Service and Repair Manual

Original Instructions

Diesel engine

KD83V16

From serial number 2021740003

KOHLER®

EN_US
33525088901_2_1
07-2021

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

Revision history

Version	Author	Modification	Date
000	TB12 - Technical documen-tation	First 3.01 engine version	2018-07
001	TB12 - Technical documen-tation	First 3.02 engine version Spelling mistakes	2019-02
002	TB12 - Technical documen-tation	According to development and improvement	2021-07

Preface

About this document

This repair and service manual is dedicated for the mechanics and the workshop personnel of the Kohler Co. dealers and subsidiaries.

This repair manual provides information regarding the assembly, disassembly, and adjustment tasks for KOHLER Diesel engines.

Information

Information for the United States

Failing to follow these instructions when installing a certified engine in a piece of nonroad equipment violates federal law (40 CFR 1068.105(b)), subject to fines or other penalties as described in the Clean Air Act.

If you install the engine in a way that makes the engine's emission control information label hard to read during normal engine maintenance, you must place a duplicate label on the equipment, as described in 40 CFR 1068.105.

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

Some illustrations in this repair and service manual show details and implements that may be different from your engine and machinery.

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 repair and service manual.

If you require further explanations or information, please contact your nearest authorized Kohler service representative. See “Service Assistance” section.

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.

Copyright - Proprietary notice ISO16016

Other applicable documents

Document	Application
Operation and Maintenance Manual	Operator's manual for the engine operation
Kodia Operation Manual	Description of Kodia, diagnosis software

General information

Manual structure

Information

Read and understand this manual before performing any service or maintenance procedures on any component.

The procedures described in this manual are based on the following structure:

1. Product description (For more information see: 1 Product description, page 17.)
2. Safety (For more information see: 2 Safety, page 38.)
3. Repair (For more information see: 3 Repair, page 58.)
4. Tools and devices (For more information see: 4 Tools and devices, page 266.)
5. Appendix (For more information see: 5 Appendix, page 272.)

Task layout

Information

Prior to any intervention, read the complete task procedure through to the end. Various symbols are used and explained in chapter (For more information see: 2.1.2 Additional identifications, page 38.) .

Each task in this manual have the following structure:

1. **Power take-off (PTO) and battery charging alternator removal and installation (SL 218, SL 223)**

2. **Previous tasks**

❑ Remove battery charging alternator cover. (For more information see: 3.2.2 Battery charging alternator & PTO cover removal and installation, page 63)

3. **Specific safety instructions**

⚠ **WARNING**
Lethal or heavy injury due to electrical shocks
The installed and powered engine is a live conductor.

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

4. **Special tools**

Special tool	Designation
 12217125	Pin for belt tensioner (x1)

Consumables and equipment

- Vaseline
- Rags
- Belt tension frequency meter

5. **Overview**

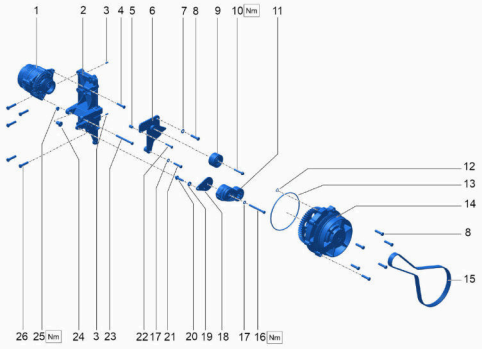


Fig. 294: Task overview

1	Battery charging alternator	14	Auxiliary PTO
2	Bracket	15	V-belt
3	Pin	16	Screw (M10)
4	Screw (M10)	17	Washer

6. **Removal**

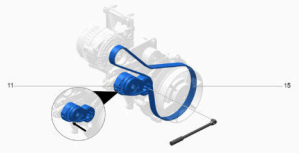


Fig. 295: Removing V-belt and pin location

- ▶ Use 1/2" toggle in tensioning device **11**.
- ▶ Pivot back the tensioning device against the spring force to the limit stop.

Installation

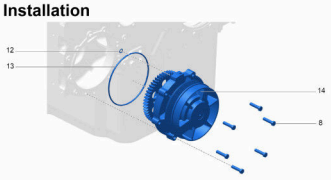


Fig. 300: Installing auxiliary PTO

- ▶ Grease o-rings **12**, **13**.
- ▶ Insert o-rings in auxiliary PTO **14**.

7. **Specific values**

Belt tension: 165 Hz (Min 149 Hz - Max 182 Hz).

Tightening specifications

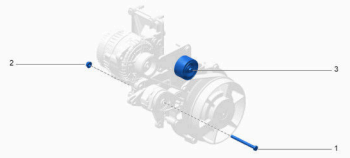


Fig. 305: Belt tensioner

8.

9.

Reference	Key	Screw specifications	Lubricant*	Reuse**	Torque		Angle (°)	
					Step	± 5%	Step	± 5°
1	441AB	ISO 4017 M10x1.5x110-10.9-FLZN	-	Yes	1	40 Nm 30 ft-lb	-	-
2	441AC	EN 1664 M10x1.5	-	Yes	1	40 Nm 30 ft-lb	-	-
3	441AD	M10x55-10.9-Zinc Coating	-	Yes	1	50 Nm 37 ft-lb	-	-

Tab. 62: Tightening specifications table

*Lubricants:
MG = Molykote G-n-plus
MW = Castrol Optimol paste white T
MH = Molykote HSC
O = Engine oil
XX = Loctite 243
YY = Loctite 577

**Refer to screws reuse rules. (For more information see: 5.3.1 Screws pre-tightening, reuse and marking, page 301)

Task layout description

1. Chapter heading
2. Previous tasks with details of the chapter
3. Specific safety instructions which complete the general safety instructions
4. Special tools, consumables and equipment which are needed to fulfill the task
5. One or more overview(s) of the assembly with list of components
6. Instructions to remove and install the components, with additional directives
7. Specific values spreadsheet to check the nominal and tolerances values of critical components and data recording sheet, if required, to inform the engine manufacturer.
8. Tightening sequence table if required
9. Tightening specifications table for specific fastener

Contents

1 Product description

1.1 Technical description

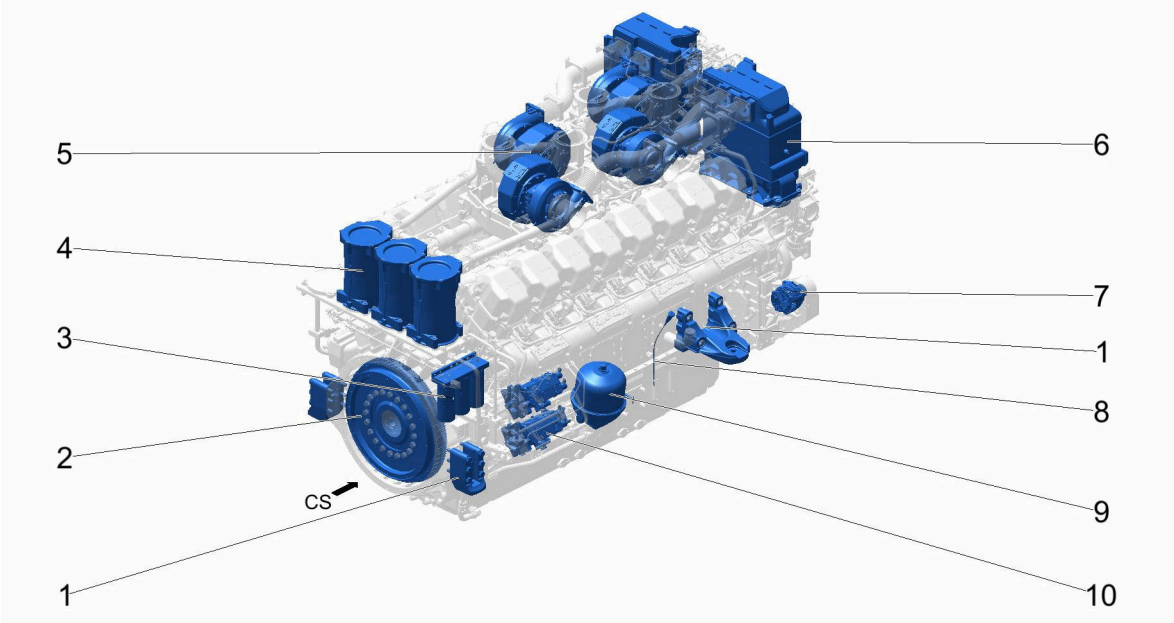


Fig. 1: Diesel engine / view from the flywheel side

CS Engine rear (flywheel side)
1 Engine brackets (x4)
2 Flywheel
3 Fuel filter
4 Crankcase breather system filter
5 Turbocharger assembly
6 Charge air cooler
7 Battery charging alternator
8 Oil dipstick
9 Oil centrifuge assembly
10 High pressure fuel pump

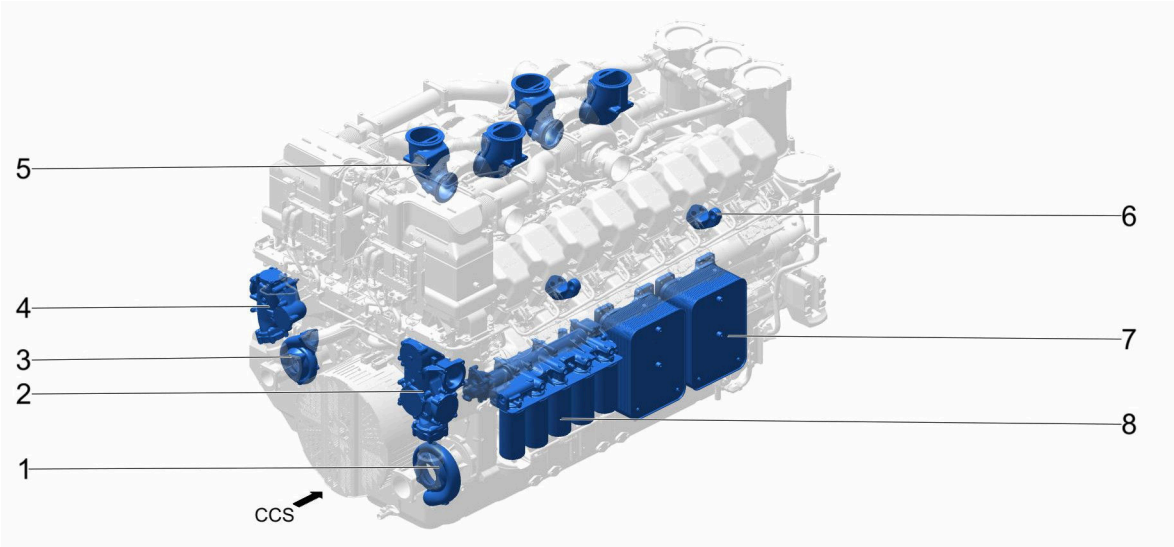


Fig. 2: Diesel engine / view from the damper side

CCS Engine front (vibration damper side)
1 Water pump high temperature
2 Thermostat housing high temperature
3 Water pump low temperature
4 Thermostat housing low temperature
5 Exhaust gas connection
6 Lifting lug
7 Oil cooler
8 Oil filter cartridge

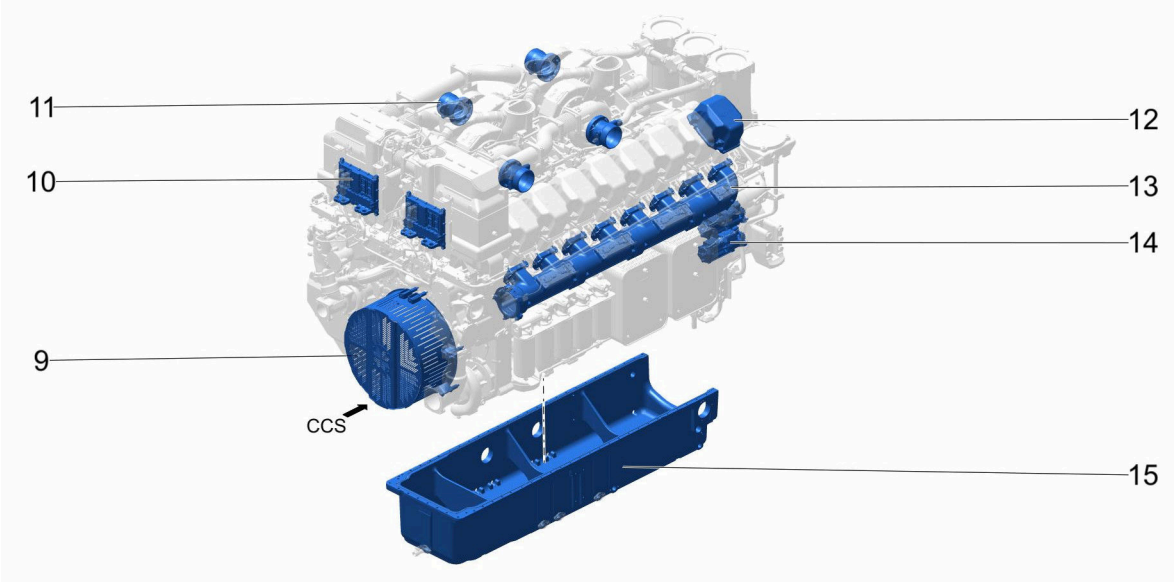


Fig. 3: Diesel engine / view from the damper side

CCS Engine front (vibration damper side)
9 Vibration damper cover
10 Engine control unit - ECU
11 Straight air intake
12 Cylinder head cover
13 Charge air pipe
14 Starter
15 Oil pan

1.1.1 Cylinder designation, direction of rotation

Principle according to ISO 1204

Cylinder 1 is located on flywheel side. Direction of rotation as shown on the flywheel side.

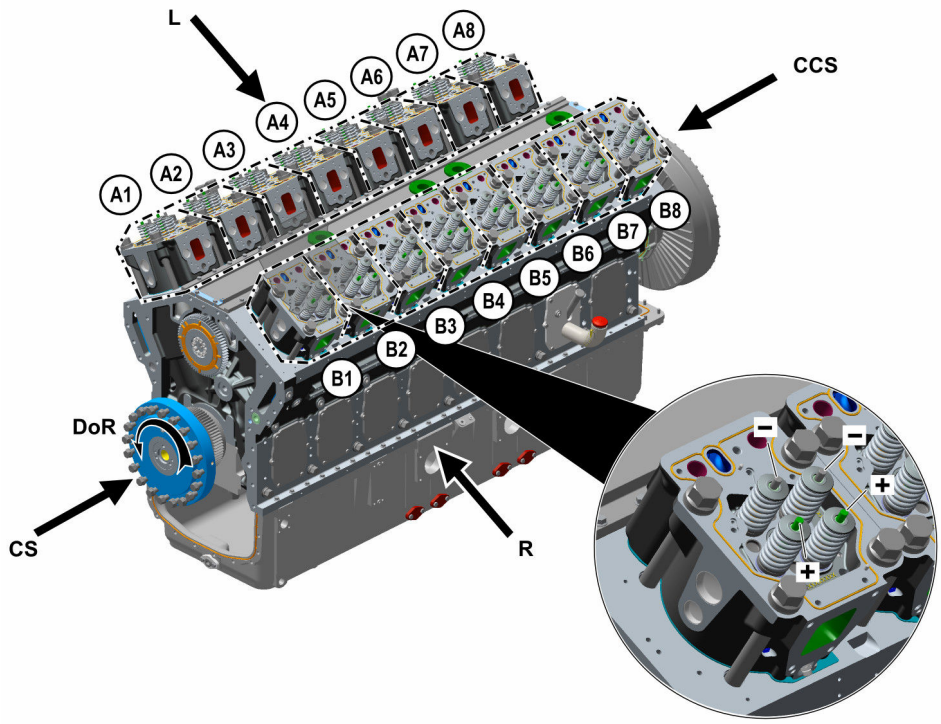


Fig. 4: Cylinder designation - direction of rotation according to ISO 1204

A1-A8	Series of cylinders – Bank A	**-**	Exhaust valves
B1-B8	Series of cylinders – Bank B	**+**	Inlet valves
CS	Engine rear (coupling/flywheel side)	**L**	Left engine side
CCS	Engine front (counter-coupling/damper side)	**R**	Right engine side
DoR	Direction of rotation		

Firing order

Cylinder B6 is located on the engine right opposite the flywheel side.

The rotational direction is on the left-hand side as viewed towards the flywheel.

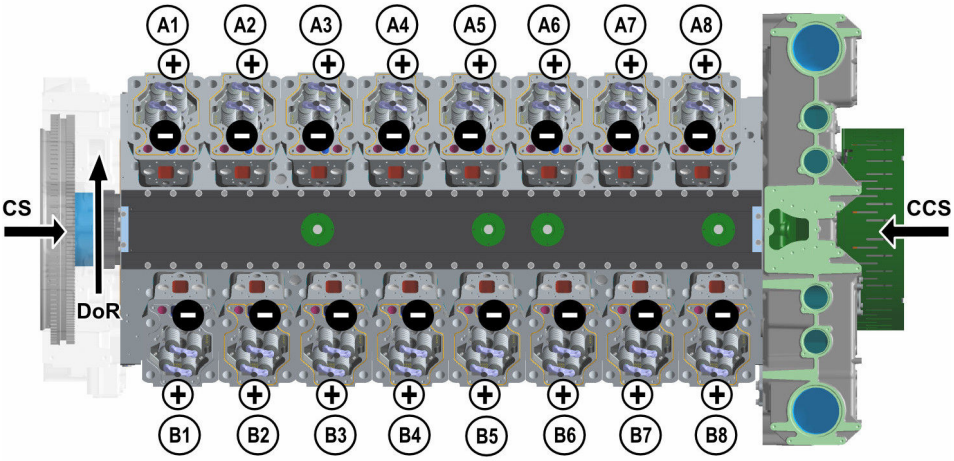


Fig. 5: Cylinder valves order

Firing order															
ISO 1204	A1	B7	A2	B5	A4	B3	A6	B1	A8	B2	A7	B4	A5	B6	A3	B8

Tab. 1: Firing order

1.1.2 Engine or component identification

Type designation

Designation										Description
K	**D**	**83**	**V**	**16**	**-**	**5**	**A**	**F**	**C**	**Engine type description**
K										Engine manufacturer
	D									Fuel type (D=Diesel)
		83								Total displacement in liter
			V							Cylinder configuration
				16						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. 2: Engine type description

Emission control information label

The emission control information label is attached on the crankcase.

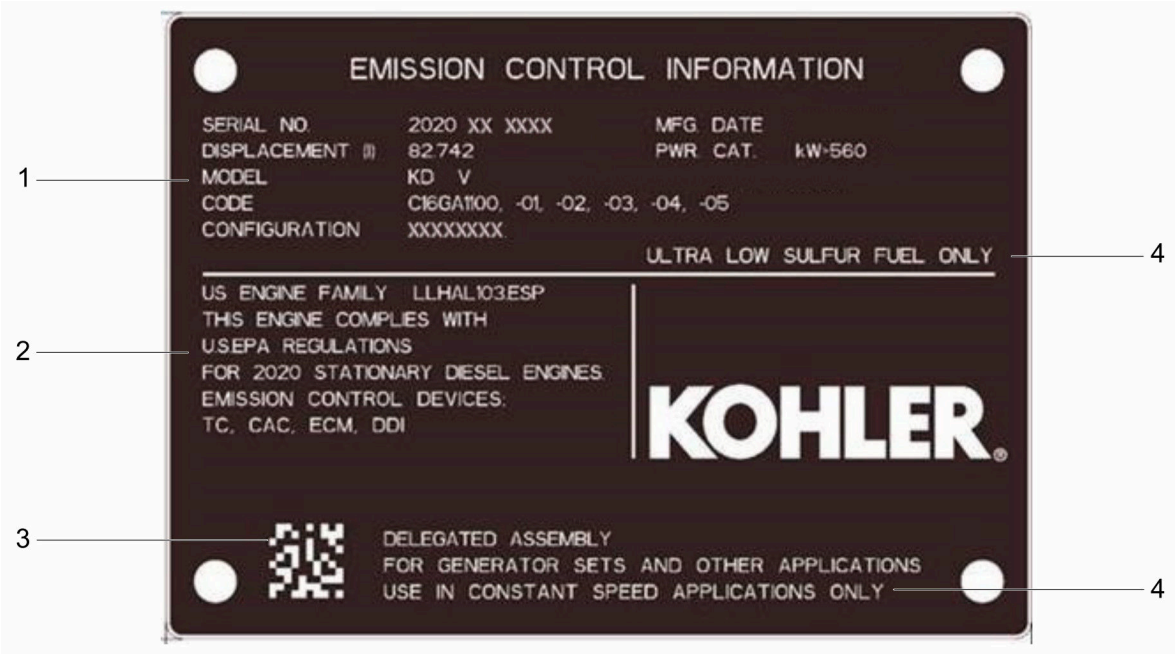


Fig. 6: Engine nameplate

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

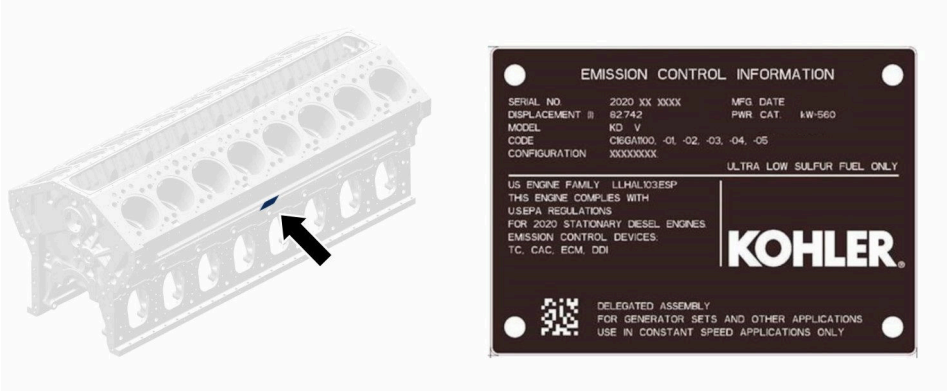


Fig. 7: Engine nameplate location

Engine serial number

The engine serial number is stamped onto the engine nameplate.

Designation			Description
2016	**73**	**0001**	**Engine serial number**
2016			Year of manufacture
	73		Engine type code (73= KD62V12) (74= KD83V16) (75= KD103V20)
		0001	Incremential production number

Tab. 3: Engine serial number

Fig. 8: Serial number on nameplate

1 Serial number

Engine control nameplates

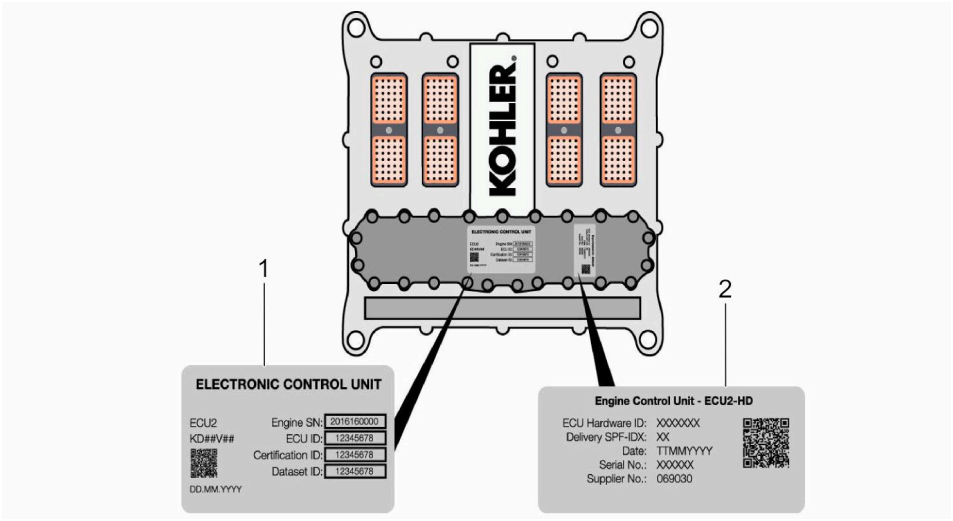


Fig. 9: Example of engine control unit nameplates

1 Software nameplate

2 Hardware nameplate

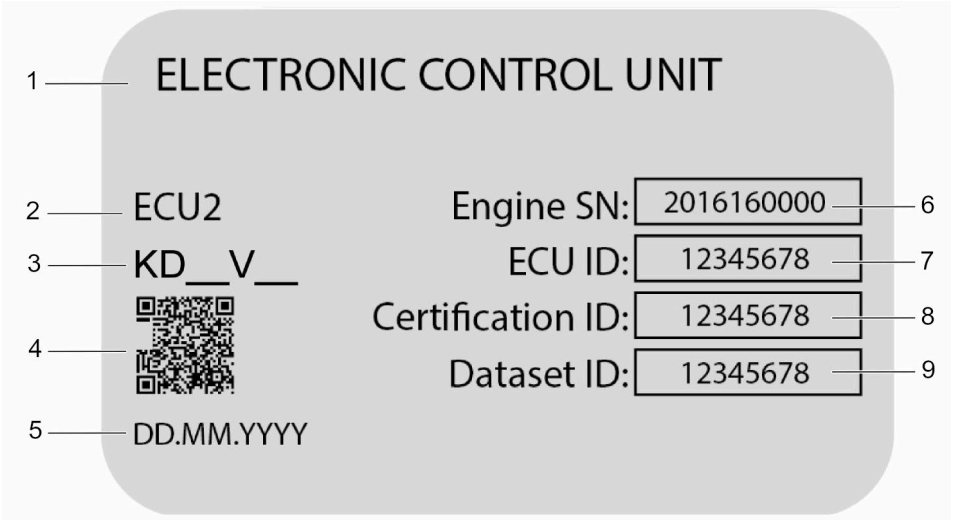


Fig. 10: Software nameplate

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

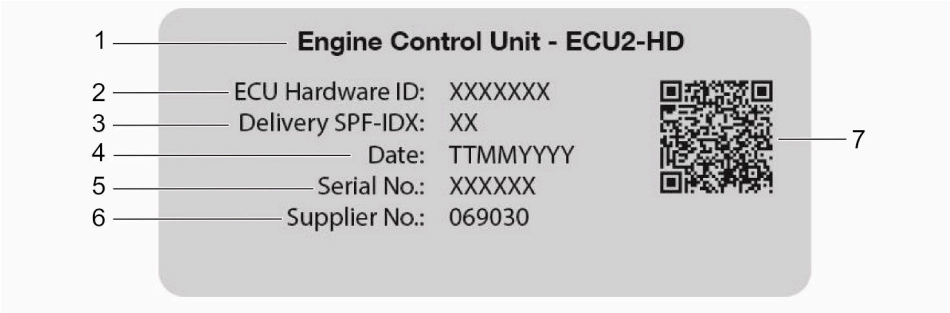


Fig. 11: Hardware nameplate

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

Information

- The information on the engine control unit nameplate corresponds to the delivery status (ex: works Kohler Co.). 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 KOHLER diagnosis and service tool KODIA.

Crankcase identification

The crankcase identification is stamped onto the left side of the crankcase.

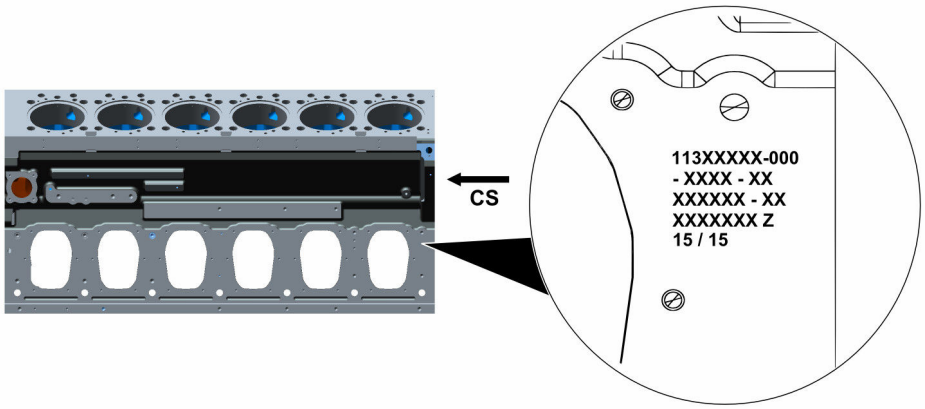


Fig. 12: Crankcase identification location

Connecting rod identification

The connecting rod identification is stamped on the connecting rod and on the connected rod bearing cap.

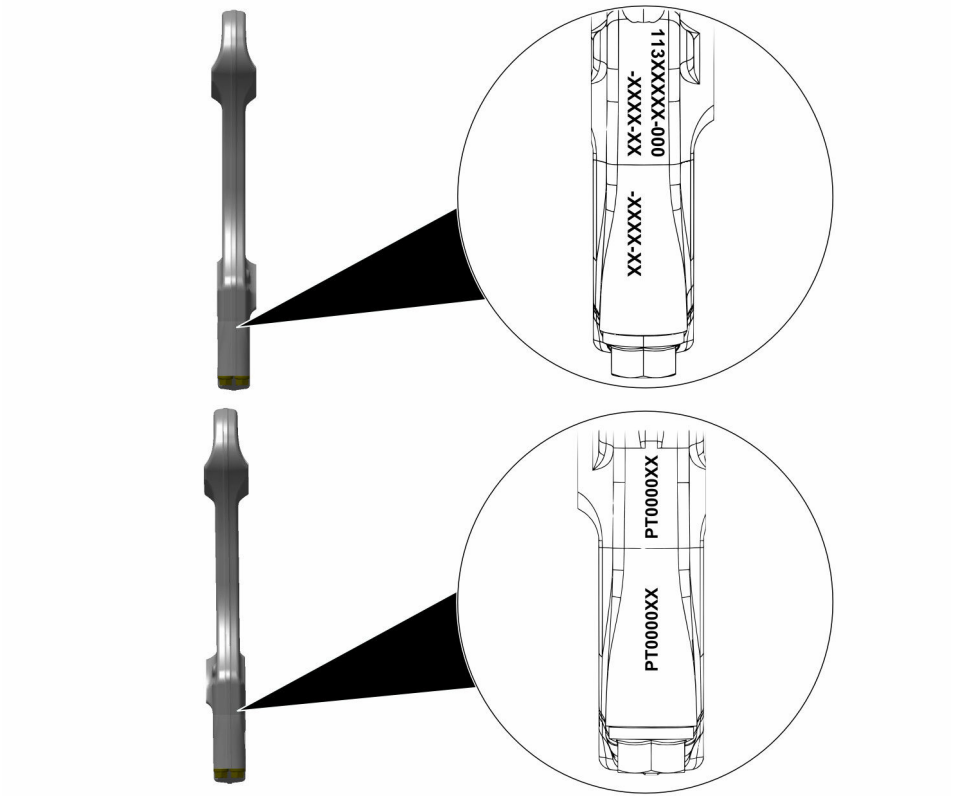


Fig. 13: Connecting rod number location

Matching of the connecting rod and connecting rod bearing cap is identified by connecting rod number.

Turbocharger identification

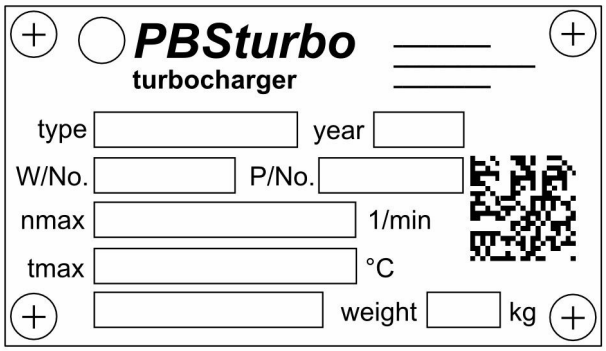


Fig. 14: Turbocharger nameplate

The turbocharger company nameplate is mounted on the turbocharger.

Oil cooler identification

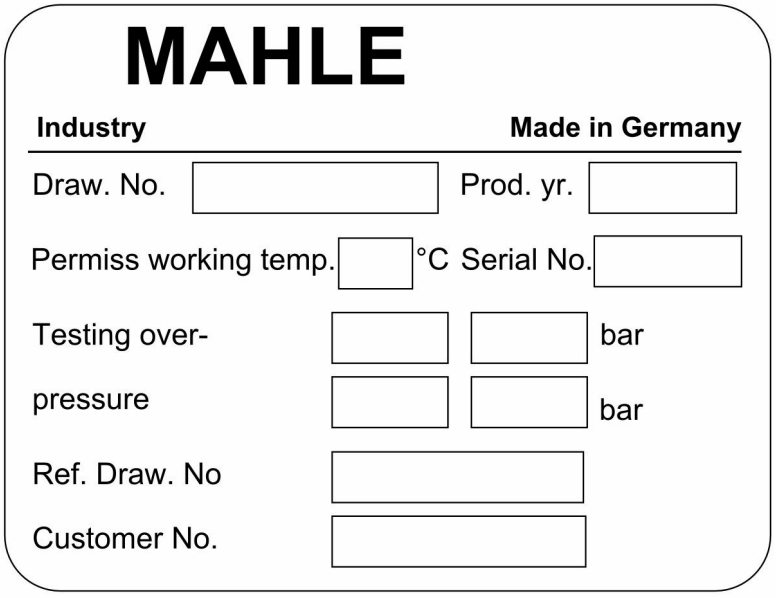


Fig. 15: Oil cooler nameplate

The oil cooler company nameplate is mounted on the oil cooler.

Injector identification

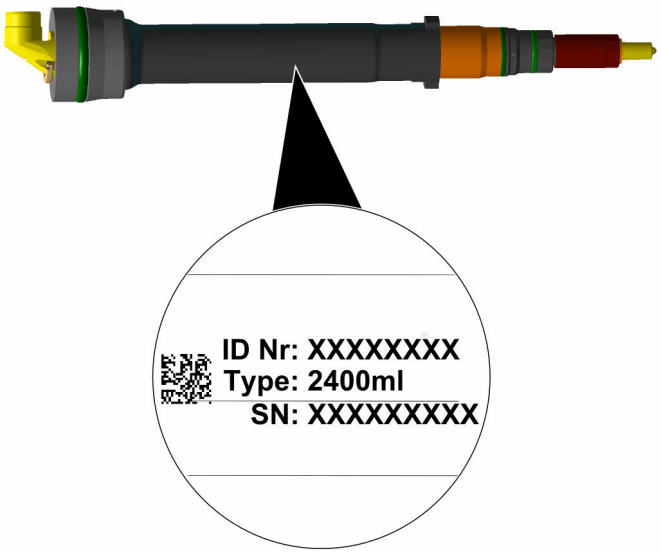


Fig. 16: Injection number location

The injector identification number is stamped on the side of the injector.

High-pressure pumps identification

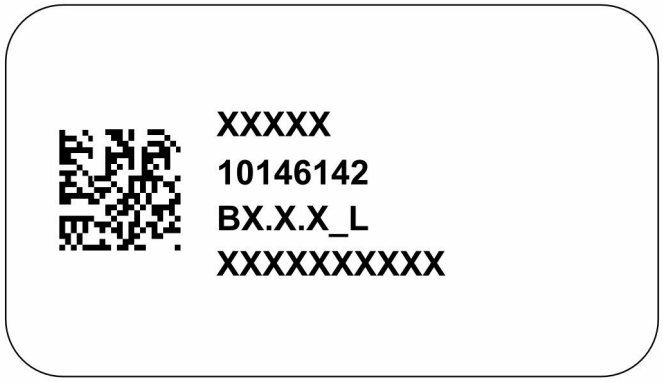


Fig. 17: High pressure pump nameplate

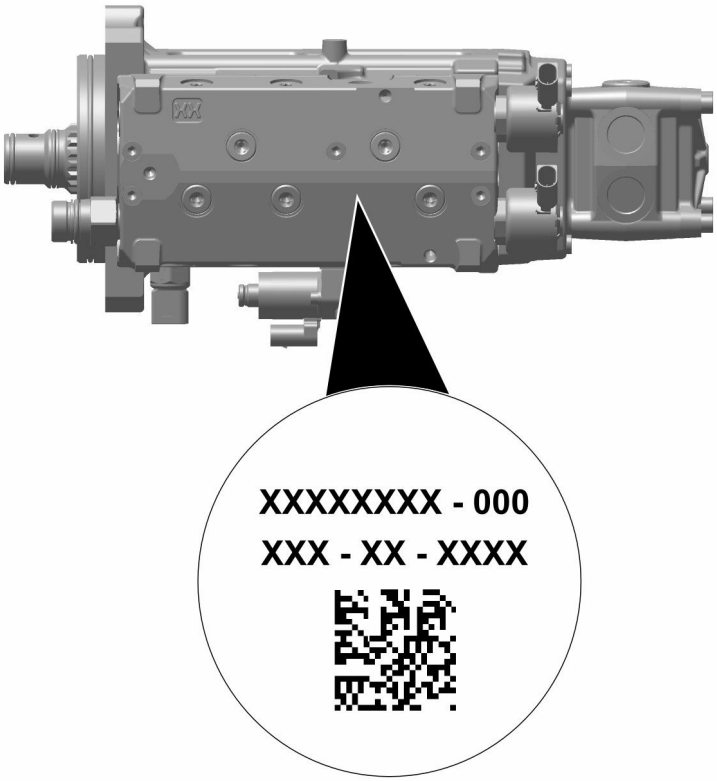


Fig. 18: High pressure pump number

The high pressure pump number is stamped on the pump.

Charge air cooler identification

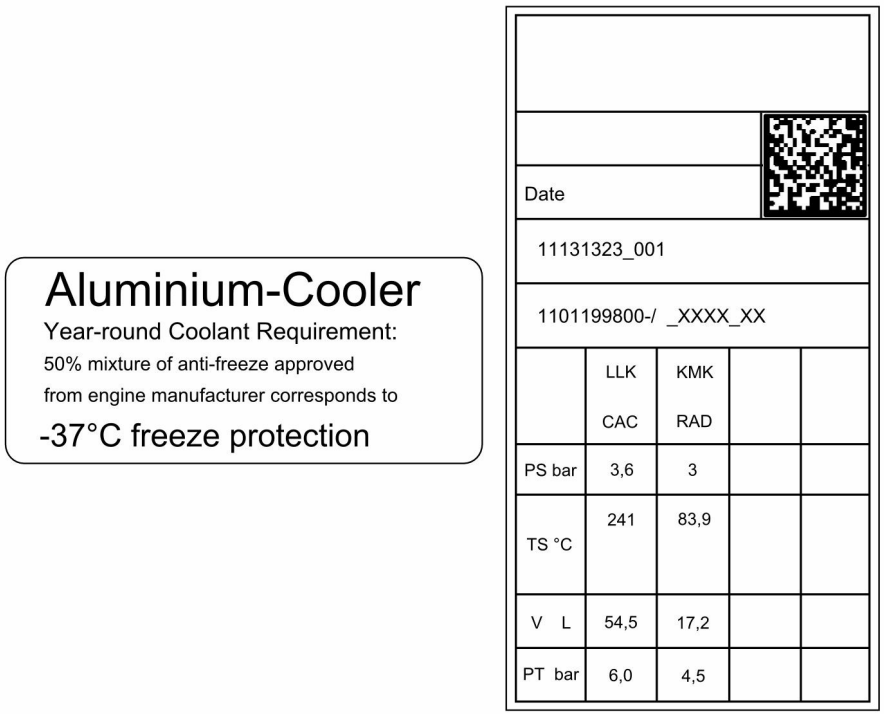


Fig. 19: Charge air cooler nameplates

The charge air cooler company nameplate is mounted on the charge air cooler.

Thermostat opening point value

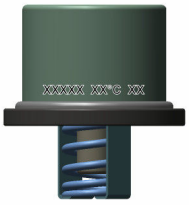


Fig. 20: Thermostat markings

The opening point value of the thermostat is engraved on the thermostat.

1.2 Technical data

Information

Refer also to the “Technical data sheet”. (For more information see: 5 Appendix, page 272.) .

1.3 Function description

1.3.1 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.

