

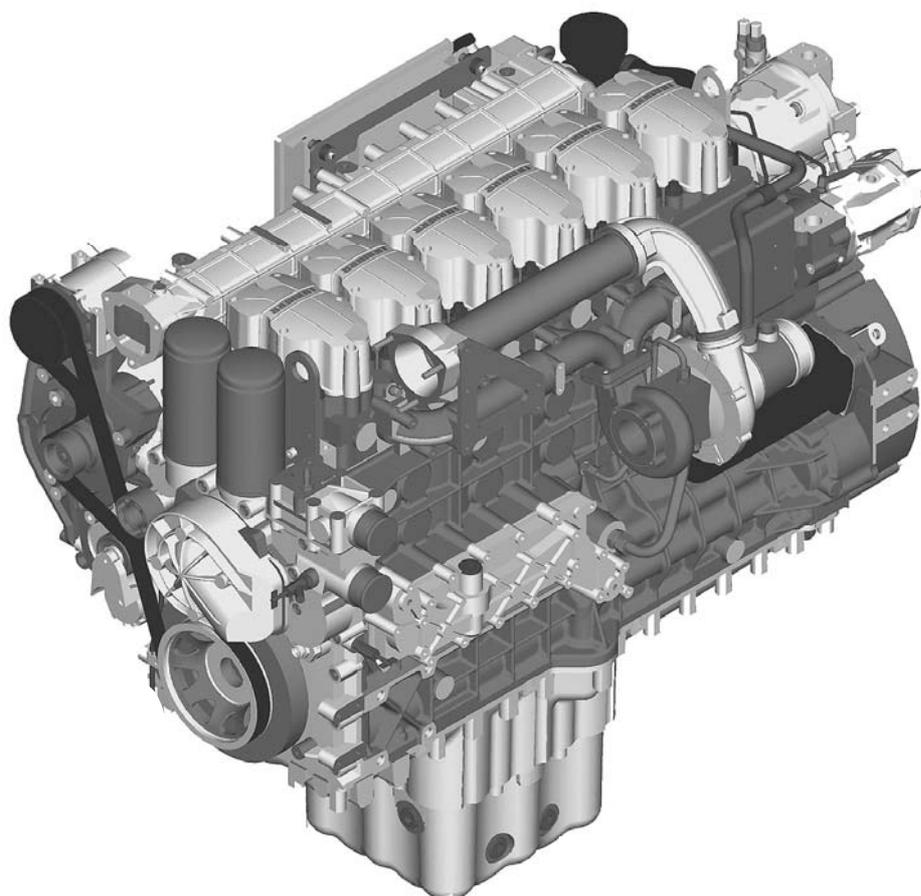
Product: 2009 Liebherr D934,D936,D946 Engine Operating Workshop Manual
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LIEBHERR Diesel engine

D934 - D936 - D946

BAL: 10115602-07-en

Operating manual



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en

Operating manual

Diesel engine
D934- D936- D946

Document identification

Order number: 10115602
Version: 01.01.2009
Document version:
07
Author: LMB/Abteilung-BE-MD3

Product identification

Type: D934- D936- D946
Serial number: 2009030001/2009040001

Address

Address: LIEBHERR MACHINES BULLE S.A.
45, rue de l'Industrie
CH-1630 BULLE
SWITZERLAND

Manufacturer

Name: LIEBHERR MACHINES BULLE S.A

Machine data:

Complete the following details upon delivery of your diesel engine.

*This details are indicated on the identification plate of the diesel engine. This will also prove beneficial when ordering spare-parts.

*** Diesel engine ident. no.:**

.

*** Diesel engine serial no.:**

. . . .

Date of initial start-up:

. . / . . / . .

Foreword

These operating instructions have been compiled for the **user** and for the **maintenance personnel** of the diesel engine.

The manual includes descriptions regarding:

- Technical data
- Safety requirements
- Operation and servicing
- Maintenance

The operating manual is to be read thoroughly and referred to before initial start-up and at regular periods thereafter by each person contracted to carry out work with/on the diesel engine.

Tasks with/on the diesel engine include for example:

- **Operation**, servicing, disposing of fuels and lubricants.
- **Repair**, including maintenance and inspection.

This simplifies training of the operator for his diesel engine and prevents malfunctions resulted from improper use.

Please understand that we do not recognise warranty claims submitted as a result of improper operation, insufficient maintenance, the utilisation of impermissible fuels or negligence of the safety guidelines.

LIEBHERR will revoke any obligations submitted to **LIEBHERR** and/or their dealers, such as guarantees, service orders, etc. without notice, if any parts other than original **LIEBHERR** parts or spare-parts sold by **LIEBHERR** are used for maintenance and repair.

It may be necessary to undertake maintenance tasks more regularly than is prescribed in the inspection plan when working in tougher conditions.

Modifications, conditions and copyright:

- Modifications of technical data, as regards information and illustrations within the documentation currently valid for the machine, remain reserved.

Conditions for warranty and liability of the general terms of trade for the LIEBHERR Company are not extended by the aforementioned details.

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1	Product description	1 - 1
1.1	Technical data	1 - 5
1.1.1	Diesel engine	1 - 5
1.1.2	Cylinder head, standard	1 - 5
1.1.3	Cylinder head with engine auxiliary brake system (ZBS)	1 - 6
1.1.4	Coolant pump	1 - 6
1.1.5	Coolant thermostat	1 - 6
1.1.6	Generator	1 - 6
1.1.7	Starter	1 - 6
1.1.8	Flywheel housing	1 - 7
1.1.9	Air compressor	1 - 7
1.1.10	Explanation of type description	1 - 7
1.1.11	Design features	1 - 8
1.1.12	Special equipment for the diesel engine	1 - 10
2	Safety regulations	2 - 1
2.1	Introduction	2 - 1
2.2	General safety guidelines	2 - 1
2.3	Use as directed	2 - 2
2.4	Notes on the prevention of crushing and burns	2 - 2
2.5	Notes on the prevention of fire and explosions	2 - 3
2.6	Observe safety precautions when starting	2 - 3
2.7	Measures for safe maintenance	2 - 3
2.8	Observe the safety precautions for diesel engines featuring electronic control units	2 - 5
2.9	Safety and emergency run program for diesel engines featuring electronic control units	2 - 5
2.10	Disposing of fuels and lubricants	2 - 6
3	Operation, Handling	3 - 1
3.1	Control elements and operating elements	3 - 1

