

Technical Publication

Diesel Engine
16 V 2000 C

Workshop Manual
M020122/01E



Printed in Germany

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Salvo alterações.

Wichtig – Important – Importante

Bitte die Karte „Inbetriebnahmemeldung“ abtrennen und ausgefüllt an MTU Friedrichshafen GmbH zurücksenden.

Die Informationen der Inbetriebnahmemeldung sind Grundlage für den vertraglich vereinbarten Logistik-Support (Gewährleistung, Ersatzteile etc.).

Please complete and return the “Commissioning Note” card below to MTU Friedrichshafen GmbH.

The Commissioning Note information serves as a basis for the contractually agreed logistic support (warranty, spare parts, etc.).

Veillez séparer la carte “Signalisation de mise en service“ et la renvoyer à la MTU Friedrichshafen GmbH.

Les informations contenues dans la signalisation de mise en service constituent la base pour l'assistance en exploitation contractuelle (garantie, rechanges, etc.).

Rogamos separen la tarjeta “Aviso de puesta en servicio“ y la devuelvan rellena a MTU Friedrichshafen GmbH.


Las informaciones respecto al aviso de puesta en servicio constituyen la base para el soporte logístico contractual (garantía, piezas de repuesto, etc.).

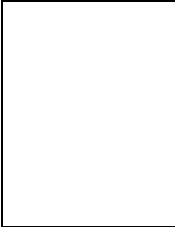
Ritagliare “Avviso di messa in servizio“ e rispedirlo debitamente compilato alla MTU Friedrichshafen GmbH.

Le informazioni ivi registrate sono la base per il supporto logistico contrattuale (garanzia, ricambi, ecc.).

É gentileza cortar o cartão "Participação da colocação em serviço", preenchê-lo e devolvê-lo a MTU Friedrichshafen.

Os dados referentes à colocação em serviço representam a base para o suporte logístico (garantia, peças sobressalentes, etc.) estabelecido contratualmente.





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Department SCSD
88040 Friedrichshafen
GERMANY

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Please use block capitals!
Prière de remplir en lettres capitales!
¡A rellenar en letras de imprenta!
Scrivere in stampatello!
Favor preencher com letras de forma!



Motornr.: Engine No.: N° du moteur: N° de motor: Motore N.: No. do motor:
--

Auftragsnr.: MTU works order No.: N° de commande: N° de pedido: N. commessa: No. do pedido:
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**Inbetriebnahme-
meldung**

**Commissioning
Note**

Motortyp: Engine model: Type du moteur: Tipo de motor: Motore tipo: Tipo do motor:

Inbetriebnahmedatum: Date put into operation: Mise en service le: Fecha de puesta en servicio: Messa in servizio il: Data da colocação em serviço:

**Notice de mise
en service**

**Aviso de puesta
en servicio**

Eingebaut in: Installation site: Lieu de montage: Lugar de montaje: Installato: Incorporado em:
--

Schiffstyp / Schiffshersteller: Vessel/type/class / Shipyard: Type du bateau / Constructeur: Tipo de buque / Constructor: Tipo di barca / Costruttore Tipo de embarcação/estaleiro naval:
--

**Avviso di messa
in servizio**

Endabnehmer/Anschrift: End user's address: Adresse du client final: Dirección del cliente final: Indirizzo del cliente finale: Usuário final/endereço:

**Participação da
colocação em
serviço**

Bemerkung: Remarks: Remarques: Observaciones: Commento: Observações:

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1 General

1.1 Important Information

1.1.1 Reman assemblies – Prerequisites for maintenance tasks and general assembly instructions

This maintenance manual is for all maintenance staff working on the unit.

Contents:

- Scheduled maintenance work corresponding to maintenance levels QL3 and QL4.
- Unscheduled work on individual assemblies.

REMAN assemblies

The following assemblies are only available through the exchange procedure:

Series 2000
Vibration damper
Camshaft
Injection pump
DDEC

Prerequisites for maintenance work

Customers performing their own maintenance must ensure that the following conditions are met:

- All safety regulations are observed.
- Use of trained and qualified personnel.
- Suitable workshop equipment with general tools.
- Suitable test equipment.
- Approved special tools.

General assembly instructions

Components that are in contact with oil, fuel, coolant or combustion air must be clean. Components for which "particular cleanness" is required (e.g. components carrying oil or fuel) must be cleaned using suitable processes and checked for cleanness prior to installation. Remove component wrappings immediately prior to installation.

Elastomer components such as rubber must not be cleaned using diesel fuel, solvents or cold cleaner.

- Remove oil or fuel coatings. The parts should be wiped with a dry cloth.
- Elastomer components such as engine mounts, damping elements, couplings and V-belts must not be painted. Install after engine painting or cover prior to painting.

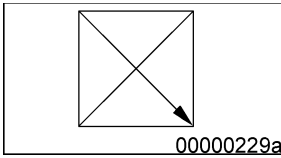
Radial shaft seals that have been treated with oil by the supplier have a pre-defined swelling when supplied. They must therefore only be cleaned (not washed) with an abrasion-proof paper cloth before installation.

The surfaces of sliding parts must be coated with SAE 30 engine oil prior to installation unless otherwise specified.

O-rings and surfaces moving against them during installation (bores and shafts) must be coated with petroleum jelly, unless otherwise specified. When installing O-rings with counterrings in coolant pumps, always follow the installation instructions. After installing O-rings in shaft grooves, pass a rounded marking tool under the O-ring in the direction of the circumference if the O-ring diameter is sufficiently large. Ensure that the O-ring is not damaged.

Prior to shaft seal installation:

- On the shaft, the sealing lip of the shaft seal must be coated with petroleum jelly and the shaft running surface with thin-film lubricant or SAE 30 engine oil.
- In the support bore, in the case of a metal outer jacket the outer surface must be coated with surface sealant, unless otherwise specified in the drawing. For elastomer outer jackets or combined metal/elastomer outer jackets, the outer surface must be coated with denaturated ethanol.



This symbol applies to radial-lip shaft seals and its significance depends on its position. The arrow indicates the position of the sealing lip.

Sealing paste must be used to keep gaskets in place. Sealing paste is to be thinly applied in spots on the gaskets or mating faces. Immediately after application of the sealing paste, the gaskets must be fitted to the component and then (no more than 20 minutes later) the seal components screwed together. .

Before installing antifriction bearings, lubricate the bearing seats. Only remove the bearings from their original packaging immediately before installation. Do not remove the corrosion inhibitor from bearings in original packaging. Use petroleum spirit or acid-free kerosene to clean the antifriction bearings. After cleaning, relubricate the bearings with engine oil.

- During assembly do not apply (axial) forces to rolling elements and do not hit the bearing rings with a hammer (use assembly aids).
- Do not use an open flame to heat bearing inner races.
- The temperature must be between 80°C and 100°C and must never exceed 120°C.
- Chilling is not permissible for the installation of antifriction bearings (risk of cracking or corrosion caused by condensate).

Do not oil dry bearings.

Coat teeth with SAE 30 engine oil during gear installation.

Mounting and contact faces of components (e. g. centering faces, flange and sealing faces, contact faces of press fittings) must be clean, shiny or coated with the specified surface protection prior to installation and must not display uneven surfaces or damage. Corrosion inhibitor (e. g. oil, grease) must be removed from the contact and mating faces.

After parts are joined which are installed by means of cooling using liquid nitrogen, all condensate must be removed and the parts coated with SAE 30 engine oil.

Coat sensors in probe area with permanent lubricant prior to installation into sleeves.

Cable connections with cutting ring unions must be preassembled and tightened in a vise, after the threads have been coated with thin-film lubricant.

If components must be marked by etching, remove etching solvent with neutralizing agent following marking. The affected areas must then be preserved with SAE 30 engine oil.

Components used in hot part areas (e. g. V-clamps, bellows, plug-in pipes) must be coated at the support and mating surfaces with assembly paste, unless otherwise specified.

The contact faces of the screws, nuts, washers and components to be connected must be clean, shiny or coated with the specified surface protection and must not display uneven surfaces or damage. Corrosion inhibitors (e. g. oil, grease) must be removed. Thread and screw contact surfaces must be coated with lubricant before installation in accordance with tightening specifications.

Unless otherwise specified, use engine oil as a lubricant (SAE 30) and assembly paste in hot-part areas.

Screw joints for which no tightening specifications are given may be tightened using a torque wrench or a spanner. For torque tightening, use tightening torque for the relevant thread size and strength classification as specified in the general tightening specifications. Screw joints with tightening specifications:

- The threaded connections must be tightened manually with a click wrench or angle-of-rotation torque wrench. The specified tightening torques must be set without considering the specified tolerance at the click wrench. When using an angle-of-rotation torque wrench, the torque indicated must be within the torque specification limit value. Proceed in a similar manner with torsionally protected threaded connections. This information also applies to checking torques.
- If no tolerance for tightening torques is stated, the tightening tolerance is +10% of specified torque.
- Rotation-angle tightening. The angles of further rotation specified in the tightening specifications must be achieved and may be exceeded within the specified tolerance. If no tightening tolerance is specified, the following tolerances must be observed: +5° for additional angle of rotation less than or equal to 90° +10° for additional angle of rotation greater than 90°. Prior to rotation-angle tightening each screw head must be marked with paint to allow checking of the angle of rotation following tightening (exception: paint marks are not required when tightening with self-checking NC torque wrenches).
- Tightening to elongation. Tightening must be carried out in accordance with tightening specifications taking the tightening tolerance into consideration.

1.2 General Conditions

1.2.1 General conditions

General

In addition to the instructions in this publication, the applicable country-specific legislation and other compulsory regulations regarding accident prevention must be observed. This engine is a state-of-the art product and conforms with all applicable specifications and regulations. Nevertheless, persons and property may be at risk in the event of:

- Incorrect use
- Operation, maintenance and repair by unqualified personnel
- Modifications or conversions
- Non-compliance with the Safety Instructions

Correct use

The engine is intended exclusively for the application specified in the contract or defined at the time of delivery. Any other use is considered improper use. The manufacturer will accept no liability for any resultant damage. The responsibility is borne by the user alone.

Correct use also includes observation of and compliance with the maintenance specifications.

Modifications or Conversions

Modifications made by the customer to the engine affect safety.

MTU will accept no liability or warranty claims for any damage caused by unauthorized modifications or conversions.

Spare parts

Only genuine MTU spare parts must be used to replace components or assemblies. In the event of any damage caused by the use of other spare parts, no liability nor warranty claims vis-à-vis the engine manufacturer will be accepted.

Reworking components

As part of repair work or an engine overhaul, reworking of components may be carried out by workshops authorized by MTU.

However, no generally valid instructions can be issued for the reworking of components as the machining tools available on site may differ.

1.2.2 Personnel and organizational requirements

Personnel requirements

Work on the engine must only be carried out by properly qualified and instructed personnel.

The specified legal minimum age must be observed.

Responsibilities of the operating, maintenance and repair personnel must be specified.

Organizational measures

This publication must be issued to all personnel involved in operation, maintenance, repair or transportation.

It must be kept at hand near the engine and accessible at any time to all personnel involved in operation, maintenance, repair or transportation.

The personnel must be instructed on engine operation and repair by means of this publication, and in particular the safety instructions must be explained.

This is especially important for personnel who work on the engine only on an occasional basis. Such personnel must be given instructions repeatedly.

Working clothes and protective equipment

Wear proper work clothing for all work.

Depending on the kind of work, use additional protective equipment, e.g. protective goggles, gloves, helmet, apron.

Work clothing must be tight fitting so that it does not catch on rotating or projecting components.

Do not wear jewelry (e.g. rings, chains etc.).

1.2.3 Safety precautions when working on the engine

Safety precautions when putting the equipment into operation

Prior to initial operation, the product must have been installed correctly and approved according to MTU specifications.

Before putting the device or the system into operation, always ensure

- that all maintenance and repair work is completed
- that all loose components have been removed from rotating parts
- that nobody is standing in the danger zone of moving engine components.

Safety requirements for operators

Procedures for cases of emergency must be practised regularly.

The operator must be familiar with the controls and displays.

The operator must know the consequences of each operation to be carried out.

The operator must carry out the individual operations according to the documentation.

During operation, the displays and monitoring units must be permanently observed with regard to present operating status, violation of limit values and warning or alarm messages.

The following steps must be taken if a malfunction of the system is recognized or reported by the system:

- notify the supervisory personnel in charge
- analyze the message
- if required, carry out emergency operations e.g. emergency engine stop.

Engine operation

When the engine is running, always wear ear protectors.

Ensure that the engine room is well ventilated.

Mop up any leaked or spilt fluids and lubricants immediately or soak up with a suitable bonding agent.

Exhaust gases from combustion engines are poisonous. Inhalation of poisonous exhaust gases is a health hazard. The exhaust pipework must be free of leaks and discharge the gases to atmosphere.

During engine operation, do not touch battery terminals, generator terminals or cables.

Inadequate protection of electrical components can lead to electric shocks and serious injuries.

When the engine is running, never release coolant, oil, fuel, compressed-air or hydraulic lines.

Maintenance and repair

Compliance with maintenance and repair specifications is an important safety factor.

Unless expressly permitted, no maintenance or repair work must be carried out with the engine running. Secure the engine against inadvertent starting. With electric starter, disconnect the battery. With pneumatic starter, close main shut-off valve of compressed-air system and release pressure from compressed-air supply line. Attach sign "Do not operate" in operating area or to control equipment. Persons not involved must keep clear.

Never attempt to rectify faults or carry out repairs if you do not have the necessary experience or special tools required. Maintenance and repair work must only be carried out by authorized, qualified personnel.

Use only proper, calibrated tools.

Do not work on engines or components which are only held by lifting equipment or crane.

Always support these components in accordance with regulations on suitable frames or stands before beginning any maintenance or repair work.

Before barring the engine, make sure that nobody is standing in the danger zone. After working on the engine, check that all guards have been installed and that all tools and loose components have been removed from the engine.

Fluids emerging under high pressure can penetrate clothing and skin and may cause serious injury. Before starting work, relieve pressure in systems and H.P. lines which are to be opened.

Never bend a fuel line and do not install bent lines. Keep fuel injection lines and connections clean.

Always seal connections with caps or covers if a line is removed or opened.

During maintenance and repair work, take care not to damage the fuel lines. To tighten the connections when installing the lines, use the correct tightening torque and ensure that all retainers and dampers are installed correctly.

Ensure that all fuel injection lines and pressurized oil lines have sufficient distance to other components to avoid contact with them. Do not place fuel or oil lines near hot components, except when necessary for design reasons during installation.

Elastomers (e.g. "Viton" sealing rings) are stable under normal operating conditions. When subjected to fire or temperatures above 300 °C the material degenerates, giving off hydrogen fluoride gas. Hydrogen fluoride vapors are released in this case. The resulting acid leads to serious burning if it contacts the skin. Do not touch elastomeric seals if they have carbonized or resinous appearance. Wear protective gloves!

Take care with hot fluids in lines, pipes and chambers ⇒ Risk of injury!

Note cooling period for components which are heated for installation or removal ⇒ Risk of injury!

Do not touch hot components of the compressor and the exhaust system ⇒ Risk of injury!

Take special care when removing ventilation or plugs from engine. In order to avoid discharge of highly pressurized liquids, hold a cloth over the screw or plug. It is even more dangerous if the engine has recently been shut down, as the liquids can still be hot.

Take special care when draining hot fluids. ⇒ Risk of injury!

When draining, collect fluids in a suitable container, mop up any spilt fluids or wipe or soak them with a suitable bonding agent.

When changing the engine oil or working on the fuel system, ensure that the engine room is adequately ventilated.

When working high on the engine, always use suitable ladders and work platforms. Make sure components are placed on stable surfaces.

In order to prevent back injuries when lifting heavy components adults, depending on age and sex, should only lift weights between max. 10 kg and 30 kg, therefore:

- Use lifting gear or seek assistance.
- Ensure that all chains, hooks, slings, etc. are tested and authorized, are sufficiently strong and that hooks are correctly positioned. Lifting eyes must not be unevenly loaded.

Welding work

Never carry out welding work on the engine or engine-mounted units.

Never use the engine as a ground connection. This prevents the welding current passing through the engine resulting in burnt/scorched bearings, sliding surfaces and tooth flanks which may lead to bearing seizure and/or other material damage.

Never position the welding power supply cable adjacent to, or crossing MTU plant wiring harnesses. The welding current could be induced in the cable harnesses and could possibly damage the electrical plant.

The welding unit ground connection must not be more than 60 cm from the weld point.

If components (e.g. exhaust manifold) are to be welded, they must be removed from the engine.

It is not necessary to remove the connector and the connections when carrying out welding operation on MTU electronics if the master switch for power supply is switched from "ON" to "OFF" and the wire is disconnected from the negative and positive poles on the battery.

Hydraulic installation and removal

Only the hydraulic installation and removal equipment specified in the work schedule and in the assembly instructions must be used.

The max. permissible push-on pressure specified for the equipment must not be exceeded.

The H.P. lines for hydraulic installation and removal are tested with 3800 bar.

Do not attempt to bend or apply force to lines.

Before starting work, pay attention to the following:

- Vent the hydraulic installation/removal tool, the pumps and the lines at the relevant points for the system to be used (e.g. open vent plugs, pump until bubble-free air emerges, close vent plugs).
- For hydraulic installation, screw on the tool with the piston retracted.
- For hydraulic removal, screw on the tool with the piston extended.

For a hydraulic installation/removal tool with central expansion pressure supply, screw spindle into shaft end until correct sealing is achieved.

During hydraulic installation and removal, ensure that nobody is standing in the immediate vicinity of the component to be installed/removed. As long as the system is under pressure, there is the risk that the component to be installed/removed may be suddenly released from the pressure connection.

Before use, the tools must be checked at regular intervals (crack test).

Working on electrical/electronic assemblies

Always obtain the permission of the person in charge before commencing maintenance and repair work or switching off any part of the electronic system required to do so.

Prior to working on assemblies, the power of the appropriate areas must be switched off. Any measures requiring power supply are expressly defined as such at the appropriate place in the manual.

Gases released from the battery are explosive. Avoid sparks and naked flames. Do not allow battery acids to come in contact with skin or clothing. Wear protective goggles. Do not place tools on the battery. Before connecting the cable to the battery, check battery polarity. Battery pole reversal may lead to injury through the sudden discharge of acid or bursting of the battery body.

Do not damage wiring during removal work and when reinstalling wiring and ensure that during operation it is not damaged by contact with sharp objects, by rubbing against other component or by a hot surface.

Do not secure wiring to fluid-carrying lines.

On completion of the maintenance and repair work, any cables which have become loose must be correctly connected and secured.

Always tighten connectors with connector pliers.

On completion of all repair work, the component and system must be subjected to a function check. Separate testing of the repaired component without system integration is insufficient.

If wires are installed beside mechanical components and there is a risk of chafing, use cable clamps to properly support the wires.

For this purpose, no cable binders must be used as, during maintenance and / or repair work, the binders can be removed but not installed a second time.

Spare parts shall be properly stored prior to replacement, i.e. particularly protected against moisture. Defective electronic components and assemblies must be suitably packed when despatched for repair, i.e. particularly protected against moisture and impact and wrapped in antistatic foil if necessary.

Working with laser equipment

When working with laser equipment, always wear special laser-protection goggles.

Laser equipment can generate extremely intensive, concentrated radiation by the effect of stimulated emission in the range of visible light or in the infrared or ultraviolet spectral range. The photochemical, thermal and optomechanical effects of the laser can cause damage. The main danger is irreparable damage to the eyes.

Laser equipment must be fitted with the protective devices necessary for safe operation according to type and application.

For conducting light-beam procedures and measurement work, only the following laser devices must be used:

- Laser devices of classes 1, 2 or 3A,
- Laser devices of class 3B, which have maximum output in the visible wavelength range (400 to 700 nm), a maximum output of 5 mW, and in which the beam axis and surface are designed to prevent any risk to the eyes.

Operation of electrical equipment

When operating electrical equipment, certain components of this equipment are live.

Noncompliance with the warning instructions given for this equipment may result in serious injury or damage to property.

1.2.4 Auxiliary materials, fire prevention and environmental protection

Fire prevention

Rectify any fuel or oil leaks immediately; even splashes of oil or fuel on hot components can cause fires - therefore always keep the engine in a clean condition. Do not leave cloths soaked with fluids and lubricants lying around on the engine. Do not store combustible fluids near the engine.

Do not weld pipes and components carrying oil or fuel. Before welding, clean with a non-combustible fluid.

When starting the engine with a foreign power source, connect the ground lead last and remove it first.

To avoid sparks in the vicinity of the battery, connect the ground lead from the foreign power source to the ground lead of the engine or to the ground terminal of the starter.

Always keep suitable fire-fighting equipment (fire extinguishers) at hand and familiarize yourself with their use.

Noise

Noise can lead to an increased risk of accident if acoustic signals, warning shouts or noises indicating danger are drowned.

At all workplaces with a sound pressure level over 85 dB(A), always wear ear protectors (protective wadding, plugs or capsules).

Environmental protection

Dispose of used fluids, lubricants and filters in accordance with local regulations.

Manipulation of the injection control system can influence the engine performance and exhaust emissions.

As a result, compliance with environmental regulations may no longer be guaranteed.

Only fuels of the specified quality required to achieve emission limits must be used.

In Germany, the VAWs (=regulations governing the use of plants that may affect water quality) is applicable, which means work must only be carried out by authorized specialist companies (MTU is an authorized specialist company).

Auxiliary materials

Use only fluids and lubricants that have been tested and approved by MTU.

Fluids and lubricants must be kept in suitable, properly designated containers. When using fluids, lubricants and other chemical substances, follow the safety instructions applicable to the product. Take care when handling hot, chilled or caustic materials. When using inflammable materials, avoid sparks and do not smoke.

Lead

- When working with lead or lead-containing pastes, avoid direct contact with the skin and do not inhale lead vapors.
- Adopt suitable measures to avoid the formation of lead dust!
- Switch on fume extraction system.
- After coming into contact with lead or lead-containing materials, wash hands!

Acids and alkaline solutions

- When working with acids and alkalis, wear protective goggles or face mask, gloves and protective clothing.
- Immediately remove clothing wetted by acids and alkalis!
- Rinse injuries with plenty of water!
- Rinse eyes immediately with eyedrops or clean tap water.

Painting

- When painting in other than spray booths equipped with extractors, ensure good ventilation. Make sure that adjacent work areas are not affected.
- No naked flames!
- No smoking.
- Observe fire prevention regulations!
- It is absolutely necessary to wear masks providing protection against paint and solvent fumes.

Liquid nitrogen

- Store liquid nitrogen only in small quantities and always in regulation containers without fixed covers.
- Do not bring liquid nitrogen in contact with the body (eyes, hands), as this causes frostbite and numbing.
- Wear protective clothing, gloves, closed shoes and protective goggles!
- Ensure the room is well ventilated. 88% contamination of breathing air with nitrogen will result in suffocation.
- Avoid all knocks and jars to the containers, fixtures or workpieces.

Compressed air

Compressed air is air compressed at excess pressure and is stored in tanks from which it can be extracted. The pressure at which the air is kept can be read off at pressure gauges which must be connected to the compressed air tanks and the compressed air lines.

When working with compressed air, safety precautions must be constantly observed:

- Pay special attention to the pressure level in the compressed air network and pressure vessel!
- Connecting devices and equipment must either be designed for this pressure or, if the permitted pressure for the connecting elements is lower than the pressure required, a pressure reducing valve and safety valve (set to permitted pressure) must form an intermediate connection. Hose coupling and connections must be securely attached!
- Always wear protective goggles when blowing off tools or extracting chips!
- The snout of the air nozzle is provided with a protective disc (e.g. rubber disc), which prevents air-borne particles being reflected and thereby prevents injury to eyes.
- First shut off compressed air lines before compressed air equipment is disconnected from the supply line or before equipment or tool is to be replaced!
- Unauthorized use of compressed air, e.g. forcing flammable liquids (danger class A1, A11 and B) out of containers, results in a risk of explosion!
- Forcing compressed air into thin-walled containers (e.g. containers made of tin, plastic and glass) for drying purposes or to check for leaks, results in a risk of explosion!
- Do not blow dirty clothing with compressed air when being worn on the body.




Used oil

Used oil may contain health-threatening combustion residues.

Rub barrier cream into hands!

Wash hands after contact with used oil.

1.2.5 Standards for warning notices in the publication

 DANGER	In the event of immediate danger. Consequences: Death or serious injury. <ul style="list-style-type: none"> • Preventive measures
 WARNING	In the event of possibly dangerous situations. Consequences: Death or serious injury. <ul style="list-style-type: none"> • Preventive measures
 CAUTION	In the event of dangerous situations. Consequences: Slight injury or material damage. <ul style="list-style-type: none"> • Preventive measures

Note: This Publication contains especially emphasized safety instructions in accordance with the American standard ANSI Z535, which begin with one of the above signal words according to the degree of danger:

Warning notices

1. Read and become acquainted with all cautions and symbols before operating or repairing this product.
2. Pass on all safety instructions to your operating, maintenance, repair and transport personnel!

1.2.6 General information regarding the Tolerances and Wear Limits List

The tolerances and wear limits are intended as a guide for the examination of engine components as well as for engine inspection and repair.

Explanation of terms for dimensions of new components	
Tolerance size	Designed size followed by a fit symbol (e.g. 24 H6) or by the permissible dimensional deviation (e.g. 24 +0.013)
Basic size	Designed size without fit symbol or permissible dimensional deviation
Deviation	Permissible deviation from the basic or tolerance size. Deviation indicates the upper and lower limits of the tolerance size/basic size.
Clearance	Difference between bore and shaft diameter when bore diameter is greater than shaft diameter
Interference	Difference between bore and shaft diameter when bore diameter is smaller than shaft diameter

Explanation of terms for reconditioning of components	
Wear limit	The wear limits specified do not represent the maximum wear limits permissible for satisfactory component operation. They indicate that the next major overhaul can be reached safely. If a wear limit is exceeded, the component must be replaced.
Reworking instructions	If wear limits are exceeded or values are below specification, the components concerned must be reworked as per reworking instructions or replaced.

Deviations from roundness, cylindricity, parallelism and coaxiality must be within specified limits unless specifically indicated. All dimensions are stated in "mm" unless alternative units of measurement are specifically indicated.

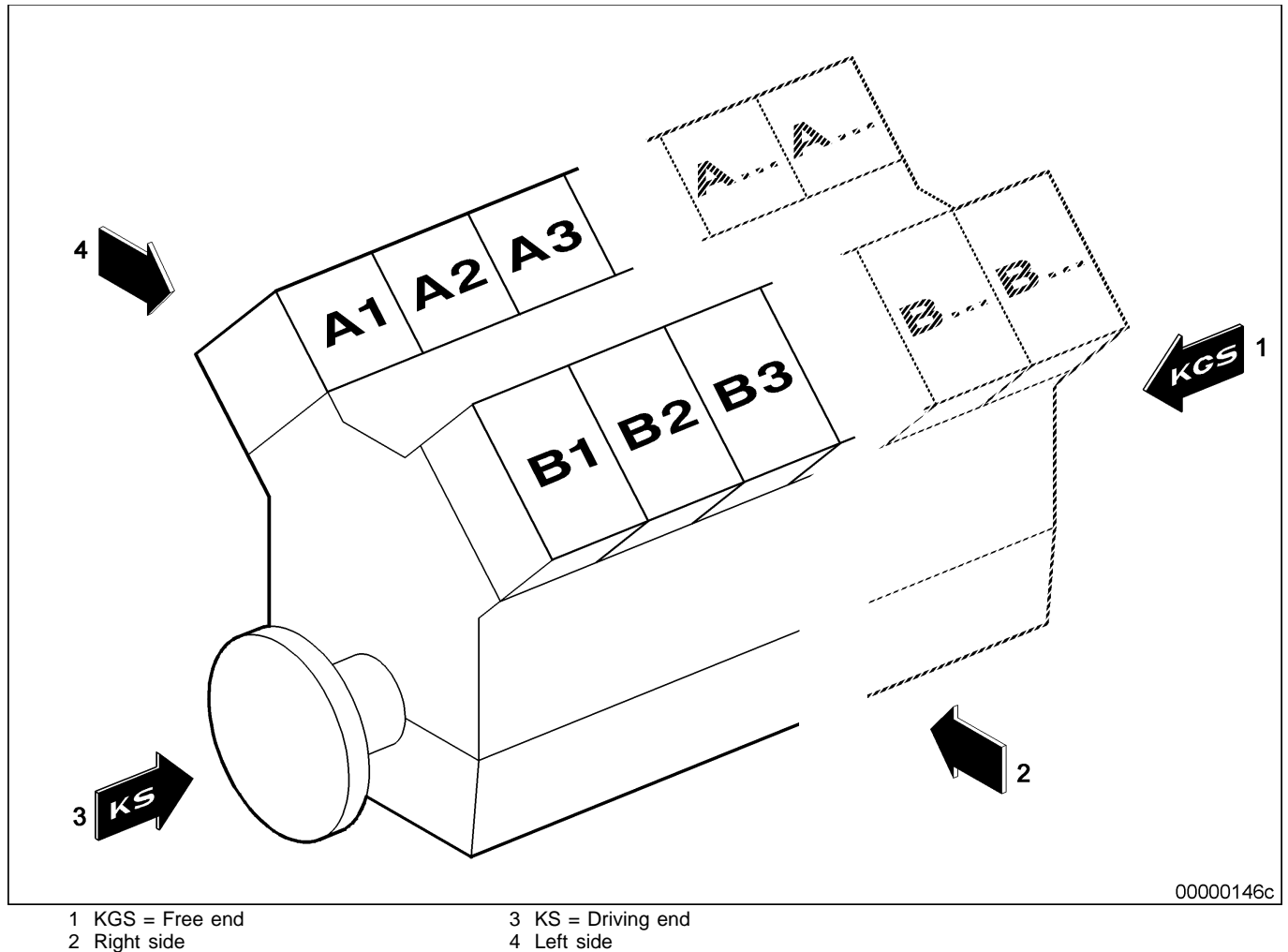
1.2.7 Engine side and cylinder designations

Engine sides are always designated as viewed from the driving end (KS).

The cylinders of the left engine side are designated "A" and those of the right side "B" (as per DIN ISO 1204).

The cylinders of each bank are numbered consecutively, starting with No. 1 at the driving end.

The numbering of engine components is also from the driving end, starting with No. 1.



1.2.8 Tightening specifications for screws and nuts

Crankcase

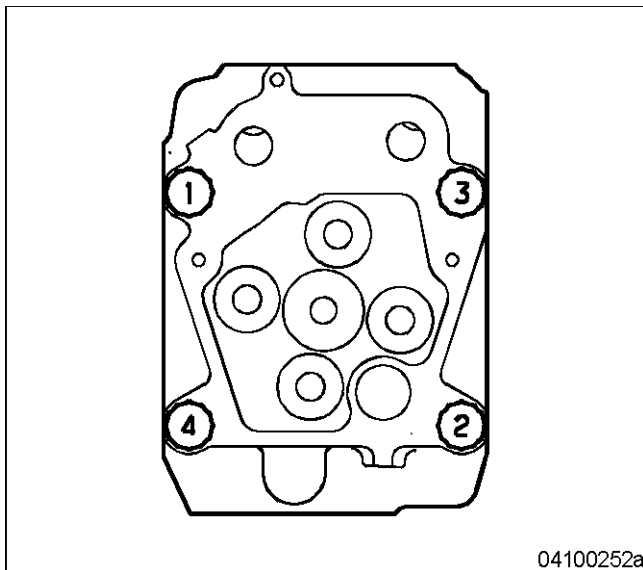
Designation	Tightening specification	Lubricant
Screw for crankshaft bearing cap <ul style="list-style-type: none"> Nominal length: 172.5 mm to 173.0 mm Max. length: 176.0 mm 		Engine oil
1 Pretightening torque	300 Nm + 30 Nm	
2 Further angle of rotation	90° + 10°	
Side screw for crankshaft bearing cap <ul style="list-style-type: none"> Nominal length: 84.5 mm to 85.0 mm 		
1 Tightening torque	140 Nm + 10 Nm	

Running gear

Designation	Tightening specification	Lubricant
Screw for counterweight <ul style="list-style-type: none"> Nominal length: 82.5 mm to 83.0 mm Max. length: 84 mm 		Engine oil
1 Pretightening torque	140 Nm + 20 Nm	
2 Further angle of rotation	90° + 10°	
Conrod screw <ul style="list-style-type: none"> Nominal length: 67.2 mm to 67.5 mm Max. elongation: 68.5 mm 		
1 Pretightening torque Sequence: A short arm B long arm	100 Nm + 15 Nm	
2 Further angle of rotation Sequence: A short arm B long arm	90° + 10°	
Measuring protrusion of cylinder liner:		
Measuring plate screw	50 Nm	

Cylinder head

Designation	Tightening specification	Lubricant
Protective sleeve for injector	45 Nm + 5 Nm	Engine oil
Cylinder head screw <ul style="list-style-type: none"> • Nominal length: 209.5 mm to 210.0 mm • Max. length: 212 mm 		
Tightening sequence for screws:1 to 4		
Pretightening torque		
1st stage	10 Nm	
2nd stage	50 Nm	
3rd stage	100 Nm	
4th stage	200 Nm	
Further angle of rotation		
1st stage	90° + 10°	
2nd stage	90° + 10°	



Valve gear

Designation	Tightening specification	Lubricant
Nut on adjusting screw for rocker arm	50 Nm	Engine oil
Screw for rocker shaft support <ul style="list-style-type: none"> • Nominal length: 90 mm • Max. length: 91 mm 		
1 Pretightening torque	60 Nm	
2 Further angle of rotation	90°	
Screw for cylinder head cover	20 Nm	

HP fuel system

Designation	Tightening specification	Lubricant
Spade lugs on injection pump	1 Nm \pm 0.2 Nm	Engine oil
Screw for injection pump	60 Nm + 12 Nm	
Screw for injector clamp	50 Nm	
Thrust screw for pressure pipe tube	35 Nm to 45 Nm	
Union nut of HP line	20 Nm + 5 Nm max. 35 Nm	

LP fuel system

Designation	Tightening specification	Lubricant
Screw for fuel pump driver	55 Nm	Engine oil
Screw for fuel line to crankcase	40 Nm + 4 Nm	
Distributor housing:		
Screw for cover to housing	9 Nm + 1 Nm	
Union (M8 x 1)	11 Nm + 1 Nm	
Union (M16 x 1.5)	39 Nm + 2 Nm	
Union (M18 x 1.5)	54 Nm + 2 Nm	
Screw for distributor housing to fuel line	24 Nm	

Exhaust turbocharger

Designation	Tightening specification	Lubricant
Screws for rear wall to bearing housing	28 Nm	
Screws for turbine-side clamping segment	40 Nm	Ultra-Therm MTU
Self-locking nut for compressor housing-side clamping segment	15 Nm	
Nut on turbine wheel		
1 Pretightening torque (left-hand thread)	10 Nm	
2 Further angle of rotation	100° – 5°	

Intercooler

Designation	Tightening specification	Lubricant
Screw (M8 x 1.25) for connection housing to flywheel housing	30 Nm + 3 Nm	Engine oil
Screw (M10 x 1.5) for connection housing to flywheel housing	60 Nm + 6 Nm	
Screw for intercooler to connection housing (bottom) and (top)	35 Nm + 4 Nm	

Exhaust line

Designation	Tightening specification	Lubricant
Screw for exhaust line	60 Nm	Ultra-Therm MTU

Lube oil system

Designation	Tightening specification	Lubricant
Connector for oil dipstick tube to oil pan	35 Nm	Engine oil
Oil dipstick tube (union nut) to connector	50 Nm	
Nut for cover on oil heat exchanger housing	108 Nm	
Screw for cover on oil heat exchanger housing	35 Nm	
Screw for oil spray nozzle	25 Nm	
Screw for oil return line on exhaust turbocharger (12 V)	30 Nm	
Screw for oil return line on exhaust turbocharger (16 V)	50 Nm	

Power supply, engine-side

Designation	Tightening specification	Lubricant
Nut for pulley on alternator	95 Nm + 13 Nm	Engine oil
Ground bolt	68 Nm + 13 Nm	
Battery clamp	75 Nm + 19 Nm	
Indicator clamp	21 Nm + 12 Nm	

Cooling air system

Designation	Tightening specification	Lubricant
Nut in fan drive pulley	339 Nm + 13 Nm	Engine oil

Engine mounts/support

Designation	Tightening specification	Lubricant
Screw for carrier and cover	250 Nm + 25 Nm	Engine oil

Monitoring and control devices

Sensor	Type	Remarks	Tightening specification	Lubricant
OTS	Temperature sensor	Lube oil temperature	16 Nm	Engine oil
CTS	Temperature sensor	Coolant temperature	16 Nm	
FTS	Temperature sensor	Fuel temperature	16 Nm	
ATS	Temperature sensor	Charge-air temperature	16 Nm	
OPS	Pressure sensor	Lube oil pressure	15 Nm	
CPS	Pressure sensor	Coolant pressure	15 Nm	
FPS	Pressure sensor	Fuel pressure	15 Nm	
TBS	Pressure sensor	Charge-air pressure	25 Nm	

Tightening specifications for setscrew and stud connections to works standard MTN 5008

This works standard applies to setscrews subject to little dynamic load as per MMN 384, DIN 912, EN 24014 (DIN 931-1), EN 24017 (DIN 933), EN 28765 (DIN 960), EN 28676 (DIN 961), DIN 6912 and to studs as per DIN 833, DIN 835, DIN 836, DIN 938, DIN 939 and associated nuts.

It does not apply to heat-proof screws in the hot component area.

Tightening torques MA are for screws of strength class 8.8 (bright surface, phosphate coating or galvanized) and 10.9 (bright surface or with phosphate coating).

The values in the table are based on a friction coefficient $\mu_{tot.} = 0.125$. Precondition: Thread and mating faces of screws and nuts must be coated with engine oil prior to assembly.

When tightening manually (tightening specifications), an assembly tolerance of +10% of the table values is permitted for unavoidable deviations of the tightening torque from the stated value during the tightening process – e. g. resulting from inaccurate readings and overtightening during assembly.

When tightening mechanically, the permitted assembly tolerance is +15%.

Thread	Hand-tightened		Machine-tightened	
	8.8 M _A (Nm)	10.9 M _A (Nm)	8.8 M _A (Nm)	10.9 M _A (Nm)
M6	9	12	8	11
M8	21	31	20	28
M8 x 1	23	32	21	30
M10	42	60	40	57
M10 x 1.25	45	63	42	60
M12	74	100	70	92
M12 x 1.25	80	110	75	105
M12 x 1.5	76	105	72	100
M14	115	160	110	150
M14 x 1.5	125	180	120	170
M16	180	250	170	235
M16 x 1.5	190	270	180	255
M18	250	350	240	330
M18 x 1.5	280	400	270	380
M20	350	500	330	475
M2 x 1.5	390	550	350	520
M22	480	680	450	650
M22 x 1.5	520	730	490	700
M24	600	850	570	810
M24 x 1.5	680	950	640	900
M24 x 2	660	900	620	850
M27	900	1250	850	1175
M27 x 2	960	1350	900	1275
M30	1200	1700	1100	1600
M30 x 2	1350	1900	1250	1800

MA = tightening torques

Tightening torques for stress bolt connections described in standard MTN 5007

This standard applies to stress pin bolts and stress bolts of strength class 10.9 which are subjected to static and dynamic load as well as to the associated nuts.

Shaft and transition dimensions as to MMN 209 standard and material and machining to MMN 389 standard (bright surface or with phosphate coating).

The values in the table are based on a friction coefficient $\mu_{\text{tot.}} = 0.125$. Precondition: Thread and mating faces of screws and nuts must be coated with engine oil prior to assembly.

When tightening manually (defined tightening), an assembly tolerance of +10% of the table values is permitted for unavoidable deviations of the tightening torque from the stated value during the tightening process – e. g. resulting from inaccurate readings and overtightening during assembly.

The values in the tables are for manual tightening with torque wrench.

Thread	Not torsion-protected M_A (Nm)	Torsion-protected M_A (Nm)
M6	9	12
M8	21	28
M8 x 1	24	30
M10	42	55
M10 x 1.25	46	60
M12	75	93
M12 x 1.5	78	99
M14	120	150
M14 x 1.5	135	160
M16	180	225
M16 x 1.5	200	245
M18	250	315
M18 x 1.5	300	360
M20	350	450
M20 x 1.5	430	495
M22	500	620
M22 x 1.5	560	675
M24	640	790
M24 x 2	700	850
M27	900	1170
M27 x 2	1000	1230
M30	1250	1575

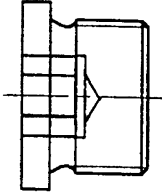
*Protect shank against torsion when tightening.

M_A = tightening torques

Tightening torques for plug screws as per MTN 5183-1 standard

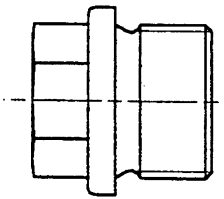
This standard applies to plug screws as per DIN 908, DIN 910 and DIN 7604 with screwed plug DIN 3852, model A (sealed by sealing ring DIN 7603-Cu).

DIN 908



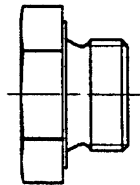
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DIN 910



00000219a

DIN 7604A/C



00000220a

Tightening torques M_A are given for plug screws made of steel (St) with surface protected by a phosphate coating and oiled or galvanized. Thread and mating faces beneath heads must be coated with engine oil prior to assembly. When tightening manually (defined tightening), an assembly tolerance of +10% of the table values is permitted for unavoidable deviations of the tightening torque from the stated value during the tightening process – e. g. resulting from inaccurate readings and overtightening during assembly.

Tightening torques for plug screws DIN 908, DIN 910 and DIN 7604A (with short screwed plug)

Thread	Inserted in	
	Steel/grey cast iron M_A (Nm)	Al alloy M_A (Nm)
M10 x 1	15	15
M12 x 1.5	35	25
M14 x 1.5	35	25
M16 x 1.5	40	30
M18 x 1.5	50	35
M20 x 1.5	55	45
M22 x 1.5	60	50
M24 x 1.5	70	60
M26 x 1.5	80	70
M27 x 2	80	70
M30 x 1.5	100	90
M30 x 2	95	85
M33 x 2	120	110
M36 x 1.5	130	115
M38 x 1.5	140	120
M42 x 1.5	150	130
M45 x 1.5	160	140
M48 x 1.5	170	145
M52 x 1.5	180	150
M56 x 2	190	160
M64 x 2	205	175

M_A = tightening torques

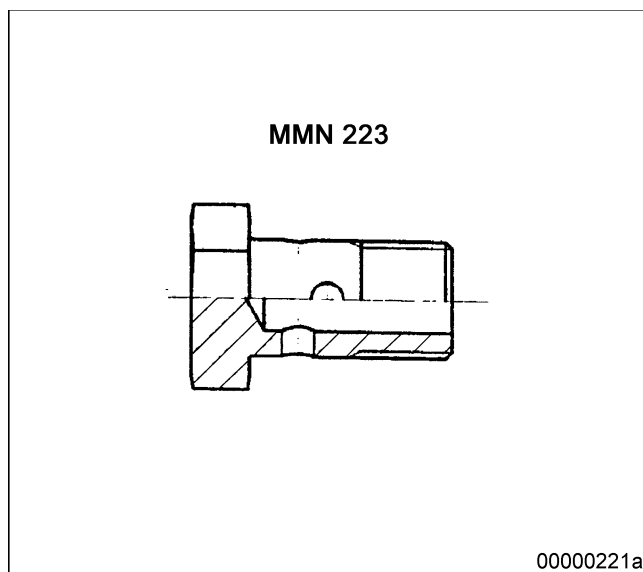
Tightening torques for plug screws as per DIN 7604C (with long screwed plug)

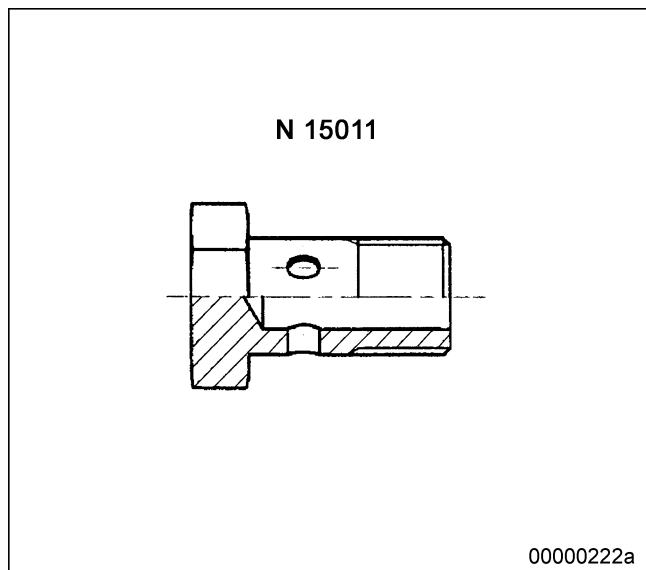
Thread	Inserted in	
	Steel/grey cast iron M_A (Nm)	Al alloy M_A (Nm)
M8 x 1	10	10
M22 x 1.5	80	65
M26 x 1.5	105	90
M30 x 1.5	130	130
M38 x 1.5	140	120
M45 x 1.5	160	140

M_A = tightening torques

Tightening torques for banjo screws as per MTN 5183-2 standard

This standard applies to banjo screws as per MMN 223 and N 15011 sealed with sealing ring DIN 7603-Cu





Tightening torques M_A are given for banjo screws made of steel (St) with surface protected by a phosphate coating and oiled or galvanized and for banjo screws made of copper-aluminium alloys.

Thread and mating faces beneath heads must be coated with engine oil prior to assembly.

When tightening manually (defined tightening), an assembly tolerance of +10% of the table values is permitted for unavoidable deviations of the tightening torque from the stated value during the tightening process – e. g. resulting from inaccurate readings and overtightening during assembly.

Tightening torques for banjo screws made of steel

Thread	Inserted in steel/grey cast iron/Al alloy M_A (Nm)
M8 x 1	10
M10 x 1	15
M12 x 1.5	20
M14 x 1.5	25
M16 x 1.5	25
M18 x 1.5	30
M22 x 1.5	60
M26 x 1.5	90
M30 x 1.5	130
M38 x 1.5	140
M45 x 1.5	160

M_A = tightening torques

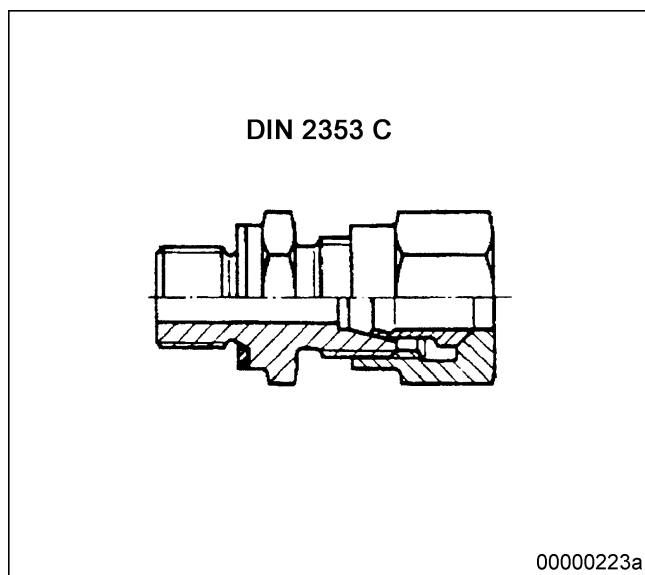
Tightening torques for banjo screws made of copper/aluminium alloys

Thread	Inserted in steel/grey cast iron/Al alloy M_A (Nm)
M10 x 1	15
M16 x 1.5	30

M_A = tightening torques

Tightening torques for male connectors as per MTN 5183-3 standard

This standard applies to male connectors DIN 2353, row L with screwed plug DIN 3852, model A (sealed by sealing ring DIN 7603-Cu)



Tightening torques M_A are given for male connectors made of steel (St) with surface protected by a phosphate coating and oiled or galvanized.

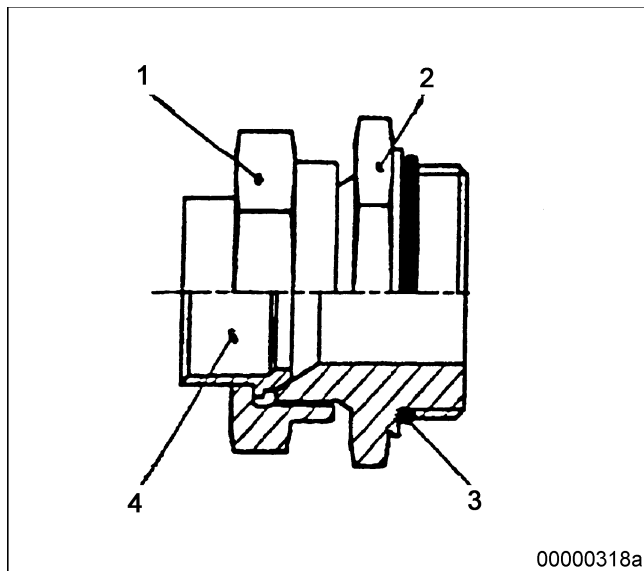
Thread and mating faces beneath heads must be coated with engine oil prior to assembly.

When tightening manually (defined tightening), an assembly tolerance of +10% of the table values is permitted for unavoidable deviations of the tightening torque from the stated value during the tightening process – e. g. resulting from inaccurate readings and overtightening during assembly.

Thread	Inserted in steel/grey cast iron M_A (Nm)
M10 x 1	10
M12 x 1.5	20
M14 x 1.5	40
M16 x 1.5	50
M18 x 1.5	60
M22 x 1.5	70
M26 x 1.5	100
M32 x 2	160
M42 x 2	260
M48 x 2	320

M_A = tightening torques

Tightening torques for union nuts on screwed plugs ISO 6149-3



- 1 Union nut
- 2 Union body
- 3 O-ring
- 4 Linear ball bearing

Union nut: When installing the linear ball bearing, the union nut should be tightened firmly by hand (noticeable increase in force) and then rotated by a further quarter turn (90°).

1.2.9 Settings

Firing order for Series 2000 engines

8V	A1-B4-A4-A2-B3-A3-B2-B1
12V	A1 – B2 – A5 – B4 – A3 – B1 – A6 – B5 – A2 – B3 – A4 – B6
16V	A1-B5-A3-A5-B2-B8-A2-A8-B3-A7-B4-B6-A4-A6-B1-B7
18V	A1-B6-A3-B4-A5-B2-A7-B1-A9-B3-A8-B5-A6-B7-A4-B9-A2-B8

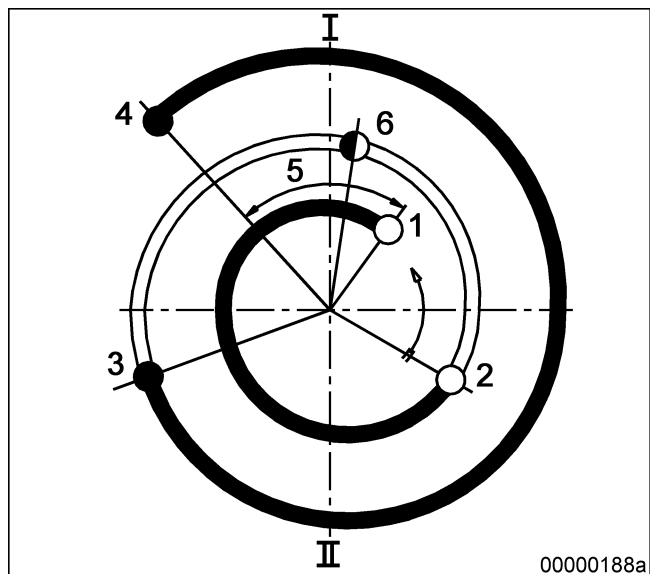
Direction of rotation, viewed from driving end

Component	Direction of rotation
Crankshaft	counter-clockwise
Camshaft	clockwise
Fuel pump	counter-clockwise
Oil pump	counter-clockwise
Engine coolant pump	counter-clockwise
Raw water pump	counter-clockwise

Valve clearance, engine cold (20 °C)

Inlet	0.40 mm
Exhaust	0.60 mm

Valve timing with valve clearance adjusted



No.	Valve position	Crank angle (for 8/12/16/V marine engines)	Crank angle (for 8V vehicle engines and 8/12/16/18V genset engines)
1	Inlet opens	12.4° before TDC	12.4° before TDC
2	Inlet closes	28.4° after BDC	18.4° after BDC
3	Exhaust opens	55.0° before BDC	55.6° before BDC
4	Exhaust closes	9.0° after TDC	9.2° after TDC
5	Overlap	21.4 °	21.6 °
6	Start of delivery	Performance-map controlled	Performance-map controlled
I	Top dead center (TDC)		
II	Bottom dead center (BDC)		

Cam and valve lift for camshaft adjustment

	Inlet (for 8/12/16V vehicle and marine engines)	Outlet (for 12/16/18V genset engines)
Cam lift at TDC	0.70 mm	0.71 mm
Valve lift at TDC (zero valve clearance)	0.85 mm	0.87 mm

	Exhaust (for 8/12/16V vehicles and marine engines)	Outlet (for 12/16/18V genset engines)
Cam lift at TDC	0.60 mm	0.64 mm
Valve lift at TDC (zero valve clearance)	0.80 mm	0.85 mm

1.2.10 Conversion tables

Length

Unit A	multiplied by factor	= Unit B
in	25.4	= mm
ft	0.3048	= m
yd	0.9144	= m
stat. mile	1.609	= km
yd	3	= ft
yd	36	= in

Unit B	multiplied by factor	= Unit A
mm	0.3937	= in
m	3.281	= ft
km	0.6215	= stat. mile

Area

Unit A	multiplied by factor	= Unit B
in ²	645.16	= mm ²
ft ²	0.0929	= m ²
yd ²	0.8361	= m ²
stat. mile ²	2.5889	= km ²

Unit B	multiplied by factor	Unit A
mm ²	0.00155	= in ²
m ²	10.7643	= ft ²
m ²	1.1960	= yd ²
km ²	0.3863	stat. mile ²

Volume

Unit A	multiplied by factor	= Unit B
in ³	16387	= mm ³
ft ³	0.02832	= m ³
yd ³	0.7646	= m ³
gallon (US)	3.787	= dm ³
gallon (Brit.)	4.546	= dm ³

Unit B	multiplied by factor	= Unit A
cm ³	0.06102	= in ³
m ³	35.31	= ft ³
dm ³	0.2642	= gallon (US)
dm ³	0.22	= gallon (Brit.)

Speed

Unit A	multiplied by factor	= Unit B
ft/s	0.3048	= m/s
stat. mile/h (mph)	1.609	= km/h
knot (Brit.)	1.852	= km/h

Unit B	multiplied by factor	= Unit B
m/s	3.281	= ft/s
km/h	0.6215	= stat. mile/h (mph)
km/h	0.54	= knot (Brit.)

Mass

Unit A	multiplied by factor	= Unit B
lb	0.4536	= kg
oz	28.35	= g
ton	1.016	= t

Unit B	multiplied by factor	= Unit A
g	0.03527	= oz
kg	2.205	= lb
t	0.9843	= ton

Force

Unit A	multiplied by factor	= Unit B
lb	0.4536	= kp
lb	4.4483	= N

Unit B	multiplied by factor	= Unit A
kp	2.205	= lb
N	0.101972	= kp
kp	9.80665	= N

Density

Unit A	multiplied by factor	= Unit B
lb s ² /ft ⁴	515.4	= kg/m ³

Unit B	multiplied by factor	= Unit A
kg/m ³	0.00194	= lb s ² /ft ⁴

Torque

Unit A	multiplied by factor	= Unit B
ft lb	1.3563	= Nm

Unit B	multiplied by factor	= Unit A
Nm	0.7373	= ft lb

Pressure

Unit A	multiplied by factor	= Unit B
lb/sq in (psi)	703.1	= kp/m ² (mm WS)
lb/sq in (psi)	0.06895	= bar
lb/sq ft	47.883	= Pa
in QS	0.03386	= bar
in QS	345.3	= kp/m ²

Unit B	multiplied by factor	= Unit A
atm	760	= mm QS
atm	1.0133	= bar
atm	10332	= kp/m ² (mm WS)
atm	1.0332	= kp/cm ² (at)
atm	14.696	= lb/sq in
bar	14.503	= lb/sq in

Mass moment, 2nd grade

Unit A	multiplied by factor	= Unit B
ft lb s ²	1.3563	= kg m ²

Unit B	multiplied by factor	= Unit A
kg m ²	0.7373	= ft lb s ²

Energy

Unit A	multiplied by factor	= Unit B
ft lb	1.356	= J
kcal	4186.8	= J
BTU	1055	= J
CHU	1899	= J

Unit B	multiplied by factor	= Unit A
J	0.7376	= ft lb
J	0.0002389	= kcal
J	0.0009479	= BTU
J	0.00052656	= CHU

Power

Unit A	multiplied by factor	= Unit B
HP (horse power)	0.7355	= kW
HP	0.7457	= kW
BTU/s	1.055	= kW
kcal/h	1.163	= W
HP	550	= ft lb/s

Unit B	multiplied by factor	= Unit A
kW	1.36	= PS
kW	1.341	= HP
kW	0.9479	= BTU/s
W	0.8598	= kcal/h
ft lb/s	0.0018	= HP

Temperature

	Celsius	Kelvin	Fahrenheit	Réaumur
$x^{\circ}\text{C}$		$= x + 273.15 \text{ K}$	$= 9/5x + 32 \text{ }^{\circ}\text{F}$	$= (4/5x) \text{ }^{\circ}\text{R}$
$x \text{ K}$	$= x - 273.15 \text{ }^{\circ}\text{C}$		$= 9/5(x - 273.15) + 32 \text{ }^{\circ}\text{F}$	$= 4/5 (x - 273.15) \text{ }^{\circ}\text{R}$
$x^{\circ}\text{F}$	$= 5/9(x - 32) \text{ }^{\circ}\text{C}$	$= 5/9 (x - 32) + 273.15 \text{ K}$		$= 4/9 (x - 32) \text{ }^{\circ}\text{R}$
$x^{\circ}\text{R}$	$= 5/4x \text{ }^{\circ}\text{C}$	$= (5/4x) + 273.15 \text{ K}$	$= (9/4x) + 32 \text{ }^{\circ}\text{F}$	

Fuel consumption

Unit A	multiplied by factor	= Unit B
mile/gal (US)	0.4251	= km/l
gal/mile (US)	2.3527	= l/km

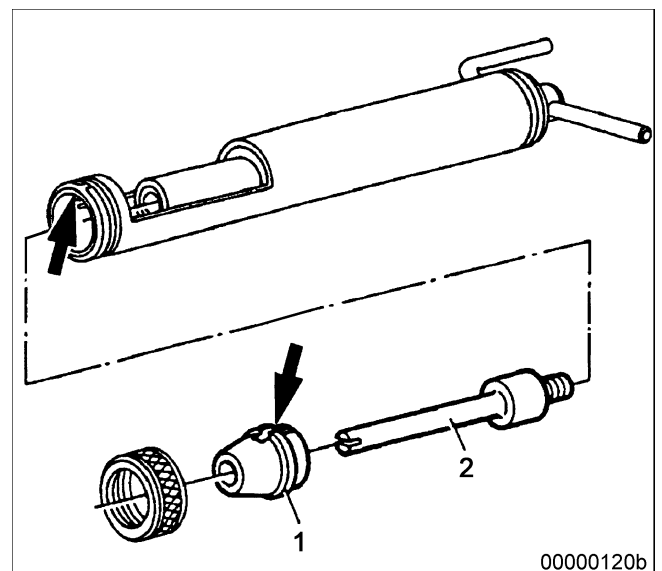
Unit B	multiplied by factor	= Unit A
km/l	2.3527	= mile/gal (US)
l/km	0.4251	= gal/mile (US)

1.2.11 Repairing threaded bores with threaded inserts (Heli-Coil)

Data

Thread	Core hole diameter (max./min.)	Twist drill diameter
M 6	6.31/6.04	6.1–6.2–6.25
M 8	8.35/8.04	8.1–8.2–8.25–8.3
M 8 x 1	8.32/8.04	8.1–8.2–8.25–8.3
M 10	10.4/10.05	10.25
M 12	12.5/12.05	12.25–12.5
M 12 x 1.5	12.43/12.05	12.25
M 14	14.53/14.06	14.25–14.5
M 14 x 1.5	14.43/14.05	14.25
M 15 x 2	15.3/15.2	15.25
M 16	16.53/16.06	16.25–16.5
M 16 x 1.5	16.43/16.05	16.25
M 24 x 1.5	24.43/24.05	24.25
M 26 x 1.5	26.43/26.05	26.25
M 30 x 1.5	30.43/30.05	30.25

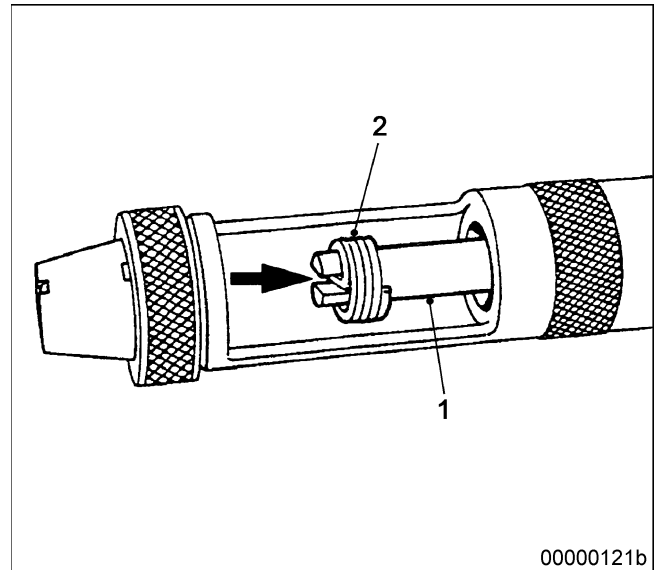
1. Remove thread insert with suitable removal tool from bore (left).
2. Bore core hole with suitable twist drill - see table.
3. Cut thread with special tap.
4. Do not countersink hole!
5. Mount spindle (2) and snout (1) corresponding with thread.
6. Groove on snout must be aligned with markings on installation tool (arrows).



1 Snout
2 Spindle

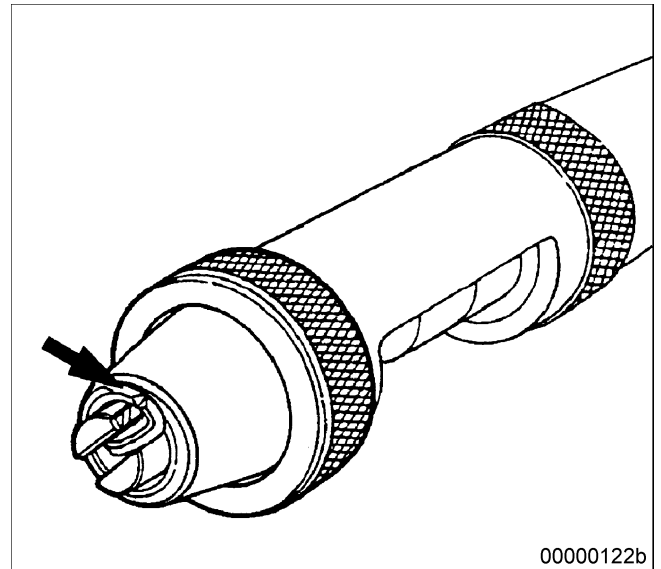
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- 7. Insert thread insert (2) into spindle (1) in installation tool.
- 8. Driver journal of the thread insert must be in groove (arrow).

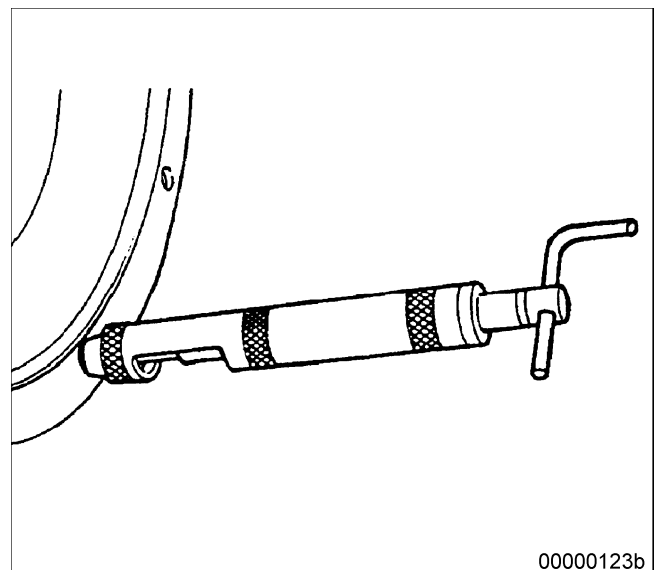


1 Spindle
2 Thread insert

- 9. Use spindle to turn thread insert through snout until it is flush at front (arrow).



- 10. Mount installation tool on threaded hole and install thread insert without applying pressure to spindle.
- 11. Insert thread insert 1/2 to 1 1/2 turns deeper than the threaded hole surface.
- 12. Use screw shearer to remove driver journals up to M 14. With threaded inserts over M14, use pointed pliers to move driver journal up and down and remove.



1.2.12 Transport

Transport

Lift the engine only with the lifting eyes provided.

Use only the transport and lifting equipment approved by MTU.

Take note of the engine center of gravity.

The engine must only be transported in installation position, max. permissible diagonal pull 10°.

In the case of special packaging with aluminium foil, suspend the engine on the lifting eyes of the transport pallet or transport with equipment for heavy loads (forklift truck).

Prior to transporting the engine, it is imperative to install transport locking devices for crankshaft and engine mounts.

Secure the engine against tilting during transportation. The engine must be especially secured against slipping or tilting when going up or down inclines and ramps.

Setting the engine down after transport

Place the engine only on an even, firm surface.

Ensure appropriate consistency and load-bearing capacity of the ground or support surface.

Never place an engine on the oil pan, unless expressly authorized by MTU on a case-to-case basis to do so.

2 Operation Schedules

2.1 Engine – Checking condition before a major overhaul

In order to assess engine performance and engine condition, a short test run should be carried out, prior to removal. The determined deviations from the Acceptance Test Record are important information for later overhaul work.

Operations to be performed	See
Put the engine into operation after a scheduled out-of-service period.	(→Operating Instructions)
Start engine.	(→Operating Instructions)
Warm up engine.	(→Operating Instructions)
Test engine at highest possible power. If this is not possible, operate the engine at adjustable upper and lower no-load speed.	(→Acceptance Test Record)
Perform operational checks.	(→Operating Instructions)
Take engine oil sample and analyze.	(→Operating Instructions)
Take engine coolant sample and analyze.	(→Operating Instructions)
Take charge-air coolant sample and analyze.	(→Operating Instructions)
Switch off engine.	(→Operating Instructions)
Drain engine coolant.	(→Operating Instructions)
Drain charge-air coolant.	(→Operating Instructions)
If engine coolant sample shows contamination, add cleaning solution.	(→Fluids and Lubricants Specification)
If charge-air coolant sample shows contamination, add cleaning solution.	(→Fluids and Lubricants Specification)
Start engine.	(→Operating Instructions)
Flush engine coolant circuits.	(→Fluids and Lubricants Specification)
Switch off engine.	(→Operating Instructions)

2.2 Preface

General

Operational availability and reliability as well as minimal operating and maintenance expenses can only be achieved if maintenance work is carried out in accordance with MTU specifications. Maintenance work on the complete system, in which the engine is integrated, must be carried out in such a way that a faultless running of the engine is ensured. This basically includes the following:

- ensuring that sufficient fuel of specified quality is available
- dry, clean combustion air

Preventive maintenance instructions:

- Keep machinery clean at all times, so that possible leaks can be detected in due time and consequential damage thereby avoided.
- Protect rubber and synthetic parts from oil and fuel, never treat with organic detergents, only wipe with dry cloth.
- Always replace all seals and gaskets.

If required, your service partner is naturally at your disposal with help and advice at all times.

MTU maintenance concept

The MTU maintenance concept is a preventive maintenance concept. Preventive maintenance permits advance operational planning and increases availability.

The maintenance schedule is based on the load profile shown below. The time intervals, after which maintenance work is to be carried out, as well as the specified inspection and maintenance work itself, are the average result of operational experience and therefore only reference values. Specific operating conditions may require modifications to the Maintenance Schedule. Exchange parts (reliabilt®) are available for components to be replaced.

Note

The maintenance task matrix covers all tasks up to a major overhaul. After a major overhaul, the maintenance tasks must continue to be performed in accordance with the specified schedule.

The task number specified in the task list is recorded on a label on the corresponding spare part and serves as a reference for the required range of parts.

The specification of fluids and lubricants and guidelines for their servicing and change as well as the list of recommended fluids and lubricants are contained in MTU fluids and lubricants specification A001061 and in the fluids and lubricants specifications of the component manufacturers. Only use fluids and lubricants that correspond to the MTU specifications or have been approved by the relevant component manufacturer.

The user/customer must perform the following maintenance tasks:

- Fuel prefilter:

Maintenance depends on fuel quality (purity). The filter elements of the fuel prefilter must be replaced every 2 years at the latest.

- Battery:

Maintenance depends on load and ambient conditions of the batteries. The specifications of the battery manufacturer are binding.

Out-of-service periods

If the engine is to remain out of service for more than 1 month, carry out engine preservation procedures according to the Fluids and Lubricants Specifications, MTU Publication No. A001061.

Application group

5B

Intermittent operation, drive for heavy vehicles, compressors and pumps

Load profile**Table load profile**

Power	100%	80%	20%	<5%
Corresponding operating time	26%	15%	12%	47%

2.3 Maintenance schedule matrix

0 to 8,000 operating hours

Item	Limit years	Operating hours [h]																	
		Daily	500	1,000	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000	5,500	6,000	6,500	7,000	7,500	8,000	
Engine operation	-	X																	
Engine oil filter	2																		
Crankcase ventilation	-		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Fuel filter	2		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Coolant cooler	-			X		X		X		X		X		X		X		X	
Valve gear	-			X		X		X		X		X		X		X		X	
Fuel injectors	-							X						X					
Combustion chambers	-							X						X					
Air filter	3							X						X					
Fuel injection pumps	-																		X
Component maintenance	-																		X
Cylinder head	-																		X
Extended component maintenance	18																		X
Fuel pressure relief valve	18																		X

2.4 Maintenance tasks

Qualification	Interval		Item	Maintenance tasks	Task
	[hours]	[a]			
QL1	Daily	-	Engine operation	Check engine oil level (→Operating instructions).	W0500
				Visually check for leaks and general engine condition (→Operating instructions).	W0501
				Check intercooler drain line (if fitted) (→Operating instructions).	W0502
				Check air filter service indicator (→Operating instructions).	W0503
				Check coolant pump relief bore(s) (→Operating instructions).	W0505
				Check engine for abnormal running noises, color of exhaust gas and leaks (→Operating instructions).	W0506
				Drain water and contamination from fuel prefilter drain cock (if fitted) (→Operating instructions).	W0507
				Check fuel prefilter service indicator (if fitted) (→Operating instructions).	W0508
QL1	-	2	Engine oil filter	Replace engine oil filter when changing oil or at the latest after limit value years (→Operating instructions).	W1008
QL1	500	-	Crankcase ventilation	Clean crankcase ventilation wire mesh (→Operating instructions).	W1140
QL1	500	2	Fuel filter	Replace fuel filter or fuel filter insert (→Operating instructions).	W1001
QL1	1,000	-	Coolant cooler	Coolant cooler: Check cooler elements for external contamination (see manufacturer's documentation).	W1010
QL1	1,000	-	Valve gear	Check valve clearance (→Operating instructions).	W1002
QL1	3,000	-	Fuel injectors	Replace fuel injectors (→Operating instructions).	W1006
QL1	3,000	-	Combustion chambers	Perform endoscopic examination of combustion chambers (→Operating instructions).	W1011
QL1	3,000	3	Air filter	Replace air filter (→Operating instructions).	W1005
QL1	8,000	-	Fuel injection pumps	Replace fuel injection pumps (→Operating instructions).	W1007
QL3	8,000	-	Component maintenance	Before starting maintenance work, drain coolant and flush coolant circuits.	W2000
				Clean air pipework (→ Page 462).	W2002
				Clean intercooler and check for leaks (→ Page 455) (→ Page 456).	W2003
				Check vibration damper (→ Page 246).	W2011
				Clean engine oil heat exchanger and check for leaks (→ Page 505) (→ Page 506).	W2018

Qualification	Interval		Item	Maintenance tasks	Task
	[hours]	[a]			
				Check engine alignment (see installation drawing). Replace engine coolant pump and charge-air coolant pump (→ Page 538) (→ Page 556). Replace coolant thermostat insert (→ Page 562). Check rocker arms, valve bridges, pushrods and ball joints for wear (→ Page 363). Overhaul exhaust turbocharger (→ Page 432). Fit all disassembled components with new sealing material.	W2036 W2100 W2073 W2074 W2075 W2062
QL3	8,000	-	Cylinder head	Overhaul cylinder heads, visually inspect piston crowns and wear pattern of cylinder liners (→ Page 303).	W1063
QL4	8,000	18	Extended component maintenance	Perform complete engine disassembly. Check engine components as per assembly instructions, repair or replace if required (→ Page 55). Replace all elastomer components and seals. Replace piston rings (→ Page 255). Replace conrod bearings (→ Page 279). Replace crankshaft bearings (→ Page 185). Replace cylinder liners (→ Page 92). Replace crankcase ventilation oil separator (→ Page 121). Replace fuel delivery pump (→ Page 399). Overhaul starter (→ Page 472). Overhaul battery-charging generator (→ Page 574).	W3000 W3001 W3002 W3003 W3004 W3005 W3009 W3010 W3041 W3042
QL4	8,000	18	Fuel pressure relief valve	Replace fuel pressure relief valve (→ Page 416).	W1056

2.5 Engine – Removal

Operations to be performed	See
Shut off fuel supply.	–
Drain engine oil at operating temperature.	(→Operating Instructions)
Examine oil sludge for metallic residues.	–
Drain engine coolant.	(→Operating Instructions)
Drain charge air coolant.	(→Operating Instructions)
Wash machinery plant (as required, without chemical detergent).	–
Disconnect all connections.	–
Install non-fibrous plugs and blanking plates to seal all open connections.	–
Release engine securing screws.	–
Remove engine and place on stands.	–
Attach engine to lifting device in accordance with transportation regulations.	(→Operating Instructions)

2.6 Engine – Disassembly

The sequence of work steps listed below corresponds to the engine disassembly process. Prior to disassembly, pictures should be taken from all engine sides or the parts installed on the engine should be marked.

Operations to be performed	See
Mark and disconnect wiring.	–
Remove DDEC.	(→ Page 598)
Remove crankcase ventilation.	(→ Page 117)
Disconnect exhaust turbocharger oil supply.	(→ Page 524)
Remove oil return line from exhaust turbocharger.	(→ Page 529)
Remove exhaust turbocharger.	(→ Page 432)
Remove exhaust line downstream of cylinder.	(→ Page 466)
Remove coolant line from/to intercooler.	(→ Page 558)
Remove charge-air coolant pump.	(→ Page 552)
Remove intercooler.	(→ Page 454)
Remove air supply to cylinders.	(→ Page 461)
Remove leak-off fuel pipework.	(→ Page 427)
Remove fuel line from fuel delivery pump to fuel filter.	(→ Page 406)
Remove fuel filter.	(→ Page 411)
Remove fuel line from fuel filter to LP line.	(→ Page 419)
Remove fuel delivery pump.	(→ Page 399)
Remove engine wiring harnesses.	(→ Page 604)
Remove coolant line downstream of engine coolant pump.	(→ Page 546)
Remove engine coolant pump.	(→ Page 535)
Remove battery-charging generator.	(→ Page 572)
Remove mechanical fan drive.	(→ Page 580)
Remove oil pump connections.	(→ Page 486)
Remove starter.	(→ Page 471)
Remove vibration damper on PTO, free end.	(→ Page 242)
Remove oil filter.	(→ Page 496)
Remove oil heat exchanger.	(→ Page 503)
Remove coolant lines with thermostat.	(→ Page 563)
Remove cylinder head cover.	(→ Page 371)
Remove HP line.	(→ Page 393)
Remove injector.	(→ Page 385)

Operations to be performed	See
Remove valve drive.	(→ Page 359)
Remove pushrod.	(→ Page 350)
Remove cylinder heads.	(→ Page 303)
Remove roller tappets.	(→ Page 350)
Remove injection pump.	(→ Page 378)
Remove flywheel PTO flange, driving end.	(→ Page 225)
Remove filling and measuring devices.	(→ Page 491)
Remove engine mounts.	(→ Page 590)
Install crankcase in crankcase rotation device.	(→ Page 66)
Remove engine lifting attachment.	(→ Page 112)
Remove oil pan.	(→ Page 104)
Remove lube oil pump with drive.	(→ Page 477)
Remove piston and conrod.	(→ Page 255)
Remove gear train oil supply.	(→ Page 519)
Remove gearcase, free end.	(→ Page 146)
Remove gear train, free end.	(→ Page 160)
Remove flywheel housing.	(→ Page 126)
Remove crankshaft.	(→ Page 185)
Remove cylinder liners.	(→ Page 92)
Remove oil duct in crankcase.	(→ Page 512)
Remove crankcase from crankcase rotation device.	(→ Page 86)
Remove camshaft.	(→ Page 334)
Remove plug screws and covers.	(→ Page 66)
Remove camshaft bearing bush.	(→ Page 66)

2.7 Engine – Assembly

The sequence of work steps listed below corresponds to the engine assembly process.

Operations to be performed	See
Clean crankcase.	(→ Page 69)
Check crankcase.	(→ Page 70)
Assemble crankcase.	(→ Page 86)
Install camshaft.	(→ Page 342)
Install crankcase in crankcase rotation device.	(→ Page 66)
Install cylinder liners.	(→ Page 99)
Install oil duct in crankcase.	(→ Page 515)
Install crankshaft.	(→ Page 217)
Install piston with conrod.	(→ Page 288)
Install gearcase, free end.	(→ Page 154)
Install gear train, free end.	(→ Page 165)
Install lube oil pump with drive.	(→ Page 482)
Install oil pan.	(→ Page 108)
Install gear train oil supply.	(→ Page 522)
Install engine mounts.	(→ Page 595)
Install flywheel housing.	(→ Page 139)
Remove crankcase from crankcase rotation device.	(→ Page 86)
Install roller tappets.	(→ Page 355)
Install cylinder heads.	(→ Page 329)
Install engine lifting attachment.	(→ Page 115)
Install flywheel PTO flange, driving end.	(→ Page 234)
Install vibration damper on PTO, free end.	(→ Page 248)
Install fuel line from fuel filter to LP line.	(→ Page 424)
Install injection pump.	(→ Page 382)
Install fuel injector.	(→ Page 389)
Install pushrods.	(→ Page 355)
Install valve drive.	(→ Page 368)
Install cylinder head cover.	(→ Page 374)
Install coolant lines with thermostat.	(→ Page 568)
Install oil heat exchanger.	(→ Page 508)
Install oil filter.	(→ Page 499)

Operations to be performed	See
Install HP line.	(→ Page 396)
Install starter.	(→ Page 475)
Install filling and measuring device.	(→ Page 494)
Install engine wiring harnesses.	(→ Page 606)
Install exhaust line downstream of cylinder.	(→ Page 469)
Install exhaust turbocharger.	(→ Page 450)
Connect turbocharger oil supply.	(→ Page 527)
Install oil return line from exhaust turbocharger.	(→ Page 532)
Install oil pump connections.	(→ Page 489)
Install leak-off fuel lines.	(→ Page 430)
Install battery-charging generator.	(→ Page 577)
Install engine coolant pump.	(→ Page 536)
Install fuel filter.	(→ Page 414)
Install fuel delivery pump.	(→ Page 403)
Install fuel line from fuel delivery pump to fuel filter.	(→ Page 409) (→ Page 424)
Install intercooler.	(→ Page 458)
Install air supply to cylinders.	(→ Page 464)
Install charge-air coolant pump.	(→ Page 553)
Install coolant line from/to intercooler.	(→ Page 561)
Install crankcase ventilation.	(→ Page 120)
Connect wiring.	(→ Page 611)
Install DDEC.	(→ Page 601)

2.8 Engine – Installation

Operations to be performed	See
Open all connections, remove caps and rubber plugs.	–
Attach engine at lifting eyes only and install as per transportation instructions.	(→Operating instructions)
Connect coolant lines, fuel lines and engine monitoring system.	–
Fill with engine coolant.	(→Operating instructions)
Fill with charge-air coolant.	(→Operating instructions)
Change/fill with engine oil.	(→Operating instructions)
Align engine.	–

2.9 Engine – Running in

Running in the engine after replacement of components.

- After replacing pistons, piston rings or cylinder liners, run in engine according to the corresponding program. Conscientious running in is of essential importance for the service life and operational reliability of the engine.
- To destroy the braking energy, use the alternator or brake.
- Power must be transmitted from the engine to the brake by means of a resilient coupling.

Setting engine operating values.

- Set temperatures, fuel and intake air according to the temperature values in the MTU acceptance test record. In doing so observe:
 - The coolant temperature depends on the operating range of the coolant thermostat.
 - The fuel temperature depends on the volume of the day tank, as long as there is no fuel cooling device on the test stand.
- Record operating data for power, fuel, oil, engine coolant, charging and exhaust gas for every test item (time, revs and effective performance) in the “MTU diesel engine factory test run” report under RUNNING IN THE ENGINE.

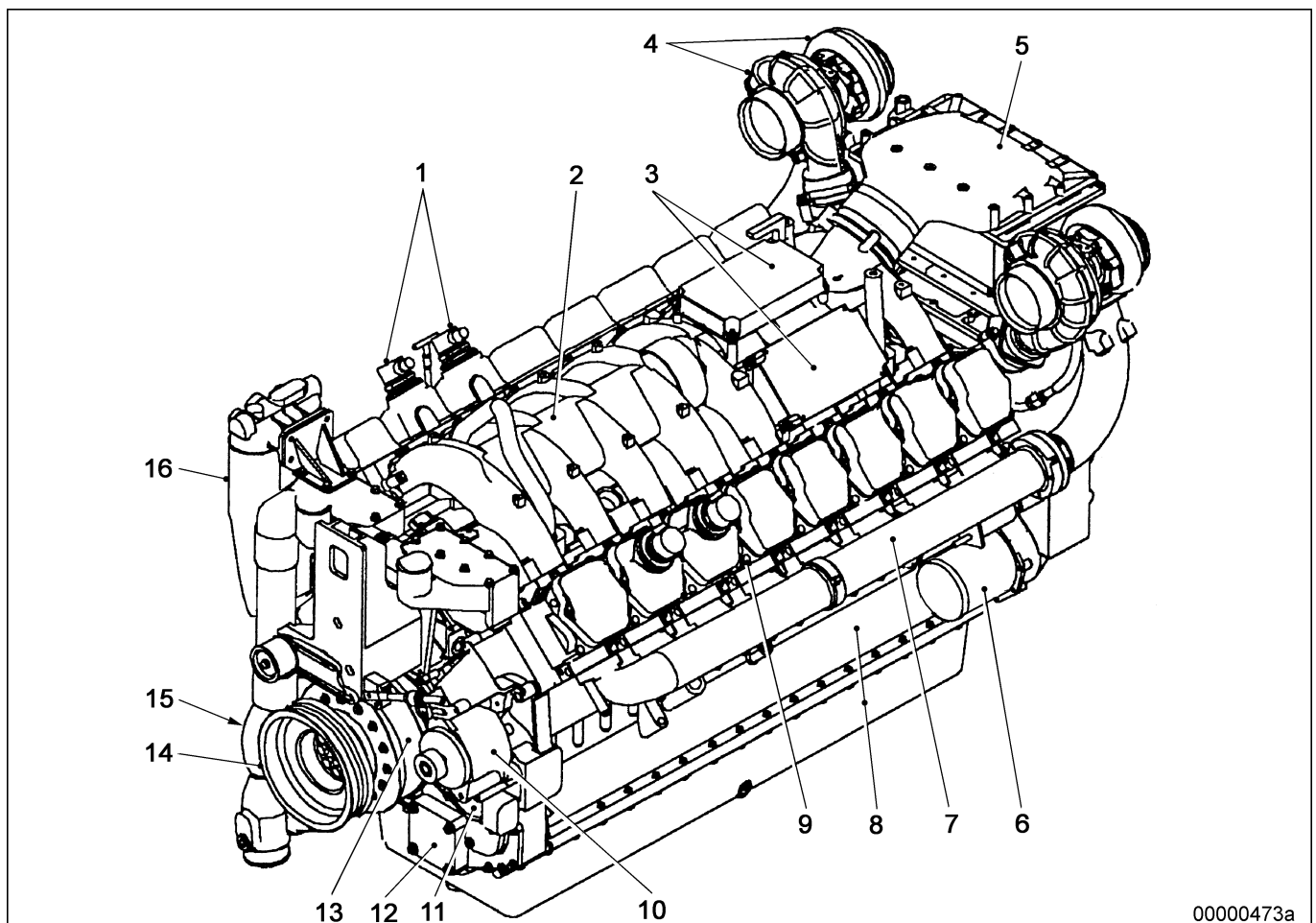
Tasks to be performed	See
Install engine on test stand.	-
Connect engine to dynamometer or generator.	-
Connect exhaust gas, engine coolant and fuel lines.	-
Connect measuring sensor and measuring lines for measuring fuel, oil, engine coolant, charging and exhaust gas to the respective measuring points.	-
Connect dialog unit to ECU.	(→Acceptance test record)
Fill with engine coolant.	(→Operating instructions)
Fill with charge-air coolant.	(→Operating instructions)
Check fuel in storage tank or day tank for prescribed specification.	(→MTU fluids and lubricants specifications A001061/..)
Vent fuel system.	(→Operating instructions)
Fill oil system with engine oil.	(→Operating instructions)
Check emergency shutdown system.	-
Start engine.	(→Operating instructions)
After approx. 1 minute no-load operation, shut down engine and: <ul style="list-style-type: none"> • Check oil level. If required, top up oil. • Remove the valve gear cover and check valve gear lubrication. 	(→Operating instructions)
Start engine and check idle speed.	-
Check engine coolant, oil and fuel lines for leaks.	-
Check air pipework and exhaust gas lines for leaks.	-
Run in engine in accordance with run-in program and record measured values.	(→Acceptance test record)
Compare values with measured values in MTU acceptance test record and evaluate.	(→Acceptance test record)

Tasks to be performed	See
Check exhaust gas color and enter.	-
Enter barometric pressure and relative air humidity in Test Record.	(→Acceptance test record)
Check engine for abnormal running noises and leaks.	-
Check engine monitoring.	-
After completion of run-in program, run down engine and switch off.	(→Operating instructions)
Cut open one oil filter and check for residues.	-
Perform acceptance test according to acceptance test record.	-
Enter operating data in acceptance test record.	(→Acceptance test record)
Compare values with measured values in MTU acceptance test record and evaluate.	(→Acceptance test record)
After completion of acceptance test, run down engine and switch off.	(→Operating instructions)
Remove sensors and measuring lines and seal measuring points.	-
Preserve engine if it is to be out of service for a prolonged period.	(→MTU fluids and lubricants specifications A001061/..)
Take protective measures for marine transport.	-
Remove engine from test stand.	-
Prepare the engine for spray painting and spray with protective paint.	-

3 Task Descriptions

3.1 Crankcase and Attachments

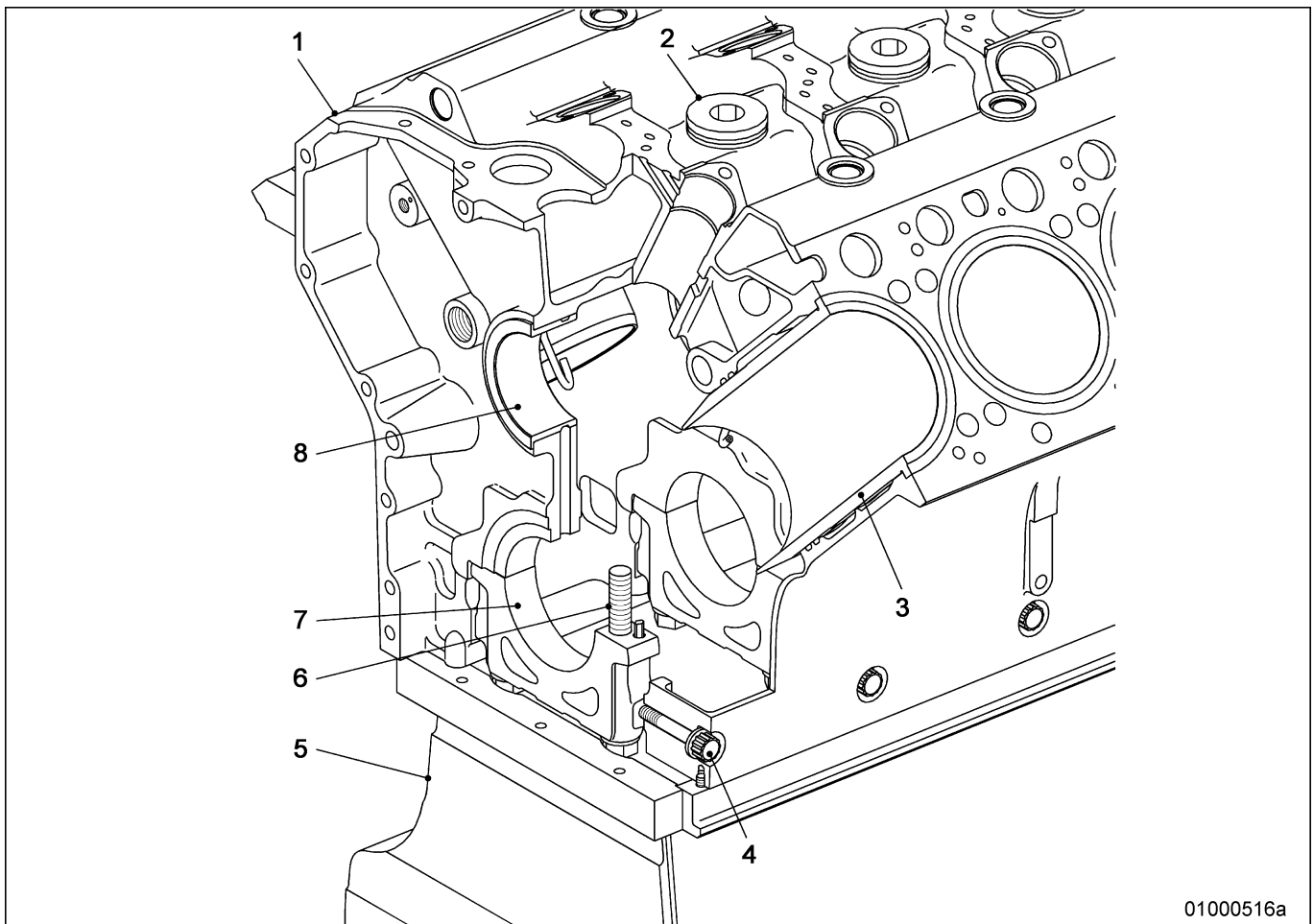
3.1.1 Engine layout



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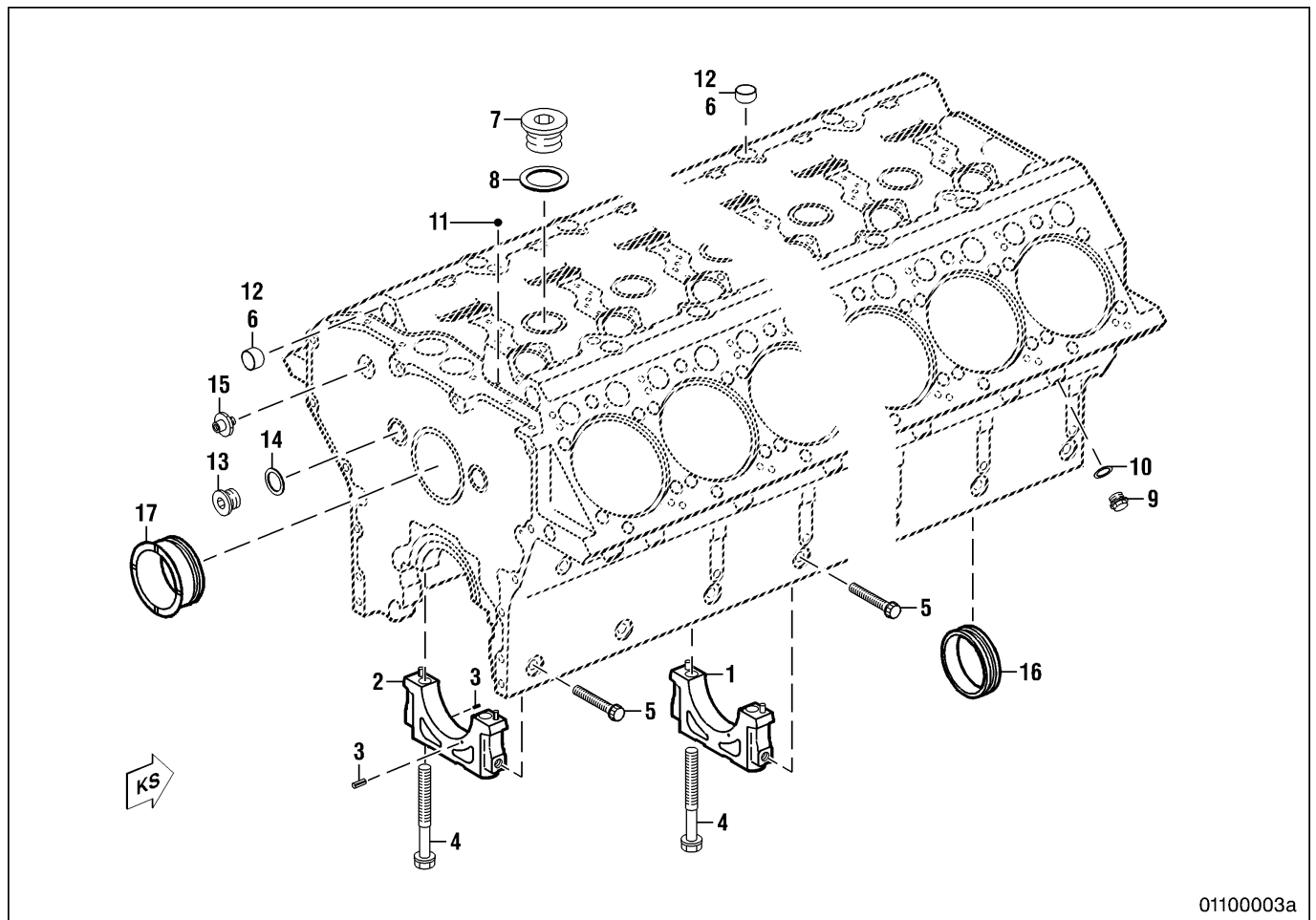
- | | | |
|---|--|--|
| 1 Crankcase ventilation (→ Page 116) | 9 Cylinder head (→ Page 294) | 17 Valve gear (not illustrated) (→ Page 332) |
| 2 Air supply (→ Page 460) | 10 Power supply (→ Page 571) | 18 Lube oil system/lube oil circuit (not illustrated) (→ Page 476) |
| 3 Monitoring and control devices, general electric devices (→ Page 597) | 11 Charge-air coolant pump (→ Page 550) | 19 Mechanical fan drive (not illustrated) (→ Page 476) |
| 4 Exhaust turbocharger (→ Page 431) | 12 Gear train (→ Page 144) | 20 Mounting system/support (not illustrated) (→ Page 579) |
| 5 Intercooler (→ Page 452) | 13 Vibration damper (→ Page 180) | |
| 6 Starting device (→ Page 470) | 14 Belt drive (→ Page 175) | |
| 7 Exhaust line (→ Page 465) | 15 Coolant pump (→ Page 533) | |
| 8 Oil pan (→ Page 103) | 16 Fuel filter (low-pressure) (→ Page 410) | |

3.1.2 Crankcase and attachments – Overview



- 1 Crankcase
- 2 Screw
- 3 Cylinder liner
- 4 Double-hex screw
- 5 Oil pan
- 6 Screw
- 7 Crankshaft alignment bearing cap
- 8 Camshaft bearing

3.1.3 Crankcase – Overview



01100003a

- | | | |
|------------------------------------|---------------------------|---------------------------------|
| 1 Main bearing cap | 7 Screw | 13 Screw |
| 2 Crankshaft alignment bearing cap | 8 Sealing ring | 14 Seal |
| 3 Notched pin | 9 Screw | 15 Screw with nozzle |
| 4 Screw | 10 Sealing ring | 16 Camshaft bearing |
| 5 Screw | 11 Sealing plug | 17 Camshaft bearing with collar |
| 6 Plug | 12 Screw locking compound | |

3.1.4 Crankcase – Disassembly

Special tools

Designation / Use	Part No.	Qty.
Extraction tool	F6559618	1
Rotation device assembly	F6554681	1
Support	F6554682	4
Distance plate	F6554683	2
Support	F6554684	2
Support	F6554685	2



WARNING

Components have sharp edges.

Risk of injury!

- Wear protective gloves.



WARNING

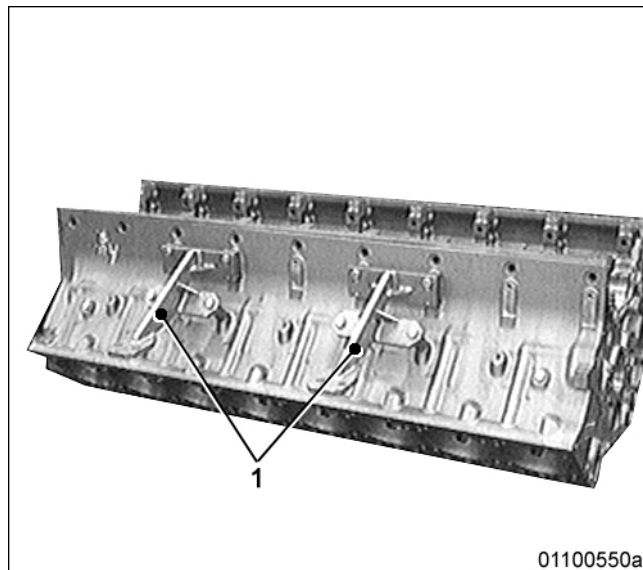
Heavy object.

Risk of crushing!

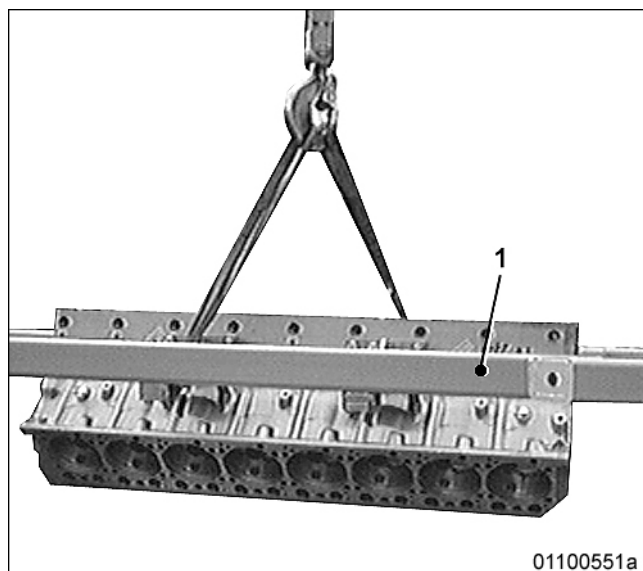
- Use appropriate lifting devices and appliances.

Installing crankcase in crankcase rotation device

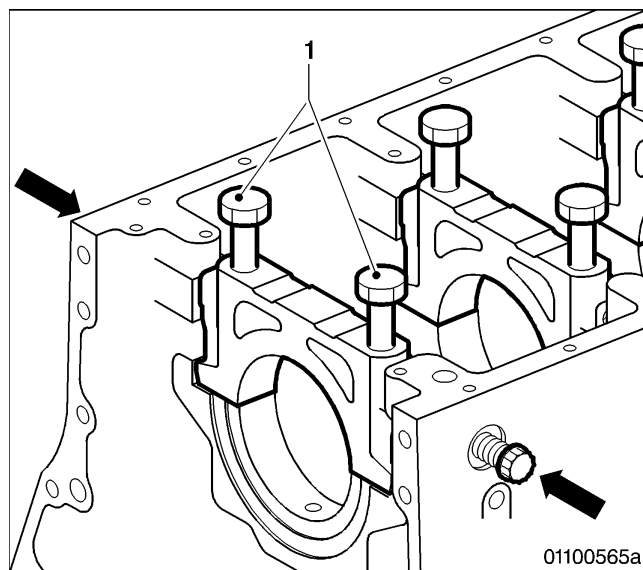
1. Install two crankcase rotation device supports (1) on each side (left and right) of the crankcase.



2. Lift crankcase with lifting device and ropes, place into rotation device (1) and secure.

**Removing main bearing caps**

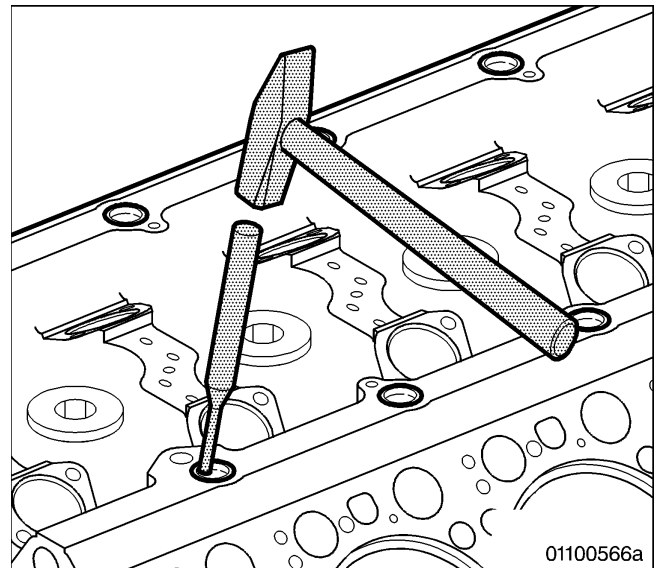
1. Remove main bearing caps (→ Page 185).
2. Protect main bearing caps from damage.



Removing plugs

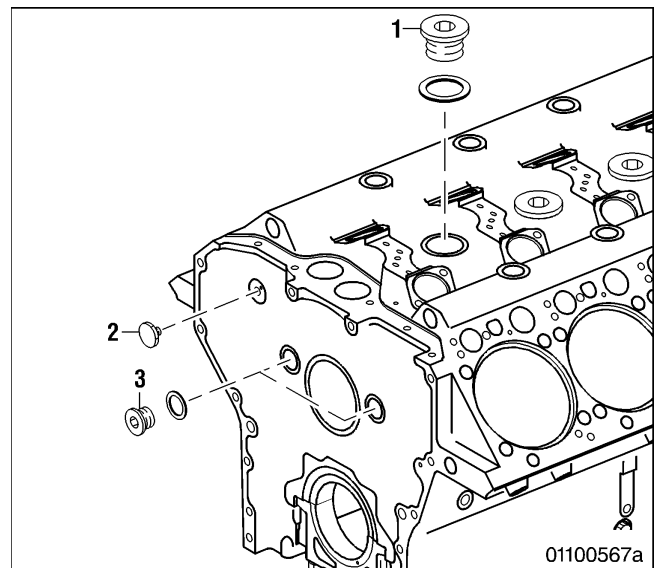
Note: Do not drill into plugs. Metal chippings in the crankcase coolant chamber may lead to localized overheating.

1. Using a drift and hammer, carefully knock the edge of the plug inwards until it tilts into the bore.
2. Use pliers to withdraw plug, taking care that it does not fall into bore.



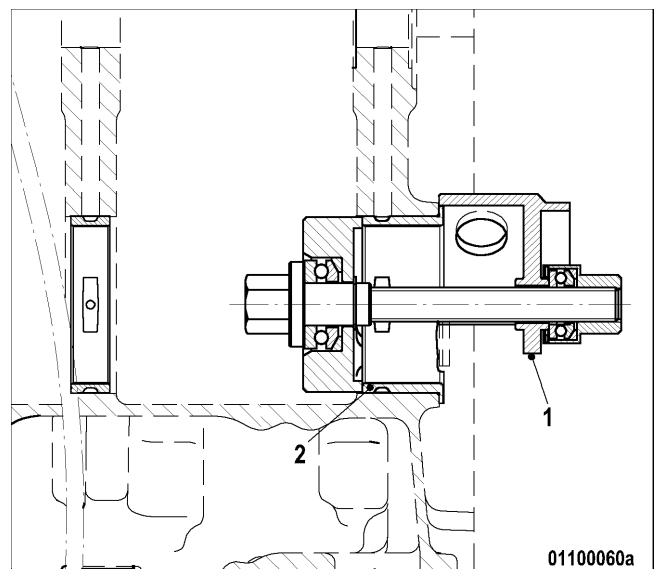
Unscrewing plug screws

1. Unscrew plug screws (3) for main oil galleries (driving end), screw (2) and for coolant chamber (1).
2. Remove sealing rings.



Removing camshaft bearing bushes

1. Cover the bottom of the camshaft chamber.
2. Use extraction tool (1) to remove camshaft bearing bush (2) from crankcase.







3.1.5 Crankcase – Cleaning

Special tools

Designation / Use	Part No.	Qty.
Hole brush		

Material

Designation / Use	Part No.	Qty.
Cleaning agent		
Cleaner (oil carbon remover)		
Dry compressed air		

 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> Do not direct compressed-air jet at persons. Wear protective goggles / safety mask and ear protectors.
 CAUTION	Contamination of components. Damage to component! <ul style="list-style-type: none"> Observe manufacturer's instructions. Check components for special cleanness.
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> Observe manufacturer's instructions. Wear protective clothing, gloves, and goggles / safety mask.
 CAUTION	Unsuitable cleaning tools. Damage to component! <ul style="list-style-type: none"> Observe manufacturer's instructions. Use appropriate cleaning tool.

Disassemble crankcase (→ Page 66).

Crankcase – Cleaning

- Clean all components with cleaning agent.
- Remove cleaning agent.
- Blow crankcase and all threaded bores clear with compressed air.

Cleaning oil bores in crankcase

Note: During a major engine overhaul, or if metal chippings have got into the engine oil system.

- Clean oil and coolant bores thoroughly with a suitable hole brush. Never use a wire brush!
- After cleaning, pressure-flush bores and blow clear with compressed air.

Cleaning main bearing cap

- Clean bearing shell mating faces and register pins of main bearing caps.
- Clean mating faces on crankcase and main bearing caps.
- Blow out dowel pins and register pins (arrows) of main bearing / crankshaft alignment bearing caps and the related crankcase bores with compressed air.

3.1.6 Crankcase – Check

Special tools

Designation / Use	Part No.	Qty.
Endoscope	Y20097353	1
Bore gauge	Y20091481	1
Bore gauge	Y20091482	1

Material

Designation / Use	Part No.	Qty.
Fluorescent magnetic powder for magnetic crack-testing		
Red penetrant dye for surface crack-testing procedure		
Corrosion inhibitor (Pfinder AP 11 F)		

Spare parts

Designation / Use	Part No.	Qty.
Crankcase		
Main bearing cap		
Screws for main bearing cap		
Double-hex screw		
Camshaft bearing		



Heavy object.

Risk of crushing!

- Use appropriate lifting devices and appliances.



Components have sharp edges.

Risk of injury!

- Wear protective gloves.



Contamination of components.

Damage to component!

- Observe manufacturer's instructions.
- Check components for special cleanness.

Clean crankcase (→ Page 69).

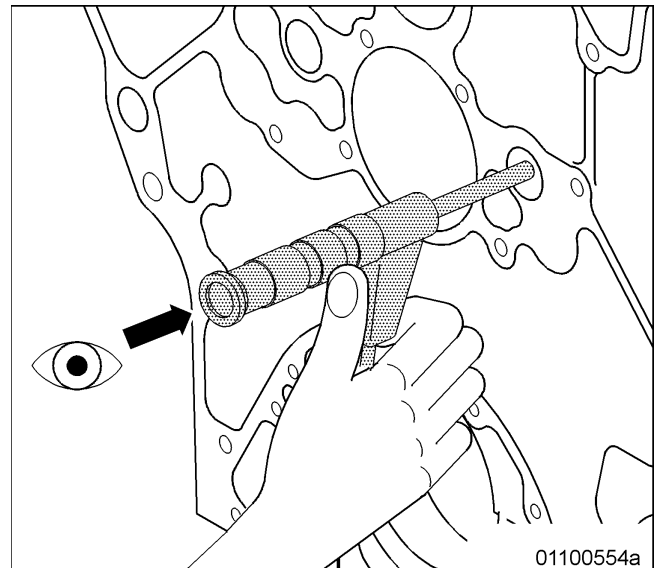
Crankcase – Check

Item	Findings	Task
Crack-test crankcase using surface crack-test method.	Signs of cracks	Contact Service.
Using the magnetic crack-testing method, check main bearing caps for cracks.	Signs of cracks	Replace component.
Check mating faces and upper and lower fits for cylinder liners in crankcase for wear, damage and cavitation.	<ul style="list-style-type: none"> • Wear • Damage • Cavitation visible 	To be carried out only in workshops authorized by MTU. Machine respective crankcase bore to next stage.
Check crankcase top for signs of wear, damage and cavitation.	<ul style="list-style-type: none"> • Wear • Damage • Cavitation visible 	To be carried out only in workshops authorized by MTU. Rework crankcase top.
Check screws for lateral location of main bearing caps for damage.	Damage visible.	Replace component.
Check camshaft bearings and guide bushes for wear and damage.	Damage visible.	Replace component (→ Page 66).
Check all mating and sealing faces and fits.	Traces of wear found.	<ul style="list-style-type: none"> • Recondition: Smooth with oilstone or emery cloth. • Replace
Check all threads for damage.	Damage visible.	Recut thread.
Check main bearing caps for wear and damage.	<ul style="list-style-type: none"> • Wear • Damage visible 	<ul style="list-style-type: none"> • Recondition • Replace
Check notched pins, register pins and dowel pins of main bearing caps for damage.	Damage visible.	Replace
Measure shaft length main bearing cap screws. Values (→ Page 23)	Values exceeded	Replace
Measure protrusion of dowel pins, register pins and notched pins. Values (→ Page 76)	Values exceeded or not attained.	Replace
Using an external micrometer, measure width of main bearing caps at upper and lower fits. Values (→ Page 76)	Values not attained.	Replace main bearing cap(s).

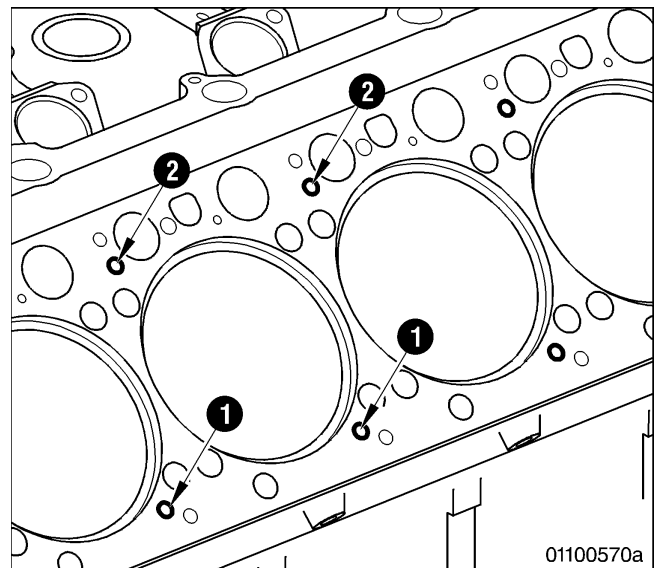
Checking oil bores in crankcase

Note: Use endoscope to inspect all coolant and oil bores. Pay special attention to metallic residues.

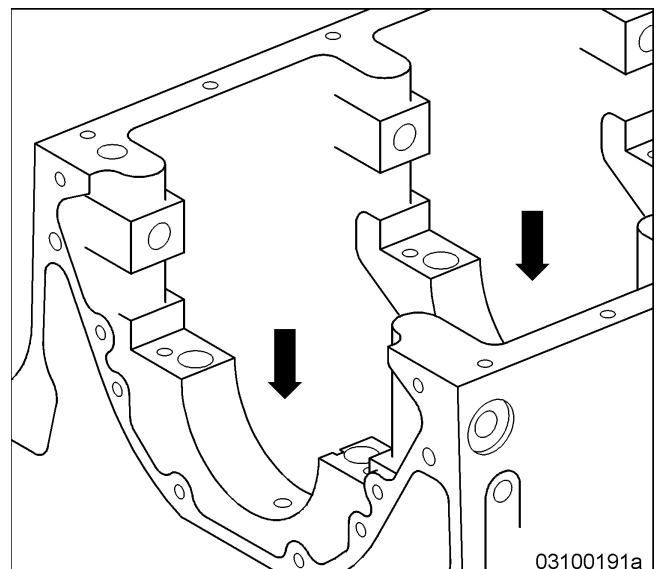
1. Check oil supply bores to valve gear at crankcase, sides A and B.



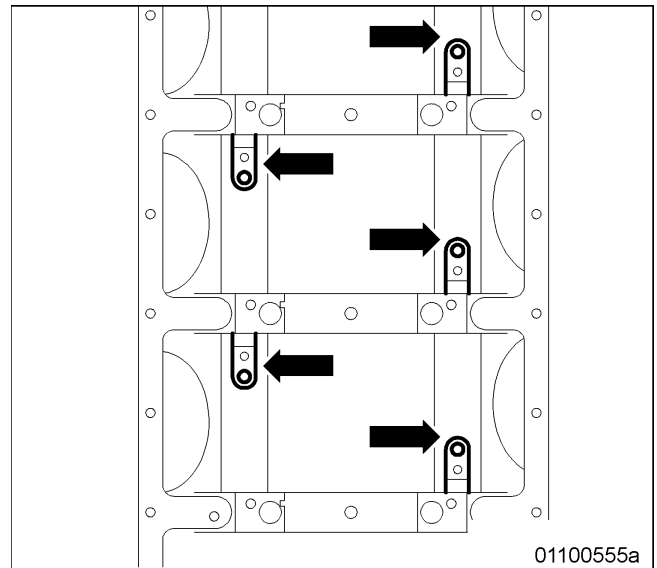
2. Check oil bores (2) for camshaft bearings and valve gear as well as oil return bores (1).



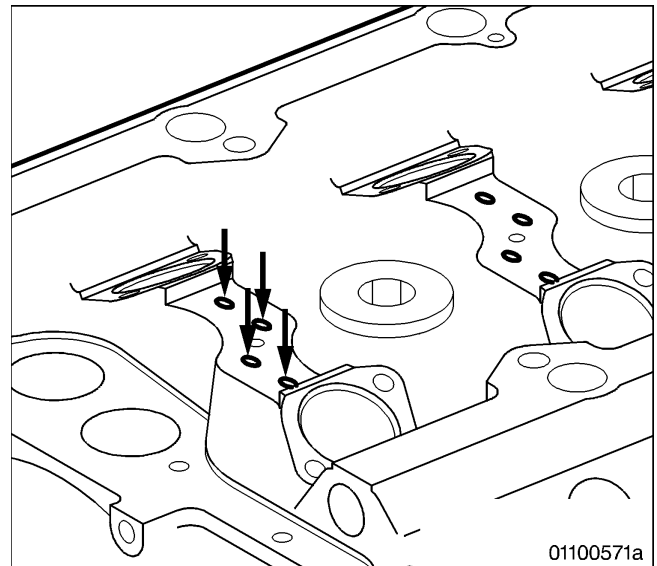
3. Check all oil bores of main bearing shells (arrows).
4. If the crankcase is then not immediately reassembled or taken back into service:
 - 4.1. Dry oil bores.
 - 4.2. Preserve oil bores.
 - 4.3. Seal oil bores air-tight with suitable plugs.



5. Check the oil bores (arrows) of the oil spray nozzles.



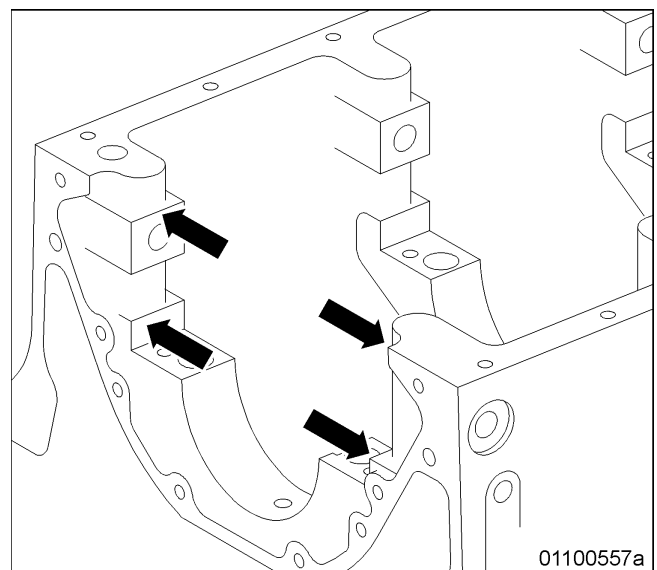
6. Check fuel bores (arrows) on all webs.
7. Check the other bores in the same way.



Measuring bearing cap guides

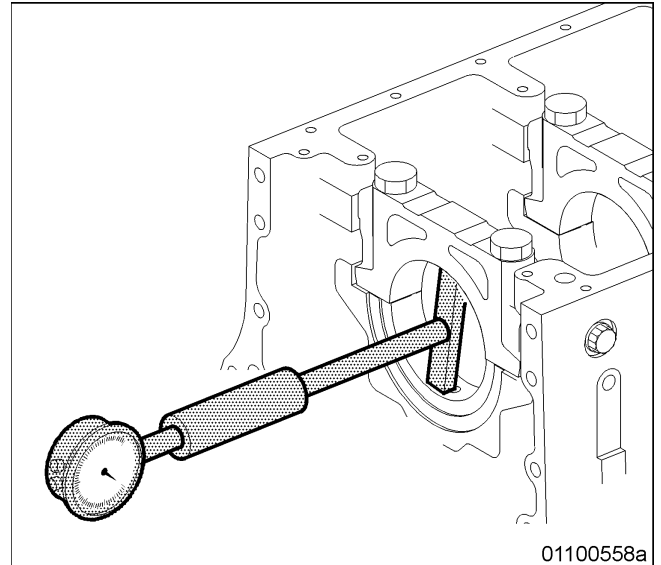
Note: Do not measure bearing cap guides with the crankcase installed in the crankcase rotation device (possible inaccuracies).

1. Remove crankcase from crankcase rotation device and place on a flat surface.
2. Using internal micrometer, measure bearing cap guides at upper and lower fits. Values (→ Page 76).
3. Install crankcase in crankcase rotation device.



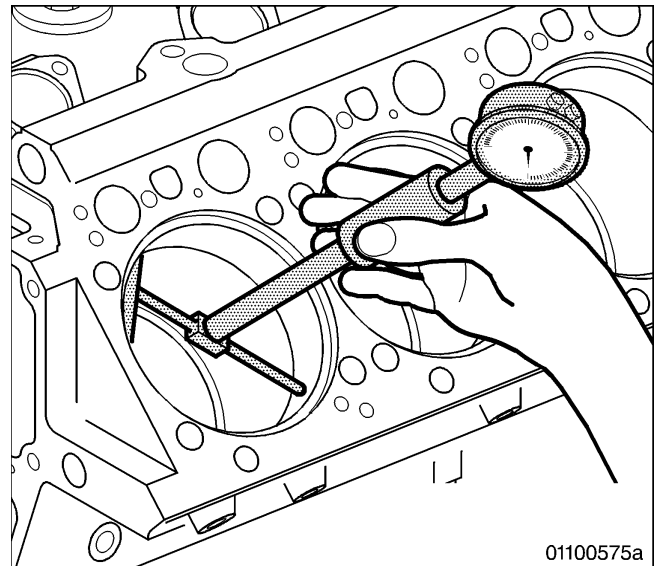
Measuring main bearing bore

1. Install bearing caps (→ Page 86).
2. Adjust bore gauge.
3. Using a bore gauge, measure the main bearing bore. Record measured values in data sheet. Values (→ Page 76)
4. If values are exceeded: Machine respective bore to next stage using a boring mill. To be carried out only in workshops authorized by MTU.



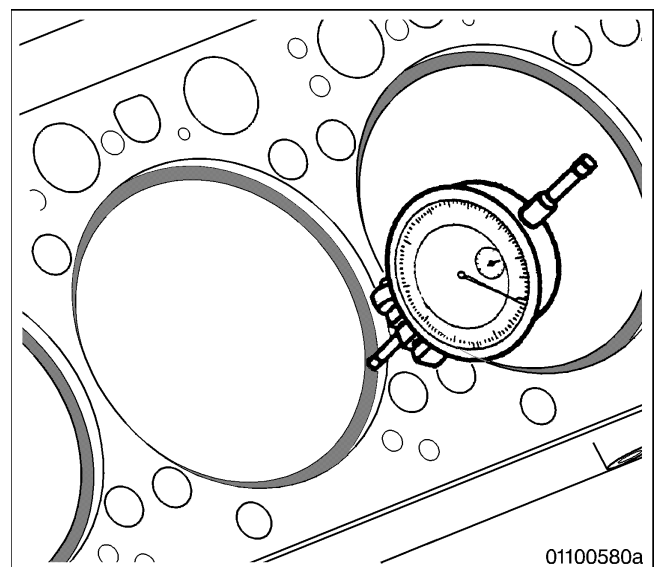
Measuring crankcase bores for cylinder liners

1. Measure upper and lower cylinder liner bores with bore gauge.
2. Record measured values in data sheet. Values (→ Page 76).
3. If values are exceeded: Machine respective crankcase bore to next stage using a boring mill. To be carried out only in workshops authorized by MTU.



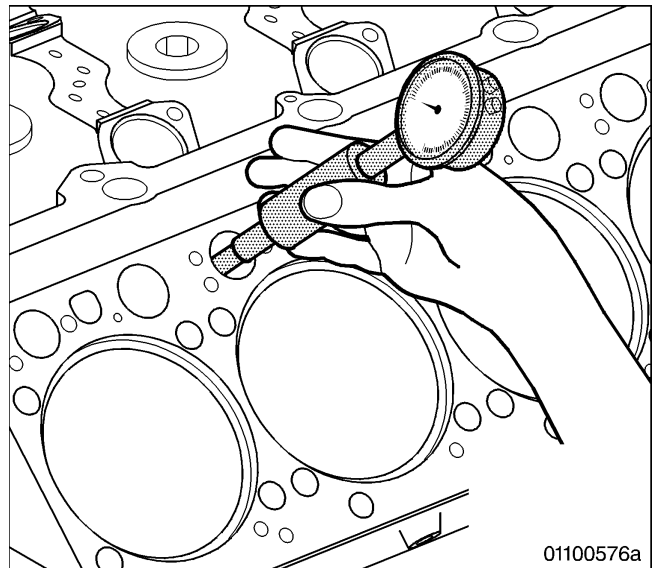
Measuring depth of upper cylinder liner fit

1. Attach dial gauge to holder.
2. Set dial gauge anvil onto seat of cylinder liner collar in crankcase.
3. Verify that dial gauge is pretensioned (approx. 3 to 4 mm).
4. Set dial gauge to zero.
5. Set dial gauge anvil onto the plane surface on crankcase and read off depth of upper cylinder liner fit.
6. Record measured values in data sheet. Values (→ Page 76).
7. If the value is exceeded: Machine respective cylinder liner fit to next stage using a boring mill. To be carried out only in workshops authorized by MTU.

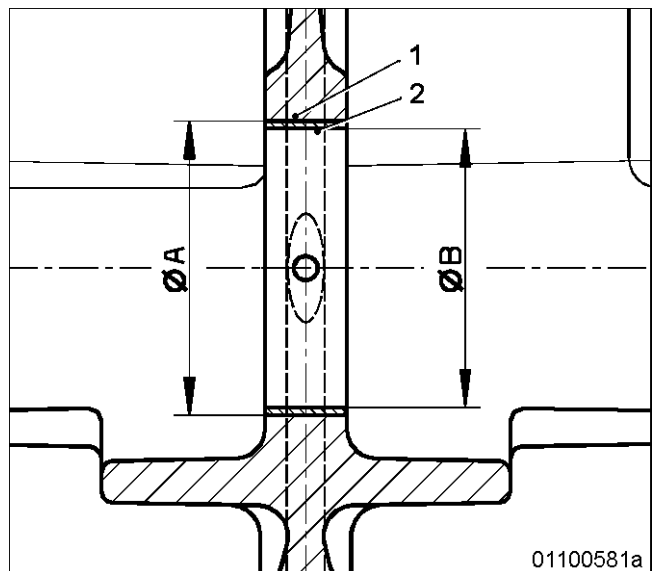


Measuring bore for valve tappets

1. Measure the bore using a bore gauge. Values (→ Page 76).
2. If the value is exceeded: Machine respective bore to next stage using a boring mill. To be carried out only in workshops authorized by MTU.

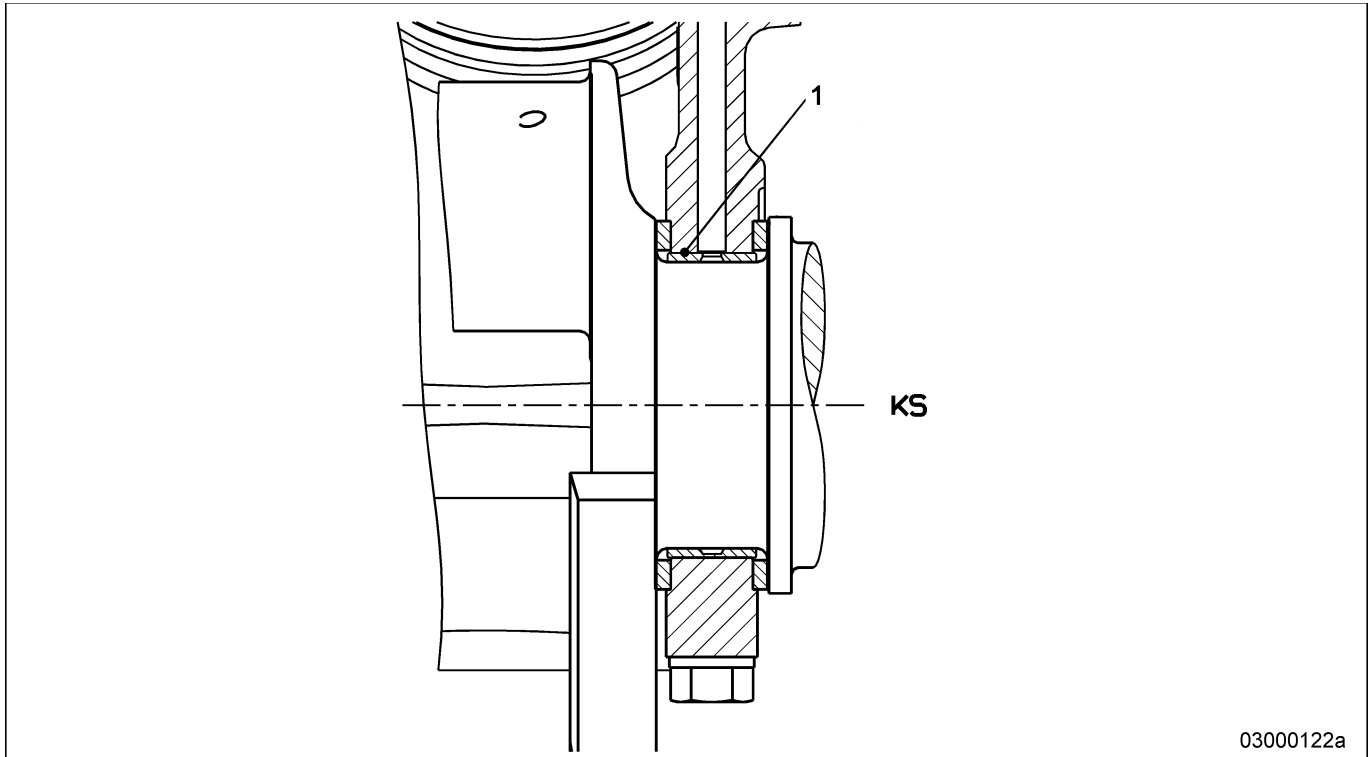
**Measuring camshaft bearing bush bore**

1. Measure diameter of camshaft bearing bush bore (dia. B) with bore gauge. Values (→ Page 76).
2. If values are exceeded: Remove camshaft bearing bush (2) (→ Page 66).
3. After removal of camshaft bearing bush: Measure diameter (dia. A) of the main camshaft bearing bore in the crankcase (1). Record measured values in data sheet. Values (→ Page 76).
4. If values are exceeded: Machine respective main camshaft bearing bore to next stage using a boring mill. To be carried out only in workshops authorized by MTU.
5. Install camshaft bearing bush (→ Page 86).



3.1.7 Crankcase – Tolerances

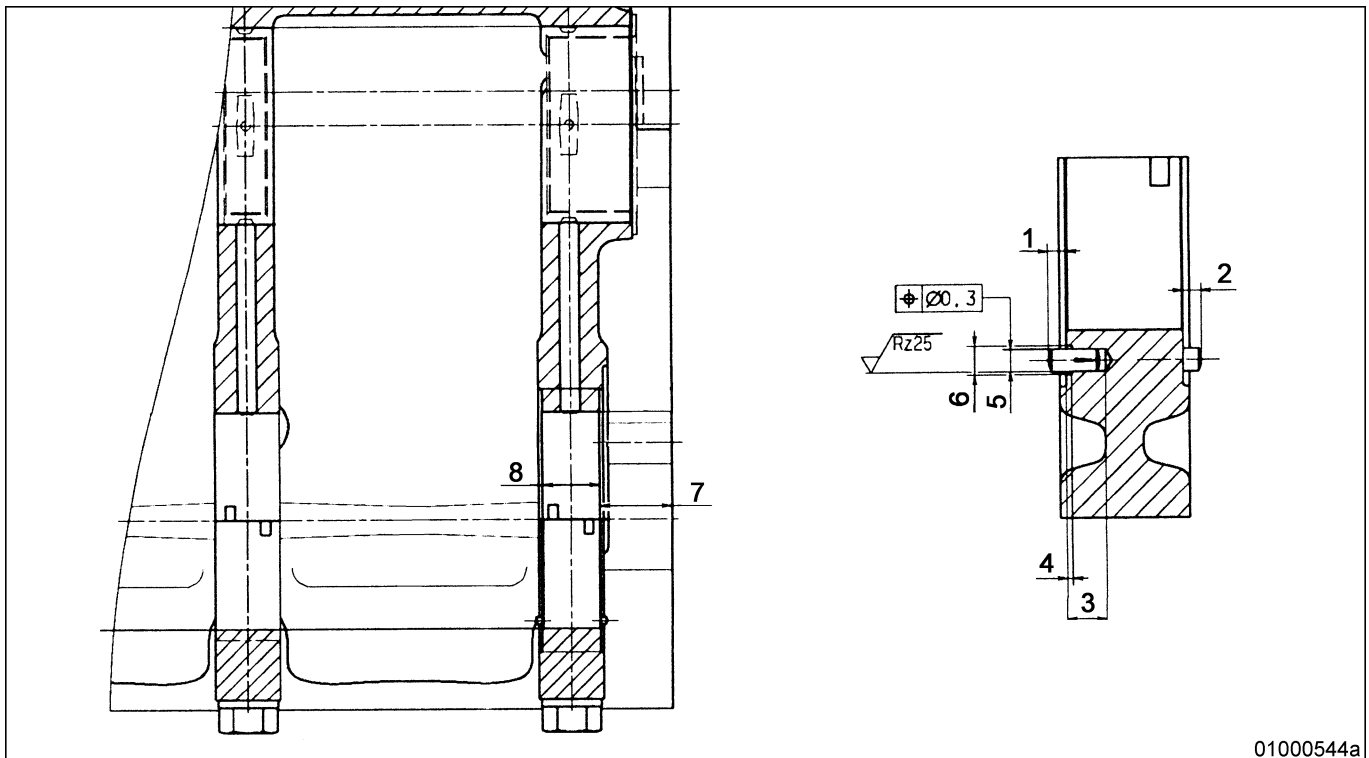
Main bearing bore



03000122a

No.	Designation	Stage	Tolerance size Basic size	Deviation		Clearance		Interference	
				lower	upper	min.	max.	min.	max.
1	Main bearing bore	0	115.000 H6	0	+0.022				
		1	115.250 H6						
		2	115.500 H6						

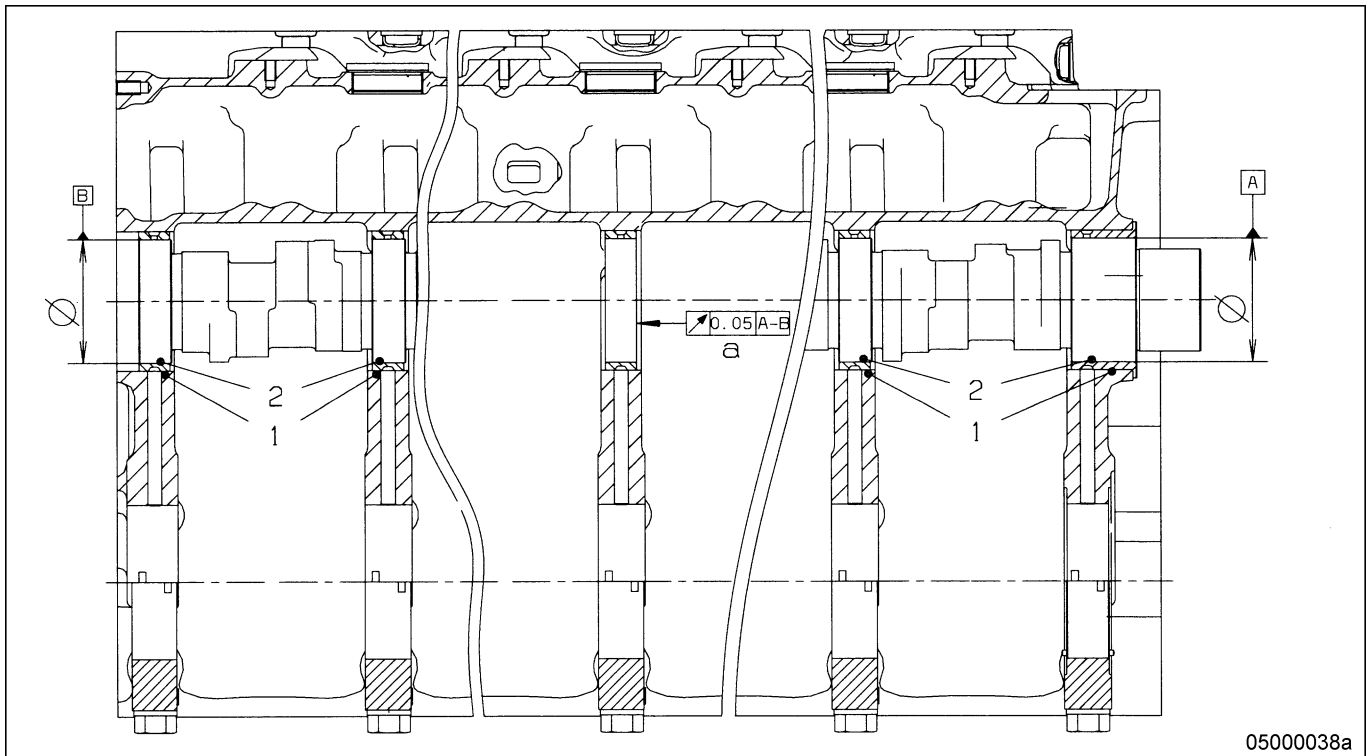
Thrust bearing and pin for thrust washer



01000544a

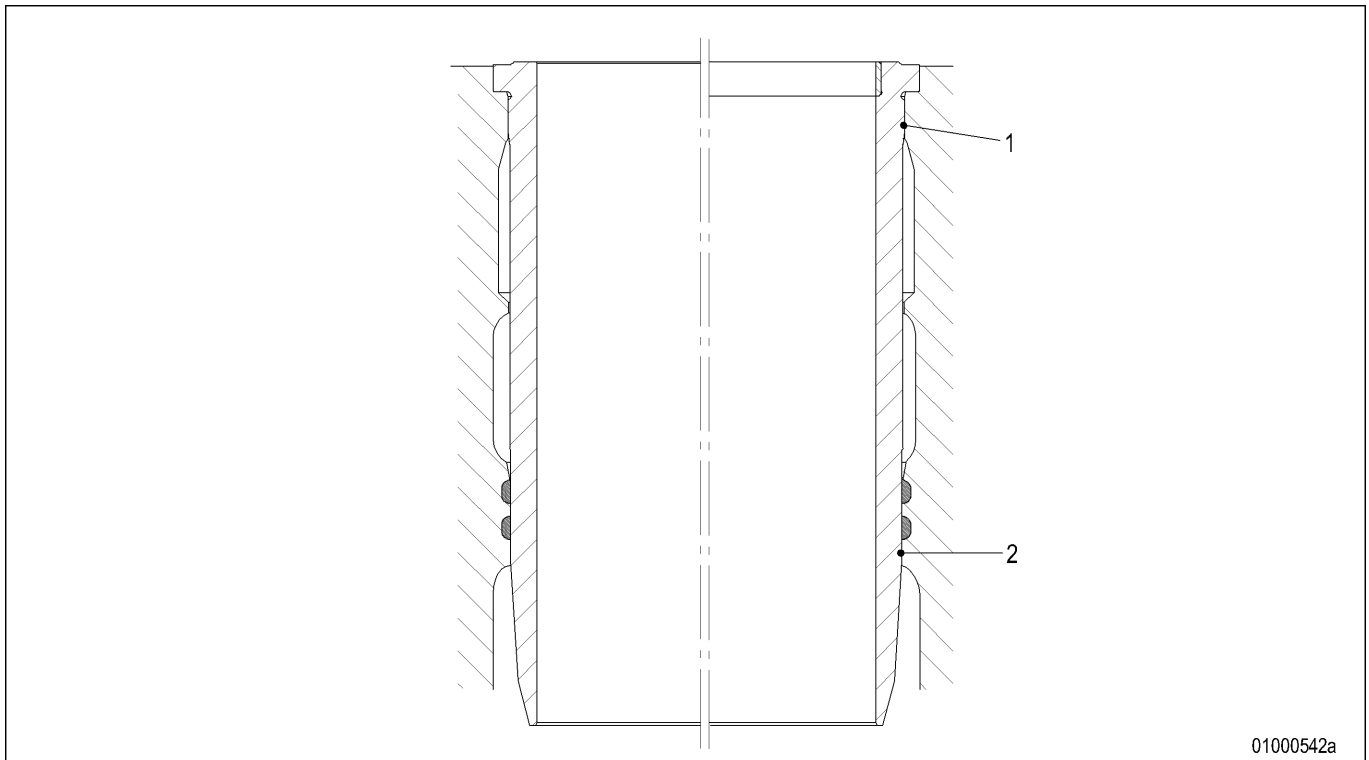
No.	Designation	Stage	Tolerance size Basic size	Deviation		Clearance		Interference	
				lower	upper	min.	max.	min.	max.
1	Pin protrusion		4.700	-0.200	0				
2	Pin protrusion		4.700	-0.200	0				
3	Pin bore depth		10.500	0	+1.000				
4	Depth of contour		1.400	0	+0.400				
5	Pin bore-Ø	0	3.950 H11	0	+0.075				
		1	5.950 H8	0	+0.018				
6	Pin bore Ø	0	5.500						
		1	7.500						
7	Thrust bearing	0	38.500	-0.100	+0.100				
		1	38.750						
8	Thrust bearing	0	31.000 h8	-0.039	0				
		1	30.500 H8						

Crankcase bore for camshaft



No.	Designation	Stage	Tolerance size Basic size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
1	Crankcase bore	0 - 0	104.000 H6	0	+0.022	0.092	0.172	0.043	0.084	
		1 - 0	104.500 H6							
	Bush OD removed	0 - 0	104.065	0	+0.019					
		1 - 0	104.565							
2	Cylinder liner ID installed		92.020	0	+0.045					
	Camshaft OD		92.000 e7	-0.107	-0.072					
a	all bearing points		0.050							

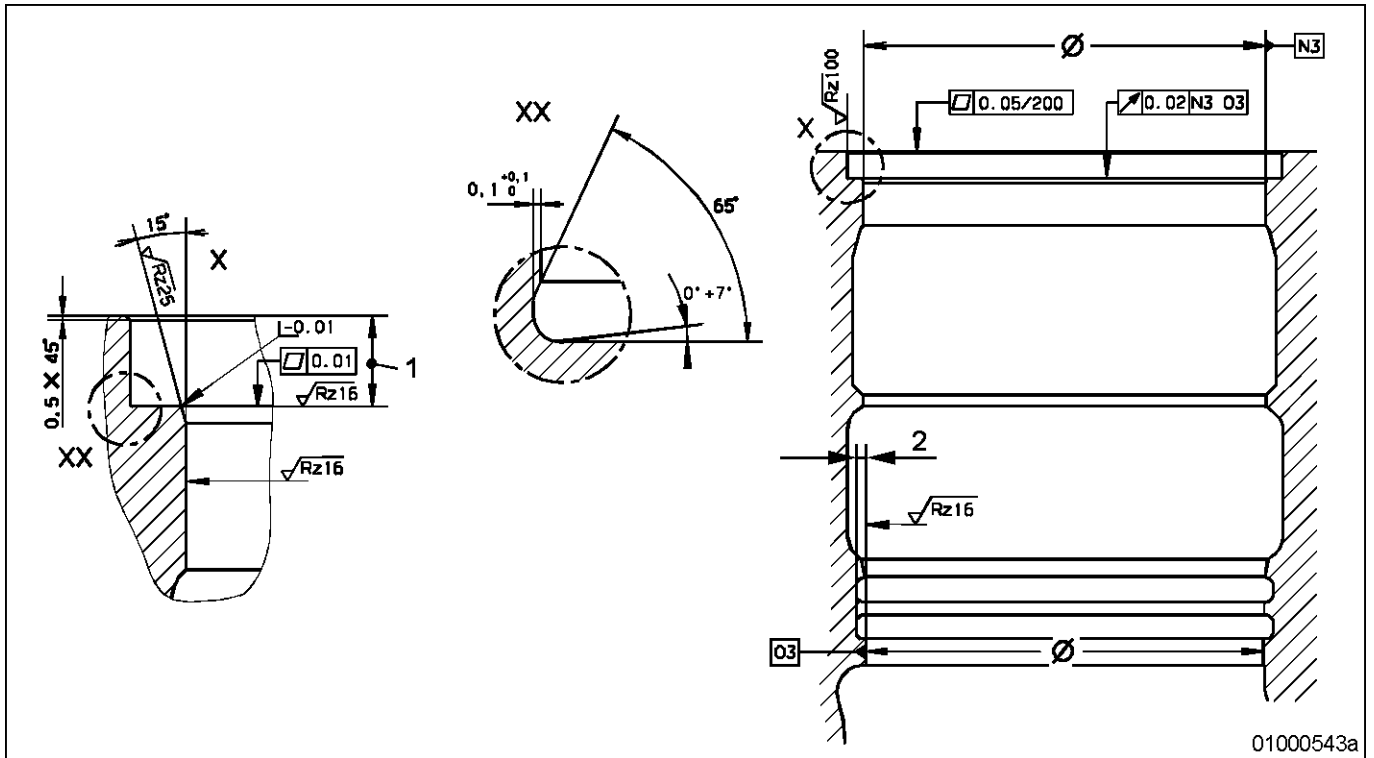
Crankcase bore for cylinder liner



01000542a

No.	Designation	Stage	Tolerance size Basic size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
1	Crankcase bore upper fit	0	152.000 H7	0	+0.040					
		1	152.500 H7							
2	Crankcase bore lower fit	0	150.000 H7	0	+0.040					
		1	150.500 H7							

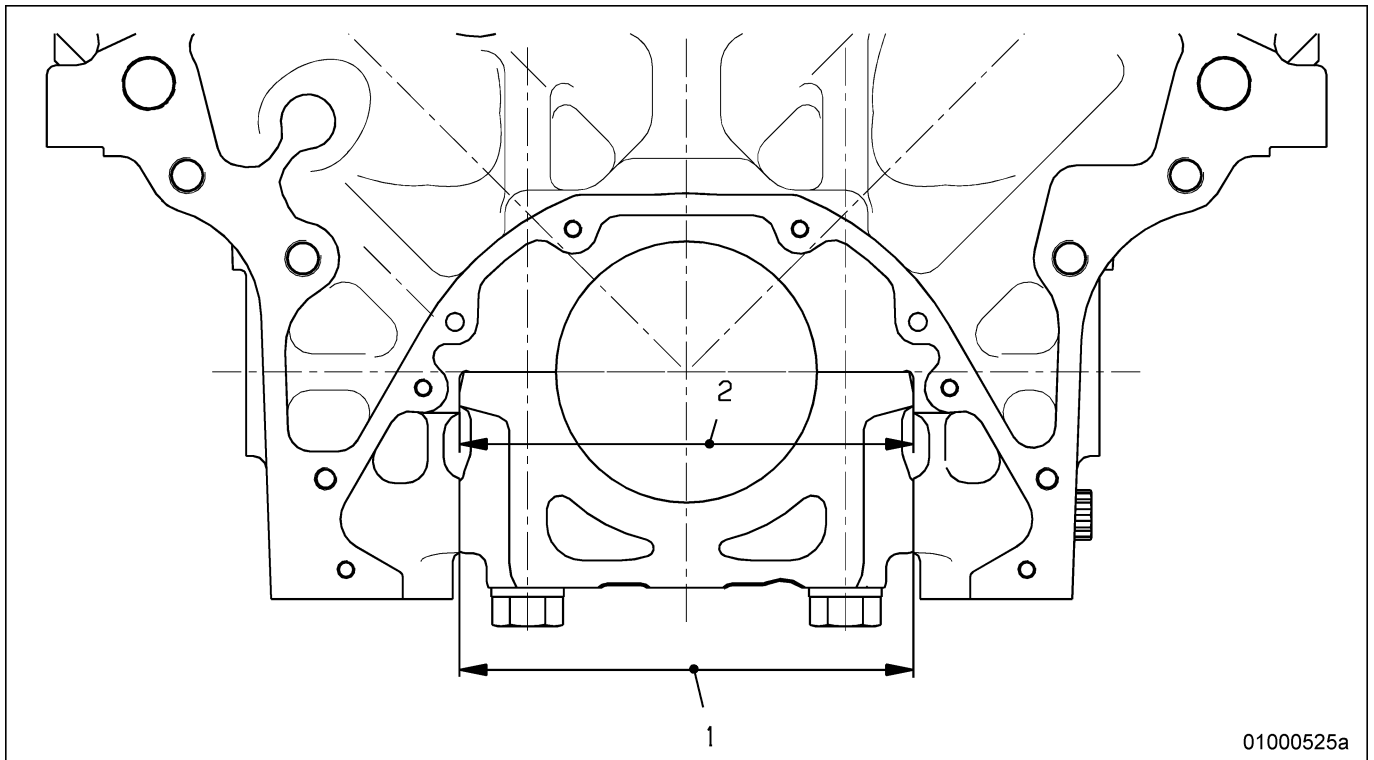
Crankcase bore for cylinder liner collar seat



01000543a

No.	Designation	Stage	Tolerance size Basic size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
1	Fit depth	0	9.980	-0.020	+0.020					10.050
		1	10.480							10.550
2	Depth	0	3.900	-0.200	+0.200					
		1	3.650							

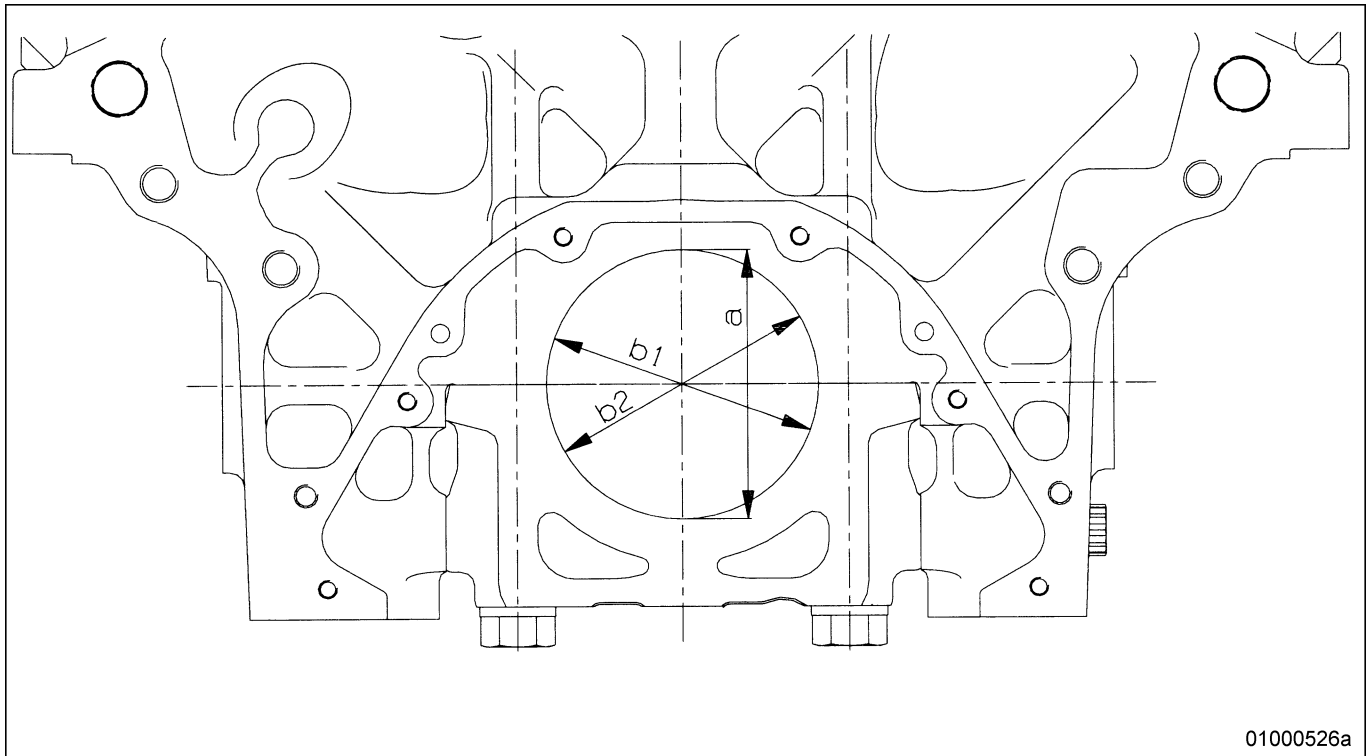
Main bearing cap



01000525a

No.	Designation	Stage	Tolerance size Basic size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
1	Bearing cap bed		200.000 E9	+0.100	+0.215	0.021	0.165			
	Bearing cap width		200.000 p6	+0.050	+0.079					
2	Bearing cap bed		200.000 H7	0	+0.046			0.004	0.079	
	Bearing cap width		200.000 p6	+0.050	+0.079					
Dowel and grooved pin protrusion: 12 mm to 13.5 mm										
Grooved pin protrusion: 4.5 mm to 4.7 mm										

Main bearing bore



Install main bearing caps in crankcase in accordance with the installation instructions and tighten screws in accordance with tightening specifications.

Measure main bearing bores:

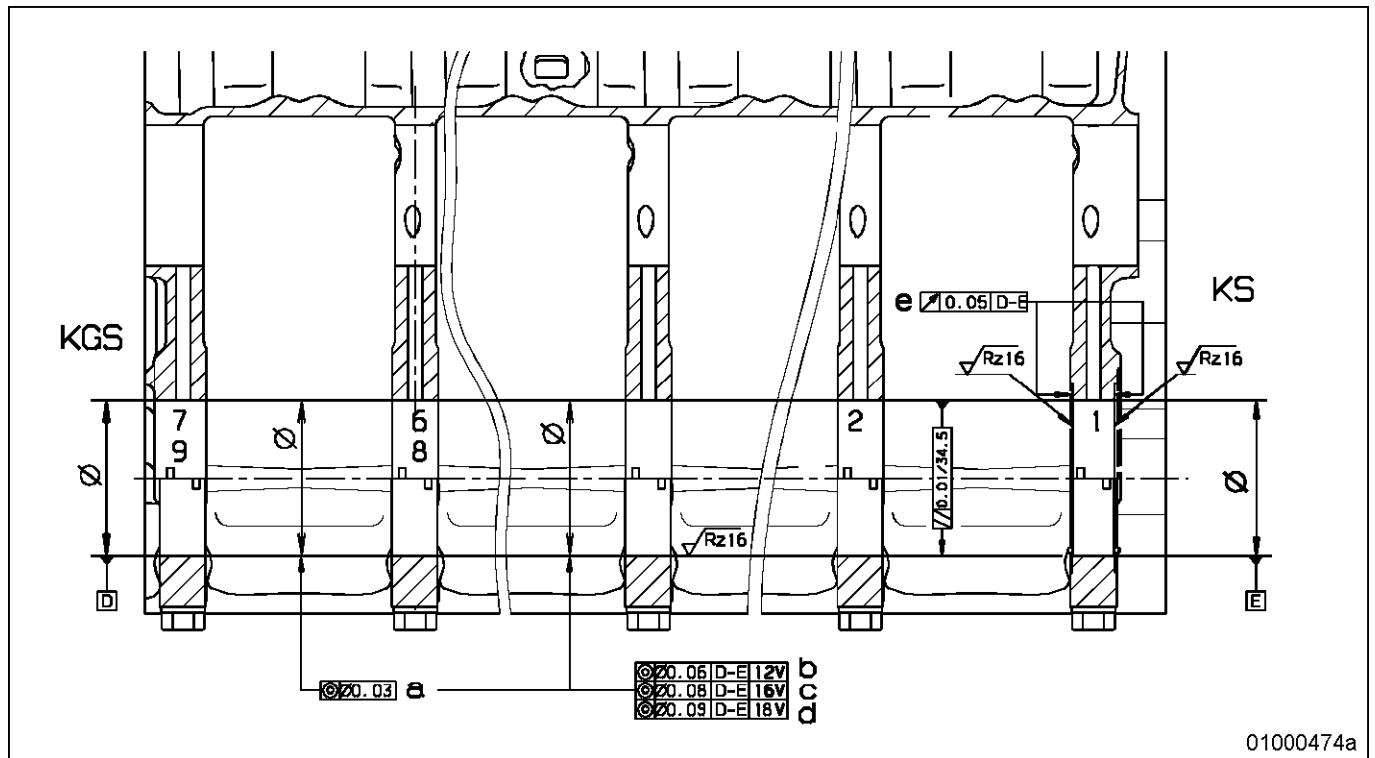
- Determine diameters a , $b1$ and $b2$ in two measuring planes and calculate the averages for a , $b1$ and $b2$.

Check bore roundness:

- Deviations from roundness can be determined from the average values for a , $b1$ and $b2$ as follows: $0.5 (b1+b2)-a$

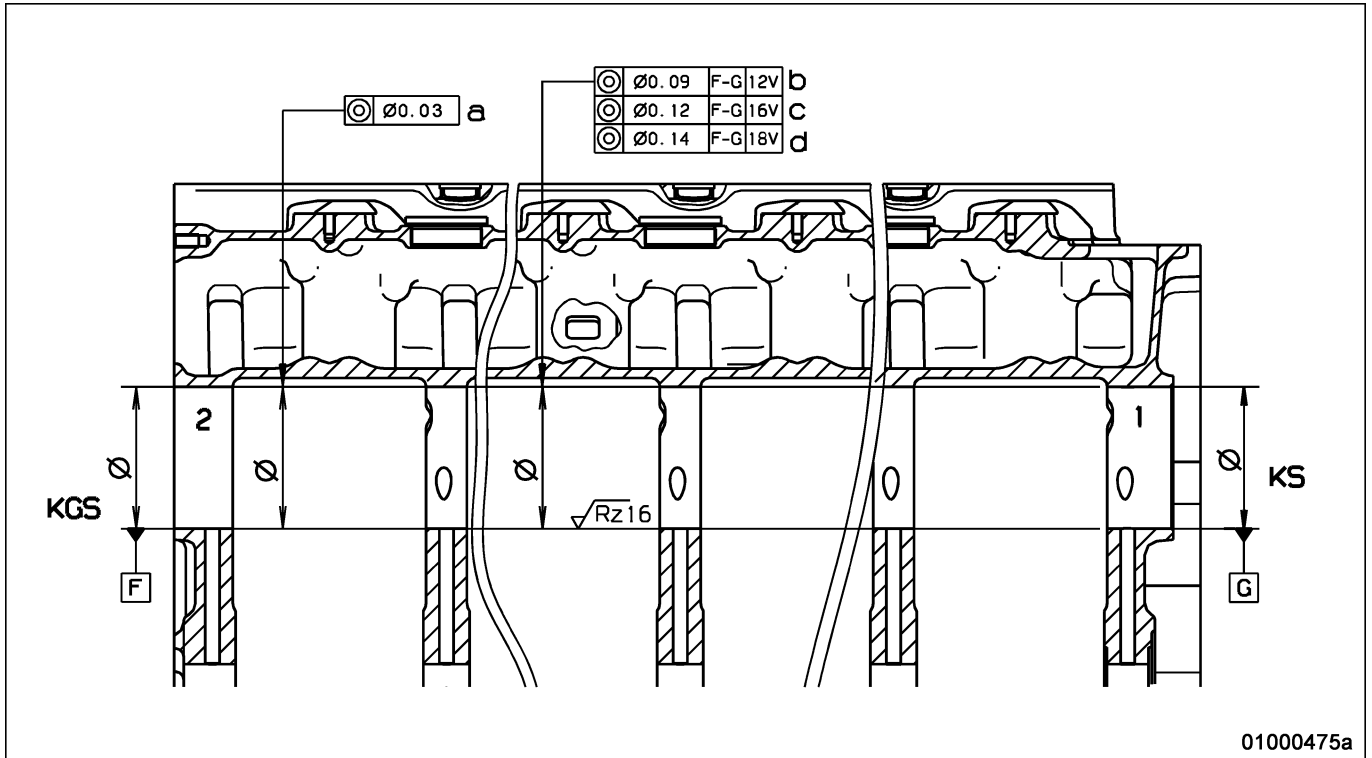
Vertical ovality greater than $0.5 (b1+b2)$ is not permitted

Crankcase crankshaft bore coaxiality



	Max. permitted deviation of concentricity	New	Wear limit
a	over three bearings, i.e. with the adjacent left and right bearing	Ø 0.030	Ø 0.040
b	12V: from main bearing 1 to 7	Ø 0.060	Ø 0.120
c	16V: from main bearing 1 to 9	Ø 0.080	Ø 0.140
d	18V: from main bearing 1 to 10	Ø 0.090	Ø 0.150
e	applies to bearing 1	∠ 0.050	∠ 0.060

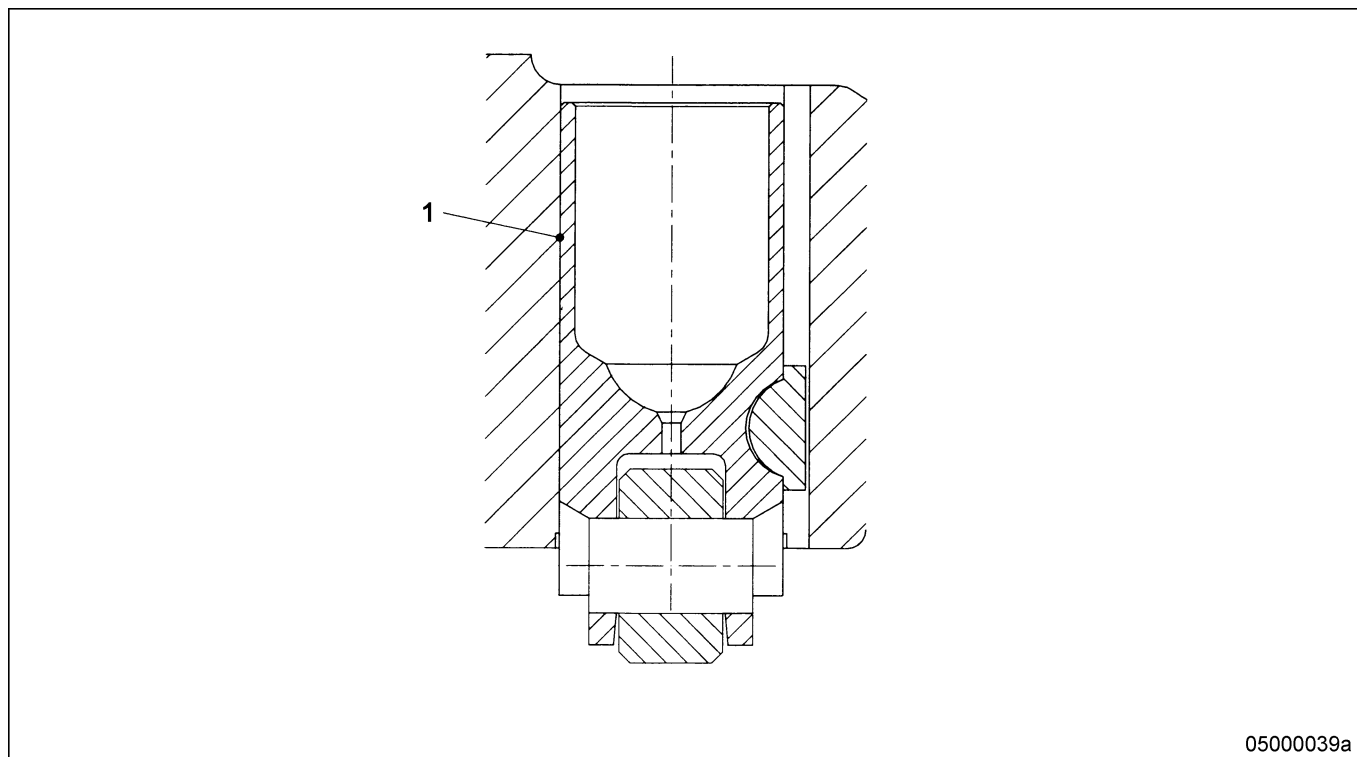
Crankcase camshaft bore coaxiality



01000475a

	Max. permitted deviation of concentricity	New	Wear limit
a	over three bearings, i.e. with the adjacent left and right bearing	∅ 0.030	∅ 0.040
b	12V: from main bearing 1 to 2	∅ 0.090	∅ 0.120
c	16V: from main bearing 1 to 2	∅ 0.120	∅ 0.140
d	18V: from main bearing 1 to 2	∅ 0.140	∅ 0.150

Valve roller tappets



05000039a

No.	Designation	Stage	Tolerance size Basic size	Tolerance size		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
1	Crankcase bore	0	30.000 H7	0	+0.021					
		1	30.500 H7	0	+0.025					

Crankcase top deck

No.	Designation	Stage	Tolerance size Basic size	Tolerance size		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
	Top deck	0	426.000	-0.100	+0.100					
		1	425.800	0						

3.1.8 Crankcase – Assembly

Special tools

Designation / Use	Part No.	Qty.
Guide tube stage 0-0	F6555713	1
Guide tube stage 1-0	F6557976	1
Stop pin Ø30	F6555714	1
Stop pin Ø30.25	F6557924	1
Stop pin Ø30.5	F6557925	1
Shrinking tool	F30377289	1
Mandrel	F30378876	1
Rotation device assembly	F6554681	1
Support	F6554682	4
Distance plate	F6554683	2
Support	F6554684	2
Support	F6554685	2

Material

Designation / Use	Part No.	Qty.
Petroleum jelly, white		
Surface sealant Loctite 573		
Engine oil		
Dry compressed air		
Liquid nitrogen		
Screw locking compound Loctite 270		

Spare parts

Designation / Use	Part No.	Qty.
Gasket		
O-rings		
Plug		
Camshaft bearing		
Main bearing cap		
Screws for main bearing cap		



DANGER

Suspended load.

