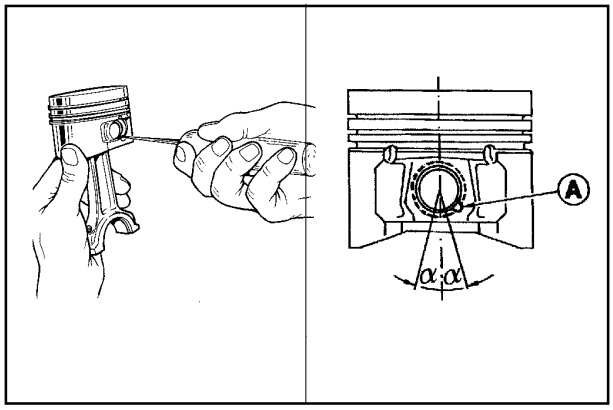


REMOVAL: Drain the oil from the oil pan. Remove all oil pan bolts. Gently, without deforming the pan, pry the pan from the crankcase using a small bar(1). Numerous attempts at several different locations around the perimeter of the pan may be required before the pan releases from the crankcase.
INSPECTION/ CLEANING: Thoroughly clean the oil pan in solvent and dry with compressed air. Remove all traces of the oil pan gasket from the oil pan and crankcase. Inspect the oil pan for warpage, cracks, dents, etc.. Inspect the oil pick-up screen for tears and/or clogging. Inspect the oil drain plug holes for thread integrity. Lay the oil pan mounting flange on a flat surface and check for flatness. Repair or replace as required.
INSTALLATION: Install a new oil pick-up O-ring. Apply Dow Corning 7091 Silicone around the perimeter of the sealing surface of the pan as shown. Allow the silicone to “skin”. Install the oil pan to the engine. Torque the oil pan bolts to 10 Nm. Torque the oil drain plug to 40 Nm.

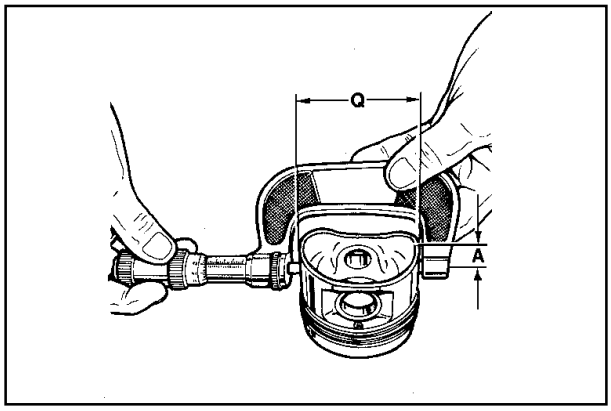


PISTON REMOVAL: Rotate the engine to BDC. Clean all carbon from the top of the cylinder bore. If a wear ridge is present at the top of the cylinder bore, remove the ridge with a suitable “ridge reamer”. Remove the connecting rod cap as shown. Using a soft, wood rod, carefully and slowly push on the connecting rod- forcing the piston upward. Do not allow the connecting rod to hit the crankshaft. Note: Slight crankshaft rotation may be required to gain adequate access to the connecting rod for purposes of pushing. Push the connecting rod until the piston oil ring is outside of the cylinder bore. Lift the piston from the cylinder bore as shown. Mark the top of the piston and the connecting rod with respect to cylinder number. Loosely re-attach the connecting rod cap to the connecting rod.

GENERAL PISTON NOTES: FOCS Series pistons are identical for the 602, 903, 1204. The 502 piston is slightly different and carries a separate part no.. The 1204/T piston is identical to the 602, 903 and 1204, but is fitted with a special top compression ring individual to the 1204/T.



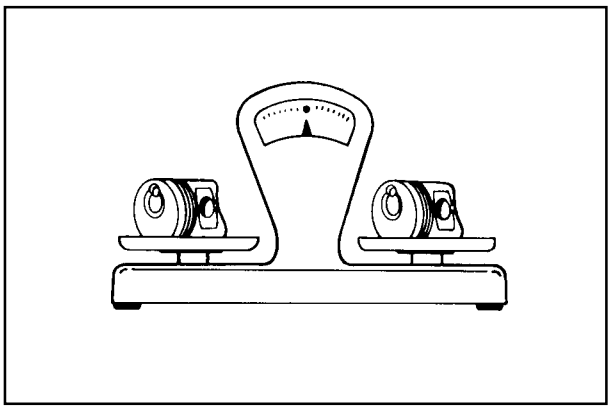
PISTON / CONNECTING ROD DISASSEMBLY and PISTON INSPECTION
Carefully remove and retain the piston pin snap ring (one(1) side only) using a suitable awl and a small screwdriver as required(see diagram). Do not damage the snap ring seat during the removal process. Push the piston wrist pin far enough to allow the piston and connecting rod to be separated. NOTE: If required, the wrist pin may be tapped with a soft faced drift to assist wrist pin movement. If tapping is required, place the piston on a protected surface so that the skirt of the piston is not damaged during the tapping process. Do not allow the drift to contact the piston pin bore.
INSPECTION: Clean the piston and piston pin in solvent. Dry with compressed air. Inspect the piston for scoring, galling and signs of localized overheating. Carefully remove the piston rings. Remove all carbon from the piston top. Clean the carbon from the ring grooves using a suitable ring groove cleaning tool.
MEASUREMENT: Measure the diameter(Q) of the piston skirt a distance(A)-9mm from the bottom of the piston skirt. Measure piston ring land/ ring clearance as detailed on page 39.



PISTON CLASS, WEIGHT IMBALANCE and GENUINE LOMBARDINI MARKINGS
As part of the high quality standards of Lombardini, pistons are fitted within FOCS engines as a function of finished cylinder size. Four(3) piston classes exist- A,B,C. The piston class is stamped into the bottom of the piston as shown in the diagram (at arrow). The Lombardini logo on the bottom of the piston crown is your assurance that the piston is GENUINE Lombardini.
PISTON CLASS DETAILS (502-602-903-1204-1204/T):

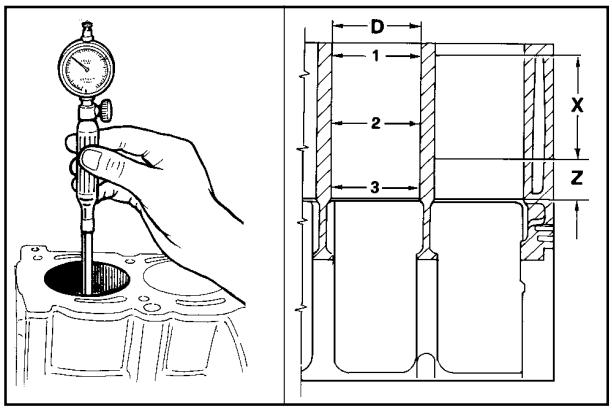
CLASS	Ø Cylinder (mm)	Ø Piston (mm)	Clearance (mm)
A	71.990 / 72.000	71.930 / 71.940	0.050 / 0.070
B	72.000 / 72.010	71.940 / 71.950	
C	72.010 / 72.020	71.950 / 71.960	

PISTON CLASS DETAILS (702-1003-1404):



CLASS	Ø Cylinder (mm)	Ø Piston (mm)	Clearance (mm)
A	74.990 / 75.000	74.930 / 74.940	0.050 / 0.070
B	75.000 / 75.010	74.940 / 74.950	
C	75.010 / 75.020	74.950 / 74.960	

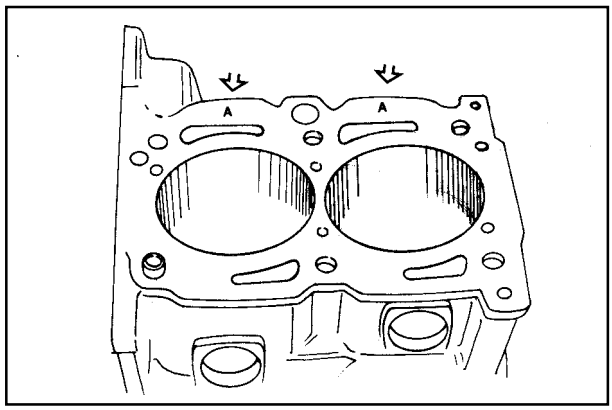
REPLACEMENT PISTONS (SPARE PARTS): Replacement pistons are supplied with piston rings reflective of the piston class. Replacement pistons are supplied as class A. Piston classes B and C are reserved for production engines. Oversized pistons are available as 0.50mm and 1.00mm and are supplied with piston rings reflective of the oversized diameter. DO NOT FIT PISTON RINGS FOR STANDARD PISTONS ON OVERSIZED PISTONS. DO NOT FIT RINGS FOR OVERSIZED PISTONS ON STANDARD PISTONS.
PISTON BALANCE: Weigh all pistons to be installed within a single engine. The total difference in weight between the lightest and heaviest piston should not exceed 4 grams.



CYLINDER INSPECTION / DIMENSIONAL SPECIFICATIONS

Thoroughly clean the cylinders and upper deck of the crankcase. Alternately, completely clean the crankcase with solvent and dry with compressed air. Remove all carbon deposits from the cylinder and carefully remove any excessive ridge at the upper portion of the cylinder using a suitable “RIDGE REAMER” tool. Inspect the cylinders for general wear, scoring, galling and discoloration.
Using a calibrated bore gauge, measure the cylinder diameter at four(4) positions in 45° intervals at each of the depths (1), (2) and (3) as shown. The piston ring contact zone is shown as (X), while the piston skirt only contact area is shown as (Z). Dimensional analysis is as follows:

D= 71.990 / 72.000mm, CLASS A- (All FOCS Models)

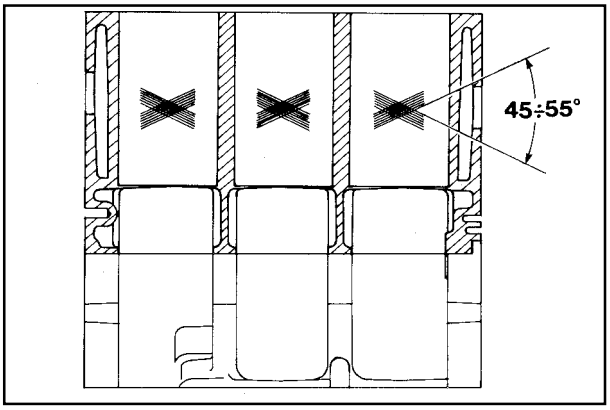


If the cylinder is found to be 72.050mm or greater at any measurement point, bore the cylinder by 0.50 or 1.00mm. Further, if the cylinder is found to be in specification, but the bore is tapered or bell-mouthed, boring is suggested. NOTE: To determine the piston running clearance, measure the piston skirt as detailed on page 37, then measure the cylinder bore in zone (Z). The piston running clearance will be the difference between the two (2) dimensions.

CYLINDER CLASS

The cylinder class (at time of manufacture) is stamped on the upper deck of the crankcase as shown in the diagram. Cylinders are classed as A,B,C depending on the exact cylinder diameter.

NOTE: Replacement pistons are available in class A. If upon disassembly, the existing pistons cannot be reused, replace the piston with class A depending on the cylinder diameters found.



NOTE 2: The LDW 502 aluminum version is designed with an aluminum crankcase and non-replaceable cast iron cylinders. The cylinders may be machined 0.500 and 1.000mm identically to standard crankcase versions of the LDW-FOCS.

CYLINDER SURFACE FINISH

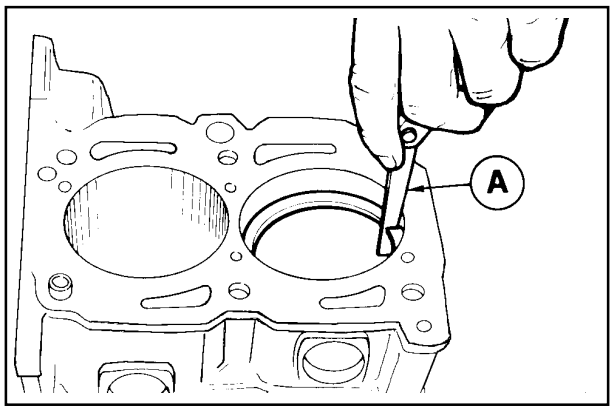
Proper cylinder surface finish is critical for low oil consumption and optimal engine performance. Therefore, the success of an engine rebuild is greatly affected by the preparation of the cylinders with respect to surface finish.

After inspection of the cylinders as detailed above, the cylinders should be power honed. A “BEAD” type hone is preferred for engines that do not require boring. Engines that require boring, should be power honed as part of the boring operation. Since honing removes material, the diameter of the cylinder should be re-checked as detailed above following honing.

The honing operation should produce a pattern oriented at 45-55° as shown in the diagram. The final surface roughness should be 0.5-1.0mm.

POST HONING CLEANING: Lombardini strongly recommends that the cylinders be washed with hot water and a strong degreasing soap following honing. Finish the cleaning operation with a thorough rinsing with clean water, then dry the crankcase with compressed air. Coat all exposed surfaces, especially the cylinders and upper crankcase deck with clean engine oil to prevent corrosion.

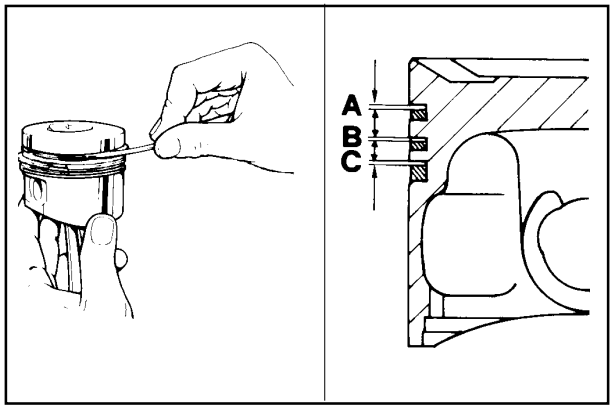
NOTE: DO NOT USE EMERY CLOTH, SAND PAPER, ETC. ON THE CYLINDER IN ATTEMPTS TO CREATE A CROSS-HATCH PATTERN BY HAND MOTION.



PISTON RING END GAP
Prior to installing piston rings on each piston, install the rings within the cylinder bore, approximately 25mm from the top of the crankcase deck as shown. A piston turned upside down should be used to push the rings to the 25mm depth so that assurances of proper orientation can be had. Use a feeler gage(A) to measure the ring end gap. The specifications are as follows:

1st piston ring(compression) = 0.25-0.45mm,(USEABLE Limit = 1.00mm)
2nd piston ring(compression) = 0.25-0.45mm,(USEABLE Limit = 1.00mm)
3rd piston ring(oil scraper) = 0.25-0.45mm,(USEABLE Limit = 1.00mm)

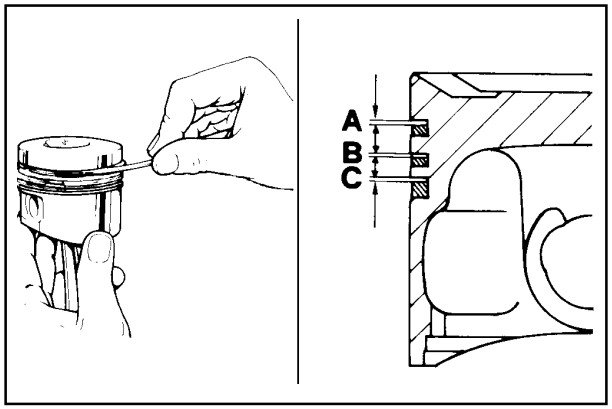
NOTE: If the ring gap is less than the minimum value shown, gently secure the ring in a soft jaw vise and file (small amount) the ends of the ring, re-checking the end gap periodically until the required clearance is achieved. Remove all burrs from the piston ring ends before installation.



PISTON RING TO PISTON LAND CLEARANCE
With reference to the diagrams, measure the piston ring to piston land clearance using a feeler gage. If the piston has previously been operated within and engine, the piston should be inspected and cleaned as described on page 36.
The specifications for piston ring to piston land clearance are as follow:

A = 0.090-0.125mm
B = 0.050-0.085mm
C = 0.040-0.075mm

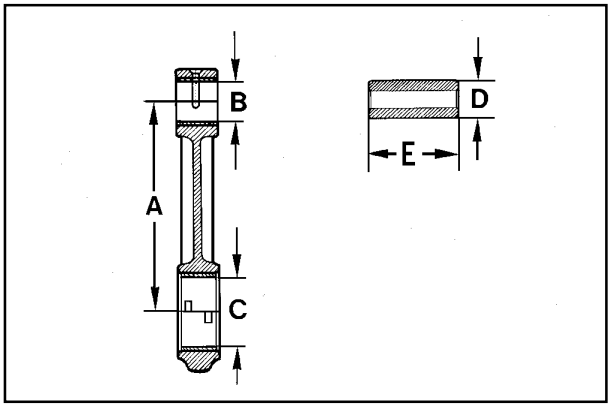
Replace the piston and/or piston rings if the piston ring to piston ring land clearance exceeds the specification.



PISTON RING ASSEMBLY LOCATION
With reference to the diagram, carefully install the piston rings onto the piston.

A Top Compression Ring (Tapered / Torsional)
B No. 2 Compression Ring (Tapered / Torsional)
C Oil Control Ring (Internal Spring, 2 piece Ring)
D Chrome Plated Portion of Top Compression Ring
E Chrome Plated Portion of Oil Control Ring

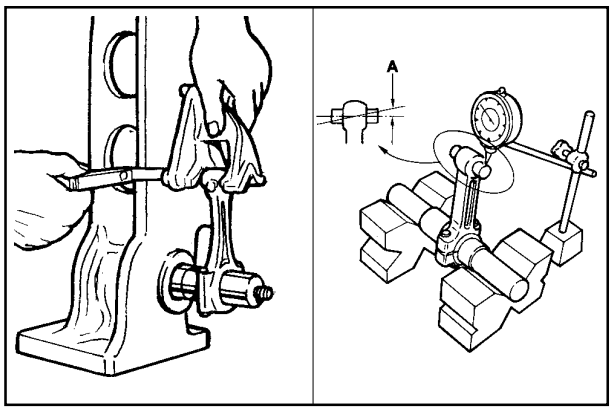
NOTE: As shown on the diagram, install the rings so that the word “top”, “UP” or any other markings faces up.



CONNECTING ROD / CONNECTING ROD BEARINGS SPECIFICATIONS
INSPECTION / SET-UP: Remove the connecting rod cap. Remove the connecting rod bearing inserts. Clean the connecting rod and bearings in solvent, then dry with compressed air. Inspect the connecting rod for nicks, gouges and potential stress risers. Inspect the wrist pin bushing for scratches and indications of galling or overheating. Discard the connecting rod if any doubt concerning the general condition of the connecting rod exists. Inspect the connecting rod bearings for wear, dis-coloration, scatches and grooves. Discard the connecting rod bearings if any doubt exists. Install the connecting rod bearing inserts (whether new or existing) into the connecting rod, then torque the connecting rod cap. See page 41 for connecting rod cap orientation and torque specifications. The following provides dimensional specifications for a fully assembled (with bearings) and torque connecting rod. Replace the connecting rod and/or connecting rod bearings if dimension conformance to the following is not shown.

Dim.	SPECIFICATION	NOTES
A	126.48÷126.520mm	LDW 502=106.98 / 107.02mm
B	18.015÷18.025mm	LDW 1204/T= 20.015 / 20.025
C	40.021÷40.050mm	(Cap Torqued to 40 Nm)
D	17.996÷18.000mm	LDW 1204/T= 19.996 / 20.000mm
E	50.900÷51.100mm	LDW 1204/T= 54.000 / 55.100mm
B-D = 0.015÷0.039mm; USEABLITY Limit = 0.060		

NOTE: If the small end bushing is replaced, the lubrication hole must be aligned

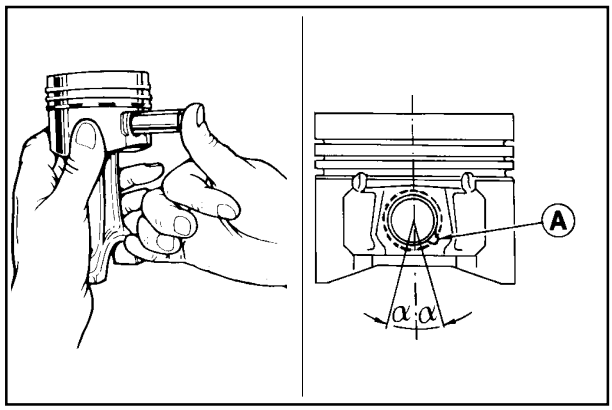


CONNECTING ROD ALIGNMENT

Check the alignment of the connecting rod wrist pin bore with respect to the connecting rod journal diameter by fitting the connecting rod to a suitable fixture as shown or by placing the connecting rod on a mandrel in V-blocks as shown. If the V-block and dial indicator method is used, center the wrist pin in the connecting rod wrist pin bore so that an equal amount of the wrist pin protrudes from each side of the connecting rod. While holding the wrist pin down and seated in the wrist pin bushing, measure the height of the wrist pin on both sides of the connecting rod. If the fixture method is used, press down on the wrist pin as shown and measure the any axial offset.

Maximum Axial Mis-alignment = .015mm (USEABILITY Limit = 0.030mm)

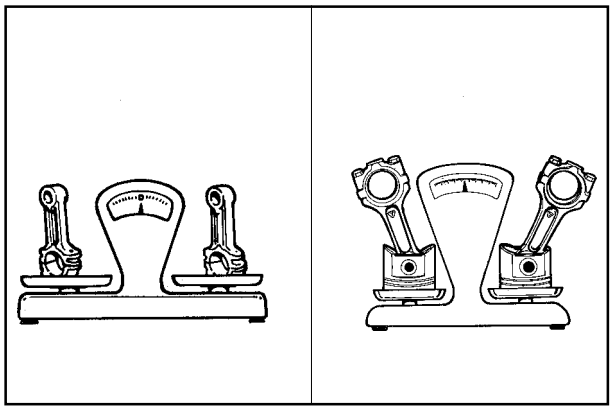
Minor mis-alignment may be corrected by skillfully and gradually working the connecting rod between centers on a press. DO NOT ATTEMPT TO CORRECT MIS-ALIGNMENT UNLESS PROPERLY TRAINED AND EXPERIENCED.



PISTON WRIST PIN INSTALLATION / RETAINING SNAP RING

After thoroughly cleaning and checking the connecting rod as described in the previous, liberally coat the wrist pin , piston wrist pin bore and wrist pin bushing with clean engine oil. While holding the piston and connecting rod as shown, insert the wrist pin into the piston and through the connecting rod. Do not force the wrist pin or use a hammer or drift pin to install the wrist pin. If hand force cannot install the wrist pin, investigate the cause of the problem.

Install the piston pin retaining pin so that the open ends of the snap ring are oriented as shown in the diagram. The radial distance between the piston centerline and the open ends of the snap ring should be equal on both sides. The snap ring may be moved into proper position after installation by carefully acting on the snap ring with a suitable awl at point(A).



CONNECTING ROD- PISTON ASSEMBLY BALANCE

Weigh the connecting rod / piston assemblies to be installed with a given engine. The maximum allowable weight difference between the lightest and heaviest assembly is 10 grams.

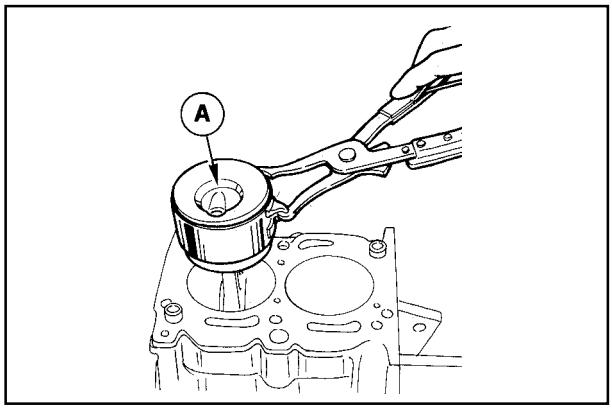
If the 10 gram differential in weight cannot be achieved, exchange pistons and/ or connecting rods until the maximum differential is 10 grams or less.