3.2	<u>Operation</u>	3 - 2
3.2.1	<u>Preparing for initial start-up</u>	3 - 2
3.2.2	<u>Maintenance tasks before daily start-up</u>	3 - 3
3.2.3	<u>Starting the diesel engine</u>	3 - 3
3.2.4	<u>Precautions for starting up in icy temperatures</u>	3 - 4
3.2.5	<u>Shutting down</u>	3 - 5
4	<u>Malfunctions</u>	4 - 1
4.1	<u>Error code tables</u>	4 - 1
5	<u>Maintenance</u>	5 - 1
5.1	<u>Maintenance and inspection schedule</u>	5 - 1
5.2	<u>Lubricant chart, Filling quantities</u>	5 - 4
5.2.1	<u>Table of filling quantities</u>	5 - 4
5.2.2	<u>Lubricant chart</u>	5 - 4
5.3	<u>Maintenance tasks</u>	5 - 6
5.3.1	<u>Special tools for maintenance tasks</u>	5 - 6
5.3.2	<u>Preparatory tasks for maintenance</u>	5 - 7
5.3.3	<u>Maintenance Tasks (daily), every 10 operating hours</u>	5 - 7
5.3.4	<u>Maintenance tasks (daily) every 50 operating hours</u>	5 - 11
5.3.5	<u>Maintenance Tasks, every 500 operating hours</u>	5 - 12
5.3.6	<u>Maintenance Tasks, every 1000 operating hours</u>	5 - 25
5.3.7	<u>Maintenance tasks every 2000 operating hours</u>	5 - 35
5.3.8	<u>Maintenance Tasks every 3000 operating hours</u>	5 - 35
5.3.9	<u>Maintenance Tasks every 10000 operating hours</u>	5 - 37
5.3.10	<u>Maintenance tasks as required</u>	5 - 38
5.3.11	<u>Confirmation of maintenance tasks which have been performed</u>	5 - 45
5.3.12	<u>Every 500 operating hours / at least once a year</u>	5 - 45

5.3.13	Additionally every 1000 / 2000 / 3000 operating hours	5 - 46
5.3.14	Additionally every 2 years	5 - 47
5.4	Lubricants and fuels	5 - 48
5.4.1	Handling lubricants and fuels	5 - 48
5.4.2	Environmental-protection guidelines	5 - 48
5.4.3	Disposal of used materials	5 - 48
5.4.4	Diesel fuels	5 - 49
5.4.5	Lube-oils for the diesel engine	5 - 50
5.4.6	Coolant for the diesel engine	5 - 51

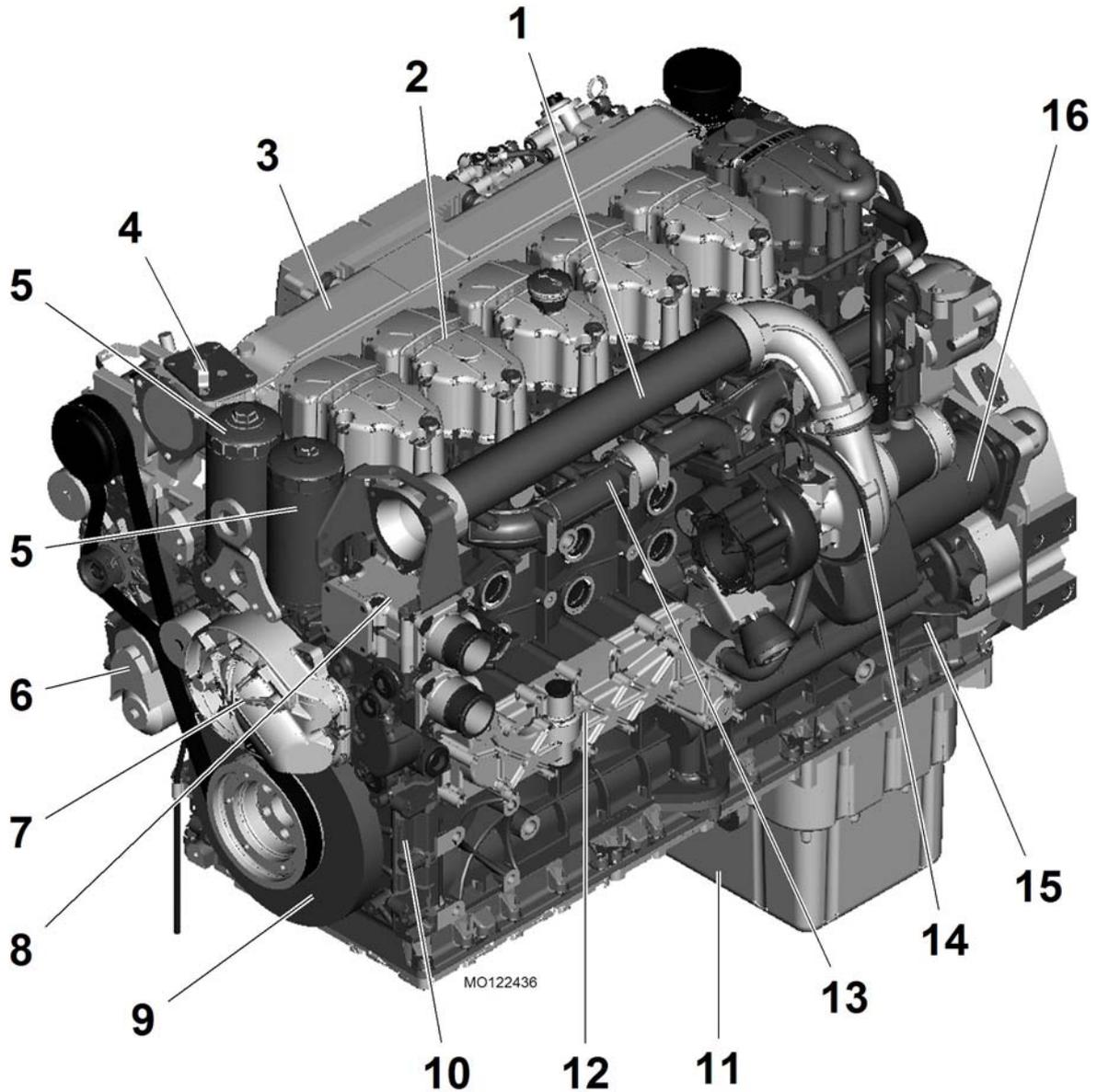
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LIEBHERR D934- D936- D946-/2009030001/2009040001

