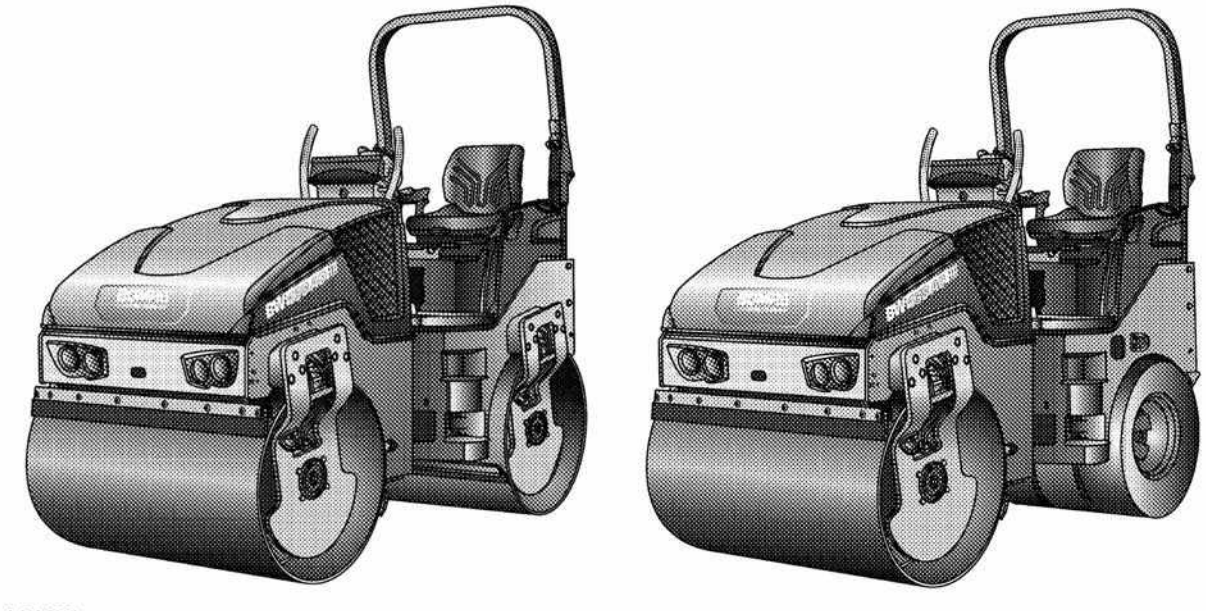
BOMAG
FAYAT GROUP

Service Manual

BW 135 AD-5 / BW 138 AC-5 / BW 138 AD-5



S-650-0037

S/N 101 650 39 1001> / S/N 101 650 38 1001> / S/N 101 650 37 1001>

Tandem vibratory roller

Combination roller

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1 General

1.1 Introduction

General

This manual:

- addresses the BOMAG Customer Service and professionally trained personnel.
- provides support for repair work or maintenance procedures on the machine.

This manual described the deinstallation, dismantling , assembly, installation as well as the repair of components and assembly groups as far as this makes sense with respect to tools and spare parts supply.

Documentation

For the BOMAG machines described in this manual the following documentation is additionally available:

- Operating and maintenance instructions
- Spare parts catalogue
- Service information (if necessary)

Genuine BOMAG spare parts

Use only genuine BOMAG spare parts.

Spare parts needed for repairs can be taken from the spare parts catalogue for the machine.

Updating service

This manual is not subject of an updating service. For this reason we would like to draw your attention to the additionally published service informations.

In case of a new release all necessary changes will be included.

In the course of technical development we reserve the right for technical modifications without prior notification.

Copyright

1.2 Concerning your safety

1.2.1 General prerequisites

1.2.1.1 General

This BOMAG machine has been built in compliance with the latest technical standard and complies with the applicable regulations and technical rules.

However, dangers for persons and property may arise from this machine, if:

- it is used for purposes other than the ones it is intended for,
- it is operated by untrained personnel,
- it is changed or converted in an unprofessional way,
- the safety instructions are not observed.

Each person involved in the operation, maintenance and repair of the machine must therefore read and comply with these safety regulations. If necessary, the customer must obtain the relevant signatures as confirmation.

Furthermore, the following obviously also applies:

- applicable accident prevention instructions,
- generally accepted safety and road traffic regulations,
- country specific safety regulations.

It is the duty of the operator to be acquainted with the safety regulations and to apply these accordingly. This also applies for local regulations amnd regulations concerning different types of handling activities. Should the recommendations in these instructions be different from the regulations valid in your country, you must comply with the safety regulations valid in your country.

1.2.1.2 Explanation of warning signs:

DANGER!

Danger to life if failing to comply!

Sections marked accordingly indicate an extremely dangerous situation that could lead to fatal or severe injuries, if this warning is disregarded.

WARNING!

Danger to life or danger of severe injuries if failing to comply!

Sections marked accordingly indicate a dangerous situation that could lead to fatal or severe injuries, if this warning is disregarded.

CAUTION!

Danger of injury if failing to comply!

Sections marked accordingly indicate a dangerous situation that could lead to fatal or severe injuries, if this warning is disregarded.

NOTICE!

Danger of material damage if failing to comply!

Sections marked accordingly indicate possible dangers for machines or components.

Sections marked accordingly indicate technical information or notes on using the machine or its components.

ENVIRONMENT!

Environmental damage if failing to comply!

Paragraphs marked accordingly indicate practices for safe and environment-friendly disposal of fuels and lubricants as well as replacement parts.

1.2.1.3 Personal protective equipment

Depending on the work to be carried out, personal protective equipment is required (to be provided by the operating company):

	Working clothes	Tight fitting working clothes with low tear resistance, tight sleeves and without any projecting parts protects against being caught by moving components.
	Safety shoes	To protect against heavy falling parts and slipping on slippery ground.
	Protective gloves	To protect the hands against excoriation, punctures or deep injuries, against irritating and caustic substances as well as against burns.

	Safety goggles	To protect the eyes against airborne particles and fluid squirts.
	Face protection	To protect the face against airborne particles and fluid squirts.
	Hard hat	To protect the head against falling parts and to protect against injuries.
	Hearing protection	To protect the hearing against too loud noise.