Fuel diagram

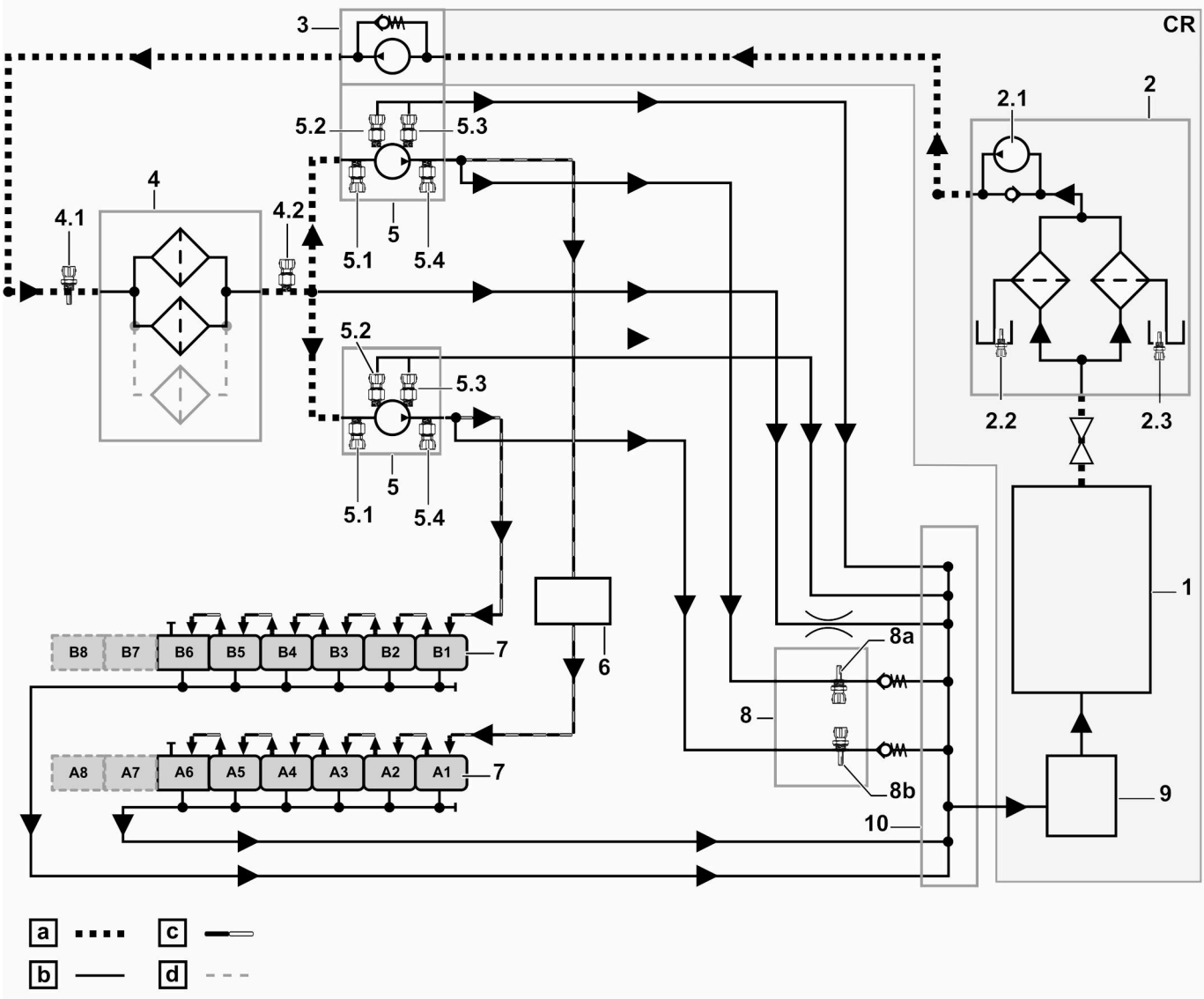


Fig. 21: Fuel diagram

a Low pressure – single walled

b Return line – single walled

c High pressure – double walled

d Depending on engine configuration

CR Customer responsibility

1 Fuel tank

2 Fuel prefilter & water separator

2.1 Servicing point

2.2 B710 – WIF pre-filter 1

2.3 B745 – WIF pre-filter 2

3 Low pressure pump

4.1 B709 – Before fuel filter (Temperature)

4.2 B702 – After fuel filter (Pressure)

5 High pressure pump A and B

5.1 Y703 and Y704 – Fuel pump VCV

5.2 Y708 and Y707 – Fuel pump PCV 1

5.3 Y728 and Y727 – Fuel pump PCV 2

6 Connecting block

7 Injectors A1 – B8

8 Break leakage detection block (if available)

8a B7921 – HP leakage detection Bank A (Leakage)

8b B7922 – HP leakage detection Bank B (Leakage)

9 Fuel cooler (optional)

See next page for continuation of the image legend

4	Fuel filter	**5.4**	B704 and B705 – HP pump (Bank A and B)	**10**	Distribution Block

1.3.2 Lubricating system

Engine oil diagram

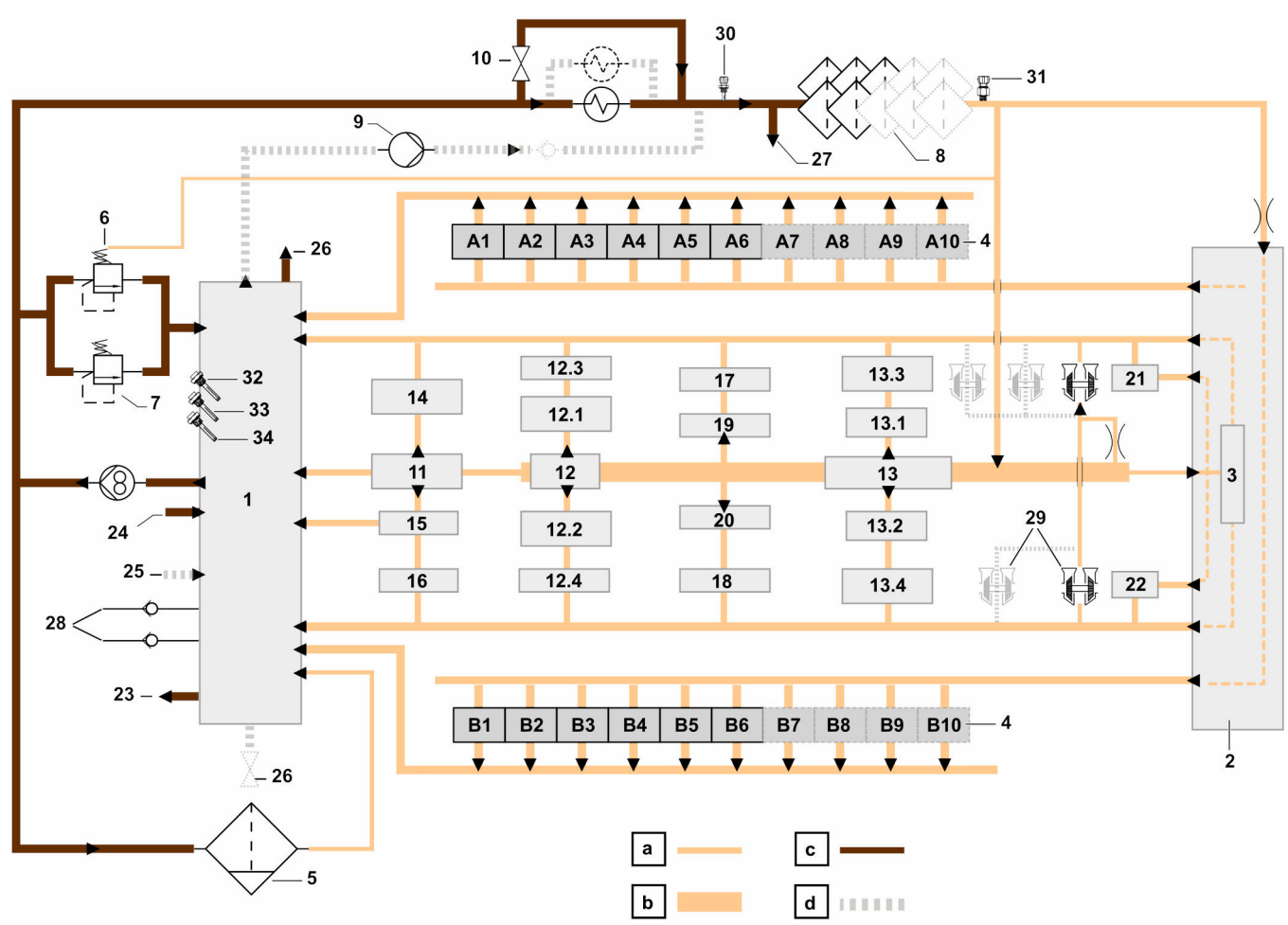


Fig. 22: Engine oil diagram

a	Filtered oil	**c**	Non-filtered oil
b	Main oil channel	**d**	Depending on engine configuration

1	Oil tank	**12.2**	Cam follower bearings B	**19**	Cylinder heads A
2	Aggregate support	**12.3**	Roller bearings A	**20**	Cylinder heads B
3	Support bearing	**12.4**	Roller bearings B	**21**	HT coolant pump
4	Piston cooling jets	**13**	Crankshaft bearings	**22**	LT coolant pump
5	Centrifugal filter	**13.1**	Conrods A	**23**	Preheating port
6	Pressure Control Valve	**13.2**	Conrods B	**24**	Oil filling
7	Pressure Safety Valve	**13.3**	Pistons pins A	**25**	Automatic oil refill
8	Spin-on oil filter	**13.4**	Pistons pins B	**26**	Drain port
9	Prelubricating pump	**14**	Support bearing Flywheel	**27**	Oil sampling
10	Bypass valve for cold start	**15**	Gear box	**28**	CCV
11	Intermediate gears Flywheel	**16**	HP Pump	**29**	Turbochargers

See next page for continuation of the image legend

12 Camshaft bearings
12.1 Cam follower bearings A
17 Rocker arms A
18 Rocker arms B

Sensors list

30 B751 – Oil lubrication temperature before filter
31 B701 – Oil pressure after filter
32 B7960 – Oil Level 3 steps system High (Max level, engine stopped) - Optional
33 B7961 – Oil Level 3 steps system Medium (Min level, engine stopped) - Optional
34 B7962 – Oil Level 3 steps system Low (Min level, engine running at idle speed) - Optional

1.3.3 Cooling system

Coolant diagram

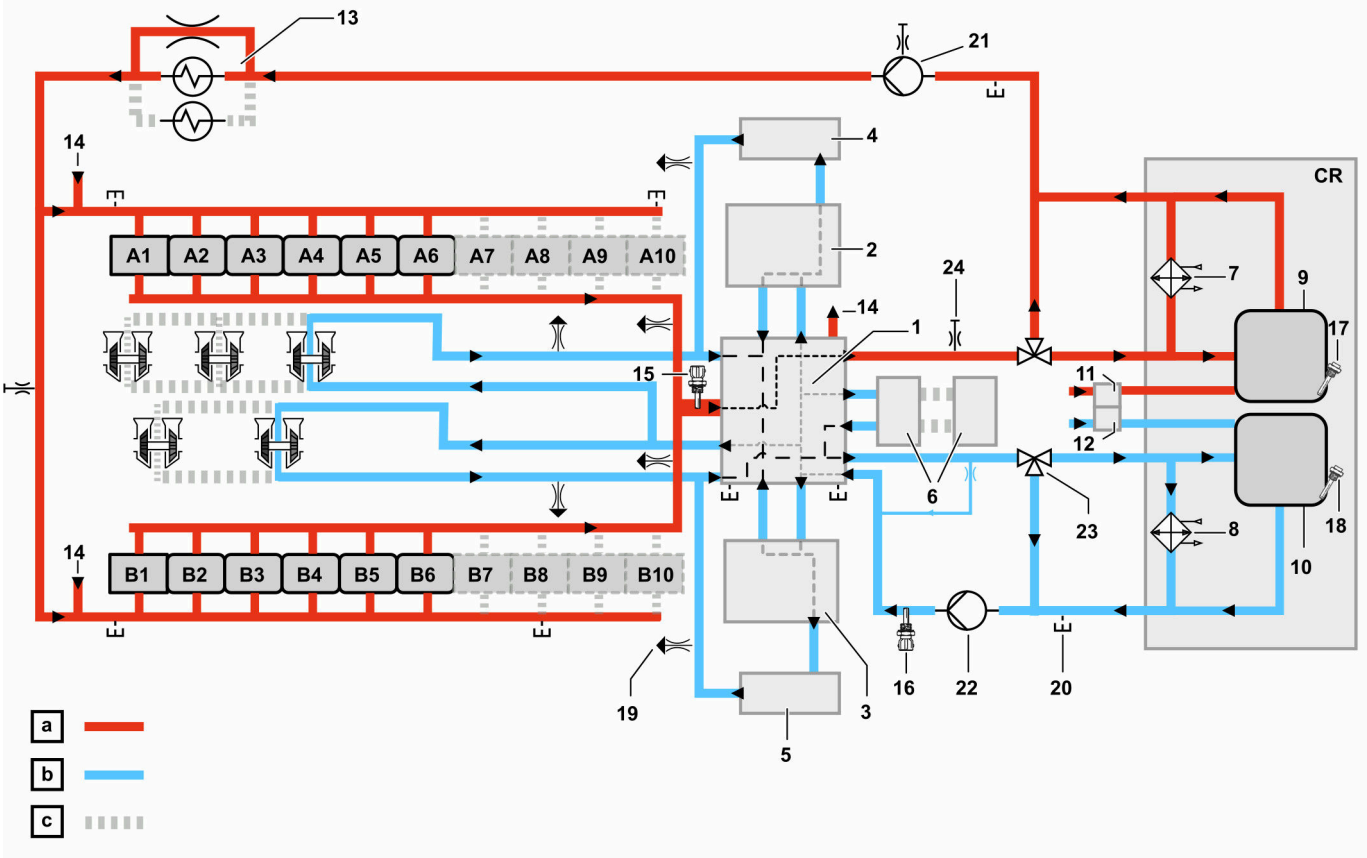


Fig. 23: Coolant diagram

a High temperature
b Low temperature
c Depending on engine configuration
CR Customer responsibility

1 Aggregate support
2 Charge Air Cooler A
3 Charge Air Cooler B
4 Elbow A
5 Elbow B
6 ECU 2-HD
8 LT Water radiator
9 HT Expansion tank (including ventilation line)
10 LT Expansion tank (including ventilation line)
11 Venting HT
12 Venting LT
13 Engine oil cooler
19 Venting point
20 Drain point
21 Coolant pump HT
22 Coolant pump LT
23 Mechanical thermostat
24 Manual venting point

See next page for continuation of the image legend

7 HT Water radiator
14 Preheating

Sensors list

15 B708 – Coolant temperature after engine
16 B718 – Coolant temperature before cooler
17 S710 – HT Coolant Min level alert
18 S711 – LT Coolant Min level alert

Coolant diagram (engine with EATS)

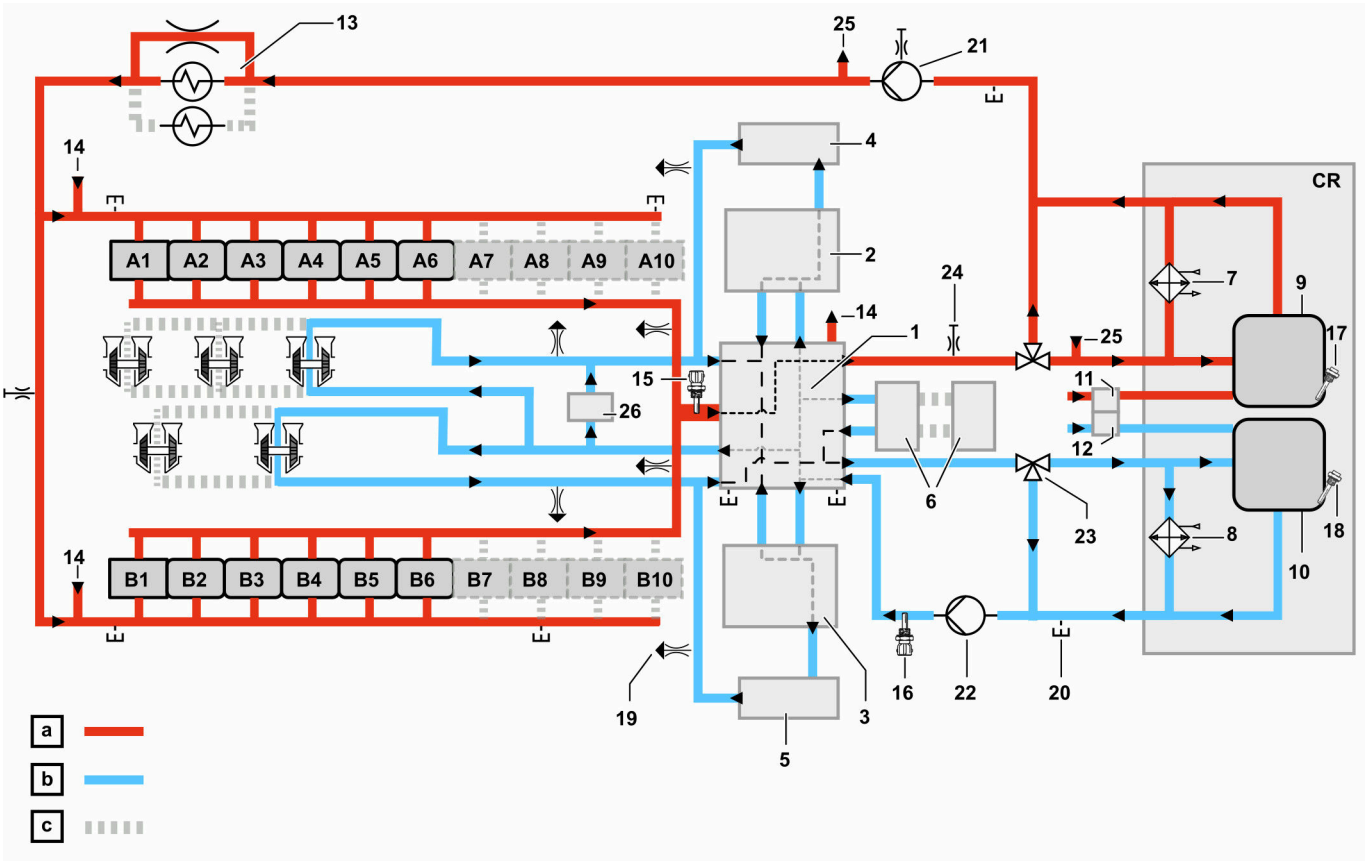


Fig. 24: Coolant diagram

a High temperature
b Low temperature
c Depending on engine configuration
CR Customer responsibility

1 Aggregate support
2 Charge Air Cooler A
3 Charge Air Cooler B
4 Elbow A
5 Elbow B
6 ECU 2-HD
7 HT Water radiator
8 LT Water radiator
9 HT Expansion tank (including ventilation line)
10 LT Expansion tank (including ventilation line)
11 Venting HT
12 Venting LT
13 Engine oil cooler
14 Preheating
19 Venting point
20 Drain point
21 Coolant pump HT
22 Coolant pump LT
23 Mechanical thermostat
24 Manual venting point
25 Urea defrosting
26 Engine Bypass flap

Sensors list

15 B708 – Coolant temperature after engine
16 B718 – Coolant temperature before cooler
17 S710 – HT Coolant Min level alert
18 S711 – LT Coolant Min level alert

1.3.4 Charge air system

Charge air diagram

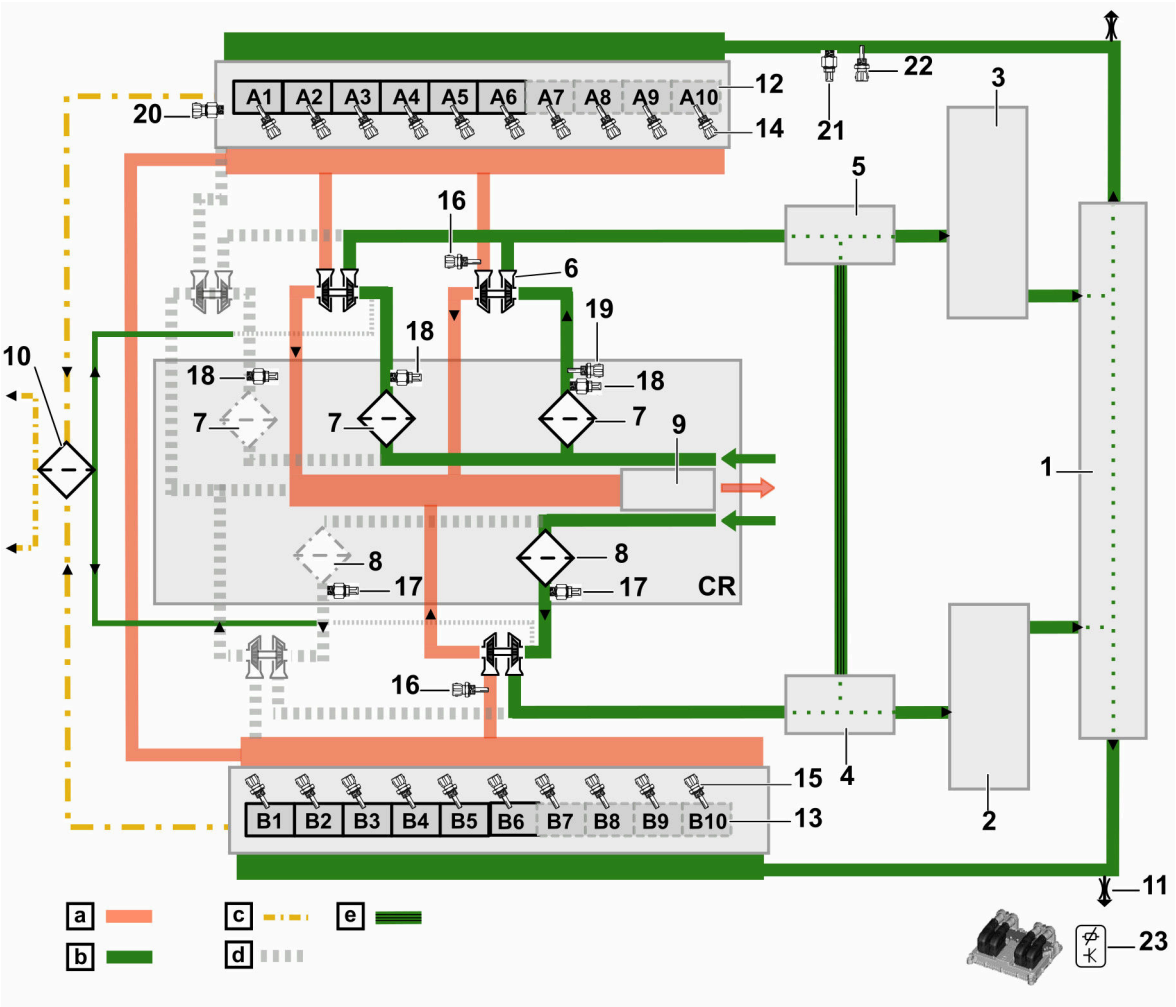


Fig. 25: Charge air diagram

a Exhaust gas
b Fresh air
c Oil vapor
d Depending on engine configuration
e For odd number of turbochargers only
CR Customer responsibility

1 Aggregate support
2 Charge air cooler - B side
3 Charge air cooler - A side
4 Elbow - B side
5 Elbow - A side
6 Turbocharger
7 Air filter - A side
8 Air filter - B side
9 Exhaust catalyst
10 Blowby filters
11 Venting point
12 Engine A bank
13 Engine B bank

Sensors list

14 B785x - Exhaust gas temperature on cylinder Ax (optional)
15 B786x - Exhaust gas temperature on cylinder Bx (optional)
16 B7811 - Exhaust gas temperature before turbocharger 1&2
18 B780 - Air intake pressure switch - A side (clogging)
19 B749 - Air intake temperature - A side
20 B7923 - Crankcase pressure
22 B707 - Charged air temperature A after charge air cooler
23 Bxx1 - Atmospheric pressure (on ECU 2-HD)

See next page for continuation of the image legend

Sensors list

17 B781 - Air intake pressure switch - B side (clogging)

21 B703 - Charged air pressure A after charge air cooler

Engine type	Number of turbochargers	TC1	TC2	TC3	TC4	TC5
V12	3		x	x		
V16	4			x	x	
V20	5				x	x

Tab. 4: Blowby connections

1.3.5 Charge air diagram (engine with EATS)

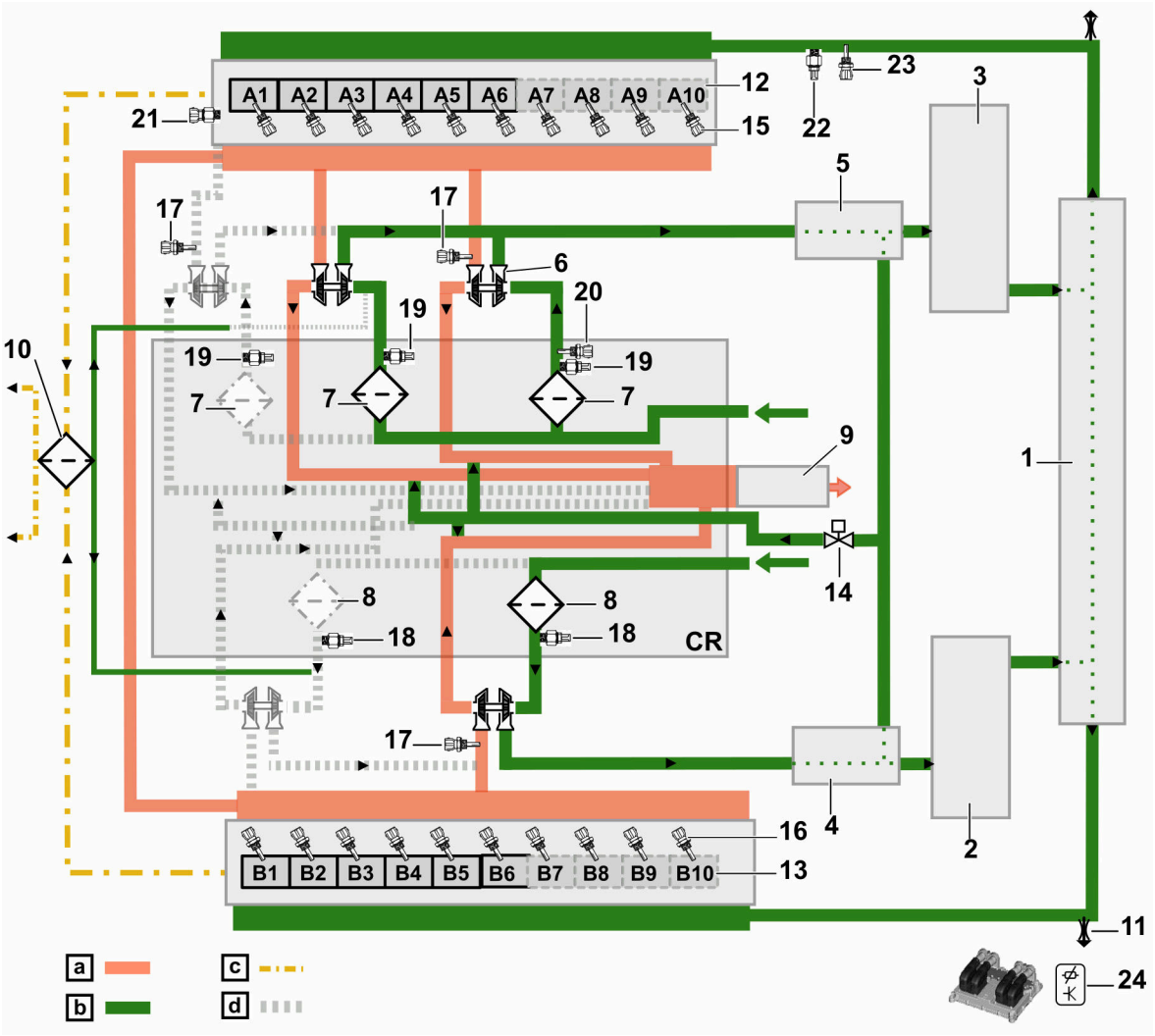


Fig. 26: Charge air diagram

a Exhaust gas

b Fresh air

c Oil vapor

d Depending on engine configuration

e For odd number of turbochargers only

CR Customer responsibility

1 Aggregate support

2 Charge air cooler - B side

6 Turbocharger

7 Air filter - A side

11 Venting point

12 Engine A bank

See next page for continuation of the image legend

3 Charge air cooler - A side
4 Elbow - B side
5 Elbow - A side
8 Air filter - B side
9 Exhaust catalyst
10 Blowby filters
13 Engine B bank
14 Engine by-pass flap

Sensors list

15 B78xx - Exhaust gas temperature on cylinder Ax (optional)
16 B78xx - Exhaust gas temperature on cylinder Bx (optional)
17 B7811 - Exhaust gas temperature before turbocharger 1&2
18 B781 - Air intake pressure switch - B side (clogging)
19 B780 - Air intake pressure switch - A side (clogging)
20 B749 - Air intake temperature - A side
21 B7923 - Crankcase pressure
22 B703 - Charged air pressure A after charge air cooler
23 B707 - Charged air temperature A after charge air cooler
24 Bxx1 - Atmospheric pressure (on ECU 2-HD)

Engine type	Number of turbochargers	TC1	TC2	TC3	TC4	TC5
V12	3		x	x		
V16	4			x	x	
V20	5				x	x

Tab. 5: Blowby connections

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. 6: 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.
	NOTICE	Used to address practices not related to personal injury.

Tab. 7: Warning signs

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. 8: 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

2.2.2 International standard classification of occupations

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

2.2.3 Occupational references

The occupations listed perform the following work in accordance with the "General safety instructions" chapter:

– the main tasks described in this manual or these instructions
– the tasks identified as requirements to prepare the main tasks

For the SL1 maintenance of power generation engines: Maintenance Technician

In relation to ILO – Power Plant or Industrial Machinery Mechanics – unit group 7233 / ISCED-97 level 2)

The work on engines, equipment as well as mechanical and electronic equipment includes:

– Operating the machine and facilities
– Performance of scheduled maintenance work
– Assembly, installation, assessment, adjustment, testing and maintenance
– Location of defects
– Recording the repair and maintenance work performed

For the SL2 maintenance of power generation engines: Technician

In relation to ILO – Power Plant or Industrial Machinery Mechanics – unit group 7233 / ISCED-97 on at least one level, from 3 to 4)

The work on engines, equipment as well as mechanical and electronic equipment includes:

– Operating the machine and facilities
– Performance of scheduled maintenance work
– Assembly, installation, assessment, adjustment, testing and maintenance

– Location of defects
– Dismantling and reassembly of the machine as well as the mechanical and electronic equipment
– Ensuring compliance with standards and specifications
– Recording the repair and maintenance work performed

For the SL3 maintenance of power generation engines: Mechanical Technician

In relation to ILO – Power Plant or Industrial Machinery Mechanics – unit group 7233 / ISCED-97 on at least one level, from 3 to 4)

The work on engines, equipment as well as mechanical and electronic equipment includes:

– Operating the machine and facilities
– Performance of scheduled maintenance work
– Assembly, installation, assessment, adjustment, testing and maintenance
– Location of defects
– Dismantling and reassembly of the machine as well as the mechanical and electronic equipment
– Replacement of complete engines or components
– Repairs to mechanical, hydraulic and electronic equipment
– Examination and testing of new machines and equipment
– Ensuring compliance with standards and specifications
– Recording the repair and maintenance work performed

2.2.4 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 operator 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 Operator 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 machinery's manufacturer 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 sytem.
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 intoxicating 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's 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, identifiy and rectify immediately.

2.6.8 Preventing electro-magnetic hazards

WARNING
Harzards 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 leakages 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 leakage, 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.

Following personal protective equipment is necessary:

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

Tab. 9: Personal protective equipments

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

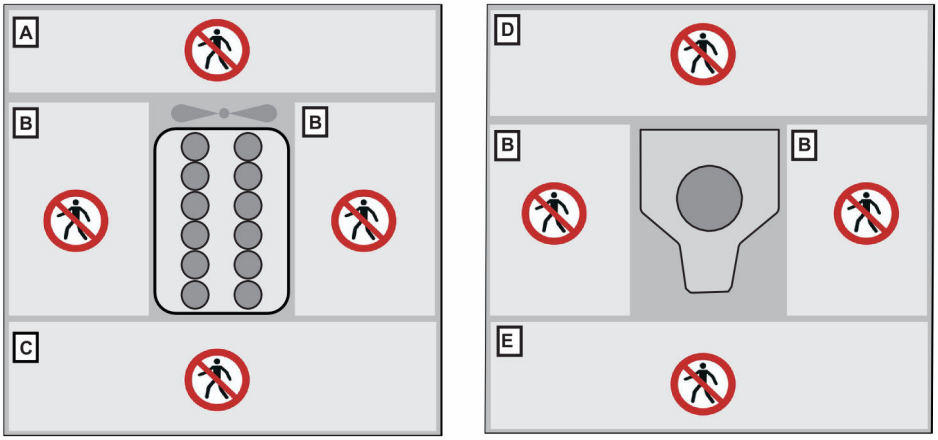


Fig. 44: Engine areas in operation — view from above and flywheel side

Access to the following areas is forbidden:

– A – Engine front (damper side)
– B – Engine sides
– C – Engine rear (flywheel side)
– D – Above the engine
– E – Below the engine

2.8.2 Engine in commissioning — test-run

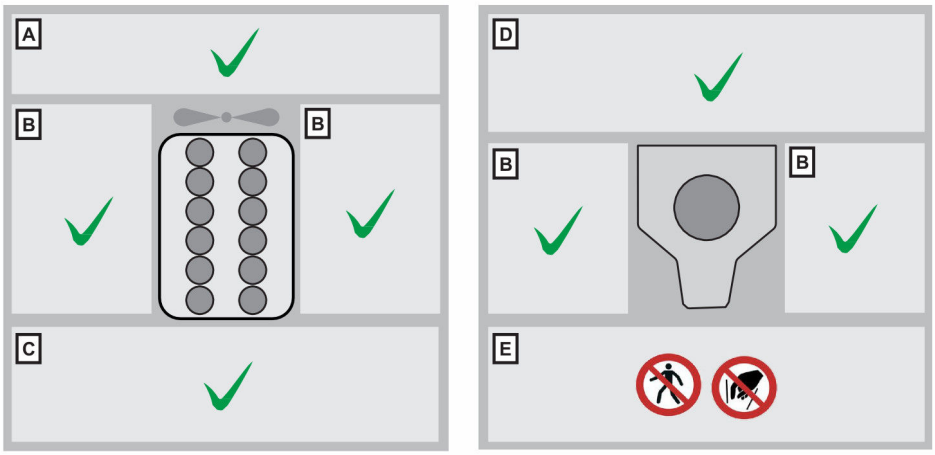


Fig. 45: Engine areas during commissioning/test run — view from above and coupling side

Following areas are accessible for commissioning and test run tasks:
– A – Counter coupling side (damper side)
– B – Engine sides
– C – Coupling side (flywheel side)
– D – Above the engine

Access to the following areas is forbidden:
– E - Below the engine

2.8.3 Emergency stop

Information

The machinery owner is responsible to mark the hazardous areas and the fail-safe devices.

The emergency stops must withstand the operational conditions, 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.

2.8.4 Signage recommendations

Information

The machinery owner is responsible to mark the hazardous areas and the fail-safe devices.

The signs must withstand the ambient conditions, 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.

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! (For more information see: 2.6.5 Preventing electrical hazards, page 48.)
	ISO 7010/W017 – Warning sign - Hot surface Severe injuries due to hot surfaces! (For more information see: 2.6.2 Preventing burns, page 46.)
	ISO 7010/W025 – Warning sign - Counterrotating rollers Severe injuries due to drawing-in movement! (For more information see: 2.6.1 Preventing bruising, page 46.)
	ISO 7010/P007 - Prohibition sign - No access for people with active implanted cardiac devices Death or serious injury due to electromagnetic fields! (For more information see: 2.6.8 Preventing electro-magnetic hazards, page 49.)
	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. 10: 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 dismounted, 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 manufacturer of the machinery is responsible to design and provide a display to get the messages and codes generated by the ECU, and to develop, document, implement, and enforce emergency procedures to be followed in the event of accident or breakdown.

Refer to the “Electrical Installation Guideline”. (For more information see: 5 Appendix, page 272.) .

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 Repair

3.1 Prevent property damage

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.

NOTICE
Risk of property damage by reuse of sealing.
Leakage by faulty seal.

▶ Replace all sealings.

– Check reusable removed parts for re-usability; see the relevant information in the Service and Repair Manual.
– Replace any removed parts that cannot be re-used.
– If no specific torques and tensioning instructions are specified: Screw connections are to be tightened with the standard torques. Additional information can be found in the “Standard tightening torques” chapter, (For more information see: 5.3 Standard tightening torques, page 274.) .
– Replace self-locking screw connections.
– Clean the Diesel engine connections and screw connections thoroughly of oil, fuel or care products before assembly.
– Use lint-free cleaning rags.
– Do not touch electric contacts. The connection may be affected by dirt or components may be destroyed by electrostatic discharges (ESD).
– Before cleaning the Diesel engine, cover or tape shut all openings into which water, steam or detergents must not penetrate due to safety or functional reasons.
– Remove the covers/seals after cleaning.
– Check the fuel lines, Diesel engine oil lines and hydraulic lines for the following defects:
  • Leaks
  • Loose connections
  • Chafe marks
  • Damage
– Make sure the electrical power supply is firmly connected when starting.
– Make sure the engine is switched off before disconnecting the electrical power supply.
– Use suitable test leads for measurements at plug connections.
– Protect the engine control unit against dust and water if no mating plug has been connected.

3.2 Covers

3.2.1 Vibration damper cover removal and installation

Previous tasks

Not applicable.

Specific safety instructions

Not applicable.

Special tools

Not applicable.

Consumables and equipment

Not applicable.

Overview

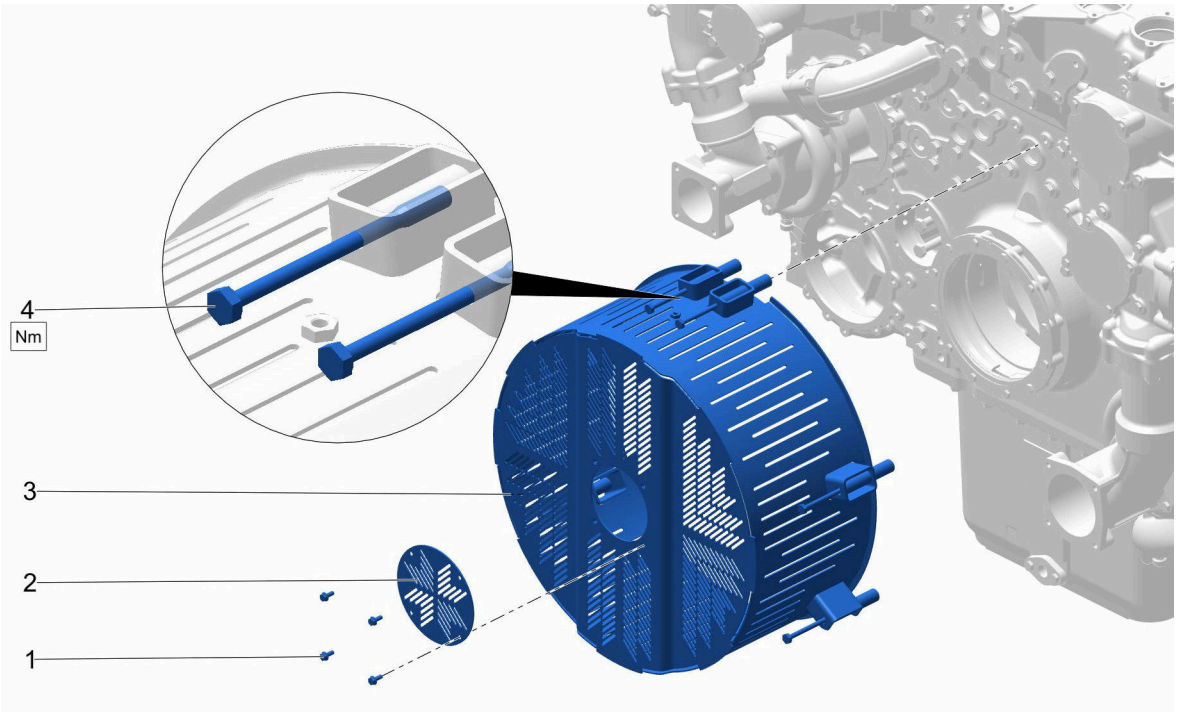


Fig. 51: Task overview

1 Screw (M8)
2 Protection plate
3 Cover
4 Screw (M12)

Removal

▶ Remove screws **1**.

- ▶ Remove cover **3**.
- ▶ Unscrew screws **4**.
- ▶ Remove protection plate **2**.

Installation

- ▶ Screw cover **3** with screws **1**.
- ▶ Screw protection plate **2** with screws **4**.

Specific values

Not applicable.

Tightening specifications

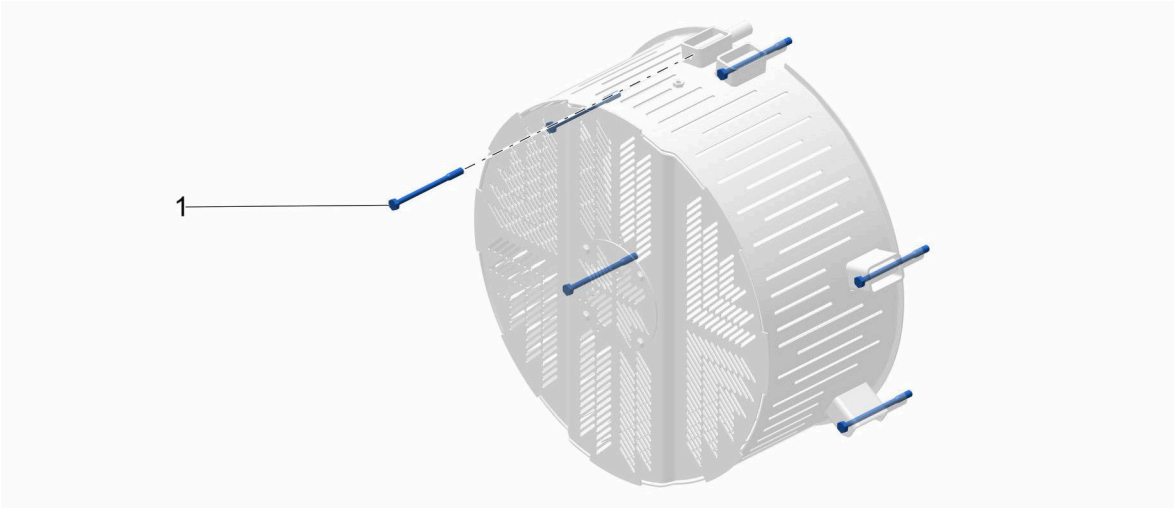


Fig. 52: Vibration damper cover screws

Reference	Key	Screw specifications	Lubricant *	Reuse**	Torque		Angle (°)	
					Step	± 5%	Step	± 5°
1	055AA	DIN 6929 M12x1.75x155-10.9-FLZN	-	Yes	1	70 Nm 52 ft-lb	-	-

Tab. 11: Tightening specifications table

*Lubricants:
MG = Molykote G-n-plus
MW = Castrol Optimol paste white T
MH = Molykote HSC
O = Engine oil
XX = Loctite 243
YY = Loctite 577

**Refer to screws reuse rules. (For more information see: 5.3.2 Screws pre-tightening, reuse and marking, page 274.)

3.2.2 Battery charging alternator & PTO cover removal and installation

Previous tasks

Not applicable.

Specific safety 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.

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’s technical data sheet.
- ▶ Check the grounding connection to avoid any risk of electrical arc.
- ▶ Observe the local safety regulations that apply to the machinery.

Special tools

Not applicable.