1 Product description

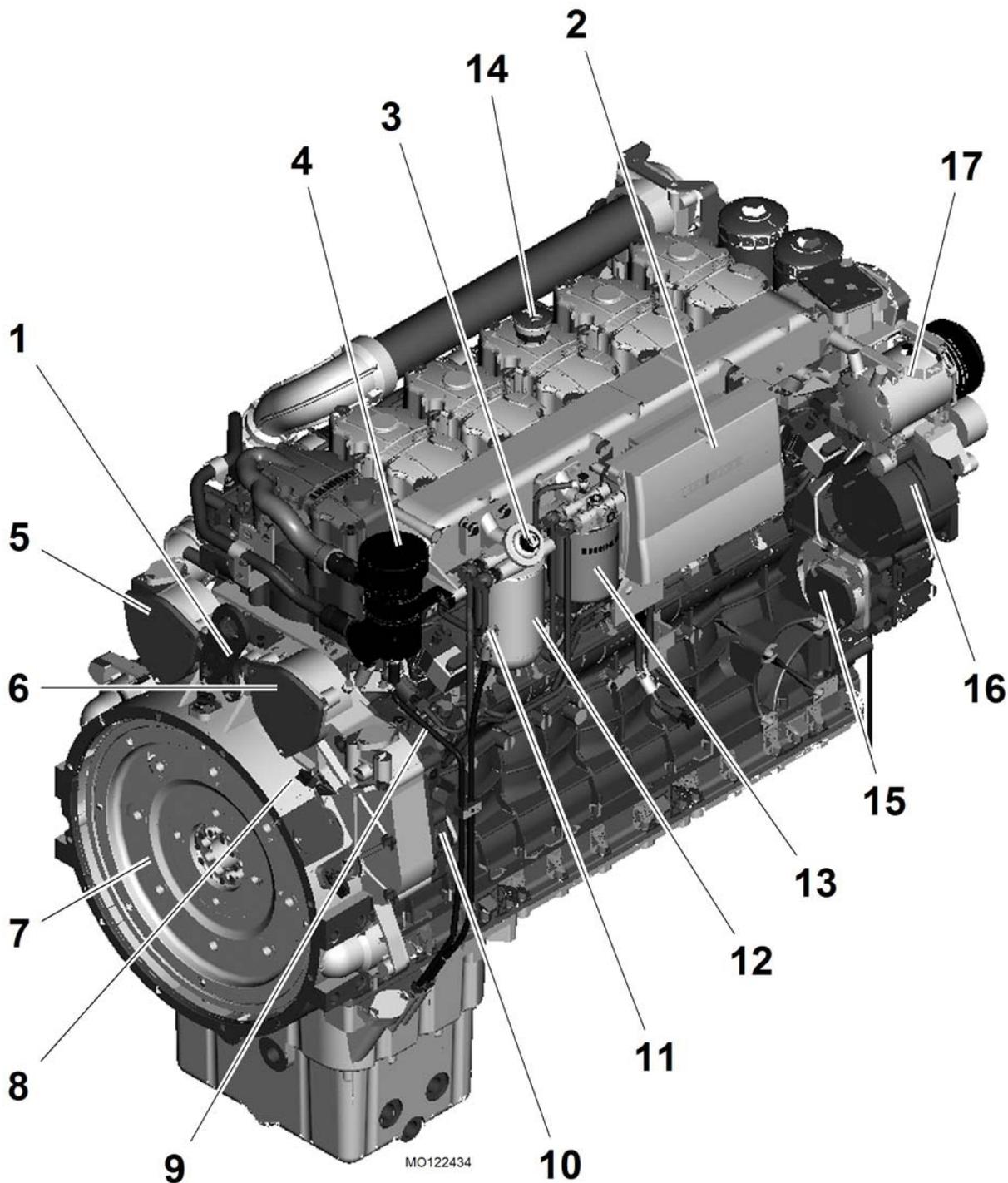
Equipment layout

This section features a summary of the diesel engine including a description of the components represented.



Components of the diesel engine featuring iAGR / as viewed from the left

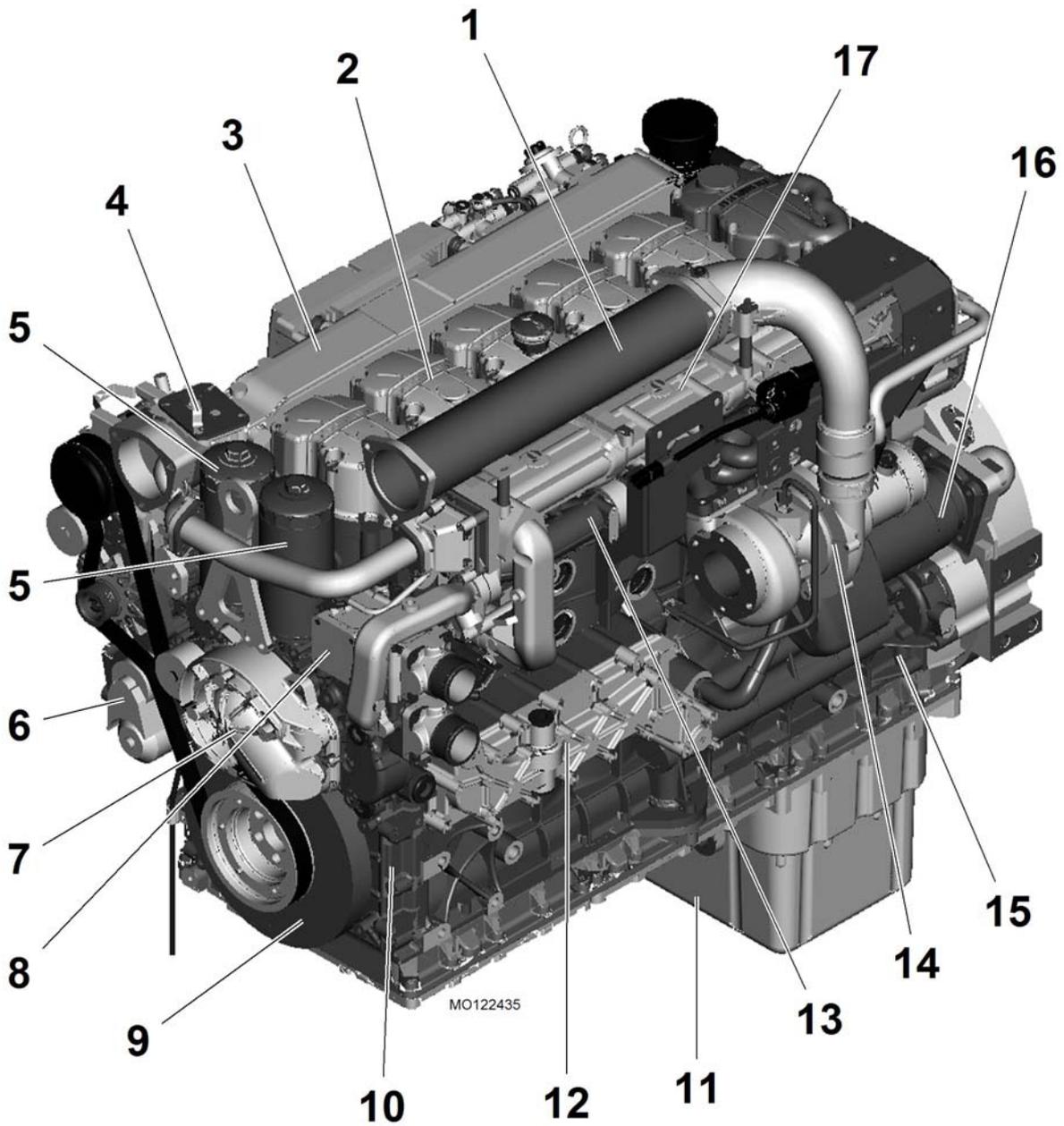
- | | | |
|----------------------------|---------------------------------|-------------------------|
| 1 Charge air duct | 7 Water pump | 13 Exhaust gas pipe |
| 2 Cylinder head | 8 Thermostat housing | 14 Exhaust turbocharger |
| 3 Air induction pipe | 9 Crankshaft / vibration damper | 15 Crankcase |
| 4 Heater flange | 10 Aggregate carrier | 16 Starter |
| 5 Oil filter | 11 Oil sump | |
| 6 Automatic tension pulley | 12 Oil cooler | |