1.2.1.4 Intended use

This machine must only be used for:

- Compaction of bituminous material, e.g. road surface layers,
- Compaction work in earth construction and road bases.

Intended use also includes compliance with the specified operating, maintenance and repair measures.

1.2.1.5 Improper use

Dangers may arise from the machine when it is used for purposes other than the one it is intended for.

Any danger caused by improper use is the sole responsibility of the operating company or driver/operator, the manufacturer cannot be made liable.

Examples for improper use are:

- work with vibration on hard concrete, cured bitumen layers or extremely frozen ground
- cleaning the drums while driving or changing nozzles during travel.
- driving on subsoils with too low load bearing capacity
- driving on slippery subsoils (e.g. ice and snow)
- driving on surfaces of insufficient size (danger of turning over)
- unauthorized use of public roads
- Using the machine for towing

transporting persons, except the machine driver, is prohibited.

starting and operation of the machine in explosive environments and in underground mining is prohibited.

1.2.2 Definition of responsible persons

1.2.2.1 Operating company

The operating company is the natural or juridical person who uses the machine or in who's name the machine is used.

The operating company must make sure that the machine is only used for the purpose it is intended for and in strict compliance with the safety regulations mentioned in these operating and maintenance instructions.

The operating company must determine and assess the danger in his company. It must then take appropriate action to ensure health and safety at work for his employees and point out any remaining dangers.

The operating company must determine whether there are special operation hazards such as a toxic atmosphere or limiting soil conditions. Such conditions requires special, additional measures to remove or reduce the hazard.

The operating company must make sure that all users read and understand the information concerning safety.

The operating company is responsible for the planning and professional execution of regular safety inspections.

1.2.2.2 Expert / qualified person

An expert / qualified person is a person who, based on his/her professional education and experience, has profound knowledge in the field of construction equipment and the machine in question in particular.

This person is acquainted with the applicable governmental industrial safety regulations, accident prevention instructions, guidelines and generally acknowledged technical rules and regulations (standards, directives, technical rules of other member states of the European Union or other contractual states concerning the agreement about the European Economic Area) in as far as is necessary to be able to judge the safe condition of these machines.

1.2.2.3 Driver / operator

This machine must only be operated by trained, instructed persons entrusted by the operating company aged 18 or more.

Observe your local laws and regulations.

Rights, obligations and rules of conduct for driver or operator:

The driver or operator must:

- be instructed about his rights and obligations,
- wear protective equipment as appropriate for the application,
- have read and understood the operating instructions,
- have made himself familiar with the operation of the machine,
- be physically and psychologically able to drive and operate the machine.

Persons under the influence of alcohol, medicine or drugs are not allowed to operate, service or repair the machine.

Maintenance and repair work requires specific knowledge and must therefore only be performed by trained specialists.

1.2.3 Fundamentals for safe operation

1.2.3.1 Remaining dangers, remaining risks

Despite careful work and compliance with standards and regulations it cannot be ruled out that further dangers may arise when working with and handling the machine.

Both the machine as well as all other system components comply with the currently valid safety regulations. Nevertheless, remaining risks cannot be ruled out completely, even when using the machine for the purpose it is intended for and following all information given in the operating instructions.

A remaining risk can also not be excluded beyond the actual danger zone of the machine. Persons remaining in this area must pay particular attention to the machine, so that they can react immediately in case of a possible malfunction, an incident or failure etc.

All persons remaining ion the area of the machine must be informed about the dangers that arise from the operation of the machine.

1.2.3.2 Regular safety inspections

Have the machine inspected by an expert (capable person) as required for the conditions the machine is working under, but at least once every year.

1.2.3.3 Modifications and alterations to the machine

Unauthorized changes to the machine are prohibited for safety reasons.

Original parts and accessories have been specially designed for this machine.

We wish to make explicitly clear that we have not tested or approved any parts or accessories not supplied by us.

The installation and/or use of such products may have an adverse effect on the active and/or passive safety.

1.2.3.4 Damage, defects, misuse of safety devices

Machines which are not safe to operate or in traffic must be immediately taken out of service and shall not be used, until these deficiencies have been properly rectified.

Safety installations and switches must neither be removed nor must they be made ineffective.

1.2.3.5 Roll Over Protective Structure (ROPS)

The frame of the machine must not be warped, bent or cracked in the area of the ROPS fastening.

The ROPS must not show any rust, damage, hairline cracks or open fractures.

The real machine weight must never exceed the testing weight for the ROPS.

No accessories may be welded or bolted on and no additional holes must be drilled without the consent of the manufacturer, since this will impair the strength of the unit.

The ROPS must therefore also not be straightened or repaired if it is damaged.

A defect ROPS must generally be replaced with an original spare part in close coordination with the manufacturer.

1.2.4 Handling fuels and lubricants

1.2.4.1 Preliminary remarks

The operating company must ensure that all professional users have read and follow the corresponding safety data sheets for the individual fuels and lubricants.

Safety data sheets provide valuable information about the following characteristics:

- Name of substance
- Possible dangers
- Composition / information on constituents
- First-Aid measures
- Fire fighting measures
- Measures in case of accidental release
- Handling and storage
- Limitation and monitoring of exposure / personal protective equipment
- physical and chemical properties
- Stability and reactivity

- Toxicological data
- Environmental data
- Notes on waste disposal
- Information on transport
- Legislation
- other data

1.2.4.2 Safety regulations and environmental protection regulations for handling diesel fuel

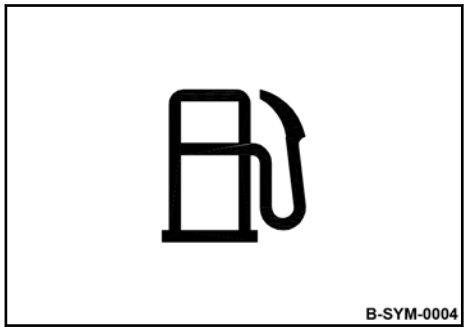

Fig. 1

WARNING!

Danger of burning by ignited diesel fuel!

– Do not allow diesel fuel to come into contact with hot components.
– Smoking and open fire is prohibited!
– Wear your personal protective equipment (protective gloves, protective clothing).