Consumables and equipment

– Rags
– Cleaner

Overview

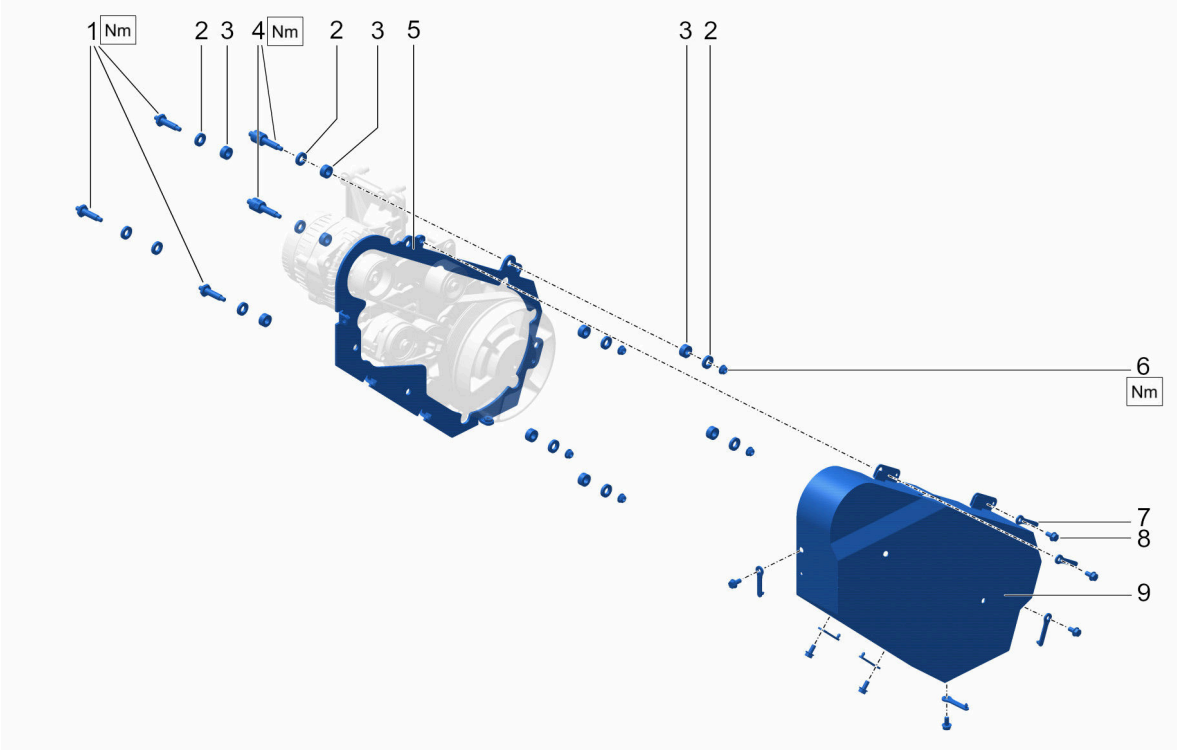


Fig. 53: Task overview

1 Pin
2 Distance sleeve
3 Vibration damper
4 Pin
5 Cover - back side
6 Nut (M8)
7 Lock washer
8 Captive screw (M8)
9 Cover - front side

Removal

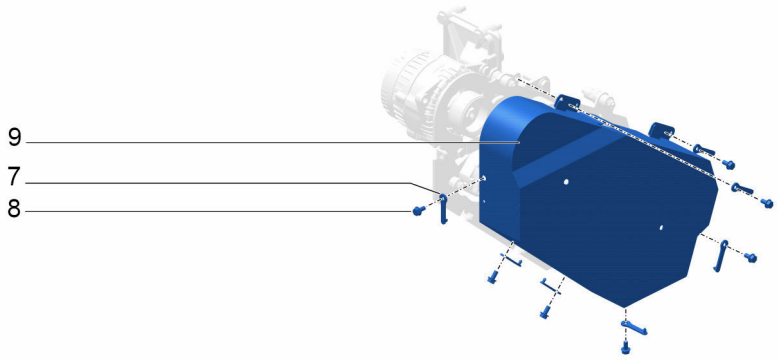


Fig. 54: Removing cover - front part

▶ Remove screws **8** and lock washers **7**.

▶ Remove cover - front side **9**.

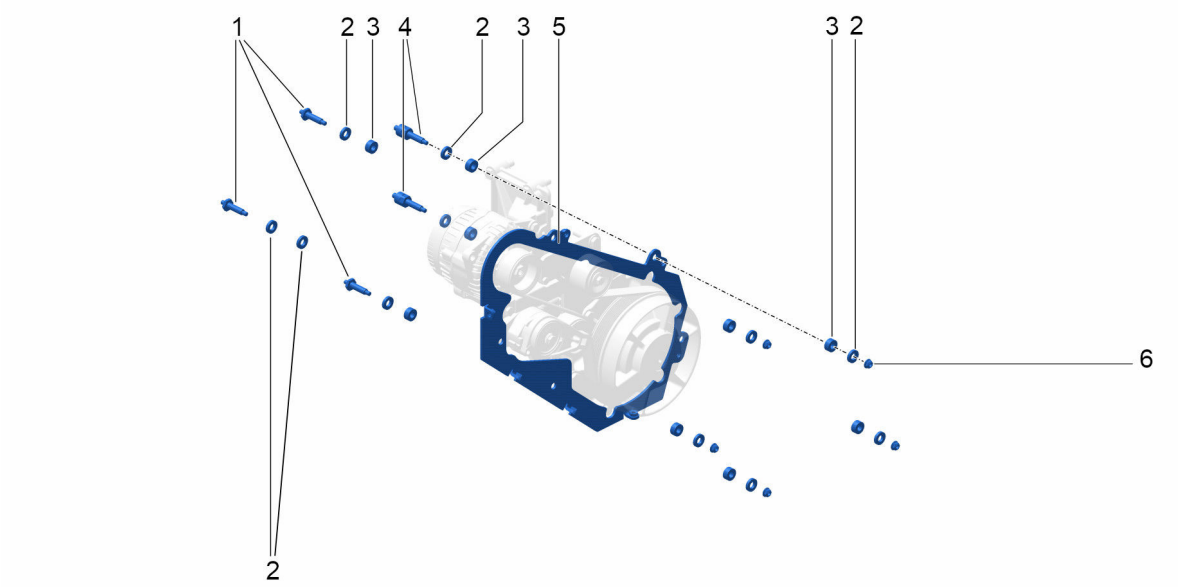


Fig. 55: Removing cover - back part

- ▶ Remove nuts **6**, vibration dampers **3**, distance sleeves **2** and pins **1, 4**.
- ▶ Remove cover - back side **5**

Installation

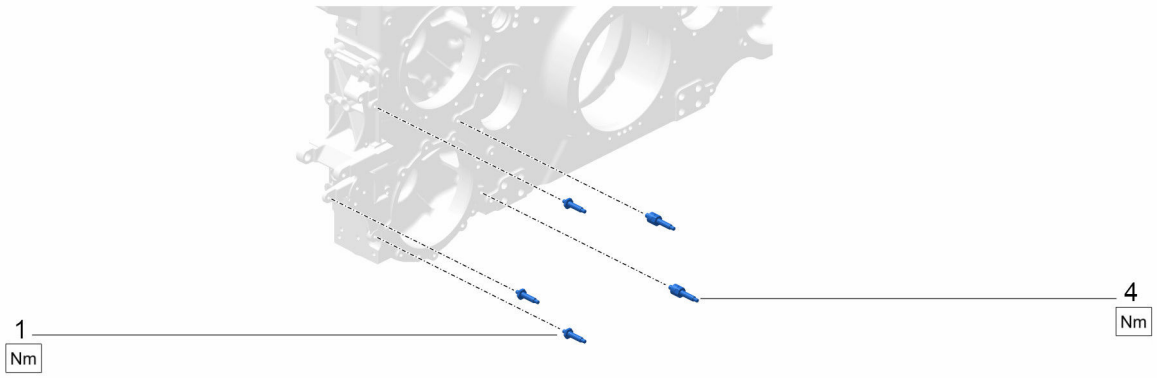


Fig. 56: Installing pins

- ▶ Screw pins **1, 4** on aggregate support and PTO bracket.

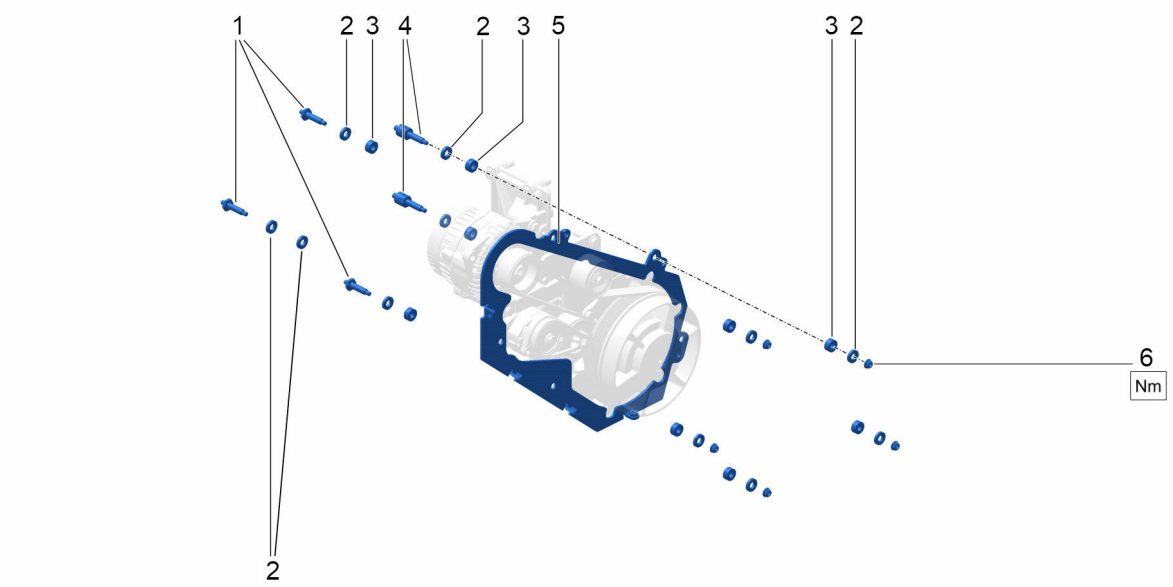


Fig. 57: Installing first part of cover

- ▶ Mount distance sleeves **2** and vibration dampers **3** on pins **1, 4**.
- ▶ Mount cover - back side **5** on pins **1, 4**.
- ▶ Mount distance sleeves **2** and vibration dampers **3** on pins **1, 4**.
- ▶ Screw cover with nuts **6**.

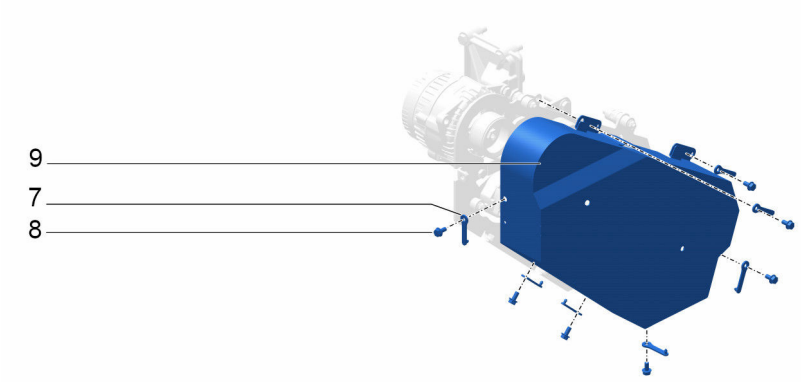


Fig. 58: Installing cover

- ▶ Mount cover **9** on pins **1, 4**.
- ▶ Fix cover **9** with lock washers **7** and screws **8**.

Specific values

Not applicable.

Tightening specifications

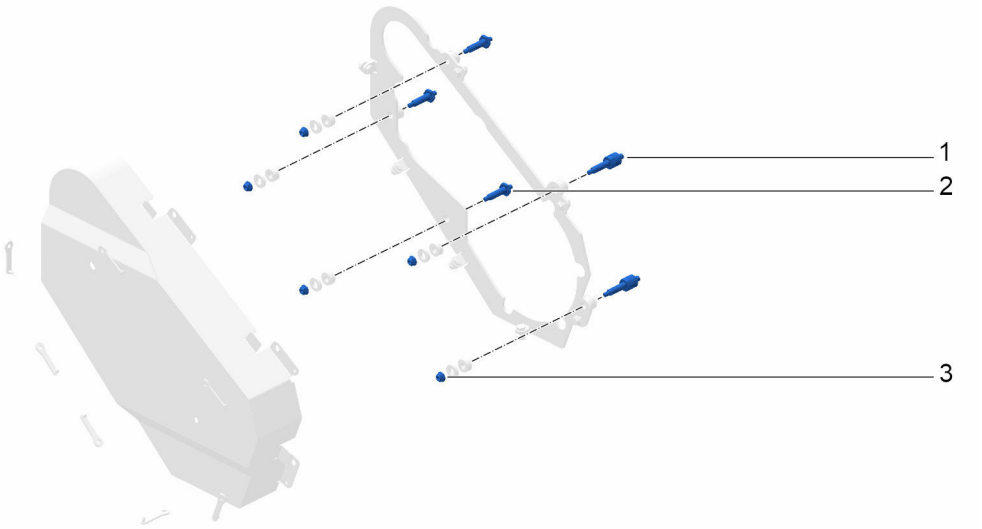


Fig. 59: Cover screws

Reference	Key	Screw specifications	Lubricant *	Reuse**	Torque		Angle (°)	
					Step	± 5%	Step	± 5°
1	440AA	M10x1,5x12	-	Yes	1	66 Nm 49 ft-lb	-	-
2	440AB	M10x1,25x12	-	Yes	1	34 Nm 25 ft-lb	-	-
3	440AC	EN 1664 M8-10-FLZN	-	Yes	1	34 Nm 25 ft-lb	-	-

Tab. 12: Tightening specifications table

*Lubricants:
MG = Molykote G-n-plus
MW = Castrol Optimol paste white T
MH = Molykote HSC
O = Engine oil
XX = Loctite 243
YY = Loctite 577

**Refer to screws reuse rules. (For more information see: 5.3.2 Screws pre-tightening, reuse and marking, page 274.)

3.2.3 Cylinder head cover removal and installation

Previous tasks

Not applicable.

Specific safety instructions

WARNING
Hot surfaces!
Could cause serious injury or death.
Engine is hot near operating temperature.

- ▶ Avoid any contact with the engine, parts carrying hot coolant or oil, the exhaust system, the turbocharger, the heat protection, the battery and the covers.
- ▶ After the temperature has cooled down to a level it can be touched, proceed with the tasks on the engine.

- ▶ Shut down the engine.
- ▶ Secure the area according to local lockout/tagout procedure.

Special tools

Not applicable.

Consumables and equipment

Not applicable.

Overview

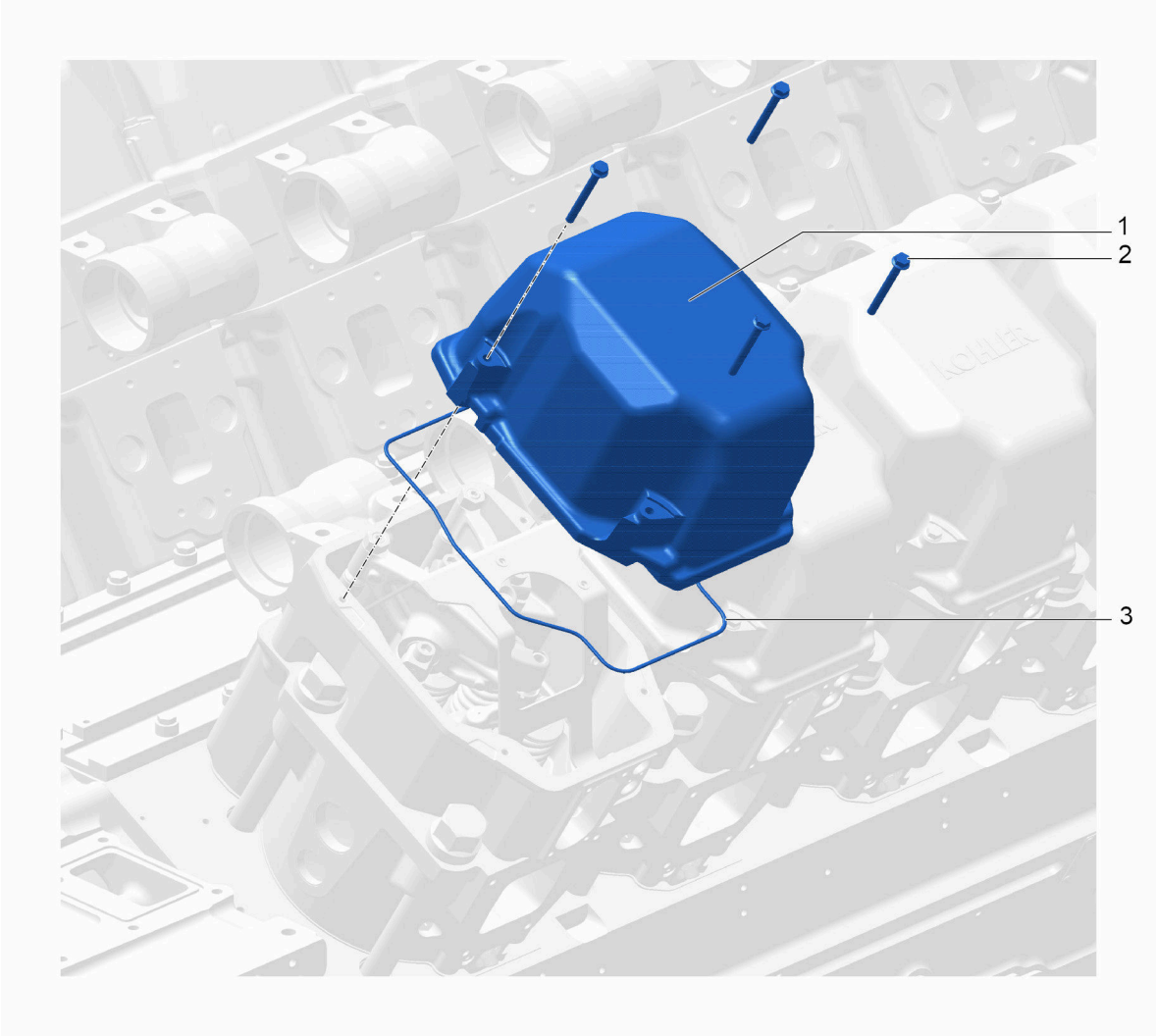


Fig. 60: Task overview

1 Cylinder head cover
2 Screw (M8)
3 Seal

Removal

- ▶ Remove screw **2**.
- ▶ Remove cylinder head cover **1** and seal **3**.

Installation

- ▶ Mount a new seal **3** on cylinder head cover **1**.
- ▶ Position screws **2** into the bores of the cylinder head cover **1**.
- ▶ Position cylinder head cover **1** on rocker arm housing.
- ▶ Tighten screws **2**.

Specific values

Not applicable.

Tightening specifications

Refer to standard tightening torques. (For more information see: 5.3 Standard tightening torques, page 274.)

3.3 Rocker arms

3.3.1 Rocker arms - Valve clearance set (SL 204)

Setting valve clearance

Previous tasks

- ❑ Remove cylinder head covers. (For more information see: 3.2.3 Cylinder head cover removal and installation, page 65.) .
- ❑ Install turning device. (For more information see: 4.1.2 Turning device, page 269.)

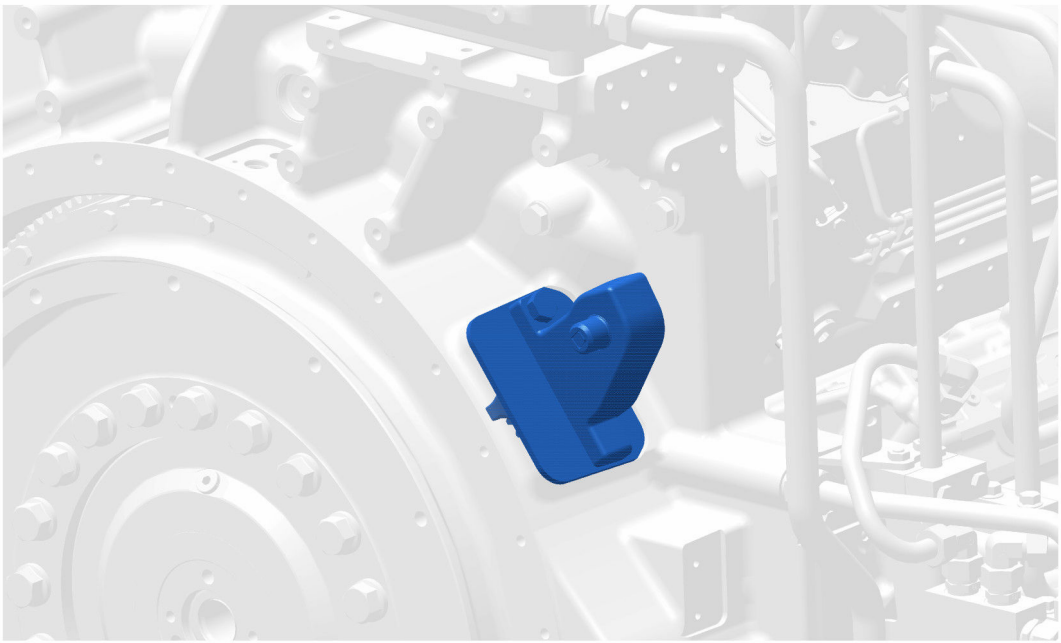


Fig. 61: Turning device installed

Specific safety instructions

WARNING
Injuries by contact with hot surfaces!
Engine is hot near operating temperature. The contact with hot surfaces could lead serious injuries or death.

- ▶ Avoid any contact with the engine, parts carrying hot coolant or oil, the exhaust system, the turbocharger, the heat protection, the battery, the covers.
- ▶ After the temperature has cooled down to a level it can be touched, proceed with the tasks on the engine.

Special tools

Special tool	Designation
 11133437	Turning device

Tab. 13: Special tools

Consumables and equipment

Not applicable.

Overview

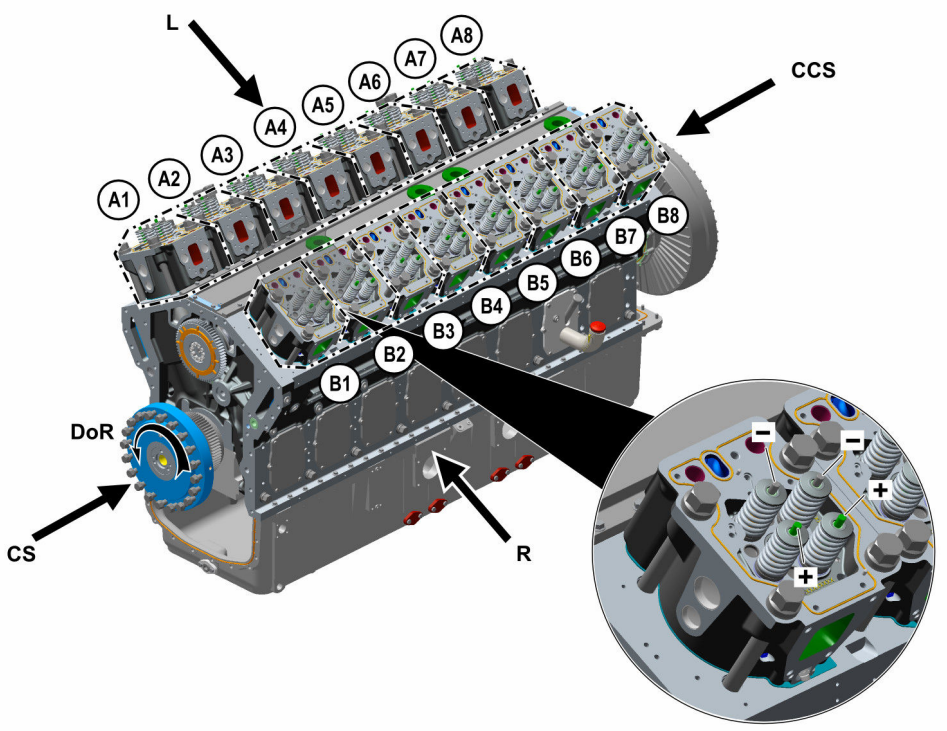


Fig. 63: Cylinder designation / direction of rotation according to ISO 1204

A1-A8 Series of cylinders
B1-B8 Series of cylinders
CS Engine rear (flywheel side)
CCS Engine front (damper side)
DoR Direction of rotation
- Exhaust valves
+ Inlet valves
L Left engine side
R Right engine side

Valve set order

Information

There is a marking on the flywheel to set the valve clearance.

The flywheel grooves 1 to 6 are identified in the picture below.

The valves must be set in the correct position for the matching cylinder.

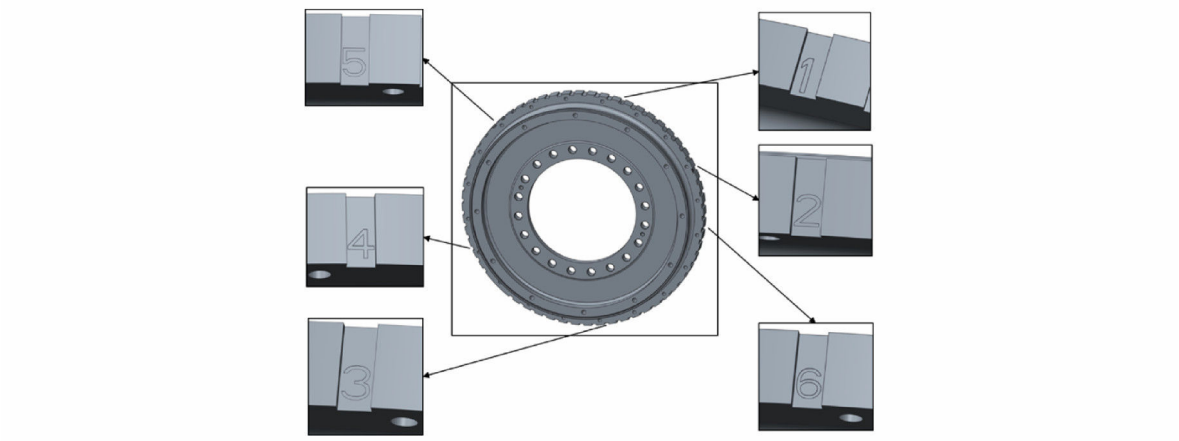


Fig. 64: Flywheel marking

Step	Start point	Groove N°	Sequence	V16	
				Bank A	Bank B
1	TDC overlap - A1	1	1st turn	No action	No action
2	-	2		**A7, A8**	**B2, B4**
3	-	6		No action	No action
4	-	3		No action	No action
5	-	4		**A3, A5**	**B6, B8**
6	-	5		No action	No action
7	TDC injection - A1	1	2nd turn	No action	No action
8	-	2		**A1, A2**	**B5, B7**
9	-	6		No action	No action
10	-	3		No action	No action
11	-	4		**A4, A6**	**B1, B3**

Tab. 14: Reference table for the flywheel positioning

Set the valve clearance

▶ Rotate crankshaft in direction of rotation with turning device to index **1**.

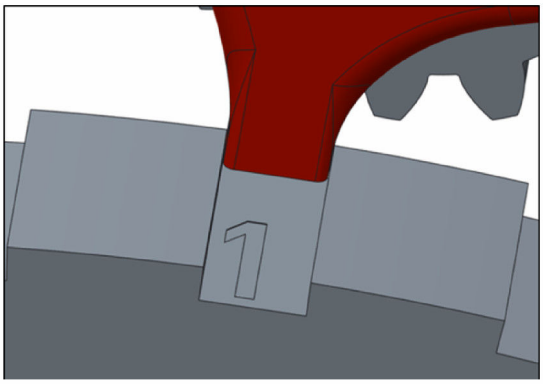


Fig. 65: Position of flywheel and turning device

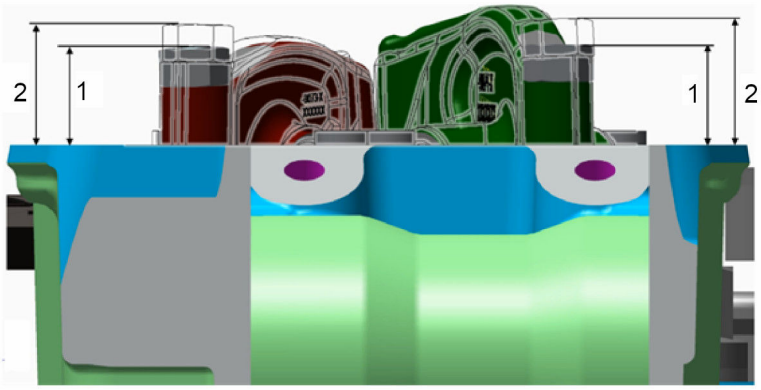


Fig. 66: TDC positions of cylinder A1

1 Rocker arm position in ignition TDC **2** Rocker arm position in overlap TDC

Step 1

▶ Check if cylinder **A1** is in TDC overlap position. If not, turn the crankshaft another 360°.

▶ Verify TDC overlap position again.

Step 2

▶ Rotate crankshaft in direction of rotation with turning device to index **2**.

▶ Set valve clearance for cylinders **A7**, **A8** and **B2**, **B4**. (For more information see: Checking valve clearance, page 74.) , (For more information see: Setting valve clearance, page 74.)

Step 3

▶ Pass flywheel groove index **6**.

Step 4

▶ Pass flywheel groove index **3**.

Step 5

▶ Stop at flywheel groove index **4**.

▶ Set valve clearance for cylinders **A3**, **A5** and **B6**, **B8**. (For more information see: Checking valve clearance, page 74.) , (For more information see: Setting valve clearance, page 74.)

Step 6

▶ Pass flywheel groove index **5**.

Step 7

▶ Pass flywheel groove index **1**.

Step 8

▶ Stop at flywheel groove index **2**.

▶ Set valve clearance for cylinders **A1**, **A2** and **B5**, **B7**. (For more information see: Checking valve clearance, page 74.) , (For more information see: Setting valve clearance, page 74.)

Step 9

▶ Pass flywheel groove index **6**.

Step 10

▶ Pass flywheel groove index **3**.

Step 11

▶ Stop at flywheel groove index **4**.

▶ Set valve clearance for cylinders **A4**, **A6** and **B1**, **B3**. (For more information see: Checking valve clearance, page 74.) , (For more information see: Setting valve clearance, page 74.)

Valve set order (alternative method)

Information

There is a marking on the flywheel to set the valve clearance.

The marking may become illegible.

The only possibility is to set by overlap position.

Ignition TDC*	A1	B7	A2	B5	A4	B3	A6	B1	A8	B2	A7	B4	A5	B6	A3	B8
Overlap TDC**	A8	B2	A7	B4	A5	B6	A3	B8	A1	B7	A2	B5	A4	B3	A6	B1
* Ignition order ** Opposite cylinder (overlap)																

Tab. 15: Valve set order

▶ Set cylinder to overlap TDC position.

▶ Adjust valve clearance of ignition TDC cylinder.

Checking valve clearance

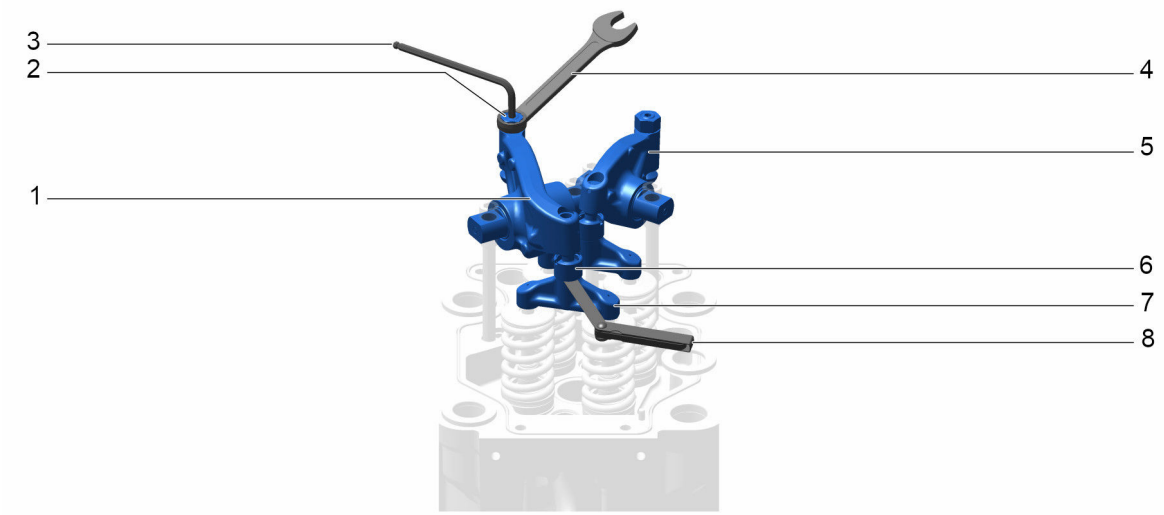


Fig. 67: Checking and adjusting valve clearance

1	Inlet rocker arm	**5**	Exhaust rocker arm
2	Locknut	**6**	Rocker ball cap
3	Allen key	**7**	Valve bridge
4	Key	**8**	Feeler gauge

▶ Check valve clearance of cylinder by entering feeler gauge between rocker ball cap **4** and valve bridge **5**. (For more information see: Specific values, page 74.)

▶ Move feeler gauge back and forth to sense the friction.
▷ The gauge shows a slight resistance when pulling.

Information

If the valve clearance is not correct, follow the valve set clearance procedure. (For more information see: Setting valve clearance, page 74.)

Setting valve clearance

▶ Loosen locknut **2** of inlet rocker arm **1**.

▶ Position feeler gauge with correct value between rocker ball cap **4** and valve bridge **5**. (For more information see: Specific values, page 74.)

▶ Turn the adjusting screw with allen key until the gauge shows a slight resistance when pulling.

▶ Tighten locknut while holding set screw with allen key in setting position.

▶ Re-check gauge tight fit.

▶ Repeat procedure for next valve.

▶ Mark cylinder when the operation is completed.

▶ Repeat entire procedure for exhaust rocker arm **5**.

Specific values

Use feeler gauge to set valve clearance.

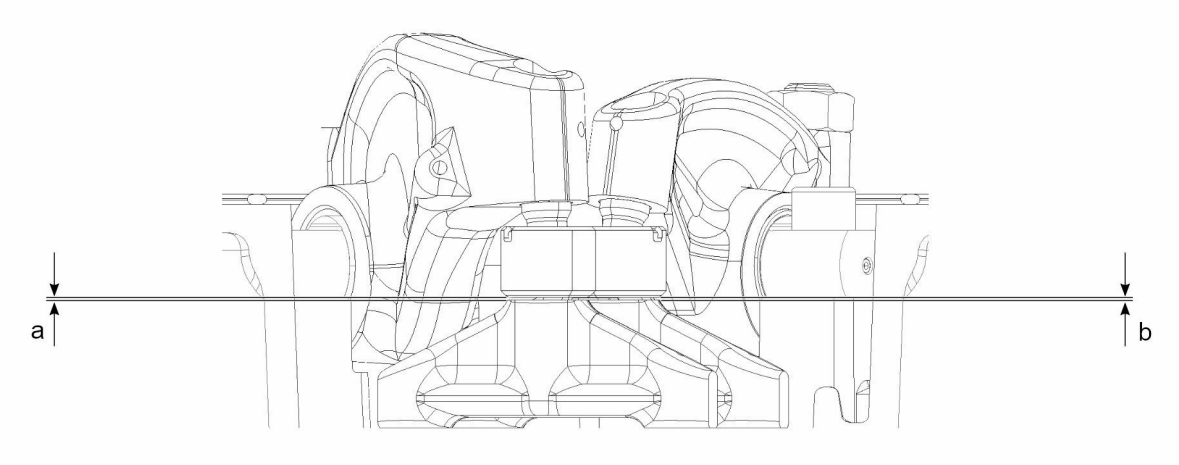


Fig. 68: Valve clearance

Reference	Denomination	Nominal value	Tolerance values			
			Upper value - Lower value	Maximum wear	Calculated gap min/max	Actual value
a	Inlet valve/ clearance	500 µm 19.69 th	+100 µm (3.94 th)	-	-	-
			0			
b	Exhaust valve/ clearance	1 mm 0.04 in	+100 µm (3.94 th)	-		-
			0			

Tab. 16: Tolerance values

Tightening specifications

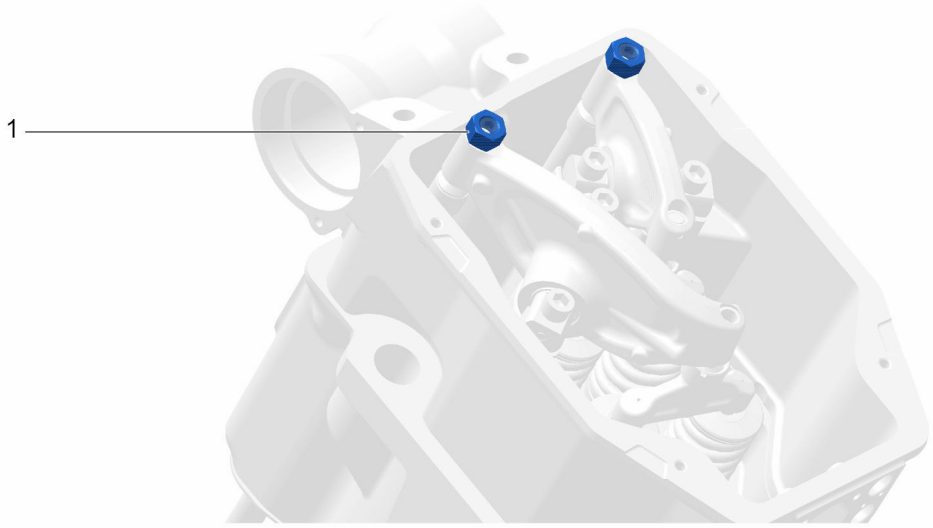


Fig. 69: Rocker arms locknuts

Reference	Key	Screw specifications	Lubricant *	Reuse**	Torque		Angle (°)	
					Step	± 5%	Step	± 5°
1	081AA	DRW 11132681	O	Yes	1	40 Nm 30 ft-lb	-	-

Tab. 17: Tightening specifications table

*Lubricants:
MG = Molykote G-n-plus
MW = Castrol Optimol paste white T
MH = Molykote HSC
O = Engine oil
XX = Loctite 243
YY = Loctite 577

**Refer to screws reuse rules. (For more information see: 5.3.2 Screws pre-tightening, reuse and marking, page 274.)

3.3.2 Inlet and outlet rocker arms removal and installation

Previous tasks

- ❑ Remove retaining plate and high pressure pipe. (For more information see: 3.6.4 Injector removal and installation (SL 205), page 122.)
- ❑ Remove cylinder head covers. (For more information see: 3.2.3 Cylinder head cover removal and installation, page 65.)

Specific safety instructions

Not applicable.

Special tools

Special tool	Designation
 11133437	Turning device. (For more information see: Use the turning device, page 270.) .

Tab. 18: Special tools

Consumables and equipment

– Engine oil
– Rags
– Cleaner

Overview

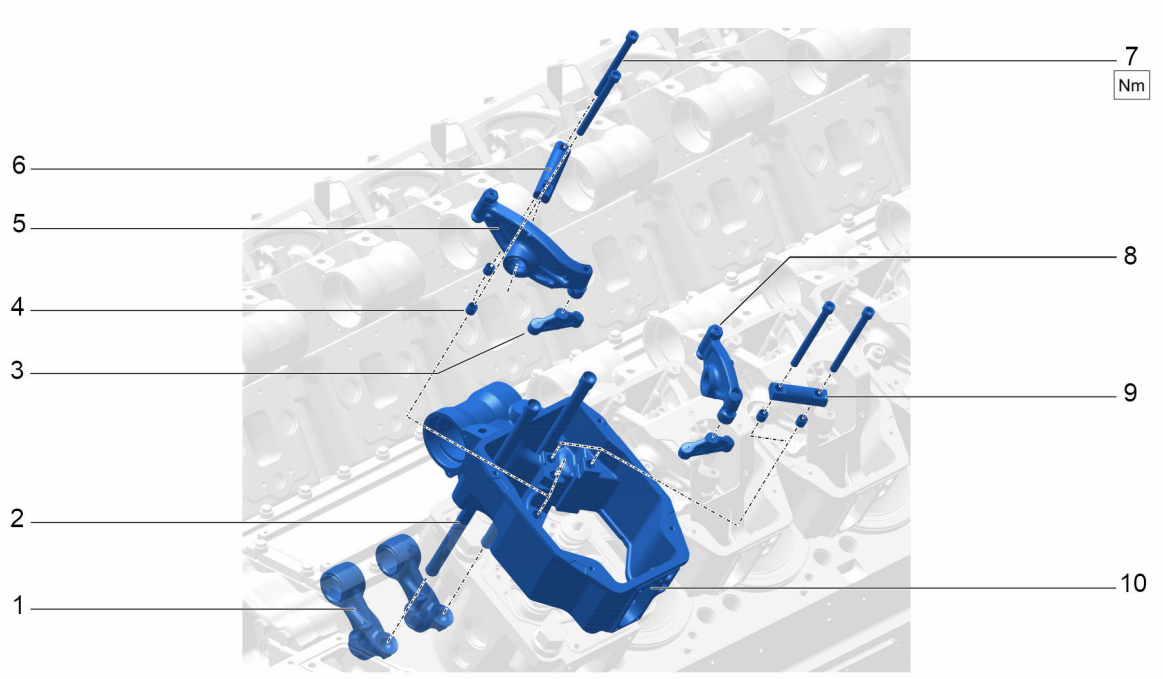


Fig. 71: Task overview

1 Swing follower
2 Pushrod
3 Valve bridge
4 Fitting sleeve
5 Inlet rocker arm
6 Inlet shaft
7 Screw (M12)
8 Exhaust rocker arm
9 Exhaust shaft
10 Rocker arm housing

Removal

WARNING
The valve springs must not be under stress.
Risk of injuries.

▶ Turn crankshaft to firing TDC position using turning device.

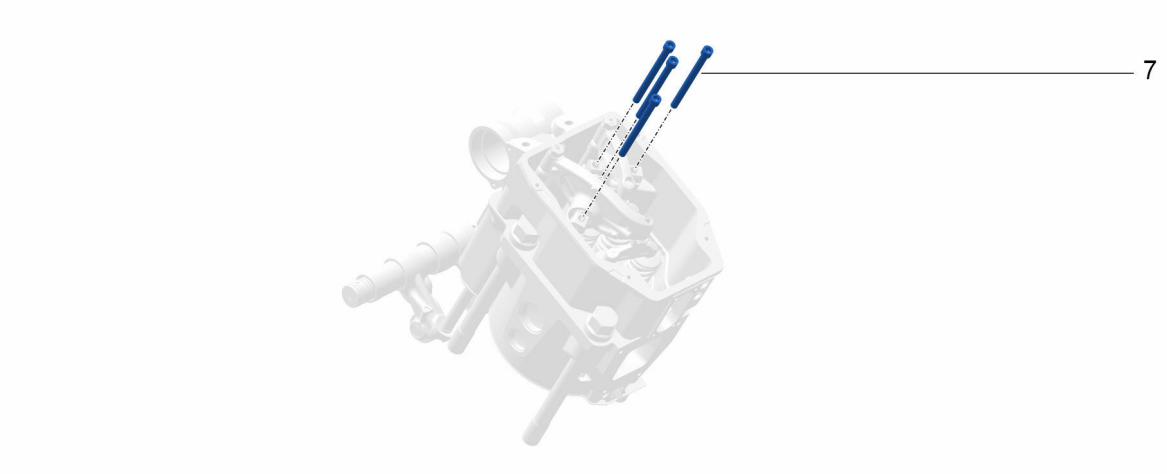


Fig. 72: Removing screws

▶ Remove screws **7**.