Danger to life!

- Use appropriate lifting devices and appliances.
- Never stand beneath a suspended load.






DANGER

Nitrogen is liquid (at -200°C).

Risk of freezing and suffocation!

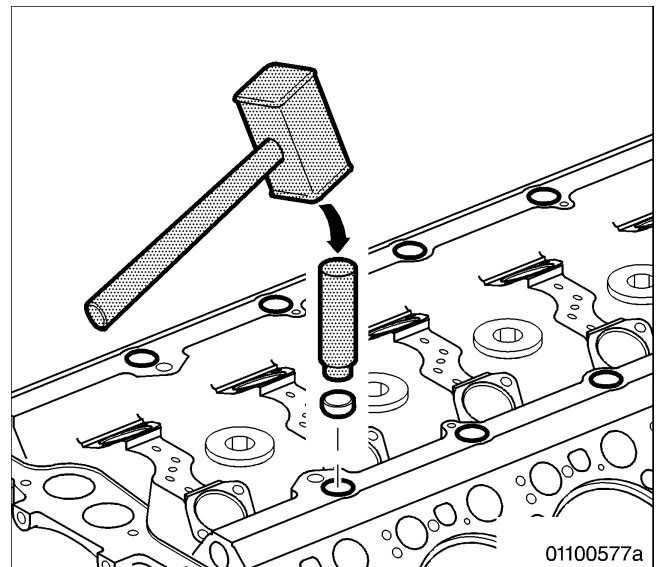
- Do not allow liquid nitrogen to come into contact with parts of body (eyes, hands).
- Wear protective clothing, gloves, and goggles / safety mask.
- Ventilate working area well.

 WARNING	Components have sharp edges. Risk of injury! <ul style="list-style-type: none"> • Wear protective gloves.
 CAUTION	Contamination of components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Check components for special cleanness.
 CAUTION	Contamination in blind hole. Damage to component! <ul style="list-style-type: none"> • Inspect and clean blind hole.

Check crankcase (→ Page 70).

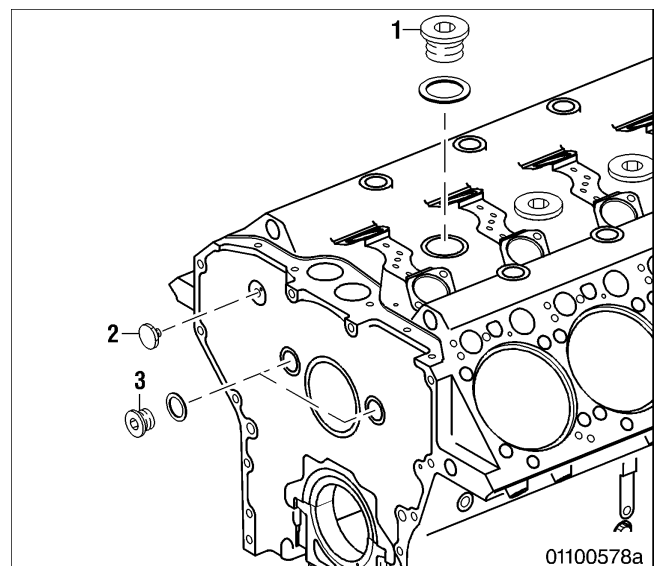
Installing plugs

1. Clean mating face on plug and crankcase bore, ensuring that it is free of grease and dry.
2. Coat mating surface with screw locking compound.
3. Using hammer and mandrel, knock plug into the crankcase bore.



Sealing coolant and oil bores

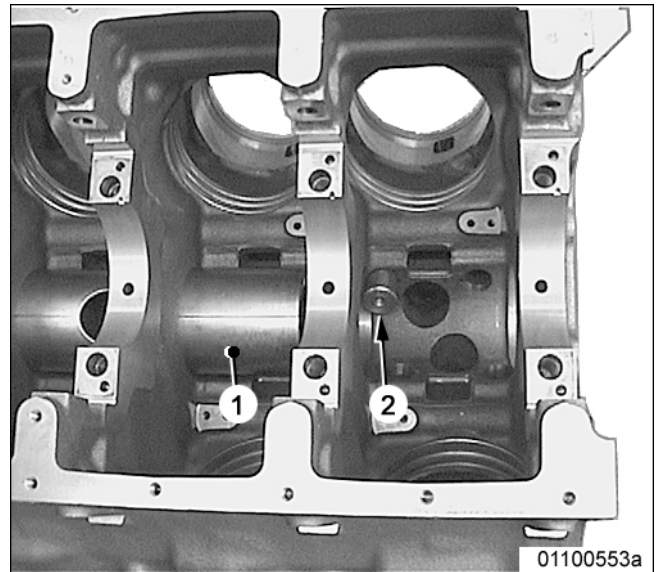
1. Screw in securing screws (3) with sealing rings and use torque wrench to tighten to specified tightening torque (→ Page 23) using torque wrench.
2. Clean thread of screw (2) and the corresponding crankcase thread to ensure that they are free of grease and dry.
3. Coat threads of screw (2) with surface sealant.
4. Insert screw (2) and tighten.
5. Insert screw (1) and sealing ring and tighten.



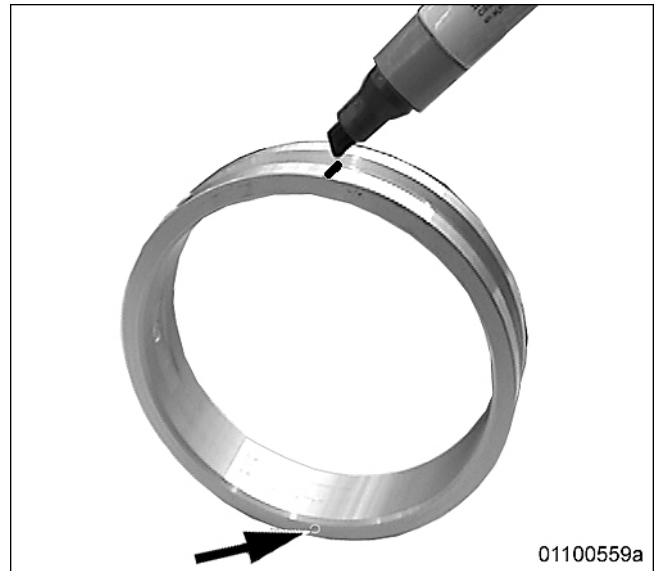
Installing camshaft bearings

Note: Installation sequence of camshaft bearings: starting from engine free end.

1. Clean oil bores and check for obstructions.
2. Insert guide tube (1) of camshaft bearing into crankcase and up to the first bearing seat at free end.
3. Fit stop pin (2) in second tappet bore of B-side, ensuring correct position.



4. Mark the camshaft bearing bush opposite the existing mark (arrow).



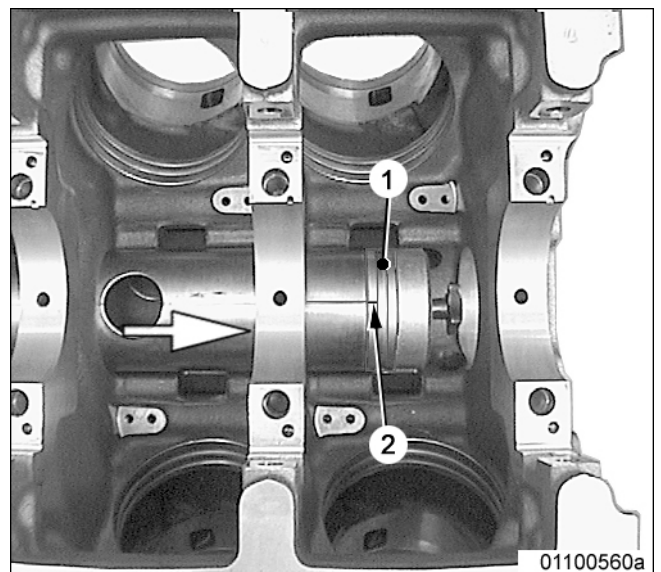
5. Chill camshaft bearing bush (1) in liquid nitrogen.
6. Insert guide tube.

Note: Bearing mark points to engine driving end

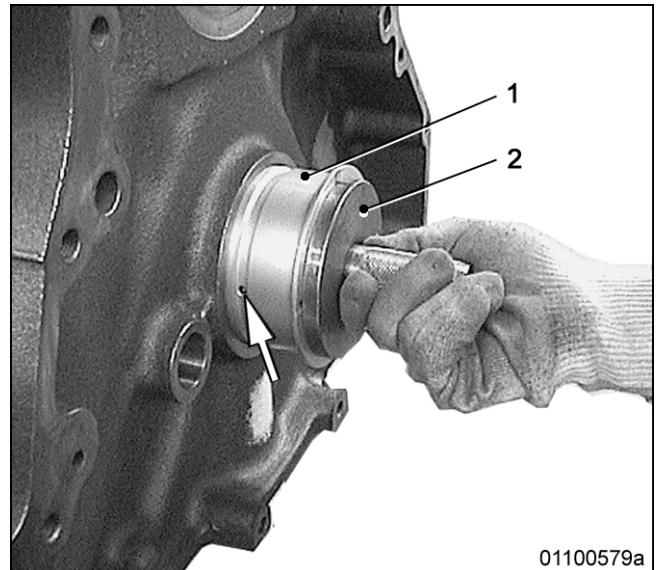
7. Fit the camshaft bearing bush (1) on guide tube, ensuring that the markings (2) of the guide tube and the camshaft bearing bush (1) are aligned.
8. Push guide tube towards engine free end (arrow) until it stops at the stop pin.

Result: The oil bore of the installed camshaft bearing bush (1) is in 9 o'clock position when viewed from driving end and with the oil-pan mating face facing upward.

9. When the camshaft bearing bush (1) is at room temperature, remove guide tube and stop pin and install the neighboring camshaft bearing bush (1) as described above.



10. Chill last camshaft bearing bush (1) in liquid nitrogen.
11. Use shrink-on tool (2) to insert camshaft bearing bush (1) from driving end flush into crankcase bore for camshaft.
Result: The oil bore of the installed camshaft bearing bush (1) is in 9 o'clock position when viewed from driving end and with the oil-pan mating face facing upward.
12. Measure diameter of camshaft bearing bushes (1) after installation. Values (→ Page 76)

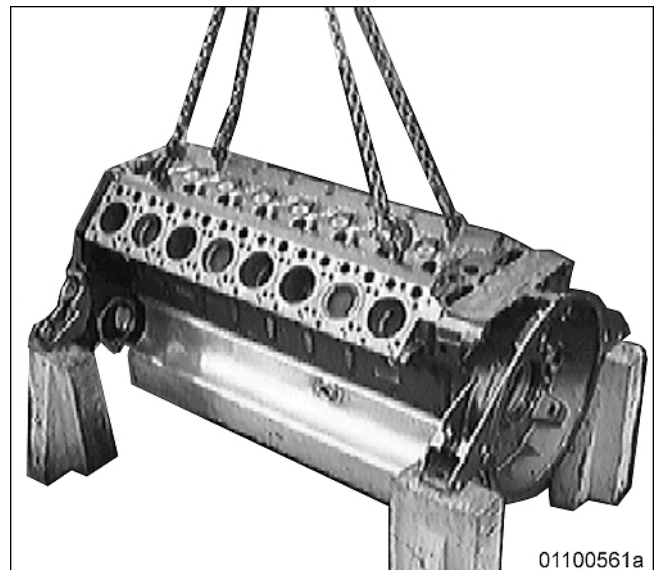


Installing main bearing caps

1. Position engine in crankcase rotation device so that its oil pan mating face is facing upward and in horizontal position.
2. Install main bearing caps (→ Page 217).

Removing crankcase from rotation device

1. Install four eyebolts in crankcase.
2. Attach crankcase with lifting device and ropes to crane, lift to remove slack and tension all ropes evenly.
3. Release crankcase from rotation device and remove supports for rotation device.
4. Lift crankcase with lifting device off the rotation device and set down on supports.



3.1.9 Dowel pin for crankshaft bearing cap – Replacement

Special tools

Designation / Use	Part No.	Qty.
Copper hammer		

Material

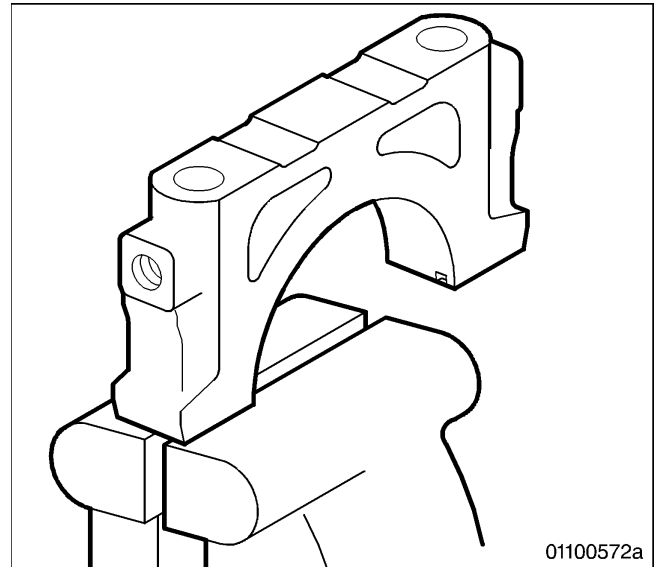
Designation / Use	Part No.	Qty.
Engine oil		

Spare parts

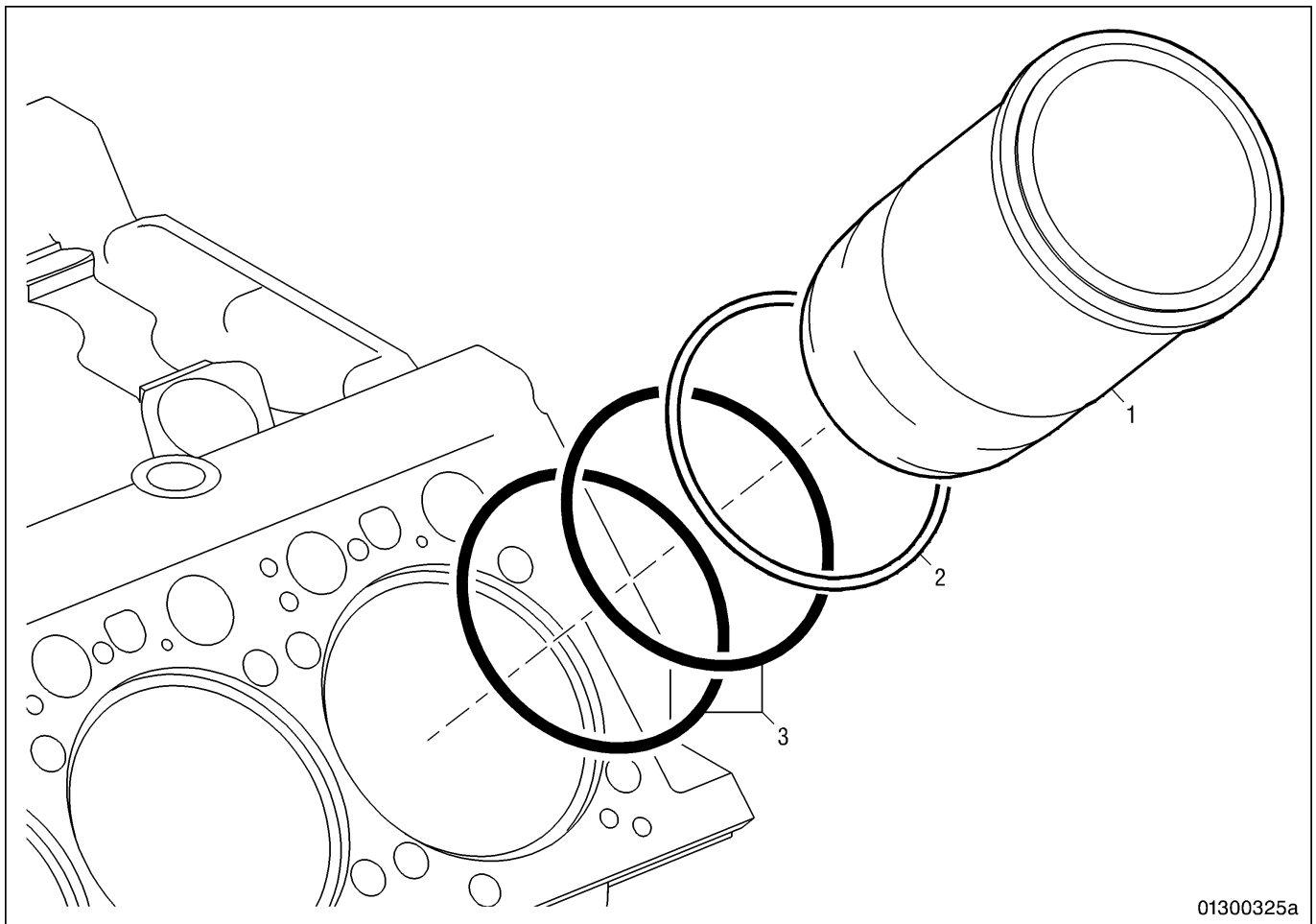
Designation / Use	Part No.	Qty.
Dowel pin		

Replacing dowel pin

1. Install crankshaft bearing cap at dowel pin in bench vise and withdraw dowel pin.
2. Clean main bearing cap (→ Page 69).
3. Use copper hammer to install new dowel pin.
4. Measure protrusion of dowel pin. Values (→ Page 76)



3.1.10 Cylinder liner – Overview



1 Cylinder liner

2 Lower sealing ring

3 Sealing ring (Tombak)



3.1.11 Cylinder liner – Removal

Preconditions

- Engine is stopped and starting disabled

Special tools

Designation / Use	Part No.	Qty.
Cylinder liner removal/installation tool	5415890133/00	1

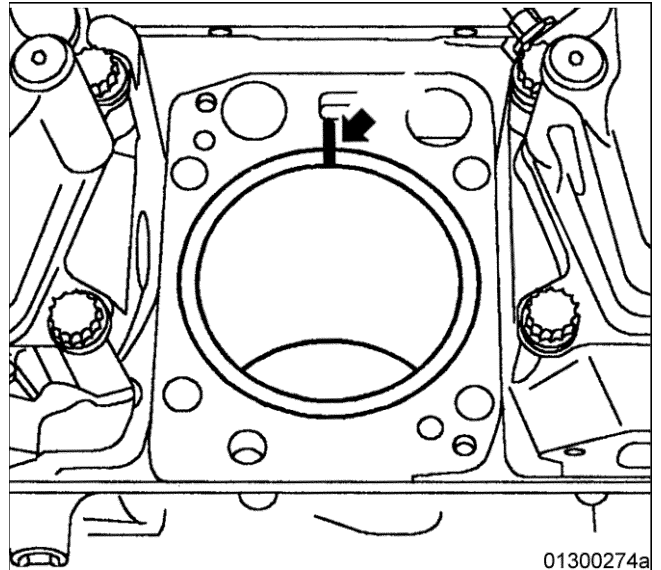
 WARNING	Heavy object. Risk of crushing! <ul style="list-style-type: none"> • Use appropriate lifting devices and appliances.
 WARNING	Components have sharp edges. Risk of injury! <ul style="list-style-type: none"> • Wear protective gloves.

Preparatory steps

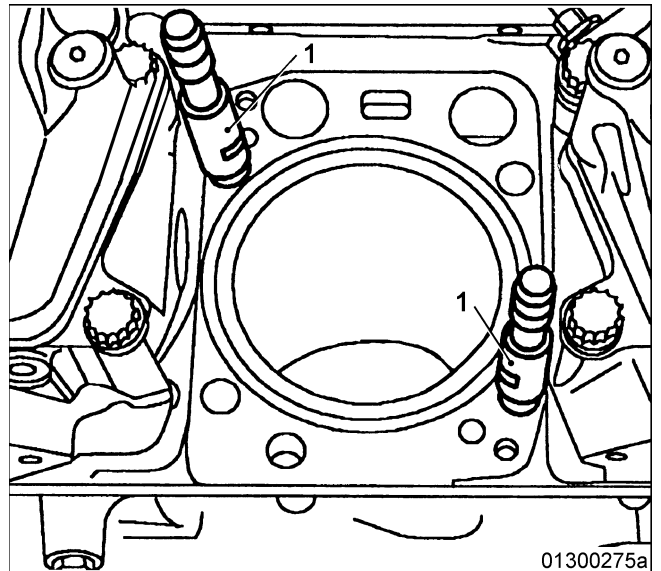
For these steps a distinction must be made as to whether				
1 the engine is to be completely disassembled				
2 the engine is to be removed but not disassembled				
3 the engine is to remain installed				
1	2	3	Operations	See
X	–	–	Remove engine.	(→ Page 55)
X	–	–	Disassemble engine.	(→ Page 56)
–	–	X	Disable engine start.	(→ Page 15)
–	–	X	Drain engine coolant.	(→Operating instructions)
–	–	X	Drain charge-air coolant.	(→Operating instructions)
–	–	X	Drain or draw off engine oil.	(→Operating instructions)
–	X	X	Remove exhaust turbocharger.	(→ Page 432)
–	X	X	Remove monitoring and control devices.	(→Operating instructions)
–	X	X	Remove charge-air pipe.	(→ Page 461)
–	X	X	Remove cylinder head cover.	(→ Page 371)
–	X	X	Remove exhaust line.	(→ Page 466)
–	X	X	Remove HP line.	(→ Page 393)
–	X	X	Remove leak-off fuel pipework.	(→ Page 427)
–	X	X	Remove valve drive.	(→ Page 359)
–	X	X	Remove pushrods.	(→ Page 350)
–	X	X	Remove cables (injector).	(→ Page 604)
–	X	X	Remove cylinder head.	(→ Page 303)
–	X	X	Lower or remove oil pan.	(→ Page 104)
–	X	X	Remove piston and conrod.	(→ Page 255)

Removing cylinder liner

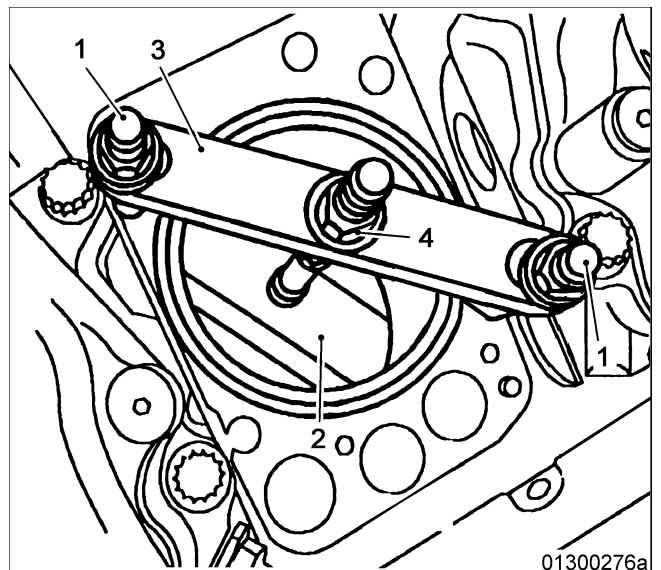
1. Mark installation position of cylinder liner to crankcase with a marking pen (arrowed).



2. Insert screws (1) into threaded bores for cylinder head screws opposite.



3. Attach extraction plate (2) at bottom collar of cylinder liner. Do not damage the oil spray nozzle.
4. Place counter support (3) onto spindle and studs (1) and screw tight.
5. Turn nut (4) on removal tool until cylinder liner loosens on crankcase bore.
6. Detach removal tool.
7. Pull cylinder liner out of crankcase.
8. Remove sealing rings from cylinder liner.



3.1.12 Cylinder liner – Cleaning

Material

Designation / Use	Part No.	Qty.
Decarbonizer		
Cleaning agent		



CAUTION

Excessive reaction time of cleaning agents on components.

Damage to component!

- Observe manufacturer's instructions.
- Wear protective clothing, gloves, and goggles / safety mask.

Remove cylinder liner (→ Page 92).

Cleaning cylinder liner

1. Clean cylinder liner using cleaning agent.
2. Remove cleaning agent.

3.1.13 Cylinder liner – Check

Special tools

Designation / Use	Part No.	Qty.
Bore gauge		
Dial gauge		
Micrometer or adjusting ring		

Material

Designation / Use	Part No.	Qty.
Fluorescent dye for magnetic crack testing		

Spare parts

Designation / Use	Part No.	Qty.
Cylinder liner		



Heavy object.
Risk of crushing!

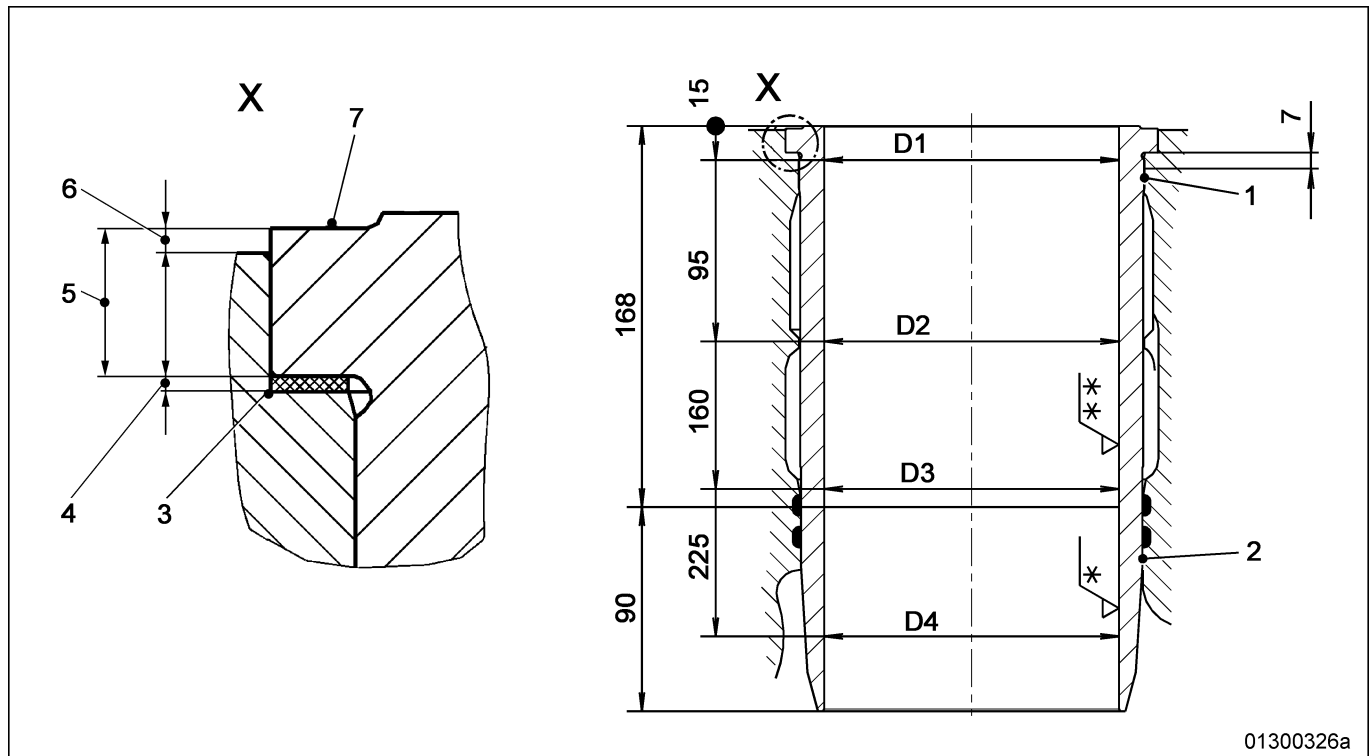
- Use appropriate lifting devices and appliances.

Clean cylinder liner (→ Page 95).

Checking cylinder liner

Item	Findings	Task
Check cylinder liner for cracks using magnetic crack testing procedure and fluorescent dye.	Cracks apparent	Replace
Check outer wall for pitting.	Pitting visible	Replace
Check sealing and mating faces for wear and damage.	<ul style="list-style-type: none"> • Traces of wear • Damage visible 	<ul style="list-style-type: none"> • Rework: Smooth using oilstone. • Replace
Check cylinder liner running surface for scores and pitting.	<ul style="list-style-type: none"> • Scores • Pitting visible 	Replace
Check reversal point of first piston ring for wear.	Wear visible	Replace cylinder liner.
Measure cylinder liner bore with bore gauge and dial gauge. Measurement plane and values (→ Page 97)	Values exceeded	Replace

3.1.14 Cylinder liner – Tolerances



01300326a

No.	Designation	Stage	Tol. size Basic size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
1	Crankcase bore - upper fit	0	152.000 H7	0	+0.040	0.007	0.071			152.070 152.570
		1	152.500 H7							
	Cylinder liner - upper fit	0	152.000	-0.031	-0.007					
		1	152.500							
2	Crankcase bore - lower fit	0	150.000 H7	0	+0.040	0.025	0.089			150.054 150.554
		1	150.500 H7							
	Cylinder liner - lower fit	0	150.000	-0.049	-0.025					
		1	150.500							
3	Crankcase bore		164.200 H9	0	+0.100	0.400	0.700			
	Gasket OD		163.700							
4	Sealing ring		0.150	-0.010	+0.010					
5	Cylinder liner collar thickness	0	10.120	-0.020	0					
		1	10.620							
6	Cylinder liner protrusion: 0.245 to 0.315									

No.	Designation	Stage	Tol. size Basic size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
7	Tolerance size letter etched in here									
D1	Plane of measurement		B	129.995	130.005					
D2	Plane of measurement		B	129.995	130.005					
D3	Plane of measurement		B	129.995	130.005					
D4	Plane of measurement		B	130.011	130.021					

Reconditioning instructions

Re. 1 Crankcase bore: Wear limit of approx. 7 mm permissible.

Re 1 and 2:

If cavitation is found on the upper and/or lower crankcase bore fit:

Introduce next repair stage and install cylinder liner of corresponding stage.

To be carried out only in workshops authorized by MTU.

Re 6:

Check scraper ring OD and ID when fitted.

3.1.15 Cylinder liner – Installation

Special tools

Designation / Use	Part No.	Qty.
Cylinder liner removal/installation tool	5415890133/00	1
Safety rail	F6555715	2
Measuring plate	5415890021/00	1

Material

Designation / Use	Part No.	Qty.
Petroleum jelly, white		
Engine oil		

Spare parts

Designation / Use	Part No.	Qty.
Sealing rings		



Heavy object.

Risk of crushing!

- Use appropriate lifting devices and appliances.



Components have sharp edges.

Risk of injury!

- Wear protective gloves.

Check cylinder liner (→ Page 96).

Installing cylinder liner

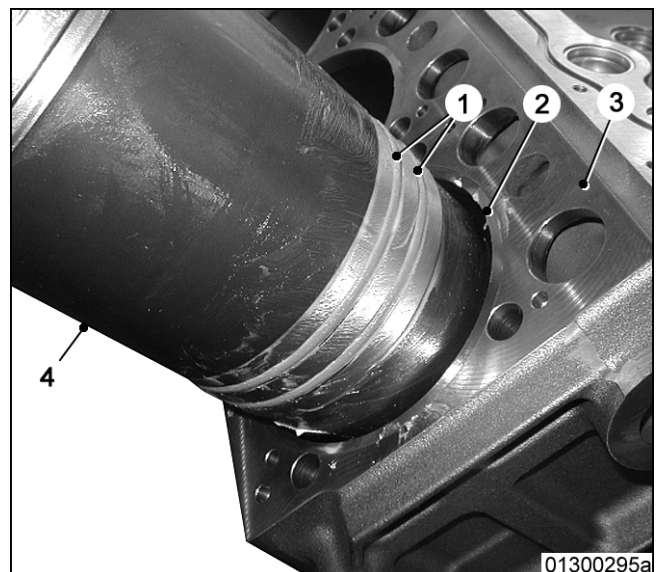
1. Wipe lower fit and chamfer of cylinder liner (4) with chamois leather.
2. Coat upper and lower fits with petroleum jelly.
3. Coat sealing rings (1) with petroleum jelly.

Note: Make sure that the flat side is resting against cylinder liner (4) and the curved side against crankcase (3).

4. Fit sealing rings (1) in grooves on cylinder liner (4).
5. Secure sealing ring (2) on crankcase using petroleum jelly.

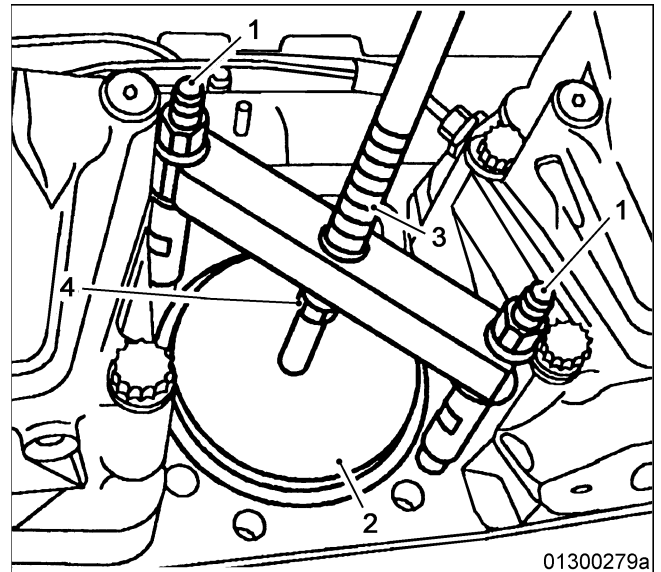
Note: Note markings when installing re-usable cylinder liners. When installing new cylinder liners, the direction may be chosen freely.

6. Insert cylinder liner (4) into crankcase (3) in the same direction as when removed.



01300295a

7. Insert installation tool screws (1) into threaded bores for cylinder head screws opposite.
8. Fit pressure plate (2) on cylinder liner.
9. Press cylinder liner into crankcase bore by turning spindle (3) with nut (4).
10. Remove installation tool.

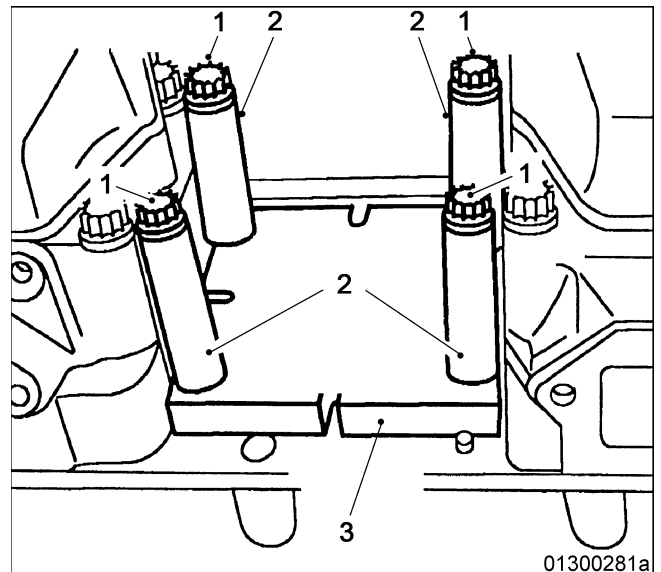


Measuring cylinder liner bore

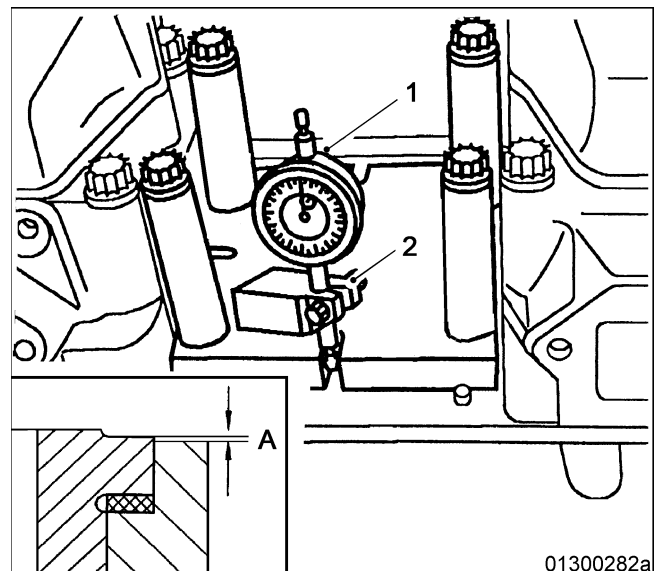
1. Adjust bore gauge and dial gauge with micrometer or gauge ring to basic size for cylinder liner. Value and measurement planes (→ Page 97).
2. Measure cylinder liner bore with bore gauge.
3. Record measured values in data sheet.
4. If out-of-round is found:
 - 4.1. Remove cylinder liner.
 - 4.2. Remeasure cylinder liner bore and outer diameter.
 - 4.3. Check correct fit of sealing rings.

Measuring protrusion of cylinder liner

1. Install measuring plate (3) and spacers (2) on cylinder liner using cylinder head screws (1). Tightening torque of the cylinder head screws for measuring plate (→ Page 23).



2. Install measuring gauge (1) to measuring gauge stand (2) and insert pre-tensioned through one of the measuring plate recesses.
3. Zero measuring gauge (1).
4. Measure protrusion of cylinder liner collar to crankcase. Note protrusion (A). Measure on each recess of the measuring plate.
5. For each measurement, set the scale of the dial gauge to zero. The difference of the 4 measured points per cylinder liner must not exceed 0.02 mm. Protrusion (A) (→ Page 97).
6. Remove measuring plate and spacers.
7. If the test values deviate, remove cylinder liner and check cause.
8. Install cylinder liner securing rail.

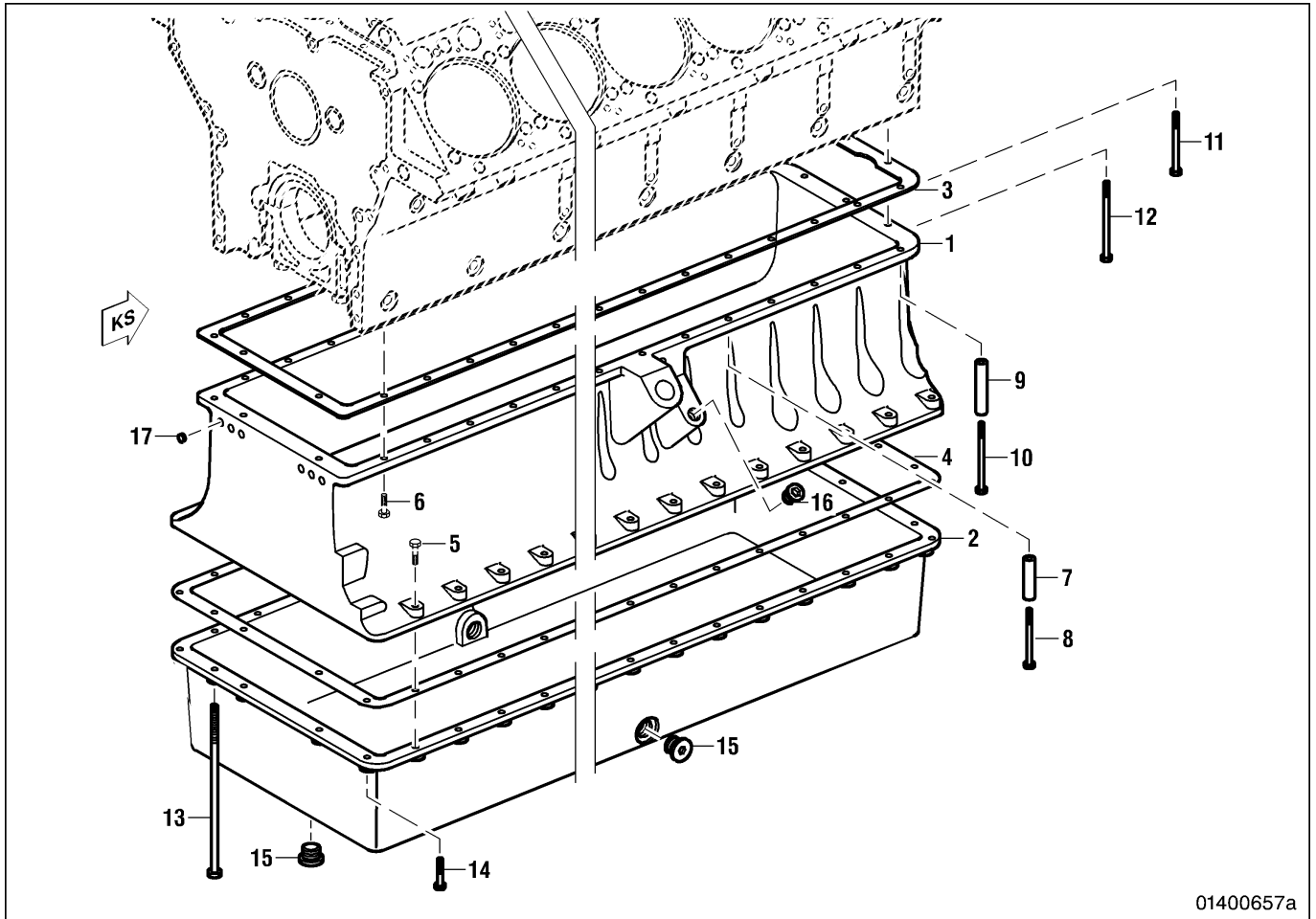


Final steps**For these steps a distinction must be made as to whether**

- 1 the engine has been completely disassembled
- 2 the engine has been removed but not disassembled
- 3 the engine has remained installed

1	2	3	Operations	See
X	–	–	Assemble engine.	(→ Page 58)
X	–	–	Install engine.	(→ Page 60)
–	X	X	Perform installation in reverse sequence of work steps described for removal.	(→ Page 92)
–	–	X	Fill with engine oil.	(→Operating instructions)
–	–	X	Fill with engine coolant.	(→Operating instructions)
–	–	X	Fill with charge-air coolant.	(→Operating instructions)
–	–	X	Enable engine start.	–

3.1.16 Oil pan – Overview



01400657a

- | | |
|----------------------|---------------|
| 1 Oil pan upper part | 9 Spacer |
| 2 Oil pan | 10 Screw |
| 3 Gasket | 12 Screw |
| 4 Gasket | 13 Screw |
| 5 Screw | 14 Screw |
| 6 Screw | 15 Plug screw |
| 7 Spacer | 16 Plug screw |
| 8 Screw | 17 Plug |


3.1.17 Oil pan – Removal


Preconditions

- Engine is stopped and starting disabled.

Special tools

Designation / Use	Part No.	Qty.
Rotation device for assembly	F6554681	1

 DANGER	Suspended load. Danger to life! <ul style="list-style-type: none"> • Use appropriate lifting devices and appliances. • Never stand beneath a suspended load.
--	--

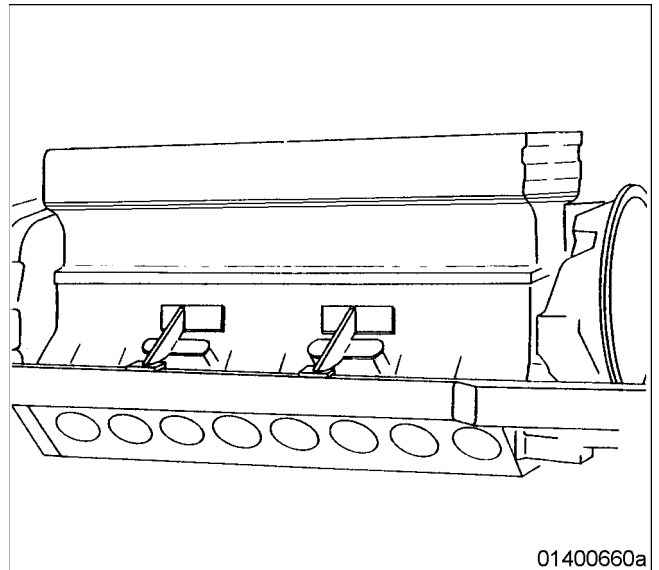
 WARNING	Heavy object. Risk of crushing! <ul style="list-style-type: none"> • Use appropriate lifting devices and appliances.
---	---

Preparatory steps

A distinction must be made as to whether				
1 the engine is to be completely disassembled				
2 the engine is to be removed but not disassembled				
3 the engine is to remain installed				
1	2	3	Operations	See
X	–	–	Remove engine	(→ Page 55)
X	–	–	Disassemble engine	(→ Page 56)
–	–	X	Drain engine oil	(→ Operating Instructions)
–	X	X	Remove fuel delivery pump	(→ Page 399)
–	X	X	Remove oil pump connections	(→ Page 486)
–	X	X	Remove filling and measuring device	(→ Page 491)
–	X	X	Remove oil filter with oil filter housing	(→ Page 496)



Removing oil pan and oil pan upper part

1. Install engine in the rotation device and rotate by 180°.
2. Remove oil pan and oil pan upper part as shown in overview drawing (→ Page 103) , in doing so protect sealing faces from mechanical damage (knocks etc.).
3. Place oil pan and oil pan upper part on to adequate surface.
4. Remove gaskets.



3.1.18 Oil pan – Cleaning

Material

Designation / Use	Part No.	Qty.
Cleaning agent		
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors. 	
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask. 	

Remove oil pan (→ Page 104).

Cleaning oil pan

1. Clean all components with cleaning agent.
2. Remove cleaning agent.
3. Clean oil pan, oil pan upper part and all threads thoroughly with compressed air.

3.1.19 Oil pan – Check

Special tools

Designation / Use	Part No.	Qty.
Red dye penetrant for surface crack test procedure		

Spare parts

Designation / Use	Part No.	Qty.
Oil pan		
Oil pan upper part		
Screw		



WARNING

Heavy object.

Risk of crushing!

- Use appropriate lifting devices and appliances.

Clean oil pan (→ Page 106).

Oil pan – Check

Item	Findings	Measure
Check oil pan for cracks using surface crack test procedure and red dye penetrant.	Signs of cracks	Replace
Check oil pan upper part for cracks using surface crack test procedure and red dye penetrant.	Signs of cracks	Replace
Check oil pan contact surface on upper part for flatness	Unevenness more than 0.2 mm.	Recondition contact surface.
Check contact surfaces on oil pan upper part on crankcase and on oil pan for flatness.	Unevenness more than 0.2 mm.	Recondition contact surface.
Check sealing faces.	Damaged	<ul style="list-style-type: none"> • Recondition • Replace
Check thread bores for freedom of movement.	Sluggish	Replace thread inserts.

3.1.20 Oil pan – Installation

Material

Designation / Use	Part No.	Qty.
Engine oil		
Sealing paste Elastosil N189		
Loctite 586		

Spare parts

Designation / Use	Part No.	Qty.
Gasket		
Gasket		



Suspended load.

Danger to life!

- Use appropriate lifting devices and appliances.
- Never stand beneath a suspended load.



Heavy object.

Risk of crushing!

- Use appropriate lifting devices and appliances.



Contamination of components.

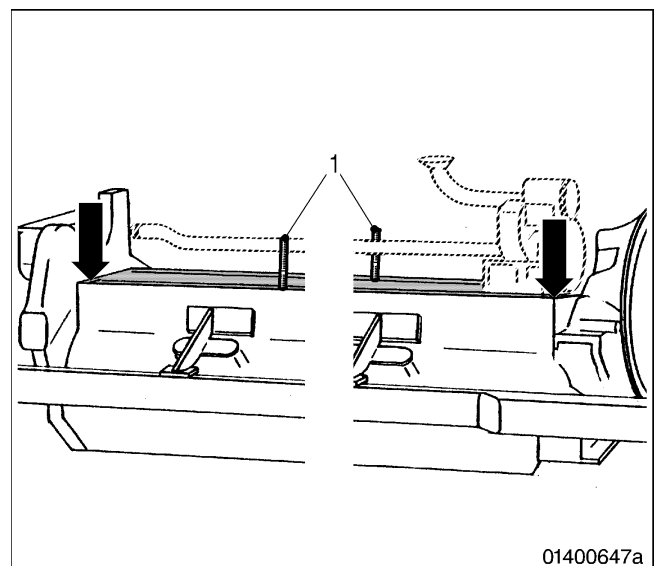
Damage to component!

- Observe manufacturer's instructions.
- Check components for special cleanliness.

Check oil pan (→ Page 107).

Installing oil pan upper part and oil pan

1. Turn crankcase in rotation device until oil pan attachment surface is horizontal and facing upwards.
2. Degrease and dry contact surfaces on oil pan upper part and crankcase.
3. Coat contact surface around the interstice of crankcase flywheel housing and crankcase gearcase (arrows) with sealing paste.
4. Screw two guide pins (1) into two opposite threaded bores of oil pan securing screws.
5. Place gasket on to the sealing face above the guide pins.
6. Carefully lower oil pan on to crankcase mating face. At the same time, align the oil pan to the bores on the crankcase mating face.
7. Remove guide pins.
8. Insert screws and spacers for oil pan upper part as shown in overview drawing (→ Page 103) and tighten evenly.
9. Place gasket on to sealing face on oil pan upper part.



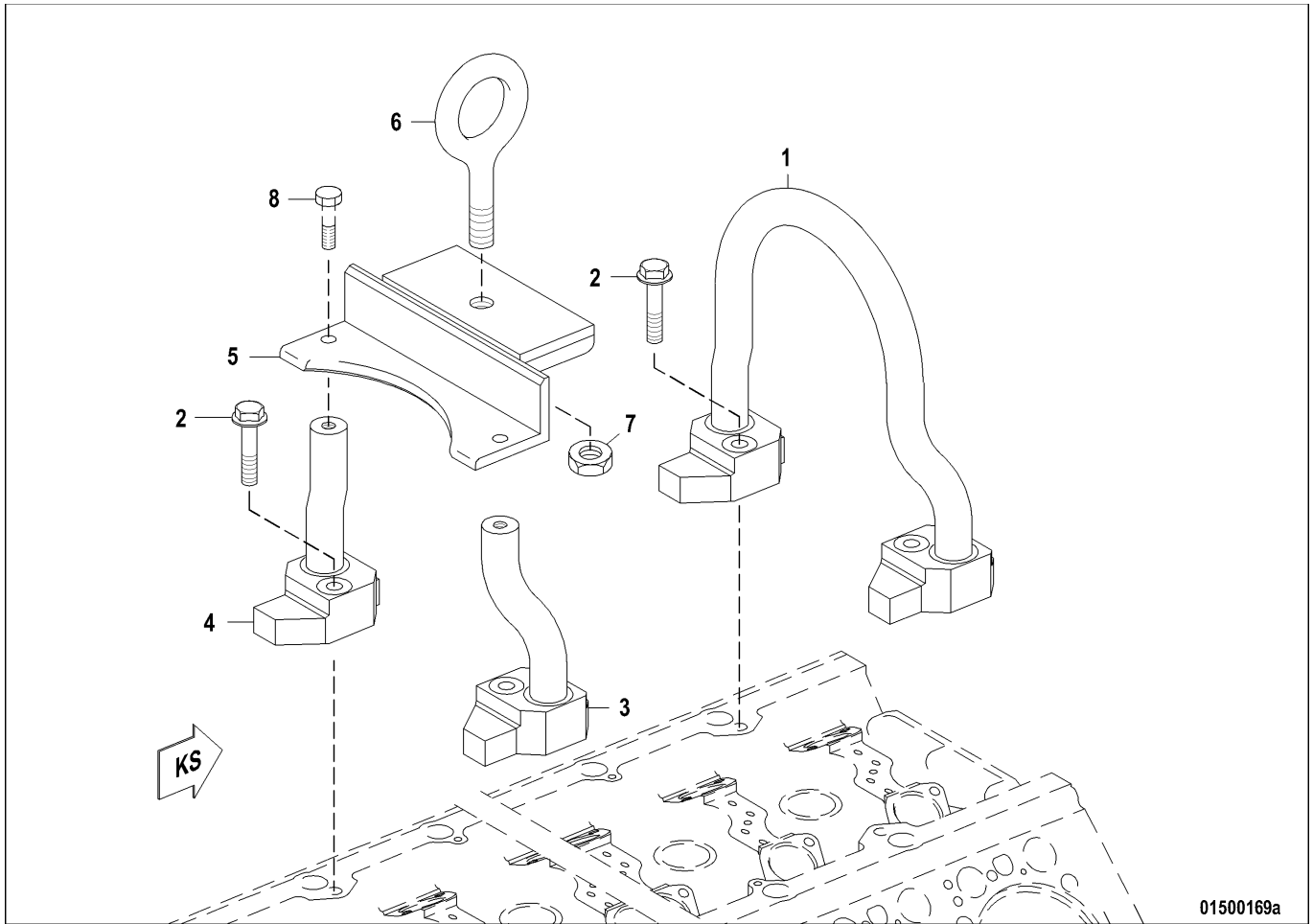
10. Tighten oil pan evenly with screws as shown in overview drawing (→ Page 103) .
11. Coat plug screws with Loctite and screw into oil pan.

Final steps

A distinction must be made as to whether				
1 the engine was completely disassembled				
2 the engine was removed but not disassembled				
3 the engine is still installed				
1	2	3	Operations	See
X	–	–	Assemble engine	(→ Page 58)
X	–	–	Install engine	(→ Page 60)
–	X	X	Assembly in reverse sequence to disassembly	(→ Page 104)
–	–	X	Fill oil system with engine oil	(→Operating Instructions)
–	–	X	Enable engine start	–

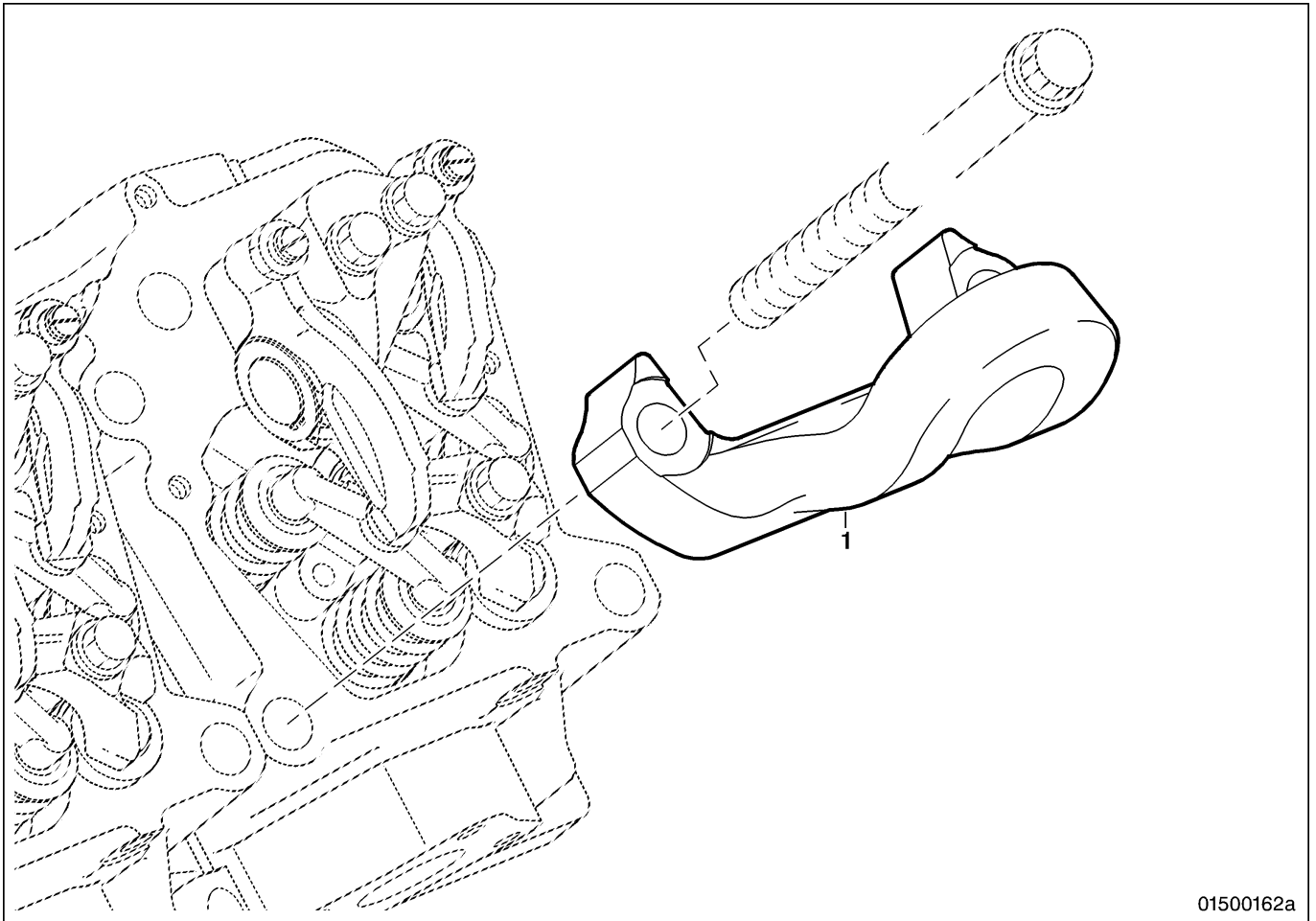
3.1.21 Engine lifting equipment – Overview

Version A



- | | |
|-------------------|-----------|
| 1 Lifting bracket | 5 Bracket |
| 2 Screw | 6 Eyebolt |
| 3 Lifting bracket | 7 Nut |
| 4 Lifting bracket | 8 Screw |

Version B



01500162a

1 Lifting eye

3.1.22 Engine lifting equipment – Removal

Preconditions

- Engine is stopped and starting disabled.

Special tools

Designation / Use	Part No.	Qty.
Box wrench (only for marine)	F30379891	1

Preparatory steps



A distinction must be made as to whether				
1 the engine is to be completely disassembled				
2 the engine is to be removed but not disassembled				
3 the engine is to remain installed				
1	2	3	Operations	See
X	–	–	Remove engine.	(→ Page 55)
X	–	–	Disassemble engine.	(→ Page 56)
–	–	X	Disable engine start.	(→ Page 15)

Engine lifting equipment – Removal

1. Remove engine lifting equipment as shown in overview drawing (→ Page 110).
2. Protect parts from damage.

3.1.23 Engine lifting equipment – Cleaning

Material

Designation / Use	Part No.	Qty.
Cleaning agent		
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors. 	
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask. 	

Remove engine lifting equipment (→ Page 112).

Engine lifting equipment – Cleaning

1. Clean all components with cleaning agent.
2. Remove cleaning agent.
3. Blow out all parts with compressed air.

3.1.24 Engine lifting equipment – Check

Material

Designation / Use	Part No.	Qty.
Red dye penetrant for surface crack test procedure		

Spare parts

Designation / Use	Part No.	Qty.
Lifting bracket		
Lifting eye		
Eyebolt		
Lifting eye		

Clean engine lifting equipment (→ Page 113).

Engine lifting equipment – Check

Item	Findings	Measure
Check lifting bracket, lifting eye and eyebolt for damage.	Damaged	Replace
Check lifting bracket, lifting eye and eyebolt with surface crack test procedure for cracks.	Signs of cracks	Replace
Check lifting eye for damage (version B).	Damaged	Replace
Check lifting eye with surface crack test procedure for cracks (version B).	Signs of cracks	Replace
Check mating / bolt-on faces for damage.	Damaged	<ul style="list-style-type: none"> • Recondition: Smooth with oilstone. • Replace
Check thread in crankcase for ease of movement.	Sluggish	Recondition: Recut thread.

3.1.25 Engine lifting equipment – Installation

Check engine lifting equipment (→ Page 114)

Engine lifting equipment – Installation

Version A

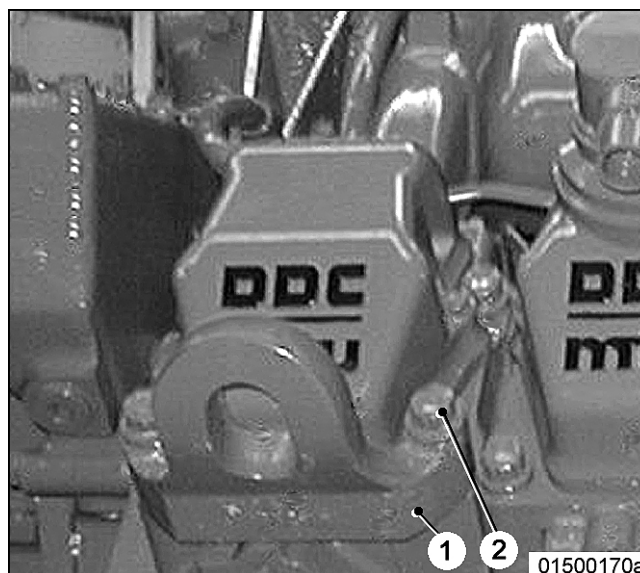
1. Install engine lifting equipment as shown in overview drawing (→ Page 110) .
2. Tighten screws with torque wrench to specified tightening torque (→ Page 23) .

Version B

1. Place lifting eye (1) on to cylinder head and align with bores for cylinder head screws.

Note: If no other than the cylinder head screws on the lifting eye were loosened, then only tighten these two cylinder head screws to the tightening torque.

2. Insert cylinder head screws (2) and tighten with torque wrench to prescribed tightening torque (→ Page 23) .



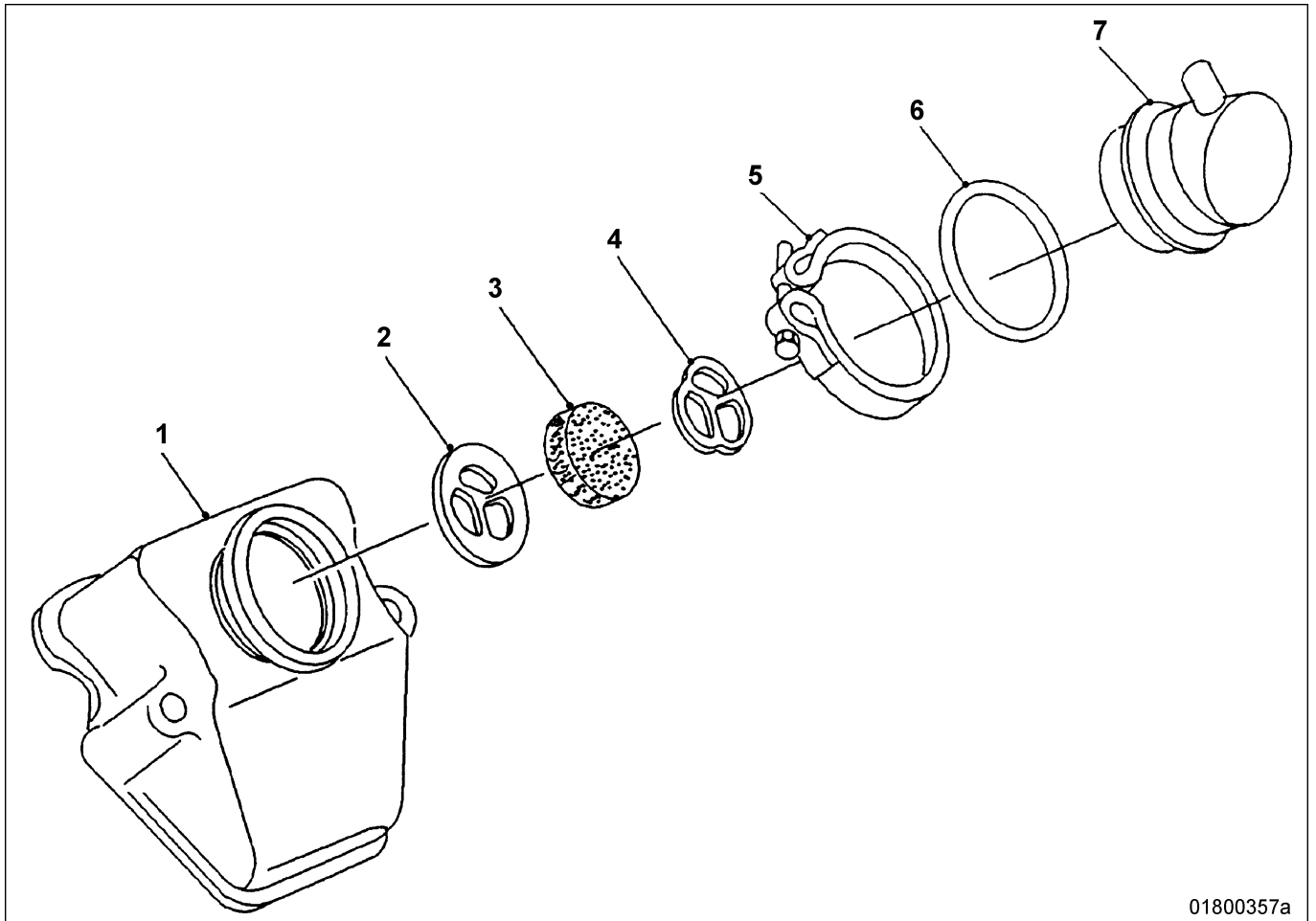
Final steps

A distinction must be made as to whether

- 1 the engine was completely disassembled
- 2 the engine was removed but not disassembled
- 3 the engine is still installed

1	2	3	Operations	See
X	–	–	Assemble engine	(→ Page 58)
X	–	–	Install engine	(→ Page 60)
–	–	X	Enable engine start	–

3.1.26 Crankcase ventilation – Overview



01800357a

- 1 Cylinder-head cover
- 2 Holder
- 3 Element (wire mesh)

- 4 Holder
- 5 Clamp
- 6 Sealing ring

- 7 Oil separator cover

3.1.27 Crankcase ventilation – Removal

Preconditions

- Engine is stopped and starting disabled.

Preparatory steps




A distinction must be made as to whether				
1 the engine is to be completely disassembled				
2 the engine is to be removed but not disassembled				
3 the engine is to remain installed				
1	2	3	Operations	See
X	–	–	Remove engine	(→ Page 55)
X	–	–	Disassemble engine	(→ Page 56)
–	X	X	Remove cylinder-head cover	(→ Page 371)

Removing pipes and oil separator

1. Remove hose.
2. Remove clamp and oil separator as shown in overview drawing (→ Page 116) .
3. Extract individual components from oil separator cover.
4. Seal openings with suitable covers.

3.1.28 Crankcase ventilation – Cleaning

Material

Designation / Use	Part No.	Qty.
Cleaning agent		
 WARNING	Fuels are combustible. Risk of fire and explosion! <ul style="list-style-type: none"> • Avoid naked flames, electrical sparks and ignition sources. • Do not smoke. 	
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors. 	
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask. 	

Remove crankcase ventilation (→ Page 117).

Cleaning crankcase ventilation

1. Clean hose with a dry cloth.
2. Clean all components apart from element (wire mesh) with cleaning agent.
3. Replace element (wire mesh).
4. Remove cleaning agent.

3.1.29 Crankcase ventilation – Check

Spare parts

Designation / Use	Part No.	Qty.
Hose		
Element (wire mesh)		
Clamp		
Sealing ring		

Clean crankcase ventilation (→ Page 118).

Checking crankcase ventilation

Item	Findings	Task
Visually inspect components for damage and wear.	Damaged	Replace
Check sealing surfaces and bolt-on faces for damage and condition.	Damaged	<ul style="list-style-type: none"> • Rework: smooth with oilstone • Replace
Check threads for ease of movement.	Damaged	<ul style="list-style-type: none"> • Rework: recut threads • Replace

3.1.30 Crankcase ventilation – Installation

Material

Designation / Use	Part No.	Qty.
Petroleum jelly, white		

Spare parts

Designation / Use	Part No.	Qty.
Hose		
Element (wire mesh)		
Clamp		
Sealing ring		

Check crankcase ventilation (→ Page 119).

Crankcase ventilation – Installation

1. Prior to installation, remove all covers.
2. Coat sealing ring with petroleum jelly and insert in groove in oil separator cover.
3. Insert both holders and element (wire mesh) in oil separator cover in correct sequence as shown in overview drawing (→ Page 116) .
4. Attach oil separator cover with clamp to cylinder-head cover.
5. Install hose without tension.

Final steps

A distinction must be made as to whether				
1 the engine was completely disassembled				
2 the engine was removed but not disassembled				
3 the engine is still installed				
1	2	3	Operations	See
X	–	–	Assemble engine	(→ Page 58)
X	–	–	Install engine	(→ Page 60)
–	X	X	Install cylinder-head cover	(→ Page 374)
–	–	X	Enable engine start	–

3.1.31 Crankcase ventilation – Replacement of wire mesh

Spare parts

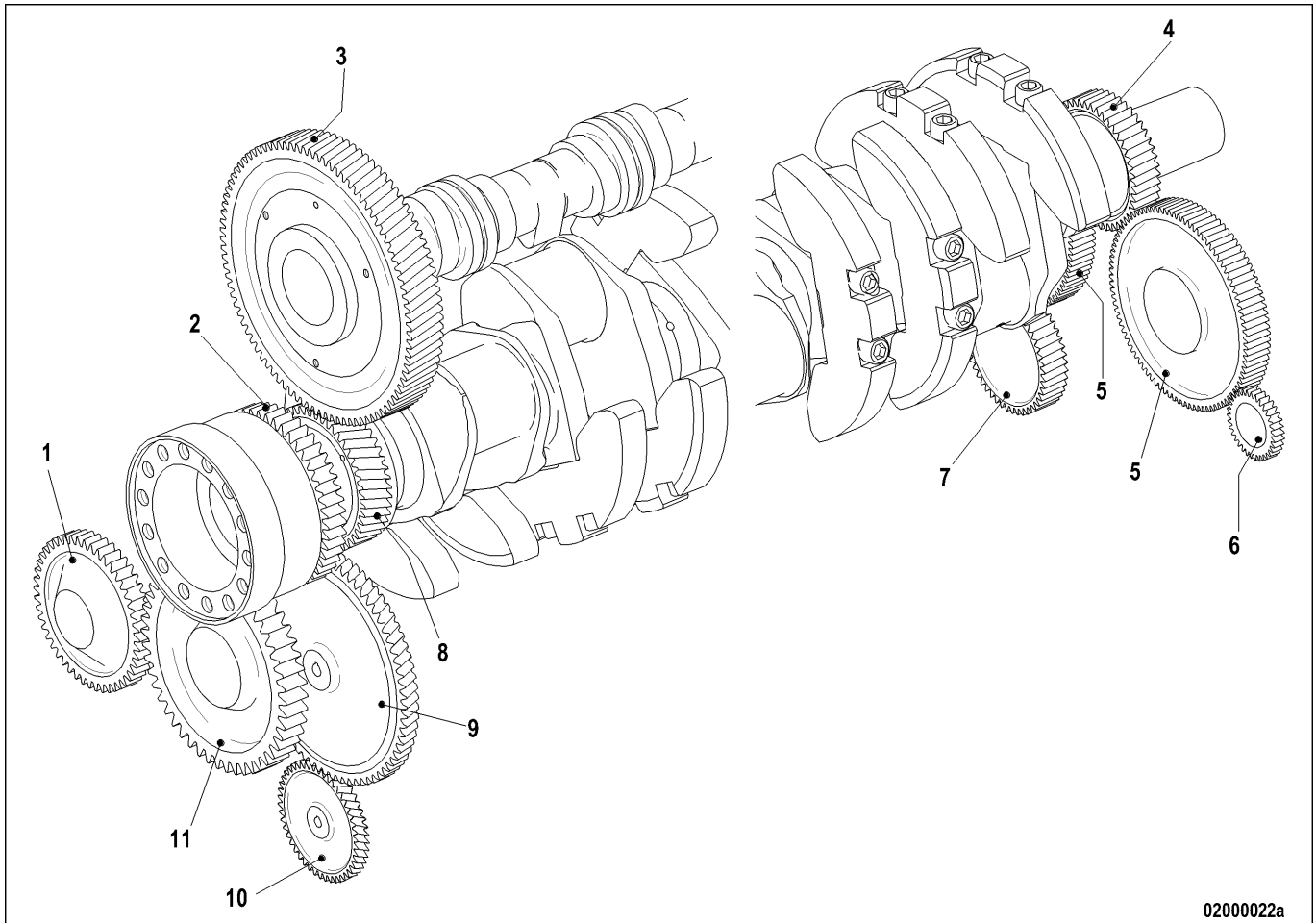
Designation / Use	Part No.	Qty.
Element (wire mesh)		

Remove crankcase ventilation (→ Page 117).

Install crankcase ventilation (→ Page 120).

3.2 Gear Train

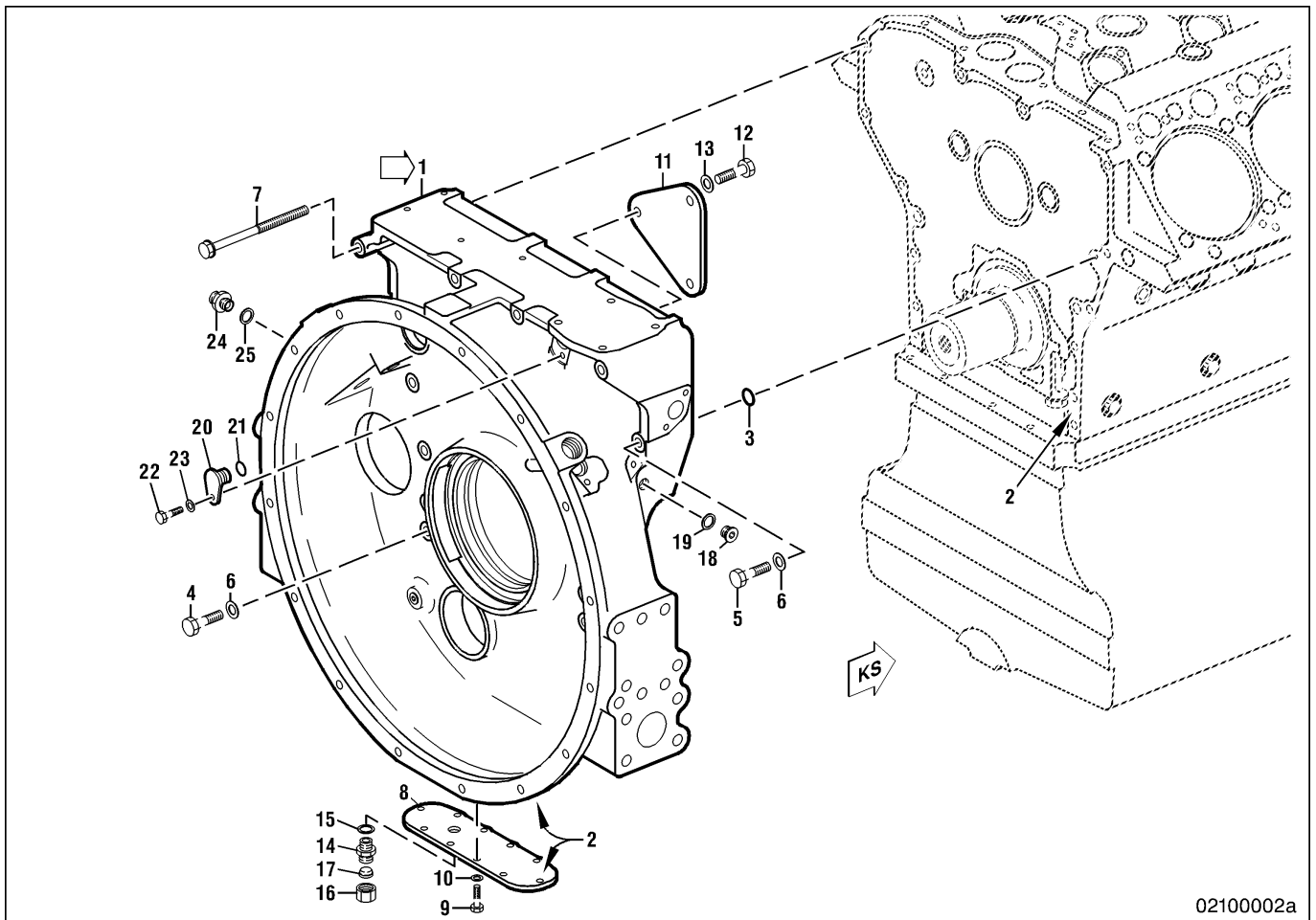
3.2.1 Gear train – Overview



Item no.	Designation	Circumferential backlash (mm)	Axial clearance (mm)
1	Driving gear (aux. PTO)*	from 0.106 to 0.226 to gear 11	
2	Gear (aux. PTO)*		
3	Camshaft gear	from 0.068 to 0.172 to gear 8	from 0.20 to 0.55 (camshaft)
4	Crankshaft gear, free end		from 0.20 to 0.30 (crankshaft)
5	Idler gear	from 0.04 to 0.32 to gear 4	from 0.05 to 0.95
6	Gear (engine coolant pump)	from 0.04 to 0.32 to gear 5	
7	Gear (raw water pump/charge-air coolant pump**)	from 0.04 to 0.32 to gear 5	
8	Crankshaft gear, driving end		

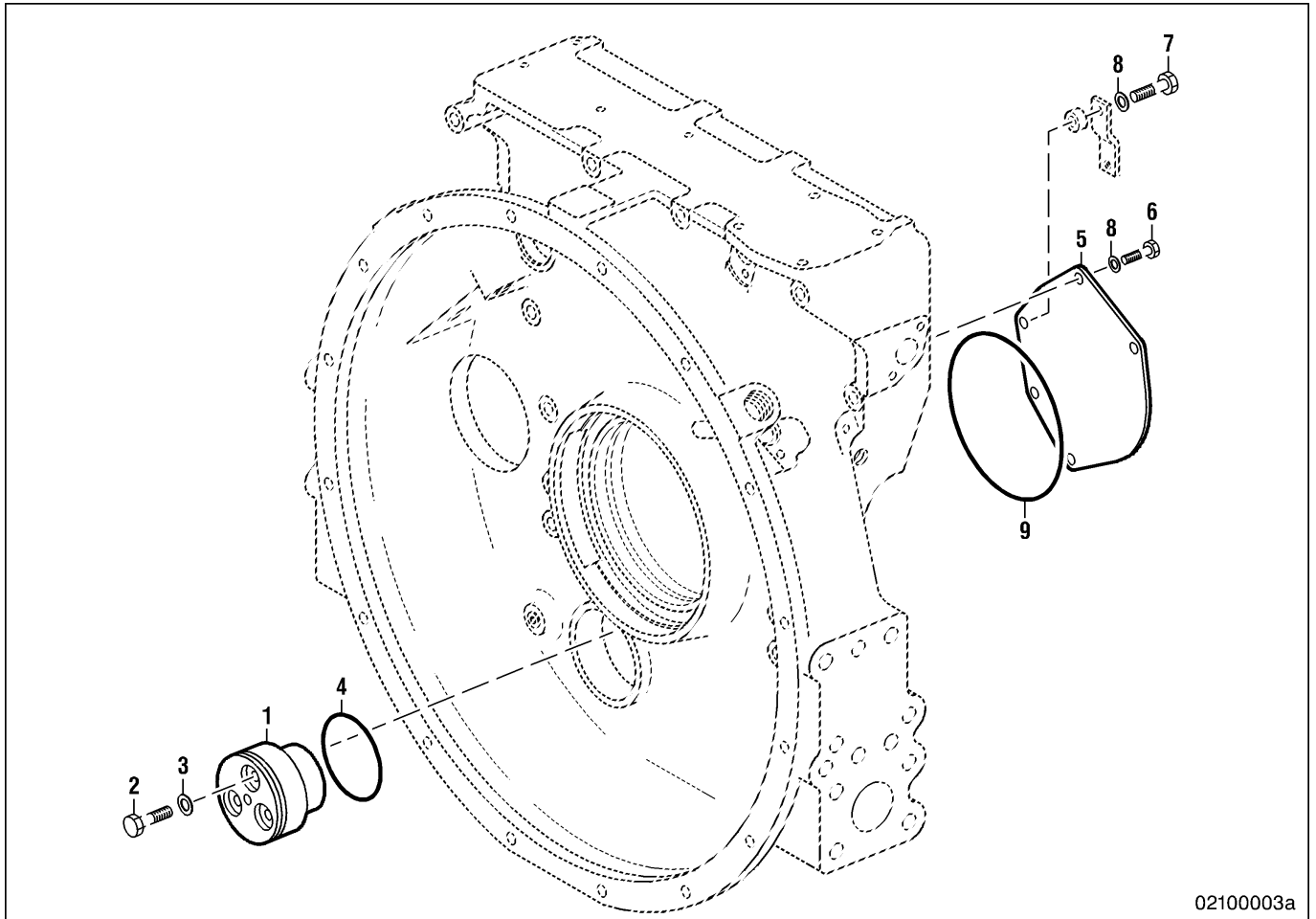
Item no.	Designation	Circumferential backlash (mm)	Axial clearance (mm)
9	Idler gear (oil pump)	from 0.07 to 0.310 to gear 8	
10	Gear (oil pump)	from 0.151 to 0.295 to gear 9	
11	Idler gear	from 0.16 to 0.31 to gear 2	from 0.40 to 0.90
* = may be not applicable, depending on order			
**= depending on order			

3.2.2 Flywheel housing – Overview



02100002a

- | | | |
|--------------------|------------------|------------------|
| 1 Flywheel housing | 10 Washer | 19 Sealing ring |
| 2 Surface sealant | 11 Plug | 20 Plug |
| 3 O-ring | 12 Screw | 21 O-ring |
| 4 Screw | 13 Washer | 22 Screw |
| 5 Screw | 14 Union | 23 Washer |
| 6 Washer | 15 Sealing ring | 24 Adapter union |
| 7 Screw | 16 Nut | 25 Sealing ring |
| 8 Cover | 17 Blanking cone | |
| 9 Screw | 18 Screw | |



02100003a

- 1 Axle
- 2 Screw
- 3 Washer

- 4 O-ring
- 5 Plug
- 6 Screw

- 7 Screw
- 8 Washer
- 9 O-ring

3.2.3 Flywheel housing – Removal

Preconditions

- Engine is stopped and starting disabled

Special tools

Designation / Use	Part No.	Qty.
Eyebolt	000580016002	2
Support pin	T80090973	2
Lifting gear	T80091151	1



DANGER

Suspended load.

Danger to life!

- Use appropriate lifting devices and appliances.
- Never stand beneath a suspended load.



WARNING

Components have sharp edges.

Risk of injury!

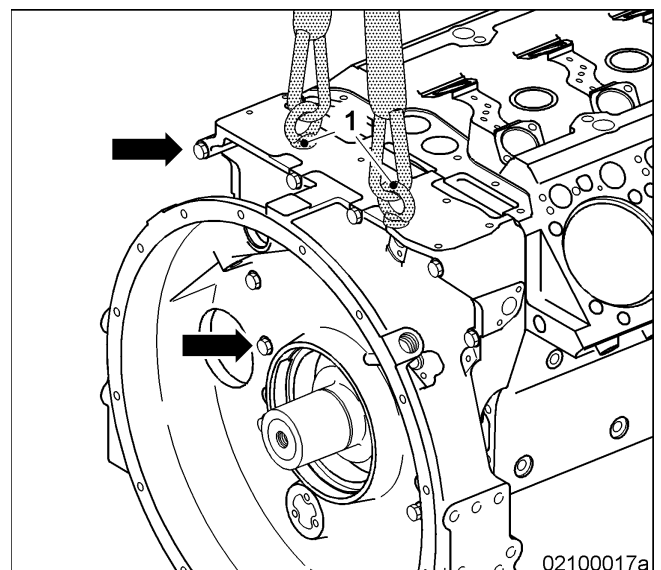
- Wear protective gloves.

Preparatory steps

For these steps a distinction must be made as to whether				
1 the engine is to be completely disassembled				
2 the engine is to be removed but not disassembled				
3 the engine is to remain installed				
1	2	3	Operations	See
X	–	–	Remove engine.	(→ Page 55)
X	–	–	Disassemble engine.	(→ Page 56)
–	–	X	Drain engine coolant.	(→Operating instructions)
–	–	X	Drain charge-air coolant.	(→Operating instructions)
–	X	X	Remove crankcase ventilation.	(→ Page 117)
–	X	X	Remove coolant line from/to intercooler.	(→ Page 558)
–	X	X	Disconnect exhaust turbocharger oil supply.	(→ Page 524)
–	X	X	Remove oil return line from exhaust turbocharger.	(→ Page 529)
–	X	X	Remove intercooler.	(→ Page 454)
–	X	X	Remove flywheel.	(→ Page 225)
–	X	X	Remove starter.	(→ Page 471)
–	X	X	Remove speed sensors.	(→ Page 608)
–	X	X	Suspend engine using lifting device.	–
–	X	X	Remove engine mounts, driving end.	–

Removing flywheel housing

1. Screw eyebolts (1) into flywheel housing.
2. Use rope to attach flywheel housing to crane with light initial tension.
3. Mark all screws (arrowed) (various lengths and versions) and remove.
4. Horizontally remove flywheel housing from crankcase.



3.2.4 Flywheel housing – Disassembly

Special tools

Designation / Use	Part No.	Qty.
Puller crankshaft / main bearing	F6781536	1
Lukas press	B80096717	1
Lukas hand pump	B80143159	1
Adapter	B80146411	1



WARNING

Equipment can drop off.
Liquid is highly pressurized.

Risk of injury, knocks or crushing!

- Only use specified and tested equipment.
- Do not enter the danger zone.
- Wear protective clothing, gloves, and goggles / safety mask.



WARNING

Heavy object.

Risk of crushing!

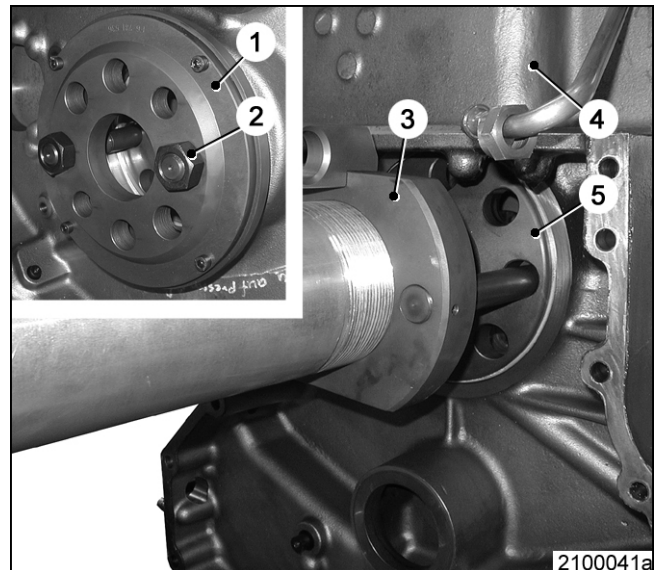
- Use appropriate lifting devices and appliances.

Remove flywheel housing (→ Page 126).

Removing crankshaft bearing from flywheel housing

Note: Renew crankshaft bearings at major overhaul.

1. Remove shaft seal from flywheel housing (4) (→ Page 229).
2. Screw Lukas press (3), pullers (1) and (5) on to flywheel housing (4) with nuts (2).
3. Force crankshaft bearing with Lukas press (3), pullers (1) and (5) off flywheel housing (4).

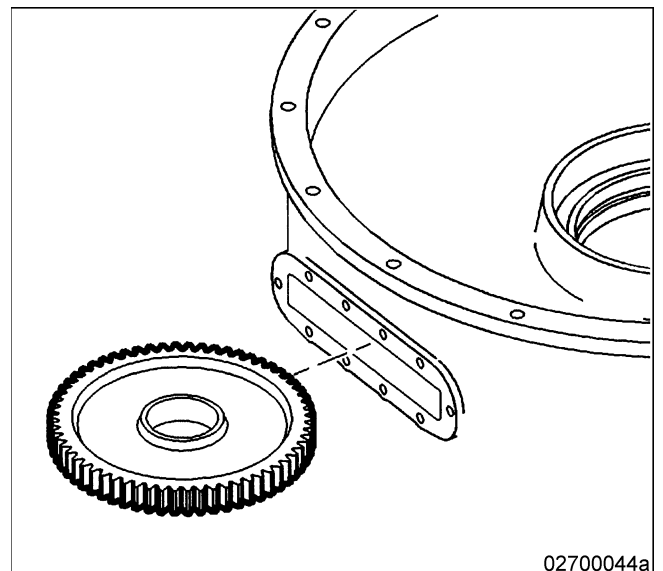


Removing axle and idler gear

1. Remove screws (2).
2. Install assembly screw in threaded bore (arrow) and withdraw cover (1) from flywheel housing.
3. Remove O-ring.





4. Remove cover from flywheel housing.
5. Remove idler gear through opening in flywheel housing.



3.2.5 Flywheel housing – Cleaning

Material

Designation / Use	Part No.	Qty.
Cleaning agent		
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors. 	
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask. 	

Disassemble flywheel housing (→ Page 128).

Flywheel housing – Cleaning

1. Clean all components with cleaning agent.
2. Remove cleaning agent.
3. Clean all parts and all threads thoroughly with compressed air.

3.2.6 Flywheel housing – Check

Special tools

Designation / Use	Part No.	Qty.
Bore gauge	Y20091481	1
Micrometer	Y20000088	1
Micrometer	Y20000169	1

Material

Designation / Use	Part No.	Qty.
Fluorescent magnetic powder for magnetic crack-testing		
Red penetrant dye for surface crack-testing procedure		

Spare parts

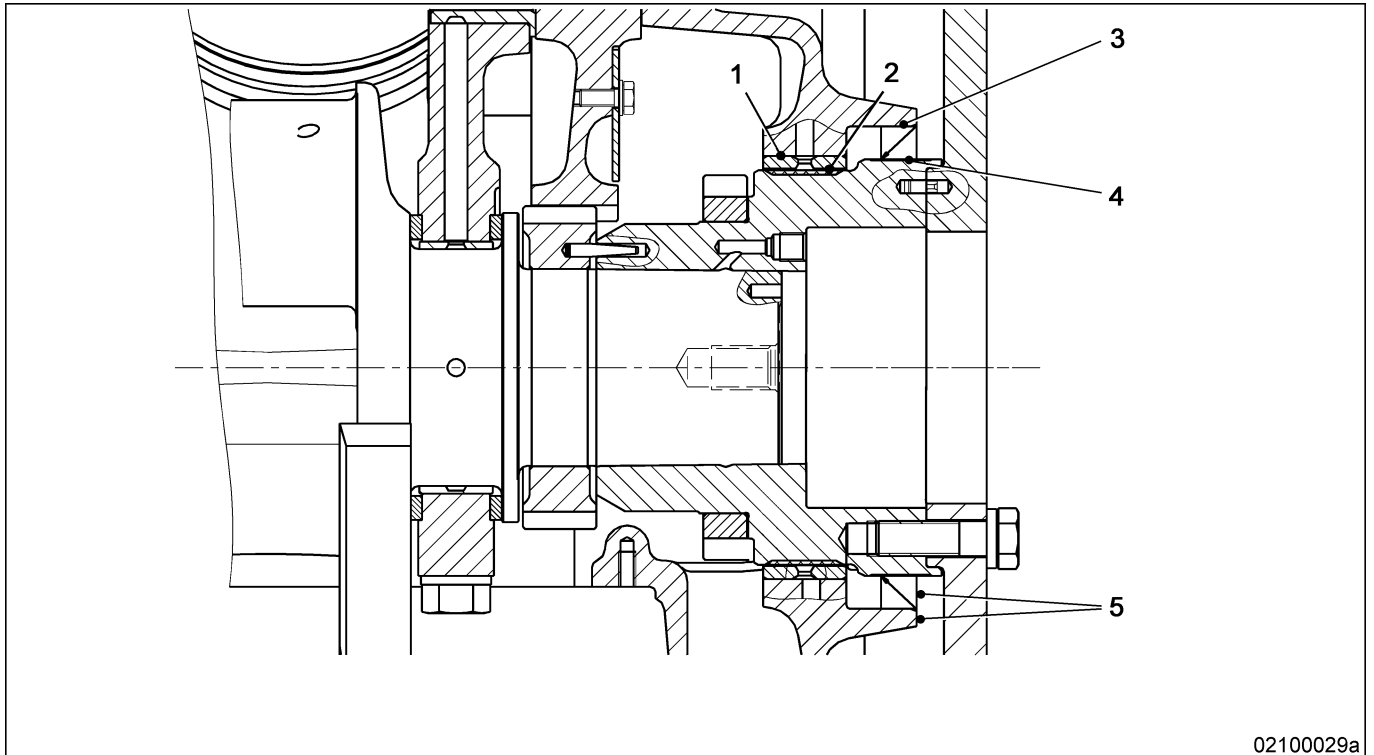
Designation / Use	Part No.	Qty.
Main bearing		
Flywheel housing		
Shaft		
Idler gear		

Clean flywheel housing (→ Page 130).

Flywheel housing – Check

Item	Findings	Task
Check flywheel housing with red dye penetrant for cracks.	Signs of cracks	Replace
Using the magnetic crack-testing method, check gear for cracks.	Signs of cracks	Replace
Check surface quality of idler gear tooth flanks with magnifying glass.	Damaged	Replace
Check axle running surface, bearing bush in idler gear and axial sliding surface of gear for wear and scoring.	<ul style="list-style-type: none"> • Wear • Scores • visible 	<ul style="list-style-type: none"> • Recondition: with oilstone or emery cloth. • Replace
Check taper seat and bolt-on surface of axle for scoring and wear.	<ul style="list-style-type: none"> • Scores • Wear • visible 	<ul style="list-style-type: none"> • Recondition • Replace
Measure bearing bush bore in idler gear. Values (→ Page 133)	Value exceeded	Replace bearing bush (→ Page 168)
Using micrometer, measure outside diameter of axle at running surface. Values (→ Page 133)	Values exceeded	Replace
Check mating and bolt-on faces.	Wear	Smooth with oilstone.
Check threads for damage.	Damaged	Recut thread.
Check crankshaft bearings for surface quality and wear.	<ul style="list-style-type: none"> • Wear • Damage • visible Replace during W6 overhaul.	Replace crankshaft bearings
Measure crankshaft bearing bore in flywheel housing. Value (→ Page 133)	Value exceeded	Replace crankshaft bearings
Measure flywheel bore of idler gear axles. Values (→ Page 133)	Value exceeded	Replace flywheel.
Check sleeve for sensor for damage.	Damaged	<ul style="list-style-type: none"> • Recondition: with oilstone or emery cloth. • Replace (→ Page 143)

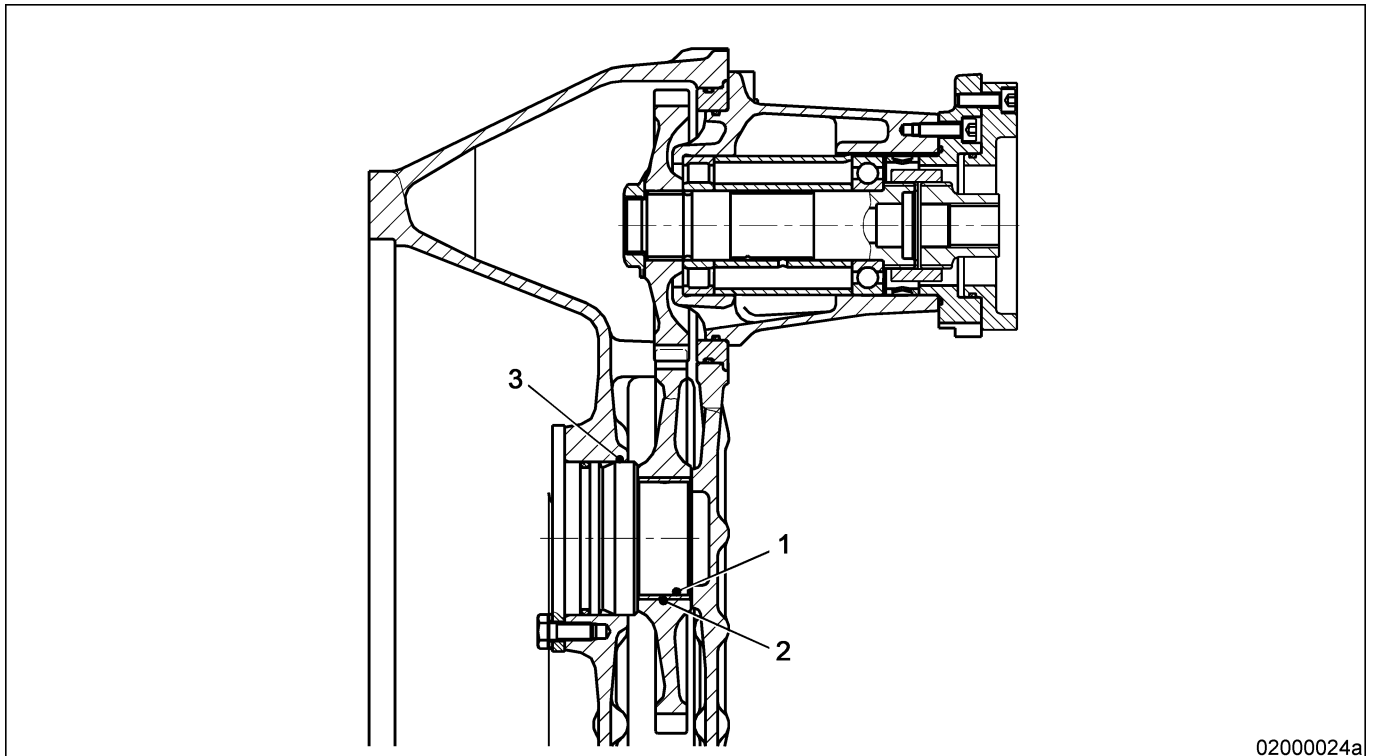
3.2.7 Flywheel housing – Tolerances



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No.	Designation	Stage	Tolerance size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
1	Flywheel housing bore	0-0 to 0-3	193.000 H6	0	+0.029			0.183	0.241	
		1-0 to 1-3	194.000 H6							
	Bearing outer Ø removed	0	193.212	0	+0.029					
		1	194.212							

No.	Designation	Stage	Tolerance size	Deviation		Clearance		Interference		Wear limit	
				lower	upper	min.	max.	min.	max.		
2	Bearing bush bore press-fitted	0-0	180.142	0	+0.079	0.142	0.237				
		0-1	179.642								
		0-2	179.142								
		0-3	178.642								
		1-0	180.142								
		1-1	179.642								
		1-2	179.142								
		1-3	178.642								
	Hub outer Ø	0-0	180.000 h6	-0.025	0						
		0-1	179.500 h6								
		0-2	179.000 h6								
		0-3	178.500 h6								
		1-0	180.000 h6								
		1-1	179.500 h6								
		1-2	179.000 h6								
1-3		178.500 h6									
3	Flywheel housing bore		220.000 H8	0	+0.072			0.228	0.550		
	Shaft seal outer Ø		220.000	+0.300	+0.550						
4	Running surface outer Ø		190.000 h11	-0.290	0						
5	Shaft seal press-fitted flush										



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No.	Designation	Stage	Tolerance size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
1	Bushing bore									
	installed		65.000 H8	0	+0.046	0.030	0.106			
	not installed		65.000 E6	+0.060	+0.079					
Axle outer Ø		65.000 f7	-0.060	-0.030						
2	Idler gear bore		70.000 H7	0	+0.030			0.029	0.078	
	Bushing outer Ø		70.000 s6	+0.059	+0.078					





3.2.8 Flywheel housing – Assembly

Special tools

Designation / Use	Part No.	Qty.
Shrinking tool	F30378021	1
Guide bushing	F6555761	1
Spacing jig idler gear	Y20097475	1

Material

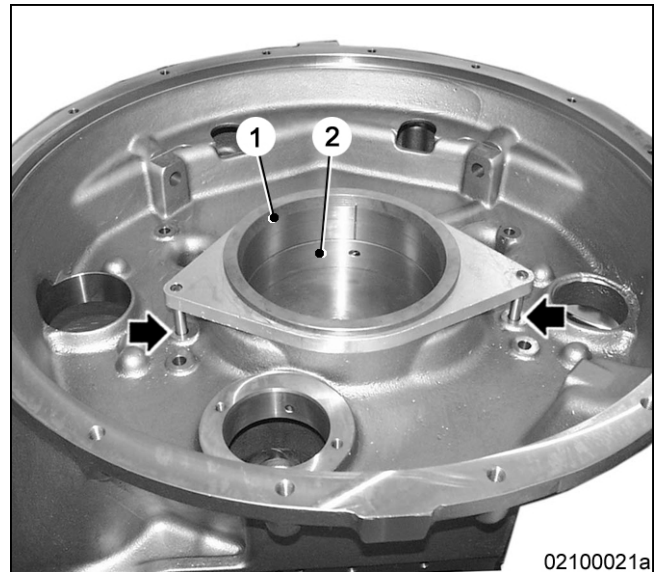
Designation / Use	Part No.	Qty.
Liquid nitrogen		
Loctite 573		
Petroleum jelly, white		
Engine oil		

 DANGER	Nitrogen is liquid (at -200°C). Risk of freezing and suffocation! <ul style="list-style-type: none"> • Do not allow liquid nitrogen to come into contact with parts of body (eyes, hands). • Wear protective clothing, gloves, and goggles / safety mask. • Ventilate working area well.
 DANGER	Suspended load. Danger to life! <ul style="list-style-type: none"> • Use appropriate lifting devices and appliances. • Never stand beneath a suspended load.
 WARNING	Components have sharp edges. Risk of injury! <ul style="list-style-type: none"> • Wear protective gloves.
 CAUTION	Contamination of components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Check components for special cleanness.

Check flywheel housing (→ Page 131).

Installing crankshaft bearing in flywheel housing

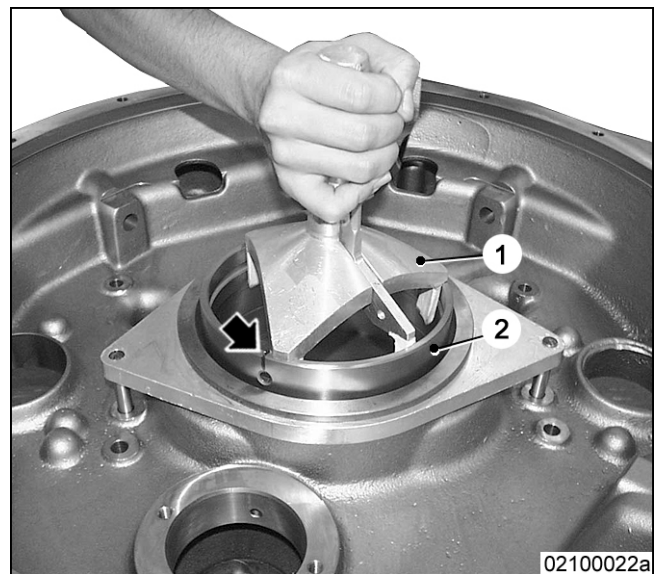
1. Place flywheel housing on to suitable surface, so that assembly of crankshaft bearing in correct position is enabled.
2. Insert guide bushing (1) into flywheel housing bore (2), in doing so observe fit of dowel pins (arrows).



3. Mark positions of both oil bores at end face (arrow) of crankshaft bearing (2).
4. Chill crankshaft bearing (2) in liquid nitrogen.

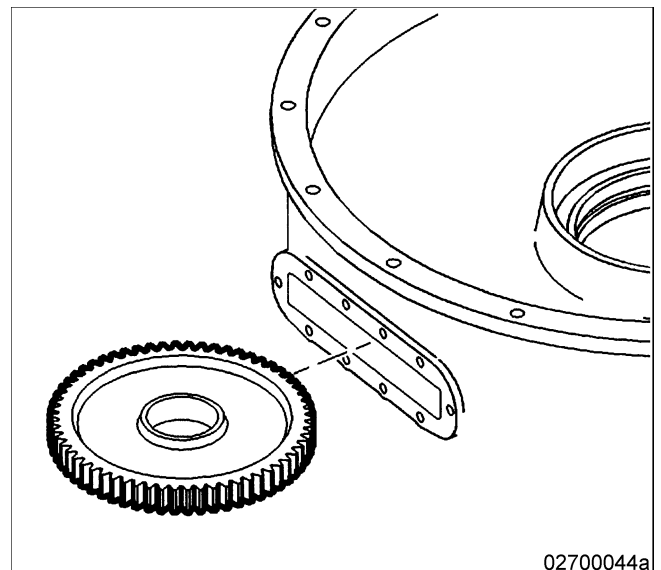
Note: Make sure that oil bores in flywheel housing and crankshaft bearing match.

5. Use shrinking tool (1) to insert crankshaft bearing (2) evenly in flywheel housing.
6. After a short period unlock and remove shrinking tool (2).
7. Check passage of both oil bores.
8. Measure crankshaft bearing bore. Values (→ Page 133)
9. Install shaft seal (→ Page 232).



Installing axle and idler gear

1. Coat bearing bushing in idler gear with engine oil.
2. Insert idler gear into flywheel housing by passing through opening.

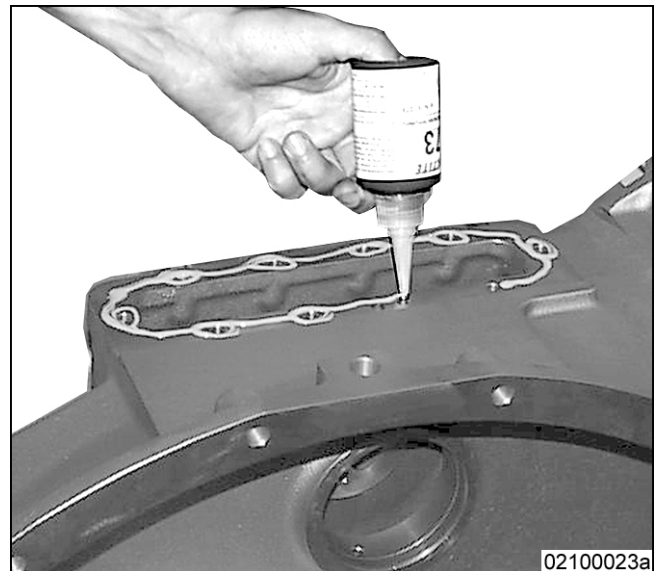


3. Coat O-rings (2) with petroleum jelly and insert into groove of axle (1).
4. Coat bearing surface of axle (1) with engine oil.
5. Insert axle (1) into flywheel housing and idler gear and fasten with screws.



Installing cover

1. Degrease and dry sealing face of cover and flywheel housing.
2. Coat sealing face on flywheel housing with Loctite.
3. Install cover with screws and washers as shown on overview drawing (→ Page 124).



3.2.9 Flywheel housing – Installation

Special tools




Designation / Use	Part No.	Qty.
Locating pin	F0140549	1
Guide bushing	F6557981	1
Guide bushing	F6780595	1
Guide ring	F6559615	1
Guide ring stage 1	F6783891	1
Guide ring stage 2	F6783892	1
Guide ring stage 3	F6783893	1
Eyebolt	000580016002	4
Support pin	T80090973	2
Lifting gear	T80091151	1

Material

Designation / Use	Part No.	Qty.
Loctite 573		
Engine oil		
Petroleum jelly, white		

Spare parts

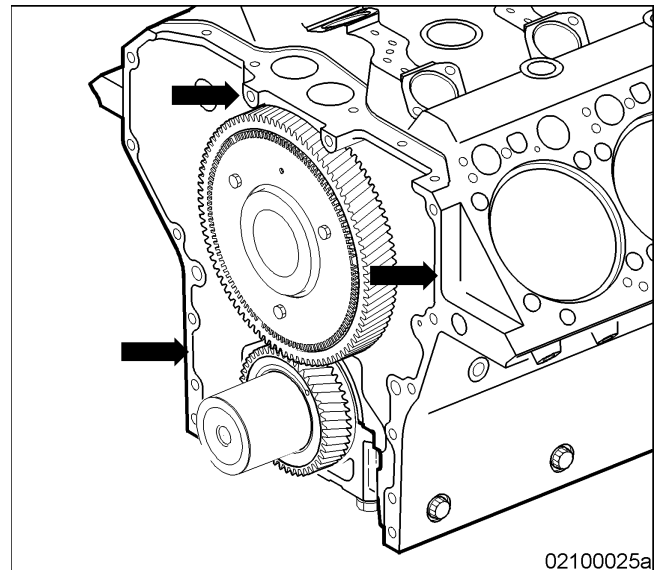
Designation / Use	Part No.	Qty.
O-ring		

 DANGER	Suspended load. Danger to life! <ul style="list-style-type: none"> • Use appropriate lifting devices and appliances. • Never stand beneath a suspended load.
 WARNING	Components have sharp edges. Risk of injury! <ul style="list-style-type: none"> • Wear protective gloves.
 CAUTION	Contamination of components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Check components for special cleanliness.

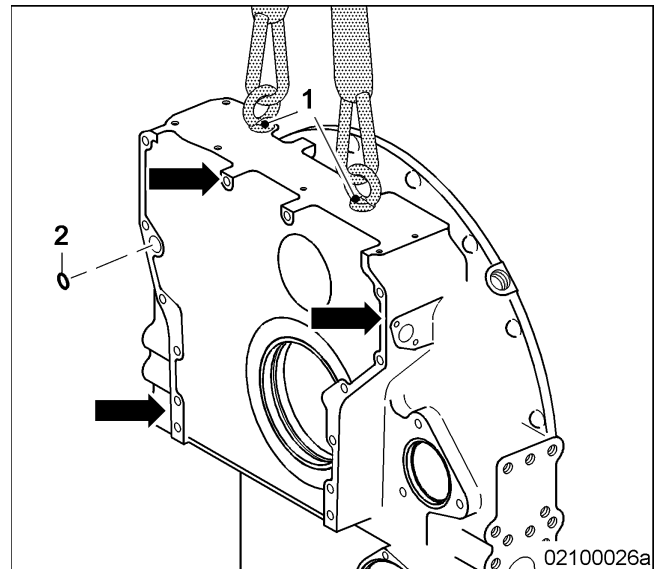
Assemble flywheel housing (→ Page 136).

Flywheel housing – Installation

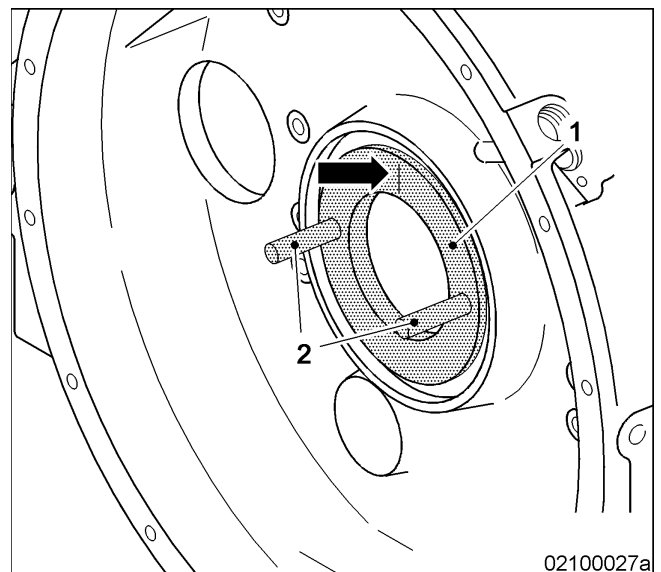
1. Degrease and dry sealing face (arrow) between flywheel housing and crankcase .
2. Coat sealing face (arrow) evenly with Loctite and smooth.



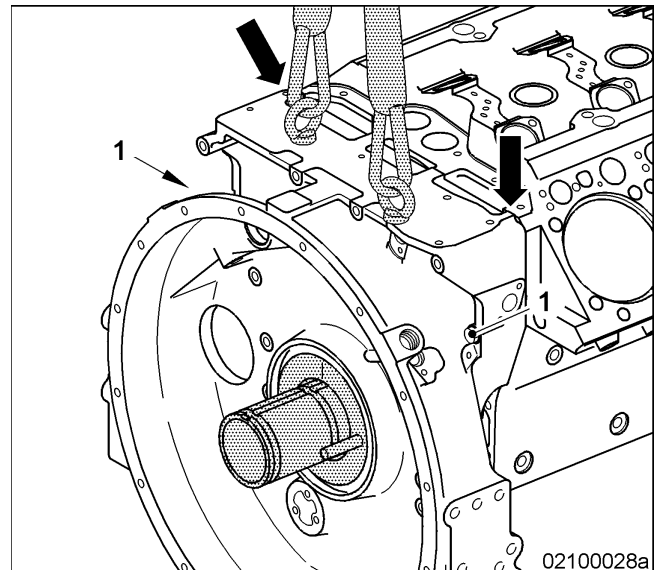
3. Coat O-ring (2) with petroleum jelly and insert into bores.
4. Screw eyebolts (1) into flywheel housing.
5. Use rope to attach flywheel housing to crane with light initial tension.



6. Install guide ring (1) with marking (arrow) facing upwards into crankshaft bearing bore on flywheel housing.
7. Lock guide ring (1) by turning the pins (2).



8. >Attach guide bushing to crankshaft with groove facing upwards.
9. Use crane to install flywheel housing on crankcase above guide bushing.
10. Insert two screws (1) and fix.
11. Bring flywheel housing in alignment with crankcase.
12. Check height tolerance and inclination at flange faces (arrows) of flywheel housing and crankcase.

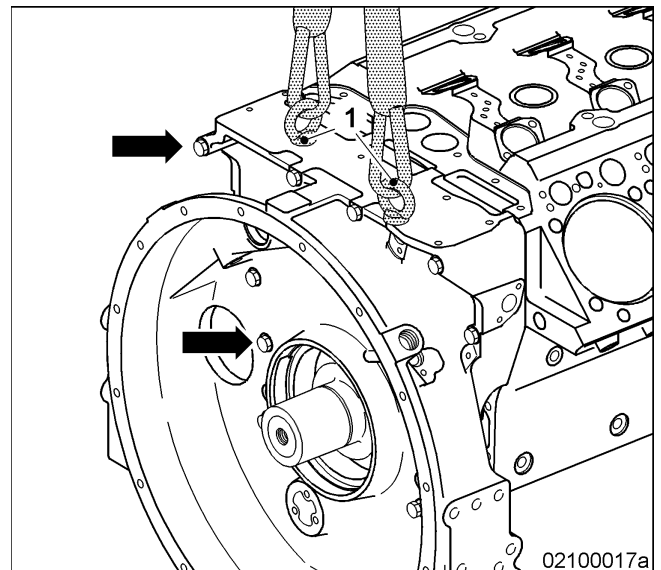


max. height tolerance	max. inclination
$\pm 0.1 \text{ mm}$	$\pm 0.01 \text{ mm}$

Result: Guide ring has freedom of movement.

Note: Observe different screw sizes and types.

13. Insert all screws (arrows) and washers and tighten evenly.
14. Remove alignment tool.
15. Remove lifting ropes and eyebolts (1).
16. Check axial play of camshaft (→ Page 342).



Final steps

A distinction must be made as to whether				
1 the engine was completely disassembled				
2 the engine was removed but not disassembled				
3 the engine is still installed				
1	2	3	Operations	See
X	–	–	Assemble engine	(→ Page 58)
X	–	–	Install engine	(→ Page 60)
–	X	X	Assembly in reverse sequence to disassembly	(→ Page 126)
–	–	X	Fill up with engine coolant	(→Operating Instructions)
–	–	X	Fill up with charge air coolant	(→Operating Instructions)
–	–	X	Enable engine start	–

3.2.10 Sensor sleeve – Removal and Installation

Special tools

Designation / Use	Part No.	Qty.
Mandrel		

Material

Designation / Use	Part No.	Qty.
Liquid nitrogen		

Spare parts

Designation / Use	Part No.	Qty.
Sleeve		



DANGER

Nitrogen is liquid (at -200°C).

Risk of freezing and suffocation!

- Do not allow liquid nitrogen to come into contact with parts of body (eyes, hands).
- Wear protective clothing, gloves, and goggles / safety mask.
- Ventilate working area well.

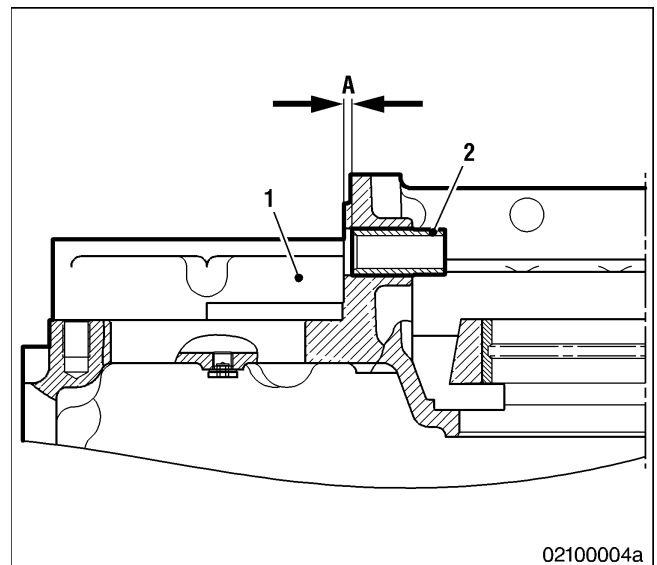
Check sleeve (→ Page 131).

Removing sleeve

1. Place flywheel housing on a suitable surface.
2. Use an appropriate mandrel and hammer to remove sleeve from flywheel housing.

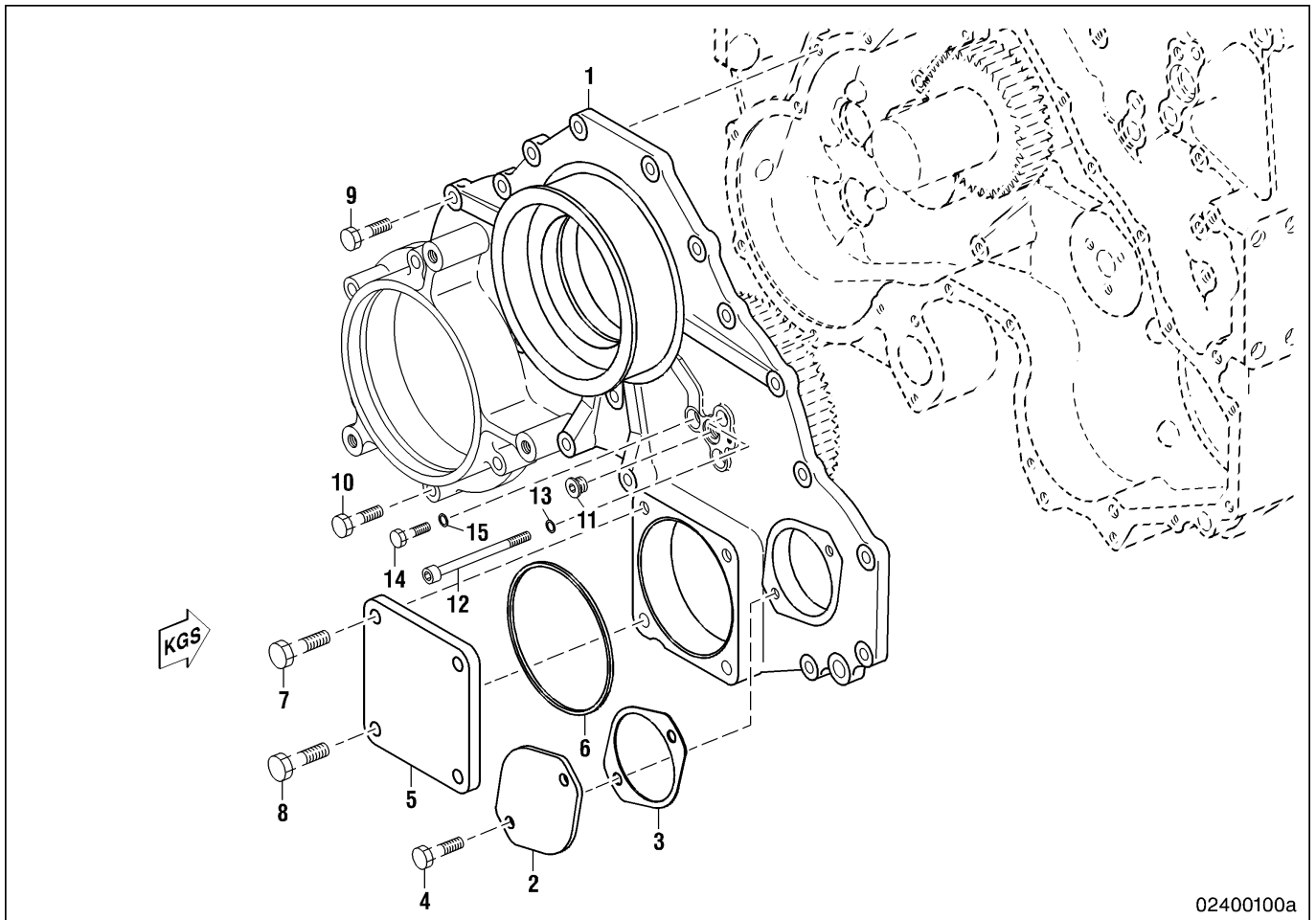
Installing sleeve

1. Clean bore in flywheel housing (1).
2. Chill sleeve (2) in liquid nitrogen.
3. Insert chilled sleeve (2) in flywheel housing (1).
Observe distance (A) $5\text{ mm} +0.50\text{ mm}$.



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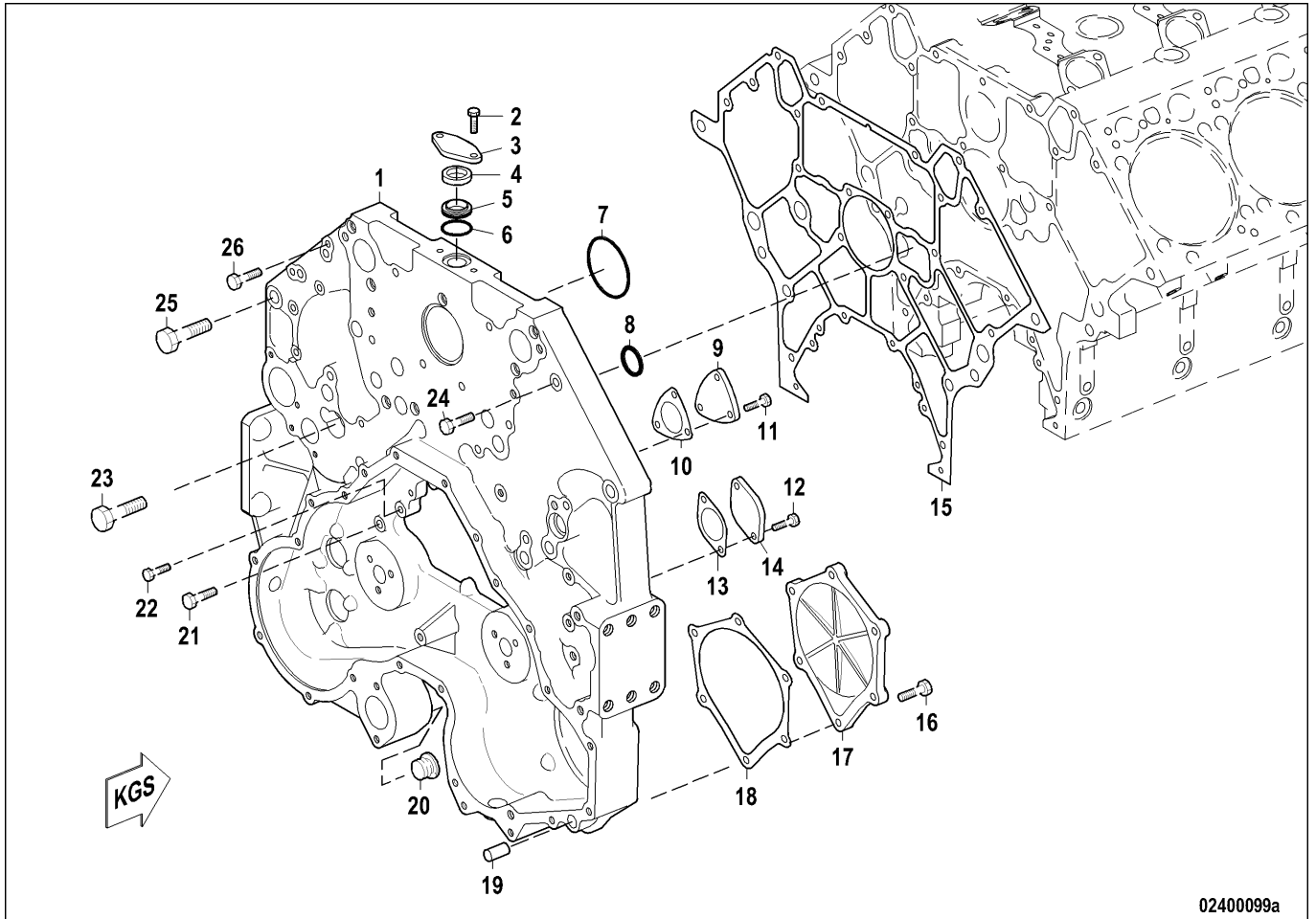
3.2.11 Gearcase, free end – Overview



- 1 Gearcase cover
- 2 Cover
- 3 Seal
- 4 Screw *
- 5 Cover *
- 6 O-ring

- 7 Screw *
- 8 Screw *
- 9 Screw
- 10 Screw
- 11 Plug screw
- 12 Screw

- 13 Sealing ring
- 14 Screw
- 15 Seal
- * Not applicable if charge-air coolant pump is installed




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- | | | |
|--------------------|-----------|------------------|
| 1 Gearcase housing | 10 Seal | 19 Centering pin |
| 2 Screw | 11 Washer | 20 Plug screw |
| 3 Cover | 12 Screw | 21 Screw |
| 4 Sealing ring | 13 Seal | 22 Screw |
| 5 Adapter | 14 Cover | 23 Screw |
| 6 O-ring | 15 Seal | 24 Screw |
| 7 O-ring | 16 Screw | 25 Screw |
| 8 O-ring | 17 Cover | 26 Screw |
| 9 Cover | 18 Seal | |

3.2.12 Gearcase, free end – Removal

Preconditions

- Engine is stopped and starting disabled.



DANGER

Suspended load.
Danger to life!

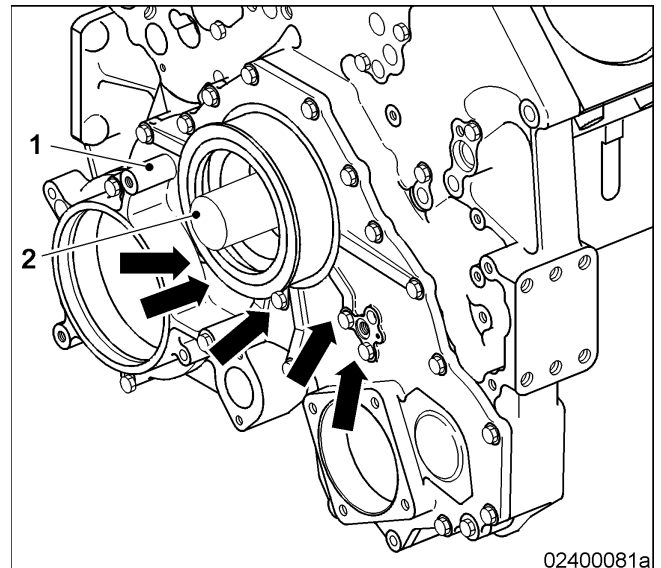
- Use appropriate lifting devices and appliances.
- Never stand beneath a suspended load.

Preparatory steps

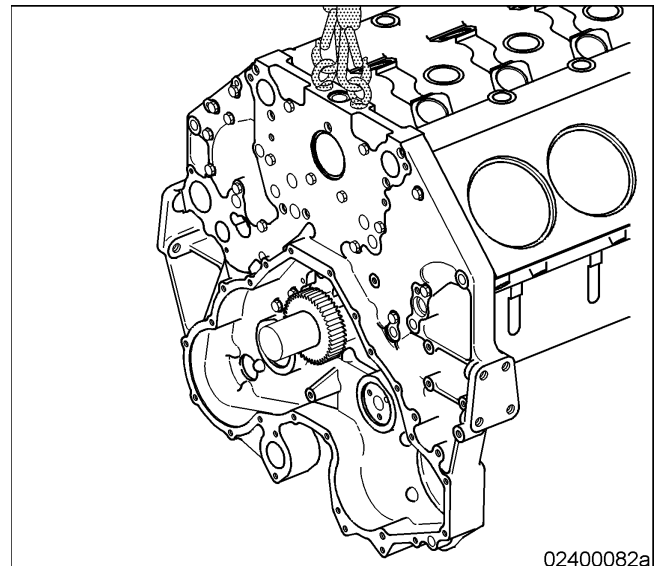
A distinction must be made as to whether 1 the engine is to be completely disassembled 2 the engine is to be removed but not disassembled 3 the engine is to remain installed				
1	2	3	Operations	See
X	–	–	Remove engine	(→ Page 55)
X	–	–	Disassemble engine	(→ Page 56)
–	–	X	Drain engine coolant	(→Operating Instructions)
–	–	X	Drain charge-air coolant	(→Operating Instructions)
–	–	X	Drain or draw off engine oil	(→Operating Instructions)
–	X	X	Remove fuel lines from pump to filter	(→ Page 406)
–	X	X	Remove fuel filter	(→ Page 411)
–	X	X	Remove fuel delivery pump	(→ Page 399)
–	X	X	Disconnect and remove electric wiring	(→ Page 604)
–	X	X	Remove belt drive	(→ Page 176)
–	X	X	Remove engine coolant pump	(→ Page 535)
–	X	X	Remove charge-air coolant pump	(→ Page 552)
–	X	X	Remove vibration damper	(→ Page 242)
–	X	X	Remove oil pump connections	(→ Page 486)
–	X	X	Remove battery-charging generator.	(→ Page 572)
–	X	X	Remove oil pan	(→ Page 104)
–	X	X	Coolant pipework with thermostat – Removal	(→ Page 563)
–	X	X	Attach engine with lifting device.	–
–	X	X	Remove engine mounting, free end	(→ Page 590)

Gearcase, free end – Removal

1. Mark and remove all screws (different sizes and types) on gearcase cover (arrows).
2. Secure gearcase cover (1) against falling, in order to avoid damage to slide bearing and crankshaft gear (2).
3. Use assembly lever to press gearcase cover (1) off gearcase housing.
4. Remove idler gears and axles (→ Page 160) .

**Removing gearcase housing**

1. Screw lifting eyes into gearcase housing.
2. Use rope to attach gearcase housing to crane with light initial tension.
3. Mark and remove all screws on gearcase housing (different lengths and types).
4. Remove gearcase housing from crankcase.
5. Remove O-rings and gasket.
6. Protect gearcase housing from damage.



3.2.13 Gearcase, free end – Disassembly

Special tools

Designation / Use	Part No.	Qty.
Extraction tool for shaft seal	F30379303	1



Heavy object.

Risk of crushing!

- Use appropriate lifting devices and appliances.



Remove gearcase, free end (→ Page 146).

Removing shaft seal from gearcase cover, free end

1. Place gearcase cover onto suitable surface.
2. Remove shaft seal with extraction tool.

3.2.14 Gearcase, free end – Cleaning

Material

Designation / Use	Part No.	Qty.
Cleaning agent		
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors. 	
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask. 	

Remove gearcase, free end (→ Page 146).

Cleaning equipment carrier

1. Clean all components with cleaning agent.
2. Remove cleaning agent.
3. Thoroughly clean equipment carrier, oil chambers and all oil bores by blowing out with compressed air.

3.2.15 Gearcase, free end – Check

Special tools

Designation / Use	Part No.	Qty.
Bore gauge	Y20091482	1
Adjusting ring		

Material

Designation / Use	Part No.	Qty.
Fluorescent magnetic powder for magnetic crack-testing		

Spare parts

Designation / Use	Part No.	Qty.
Gearcase housing		
Gearcase cover		



Heavy object.
Risk of crushing!

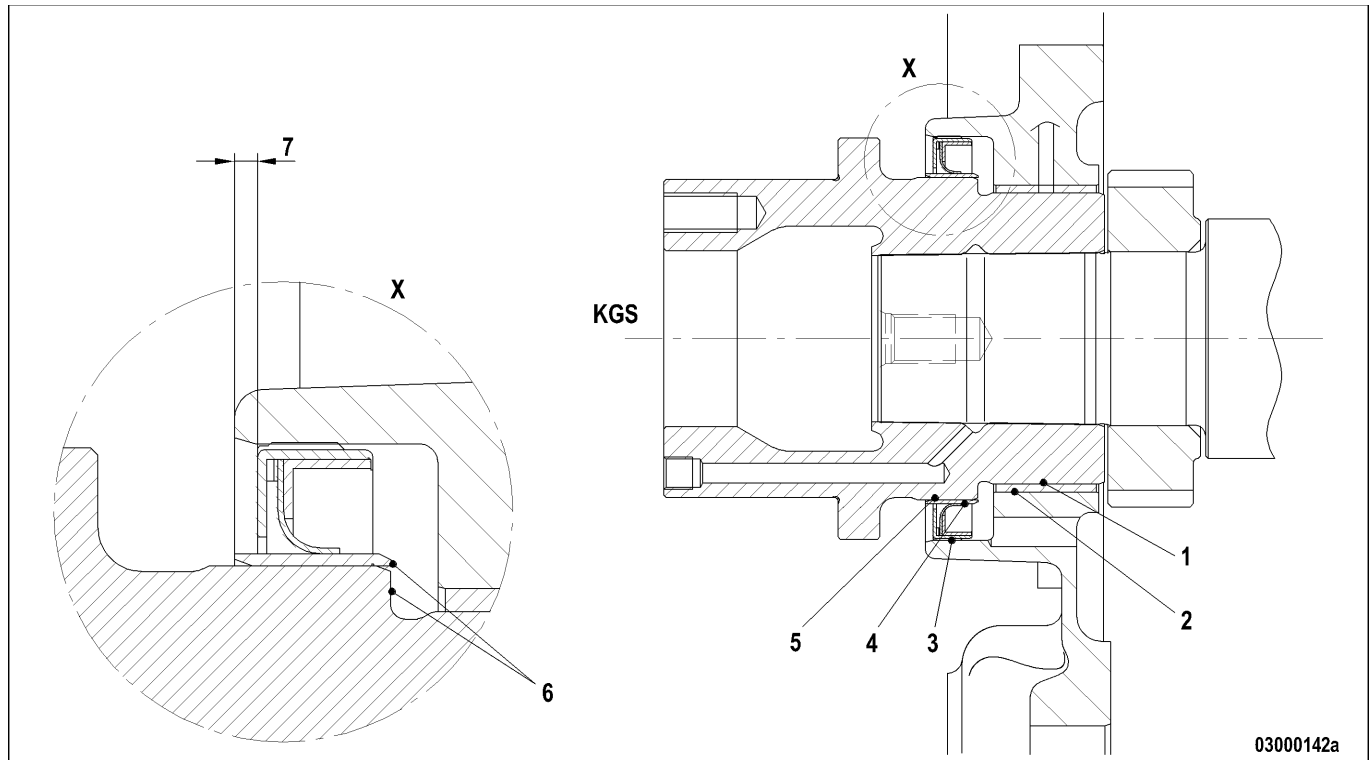
- Use appropriate lifting devices and appliances.

Disassemble gearcase, free end (→ Page 148).

Gearcase, free end – Check

Item	Findings	Task
Check gearcase housing and cover with magnetic crack test procedure for cracks.	Signs of cracks	Replace
Check crankshaft bearings for wear, scoring and indentation.	<ul style="list-style-type: none"> • Scores • Indentations visible 	Replace crankshaft bearing (→ Page 158).
Measure crankshaft bearings in gearcase cover. Values (→ Page 151)	Values exceeded	Replace crankshaft bearing (→ Page 158)
Check threads in gearcase housing for ease of movement.	Sluggish	Recut threads
Check threads and shanks of screws for damage.	Damaged	Replace screws.
Check all mating and sealing faces and fits.	Damaged	<ul style="list-style-type: none"> • Recondition with oilstone or emery cloth. • Replace

3.2.16 Gearcase, free end – Tolerances



No.	Designation	Level	Toleranced size		Clearance		Interference		Wear limit
			lower	upper	min.	max.	min.	max.	
1	Bearing bore		119.270	119.350					
2	Gearcase cover bore		125.387	125.438		0.051		0.051	
	Bearing outer Ø		125.387	125.437					
3	Gearcase cover bore		165.050	165.150			0.280	0.450	
	Shaft seal outer Ø		165.330	165.590					
4	Bearing race outer Ø		134.924	134.924					
5	Track ring bore		131.470	131.622					
6	Track ring press-fitted flush.								
7	Gap Shaft seal press-fitted		3.000						

3.2.17 Gearcase, free end – Assembly

Special tools

Designation / Use	Part No.	Qty.
Drift for shaft seal	F30378879	1

Material

Designation / Use	Part No.	Qty.
Denatured ethanol		

Spare parts

Designation / Use	Part No.	Qty.
Shaft seal		



Heavy object.

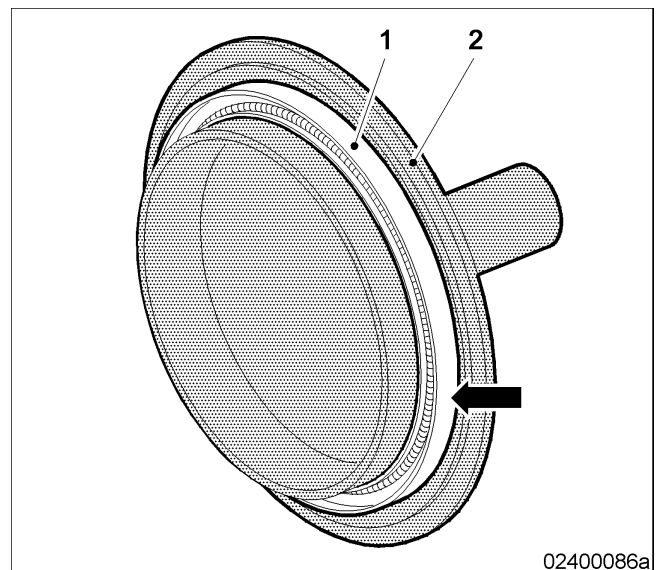
Risk of crushing!

- Use appropriate lifting devices and appliances.

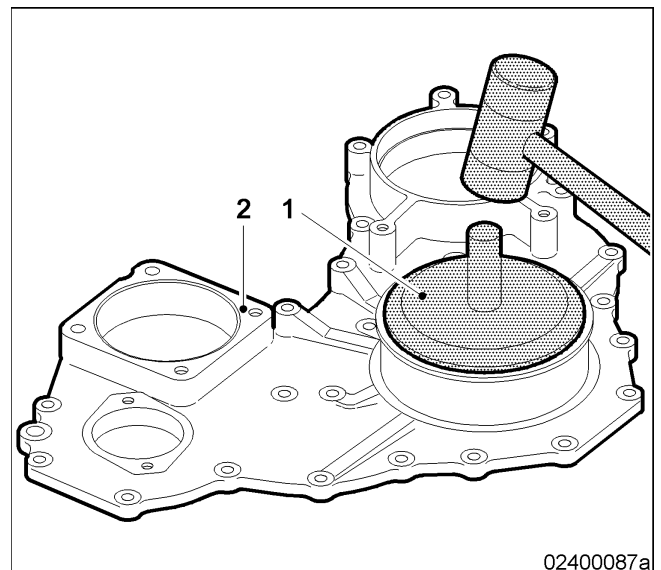
Check gearcase, free end (→ Page 150).

Installing shaft seal

1. Place shaft seal (1) on to drift (2), with sealing lip facing outwards.
2. Degrease and dry sealing face for shaft seal (1).
3. Coat sealing face on shaft seal with denatured ethanol.



4. Degrease and dry sealing face for shaft seal in gearcase cover (2).
5. Use drift (1) to press-fit shaft seal in gearcase cover.
6. Check metallic residue on shaft seal in gearcase cover (2). Value: $3 \text{ mm} \pm 0.2 \text{ mm}$
7. Install idler gears and axles (→ Page 165).



3.2.18 Gearcase, free end – Installation

Special tools

Designation / Use	Part No.	Qty.
Guide pin	F6558527	4
Alignment tool	F6554690	1
Press-in device shaft seal	F6557984	1
Press-in device shaft seal	F6780507	1

Material

Designation / Use	Part No.	Qty.
Engine oil		
Loctite 573		
Petroleum jelly, white		

Spare parts

Designation / Use	Part No.	Qty.
O-ring		
Gasket		
Pipe half-clamp		



Suspended load.

Danger to life!

- Use appropriate lifting devices and appliances.
- Never stand beneath a suspended load.



Heavy object.

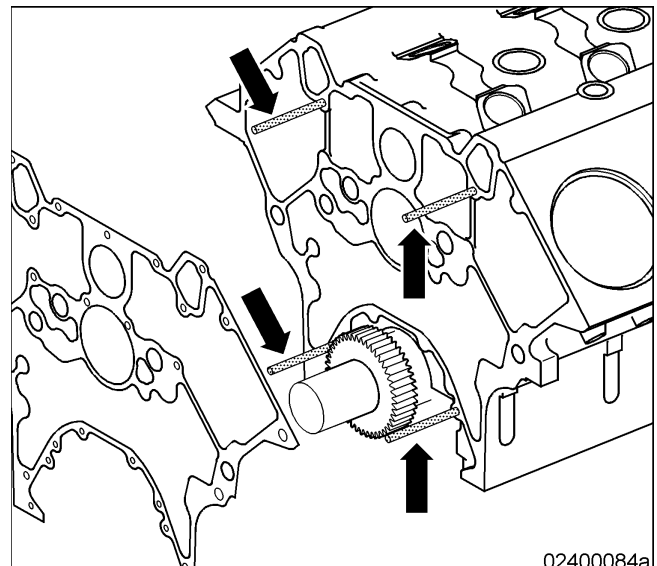
Risk of crushing!

- Use appropriate lifting devices and appliances.

Assemble gearcase, free end (→ Page 152).

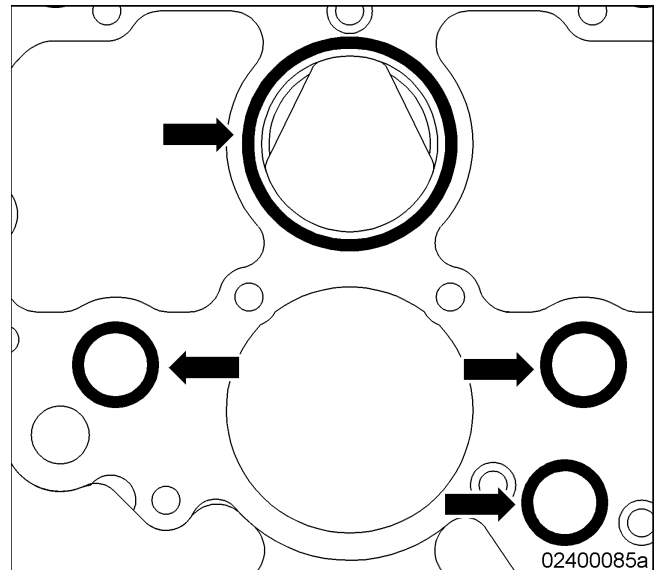
Installing gearcase, free end

1. Screw guide pins (arrows) into crankcase.
2. Attach gasket above the guide pins.
3. Adjust seal length to fit oil pan mating face.



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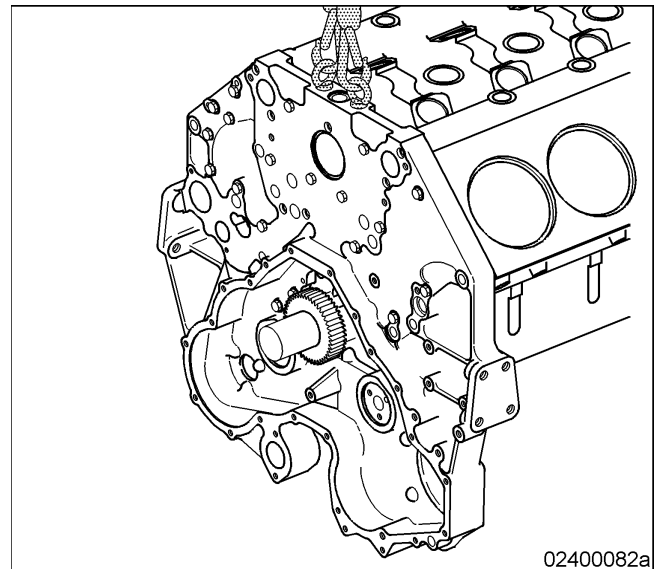
4. Coat O-rings (arrows) with petroleum jelly and insert into grooves on gearcase housing.



5. Screw lifting eyes into gearcase housing and use rope to attach to crane with light initial tension.
6. Install gearcase housing on crankcase above the guide pins.
7. Remove suspension ropes and lifting eyes.

Note: Observe markings / different screw lengths.

8. Insert all screws and tighten uniformly.

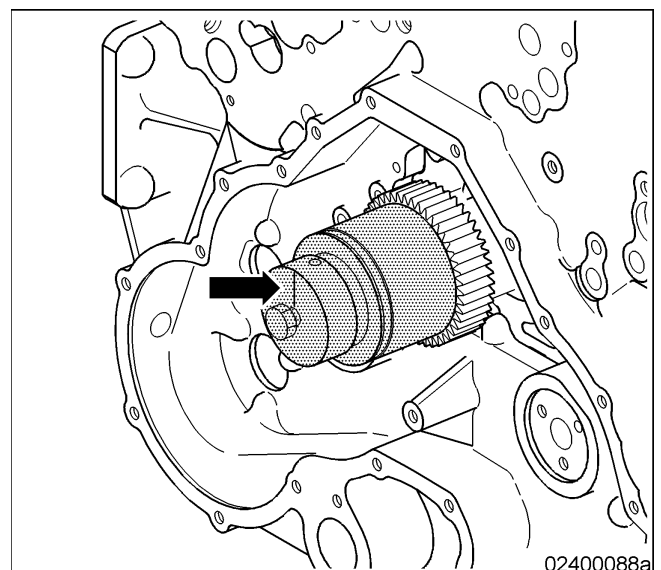


Installing gearcase cover

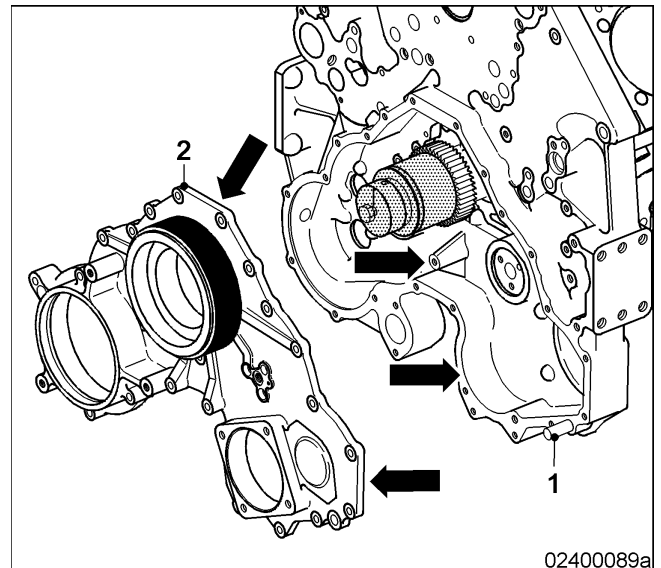
1. Turn back jackscrew on alignment tool.

Note: Marking (arrow) always faces upwards, independent of crankcase position.

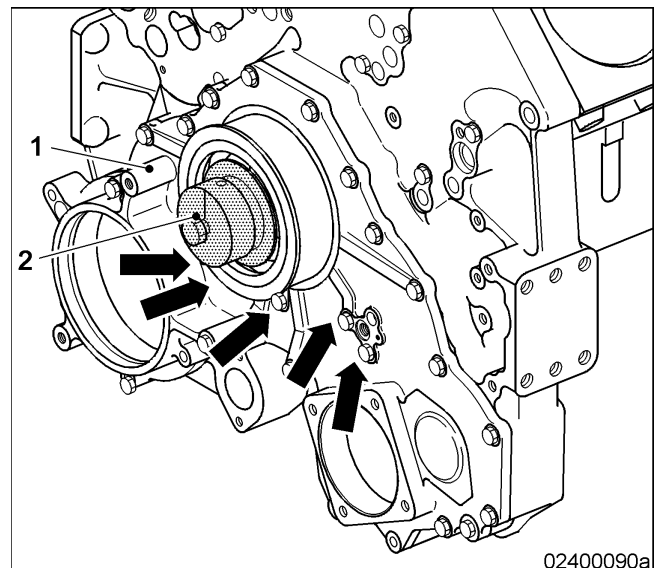
2. Install alignment tool on crankshaft.



3. Degrease and dry contact surfaces (arrows) on gearcase housing and gearcase cover (2).
4. Coat contact surface on gearcase housing with Loctite.
5. Drive centering pin (1) into gearcase housing.

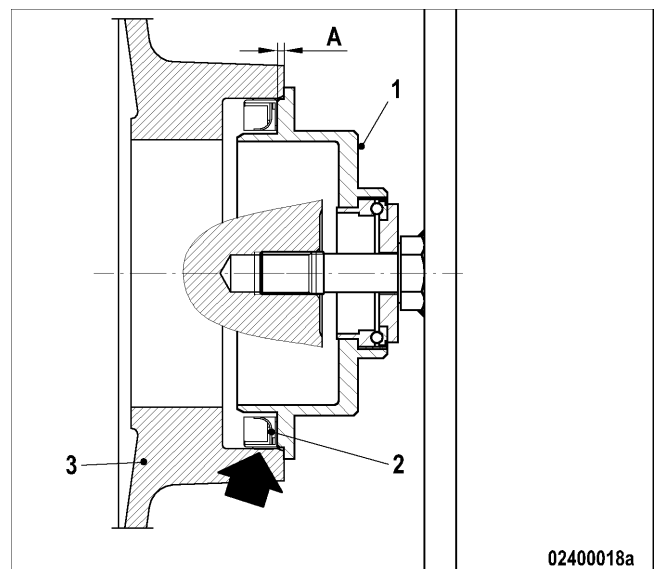


6. Install gearcase cover (1) on gearcase housing above the alignment tool (2).
- Note:** Observe markings / different screw lengths.
7. Insert all screws and washers into gearcase cover (arrows) and tighten uniformly.
 8. Remove alignment tool from crankshaft with jackscrew.



Installing shaft seal with gearcase cover attached

1. Place shaft seal (2) on to press-in device (1), with sealing lip facing outwards.
2. Coat sealing face (arrow) with denatured ethanol.
3. Degrease and dry sealing face in gearcase cover.
4. Use press-in device (1) to install shaft seal (2) in gearcase cover.
5. Check clearance (A) of shaft seal (2) in gearcase cover. $A = 3 \text{ mm} \pm 0.2 \text{ mm}$



Final steps

A distinction must be made as to whether				
1 the engine was completely disassembled				
2 the engine was removed but not disassembled				
3 the engine is still installed				
1	2	3	Operations	See
X	–	–	Assemble engine	(→ Page 58)
X	–	–	Install engine	(→ Page 60)
–	X	X	Assembly in reverse sequence to disassembly	(→ Page 146)
–	–	X	Fill oil system with engine oil	(→Operating Instructions)
–	–	X	Fill with engine coolant	(→Operating Instructions)
–	–	X	Fill with charge-air coolant	(→Operating Instructions)
–	–	X	Fill fuel system	(→Operating Instructions)
–	–	X	Enable engine start	–

3.2.19 Gearcase main bearing, free end – Removal and installation

Special tools



Designation / Use	Part No.	Qty.
Insertion tool	F30379217	1

Material

Designation / Use	Part No.	Qty.
Liquid nitrogen		

Spare parts

Designation / Use	Part No.	Qty.
Main bearing		

 DANGER	Nitrogen is liquid (at -200°C). Risk of freezing and suffocation! <ul style="list-style-type: none"> • Do not allow liquid nitrogen to come into contact with parts of body (eyes, hands). • Wear protective clothing, gloves, and goggles / safety mask. • Ventilate working area well.
 WARNING	Component is hot. Risk of burning! <ul style="list-style-type: none"> • Wear protective gloves.

Check main bearing bore (→ Page 150).

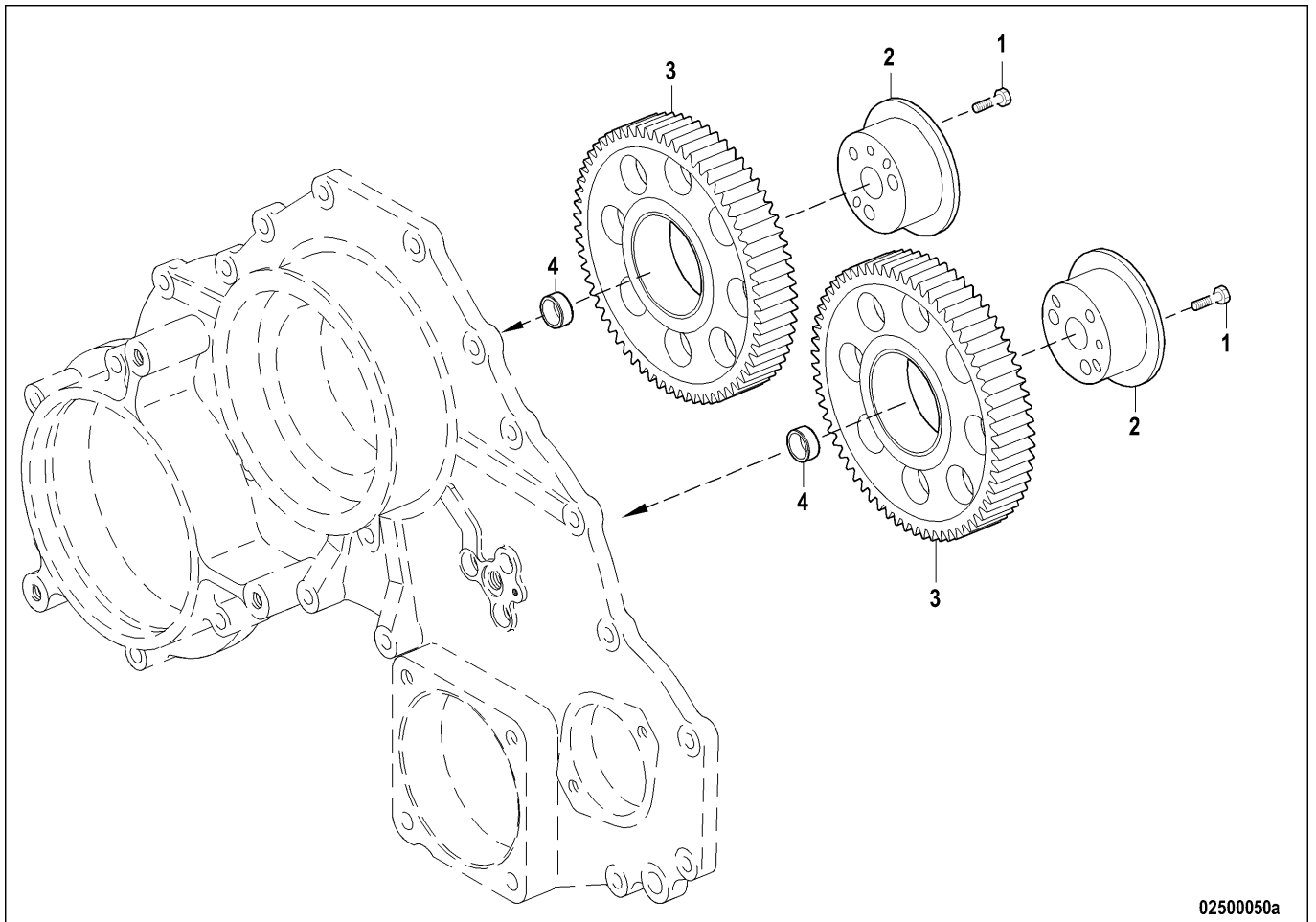
Removing main bearing

1. Remove main bearing with appropriate mandrel and remove press from gearcase cover.
2. Measure main bore in gearcase cover. Values (→ Page 151).
3. If values are exceeded, replace gearcase cover.

Installing main bearing

1. Place gearcase cover on to suitable surface.
2. Chill crankshaft bearing in liquid nitrogen.
3. Insert chilled crankshaft bearing in gearcase cover.
4. Recondition crankshaft bearing to finished dimension.

3.2.20 Gear train, free end – Overview



02500050a

1 Screw
2 Shaft

3 Idler gear
4 Centering sleeve

3.2.21 Gear train, free end – Removal



Heavy object.

Risk of crushing!

- Use appropriate lifting devices and appliances.

Preparatory steps

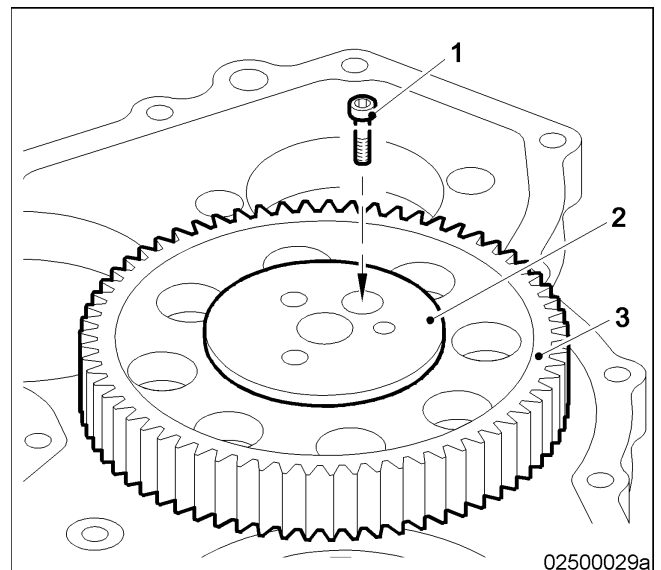
A distinction must be made as to whether

- 1 the engine is to be completely disassembled
- 2 the engine is to be removed but not disassembled
- 3 the engine is to remain installed

1	2	3	Operations	See
X	–	–	Remove engine	(→ Page 55)
X	–	–	Disassemble engine	(→ Page 56)
–	–	X	Drain engine coolant	(→Operating Instructions)
–	–	X	Drain charge-air coolant	(→Operating Instructions)
–	–	X	Drain or draw off engine oil	(→Operating Instructions)
–	X	X	Remove fuel lines from pump to filter	(→ Page 406)
–	X	X	Remove fuel delivery pump	(→ Page 399)
–	X	X	Disconnect and remove electric wiring	(→ Page 604)
–	X	X	Remove belt drive	(→ Page 176)
–	X	X	Remove fan drive	(→ Page 176)
–	X	X	Remove engine coolant pump	(→ Page 535)
–	X	X	Remove charge-air coolant pump	(→ Page 552)
–	X	X	Removing vibration damper	(→ Page 242)
–	X	X	Remove battery-charging generator.	(→ Page 572)
–	X	X	Remove gearcase, free end	(→ Page 146)



Removing idler gears

1. Place gearcase cover on a clean, flat surface.
2. Mark relevant axle and idler gear according to place of installation.
3. Remove screw (1).
4. Remove axle (2) together with idler gear (3) from centering sleeve.
5. Remove centering sleeve from gearcase cover.



3.2.22 Gear train, free end – Cleaning

Material

Designation / Use	Part No.	Qty.
Cleaning agent		
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors. 	
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask. 	

Remove gear train, free end (→ Page 160).

Gear train, free end – Cleaning

1. Clean all components with cleaning agent.
2. Remove cleaning agent.
3. Clean gear train, free end, and all threads thoroughly with compressed air.

3.2.23 Gear train, free end – Check

Special tools

Designation / Use	Part No.	Qty.
Bore gauge	Y20091481	1
Micrometer	Y20000088	1
Magnifying glass		

Material

Designation / Use	Part No.	Qty.
Fluorescent magnetic powder for magnetic crack-testing		

Spare parts

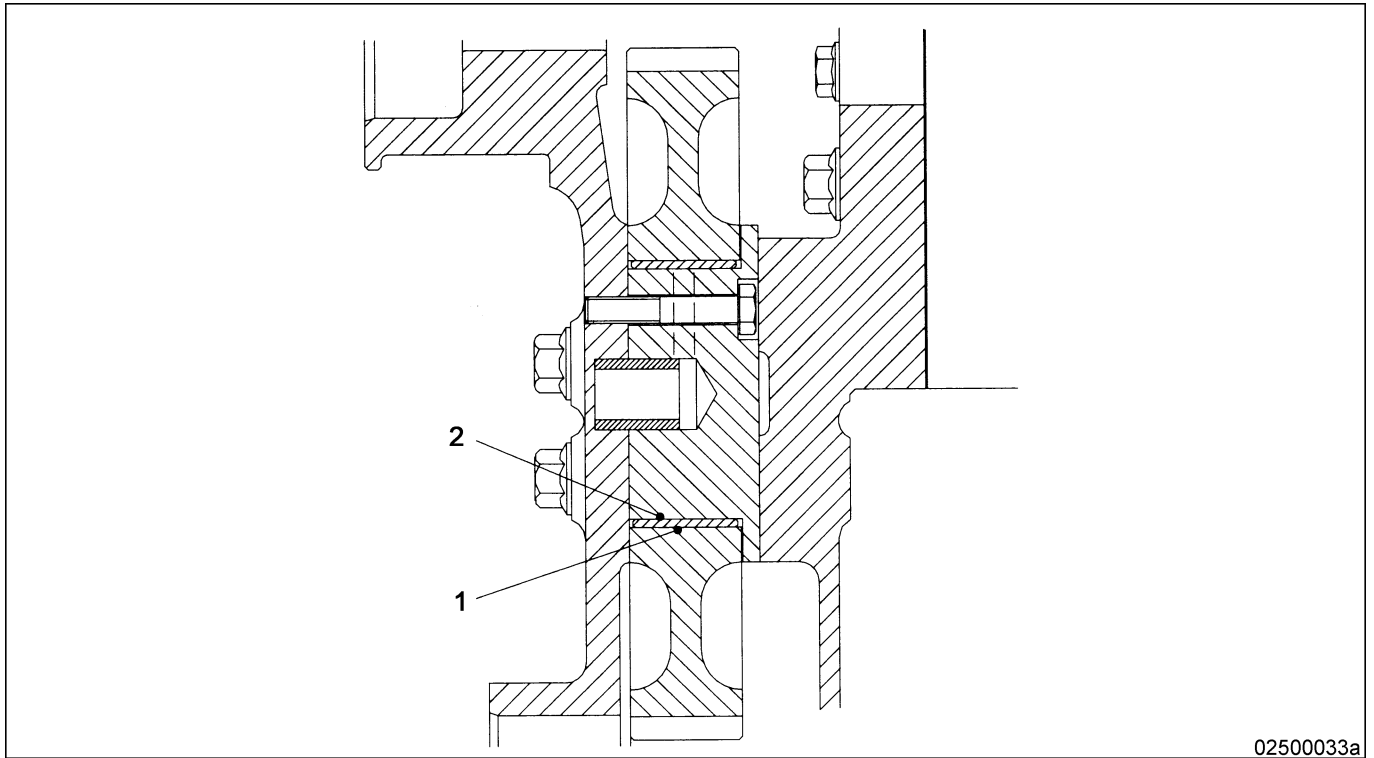
Designation / Use	Part No.	Qty.
Idler gears		
Axle		

Clean gear train, free end (→ Page 162).