CAUTION!

Health hazard caused by contact with diesel fuel!

– Wear your personal protective equipment (protective gloves, protective clothing).
– Do not inhale any fuel fumes.
– Avoid contact.

CAUTION!

Danger of slipping on spilled diesel fuel!

– Immediately bind spilled diesel fuel with an oil-binding agent.

ENVIRONMENT!

Diesel fuel is an environmentally hazardous substance

– Always keep diesel fuel in proper containers.
– Immediately bind spilled diesel fuel with an oil-binding agent.
– Dispose of diesel fuel and fuel filters according to regulations.

1.2.4.3 Safety regulations and environmental protection regulations for handling oil

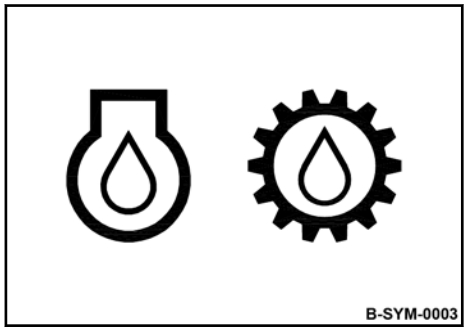

Fig. 2

WARNING!

Danger of burning by ignited oil!

– Do not allow oil to come into contact with hot components.
– Smoking and open fire is prohibited!
– Wear your personal protective equipment (protective gloves, protective clothing).

CAUTION!

Health hazard caused by contact with oil!

– Wear your personal protective equipment (protective gloves, protective clothing).
– Do not inhale any oil vapours.
– Avoid contact.

CAUTION!

Danger of slipping on spilled oil!

– Immediately bind spilled oil with an oil-binding agent.

ENVIRONMENT!

Oil is an environmentally hazardous substance

– Always keep oil in proper containers.
– Immediately bind spilled oil with an oil-binding agent.
– Dispose of oil and oil filter according to regulations.

1.2.4.4 Safety regulations and environmental protection regulations for handling hydraulic oil

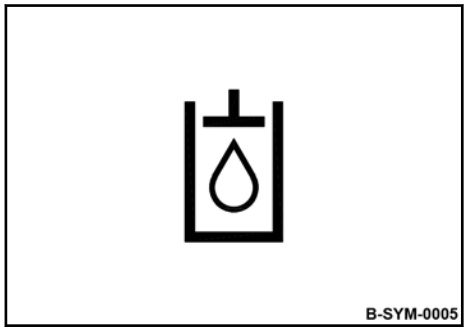

Fig. 3

WARNING!

Danger of injury caused by escaping pressure fluid!

– Always depressurize the hydraulic system before starting work in the hydraulic system.
– Wear your personal protective equipment (protective gloves, protective clothing, goggles).

Should pressure fluid penetrate the skin, immediate medical help is required.

WARNING!

Danger of burning by ignited hydraulic oil!

– Do not allow hydraulic oil to come into contact with hot components.
– Smoking and open fire is prohibited!
– Wear your personal protective equipment (protective gloves, protective clothing).

CAUTION!

Health hazard caused by contact with hydraulic oil!

– Wear your personal protective equipment (protective gloves, protective clothing).
– Do not inhale any oil vapours.
– Avoid contact.

CAUTION!

Danger of slipping on spilled oil!

– Immediately bind spilled oil with an oil-binding agent.

ENVIRONMENT!

Oil is an environmentally hazardous substance

– Always keep oil in proper containers.
– Immediately bind spilled oil with an oil-binding agent.
– Dispose of oil and oil filter according to regulations.

1.2.4.5 Safety regulations and environmental protection regulations for handling coolants

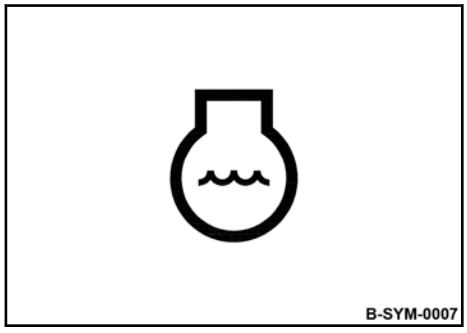

Fig. 4

WARNING!

Danger of scalding by hot fluid!

– Open the compensation tank only when the engine is cold.
– Wear your personal protective equipment (protective gloves, protective clothing, goggles).

CAUTION!

Health hazard caused by contact with coolant and coolant additives!

– Wear your personal protective equipment (protective gloves, protective clothing).
– Do not inhale any fumes.
– Avoid contact.

CAUTION!

Danger of slipping on spilled coolant!

– Immediately bind spilled coolant with an oil-binding agent.

ENVIRONMENT!

Coolant is an environmentally hazardous substance!

– Always keep coolant and coolant additives in proper containers.
– Immediately bind spilled coolant with an oil-binding agent and dispose of it according to regulations.
– Dispose of coolant according to regulations.

1.2.4.6 Safety regulations and environmental protection regulations for handling battery acid

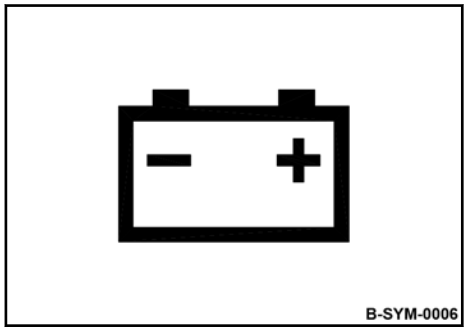

Fig. 5

WARNING!

Danger of cauterization with acid!

- Wear your personal protective equipment (protective gloves, protective clothing, goggles).
- Do not allow clothes, skin or eyes to come into contact with acid.
- Rinse off spilled battery acid immediately with lots of water.

Rinse acid off clothes, skin or eyes immediately with lots of clear water.

Immediately call for medical advice in case of cauterization.

WARNING!

Danger of injury caused by exploding gas mixture!

- Remove the plugs before starting to recharge the battery.
- Ensure adequate ventilation.
- Smoking and open fire is prohibited!
- Do not lay any tools or other metal objects on the battery.
- Do not wear jewellery (watch, bracelets, etc.) when working on the battery.
- Wear your personal protective equipment (protective gloves, protective clothing, goggles).