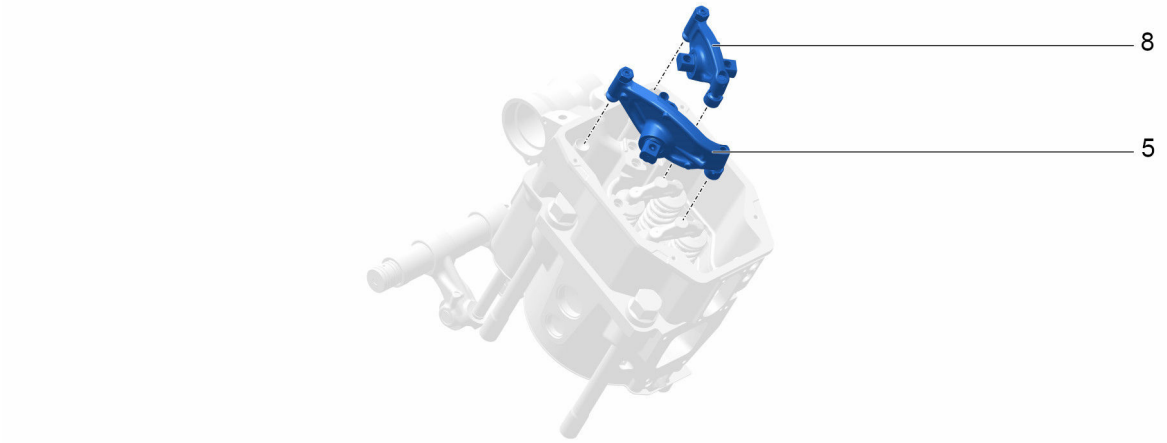


Fig. 73: Removing rocker arms

▶ Remove inlet rocker arm assembly **5** and exhaust rocker arm assembly **8**.

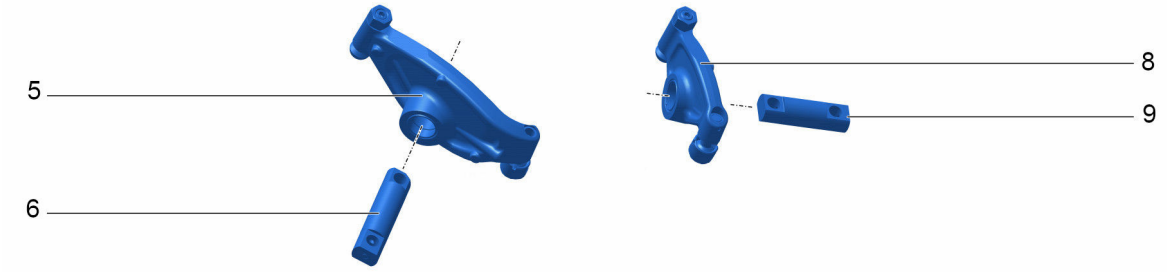


Fig. 74: Removing shafts from rocker arms

▶ Remove inlet shaft **6** from inlet rocker arm **5**.

▶ Remove exhaust shaft **9** from exhaust rocker arm **8**.

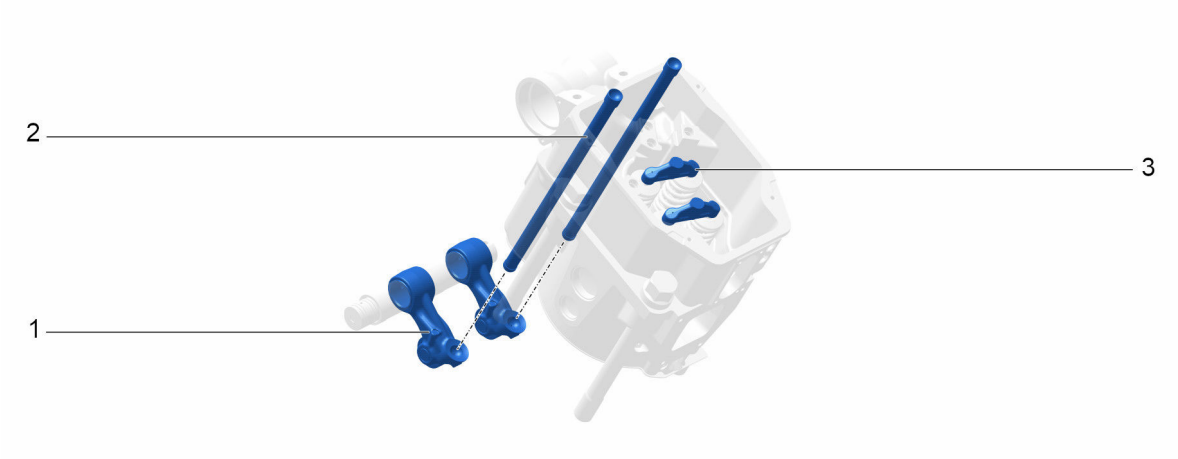


Fig. 75: Removing pushrods and valve bridges

▶ Remove valve bridges **3** and pushrods **2** from swing followers **1**.

Installation

Information

Put matching cylinder in firing TDC position.

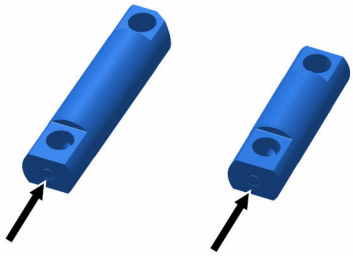


Fig. 76: Preparing inlet and exhaust shafts

▶ Inspect presence of plug in inlet shaft and exhaust shaft.

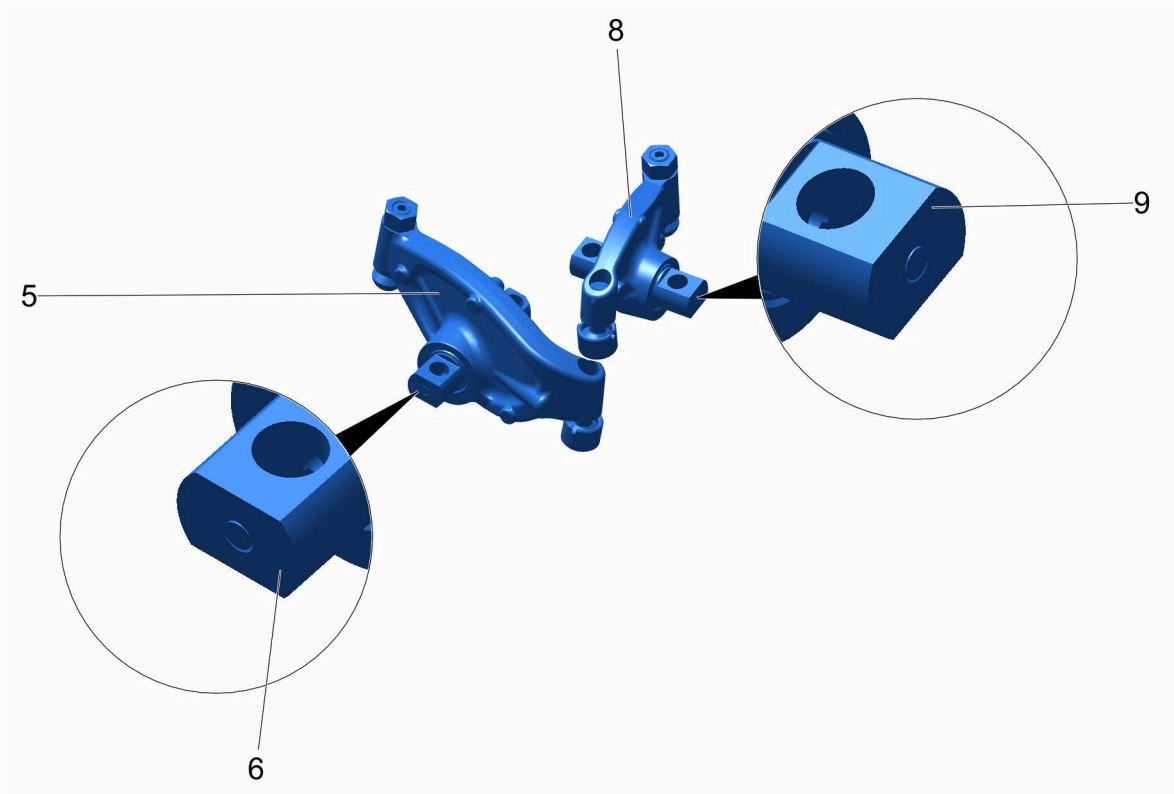


Fig. 77: Pre-mounting rockers arms

- ▶ Insert inlet shaft **6** into inlet rocker arm **5**, making sure the plug on the shaft faces outwards.
- ▶ Insert exhaust shaft **9** into exhaust rocker arm **8**, making sure the plug on the shaft faces outwards.

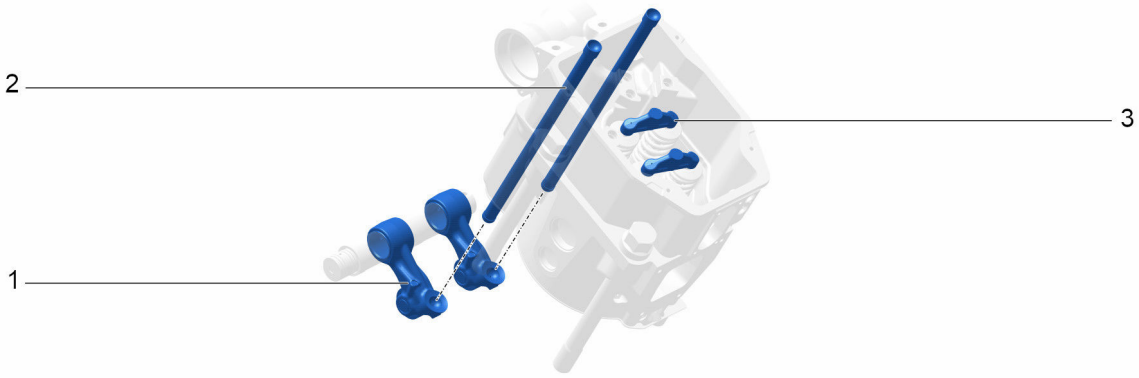


Fig. 78: Installing pushrods and valve bridges

- ▶ Insert pushrods **2** into cylinder head and fit it with swing followers **1**.
- ▶ Insert valve bridges **3** into inlet and exhaust valves.

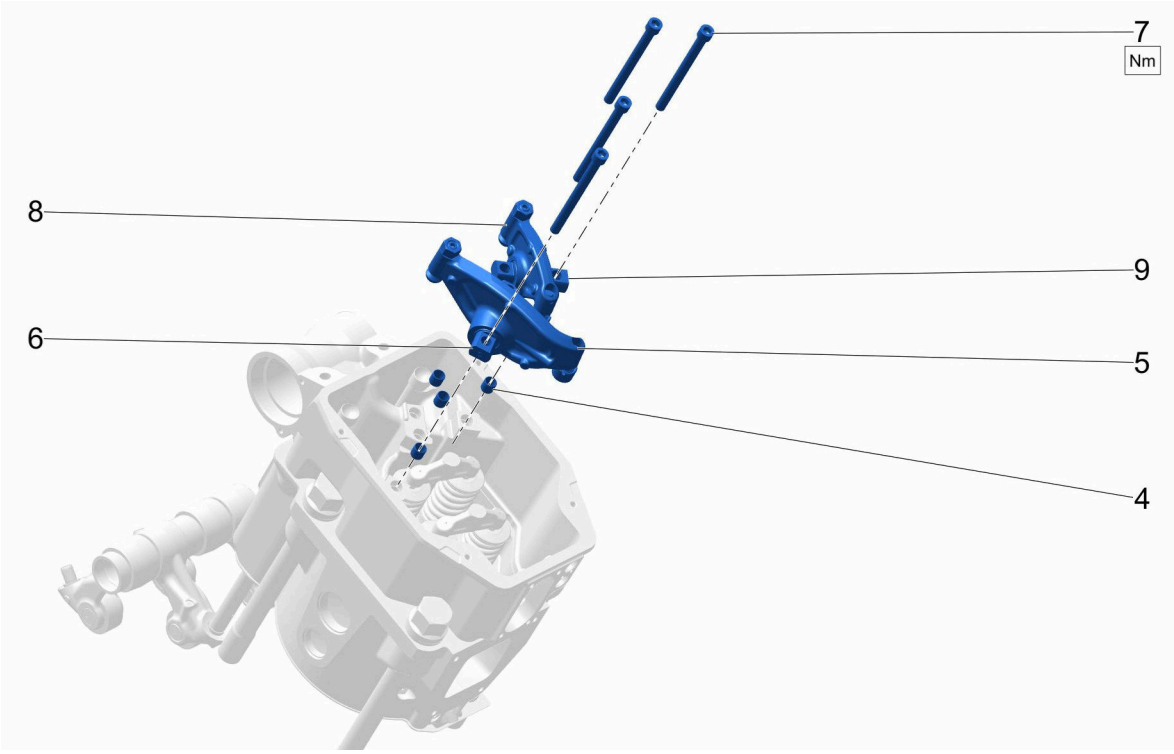


Fig. 79: Installing screws

▶ Screw and fit rocker arms with screws **7** in inlet shaft, exhaust shaft and fitting sleeves **4**.

Specific values

(For more information see: 3.3.1 Rocker arms - Valve clearance set (SL 204), page 69.)

Tightening specifications

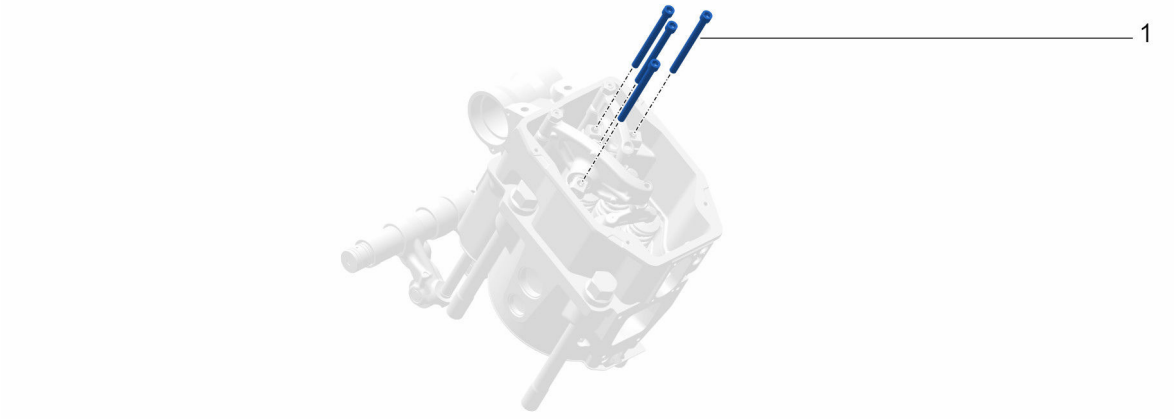


Fig. 80: Rocker arms screws

Reference	Key	Screw specifications	Lubricant *	Reuse**	Torque		Angle (°)	
					Step	± 5%	Step	± 5°
1	081AC	ISO 4762 M12x1.75x150-10.9	O	Yes	1	100 Nm 74 ft-lb	-	-

Tab. 19: Tightening specifications table

*Lubricants:
MG = Molykote G-n-plus
MW = Castrol Optimol paste white T
MH = Molykote HSC
O = Engine oil
XX = Loctite 243
YY = Loctite 577

**Refer to screws reuse rules. (For more information see: 5.3.2 Screws pre-tightening, reuse and marking, page 274.)

3.3.3 Rocker arms housing removal and installation

Previous tasks

- ❑ Drain HT coolant.
- ❑ Remove turbochargers. (For more information see: 3.8.3 Exhaust gas turbocharger removal and installation (SL 213), page 170.) .
- ❑ Remove turbocharger brackets. (For more information see: 3.8.5 Turbocharger brackets removal and installation, page 180.) .
- ❑ Remove retaining plate. (For more information see: 3.6.4 Injector removal and installation (SL 205), page 122.) .
- ❑ Remove inlet and outlet rocker arms. (For more information see: 3.3.2 Inlet and outlet rocker arms removal and installation, page 76.)
- ❑ Remove high pressure pipes. (For more information see: 3.6.2 High pressure pipes removal and installation, page 113.)

Specific safety instructions

– Set cylinders to ignition TDC position.

Special tools

Special tool	Designation
 11343242	Coolant connector pipe tool

Tab. 20: Special tools

Consumables and equipment

– Engine oil
– Rags
– Cleaner

Overview

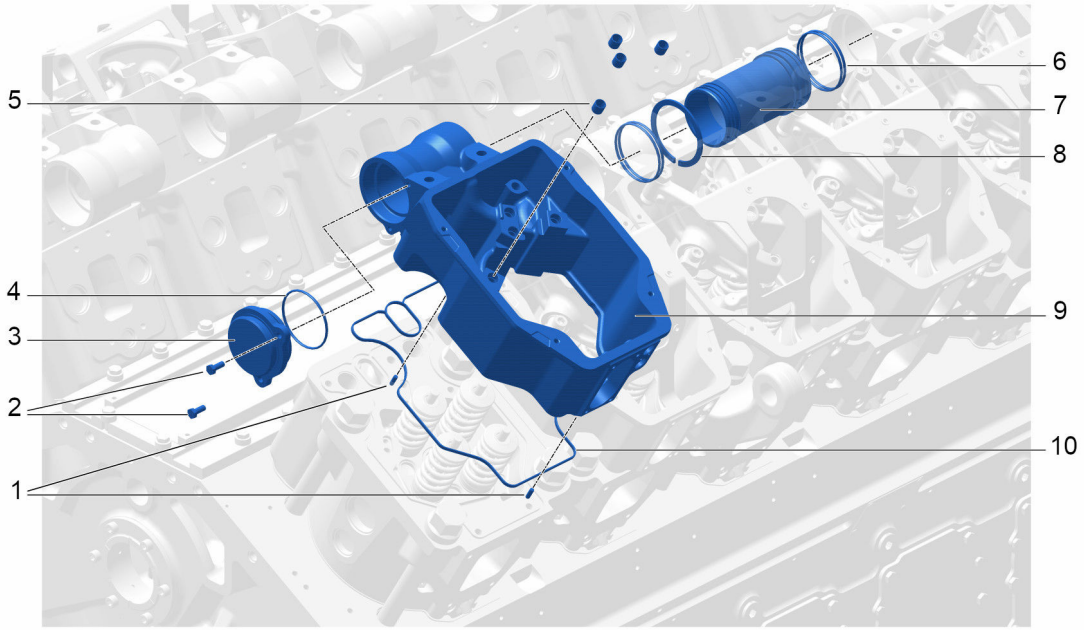


Fig. 82: Task overview

1 Positioning pin
2 Screw (M8)
3 Closing cover
4 Seal
5 Fitting sleeve (x5)
6 Seal (x4)
7 Coolant pipe HT
8 Locking ring
9 Rocker arm housing
10 Seal

Removal

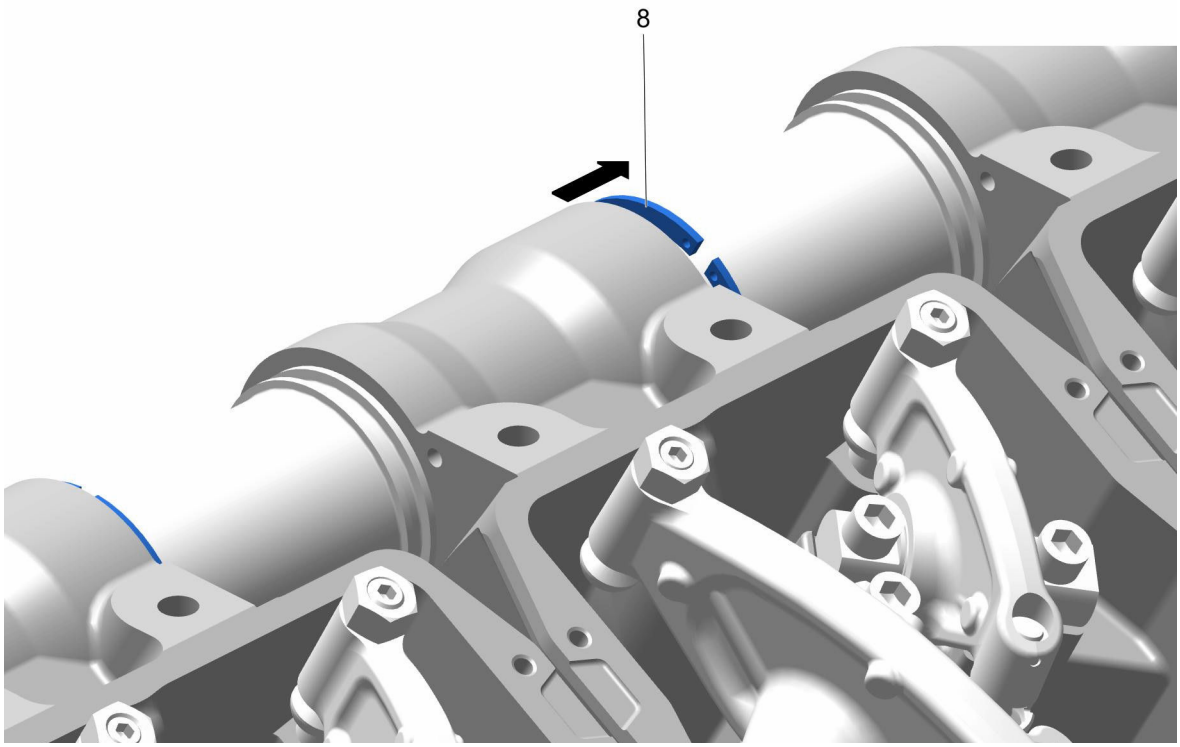


Fig. 83: Sliding locking ring

▶ Slide locking ring **8**.

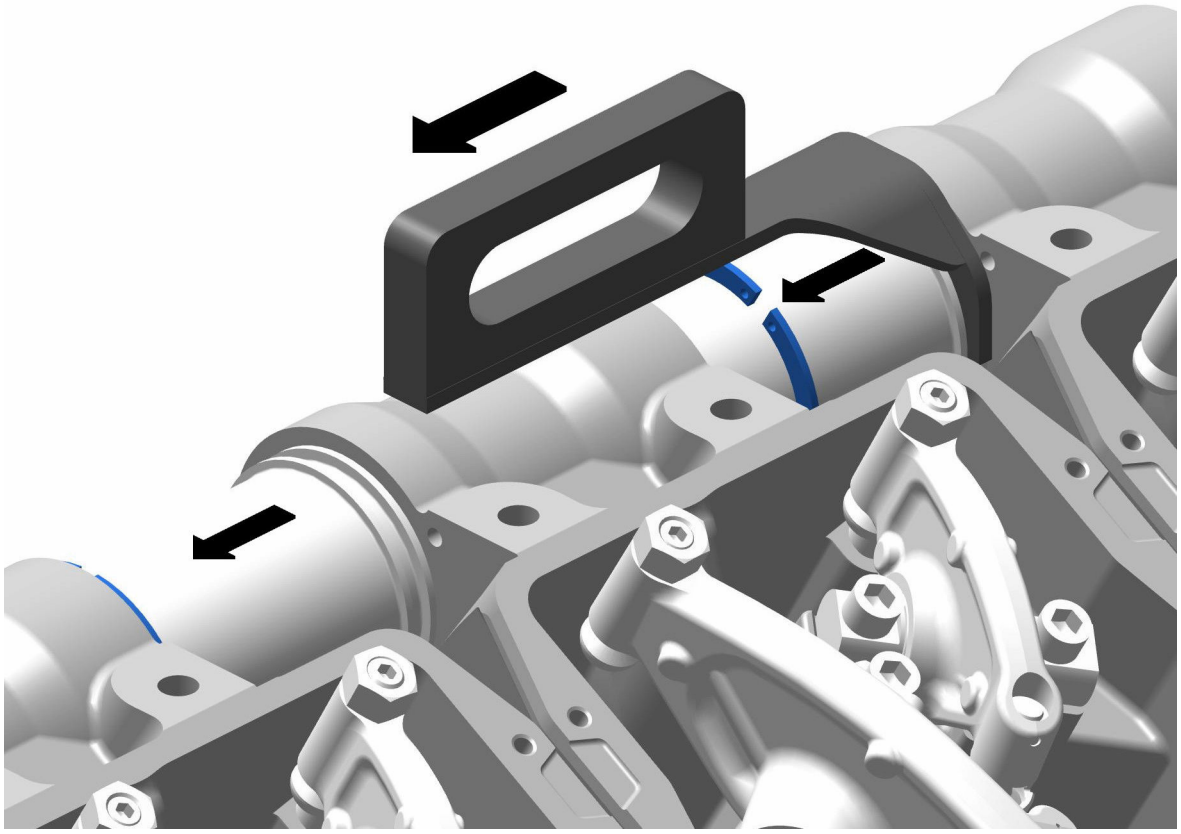


Fig. 84: Placing tool

- ▶ Place tool on pipe.
- ▶ Slide pipes out of rocker arm housing.

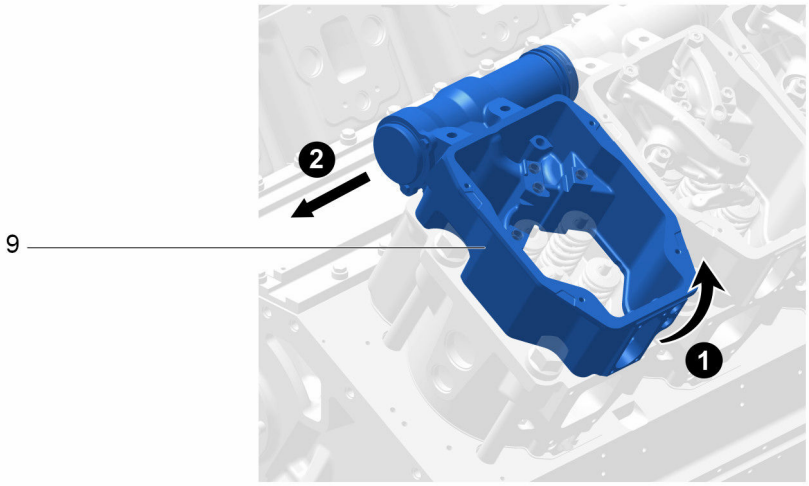


Fig. 85: Removing rocker arm housing

- ▶ Lift rocker arm housing **9**.
- ▶ Move rocker arm housing and coolant pipe HT to remove the assembly.

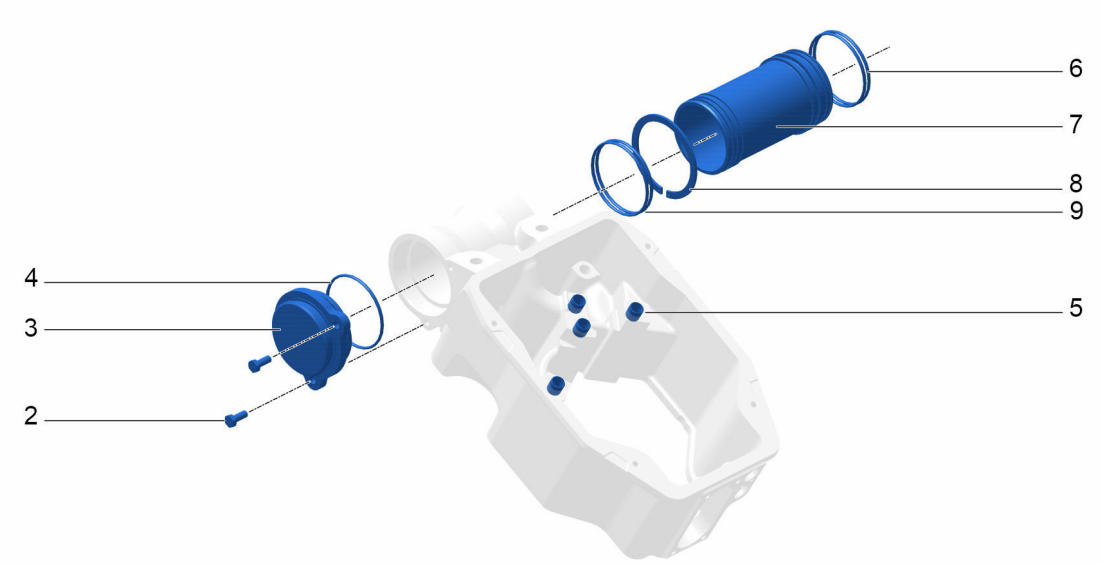


Fig. 86: Removing coolant pipe HT and closing cover

- ▶ Remove screws **2** and locking ring **8**.
- ▶ Separate rocker arm housing from coolant pipe HT **7** and closing cover **3**.
- ▶ Remove seals **4, 6** from closing cover and coolant pipe HT.
- ▶ Remove fitting sleeves **5**.

Installation

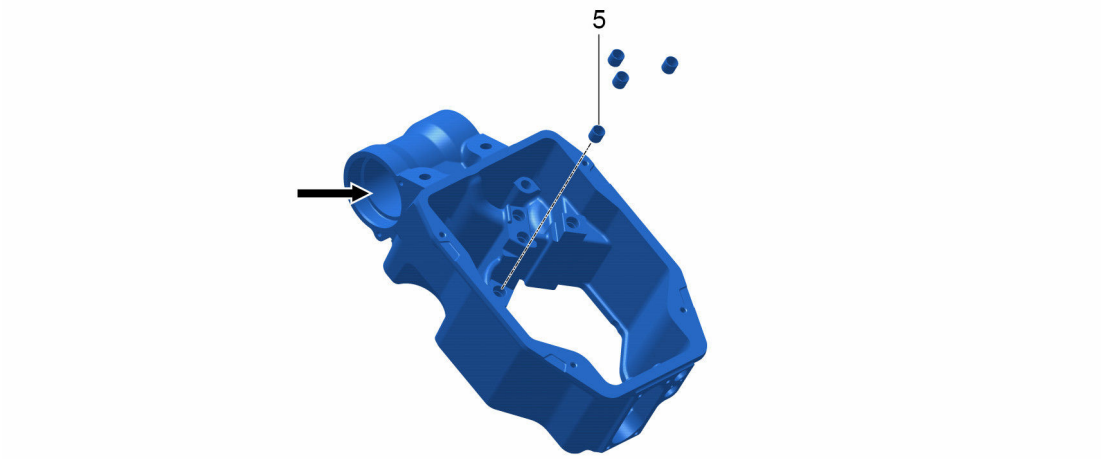


Fig. 87: Preparing rocker arm housing

- ▶ Grease coolant pipe.
- ▶ Insert fitting sleeves **5**.

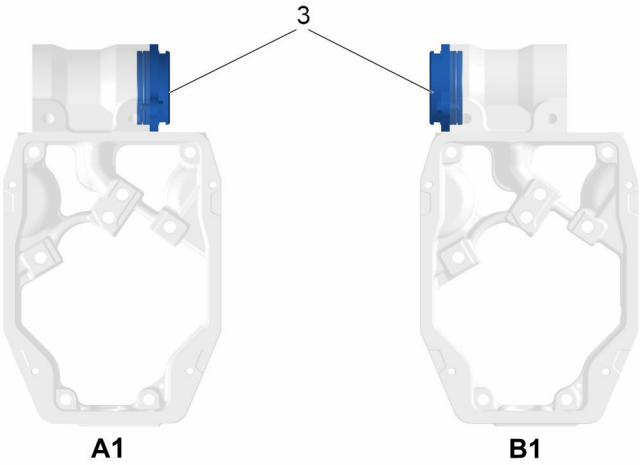


Fig. 88: Mounting closing cover

▶ Mount closing cover **3** on rocker arm housing with screws **2** and seal **4**.

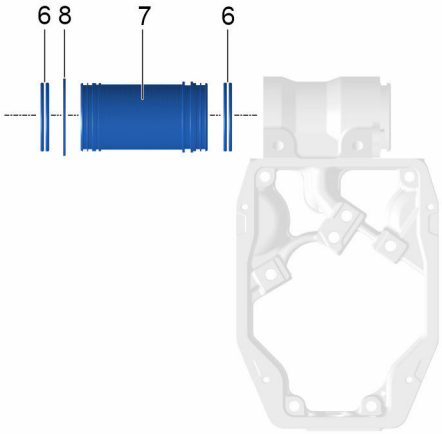


Fig. 89: Mounting coolant pipe HT

▶ Put seals **6** and locking ring **8** on coolant pipe HT **7**.

▶ Insert coolant pipe HT **7** in rocker arm housing.

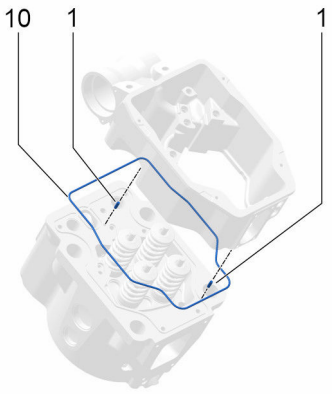


Fig. 90: Inserting pins and seal

- ▶ Position seal **10** on cylinder head.
- ▶ Insert positioning pins **1** in rocker arm housing.

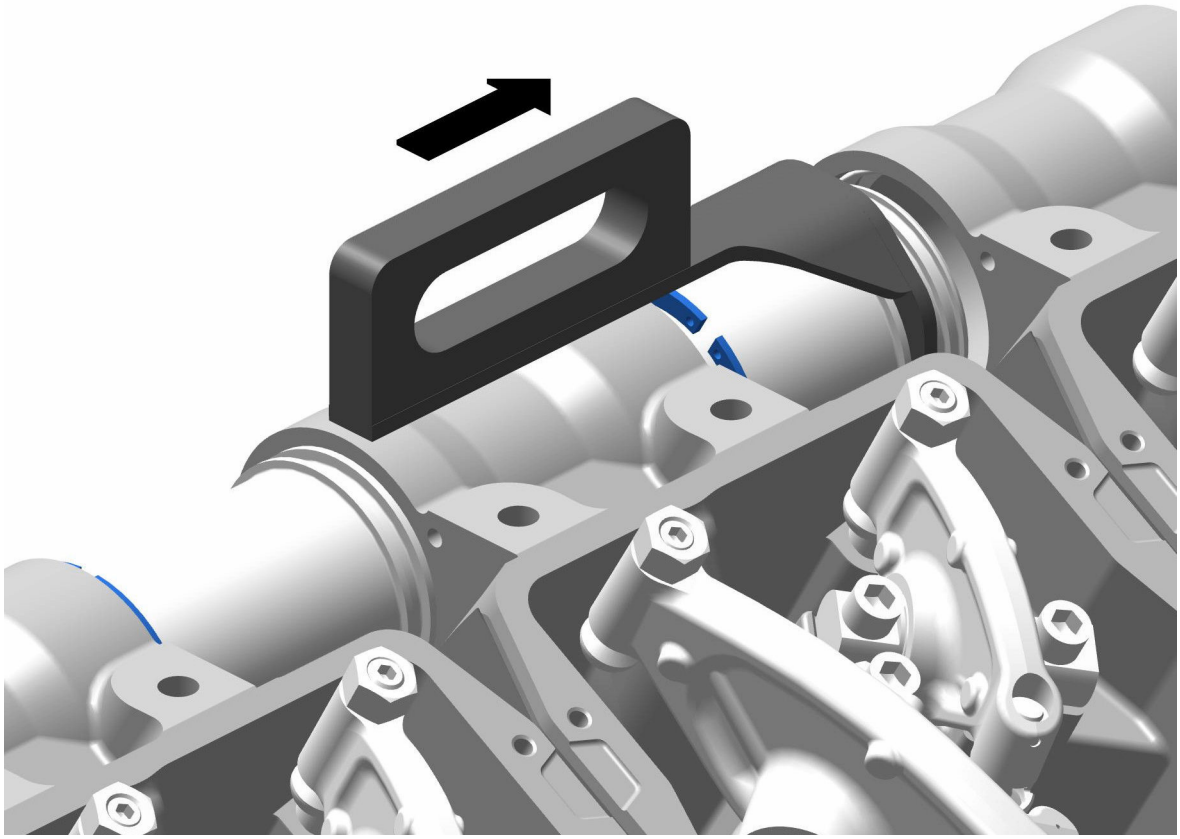


Fig. 91: Placing tool

Information

Tighten screws from inlet and outlet rocker arms.

- ▶ Place tool on pipe.
- ▶ Insert pipe into rocker arm housing.

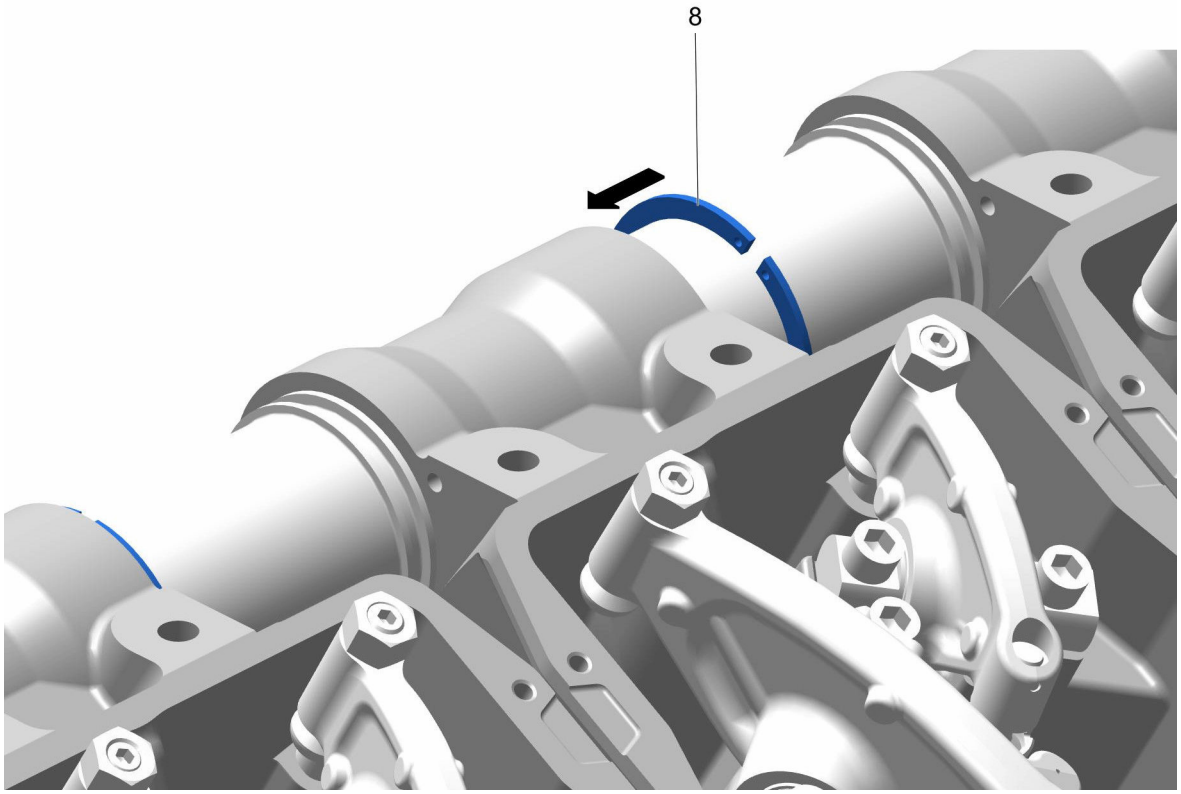


Fig. 92: Installing locking ring

- ▶ Secure pipe with locking ring **8**.
- ▶ Mount rocker arm housing on cylinder head.

Information

Vent cooling system at the end of installation.

Specific values

Not applicable.

Tightening specifications

Refer to standard tightening torques. (For more information see: 5.3 Standard tightening torques, page 274.)

3.4 Cylinder head (SL 224)

3.4.1 Cylinder head removal and installation

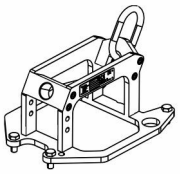
Previous tasks

- ❑ Remove turbochargers. (For more information see: 3.8.3 Exhaust gas turbocharger removal and installation (SL 213), page 170.)
- ❑ Remove turbocharger brackets. (For more information see: 3.8.5 Turbocharger brackets removal and installation, page 180.)
- ❑ Remove rocker arm housings. (For more information see: 3.3.3 Rocker arms housing removal and installation, page 82.)
- ❑ Remove exhaust pipes to turbocharger. (For more information see: Previous tasks, page 161.)
- ❑ Remove inlet and outlet rocker arms. (For more information see: 3.3.2 Inlet and outlet rocker arms removal and installation, page 76.)
- ❑ Remove admission pipes to turbocharger. (For more information see: 3.8.1 Admission pipes to turbocharger removal and installation, page 159.)
- ❑ Remove retaining plate. (For more information see: 3.6.4 Injector removal and installation (SL 205), page 122.)
- ❑ Remove oil supply turbocharger. (For more information see: 3.8.4 Oil supply – turbocharger removal and installation, page 175.)
- ❑ Remove air intake line. (For more information see: 3.7.1 Air intake line removal and installation, page 140.)
- ❑ Remove return pipes. (For more information see: 3.6.1 Fuel return and venting pipes removal and installation, page 110.)

Specific safety instructions

Not applicable.