Gear train, free end – Check

Item	Findings	Measure
Check idler gear(s) with magnetic crack test procedure for cracks.	Signs of cracks	Replace idler gears.
Check surface quality of idler gear tooth flanks with magnifying glass.	Damaged	Replace idler gear.
Check running surface of axle(s), bearing bush in idler gear(s) and axial slip surface of gear(s) for wear, scores and stress marks.	<ul style="list-style-type: none"> • Scores • Stress marks visible 	<ul style="list-style-type: none"> • Recondition: with oilstone or emery cloth. • Replace
Check bearing seat and mating face of axle(s) for scores and stress marks.	<ul style="list-style-type: none"> • Scores • Stress marks visible 	<ul style="list-style-type: none"> • Recondition: • Replace
Check screws for damage and thread for ease of movement.	<ul style="list-style-type: none"> • Damaged • Sluggish 	Replace screws.
Measure bearing bush bore of idler gear(s). Values (→ Page 164)	Values exceeded.	Replace bearing bush (→ Page 168)
Measure outer diameter of axle(s) at running surface with micrometer. Values (→ Page 164)	Values not attained.	Replace axle.

3.2.24 Gear train, free end – Tolerances



02500033a

No.	Designation	Stage	Tolerance size		Clearance		Interference		Wear limit
			lower	upper	min.	max.	min.	max.	
1	Idler gear bore		79.337	79.374			0.165	0.210	
	Bush outer Ø		79.539	79.547					
2	Cylinder liner ID		74.385	74.413	0.035	0.078			
	Axle outer Ø		74.335	74.350					

3.2.25 Gear train, free end – Installation

Special tools

Designation / Use	Part No.	Qty.
Drive in tool for centering sleeve	F30378645	1

Material

Designation / Use	Part No.	Qty.
Engine oil		

Spare parts

Designation / Use	Part No.	Qty.
Centering sleeve		



Suspended load.

Danger to life!

- Use appropriate lifting devices and appliances.
- Never stand beneath a suspended load.



Contamination of components.

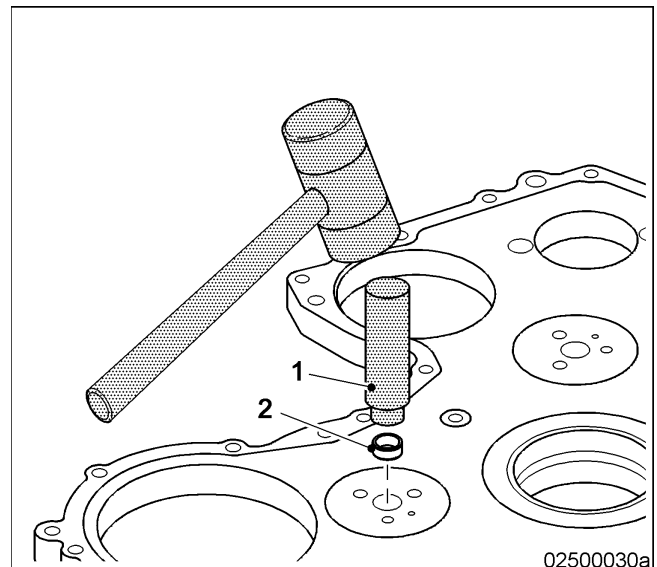
Damage to component!

- Observe manufacturer's instructions.
- Check components for special cleanliness.

Check gear train, free end (→ Page 163).

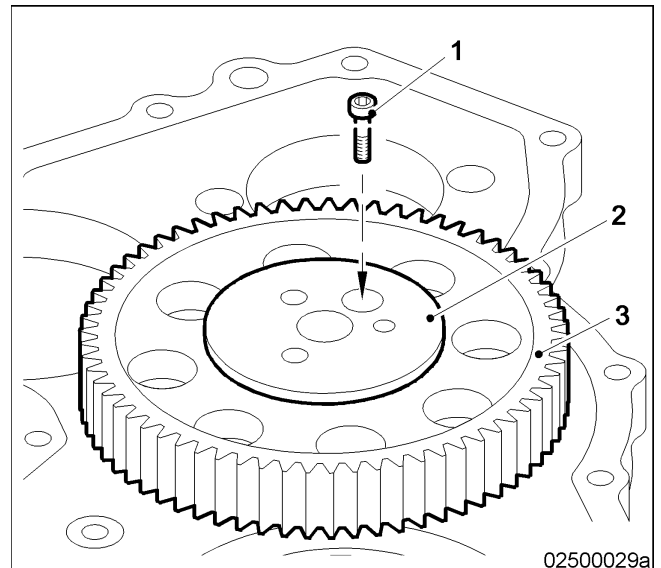
Installing centering sleeve

1. Coat centering sleeve (2) with engine oil.
2. Use drive in tool (1) to drive centering sleeve (2) up to stop in relevant bore on gearcase cover.

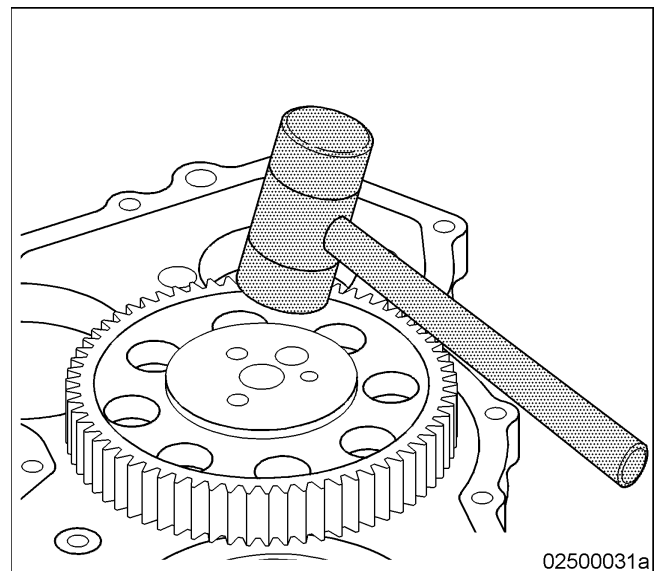


Installing idler gear and axle in gearcase cover

1. Coat idler gear and axle with engine oil.
2. Install idler gear (3) with axle (2) in the centering sleeve as marked.

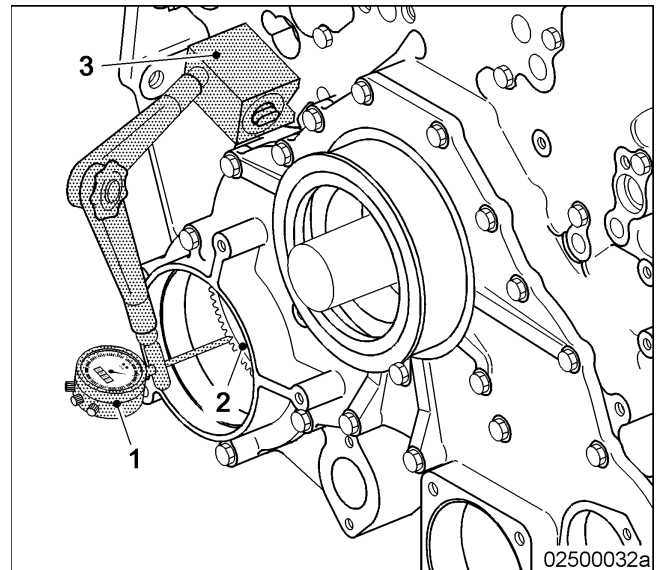


3. Use plastic mallet to drive axle up to stop in centering sleeves.
4. Tighten screw in the axle.
5. Check idler gears for ease of movement.
6. Install gearcase cover (→ Page 154).



Checking axial clearance and circumferential backlash

1. Attach magnetic dial gauge holder (3) with dial gauge (1) to gearcase cover.
2. Measure axial clearance:
 - 2.1. Place preloaded dial gauge stylus on lateral collar of idler gear (2).
 - 2.2. Set dial gauge to zero.
 - 2.3. Check axial play by moving idler gear back and forth in axial direction. Axial play values (→ Page 122).
3. Measure circumferential backlash:
 - 3.1. Place preloaded dial gauge stylus on a tooth flank of idler gear (2).
 - 3.2. Set dial gauge to zero.
 - 3.3. Check backlash by moving idler gear back and forth in radial direction.
 - 3.4. Compare with desired values in table (→ Page 122).
4. If limit values are exceeded, replace idler gears.



Final steps

A distinction must be made as to whether

- 1 the engine was completely disassembled
- 2 the engine was removed but not disassembled
- 3 the engine is still installed

1	2	3	Operations	See
X	–	–	Assemble engine	(→ Page 58)
X	–	–	Install engine	(→ Page 60)
–	X	X	Assembly in reverse sequence to disassembly	(→ Page 160)
–	–	X	Fill oil system with engine oil.	(→Operating Instructions)
–	–	X	Fill with engine coolant	(→Operating Instructions)
–	–	X	Fill with charge-air coolant	(→Operating Instructions)
–	–	X	Enable engine start	–

3.2.26 Bearing bush – Removal and installation

Special tools

Designation / Use	Part No.	Qty.
Manual press		
Sleeve		

Material

Designation / Use	Part No.	Qty.
Liquid nitrogen		

Spare parts

Designation / Use	Part No.	Qty.
Bush		



DANGER

Nitrogen is liquid (at -200°C).

Risk of freezing and suffocation!

- Do not allow liquid nitrogen to come into contact with parts of body (eyes, hands).
- Wear protective clothing, gloves, and goggles / safety mask.
- Ventilate working area well.



WARNING

Component is hot.

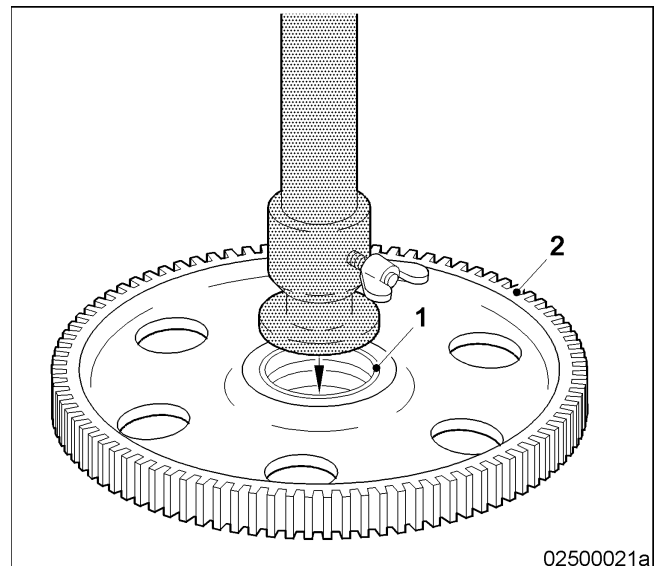
Risk of burning!

- Wear protective gloves.

Check bearing bush bore (→ Page 163).

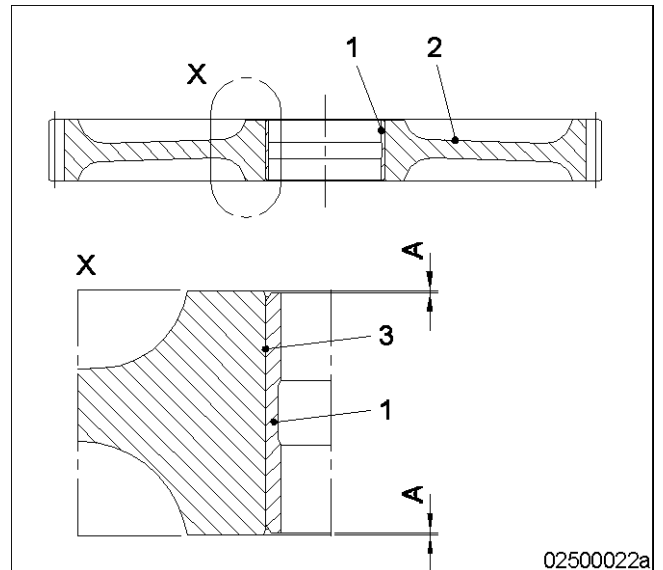
Removing bearing bush

1. Clean idler gear (→ Page 162).
2. Using a suitable sleeve and manual press, remove bearing bush (1) from idler gear (2).

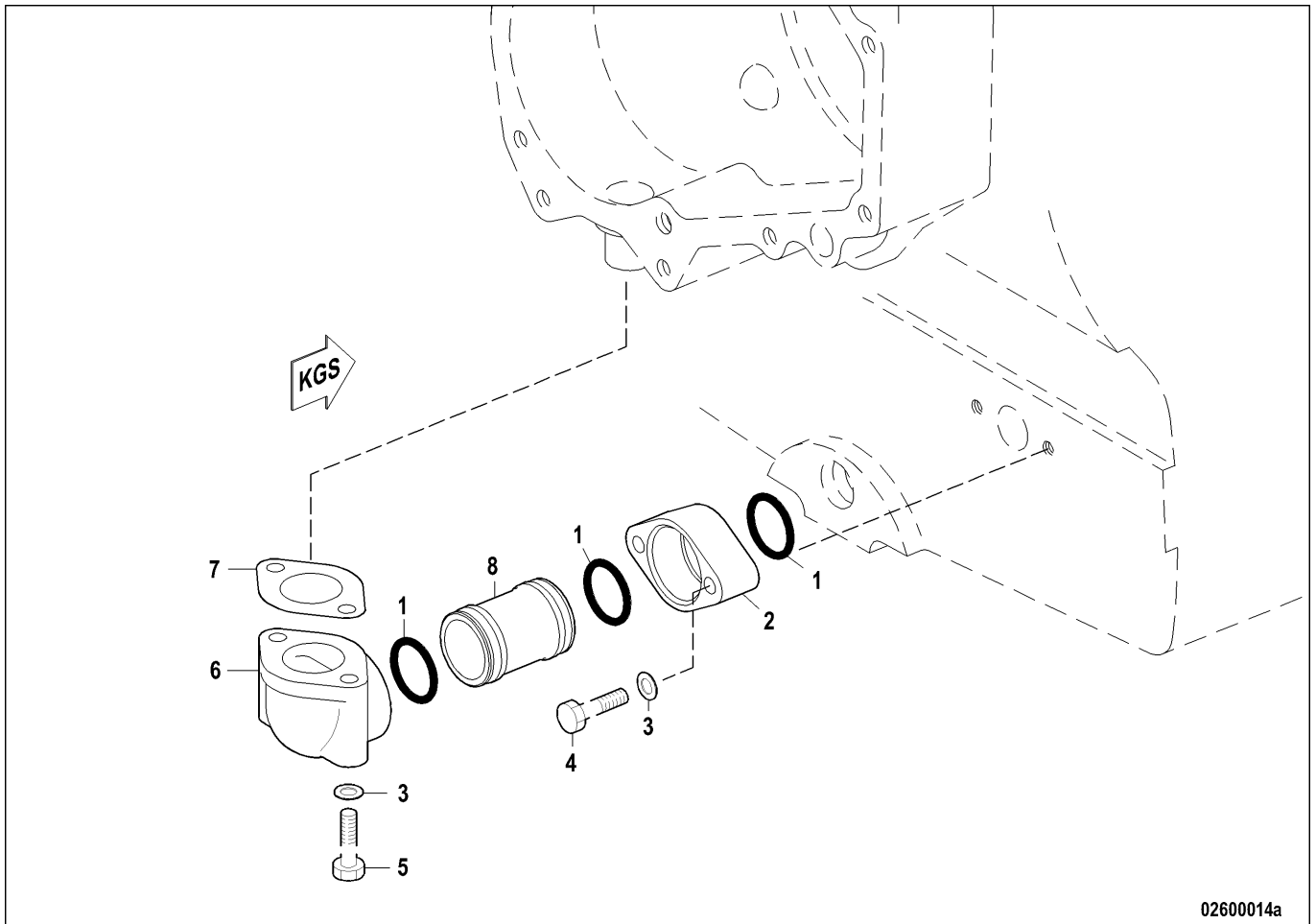


Installing bearing bush

1. Measure main bore (3) in idler gear (2). Values (→ Page 164)
2. Place idler gear (2) on suitable surface. When inserting the bearing bush (1), make sure there is no lateral protrusion.
3. Cool bearing bush in liquid nitrogen and heat idler gear to 80 °C.
4. Insert chilled bearing bush into idler gear. Observe clearance (A) $0.3 \text{ mm} \pm 0.1 \text{ mm}$.



3.2.27 Gearcase attachments, free end – Overview



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- | | |
|----------|----------------|
| 1 O-ring | 5 Screw |
| 2 Flange | 6 Elbow |
| 3 Washer | 7 Seal |
| 4 Screw | 8 Plug-in pipe |

3.2.28 Gearcase, free end – Removing attachments

Preconditions

- Engine is stopped and starting disabled.

Preparatory steps



A distinction must be made as to whether				
1 The engine is to be completely disassembled				
2 The engine is to be removed but not disassembled				
3 The engine is to remain installed				
1	2	3	Operations	See
X	–	–	Remove engine	(→ Page 55)
X	–	–	Disassemble engine	(→ Page 56)
–	–	X	Disable engine start	(→ Page 15)
–	–	X	Drain or draw off engine oil	(→Operating Instructions)

Removing gearcase attachments, free end

1. Remove gearcase attachments, free end, as shown in overview drawing (→ Page 170).
2. After removal, close all openings with suitable covers.

3.2.29 Gearcase, free end – Cleaning attachments

Material

Designation / Use	Part No.	Qty.
Cleaning agent		
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors. 	
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask. 	

Remove gearcase attachments, free end (→ Page 171).

Cleaning gearcase attachments, free end

1. Clean all components with cleaning agent.
2. Remove cleaning agent.
3. Blow out all parts with compressed air.

3.2.30 Gearcase attachments, free end – Check

Spare parts

Designation / Use	Part No.	Qty.
Elbow		
Plug-in pipe		
Flange		

Clean gearcase attachments, free end (→ Page 172).

Gearcase attachments, free end – Check

Item	Findings	Measure
Check plug connection and annular grooves on elbows and flange visually for wear.	Wear visible	Replace
Check sealing and mating faces for stress marks and damage.	Damaged	<ul style="list-style-type: none"> • Recondition: with oilstone or emery cloth. • Replace

3.2.31 Gearcase attachments, free end – Installation

Material

Designation / Use	Part No.	Qty.
Engine oil		
Petroleum jelly, white		

Spare parts

Designation / Use	Part No.	Qty.
O-ring		
Seal		

Check gearcase attachments, free end (→ Page 173).

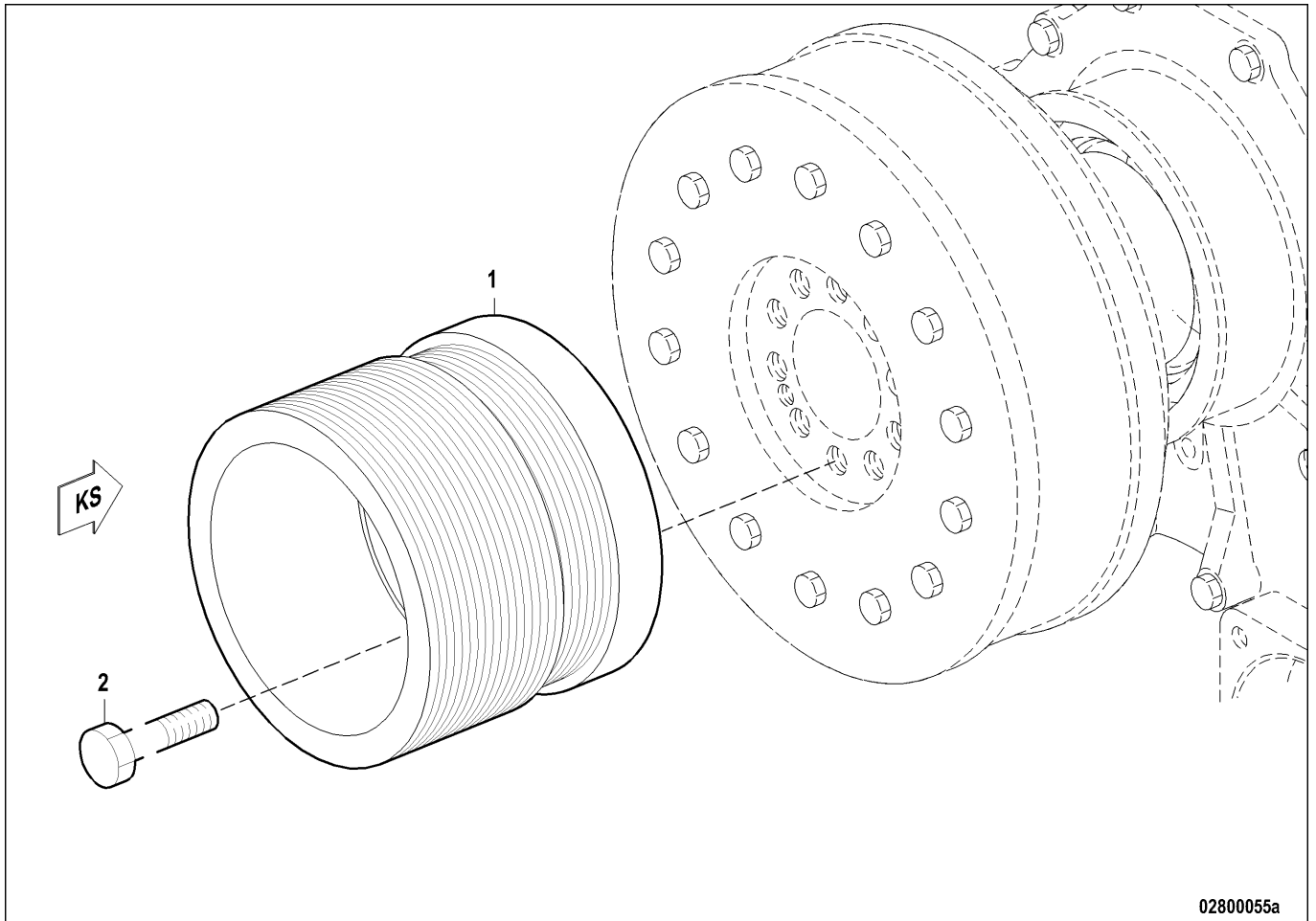
Gearcase attachments, free end – Installation

1. Coat O-rings with petroleum jelly and insert in grooves of plug-in pipe and flange.
2. Install gearcase attachments, free end, as shown in overview drawing (→ Page 110) .

Final steps

A distinction must be made as to whether				
1 the engine was completely disassembled				
2 the engine was removed but not disassembled				
3 the engine is still installed				
1	2	3	Operations	See
X	–	–	Assemble engine	(→ Page 58)
X	–	–	Install engine	(→ Page 60)
–	–	X	Fill oil system with engine oil	(→Operating Instructions)
–	–	X	Enable engine start	–

3.2.32 Belt drive – Overview



1 Belt pulley

2 Screw

3.2.33 Belt drive – Removal

Preconditions

- Engine is stopped and starting disabled

Preparatory steps



For these steps a distinction must be made as to whether				
1 the engine is to be completely disassembled				
2 the engine is to be removed but not disassembled				
3 the engine is to remain installed				
1	2	3	Operations	See
X	–	–	Remove engine.	(→ Page 55)
X	–	–	Disassemble engine.	(→ Page 56)
–	–	X	Disable engine start.	(→ Page 15)
–	X	X	Remove protection.	–
–	X	X	Remove fan wheel.	–

Removing belt drive

1. Remove drive belt of mechanical fan drive (→Operating instructions).
2. Remove drive belt of battery-charging generator (→Operating instructions).
3. Remove belt pulley as per overview (→ Page 175).

3.2.34 Belt drive – Cleaning

Material

Designation / Use	Part No.	Qty.
Cleaning agent		
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors. 	
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask. 	

Remove belt drive (→ Page 176).

Belt drive – Cleaning

1. Clean all components with cleaning agent.
2. Remove cleaning agent.
3. Blow out all parts with compressed air.

3.2.35 Belt drive – Check

Spare parts

Designation / Use	Part No.	Qty.
Belt pulley		

Clean belt drive (→ Page 177).

Checking belt drive

Item	Findings	Task
Visually inspect belt pulley for damage and wear.	Damaged	Replace
Check screw joint surfaces for damage and condition.	Damaged	<ul style="list-style-type: none"> • Rework: smooth with oilstone • Replace
Check threads for ease of movement.	Damaged	<ul style="list-style-type: none"> • Rework: recut threads • Replace

3.2.36 Belt drive – Installation

Material

Designation / Use	Part No.	Qty.
Engine oil		

Check belt drive (→ Page 178).

Installing belt drive

1. Install belt pulley as per overview (→ Page 175).
2. Tighten screws to specified tightening torque using a torque wrench (→ Page 23).
3. Install drive belt of battery-charging generator drive (→Operating instructions).
4. Install drive belt of mechanical fan drive (→Operating instructions).

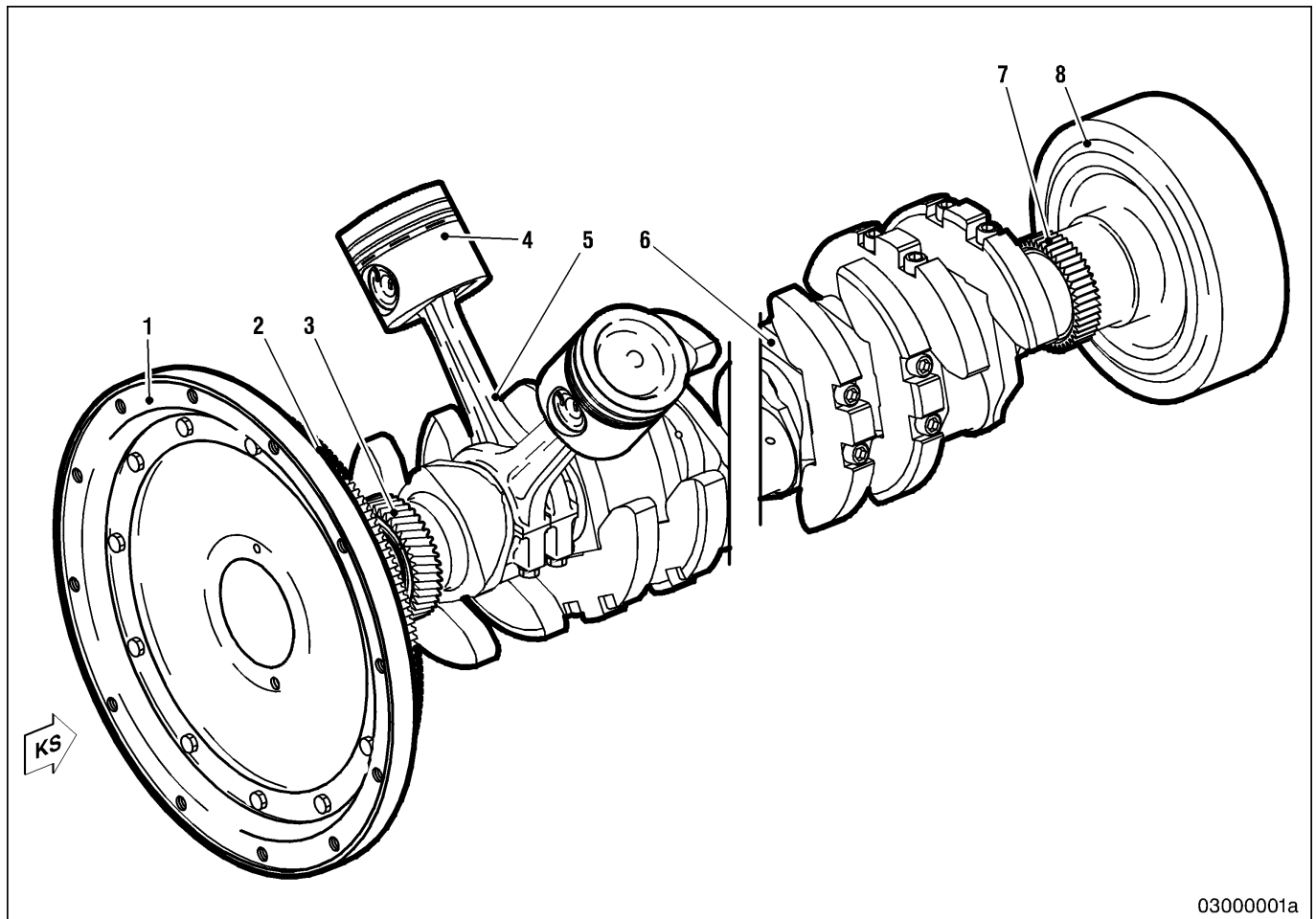
Final steps

For these steps a distinction must be made as to whether				
1 the engine has been completely disassembled				
2 the engine has been removed but not disassembled				
3 the engine has remained installed				
1	2	3	Operations	See
X	–	–	Assemble engine.	(→ Page 58)
X	–	–	Install engine.	(→ Page 60)
–	X	X	Install fan wheel.	–
–	X	X	Install protection.	–
–	–	X	Enable engine start.	–

3.3 Running Gear

3.3.1 Running gear – Overview

Running gear

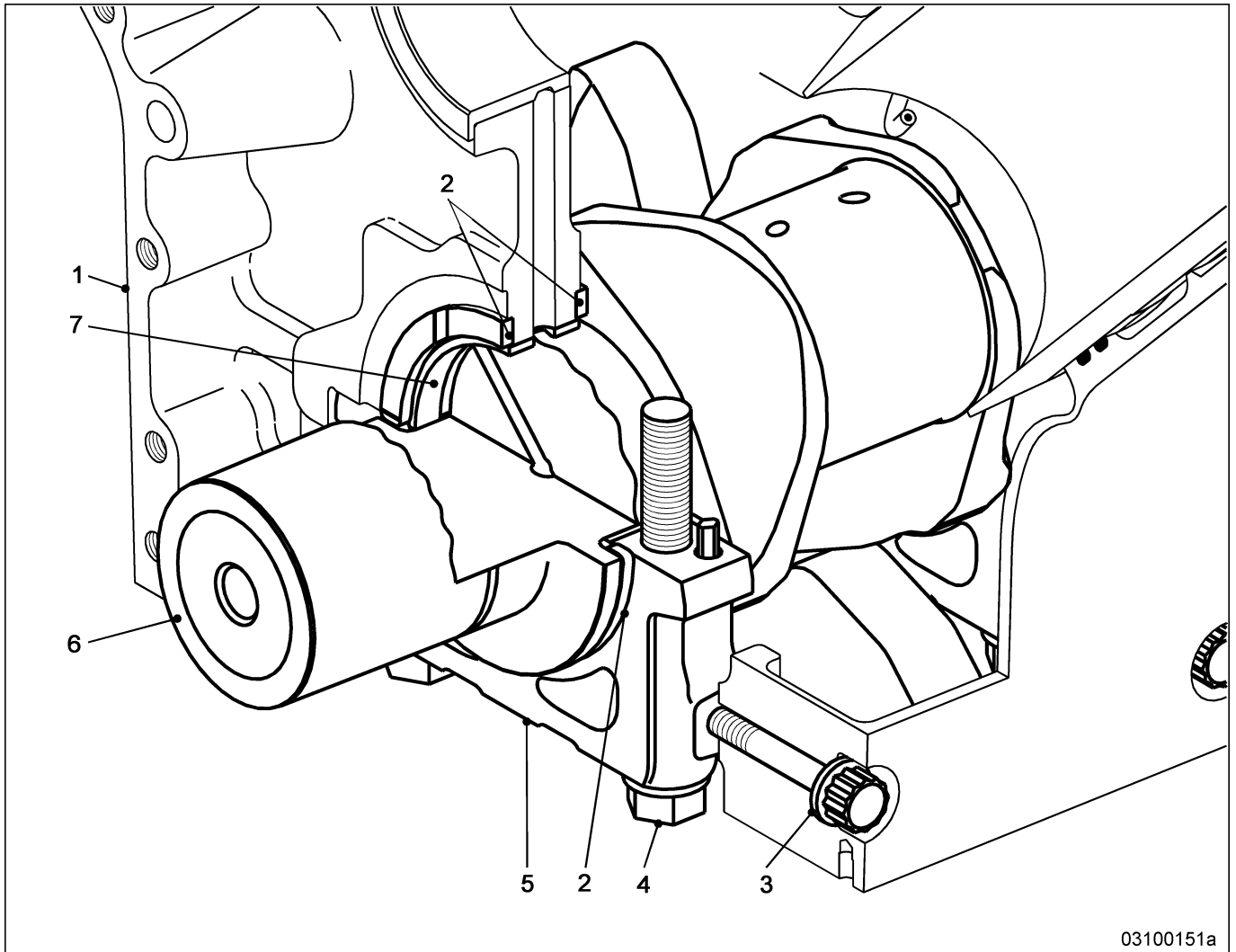


- 1 Flywheel
- 2 Gear ring
- 3 Crankshaft gear, driving end

- 4 Piston
- 5 Conrod
- 6 Crankshaft

- 7 Crankshaft gear, free end
- 8 Vibration damper

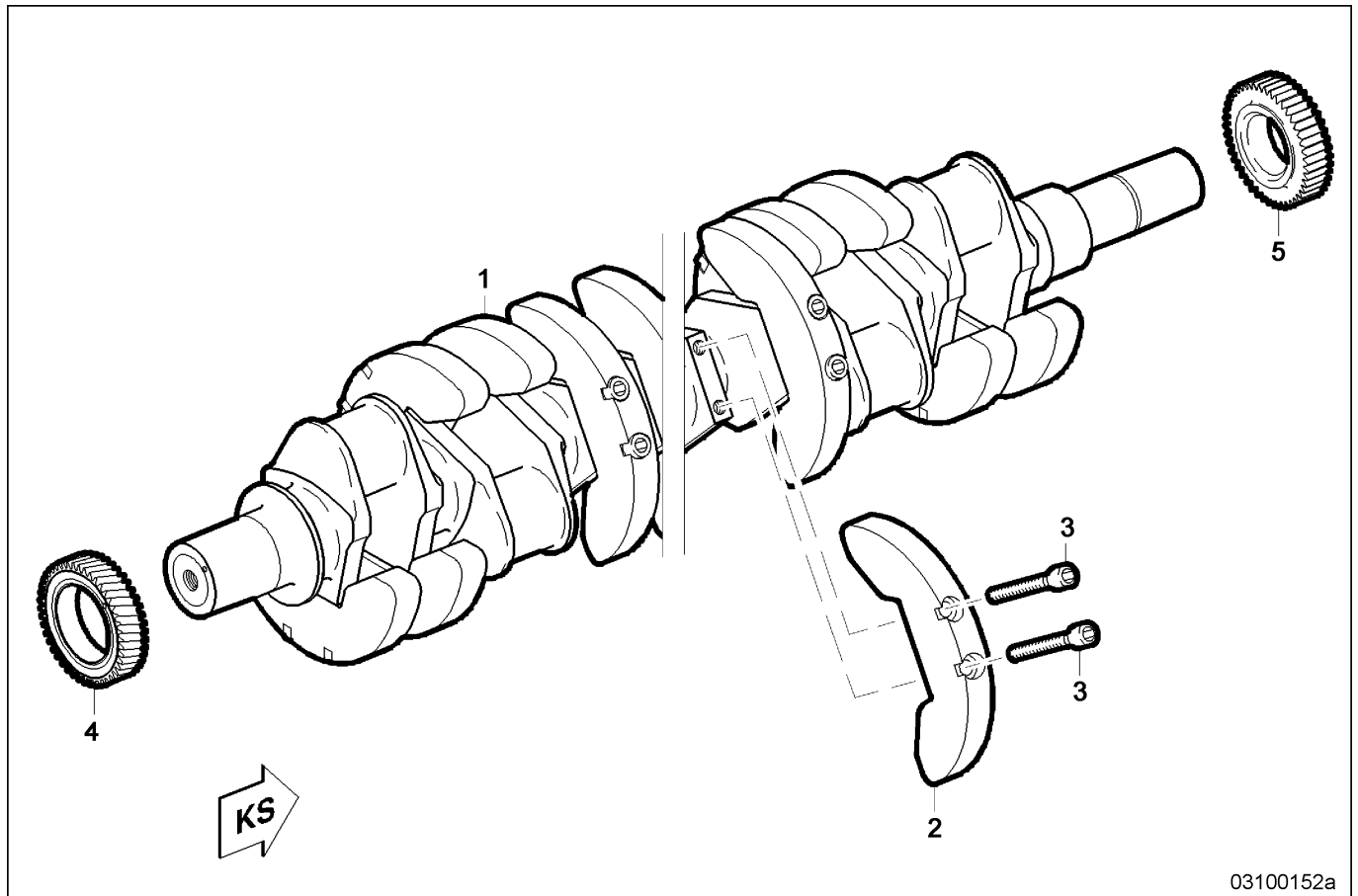
3.3.2 Crankshaft – Overview



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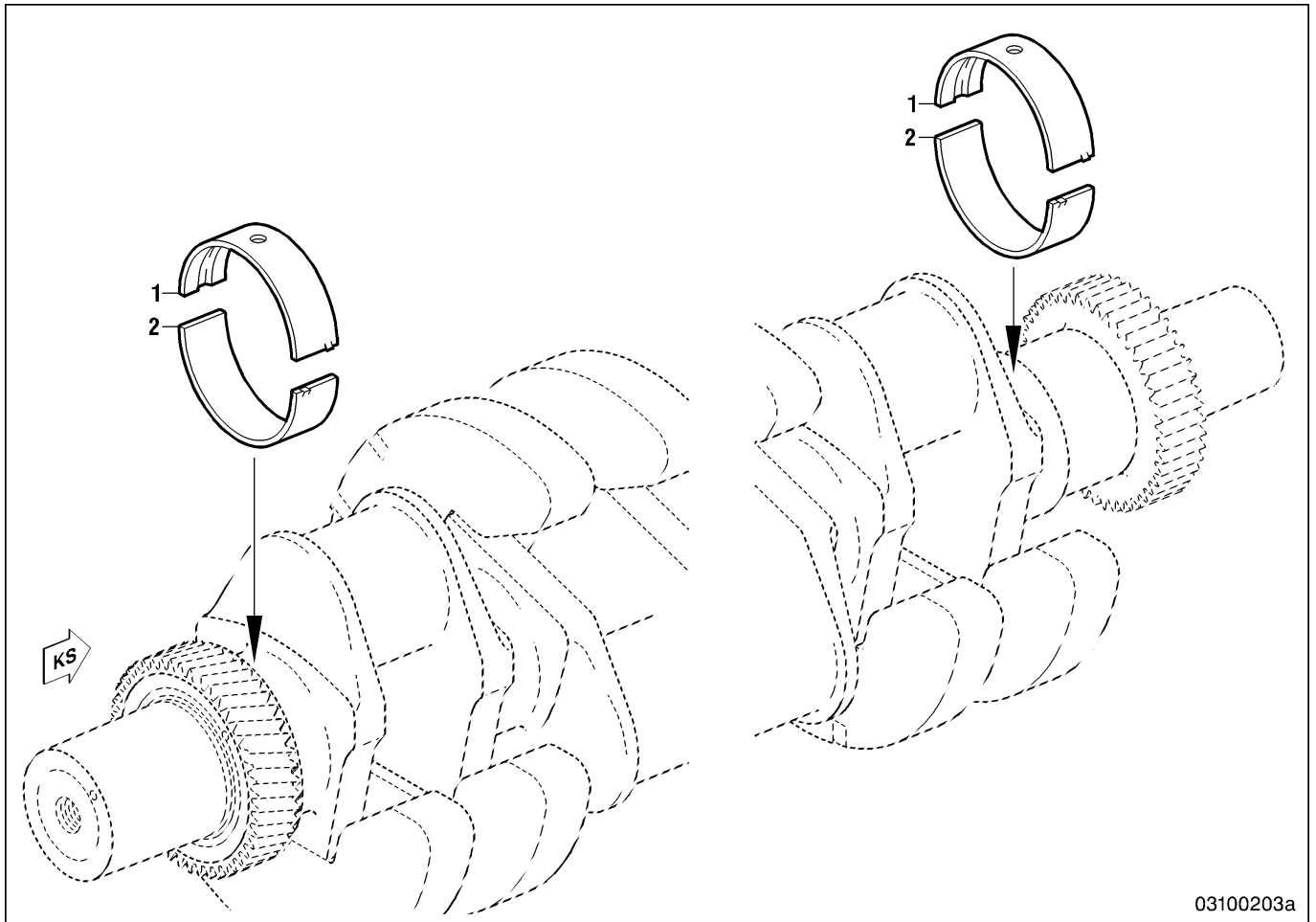
- | | | |
|-------------------|--------------------|----------------------|
| 1 Crankcase | 4 Screw | 7 Crankshaft bearing |
| 2 Thrust washer | 5 Main bearing cap | |
| 3 Double hex bolt | 6 Crankshaft | |

Crankshaft



- 1 Crankshaft
- 2 Counterweight
- 3 Screw
- 4 Crankshaft gear, driving end
- 5 Crankshaft gear, free end

Crankshaft with bearings

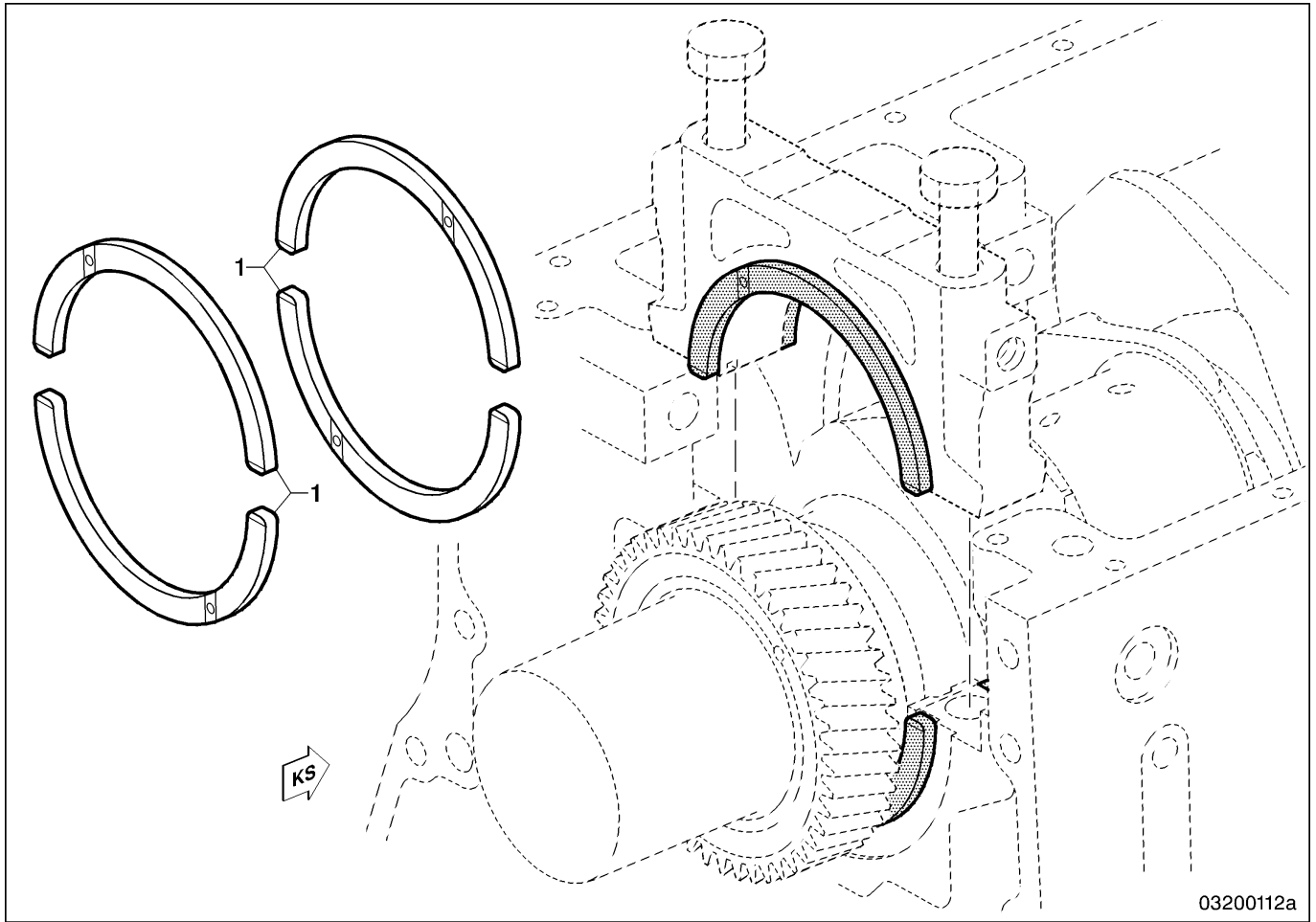


1 Crankshaft bearing, upper half

2 Crankshaft bearing, lower half

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Crankshaft with thrust washer



1 Thrust washer

3.3.3 Crankshaft – Removal

Special tools

Designation / Use	Part No.	Qty.
Percussion puller	F6557901	1
Guide pin	F6555644	4



DANGER

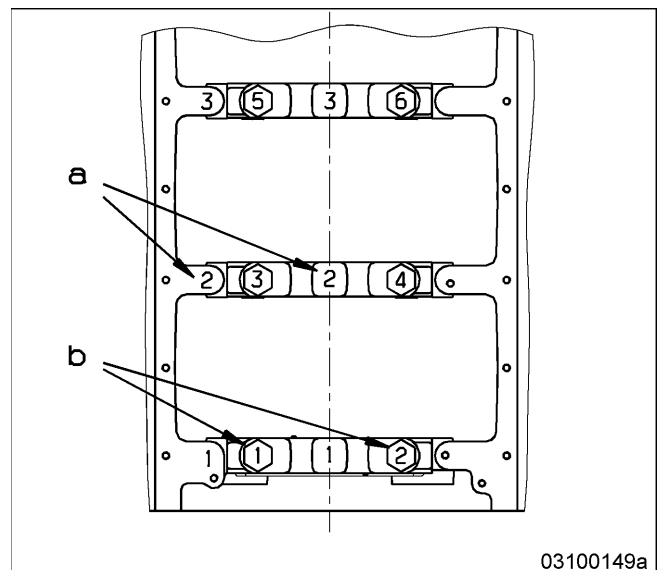
Suspended load.

Danger to life!

- Use appropriate lifting devices and appliances.
- Never stand beneath a suspended load.

Removing main bearing caps

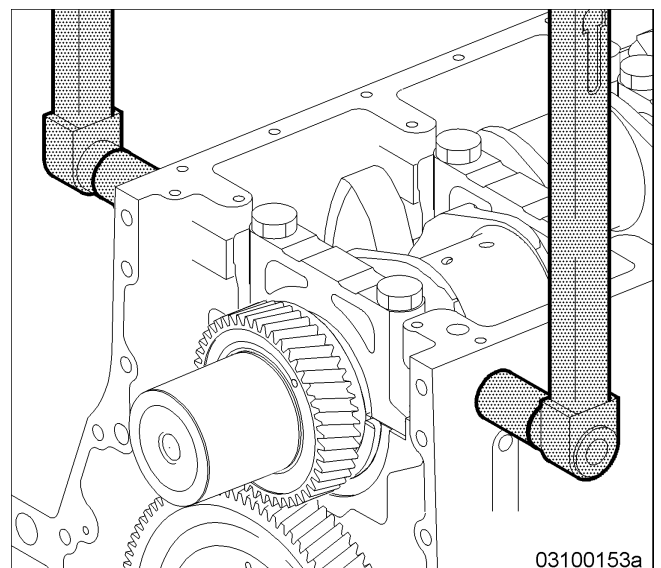
1. Check marking of main bearing caps to crankcase and consecutive numbering of screws.
 - a Consecutive numbering of main bearings, starting from driving end
 - b Consecutive numbering of screws
2. If marking is not present: Starting from the driving end, emboss main bearing numbers making sure they can be read from the same direction.



Removing main bearing caps

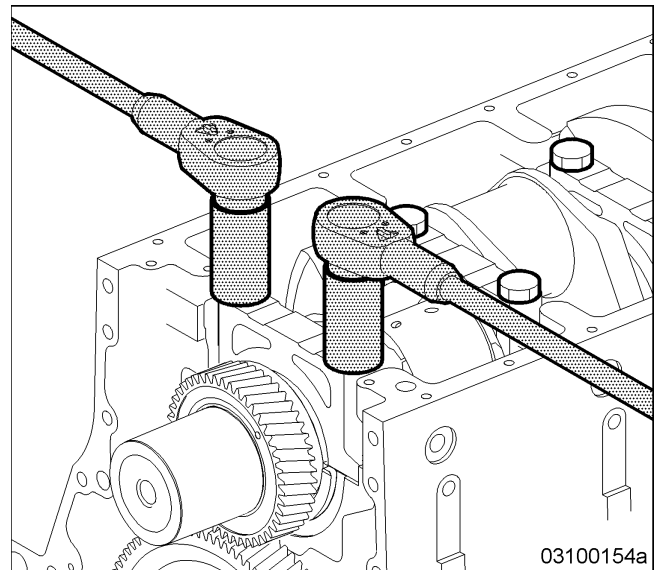
1. Turn crankcase upside down in crankcase rotation device with oil pan mating face upwards horizontally.

Note: Tighten screws of one bearing in one cycle.
2. Remove all lateral double-hex screws for main bearing caps.



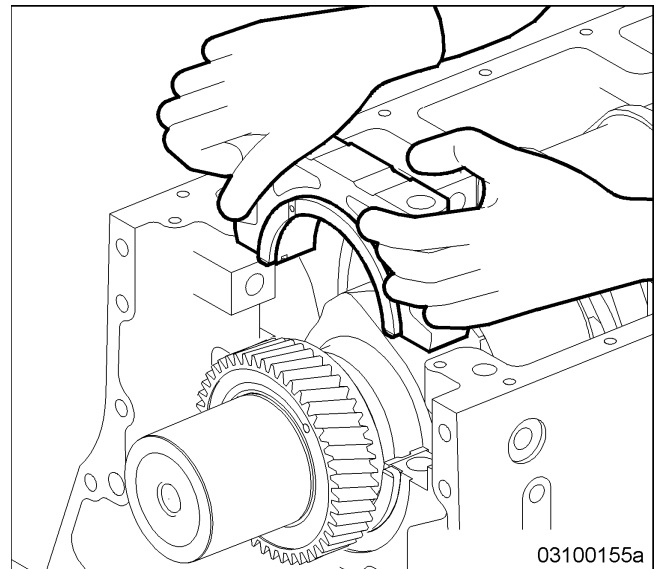
Note: Tighten screws of one bearing in one cycle.

3. Remove screws for crankshaft bearing cap.



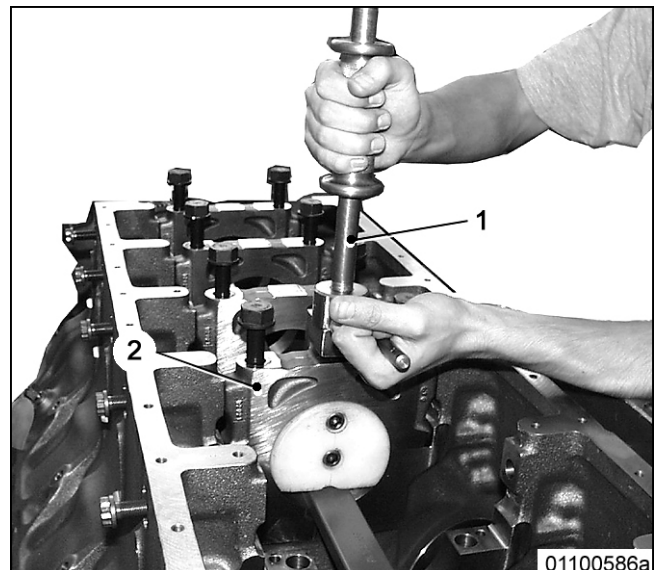
Removing main bearing caps, method 1

1. Withdraw all bearing caps carefully, i.e. without tilting, from crankcase.
2. Mark position of bearing shell to the corresponding bearing cap and remove.
3. Protect bearing shells from damage.
4. Remove thrust washers.



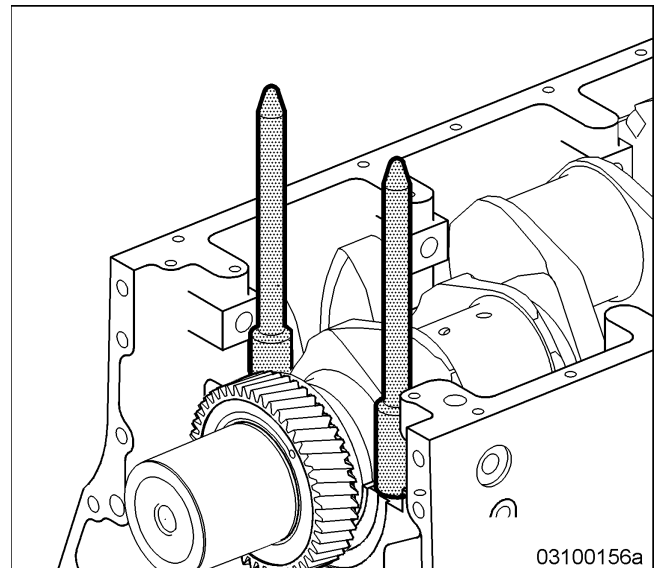
Removing main bearing caps, method 2

1. Use percussion puller (1) to loosen crankshaft bearing cap (2) in fit and remove.
2. Mark position of bearing shell to the corresponding bearing cap and remove.
3. Protect bearing shells from damage.
4. Remove thrust washers.

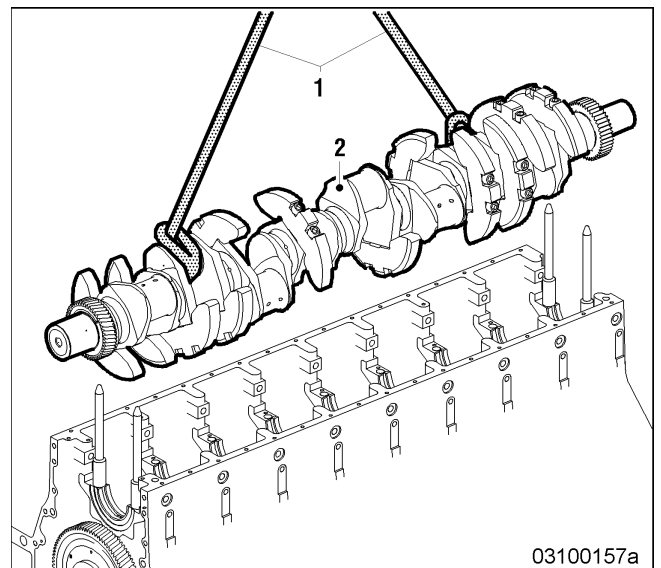


Crankshaft - Removal

1. To protect the crankshaft, install four guide pins at the first and last bearing.



2. Using rope slings (1) and a crane, raise crankshaft (2) clear of crankcase.
3. Ensure horizontal positioning of the crankshaft when lifting.
4. Lower crankshaft onto a firm base.
5. Remove guide pin.
6. Mark position of bearing shells on housing side to the crankshaft bearing cap and remove from the crankcase.



3.3.4 Crankshaft – Disassembly



Heavy object.
Risk of crushing!

- Use appropriate lifting devices and appliances.



Components have sharp edges.
Risk of injury!

- Wear protective gloves.



Contamination of components.
Damage to component!

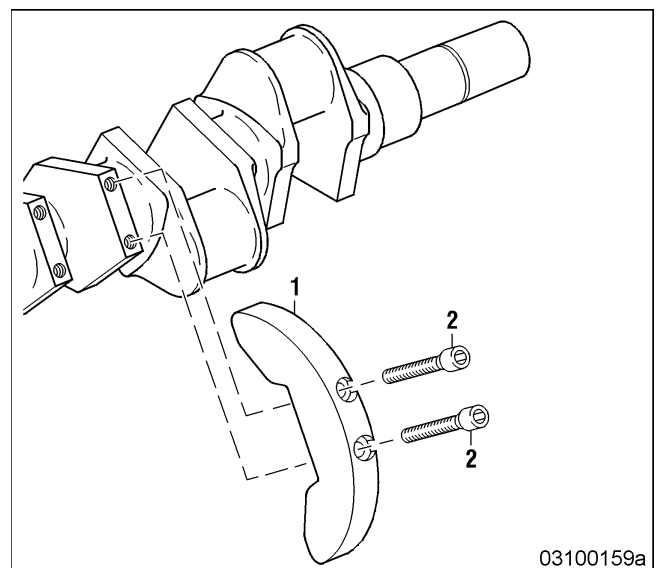
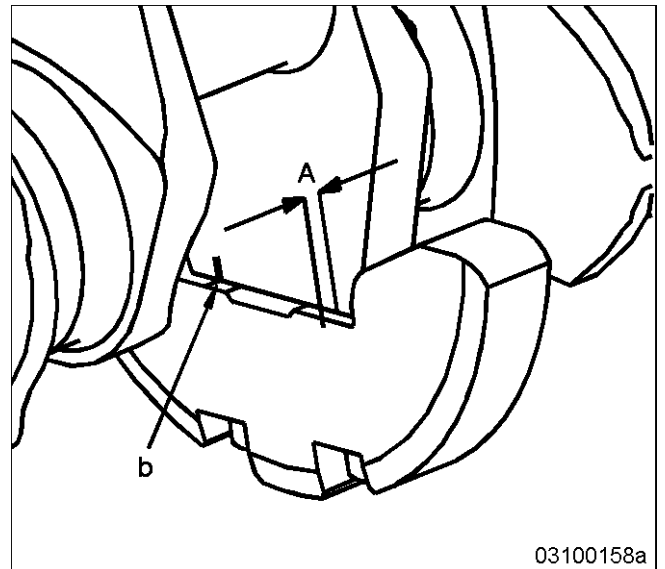
- Observe manufacturer's instructions.
- Check components for special cleanness.

Remove crankshaft (→ Page 185).

Removing counterweights

Note: If counterweights are to be removed, mark relevant counterweight in its installation position on the crankshaft prior to removal.

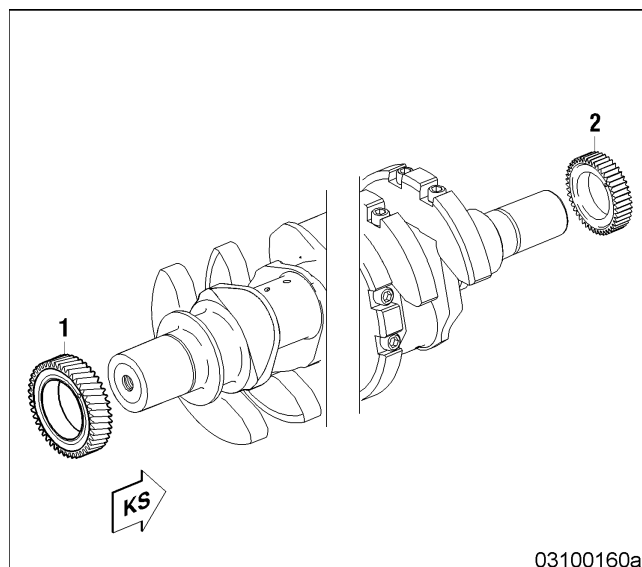
1. Determine and record distance A (web to counterweight).
2. Draw mark b.
3. Check that counterweights are numbered consecutively.
4. If consecutive numbering is not visible: Stamp new numbers.
5. Remove counterweights with the crankshaft supported in a firm assembly base.
6. Remove screws (2) and counterweight (1).



Removing crankshaft gears on driving and free end

Note: Remove gear only if damaged.

1. Withdraw driving-end crankshaft gear (1) from crankshaft.
2. Withdraw free-end crankshaft gear (2) from crankshaft.







3.3.5 Crankshaft – Cleaning

Special tools

Designation / Use	Part No.	Qty.
Bottle brush		

Material

Designation / Use	Part No.	Qty.
Cleaning agent		

 WARNING	<p>Compressed air.</p> <p>Risk of injury!</p> <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors.
 WARNING	<p>Heavy object.</p> <p>Risk of crushing!</p> <ul style="list-style-type: none"> • Use appropriate lifting devices and appliances.
 WARNING	<p>Components have sharp edges.</p> <p>Risk of injury!</p> <ul style="list-style-type: none"> • Wear protective gloves.
 CAUTION	<p>Excessive reaction time of cleaning agents on components.</p> <p>Damage to component!</p> <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask.

Disassemble crankshaft (→ Page 188).

Crankshaft – Cleaning

1. Clean crankshaft using cleaning agent and bottle brush.
2. Remove cleaning agent.
3. Thoroughly clean crankshaft and all threads with compressed air.

3.3.6 Crankshaft – Check

Special tools



Designation / Use	Part No.	Qty.
Endoscope	Y20097353	
Micrometer		
Taper gauge 1:50		
Microdur testing device		
Depth gauge		
Dial gauge holder		
Bore gauge		
Dial gauge		

Material

Designation / Use	Part No.	Qty.
Fluorescent magnetic powder for magnetic crack-testing		

Spare parts

Designation / Use	Part No.	Qty.
Crankshaft		
Counterweight		
Screw		
Crankshaft gear		

	<p>Compressed air. Risk of injury!</p> <ul style="list-style-type: none"> Do not direct compressed-air jet at persons. Wear protective goggles / safety mask and ear protectors.
	<p>Heavy object. Risk of crushing!</p> <ul style="list-style-type: none"> Use appropriate lifting devices and appliances.

Clean crankshaft (→ Page 190).

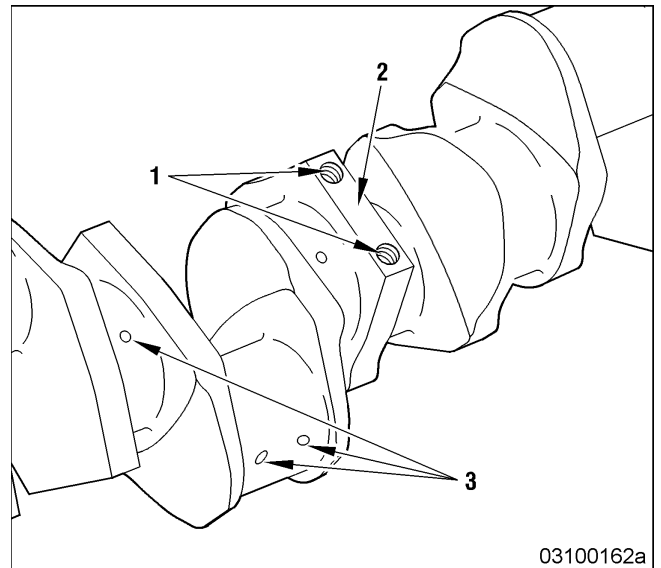
Checking crankshaft

Item	Findings	Task
Check mating faces of counterweights for wear.	Traces of wear found.	Smooth with oilstone.
Using micrometer, measure diameter and roundness of main bearing journals and crankpins. Record measured values in data sheet. Values (→ Page 195)	Values not attained.	To be carried out only in workshops authorized by MTU. Grind crankshaft to next stage.

Item	Findings	Task
Check friction washers of first main bearing for wear. Values (→ Page 195)	Wear visible.	<ul style="list-style-type: none"> Recondition: smooth with oilstone. To be carried out only in workshops authorized by MTU. Grind main bearing to next stage.
Check taper surfaces for scoring and damage.	Scores visible.	<ul style="list-style-type: none"> Recondition: smooth with oilstone. To be carried out only in workshops authorized by MTU. Rework taper.
Check cones with taper gauge.	Not true to gauge.	To be carried out only in workshops authorized by MTU. Rework taper.
Check friction washers and steel bushing for wear and damage.	<ul style="list-style-type: none"> Scores Damage visible 	Replace
Using the magnetic crack-testing method with fluorescent magnetic powder, check the crankshaft counterweight for crankshaft.	Signs of cracks	Replace crankshaft counterweight (→ Page 205).
Check crankshaft mating face to counterweights for traces of wear.	Traces of wear visible.	<ul style="list-style-type: none"> To be carried out only in workshops authorized by MTU. Recondition: grind with grinding machine. Replace
Check crankshaft gear for wear.	Traces of wear visible.	<ul style="list-style-type: none"> Recondition Replace (→ Page 188)
Check crankshaft gear with magnetic crack test procedure for cracks.	Signs of cracks	Replace (→ Page 188)
Using engineer's blue, check that screw head mating face is in good contact with counterweight surface.	Not evenly seated.	Smoothen mating face.
Measure shaft length of screws with depth gauge. Permitted shaft length (→ Page 23)	Value exceeded	Replace
Using the magnetic crack-testing method with fluorescent magnetic powder, check screws for cracks.	Signs of cracks	Replace
Make sure that threads are in perfect condition.	<ul style="list-style-type: none"> Sluggish Damaged 	Replace

Checking crankshaft for cracks

1. Install crankshaft in longitudinal direction between jaws of test device.
2. The specified magnetic field strength of 20 A/cm to 60 A/cm must be applied at every part of the component.
3. Check crankshaft with magnetic crack test procedure for cracks. When doing this, also check oil and journal bores (3), transition radii of journals, as well as mating faces on counterweights (2) and threaded holes (1).
4. After crack-testing, demagnetize crankshaft. A residual field strength of 2.5 A/cm to 4 A/cm must not be exceeded.

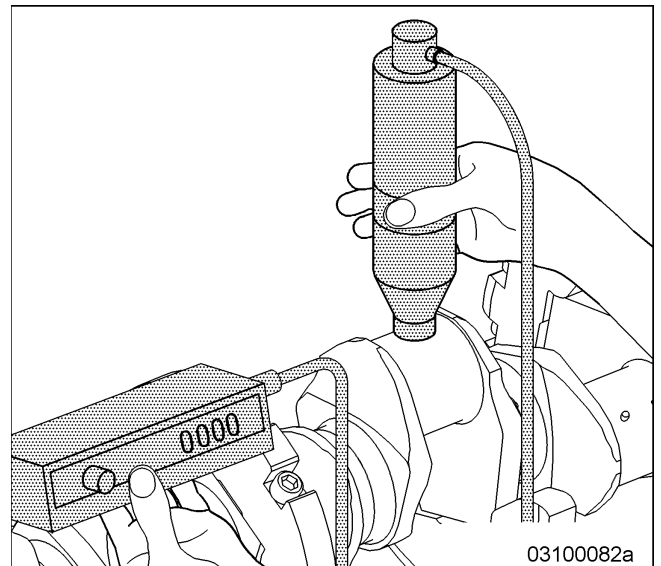


Checking hardness of journals

Note: Check hardness of all journals when not installed.

1. Check hardness of all journals using the Microdur tester or other suitable hardness tester. Required hardness: 49 HRC to 53 HRC.
2. Test hardness of each journal at four points at 90° intervals around circumference.

Result: Values out of range, should only be carried by workshops authorized by MTU. Let crankshaft harden.

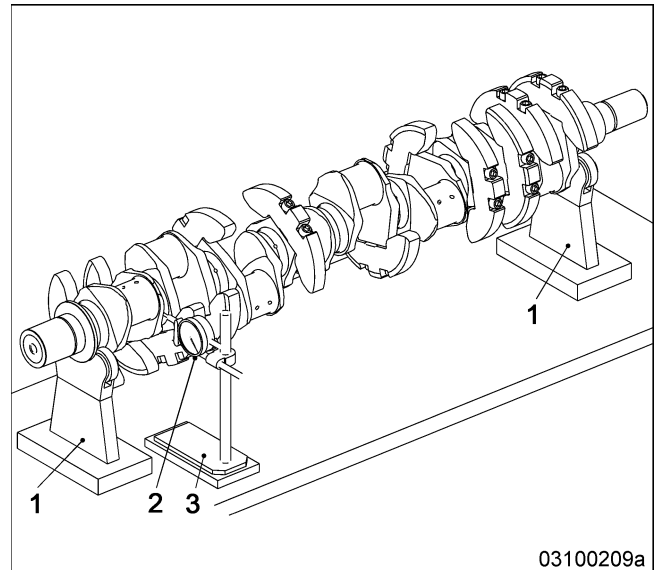


Checking crankshaft concentricity

1. Support crankshaft with roller blocks at the following journals:
 - 8V: Journals 1 and 5 supported by roller blocks
 - 12V: Journals 1 and 7 supported by roller blocks
 - 16V: Journals 1 and 9 supported by roller blocks
 - 18V: Journals 1 and 10 supported by roller blocks
2. Using adjustable measuring stands and dial gauge, check bearing journals for concentricity.
3. If wear across circumference of journal is irregular, measure at transition from cylindrical section of journal to radius.

Note: Crankshaft must not be leveled.

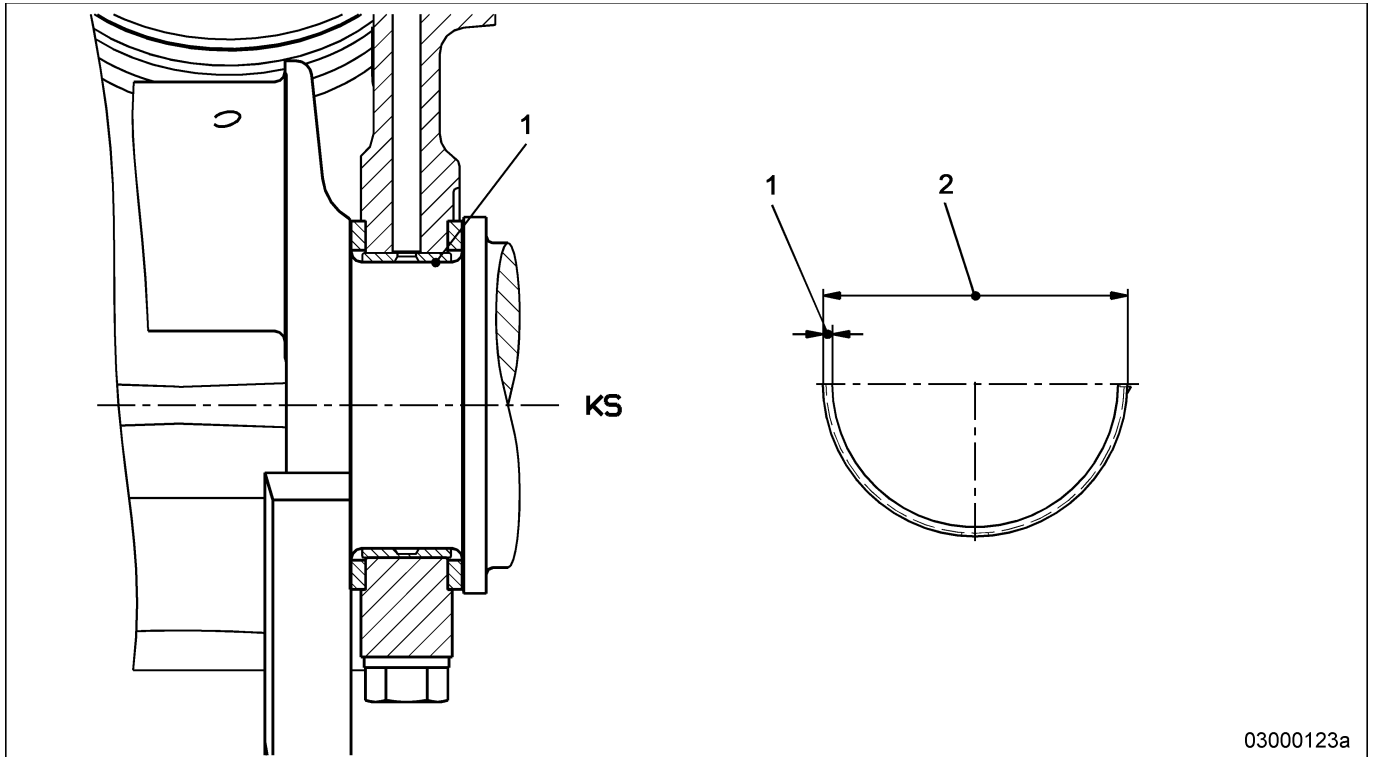
4. If measured values deviate, carry out only by workshops authorized by MTU. Grind main bearing journal to stage. Values (→ Page 195)



- 1 Fixed support (roller block, rigid version)
- 2 Dial gauge
- 3 Magnetic holder

3.3.7 Crankshaft – Tolerances

Crankshaft bearings

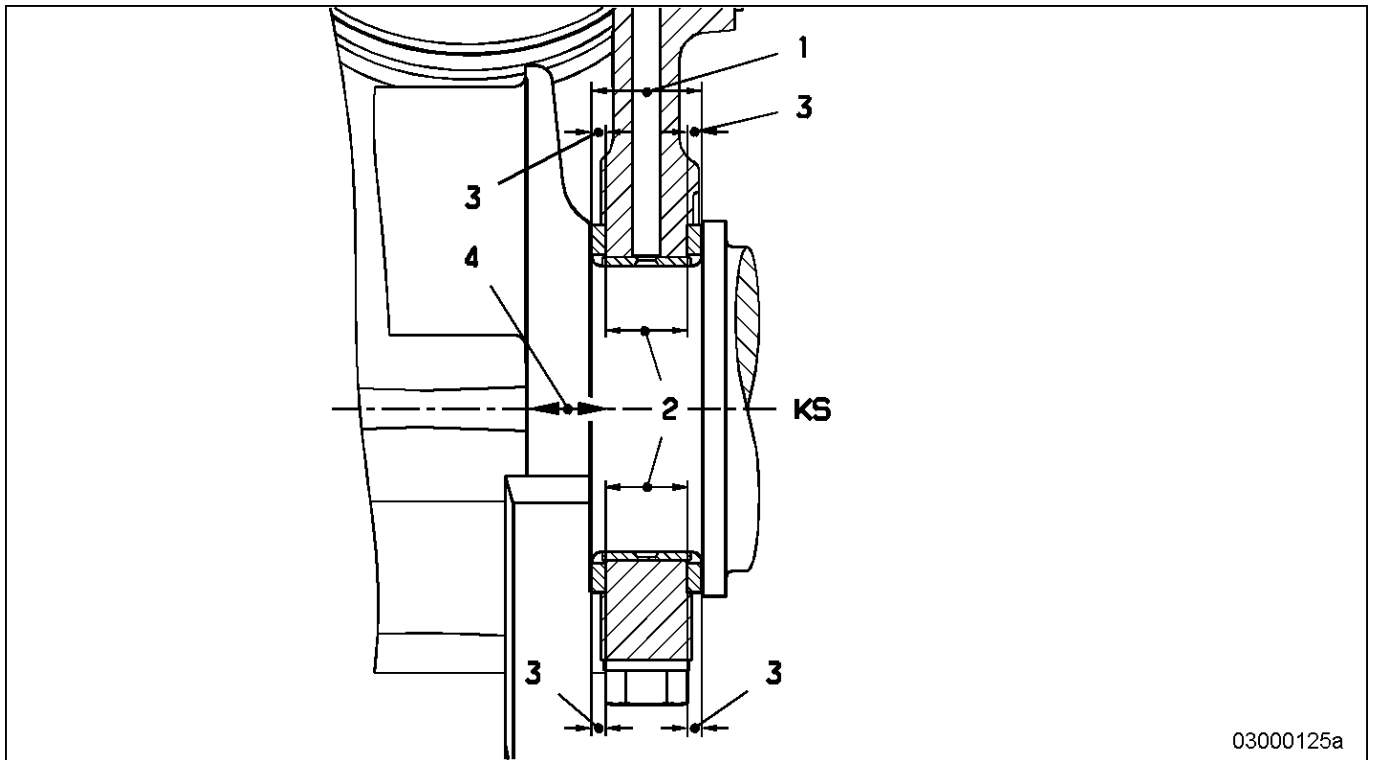


03000123a

No.	Designation	Stage	Tol. size Basic size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
1	Main bearing journal Ø	0	108.000	-0.020	0					
		1	107.900	-0.020	0					
	Main bearing installed - upper half	0	3.460*	0	+0.012					
		1	3.510*	0	+0.012					
	Main bearing installed - lower half	0	3.460*	0	+0.012					
		1	3.510*	0	+0.012					

No.	Designation	Stage	Tol. size Basic size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
2	Bearing shell spread dimension - upper half - removed		115.000	+0.300	+1.300					
	Bearing shell spread dimension - lower half - removed		115.000	+0.300	+1.300					
Re 1: <ul style="list-style-type: none"> • Clearance: Theoretical value 0.066 to 0.132; • Difference in wall thickness per bearing shell 0.006; • * = wall thickness 										

Crankshaft end play

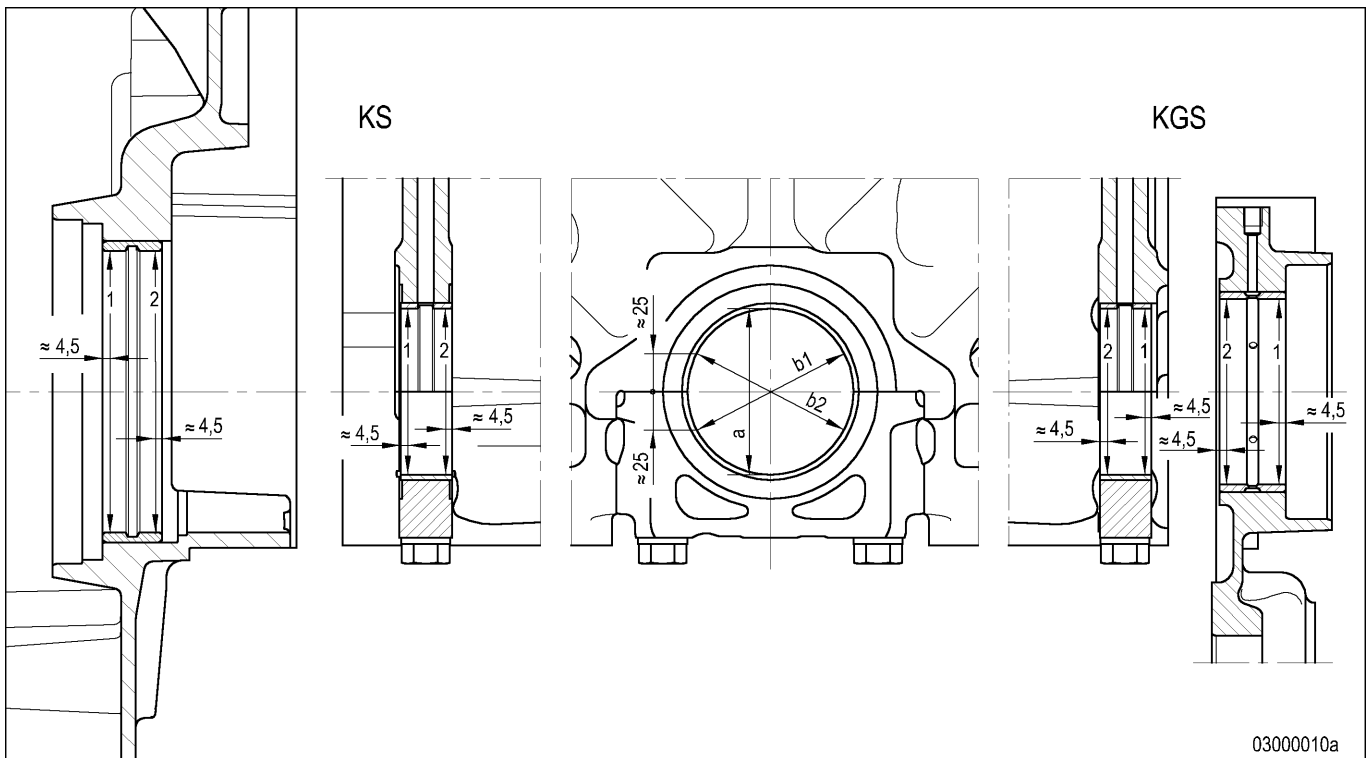


03000125a

No.	Designation	Stage	Tol. size Basic size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
1	Main bearing journal - width	0	42.000 H9	0	+0.062					
		1	42.000 H9							
		2	42.500 H9	0	+0.062					
		3	42.500 H9							
		4	43.000 H9	0	+0.062					
		5	43.000 H9							
2	Crankcase, bearing cap - width	0	31.000 h8	-0.039	0					
		1	30.000 h8							
3	Thrust washer - upper half, thickness	01	5.375	0	+0.050					
		02	5.625	0	+0.050					
		03	5.875	0	+0.050					
	Thrust washer - lower half, thickness	01	5.375	0	+0.050					
		02	5.625	0	+0.050					
		03	5.875	0	+0.050					

No.	Designation	Stage	Tol. size Basic size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
4	Crankshaft end play					0.150	0.300			
<ul style="list-style-type: none"> • Crankshaft end play: Set using thrust washers No. 3. • Thrust washers of the same thickness must be installed on both crankshaft alignment bearing sides. 										

Main bearing shells



Install bearing shells and bearing caps and tighten as per specification.

Measure main bearing bores in crankcase:

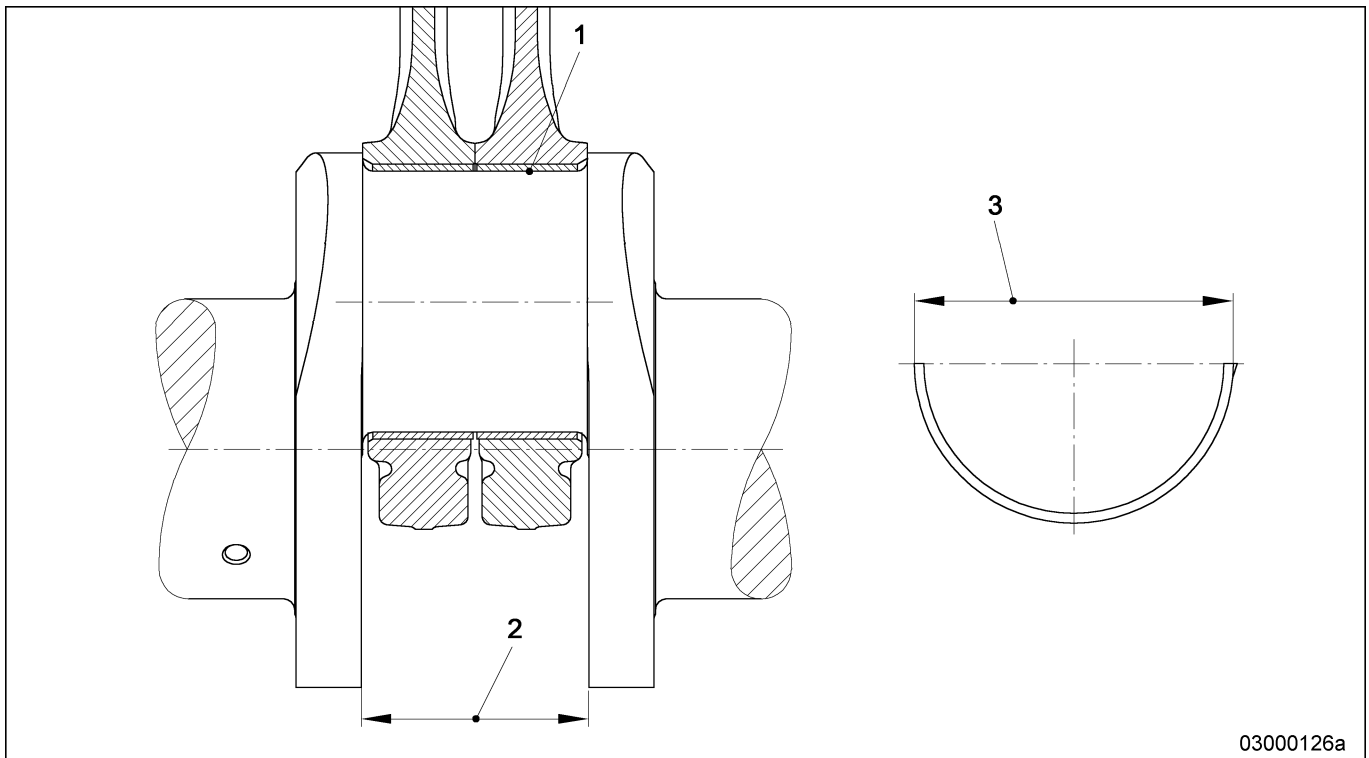
- Determine diameters a, b1 and b2 in measuring planes 1 and 2 and calculate the average for a, b1 and b2.
- Check bore roundness:

Deviations from roundness can be determined from the average values for a, b1 and b2 as follows: $0.5 (b1+b2) - a$

Replace bearing shells if:

- roundness deviation >0.040
- $b1 : b2$ is above/below 0.040
- Not permissible for ovality $-a > 0.5 (b1+b2)$.

Conrod bearings



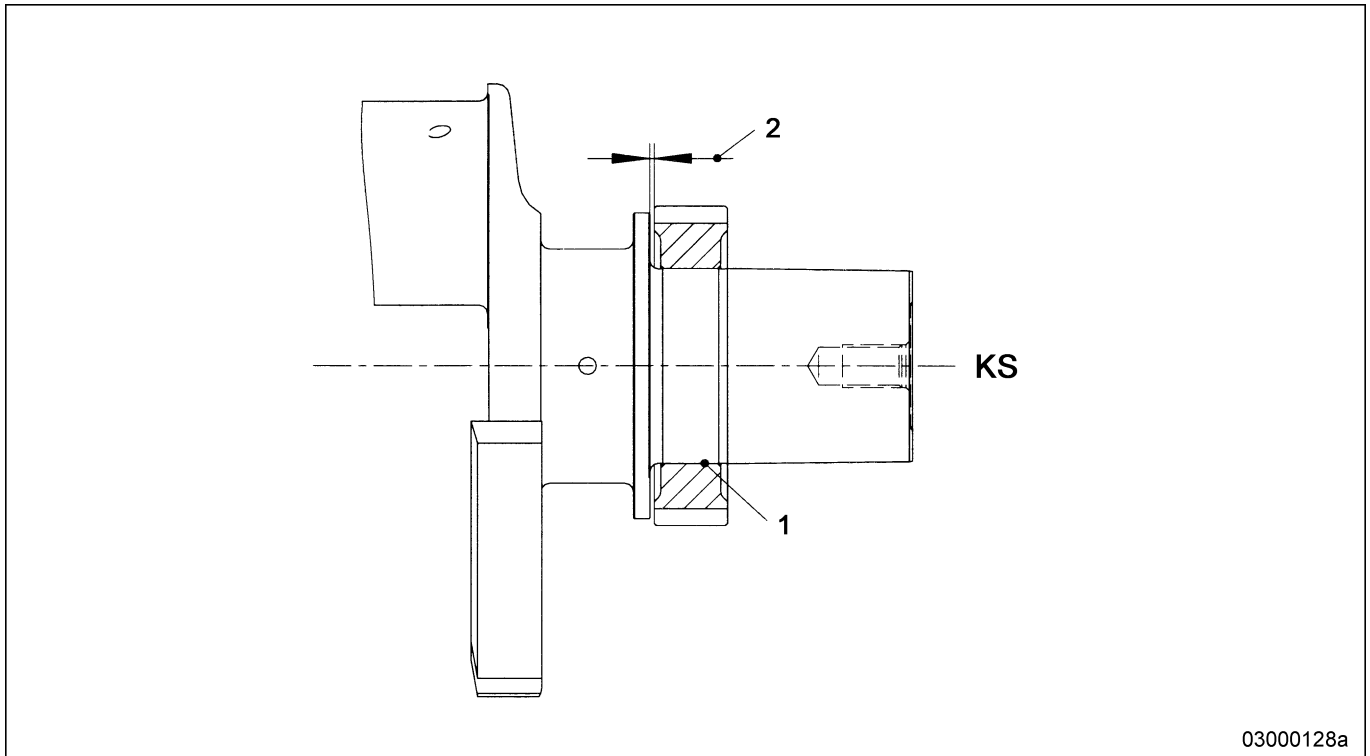
No.	Designation	Stage	Tol. size Basic size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
1	Crankpin Ø	0	94.000	-0.020	0					
		1	93.900	-0.020	0					
	Conrod bearing - upper half	0	2.463*	0	+0.010					
		1	2.513*	0	+0.010					
	Conrod bearing - lower half	0	2.463*	0	+0.010					
		1	2.513*	0	+0.010					
2	Crankpin length		81.000 H10	0	+0.140					

No.	Designation	Stage	Tol. size Basic size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
3	Bearing shell spread dimension - upper half - removed		99.600	0	+1.000					
	Bearing shell spread dimension - lower half - removed		99.600	0	+1.000					

Re 1:

- Theoretical value 0.064 to 0.126;
- Difference in wall thickness per bearing shell 0.006;
- * = wall thickness

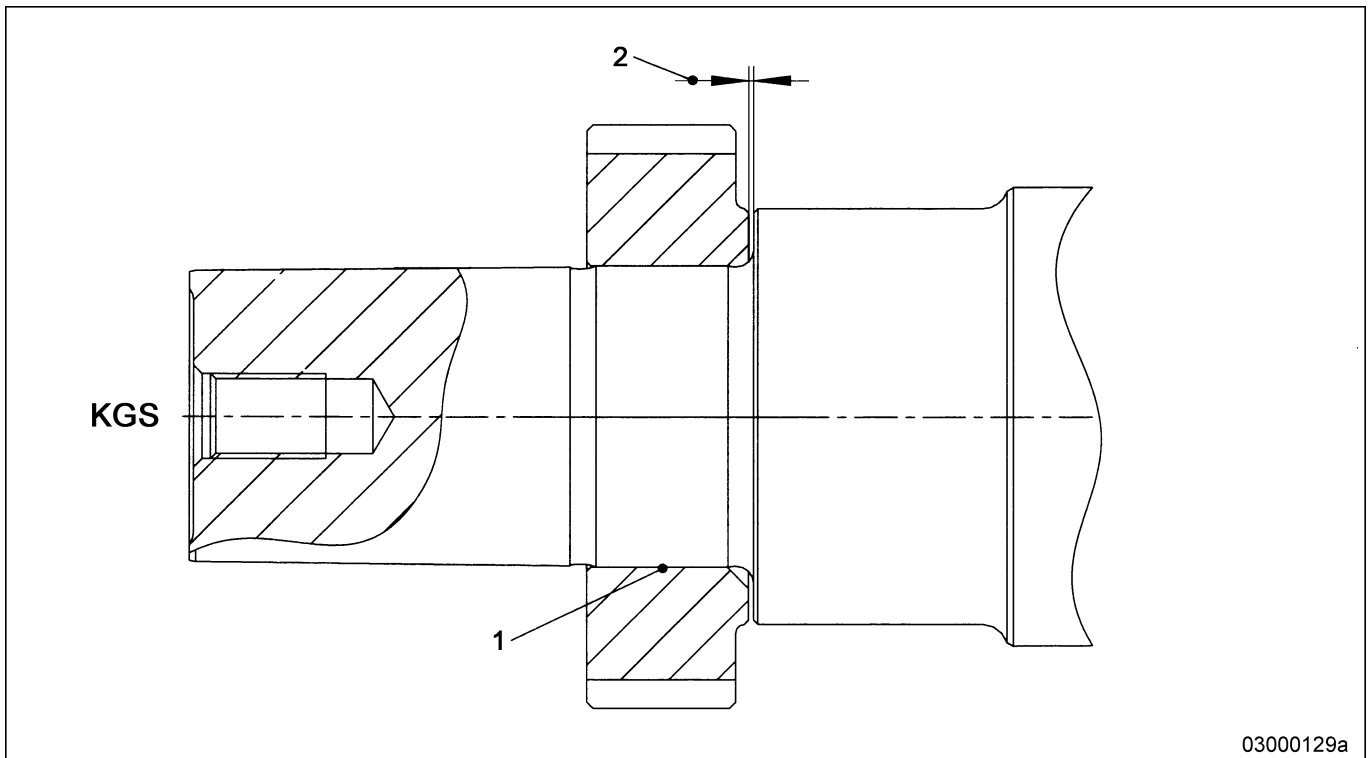
Crankshaft gear, driving end



03000128a

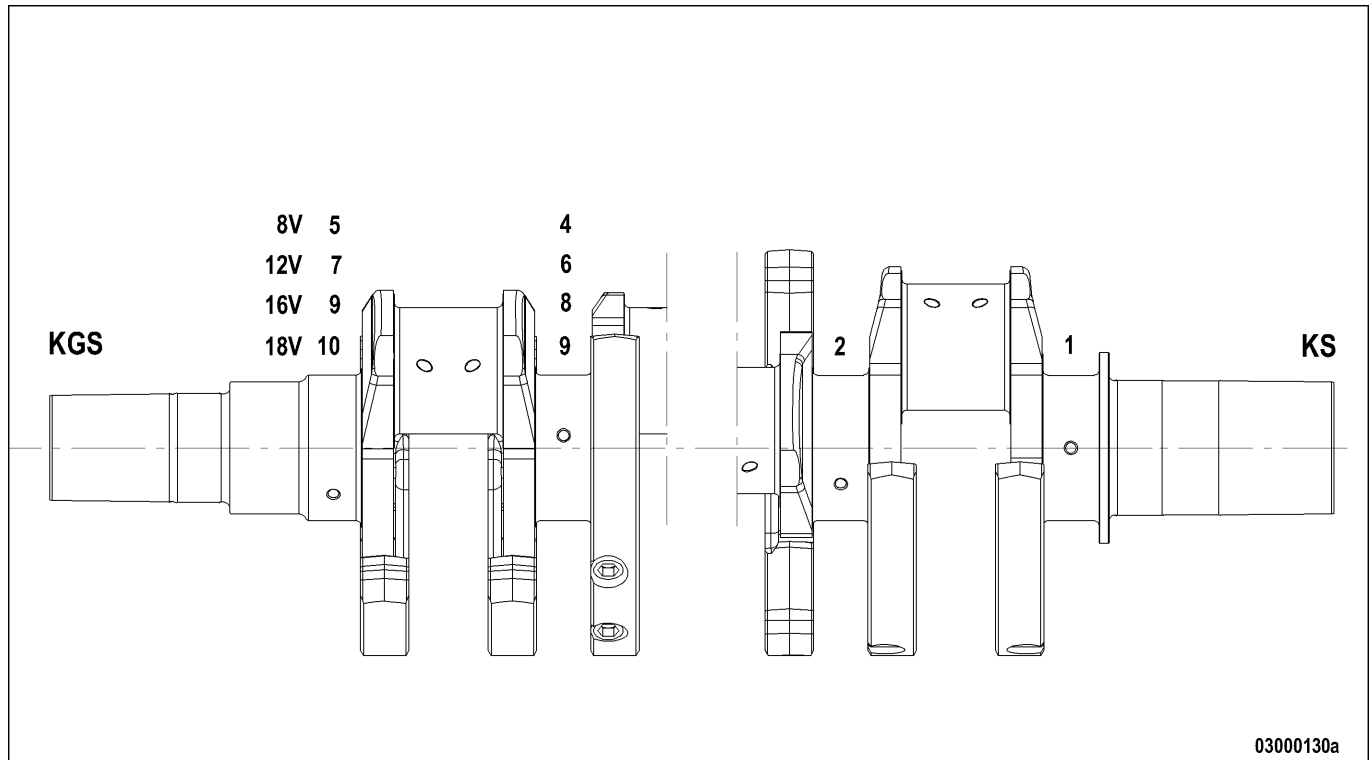
No.	Designation	Stage	Tol. size Basic size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
1	Gear bore		90.300 N6	-0.038	-0.016			0.107	0.151	
	Shaft OD		90.300 t6	+0.091	+0.113					
2	Clearance - gear pressed on		2.000	-0.200	+0.200					

Crankshaft gear, free end



No.	Designation	Stage		Tol. size		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
1	Gear bore		71S7	-0.078	-0.048			0.080	0.140	
	Shaft OD		71.000 _{p7}	+0.032	+0.062					
2	Clearance - gear pressed on		2.000	-0.200	+0.200					

Crankshaft journal coaxiality



03000130a

Max. permissible deviation from concentricity		New	Wear limit
8V	From main bearing journal 1 to main bearing journal 5	∇ 0.080	
	From main bearing journal to main bearing journal	∇ 0.020	
	With fixed bearing under main bearing journals 1 and 5		
12V	From main bearing journal 1 to main bearing journal 7	∇ 0.080	
	From main bearing journal to main bearing journal	∇ 0.020	
	With fixed bearings under main bearing journals 1 and 7		
16V	From main bearing journal 1 to main bearing journal 9	∇ 0.100	
	From main bearing journal to main bearing journal	∇ 0.020	
	With fixed bearings under main bearing journals 1 and 9		

18V	From main bearing journal 1 to main bearing journal 10	∇ 0.100	
	From main bearing journal to main bearing journal	∇ 0.020	
	With fixed bearings under main bearing journals 2 and 9		

3.3.8 Crankshaft – Assembly

Special tools





Designation / Use	Part No.	Qty.
Alignment device for driving-end crankshaft gear	F6552506	1
Clearance gauge driving-end crankshaft gear	Y4341111	1
Assembly jig free-end crankshaft gear	F6554711	1
Clearance gauge free-end crankshaft gear	Y4341107	1
Clearance gauge	Y20010128	1

Material

Designation / Use	Part No.	Qty.
Engine oil		

Spare parts

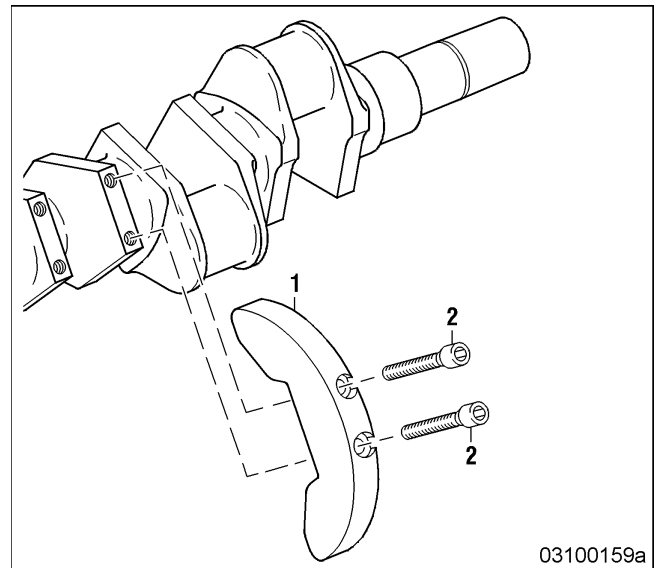
Designation / Use	Part No.	Qty.
Crankshaft gears, driving and free end		

 WARNING	<p>Component is hot. Risk of burning!</p> <ul style="list-style-type: none"> Wear protective gloves.
 WARNING	<p>Heavy object. Risk of crushing!</p> <ul style="list-style-type: none"> Use appropriate lifting devices and appliances.
 WARNING	<p>Components have sharp edges. Risk of injury!</p> <ul style="list-style-type: none"> Wear protective gloves.
 CAUTION	<p>Contamination of components. Damage to component!</p> <ul style="list-style-type: none"> Observe manufacturer's instructions. Check components for special cleanness.

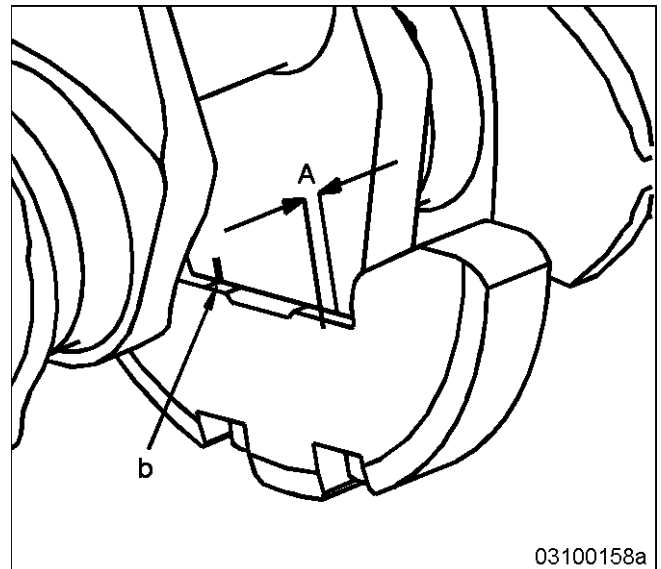
Check crankshaft (→ Page 191).

Installing counterweights

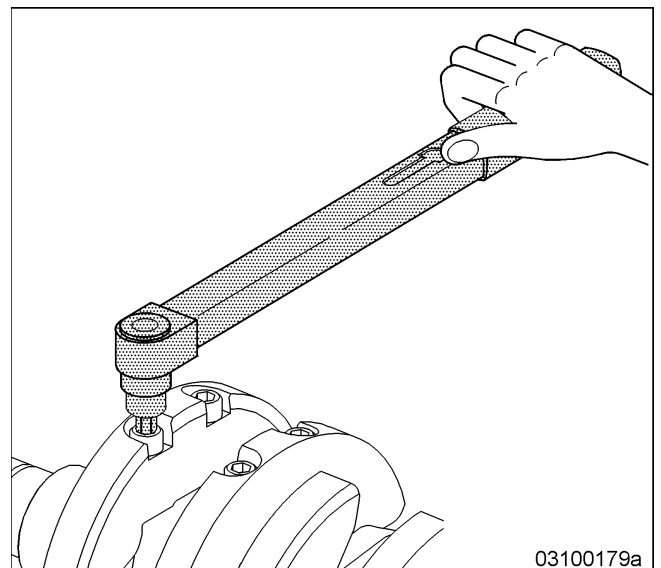
1. Measure shank lengths of counterweight screws.
Max. shank length (→ Page 23).
2. Clean the mating faces of crankshaft and counterweight (1) so that they are dry and free of grease.
3. Coat threads and screw head mating face of screws (2) with engine oil.
4. Position counterweight on crankshaft according to markings and slightly tighten screws.



5. Align counterweight with mark b and dimension A and tighten screws with torque wrench to specified pretightening torque (→ Page 23) .
6. Check that the installation position of the counterweight matches the markings made before installation or measured dimensions.



7. Mark screw heads.
8. Turn screws further to specified angle of further rotation (→ Page 23) .
9. After installing counterweights, check identification marks on counterweights and webs.
10. Starting from driving end, mark counterweights with number punch.

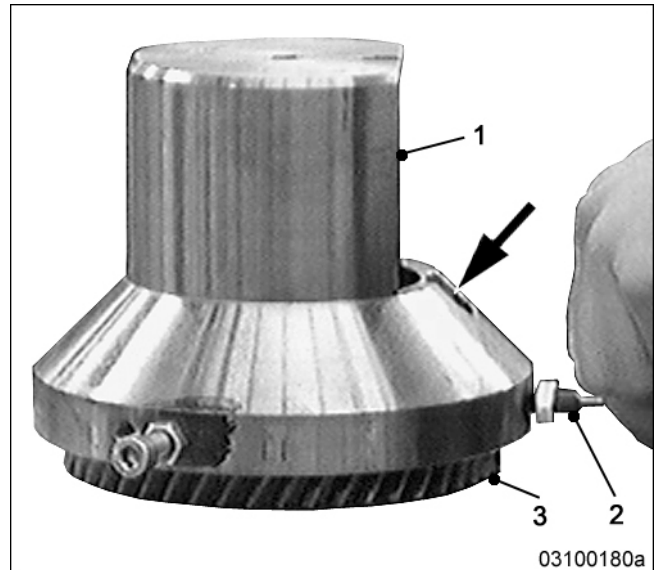


Installing crankshaft gear, driving end

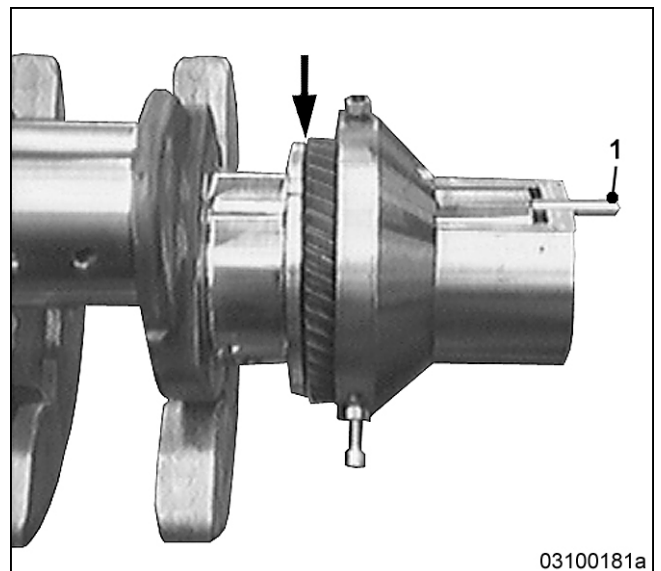
1. Clean surfaces of shaft stub and gear bore so that they are free of grease and dry.
2. Place crankshaft gear, driving end (3) in the alignment tool (1), aligning the spring-pin bore in the crankshaft gear with the bore (arrow) of the alignment tool.
3. Lock crankshaft gear with threaded pin (2) in its position.

Note: Crankshaft gear may remain in preheated oven for max. 1 hour at assembly temperature.

4. Heat driving-end crankshaft gear with heating equipment to $210\text{ }^{\circ}\text{C} + 10\text{ }^{\circ}\text{C}$.



5. Insert guide pin (1) in crankshaft bore on free end.
6. Set clearance device (arrow) on to crankshaft and use alignment device to slide heated driving-end crankshaft gear on to crankshaft up to attachment.
7. Remove alignment tool and clearance gauge after the components have cooled down to room temperature .
8. Check clearance (arrow) between gear and crankshaft collar with clearance gauge.
9. Specified clearance (→ Page 195)

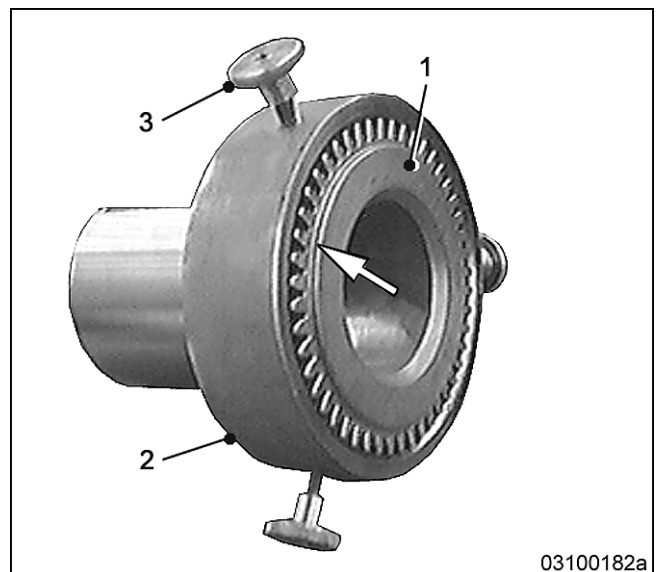


Installing crankshaft gear, free end

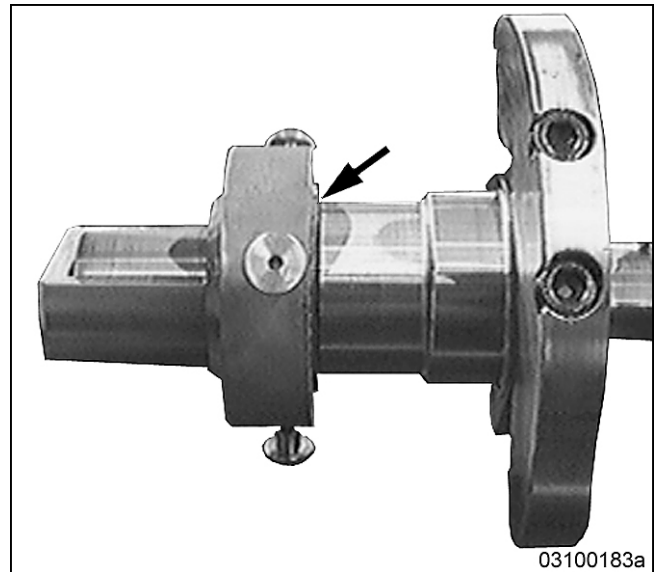
1. Clean surfaces of shaft stub and gear bore so that they are free of grease and dry.
2. Place free-end crankshaft gear (1) in assembly jig (2) and secure in position with knurled nuts (3).
3. Pay attention to installation position of chamfer (arrow).

Note: Crankshaft gear may remain in preheated oven for max. 1 hour at assembly temperature.

4. Heat free-end crankshaft gear with heating equipment to $230\text{ }^{\circ}\text{C} + 10\text{ }^{\circ}\text{C}$.




5. Slide heated free-end crankshaft gear with assembly jig onto crankshaft.
6. Adjust clearance (arrow) between crankshaft and free-end crankshaft gear with clearance gauge. Specified clearance (→ Page 195)
7. Remove assembly jig after the parts have cooled down to room temperature.
8. Dynamically balance crankshaft (→ Page 209).



3.3.9 Crankshaft – Balancing

Special tools

Designation / Use	Part No.	Qty.
Master weights		

 WARNING	Heavy object. Risk of crushing! <ul style="list-style-type: none"> • Use appropriate lifting devices and appliances.
---	---

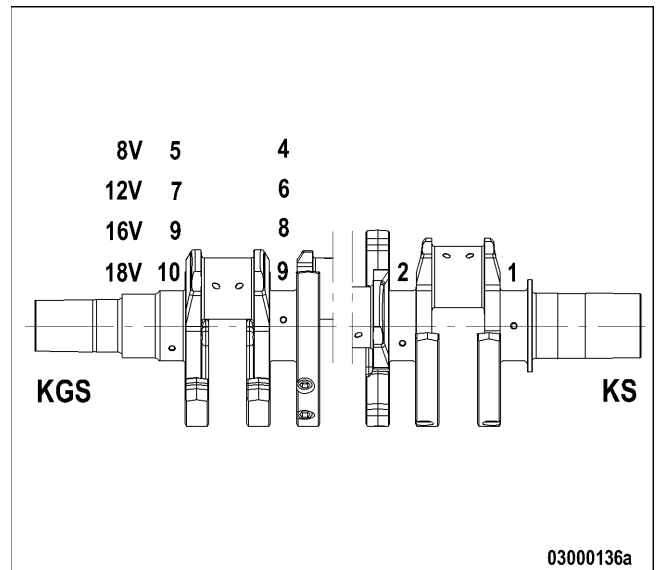
 WARNING	Components have sharp edges. Risk of injury! <ul style="list-style-type: none"> • Wear protective gloves.
---	--

Assemble crankshaft (→ Page 205).

Preparatory steps

1. Prior to balancing, seal all oil bores.
2. Support crankshaft at shaft journals.
3. Depending on stroke position (free residual moment), master weights must be used for dynamic balancing to simulate the rotating and oscillating mass of conrod and piston.

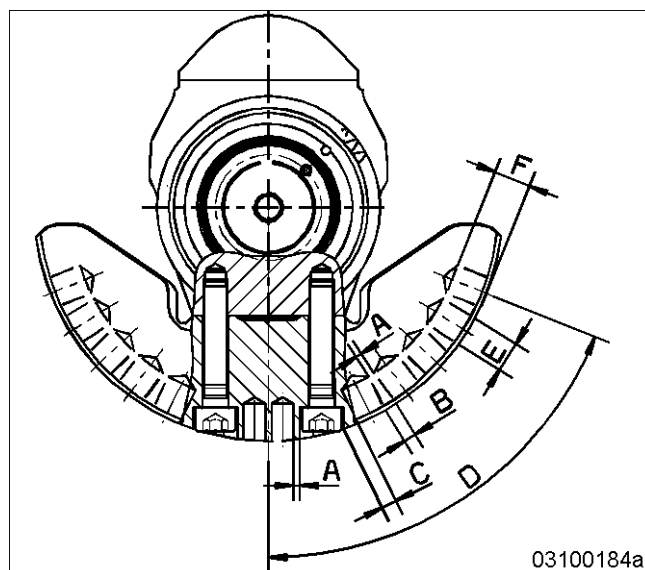
Dynamic balancing



	Crankshaft (8V)	Crankshaft (12V)	Crankshaft (16V)
Maximum operating speed	2300 rpm	2300 rpm	2300 rpm
Take up crankshaft at shaft journals	1 and 5	1 and 7	1 and 9
Mass of balancing group	153 kg	175 kg	303 kg
Balancing speed	150 rpm	150 rpm	150 rpm
Permitted residual unbalance per balancing plane when balancing first time	60 gcm	60 gcm	80 gcm
Permitted residual unbalance per balancing plane when comparing balancing with different clamping or balancing machine	160 gcm	180 gcm	240 gcm
Minimum wall thickness around bore-hole	4 mm	4 mm	4 mm

Bore values for counterweights

1. To balance crankshaft remove material from counterweights by drilling with twist drill.
2. After balancing, recheck numbers on counterweights and exchange counterweights if necessary.



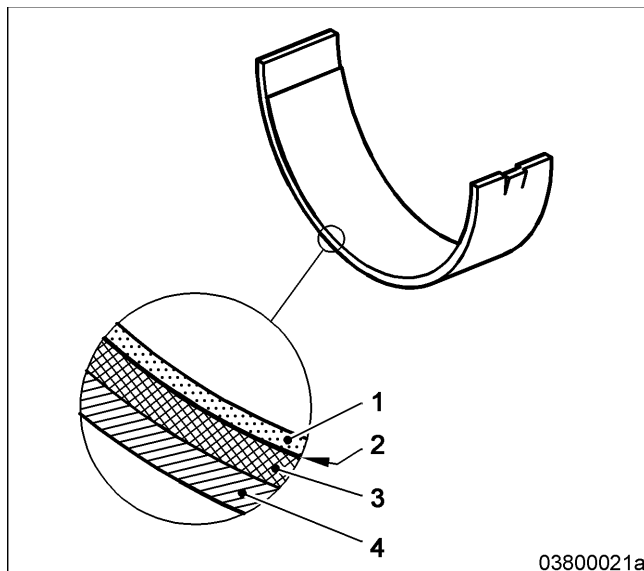
- A 4 mm (min.)
- B 9 mm (min.)
- C 10.3 mm (min.)
- D 72° C (max.)
- E 22 mm (max. Ø)
- F 25 mm (max. bore depth)

3.3.10 Main bearing shells – Check

Remove crankshaft (→ Page 185).

Main bearing shells – Check

Item	Findings	Task
In the case of reuse (e.g. non-scheduled removal), check bearing shells for surface wear, scores, cracks, corrosion, erosion and damage.	Wear, scores, cracks, corrosion, erosion or damage visible	Replace
Check bearing shell butt and bearing rear side for damage and fretting corrosion (pitting).	Fretting corrosion visible	Replace and determine cause. Possible causes: <ul style="list-style-type: none"> • Insufficient screw pretension • Assembly error • Spread dimension of bearing shell outside tolerance • Faulty bearing support bore
Measure spread dimension (→ Page 195).	Determined value exceeded	Replace bearing shell.



- 1 Slide layer
- 2 Barrier layer
- 3 Intermediate layer
- 4 Protective steel shell

Assessment

An important indicator for assessing the extent of wear on the bearing shell is the shape and extent of the barrier layer areas exposed.

Wear of the bearing running surfaces starts at the galvanized slide layer (1).

A reduction of the slide layer contact surface to 70% significantly limits the usability of the bearing shell!

It is often difficult to differentiate between the nickel barrier and softer slide layer.

If in doubt, consult a bearing specialist.

Damage to bearing

Damage to bearings occurs mainly through foreign body scoring, impressions and embedding, cavitation and corrosion, pitting, fatigue and installation faults.

Bearings showing such damage must be replaced.

3.3.11 Crankshaft bearing bore – Check

Special tools




Designation / Use	Part No.	Qty.
Bore gauge		
Dial gauge		

Material

Designation / Use	Part No.	Qty.
Engine oil		

Spare parts

Designation / Use	Part No.	Qty.
Crankshaft bearing shells		

 WARNING	<p>Compressed air.</p> <p>Risk of injury!</p> <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors.
 WARNING	<p>Components have sharp edges.</p> <p>Risk of injury!</p> <ul style="list-style-type: none"> • Wear protective gloves.
 CAUTION	<p>Contamination of components.</p> <p>Damage to component!</p> <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Check components for special cleanness.

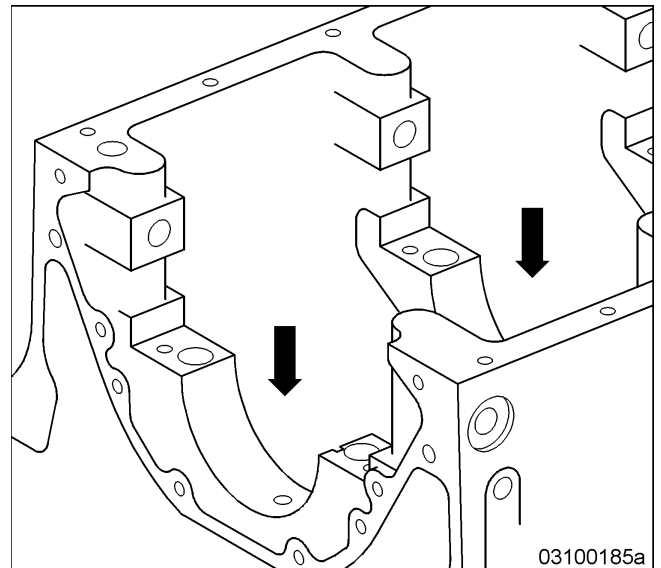
Remove crankshaft (→ Page 185).

Note: The crankshaft bearing bore must first be checked without and subsequently with main bearings installed.

Measuring crankshaft bearing bore with main bearings installed

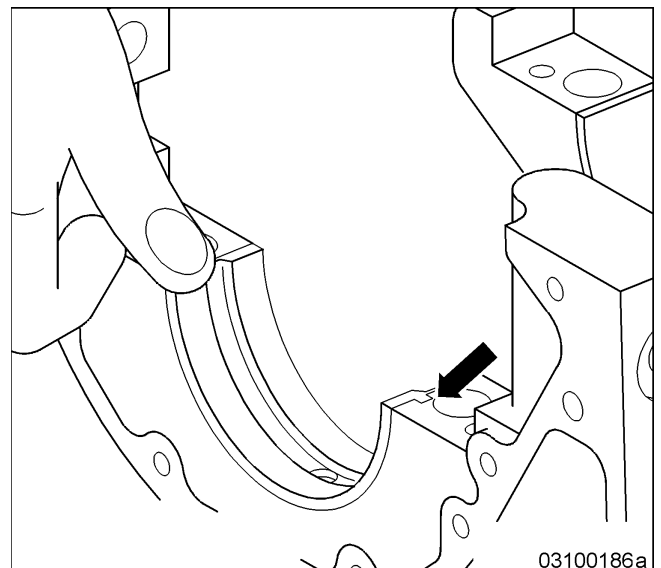
Installing bearing shells

1. Turn crankcase upside down in rotation device with oil pan mating face horizontal.
2. Wipe bores (arrowed) for main bearing in crankcase and bearing shells on both sides with chamois leather.



Note: Top and bottom bearing shells have different part numbers.

3. Check marking of repair stage and journal diameter on new bearing shells and bearing numbers on used bearing shells.
4. Compare crankcase data sheet and crankshaft data sheet.
5. Insert bearing shells at housing side (bearing shells with oil groove and oil bore) in housing bore with pressure by hand so that they fit positively.
6. Locating lug (arrow) of the bearing shell must be in crankcase groove.
7. Oil bores of bearing shells and crankcase must be aligned.

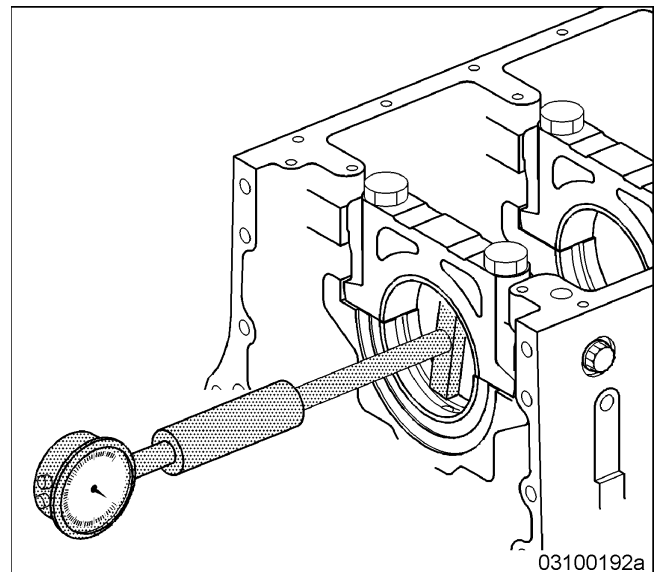


Installing main bearing caps

1. Position engine in crankcase rotation device so that its oil pan mating face is facing upwards and in horizontal position.
2. Install crankshaft bearing cap (→ Page 217).

Measuring crankshaft bore

1. Adjust bore gauge with adjusting ring or micrometer to basic size of bearing bore.
2. Coat running surfaces of main bearing shells with engine oil.
3. Measure crankshaft bearing bore ID with bore gauge.
4. Record measured values in data sheet.
5. Compare planes of measurement and limit values (→ Page 195).
6. If wear limits are exceeded, replace bearing shells or work to next repair stage.
7. After measuring crankshaft bearing bores, if necessary mark bearing shells according to bearing point number.

**Checking crankshaft bearing bore without main bearing installed**

1. Remove crankshaft bearing cap (→ Page 185).
2. Remove bearing shells. Protect against damage.
3. Install crankshaft bearing cap (→ Page 217).
4. Measure crankshaft bearing bore ID in the same way as with installed bearing shells.

3.3.12 Crankshaft – Installation

Special tools

Designation / Use	Part No.	Qty.
Guide pin	F6555644	4
Magnetic holder		
Dial gauge		



Suspended load.

Danger to life!

- Use appropriate lifting devices and appliances.
- Never stand beneath a suspended load.



Heavy object.

Risk of crushing!

- Use appropriate lifting devices and appliances.



Compressed air.

Risk of injury!

- Do not direct compressed-air jet at persons.
- Wear protective goggles / safety mask and ear protectors.



Components have sharp edges.

Risk of injury!

- Wear protective gloves.



Contamination of components.

Damage to component!

- Observe manufacturer's instructions.
- Check components for special cleanliness.

Check crankshaft (→ Page 191).

Check main bearing shells (→ Page 212).

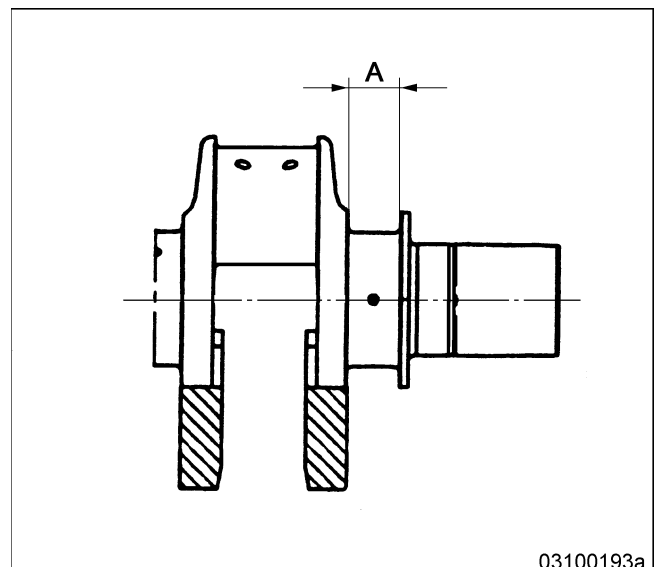
Check main bearing bore (→ Page 214).

Determining wall thickness of thrust washers

1. In order to achieve the specified axial play (→ Page 195) the wall thickness of the thrust washers must be determined as follows.
2. Calculate wall thickness of the thrust washers using the following formula: $(A - B + \text{average axial play}) / 2$.

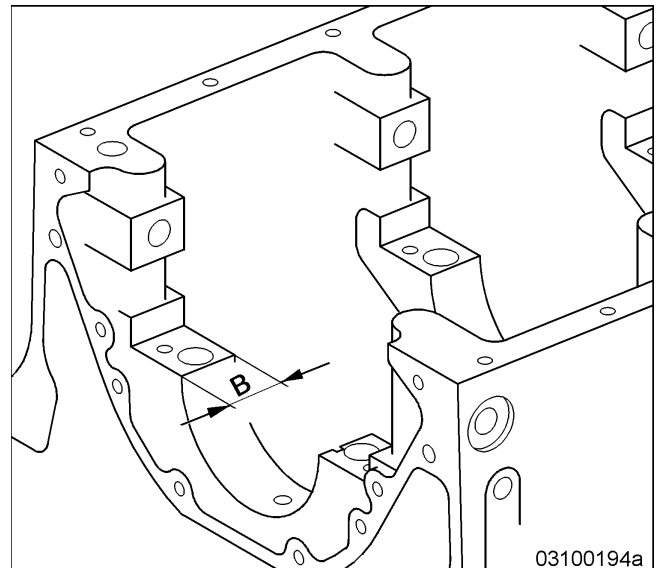
Note: Thrust washers of the same thickness must be installed on both crankshaft fit sides. Thrust washers are delivered ex works ready for installation. Oversizes are available for repair work.

3. Measure alignment bearing width A of crankshaft and record the measured value.

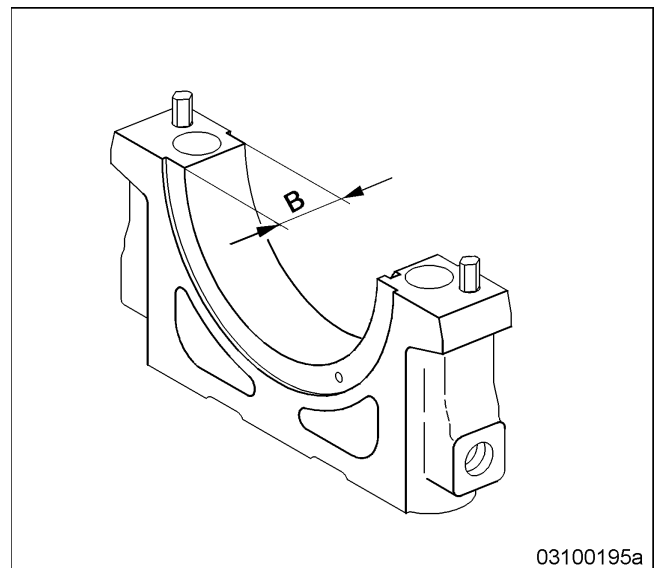


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4. Measure crankcase wall thickness (B) and record measured value.

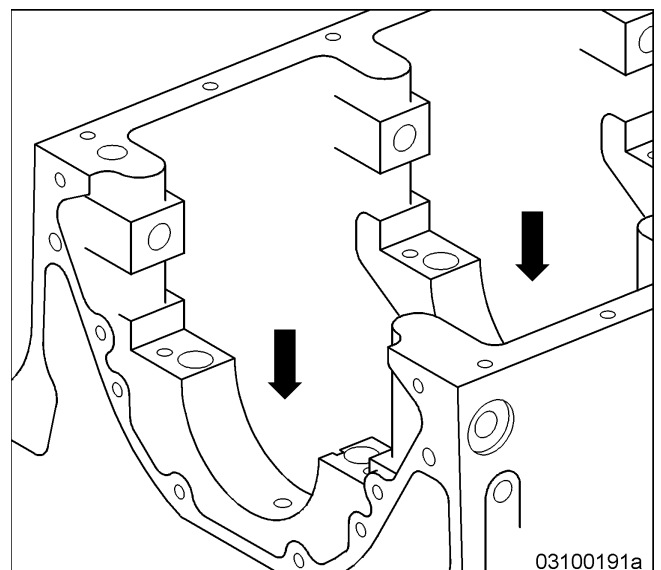


5. Measure alignment bearing thickness (B) and record measured value.



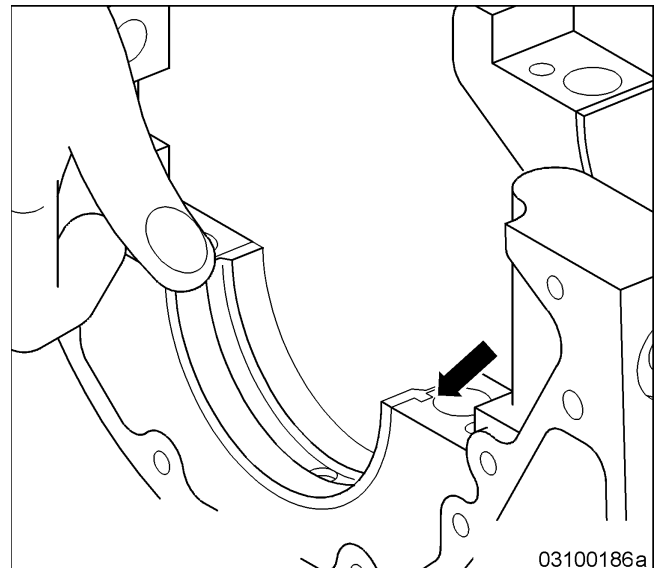
Installing bearing shells in crankcase

1. Turn crankcase upside down in rotation device with oil pan mating face horizontal.
2. Wipe bores for main bearing in crankcase and bearing shells on both sides with chamois leather.



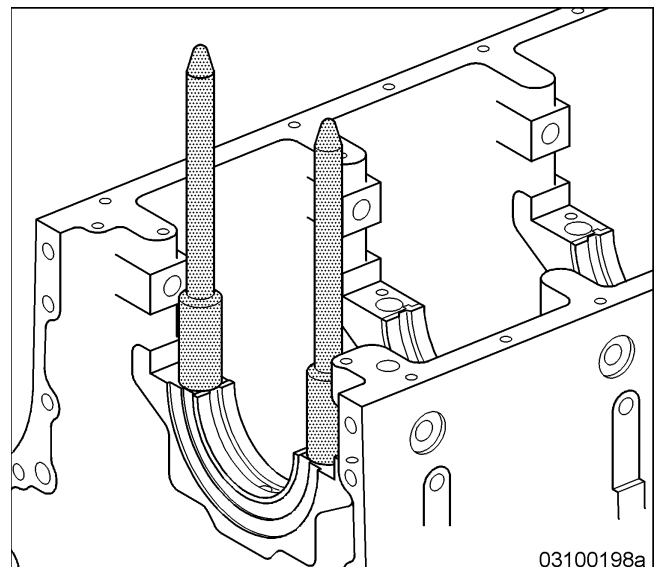
Note: Top and bottom bearing shells have different part numbers.

3. Manually insert crankcase-side bearing shells (with oil groove and oil bore) in accordance with bearing point number in housing bore to form a positive connection.
4. Check stage of main bearing bore and stage of bearing shells. For data, see crankcase data sheet and crankshaft data sheet.
5. Locating lug (arrowed) of the bearing shell must be in crankcase groove.
6. Oil bores of bearing shells and crankcase must be aligned.
7. Coat bearing surfaces of the crankcase-side bearing shells with engine oil.

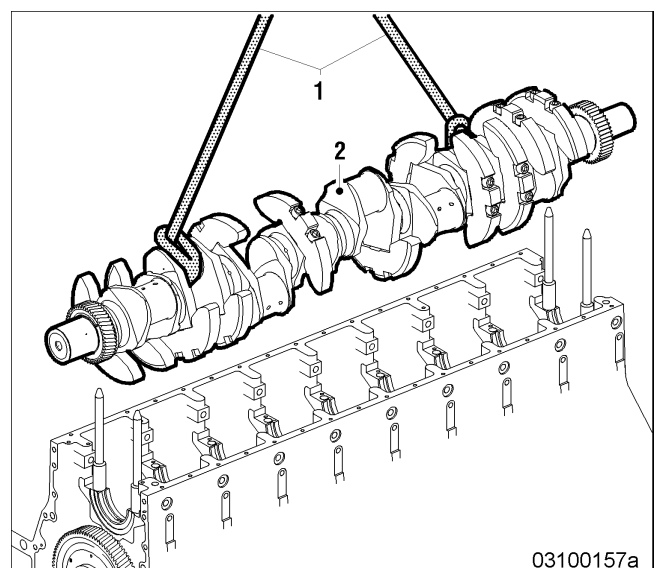


Crankshaft – Installation

1. Wipe crankshaft bearing surfaces with chamois leather.
2. Attach guide pin at the first and last bearing.

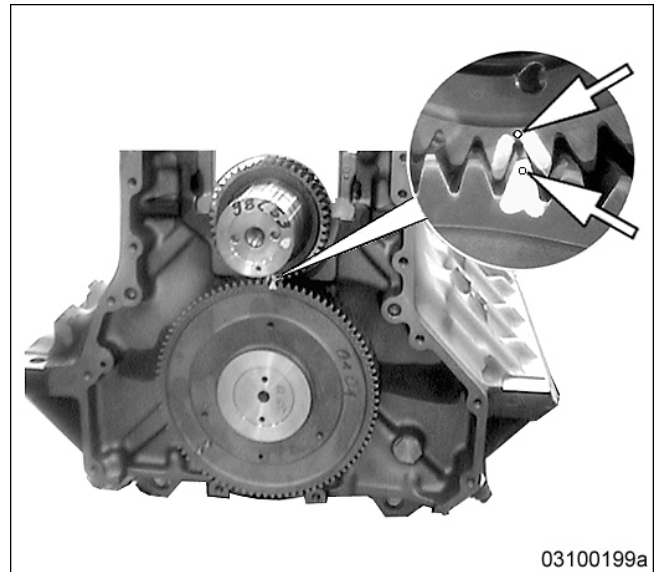


3. Attach crankshaft (2) with rope slings (1) to crane and lift.
4. Slowly lower crankshaft on to the crankcase bearings.



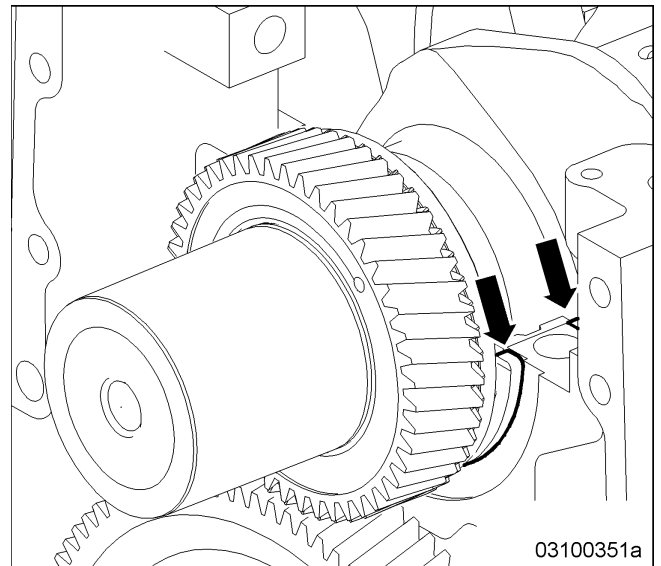
Note: Do not rotate the crankshaft until the axial alignment bearing has been installed.

5. If the camshaft is installed, before the limit position is reached, make sure that the markings (arrows) on crankshaft gear and camshaft gear match.
6. Lower crankshaft slowly onto bearing shells.
7. Remove guide pin.



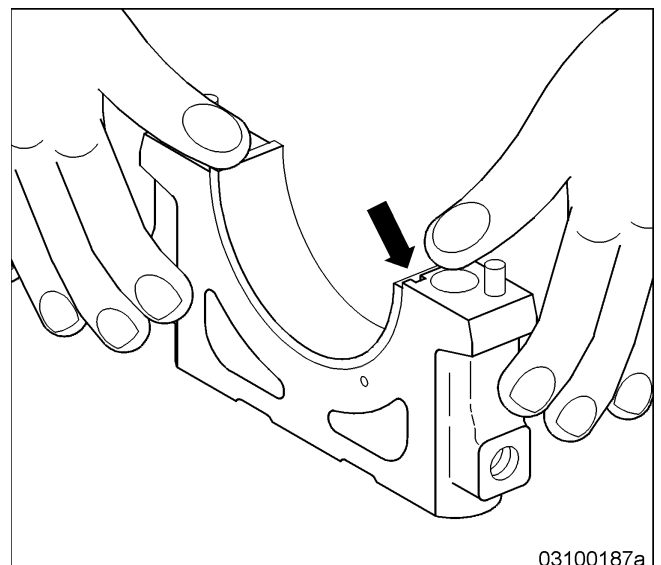
Installing upper thrust washer halves

1. Coat thrust washers (arrows) with engine oil.
2. Insert thrust washers (arrows) in guides between crankshaft alignment bearing and contact surfaces in the crankcase on both sides of the first bearing surface.

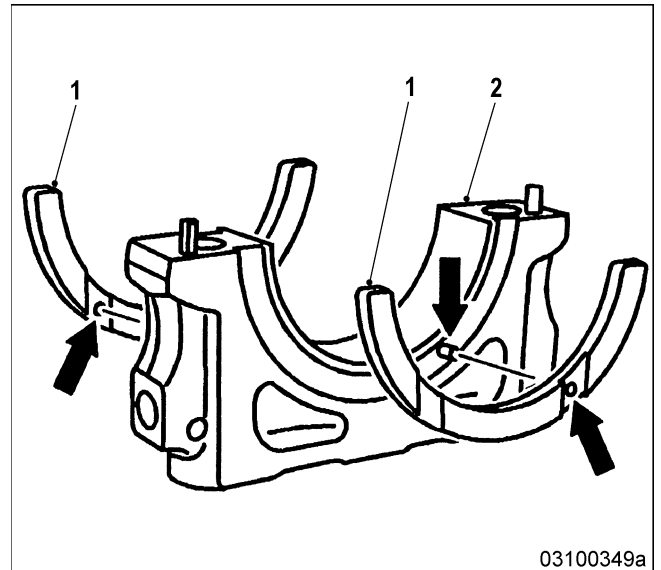


Installing main bearing caps

1. Wipe bearing shell mating faces on main bearing cap.
2. Wipe lower bearing shell (without oil bore) on both sides with chamois leather and insert in the bearing cap in accordance with the marking / bearing number.
3. Locating lug (arrowed) of the bearing shell must be in main bearing cap groove.



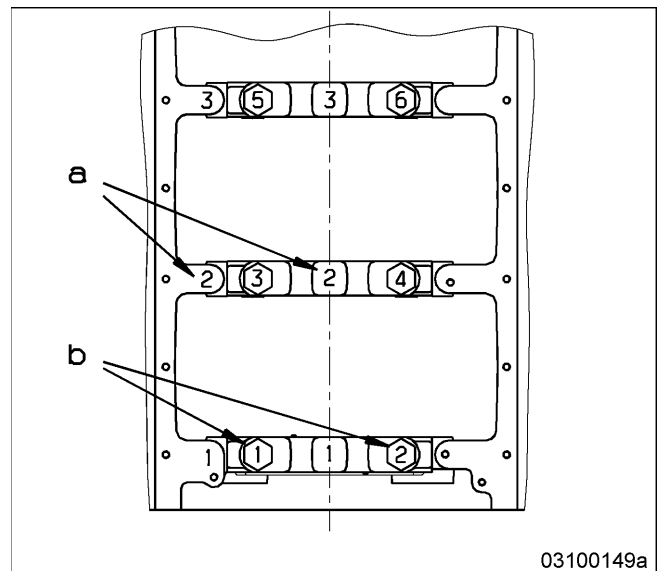
4. Coat thrust washers (1) with engine oil.
5. Install thrust washers (1) on both sides of the crankshaft alignment bearing (2), in doing so observe grooved pin fit (arrows).



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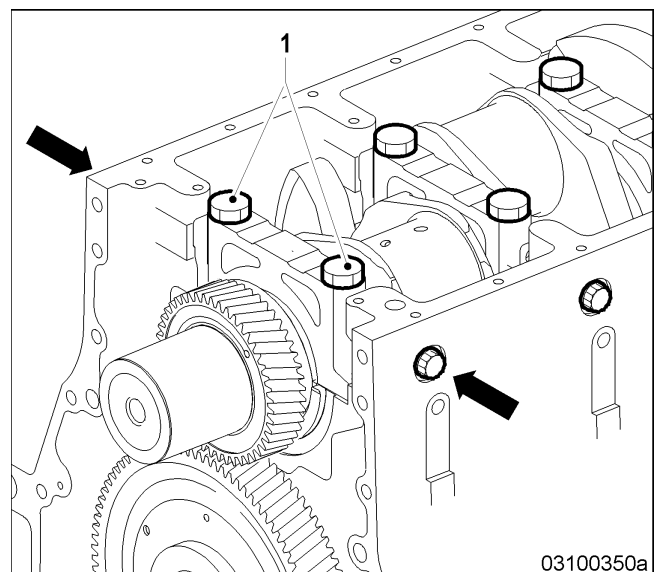
Note: Main bearing caps and corresponding screws must not be confused.

6. Coat main bearing journal of the crankshaft with engine oil.
7. Fit bearing caps to the corresponding bearings in the crankcase in accordance with the relevant marking.
 - a Consecutive numbering of main bearings, starting from driving end
 - b Consecutive numbering of the screws



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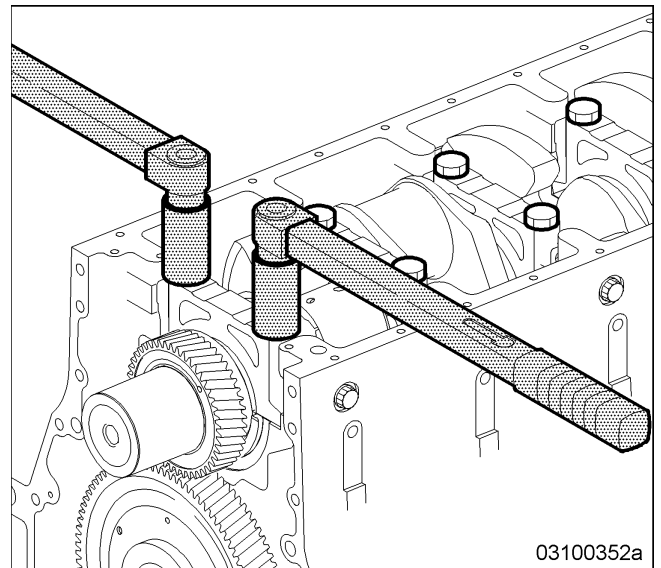
8. Coat threads and screw head mating faces of the screws (1) with engine oil.
9. Insert screws (1) as marked (see previous figure) and hand tighten.
10. Coat threads and screw head mating faces of the double-hex screws (arrows) with engine oil.
11. Insert double hex screws (arrows) and hand tighten.



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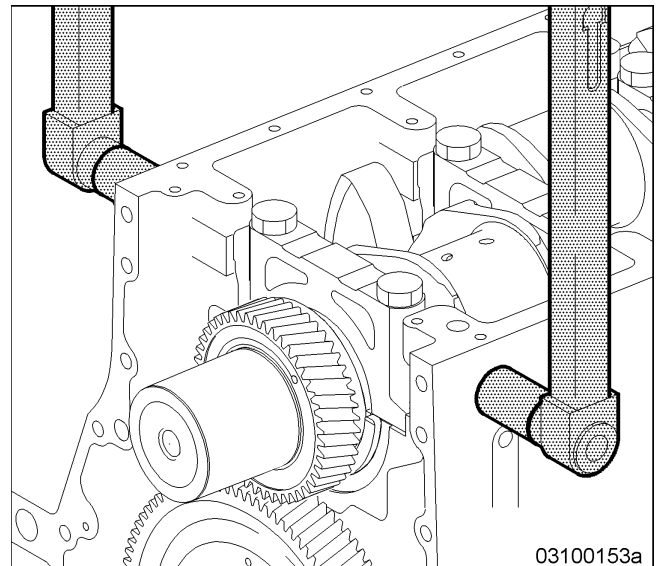
Note: Always tighten screws of one bearing in one cycle.

12. Using a torque wrench and starting at the alignment bearing, tighten screws for crankshaft bearing cap to specified torque (→ Page 23).
13. Mark screw heads.
14. Tighten screws for main bearing caps to specified further angle of rotation (→ Page 23).



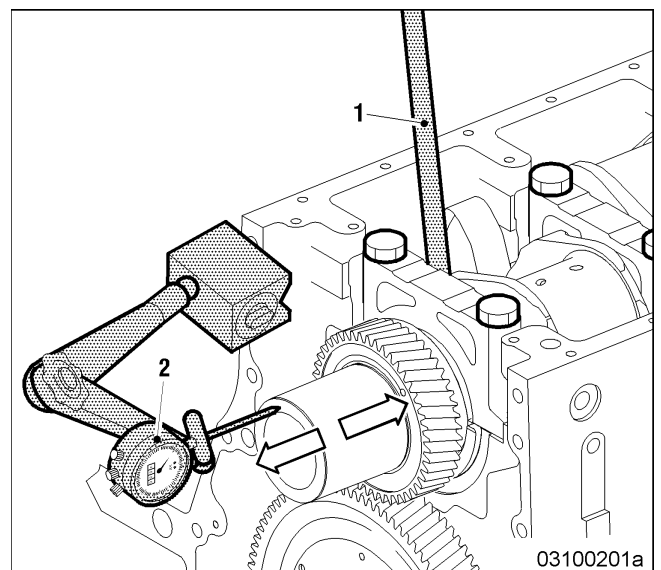
Note: Tighten lateral double-hex screws of one bearing simultaneously.

15. Using a torque wrench and starting from the alignment bearing, tighten lateral double-hex screws in one cycle to specified torque (→ Page 70).

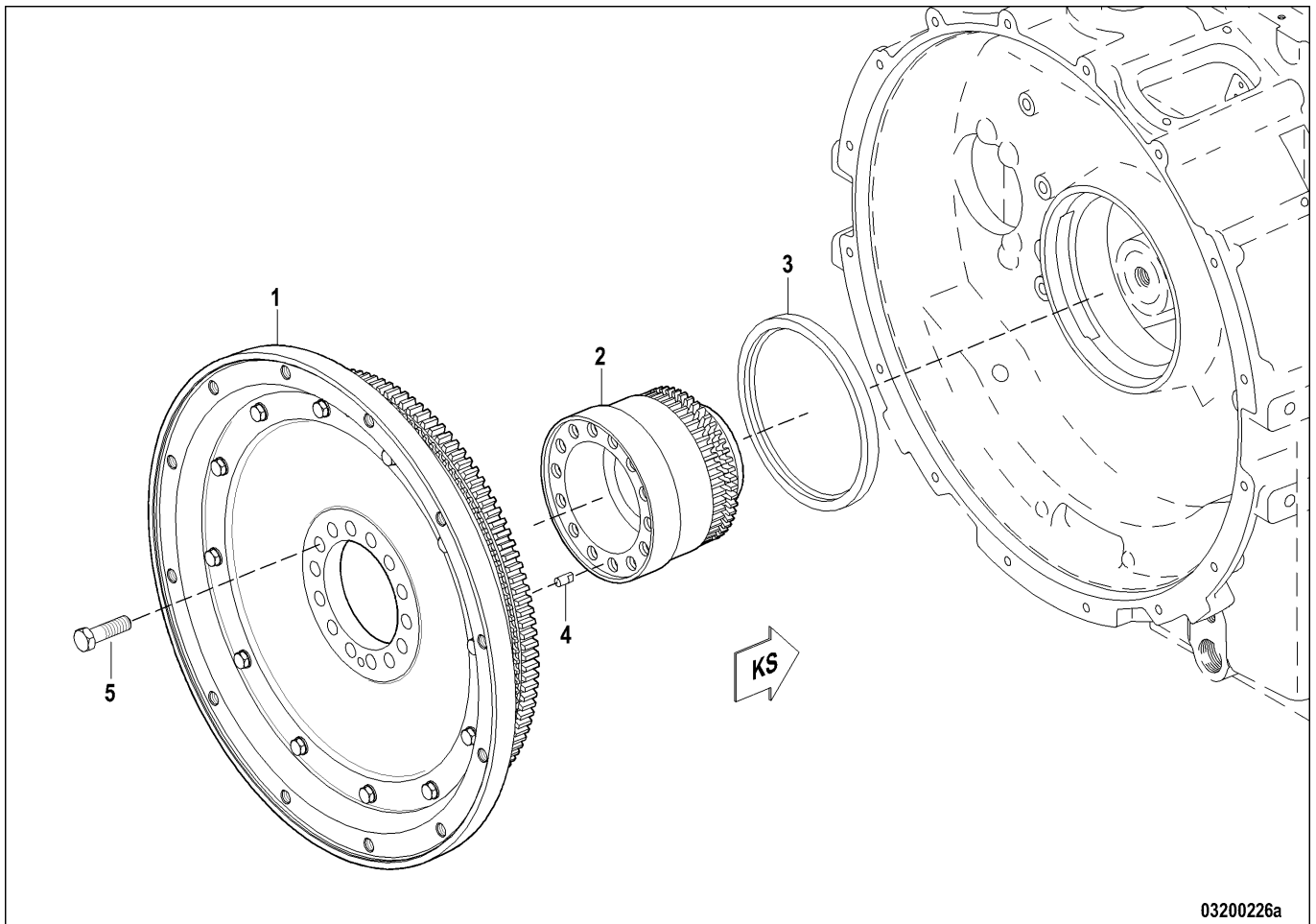


Measuring crankshaft axial play

1. Mount magnetic dial gauge holder with dial gauge (2) on crankcase.
2. Position dial gauge tip against front face of crankshaft.
3. Using pry bar (1), press crankshaft axially as far as it will go.
4. Set preloaded dial gauge to zero.
5. Move crankshaft from stop to stop (arrows) and enter measured value in data sheet.
6. If the determined value is outside the permissible tolerance range (→ Page 195), remove crankshaft and check cause.

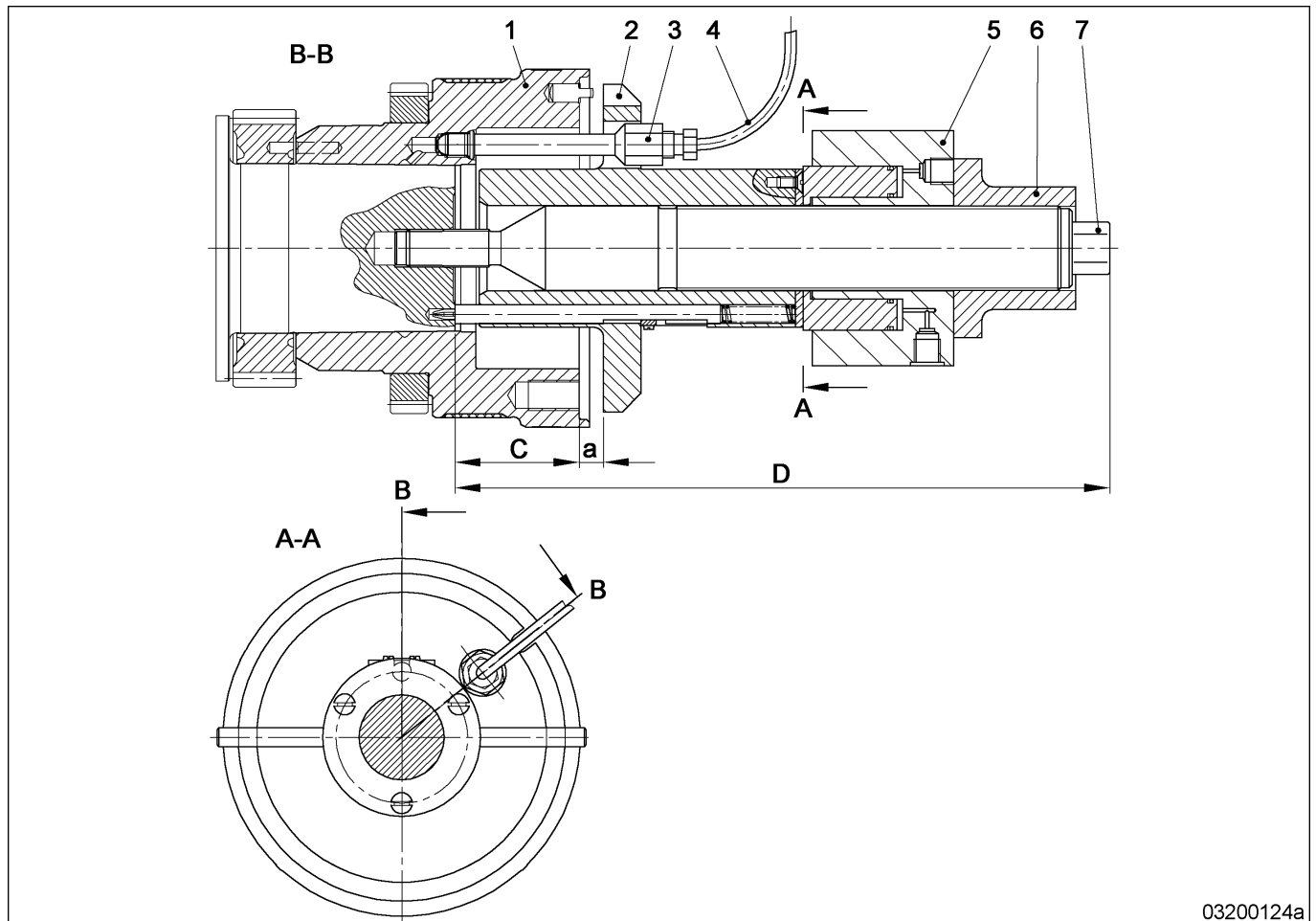


3.3.13 PTO flange, driving end – Flywheel overview



- 1 Flywheel
- 2 Hub
- 3 Shaft seal
- 4 Dowel pin
- 5 Screw

Layout of installation/removal tool for flywheel



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- 1 Hub
- 2 Pressure sleeve
- 3 Adapter
- 4 Line
- 5 Hydraulic nut
- 6 Nut

- 7 Puller spindle
- C Push-on dimension: 66 mm
±0.05 mm
- a Push-on dimension: 12.1 mm
to 14.6 mm
- D Reference dimension

- for version F6781531 = 413 mm
- for version F6554700 = 345 mm
- for version F6555797 = 345 mm

3.3.14 PTO flange, driving end, flywheel – Removal

Preconditions

- Engine is stopped and starting disabled.

Special tools

Designation / Use	Part No.	Qty.
Retaining device	F6783166	1
Installation/removal device assembly	F0099990	1
Protective sleeve	F6558561	1
Locating pin	F6555162	2
Eyebolt	000580016002	1
SKF hand pump	5555890063/00	1
Lukas hand pump	B80094179	1
Puller	F6555793	1



Suspended load.

Danger to life!

- Use appropriate lifting devices and appliances.
- Never stand beneath a suspended load.



Equipment can drop off.
Liquid is highly pressurized.

Risk of injury, knocks or crushing!

- Only use specified and tested equipment.
- Do not enter the danger zone.
- Wear protective clothing, gloves, and goggles / safety mask.

Preparatory steps

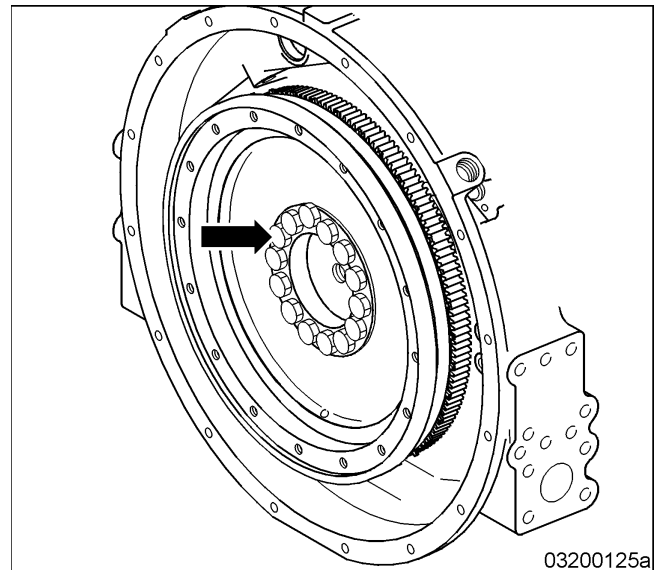
A distinction must be made as to whether

- 1 The engine is to be completely disassembled
- 2 The engine is to be removed but not disassembled
- 3 The engine is to remain installed

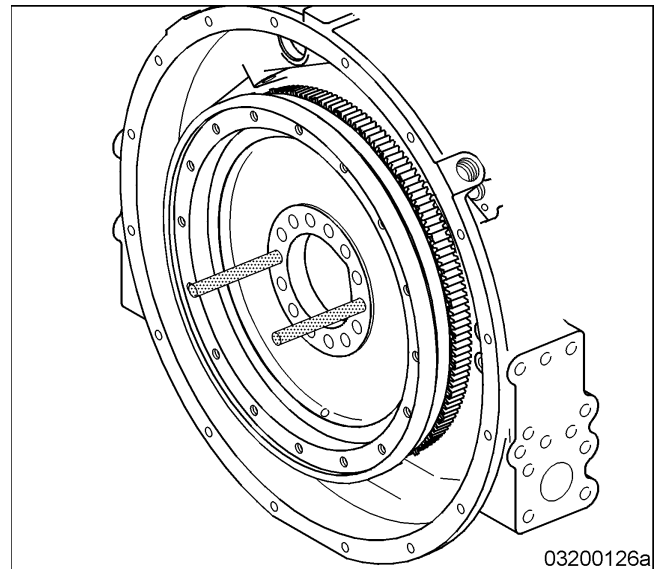
1	2	3	Operations	See
X	–	–	Remove engine	(→ Page 55)
X	–	–	Disassemble engine	(→ Page 56)
–	–	X	Disable engine start	–
–	X	X	Disconnect engine from gearbox	–

Removing flywheel

1. Install retaining device on flywheel.
2. Remove all screws (arrow) but one on flywheel.



3. Screw locating pins into opposite threaded holes on hub.

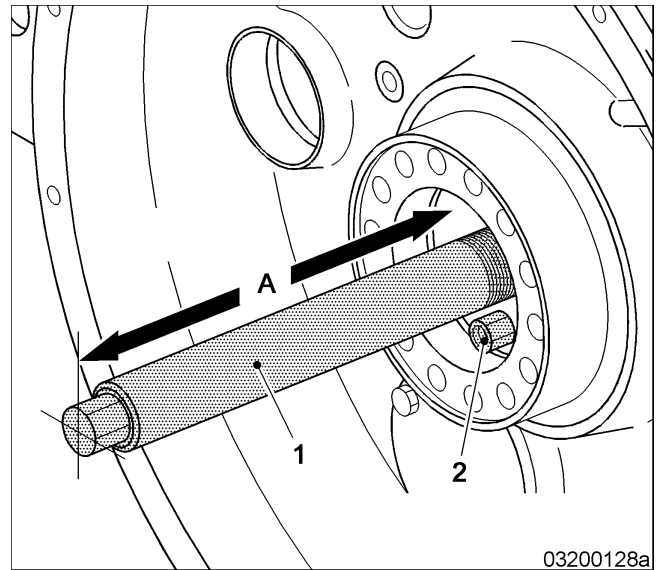


4. Screw eyebolt into flywheel.
5. Hook flywheel with rope on to crane with light initial tension.
6. Remove remaining screw from flywheel.
7. Take flywheel out of flywheel housing above locating pins.
8. Remove locating pins and retaining device.
9. Extract dowel pin from hub.



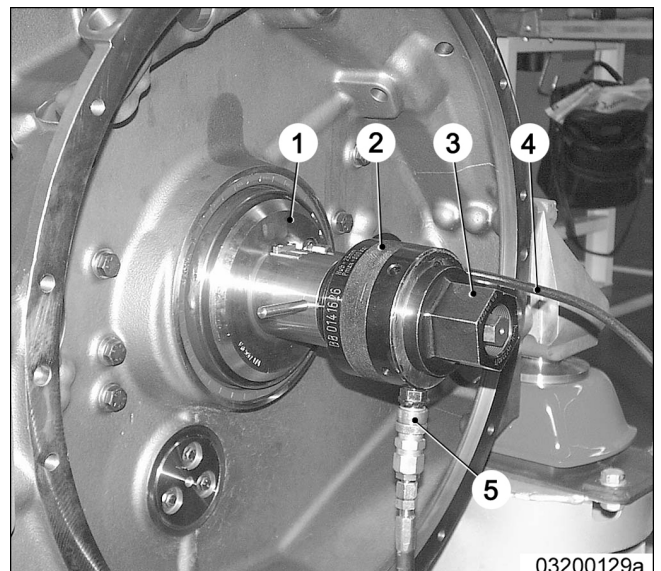
Removing hub

1. Screw hydraulic pressure testing device on to crankshaft extension, driving end, according to arrangement (→ Page 223) and tighten.
2. Screw puller spindle (1) into crankshaft.
3. Check reference dimension (→ Page 223).
4. Screw reducer (2) into hub and tighten.

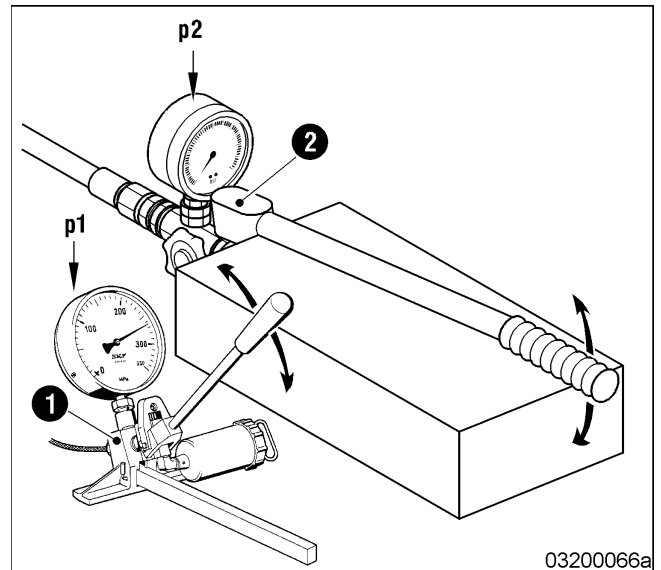


Note: Observe tracer pin of pressure sleeve (1) in crankshaft.

5. Push pressure sleeve (1) and hydraulic nut (2) over feed shaft and screw on nut (3).
6. Screw HP line (4) on to reducer.
7. Connect HP line (5) for hydraulic nut (2).
8. Set hydraulic nut (2) to initial position with zero stroke.
9. Screw nut on up to stop and turn back to force-on dimension value. Force-on dimension (→ Page 223).



10. Fill hand pumps (1) and (2) with engine oil SAE10.
11. Vent hand pump (1) and line system until bubble-free oil emerges.
12. Tighten HP line.
13. Operate hand pump (2) for hydraulic nut and bring into final position using minimal pressure p_2 (light pressure increase) on hub.
14. Read off maximum expansion pressure p_{max} at hub.
15. Operate hand pump (1) for expanding hub until half the maximum expansion pressure p_1 is attained.
16. Maintain pressure p_1 for approx. 5 minutes.
17. Increase expansion pressure in stages of $0.1 \times p_{max}$, waiting approx. 2 minutes between increases, until hub is released from crankshaft. Do not exceed maximum permissible expansion pressure p_{max} .
18. Use hand pump (1) to keep decreasing expansion pressure at constant level.
19. Observe pressure p_2 in the hydraulic nut. The release of the hub from the taper seat is indicated by rising pressure p_2 .
20. Gradually drain oil from hydraulic nut, while at the same time operating hand pump (1).
21. Relieve hand pumps (1) and (2).
22. Remove high-pressure line and reducer.
23. Remove nut, hydraulic nut and pressure bush.
24. Remove hub from crankshaft.



3.3.15 Radial-lip shaft seal, driving end – Removal

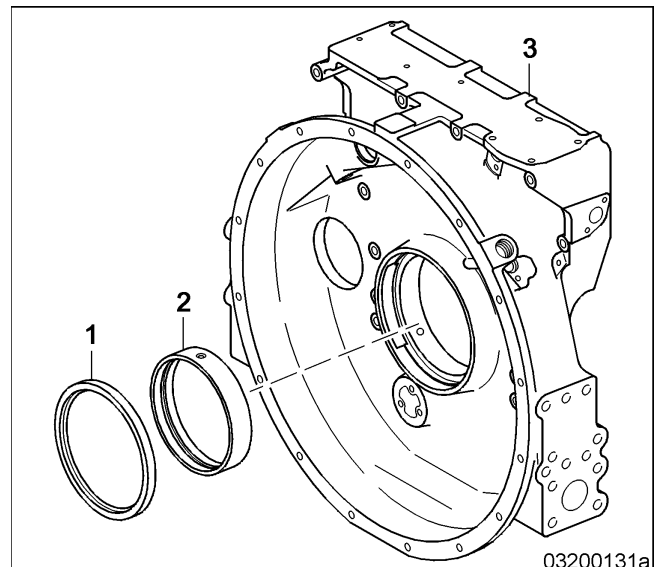
Special tools

Designation / Use	Part No.	Qty.
Extraction tool	F30379303	1

Remove PTO flange flywheel, driving end (→ Page 225).