Components of the diesel engine featuring iAGR / as viewed from the right

- | | | |
|------------------------|-----------------------|--------------------------------|
| 1 Transport device | 7 Flywheel | 13 Fuel fine filter |
| 2 Control unit | 8 Flywheel housing | 14 Oil intake |
| 3 Manual delivery pump | 9 Fuel delivery pump | 15 Power take-off NA4 |
| 4 Crankcase breather | 10 Power take-off NA3 | 16 Alternator |
| 5 Power take-off NA2 | 11 Oil dipstick | 17 Air-conditioning compressor |
| 6 Power take-off NA1 | 12 Fuel prefilter | |

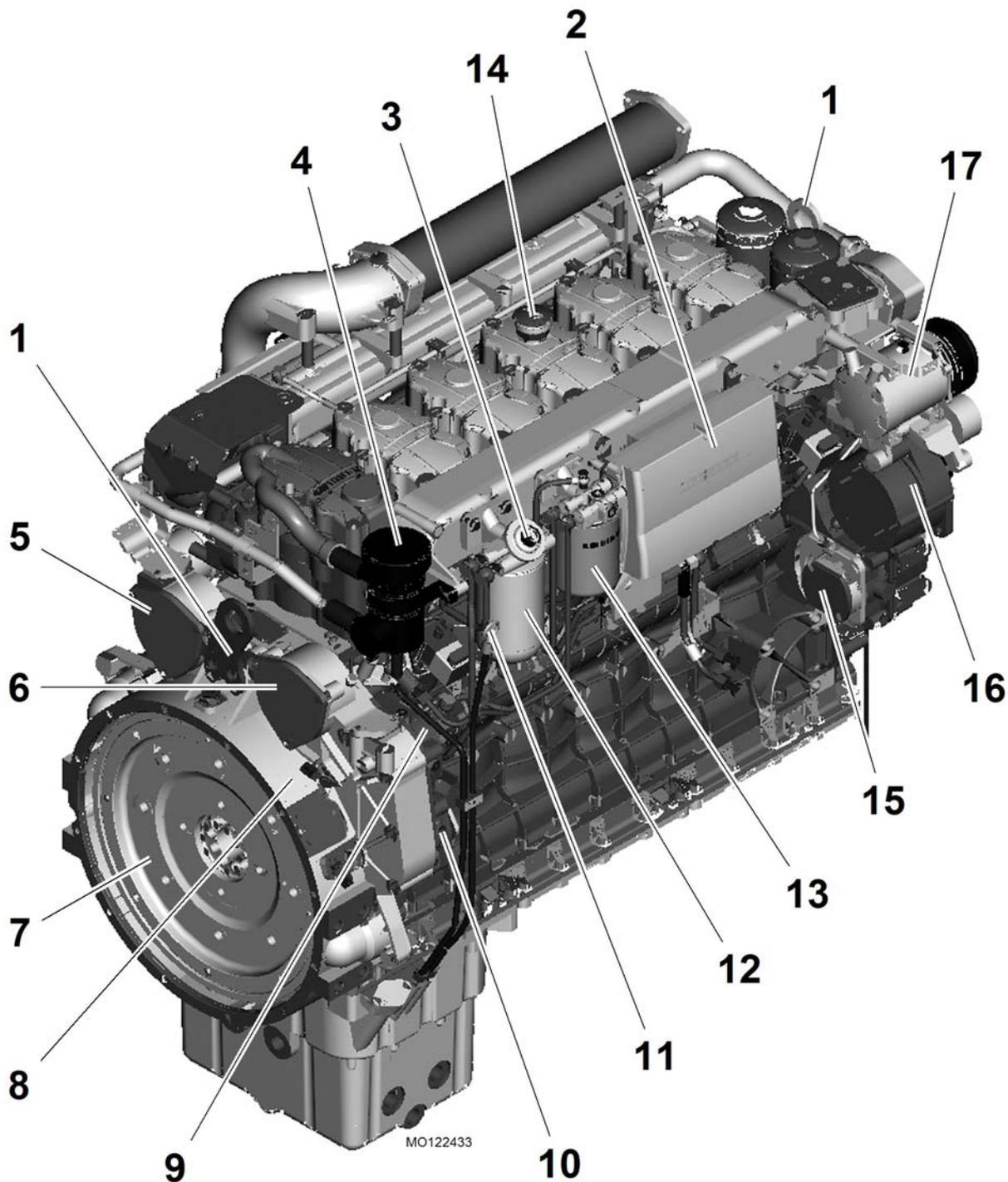
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Components of the diesel engine featuring eAGR / as viewed from the left

- | | | |
|----------------------------|---------------------------------|-------------------------|
| 1 Charge air duct | 7 Water pump | 13 Exhaust gas pipe |
| 2 Cylinder head | 8 Thermostat housing | 14 Exhaust turbocharger |
| 3 Air induction pipe | 9 Crankshaft / vibration damper | 15 Crankcase |
| 4 Heater flange | 10 Aggregate carrier | 16 Starter |
| 5 Oil filter | 11 Oil sump | 17 eAGR module |
| 6 Automatic tension pulley | 12 Oil cooler | |

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Components of the diesel engine featuring eAGR / as viewed from the left

