

Operation and Maintenance Manual

(Original Operation and Maintenance Manual)

Diesel engine

KD103V20

From serial number 2020750114

KOHLER®

EN_US
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For United States only

▲ WARNING: This product can expose you to chemicals, including carbon monoxide and benzene, which are known to the State of California to cause cancer and birth defects or other reproductive harm.
For more information, go to www.p65warnings.ca.gov/

▲ WARNING: Breathing diesel engine exhaust exposes you to chemicals known to the State of California to cause cancer and birth defects or other reproductive harm.

- Always start and operate the engine in a well-ventilated area.
- If in an enclosed area, vent the exhaust to the outside.
- Do not modify or tamper with the exhaust system.
- Do not idle the engine except as necessary.

For more information, go to www.p65warnings.ca.gov/diesel

KOHLER.

EMISSION CONTROL WARRANTY STATEMENT (USA)

For the United States only

EMISSION WARRANTY

Kohler warrants to the initial and subsequent owners of a stationary equipment certified diesel engine that such engine is:

- Designed, manufactured and equipped to conform at the time of sale with all applicable emission regulations adopted by the United States Environmental Protection Agency (“EPA”) under Section 213 of the Clean Air Act.
- Free from defects in materials and workmanship with respect to the warranted emission control system and components for a period of five (5) years or 3000 hours of total operation by all persons, whichever event occurs first, after date of delivery to the initial owner.

If any warranted part that is scheduled for replacement as required maintenance fails prior to the first scheduled replacement point for that part, that part will be repaired or replaced by Kohler. If a component of the emission control system fails during the warranty period, it will be repaired or replaced under warranty and warranted for the remainder of the warranty period. Kohler will provide the repair or replacement of any component warranted to the stationary equipment engine owner. The warranty period begins on the date the engine (in service) or machine (in production) is delivered to the initial owner, and upon any sale of the engine by such initial owner to a subsequent owner, the warranty period does not restart, but rather the remaining balance of the warranty period transfers to the subsequent owner.

WARRANTED PARTS

The following parts (as equipped) are warranted under this warranty for all Kohler engines:

- Fuel Injection System
- Air Induction System
- Turbocharger System
- Charge Air Cooling System
- Exhaust Gas Recirculation (EGR) System
- EGR Control System
- Exhaust Manifold
- Ignition System
- Diesel Particulate Filter System
- Diesel Oxidation Catalyst
- Fuel Additive Devices or Exhaust Aftertreatment Devices
- Selective Catalyst Reduction
- Reductant Containers
- Electronic Control Unit, Sensors, Solenoids, and Wiring Harnesses
- Emission Control Information Label
- Crankcase Ventilation Valves

RESPONSIBILITIES & LIMITATIONS

This warranty is subject to the following conditions.

Kohler’s Responsibilities:

In case an emission-related defect is found in a warranted component during the warranty period, Kohler will provide:

- New, remanufactured, or properly repaired components, approved pursuant to applicable regulations, required to correct the defect.
- Reasonable and customary labor as established by Kohler, during normal working hours, required to make the warranted repairs, including labor to remove and install the engine, if so required.
- Parts replaced under this warranty become the property of Kohler.

Owner's Responsibilities:

During the warranty period, the owner of the stationary equipment engine is responsible for:

- Premium or overtime labor costs.
- Costs to investigate engine problems which are not caused by a defect in Kohler's material or workmanship.
- Kohler may deny warranty coverage if the stationary engine or a part thereof has failed due to abuse, neglect, improper maintenance, or unapproved modifications.
- Providing timely notice of a warranted failure to an authorized Kohler Dealer, and to promptly make the equipment or engine available to the Kohler Dealer for repair.
- Proper scheduled and preventive maintenance as outlined in the Operation & Maintenance Manual supplied with the equipment. This includes, but is not limited to, valve adjustment, fuel and oil filter changes, and any other maintenance procedure related to emission control.
- Using the proper fuel in the engine, as specified in the Operator's Manual. Engines other than Tier 4 diesel engines shall only be operated on commercially available diesel fuel. Use of any other fuel may result in the engine no longer operating in compliance with EPA requirements. The Tier 4 diesel engine shall only be operated on ultra-low sulfur diesel fuel.
- The owner is responsible for initiating the warranty process. Owners are advised to contact their local authorized Kohler Dealer to perform warranty service as soon as a problem arises. The warranty repairs should be completed by the authorized Kohler Dealer as expeditiously as possible.

EXCLUSIONS

This warranty does not cover:

- **This warranty shall only apply** to KOHLER Co. engines.
- Malfunctions in any part caused by abuse, misuse, alterations, tampering, disconnection, or improper or inadequate maintenance.
- Attachments, accessories or components not supplied or approved by Kohler.
- Damage resulting from fire, accident, negligence, act of God or other events beyond the control of Kohler.
- Consequential damage such as loss of use of the engine or equipment powered by the engine, towing, machine transportation, loss of time, downtime, inconvenience, telephone, travel, lodging, or any other indirect or direct damage.
- Loss or damage to personal property, loss of revenue, commercial loss or any other matters not specifically included in this warranty statement.
- Any warranted part that was required to be previously replaced as part of required scheduled maintenance.
- Owner's unreasonable delay in making the equipment available after being notified of a potential product problem.
- Engines installed outside United States of America.

This warranty is in addition to the Kohler Standard Warranty and any extended warranty (if applicable) for the equipment and engine involved. Remedies under this warranty are limited to the provisions as specified in this warranty statement.

IN NO EVENT SHALL KOHLER, ITS COMPONENT SUPPLIERS NOR THE SELLING DEALER BE LIABLE FOR ANY DELAY, WORK STOPPAGE, LOSS OF USE OF EQUIPMENT, LOSS OF TIME, INCONVENIENCE, LOSS OF PROFITS, OR ANY INDIRECT, INCIDENTAL, SPECIAL, OR CONSEQUENTIAL DAMAGES RESULTING FROM OR ATTRIBUTABLE TO, DEFECTS IN KOHLER PRODUCTS OR SERVICE, WHETHER RESULTING FROM NEGLIGENCE (INCLUDING GROSS NEGLIGENCE) OR OTHER TORT WARRANTY, CONTRACT, INDEMNITY, BREACH OF THE PROMISE TO REPAIR OR REPLACE CONTAINED HEREIN, STRICT LIABILITY OR OTHERWISE.

IN ADDITION, KOHLER, ITS COMPONENT SUPPLIERS AND THE SELLING DEALER SHALL NOT BE LIABLE IN TORT OR STRICT LIABILITY FOR ANY ECONOMIC LOSS RESULTING, IN WHOLE OR IN PART, FROM THE MANUFACTURE OR SUPPLY OF THE PRODUCT, PARTS, COMPONENTS AND/OR LABOR.

NOTWITHSTANDING ANYTHING IN THIS WARRANTY TO THE CONTRARY, THE MAXIMUM LIABILITY, IF ANY, OF KOHLER, ITS COMPONENT SUPPLIERS AND THE SELLING DEALER FOR

ALL DIRECT DAMAGES SHALL NOT EXCEED THE PRICE OF THE PARTICULAR DEFECTIVE PRODUCT, PART OR SERVICE, AS APPLICABLE.

THE STANDARD WARRANTY, THE EMISSION CONTROL WARRANTIES, AND THE EXTENDED LIMITED MACHINE AND POWERTRAIN WARRANTIES, IF APPLICABLE, ARE THE ONLY WARRANTIES APPLICABLE TO KOHLER PRODUCTS AND COMPONENTS USED IN KOHLER PRODUCTS AND ARE EXPRESSLY IN LIEU OF ANY WARRANTIES OR CONDITIONS OTHERWISE IMPLIED BY LAW (INCLUDING ANY WARRANTY OTHERWISE IMPLIED BY LAW FOR THE PRODUCT BY THE MANUFACTURER OR ITS COMPONENT SUPPLIERS), INCLUDING, BUT NOT LIMITED TO, IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE AND IS NOT A WARRANTY OF FUTURE PERFORMANCE.

THE REMEDIES UNDER THIS WARRANTY SHALL BE THE ONLY REMEDIES AVAILABLE TO THE OWNER OF KOHLER PRODUCTS OR ANY OTHER PERSON, AND NEITHER KOHLER NOR THE SELLING DEALER ASSUMES ANY OTHER OBLIGATION OR RESPONSIBILITY WITH RESPECT TO THE CONDITION OF KOHLER PRODUCTS, AND AUTHORIZES NO OTHER PERSON TO ASSUME FOR ANY OF THEM, ANY OTHER OBLIGATION OR LIABILITY.

Kohler reserves the right to make changes in design or add any improvements on its products at any time without incurring any obligation to install same on units previously delivered.

If the original owner sells the engine and machine, the remaining period of this warranty shall be transferred to the new owner.

“Kohler” means both Kohler Co. and its Affiliates, d/b/a Kohler Power Systems.

Kohler request that each owner of the engine and machine complete and provide the following requested information, sign in the space indicated, retain a completed and signed copy of this statement for the owner’s records, and return a completed and signed copy of this statement to Kohler. Failure to complete, sign, or return this form will not affect any owner’s rights or Kohler’s obligations under this warranty statement and will not result in denial of warranty coverage by Kohler.

| | |
|--|---|
| MODEL: _____ | PIN (Prod. Id. No.): _____ |
| NAME OF DEALER | NAME OF OWNER |
| SIGNATURE OF AUTHORIZED REPRESENTATIVE OF DEALER | SIGNATURE OF AUTHORIZED REPRESENTATIVE OF OWNER |
| CITY / STATE / ZIP CODE OF DEALER | CITY / STATE / ZIP CODE OF OWNER |
| DATE MACHINE PLACED INTO SERVICE | |

This Emission Control Warranty Statement is applicable to KD18L06, KD27V12, KD36V16, KD45V20, KD62V12, KD83V16 and KD103V20 Engines



Revision history

| Version | Author | Modification | Date |
|---------|--------------------------------|--|---------|
| 000 | TB12 - Technical documentation | Initial release | 2020-04 |
| 001 | TB12 - Technical documentation | According to development and improvement | 2020-12 |
| 002 | TB12 - Technical documentation | HVO introduction According to development and improvement | 2022-09 |



Preface

About this document

This Operation and Maintenance Manual (OMM) has been written for the diesel engine **operator** and **maintenance personnel**.

This OMM provides information regarding:

- **Safety Regulations**
- **Handling and operation**
- **Maintenance**

Anyone involved in working with or on the diesel engine must read and follow the instructions in the OMM carefully before the first commissioning and at regular intervals.

Work with the diesel engine includes :

- **Handling**, storing of the components.
- **Servicing**, including inspections and preventive maintenance.



Information

- ▶ For any information concerning the machinery in which the engine is mounted, refer to the instructions of the generator set.
 - ▶ For further explanation or information, the Customer Service and Customer Service training center departments of the Kohler Co. are available any time to answer any queries.
-

The OMM facilitates the operator's familiarization with the diesel engine and prevents faults through incorrect operation.

The machinery owner is responsible for supplementing the operating instructions of the engine with its machinery and with instructions based on existing national regulations on accident prevention and environmental protection. In addition to these operating instructions and the regulations on accident prevention applicable in the user's country and at the place of use, it is also necessary to comply with the recognized technical rules on safety and technically proficient working.

Some sections of this operating manual do not apply to all engines.

Some illustrations in this manual may show details and implements that are different from your engine.

Protective devices and covers have been removed to provide a clearer representation in some illustrations.

KOHLER engines are subject to continuous development and improvement.

This may result in modifications to your engine which may not be referred to in this OMM.

If you require further explanations or information, please contact your nearest authorized Kohler service representative.

Spare parts

Only original KOHLER spare parts, or spare parts purchased by Kohler Co. should be used for repairing KOHLER Diesel engines.

Kohler Co. will declare all possible undertakings carried out by Kohler Co. and/or their dealers, such as guarantees, service orders, etc. null and void without advance notice, if spare parts other than original KOHLER spare parts or spare parts purchased by Kohler Co. are used for maintenance or repair.

Fuels, lubricants and coolants

Only fuels, lubricants and coolants approved by Kohler Co. may be used for the operation of KOHLER Diesel engines.

Kohler Co. will declare all possible undertakings carried out by Kohler Co. and/or their dealers, such as guarantees, service orders, etc. null and void without advance notice, if fuel, lubricants and coolants other than fuel, lubricants and coolants approved by Kohler Co. are used for maintenance or repair.

Liability and warranty

Due to the wide variety of products offered by other manufacturers (e.g. service products, lubricants, tool attachments and spare parts), Kohler Co. cannot examine the general suitability and absence of defects in third-party products which are used in or on KOHLER products. The same applies to possible interactions between third-party products and products approved by Kohler Co.

Third-party products are used in or on KOHLER engines at the user's own discretion. Kohler Co. does not offer any warranty or accept any liability for losses of any kind caused by failures of or damage to KOHLER engines attributable to the use of third-party products.

Furthermore, Kohler Co. will not recognize any warranty claims attributable to incorrect operation, inadequate or insufficient maintenance or use of unapproved operating fluids or non-compliance with safety regulations.

Kohler Co. will cancel any obligations entered into by Kohler Co. and/or its dealers, such as guarantees, service contracts etc., without advance notice if any parts other than original KOHLER parts or spare parts purchased from Kohler Co. are used for maintenance and repairs.

The aforementioned provisions do not extend the warranty and liability conditions in the general terms and conditions of business of Kohler Co.

Modifications, conditions, copyright

Kohler Co. reserves the right to make modifications in the course of technical development, without issuing prior notification.

The aforementioned provisions do not extend the warranty and liability conditions in the general terms and conditions of business of Kohler Co..

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1 Product description

1.1 Technical description

1.1.1 Design overview

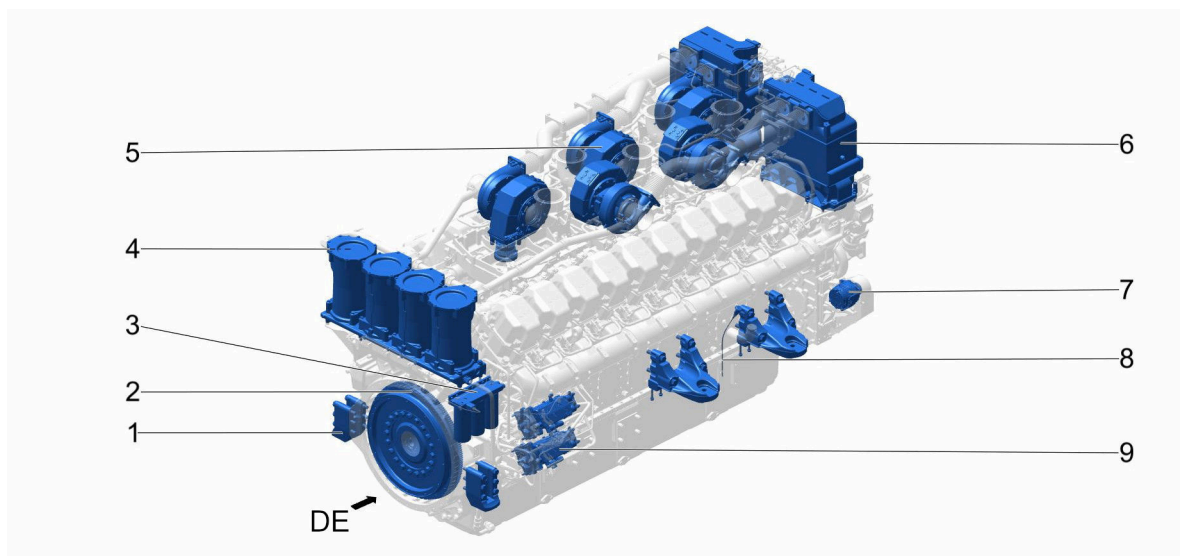


Fig. 1: Diesel engine / view from the driving end

| | | | |
|-----------|----------------------------------|----------|-----------------------------------|
| DE | Driving end | 5 | Exhaust gas turbocharger assembly |
| 1 | Diesel engine brackets | 6 | Charge air cooler |
| 2 | Flywheel | 7 | Battery charging alternator |
| 3 | Fuel filter | 8 | Oil dipstick |
| 4 | Crankcase breather system filter | 9 | High-pressure fuel pump |

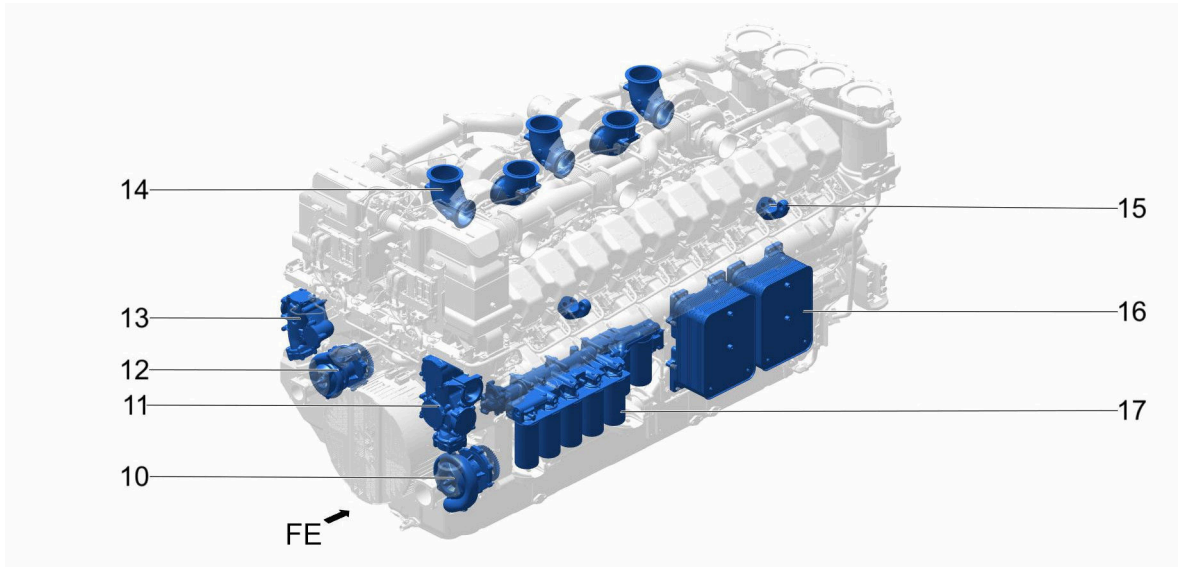


Fig. 2: Diesel engine / view from the free end

- | | | | |
|-----------|-------------------------------------|-----------|---|
| FE | Free end | 14 | Exhaust gas connection |
| 10 | High-temperature coolant pump | 15 | Lifting lug |
| 11 | High-temperature thermostat housing | 16 | Oil cooler |
| 12 | Low-temperature coolant pump | 17 | Oil filter cartridge (lubrication system) |
| 13 | Low-temperature thermostat housing | | |

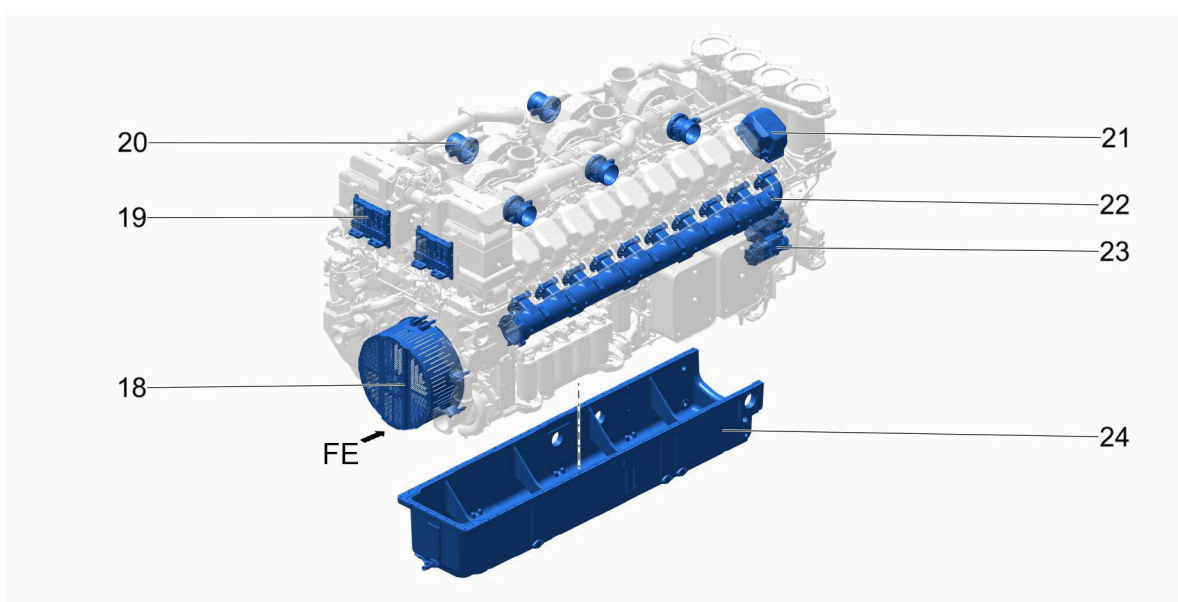


Fig. 3: Diesel engine / view from the free end

- | | | | |
|-----------|----------------------------------|-----------|---------------------|
| FE | Free end | 21 | Cylinder head cover |
| 18 | Torsional vibration damper cover | 22 | Air intake line |
| 19 | Engine control unit - ECU | 23 | Starter |
| 20 | Air intake | 24 | Oil pan |

Design

The diesel engine is designed as a water-cooled engine with common rail fuel injection system, exhaust gas turbo charging, and air to coolant charge air cooling.

Characteristics

A robust basic design and generous dimensioning form the basis for high operational safety and a long service life. Fuel consumption and exhaust gas emissions are lowered due to an optimized combustion process adapted to the emission requirements. Minimized maintenance obtained by optimized engine components and accessories leads to higher availability and increased efficiency.

Driving gear

The engine has a quench tempered steel crankshaft with inductively hardened pins and fillets. A torsional vibration damper is mounted on the crankshaft on the engine damper side. Motion transfer is ensured by precisely forged con-rods, complete with sputtered driving gear bearings. The steel brazed pistons benefit from stage support and cooling duct.

Housing

The rigid, laterally drawn down crankcase has an upper section with optimized structure and an oil pan as lower section. Four-valve single cylinder heads benefit from flow optimized ports as well as replaceable valve seats and valve guide. Brackets, flywheel housing, aggregate support, and oil pan on the bottom close the engine.

Drive control

Two inlet and outlet valves are mounted in the cylinder head for each cylinder. The valves are actuated through steel camshaft via cam follower, push rod and rocker arm.

Driven by gear train on the flywheel side:

- Camshaft
- Fuel high pressure pump
- Fuel prefeed pump
- Oil pump

Driven by gear train on the damper side:

- Coolant pumps
- Battery charging alternator
- Air conditioning compressor (depending on application)
- Air compressor (depending on application)

Lubrication

An engine oil pump ensures force-feed lubrication of bearings (crankshaft, con-rods, camshaft, gears), bushings (piston pins), cam followers, and rocker arms.

Oil filtration depends on requirements.

The following auxiliary units are also connected to the engine oil circuit:

- Fuel high pressure pump(s)
- Coolant pumps
- Turbochargers
- Air compressor (depending on application)

Crankcase ventilation

As modular arrangement depending on requirements, up to four high efficiency passive filter units are mounted on top of the engine.

The blow by gases leaving the filter system are fed back to the turbocharger intake by pipes made of galvanized steel.

Oil sampling location

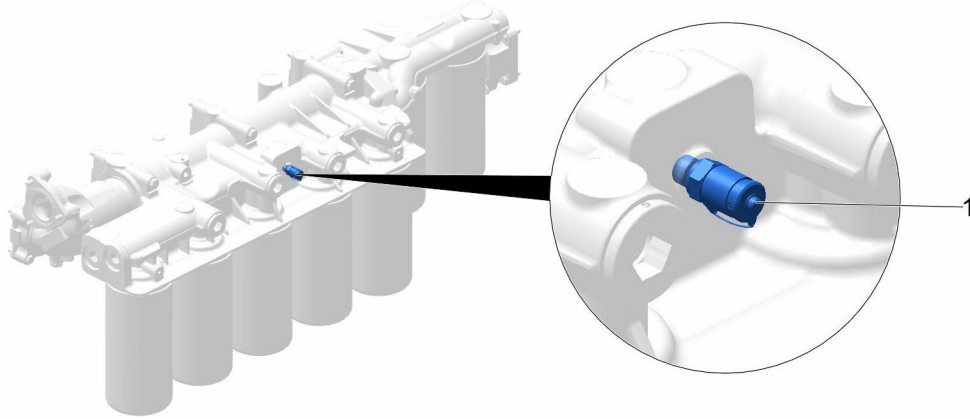


Fig. 4: Oil sampling point on engine left side

1 Sampling point

See the Application Set manual for more details.

High/low temperatures cooling systems

The coolant is thermostatically controlled with separate pumps for high and low temperature.

Each cylinder is individually supplied via distribution channels cast into the crankcase.

Pistons are cooled by the engine lubricating system. Each piston is supplied with oil by piston cooling jets.

Fuel filters

Depending on requirements, several filter combinations such as pre-filter unit or working filter ensure the fuel conditioning.

Therefore a high contamination retention capacity between tank and engine is ensured.

Injection system

The high pressure fuel system is supplied by a high pressure pump.

The low pressure system is supplied by the fuel pre-feed pump which ensures the circulation from the tank and pre-feeds the high pressure system.

The high pressure system leads the pressurized fuel from high pressure pump to the injectors.

The high pressure system is secured by a pressure control valve.

Electronic Control System



Information

To connect the interfaces, refer to the "Electrical Installation Guideline" of your engine application and generation.

The information on the engine control unit nameplate corresponds to the delivery status. Depending on software updates in the field, it may be the case that this information is no longer up to date.

The real information can be viewed in the device display or read out with the diagnosis and service tool KoDIA.

The engine control system consists of a programmable engine control unit.

The ECU controls the actuators and reads values from the sensors to ensure optimal engine performance.

The ECU is programmed according to configuration and application. Mappable parameters among others are:

- Maximum RPM
- Cooling temperature correction
- Transient fueling

The diagnosis and service tool KoDIA provides several functions including:

- General information
- Status overview
- Configuration adjustment
- Error list information
- Process data list
- Oscilloscope
- Direct triggering
- Main values display
- CRS visualization and operation
- Long-term error memory
- Fault reactions

Engine electronic sensors

The engine sensors are interfaces for external monitoring of the following parameters:

- Charge air pressure
- Fuel pressure
- Rail pressure
- Oil pressure
- Coolant temperature
- Charge air temperature
- Engine speed and position

The engine actuators are interfaces for the following control functions:

- Starters
- Volume control valve
- Pressure control valve
- Injectors

The individual functions and error messages are described in the instructions manual of the manufacturer's machinery.

1.1.2 Conventions

Cylinder designation, direction of rotation, firing sequence

In this manual, all locations and directions shown on the diesel engine are compliant with ISO 1204 in its English version.

Cylinder A1 and cylinder B1 are located on the driving end of the diesel engine. Direction of rotation is counterclockwise, as seen from the driving end of the diesel engine.

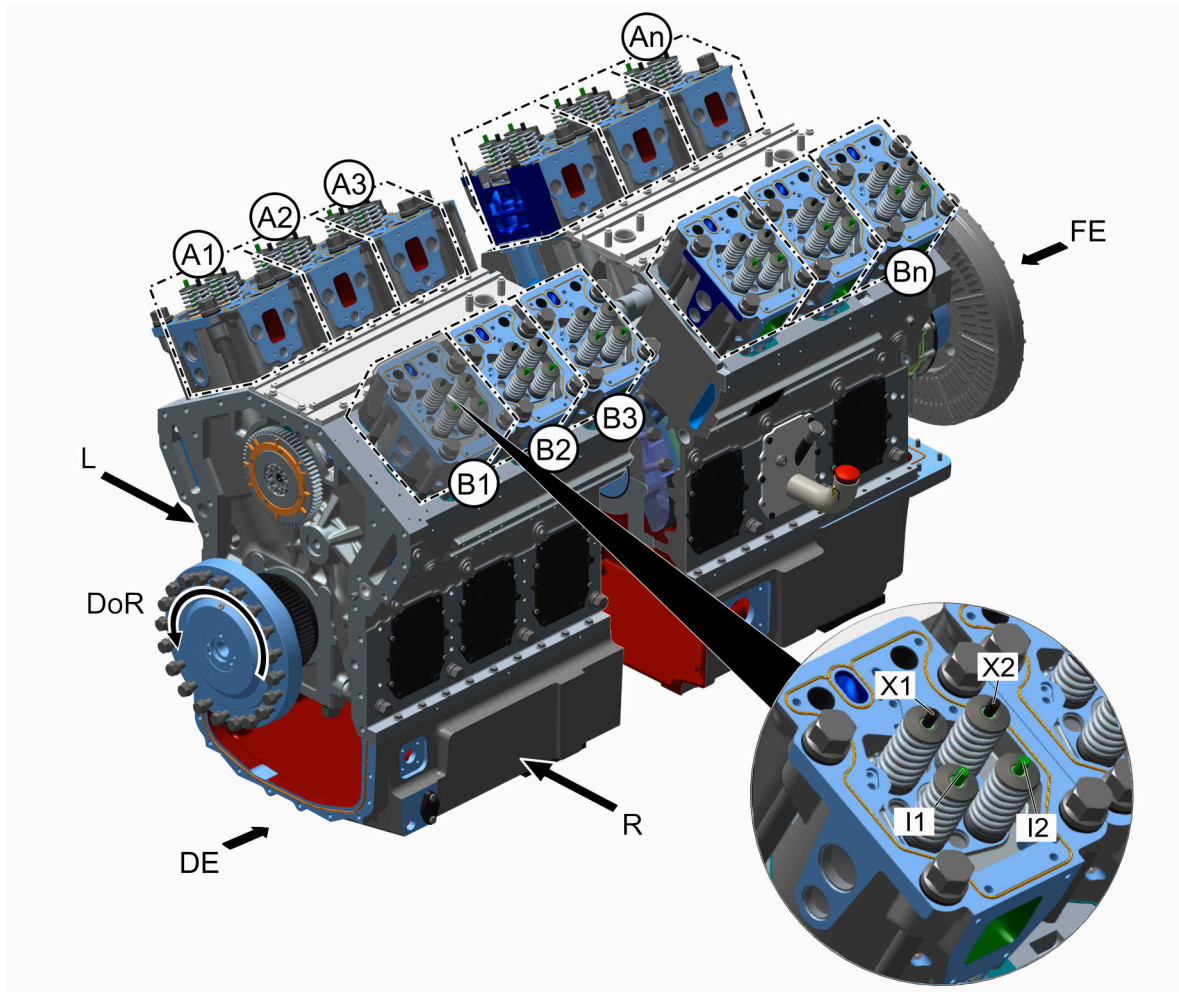


Fig. 5: Cylinder designation - direction of rotation according to ISO 1204

A1-An Series of cylinders – Bank A
B1-Bn Series of cylinders – Bank B
DE Driving end
FE Free end
DoR Direction of rotation

X Exhaust valves
I Intake valves
L Left engine side
R Right engine side

Firing sequence: A1-A6-B2-B10-A2-A10-B7-B9-A7-A9-B8-B4-A8-A4-B5-B3-A5-A3-B1-B6

1.1.3 Engine or component identification

Type designation

| Designation | | | | | | | | | | Description |
|-------------|---|-----|---|----|---|---|---|---|---|--|
| K | D | 103 | V | 20 | - | 5 | A | F | C | Engine type description |
| K | | | | | | | | | | Engine manufacturer |
| | D | | | | | | | | | Fuel type (D=Diesel) |
| | | 103 | | | | | | | | Total displacement in liter |
| | | | V | | | | | | | Cylinder configuration |
| | | | | 20 | | | | | | Number of cylinders |
| | | | | | | 5 | | | | Frequency. 5=50Hz; 6=60Hz |
| | | | | | | | A | | | Power level. A=power level designation, where A= the lowest power level, B=next higher power level, C=next higher power level... |
| | | | | | | | | F | | Emissions or fuel optimization. F=Fuel Optimized, E=Emissions Optimized |
| | | | | | | | | | C | Application. C=COP; P=Prime; S=Stand by; D=Data center |

Tab. 1: Engine type description

Diesel engine nameplate

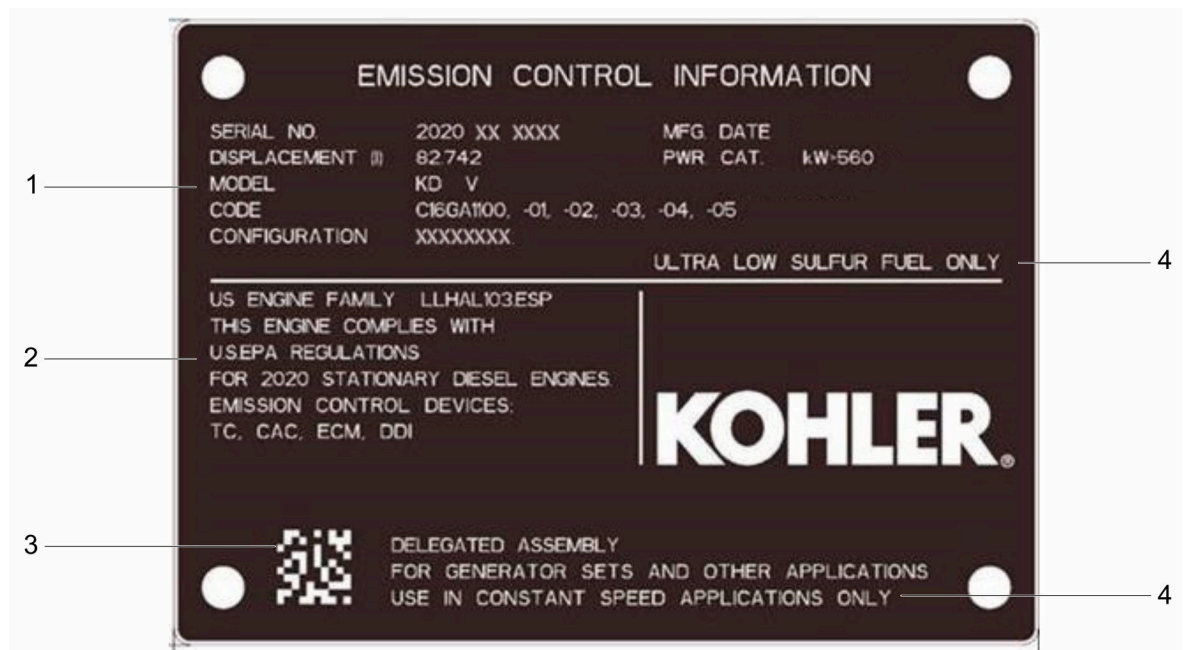


Fig. 6: Engine nameplate

- 1 Engine main values
- 2 USA regulations references
- 3 QR code area
- 4 Notes regarding emissions exemptions, fuel, and application types

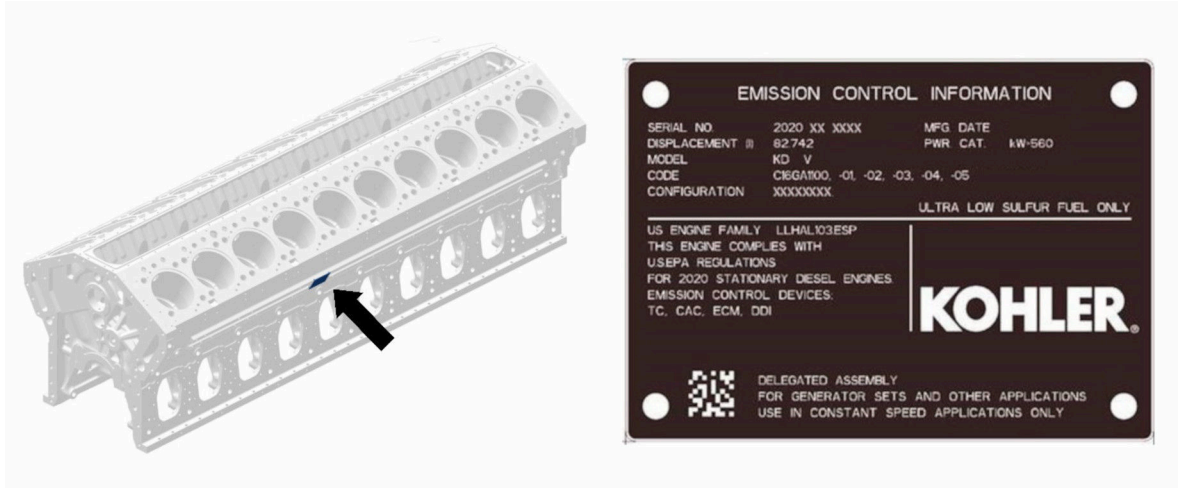


Fig. 7: Engine nameplate location

Engine serial number

The engine serial number is stamped onto the engine nameplate.

| Designation | | | Description |
|-------------|----|------|--|
| 20## | 73 | 0001 | Engine serial number |
| 20## | | | Year of manufacture |
| | 73 | | Engine type code (73- KD62V12) (74- KD83V16) (75- KD103V20) |
| | | 0001 | Incremental production number |

Tab. 2: Engine serial number



Fig. 8: Serial number on nameplate

1 Serial number

Engine control nameplates



Information

- ▶ The information on the engine control unit nameplate corresponds to the delivery status. Depending on software updates in the field, it may be the case that this information is no longer up to date.
- ▶ The real information can be viewed in the device display or read out with the diagnosis and service tool KoDIA.

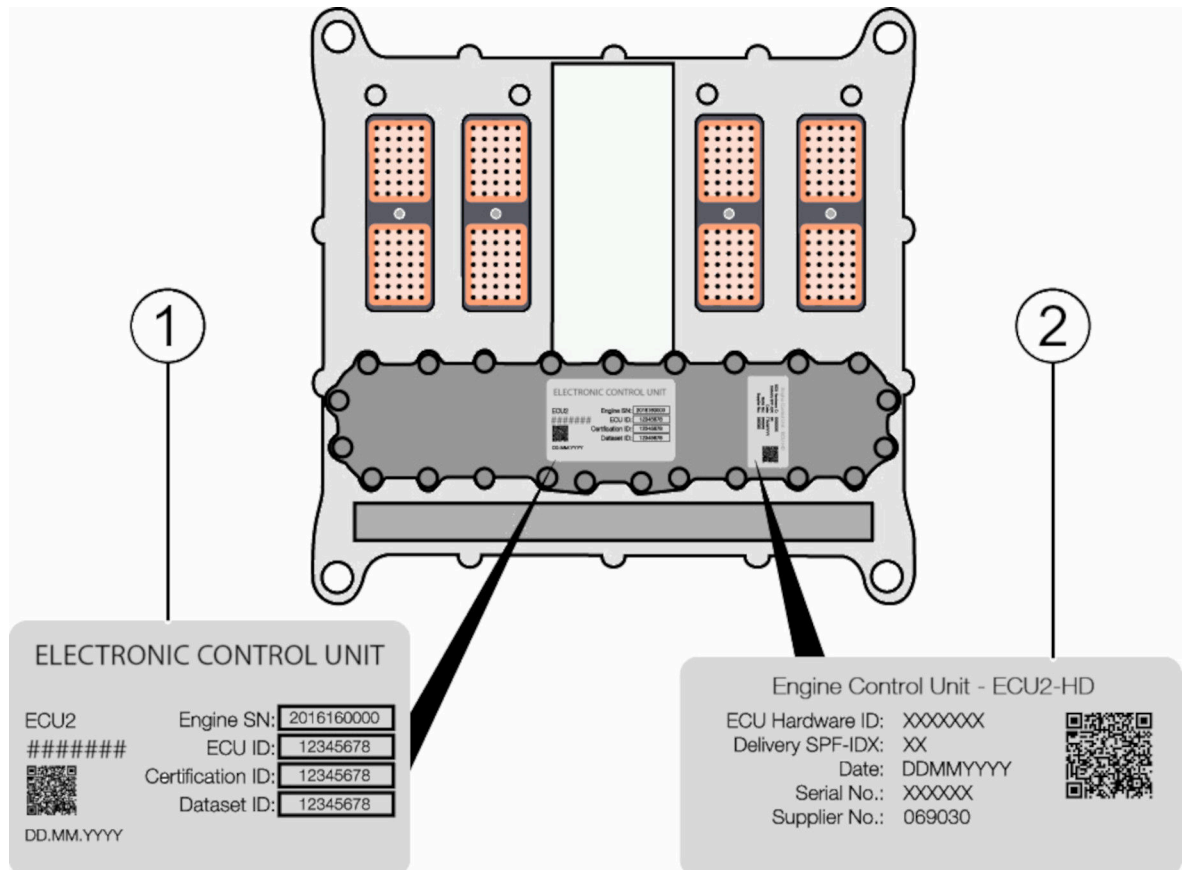


Fig. 9: Engine control unit nameplates location

1 Software nameplate

2 Hardware nameplate

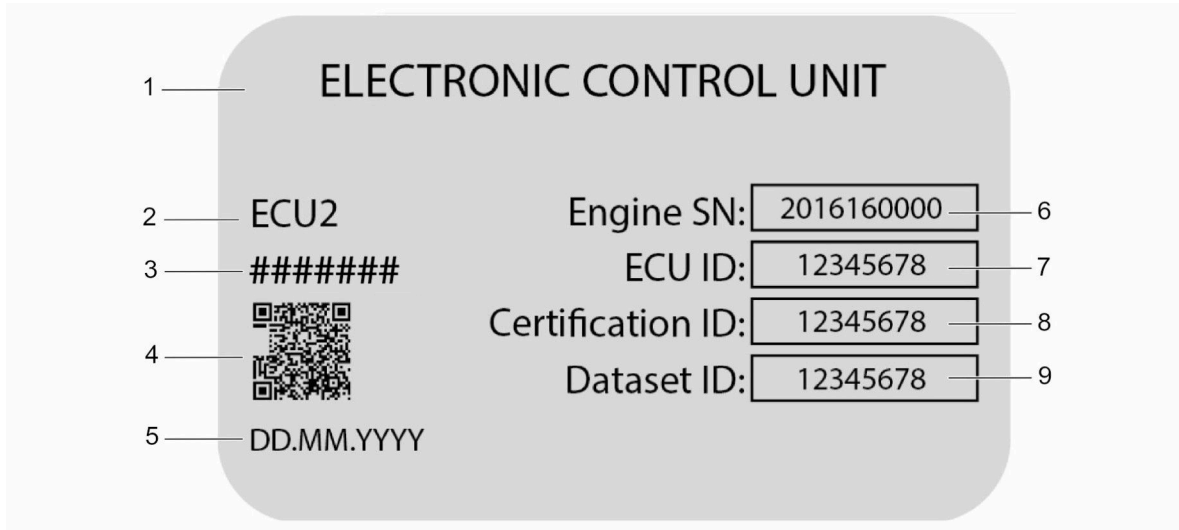


Fig. 10: Software nameplate

- | | | | |
|----------|---------------------|----------|-------------------------------|
| 1 | Product designation | 6 | Engine serial number |
| 2 | Product type | 7 | Engine control unit ID number |
| 3 | Engine designation | 8 | Certification ID number |
| 4 | QR Code | 9 | Data set ID number |
| 5 | Delivery date | | |

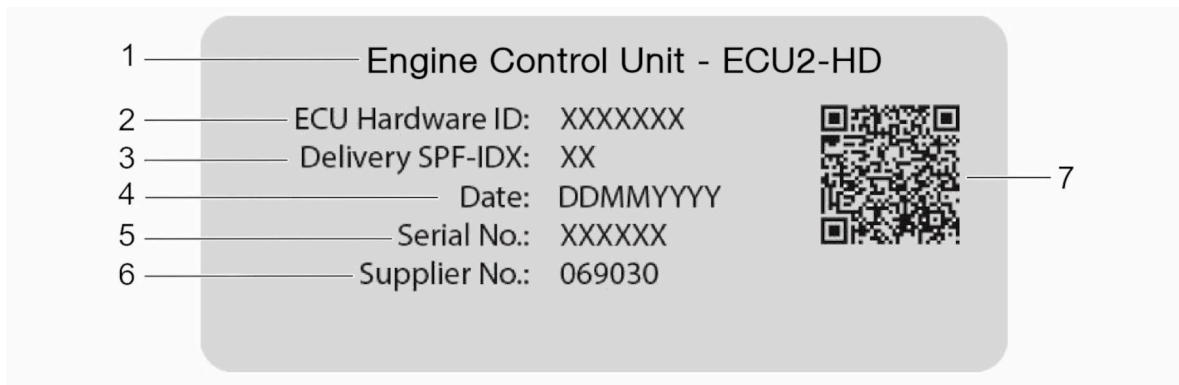


Fig. 11: Hardware nameplate

- | | | | |
|----------|-------------------------------|----------|-----------------|
| 1 | Product designation | 5 | Serial number |
| 2 | Engine control unit ID number | 6 | Supplier number |
| 3 | Hardware version | 7 | QR Code |
| 4 | Delivery date | | |

1.1.4 Diesel engine accessory equipment



Information

For more information about the accessories attached on auxiliary drives and their respective range of use of engine, contact your nearest authorized Kohler service representative.

Battery charging alternator

The engine is equipped with a battery charging alternator.

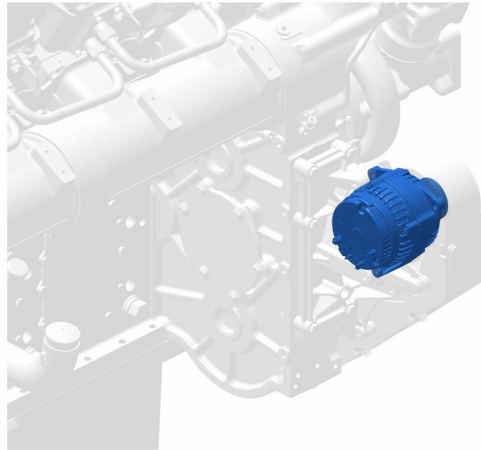


Fig. 12: Battery charging alternator

Retrofitting preheating devices



Information

For the connections dimensions provided, contact your nearest authorized Kohler service representative.

The interfaces for retrofitting preheating devices such as coolant, fuel and Diesel engine oil have already been integrated.

Battery charging alternator cover

Technical solution

The battery charging alternator cover is a protective device fitted directly behind the battery charging alternator. It ensures a global protection to the alternator environment while the engine is running.