ENVIRONMENT!

Battery acid is an environmentally hazardous substance

- Dispose of battery and battery acid according to regulations.

1.2.5 Park the machine in secured condition.

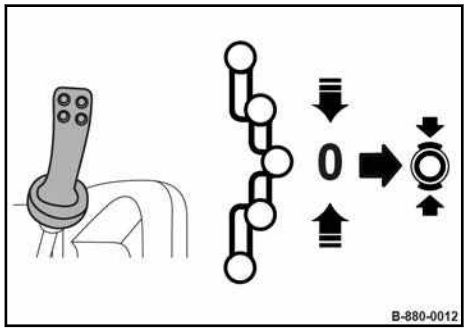

Fig. 6

1. Drive the machine onto level and firm ground.
2. Shift the travel lever to “Middle” position and engage it in parking brake position.
   ⇨ The machine will decelerate down to standstill and the parking brake will be applied after approx. 2 seconds.
   The parking brake warning lamp lights up.

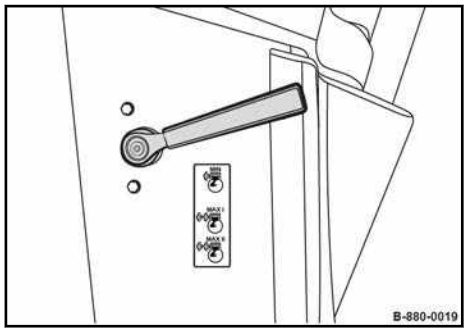

Fig. 7

3. Shift the throttle lever to position "MIN" (idle speed).

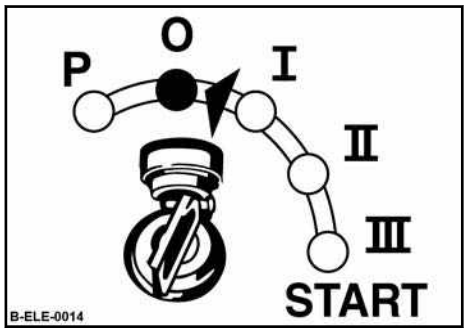

Fig. 8

4.

NOTICE!

Danger of engine damage!

– Do not shut down the engine all of a sudden from full load speed, but let it idle for about 2 minutes.

Turn the ignition key to position "0" and pull it out.

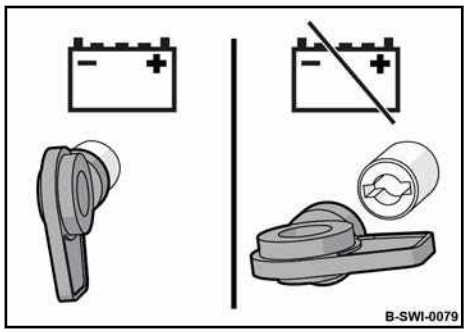

Fig. 9

5. Turn the main battery switch (if present) anticlockwise and pull it out.

1.2.6 Maintenance and repair

1.2.6.1 Preliminary remarks and safety notes

DANGER!

Danger to life caused by an operationally unsafe machine!

– The machine must only be serviced by qualified and authorized personnel.
– Follow the safety regulations for maintenance work ↳ *Chapter 1.4 'Maintenance work' on page 41*.

WARNING!

Health hazard caused by fuels and lubricants!

– Safety regulations and environmental protection regulations when handling fuels and lubricants must be followed ↳ *Chapter 1.2.4 'Handling fuels and lubricants' on page 16*.

CAUTION!

Danger of being injured by the engine hood dropping down!

– Always secure an opened engine hood.

The terms right/left always correspond with travel direction forward.

1. Always clean machine and engine thoroughly before starting maintenance work.
2. For all maintenance work park the machine is secured condition ↳ *Chapter 1.2.5 'Park the machine in secured condition.' on page 22*.
3. Wear your personal protective outfit.
4. Do not touch hot engine parts.
5. Always remove the main battery switch for all maintenance work.
6. Perform maintenance work only with the engine shut down.
7. Always attach the articulation lock when working in the area of the articulated joint.
8. Relieve hydraulic pressures before working on hydraulic lines.
9. Before working on electric parts disconnect the battery and cover it with insulation material.
10. After all maintenance work is completed reinstall all guards and safety installations.

1.2.6.2 Work on hydraulic lines

Relieve hydraulic pressures before working on hydraulic lines. Hydraulic oil escaping under pressure can penetrate the skin and cause severe injury. Immediately call for medical advice when injured by hydraulic oil.

Do not step in front of or behind the wheels when performing adjustment work in the hydraulic system.

Do not change the setting of pressure relief valves.

Drain the hydraulic oil at operating temperature – danger of scalding!

Any hydraulic oil must be caught and disposed of in an environmentally friendly manner.

Always catch and dispose of hydraulic oils separately.

Do not start the engine after draining the hydraulic oil. Once all work is completed (with the system still depressurized!) check all connections and fittings for leaks.

Hydraulic hoses must be visually inspected at regular intervals.

Do not mix up hoses by mistake.

Only genuine BOMAG replacement hydraulic hoses ensure that the correct hose type (pressure range) is used at the right location.

1.2.6.3 Working on the engine

Do not work on the fuel system while the engine is running - danger to life due to high pressures!

Wait until the engine has stopped, then wait another approx. 15 minutes.

Keep out of the danger zone during the initial test run.

In case of leaks return to the workshop immediately.

Drain the engine oil at operating temperature – danger of scalding!

Wipe off spilled oil, collect leaking oil and dispose of it in an environmentally friendly way.

Store used filters and other oil contaminated materials in a separate, specially marked container and dispose of them environmentally.

The settings for idle speed and highest speed must not be changed, since this would affect the exhaust gas values and cause damage to engine and power train.

Engine and exhaust system work with high temperatures. Keep combustible materials away and do not touch any hot surfaces.

Check and change coolant only when the engine is cold. Catch coolant and dispose of it environmentally.

1.2.6.4 Maintenance work on electric components and battery

Before starting to work on electric parts of the machine disconnect the battery and cover it with insulating material.