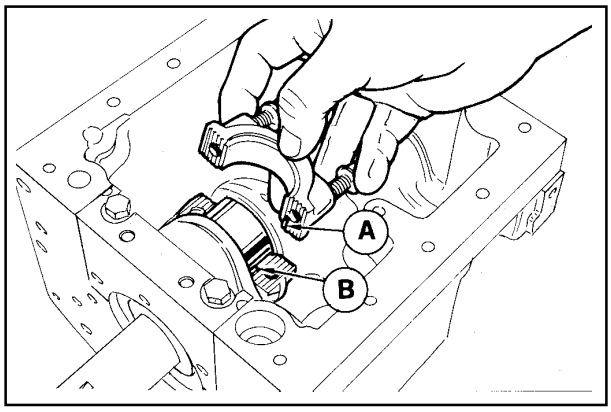
PISTON / CONNECTING ROD INSTALLATION

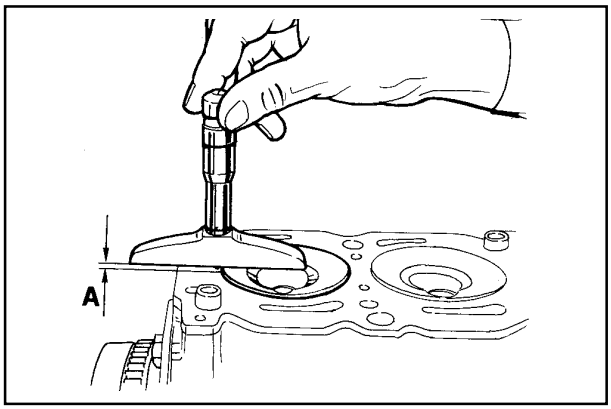
With reference to the cylinder bore and preparation specifications on page 38 and the information presented prior regarding pistons, piston rings and connecting rods, install the piston / connecting rod assembly.

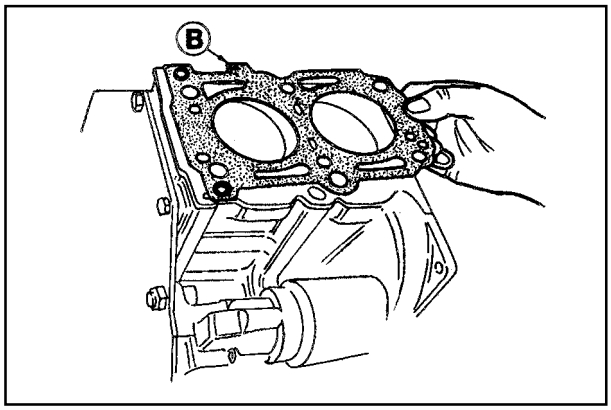
Rotate the engine so that the respective cylinder for piston/ connecting rod installation is at BDC. Clean the crankshaft rod journal. Coat the rod journal with clean engine oil. Remove the connecting rod cap. Install the upper and lower connecting rod bearings (see page 41). Liberally coat the connecting rod bearings, cylinder, piston and piston rings with clean engine oil. Rotate the piston rings to insure that no ring end gap is located on the thrust side of the piston (90° ± 10° from the wrist pin axis) and that all ring end gaps are spaced approximately 120° relative to each other.

Compress the piston rings with a suitable tool as shown. Orient the piston so that the turbulence chamber(A) in the top of the piston will correspond to the pre-combustion chamber in the cylinder head. Gently lower the piston / connecting rod assembly into the cylinder taking extreme care not to cock the piston in the bore and preventing the connecting rod from contacting the crankshaft. Gently tap the center of the piston with the wooden end of a light hammer while guiding the connecting rod over the crankshaft journal.









Match the piston protrusion dimension determined above with dimension(A) from the chart. Install the corresponding head gasket. If a head gasket cannot be chosen based upon the piston protrusion measured, check the connecting rod length, rod bearings, wrist pin bushing, etc. for the cause of the problem.

Completely clean the deck surface of oil, old gasket material, varnish, coolant, etc. Remove all traces of fluid from the cylinder head bolt bores. Install the head gasket so that the gasket aligns with the deck dowels and the brand name or “TOP” printed on the gasket faces up.

CONNECTING BEARING / ROD CAP INSTALLATION

Install the connecting rod bearing inserts into the connecting rod and connecting rod cap. Make sure that the back of the bearing insert and the connecting rod and connecting rod cap bore is free of dirt, rust, oil etc. Insert the bearing inserts so that the tab on the bearing aligns with the slot in the connecting rod or connecting rod cap. Push the bearing completely into the connecting rod and connecting rod cap. Liberally oil the bearings with clean engine oil. Install the connecting rod cap onto the connecting rod making sure that the respective tang/slot locks on the connecting rod cap aligns with the tang/ slot lock on the connecting rod.

Torque the connecting rod bolts to 40 Nm in 5 Nm steps.

PISTON PROTRUSION

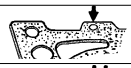
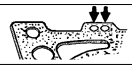
Rotate each cylinder to exact TDC. TDC may be determined by the use of a dial indicator mounted to the cylinder deck and indicating piston height as a function of crankshaft rotation.

After TDC is established, measure the protrusion of the piston (A) from the cylinder deck plane using a calibrated depth micrometer. The height should be measured on a line corresponding to the wrist pin axis as shown. Record the protrusion. Repeat the TDC establishment and piston protrusion procedure for each cylinder, recording the value for each cylinder. The **HIGHEST** protrusion measured will be used to establish the proper head gasket selection as presented below.

HEAD GASKET SELECTION/ INSTALLATION

Three(3) separate head gasket thickness’ are available for FOCS engines depending on the measured piston protrusion as measured above. The head gaskets are identified by notches cut in the edge located at point (B) as detailed below. Head gaskets are provided with “0 notch”, “1 notch” or “2 notches” to

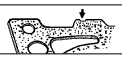
For 502,602,903,1204,1204/T

A (mm) (PISTON PROTRUSION) Head Clearance (mm)	No. of hole	Piston to Cylinder
0.97/1.06	0	0.39/0.48
1.07/1.16	1 	
1.17/1.25	2 	0.40/0.48

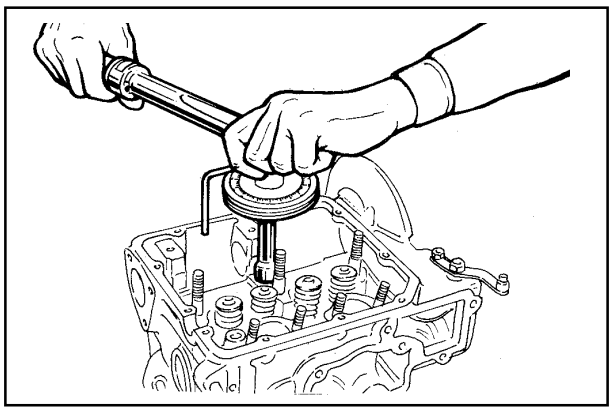
For 702,1003

A (mm) (PISTON PROTRUSION) Head Clearance (mm)	No. of hole	Piston to Cylinder
0.82/0.91	0	0.54/0.63
0.92/1.01	1	
1.02/1.10	2	0.55/0.63

For 1404

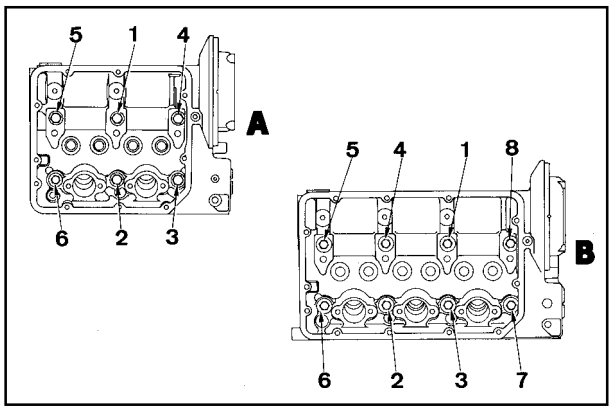
A (mm) (PISTON PROTRUSION) Head Clearance (mm)	No. of Notches	Piston to Cylinder
0.82/0.91	1 	0.52/0.61
0.92/1.01	2	
1.02/1.10	3	0.53/0.61

assist in the identification of the different gaskets.



CYLINDER HEAD INSTALLATION

FOCS cylinder head bolts are tightened/ torqued using a constant tension method as opposed to the traditional simple torque method. In short, the bolts are pre-loaded, then rotated in two(2) steps to ensure all bolts are tensioned exactly the same. The additional rotation after the initial pre-load stretches the bolts.
PREPARATION: Clean the cylinder deck thread holes of all liquid, gasket material, rust, etc. Clean the cylinder head sealing surface of all gasket material, deposits, etc. Clean the head bolt threads. Measure the length of the head bolts. The nominal length (new) is 89.5 / 90.5mm. Each time the bolts are tightened, the bolt stretches slightly. DO NOT USE HEAD BOLTS WITH MEASURED LENGTHS OF 92mm OR GREATER. In general terms, head bolts may be tightened three(3) times before replacement. Liberally oil the cylinder head bolt thread, bolt head thrust area and washer. Install the head gasket according to the instructions on page 41. Gently place the cylinder head on the crankcase aligning the index dowels. Fit a suitably sized torque wrench with a dividing head as shown.



CYLINDER HEAD TIGHTENING PROCEDURE- LDW 502, 602, 702, 903 and 1003:

FIGURE A = LDW 502, LDW 602, LDW 702

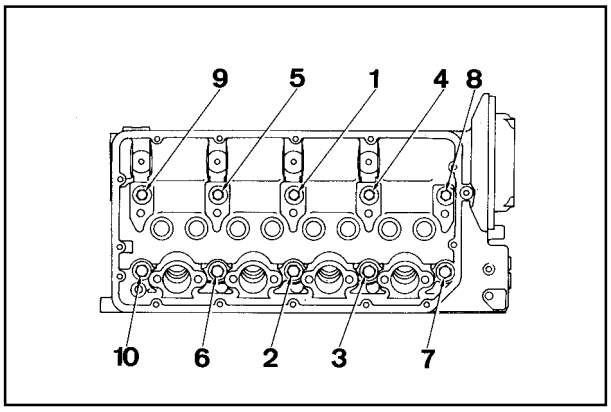
FIGURE B = LDW 903, LDW 1003

STEP 1: Torque the head bolts to 50 Nm in 10 Nm steps in the order shown.

STEP 2: Rotate each head bolt, in the order shown, 90° (clockwise)

STEP 3: Rotate each head bolt, in the order shown, 90° (clockwise)

NOTE: NO POST OPERATION RE-TORQUE OF THE CYLINDER HEAD IS REQUIRED OR RECOMMENDED.



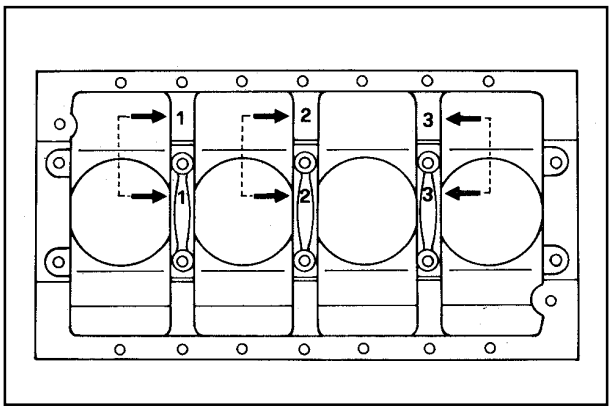
CYLINDER HEAD TIGHTENING PROCEDURE- LDW 1204, LDW 1404, LDW 1204/T

STEP 1: Torque the head bolts to 50 Nm in 10 Nm steps in the order shown.

STEP 2: Rotate each head bolt, in the order shown, 90° (clockwise)

STEP 3: Rotate each head bolt, in the order shown, 90° (clockwise)

NOTE: NO POST OPERATION RE-TORQUE OF THE CYLINDER HEAD IS REQUIRED OR RECOMMENDED.

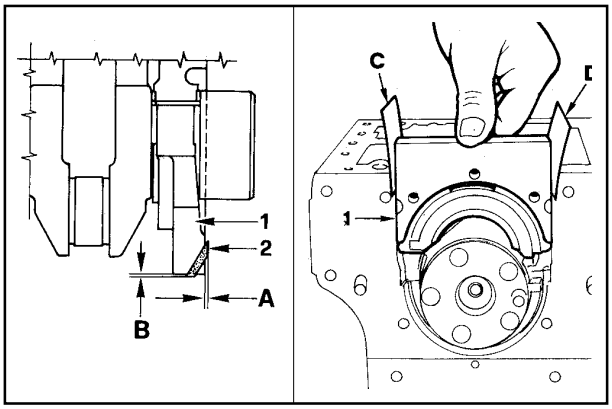


MAIN BEARING CAPS / BEARINGS- CENTER

The center main caps are referenced on the actual cap and on the crankcase as shown to allow replacement of the caps in the identical position of removal. The reference number locations are shown in the figure at the left. Always reposition main caps in the original position. NOTE: If main bearings are intended to be re-used following disassembly, mark the bearing position using a permanent marker.

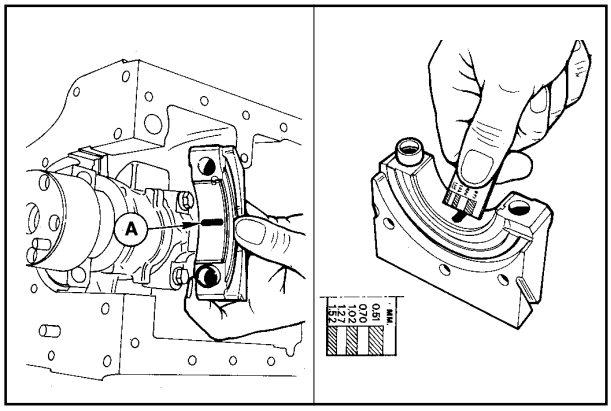
INSPECTION / CLEANING: Clean the main bearing caps in solvent and dry with compressed air. Remove all dirt, oil and deposits from the bearing seats. Check/ clean all oil passages and remove any and all impurities. Flush the oil passages with clean solvent before assembling the crankshaft. Inspect the main bearing caps and crankcase for cracks, signs of overheating, nicks, etc. Inspect the main bearings for wear and signs of oil starvation, pitting, scoring, etc. Thoroughly scrub, but do not damage the non-bearing surface (back side) of the main bearings if re-use is intended. Replace the main bearings if any doubt exists.

BEARING INSTALLATION / TORQUE SPECIFICATION. Install the main bearings (upper and lower) into the respective bearing seats/ caps aligning the “tang” on the bearing with the “slot” in the seat or cap. Liberally oil the bearing surface with clean engine oil. Install the main bearing caps with reference to original position (see above). Torque the main bearing caps to 60 Nm in 10 Nm steps.



FRONT / REAR MAIN BEARING CAPS / BEARINGS

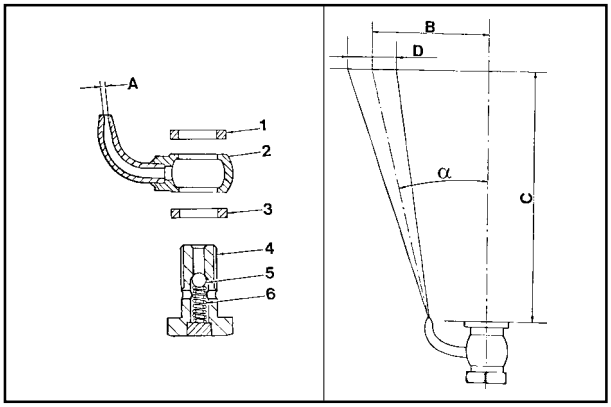
The front and rear main bearings of the FOCS engine are designed with lateral seals (2) installed between the sides of the main bearing cap and the crankcase saddle. The lateral seals MUST be replaced each time the main bearing caps are removed. Thoroughly clean the main bearing cap and crankcase as described above. Install and lubricate the main bearings as described above. Install the thrust bearings (rear main only) as described on page 43. Install the lateral seals onto the main bearing cap(1). Liberally lubricate the exterior of the seals. Place the special shims (part no. 1460-053) as shown in the figure between the crankcase and the main bearing. Push the main bearing into place. Remove the shims (part no. 1460-053). Torque the front and rear main bearing caps to 60 Nm in 10 Nm steps. Following installation, the lateral seal must extended 0.5-1.0mm past the crankcase planes(A) at the front and rear face of the crankcase and 0.5-1.0mm past the oil pan plane(B) to allow complete sealing. Trim material in excess of 1.00mm with a razor knife. NOTE: Prior to installation of the rear seal support, oil pump or the oil pan, apply a small amount of RTV Silicone to the lateral seal extended area.



MAIN BEARING CLEARANCE

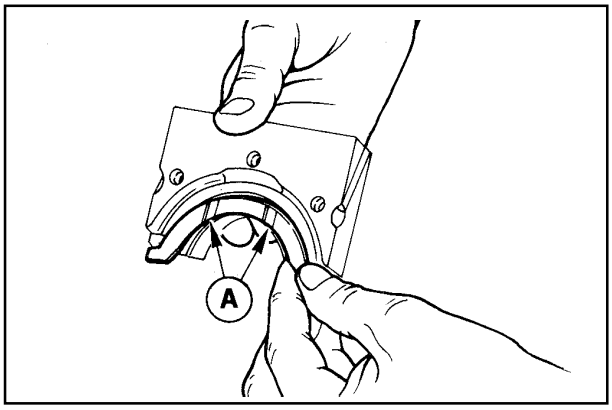
Ideally, main bearing clearance is determined following actual measurement of the main bearing journals and the main bearing diameters. “PLASTIGAGE” however, can provide a quick and reasonably accurate determination of main bearing clearance. Review and understand the instructions provided with the “PLASTIGAGE” kit. Invert (if possible) the engine so that the crankshaft weight is directed away from the main bearing cap. Remove the main bearing cap in question. Clean all oil from the main bearing and crankshaft using a spray solvent. Place a small strip of PLASTIGAGE across the main bearing as shown at (A). Install and torque the main bearing to 60 Nm. DO NOT ROTATE THE ENGINE!. Remove the main bearing cap and compare the width of the compressed PLASTIGAGE strip to the “KEY” provided with the PLASTIGAGE (as shown) to determine the bearing clearance.

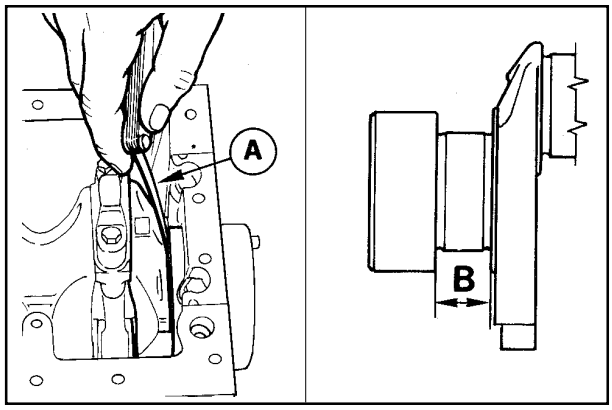
PISTON COOLING JETS- LDW 1204/T: The LDW 1204/T engine is equipped with cooling jets which spray engine oil on the underside of the piston providing additional engine cooling. The cooling jets attach to the crankcase directly adjacent to the lower cylinder.

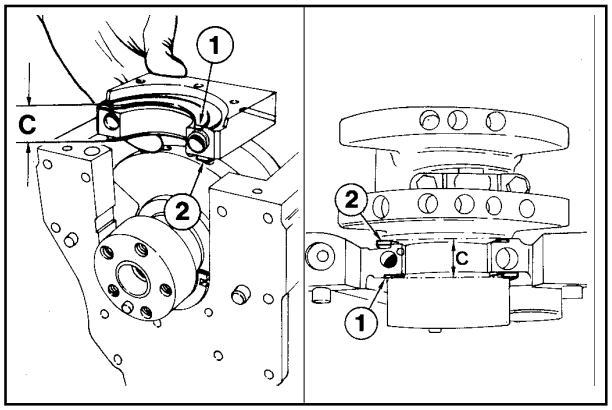


COMPONENTS:		SPECIFICATIONS:
1	Washer	A = 0.80 / 0.85mm
2	Nozzle	B = 34mm
3	Washer	C = 150mm
4	Banjo Bolt	D = 16mm
5	Check Ball	a = 5°
6	Spring	

INSPECTION / CLEANING / INSTALLATION: Inspect the spray jets for damage and clogging. Using new washers(1),(3), affix the nozzle(2) to the crankcase with bolt(4). Slowly rotate the engine to BDC (each cylinder). Adjust the position of the nozzle(2) so that no contact is made with the piston at BDC and the nozzle is pointed at the center of the piston bottom. Torque the bolt (4)







THRUST BEARINGS

Thrust bearings on the FOCS engine are supported by the rear main bearing cap and the crankcase. The thrust bearing assembly consists of four(4) separate thrust bearing segments. Two(2) of the segments are supported by the crankcase and the remaining two(2) are supported by the rear main bearing cap. All four(4) of the thrust bearing segments act upon the crankshaft thrust surfaces.

INSPECTION: Thoroughly clean the rear main bearing cap thrust bearing socket and the crankcase side thrust bearing socket. Inspect the thrust bearings for indications of high wear, scuffing, scratches and general condition. Inspect the crankshaft thrust surfaces for galling, scratches, pitting, etc..

INSTALLATION: Liberally coat the crankcase side thrust bearings with clean engine oil and install by “rolling” the segments between the crankcase thrust bearing socket and the crankshaft thrust surface. The bearings must be installed so that the bearing surface, as indicated by oil grooves(A) is oriented toward the crankshaft thrust surface. The main bearing cap thrust bearings are simply placed on the thrust bearing reliefs and indexed with location “ears” as shown in the diagram. The thrust bearings must be oriented so that the oil grooves(A) face the crankshaft thrust surfaces. Liberally coat the thrust bearings with clean engine oil, then install the rear main bearing following the instructions presented on page 43. NOTE: The upper thrust bearings (crankcase side) do not include the locator “ears” for purposes of locational index.

CRANKSHAFT END PLAY

After installing all main bearings and the thrust bearings, the crankshaft end play may be measured.

1. Push the crankshaft toward the crankshaft pulley end of the engine.
2. Using a feeler gage, measure the clearance between the thrust bearing wear surface and the crankshaft thrust surface.

SPECIFICATIONS:
A = 0.130 / 0.313mm (Wear Limit = 0.5mm)
B = 23.05 / 23.10mm (Wear Limit = 23.50mm)

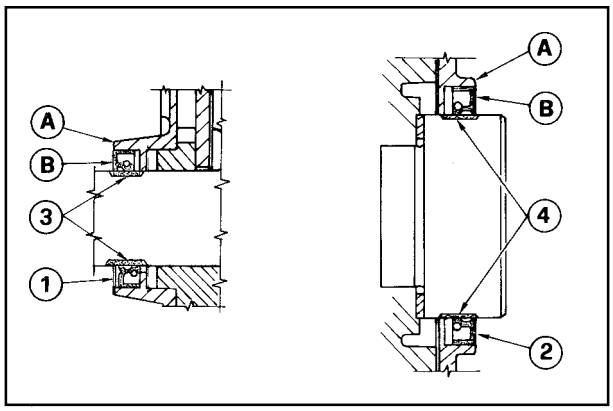
If the crankshaft end play exceeds the specifications above, fit the engine with oversize thrust bearing segments and/or grind the crankshaft thrust surfaces. The following provides guidelines for the application of oversize bearings and for grinding the crankshaft thrust surfaces.

THRUST SURFACE SPECIFICATIONS- CRANKSHAFT END PLAY CORRECTIONS

Depending on the condition/ width of the crankshaft thrust surfaces(B)(above figure) and the width(C) of of the main bearing cap thrust bearing socket/ thrust bearing width combination, crankshaft end play can be corrected in several ways. Std, 0.1mm oversized and 0.2mm oversized thrust bearings can be fitted on side(1), side(2) or both. The following table provides details of the combinations of thrust bearing width, thrust surface width(main bearing cap / crankcase) and crankshaft thrust surface width.

TABLE KEY:
A = Crankshaft End Play (resultant)
B = Width of crankshaft thrust surface

THRUST BEARING COMBINATION	C (mm)	B (mm)	A (mm)
Standard	22.787÷22.920	23.050÷23.100	0.130÷0.313
0.1mm (both sides)	22.987÷23.120	23.250÷23.300	0.130÷0.313
0.1mm (one side) 0.2mm (one side)	23.087÷23.220	23.350÷23.400	0.130÷0.313
0.2mm (both sides)	23.187÷23.320	23.450÷23.500	0.130÷0.313



Front Crankshaft Seal Rear Crankshaft Seal

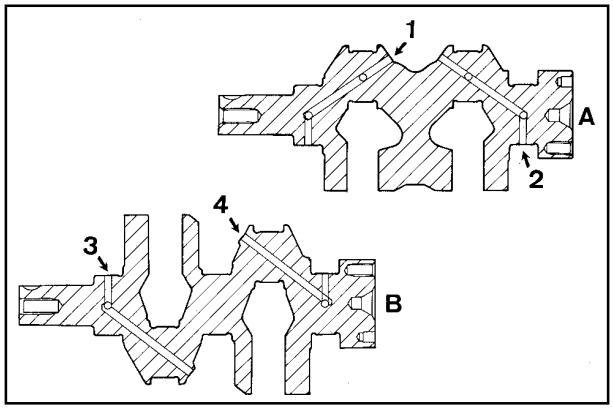
CRANKSHAFT SEALS - FRONT and REAR

The front seal for the FOCS diesel engine is housed within the oil pump assembly. The rear oil seal is supported by the rear oil seal support. Lombardini recommends that oil seals be replaced if removed from the supporting bores. The oil seals should also be replaced if upon inspection, signs of hardening, stress cracks, dampness on the exterior or dry rot is noted.