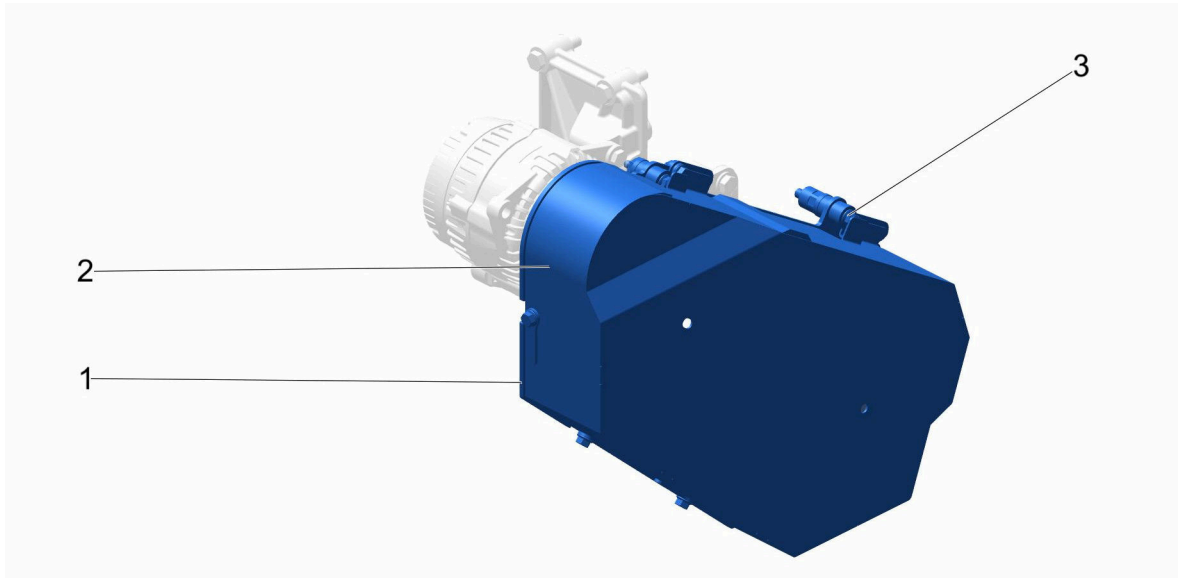


Fig. 13: Task overview

- 1 Cover - back side
- 2 Cover - front side

- 3 Captive screw (M8)

Features

- Protection device ensuring isolation of moving parts
- Adapted fastening points
- Captive screws technology to avoid fastener loss
- Ease of (dis)-assembly, free of maintenance
- Additional solution to fulfill the machine compliance with the applicable regulations

Cover of torsional vibration damper



Information

The design of the cover depends on the application.

Technical solution

The cover of torsional vibration damper is a protective device fitted directly onto the front end of the engine. It ensures an overall protection to the torsional vibration damper environment while the engine is running.

1.2 Technical data

1.2.1 Diesel engine

| Designation | Value |
|---|--------------------|
| Cylinder configuration | V-Diesel Engine |
| Number of cylinders | 20 |
| Bore | 175 mm 6.89 in |
| Stroke | 215 mm 8.46 in |
| Displacement | 103 l 27.21 gal |
| Compression ratio | 16 |
| Direction of rotation of the diesel engine (seen from flywheel) | Counterclockwise |
| Power specification as per | ISO 3046-1 |
| Rated power | See nameplate |
| Rated speed | See nameplate |
| Emission control information | See nameplate |
| Flywheel housing connection | SAE 00 |

Tab. 3: Technical data table – diesel engine

1.2.2 Cylinder head

| Designation | Value |
|-------------------------------|-------------------|
| Inlet valve clearance, cold | 0.5 mm 0.02 in |
| Exhaust valve clearance, cold | 1 mm 0.04 in |

Tab. 4: Technical data table – cylinder head

1.2.3 Coolant thermostat

| Designation | Value | |
|----------------------------------|-----------------|-----------------|
| Low Temperature (LT) Thermostat | Opening start | 45 °C 113 °F |
| | Completely open | 57 °C 135 °F |
| High Temperature (HT) Thermostat | Opening start | 71 °C 160 °F |

| Designation | | Value |
|-------------|-----------------|-----------------|
| | Completely open | 81 °C 178 °F |

Tab. 5: Technical data table – coolant thermostat

1.2.4 Battery charging alternator

| Designation | Value |
|-------------|-------|
| Voltage | 28 V |
| Current | 140 A |

Tab. 6: Technical data table – battery charging alternator

1.2.5 Starter

| Designation | Value |
|-------------------|-------|
| Voltage | 24 V |
| Power per starter | 9 kW |

Tab. 7: Technical data table – starter




Information

In standard configuration, two starters are installed.

2 Safety

2.1 Identification of the warnings




2.1.1 Warnings

| | |
|---|--|
|  | This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injuries or death. |
|---|--|

Tab. 8: Example of warning

The safety alert symbol always appears in connection with one of the signal words:

- **DANGER**
- **WARNING**
- **CAUTION**

| | | |
|---|----------------|---|
|  | DANGER | Indicates a hazardous situation that, if not avoided, will result in death or serious injury. |
|  | WARNING | Indicates a hazardous situation that, if not avoided, could result in death or serious injury. |
|  | CAUTION | Indicates a hazardous situation that, if not avoided, could result in minor or moderate injury. |

Tab. 9: Warning signs


The **NOTICE** signal word indicates a risk not related to personal injury.






The risks of engine failure are classified according to ISO 2710-2:

- Critical failure: that may cause engine scrap or breaking the laws or regulations
- Major failure: that causes remarkable degradation of engine performance or operating fault of main components, and cannot be repaired by replacing the part with spare with common tools in a short time
- Minor failure: that affects the performance of the engine, but does not cause operating fault of main components, and can be repaired by replacing the part with spare with common tools, usually in a short time

The short time is generally 30 minutes.

2.1.2 Additional identifications

| | | |
|---|-------------|------------------------------------|
|  | Note | Indicates helpful advice and tips. |
|---|-------------|------------------------------------|

| | | |
|---|---------------------|--|
|  | Precondition | Identifies a condition that must be fulfilled in order to be able to carry out the actions subsequently described. |
|  | Action | Identifies an action which has to be carried out. |
|  | Result | Identifies the result of an action. |
|  | Listing | Identifies a listing. |
|  | Torque value | Identifies special tightening torque or specification. |

Tab. 10: Additional symbols

2.1.3 Additional rules and directives

Follow these instructions and observe any additional or local rules and directives.

Note the following points:

- Safety regulations applicable on site
- Guidelines provided by professional associations

2.2 Target audience

2.2.1 Responsibility of machinery owner



Information

The machinery owner is responsible for the following:

- ▶ Checking the knowledge and skills of the personnel
- ▶ Establishing the required additional, refresher, and further training
- ▶ Establishing the responsibilities and authorizations
- ▶ Applying the ILO – “C138 - Minimum Age Convention, 1973” with a minimum age for admission to employment of 14 years
- ▶ Supplying the required tools and spare parts



Information

The Customer Service training center departments of the Kohler Co. provides several training programs.

Please contact your nearest authorized Kohler service representative for queries.

2.2.2 Recommended occupations according to International standards

The international standard classification of occupations (ISCO-08) of the International Labor Office (ILO) determines occupational unit groups. The following groups are listed as references to define the target groups, occupations, and joint tasks.

The listed skill levels and occupation unit groups perform the following work in accordance with the "General safety instructions" chapter ([For more information see: 2.5.1 General safety instructions, page 38.](#)) :

- Main tasks described in this manual or these instructions
- Tasks identified as requirements to prepare the main tasks

ILO - Skill level

Skill level 2 definition

Occupations at skill level 2 involve the performance of the following tasks:

- Operating machinery and electronic equipment
- Driving vehicles
- Maintaining and repairing electrical and mechanical equipment
- Using, managing, and storing information

The following abilities are essential:

- Many occupations at this skill level require relatively advanced literacy and numeracy skills, good interpersonal communication skills, and a high level of manual dexterity.

The following education levels are essential:

- The knowledge and skills are obtained through completion of the first stage of secondary education (ISCED-97 Level 2).
- Some occupations require the completion of the second stage of secondary education (ISCED-97 Level 3), which may include a significant component of specialized vocational education and on-the-job training.

- Some occupations require the completion of vocation-specific education undertaken after completion of secondary education (ISCED-97 Level 4). In some cases, experience and on-the-job training may substitute for the normal education.

Skill level 3 definition

Occupations at skill level 3 involve the performance of the following tasks:

- Ensuring compliance with health, safety and related regulations
 - Preparing detailed estimates of quantities and costs of materials and labour required for specific projects
 - Coordinating, supervising, controlling, and scheduling the activities of other workers
 - Performing technical functions in support of professionals

The following abilities are essential:

- Many occupations at this skill level require high level of literacy and numeracy skills and well-developed interpersonal communication skills.

The following education levels are essential:

- The knowledge and skills are obtained as the result of study at a higher educational institution for a period of 1 to 3 years following completion of secondary education (ISCED-97 Level 5b). In some cases, extensive relevant work experience and prolonged on-the-job training may substitute for the formal education.

ILO - Occupations unit groups

For operation and SLO maintenance: Power Production Plant Operator - unit group 3131 / ISCED-97 level 2 to 4

Skill level 2 required.

Power production plant operators operate, monitor, and maintain switchboards and related equipment in electrical control centers, which control the production and distribution of electrical power-generating stations.

Tasks include:

- Operating, monitoring and inspecting power plants
- Operating and controlling power-generating systems and equipment
- Controlling start-up and shut-down of power plant equipment
- Controlling switching operations, regulating coolant levels
- Communicating with systems operators to regulate and coordinate transmission loads, frequency and line voltages
- Taking readings from charts, meters and gauges at established intervals, troubleshooting and performing corrective action as necessary
- Completing and maintaining station records, logs and reports, and communicating with other plant personnel to assess equipment operating status
- Cleaning and maintaining equipment such as generators, pumps, and compressors in order to prevent equipment failure or deterioration

For SL1 maintenance: Agricultural and Industrial Machinery Mechanics and Repairers – Unit group 7233 / ISCED-97 level 2

Skill level 2 required.

Agricultural and industrial machinery mechanics and repairers fit, install, examine, service and repair engines, agricultural and industrial machinery and mechanical equipment, except motor vehicle, aircraft, and electric motors.

Tasks include:

- Fitting, installing, examining, servicing, and repairing engines, machinery, and mechanical equipment

- Oiling and greasing stationary engines and machinery
- Inspecting and testing new machinery and mechanical equipment for conformity with standards and specifications
- Disassembling machinery and equipment to remove parts and make repairs
- Examining parts for defects such as breakage and excessive wear
- Operating newly repaired machinery and equipment to verify the adequacy of repairs
- Recording repairs and maintenance performed

For SL2 to SL3 maintenance: Agricultural and Industrial Machinery Mechanics and Repairers – Unit group 7233 / ISCED-97 level 3 to 4

Skill level 3 required.

Agricultural and industrial machinery mechanics and repairers fit, install, examine, service and repair engines, agricultural and industrial machinery and mechanical equipment, except motor vehicle, aircraft, and electric motors.

Tasks include:

- Fitting, installing, examining, servicing, and repairing engines, machinery, and mechanical equipment
- Oiling and greasing stationary engines and machinery
- Inspecting and testing new machinery and mechanical equipment for conformity with standards and specifications
- Disassembling machinery and equipment to remove parts and make repairs
- Examining parts for defects such as breakage and excessive wear
- Operating newly repaired machinery and equipment to verify the adequacy of repairs
- Recording repairs and maintenance performed

2.2.3 Unauthorized personnel - servicing

All other persons, including operators, supervisors and trainees, are classified as "unauthorized personnel" for maintenance work.

They are not allowed to service the engine or access the engine compartment or engine cover.

2.3 Intended use

The Diesel engines produced by Kohler Co. are partly completed machinery according to Machinery Directive 2006/42/EC Article 2 g (only for European Union).

The Kohler Co. products described in these instructions are intended for use according to the followings:

- The engines are intended to supply power to equipment (electric generator) and to equipment auxiliaries as specified by customer.
- The engines are intended for installation in machineries.
- Engines that are used in conjunction with alternators as emergency power generator must be firmly connected to the ground of the operation site. Appropriate mounting must be used to reduce the generated vibrations. This mounting must be released by Kohler Co.
- The engines may only be operated in faultless condition.
- The engines may be operated in closed rooms only with adequate ventilation. If additional fresh air is needed, open the doors and windows.
- The conditions prescribed by the manufacturer of the machinery in which the engine has been installed are also part of intended use.
- The engines must only be installed by personnel who have been trained and familiarized herewith and are aware of the dangers.

- Unauthorized changes on the engines or their components void the liability of Kohler Co. for any resulting property damage or personal injury.
- Interference with the injection and control system may influence the power and exhaust gas parameters of the engines, meaning that compliance with statutory environmental requirements is no longer assured.

Any other use above and beyond this is considered to be improper use. In this case, Kohler Co. is not liable for any damage. The risk is borne solely by the user.

2.4 Limitation of liability

The use of an engine under conditions or for purposes not intended by Kohler Co., but which can happen, induced by the engine in combination with, or as a result of, common human behavior, is considered as reasonably foreseeable misuse. It includes, but is not limited to the following:

- Drive of machinery not specified by the documentation.
- Overload of the engine
- Use of different applications and conditions rather than those specified
- Improper use of fuels, lubricants, starting aids and coolants
- Use of the engine manipulated overspeeds controls
- Modifications of the engine mounting and suspensions
- Lifting of the engine using unforeseen lifting points
- Continued use of the engine in emergency mode
- Operation of the engine with open engine cover
- Attachment of external cables and wires on Diesel engine cables and pipes
- Drawing of power from the damper side
- Unauthorized modifications to the engine

In the event that the above mentioned uses are undertaken in combination with the engine, the risk is borne entirely by the user and Kohler Co. is not liable.

NOTICE

Risk of engine failure.

Non-compliant installation according to installation plan and torque tightening values will lead to engine main failure (leakage in the charge air circuit, parts ejection, and others).

Mount any component according to:

- ▶ For the KOHLER application, the "Operation and Maintenance Manual" and its "Service and Repair Manual".
 - ▶ For non KOHLER components, refer to the "Instructions" or "Assembly Instructions" from the supplier.
-

2.5 Safety instructions

2.5.1 General safety instructions



DANGER

Failure to follow safety and hazard instructions will result in death or serious injury.
Death or serious injury by failure to follow safety and hazard prevention instructions.

- ▶ Follow and enforce the safety instructions according to this Operation and Maintenance Manual, the application set manual and local regulations.
-

**The machinery owner must apply following requirements:**

- Before receiving the engine, the responsibilities and the definition of the safe conditions have to be established by the machinery owner.
- Only trained and instructed operators expressly authorized to do so must install, operate, maintain or repair the engine and the machinery.
- Only allow operators who have been trained, instructed or are present for training purposes, to work on the engine or the machinery under constant supervision of an experienced supervisor.

Organization commitments for the machinery owner:

- The Operation and Maintenance Manual of the engine has to be at the operator's disposal until the commissioning of the machinery. Afterwards the Operation and Maintenance Manual has to be a part of operator's manual of the manufacturer of the machinery.
 - Familiarize yourself with the Operation and Maintenance Manual of the machinery before commissioning the machine.
 - Develop, document, implement, and enforce a safety and health program, adapted to the machinery and its environment, and comply with the local regulations or at least with the International Labour Organization Standards.
 - Make sure that operators are conscious of safety and hazards involved in their work and that they regularly check the Operation and Maintenance Manual of the machinery. This is especially to be repeated for the operators which occasionally operate the machinery.
-

NOTICE

Risk of engine failure by use of non-compliant operating fluids!
Use of non-compliant operating fluids will lead to engine main failure.

- ▶ Use only operating fluids tested and approved by Kohler Co.
-

NOTICE

Risk of engine failure by use of non-original spare parts!
The use of original spare parts guarantees the compliance with the technical requirements established by Kohler Co.

- ▶ Use only original spare parts approved by Kohler Co.
-

2.5.2 Safety while commissioning

Before initial operation, the owner must check that the installation complies with local regulations and instructions of the manufacturer of the application set.

Always ensure that:

- All installation, maintenance, and repair works are fulfilled.
- All loose parts and tools have been secured or removed, especially safety devices.
- Each operator has been properly trained and applies the local safety measures.

After start-up of the application set, make sure that all control, display, and warning devices are working.

2.5.3 Safety when starting



DANGER

Hazards by entanglement, trapping, ejection of parts or impact.
On starting and while operation, hazards by entanglement, trapping, impact by ejection of parts will result in death or serious injury.

- ▶ The engine shall not be started until the drive train has been connected to the flywheel.
- ▶ Ensure the integrity of the machine and the engine before starting.
- ▶ All openings must be closed and the safe conditions established by the manufacturer of the machinery must be fulfilled.
- ▶ Standing in the vicinity of the engine while starting or operating the manufacturer's machinery is forbidden.



DANGER

Crushing, ejection of parts or high-pressure fluid ejection hazards.
Fatal or serious injuries.

- ▶ Standing in the vicinity of the engine while starting or operating the machinery of the manufacturer is forbidden.
- ▶ Wear proper personal protective equipment.



WARNING

Hazards generated by exposure to environments temperatures.
Exposure to radiant heat sources in the engine compartment could result in death or serious injuries.

- ▶ The manufacturer of the machinery shall define the appropriate ventilation of the engine compartment.
- ▶ The manufacturer of the machinery shall define the appropriate insulation of the exhaust pipe and the engine compartment.
- ▶ Wear proper personal protective equipment.
- ▶ Wait until the environment of the engine and the engine itself have cooled down.



WARNING

Hazards due to high sound level.
Exposure to high sound level could result in death or serious injuries by hearing loss or other physiological disorders (e.g. loss of balance, loss of awareness).

- ▶ Wear proper personal protective equipment in the vicinity of the engine.
- ▶ Noise reduction systems adapted to the machinery should be designed by the manufacturer, to comply with the local regulations.



WARNING

Hazards generated by excessive vibrations.
Vibrations generated by the engine could result in death or serious injuries.

- ▶ Standing in the vicinity of the engine while starting or operating the equipment is forbidden.

**WARNING**

Hazards generated by materials and substances processed, used or exhausted by machinery for example.

Materials and substances processed, used or exhausted could result in death or serious injuries by intoxication or poisoning.

- ▶ The manufacturer of the machinery shall design and implement an adapted extraction system.
 - ▶ Wear proper personal protective equipment.
-

**DANGER**

Ejection of parts due to moving parts.

Fatal or serious injuries.

- ▶ Standing in the vicinity of the engine while starting or operating the manufacturer's machinery is forbidden.
 - ▶ Starter activation for service without engine start, e.g. for fuel injection system, must not operate longer than a maximum of 3 cycles lasting 30 seconds each, and with a minimum of 30 seconds between each starter activation.
 - ▶ Wear proper personal protective equipment.
-

NOTICE

Engine failure by non-compliant starting procedure.

- ▶ Unless otherwise instructed, start the engine according to the instructions in the instructions manual of the machinery.
 - ▶ Ensure that the engine is started after all display units and control devices have been checked.
 - ▶ Ensure that the engine is only running in an enclosed space and sufficient ventilation is available.
 - ▶ Ensure that all devices used to ensure evacuation of stagnant air and ensure air supply are functional.
-

**WARNING**

Ejection of parts and impact hazards by missing guards on rotating or drive system.

On starting and while operation, accessing to the engine could cause serious injury or death by ejection of parts and impact on human body.

- ▶ The manufacturer of the machinery shall observe and enforce the country-specific regulations regarding prevention of injuries and risks.
 - ▶ The manufacturer of the machinery shall define the appropriate guards according to the country-specific regulations regarding ergonomics-related hazards, for the entire life-cycle of the machinery.
 - ▶ Standing in the vicinity of the engine while starting or operating the machinery is forbidden.
 - ▶ Wear proper personal protective equipment.
-

2.6 Preventing injuries

2.6.1 Preventing bruising



WARNING

Hazards by moving parts.

Impacts by ejected objects coming into contact with moving parts could result in death or serious injuries and property damage.

- ▶ When the engine is running, avoid any contact with moving parts.
 - ▶ It is forbidden to throw any object into the engine while running.
-

2.6.2 Preventing burns



WARNING

Hazards by hot engine near operating temperature.

Any contact with hot surfaces could result in death or serious injuries by burns.

The engine control unit (ECU) is hot while operating the engine.

- ▶ Avoid any contact with the engine, parts carrying hot coolant or oil, the exhaust system, the turbocharger, the heat protection, the battery, the covers, and the ECU.
 - ▶ Proceed with the tasks on the engine only once the temperature has cooled down enough so that surfaces can be touched with bare hands.
-



WARNING

Hazards by ejection of operating fluids under pressure.

Ejection of operating fluids under pressure could result in death or serious injuries by burns.

- ▶ Check operating fluid levels only once the temperature has cooled down enough so that surfaces can be touched with bare hands.
 - ▶ Carefully open the cover in order to first reduce the excessive pressure.
-

2.6.3 Preventing fires and explosion hazards



DANGER

Fire or explosion by flammable and explosive lubricants and fuels.
Burns or explosion release will result in death or serious injury.

- ▶ Keep all caps and valves closed near the operating temperature.
- ▶ Avoid any contact of flammable and explosive operating fluids, gases or combustible materials with any hot surface or ignition source.
- ▶ Keep the engine clean and free from accumulation of dust and flammable liquids.
- ▶ Keep the insulation free of operating fluids contamination.
- ▶ Never release operating fluids while operating the engine.
- ▶ Check the electrical system. Immediately rectify all errors, such as loose connections and frayed cables.
- ▶ During refueling, switch off any additionally installed heater (optional).
- ▶ Lock out and tag out the engine prior to accessing to engine.
- ▶ Ensure a good ventilation while refueling or prior to accessing to the engine.
- ▶ Regularly check all lines, hoses and screw connections for leaks and damage. Immediately rectify the leaks and replace the damaged parts.
- ▶ Smoking and open flames are forbidden in the vicinity of the engine.
- ▶ Always start the engine according to the instructions in the instructions manual of the machinery.



DANGER

Fire or explosion by ignition of the air/gas mixture in the air intake, initiated by electrostatic charging from insulated mounting.
Burns or explosion release will result in death or serious injury.

- ▶ Ground every component potentially electrically insulated from the engine, especially the turbocharger.



Information

According to local regulations, the manufacturer of the specific application is responsible to design adapted fire protection system.



Information

Engines provided by Kohler Co. are not intended to be used in potentially explosive atmospheres according to Directive 2014/34/EC.

2.6.4 Preventing intoxication and poisoning hazards



WARNING

Hazards by operating fluids and exhaust gases emissions.

Exhaust gases emissions increase the likelihood of cancers and could result in death or serious injury.

Operating fluids generate toxic gases and emanations and could result in death or serious injury.

- ▶ Ensure a good ventilation while running or refueling the engine.
- ▶ In case of doubt, apply any means to ensure evacuation of personnel and stale air, ensure air supply and ventilation.
- ▶ Respect the local health and safety regulations, the material safety data sheets (MSDS) and the instructions manual of the manufacturer's machinery.
- ▶ Avoid any contact with additives, operating fluids, gases, battery acid and fumes and acid condensate in charge air or exhaust system, especially by inhalation.
- ▶ Regularly check the exhaust gas circuit and turbochargers.
- ▶ Immediately rectify the errors and replace the damaged parts. Safety instructions of the fluids have to be considered.

2.6.5 Preventing electrical hazards



WARNING

Hazards by electrical shocks.

Contact with live conductor could result in death or serious injury.

- ▶ Access to live parts shall only be possible with voluntary action.
- ▶ Proceed to lock out and tag out prior to accessing to the engine.
- ▶ Respect the voltage indication of the engine technical data sheet.
- ▶ Check the grounding connection to avoid any risk of electrical arc.
- ▶ Observe the local safety regulations that apply to the machinery.

2.6.6 Preventing noise hazards



CAUTION

Increased hazards by drowned out warning sounds and high sound pressure level.

Exposure to drowned out warning sounds and high sound pressure level could result in minor or moderate injuries by hearing loss or other physiological disorders.

- ▶ Wear proper personal protective equipment where applicable.
- ▶ Noise reduction systems adapted to the machinery must be designed by the manufacturer, to comply with the local regulations.
- ▶ In case of abnormal noises, rectify it immediately.

2.6.7 Preventing vibrations hazards



CAUTION

Hazards by exposure to vibrations.

Vibrations, by their acceleration, intensity, frequency and duration of exposure, could affect the health of personnel through vascular, neuro-sensory or musculoskeletal disorders, could result in minor or moderate injuries and cause property damage.

- ▶ The manufacturer of the machinery must design adapted dampering to comply with the local legislation.
 - ▶ In case of abnormal vibration noises, identify and rectify immediately.
-

2.6.8 Preventing electro-magnetic hazards



WARNING

Hazards by electromagnetic field and pulse generated by the engine starting and speed variations.

Exposure to electromagnetic fields could result in death or serious injury.

- ▶ The manufacturer must ensure the conformity of its machinery to the current Electromagnetic Compatibility (EMC) Directive.
 - ▶ Observe the safety regulations that apply to the machinery.
 - ▶ Avoid any electromagnetic sensitive devices in the vicinity of the engine, especially artificial health assist devices.
-

2.6.9 Preventing falling risks



CAUTION

Hazards by slipping and falling.

Climbing on the engine or leaks could result in minor or moderate injuries by slip and fall.

- ▶ Climbing on the engine is prohibited.
 - ▶ Perform visual inspections for leaks or damage.
 - ▶ In case of leak, correct deficiencies discovered immediately, clean and dry the operating fluids contaminated area.
 - ▶ The manufacturer of the machinery must provide adapted stairs and gangways to work in safe conditions.
-

2.7 Personal Protective Equipment (PPE)









WARNING

Risk of injuries by not wearing of personal protective equipment.

Missing, non-adapted, altered or misuse of personal protected equipment may accentuate the severity of injuries and could result in death or serious injuries.

- ▶ The manufacturer of the machinery shall define the safe conditions, including the personal protective equipment to wear before starting to work on the engine.
 - ▶ The manufacturer of the machinery shall forbid any accessories and loose clothing.
-

The following personal protective equipment is necessary:

| Sign (ISO 7010) | Description |
|--|---|
|  | <p>Protective work wear Protection against objects and chemical splashes Must be worn in the direct vicinity of the engine</p> |
|  | <p>Safety helmet Protection against falling/flying objects and against head injuries Must be worn in the direct vicinity of the engine</p> |
|  | <p>Safety shoes Protect feet against falling objects and from entanglement. Additional protection against slipping Must be worn in the direct vicinity of the engine</p> |
|  | <p>Safety gloves Protection against hot elements and chemicals Must be worn when handling hot parts, chemicals, operating fluids</p> |
|  | <p>Hearing protection Protection against noise Must be worn in the direct vicinity of the engine</p> |
|  | <p>Safety goggles Protection against flying objects and chemical splashes Must be worn when handling operating materials and during mechanical operations</p> |

Tab. 11: Personal protective equipment

2.8 Accessible areas

Before first start-up, the manufacturer of the machinery shall observe and enforce following safety and health instructions:



DANGER

Hazards by entanglement, trapping, ejection of parts or impact.

On starting and while operation, hazards by entanglement, trapping, impact by ejection of parts will result in death or serious injury.

- ▶ The engine shall not be started until the drive train has been connected to the flywheel.
- ▶ Ensure the integrity of the machine and the engine before starting.
- ▶ All openings must be closed and the safe conditions established by the manufacturer of the machinery must be fulfilled.
- ▶ Standing in the vicinity of the engine while starting or operating the manufacturer's machinery is forbidden.

2.8.1 Engine ready for use or in operation

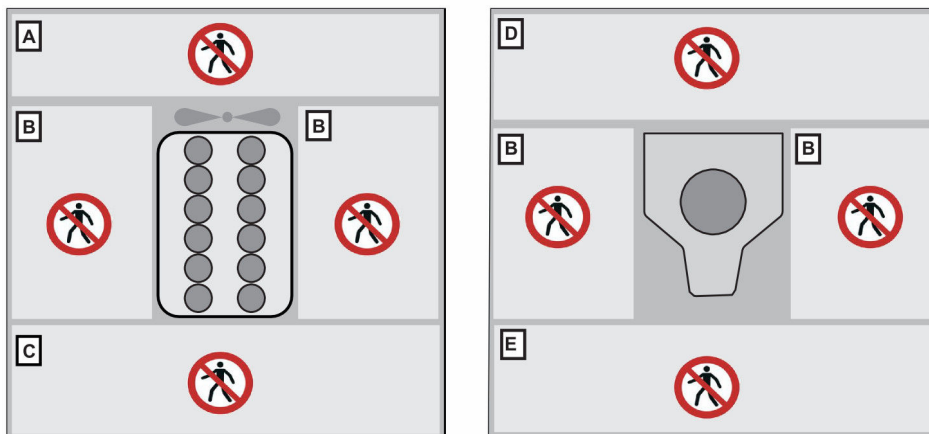


Fig. 32: Areas in operation – view from above and driving end

Access to the following areas is forbidden:

- | | | | |
|----------|--------------------|----------|------------------|
| A | Engine free end | D | Above the engine |
| B | Engine sides | E | Below the engine |
| C | Engine driving end | | |

2.8.2 Engine in commissioning – test run

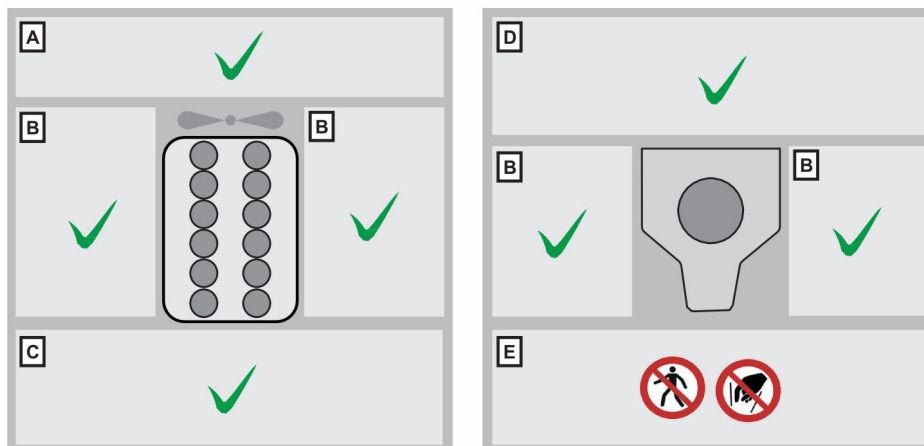


Fig. 33: Engine areas during commissioning and test run – view from above and driving end

Access to the following areas for commissioning and test run tasks is permitted:

- | | |
|--------------------------|-----------------------------|
| A Engine free end | C Engine driving end |
| B Engine sides | D Above the engine |

Access to the following areas is forbidden:

- E** Below the engine

2.8.3 Lockout/tagout

Lockout/tagout is an isolation process that protects workers from exposure to the unintentional or inadvertent release of hazardous energy (electrical energy, mechanical potential energy, etc.).

Lockout/tagout process helps prevent:

- Contact with a hazard while performing tasks that require the removal, by-passing, or deactivation of safe guarding devices.
- Unintended release of hazardous energy (stored energy).
- Unintended start-up or motion of machinery, equipment, or processes.

Lockout/tagout process

Lockout process involves the installation of a lockout device (for example, a padlock) on an isolation device (for example, a circuit breaker or a line valve) to isolate energy by engaging a position that prevents system energization.

Tagout is a labeling process that is always used when lockout is required. Tagout process involves the use of informative labels (usually a standardized label).

Generally, lockout/tagout process includes:

1. Identifying which energy sources are present and must be controlled.
2. Informing all affected employees of the lockout/tagout process.
3. Proceeding to shut down the system, ensuring that all moving parts have completely stopped. (For more information see: [4.4.1 Shutting down the engine, page 74.](#))
4. Isolating the system from hazardous energy using lockout devices.
5. Dissipating any residual or stored energy.
6. Making sure that the lockout device cannot be removed and that the system cannot be operated inadvertently.
7. Tagging out the system by attaching or using an information tag or indicator.
8. Verifying isolation by visually inspecting the system and engaging or activating system controls (push buttons, switches, etc.).

9. Completing the activity that required the lockout/tagout process to be started.
10. Making sure that all tools and items have been removed before removing lockout/tagout devices.



DANGER

Failure to observe safety notes!
Risk of death or injury.

- ▶ Observe local regulations, site rules, and safety notes.
- ▶ In doubt, immediately seek advice from a competent person (for example, safety officer, supervisor).

2.8.4 Emergency stop



Information

The machinery owner is responsible for marking the hazardous areas and the fail-safe devices.

The emergency stops must withstand the operational conditions, be kept visible and legible during the entire life cycle.

Additional emergency stops and measures according to project standards and local regulations and standards are possible.

The emergency stop button and signals, as the acknowledge buttons are described in the generator set manual.

NOTICE

Property damage by misuse of emergency stops.
Misusing the emergency stops to stop the engine could lead to property damage.

- ▶ Initiate an emergency stop only in emergency situations.

Initiating an emergency stop:

- ▶ Press the emergency stop button.

After an emergency stop:

- ▶ Remedy to the emergency situation.
- ▶ Acknowledge the emergency stop button and signals.

2.8.5 Signage recommendations







Information

The machinery owner is responsible for marking the hazardous areas and the fail-safe devices.

The signs must withstand the ambient conditions, and be kept visible and legible during the entire life cycle.

Additional signs and measures according to project standards and local regulations and standards are possible. For example: the signs for the United States market shall comply with ANSI Z535.4.

The following warning signs must be clearly visible and mounted in the accessible areas:

| Sign (ISO 7010) | Description |
|---|--|
|  | ISO 7010/W012 – Warning sign - Electricity Death or serious injury due to electrical shocks! |
|  | ISO 7010/W017 – Warning sign - Hot surface Severe injuries due to hot surfaces! |
|  | ISO 7010/W025 – Warning sign - Counterrotating rollers Severe injuries due to drawing-in movement! |
|  | ISO 7010/M002 – Mandatory action sign - Refer to instruction manual/booklet In order to ensure that all residual risks are known by the personnel, the system documentation must be read and understood. Make sure that all residual risks according to the risk assessment are reflected in the system documentation. Provide documentation to the personnel according to the “Target audience”. |

Tab. 12: Engine area signs requirement

2.9 Prevent property damage

2.9.1 Safety instructions for engine control unit (ECU)

NOTICE

Improper installation or misuse of the engine leads to ECU damage.
Property damage due to non-compliant installation or operation.

- ▶ Ensure the connection to power supply before starting the engine.
 - ▶ It is prohibited to disconnect the electrical power supply during operation.
 - ▶ Ensure the connection of the ECU before starting the engine.
 - ▶ Using a rapid charging device to start the engine is prohibited. Only jump start with separate batteries is allowed.
 - ▶ Electrical welding in the vicinity of the engine is forbidden, especially near the ECU.
 - ▶ Switch off the electrical system before connecting or disconnecting the ECU. Apply to the prescribed tightening torque to tighten the fixing screws of the interface plugs. The manufacturer of the machinery has to provide an electrical disconnect.
 - ▶ Reversing the polarity of supply voltage results in the ECU destruction.
 - ▶ Apply to the prescribed torque to tighten the connections to the injection system.
 - ▶ Extreme engine compartment temperatures will damage the ECU. Please refer to the technical data sheet for temperatures values.
 - ▶ Use suitable test cables to ensure the measures at plug connectors.
 - ▶ Connecting the sensors or actuators individually to or between external voltage sources for testing purposes is prohibited. Risk of destruction or malfunction of the engine. Connect the sensors or actuators to the ECU.
 - ▶ Mount and fix the mating connectors to protect the ECU against dust and moisture. When the mating connectors are dismantled, ensure protection of the ECU against dust and moisture by protective covers.
 - ▶ Using mobile phones and wireless devices in the vicinity of the engine is prohibited. Risk of malfunction of the ECU and the engine.
-

2.9.2 Alarm conditions

**CAUTION**

Property damage and/or injuries due to neglect of fault codes.

Neglecting the fault code may lead to engine failure (for example, overspeed) and could result in minor or moderate injuries (for example, ejection of parts) by hazards from related actions. The engine is equipped with an engine control unit, which monitors the engine and itself (self-diagnosis). After assessment of an identified fault, the following actions are automatically initiated:

- ▶ Issue of a fault message with a fault code.
 - ▶ In combination with the machinery diagnosis system, the fault code is shown via a display.
 - ▶ Switch over to appropriate backup/emergency functions for additional, restricted operation of the engine (for example, constant limp-home speed).
 - ▶ Make sure that the faults are immediately repaired.
-



Information

The machinery owner is responsible for implementing and enforcing emergency procedures to be followed in the event of accident or breakdown, according to the messages and codes displayed.

The ECU generates the signals and error codes for the engine.

The messages and codes are displayed on the generator set display.

See the generator set manual for more details.

2.9.3 Safety instructions for the fuel system

**DANGER**

Hazards due to flammable fluids under high pressure.

When the engine is running, the fuel lines are under a constant pressure of up to 2000 bar (29,007.40 psi).

Fuel escaping under pressure can penetrate the skin or vaporize and explode when an ignition source is present, which will result in death or serious injury.

- ▶ Never release the screws on the fuel circuit, especially between the high-pressure pump and the injector when the engine is running.
 - ▶ Before starting any task on the fuel system, ensure the build-up pressure in the circuit has been released, and the temperature of the engine has cooled down.
 - ▶ Keep the engine away from heat, sparks, open flame, or any other ignition source.
-

2.9.4 Cleanliness standards and safety

NOTICE

Property damage due to neglect of cleanliness standards!

Modern components, especially the injection system, consist of high precision parts that are subject to extreme loading.

Dirt particles of 20 µm (0.79 th) or greater can result in component outages. Due to this high precision engineering, maintain a high standard of cleanliness for all tasks.

Before and while performing any task, observe the following precautions:

- ▶ Ensure a clean area, free of stirred up dust by air movements.
 - ▶ Perform visual inspections for leaks or damage.
 - ▶ Before starting any task on the closed fuel system, clean the engine and its compartment with lint free tissue.
 - ▶ Ensure waterproof covers are on the electrical components.
 - ▶ Do not direct steam jet at electrical components or their covers.
 - ▶ Clean and dry the area around the still closed fuel system with compressed air.
 - ▶ Remove loose dirt particles such as paint chips and insulation material with suitable equipment.
 - ▶ Cover the areas of the engine compartment which could produce dirt particles with a new and clean covering film.
 - ▶ Before beginning the dismantling work, wash hands and put on fresh personal protective equipment.
 - ▶ Clean tools and working materials.
 - ▶ Perform work on components at a suitably equipped workplace.
 - ▶ Use only undamaged tools.
 - ▶ After opening the fuel system, the use of compressed air for cleaning is prohibited.
 - ▶ Remove any loose dirt during installation work with suitable equipment.
 - ▶ Remove any paint chips before loosening or tightening any connections.
 - ▶ Use only lint-free cleaning tissues.
 - ▶ Use particle and fiber-free materials.
 - ▶ Immediately seal the opened connection with sealing caps.
 - ▶ Keep the sealing material in dust-free packaging until use and dispose of it after single use.
 - ▶ Place the components into a clean, sealed container.
 - ▶ Never use contaminated cleaning or testing fluids.
 - ▶ Remove new components from the original packaging immediately before use.
 - ▶ Use the original packaging of the new parts to ship removed parts.
-

2.10 Disposal and environment protection



CAUTION

Environmental and health hazards by incorrect disposal.

Incorrect waste disposal leads to environment and water supply pollution and could result in minor or moderate injuries by hazards from related actions.

- ▶ Observe the country-specific regulations regarding environmental protection when disposing of scrap materials.
 - ▶ Before disposing or recycling waste products, ask for the correct method at the responsible environmental or recycling center.
 - ▶ When handling waste, lubricants and fuel make sure that none is disposed into the environment.
 - ▶ Collect and dispose waste, lubricants and fuel in separate, suitable, properly designated containers.
 - ▶ Use adapted leak-proof containers to drain lubricants and fuel. Use of food or drink containers is prohibited.
 - ▶ Dispose all scrap materials only at official locations in an environment-friendly manner.
-

3 Transportation - Storage



Information

The machinery owner is responsible for the lifting, handling, and storage of the engine.

The storage concrete foundation shall have a sufficient load capacity.

For actual dimensions and weight, refer to "Installation drawing" which is considered as reference. [\(For more information see: 8.1 Technical design documents, page 164.\)](#)

3.1 Safe handling



DANGER

Death by crushing hazards.

Lifting and handling heavy loads will lead to death by crushing hazards.

- ▶ Use only adapted transport and lifting devices.
- ▶ Lift and handle the packed engine according to the markings on the packaging.
- ▶ After engine unpacking, separate the engine from its stand.
- ▶ Use the lifting hooks to lift the engine only.
- ▶ Before handling or lifting the load, fix or remove any loose part.
- ▶ Avoid friction between components of the engine and suspension devices by putting protection between them.
- ▶ Prevent the load from swinging.
- ▶ Before handling or lifting the load, warn all employees in the immediate vicinity.
- ▶ Before readjusting the lifting devices, warn all employees in the immediate vicinity.
- ▶ Only readjust the lifting devices when the load is on the floor and the suspension devices are tension-free. Pay attention to the center of gravity.
- ▶ Respect a safe distance while handling and never pass under the load.
- ▶ While moving the load, keep a constant attention on the load and the other employees.
- ▶ While moving the load, warn everyone to keep a safe distance and forbid anyone to pass under the load.



Information

Several adapted lifting devices are available.

Follow the instructions manual of the hoisting beam, handling devices and the local safety regulations.

For further information, please contact your nearest authorized Kohler service representative.

3.2 Dimensions and weight



Information

The manufacturer of the machinery is responsible for the lifting, handling, and storage of the engine.

For the latest engine dimensions and weights, refer to the "Installation Drawing". ([For more information see: 8 Appendix, page 164.](#))



WARNING

Crushing, impact, shearing, part ejection hazards by load movement or lifting devices failure. Guiding the moving load by hand could cause serious injury or death by crushing or shearing. Lifting the entire machinery could cause serious injury or death by crushing, impact, or parts ejection.

Falling load could cause serious injury or death by crushing, impact, or parts ejection.

Failure of lifting devices could cause serious injury or death by ejection of parts, crushing, and impact.

- ▶ It is forbidden to guide the load by hand.
 - ▶ Use the lifting hooks to lift the engine only.
 - ▶ Use only adapted lifting devices in good shape.
 - ▶ Check and replace the lifting devices according to local regulations.
 - ▶ Respect a safe distance while lifting and moving the load.
 - ▶ It is forbidden to pass under the load.
-

NOTICE

Falling/hanging lifting devices on the engine.

Falling/hanging lifting devices could result in property damage by impacts or tearing.

- ▶ Check and replace the lifting devices according to local regulations.
 - ▶ Move the lifting devices near the engine cautiously.
-

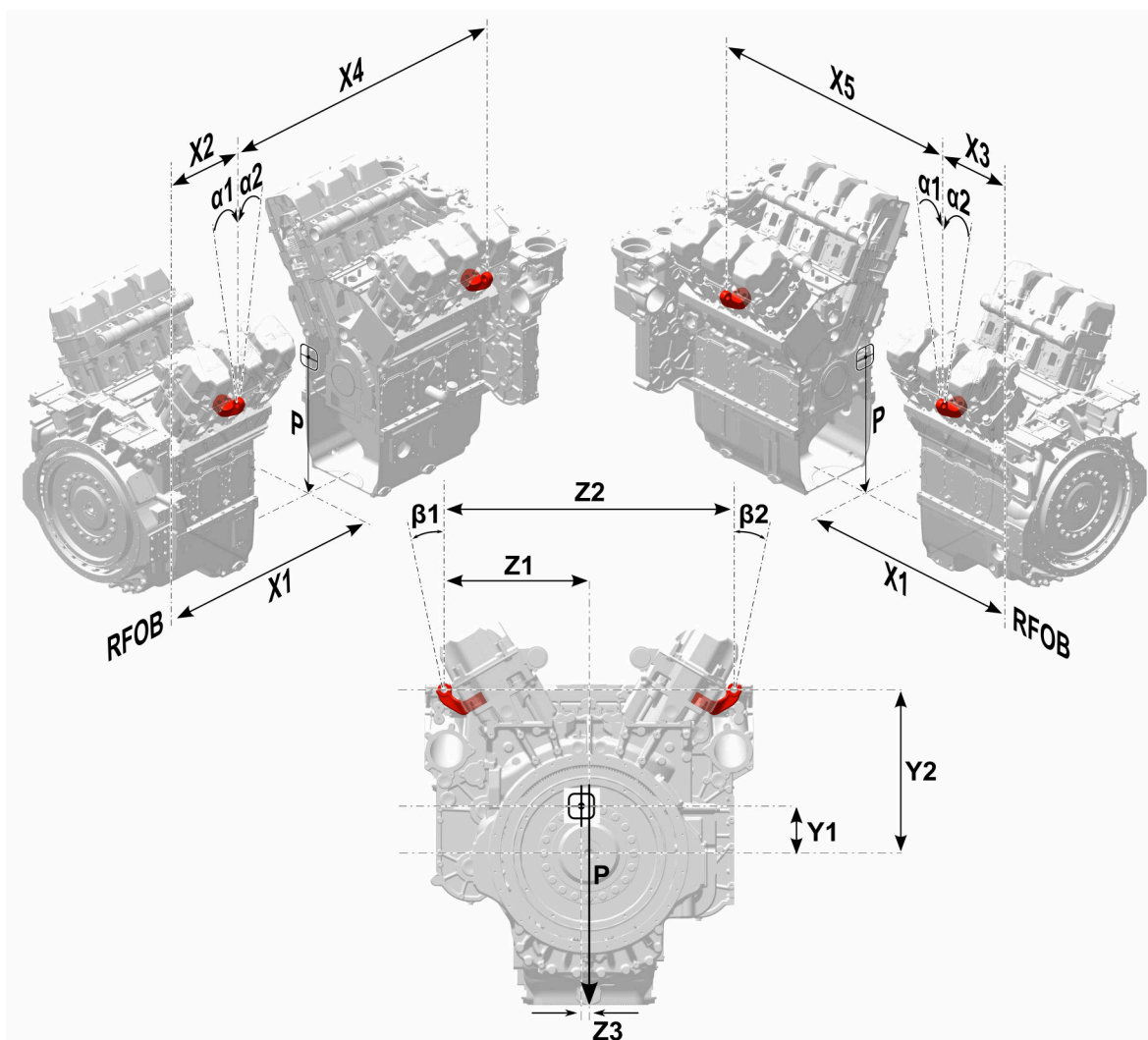


Fig. 38: Dimensions and weight of engine



Information

► RFOB stands for “Rear Face of Block”.

| Designation | Ref. | Dimensions |
|---|------|----------------------|
| Overall length | | 3637 mm 11.93 ft |
| Overall width | | 1743 mm 5.72 ft |
| Overall height | | 2174 mm 7.13 ft |
| From RFOB to center of gravity | X1 | 1442.9 mm 4.73 ft |
| From RFOB to lifting point - right side | X2 | 594 mm 1.95 ft |
| From RFOB to lifting point - left side | X3 | 545 mm 1.79 ft |

| Designation | Ref. | Dimensions |
|---|-------------------------|-----------------------|
| Distance between engine lifting points - right side | X4 | 1820 mm 5.97 ft |
| Distance between engine lifting points - left side | X5 | 1560 mm 5.12 ft |
| Axis to center of gravity | Y1 | 323.5 mm 1.06 ft |
| Axis to lifting point | Y2 | 729 mm 2.39 ft |
| From axis to lifting point | Z1 | 645 mm 2.12 ft |
| Distance between engine lifting points | Z2 | 1290 mm 4.23 ft |
| Axis to center of gravity | Z3 | 14.3 mm 0.56 in |
| Maximum weight | P | 13500 kg 29,762 lb |
| Maximum angles of lifting devices – side view | α_1 - α_2 | 15° |
| Maximum angles of lifting devices – front view | β_1 - β_2 | 15° |

Tab. 13: dimensions and weight of engine - values

3.3 Transport

3.3.1 Safe transportation



Information

The generator set owner is responsible for the transportation and storage of the engine. The storage concrete foundation shall have a sufficient load capacity.



DANGER

Crushing hazards!

Will cause serious injury or death.

Lifting heavy loads can lead to death by crushing hazards.