Do not use fuses with higher ampere ratings and do not bridge fuses - fire hazard!

When working on the battery do not smoke, do not use open fire.

Do not let acid come in contact with hands or clothes. When injured by acid, flush off with clear water and seek medical advice.

Metal objects (e.g. tools, rings, watch straps) must not come in contact with the battery poles – danger of short circuit and burning!

When recharging non-serviceable batteries remove all plugs, to avoid the accumulation of explosive gases.

Switch off the charging current before removing the charging clamps.

Ensure sufficient ventilation, especially if the battery is to be charged in a closed room.

Dispose of old batteries according to regulations.

1.2.6.5 Cleaning work

Do not perform cleaning work while the motor is running.

Allow the engine to cool down before starting cleaning work on engine and exhaust system.

Do not use gasoline or other easily inflammable substances for cleaning.

When cleaning with a high pressure cleaner do not direct the wter jet to electrical insulation material or cover it beforehand.

Do not guide the water jet into the exhaust pipe and into the air filter.

1.3 Notes on repair

1.3.1 General repair instructions

NOTICE!

Ensure strict cleanliness when performing repair work!

- No foreign objects should enter into open systems.
- Thoroughly clean the area around the affected components.
- Dry off wet locations with compressed air.

Before removing or disassembling parts, assembly groups, components or hoses mark these parts for easier assembly.

1.3.1.1 Repair notes for electrics

Electrics and welding

NOTICE!

Electrical components may get damaged by welding work!

- Always remove the main battery switch.
- Disconnect the batteries and connect negative and positive cables.
- Pull the plugs off the control units.

Always fasten the earth clamp of the welding unit in the immediate vicinity of the welding location.

When choosing the location for the earth clamp make sure that the welding current will not pass through joints or bearings.

Battery

Maintenance free batteries also need care. Maintenance free only means that the fluid level does not need to be checked.

Each battery suffers under self-discharge, which may, in not checked occasionally, even cause damage to the battery as a result of exhaustive discharge.

Exhausted batteries (batteries with formation of sulphate on the plates) are not covered under warranty!

- When removing a battery always disconnect the minus pole before the plus pole. When installing the battery connect the minus pole after the plus pole to avoid short circuits.
- Assemble the battery terminal clamps without force.

- Always keep battery poles and terminal clams clean to avoid high transition resistances when starting and the related development of heat.
- Make sure the battery is properly fastened in the vehicle.

Generator

- Before removing the generator you must disconnect the ground cable from the minus pole of the battery while the ignition is switched off. Do not disconnect the generator while the engine is running, because this may cause extremely high voltage peaks in the vehicle wiring system ("Load Dump"), which could possibly damage control units, radios or other electronic equipment.
- When removing the battery cable, the B+-nut underneath on the generator side may also be loosened. This nut must in this case be retightened.
- When connecting e.g. the battery cable to the terminal of the generator you must make sure that the polarity is correct (generator B+ to the + pole of the battery). Mixing up the polarities by mistake causes short circuit and damage to the rectifier elements - the generator will be out of function.
- The generator can only be operated with the battery connected. Under special conditions emergency operation without battery is permitted, the lifetime of the generator is in such cases especially limited.
- Plus and minus cables must be disconnected during rapid charging of the battery or electric welding on the vehicle.
- When cleaning the generator with a steam or water jet make sure not to direct the steam or water jet directly on or into the generator openings or ball bearings. After cleaning the generator should be operated for about 1 - 2 minutes to remove any deposits of water from the generator.

Starter

- So-called jump starting (using an additional external battery) without the battery connected is dangerous. When disconnecting the cables from the poles high inductivities (arcs, voltage peaks) may occur and destroy the electrical installation.
- For purposes like e.g. purging the fuel systems, starters may be operated for maximum 1 minute without interruption. Then you should wait for at least 30 minutes (cooling down) until trying again. During the 1 minute starting period this process should not be interrupted.
- Starter motors must not be cleaned with high pressure steam cleaning equipment.
- The contacts on starter terminals 30, 45, 50 must be protected against unintended shorting (jump protection).
- When replacing the starter the ring gear on the engine flywheel must be checked for damage and its number of teeth - if necessary replace the ring gear.
- Always disconnect the battery before starting assembly work in the starter area of the engine or on the starter itself.

1.3.1.2 Repair notes for hydraulics

Please note

Cleanliness is of utmost importance. Dirt and other contaminations must strictly be kept out of the system.

- Connections and screw fittings, filler neck covers and their immediate surrounding areas must be cleaned before removal.
- Before loosening hoses, pipe lines etc. relieve all pressure from the system.
- During repair work keep all openings closed with clean plastic plugs and caps.
- Never run pumps, motors and engine without oil or hydraulic oil.
- When cleaning hydraulic components take care not to damage any fine machined surfaces.
- Chemical and rubber dissolving cleansing agents may only be used to clean metal parts. Do not let such substances come in contact with rubber parts.
- Rinse of cleaned parts thoroughly, dry them with compressed air and apply anti-corrosion oil immediately. Do not install parts that show traces of corrosion.
- Avoid the formation of rust on fine machined parts caused by hand sweat.
- Use new O-rings or seal rings for reassembly.
- Use only hydraulic oil as sliding agent when reassembling. Do not use any grease!
- Use only the specified pressure gauges. Risk of damaging the pressure gauges under too high pressure.
- Check the hydraulic oil level before and after the work.
- Use only clean hydraulic oil in strict compliance with the specification in the operating and maintenance instructions to fill the hydraulic system.
- Check the hydraulic system for leaks, if necessary find and rectify the cause.
- Before taking new hydraulic components into operation fill these with hydraulic oil as specified in the operating and maintenance instructions.
- After changing a hydraulic component thoroughly flush, refill and bleed the complete hydraulic system.
- Perform pressure tests at operating temperature of the hydraulic oil (approx. 40 °C).
- After the completion of all tests perform a test run and then check all connections and fittings for leaks with the engine still stopped and the hydraulic system depressurized.

Before commissioning

- Fill the housings of hydraulic pumps and motors with hydraulic oil. Use only hydraulic oils according to the specification in the maintenance instructions.
- After changing a component flush the hydraulic system as described in the flushing instructions.