- | | | |
|------------------------|-----------------------|--------------------------------|
| 1 Transport device | 7 Flywheel | 13 Fuel fine filter |
| 2 Control unit | 8 Flywheel housing | 14 Oil intake |
| 3 Manual delivery pump | 9 Fuel delivery pump | 15 Power take-off NA4 |
| 4 Crankcase breather | 10 Power take-off NA3 | 16 Alternator |
| 5 Power take-off NA2 | 11 Oil dipstick | 17 Air-conditioning compressor |
| 6 Power take-off NA1 | 12 Fuel prefilter | |

LMB07/003801/1.9/en/Version:01.01.2009

1.1 Technical data

1.1.1 Diesel engine

Name	Value	Units
Design	Inline diesel engine	
Number of cylinders (D934)	4	
Firing sequence (D934)	1-3-4-2	
Number of cylinders (D936/D946)	6	
Firing sequence (D936/D946)	1-5-3-6-2-4	
Bore (D934/D936)	122	mm
Bore (D946)	130	mm
Stroke S / L	136 / 150	mm
Displacement (D934S/L)	6.4 / 7.0	Litres
Displacement (D936S/L)	9.5 / 10.5	Litres
Displacement (D946L)	11.95	Litres
Compression ratio	17:1 / 18:1	
Diesel engine's direction of rotation (looking at the flywheel)	left	
Performance group	LG1 to LG5	
Power rating in accordance with	see identification plate	
Nominal output	see identification plate	kW
Nominal speed	see identification plate	rpm
Emission standards	see identification plate	
D934 diesel engine weight (without water, without oil)	approx. 900	kg
D936 / D946 Diesel engine weight (dry)	approx. 1150	kg

1.1.2 Cylinder head, standard

Name	Value	Units
Valve clearance intake cold	see identification plate	mm
Valve clearance exhaust cold	0.4	mm

1.1.3 Cylinder head with engine auxiliary brake system (ZBS)

Name	Value	Units
Valve clearance intake cold	see identification plate	mm
Valve clearance exhaust valve fitting/rocker arm cold	0.4	mm
Valve clearance exhaust valve fitting/retainer cold	0.2	mm

1.1.4 Coolant pump

Name	Value	Units
Flow rate (at nominal speed 1900 rpm and counterpressure 0.6 bar)	D934 approx. 315	l
Flow rate (at nominal speed 1900 rpm and counterpressure 0.6 bar)	D936/D946 ca. 475	l
Flow rate (at nominal speed 1900 rpm and counterpressure 0.6 bar)	D936 mit eAGR ca. 400 (475–75)	l

1.1.5 Coolant thermostat

Name	Value	Units
Beginning of opening	79 / 83	°C
Fully opened	92 / 98	°C

1.1.6 Generator

Name	Value	Units
Voltage	28	V
Amperage	80 / 110	A

1.1.7 Starter

Name	Value	Units
Voltage	24	V
Output	5.4 / 6.6 / 7.8	kW

1.1.8 Flywheel housing

Name	Value	Units
Connection	SAE1 / SAE2	

1.1.9 Air compressor

Name	Value	Units
Flow rate at nominal speed 1900 rpm and 6 bar	465	l/min
Gear transmission ratio	1:1.388	
Water-cooled	Yes	

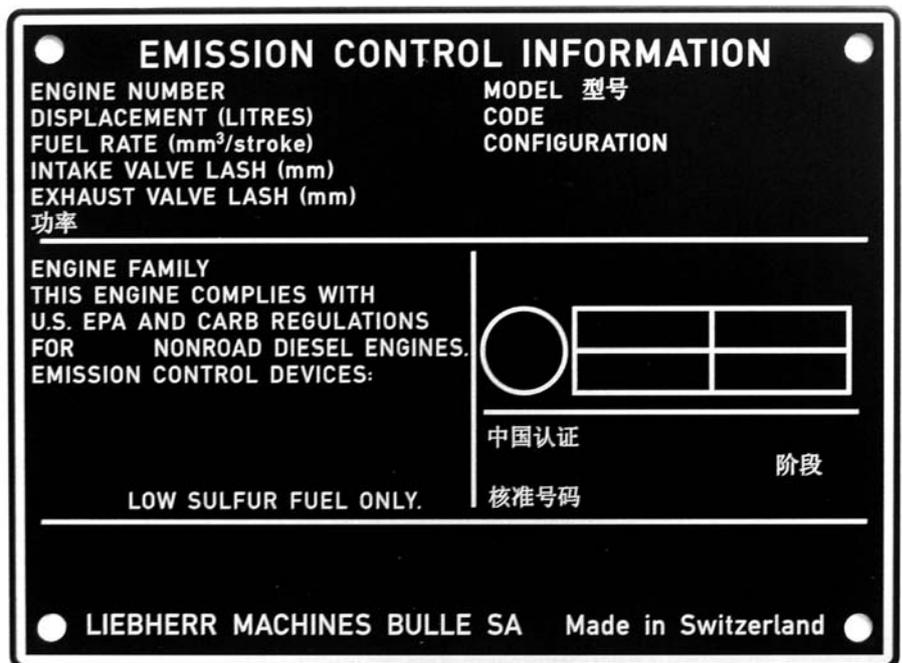
1.1.10 Explanation of type description

Type description

				Description
D	93	6	L	Type description
D				Diesel engine
	93			Bore 122 mm (94= Bore 130 mm)
		6		Number of cylinders (6 cylinder)
			L	Long / S= Short, stroke L=150 / S=136 mm

Diesel engine type identification plate

The diesel engine identification plate is mounted on the right-hand side of the crankcase looking at the flywheel. A second identification plate on the air induction pipe.