- ▶ Use only adapted transport and lifting devices.
- ▶ Lift and handle the packed engine according to the markings on the packaging.
- ▶ After engine unpacking, separate the engine from its stand.
- ▶ Use the lifting hooks to lift the engine only.
- ▶ Before handling or lifting the load, fix or remove any loose part.
- ▶ Avoid friction between components of the engine and suspension devices by putting protection between them.
- ▶ Prevent the load from swinging.
- ▶ Before lifting the load, warn all employees in the immediate vicinity.
- ▶ Fix or remove any loose part on the engine.
- ▶ Before readjust the lifting devices, warn all employees in the immediate vicinity.
- ▶ Only readjust the lifting devices when the load is on the floor and the suspension devices are tension-free. Pay attention to the center of gravity.
- ▶ Respect a safe distance while lifting and never pass under the load.
- ▶ While moving the load, keep a constant attention on the load and the other employees
- ▶ While moving the load warn everyone to keep a safe distance and forbid anyone to pass under the load.



Information

- ▶ Several adapted lifting devices are available. Follow the operator's manual of the hoisting beam, lifting devices and the local safety regulations. For further information, please contact your nearest authorized Kohler service representative.

3.3.2 Transport fastening



Information

- ▶ For transportation, the engine should be deposited on adapted stands.
- ▶ Kohler Co. provides one wooden stand with engine. For transportation and storage use the provided stand.



Fig. 39: Example of wood stand on undercarriage



Fig. 40: Example of transportation fixing



Fig. 41: Example of waterproof packaging

3.3.3 Transport devices

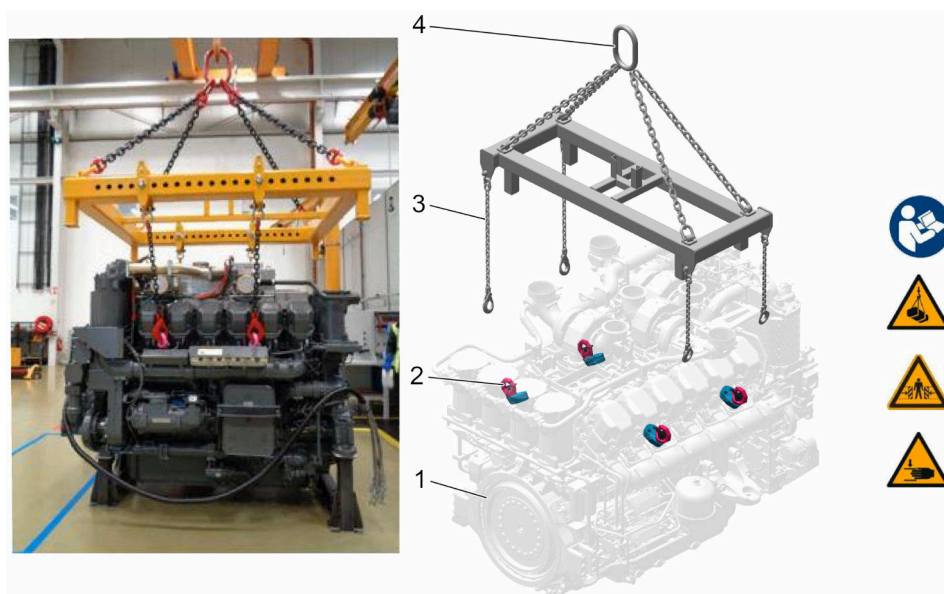


Fig. 42: Examples of fixing the lifting devices on the engine

- | | | | |
|----------|--------------|----------|---------------|
| 1 | Engine | 3 | Lifting beam |
| 2 | Lifting hook | 4 | Lifting point |

3.3.4 Transport conditions

Transport conditions should comply with the following minimum requirements:

Land transport:

In a freight wagon or a closed lorry.

Sea and river transport:

In the hatch of the boat with the measures to prevent the penetration of water.

Air transport:

In a closed air freight container.



Information

For further information, please contact your nearest authorized Kohler service representative.

3.4 Storage

3.4.1 Storage conditions



Information

Respect the preservation and storage conditions according to “ISO 6749” standards.
The storage is part of the scope of the application set owner.
In any doubt, please contact your nearest authorized Kohler service representative.

Storage conditions should meet the following minimum requirements:

In temperate or cool areas:

- In a closed and unheated warehouse
- In coastal area, in an air-conditioned warehouse

In dry tropical climatic areas:

- In a closed and unheated warehouse
- In coastal area, in an air-conditioned warehouse

In humid tropic zones:

- In a closed and air-conditioned warehouse



Information

The relative humidity of the air in a closed and air-conditioned warehouse should not exceed 70%.

3.4.2 Storage site foundation requirements



Information

The storage site foundation is part of the scope of the generator set owner.
The generator set owner shall measure the foundation performances before storing the engine.
[\(For more information see: 3.2 Dimensions and weight, page 55.\)](#)



Information

Kohler Co. provides one wooden stand with engine. For transportation and storage use the provided stand.

Steel stands are available for long term storage.

For further information, please contact your nearest authorized Kohler service representative.

3.4.3 Storage up to 12 months

The engine is kept from the date of shipment in its original packaging. Storage in a closed, dry, and ventilated area ensures a conservation and storage life of 12 months.

3.4.4 Storage over 12 months

For storage longer than 12 months, please contact your nearest authorized Kohler service representative.

3.5 Unpacking and depreservation

3.5.1 Unpacking



CAUTION

Environmental and health hazards by incorrect disposal. Incorrect waste disposal leads to environment and water supply pollution and could result in minor or moderate injuries by hazards from related actions.

- ▶ Observe the country-specific regulations regarding environmental protection when disposing of scrap materials.
- ▶ Before disposing or recycling waste products, ask for the correct method at the responsible environmental or recycling center.
- ▶ When handling waste, lubricants and fuel make sure that none is disposed into the environment.
- ▶ Collect and dispose waste, lubricants and fuel in separate, suitable, properly designated containers.
- ▶ Use adapted leak-proof containers to drain lubricants and fuel. Use of food or drink containers is prohibited.
- ▶ Dispose all scrap materials only at official locations in an environment-friendly manner.



CAUTION

Cutting or scratches hazards by contact with sharpen surfaces, tools or materials. Contact with sharpen surfaces, tools or materials could result in minor or moderate injuries by cuts or scratches.

- ▶ Wear proper personal protective equipment.

- Engine is stored close to the installation site.

Unpack and depreserve the engine or delivered components shortly before the use or the installation.

- ▶ Cut and remove the packing tape.
- ▶ Open the packaging film and release the engine or component.
- ▶ Perform a visual check for damage or deformations.
- ▶ Check for corrosions which impair function and strength.
- ▶ Check for abrasions, breaks or dislocation of components, connections and systems.
- ▶ Perform a visual check of lines and hoses for damage (chafe marks, cuts, tears), embrittlement of the outer layer (crack formation in the material), any deformations (swollen, crushes), non-compliant bends, delamination, blister formation.
- ▶ Check for damage or deformations to the fittings.
- ▶ Check for dislocation from the fittings.
- ▶ Leave all opening seals until connection.

Troubleshooting

By damage

- ▶ Register the date of unpacking
 - ▶ Please contact your nearest authorized Kohler service representative.
-

3.5.2 Depreservation

After an extended storage period, observe the following procedures to bring the engine out of preservation status before putting it into service:

Engine oil system

- ▶ Drain the long-term storage engine oil. (For more information see: [5.9.6 Changing Diesel engine oil – SL101, SL121, page 118.](#))
- ▶ Fill the engine oil system with factory approved engine oil. (For more information see: [5.9.6 Changing Diesel engine oil – SL101, SL121, page 118.](#))
- ▶ Replace all engine oil filters. (For more information see: [5.9.4 Changing oil filters – SL101, page 113.](#)) , (For more information see: [5.9.5 Replacing centrifuge paper filter – SL102, page 114.](#))
 - ▷ The engine oil system is ready for operation.

Cooling system:

- ▶ Check coolant levels.
- ▶ Replace coolant if necessary.
 - ▷ The engine cooling system is ready for operation.

Fuel system

- ▶ The corrosion inhibitor B0 fuel mixture can be run through the engine upon initial startup.
- ▶ Replace the mixture with an approved diesel engine fuel.
- ▶ Replace all fuel filters. (For more information see: [5.11.3 Replacing main filter - SL105, page 131.](#))
 - ▷ The engine fuel system is ready for operation.

Air system

- ▶ Check all air filters for damage and replace if necessary. (For more information see: [5.12 Air system, page 133.](#))

or

Remove all air system covers, check that there is no debris in the intake system, and install new air filters. (For more information see: [5.12 Air system, page 133.](#))

- ▶ Remove all covers on exhaust mufflers, and check that there is no debris in the exhaust system.

or

Remove all exhaust system covers, check that there is no debris in the exhaust system, and install the muffler/exhaust handling system.

▷ The engine air system is ready for operation.

Combustion chambers

- ▶ No special instructions required.

External surfaces

- ▶ Remove the VCI film from the engine.

- ▶ Remove corrosion inhibitors from the engine with mineral spirits or according to the instructions.
- ▶ Check all belts and replace if necessary.



Information

If the engine has been in storage for longer than 3 years, all belts must be replaced.

- ▶ Check all belt pulleys for rust or pitting and clean or replace if necessary.
 - ▷ Engine belts and pulleys are ready for operation.

Initial run after depreservation



Information

Engine components, particularly exhaust components, should be monitored closely during initial run after depreservation.

Smoke emissions are likely to happen, due to inhibitor remnants and mineral spirits burning off.

Once all engine fluids are checked or replaced with acceptable engine running fluids, observe the following start-up process:

- Connect all batteries and other electric connections that were disconnected before preservation.
- Perform engine over crank procedure.
This procedure is critical as it will circulate oil throughout the engine and provide a prelubricating effect for the engine rotating components as well as pistons and overhead.
- Prime the fuel system.
- Run the engine at idle speed for 5 minutes.
- Check for leaks during operation.
- Shut down the engine.
- Check the engine for leaks in oil, fuel, and cooling systems.
- Run the engine at idle speed for 5 more minutes.
- Allow the engine to ramp up to rated speed after the idle timer finishes.
- After 15 minutes at rated speed, begin adding load to the engine.
- Add load in 20% increments until 100% load is reached. Maintain each interval for 15 minutes.
- Monitor the engine operation for issues.

3.6 Suspension of activity

The measures set herein are used for protection against engine corrosion damage when engine is installed and activity is suspended for up to 12 months.

Divergent measures must be coordinated with KOHLER.

- ▶ Fill with operating fluids. Respect the filling volumes. (For more information see: 5.14 Filling volume, page 150.)



Information

- ▶ The delivered engine and components are ready for immediate use and do not require depreservation.
- ▶ In an environmentally friendly manner, reuse the packaging to send back the engine or other components.

-
- ▶ Clean the engine and remove any rust.
 - ▶ Spray or apply corrosion inhibitor on unprotected parts. Recommended corrosion inhibitor is Rustilio DWX 30.



Information

- ▶ Do not spray the corrosion inhibitor on electrical connections.

-
- ▶ Follow the procedure for the suspension of activity in the Instructions of the application set.

To start engine after 12 months of suspension of activity:

- ▶ Follow the starting procedure according to the Instructions of the application set.

3.7 Preservation, packaging

3.7.1 Preservation

- ▶ After dismantling of the machinery and dismounting of the engine, preserve, pack, and store the engine according to the following standards:
 - ISO 6749 - Earth-moving machinery - Preservation and storage
 - EN ISO 780 - Packaging - Pictorial marking for the handling of goods

4 Control and operation

4.1 Filling lubricants and operating fluids

- Charge air is connected.
- Exhaust system is connected.
- Electrical power supply is ready.
- Fuel and cooling supplies are connected.

4.1.1 Lubricating oil

Filling

- ▶ Fill with lubricating oil according to “Maintenance” section. (For more information see: [5.9.6 Changing Diesel engine oil – SL101, SL121, page 118.](#))

Requirements

- ▶ Fill with approved lubricating oils and lubricating oil additives only. (For more information see: [5.13.3 Approved lubricating oils and lubricating oil additives, page 140.](#))

4.1.2 Coolant

Filling

Refer to the generator set manual for more details.

Requirements

- ▶ Fill with approved coolants only. (For more information see: [5.13.4 Approved coolants, page 146.](#))

4.1.3 Diesel fuel

Filling

Refer to the generator set manual for more details.

Requirements

- ▶ Fill with approved diesel fuels, diesel exhaust fluids (DEF), and fuel additives only. (For more information see: [5.13.2 Approved diesel fuels, diesel exhaust fluids \(DEF\), and fuel additives, page 135.](#))

4.2 Starting the engine



DANGER

Contact with moving part!

Risk of death or injury by entanglement or impact of ejected part.

- ▶ Make sure that the drive train is connected to the flywheel before starting the engine.
- ▶ Start or operate the engine with covers and guards secured in place.
- ▶ Remove all tools or loose parts from the vicinity of the engine after a service activity.
- ▶ Keep tools away from the starting or running engine.
- ▶ When the engine is in operation, stay away from the engine.



DANGER

Fire or hotspot - Overheating of starter or prelube pump due to excessive run-time!

Risk of death or injury by asphyxiation or burn.

- ▶ Observe specified maximal consecutive start attempts.
- ▶ Stay away from starter or prelube pump after start attempt.

NOTICE

Fire - Overheating of starter or prelube pump due to excessive run-time!

Property damage - Risk of destruction of the machine or the engine.

- ▶ Observe specified maximal consecutive start attempts.

NOTICE

Use of non-approved lubricating oil!

Property damage - Risk of engine critical failure.

- ▶ Use an approved lubricating oil. [\(For more information see: 5.13.3 Approved lubricating oils and lubricating oil additives, page 140.\)](#)

Make sure that the following preconditions are met:

- Operating fluids levels are correct.

4.2.1 Final check

Before starting the engine, carry out the following checks and top off with operating materials if necessary:

- ▶ Check the oil level.
- ▶ Check the coolant level.

Once the engine has started, carry out the following checks:

- ▶ Perform a visual check for any leaks in the lines.
- ▶ Check for KoDIA error messages.
- ▶ Check for error messages on the generator set.

4.2.2 Starting in cold temperatures



WARNING

Hazards by use of starting aids containing ether.
Using starting aids containing ether could cause serious injury or death by inhalation of toxic gases.

- ▶ Using starting aids containing ether is forbidden.
-

The KOHLER generators are equipped with a preheating system.

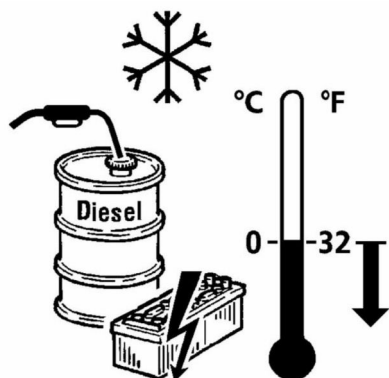


Fig. 43: Precautions at cold temperatures

The following precautions improve the starting performance at low temperatures. Precautions:

- ▶ Check battery charging.
- ▶ Recharge battery if required.
- ▶ Use Diesel fuel with sufficient flow properties.

4.3 Monitoring the running engine



DANGER

Contact with moving part!

Risk of death or injury by entanglement or impact of ejected part.

- ▶ Make sure that the drive train is connected to the flywheel before starting the engine.
- ▶ Start or operate the engine with covers and guards secured in place.
- ▶ Remove all tools or loose parts from the vicinity of the engine after a service activity.
- ▶ Keep tools away from the starting or running engine.
- ▶ When the engine is in operation, stay away from the engine.



WARNING

Toxic exhaust gas inhalation!

Risk of lung disease or injury by irritation.

- ▶ Make sure that there is a proper evacuation of exhaust gas.
- ▶ Ensure a good ventilation while running the engine.



Information

It is forbidden to continuously operate the diesel engine when an alarm is displayed.

Investigate any alarm according to operating conditions, and make sure that authorized personnel correct the defect at first opportunity.

Make sure that the following preconditions are met:

- Engine is under load at rated speed.



Information

Kohler diesel engines have been approved for running at low loads. Operating the engine at low loads for extended periods of time can increase deposits/carbon buildup (intensified at low ambient temperature). This can be detrimental to the longevity and compliance of the engine. If your operating profile has a prolonged low load duration, it is necessary to contact your genset supplier to take the necessary precautions.

To ensure engine performance and endurance, perform the following tasks when operating the application set:

- ▶ Check for unusual noises and vibrations.
- ▶ Record and report any anomaly found on generator set display (for example: faulty parameter).
- ▶ Make sure that authorized service personnel correct the defect.

4.4 Stopping the engine

4.4.1 Shutting down the engine

NOTICE

Misuse of emergency stop!
Property damage - Risk of engine damage.

- ▶ Use the emergency stop only in emergency situations (emergency stop is not a normal stop).
-

To stop the engine in normal conditions, observe the following instructions:

- ▶ Make sure the load is reduced to zero.
- ▶ Let the engine run at idle speed for 3 minutes.
- ▶ Shut down the engine.

4.4.2 Emergency stop

The emergency stop button and signals, as the acknowledge buttons are described in the the application set manual.

NOTICE

Misuse of emergency stop!
Property damage - Risk of engine damage.

- ▶ Use the emergency stop only in emergency situations (emergency stop is not a normal stop).
-

Initiating an emergency stop:

- ▶ Press the emergency stop button.

After an emergency stop:

- ▶ Remedy to the emergency situation.
- ▶ Acknowledge the emergency stop button and signals.

4.5 Initial starting after out of service period

4.5.1 Preparation of initial starting

For initial starting or after a suspension of activity, perform the following tasks:

- ▶ Replace engine oil. Refer to chapter Maintenance.
- ▶ Replace oil filters. Refer to chapter Maintenance.
- ▶ Perform a general visual inspection. Refer to chapter Maintenance.
- ▶ Check coolant level. Refer to chapter Maintenance.
- ▶ Drain off water and sediment of fuel tank. Refer to Operation and Maintenance Manual.
- ▶ Check water separator of fuel pre-filter and bleed water if necessary. Refer to Operation and Maintenance Manual.
- ▶ Check visually the starter, battery charging alternator.
- ▶ Check belt, and replace if necessary. Refer to chapter Maintenance.
- ▶ Vent the fuel system. Refer to Operation and Maintenance Manual of generator set.

4.6 Dismantling

The dismantling must be carried out or supervised by a trained and qualified staff.

Prepare the dismantling as follows:

- ▶ According to local regulations, clarify the means and quality of the dismantling process.
- ▶ Disconnect the electrical power supply.
- ▶ Remove any electronic control or electrical connections.
- ▶ Drain all fluids.
- ▶ Remove any coolant, lubricants and fuel connections.
- ▶ Collect and dispose of waste, coolant, lubricants and fuel.
- ▶ Disassemble the component or engine according to general mechanics procedures.

4.7 Components disposal



CAUTION

Environmental and health hazards by incorrect disposal.

Incorrect waste disposal leads to environment and water supply pollution and could result in minor or moderate injuries by hazards from related actions.

- ▶ Observe the country-specific regulations regarding environmental protection when disposing of scrap materials.
- ▶ Before disposing or recycling waste products, ask for the correct method at the responsible environmental or recycling center.
- ▶ When handling waste, lubricants and fuel make sure that none is disposed into the environment.
- ▶ Collect and dispose waste, lubricants and fuel in separate, suitable, properly designated containers.
- ▶ Use adapted leak-proof containers to drain lubricants and fuel. Use of food or drink containers is prohibited.
- ▶ Dispose all scrap materials only at official locations in an environment-friendly manner.

Dispose of the components for recycling according to the categories as follows:

- Steel and iron
- Aluminum
- Nonferrous metal
- Insulating material
- Cables and wires
- Electrical waste
- Plastics
- Lubricants and lubricating greases
- Fuels
- Coolant
- Paint residues
- Cleaning agents and rags

4.8 Packaging material disposal



Information

Use the original packaging of the new parts to ship removed parts.

Recover packaging material as follows:

- Wood, impregnated wood
- Packaging foils
- Board
- Tinplate
- Adhesive tape
- Contaminated packaging materials

5 Maintenance

5.1 Maintenance information

5.1.1 General information

Shorten the maintenance intervals according to the operating conditions, for example:

- Dusty environment
- Oil quality
- Fuel quality

Always make sure that lubricants, fuel, other liquids, and replaced parts are disposed of in a safe and environmentally acceptable manner. The environmental regulations applicable in the country of use must be adhered to.

5.1.2 Maintenance intervals

The time intervals during which a component can remain in operation between two servicing are divided into:

- **Time limit** is the duration in hours of service.
- **Calendar limit** is the maximum duration in years.

A maintenance task is carried out as soon as a deadline is reached, hourly or calendar.

5.1.3 Time between overhaul (TBO)

Time between overhaul (TBO) designates the average duration until the diesel engine is revised.

5.2 Generator set ratings

The following generator set ratings are defined by the standard ISO 8528-1:2018.

The classifications according to ISO 8528-1: 2018 are intended to help to improve the understanding between manufacturer and customer.

The power of the generator set is the power output available for consumer loads at the generator set terminals, excluding the electrical power absorbed by the essential independent auxiliaries.

5.2.1 Continuous Operating Power (COP)

Continuous power (COP) is the maximum power, which the generator set can deliver continuously while supplying a constant electrical load. Continuous power (COP) can be operated for an unlimited number of hours per year under the agreed operating conditions.

Always observe the maintenance intervals and procedures prescribed by the manufacturer.

5.2.2 Prime Power (PRP)

Prime power (PRP) is the maximum power, which the generator set can deliver continuously while supplying a variable electrical load. Prime power (PRP) can be operated for an unlimited number of hours per year under the agreed operating conditions. Over 24 hours, the average power output cannot exceed 70% of the PRP, unless otherwise agreed by the engine manufacturer.

Always observe the maintenance intervals and procedures prescribed by the manufacturer.

5.2.3 Emergency Standby Power (ESP)

Emergency standby power (ESP) is the maximum power, which the generator set can deliver during a variable electrical power sequence, in case of a utility power outage, or under test conditions. Emergency standby power (ESP) can be operated for up to 200 hours per year under the agreed operating conditions. Over 24 hours, the average power output cannot exceed 70% of the ESP, unless otherwise agreed by the engine manufacturer.

Always observe the maintenance intervals and procedures prescribed by the manufacturer.

5.3 Service level definition



Information

- ▶ The information on the engine nameplate corresponds to the delivery status (ex-works Kohler Co.). Refer to the generator set ratings to know which maintenance schedule to use. [\(For more information see: 5.2 Generator set ratings, page 81.\)](#)

| Preventive Maintenance | | | Corrective Maintenance |
|---|--|--|---|
| Level 1 - Basic Maintenance | Level 2 - Advanced Maintenance | Level 3 - Main Overhaul | Troubleshooting and repair |
| Daily checks, inspection and maintenance tasks which can be carried out in intervals between operation without dismantling parts from engine. For example: oil and fuel refilling | Maintenance tasks involving partial disassembly of the engine in situ (mid-life service). For example: change of pump, injectors, heads. | Operations for which the procedures entail expert knowledge of a specific technique or technology and/or use of specialized support equipment. | Repair services such as exchange of components needed to correct failures or malfunctions including parts and labor |
| By customer or authorized Kohler service representative | By authorized Kohler service representative | By authorized Kohler service representative | By authorized Kohler service representative |

Tab. 14: Service level definition

The descriptions of the maintenance activities are given in the following documents:

- Level 1 in this **Operating and Maintenance Manual**
- Level 2 and 3 in the **Service and Repair Manual**

5.4 Inspection and maintenance schedules

5.4.1 Daily or monthly maintenance activities (Level 1) - Version: 2018-07

| Task identification | Component | Schedule | | Service Type | | | Task description |
|---------------------|------------------|----------------|-----------------------|--------------|----------|------------------------------------|--|
| | | Time limit (h) | Calendar limit (year) | Replacement | Overhaul | Inspection/Clean Repair/Adjustment | |
| SL000 | Engine operation | Daily | Before start | | | X | Visual inspection of the engine for overall condition. Record and report any abnormality found (leaks, damage, loose components, unusual noise, etc.). (For more information see: 5.7.1 Inspecting engine overall condition – SL000, page 100.) |
| SL001 | | Daily | Before start | | | X | Check engine oil, fuel, and coolant levels. (For more information see: 5.9.3 Checking the engine oil level – SL001, page 112.) |
| SL002 | | Daily | Before start | | | X | Inspect low temperature circuit (intercooler) vent system. Check dewatering bores on air intake manifold. (For more information see: 5.10.3 Inspecting low temperature circuit (charge air cooler) – SL002, page 125.) |
| SL003 | | Daily | Before start | | | X | Check relieve bores - coolant pump. (For more information see: 5.10.4 Checking relief bores – coolant pump – SL003, page 126.) |
| SL004 | | Daily | Before start | | | X | Drain off water from fuel pre-filter. If applicable, see supplier's manual. (For more information see: 5.11.1 Draining off water from fuel pre-filter – SL004, page 131.) |
| SL005 | | Daily | Before start | | | X | Check differential pressure gauge of fuel pre-filter / indicator for check monitoring (if installed). (For more information see: 5.11.5 Checking differential pressure – fuel pre-filter – SL005, page 132.) |
| SL006 | | Daily | Before start | | | X | Inspect service indicator of air filter / dismount and visual check - depending on environment. Customer set. (For more information see: 5.12.1 Checking service indicator on air filter – SL006, page 133.) |
| SL007 | | Daily | Before start | | | X | Observe engine operation. Record and report any abnormality found (faulty parameters, unusual noise, vibration, exhaust gas color, etc.). (For more information see: 5.7.2 Inspecting engine running at idle speed – SL0-007, page 104.) |

| Task identification | Component | Schedule | | Service Type | | | Task description |
|---------------------|-----------|----------------|-----------------------|--------------|----------|------------------------------------|--|
| | | Time limit (h) | Calendar limit (year) | Replacement | Overhaul | Inspection/Clean Repair/Adjustment | |
| SL008 | | Monthly | - | | | X | Test run (if parameters are in the setting range) at more than a 1/3 load and at least until steady-state temperature is reached (monthly). (For more information see: 5.7.3 Testing engine in operation (ESP application) – SL008, page 104.) |

Tab. 15: Daily maintenance activities – Engine operation - Version: 2018-07

5.4.2 Service level 1 – Engine Service, TBO 4000 hours for ESP – Engine Operation - Version: 2018-07

| Task identification | Component | Schedule | | Service Type | | | Task description |
|---------------------|------------------|----------------|-----------------------|--------------|----------|------------------------------------|--|
| | | Time limit (h) | Calendar limit (year) | Replacement | Overhaul | Inspection/Clean Repair/Adjustment | |
| SL100 | Oil sampling | 100 | 1Y | | | X | Collect and send oil sample for analysis every 100 hours on ESP or 250 hours (in PRP and COP applications). If the results are not within the requested parameters, repeat analysis at shorter intervals. In case of use of high sulfure rate (>0.5%). No oil Category 1 in case of K175. (For more information see: 5.9.1 Collecting and analyzing oil sample – SL100, page 111.) |
| SL120 | Coolant sampling | - | 2Y | | | X | Check coolant quality. (For more information see: 5.10.1 Collecting coolant sample – SL120, page 122.) |

| Task identification | Component | Schedule | | Service Type | | | Task description |
|--------------------------------|---|----------------|-----------------------|--------------|----------|------------------------------------|--|
| | | Time limit (h) | Calendar limit (year) | Replacement | Overhaul | Inspection/Clean Repair/Adjustment | |
| SL122 | Recommended: First 250 service hours for a new or overhauled engine | 250 | 1Y | X | | X | <p>Engine oil replacement. (For more information see: 5.9.6 Changing Diesel engine oil – SL101, SL121, page 118.)</p> <p>Oil filters and oil filters for cooling jet replacement. (For more information see: 5.9.4 Changing oil filters – SL101, page 113.)</p> <p>It is recommended to check the engine oil characteristics at the same time. (For more information see: 5.9.1 Collecting and analyzing oil sample – SL100, page 111.)</p> <p>Perform all check before starting and perform a test run. (For more information see: 5.7.3 Testing engine in operation (ESP application only) – SL008, page 104.)</p> |
| Without centrifugal oil filter | | | | | | | |
| SL101 | Engine oil filters standard - main bearing with engine oil “Category 3” | 250 | 2Y | X | | | <p>Replace filters. Clean the seal area before removal the old filter to prevent oil contamination. (For more information see: 5.9.6 Changing Diesel engine oil – SL101, SL121, page 118.)</p> |
| SL121 | Engine oil change with engine oil “Category 2” (2) | 250 | 2Y | X | | | <p>Oil change maximum interval. Note: Replace engine oil at least every 2 years. Final engine oil interval depends on exchange interval factor according to engine oil category and fuel sulfur rate. 0<fuel sulfur rate<0.5%: the factor is 1 (no change on the engine oil change interval). 0.5<fuel Sulfur rate<1%: the factor is 1/2 (reduce by 2 times the engine oil change interval and use only engine oil category 2 or 3). 1<fuel sulfur rate <1.5%: requires additional approval. No oil Category 1 in case of K175. (For more information see: 5.9.6 Changing Diesel engine oil – SL101, SL121, page 118.)</p> |
| | Engine oil change with engine oil “Category 3” (2) | 500 | 2Y | X | | | |
| With centrifugal oil filter | | | | | | | |
| SL101 | Engine oil filters standard - main bearing with engine oil “Category 3” | 500 | 2Y | X | | | <p>Replace filters. Clean the seal area before removal the old filter to prevent oil contamination. (For more information see: 5.9.6 Changing Diesel engine oil – SL101, SL121, page 118.)</p> |

| Task identification | Component | Schedule | | Service Type | | | Task description |
|---------------------|--|----------------|-----------------------|--------------|----------|------------------------------------|---|
| | | Time limit (h) | Calendar limit (year) | Replacement | Overhaul | Inspection/Clean Repair/Adjustment | |
| SL102 | Centrifugal oil filter - paper filter | 500 | 2Y | X | | | Replace the paper (sleeve) for sludge at each oil change. Measure and record thickness of the sludge accumulated on paper if above limits. Reduce engine oil interval if the sludge accumulated is above limits. (For more information see: 5.9.5 Replacing centrifuge paper filter – SL102, page 114.) |
| SL121 | Engine oil change with engine oil “Category 2” (2) | 500 | 2Y | X | | | Oil change maximum interval. Note: Replace engine oil at least every 2 years. Final engine oil interval depends on exchange interval factor according to engine oil category and fuel sulfur rate. 0<fuel sulfur rate<0.5%: the factor is 1 (no change on the engine oil change interval). 0.5<fuel Sulfur rate<1%: the factor is 1/2 (reduce by 2 times the engine oil change interval and use only engine oil category 2 or 3). 1<fuel sulfur rate <1.5%: requires additional approval. No oil Category 1 in case of K175. (For more information see: 5.9.6 Changing Diesel engine oil – SL101, SL121, page 118.) |
| | Engine oil change with engine oil “Category 3” (2) | 1000 | 2Y | X | | | |
| SL105 | Fuel main filter | 1000 | 2Y | X | | | Replace main fuel filter cartridge. (For more information see: 5.11.3 Replacing main filter - SL105, page 131.) |
| SL106 | Recommended: Fuel pre-filters | 1000 | 2Y | X | | | Replace primary fuel filter cartridge. See the operator and maintenance manual of your application. |
| SL107 | Oil separator filters | - | 2Y | X | | | Replace oil separator filters. (For more information see: 5.12.2 Replacing crankcase breather – SL107, page 133.) |
| SL108 | Recommended: Air filters + Air ducting | 3000 | 2Y | X | | | Replace the air filter and clean air ducting between air filter and compressor. See the operator and maintenance manual of your application. |
| SL109 | Alternator belt | 1000 | 2Y | X | | X | Inspect conditions of drive belt and fit new one if necessary. (For more information see: 5.8.1 Removing the battery charging alternator cover, page 106.) Check belt tension. (For more information see: 5.8.3 Replacing drive belt – SL 109, page 108.) |
| SL110 | Alternator belt tensioner | 1000 | 18Y | | | X | Visual inspection of the tensioner. Replacement if necessary. (For more information see: 5.8.4 Replacing tensioning device – SL110, page 109.) |

| Task identification | Component | Schedule | | Service Type | | | Task description |
|---------------------|----------------|----------------|-----------------------|--------------|----------|------------------------------------|--|
| | | Time limit (h) | Calendar limit (year) | Replacement | Overhaul | Inspection/Clean Repair/Adjustment | |
| SL116 | Cooling system | - | 4Y | | | X | <p>Replace coolant (at least every 4 years for coolant formulated with Glysantin G48). Respect fluids and lubricants specifications. (For more information see: 5.13 Lubricants and operating fluids, page 134.) Note: for coolant formulated with Glysantin G40, the extension up to 8000h/6Y is possible after analysis. (For more information see: 5.10.2 Replacing coolant – SL116, page 122.)</p> |

Tab. 16: Service level 1 – ESP – Basic maintenance - Version: 2018-07

5.4.3 Service level 2– Engine Service, TBO 4000 hours for ESP – Advanced maintenance - Version: 2018-07

| Task identification | Component | Schedule | | Service Type | | | Task description |
|---------------------|---|----------------|-----------------------|--------------|----------|------------------------------------|---|
| | | Time limit (h) | Calendar limit (year) | Replacement | Overhaul | Inspection/Clean Repair/Adjustment | |
| SL204 | Valves clearance | 2000 | 2Y | | | X | <p>Clearance check and adjustment. First inspection at 1000 hours, second at 1500 hours. Proceed in the same way after cylinder head repair work.</p> |
| SL205 | Fuel injectors | - | 8Y | X | | | Replace. |
| SL206 | Combustion chambers | - | 4Y | | | X | Done at the time the injectors are replaced. Use a borescope to identify condition of combustion chamber (piston crown, liner hatches, fire deck, etc.). |
| SL2-13 45 | Silicon oil of torsional vibration damper | 1000 | 1Y | | | X | Collect and send silicon oil sample for analysis. |
| SL209 | HP fuel pump and LP fuel pump | - | 8Y | | | X | Inspect for leaks. Replace pump if necessary. |
| SL212 | Cold start oil cooler by-pass valve | - | 18Y | X | | | Replace. |

| Task identification | Component | Schedule | | Service Type | | | Task description |
|---------------------|-----------------------------|----------------|-----------------------|--------------|----------|------------------------------------|---|
| | | Time limit (h) | Calendar limit (year) | Replacement | Overhaul | Inspection/Clean Repair/Adjustment | |
| SL213 | Exhaust gas turbochargers | - | 18Y | X | | | Check overall condition (compressor blades, leaks, connections, housings, etc.) every 4000 hours. Replace the exhaust gas turbocharger at the indicated service interval. |
| SL215 | LT coolant pump | - | 18Y | X | | | Replace. |
| SL216 | HT coolant pump | - | 18Y | X | | | Replace. |
| SL217 | Coolant thermostats | - | 18Y | X | | | Replace. |
| SL218 | Auxiliary belt drive - PTO | - | 18Y | X | | | Replace. |
| SL219 | Rubber sleeves | - | 18Y | X | | | Replace all rubber hose connections on the engine: e.g., coolant hoses for ECU cooling, hose connections for crankcase ventilation. |
| SL220 | Charge air cooler | - | 18Y | | | X | Clean component according to supplier requirements. Check visually for leaks. If shown, identify reason. Replace component if needed. |
| SL221 | Oil cooler | - | 18Y | | | X | Inspect the oil cooler. |
| SL222 | Recommended: Starter | - | 18Y | | | X | Inspect the starter (winding insulation, relay, condition of the gear teeth, etc.). |
| SL223 | Battery charging alternator | - | 18Y | X | | | Replace. |
| SL224 | Cylinder heads | - | 18Y | | X | | Replace. |

Tab. 17: Service level 2 – ESP – Advanced maintenance - Version: 2018-07

5.4.4 Service level 1 – Engine Service, TBO 15000 hours for PRP – Engine Operation - Version: 2018-07

| Task identification | Component | Schedule | | Service Type | | | Task description |
|--------------------------------|---|----------------|-----------------------|--------------|----------|------------------------------------|---|
| | | Time limit (h) | Calendar limit (year) | Replacement | Overhaul | Inspection/Clean Repair/Adjustment | |
| SL100 | Oil sampling | 250 | 1Y | | | X | Collect and send oil sample for analysis every 100 hours on ESP or 250 hours (in PRP and COP applications). If the results are not within the requested parameters, repeat analysis at shorter intervals. In case of use of high sulfure rate (>0.5%). No oil Category 1 in case of K175. (For more information see: 5.9.1 Collecting and analyzing oil sample – SL100, page 111.) |
| SL120 | Coolant sampling | - | 2Y | | | X | Check coolant quality. (For more information see: 5.10.1 Collecting coolant sample – SL120, page 122.) |
| SL122 | Recommended: First 250 service hours for a new or overhauled engine | 250 | 1Y | X | | X | Engine oil replacement (For more information see: 5.9.6 Changing Diesel engine oil – SL101, SL121, page 118.) . Oil filters and oil filters for cooling jet replacement. (For more information see: 5.9.4 Changing oil filters – SL101, page 113.) It is recommended to check the engine oil characteristics at the same time. (For more information see: 5.9.1 Collecting and analyzing oil sample – SL100, page 111.) . Perform all check before starting and perform a test run. |
| Without centrifugal oil filter | | | | | | | |
| SL101 | Engine oil filters standard - main bearing with engine oil “Category 3” | 250 | 2Y | X | | | Replace filters. Clean the seal area before removal the old filter to prevent oil contamination. (For more information see: 5.9.6 Changing Diesel engine oil – SL101, SL121, page 118.) |
| SL121 | Engine oil change with engine oil “Category 2” (2) | 250 | 2Y | X | | | Oil change maximum interval. Note: Replace engine oil at least every 2 years. Final engine oil interval depends on exchange interval factor according to engine oil category and fuel sulfur rate. 0<fuel sulfur rate<0.5%: the factor is 1 (no change on the engine oil change interval). 0.5<fuel Sulfur rate<1%: the factor is 1/2 (reduce by 2 times the engine oil change interval and use only engine oil category 2 or 3). 1<fuel sulfur rate <1.5%: requires additional approval. No oil Category 1 in case of K175. (For more information see: 5.9.6 Changing Diesel engine oil – SL101, SL121, page 118.) |

| Task identification | Component | Schedule | | Service Type | | | Task description |
|-----------------------------|---|----------------|-----------------------|--------------|----------|------------------------------------|---|
| | | Time limit (h) | Calendar limit (year) | Replacement | Overhaul | Inspection/Clean Repair/Adjustment | |
| | Engine oil change with engine oil "Category 3" (2) | 500 | 2Y | X | | | |
| With centrifugal oil filter | | | | | | | |
| SL101 | Engine oil filters standard - main bearing with engine oil "Category 3" | 500 | 2Y | X | | | Replace filters. Clean the seal area before removal the old filter to prevent oil contamination. (For more information see: 5.9.6 Changing Diesel engine oil – SL101, SL121, page 118.) |
| SL102 | Centrifugal oil filter - paper filter | 500 | 2Y | X | | | Replace the paper (sleeve) for sludge at each oil change. Measure and record thickness of the sludge accumulated on paper if above limits. Reduce engine oil interval if the sludge accumulated is above limits. (For more information see: 5.9.5 Replacing centrifuge paper filter – SL102, page 114.) |
| SL121 | Engine oil change with engine oil "Category 2" (2) | 500 | 2Y | X | | | Oil change maximum interval. Note: Replace engine oil at least every 2 years. Final engine oil interval depends on exchange interval factor according to engine oil category and fuel sulfur rate. 0<fuel sulfur rate<0.5%: the factor is 1 (no change on the engine oil change interval). 0.5<fuel Sulfur rate<1%: the factor is 1/2 (reduce by 2 times the engine oil change interval and use only engine oil category 2 or 3). 1<fuel sulfur rate <1.5%: requires additional approval. No oil Category 1 in case of K175. (For more information see: 5.9.6 Changing Diesel engine oil – SL101, SL121, page 118.) |
| | Engine oil change with engine oil "Category 3" (2) | 1000 | 2Y | X | | | |
| SL105 | Fuel main filter | 1000 | 2Y | X | | | Replace main fuel filter cartridge. (For more information see: 5.11.3 Replacing main filter - SL105, page 131.) |
| SL106 | Recommended: Fuel pre-filters | 1000 | 2Y | X | | | Replace primary fuel filter cartridge. See the operator and maintenance manual of your application. |
| SL107 | Oil separator filters | 7500 | 2Y | X | | | Replace oil separator filters. (For more information see: 5.12.2 Replacing crankcase breather – SL107, page 133.) |
| SL108 | Recommended: Air filters + Air ducting | 3000 | 2Y | X | | | Replace the air filter and clean air ducting between air filter and compressor. See the operator and maintenance manual of your application. |

| Task identification | Component | Schedule | | Service Type | | | Task description |
|---------------------|---------------------------|----------------|-----------------------|--------------|----------|------------------------------------|--|
| | | Time limit (h) | Calendar limit (year) | Replacement | Overhaul | Inspection/Clean Repair/Adjustment | |
| SL109 | Alternator belt | 1500 | 2Y | X | | X | Inspect conditions of drive belt and fit new one if necessary. (For more information see: 5.8.1 Removing the battery charging alternator cover, page 106.) Check belt tension. (For more information see: 5.8.3 Replacing drive belt – SL 109, page 108.) |
| SL110 | Alternator belt tensioner | 4000 | 18Y | | | X | Visual inspection of the tensioner. Replacement if necessary. (For more information see: 5.8.4 Replacing tensioning device – SL110, page 109.) |
| SL116 | Cooling system | 6000 | 4Y | | | X | Replace coolant (at least every 4 years for coolant formulated with Glysantin G48). Respect fluids and lubricants specifications. (For more information see: 5.13 Lubricants and operating fluids, page 134.) Note: for coolant formulated with Glysantin G40, the extension up to 8000h/6Y is possible after analysis. (For more information see: 5.10.2 Replacing coolant – SL116, page 122.) |

Tab. 18: Service level 1 – PRP – Basic maintenance - Version: 2018-07

5.4.5 Service level 2– Engine Service, TBO 15000 hours for PRP – Advanced maintenance - Version: 2018-07

| Task identification | Component | Schedule | | Service Type | | | Task description |
|---------------------|------------------|----------------|-----------------------|--------------|----------|------------------------------------|--|
| | | Time limit (h) | Calendar limit (year) | Replacement | Overhaul | Inspection/Clean Repair/Adjustment | |
| SL204 | Valves clearance | 2000 | 2Y | | | X | Clearance check and adjustment. First inspection at 1000 hours, second at 1500 hours. Proceed in the same way after cylinder head repair work. |
| SL205 | Fuel injectors | 7500 | 8Y | X | | | Replace. |

Maintenance

Inspection and maintenance schedules

| Task identification | Component | Schedule | | Service Type | | | Task description |
|---------------------|---|----------------|-----------------------|--------------|----------|------------------------------------|---|
| | | Time limit (h) | Calendar limit (year) | Replacement | Overhaul | Inspection/Clean Repair/Adjustment | |
| SL206 | Combustion chambers | 7500 | 8Y | | | X | Done at the time the injectors are replaced. Use a borescope to identify condition of combustion chamber (piston crown, liner hatches, fire deck, etc.). |
| SL2-13 45 | Silicon oil of torsional vibration damper | 1000 | 1Y | | | X | Collect and send silicon oil sample for analysis. |
| SL209 | HP fuel pump and LP fuel pump | - | 8Y | | | X | Inspect for leaks. Replace pump if necessary. |
| SL212 | Cold start oil cooler by-pass valve | 7500 | 18Y | X | | | Replace. |
| SL213 | Exhaust gas turbochargers | 7500 | 18Y | X | | | Visual check condition on compressor side (blades, leaks, connections, housings, etc.) every 4000 hours. Replace the exhaust gas turbocharger at the indicated service interval. |
| SL215 | LT coolant pump | 7500 | 18Y | X | | | Replace. |
| SL216 | HT coolant pump | 7500 | 18Y | X | | | Replace. |
| SL217 | Coolant thermostats | 7500 | 18Y | X | | | Replace. |
| SL218 | Auxiliary Belt Drive - PTO | 7500 | 18Y | X | | | Replace. |
| SL219 | Rubber sleeves | 7500 | 18Y | X | | | Replace all rubber hose connections on the engine: e.g., coolant hoses for ECU cooling, hose connections for crankcase ventilation. |
| SL220 | Charge air cooler | 7500 | 18Y | | | X | Clean component according to supplier requirements. Check visually for leaks. If shown, identify reason. Replace component if needed. |
| SL221 | Oil cooler | 7500 | 18Y | | | X | Inspect the oil cooler. |
| SL222 | Recommended: Starter | 7500 | 18Y | | | X | Inspect the starter (winding insulation, relay, condition of the gear teeth, etc.). |
| SL223 | Battery charging alternator | 7500 | 18Y | X | | | Replace. |
| SL224 | Cylinder heads | 7500 | 18Y | | X | | Replace. |

Tab. 19: Service level 2 – PRP – Advanced maintenance - Version: 2018-07

5.4.6 Service level 1 – Engine Service, TBO 24000 hours for COP – Engine Operation - Version: 2018-07

| Task identification | Component | Schedule | | Service Type | | | Task description |
|--------------------------------|---|----------------|-----------------------|--------------|----------|------------------------------------|---|
| | | Time limit (h) | Calendar limit (year) | Replacement | Overhaul | Inspection/Clean Repair/Adjustment | |
| SL100 | Oil sampling | 250 | 1Y | | | X | Collect and send oil sample for analysis every 100 hours on ESP or 250 hours (in PRP and COP applications). If the results are not within the requested parameters, repeat analysis at shorter intervals. In case of use of high sulfure rate (>0.5%). No oil Category 1 in case of K175. (For more information see: 5.9.1 Collecting and analyzing oil sample – SL100, page 111.) |
| SL120 | Coolant sampling | - | 2Y | | | X | Check coolant quality. (For more information see: 5.10.1 Collecting coolant sample – SL120, page 122.) |
| SL122 | Recommended: First 250 service hours for a new or overhauled engine | 250 | 1Y | X | | X | Engine oil replacement. (For more information see: 5.9.6 Changing Diesel engine oil – SL101, SL121, page 118.) Oil filters and oil filters for cooling jet replacement. (For more information see: 5.9.4 Changing oil filters – SL101, page 113.) It is recommended to check the engine oil characteristics at the same time. (For more information see: 5.9.1 Collecting and analyzing oil sample – SL100, page 111.) Perform all check before starting and perform a test run. |
| Without centrifugal oil filter | | | | | | | |
| SL101 | Engine oil filters standard - main bearing with engine oil "Category 3" | 250 | 2Y | X | | | Replace filters. Clean the seal area before removal the old filter to prevent oil contamination. (For more information see: 5.9.6 Changing Diesel engine oil – SL101, SL121, page 118.) |
| SL121 | Engine oil change with engine oil "Category 2" (2) | 250 | 2Y | X | | | Oil change maximum interval. Note: Replace engine oil at least every 2 years. Final engine oil interval depends on exchange interval factor according to engine oil category and fuel sulfur rate. 0<fuel sulfur rate<0.5%: the factor is 1 (no change on the engine oil change interval). 0.5<fuel Sulfur rate<1%: the factor is 1/2 (reduce by 2 times the engine oil change interval and use only engine oil category 2 or 3). 1<fuel sulfur rate <1.5%: requires additional approval. No oil Category 1 in case of K175. (For more information see: 5.9.6 Changing Diesel engine oil – SL101, SL121, page 118.) |

| Task identification | Component | Schedule | | Service Type | | | Task description |
|-----------------------------|---|----------------|-----------------------|--------------|----------|------------------------------------|---|
| | | Time limit (h) | Calendar limit (year) | Replacement | Overhaul | Inspection/Clean Repair/Adjustment | |
| | Engine oil change with engine oil "Category 3" (2) | 500 | 2Y | X | | | |
| With centrifugal oil filter | | | | | | | |
| SL101 | Engine oil filters standard - Main bearing with engine oil "Category 3" | 500 | 2Y | X | | | Replace filters. Clean the seal area before removal the old filter to prevent oil contamination. (For more information see: 5.9.6 Changing Diesel engine oil – SL101, SL121, page 118.) |
| SL102 | Centrifugal oil filter - paper filter | 500 | 2Y | X | | | Replace the paper (sleeve) for sludge at each oil change. Measure and record thickness of the sludge accumulated on paper if above limits. Reduce engine oil interval if the sludge accumulated is above limits. (For more information see: 5.9.5 Replacing centrifuge paper filter – SL102, page 114.) |
| SL121 | Engine oil change with engine oil "Category 2" (2) | 500 | 2Y | X | | | Oil change maximum interval. Note: Replace engine oil at least every 2 years. Final engine oil interval depends on exchange interval factor according to engine oil category and fuel sulfur rate. 0<fuel sulfur rate<0.5%: the factor is 1 (no change on the engine oil change interval). 0.5<fuel Sulfur rate<1%: the factor is 1/2 (reduce by 2 times the engine oil change interval and use only engine oil category 2 or 3). 1<fuel sulfur rate <1.5%: requires additional approval. No oil Category 1 in case of K175. (For more information see: 5.9.6 Changing Diesel engine oil – SL101, SL121, page 118.) |
| | Engine oil change with engine oil "Category 3" (2) | 1000 | 2Y | X | | | |
| SL105 | Fuel main filter | 1000 | 2Y | X | | | Replace main fuel filter cartridge. (For more information see: 5.11.3 Replacing main filter - SL105, page 131.) |
| SL106 | Recommended: Fuel pre-filters | 1000 | 2Y | X | | | Replace primary fuel filter cartridge. See the operator and maintenance manual of your application. |
| SL107 | Oil separator filters | 7500 | 2Y | X | | | Replace oil separator filters. (For more information see: 5.12.2 Replacing crankcase breather – SL107, page 133.) |
| SL108 | Recommended: Air filters + Air ducting | 3000 | 2Y | X | | | Replace the air filter and clean air ducting between air filter and compressor. See the operator and maintenance manual of your application. |

| Task identification | Component | Schedule | | Service Type | | | Task description |
|---------------------|---------------------------|----------------|-----------------------|--------------|----------|------------------------------------|--|
| | | Time limit (h) | Calendar limit (year) | Replacement | Overhaul | Inspection/Clean Repair/Adjustment | |
| SL109 | Alternator belt | 1500 | 2Y | X | | X | Inspect conditions of drive belt and fit new one if necessary. (For more information see: 5.8.1 Removing the battery charging alternator cover, page 106.) Check belt tension. (For more information see: 5.8.3 Replacing drive belt – SL 109, page 108.) |
| SL110 | Alternator belt tensioner | 4000 | 18Y | | | X | Visual inspection of the tensioner. Replacement if necessary. (For more information see: 5.8.4 Replacing tensioning device – SL110, page 109.) |
| SL116 | Cooling system | 6000 | 4Y | | | X | Replace coolant (at least every 4 years for coolant formulated with Glysantin G48). Respect fluids and lubricants specifications. (For more information see: 5.13 Lubricants and operating fluids, page 134.) Note: for coolant formulated with Glysantin G40, the extension up to 8000h/6Y is possible after analysis. (For more information see: 5.10.2 Replacing coolant – SL116, page 122.) |

Tab. 20: Service level 1 – COP – Basic maintenance - Version: 2018-07

5.4.7 Service level 2– Engine Service, TBO 24000 hours for COP – Advanced maintenance - Version: 2018-07

| Task identification | Component | Schedule | | Service Type | | | Task description |
|---------------------|------------------|----------------|-----------------------|--------------|----------|------------------------------------|--|
| | | Time limit (h) | Calendar limit (year) | Replacement | Overhaul | Inspection/Clean Repair/Adjustment | |
| SL204 | Valves clearance | 2000 | 2Y | | | X | Clearance check and adjustment. First inspection at 1000 hours, second at 1500 hours. Proceed in the same way after cylinder head repair work. |
| SL205 | Fuel injectors | 8000 | 8Y | X | | | Replace. |

| Task identification | Component | Schedule | | Service Type | | | Task description |
|---------------------|-------------------------------------|----------------|-----------------------|--------------|----------|------------------------------------|---|
| | | Time limit (h) | Calendar limit (year) | Replacement | Overhaul | Inspection/Clean Repair/Adjustment | |
| SL206 | Combustion chambers | 8000 | 8Y | | | X | Done at the time the injectors are replaced. Use a borescope to identify condition of combustion chamber (piston crown, liner hatches, fire deck, etc.). |
| SL209 | HP fuel pump and LP fuel pump | - | 8Y | | | X | Inspect for leaks. Replace pump if necessary. |
| SL212 | Cold start oil cooler by-pass valve | 12000 | 18Y | X | | | Replace. |
| SL213 | Exhaust gas turbochargers | 12000 | 18Y | X | | | Visual check condition on compressor side (blades, leaks, connections, housings, etc.) every 4000 hours. No dismantling of the exhaust gas turbocharger only the air ducting. Replace the exhaust gas turbocharger at the indicated service interval. |
| SL215 | LT coolant pump | 12000 | 18Y | X | | | Replace. |
| SL216 | HT coolant pump | 12000 | 18Y | X | | | Replace. |
| SL217 | Coolant thermostats | 12000 | 18Y | X | | | Replace. |
| SL218 | Auxiliary belt drive - PTO | 12000 | 18Y | X | | | Replace. |
| SL219 | Rubber sleeves | 12000 | 18Y | X | | | Replace all rubber hose connections on the engine: e.g., coolant hoses for ECU cooling, hose connections for crankcase ventilation. |
| SL220 | Charge air cooler | 12000 | 18Y | | | X | Clean component according to supplier requirements. Check visually for leaks. If shown, identify reason. Replace component if needed. |
| SL221 | Oil cooler | 12000 | 18Y | | | X | Inspect the oil cooler. |
| SL222 | Recommended: Starter | 12000 | 18Y | | | X | Inspect the starter (winding insulation, relay, condition of the gear teeth, etc.). |
| SL223 | Battery charging alternator | 12000 | 18Y | X | | | Replace. |
| SL224 | Cylinder heads | 12000 | 18Y | | X | | Replace. |

Tab. 21: Service level 2 – COP – Advanced maintenance - Version: 2018-07

5.5 Preparatory maintenance activities



DANGER

Hazards by entanglement, rotating or moving and ejected parts.
Impacts by ejected parts will result in death or serious injury.