Removing radial-lip shaft seal from flywheel housing

1. Remove flywheel housing (3) (→ Page 126).
2. Pull out radial-lip shaft seal (1) using extraction tool.



3.3.16 PTO flange, driving end, flywheel – Cleaning

Material

Designation / Use	Part No.	Qty.
Cleaning agent		
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors. 	
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask. 	

Remove radial-lip shaft seal, driving end (→ Page 229).

Cleaning flywheel, PTO flange, driving end

1. Clean all components with cleaning agent.
2. Remove cleaning agent.
3. Thoroughly blow out all threads with compressed air.

3.3.17 PTO flange, driving end – Flywheel check

Special tools

Designation / Use	Part No.	Qty.
Taper gauge 1:50		

Material

Designation / Use	Part No.	Qty.
Fluorescent dye for magnetic crack testing		

Spare parts

Designation / Use	Part No.	Qty.
Flywheel		
Ring gear		
Hub		



Heavy object.
Risk of crushing!

- Use appropriate lifting devices and appliances.

Clean PTO flange flywheel, driving end (→ Page 230).

Checking PTO flange flywheel, driving end

Item	Findings	Task
Check flywheel and ring gear for cracks using magnetic crack test procedure.	Cracks apparent	Replace.
Check ring gear for wear and stress marks.	Signs of wear	<ul style="list-style-type: none"> • Recondition • Replace
Check mating faces on flywheel for flatness, stress marks, scores and indentations.	Signs of wear	<ul style="list-style-type: none"> • Recondition • Replace
Measure hub OD, value (→ Page 133).	Value not reached.	Replace hub.
Check hub gear for wear and stress marks.	Signs of wear	Replace hub.
Check hub cone using taper gauge.	Not true to gauge.	Replace hub.
Check thread of expansion bore.	Damaged	Rework thread.

3.3.18 Radial-lip shaft seal, driving end – Installation

Special tools

Designation / Use	Part No.	Qty.
Shaft seal installation device	F6550770	1

Material

Designation / Use	Part No.	Qty.
Denatured ethanol		

Spare parts

Designation / Use	Part No.	Qty.
Radial-lip shaft seal		



Suspended load.

Danger to life!

- Use appropriate lifting devices and appliances.
- Never stand beneath a suspended load.



Heavy object.

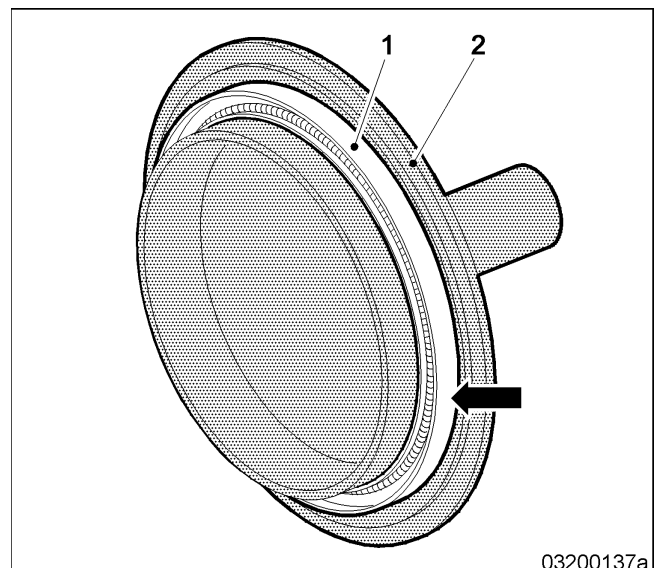
Risk of crushing!

- Use appropriate lifting devices and appliances.

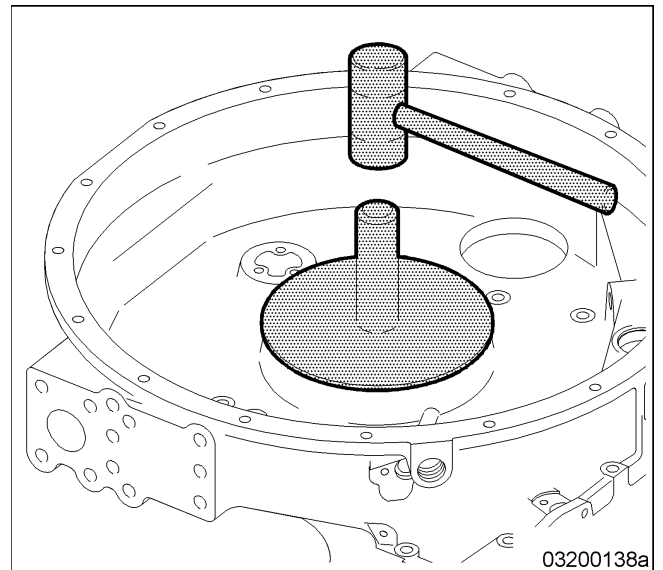
Check flywheel housing (→ Page 131).

Installing radial-lip shaft seal in flywheel housing

1. Push radial-lip shaft seal (1) onto installation tool (2) with the sealing lip facing outward.
2. Coat sealing face on radial-lip shaft seal (1) with denatured ethanol.



3. Degrease flywheel housing bore for radial-lip shaft seal (dry).
4. Install radial-lip shaft seal into flywheel housing using installation tool until flush.
5. Install flywheel housing (→ Page 139).



3.3.19 PTO flange, driving end – Flywheel installation

Special tools

Designation / Use	Part No.	Qty.
Lukas hand pump	B80094179	1
SKF hand pump	5555890063/00	1
Eyebolt	000580016002	1
Locating pin	F6555162	2
Protective sleeve	F6558561	1
Removal/installation device	F0099990	1
Retaining device	F6783166	1

Material

Designation / Use	Part No.	Qty.
Engine oil		



Suspended load.

Danger to life!

- Use appropriate lifting devices and appliances.
- Never stand beneath a suspended load.



Heavy object.

Risk of crushing!

- Use appropriate lifting devices and appliances.



Equipment can drop off.

Liquid is highly pressurized.

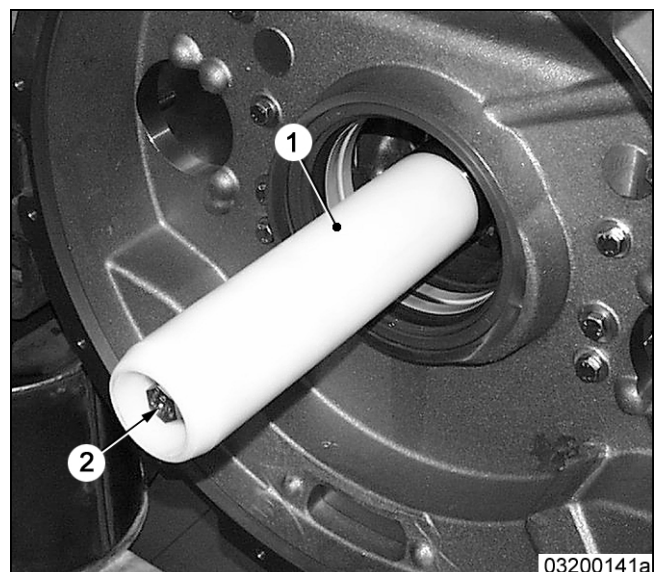
Risk of injury, knocks or crushing!

- Only use specified and tested equipment.
- Do not enter the danger zone.
- Wear protective clothing, gloves, and goggles / safety mask.

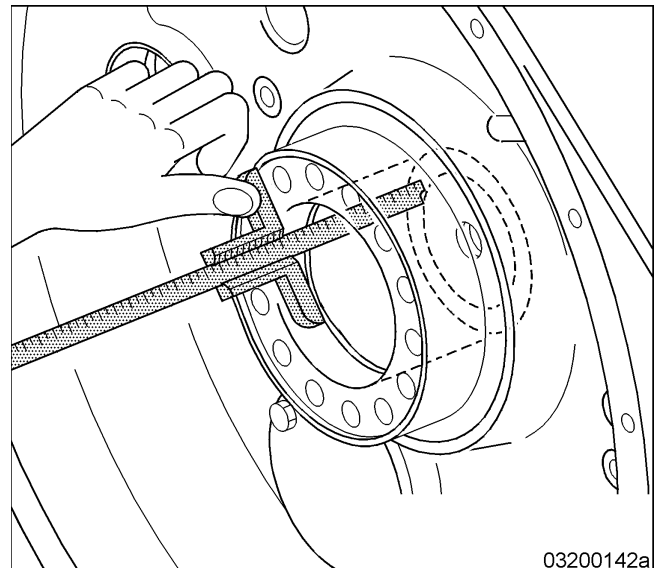
Install radial-lip shaft seal, driving end (→ Page 232).

Installing hub

1. Degrease and dry clean cone surface on crankshaft and hub using cleaning agent and lint-free cloth.
2. Coat running surface of crankshaft bearing and hub with oil.
3. Coat hub running surface for shaft seal with thin-film lubricant.
4. Coat shaft seal lip with petroleum jelly.
5. Screw puller spindle (2) into crankshaft.
6. Check reference dimension (D) (→ Page 223).
7. Push protective sleeve (1) over puller spindle (2).

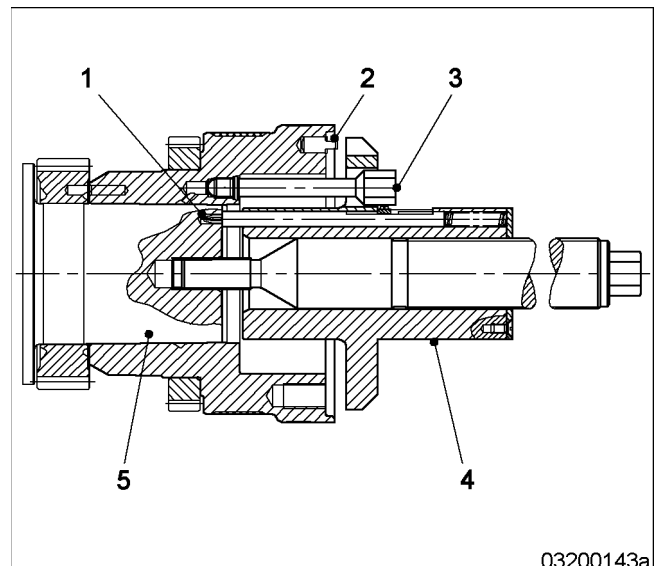


8. Push hub over protective sleeve onto crankshaft cone.
9. Remove protective sleeve.
10. To determine the push-on dimension, measure distance from the crankshaft front face to the hub front face using a depth gauge.
11. Calculate difference (= push-on dimension) between measured value and value "C" (→ Page 223) .
12. If the calculated value is smaller than push-on dimension "a" (→ Page 223) check taper for dimensional accuracy.



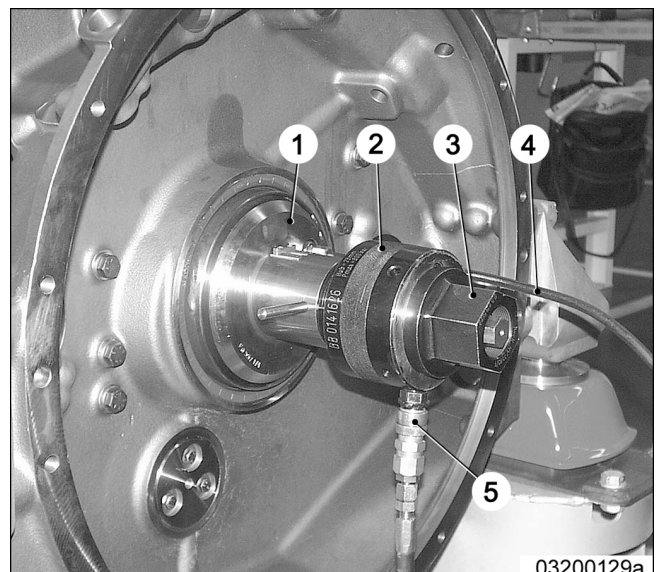
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13. Screw adapter (3) into hub and tighten.
14. Push pressure sleeve (4) over puller spindle noting the fit of pin (1) in crankshaft (5).



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15. Push pressure sleeve (1) and hydraulic nut (2) over puller spindle and install nut (3).
16. Screw HP line (4) into adapter and tighten by hand.
17. Connect HP line (5) for hydraulic nut (2).
18. Set hydraulic nut to initial position with zero stroke.

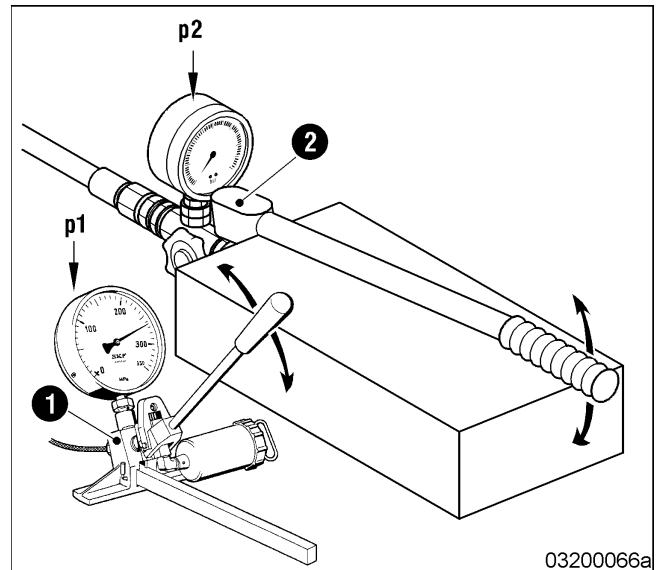


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19. Fill hand pumps (1) and (2) with engine oil SAE10.
20. Vent hand pump (1) and line system until bubble-free oil emerges.
21. Tighten HP line for adapter.
22. Before fitting, taper fits must be moistened with expansion fluid. Actuate hand pump (1) until expansion fluid escapes at the hub end.
23. Actuate hand pump (2) for hydraulic nut and make contact with hub using minimum pressure.

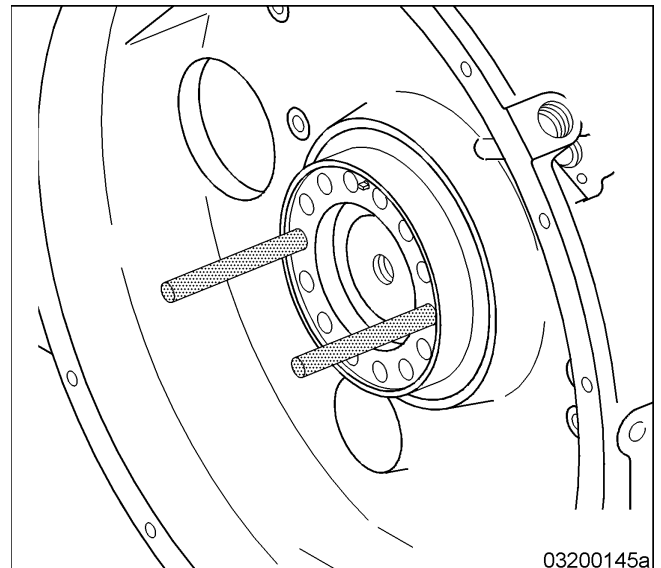
Note: Read off expansion pressure p_{\max} at hub.

24. Pump in expansion fluid until expansion pressure (p_1) can no longer be increased (do not exceed expansion pressure P_{\max}). Subsequently increase push-on force by increasing push-on pressure (p_2).
25. Select push-on force so that end position is reached after approx. 5 steps.
26. Open valve screw on hand pump (1) to relieve expansion pressure.
27. Maintain maximum push-on pressure for 60 minutes, to ensure that the expansion fluid is expelled from the joint and static friction can build up between the fixed components.
28. Unscrew HP lines.
29. Allow specified retention time to elapse and remove nut, hydraulic nut, pressure sleeve and puller spindle.
30. Check push-on dimension "C", value (→ Page 223).
31. Do not subject press fitting to operating load for at least 8 hours.



Installing flywheel

1. Screw two locating pins into opposite threaded bores of hub.



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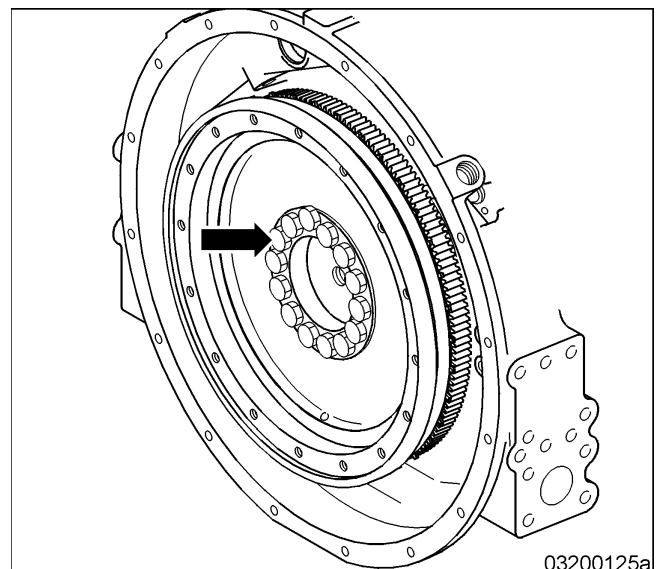
2. Screw eyebolt into flywheel.
3. Use rope to attach flywheel to crane with light initial tension.



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Note: Note pin fit in flywheel.

4. Place flywheel over guide pin onto hub.
5. Install flywheel screws (arrowed) and tighten diagonally and evenly.
6. Remove locating pins and lifting device.
7. Block engine at flywheel with retaining device.
8. Using a torque wrench, tighten screws diagonally to specified tightening torque (→ Page 23) .
9. Remove retaining device.

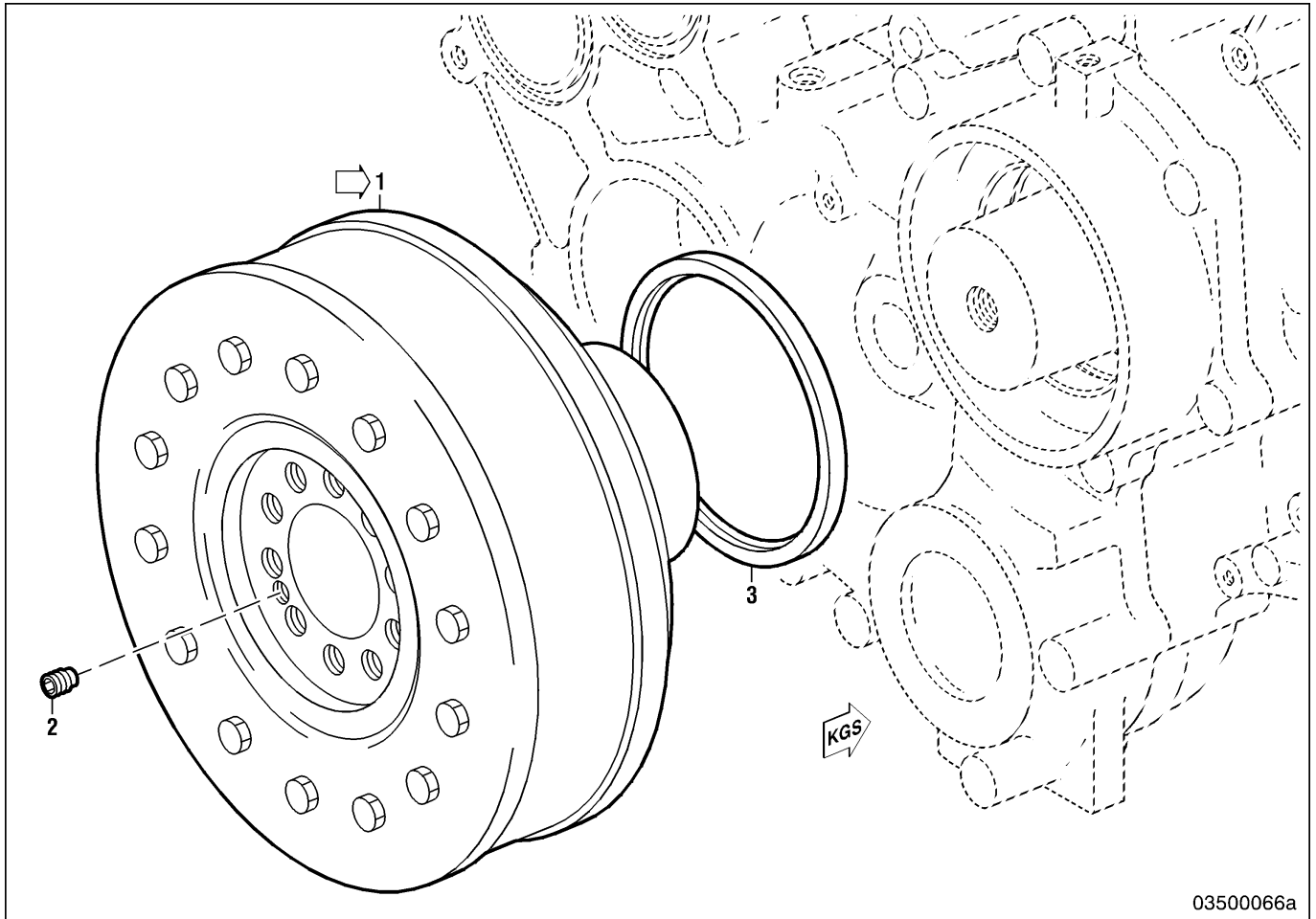


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Final steps

For these steps a distinction must be made as to whether				
1 the engine has been completely disassembled				
2 the engine has been removed but not disassembled				
3 the engine has remained installed				
1	2	3	Operations	See
X	–	–	Assemble engine.	(→ Page 58)
X	–	–	Install engine.	(→ Page 60)
–	–	X	Attach engine to gearbox/generator	–
–	–	X	Enable engine start.	–

3.3.20 Vibration damper on PTO, free end – Overview

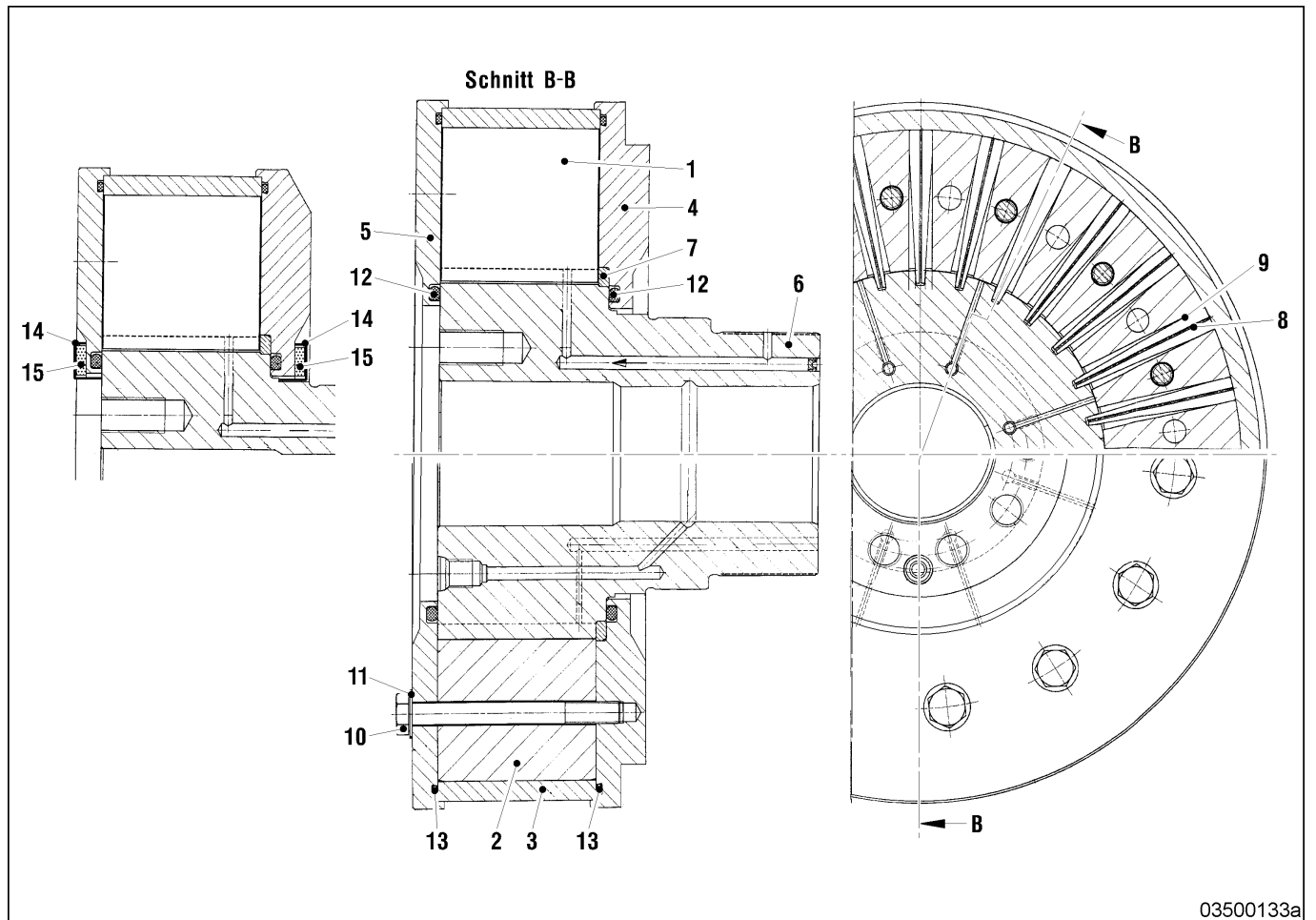


1 Vibration damper

2 Threaded pin

3 Shaft seal

Overview drawing

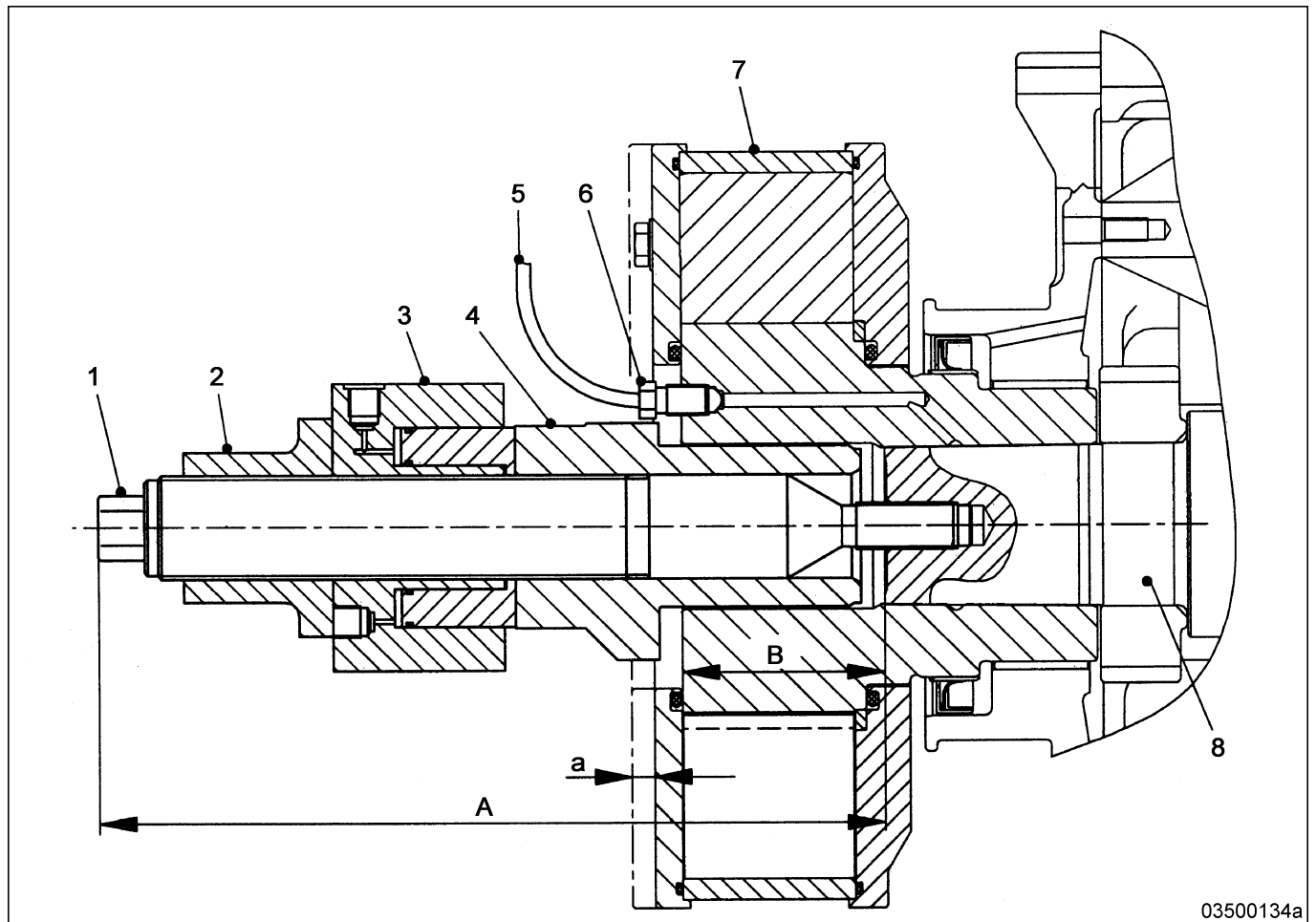


- 1 Spring pack
- 2 Adapters
- 3 Clamping ring
- 4 Flange
- 5 Side plate

- 6 Inner star
- 7 Bearing bush
- 8 Insert
- 9 Insert
- 10 Screw

- 11 Washer
- 12 Gasket
- 13 Sealing ring
- 14 Sealing ring
- 15 Sealing ring

Layout of installation/removal tool for vibration damper



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- | | |
|---|---|
| <ul style="list-style-type: none"> 1 Puller spindle 2 Nut 3 Hydraulic nut 4 Pressure sleeve 5 Line 6 Adapter 7 Vibration damper 8 Crankshaft A Reference dimension | <ul style="list-style-type: none"> • for version F6781531 = 413 mm • for version F6555797 = 345 mm B Push-on dimension: 87.8 mm to 88.2 mm a Push-on dimension: 10.5 mm ±1 mm |
|---|---|


3.3.21 Vibration damper on PTO, free end – Check


Preconditions

- Engine is stopped and starting disabled.

Special tools

Designation / Use	Part No.	Qty.
Installation/removal device assembly	F0099996	1
Protective sleeve	F6558561	1
SKF hand pump	5555890063/00	1
Lukas hand pump	B80094179	1
Support bracket	T80090974	1

 DANGER	<p>Suspended load. Danger to life!</p> <ul style="list-style-type: none"> • Use appropriate lifting devices and appliances. • Never stand beneath a suspended load.
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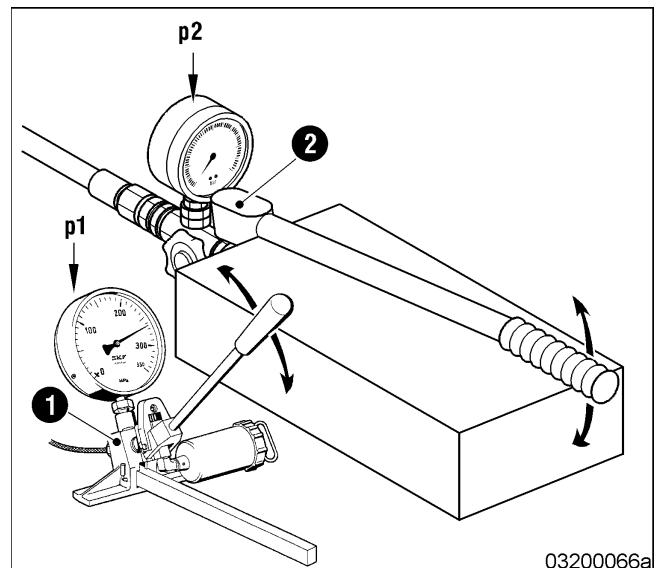
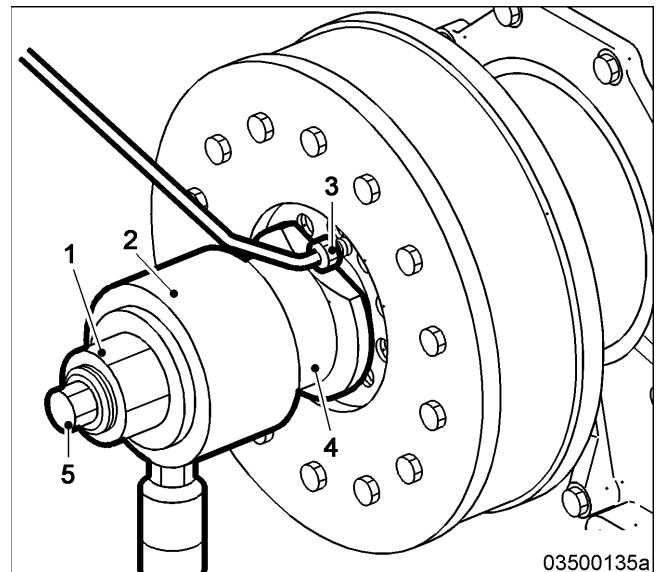
 WARNING	<p>Equipment can drop off. Liquid is highly pressurized. Risk of injury, knocks or crushing!</p> <ul style="list-style-type: none"> • Only use specified and tested equipment. • Do not enter the danger zone. • Wear protective clothing, gloves, and goggles / safety mask.
---	---

Preparatory steps

A distinction must be made as to whether				
1 the engine is to be completely disassembled				
2 the engine is to be removed but not disassembled				
3 the engine is to remain installed				
1	2	3	Operations	See
X	–	–	Remove engine	(→ Page 55)
X	–	–	Disassemble engine	(→ Page 56)
–	–	X	Disable engine start	(→ Page 15)
–	X	X	Remove belt drive	(→ Page 176)

Removing vibration damper

1. Remove stud from expanding bore in vibration damper.
 2. Screw feed shaft (5) into crankshaft.
 3. Check reference dimension "A" for feed shaft (→ Page 239).
 4. Slide pressure sleeve (4) and hydraulic nut (2) on to feed shaft.
 5. Screw on nut (1).
 6. Screw reducer (3) into vibration damper and connect HP line.
 7. Connect HP line on hand pump to hydraulic nut.
 8. Set hydraulic nut to original position: zero stroke.
 9. Turn back nut to force-on dimension value. Force-on dimension "a" can be found on vibration damper
10. Fill hand pumps (1) and (2) with engine oil SAE10.
 11. Vent hand pump (1) and line system until bubble-free oil emerges.
 12. Tighten HP line.
 13. Operate hand pump (2) for hydraulic nut and bring into final position using minimal pressure p_2 (light pressure increase) on vibration damper.
 14. Read off maximum expansion pressure p_{max} at vibration damper.
 15. Operate hand pump (1) for expanding hub until half the maximum expansion pressure p_1 is attained.
 16. Maintain pressure p_1 for approx. 5 minutes.
 17. Increase expansion pressure in stages of $0.1 \times p_{max}$, waiting approx. 2 minutes between increases, until vibration damper is released from crankshaft. Do not exceed maximum permissible expansion pressure p_{max} .
 18. Use hand pump (1) to keep decreasing expansion pressure at constant level.
 19. Observe pressure p_2 in hydraulic nut. The release of the vibration damper from the taper seat is indicated by rising pressure p_2 .
 20. Gradually drain oil from hydraulic nut, while at the same time operating hand pump (1).
 21. Relieve hand pumps (1) and (2).
 22. Remove high-pressure line and reducer.
 23. Remove nut, hydraulic nut and pressure bush.
 24. Remove vibration damper from crankshaft.



3.3.22 Vibration damper on PTO, free end – Disassembly

Remove vibration damper (→ Page 242).



Vibration damper – Disassembly

Disassembly of this component is not planned.

This component is an exchange component (Reman) and is available through the usual exchange procedure.

3.3.23 Vibration damper on PTO, free end – Cleaning

Material

Designation / Use	Part No.	Qty.
Cleaning agent		
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors. 	
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask. 	

Remove vibration damper (→ Page 242).

Vibration damper – Cleaning

1. Clean vibration damper on PTO, free end, with cleaning agent.
2. Remove cleaning agent.
3. Clean vibration damper on PTO, free end, by blowing out with compressed air.



3.3.24 Vibration damper on PTO, free end – Check

Special tools

Designation / Use	Part No.	Qty.
Taper gauge 1:50		
Outside micrometer		

Spare parts

Designation / Use	Part No.	Qty.
Vibration damper		
Bearing race		

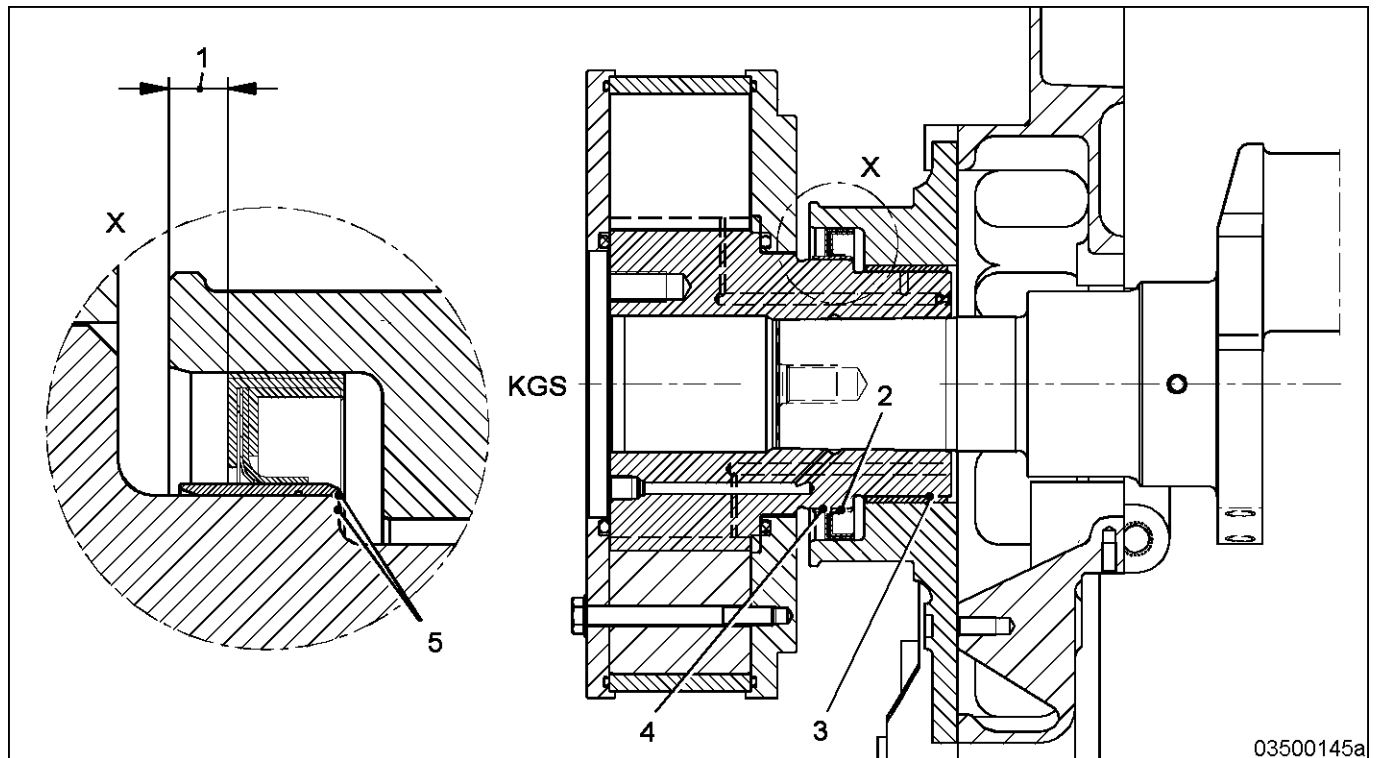
	<p>Heavy object. Risk of crushing!</p> <ul style="list-style-type: none"> Use appropriate lifting devices and appliances.
	<p>Components have sharp edges. Risk of injury!</p> <ul style="list-style-type: none"> Wear protective gloves.

Clean vibration damper (→ Page 245).

Checking vibration damper

Item	Findings	Task
Visually inspect vibration damper for damage and wear.	<ul style="list-style-type: none"> Damage Wear visible 	Replace vibration damper.
Check taper with taper gauge.	Not true to gauge.	Replace vibration damper.
Measure bearing race outer Ø. Value (→ Page 247)	Value not attained.	Replace bearing race (→ Page 251).
Measure bearing race outer Ø. Value (→ Page 247)	Value not attained.	Replace vibration damper.
Check thread of expansion bore.	Damaged	Recut thread.

3.3.25 Vibration damper on PTO, free end – Tolerances



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No.	Designation	Stage	Tol. size		Clearance		Interference		Wear limit
			lower	upper	min.	max.	min.	max.	
1	Clearance Shaft seal		7.000	9.000					
2	Track ring OD		134.925	134.925					
3	Vibration damper OD		119.030	119.050					
4	Track ring bore		131.470	131.630		0.012		0.212	
	Vibration damper not press-fitted		131.618	131.682					
5	Track ring press-fitted flush.								

3.3.26 Vibration damper on PTO, free end – Installation

Special tools

Designation / Use	Part No.	Qty.
Installation/removal device assembly	F0099996	1
Support bracket	T80090974	1
Protective sleeve	F6558561	1
SKF hand pump	5555890063/00	1
Lukas hand pump	B80094179	1

Material

Designation / Use	Part No.	Qty.
Engine oil		
Petroleum jelly, white		

Spare parts

Designation / Use	Part No.	Qty.
O-ring		



Suspended load.

Danger to life!

- Use appropriate lifting devices and appliances.
- Never stand beneath a suspended load.



Heavy object.

Risk of crushing!

- Use appropriate lifting devices and appliances.



Equipment can drop off.

Liquid is highly pressurized.

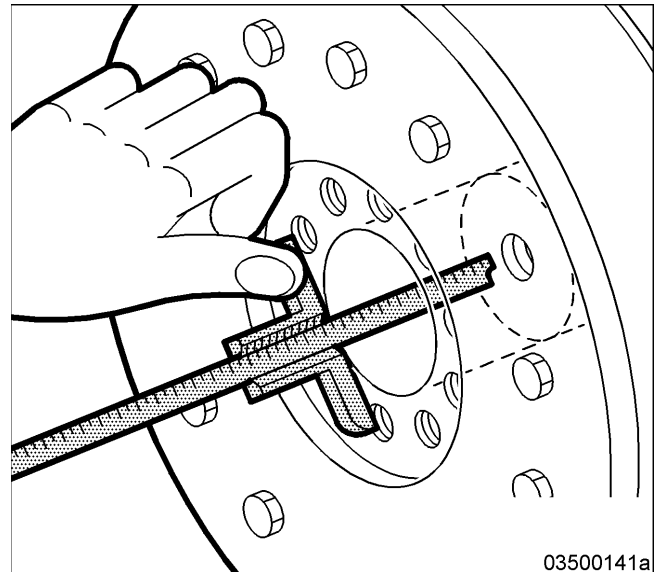
Risk of injury, knocks or crushing!

- Only use specified and tested equipment.
- Do not enter the danger zone.
- Wear protective clothing, gloves, and goggles / safety mask.

Check vibration damper on PTO, free end (→ Page 246).

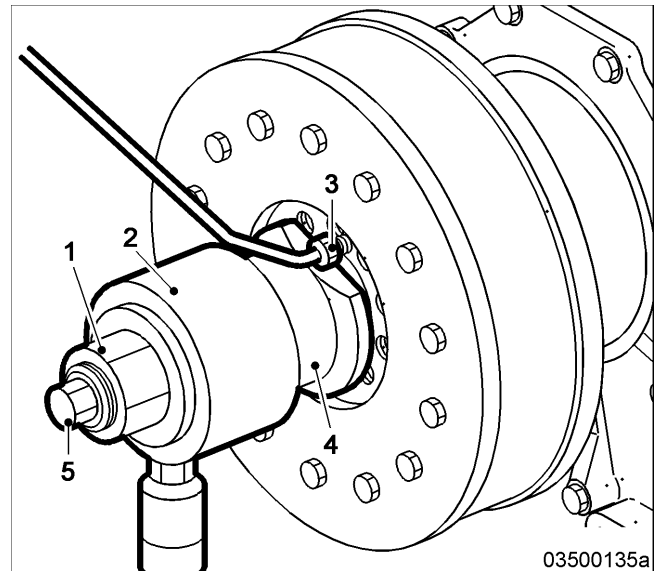
Installing vibration damper

1. Clean and degrease tapers of crankshaft and vibration damper.
2. Coat bearing surface on crankshaft bearing and on vibration damper with oil.
3. Coat sealing lip on shaft seal with petroleum jelly.
4. Push vibration damper on to crankshaft taper.
5. In order to determine push-on distance, use depth gauge to measure distance from crankshaft front end to vibration damper front end.
6. Calculate difference (=push-on distance) between measured dimension and dimension "C" (→ Page 239).
7. If calculated distance is less than push-on distance "a" (→ Page 239), check taper for dimensional accuracy.



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8. Screw feed shaft (5) into crankshaft.
9. Check reference dimension "A" (→ Page 239).
10. Push pressure bush (4) and hydraulic nut (2) over feed shaft and screw on nut (1).
11. Screw HP line on to reducer (3) and screw hand-tight.
12. Connect high-pressure line for hydraulic nut.
13. Set hydraulic nut to initial position with zero stroke.

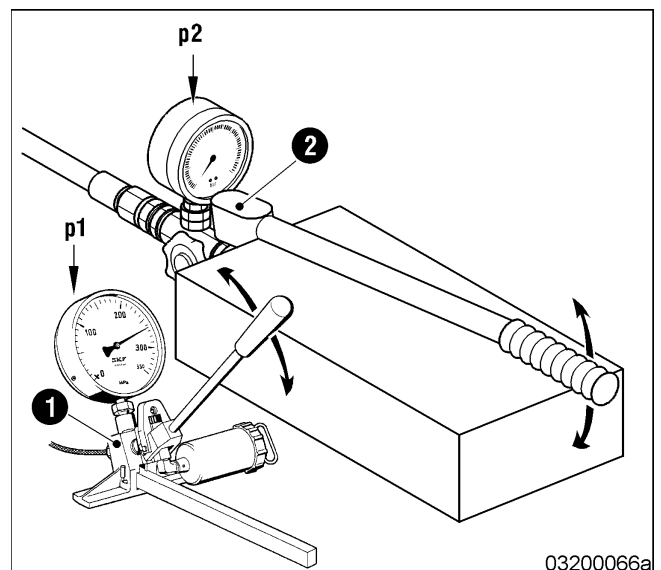


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14. Fill hand pumps (1) and (2) with engine oil SAE 10.
15. Vent hand pump (1) and line system until bubble-free oil emerges.
16. Tighten HP line for reducer.
17. Before fitting, taper fits must be moistened with expansion fluid. To do so, operate hand pump (1) until expansion fluid appears at hub end.
18. Operate hand pump (2) for hydraulic nut and bring into final position using minimal pressure on hub.

Note: Read off expansion pressure P_{\max} at hub.

19. Pump in expansion fluid until expansion pressure (p_1) can no longer be increased (do not exceed expansion pressure P_{\max}), then increase push-on pressure by increasing force-on pressure (p_2).
20. Select force-on pressure such as to achieve positioning in approx. 5 steps.



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21. Decrease expansion pressure by loosening valve screw on hand pump (1).
22. Maintain maximum press-on pressure for 60 minutes, to ensure that the expansion fluid is expelled from the joint and static friction can build up between the fixed components.
23. Unscrew HP lines.
24. Remove nut, hydraulic nut, pressure sleeve and feed shaft after specified holding time.
25. Check force-on dimension "B". Value (→ Page 239)
26. Do not subject press fitting to operating load for at least 8 hours.

Final steps

A distinction must be made as to whether				
1 the engine was completely disassembled				
2 the engine was removed but not disassembled				
3 the engine is installed				
1	2	3	Operations	See
X	–	–	Assemble engine	(→ Page 58)
X	–	–	Install engine	(→ Page 60)
–	–	X	Enable engine start	–

3.3.27 Vibration damper on PTO, free end – Replacement of bearing race

Special tools

Designation / Use	Part No.	Qty.
Puller	F30379133	1
Assembly jig	F6554708	1
Support bracket	T80090974	1

Spare parts

Designation / Use	Part No.	Qty.
Bearing race		

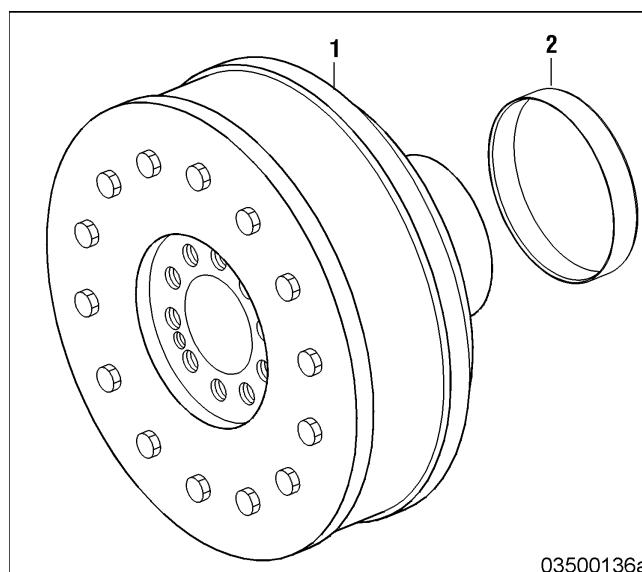


Component is hot.
Risk of burning!
 • Wear protective gloves.

Check vibration damper on PTO, free end (→ Page 246).

Removing bearing race

1. Use puller to remove bearing race (2) from vibration damper (1).
2. Measure outer Ø of vibration damper (1). Values (→ Page 247)

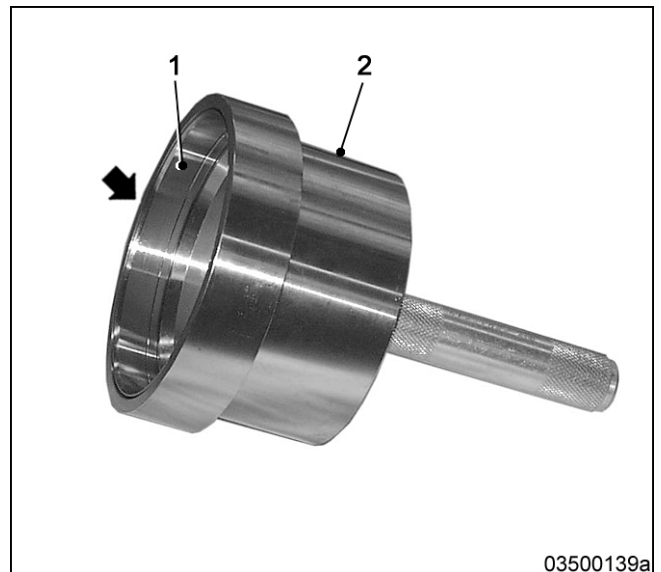


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Installing bearing race

Note: Liner can either be press-fitted or assembled by heating.

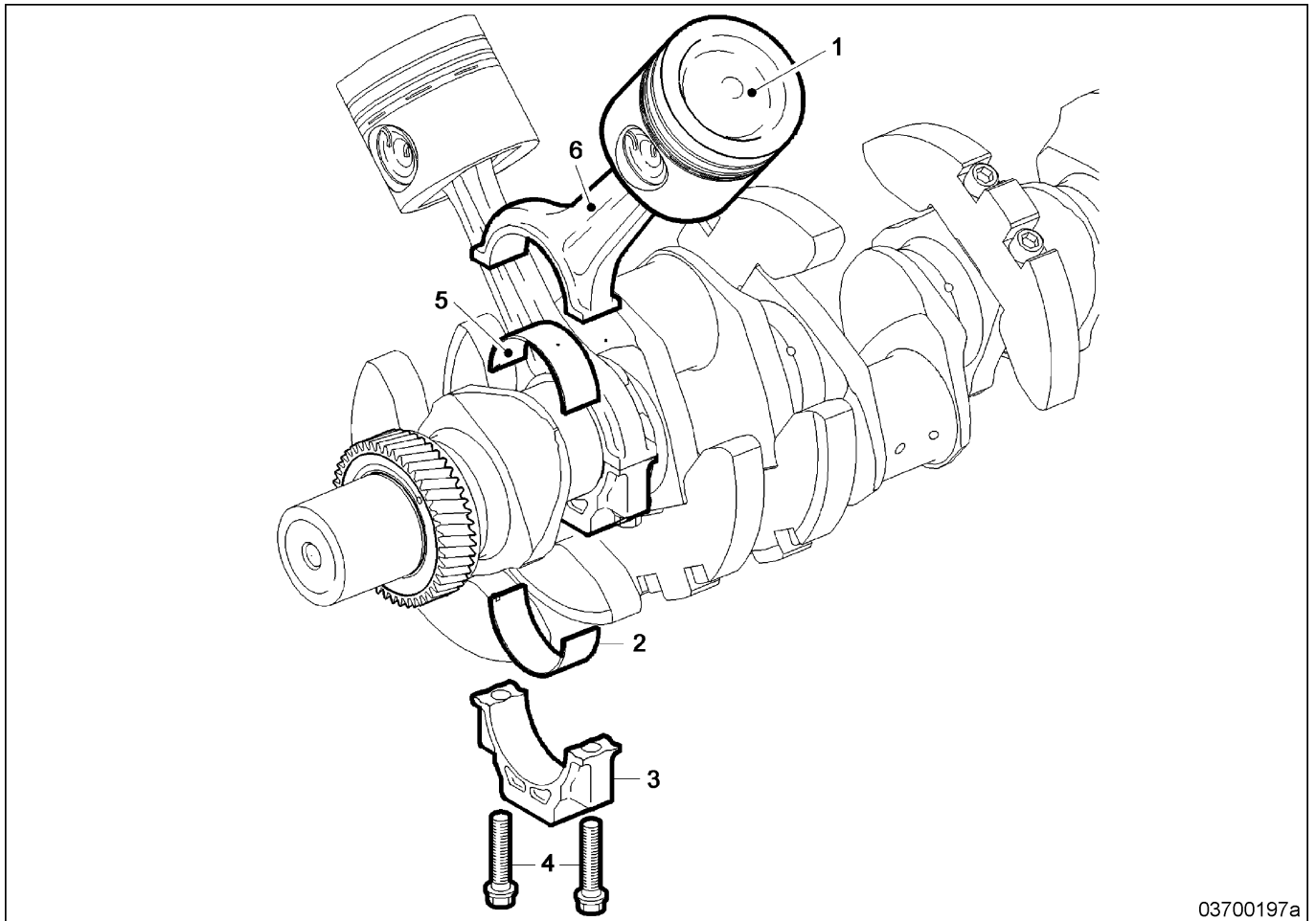
1. Heat liner (1) to $130\text{ }^{\circ}\text{C} +30\text{ }^{\circ}\text{C}$.
2. Insert heated liner in assembly jig (2), with bevel facing upwards (arrow).



3. Use assembly jig to knock bearing race on to vibration damper.
4. Let bearing race cool to room temperature, then remove assembly jig.
5. Check if entire circumference of bearing race is flush.



3.3.28 Piston and conrod – Overview

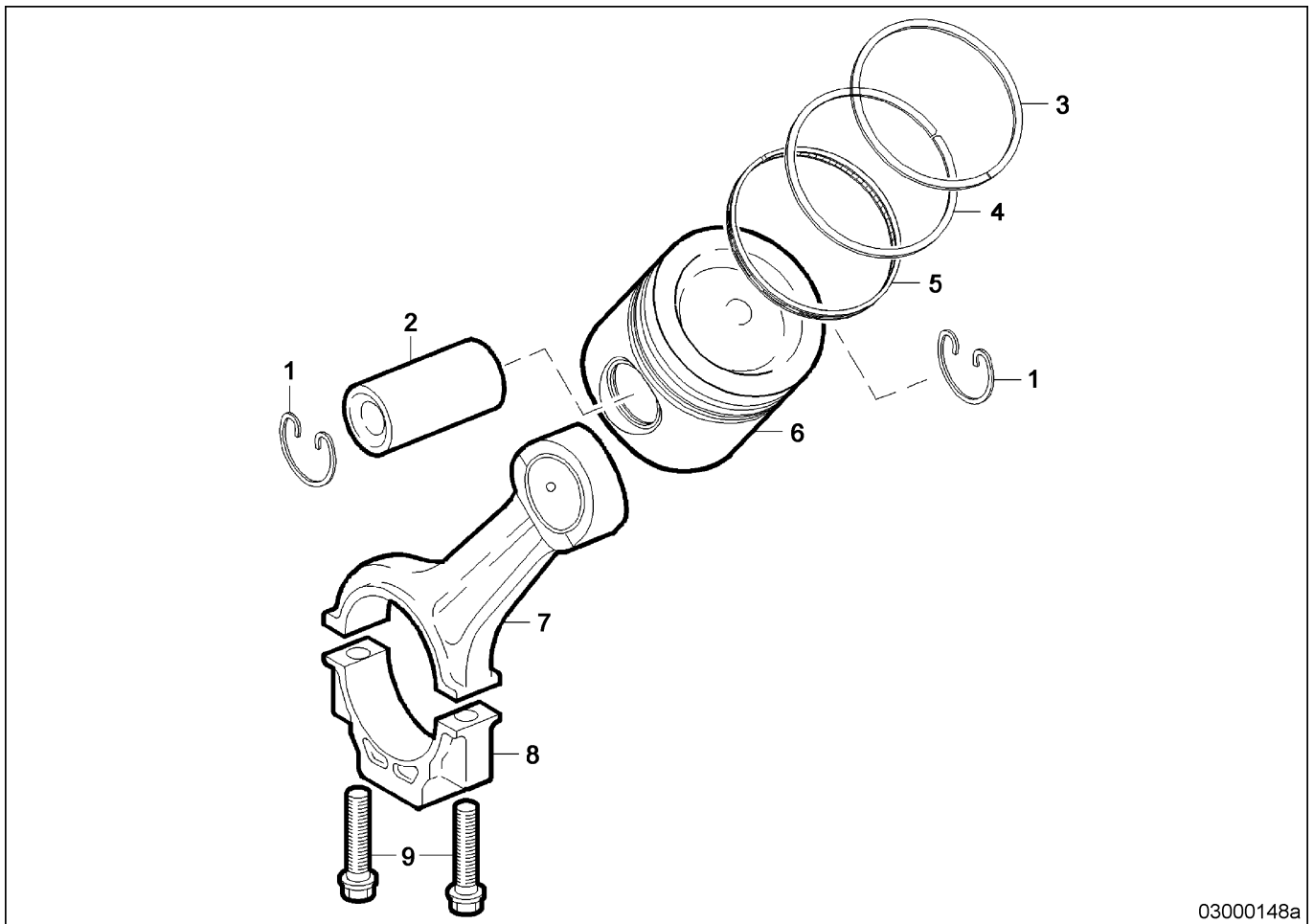


1 Piston
2 Conrod bearing shell, lower

3 Conrod cap
4 Conrod screw

5 Conrod bearing shell, upper
6 Conrod

Overview drawing



- | | | |
|----------------------------------|-------------------------------|----------------|
| 1 Snap ring | 4 Taper-face compression ring | 7 Conrod |
| 2 Piston pin | 5 Oil control ring | 8 Conrod cap |
| 3 Keystone-type compression ring | 6 Piston | 9 Conrod screw |


3.3.29 Piston and conrod – Removal


Preconditions

- Engine is stopped and starting disabled

Special tools

Designation / Use	Part No.	Qty.
Barring device, 12V	F6557971	1
Barring device, 16V	F6558531	1
Lowering device (aluminum oil pan)	F6555180	3
Puller	F6782138	1

 DANGER	Suspended load. Danger to life! <ul style="list-style-type: none"> • Use appropriate lifting devices and appliances. • Never stand beneath a suspended load.
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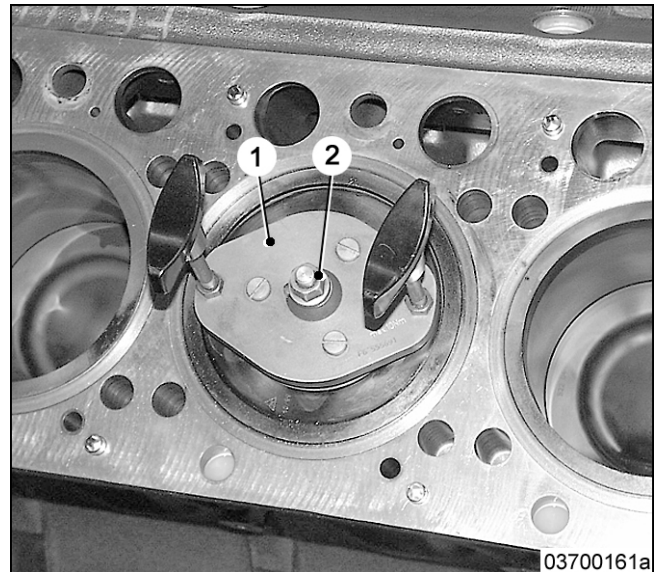
 WARNING	Heavy object. Risk of crushing! <ul style="list-style-type: none"> • Use appropriate lifting devices and appliances.
---	---

Preparatory steps

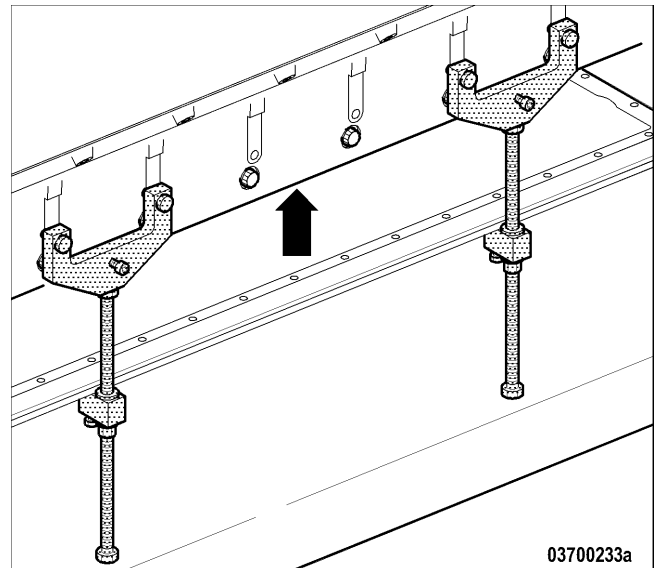
For these steps a distinction must be made as to whether				
1 the engine is to be completely disassembled				
2 the engine is to be removed but not disassembled				
3 the engine is to remain installed				
1	2	3	Operations	See
X	–	–	Remove engine.	(→ Page 55)
X	–	–	Disassemble engine.	(→ Page 56)
–	–	X	Disable engine start.	(→ Page 15)
–	X	X	Drain engine coolant.	(→Operating instructions)
–	X	X	Drain charge-air coolant.	(→Operating instructions)
–	X	X	Drain or draw off engine oil.	(→Operating instructions)
–	X	X	Remove cylinder head.	(→ Page 303)
–	X	X	Lower or remove oil pan.	(→ Page 104)

Removing piston and conrod with oil pan lowered

1. Remove combustion residues from cylinder liner.
2. Install puller (1) in piston.

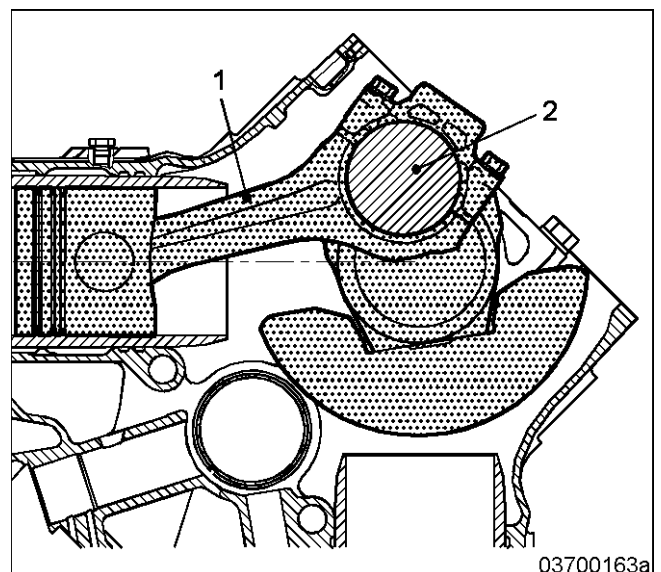


3. Use socket and ratchet to loosen conrod screws from below (arrowed).
4. For further removal, except for altered removal position of crankcase: see "Removing piston and conrod in assembly dolly" in next section.



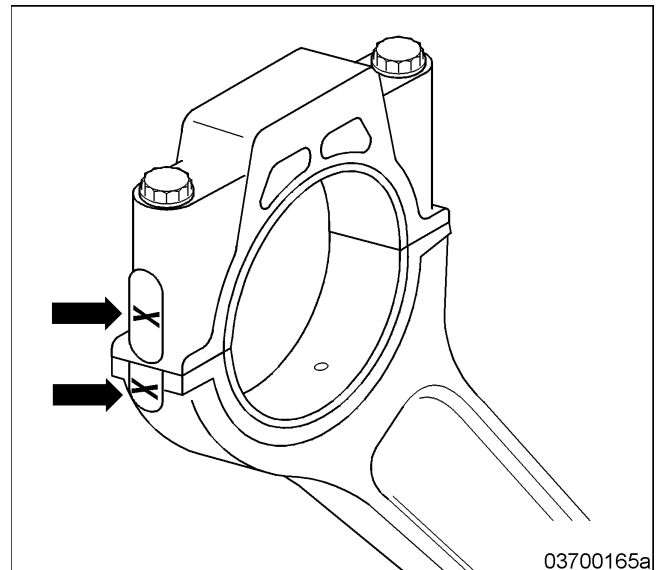
Removing piston and conrod in assembly dolly

1. Turn crankcase in assembly dolly so that the pistons to be removed are in horizontal position.
2. Turn crankpin (2) of piston and conrod (1) to be removed into removal position as shown in the drawing.



Note: Bearing cap and conrod are a single unit and must not be interchanged.

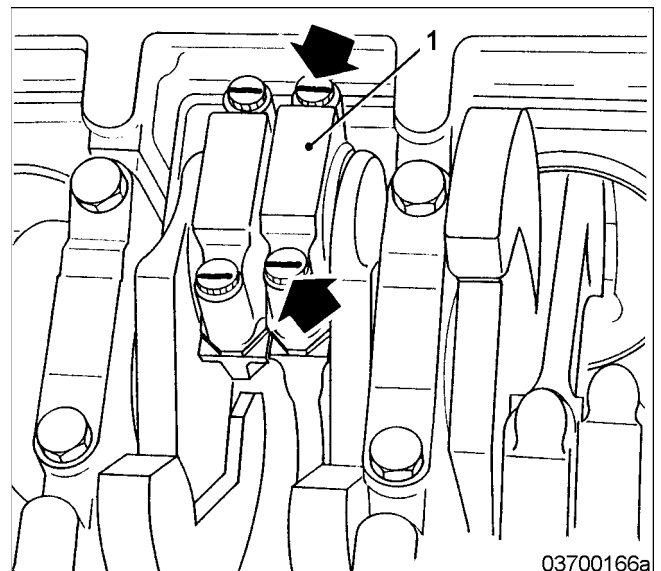
3. Check marking (arrowed) of conrod bearing cap and conrod. If necessary, mark components.



4. Use socket extension and ratchet to loosen conrod screws (arrowed).
5. Remove conrod screws (arrowed) and take off conrod bearing cap (1).
6. Remove bearing shell from conrod bearing cap (1).
7. Protect bearing shell and conrod bearing cap from damage.

Note: Ensure that the oil spray nozzle is not damaged.

8. Pull piston and conrod out of cylinder liner.
9. Remove bearing shell from conrod and protect from damage.
10. Carefully place piston and conrod onto soft surface.
11. Remove puller from piston crown.



3.3.30 Piston and conrod – Disassembly

Special tools

Designation / Use	Part No.	Qty.
Piston-ring pliers	F30378001	1
Snap ring pliers		



Heavy object.

Risk of crushing!

- Use appropriate lifting devices and appliances.



Components have sharp edges.

Risk of injury!

- Wear protective gloves.



Spring/circlip/tensioning roller preload.

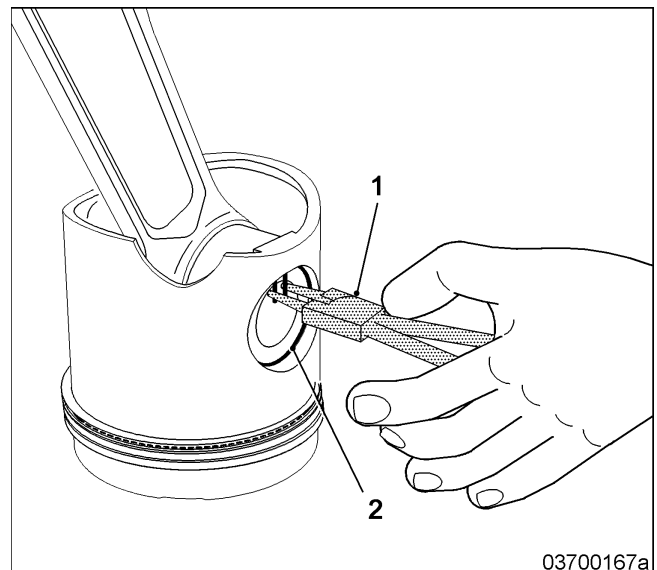
Risk of injury!

- Only use specified tool and equipment.

Remove piston and conrod (→ Page 255).

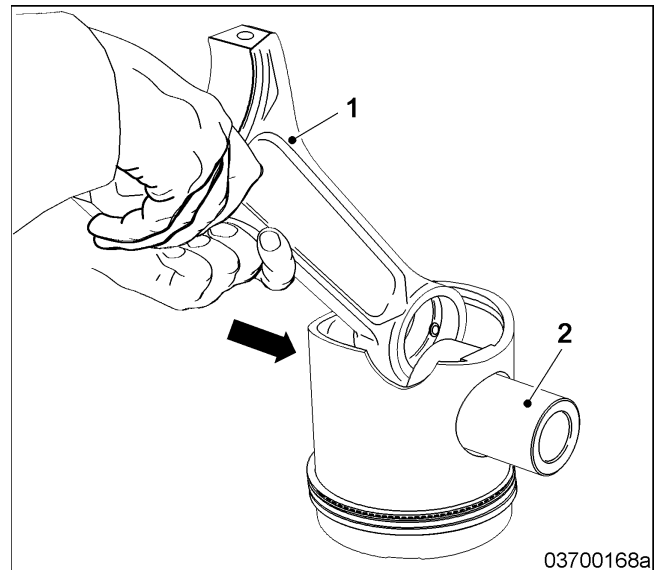
Removing conrod from piston

1. Place piston and conrod on assembly table.
2. Check markings conrod, piston and piston pin. If necessary, re-mark components.
3. Remove snap ring (2) with snap ring pliers (2).



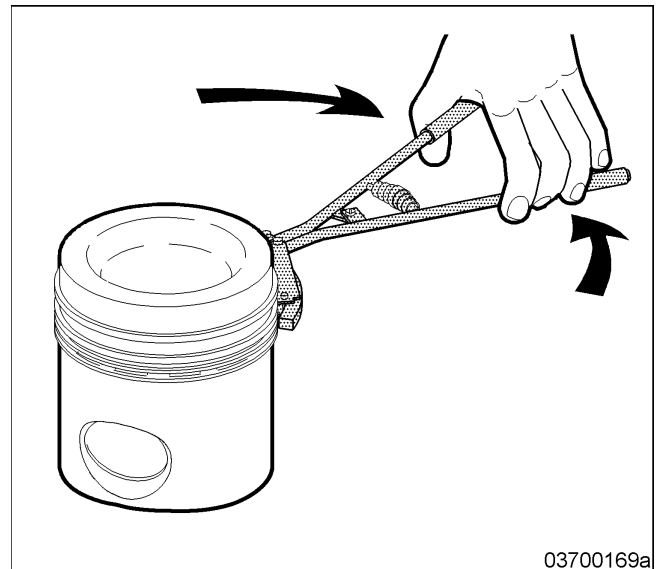
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4. Use round timber to press piston pin (2) out (arrow) while holding conrod (1) firmly.
5. Take conrod out of piston.



Removing piston rings





1. Stretch piston rings only far enough so that they can be taken off piston.
2. Remove piston rings with piston-ring pliers in sequence from top to bottom.



3.3.31 Piston – Cleaning

Special tools

Designation / Use	Part No.	Qty.
Decarbonizer		
Synthetic rotary brush		

 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors.
 WARNING	Heavy object. Risk of crushing! <ul style="list-style-type: none"> • Use appropriate lifting devices and appliances.
 WARNING	Components have sharp edges. Risk of injury! <ul style="list-style-type: none"> • Wear protective gloves.
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask.

Disassemble piston and conrod (→ Page 258).

Piston – Cleaning

Note: The graphite layer on the piston skirt must not be mechanically removed or treated with strong cleaners!

1. Clean all components.
2. Clean area of piston ring grooves with rotating plastic brush.
3. Remove cleaning agent.
4. After cleaning, blow out oil chamber and oil bores with compressed air.

3.3.32 Piston – Check

Special tools

Designation / Use	Part No.	Qty.
Ring gauge	Y4340797	1

Material

Designation / Use	Part No.	Qty.
Surface crack-testing method with fluorescent penetrant dye		
Fluorescent magnetic powder for magnetic crack-testing		

Spare parts

Designation / Use	Part No.	Qty.
Piston		
Piston pin		
Oil control ring		
Taper-face compression ring		
Keystone-type compression ring		



Heavy object.
Risk of crushing!
 • Use appropriate lifting devices and appliances.



Components have sharp edges.
Risk of injury!
 • Wear protective gloves.

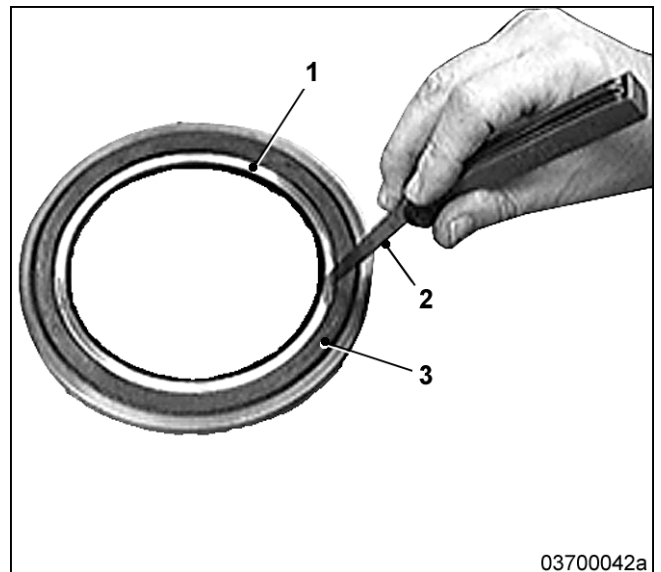
Clean piston (→ Page 260).

Checking piston

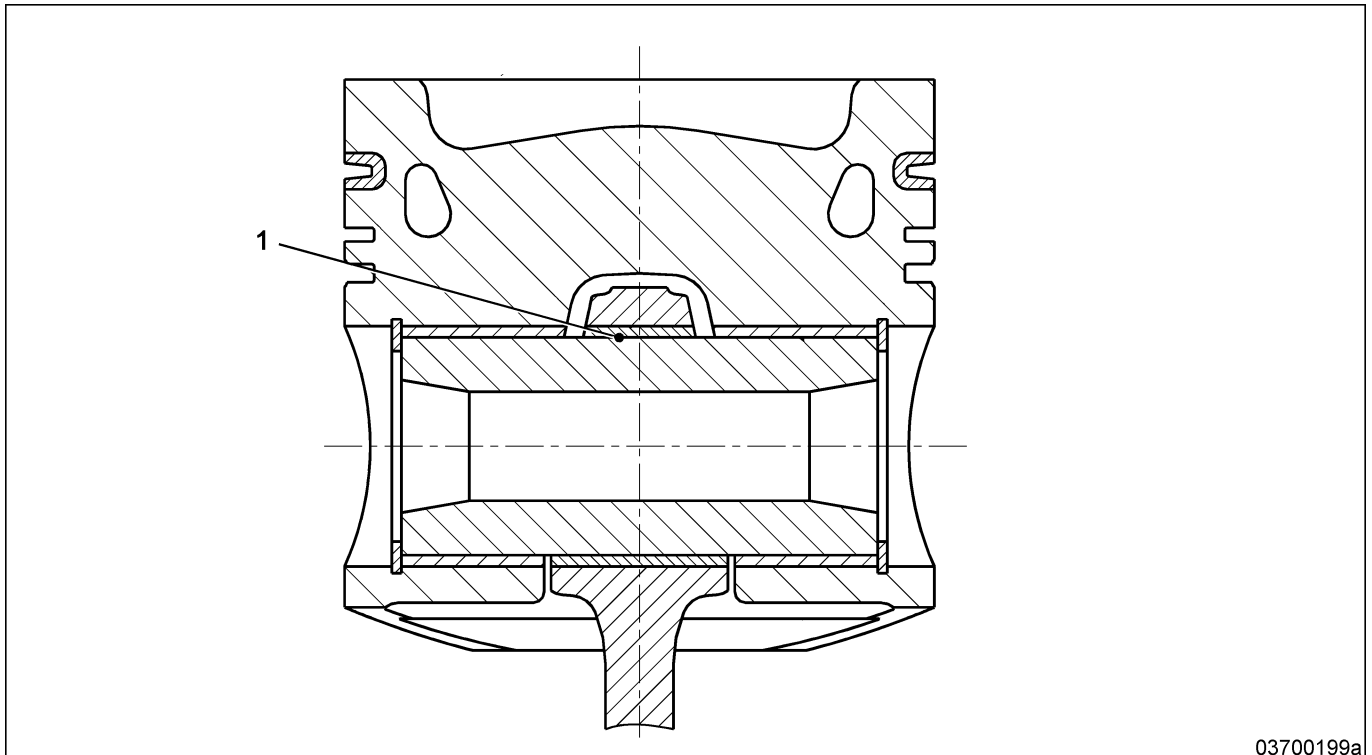
Item	Findings	Task
Ensure oil chamber and oil bores are particularly clean.	Uncleanliness	Clean
Check piston with red penetrant dye for cracks.	Signs of cracks	Replace piston.
Check piston for wear.	<ul style="list-style-type: none"> • Contact erosion at piston edge and valve clearance pockets • Large-area wear on piston skirt (appears matt) • Concentrated occurrence of scoring • Pitting 	Replace piston.
Measure piston pin boss. Values (→ Page 264)	Values exceeded	Replace piston.
Check sliding surface of bronze bush for wear and scoring.	<ul style="list-style-type: none"> • Wear • Scores visible 	Replace piston.
Check groove width with final measurements. If no final dimension is available, alternatively a new piston ring can be inserted in the groove and the axial clearance checked with a feeler gauge. Values (→ Page 264)	Values exceeded	Replace piston.
Using the magnetic crack-testing method, check piston pin for cracks.	Signs of cracks	Replace piston pin.
Check condition of piston.	<ul style="list-style-type: none"> • Wear • Scores • Impact points visible 	Replace piston pin.
Use outside micrometer to measure piston pin outer diameter. Values (→ Page 264)	Values exceeded	Replace piston pin.
Inspect piston rings.	<ul style="list-style-type: none"> • Piston ring with burring, chipping or sharp edges • if scores, cracks or burn marks are visible on chrome layer. 	Replace

Checking piston rings

1. Place piston ring (1) in ring gauge (3) to measure piston ring end clearance. Observe even fitting of piston ring in ring gauge (3).
2. Check ring end clearance with feeler gauge (2). Values (→ Page 264).
3. Values exceeded: Replace piston rings Replace piston rings only in sets.
4. After installing new piston rings, replace cylinder liners. (→ Page 92).

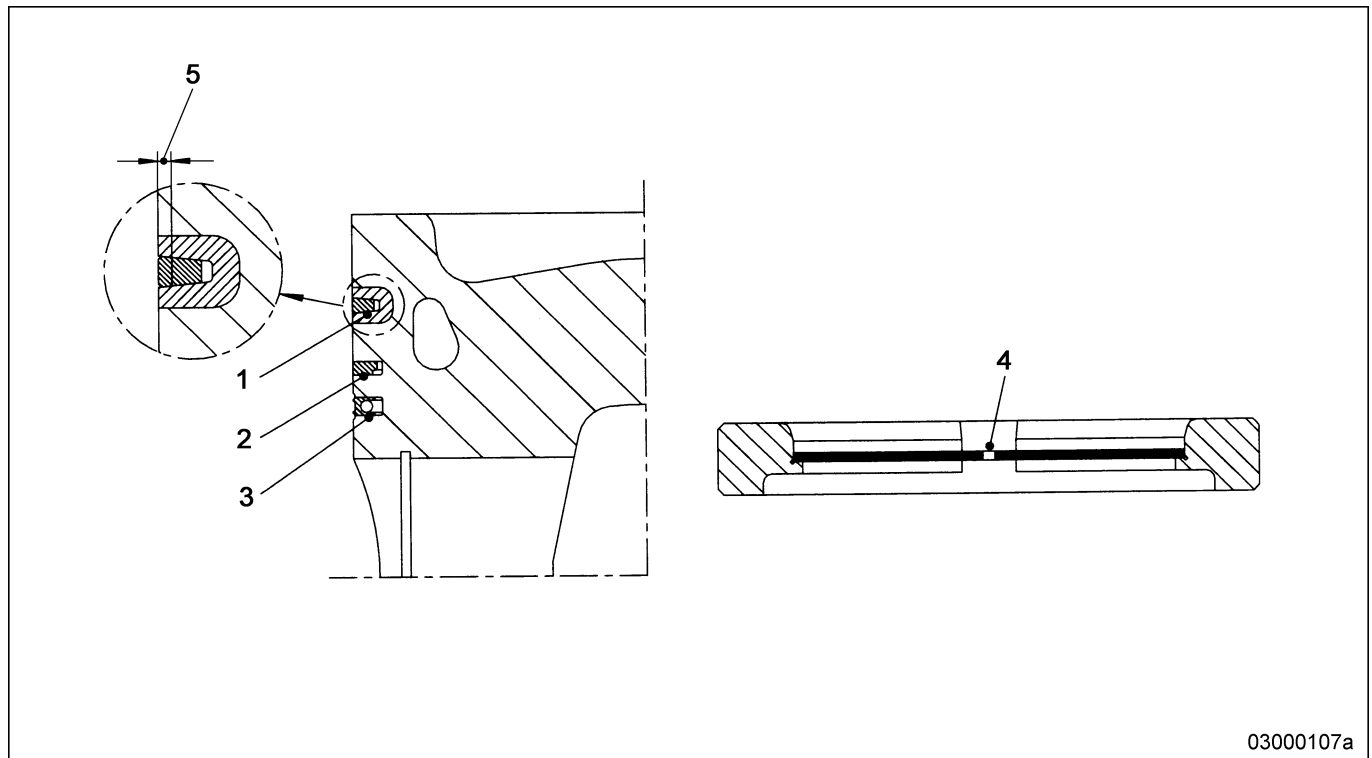


3.3.33 Piston – Tolerances



No.	Designation	Stage	Tol. size Basic size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
1	Piston bore		52.000	+0.010	+0.018	0.012	0.026			
	Piston pin OD		52.000	-0.008	-0.002					

Piston rings

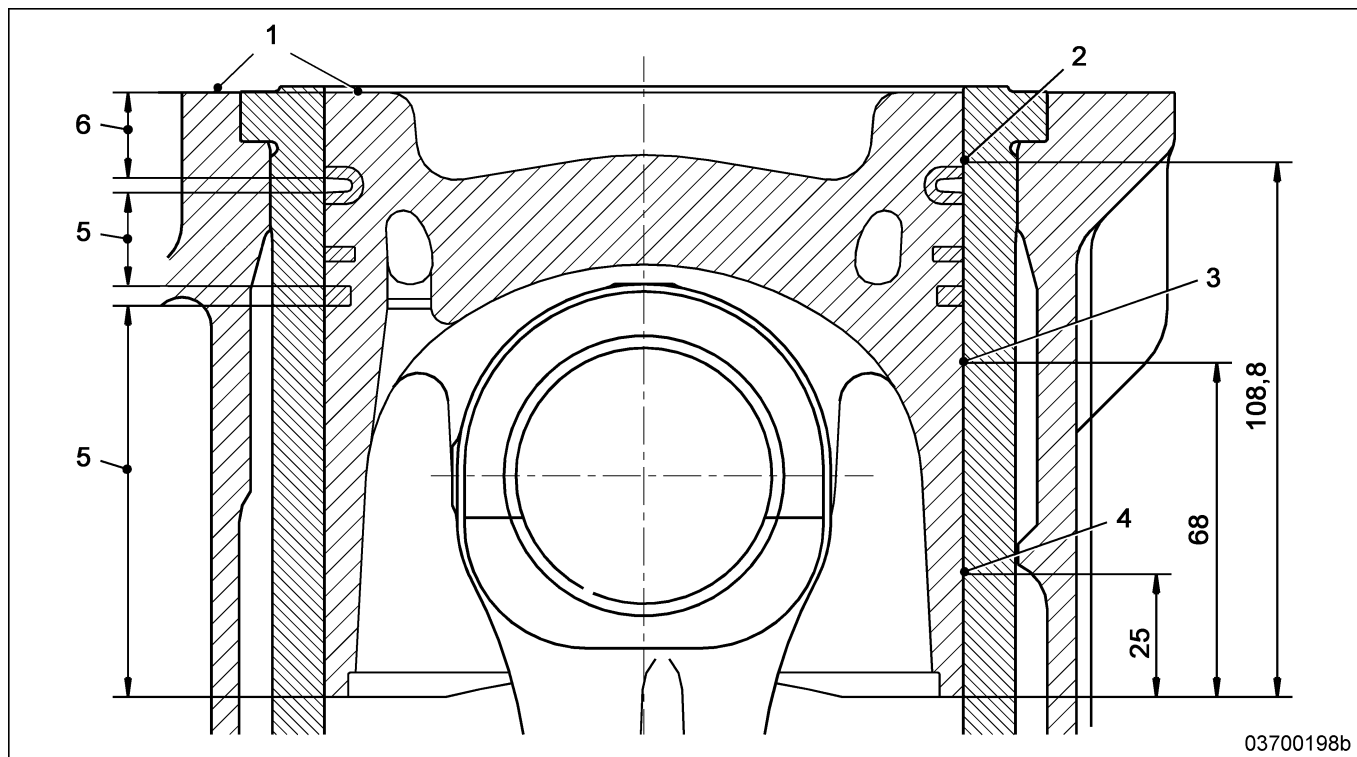


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No.	Designation	Stage	Tol. size Basic size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
1	Groove width		2.960	-0.015	+0.015	0.107	0.161			
	Keystone-type compression ring		2.838	-0.024	0					
2	Groove width		3.000	+0.060	+0.080	0.060	0.110			
	Taper-face compression ring		3.000	-0.030	0					
3	Groove width		4.000	+0.030	+0.050	0.030	0.080			
	Bevelled-edge oil control ring		4.000	-0.030	0					

No.	Designation	Stage	Tol. size Basic size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
4	Piston ring gap									
	Keystone-type compression ring					0.460	0.710			
	Taper-face compression ring					0.800	1.050			
	Bevelled-edge oil control ring					0.300	0.450			
Measure piston ring gap in ring gauge 130.000 H ⁶ .										
5	Measure groove width/keystone-type compression ring width in 1.500 mm recess.									

Piston clearance in cylinder liner





No.	Designation	Stage	Tol. size Basic size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
1	Piston protrusion		0.290 to 0.770							
2	Liner Ø		130.000	-0.010	+0.010	0.476	0.520			
	Piston skirt Ø		129.502	-0.012	+0.012					
3	Liner Ø		130.000	-0.010	+0.010	0.230	0.266			
	Piston skirt Ø		129.752	-0.008	+0.008					
4	Liner Ø		130.000	-0.010	+0.010	0.141	0.175			
	Piston crown Ø		129.824	-0.007	+0.007					
Measure dimensions 2 to 4 at a right angle to the piston pin axis.										
5	Convex/oval piston skirt									
6	Cylindrical piston skirt									

Note

Re. 1 Measure protrusion between piston crown and cylinder crankcase surface with the cylinder head gasket removed.
To avoid lateral piston movement, measurement must be carried out in the direction of the piston pin.

3.3.34 Conrod – Cleaning

Material

Designation / Use	Part No.	Qty.
Cleaning agent		
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors. 	
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask. 	

Disassemble conrod (→ Page 258).

Conrod – Cleaning

1. Clean conrod and conrod screws with cleaning agent.
2. Remove cleaning agent.
3. Blow out conrod and conrod screws with compressed air.
4. Clean meshing on separating plates of conrod and conrod bearing cap with brass brush and blow dry with compressed air.
5. Clean conrod oil bore with hole brush and blow out with compressed air.

3.3.35 Conrod – Check

Special tools

Designation / Use	Part No.	Qty.
Testing device	Y4341492	1
Test mandrel	Y4341915	1
Test mandrel	Y4341916	1
Bore gauge		
Dial gauge		

Material

Designation / Use	Part No.	Qty.
Fluorescent dye for magnetic crack testing		

Spare parts

Designation / Use	Part No.	Qty.
Conrod		
Conrod screw		
Conrod bush		

Clean conrod (→ Page 268).

Checking conrod

Item	Findings	Task
Check conrod main bore for blue discoloration.	Blue discoloration	Replace conrod.
Check conrod bush for scoring, dirt, wear and overheating.	Damaged	<ul style="list-style-type: none"> • Recondition • Replace conrod bush.
Check conrod, conrod bearing cap and conrod bearing screws for cracks using magnetic crack testing procedure.	Cracks apparent	Replace
Check threads of conrod and conrod bearing screw for damage.	Damaged	<ul style="list-style-type: none"> • Replace conrod. • Replace conrod screw.
Check conrod screw length. Values (→ Page 275)	Value exceeded	Replace
Check conrod bearing cap mating face for conrod screws for traces of wear and scoring.	<ul style="list-style-type: none"> • Traces of wear • Scores visible 	Replace
Check main bore for traces of wear and scoring.	<ul style="list-style-type: none"> • Traces of wear • Scores visible 	<ul style="list-style-type: none"> • Recondition • Replace
Check tothing for damage and check contact pattern using dye.	Damaged	Replace

Measuring conrod main bore without bearing shells

1. Assemble conrod (→ Page 281).
2. Adjust bore gauge and measure conrod main bore. Values (→ Page 275).
3. If values are exceeded, replace conrod.

Measuring conrod main bore with bearing shells

1. Assemble conrod (→ Page 281).
2. Coat bearing shell sliding surfaces with engine oil.
3. Measure conrod bearing bore. Values (→ Page 275).
4. Record measured values in data sheet.
5. Replace bearing shells if limit values are not reached or exceeded.
6. Remove conrod screws, conrod cap and bearing shells.
7. Protect bearing shells from damage.

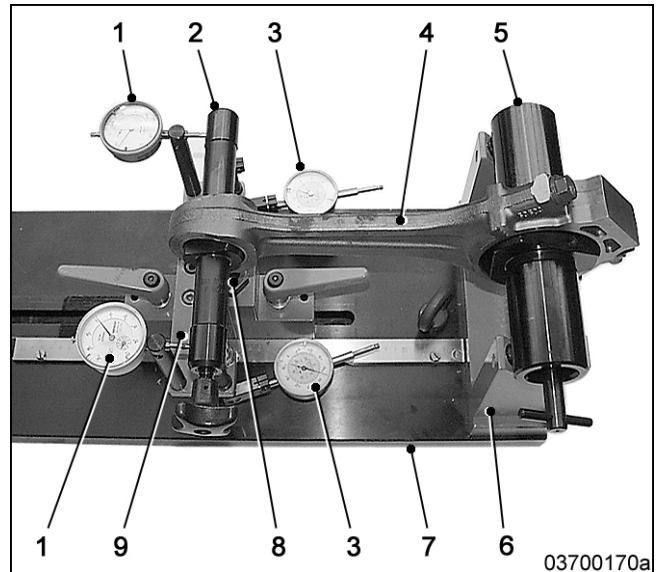
Measuring conrod bore and conrod bush of small conrod eye

1. Adjust bore gauge to zero dimension of conrod bush bore and measure conrod bush bore. Values (→ Page 275).
2. Replace conrod bush if values are exceeded (→ Page 279)
3. After removing the conrod bush, measure main bore in conrod with bore gauge. Values (→ Page 275)
4. If values are exceeded: Replace conrod.

Checking conrod bush for axial seating

1. Check conrod bush with hydraulic press for secure axial fit. Required test force (→ Page 275).
2. If test force is not reached, replace conrod.

Checking conrod bore axial parallelism and twist



Test device layout

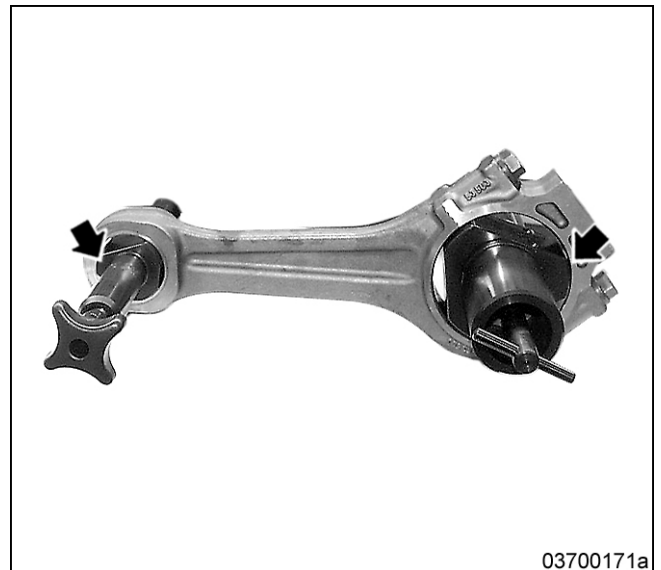
- 1 Dial gauge for axial parallelism
- 2 Test mandrel, small conrod bore
- 3 Dial gauge for conrod twist
- 4 Conrod
- 5 Test mandrel, large conrod bore
- 6 Prism
- 7 Base plate
- 8 Resilient stop
- 9 Adjustable dial gauge holder

Note: For checking axial parallelism and twist of conrod bores, the conrod cap is installed and conrod screws are only inserted (10 to 20 Nm).

1. Clean large and small conrod bores.
2. Pay attention to installation position as shown in illustration.

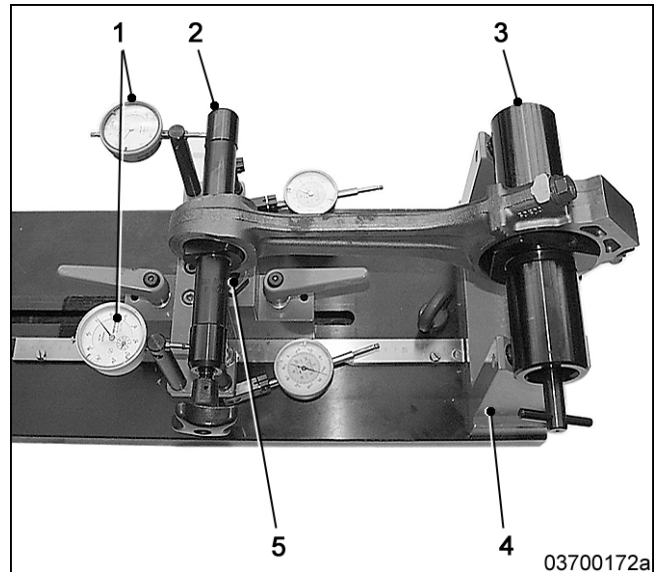
Note: Insert test mandrels in such a way that the clamp pins (arrowed) of the test mandrels face outward and lie in one plane.

3. Tighten test mandrels lightly with locking screw. In doing so, do not twist test mandrel.



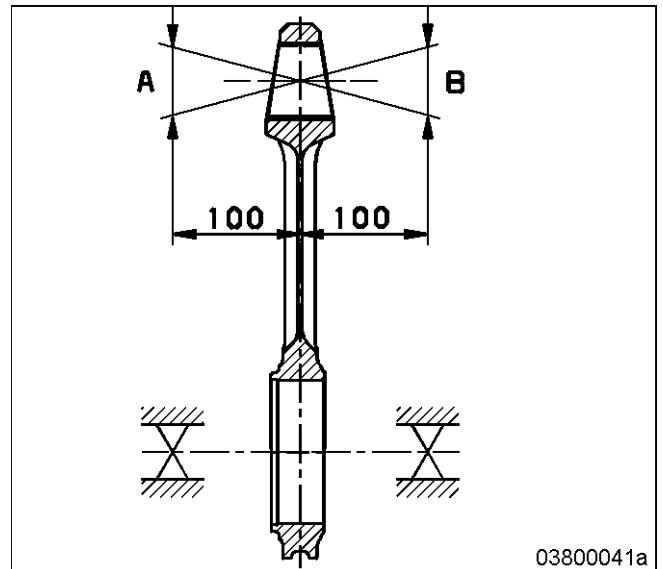
Checking axial parallelism

1. Insert conrod with test mandrel (3) into prisms (4) of testing device.
2. Place with the small test eye onto resilient stop (5).
3. Adjust fixed support on resilient stop so that the axis of the test mandrel (2) lies approx. 2 mm under the tracer pin of the dial gauges (1).
4. With a pretension of approx. 2 mm at the highest point of the test mandrel axis, zero measuring gauges.
5. Turn conrod through 180° and carefully position in testing device.
6. Move the test mandrel over the sensing devices of the dial gauges at the highest point of the test mandrel axis.
7. Determine and note deviations from zero position on the dial gauges.



Calculating axial parallelism

1. The testing device is set for measuring axial parallelism at 200 mm intervals.
2. To obtain the correct value at a distance of 100 mm (→ Page 275) calculate value read from gauges as per following example.



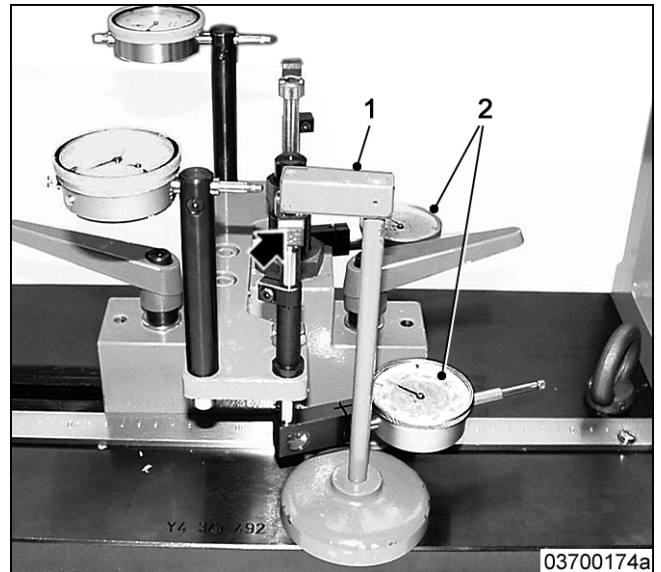
Description	Value
Left dial gauge	A = -0.05 mm
Right dial gauge	B = +0.03 mm
Result	= 0.08 mm

Result: Axle parallelism: $0.08 \text{ mm} : 4 = 0.02 \text{ mm}$

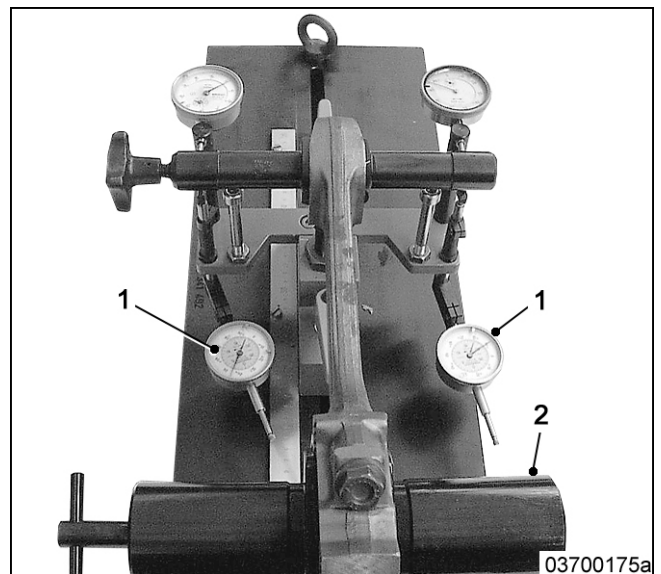
3. Compare calculated value with (→ Page 275)
4. If the limit value is exceeded, replace conrod.

Checking axial twist

1. Set both dial gauges (2) for axial twist with setting gauge (1) above dial gauge anvil (arrowed) to zero.
2. Remove adjusting gauge from test device.

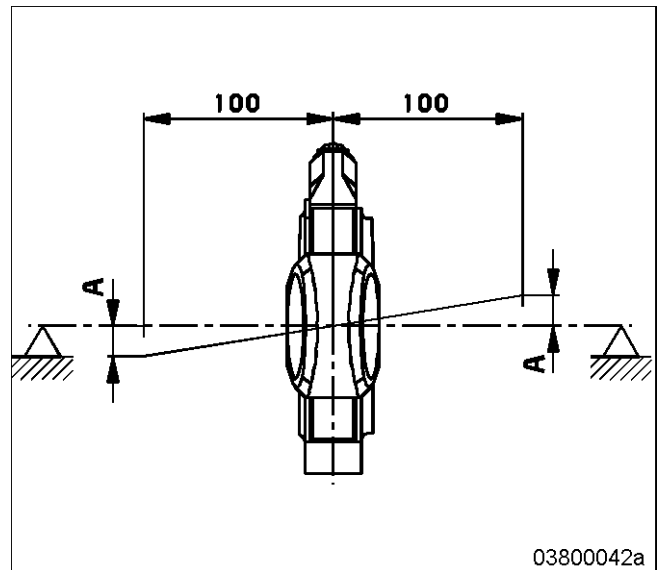


3. Insert conrod with test mandrel (2) into prisms of testing device.
4. Set fixed rest of the spring stop so that the travel of the measuring gauge probes is approx. 2 mm.
5. Push conrod onto fixed rest at small conrod eye.
6. Read and record values on dial gauges (1).



Measuring axial twist at conrod

1. In order to determine the axial twist of the conrod bore, calculate the value measured at a distance of 100 mm as shown in the following example.



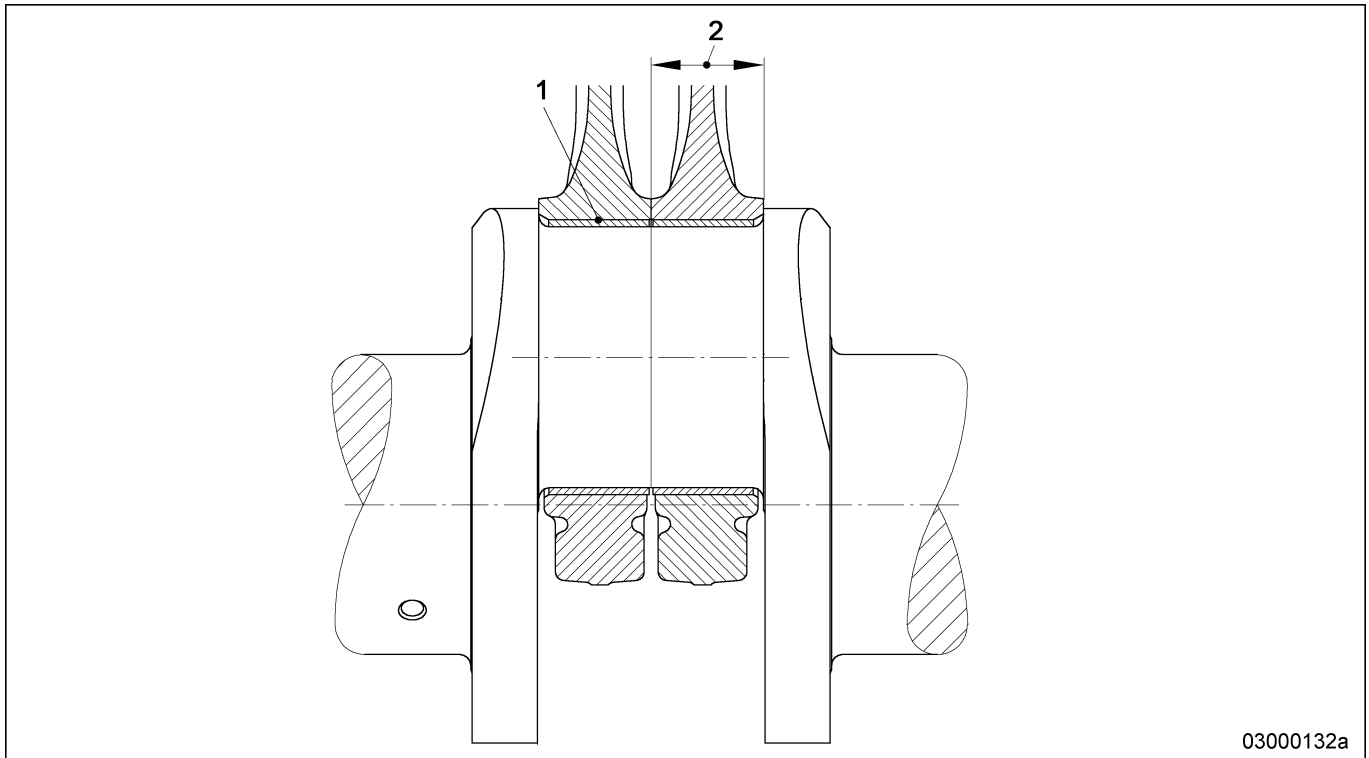
Description	Value
Left dial gauge	A = -0.06 mm
Right dial gauge	B = +0.04 mm
Result	= 0.10 mm

Result: Axial twist A: $0.10 \text{ mm} / 2 = 0.05 \text{ mm}$

2. Specified values (→ Page 275).
3. If the limit value is exceeded, replace conrod.

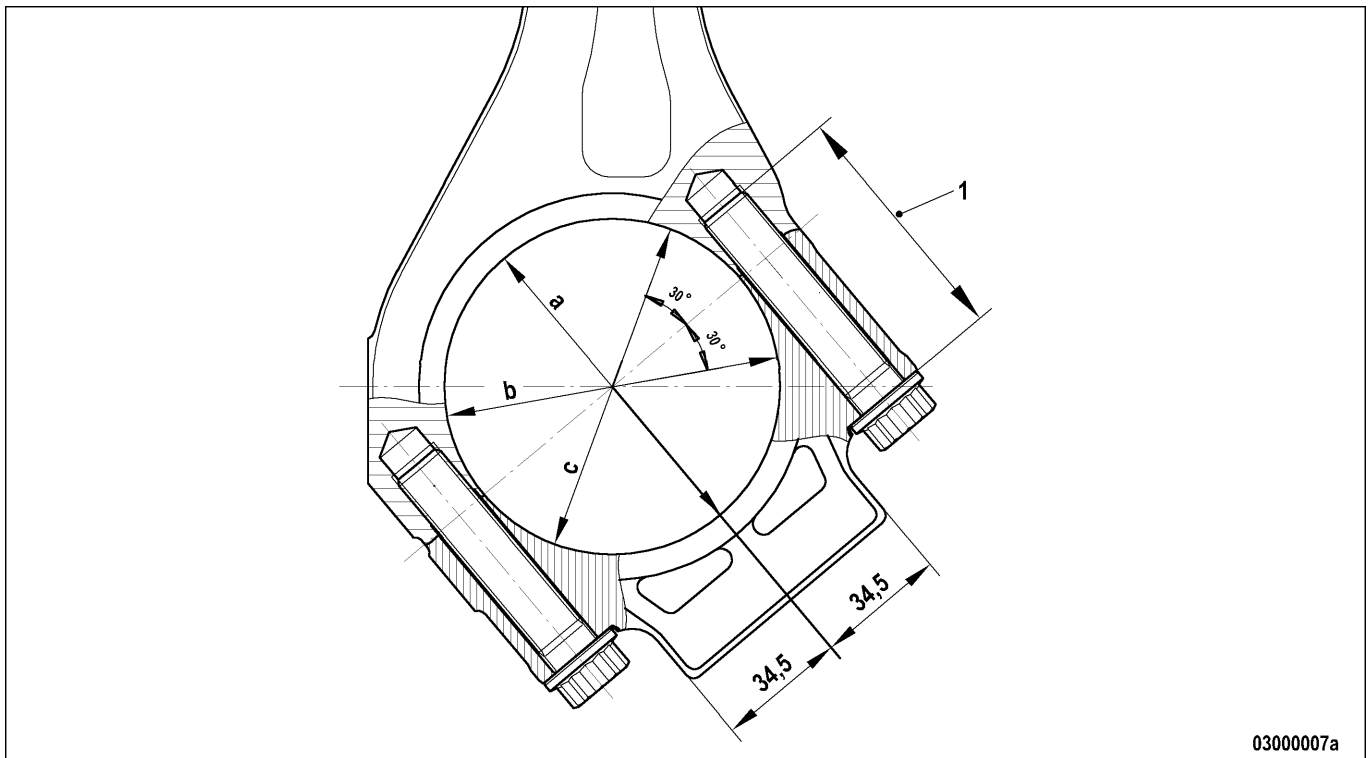
3.3.36 Conrod – Tolerances

CONROD BEARINGS



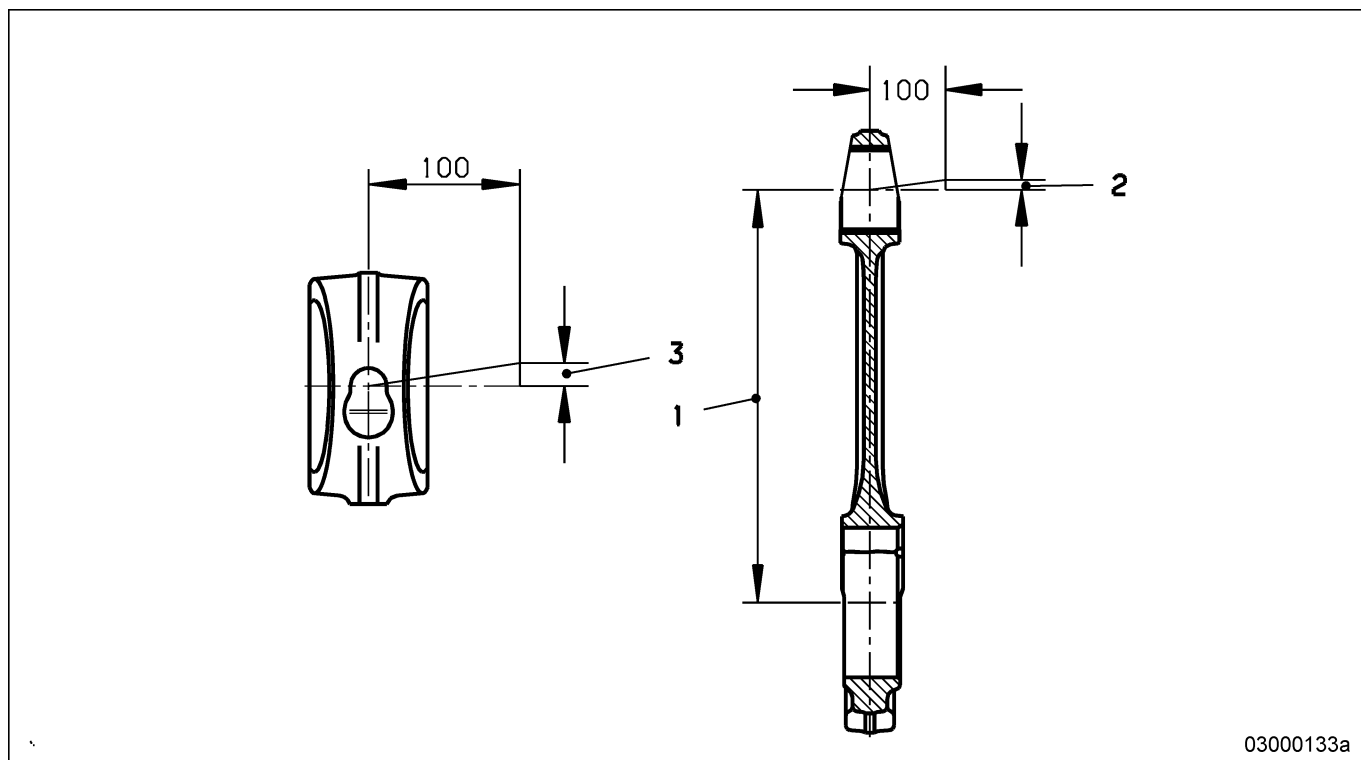
No.	Designation	Stage	Tol. size Basic size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
1	Conrod bore		99.000 H6	0	+0.022					
2	Conrod width		40.500	-0.190	-0.120					

Conrod screw length, plane of measurement



No.	Designation	Stage	Tol. size Basic size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
1	Screw length removed		67.500	-0.300	0					68.500
Re-installation with bearing shells. Measurement in direction a/b/c. Smallest dimension must be in direction a.										

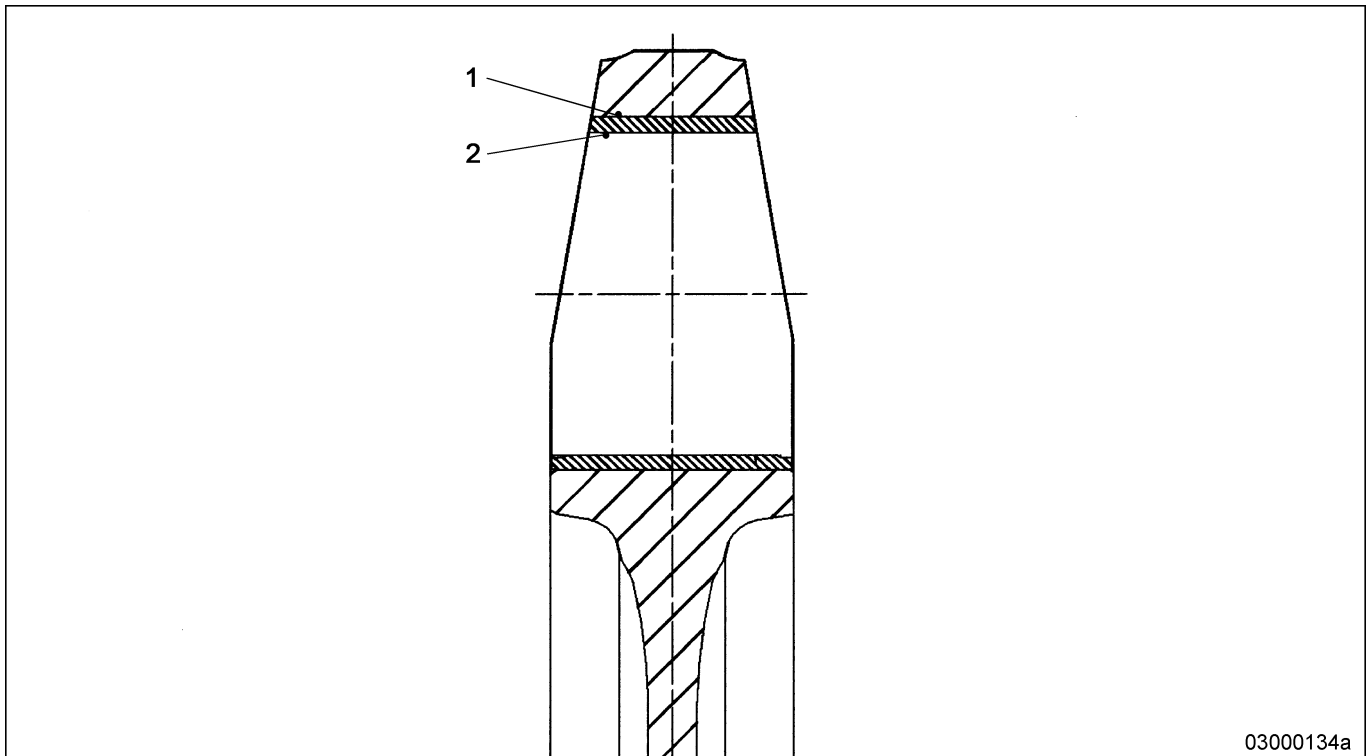
CONROD BORE PARALLELISM



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No.	Designation	Stage	Tol. size Basic size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
1	Conrod length - with bush and without bearing shell		273.000	-0.020	+0.020					
	Conrod length - without bush and without bearing shell		273.000	-0.050	+0.050					
2	Parallelism of axial inclination	0.050 measured over a distance of 100 mm								
3	Parallelism of axial twist	0.100 measured over a distance of 100 mm								
Conrod weight without bearing shells			3930 g	-30 g	+30 g					

CONROD BORE



No.	Designation	Stage	Tol. size Basic size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
1	Conrod bore		57.000 H6	0	+0.019			0.061	0.100	
	Conrod bush OD		57.080	0	+0.020					
Press-in force min. 10000 N max. 30000 N										
2	Conrod bush ID - final machining		52.060	-0.005	+0.005					

3.3.37 Conrod – Repair

Special tools

Designation / Use	Part No.	Qty.
Assembly jig hydraulic press	F6780557	1
Press-in device	F6781639	1
Retainer small boss	F6347932	1
Fit small boss	F6376294	1
Retainer large boss	F6554737	1
Shrinking tool	F30377859	1

Material

Designation / Use	Part No.	Qty.
Liquid nitrogen		

Spare parts

Designation / Use	Part No.	Qty.
Conrod bushing		



Nitrogen is liquid (at -200°C).

Risk of freezing and suffocation!

- Do not allow liquid nitrogen to come into contact with parts of body (eyes, hands).
- Wear protective clothing, gloves, and goggles / safety mask.
- Ventilate working area well.



Contamination of components.

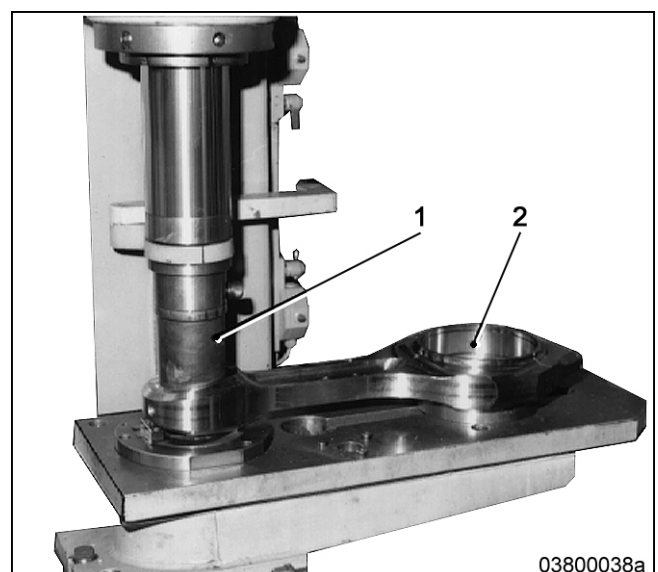
Damage to component!

- Observe manufacturer's instructions.
- Check components for special cleanness.

Check conrod (→ Page 269).

Ejecting conrod bushing

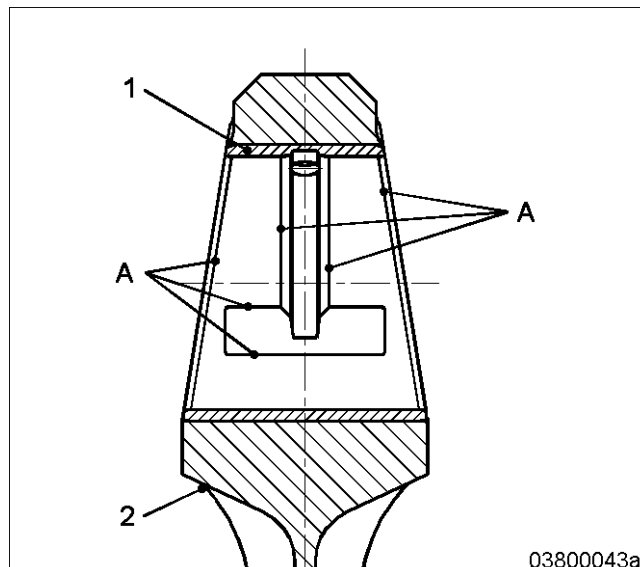
1. Use ejection mandrel (1) and hydraulic press to remove conrod bushing from conrod (2).
2. Measure conrod bore (→ Page 275).



Inserting conrod bushing

Note: Observe matching of lube oil bores.

1. Chill new conrod bushing (1) in liquid nitrogen and use shrinking tool without pressure to insert in correct position in conrod bore (2).
2. Check if conrod bushing is securely positioned. Values (→ Page 275)
3. Use fine boring machine to work conrod bushing to finished dimension.
4. Deburr edges (A) after twisting out.
5. Round outer edges of conrod bushing (1) after twisting out.



3.3.38 Conrod – Assembly

Special tools

Designation / Use	Part No.	Qty.
Torque wrench		
Assembly jig	F6557995	1



WARNING

Compressed air.

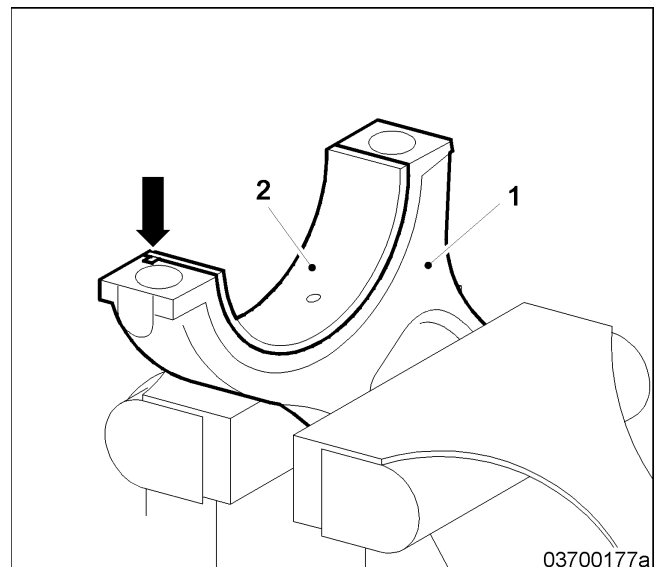
Risk of injury!

- Do not direct compressed-air jet at persons.
- Wear protective goggles / safety mask and ear protectors.

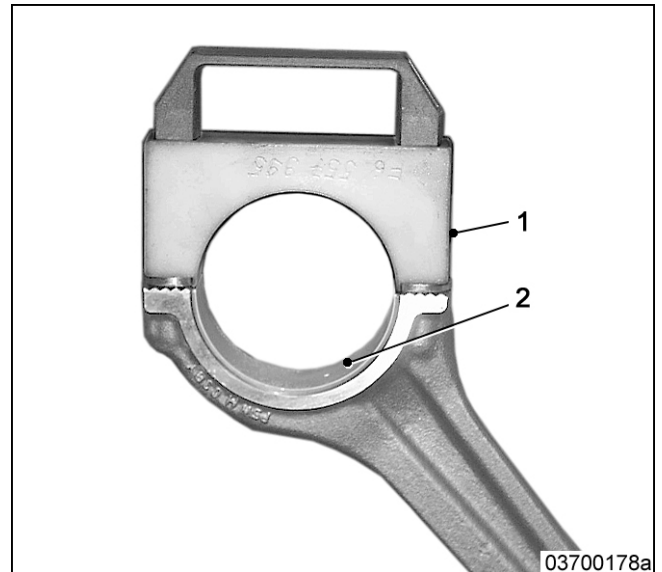
Check conrod (→ Page 269).

Preparing conrod

1. Blow off separation planes (arrows) on conrod and conrod bearing cap with compressed air and clean.
2. Wipe bearing shell contact surfaces on conrod and conrod bearing cap with chamois leather.
3. Before installing bearing shells, compare repair stage entries on conrod and on crankshaft data sheet.
4. Clamp conrod with separation planes in horizontal position in conrod assembly dolly or in bench vise with aluminum jaws.
5. Insert upper conrod bearing (2) in conrod (1).



6. Use assembly jig (1) to align conrod bearing shell (2).

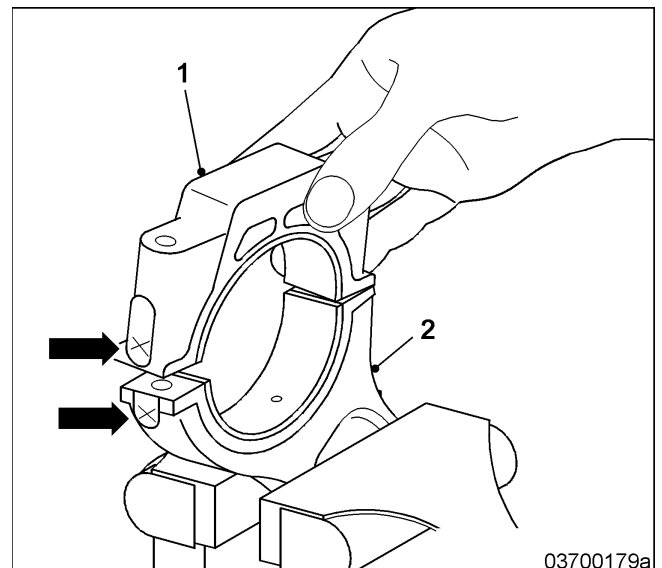


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7. Press conrod bearing cap carefully by hand on to conrod.
 8. Coat threads and mating faces of conrod bearing screws with engine oil.

Note: Threads must not be recut.

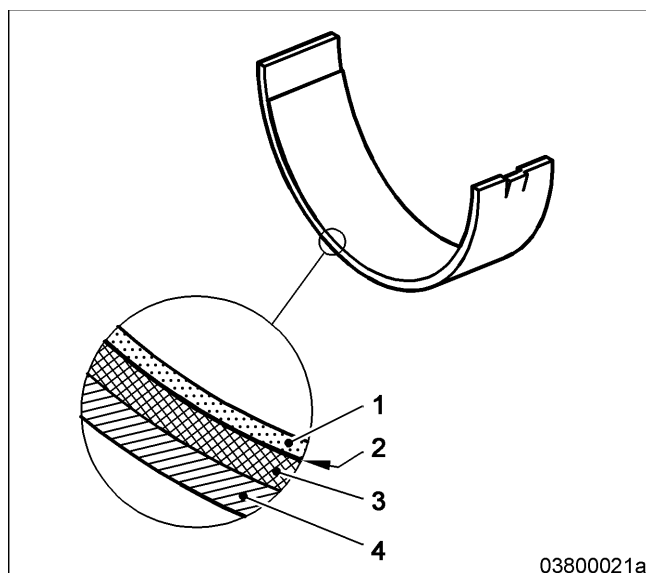
9. Screw conrod bearing screw in bore on conrod bearing cap by hand three full circles without tool.
 10. Twist on conrod bearing screws until screw head touches, and use socket wrench to tighten by hand. Make sure that conrod parting groove is closed on short and on long conrod arm.
 11. Tighten conrod bearing screws with torque wrench to prescribed tightening torque (→ Page 23).



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3.3.39 Conrod bearing shells – Check

Item	Findings	Task
Check conrod bearing shells for wear, scoring, corrosion, erosion and damage.	Wear, scores, corrosion, erosion or damage visible	Replace
Check conrod bearing shell butt and bearing rear side for damage and fretting corrosion .	Fretting corrosion visible	Replace and determine cause. Possible causes: <ul style="list-style-type: none"> • Insufficient screw pretension • Assembly error • Spread dimension of bearing shell out of tolerance • Faulty bearing support bore
Measure spread dimension (→ Page 195).	Value exceeded	Replace bearing shell.



- 1 Slide layer
- 2 Barrier layer
- 3 Intermediate layer
- 4 Steel support shell

Assessment

An important indicator for assessing the extent of wear on the bearing shell is the shape and extent of the blocking layer areas exposed.

Use of bearing shell is already restricted in friction area once the sliding layer is reduced to 70%!

It is often difficult to differentiate between the nickel barrier and softer slide layer.

If in doubt, consult a bearing specialist.

Damage to bearing

Damage to bearings occurs mainly through impressions and embedding, cavitation and corrosion, pitting, fatigue and installation faults.

Bearings showing such damage must be replaced.

3.3.40 Piston – Assembly

Special tools

Designation / Use	Part No.	Qty.
Piston-ring pliers	F30378001	1
Snap ring pliers		

Material

Designation / Use	Part No.	Qty.
Engine oil		

Spare parts

Designation / Use	Part No.	Qty.
Snap ring		



WARNING

Heavy object.

Risk of crushing!

- Use appropriate lifting devices and appliances.



WARNING

Components have sharp edges.

Risk of injury!

- Wear protective gloves.



CAUTION

Contamination of components.

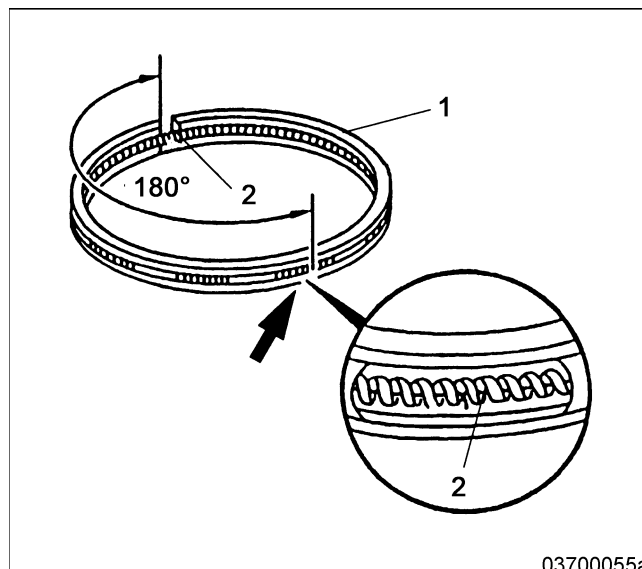
Damage to component!

- Observe manufacturer's instructions.
- Check components for special cleanness.

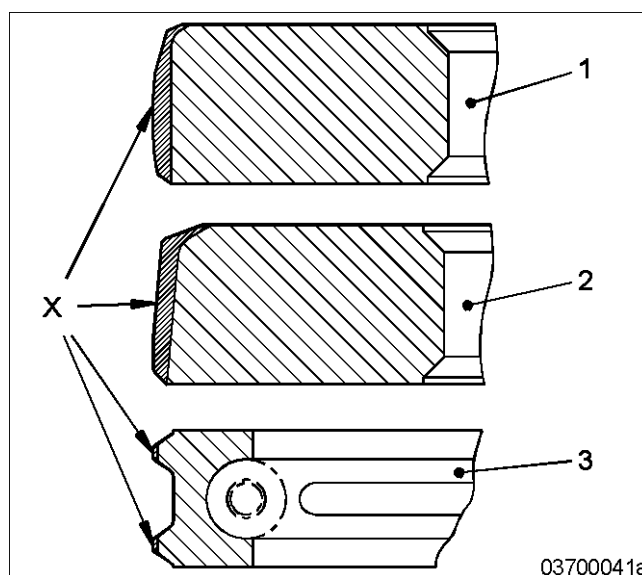
Check piston (→ Page 261).

Installing piston rings

1. By rotating coiled-spring expander (2) in oil control ring (1) relocate coiled-spring expander gap (arrow) at an angle of 180° to oil control ring gap.

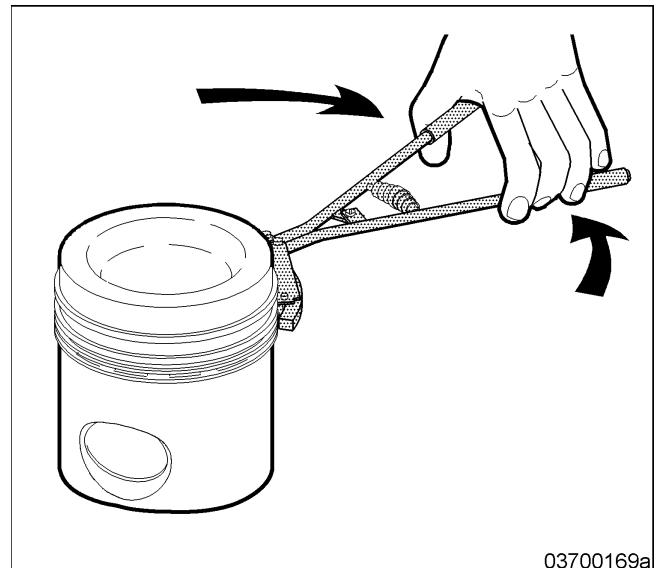


2. Prepare piston rings in accordance with installation sequence. Observe that new piston rings must be replaced as a set.
3. After replacing piston rings, replace cylinder liners (→ Page 92).



- 1 Keystone-type compression ring
- 2 Taper-face compression ring
- 3 Oil control ring

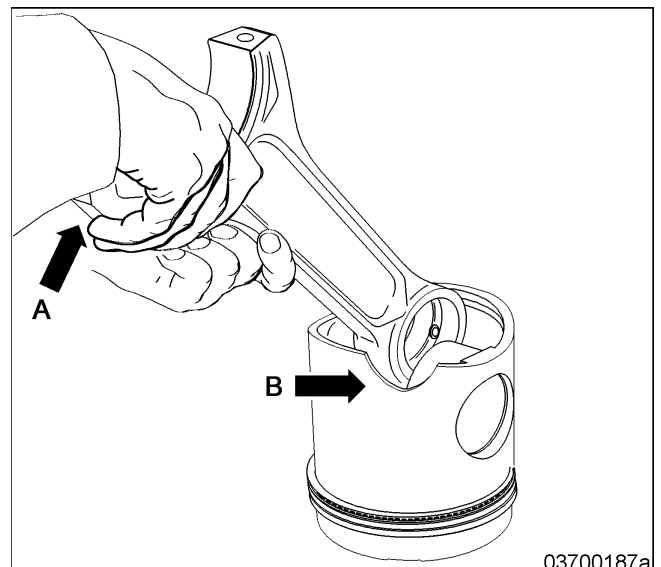
4. Use pliers to stretch piston rings so that they can be pushed over piston.
5. Insert piston rings in sequence from bottom to top (oil control ring first) in annular grooves on piston in such a way, that marking TOP on piston rings faces piston crown.
6. Check piston rings for ease of movement.



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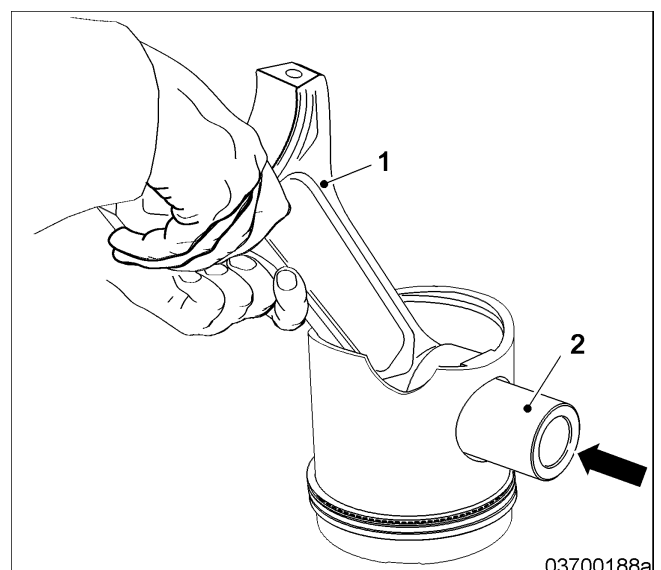
Installing conrod in piston

1. Wipe piston pin, conrod bushing and piston pin bore with chamois leather and coat with engine oil.
2. Insert conrod according to markings in corresponding pistons so that longer side (A) of angle-split conrod faces cavity (B).



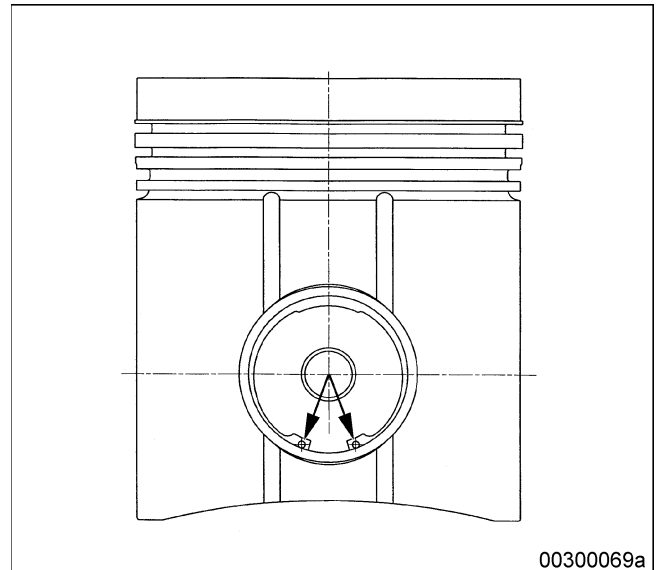
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3. Insert corresponding piston pin (2) in piston and conrod (1) until pin touches installed snap ring (arrow).



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4. Insert second snap ring with snap ring pliers.
5. Check if position (arrows) of both snap rings is satisfactory.







3.3.41 Piston and conrod – Installation

Special tools

Designation / Use	Part No.	Qty.
Barring device 8V	F6557929	1
Barring device 12V/16V	F6554695	1
Assembly sleeve	F6557147	1
Piston-ring compressor	F6554678	1
Assembly device	F6557995	1
Bridge meter	5415890121/00	1
Dial gauge	0015895321/00	1

Material

Designation / Use	Part No.	Qty.
Engine oil		

 DANGER	Suspended load. Danger to life! <ul style="list-style-type: none"> • Use appropriate lifting devices and appliances. • Never stand beneath a suspended load.
 WARNING	Heavy object. Risk of crushing! <ul style="list-style-type: none"> • Use appropriate lifting devices and appliances.
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors.
 CAUTION	Contamination of components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Check components for special cleanness.

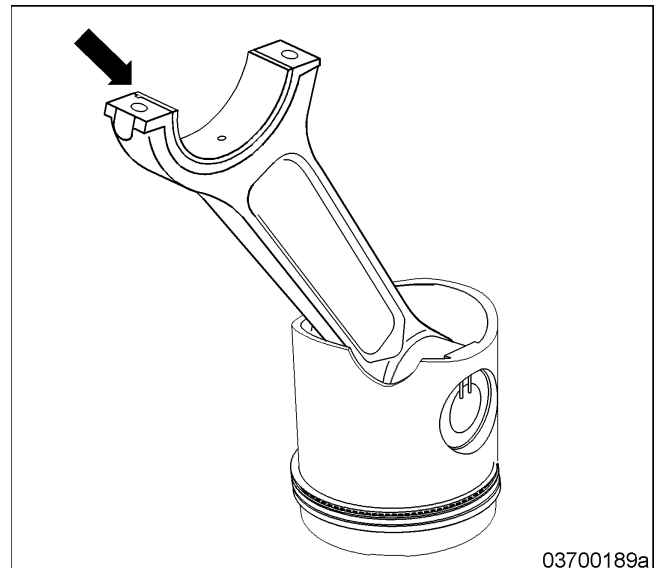
Assemble piston (→ Page 284).

Preparing piston for installation

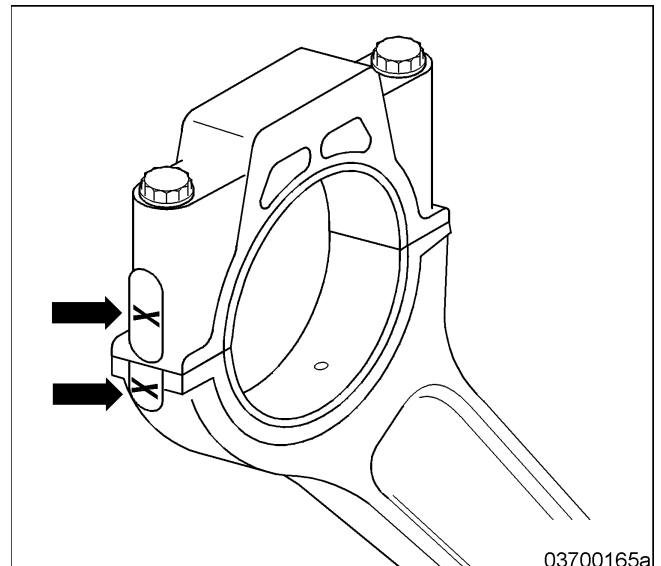
1. Coat piston and piston rings with engine oil.
2. Arrange piston ring joints one after the other at 120° intervals around the circumference of the piston.
3. Center piston rings and bevelled-edge oil control ring in grooves.

Preparing conrod bearing for installation

1. Wipe conrod bearing shells with chamois leather.
2. Install upper conrod bearing shell (bearing shell with oil bore) with locating lug (arrowed) in conrod groove.
3. Install lower conrod bearing shell with locating lug in groove on assembly device.
4. Coat running surfaces of conrod bearing shells with engine oil.



5. Check if markings (arrowed) of conrod cap and conrod match.



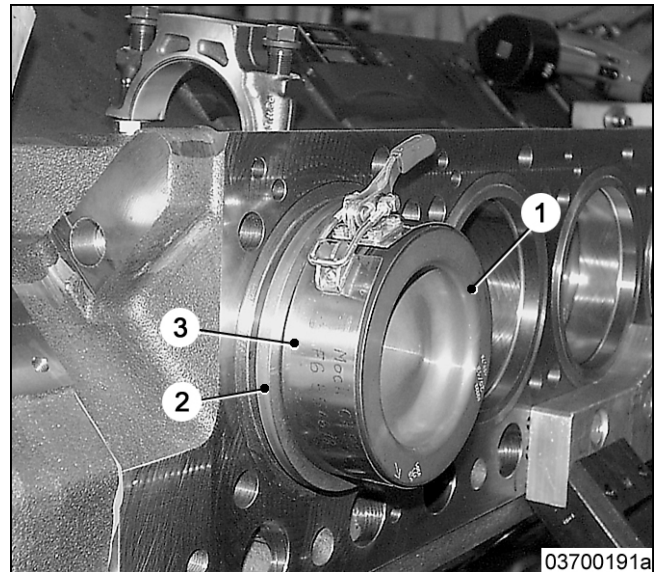
Installing piston and conrod in assembly dolly

Note: The piston must be installed by two mechanics, to guide the conrod and to avoid damage to the oil spray nozzle.

1. Turn crankcase in assembly dolly so that the cylinder liner is in horizontal position.
2. Rotate crankpin of piston and conrod to be installed to assembly position (→ Page 255).
3. Wipe crankpin and running surface on cylinder liner with chamois leather and coat with engine oil.
4. Insert assembly sleeve (2) in fit for carbon scraper ring.
5. Coat assembly sleeve (2) and cylinder liner with engine oil.
6. Install piston-ring compressor (3) on piston (1).

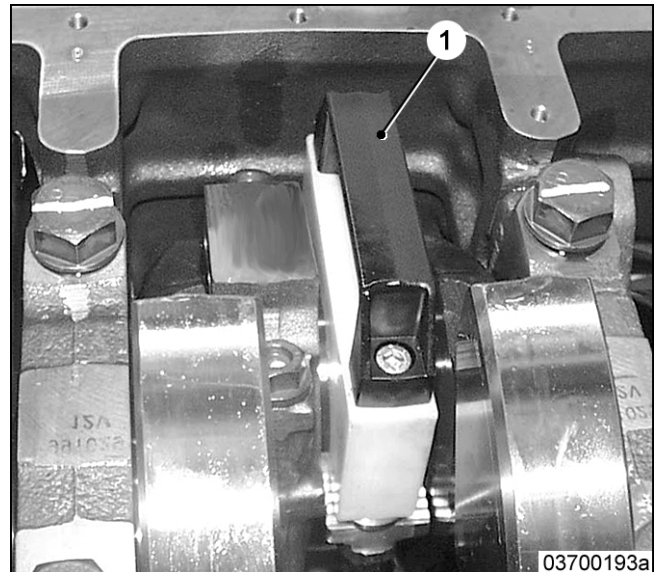
Note: The recess for the oil spray nozzle on piston (1) must face the center of the engine

7. Insert piston (1) and conrod into cylinder liner in a slightly twisted way so that the oil spray nozzle is not damaged.
8. Remove piston-ring compressor (3) and assembly sleeve (2).

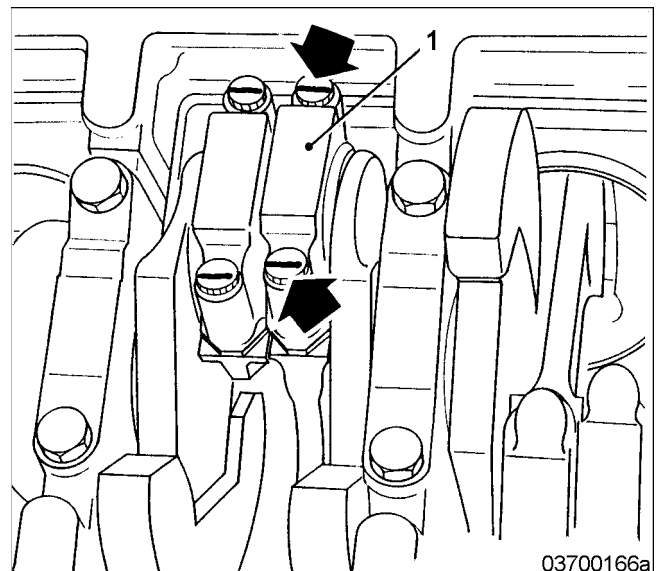


Installing conrod bearing caps

1. Align conrod bearing shell using assembly dolly (1), while doing so hold piston and conrod firmly in position.

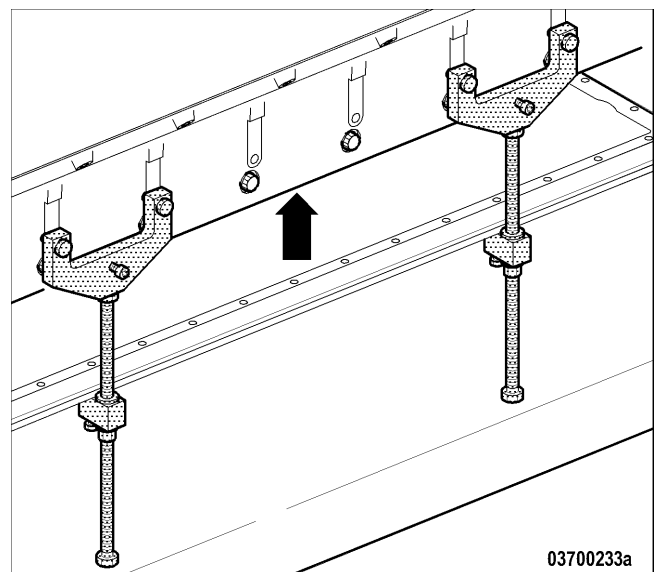


2. Coat thread and screw head mating face of conrod screws (arrowed) with engine oil.
3. Insert conrod screws (arrowed) by hand into screw bores on conrod cap, screw in for the first three revolutions without using any tool.
4. Screw conrod screws (arrowed) in up to the stop on the screw head and use socket wrench to tighten by hand.
5. Tighten conrod screws with torque wrench to specified tightening torque. Value (→ Page 23).
6. Check conrod for axial movement.
7. Using a torque wrench, tighten conrod screws to specified tightening torque. Value (→ Page 23).
8. Check conrod end play.
9. Turn crankshaft and check for clearance between oil spray nozzle, piston and conrod.



Installing piston and conrod with oil pan lowered

1. The installation is continued as described in Installing piston and conrod in assembly dolly.
2. Install conrod bearing, conrod bearing cap and conrod screws from below (arrowed).

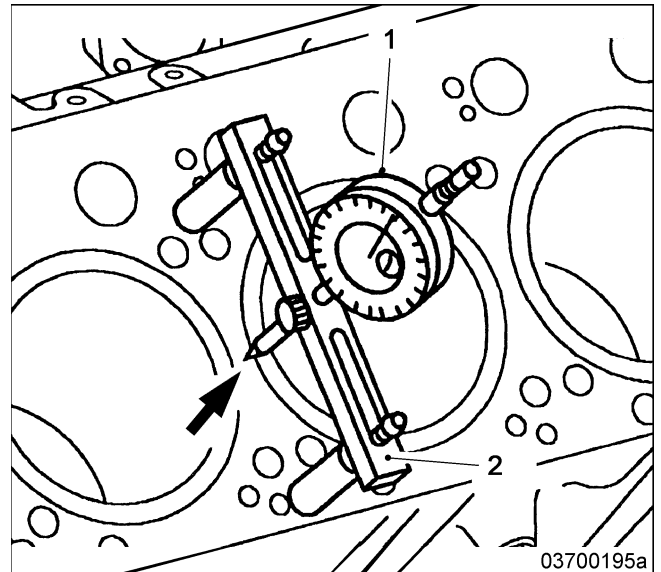


Determine TDC position (→ Page 346).

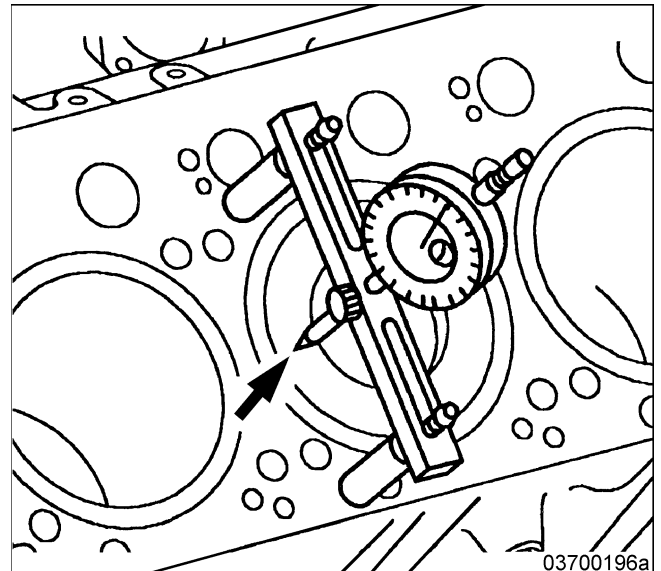
Measuring negative/positive piston deck height

Note: Measure protrusion between piston crown and crankcase without cylinder head gasket.

1. Remove deposits from piston and crankcase.
2. Turn crankshaft in engine direction of rotation until the piston to be measured is approx. 1 cm before TDC.
3. Attach dial gauge (1) with light pretension in bridge meter (2).
4. Set bridge meter (2) with dial-gauge anvil (arrowed) onto crankcase and set dial gauge to zero.



5. Slide bridge meter of crankcase over the outer piston surface (arrowed).
6. Turn crankshaft in engine direction of rotation until the piston is at TDC.
7. Read off and note down negative/positive piston deck height at the dial gauge. Values (→ Page 264).
8. If tolerance deviation is not permitted, recheck and replace if necessary.

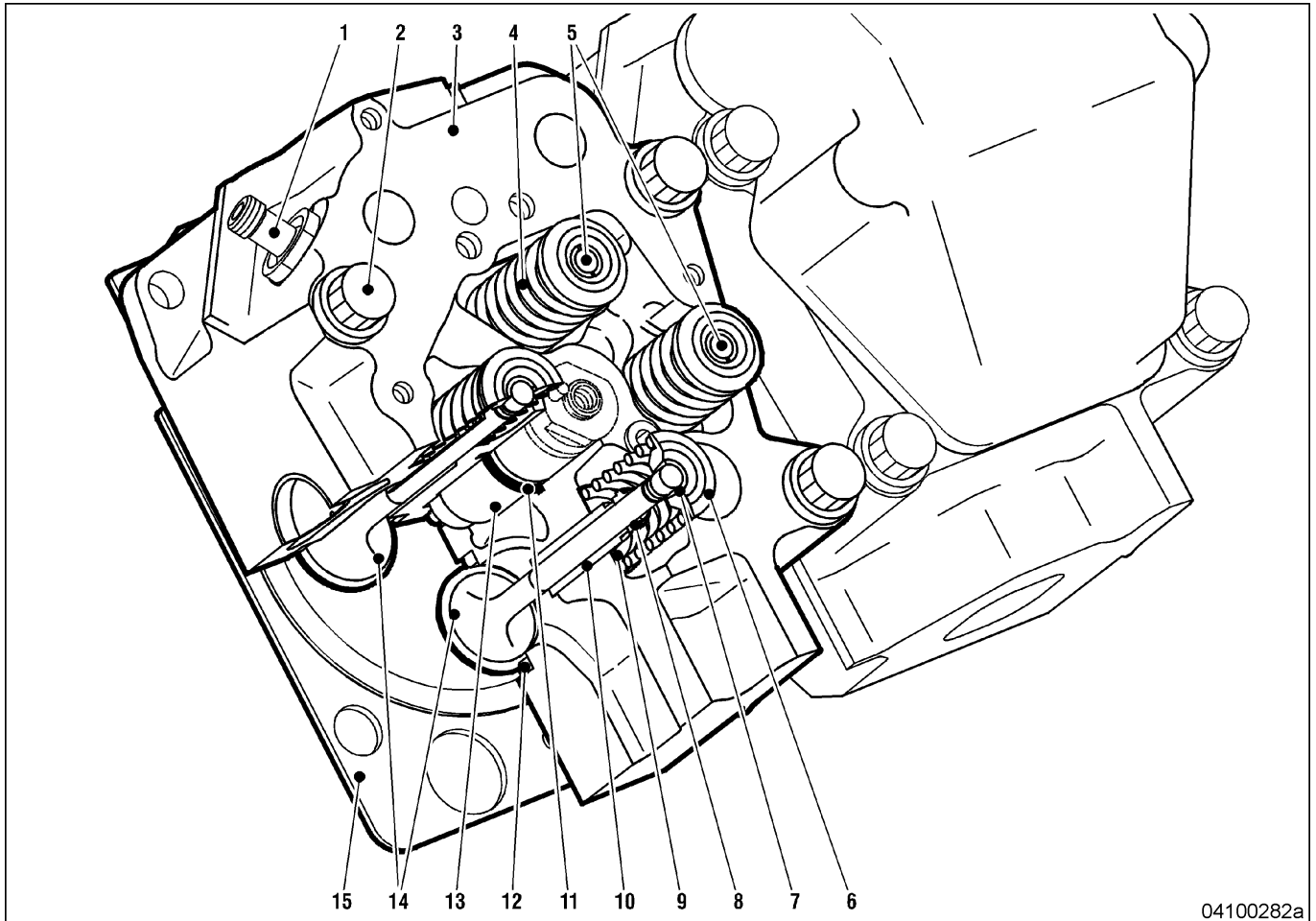


Final steps

For these steps a distinction must be made as to whether				
1 the engine has been completely disassembled				
2 the engine has been removed but not disassembled				
3 the engine has remained installed				
1	2	3	Operations	See
X	–	–	Assemble engine.	(→ Page 58)
–	X	X	Assembly in reverse disassembly sequence.	(→ Page 255)
–	–	X	Fill with engine oil.	(→Operating instructions)
–	–	X	Fill with engine coolant.	(→Operating instructions)
–	–	X	Fill with charge air coolant.	(→Operating instructions)
–	–	X	Enable engine start.	–

3.4 Cylinder Head

3.4.1 Cylinder head with attachments – Overview

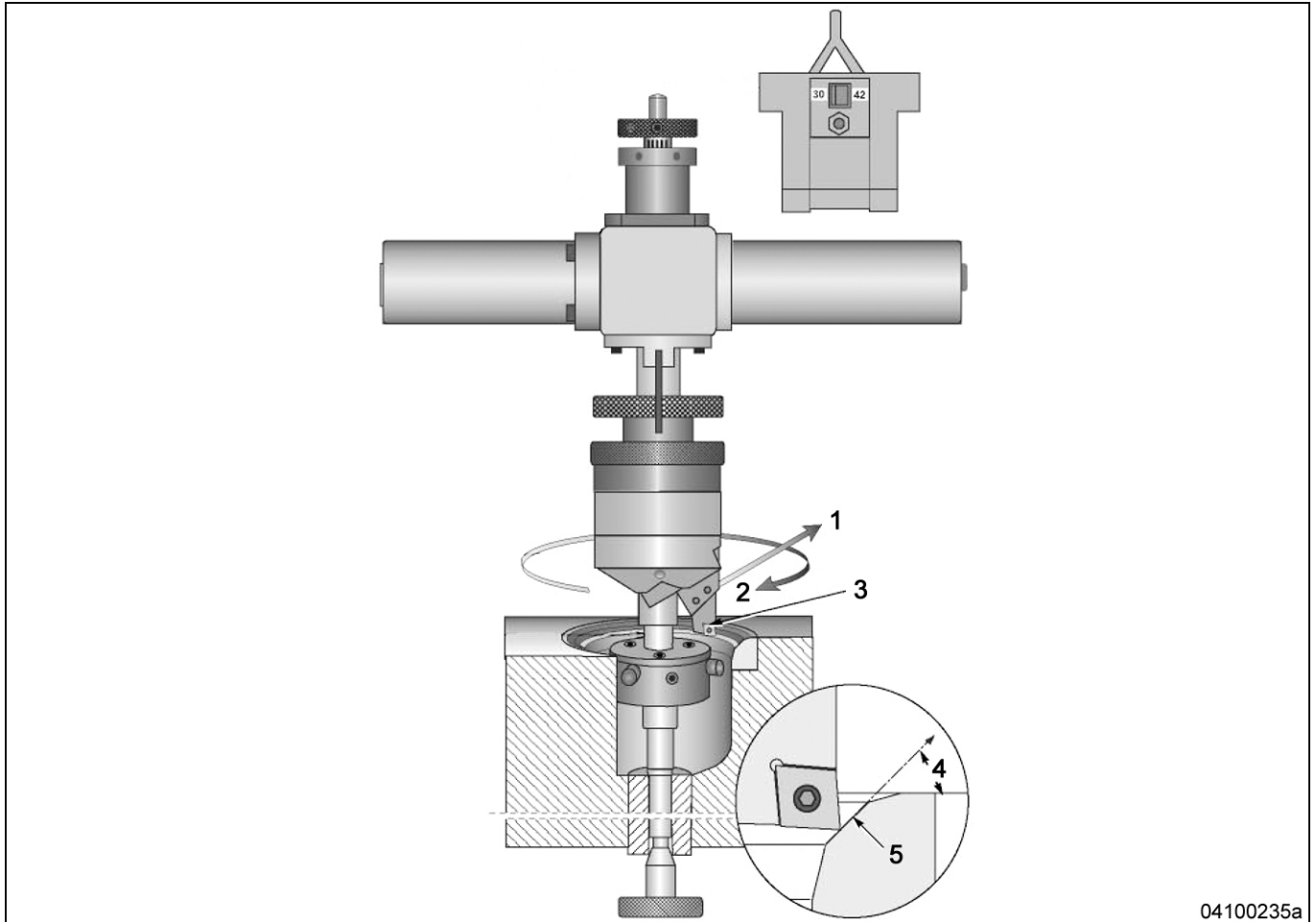


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- | | | |
|------------------------|-------------------------|-------------------------|
| 1 Pressure pipe neck | 6 Valve-spring retainer | 11 O-ring |
| 2 Cylinder head screws | 7 Valve collet | 12 Valve-seat insert |
| 3 Cylinder head | 8 Seal | 13 Protective sleeve |
| 4 Valve spring | 9 Washer | 14 Exhaust valves |
| 5 Inlet valves | 10 Valve guide | 15 Cylinder-head gasket |

3.4.2 Valve-seat turning machine for cylinder head

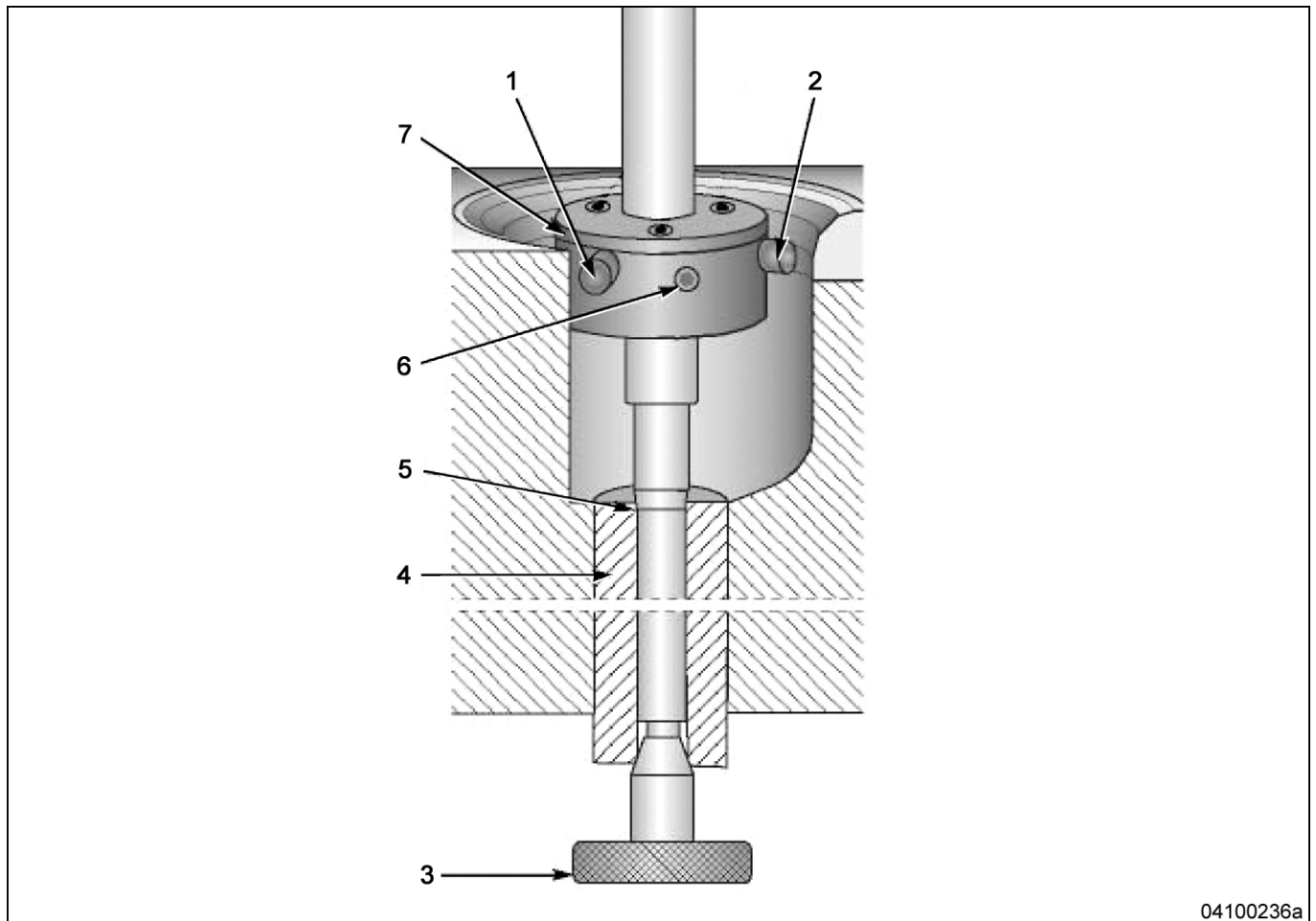
Working principle of valve-seat turning machine



04100235a

The valve-seat turning machine is an inside turning device. While the cutter (3) rotates around the valve-seat (5), a feed gear mechanism ensures a continuous outward feed motion (1). The feed motion under the proper valve-seat angle (4) is defined by an inclined slideway in the exchangeable adapter head.