Identification plate

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Features	A rugged basic design and largely-dimensioned size form the basis for optimum operating safety and long life-expectancy. Reduced fuel-consumption, as well as low noise and exhaust emissions due to a combustion process which is specially adapted to suit the requirements. Reduced maintenance to easily accessible components and a multitude of mounting options for special equipment contribute to optimum overall efficiency of the diesel engines.
Engine	<p>The 4-cylinder diesel engines feature a steel crankshaft with 5 bearing points with 2 mass equalising shafts / the 6-cylinder diesel engines feature a steel crankshaft with 7 bearing points with inductive-hardened running surfaces and 8 / 8 forged-on counterweights.</p> <p>A torsion damper is mounted on the crankshaft on the same side as the fan. Forge pressed, diagonally-sectioned connecting rod, transmission bearing in lead bronze-triplex-friction bearings or sputter bearing. Three-ring piston made of aluminium ally or steel alloy featuring ring inserts and combustion recess in the piston crown. Replaceable, wet cylinder liners</p>
Housing	<p>Crankcase designed as one unit made of alloyed cast iron. Individual cylinder heads featuring cast integral swirl inlet, as well as replaceable valve seat rings and valve guides.</p> <p>Flywheel housing, front-mounted aggregate carrier and oil sump mounted on the underside encase the diesel engine.</p>
Drive control	Two intake valves and exhaust valves respectively per cylinder suspended in the cylinder head. Actuated by steel camshaft featuring 5 or 7 bearing points via roller tappet, push rod and rocker arm. Drive of the camshaft, fuel delivery pump, lube oil pump, air compressor and auxiliary hydraulic pumps from the crankshaft via nitrified gears on the same side as the flywheel, and water pump on the same side as the aggregate carrier.
Lubrication	<p>Forced-feed lubrication with gear pump crankshaft bearing, connecting rod bearing and camshaft bearing, as well as small end bush and rocker arm.</p> <p>Oil filtering via two replaceable cartridge filters in the main flow. Accessories such as individual injection pumps, water pump, turbocharger, power take-offs, fuel delivery pump and air compressor are connected to the diesel engine lube oil circuit. The diesel engine oil cooler is integrated in the cooling water circuit.</p>
Cooling	<p>Double thermostatic regulated liquid cooling with water pump. Individual supply of each cylinder unit via cast distributor ducts in the crankcase.</p> <p>Piston cooling via oil spraying or cooling duct from the lube oil circuit of the diesel engine.</p>
Injection system	PLD (pump, line and nozzle) fuel delivery pump, fuel filter, individual injection pump, short injection line and injection nozzle.
Heater flange	<p>The heater flange is a cold-start aid.</p> <p>The heater flange installed in the air induction pipe warms the combustion air for the start procedure.</p> <p>Curtailement of the start time conserves the starter and the batteries.</p>
Electrical equipment	Starter and alternator: 24 Volt.
Exhaust gas recirculation (AGR)	<p>With the internal AGR, part of the exhaust gas is pushed into the intake stroke during the exhaust stroke and then sucked in again upon the next intake stroke. This ensures lower NOx emissions.</p> <p>With external AGR, part of the combusted hot exhaust is supplied again to the cylinder charge via a heat exchanger integrated in the engine cooling system. This ensures reduced combustion temperatures and lower NOx emissions.</p>

Electronic diesel engine regulation	The electronic diesel control (EDC) regulates the speed, injection begin and torque of the LIEBHERR diesel engines. The EDC is comprised essentially of sensors and the control unit. Devices located on the same side as the diesel engine and on the same side as the vehicle are connected to the EDC-control unit via cable harnesses.
Electronic sensors on the engine side	Charge air pressure sensor, temperature sensor for coolant, charge air and fuel, speed sensors and oil pressure sensor are interfaces for external monitoring and control functions. The individual functions and error reports are described in the respective user documentation.
Mounting options for pumps	The mounting of hydraulic pumps is possible on up to 4 power take-offs of the diesel engine.

1.1.12 Special equipment for the diesel engine

Diesel engine brake	The diesel engine exhaust gas brake flap is installed in the exhaust gas pipe which runs from the exhaust turbocharger to the muffler. The diesel engine exhaust brake flap is actuated via a cylinder pressurised with compressed air, whereby the diesel engine braking action is generated via closing of the diesel engine exhaust gas brake flap.
Diesel engine brake and auxiliary brake system	A diesel engine auxiliary brake system (ZBS), in addition to the diesel engine exhaust gas brake flap, has been installed to increase diesel engine braking action. Thus, during the engine braking procedure, the ZBS allows a gap in the exhaust valves to remain open, increasing diesel engine braking action.
Air-conditioning compressor	The air-conditioning compressor can be mounted directly onto the diesel engine and powered via a magnetic clutch featuring a ribbed V-belt. When the air-conditioning is switched on, the magnetic clutch is active and the compressor is working.
Air compressor	The air compressor is flange-mounted to a power take-off integrated on the flywheel housing. Cooling or lubrication of the air compressor is connected to the respective circuits of the diesel engine.
Cold start package	The interfaces for the retrofitting of preheating devices, e.g. for coolant, fuel and diesel engine oil, are already integrated.

2 Safety regulations

Working on the diesel engine is extremely hazardous to user, machine operator or maintenance technician. Dangers and accidents can be avoided if the various notes on safety are frequently read and adhered to. This applies in particular for personnel carrying out maintenance tasks opportunely on the diesel engine.

Conscientious adherence of the safety guidelines, specified as follows, will guarantee the safety of yourself and others, as well as safeguarding against damage to the diesel engine.

All necessary safety precautions relevant to the description of tasks which could cause injury to personnel, or damage to the diesel engine, are described in this book.

They are indicated with the references **Danger**, **Warning** or **Caution**.

2.1 Introduction

1. The terms represent the following meaning throughout this book:



"Danger"

signifies an immediately dangerous situation which could result in fatalities or serious injury if it is not prevented.



"Warning"

signifies a dangerous situation which could result in fatalities or serious injury if it is not prevented.



Caution signifies a dangerous situation which could result in minor or significant injury if it is not prevented.



"Note"

signifies useful notes and tips.

2. **Observation of these points does not exempt you from the adherence of additional rules and regulations!**

All safety regulations valid for the application site are also to be adhered to.

2.2 General safety guidelines

1. Familiarise yourself with the operating and maintenance instructions before starting up the machine.
Make sure that you possess, have read, and have understood any additional instructions relevant to the machine's optional features.
2. Only expressly authorised personnel may operate, maintain or repair the diesel engine.
Observe the legal, permissible minimum age!
3. Employ only trained or instructed personnel and allocate definitive responsibility for personnel regarding operation, setting up, maintenance and repair.
4. Personnel who are still undergoing training, or are involved with a general apprenticeship, should only be allowed to work on the diesel engine while under constant supervision of an experienced person.

5. Ensure regularly that personnel are conscientious of safety and dangers while working, and are observing the operating instructions.
6. Do not remain in direct proximity of the diesel engine while the diesel engine is running.
Persons with pacemakers should not approach within 20 cm of the running diesel engine. Do not touch voltage-carrying parts on the electrical connection of the solenoid valve-controlled individual injection pumps (Unit Pumps UP) while the diesel engine is running.
Always wear safety clothing when working on the diesel engine.
Avoid the wearing of rings, wrist watches, ties, scarves, open jackets, baggy clothing etc. There is a risk of injury as a result of getting caught up or being drawn into machinery.