Before monitoring or accessing to the engine covers, housing or compartment:

- ▶ Switch off the engine. [\(For more information see: 4.4.1 Shutting down the engine, page 74.\)](#)
- ▶ Make sure that all parts are stopped.
- ▶ Secure all parts against unexpected movements.



Information

The application set owner shall develop, document, implement, and enforce lockout/tagout procedures.

Ensure the engine maintenance conditions as follows:

- ▶ Position the engine horizontally.
- ▶ Secure the area according to local lockout/tagout procedures.
- ▶ Turn off battery main switch.
- ▶ If present, remove main switch key.
- ▶ Let the engine cool down to ambient temperature.

5.6 Post maintenance activities

5.6.1 Spray painting

Specific safety instructions



DANGER

Fire or explosion by flammable and explosive chemical products.
Burns or explosion release will result in death or serious injury.

- ▶ Avoid any contact of flammable and explosive chemical products with any hot surface or ignition source.
- ▶ Lock out and tag out the engine prior to carrying out paint works on it.
- ▶ Ensure a good ventilation while carrying out paint works on the engine.
- ▶ Smoking and open flames are forbidden in the vicinity of the engine.



WARNING

Risk of injuries by contact with or inhalation of chemical products.
Contact with or inhalation of chemical products could result in death or serious injuries by intoxication or poisoning.

- ▶ Wear proper personal protective equipment.
- ▶ Refer to the local regulations and the product associated data to safely handle, store, and use these products.



WARNING

Risk of injuries by explosion of pressurized container.
Explosion of pressurized container could result in death or serious injuries.

- ▶ Do not pierce or burn the pressurized container, even after use.
- ▶ Protect the pressurized container from sunlight.
- ▶ Make sure the pressurized contained is not exposed to temperatures over 50 °C (122 °F).

Scope

Spray painting may be necessary in the following cases:

- Touch-ups following damage to the original paint
- Painting of spare parts delivered unpainted

Previous tasks

- Make sure that the surface to be painted is clean and free of grease, dust, and debris.
- Make sure that the spray paint can is at ambient temperature.
- Make sure that all areas not to be painted are masked.

Consumables and equipment

- Spray paint can - black color (12692707)
- Rags
- Cleaner

Painting

- ▶ Shake the spray paint can for 3 minutes.
- ▶ Spray the paint at a distance of 25 cm (9.84 in) to 30 cm (11.81 in), making a criss-cross pattern.
- ▶ Spray enough layers to cover the whole unpainted area.
- ▶ Turn the spray can upside down and bleed the valve after finishing the paint work.



Information

In optimal conditions (20 °C (68 °F), 65% of humidity), the paint is completely dry after 24 hours.

5.7 Daily or monthly maintenance activities

5.7.1 Inspecting engine overall condition – SL000

Previous tasks

Make sure that the following preconditions are met:

- Preparatory maintenance activities are fulfilled. (For more information see: [5.5 Preparatory maintenance activities, page 97.](#))

Specific safety instructions

Not applicable.

Consumables and equipment

Not applicable.

Visual inspection

Carry out a visual inspection of the engine, ducts, and hoses in order to:

- Search for possible leaks.
- Eliminate the risk of contamination.
- Search for loose components.
- Prevent engine damage.

The lines and hoses must be free of the following defects:

- Damage to the outer layer (for example: scratches, cuts, and tears)
- Embrittlement of the outer layer (for example: crack formation in the material)
- Deformation of the hose or line, taking into account depressurized and pressurized conditions of the hose or line, as well as bends (for example: delamination, blister formation)
- Leaks
- Failure to comply with the installation requirements
- Damage or deformation to fittings
- Dislocation of hoses from fittings
- Corrosion on fittings

- ▶ Inspect all the points shown in the pictures below.

If defect is detected:

- ▶ Record and report any defect.
- ▶ Make sure that authorized service personnel correct the defect.

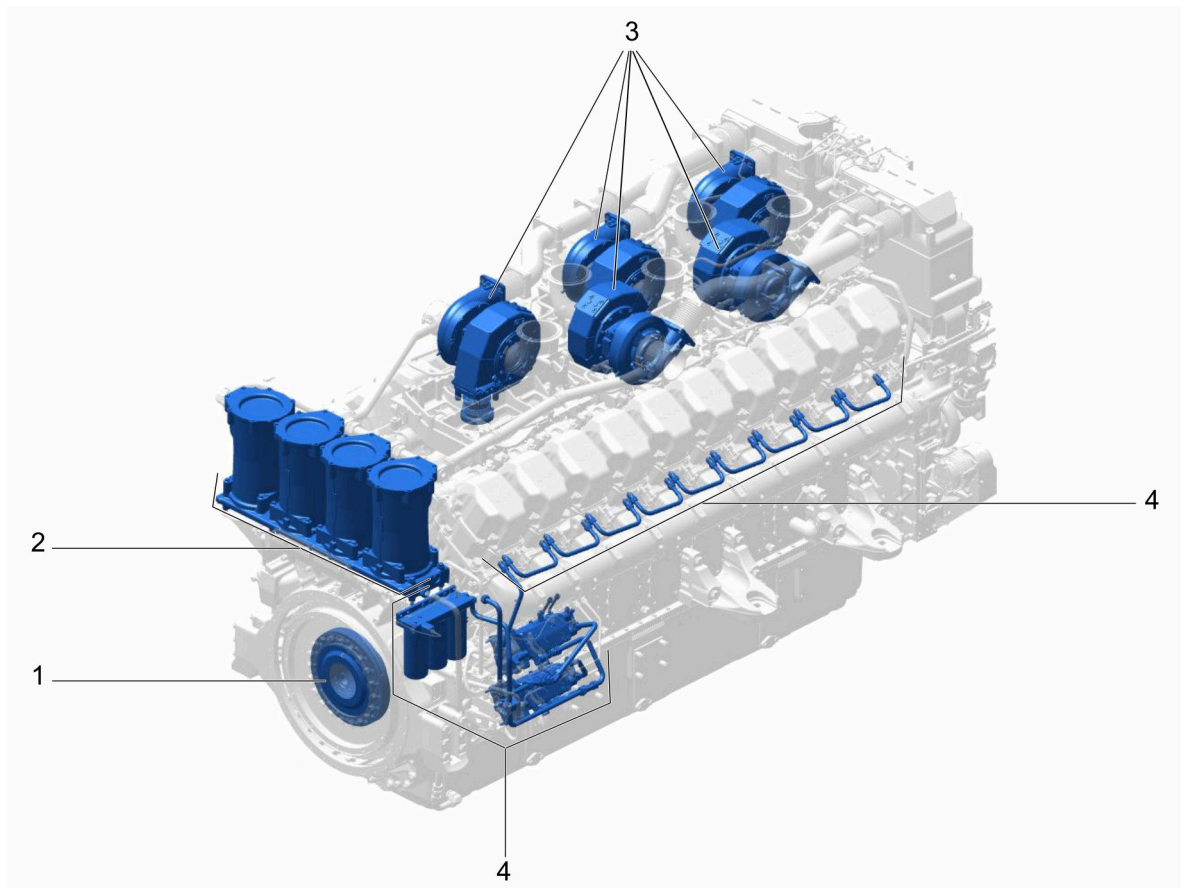


Fig. 44: Visual inspection of Diesel engine (1)

- | | | | |
|----------|--------------------------------|----------|--------------------------|
| 1 | Crankshaft flange - shaft seal | 3 | Exhaust gas turbocharger |
| 2 | Crankcase breather system | 4 | Injection system |

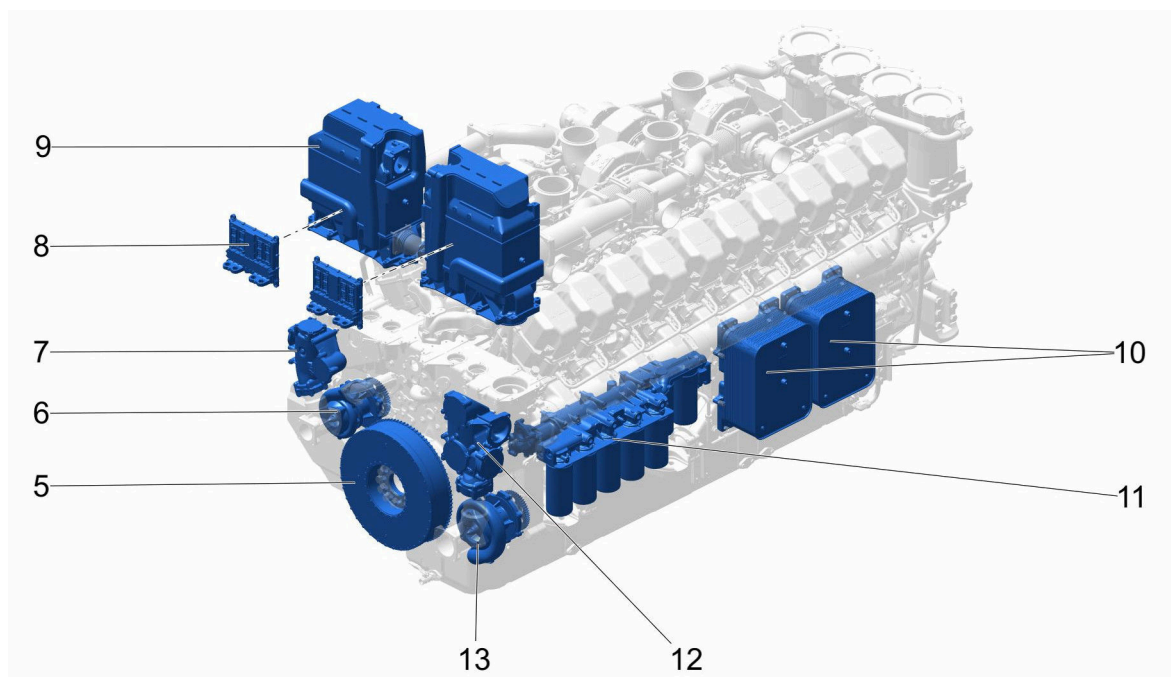


Fig. 45: Visual inspection of Diesel engine (2)

- | | | | |
|----------|--------------------------------------|-----------|-------------------------------|
| 5 | Vibration damper flange - shaft seal | 10 | Oil cooler |
| 6 | Coolant pump low temperature | 11 | Spin-on oil filters |
| 7 | Thermostat low temperature | 12 | Thermostat high temperature |
| 8 | Engine control unit (ECU) | 13 | Coolant pump high temperature |
| 9 | Charge air cooler | | |

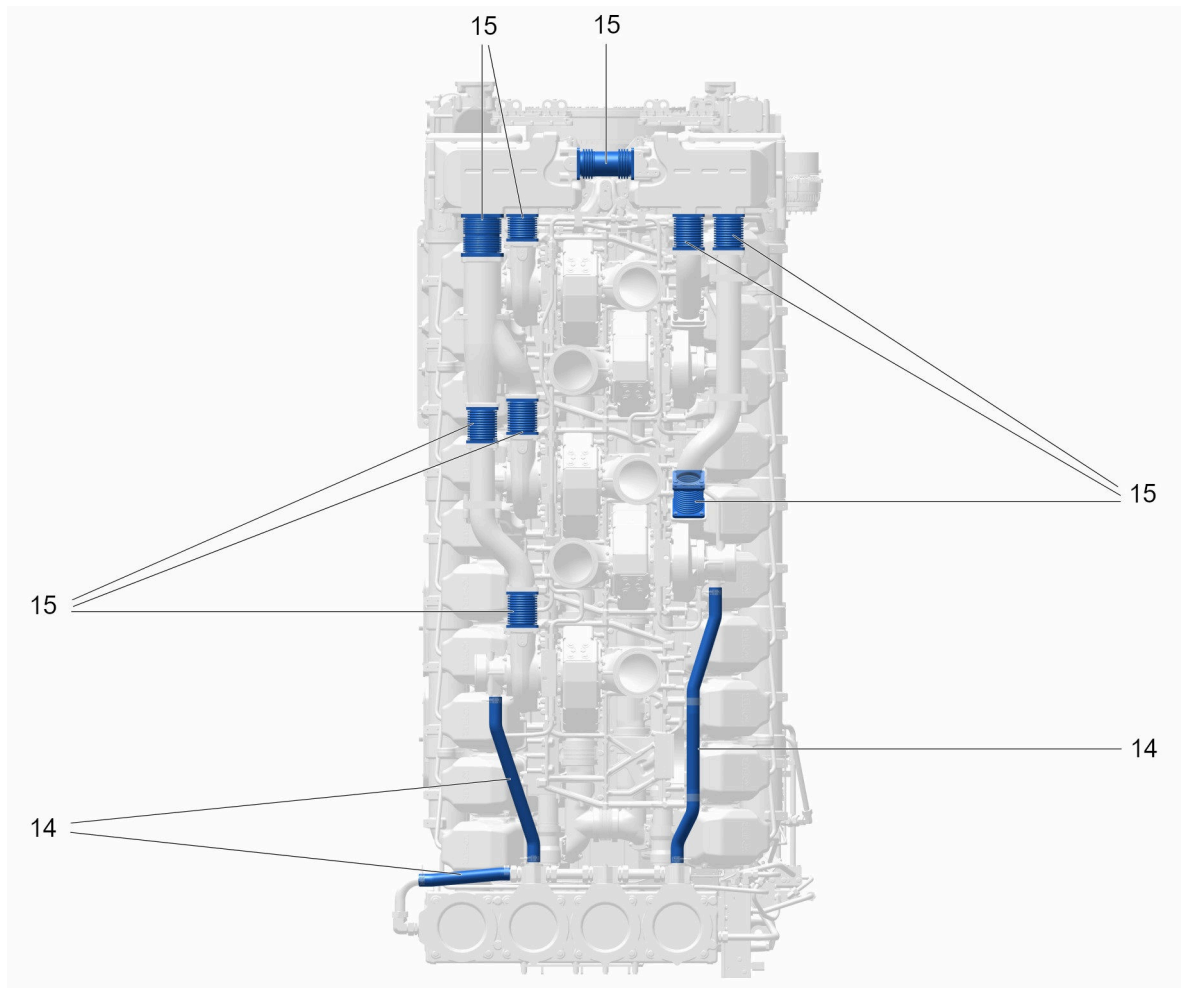


Fig. 46: Visual inspection of Diesel engine (3)

14 Rubber sleeve

15 Charge air line compensator

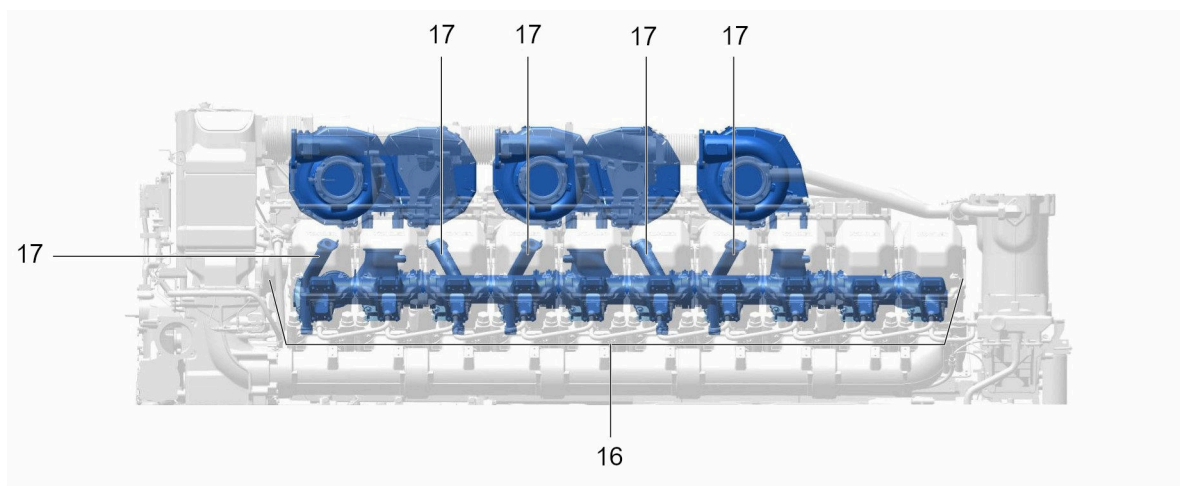


Fig. 47: Visual inspection of Diesel engine (4)

16 Exhaust line

17 Oil return (from exhaust gas turbo-charger to crankcase)

5.7.2 Inspecting engine running at idle speed – SLO-007

Previous tasks

Make sure that the following preconditions are met:

- Engine is running at idle speed.
- Engine is secured in the idle speed operating mode.

Specific safety instructions

Not applicable.

Consumables and equipment

Not applicable.

Inspection

- ▶ Observe the engine running at idle speed.
- ▶ Record and report any defect found on the engine (for example: leak, unusual noise, unusual vibration, unusual exhaust gas color).
- ▶ Record and report any anomaly found on generator set display (for example: faulty parameter).
- ▶ Make sure that authorized service personnel correct the defect.

5.7.3 Testing engine in operation (ESP application only) – SL008

Previous tasks

Make sure that the following preconditions are met:

- Operating test is planned and agreed with the responsible person for the electrical network.
- Electrical load is available for the test.
- Generator set is ready for operation.

Specific safety instructions

Not applicable.

Consumables and equipment

Not applicable.

Test

- ▶ Run engine at a higher load than 1/3 of its nominal power until temperature reaches steady state. All parameters must remain within expected range (no alarm).
- ▶ Monitor the running engine and the generator set display.
- ▶ Record and report any defect found on the engine (for example: leak, unusual noise, unusual vibration, unusual exhaust gas color).

- ▶ Record and report any anomaly found on generator set display (for example: faulty parameter).
- ▶ Make sure that authorized service personnel correct the defect.

5.8 Generic maintenance activities

5.8.1 Removing the battery charging alternator cover

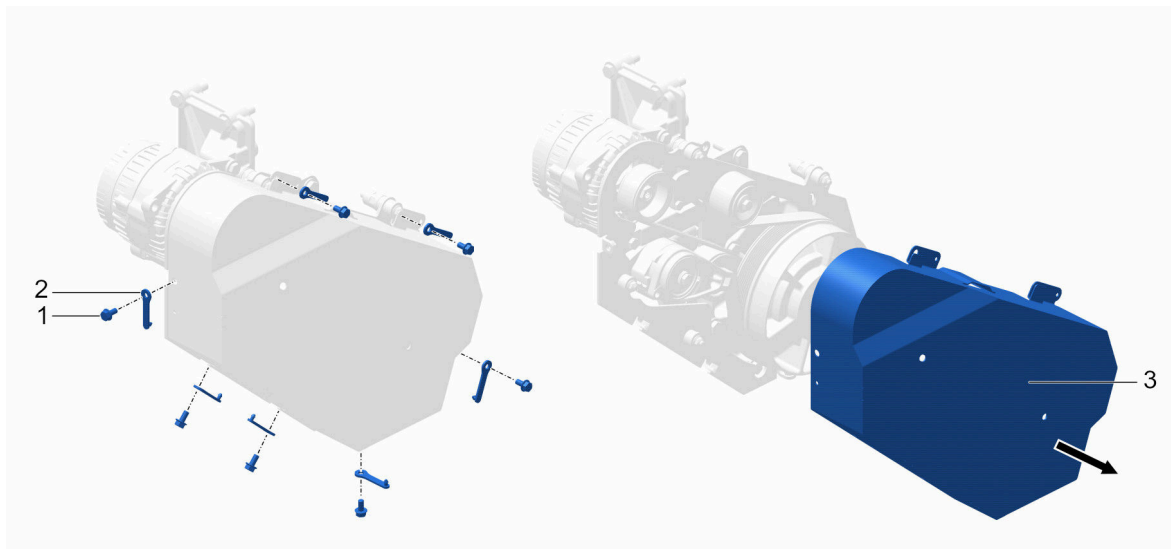


Fig. 48: Battery charging alternator cover details

- | | | | |
|----------|-------------|----------|-------|
| 1 | Screw (M8) | 3 | Cover |
| 2 | Lock washer | | |

Preparatory maintenance activities are fulfilled. (For more information see: [5.5 Preparatory maintenance activities, page 97.](#)) .

- ▶ Unscrew and remove screws **1**.
- ▶ Remove cover **3** with screws and lock washers **2**.



Information

Perform assembly in reverse sequence.

5.8.2 Checking drive belt – SL109

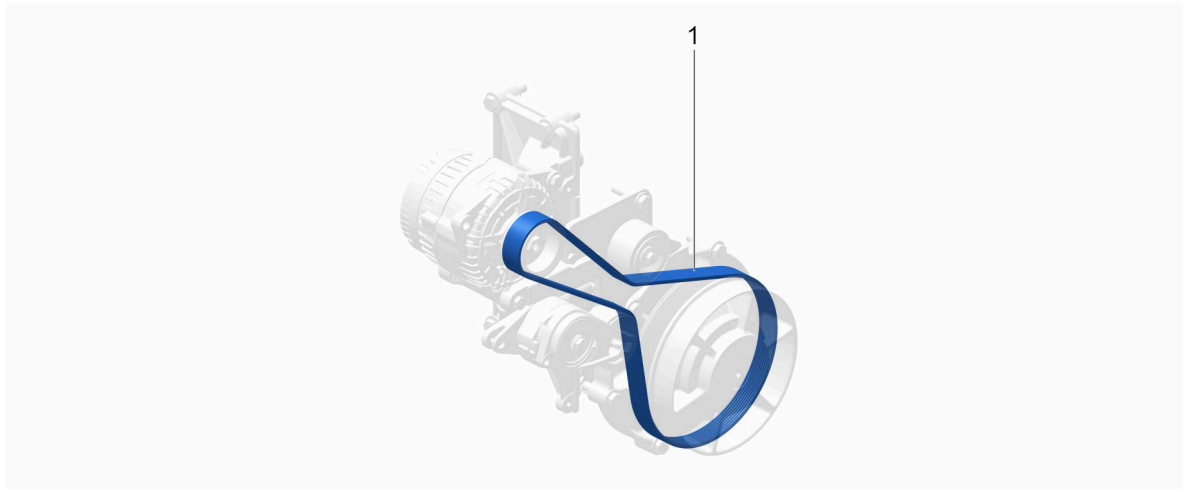


Fig. 49: Drive belt alternator

1 Drive belt



WARNING

Crushing hazards! During the assembly of auxiliaries, fingers can be crushed between tensioner and bracket.

Could cause serious injury or death.

- ▶ Wear proper personal protective equipment.
- ▶ Use assembly and lifting devices.

Examples of damage to the drive belt are the following:

- Rip breaks
- Rubber nodules in the belt base
- Deposits of dirt and / or stones
- Ribs detached from belt base
- Traverse cracks on the back
- Traverse cracks in several ribs

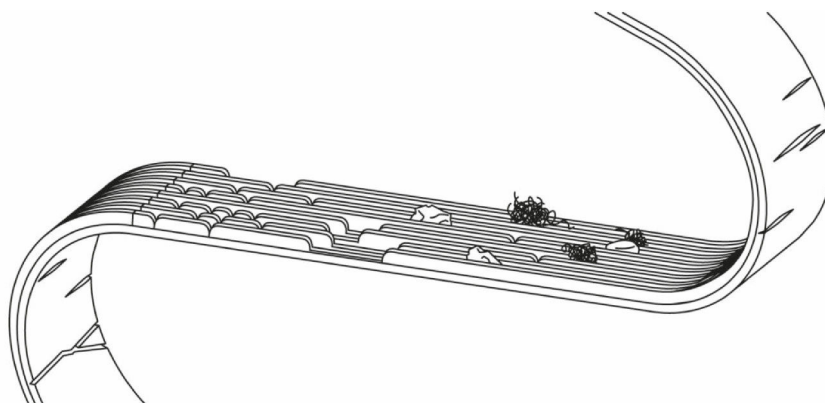


Fig. 50: Damage to the drive belt

The belt attachment is self-tensioning and maintenance-free.

The belt drive is located at the engine damper side.

In case of wear, have the belt replaced immediately by the authorized service personnel.

5.8.3 Replacing drive belt – SL 109

- ❑ Battery charging alternator cover is removed. (For more information see: [5.8.1 Removing the battery charging alternator cover, page 106.](#)) .
- ❑ New drive belt is available.
- ❑ Ratchet wrench (1/2-inch square drive) with lever is available.
- ❑ Guiding pin (8 mm (0.31 in) diameter) is available.
- ❑ Frequency meter is available.

Removing drive belt

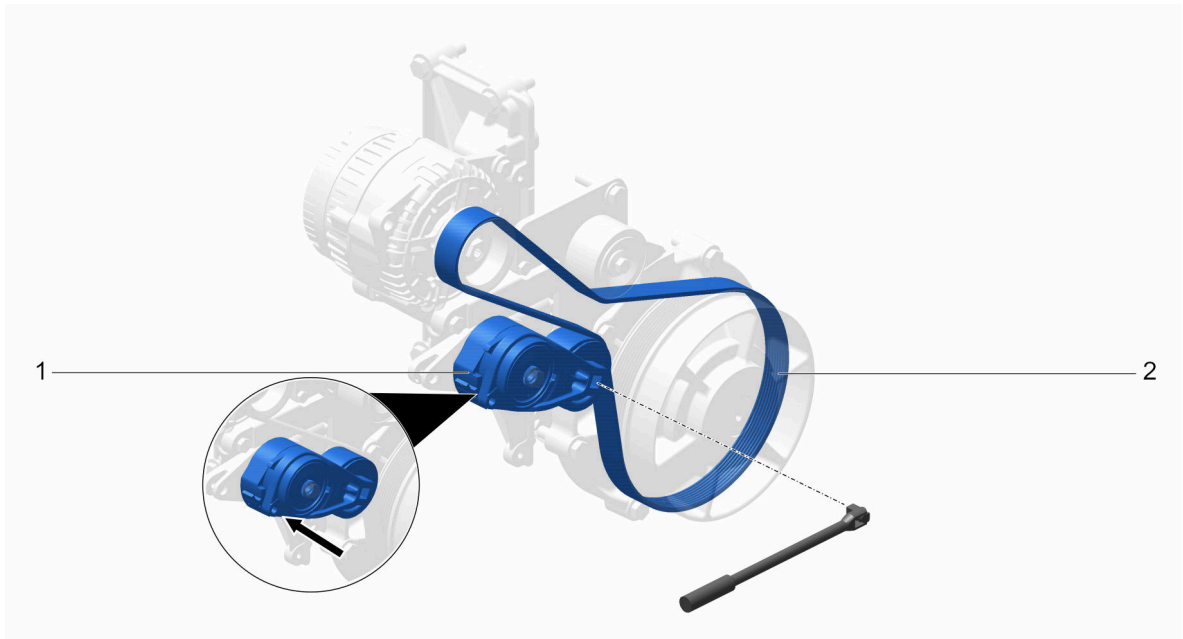


Fig. 51: Removing drive belt

- ▶ Install ratchet wrench on tensioning device **1**.
- ▶ Pivot back tensioning device **1** against the spring force to the limit stop.
- ▶ Insert guiding pin (8 mm (0.31 in) diameter) to block the tensioning device.
- ▶ Remove drive belt **2**.
- ▶ Remove guiding pin.
- ▶ Release and remove ratchet wrench.
 - ▷ The tensioning device is released.

Installing drive belt

- ▶ Install ratchet wrench on tensioning device **1**.
- ▶ Pivot back tensioning device **1** against the spring force to the limit stop.
- ▶ Insert guiding pin (8 mm (0.31 in) diameter) to block the tensioning device.
- ▶ Install new drive belt **2**.
- ▶ Remove guiding pin.

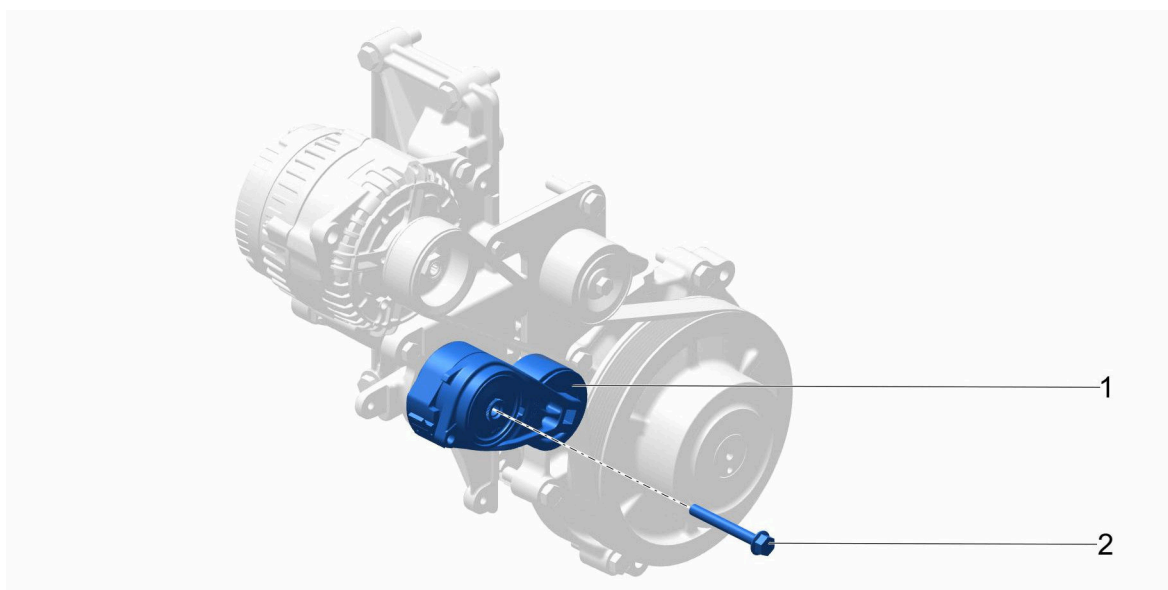


Fig. 53: Replacing tensioning device

1 Tensioning device

2 Screw (M10)

Removing tensioning device

- ▶ Remove screw (M10) **2**.
- ▶ Remove tensioning device **1**.

Installing tensioning device

- ▶ Install tensioning device **1** with screw (M10) **2**.
- ▶ Tighten screw (M10) **2** to standard torque.



Information

Install battery charging alternator cover in reverse sequence. ([For more information see: 5.8.1 Removing the battery charging alternator cover, page 106.](#)) .

5.9 Lubricating system

5.9.1 Collecting and analyzing oil sample – SL100

Make sure that the following preconditions are met:

- ❑ Preparatory maintenance activities are fulfilled. (For more information see: [5.5 Preparatory maintenance activities, page 97.](#))



WARNING

Hazards by ejection of hot engine oil.
Hot engine oil could result in death or serious injuries by burns or skin penetrating oil.

- ▶ Avoid skin contact with the engine oil.
- ▶ Wear proper personal protective equipment.

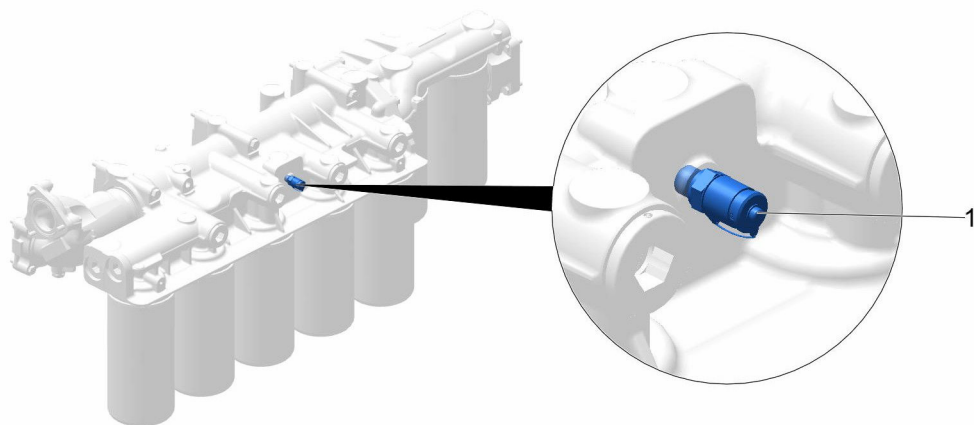


Fig. 54: Oil sampling point on engine left side

- 1 Sampling point



Information

The oil quality is to be ensured by regular analyses.

For more information, refer to the instructions of the application.

- ▶ Take oil sample from the sampling point.
- ▶ Ensure analyses according to the instructions of the application.

5.9.2 Checking prelubricating pump (optional) – SL103

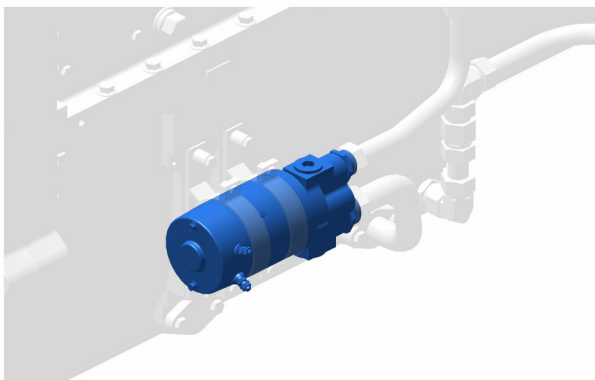


Fig. 55: Prelubricating pump

- ▶ Check for abnormal noise when operating.
- ▶ Check pump for leaks.
- ▶ Control pump functions.
- ▶ Identify and report any failure. Make sure that authorized service personnel correct the defect.

5.9.3 Checking the engine oil level – SL001

- Engine stopped since at least 30 minutes.
- Preparatory maintenance activities are fulfilled. ([For more information see: 5.5 Preparatory maintenance activities, page 97.](#)) .

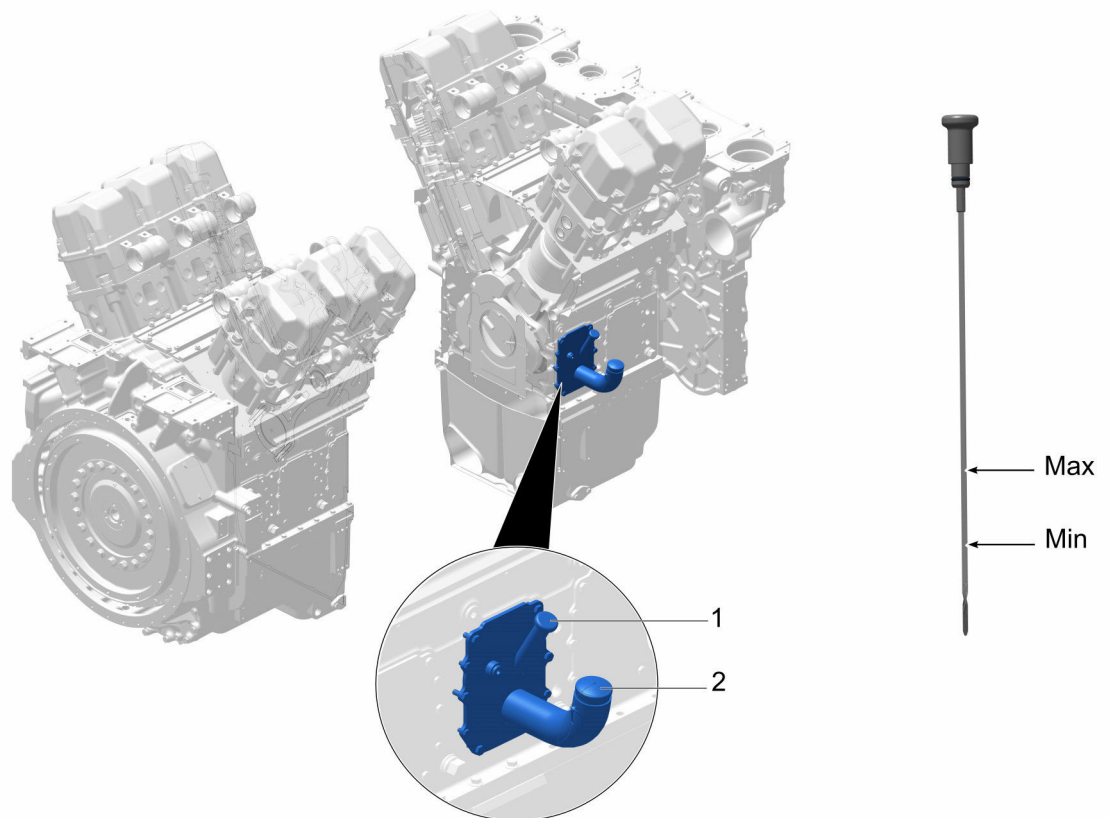


Fig. 56: Example of oil dipstick – oil filler neck

1 Dipstick

2 Oil filler neck



Information

Depending on application, some dipsticks have markings ("stopped" / "started").
Check the oil level on the "stopped" side.

- ▶ Pull out dipstick **1**, wipe with clean cloth and re-insert as far as it goes.
- ▶ Pull the oil dipstick again and determine the oil level.
 - ▷ The oil level must be between the "min." and "max." marks on the dipstick.

If the oil level is too low:

- ▶ Remove oil filling cap.
- ▶ Replenish oil via the oil filler neck **2**.
- ▶ Do not replenish Diesel engine with oil over the "max." mark.
- ▶ Clean filling cap and close the filler neck.

5.9.4 Changing oil filters – SL101

- Preparatory maintenance activities are fulfilled. (For more information see: [5.5 Preparatory maintenance activities, page 97.](#))

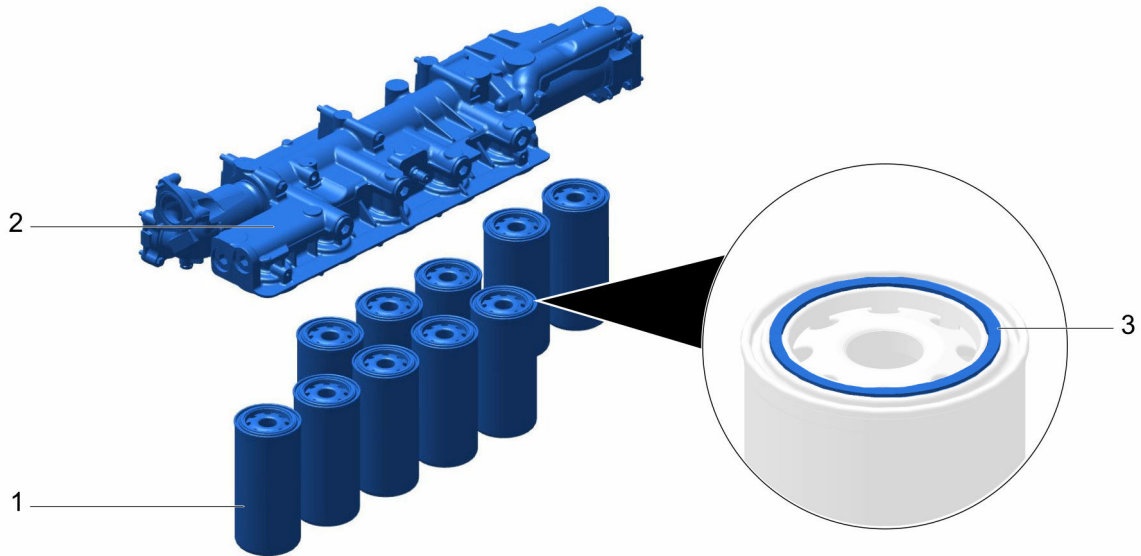


Fig. 57: Spin-on oil filters

- 1** Spin-on oil filter
2 Filter head
3 Seal

Spin-on oil filter removal

- ▶ Clean sealing area.
- ▶ Open spin-on oil filter **1** with filter wrench.
- ▶ Remove filter.
- ▶ Repeat procedure for all filters.

Spin-on oil filter installation

- ▶ Clean sealing area.
- ▶ Lubricate filter seal **3** with engine oil.
- ▶ Screw spin-on oil filter **1** in filter head **2** until it contacts base.
- ▶ Tighten filter by hand by 1/2 turn.
- ▶ Operate prelubricating pump to vent the filters.
- ▶ In the absence of prelubricating pump, disconnect TDC sensor (flywheel) and start engine until oil pressure shows up.
- ▶ Reconnect TDC sensor.
- ▶ Check for leaks and damage.
- ▶ Retighten if necessary.

5.9.5 Replacing centrifuge paper filter – SL102

- Preparatory maintenance activities are fulfilled. (For more information see: [5.5 Preparatory maintenance activities, page 97.](#))
- Original KOHLER oil filters with the seals are available.
- A suitable drainage container is available.
- The required quantity of approved oil is available. (For more information see: [5.13 Lubricants and operating fluids, page 134.](#))



WARNING

Hazards by ejection of hot engine oil.
Hot engine oil could result in death or serious injuries by burns or skin penetrating oil.

- ▶ Avoid skin contact with the engine oil.
- ▶ Wear proper personal protective equipment.