SEAL DETAILS:
A Seal Support
B Seal
1 Installation depth plane (initial), front
2 Installation depth plane (initial), rear
3 Crankshaft wear surface- front
4 Crankshaft wear surface- rear

INSTALLATION: Remove the oil pump or seal support depending upon front or rear seal replacement. Gently, without deforming the seal supporting bore, pry the seal from the bore. Carefully clean, in a non abrasive manner, the wear surface of the crankshaft. Soak the oil seal in clean engine oil for approximately 1/2 hour. Coat the crankshaft with clean engine oil. Using a suitable mandrel, evenly and squarely push the seal into the bore until the outer seal plane coincides with planes (1) or (2). Reinstall the oil pump or seal support using new gaskets as required. Torque the rear seal support retaining bolts to 12 Nm. Torque the oil pump retaining bolts to 25 Nm.

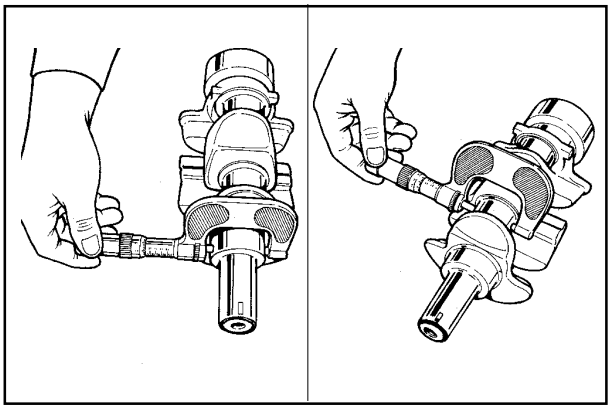
NOTE: If the wear surface of the crankshaft showed signs of grooving at the initial installation depth reference (1) or (2), push the seal into the bore an additional 2mm using a suitable mandrel.



CRANKSHAFT LUBRICATION DRILLINGS- TYPICAL

The lubrication drillings for the LDW 502(A) and LDW 602-702(B) are shown in the diagram. The lubrication drillings for the LDW 903, LDW 1204 and LDW 1204T are very similar to the LDW 602-702.

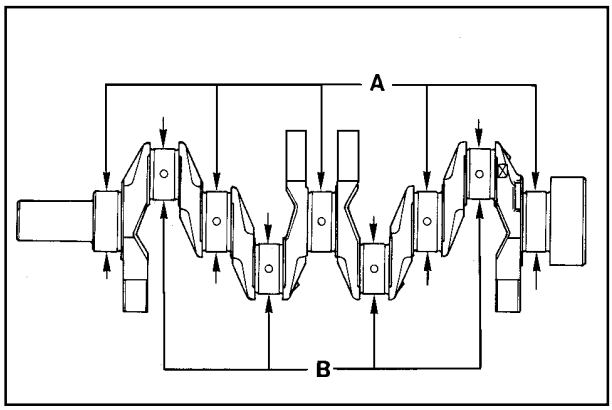
CLEANING: Remove plugs at (1) and (4) by suitable means. Soak the crankshaft in solvent to loosen any deposits within the drillings. Clean the drillings (1), (2), (3), and (4) by blowing with compressed air, using stem brushes, etc.. Cap the drillings at (1) and (4) with new plugs.



CRANKSHAFT JOURNAL INSPECTION / MEASUREMENT

INSPECTION: Inspect each journal (main and rod) for scratches, scoring, grooves and general wear. Replace the crankshaft or machine as required. See page 456for dimensional specifications.

MEASUREMENT: With reference to the diagram, measure each journal with a calibrated micrometer. Each journal should be measured at 45° intervals around the circumference of each journal beginning at the position shown on the left most diagram. At each interval, measure two seperate parts of the given diameter- once near the center of the journal and once near the fillet of the journal.



CRANKSHAFT JOURNAL SPECIFICATIONS

For LDW 502,602,903,1204,1204/T
A = Main Journals= 47.984 / 48.000mm (WEAR Limit = 47.900mm)

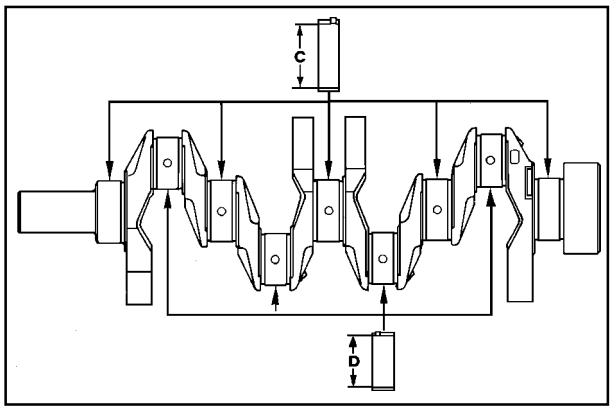
For LDW 702,1003,1404
A = Main Journals= 50,981 / 51.000mm (WEAR Limit = 50.900mm)

For LDW 502,602,702,903,1003,1204,1204/T,1404
B = Rod Journals = 39.984 / 40.000mm (WEAR Limit = 39.900mm)

NOTE 2: THE CRANKSHAFTS IN THE ALUMINUM AND CAST IRON VERSIONS OF THE LDW 502 ARE NOT INTERCHANGEABLE.

UNDERSIZED BEARINGS- ROD and MAIN

Undersized connecting rod and main bearings are available in sizes 0.25 and 0.50mm. Use of the undersized bearings will require the nominal size of the rod/ main journals to be reduced by 0.25 or 0.50mm respectively.



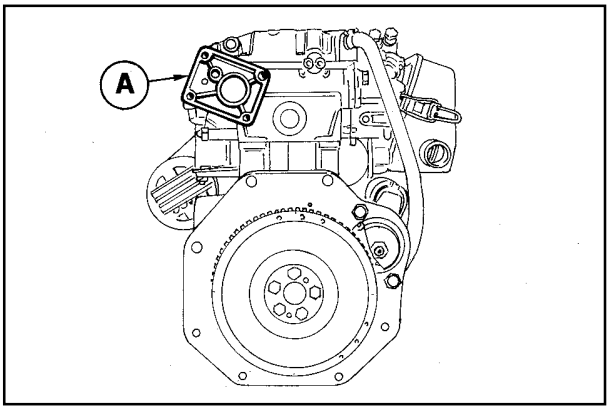
MAIN and CONNECTING ROD BEARINGS

The dimensions shown reflect clean, installed and torqued bearing inserts.

For LDW 502,602,903,1204,1204/T
C = Main Bearings =47.984 / 48.016mm (WEAR Limit = 48.055mm)
C-A = 0.022 / 0.074mm (WEAR Limit = 0.200mm)

For LDW 702,1003,1404
C = Main Bearings =51,023 / 51,059mm (WEAR Limit = 51,098mm)
C-A = 0.023 / 0.078mm (WEAR Limit = 0.200mm)

For LDW 502,602,702,903,1003,1204,1204/T,1404
D = Rod Bearings =40.021 / 40.050mm (WEAR Limit = 40.100mm)
D-B = 0.021 / 0.066mm (WEAR Limit = 0.130mm)



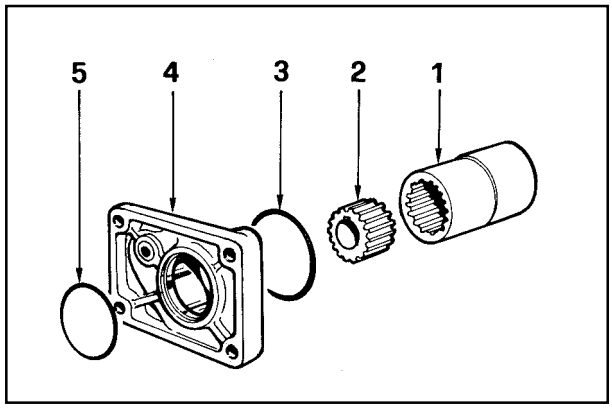
HYDRAULIC PUMP PTO- (No. 3 PTO)

All FOCS diesel engines may be fitted with a hydraulic pump drive(A) as shown. The hydraulic drive takes power from the back of the engine camshaft.
Hydraulic pump adaptations for DIN size 2PD, DIN size 1P and BOSCH pumps are available.

DRIVE SPECIFICATIONS:

Speed Ratio: 1 : 2, or 1/2 engine speed.

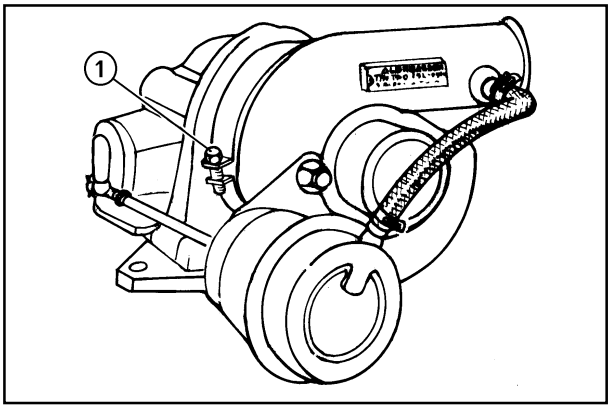
Maximum Torque = 37 Nm, irrespective of engine speed.
NOTE: 37 Nm @ 3600 r/min corresponds to 7 kW.



HYDRAULIC DRIVE COMPONENTS- No. 3 PTO

1 Splined Drive- (Bolts to Camshaft)
2 Pump Drive Gear (Attaches to Pump Input Shaft)
3 O-Ring
4 Pump Support (Bolts to Cylinder Head)
5 O-Ring

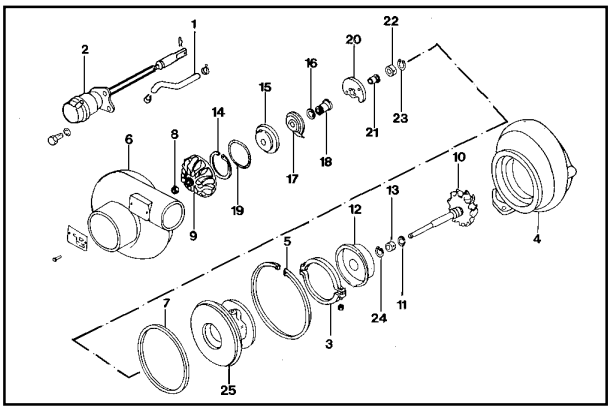
The splined drive(1) also includes the eccentric for the fuel lift pump. The splined drive must be bolted to the camshaft end and torqued to 80 Nm. The pump drive gear(2) must be torqued to the hydraulic pump input shaft. Check with the pump manufacturer for torque specifications at the input shaft.



TURBOCHARGER IDENTIFICATION

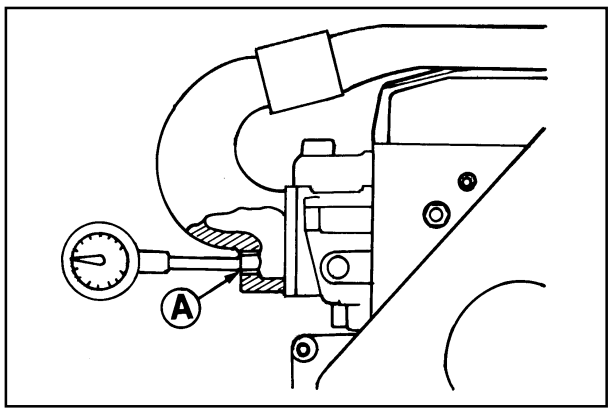
Only the LDW 1204/T is supplied with a turbocharger. The LDW 1204/T is available in two(2) versions with respect to no-load speed. A version operating up to 3000 rpm and a version operating up to 3600 rpm is offered. The two(2) engine versions are fitted with different turbocharger models with respect to the engine speed. The turbocharger can be identified by the manufacturing ID numbers on the data plate of the turbocharger.

TD 025 03C 2.8- 3600r/min
TD 025 03C 2.0- 3000r/min



TURBOCHARGER COMPONENTS

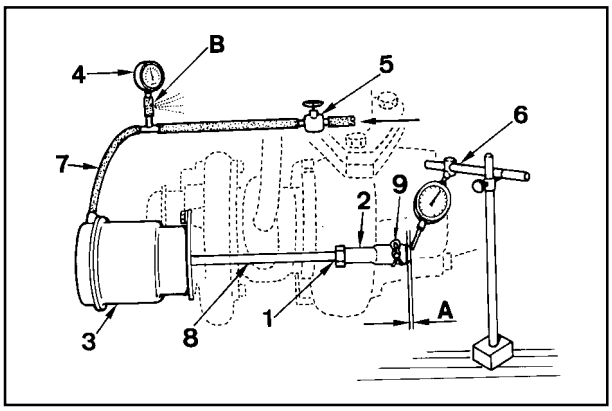
1 Waste gate tube
2 Waste gate actuator
3 Band clamp
4 Turbine housing
5 Ring
6 Compressor scroll
7 Shim
8 Nut
9 Lock nut
10 Turbine wheel
11 Ring-oil
12 Fire ring
13 Bearing
14 Band clamp
15 Shim
16 Ring-oil
17 Oil shield
18 Thrust bearing
19 O-ring
20 Thrust bearing
21 Thrust ring
22 Bearing
23 Ring
24 Ring
25 Bearing support



TURBOCHARGER PRESSURE TESTING

Install a 0-2bar pressure gauge at position(A) after removing the existing plug.
Start the engine and operate at low idle for five(5) minutes to allow warm-up. Increase the engine speed to 3000 r/min or 3600 r/min (depending on engine specification while applying full Nb load to the engine). See page 10 for the power output curve.

The gauge pressure, at full speed, full load, should be 0.87-0.91 bar. If the pressure setting does not reach specification, adjust the turbocharger waste gate as is defined on page 48.



TURBOCHARGER WASTE GATE ADJUSTMENT- BENCH METHOD

The adjustment of the turbocharger wastegate is a critical adjustment that should be carried out with the utmost care.

Prepare the following group of tools/ materials.

1 Calibrated, liquid filled pressure gauge with a mid-range scale of 1.2 bar.
2 Dial indicator with suitable magnetic base.
3 Regulated compressed air supply.
4 Suitable “TEE” fitting for gauge.

PROCEDURE:

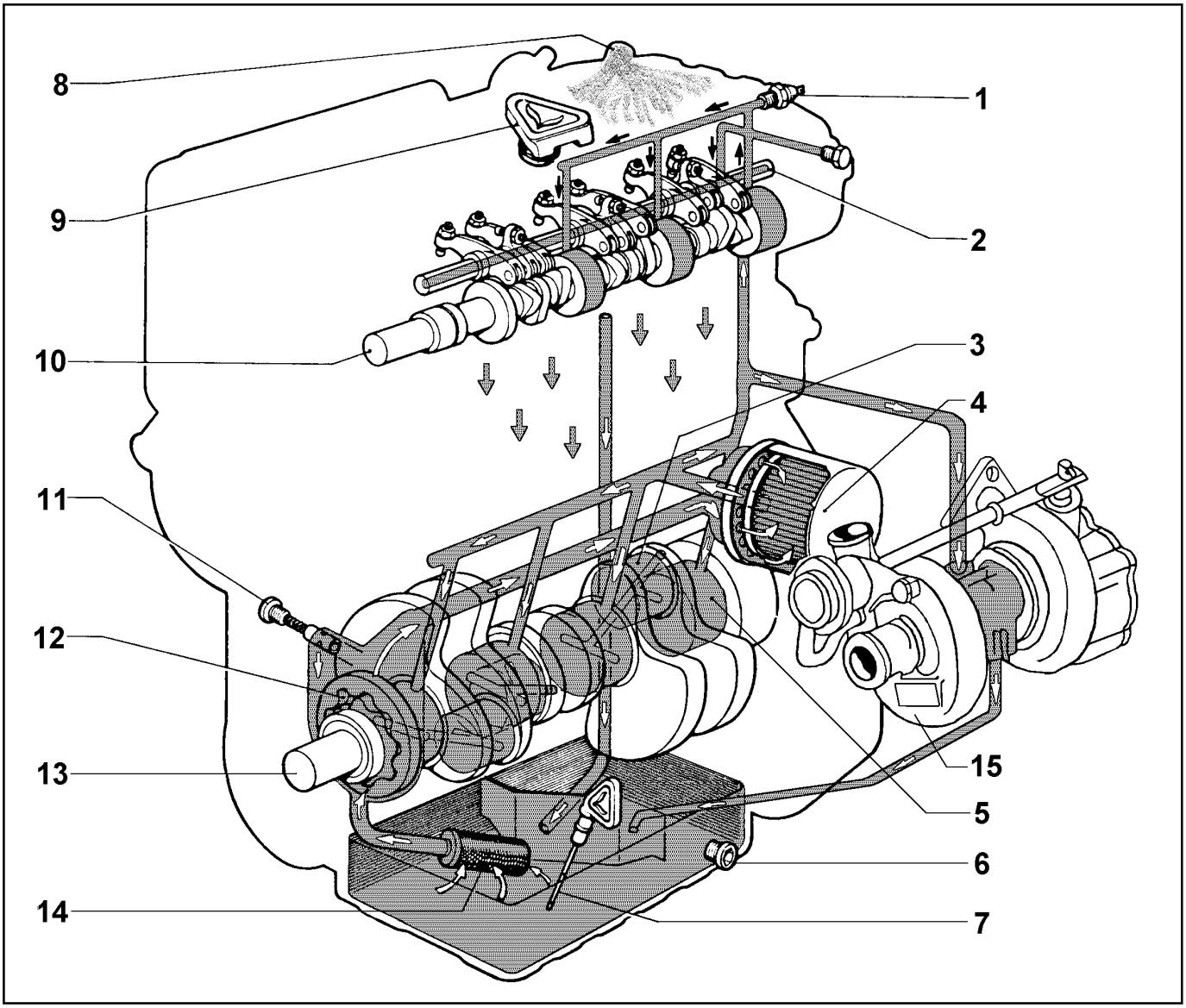
1 Disconnect wastegate tube (7) from the turbocharger compressor side.
2 Drill a 1.5 mm hole (B) in the gauge side of the “TEE” fitting. The relief hole will be required to allow stable pressure readings.
3 Sub-assemble the gauge onto the “TEE” fitting.
4 Using a suitable barb fitting, connect the gauge sub-assembly to the tube (7).
5 Fit the remaining open port of the “TEE” with a suitable regulated compressed air supply.
6 Set-up a magnetic based dial indicator so as to accurately measure the horizontal travel of actuation rod (8). The dial indicator should act upon rod end (2). Zero the dial indicator.
7 Slowly charge the tube(7) with air by gradually increasing air pressure from the regulated air supply(5). Continue to allow air flow until the dial indicator shows a total and accurate rod(8) movement of 1.00mm.
8 Note the gauge(4) pressure when the rod movement is 1.00mm(A).
9 The gauge pressure should be 1.11-1.19 bar.
10 If the proper gauge reading is not observed, remove pin(9), loosen nut(1), and adjust the rod end(2) position until the proper pressure reading is observed. Repeat the above procedure as required.

NOTE: When reassemblting the rod end(2) onto the waste gate, take care not to position rod end (2) so as to impede free motion. DO NOT LOAD THE WASTEGATE LEVER.

IV LUBRICATION SYSTEM

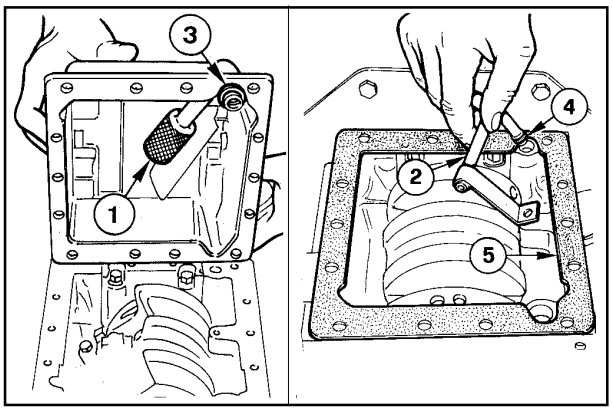
The engine can be damaged if allowed to operate with insufficient oil. It is also dangerous to add too much oil because its combustion may lead to a sharp increase in the rotation speed.
Use suitable oil in order to protect the engine.
Nothing more than lubrication oil can influence the performances 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.

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.

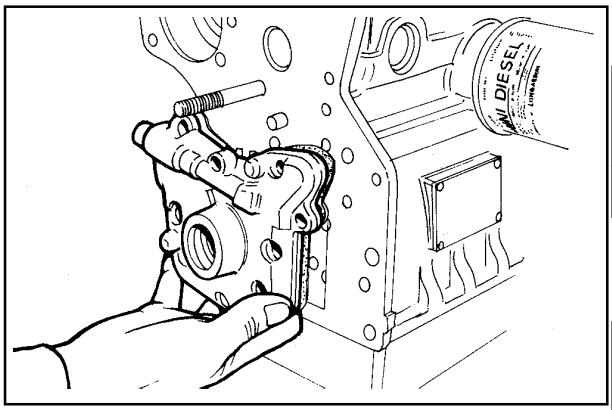


1	Oil pressure Switch	**6**	Oil Drain Plug	**11**	Oil Pressure Relief Valve
2	Rocker Arm Shaft	**7**	Oil Dipstick	**12**	Oil pump
3	Connecting Rod Journal	**8**	Crankcase Breather	**13**	Crankshaft
4	Oil Filter	**9**	Oil Fill Cap	**14**	Oil Pick-up Screen
5	Main Bearing Journal	**10**	Camshaft	**15**	Turbocharger

NOTE : Only the LDW 1204/T is equipped with a turbocharger (item 15) and turbocharger lubrication circuit.



OIL PICK-UP SCREEN AND OIL DRAIN BACK TUBE
After oil pan removal, remove the oil drain back tube(2) from the engine crankcase. Clean both the oil pan and drain back tube in solvent. Dry the oil pan and oil drain back tube with compressed air.
Inspection: Inspect the oil pick-up tube for dents, holes, corrosion and cracks. The oil pick-up screen must be free of obstructions. Inspect the oil pick-up tube O-ring seat for any damage or dents. Replace as required. Inspect the oil drain back tube for crimps, dents and cracks. Inspect the oil drain back tube O-ring seat for any damage. Replace as required.
Installation: Always replace O-rings (3) and (4) and oil pan gasket (5).
NOTE: The oil pan gasket may be replaced by Dow Cornkn 7091. See pag 40

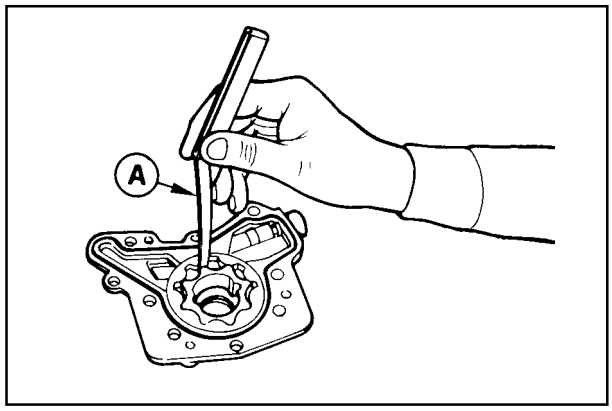


OIL PUMP SPECIFICATION:
Oil pump delivery (average figures) at 1000 r/min and oil temperature of 120°C

ENGINE MODEL	DELIVERY (l/min)	Pressure (Bar)
LDW 502,602,702,903,1003	4.0-4.3	3.0-3.5
LDW 1204,1204/T,1404	6.0-6.5	3.0-4.5

Oil pump delivery (average figures) at 3600 r/min and oil temperature of 120°C

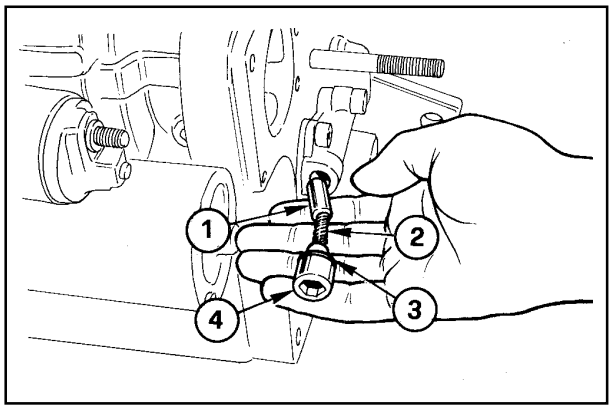
ENGINE MODEL	DELIVERY (Ilmin)	Pressure (Bar)
LDW 502,602,702,903,1003	19.3	4.0-4.5
LDW 1204,1204/T,1404	28.5	4.0-4.5



OIL PUMIP ROTOR INSPECTION

NOTE: Seee page 28, «OIL PUMP ASSEMBLY» for additional comments.