Installing the solid pilot



Precondition:

Valve guide is installed and machined to finished dimension.

Valve guide was cleaned.

Cylinder head is securely clamped and valve guide accessible from both sides.

Mounting the supporting spider

To achieve maximum accuracy, the pilot must be supported by the supporting spider (7) below the valve seat. Slide the supporting spider (7) over the pilot shaft to such position that the spring-loaded spider elements (1) rest just below the valve seat level when the pilot is installed in the valve guide (4) and tighten the clamping screw (6).

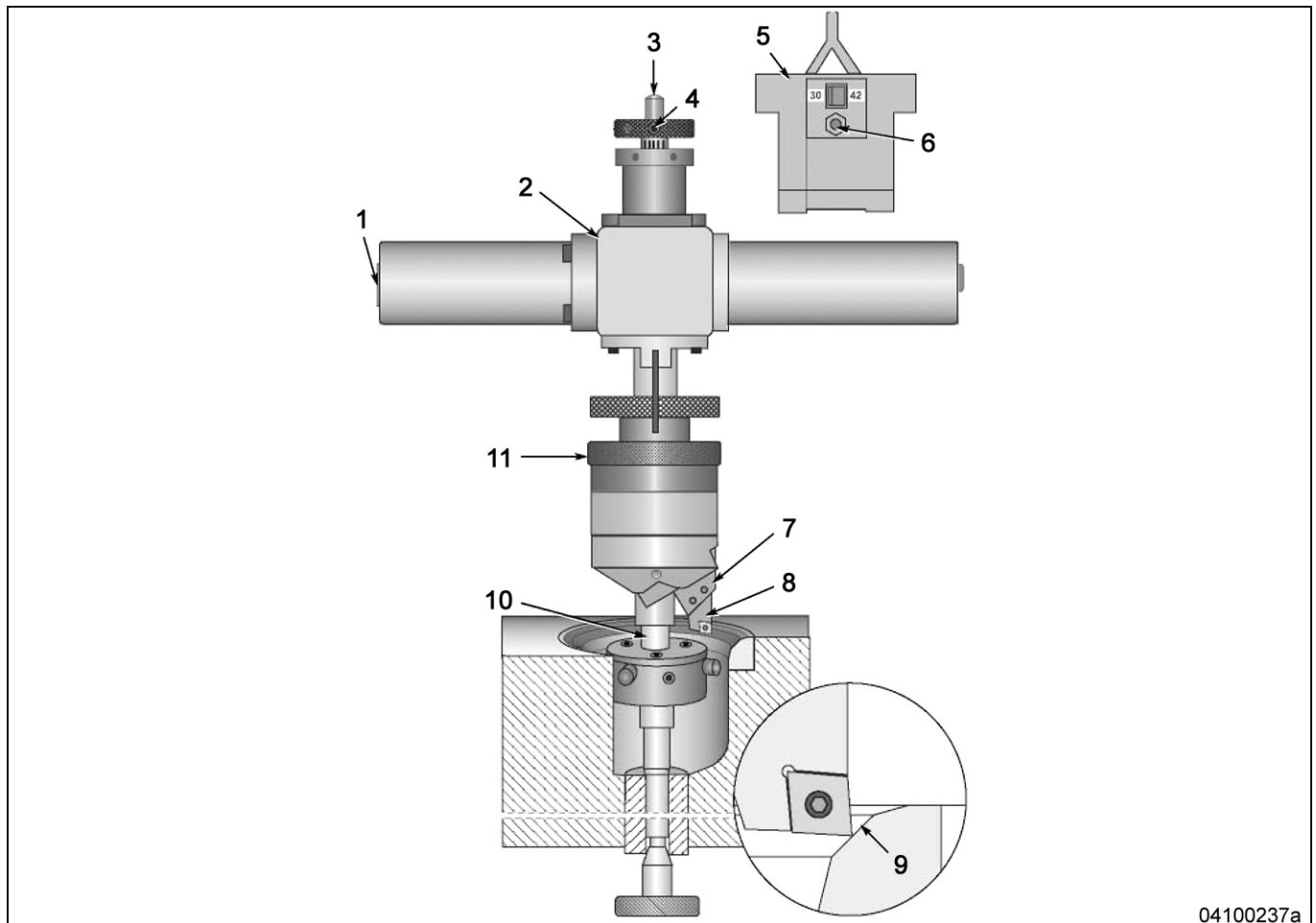
Inserting the pilot into the valve guide

Remove clamping nut (3) from pilot and insert the threaded end of the pilot into the valve guide (4), until the tapered portion (5) bears against the conical seating of the valve guide (4). The spring-loaded elements (1) of the spider (7) will bear against the exhaust/inlet canal below the valve seat.

Locking the pilot

Screw clamping nut (3) onto the pilot and tighten with moderate force. Tighten the screws (6) on top of the spider to lock the spring-loaded elements (1) of the spider (7). Apply standard machine oil to the top and around the periphery of the pilot shaft.

Setting up valve turning machine



Mounting the cutter

Fit the appropriate tool holder of the cutter (8) with an indexable insert and attach to the tool slide (7).

Placing the valve-turning machine on the pilot

Take care that the cutter (8) does not bump against the cylinder head.

Slide the valve-seat cutting machine over the pilot (10) until either the depth stop (3) rests upon the pilot (10) or the cutter (8) contacts the cylinder head.

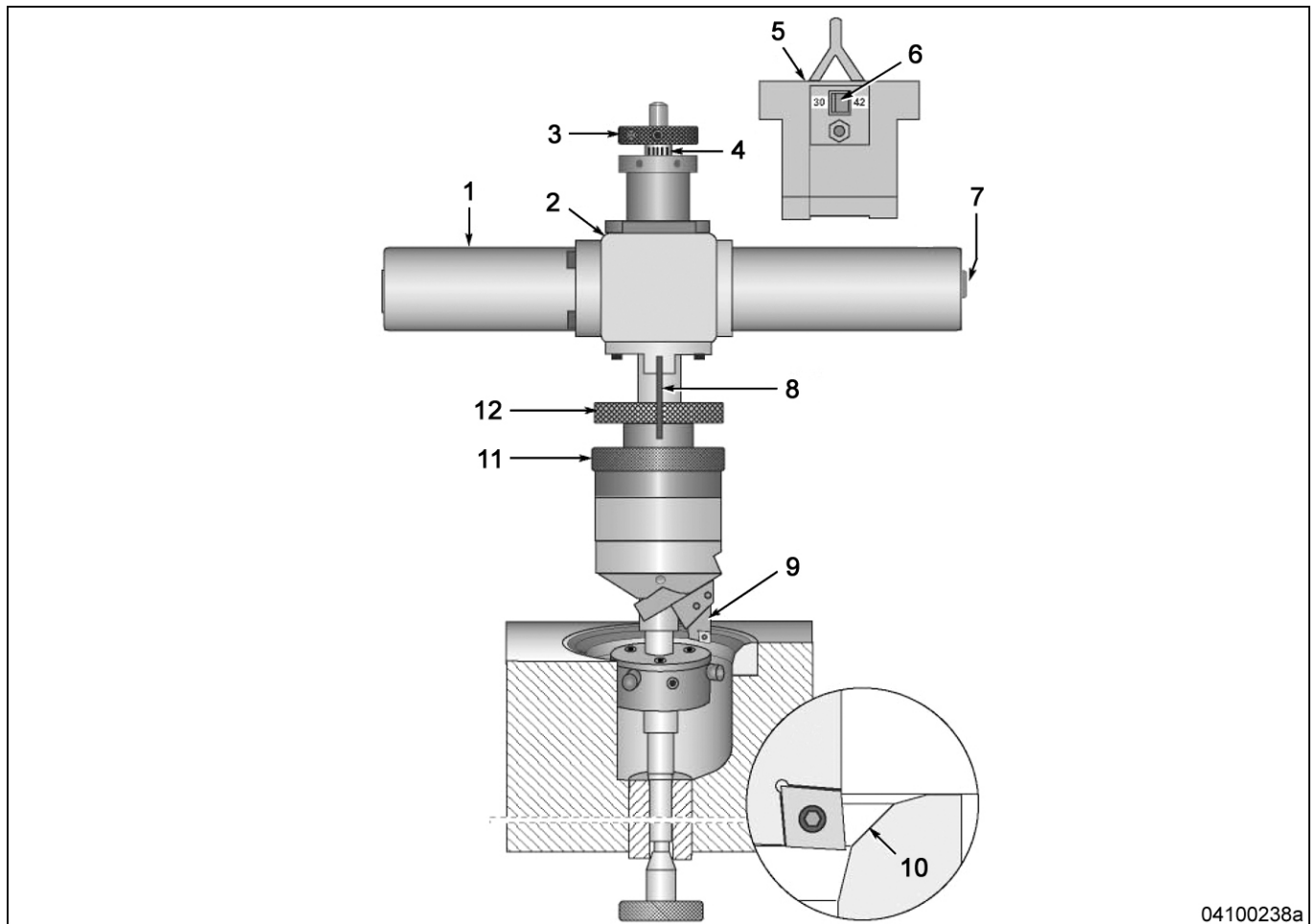
Aligning the cutting edge with the valve-seat center

Turn rapid tool adjuster (11) to position cutting edge of cutter over the valve-seat center (9). Hold the machine with one hand. Loosen screw (4) of depth stop (3) and allow machine to slide down until the cutting edge contacts the valve seat (9) lightly. Push depth stop (3) slightly downward against the pilot (10) and then tighten depth stop locking screw (4).

Connecting the machine to power supply

Insert the round plug of the outlet cable (6) of the power supply unit (5) into the corresponding socket (1) on the driving assembly (2) and allow the securing latch to engage.

Valve seat turning



Positioning the cutter at the inner valve-seat edge

Slightly lift machine with one hand and then turn rapid tool adapter (11) with the other hand until the cutting edge is just clear of the inner edge of the valve seat (10).

Setting cutting depth

To set the depth of cut, turn depth feed (3) counterclockwise. One notch of the depth-feed scale (4) corresponds to a depth feed of 0.025 mm. As the valve seat (10) usually shows unequal wear, the depth of the first turning cycle must be selected (max. 0.2 mm) to ensure that the entire valve-seat surface is undercut.

If the cutting edge is just scraping along the surface instead of undercutting the hard surface zone, there is a risk of premature wear and chipping of the cutting edge.

Lubricating the valve seat

Apply a few drops of metalworking lubricant on hard valve-seat surfaces before turning.

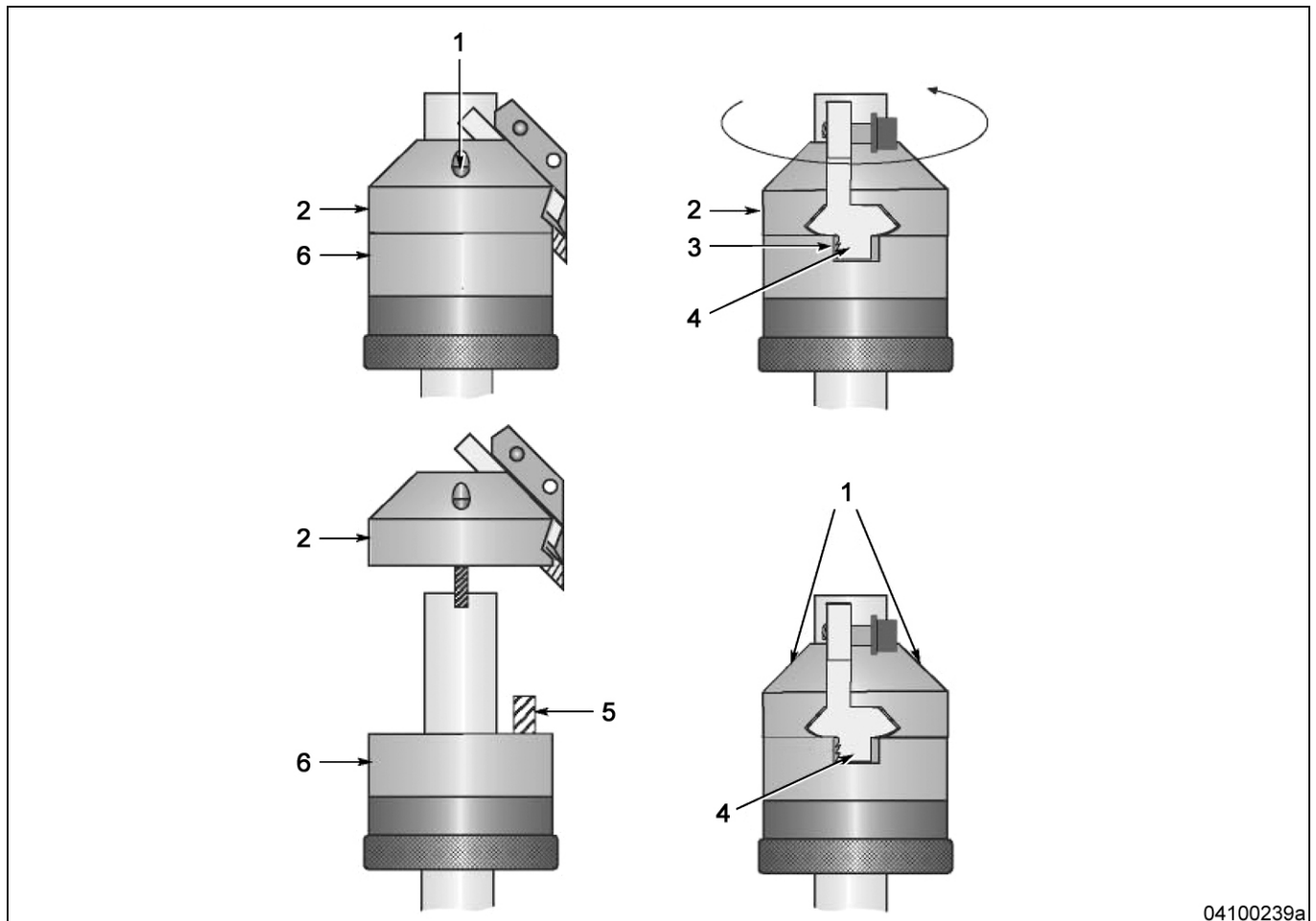
Valve seat turning

Make sure that the pivoted lever (8) is engaged in the groove of the feed actuator (12). Select proper speed by shifting the switch (6) at the power supply unit (5). Speed can be increased by changing over from 30 VDC to 42 VDC. Hold driving unit (2) with both hands at the motors (1) and press pushbutton switch (7) to start the cutting pass. Release the pushbutton switch (7) as soon as the cutter has been traversed beyond the top edge of the valve seat (10).

Repeating the cutting pass

Repeat steps with a cutting depth between 0.05 mm and 0.1 mm until the valve seat surface (10) is plane all around. To ensure a smooth valve-seat surface (10) finish, proceed with a final pass at high speed with 0.025 mm cutting depth.

Replacing the adapter head



04100239a

Removing the adapter head

Unscrew the two screws (1) from the adapter head (2).

Turn adapter head (2) in the direction of the arrow until the back of the toothed rack (4) is no longer engaged with the pinion (4) in the gear housing (6). Now the adapter head can be withdrawn off the gear housing (6).

Mounting the adapter head

Place adapter head (2) onto gear housing (6) so that the pinion (5) projecting from the gear housing (6) is seated in the corresponding bore of the adapter head (2).

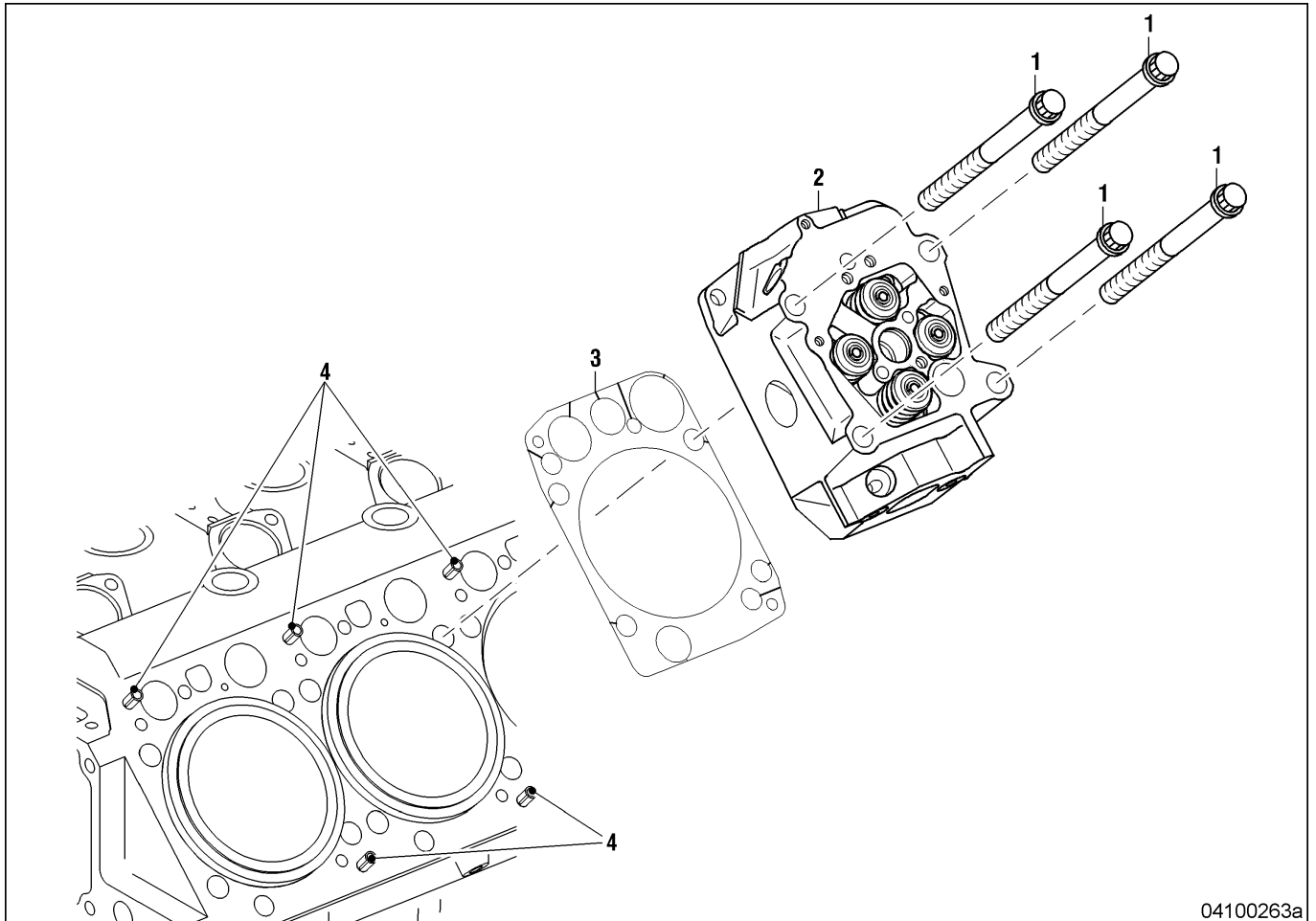
The adapter head (2) must be seated flush with the gear housing (6).

Screw the two screws (1) loosely into the gear housing so that the adapter head (2) can still be moved to adjust proper clearance between toothed rack (4) and pinion.

Adjust the adapter head so that the gap between the toothed side of the rack (4) and the opposite side of the recess (3) is approximately 0.3 mm to 0.5 mm. Tighten both screws (1).

Turn the rapid tool adjuster to move the tool slide back and forth. If tool slide does not move freely, readjust the adapter head.

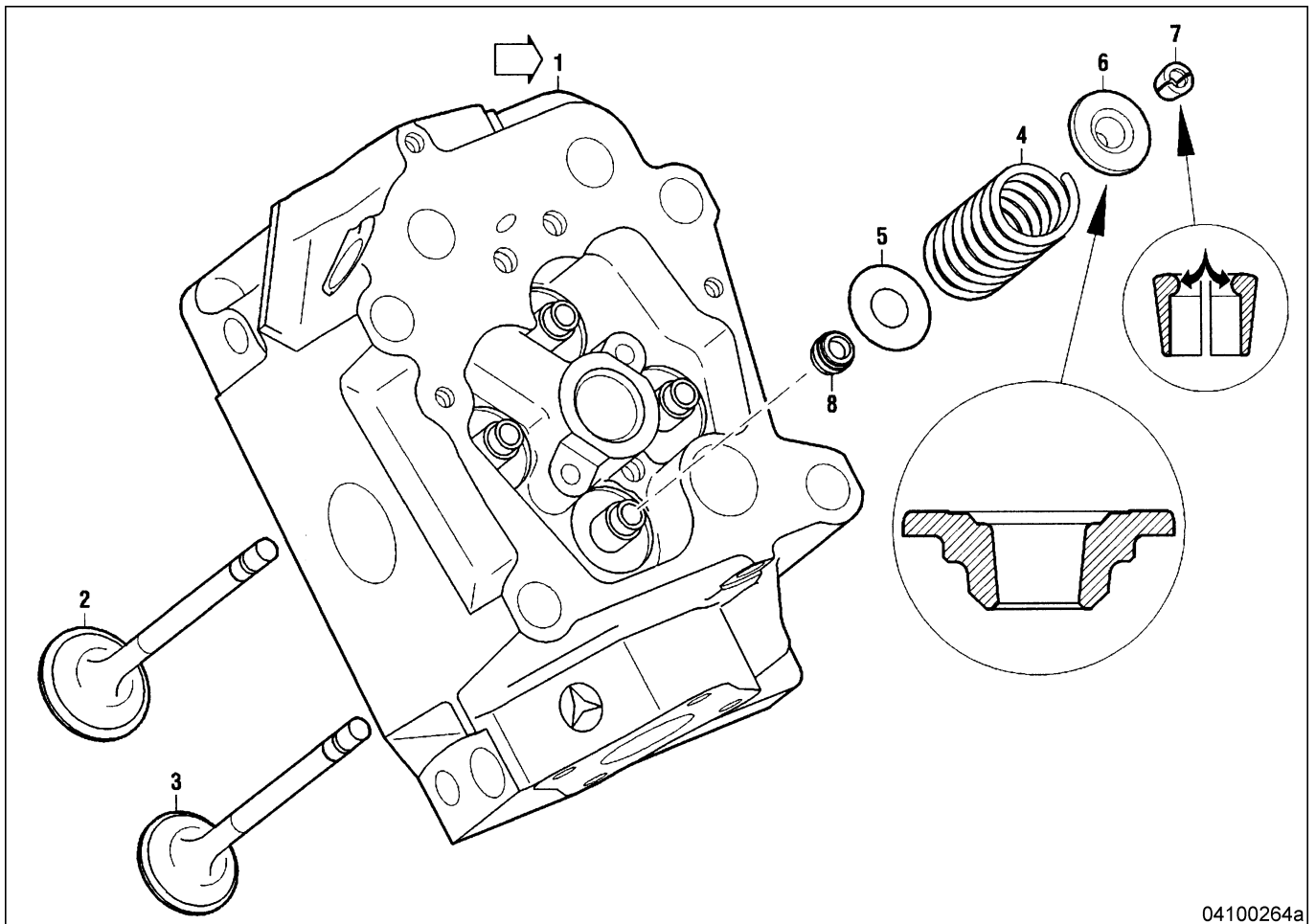
3.4.3 Cylinder head – Overview



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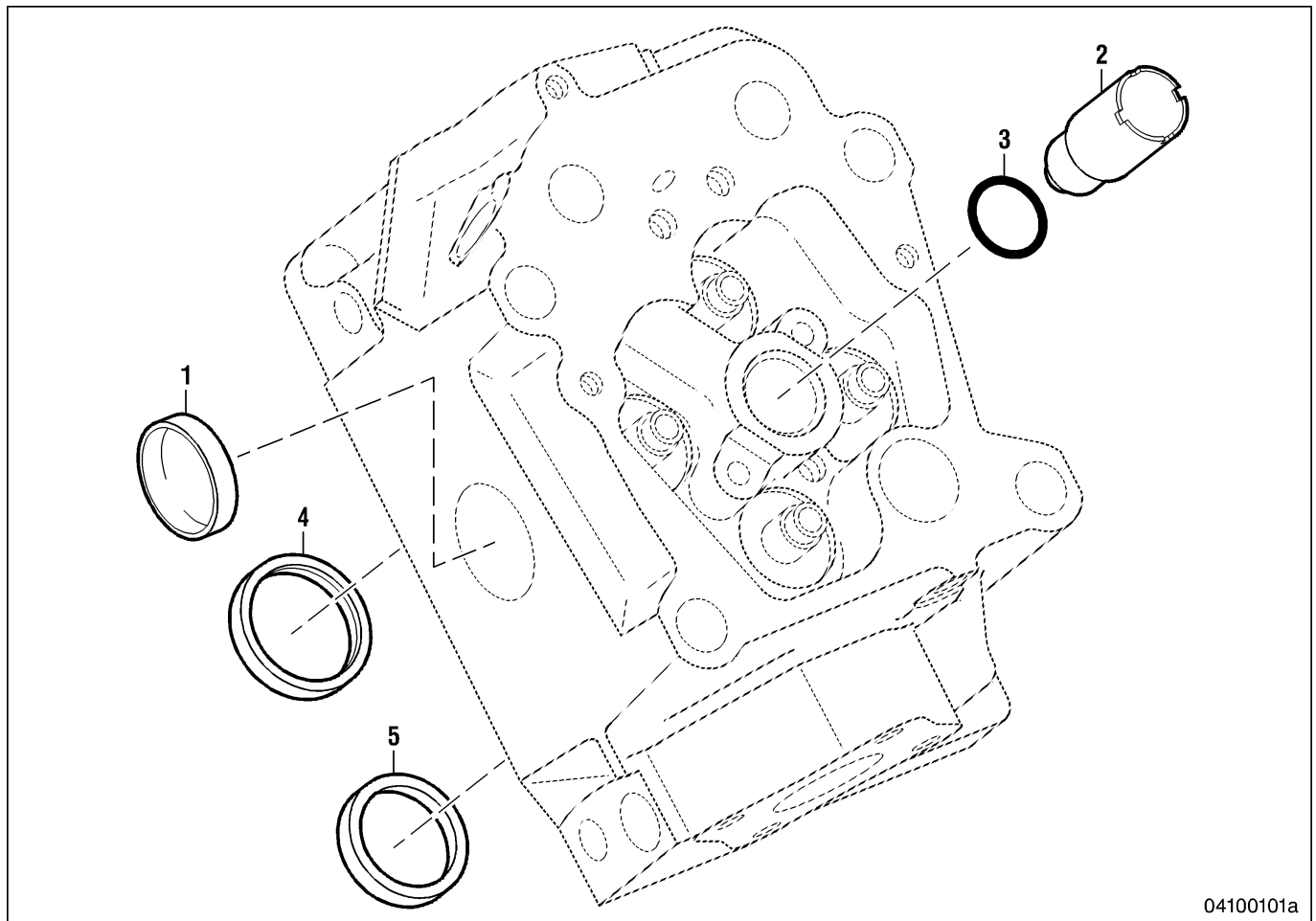
- 1 Screw
- 2 Cylinder head
- 3 Cylinder-head gasket
- 4 Spring sleeve

Overview drawing



04100264a

- | | |
|-----------------|-------------------------|
| 1 Cylinder head | 5 Washer |
| 2 Inlet valve | 6 Valve spring retainer |
| 3 Valve | 7 Valve collet |
| 4 Valve spring | 8 Seal |

Overview drawing

04100101a

- 1 End cover
- 2 Protective sleeve
- 3 Sealing ring
- 4 Valve-seat insert
- 5 Valve-seat insert

3.4.4 Cylinder head – Removal


Preconditions

- Engine is stopped and starting disabled

Special tools

Designation / Use	Part No.	Qty.
Socket	F30907150	1

 WARNING	Components have sharp edges. Risk of injury! <ul style="list-style-type: none"> • Wear protective gloves.
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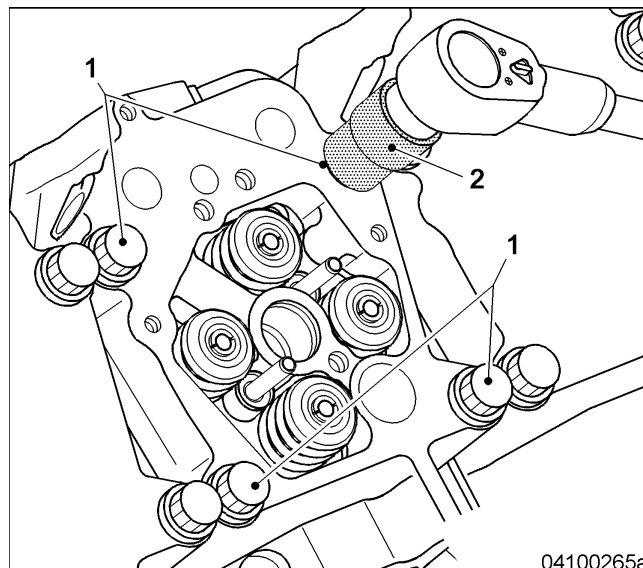
 WARNING	Heavy object. Risk of crushing! <ul style="list-style-type: none"> • Use appropriate lifting devices and appliances.
---	---

Preparatory steps

For these steps a distinction must be made as to whether				
1 the engine is to be completely disassembled				
2 the engine is to be removed but not disassembled				
3 the engine is to remain installed				
1	2	3	Operations	See
X	–	–	Remove engine.	(→ Page 55)
X	–	–	Disassemble engine.	(→ Page 56)
–	–	X	Disable engine start.	(→ Page 15)
–	–	X	Drain engine coolant.	(→ Operating instructions)
–	X	X	Remove exhaust line downstream of cylinder.	(→ Page 466)
–	X	X	Remove air supply line to cylinders.	(→ Page 461)
–	X	X	Remove cylinder head covers.	(→ Page 371)
–	X	X	Remove valve drive.	(→ Page 359)
–	X	X	Remove sensors, actuators and injectors.	(→ Page 604)
–	X	X	Remove injector.	(→ Page 385)
–	X	X	Remove leak-off fuel lines.	(→ Page 426)

Removing cylinder head

1. Use socket (2) to loosen screws (1) on cylinder head evenly and remove.
2. Take cylinder head off crankcase and place on firm surface.
3. Remove cylinder head gasket from mating face of crankcase.
4. Close openings using suitable covers.



3.4.5 Cylinder head – Disassembly

Special tools

Designation / Use	Part No.	Qty.
Valve lifter	4425890031/00	1
Removal tool for valve guide	F30450454	1
Socket	F30377657	1
Retaining device	F6554686	1
Bar magnet	8205892961/00	1



Heavy object.
Risk of crushing!
 • Use appropriate lifting devices and appliances.



Components have sharp edges.
Risk of injury!
 • Wear protective gloves.

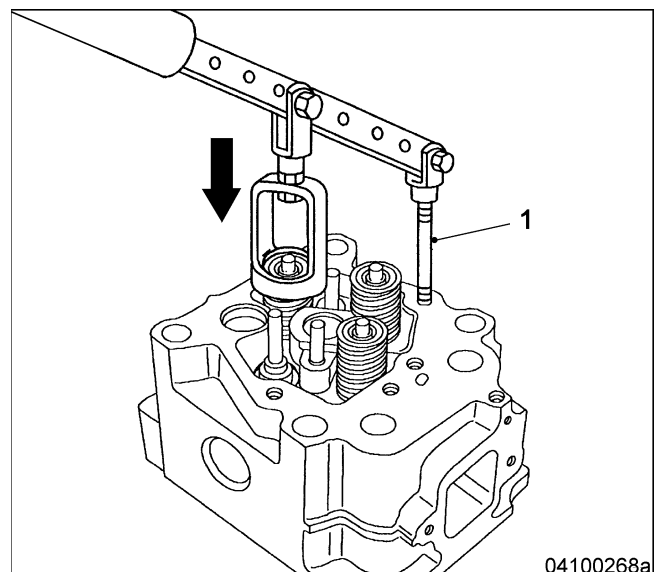


Spring/circlip/tensioning roller preload.
Risk of injury!
 • Only use specified tool and equipment.

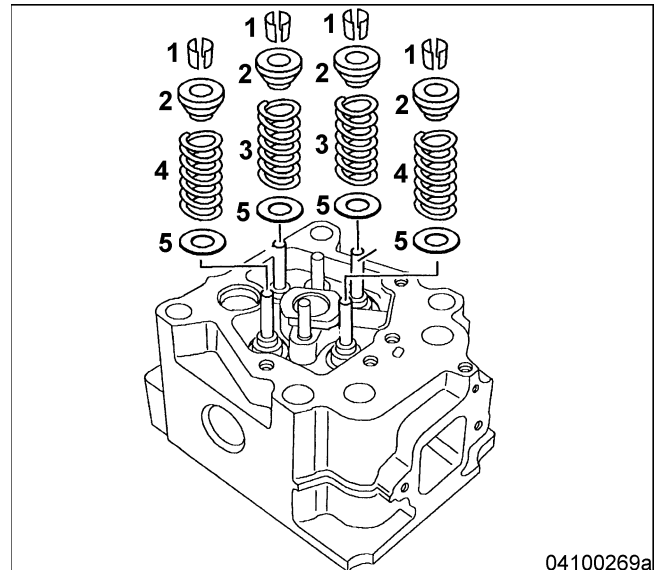
Remove cylinder head (→ Page 303).

Removing valves

1. Insert cylinder head in retaining device.
2. Install valve lifter (1).
3. Use valve lifter to press down valve-spring retainer (1).

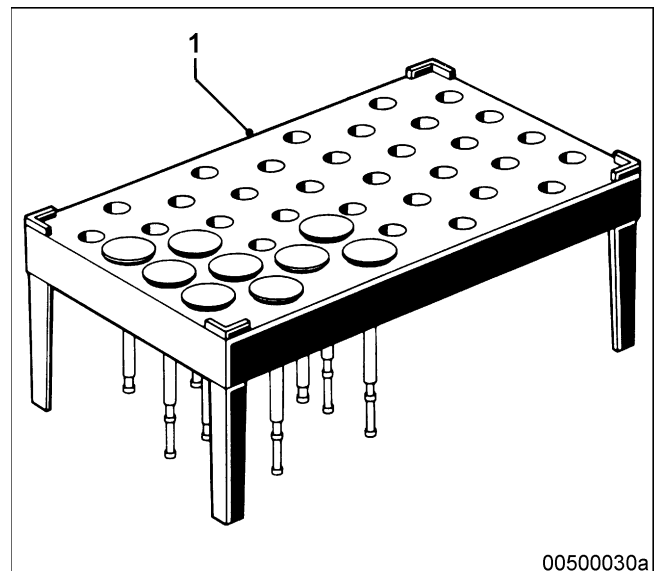


4. Remove valve collets (1) with bar magnet and relieve valve spring of tension.
5. Remove valve lifter and retaining device.
6. Remove valve-spring retainer (2), washer (5) and valve springs (3) and (4).
7. Lay cylinder head on its side.
8. Remove exhaust and inlet valves.



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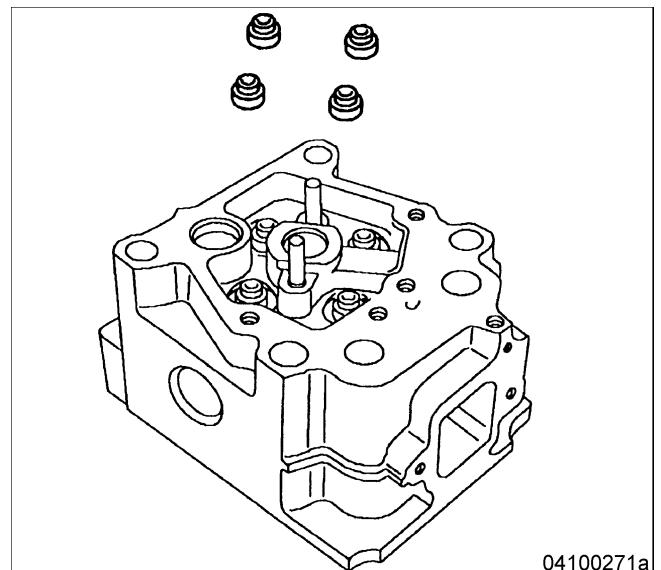
9. Place valves in storage rack (1).



00500030a

Removing gaskets

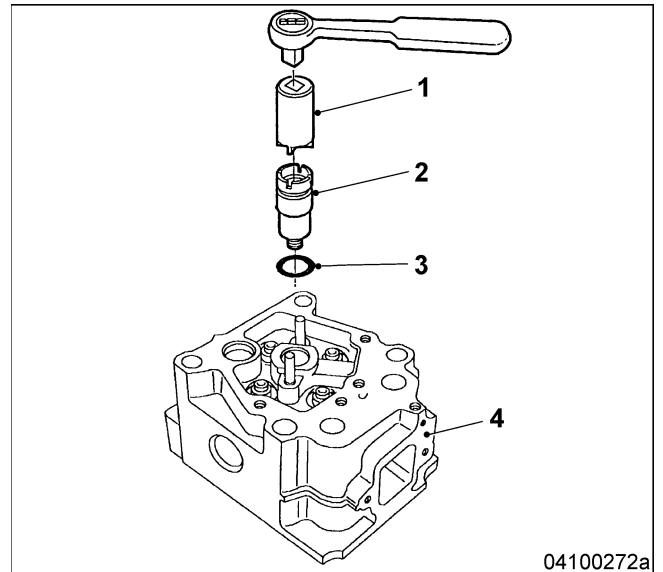
1. Place cylinder head on to cylinder head base.
2. Remove gasket from valve guide with two screwdrivers; be careful not to damage valve guide.



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Removing protective sleeve





1. Unscrew protective sleeve (2) with socket (1) from cylinder head (4).
2. Remove sealing ring (3) from cylinder head (4).



3.4.6 Cylinder head – Cleaning

Special tools

Designation / Use	Part No.	Qty.
Decarbonizer		
Cleaning agent		

 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors.
 WARNING	Heavy object. Risk of crushing! <ul style="list-style-type: none"> • Use appropriate lifting devices and appliances.
 WARNING	Components have sharp edges. Risk of injury! <ul style="list-style-type: none"> • Wear protective gloves.
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask.

Removing cylinder head (→ Page 303).

Cleaning cylinder head

1. Clean all components with cleaning agent.
2. Remove cleaning agent.
3. Remove carbon deposits with decarbonizer.
4. After cleaning with decarbonizer, rinse components in water until no further residues are washed off.

Note: Pay particular attention to the coolant bores in the bottom of the cylinder head!

5. Blow out all parts with compressed air.

3.4.7 Cylinder head – Check

Special tools

Designation / Use	Part No.	Qty.
Limit plug gauge	Y20098136	1
Gauge for exhaust valve seat	Y4346861	1
Gauge for inlet valve seat	Y4346862	1
Pressure testing device	Y4341042	1
Depth gauge		
External micrometer		
Precision bore gauge		

Material

Designation / Use	Part No.	Qty.
Surface crack-testing method with fluorescent dye penetrant		

Spare parts

Designation / Use	Part No.	Qty.
Cylinder head		
Screw		
Cover		
Valve-seat inserts		
Sealing ring		
Protective sleeve		
Cylinder-head gasket		
Spring sleeve		
Valve		
Valve spring		
Washer		
Valve-spring retainer		
Valve collet		
Gasket		



WARNING

Compressed air.

Risk of injury!

- Do not direct compressed-air jet at persons.
- Wear protective goggles / safety mask and ear protectors.



WARNING

Heavy object.

Risk of crushing!

- Use appropriate lifting devices and appliances.



WARNING

Test liquid is hot and pressurized.

Risk of injury and scalding!

- Wear protective clothing, gloves, and goggles / safety mask.

Clean cylinder head (→ Page 308).

Cylinder head – Check

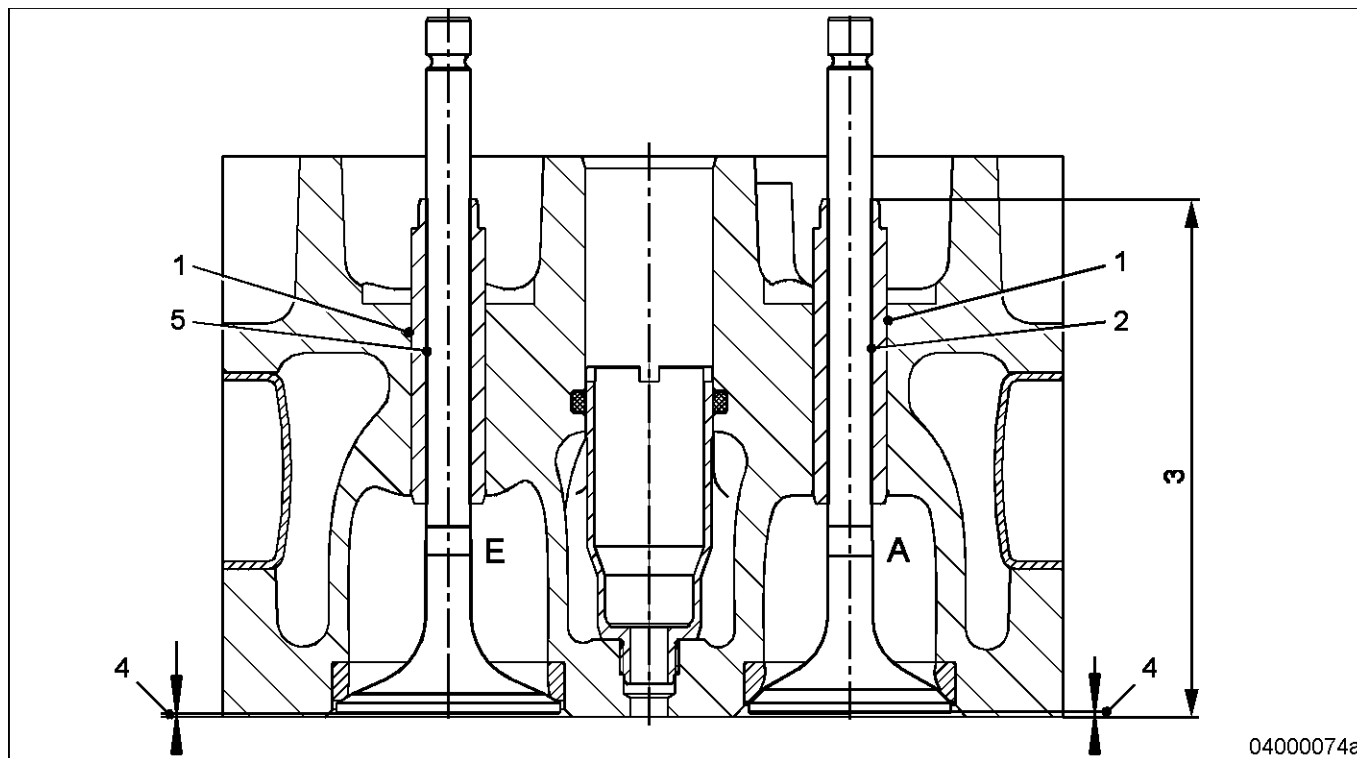
Item	Findings	Measure
Measure cylinder head height. Values (→ Page 311)	Minimum height not reached	Recondition cylinder head (→ Page 320).
Check cylinder head mating face (combustion chamber side) for evenness and damage.	Damaged	Recondition cylinder head (→ Page 320).
Check mating face of protective sleeve in cylinder head for scores and stress marks.	<ul style="list-style-type: none"> • Scores • Stress marks visible 	Recondition cylinder head (→ Page 320).
Measure valve guides with bore gauge. Values (→ Page 311)	Not true to gauge.	Recondition cylinder head (→ Page 320).
Check valve springs for damage. Check spring force and length of valve springs. Values (→ Page 311)	<ul style="list-style-type: none"> • Damaged • Values exceeded. 	Replace valve springs
Check all threads for ease of movement.	Sluggish	<ul style="list-style-type: none"> • Recondition • Replace cylinder head.
Check valve seats on cylinder head for pitting and wear.	Pitting or wear	Recondition cylinder head (→ Page 320).
Check cylinder head screw threads, screw head mating faces and thrust washer for damage.	Damaged	Replace
Measure shank length of cylinder head screws with depth gauge.	Values (→ Page 311) exceeded.	Replace
Check valves with red dye penetrant for cracks.	Signs of cracks	Replace
Check valves for damage. Check valves for concentricity and dimensional accuracy. Values (→ Page 311)	<ul style="list-style-type: none"> • Chrome layer damaged • Valve keyways damaged or burnt • Out-of-round 	Replace
Replace spring retainer and valve collet.		

Checking cylinder head for leaks

1. Install protective sleeve prior to leak test (→ Page 326)
2. Prepare water for water bath with corrosion inhibitor.
3. Install pressure testing device.
4. Place cylinder head in a water bath heated to 80 °C until cylinder head has warmed up.
5. Pressure-test cylinder head with 0.5 bar compressed air.
6. Pressure must be maintained with cylinder in water bath for at least 30 minutes. No air bubbles must emerge.
7. Remove hydraulic pressure testing device.
8. Replace leaky covers (→ Page 331).

3.4.8 Cylinder head – Tolerances

Inlet and exhaust valve guides

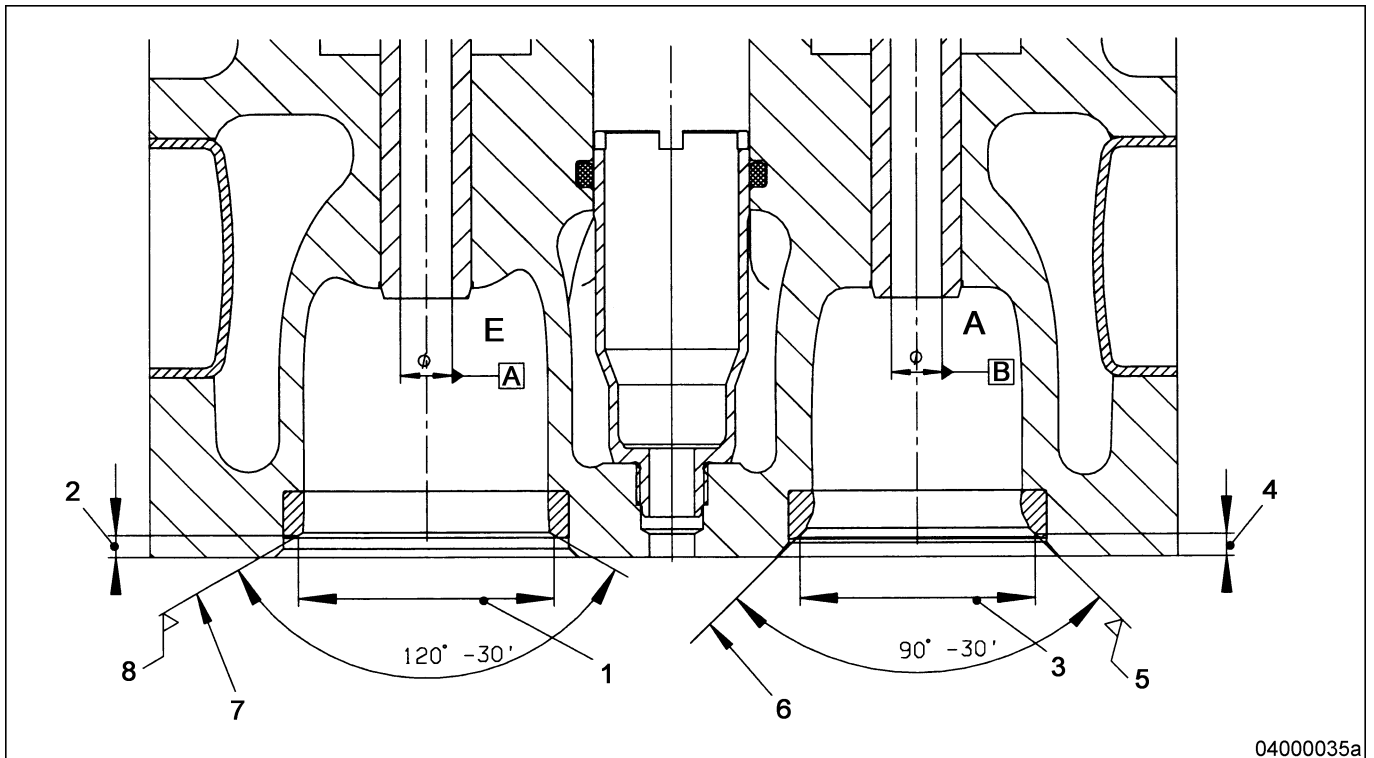


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No.	Designation	Stage	Tolerance size Basic size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
1	Cylinder head bore		15.000 H7	0	+0.018			+0.010	+0.046	
	Valve guide outer Ø		15.000 s7	+0.028	+0.046					
2	Exhaust									
	Valve guide bore installed		9.000 H8	0	+0.022	0.060	0.097			
	Valve stem Ø		8.940 h7	-0.015	0					
3	Valve guide dimension		104.300	-0.350	+0.350					
4	Valve clearance Exhaust		0.700 to 1.150							
	Valve clearance Inlet		0.700 to 1.150							

No.	Designation	Stage	Tolerance size Basic size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
5	Inlet									
	Valve guide bore installed		9.000 H8	0	+0.022	0.050	0.087			
	Valve stem Ø		8.950 h7	-0.015	0					
Re 2 and 3:	After press-fitting it into cylinder head, finish work on valve guide bore.									
Re 4	Permitted difference: Valve clearance to cylinder head underside per cylinder: up to -0.200 mm									

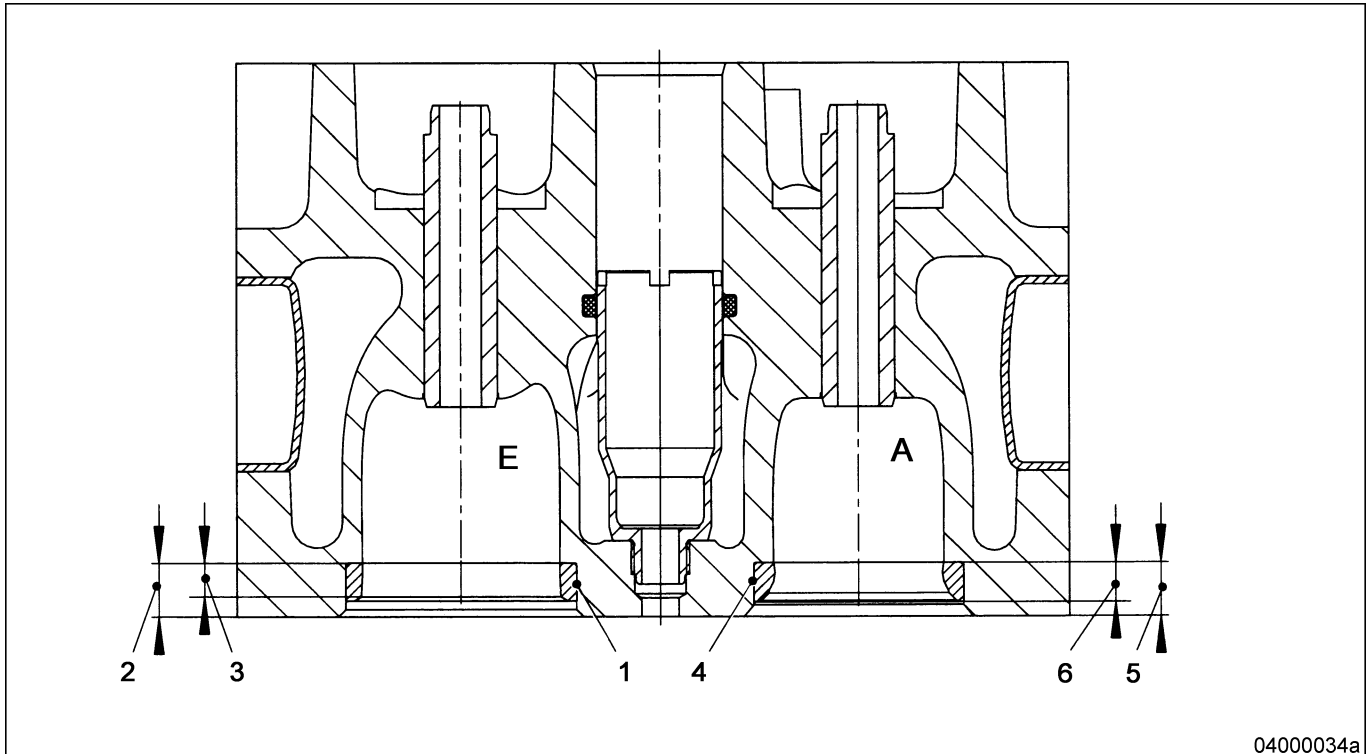
Inlet and exhaust valve seats



04000035a

No.	Designation	Stage	Tolerance size Basic size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
Inlet										
1	Valve seat diameter		42.000	-0.010	+0.010					
2	Valve seat depth		4.000	0	+0.150					up to min. 3.300
Exhaust										
3	Valve seat diameter		39.000	-0.010	+0.010					
4	Valve seat depth		3.800	0	+0.150					up to min. 3.100
5	Roughness value: R3z 6.3									
6	Concentricity: ∇ 0.04 to B									
7	Concentricity: ∇ 0.04 to A									
8	Roughness value: R3z 6.3									

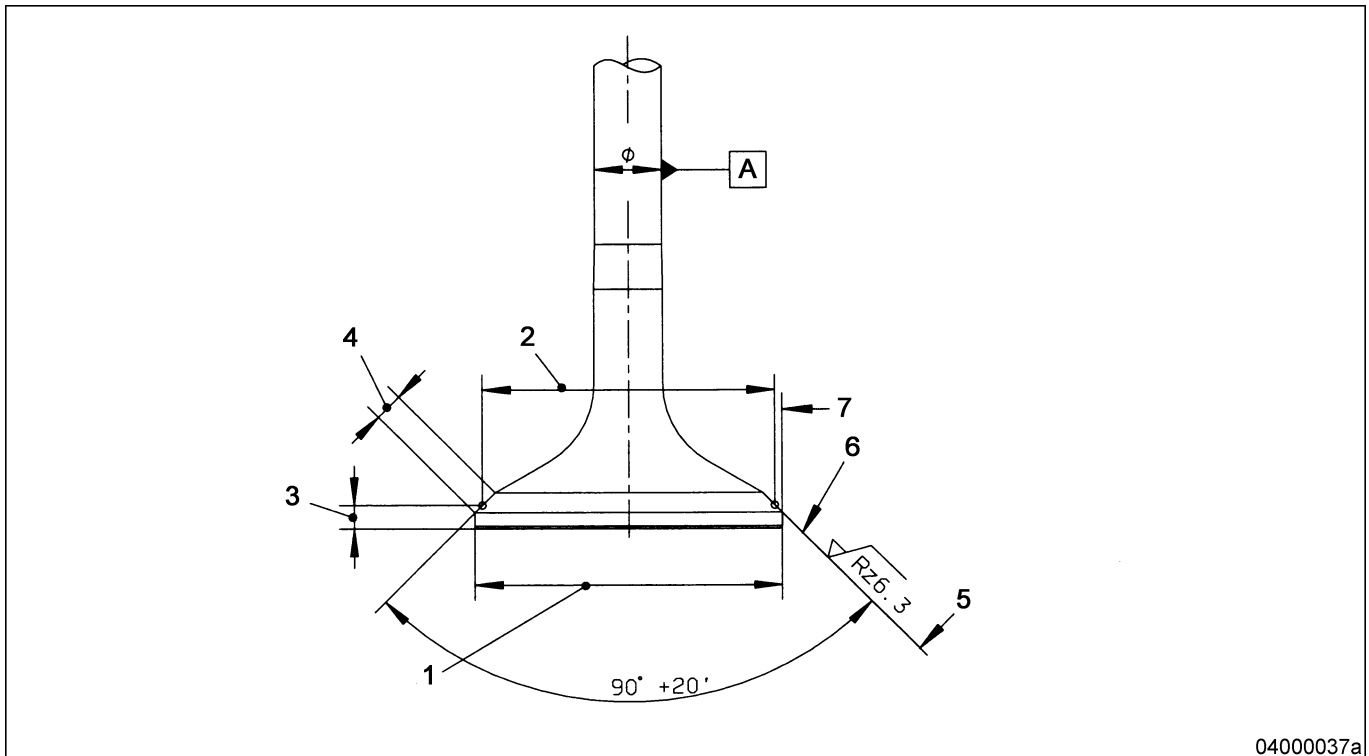
Inlet and exhaust valve seats



0400034a

No.	Designation	Stage	Tolerance size Basic size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
Inlet										
1	Cylinder head bore		47.300 H7	0	+0.025			0.065	0.110	
	Valve-seat insert Outer Ø		47.400	-0.010	+0.010					
2	Cylinder head Bore depth		11.000	-0.100	+0.100					
3	Valve seat ring height		7.700	-0.100	+0.100					
Exhaust										
4	Cylinder head bore		43.000 H7	0	+0.025			0.055	0.090	
	Valve-seat insert Outer Ø		43.090	-0.010	0					
5	Cylinder head Bore depth		11.000	-0.100	+0.100					
6	Valve seat ring height		8.100	-0.100	0					

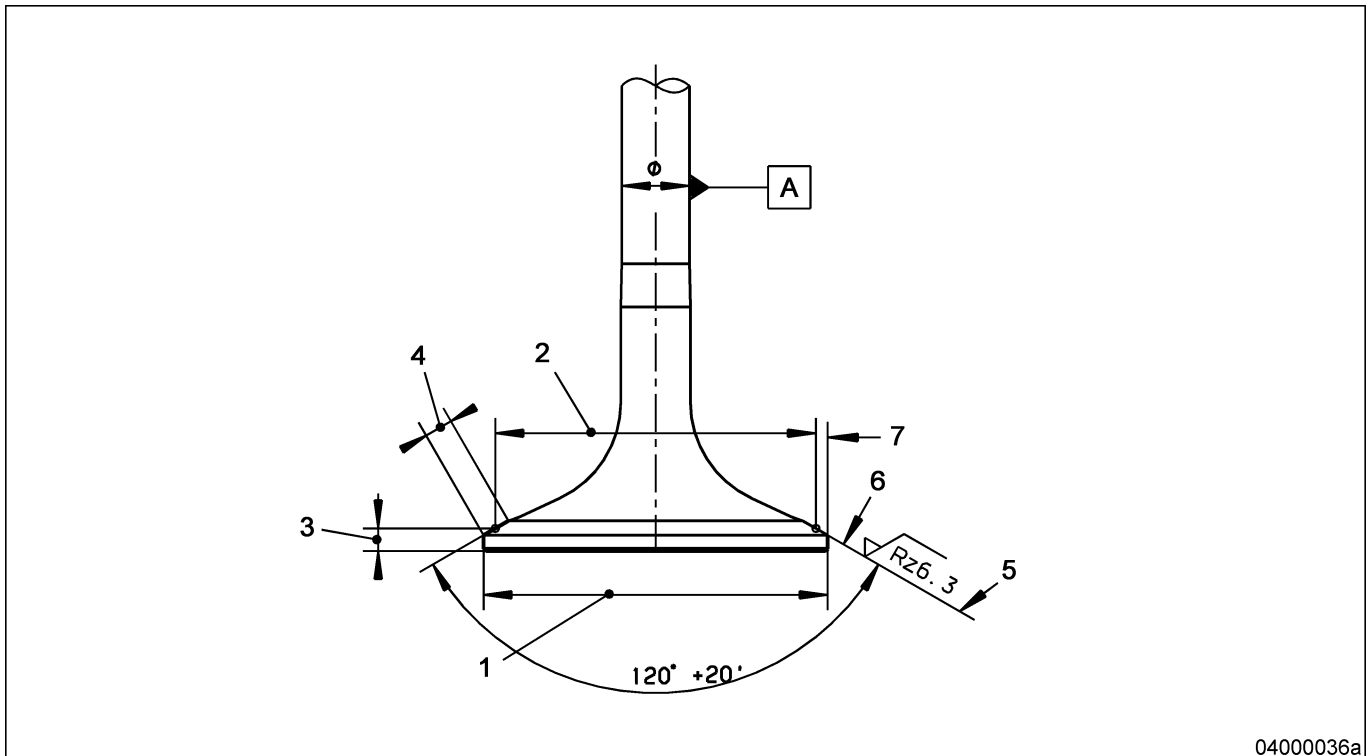
Exhaust valve



04000037a

No.	Designation	Stage	Tolerance size Basic size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
1	Valve head Outer Ø		41.100	-0.200	+0.200					
2	Reference dimension Valve seat Ø		39.000							
3	Reference dimension Valve seat height		3.100	-0.300	0					up to min. 2.400
4	Valve seat width		3.500							
Only rework valve seat height until a satisfactory surface has been achieved.										
5	Roundness: \bigcirc 0.010									
6	Concentricity: ⌢ 0.030 to A									
7	Concentricity: ⌢ 0.200 to A									

Inlet valve



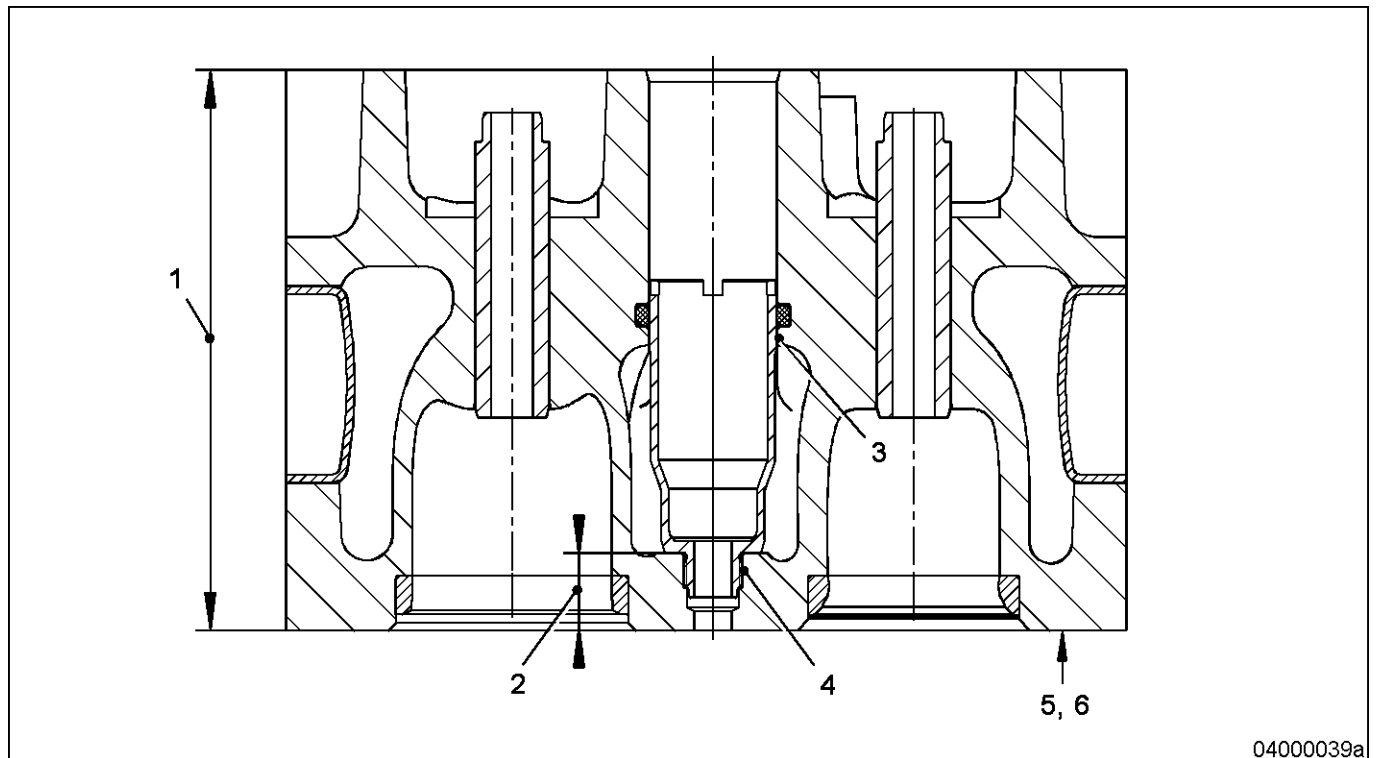
04000036a

No.	Designation	Stage	Tolerance size Basic size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
1	Valve head Outer Ø		45.600	-0.200	+0.200					
2	Reference dimension Valve seat Ø		42.000							
3	Reference dimension Valve seat height		3.300	-0.300	0					up to min. 2.600
4	Valve seat width		3.500							
Only rework valve seat height until a satisfactory surface has been achieved.										
5	Roundness: \bigcirc 0.010									
6	Concentricity: ⌢ 0.045 to A									
7	Concentricity: ⌢ 0.200 to A									

Rework instruction:

- Re 2 and 3: Only rework valve seat height until a satisfactory surface has been achieved.

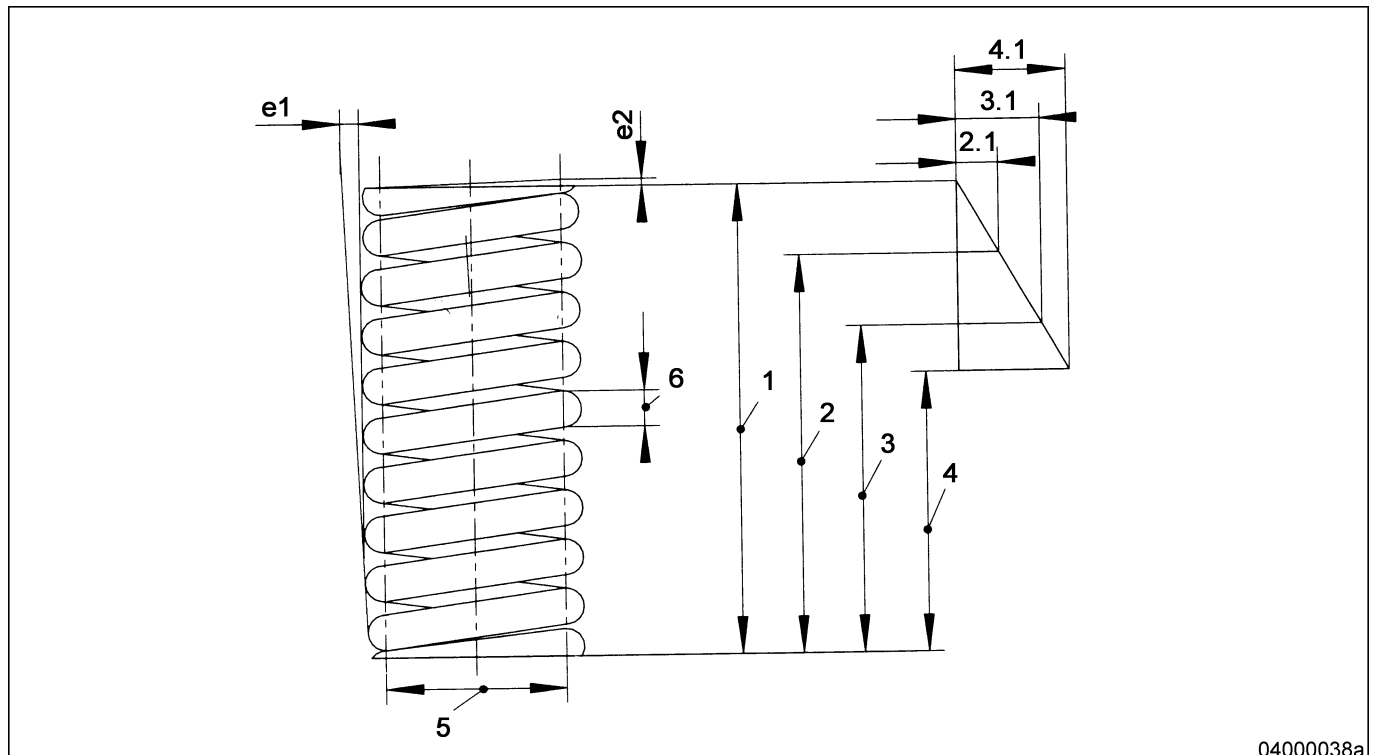
Mating face – protective sleeve



04000039a

No.	Designation	Stage	Tolerance size Basic size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
1	Cylinder head height		114.000	-0.150	+0.150					113.500
2	Protective sleeve mating surface		15.700	-0.100	+0.100					
3	Protective sleeve bore		26.000 H7	0	+0.021	0.100	0.173			
	Protective sleeve Outer Ø		25.900 h9	-0.052	0					
4	Thread		M14 x 1							
5	Flatness: 0.020/150									
6	Roughness value: R3z / Im40 Wt 10									

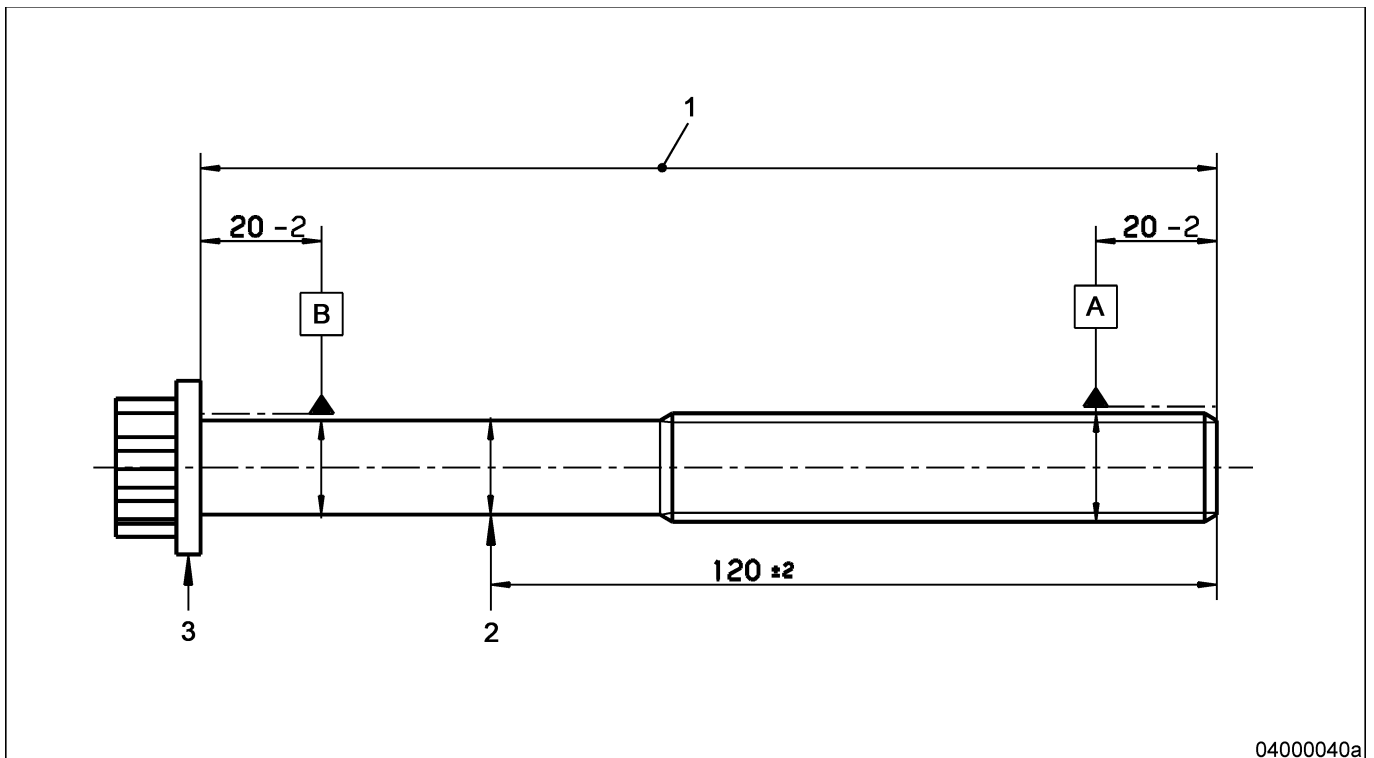
Inlet and exhaust valve springs



No.	Designation	Stage	Tolerance size Basic size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
1	Spring length released		69.700							
2	Spring length compressed		49.000							
2.1	Spring tension, loaded spring length 49.0		400.000 N	-18 N	+18 N					
3	Spring length compressed		37.000							
3.1	Spring tension, loaded spring length 37.0		675.000 N	-31 N	+31 N					
4	Spring length compressed		47.700							
4.1	Spring tension, loaded spring length 35.3		722.000 N							
5	Winding Ø		28.900							
6	Wire Ø		4.200							

No.	Designation	Stage	Tolerance size Basic size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
e1	permitted deviation of generating line from vertical position with spring unloaded									max. 2.090
e2	Spring seat, permitted parallelism deviation									max. 0.740

Cylinder head screws



04000040a

No.	Designation	Stage	Tolerance size Basic size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
1	Cylinder head screw		210.000	-0.500	0					max. length: 212.00
2	Concentricity: $\nabla 0.8/AB$									
3	Concentricity: $\nabla 0.8/AB$									

3.4.9 Cylinder head – Repair

Special tools






Designation / Use	Part No.	Qty.
Tool kit	F6783844	1
Tool kit	F6784110	1
Retaining device	F6554686	1
Reamer for valve guide Ø8.8 mm	F30543151	1
Reamer for valve guide Ø9.0 mm	F30543150	1
Floating tool holder MK2	F70007011	1
Centering tip MK3	F70000966	1
Extension sleeve MK3/MK3	F70000417	1
Taper reduction sleeve MK4/MK2	F70001021	1
Taper reduction sleeve MK4/MK3	F70000146	1
Taper reduction sleeve MK3/MK2	F70000073	1
Drift key MK1/MK2	F70000199	1
Drift key MK3	F70000200	1
Drift key MK4	F70000637	1
Reamer for valve guide in cylinder head	0005891853/00	1
Mandrel	5415890043/00	1
Punch for inlet valve seat	F30378880	1
Punch for exhaust valve seat	F30378881	1
Valve seat countersink for exhaust valve	F30378896	1
Valve seat countersink for inlet valve	F30450549	1
Removal tool	F30450454	1
Testing device	Y4341935	1
Plug gauge	Y20098136	1
Mounting plate for valve guides	F6784237	1
Gauge for exhaust valve	Y4346861	1
Gauge for inlet valve	Y4346862	1
Bottle brush		

Material

Designation / Use	Part No.	Qty.
Liquid nitrogen		
Corrosion inhibitor		

Spare parts

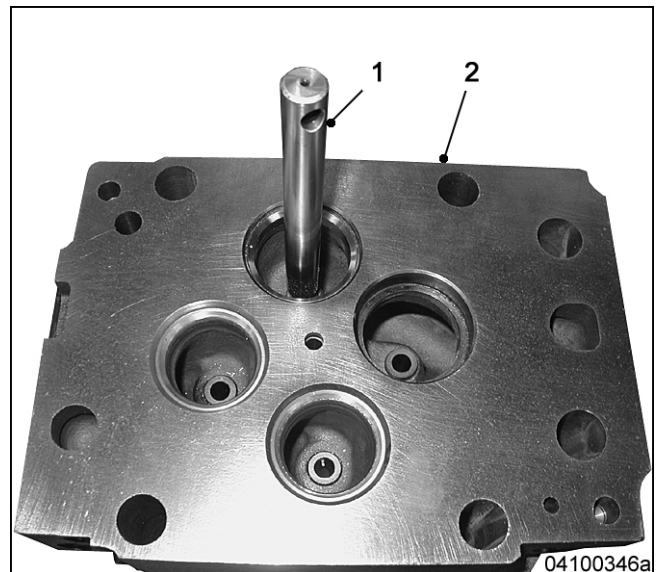
Designation / Use	Part No.	Qty.
Valve guide, inlet		
Valve guide, exhaust		
Valve-seat insert, inlet valve		
Valve-seat insert, exhaust valve		

 DANGER	Nitrogen is liquid (at -200°C). Risk of freezing and suffocation! <ul style="list-style-type: none">• Do not allow liquid nitrogen to come into contact with parts of body (eyes, hands).• Wear protective clothing, gloves, and goggles / safety mask.• Ventilate working area well.
 WARNING	Heavy object. Risk of crushing! <ul style="list-style-type: none">• Use appropriate lifting devices and appliances.
 WARNING	Component is hot. Risk of burning! <ul style="list-style-type: none">• Wear protective gloves.
 CAUTION	Contamination of components. Damage to component! <ul style="list-style-type: none">• Observe manufacturer's instructions.• Check components for special cleanliness.
 CAUTION	Incorrect installation of components and lines. Damage to component! <ul style="list-style-type: none">• Ensure that components/lines are installed so that they are never under tension or strain.• Ensure correct installation position of components.

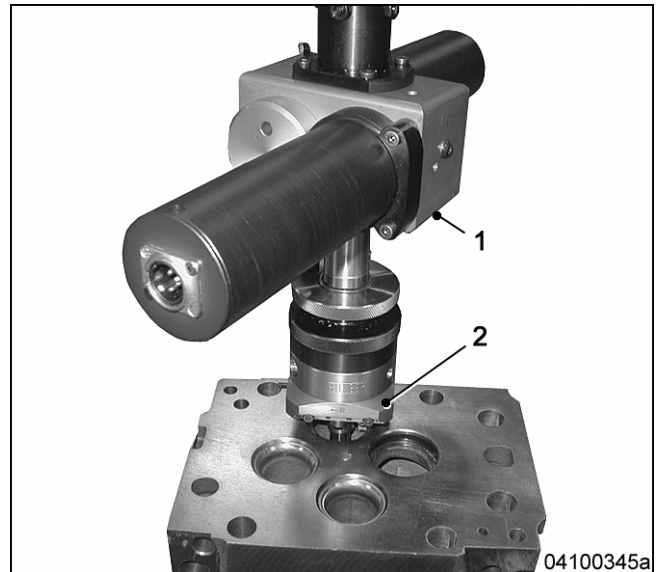
Check cylinder head (→ Page 309).

Removing valve-seat insert

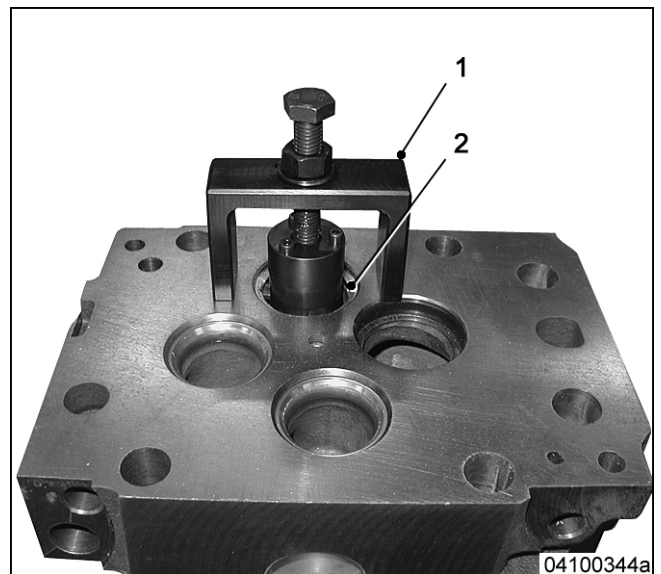
1. Clean valve guide using bottle brush.
2. Insert pilot (1) into valve guide of cylinder head (2) and secure.



3. Fit tool head (2) with turning tool on valve-seat turning machine (1).
4. Set up valve-seat turning machine (→ Page 295).
5. Fit valve-seat turning machine (1) on the pilot and mount steady rest.
6. Machine valve seat to facilitate installation of valve-seat insert removal tool.
7. Remove steady rest, valve-seat turning machine (1) and pilot.

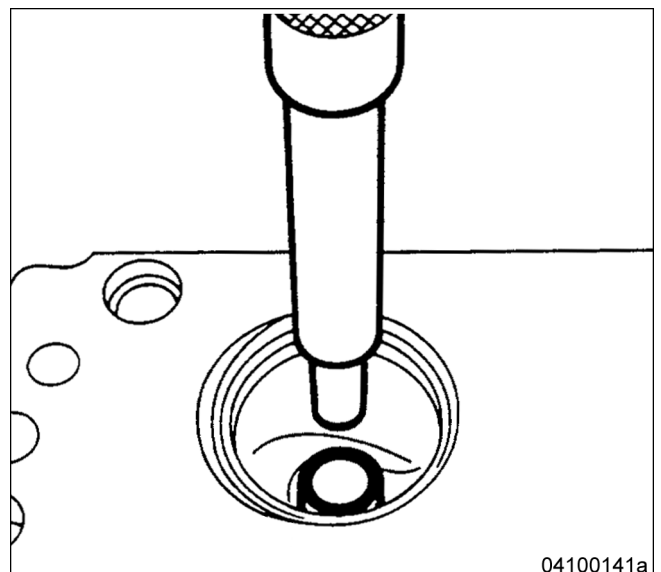


8. Mount valve-seat insert (1) on the valve-seat insert (2) to be removed.
9. Remove valve-seat insert (2) using extractor (1).
10. Check valve-seat bore (2) in cylinder head. Values (→ Page 311). Fit new cylinder head in the event of dimensional deviation.



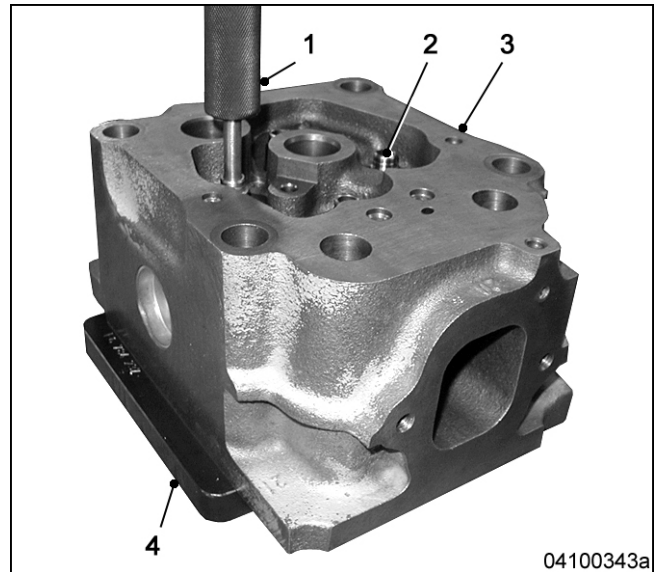
Removing valve guide

1. Place cylinder head on hydraulic press. Ensure correct cylinder head side mating.
2. From the combustion side, press valve guide out of cylinder head with removal tool.
3. Check valve guide bore in cylinder head. Values (→ Page 311). Rework to next stage in the event of dimensional deviation.
4. Clamp cylinder head in boring mill.
5. Ream valve guide bores in cylinder head with chucking reamer.

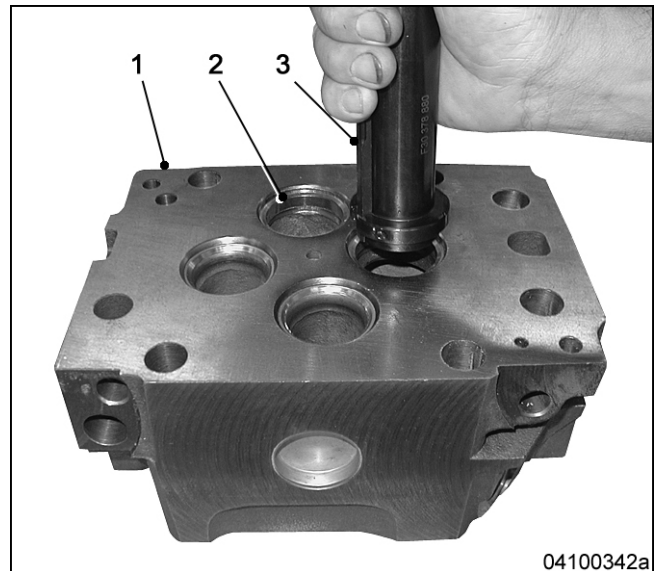


Installing valve guide

1. Prepare water for water bath with corrosion inhibitor.
2. Place cylinder head (3) in water bath heated to 80 °C until cylinder head (3) has warmed up.
3. Chill valve guide (2) in liquid nitrogen for approx. 20 to 30 minutes.
4. Place heated cylinder head (3) onto installation device (4).
5. Use mandrel (1) to install chilled valve guide (2) in cylinder head bore (3) up to the stop of the installation device (4).

**Installing valve-seat insert**

1. Prepare water for water bath with corrosion inhibitor.
2. Place cylinder head (1) in water bath heated to 80 °C until cylinder head (1) has warmed up.
3. Chill valve-seat insert (2) in liquid nitrogen for approx. 20 to 30 minutes.
4. Place heated cylinder head (1) on a suitable surface.
5. Use installation mandrel (3) to insert chilled valve-seat insert (2) in cylinder-head bore (1) up to the stop.



Machining valve guides to finished dimension

Note: Do not displace the cylinder head after alignment.

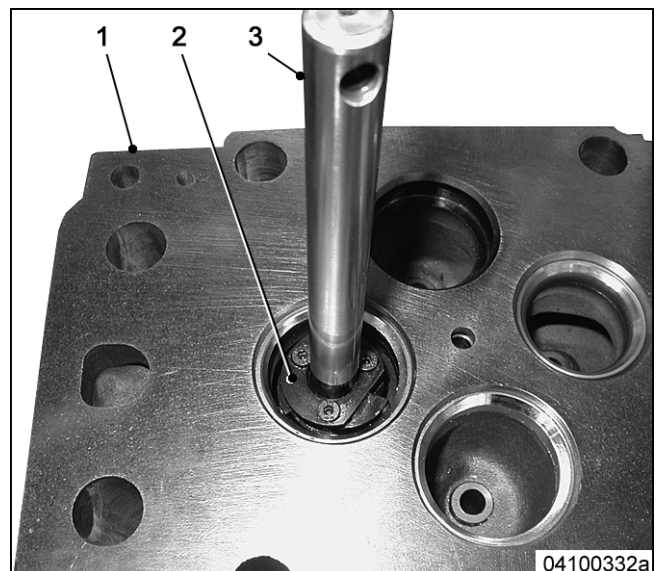
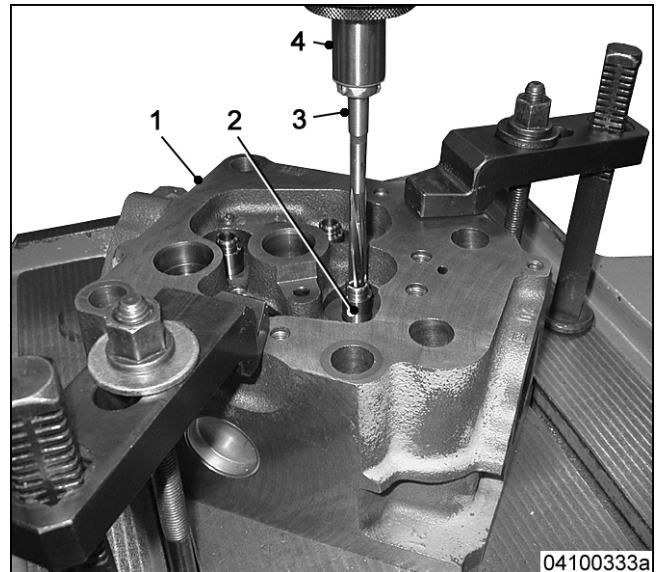
1. Clamp cylinder head (1) in boring mill and align the valve guide (2) to be machined with centering tip.
2. Remove centering tip and install reamer (3) $\text{\O}8.8$ mm with floating tool holder (4) in boring mill.
3. Machine valve guide (2) with reamer (3) $\text{\O}8.8$ mm.
4. Remove reamer (3) $\text{\O}8.8$ mm and install reamer $\text{\O}9.0$ mm with floating tool holder (4) in boring mill.
5. Machine valve guide (2) with reamer $\text{\O}9.0$ mm.
6. Remove reamer $\text{\O}9.0$ mm.

Note: Go-end plug gauge must move easily through the whole valve guide. Insertion of the no-go-end must not be possible.

7. Check valve guides (2) with plug gauge.

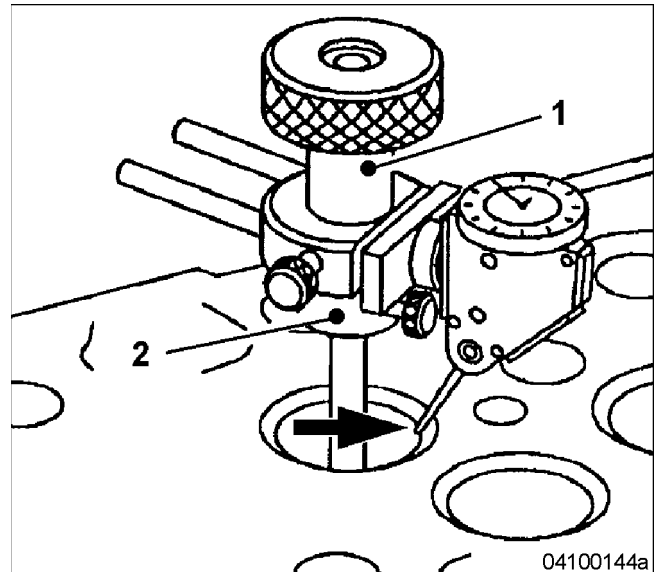
Machining valve-seat insert

1. Clean valve guide using bottle brush.
2. Insert pilot (3) with supporting spider (2) in valve guide of cylinder head (1) and secure.
3. The machining procedure for the valve-seat insert is identical with that for valve-seat removal, only the tool head to be used is different \rightarrow 3.
4. Remove pilot (3) and supporting spider (2) from valve guide.
5. Machine valve-seat insert with the appropriate countersink.



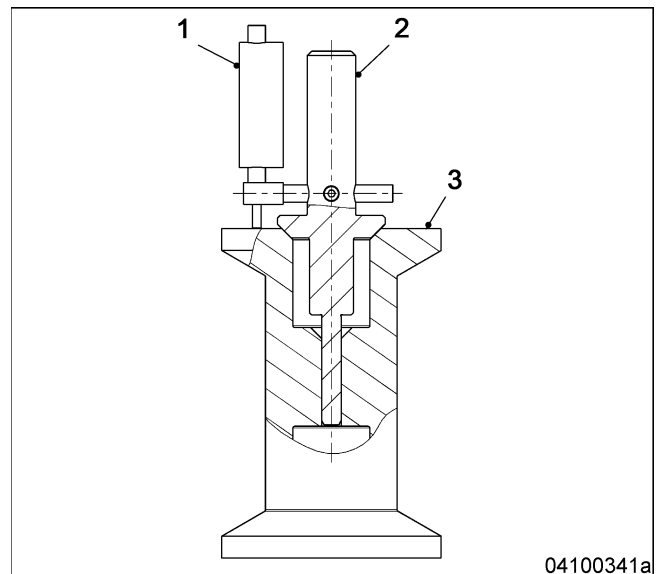
Checking concentricity of valve seat

1. Insert pilot into valve guide.
2. Mount clamp ring (2) over the inserted pilot and secure firmly in position.
3. Mount the testing device (1) on the clamp ring.
4. Set feeler of testing device with preload on valve seat center (arrowed).
5. Check concentricity of valve seat in relation to valve guide. Values (→ Page 311).
6. In event of deviation from test values, rework valve seat again.
7. Remove testing device (1), clamp ring (2) and pilot.
8. Clean cylinder head after machining.



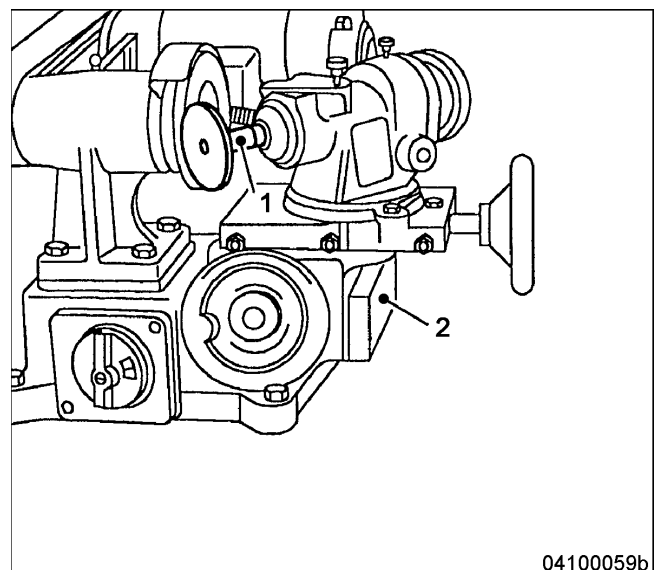
Measuring valve seat depths

1. Set the distance between plug gauge (2) to ring gauge (3).
2. Set scale on dial gauge (1) to zero.
3. Measure valve seat depths.
4. If the values (→ Page 311) are exceeded, fit new cylinder head.



Regrinding valve seats on valve heads

1. Mount valve (1) as directly as possible behind valve head in valve grinding machine (2).
2. Set valve seat grinding angle on valve grinding machine.
3. Grind valve seat with slight advance until valve seat is smooth and free from chatter marks over the entire circumference.
4. Measure height of outside edge of valve seat and width of valve seat. Values (→ Page 311) Fit new valve in the event of dimensional deviation.



3.4.10 Cylinder head – Assembly

Special tools




Designation / Use	Part No.	Qty.
Socket	F30377657	1
Valve lifter	4425890031/00	1
Retaining device	F6554686	1
Drift	F30377883	1
Expander	F30377930	1
Dial-gauge holder	3435890040/00	1
Dial gauge		

Material

Designation / Use	Part No.	Qty.
Petroleum jelly, white		
Engine oil		

Spare parts

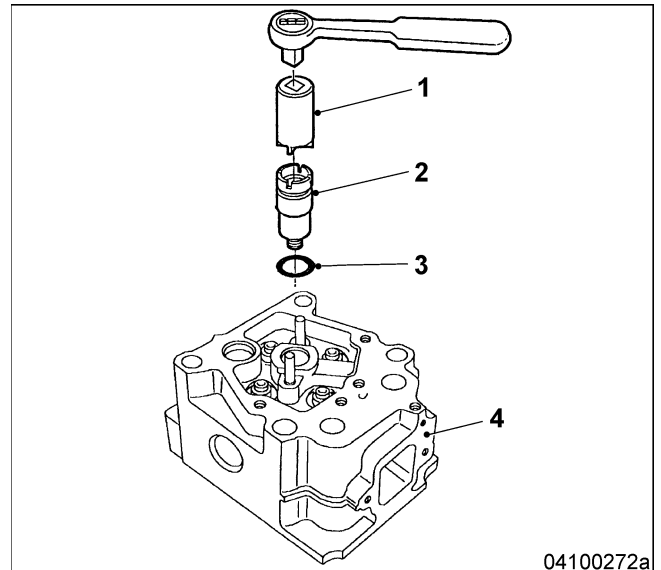
Designation / Use	Part No.	Qty.
O-ring		
Sealing ring		

 WARNING	Spring/circlip/tensioning roller preload. Risk of injury! <ul style="list-style-type: none"> • Only use specified tool and equipment.
 WARNING	Heavy object. Damage to equipment due to falling components! <ul style="list-style-type: none"> • Ensure that all components are secured during removal and installation work.
 CAUTION	Contamination of components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Check components for special cleanness.

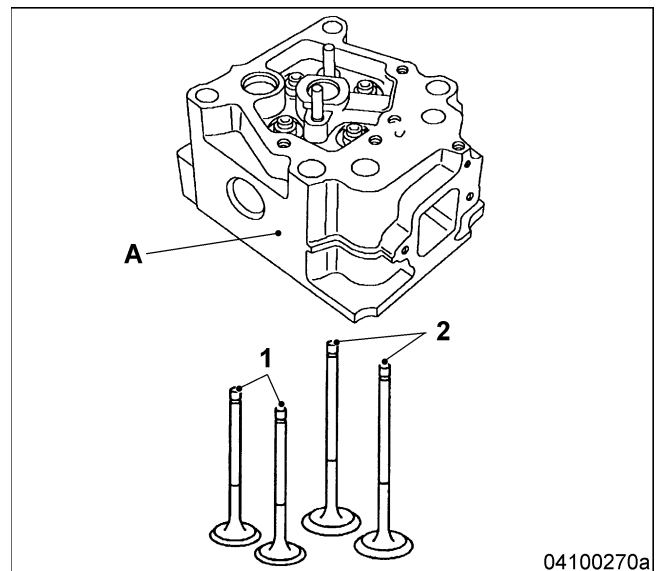
Service cylinder head (→ Page 309).

Installing protective sleeve

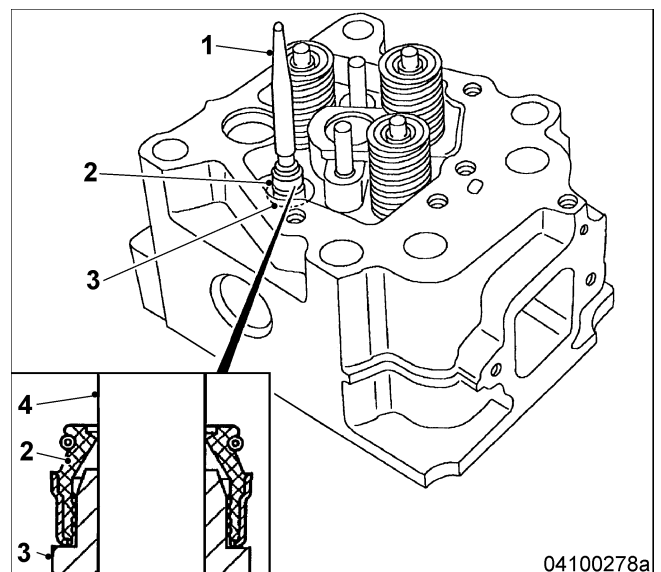
1. Clamp cylinder head.
2. Clean sealing faces.
3. Coat O-rings (3) with petroleum jelly and insert into cylinder head groove (4).
4. Use wrench insert (1) to screw protective sleeve (2) into cylinder head and tighten with torque wrench to prescribed tightening torque (→ Page 23).

**Installing valves**

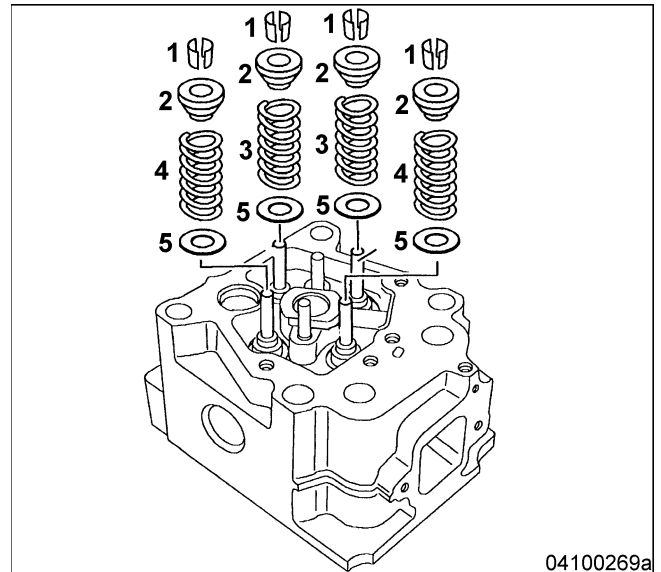
1. Lay cylinder head on its side (A).
2. Wipe valves (1) and (2) with chamois leather and coat valve stems with engine oil.
3. Insert valves in valve guide. Observe arrangement of valves.



4. Insert cylinder head in retaining device.
5. Insert gasket (2).
6. Use expander (1) and drift to press in manually up to stop on valve guide (3).
7. Check if gasket (2) is positioned securely.
8. Remove expander (1).

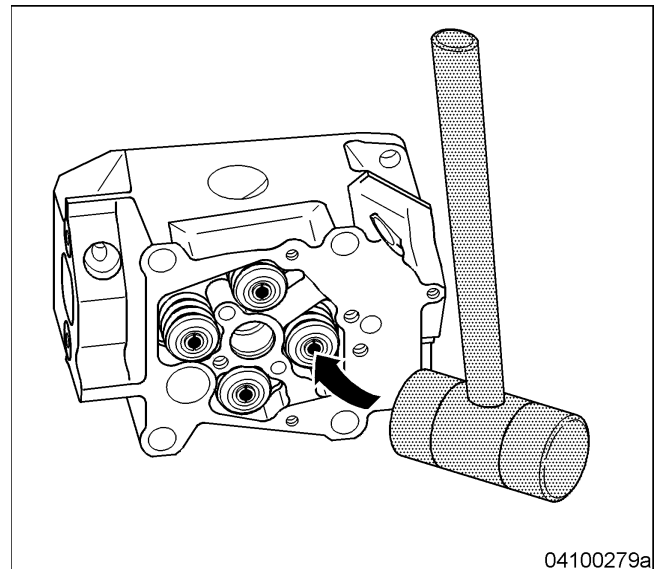


9. Put washer (5) on valve guide.
10. Place valve springs (3) and (4) on to washer (5) with colored marking facing upwards.
11. Place spring retainer (2) on to valve spring.
12. Install valve lifter.
13. Insert valve collets (1) into spring retainer (2) and center.
14. Ensure that valve collet lip (1) is securely positioned.
15. Relieve valve spring (4) of tension.
16. Remove holding plate and valve lifter.



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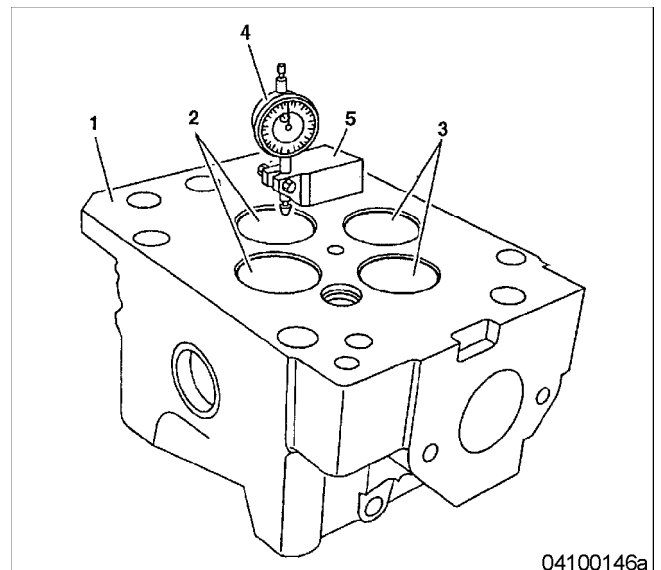
17. Lay cylinder head on its side.
 18. Ensure that valves operate correctly.
 19. Hit valve stem lightly with plastic mallet.
- Result: Valve collets are in groove of valve neck.



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Measuring valve clearance to cylinder head

1. Install dial gauge (4) in dial-gauge holder (5).
2. Place dial gauge (4) with initial tension on to end face of cylinder head (4).
3. Set dial gauge to zero.
4. Place tracer pin on valve heads of valves (2) and (3) and measure clearance between valve and end face.
5. If recorded value is out of tolerance range (→ Page 311) then check valve seat on cylinder head and valve head.



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3.4.11 Cylinder head – Installation

Special tools

Designation / Use	Part No.	Qty.
Rotation angle measuring device	Y20044010	1
Socket	F30907150	1

Material

Designation / Use	Part No.	Qty.
Engine oil		

Spare parts

Designation / Use	Part No.	Qty.
Clamping sleeve		
Gasket		



Components have sharp edges.

Risk of injury!

- Wear protective gloves.



Heavy object.

Risk of crushing!

- Use appropriate lifting devices and appliances.



Contamination of components.

Damage to component!

- Observe manufacturer's instructions.
- Check components for special cleanliness.



Contamination in blind hole.

Damage to component!

- Inspect and clean blind hole.

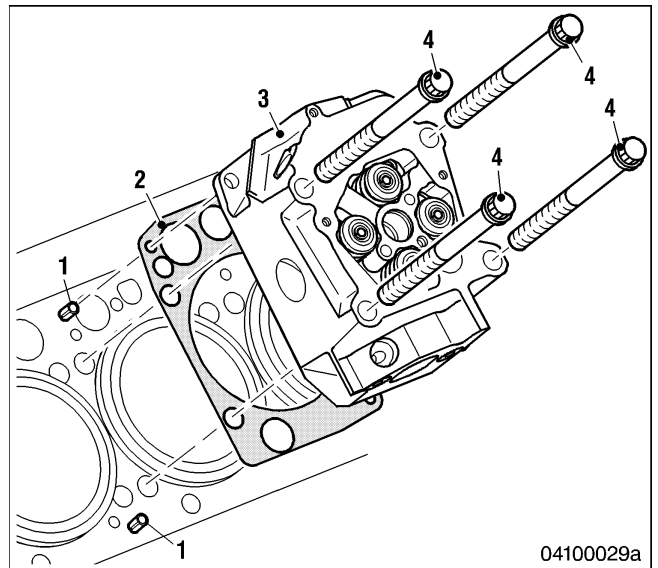
Assemble cylinder head (→ Page 326).

Installing cylinder head

1. Drive clamping sleeves (1) into crankcase up to stop.
2. Install cylinder head gasket (2).
3. Position cylinder head (3) on cylinder head gasket (2).
4. Coat threads, head mating face and shaft of double-hex screw (4) with engine oil.
5. Install double-hex screw (4) by hand into crankcase.

Note: To check the angle of rotation, mark screw head of double-hex screw with paint following pre-tightening.

6. Evenly tighten double-hex screw (4). Ensure correct tightening sequence and tightening torque (→ Page 23).



Final steps

For these steps a distinction must be made as to whether

- 1 the engine has been completely disassembled
- 2 the engine has been removed but not disassembled
- 3 the engine has remained installed

1	2	3	Operations	See
X	–	–	Assemble engine.	(→ Page 58)
X	–	–	Install engine.	(→ Page 60)
–	X	X	Perform installation in reverse sequence of work steps as described for removal.	(→ Page 303)
–	–	X	Fill with engine coolant.	(→Operating instructions)
–	–	X	Fill with fuel.	(→Operating instructions)
–	–	X	Enable engine start.	–

3.4.12 Cylinder head seals – Repair

Special tools





Designation / Use	Part No.	Qty.
Drift	F30378878	1

Material

Designation / Use	Part No.	Qty.
Cleaning agent		
Loctite 270		

Spare parts

Designation / Use	Part No.	Qty.
Plug		

 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> Do not direct compressed-air jet at persons. Wear protective goggles / safety mask and ear protectors.
 WARNING	Heavy object. Risk of crushing! <ul style="list-style-type: none"> Use appropriate lifting devices and appliances.
 WARNING	Components have sharp edges. Risk of injury! <ul style="list-style-type: none"> Wear protective gloves.
 CAUTION	Contamination of components. Damage to component! <ul style="list-style-type: none"> Observe manufacturer's instructions. Check components for special cleanliness.

Check cylinder head (→ Page 309).

Replacing plug

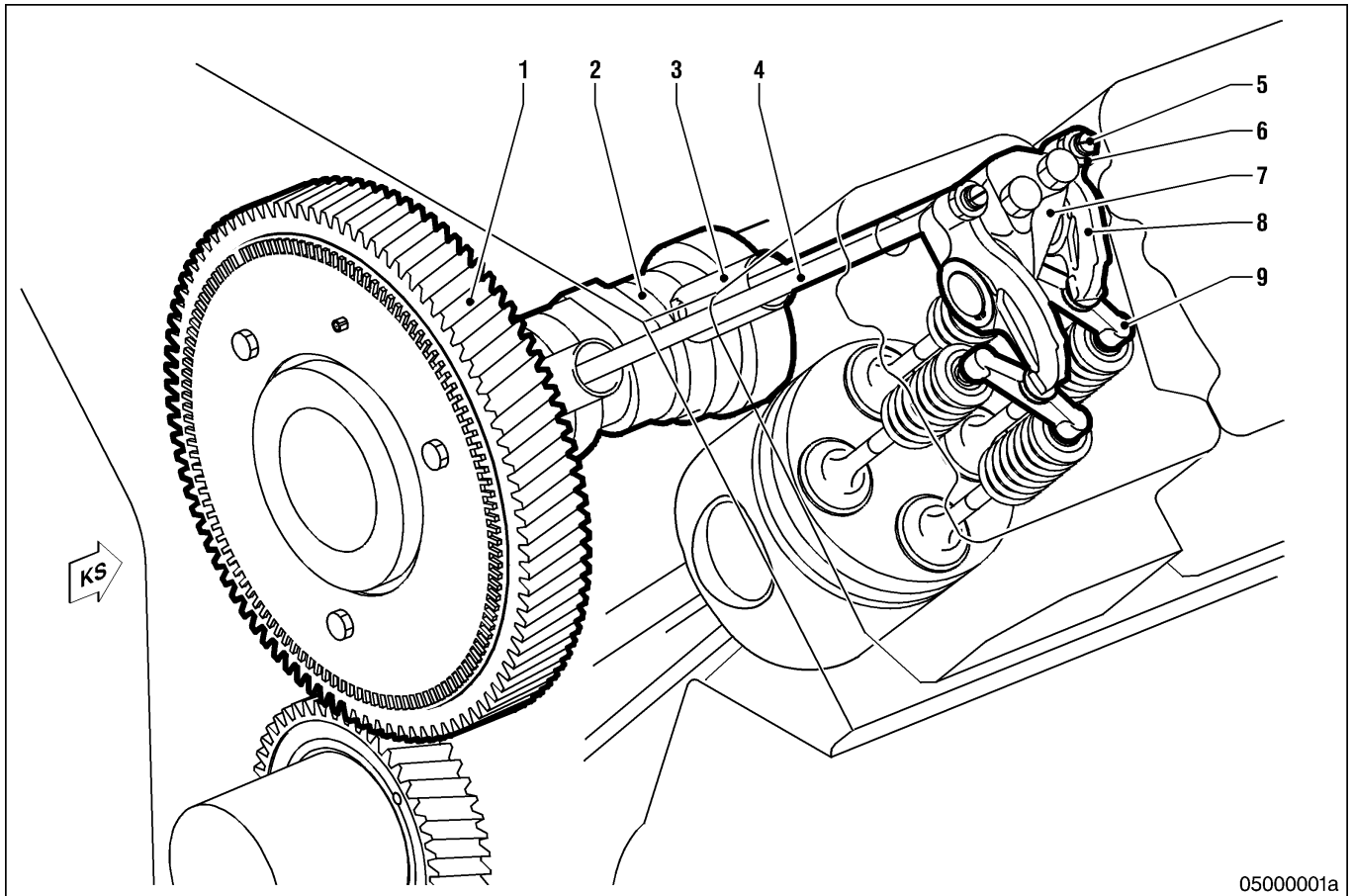
Note: Replace plug only if necessary.

1. Twist plug off using a boring mill.
2. Clean water chambers.
3. Blow out water chambers with compressed air and check for dirt.
4. Degrease and dry mating surface on new plug and cylinder head bore.
5. Coat plug mating surface with Loctite.
6. Use drift to hit plug evenly into cylinder head bore.
7. Check cylinder head for leaks (→ Page 309).

3.5 Valve Gear

3.5.1 Valve gear – Overview

Valve gear – Overview

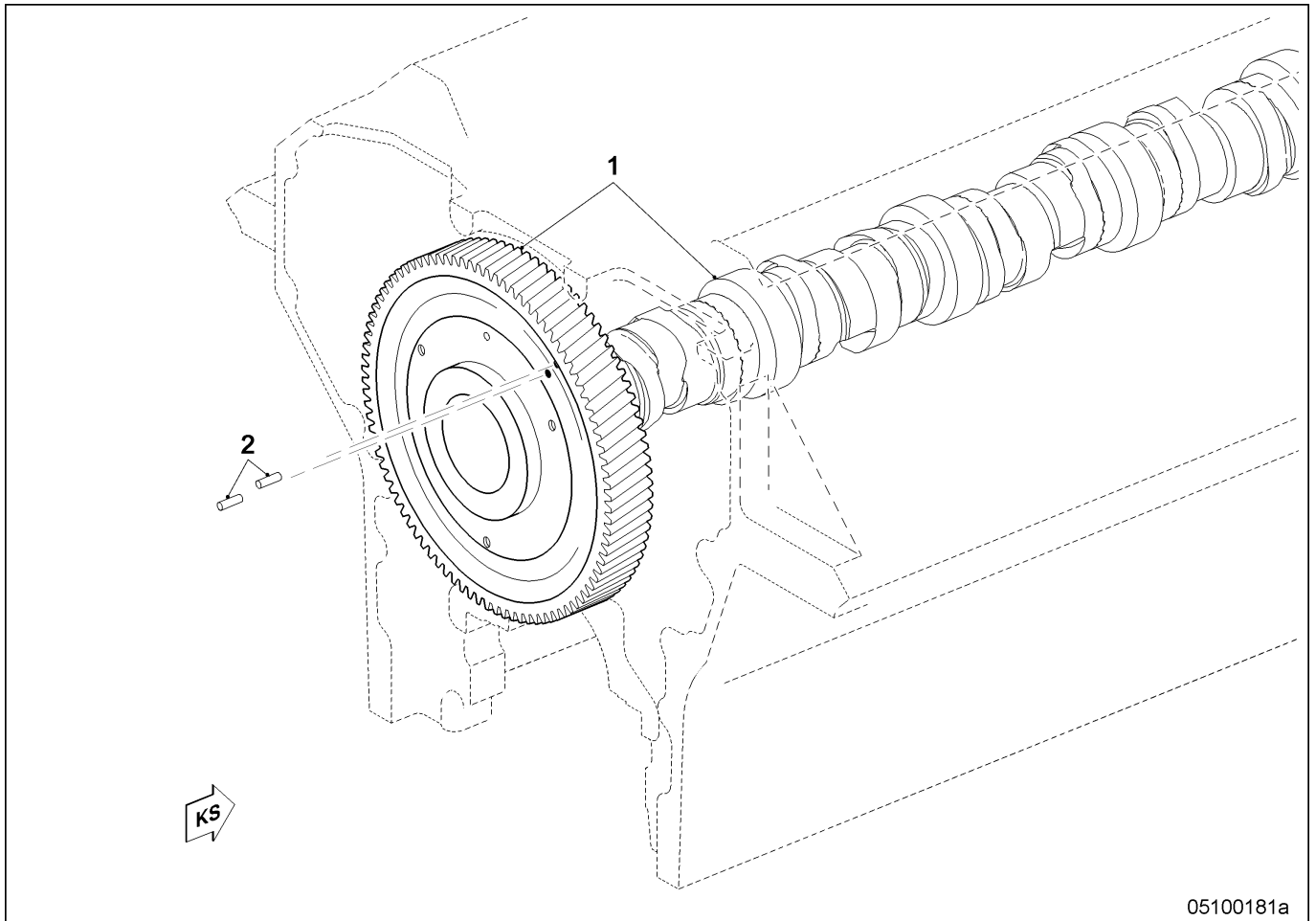


- 1 Camshaft gear
- 2 Camshaft
- 3 Roller tappet

- 4 Pushrod
- 5 Adjusting screw
- 6 Nut

- 7 Rocker arm, inlet
- 9 Valve bridge

3.5.2 Camshaft – Overview



1 Camshaft and camshaft gear

2 Dowel pin

3.5.3 Camshaft – Removal

Preconditions

- Engine is stopped and starting disabled

Special tools

Designation / Use	Part No.	Qty.
Installation/removal device for camshaft	F6554679	1
Guide mandrel for camshaft	F6557148	1



Heavy object.

Risk of crushing!

- Use appropriate lifting devices and appliances.

Preparatory steps

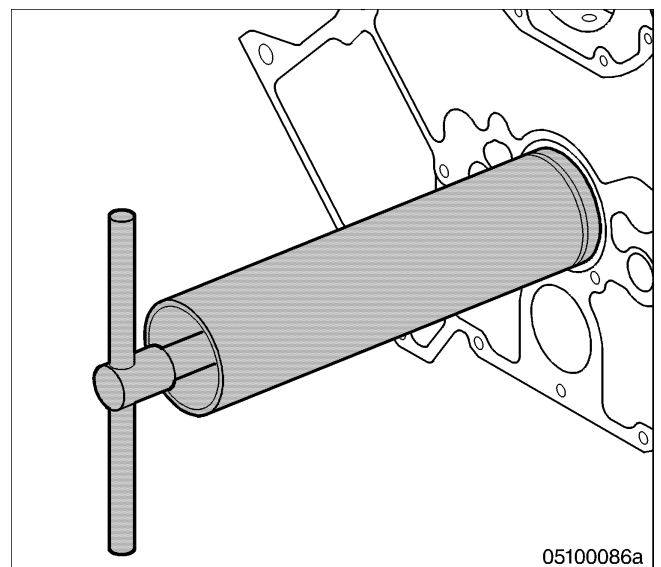
For these steps a distinction must be made as to whether

- 1 the engine is to be completely disassembled
- 2 the engine is to be removed but not disassembled
- 3 the engine is to remain installed

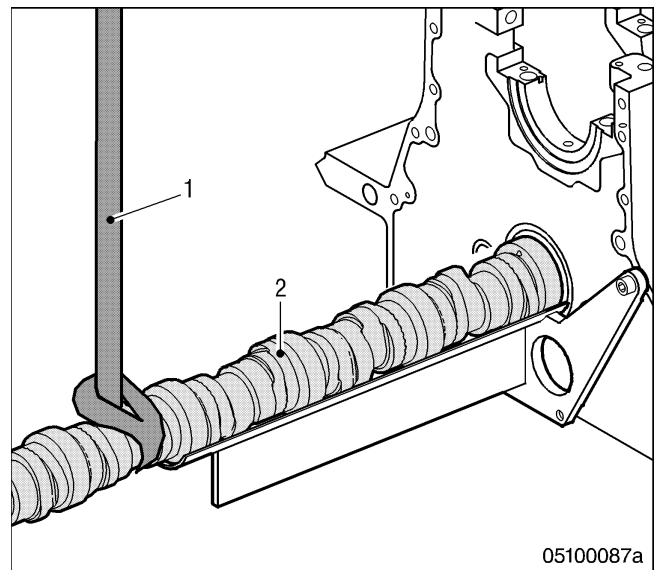
1	2	3	Operations	See
X	–	–	Remove engine.	(→ Page 55)
X	–	–	Disassemble engine.	(→ Page 56)
–	X	X	No removal.	–

Removing camshaft

1. Screw guide mandrel into front face of the camshaft installed into the crankcase.
2. Make sure it fits perfectly.




3. Carefully pull camshaft (2) approx. 500 mm out of the crankcase.
4. Install installation device.
5. Carefully pull camshaft (2) out of crankcase until rope (1) can be attached to the middle of camshaft (2).
6. Slightly tension rope (1) and carefully pull camshaft (2) out of crankcase.
7. Remove guide mandrel and installation device.



3.5.4 Camshaft – Cleaning

Material

Designation / Use	Part No.	Qty.
Cleaning agent		

 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors.
---	---

Remove camshaft (→ Page 334).

Camshaft – Cleaning

1. Clean all components with cleaning agent.
2. Remove cleaning agent.
3. Thoroughly blow out camshaft and threads with compressed air.

3.5.5 Camshaft – Check

Special tools

Designation / Use	Part No.	Qty.
Hardness test unit (e.g. Microdur test unit)		
Magnifying glass		
Dial gauge		

Material

Designation / Use	Part No.	Qty.
Fluorescent dye for magnetic crack testing		
Red penetrant dye for surface crack testing		

Spare parts

Designation / Use	Part No.	Qty.
Camshaft		
Camshaft gear		

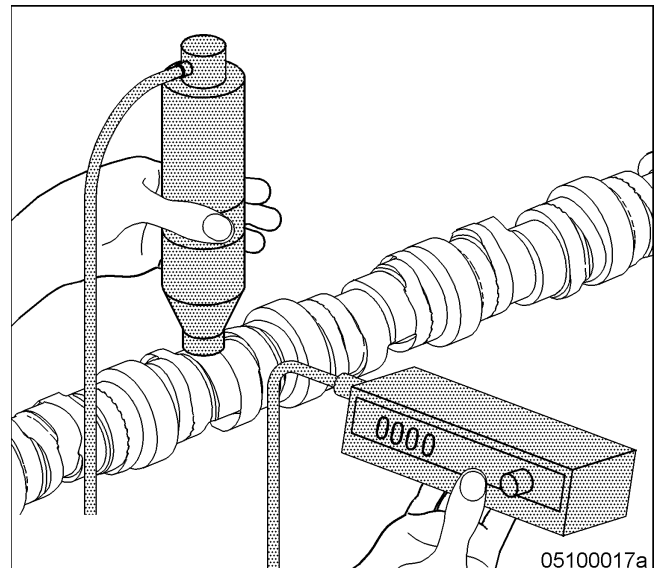
Clean camshaft (→ Page 336).

Checking camshaft

Item	Findings	Task
Using the magnetic crack-testing method, check camshaft for cracks.	Cracks apparent	Replace camshaft.
Using the surface crack-testing method, check thrust bearing flange for cracks.	Cracks apparent	Replace camshaft.
Check mating face of camshaft gear.	Traces of wear visible.	<ul style="list-style-type: none"> • Rework: Smooth with oilstone or emery cloth. • Replace
Check axial sliding surface, journal faces and roller tracks of cams for scoring, wear and indentations.	<ul style="list-style-type: none"> • Scores • Traces of wear • Indentations visible 	Replace camshaft.
Check tooth flanks of camshaft gear with magnifying glass.	Damaged	Replace camshaft.
Camshaft gear: Check pins for speed sensor for damage.	Damaged	Replace.

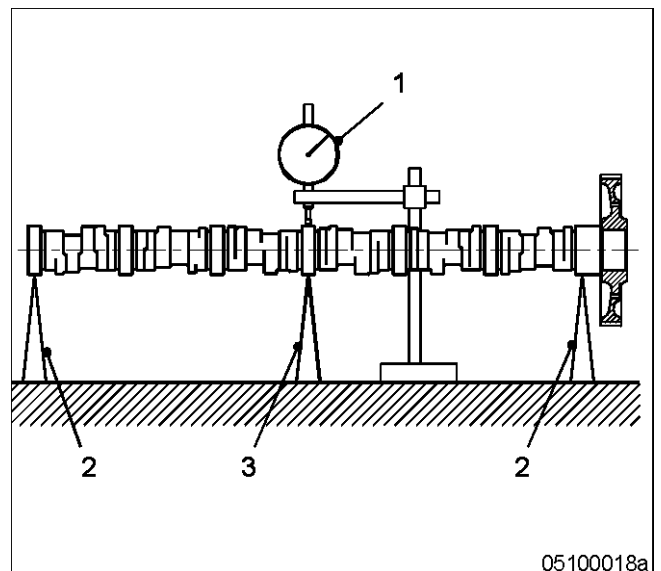
Checking hardness of cams and journals

1. Use hardness test unit to test cam hardness (inlet/exhaust rocker arms) and journals. Required hardness: 60 HRC \pm 2 HRC
2. Test hardness of each journal at four points at 90° intervals around circumference.
3. Replace camshaft if values are not attained.



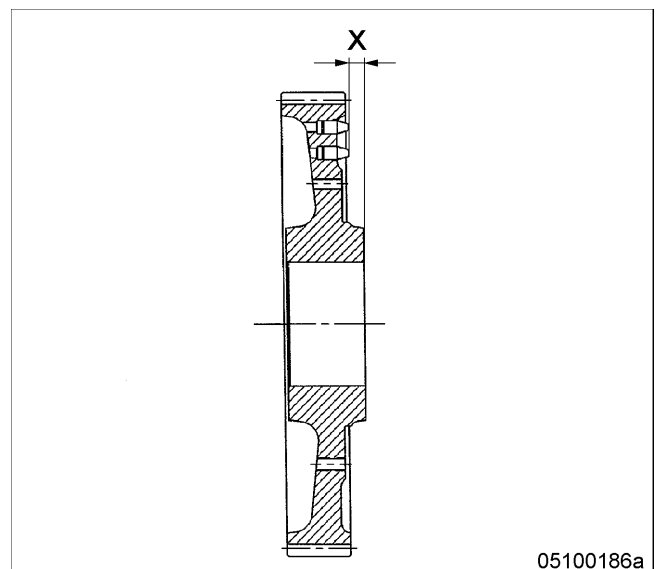
Checking concentricity and cam lift

1. Set camshaft at outer journals on prisms (2) or roller stands.
2. Place supporting mount (3) at center journal.
3. Measure radial runout of cam base circle and bearings with dial gauge (1). Values (\rightarrow Page 339).



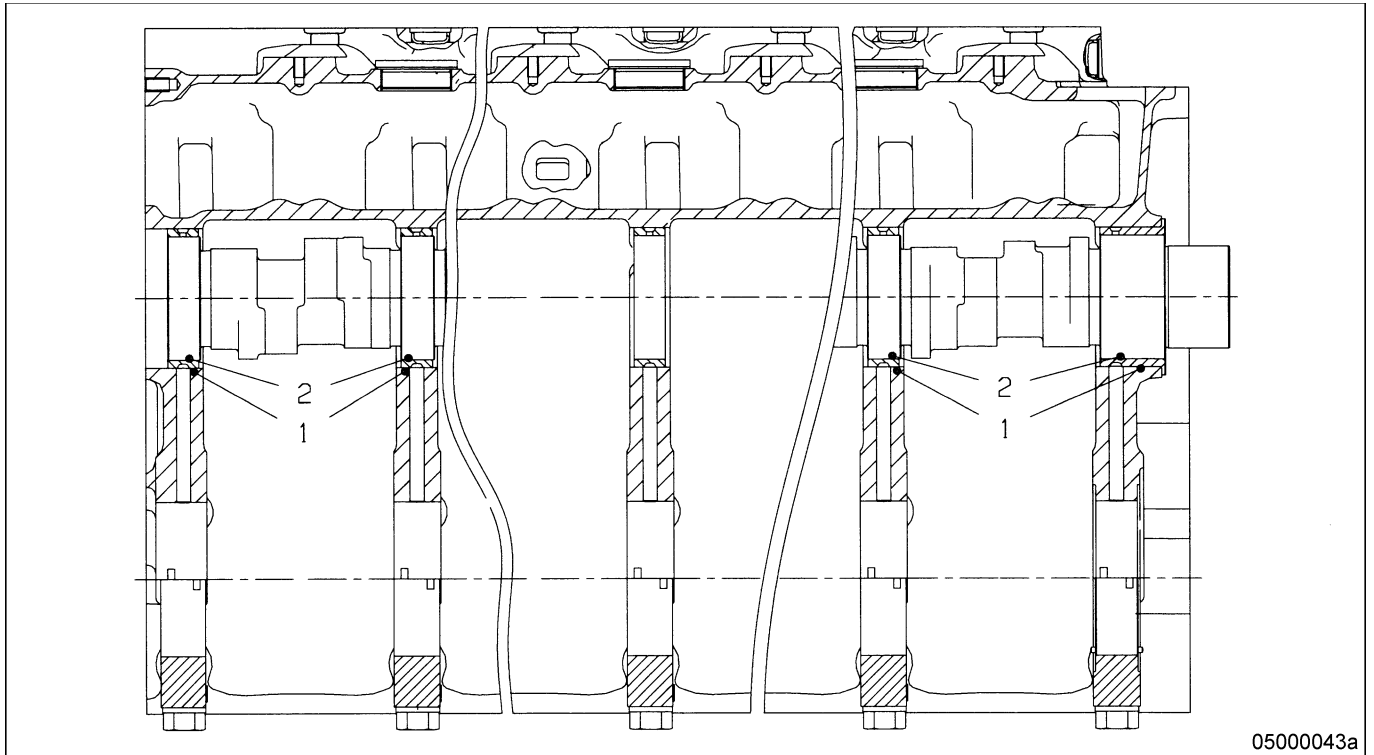
Checking pin protrusion

1. Measure dimension x (8.6 mm to 8.8 mm).
2. If the value is exceeded, replace pin(s).



3.5.6 Camshaft – Tolerances

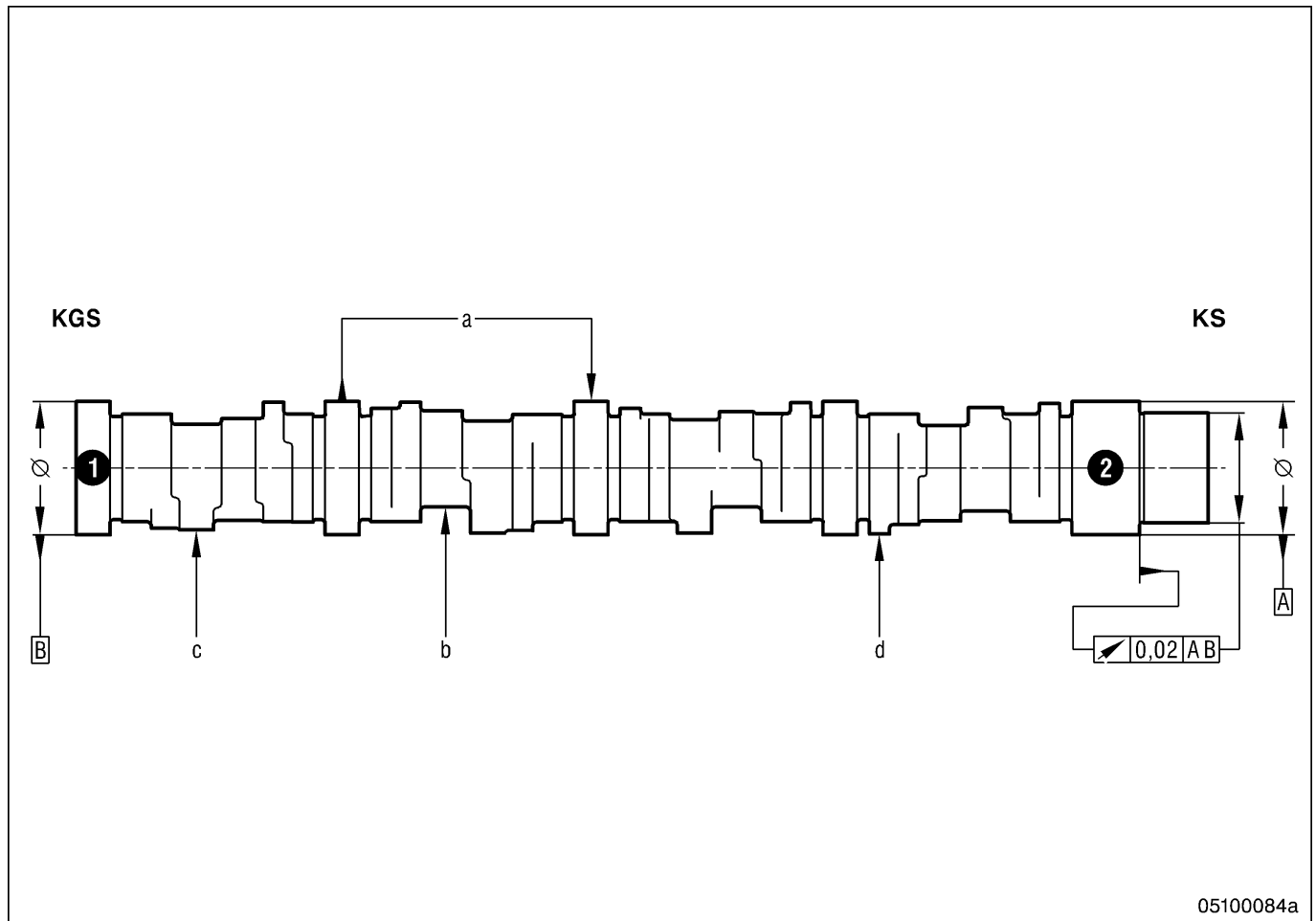
Camshaft bearings



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No.	Designation	Stage	Tol. size Basic size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
1	Crankcase bore	0-0	104.000 H6	0	+0.022			0.043	0.084	
		1-0	104.500 H6							
	Camshaft bearing OD removed	0-0	104.065	0	+0.019					
		1-0	104.565							
2	Camshaft bearing installed			92.020	92.065	0.090	0.175			
	Camshaft OD			91.890	91.930					

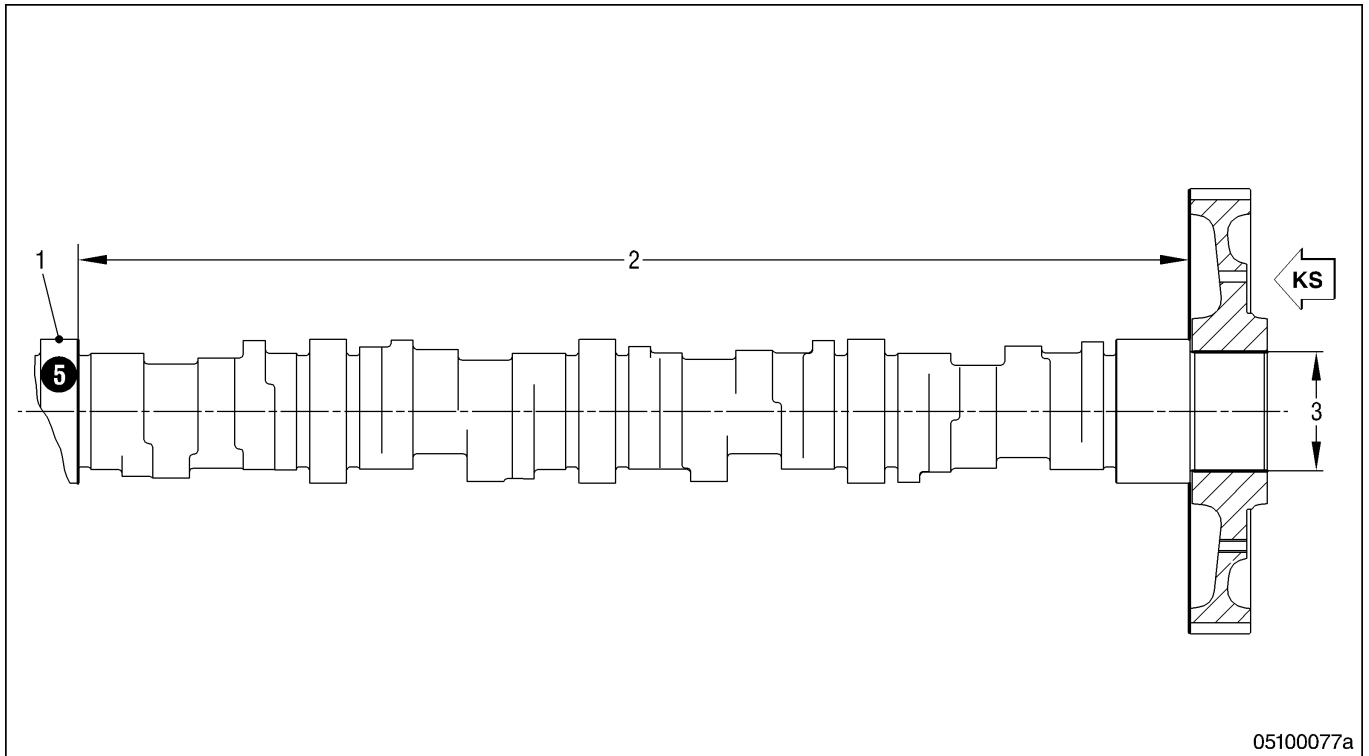
Bearing coaxiality



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Max. permissible deviation of concentricity	New	Wear limit	Cylinders
During the concentricity check, provide supports for and align the following bearings. <ul style="list-style-type: none"> • 12V: bearing 4, beginning at driving end • 16V: bearing 5, beginning at driving end 			
from bearing 1 to bearing 2	∇ 0.013		
a from bearing to bearing	∇ 0.050		
b all cams on the base circle	∇ 0.050		
c all pump cams	∇ 0.008		
d all control cams	∇ 0.005		

Camshaft gear



No.	Designation	Stage	Tol. size Basic size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
1	Clearance, bearing 5									
2	Distance: Gear fitted		712.400	-0.100	+0.100					
3	Gear bore			75.988	76.018			0.062	0.102	
	Shaft OD			76.080	76.090					

3.5.7 Camshaft – Installation

Special tools

Designation / Use	Part No.	Qty.
Guide mandrel for camshaft	F6557148	1
Installation/removal device for camshaft	F6554679	1
Barring tool	F6554695	1
Measuring gauge tripod	0015890321/00	1
Dial gauge	0015895321/00	1

Material

Designation / Use	Part No.	Qty.
Petroleum jelly, white		
Engine oil		
Loctite 270		



Heavy object.

Risk of crushing!

- Use appropriate lifting devices and appliances.



Contamination of components.

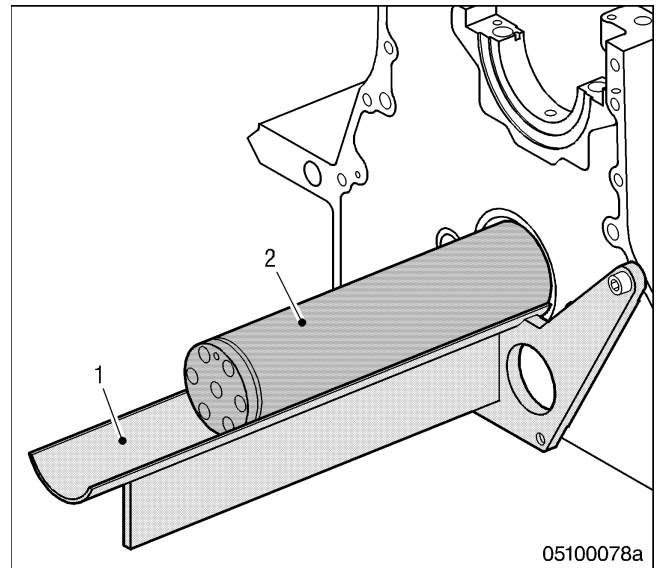
Damage to component!

- Observe manufacturer's instructions.
- Check components for special cleanness.

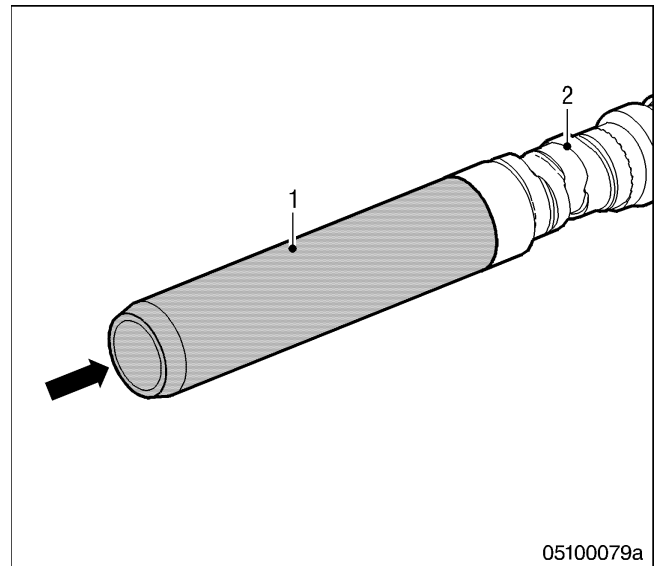
Check camshaft (→ Page 337)

Installing camshaft

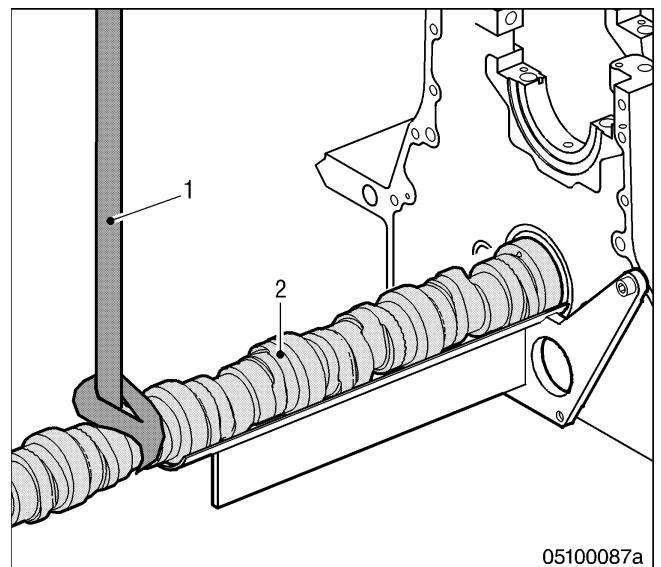
1. Screw installation device (1) onto front end of crankcase and use guide mandrel (2) to center it to the camshaft bearings.



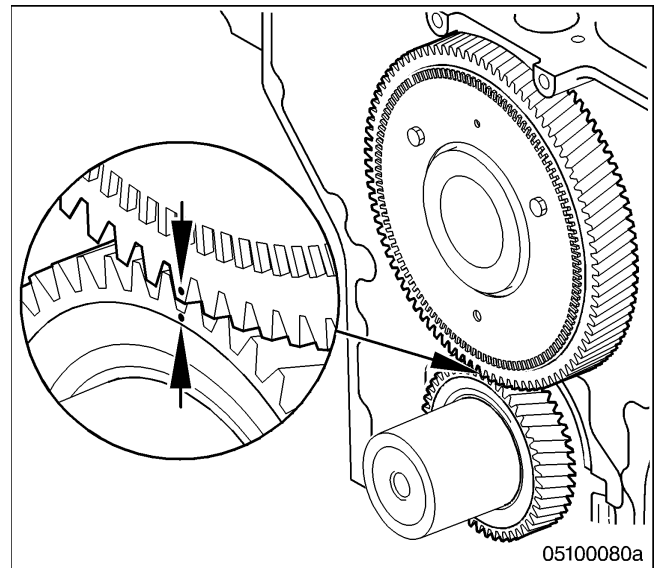
2. Screw guide mandrel (1) onto front end of camshaft (2) (arrowed).



3. Attach the middle of camshaft (2) with rope (1) to crane and wipe with chamois leather.
4. Coat camshaft (2), camshaft bearings, installation device and guide mandrel (1) with engine oil.

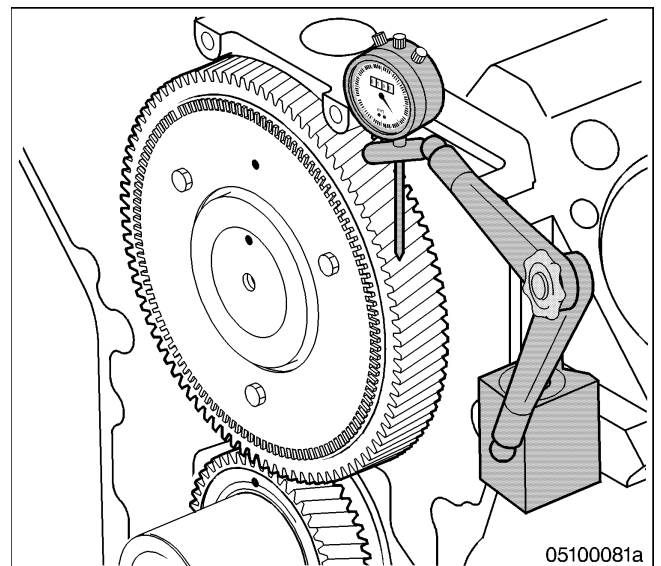


5. Insert camshaft in such a way that the markings (arrowed) on the teeth of camshaft gear and crankshaft gear match.
6. Remove guide mandrel and installation device.
7. Secure camshaft axially/prevent from falling out until the flywheel housing is installed.



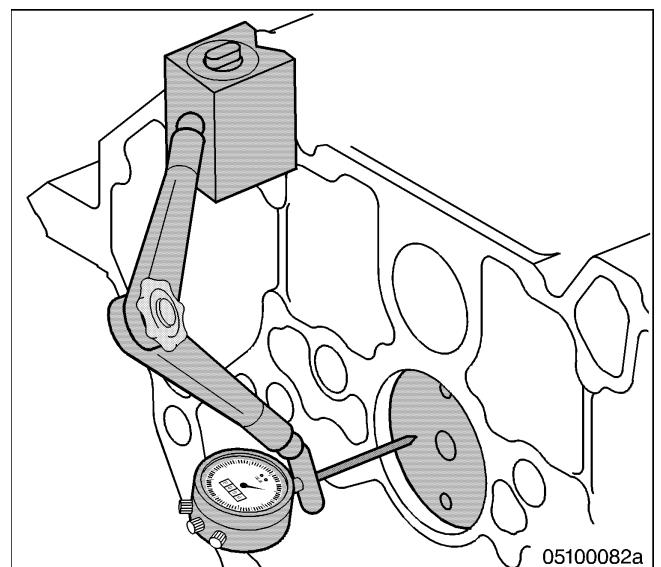
Measuring backlash

1. Mount measuring gauge tripod with dial gauge on crankcase.
2. Position gauge probe on tooth flank with small pretension.
3. Set dial gauge to zero.
4. Check circumferential backlash by turning the camshaft gear in both directions. Circumferential backlash (→ Page 122).



Measuring camshaft end play

1. Mount measuring gauge tripod with dial gauge (1) on crankcase (free end).
2. Position dial gauge probe on front face (arrowed).
3. Press camshaft on camshaft gear axially as far as it will go.
4. Zero pretensioned dial gauge.
5. Move camshaft from stop to stop and record value (end play). End play (→ Page 122).



Final steps

For these steps a distinction must be made as to whether				
1 the engine has been completely disassembled				
2 the engine has been removed but not disassembled				
3 the engine has remained installed				
1	2	3	Operations	See
X	–	–	Assemble engine.	(→ Page 58)
X	–	–	Install engine.	(→ Page 60)
–	–	X	Enable engine start.	–

3.5.8 Camshaft timing – Check

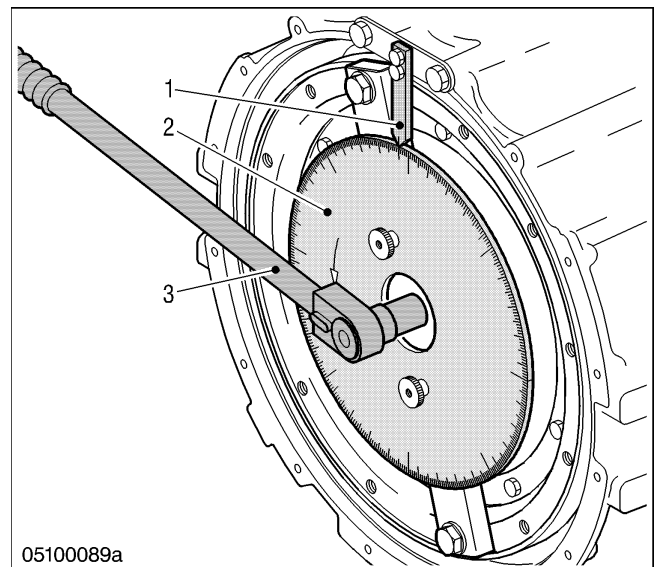
Special tools

Designation / Use	Part No.	Qty.
Barring device for 8V	F6557929	1
Barring device for 12 – 18V	F6554695	1
Pointer for 8V	F6557932	1
Pointer for 12 – 18V	F6554696	1
Graduated disk for 8V	Y4341946	1
Graduated disk for 12V	Y4343817	1
Graduated disk for 16V	Y4343816	1
Graduated disk for 18V	Y4343815	1
Measuring stand	0015890321/00	1
Dial gauge	0015895321/00	1
Measuring device	Y4341106	1

Check camshaft (→ Page 337)

Installing pointer, graduated disk and barring device

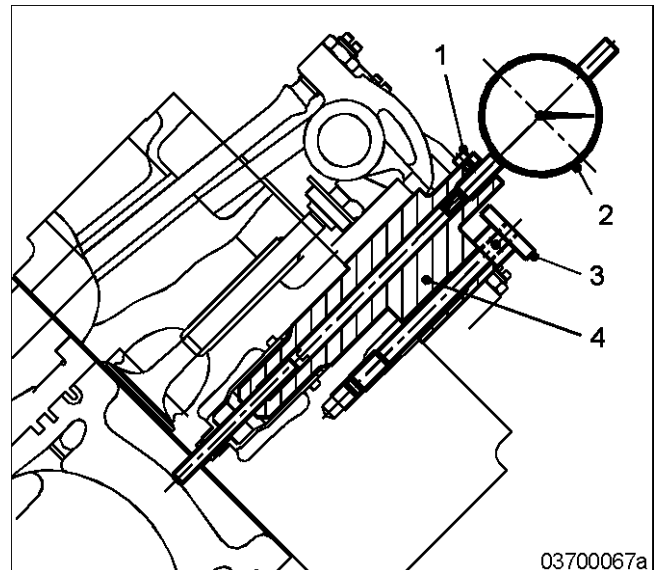
1. Set A1 piston to TDC.
2. Install corresponding pointer (1) on flywheel housing.
3. Install corresponding graduated disk (2) with appropriate barring device, set to TDC mark of A1 and tighten.
4. Attach ratchet (3) on barring device.



Determination of TDC position

Note: With installed cylinder head and valve drive.

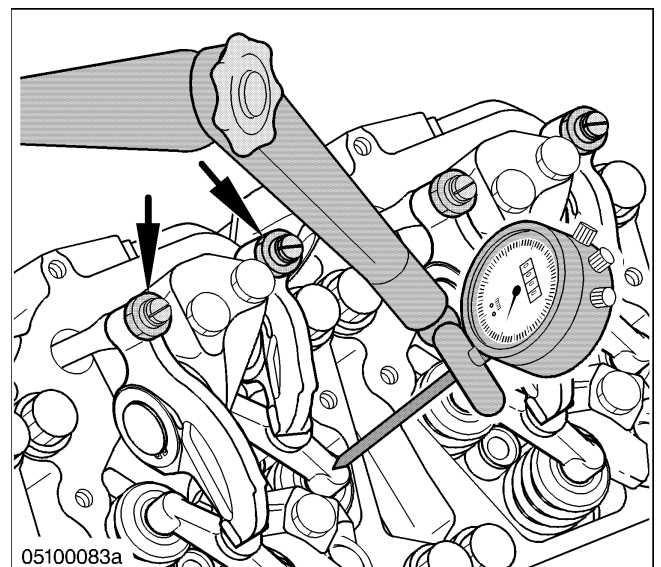
1. Install preloaded dial gauge (2) in measuring device (4) and clamp with screw (1).
2. Install measuring device (4) in the cylinder head and fasten with knurled-head screw (3).
3. Set dial gauge (2) to zero.
4. Using the barring tool, bar the engine until the piston of cylinder A1 is in the firing TDC.
Result: Both rockers are relieved, this gives them play.
5. Move piston in top dead center up and down several times and then position it in such a way that the dial gauge's pointer (2) displays the highest value.
6. Set dial gauge (2) to zero.
7. Rotate crankshaft in reverse direction of rotation by approx. 10°.
8. Set crankshaft in direction of rotation to 0.3 mm (dial gauge indicator) before TDC.
9. Mark exact line on graduated disk opposite TDC pointer tip.
10. Rotate crankshaft in direction of rotation approx. 10 ° past TDC (bearing play compensation).
11. Bar crankshaft in direction opposite to normal direction of rotation to 0.3 mm after TDC and make a second mark.
12. Mark the third line exactly in the center between the line marks.
13. Align graduated disk in such a way that the line mark for cylinder A1 matches the pointer.
14. Check TDC position.
15. Remove measuring device (4) with dial gauge (2).



Measuring valve lift

Note: With installed cylinder head and valve drive.

1. Set cylinder A1 to firing TDC.
2. Loosen locknut (arrow).
3. Screw in adjusting screws until there is no more valve clearance, then tighten locknut lightly.
4. Attach measuring stand with dial gauge to cylinder A1.
5. Place lightly pretensioned dial-gauge anvil on to the valve bridge of the inlet valve and set dial gauge scale to zero.
6. Rotate crankshaft in direction of engine rotation slowly another 360° and set exactly to overlap-TDC (line mark of index plate).
7. Read valve stroke from dial gauge and record readings in Data Sheet.

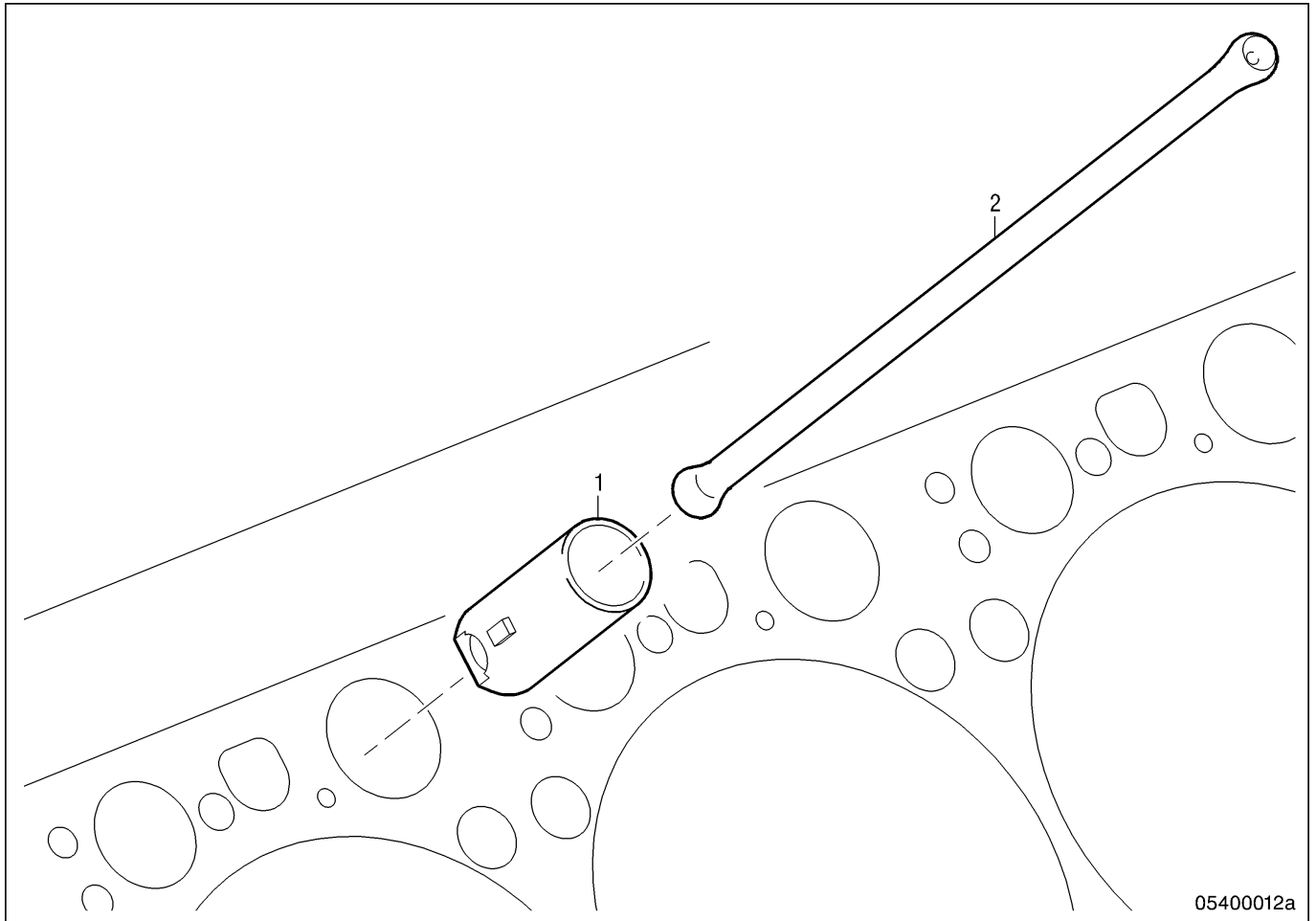


8. Place dial-gauge anvil on valve bridge of exhaust valve and set dial gauge scale to zero.
9. Further rotate crankshaft slowly in engine direction of rotation until pointer of dial gauge no longer moves.
10. Read valve stroke from dial gauge and record readings in Data Sheet.
11. Check that specified values are observed. Specified values (→ Page 36)
12. Specified value not attained, notify Service.
13. Remove measuring stand with dial gauge, TDC pointer and graduated disk.
14. Valve clearance at cylinder A1 (→Set operating instructions)

Final steps

A distinction must be made as to whether				
1 the engine was completely disassembled				
2 the engine was removed but not disassembled				
3 the engine is still installed				
1	2	3	Operations	See
X	–	–	Assemble engine	(→ Page 58)
X	–	–	Install engine	(→ Page 60)
–	–	X	Enable engine start	–

3.5.9 Valve roller tappet, pushrod – Overview



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1 Roller tappet

2 Pushrod

3.5.10 Roller tappet and pushrod – Removal

Preconditions

- Engine is stopped and starting disabled.

Special tools

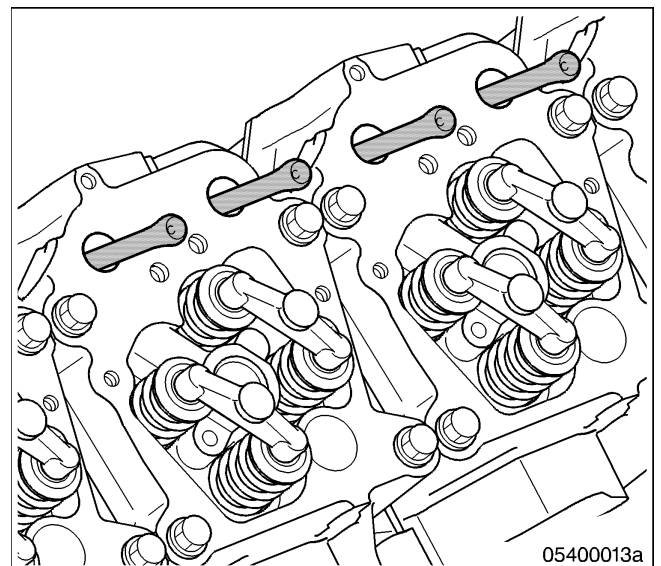
Designation / Use	Part No.	Qty.
Pliers	F30378037	1

Preparatory steps

A distinction must be made as to whether				
			1 the engine is to be completely disassembled	
			2 the engine is to be removed but not disassembled	
			3 the engine is to remain installed	
1	2	3	Operations	See
X	–	–	Remove engine	(→ Page 55)
X	–	–	Disassemble engine	(→ Page 56)
–	–	X	Disable engine start	(→ Page 15)
–	X	X	Remove cylinder head cover	(→ Page 371)
–	X	X	Remove valve drive	(→ Page 359)

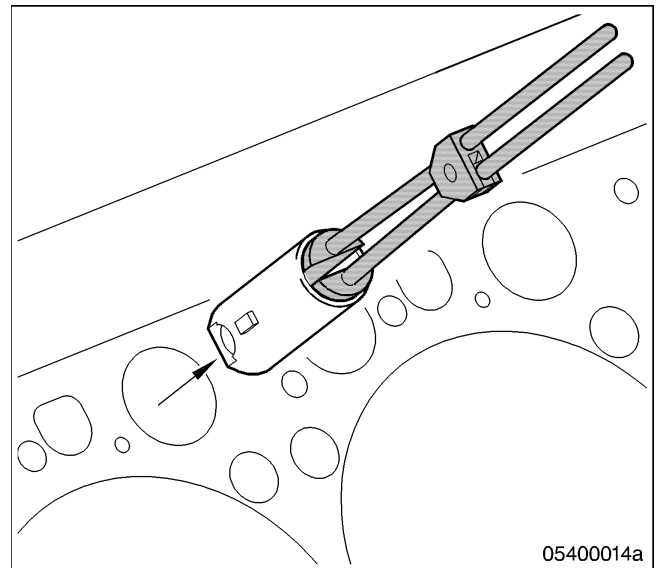
Removing pushrod

1. Rotate pushrod so that the roller tappet is loosened
2. Remove pushrod





Removing roller tappet

1. Remove cylinder head (→ Page 303).
2. Remove roller tappets with pliers from crankcase.
3. Mark roller tappet to crankcase.



3.5.11 Roller tappet, pushrod – Cleaning

Material

Designation / Use	Part No.	Qty.
Cleaning agent		
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors. 	
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask. 	

Roller tappet, remove pushrod (→ Page 350).

Roller tappet, pushrod – Cleaning

1. Clean all parts with cleaning agent.
2. Remove cleaning agent.
3. Blow out all parts with compressed air.

3.5.12 Roller tappet, pushrod – Check

Special tools


Designation / Use	Part No.	Qty.
Bore gauge		
Outside micrometer		

Material

Designation / Use	Part No.	Qty.
Fluorescent magnetic powder for magnetic crack-testing		

Spare parts

Designation / Use	Part No.	Qty.
Roller tappet		
Pushrod		

 CAUTION	Contamination of components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Check components for special cleanliness.
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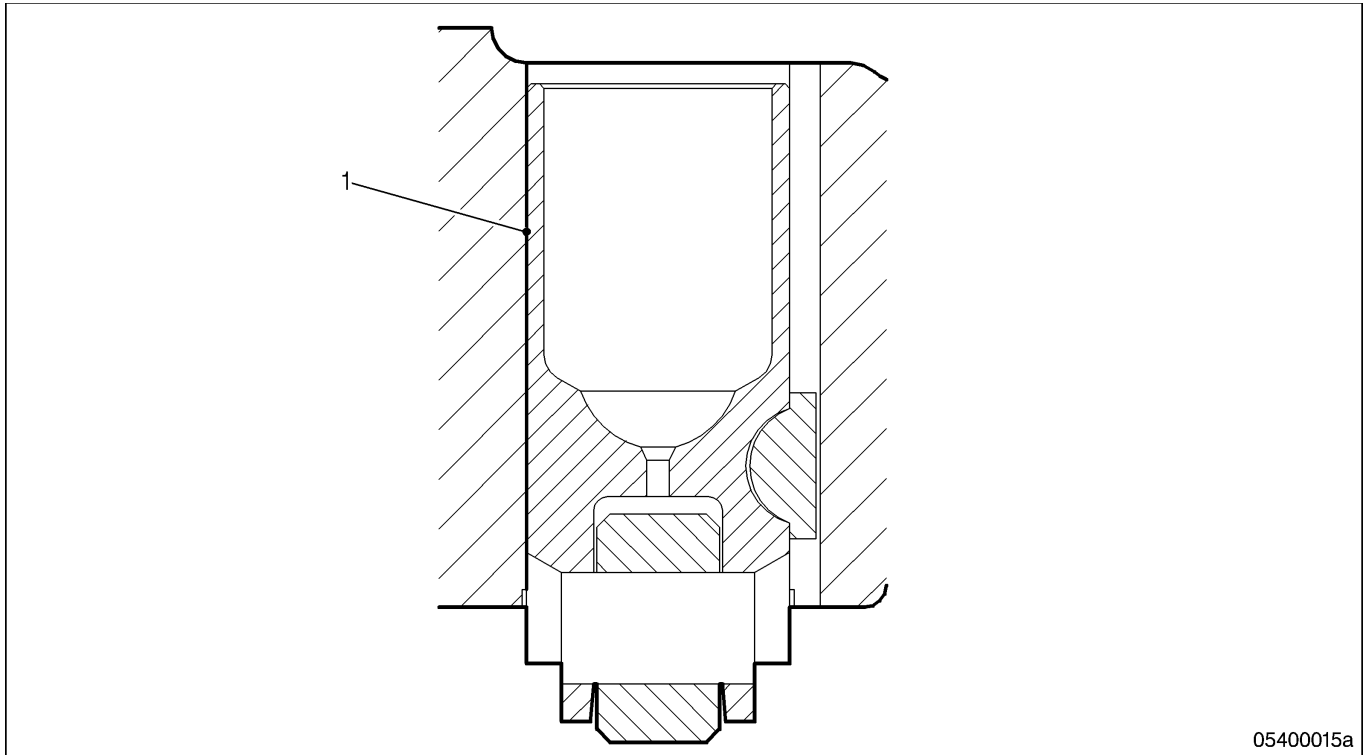
Clean roller tappet, pushrod (→ Page 352).