Taking into operation

- Bleed the hydraulic circuits.
- Start up the hydraulic system without load.
- Check the hydraulic oil level in the tank, if necessary top up with hydraulic oil as specified in the operating and maintenance instructions or drain oil off into a suitable container.

After taking into operation

- Check fittings and flanges for leaks.
- After each repair check all adjustment data, system pressures, rotational speeds and nominal values in the hydraulic system, adjust if necessary.
- Do not adjust pressure relief valves and control valves to values above their specified values.

1.3.1.3 Repair notes for gaskets and mating surfaces

Leaking sealing faces can mostly be traced back to incorrect assembly of seals and gaskets.

- Before assembling a new seal or gasket make sure that the sealing surface is free of pitting, flutes, corrosion or other damage.
- Inappropriately stored or handled seals (e.g. hanging from hooks or nails) must under no circumstances be used.
- Install seals and gaskets only with sealing compound, grease or oil, if this is specifically specified in the repair instructions.
- If necessary remove any old sealing compound before assembling. For this purpose do not use any tools that could damage the sealing surfaces.
- Sealing compound must be applied thin and evenly on the corresponding surfaces; take care that the compound does not enter into oil galleries or blind threaded bores.
- Examine the contact faces for scratches and burrs, remove these with a fine file or an oilstone; take care that no grinding dust and dirt enters into tapped bores or enclosed components.
- Blow out lines, ducts and gaps with compressed air, replace any O-rings and seals that have been dislodged by the compressed air.

Assembly of radial seals

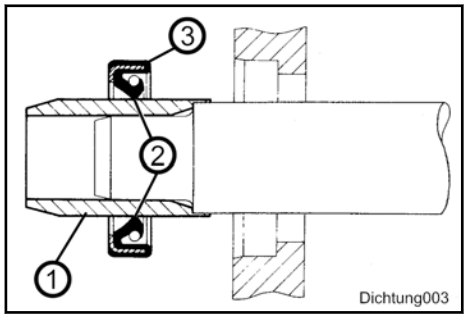

Fig. 10

1. Lubricate sealing lips (2) with clean grease; in case of double seals fill the space between the sealing lips with a generous amount of grease.

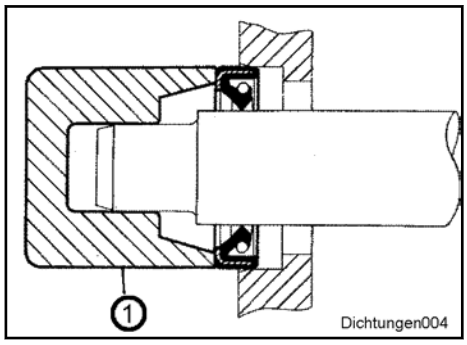

Fig. 11

2. Slide the seal over the shaft, with the lip facing towards the fluid to be sealed.

NOTICE!

Use an assembly sleeve.

If possible, use an assembly sleeve (1) **to protect the lip from being damaged by sharp edges, threads or splines.** If no assembly sleeve is available, you should use a plastic tube or adhesive tape to prevent the sealing lip from being damaged.

3. Lubricate the outer rim of the seal (3) and press it flat on the housing seat.

4. Press or knock the seal into the housing, until it is flush with the housing surface.

NOTICE!

Use an assembly bell.

If possible, use an "assembly bell" (1), to make sure **that the seal will not skew.** In some cases it may be advisable to assemble the seal into the housing first, before sliding it over the shaft. Under no circumstances should the full weight of the shaft rest on the seal.

If you have no proper service tools at hand, use a suitable drift punch with a diameter which is about 0.4 mm smaller than the outer diameter of the seal. Use VERY LIGHT blows with the hammer if no press is available.

1.3.1.4 Repair notes for ball and roller bearings

Fig. 12

- If one bearing of a pair of bearings shows defects, we highly recommend the replacement of both bearings.
- Remove any lubricant residues from the bearing to be examined by washing it with a suitable degreasing agent.
- Check balls or rollers, running surfaces, outer faces of outer races and inner faces of inner races for visible damage. If necessary, replace the bearing.
- Check the bearing for clearance and resistance between the inner and outer races, replace if necessary.
- Lubricate the bearing with the recommended type of grease before assembly or reassembly.
- On greased bearings (e.g. wheel bearings) fill the space between the bearing and the outer seal with the recommended type of grease before assembling the seal.
- Check shaft and bearing housing for discolouration or other signs of movement between bearing and seats.
- Make sure that shaft and housing are free of burrs before assembling the bearing.
- Always mark the individual parts of separable bearings (e.g. taper roller bearings) to enable correct reassembling. Never assemble the rollers to an outer race that has already been used, replace the complete bearing instead.

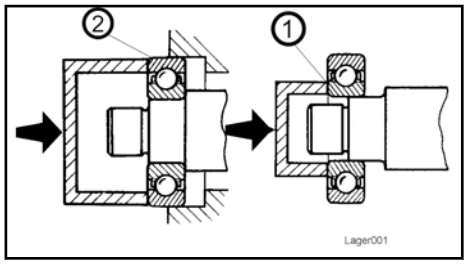

Fig. 13

NOTICE!

When assembling the ball or roller bearing to the shaft load must only be applied to the inner race (1).

When fitting the bearing into the housing load must only be applied to the outer race (2).

1.3.1.5 Feather keys and keyways

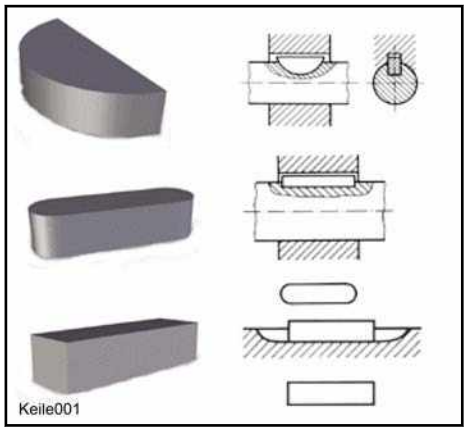

Fig. 14

1. Clean the feather key, examine it and only use it again if it had not been damaged.
2. Deburr and clean the edges of keyways thoroughly before reassembling the feather key.