2.3 Use as directed

1. This diesel engine has been designed exclusively for the intended use defined by the manufacturer and stipulated in the scope of delivery (use as directed). Any other form of use is not considered use as directed. The manufacturer can not be held responsible for any damage which occurs as a result. The user bears full responsibility.
2. Use as directed also includes the adherence of operating, maintenance and repair requirements prescribed by the manufacturer. The diesel engine may only be operated, maintained and repaired by persons who are familiar with these tasks and are fully aware of the dangers.
3. The manufacturer does not bear responsibility for any material damage or injury to persons which occurs as a result of unauthorised modifications to the diesel engine.
Likewise, manipulation of the injection system and servo system could influence output and exhaust characteristics of the diesel engine, whereby compliance of the legal environmental regulations can no longer be guaranteed.

2.4 Notes on the prevention of crushing and burns

1. Do not use any lifting materials, such as ropes or chains, which are damaged or do not feature sufficient lift capacity.
Always wear industrial gloves when handling wire cables.
2. Ensure that no objects come into contact with the fan while the diesel engine is running.
Objects which fall into, or protrude into, the fan will be flung back out or destroyed, and could cause damage to the fan.
3. When verging on operating temperature, the diesel engine's cooling system is hot and under pressure.
Avoid any contact with parts carrying cooling water.
Risk of burns!
4. Only check the cooling water level if the sealing cap of the expansion tank is cool enough to touch.
Open the cap carefully to relieve any excess pressure.
5. The diesel engine oil is extremely hot when verging on operating temperature.

Avoid skin contact with hot oil or parts carrying oil.

6. Always wear protective glasses and industrial gloves when working on the battery.
Avoid sparks and naked flames.

2.5 Notes on the prevention of fire and explosions

1. The diesel engine must be switched off when refuelling.
2. Do not smoke and avoid naked flames in the area where batteries are being recharged and when refuelling.
3. Always start the diesel engine in accordance with the operating and maintenance instructions guidelines.
4. Check the electrical system.
Remedy all faults, such as loose connections and worn cables, immediately.
5. Check all lines, hoses and threaded unions regularly for leaks and damage.
6. Remedy leaks and replace damaged components immediately.
Oil spraying out of points which are not properly sealed is highly flammable.

2.6 Observe safety precautions when starting

1. Unless otherwise specified, always start the diesel engine in compliance with the guidelines in the “**Operating and Maintenance Instructions**“.
2. Start the diesel engine and then check all display equipment and control devices.
3. Only allow the diesel engine to run in enclosed areas if sufficient ventilation has been provided.
If necessary, open doors and windows to ensure that a sufficient supply of fresh air can be guaranteed.

2.7 Measures for safe maintenance

1. Do not carry out any maintenance or repair tasks with which you are not familiar.
2. Adhere to any intervals for recurring checks or inspections which have been prescribed or are specified in the operating instructions.
To carry out servicing measures, it is absolutely imperative that factory equipment appropriate for the respective task is used.
3. The tasks to be carried out, as well as the personnel by which these tasks must, or may be performed, are clearly defined in the listing at the end of these “**Operating and Maintenance Instructions**“.

The tasks listed under “**daily/weekly**“ in the maintenance chart can be carried out by the machine operator or the maintenance personnel.

All other tasks may only be carried out by authorised personnel who have undergone the appropriate training.

4. Spare parts must comply with the technical requirements specified by the manufacturer. This can always be guaranteed with original spare parts.
5. Always wear protective clothing when carrying out maintenance tasks.
6. Unless otherwise specified in these “**Operating and Maintenance Instructions**“, all maintenance tasks to the diesel engine must be carried out on firm, even ground with the diesel engine switched off.
7. When carrying out maintenance and repair tasks, tighten the loosened screw connections with the respective tightening torque.
8. Clean the diesel engine of oil, fuel or detergents, in particular connections and threaded unions, before commencing maintenance/repair tasks. Do not use any aggressive cleaning agents. Use fibre-free cleaning cloths. Do not use any flammable liquids for cleaning the diesel engine.
9. Before cleaning the machine with water, steam jet (high-pressure cleaner) or other cleaning agents, seal or cover all openings into which water/steam/cleaning agents should not be allowed to penetrate due to reasons of safety or functionality.
The crankcase breather, electronics box, starter and generator are at particular risk.
Additional tasks:
 - After cleaning, remove the covers/bondings completely.
 - After cleaning, examine all fuel lines, diesel engine oil lines and engine oil lines for leaks, loose connections, points of wear and damages.
 - Remedy any determined faults immediately.
10. Observe the safety guidelines valid for the product when handling oils, greases and other chemical substances.
11. Ensure a safe and environmentally-sound disposal of fuels and consumables, as well as replacement parts.
12. Observe caution when handling hot fuels and consumables (danger of burning and scalding).
13. Always wear gloves when searching for leaks. A fine jet of liquid, when pressurised, could penetrate the skin.
14. Shut down the diesel engine before loosening oil lines.
15. Combustion engines may only be operated in sufficiently ventilated areas. Ensure sufficient ventilation before initiating operation in enclosed areas. Observe the valid guidelines for the respective jobsite.
16. Do not try to lift heavy parts. Suitable lifting gear featuring sufficient lift capacity must be used for these tasks.
Procedure:
 - Tighten and secure individual parts and larger assemblies carefully to the hoist when replacing heavy parts, in order that no danger is resulted.
 - Only use suitable and technically-sound hoists, as well as load carrying equipment featuring sufficient lift capacity.
- It is prohibited to remain or work beneath suspended loads.**
17. Do not use ropes which are damaged, or do not feature sufficient lift capacity. Always wear industrial gloves when handling wire cables.
18. Tasks to electrical equipment on the machine may only be carried out by an electrical specialist or by trained personnel under the supervision and instruction of an electrical specialist in compliance with the electro-technical regulations.

19. Disconnect the battery when working on the electrical system and also remove the plug from the control unit if electric welding is to be carried out on the machine.
Always disconnect the negative terminal first and reconnect last.

2.8 Observe the safety precautions for diesel engines featuring electronic control units

1. Only start up the diesel engine with the batteries securely connected.
2. Do not disconnect batteries while the diesel engine is running.
3. The diesel engine may only ever be started with the control unit connected.
4. Do not use a fast charger to start the diesel engines. Only use jump leads with separate batteries.
5. The battery terminal clips must be disconnected for fast charging of the batteries. Observe the operating instructions of the fast charger.
6. When carrying out electrical welding tasks, the batteries must be disconnected and both cables (+ and —) must be securely connected with each other. Connection to the engine electronics is to be cut via both interface plugs.
7. Connections of the control units may only be connected or disconnected with the electrical system switched off.
8. Incorrect polarity of the control units voltage or supply voltage (e.g. via incorrect polarity of the batteries) can lead to ruination of the control units.
9. If temperatures exceeding 80 °C (e.g. drying kiln) are expected, the control units must be removed.
10. Only use suitable test leads for measurements at the plug connections.
11. Neither sensors nor actuators may be connected individually to, or between, external voltage sources for inspection or test purposes, but rather always with the electronic control unit, otherwise there is a risk of the diesel engine malfunctioning or even becoming ruined.
12. The electronic control unit is only sufficiently protected against dust and water if the mating connector is mounted and attached. If no mating connectors have been attached, the control unit must be sufficiently protected against dust and water.
13. Telephones and radio equipment which are not connected to an exterior aerial could lead to functional failure of the vehicle's electronics, and thus jeopardise operational safety of the diesel engine.