Check

Item	Findings	Task
Using the magnetic crack-testing method, check following components for cracks: <ul style="list-style-type: none"> • Roller tappet • Pushrod 	Signs of cracks	Replace
Check pushrod ball seat and ball end for wear.	<ul style="list-style-type: none"> • Wear • Indentations • Scores visible 	Replace
Measure outer Ø of roller tappet with outside micrometer. Values (→ Page 354)	Dimensions not as specified	Replace
Check tappet roller for ease of movement and excessive play.	Sluggish Excessive play	Replace roller tappet.
Check roller tappet for damage and wear.	Damaged Wear	Replace

3.5.13 Roller tappet, pushrod – Tolerances

Roller tappet, pushrod



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No.	Designation	Stage	Toleranced size Basic size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
1	Housing bore	0		30.000	30.021	0.035	0.077			
		1		30.500	30.525	0.035	0.085			
	Tappet outer Ø	0		29.944	29.965					
		1		30.440	30.465					

3.5.14 Roller tappet, pushrod – Installation

Special tools

Designation / Use	Part No.	Qty.
Pliers	F30378037	1

Material

Designation / Use	Part No.	Qty.
Engine oil		



Compressed air.

Risk of injury!

- Do not direct compressed-air jet at persons.
- Wear protective goggles / safety mask and ear protectors.



Contamination of components.

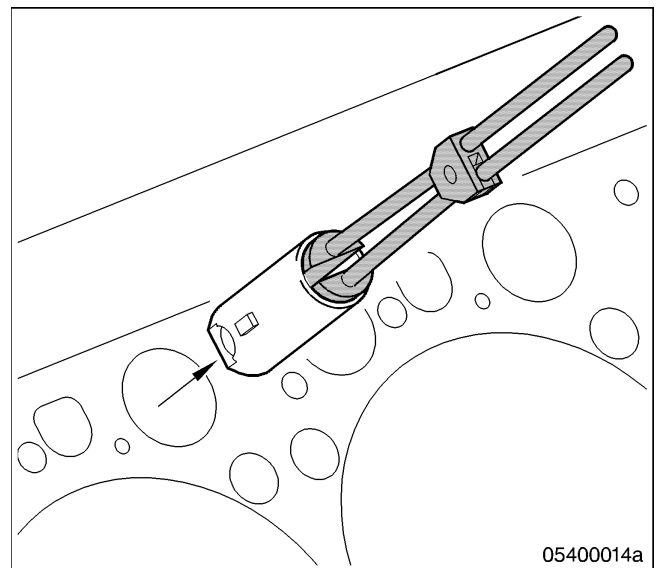
Damage to component!

- Observe manufacturer's instructions.
- Check components for special cleanness.

Check roller tappet, pushrod (→ Page 353).

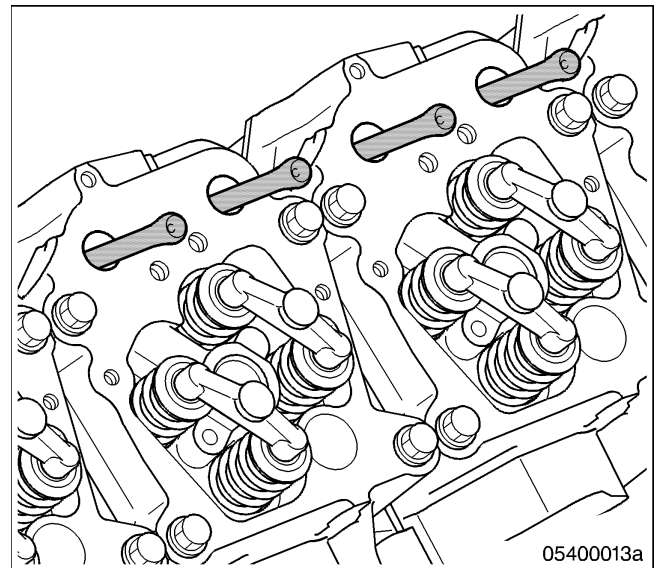
Installing roller tappet

1. Coat roller tappet and bore in crankcase with engine oil.
2. Use pliers to insert roller tappet; in doing so observe guide slot.
3. Check ease of movement of roller tappet in guide bore.



Installing pushrod

1. Install cylinder head (→ Page 329).
2. Coat pushrod with engine oil.
3. Insert pushrod with ball head side, in doing so observe correct fit in roller tappet.



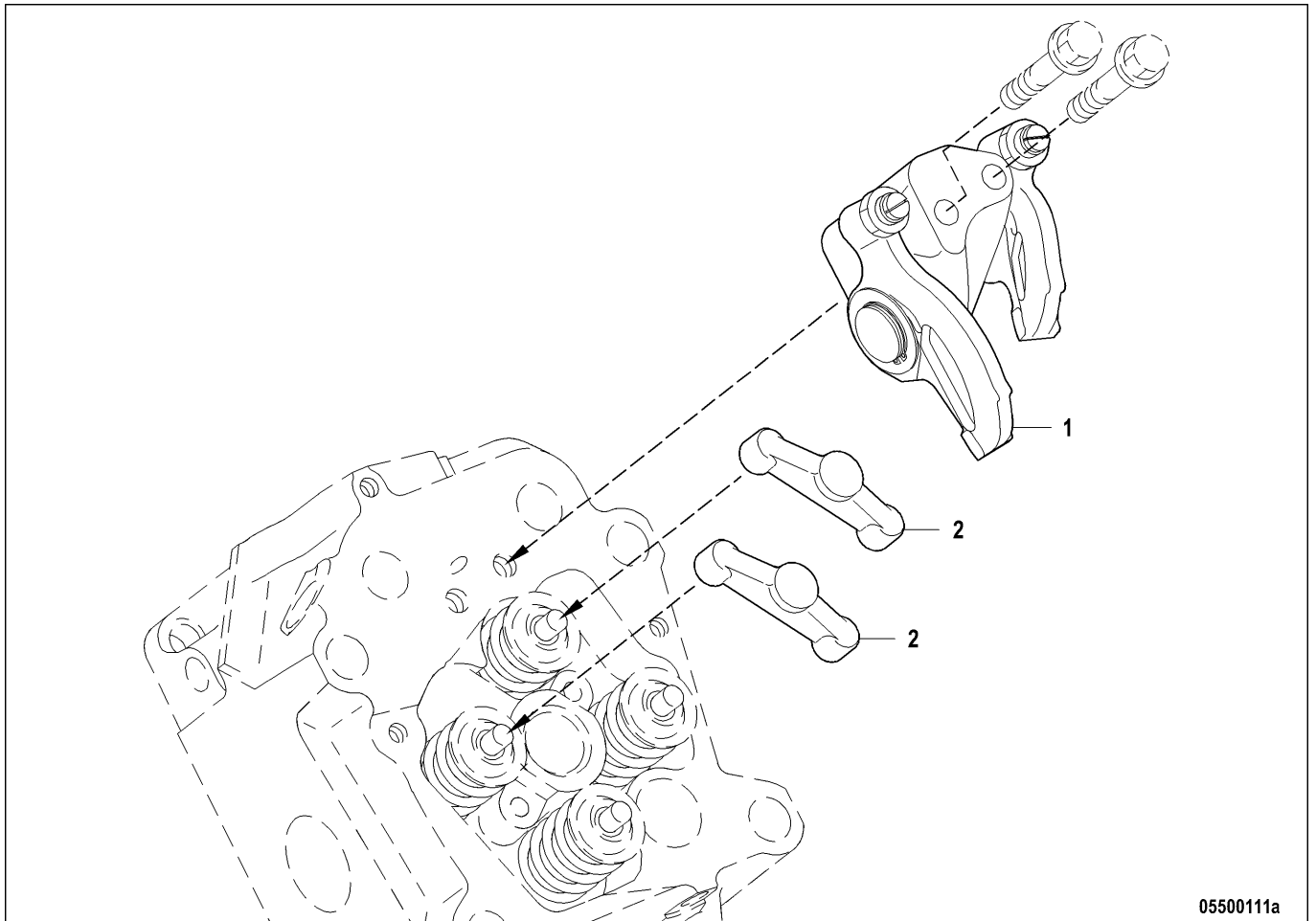
Final steps

A distinction must be made as to whether

- 1 the engine was completely disassembled
- 2 the engine was removed but not disassembled
- 3 the engine is still installed

1	2	3	Operations	See
X	–	–	Assemble engine	(→ Page 58)
X	–	–	Install engine	(→ Page 60)
–	X	X	Assembly in reverse disassembly sequence	(→ Page 350)
–	–	X	Enable engine start	–

3.5.15 Valve drive – Overview

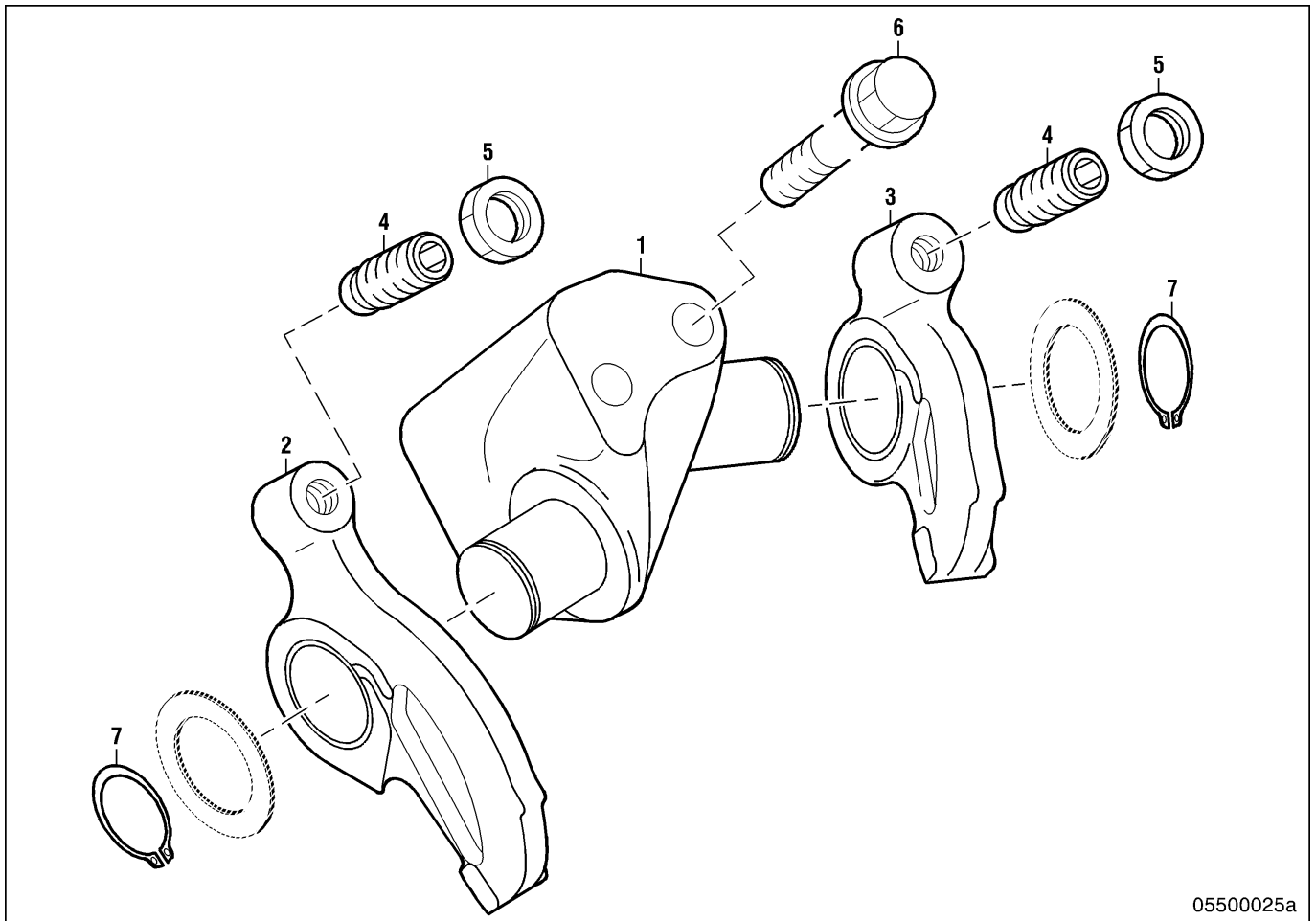


1 Rocker shaft support

2 Valve bridge

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Rocker shaft support



- 1 Rocker shaft support
- 2 Rocker arm , exhaust
- 3 Rocker arm, inlet
- 4 Adjusting screw

- 5 Nut
- 6 Washer
- 7 Snap ring
- 8 Screw

3.5.16 Valve drive – Removal

Preconditions

- Engine is stopped and starting disabled.

Preparatory steps

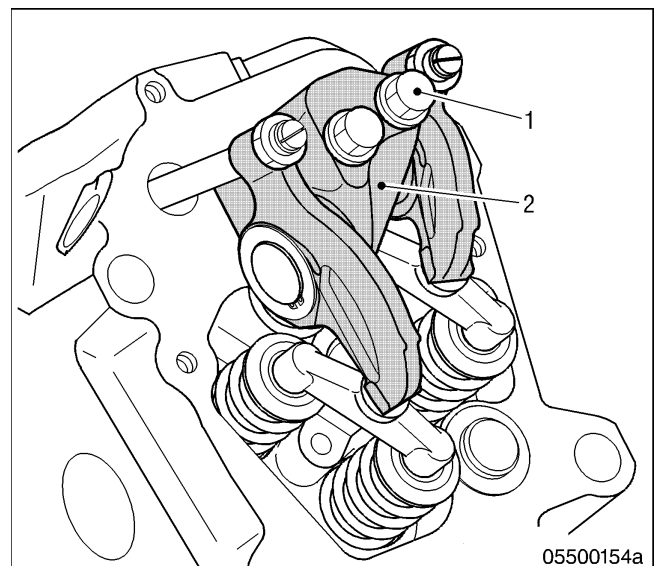
A distinction must be made as to whether

- 1 the engine is to be completely disassembled
- 2 the engine is to be removed but not disassembled
- 3 the engine is to remain installed

1	2	3	Tasks	See
X	–	–	Remove engine.	(→ Page 55)
X	–	–	Disassemble engine.	(→ Page 56)
–	–	X	Disable the engine starter.	(→ Page 15)
–	X	X	Remove cylinder head cover.	(→ Page 371)

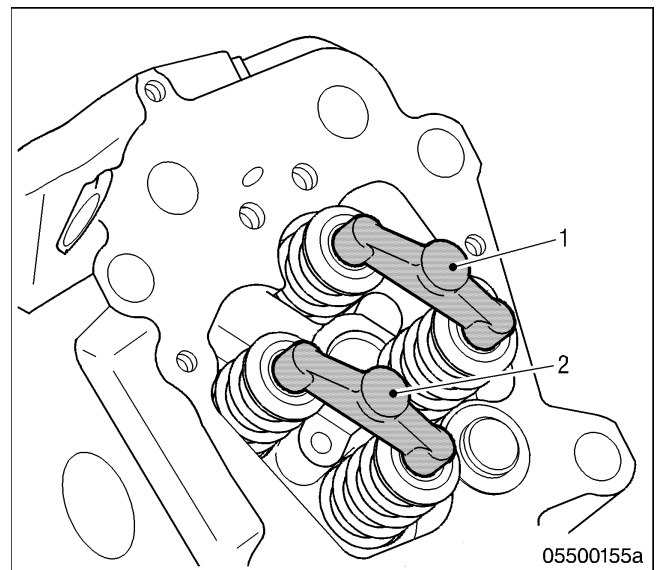
Removing rocker arms

1. Remove screw (1).
2. Remove rocker shaft support (2).



Removing valve bridge

1. Mark position of valve bridges (1) and (2) to the valves.
2. Remove valve bridges.

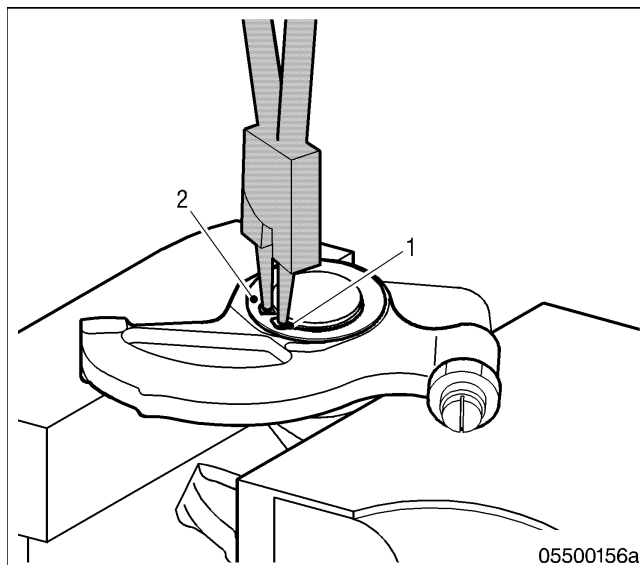


3.5.17 Valve drive – Disassembly

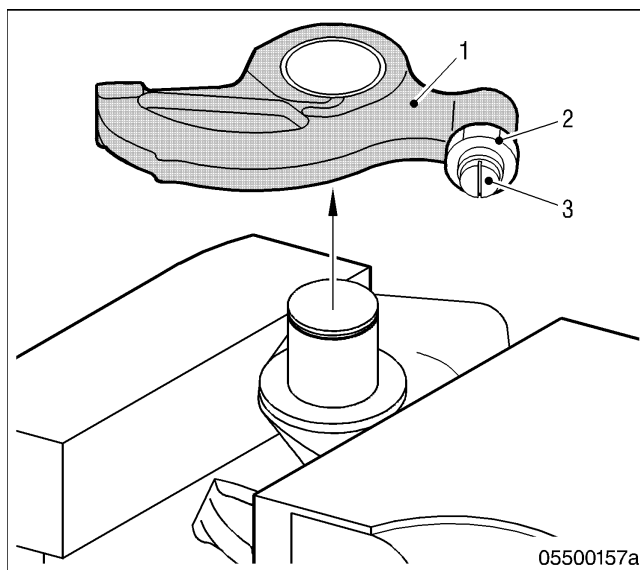
Remove valve drive (→ Page 359)

Disassembling rocker arm

1. Clamp rocker shaft support in vice with aluminium jaws.
2. Use circlip pliers to remove snap ring (1) from shaft.
3. Remove washer (2).





4. Remove rocker arm (1).
5. Remove nut (2) and adjusting screw (3).



3.5.18 Valve drive – Cleaning

Material

Designation / Use	Part No.	Qty.
Cleaning agent		
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors. 	
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask. 	

Remove valve drive (→ Page 359).

Valve drive – Cleaning

1. Clean all components with cleaning agent.
2. Remove cleaning agent.
3. Blow out all parts with compressed air.

3.5.19 Valve drive – Check

Special tools

Designation / Use	Part No.	Qty.
Bore gauge		
Depth gauge		
Outside micrometer		

Material

Designation / Use	Part No.	Qty.
Fluorescent magnetic powder for magnetic crack test procedure		

Spare parts

Designation / Use	Part No.	Qty.
Snap ring		
Washer		
Rocker shaft support		
Rocker arm, exhaust		
Rocker arm, inlet		
Valve bridge		
Screw		
Adjusting screw		



CAUTION

Contamination of components.

Damage to component!

- Observe manufacturer's instructions.
- Check components for special cleanliness.

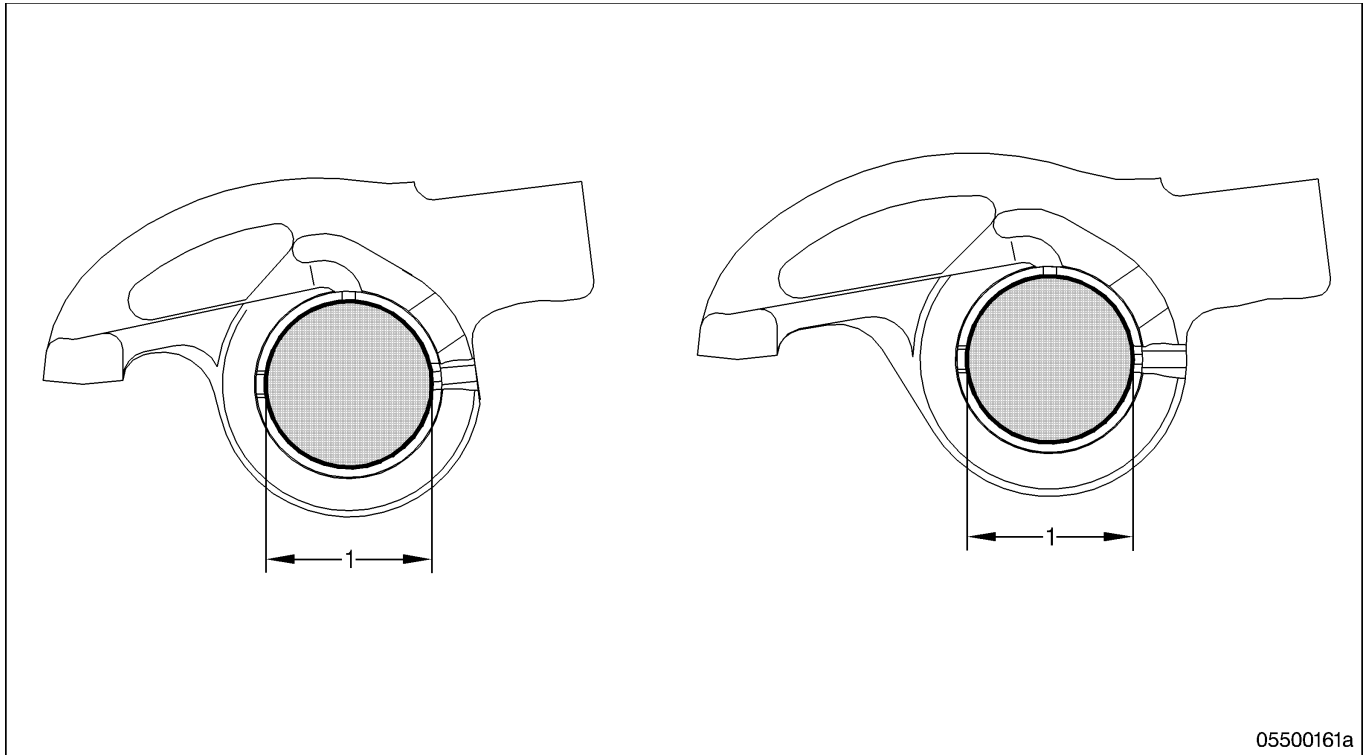
Disassemble valve drive (→ Page 361).

Valve drive – Check

Item	Findings	Measure
Check the following parts with magnetic crack test procedure for cracks. <ul style="list-style-type: none"> • Rocker shaft support • Rocker arm, exhaust • Rocker arm, inlet • Nut • Screws • Adjusting screws 	Signs of cracks	Replace
Check bearing surfaces on shaft support, valve bridges and rocker for wear, indentations and scores.	<ul style="list-style-type: none"> • Wear • Indentations • Scores visible 	<ul style="list-style-type: none"> • Recondition • Replace
Check mating faces on rocker shaft support.	Damaged	<ul style="list-style-type: none"> • Recondition • Replace
Check condition of snap ring grooves of axles.	Damaged	<ul style="list-style-type: none"> • Recondition • Replace
Check screws, nuts and adjusting screws for damage.	Damaged	Replace component.
Measure diameter of bush bore in rocker arm. Value (→ Page 365)	Value exceeded	Replace
Measure diameter of shaft support axle. Value (→ Page 365)	Value exceeded	Replace
Measure screws for rocker shaft support. Value (→ Page 365)	Value exceeded	Replace

3.5.20 Valve drive – Tolerances

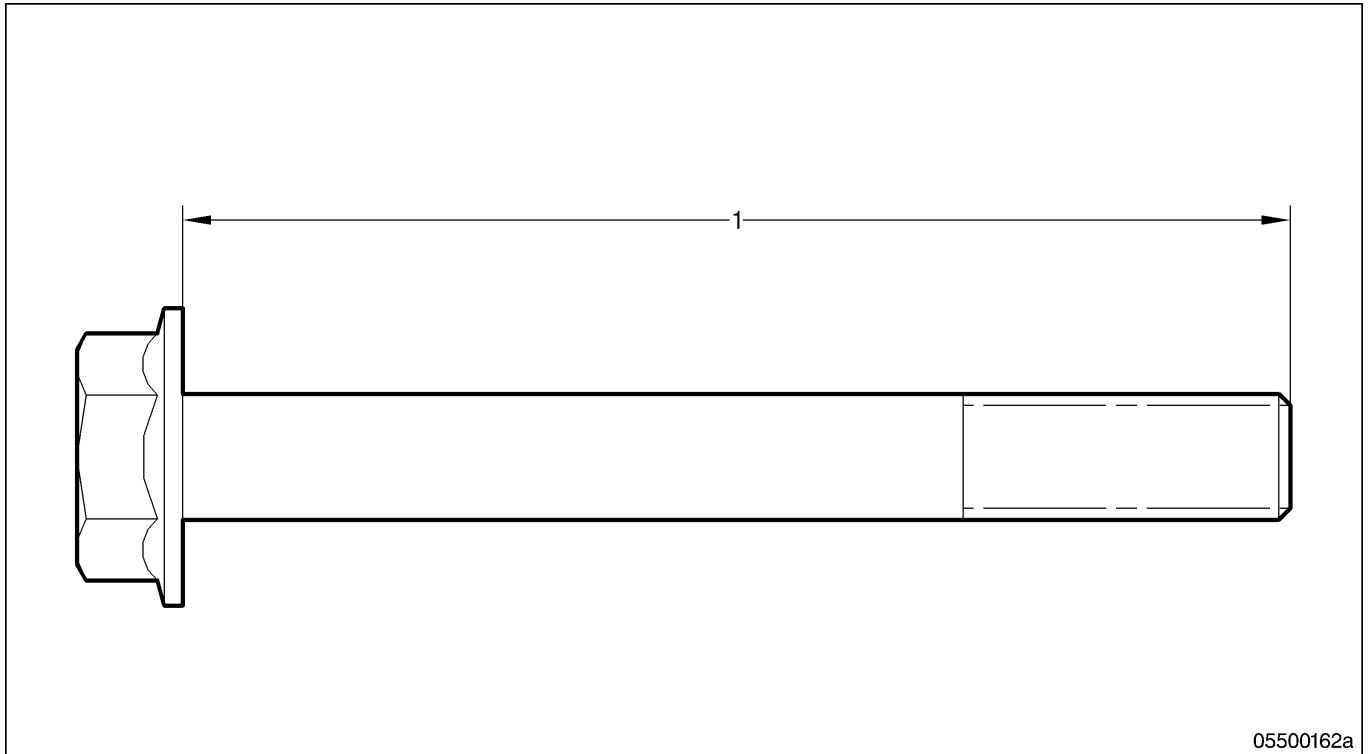
Rocker shaft support, inlet and exhaust



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No.	Designation	Level	Tol. size Basic size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
1	Rocker arm bush bore		25.000	+0.005	+0.021	0.025	0.054			
	Rocker shaft support outer Ø		25.000 f ₆	-0.033	-0.020					



Screw



No.	Designation	Level	Tol. size Basic size	Deviation		Clearance		Interference		Wear limit
				lower	upper	min.	max.	min.	max.	
1	Screw length — removed		90.000	-0.200	0					91.000

3.5.21 Valve drive – Assembly

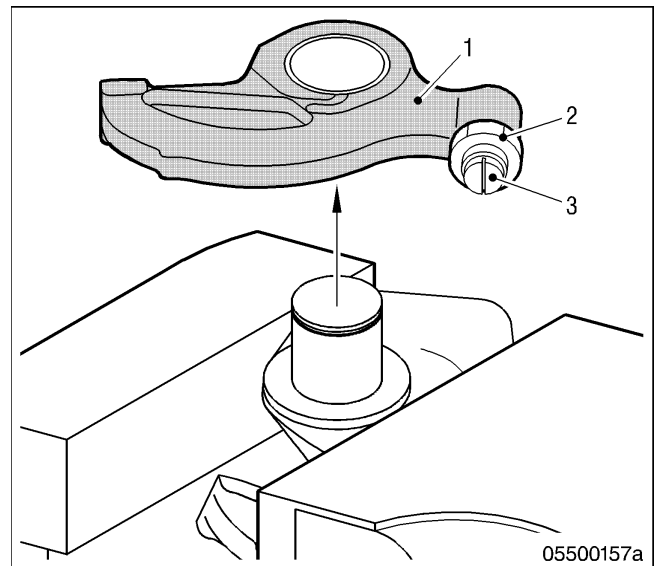
Material

Designation / Use	Part No.	Qty.
Engine oil		
 WARNING	Spring/circlip/tensioning roller preload. Risk of injury! <ul style="list-style-type: none"> • Only use specified tool and equipment. 	
 CAUTION	Contamination of components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Check components for special cleanness. 	

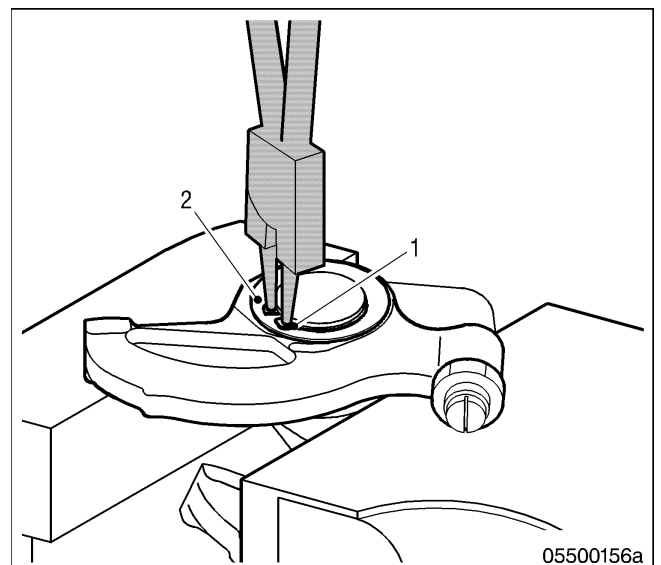
Check valve drive (→ Page 363).

Assembling rocker arm

1. Insert adjusting screw (1) into rocker arm (3).
2. Fit nut (2) on adjusting screw (1), do not tighten!
3. Coat axles on rocker shaft support and bushes of rocker arm (3) with engine oil.
4. Clamp rocker shaft support in vice with aluminium jaws.
5. Place rocker arm (3) on axle.



6. Fit washer (2) and secure with snap ring (1).
7. Check whether snap ring (1) is correctly seated.
8. Install second rocker arm in the same way.



3.5.22 Valve drive – Installation

Special tools

Designation / Use	Part No.	Qty.
Barring device	F6557929	1
Pointer for barring device	F6557932	1
Graduated disk	Y341946	1
Box wrench	F30030450	1

Material

Designation / Use	Part No.	Qty.
Engine oil		



Compressed air.

Risk of injury!

- Do not direct compressed-air jet at persons.
- Wear protective goggles / safety mask and ear protectors.



Contamination of components.

Damage to component!

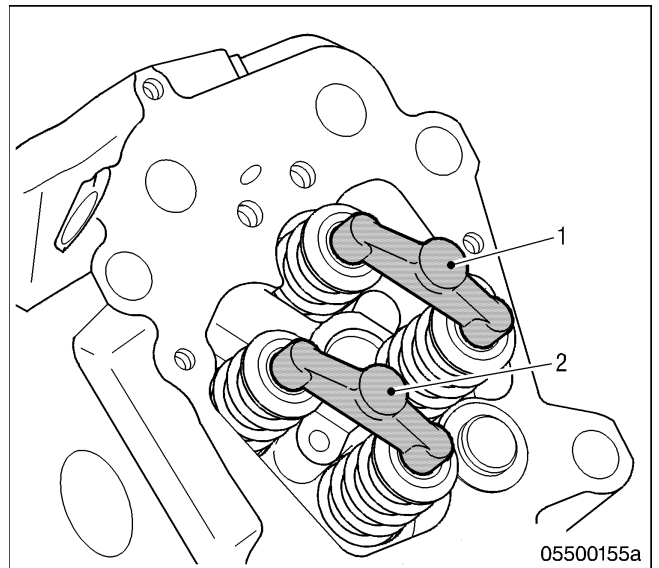
- Observe manufacturer's instructions.
- Check components for special cleanness.

Assemble valve drive (→ Page 367).

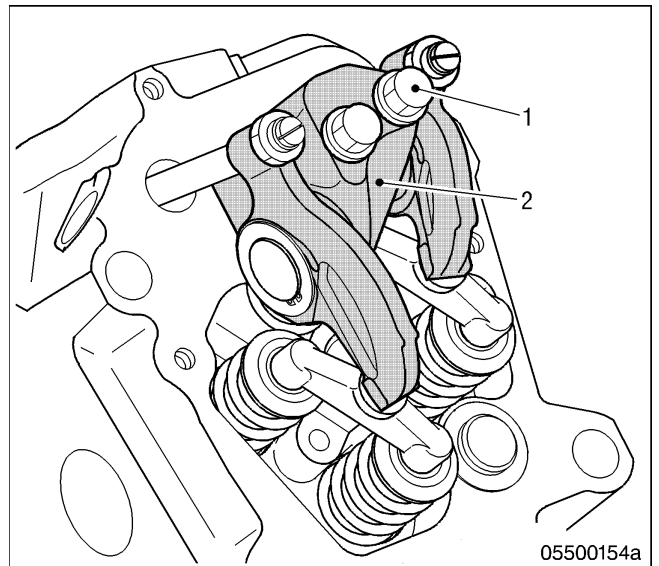
Install barring device (→ Page 346).

Installing valve bridge and rocker arm

1. Place valve bridges (1) and (2) on valves in accordance with marking.



2. Coat ball seat of pushrod with engine oil.
3. Use barring device to set piston to firing TDC.
4. Loosen adjusting screw nuts on rocker shaft support (2) and turn back adjusting screws.
5. Place rocker shaft support (2) on cylinder head, checking the position of the ball in the pushrod.
6. Coat threads and screw head mating face of screw (1) with engine oil.
7. Install screw (1) in cylinder head and tighten to specified tightening torque with torque wrench and box wrench. (→ Page 23) using torque wrench.
8. Adjust valve clearance (→Operating Instructions).



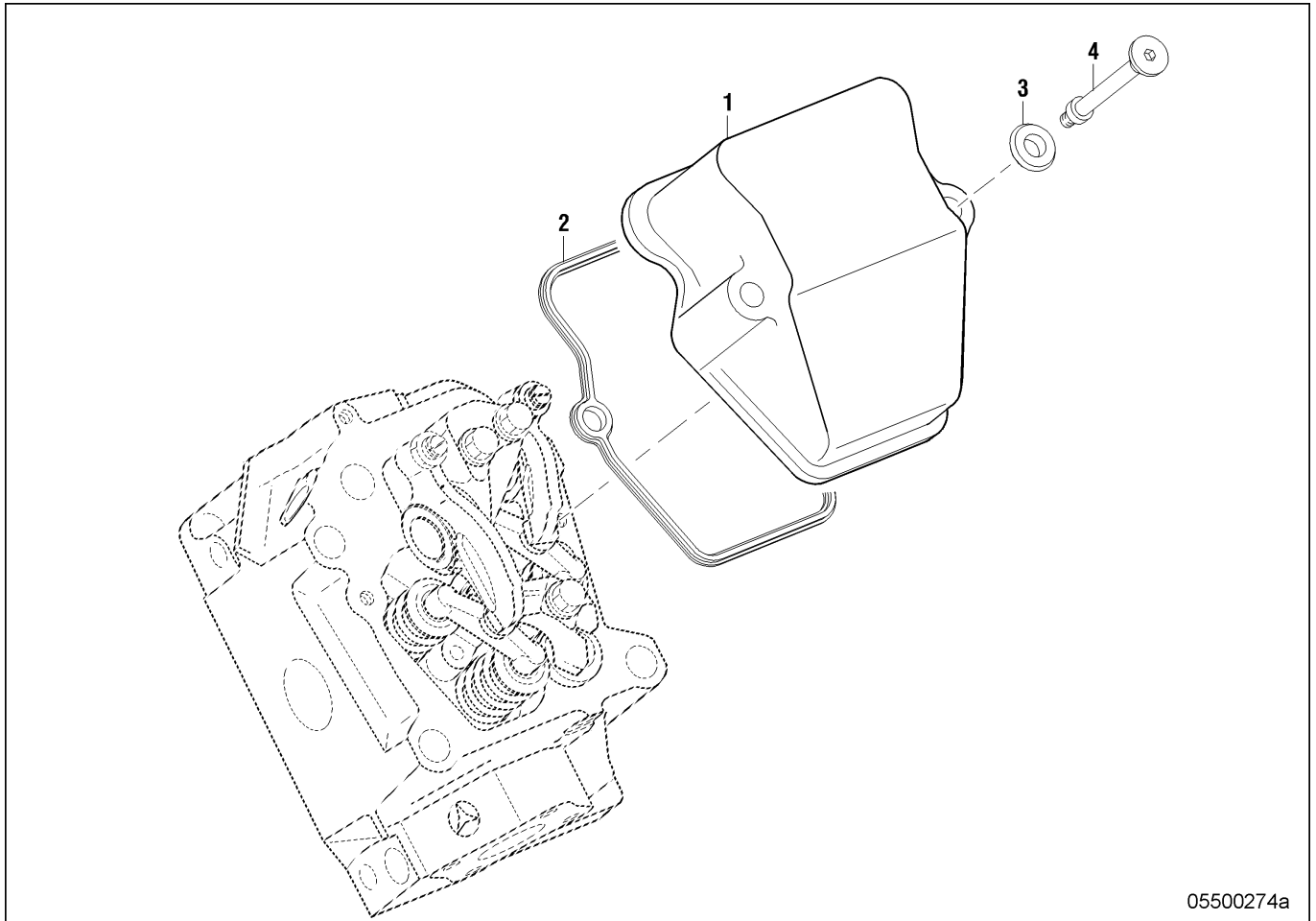
Final steps

A distinction must be made whether:

- 1 The engine was completely disassembled
- 2 The engine was removed but not disassembled
- 3 The engine is still installed

1	2	3	Operations	See
X	-	-	Assemble engine	(→ Page 58)
X	-	-	Install engine	(→ Page 60)
-	-	X	Enable engine start	-

3.5.23 Cylinder head cover – Overview



1 Cylinder head cover
2 Gasket

3 Sealing washer
4 Screw

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3.5.24 Cylinder head cover – Removal

Preconditions

- Engine is stopped and starting disabled.

Preparatory steps



A distinction must be made as to whether				
1 the engine is to be completely disassembled				
2 the engine is to be removed but not disassembled				
3 the engine is to remain installed				
1	2	3	Operations	See
X	–	–	Remove engine	(→ Page 55)
X	–	–	Disassemble engine	(→ Page 56)
–	–	X	Disable engine start	(→ Page 15)

Cylinder head cover – Removal

1. Remove cylinder head cover as shown in overview drawing (→ Page 370).
2. Remove gaskets.
3. Seal openings with suitable covers.

3.5.25 Cylinder head cover – Cleaning

Material

Designation / Use	Part No.	Qty.
Cleaning agent		
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors. 	
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask. 	

Remove cylinder head cover (→ Page 371).

Cleaning cylinder head cover

1. Clean cylinder head cover with cleaning agent.
2. Remove cleaning agent.
3. Blow out cylinder head cover with compressed air.

3.5.26 Cylinder head cover – Check

Spare parts

Designation / Use	Part No.	Qty.
Cylinder head cover		

Clean cylinder head cover (→ Page 372).

Cylinder head cover – Check

Item	Findings	Measure
Check cylinder head cover for damage.	Damaged	<ul style="list-style-type: none"> • Recondition: Smooth with emery cloth or oilstone. • Replace
Seal	Damaged	Replace
Check thread of screws for ease of movement.	Sluggish	<ul style="list-style-type: none"> • Recondition: Recut thread. • Replace

3.5.27 Cylinder head cover – Installation

Material

Designation / Use	Part No.	Qty.
Engine oil		

Spare parts

Designation / Use	Part No.	Qty.
Gasket		
Screw		
Sealing washer		



CAUTION

Contamination of components.

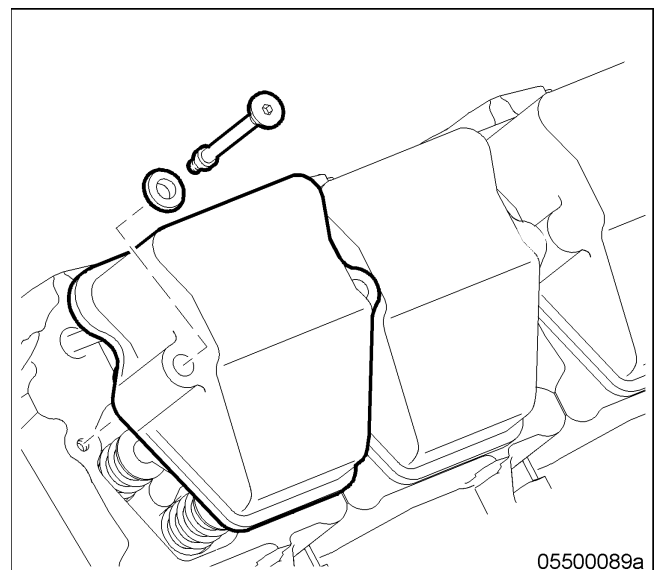
Damage to component!

- Observe manufacturer's instructions.
- Check components for special cleanness.

Check cylinder head cover (→ Page 373).

Installing cylinder head cover

1. Insert gasket into cylinder head cover.
2. Install cylinder head cover with gasket.
3. Tighten screws to specified tightening torque using a torque wrench (→ Page 23).

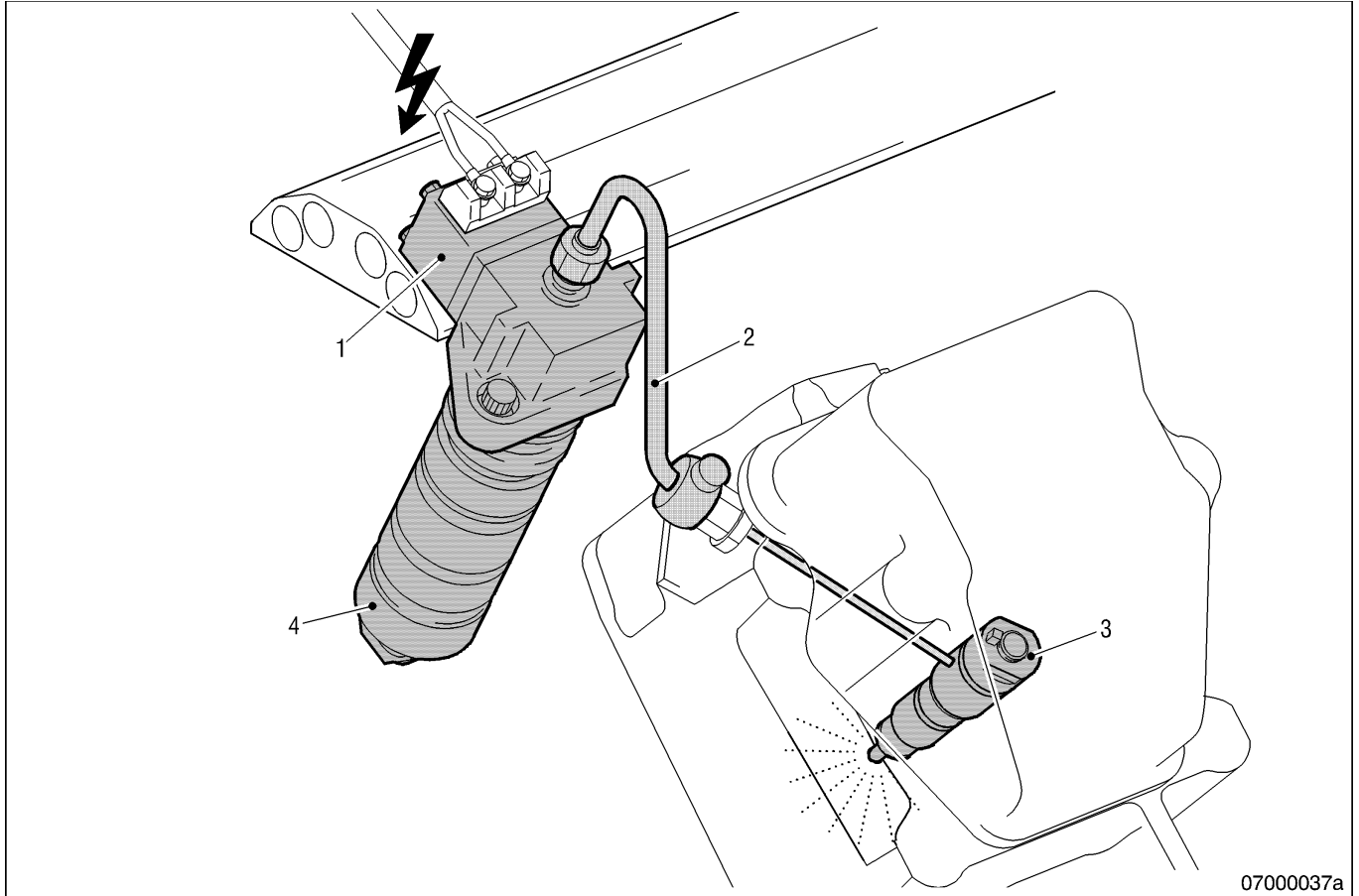


Final steps

For these steps a distinction must be made as to whether				
1 the engine has been completely disassembled				
2 the engine has been removed but not disassembled				
3 the engine has remained installed				
1	2	3	Operations	See
X	–	–	Assemble engine.	(→ Page 58)
X	–	–	Install engine.	(→ Page 60)
–	–	X	Enable engine start.	–

3.6 HP Fuel System

3.6.1 H.P. fuel system – Overview

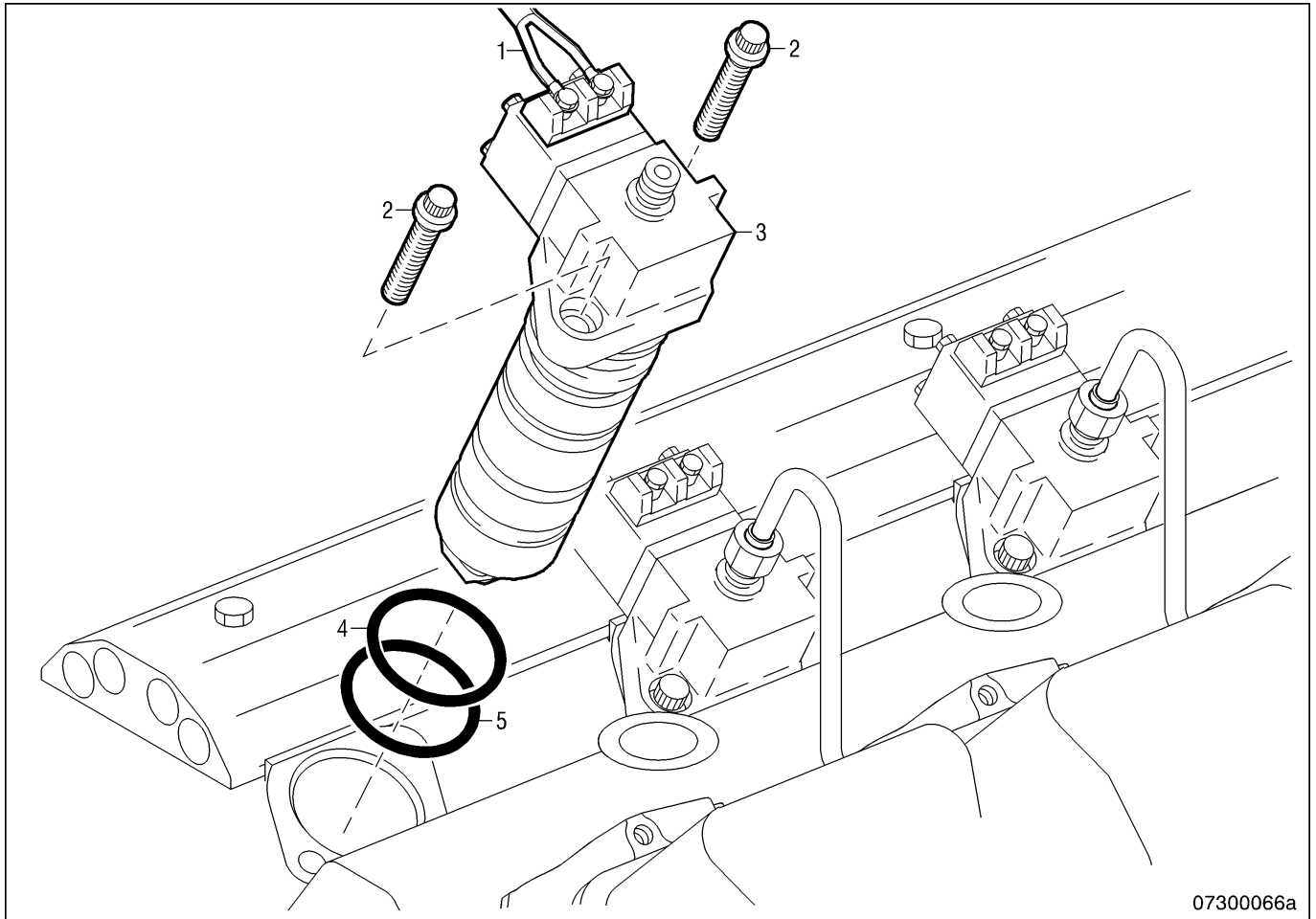


07000037a

1 Solenoid valve
2 H.P. line

3 Injector
4 Injection pump

3.6.2 Injection pump – Overview



- 1 Cable
- 2 Screw
- 3 Injection pump
- 4 Sealing ring
- 5 Sealing ring


3.6.3 Injection pump – Removal

Preconditions

- Engine is stopped and starting disabled.

Special tools

Designation / Use	Part No.	Qty.
Engine barring device	F6557929	1

 WARNING	Fuels are combustible. Risk of fire and explosion! <ul style="list-style-type: none"> • Avoid naked flames, electrical sparks and ignition sources. • Do not smoke.
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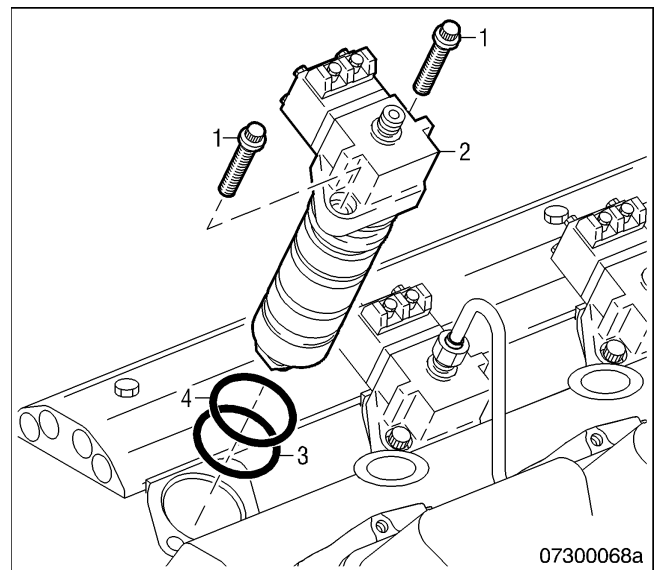
 WARNING	Component is hot. Risk of burning! <ul style="list-style-type: none"> • Wear protective gloves.
---	--

Preparatory steps

A distinction must be made as to whether				
1 the engine is to be completely disassembled				
2 the engine is to be removed but not disassembled				
3 the engine is to remain installed				
1	2	3	Operations	See
X	–	–	Remove engine	(→ Page 55)
X	–	–	Disassemble engine	(→ Page 56)
–	–	X	Disable engine start	(→ Page 15)
–	X	X	Remove cable from injection pump	(→ Page 604)
–	X	X	Remove high-pressure line	(→ Page 393)
–	X	X	Remove air supply to the cylinders	(→ Page 460)
–	X	X	Remove engine lifting equipment (if required)	(→ Page 112)

Injection pump – Removal

1. Mark installation position of injection pump (2).
2. Unscrew screw (1) approx. 6 mm.
 - Pretensioned compression spring forces the injection pump (2) out of the crankcase, if not
 - 2.1. rotate crankshaft with engine barring device,
 - pump cam forces the injection pump (2) through the pump cam out of the crankcase, if not
 - 2.2. carefully press injection pump (2) out at the recess on the injection pump head.
3. Remove screw (1) and injection pump (2).
4. Remove sealing rings (3) and (4).
5. After removal, seal all openings with suitable covers.



3.6.4 Injection pump – Disassembly

Disassembly of this component is not planned.

This component is an exchange component (Reman) and is available through the usual exchange procedure.

3.6.5 Injection pump – Check

Spare parts

Designation / Use	Part No.	Qty.
Injection pump		
Screw		

Remove injection pump (→ Page 378).

Checking injection pump

Item	Findings	Task
Check screws for damage.	Damaged	Replace
Check threads.	Sluggish	<ul style="list-style-type: none"> • Recondition • Replace
Check cabling for damage.	Damaged	Replace
Check sealing faces for damage.	Damaged	<ul style="list-style-type: none"> • Recondition • Replace
Check roller bearing surface for damage and wear	<ul style="list-style-type: none"> • Wear • Damaged 	Replace

3.6.6 Injection pump – Installation

Special tools

Designation / Use	Part No.	Qty.
Barring tool	F6557929	1
Torque wrench		

Material

Designation / Use	Part No.	Qty.
Engine oil		
Petroleum jelly, white		

Spare parts

Designation / Use	Part No.	Qty.
Sealing ring		
Sealing ring		

Check injection pump (→ Page 381).

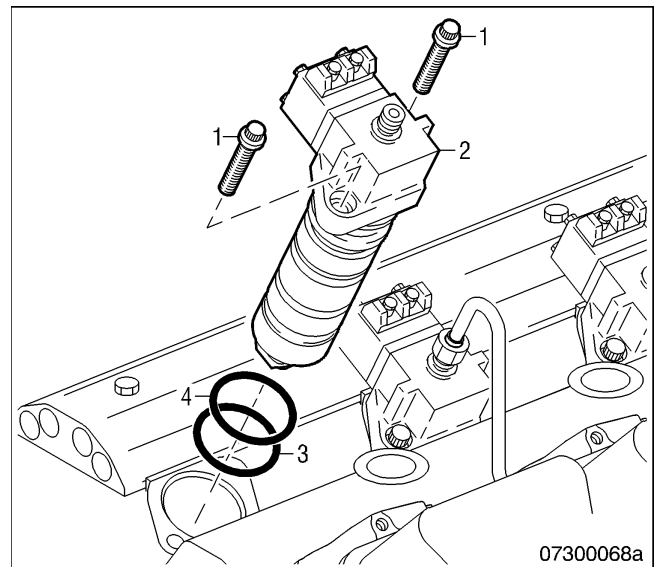
Injection pump – Installation

Note: Sealing ring (4) Ø47 mm

1. Coat sealing ring (4) with petroleum jelly and fit onto injection pump (2).

Note: Sealing ring (3) Ø45 mm

2. Coat sealing ring (3) with petroleum jelly and fit onto injection pump (2).
3. Coat roller on injection pump (2) with engine oil.
4. Remove all blanking plugs and/or covers.
5. Clean sealing face and installation bore in crankcase.
6. Use barring tool to align camshaft pump cams with base circle.
7. Install injection pump (2) according to marked installation position by pressing it manually into the crankcase, overcoming spring force.
8. Install screw (1) and tighten uniformly to specified torque (→ Page 23) using torque wrench.
9. Install screw for injection pump wiring and tighten to specified torque (→ Page 23) using torque wrench.

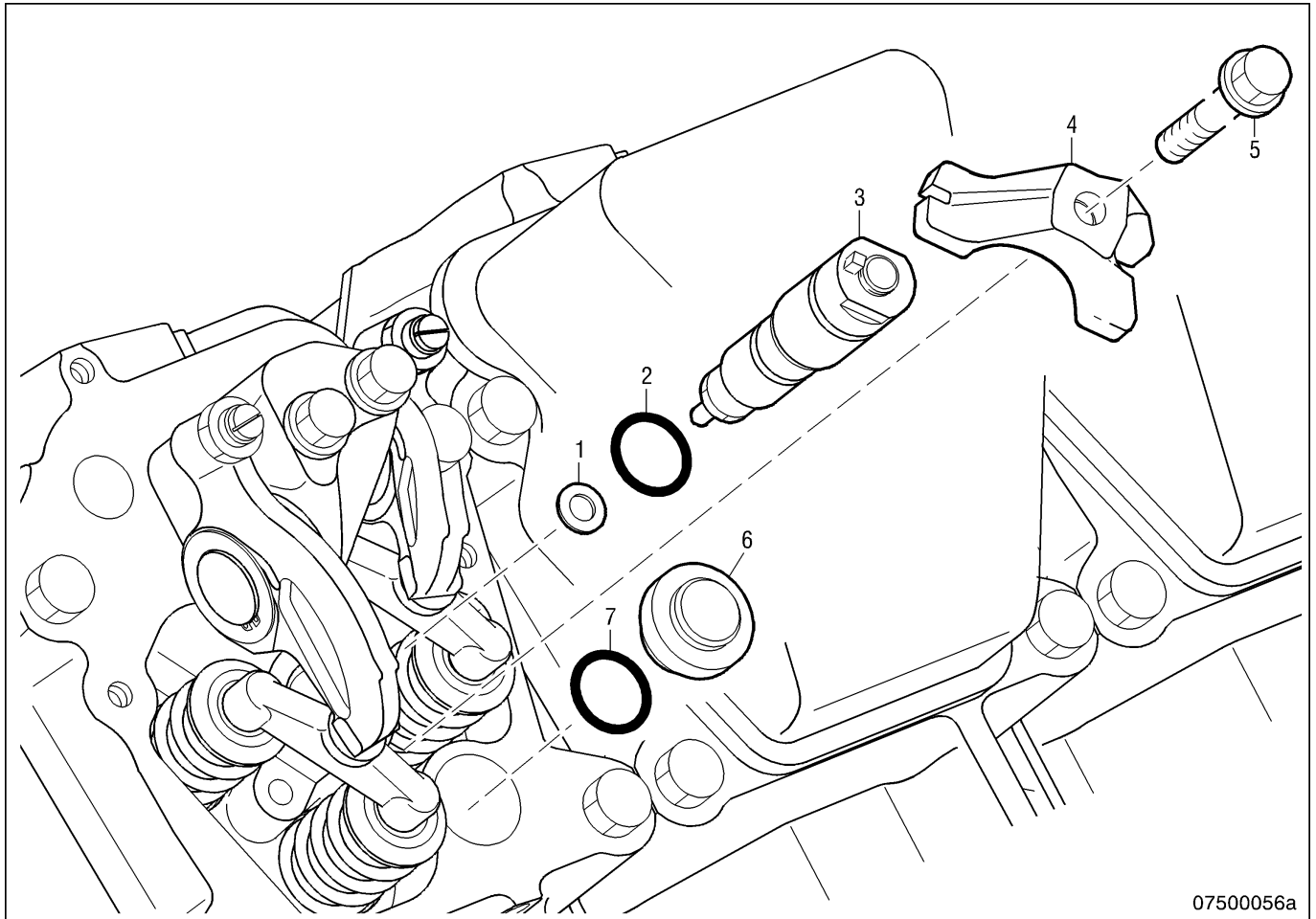


After installation**A distinction must be made whether:**

- 1 The engine was completely disassembled
- 2 The engine was removed but not disassembled
- 3 The engine is still installed

1	2	3	Operations	See
X	–	–	Assemble engine	(→ Page 58)
X	–	–	Install engine	(→ Page 60)
–	X	X	Assemble in reverse sequence to disassembly	(→ Page 378)
–	–	X	Fill and vent fuel system	(→ Operating Instructions)
–	–	X	Enable engine start	–

3.6.7 Fuel injector – Overview



07500056a

- 1 Sealing ring (copper)
- 2 Sealing ring
- 3 Injector

- 4 Clamp
- 5 Screw
- 6 Plug

- 7 Sealing ring

3.6.8 Fuel injector – Removal

Preconditions

- Engine is stopped and starting disabled.

Special tools

Designation / Use	Part No.	Qty.
Extractor	F30377999	1



WARNING

Fuels are combustible.

Risk of fire and explosion!

- Avoid naked flames, electrical sparks and ignition sources.
- Do not smoke.

Preparatory steps

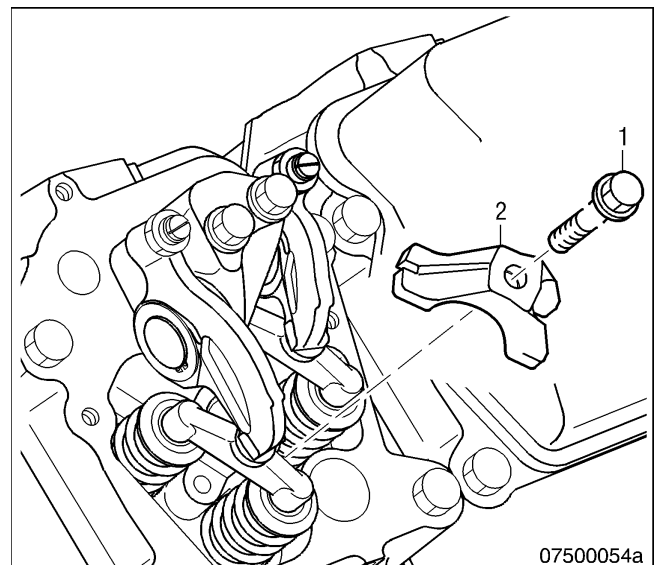
A distinction must be made as to whether

- 1 the engine is to be completely disassembled
- 2 the engine is to be removed but not disassembled
- 3 the engine is to remain installed

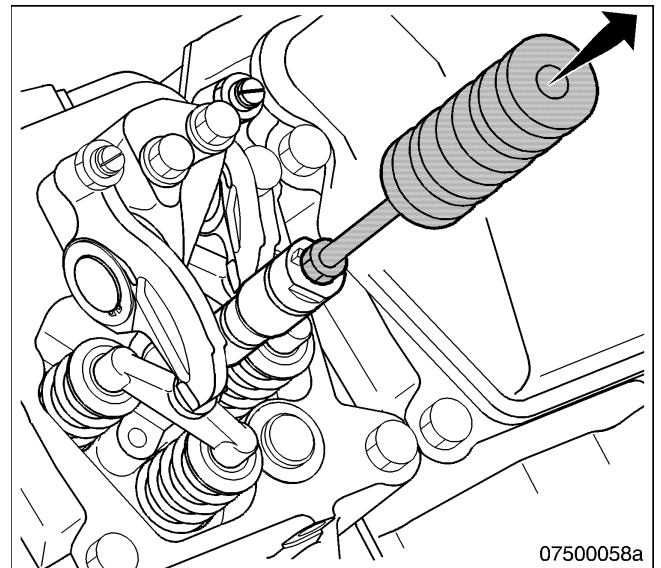
1	2	3	Operations	See
X	–	–	Remove engine	(→ Page 55)
X	–	–	Disassemble engine	(→ Page 56)
–	–	X	Disable engine start.	(→ Page 15)
–	X	X	Remove cylinder head cover	(→ Page 371)
–	X	X	Remove cabling of injectors	(→ Page 604)
–	X	X	Remove high-pressure line and pressure pipe tube.	(→ Page 393)

Fuel injector – Removal

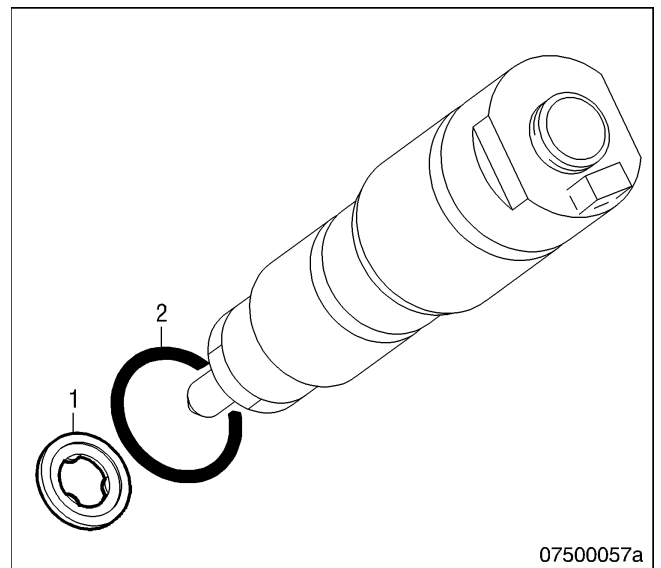
1. Remove screw (1).
2. Remove clamp (2).



3. Screw extractor into injector.
4. Remove injector with extractor.

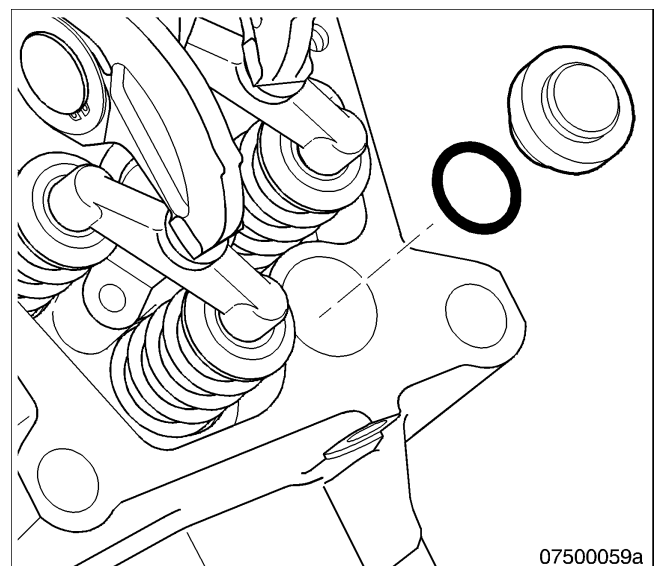


5. Remove sealing ring (2).
6. Remove sealing ring (1).



Remove sealing cap for clamp

1. Remove sealing cap from cylinder head with screwdriver.
2. Remove sealing ring.



3.6.9 Injector – Disassembly

Disassembly of this component is not planned.

This component is an exchange component (Reman) and is available through the usual exchange procedure.

3.6.10 Fuel injector – Check

Material

Designation / Use	Part No.	Qty.
Fluorescent magnetic powder for magnetic crack test procedure		

Spare parts

Designation / Use	Part No.	Qty.
Injector		
Clamping element		
Screw		
Sealing ring		

Remove fuel injector (→ Page 385).

Checking injector

Item	Findings	Task
Check injector externally for damage.	Damaged	Replace
Check screw and clamp with magnetic crack test procedure for cracks.	Signs of cracks	Replace component.
Check contact surfaces on clamp and plug.	Damaged	<ul style="list-style-type: none"> • Recondition: smooth with oilstone. • Replace component.
Check screw for damage and thread for ease of movement.	Sluggish	<ul style="list-style-type: none"> • Recut thread. • Replace screw.

3.6.11 Fuel injector – Installation

Special tools

Designation / Use	Part No.	Qty.
Engine barring device	F6557929	1

Material

Designation / Use	Part No.	Qty.
Petroleum jelly, white		
Engine oil		
Grease		

Spare parts

Designation / Use	Part No.	Qty.
Sealing ring		
Copper sealing ring		



Fuels are combustible.

Risk of fire and explosion!

- Avoid naked flames, electrical sparks and ignition sources.
- Do not smoke.



Contamination of components.

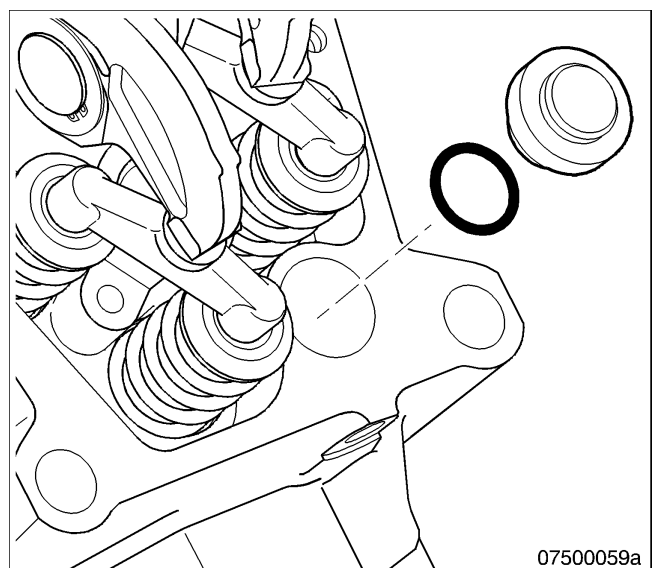
Damage to component!

- Observe manufacturer's instructions.
- Check components for special cleanliness.

Check injector (→ Page 388)

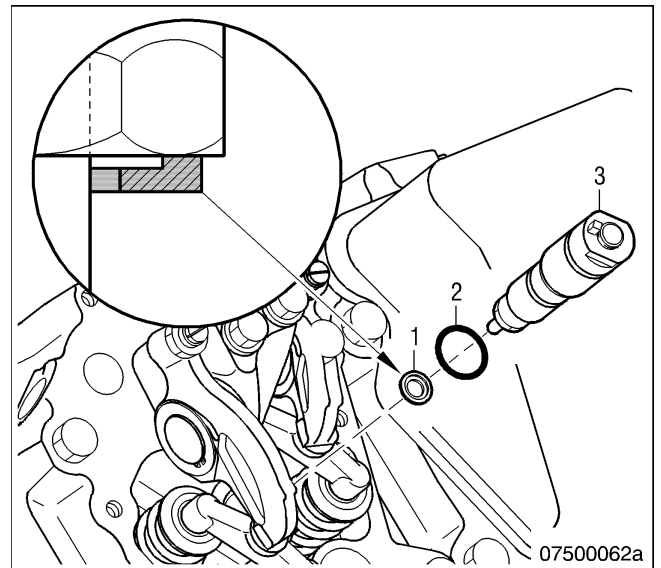
Sealing cap installation

1. Coat sealing ring with petroleum jelly and insert into groove of sealing cap.
2. Insert sealing cap into bore.



Fuel injector installation

1. Use engine barring device to turn engine several times to blow out remaining fuel.
2. Coat sealing ring (2) with petroleum jelly.
3. Wind sealing ring (2) on to injector (3).
4. Fix copper sealing ring (1) with grease on injector (3).
5. Press injector (3) by hand into cylinder head, in doing so make sure that the pin in the injector (3) is at 11 o'clock position to the engine's longitudinal axis.



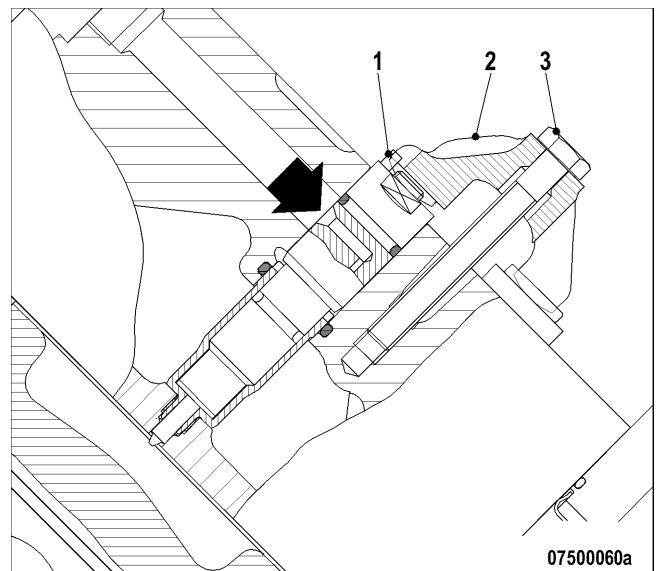
6. Attach clamp (2) in correct position.

Result:

- Pin (1) is in recess of clamp (2).
- Fork of clamp (2) engages in sealing cap fixation.

7. Insert screw (3) by hand.

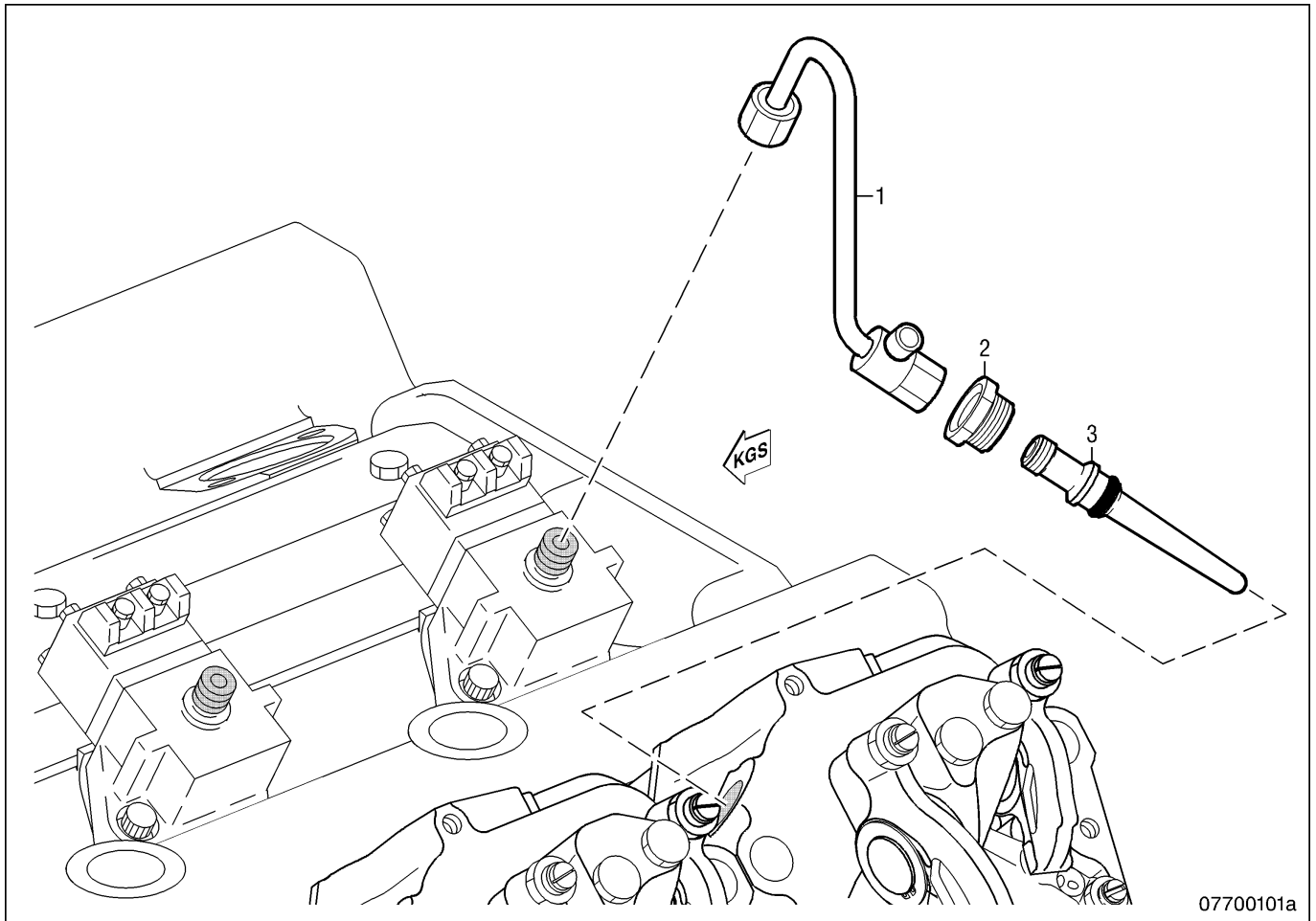
Result: Injector can still be turned.



Final steps

A distinction must be made as to whether				
1 the engine was completely disassembled				
2 the engine was removed but not disassembled				
3 the engine is still installed				
1	2	3	Operations	See
X	–	–	Assemble engine	(→ Page 58)
X	–	–	Install engine	(→ Page 60)
–	X	X	Assembly in reverse disassembly sequence	(→ Page 385)
–	–	X	Bleed fuel system	(→ Operating Instructions)
–	–	X	Enable engine start	–

3.6.12 H.P. fuel line – Overview



07700101a

1 H.P. fuel line

2 Thrust screw

3 Pressure pipe neck

3.6.13 H.P. fuel line – Removal

Preconditions

- Engine is stopped and starting disabled.

Special tools

Designation / Use	Part No.	Qty.
Socket wrench 19 A/F	F30025897	1
Spider patch spanner 22 A/F	F30027425	1
Spider patch spanner 19 A/F	F30027424	1
Box wrench 19 A/F	F30038493	1
Box wrench 22 A/F	F30038494	1
Fuel suction device	F30378207	1



WARNING

Fuels are combustible.

Risk of fire and explosion!

- Avoid naked flames, electrical sparks and ignition sources.
- Do not smoke.

Preparatory steps

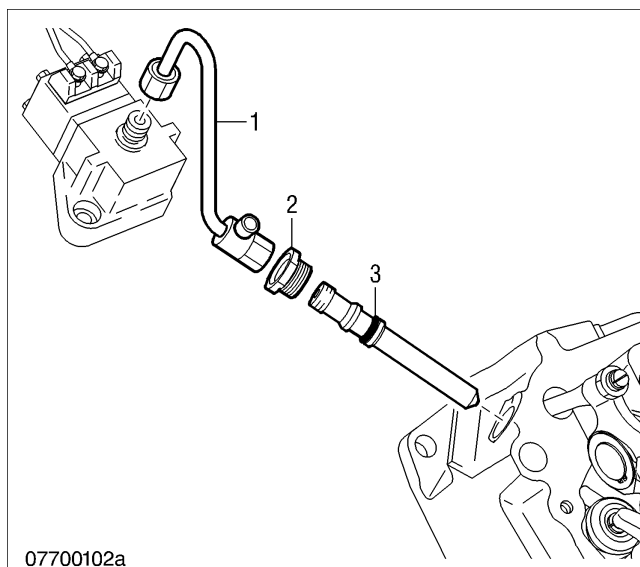
A distinction must be made whether:

- 1 the engine is to be completely disassembled
- 2 the engine was removed but not disassembled
- 3 The engine is to remain installed

1	2	3	Operations	See
X	–	–	Remove engine	(→ Page 55)
X	–	–	Disassemble engine	(→ Page 56)
–	–	X	Disable engine start	(→ Page 15)
–	X	X	Remove leak-off fuel line.	(→ Page 427)




H.P. fuel line – Removal

1. Remove H.P. line (1).
2. Unscrew thrust screw (2).
3. Withdraw pressure pipe neck (3).
4. Extract fuel with fuel suction device.
5. Remove sealing ring from pressure pipe neck (3).
6. After removal, seal all connections with suitable plugs.



3.6.14 H.P. fuel line – Cleaning

Material

Designation / Use	Part No.	Qty.
Cleaning agent		
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors. 	
 WARNING	Fuels are combustible. Risk of fire and explosion! <ul style="list-style-type: none"> • Avoid naked flames, electrical sparks and ignition sources. • Do not smoke. 	
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask. 	

Remove H.P. fuel line (→ Page 393).

H.P. fuel line – Cleaning

1. Clean all components with cleaning agent.
2. Remove cleaning agent.
3. Thoroughly blow out all parts with compressed air.

3.6.15 HP line – Check

Material

Designation / Use	Part No.	Qty.
Fluorescent dye for magnetic crack testing		

Spare parts

Designation / Use	Part No.	Qty.
HP line		
Thrust screw		
Pressure pipe union		

Checking HP line

Item	Findings	Task
Using the magnetic crack testing procedure, check HP line and union for cracks.	Cracks apparent	Replace component.
Check all threads for ease of movement.	No ease of movement	<ul style="list-style-type: none"> • Rework: Recut threads. • Replace
Check pressure screw and union for damage and traces of wear.	<ul style="list-style-type: none"> • Damage • Traces of wear visible 	Replace component.
Check HP line for damage.	Damaged	Replace

3.6.16 High-pressure line – Installation

Special tools

Designation / Use	Part No.	Qty.
Torque wrench	F30026582	1
Insertion box-end wrench	F30027425	1
Insertion box-end wrench	F30027424	1
Crow-foot box-end wrench	F30027424	1
Crow-foot box-end wrench	F30027425	1
Insertion flat wrench	F30025897	1
Ratchet adapter	F30027340	1
Double-end box wrench	F30011450	1

Material

Designation / Use	Part No.	Qty.
Petroleum jelly, white		
Engine oil		

Spare parts

Designation / Use	Part No.	Qty.
Sealing ring		



Fuels are combustible.

Risk of fire and explosion!

- Avoid naked flames, electrical sparks and ignition sources.
- Do not smoke.



Compressed air.

Risk of injury!

- Do not direct compressed-air jet at persons.
- Wear protective goggles / safety mask and ear protectors.

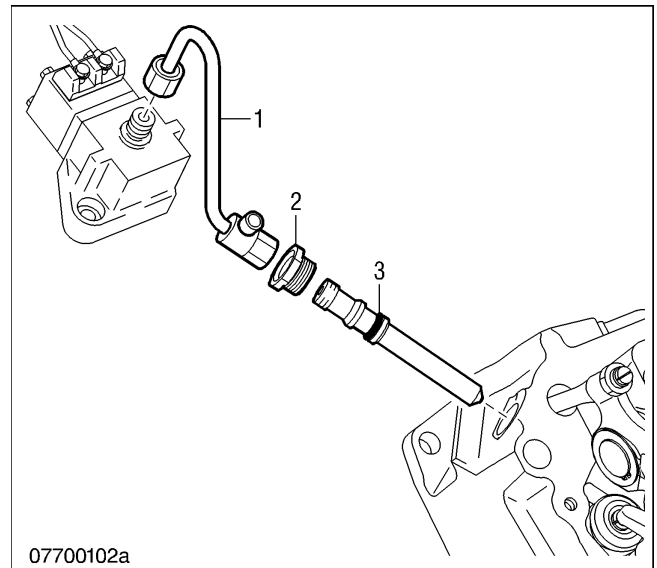
Clean high-pressure line (→ Page 394).

High-pressure line – Installation

1. Coat sealing ring with petroleum jelly and wind on to pressure pipe tube (3).
2. Moisten taper of pressure pipe tube (3) with engine oil.
3. Slide pressure pipe tube (3) up to attachment on sealing ring in cylinder head.
4. Screw thrust screw (2) in to cylinder head.
5. Press pressure pipe tube (3) in completely by hand.
6. Tighten thrust screw (2) with torque wrench to prescribed tightening torque (→ Page 23) .

Note: High-pressure line must not be bent. Observe installation position.

7. Install high-pressure line (1) and tighten union nut with torque wrench to prescribed tightening torque (→ Page 23).
8. Tighten screw for clamp (→ Page 389)with torque wrench to prescribed tightening torque (→ Page 23).



Final steps

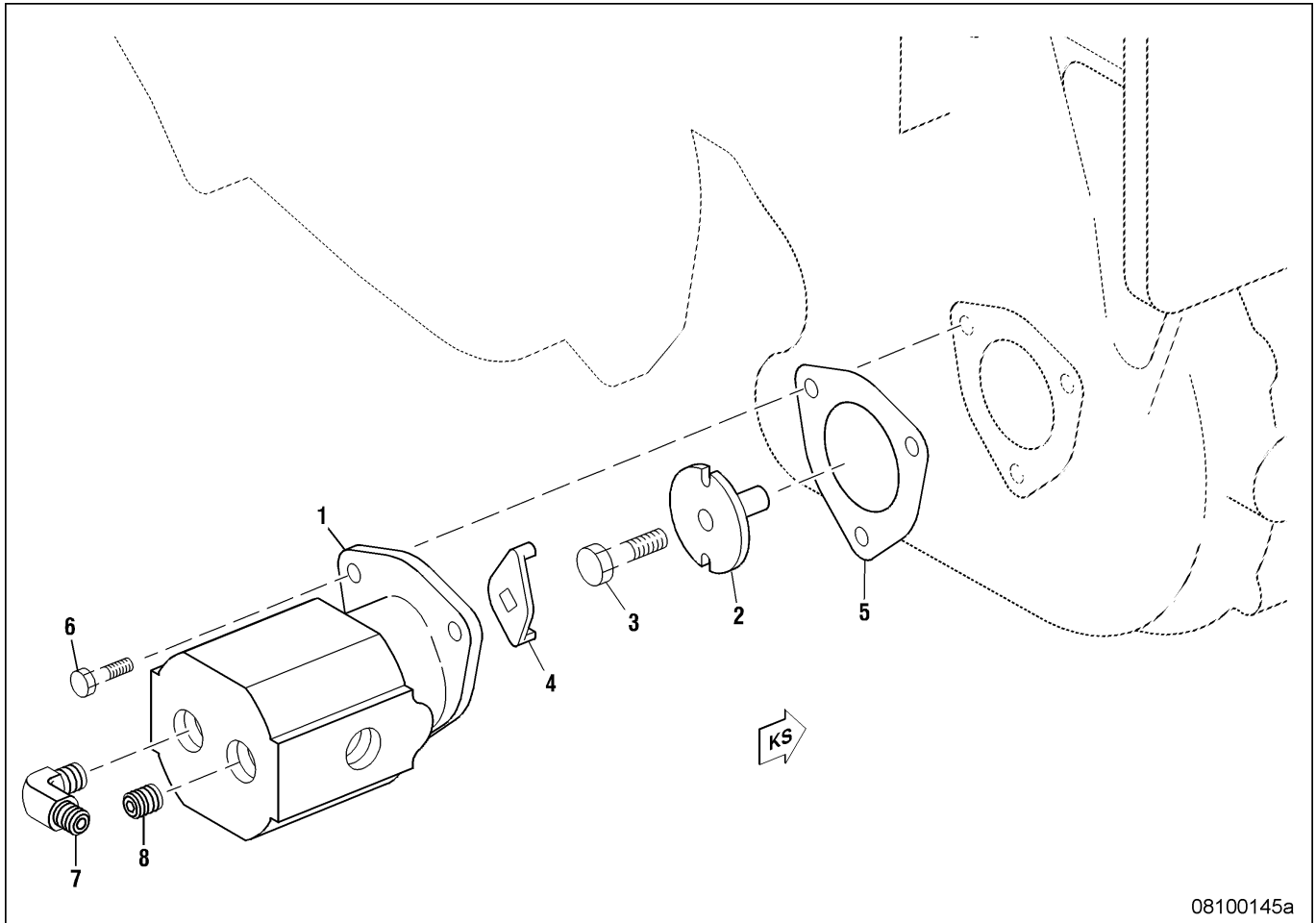
A distinction must be made as to whether

- 1 the engine was completely disassembled
- 2 the engine was removed but not disassembled
- 3 the engine is still installed

1	2	3	Operations	See
X	–	–	Assemble engine	(→ Page 58)
X	–	–	Install engine	(→ Page 60)
–	X	X	Assembly in reverse disassembly sequence	(→ Page 385)
–	–	X	Bleed fuel system	(→Operating Instructions)
–	–	X	Enable engine start	–

3.7 LP Fuel System

3.7.1 Fuel delivery pump – Overview



08100145a

- 1 Fuel delivery pump
- 2 Driver
- 3 Screw

- 4 Driver
- 5 Gasket
- 6 Screw

- 7 Bracket
- 8 Plug screw

3.7.2 Fuel delivery pump – Removal

Preconditions

- Engine is stopped and starting disabled.



Fuels are combustible.

Risk of fire and explosion!

- Avoid naked flames, electrical sparks and ignition sources.
- Do not smoke.

Preparatory steps

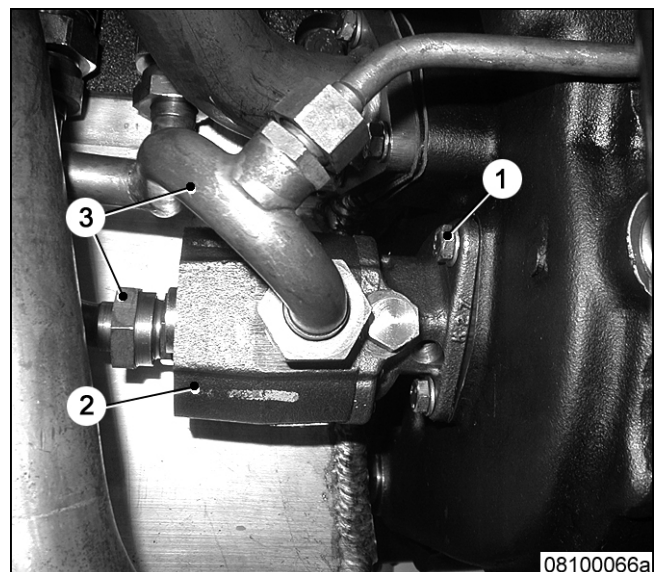
A distinction must be made as to whether

- 1 The engine is to be completely disassembled
- 2 The engine is to be removed but not disassembled
- 3 The engine is to remain installed

1	2	3	Operations	See
X	–	–	Remove engine	(→ Page 55)
X	–	–	Disassemble engine	(→ Page 56)
–	–	X	Disable engine start	(→ Page 15)

Removing fuel delivery pump

1. Disconnect fuel lines (3) to fuel delivery pump (2) and catch fuel emerging.
2. Remove screws (1) and washers.
3. Remove fuel delivery pump (2) from housing and remove driver.
4. Remove gasket.
5. Remove screw from driver in engine coolant pump.
6. Seal all openings with suitable covers.



08100066a

3.7.3 Fuel delivery pump – Disassembly

Remove fuel delivery pump (→ Page 399).




Disassembling fuel delivery pump

Disassembly of this component is not planned.

In the case of wear or objection, the fuel delivery pump must be replaced.

3.7.4 Fuel delivery pump – Cleaning

Material

Designation / Use	Part No.	Qty.
Cleaning agent		
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors. 	
 WARNING	Fuels are combustible. Risk of fire and explosion! <ul style="list-style-type: none"> • Avoid naked flames, electrical sparks and ignition sources. • Do not smoke. 	
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask. 	

Remove fuel delivery pump (→ Page 399).

Cleaning fuel delivery pump

1. Clean all components with cleaning agent.
2. Remove cleaning agent.
3. Thoroughly blow all parts clean with compressed air.

3.7.5 Fuel delivery pump – Check

Spare parts

Designation / Use	Part No.	Qty.
Fuel delivery pump		
Screw		
Driver		



WARNING

Fuels are combustible.

Risk of fire and explosion!

- Avoid naked flames, electrical sparks and ignition sources.
- Do not smoke.

Clean fuel delivery pump (→ Page 401).

Checking fuel delivery pump

Item	Findings	Task
Check fuel-delivery pump externally for damage.	Damaged	Replace
Check screw and driver for damage.	Damaged	Replace
Check screw threads for damage.	Damaged	Replace

3.7.6 Fuel delivery pump – Installation

Material

Designation / Use	Part No.	Qty.
Engine oil		

Spare parts

Designation / Use	Part No.	Qty.
Gasket		



WARNING

Fuels are combustible.

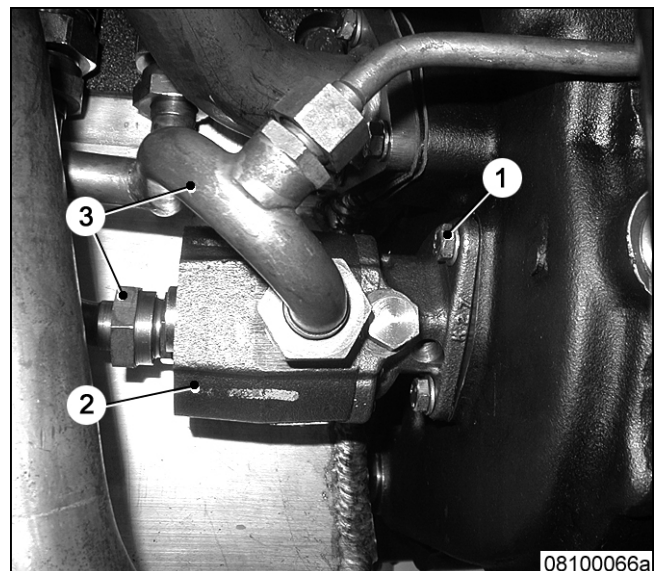
Risk of fire and explosion!

- Avoid naked flames, electrical sparks and ignition sources.
- Do not smoke.

Check fuel delivery pump (→ Page 402).

Installing fuel delivery pump

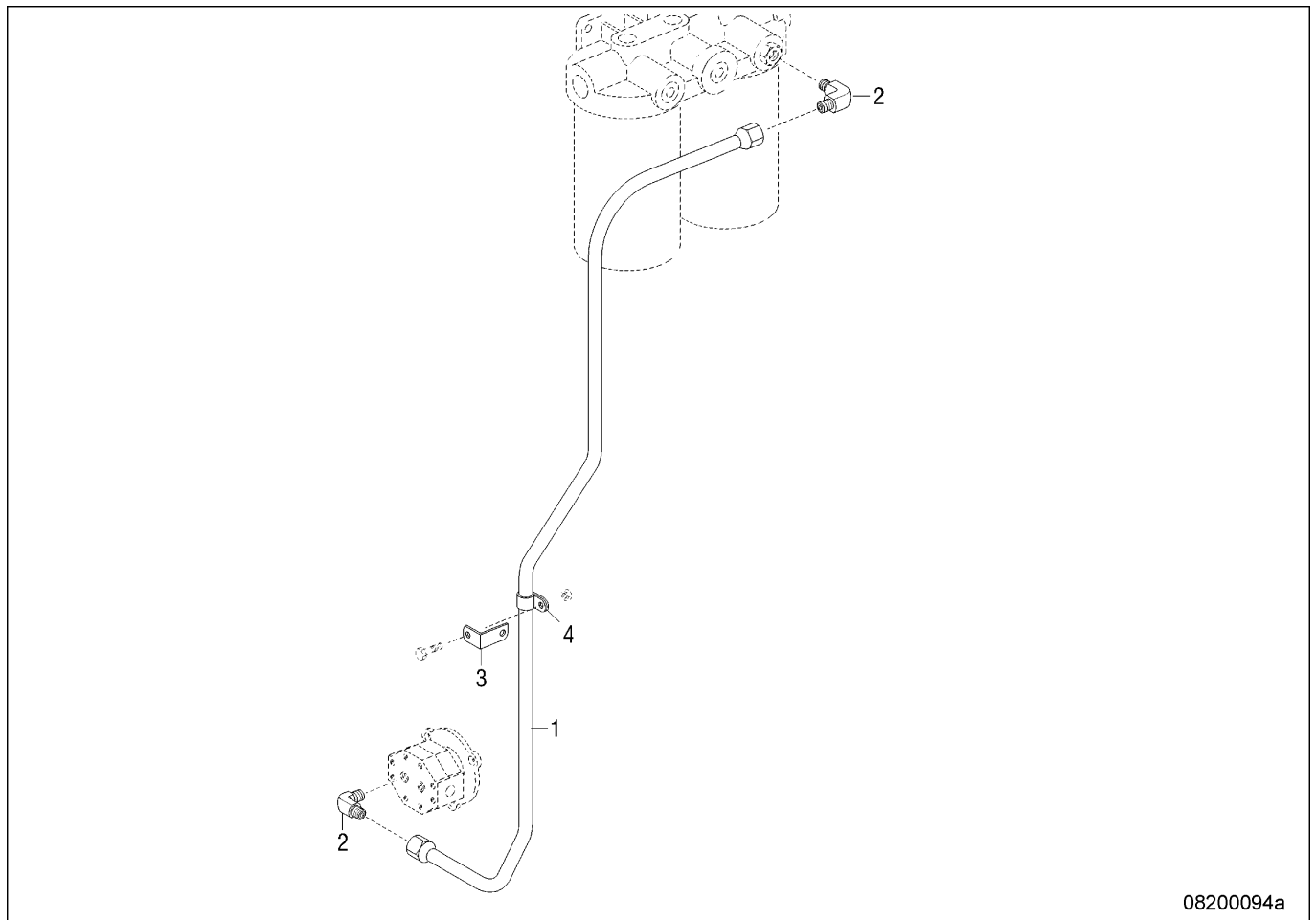
1. Prior to installation, remove all covers.
2. Insert screw for driver on coolant pump shaft and tighten with torque wrench to prescribed tightening torque (→ Page 23).
3. Align fuel delivery pump driver (2).
4. Place gasket on fuel delivery pump (2).
5. Insert fuel delivery pump (2) in locating bore.
6. If fuel delivery pump (2) can not be inserted right up to the stop, then remove fuel delivery pump (2) again and check alignment of driver to screw.
7. Insert screws (1) and tighten.
8. Connect fuel lines (3) to fuel delivery pump (2).



Final steps

A distinction must be made as to whether				
1 the engine was completely disassembled				
2 the engine was removed but not disassembled				
3 the engine is installed				
1	2	3	Operations	See
X	–	–	Assemble engine	(→ Page 58)
X	–	–	Install engine	(→ Page 60)
–	X	X	Assemble in reverse sequence	(→ Page 399)
–	–	X	Fill fuel system	(→ Operating Instructions)
–	–	X	Enable engine start	–
–	–	X	After engine start, visually inspect fuel lines for leaks.	

3.7.7 Fuel line from fuel delivery pump to fuel filter – Overview



1 Fuel line
2 Union

3 Bracket
4 Clamp

08200094a

3.7.8 Fuel line from fuel delivery pump to filter – Removal

Preconditions

- Engine is stopped and starting disabled.



Fuels are combustible.

Risk of fire and explosion!

- Avoid naked flames, electrical sparks and ignition sources.
- Do not smoke.

Preparatory steps

A distinction must be made as to whether

- 1 The engine is to be completely disassembled
- 2 The engine is to be removed but not disassembled
- 3 The engine is to remain installed



1	2	3	Operations	See
X	–	–	Remove engine	(→ Page 55)
X	–	–	Disassemble engine	(→ Page 56)
–	–	X	Disable engine start	(→ Page 15)

Removing fuel supply line from fuel delivery pump to filter

1. Prior to removal, it is advisable to take photographs of all lines or to mark lines.
2. Release threaded union on fuel line and catch fuel emerging.
3. Disconnect fuel supply as shown in overview drawing (→ Page 405).
4. Seal all openings with suitable covers.

3.7.9 Fuel supply line from fuel delivery pump to fuel filter – Cleaning

Material

Designation / Use	Part No.	Qty.
Cleaning agent		
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors. 	
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask. 	

Remove fuel supply line from fuel delivery pump to fuel filter (→ Page 406).

Cleaning fuel supply line from fuel delivery pump to fuel filter

1. Clean fuel supply line from fuel delivery pump to fuel filter with cleaning agent.
2. Remove cleaning agent.
3. Thoroughly blow out fuel supply line from fuel delivery pump to fuel filter using compressed air.

3.7.10 Fuel supply line from fuel delivery pump to fuel filter – Check

Spare parts

Designation / Use	Part No.	Qty.
Fuel line		
Union		



Compressed air is pressurized.

Risk of injury!

- Pressure must not exceed 0.5 bar.
- Wear protective clothing, gloves, and goggles / safety mask.

Clean fuel supply line from fuel delivery pump to fuel filter (→ Page 407).


Checking fuel supply line from fuel delivery pump to fuel filter (→ Page 408)


Item	Findings	Task
Visually inspect all components for damage.	Damaged	Replace
Check fuel line fasteners for damage and wear.	Damaged	Replace
Check threads of nuts and screw joints for ease of movement.	No ease of movement	<ul style="list-style-type: none"> • Rework: Recut threads. • Replace
Pressure-test fuel line with air in water bath for leaks. A water temperature of min = 30°C or max = 40°C at a test pressure of 0.5 bar must be observed.	Leaking	Replace

3.7.11 Fuel supply line from fuel delivery pump to fuel filter – Installation

Spare parts

Designation / Use	Part No.	Qty.
Bracket		
Clamp		

 WARNING	Fuels are combustible. Risk of fire and explosion! <ul style="list-style-type: none"> • Avoid naked flames, electrical sparks and ignition sources. • Do not smoke.
---	---

 CAUTION	Contamination of components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Check components for special cleanness.
---	---

Check fuel supply line from fuel delivery pump to fuel filter (→ Page 408) .

Installing fuel supply line from fuel delivery pump to fuel filter

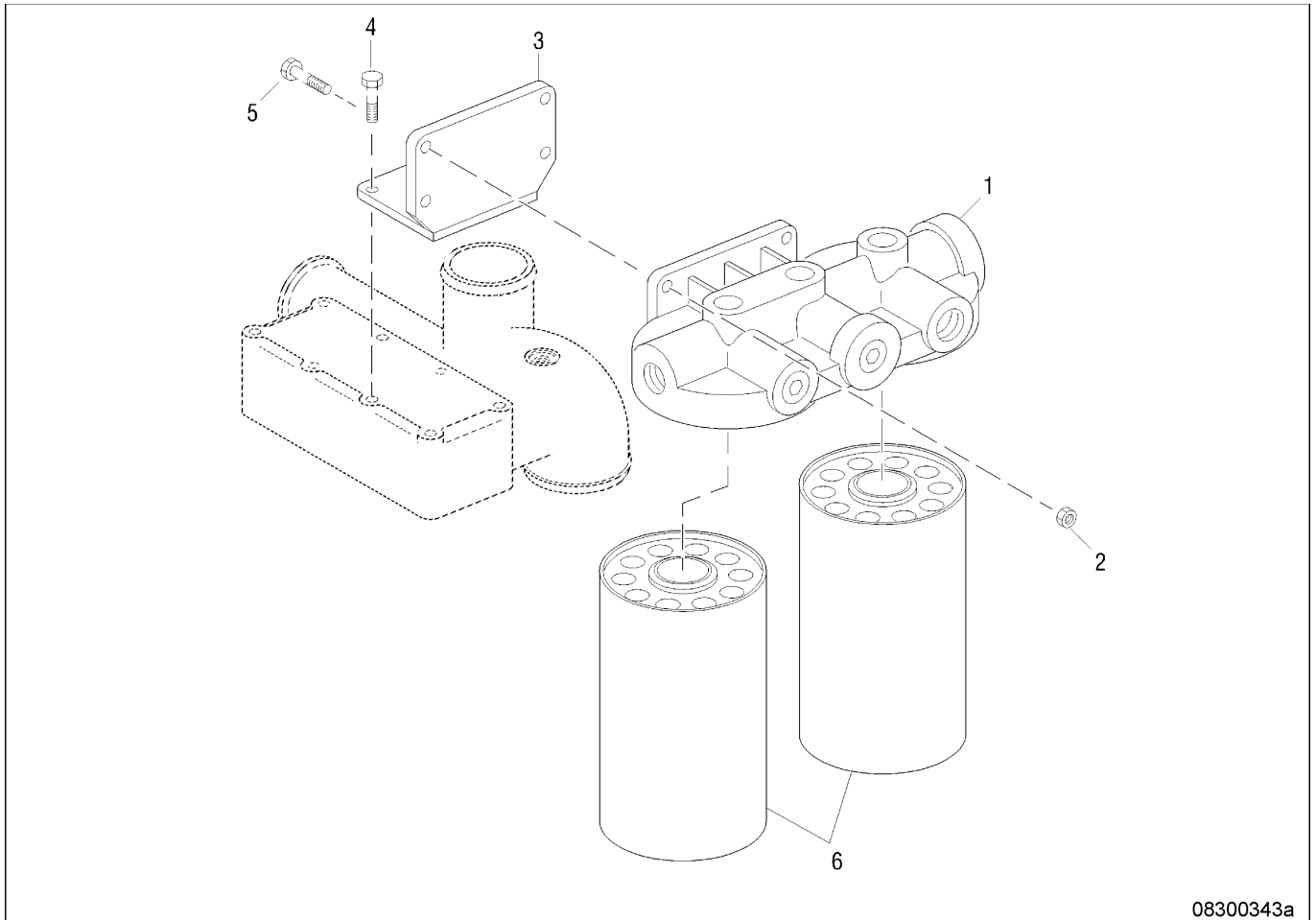
1. Remove all plug screws.
2. Blow out fuel line with compressed air.
3. Install fuel line with adapters and fasteners as per overview, pictures taken or markings made. Ensure that the components are not subject to tension (→ Page 405).

Final steps

For these steps a distinction must be made as to whether				
1 the engine has been completely disassembled				
2 the engine has been removed but not disassembled				
3 the engine has remained installed				
1	2	3	Operations	See
X	–	–	Assemble engine.	(→ Page 58)
X	–	–	Install engine.	(→ Page 60)
–	X	X	Fill fuel system.	(→Operating instructions)
–	–	X	Enable engine start.	–

3.7.12 Fuel filter – Overview

Fuel filter



08300343a

1 Filter head
2 Nut

3 Bracket
4 Screw

5 Screw
6 Filter element

3.7.13 Fuel filter – Removal

Preconditions

- Engine is stopped and starting disabled

Special tools

Designation / Use	Part No.	Qty.
Filter wrench	F30379104	1



WARNING

Fuels are combustible.

Risk of fire and explosion!

- Avoid naked flames, electrical sparks and ignition sources.
- Do not smoke.

Preparatory steps

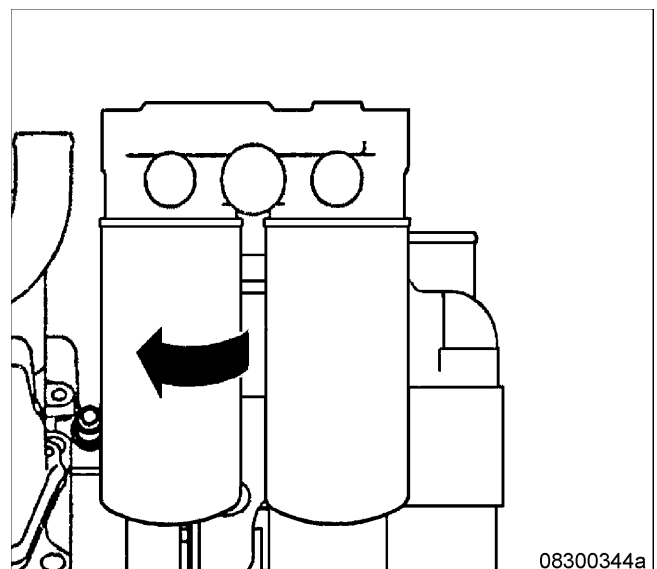
For these steps a distinction must be made as to whether

- 1 the engine is to be completely disassembled
- 2 the engine is to be removed but not disassembled
- 3 the engine is to remain installed

1	2	3	Operations	See
X	–	–	Remove engine.	(→ Page 55)
X	–	–	Disassemble engine.	(→ Page 56)
–	–	X	Disable engine start.	(→ Page 15)
–	X	X	Disconnect fuel lines.	(→ Page 406) (→ Page 419)



Removing fuel duplex filter

1. Remove filter elements using a filter wrench.
2. Collect emerging fuel.
3. Remove filter head and bracket as per overview (→ Page 410).



3.7.14 Fuel filter – Cleaning

Material

Designation / Use	Part No.	Qty.
Cleaning agent		
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors. 	
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask. 	

Remove fuel filter (→ Page 411).

Cleaning fuel filter

1. Clean all components using cleaning agent.
2. Remove cleaning agent.
3. Thoroughly blow out all parts with compressed air.

3.7.15 Fuel filter – Check



Compressed air is pressurized.

Risk of injury!

- Pressure must not exceed 0.5 bar.
- Wear protective clothing, gloves, and goggles / safety mask.

Clean fuel filter (→ Page 412).

Checking fuel filter

Item	Findings	Task
Visually check filter head for damage and condition.	Damaged	Replace
Leak-test filter head using air and water bath. A water temperature of min = 30°C and max = 40°C at a test pressure of 0.5 bar must be observed. Install filter elements for leak testing.	Leaking	<ul style="list-style-type: none"> • Replace blanking plug. • Replace filter head
Check sealing and bolt-on faces for damage.	Damaged	<ul style="list-style-type: none"> • Smooth using oilstone. • Replace

3.7.16 Fuel filter – Installation

Spare parts

Designation / Use	Part No.	Qty.
Filter element		



WARNING

Fuels are combustible.

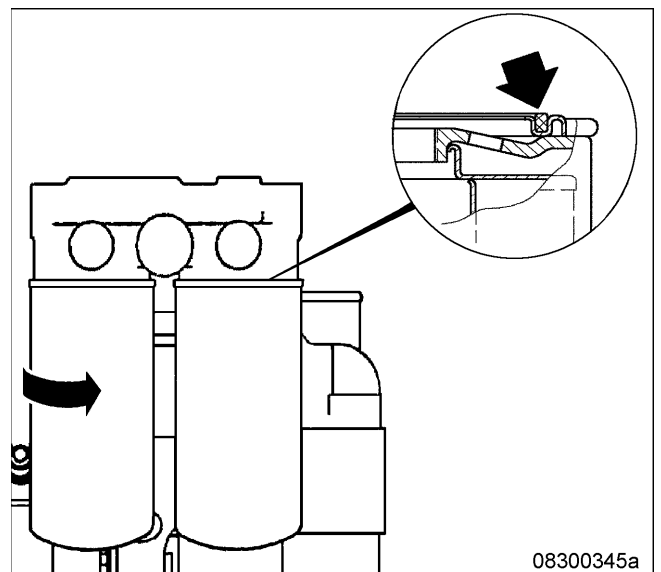
Risk of fire and explosion!

- Avoid naked flames, electrical sparks and ignition sources.
- Do not smoke.

Check fuel filter (→ Page 413).

Installing fuel filter

1. Install fuel filter as per overview (→ Page 410).
2. Coat filter O-rings (arrowed) with fuel.
3. Install filter and tighten by hand.

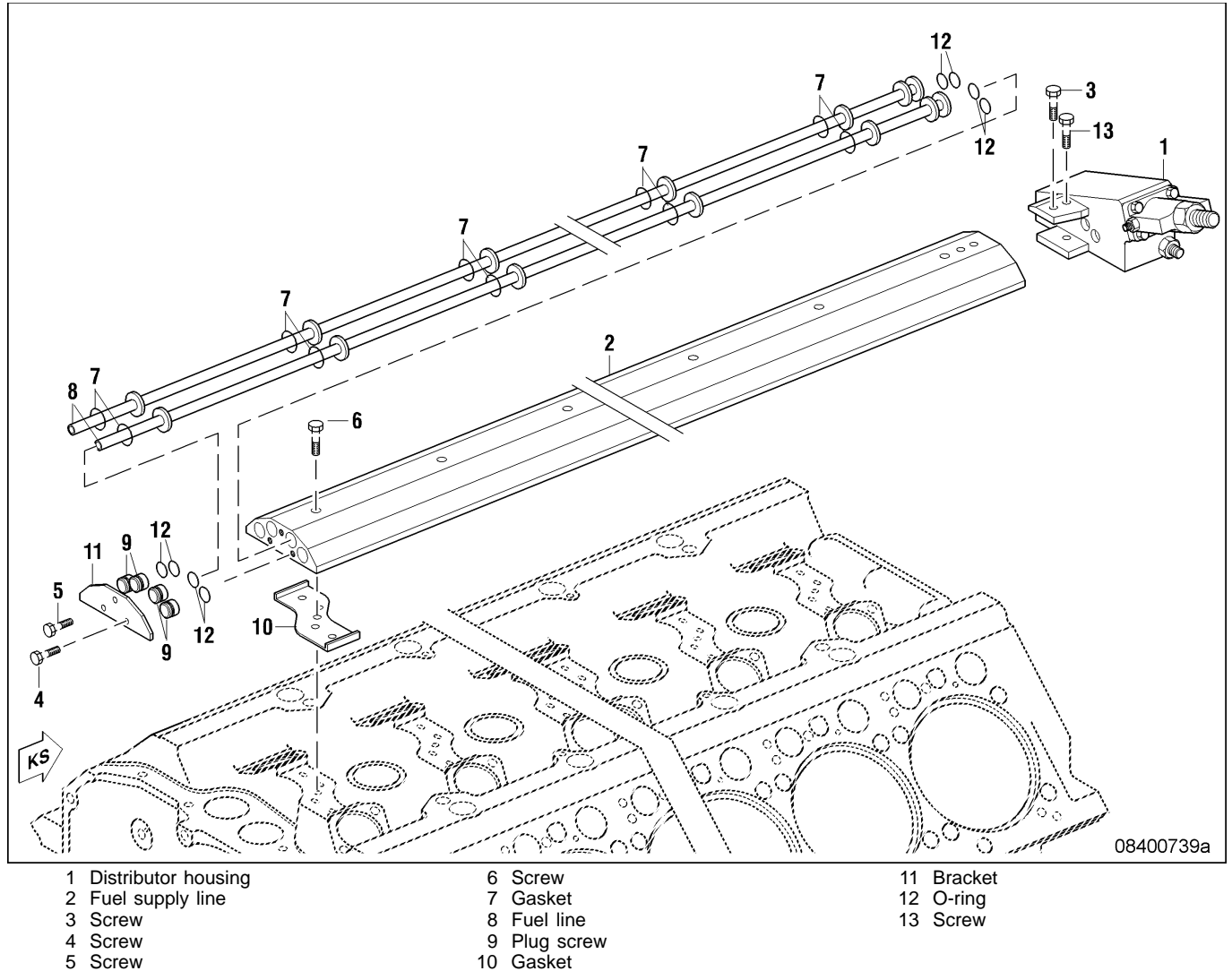


Final steps

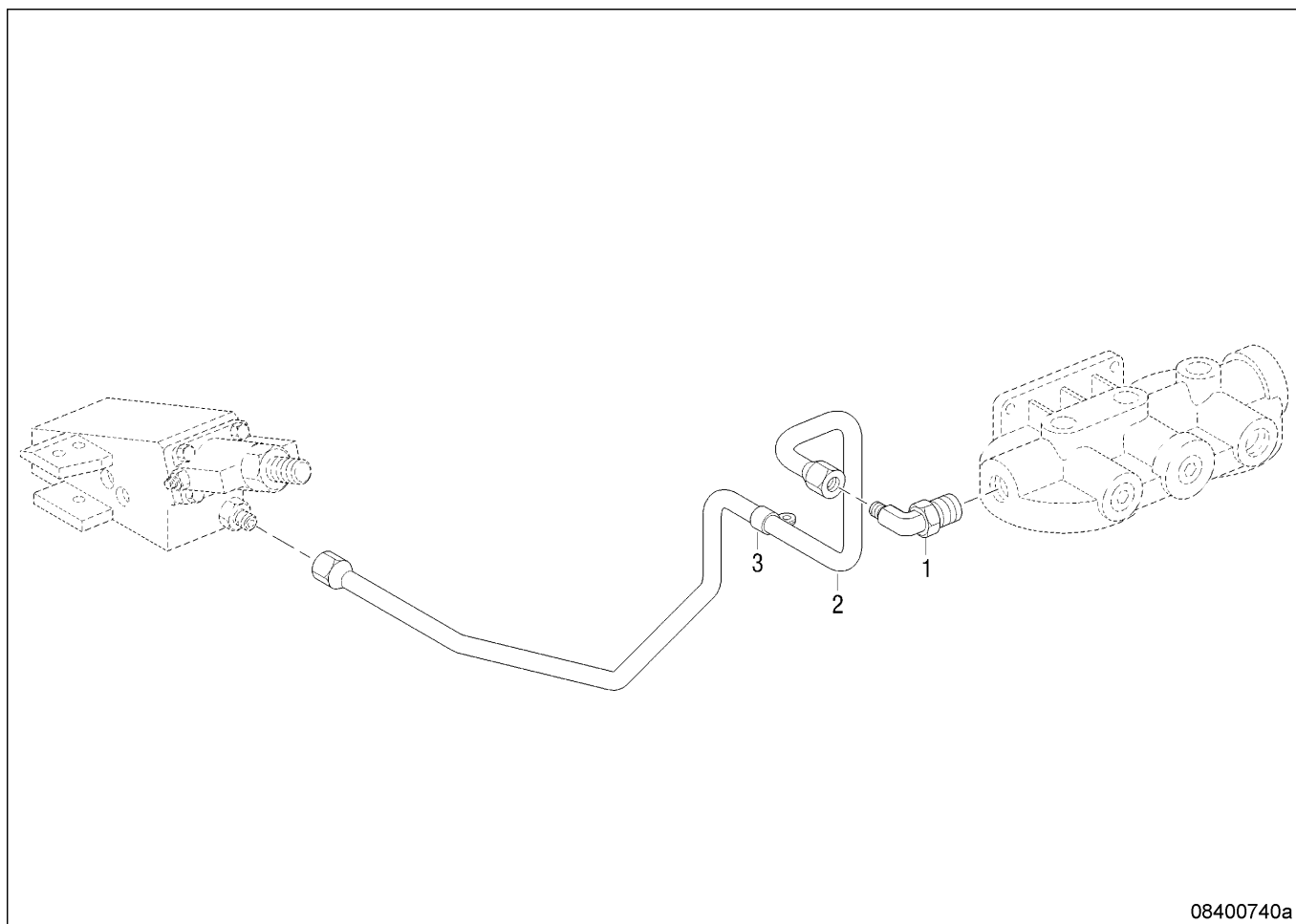
For these steps a distinction must be made as to whether				
1 the engine has been completely disassembled				
2 the engine has been removed but not disassembled				
3 the engine has remained installed				
1	2	3	Operations	See
X	–	–	Assemble engine.	(→ Page 58)
X	–	–	Install engine.	(→ Page 60)
–	X	X	Perform installation in reverse sequence of work steps as described for removal.	(→ Page 411)
–	–	X	Fill fuel system.	(→Operating instructions)
–	X	X	Enable engine start.	–

3.7.17 Fuel supply line from fuel filter to LP line – Overview

Fuel supply line



Fuel line



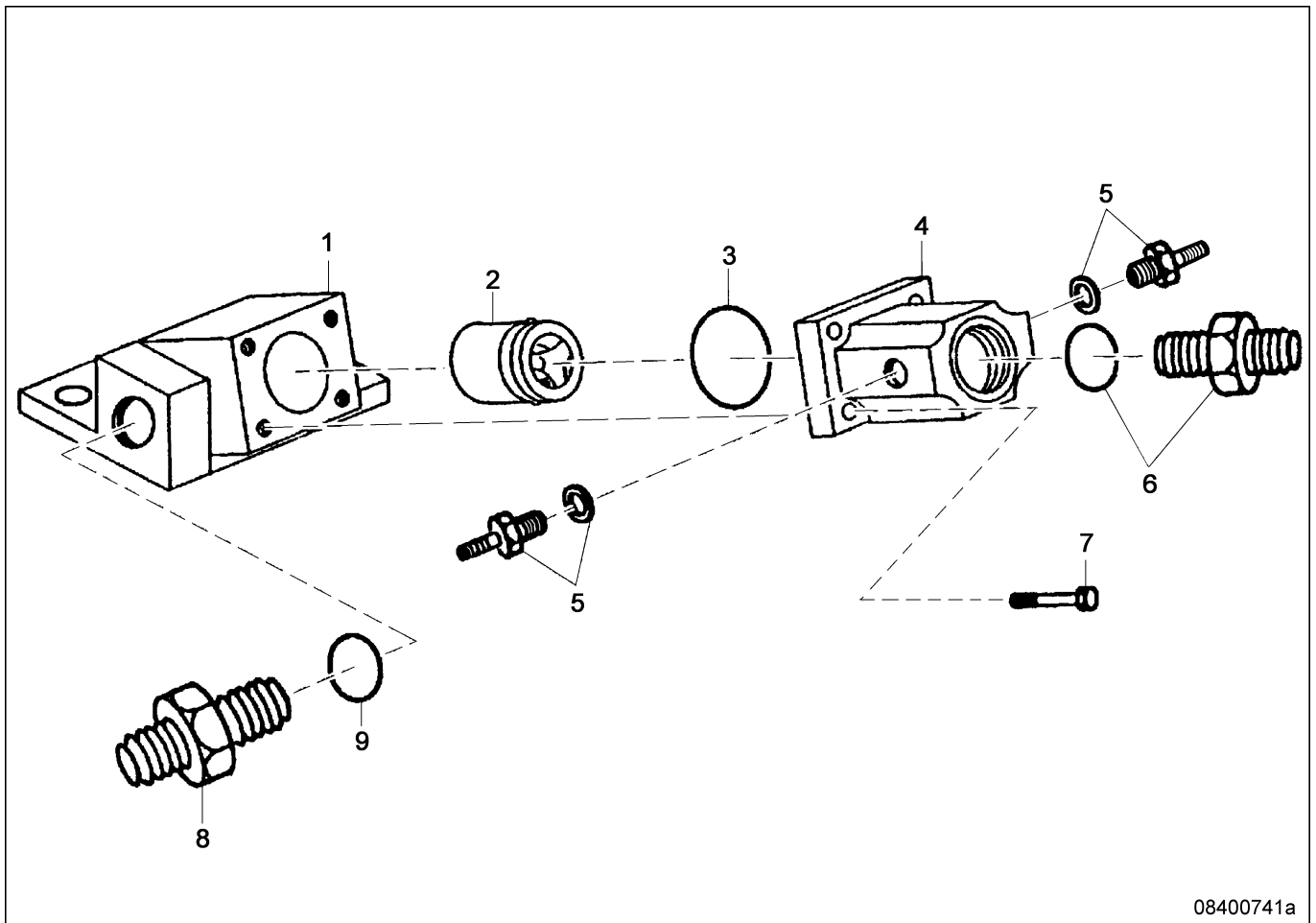
08400740a

1 Bracket

2 Fuel line

3 Clamp

Fuel distributor housing



08400741a

1 Housing
2 Pressure-relief valve
3 O-ring

4 Cover
5 Union
6 Union

7 Screw
8 Union
9 O-ring

3.7.18 Fuel line from fuel filter to LP line – Removal



Fuels are combustible.

Risk of fire and explosion!

- Avoid naked flames, electrical sparks and ignition sources.
- Do not smoke.

Preparatory steps

For these steps a distinction must be made as to whether

- 1 the engine is to be completely disassembled
- 2 the engine is to be removed but not disassembled
- 3 the engine is to remain installed

1	2	3	Operations	See
X	–	–	Remove engine.	(→ Page 55)
X	–	–	Disassemble engine.	(→ Page 56)
–	–	X	Disable engine start.	(→ Page 15)
–	–	X	Drain charge-air coolant.	(→ Operating instructions)
–	X	X	Remove coolant line from/to intercooler.	(→ Page 558)
–	X	X	Remove crankcase ventilation.	(→ Page 117)
–	X	X	Remove engine wiring harness.	(→ Page 604)
–	X	X	Remove air supply to the cylinders.	(→ Page 461)
–	X	X	Remove injection pump.	(→ Page 378)

Removing fuel line from fuel filter to LP line

1. Release threaded union on fuel line and collect emerging fuel.
2. Take pictures prior to removal or mark installed components and line.
3. Remove fuel line as per overview (→ Page 416).
4. Remove fuel line and distributor housing as per overview (→ Page 416).
5. Remove gaskets.
6. Close openings using suitable covers.

3.7.19 Fuel supply line from fuel filter to LP line – Disassembly



Fuels are combustible.

Risk of fire and explosion!

- Avoid naked flames, electrical sparks and ignition sources.
- Do not smoke.

Remove fuel supply line from fuel filter to LP line (→ Page 419).

Disassembling fuel supply line



1. Remove bracket and distributor housing from fuel supply line as per overview (→ Page 416) .
2. Screw suitable installation bolt into the plug screws and pull out.
3. Carefully push both fuel lines out of the fuel supply line using a suitable sleeve and plastic mallet. Work from the driving end towards the free end.
4. Remove gaskets and O-rings.

Disassembling distributor housing

1. Disassemble distributor housing as per overview (→ Page 416) .
2. Remove union.
3. Remove O-rings.

3.7.20 Fuel supply from fuel filter to L.P. line – Cleaning

Material

Designation / Use	Part No.	Qty.
Cleaning agent		
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors. 	
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask. 	

Remove fuel supply from fuel filter to L.P. line (→ Page 419).

Cleaning fuel supply from fuel filter to L.P. line

1. Clean all components with cleaning agent.
2. Remove cleaning agent.
3. Thoroughly blow out all parts using compressed air.

3.7.21 Fuel supply line from fuel filter to LP line – Check

Spare parts

Designation / Use	Part No.	Qty.
Fuel supply line		
Fuel line		
Union		
Pressure-relief valve		



WARNING

Compressed air is pressurized.

Risk of injury!

- Pressure must not exceed 0.5 bar.
- Wear protective clothing, gloves, and goggles / safety mask.

Clean fuel supply line from fuel filter to LP line (→ Page 421).

Checking fuel supply line from fuel filter to LP line

Item	Findings	Task
Visually inspect fuel lines for damage.	Damaged	<ul style="list-style-type: none"> • Recondition • Replace
Pressure-test fuel line with air in water bath for leaks. A water temperature of min = 30°C and max = 40°C at a test pressure of 0.5 bar must be observed.	Leaking	Replace
Check sealing and bolt-on faces for damage.	Damaged	<ul style="list-style-type: none"> • Rework: Smooth using oilstone. • Replace
Check threads of union nut and screw joints for ease of movement.	No ease of movement	<ul style="list-style-type: none"> • Rework: Recut threads. • Replace
Check securing elements on fuel lines for damage.	Damaged	Replace
Check fuel line, unions and plug-in pipes for damage.	Damaged	Replace
Check pressure-relief valve for damage.	Damaged	Replace
Check opening pressure of pressure-relief valve. Opening pressure 4.0 bar.	Opening pressure not reached.	Replace

3.7.22 Fuel supply line from fuel filter to LP line – Assembly

Special tools

Designation / Use	Part No.	Qty.
Installation device	F6557958	8

Material

Designation / Use	Part No.	Qty.
Engine oil		
Petroleum jelly, white		

Spare parts

Designation / Use	Part No.	Qty.
Gasket		
O-rings		
Pressure-relief valve		



WARNING

Compressed air is pressurized.

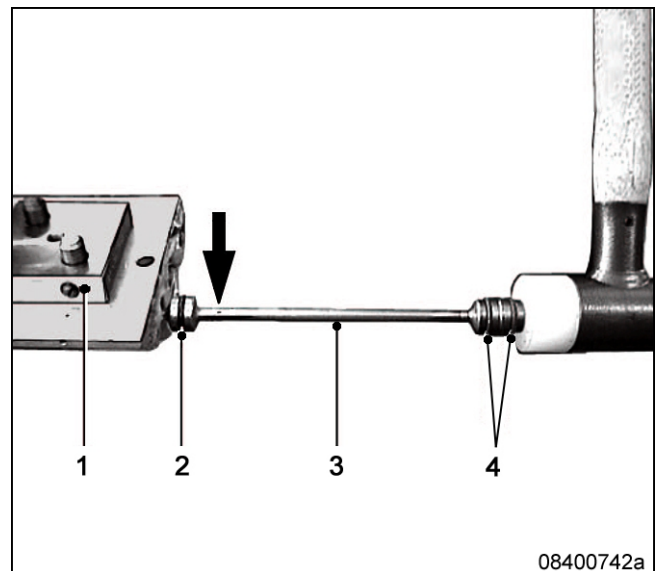
Risk of injury!

- Pressure must not exceed 0.5 bar.
- Wear protective clothing, gloves, and goggles / safety mask.

Check fuel supply line from fuel filter to LP line (→ Page 422).

Assembling fuel supply line

1. Blow out fuel lines and fuel bores in the fuel rail using compressed air.
 2. Attach installation devices (1) for fuel lines to fuel rail.
 3. Coat bores in the fuel rail with petroleum jelly using suitable brush.
 4. Coat gaskets (2) and O-rings (4) with petroleum jelly and position in grooves of plug screws and fuel lines.
- Note:** The bores (arrowed) in the fuel line point to the bolt-on face of the fuel rail.
5. Using a plastic mallet and working from the free end, carefully push both fuel lines (3) into the fuel rail up to the stop.
 6. Install plug screws into fuel rail as per overview and secure using bracket (→ Page 416).
 7. Remove installation devices (1).



Assembling distributor housing

1. Coat O-rings with petroleum jelly.
2. Assemble distributor housing with new pressure-relief valve and new O-rings as per overview ensuring correct positioning of the pressure-relief valve (→ Page 416).
3. Tighten union and screws to specified tightening torque using a torque wrench (→ Page 23).

3.7.23 Fuel supply line from fuel filter to LP line – Installation

Material

Designation / Use	Part No.	Qty.
Engine oil		
Petroleum jelly, white		

Spare parts

Designation / Use	Part No.	Qty.
Gasket		



Fuels are combustible.

Risk of fire and explosion!

- Avoid naked flames, electrical sparks and ignition sources.
- Do not smoke.



Compressed air.

Risk of injury!

- Do not direct compressed-air jet at persons.
- Wear protective goggles / safety mask and ear protectors.



Contamination of components.

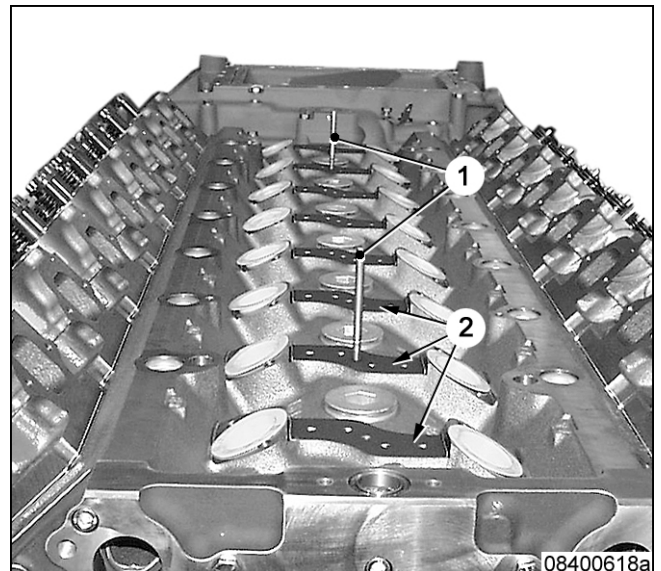
Damage to component!

- Observe manufacturer's instructions.
- Check components for special cleanness.

Check fuel supply line from fuel filter to LP line (→ Page 422).

Installing fuel supply line from fuel filter to LP line

1. Remove all covers prior to installation.
2. Blow out fuel lines with compressed air.
3. Attach distributor housing to fuel line as per overview (→ Page 416).
4. Position gaskets (2) on crankcase.
5. Screw two assembly studs (1) into crankcase.
6. Position fuel line over assembly studs onto gaskets.
7. Remove assembly studs (1).
8. Install fuel rail and fuel line with connectors and fasteners as per overview, ensuring that the components are not subject to tension (→ Page 416).
9. Tighten screws to specified tightening torque using a torque wrench (→ Page 23).

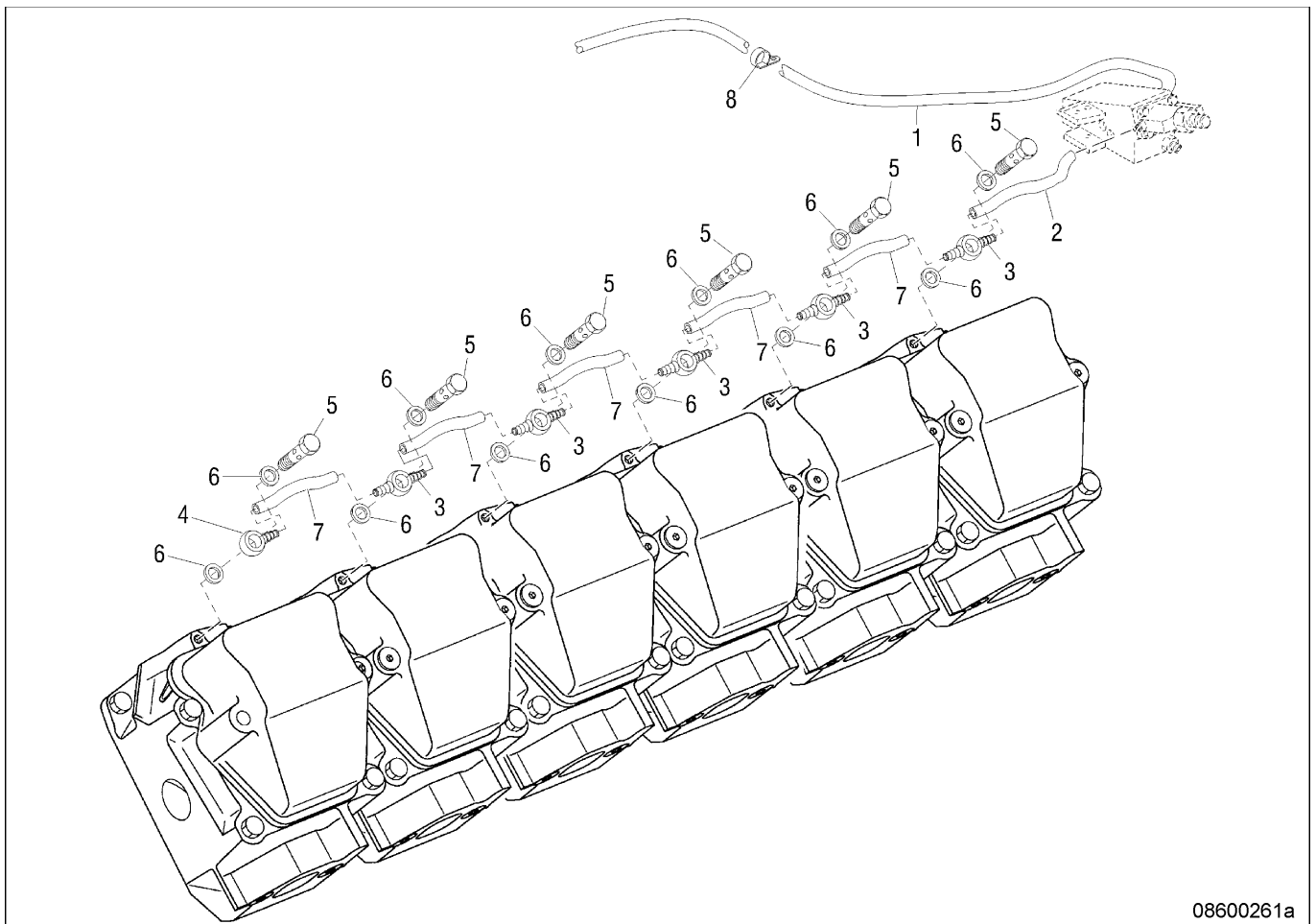


Final steps

For these steps a distinction must be made as to whether				
1 the engine has been completely disassembled				
2 the engine has been removed but not disassembled				
3 the engine has remained installed				
1	2	3	Operations	See
X	–	–	Assemble engine.	(→ Page 58)
X	–	–	Install engine.	(→ Page 60)
–	–	X	Fill fuel system.	(→Operating instructions)
–	X	X	Enable engine start.	–
–	X	X	Visually inspect fuel lines for leaks following engine start.	–

3.7.24 Leak-off fuel system – Overview

Also applies to 16V



08600261a

- | | |
|-------------|----------------|
| 1 Fuel line | 5 Banjo screw |
| 2 Fuel line | 6 Sealing ring |
| 3 Union | 7 Fuel line |
| 4 Union | 8 Clamp |

3.7.25 Leak-off fuel system – Removal

Preconditions

- Engine is stopped and starting disabled.



Fuels are combustible.

Risk of fire and explosion!

- Avoid naked flames, electrical sparks and ignition sources.
- Do not smoke.

Preparatory steps

A distinction must be made as to whether

- 1 the engine is to be completely disassembled
- 2 the engine is to be removed but not disassembled
- 3 the engine is to remain installed



1	2	3	Operations	See
X	–	–	Remove engine	(→ Page 55)
X	–	–	Disassemble engine	(→ Page 56)
–	–	X	Disable engine start	(→ Page 15)
–	X	X	Remove charge air manifold (if necessary)	(→ Page 461)

Leak-off fuel system – Removal

1. Take photos or mark attachments and lines before removing them.
2. Release threaded union on fuel line and catch fuel emerging.
3. Remove fuel lines with securing elements as shown in overview drawing (→ Page 426) .
4. Seal openings with suitable covers.

3.7.26 Leak-off fuel line – Cleaning

Material

Designation / Use	Part No.	Qty.
Cleaning agent		
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors. 	
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask. 	

Remove leak-off fuel pipework (→ Page 427).

Leak-off fuel line – Cleaning

1. Clean all components with cleaning agent.
2. Remove cleaning agent.
3. Thoroughly blow out all parts with compressed air.

3.7.27 Leak-off fuel line – Check

Spare parts

Designation / Use	Part No.	Qty.
Leak-off fuel line		
Banjo screw		

Clean leak-off fuel line (→ Page 428).




Checking leak-off fuel line

Item	Findings	Task
Visually inspect all leak-off fuel lines for damage.	Damaged	Replace
Check banjo screws for damage and threads for ease of movement.	<ul style="list-style-type: none"> • Damaged • Threads sluggish 	<ul style="list-style-type: none"> • Rework: Recut threads. • Replace
Check sealing and bolt-on faces for damage.	Damaged	<ul style="list-style-type: none"> • Rework: Smooth using oilstone. • Replace

3.7.28 Leak-off fuel line – Installation

Spare parts

Designation / Use	Part No.	Qty.
Fuel line		
Sealing ring		

 WARNING	Fuels are combustible. Risk of fire and explosion! <ul style="list-style-type: none"> • Avoid naked flames, electrical sparks and ignition sources. • Do not smoke.
 CAUTION	Incorrect installation of components and lines. Damage to component! <ul style="list-style-type: none"> • Ensure that components/lines are installed so that they are never under tension or strain. • Ensure correct installation position of components.
 CAUTION	Contamination of components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Check components for special cleanness.

Check leak-off fuel line (→ Page 429).

Installing leak-off fuel line

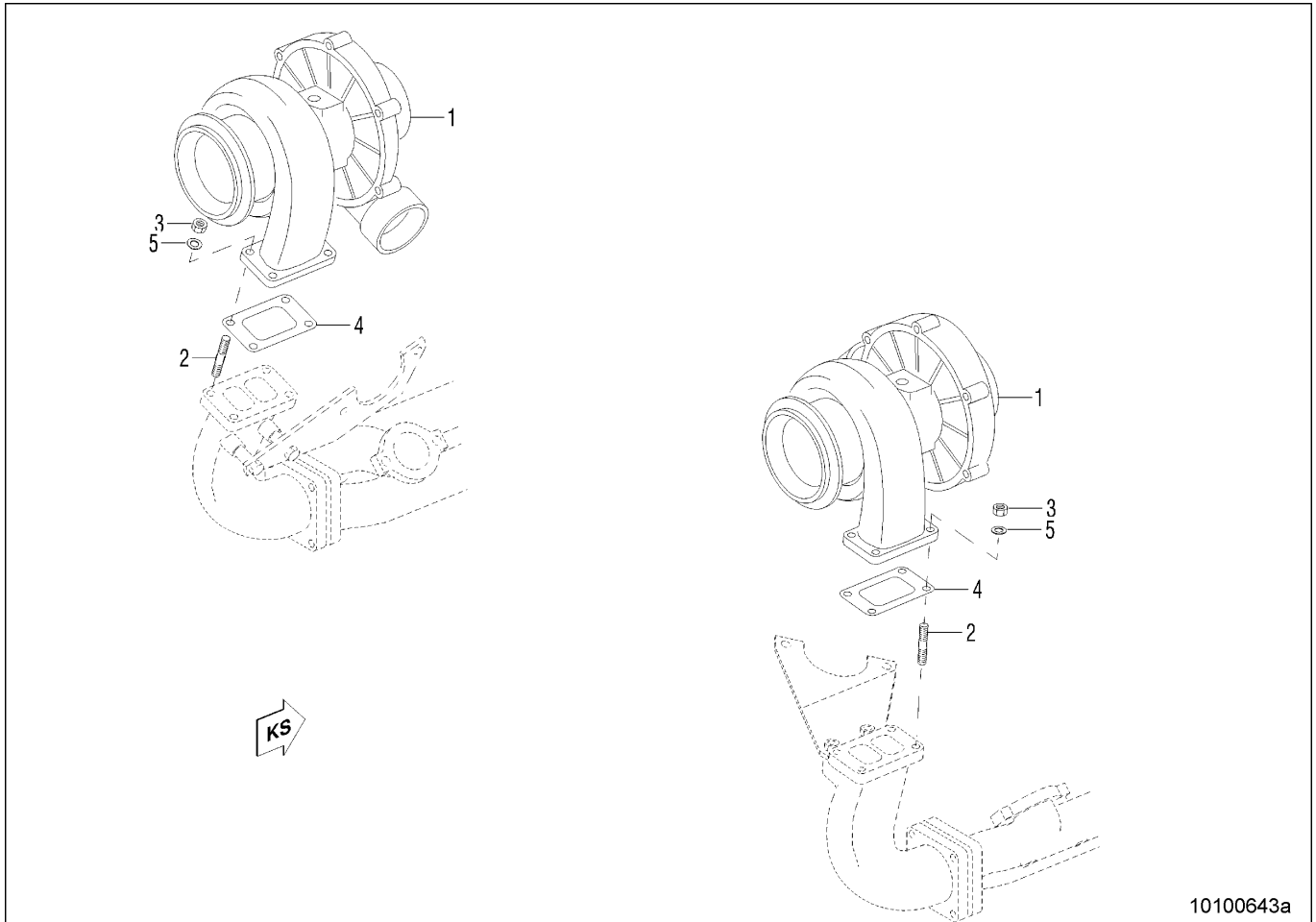
1. Remove all covers prior to installation.
2. Blow out leak-off fuel lines with compressed air.
3. Install leak-off fuel lines as per overview, pictures taken or markings made (→ Page 426) .

Final steps

For these steps a distinction must be made as to whether				
1 the engine has been completely disassembled				
2 the engine has been removed but not disassembled				
3 the engine has remained installed				
1	2	3	Operations	See
X	–	–	Assemble engine.	(→ Page 58)
X	–	–	Install engine.	(→ Page 60)
–	X	X	Perform installation in reverse sequence of work steps as described for removal.	(→ Page 427)
–	–	X	Enable engine start.	–

3.8 Exhaust Turbocharger

3.8.1 Exhaust turbocharger – Overview



1 Exhaust turbocharger
2 Stud

3 Nut
4 Gasket

5 Washer

10100643a

3.8.2 Exhaust turbocharger – Removal

Preconditions

- Engine is stopped and starting disabled



Heavy object.
Risk of crushing!

- Use appropriate lifting devices and appliances.

Preparatory steps

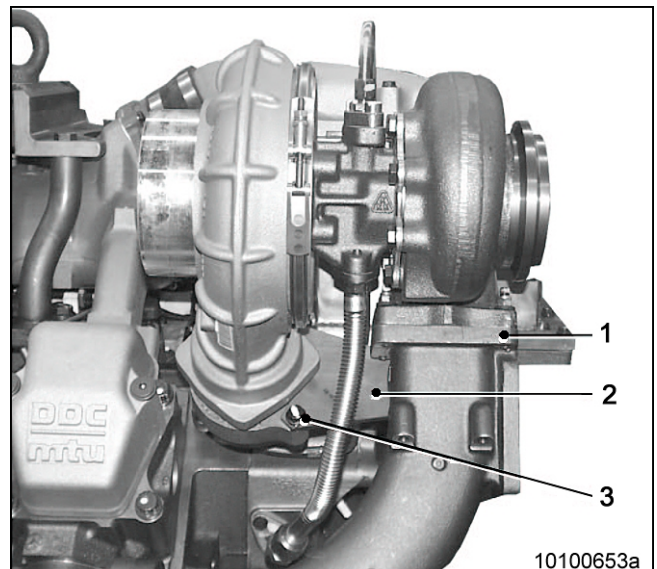
For these steps a distinction must be made as to whether

- 1 the engine is to be completely disassembled
- 2 the engine is to be removed but not disassembled
- 3 the engine is to remain installed

1	2	3	Operations	See
X	–	–	Remove engine.	(→ Page 55)
X	–	–	Disassemble engine.	(→ Page 56)
–	–	X	Disable engine start.	(→ Page 15)
–	X	X	Remove air ducting upstream of exhaust turbocharger.	–
–	X	X	Remove exhaust system downstream of exhaust turbocharger.	–
–	X	X	Remove exhaust turbocharger oil supply.	(→ Page 524)

Removing exhaust turbocharger

1. Remove screws (3) from flange.
2. Remove bracket (2).
3. Use rope to attach exhaust turbocharger to crane with light initial tension.
4. Remove nuts and washers for exhaust turbocharger from exhaust manifold (1).
5. Remove exhaust turbocharger from exhaust manifold (1).
6. Remove gasket.
7. Close openings using suitable covers.



3.8.3 Exhaust turbocharger – Disassembly

Special tools

Designation / Use	Part No.	Qty.
Vibe jaw	F70144375	2
T torque wrench	F30520703	1
Snap ring pliers	F30376601	1



WARNING

Equipment can drop off.
Liquid is highly pressurized.

Risk of injury, knocks or crushing!

- Only use specified and tested equipment.
- Do not enter the danger zone.
- Wear protective clothing, gloves, and goggles / safety mask.



WARNING

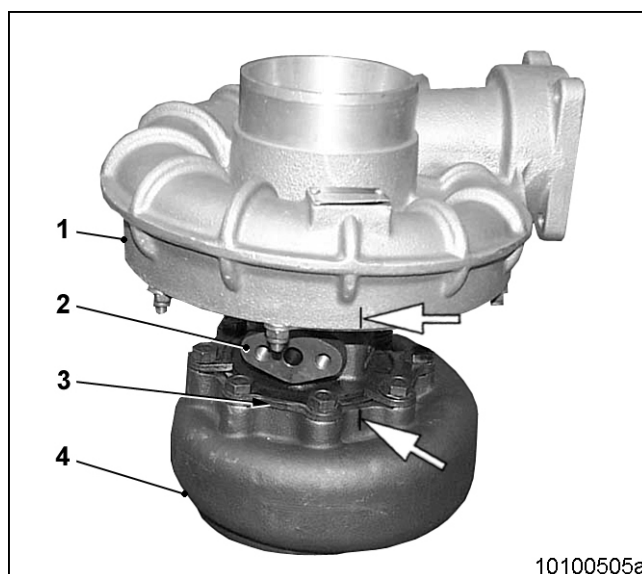
Spring/circlip/tensioning roller preload.

Risk of injury!

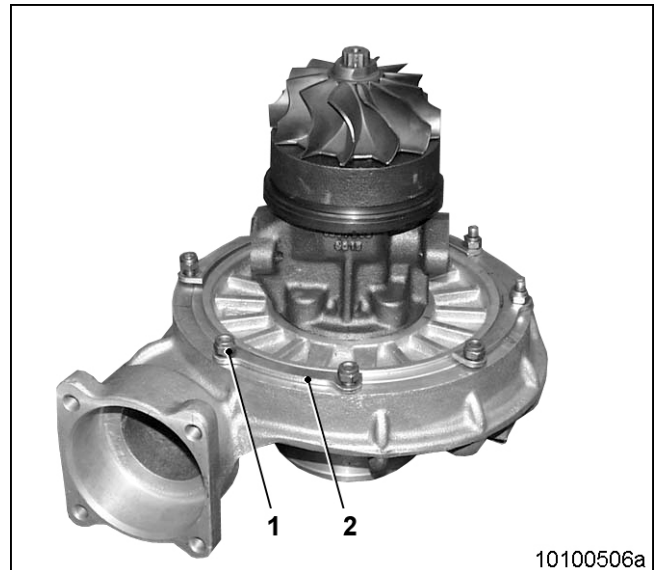
- Only use specified tool and equipment.

Exhaust turbocharger – Disassembly

1. Mark positions of compressor casing (1) and turbine housing (4) to the bearing housing (2) and to the back wall of the compressor (arrows).
2. Mount turbine housing (4) on the gas intake flange with braces.
3. Remove tensioning segments (3) from turbine housing.
4. Carefully take turbine housing (4) off bearing housing, in doing so do not tilt housing. Tilting can cause damage to the blade.
5. If the turbine housing (4) sticks, use rust-removing agent. If necessary, use copper hammer.



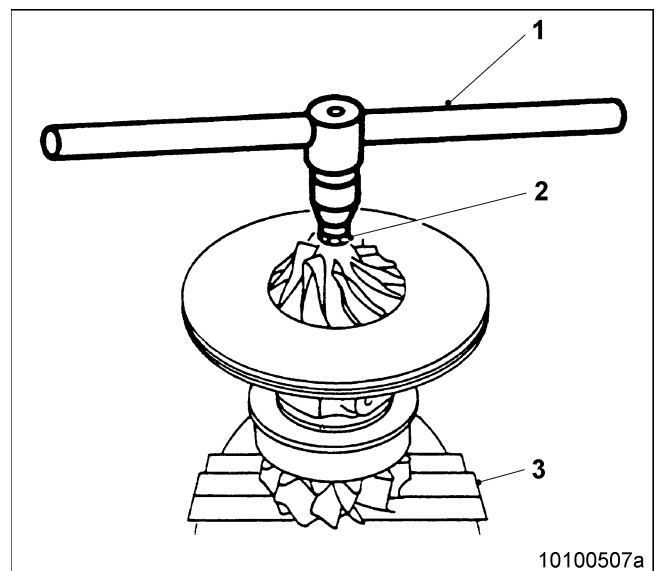
6. Remove nuts (1) and tensioning segments (2) from compressor casing.
7. Carefully take compressor casing off bearing housing. Take care that the blade is not damaged.
8. If the turbine housing sticks, use a rubber mallet.



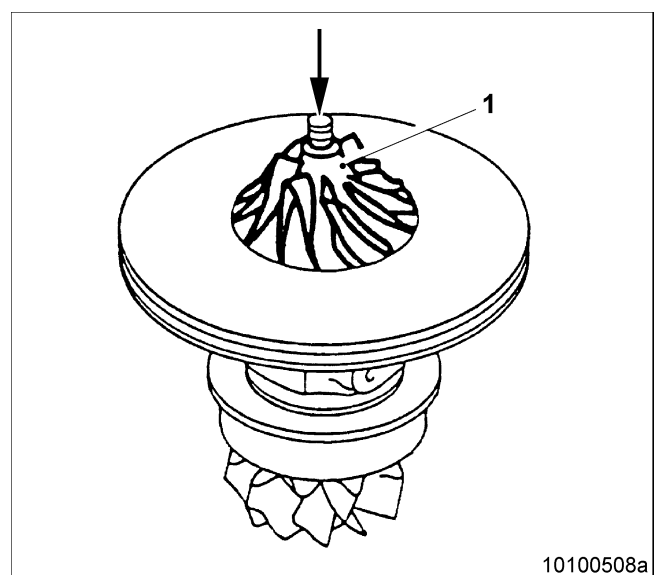
9. Mount impeller on the hub in the vibe jaw (3).

Note: Left-hand thread

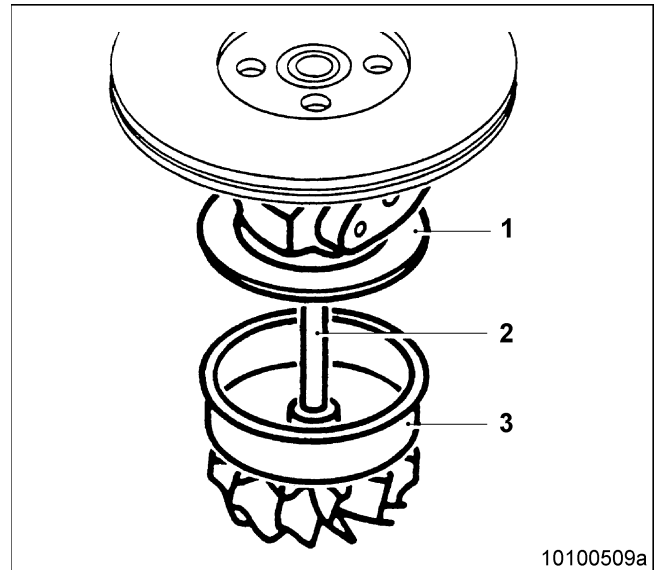
10. Remove self-locking nut (2) with two-armed wrench (1).
11. The nut is only loosened with the two-armed wrench so that the impeller shaft is not damaged.



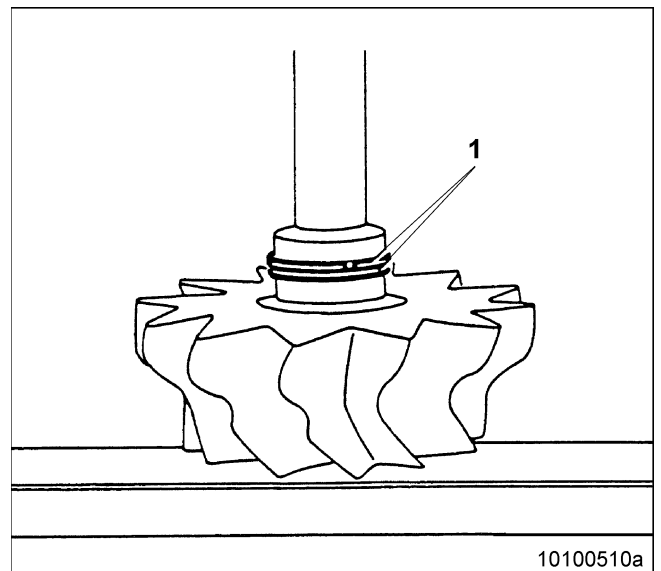
12. Pull compressor wheel (1) off compressor shaft, if necessary press the impeller out with a handpress (arrow).



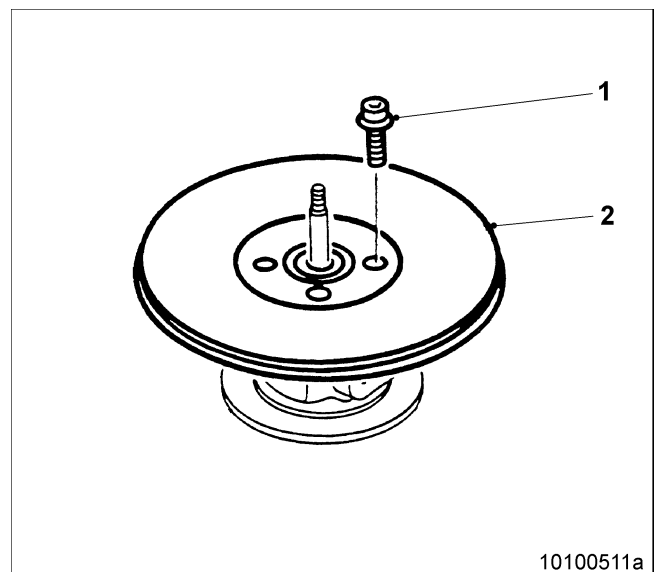
13. Carefully remove impeller shaft (2) from bearing housing (1).
14. Center heat shield (3) and remove from the impeller shaft, in doing so observe piston rings.



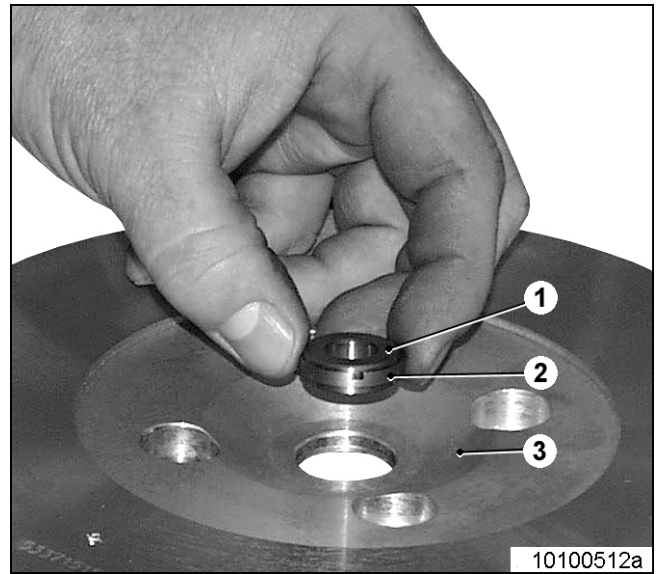
15. Remove piston rings (1) with pliers from the impeller shaft.



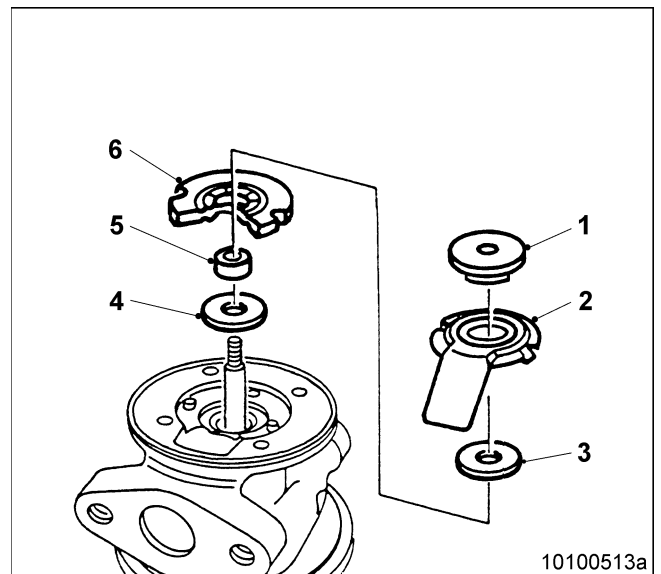
16. Mount bearing housing between both flange faces in bench vise (use braces).
17. Remove screws (1), take back wall (2) off bearing housing and remove O-rings.



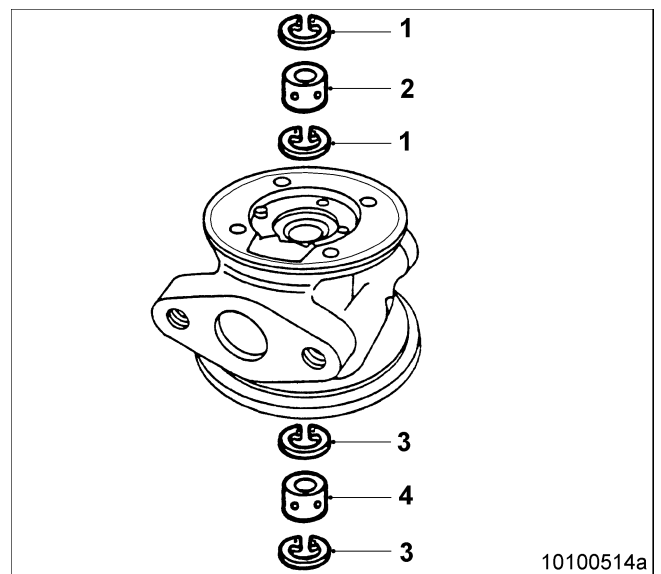
- 18. Press sealing bushing (1) out of back wall (3).
- 19. Remove piston rings (2) from the sealing bushing (1).



- 20. Remove oil thrower ring (1), oil retainer (2), bearing collar (3), axial bearing washer (6), bushing (5) and bearing collar (4) from bearing housing.






- 21. Install snap rings (1) and bearing bushing (2) at the compressor side and then remove snap rings (3) and bearing bushing (4) at the turbine side.



3.8.4 Exhaust turbocharger – Cleaning

Material

Designation / Use	Part No.	Qty.
Cleaning agent		
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors. 	
 WARNING	Fuels are combustible. Risk of fire and explosion! <ul style="list-style-type: none"> • Avoid naked flames, electrical sparks and ignition sources. • Do not smoke. 	
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask. 	

Disassemble exhaust turbocharger (→ Page 433).

Exhaust turbocharger – Cleaning

1. Clean all parts with cleaning agent.
2. Remove cleaning agent.
3. Thoroughly blow off all parts with compressed air.

Wet sand blasting

1. Protect bearing bores and piston ring sealing faces on the bearing housing and shaft and piston ring sealing faces on the back wall from cast-steel shots.
2. Wet sand blast housing, impeller, compressor wheel, back wall and heat shield.

3.8.5 Exhaust turbocharger – Check

Spare parts

Designation / Use	Part No.	Qty.
Exhaust turbocharger		
Bearing housing		
Turbine housing		
Compressor housing		
Rotor		
Compressor		

Clean exhaust turbocharger (→ Page 437).

Checking exhaust turbocharger

Item	Findings	Task
Visually check housing, guide vane ring, heat shield and rotors for cracks, foreign objects and scoring.	<ul style="list-style-type: none"> Cracks Foreign objects Scoring visible 	Replace
Check oil supply bores in bearing housing for foreign objects.	Foreign objects visible.	Replace
Check piston sealing faces and bearing points for damage.	Damaged	Replace
Check turbine housing for scaling.	Scale visible on gas inlet stay or circumference.	Replace
Check gas inlet flange and gas outlet flange for planeness.	Flange uneven.	<ul style="list-style-type: none"> Rework: Smooth using oilstone. Replace
Check rotors for bent or broken blades and check rotor shaft for scored bearings.	Damaged	Replace
Check piston seat in rear wall and bearing housing for scoring and damage.	<ul style="list-style-type: none"> Scores Damage visible 	Replace
Self-locking nuts O-rings	Replace	
Wear parts and rotating parts that display cracks must be replaced.		
Replace clamping segments, nut, shaft nut, piston rings, cylinder head bolts and washers, O-rings, oil deflector, thrust washer, snap rings, bearing bushes and screws during overhaul.		

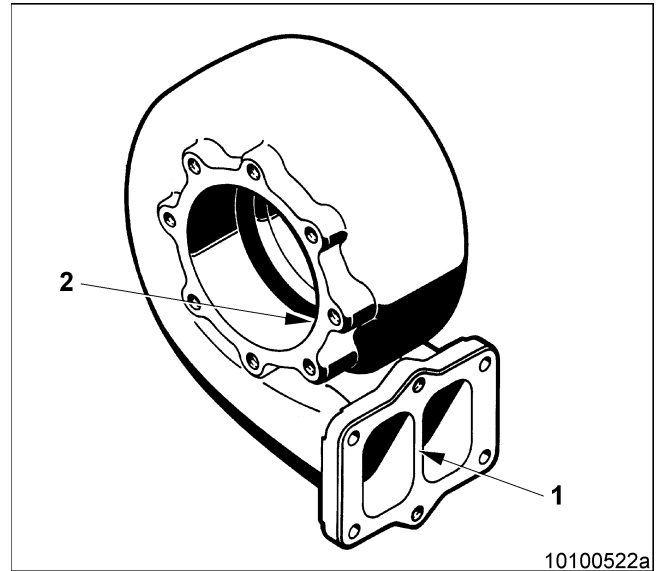
Bearing housing

Note: The segment mating faces must not display severe corrosion.

1. Measure max. bore ID at the bearing points using a bore gauge.
 - Max. bore ID = 22.272 mm
2. If the limit value is exceeded, replace bearing housing.

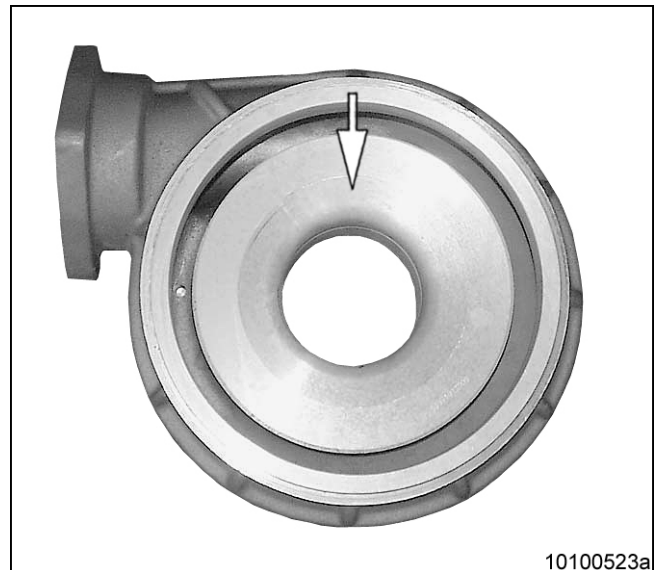
Turbine housing

1. Radial cracks of up to 10 mm in length in the area of lug (2) and partition wall (1) are permissible.
2. Complete cracking is not permissible.
3. Slight scoring in the circumferential area is permissible.
4. Replace component if the gas inlet flange or gas outlet flange is distorted.