1.3.1.6 Repair notes for cotter pins

Cotter pins

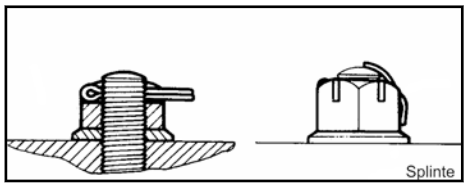

Fig. 15

In places where cotter pins are used, these must be reassembled. Cotter pins must generally be renewed after disassembly.

Cotter pins must be assembled as shown in the illustration, unless specified differently.

1.3.1.7 Repair notes for screws and nuts

NOTICE!

Tighten screws and nuts in accordance with the values in the following tables. Tightening torques deviating from the ones in the table are specially mentioned in the repair instructions.

Damaged screws must not be used again.

Recutting threads with thread cutters or taps adversely affects the strength and leak tightness of the screw joint. Damaged or corroded thread pitches can cause incorrect torque value readings.

Self-locking nuts must generally be replaced after disassembly.

The use of screws with too high strength can cause damage!

- Nuts of a higher strength can generally be used instead of nuts of a lower strength classification.
- When checking or retightening screw joints to the specified tightening torque you should first relieve by a quarter turn and then tighten to the correct torque.
- Before tightening you should slightly oil the thread, in order to ensure low friction movement. **This, however, does not apply for self-locking nuts.**
- Make sure that no oil or grease will enter into blind tapped bores. The hydraulic power generated when turning in the screw could cause breakage of the part in question.

1.3.1.8 Strength classes, metric screws and nuts

Strength classes, metric screws

The strength classes (from 3.6 to 12.9) are specified for all strength classes from a nominal diameter of 5mm. The corresponding identification can be found where allowed for by the shape of the screw.

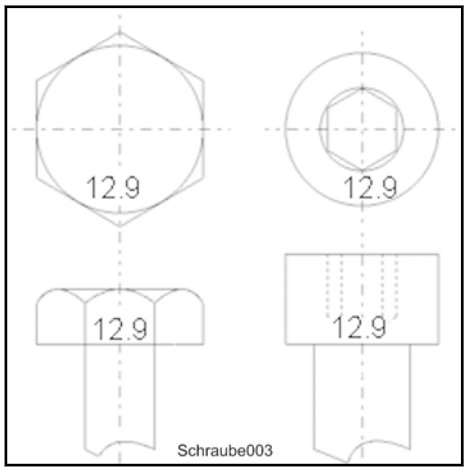

Fig. 16: Identification of screws

Example: A screw is identified with 12.9.

The first number corresponds with 1/100 of the nominal tensile strength (minimum tensile strength) in N/mm^2.

- The nominal tensile strength is 12 X 100 N/mm^2 = 1200 N/mm^2.

The second number specifies 10-times the ration between lower yield point and nominal tensile strength (yield point ratio).

When exceeding the lower yield point, the material will return to its original shape when being relieved (plastic deformation).

When exceeding the upper yield point the material will not restore its original shape after being relieved.

- The lower tensile strength is 9/10 X 1200 N/mm^2 = 1080 N/mm^2.

However, these values are by no means identical with the tightening torques, which are to be set on a torque wrench. The corresponding calculation requires a higher effort and, in the end, depends on the materials to be bolted together.

Strength classes of metric nuts

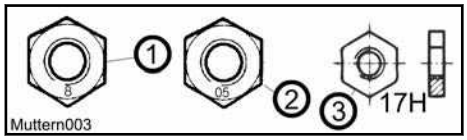

Fig. 17: Identification of nuts

Nuts are differentiated by three load groups. Each load group has a special designation system for the strength class assigned, so that the load group can be clearly identified.

Nuts (1) for screw connections with full load capacity

In a connection with a screw, these nuts (1) must be able to bear the full pre-load at the yield point.

Nut height above 0.8 d (d = nominal dimension).

Strength class of nut	Strength class of associated screw
4	3.6, 4.6, 4.8
5	3.6, 4.6, 4.8 5.6, 5.8
6	6.8
8	8.8
9	9.8
10	10.8
12	12.8

Nuts (2) for screw connections with limited load capacity

The preceding "0" indicates that, due to their low height, nuts 2 ↳ Fig. 17 in this group are only able to withstand the force of a screw to a limited extent.

Nut height below 0,8 d (d = nominal dimension).

Nuts (3) for screw connections without specified load capacity

This standard contains strength classes (hardness classes) for nuts 3 ↳ Fig. 17, for which no load values can be specified, e.g. because of their shape and dimensions, but which can only be classified by their hardness.

Nut height below 0,5 d (d = nominal dimension).

Identification in clock system

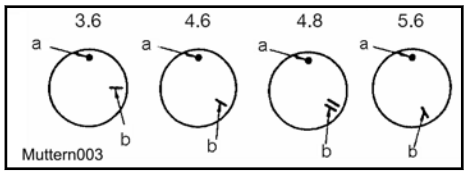

Fig. 18: Identification of nuts in clock system

For small nuts ↳ Fig. 18 the clock system can be used for identification.

- The 12 o'clock position is identified by a dot or the manufacturer's symbol.
- The strength class is identified by a dash (b).

1.3.1.9 Identification of UNF-threads

Identification of UNF-threads

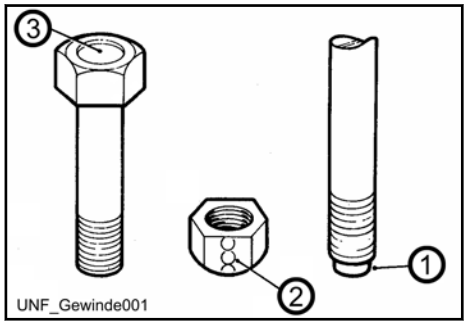

Fig. 19

Studs (1)

At the outmost end a short end of the component is reduced to its core diameter.

Nuts (2).

An uninterrupted series of stamped in circles parallel to the axis of the nut on a hexagon area.

Screws (3)

The screw head is marked with a stamped in, round cavity.