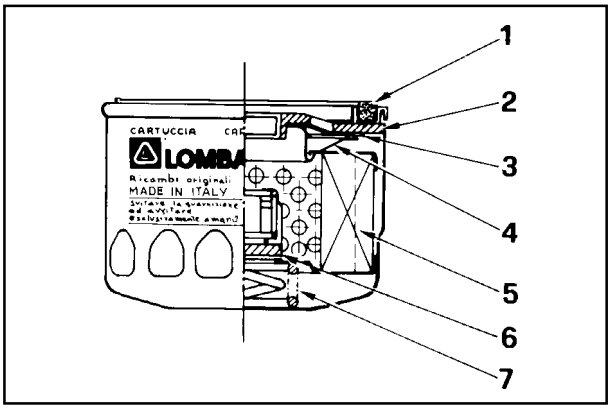
The oli pump rotor set should be replaced as part of the oil pump assembly. The condition of the oil pump can be ascertained by carefully disassembling the oil pump noting the thrust surface position of the rotor sets. The rotor set should be refitted in the original position. Remove the oil pressure relief valve (see below).
Carefully clean the oil pump rotor and oil pump body in clean solvent. Dry the components with compressed air.DO NOT DRY OR WIPE THE OIL PUMP COMPONENTS WITH A RAG. Coat the rotor the assembly and oil pump body with clean engine oil. Reassembly the rotor assembly as exp'lained above. Using a tapered feeler guage, gently determine the the rotor tip clearance. DO NOT FORCE THE MEASUREMENT.



MAXIMUM CLEARANCE = 0.174 mm

OIL PRESSURE RELIEF VALVE
Components:
1 Plunger Valve
2 Spring
3 Gasket
4 Plug
Inspect the plunger (1) for scoring or galling. Replace the oil pump assembly if any damage is noted. Measure the lenght of the pressure relief spring. The spring lenght tolerance is 27.50 - 27.75 mm.

By-pass pressure setting (opening threshold)= 4.5 - 5.5 Bar.



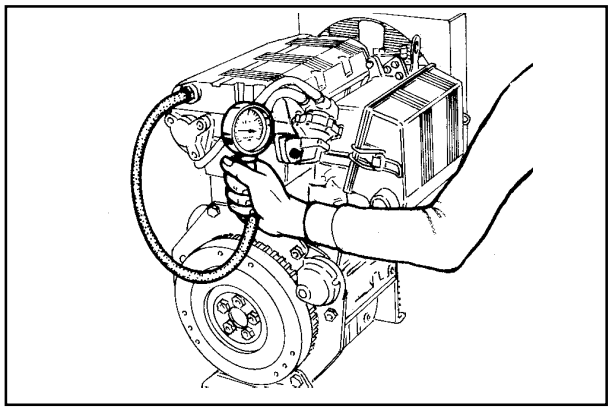
OIL FILTER

Components:

1 GASKET	5 FILTRATION MEDIA
2 HEAD PLATE	6 BYPASS VALVE
3 GASKET	7 SPRING-BYPASS
4 SPRING	

Oil filter Specifications : Max. operating pressure :7 Bar
Max. rupture pressure : 20 Bar
Filtration level : 20µm
By-pass valve setting: 1,5 - 1,7 Bar
Total filter area (502,602,903): 730 cm²
Total filter area (1204): 1450 cm²

NOTE: Always use genuine Lombardini replacement oil filters. Apply a coating of clean engine oil to the oil filter gasket before installation. Hand tighten the oil filter onto the engine.



OIL PRESSURE TESTING

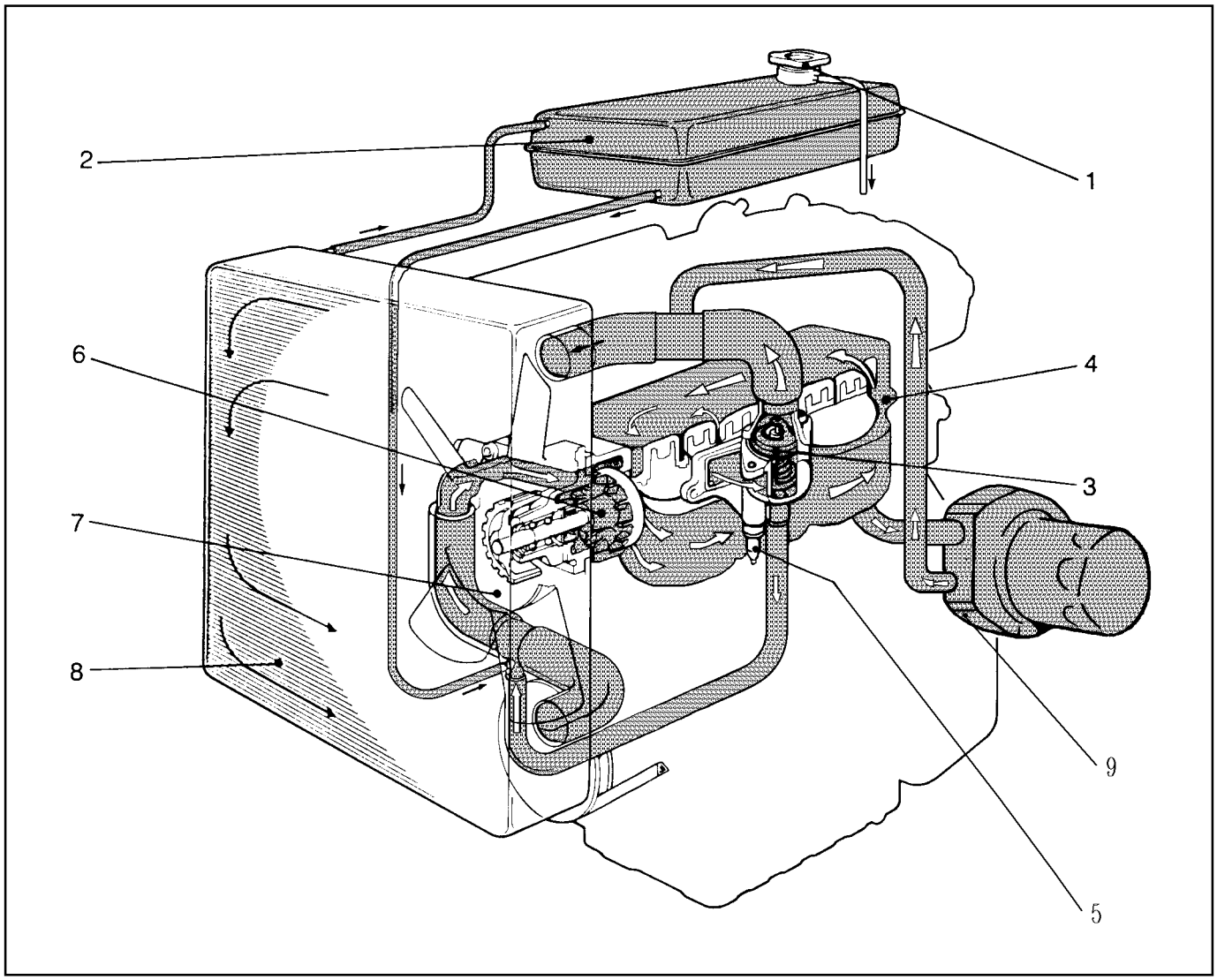
Remove the standard oil pressure switch from the engine valve cover. Replace the oil pressure switch with a calibrated oil pressure gauge arrangement as shown.
The following describes the proper procedure to measure engine oil pressure.

1 Check and top off all engine fluid levels.
2 Start the engine and allow a five (5) minute warm-up period at low idle.
3 Increase the engine speed to high idle.
4 Allow the engine to reach operating temperature
5 Record the oil pressure at high idle and at low idle only after the engine is at operating temperature.

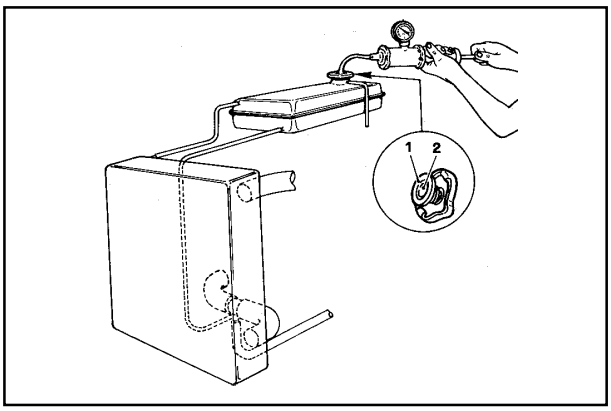
NOTE: The minimum allowable oil pressure is 1.1 Bar at an oil temperature of 120° C and operating at 900 r/min.

The cooling circuit contains fluid under pressure. Do not carry out any inspections until the engine has cooled and even then, open the plug of the radiator or expansion chamber with caution.
Keep well away from a hot engine if an electric fan is installed since this could start up even when the engine is at a standstill.
Coolant fluid is polluting. It must therefore be disposed of correctly. Do not litter.

LDW- FOCS COOLING SYSTEM SCHEMATIC



1 Pressure cap
2 Expansion Tank
3 Thermostat
4 Cylinder Block Coolant Jacket
5 High Temperature Switch
6 Coolant Pump
7 Cooling Fan
8 Radiator (Heat Exchanger)
9 Oil Cooler



COOLING SYSTEM PRESSURE CHECK / RADIATOR CAP INSPECTION

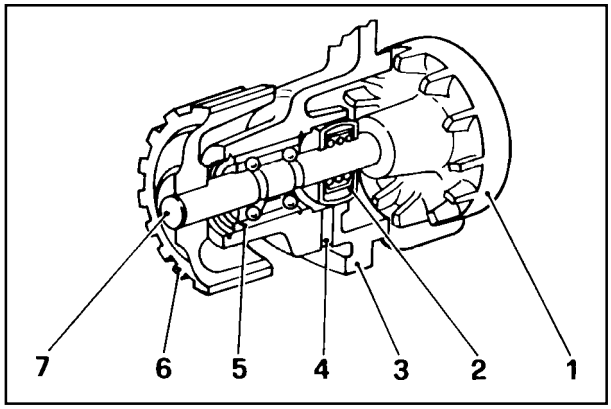
Pressure checking the cooling system is the only reliable method of determining the source of coolant leaks and the condition of the radiator, hoses and coolant pump seals. The radiator cap controls operating cooling system pressure and thus must be inspected regularly. The illustration shown depicts a cross flow type radiator with a remote expansion tank. The proceedures / inspection criterion below is applicable to both cross flow and top tank radiators.

Radiator Cap: Inspect the vacuum valve (1) and the relief valve (2). Fit the radiator cap onto a suitable radiator cap testing fixture. Pressurize to 0.7 bar to insure the radiator cap holds rated pressure. Replace the cap if 0.7 bar cannot be reached before pressure relief. Replace the radiator cap if any degradation is seen on the vacuum valve seal or the pressure relief seal or if the cap is bent, deformed or damaged.

Radiator Seat: The sealing ability of the radiator cap is a function of the radiator or expansion tank seat. Inspect the radiator cap seat and replace/ repair as needed.

Cooling System Pressure Test: Fill the cooling system completely with a 50/50% solution- water/ ethylene glycol. Fit a cooling system pressurizing device to the cooling system fill port. Pressurize the cooling system to 0.7 bar. The pressure should hold steady. If the pressure does not hold steady at 0.7 bar, a malfunction in the pressure device exists or a leak in the cooling system exists. Inspect the cooling system for signs of liquid at all joints, hoses and at the coolant pump. Tighten, repair or replace as required.

NOTE: Lombardini recommends a radiator cap pressure relief setting of 0.7 bar. Do not operate the engine with a pressure cap of higher or lower setting installed.

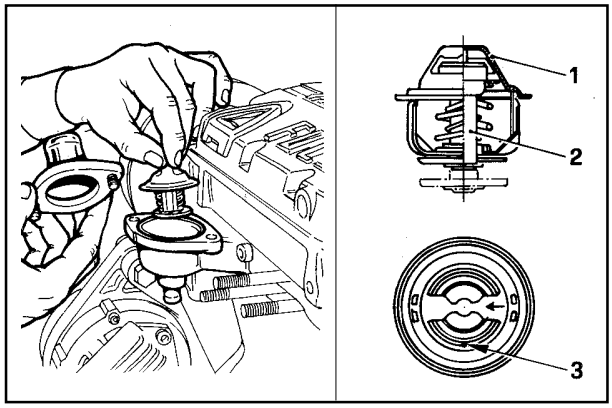


COOLANT PUMP DETAILS

The design of all LDW-FOCS coolant pumps is similiar. However, the impeller(1) size and seal assembly (2) are larger for the LDW 1204 ,LDW 1204/T and 1404, allowing for greater coolant flow.

Components:

1 Impeller
2 Seal assembly
3 Pump body
4 Weep hole
5 Bearing
6 Pulley
7 Shaft



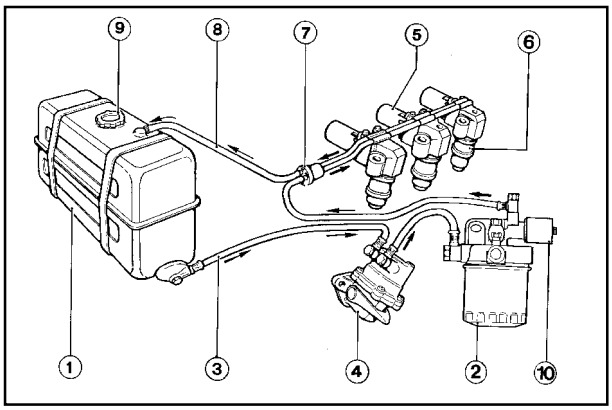
THERMOSTAT

Removal: Drain the engine coolant in a suitable container. Remove the two(2) capcrews retaining the coolant outlet to the thermostat housing. Remove the thermostat from the thermostat housing.

Inspection: Inspect the the thermostat for deposits, corrosion and deformation. Clean or replace as required.

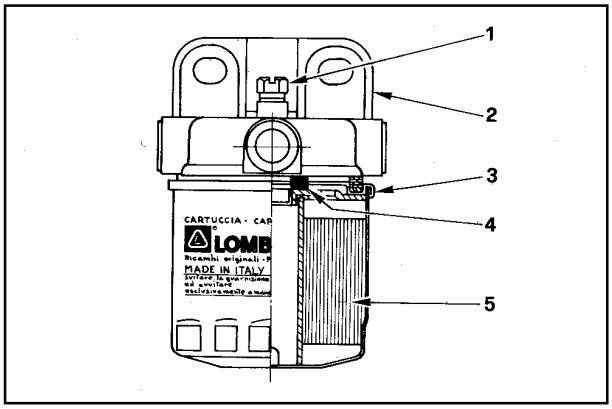
Components:
1 Thermostat body- stainless steel, brass or thermoplastic.
2 Expansion bulb
3 Bleed vent

NOTE: Metalic thermostats require a O-ring gasket- replace as required.



FUEL SYSTEM SCHEMATIC

1 Fuel Tank
2 Fuel Filter
3 Supply Hose
4 Fuel Pump
5 Injector
6 Injection Pump
7 Fuel Rail Grommet
8 Return Hose
9 Fuel Tank Fill Cap (Vented)
10 Fuel Shut-off Valve (Electric)

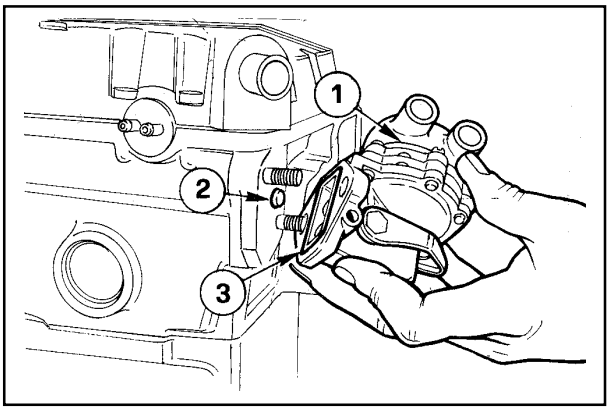


FUEL FILTER ASSEMBLY

1 Air Bleed Plug
2 Filter Head(Base)
3 Spin-on Fuel Filter
4 Gasket
5 Filter Media

Fuel Filter Specifications:

Media Type	PF 905
Filtration Area	2400 cm^3
Filtration Level	2-3µm
Max. Pressure	4 bar



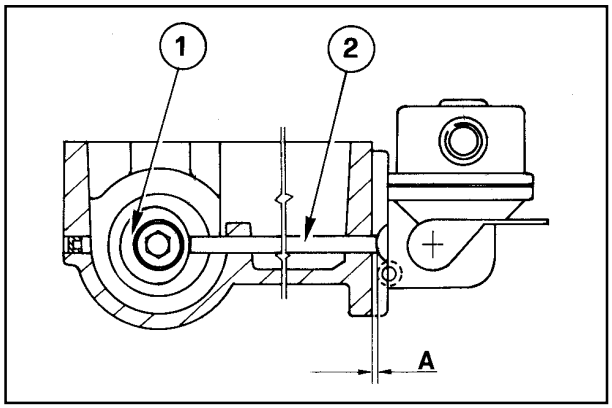
FUEL TRANSFER PUMP

Components:

1 Fuel Transfer Pump Assembly
2 Push Rod
3 Sealing O-Ring

The fuel transfer pump is a diaphragm type pump actuated by the camshaft driven push rod. Manual fuel system bleeding is facilitated by operating the pumping bail lever.

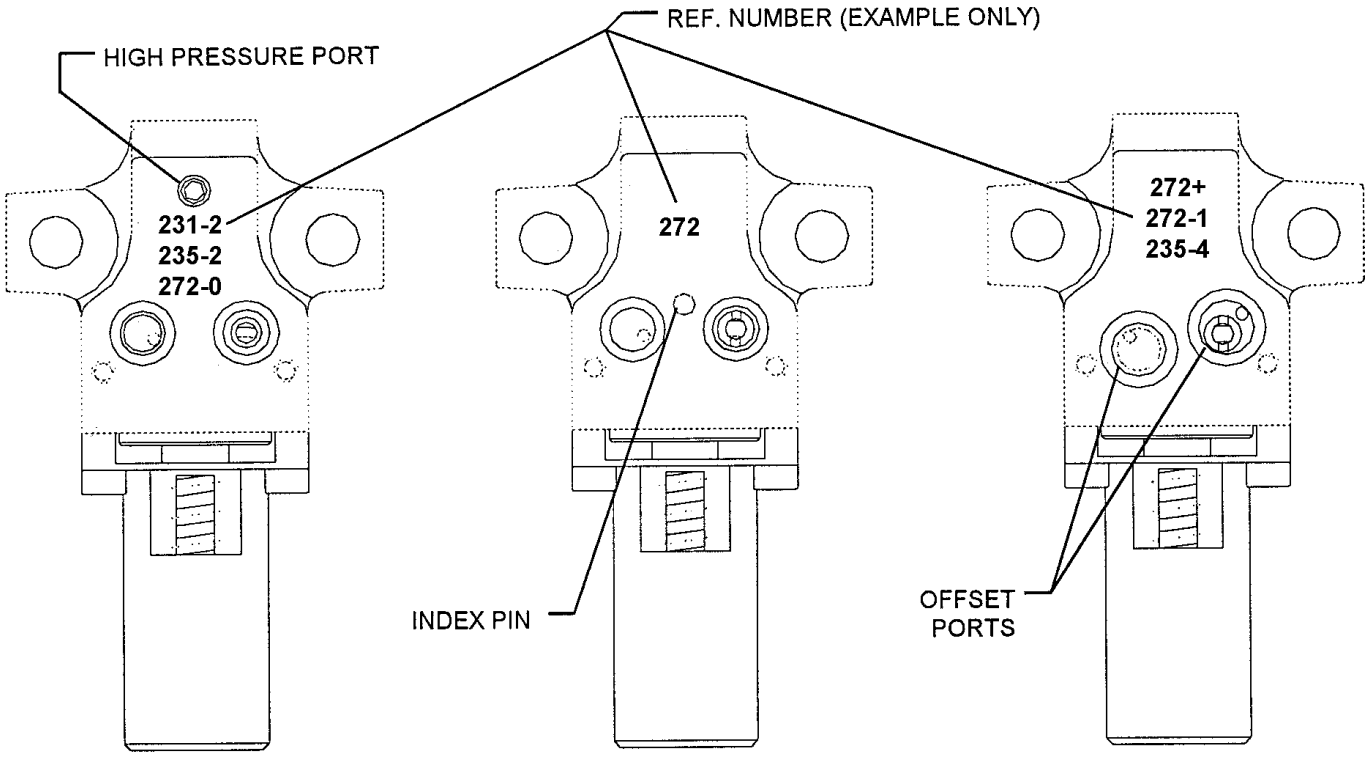
Performance: At an engine speed of 3000 r/min, the fuel transfer pump delivers 60 l/h at a self-regulated pressure of 4.5 / 5.5 m - H_2O.



FUEL TRANSFER PUMP PUSH ROD PROTRUSION

With the engine rotated to position the camshaft eccentric (1) as shown, resulting in the lowest possible push rod (2) position with respect to the cylinder head plain, dimension 'A' should be 0.96-1.48mm.

If the proper clearance cannot be attained, measure the push rod (2) length. The push rod (2) should be 152.45-152.65mm in length. Replace the push rod as required. No other adjustments can be made to change fuel pump push rod protrusion.



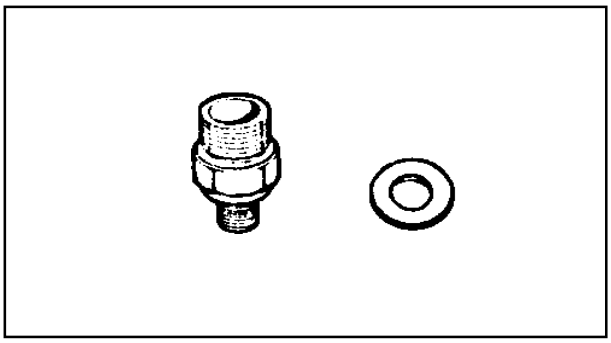
LOMBARDINI CONTINUALLY DEVELOPS THE FOCS DIESEL LINE. CONSTANT RESEARCH AND DEVELOPMENT IS CARRIED OUT TO IMPROVE OVERALL PERFORMANCE OF FOCS PRODUCTS. AS SUCH, THE DESIGN OF THE FOCS UNIT INJECTOR HAS CHANGED DURING THE DEVELOPMENT PROCESS. THE FIGURE ABOVE PROVIDES A REFERENCE FOR THE THREE(3) DIFFERENT VERSIONS OF THE FOCS UNIT INJECTOR TO DATE.

EARLY UNIT INJECTORS ARE CHARACTERIZED BY THE HIGH PRESSURE PORT AS SHOWN.
INTERMEDIATE UNIT INJECTORS ARE CHARACTERIZED BY THE LACK OF A DRILLED HIGH PRESSURE PORT (HIGH PRESSURE PLUG MAY BE PRESENT, BUT IS NOT FUNCTIONAL) AND THE ADDITIONAL INDEX PIN AS SHOWN.
CURRENT UNIT INJECTORS ARE CHARACTERIZED BY OFFSET FUEL PORTS, NO HIGH PRESSURE PORT AND RELATIVELY LARGER PORT SIZES.

THE FOLLOWING CHART MAY BE USED AS A GENERAL REFERENCE FOR UNIT INJECTOR IDENTIFICATION, SPECIAL TOOL REQUIREMENTS AND CRITICAL ADJUSTMENT SPECIFICATIONS. WHEN SERVICING FOCS UNIT INJECTORS, ALWAYS REFERENCE THE ENGINE MODEL, ENGINE SERIAL NUMBER, APPLICATION AND UNIT INJECTOR REFERENCE NUMBER.

REFERENCE NUMBER	PART NUMBER	APPLICATION	STATIC TIMING (°BTDC)	STATIC TIMING METHOD	SPECIAL TOOLS FOR TDC, TIMING AND PRESSURE TESTING
231-2	6590.262	502, 602, 903, 1204	11-13	HIGH PRESSURE	TIMING- 1460.028 + 1460.024 PRESSURE- 1460.028 TDC- 1460.048
272-0	6590.283	502 MINI CAR	11-13	HIGH PRESSURE	TIMING- 1460.028 + 1460.024 PRESSURE- 1460.028 TDC- 1460.048
235-2	6590.235	1204/T	4-6	HIGH PRESSURE	TIMING- 1460.028 + 1460.024 PRESSURE- 1460.028 TDC- 1460.048
272	6590.272	502, 602, 903, 1204	8-10	LOW PRESSURE	TIMING/PRESSURE-1460.056 1460.028 / TDC -1460.048
272-1	6590.285	502, 602, 903, 1204	8-10 > 2999 rpm 12-14 < 3000 rpm	LOW PRESSURE	TIMING/PRESSURE-1460.074 TDC- 1460.048
272- 272+	6590.286 6590.307	502 MINI CAR	11-13	LOW PRESSURE	TIMING/PRESSURE-1460.074 TDC- 1460.048
235-4 235-3	6590.290 6590.287	1204/T	6-8	LOW PRESSURE	TIMING/PRESSURE-1460.074 TDC- 1460.048
235-4	6590.290	702, 1003, 1404	8-10	LOW PRESSURE	TIMING/PRESSURE-1460.074 TDC- 1460.048

COMPILER TECCIATI	REG. CODE	MODEL N°	DATE OF ISSUE	REVISION 04	DATE	ENDORSED
	1-5302-351	50563	04.90		15.11.99	

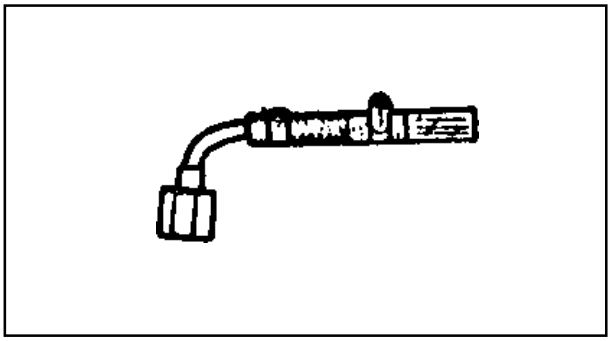


FUEL SYSTEM SPECIAL TOOLS

UNION- 1460.028

FUNCTION: Allows high pressure testing of unit injectors. Use for both static timing and pressure testing of early unit injectors. The 1460.028 union screws directly into the unit injector after removal of the high pressure plug.