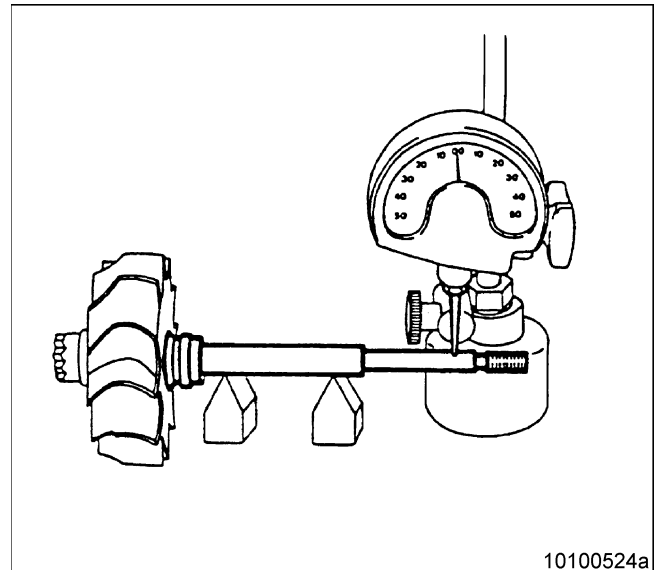
Compressor housing

1. Check circumferential area (arrowed) for scoring and deformation. Scoring of up to 0,2 mm is permissible.
2. Replace compressor housing if deformed.



Rotor

1. Check rotor shaft for roundness:
 - 1.1. Position rotor shaft on two prisms at the bearing points.
 - 1.2. Position probe on the shaft at a distance of 5 mm to the end of the compressor wheel seat.
 - 1.3. Evenly press rotor shaft onto the prisms during testing.
 - 1.4. Maximum permissible out-of-round < 0.008 mm.
 - 1.5. Replace rotor if the permissible out-of-round is exceeded.
2. Measure shaft diameter at the bearing points and piston ring groove width.
 - Min. diameter = 14.25 mm
 - Max. groove width = 3.32 mm
3. Replace shaft if out of tolerance.

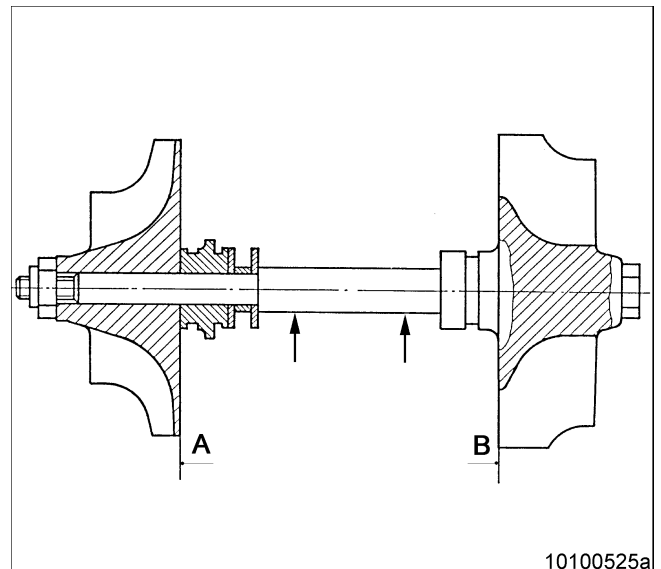


Note: During production, all compressor wheels and shafts are balanced separately. Deposits and contamination on the compressor and turbine wheels can lead to imbalance during operation. Unless a new rotor assembly is installed, the entire rotor assembly must be balanced during each repair.

Balancing rotor assembly

1. Clean all parts of the rotor assembly (rotors, bearing flange, seal bushing (oil deflector ring), bush, compressor wheel and shaft nut) prior to balancing.
2. The position of the parts relative to each other must be marked.

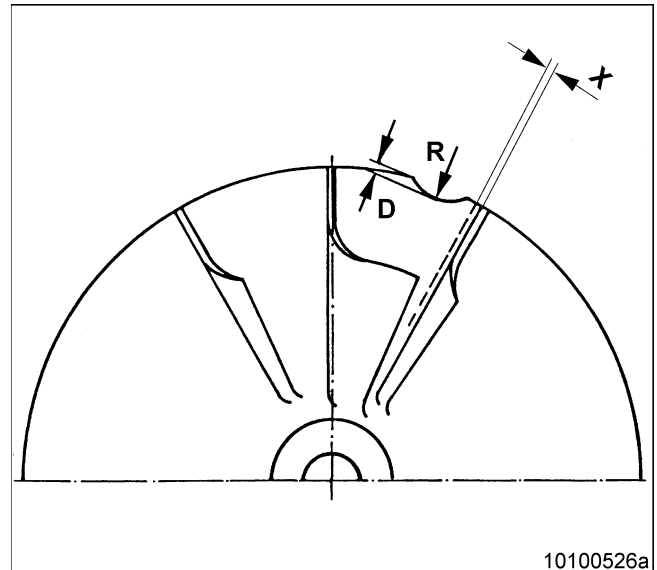
Note: The rotor assembly must only be balanced in planes A and B!
3. Support rotor assembly at bearing points (arrowed) in balancing device.
4. Impermissible residual imbalance of the rotor assembly must be reduced by taking off material (see following paragraphs) in planes A and B to the max. values stated in the table.



Turbocharger type	Balancing plane A (C) in mmg	Balancing plane B (T) in mmg
K 36	4.0	3.1
K 37	4.6	3.6

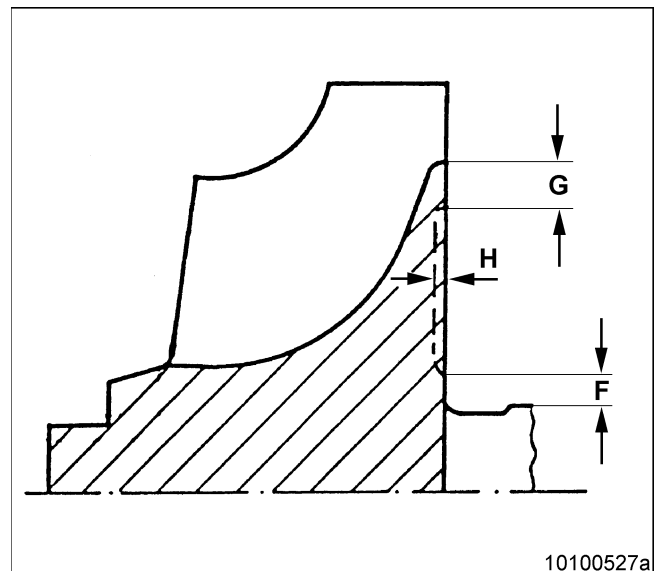
Removing material at compressor wheel

1. During material removal in the area of the blade base a minimum distance (X) of 2 mm must be adhered to.
2. Any recesses must not show edges to the surrounding area.



Removing material at turbine wheel

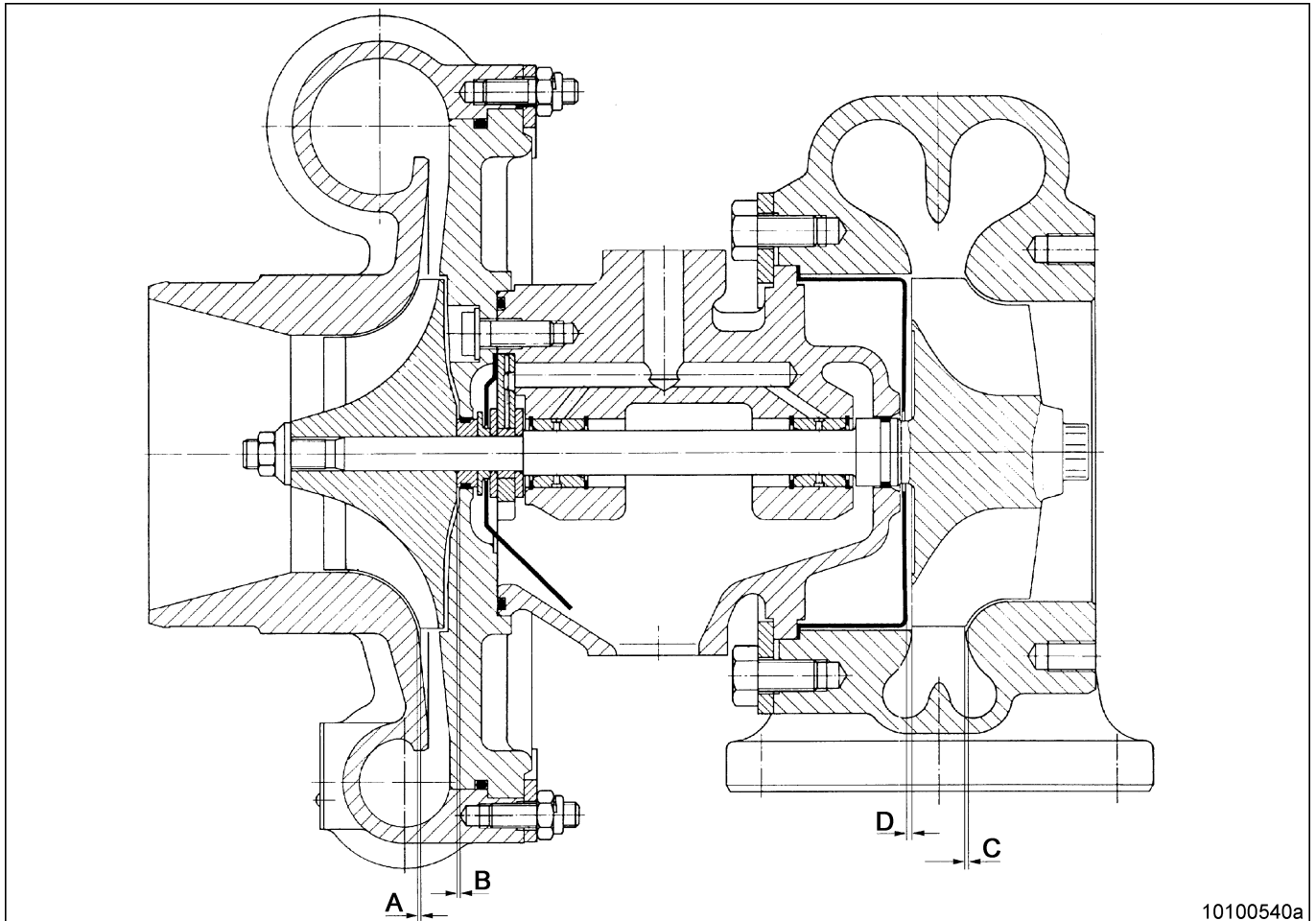
1. Material removal during balancing in a circle segment of max. 150°.
2. Any recesses must not show edges to the surrounding area.



Max. permissible material removal

Turbocharger type	Compressor		Turbine		
	D (mm)	R (mm)	F (mm)	G (mm)	H (mm)
K 36	4	4	2.5	4.0	1.5
K 37	4	5	2.5	4.0	1.5

3.8.6 Exhaust turbocharger – Tolerances



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Permissible contour gap for K36

Gap clearance between		min. (mm)	max. (mm)
A	Compressor wheel contour	0.35	0.8
B	Compressor wheel back	–	–
C	Turbine wheel contour	0.62	1.06
D	Turbine wheel back	0.8	1.2
–	Axial play	0.08	0.135

Permissible contour gap for K37

Gap clearance between		min. (mm)	max. (mm)
A	Compressor wheel contour	0.35	0.8
B	Compressor wheel back	0.8	–
C	Turbine wheel contour	0.62	1.06
D	Turbine wheel back	0.8	1.2
–	Axial play	0.08	0.135

3.8.7 Exhaust turbocharger – Assembly

Special tools

Designation / Use	Part No.	Qty.
Vibe jaw	F70144375	2nd
T torque wrench	F30520703	1
Snap ring pliers	F30376601	1

Material

Designation / Use	Part No.	Qty.
Engine oil		
Assembly paste Ultra-Therm MTU		
Loctite 640		
Petroleum jelly, white		

Spare parts

Designation / Use	Part No.	Qty.
O-rings		
Coiled spring pins		
Piston rings		
Bearing bushings		
Piston rings		
Snap ring		



Heavy object.
Risk of crushing!
 • Use appropriate lifting devices and appliances.

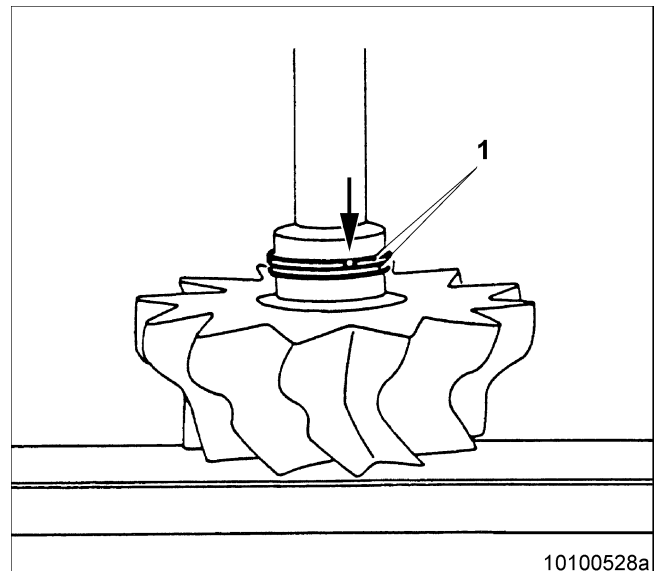
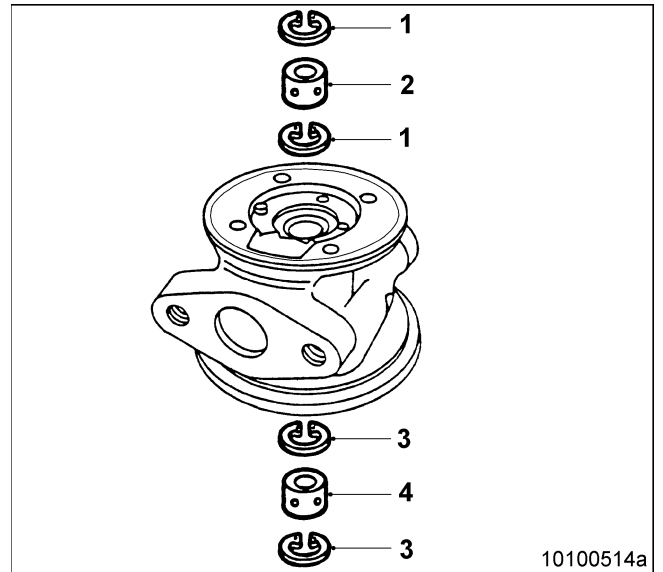


Equipment can drop off.
 Liquid is highly pressurized.
Risk of injury, knocks or crushing!
 • Only use specified and tested equipment.
 • Do not enter the danger zone.
 • Wear protective clothing, gloves, and goggles / safety mask.

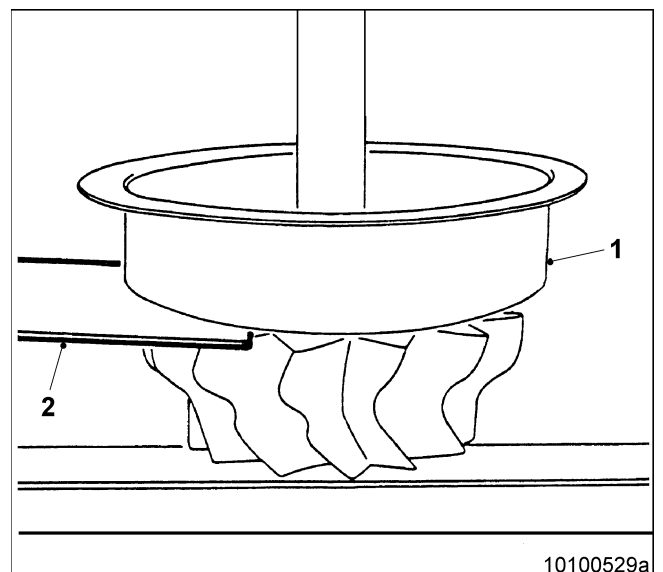
Check exhaust turbocharger (→ Page 438).

Exhaust turbocharger – Assembly

1. Check if parts are particularly clean. Clean if necessary.
2. Lubricate the following bearing parts with oil prior to installation:
 - Bearings of the impeller
 - Bearing bushings
 - Axial bearing washer
 - Sealing bushing
 - Oil thrower ring
 - Bearing collar
 - Piston rings
 - Bushing
3. Install snap rings (1) and bearing bushing (2) at the compressor side and then snap rings (3) and bearing bushing (4) at the turbine side in the bearing housing.
4. Insert snap rings in such a way that the rounded side faces the bearing bushing. Make sure that the snap ring fits in the groove perfectly!
5. Mount impeller shaft in bench vise (use braces).
6. Carefully mount piston rings (1) on the shaft and align piston ring gaps (arrow) so that they are offset by 180°.
7. Center piston rings on the impeller shaft.



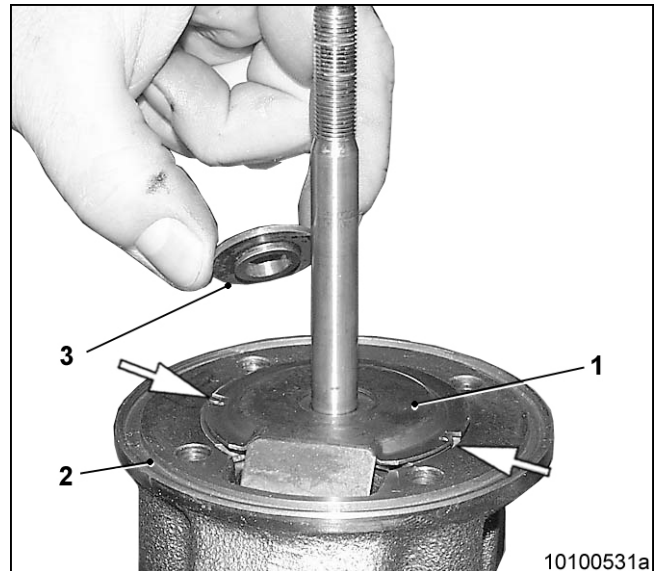
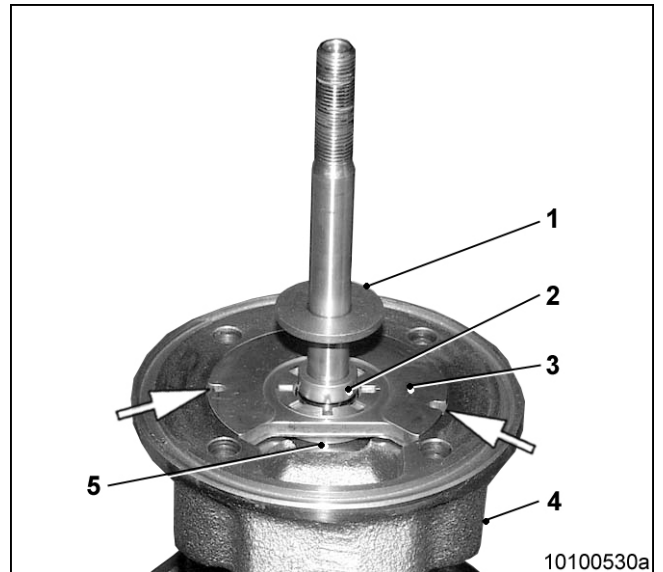
8. Carefully set heat shield (1) down on the turbine wheel above the piston rings.
9. Place a 1 mm thick metal strip (2) between heat shield and back side of turbine wheel to ensure the guidance of the piston rings in the bearing housing bore.



10. If the rotor assembly was rebalanced, observe appropriate position markings.
11. Put sleeve for protecting the thread over the impeller shaft.
12. Carefully guide bearing housing (4) over the impeller shaft. In doing so, make sure that the oil intake bore of the bearing housing is offset by 90° to the piston ring gap.

Note: The piston rings are fitted correctly if heat shield and bearing housing can be turned with ease.

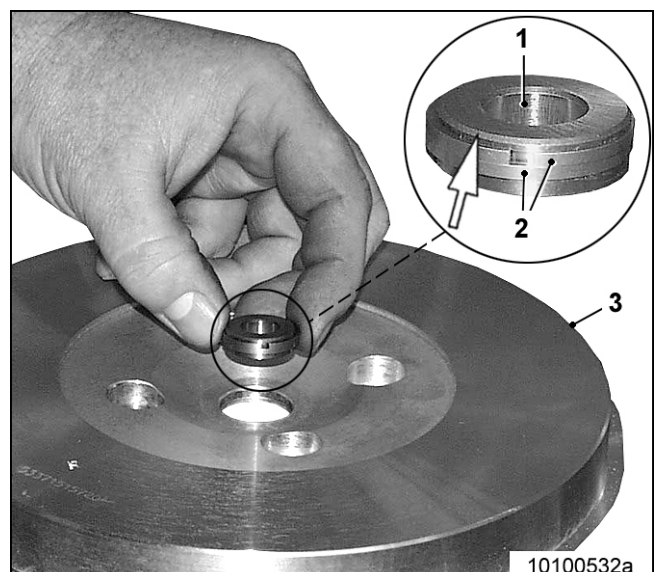
13. Guide first bearing collar (5) and bushing (2) over the impeller shaft.
14. Place axial bearing washer (3) in the bearing housing, in doing so observe fit of centering pins (arrows).
15. Guide second bearing collar (1) over the impeller shaft.
16. Place oil deflection plate (1) on axial bearing washer, in doing so observe fit of oil deflection plate (arrows).
17. Guide oil thrower ring (3) with small collar downwards over the impeller shaft.
18. Coat new O-ring (2) with petroleum jelly and insert in groove in bearing housing.



19. Carefully mount two piston rings (2) on the sealing bushing (1).
20. Align piston ring gaps, offset by 180°.
21. Install sealing bushing with chamfer (arrow) in the back wall (3) in the direction of the back of the compressor wheel (in upward direction).

Note: If necessary, press piston ring together with screwdriver.

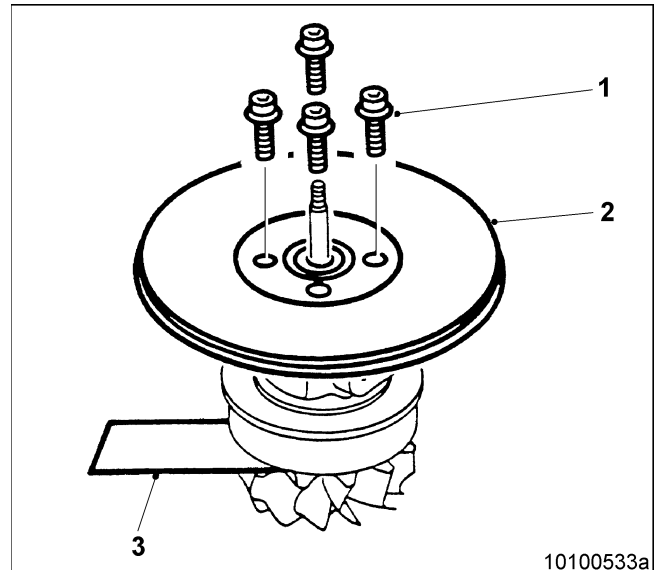
22. Position sealing bushing in such a way that the oil intake bore of the bearing housing is offset by 90° to the piston ring gap.



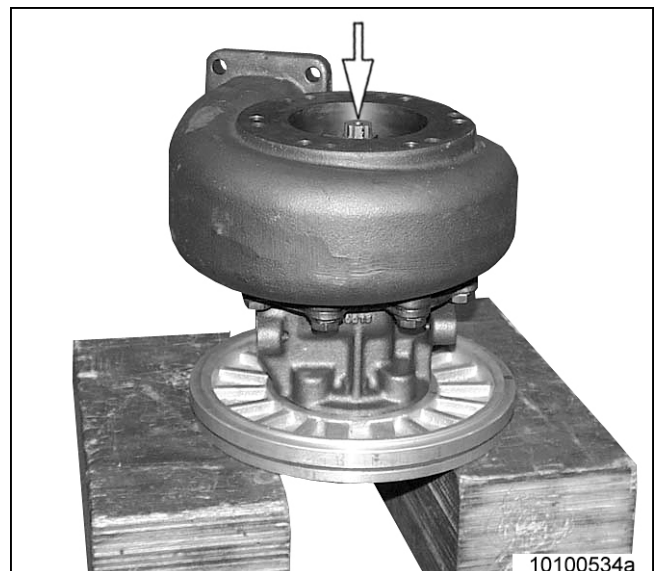
23. Degrease and dry clean socket-head screw threads (1) and threads in the bearing housing.
24. Coat socket-head screw threads with "Loctite 640".
25. Set down back wall (2) in marked position on bearing housing.

Note: The final strength of "Loctite 640" is reached after approx. 24 hours.

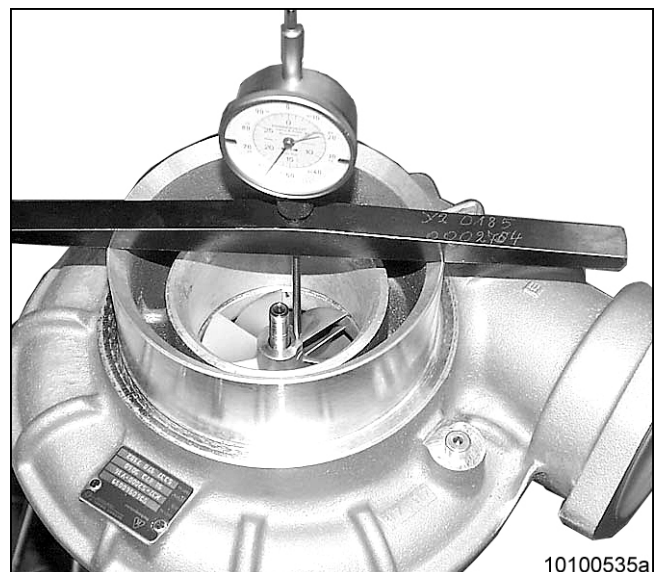
26. Insert socket-head screws and washers and tighten to prescribed tightening torque. Values (→ Page 23).
27. Remove metal strip (3) between heat shield and turbine wheel back side.



28. Measure contour gap on turbine side:
 - 28.1. Place core group in turbine housing, without compressor wheel and shaft nut and tighten with screws.
 - 28.2. Place dial-gauge anvil on turbine wheel hub.
 - 28.3. Press impeller down and set dial gauge to "0".
 - 28.4. Press impeller against dial-gauge anvil and record measured value.
 - 28.5. Required contour gap (→ Page 442).
29. After measuring, remove turbine housing.



30. Measure contour gap on compressor side:
 - 30.1. Slide compressor wheel on to the shaft. Place core group, without shaft nut, in compressor casing and tighten with nuts.
 - 30.2. Place dial-gauge anvil on the compressor wheel hub and set dial gauge to "0".
 - 30.3. Raise compressor wheel to maximum position and record measured value.
 - 30.4. Required contour gap (→ Page 442).
31. After measuring, remove compressor housing.

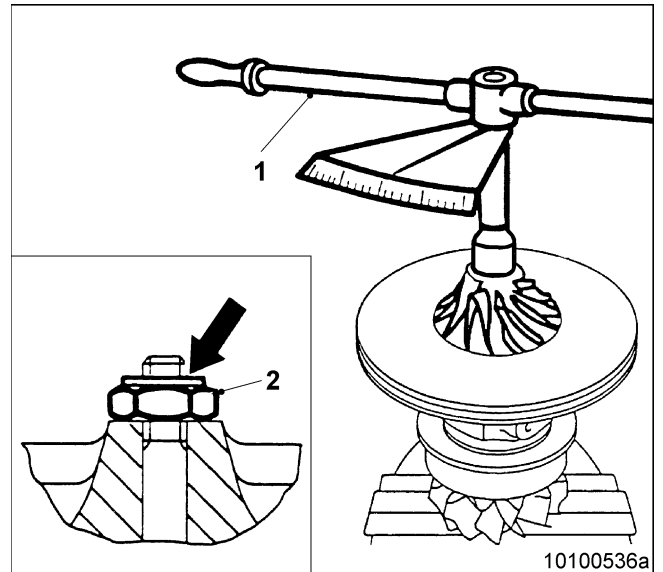


Note: Do not apply any bending stress to the shaft.

32. Tighten new shaft nut (2) with T torque wrench (1) to prescribed pretightening torque and then tighten to rotation angle. For values see (→ Page 23).

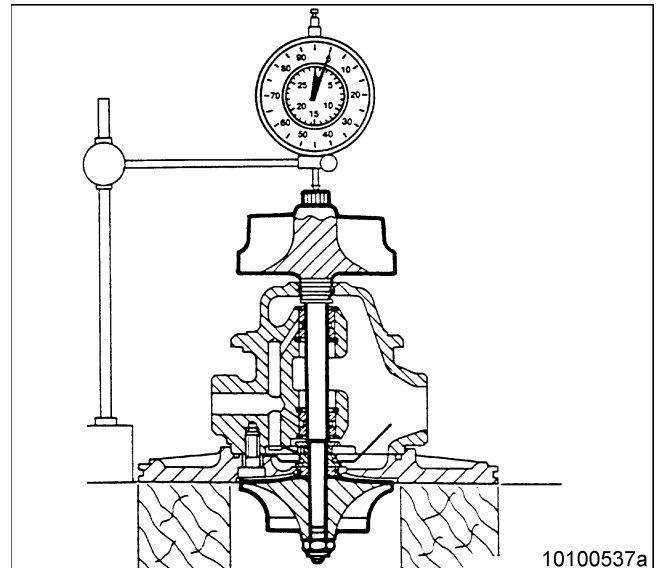
Note: The piston rings are fitted correctly on the turbine side, if heat shield and bearing housing can be turned with ease after assembly.

33. Seal shaft nut and threaded pin of the impeller with screw locking varnish (arrow).

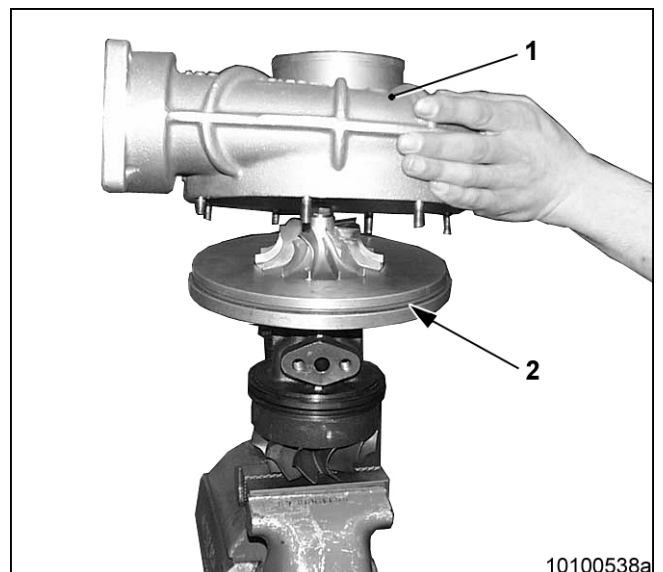


34. Measure axial play of impeller shaft:

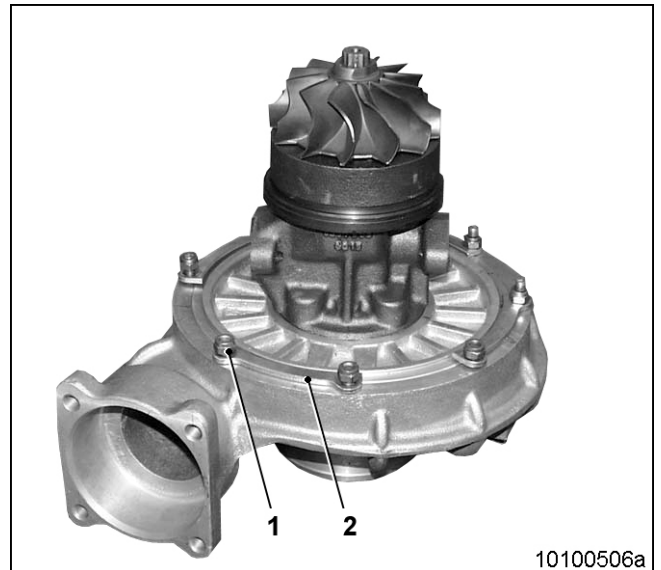
- 34.1. Place preloaded dial-gauge anvil on turbine wheel hub.
 34.2. Press impeller down and set dial gauge to "0".
 34.3. Press impeller against dial-gauge anvil and record measured value.
- Max. permissible axial play = 0.10 mm



35. Coat new O-ring (2) with petroleum jelly and insert in groove in back wall.
 36. Set down compressor housing (1) on back wall without tilting. In doing so, observe the markings made prior to removal.

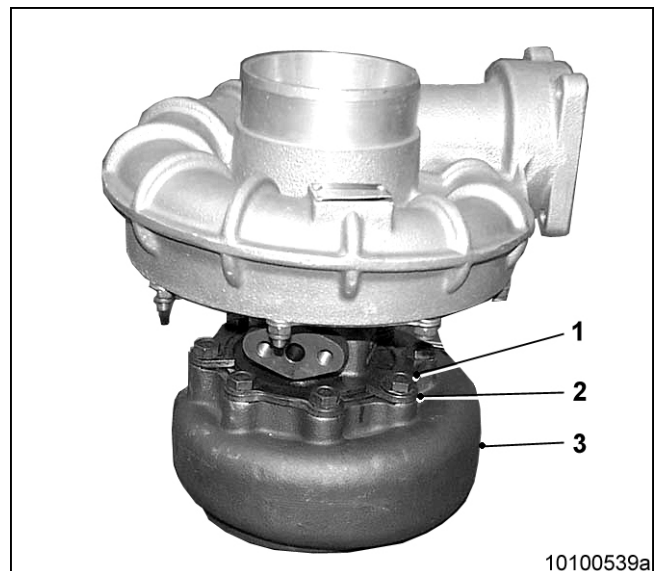


37. Put on tensioning segments (2) and screw on new nuts (1).
38. Tighten with torque wrench to specified tightening torque Values (→ Page 23).



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39. Set down turbine housing (3) on bearing housing without tilting. In doing so, observe the markings made prior to removal.
40. Coat screw threads (1) with assembly paste.
41. Put on tensioning segments (2) and insert screws.
42. Tighten with torque wrench to specified tightening torque Values (→ Page 23).
43. Check impeller shaft for freedom of movement.



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3.8.8 Exhaust turbocharger – Installation

Material

Designation / Use	Part No.	Qty.
Assembly paste Ultra-Therm MTU		
Engine oil		

Spare parts

Designation / Use	Part No.	Qty.
Gasket		
O-rings		
Nut		
Washer		



WARNING

Heavy object.

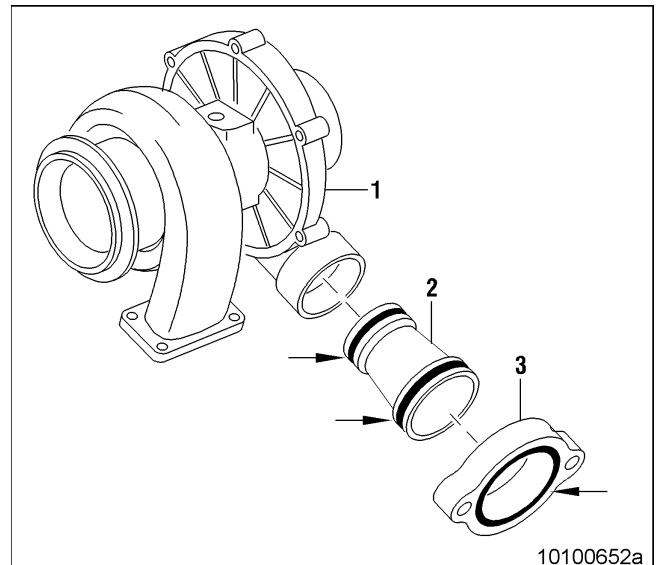
Risk of crushing!

- Use appropriate lifting devices and appliances.

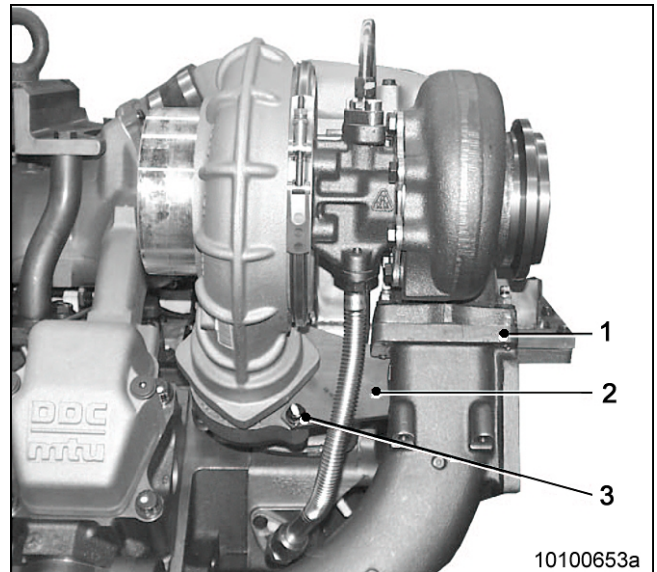
Check exhaust turbocharger (→ Page 438).

Installing exhaust turbocharger

1. Clean and degrease bolt-on faces on exhaust turbocharger and exhaust manifold using a dry cloth.
2. Coat new O-rings (arrowed) with assembly paste and insert in union (2) and flange (3).
3. Position union (2) in compressor housing (1).
4. Position flange (3) on union (2).



5. Position new gasket over studs on exhaust manifold (1).
6. Attach exhaust turbocharger to crane using a rope and position on exhaust manifold.
7. Attach bracket (2) and tighten screws (3).
8. Coat threads of exhaust turbocharger studs with assembly paste.
9. Install new nuts and washers and tighten diagonally.
10. Fill turbocharger bearing housing with engine oil through oil inlet bore while turning the shaft by hand to ensure that the bearing points are coated in oil.
11. Install turbocharger oil supply (→ Page 527).
12. Visually inspect oil lines for leaks following engine start.

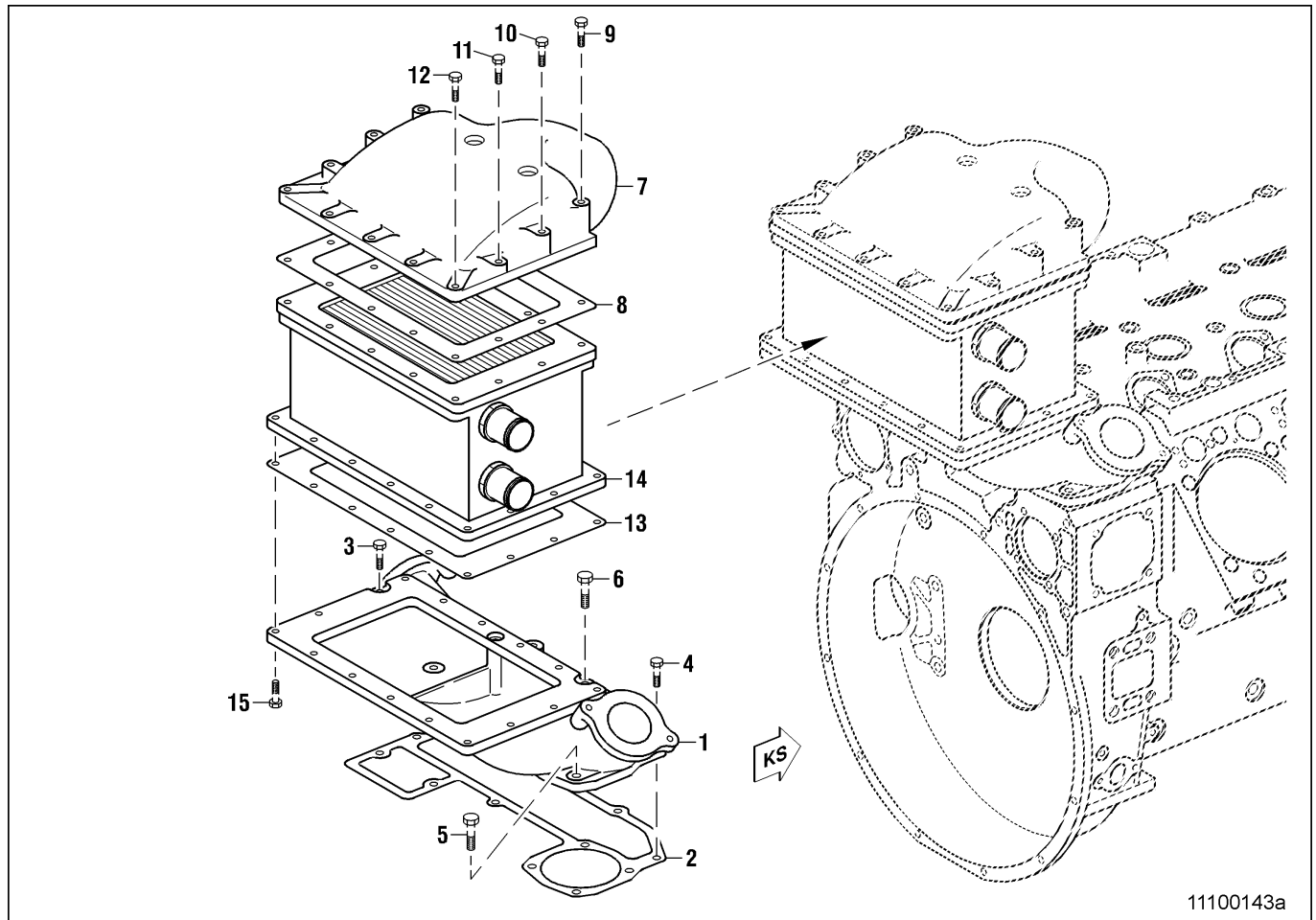


Final steps

<p>For these steps a distinction must be made as to whether</p> <p>1 the engine has been completely disassembled 2 the engine has been removed but not disassembled 3 the engine has remained installed</p>				
1	2	3	Operations	See
X	–	–	Assemble engine.	(→ Page 58)
X	–	–	Install engine.	(→ Page 60)
–	X	X	Perform installation in reverse sequence of work steps as described for removal.	(→ Page 432)
–	X	X	Install exhaust system downstream of exhaust turbocharger.	–
–	X	X	Install air ducting upstream of exhaust turbocharger.	–
–	–	X	Enable engine start.	–

3.9 Charge-air Cooling

3.9.1 Charge-air cooling – Overview

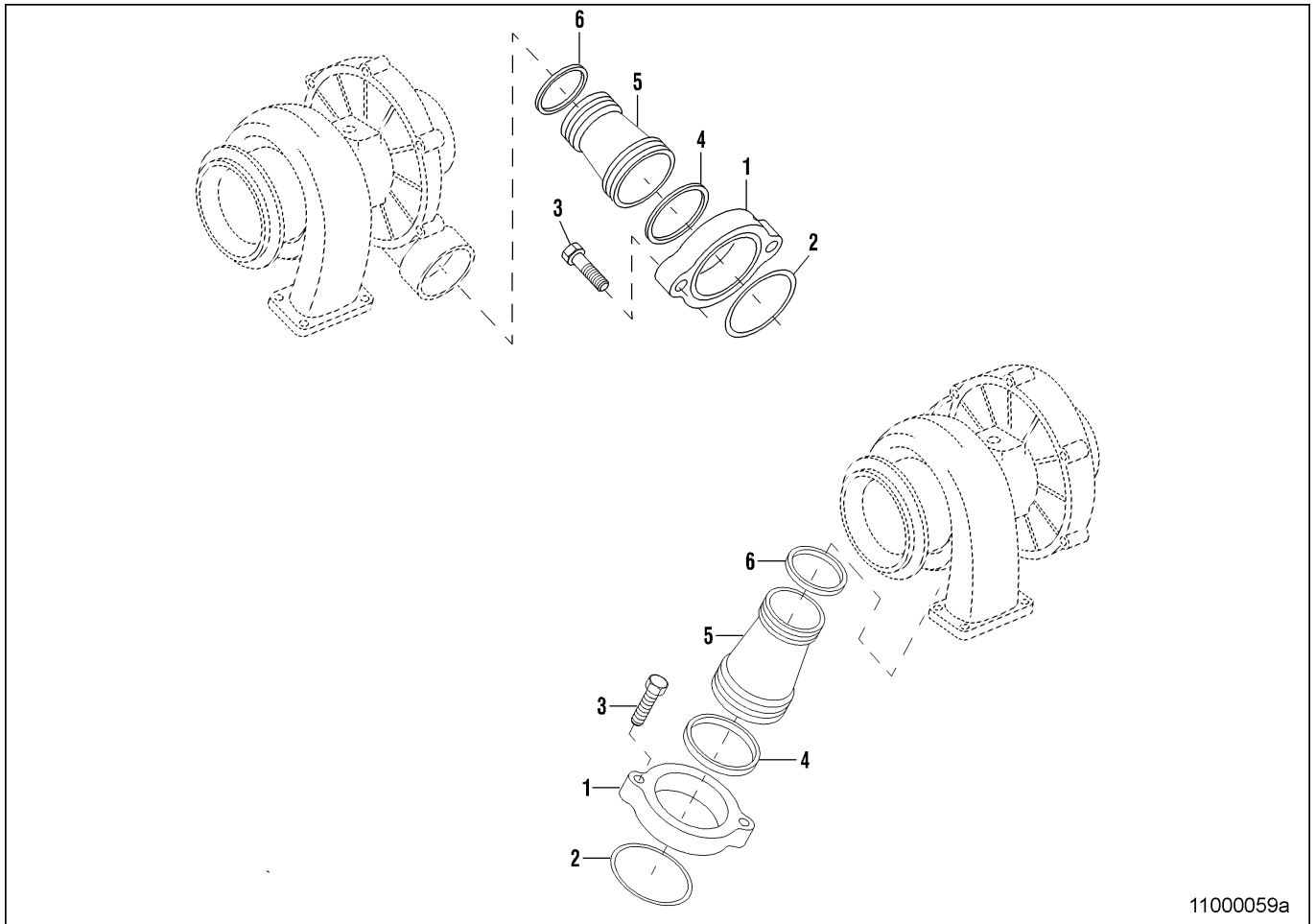


- 1 Connection housing
- 2 Gasket
- 3 Screw
- 4 Screw
- 5 Screw

- 6 Screw
- 7 Connection housing
- 8 Gasket
- 9 Screw
- 10 Screw

- 11 Screw
- 12 Screw
- 13 Gasket
- 14 Intercooler
- 15 Screw

Connecting line between exhaust turbocharger and intercooler



1 Flange
2 O-ring

3 Screw
4 O-ring

5 Union
6 O-ring

3.9.2 Intercooler – Removal

Preconditions

- Engine is stopped and starting disabled



Heavy object.

Risk of crushing!

- Use appropriate lifting devices and appliances.

Preparatory steps

For these steps a distinction must be made as to whether

- 1 the engine is to be completely disassembled
- 2 the engine is to be removed but not disassembled
- 3 the engine is to remain installed

1	2	3	Operations	See
X	–	–	Remove engine.	(→ Page 55)
X	–	–	Disassemble engine.	(→ Page 56)
–	–	X	Disable engine start.	(→ Page 15)
–	–	X	Drain charge-air coolant.	(→Operating instructions)
–	–	X	Remove coolant line from/to intercooler.	(→ Page 558)

Removing intercooler

1. Remove connecting housing, intercooler and adapters as per overview (→ Page 452).
2. Remove gaskets and O-rings.
3. Seal all openings on the engine with suitable covers after removal of intercooler.
4. Protect intercooler from damage; cover cooler elements.

3.9.3 Intercooler -- Cleaning

Work on the intercooler must always be carried out by qualified personnel.

The following contains instructions for the specialist cleaning company.

Air-side cleaning

Grease and oil contamination of the intercooler's air-side is to be removed in a closed cleaning unit.

The cleaning agent must circulate opposite to the cooling-air direction.

It is imperative to avoid damaging the cooler, especially the cooling fins.

To remove deposits, only use cleaning agents that do not attack metal surfaces.

(→Fluids and Lubricants Specifications).

Dwell time depends on the condition and temperature of the solution and the nature and stubbornness of the deposits.

Water-side cleaning

It is recommended that the water-side be cleaned in a closed cleaning unit with forced flushing and filter.

The water-side can also be cleaned in an immersion- or ultrasonic bath.

To remove deposits, only use cleaning agents that do not attack metal surfaces.

(→Fluids and Lubricants Specifications).

Dwell time depends on the condition and temperature of the solution and the nature and stubbornness of the deposits.

Intercooler flushing

After cleaning, flush the intercooler with water until pH values of clean water and rinsing water are approximately the same (permissible difference pH value: 1 pH).

Intercooler drying and preservation

If the cooler is not to be put into operation immediately after cleaning, the cooler must be dried in a drying oven for approx. 3 hours at a temperature of 110 to 120 °C.

After drying, the cooler must be preserved with a preservation agent.

3.9.4 Intercooler – Check

Special tools


Designation / Use	Part No.	Qty.
Oilstone		


Material

Designation / Use	Part No.	Qty.
Emery cloth		
Red penetrant dye for surface crack-testing procedure		

Spare parts

Designation / Use	Part No.	Qty.
O-rings		
Sealing rings		
Gaskets		

 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors.
--	---

 WARNING	Compressed air is pressurized. Hot testing liquid. Risk of injury and scalding! <ul style="list-style-type: none"> • Pressure must not exceed 0.5 bar. • Wear protective clothing, gloves, and goggles / safety mask.
---	--

 WARNING	Component is hot. Risk of burning! <ul style="list-style-type: none"> • Wear protective gloves.
---	--

Remove intercooler (→ Page 454).

Intercooler – Check

Item	Findings	Task
Visually inspect all components for damage.	Damaged	<ul style="list-style-type: none"> • Recondition • Replace
Check connection housing with surface crack test procedure and red penetrant dye for cracks.	Cracks visible	Replace
Check all sealing, mating and contact faces for damage and unevenness.	<ul style="list-style-type: none"> • Damaged • Uneven 	<ul style="list-style-type: none"> • Recondition: Smooth with oilstone or emery cloth. • Replace
Check threads in connection housing for ease of movement.	Sluggish	Recondition

Intercooler – Leak check

1. Seal coolant chamber connections on intercooler with suitable sleeves and covers with gaskets and clamps.
2. Connect compressed air line at plug.
3. Preheat test bath to 80 °C.
4. Immerse intercooler in test bath.
5. Open compressed air supply and set pressure reducer to 0.5 bar.
6. Pressure-test intercoolers with air in water bath for leaks. Ensure that no bubbles rise to the surface.
7. Replace intercooler if leaks are found.
8. After checking, blow through cooling air ducts with compressed air in vertical direction.




3.9.5 Intercooler – Installation

Material

Designation / Use	Part No.	Qty.
Assembly paste Ultra-Therm MTU		
Engine oil		

Spare parts

Designation / Use	Part No.	Qty.
O-rings		
Gasket		

 WARNING	Heavy object. Risk of crushing! <ul style="list-style-type: none"> Use appropriate lifting devices and appliances.
 CAUTION	Contamination of components. Damage to component! <ul style="list-style-type: none"> Observe manufacturer's instructions. Check components for special cleanness.
 CAUTION	Incorrect installation of components and lines. Damage to component! <ul style="list-style-type: none"> Ensure that components/lines are installed so that they are never under tension or strain. Ensure correct installation position of components.

Check intercooler (→ Page 456).

Installing intercooler

1. Remove all covers.
2. Clean both mating faces prior to installing the intercooler.
3. Coat O-rings with assembly paste prior to installation.
4. Install connecting housing, intercooler and adapters with new gaskets and O-rings as per overview (→ Page 452).
5. Tighten screws to specified tightening torque using a torque wrench (→ Page 23).

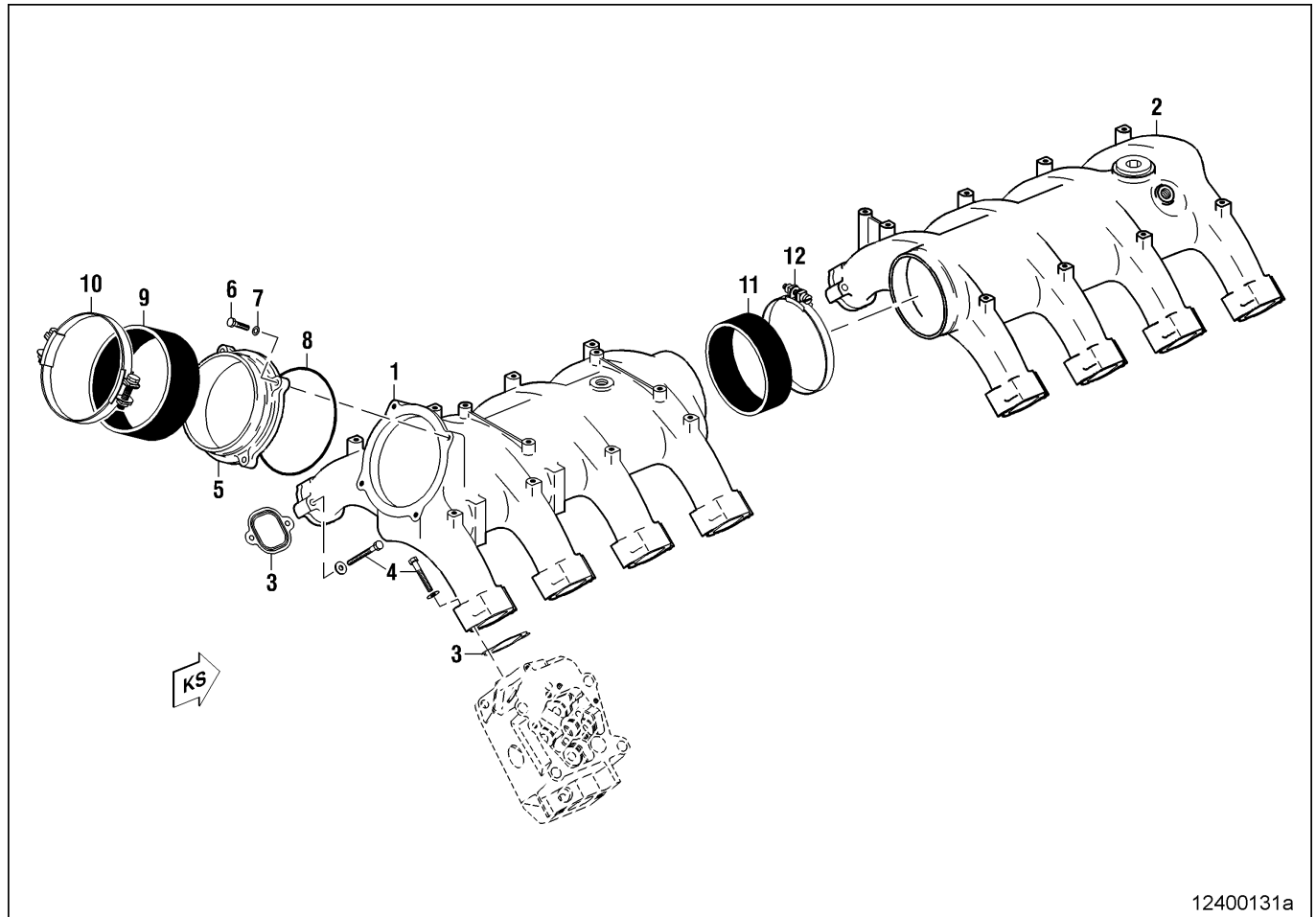
Final steps

For these steps a distinction must be made as to whether				
1 the engine has been completely disassembled				
2 the engine has been removed but not disassembled				
3 the engine has remained installed				
1	2	3	Operations	See
X	–	–	Assemble engine.	(→ Page 58)
X	–	–	Install engine.	(→ Page 60)
–	X	X	Perform installation in reverse sequence of work steps as described for removal.	(→ Page 454)
–	–	X	Fill charge-air coolant system.	(→Operating instructions)
–	–	X	Enable engine start.	–

3.10 Air Intake/Air Supply

3.10.1 Air supply system to cylinders – Overview

Also applies to 12V



- 1 Charge-air manifold
- 2 Charge-air manifold
- 3 Gasket
- 4 Screw

- 5 Flange
- 6 Screw
- 7 Washer
- 8 O-ring

- 9 Rubber sleeve
- 10 Clamp
- 11 Rubber sleeve
- 12 Clamp

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3.10.2 Air supply system to cylinders – Removal

Preconditions

- Engine is stopped and starting disabled

Preparatory steps



For these steps a distinction must be made as to whether				
1 the engine is to be completely disassembled				
2 the engine is to be removed but not disassembled				
3 the engine is to remain installed				
1	2	3	Operations	See
X	–	–	Remove engine.	(→ Page 55)
X	–	–	Disassemble engine.	(→ Page 56)
–	–	X	Disable engine start.	(→ Page 15)
–	X	X	Disconnect or remove wiring.	(→ Page 604)
–	X	X	Remove electronic controls.	(→ Page 598)
–	X	X	Remove engine mounts (if required).	(→ Page 112)

Removing charge-air pipe

1. Remove charge-air pipe as per overview (→ Page 460).
2. Remove gaskets and O-rings.
3. Close openings using suitable covers.

3.10.3 Air supply system to cylinders – Cleaning

Material

Designation / Use	Part No.	Qty.
Cleaning agent		
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors. 	
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask. 	

Remove air supply system to cylinders (→ Page 461).

Cleaning air supply system to cylinders

1. Clean air lines to cylinders with cleaning agent.
2. Remove cleaning agent.
3. Blow out air lines to cylinders thoroughly with compressed air.

3.10.4 Air supply system to cylinders – Check

Material

Designation / Use	Part No.	Qty.
Red penetrant dye for surface crack-testing procedure		

Spare parts

Designation / Use	Part No.	Qty.
Charge-air manifold		
Rubber sleeve		
Clamp		
Screws		
Plug		



WARNING

Compressed air.

Risk of injury!

- Do not direct compressed-air jet at persons.
- Wear protective goggles / safety mask and ear protectors.

Clean air supply system to cylinders (→ Page 462).

Checking air supply system to cylinders

Item	Findings	Task
Check charge-air manifold with fluorescent dye penetrant for cracks.	Signs of cracks	Replace
Pressure-test charge-air manifold for leaks with air in water bath at a max. barometric pressure of 0.5 bar.	Leaking: <ul style="list-style-type: none"> • at blanking plugs • at charge-air manifold 	<ul style="list-style-type: none"> • Replace blanking plug. • Replace charge-air manifold.
Check sealing and bolt-on faces for evenness and damage.	<ul style="list-style-type: none"> • Uneven • Damaged 	<ul style="list-style-type: none"> • Recondition: smooth with oilstone. • Replace
Check threads for ease of movement.	Sluggish	<ul style="list-style-type: none"> • Recut threads • Replace thread inserts.
Check screws and plugs for damage.	Damaged	Replace


3.10.5 Air supply to the cylinders – Installation


Material

Designation / Use	Part No.	Qty.
Petroleum jelly, white		
Engine oil		

Spare parts

Designation / Use	Part No.	Qty.
Seal		
Sealing ring		
O-ring		

 CAUTION	Contamination of components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Check components for special cleanness.
---	---

 CAUTION	Incorrect installation of components and lines. Damage to component! <ul style="list-style-type: none"> • Ensure that components/lines are installed so that they are never under tension or strain. • Ensure correct installation position of components.
--	--

Check air supply to the cylinders (→ Page 463).

Air supply to the cylinders – Installation

1. Prior to installation, remove all covers.
2. Place seals on cylinder heads.
3. Install air supply to the cylinders as shown in overview drawing (→ Page 460) .

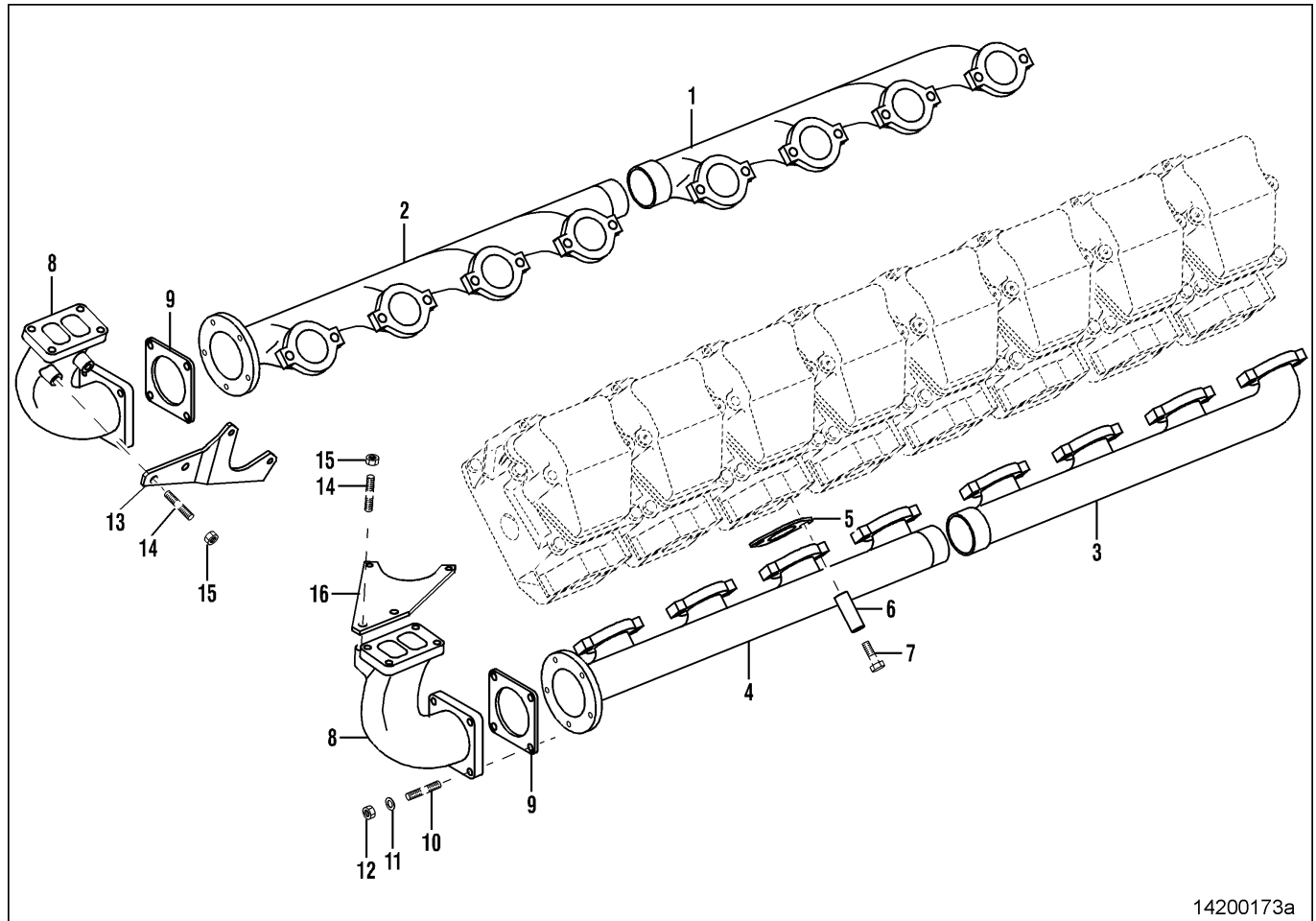
Final steps

A distinction must be made as to whether				
1 the engine was completely disassembled				
2 the engine was removed but not disassembled				
3 the engine is still installed				
1	2	3	Operations	See
X	–	–	Assemble engine	(→ Page 58)
X	–	–	Install engine	(→ Page 60)
–	X	X	Assembly in reverse disassembly sequence	(→ Page 461)
–	–	X	Enable engine start	–

3.11 Exhaust System

3.11.1 Exhaust lines downstream of cylinders – Overview

Also applies to 12V



14200173a

- | | | |
|----------------|-----------------|------------|
| 1 Exhaust line | 7 Screw | 13 Bracket |
| 2 Exhaust line | 8 Exhaust elbow | 14 Stud |
| 3 Exhaust line | 9 Gasket | 15 Nut |
| 4 Exhaust line | 10 Stud | 16 Bracket |
| 5 Gasket | 11 Washer | |
| 6 Spacer | 12 Nut | |

3.11.2 Exhaust pipework after cylinder – Removal

Preconditions

- Engine is stopped and starting disabled.



Components have sharp edges.

Risk of injury!

- Wear protective gloves.

Preparatory steps

A distinction must be made as to whether

- 1 the engine is to be completely disassembled
- 2 the engine is to be removed but not disassembled
- 3 the engine is to remain installed



1	2	3	Tasks	See
X	–	–	Remove engine.	(→ Page 55)
X	–	–	Disassemble engine.	(→ Page 56)
–	–	X	Disable the engine starter.	(→ Page 15)
–	X	X	Remove exhaust turbocharger.	(→ Page 432)

Exhaust pipework – Removal

1. Remove exhaust pipework as shown in overview diagram (→ Page 465).
2. Remove gaskets.
3. Seal openings with suitable covers.

3.11.3 Exhaust pipework after cylinder head – Cleaning

Material

Designation / Use	Part No.	Qty.
Cleaning agent		
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> Do not direct compressed-air jet at persons. Wear protective goggles / safety mask and ear protectors. 	
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> Observe manufacturer's instructions. Wear protective clothing, gloves, and goggles / safety mask. 	

Remove exhaust pipework after cylinder head (→ Page 466).

Exhaust pipework after cylinder head – Cleaning

- Clean all parts with cleaning agent.
- Put parts with carbon deposits in a container with "decarbonizer". Exposure time depends on the thickness of the deposits.
- After cleaning with "decarbonizer", rinse parts under water until no more residues are washed off.
- In the event of stubborn deposits, additional cleaning using plastic cast-steel shots (reference grain size 16 to 20) is possible.
- Remove cleaning agent.
- Thoroughly blow out all parts with compressed air.

3.11.4 Exhaust lines downstream of cylinders – Check

Material

Designation / Use	Part No.	Qty.
Red penetrant dye for surface crack testing		

Spare parts

Designation / Use	Part No.	Qty.
Exhaust line		
Exhaust elbow		

Clean exhaust lines downstream of cylinders (→ Page 467).

Checking exhaust lines downstream of cylinders

Item	Findings	Task
Using fluorescent dye, check exhaust lines and exhaust manifold for cracks.	Cracks apparent	Replace
Check exhaust lines for deformation.	Deformation	Replace
Check sealing and bolt-on faces for planeness and damage.	<ul style="list-style-type: none"> • Uneven • Damaged 	<ul style="list-style-type: none"> • Rework: Smooth using oilstone. • Replace
Check threads for ease of movement.	No ease of movement	<ul style="list-style-type: none"> • Recut threads. • Replace thread inserts.

3.11.5 Exhaust lines downstream of cylinders – Installation

Material

Designation / Use	Part No.	Qty.
Engine oil		
Assembly paste Ultra-Therm MTU		

Spare parts

Designation / Use	Part No.	Qty.
Gasket		
Gasket		



Components have sharp edges.

Risk of injury!

- Wear protective gloves.

Check exhaust line (→ Page 468).

Installing exhaust line

1. Remove all covers prior to installation.
2. Using a steel straightedge, check cylinder heads for alignment on one engine side; re-align if required.
3. Coat seals and gaskets with assembly paste and install exhaust line as per overview (→ Page 465).
4. Tighten screws to specified tightening torque using a torque wrench (→ Page 23).

Final steps

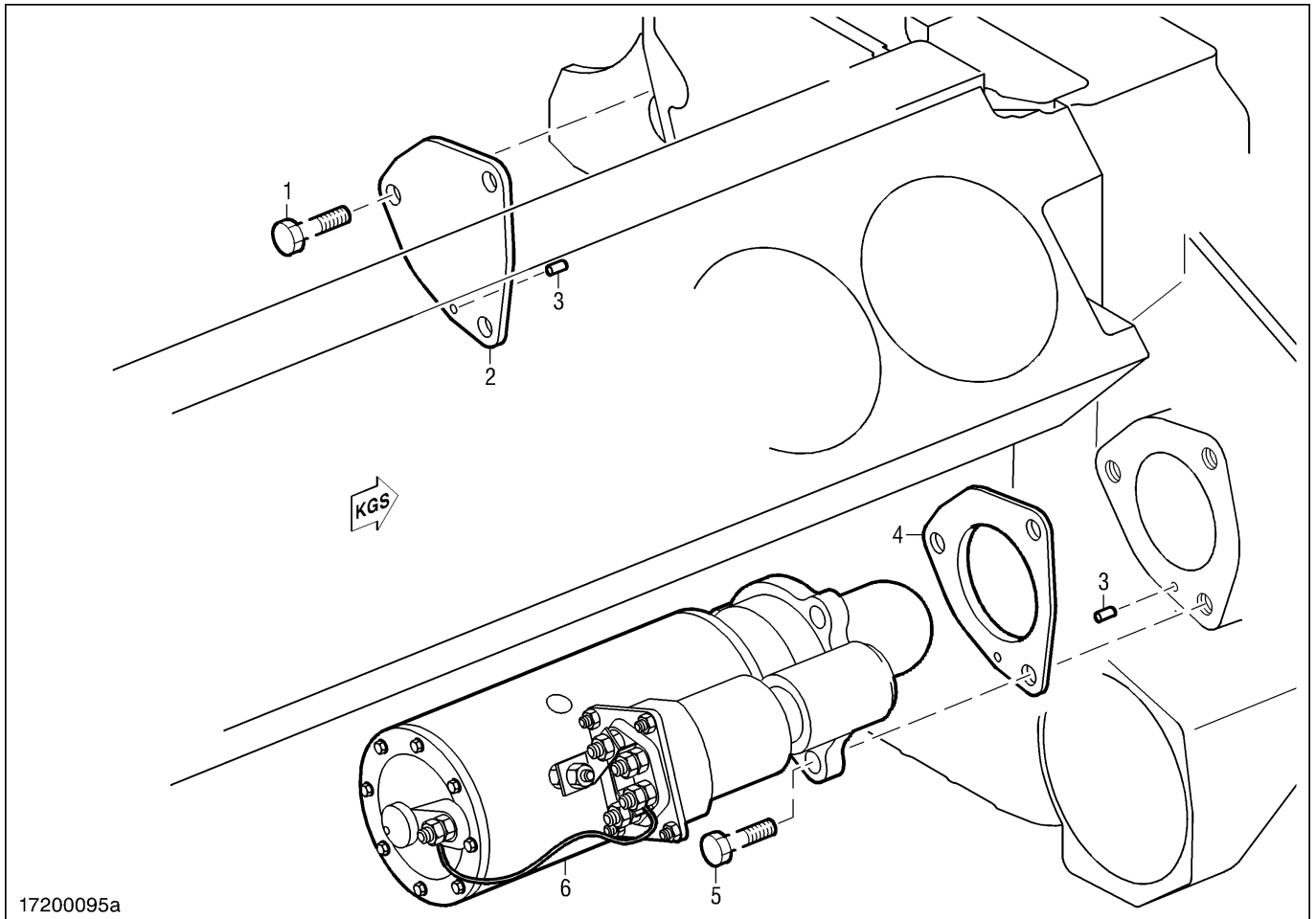
For these steps a distinction must be made as to whether

- 1 the engine has been completely disassembled
- 2 the engine has been removed but not disassembled
- 3 the engine has remained installed

1	2	3	Operations	See
X	–	–	Assemble engine.	(→ Page 58)
X	–	–	Install engine.	(→ Page 60)
–	–	X	Fill with engine coolant.	(→ Operating instructions)
–	–	X	Enable engine start.	–

3.12 Starting Equipment

3.12.1 Electric starter – Overview



17200095a

1 Screw
2 Cover


3 Spring pin
4 Flange


5 Screw
6 Starter

3.12.2 Starter – Removal

Preconditions

- Engine is stopped and starting disabled

 DANGER	Electrical voltage. Risk of serious injury - danger to life! <ul style="list-style-type: none"> • Make certain that the power supply to the engine is switched off before starting to work. Ensure that the power supply cannot be switched on unintentionally!
--	--

 WARNING	Heavy object. Risk of crushing! <ul style="list-style-type: none"> • Use appropriate lifting devices and appliances.
---	---

Preparatory steps

For these steps a distinction must be made as to whether <ol style="list-style-type: none"> 1 the engine is to be completely disassembled 2 the engine is to be removed but not disassembled 3 the engine is to remain installed 				
1	2	3	Operations	See
X	–	–	Remove engine.	(→ Page 55)
X	–	–	Disassemble engine.	(→ Page 56)
–	–	X	Disable engine start.	(→ Page 15)

Disconnecting and removing starter

1. Mark all cables using suitable adhesive tape prior to removal.
2. Disconnect all cables from starter.
3. Protect all cables from damage.
4. Remove starter screws as per overview (→ Page 470).
5. Remove starter.
6. Protect starter from damage.

3.12.3 Starter – Disassembly

Remove starter (→ Page 471).

Disassembling starter

See separate Publication No. M060710.

3.12.4 Starter – Cleaning



Compressed air.

Risk of injury!

- Do not direct compressed-air jet at persons.
- Wear protective goggles / safety mask and ear protectors.

Disassemble starter (→ Page 472).


Starter – Cleaning

1. Clean starter with compressed air; do not wet-clean.
2. Protect starter against moisture.

3.12.5 Starter – Inspection

Spare parts

Designation / Use	Part No.	Qty.
Starter		

 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors.
---	---

Clean starter (→ Page 473).


Starter – Inspection


Item	Findings	Task
Check tooth flanks of drive gear for wear, indentations and chipping.	<ul style="list-style-type: none"> • Wear • Indentations • Chipping visible. 	<ul style="list-style-type: none"> • Recondition • Replace
Check nuts and studs for condition and check threads for ease of movement.	No ease of movement	Replace
Check mating face on end housing for wear.	Wear traces are found.	Recondition Re-surface with crocus cloth or oil stone.

3.12.6 Starter – Installation

Material

Designation / Use	Part No.	Qty.
Long-life grease		

 DANGER	Electrical voltage. Risk of serious injury - danger to life! <ul style="list-style-type: none"> Make certain that the power supply to the engine is switched off before starting to work. Ensure that the power supply cannot be switched on unintentionally!
--	--

 WARNING	Heavy object. Risk of crushing! <ul style="list-style-type: none"> Use appropriate lifting devices and appliances.
---	---

Check starter (→ Page 474).

Installing starter

- Coat starter pinion with long-life grease.
- Install starter as in accordance with overview drawing (→ Page 470).

Connecting starter electrically

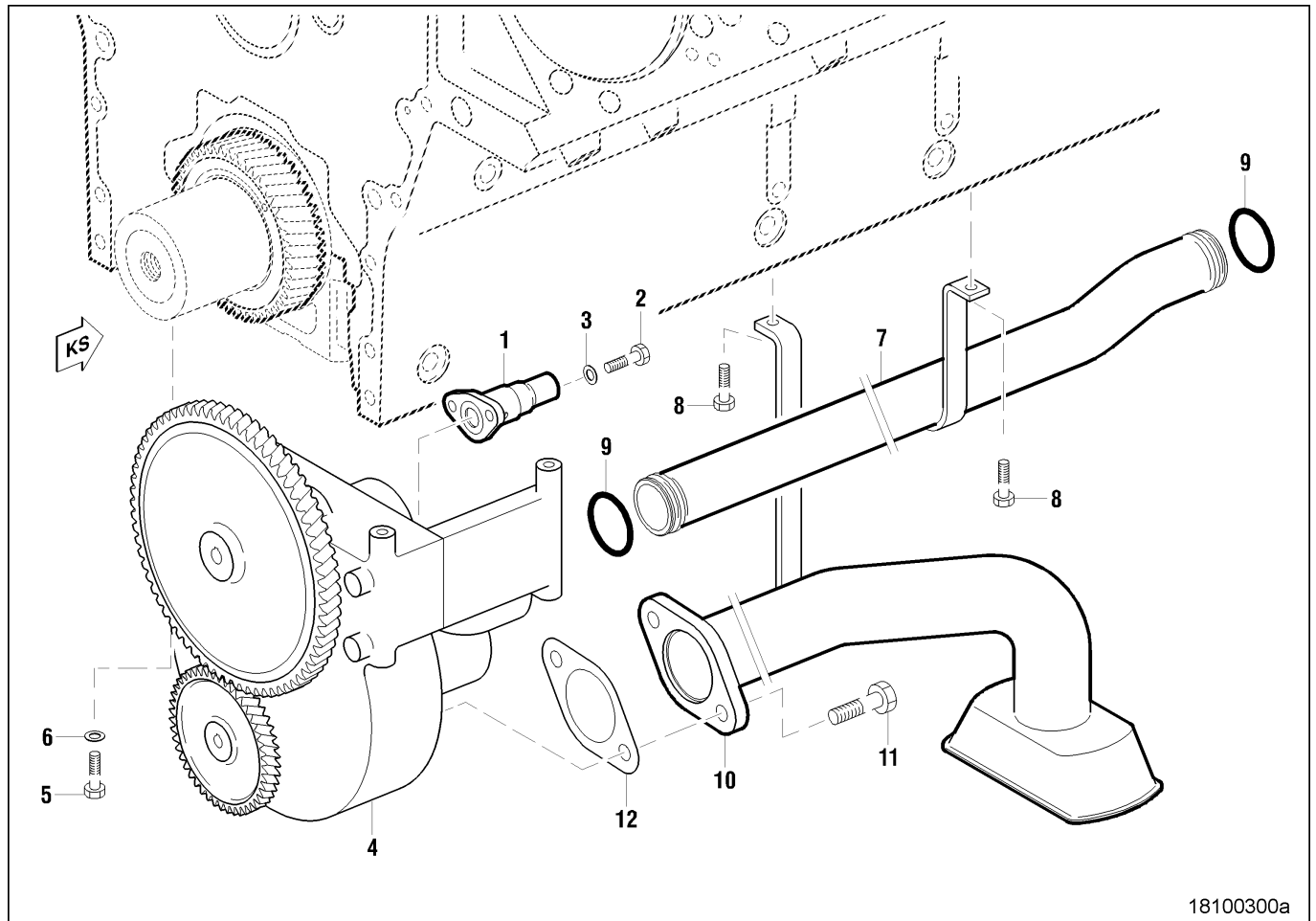
- Connect lines according to markings.
- Check operation of starter.

Final steps

A distinction must be made as to whether				
1	2	3	Operations	See
			1 The engine was completely disassembled	
			2 The engine was removed but not disassembled	
			3 The engine is installed	
X	–	–	Assemble engine	(→ Page 58)
X	–	–	Install engine	(→ Page 60)
–	–	X	Enable engine start	–

3.13 Lube Oil System

3.13.1 Lube-oil pump with drive – Overview



18100300a

- 1 Pressure-relief valve
- 2 Screw
- 3 Washer
- 4 Oil pump


- 5 Screw
- 6 Washer
- 7 Plug-in pipe
- 8 Screw

- 9 O-ring
- 10 Suction line
- 11 Screw
- 12 Gasket

3.13.2 Lube-oil pump with drive – Removal

Preconditions

- Engine is stopped and starting disabled.



WARNING

Heavy object.
Risk of crushing!

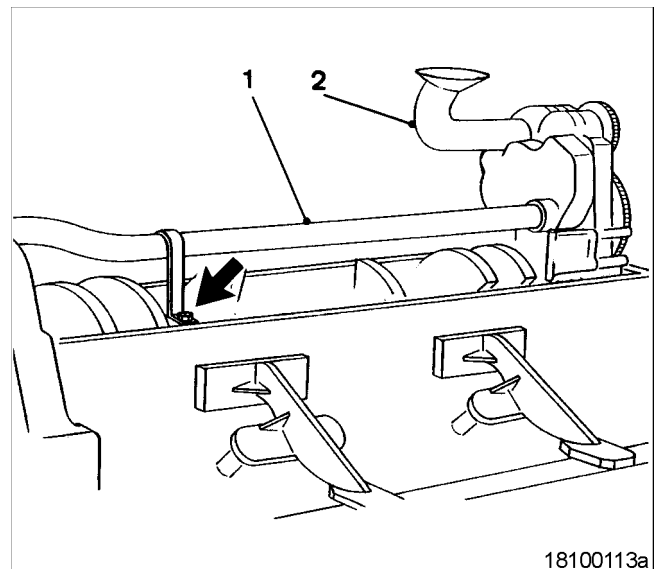
- Use appropriate lifting devices and appliances.

Preparatory steps

A distinction must be made as to whether				
1 the engine is to be completely disassembled				
2 the engine is to be removed but not disassembled				
3 the engine is to remain installed				
1	2	3	Tasks	See
X	–	–	Remove engine.	(→ Page 55)
X	–	–	Disassemble engine.	(→ Page 56)
–	–	X	Disable the engine starter.	(→ Page 15)
–	–	X	Drain or draw off engine oil.	(→ Operating instructions)
–	X	X	Remove oil pump connections.	(→ Page 486)
–	X	X	Remove oil pan.	(→ Page 104)

Removing suction and pressure lines

1. Remove screw (arrow) and washer on holder for plug-in pipe (1).
2. Remove plug-in pipe from lube-oil pump.
3. Remove screws and washers for oil suction line (2).
4. Remove intake elbow.
5. Remove gasket and O-rings.



Lube-oil pump with drive – Removal

1. Remove all screws and washers for lube-oil pump.
2. Remove lube-oil pump as shown in overview diagram (→ Page 476).

3.13.3 Lube oil pump with drive – Disassembly



Remove lube oil pump with drive (→ Page 477).

Disassembling lube oil pump with drive

1. Lube oil pump must not be disassembled.
2. Contact Service.

3.13.4 Lube oil pump with drive – Cleaning

Material

Designation / Use	Part No.	Qty.
Cleaning agent		
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors. 	
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask. 	

Remove lube oil pump with drive (→ Page 477).

Cleaning oil line

1. Clean oil line with cleaning agent.
2. Remove cleaning agent.
3. Blow out oil line with compressed air.

3.13.5 Lube oil pump with drive – Check

Material

Designation / Use	Part No.	Qty.
Fluorescent magnetic powder for magnetic crack test procedure		

Spare parts

Designation / Use	Part No.	Qty.
Oil pump		
Oil pressure relief valve		
Connecting pipe		
Oil intake pipe		
Screw		



WARNING

Test liquid is hot and pressurized.

Risk of injury and scalding!

- Wear protective clothing, gloves, and goggles / safety mask.



WARNING

Compressed air is pressurized.

Risk of injury!

- Pressure must not exceed 0.5 bar.
- Wear protective clothing, gloves, and goggles / safety mask.

Clean lube oil pump with drive (→ Page 479).

Checking lube oil pump with drive

Item	Findings	Task
Visually inspect outside of lube oil pump for damage and defects.	Damaged	Have lube oil pump operation checked and repaired at manufacturer's.
Visually inspect oil line for damage.	Damaged	<ul style="list-style-type: none"> • Recondition • Replace
Pressure-test oil line with air in water bath. <ul style="list-style-type: none"> • Pressure: 0.5 bar • Water temperature min. 30 °C 	Leaking	Replace
Check sealing surfaces for irregularities.	Uneven	<ul style="list-style-type: none"> • Recondition and check for evenness with ink-check plate. • Replace
Using the magnetic crack-testing method, test drive gear for cracks.	Signs of cracks	Replace
Check tooth flanks of drive gear for wear, indentations and chipping.	<ul style="list-style-type: none"> • Wear • Indentations • Chipping visible 	<ul style="list-style-type: none"> • Recondition • Replace lube oil pump
Check screws for damage.	Damaged	Replace
Visually inspect oil pressure relief valve for damage.	Damaged	Replace
Check opening pressure of 8.5 bar \pm 0.7 bar for oil pressure relief valve.	Opening pressure not reached, or exceeded.	Replace
Check sealing face of oil pressure relief valve for unevenness. Permitted unevenness = 0.2 mm	Uneven	Replace

3.13.6 Lube-oil pump with drive – Installation

Material

Designation / Use	Part No.	Qty.
Petroleum jelly, white		
Engine oil		

Spare parts

Designation / Use	Part No.	Qty.
Gasket		
O-ring		



Heavy object.
Risk of crushing!

- Use appropriate lifting devices and appliances.



Compressed air.
Risk of injury!

- Do not direct compressed-air jet at persons.
- Wear protective goggles / safety mask and ear protectors.



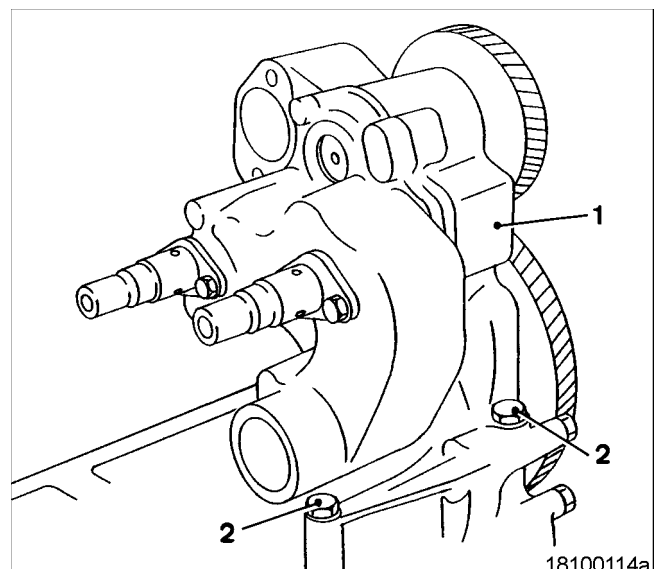
Contamination of components.
Damage to component!

- Observe manufacturer's instructions.
- Check components for special cleanness.

Check lube-oil pump with drive (→ Page 480).

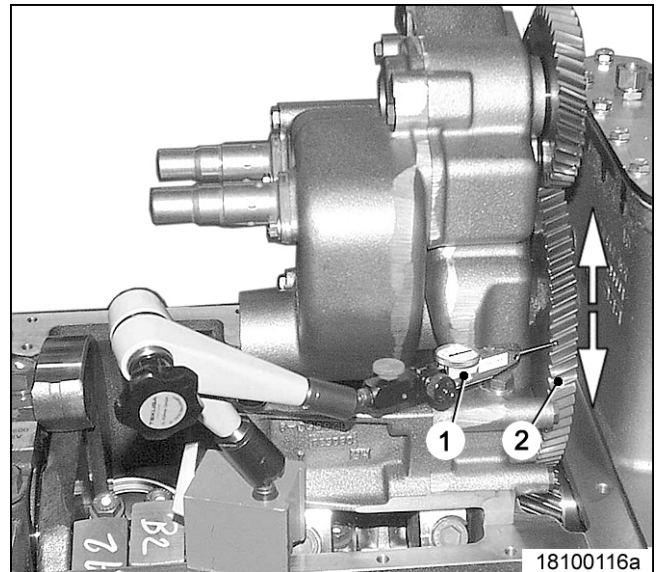
Installing lube-oil pump with drive

1. Position lube-oil pump (1) on crankcase.
2. Install all screws (2) and washers for the lube-oil pump and tighten diagonally.



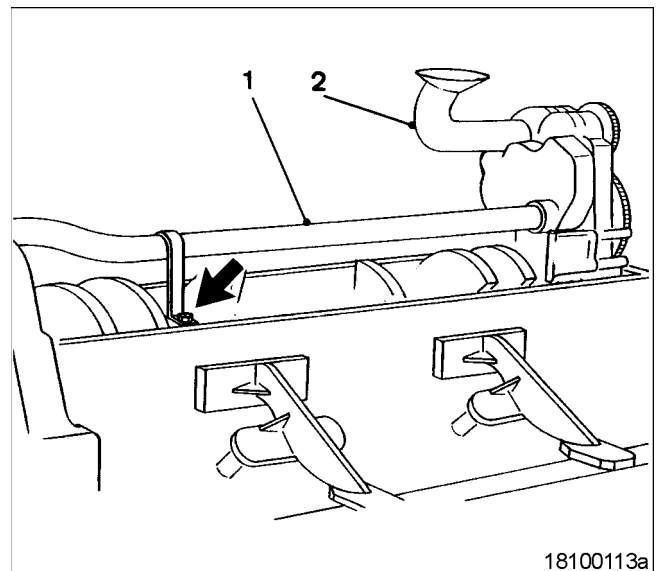
Measuring backlash

1. Attach magnetic base with measuring device (1) to crankcase.
2. Position measuring device (1) on one tooth flank of lube-oil pump gear (2).
3. Turn lube-oil pump gear in both directions (arrowed) and measure backlash. Circumferential backlash (→ Page 122)



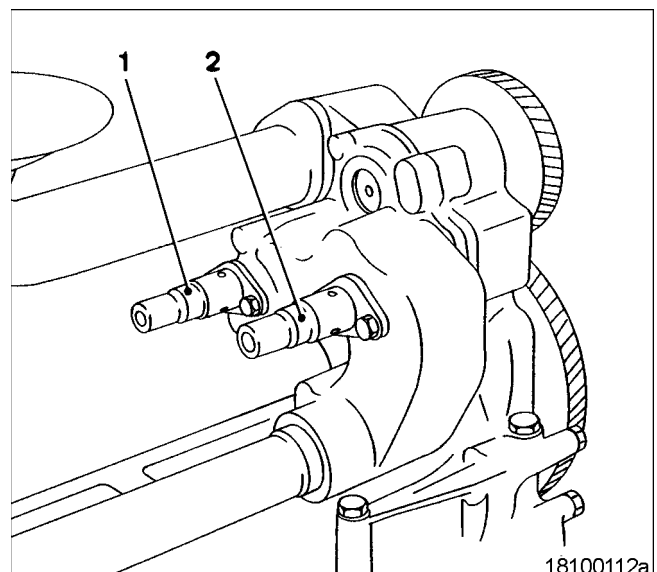
Installing suction and pressure line

1. Coat O-rings with petroleum jelly and position in grooves of plug-in pipe (1).
2. Insert plug-in pipe (1) into lube-oil pump and secure on the bracket using screw (arrowed) and washer.
3. Position new gasket and attach oil-suction pipe (2) to lube-oil pump using screws and washers.



Installing lube-oil pump with drive

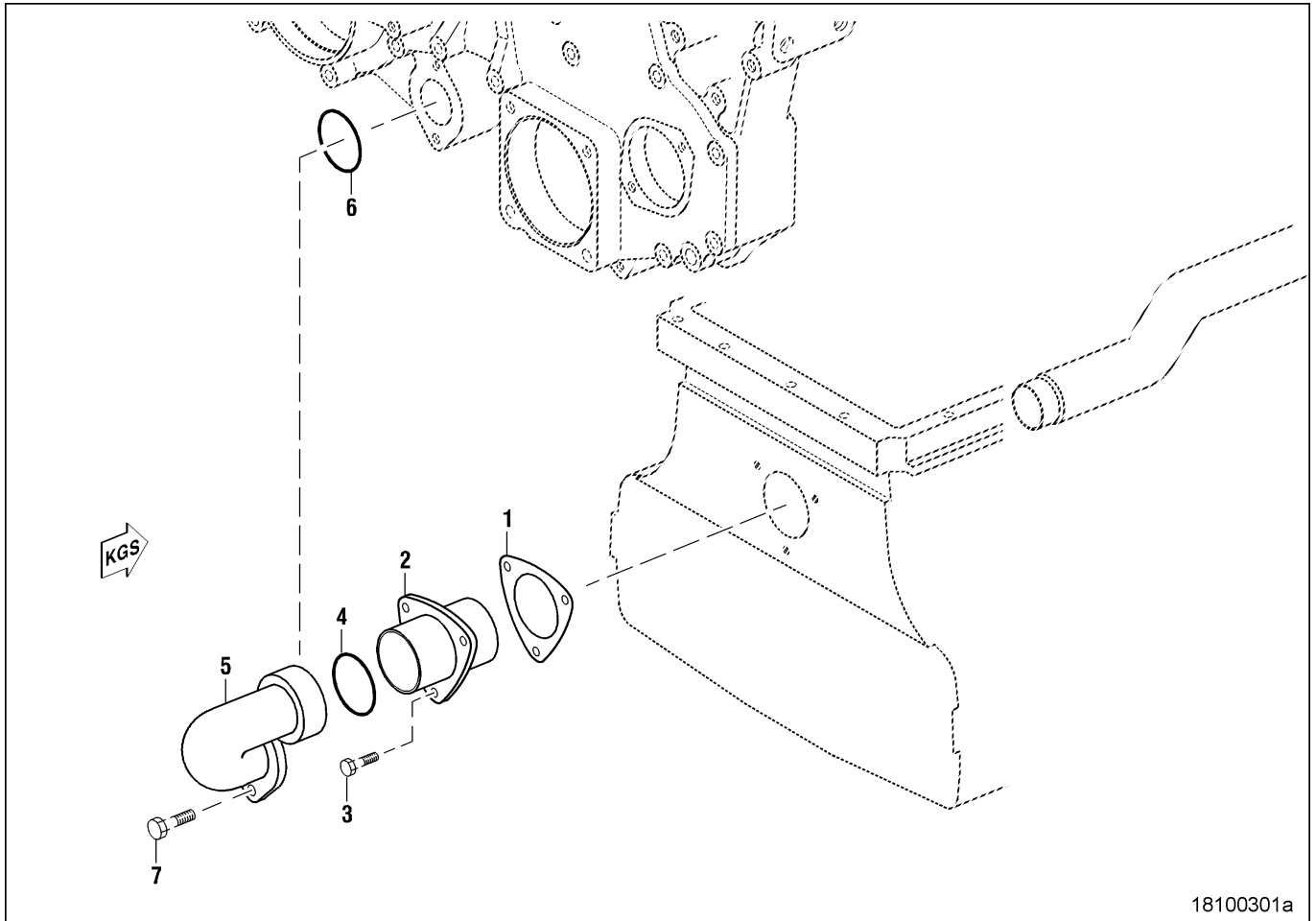
1. Clean sealing faces.
2. Attach pressure-relief valves (1) and (2) to lube-oil pump using screws and washers.



Final steps

For these steps a distinction must be made as to whether				
1 the engine has been completely disassembled				
2 the engine has been removed but not disassembled				
3 the engine has remained installed				
1	2	3	Operations	See
X	–	–	Assemble engine.	(→ Page 58)
X	–	–	Install engine.	(→ Page 60)
–	X	X	Assemble in reverse sequence to disassembly.	(→ Page 477)
–	–	X	Fill with engine oil.	(→Operating instructions)
–	–	X	Enable engine start.	–

3.13.7 Oil pump connections – Overview



18100301a

- 1 Gasket
- 2 Flange
- 3 Screw

- 4 O-ring
- 5 Elbow
- 6 O-ring

- 7 Screw

3.13.8 Connections for oil pump – Removal

Preconditions

- Engine is stopped and starting disabled.

Preparatory steps



A distinction must be made as to whether				
1 the engine is to be completely disassembled				
2 the engine is to be removed but not disassembled				
3 the engine is to remain installed				
1	2	3	Tasks	See
X	–	–	Remove engine.	(→ Page 55)
X	–	–	Disassemble engine.	(→ Page 56)
–	–	X	Disable the engine starter.	(→ Page 15)
–	–	X	Drain or draw off engine oil.	(→Operating instructions)

Connections for oil pump – Removal

1. Remove lines as shown in overview diagram. (→ Page 485)
2. Remove gaskets (if installed) and O-rings.
3. After removal, seal all openings with suitable covers.

3.13.9 Oil pump connections – Cleaning

Material

Designation / Use	Part No.	Qty.
Cleaning agent		
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors. 	
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask. 	

Remove oil pump connections (→ Page 486).



Cleaning oil pump connections

1. Clean oil pump connections with cleaning agent.
2. Remove cleaning agent.
3. Blow oil pump connections dry with compressed air.

3.13.10 Connections for oil pump – Check

Spare parts

Designation / Use	Part No.	Qty.
Elbow (if installed)		
Oil line (if installed)		
Flange		
Plug-in pipe		

 WARNING	<p>Compressed air.</p> <p>Risk of injury!</p> <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors.
 WARNING	<p>Compressed air is pressurized.</p> <p>Risk of injury!</p> <ul style="list-style-type: none"> • Pressure must not exceed 0.5 bar. • Wear protective clothing, gloves, and goggles / safety mask.

Clean connections for oil pump (→ Page 487).

Connections for oil pump – Check

Item	Findings	Measure
Visually inspect connections for damage.	Damaged	Replace
Pressure-test connections with air in water bath for leaks. A water temperature of min = 30 °C or max = 40 °C at a test pressure of 0.5 bar must be observed.	Leaking	Replace
Check connecting and securing elements of the connections for damage.	Damaged	Replace
Check sealing and bolt-on faces.	Damaged	<ul style="list-style-type: none"> • Recondition: Smooth with oilstone or emery cloth. • Replace
Check threads for ease of movement.	Sluggish	<ul style="list-style-type: none"> • Recondition: Recut threads. • Replace

3.13.11 Connections for oil pump – Installation

Material

Designation / Use	Part No.	Qty.
Petroleum jelly, white		
Engine oil		

Spare parts

Designation / Use	Part No.	Qty.
O-rings		
Gasket (if installed)		



WARNING

Compressed air.

Risk of injury!

- Do not direct compressed-air jet at persons.
- Wear protective goggles / safety mask and ear protectors.

Check connections for oil pump (→ Page 488).

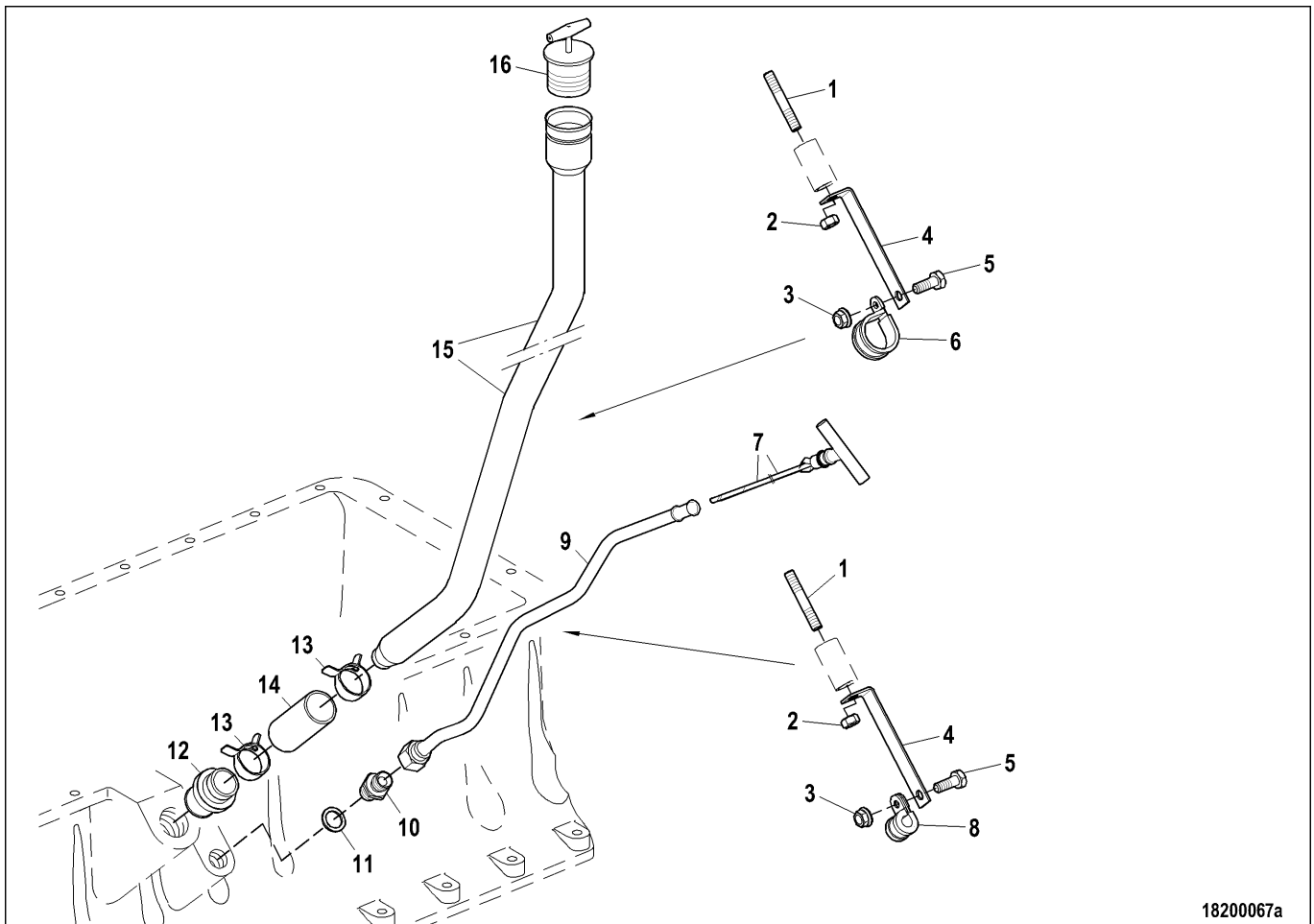
Connections for oil pump – Installation

1. Remove all covers prior to installation.
2. Coat O-rings with petroleum jelly and insert.
3. Insert gasket (if available).
4. Install connections with connecting and securing elements, tension-free as shown in overview diagram. (→ Page 485)
5. After engine start, visually inspect oil lines for leaks.

Final steps

A distinction must be made as to whether				
1 the engine was completely disassembled				
2 the engine was removed but not disassembled				
3 the engine is still installed				
1	2	3	Tasks	See
X	–	–	Assemble engine.	(→ Page 58)
X	–	–	Install engine.	(→ Page 60)
–	–	X	Enable the engine starter.	–

3.13.12 Filling and measuring equipment – Overview



18200067a

- | | |
|----------------|---------------------|
| 1 Stud | 9 Oil dipstick tube |
| 2 Nut | 10 Union |
| 3 Nut | 11 Gasket |
| 4 Bracket | 12 Adapter |
| 5 Screw | 13 Hose clamp |
| 6 Clamp | 14 Rubber hose |
| 7 Oil dipstick | 15 Oil filler neck |
| 8 Clamp | 16 Cover |

3.13.13 Filling and measuring equipment – Removal

Preconditions

- Engine is stopped and starting disabled

Preparatory steps

For these steps a distinction must be made as to whether

- 1 the engine is to be completely disassembled
- 2 the engine is to be removed but not disassembled
- 3 the engine is to remain installed



1	2	3	Operations	See
X	–	–	Remove engine.	(→ Page 55)
X	–	–	Disassemble engine.	(→ Page 56)
–	–	X	Disable engine start.	(→ Page 15)

Removing filling and measuring equipment

1. Remove oil dipstick, oil dipstick tube, oil filler neck and attachments as per overview (→ Page 490).
2. After removal, seal all openings with suitable covers.

3.13.14 Filling and measuring equipment – Cleaning

Material

Designation / Use	Part No.	Qty.
Cleaning agent		
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors. 	
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask. 	

Remove filling and measuring equipment (→ Page 491).


Cleaning filling and measuring equipment


1. Clean oil dipstick tube and oil filler neck using cleaning agent.
2. Remove cleaning agent.
3. Dry oil dipstick tube and oil filler neck using compressed air.

3.13.15 Filling and measuring equipment – Check

Spare parts

Designation / Use	Part No.	Qty.
Oil dipstick		
Oil dipstick tube		
Oil filler neck		
Cover		

 WARNING	<p>Compressed air.</p> <p>Risk of injury!</p> <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors.
---	--

 WARNING	<p>Compressed air is pressurized.</p> <p>Risk of injury!</p> <ul style="list-style-type: none"> • Pressure must not exceed 0.5 bar. • Wear protective clothing, gloves, and goggles / safety mask.
---	---

Clean filling and measuring equipment (→ Page 492).

Checking filling and measuring equipment

Item	Findings	Task
Visually inspect all components for damage.	Damaged	Replace
Check sealing and bolt-on faces.	Damaged	<ul style="list-style-type: none"> • Rework: Re-surface with oil stone or crocus cloth. • Replace
Check threads for ease of movement.	No ease of movement	<ul style="list-style-type: none"> • Rework: Recut threads. • Replace


3.13.16 Filling and measuring equipment – Installation

Material

Designation / Use	Part No.	Qty.
Engine oil		

Spare parts

Designation / Use	Part No.	Qty.
Hose line		

 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors.
---	---

Check filling and measuring equipment (→ Page 493).

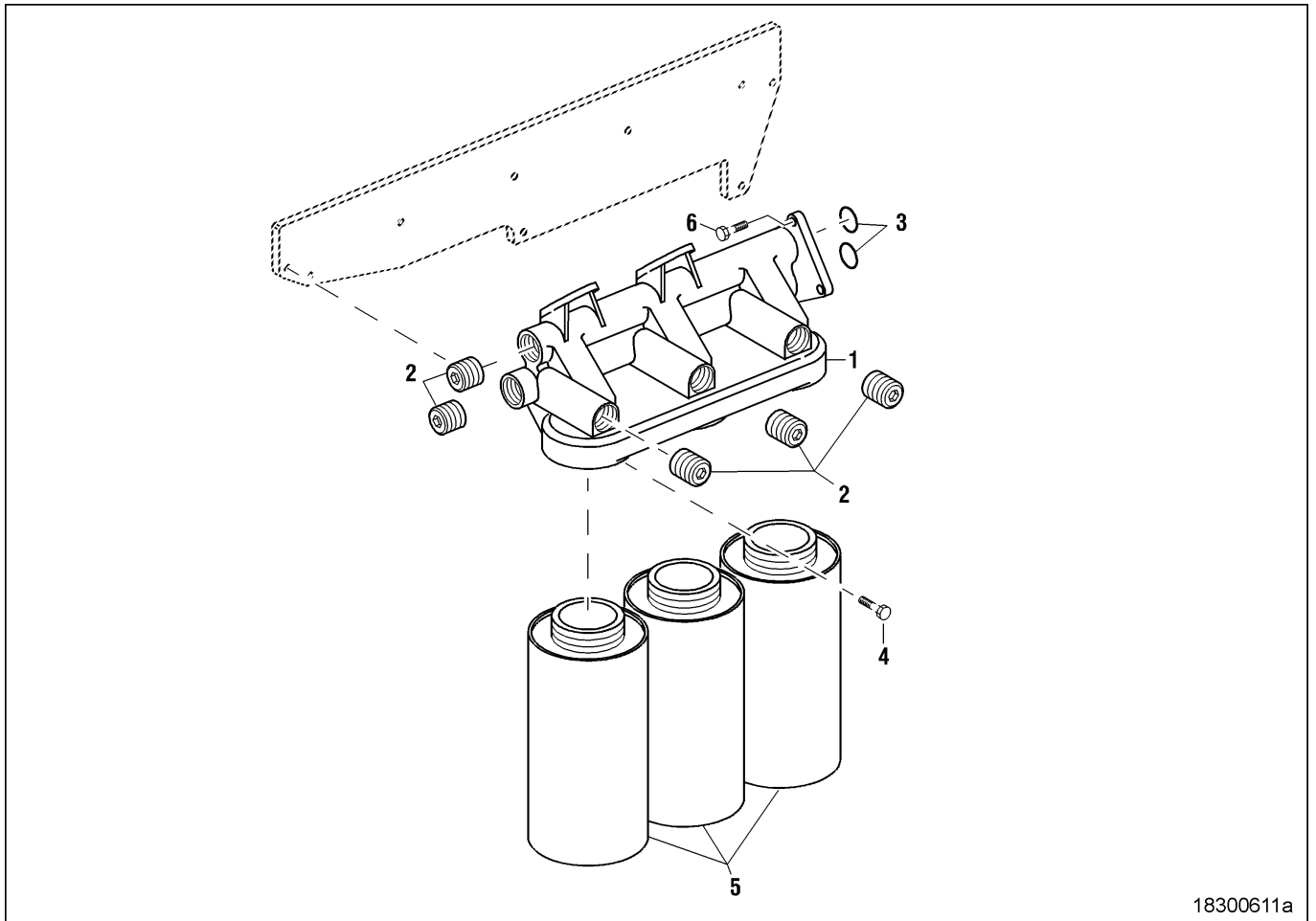
Installing filling and measuring equipment

1. Remove all covers prior to installation.
2. Install filling and measuring equipment with connectors and attachments as per overview, ensuring that the components are not subject to tension (→ Page 490).
3. Using a torque wrench, tighten connector and union of the oil dipstick tube to specified tightening torque (→ Page 23).

Final steps

For these steps a distinction must be made as to whether				
1 the engine has been completely disassembled				
2 the engine has been removed but not disassembled				
3 the engine has remained installed				
1	2	3	Operations	See
X	–	–	Assemble engine.	(→ Page 58)
X	–	–	Install engine.	(→ Page 60)
–	–	X	Enable engine start.	–
–	–	X	Visually inspect oil lines for leaks following engine start.	–

3.13.17 Oil filter – Overview



18300611a

1 Oil filter housing
2 Plug screw

3 O-ring
4 Screw

5 Oil filter
6 Screw

3.13.18 Oil filter – Removal

Preconditions

- Engine is stopped and starting disabled

Special tools

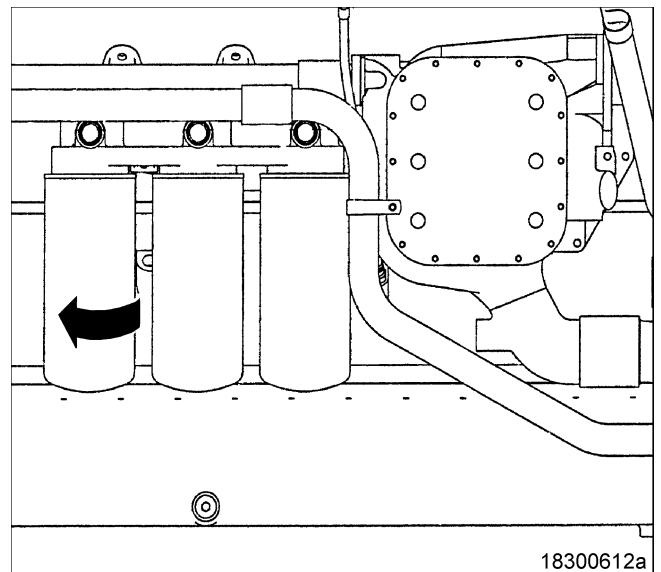
Designation / Use	Part No.	Qty.
Oil filter wrench	F30379104	1

Preparatory steps

<p>For these steps a distinction must be made as to whether</p> <p>1 the engine is to be completely disassembled</p> <p>2 the engine is to be removed but not disassembled</p> <p>3 the engine is to remain installed</p>				
1	2	3	Operations	See
X	–	–	Remove engine.	(→ Page 55)
X	–	–	Disassemble engine.	(→ Page 56)
–	–	X	Disable engine start.	(→ Page 15)

Removing oil filter and oil filter housing



1. Remove oil filter with oil filter wrench.
2. Drain oil from engine oil filter into a container.
3. Remove oil filter housing as per overview (→ Page 495).
4. Close openings using suitable covers.



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3.13.19 Oil filter housing – Cleaning

Material

Designation / Use	Part No.	Qty.
Cleaning agent		
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors. 	
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask. 	

Remove oil filter housing (→ Page 496).

Cleaning oil filter housing

1. Clean oil filter housing using cleaning agent.
2. Remove cleaning agent.
3. Blow out oil filter housing with compressed air.


3.13.20 Oil filter housing – Check

Special tools

Designation / Use	Part No.	Qty.
Test bath		

Spare parts

Designation / Use	Part No.	Qty.
Oil filter housing		

 WARNING	<p>Compressed air is pressurized. Hot testing liquid.</p> <p>Risk of injury and scalding!</p> <ul style="list-style-type: none"> • Pressure must not exceed 0.5 bar. • Wear protective clothing, gloves, and goggles / safety mask.
---	--

Clean oil filter housing (→ Page 497).

Oil filter housing – Check

Item	Findings	Measure
Check all sealing, mating and sliding surfaces for stress marks, scoring and indentations.	<ul style="list-style-type: none"> • Stress marks • Scores • Indentations visible. 	<ul style="list-style-type: none"> • Recondition: Smooth with oilstone or emery cloth. • Replace
Check all threads and tapped holes.	Damaged	<ul style="list-style-type: none"> • Recondition: Recut threads. • Replace
Pressure-test oil filter housing with air in water bath for leaks. Install filter elements for leak test. Test temperature: min. 30 °C, max. 40 °C, if oil filter housing has to be held in hands. Test pressure: 0.5 bar.	Leaking	<ul style="list-style-type: none"> • Replace plugs. • Replace double nipple. • Replace oil filter housing.

3.13.21 Oil filter – Installation

Material

Designation / Use	Part No.	Qty.
Engine oil		

Spare parts

Designation / Use	Part No.	Qty.
O-ring		



Heavy object.

Risk of crushing!

- Use appropriate lifting devices and appliances.



Contamination of components.

Damage to component!

- Observe manufacturer's instructions.
- Check components for special cleanness.

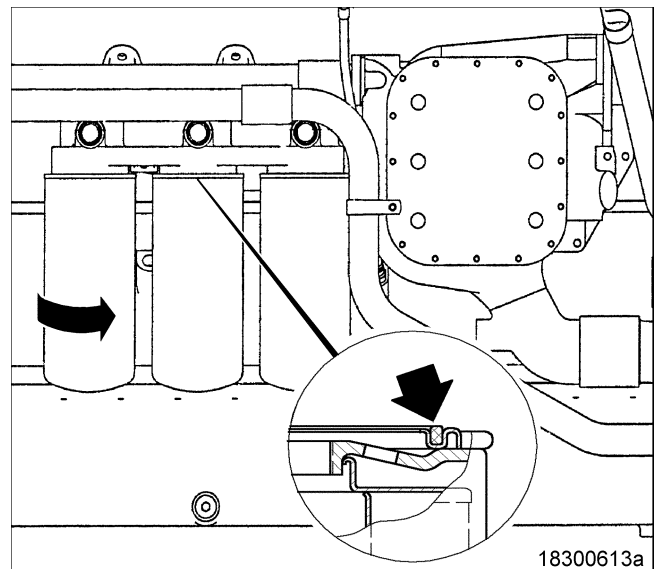
Check oil filter (→ Page 498).

Installing oil filter housing

1. Remove all covers prior to installation.
2. Coat O-ring with petroleum jelly.
3. Position O-ring in oil filter housing groove.
4. Install oil filter housing as per overview (→ Page 495).

Installing oil filter

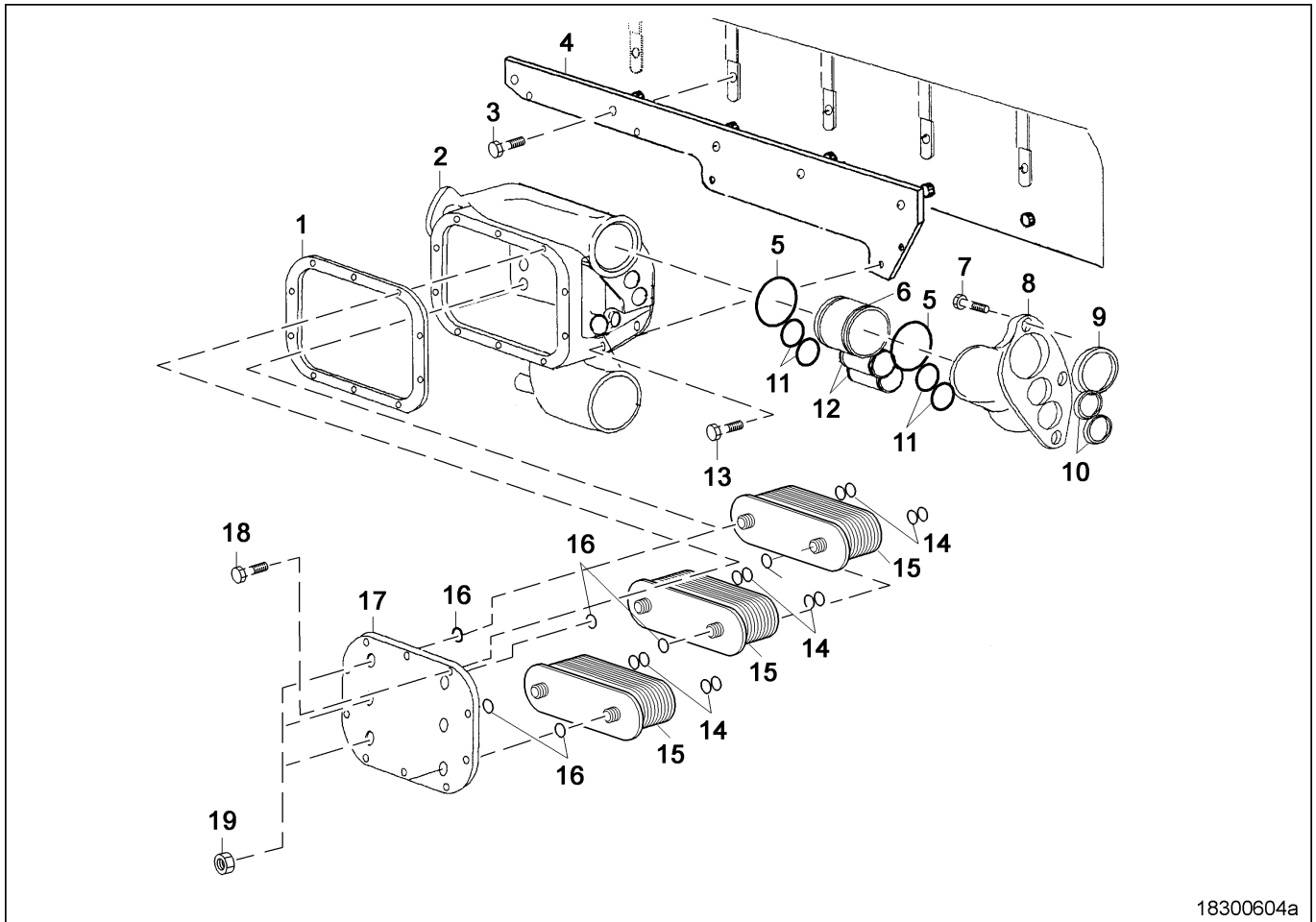
1. Coat sealing ring of oil filter with oil.
2. Install oil filter and tighten by hand.



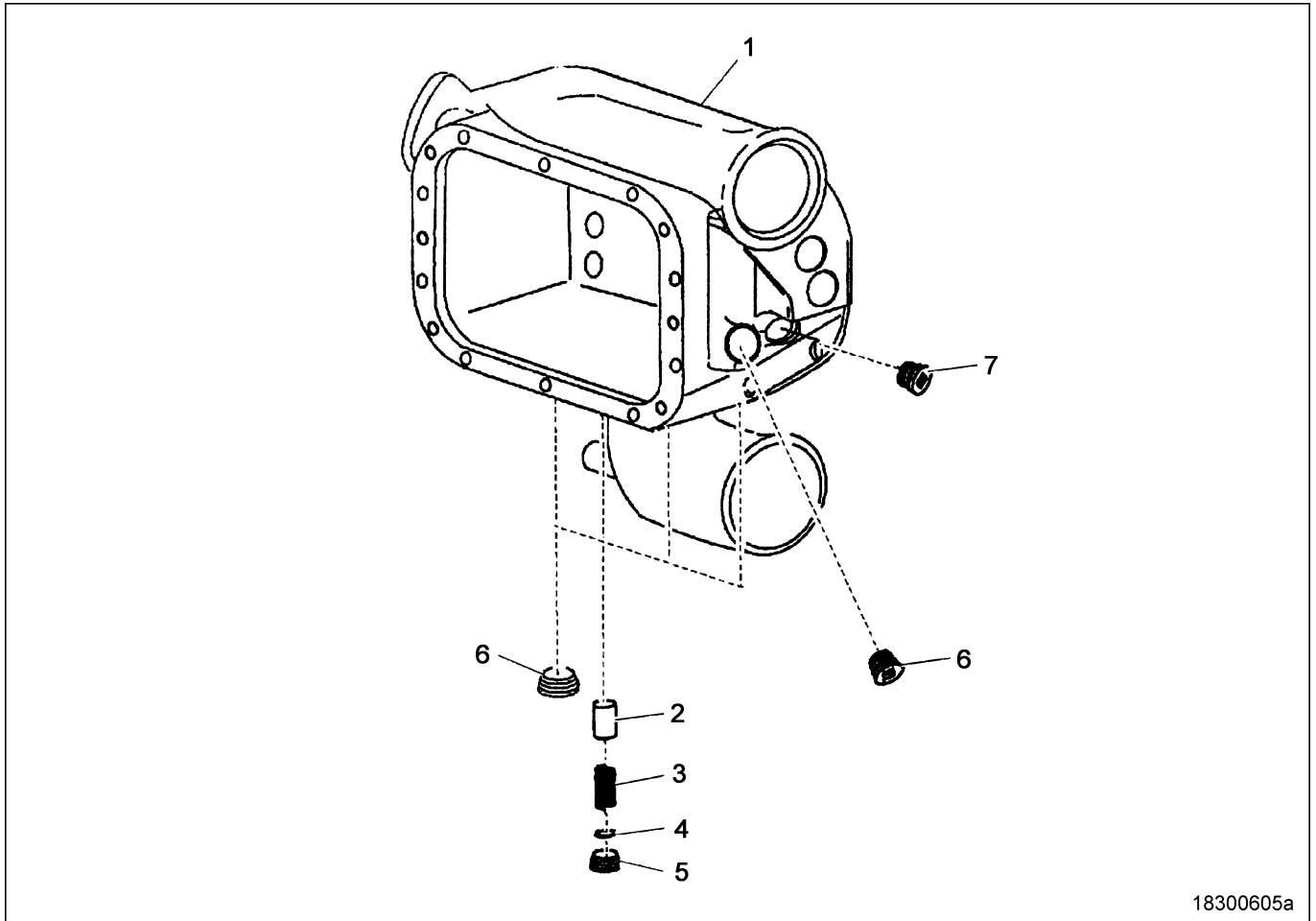
Final steps

For these steps a distinction must be made as to whether				
1 the engine has been completely disassembled				
2 the engine has been removed but not disassembled				
3 the engine has remained installed				
1	2	3	Operations	See
X	–	–	Assemble engine.	(→ Page 58)
X	–	–	Install engine.	(→ Page 60)
–	X	X	Perform installation in reverse sequence of work steps as described for removal.	(→ Page 496)
–	X	X	Top up with engine oil.	–
–	–	X	Enable engine start.	–
–	–	X	Check oil filter for leaks.	–

3.13.22 Oil cooler – Overview



- | | | |
|----------------------|-----------|------------------|
| 1 Gasket | 8 Housing | 15 Cooler insert |
| 2 Oil cooler housing | 9 O-ring | 16 O-ring |
| 3 Screw | 10 O-ring | 17 Cover |
| 4 Bracket | 11 O-ring | 18 Screw |
| 5 O-ring | 12 Pipe | 19 Nut |
| 6 Pipe | 13 Screw | |
| 7 Screw | 14 O-ring | |



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- 1 Oil cooler housing
- 2 Bypass valve
- 3 Spring

- 4 Sealing ring
- 5 Plug screw
- 6 Plug screw

- 7 Plug screw

3.13.23 Oil cooler – Removal


Preconditions

- Engine is stopped and starting disabled

Special tools

Designation / Use	Part No.	Qty.
Lifting eye		2

 WARNING	Components have sharp edges. Risk of injury! <ul style="list-style-type: none"> • Wear protective gloves.
---	--

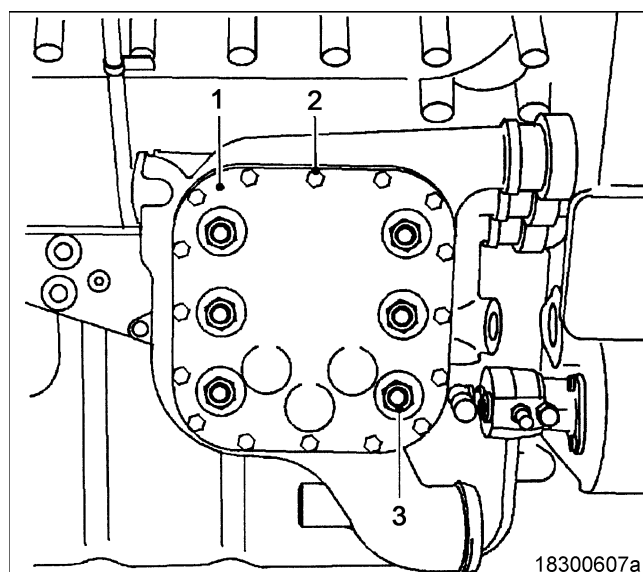
 WARNING	Heavy object. Risk of crushing! <ul style="list-style-type: none"> • Use appropriate lifting devices and appliances.
---	---

Preparatory steps

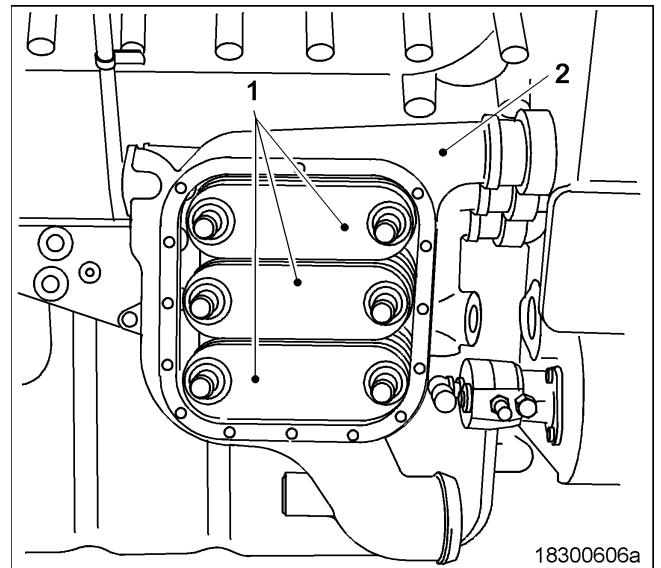
For these steps a distinction must be made as to whether <ul style="list-style-type: none"> 1 the engine is to be completely disassembled 2 the engine is to be removed but not disassembled 3 the engine is to remain installed 				
1	2	3	Operations	See
X	–	–	Remove engine.	(→ Page 55)
X	–	–	Disassemble engine.	(→ Page 56)
–	–	X	Disable engine start.	(→ Page 15)
–	–	X	Drain engine coolant.	(→Operating instructions)

Removing oil cooler

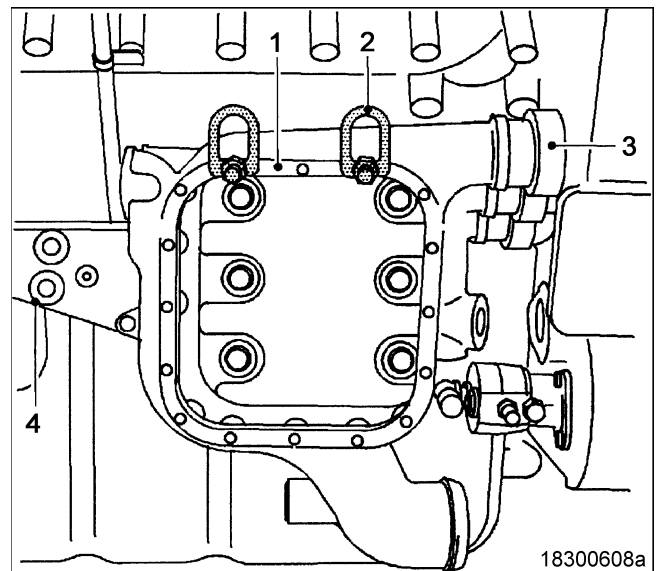
1. Remove all screws (2) from cover (1).
2. Remove all nuts (3) from cover (1).
3. Remove cover (1) and gasket.



4. Pull cooler inserts (1) out of oil cooler housing (2).
5. Remove O-rings.
6. Plug cooler inserts (1) using suitable plugs.
7. Store cooler inserts (1) separately and protect from mechanical damage.





8. Attach oil cooler housing (1) to crane using lifting eyes (2) and ropes. Evenly tension ropes.
9. Remove all screws from oil cooler housing (1).
10. Remove oil cooler housing (1) using ropes and crane; note plug-in pipe fits.
11. Remove oil cooler housing (1) and bracket (4) as per overview (→ Page 501).
12. Close crankcase oil bores using suitable plugs.
13. Remove plug from bypass valve in oil cooler housing (1) and take out sealing ring, spring and bypass valve (→ Page 501).



3.13.24 Oil cooler – Cleaning

Material

Designation / Use	Part No.	Qty.
Cleaner		
 CAUTION Contamination of components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Check components for special cleanness. 		
 CAUTION Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask. 		

Remove oil cooler (→ Page 503).

Cleaning oil cooler housing and plug-in pipe

1. Clean oil cooler housing and plug-in pipe with cleaner.
2. Remove cleaner.
3. Blow out components with compressed air.

Cleaning cooler inserts on coolant and oil side

Note: If swarf has got into the engine oil system, e.g. as a result of piston scuffing or bearing damage, replace oil cooler.

Cleaning water side

1. Examine the degree of contamination.
2. In event of visible encrustation as a result of hardness structure, contamination and oil deposits, clean with suitable cleaners, e.g. Porodox (from Henkel) or Porozink (from Parobe-Chemie, Basel). Always follow manufacturer's instructions.
3. After cleaning, flush the cooler with water until pH values of clean water and rinsing water are approximately the same (difference 1 pH).
4. If the cooler is not put into operation immediately after cleaning, dry and preserve coolant side.

Cleaning oil side

1. Connect cooler element (oil side) to a closed flushing system with a filter system of 0.05 mm mesh size.
2. Clean cooler element with suitable cleaner, e.g. buffered alkaline agents such as 3 to 5% solution of Henkel P3 FD.
3. Ensure flow direction of cleaner is against normal direction of oil flow during operation.
4. After cleaning, oil side must be flushed with water until pH values of fresh water and flushing water are roughly equal (permissible difference 1pH).
5. If the cooler is not put into operation immediately after cleaning, dry and preserve oil side.

Drying and preserving oil cooler

1. Dry oil cooler in oven at 110 °C to 120 °C for approx. 3 hours.
2. Spray oil cooler with preservation agent (Branorol 32/10 from Brangs & Heinrich). A dosage of max. 2 ml Branorol 32/10 per litre of cooling volume must be observed. The preservation agent vaporises and forms a protective film on all interior surfaces.
3. After preservation, seal all openings airtight with suitable plugs.

3.13.25 Oil cooler – Check

Special tools


Designation / Use	Part No.	Qty.
Test bath		


Material

Designation / Use	Part No.	Qty.
Red penetrant dye for surface crack testing		


Spare parts

Designation / Use	Part No.	Qty.
Oil cooler housing		
Cooler insert		
Bracket		
Plug-in pipe		

 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> Do not direct compressed-air jet at persons. Wear protective goggles / safety mask and ear protectors.
--	---

 WARNING	Compressed air is pressurized. Hot testing liquid. Risk of injury and scalding! <ul style="list-style-type: none"> Pressure must not exceed 0.5 bar. Wear protective clothing, gloves, and goggles / safety mask.
---	--

 WARNING	Component is hot. Risk of burning! <ul style="list-style-type: none"> Wear protective gloves.
---	--

 CAUTION	Contamination of components. Damage to component! <ul style="list-style-type: none"> Observe manufacturer's instructions. Check components for special cleanness.
---	---

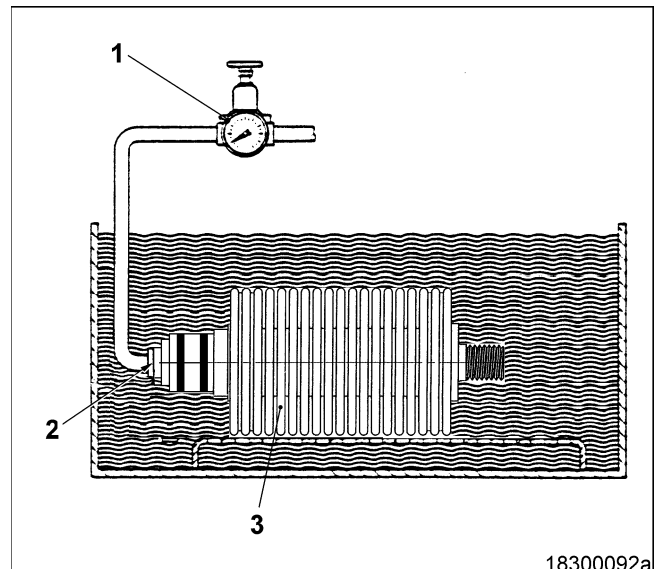
Clean oil cooler (→ Page 505).

Checking oil cooler

Item	Findings	Task
Visually inspect all components for damage.	Damaged	<ul style="list-style-type: none"> • Recondition • Replace
Check all sealing, mating and contact faces for damage and unevenness.	<ul style="list-style-type: none"> • Damaged • Uneven 	<ul style="list-style-type: none"> • Rework: Smooth with oilstone or emery cloth. • Replace
Check threads for ease of movement.	No ease of movement	<ul style="list-style-type: none"> • Recut • Replace
Check oil cooler housing for cracks using red penetrant dye.	Cracks apparent	Replace

Cooler insert leak check

1. Seal oil chamber connections of cooler insert (3) with suitable sleeves, blanking plugs, plugs (2) and clamps.
2. Connect pressure line (1) at plug (2).
3. Preheat test bath to 80°C.
4. Immerse cooler insert (3) in test bath.
5. Open compressed air supply and set pressure reducer (1) to 0.5 bar.
6. Using compressed air, check cooler insert (3) for leaks under water. There must not be any bubbles emerging.
7. Replace cooler insert (3) if leaks are found.
8. Remove compressed-air line (1), sleeves and plugs (2).
9. Using compressed air, dry fins of cooler insert (3) by blowing vertically.



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3.13.26 Oil cooler – Installation

Special tools

Designation / Use	Part No.	Qty.
Lifting eye		2

Material

Designation / Use	Part No.	Qty.
Petroleum jelly, white		
Engine oil		

Spare parts

Designation / Use	Part No.	Qty.
Gasket		
O-ring		
Sealing ring		



Heavy object.

Risk of crushing!

- Use appropriate lifting devices and appliances.



Contamination of components.

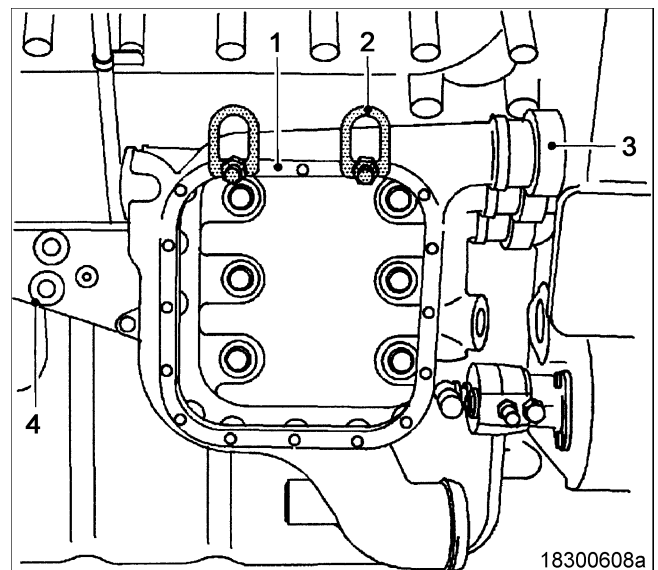
Damage to component!

- Observe manufacturer's instructions.
- Check components for special cleanliness.

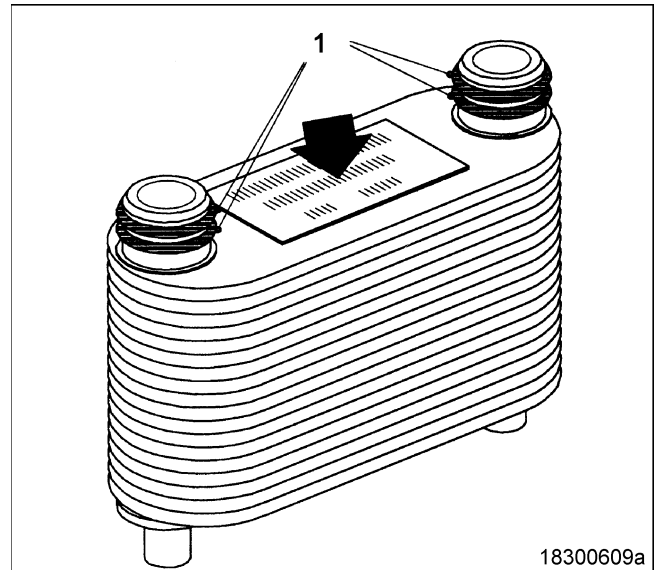
Check oil cooler (→ Page 506).

Installing oil cooler

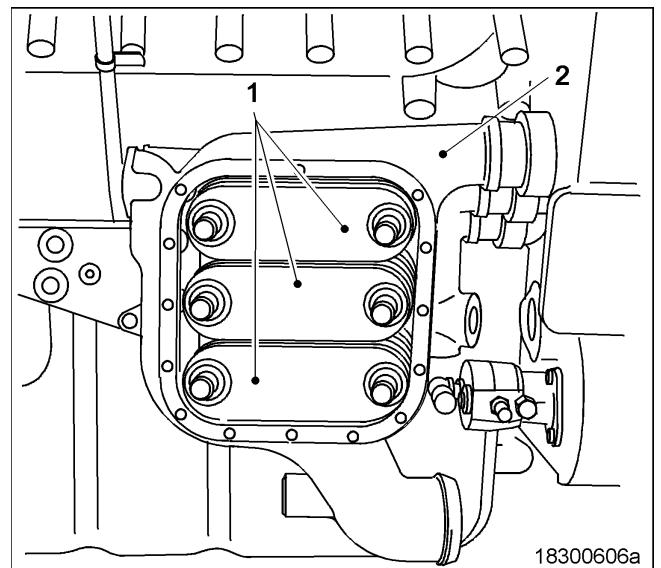
1. Prior to installation, remove all blanking plugs.
2. Ensure oil chambers and oil ducts are particularly clean.
3. Coat O-rings with petroleum jelly.
4. Attach bracket (4) and oil cooler housing (1) to crankcase as per overview (→ Page 501).
5. Coat sliding faces of bypass valve with engine oil.
6. Install bypass valve, spring, plug and sealing ring in oil cooler housing (1) as per overview (→ Page 501).
7. Check bypass valve for ease of movement in the oil cooler housing bore.
8. Attach oil cooler housing (1) to crane using lifting eyes (2) and rope and install on bracket (4) using screws. Note fit of plug-in pipes (3).
9. Remove lifting eyes (2).



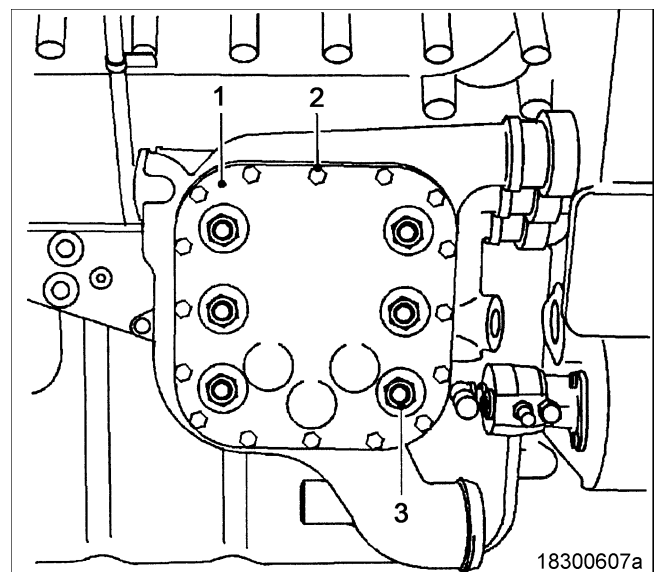
10. Remove plugs from cooler insert.
11. Coat O-rings (1) with petroleum jelly and position in the cooler insert grooves. Note installation position mark (arrowed) on the cooler insert.



12. Position cooler inserts (1) in oil cooler housing (2) as per installation position marks.
13. Coat O-rings with petroleum jelly.
14. Position O-rings over threads on cooler inserts (1).



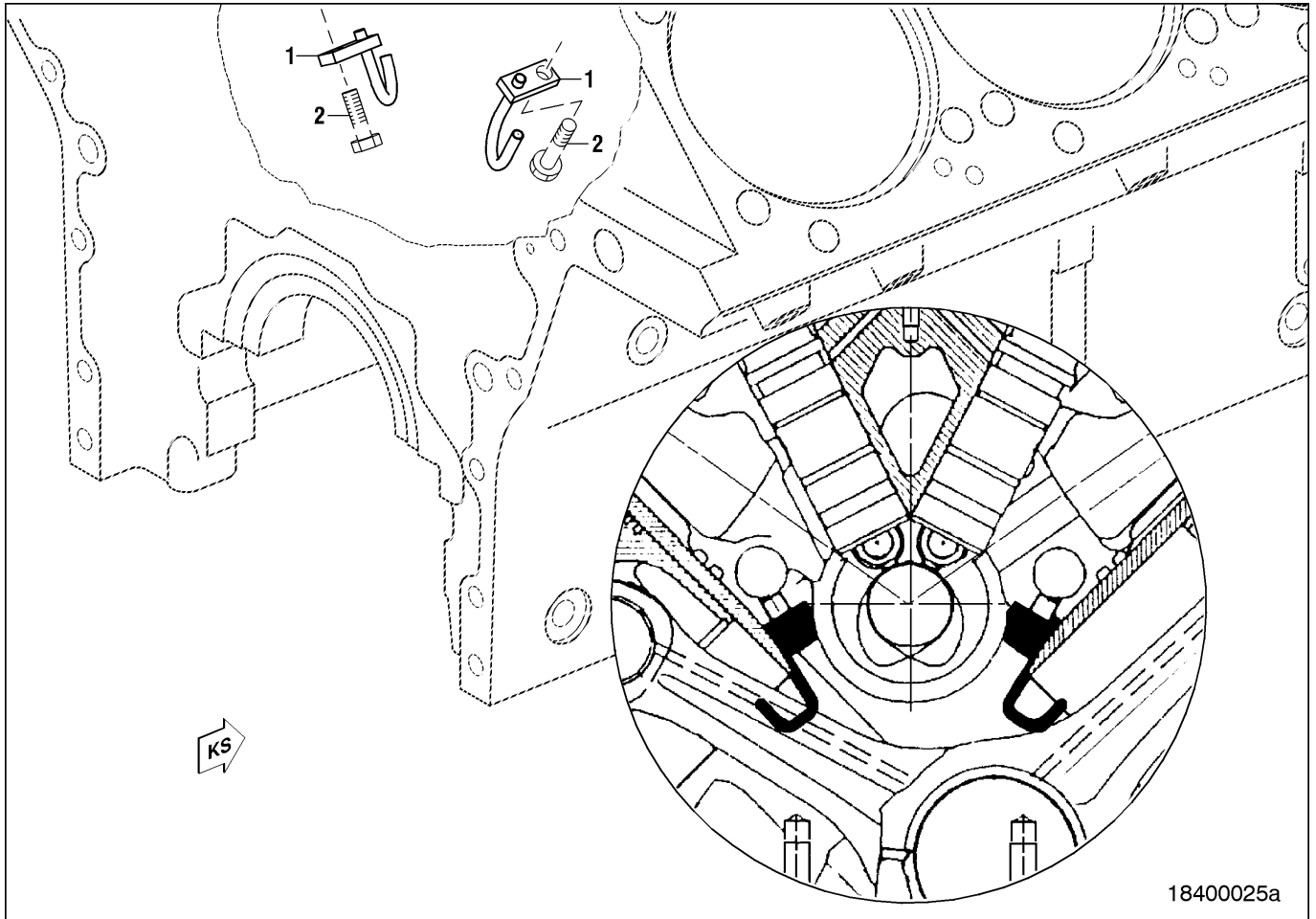
15. Install cover (1) and gasket and tighten screws (2) to specified tightening torque using a torque wrench (→ Page 23).
16. Screw on nuts (3) and tighten to specified tightening torque using a torque wrench (→ Page 23).



Final steps

For these steps a distinction must be made as to whether				
1 the engine has been completely disassembled				
2 the engine has been removed but not disassembled				
3 the engine has remained installed				
1	2	3	Operations	See
X	–	–	Assemble engine.	(→ Page 58)
X	–	–	Install engine.	(→ Page 60)
–	–	X	Fill with engine coolant.	(→Operating instructions)
–	–	X	Enable engine start.	–

3.13.27 Oil system in crankcase – Overview



1 Oil spray nozzle

2 Screw

3.13.28 Oil system in crankcase – Removal

Preconditions

- Engine is stopped and starting disabled.



Components have sharp edges.

Risk of injury!

- Wear protective gloves.

Preparatory steps

A distinction must be made as to whether

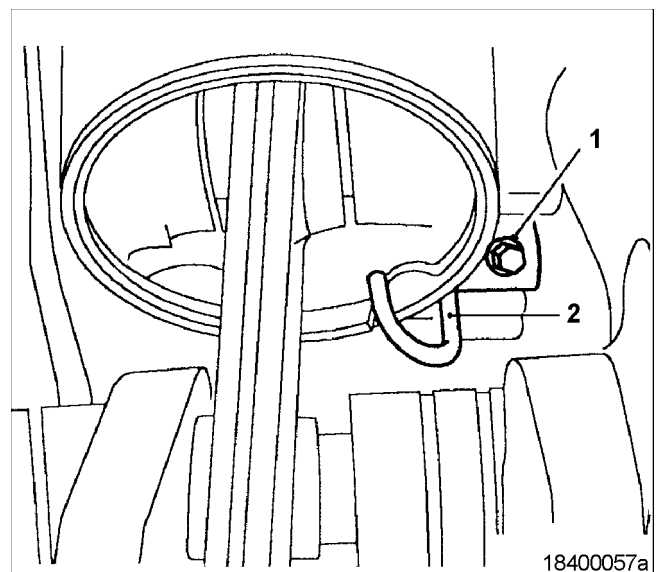
- 1 The engine is to be completely disassembled
- 2 The engine is to be removed but not disassembled
- 3 The engine is to remain installed

(*) Work steps only to be carried out when removing washer (sealing fit)

1	2	3	Operations	See
X	–	–	Remove engine	(→ Page 55)
X	–	–	Disassemble engine	(→ Page 56)
–	–	X	Disable engine start	(→ Page 15)
–	–	X	Drain engine coolant	(→ Operating Instructions)
–	–	X	Drain or draw off engine oil	(→ Operating Instructions)
–	–	X	Remove oil pump connections	(→ Page 486)
–	X	X	Remove filling and measuring equipment	(→ Page 491)
–	X	X	Lower oil pan	(→ Page 104)



Removing oil spray nozzle

1. Rotate crankshaft until oil spray nozzle (2) is accessible.
2. Remove screw (1).
3. Remove oil spray nozzle (2).



3.13.29 Oil system in crankcase – Cleaning

Material

Designation / Use	Part No.	Qty.
Cleaning agent		
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors. 	
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask. 	

Remove oil system in crankcase (→ Page 512).

Cleaning oil spray nozzles

1. Clean oil spray nozzles with cleaning agent.
2. Remove cleaning agent.
3. Then blow oil spray nozzles dry with compressed air.

3.13.30 Oil system in crankcase – Check

Special tools



Designation / Use	Part No.	Qty.
Testing device for oil spray nozzle	5415890023/00	1

Material

Designation / Use	Part No.	Qty.
Red penetrant dye for surface crack-testing procedure		

Spare parts

Designation / Use	Part No.	Qty.
Oil spray nozzle		

 DANGER	Component to be tested is under pressure. Risk of explosion! <ul style="list-style-type: none"> Observe test specification.
 WARNING	Compressed air is pressurized. Risk of injury! <ul style="list-style-type: none"> Pressure must not exceed 0.5 bar. Wear protective clothing, gloves, and goggles / safety mask.

Clean oil system in crankcase (→ Page 513).

Checking oil system in crankcase

Item	Findings	Task
Check oil spray nozzles with red penetrant dye for cracks.	Signs of cracks	Replace
Check operation of oil bores for oil spray nozzles.	Malfunction	<ul style="list-style-type: none"> Recondition: Clean Replace
Check oil spray nozzle with testing device for deformation.	Deformation of oil spray nozzle.	Replace
Check oil spray nozzle contact and sealing surfaces.	<ul style="list-style-type: none"> Damaged Wear visible 	<ul style="list-style-type: none"> Recondition: smooth with oilstone or emery cloth. Replace
Check bore in crankcase for wear.	Wear visible.	smooth with oilstone.


3.13.31 Oil system in crankcase – Installation


Material

Designation / Use	Part No.	Qty.
Engine oil		

Spare parts

Designation / Use	Part No.	Qty.
Screw		

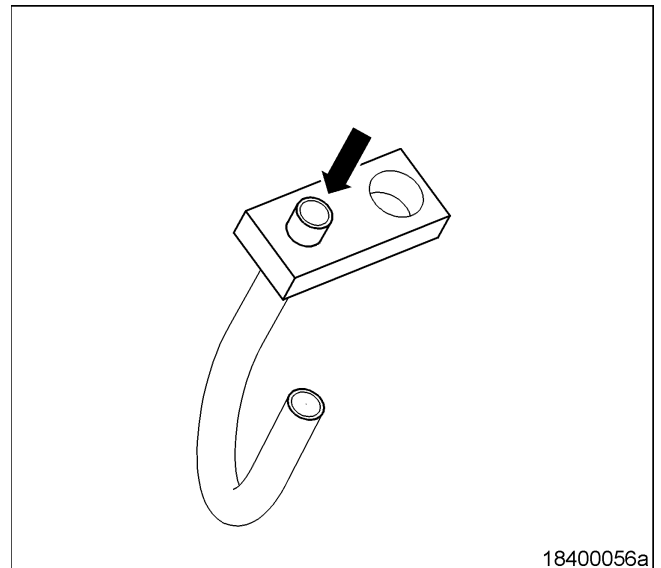
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors.
---	---

 CAUTION	Contamination of components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Check components for special cleanness.
---	---

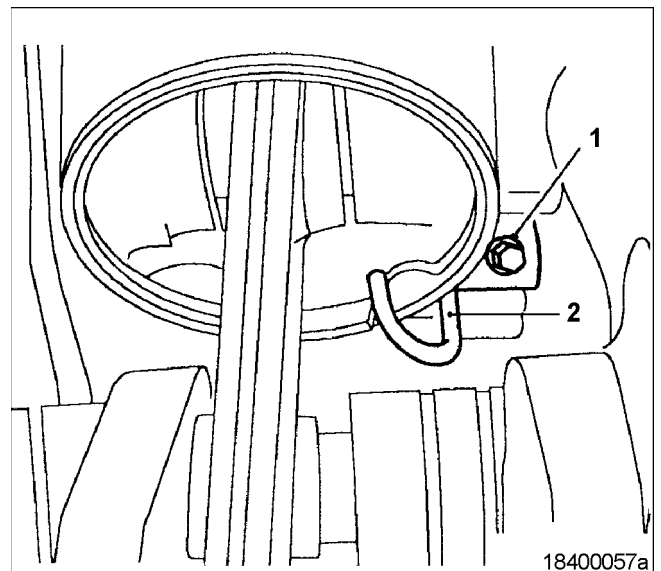
Check oil system in crankcase (→ Page 514).

Installing oil spray nozzle

1. Blow out oil bore (arrow) with compressed air.



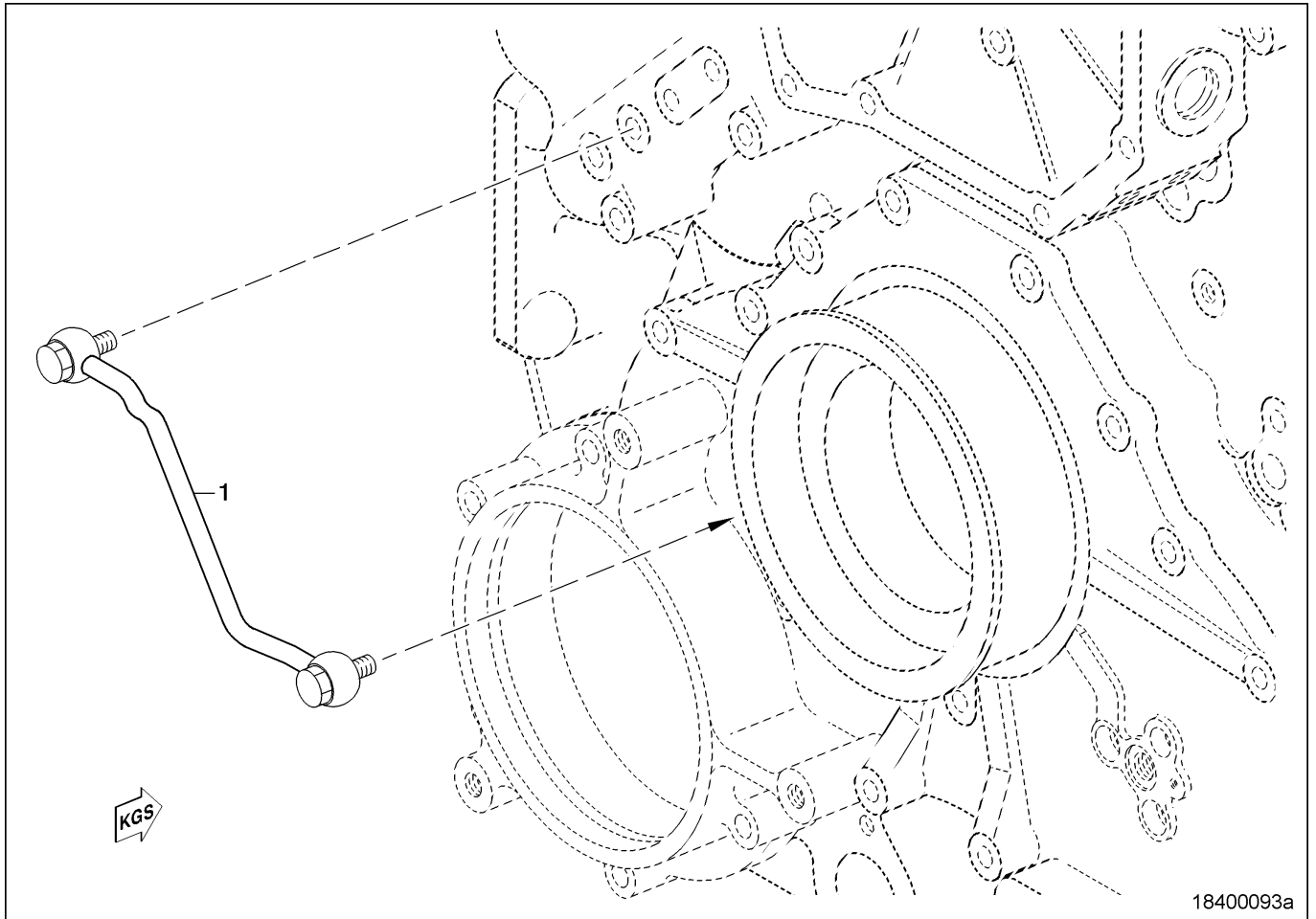
2. Place oil spray nozzle (2) on crankcase in such a way, that guiding appliance on oil spray nozzle engages in bore on crankcase.
3. Tighten screw (1) with torque wrench to prescribed tightening torque (→ Page 23).
4. After installing the piston, rev up the engine and check clearance between oil spray nozzle and piston.



Final steps

A distinction must be made as to whether				
1 The engine was completely disassembled				
2 The engine was removed but not disassembled				
3 The engine is installed				
1	2	3	Operations	See
X	–	–	Assemble engine	(→ Page 58)
X	–	–	Install engine	(→ Page 60)
–	X	X	Assemble in reverse sequence	(→ Page 512)
–	–	X	Fill engine coolant system	(→Operating Instructions)
–	–	X	Fill with engine oil	(→Operating Instructions)

3.13.32 Gear train oil supply – Overview



1 Oil line

3.13.33 Gear train oil supply – Removal

Preconditions

- Engine is stopped and starting disabled

Preparatory steps



For these steps a distinction must be made as to whether				
1 the engine is to be completely disassembled				
2 the engine is to be removed but not disassembled				
3 the engine is to remain installed				
1	2	3	Operations	See
X	–	–	Remove engine.	(→ Page 55)
X	–	–	Disassemble engine.	(→ Page 56)
–	–	X	Disable engine start.	(→ Page 15)

Removing gear train oil supply

1. Remove oil line and fasteners from engine as per overview (→ Page 518).
2. Remove all gaskets.
3. After removal, seal all openings with suitable covers.
4. Protect oil lines from damage.

3.13.34 Gear train oil supply – Cleaning

Material

Designation / Use	Part No.	Qty.
Cleaning agent		
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors. 	
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask. 	

Remove gear train oil supply (→ Page 519).


Cleaning gear train oil supply


1. Clean gear train oil supply line with cleaning agent.
2. Remove cleaning agent.
3. Blow dry gear train oil supply line with compressed air.

3.13.35 Gear train oil supply – Check

Spare parts

Designation / Use	Part No.	Qty.
Oil line		
Banjo screw		

 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> Do not direct compressed-air jet at persons. Wear protective goggles / safety mask and ear protectors.
---	---

 WARNING	Compressed air is pressurized. Risk of injury! <ul style="list-style-type: none"> Pressure must not exceed 0.5 bar. Wear protective clothing, gloves, and goggles / safety mask.
---	--

Clean gear train oil supply (→ Page 520).

Checking gear train oil supply

Item	Findings	Task
Visually check oil line for damage.	Damaged	Replace
Pressure-test oil line with air in water bath for leaks. A water temperature of min = 30°C and max = 40°C at a test pressure of 0.5 bar must be observed.	Leaking	Replace
Check connectors and fasteners of the oil lines for damage.	Damaged	Replace
Check sealing and bolt-on faces.	Damaged	<ul style="list-style-type: none"> Rework: Re-surface with oil stone or crocus cloth. Replace
Check threads for ease of movement.	No ease of movement	<ul style="list-style-type: none"> Rework: Recut threads. Replace


3.13.36 Gear train oil supply – Installation


Material

Designation / Use	Part No.	Qty.
Engine oil		

Spare parts

Designation / Use	Part No.	Qty.
Banjo screw		
Sealing ring		

 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> Do not direct compressed-air jet at persons. Wear protective goggles / safety mask and ear protectors.
---	---

 CAUTION	Contamination of components. Damage to component! <ul style="list-style-type: none"> Observe manufacturer's instructions. Check components for special cleanness.
---	---

Check gear train oil supply (→ Page 521).

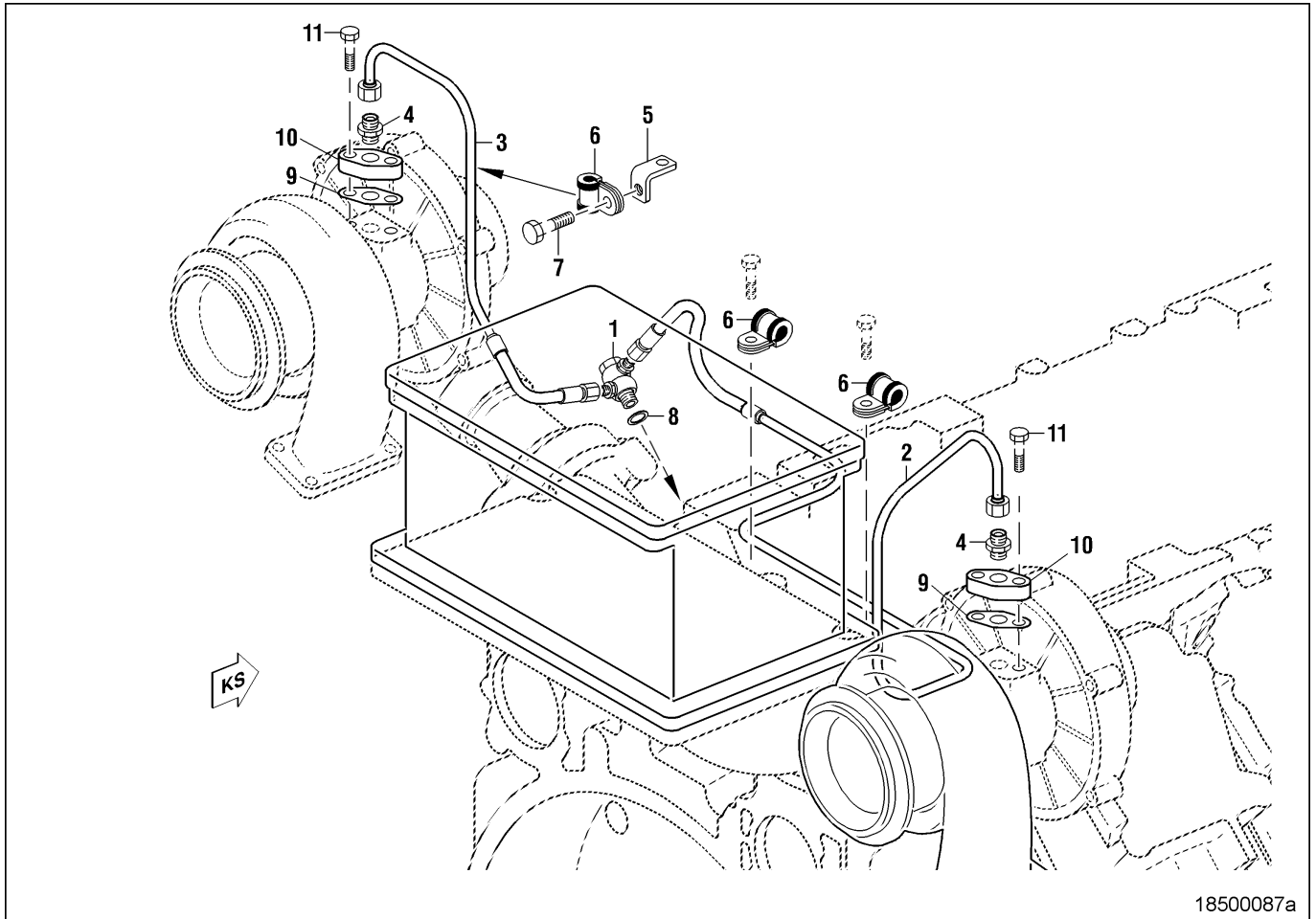
Installing gear train oil supply

1. Remove all covers prior to installation.
2. Blow out oil line using compressed air.
3. Install oil line with fasteners as per overview (→ Page 518), ensuring it is free of tension.

Final steps

For these steps a distinction must be made as to whether				
1 the engine has been completely disassembled				
2 the engine has been removed but not disassembled				
3 the engine has remained installed				
1	2	3	Operations	See
X	–	–	Assemble engine.	(→ Page 58)
X	–	–	Install engine.	(→ Page 60)
–	–	X	Enable engine start.	–
–	–	X	Visually inspect oil line for leaks following engine start.	–

3.13.37 Exhaust turbocharger oil supply – Overview



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- | | | |
|------------|----------------|----------|
| 1 Union | 5 Bracket | 9 Gasket |
| 2 Oil line | 6 Clamp | 10 Cover |
| 3 Oil line | 7 Screw | 11 Screw |
| 4 Union | 8 Sealing ring | |

3.13.38 Turbocharger oil supply – Removal

Preconditions

- Engine is stopped and starting disabled.