Special tools

Special tool	Designation
 12588878	Cylinder head lifting device
No illustration	Socket
No illustration	Torque spanner
No illustration	Marker
No illustration	Electric torque multiplier or manual torque multiplier
No illustration	Torque reaction arm for electric torque multiplier or manual torque multiplier
No illustration	Spare battery pack for electric torque multiplier only
No illustration	Battery charger 110V for electric torque multiplier only
No illustration	Battery charger 230V for electric torque multiplier only

Special tool	Designation
No illustration	Adapter

Tab. 21: Special tools

Consumables and equipment

– Vaseline
– Castrol Optimol paste white T
– Rags
– Cleaner

Overview

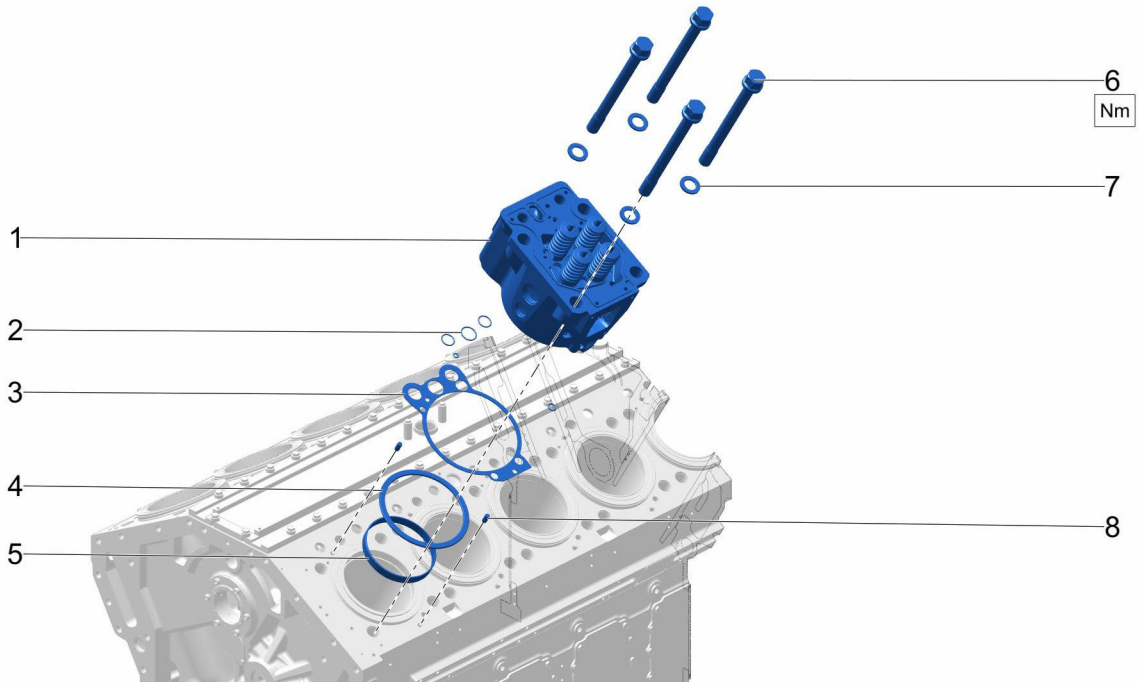


Fig. 94: Task overview

1 Cylinder head
2 O-ring set
3 Seal carrier
4 Cylinder head gasket (soft metal)
5 Flame ring
6 Bolt (M30)
7 Washer
8 Locating pin

Removal

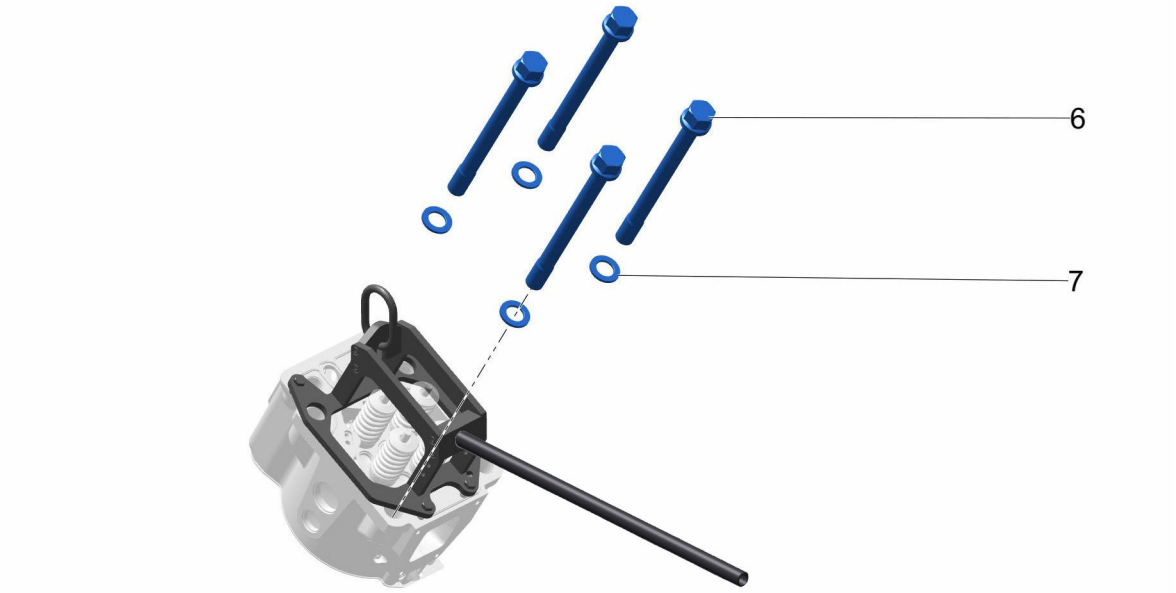


Fig. 95: Lifting the cylinder head

- ▶ Unscrew bolts **6** with washers **7**.
- ▶ Mount lifting device on cylinder head.
- ▶ Lift and push cylinder head up and down to dismantle it.
- ▶ Remove cylinder head.
- ▶ Remove cylinder head gasket **4**.
- ▶ Remove flame ring **5**.

Installation

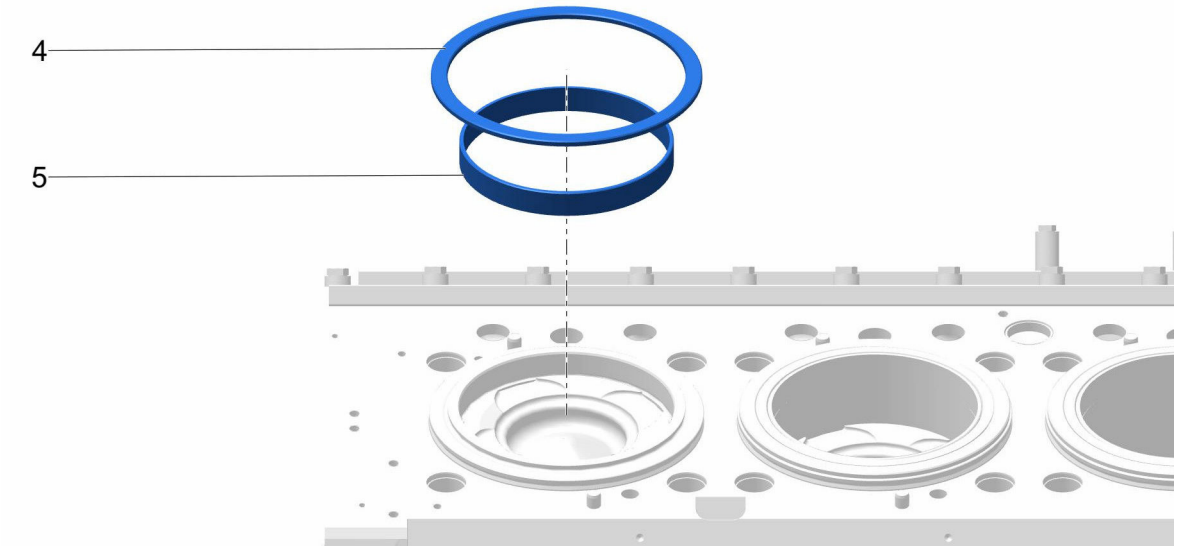


Fig. 96: Installing cylinder head gasket and flame ring

- ▶ Mount cylinder head gasket **4** on liner.
- ▶ Mount flame ring **5** in liner.

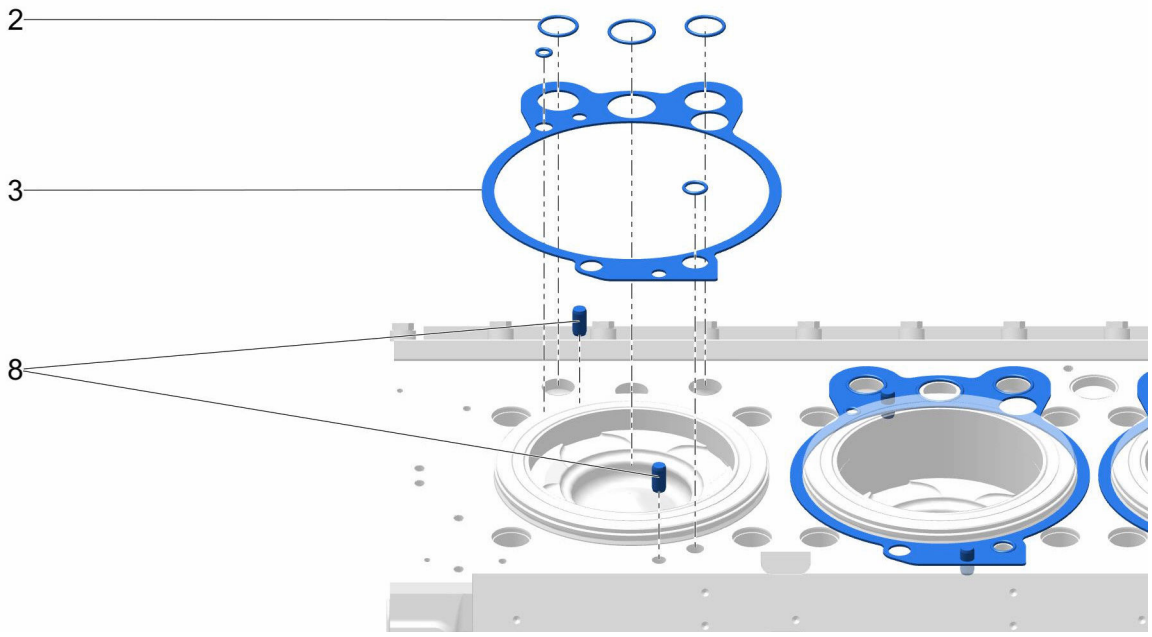


Fig. 97: Installing sealing carrier and O-rings

- ▶ Mount locating pins **8**.
- ▶ Mount seal carrier **3** with O-rings **2**.
- ▶ Grease O-rings **2**.

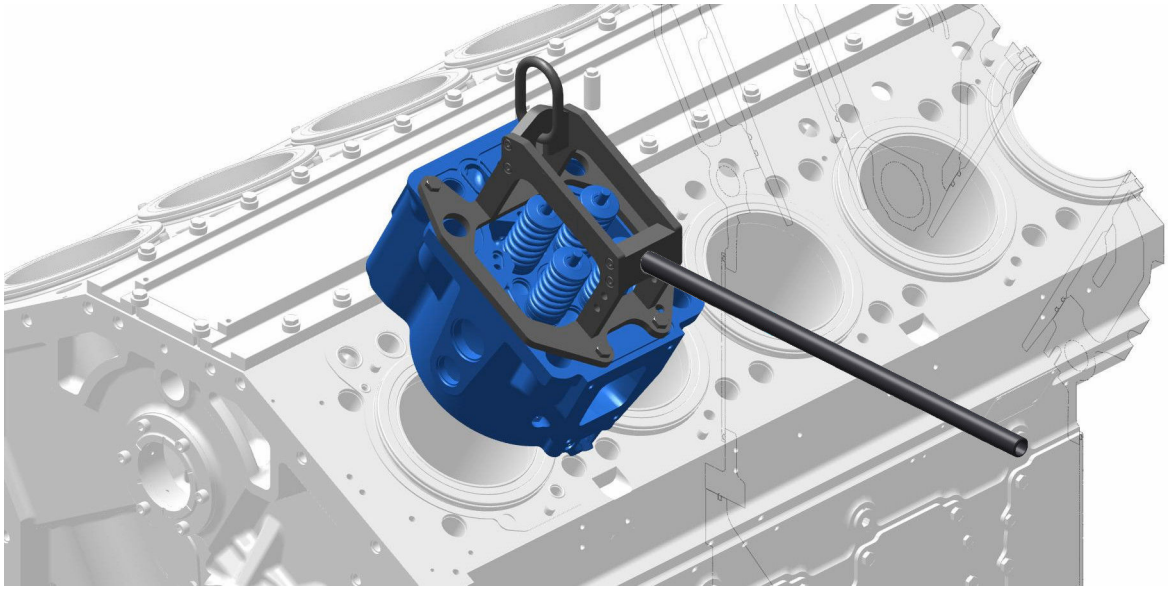


Fig. 98: Installing cylinder head

- ▶ Mount lifting device on cylinder head.
- ▶ Mount cylinder head.

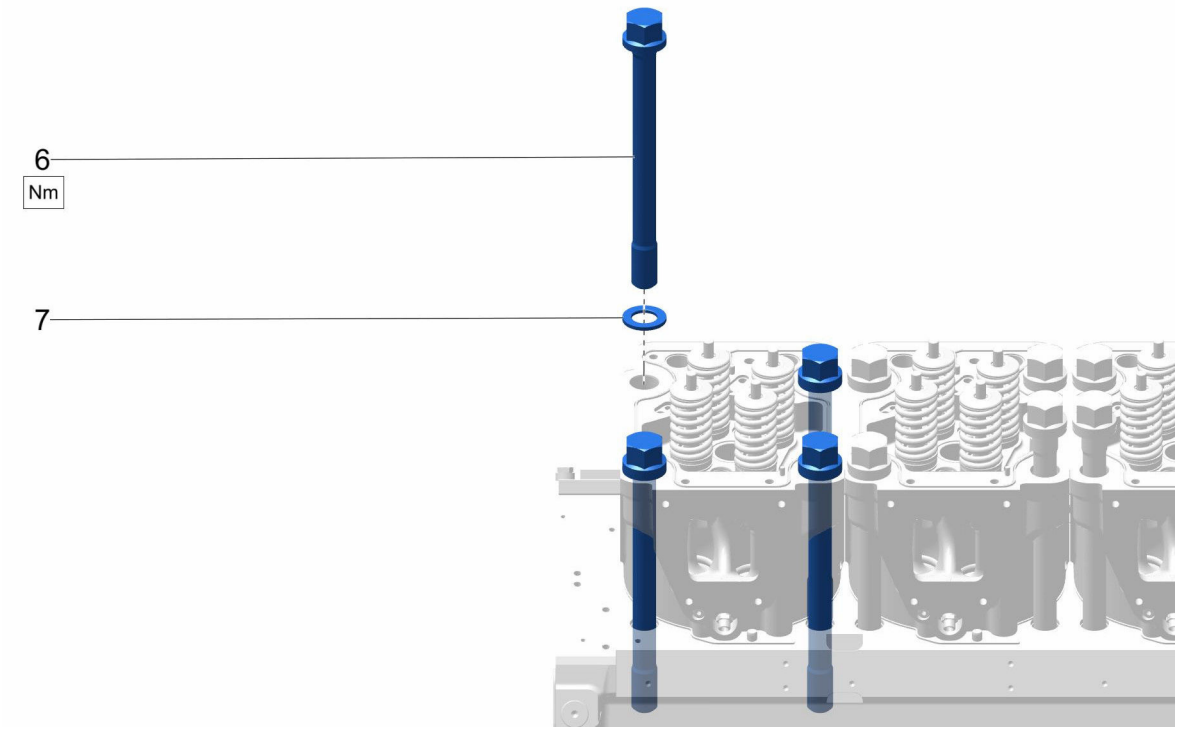


Fig. 99: Inserting cylinder head bolts

- ▶ Lubricate bolts **6** and washers **7** with Castrol Optimol paste white T.
- ▶ Insert and tighten the bolts.

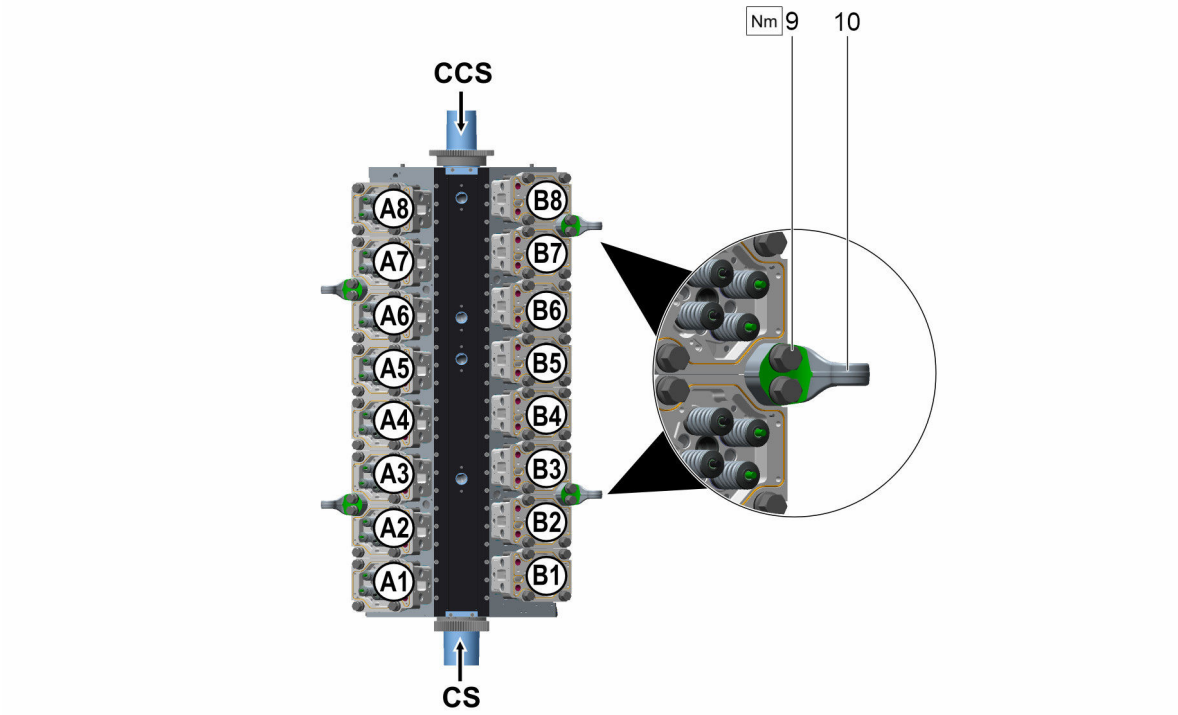


Fig. 100: Mounting lifting lug

- ▶ Mount lifting lug **10** with extended length bolts **9**.

- ▶ Lubricate bolts **9** with Castrol Optimol paste white T.
- ▶ Insert and tighten the bolts.

Information

If cylinder heads are connected with a lifting lug bracket, both need to be taken off and replaced.

Information

Vent coolant circuit at the end of installation.

Specific values

Not applicable.

Tightening specifications

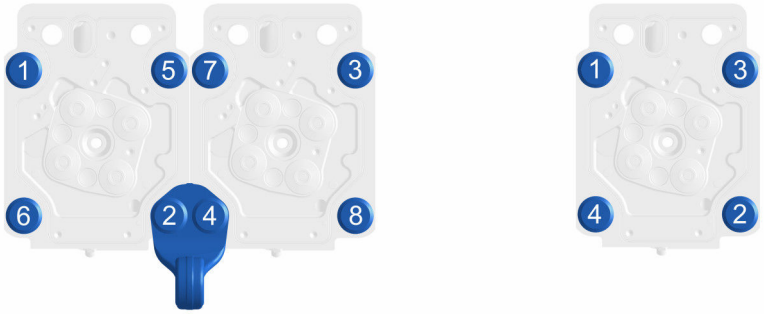


Fig. 101: Cylinder head tightening sequence

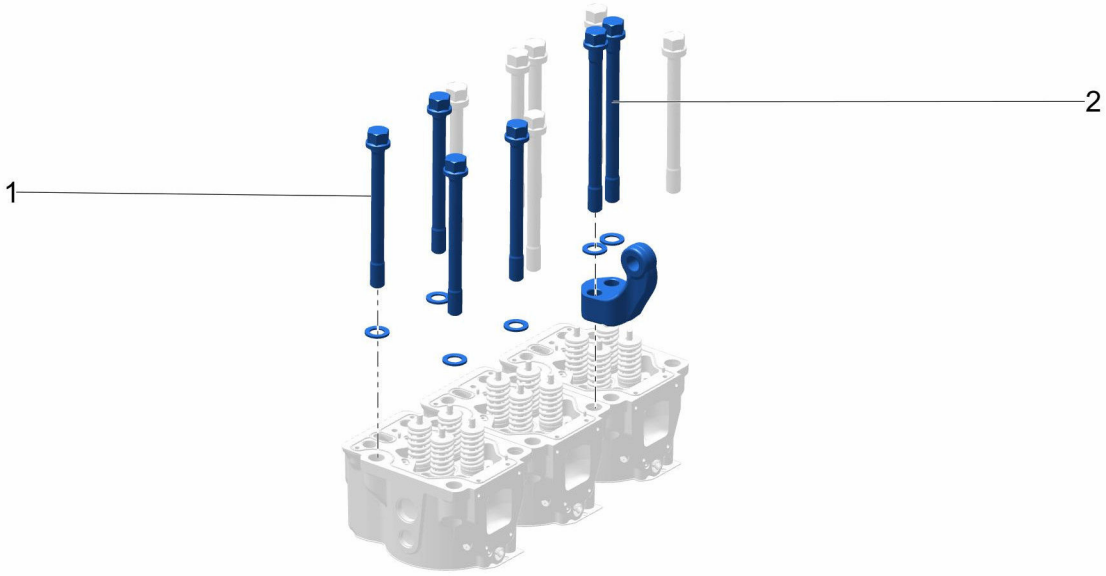


Fig. 102: Cylinder head bolts

Reference	Key	Screw specifications	Lubricant *	Reuse**	Torque		Angle (°)	
					Step	± 5%	Step	± 5°
1	080AA	DRW 11342809 M30x2x322	MW	No	1	250 Nm 184 ft-lb	2	180°
2	080AB	DRW 11342818 M30x2x377	MW	No	1	280 Nm 207 ft-lb	2	180°

Tab. 22: Tightening specifications table

*Lubricants:
MG = Molykote G-n-plus
MW = Castrol Optimol paste white T
MH = Molykote HSC
O = Engine oil
XX = Loctite 243
YY = Loctite 577

**Refer to screws reuse rules. (For more information see: 5.3.2 Screws pre-tightening, reuse and marking, page 274.)

3.5 Driving gear

3.5.1 Power unit

Endoscopy - Combustion chambers (SL 206)

Previous tasks

- ❑ Remove cylinder head covers. (For more information see: 3.2.3 Cylinder head cover removal and installation, page 65.)
- ❑ Remove injectors. (For more information see: 3.6.4 Injector removal and installation (SL 205), page 122.)

Specific safety instructions

Not applicable.

Special tools

Special tool	Designation
 11133437	Turning device. (For more information see: Use the turning device, page 270.) .

Tab. 23: Special tool

Consumables and equipment

– Not applicable.

Overview

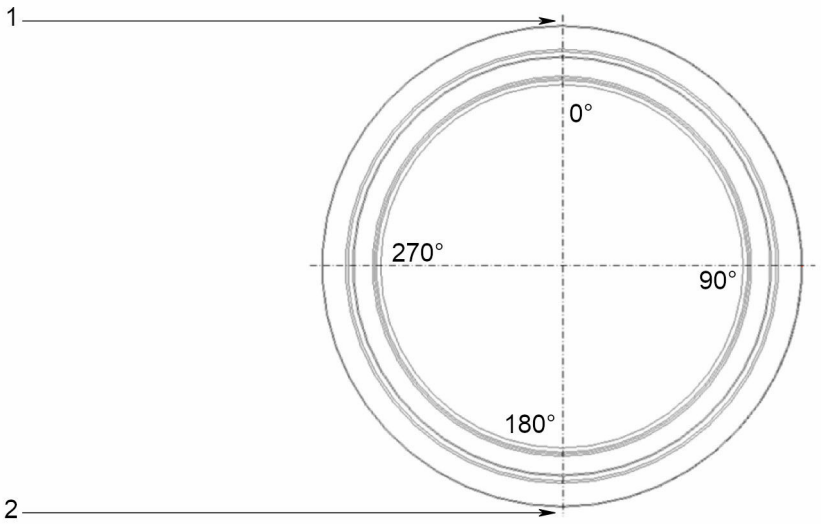


Fig. 104: Task overview

1 Exhaust side **2** Admission side

Endoscopy

- ▶ Place endoscope in injector hole on top of cylinder head.
- ▶ Turn engine until piston is in BDC (Bottom Dead Center) position.
- ▶ Check inside of liner by endoscope.
- ▶ Note findings on data sheet.
- ▶ Repeat procedure for each cylinder.

Specific values

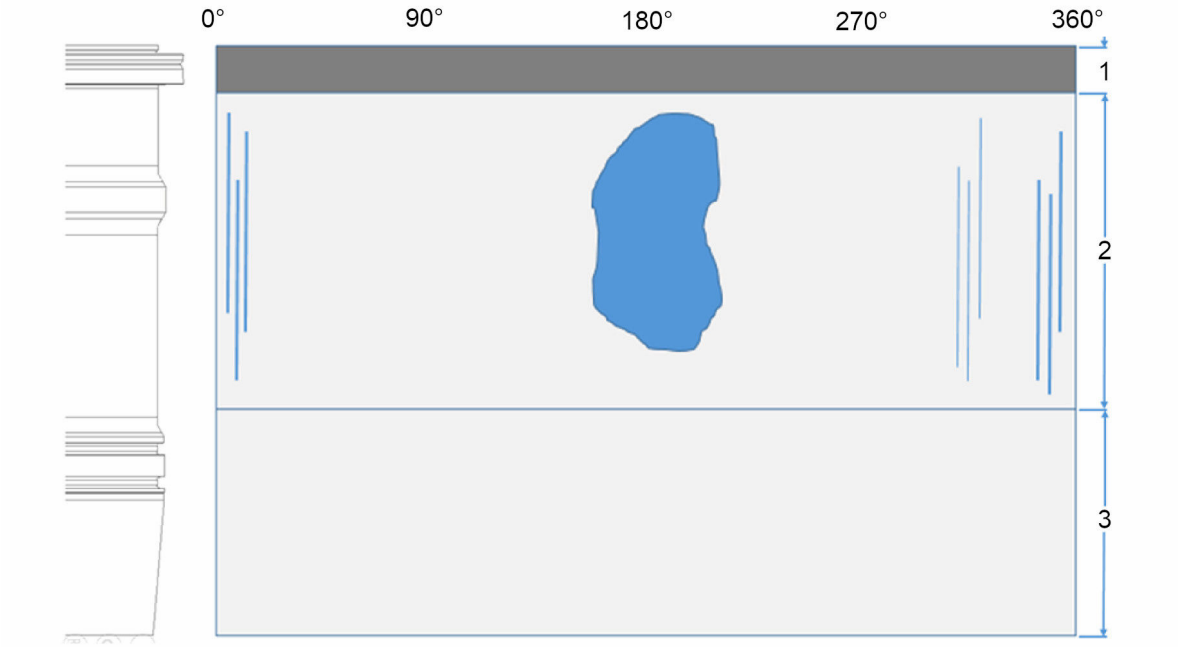


Fig. 105: Example of note on datasheet

1 Carbon ring area
2 Visible liner space
3 Space covered by piston in BDC position

Endoscopy results			
Position		Findings	Remarks
From	To		
350°	10°	Scratch traces	Complete length
290°	-	Dirt traces	Center 2 cm
170°	200°	Traces	80% of height
-	-	-	Honing pattern visible

Tab. 24: Example of note on endoscopy results

3.5.2 Torsional vibration damper removal and installation - SL2-1340

Previous tasks

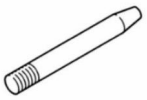
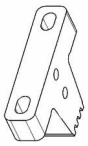
❑ Remove the protection plate of the torsional vibration damper. (For more information see: 3.2.1 Vibration damper cover removal and installation, page 59.)

Specific safety instructions

NOTICE
Risk of engine failure.
Shock or damage to the torsional vibration damper will lead to engine failure.

- ▶ Observe the lifting instructions.
- ▶ Use only adapted lifting devices.
- ▶ In case of shock or damage, always replace the torsional vibration damper.

Special tools

Special tool	Designation
 **11133372**	Guiding rod M28 – Damper (x2)
 11343230	Locking device

Tab. 25: Special tools

Consumables and equipment

– Rags
– Cleaner

Overview

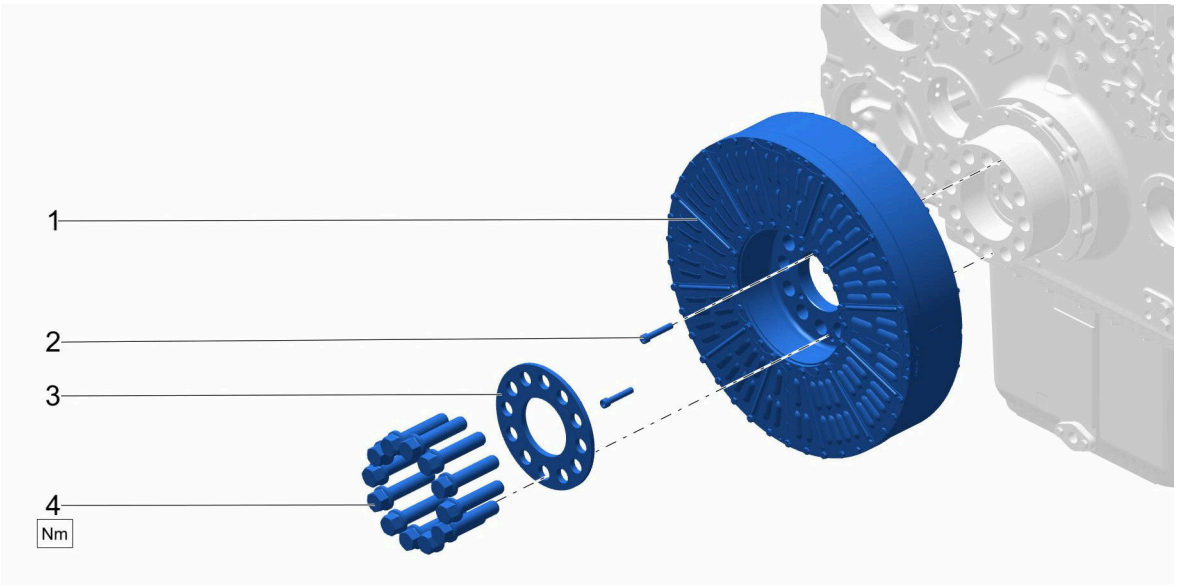


Fig. 108: Task overview

1 Torsional vibration damper
2 Allen screw (M12)
3 Disk
4 Bolt (M28)

Removal

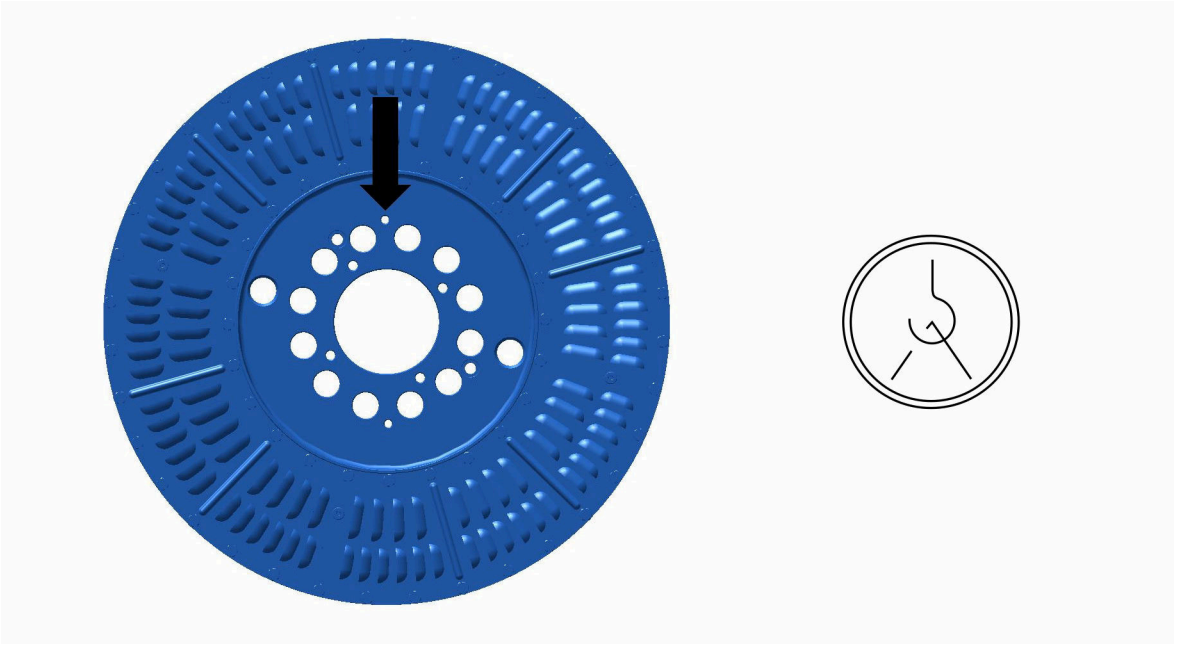


Fig. 109: Lifting thread location

▶ Using the turning device, rotate the torsional vibration damper so that the lifting thread is located at the top. (For more information see: 4.1.2 Turning device, page 269.)

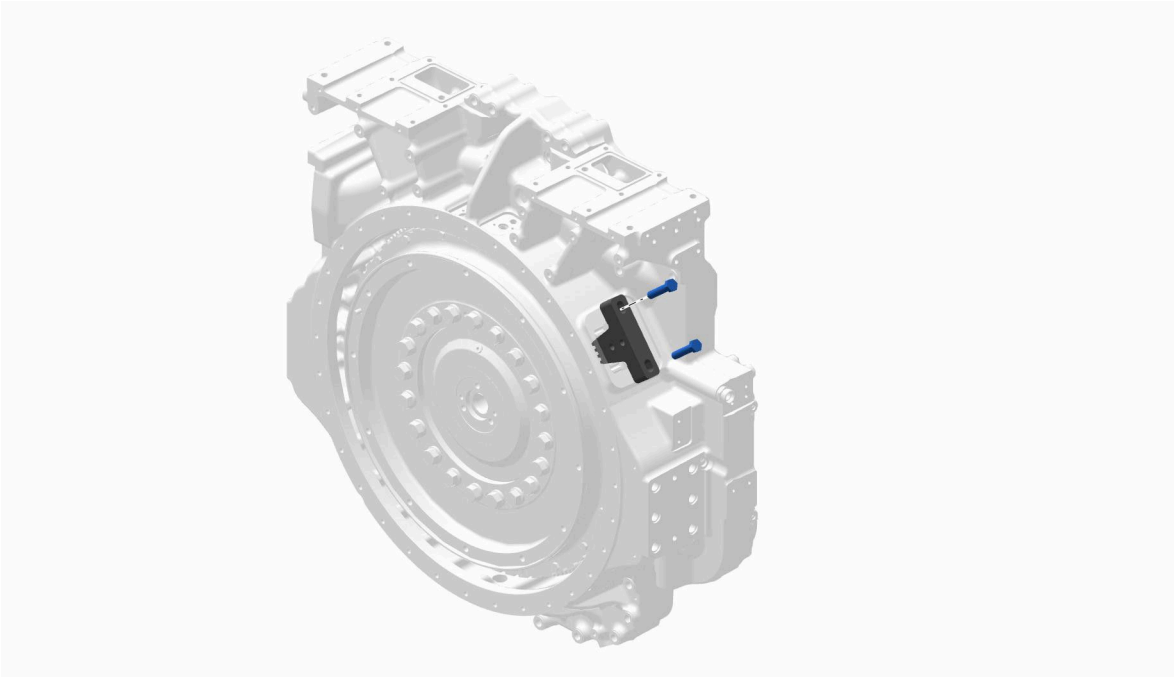


Fig. 110: Locking device

- ▶ Install locking device with screws (M16) to lock crankshaft.
- ▶ Remove two diametrically opposed bolts **4**.
- ▶ Install guiding rods.
- ▶ Remove bolts **4** and disk **3**.

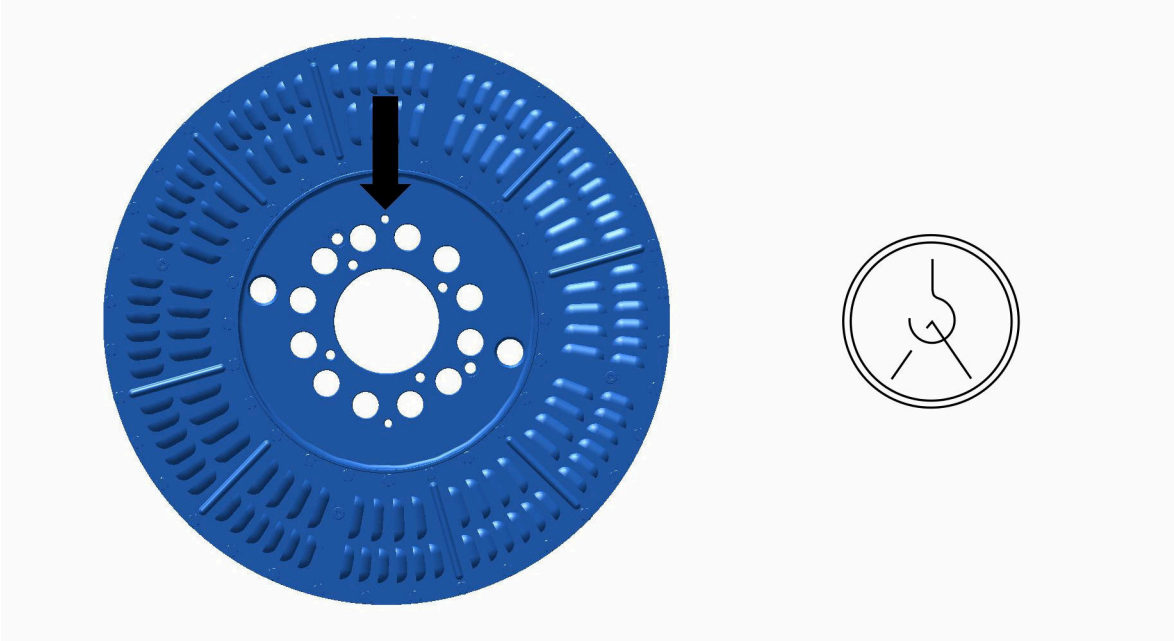


Fig. 111: Lifting thread location

- ▶ Install lifting device on the lifting thread.
- ▶ Remove screws **2**.
- ▶ Remove torsional vibration damper **1**.

- ▶ Remove guiding rods.
- ▶ Remove locking device.

Installation

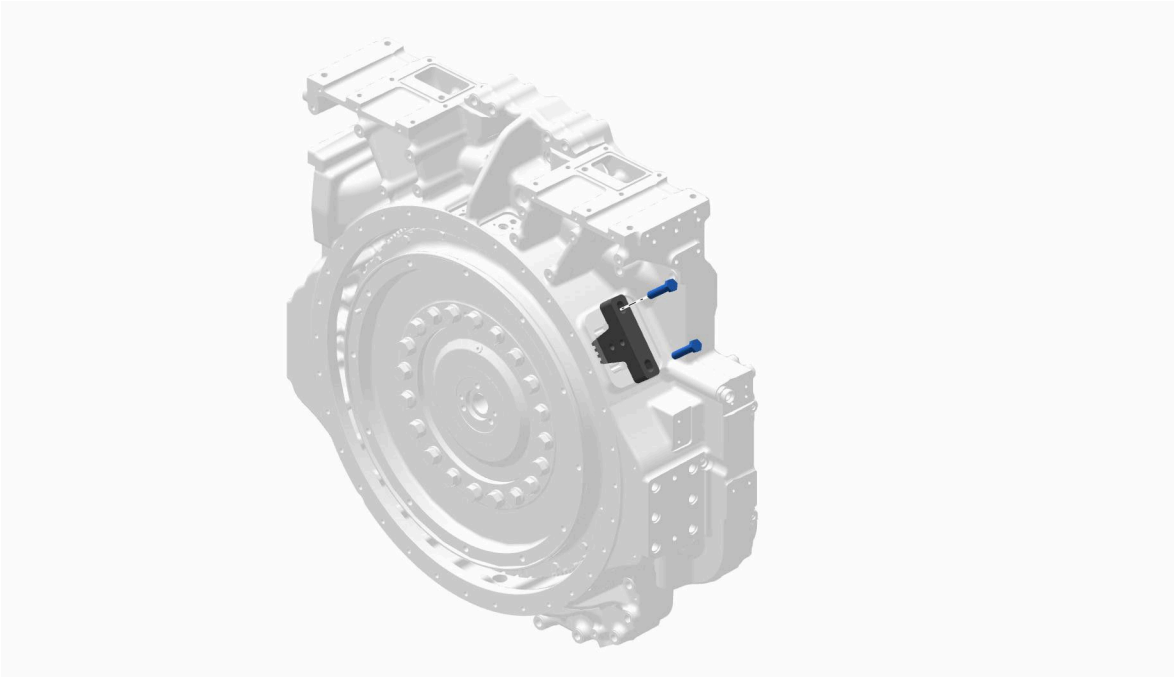


Fig. 112: Locking device

- ▶ Install locking device with screws (M16) to lock crankshaft.

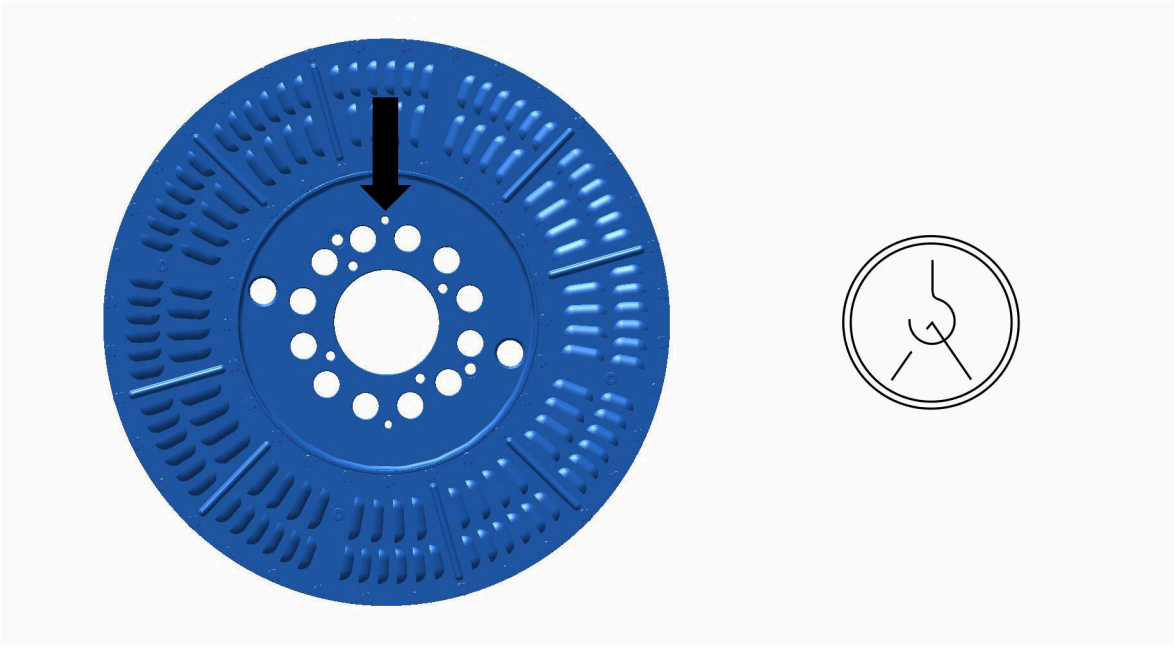


Fig. 113: Lifting thread location

- ▶ Install lifting device on the lifting thread.
- ▶ Lift torsional vibration damper **1**.

Information

Use lifting thread at the top to lift and align torsional vibration damper to flange.