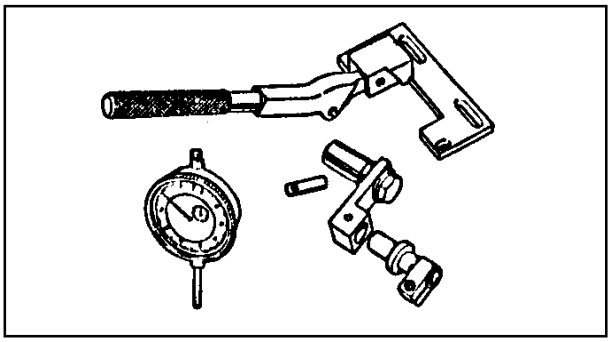
Application: 6590.262, 6590.283, 6590.235 unit injectors.



TIMING TOOL- 1460.024

FUNCTION: Allows high pressure static timing of early unit injectors. Use with the 1460.028 union.

Application: 6590.262, 6590.283, 6590.235 unit injectors.

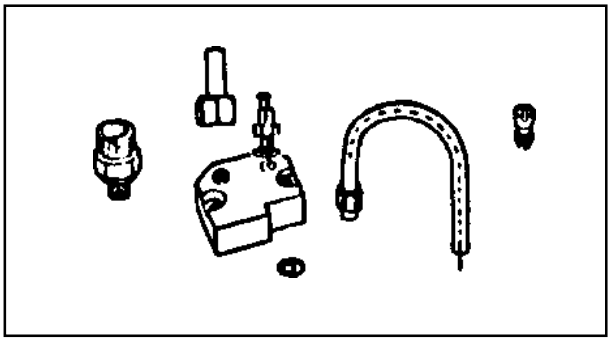


LOW PRESSURE TEST SET

Includes adapter block, union, plug, drip tube, eccentric washers and fill tube for low pressure static timing and allows pressure testing for intermediate and current unit injectors.

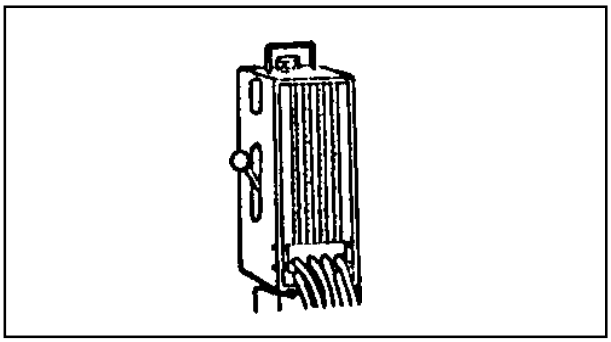
PART No. 1460.056- Only for 6590.272 unit injectors

PART No. 1460.074-Use with 6590.285, 6590.286, 6590.287 and 6590.290 Unit Injectors.



TDC DETERMINATION / TIMING FIXTURE- 1460.048

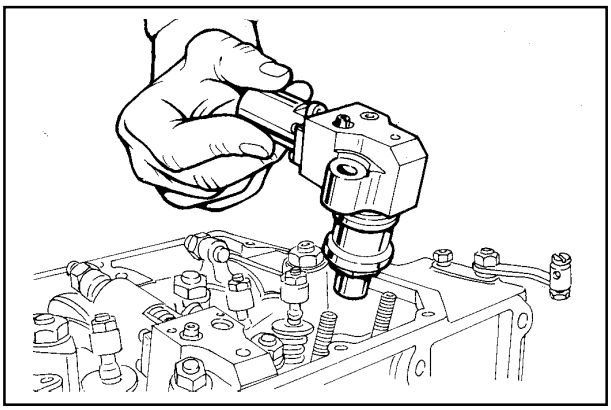
FUNCTION: Determination of exact TDC for purposes of static injection timing. After exact TDC is found, the static injection point may be determined as a function of piston position as measured by the TDC fixture. Refer to the following pages for more detail.



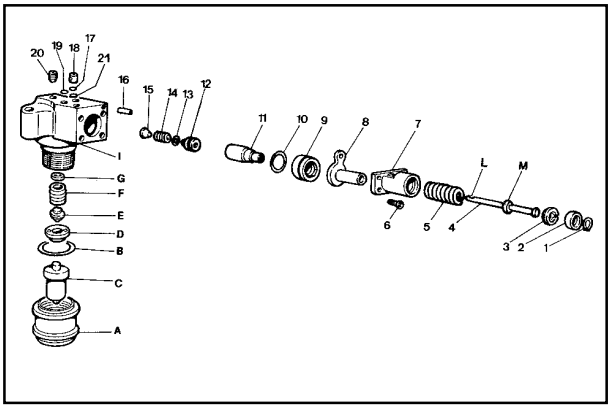
EQUALIZATION TOOL

FUNCTION: Allows each individual cylinder fuel consumption to be measured. Thus, the individual delivery rates can be adjusted to insure equivalent fuel delivery to all cylinders. The equalization tool set includes fuel rail blocks to allow attachment to the unit injectors. Three(3) different equalization tools have been issued reflective of improvements in the tool and changes to the unit injectors. Aside from the fuel rail blocks included with the equalization tool, the equalization tool will work on all unit injector types. Fuel rail blocks as detailed below can be ordered to allow complete interchangability with all unit injector styles.

Equalization Part No.'s: 1460.020(early),1460.050(intermediate) and 1460.090 (current).
Fuel Block Part No.'s: 1460.081 (early / intermediate) with in-line fuel ports. 1460.089 (current) with offset fuel ports.



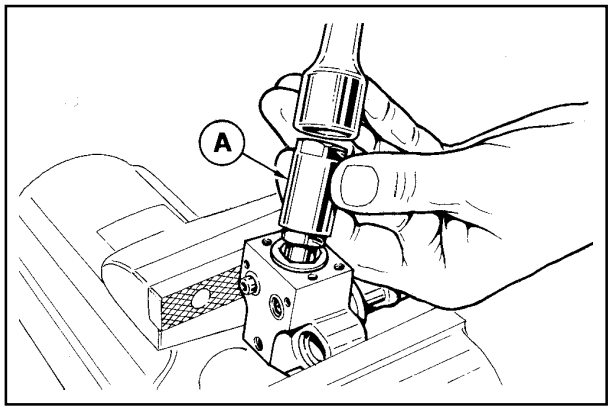
UNIT INJECTOR: The unit injectors fitted within Lombardini FOCS diesel engines are designed by Lombardini. One unit injector is required for each cylinder. In the continuing development of the FOCS diesel engine, design changes have been made to the unit Injector resulting in less that total interchangability between older and newer FOCS engines. Please refer to the previous pages for details regarding the identification, special tool requirement, testing method and application of unit injectors. Always use the utmost cleanliness and care when servicing fuel injection equipment.



UNIT INJECTOR COMPONENTS

1	Circlip	12	Delivery Valve	A	Cup
2	Tappet	13	Shim/ Gasket	B	O-Ring
3	Retainer	14	Spring	C	Nozzle
4	Plunger	15	Filler	D	Spacer
5	Spring	16	Pin	E	Spring Seat
6	Bolt	17	O-Ring	F	Spring
7	Support	18	Check Valve	G	Shim
8	Rack Lever	19	O-Ring	I	Unit Inj. Body
9	Ring Nut	20	Plug	L	Helix
10	O-Ring	21	Gasket	M	Index
11	Barrel				

Note: Cup (A) torque = 70 Nm.

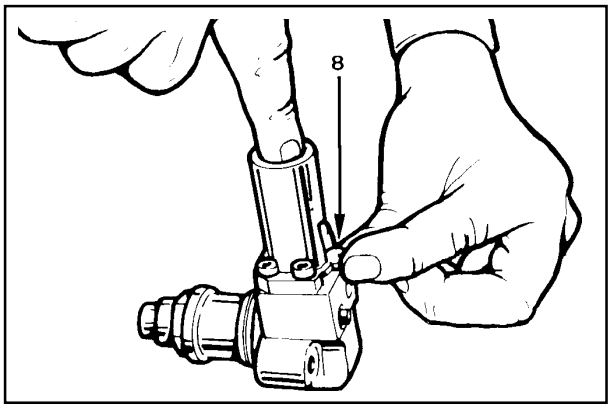


UNIT INJECTOR RING NUT REMOVAL / REPLACEMENT

When disassembling or reassembling the unit injector, follow the numerical order presented above, then proceed through the alphabetical order A-I.

After disassembling items one(1) through seven (7) (see above), fit the injector into a suitable vice with soft jaws. Use special tool (A) 1460-029 to remove the ring nut (9) as shown.

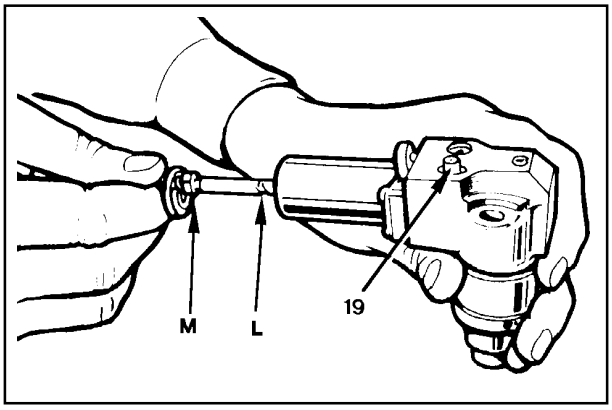
When reassembling the unit injector, torque the ring nut to 34 Nm.



UNIT INJECTOR PLUNGER REASSEMBLY

When reassembling the unit injector, refer to the above exploded diagram. Assemble in the following order: I-A, then 21-1.

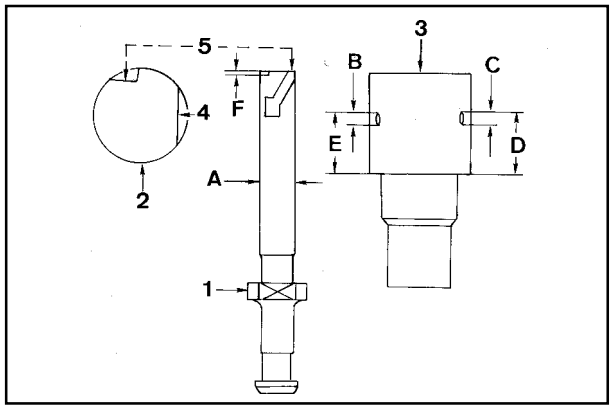
When refitting the plunger, orient the plunger helix (L) to align with the check valve(18). See also the figure and explanation on the next page.



UNIT INJECTOR REASSEMBLY (CONT.)

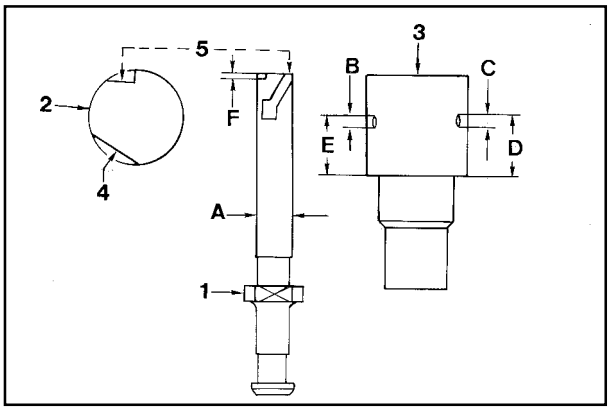
With reference to the previous frame, and the exploded view of the unit injector on the previous page, continue to introduce the plunger into the unit injector, while gently rotating rack lever (8) back and forth until index (M) can be engaged with the rack lever (8).

NOTE: If the plunger is accidentally installed incorrectly positioned with respect to the helix location, the engine will not operate.



BARREL AND PLUNGER DETAIL- EARLY UNIT INJECTORS (TYPICAL)

Component Details	Dimensional Details
1 Plunger	A = 5.5 mm (nominal)
2 Plunger End View	B = 2.00/2.03 mm (Inlet Port)
3 Barrel	C = 1.50/1.53 mm (Bypass)
4 Retardation Notch	D = 10.00 mm
5 Helix	E = 9.6 mm
	F = 0.7 mm

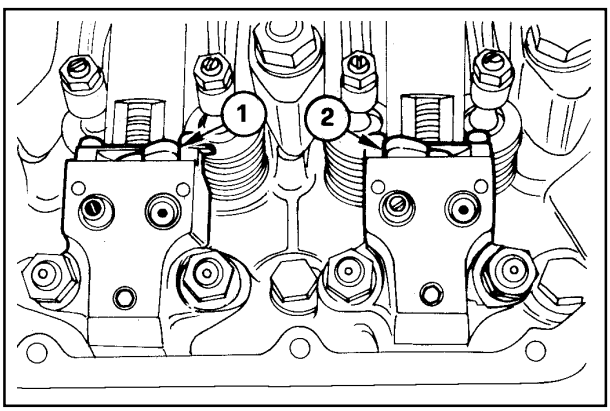


BARREL AND PLUNGER DETAIL- (TYPICAL) CURRENT UNIT INJECTORS (EXAMPLE- 6590-285)

Component Details	Dimensional Details
1 Plunger	A = 6.0 mm (nominal)
2 Plunger End View	B = 1.50/1.53 mm (Inlet Port)
3 Barrel	C = 1.50/1.53 mm (Bypass)
4 Retardation Notch	D = 9.965/10.035 mm
5 Helix	E = 9.565/9.635 mm
	F = 0.9 mm

For LDW 702,1003,1204/T,1404 CURRENT UNIT INJECTORS (EXAMPLE- 6590-290)

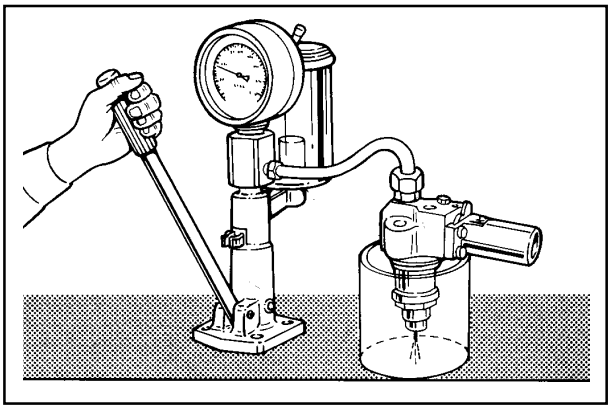
A = 6.5 mm (nominal)



UNIT INJECTOR TEST STAND SPECIFICATIONS

1 Rack lever in stop or no delivery position
2 Rack lever in maximum delivery position

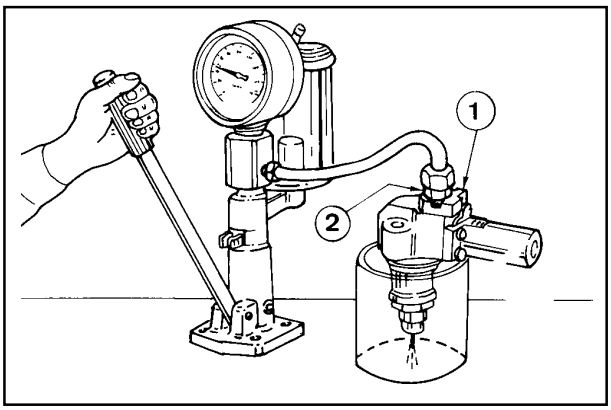
WARNING: THE TESTING AND SERVICE OF FUEL INJECTION EQUIPMENT SUCH AS DETAILED BELOW INCLUDES HIGH PRESSURE AND SPRAYING FLUIDS. WEAR PROPER EYE AND HAND PROTECTION. DO NOT ALLOW ANY PART OF YOUR BODY TO COME INTO CONTACT WITH HIGH PRESSURE FUEL OR TESTING FLUID. FURTHER, HIGH PRESSURE FUEL IS VERY FLAMMABLE. DO NOT TEST FUEL INJECTION EQUIPMENT NEAR ANY OPEN FLAME, SPARKS OR LIT CIGARETTES.



UNIT INJECTOR POPPING PRESSURE TESTING AND ADJUSTMENT-HIGH PRESSURE PROCEDURE (EARLY UNIT INJECTORS- ALL REF. NO's OTHER THAN 272, 272-, 272-1, 235-3)

With reference to the exploded view from page 57, remove the high pressure plug(20). Fit to the injector, in place of plug(20), union 1460-028. Install the injector onto a hand pop test machine. Using extreme care and proper eye and hand protection, cycle the injector several times until all air is out of the injector. Operate the popping tester taking note of the injection pressure. The injector should require 130-140 bar before injection. If the pressure is not to specification, again refer to the exploded view as above. The pressure can be increased by adding shims(G) or reduced by removing shims(G). Shims are available ranging from 1 to 2 mm in eleven steps. When servicing the unit injector, initial pressure settings should be 10 bar higher than specified to allow for seating during operation.

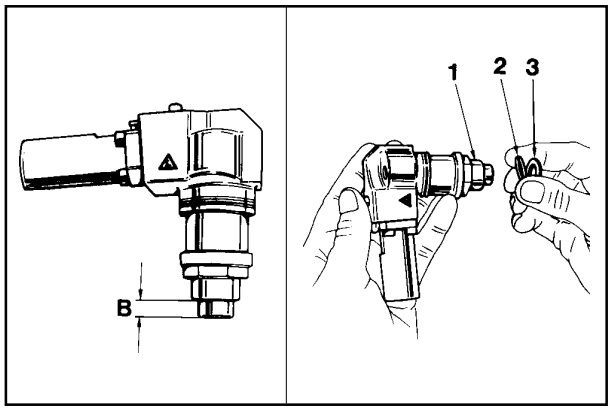
Injector nozzle leakage may be checked by holding a pressure of 130 bar on the injector for 10 seconds. The nozzle should be replaced if leakage is noted.



UNIT INJECTOR POPPING PRESSURE TESTING AND ADJUSTMENT-LOW PRESSURE PROCEDURE (CURRENT / INTERMEDIATE UNIT INJECTORS)

Unit injectors having codes 272, 272-, 272-1, 235-3, 235-4 are not equipped with a high pressure port drilling as above. With reference to the exploded view on page 57, pressure checks of the unit injector are facilitated by removing the check valve(18) , then installing the plug, eccentric gasket and block (1) which are supplied as components within part no. 1460-074. Fit the block (1) onto the injector making sure that the rack lever is held in the maximum deliver position as is shown. Fit the supplied union (2)(part of 1460-074) onto the block. Using extreme care and proper eye and hand protection, test the injector on a hand popping pressure testing machine as is detailed above. Pressure settings, nozzle leakage testing and pressure adjustments are carried out as explained above. The new style injector should require 140 / 150 bar of pressure before injection. If service is required to increase the injection pressure, set the injector to 10 bar higher than nominal to allow for seating.

NOTE: 6590-272 (ref. no. 272) unit injectors will require the block(1) as supplied within part no. 1460-056.

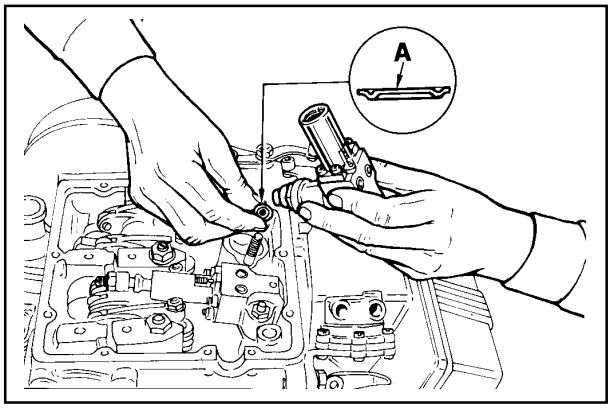


INJECTOR NOZZLE PROTRUSION

Injector nozzle protrusion (B) should be 6.80 / 7.05 mm

If the injector nozzle protrusion exceeds the above dimension, additional 0.25 mm copper washers(2) may be placed on the injector nozzle, resting against the cup (1) to supplement the thickness of the standard copper washer(3) and offset any injector nozzle protrusion problems.

The 0.25 mm supplemental washers are available as special spare parts. Contact your local distributor for details.



UNIT INJECTOR FIRE RING

The unit injector fire ring should be replaced following unit injector removal. DO NOT REUSE fire rings.

Clean the fire ring sealing surface in the cylinder head and injection nozzle. (Do not damage the injector nozzle or pre-cup ring nut.

Orient the fire ring so that plane (A) will face the unit injector nozzle.

Reinstall the injector, tightening the unit injector securing nuts to 20 Nm alternately and in 5 Nm steps.

Gruppo motori		Tipo	
Groupe moteurs		Type	
Engine group	32	Type	LDW 702-1003-1404
Motorgruppe		Typ	
Grupo motores		Tipo	

- Variato valore di anticipo iniezione sui motori LDW 702-1003-1404 causa migliorie funzionali. Per il motore 1404 Piaggio i valori rimangono inalterati.
- Le valeur d'avance de l'injection a été modifiée sur les moteurs LDW 702-1003-1404 à cause d'améliorations fonctionnelles. Pour le moteur 1404 Piaggio les valeurs demeurent inchangées.
- The injection lead value has been changed in engines LDW 702-1003-1404 following functional improvements. The values remain unchanged for the Piaggio 1404 engine.
- Der Wert der Früheinspritzung ist auf den Motoren LDW 702-1003-1404 wegen funktioneller Verbesserungen geändert worden. Für den Motor 1404 Piaggio bleiben die Werte unverändert.
- Ha sido variado el valor de anticipación inyección en los motores LDW 702-1003-1404 para lograr mejoramentos funcionales. Para el motor 1404 Piaggio los valores no cambian.

Antemodifica Avant la modification Prior to improvement Vor der Änderung Antes de la modificación	Postmodifica Après la modification After improvement Nach der Änderung Después de la modificación
1500÷3600 g/min - anticipo 8°÷10°	1500÷2999 g/min - anticipo 8°÷10° 3000÷3600 g/min - anticipo 12°÷14°

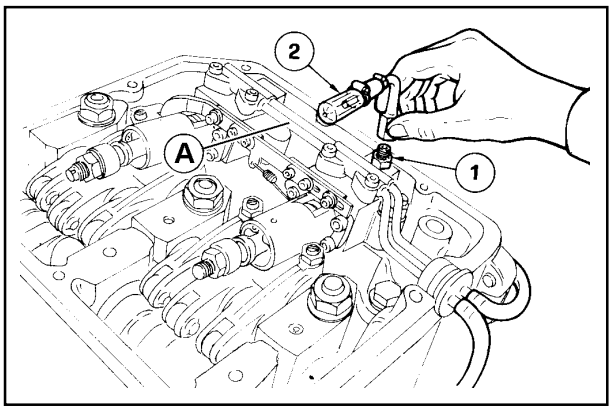
Tabella di trasformazione da mm in gradi
Tableau de transformation de mm en degrés
Conversion table from mm to degrees
Umrechnungstabelle von mm in Grad
Tabla de transformación de mm en grados

α	LDW 502 (mm)	LDW 602-903-1204-1204/T (mm)	LDW 702-1003-1404 (mm)
15°	1.358	1.651	1.722
14°	1.184	1.440	1.502
13°	1.022	1.242	1.296
12°	0.871	1.059	1.105
11°	0.733	0.891	0.930
10°	0.606	0.737	0.769
9°	0.491	0.597	0.623
8°	0.388	0.472	0.493
7°	0.297	0.362	0.378
6°	0.218	0.266	0.277
5°	0.152	0.185	0.193
4°	0.097	0.118	0.123

LOMBARDINI intermotor SLANZI SERVICE

CIRCOLARE TECNICA
CIRCULAIRE TECHNIQUE
SERVICE LETTER
TECHNISCHES RUNDSCHREIBEN
CIRCULAR TECNICA

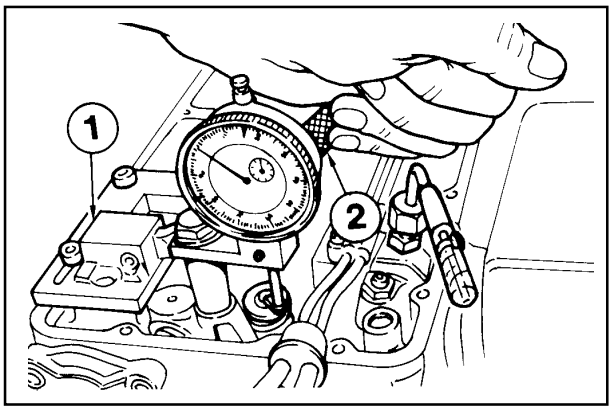
Compilazione	Sez.Sect. 320
	N. 320134
Visto/approvazione	Data 20.12.2011
	M.A.T. .....
Modello 50722	....
	....