Information

The oil centrifuge is equipped with a stop valve which stops the oil inlet.

Replacing centrifuge paper filter

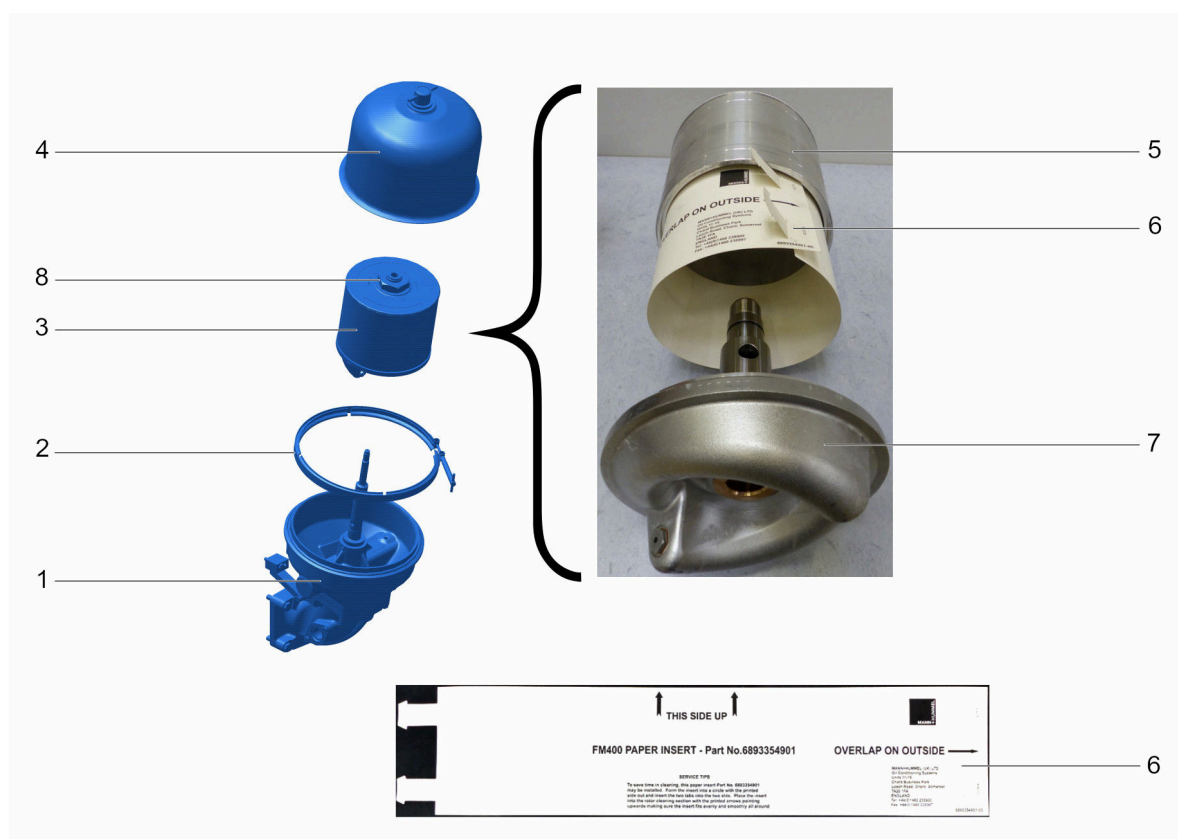


Fig. 58: Oil centrifuge

- | | |
|---|--|
| <p>1 Centrifuge base</p> <p>2 V-clamp</p> <p>3 Rotor</p> <p>4 Cover</p> | <p>5 Rotor cylinder</p> <p>6 Paper filter</p> <p>7 Rotor base</p> <p>8 Rotor cover</p> |
|---|--|

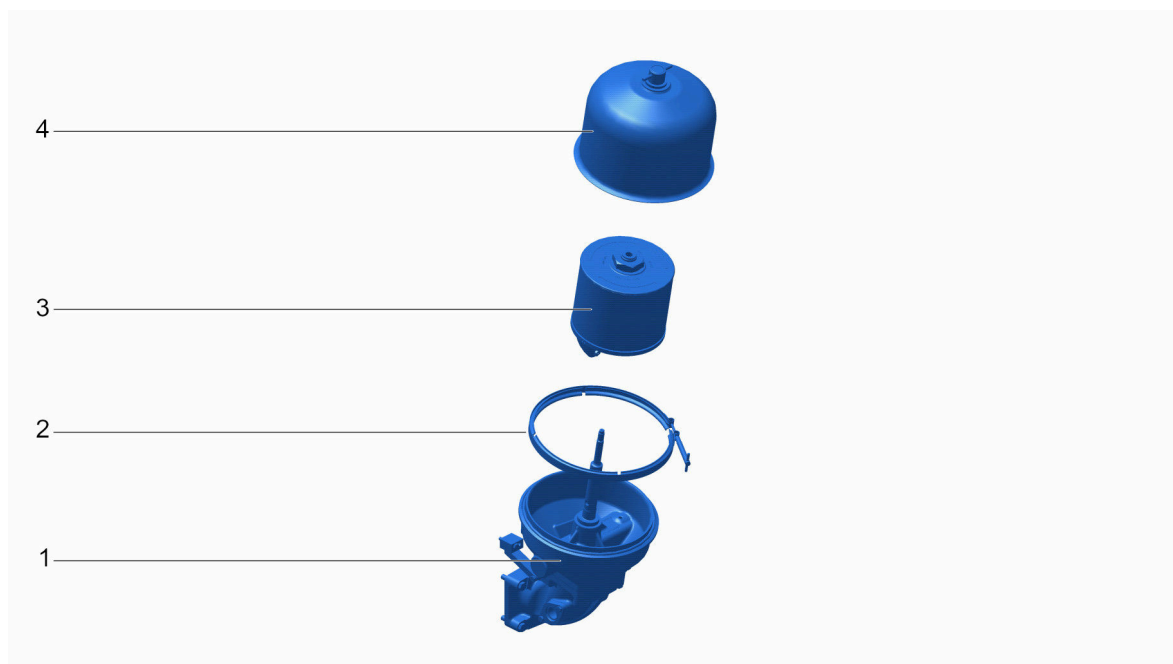


Fig. 59: Opening the centrifuge

- ▶ Unclamp and remove V-clamp **2**.
- ▶ Open screw on top of cover **4**.
- ▶ Remove cover **4**.



Fig. 60: Opening the rotor

- ▶ Unscrew and remove the nut of rotor cover **8**.
- ▶ Lift carefully the rotator cylinder **5** so that the mud remains in the cylinder.
- ▶ Recycle paper filter **6** and mud according to specific national regulations.



Information

The thickness of mud deposit inside the rotor should not be more than 45 mm (1.77 in). Otherwise:

- ▶ Reduce maintenance intervals and operate oil analysis.

- ▶ Clean all components of oil centrifuge.

- ▶ Replace rotor cover **8** seals in cover **4**.

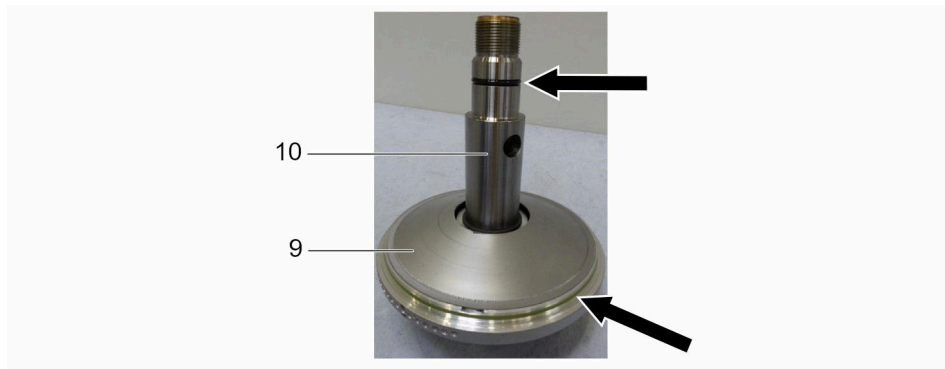


Fig. 61: Deflector disk and seals on rotor base and bearing tube

- ▶ Lift and clean the deflector disk **9**.
- ▶ Clean bearing tube **10** and rotor base **7**.
- ▶ Replace seals of rotor base **7** and bearing tube **10**.
- ▶ Insert deflector disk **9**.

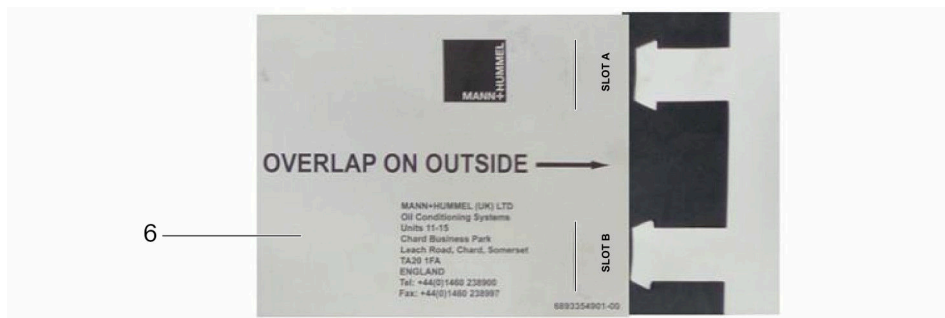


Fig. 62: Paper filter preparation

- ▶ Insert paper filter **6** tabs in slot A and slot B.



Fig. 63: Inserting paper filter

- ▶ Insert paper filter **6** in rotor cylinder **5**.



Fig. 64: Assembling rotor

- ▶ Assemble rotor cylinder **5** on rotor base **7**.
- ▶ Mount rotor cover **8** and tighten nut to 40 Nm (30 ft-lb).

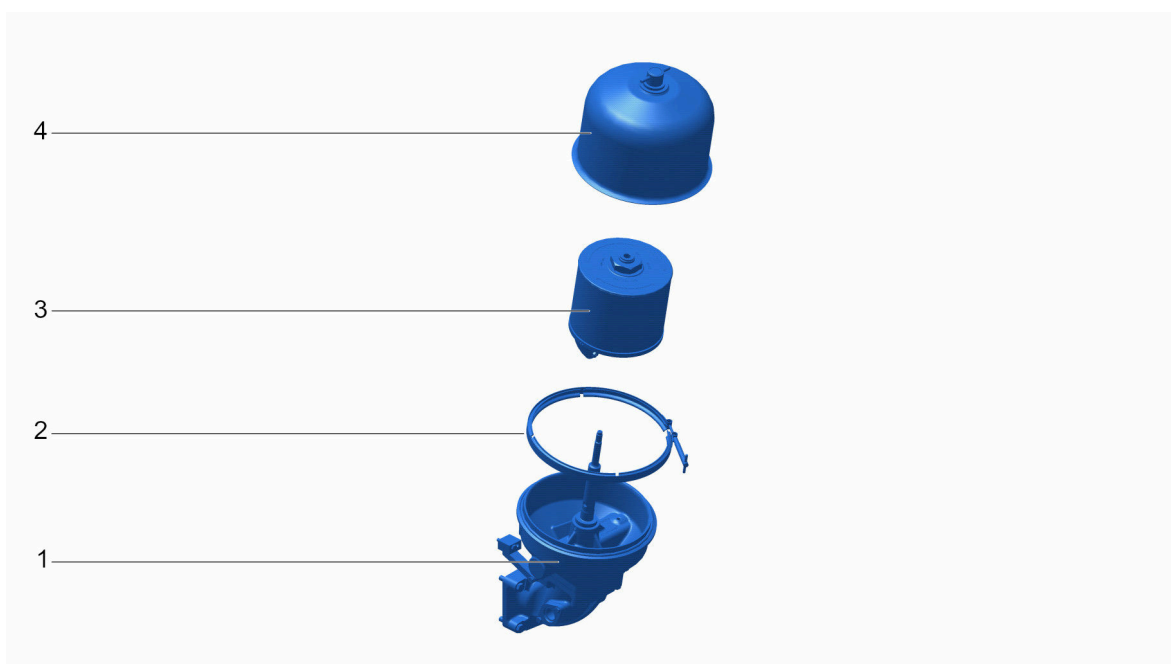


Fig. 65: Assembling the centrifuge

- ▶ Place rotor **3** in centrifuge base **1**.
- ▶ Install cover **4** and tighten nut to 13 Nm (10 ft-lb).
- ▶ Check seal of V-clamp **2**. Replace if necessary.
- ▶ Install and tighten V-clamp **2** to 15 ⁺² Nm (11 ⁺¹ ft-lb).
- ▶ Start and run engine for three minutes.
- ▶ Check engine oil level. (For more information see: [5.9.3 Checking the engine oil level – SL001, page 112.](#))

5.9.6 Changing Diesel engine oil – SL101, SL121

- Preparatory maintenance activities are fulfilled. (For more information see: [5.5 Preparatory maintenance activities, page 97.](#))
- A container with the required capacity is ready.
- Original KOHLER oil filters with the seals are available.
- A suitable drainage container is available.

- ❑ The required quantity of approved oil is available. (For more information see: 5.13 Lubricants and operating fluids, page 134.)



WARNING

Hazards by ejection of hot engine oil.
Hot engine oil could result in death or serious injuries by burns or skin penetrating oil.

- ▶ Avoid skin contact with the engine oil.
- ▶ Wear proper personal protective equipment.

Draining off Diesel engine oil

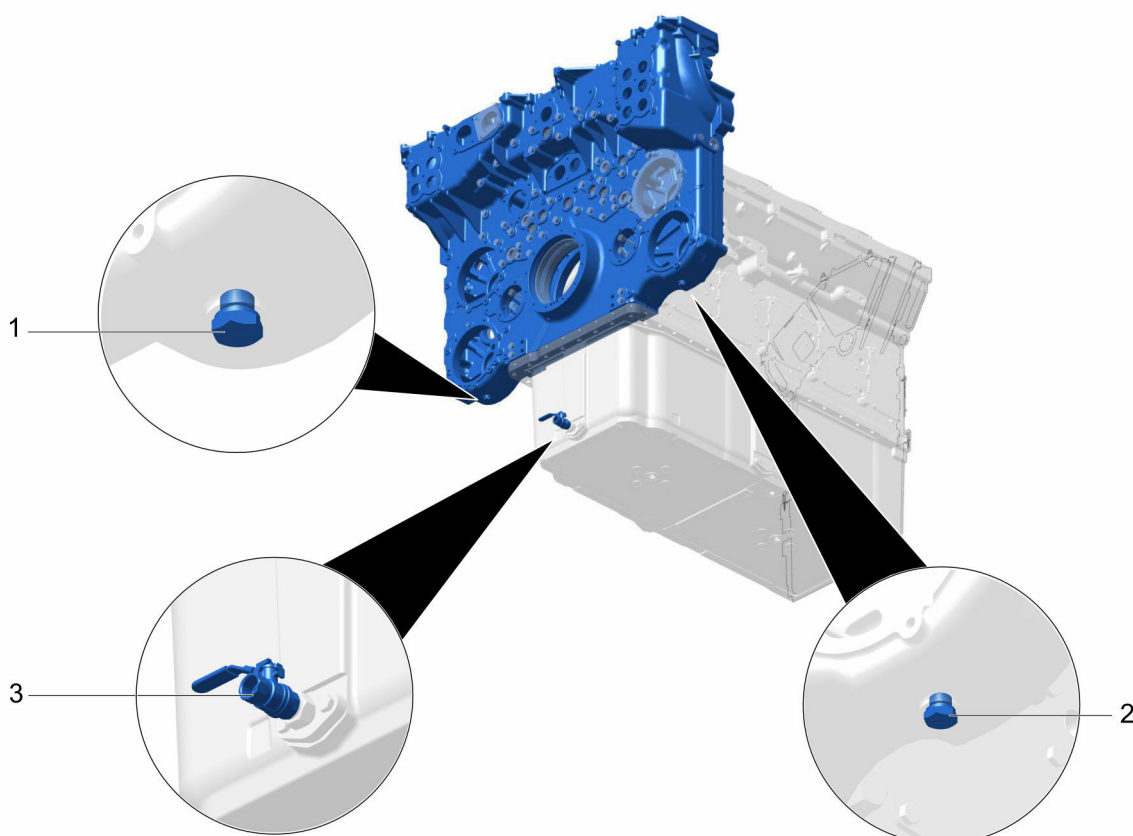


Fig. 66: Principal oil drain point - engine rear side

- | | | | |
|----------|--|----------|----------------------|
| 1 | Oil drain aggregate support. Engine right side | 3 | Oil drain on oil pan |
| 2 | Oil drain aggregate support. Engine left side | | |

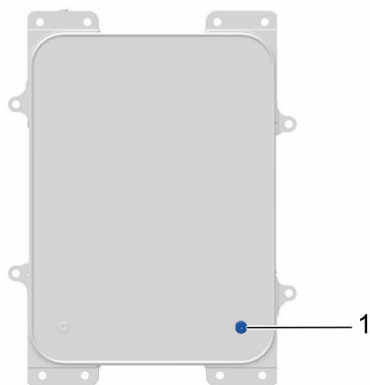


Fig. 67: Oil drain - engine left side

1 Oil drain on oil cooler

On each drain-off point:

- ▶ Unscrew and remove plug or open valve.
- ▶ Let the oil flow into the container.
- ▶ Wait until no more oil drips.
- ▶ Clean the drain-hole, plug, or valve and the surrounding area with a clean rag.
- ▶ Check washer condition.

Troubleshooting

If washer is worn or broken:

- ▶ Replace washer.
-
- ▶ Refit the plug or close the valve.
 - ▶ Tighten plug according to standard torque.

Filling Diesel engine oil

- Engine oil drained.
- Filters replaced.
- Draining plugs and valves closed.

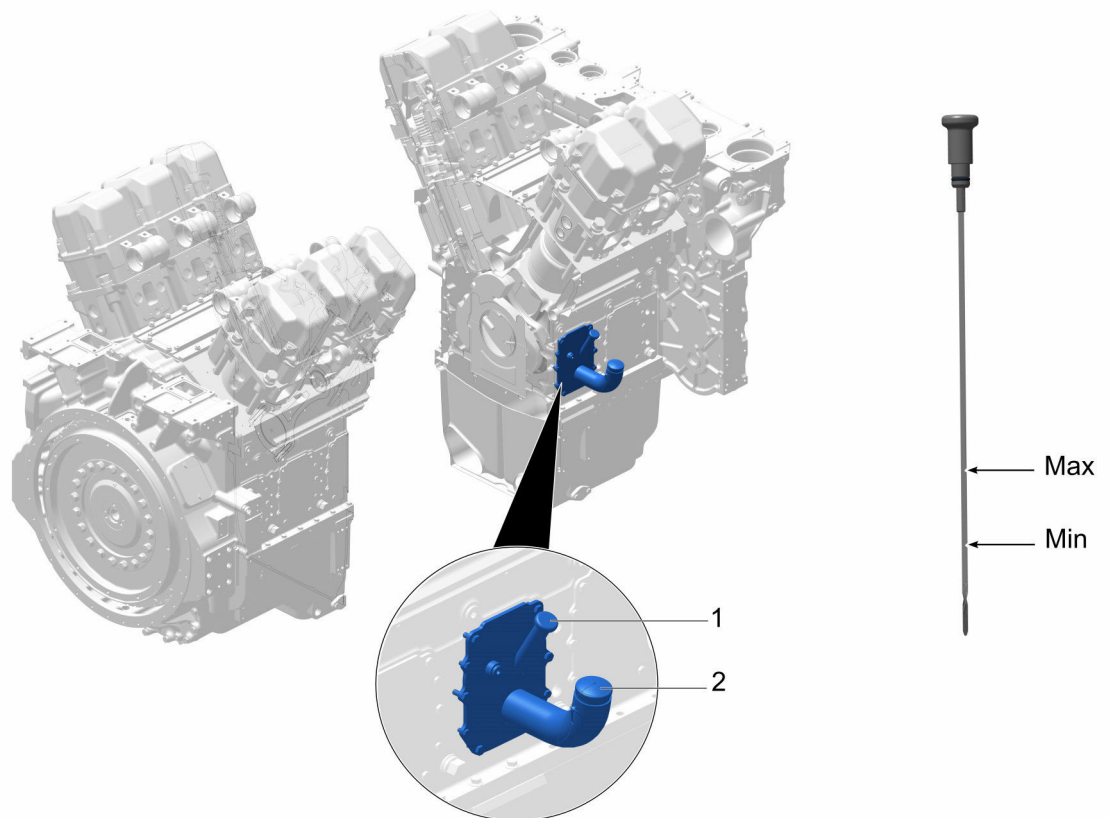


Fig. 68: Filling engine oil – right side

1 Dipstick

2 Filler neck

- ▶ Remove oil filling cap.
- ▶ Fill with oil via filler neck **2** until between “min.” and “max.” marks on the dipstick **1**.
- ▶ Clean oil filling cap, place on the filler neck and tighten by hand.
- ▶ Start the engine.
- ▶ Check oil pressure (engine oil pressure display unit) and check oil filter for leaks.
- ▶ Shut down the engine.
- ▶ After 2 to 3 minutes, check oil level on the dipstick. (For more information see: [5.9.3 Checking the engine oil level – SL001, page 112.](#))

5.10 Cooling system

5.10.1 Collecting coolant sample – SL120

See the generator set manual for more details.

5.10.2 Replacing coolant – SL116

Draining coolant

Make sure that the following preconditions are met:

- Preparatory maintenance activities are fulfilled. (For more information see: [5.5 Preparatory maintenance activities, page 97.](#))
- A container with the required capacity is ready.
- A suitable drainage container is available.
- Required quantity of approved coolant is available. (For more information see: [5.13 Lubricants and operating fluids, page 134.](#))



DANGER

Hazards by ejection of hot operating fluids or filler cap.

Hot fluid spray from a pressurized cooling system will result in death or serious injury by burns.

Filler cap ejected by operating fluid under pressure will result in death or serious injury by impact.

- ▶ Only perform maintenance and inspection work on the cooling system when the engine has cooled down to ambient temperature.
 - ▶ Wear proper personal protective equipment.
-

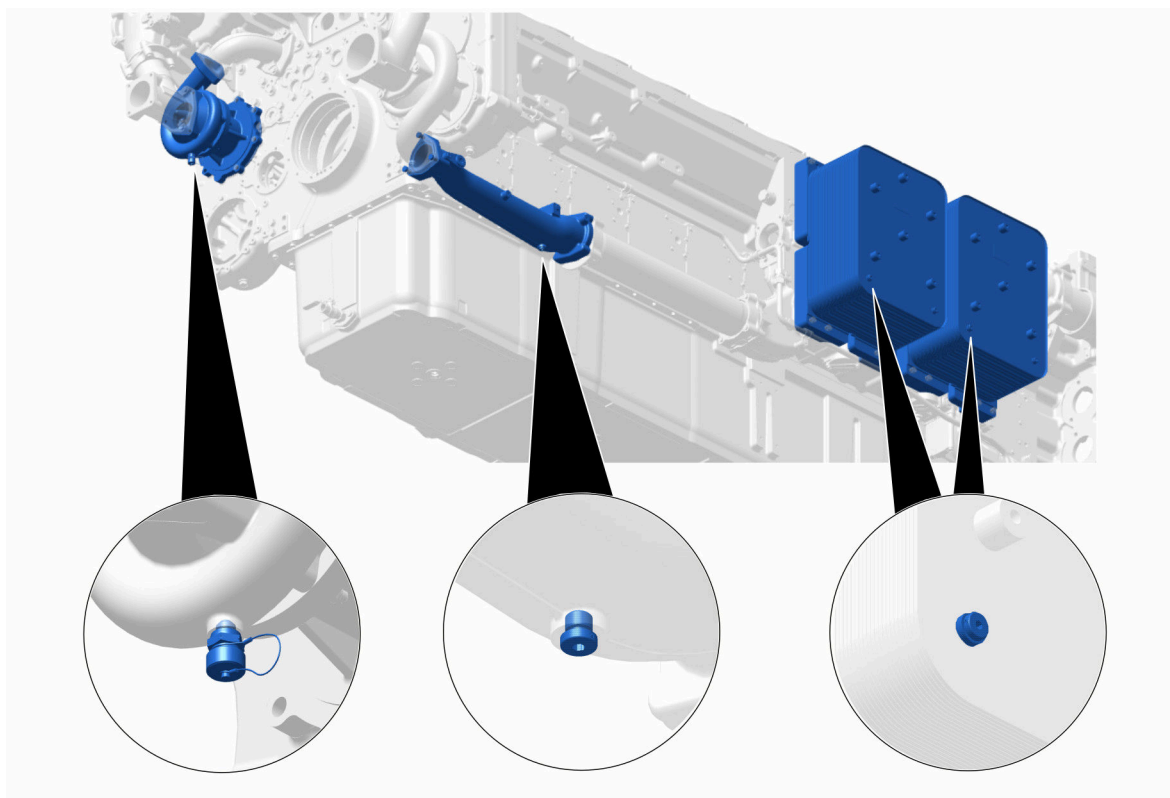


Fig. 69: Coolant drain points

- ▶ Drain cooling system at the deepest point. Refer to the instructions of the application set for more details.

Filling coolant



Information

Observe the instructions manual of the manufacturer's application set to fill and check the cooling system.

- ▶ Fill the cooling system with an approved coolant.
 - ▷ Usually, a level indicator is present and coolant level must be between the "min." and "max." marks.

Bleeding coolant



DANGER

Hazards by hot operating fluids under pressure.
Burns or skin penetrating fluids will result in death or serious injury.

- ▶ Check operating fluid levels only once the temperature has cooled down enough so that surfaces can be touched with bare hands.
- ▶ Carefully open the cover in order to first reduce the excessive pressure.



DANGER

Danger to environment and health by neglect of environmental regulations. Neglect environmental regulations will result in death or serious injury.

- ▶ Observe the country-specific regulations regarding environmental protection when disposing of scrap materials.
- ▶ Collect and store all scrap materials separately in appropriate containers.
- ▶ Dispose all scrap materials only at official locations in an environment-friendly manner.



Information

Bleeding the cooling system is part of the scope of the manufacturer of the machinery and depends on the cooling system design. The following procedure shall be adapted by the manufacturer of the machinery according to its cooling system design.

Use only operating fluids that have been tested and approved by Kohler.

Proper operation of the engine requires a bubble-free cooling system.

Make sure that the following preconditions are met:

- Cooling system is filled and functional.

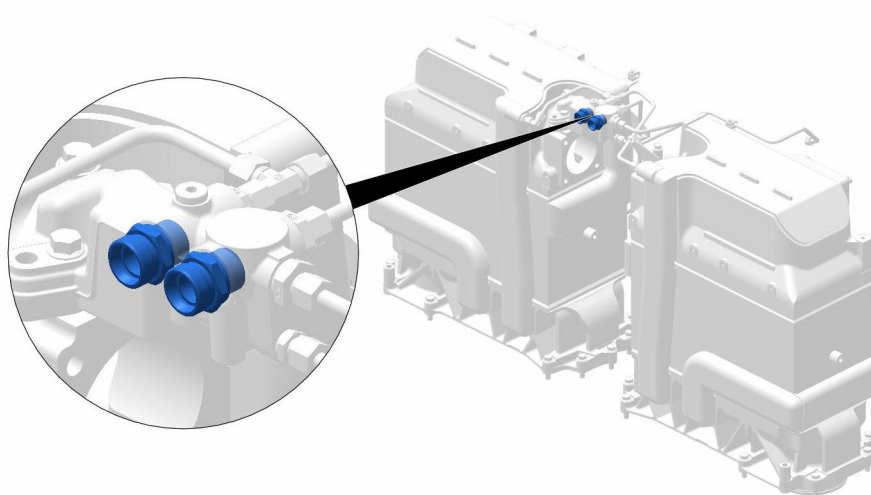


Fig. 70: Bleeding connections on vent tube assembly

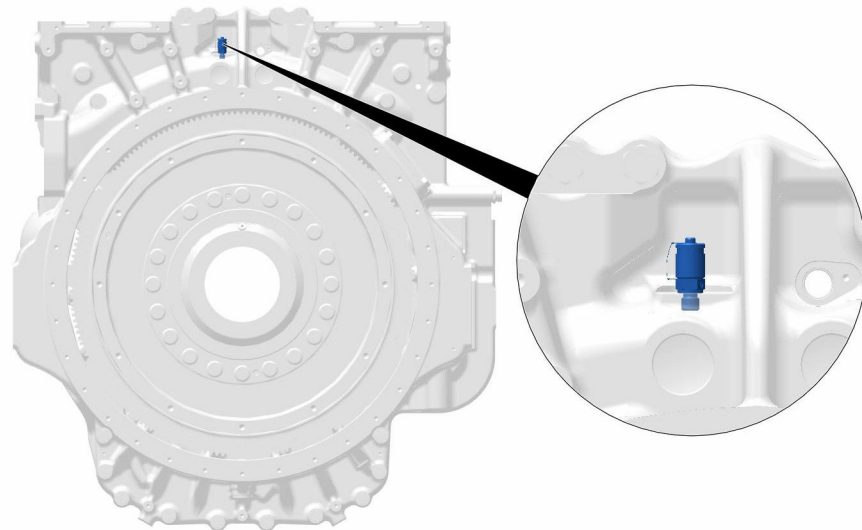


Fig. 71: Bleeding connection on flywheel housing

- ▶ Open the cap on the expansion tank.
- ▶ Make sure that the expansion tank is filled between the “min.” and “max.” marks.
- ▶ Open the fast coupling on the flywheel housing.
- ▶ Open the bleeding connections on vent tube assembly.
- ▶ Bleed the circuit until it is bubble free.
- ▶ Close the fast coupling on the flywheel housing.
- ▶ Close the bleeding connections on vent tube assembly.
- ▶ Close the cap on the expansion tank.
- ▶ Operate the engine until the coolant temperature is above 60 °C (140 °F).
- ▶ Check coolant level on the expansion tank.
- ▶ If necessary, top up coolant.

5.10.3 Inspecting low temperature circuit (charge air cooler) – SL002

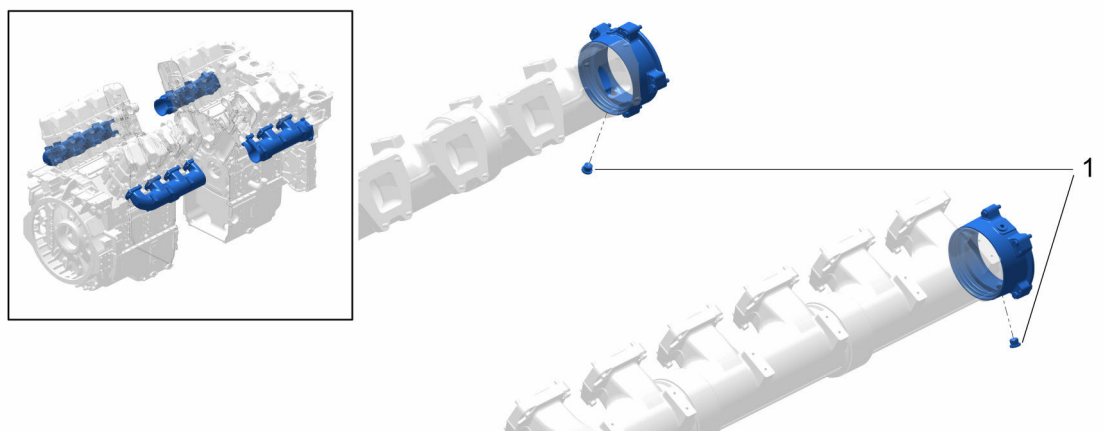


Fig. 72: Drain holes of low temperature circuit

At drain holes **1**:

- ▶ Check for leaks.

In case of water leaks:

- ▶ Leaking of condensation water is not an issue. Let the condensation water flow out.

In case of air leaks:

- ▶ Air leaks are normal.

In case of leaks of water mixed with antifreeze:

- ▶ Inspect charge air cooler for leaks. If necessary, make sure that the leaks are repaired by the authorized service personnel.

5.10.4 Checking relief bores – coolant pump – SL003

- ❑ Preparatory maintenance activities are fulfilled. (For more information see: [5.5 Preparatory maintenance activities, page 97.](#))



DANGER

Hazards by ejection of hot operating fluids or filler cap.

Hot fluid spray from a pressurized cooling system will result in death or serious injury by burns. Filler cap ejected by operating fluid under pressure will result in death or serious injury by impact.

- ▶ Only perform maintenance and inspection work on the cooling system when the engine has cooled down to ambient temperature.
- ▶ Wear proper personal protective equipment.

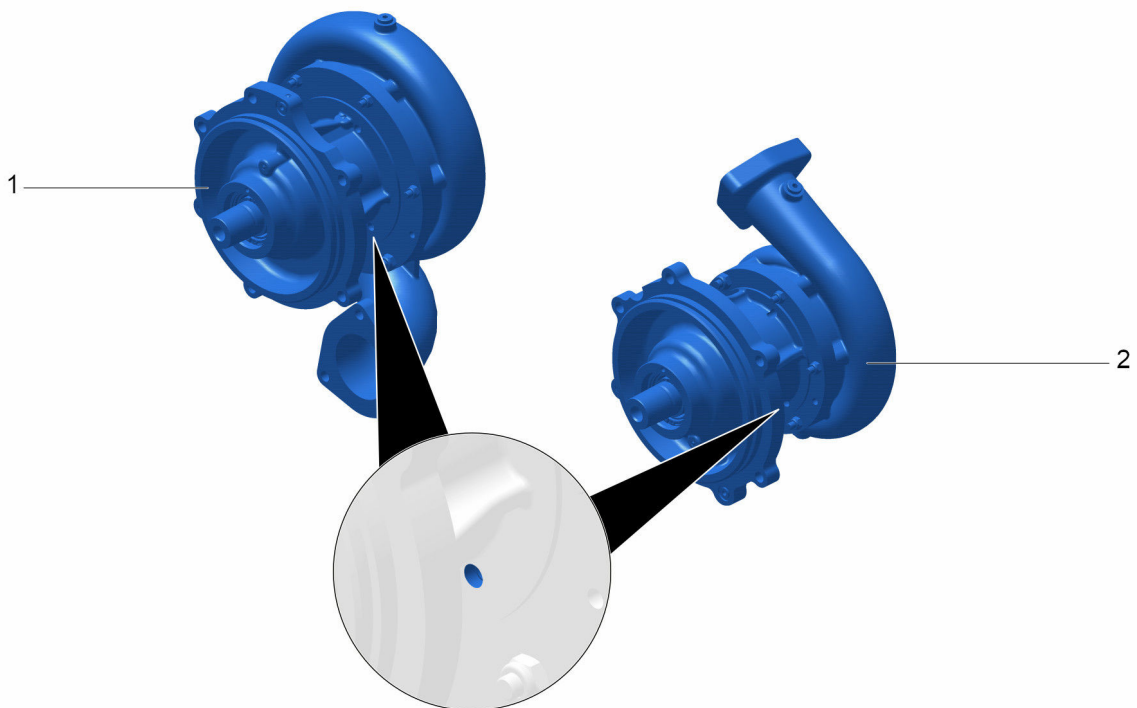


Fig. 73: Relief bores on coolant pumps

1 Coolant pump high temperature

2 Coolant pump low temperature

- ▶ Check relief bores of coolant pump high temperature **1** and coolant pump low temperature **2** for leaks on oil or water side.

In case of oil or water leaks:

- ▶ Replace the pump. Make sure that the pump is replaced by authorized service personnel.



Information

Slight drops are not critical.

5.10.5 Bleeding the HT/LT coolant system



DANGER

Hazards by hot operating fluids under pressure.
Burns or skin penetrating fluids will result in death or serious injury.

- ▶ Check operating fluid levels only once the temperature has cooled down enough so that surfaces can be touched with bare hands.
 - ▶ Carefully open the cover in order to first reduce the excessive pressure.
-



DANGER

Danger to environment and health by neglect of environmental regulations.
Neglect environmental regulations will result in death or serious injury.

- ▶ Observe the country-specific regulations regarding environmental protection when disposing of scrap materials.
 - ▶ Collect and store all scrap materials separately in appropriate containers.
 - ▶ Dispose all scrap materials only at official locations in an environment-friendly manner.
-



Information

Bleeding the cooling system is part of the scope of the manufacturer of the machinery and depends on the cooling system design. Following procedure shall be adapted by the manufacturer of the machinery according to its cooling system design.

Use only operating fluids that have been tested and approved by KOHLER.

A pressurized and bubble-free system ensures the performance and function of a cooling system.

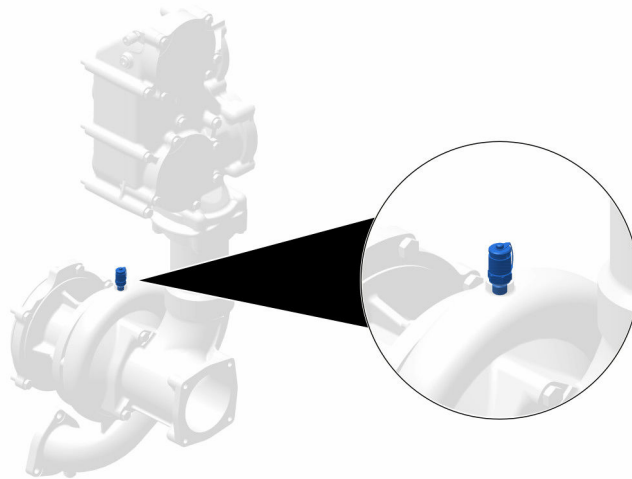


Fig. 74: Bleeding point on HT coolant pump

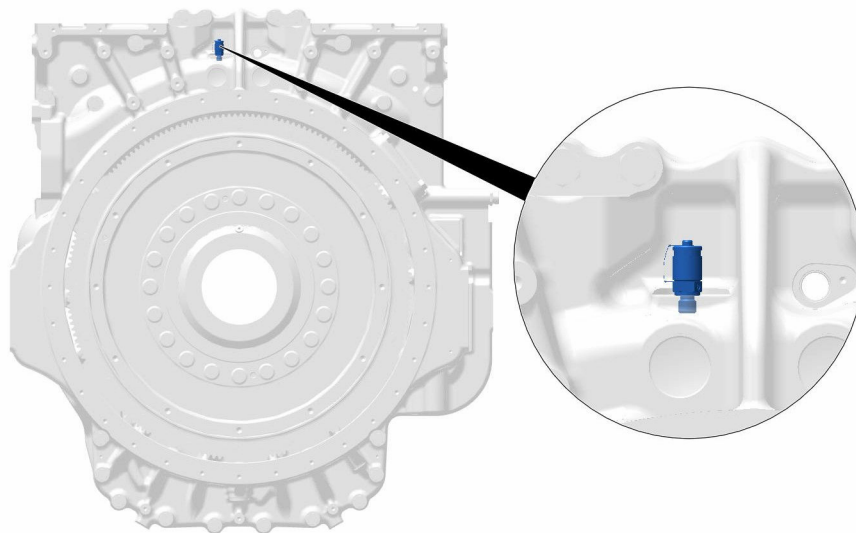


Fig. 75: Bleeding point on flywheel housing

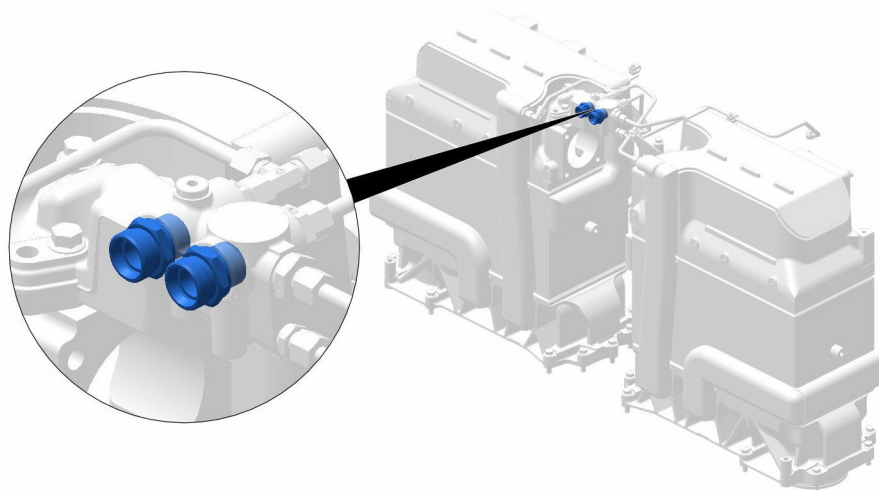


Fig. 76: Venting connection on charge air cooler

- ❑ The LT and HT coolant systems are filled completely.

Bleeding the HT coolant system:

- ▶ Open the valve cover on the HT expansion tank.
- ▶ Fill the HT expansion tank up to the “MAX” level marking.
- ▶ Open the fast coupling on the HT coolant pump.
- ▶ Vent the HT coolant system (coolant pump) until bubble free.
- ▶ Close the fast coupling.
- ▶ Open the fast coupling on the flywheel housing.
- ▶ Vent the HT coolant system (flywheel housing) until bubble free.
- ▶ Close the fast coupling.
- ▶ Open the HT connection on the venting block.
- ▶ Vent the HT coolant system (venting block) until bubble free.
- ▶ Tighten the HT connection (venting block).
- ▶ Top up the HT expansion tank up to the “MAX” level marking.
- ▶ Close the valve cover on the HT expansion tank.

Bleeding the LT coolant system:

- ▶ Open the valve cover on the LT expansion tank.
- ▶ Fill the LT expansion tank up to the “MAX” level marking.
- ▶ Open the LT connection on the venting block.
- ▶ Vent the LT coolant system (venting block) until bubble free.
- ▶ Tighten the LT connection (venting block).
- ▶ Top up the LT expansion tank up to the “MAX” level marking.
- ▶ Close the valve cover on the LT expansion tank.

Rechecking the HT/LT coolant levels:

- ▶ Start the engine.
- ▶ Operate the engine until the HT coolant temperature has reached > 60 °C (140 °F).

- ▶ Check the expansion tank coolant level of HT and LT systems.
- ▶ Top up the expansion tanks if necessary.

5.11 Fuel system



DANGER

Fire or explosion by flammable and explosive lubricants and fuels.
Burns or explosion release will result in death or serious injury.

- ▶ Keep all caps and valves closed near the operating temperature.
- ▶ Avoid any contact of flammable and explosive operating fluids, gases or combustible materials with any hot surface or ignition source.
- ▶ Keep the engine clean and free from accumulation of dust and flammable liquids.
- ▶ Keep the insulation free of operating fluids contamination.
- ▶ Never release operating fluids while operating the engine.
- ▶ Check the electrical system. Immediately rectify all errors, such as loose connections and frayed cables.
- ▶ During refueling, switch off any additionally installed heater (optional).
- ▶ Lock out and tag out the engine prior to accessing to engine.
- ▶ Ensure a good ventilation while refueling or prior to accessing to the engine.
- ▶ Regularly check all lines, hoses and screw connections for leaks and damage. Immediately rectify the leaks and replace the damaged parts.
- ▶ Smoking and open flames are forbidden in the vicinity of the engine.
- ▶ Always start the engine according to the instructions in the instructions manual of the machinery.

5.11.1 Draining off water from fuel pre-filter – SL004

Refer to the generator set manual for more details.

5.11.2 Draining off water and sediment of fuel tank

Refer to the Operation and Maintenance Manual of the application set for more details.

5.11.3 Replacing main filter - SL105

- Preparatory maintenance activities are fulfilled. ([For more information see: 5.5 Preparatory maintenance activities, page 97.](#))
- A container with the required capacity is ready.
- Original KOHLER main fuel filters are available.
- A suitable drainage container is available.
- A fuel filter ribbon spanner is available.

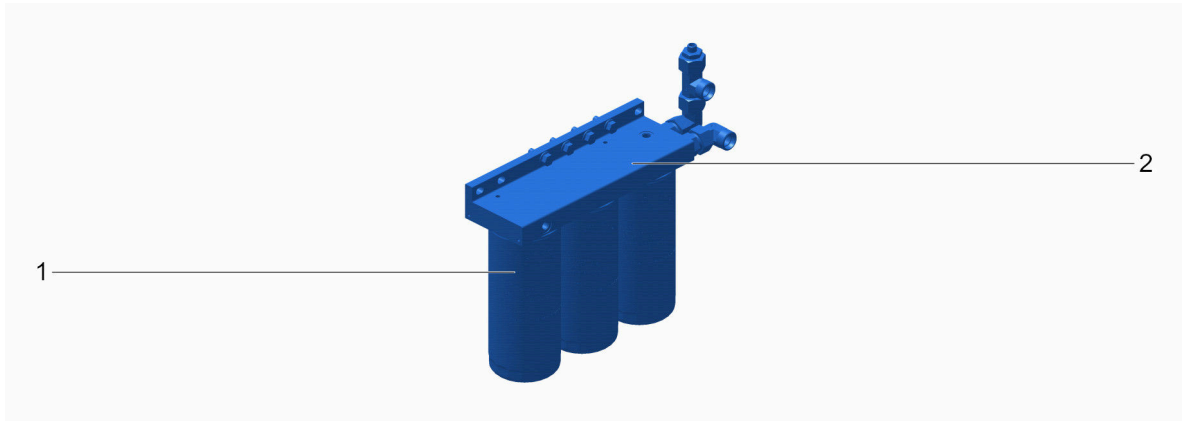


Fig. 77: Fuel filters

1 Fuel filter

2 Filter head

Fuel filter removal

- ▶ Remove dust from sealing area.
- ▶ Open fuel filter **1** with filter ribbon spanner.
- ▶ Remove filter.
- ▶ Repeat procedure for all filters.

Fuel filter installation

- ▶ Remove dust from sealing area.
- ▶ Lubricate filter seal with engine oil.
- ▶ Screw fuel filter **1** in filter head **2** until it contacts base.
- ▶ Tighten filter by hand by 3/4 to 1 turn.
- ▶ Check for leaks and damage.
- ▶ Retighten if necessary.

5.11.4 Bleeding the fuel system

Refer to the generator set manual for more details.

5.11.5 Checking differential pressure – fuel pre-filter – SL005

Refer to the generator set manual for more details.

5.12 Air system

5.12.1 Checking service indicator on air filter – SL006

Refer to the generator set manual for more details.