- ▶ Position torsional vibration damper **1** using guiding rod.
- ▶ Screw torsional vibration damper **1** with screws **2**.
- ▶ Tighten screws **2** to torque.
- ▶ Position disk **3** and bolts **4**.
- ▶ Tighten bolts **4** to torque.
- ▶ Remove locking device.

Specific values

Not applicable.

Tightening specifications

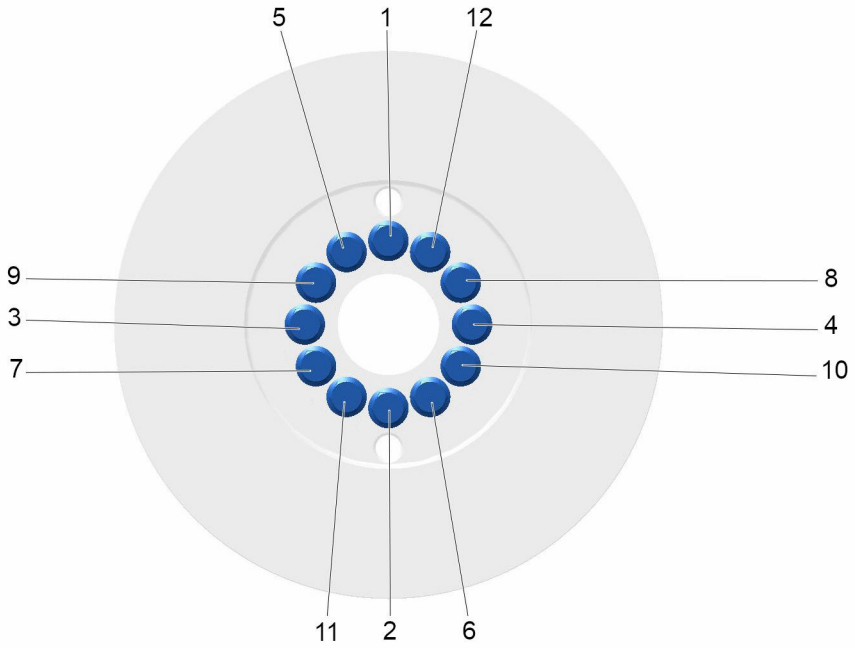


Fig. 114: Bolts sequence

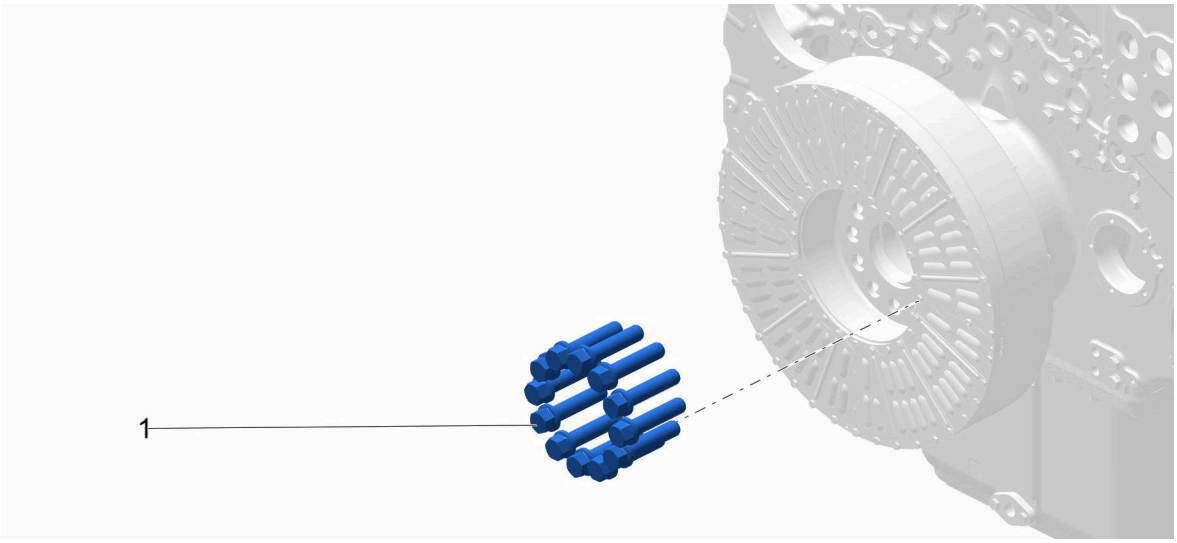


Fig. 115: Torsional vibration damper bolts

Reference	Key	Screw specifications	Lubricant *	Reuse**	Torque		Angle (°)	
					Step	± 5%	Step	± 5°
1	056AC	M28x2x122	-	No	1	430 Nm 317 ft-lb	2	75°

Tab. 26: Tightening specifications table

*Lubricants:
MG = Molykote G-n-plus
MW = Castrol Optimol paste white T
MH = Molykote HSC
O = Engine oil
XX = Loctite 243
YY = Loctite 577

**Refer to screws reuse rules. (For more information see: 5.3.2 Screws pre-tightening, reuse and marking, page 274.)

Sampling silicon oil from torsional vibration damper - SL2-1345

Previous tasks

Make sure that the following tasks are performed:
- ❑ Torsional vibration damper is cool enough to be touched with bare hands.
- ❑ The area around the sample openings is clean and free from engine oil and dirt.
- ❑ Torsional vibration damper cover is removed.

Specific safety instructions

Not applicable.

Special tools

Not applicable.

Consumables and equipment

Make sure that the following consumables and equipment are available:
– Sampling kit for silicon oil collection (sampling instructions, form, sample container, sample plugs, padded return envelope)

Overview

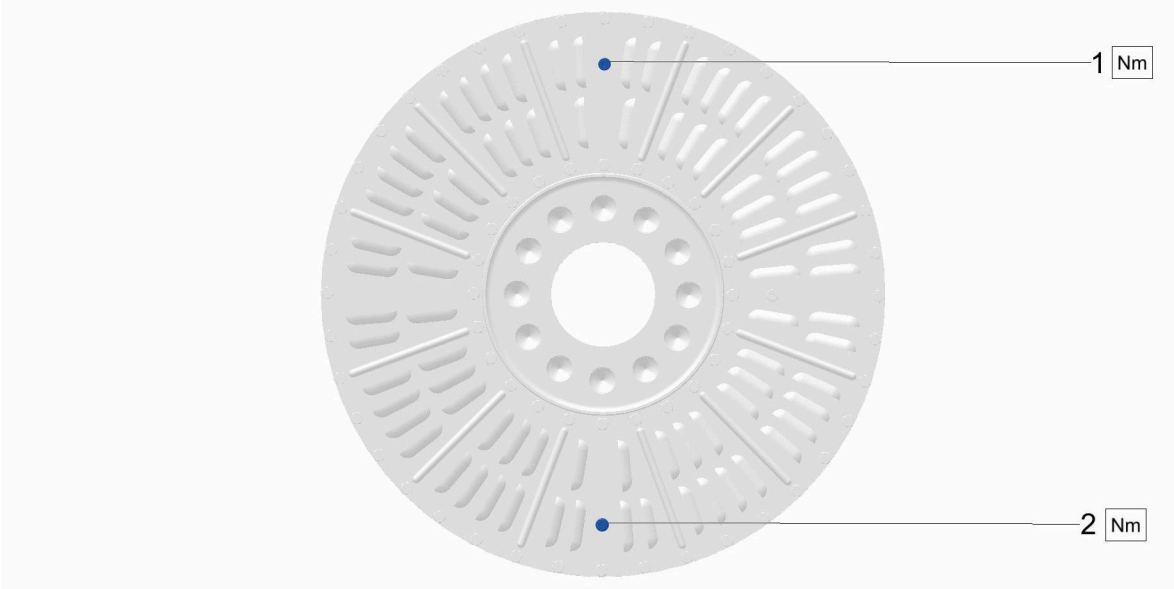


Fig. 116: Task overview

1 Upper sample opening

2 Lower sample opening

Sample collection

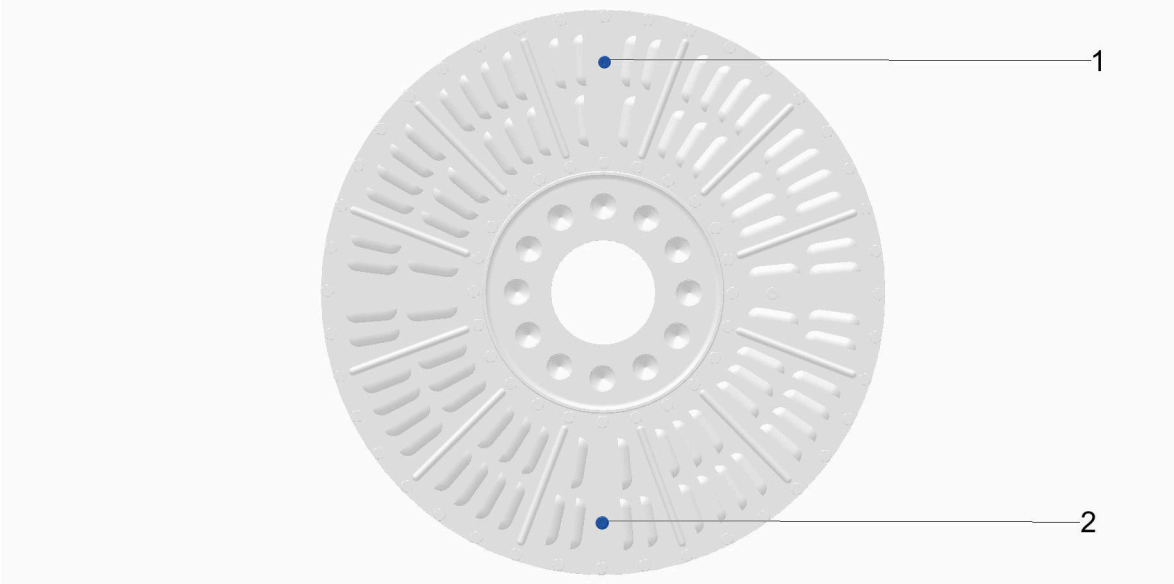


Fig. 117: Collecting silicon oil sample

▶ Rotate the crankshaft until sample openings **1, 2** are located vertically.

Information

Use the turning device to rotate the crankshaft. (For more information see: 4.1.2 Turning device, page 269.)

- ▶ Remove the cap from one end of the sample container.

Information

Place the sample container cap in a safe place.

- ▶ Make sure that the lower sample opening **2** is clean and free from dirt, grease, and engine oil.
- ▶ Remove the plug from the lower sample opening **2**.
- ▶ Immediately install the sample container into the lower sample opening **2**.
- ▶ Tighten the sample container by hand, then loosen it by one turn.

Information

Do not use any tool to tighten the sample container.

- ▶ Remove the cap from the other end of the sample container.

Information

Place the sample container cap in a safe place.

- ▶ Make sure that silicon oil flows from the torsional vibration damper into the sample container.

Information

If the flow of silicon oil is very slow, open the upper sample opening **1**.

- ▶ When the sample container is 75% full, install a cap on the end of the sample container.
- ▶ Tighten the sample container cap by hand.

Information

Do not use any tool to tighten the sample container cap.

- ▶ Install a new screw plug into the upper sample opening **1** if it has been opened.

Information

Always replace the screw plug.

- ▶ Tighten the screw plug to torque. (For more information see: Tightening specifications, page 108.)
- ▶ Remove the sample container from the lower sample opening **3**.

Information

Make sure that silicon oil does not leak from the sample container.

- ▶ Install a cap on the sample container.
- ▶ Tighten the sample container cap by hand.
- ▶ Install a new screw plug into the lower sample opening **2**.

Information

Always replace the screw plug.

- ▶ Tighten the screw plug to torque. (For more information see: Tightening specifications, page 108.)
- ▶ Fill in the sample form delivered with the sampling kit.
- ▶ Place the sample container and form into the padded envelope and send them for analysis.

Specific values

Not applicable.

Tightening specifications

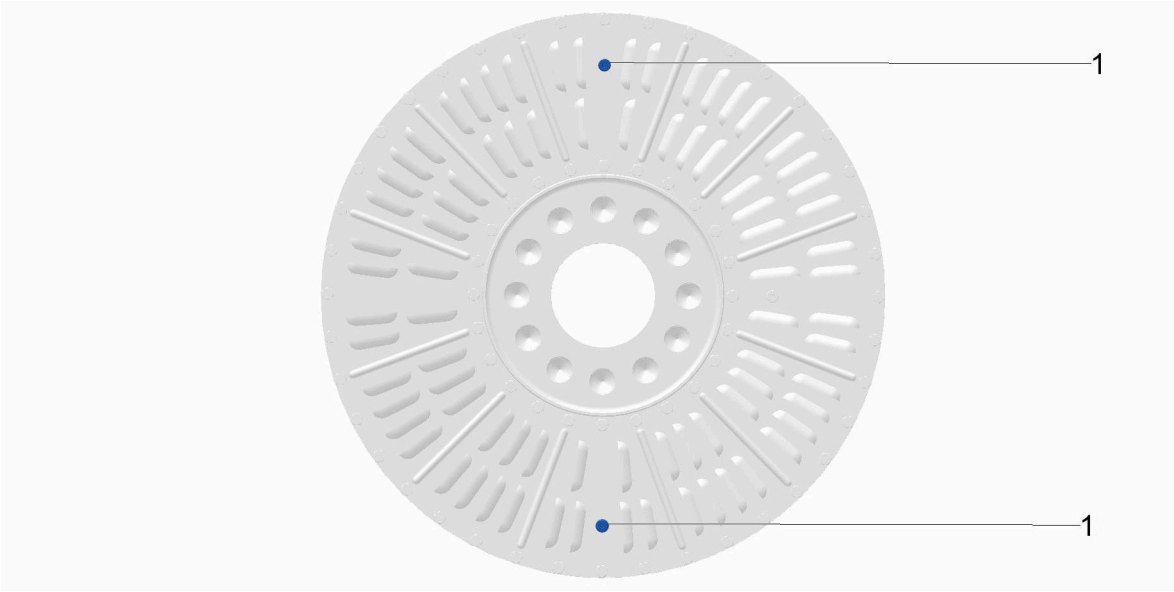


Fig. 118: Screw plugs for silicon oil collection

Reference	Key	Screw specifications	Lubricant *	Reuse**	Torque		Angle (°)	
					Step	± 5%	Step	± 5°
1	-	Screw plug	-	No	1	15 Nm 11 ft-lb	-	-

Tab. 27: Tightening specifications table

*Lubricants:
MG = Molykote G-n-plus
MW = Castrol Optimol paste white T
MH = Molykote HSC

O = Engine oil
XX = Loctite 243
YY = Loctite 577

**Refer to screws reuse rules.

Otherwise, refer to standard tightening torques.

3.6 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.

3.6.1 Fuel return and venting pipes removal and installation

Previous tasks

❑ Close fuel supply.

Specific safety instructions

Not applicable.

Special tools

Not applicable.

Consumables and equipment

– Rags
– Cleaner
– Bucket for fuel

Overview

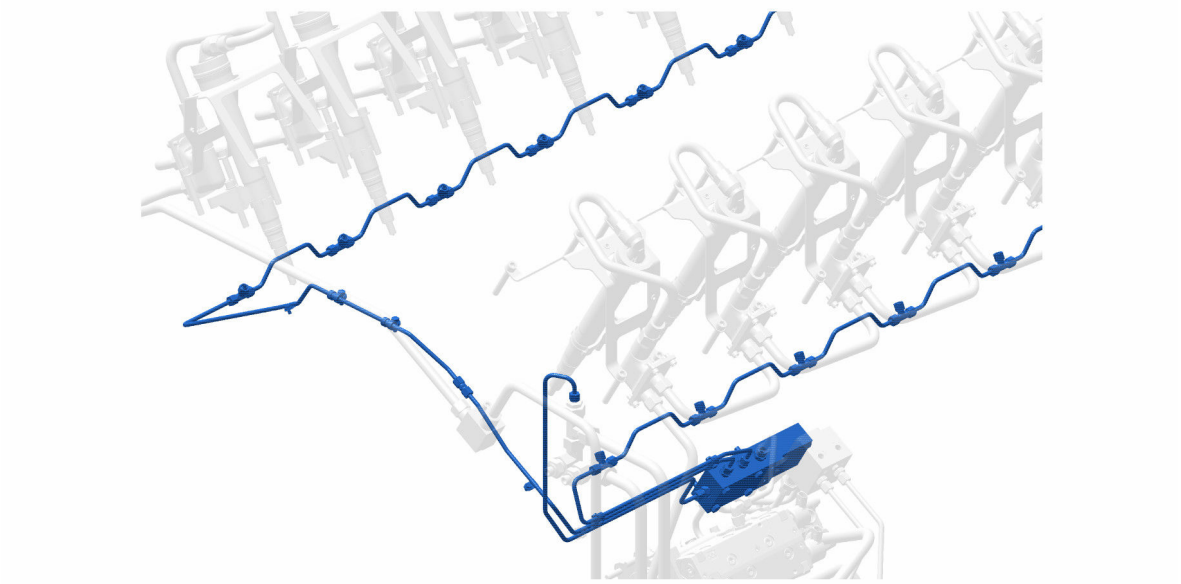


Fig. 119: Fuel return and venting pipes

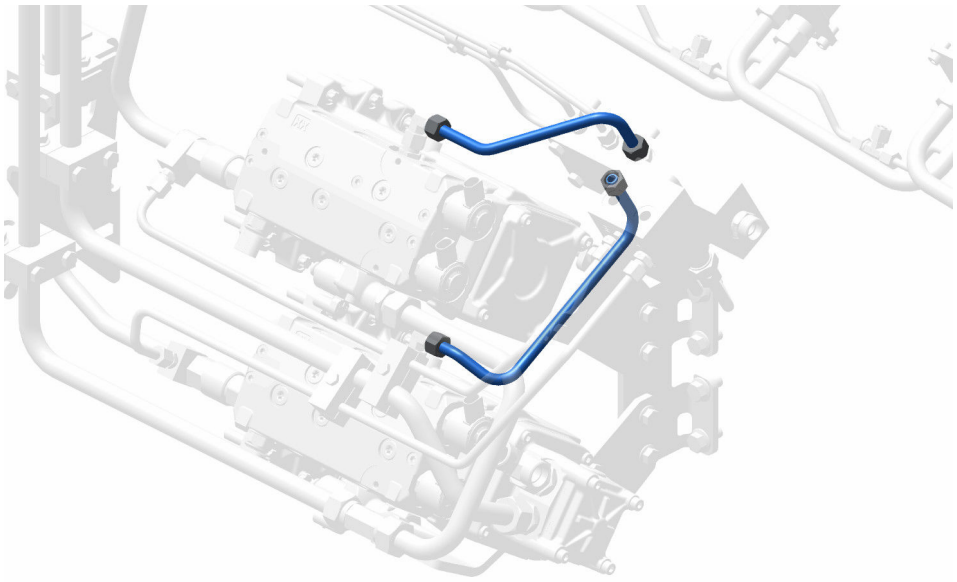


Fig. 120: Fuel pump pipes

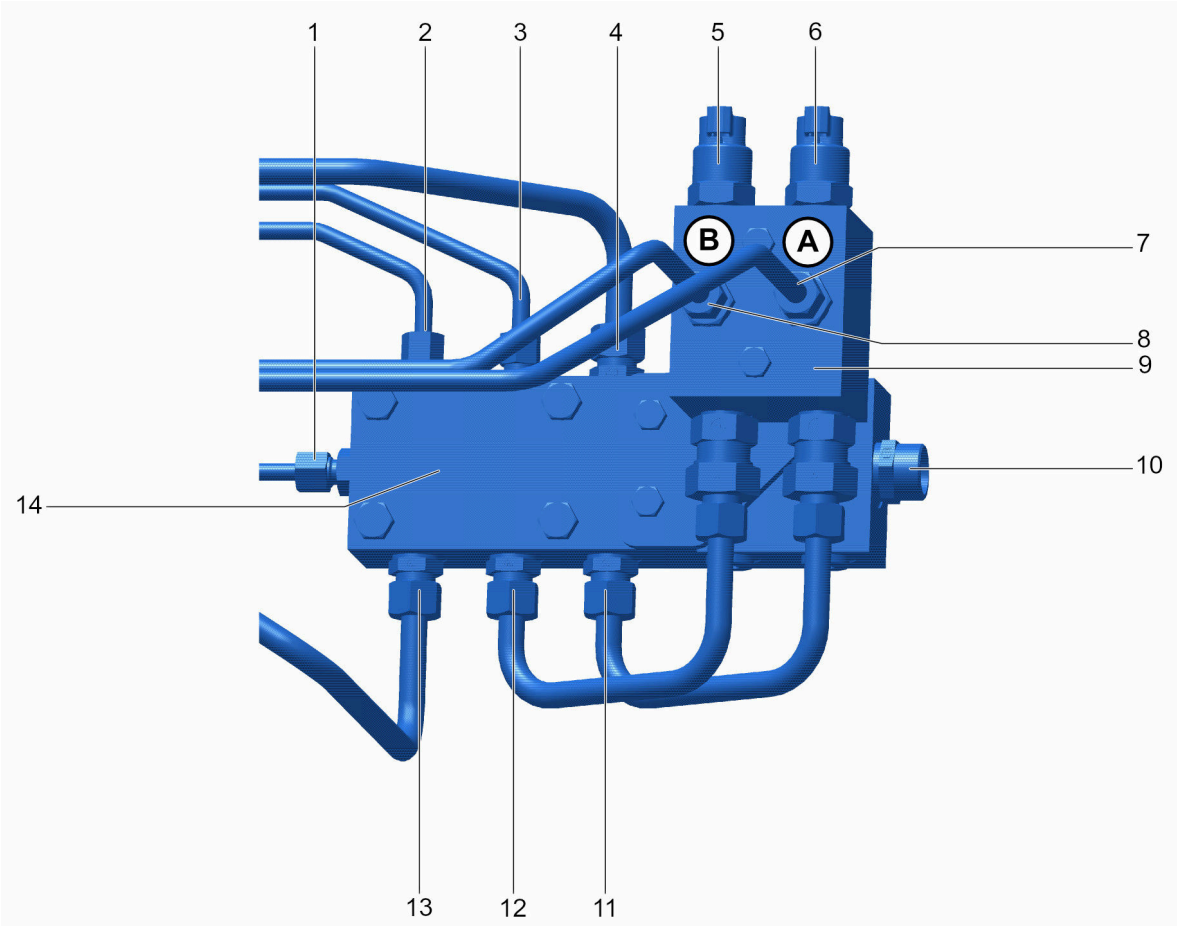


Fig. 121: Connections of leakage-fuel distributor block

1	Connection permanent venting fuel filters	**8**	Leakage indication high-pressure system
2	Connection leakage fuel from nozzles (A bank)	**9**	Leakage-fuel detection block
3	Connection leakage fuel from nozzles (B bank)	**10**	Connection to tank
4	Connection leakage fuel HP pump (B bank)	**11**	Leakage-fuel detection block to leakage-fuel distributor block
5	Sensor B	**12**	Leakage-fuel detection block to leakage-fuel distributor block
6	Sensor A	**13**	Connection leakage fuel HP pump (A bank)
7	Leakage indication high-pressure system	**14**	Leakage-fuel distributor block

Removal

▶ Remove fuel return and venting pipes.

Installation

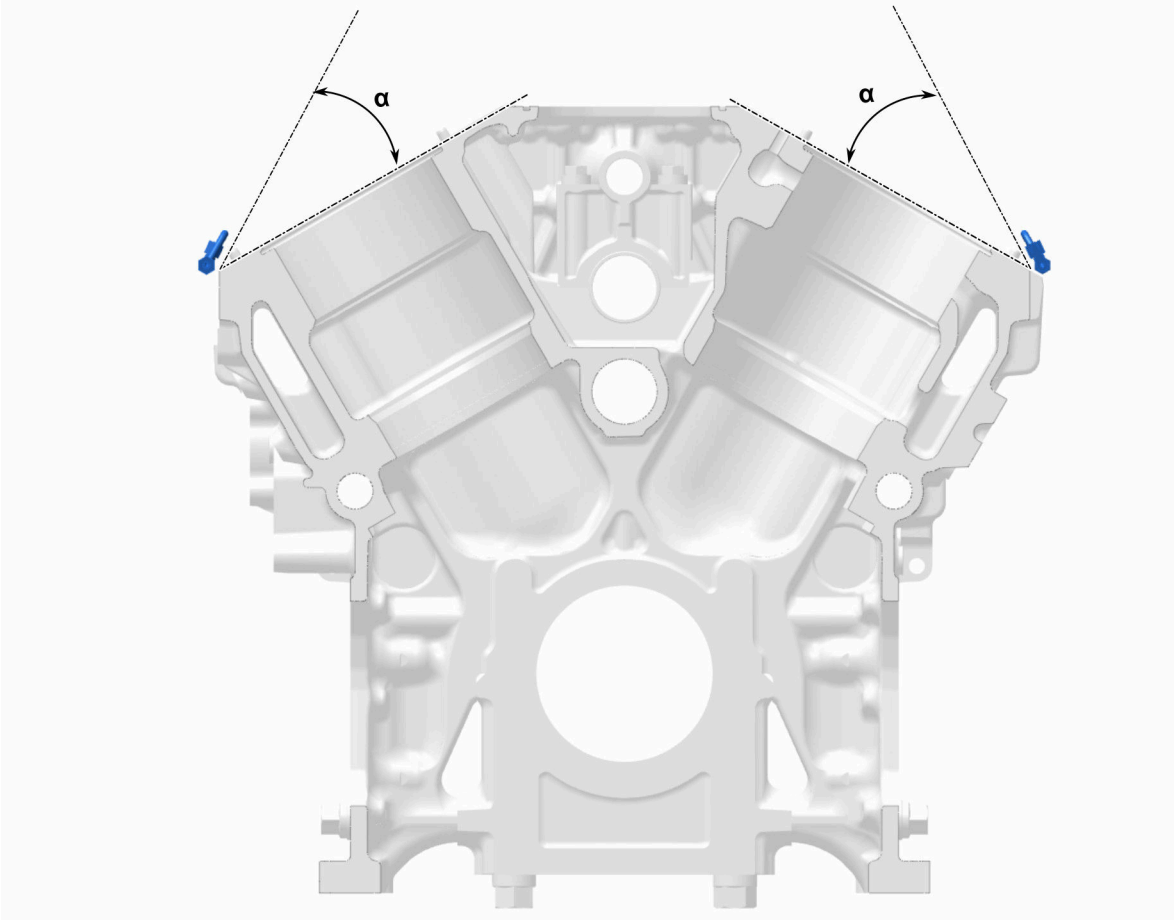


Fig. 122: Fuel return and venting pipes inclination

▶ Mount fuel return and venting pipes.

Information

Install fuel return and venting pipes with an angle of 30° minimum in relation to the crankcase.

▶ Tighten fuel return and venting pipes to torque.

Specific values

Not applicable.

Tightening specifications

Refer to standard tightening torques. (For more information see: 5.3 Standard tightening torques, page 274.)

3.6.2 High pressure pipes removal and installation

Previous tasks

❑ Release the pressure of the HP fuel system using Kodia tool.

❑ Close the fuel supply.

Specific safety instructions

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.

NOTICE
Risk of property damage by reuse of sealing.
Leakage by faulty seal.

▶ Replace all sealings.

Special tools

– Plugs for piping

Consumables and equipment

– Rags
– Cleaner
– Bucket for fuel

Overview

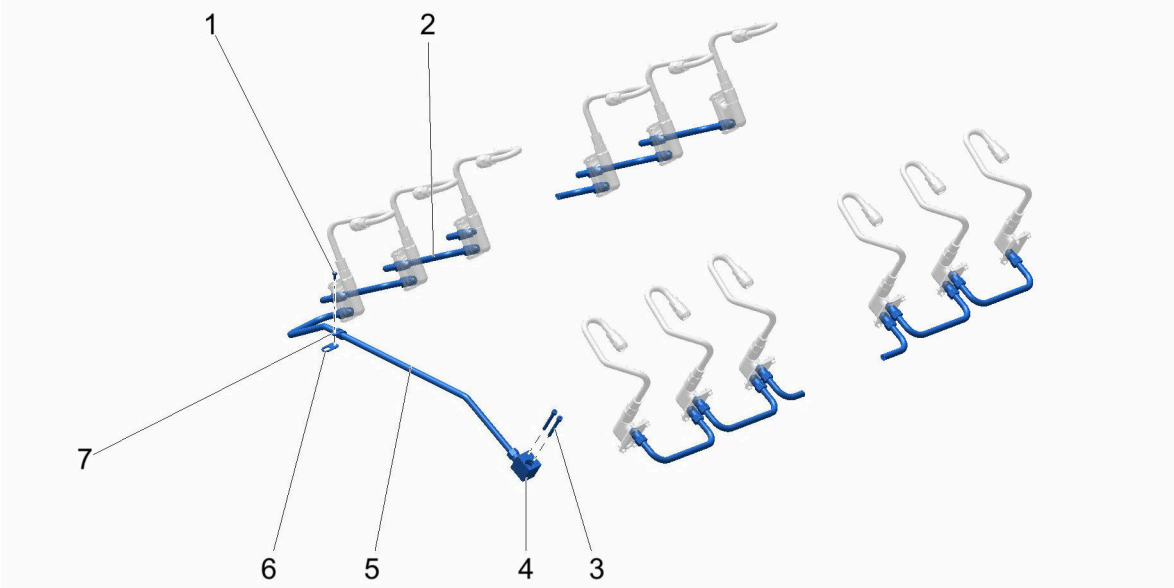


Fig. 123: Task overview

1 Screw (M8)
2 Fuel pipe
3 Screw (M10)
4 Distributor block
5 Fuel pipe
6 Retaining plate
7 Clamp

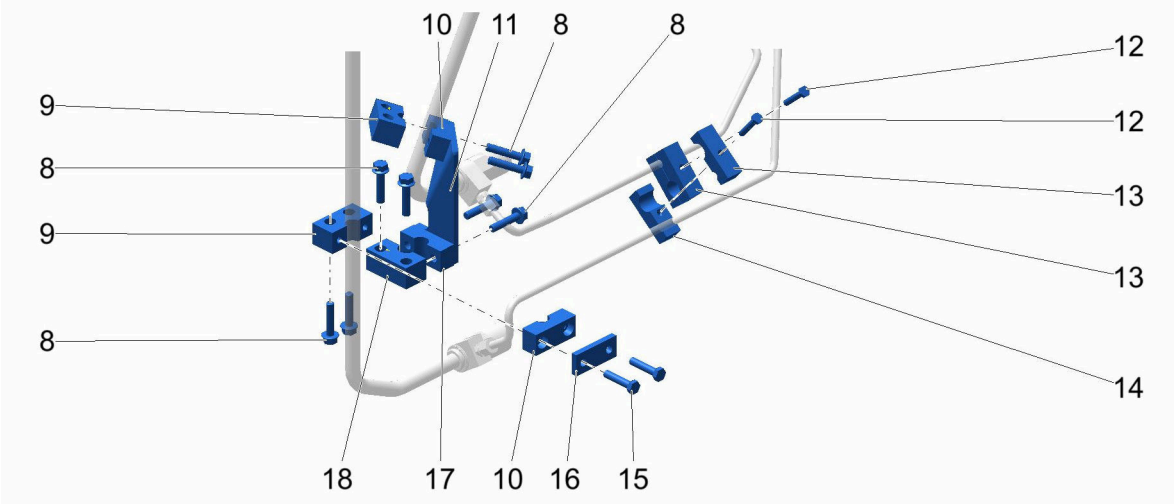


Fig. 124: Task overview

8 Screw (M10)
9 Clamp
10 Clamp
11 Holder
12 Screw (M8)
13 Clamp
14 Clamp
15 Screw (M10)
16 Plate
17 Clamp
18 Clamp

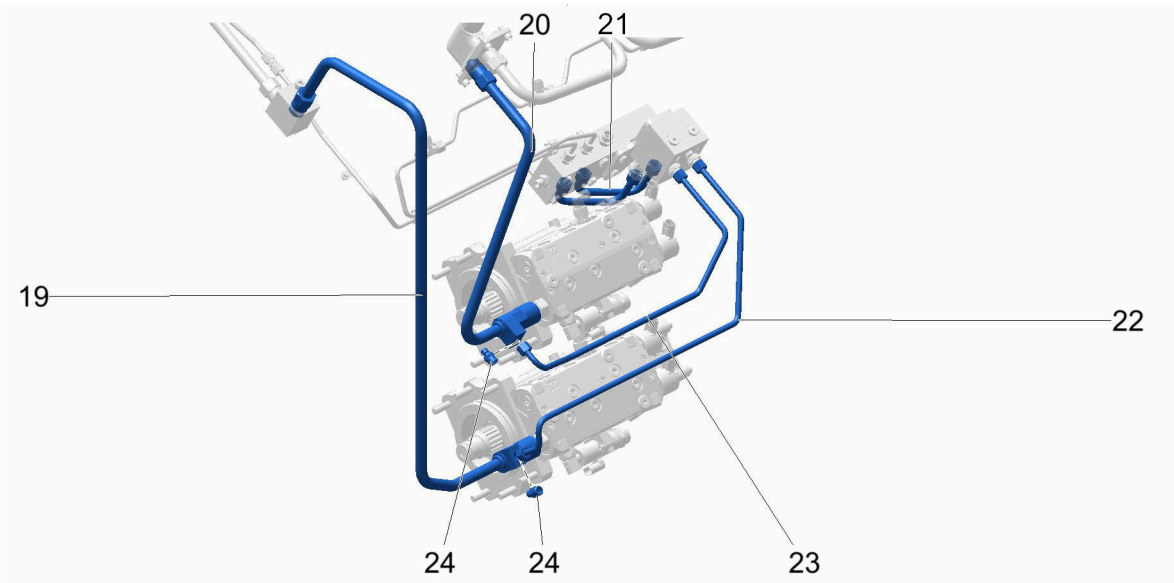


Fig. 125: Task overview

19 Fuel pipe
20 Fuel pipe
21 Fuel pipe
22 Fuel pipe
23 Fuel pipe
24 Flange joint

Removal

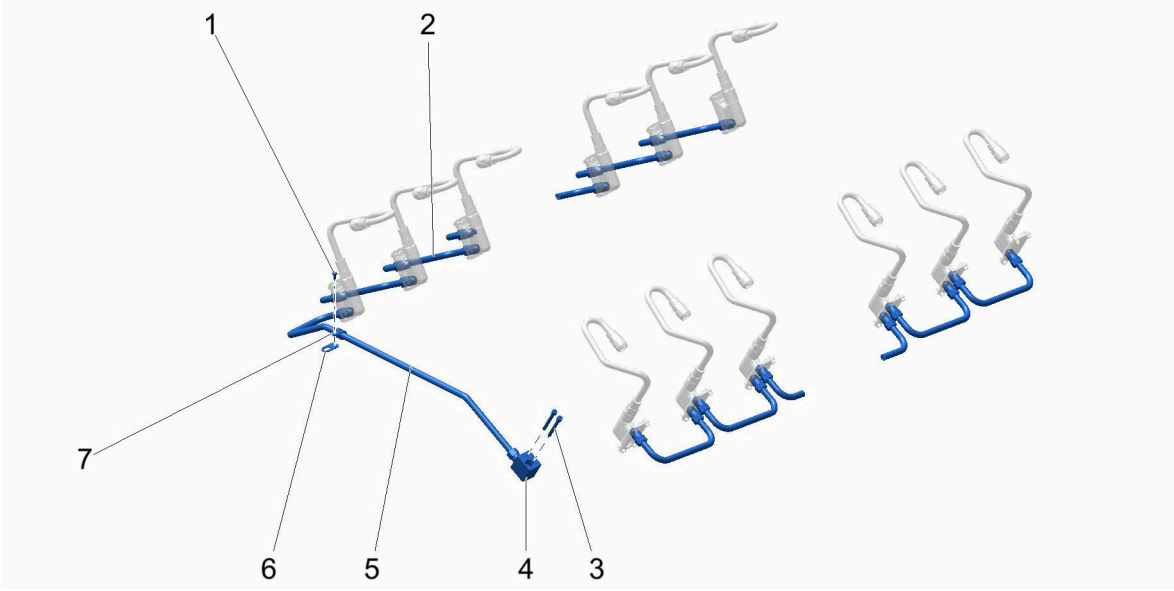


Fig. 126: Removing high pressure piping

- ▶ Remove screw **1** with retaining plate **6** and clamp **7**.
- ▶ Remove screw **3**.
- ▶ Remove distributor block **4**.
- ▶ Remove fuel pipes **2, 5**.

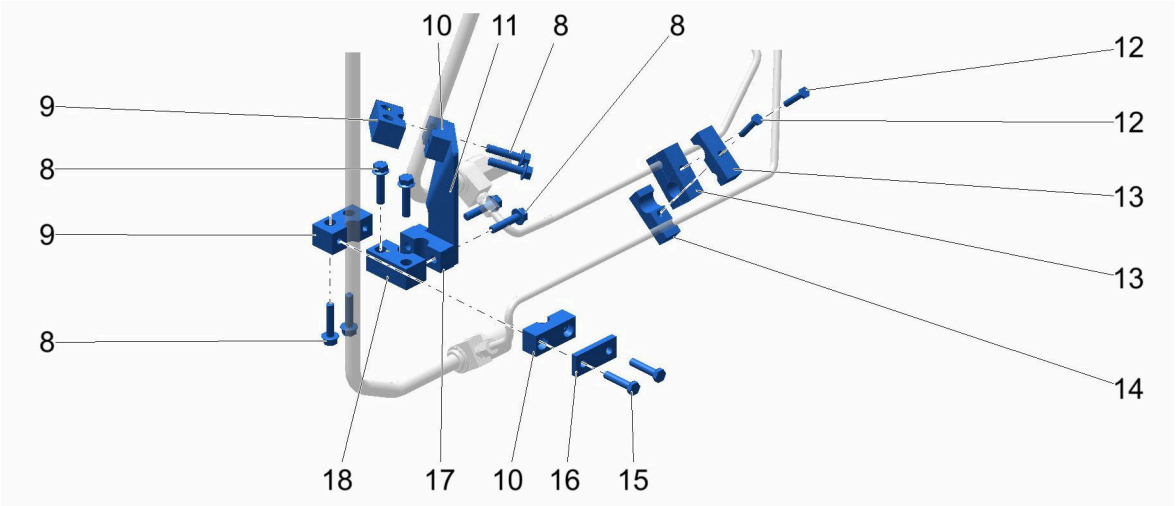


Fig. 127: Removing clamps

- ▶ Remove screws **8, 15**.
- ▶ Remove clamps **9, 10, 17, 18** and plate **16**.
- ▶ Remove holder **11**.
- ▶ Remove screws **12**.
- ▶ Remove clamps **13, 14**.

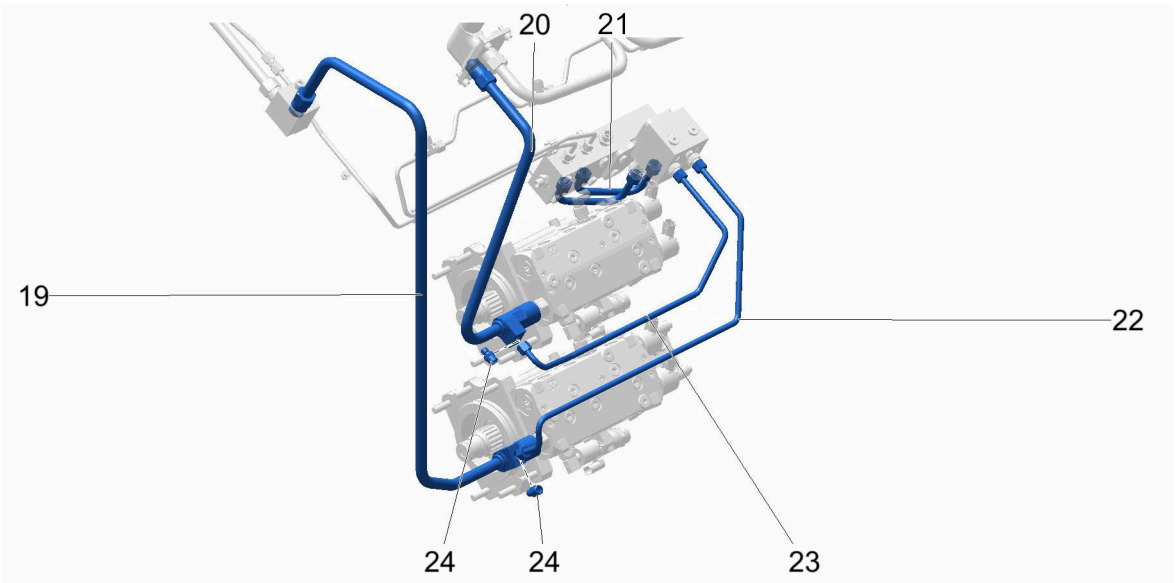


Fig. 128: Removing high pressure piping

- ▶ Remove fuel pipes **19, 20, 21, 22, 23** with flange joints **24**.

Installation

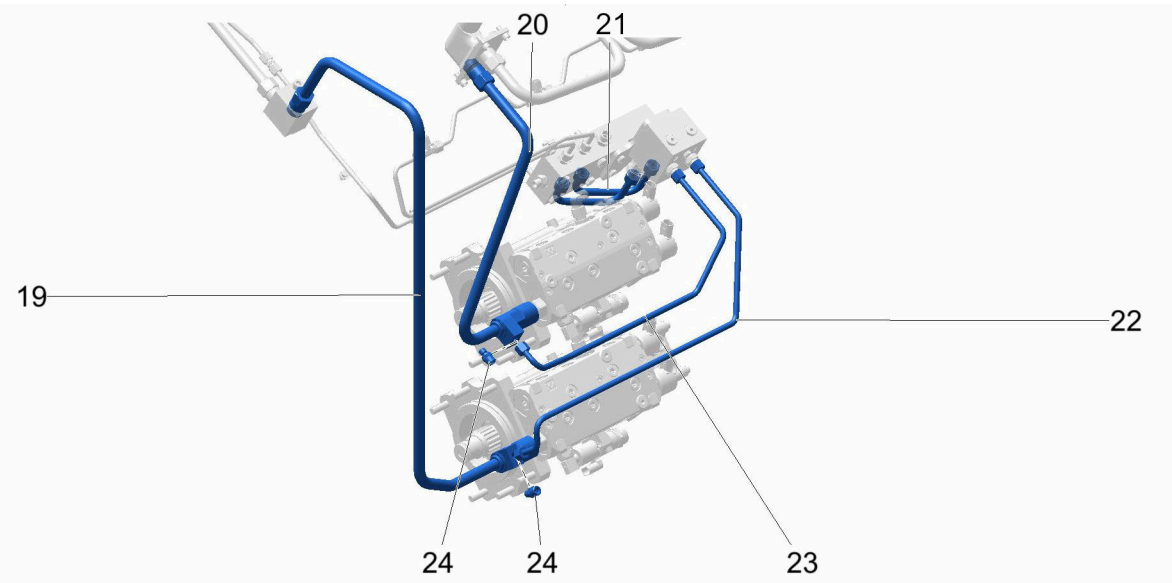


Fig. 129: Installing high pressure piping

- ▶ Lubricate o-rings of fuel pipes **19, 20** with Castrol Optimol Paste White T.
- ▶ Lubricate threads and cones of fuel pipes **19, 20** with clean engine oil.
- ▶ Install fuel pipes **19, 20, 21, 22, 23** with flange joints **24**.