Preparatory steps



A distinction must be made as to whether				
1 The engine is to be completely disassembled				
2 The engine is removed but not disassembled				
3 The engine is to remain installed				
1	2	3	Operations	See
X	–	–	Remove engine	(→ Page 55)
X	–	–	Disassemble engine	(→ Page 56)
–	–	X	Disable engine start	(→ Page 15)

Removing turbocharger oil supply

1. Remove oil lines, connecting and mounting parts from engine in accordance with overview drawing (→ Page 523).
2. Remove all sealing elements.
3. After removal, close all openings with suitable covers.
4. Protect oil lines from damage.

3.13.39 Turbocharger oil supply – Cleaning

Material

Designation / Use	Part No.	Qty.
Cleaning agent		
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors. 	
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask. 	

Remove turbocharger oil supply (→ Page 524).


Cleaning turbocharger oil supply


1. Clean exhaust turbocharger oil supply with cleaning agent.
2. Remove cleaning agent.
3. Then blow dry turbocharger oil system with compressed air.

3.13.40 Turbocharger oil supply – Check

Spare parts

Designation / Use	Part No.	Qty.
Oil line		
Retainer		
Union		
Clamp		

 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> Do not direct compressed-air jet at persons. Wear protective goggles / safety mask and ear protectors.
---	---

 WARNING	Compressed air is pressurized. Risk of injury! <ul style="list-style-type: none"> Pressure must not exceed 0.5 bar. Wear protective clothing, gloves, and goggles / safety mask.
---	--

Clean turbocharger oil supply (→ Page 525).

Checking turbocharger oil supply

Item	Findings	Task
Check oil lines visually for damage.	Damaged	Replace
Pressure-test oil return lines for leaks with air in water bath. Maintain a water temperature of min. = 30 °C or max. = 40 °C at a test pressure of 0.5 bar.	Leaking	Replace
Check connecting and mounting parts of connections for damage.	Damaged	Replace
Check sealing and bolt-on faces.	Damaged	<ul style="list-style-type: none"> Recondition: smooth with oilstone or emery cloth. Replace
Check thread for freedom of movement.	Sluggish	<ul style="list-style-type: none"> Recondition: Recut threads Replace


3.13.41 Exhaust turbocharger oil supply – Installation


Material

Designation / Use	Part No.	Qty.
Petroleum jelly, white		
Engine oil		

Spare parts

Designation / Use	Part No.	Qty.
Clamp		
Gasket		
Sealing ring		

 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> Do not direct compressed-air jet at persons. Wear protective goggles / safety mask and ear protectors.
---	---

 CAUTION	Contamination of components. Damage to component! <ul style="list-style-type: none"> Observe manufacturer's instructions. Check components for special cleanness.
--	---

Check turbocharger oil supply (→ Page 526).

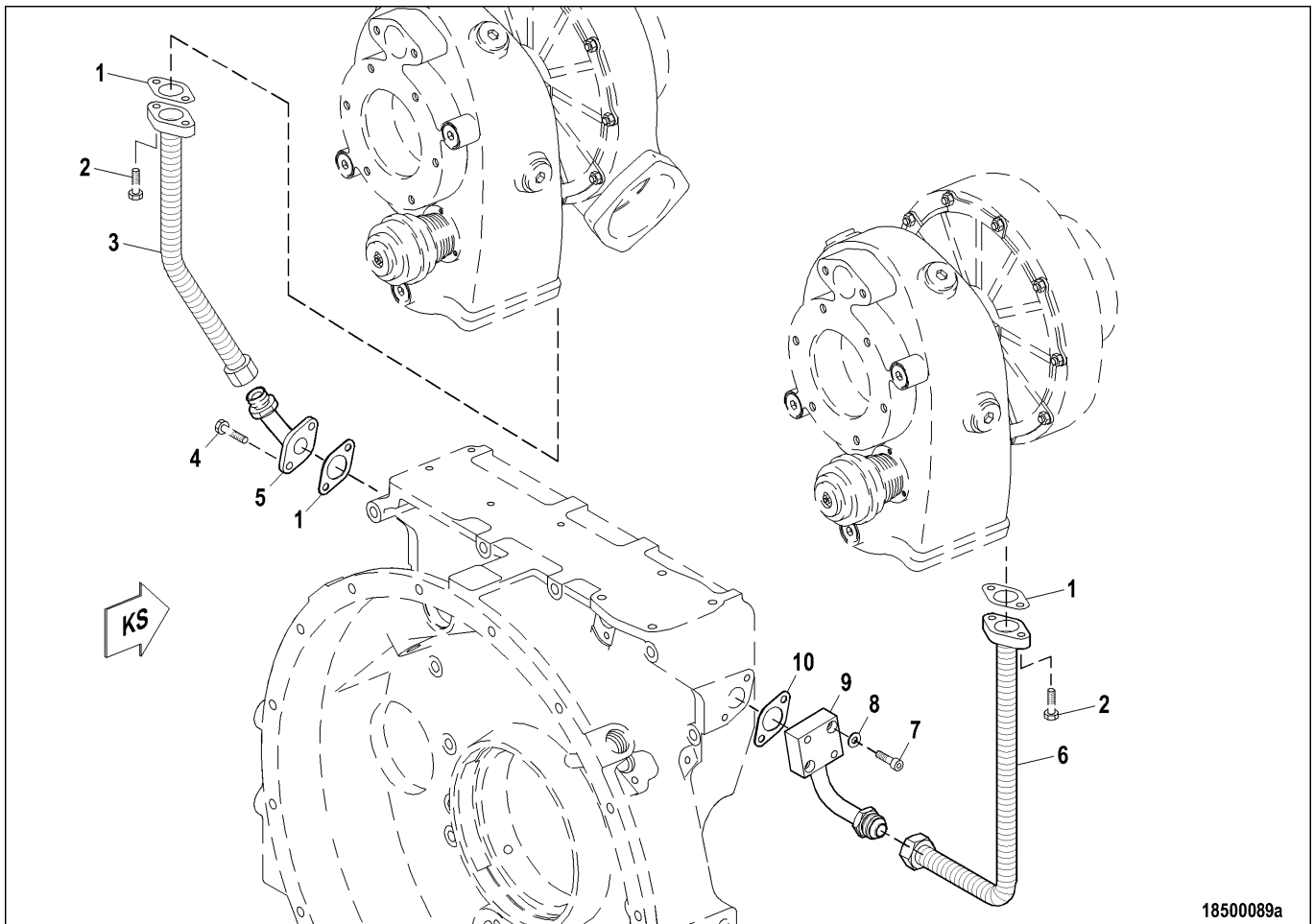
Exhaust turbocharger oil supply – Installation

1. Remove all covers prior to installation.
2. Blow out oil lines with compressed air.
3. Install oil lines tension-free with connecting and securing elements as shown in overview diagram.
(→ Page 523)
4. After starting the engine, visually inspect oil lines for leaks.

Final steps

A distinction must be made as to whether				
1 the engine was completely disassembled				
2 the engine was removed but not disassembled				
3 the engine is still installed				
1	2	3	Tasks	See
X	–	–	Assemble engine.	(→ Page 58)
X	–	–	Install engine.	(→ Page 60)
–	–	X	Enable the engine starter.	–

3.13.42 Exhaust turbocharger oil return line – Overview



- | | |
|-------------------|-------------------|
| 1 Gasket | 6 Oil line |
| 2 Screw | 7 Screw |
| 3 Oil line | 8 Washer |
| 4 Screw | 9 Oil return line |
| 5 Oil return line | 10 Gasket |

3.13.43 Exhaust turbocharger oil return line – Removal

Preconditions

- Engine is stopped and starting disabled.

Preparatory steps



A distinction must be made as to whether				
1 the engine is to be completely disassembled				
2 the engine is to be removed but not disassembled				
3 the engine is to remain installed				
1	2	3	Tasks	See
X	–	–	Remove engine.	(→ Page 55)
X	–	–	Disassemble engine.	(→ Page 56)
–	–	X	Disable the engine starter.	(→ Page 15)

Exhaust turbocharger oil return line – Removal

1. Remove oil lines, connecting and securing elements from the engine as shown in overview diagram.
(→ Page 528)
2. Remove all sealing components.
3. After removal, seal all openings with suitable covers.
4. Protect oil lines from damage.

3.13.44 Exhaust turbocharger oil return line – Cleaning

Material

Designation / Use	Part No.	Qty.
Cleaning agent		
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors. 	
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask. 	

Remove exhaust turbocharger oil return line (→ Page 529).


Cleaning exhaust turbocharger oil return line


1. Clean exhaust turbocharger oil return line using cleaning agent.
2. Remove cleaning agent.
3. Using compressed air, dry exhaust turbocharger oil return line.

3.13.45 Exhaust turbocharger oil return line – Check

Spare parts

Designation / Use	Part No.	Qty.
Oil line		

 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors.
---	---

 WARNING	Compressed air is pressurized. Risk of injury! <ul style="list-style-type: none"> • Pressure must not exceed 0.5 bar. • Wear protective clothing, gloves, and goggles / safety mask.
---	--

Clean oil return line from exhaust turbocharger (→ Page 530).

Exhaust turbocharger oil return line – Check

Item	Findings	Measure
Visually inspect oil lines for damage.	Damaged	Replace
Pressure-test oil line with air in water bath for leaks. A water temperature of min = 30 °C or max = 40 °C at a test pressure of 0.5 bar must be observed.	Leaking	Replace
Check connecting and securing elements of the oil lines for damage.	Damaged	Replace
Check sealing and bolt-on faces.	Damaged	<ul style="list-style-type: none"> • Recondition: Smooth with oilstone or emery cloth. • Replace
Check threads for ease of movement.	Sluggish	<ul style="list-style-type: none"> • Recondition: Recut threads. • Replace


3.13.46 Exhaust turbocharger oil return line – Installation

Material

Designation / Use	Part No.	Qty.
Engine oil		
Petroleum jelly, white		

Spare parts

Designation / Use	Part No.	Qty.
Gasket		
Gasket		

 WARNING	<p>Compressed air. Risk of injury!</p> <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors.
---	--

Check exhaust turbocharger oil return line (→ Page 531).

Installing exhaust turbocharger oil return line

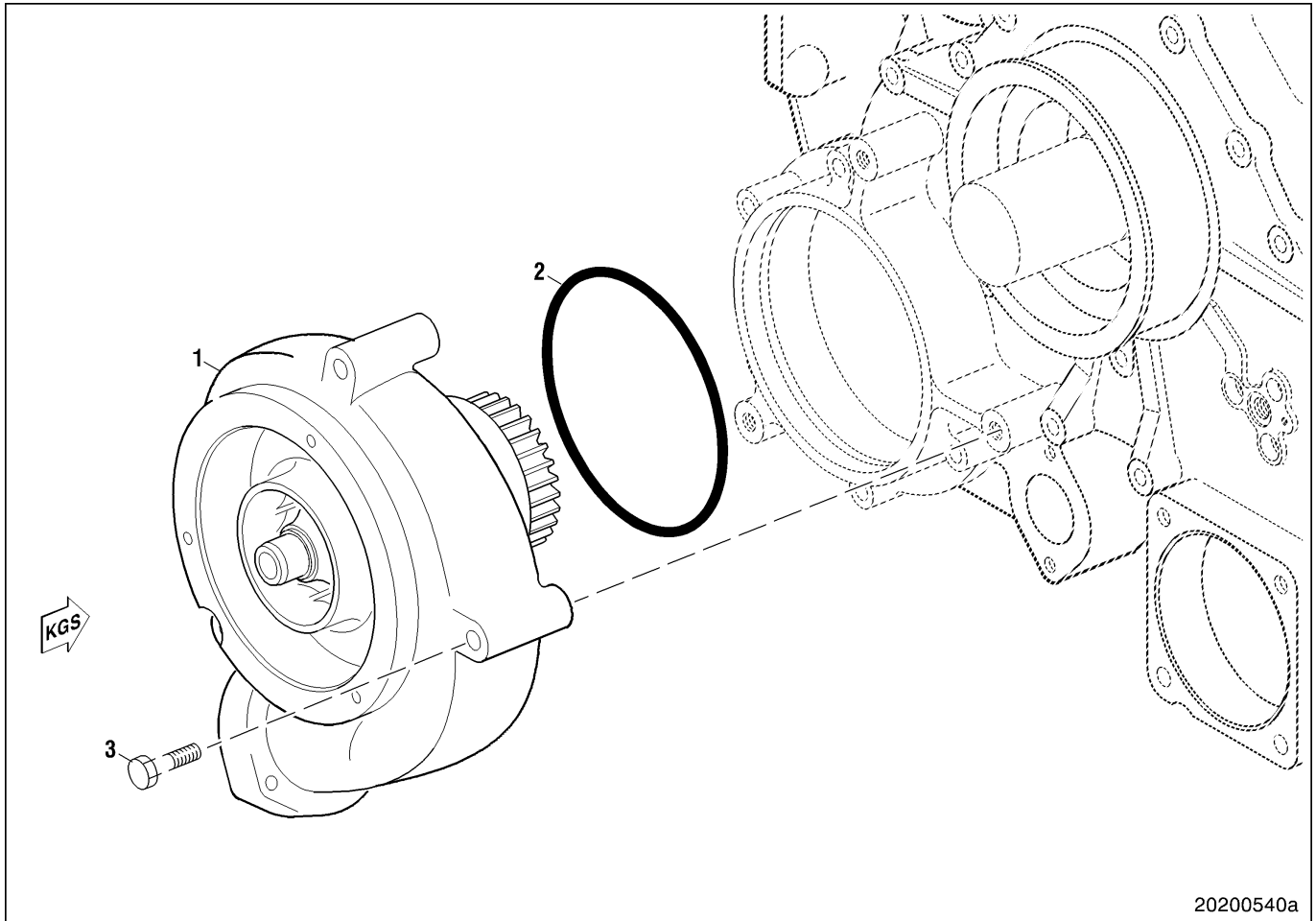
1. Remove all covers prior to installation.
2. Blow out oil line using compressed air.
3. Attach oil line with connectors and fasteners as per overview (→ Page 528), ensuring it is free of tension.
4. Tighten oil line to exhaust turbocharger screws to specified tightening torque using a torque wrench (→ Page 23).

Final steps

For these steps a distinction must be made as to whether				
1 the engine has been completely disassembled				
2 the engine has been removed but not disassembled				
3 the engine has remained installed				
1	2	3	Operations	See
X	–	–	Assemble engine.	(→ Page 58)
X	–	–	Install engine.	(→ Page 60)
–	–	X	Enable engine start.	–
–	–	X	Visually inspect oil lines for leaks following engine start.	–

3.14 Coolant System

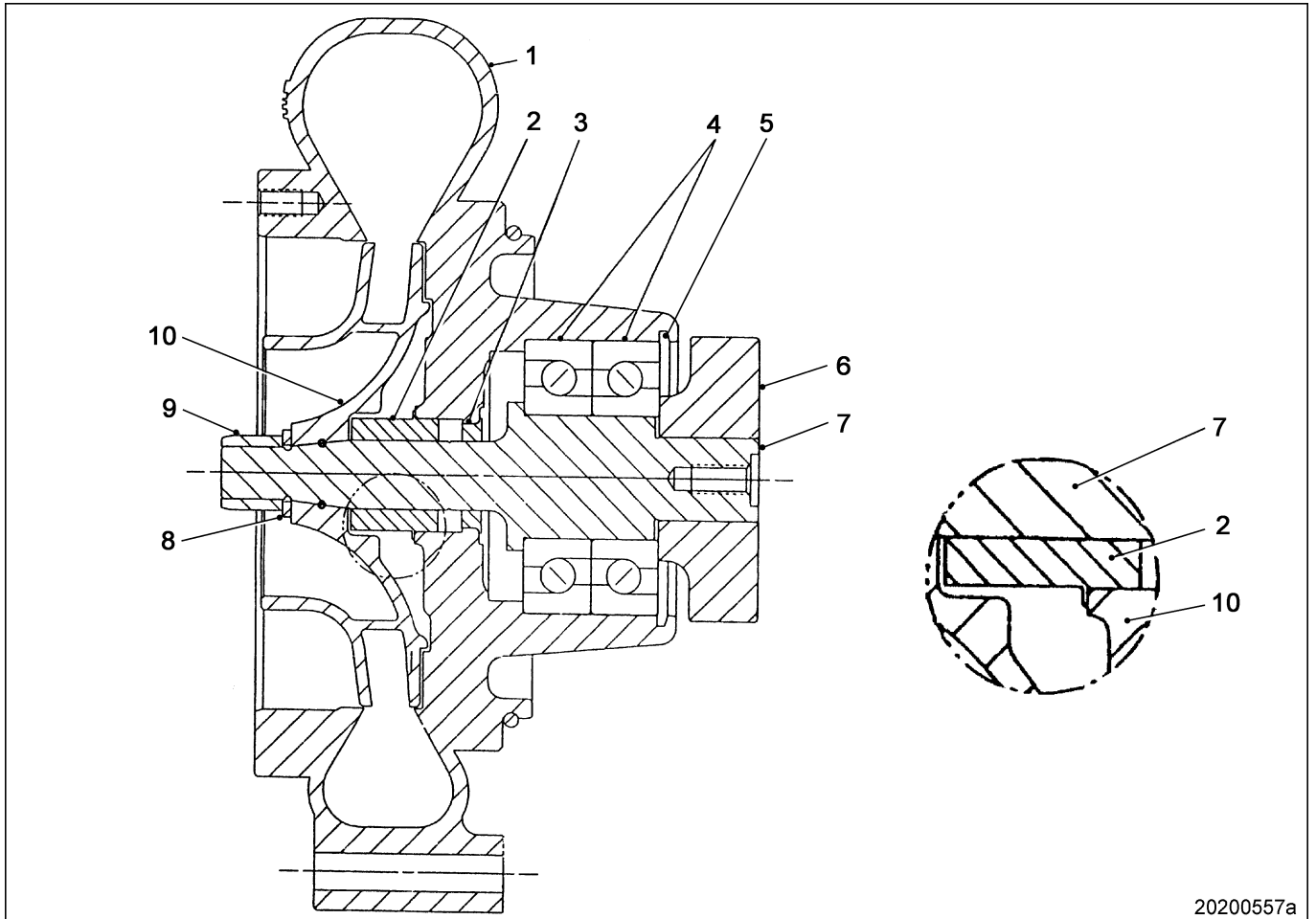
3.14.1 Engine coolant pump – Overview



1 Engine coolant pump

2 O-ring

3 Screw



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- | | | |
|--------------|-------------|-------------|
| 1 Housing | 5 Snap ring | 9 Nut |
| 2 Seal | 6 Gear | 10 Impeller |
| 3 Shaft seal | 7 Shaft | |
| 4 Bearing | 8 Washer | |

3.14.2 Engine coolant pump – Removal

Preconditions

- Engine is stopped and starting disabled.

 WARNING	Components have sharp edges. Risk of injury! <ul style="list-style-type: none"> • Wear protective gloves.
---	--

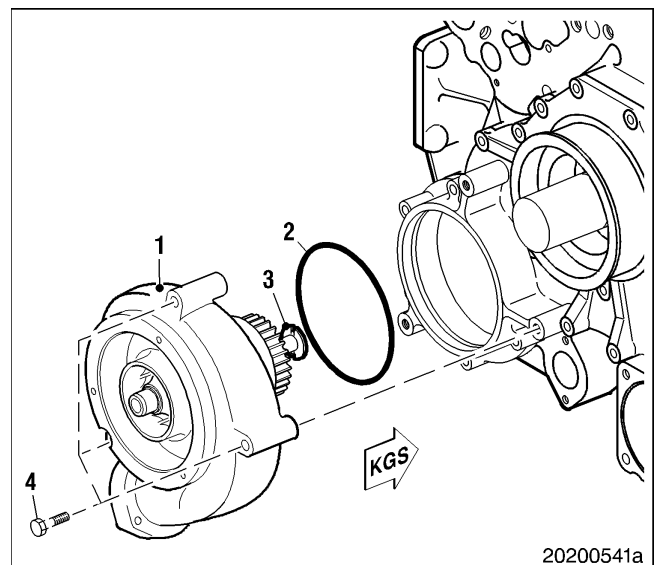
 WARNING	Heavy object. Risk of crushing! <ul style="list-style-type: none"> • Use appropriate lifting devices and appliances.
---	---

Preparatory steps

A distinction must be made as to whether				
			1 the engine is to be completely disassembled 2 the engine is to be removed but not disassembled 3 the engine is to remain installed	
1	2	3	Operations	See
X	–	–	Remove engine	(→ Page 55)
X	–	–	Disassemble engine	(→ Page 56)
–	–	X	Drain engine coolant	(→ Operating Instructions)
–	X	X	Remove elbow	(→ Page 539)
–	X	X	Remove fuel delivery pump	(→ Page 398)

Engine coolant pump – Removal

1. Remove screws (4).
2. Loosen engine coolant pump (1) with crowbar from gear train cover and remove.
3. Cover installation hole on engine coolant pump.
4. Remove O-ring from engine coolant pump.
5. Remove driver (3) for fuel pump.



3.14.3 Engine coolant pump – Installation

Special tools

Designation / Use	Part No.	Qty.
Magnetic base		1
Puppi gauge		1

Material

Designation / Use	Part No.	Qty.
Petroleum jelly, white		
Engine oil		

Spare parts

Designation / Use	Part No.	Qty.
O-ring		



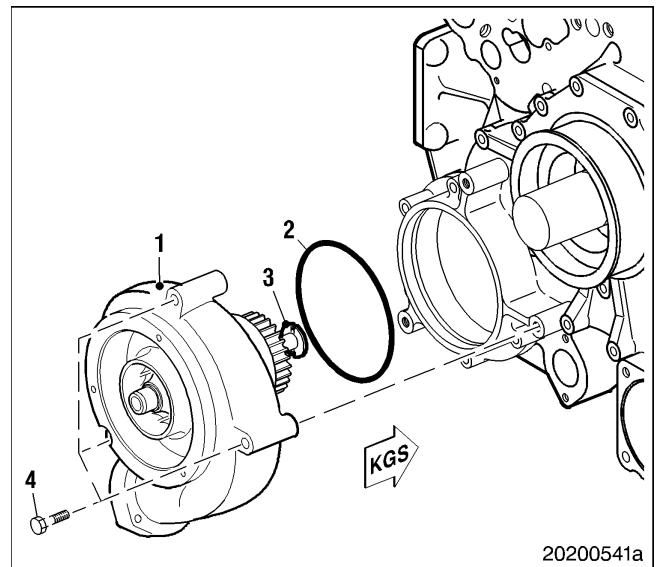
Heavy object.
Risk of crushing!
 • Use appropriate lifting devices and appliances.



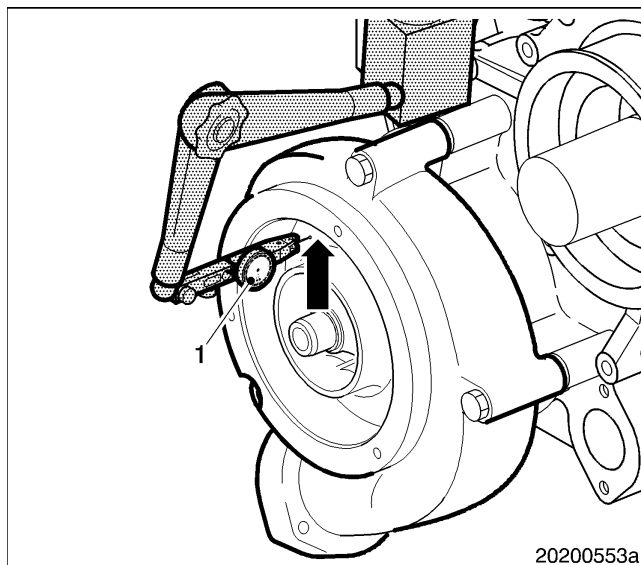
Components have sharp edges.
Risk of injury!
 • Wear protective gloves.

Installing engine coolant pump

1. Remove all covers prior to installation.
2. Coat O-ring (2) with petroleum jelly and insert into groove on housing.
3. Screw driver (3) for fuel pump on to pump shaft and tighten to specified tightening torque using a torque wrench (→ Page 23).
4. Correctly position engine coolant pump (1) in bore on gearcase cover (note gear engagement and driver fit).
5. Install screws (4).
6. Tighten screws (4) evenly.



7. Measure circumferential backlash on impeller.
8. Attach magnetic base with Puppi gauge (1) to gearcase cover.
9. Insert a screw into the impeller (arrowed).
10. Attach Puppi gauge to the screw.
11. Set dial gauge to zero.
12. Check circumferential backlash by turning engine coolant pump drive gear back and forth.
13. Read circumferential backlash off gauge and record value.
14. Subtract circumferential backlash of idler gear from measured value. Circumferential backlash (→ Page 159).
15. Remove screw from impeller.



Final steps

For these steps a distinction must be made as to whether				
1 the engine has been completely disassembled				
2 the engine has been removed but not disassembled				
3 the engine has remained installed				
1	2	3	Operations	See
X	–	–	Assemble engine.	(→ Page 58)
X	–	–	Install engine.	(→ Page 60)
–	X	X	Assemble in reverse sequence of work steps described for removal.	(→ Page 535)
–	–	X	Fill with engine coolant.	(→Operating instructions)
–	–	X	Bleed fuel system.	(→Operating instructions)
–	–	X	Enable engine start.	–

3.14.4 Engine coolant pump – Replacement

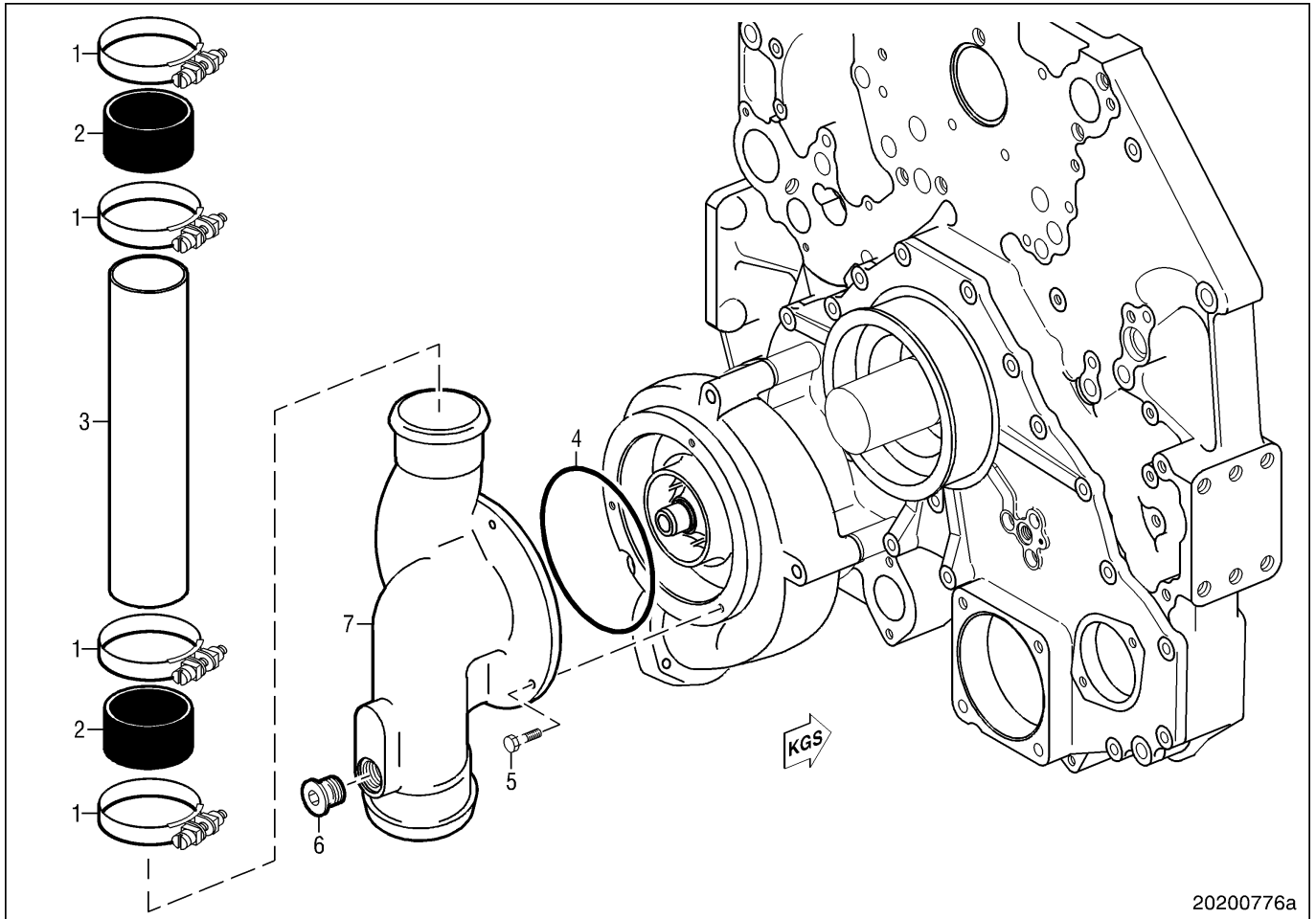
Spare parts

Designation / Use	Part No.	Qty.
Engine coolant pump		

Remove engine coolant pump (→ Page 535).

Install new engine coolant pump (→ Page 536).

3.14.5 Coolant pump pipework – Overview



- 1 Clamp
- 2 Hose line
- 3 Coolant line

- 4 O-ring
- 5 Screw
- 6 Plug screw

- 7 Filler neck

3.14.6 Coolant pump lines – Removal

Preconditions

- Engine is stopped and starting disabled.

Preparatory steps

A distinction must be made as to whether				
1 The engine is to be completely disassembled				
2 The engine is removed but not disassembled				
3 The engine is still installed				
1	2	3	Operations	See
X	–	–	Remove engine	(→ Page 55)
X	–	–	Disassemble engine	(→ Page 56)
–	–	X	Disable engine start	(→ Page 15)
–	–	X	Drain engine coolant	(→Operating Instructions)

Removing coolant lines

1. Before removing the lines it is advisable to take photographs of the fitted lines or to mark lines and attachments.
2. Remove coolant lines in accordance with overview drawing (→ Page 539).
3. After removal, close all openings with suitable covers.




3.14.7 Coolant pump lines – Cleaning

Special tools

Designation / Use	Part No.	Qty.
Cleaning brush		

Material

Designation / Use	Part No.	Qty.
Cleaning agent		

 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors.
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask.
 CAUTION	Unsuitable cleaning tools. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Use appropriate cleaning tool.

Remove coolant pump lines (→ Page 540).

Cleaning coolant pump lines

1. Clean coolant lines with cleaning agent and brush.
2. Remove cleaning agent.
3. Blow coolant lines dry with compressed air.

3.14.8 Coolant pump pipework – Check

Spare parts

Designation / Use	Part No.	Qty.
Clamp		
Hose line		



WARNING

Compressed air is pressurized.

Risk of injury!

- Pressure must not exceed 0.5 bar.
- Wear protective clothing, gloves, and goggles / safety mask.

Clean coolant pump pipework (→ Page 541).

Checking coolant pump pipework

Item	Findings	Task
Visually check ring grooves on filler neck for wear, pitting and cavitation.	<ul style="list-style-type: none"> • Traces of wear • Pitting • Cavitation visible 	<ul style="list-style-type: none"> • Rework: smooth with oilstone or emery cloth. • Replace
Check sealing and mating faces for wear and damage.	Damaged	<ul style="list-style-type: none"> • Rework: smooth with oilstone or emery cloth. • Replace
Check clamps and hoses for damage.	Damaged	Replace
Check coolant line and filler neck for leaks with air in water bath as necessary. A water temperature of min = 30°C and max = 40°C at a test pressure of 0.5 bar must be observed.	Leaking	Replace


3.14.9 Coolant pump lines – Installation


Material

Designation / Use	Part No.	Qty.
Petroleum jelly, white		
Engine oil		

Spare parts

Designation / Use	Part No.	Qty.
Sealing rings		
O-rings		

 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> Do not direct compressed-air jet at persons. Wear protective goggles / safety mask and ear protectors.
---	---

 CAUTION	Contamination of components. Damage to component! <ul style="list-style-type: none"> Observe manufacturer's instructions. Check components for special cleanness.
---	---

Check coolant pump lines (→ Page 542).

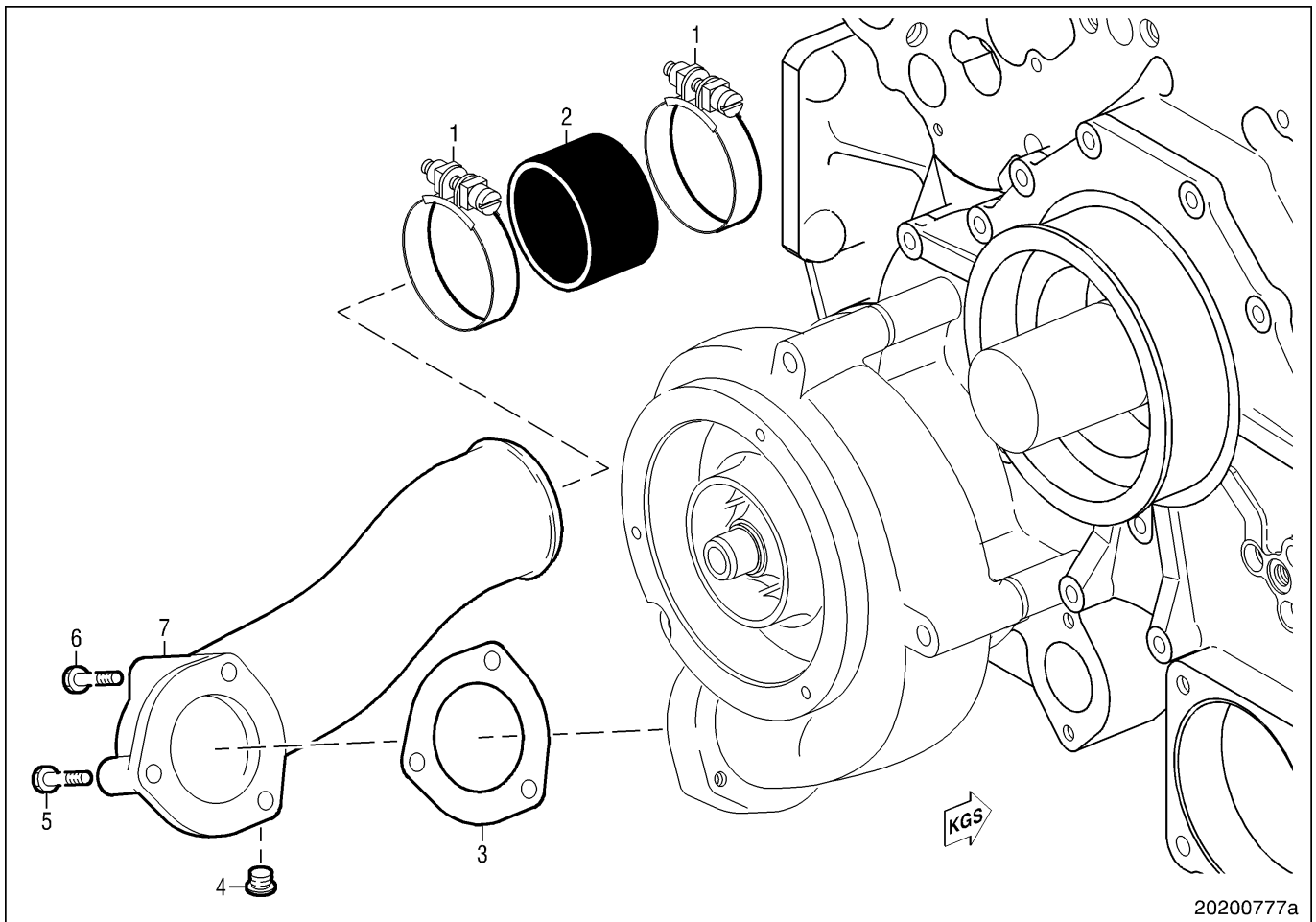
Installing coolant pump lines

1. Remove all covers.
2. Blow out coolant lines with compressed air.
3. Coat all O-rings with petroleum jelly.
4. Install coolant lines with new O-rings without tension and screw on with tape clamps.

Final steps

A distinction must be made as to whether				
1 The engine was completely disassembled				
2 The engine was removed but not disassembled				
3 The engine is installed				
1	2	3	Operations	See
X	–	–	Assemble engine	(→ Page 58)
X	–	–	Install engine	(→ Page 60)
–	X	X	Fill engine coolant system	(→ Operating Instructions)
–	X	X	Enable engine start	–

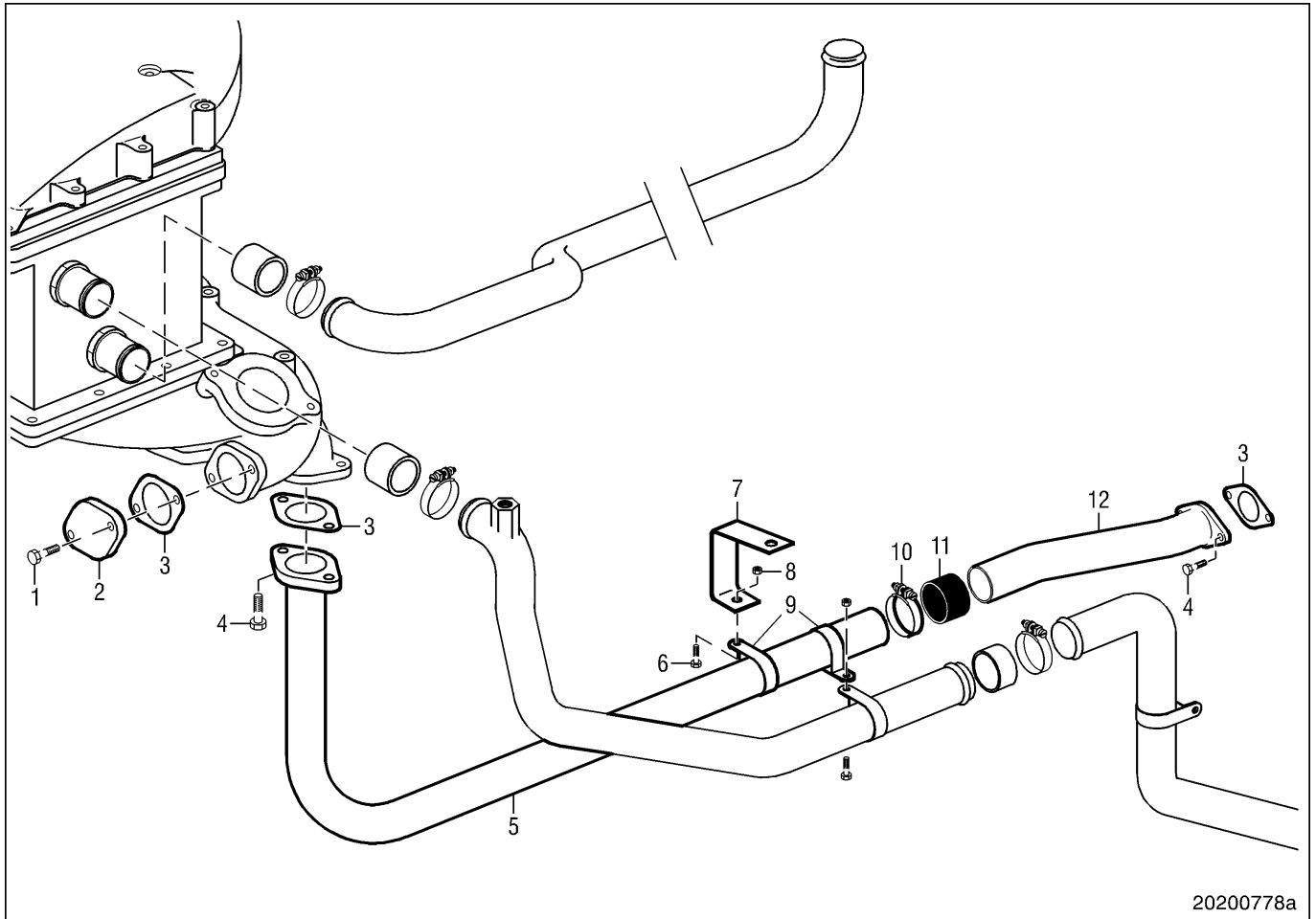
3.14.10 Coolang pump pipework, pressure-side – Overview



1 Clamp
2 Hose line
3 Gasket

4 Plug screw
5 Screw
6 Screw

7 Union



- 1 Screw
- 2 Cover
- 3 Gasket
- 4 Screw

- 5 Pipe
- 6 Screw
- 7 Bracket
- 8 Nut

- 9 Clamp
- 10 Clamp
- 11 Hose line
- 12 Pipe

3.14.11 Coolant pipework after coolant pump – Removal

Preconditions

- Engine is stopped and starting disabled.

Preparatory steps

A distinction must be made as to whether				
1 The engine is to be completely disassembled				
2 The engine is removed but not disassembled				
3 The engine is still installed				
1	2	3	Operations	See
X	–	–	Remove engine	(→ Page 55)
X	–	–	Disassemble engine	(→ Page 56)
–	–	X	Disable engine start	(→ Page 15)
–	–	X	Drain engine coolant	(→Operating Instructions)

Coolant pipework after coolant pump – Removal

1. Before disconnecting the lines, take photographs or mark attachments and lines.
2. Remove lines in accordance with overview drawing (→ Page 544).
3. After removal, close all openings with suitable covers.




3.14.12 Coolant pipework after coolant pump – Cleaning

Special tools

Designation / Use	Part No.	Qty.
Cleaning brush		

Material

Designation / Use	Part No.	Qty.
Cleaning agent		

 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors.
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask.
 CAUTION	Unsuitable cleaning tools. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Use appropriate cleaning tool.

Remove coolant pipework after coolant pump (→ Page 546).

Coolant pipework after coolant pump – Cleaning

1. Clean coolant lines with cleaning agent and brush.
2. Remove cleaning agent.
3. Blow coolant lines dry with compressed air and preserve in oil bath.

3.14.13 Coolant pump pipework, pressure-side – Checking

Spare parts

Designation / Use	Part No.	Qty.
Clamps		
Hose lines		
Gaskets		



Compressed air is pressurized.

Risk of injury!

- Pressure must not exceed 0.5 bar.
- Wear protective clothing, gloves, and goggles / safety mask.

Clean coolant pump pipework, pressure-side (→ Page 547).

Checking coolant pump pipework, pressure-side

Item	Findings	Task
Visually check ring grooves on coolant lines and union for traces of wear, pitting and cavitation.	<ul style="list-style-type: none"> • Traces of wear • Pitting • Cavitation visible 	<ul style="list-style-type: none"> • Rework: smooth with oilstone or emery cloth. • Replace
Check sealing and mating faces for wear and damage.	Damaged	<ul style="list-style-type: none"> • Rework: smooth with oilstone or emery cloth. • Replace
Check clamps and hoses for damage.	Damaged	Replace
Check coolant lines and union for leaks with air in water bath as necessary. A water temperature of min = 30°C and max = 40°C at a test pressure of 0.5 bar must be observed.	Leaking	Replace


3.14.14 Coolant pump pipework, pressure-side – Installation


Material

Designation / Use	Part No.	Qty.
Petroleum jelly, white		
Engine oil		

Spare parts

Designation / Use	Part No.	Qty.
Gasket		

 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> Do not direct compressed-air jet at persons. Wear protective goggles / safety mask and ear protectors.
---	---

 CAUTION	Contamination of components. Damage to component! <ul style="list-style-type: none"> Observe manufacturer's instructions. Check components for special cleanness.
---	---

Check coolant pump pipework, pressure-side (→ Page 548).

Installing coolant pump pipework, pressure-side

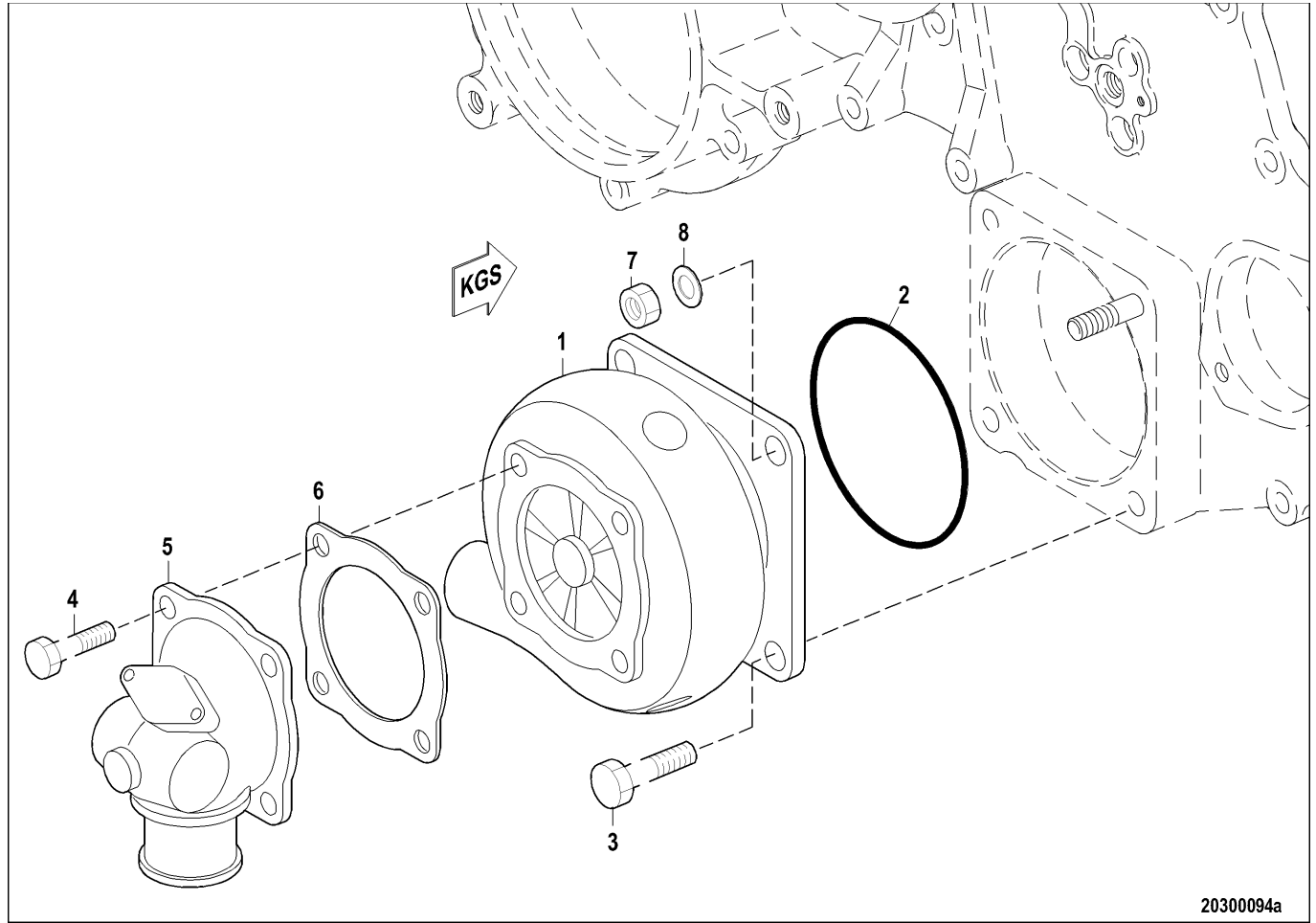
1. Remove all covers.
2. Blow out coolant lines with compressed air.
3. Coat all gaskets with petroleum jelly.
4. Install coolant lines with new gaskets as per overview ensuring the components are not subject to tension (→ Page 544).

Final steps

For these steps a distinction must be made as to whether				
1 the engine has been completely disassembled				
2 the engine has been removed but not disassembled				
3 the engine has remained installed				
1	2	3	Operations	See
X	–	–	Assemble engine.	(→ Page 58)
X	–	–	Install engine.	(→ Page 60)
–	X	X	Fill with engine coolant.	(→ Operating instructions)
–	X	X	Enable engine start.	–

3.14.15 Charge-air coolant pump – Overview

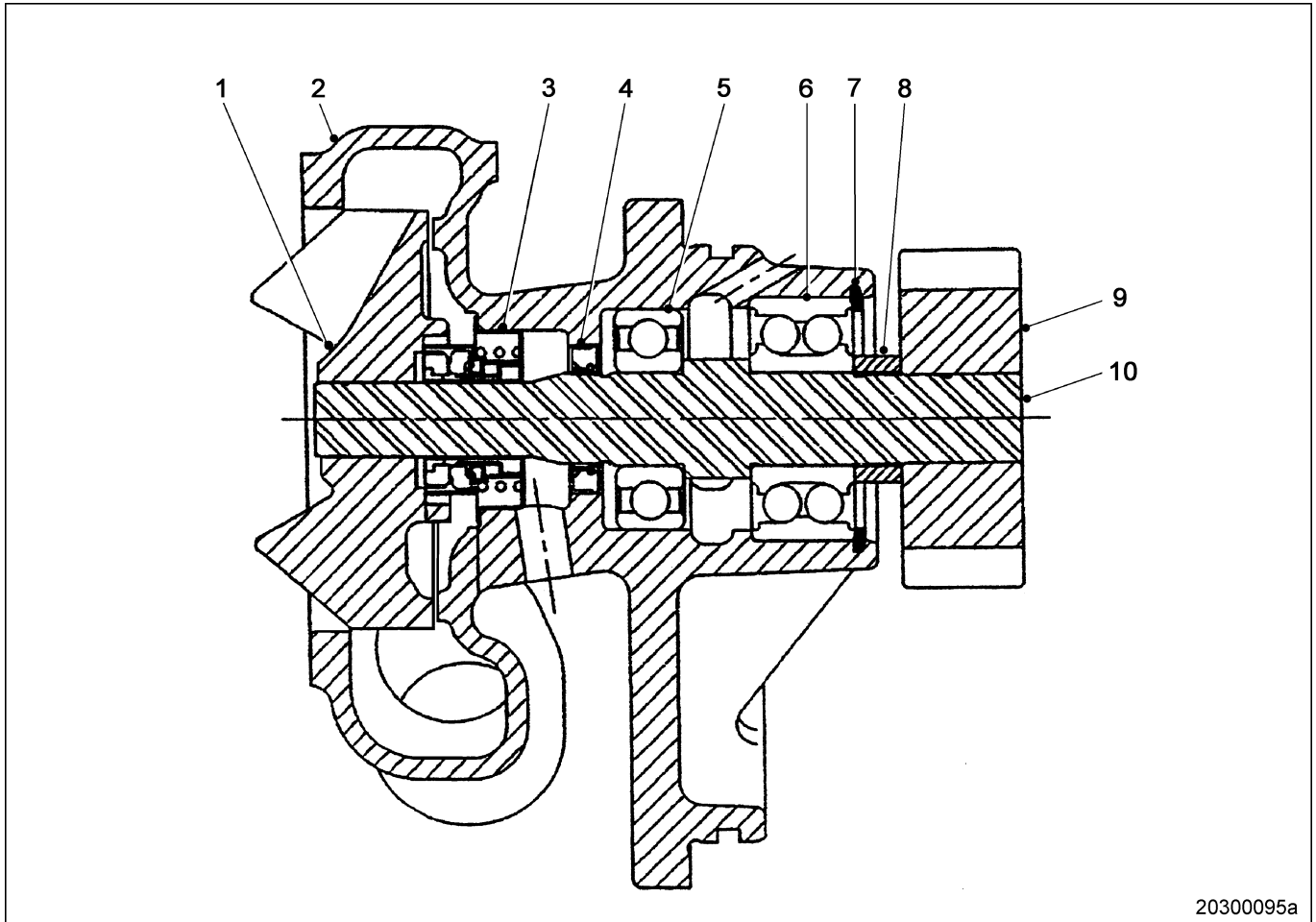
Charge-air coolant pump – Overview



- 1 Charge air coolant pump
- 2 O-ring
- 3 Screw
- 4 Screw

- 5 Cover
- 6 Gasket
- 7 Nut
- 8 Washer

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- | | |
|------------------------|--------------------------------|
| 1 Impeller | 6 Angular-contact ball bearing |
| 2 Housing | 7 Snap ring |
| 3 Rotary seal | 8 Spacer |
| 4 Shaft seal | 9 Gear |
| 5 Grooved ball bearing | 10 Shaft |

3.14.16 Charge-air coolant pump – Removal

Preconditions

- Engine is stopped and starting disabled.

 WARNING	Heavy object. Risk of crushing! <ul style="list-style-type: none"> • Use appropriate lifting devices and appliances.
---	---

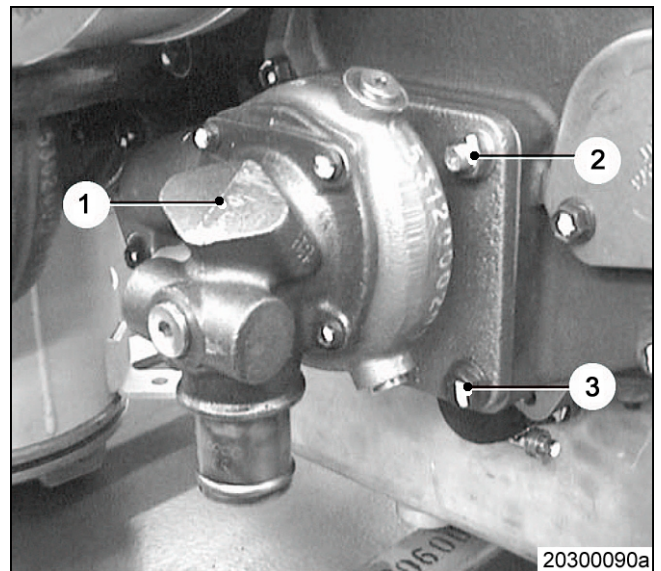
 WARNING	Components have sharp edges. Risk of injury! <ul style="list-style-type: none"> • Wear protective gloves.
---	--

Preparatory steps

A distinction must be made as to whether <ol style="list-style-type: none"> 1 the engine is to be completely disassembled 2 the engine is to be removed but not disassembled 3 the engine is to remain installed 				
1	2	3	Operations	See
X	–	–	Remove engine	(→ Page 55)
X	–	–	Disassemble engine	(→ Page 56)
–	–	X	Drain charge-air coolant	(→ Operating Instructions)

Charge-air coolant pump – Removal

1. Remove cover (1).
2. Remove gasket.
3. Remove nuts (2) and screws (3).
4. Loosen charge-air coolant pump with crowbar from gear train cover and remove.
5. Cover installation hole on charge-air coolant pump.
6. Remove O-ring from charge-air coolant pump.



3.14.17 Charge-air coolant pump – Installation

Special tools

Designation / Use	Part No.	Qty.
Magnetic holder		1
Puppi gauge		1

Material

Designation / Use	Part No.	Qty.
Petroleum jelly, white		
Engine oil		

Spare parts

Designation / Use	Part No.	Qty.
O-ring		
Gasket		



Heavy object.

Risk of crushing!

- Use appropriate lifting devices and appliances.



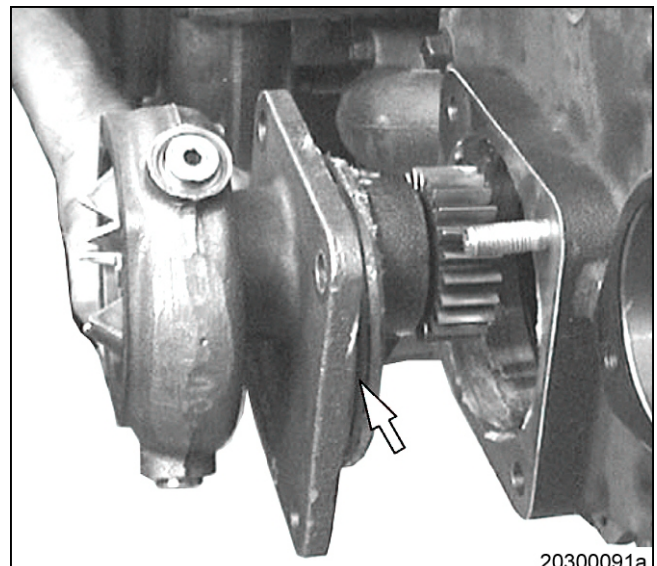
Components have sharp edges.

Risk of injury!

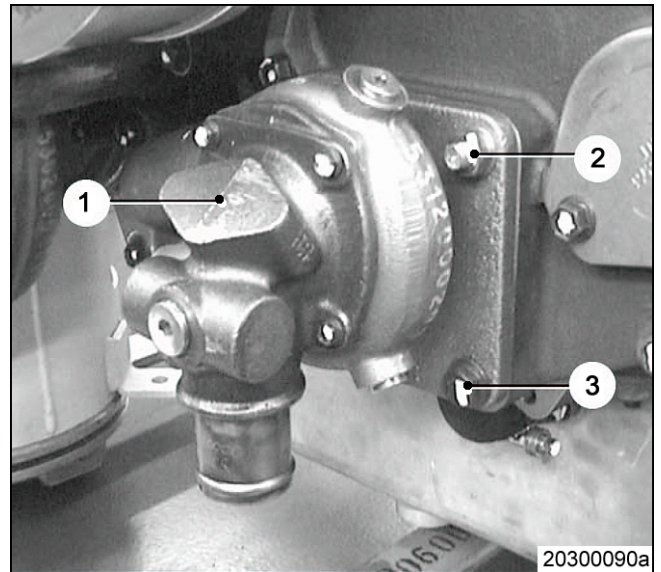
- Wear protective gloves.

Charge-air coolant pump – Installation

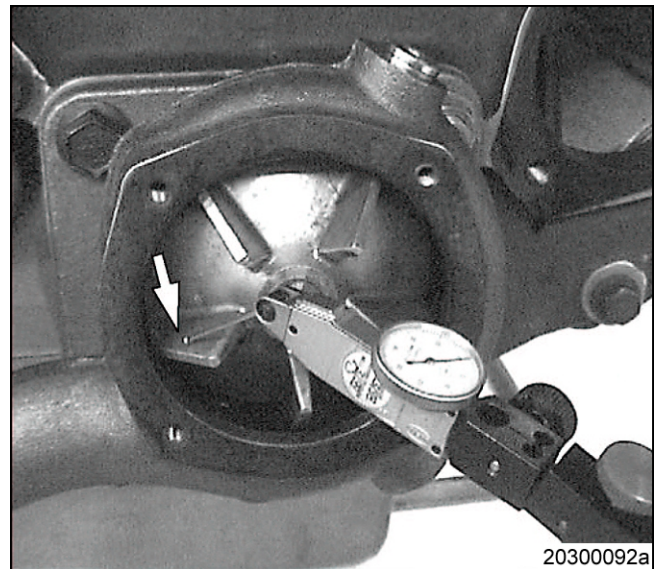
1. Prior to installation, remove all covers.
2. Coat O-ring (arrow) with petroleum jelly and insert into groove on housing.
3. Insert charge-air coolant pump in correct position in bore on gearcase cover, in doing so observe gear contact and fit of driver.



4. Insert screws (3) and nut (2).
5. Tighten screws (3) and nut (2) evenly.



6. Measure circumferential backlash on impeller.
7. Attach magnetic-base holder with puppi gauge to gearcase cover.
8. Attach puppi gauge to idler gear (arrow).
9. Set dial gauge to zero.
10. Check circumferential backlash by turning charge-air coolant pump drive gear back and forth.
11. Read off circumferential backlash on dial gauge and make a note.
12. Subtract circumferential backlash of idler gear from measured value. Circumferential backlash (→ Page 159).
13. Install cover with gasket.



Final steps

A distinction must be made as to whether				
1 the engine was completely disassembled				
2 the engine was removed but not disassembled				
3 the engine is still installed				
1	2	3	Operations	See
X	–	–	Assemble engine	(→ Page 58)
X	–	–	Install engine	(→ Page 60)
–	X	X	Assembly in reverse sequence to disassembly	(→ Page 535)
–	–	X	Fill with charge-air coolant	(→ Operating Instructions)
–	–	X	Enable engine start	–

3.14.18 Charge-air coolant pump – Replacement

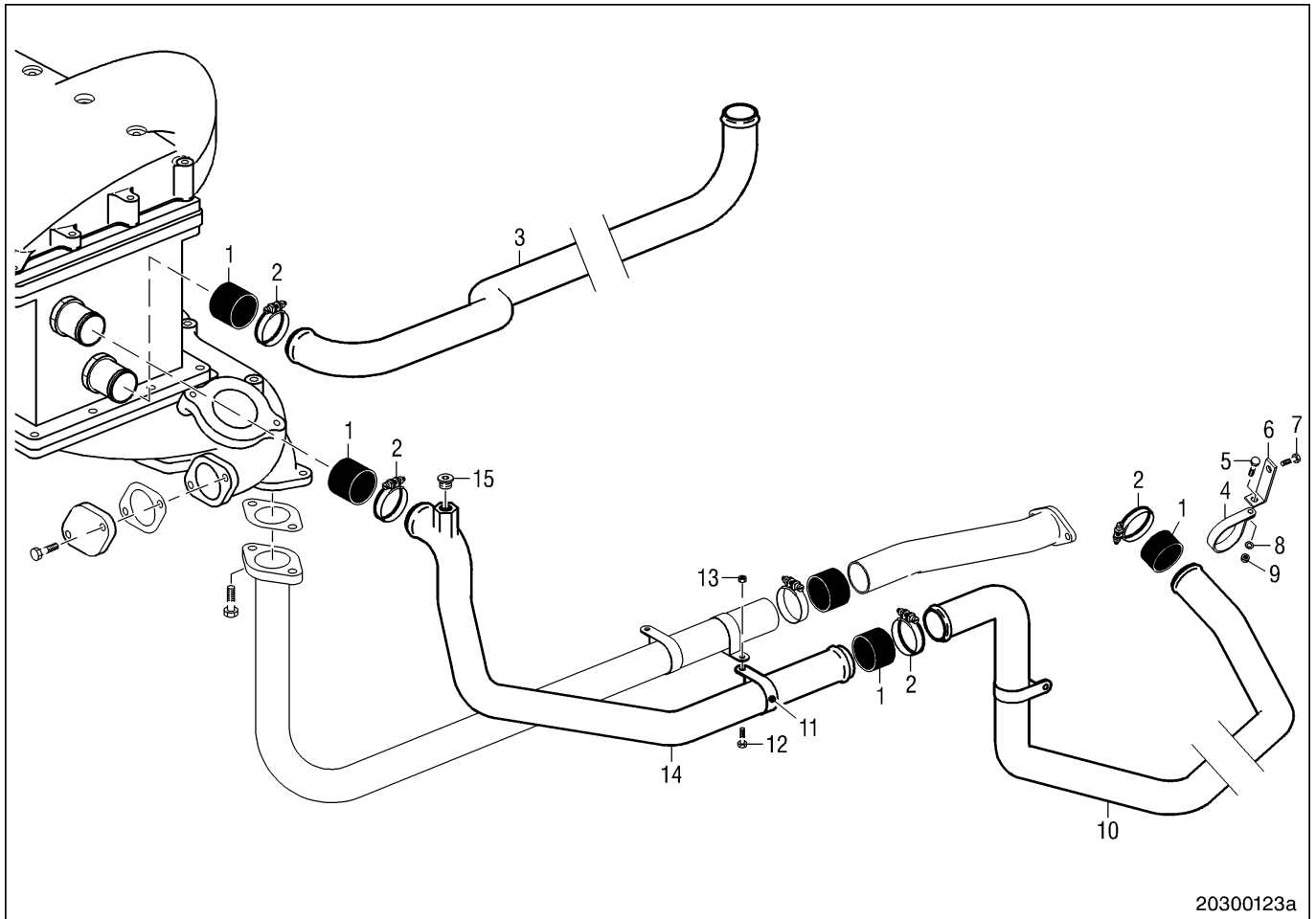
Spare parts

Designation / Use	Part No.	Qty.
Charge-air coolant pump		

Remove charge-air coolant pump (→ Page 552).

Install new charge-air coolant pump (→ Page 553).

3.14.19 Coolant lines from/to intercooler – Overview



20300123a

- 1 Hose line
- 2 Clamp
- 3 Pipe
- 4 Clamp
- 5 Screw

- 6 Bracket
- 7 Screw
- 8 Washer
- 9 Nut
- 10 Pipe

- 11 Clamp
- 12 Screw
- 13 Nut
- 14 Pipe
- 15 Plug screw

3.14.20 Coolant pipework from – to intercooler – Removal

Preconditions

- Engine is stopped and starting disabled.

Preparatory steps

A distinction must be made as to whether				
1 the engine is to be completely disassembled				
2 the engine is to be removed but not disassembled				
3 the engine is to remain installed				
1	2	3	Tasks	See
X	–	–	Remove engine.	(→ Page 55)
X	–	–	Disassemble engine.	(→ Page 56)
–	–	X	Disable the engine starter.	(→ Page 15)
–	–	X	Drain charge-air coolant.	(→Operating instructions)

Coolant pipework from – to intercooler – Removal

1. Prior to removing the lines, take photographs or mark attachments and lines.
2. Remove lines as shown in overview diagram (→ Page 557).
3. After removal, seal all openings with suitable covers.




3.14.21 Coolant pipework from – to intercooler – Cleaning

Special tools

Designation / Use	Part No.	Qty.
Cleaning brush		

Material

Designation / Use	Part No.	Qty.
Cleaning agent		

 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors.
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask.
 CAUTION	Unsuitable cleaning tools. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Use appropriate cleaning tool.

Remove coolant pipework from – to intercooler (→ Page 558).

Coolant pipework from – to intercooler – Cleaning

1. Clean coolant lines with cleaning agent and cleaning brush.
2. Remove cleaning agent.
3. Blow coolant lines dry with compressed air and preserve in oil bath.

3.14.22 Coolant pipework from – to intercooler – Check

Spare parts

Designation / Use	Part No.	Qty.
Clamps		
Hose lines (C&I)		



Compressed air is pressurized.

Risk of injury!

- Pressure must not exceed 0.5 bar.
- Wear protective clothing, gloves, and goggles / safety mask.

Clean coolant pipework from – to intercooler (→ Page 559).


Coolant pipework from – to intercooler – Check


Item	Findings	Measure
Check sealing and bolt-on faces for stress marks and damage.	Damaged	<ul style="list-style-type: none"> • Recondition: Smooth with oilstone or emery cloth. • Replace
Check clamps and hose lines (C&I) for damage.	Damaged	Replace
If required, pressure-test coolant lines with air in water bath for leaks. A water temperature of min = 30 °C or max = 40 °C at a test pressure of 0.5 bar must be observed.	Leaking	Replace

3.14.23 Coolant pipework from – to intercooler – Installation

Material

Designation / Use	Part No.	Qty.
Engine oil		

 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> Do not direct compressed-air jet at persons. Wear protective goggles / safety mask and ear protectors.
---	---

 CAUTION	Contamination of components. Damage to component! <ul style="list-style-type: none"> Observe manufacturer's instructions. Check components for special cleanness.
---	---

Check coolant pipework from – to intercooler (→ Page 560).

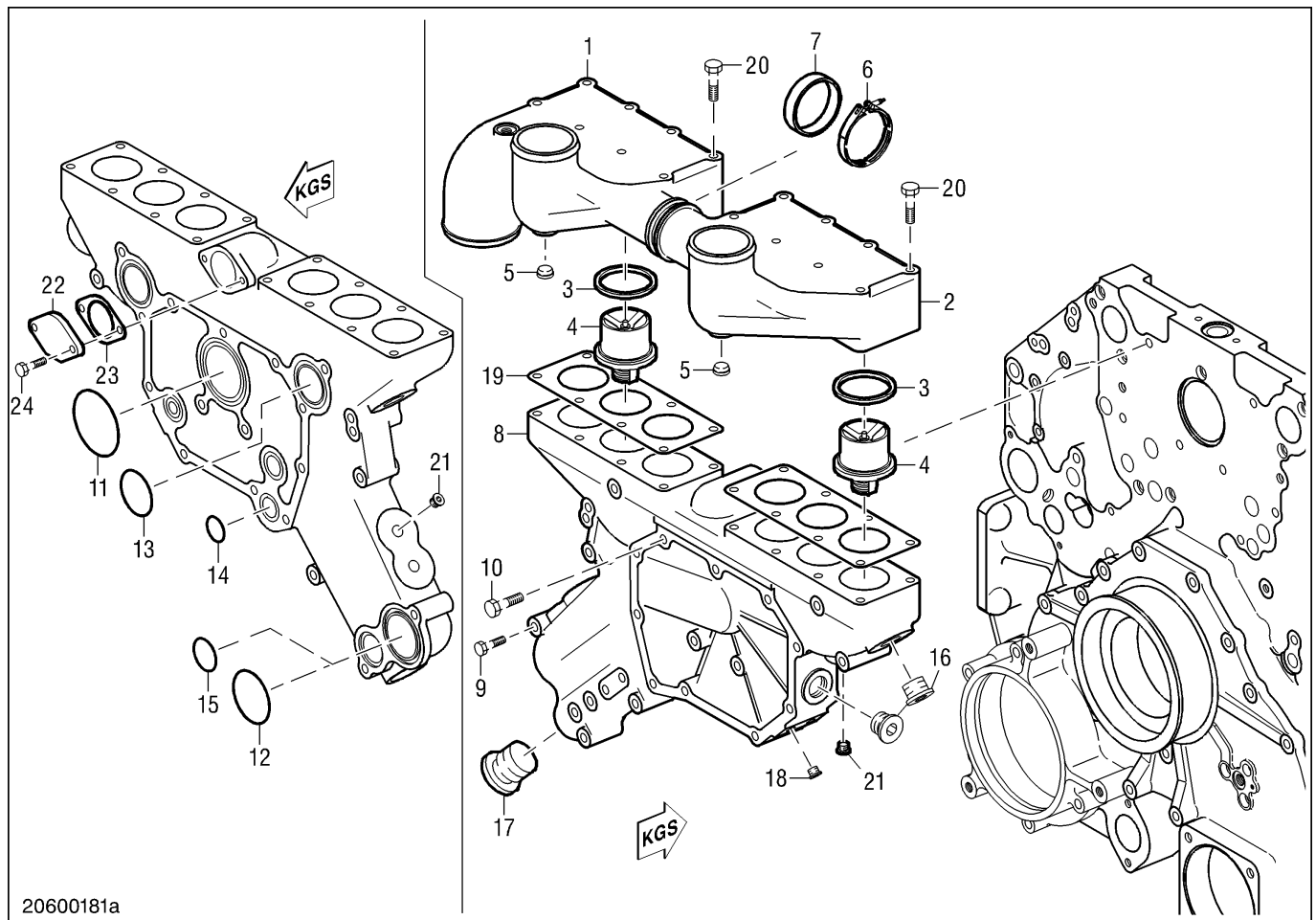
Coolant pipework from – to intercooler – Installation

1. Remove all covers.
2. Blow out coolant lines with compressed air.
3. Install coolant lines as shown in overview diagram so that they are free of tension (→ Page 557).

Final steps

A distinction must be made as to whether					
1	2	3	Tasks	See	
	1 the engine was completely disassembled				
	2 the engine was removed but not disassembled				
	3 the engine is still installed				
X	–	–	Assemble engine.	(→ Page 58)	
X	–	–	Install engine.	(→ Page 60)	
–	X	X	Fill with charge-air coolant.	(→Operating instructions)	
–	X	X	Enable the engine starter.	–	

3.14.24 Coolant lines with thermostat – Overview



20600181a

- | | | |
|--------------------------------|---------------|---------------|
| 1 Thermostat housing | 9 Screw | 17 Plug screw |
| 2 Thermostat housing | 10 Screw | 18 Plug screw |
| 3 Sealing ring (Teflon) | 11 O-ring | 19 Gasket |
| 4 Thermostat insert | 12 O-ring | 20 Screw |
| 5 Vent valve | 13 O-ring | 21 Plug screw |
| 6 Clamp | 14 O-ring | 22 Cover |
| 7 Sleeve | 15 O-ring | 23 Gasket |
| 8 Coolant distribution housing | 16 Plug screw | 24 Screw |

3.14.25 Coolant lines with thermostat – Removal

Preconditions

- Engine is stopped and starting disabled

Special tools

Designation / Use	Part No.	Qty.
Extractor		1
Guide pin		2



Suspended load.

Danger to life!

- Use appropriate lifting devices and appliances.
- Never stand beneath a suspended load.

Preparatory steps

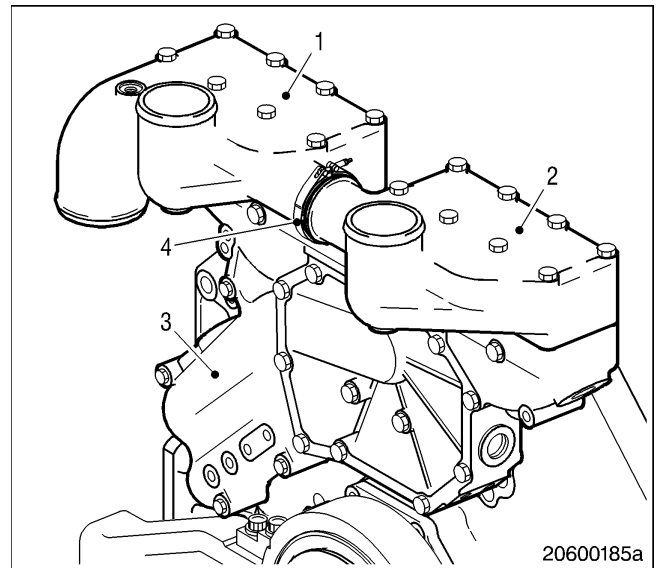
For these steps a distinction must be made as to whether

- 1 the engine is to be completely disassembled
 - 2 the engine is to be removed but not disassembled
 - 3 the engine is to remain installed
- (*) applicable to installation only

1	2	3	Operations	See
X	–	–	Remove engine.	(→ Page 55)
X	–	–	Disassemble engine.	(→ Page 56)
–	–	X	Disable engine start.	(→ Page 15)
–	–	X	Drain engine coolant.	(→Operating instructions)
–	–	X	Drain or draw off engine oil.	(→Operating instructions)
–	X	X	Remove fuel line from fuel pump to fuel filter.	(→ Page 406)
–	X	X	Remove fuel filter.	(→ Page 411)
–	X	X	Remove fuel line from fuel filter to injection pump.	(→ Page 419)
–	X	X	Remove oil line.	(→ Page 519)
–	X	X	Remove engine coolant lines.	(→ Page 540)
–	X	X	Remove battery-charging generator drive.	(→ Page 572)
–	X	X	Disconnect wiring and remove.	(→ Page 604)

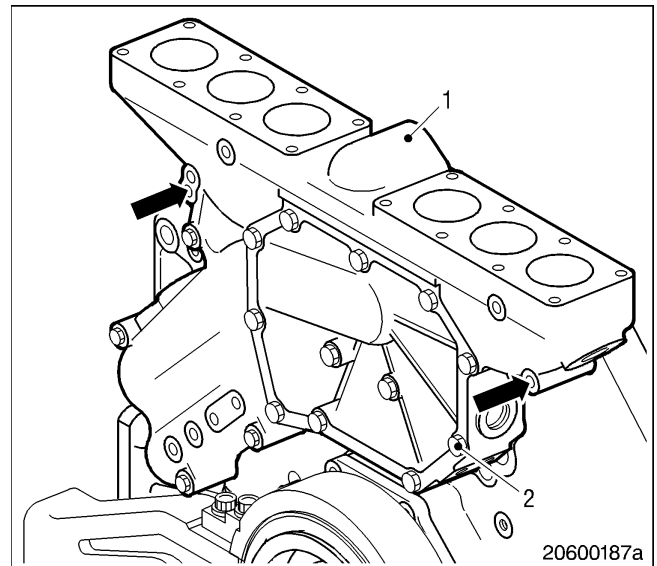
Removing thermostat housings

1. Remove thermostat housing screws (1) and (2).
2. Remove thermostat housings (1) and (2) from coolant distribution housing (3).
3. Remove clamp (4) and sleeve.
4. Remove thermostat inserts and pins from thermostat housings.
5. Using an extractor, remove sealing rings (Teflon) as per overview (→ Page 562).
6. Remove gaskets.





Removing coolant distribution housing

1. Screw two guide pins into two opposing threaded bores (arrowed) in crankcase.
2. Remove screws (2) and lift coolant distribution housing (1) over guide pins to remove.
3. Remove O-rings.
4. After removal, seal all openings with suitable covers.
5. Remove guide pins.



3.14.26 Coolant pipework with thermostat – Cleaning

Material

Designation / Use	Part No.	Qty.
Cleaning agent		
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors. 	
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask. 	

Remove coolant pipework with thermostat (→ Page 563).

Cleaning coolant pipework with thermostat

1. Clean all components with cleaning agent.
2. Remove cleaning agent.
3. Thoroughly blow out all parts using compressed air.


3.14.27 Coolant lines with thermostat – Check

Material

Designation / Use	Part No.	Qty.
Red penetrant dye for surface crack testing		

Spare parts

Designation / Use	Part No.	Qty.
Coolant distribution housing		
Thermostat housing		
Thermostat insert		

 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> Do not direct compressed-air jet at persons. Wear protective goggles / safety mask and ear protectors.
---	---

 WARNING	Component is hot. Risk of burning! <ul style="list-style-type: none"> Wear protective gloves.
---	--

Clean coolant lines with thermostat (→ Page 565).

Checking coolant lines with thermostat

Item	Findings	Task
Using fluorescent dye, check coolant distribution housing and thermostat housing for cracks.	Cracks apparent	Replace
Check all mating and sealing faces for traces of wear and damage.	<ul style="list-style-type: none"> Traces of wear Damage visible 	<ul style="list-style-type: none"> Rework: smooth with oilstone or emery cloth. Replace
Check locating bores of thermostat inserts for damage.	Damaged	<ul style="list-style-type: none"> Rework: smooth with oilstone. Replace
Check threads in coolant distribution housing for ease of movement.	No ease of movement	Replace thread inserts.
Check coolant and oil chambers of the coolant distribution housing and thermostat housing for leaks using air and corrosion inhibitor in a water bath. A water temperature of min = 30°C and max = 40°C at a test pressure of 0.5 bar must be observed.	Leaking	Replace

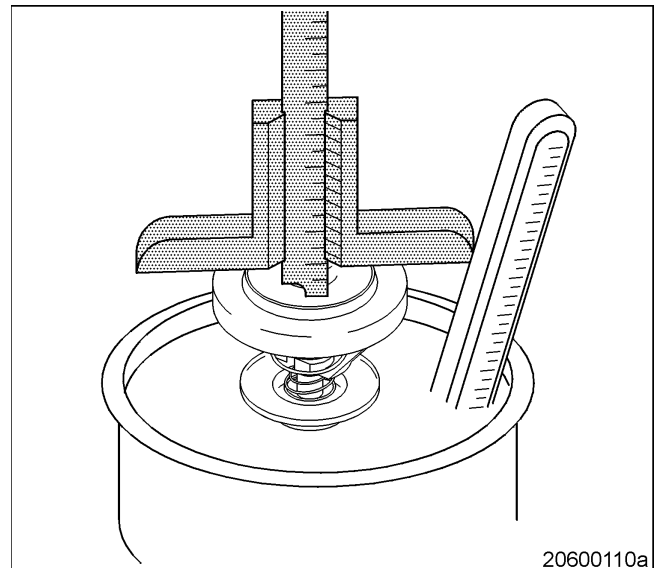
Checking thermostat insert

Note: The thermostat insert must not contact the basin.

1. Using a piece of wire, suspend the thermostat insert in a basin filled with water.
2. Heat water with suitable heat source.

Note: Start-of-opening temperature is stamped on thermostat insert.

3. Steadily heat and agitate (stir) water and check thermostat insert for opening temperature: $74.4^{\circ}\text{C} + 3.9^{\circ}\text{C}$. As from approx. 10°C below the start-of-opening temperature, the heating-up rate should not be more than 1°C per minute.
4. Replace thermostat insert if results of check are negative.
5. Continue to heat water to temperature of complete opening. Fully open at 87.2°C .
Result: Thermostat insert must be completely open after 6 to 8 minutes.
6. Measure thermostat insert stroke.
7. Replace thermostat insert if the stroke is less than 9.5 mm.



3.14.28 Coolant lines with thermostat – Installation

Special tools

Designation / Use	Part No.	Qty.
Guide pin		2
Mandrel		1

Material

Designation / Use	Part No.	Qty.
Petroleum jelly, white		
Engine oil		

Spare parts

Designation / Use	Part No.	Qty.
O-rings		
Sealing ring		
Gaskets		



CAUTION

Contamination of components.

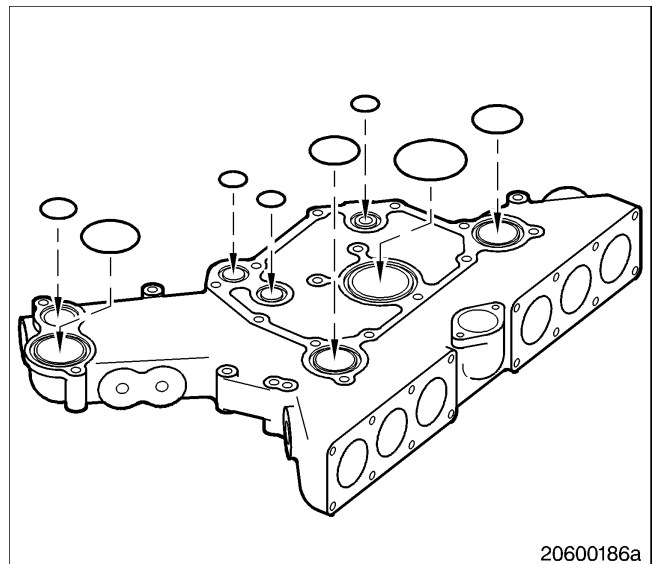
Damage to component!

- Observe manufacturer's instructions.
- Check components for special cleanliness.

Check coolant lines with thermostat (→ Page 566).

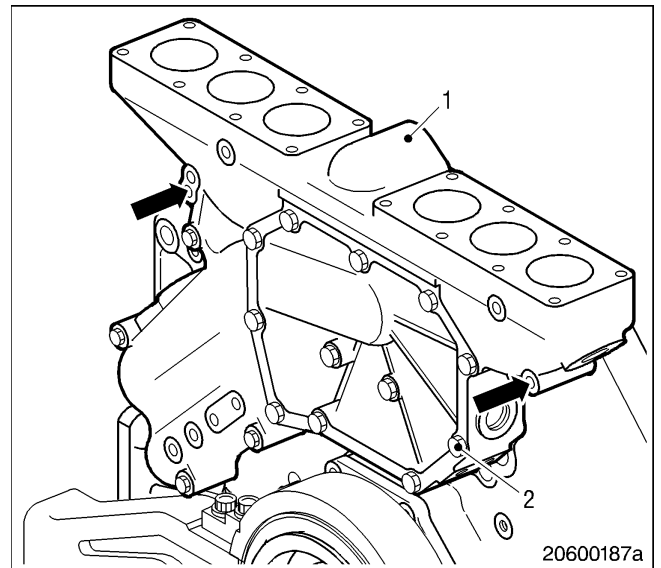
Installing coolant distribution housing

1. Assemble coolant distribution housing as per overview (→ Page 562).
2. Coat O-rings with petroleum jelly and insert into grooves.



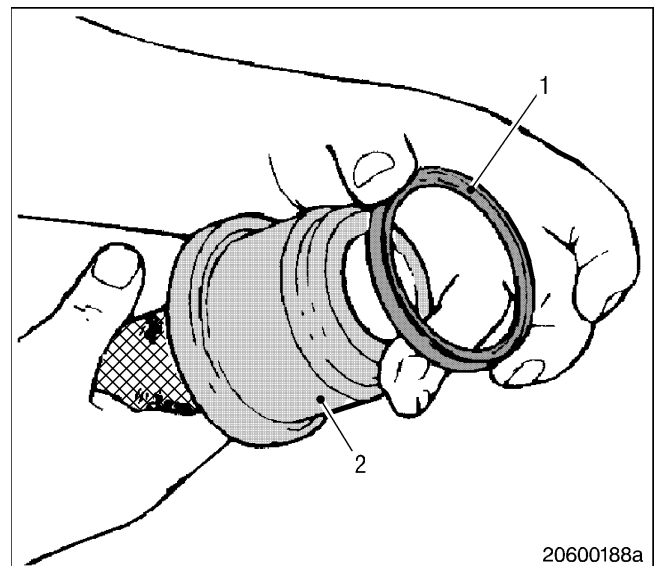
20600186a

3. Screw two guide pins into two opposing threaded bores (arrowed) in crankcase.
4. Using the guide pins, bolt coolant distribution housing (1) onto gearcase as per overview (→ Page 562).
5. Remove guide pins.

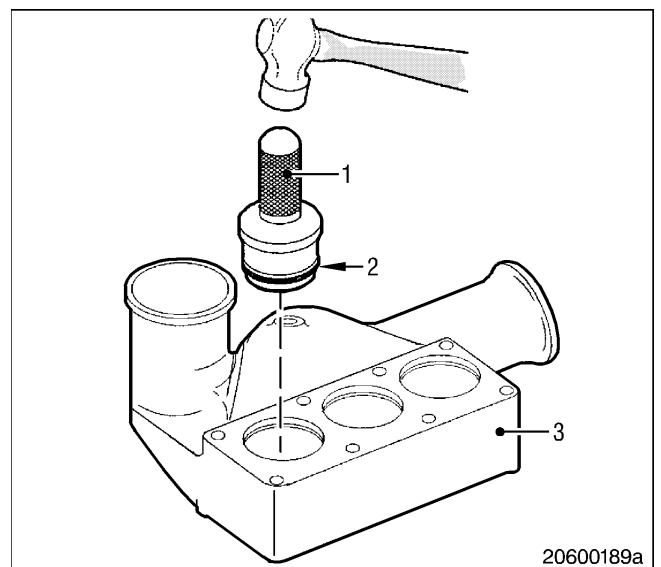


Installing sealing ring (Teflon) in thermostat housing

1. Position sealing ring (1) on mandrel (2) with the flat face facing the mandrel.

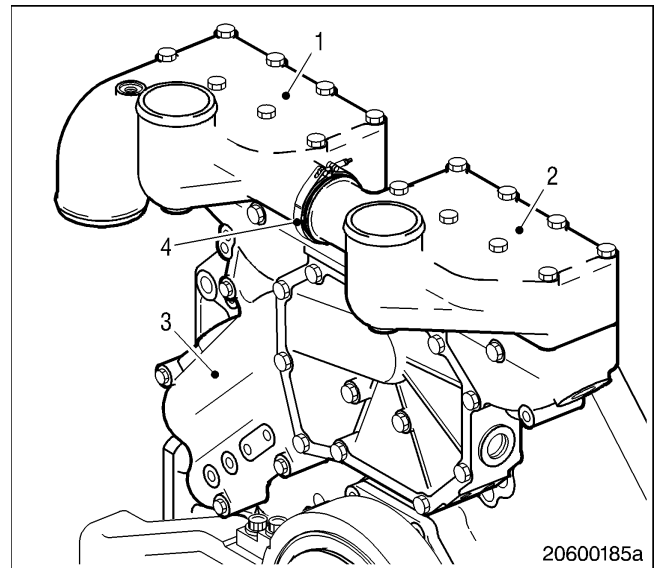


2. Using mandrel (1) install sealing rings (2) into thermostat housing (3) as per overview until the mandrel contacts the stop (→ Page 562).
3. Turn mandrel during installation to ensure even position of the sealing ring in the thermostat housing.



Installing thermostat housings

1. Position pins in vent bores of thermostat housings (1) and (2).
2. Manually press thermostat inserts into thermostat housings (1) and (2) as per overview (→ Page 562).
3. Position sleeve and clamp (4) on thermostat housings (1) and (2) but do not tighten clamp.
4. Position gaskets on sealing faces on coolant distribution housing (3).
5. Install thermostat housings (1) and (2) as per overview and tighten clamp (→ Page 562).



Final steps

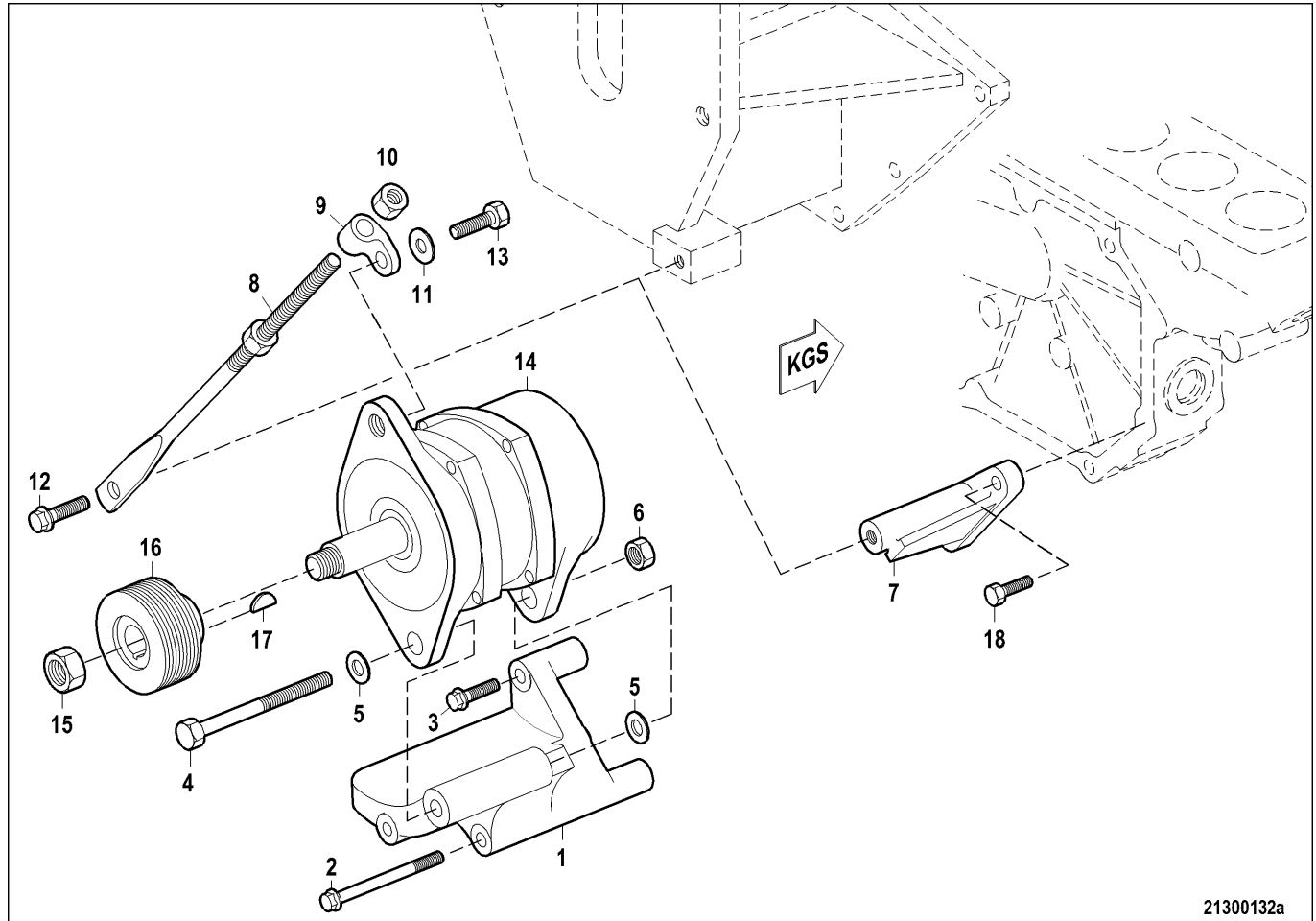
For these steps a distinction must be made as to whether

- 1 the engine has been completely disassembled
- 2 the engine has been removed but not disassembled
- 3 the engine has remained installed

1	2	3	Operations	See
X	–	–	Assemble engine.	(→ Page 58)
X	–	–	Install engine.	(→ Page 60)
–	X	X	Perform installation in reverse sequence of work steps as described for removal.	(→ Page 563)
–	X	X	Fill with engine coolant.	(→Operating instructions)
–	–	X	Fill with engine oil.	(→Operating instructions)
–	–	X	Fill with fuel.	(→Operating instructions)
–	–	X	Enable engine start.	–

3.15 Power Supply, Engine Side

3.15.1 Battery-charging generator – Overview



21300132a

- | | | |
|-----------|---------------|-------------------------------|
| 1 Bracket | 7 Bracket | 13 Screw |
| 2 Screw | 8 Clamp screw | 14 Battery-charging generator |
| 3 Screw | 9 Lug | 15 Nut |
| 4 Screw | 10 Nut | 16 Belt pulley |
| 5 Washer | 11 Washer | 17 Woodruff key |
| 6 Nut | 12 Screw | 18 Screw |

3.15.2 Battery-charging generator – Removal

Preconditions

- Engine is stopped and starting disabled



Heavy object.

Risk of crushing!

- Use appropriate lifting devices and appliances.

Preparatory steps

For these steps a distinction must be made as to whether

- 1 the engine is to be completely disassembled
- 2 the engine is to be removed but not disassembled
- 3 the engine is to remain installed

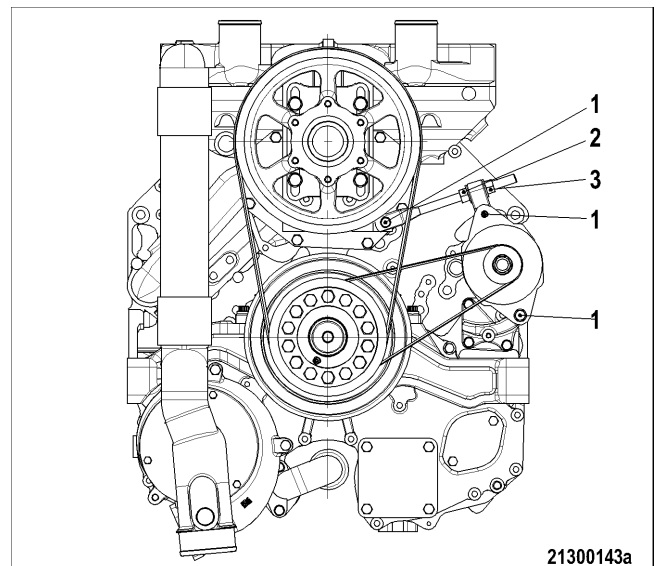
1	2	3	Operations	See
X	–	–	Remove engine.	(→ Page 55)
X	–	–	Disassemble engine.	(→ Page 56)
–	–	X	Disable engine start.	(→ Page 15)
–	X	X	Remove protection.	–

Disconnecting wiring

1. Prior to removal, mark all cables with suitable adhesive tape at the cable terminals.
2. Note terminal identification on adhesive tape.
3. Remove all cables from battery-charging generator while counter-holding the lower nut on threaded studs.
4. Protect all cables from damage.

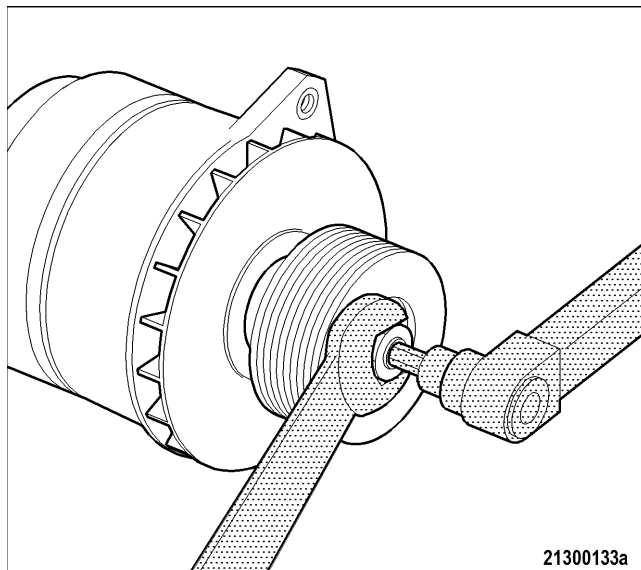
Removing battery-charging generator and drive

1. Remove screws (1).
2. Remove nuts (2) and (3) until the drive belt has slackened.
3. Remove drive belt while securing the battery-charging generator against falling.
4. Remove battery-charging generator, battery-charging generator drive and bracket as per overview (→ Page 571).
5. Protect battery-charging generator from damage.



Removing belt pulley from battery-charging generator

1. Brace rotor shaft with socket-head wrench.
2. Remove nut.
3. Remove belt pulley.
4. Remove Woodruff key.



3.15.3 Battery-charging generator – Disassembly



Remove battery-charging generator (→ Page 572).

Disassembling battery-charging generator

See separate publication No. M060710.

3.15.4 Battery-charging generator – Cleaning

Material

Designation / Use	Part No.	Qty.
Cleaner		
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors. 	
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask. 	

Remove battery-charging generator (→ Page 572).

Battery-charging generator — Cleaning

1. Clean generator with compressed air only; do not use any liquids in cleaning process.
2. Clean mechanical restraint device and mounting parts with cleaner.
3. Remove cleaner.
4. Thoroughly blow all parts clean with compressed air.

3.15.5 Battery-charging generator – Check

Spare parts

Designation / Use	Part No.	Qty.
Battery-charging generator		
Belt pulley		
Drive belt		
Clamp screw		

Clean battery-charging generator (→ Page 575).

Checking battery-charging generator and drive

Item	Findings	Task
Check drive belt.	(→Operating instructions)	(→Operating instructions)
Externally check battery-charging generator for damage.	Damaged	Replace
Check all contact surfaces and mating faces for damage.	Damaged	<ul style="list-style-type: none"> • Rework: Re-surface with oil stone or crocus cloth. • Replace
Check threads for ease of movement.	No ease of movement	<ul style="list-style-type: none"> • Rework: Recut threads. • Replace
Check battery-charging generator for abnormal running noises.	Abnormal running noises	Disassemble battery-charging generator (→ Page 574)

3.15.6 Battery-charging generator – Installation

Special tools

Designation / Use	Part No.	Qty.
Pre-tension measuring device		

Material

Designation / Use	Part No.	Qty.
Engine oil		

Spare parts

Designation / Use	Part No.	Qty.
Drive belt		



Heavy object.

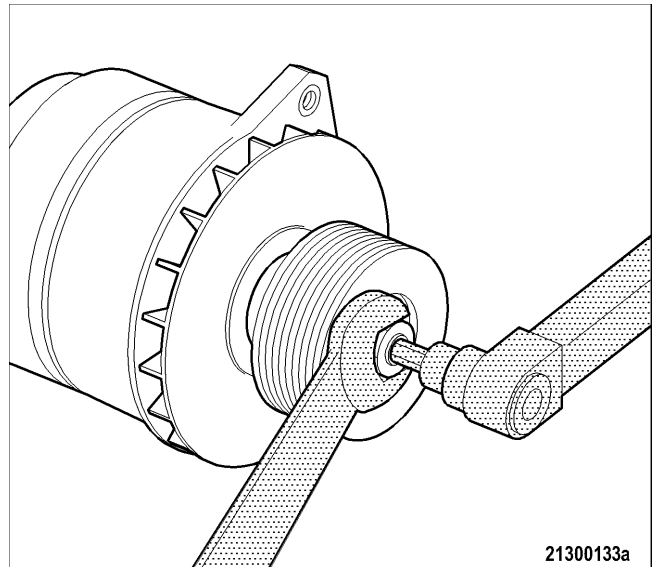
Risk of crushing!

- Use appropriate lifting devices and appliances.

Check battery-charging generator (→ Page 576).

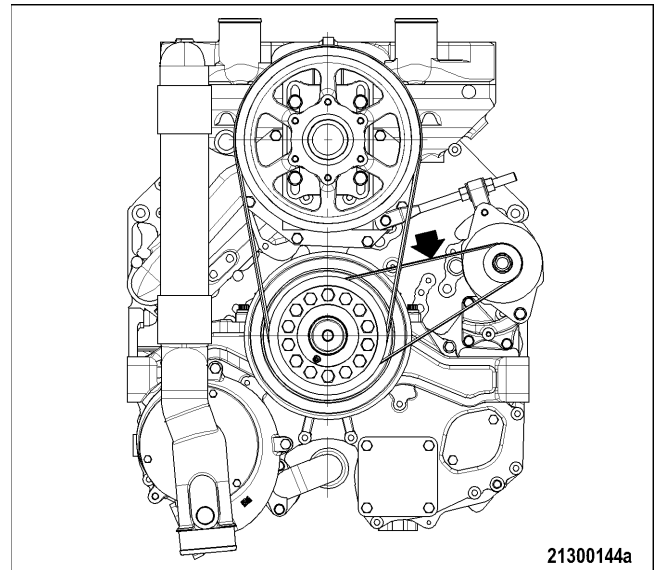
Installing belt pulley on battery-charging generator

1. Position Woodruff key in rotor shaft fit.
2. Push belt pulley into correct position on the rotor shaft.
3. Install nut.
4. Tighten nut to specified tightening torque using a torque wrench (→ Page 23).



Installing battery-charging generator and drive

1. Install battery-charging generator and drive as per overview (→ Page 571).
2. Position drive belt on belt pulleys.
3. Adjust and check V-belt tension (→Operating instructions).
4. Connect cables to battery-charging generator.
5. Using a torque wrench, tighten earthing screw and locknuts to specified tightening torque while counter-holding lower nut on threaded studs (→ Page 23).



Final steps

For these steps a distinction must be made as to whether

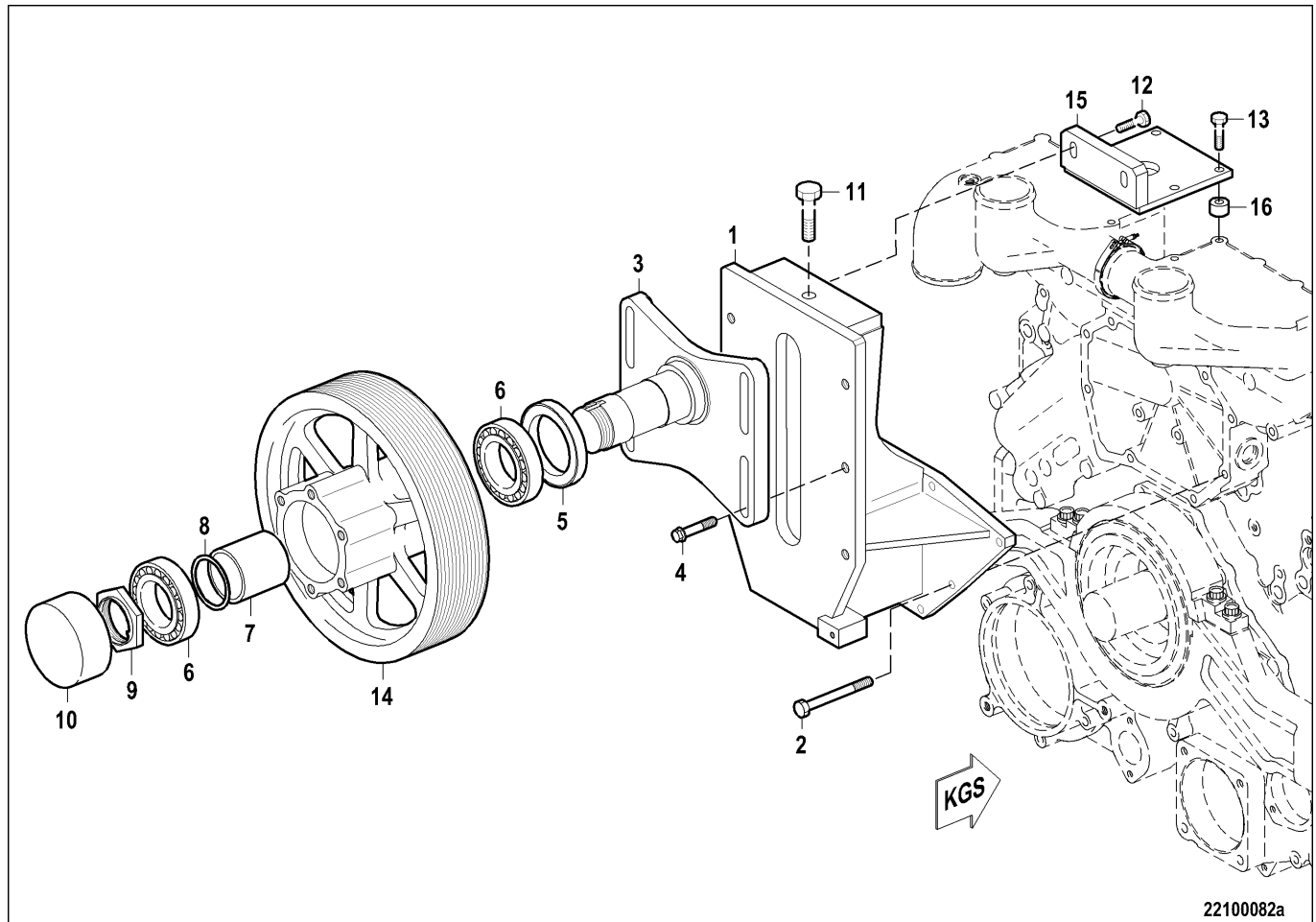
- 1 the engine has been completely disassembled
- 2 the engine has been removed but not disassembled
- 3 the engine has remained installed

1	2	3	Operations	See
X	–	–	Assemble engine.	(→ Page 58)
X	–	–	Install engine.	(→ Page 60)
–	X	X	Install protection.	–
–	–	X	Enable engine start.	–

3.16 Cooling Air System

3.16.1 Mechanical fan drive – Overview

Fan Drive



22100082a

- | | | |
|-----------|----------|----------------|
| 1 Bracket | 7 Spacer | 13 Screw |
| 2 Screw | 8 Spacer | 14 Belt pulley |
| 3 Bracket | 9 Nut | 15 Bracket |
| 4 Screw | 10 Cap | 16 Spacer |
| 5 Gasket | 11 Screw | |
| 6 Bearing | 12 Screw | |

3.16.2 Mechanical fan drive – Removal

Preconditions

- Engine is stopped and starting disabled



Heavy object.

Risk of crushing!

- Use appropriate lifting devices and appliances.

Preparatory steps

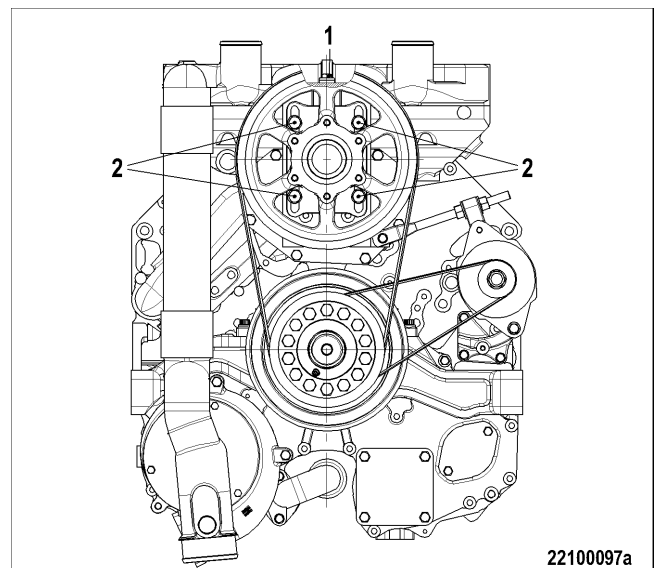
For these steps a distinction must be made as to whether

- 1 the engine is to be completely disassembled
- 2 the engine is to be removed but not disassembled
- 3 the engine is to remain installed

1	2	3	Operations	See
X	–	–	Remove engine.	(→ Page 55)
X	–	–	Disassemble engine.	(→ Page 56)
–	–	X	Disable engine start.	(→ Page 15)
–	X	X	Remove protection.	–
–	X	X	Remove fan wheel.	–

Removing mechanical fan drive

1. Remove screws (2).
2. Slacken screw (1) until the drive belt is no longer tensioned.
3. Remove drive belt.
4. Remove bearing assembly and carrier as per overview (→ Page 579).
5. Set down bearing assembly on suitable surface.



3.16.3 Mechanical fan drive – Disassembly



Heavy object.

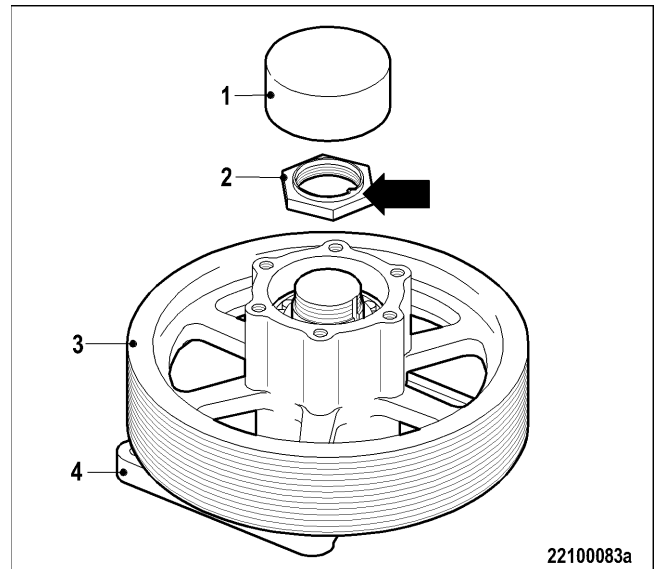
Risk of crushing!

- Use appropriate lifting devices and appliances.

Remove mechanical fan drive (→ Page 580).

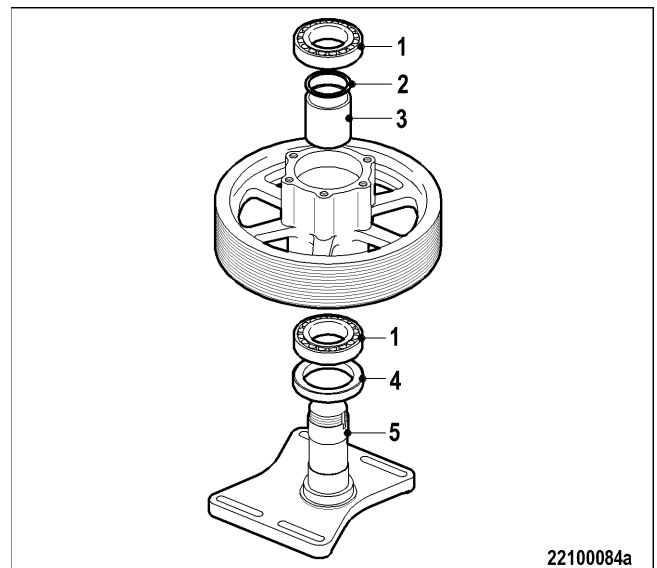
Disassembling bearing assembly

1. Secure bracket (4) in vise.
2. Penetrate and remove cap (1) with a suitable tool.
Result: The cap is destroyed during removal and must not be re-used!
3. Unlock nut (2) at lip (arrowed) and remove.



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4. Using a manual press and a suitable mandrel, remove bracket (5) from belt pulley ensuring that:
 - removal is carried out very carefully;
 - the removal forces are not applied via the bearing rollers;
 - inner and outer bearing race are not swapped; they form an assembly.
5. Remove seal (4) from belt pulley.
6. Remove bearing (1), spacer (3) and washers (2) ensuring that:
 - number and thickness of the washers removed are noted for assembly.
7. Remove outer bearing races from belt pulley using a brass mandrel and a hammer.






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3.16.4 Mechanical fan drive – Cleaning

Material

Designation / Use	Part No.	Qty.
Cleaning agent		
Diesel fuel		

 WARNING	Fuels are combustible. Risk of fire and explosion! <ul style="list-style-type: none"> • Avoid naked flames, electrical sparks and ignition sources. • Do not smoke.
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors.
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask.

Remove mechanical fan drive (→ Page 580).

Mechanical fan drive – Cleaning

1. Only dry rub drive belt, do not clean with organic cleaning agent.
2. Clean bearing with fuel.
3. Clean all other parts with cleaning agent.
4. Remove fuel and cleaning agent.
5. Thoroughly blow off all parts with compressed air.

3.16.5 Mechanical fan drive – Check

Material

Designation / Use	Part No.	Qty.
Surface crack testing with red penetrant dye		

Spare parts

Designation / Use	Part No.	Qty.
Bearing		
Gasket		
Spacer		
Cap		
Bracket		
Drive belt		

Clean mechanical fan drive (→ Page 582).

Checking mechanical fan drive

Item	Findings	Task
Check drive belt.	(→Operating instructions)	(→Operating instructions)
Using surface crack testing method with red penetrant dye, check bracket for cracks.	Cracks apparent	Replace
Check bearing for traces of wear and damage.	Damaged	Replace
Visually inspect all components for damage and deformation.	Damaged, deformation visible	Replace
Check all contact and mating faces for damage.	Damaged	<ul style="list-style-type: none"> • Rework: Re-surface with oil stone or crocus cloth. • Replace
Check threads for ease of movement.	No ease of movement	<ul style="list-style-type: none"> • Rework: Recut threads. • Replace

3.16.6 Mechanical fan drive – Assembly

Special tools

Designation / Use	Part No.	Qty.
Sleeve for installation of outer bearing race into belt pulley		1
Installation sleeve for cap		1

Material

Designation / Use	Part No.	Qty.
Multi-purpose grease Multifak EP2		
Engine oil		

Spare parts

Designation / Use	Part No.	Qty.
Bearing		
Gasket		



CAUTION

Contamination of components.

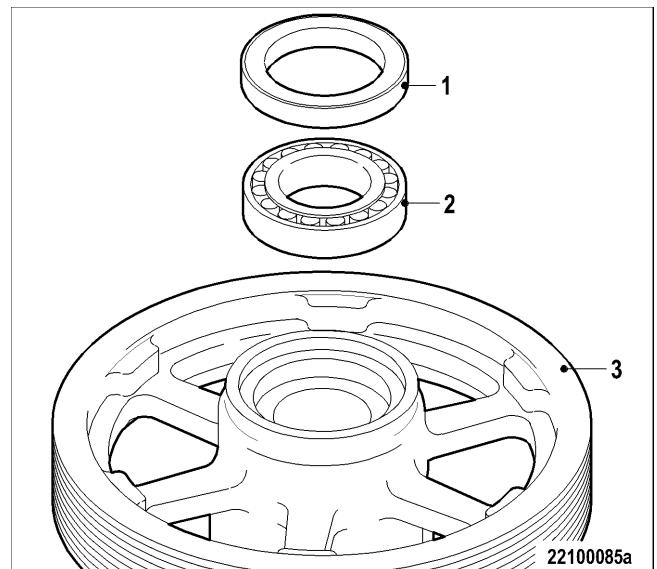
Damage to component!

- Observe manufacturer's instructions.
- Check components for special cleanliness.

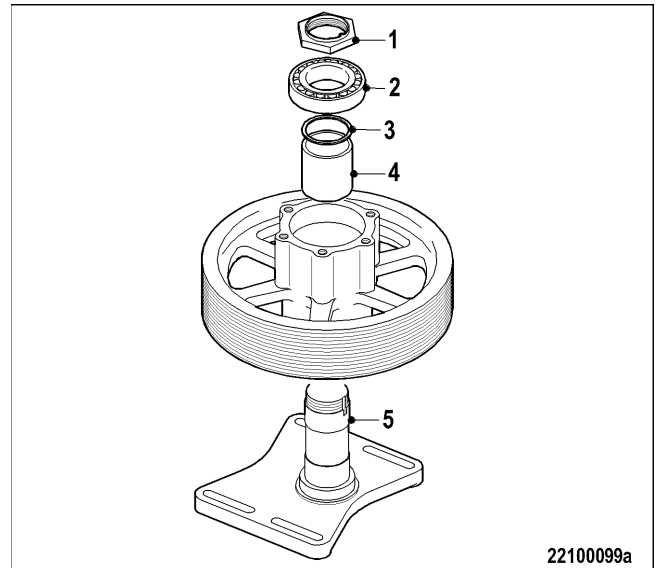
Check mechanical fan drive (→ Page 583).

Assembling bearing assembly

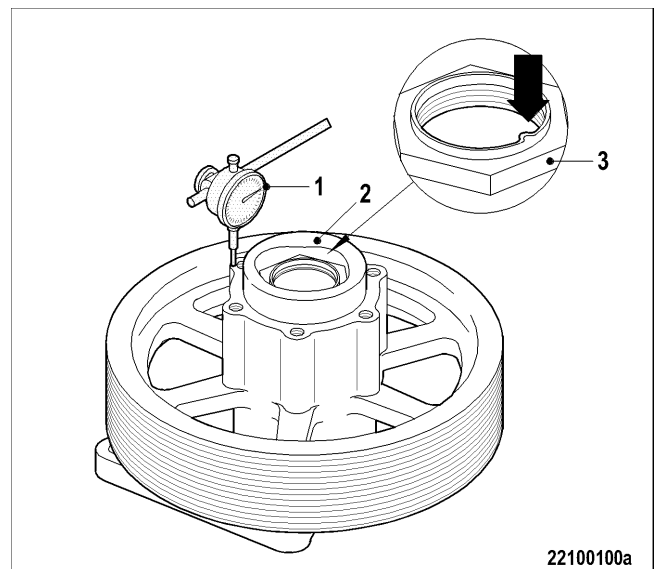
1. Lightly coat bore in belt pulley (3) with oil.
2. Thoroughly grease both inner bearing races.
3. Squeeze multi-purpose grease between cage, inner race and rollers.
4. Press bearing outer race (2) into belt pulley up to stop using a manual press and the installation sleeve. The marked race side must face to the outside.
5. Position inner race in outer race.
6. Press new gasket (1) into belt pulley up to stop using a manual press and the installation sleeve. The marked side must face to the outside.



7. Press bearing outer race (2) into belt pulley up to stop using a manual press and the installation sleeve. The marked race side must face to the outside.
8. Secure bracket (5) in vise.
9. Push belt pulley over the shaft of bracket (5) ensuring that the gasket is not damaged.
10. Push spacer (4) and washers (3) over the shaft of bracket (5).
11. Fill 20 to 30% of the space between the bearings in the belt pulley with multi-purpose grease.
12. Push bearing inner race over the shaft of bracket (5).
13. Install nut (1) and, using a torque wrench, tighten to specified tightening torque while turning the belt pulley (→ Page 23).
14. Turn belt pulley to check for ease of movement.



15. Attach magnetic base with measuring device (1) to bracket.
16. Position pretensioned measuring device pointer onto face of belt pulley and zero measuring device.
17. Move belt pulley axially and measure end clearance.
 - End clearance specification: 0.026 mm to 0.152 mm
18. If the end clearance is out of specification, correct using washers.
19. Lock nut (3) by pressing lip (arrowed) into the shaft groove.
20. Fill 70 to 80% of cap (2) with multi-purpose grease.
21. Using the manual press and the installation sleeve, press cap into belt pulley up to the stop.
22. Turn belt pulley to check for ease of movement.



3.16.7 Mechanical fan drive – Installation

Preconditions

- Engine is stopped and starting disabled.

Spare parts

Designation / Use	Part No.	Qty.
Drive belt		



WARNING

Heavy object.

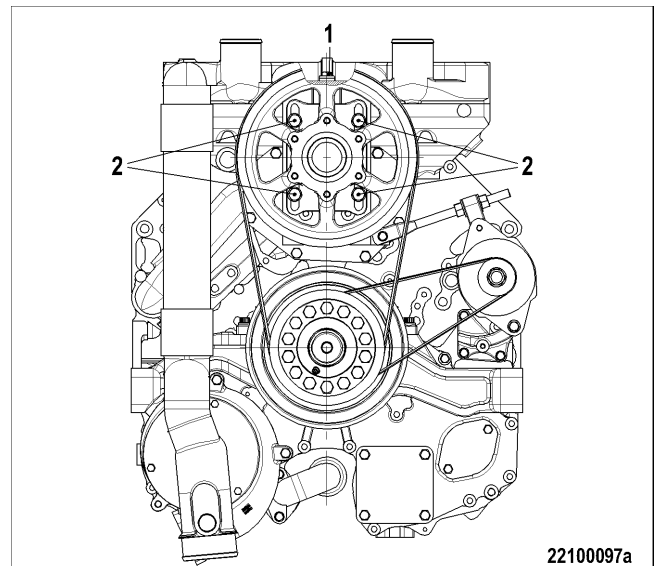
Risk of crushing!

- Use appropriate lifting devices and appliances.

Check mechanical fan drive (→ Page 583).

Installing mechanical fan drive

1. Install carrier and bearing assembly as per overview (→ Page 579).
2. Insert screws (2) and hand-tighten.
3. Position drive belt.
4. Install screw (1) and turn until the correct belt tension has been reached.
5. Set belt tension (→Operating instructions).



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Final steps

For these steps a distinction must be made as to whether

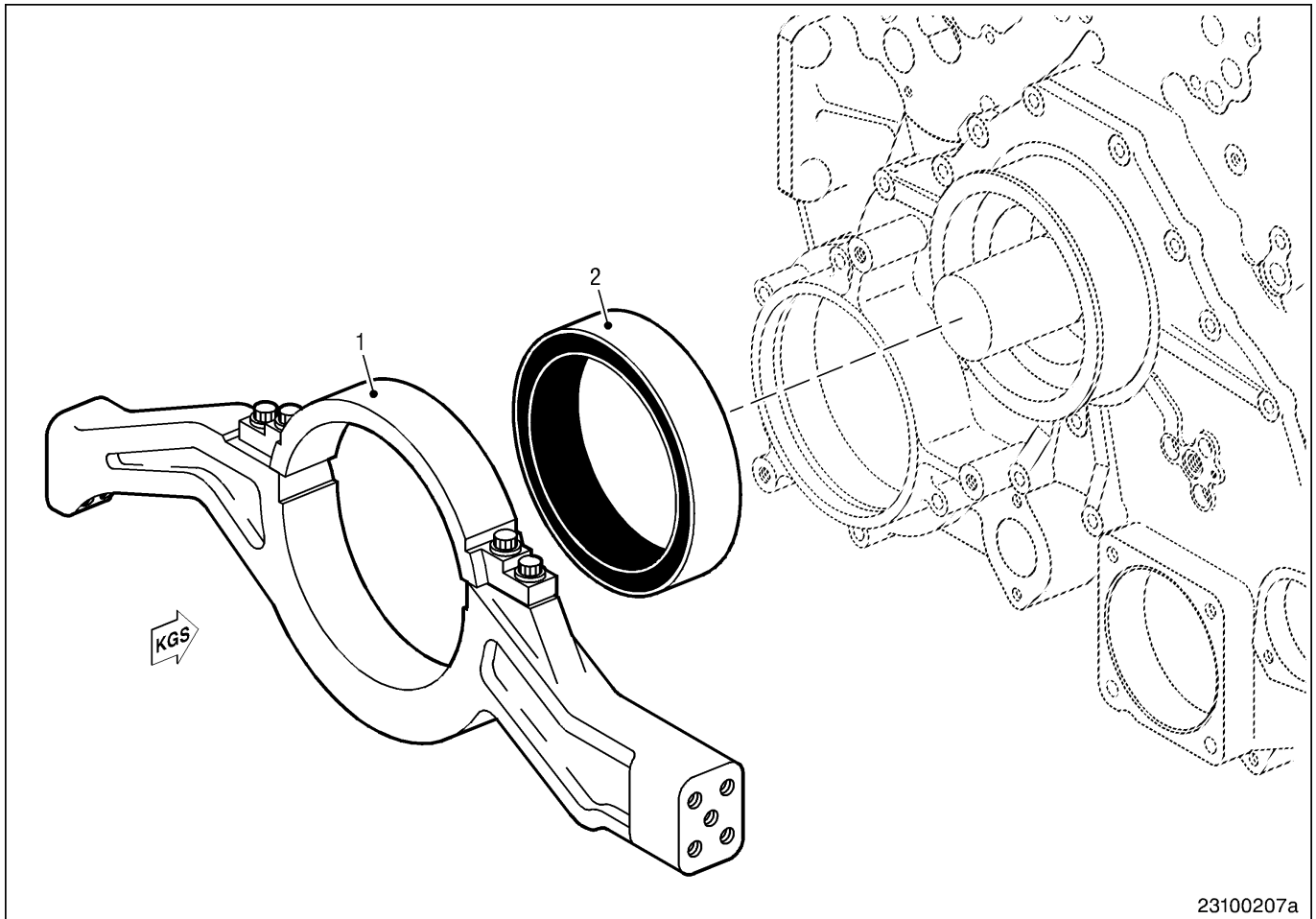
- 1 the engine has been completely disassembled
- 2 the engine has been removed but not disassembled
- 3 the engine has remained installed

1	2	3	Operations	See
X	–	–	Assemble engine.	(→ Page 58)
X	–	–	Install engine.	(→ Page 60)
–	X	X	Install fan wheel.	–
–	X	X	Install protection.	–
–	–	X	Enable engine start.	–

3.17 Mounting/Support

3.17.1 Engine mounts – Overview

Engine mounts, free end

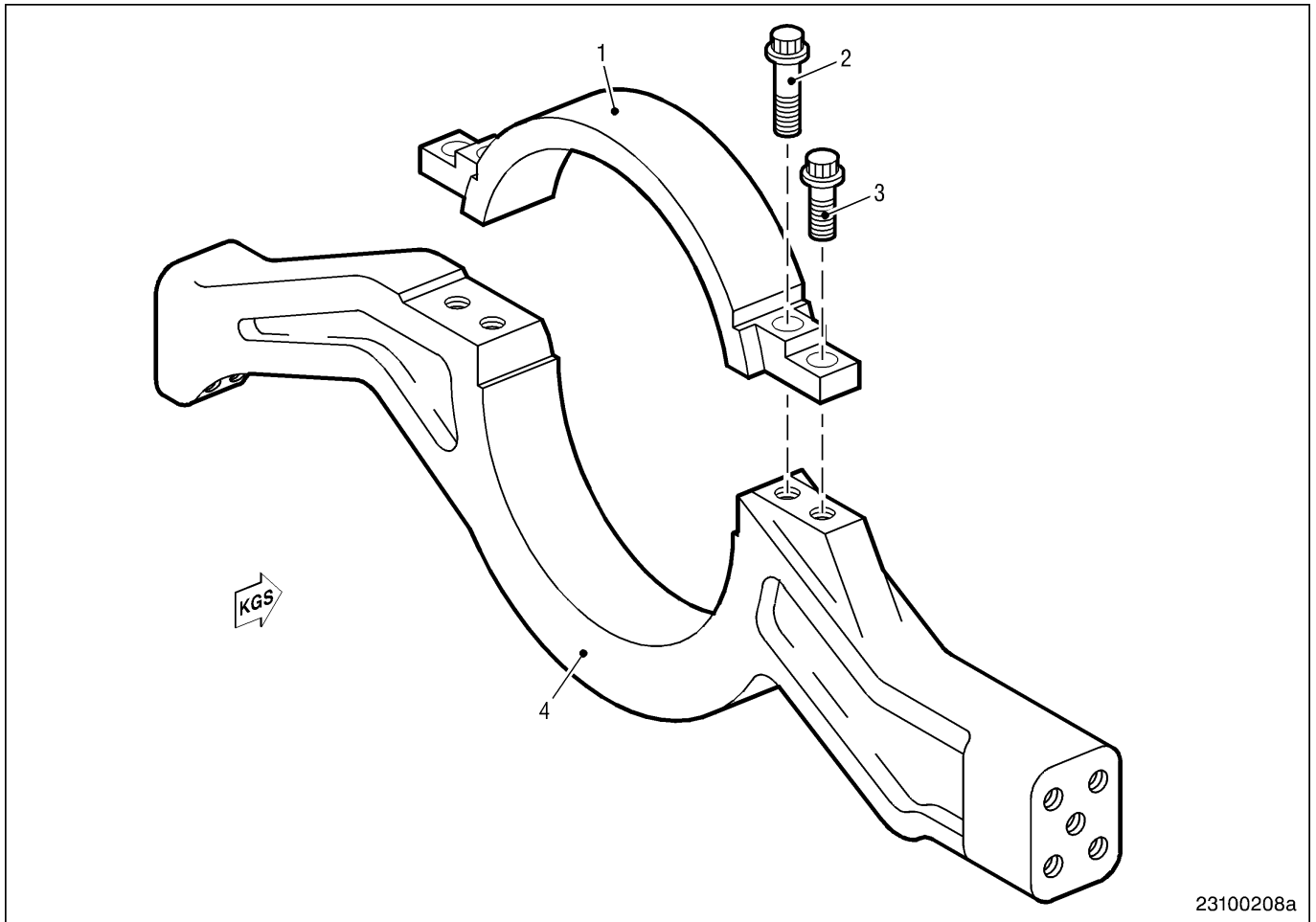


1 Engine mounting bracket

2 Shock absorber

23100207a

Engine mounts, free end



- | | |
|--------------------|--------------------|
| 1 Cover | 3 Double-hex screw |
| 2 Double-hex screw | 4 Carrier |

3.17.2 Engine mounts – Removal

Preconditions

- Engine is stopped and starting disabled



DANGER

Engine can tilt over.

Danger to life!

- Use appropriate lifting devices and appliances.



DANGER

Suspended load.

Danger to life!

- Use appropriate lifting devices and appliances.
- Never stand beneath a suspended load.

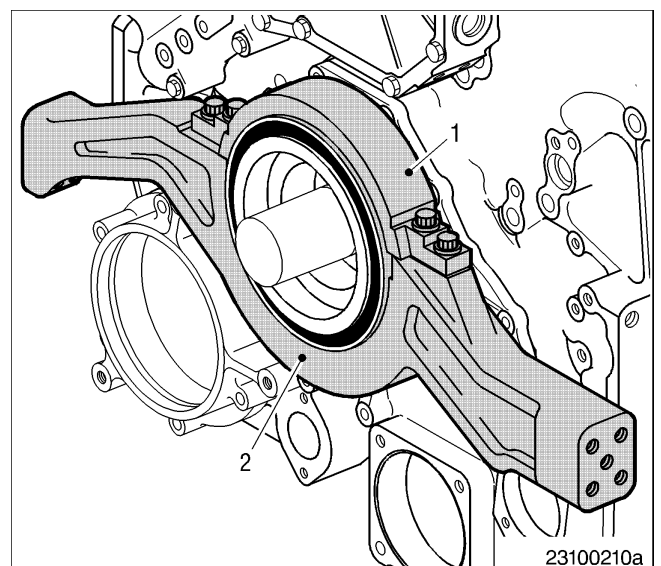
Preparatory steps

For these steps a distinction must be made as to whether 1 the engine is to be completely disassembled 2 the engine is to be removed but not disassembled 3 the engine is to remain installed				
1	2	3	Operations	See
X	–	–	Remove engine.	(→ Page 55)
X	–	–	Disassemble engine.	(→ Page 56)
–	X	X	Suspend engine using lifting device.	(→ Page 47)
–	–	X	Slacken screw joints of foundation.	–
–	–	X	Drain engine coolant*.	(→Operating instructions)
–	–	X	Drain charge-air coolant*.	(→Operating instructions)
–	–	X	Drain or draw off engine oil*.	(→Operating instructions)
–	X	X	Remove drive belt*.	(→ Page 572), (→ Page 580)
–	X	X	Remove belt drive*.	(→ Page 176)
–	X	X	Remove coolant lines downstream of coolant pump*.	(→ Page 546)
–	X	X	Remove engine coolant pump*.	(→ Page 535)
–	X	X	Remove coolant line from/to intercooler*.	(→ Page 558)
–	X	X	Remove charge-air coolant pump*.	(→ Page 552)
–	X	X	Remove vibration damper*.	(→ Page 242)
–	X	X	Remove oil pump connections*.	(→ Page 486)
–	X	X	Remove battery-charging generator*.	(→ Page 572)
–	X	X	Remove gearcase cover*.	(→ Page 146)

*applicable only when replacing the shock absorber

Removing enging mounts, free end

1. Remove double-hex screws while securing carrier (2) against falling.
2. Remove cover (1) and carrier (2).





Removing shock absorber

1. Only remove shock absorber if required.
2. Axially cut open shock absorber and remove from gearcase cover.

3.17.3 Engine mounts – Cleaning

Material

Designation / Use	Part No.	Qty.
Cleaning agent		
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors. 	
 CAUTION	Excessive reaction time of cleaning agents on components. Damage to component! <ul style="list-style-type: none"> • Observe manufacturer's instructions. • Wear protective clothing, gloves, and goggles / safety mask. 	

Remove engine mounts (→ Page 590).

Cleaning engine mounts

Note: Protect shock absorbers from oil and fuel.

1. Clean shock absorbers with a dry cloth only, do not use organic detergents.
2. Clean all other components using cleaning agent.
3. Thoroughly dry all parts with compressed air.

3.17.4 Engine mounts – Check

Material

Designation / Use	Part No.	Qty.
Red penetrant dye for surface crack testing		

Spare parts

Designation / Use	Part No.	Qty.
Shock absorber		
Cover		
Carrier		

Clean engine mounts (→ Page 593).

Checking engine mounts

Item	Findings	Task
Check cover and carrier for cracks using red penetrant dye.	Cracks apparent	Replace
Visually check shock absorbers for damage, cracks and deformation.	<ul style="list-style-type: none"> • Damage • Cracks • Deformation visible 	Replace
Check threads for ease of movement.	No ease of movement	<ul style="list-style-type: none"> • Rework: Recut threads. • Replace
Check bolt-on faces for flatness.	Uneven	<ul style="list-style-type: none"> • Rework: Smooth using oilstone. • Replace



3.17.5 Engine mounts – Installation

Special tools

Designation / Use	Part No.	Qty.
Mandrel		1

Material

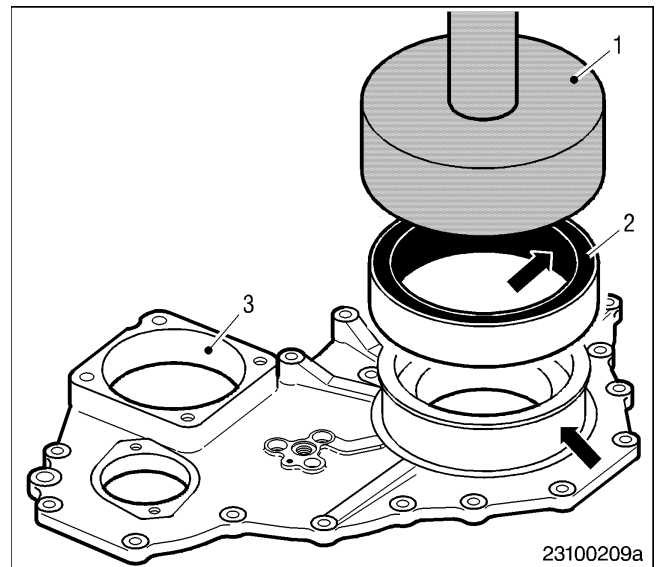
Designation / Use	Part No.	Qty.
Soapy water		
Engine oil		

 DANGER	Engine can tilt over. Danger to life! <ul style="list-style-type: none"> • Use appropriate lifting devices and appliances.
 DANGER	Suspended load. Danger to life! <ul style="list-style-type: none"> • Use appropriate lifting devices and appliances. • Never stand beneath a suspended load.

Check engine mounts (→ Page 594).

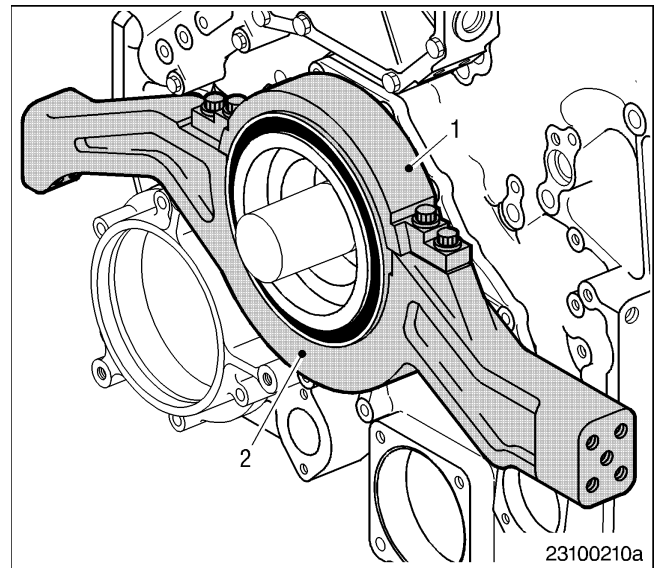
Installing shock absorber

1. Coat mating faces (arrowed) on gearcase cover (3) and shock absorber (2) with soapy water.
2. Using a manual press and installation mandrel (1), press shock absorber (2) onto gearcase cover (3) up to stop.
3. Install gearcase cover (3) (→ Page 154).



Installing engine mounts, free end

1. Install carrier (2) and cover (1) to shock absorber using double-hex screws.
2. Tighten double-hex screws to specified tightening torque using a torque wrench (→ Page 23).



Final steps

For these steps a distinction must be made as to whether

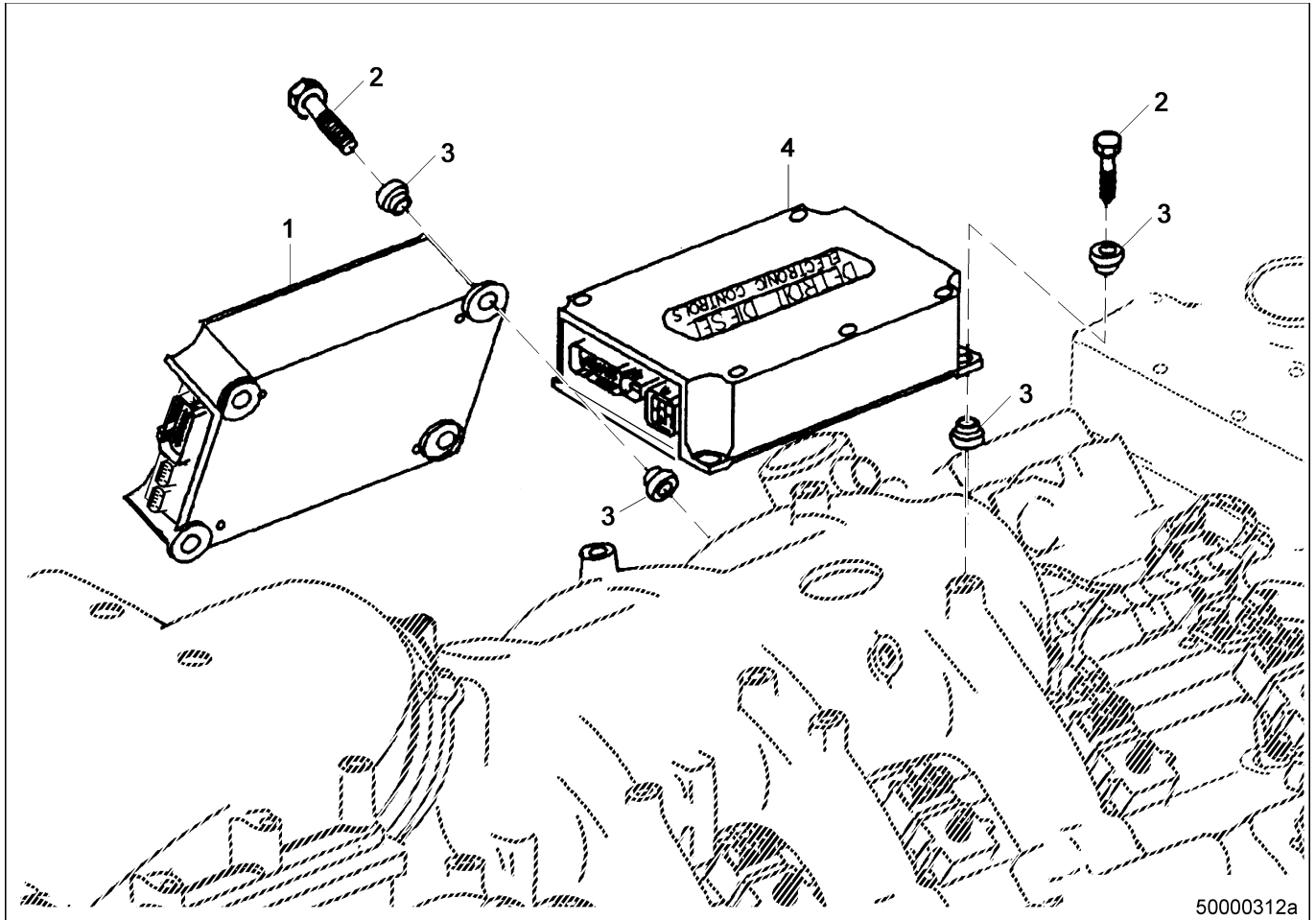
- 1 the engine has been completely disassembled
- 2 the engine has been removed but not disassembled
- 3 the engine has remained installed

1	2	3	Operations	See
X	–	–	Assemble engine.	(→ Page 58)
X	–	–	Install engine.	(→ Page 60)
–	X	X	Assemble in reverse disassembly sequence.	(→ Page 590)
–	–	X	Fill with engine oil.	(→Operating instructions)
–	–	X	Fill with engine coolant.	(→Operating instructions)
–	–	X	Fill with charge-air coolant.	(→Operating instructions)
–	–	X	Enable engine start.	–

3.18 Monitoring and Control Equipment

3.18.1 Monitoring and control devices – Overview

DDEC electronic control



1 DDEC electronic control,
left-hand side

2 Screw
3 Vibration damper

4 DDEC electronic control,
right-hand side

3.18.2 DDEC electronic control – Removal

Preconditions

- Engine is stopped and starting disabled

Preparatory steps

For these steps a distinction must be made as to whether

- 1 the engine is to be completely disassembled
- 2 the engine is to be removed but not disassembled
- 3 the engine is to remain installed

1	2	3	Operations	See
X	–	–	Remove engine.	(→ Page 55)
X	–	–	Disassemble engine.	(→ Page 56)
–	–	X	Disable engine start.	(→ Page 15)

Removing DDEC electronic control

1. Prior to removing wiring fitted to engine take photographs or mark cables.
2. Detach connectors from DDEC.
3. Remove DDEC as per overview (→ Page 597).
4. Cap all connections.
5. Protect DDEC from oil and dirt.

3.18.3 DDEC electronic control – Cleaning

Material

Designation / Use	Part No.	Qty.
Isopropyl alcohol		

Remove DDEC electronic control (→ Page 466).

Cleaning DDEC electronic control

1. Remove coarse dirt on housing surface using isopropyl alcohol.
2. Clean contacts and female connectors using isopropyl alcohol.

3.18.4 DDEC electronic control – Check

Spare parts

Designation / Use	Part No.	Qty.
Vibration damper		

Clean DDEC electronic control (→ Page 599)

Checking DDEC electronic control

Item	Findings	Task
Visually inspect all components for damage.	Damaged	Replace
Check connector terminals for damage.	Damaged	<ul style="list-style-type: none"> • Rework: Repair connector terminals. • Replace connector terminals.
Visually check vibration dampers for damage, cracks and deformation.	<ul style="list-style-type: none"> • Damage • Cracks • Deformation visible 	Replace

3.18.5 DDEC electronic control – Installation

Spare parts

Designation / Use	Part No.	Qty.
Vibration damper		

Check DDEC electronic control (→ Page 605).

Installing DDEC electronic control

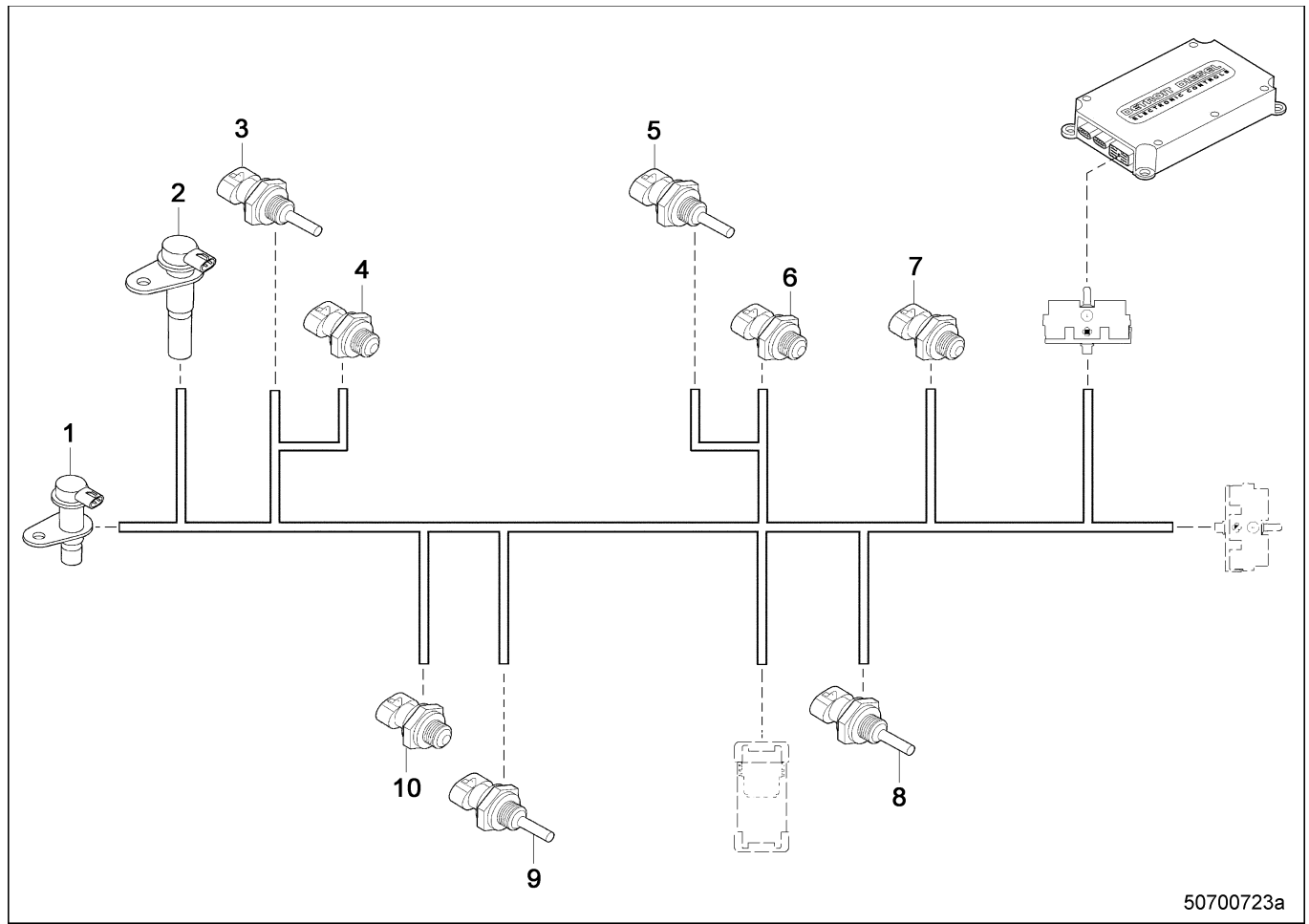
1. Install DDEC as per overview using new vibration dampers (→ Page 597).
2. Remove dust caps.
3. Attach and secure DDEC connectors.

Final steps

For these steps a distinction must be made as to whether				
1 the engine has been completely disassembled				
2 the engine has been removed but not disassembled				
3 the engine has remained installed				
1	2	3	Operations	See
X	–	–	Assemble engine.	(→ Page 58)
X	–	–	Install engine.	(→ Page 60)
–	–	X	Check firm and exact fit of all plug connections.	–
–	–	X	Enable engine start.	–

3.18.6 Wiring and engine harnesses – Overview

Engine harness – Sensors

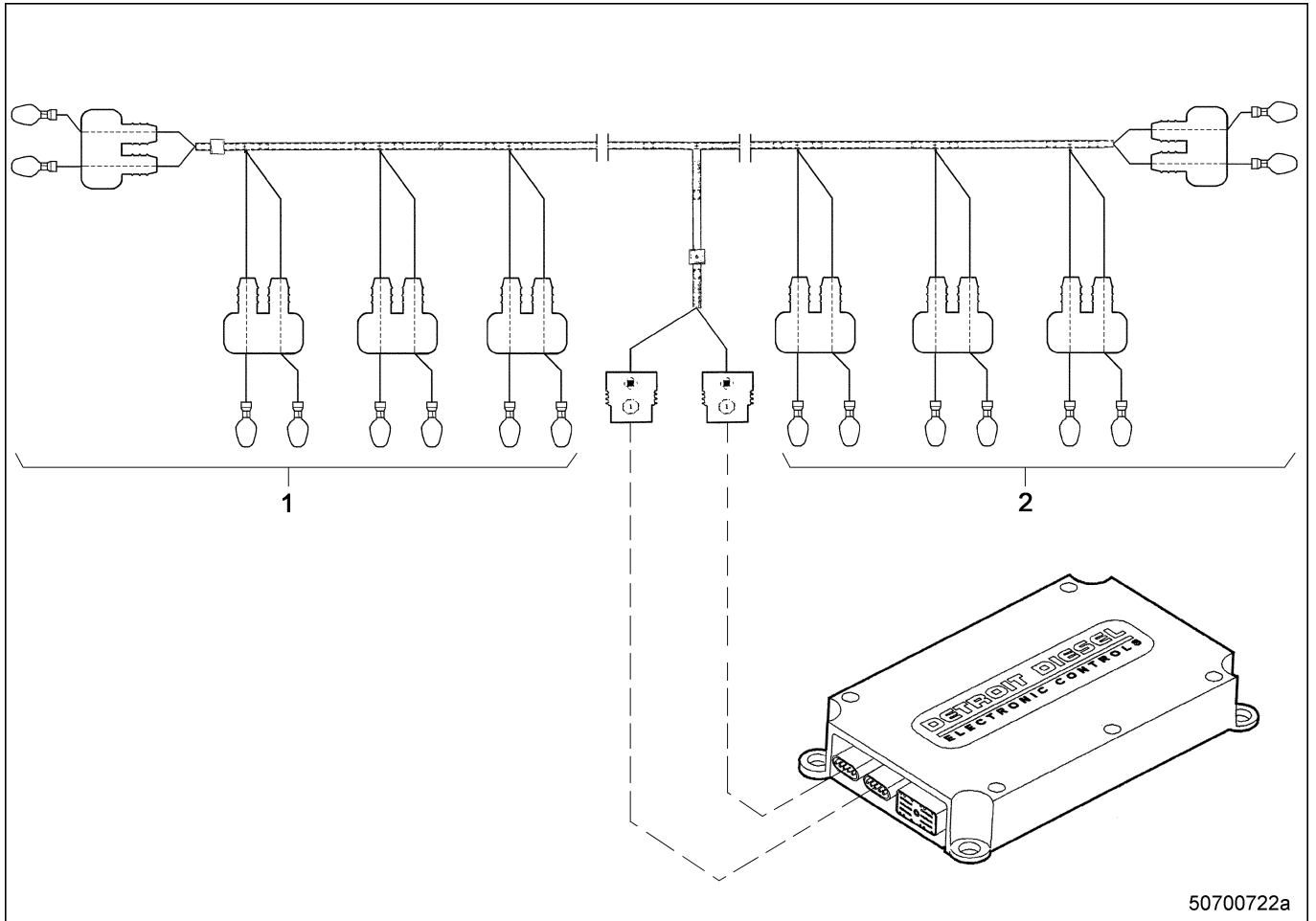


- 1 Speed sensor, SRS
- 2 Speed sensor, TRS
- 3 Oil temperature sensor, OTS
- 4 Oil pressure sensor, OPS
- 5 Fuel temperature sensor, FTS

- 6 Fuel pressure sensor, FPS
- 7 Charge-air pressure sensor, TBS
- 8 Charge-air temperature sensor, ATS
- 9 Coolant temperature sensor, CTS

- 10 Coolant pressure sensor, CPS

Engine harness – Injectors



50700722a

1 Injectors A1 to A8

2 Injectors B1 to B8

3.18.7 Engine wiring harnesses – Removal

Preconditions

- Engine is stopped and starting disabled

Preparatory steps

For these steps a distinction must be made as to whether				
1 the engine is to be completely disassembled				
2 the engine is to be removed but not disassembled				
3 the engine is to remain installed				
1	2	3	Operations	See
X	–	–	Remove engine.	(→ Page 55)
X	–	–	Disassemble engine.	(→ Page 56)
–	–	X	Disable engine start.	(→ Page 15)

Removing engine wiring harnesses

1. Identify wiring harness using marking and note routing.
2. Disconnect connectors of the attached sensors and of the DDEC.
3. Remove cable terminals from injection pumps.

Note: Note position of cable ties. The cable ties must be placed in the same position during reinstallation.

4. Remove cable ties on the wiring harness to be changed.
5. Remove clamps.
6. Carefully remove wiring harness(es).
7. Cap all connections.
8. Protect wiring harnesses from oil and dirt.

3.18.8 Engine wiring harnesses – Check

Material

Designation / Use	Part No.	Qty.
Insulating tape		
Cable tie		

Spare parts

Designation / Use	Part No.	Qty.
Engine wiring harness		

Remove engine wiring harnesses (→ Page 604)

Checking engine wiring harnesses

Item	Findings	Task
Check engine wiring harness for cracks, buckles and abrasion points.	<ul style="list-style-type: none"> • Cracks • Buckles • Abrasion points visible 	<ul style="list-style-type: none"> • Rework: Repair using insulating tape. • Replace engine wiring harness.
Check connector terminals for damage.	Damaged	<ul style="list-style-type: none"> • Rework: Repair connector terminals. • Replace connector terminals.
Check engine wiring harness for secure seating.	Engine wiring harness loose	Secure engine wiring harness using cable ties.

3.18.9 Engine wiring harnesses – Installation

Spare parts

Designation / Use	Part No.	Qty.
Cable clamp		

Check engine wiring harnesses (→ Page 605).

Installing engine wiring harnesses

1. Position wiring harness(es).
2. Align wiring harness so that it reaches the sensors to be connected and the DDEC without being subject to tension.
3. Remove dust caps.
4. Secure wiring harness using clamps.

Note: Attache cable ties in the positions noted during removal.

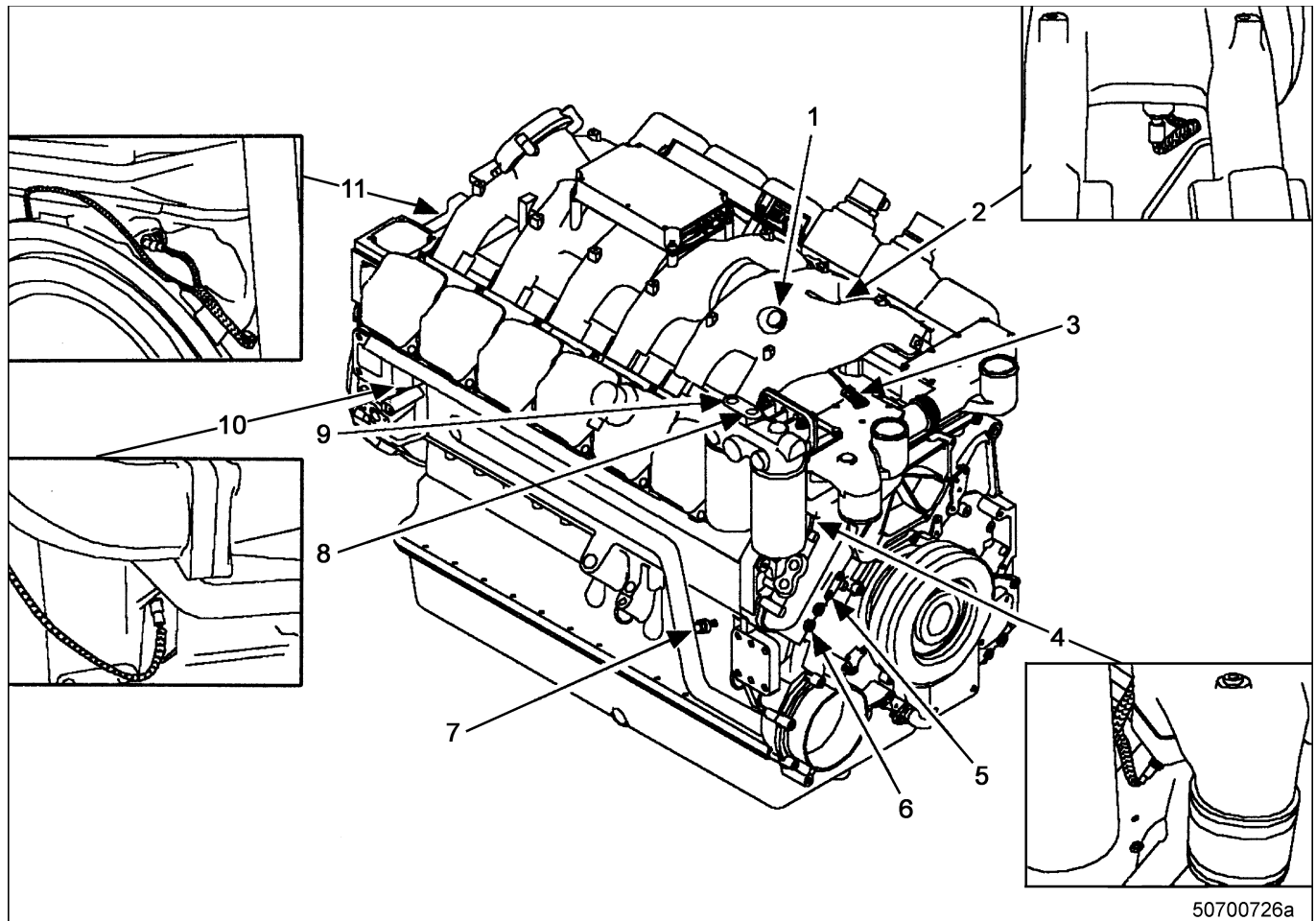
5. Secure wiring harness using cable ties.
6. Connect all connectors on sensors and DDEC.
7. Tighten terminals on injection pump to specified tightening torque using a torque wrench (→ Page 23).

Final steps

For these steps a distinction must be made as to whether				
1 the engine has been completely disassembled				
2 the engine has been removed but not disassembled				
3 the engine has remained installed				
1	2	3	Operations	See
X	–	–	Assemble engine.	(→ Page 58)
X	–	–	Install engine.	(→ Page 60)
–	–	X	Check firm and exact fit of all plug connections.	–
–	–	X	Enable engine start.	–

3.18.10 Sensors, actuators and injectors – Overview

Engine wiring harness – Sensors






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- | | | |
|--------------------------------------|-----------------------------------|--------------------------------|
| 1 Charge-air pressure sensor, TBS | 4 Coolant temperature sensor, CTS | 8 Fuel pressure sensor, FPS |
| 2 Charge-air temperature sensor, ATS | 5 Oil pressure sensor, OPS | 9 Fuel temperature sensor, FTS |
| 3 Secondary connection | 6 Oil temperature sensor, OTS | 10 Speed sensor, TRS |
| | 7 Coolant pressure sensor, CPS | 11 Speed sensor, SRS |

3.18.11 Sensors, actuators and injectors – Removal

Preconditions

- Engine is stopped and starting disabled

 WARNING	Fuels are combustible. Risk of fire and explosion! <ul style="list-style-type: none"> • Avoid naked flames, electrical sparks and ignition sources. • Do not smoke.
 WARNING	Hot oil. Oil can contain combustion residues which are harmful to health. Risk of injury and poisoning! <ul style="list-style-type: none"> • Wear protective clothing, gloves, and goggles / safety mask. • Avoid contact with skin. • Do not inhale oil vapor.
 WARNING	Coolant is hot and under pressure. Risk of injury and scalding! <ul style="list-style-type: none"> • Let the engine cool down. • Wear protective clothing, gloves, and goggles / safety mask.

Preparatory steps

For these steps a distinction must be made as to whether <ol style="list-style-type: none"> 1 the engine is to be completely disassembled 2 the engine is to be removed but not disassembled 3 the engine is to remain installed 				
1	2	3	Operations	See
X	–	–	Remove engine.	(→ Page 55)
X	–	–	Disassemble engine.	(→ Page 56)
–	–	X	Disable engine start.	(→ Page 15)
–	–	X	Drain engine coolant (only when removing coolant sensors).	(→Operating instructions)

Removing temperature and pressure sensors

1. Always note:
 - All temperature sensors have the same design and electrics. Removal procedure is identical for all.
 - All pressure sensors have the same design and electrics. Removal procedure is identical for all.
 - Arrangement and position of sensors (→ Page 607).
2. Observe the following prior to removal:

Coolant temperature and coolant pressure sensor	During removal, small amounts of engine coolant may emerge. Collect coolant in a suitable container.
Oil temperature and oil pressure sensor	During removal, small amounts of engine oil may emerge. Collect oil in a suitable container.
Fuel temperature and fuel pressure sensor	During removal, small amounts of fuel may emerge. Collect fuel in a suitable container.

3. Remove connector from sensor.
4. Remove sensor using an open-ended wrench.
5. Plug bores.

Removing speed sensors

1. Always note:
 - All sensors have the same design and electrics. Removal procedure is identical for all.
 - Arrangement and position of sensors (→ Page 607).
2. Remove speed sensor connector.
3. Remove screw.
4. Pull out speed sensor.

3.18.12 Sensors, actuators and injectors – Check

Material

Designation / Use	Part No.	Qty.
Isopropyl alcohol		

Spare parts

Designation / Use	Part No.	Qty.
Temperature sensors		
Pressure sensors		
Speed sensors		

Remove sensors, actuators and injectors (→ Page 608).

Checking sensors

1. Always note:
 - The engine control system detects defective electric units, open circuits, short circuits and deviating sensor values.
2. Carry out the following checks:

Item	Findings	Task
Check temperature and pressure sensors for secure seating.	Sensors loose.	Tighten.
Check speed sensors for secure seating.	Sensors loose.	Retighten securing screws.
Check connectors for secure seating.	Plug-in connections loose.	Insert connectors correctly and secure.
Check sensors and connectors for mechanical damage.	Damaged	Replace
Check sensors and connectors for contamination (e. g. oil sludge).	Contamination visible.	Clean assembly using isopropyl alcohol.

3.18.13 Sensors, actuators and injectors – Installation

Material

Designation / Use	Part No.	Qty.
Petroleum jelly, white		

Spare parts

Designation / Use	Part No.	Qty.
O-rings		

Check sensors, actuators and injectors (→ Page 610).

Installing temperature and pressure sensors

1. Always note:
 - All temperature sensors have the same design and electrics. Installation procedure is identical for all.
 - All pressure sensors have the same design and electrics. Installation procedure is identical for all.
 - Arrangement and position of sensors (→ Page 607).
2. Coat O-ring of sensor with petroleum jelly.
3. Insert sensor in bore by hand.
4. Tighten sensor to specified tightening torque using a torque wrench (→ Page 23).
5. Attach wiring connector.

Installing speed sensors

1. Always note:
 - All sensors have the same design and electrics. Installation procedure is identical for all.
 - Arrangement and position of sensors (→ Page 607).
2. Coat O-ring of sensor with petroleum jelly.
3. Fit sensor in bore and press in.
4. Tighten sensor with screw.
5. Attach wiring connector.

Final steps

For these steps a distinction must be made as to whether				
1 the engine has been completely disassembled				
2 the engine has been removed but not disassembled				
3 the engine has remained installed				
1	2	3	Operations	See
X	–	–	Assemble engine.	(→ Page 58)
X	–	–	Install engine.	(→ Page 60)
–	–	X	Fill with engine coolant.	(→ Operating instructions)
–	–	X	Check firm and exact fit of all plug connections.	–
–	–	X	Enable engine start.	–

4 Annex

4.1 Manufacturer's documentation

See manufacturer's documentation.

4.2 MTU contact/service partner

You can find the MTU contacts/service partners for your region under www.mtu-online.com on the left-hand navigation bar under worldwide.

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