5.12.2 Replacing crankcase breather – SL107

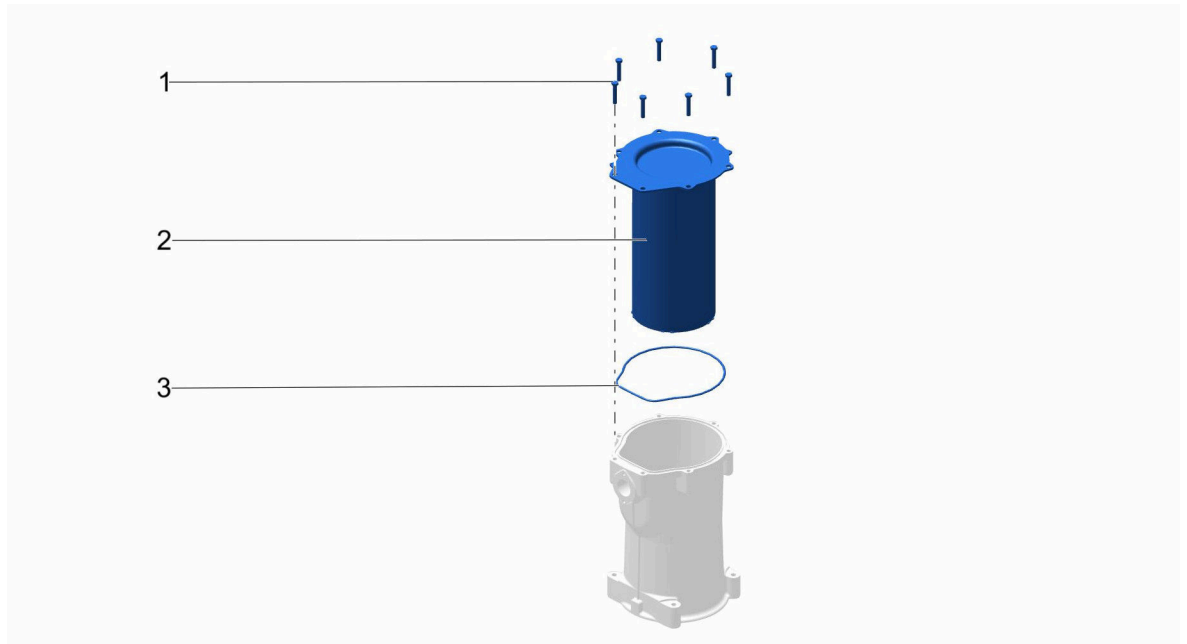


Fig. 78: Crankcase ventilation

1 Screw (M10)
2 Filter element

3 Seal



Information

Actual number and location of crankcase breather filters may depend on application set.

Removal

- ▶ Remove screws **1**.
- ▶ Remove filter element **2**.
- ▶ Remove seal **3**.

Installation

- ▶ Screw filter element **2** with screws **1** and seal **3**.

5.13 Lubricants and operating fluids

5.13.1 Handling lubricants and operating fluids



Information

- ▶ Only operating fluids approved by Kohler Co. may be used for the operation of Kohler Co. engines. Kohler Co. will declare all possible undertakings carried out by Kohler Co. and/or their dealers, such as guarantees, service orders, etc. null and void without advance notice, if fuel and lubricants other than fuel and lubricants approved by Kohler Co. are used.

The conscientious observance of the regulations for handling lubricants and operating fluids increases the reliability and service life of the engine.

It is particularly important to observe the stated replacement intervals and lubricant quantities.

- ▶ Lubricate the machine within the specified time intervals.
- ▶ Change the oils within the specified time intervals.
- ▶ Observe environmental regulations and rules for handling lubricants and operating fluids.

Environmental protection measures



CAUTION

Environmental and health hazards by incorrect disposal. Incorrect waste disposal leads to environment and water supply pollution and could result in minor or moderate injuries by hazards from related actions.

- ▶ Observe the country-specific regulations regarding environmental protection when disposing of scrap materials.
- ▶ Before disposing or recycling waste products, ask for the correct method at the responsible environmental or recycling center.
- ▶ When handling waste, lubricants and fuel make sure that none is disposed into the environment.
- ▶ Collect and dispose waste, lubricants and fuel in separate, suitable, properly designated containers.
- ▶ Use adapted leak-proof containers to drain lubricants and fuel. Use of food or drink containers is prohibited.
- ▶ Dispose all scrap materials only at official locations in an environment-friendly manner.

Disposal of scrap materials

Concerning scrap materials and hazardous waste, such as:

- Oils, lubricants, refrigerants from air conditioning systems
- Coolant
- Fuels
- Filters, oil filter cartridges, etc.

Follow these instructions and observe any additional or local rules and directives. [\(For more information see: Environmental protection measures, page 134.\)](#)

5.13.2 Approved diesel fuels, diesel exhaust fluids (DEF), and fuel additives

All performance data provided by Kohler Co. are guaranteed only for an EN 590 compliant fuel, with an LHV of 42.8 MJ/kg. Please apply correction factors when using a fuel with a different LHV (Lower Heating Value).

Diesel fuels

Sulfur content and biodiesel content:

Only diesel fuels with a sulfur content lower than 1.5% (15000 ppm) are allowed in Kohler KD diesel engines.



Information

For emission-certified engines (Tier 2, USA EPA CARB Tier 4 final, 97/68/EC Stage IIIA), only ultra low sulfur diesel fuels (ULSD) with a sulfur content lower than 0.0015% (15 ppm) are allowed in Kohler KD diesel engines.

Only diesel fuels with a biodiesel content lower than 10% are allowed in Kohler KD diesel engines.

Winter operation (cold operation):

Most diesel fuels produce paraffin crystals at low ambient temperatures. These crystals increase the flow resistance in the fuel filters and deteriorate the fuel feed to the diesel engine.

To prevent property damage, use only diesel fuels adequate to your ambient conditions. Pay a particular attention in countries changing standard according to season. Filling the tank with “summer fuel” may endanger your operability during winter.

The following fuels are approved for use in Kohler KD diesel engines. On request, other fuels may be evaluated. Please contact your Kohler Co. representative before any use.

On-road diesel

| Fuel standard (norm) | Fuel quality (norm complement) | Required lubricating capacity (max. HFRR) | Required max. biodiesel ratio (%) | Additional required criteria | Compatible with EATS | Performance alteration / Reduced maintenance interval |
|----------------------|--------------------------------|---|-----------------------------------|------------------------------|----------------------|---|
| EN 590 | CSR 4.0.05 | - | 10% | - | OK | No |
| ASTM D975 | 1D-S15 | 460 µm 18.11 th | - | - | OK | No |
| ASTM D975 | 1D-S500 | 460 µm 18.11 th | - | - | No | No |
| ASTM D975 | 1D-S5000 | 460 µm 18.11 th | - | - | No | No |
| ASTM D975 | 2D-S15 | 460 µm 18.11 th | - | - | OK | No |
| ASTM D975 | 2D-S500 | 460 µm 18.11 th | - | - | No | No |

| Fuel standard (norm) | Fuel quality (norm complement) | Required lubricating capacity (max. HFRR) | Required max. biodiesel ratio (%) | Additional required criteria | Compatible with EATS | Performance alteration / Reduced maintenance interval |
|----------------------|--------------------------------|---|-----------------------------------|------------------------------|----------------------|---|
| ASTM D975 | 2D-S5000 | 460 µm 18.11 th | - | - | No | No |
| ASTM D975 | 4D | 460 µm 18.11 th | - | - | No | No |

Tab. 22: KD approved on-road diesel fuels

Non-road diesel

| Fuel standard (norm) | Fuel quality (norm complement) | Required lubricating capacity (max. HFRR) | Required max. biodiesel ratio (%) | Additional required criteria | Compatible with EATS | Performance alteration / Reduced maintenance interval |
|----------------------|--------------------------------|---|-----------------------------------|------------------------------|----------------------|---|
| EN 590 | CSR 4.1.03 | - | 10% | - | OK | No |
| BS 2869 | A2 | - | 10% | - | OK | No |

Tab. 23: KD approved non-road diesel fuels

Heating-oil

| Fuel standard (norm) | Fuel quality (norm complement) | Required lubricating capacity (max. HFRR) | Required max. biodiesel ratio (%) | Additional required criteria | Compatible with EATS | Performance alteration / Reduced maintenance interval |
|----------------------|--------------------------------|---|-----------------------------------|------------------------------|----------------------|---|
| DIN 51603 | CSR 4.4.06 | - | - | Fuel filtration | No | Yes ¹⁾ |

Tab. 24: KD approved heating-oil fuels

¹⁾ Reinforced fuel primary filtration system, including water separator between main storage and daily tank, is mandatory.

Military fuels

| Fuel standard (norm) | Fuel quality (norm complement) | Required lubricating capacity (max. HFRR) | Required max. biodiesel ratio (%) | Additional required criteria | Compatible with EATS | Performance alteration / Reduced maintenance interval |
|-------------------------|---|---|-----------------------------------|--|----------------------|---|
| F-34 | Equivalent to Jet A-1 | 460 µm 18.11 th | - | With additive S-1750 Not suitable for ESP | No | Yes ²⁾ |
| F-35 | Equivalent to Jet A-1 | 460 µm 18.11 th | - | With additive S-1750 | No | Yes ²⁾ |
| F-54 (Road diesel) | Equivalent to EN 590 CSR 4.0.05 | 460 µm 18.11 th | - | - | OK | Yes ²⁾ |
| F-63 | - | 460 µm 18.11 th | - | With additive S-1750 | No | Yes ²⁾ |
| XF-10 (Heating-oil) | Equivalent to heating-oil CSR 4.0.06 | 460 µm 18.11 th | - | - | No | Yes ²⁾ |
| XF-51 (Non-road diesel) | Equivalent to EN 590 CSR 4.0.02 => 4.1.03 | 460 µm 18.11 th | 10% | - | OK | Yes ²⁾ |
| XF-63 | - | 460 µm 18.11 th | - | With additive S-1750 | No | Yes ²⁾ |

Tab. 25: KD approved military fuels

Aviation kerosene

| Fuel standard (norm) | Fuel quality (norm complement) | Required lubricating capacity (max. HFRR) | Required max. biodiesel ratio (%) | Additional required criteria | Compatible with EATS | Performance alteration / Reduced maintenance interval |
|----------------------|--------------------------------|---|-----------------------------------|------------------------------|----------------------|---|
| Jet A-1 | - | 460 µm 18.11 th | - | With additive S-1750 | No | Yes ²⁾ |

Tab. 26: KD approved aviation kerosene fuels

Biofuels

Due to the wide range of fuels available on the market, please contact your Kohler Co. representative before any use of synthetic fuels not included in the following list.

²⁾ Exchange interval of fuel filters is reduced (1/2), lifespan of fuel line components may be reduced, fuel consumption is not guaranteed anymore.

Biodiesels

Only diesel fuels with a biodiesel content lower than 10% are allowed in Kohler KD diesel engines.



Information

Diesel fuels with a biodiesel content between 10% and 20% may be used, but Kohler do not recommend it as the operating costs linked to maintenance will drastically increase.

| Fuel standard (norm) | Fuel quality (norm complement) | Required lubricating capacity (max. HFRR) | Required max. biodiesel ratio (%) | Additional required criteria | Compatible with EATS | Performance alteration / Reduced maintenance interval |
|----------------------|--------------------------------|---|-----------------------------------|---------------------------------|----------------------|---|
| EN 14214 | - | - | 10% | Fuel storage Fuel filtration | No | Yes ^{2) 3) 4) 5) 6)} |
| EN 14214 | - | - | 20% | Fuel storage Fuel filtration | No | Yes ^{2) 3) 4) 5) 6)} |
| ASTM D6751 | - | - | 10% | Fuel storage Fuel filtration | No | Yes ^{2) 3) 4) 5) 6)} |
| ASTM D6751 | - | - | 20% | Fuel storage Fuel filtration | No | Yes ^{2) 3) 4) 5) 6)} |

Tab. 27: KD approved biodiesel fuels

Paraffinic fuels (according to EN 15940)

Paraffinic fuels (“synthetic diesel”) have a high cetane number and a low density compared to diesel fuels. HVOs (Hydrotreated Vegetable Oils) are renewable. GTLs (Gas-To-Liquids) are fossil paraffinic fuels. The use of paraffinic fuels results in lower emissions, but also slightly higher fuel consumption and lower performance.

When using paraffinic diesel, a reduced filter change interval may be necessary due to the cleaning effect.

Rubber and elastomers in the fuel system can be affected when changing from diesel fuel to paraffinic fuel. Check daily whether fuel is leaking, and contact customer service for assistance if necessary.



Information

EN 15940 fits into specification ASTM D975 1D-15 and ASTM D975 2D-15.

²⁾ Exchange interval of fuel filters is reduced (1/2), lifespan of fuel line components may be reduced, fuel consumption is not guaranteed anymore.

³⁾ Biodiesels are not recommended for ESP (Emergency Standby Power) generator set applications because of the risk of bacteria development.

⁴⁾ Specific improved storage condition is mandatory.

⁵⁾ Reinforced fuel primary filtration system, including water separator between main storage and daily tank, is mandatory.

⁶⁾ Polishing primary fuel filtration is mandatory.

Hydrotreated Vegetable Oil (HVO)

| Fuel standard (norm) | Fuel quality (norm complement) | Required lubricating capacity (max. HFRR) | - | Additional required criteria | Compatible with EATS | Performance alteration / Reduced maintenance interval |
|----------------------|--------------------------------|---|---|------------------------------|----------------------|---|
| EN 15940 | - | - | - | - | No | Yes ^{7) 8) 9)} |

Tab. 28: KD approved HVO fuels

Gas To Liquid (GTL)

| Fuel standard (norm) | Fuel quality (norm complement) | Required lubricating capacity (max. HFRR) | Required max. biodiesel ratio (%) | Additional required criteria | Compatible with EATS | Performance alteration / Reduced maintenance interval |
|----------------------|--------------------------------|---|-----------------------------------|------------------------------|----------------------|---|
| EN 15940 | - | - | - | - | OK | Yes ^{2) 8) 9)} |

Tab. 29: KD approved GTL fuels

Diesel exhaust fluids (DEF)

The following diesel exhaust fluids (DEF) are approved for use in Kohler exhaust gas aftertreatment systems (EATS) coupled with KD diesel engines.

| DEF standard (norm) | DEF quality (norm complement) | Additional required criteria |
|-----------------------|-------------------------------|--|
| ISO 22241 / DIN 70070 | 32.5% of urea in mass | Cleanliness according to ISO 4406 18/16/13 needing specific filtration during tank filling |

Tab. 30: KD approved diesel exhaust fluids

Fuel additives

Kohler KD diesel engines are designed in such a way that the use of general additives is not necessary nor recommended. However, under specific circumstances, biocide additives may be used according to the supplier recommendations.

⁷⁾ Exchange interval of fuel filters may be reduced.

⁸⁾ Rubber and elastomer parts must be monitored daily.

⁹⁾ Exchange interval of lubricating oil and lubricating oil filters is reduced (monitor soot in oil).

²⁾ Exchange interval of fuel filters is reduced (1/2), lifespan of fuel line components may be reduced, fuel consumption is not guaranteed anymore.

Biocides

Should the diesel engine be stopped for a long period or infested with micro-organisms, or should the tank be polluted with sludge, the fuel system must be cleaned and the fuel treated with biocides.

The following biocides are approved for use in Kohler KD diesel engines:

| Commercial designation | Maker | Compatible with EATS |
|------------------------|----------------------|----------------------|
| Grotamar 71 | Schülke & Mayr GmbH. | OK |
| Grotamar 82 | Schülke & Mayr GmbH. | OK |

Tab. 31: KD approved biocides

Starting fluids

The use of starting fluids (ether based or any other low flash point product) is strictly forbidden in KD diesel engines.

5.13.3 Approved lubricating oils and lubricating oil additives

Lubricating oils essential characteristics and maintenance

SAPS and lubricating oil quality

Kohler classifies synthetic lubricating oils among two main categories for SAPS level and three subcategories for quality level.

SAPS stands for Sulfated Ash, Phosphorus, and Sulfur. Phosphorus and sulfur are often incorporated as part of additives to increase oil performances (for example: anti-wear, anti-oxidization, cleanliness); sulfated ashes are the result of the combustion of the additives in a running diesel engine. SAPS can quickly damage exhaust gas aftertreatment systems (EATS) if not mastered properly. This is why the use of “low SAPS” lubricating oils is mandatory in diesel engines equipped with exhaust gas aftertreatment systems.



Information

The use of mineral oils is strictly forbidden in Kohler KD diesel engines.

Kohler classifies synthetic lubricating engine oils in three categories for quality and two subcategories for SAPS content:

- **Oil category 1:** mineral oils
- **Oil category 2:** standard quality / synthetic multigrade oils
- **Oil category 2.1:** standard quality / synthetic multigrade oils dedicated for engines with EATS (low SAPS engine oils)
- **Oil category 3:** high quality / synthetic multigrade oils
- **Oil category 3.1:** high quality / synthetic multigrade oils dedicated for engines with EATS (low SAPS engine oils)



Information

Oil categories 2.1 and 3.1 must be used only with USLD fuels (with a sulfur content lower than 15 ppm).

These quality levels help to determine the lubricating oil change interval. They indicate the oil category factor to be used in relationship to the change interval mentioned in the technical documentation accompanying your diesel engine.

| Category | Oil category factor | Comment |
|------------------|---------------------|---|
| Oil category 1 | - | Prohibited |
| Oil category 2 | 1 | The change interval is conserved. |
| Oil category 2.1 | 1 | The change interval is conserved. |
| Oil category 3 | 2 | The change interval can be extended by two times. |
| Oil category 3.1 | 2 | The change interval can be extended by two times. |

Tab. 32: KD lubricating oil category factors

Lubricating oil requirements

Generally speaking, lubricating oils fulfilling the following criteria can be used in Kohler KD diesel engines. However, a careful check of the characteristics must be undertaken. This measure ensures that the criteria mentioned in the following sections are explicitly fulfilled before considering the oil as approved for use in KD diesel engines.

| Parameter | Unit | Expected value | | Methods |
|-----------------------------------|---------------------|----------------|-------------|--------------|
| | | Without EATS | With EATS | |
| Visual appearance | - | Clear | Clear | Visual |
| Viscosity @ minimum temperature | mm ² / s | 3500 | 3500 | DIN 51562 |
| Viscosity @ operation temperature | mm ² / s | 10.0 - 14.8 | 10.0 - 14.8 | DIN 51562 |
| VI-index | - | > 145 | > 155 | ISO 2909 |
| High temperature - High shear | cP | 3.5 - 4.3 | 3.5 - 4.3 | CEC L36-A-90 |
| Ignition point | °C | > 220 | > 220 | ISO 2592 |
| Total base number | mg KOH / g | > 10 | > 8 | ISO 3771 |
| Shear stability | % | 10 | 10 | ASTM D6278 |
| NOAK (1 hour @ 250 °C (482 °F)) | % | < 10 | < 10 | CEC L-040-93 |
| Ash (sulfur) maximum | g / 100 g | 1.9 | 0.95 | DIN 51575 |

Tab. 33: KD lubricating oil minimum requirements

Lubricating oil viscosity grade

The viscosity grade is measured against SAE standards. The first number indicates oil viscosity at start-up, on cold conditions (W stands for Winter); the second number indicates oil viscosity at operating conditions (usually considered at 100 °C (212 °F)).

The lubricating oils presenting these viscosity grades are approved for use in Kohler KD diesel engines:

| SAE grade | Viscosity (Cranking) mPA.s @ °C | Viscosity (Pumping ability) mPA.s @ °C | Viscosity (Operating) mm ² .s ⁻¹ @ °C |
|---------------------|------------------------------------|--|--|
| As per: | ASTM D5293 | ASTM D4684 | ISO 3104 |
| 5W40 | 6600 @ -30 | 60000 @ -35 | 12.5 < μ < 16.3 @ 100 |
| 10W40 | 7000 @ -25 | 60000 @ -30 | |
| 15W40 ^{A)} | 7000 @ -20 | 60000 @ -25 | |

Tab. 34: KD lubricating oil viscosity grade requirements

A) Use of 15W40 lubricating oil presents some restrictions in cold environments.

Kohler KD diesel engines are designed to start with an ambient temperature above -10 °C (14 °F) with 5W40 or 10W40 lubricating oils. Specific additional devices should be considered for application intended to start at a temperature below -10 °C (14 °F) or when using a 15W40 lubricating oil. Please contact your Kohler Co. representative for additional information.

Fuel sulfur content and lubricating oil soot

Fuel sulfurs impact diesel engine hardware by developing sulfuric acids during combustion, thus creating corrosion. Lubricating oil embeds basic compounds (detergents) to neutralize these acids. The TBN (Total Base Number) measures the detergent content by providing an index of basicity for the lubricating oil.

With generalization of low sulfur content fuels and the associated evolution of lubricating oils, the TBN is no more sufficient to monitor operating oil status. The TAN (Total Acid Number) is also needed to get an accurate picture of the lubricating oil condition.

Lubricating oil soot is a by-product of the combustion comprised of roughly 98% of carbon in mass. It forms on the coolest part of the combustion chamber. Then soot is dragged into the oil by the piston rings or migrates to the crankcase through the crankcase breather system.

TBN ratio

The following TBN lubricating oils are approved for use in Kohler KD diesel engines.

- When diesel engine is operated with low sulfur content fuels (sulfur content lower than 0.5%):
 - TBN must be higher than 8 mgKOH/g and the soot (S₀) must be lower than 3%.
- When diesel engine is operated with sulfur content fuels between 0.5% and 1%:
 - TBN must be higher than 10 mgKOH/g and the soot (S₀) must be lower than 3%.
 - Lubricating oil change interval must be reduced according to the following table.
 - Oil change intervals must be confirmed through analysis process.
- When diesel engine is operated with sulfur content fuels between 1.0% and 1.5%:
 - TBN must be higher than 12 mgKOH/g and the soot (S₀) must be lower than 3%.
 - Lubricating oil change interval must be reduced according to the following table.
 - Oil change intervals must be confirmed through analysis process.

As a reminder, Kohler KD diesel engines must not be operated with fuels having a sulfur content higher than 1.5% (15000 ppm).

Emission-certified engines must not be operated with fuel having a sulfur content higher than 0.0015% (15 ppm).

| Category | Sulfur content factor | Comment |
|-----------------|-----------------------|-----------------------------------|
| 0.0% < S < 0.5% | 1 | The change interval is conserved. |

| Category | Sulfur content factor | Comment |
|-----------------|-----------------------|---|
| 0.5% < S < 1.0% | 1/2 | The change interval is divided by two. |
| 1.0% < S < 1.5% | 1/4 | The change interval is divided by four. |

Tab. 35: KD fuel sulfur content factors

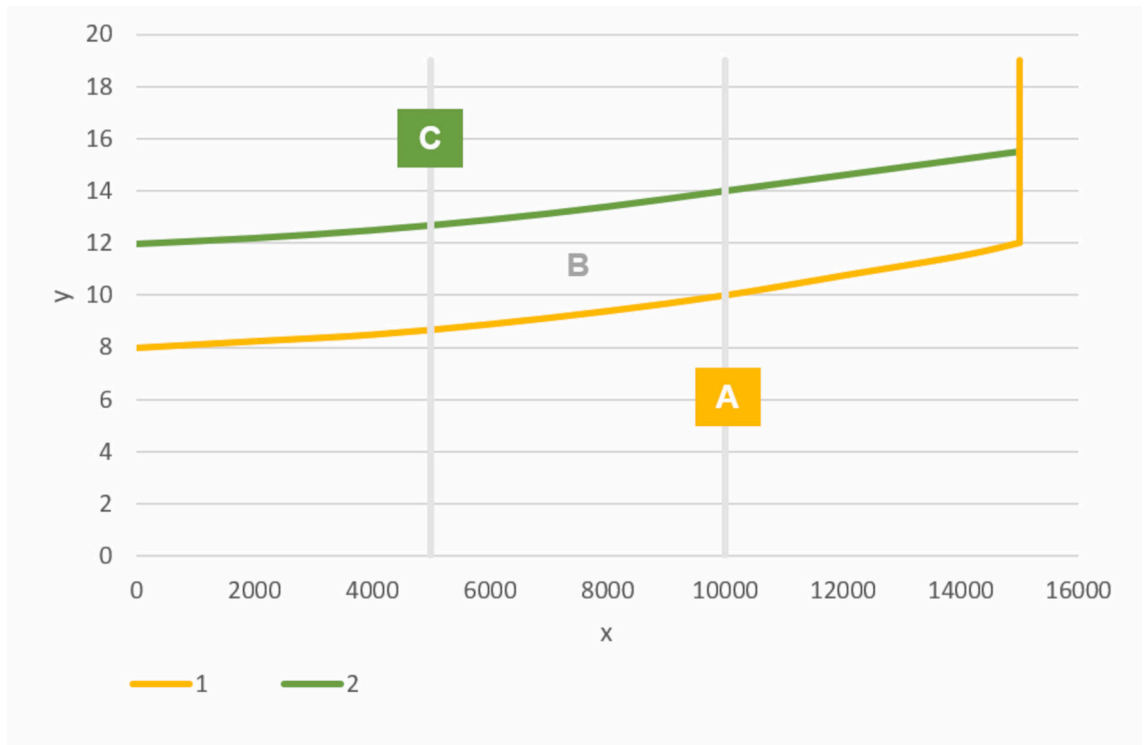


Fig. 79: KD recommended TBN according to fuel sulfur content

- | | |
|---|----------------------------------|
| A Operation forbidden zone | C Safe operating zone |
| B Lubricating oil change to be initiated | |
| x Fuel sulfur content (ppm) | y Total Base Number (TBN) |
| 1 Minimum TBN | 2 Recommended TBN |

TAN ratio

Kohler does not recommend any specific TAN for the lubricating oil to be used in KD diesel engines.

However, the user must pay a particular attention to the TAN and ensures that the following criteria are always true: $TAN < TBN - 2mgKOH / g$.

The following graph represents the influence of the TAN and the TBN on engine wear, represented by the quantity of iron found in lubricating oil.

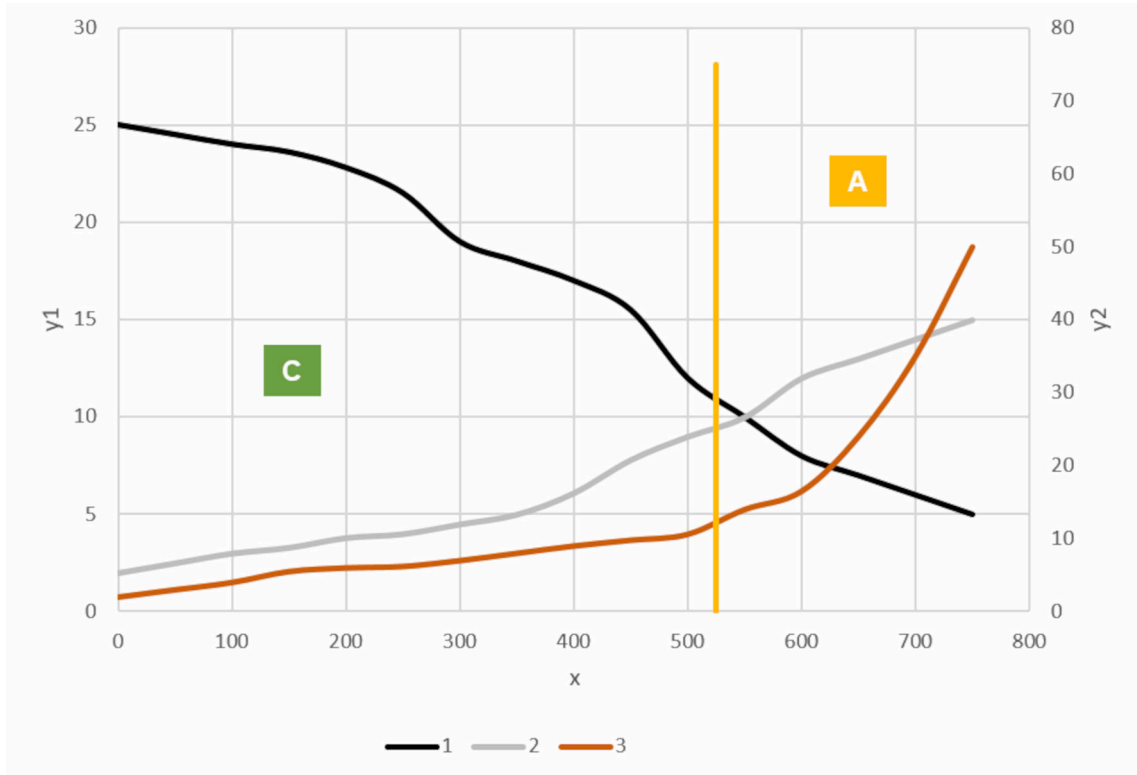


Fig. 80: KD recommended TAN / TBN evolution

- | | |
|-----------------------------------|------------------------------|
| A Operation forbidden zone | C Safe operating zone |
| x Operating hours | y2 Iron (ppm) |
| y1 TAN-TBN (mgKOH / g) | |
| 1 TBN | 3 Iron |
| 2 TAN | |

Lubricating oil change intervals and monitoring

Lubricating oil change intervals

Standard change interval for the lubricating oil is mentioned in the technical documentation accompanying the diesel engine (see “maintenance schedule” section). Additionally, the change interval is also influenced by the oil initial quality and the severity of the operation.

The following types of operation are considered as “severe”:

- Frequent cold starts
- Extended non operated period (standstill)
- Severe ambient conditions:
 - Extreme operating temperatures (cold or hot)
 - High humidity
 - Dust

Always refer to the technical documentation of the diesel engine to determine the lubricating oil change interval. In most of the case, the following definition applies: Change interval = Basic oil change interval * Oil category factor * Sulfur content factor

Where:

- Standard oil change interval is indicated in the technical documentation of the diesel engine.
- Oil category factor is defined in the table on KD lubricating oil category factors (see: [tab. 37, page 146](#)).

- Sulfur content factor is defined in the table on KD fuel sulfur content factors (see: tab. 35, page 142).

As an example:

- Standard oil change interval is 500 operating hours.
- Oil category is 3, so oil category factor is 2.
- Sulfur content is 1.3%, so sulfur content factor is ¼.
- Change interval = 500 * 2 * 1/4 = 250 hours

Lubricating oil monitoring

Close monitoring of lubricating oil quality brings benefits in several areas:

- Optimization of oil-change intervals
 - Improves your economics
 - Reduces environmental footprint
- Optimization of diesel engine availability
- Early detection of potential damage

When one of these criteria is no more fulfilled in operating lubricating oil, oil must be changed immediately:

| Criteria group | Criteria | Maximum values |
|--------------------|-------------------------|--|
| Contaminants | Aluminum | < 15 ppm |
| | Iron | < 40 ppm |
| | Chromium | < 10 ppm |
| | Copper | < 20 ppm |
| | Lead | < 25 ppm |
| | Silicon | < 15 ppm |
| | Sodium | < 20 ppm |
| | Potassium ^{A)} | < 25 ppm ^{A)} |
| Other contaminants | Water | < 0.2% |
| | Carbon | < 3% |
| | Fuel | < 3% |
| Viscosity | @ 40 °C (104 °F) | 0.9 V ₀ < V < 1.1 V ₀ (V ₀ = fresh oil viscosity) |
| | @ 100 °C (212 °F) | 0.9 V ₀ < V < 1.1 V ₀ (V ₀ = fresh oil viscosity) |
| | Viscosity index | 0.88 V _{i0} < V _i < 1.12 V _{i0} (V _{i0} = fresh oil viscosity) |
| Acid / Basic | TAN & TBN | TAN < TBN - 2 mgKOH/g |
| Oxidation | | < 25 abs.cm ⁻¹ |

Tab. 36: KD lubricating oil change criteria

A) Potassium is now incorporated in new-generation lubricating oils; conclusion must be drawn only by having initial composition and evolution available.

Mineral lubricating oils

The use of mineral lubricating oils is strictly forbidden in Kohler KD diesel engines.

Synthetic lubricating oils

| Oil category | Oil standard | Type of Lubricant | Oil category factor | Compatible with EATS |
|------------------|---|---|---------------------|----------------------|
| Oil category 2 | ACEA E4 ACEA E7 API CI-4 Plus DHD-1 JASO DH-1 | Synthetic (Group 2 and/or 3 base oils) | 1 | No |
| Oil category 2.1 | ACEA E6 ACEA E9 API CJ-4 JASO DH-2 | Synthetic (Group 2 and/or 3 base oils) | 1 | OK |
| Oil category 3 | ACEA E4-16 Both ACEA E4 and ACEA E7 | Synthetic (Group 3 and/or 4 base oils) VI > 155 Long live additive | 2 | No |
| Oil category 3.1 | ACEA E6-12 Both ACEA E6 and ACEA E9 API CK-4 | Synthetic (Group 3 and/or 4 base oils) VI > 155 Long live additive | 2 | OK |

Tab. 37: KD lubricating oil categories

Lubricating oil additives

Kohler prohibit the use of lubricating oil additives in the KD diesel engines.

5.13.4 Approved coolants

Coolant function

Diesel engine coolant fulfills three functions:

- Heat transfer from the diesel engine and its components to the radiators, without fluid cavitation
- Corrosion protection and deposit prevention in the cooling system
- Antifreeze protection in the cooling system



Information

Corrosion inhibitors present no cavitation protection. Use of water and corrosion inhibitor only in the cooling system is not recommended.

Coolant specification

Kohler KD diesel engines are designed to operate with either SI, SI-OAT or hybrid technology with ethylene glycol basis products as coolant.

The user can choose a ready-to-use preparation or prepare their own blend of water with anti-freeze and corrosion-protection agents. Kohler recommends the use of ready-to-use mixture as it reduces the risk of error in concentration and pollution of the system.

Water specification

When the user wants to blend their own mixture, Kohler recommends the use of fully deionized water. If the user wants to use tap water, this water must fulfill the requirements for drinking water according to 2006 WHO (World Health Organization) guideline.

| Criteria | Value |
|--------------------------------|------------------------------------|
| Water hardness | < 2.14 mmol/l (214 ppm) < 10°dH |
| pH-value | 6.7 < pH < 9 |
| Chloride (ions) | < 100 mg/l (100 ppm) |
| Sulfate | < 100 mg/l (100 ppm) |
| Bacteria and toxic constituent | Without |
| Impurities | Clear and free |
| Conductivity | 4 < mS |

Tab. 38: KD water requirements



Information

The use of sea water, brackish water, salt water, and industrial waste water is prohibited.

Coolant concentration

Kohler recommends a concentration of antifreeze and corrosion-protection agents of 40% all year round in power supply applications.

Only coolants with a glycol content lower than 55% are allowed in Kohler KD diesel engines. Higher concentrations prevent proper heat transfer and are thus forbidden. Should your application need additional antifreeze protection (arctic conditions), please contact your Kohler Co. representative for additional information.

Coolant monitoring

Kohler recommends a close monitoring of the coolant to prevent diesel engine damage by cavitation, corrosion, overheating, or freezing. Monitoring of the coolant can extend the exchange period of the fluid for up to 6 years for SI and SIOAT-based coolants. It can extend the exchange period of the fluid for up to 4 years for hybrid technology coolants.

Kohler recommends the following list of parameters to be checked by coolant analysis at least once a year. However, the user should always check with their coolant provider what the recommendations for analysis and monitoring of their coolant are, according to engine operating conditions.



Information

Topping up the cooling system with inadequate water or non-compatible coolant mixtures can lead to precipitation in the fluid and malfunction of the engine.

| Parameter | Unit | Method |
|---------------------------|---------------|--------------|
| Visual appearance / color | - | Visual |
| Water hardness | mmol/l ppm | EN/ISO 11885 |

| Parameter | Unit | Method |
|--|--------------|-------------------------|
| Nitrate / Nitrite | - | EN 12014 |
| pH value | - | EN/ISO 10523 ASTM D1287 |
| Glycol | % | DIN 51375 |
| Pour point | °C °F | ISO 3016 ASTM D5985 |
| Freezing point | °C °F | ISO 3013 ASTM D1177 |
| Bacteria | count | - |
| Additive elements (B, Ba, Ca, K, Mg, Na, P, S, Si) | mg/kg ppm | DIN 51399 |
| Wear elements (Al, Cr, Cu, Fe, Mg, Mo, Ni, Pb, Sn, Ti, V) | mg/kg ppm | DIN 51399 |
| Contamination (Ca, Mg, Mo, Si, Sn, Zn) | mg/kg ppm | DIN 51399 |
| Corrosion copper | - | EN/ISO 2160 |
| Corrosion steel | - | ISO 7120 |

Tab. 39: KD coolant analysis parameters

Keeping the cooling system clean

Usually, cleaning the cooling system is not necessary.

In case of contamination with bacteria, fungi or yeast, a mixture of fresh coolant added with biocides is suitable. The following products are approved:

| Manufacturer | Product-name | Concentration | Packin g | Order # |
|-----------------------|----------------|-----------------|-------------|---|
| Schülke & Mayr GmbH | Grotan WS Plus | 0.15% by volume | Liquid | X00065326 (10 kg (22.05 lb)) |
| | Grotanol SR1 | 1% by volume | Liquid | X00057297 (10 kg (22.05 lb)) X00057298 (200 kg (441 lb)) |
| Troy chemical company | Troyshield | 1% by volume | Liquid | - |

Tab. 40: KD cooling system cleaners

If there is need for a full cleaning of the system, flush the entire system with adequate water, then:

- Use the approved products to clean the system (see: tab. 41, page 148).
- Use the approved products to clean the components (see: tab. 42, page 149).

| Manufacturer | Product-name | Concentration | Packin g | Order # |
|--------------|------------------|---------------|-------------|-----------|
| Kluthe | Hakutex 111 | 2% by volume | Liquid | X00065751 |
| | Hakupur 50-706-3 | 2% by volume | Liquid | X00055629 |

| Manufacturer | Product-name | Concentration | Packin g | Order # |
|--------------|--------------|---------------|-------------|---------|
| Nalco | Maxi-Clean 2 | 2% by volume | Liquid | - |

Tab. 41: KD cooling system flushing chemicals

| Manufacturer | Product-name | Concentration | Packin g | Order # |
|--------------|--------------|--------------------|-------------|---------------------------------|
| Henkel | P3-FD | 3 to 5% by weight | Powder | - |
| | Porodox | 5 to 10% by weight | Powder | - |
| Kluthe | Hakutex 60 | 100% by volume | Liquid | X00056750 (25 kg (55.11 lb)) |

Tab. 42: KD cooling system components cleaners

5.14 Filling volume



Information

The following values are indicative. Refer to the technical data sheet of your diesel engine for the latest values. [\(For more information see: 8 Appendix, page 164.\)](#)

| Description | Quantity max. | Quantity min. |
|-------------|---|-----------------------|
| Engine oil | 610.1 l 161.17 gal | 509.7 l 134.65 gal |
| Coolant | Filling volume in the engine – high temperature circuit 295 l 77.93 gal | |
| | Filling volume in the engine – low temperature circuit 105 l 27.74 gal | |

Tab. 43: Filling volume in the engine (indicative value)

6 Operating faults

6.1 Diagnosis principles

For some engine problems with possible causes and corrective measures, see the table Faults - Causes - Remedy.



Information

Engine faults are displayed by means of a fault code on the device display for diagnostic purposes.

The explanations and remedies are explained in the KoDIA manual.

Basic logical steps for diagnosis are as following:

- ▶ Know the engine and the associated systems.
- ▶ Thoroughly analyze the problem.
- ▶ Relate symptoms to current knowledge about the engine and the systems.
- ▶ Diagnose problem, starting from the most obvious assumptions.
- ▶ Examine closely before starting to take the engine apart.
- ▶ Identify the causes and thoroughly perform any repair work.

After correction:

- ▶ Check for rectification of the causes.
- ▶ Close the incident.
- ▶ Run the engine according to Operation and Maintenance Manual.

6.2 Faults - Cause - Remedy

| Malfunction / error | Cause | Remedy |
|--|---|---|
| Starter does not turn. | Main fuse burnt through. | Replace fuse. |
| | Battery connections loose or corroded. | Clean and tighten loose connections. |
| | Battery voltage too low. | Recharge or replace battery. |
| | Starter circuit broken or contacts corroded. | Contact your nearest authorized Kohler service representative. |
| | Starter defective. | Contact your nearest authorized Kohler service representative. |
| Starter turns over slowly. | Battery voltage too low. | Recharge or replace battery. |
| | Battery connections loose or corroded. | Clean and tighten loose connections. |
| | Exterior temperature too low. | Implement measures for winter operation. |
| Diesel engine does not start and/or stops immediately. | Fuel tank empty. | Refuel the engine. |
| | Fuel filter blocked. | Replace fuel filter. |
| | Fuel line, precleaner or sieve in fuel tank blocked. | Clean and vent fuel system. |
| | Fuel system or filter leaking. | Seal and vent. |
| | Air in the fuel system. | Vent fuel system. |
| | Fuel not cold-resistant. | Clean pre-filter, replace fuel filter; use winter fuel. |
| | Exterior temperature too low. | Implement measures for winter operation. |
| Diesel engine starts poorly. | Leaks or pressure too low in fuel low pressure circuit. | Visually control there is no leak; Contact your nearest authorized Kohler service representative to check engine. |
| | Diesel engine compression too low. | Contact your nearest authorized Kohler service representative. |
| | Fault in electronics. | Read out fault memory of engine control unit. Contact your nearest authorized Kohler service representative. |

Operating faults

Faults - Cause - Remedy

| Malfunction / error | Cause | Remedy |
|---|---|---|
| Diesel engine shuts down when not desired. | Voltage supply interrupted. | Contact your nearest authorized Kohler service representative. |
| | Leaks or pressure too low in fuel low pressure circuit. | Leak test (visual inspection) ; Contact your nearest authorized Kohler service representative to check engine. |
| | Fault in electronics. | Read out fault memory of engine control unit, contact your nearest authorized Kohler service representative. |
| Low Diesel engine power (lack of power). | Defect in fuel system (blocked, leaking). | Visual inspection for leaks, change filter, contact your nearest authorized Kohler service representative. |
| | Charging pressure too low. | Loose clips, defective seals and hoses, air filter contaminated, turbocharger has no power. |
| | Charging air temperature too high. | Charge air cooler contaminated, low fan power, ambient too temperature too high, contact your nearest authorized Kohler service representative. |
| | Coolant temperature too high. | Check cooler for contamination, check fan and thermostat, check coolant level, contact your nearest authorized Kohler service representative. |
| | Fuel temperature too high. | Contact your nearest authorized Kohler service representative. |
| | Use at elevation over 1800 m above sea level. | No remedy. Diesel engine power is automatically reduced. |
| | Injection nozzles stuck or do not vaporize. | Contact your nearest authorized Kohler service representative. |
| | Diesel engine compression too low. | Contact your nearest authorized Kohler service representative. |
| Diesel engine too hot (according to coolant temperature display). | Fault in electronic system. | Read out fault logs of engine control unit, contact your nearest authorized Kohler service representative. |
| | Coolant quantity low. | Check the level. |
| | Cooler contaminated or scaled. | Clean or descale. |
| | Thermostat failure. | Check, replace if necessary, contact your nearest authorized Kohler service representative. |
| | Coolant temperature thermocouple failure. | Check, replace if necessary, contact your nearest authorized Kohler service representative. |

| Malfunction / error | Cause | Remedy |
|---------------------------------|---|--|
| Black smoke from Diesel engine. | Injection nozzles stuck or inefficient. | Contact your nearest authorized Kohler service representative. |
| | Turbocharger failure (charge pressure too low). | Contact your nearest authorized Kohler service representative. |
| | Engine overloaded. | Contact your nearest authorized Kohler service representative. |
| Exhaust gases blue. | Oil level in the Diesel engine too high. | Adjust oil level. |
| | Lubricant reaches the combustion chamber and is burned. | Contact your nearest authorized Kohler service representative. |
| | Compressor-side seal on the exhaust gas turbocharger defective. | Contact your nearest authorized Kohler service representative. |
| | Crankcase ventilation defective. | Check, if necessary replace. |
| Exhaust gases white. | Injection starts too late. | Contact your nearest authorized Kohler service representative. |
| | Operating temperature not reached. | Warm up the engine until operating temperature is reached. |
| | Water in fuel system. | Check fuel system and drain pre-filter. |
| | Charge air cooler leaking. | Contact your nearest authorized Kohler service representative. |
| Diesel engine rattles. | Combustion faults. | Contact your nearest authorized Kohler service representative. |
| Diesel engine knocks. | Wrong Valve clearance. | Set valve clearance. |
| | Injection nozzles damaged or carbonized. | Contact your nearest authorized Kohler service representative. |
| | Bearing damage. | Contact your nearest authorized Kohler service representative. |
| | Piston rings worn or broken, pistons eroded. | Contact your nearest authorized Kohler service representative. |
| Abnormal noises. | Leaks in the suction and exhaust lines cause whistling noise. | Seal leaks, replace seal if necessary. |
| | Turbine or compressor wheel rubbing against the housing; foreign bodies in the compressor or turbine; seized up bearings of rotating parts. | Contact your nearest authorized Kohler service representative. |

Operating faults


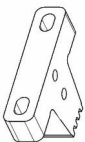
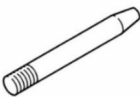
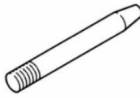
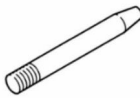
Faults - Cause - Remedy

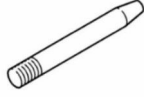
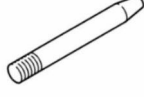
| Malfunction / error | Cause | Remedy |
|--------------------------------------|--|--|
| Lubricant oil pressure too low. | Oil level in the oil pan too low. | Fill oil to prescribed mark. |
| | Bad viscosity (oil diluted by Diesel fuel). | Drain off oil, fill with prescribed oil. |
| | Pressure transducer failure. | Check oil pressure and replace damaged oil pressure transducer; contact your nearest authorized Kohler service representative. |
| | End control valve does not work properly or dirt in the end control valve. | Contact your nearest authorized Kohler service representative. |
| | Bearing play too great due to wear or bearing damage. | Contact your nearest authorized Kohler service representative. |
| Lubricant oil in the cooling system. | Oil cooler or oil cooler plate leaking. | Contact your nearest authorized Kohler service representative. |
| Cooling water in the lubricant oil. | Cylinder liners seals leaking. | Contact your nearest authorized Kohler service representative. |
| | Oil cooler or oil cooler plate leaking. | Contact your nearest authorized Kohler service representative. |
| Charge air temperature too high. | Coolant concentration incorrect. | Check concentration using test kit. |
| | Charge air cooler contaminated. | Contact your nearest authorized Kohler service representative. |
| | Air intake temperature too high. | Check fans, air supply and ventilation. |
| Charge air pressure too low. | Air filter clogged. | Check air filter service indicator. |
| | Charge air cooler contaminated. | Contact your nearest authorized Kohler service representative. |
| | Turbocharger exhaust defect. | Contact your nearest authorized Kohler service representative. |
| Coolant leaks on charge air cooler. | Leaking, breaking. | Contact your nearest authorized Kohler service representative. |

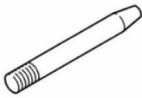
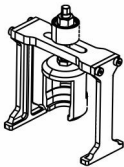
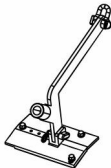
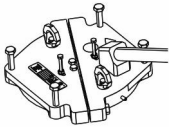
7 Tools and devices


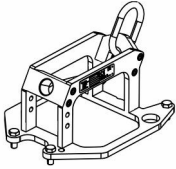
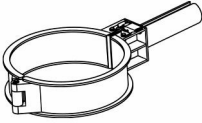
7.1 Tools

7.1.1 Special tools

| Special tool | Designation | Qty | Ident | KOHLER Ident number |
|---|---------------------------------------|-----|----------|---------------------|
|  11133437 | Turning device | 1 | 11133437 | 230611637 |
|  11343230 | Locking device | 1 | 11343230 | 230612868 |
|  11133371 | Guiding rod M30x2 - Cylinder head | 2 | 11133371 | 230610035 |
|  11133372 | Guiding rod M28x2 - Damper | 2 | 11133372 | 230610036 |
|  11133373 | Guiding rod M24x2 - Intermediate gear | 2 | 11133373 | 230610037 |

| Special tool | Designation | Qty | Ident | KOHLER Ident number |
|---|--------------------------------------|-----|----------|---------------------|
|  11133374 | Guiding rod M22x2 - Flywheel | 2 | 11133374 | 230612869 |
|  11133375 | Guiding rod M20 - Oil filter | 2 | 11133375 | 230610038 |
|  11133376 | Guiding rod M16 - Oil cooler support | 2 | 11133376 | 230610039 |
|  11133377 | Guiding rod M12 - Oil cooler | 2 | 11133377 | 230610040 |
|  11133379 | Guiding rod M10 - Exhaust line | 2 | 11133379 | 230610041 |
|  12427300 | Guiding rod M12 coolant pump | 2 | 12427300 | 230610042 |
|  12465862 | Guiding rod M12 Thermostat | 2 | 12465862 | 230611638 |

| Special tool | Designation | Qty | Ident | KOHLER Ident number |
|--|--|-----|----------|---------------------|
|  12217125 | Pin for belt tensioner | 1 | 12217125 | 230611639 |
| | Frequency meter | 1 | 12693396 | 230612870 |
|  12226280 | Injector Extraction Tool | 1 | 12226280 | 230611925 |
|  12226441 | HP Fuel Pump Lifting Device | 1 | 12226441 | 230612457 |
|  12588884 | Power unit extracting and lifting device | 1 | 12588884 | 230612871 |
| | Injector Connector Torque Screwdriver | 1 | 12691409 | 230612675 |
| | Sampling Tube for each liquid sampling | 1 | 7002475 | 230612676 |
| | Handling bar | 1 | 11344345 | 230612677 |
| | Electric Torque Multiplier | 1 | 12226986 | 230612678 |
| | Torque Reaction Arm for Electric Torque Multiplier | 1 | 12226968 | 230612679 |
| | Manual Torque Multiplier | 1 | 12227994 | 230612680 |
| | Torque Reaction Arm for Manual Torque Multiplier | 1 | 12227989 | 230612681 |
| | Spare Battery pack | 1 | 12226992 | 230612682 |
| | Battery Charger 110V | 1 | 12226970 | 230612683 |
| | Battery Charger 230V | 1 | 12226972 | 230612684 |
| | Adapter | 1 | 11343096 | 230612685 |

| Special tool | Designation | Qty | Ident | KOHLER Ident number |
|--|------------------------------|-----|----------|---------------------|
|  11343242 | Coolant Connector Pipe Tool | 1 | 11343242 | 230612686 |
|  12588878 | Cylinder head lifting device | | 12588878 | 230612865 |
|  12569852 | Piston ring compressor | | 12569852 | 230613049 |

Tab. 44: Special tools

7.1.2 Turning device

Specific safety instructions

The turning device is used to turn a gearwheel that drives the flywheel gear rim.