1.3.2 Tightening torques

The values specified in the table apply for screws:

- black oiled
- with surface protection A4C
- with surface protection DACROMET

DACROMET is a surface protection that mainly consists of zinc and aluminium in a chromium oxide matrix. DACROMETIZATION provides excellent corrosion protection for metal surfaces by applying a mineral coating with metallic-silver appearance.

The difference between Withworth and UNF/UNC threads is the fact that UNF and UNC threads have 60° flanks, as the metric ISO-thread, whereas Withworth has a flank of only 55°.

Tightening torques for screws with metric unified thread

Screw dimension	Tightening torques Nm (Coefficient of friction µ tot. = 0.14)		
	8.8	10.9	12.9
M4	3	5	5
M5	6	9	10
M6	10	15	18
M8	25	35	45
M10	50	75	83
M12	88	123	147
M14	137	196	235
M16	211	300	358
M18	290	412	490
M20	412	578	696
M22	560	785	942
M24	711	1000	1200
M27	1050	1480	1774
M30	1420	2010	2400

Tightening torques for screws with metric unified fine thread

Screw dimension	Tightening torques Nm (Coefficient of friction µ tot. = 0.14)		
	8.8	10.9	12.9
M8 x 1	26	37	48
M10 x 1.25	52	76	88
M12 x 1.25	98	137	162
M12 x 1.5	93	127	152
M14 x 1.5	152	216	255

Screw dimension	Tightening torques Nm (Coefficient of friction μ tot. = 0.14)		
	8.8	10.9	12.9
M16 x 1.5	225	318	383
M18 x 1.5	324	466	554
M20 x 1.5	461	628	775
M22 x 1.5	618	863	1058
M24 x 2	780	1098	1294
M27 x 2	1147	1578	1920
M30 x 2	1568	2254	2695

Tightening torques for screws treated with anti-seizure paste OKS 240 (copper paste)

Screw dimension	Tightening torques Nm		
	8.8	10.9	12.9
M16	169	240	287
M16 x 1.5	180	255	307
M18	232	330	392
M18 x 1.5	260	373	444
M20	330	463	557
M20 x 1.5	369	502	620
M22	448	628	754
M22 x 1.5	495	691	847
M24	569	800	960
M24 x 2	624	879	1036
M27	840	1184	1520
M27 x 2	918	1263	1536
M30	1136	1608	1920
M30 x 2	1255	1804	2156
$^3/_4$″ - 10 UNC	276	388	464
$^3/_4$″ - 16 UNC	308	432	520

Anti-seizure paste (copper paste) is used for the assembly of screw connections, which are exposed to high temperatures and corrosive effects. Prevents seizure and corrosion.

Tightening torques for wheel nuts (fine thread)

Thread diameter	Tightening torques Nm (Coefficient of friction μ tot. = 0.14)
	10.9
M12 x 1.5	100
M14 x 1.5	150
M18 x 1.5	300 - 350
M20 x 1.5	400 - 500
M22 x 1.5	500 - 600

Tightening torques for screws with UNC thread, UNC Unified Coarse Thread Series, American Unified Coarse Thread

Screw dimension	Tightening torques Nm (Coefficient of friction μ tot. = 0.14)		
	8.8	10.9	12.9
1/4″ - 20	11	15	19
5/16″ - 18	23	32	39
3/8″ - 16	39	55	66
7/16″ - 14	62	87	105
1/2″ - 13	96	135	160
9/16″ - 12	140	200	235
5/8″ - 11	195	275	330
3/4″ - 10	345	485	580
7/8″ - 9	560	770	940
1″ - 8	850	1200	1450
1 1/8″ - 7	1200	1700	2000
1 1/4″ - 7	1700	2400	2900
1 3/8″ - 6	2200	3100	3700
1 1/2″ - 6	3000	4200	5100

Tightening torques for screws with UNF thread, UNF Unified National Fine Thread Series = American Unified Fine Thread

Screw dimension	Tightening torques Nm (Coefficient of friction μ tot. = 0.14)		
	8.8	10.9	12.9
1/4″ - 28	13	18	22
5/16″ - 24	25	35	42
3/8″ - 24	45	63	76
7/16″ - 20	70	100	120
1/2″ - 20	110	155	185
9/16″ - 18	155	220	260
5/8″ - 18	220	310	370
3/4″ - 16	385	540	650
7/8″ - 14	620	870	1050
1″ - 12	930	1300	1600
1 1/8″ - 12	1350	1900	2300
1 1/4″ - 12	1900	2700	3200
1 3/8″ - 12	2600	3700	4400
1 1/2″ - 12	3300	4600	5600

Tightening torques for hydraulic fittings with metric thread - series “L” (pressures up to 250 bar)

Thread	Spanner width	Tightening torque [Nm]
M12 x 1.5	14	15
M14 x 1.5	17	20
M16 x 1.5	19	30
M18 x 1.5	22	35
M22 x 1.5	27	65
M26 x 1.5	32	80
M30 x 2	36	130
M36 x 2	41	160
M45 x 2	50	200
M52 x 2	60	250

Tightening torques for hydraulic fittings with metric thread - series “S” (pressures up to 400 bar)

Thread	Spanner width	Tightening torque [Nm]
M14 x 1.5	17	14
M16 x 1.5	19	25
M18 x 1.5	22	27
M20 x 1.5	24	48
M22 x 1.5	27	55
M24 x 1.5	30	65
M30 x 2	36	110
M36 x 2	46	140
M42 x 2	50	180
M52 x 2	60	220

Tightening torques for hydraulic fittings with UNF-thread (Unified Fine Thread)

Thread	Spanner width	Tightening torque [Nm]
$^{7}/_{16}$″ - 20	14	15
$^{1}/_{2}$″ - 20	17	20
$^{9}/_{16}$″ - 18	19	27
$^{3}/_{4}$″ - 16	22	55
$^{7}/_{8}$″ - 14	27	80

Thread	Spanner width	Tightening torque [Nm]
1 1/16″ - 12	32	110
1 3/16″ - 12	36	125
1 5/16″ - 12	41	160
1 5/8″ - 12		220
1 7/8″ - 12		270