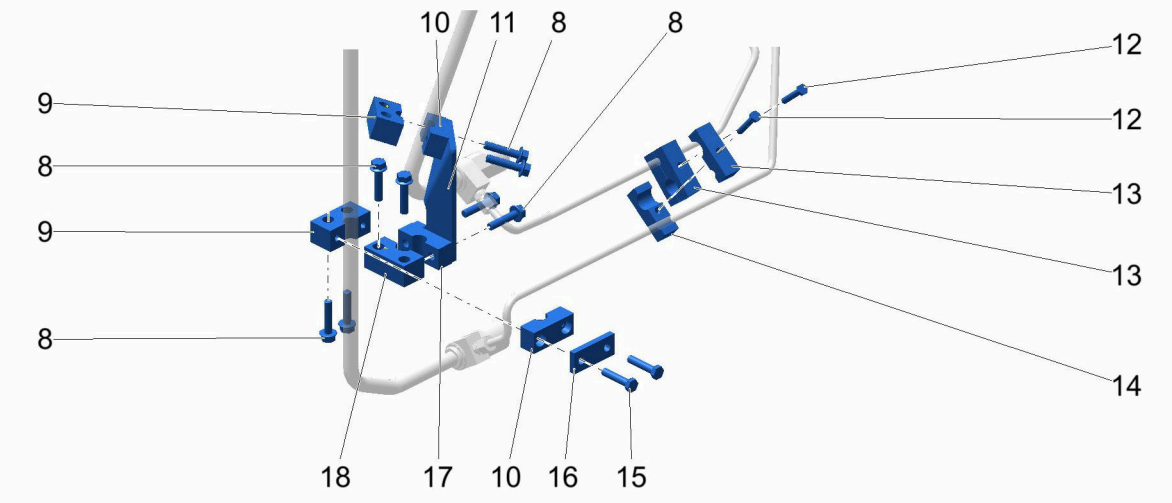


Fig. 130: Installing clamps

- ▶ Install clamps **13, 14** with screws **12**.
- ▶ Install clamps **9, 10, 17, 18**,plate **16** and holder **11** with screws **8, 15**.

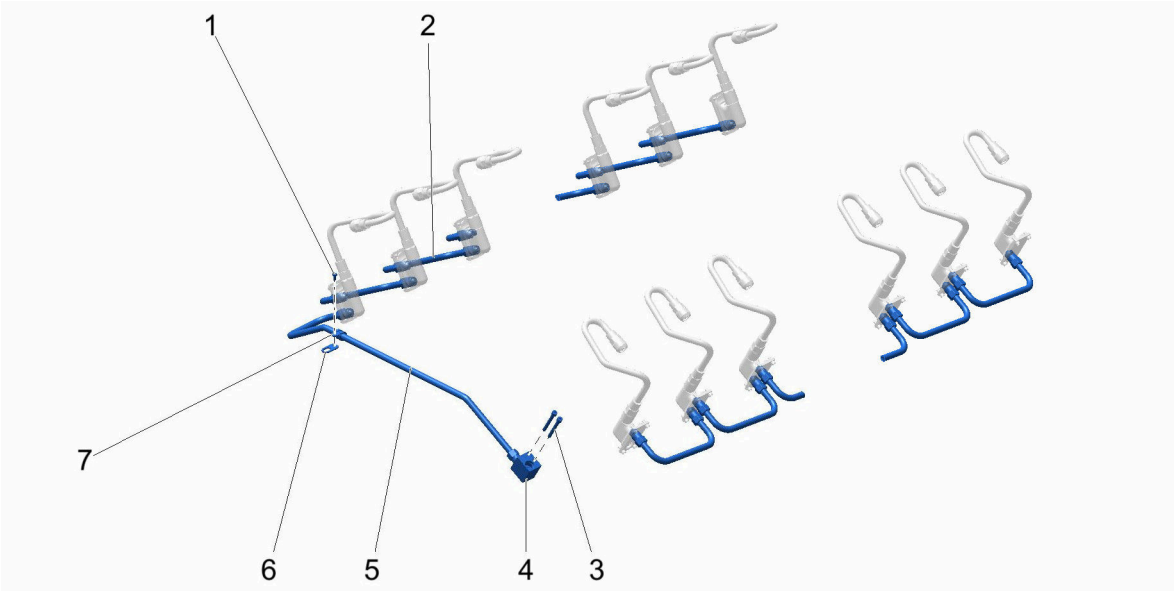


Fig. 131: Installing high pressure piping

- ▶ Lubricate o-rings of fuel pipes **2, 5** with Castrol Optimol Paste White T.
- ▶ Lubricate threads and cones of fuel pipes **2, 5** with clean engine oil.
- ▶ Install fuel pipes **2, 5**.
- ▶ Install distributor block **4** with screws **3**.
- ▶ Install clamp **7** with retaining plate **6** and screw **1**.
- ▶ Pre-tighten all fuel pipes to torque. (For more information see: Tightening specifications, page 119.)
- ▶ Tighten all fuel pipes and screws to torque. (For more information see: Tightening specifications, page 119.)

Specific values

Not applicable.

Tightening specifications

Refer to standard tightening torques. (For more information see: 5.3 Standard tightening torques, page 274.)

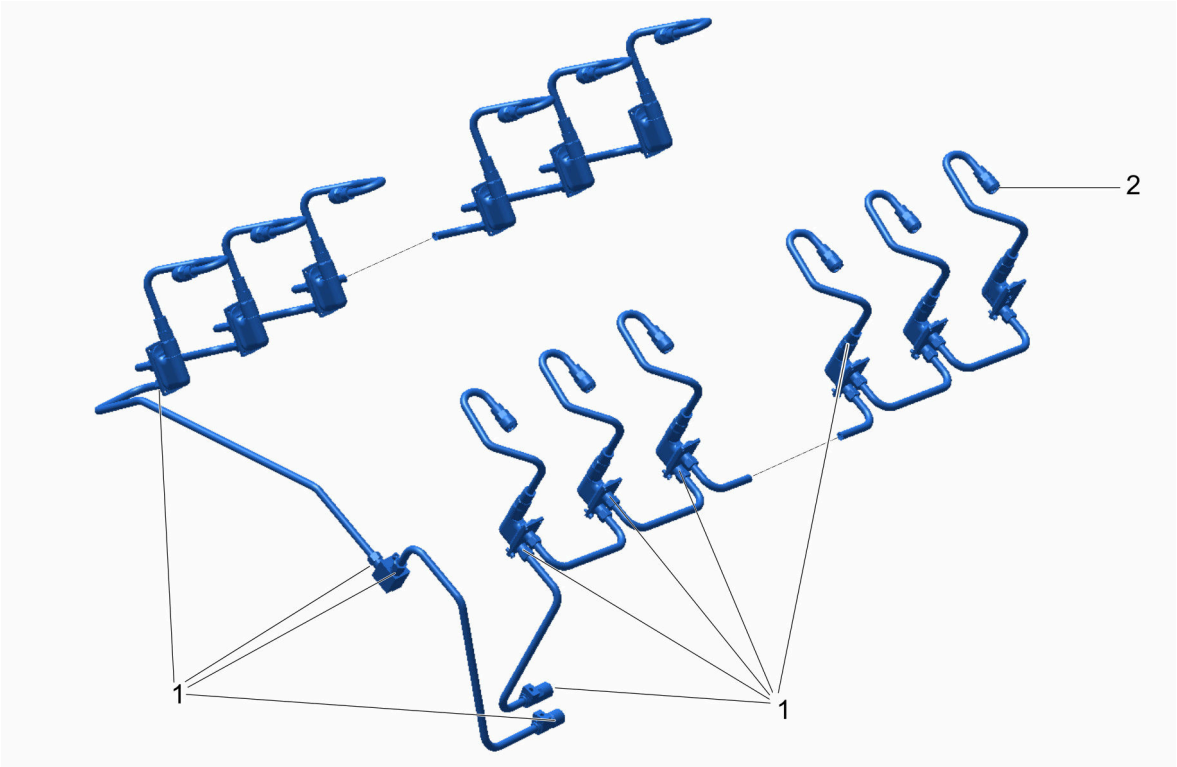


Fig. 132: High pressure pipes

Reference	Key	Screw specifications	Lubricant *	Reuse**	Torque		Angle (°)	
					Step	± 5%	Step	± 5°
1	-	-	O	Yes	1	26 Nm 19 ft-lb	-	-
					2	189 Nm 139 ft-lb		
2	-	-	O	Yes	1	26 Nm 19 ft-lb	-	-
					2	150 Nm 111 ft-lb		

Tab. 28: Tightening specifications table

*Lubricants:
MG = Molykote G-n-plus
MW = Castrol Optimol paste white T
MH = Molykote HSC
O = Engine oil
XX = Loctite 243
YY = Loctite 577

**Refer to screws reuse rules. (For more information see: 5.3.2 Screws pre-tightening, reuse and marking, page 274.)

3.6.3 Fuel supply pipes removal and installation

Previous tasks

❑ Close fuel supply line.

Specific safety instructions

Not applicable.

Special tools

Not applicable.

Consumables and equipment

– Rags
– Cleaner

Overview

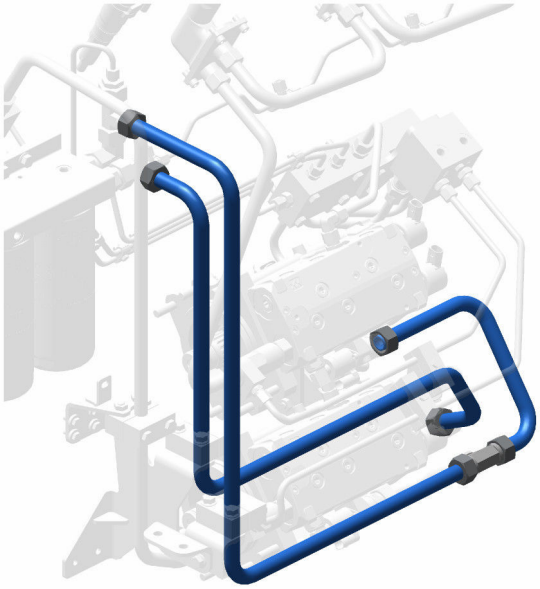


Fig. 133: Low pressure circuit piping

Removal

▶ Remove fuel supply pipes.

Information

Close all open connections with original plugs.

Installation

▶ Mount fuel supply pipes.

▶ Tighten according to tightening specifications.

Specific values

Not applicable.

Tightening specifications

Refer to standard tightening torques. (For more information see: 5.3 Standard tightening torques, page 274.)

3.6.4 Injector removal and installation (SL 205)

Previous tasks

❑ Remove cylinder head covers. (For more information see: 3.2.3 Cylinder head cover removal and installation, page 65.)

Specific safety instructions

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.

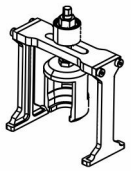
▶ Before starting any task on the fuel system, ensure the build-up pressure in the circuit has been released, and the temperature of the engine has cooled down.

▶ Keep the engine away from heat, sparks, open flame, or any other ignition source.

NOTICE
Risk of property damage by reuse of sealing.
Leakage by faulty seal.

▶ Replace all sealings.

Special tools

Special tool	Designation
 **12226280**	Injector extractor

Tab. 29: Special tools

Consumables and equipment

– Rags
– Cleaner
– Loctite 243
– Engine oil
– Castrol Optimol Paste White T

Overview

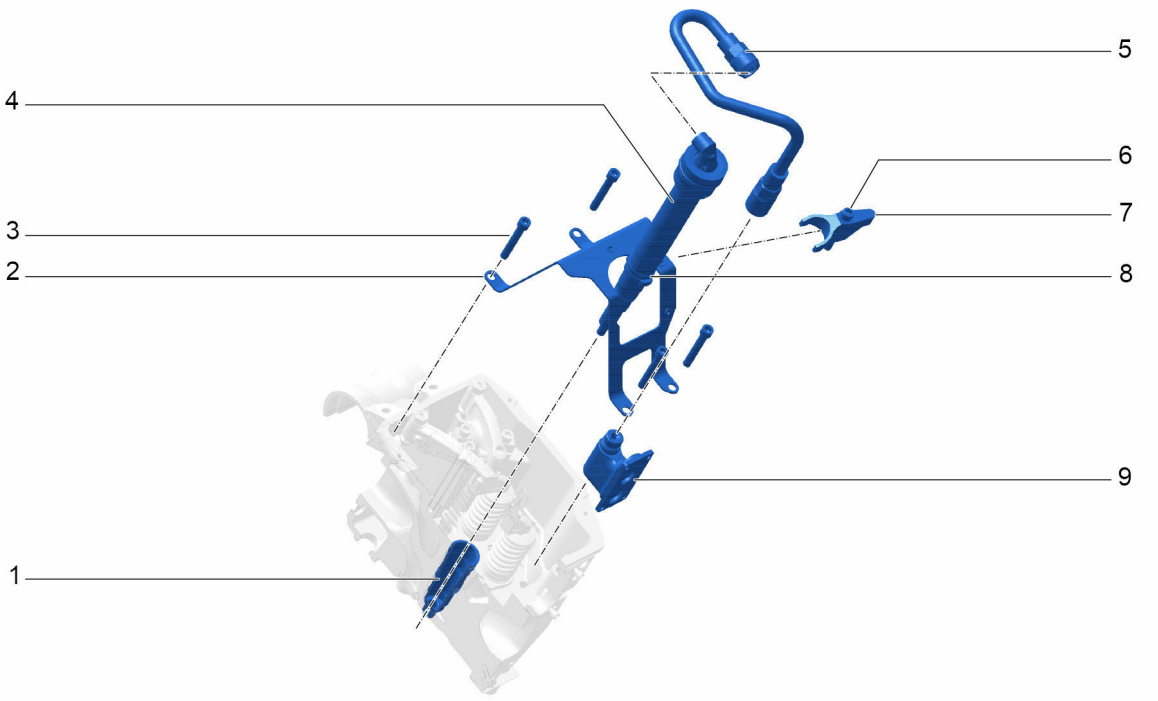


Fig. 135: Task overview

1 Injector sleeve
2 Retaining plate
3 Screw (M12)
4 Injector
5 High-pressure pipe
6 Screw (M12)
7 Injector clamp
8 Collet
9 Adaptor

Removal

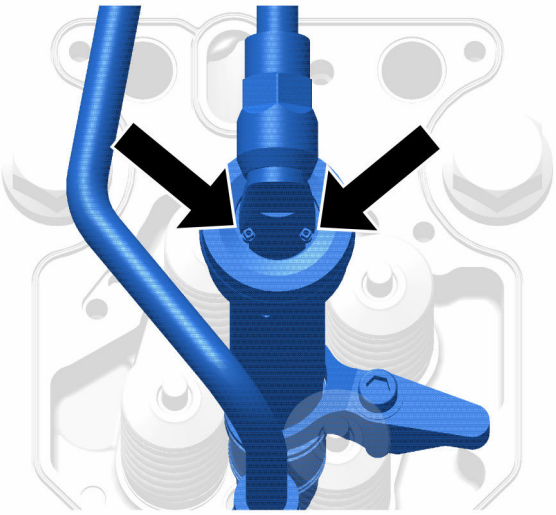


Fig. 136: Removing electrical contacts

- ▶ Remove electrical contacts from injector.
- ▶ Disconnect injector cable on both ends.
- ▶ Disconnect HT sensor on both ends if installed.
- ▶ Remove both adaptors from rocker arm housing.

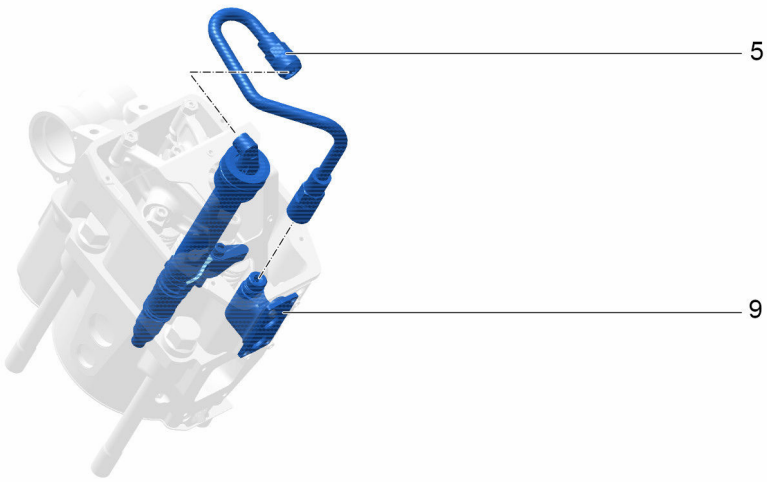


Fig. 137: Removing high-pressure pipe

- ▶ Take off high-pressure pipe **5** from adaptor **9**.

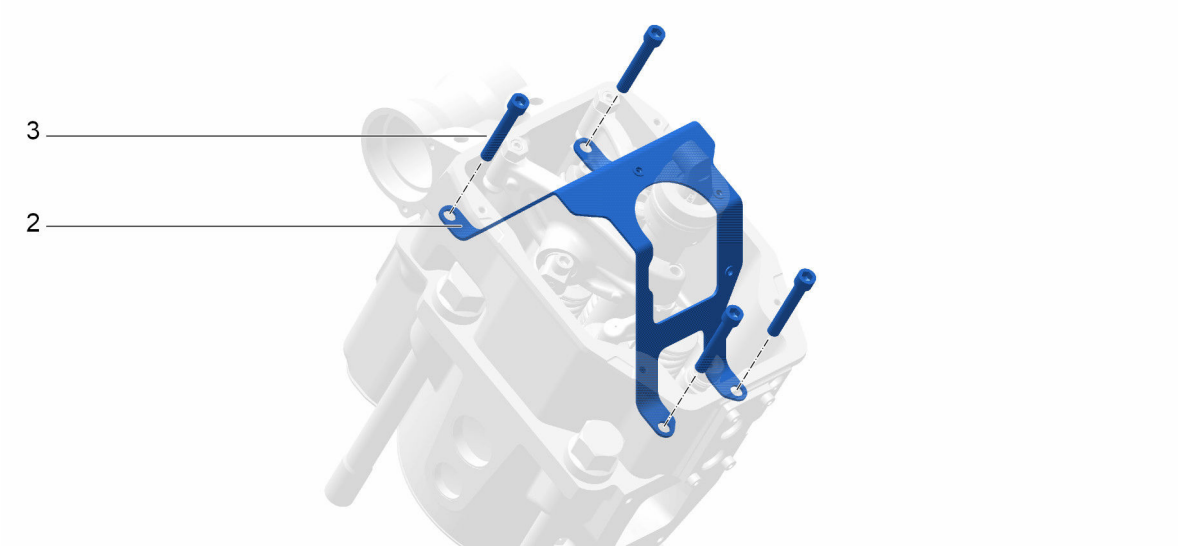


Fig. 138: Removing retaining plate

- ▶ Remove retaining plate **2** with screws **3**.
- ▶ Close all open connections with the matching plugs (available as replacement parts).

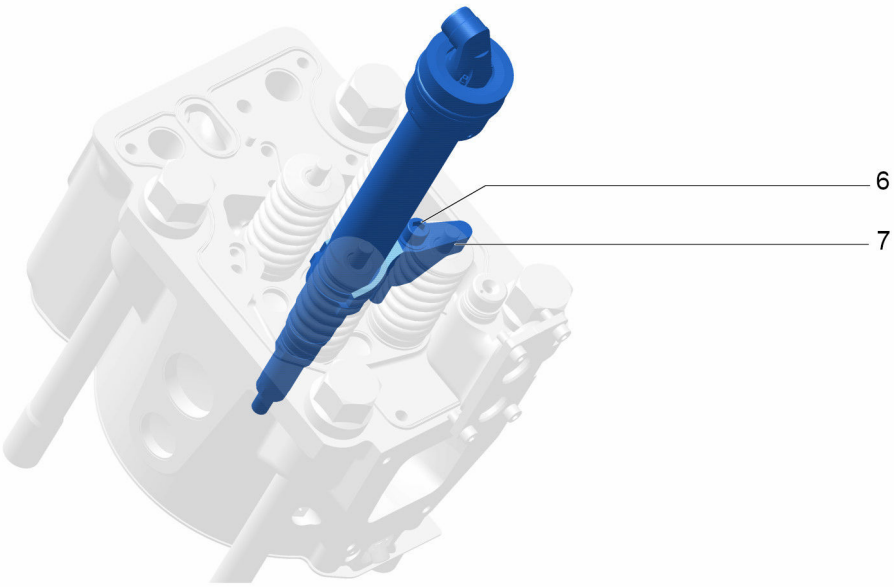


Fig. 139: Removing clamp

- ▶ Remove clamp **7** by opening screw **6**.

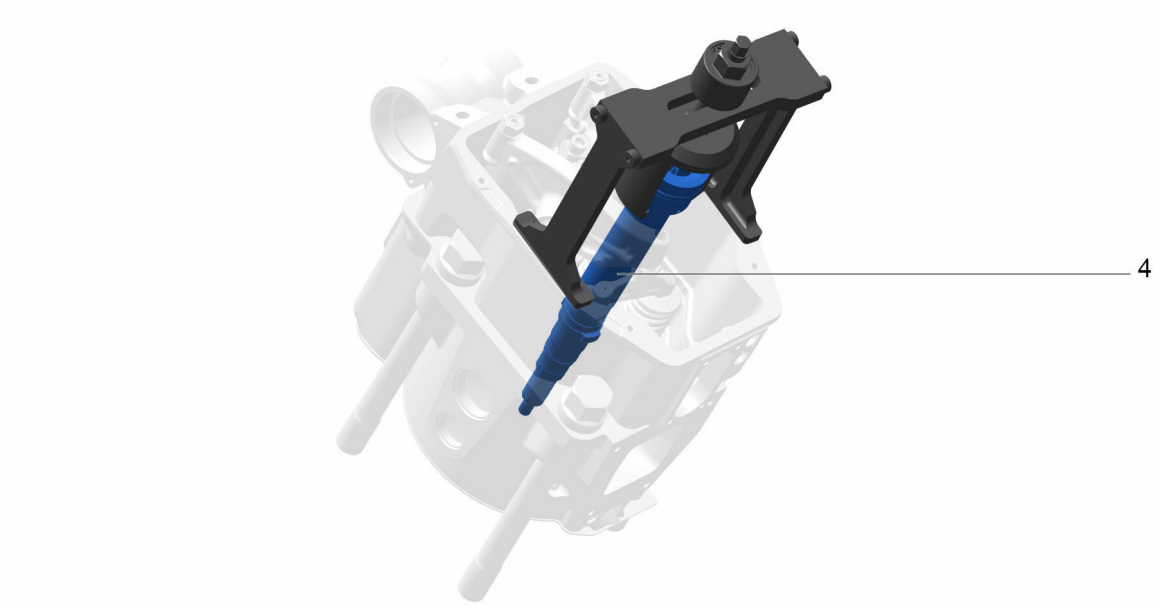


Fig. 140: Extracting injector

▶ Remove injector **4** with extracting tool.

Installation

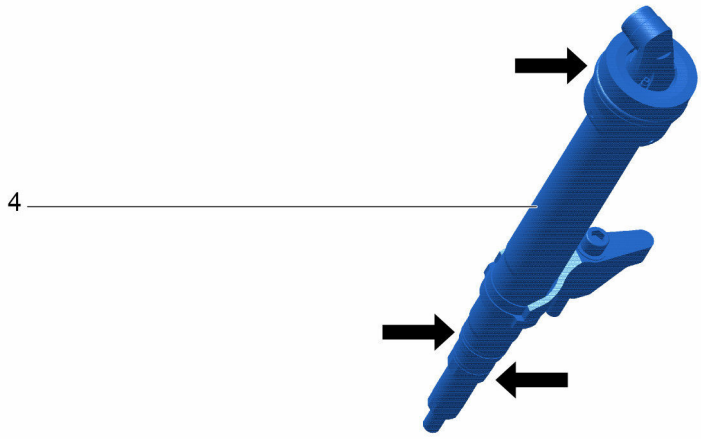


Fig. 141: Lubricating injector O-rings

▶ Clean carbon from injector seat surface on injector sleeve.

▶ Lubricate injector **4** O-rings with Castrol Optimol Paste White T.

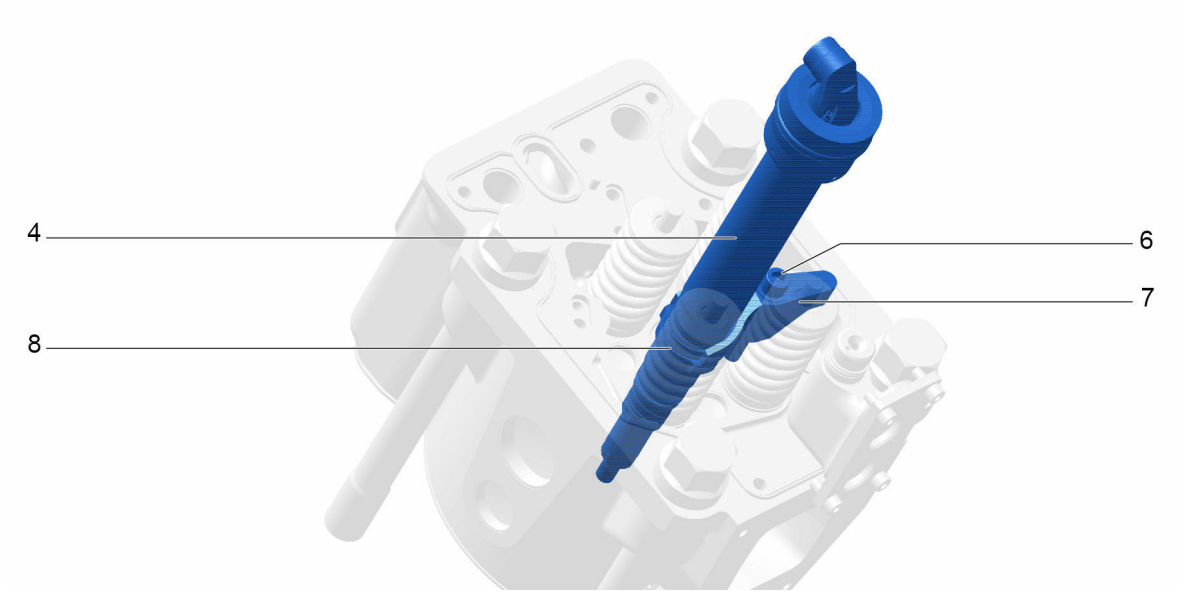


Fig. 142: Installing injector and clamp

▶ Lubricate thread and head contact surface of screw **6** with clean engine oil.

Information

Make sure the copper washer is present before installing the injector.

▶ Position injector **4** with its connection upwards into sleeve **1**.

▶ Install clamp **7** with screw **6**.

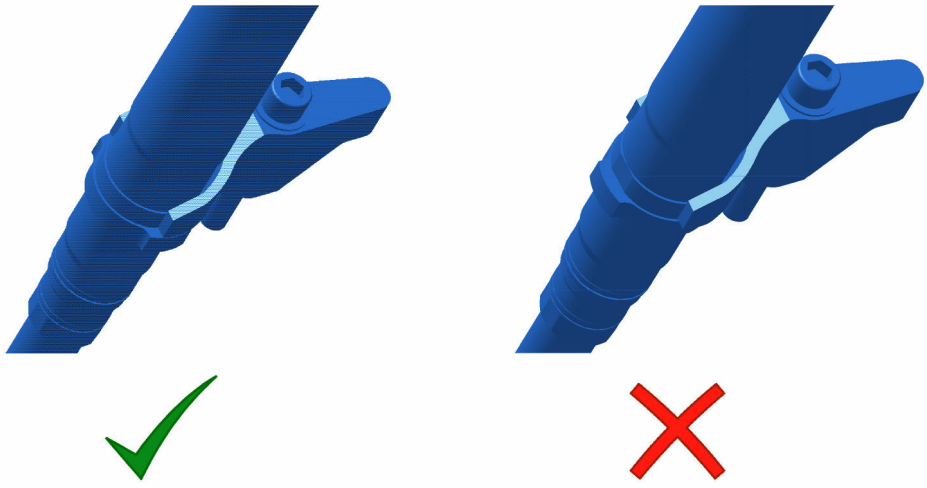


Fig. 143: Positioning injector and clamp

Information

Injectors can be mounted in two positions. Note that only one position is correct.

Make sure the clamp is centered between valve springs.

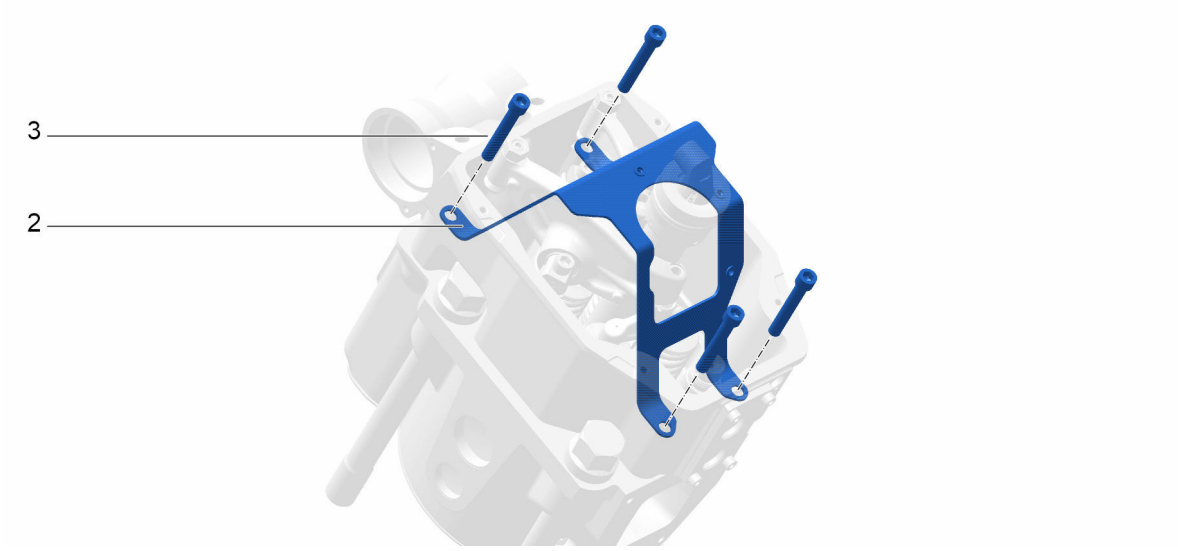


Fig. 144: Installing retaining plate

- ▶ Lubricate screws **3** with engine oil.
- ▶ Position retaining plate **2** with screws **3**.

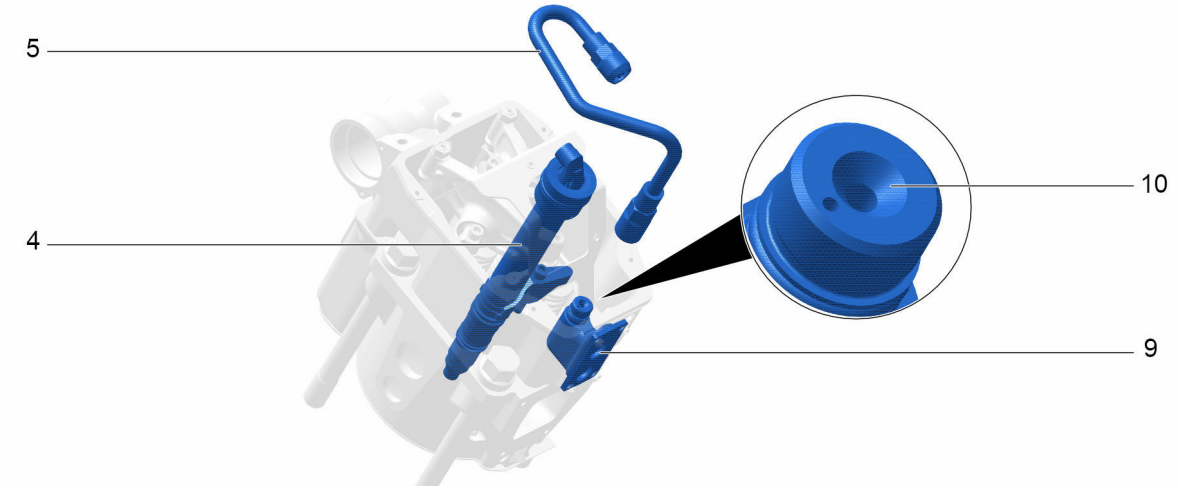


Fig. 145: Installing high-pressure pipe

- ▶ Lubricate threads and cones of high-pressure pipe **5** with clean engine oil.
- ▶ Lubricate o-rings of adaptor **9** with Castrol Optimol Paste White T.
- ▶ Push back the union nut of fuel pipe.
- ▶ Install high-pressure pipe **5** above the adaptor **9**.
- ▶ Pre-tighten screw **6** to torque. (For more information see: Tightening specifications, page 129.)
- ▶ Pre-tighten high-pressure pipe **5** to torque. (For more information see: Tightening specifications, page 129.)
- ▶ Tighten screw **6** to torque. (For more information see: Tightening specifications, page 129.)
- ▶ Tighten high-pressure pipe **5** to torque. (For more information see: Tightening specifications, page 129.)

Fig. 146: Connecting electrical contacts

- ▶ Connect electrical cables on the corresponding solenoid connector.
- ▶ Tighten to torque.

Specific values

Not applicable.

Tightening specifications

- ❑ Put all parts in place and tighten by hand before following the sequence.

Information

Refer to screws reuse rules. (For more information see: 5.3.2 Screws pre-tightening, reuse and marking, page 274.)

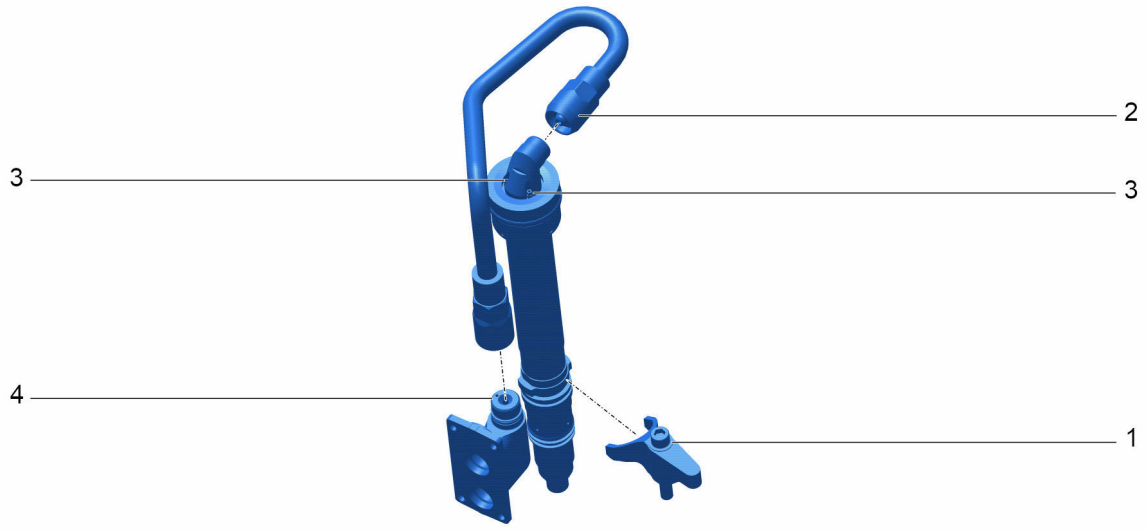


Fig. 147: Injector

Step	Bolt / Tie rod.	Sequence from to	Action	Torque	Angle (°)
1	Clamp **1** (Allen screw)	-	Pre-tighten	26 Nm 19 ft-lb	-
2	Distributor block nut **4** and injector nut **2**	-	Pre-tighten	26 Nm 19 ft-lb	-
3	Clamp **1** (Allen screw)	-	Tighten	76 Nm 56 ft-lb	-
4	Distributor block nut **4**	-	Tighten	189 Nm 139 ft-lb	-
5	Injector nut **2**	-	Tighten	150 Nm 111 ft-lb	-
6	Electrical wires **3**	-	Tighten	0.5 Nm 0.36 ft-lb	-

Tab. 30: Tightening sequence Injector

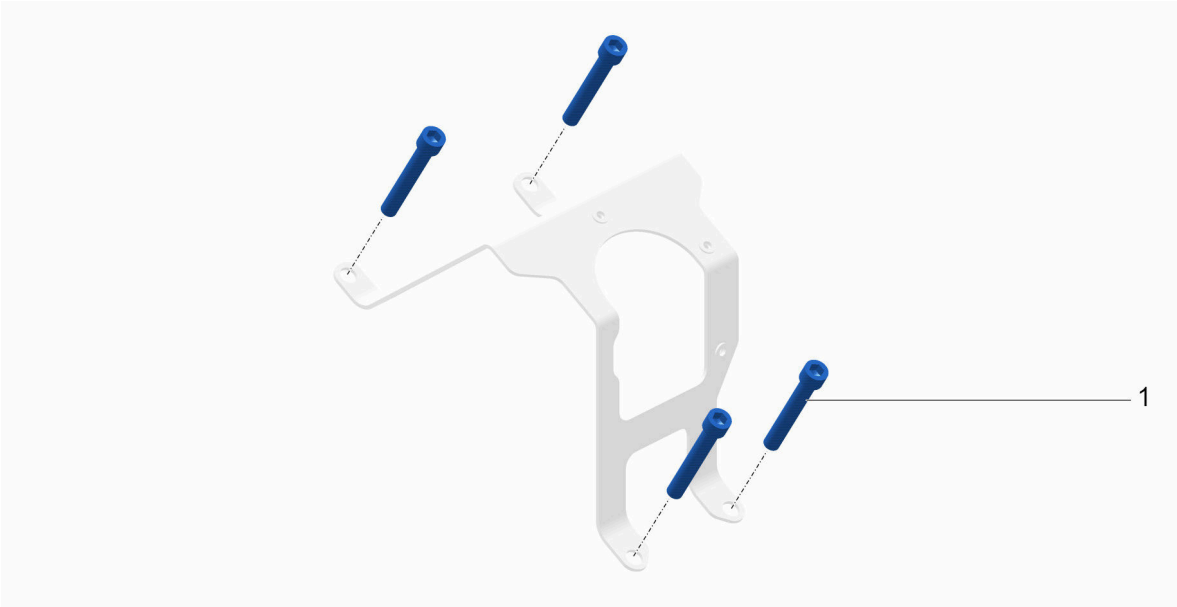


Fig. 148: Retaining plate screws

Reference	Key	Screw specifications	Lubricant *	Reuse**	Torque		Angle (°)	
					Step	± 5%	Step	± 5°
1	081AB	ISO 4762 M12x1.75x80-10.9	O	Yes	1	70 Nm 52 ft-lb	-	-

Tab. 31: Tightening specifications table

*Lubricants:
MG = Molykote G-n-plus
MW = Castrol Optimol paste white T
MH = Molykote HSC
O = Engine oil

XX = Loctite 243
YY = Loctite 577

**Refer to screws reuse rules. (For more information see: 5.3.2 Screws pre-tightening, reuse and marking, page 274.)

3.6.5 Fuel filters removal and installation

Previous tasks

- ❑ Disconnect fuel pipes and sensors.
- ❑ Close fuel supply.

Specific safety instructions

Not applicable.

Special tools

Not applicable.

Consumables and equipment

– Rags
– Cleaner
– Bucket for fuel

Overview

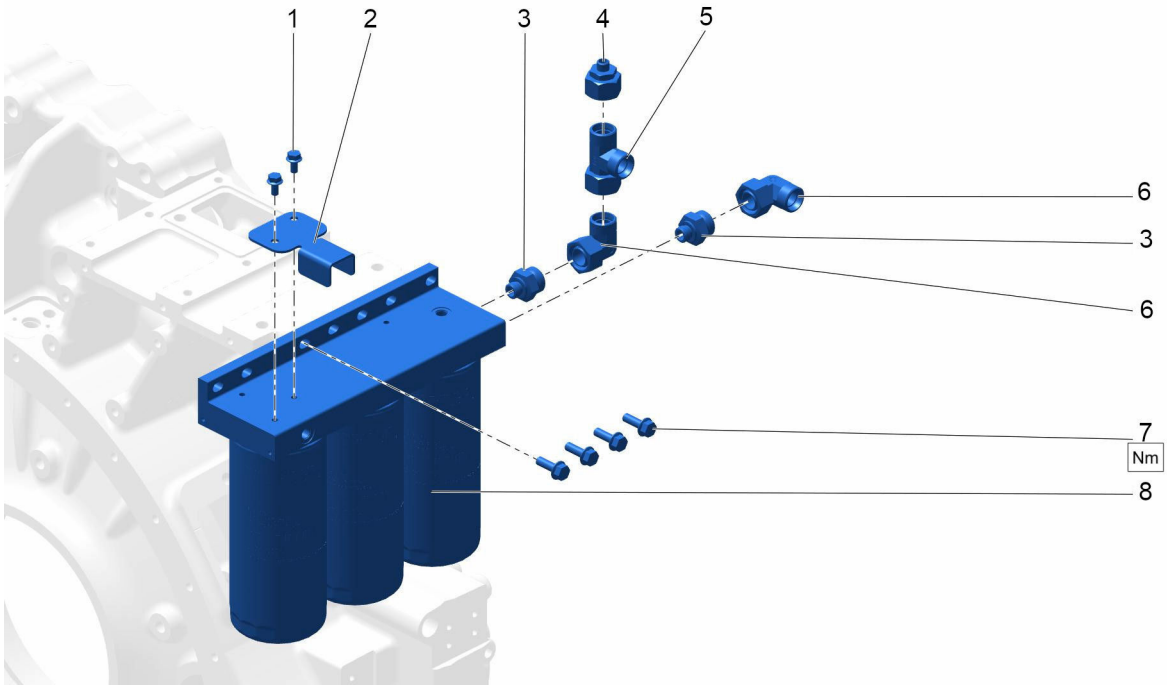


Fig. 149: Task overview

1 Screw (M8)
2 Protection guard
5 Flange joint
6 Flange joint

See next page for continuation of the image legend

3 Flange joint
4 Flange joint
7 Screw (M10)
8 Fuel filter unit

Removal

- ▶ Remove flange joints **3, 4, 5, 6**.
- ▶ Remove screws **1**.
- ▶ Remove protection guard **2**.
- ▶ Remove screws **7**.
- ▶ Remove fuel filter units **8**.