STATIC INJECTION TEST INSTRUMENTATION- EARLY UNIT INJECTORS

Carefully remove the engine valve cover. With reference to the exploded unit injector diagram on page 57, remove plug (20). Replace plug(20) with union(1)- 1460-028.
Install Injection timing tool (2)- 1460-024 onto the 1460-028 union.

NOTE 1: When refitting the plug(20), carefully check the sealing properties of the plug.
NOTE 2: Later versions of the unit injector are not equipped with the plug(20). Therefore, static timing adjustments require alternative approaches than those shown. Please see page 56 for details of the static injection timing instrumentation for later versions of the FOCS unit injector.



TDC DETERMINATION and STATIC INJECTION TIMING CHECKING

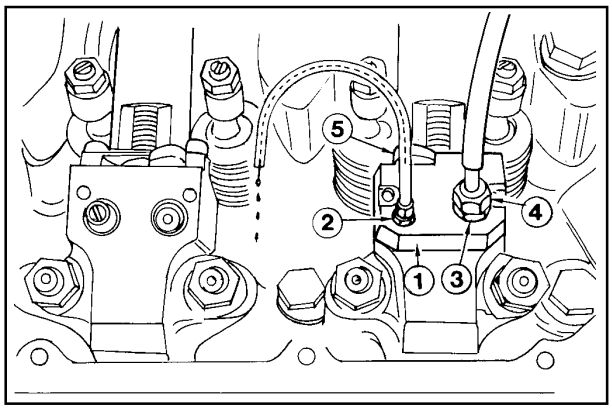
With the static injection timing instrumentation installed as described above, fit the engine with the timing fixture(1), part no. 1460-048 as shown. The dial indicator support should be oriented over the engine valve spring cap. Remove the injection pump rack assembly starting aid spring. Adjust and secure the injection pump rack at 1/2 stroke.

Rotate the engine until the cylinder being static timed approaches TDC, compression stroke. Alternately, rotate the crankshaft toward TDC and press down on the timing fixture lever(2) until minimum dial indicator travel is established. At minimum dial indicator travel, TDC is established. Zero the dial indicator at the TDC position.

Insure that a good supply of clean diesel fuel is available to the engine, preferable from an external fuel tank elevated above the level of the engine.

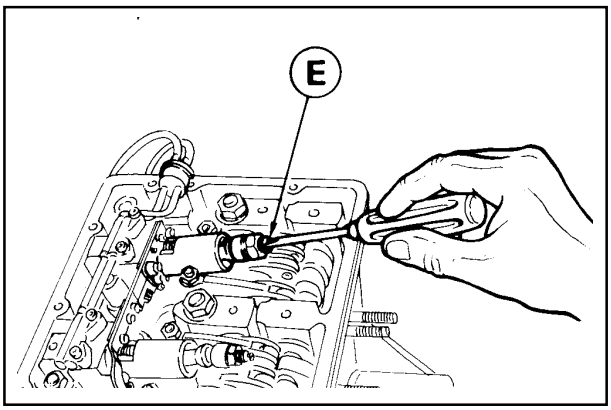
EARLY UNIT INJECTORS (Ref No's: 231-2, 235-2, 272o)-With reference to the upper figure, bleed the injection the injection timing tool by bringing the engine to such as position as the injection pump is being acted upon via the camshaft. Alternately rotate the engine back and forth until fuel is injected out of the injection timing tool and free of air.
Rotate the engine in opposite normal direction approximately 90°. Rotate the engine in normal direction of rotation until a fuel movement is noted in the static timing sight glass. Stop rotation IMMEDIATELY upon any notice of fuel movement. Depress the timing fixture lever and note the dial indicator reading. Check the corresponding dimension listed in the chart to the left- determine static injection timing from the chart. Correct, if needed, the injection timing by turning screw(E)- see next page. Refer to the chart on page 55 for static timing specifications with respect to the injector reference number. See the following page for static timing adjustment procedures.

a	LDW 502 (mm)	LDW 602, 903, 1204,1204/T (mm)	LDW 702 1003,1404 (mm)
13°	1.022	1.242	1.296
12°	0.871	1.059	1.105
11°	0.733	0.891	0.930
10°	0.606	0.737	0.769
9°	0.491	0.597	0.623
8°	0.388	0.472	0.493
7°	0.297	0.362	0.378
6°	0.218	0.266	0.277
5°	0.152	0.185	0.193
4°	0.097	0.118	0.123



LATE/ INTERMEDIATE UNIT INJECTORS- (6590-272, 6590-285, 6590-286, 6590-287, 6590-290) Remove the check valve from all injectors, remove the check valve side o-ring from all injectors, replace the o-ring with special eccentric gasket supplied within 1460-074. With reference to the lower diagram, fit the unit injectors with a special tool block(1), bleed fitting(2), union(3), supply fitting(4) and nylon bleed tube(5) as supplied within 1460-074. **Note: 6590-272 unit injectors do not require the eccentric gaskets as detailed above but do require a special block(1) as supplied under part no. 1460-056.**

Place a small cup beneath the nylon bleed tube, rotate the engine in the normal direction of rotation until fuel stops flowing from the bleed tube. At the very instant of fuel flow stoppage, stop rotating the engine. The fuel flow stoppage indicates the beginning of injection. Depress the timing fixture lever and note the dial indicator reading. Check the corresponding dimension listed in the chart to the left- determine static injection timing from the chart. Correct, if needed, the injection timing by turning screw(E)- see next page. Refer to page 64 for the static timing specification with respect to the unit injector reference number. See the following page for static timing adjust procedures.

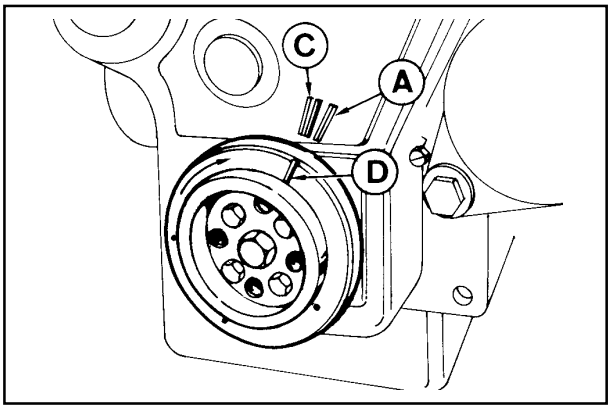


STATIC TIMING ADJUSTMENT

Should the static timing testing procedures as presented on the previous page show the need for static timing adjustment, proceed as follows.

1. Locate timing adjustment screw (E), loosen the locking nut.
2. Rotate the adjustment screw(E) clockwise to advance the static timing, or rotate the adjustment screw counterclockwise to delay the static timing.
3. Tighten the timing adjustment screw lock nut.
4. Repeat the static timing test procedure.

NOTE: 1/2 turn equates to approximately a 5° change in static timing.

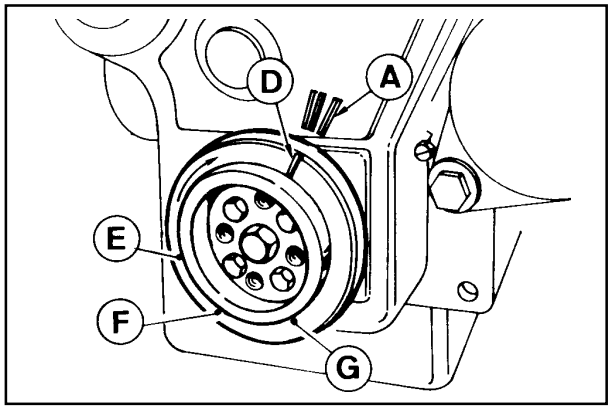


ENGINE TIMING REFERENCE MARKS

Although not as accurate as the procedure presented in the previous section, TDC for FOCS diesel engines may be determined via timing marks on the timing cover and crankshaft pulley. Further, the timing marks on the timing cover can greatly assist the static timing test due to outside confirmation of TDC with respect to the findings of the timing fixture assembly- 1460-048. Lombardini strongly recommends the use of the 1460-048 timing fixture for purposes of static timing adjustments.

With reference to the figure to the left, Pulley mark (D) corresponds to the No. 1 piston (flywheel side piston). Timing cover mark (C) corresponds to approximately 11°-13° BTDC.

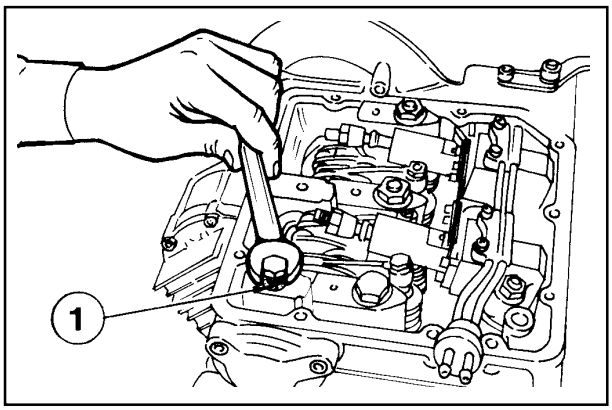
With reference to the figure below, note the following:



D aligns with A-	TDC No. 1 cyl. and No. 4 cyl.,1204,1204/T,1404 TDC No. 1 and No. 2 cyl., 502
E aligns with A-	TDC No. 2 cyl., 903,1003
F aligns with A-	TDC No. 2 cyl., 602,702 TDC No. 2 cyl. and No. 3 cyl.,1204,1204/T,1404
G aligns with A-	TDC No. 3 cyl., 903, 1003

NOTE 1: The firing order of the LDW 903, 1003 is 1-3-2, thus on the crankshaft pulley, D,G,E.

NOTE 2: The firing order of the LDW 1204 and LDW 1204/T,1404 is 1-3-4-2, thus on the crankshaft pulley, D,F,D,F. However, in order to properly follow the LDW 1204 and 1204/T firing order, an initial establishment of TDC compression stroke for No. 1 cylinder must be made.

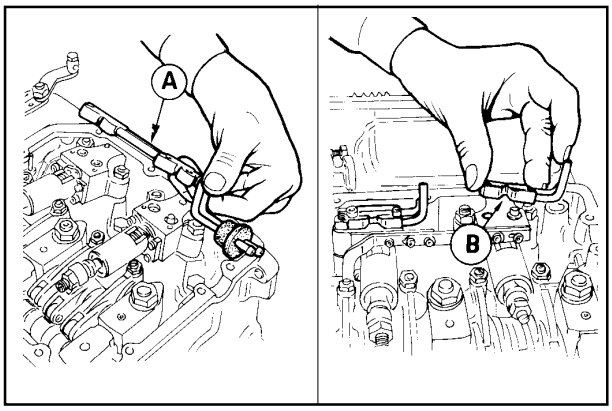


UNIT INJECTOR DELIVERY EQUALIZATION- PREPARATION

Due to the fact that unit injectors are both injection pump and injector, all unit injectors within a FOCS diesel engine must be equalized to facilitate the identical delivery of fuel within individual cylinders. The equalization procedure is a operational test with the valve cover removed. Therefore, proper eye protection must be worn and great care must be taken to insure no body or clothing contact with rotating engine components.

After carefully removing the engine valve cover, install a M8x1.25x10mm capscrew and 8mm copper gasket at position(1) as shown. Failure to install the bolt as shown will result in a large scale oil spill and loss of oil pressure to the engine during the operational procedure presented below.

NOTE: SEE PAGE 74 FOR INITIAL INJECTOR CONTROL RACK AND GOVERNOR ADJUSTMENT PROCEDURES.

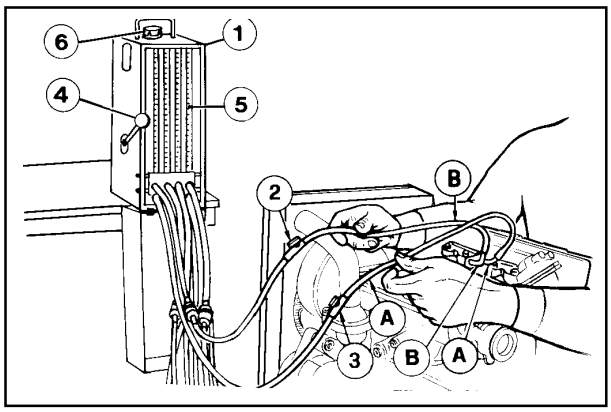


UNIT INJECTOR DELIVERY EQUALIZATION- PREPARATION (cont.)

Remove the fuel manifold assembly(A). In place of the fuel manifold, install on each unit injector a test head(B). The test heads are supplied as part of the equalization tool package. Please note that early versions of the unit injector and late versions of the unit injector require different test heads. Please refer to page 56 for further details.

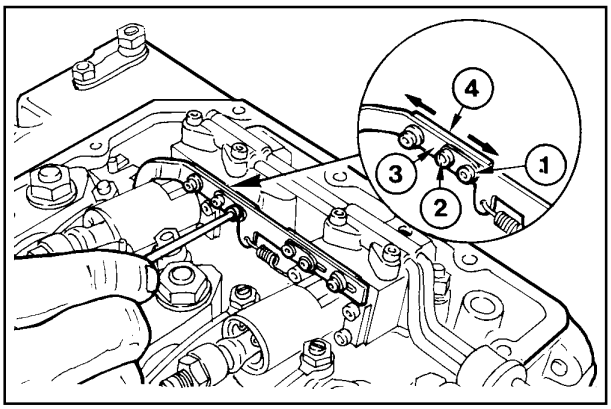
EQUALIZATION TOOL INSTALLATION, PLUMBING

Place the equalization tool on a stable surface , with the base of the equalization tool at least 20cm higher than the level of the unit injectors. Close all valves(2,3). Remove fuel cap(6) and fill the reservoir with clean diesel fuel. With reference to the diagram, connect the lower hoses (A)coming from the equalization fixture to the test head position(A). The hoses should be connected to the test heads in a logical manner. That is, the left most hose should be connected to No. 1 unit injector (flywheel side), then subsequent hoses from left to right, connected to cylinders 2, 3, 4 as required. Connect the upper hoses(B) to the test head position (B). Make sure that the control lever(4) is in the upper position.



After completion of the hose routing/ plumbing, open the valves (2,3). Start the engine and allow to idle. Increase and lock the engine speed to 1500 rpm. Once the engine operates smoothly and the 1500rpm is reconfirmed, pull the control lever(4) downward for approximately one(1) minute. While closely watching the fuel level in the cylinder tubes(5), note the rate at which fuel is consumed. NOTE:, the control lever(4) must be returned to the upper position prior to fuel depletion in the tubes(5).

During operation with the control lever down, determine the cylinder(s) which are consuming more fuel as indicated by the speed at which the fuel is depleted from each individual tube(5). Delivery rates in each cylinder should be within 2 cm^3 during one(1) minute of operation. Reduce the fuel delivery rate to the cylinder(s) consuming the most fuel. Delivery may be adjusted as follows:



FUEL RATE ADJUSTMENT DETAILS

To increase the fuel delivery of an individual unit injector, the injector rack must be moved slightly toward the flywheel end of the engine. With reference to the figure on the left, loosen screws (1) and (2) 1/2 turn. Increase the cylinder fuel delivery by moving plate (4) slightly towards the flywheel, thus changing the relative position of control rod (3). Reductions in fuel delivery can be facilitated by moving the plate away from the flywheel. After adjustment, torque screws (1) and (2) to 1.1 Nm.

Repeat the equalization test until the individual cylinder fuel consumptions are within 2 cm^3 during a one(1) minute period.

NOTE: The equalization procedure should be performed following an injector re

ELECTRICAL SYSTEM SERVICE PRECAUTIONS / WARNING:

The improper service of electrical components can result in shock injuries, burn injuries (from both heat and chemical acids) and produce sparks which could ignite fires. Therefore proper precautions must always be taken.

1. Always wear safety glasses and hand protection when performing diagnostic work of electrical systems.

2. Keep hands, arms, clothing, hair, etc. well away from rotating components.

3. Always remove the negative (-) battery cable before removing and/or handling any electrical system wires or components.

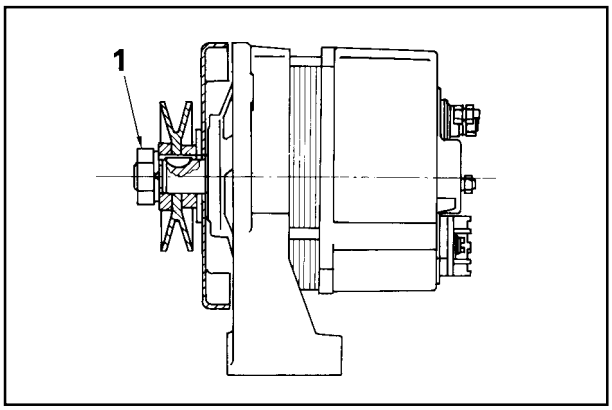
4. Use extreme care when handling batteries. Hand protection and eye protection should be worn at all times. Batteries contain acids which can cause severe chemical burns.

5. The fumes emitted from batteries are flammable, therefore do not weld, smoke or use an open flame around batteries.

6. Read, understand and follow the operational and safety precautions supplied with your electrical service equipment (battery chargers, load testers, meters, etc.).

BATTERY SIZING: The chart presented below provides strict guidelines for the sizing of system batteries for Lombardini FOCS diesel engines. Batteries must be sized so as to provide sufficient reserve capacity (Amp-Hours), but yet not so large as to damage the starter motor due to excessive amperage. Depending on the cold starting ambient conditions (Normal or Extreme), size the system battery according to the data presented below with respect to the engine model and engine starter rating.

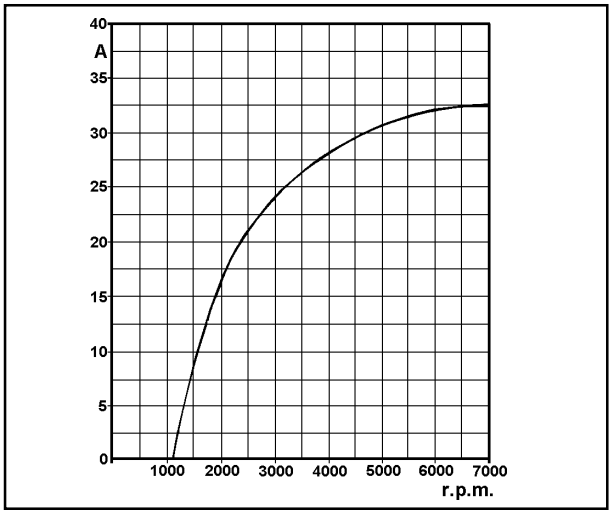
ENGINE MODEL	STARTER RATING (KW)	NORMAL AMBIENT CONDITIONS		EXTREME AMBIENT CONDITIONS	
		Amp-Hours @ 20 hour Rating	Maximum Battery Amps @ -18°C	Amp-Hours @ 20 hour Rating	Maximum Battery Amps @ -18°C
LDW 502 FOCS	1.2	44	210	66	300
LDW 502 FOCS	1.1	44	210	66	300
LDW 602 FOCS	1.1	44	210	66	300
LDW 602 FOCS	1.6	66	300	88	330
LDW 903 FOCS	1.1	44	210	66	300
LDW 903 FOCS	1.6	66	310	88	330
LDW 1204 FOCS	1.1	44	210	66	300
LDW 1204 FOCS	1.6	66	310	88	330
LDW 1204/ T FOCS	1.1	55	255	66	300
LDW 1204/ T FOCS	1.6	66	300	88	330



ISKRA ALTERNATOR- 14V / 33A

NOMINAL VOLTAGE:	14V
NOMINAL CURRENT OUTPUT:	33A
MAXIMUM r/min:	12000 r/min
VOLTAGE REGULATOR:	AER 1503
ROTATION (VIEWED AT PULLEY END):	CLOCKWISE

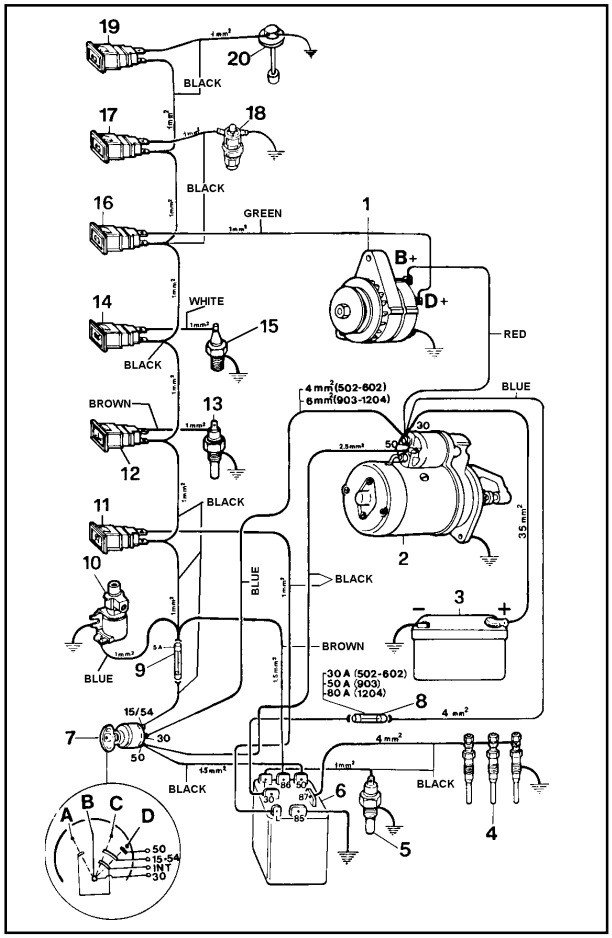
NOTE: Pulley nut torque (1): 35-45 Nm



ISKRA 14V / 33A PERFORMANCE CURVE

The attached performance curve was plotted at a constant system voltage
voltage of 13V and at an ambient temperature of 25°C.

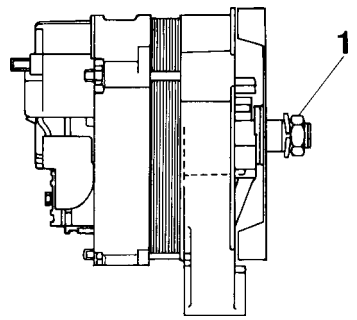
NOTE: The rpm shown is reflective of an ISKRA alternator fitted to an engine with a 88mm crankshaft pulley. The rpm shown is that of the alternator rotor. Thus, at at an engine speed of 3600 rpm, the alternator is turning approximately 4680 rpm, or a ratio of 1.3 :1.



12V ELECTRICAL SCHEMATIC- ISKRA 14V-33A

1 Alternator
2 Starter Motor
3 Battery- (See below for sizing details)
4 Glow Plugs
5 Thermistor (Glow Plug Controller Circuit)
6 Glow Plug Controller / Timer
7 Key Switch
8 System Fuse, 30A (502, 602), 50A (903), 80A (1204, 1204/T)
9 Fuse (Accessory)- 5A
10 Fuel Valve
11 Glow Plug Indicator Lamp
12 Coolant High Temperature Lamp
13 Coolant High Temperature Switch (N.O.)
14 Oil Pressure (Low) Lamp
15 Oil Pressure Switch (N.C.)
16 Alternator Charging Lamp (Off if Charging)
17 Air Filter High Restriction Indicator Lamp
18 Air Filter Restriction Switch (N.O.)
19 Low Fuel Level Lamp
20 Low Fuel Level Switch (N.O.)