NOTICE

Turning device screwed on the flywheel housing during engine operation!
Property damage - Risk of engine major failure.

- ▶ Dismount immediately the turning device and mount the cover on the flywheel housing.



WARNING

Use of turning device!
Risk of death or injury by crushing, shearing, cutting, or severing.

- ▶ Tag out the application area according to local regulations and site rules.
- ▶ Before using the turning device, warn the personnel in the vicinity of the engine.
- ▶ Use the turning device under the supervision of another authorized technician.
- ▶ Before and during use of the turning device, stay away from the engine.



WARNING

Turning device screwed on the flywheel housing or wrench tool on the turning device during engine operation!

Risk of death or injury by ejected tools or turning device parts.

- ▶ Check spring function of the turning device. If faulty, replace by new turning device.
- ▶ After the rotation of the flywheel, always take away the wrench tool from the turning device.
- ▶ Dismount immediately the turning device and mount the cover on the flywheel housing.



Information

The wrench tool and the turning device are available for maintenance task only.

Please contact your nearest authorized Kohler service representative.

Installation

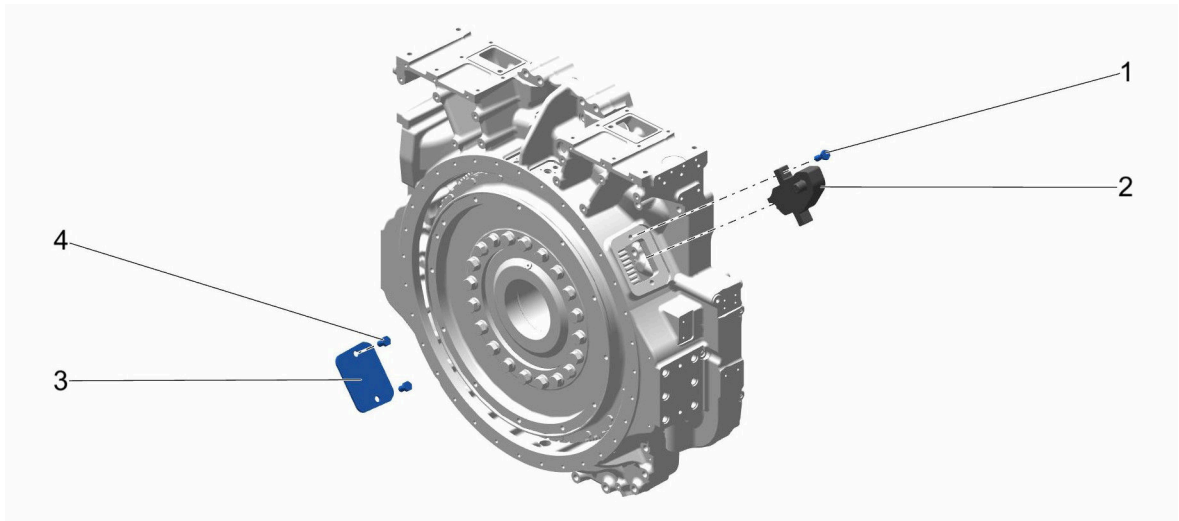


Fig. 100: Mounting the turning device

- | | |
|-------------------------------|-------------------------------|
| 1 Screws (M16x35 -8.8) | 3 Cover |
| 2 Turning device | 4 Screws (M16x25 -8.8) |

To mount the turning device:

- ▶ Unscrew screws **4**.
- ▶ Remove cover **3**.
- ▶ Position turning device **2**.
- ▶ Mount and tighten screws **1** according to standard torque values.



Information

For queries, please contact your nearest authorized Kohler service representative.

Operation

Make sure that the following preconditions are met:

- Turning device is mounted on the engine.

Depending on the required setting:

- ▶ Engage a manual wrench tool to turn the wheel from the turning device that drives the flywheel gear rim.
- ▶ Turn the engine flywheel to the required position or as long needed by turning the wrench.
- ▶ Disengage the manual wrench each time you stop to turn.

At the end of the setting:

- ▶ Dismount the turning device and mount the cover on the flywheel housing.
- ▶ Tighten the turning device cover bolts according to standard torques values.

Removal

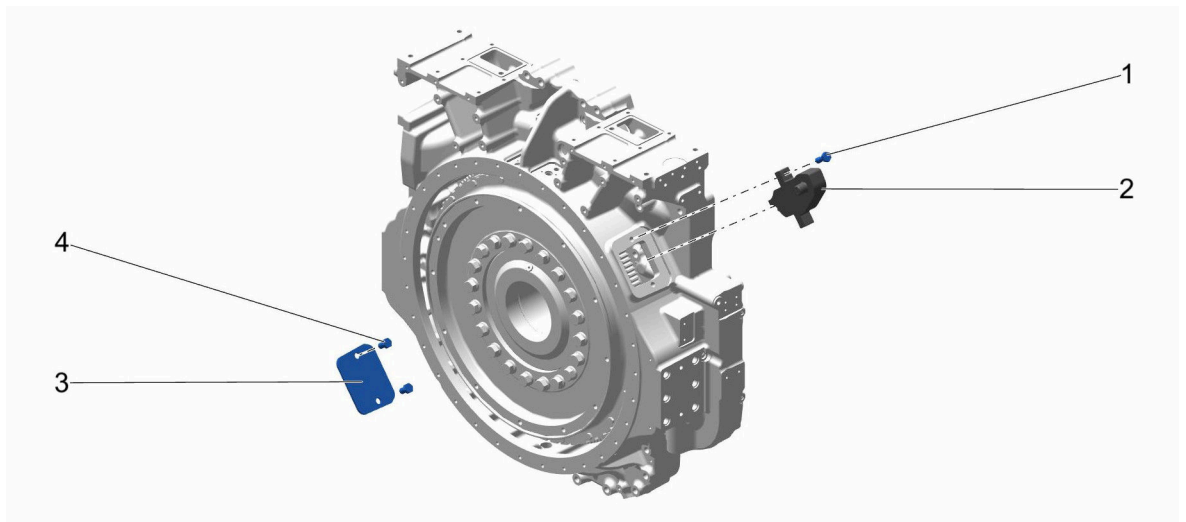


Fig. 101: Dismounting the turning device

- | | |
|-------------------------------|-------------------------------|
| 1 Screws (M16x35 -8.8) | 3 Cover |
| 2 Turning device | 4 Screws (M16x25 -8.8) |

To dismount the turning device:

- ▶ Unscrew screws **1**.
- ▶ Remove turning device **2**.
- ▶ Position cover **3**.
- ▶ Mount and tighten screws **4** according to standard torques values.



Information

For queries, please contact your nearest authorized Kohler service representative.

8 Appendix

8.1 Technical design documents



Information

The technical design documents are specific to the delivered engine.

Using those documents for other engines is forbidden.

For inquiry, please contact your nearest authorized Kohler service representative.

8.2 Error code



Information

Error code list extracted from engine control unit software version 21.12.10 and dataset revision 9.

The following error code table is indicative. Refer to the technical data sheet of your engine for the latest software version.

For further information, please contact your nearest authorized Kohler service representative.

Abbreviations:

- SPN - Suspect Parameter Number
- FMI - Failure Mode Identification

| SPN | FMI | Designation |
|--------|-----|---|
| 107 | 11 | Air filter - Blocked/clogged |
| 516101 | 31 | Air filter pressure switch - Supply voltage out of range |
| 516428 | 31 | Air pressure sensors - Plausibility error |
| 108 | 31 | Ambient pressure sensor - Supply voltage out of range |
| 171 | 5 | Ambient temperature sensor - Open circuit |
| 171 | 3 | Ambient temperature sensor - Short circuit to battery |
| 171 | 4 | Ambient temperature sensor - Short circuit to ground |
| 171 | 31 | Ambient temperature sensor - Supply voltage out of range |
| 1176 | 1 | Boost pressure - Pressure too high |
| 1176 | 0 | Boost pressure - Pressure too low |
| 636 | 2 | Camshaft position - Plausibility error |
| 636 | 14 | Camshaft position sensor - Ground error |
| 636 | 5 | Camshaft position sensor - Open circuit |
| 636 | 3 | Camshaft position sensor - Short circuit to battery |
| 636 | 3 | Camshaft position sensor - Short circuit to battery or open circuit |
| 636 | 4 | Camshaft position sensor - Short circuit to ground |
| 636 | 31 | Camshaft position sensor - Supply voltage out of range |
| 157 | 0 | Common rail - Critical overpressure |
| 1239 | 2 | Common rail - Leakage |
| 157 | 15 | Common rail - Overpressure warning |
| 516117 | 11 | Common rail - PCV opened due to overpressure |
| 1075 | 2 | Common rail - Plausibility error |
| 516118 | 11 | Common rail - Plausibility error of VCV current |
| 516121 | 11 | Common rail - Pressure remains above the set point |
| 516122 | 11 | Common rail - Pressure remains below the set point |

| SPN | FMI | Designation |
|--------|-----|--|
| 516123 | 11 | Common rail - Start pressure too low |
| 1349 | 0 | Common rail 2 - Critical overpressure |
| 1240 | 2 | Common rail 2 - Leakage |
| 1349 | 15 | Common rail 2 - Overpressure warning |
| 516124 | 11 | Common rail 2 - PCV opened due to overpressure |
| 516125 | 11 | Common rail 2 - Plausibility error of VCV current |
| 516128 | 11 | Common rail 2 - Pressure remains above the set point |
| 516129 | 11 | Common rail 2 - Pressure remains below the set point |
| 516130 | 11 | Common rail 2 - Start pressure too low |
| 1239 | 0 | Common rail leakage 1 - Fuel leak |
| 1239 | 11 | Common rail leakage 1 - Out of range |
| 1239 | 31 | Common rail leakage 1 - Supply voltage out of range |
| 1240 | 0 | Common rail leakage 2 - Fuel leak |
| 1240 | 11 | Common rail leakage 2 - Out of range |
| 1240 | 31 | Common rail leakage 2 - Supply voltage out of range |
| 516131 | 11 | Common rail pressure sensor - No signal variation |
| 157 | 3 | Common rail pressure sensor - Short circuit to battery or open circuit |
| 157 | 4 | Common rail pressure sensor - Short circuit to ground |
| 157 | 31 | Common rail pressure sensor - Supply voltage out of range |
| 516133 | 11 | Common rail pressure sensor 2 - No signal variation |
| 1349 | 3 | Common rail pressure sensor 2 - Short circuit to battery or open circuit |
| 1349 | 4 | Common rail pressure sensor 2 - Short circuit to ground |
| 1349 | 31 | Common rail pressure sensor 2 - Supply voltage out of range |
| 2430 | 11 | Coolant level sensor - Out of range |
| 2430 | 3 | Coolant level sensor - Short circuit to battery |
| 2430 | 4 | Coolant level sensor - Short circuit to ground or open circuit |
| 2430 | 31 | Coolant level sensor - Supply voltage out of range |
| 6303 | 11 | Coolant level sensor 2 - Out of range |
| 6303 | 3 | Coolant level sensor 2 - Short circuit to battery |
| 6303 | 4 | Coolant level sensor 2 - Short circuit to ground or open circuit |
| 6303 | 31 | Coolant level sensor 2 - Supply voltage out of range |
| 6209 | 0 | Coolant temperature at intercooler - Critical overtemperature |
| 6209 | 15 | Coolant temperature at intercooler - Overtemperature warning |
| 110 | 5 | Coolant temperature sensor - Open circuit |
| 110 | 3 | Coolant temperature sensor - Short circuit to battery |
| 110 | 4 | Coolant temperature sensor - Short circuit to ground |

| SPN | FMI | Designation |
|--------|-----|---|
| 110 | 31 | Coolant temperature sensor - Supply voltage out of range |
| 101 | 0 | Crankcase pressure - Critical overpressure |
| 101 | 15 | Crankcase pressure - Overpressure warning |
| 101 | 31 | Crankcase pressure - Supply voltage out of range |
| 101 | 3 | Crankcase pressure sensor - Short circuit to battery |
| 101 | 4 | Crankcase pressure sensor - Short circuit to ground or open circuit |
| 637 | 2 | Crankshaft position - Plausibility error |
| 637 | 14 | Crankshaft position sensor - Ground error |
| 637 | 5 | Crankshaft position sensor - Open circuit |
| 637 | 3 | Crankshaft position sensor - Short circuit to battery |
| 637 | 3 | Crankshaft position sensor - Short circuit to battery or open circuit |
| 637 | 4 | Crankshaft position sensor - Short circuit to ground |
| 637 | 31 | Crankshaft position sensor - Supply voltage out of range |
| 1136 | 0 | Engine control unit - Critical overtemperature |
| 516543 | 31 | Engine control unit - Data recorder was triggered |
| 1136 | 15 | Engine control unit - Overtemperature warning |
| 516495 | 31 | Engine control unit - Runtime reached the maximum time without reset |
| 1136 | 31 | Engine control unit temperature sensor 1 - Supply voltage out of range |
| 516140 | 31 | Engine control unit temperature sensor 2 - Supply voltage out of range |
| 516141 | 31 | Engine control unit temperature sensor 3 - Supply voltage out of range |
| 51644 | 31 | Engine - Starter activated but no engine rotation detected |
| 516356 | 31 | Engine control unit - Communication error to slave injection control unit |
| 639 | 5 | Engine control unit CAN 1 - Open circuit |
| 639 | 11 | Engine control unit CAN 1 - Short circuit |
| 625 | 5 | Engine control unit CAN 2 - Open circuit |
| 625 | 11 | Engine control unit CAN 2 - Short circuit |
| 516148 | 5 | Engine control unit CAN 4 - Open circuit |
| 516148 | 11 | Engine control unit CAN 4 - Short circuit |
| 110 | 0 | Engine coolant - Critical overtemperature |
| 111 | 17 | Engine coolant - Level low |
| 110 | 15 | Engine coolant - Overtemperature warning |
| 4076 | 14 | Engine coolant 2 - Level low |
| 175 | 0 | Engine oil - Critical overtemperature |

| SPN | FMI | Designation |
|--------|-----|---|
| 100 | 1 | Engine oil - Critical underpressure |
| 175 | 15 | Engine oil - Overtemperature warning |
| 100 | 2 | Engine oil - Plausibility error |
| 100 | 17 | Engine oil - Underpressure warning |
| 1180 | 2 | Exhaust boost temperature (CMR sensor) - Communication error |
| 1180 | 2 | Exhaust boost temperature 1 (CMR sensor) - Communication error |
| 1181 | 2 | Exhaust boost temperature 2 (CMR sensor) - Communication error |
| 3245 | 0 | Exhaust temperature before turbocharger 1 - Critical overtemperature |
| 1180 | 15 | Exhaust temperature before turbocharger 1 - Overtemperature warning |
| 3279 | 0 | Exhaust temperature before turbocharger 2 - Critical overtemperature |
| 1181 | 15 | Exhaust temperature before turbocharger 2 - Overtemperature warning |
| 94 | 0 | Fuel supply - Critical overpressure |
| 174 | 0 | Fuel supply - Critical overtemperature |
| 94 | 1 | Fuel supply - Critical underpressure |
| 174 | 15 | Fuel supply - Overtemperature warning |
| 94 | 3 | Fuel supply pressure sensor - Short circuit to battery |
| 94 | 4 | Fuel supply pressure sensor - Short circuit to ground or open circuit |
| 94 | 31 | Fuel supply pressure sensor - Supply voltage out of range |
| 174 | 5 | Fuel temperature sensor - Open circuit |
| 174 | 3 | Fuel temperature sensor - Short circuit to battery |
| 174 | 4 | Fuel temperature sensor - Short circuit to ground |
| 174 | 31 | Fuel temperature sensor - Supply voltage out of range |
| 516195 | 2 | Generator Set Controller - Communication error |
| 190 | 0 | Genset - Engine over speed |
| 729 | 6 | Heating flange 1 - Critical high output current |
| 729 | 11 | Heating flange 1 - Electrical error |
| 729 | 5 | Heating flange 1 - Open circuit |
| 729 | 3 | Heating flange 1 - Short circuit to battery high side |
| 516304 | 3 | Heating flange 1 - Short circuit to battery low side |
| 729 | 4 | Heating flange 1 - Short circuit to ground high side |
| 516305 | 4 | Heating flange 1 - Short circuit to ground low side |
| 730 | 6 | Heating flange 2 - Critical high output current |

| SPN | FMI | Designation |
|--------|-----|--|
| 730 | 11 | Heating flange 2 - Electrical error |
| 730 | 5 | Heating flange 2 - Open circuit |
| 730 | 3 | Heating flange 2 - Short circuit to battery high side |
| 516344 | 3 | Heating flange 2 - Short circuit to battery low side |
| 730 | 4 | Heating flange 2 - Short circuit to ground high side |
| 516345 | 4 | Heating flange 2 - Short circuit to ground low side |
| 516346 | 5 | Heating flange status input 1 - Open circuit |
| 516346 | 3 | Heating flange status input 1 - Short circuit to battery high side |
| 516347 | 3 | Heating flange status input 1 - Short circuit to battery low side |
| 516346 | 4 | Heating flange status input 1 - Short circuit to ground high side |
| 516347 | 4 | Heating flange status input 1 - Short circuit to ground low side |
| 516348 | 8 | Heating flange status input 2 - Open circuit |
| 516348 | 3 | Heating flange status input 2 - Short circuit to battery high side |
| 516349 | 3 | Heating flange status input 2 - Short circuit to battery low side |
| 516348 | 4 | Heating flange status input 2 - Short circuit to ground high side |
| 516349 | 4 | Heating flange status input 2 - Short circuit to ground low side |
| 516187 | 31 | Ignition digital input - Supply voltage out of range |
| 516509 | 31 | Injection data synchronization - Error during measurement of voltage-based small quantity injection correction |
| 651 | 0 | Injector 1 - Current Rise time too long |
| 651 | 8 | Injector 1 - No current rise time measured |
| 651 | 5 | Injector 1 - Open circuit |
| 651 | 3 | Injector 1 - Short circuit to battery |
| 651 | 4 | Injector 1 - Short circuit to ground |
| 660 | 0 | Injector 10 - Current Rise time too long |
| 660 | 8 | Injector 10 - No current rise time measured |
| 660 | 5 | Injector 10 - Open circuit |
| 660 | 3 | Injector 10 - Short circuit to battery |
| 660 | 4 | Injector 10 - Short circuit to ground |
| 661 | 0 | Injector 11 - Current Rise time too long |
| 661 | 8 | Injector 11 - No current rise time measured |
| 661 | 5 | Injector 11 - Open circuit |
| 661 | 3 | Injector 11 - Short circuit to battery |
| 661 | 4 | Injector 11 - Short circuit to ground |
| 662 | 0 | Injector 12 - Current Rise time too long |
| 662 | 8 | Injector 12 - No current rise time measured |
| 662 | 5 | Injector 12 - Open circuit |
| 662 | 3 | Injector 12 - Short circuit to battery |

| SPN | FMI | Designation |
|-----|-----|---|
| 662 | 4 | Injector 12 - Short circuit to ground |
| 663 | 0 | Injector 13 - Current Rise time too long |
| 663 | 8 | Injector 13 - No current rise time measured |
| 663 | 5 | Injector 13 - Open circuit |
| 663 | 3 | Injector 13 - Short circuit to battery |
| 663 | 4 | Injector 13 - Short circuit to ground |
| 664 | 0 | Injector 14 - Current Rise time too long |
| 664 | 8 | Injector 14 - No current rise time measured |
| 664 | 5 | Injector 14 - Open circuit |
| 664 | 3 | Injector 14 - Short circuit to battery |
| 664 | 4 | Injector 14 - Short circuit to ground |
| 665 | 0 | Injector 15 - Current Rise time too long |
| 665 | 8 | Injector 15 - No current rise time measured |
| 665 | 5 | Injector 15 - Open circuit |
| 665 | 3 | Injector 15 - Short circuit to battery |
| 665 | 4 | Injector 15 - Short circuit to ground |
| 666 | 0 | Injector 16 - Current Rise time too long |
| 666 | 8 | Injector 16 - No current rise time measured |
| 666 | 5 | Injector 16 - Open circuit |
| 666 | 3 | Injector 16 - Short circuit to battery |
| 666 | 4 | Injector 16 - Short circuit to ground |
| 667 | 0 | Injector 17 - Current Rise time too long |
| 667 | 8 | Injector 17 - No current rise time measured |
| 667 | 5 | Injector 17 - Open circuit |
| 667 | 3 | Injector 17 - Short circuit to battery |
| 667 | 4 | Injector 17 - Short circuit to ground |
| 668 | 0 | Injector 18 - Current Rise time too long |
| 669 | 8 | Injector 18 - No current rise time measured |
| 669 | 5 | Injector 18 - Open circuit |
| 669 | 3 | Injector 18 - Short circuit to battery |
| 669 | 4 | Injector 18 - Short circuit to ground |
| 652 | 0 | Injector 19 - Current Rise time too long |
| 652 | 8 | Injector 19 - No current rise time measured |
| 652 | 5 | Injector 19 - Open circuit |
| 652 | 3 | Injector 19 - Short circuit to battery |
| 652 | 4 | Injector 19 - Short circuit to ground |
| 652 | 0 | Injector 2 - Current Rise time too long |
| 652 | 8 | Injector 2 - No current rise time measured |

| SPN | FMI | Designation |
|-----|-----|---|
| 652 | 5 | Injector 2 - Open circuit |
| 652 | 3 | Injector 2 - Short circuit to battery |
| 652 | 4 | Injector 2 - Short circuit to ground |
| 670 | 0 | Injector 20 - Current Rise time too long |
| 670 | 8 | Injector 20 - No current rise time measured |
| 670 | 5 | Injector 20 - Open circuit |
| 670 | 3 | Injector 20 - Short circuit to battery |
| 670 | 4 | Injector 20 - Short circuit to ground |
| 653 | 0 | Injector 3 - Current Rise time too long |
| 653 | 8 | Injector 3 - No current rise time measured |
| 653 | 5 | Injector 3 - Open circuit |
| 653 | 3 | Injector 3 - Short circuit to battery |
| 653 | 4 | Injector 3 - Short circuit to ground |
| 654 | 0 | Injector 4 - Current Rise time too long |
| 654 | 8 | Injector 4 - No current rise time measured |
| 654 | 5 | Injector 4 - Open circuit |
| 654 | 3 | Injector 4 - Short circuit to battery |
| 654 | 4 | Injector 4 - Short circuit to ground |
| 655 | 0 | Injector 5 - Current Rise time too long |
| 655 | 8 | Injector 5 - No current rise time measured |
| 655 | 5 | Injector 5 - Open circuit |
| 655 | 3 | Injector 5 - Short circuit to battery |
| 655 | 4 | Injector 5 - Short circuit to ground |
| 656 | 0 | Injector 6 - Current Rise time too long |
| 656 | 8 | Injector 6 - No current rise time measured |
| 656 | 5 | Injector 6 - Open circuit |
| 656 | 3 | Injector 6 - Short circuit to battery |
| 656 | 4 | Injector 6 - Short circuit to ground |
| 657 | 0 | Injector 7 - Current Rise time too long |
| 657 | 8 | Injector 7 - No current rise time measured |
| 657 | 5 | Injector 7 - Open circuit |
| 657 | 3 | Injector 7 - Short circuit to battery |
| 657 | 4 | Injector 7 - Short circuit to ground |
| 658 | 0 | Injector 8 - Current Rise time too long |
| 658 | 8 | Injector 8 - No current rise time measured |
| 658 | 5 | Injector 8 - Open circuit |
| 658 | 3 | Injector 8 - Short circuit to battery |
| 658 | 4 | Injector 8 - Short circuit to ground |

| SPN | FMI | Designation |
|--------|-----|---|
| 659 | 0 | Injector 9 - Current Rise time too long |
| 659 | 8 | Injector 9 - No current rise time measured |
| 659 | 5 | Injector 9 - Open circuit |
| 659 | 3 | Injector 9 - Short circuit to battery |
| 659 | 4 | Injector 9 - Short circuit to ground |
| 516191 | 17 | Injector supply boost converter - Undervoltage warning |
| 105 | 5 | Intake air temperature sensor - Open circuit |
| 105 | 3 | Intake air temperature sensor - Short circuit to battery |
| 105 | 4 | Intake air temperature sensor - Short circuit to ground |
| 105 | 31 | Intake air temperature sensor - Supply voltage out of range |
| 102 | 0 | Intake manifold - Critical overpressure |
| 1636 | 0 | Intake manifold - Critical overtemperature |
| 102 | 1 | Intake manifold - Critical underpressure |
| 102 | 15 | Intake manifold - Overpressure warning |
| 1636 | 15 | Intake manifold - Overtemperature warning |
| 102 | 17 | Intake manifold - Underpressure warning |
| 102 | 3 | Intake manifold pressure sensor - Short circuit to battery |
| 102 | 4 | Intake manifold pressure sensor - Short circuit to ground or open circuit |
| 102 | 31 | Intake manifold pressure sensor - Supply voltage out of range |
| 1636 | 5 | Intake manifold temperature sensor - Open circuit |
| 1636 | 3 | Intake manifold temperature sensor - Short circuit to battery |
| 1636 | 4 | Intake manifold temperature sensor - Short circuit to ground |
| 1636 | 31 | Intake manifold temperature sensor - Supply voltage out of range |
| 6209 | 5 | Intercooler coolant temperature sensor - Open circuit |
| 6209 | 3 | Intercooler coolant temperature sensor - Short circuit to battery |
| 6209 | 4 | Intercooler coolant temperature sensor - Short circuit to ground |
| 6209 | 31 | Intercooler coolant temperature sensor - Supply voltage out of range |
| 516197 | 2 | Master slave injection - Communication error |
| 516223 | 11 | Monitoring system - Engine control unit internal safety error |
| 516226 | 11 | Monitoring system - Injector safety error |
| 100 | 3 | Oil pressure sensor - Short circuit to battery |
| 100 | 4 | Oil pressure sensor - Short circuit to ground or open circuit |
| 100 | 31 | Oil pressure sensor - Supply voltage out of range |
| 175 | 5 | Oil temperature sensor - Open circuit |

| SPN | FMI | Designation |
|--------|-----|--|
| 175 | 3 | Oil temperature sensor - Short circuit to battery |
| 175 | 4 | Oil temperature sensor - Short circuit to ground |
| 175 | 4 | Oil temperature sensor - Short circuit to ground or open circuit |
| 175 | 31 | Oil temperature sensor - Supply voltage out of range |
| 4811 | 0 | Piston cooling pressure 1 - Critical overpressure |
| 4811 | 1 | Piston cooling pressure 1 - Critical underpressure |
| 4811 | 15 | Piston cooling pressure 1 - Overpressure warning |
| 4811 | 17 | Piston cooling pressure 1 - Underpressure warning |
| 4811 | 3 | Piston cooling pressure sensor 1 - Short circuit to battery |
| 4811 | 4 | Piston cooling pressure sensor 1 - Short circuit to ground or open circuit |
| 4811 | 31 | Piston cooling pressure sensor 1 - Supply voltage out of range |
| 3597 | 1 | Power supply - Critical undervoltage |
| 3597 | 15 | Power supply - Overvoltage warning |
| 3597 | 17 | Power supply - Undervoltage warning |
| 5571 | 6 | Pressure control valve - Critical high output current |
| 5571 | 0 | Pressure control valve - Critical overcurrent |
| 5571 | 1 | Pressure control valve - Critical undercurrent |
| 516209 | 15 | Pressure control valve - Current remains above the set point |
| 516209 | 17 | Pressure control valve - Current remains below the set point |
| 5571 | 11 | Pressure control valve - Electrical error |
| 5571 | 5 | Pressure control valve - Open circuit |
| 516211 | 11 | Pressure control valve - PWM signal - High limit reached |
| 516212 | 11 | Pressure control valve - PWM signal - Plausibility error |
| 516422 | 11 | Pressure control valve - Short circuit load |
| 5571 | 3 | Pressure control valve - Short circuit to battery high side |
| 516331 | 3 | Pressure control valve - Short circuit to battery low side |
| 5571 | 4 | Pressure control valve - Short circuit to ground high side |
| 516331 | 4 | Pressure control valve - Short circuit to ground low side |
| 516215 | 6 | Pressure control valve 2 - Critical high output current |
| 516215 | 0 | Pressure control valve 2 - Critical overcurrent |
| 516215 | 1 | Pressure control valve 2 - Critical undercurrent |
| 516216 | 11 | Pressure control valve 2 - Current remains above the set point |
| 516217 | 11 | Pressure control valve 2 - Current remains below the set point |
| 516337 | 11 | Pressure control valve 2 - Electrical error |
| 516215 | 5 | Pressure control valve 2 - Open circuit |
| 516220 | 11 | Pressure control valve 2 - PWM signal - High limit reached |
| 516221 | 11 | Pressure control valve 2 - PWM signal - Plausibility error |

| SPN | FMI | Designation |
|--------|-----|--|
| 516215 | 11 | Pressure control valve 2 - Short circuit load |
| 516215 | 3 | Pressure control valve 2 - Short circuit to battery high side |
| 516337 | 3 | Pressure control valve 2 - Short circuit to battery low side |
| 516215 | 4 | Pressure control valve 2 - Short circuit to ground high side |
| 516337 | 4 | Pressure control valve 2 - Short circuit to ground low side |
| 516752 | 0 | SCR system (filter) - Run time critical |
| 516752 | 16 | SCR system (filter) - Run time warning |
| 516493 | 31 | Slave injection control unit - Emission relevant error |
| 3938 | 2 | Speed adjustment - Plausibility error |
| 3938 | 3 | Speed adjustment (current) - Short circuit to battery |
| 3938 | 4 | Speed adjustment (current) - Short circuit to ground or open circuit |
| 3938 | 31 | Speed adjustment (current) - Supply voltage out of range |
| 3938 | 3 | Speed adjustment (voltage) - Short circuit to battery |
| 3938 | 4 | Speed adjustment (voltage) - Short circuit to ground or open circuit |
| 3938 | 31 | Speed adjustment (voltage) - Supply voltage out of range |
| 677 | 6 | Starter - Critical high output current |
| 677 | 11 | Starter - Electrical error |
| 516342 | 31 | Starter - Locked due to overtemperature |
| 677 | 5 | Starter - Open circuit |
| 677 | 3 | Starter - Short circuit to battery high side |
| 516276 | 3 | Starter - Short circuit to battery low side |
| 677 | 4 | Starter - Short circuit to ground high side |
| 516277 | 4 | Starter - Short circuit to ground low side |
| 516369 | 6 | Starter 2 - Critical high output current |
| 516369 | 11 | Starter 2 - Electrical error |
| 516369 | 31 | Starter 2 - Locked due to overtemperature |
| 516369 | 5 | Starter 2 - Open circuit |
| 516369 | 3 | Starter 2 - Short circuit to battery high side |
| 516370 | 3 | Starter 2 - Short circuit to battery low side |
| 516369 | 4 | Starter 2 - Short circuit to ground high side |
| 516371 | 4 | Starter 2 - Short circuit to ground low side |
| 516424 | 11 | Starter digital input - Starter inhibition due to short circuit |
| 516247 | 31 | Starter digital input - Supply voltage out of range |
| 516425 | 11 | Starter digital input 2 - Starter inhibition due to short circuit |
| 516264 | 31 | Starter digital input 2 - Supply voltage out of range |
| 516511 | 31 | Starters - Not connected in the output 1 to engine control unit |

| SPN | FMI | Designation |
|--------|-----|---|
| 516512 | 31 | Starters - Not connected in the output 2 to engine control unit |
| 1076 | 6 | Volume control valve - Critical high output current |
| 1076 | 0 | Volume control valve - Critical overcurrent |
| 1076 | 1 | Volume control valve - Critical undercurrent |
| 516251 | 11 | Volume control valve - Current remains above the set point |
| 516252 | 11 | Volume control valve - Current remains below the set point |
| 516330 | 11 | Volume control valve - Electrical error |
| 1076 | 5 | Volume control valve - Open circuit |
| 516253 | 11 | Volume control valve - PWM signal - High limit reached |
| 516254 | 11 | Volume control valve - PWM signal - Plausibility error |
| 1076 | 11 | Volume control valve - Short circuit load |
| 1076 | 3 | Volume control valve - Short circuit to battery high side |
| 516328 | 3 | Volume control valve - Short circuit to battery low side |
| 1076 | 4 | Volume control valve - Short circuit to ground high side |
| 516329 | 4 | Volume control valve - Short circuit to ground low side |
| 516255 | 6 | Volume control valve 2 - Critical high output current |
| 516255 | 0 | Volume control valve 2 - Critical overcurrent |
| 516255 | 11 | Volume control valve 2 - Critical undercurrent |
| 516256 | 11 | Volume control valve 2 - Current remains above the set point |
| 516257 | 11 | Volume control valve 2 - Current remains below the set point |
| 516336 | 11 | Volume control valve 2 - Electrical error |
| 516255 | 5 | Volume control valve 2 - Open circuit |
| 516258 | 11 | Volume control valve 2 - PWM signal - High limit reached |
| 516259 | 11 | Volume control valve 2 - PWM signal - Plausibility error |
| 516255 | 11 | Volume control valve 2 - Short circuit load |
| 516255 | 3 | Volume control valve 2 - Short circuit to battery high side |
| 516336 | 3 | Volume control valve 2 - Short circuit to battery low side |
| 516255 | 4 | Volume control valve 2 - Short circuit to ground high side |
| 516336 | 4 | Volume control valve 2 - Short circuit to ground low side |
| 5386 | 6 | Wastegate valve - Critical high output current |
| 5386 | 11 | Wastegate valve - Electrical error |
| 5386 | 5 | Wastegate valve - Open circuit |
| 516318 | 31 | Wastegate valve - Short circuit load |
| 5386 | 3 | Wastegate valve - Short circuit to battery high side |
| 516266 | 3 | Wastegate valve - Short circuit to battery low side |
| 5386 | 4 | Wastegate valve - Short circuit to ground high side |
| 516266 | 4 | Wastegate valve - Short circuit to ground low side |
| 97 | 5 | Water in fuel sensor - Open circuit |

| SPN | FMI | Designation |
|------|-----|--|
| 97 | 11 | Water in fuel sensor - Out of range |
| 97 | 3 | Water in fuel sensor - Short circuit to battery |
| 97 | 4 | Water in fuel sensor - Short circuit to ground |
| 97 | 31 | Water in fuel sensor - Supply voltage out of range |
| 97 | 0 | Water in fuel sensor - Water in fuel detected |
| 6301 | 5 | Water in fuel sensor 2 - Open circuit |
| 6301 | 11 | Water in fuel sensor 2 - Out of range |
| 6301 | 3 | Water in fuel sensor 2 - Short circuit to battery |
| 6301 | 4 | Water in fuel sensor 2 - Short circuit to ground |
| 6301 | 31 | Water in fuel sensor 2 - Supply voltage out of range |
| 6301 | 0 | Water in fuel sensor 2 - Water in fuel detected |

Tab. 45: Error code table

8.3 Cleaning agents, thread-locking adhesives and greases

This list includes all thread-locking adhesives and greases required for repair and maintenance tasks on the engine.

The application is described in the respective job specifications.



Information

Should a thread-locking adhesive be required, first clean, degrease, and dry the respective screw thread and threaded bore.

8.3.1 Cleaning agents and thread-locking adhesives

| Designation | | Designation | Amount (g / fl-oz) | Supplier |
|---------------------|----|---------------|--------------------|----------|
| Omniclean | or | Loctite 7063 | 500 / 16.9 | Loctite |
| Loctite 243 | | | 250 / 8.4 | Loctite |
| Loctite 270 | or | Omnifit 200 M | 250 / 8.4 | Loctite |
| Loctite 577 | | | 250 / 8.4 | Loctite |
| Loctite 648 | or | Omnifit 230 M | 250 / 8.4 | Loctite |
| Loctite 5900 | | | 50 / 1.7 | Loctite |
| Loctite 5910 | | | 300 / 10.1 | Loctite |

Tab. 46: Cleaning agents and thread-locking adhesives

| Designation | | Designation | Amount (g / fl-oz) | Supplier |
|----------------------|----|---|--------------------|----------|
| Omnivisc 1050 | or | Loctite 601, Reinzo-plast, Hylomar SQ32 / M | 90 / 3.0 | Loctite |
| Loctite 480 | | | 500 / 16.9 | Loctite |

Tab. 47: Cleaning agents and thread-locking adhesives



8.3.2 Greases

| Designation | Amount (g / fl-oz) | Supplier |
|---------------------------------|--------------------|----------|
| Molykote Longterm 2 Plus | 1000 / 33.8 | Molykote |
| Staburags NBU 30 | 1200 / 40.6 | Kübler |
| Copper Paste; Motorex 14 | 850 / 28.7 | Motorex |
| Optimol White T | 100 / 3.4 | Castrol |

Tab. 48: Greases

8.4 Standard tightening torques

8.4.1 Lubricant and threadlocker application rules

| | Application method | Product |
|--------------|---|---|
| Lubricant |  <p>Apply lubricant under the screw head and on the first third of the thread.</p> | MG = Molykote G-n-plus MW = Castrol Optimol paste white T MH = Molykote HSC O = Engine oil |
| Threadlocker |  <p>Apply threadlocker on the first third of the thread.</p> | XX = Loctite 243 YY = Loctite 577 |

Tab. 49: Lubricant and threadlocker application rules

8.4.2 Screws pre-tightening, reuse, and marking

NOTICE

Property damage by improper pre-tightening, turning angle or reuse of screws or nuts. Improper pre-tightening, turning angle or reuse of screws or nuts could lead to the rupture of the screw or nut and lead to property damage by malfunction, ejection, fall or tilting of components.

- ▶ Respect the following pre-tightening, turning angle, reuse and marking specifications.
- ▶ In case of failure or damage, replace any threaded fastener immediately by the authorized personnel.



Information

The values of the pre-tightening torque and the turning angle are specified in the maintenance tasks.

Unless otherwise noted, use the standard torque values into the column of screws quality class "8.8" to tighten screws and bolts.

The screws quality classes "10.9" and "12.9" are always indicated with the "Nm" symbol.

Pre-tightening torque and turning angle

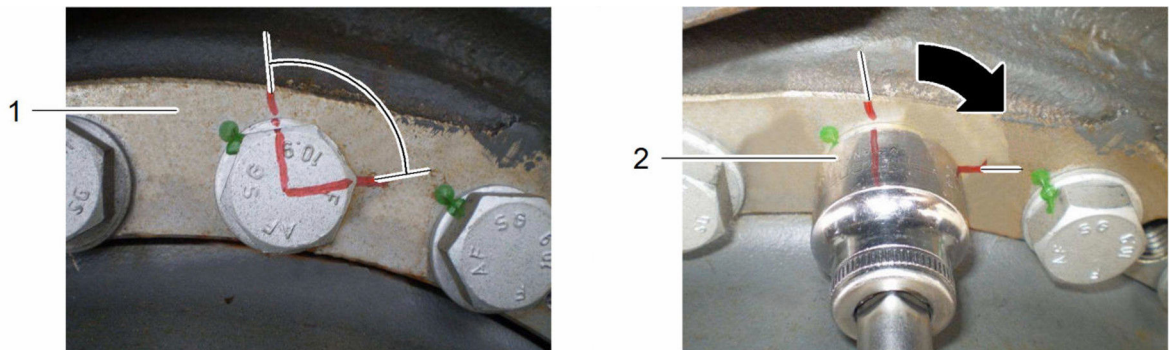


Fig. 104: Pre-tightening marking and angles

- ▶ Tighten mounting bolt with the specified pre-tightening torque.
- ▶ Mark the specified turning angle on the screw head and on the component 1.



Information

One edge of hexagonal screw corresponds to 60°.

- ▶ On the socket key of the torque wrench 2, mark the initial position, aligned with the marking on the component.
- ▶ Use the torque wrench to tighten until the marking of the initial position is aligned with the marking on the component.
- ▶ Repeat process for the other screws, according to standard or described sequence.



Information

For every maintenance task, when a sequence is specified, achieve step 1 for all the sequence before starting step 2.

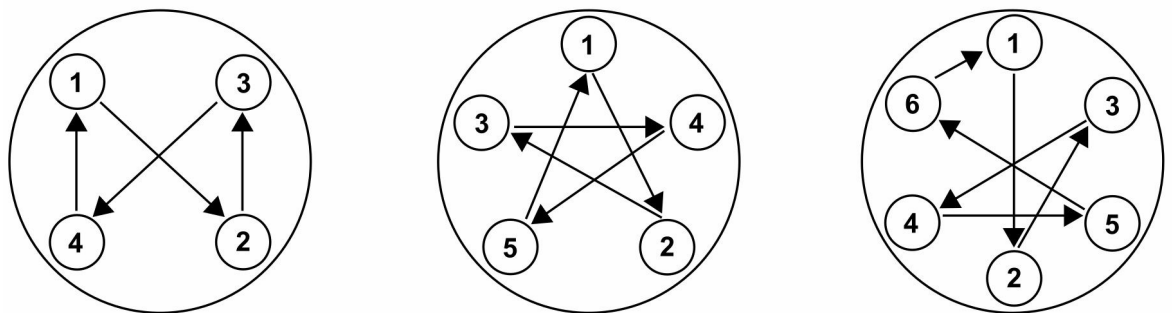


Fig. 105: Standard sequence for four, five, and six screws.

Screws reuse



Information

Except components listed below, and otherwise noted,

- ▶ Reuse screws as many times as no visible damage appears (thread, coating).
- ▶ Replace screws with the same quality class as soon as damage appears (thread, coating).

For screws on:

- **Main bearing**
- **Connecting rod**
- **Cylinder head**
- **Damper**
- **Flywheel**
- **Camshaft**
- **Trunnion mount**
- **Exhaust screws with copper coating**

- ▶ Replace screws after each dismounting.

Counterweight:

- ▶ Untightening screws is forbidden.

Screw plugs:

- ▶ Replace screw plugs after each dismounting.

On fuel and HP injections pipes:

- ▶ Replace connections after first dismounting.
- ▶ Change connections after 3 tightenings.

For cutting rings:

- ▶ Replace connections after first dismounting.
- ▶ Change connections after 3 tightenings.

Screws marking



Information

Except components listed below, and otherwise noted,

- ▶ Marking on screws or nuts to track their reuse is not required.



Fig. 106: Examples of markings on screws and HP pipe nut

Some nuts and screws are marked to track their reuse:

- **Fuel and HP injection pipes**
- **Cutting rings**

If 2 punches appear:

- ▶ Replace pipe or system after each untightening.

If none or 1 punch appears:

- ▶ Add one punch after each untightening.

8.4.3 Standard torques for hexagonal / socket / flange screws and hexagonal / flange nuts



Information

Tolerances of the indicated tightening torques: 10%.

Values apply only to screws with coating and without lubricant.

For hexagonal screws in accordance with:

- ISO 4014
- ISO 4017

For socket screws in accordance with:

- ISO 4762

For flange screws in accordance with:











- EN 1665

For hexagonal nuts in accordance with:

- ISO 4032 / ISO 4034 / ISO 4035

For flange nuts in accordance with:

- EN 1664

| Thread diameter | Quality class 8.8 | | | | | Quality class 10.9 | | | | |
|-----------------|---|---|---|---|---|--|---|---|---|---|
| | Hexagonal screw | Socket screw | Hexagonal nut | Flange screw | Flange nut | Hexagonal screw | Socket screw | Hexagonal nut | Flange screw | Flange nut |
| |  |  |  |  |  |  |  |  |  |  |
| M6 | 9 Nm 7 ft-lb | | | | | 14 Nm 10 ft-lb | | | | |
| M8 | 22 Nm 16 ft-lb | | | | | 33 Nm 24 ft-lb | | | | |
| M10 | 43 Nm 32 ft-lb | | | | | 63 Nm 46 ft-lb | | | | |
| M12 | 70 Nm 52 ft-lb | | 75 Nm 55 ft-lb | | | 100 Nm 74 ft-lb | | 110 Nm 81 ft-lb | | |
| M16 | 165 Nm 122 ft-lb | | 183 Nm 135 ft-lb | | | 240 Nm 177 ft-lb | | 270 Nm 199 ft-lb | | |

| Thread diameter | Quality class 8.8 | | Quality class 10.9 | |
|-----------------|----------------------|---------------------|------------------------|---------------------|
| | M20 | 320 Nm 236 ft-lb | 358 Nm 264 ft-lb | 470 Nm 347 ft-lb |
| M24 | 550 Nm 406 ft-lb | - | 800 Nm 590 ft-lb | - |
| M30 | 1100 Nm 811 ft-lb | - | 1600 Nm 1,180 ft-lb | - |

Tab. 50: Standard torques for hexagonal / socket / flange screws and hexagonal / flange nuts, with coating without lubricant

8.4.4 Standard torques for internal drive pipe plug with conical thread

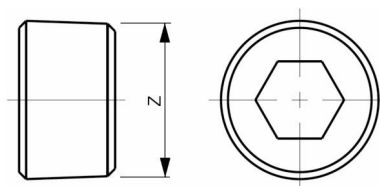


Fig. 117: Internal drive pipe plug with conical thread DIN 906



Information

Tolerances of the indicated tightening torques: 10%.