2.9 Safety and emergency run program for diesel engines featuring electronic control units

1. The diesel engine features an electronic regulating system, which monitors the diesel engine as well as the electronic regulating system itself (self-diagnosis).

If a fault is recognised, one of the following measures is automatically initiated following evaluation of the fault:

- Issue of an error report featuring error code.
- The error code is issued directly via a display in conjunction with the vehicle diagnosis system.
- Changeover to suitable back-up function for further, however limited, operation of the diesel engine (e.g. constant emergency-run speed).

Have all faults remedied immediately by the respective LIEBHERR after-sales service.

2.10 Disposing of fuels and lubricants

1. Ensure when handling fuels and lubricants, that no substances are spilled or poured onto the earth, into drainage systems or into bodies of water.
2. Different fuels and lubricants are to be collected and disposed of in separate containers.
3. Use sealed containers for draining fuels and lubricants. Under no circumstances should containers for food or drinks be used as the liquids could be drunk inadvertently.
4. Before recycling or disposing of waste products, enquire about the correct method at the appropriate environmental or recycling centre. Incorrect disposal of waste products can harm the environment and the ecology.

3 Operation, Handling

3.1 Control elements and operating elements

The control elements and operating elements are integral parts of the equipment and are described in the documentation of the manufacturer. Data regarding oil pressure, coolant temperature, speed, operating hours and service code, for example, are transferred to the equipment via the electronic interface on the diesel engine for operation and regulation of the diesel engine.

3.2 Operation

3.2.1 Preparing for initial start-up

Brand new diesel engines are delivered from the factory already filled with the oil required for initial start-up. As a rule, replacement engines and engines which have undergone a general overhaul are delivered without fuel.

The high-grade oils used for initial start-up are ideally suited for the break-in process and allow the first oil-change to be carried out at the normal oil-change interval.

For filling amounts and quality, see the chapter, Fuels and Lubricants—Specifications.

Filling in fuels

The following fuels are to be filled in before initial start-up:

- **Diesel engine oil**
With replacement engines or engines which have undergone a general overhaul, use authorised diesel engine oils only, see the chapter, Fuels and Lubricants-Specifications.
- **Coolant**
For coolant composition, see the chapter, Fuel and Lubricant Specifications.
- **Fuel**
Use summer fuel or winter fuel in accordance with the season. Diesel fuels must comply with the permissible fuel specifications, see the chapter, Fuel and Lubricants Specifications.
- Ensure utmost cleanliness, use a funnel with sieve. When refuelling from drums or canisters, observe the safety guidelines, see the chapter, Safety Guidelines. It is imperative that the penetration of water is avoided.

The following preparations must be carried out following the filling of fuels:

- Lubricate articulated shafts, cables, ball sockets, grease nipples and starting ring gear with oil or grease.
- Check the batteries. Only use fully charged batteries which have undergone regular maintenance.
- Bleed the fuel system. (see the chapter, Maintenance)
- If a fuel shut-off valve is featured:
Open the fuel shut-off valve.
- Start the diesel engine.
- Check the oil pressure gauge immediately after starting the diesel engine.

Troubleshooting

No oil pressure has been attained within 5 seconds?

- Switch off diesel engine immediately.
- Determine and remedy the cause.

- Carry out a test-run after completing the prescribed preparations.
- Allow the diesel engine speed to increase gradually to 3/4 of the permissible maximum speed, until operating temperature has been reached.

Tasks during and following the test-run

Bleeding the cooling system:

- Allow the diesel engine to run for approx. 5–10 minutes at medium speed.
- Switch off the diesel engine and check the coolant level again, top up coolant as required.
- If a heating system is connected to the cooling system, all heating valves must be opened when refilling. The heating valves may only be closed again after the diesel has been allowed to run for a short time and, if necessary, has been refilled.

Checking the diesel engine oil level:

- Check the diesel engine oil level approx. 2–3 minutes after switching off the diesel engine, if necessary refill oil up to the maximum marking on the oil dipstick.

Checking the diesel engine

- Check the diesel engine for leaks.
- Check hose clamps and pipe connections around the entire system for leaks and correct tightening, tighten as necessary.

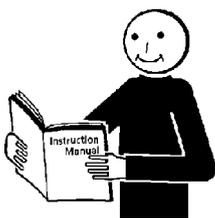
3.2.2 Maintenance tasks before daily start-up

Before daily start-up, the maintenance tasks (daily) must be carried out every 10 operating hours (see the chapter, Maintenance).

3.2.3 Starting the diesel engine**Start procedure**

Starting of the diesel engine is only permissible if you have read and thoroughly understand the operating instructions.

- If a fuel shut-off valve is featured:
Open the fuel shut-off valve.
- Speed adjusting device in idle speed.
- Start the diesel engine with the ignition key or starter button.



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Operating instructions

Troubleshooting

The engine has still not started after approx. 20 seconds?

- Wait for 1 minute.
- When this action has been repeated three times:
Determine and remedy the cause.

- Check the oil pressure gauge immediately after starting the diesel engine.
 - The oil pressure is not displayed within 5 seconds.
 - Switch off diesel engine immediately.
- Do not subject the engine to full load immediately after starting. After a brief (10–15 sec.) spell at idle speed, allow the diesel engine to run warm at medium speed and medium load.

Operation

- Checking the diesel engine in operation.
 - Oil pressure is constant.
 - Output and speed are constant.
 - Exhaust gas is colourless.
 - Cooling water temperature is stable.
 - The sounds of the diesel engine appear normal.

Troubleshooting

Faults have been determined?

- Switch off diesel engine immediately.

3.2.4 Precautions for starting up in icy temperatures**Low temperatures**

The following will ensure a considerably improved starting behaviour in low temperatures:

**Warning**

Danger of the diesel engine exploding!

There is a serious risk of the engine exploding if ether-based starting aids are used for starting the diesel engine with preheating system!

! Ether-based start aids are prohibited.