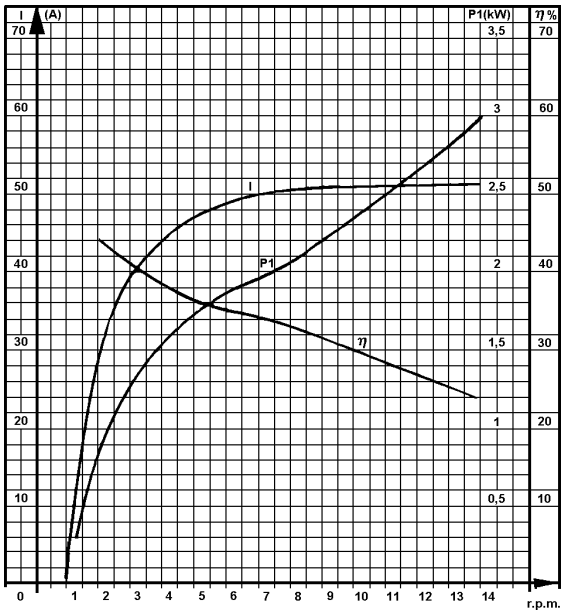
A Accessory Position
B Off Position
C On Position
Starting Position



MARELLI ALTERNATOR (AA 125 R) - 14V / 45A

NOMINAL VOLTAGE:	14V
NOMINAL CURRENT OUTPUT:	45A
MAXIMUM r/min:	14000 r/min
VOLTAGE REGULATOR:	RTT 119 A
BEARING (Pulley End):	6203-2Z
BEARING (Voltage Regulator End)	6201-2Z/C3
ROTATION (VIEWED AT PULLEY END):	CLOCKWISE

NOTE: 1. Pulley nut torque (1): 60 Nm
2. Use only high temperature grease when servicing bearings.



MARELLI AA 125 R, 14V / 45A PERFORMANCE CURVE

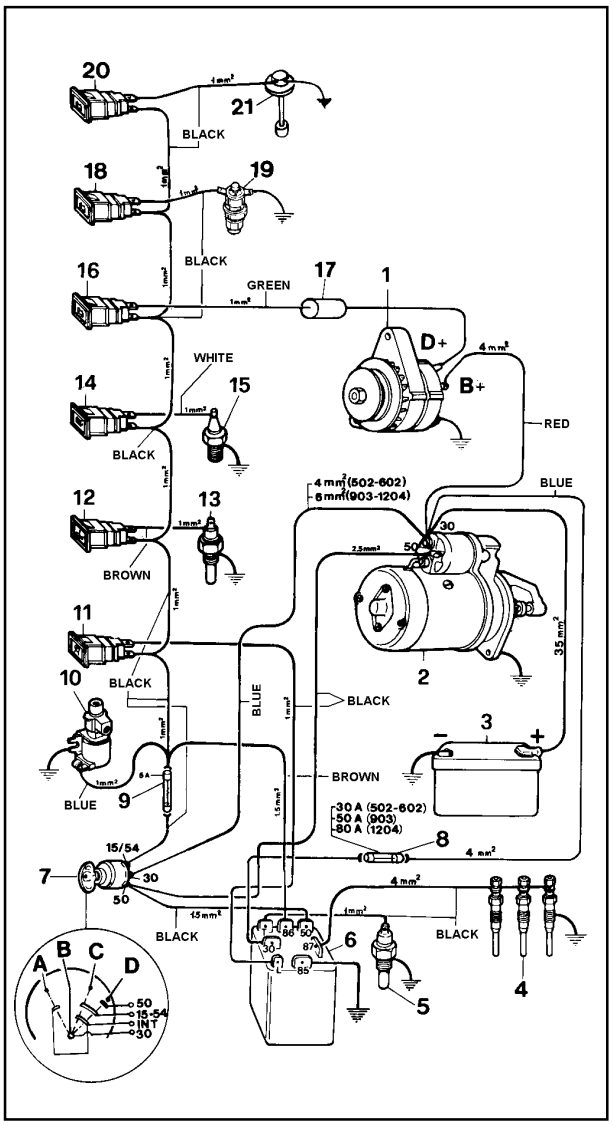
The attached performance curve was plotted at a constant system voltage
voltage of 13.5V and at an ambient temperature of 25°C.

P1 = Power Output (KW)
I = Current Output (Amps)
n= Efficiency

NOTES:

1. The RPM shown is that of the alternator. The value of the rpm axis must be multiplied by 1000.

2. Alternator speed is a function of engine speed and the crankshaft pulley diameter. If the engine pulley is 88 mm, then the alternator speed ration is 1.3:1. If the engine pulley is 108 mm, then the alternator speed ratio is 1.6 : 1.

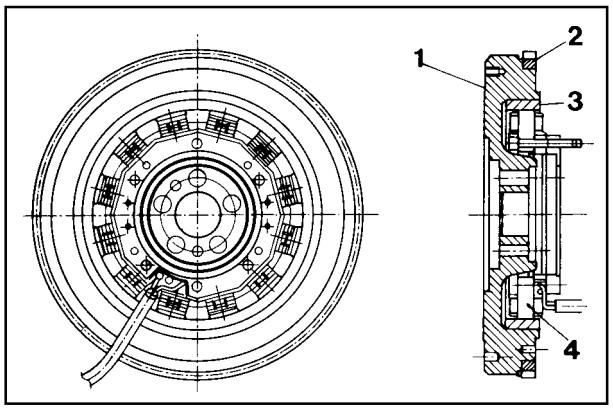


12V ELECTRICAL SCHEMATIC- MARELLI 14V-33A

1 Alternator
2 Starter Motor
3 Battery- (See below for sizing details)
4 Glow Plugs
5 Thermistor (Glow Plug Controller Circuit)
6 Glow Plug Controller / Timer
7 Key Switch
8 System Fuse, 30A (502, 602), 50A (903), 80A (1204, 1204/T)
9 Fuse (Accessory)- 5A
10 Fuel Valve
11 Glow Plug Indicator Lamp
12 Coolant High Temperature Lamp
13 Coolant High Temperature Switch (N.O.)
14 Oil Pressure (Low) Lamp
15 Oil Pressure Switch (N.C.)
16 Alternator Charging Lamp (Off if Charging)
17 Diode
18 Air Filter High Restriction Indicator Lamp
19 Air Filter Restriction Switch (N.O.)
20 Low Fuel Level Lamp
21 Low Fuel Level Switch (N.O.)

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

BATTERY SIZING- PLEASE REVIEW PAGE 62

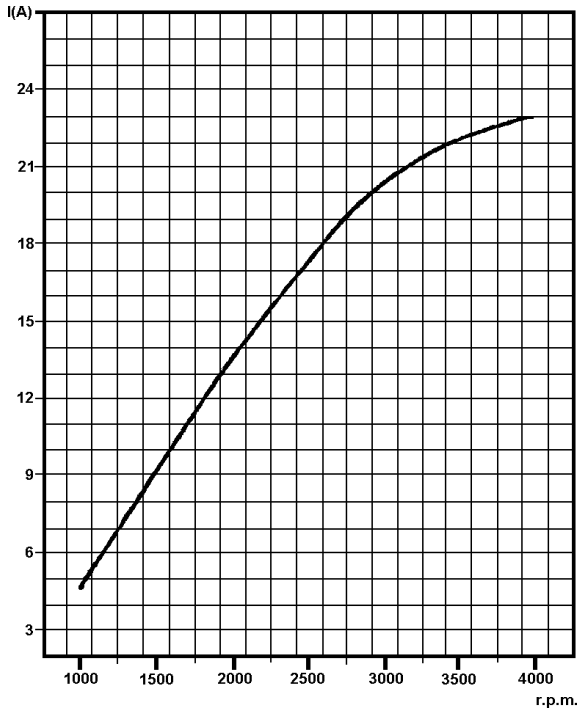


FLYWHEEL ALTERNATOR- 12V

Flywheel driven alternators are available in two(2) amperage ratings at 3600 r/min - 20A and 30A.

COMPONENTS:

1 Flywheel
2 Ring Gear
3 Magnet Ring (Rotor)
4 Stator

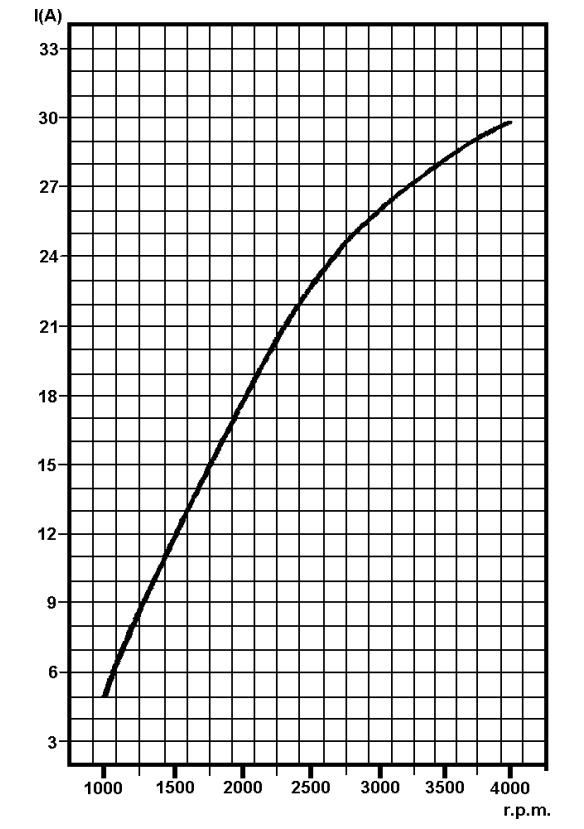


PERFORMANCE CURVE- 20A FLYWHEEL ALTERNATOR

The performance curve at the left was plotted at a constant system voltage of 12V and an ambient temperature of 20°C.

RPM values shown on the performance curve are engine speeds.

The statistical charging output of the flywheel alternator is +10% to -5% of the values shown.

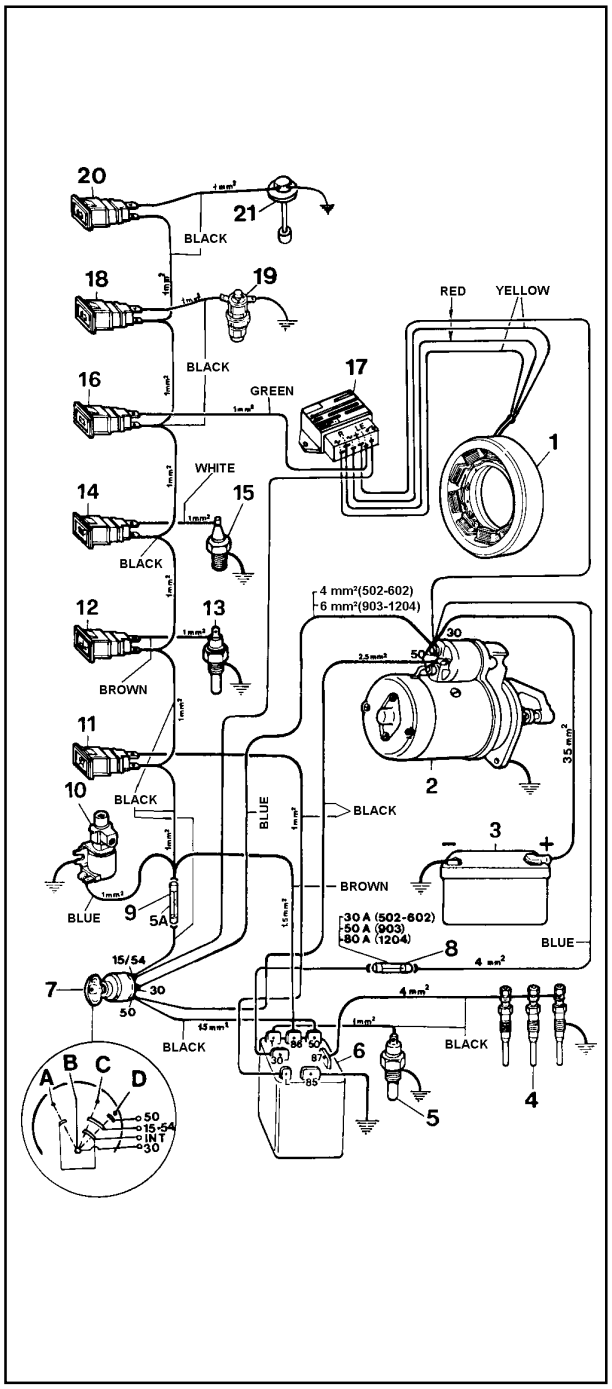


PERFORMANCE CURVE- 30A FLYWHEEL ALTERNATOR

The performance curve at the left was plotted at a constant system voltage of 12V and an ambient temperature of 20°C.

RPM values shown on the performance curve are engine speeds.

The statistical charging output of the flywheel alternator is +10% to -5% of the values shown.

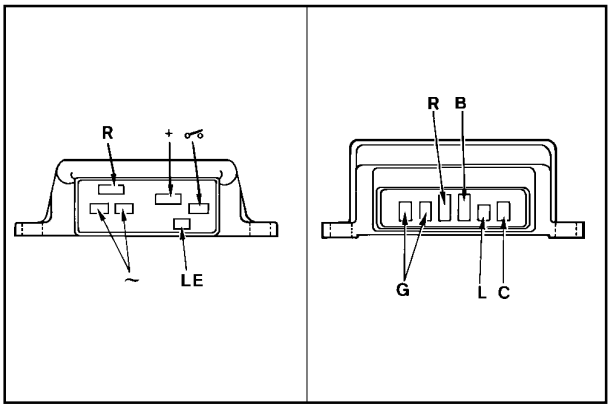


12V ELECTRICAL SCHEMATIC- 20/30A FLYWHEEL ALTERNATOR

1 Alternator
2 Starter Motor
3 Battery- (See below for sizing details)
4 Glow Plugs
5 Thermistor (Glow Plug Controller Circuit)
6 Glow Plug Controller / Timer
7 Key Switch
8 System Fuse, 30A (502, 602), 50A (903,702,1003), 80A (1204, 1204/T, 1404)
9 Fuse (Accessory)- 5A
10 Fuel Valve
11 Glow Plug Indicator Lamp
12 Coolant High Temperature Lamp
13 Coolant High Temperature Switch (N.O.)
14 Oil Pressure (Low) Lamp
15 Oil Pressure Switch (N.C.)
16 Alternator Charging Lamp (Off if Charging)
17 Voltage Regulator
18 Air Filter High Restriction Indicator Lamp
19 Air Filter Restriction Switch (N.O.)
20 Low Fuel Level Lamp
21 Low Fuel Level Switch (N.O.)

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

BATTERY SIZING- PLEASE SEE PAGE 62

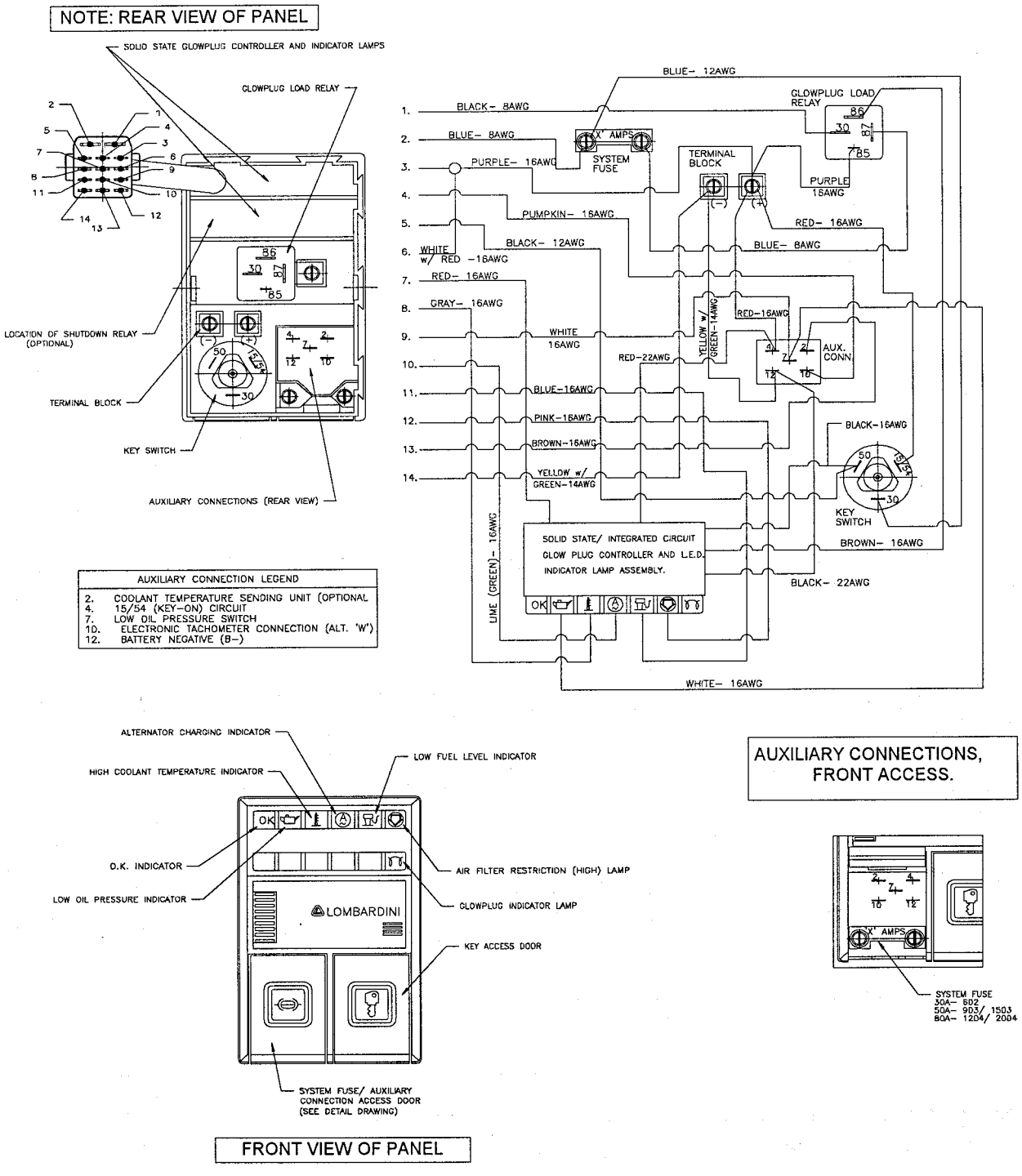


VOLTAGE REGULATOR CONNECTION DETAILS (FLYWHEEL ALTERNATOR ONLY)

SAPRISA, AETSA, NICSA	STD. WIRE COLOR	DUCATI	CONNECTOR DIMENSIONS	
			WIDTH	THICKNESS
~	YELLOW	G	6.35	0.8
R	RED	R	9.5	1.2
+	RED	B	9.5	1.2
LE	GREEN	L	4.75	0.5
	BROWN	C	6.35	0.8

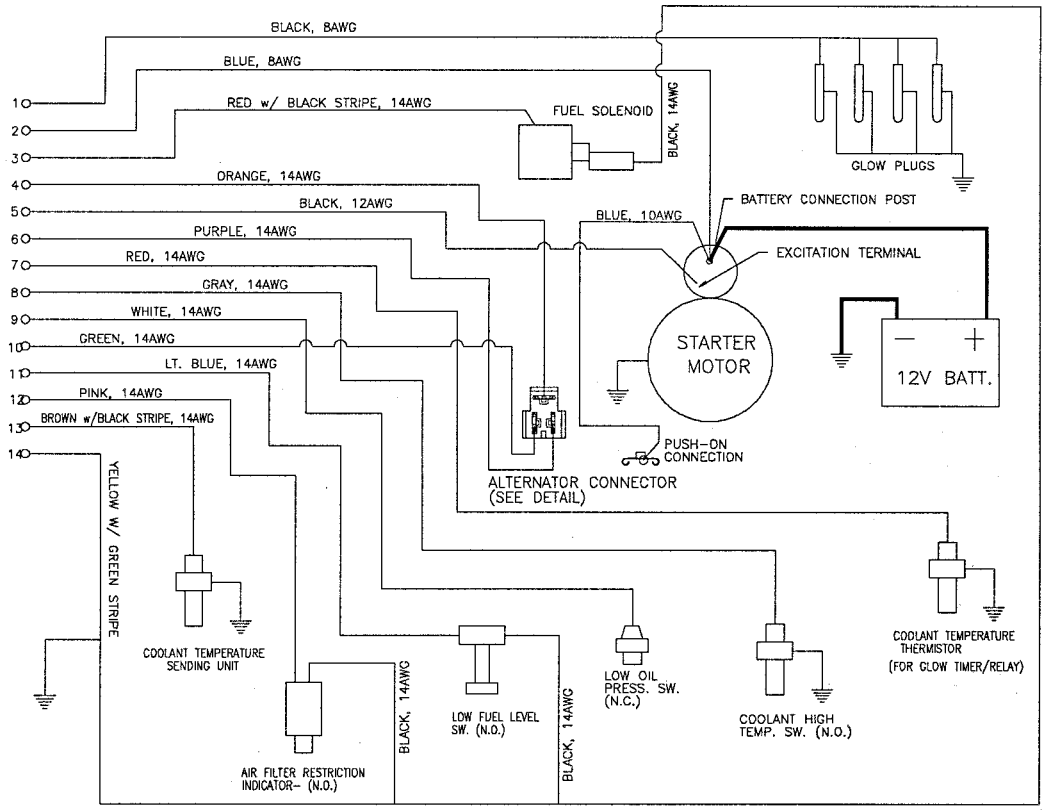
LOMBARDINI SUPPLIED CONTROL PANEL

As an accessory, LDW-FOCS series engines may be fitted with a Lombardini supplied engine control panel. The control panel includes indicator lamps for low oil pressure, high coolant temperature, charging failure, high air filter restriction, low fuel level, glow plug heating and “OK”. Intergral to the panel, a glow plug relay and solid state glow plug controller is included. The diagram below provides details of the control panel. Please also refer to the diagram on page 70, which details the interface engine side wiring harness for the Lombardini control panel. The panel connector index numbers correspond to the index numbers for the engine side harness.

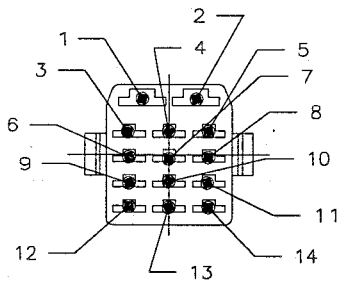


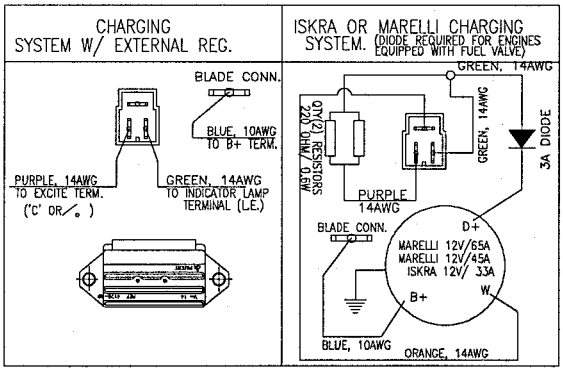
ENGINE SIDE WIRING HARNESS FOR THE LOMBARDINI SUPPLIED CONTROL PANEL

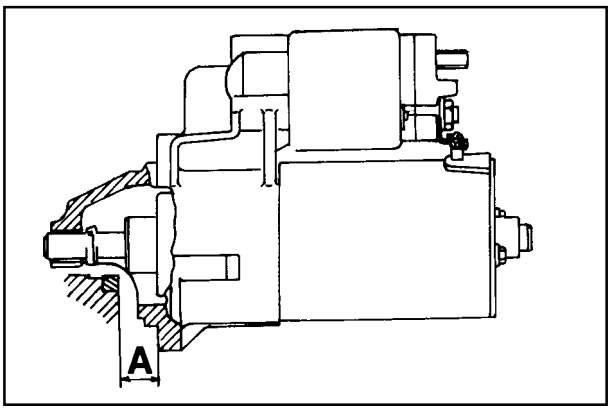
In conjuction with the engine control panel detailed on page 69, LDW-FOCS engines may be fitted with an engine side wiring harness and optional sensors. The following diagram details the engine side wiring harness. Please also reference the diagram on page 69. The connector index numbers as shown on the engine side wiring harness interfaces with the connector index numbers for the control panel.



Connector Key





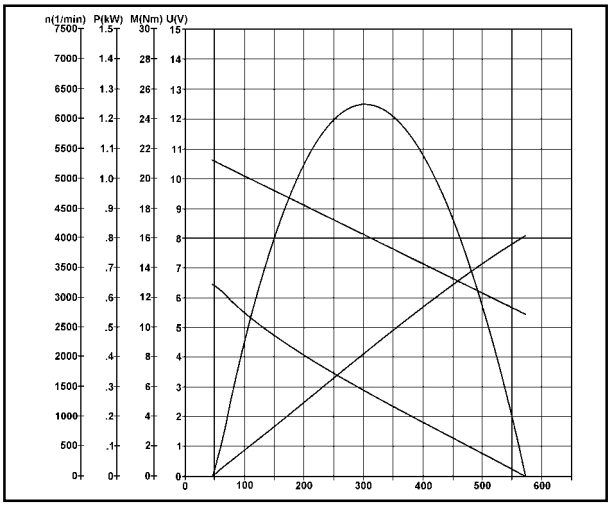


BOSCH 12V / 1.1 KW STARTER MOTOR (DW 12V)

NOTE: Before removing the starter motor or attempting to service any electrical component, remove the negative(-) cable from the system battery.

Distance (A), from starter mounting flange to ring gear face must be checked and confirmed to be 17.5 / 19.5mm.