Always lubricate the thread before tightening these parts (engine oil).

| Thread | Tightening torque | Thread | Tightening torque | Thread | Tightening torque |
|-------------------|-------------------------------|-------------------|-------------------|-------------------|---------------------|
| M 6 x 1 | 5 Nm 4 ft-lb ¹⁾ | M 14 x 1.5 | 57 Nm 42 ft-lb | M 20 x 1.5 | 98 Nm 72 ft-lb |
| M 8 x 1 | 12 Nm 9 ft-lb | M 16 x 1.5 | 68 Nm 50 ft-lb | M 36 x 1.5 | 280 Nm 207 ft-lb |
| M 10 x 1 | 18 Nm 13 ft-lb | M 18 x 1.5 | 87 Nm 64 ft-lb | M 48 x 1.5 | 280 Nm 207 ft-lb |
| M 12 x 1.5 | 30 Nm 22 ft-lb | - | - | - | - |

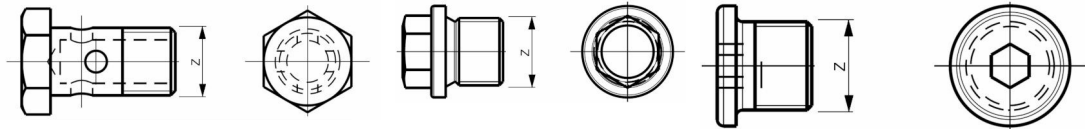
Tab. 51: Standard torques for internal drive pipe plug with conical thread

¹⁾ Special tolerance: +0.5 mm (0.02 in)

8.4.5 Standard torques for screws according to DIN 7643, DIN 910, DIN 908

With copper sealing ring according to DIN 7603, for:

- Hollow screw for ring-type banjos according to DIN 7643
- Hexagon head screw plugs with collar - Cylindrical thread according to DIN 910
- Internal drive screw plugs with collar - Cylindrical thread according to DIN 908



Tab. 52: Hollow screw DIN 7643, Hexagon head screw DIN 910, Internal drive screw DIN 908



Information

Tolerances of the indicated tightening torques: 10%.

Always lubricate the thread before tightening these parts (engine oil).

| Thread | Tightening torque | Thread | Tightening torque | Thread | Tightening torque |
|--------------------|-------------------|-------------------|---------------------|-------------------|---------------------|
| M 6 x 1 | 7 Nm 5 ft-lb | M 24 x 1.5 | 68 Nm 50 ft-lb | M 42 x 2 | 240 Nm 177 ft-lb |
| M 8 x 1 | 7.5 Nm 6 ft-lb | M 26 x 1.5 | 75 Nm 55 ft-lb | M 45 x 1.5 | 270 Nm 199 ft-lb |
| M 8 x 1.5 | 7.5 Nm 6 ft-lb | M 27 x 2 | 87 Nm 64 ft-lb | M 45 x 2 | 270 Nm 199 ft-lb |
| M 10 x 1 | 15 Nm 11 ft-lb | M 30 x 1.5 | 115 Nm 85 ft-lb | M 48 x 1.5 | 300 Nm 221 ft-lb |
| M 10 x 1.25 | 15 Nm 11 ft-lb | M 30 x 2 | 115 Nm 85 ft-lb | M 48 x 2 | 300 Nm 221 ft-lb |
| M 12 x 1.5 | 20 Nm 15 ft-lb | M 33 x 2 | 120 Nm 89 ft-lb | M 52 x 1.5 | 380 Nm 280 ft-lb |
| M 14 x 1.5 | 30 Nm 22 ft-lb | M 36 x 1.5 | 155 Nm 114 ft-lb | M 52 x 2 | 380 Nm 280 ft-lb |
| M 16 x 1.5 | 40 Nm 30 ft-lb | M 36 x 2 | 155 Nm 114 ft-lb | M 56 x 2 | 430 Nm 317 ft-lb |
| M 18 x 1.5 | 40 Nm 30 ft-lb | M 38 x 1.5 | 171 Nm 126 ft-lb | M 60 x 2 | 510 Nm 376 ft-lb |
| M 20 x 1.5 | 47 Nm 35 ft-lb | M 39 x 2 | 215 Nm 159 ft-lb | M 64 x 2 | 570 Nm 420 ft-lb |
| M 22 x 1.5 | 70 Nm 52 ft-lb | M 42 x 1.5 | 240 Nm 177 ft-lb | M 65 x 2 | 620 Nm 457 ft-lb |

Tab. 53: Tightening torques for screws according to DIN 7643, DIN 910, DIN 908

8.4.6 Standard torques for flange joints

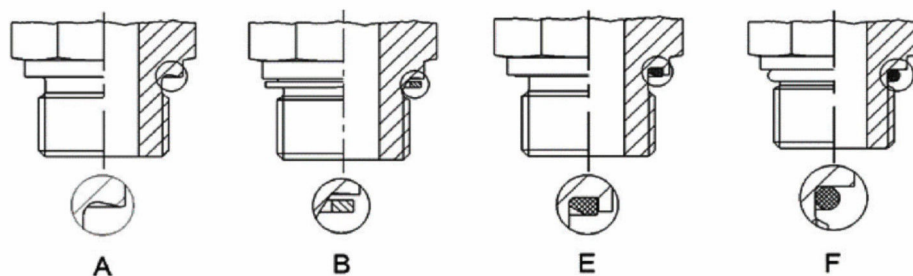


Fig. 121: Flange joints overview

Standard torques for metric thread unions L series (up to 500 bar/ 7252 Psi) for steel and iron cast part

According to ISO 9974-2/3 / ISO 6149-2/3 / DIN 3852-1/2, metric threading.



Information

Tolerances of the indicated tightening torques: 10%.

Always lubricate the thread before tightening these parts (engine oil).

| Thread Y | Form A with sealing edge | Form B with sealing ring | Form E with flat sealing | Form F with O-ring |
|-------------------|--------------------------|--------------------------|--------------------------|---------------------|
| M 10 x 1.0 | 9 Nm 7 ft-lb | 18 Nm 13 ft-lb | 18 Nm 13 ft-lb | 15 Nm 11 ft-lb |
| M 12 x 1.5 | 20 Nm 15 ft-lb | 30 Nm 22 ft-lb | 25 Nm 18 ft-lb | 25 Nm 18 ft-lb |
| M 14 x 1.5 | 35 Nm 26 ft-lb | 45 Nm 33 ft-lb | 45 Nm 33 ft-lb | 35 Nm 26 ft-lb |
| M 16 x 1.5 | 45 Nm 33 ft-lb | 65 Nm 48 ft-lb | 55 Nm 41 ft-lb | 40 Nm 30 ft-lb |
| M 18 x 1.5 | 55 Nm 41 ft-lb | 80 Nm 59 ft-lb | 70 Nm 52 ft-lb | 45 Nm 33 ft-lb |
| M 22 x 1.5 | 65 Nm 48 ft-lb | 140 Nm 103 ft-lb | 125 Nm 92 ft-lb | 60 Nm 44 ft-lb |
| M 26 x 1.5 | 90 Nm 66 ft-lb | 190 Nm 140 ft-lb | 180 Nm 133 ft-lb | 100 Nm 74 ft-lb |
| M 33 x 2.0 | 150 Nm 111 ft-lb | 340 Nm 251 ft-lb | 310 Nm 229 ft-lb | 160 Nm 118 ft-lb |
| M 42 x 2.0 | 240 Nm 177 ft-lb | 500 Nm 369 ft-lb | 450 Nm 332 ft-lb | 210 Nm 155 ft-lb |
| M 48 x 2.0 | 290 Nm 214 ft-lb | 630 Nm 465 ft-lb | 540 Nm 398 ft-lb | 260 Nm 192 ft-lb |

Tab. 54: Standard torques for metric thread unions L series, for steel and iron cast part

Standard torques for metric thread unions S series (up to 800 bar/11603 Psi) for steel and iron cast part

According to ISO 9974-2/3 / ISO 6149-2/3 / DIN 3852-1/2, metric threading.



Information

Tolerances of the indicated tightening torques: 10%.

Always lubricate the thread before tightening these parts (engine oil).

| Thread Y | Form A with sealing edge | Form B with sealing ring | Form E with flat sealing | Form F with O-ring |
|-------------------|--------------------------|--------------------------|--------------------------|---------------------|
| M 10 x 1.0 | / | / | 23 Nm 17 ft-lb | / |
| M 12 x 1.5 | 20 Nm 15 ft-lb | 35 Nm 26 ft-lb | 35 Nm 26 ft-lb | 35 Nm 26 ft-lb |
| M 14 x 1.5 | 35 Nm 26 ft-lb | 55 Nm 41 ft-lb | 55 Nm 41 ft-lb | 45 Nm 33 ft-lb |
| M 16 x 1.5 | 45 Nm 33 ft-lb | 70 Nm 52 ft-lb | 70 Nm 52 ft-lb | 55 Nm 41 ft-lb |
| M 18 x 1.5 | 55 Nm 41 ft-lb | 110 Nm 81 ft-lb | 90 Nm 66 ft-lb | 70 Nm 52 ft-lb |
| M 20 x 1.5 | 55 Nm 41 ft-lb | 150 Nm 111 ft-lb | 125 Nm 92 ft-lb | 80 Nm 59 ft-lb |
| M 22 x 1.5 | 65 Nm 48 ft-lb | 170 Nm 125 ft-lb | 135 Nm 100 ft-lb | 100 Nm 74 ft-lb |
| M 27 x 2.0 | 90 Nm 66 ft-lb | 270 Nm 199 ft-lb | 180 Nm 133 ft-lb | 170 Nm 125 ft-lb |
| M 33 x 2.0 | 150 Nm 111 ft-lb | 410 Nm 302 ft-lb | 310 Nm 229 ft-lb | 310 Nm 229 ft-lb |
| M 42 x 2.0 | 240 Nm 177 ft-lb | 540 Nm 398 ft-lb | 450 Nm 332 ft-lb | 330 Nm 243 ft-lb |
| M 48 x 2.0 | 290 Nm 214 ft-lb | 700 Nm 516 ft-lb | 540 Nm 398 ft-lb | 420 Nm 310 ft-lb |

Tab. 55: Standard torques for metric thread union S series, for steel and iron cast part

Standard torques for imperial thread unions L series (up to 500 bar/7252 Psi) for steel and iron cast part

According to ISO1179-1 / DIN 3852-T2-Form X / DIN 3852-T3-Form X BSP threading.



Information

Tolerances of the indicated tightening torques: 10%.

Always lubricate the thread before tightening these parts (engine oil).

| Thread Y | Form A with sealing edge | Form B with sealing ring | Form E with flat sealing |
|-----------------|--------------------------|--------------------------|--------------------------|
| G 1/8A | 9 Nm 7 ft-lb | 18 Nm 13 ft-lb | 18 Nm 13 ft-lb |
| G 1/4A | 35 Nm 26 ft-lb | 35 Nm 26 ft-lb | 35 Nm 26 ft-lb |
| G 1/4A | 35 Nm 26 ft-lb | 35 Nm 26 ft-lb | 35 Nm 26 ft-lb |
| G 3/8A | 45 Nm 33 ft-lb | 70 Nm 52 ft-lb | 70 Nm 52 ft-lb |
| G 1/2A | 65 Nm 48 ft-lb | 140 Nm 103 ft-lb | 90 Nm 66 ft-lb |
| G 1/2A | 65 Nm 48 ft-lb | 100 Nm 74 ft-lb | 90 Nm 66 ft-lb |
| G 3/4A | 90 Nm 66 ft-lb | 180 Nm 133 ft-lb | 180 Nm 133 ft-lb |
| G 1A | 150 Nm 111 ft-lb | 330 Nm 243 ft-lb | 310 Nm 229 ft-lb |
| G 1 1/4A | 240 Nm 177 ft-lb | 540 Nm 398 ft-lb | 450 Nm 332 ft-lb |
| G 1 1/2A | 290 Nm 214 ft-lb | 630 Nm 465 ft-lb | 540 Nm 398 ft-lb |

Tab. 56: Standard torques for imperial thread unions L series, for steel and iron cast part

Standard torques for imperial thread unions S series (up to 800 bar/11603 Psi) for steel and iron cast part

According to ISO1179-1 / DIN 3852-T2-Form X / DIN 3852-T3-Form X BSP threading.



Information

Tolerances of the indicated tightening torques: 10%.

Always lubricate the thread before tightening these parts (engine oil).

| Thread Y | Form A with sealing edge | Form B with sealing ring | Form E with flat sealing |
|---------------|--------------------------|--------------------------|--------------------------|
| G 1/4A | 35 Nm 26 ft-lb | 55 Nm 41 ft-lb | 40 Nm 30 ft-lb |
| G 1/4A | 35 Nm 26 ft-lb | 55 Nm 41 ft-lb | 40 Nm 30 ft-lb |
| G 3/8A | 45 Nm 33 ft-lb | 90 Nm 66 ft-lb | 80 Nm 59 ft-lb |
| G 3/8A | 45 Nm 33 ft-lb | 90 Nm 66 ft-lb | 80 Nm 59 ft-lb |
| G 1/2A | 65 Nm 48 ft-lb | 150 Nm 111 ft-lb | 115 Nm 85 ft-lb |
| G 1/2A | 65 Nm 48 ft-lb | 130 Nm 96 ft-lb | 115 Nm 85 ft-lb |

| Thread Y | Form A with sealing edge | Form B with sealing ring | Form E with flat sealing |
|-----------------|--------------------------|--------------------------|--------------------------|
| G 3/4A | 90 Nm 66 ft-lb | 270 Nm 199 ft-lb | 180 Nm 133 ft-lb |
| G 1A | 150 Nm 111 ft-lb | 340 Nm 251 ft-lb | 310 Nm 229 ft-lb |
| G 1 1/4A | 240 Nm 177 ft-lb | 540 Nm 398 ft-lb | 450 Nm 332 ft-lb |
| G 1 1/2A | 290 Nm 214 ft-lb | 700 Nm 516 ft-lb | 540 Nm 398 ft-lb |

Tab. 57: Standard torques for imperial thread union S series, for steel and iron cast part

Standard torques for metric thread unions L series (up to 500 bar/ 7252 Psi) for aluminum

According to ISO 9974-2/3 / ISO 6149-2/3 / DIN 3852-1/2, metric threading.



Information

Tolerances of the indicated tightening torques: 10%.

Always lubricate the thread before tightening these parts (engine oil).

| Thread Y | Form A with sealing edge | Form B with sealing ring | Form E with flat sealing | Form F with O-ring |
|-------------------|--------------------------|--------------------------|--------------------------|---------------------|
| M 10 x 1.0 | 7 Nm 5 ft-lb | 14 Nm 10 ft-lb | 14 Nm 10 ft-lb | 12 Nm 9 ft-lb |
| M 12 x 1.5 | 16 Nm 12 ft-lb | 24 Nm 18 ft-lb | 20 Nm 15 ft-lb | 20 Nm 15 ft-lb |
| M 14 x 1.5 | 28 Nm 21 ft-lb | 36 Nm 27 ft-lb | 36 Nm 27 ft-lb | 28 Nm 21 ft-lb |
| M 16 x 1.5 | 36 Nm 27 ft-lb | 52 Nm 38 ft-lb | 44 Nm 32 ft-lb | 32 Nm 24 ft-lb |
| M 18 x 1.5 | 44 Nm 32 ft-lb | 64 Nm 47 ft-lb | 56 Nm 41 ft-lb | 36 Nm 27 ft-lb |
| M 22 x 1.5 | 52 Nm 38 ft-lb | 112 Nm 83 ft-lb | 100 Nm 74 ft-lb | 48 Nm 35 ft-lb |
| M 26 x 1.5 | 72 Nm 53 ft-lb | 152 Nm 112 ft-lb | 144 Nm 106 ft-lb | 80 Nm 59 ft-lb |
| M 33 x 2.0 | 120 Nm 89 ft-lb | 272 Nm 201 ft-lb | 248 Nm 183 ft-lb | 128 Nm 94 ft-lb |
| M 42 x 2.0 | 192 Nm 142 ft-lb | 400 Nm 295 ft-lb | 360 Nm 266 ft-lb | 168 Nm 124 ft-lb |
| M 48 x 2.0 | 232 Nm 171 ft-lb | 504 Nm 372 ft-lb | 432 Nm 319 ft-lb | 208 Nm 153 ft-lb |

Tab. 58: Standard torques for metric thread unions L series, for aluminium – see figure above

Standard torques for metric thread unions S series (up to 800 bar/11603 Psi) for aluminum

According to ISO 9974-2/3 / ISO 6149-2/3 / DIN 3852-1/2, metric threading.



Information

Tolerances of the indicated tightening torques: 10%.

Always lubricate the thread before tightening these parts (engine oil).

| Thread Y | Form A with sealing edge | Form B with sealing ring | Form E with flat sealing | Form F with O-ring |
|-------------------|--------------------------|--------------------------|--------------------------|---------------------|
| M 10 x 1.0 | - | - | 19 Nm 14 ft-lb | - |
| M 12 x 1.5 | 16 Nm 12 ft-lb | 28 Nm 21 ft-lb | 32 Nm 24 ft-lb | 28 Nm 21 ft-lb |
| M 14 x 1.5 | 28 Nm 21 ft-lb | 44 Nm 32 ft-lb | 32 Nm 24 ft-lb | 36 Nm 27 ft-lb |
| M 16 x 1.5 | 36 Nm 27 ft-lb | 56 Nm 41 ft-lb | 56 Nm 41 ft-lb | 44 Nm 32 ft-lb |
| M 18 x 1.5 | 44 Nm 32 ft-lb | 88 Nm 65 ft-lb | 72 Nm 53 ft-lb | 56 Nm 41 ft-lb |
| M 20 x 1.5 | 44 Nm 32 ft-lb | 120 Nm 89 ft-lb | 100 Nm 74 ft-lb | 64 Nm 47 ft-lb |
| M 22 x 1.5 | 52 Nm 38 ft-lb | 136 Nm 100 ft-lb | 108 Nm 80 ft-lb | 100 Nm 74 ft-lb |
| M 27 x 2.0 | 72 Nm 53 ft-lb | 216 Nm 159 ft-lb | 144 Nm 106 ft-lb | 136 Nm 100 ft-lb |
| M 33 x 2.0 | 120 Nm 89 ft-lb | 328 Nm 242 ft-lb | 248 Nm 183 ft-lb | 248 Nm 183 ft-lb |
| M 42 x 2.0 | 192 Nm 142 ft-lb | 432 Nm 319 ft-lb | 360 Nm 266 ft-lb | 264 Nm 195 ft-lb |
| M 48 x 2.0 | 232 Nm 171 ft-lb | 560 Nm 413 ft-lb | 432 Nm 319 ft-lb | 336 Nm 248 ft-lb |

Tab. 59: Standard torques for metric thread unions S series, for aluminium – see figure above

Standard torques for imperial thread unions L series (up to 500 bar/7252 Psi) for aluminium

According to ISO1179-1 / DIN 3852-T2-Form X / DIN 3852-T3-Form X BSP threading.



Information

Tolerances of the indicated tightening torques: 10%.

Always lubricate the thread before tightening these parts (engine oil).

| Thread Y | Form A with sealing edge | Form B with sealing ring | Form E with flat sealing |
|-----------------|--------------------------|--------------------------|--------------------------|
| G 1/8A | 7 Nm 5 ft-lb | 14 Nm 10 ft-lb | 14 Nm 10 ft-lb |
| G 1/4A | 28 Nm 21 ft-lb | 28 Nm 21 ft-lb | 28 Nm 21 ft-lb |
| G 1/4A | 28 Nm 21 ft-lb | 28 Nm 21 ft-lb | 28 Nm 21 ft-lb |
| G 3/8A | 36 Nm 27 ft-lb | 56 Nm 41 ft-lb | 56 Nm 41 ft-lb |
| G 1/2A | 52 Nm 38 ft-lb | 112 Nm 83 ft-lb | 72 Nm 53 ft-lb |
| G 1/2A | 52 Nm 38 ft-lb | 80 Nm 59 ft-lb | 72 Nm 53 ft-lb |
| G 3/4A | 72 Nm 53 ft-lb | 144 Nm 106 ft-lb | 144 Nm 106 ft-lb |
| G 1A | 120 Nm 89 ft-lb | 264 Nm 195 ft-lb | 248 Nm 183 ft-lb |
| G 1 1/4A | 192 Nm 142 ft-lb | 432 Nm 319 ft-lb | 360 Nm 266 ft-lb |
| G 1 1/2A | 232 Nm 171 ft-lb | 504 Nm 372 ft-lb | 432 Nm 319 ft-lb |

Tab. 60: Standard torques for imperial thread unions L series, for aluminium – see figure above

Standard torques for imperial thread unions S series (up to 800 bar/11603 Psi) for aluminium

According to ISO1179-1 / DIN 3852-T2-Form X / DIN 3852-T3-Form X BSP threading.



Information

Tolerances of the indicated tightening torques: 10%.

Always lubricate the thread before tightening these parts (engine oil).

| Thread Y | Form A with sealing edge | Form B with sealing ring | Form E with flat sealing |
|---------------|--------------------------|--------------------------|--------------------------|
| G 1/8A | 29 Nm 21 ft-lb | 45 Nm 33 ft-lb | 45 Nm 33 ft-lb |
| G 1/4A | 28 Nm 21 ft-lb | 44 Nm 32 ft-lb | 32 Nm 24 ft-lb |
| G 1/4A | 28 Nm 21 ft-lb | 44 Nm 32 ft-lb | 32 Nm 24 ft-lb |
| G 3/8A | 36 Nm 27 ft-lb | 72 Nm 53 ft-lb | 64 Nm 47 ft-lb |
| G 1/2A | 52 Nm 38 ft-lb | 120 Nm 89 ft-lb | 92 Nm 68 ft-lb |
| G 1/2A | 52 Nm 38 ft-lb | 104 Nm 77 ft-lb | 92 Nm 68 ft-lb |

| Thread Y | Form A with sealing edge | Form B with sealing ring | Form E with flat sealing |
|-----------------|--------------------------|--------------------------|--------------------------|
| G 3/4A | 72 Nm 53 ft-lb | 216 Nm 159 ft-lb | 144 Nm 106 ft-lb |
| G 1A | 120 Nm 89 ft-lb | 272 Nm 201 ft-lb | 248 Nm 183 ft-lb |
| G 1 1/4A | 192 Nm 142 ft-lb | 432 Nm 319 ft-lb | 360 Nm 266 ft-lb |
| G 1 1/2A | 232 Nm 171 ft-lb | 560 Nm 413 ft-lb | 432 Nm 319 ft-lb |

Tab. 61: Standard torques for imperial thread union S series, for aluminium – see figure above

8.4.7 Assembling pipes with cutting rings

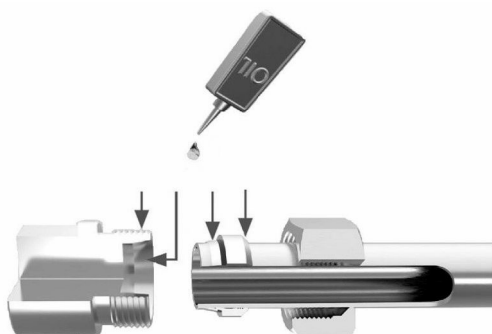


Fig. 122: Cutting ring lubrication



Information

Tolerances of the indicated tightening torques: 10%.

Always lubricate the thread before tightening these parts (engine oil).

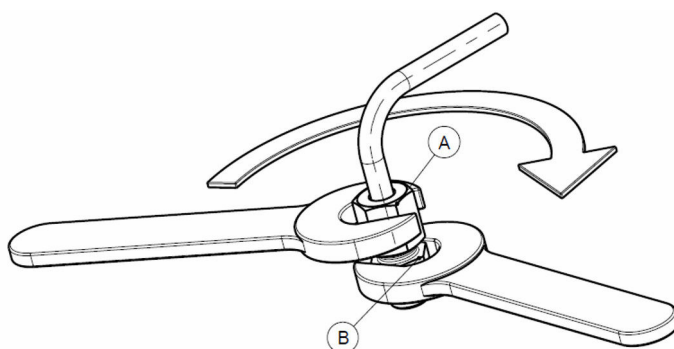


Fig. 123: Cutting ring tightening



Information

To assemble pipes with cutting rings, observe the following steps:

- ▶ Assemble pipe tension free. Mount support clamp after pipe assembling.
- ▶ When tightening nut **A**, make sure connector **B** does not rotate.
- ▶ Tighten nut **A** by hand until the resisting point.
- ▶ Tighten nut **A** a further 90°.
- ▶ Tighten all pipe support clamps if necessary.

Alternatively, refer to the following table for tightening sequence of nut **A**:

| Size | Equivalent specification | Size | Equivalent specification |
|------|--------------------------|------|--------------------------|
| 06L | 14 Nm (10 ft-lb) + 90° | 06S | 20 Nm (15 ft-lb) + 90° |
| 08L | 20 Nm (15 ft-lb) + 90° | 08S | 24 Nm (18 ft-lb) + 90° |
| 10L | 26 Nm (19 ft-lb) + 90° | 10S | 34 Nm (25 ft-lb) + 90° |
| 12L | 30 Nm (22 ft-lb) + 90° | 12S | 36 Nm (27 ft-lb) + 90° |
| 15L | 50 Nm (37 ft-lb) + 90° | 14S | 58 Nm (43 ft-lb) + 90° |
| 18L | 82 Nm (60 ft-lb) + 90° | 16S | 70 Nm (52 ft-lb) + 90° |
| 22L | 120 Nm (89 ft-lb) + 90° | 20S | 130 Nm (96 ft-lb) + 90° |
| 28L | 95 Nm (70 ft-lb) + 90° | 25S | 120 Nm (89 ft-lb) + 90° |
| 35L | 190 Nm (140 ft-lb) + 90° | 30S | 165 Nm (122 ft-lb) + 90° |
| 42L | 310 Nm (229 ft-lb) + 90° | 38S | 325 Nm (240 ft-lb) + 90° |

Tab. 62: Alternative tightening torques for cutting ring flange joints

8.4.8 Standard torques for triple lock flange joints

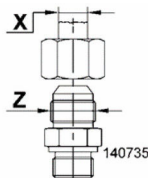


Fig. 124: Triple lock flange joints

| Serie | Pipe diam. X | | Thread Z UN/UNF | Tightening torque | |
|-------|--------------|------|--------------------|-------------------|--------------------|
| | mm | inch | | Steel | Stainless steel |
| 4 | 6 | 1/4 | 7/17-20 | 15 Nm 11 ft-lb | 30 Nm 22 ft-lb |
| 5 | 8 | 5/16 | 1/2-20 | 20 Nm 15 ft-lb | 40 Nm 30 ft-lb |
| 6 | 10 | 3/8 | 9/16-18 | 30 Nm 22 ft-lb | 60 Nm 44 ft-lb |
| 8 | 12 | 1/2 | 3/4-16 | 60 Nm 44 ft-lb | 115 Nm 85 ft-lb |

| Serie | Pipe diam. X | | Thread Z UN/UNF | Tightening torque | |
|-------|--------------|-------|--------------------|---------------------|---------------------|
| | mm | inch | | Steel | Stainless steel |
| 10 | 14, 15, 16 | 5/8 | 7/8-14 | 75 Nm 55 ft-lb | 145 Nm 107 ft-lb |
| 12 | 18, 20 | 3/4 | 1 1/16-12 | 110 Nm 81 ft-lb | 180 Nm 133 ft-lb |
| 16 | 22 | 7/8 | 1 5/16-12 | 135 Nm 100 ft-lb | 225 Nm 166 ft-lb |
| 16 | 25 | 1 | 1 5/16-12 | 175 Nm 129 ft-lb | 255 Nm 188 ft-lb |
| | 28 | | 1 5/8-12 | 260 Nm 192 ft-lb | 295 Nm 218 ft-lb |
| 20 | 30, 32 | 1 1/4 | 1 5/8-12 | 260 Nm 192 ft-lb | 295 Nm 218 ft-lb |
| | 35 | | 1 7/8-12 | 340 Nm 251 ft-lb | 345 Nm 254 ft-lb |
| 24 | 38 | 1 1/2 | 1 7/8-12 | 340 Nm 251 ft-lb | 345 Nm 254 ft-lb |
| 28 | 42 | | 2 1/4-12 | 380 Nm 280 ft-lb | 400 Nm 295 ft-lb |
| 32 | | 2 | 2 1/2-12 | 450 Nm 332 ft-lb | 470 Nm 347 ft-lb |

Tab. 63: Standard torques for triple lock flange joints

**Information**

To tighten the screwed socket:

- ▶ Hold screwed socket instead.
- ▶ Unscrew union nut until noticeable resistance (without wrench extension).
- ▶ Tighten union nut according to torque above.

8.4.9 Standard torques for VSTI screw plugs for steel and iron cast part

According to DIN EN ISO 6149-2 / ISO 11926-2, metric threading.

**Information**

Tolerances of the indicated tightening torques: 10%.

Always lubricate the thread before tightening these parts (engine oil).

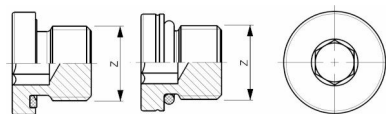


Fig. 125: VSTI screw plugs with ED seal (left), with o-ring (right)

| Size | Tightening torque | | Size | Tightening torque | |
|---------|-----------------------|---------------------|-------------|-----------------------|--------------------|
| | ¹⁾ VSTI ED | VSTI o-ring | | ¹⁾ VSTI ED | VSTI o-ring |
| M8x1 | 10 Nm 7 ft-lb | 10 Nm 7 ft-lb | G 1/8 | 13 Nm 10 ft-lb | - |
| M10x1 | 12 Nm 9 ft-lb | 20 Nm 15 ft-lb | G 1/4 | 30 Nm 22 ft-lb | - |
| M12x1.5 | 25 Nm 18 ft-lb | 35 Nm 26 ft-lb | G 3/8 | 60 Nm 44 ft-lb | - |
| M14x1.5 | 35 Nm 26 ft-lb | 45 Nm 33 ft-lb | G 1/2 | 80 Nm 59 ft-lb | - |
| M16x1.5 | 50 Nm 37 ft-lb | 55 Nm 41 ft-lb | G 3/4 | 140 Nm 103 ft-lb | - |
| M18x1.5 | 65 Nm 48 ft-lb | 70 Nm 52 ft-lb | G 1 | 200 Nm 148 ft-lb | - |
| M20x1.5 | 75 Nm 55 ft-lb | 80 Nm 59 ft-lb | G 1 1/4 | 400 Nm 295 ft-lb | - |
| M22x1.5 | 90 Nm 66 ft-lb | 100 Nm 74 ft-lb | G 1 1/2 | 450 Nm 332 ft-lb | - |
| M24x1.5 | 90 Nm 66 ft-lb | - | - | - | - |
| M26x1.5 | 125 Nm 92 ft-lb | - | 3/4-16 UNF | 70 Nm 52 ft-lb | - |
| M30x1.5 | 240 Nm 177 ft-lb | - | 7/8-1/4 UNF | 100 Nm 74 ft-lb | - |
| M27x2 | 130 Nm 96 ft-lb | 170 Nm 125 ft-lb | R 3/4" | 140 Nm 103 ft-lb | 120 Nm 89 ft-lb |
| M30x2 | - | 215 Nm 159 ft-lb | - | - | - |
| M33x2 | 225 Nm 166 ft-lb | 310 Nm 229 ft-lb | - | - | - |
| M42x2 | 360 Nm 266 ft-lb | 330 Nm 243 ft-lb | - | - | - |
| M48x2 | 360 Nm 266 ft-lb | 420 Nm 310 ft-lb | - | - | - |
| M60x2 | - | 500 Nm 369 ft-lb | - | - | - |

Tab. 64: VSTI screw plug tightening torques for steel and iron cast parts

¹⁾Do not use hydropneumatic screwdriver.

8.4.10 Standard torques for VSTI screw plugs for aluminium

According to DIN EN ISO 6149-2 / ISO 11926-2, metric threading.

**Information**

Tolerances of the indicated tightening torques: 10%.

Always lubricate the thread before tightening these parts (engine oil).

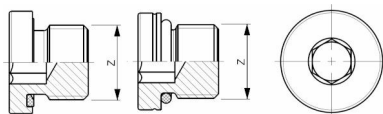


Fig. 126: VSTI screw plugs with ED seal (left), with o-ring (right)

| Size | Tightening torque | | Size | Tightening torque | |
|---------|-----------------------|---------------------|-------------|-----------------------|-------------------|
| | ¹⁾ VSTI ED | VSTI o-ring | | ¹⁾ VSTI ED | VSTI o-ring |
| M8x1 | 8 Nm 6 ft-lb | 8 Nm 6 ft-lb | G 1/8 | 10 Nm 7 ft-lb | - |
| M10x1 | 10 Nm 7 ft-lb | 16 Nm 12 ft-lb | G 1/4 | 25 Nm 18 ft-lb | - |
| M12x1.5 | 20 Nm 15 ft-lb | 28 Nm 21 ft-lb | G 3/8 | 50 Nm 37 ft-lb | - |
| M14x1.5 | 28 Nm 21 ft-lb | 36 Nm 27 ft-lb | G 1/2 | 65 Nm 48 ft-lb | - |
| M16x1.5 | 40 Nm 30 ft-lb | 44 Nm 32 ft-lb | G 3/4 | 112 Nm 83 ft-lb | - |
| M18x1.5 | 52 Nm 38 ft-lb | 56 Nm 41 ft-lb | G 1 | 160 Nm 118 ft-lb | - |
| M20x1.5 | 60 Nm 44 ft-lb | 64 Nm 47 ft-lb | G 1 1/4 | 320 Nm 236 ft-lb | - |
| M22x1.5 | 72 Nm 53 ft-lb | 80 Nm 59 ft-lb | G 1 1/2 | 360 Nm 266 ft-lb | - |
| M24x1.5 | 72 Nm 53 ft-lb | - | - | - | - |
| M26x1.5 | 100 Nm 74 ft-lb | - | 3/4-16 UNF | 56 Nm 41 ft-lb | - |
| M30x1.5 | 192 Nm 142 ft-lb | - | 7/8-1/4 UNF | 80 Nm 59 ft-lb | - |
| M27x2 | 105 Nm 77 ft-lb | 135 Nm 100 ft-lb | R 3/4" | 112 Nm 83 ft-lb | 96 Nm 71 ft-lb |
| M30x2 | - | 172 Nm 127 ft-lb | - | - | - |
| M33x2 | 180 Nm 133 ft-lb | 250 Nm 184 ft-lb | - | - | - |
| M42x2 | 290 Nm 214 ft-lb | 265 Nm 195 ft-lb | - | - | - |
| M48x2 | 290 Nm 214 ft-lb | 335 Nm 247 ft-lb | - | - | - |

| Size | Tightening torque | | Size | Tightening torque | |
|-------|-----------------------|---------------------|------|-----------------------|-------------|
| | ¹⁾ VSTI ED | VSTI o-ring | | ¹⁾ VSTI ED | VSTI o-ring |
| M60x2 | - | 400 Nm 295 ft-lb | - | - | - |

Tab. 65: VSTI screw plug tightening torques for aluminium parts

¹⁾ Do not use hydropneumatic screwdriver.

8.4.11 Assembling pipes with DKO connectors (EL, ET, EW, GZ, GZR, RED)

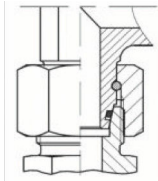


Fig. 127: DKO connector

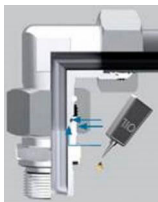


Fig. 128: DKO connector lubrication



Information

Tolerances of the indicated tightening torques: 10%.

Always lubricate the thread before tightening these parts (engine oil).



Information

To assemble pipes with DKO connectors:

- ▶ When tightening the nut, make sure that the connector does not rotate.
- ▶ Tighten the nut by hand.
- ▶ Hold a wrench as close as possible to the nut.
- ▶ Tighten the nut with the wrench until the resisting point.
- ▶ Tighten the nut a further 90°.

Alternatively, refer to the following table for tightening sequence of the nut:

| Size | Equivalent specification | Size | Equivalent specification |
|------|--------------------------|------|--------------------------|
| 06L | 20 Nm 15 ft-lb | 06S | 25 Nm 18 ft-lb |
| 08L | 30 Nm 22 ft-lb | 08S | 40 Nm 30 ft-lb |

| Size | Equivalent specification | Size | Equivalent specification |
|------|--------------------------|------|--------------------------|
| 10L | 40 Nm 30 ft-lb | 10S | 50 Nm 37 ft-lb |
| 12L | 50 Nm 37 ft-lb | 12S | 60 Nm 44 ft-lb |
| 15L | 70 Nm 52 ft-lb | 14S | 75 Nm 55 ft-lb |
| 18L | 90 Nm 66 ft-lb | 16S | 85 Nm 63 ft-lb |
| 22L | 120 Nm 89 ft-lb | 20S | 140 Nm 103 ft-lb |
| 28L | 160 Nm 118 ft-lb | 25S | 190 Nm 140 ft-lb |
| 35L | 250 Nm 184 ft-lb | 30S | 270 Nm 199 ft-lb |
| 42L | 380 Nm 280 ft-lb | 38S | 400 Nm 295 ft-lb |

Tab. 66: Alternative tightening torques for DKO connectors

8.4.12 Standard torques for collar clamps



Fig. 129: Collar clamp

| Band width | Tightening torque |
|------------------|-------------------|
| 18 mm 0.71 in | 4 Nm 3 ft-lb |
| 20 mm 0.79 in | 7 Nm 5 ft-lb |
| 25 mm 0.98 in | 12 Nm 9 ft-lb |
| 30 mm 1.18 in | 30 Nm 22 ft-lb |

Tab. 67: Tightening torques for collar clamps according to DIN 3017-3

8.4.13 Standard torques for pipe clamps according to DIN 3015

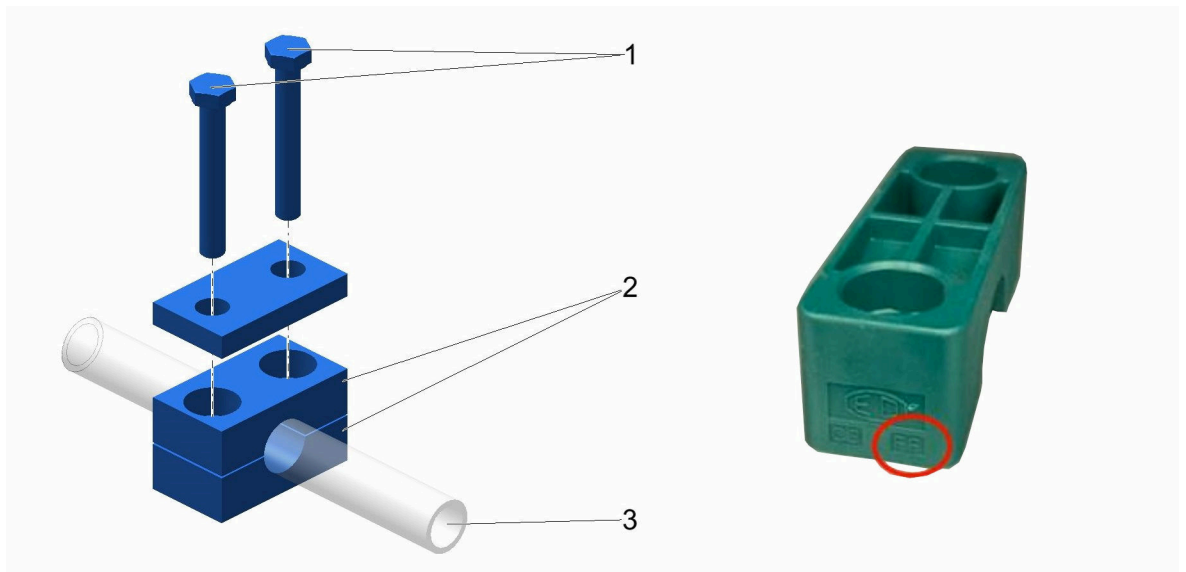


Fig. 130: Pipe clamps

| Series | Dimension | Dimension of screw 1 | External diameter of pipe 3 | Tightening torque according to material marking of clamp 2 | |
|--------------------|-----------|----------------------|-----------------------------------|--|---------------------|
| | | | | PP (polypropylene) | PA (polyamid) |
| Light (DIN 3015-1) | All | M6 | All | 8 Nm 6 ft-lb | 10 Nm 7 ft-lb |
| Heavy (DIN 3015-2) | 1 | M10 | 6 mm (0.24 in)-18 mm (0.71 in) | 12 Nm 9 ft-lb | 20 Nm 15 ft-lb |
| | 2 | | 19 mm (0.75 in)-30 mm (1.18 in) | 12 Nm 9 ft-lb | 20 Nm 15 ft-lb |
| | 3 | | 30 mm (1.18 in)-42 mm (1.65 in) | 15 Nm 11 ft-lb | 25 Nm 18 ft-lb |
| | 4 | M12 | 38 mm (1.5 in)-66 mm (2.6 in) | 30 Nm 22 ft-lb | 40 Nm 30 ft-lb |
| | 5 | M16 | 70 mm (2.76 in)-90 mm (3.54 in) | 45 Nm 33 ft-lb | 55 Nm 41 ft-lb |
| | 6 | M20 | 90 mm (3.54 in)-127 mm (5 in) | 80 Nm 59 ft-lb | 150 Nm 111 ft-lb |
| | 7 | M24 | 127 mm (5 in)-168 mm (6.61 in) | 110 Nm 81 ft-lb | 200 Nm 148 ft-lb |
| | 8 | M30 | 168 mm (6.61 in)-220 mm (8.66 in) | 180 Nm 133 ft-lb | 350 Nm 258 ft-lb |

Tab. 68: Tightening torques for pipe clamps according to DIN 3015

8.5 Abbreviations - Acronyms

To ensure consistency, we kept the abbreviations and acronyms in English in all translated versions of this document. The following tables include their translations in the targeted language of the manual.

| Abbr. | Designation | Translation |
|-------|---|---|
| AC | Alternating Current | Alternating Current |
| BDC | Bottom Dead Center | Bottom Dead Center |
| CAN | Controller Area Network | Controller Area Network |
| CCS | Counter Coupling Side = Damper side | Counter Coupling Side = Damper side |
| CR | Common Rail | Common Rail |
| CS | Coupling Side = Flywheel side | Coupling Side = Flywheel side |
| DC | Direct Current | Direct Current |
| DE | Driving End | Driving End |
| EATS | Exhaust Gas Aftertreatment System | Exhaust Gas Aftertreatment System |
| ECU | Engine Control Unit | Engine Control Unit |
| EMC | Electromagnetic Compatibility | Electromagnetic Compatibility |
| EPDM | Ethylene-Propylene-Diene Monomer | Ethylene-Propylene-Diene Monomer |
| FE | Free End | Free End |
| HFRR | High Frequency Reciprocating Rig – Measured value for the lubricity of diesel fuels | High Frequency Reciprocating Rig – Measured value for the lubricity of diesel fuels |
| HP | High Pressure | High Pressure |
| HT | High Temperature | High Temperature |
| LOTO | Lockout/tagout | Lockout/tagout |
| LP | Low Pressure | Low Pressure |
| LT | Low Temperature | Low Temperature |
| OMM | Operation and Maintenance Manual | Operation and Maintenance Manual |
| PCV | Pressure Control Valve | Pressure Control Valve |
| PPE | Personal Protective Equipment | Personal Protective Equipment |
| PTO | Power Take-Off | Power Take-Off |
| SAPS | Sulphated Ash, Phosphorus, and Sulfur | Sulphated Ash, Phosphorus, and Sulfur |
| SRM | Service and Repair Manual | Service and Repair Manual |
| TDC | Top Dead Center | Top Dead Center |
| VCV | Volume Control Valve | Volume Control Valve |

Tab. 69: Abbreviations table

| Acronym | Designation | Translation |
|---------|---------------------------------------|---------------------------------------|
| ANSI | American National Standards Institute | American National Standards Institute |

| Acronym | Designation | Translation |
|----------------|--|--|
| DIN | German standard | German standard |
| EN | European standard | European Standard |
| EU | European Union | European Union |
| ILO | International Labor Organization | International Labor Organization |
| ISCED | International Standard Classification of Education | International Standard Classification of Education |
| SAE | Society of Automotive Engineers | Society of Automotive Engineers |
| WHO | World Health Organization | World Health Organization |

Tab. 70: Acronyms table

8.6 Unit conversion tables

Use the following tables to convert units used in this guideline. Suitable number of decimals are used for inaccurate conversion factor.

8.6.1 Length conversion factors

| Convert from | To | Multiply by |
|--------------|----|-------------|
| mm | in | 0.0394 |
| mm | ft | 0.00328 |
| µm | th | 0.0394 |

Tab. 71: Length conversion factors

8.6.2 Mass conversion factors

| Convert from | To | Multiply by |
|--------------|----|-------------|
| kg | lb | 2.205 |
| kg | oz | 35.274 |

Tab. 72: Mass conversion factors

8.6.3 Pressure conversion factors

| Convert from | To | Multiply by |
|--------------|----------------------------|-------------|
| kPa | psi (lbf/in ²) | 0.145 |
| kPa | lbf/ft ² | 20.885 |
| kPa | inch H ₂ O | 4.015 |
| kPa | foot H ₂ O | 0.335 |
| kPa | mm H ₂ O | 101.972 |

Tab. 73: Pressure conversion factors

8.6.4 Volume conversion factors

| Convert from | To | Multiply by |
|----------------|-----------------|-------------|
| m ³ | in ³ | 61023.744 |
| m ³ | ft ³ | 35.315 |
| m ³ | Imperial gallon | 219.969 |
| m ³ | US gallon | 264.172 |
| m ³ | l (liter) | 1000 |

Tab. 74: Volume conversion factors

8.6.5 Power conversion factors

| Convert from | To | Multiply by |
|--------------|-------------|-------------|
| kW | hp (metric) | 1.360 |
| kW | US hp | 1.341 |

Tab. 75: Power conversion factors

8.6.6 Moment of inertia and torque conversion factors

| Convert from | To | Multiply by |
|------------------|-------------------|-------------|
| kgm ² | lbft ² | 23.730 |
| kNm | lbf ft | 737.562 |

Tab. 76: Moment of inertia and torque conversion factors

8.6.7 Factors of fuel consumption conversion

| Convert from | To | Multiply by |
|--------------|--------|-------------|
| g/kWh | g/hph | 0.736 |
| g/kWh | lb/hph | 0.00162 |

Tab. 77: Factors of fuel consumption conversion

8.6.8 Flow conversion factors

| Convert from | To | Multiply by |
|----------------------------|----------------------|-------------|
| m ³ /h (liquid) | US gallon/min | 4.403 |
| m ³ /h (gas) | ft ³ /min | 0.586 |

Tab. 78: Flow conversion factors

8.6.9 Temperature conversion factors

| Convert from | To | Multiply by |
|--------------|----|------------------------|
| °C | °F | $F = 9/5 \cdot C + 32$ |
| °C | K | $K = C + 273.15$ |

Tab. 79: Temperature conversion factors

8.6.10 Density conversion factors

| Convert from | To | Multiply by |
|-------------------|--------------------|-------------|
| Kg/m ³ | lb/US gallon | 0.00834 |
| Kg/m ³ | lb/imperial gallon | 0.01002 |

Appendix

Unit conversion tables

| Convert from | To | Multiply by |
|-------------------|--------------------|-------------|
| Kg/m ³ | lb/ft ³ | 0.0624 |

Tab. 80: Density conversion factors

8.7 Prefix

| Name | Symbol | Factor |
|-------|--------|-----------|
| tera | T | 10^{12} |
| giga | G | 10^9 |
| mega | M | 10^6 |
| kilo | k | 10^3 |
| milli | m | 10^{-3} |
| micro | μ | 10^{-6} |
| nano | n | 10^{-9} |

Tab. 81: Common prefix multipliers table

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