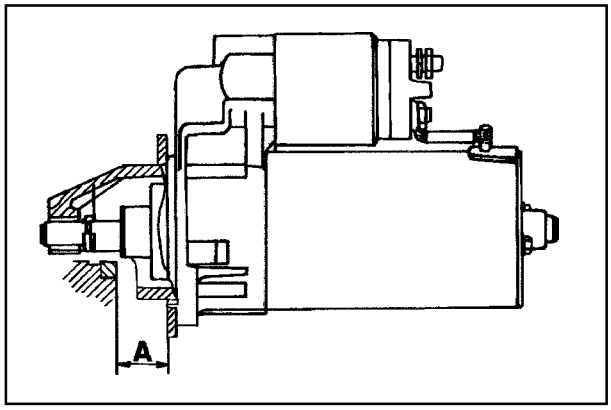
Please refer to your local BOSCH distributor for service parts, repair criterion and warranty service.



PERFORMANCE CURVE- BOSCH 12V / 1.1KW (DW 12V) STARTER

The performance data presented is reflective of an ambient temperature of
-20°C and operation with a fully charged 66Ah battery.

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

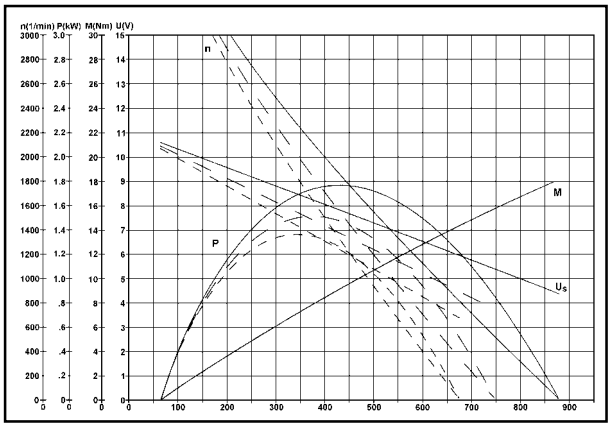


BOSCH 12V / 1.6 KW STARTER MOTOR (DW 12V)

NOTE: Before removing the starter motor or attempting to service any electrical component, remove the negative(-) cable from the system battery.

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

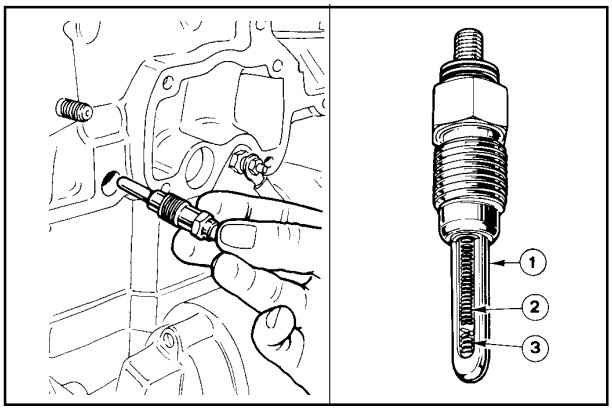
Distance (A), from starter mounting flange to ring gear face must be checked and confirmed to be 29.5 / 31.5mm.



PERFORMANCE CURVE- BOSCH 12V / 1.6KW (DW 12V) STARTER

The performance data presented is reflective of an ambient temperature of
-20°C and operation with a fully charged 88Ah battery.

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

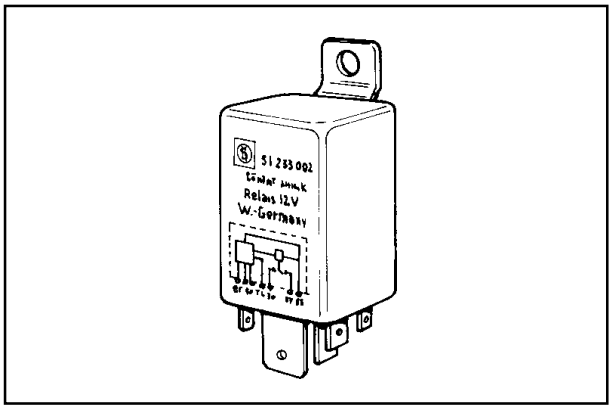


GLOW PLUG

One(1) glow plug is required per engine cylinder. Proper glow plug operation is required for good start ability at any ambient temperature. All FOCS diesel engines should be preheated before attempting to start the engine. Further, Lombardini recommends that all applications be fitted with an automatic glow plug controller system such as is detailed below. The use of a glow plug control circuit will insure the proper amount of preheat at all temperatures.

Glow Plug Specifications: Nominal Voltage- 12.5V
Current Absorption-12/14A at 5 seconds
Sheath Temperature-850°C at 5 seconds

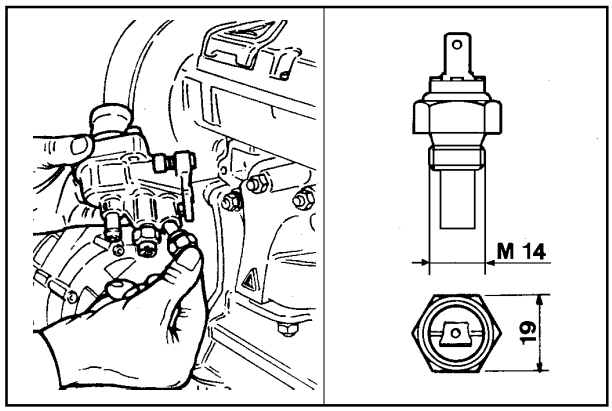
COMPONENTS:
1 Sheath
2 Primary Heating Coil
3 Secondary Heating Coil
NOTE: GLOW PLUG TORQUE- 20Nm



GLOW PLUG CONTROLLER / RELAY WITH COOLANT TEMP. SENSOR

As discussed above, a glow plug control circuit is available. The glow plug controller acts as both a load relay and timer. The timer function is a function of coolant temperature as measured by a temperature sensor (thermistor) as shown below. An electrical schematic of the glow plug control circuit is shown on page 65.

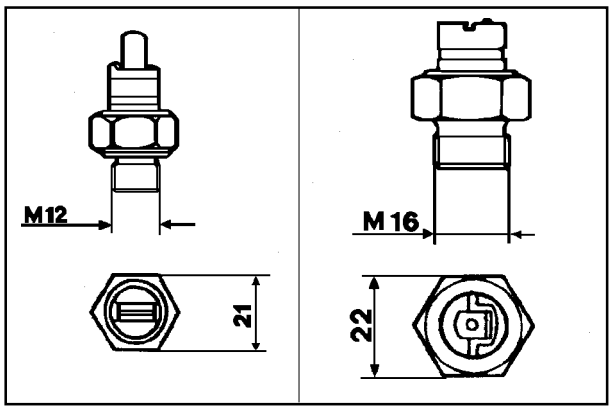
THERMISTOR INPUT		GLOW PLUG HEAT TIME (sec)	
Resistance (ohms)	Coolant Temp. (°C)	Pre-heat	Post-heat
7000	-20	26.5±3	5 (+2, -1)
2400	0	15.0±1.5	5 (+2, -1)
1000	+20	9.5±1	5 (+2, -1)
460	+40	7.0±1	5 (+2, -1)
#320	+50	0	0



TEMPERATURE SENSOR (THERMISTOR)

The thermistor is located on the thermostat housing, adjacent to the high coolant temperature switch. The thermistor must be installed in the thermostat housing in the port located nearest to the cylinder head. (see the figure to the left)

THERMISTOR SPECIFICATIONS:
Temperature Range: 30-50°C
Voltage Range: 6-24V
Maximum Temperature: 150°C
Installation Torque: 30 Nm



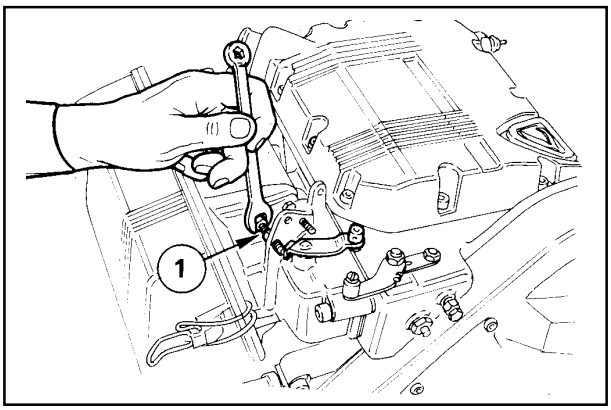
OIL PRESSURE (LOW) SWITCH, COOLANT TEMPERATURE (HIGH) SWITCH

Oil Pressure (low) Switch Specifications:

General: Single Pole, N.C.
Opening Pressure: 0.15 / 0.45 bar
Installation Torque: 25 Nm

Coolant Temperature (High) Switch Specifications:

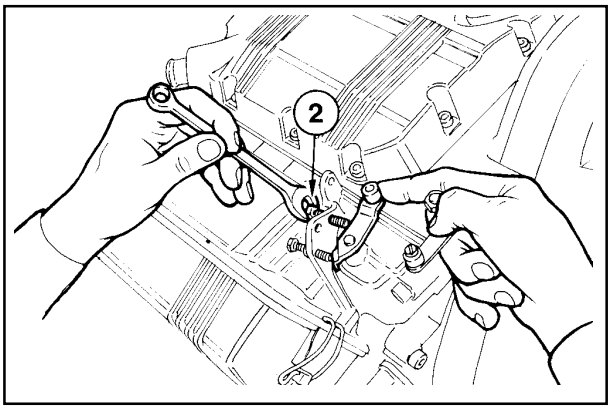
General: Single Pole, N.O.
Closing Temp.: 107 / 113°C
Max. Power Absorption: 3 W
Voltage Range: 6 / 24V
Installation Torque: 25 Nm



IDLE SPEED ADJUSTMENT

1. Check and/or fill the engine with coolant and engine oil. Fill the engine or machine fuel tank with fuel.
2. Attach or set-up a calibrated tachometer.
3. Start the engine and allow a 10 Minute warm-up period.
4. Remove all loads from the engine.
5. Loosen the locknut at position(1). Adjust screw(1) until an idle speed of 850 - 900 r/min is achieved.
6. Tighten the locknut at position(1).

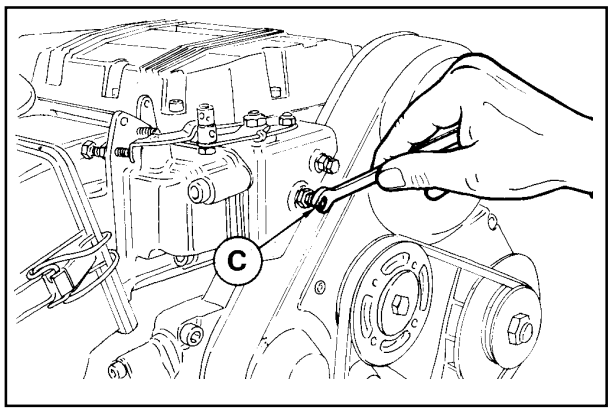
NOTE: Rotating the screw(1) clockwise increases the idle speed, while rotating the screw(1) counter-clockwise reduces the idle speed.



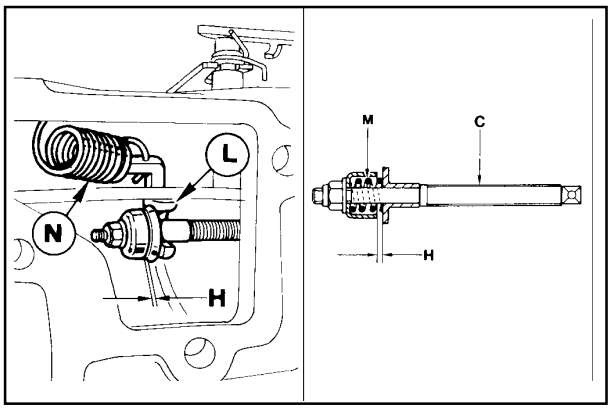
HIGH (MAXIMUM) SPEED ADJUSTMENT

1. Check and/or fill the engine with coolant and engine oil. Fill the engine or machine fuel tank with fuel.
2. Attach or set-up a calibrated tachometer.
3. Start the engine and allow a 10 Minute warm-up period.
4. Remove all loads from the engine.
5. Loosen the lock nut at position(2). Simultaneously adjust screw(2) and hold the throttle lever at full travel as shown until the maximum speed is 3800 r/min.
6. Tighten the locknut at position(2)

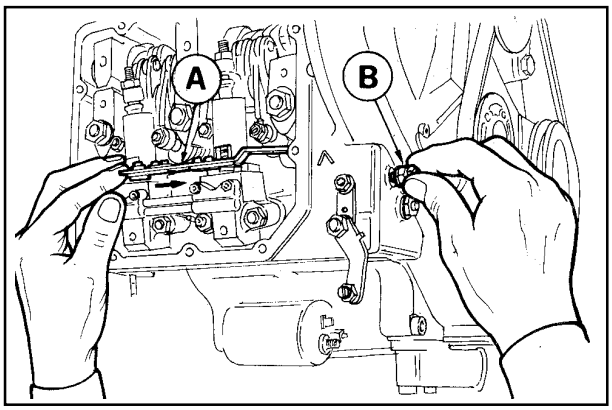
NOTES: Rotating screw(2) clockwise will reduce the maximum speed, while rotating the screw(2) counter-clockwise will allow a higher maximum speed. Setting the maximum no-load speed at 3800 r/min will allow for 3600 r/min operation when the engine is fully loaded. Some fine adjustment may be required after the engine is applied within the given machine.



TORQUE DEVICE ADJUSTMENT (WITHOUT DYNAMOMETER)
Lombardini recommends that the engine torque device be adjusted on a dynamometer. Therefore, the adjustment procedure presented in the following is only approximate. **WARNING: ADJUSTMENT OF THE TORQUE DEVICE WILL REQUIRE THE USE OF TOOLS IN CLOSE PROXIMITY TO THE COOLING FAN. DO NOT PERFORM THIS OPERATION WITHOUT A PROPER FAN GUARD IN PLACE. USE EXTREME CARE NOT TO ALLOW TOOLS OR BODY PARTS TO COME IN CONTACT WITH THE COOLING FAN, FAN SUPPORT OR FAN BELT.**
1. Loosen the torque device locknut at point(C).
2. Rotate the torque device(C) clockwise several revolutions.
3. Tighten the torque device locknut.
4. Start the engine, allow to warm and lock the speed at 3800 r/min.
5. Loosen the locknut at position(C)
6. Rotate the torque device(C) counter-clockwise until the speed begins to reduce.
7. Rotate the torque device(C) clockwise 2.5 revolutions.
8. Tighten the locknut at position(C).

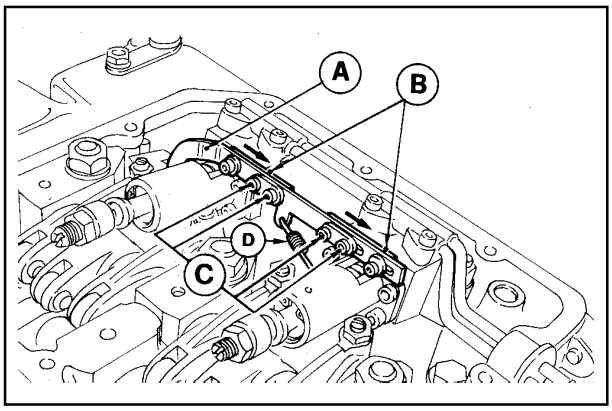


TORQUE DEVICE DETAILS
The torque device(C) serves two(2) primary functions. First, the torque device limits the maximum power output by limiting maximum fuel delivery. Fuel delivery is limited by controlling the travel of lever(L), thus the injection control rack. Secondly, the torque device(C) provides a torque rise in the engine as the fuel delivery is limited. As the governor spring(N) pulls the lever(L) toward the torque device(C) during high load situations, an additional travel equivalent to (H) is allowed providing for the maximum fuel delivery and maximum enginer torque. The distance (H) is a direct function of the internal torque device spring(M). (H) is typically equal to 0.4mm.



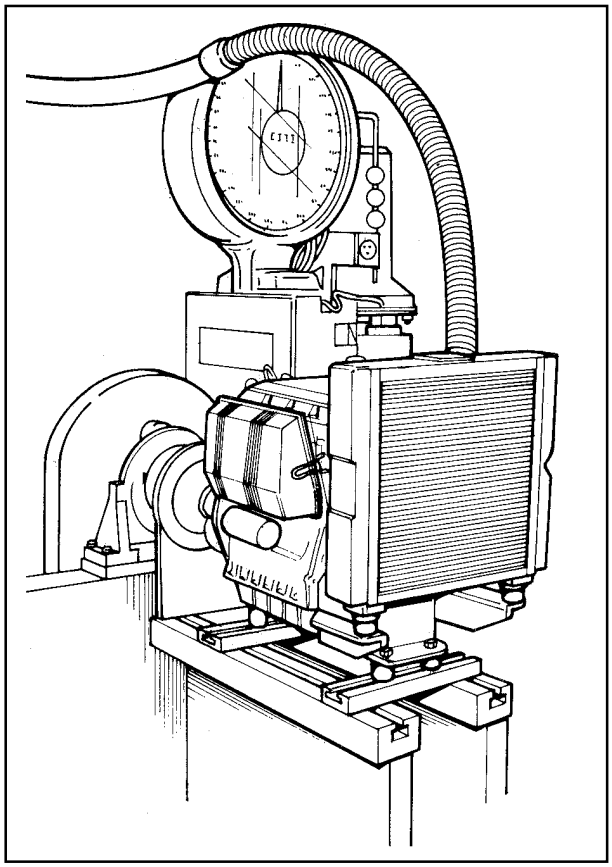
INJECTION PUMP CONTROL ROD STROKE LIMIT ADJUSTMENT

1. Remove the valve/ rocker cover.
2. Loosen bolt(B) completely.
3. Push the injection pump control rod toward the fan end of the engine and hold in position as shown.
4. Rotate screw(B) clockwise until contact is made with the control rod.
5. Rotate screw(B) clockwise an additional 1/2 to 1 turn.
6. While holding screw(B) in position and preventing rotation, tighten the locknut.
7. Replace the valve cover following the instructions from page 29.



GOVERNOR / UNIT INJECTOR RACK ADJUSTMENT

1. Remove the valve/ rocker cover.
2. Loosen screws(C).
3. Make sure that starting aid spring(D) is connected to the control arm(A) as shown.
4. Push the control arm(A) fully toward the flywheel (“right” as shown).
5. Slide each plate(B)- (One(1) per unit injector) toward the flywheel(“right as shown).
6. While holding the plates in the direction shown tighten screws(C) at each unit injector.
7. Torque screws(C) to 1.1Nm



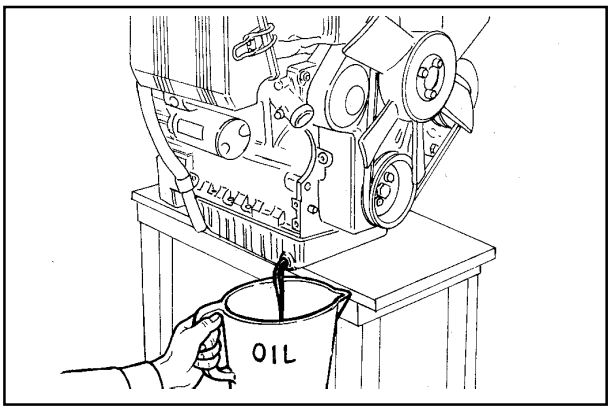
POWER, TORQUE DEVICE and SPEED ADJUSTMENTS- DYNAMOMETER METHOD. (SEE WARNINGS REGARDING TORQUE DEVICE ADJUSTMENT ON PAGE 73.)

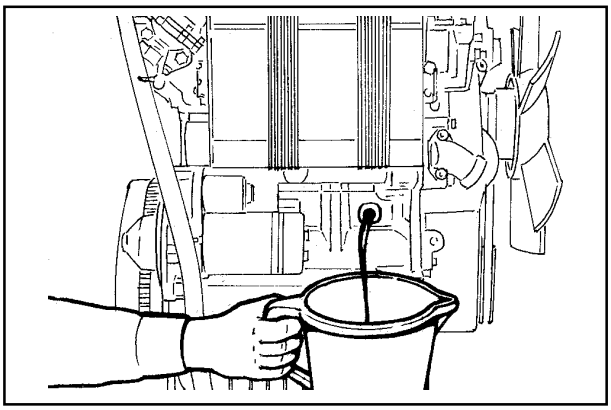
1. Assemble the engine to the dyno. Fill the engine with fluids. Start the engine and allow an idling warm-up of 5 minutes.
2. Loosen the torque device locknut and rotate the torque device several revolutions clockwise. Tighten the locknut.
3. Adjust the engine speed and dynamometer load as required.
4. Allow the engine to stabilize thermally.
5. Check the specific fuel consumption. If the fuel consumption is not within specification, remove the load, allow the engine to cool and re-adjust the governor and fuel delivery rates. Repeat steps 1-4.
6. Rotate the torque device counterclockwise until the engine speed begins to fall. Lock the torque device locknut.
7. Remove the dyno load while maintaining the existing throttle position. Note the speed increase for purposes of droop calculation.
8. Allow the engine to cool at idle speed for 10 minutes.

DYNO TEST PARAMETERS- kW and SPECIFIC FUEL CONSUMPTION

ENGINE	r/min	NB Output (kW)	Specific Fuel Consumption	
			Sec./100cc	g/kW*hr
LDW 502	2200	5.5		285-299
	3600	9.1	115-120	326-340
LDW 602	2200	7.4	147-155	265-279
	3600	10.3	89-93	326-340
LDW 903	2200	11.1	99-105	261-274
	3600	15.6	58-60	328-342
LDW 1204	2200	22.0	75-79	258-272
	3600	20.2	44-45.8	326-340
LDW 1204/T	3600	28.5	35-36	284-290

IX STORAGE





STORAGE

Measures shouLd be taken to protect your FOCS series engine if the engine is not operated for a period of 30 days or more. Proper storage will protect the engine from corrosion and prevent costly repairs due to storage induced problems.

STORAGE - 1 to 6 MONTHS

1. Start and idle the engine at a no-load condition for 15 minutes.
2. Stop the engine, allow the engine to cool enough to safely drain the oil as shown. Reinstall the oil drain plug, then fill the crankcase with MIL-L-644-P9
protectant oil. Fill the fuel tank with a high grade fuel preservative (add-mix) such as STA-BIL per the manufacturer recommendations.
3. Start and operate the engine at 3/4 speed for 5-10 minutes.
4. Stop the engine, allow to cool enough to safely drain the engine oil as shown. Reinstall the oil drain plug.
5. Refill the engine with standard recommended lubricating oil. See page 17.
6. Drain the fuel tank. Remove the fuel filter. Install a new fuel filter.
7. Carefully clean all debris from the radiators fins.
8. Remove the intake manifold. Rotate the engine until the íntake valve opens at each cylinder. Using suitable means, pour approximately one(1) teaspoon of engine oil into each cylinder. Rotate the engine several revolutions. Spray the inside of the intake manifold with SAE 10 W oil. Replace the intake manifold
using a new gasket.
9. Spray the inside of the exhaust manifold with SAE 10 W oil.
10. Cover all openings with tape.
11. Apply grease to any and all unpainted surfaces.
12. Loosen the fan belt.
13. Wrap the engine in plastic film and store in a dry place off of the ground and away from any high voltage source.

STORAGE- IN EXCESS OF 6 MONTHS

Perform the storage preparation procedures approximately as detailed above, except with the following changes.

I. Replace the oil in step 2 above with MIL-L-21260 P 10, grade 2, SAE 30W rustproof oil.
2. Delete step 5 from above.
3. Delete step 11 from above.
4. Cod any and all unpainted surfaces with MIL-C 16173D, grade 3 anti-rust grease.
5. Replace the anti-freeze solution every two(2) years by draining the crankcase water jacket as shown and refilling with a pre-mixed coolant solution according to the prevailling lowest ambient temperatures and the recommendations from pag 17.

PREPARING THE ENGINE FOR USE AFTER STORAGE

I. Romun all plastic wraps and protective tape.
2. Clean all grease, dirt and oil from the exterior of the engine.
3. Drain the oil.
4. Drain the coolant as shown.
5. Refill the engine with the recommended lubricating oil (page 17). Install a new oil filter.
6. Refill the engine with the recommended anti-freeze / coolant (page 19)
7. Remove the injectors. Test and repair the injectors as required.
8. Pour a teaspoon of oil into each cylinder. Rotate the engine several revolutions.
9. Reassemble the injectors, adjust the govemor, adjust the valves.
10. Inspect the fuel tank for rust and corrosion. Clean as required.
11. Fill the fuel tank with fresh fuel. Install a new fuel filter.
12. Install a new air filter.
13. Carefully start the engine and allow to idle for 20 minutes. Repeat step 5.

NOTE: lf the engine has been stored for more than six(6) months, remove the oil pan and inspect several engine bearings to make sure no corrosion damage has taken place.

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