Installation

- ▶ Install fuel filter units **8** with screws **7**.
- ▶ Tighten screws **7** to torque.
- ▶ Screw protection guard **2** with screws **1**.
- ▶ Tighten screws **1** to torque.
- ▶ Install flange joints **3, 4, 5, 6**.

Specific values

Not applicable.

Tightening specifications

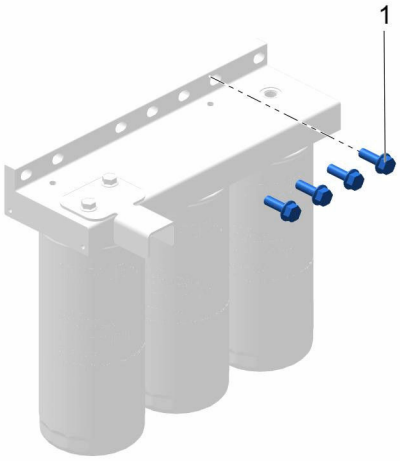


Fig. 150: Fuel filter screws

Reference	Key	Screw specifications	Lubricant *	Reuse**	Torque		Angle (°)	
					Step	± 5%	Step	± 5°
1	201AA	EN 1665 M10x1.5x30-8.8-FLZN	-	Yes	1	25 Nm 18 ft-lb	-	-

Tab. 32: Tightening specifications table

*Lubricants:
MG = Molykote G-n-plus
MW = Castrol Optimol paste white T
MH = Molykote HSC
O = Engine oil
XX = Loctite 243
YY = Loctite 577

**Refer to screws reuse rules. (For more information see: 5.3.2 Screws pre-tightening, reuse and marking, page 274.)

3.6.6 Leakage fuel block removal and installation

Previous tasks

❑ Disconnect leak fuel piping and sensors.

Specific safety instructions

Not applicable.

Special tools

Not applicable.

Consumables and equipment

– Rags
– Cleaner
– Bucket for fuel

Overview

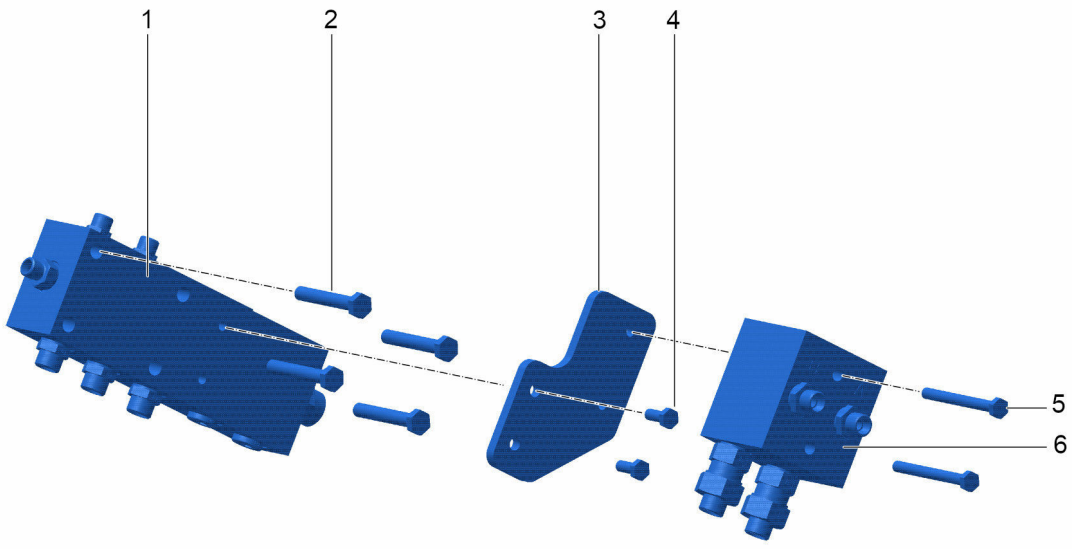


Fig. 151: Task overview

1 Fuel return block
2 Screw (M10)
3 Retaining plate
4 Screw (M8)
5 Screw (M8)
6 Break leakage detection block

Removal

- ▶ Remove screws **5** and break leakage detection block **6**.
- ▶ Remove screws **4** and retaining plate **3**.
- ▶ Remove screws **2** and fuel return block **1**.

Installation

- ▶ Mount fuel return block **1** with screws **2**.
- ▶ Mount retaining plate **3** with screws **4**.
- ▶ Mount break leakage detection block **6** with screws **5**.
- ▶ Tighten screws **2, 4, 5** to torque.

Specific values

Not applicable.

Tightening specifications

Refer to standard tightening torques. (For more information see: 5.3 Standard tightening torques, page 274.)

3.6.7 Fuel pump HP and LP removal and installation (SL 250)

Previous tasks

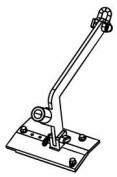
- ❑ Close fuel supply.
- ❑ Release the pressure of the HP fuel system using Kodia tools.
- ❑ Remove fuel pipings connected to HP fuel pump.

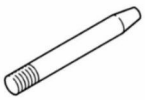
Specific safety instructions

NOTICE
Risk of property damage by reuse of sealing.
Leakage by faulty seal.

- ▶ Replace all sealings.

Special tools

Special tool	Designation
 **12226441**	HP Fuel Pump Lifting Device

Special tool	Designation
 12427300	Guiding rod M12 (x2)

Tab. 33: Special tools

Consumables and equipment

– Vaseline
– Oil
– Castrol Optimol paste white T
– Rags
– Cleaner

Overview

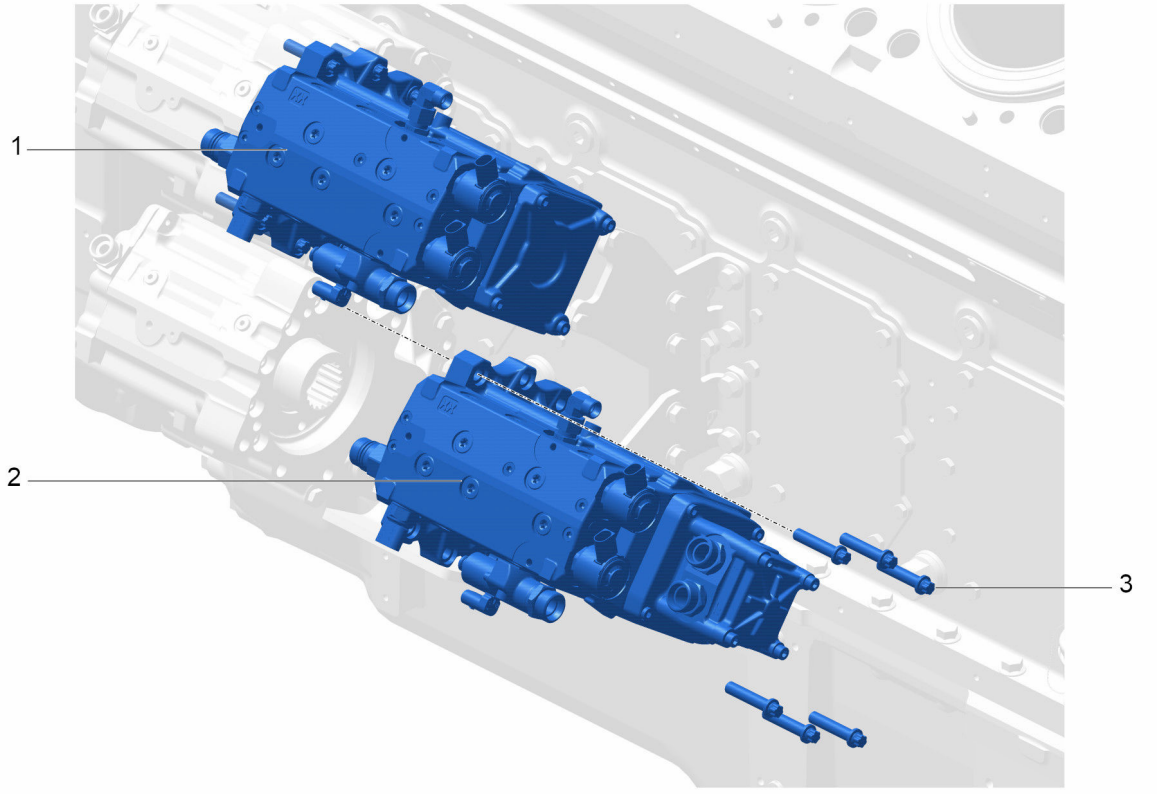


Fig. 154: Task overview

1 HP Fuel pump without LP pump
2 HP Fuel pump with LP pump
3 Screw (M12)

Removal

▶ Remove a first screw **3** and a second one diametrically opposed.

▶ Place guiding rods in place of the two screws.

▶ Remove remaining screws **3**.

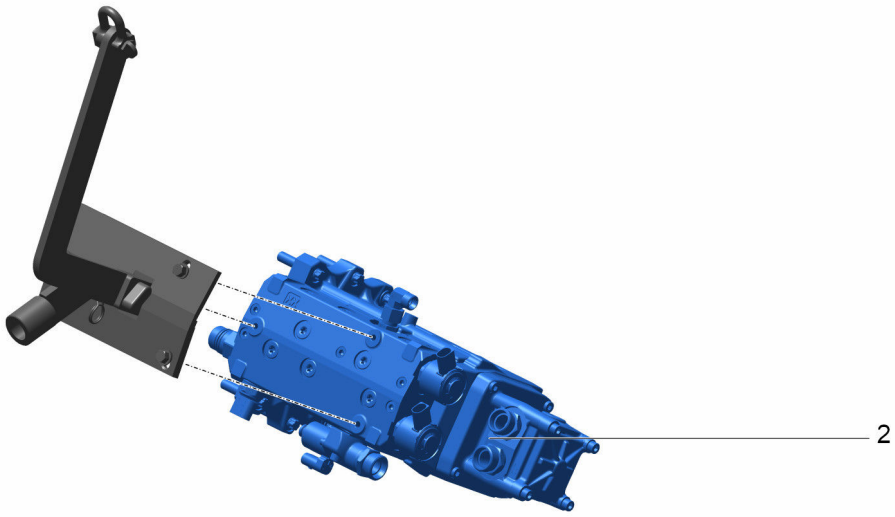


Fig. 155: Installing fuel pump lifting device

▶ Install fuel pump lifting device.

▶ Remove fuel pumps.

▶ Remove guiding rods.

Installation

▶ Install new O-ring.

Information

Lubricate HP connection o-ring with Castrol Optimol paste white T.

Lubricate shaft teeth and o-rings with engine oil.

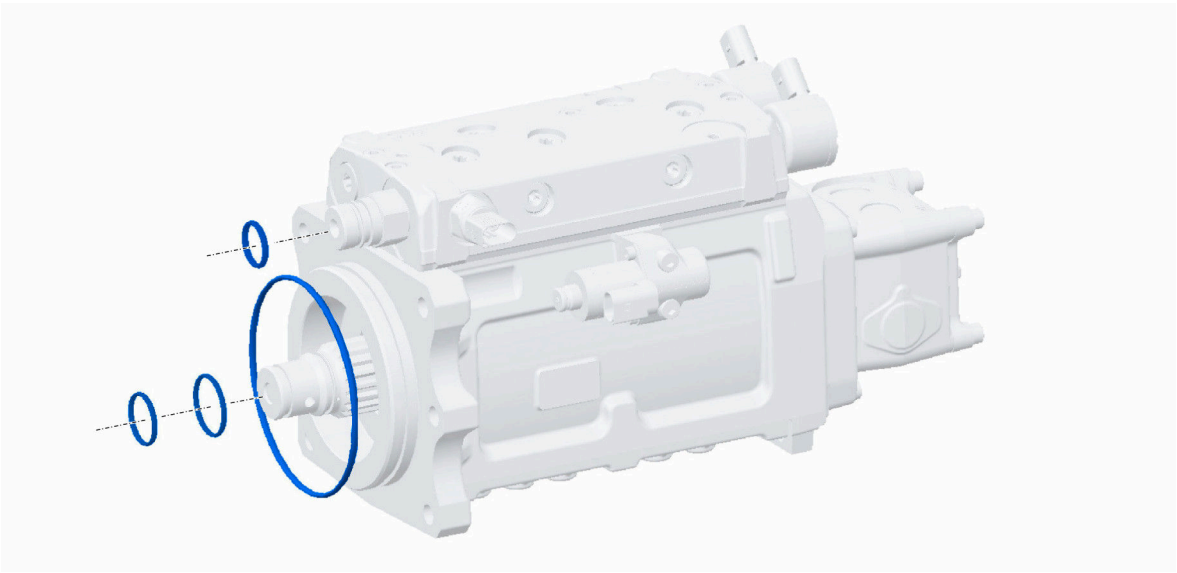


Fig. 156: Fuel pump O-rings

▶ Place guiding rods.

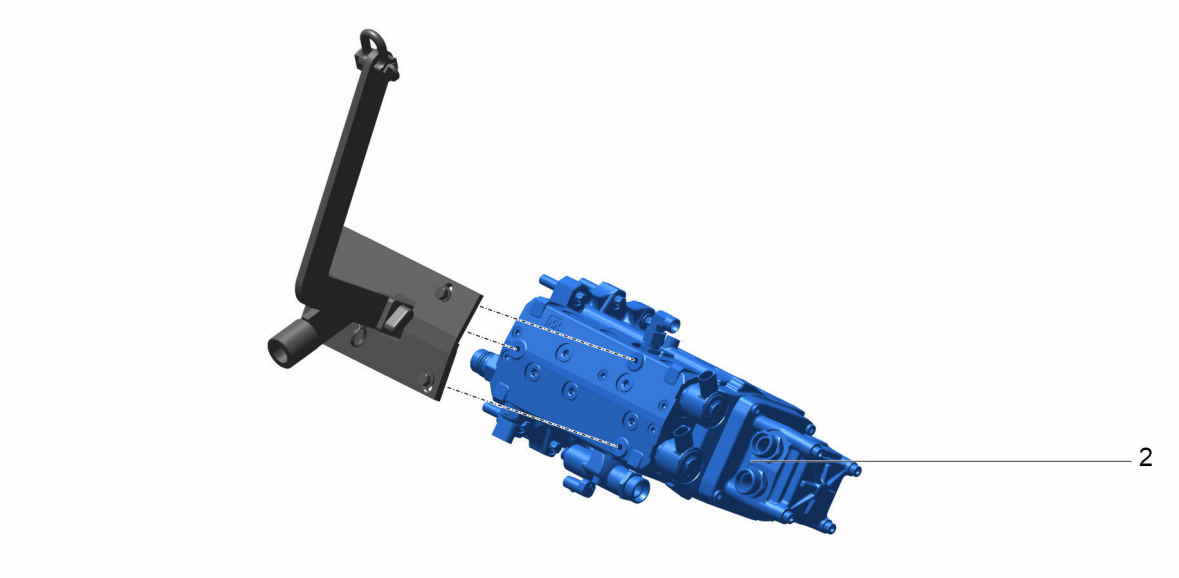


Fig. 157: Installing fuel pump lifting device

▶ Use lifting device to position fuel pumps into gearbox.

▶ Place screw **3**.

▶ Remove guiding rods.

▶ Place remaining screws and remove lifting tools.

▶ Tighten screws to torque following the given order. (For more information see: Tightening specifications, page 138.)

▶ Install HP pump piping.

▶ Perform the venting on the fuel circuit.

Specific values

Not applicable.

Tightening specifications

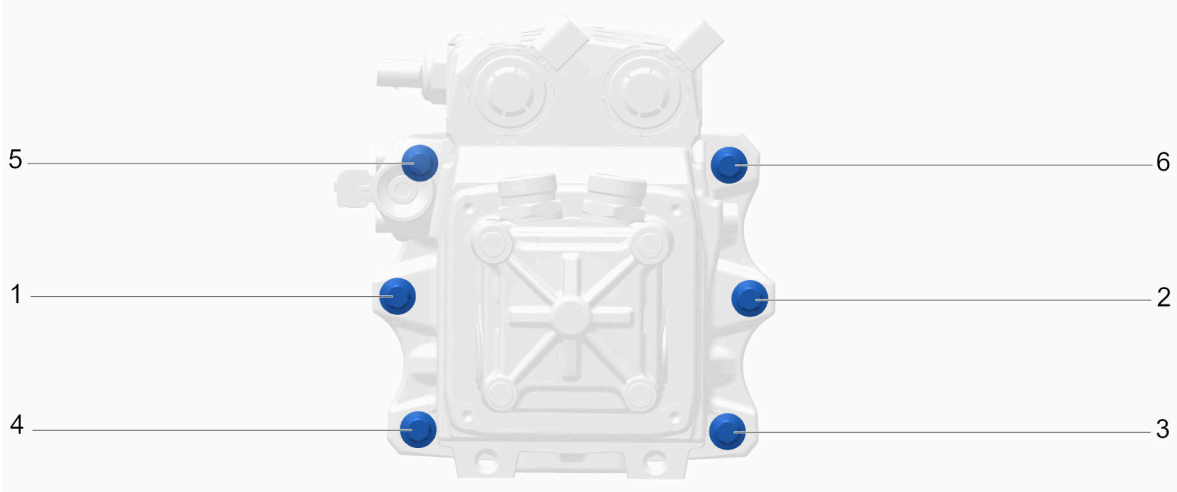


Fig. 158: Fuel pump tightening sequence

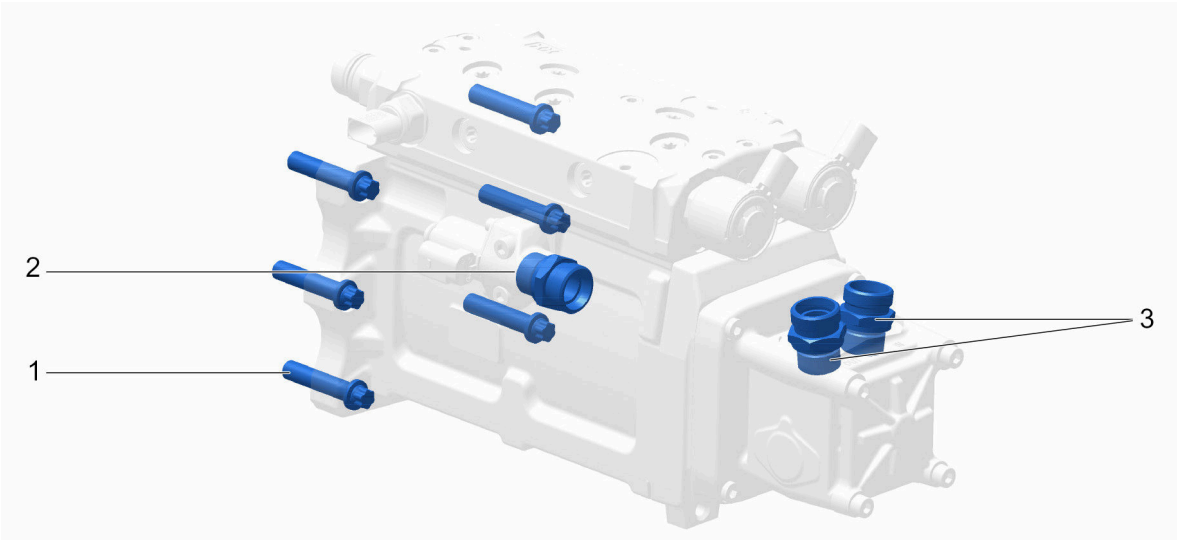


Fig. 159: Fuel pump screws

Reference	Key	Screw specifications	Lubricant *	Reuse**	Torque		Angle (°)	
					Step	± 5%	Step	± 5°
1	171AA	DIN 34800 M12x1.75x55-10.9-FLZN	-	Yes	1	60 Nm 44 ft-lb	-	-
					2	120 Nm 89 ft-lb	-	-
2	171AB	22L M26x1.5	O	Yes	1	140 Nm 103 ft-lb	-	-
3	212AA	22L M26x1.5	O	Yes	1	140 Nm 103 ft-lb	-	-

Tab. 34: Tightening specifications table

*Lubricants:
MG = Molykote G-n-plus
MW = Castrol Optimol paste white T
MH = Molykote HSC
O = Engine oil
XX = Loctite 243
YY = Loctite 577

**Refer to screws reuse rules. (For more information see: 5.3.2 Screws pre-tightening, reuse and marking, page 274.)

3.7 Charge air system

3.7.1 Air intake line removal and installation

Previous tasks

Not applicable.

Specific safety instructions

Not applicable.

Special tools

Not applicable.

Consumables and equipment

– Vaseline
– Rags

Overview

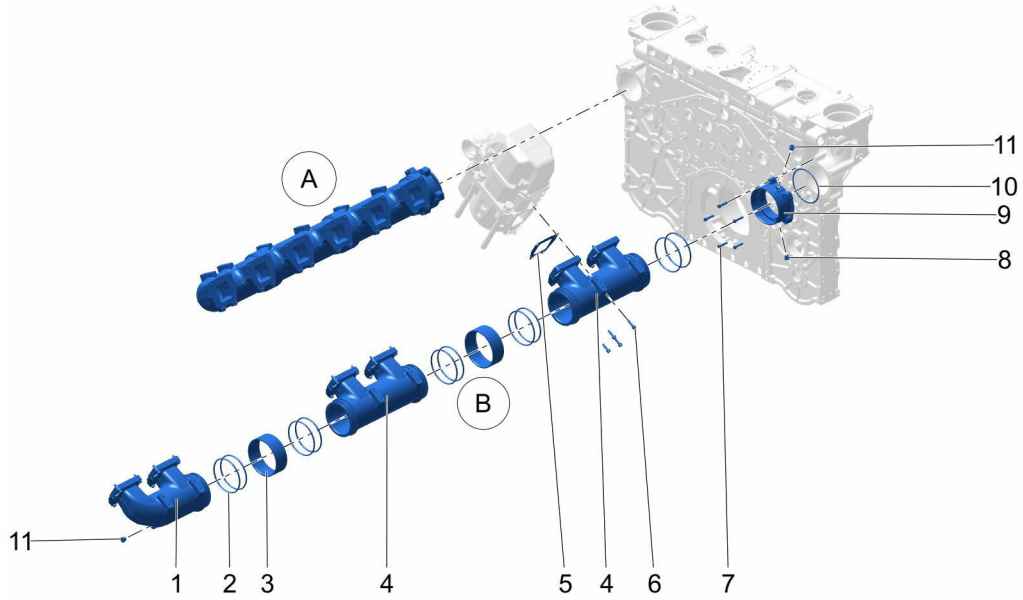


Fig. 160: Task overview

1 Charge air pipe – end segment (B bank)
2 O-ring
3 Pipe
4 Charge air pipe – middle segment (B bank)
5 Gasket
6 Screw (M10)
7 Screw (M10)
8 Screw plug
9 Connection piece
10 O-ring
11 Screw plug

Information

There are four **charge air pipes – middle segments** in V12 engine.

There are six **charge air pipes – middle segments** in V16 engine.

There are eight **charge air pipes – middle segments** in V20 engine.

Removal

- ▶ Remove screws **6**.
- ▶ Remove charge air pipes **1, 4** and pipes **3** individually.

Installation

- ▶ Install screw plugs **11** on charge air pipe **1**.
- ▶ Put o-rings **2** on charge air pipes **1, 4** and grease them.
- ▶ Put o-ring **10** and screw plugs **8, 11** on connection piece **9**.
- ▶ Screw connection piece **9** with screws **7**.
- ▶ Mount charge air pipe **4** next to connection piece **9** using gasket **5** and screws **6** to fix charge air pipe to cylinder heads.
- ▶ Repeat procedure for next charge air pipes **4** using pipe **3**.
- ▶ Repeat procedure for last charge air pipe **1** using pipe **3**.

Specific values

Not applicable.

Tightening specifications

Refer to standard tightening torques. (For more information see: 5.3 Standard tightening torques, page 274.)

3.7.2 Charge air line removal and installation

Previous tasks

Not applicable.

Specific safety instructions

NOTICE
Risk of property damage by reuse of sealing.
Leakage by faulty seal.

- ▶ Replace all sealings.

Special tools

Not applicable.

Consumables and equipment

– Rags
– Cleaner
– Grease (Optimol)

Overview

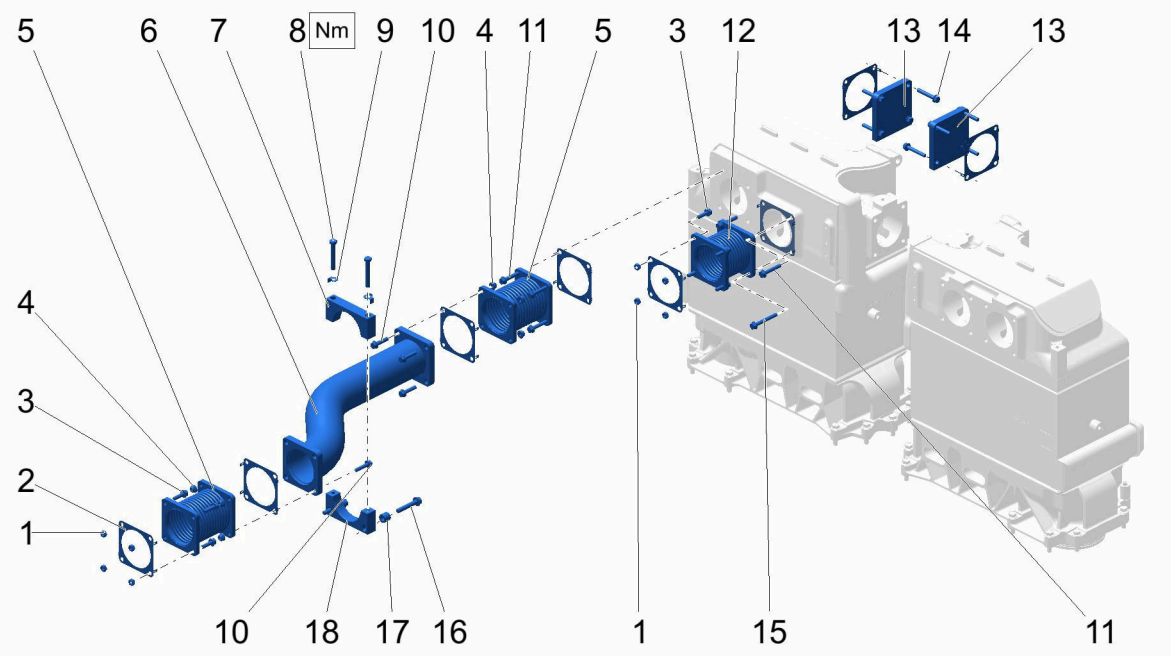


Fig. 161: Task overview

1 Nut (M10)
2 Seal
3 Screw (M10)
4 Nut (M10)
5 Compensator
6 Pipe
7 Clamp
8 Screw (M12)
10 Screw (M10)
11 Screw (M10)
12 Compensator
13 End cover
14 Screw (M10)
15 Screw (M10)
16 Screw (M12)
17 Distance sleeve

See next page for continuation of the image legend

9 Locking plate

18 Clamp

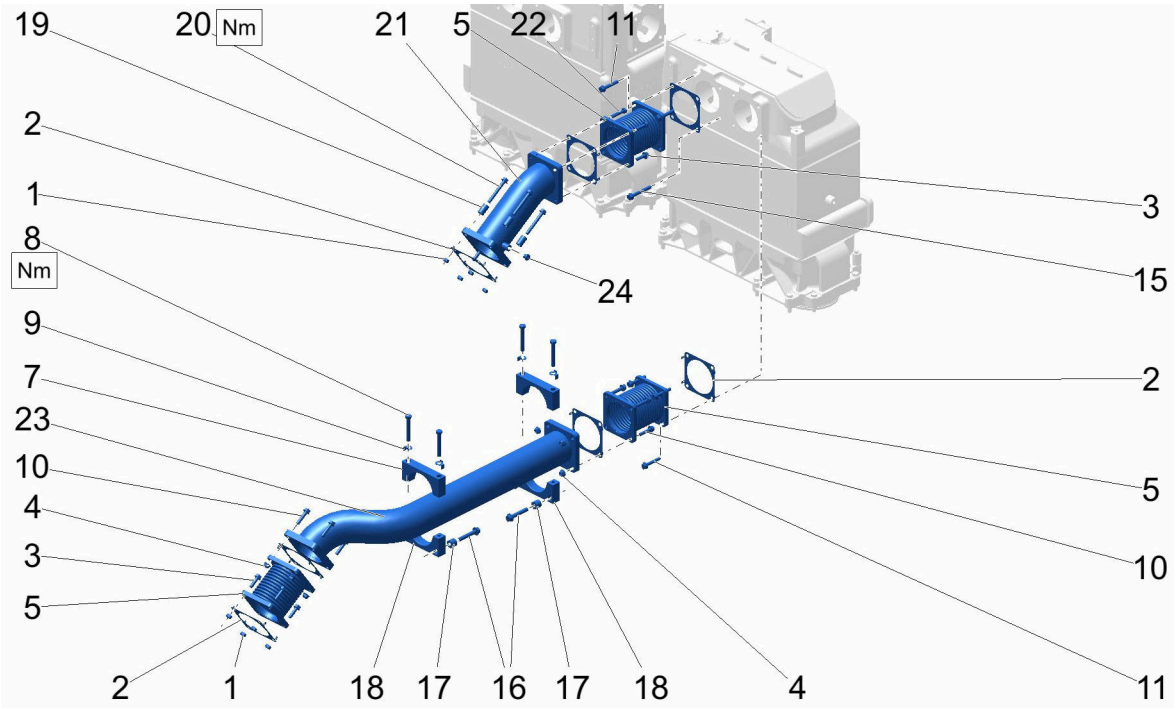


Fig. 162: Task overview

19 Distance sleeve
20 Screw (M10)
21 Pipe
22 Screw (M12)
23 Pipe
24 Screw plug

Removal

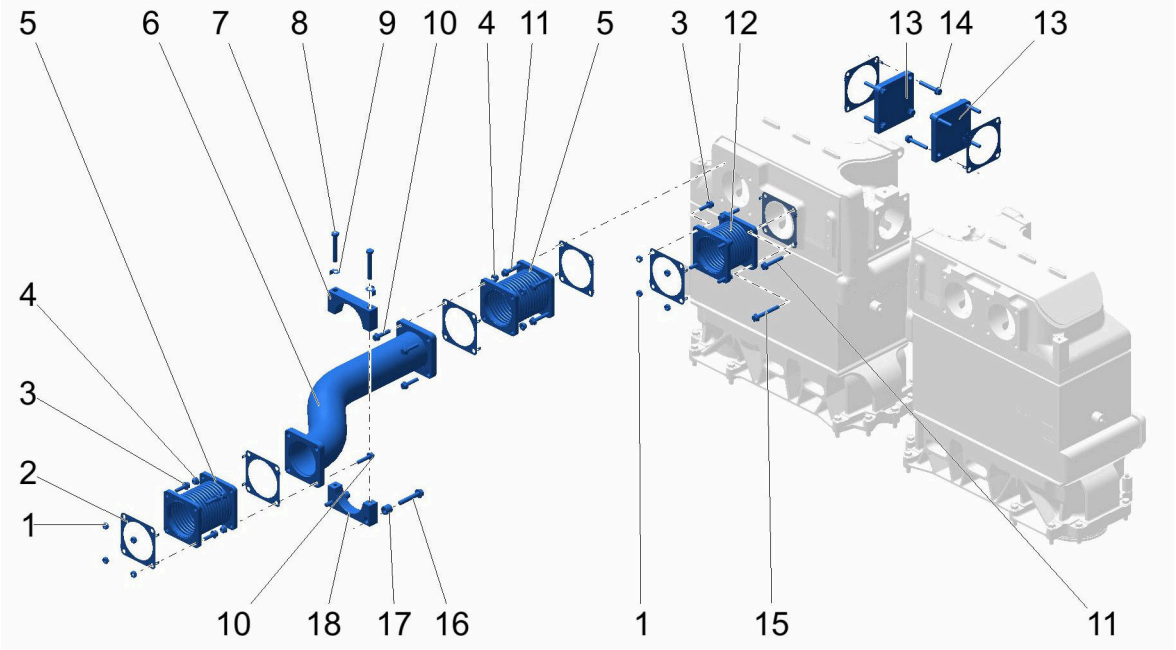


Fig. 163: Removing charge air lines

▶ Remove screws **3, 10** with nuts **1, 4**.

- ▶ Remove compensator **5** with seals **2**.
- ▶ Remove screws **8, 16** with locking plates **9** and distance sleeves **17**.
- ▶ Remove clamps **7, 18**.
- ▶ Remove screws **10** with nuts **4**.
- ▶ Remove pipe **6**.
- ▶ Remove screws **11**.
- ▶ Remove compensator **5** with seals **2**.
- ▶ Remove screws **3, 11, 15** with nuts **1**.
- ▶ Remove compensator **12** with seals **2**.
- ▶ Remove screws **14**.
- ▶ Remove end covers **13** with seals **2**.

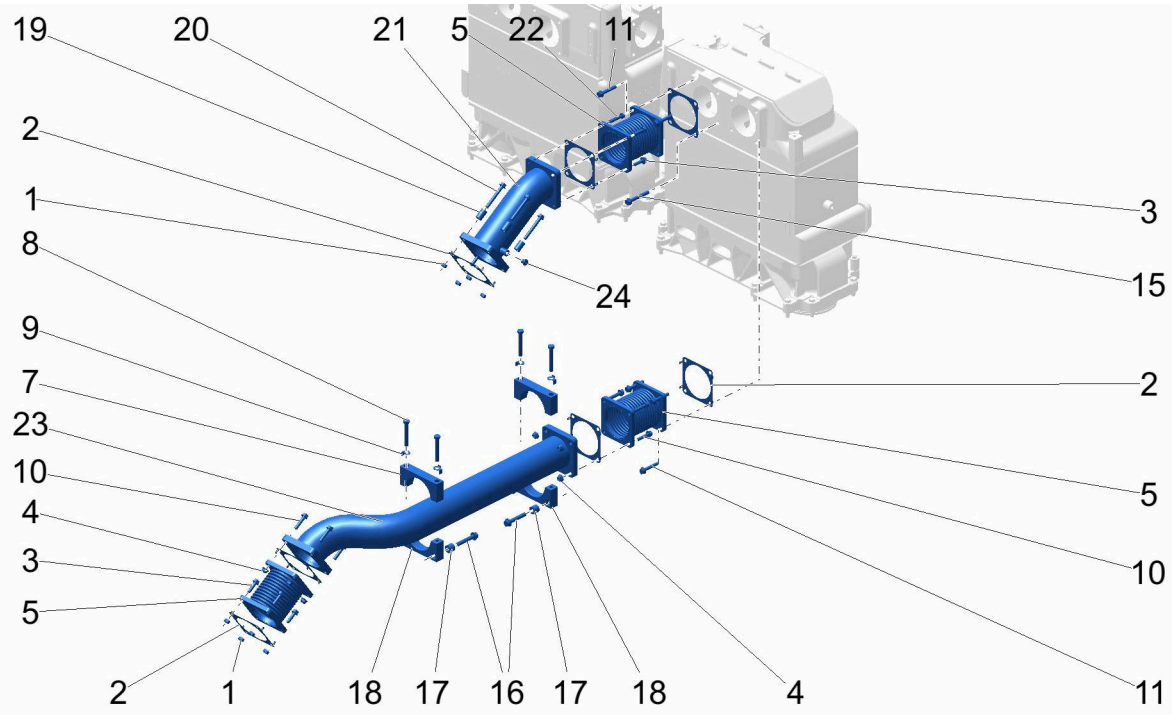


Fig. 164: Removing charge air lines

- ▶ Remove screws **3, 10** with nuts **1**.
- ▶ Remove compensator **5** with seals **2**.
- ▶ Remove screws **8, 16** with locking plates **9** and distance sleeves **17**.
- ▶ Remove clamps **7, 18**.
- ▶ Remove screws **10** with nuts **4**.
- ▶ Remove pipe **23**.
- ▶ Remove screws **10**.
- ▶ Remove compensator **5** with seals **2**.
- ▶ Remove screws **20** with distance sleeves **19** and nuts **1**.
- ▶ Remove screws **3, 22**.
- ▶ Remove pipe **21** with seals **2**.

- ▶ Remove screws **11, 15**.
- ▶ Remove compensator **5** with seals **2**.

Installation

Information

Preassemble all seals on compensators.

Information

At first, install the whole line without tightening the screws.

Tighten all screws to torque at the end of installation, making sure that compensators are aligned evenly.

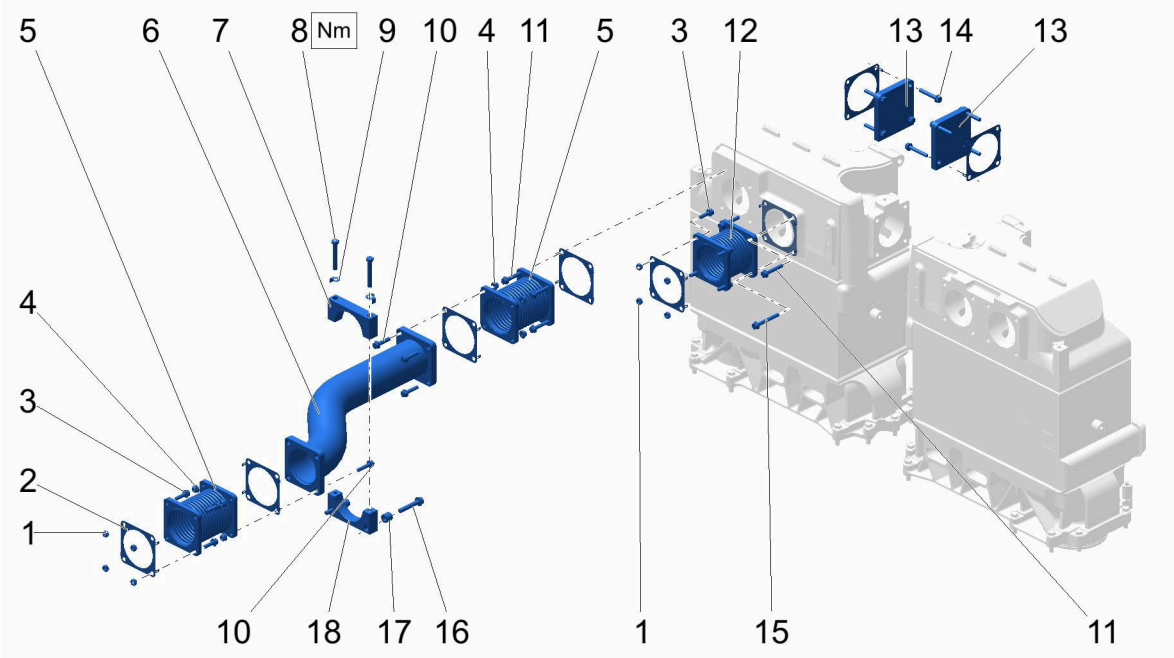


Fig. 165: Installing charge air lines

- ▶ Screw end covers **13** with screws **14** and seals **2**.
- ▶ Screw compensator **12** to charge air cooler with screws **3, 11, 15** and seal **2**.
- ▶ Screw compensator **5** to turbocharger with screws **3**, seal **2** and nuts **1**.
- ▶ Assemble pipe **6** with compensators **5** on both sides using screws **10**, seals **2** and nuts **4**.
- ▶ Screw assembly to charge air cooler with screws **11** and seal **2**.
- ▶ Screw clamps **7, 18** with screws **8, 16**, locking plates **9** and distance sleeves **17**.

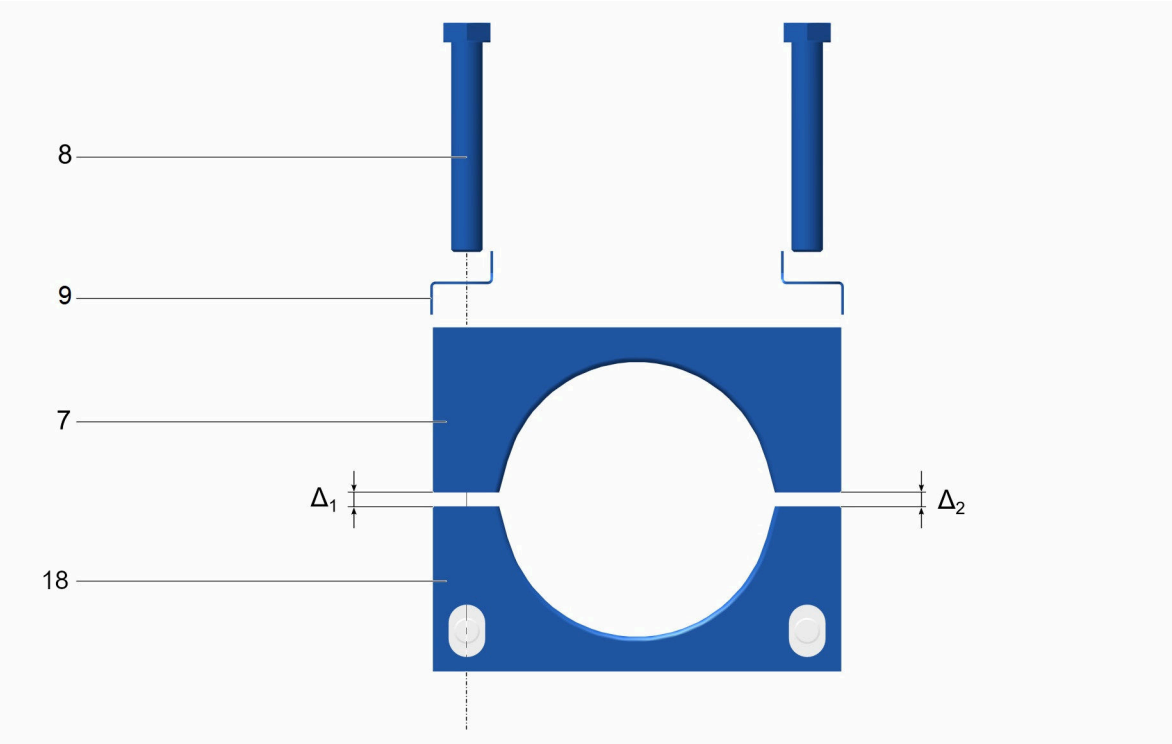


Fig. 166: Installing clamps

▶ Pretighten both screws **8** simultaneously to ensure $\Delta_1 = \Delta_2$ after tightening.

Information

Bend locking plates **9** after assembly.

▶ Tighten screws **8** to torque.

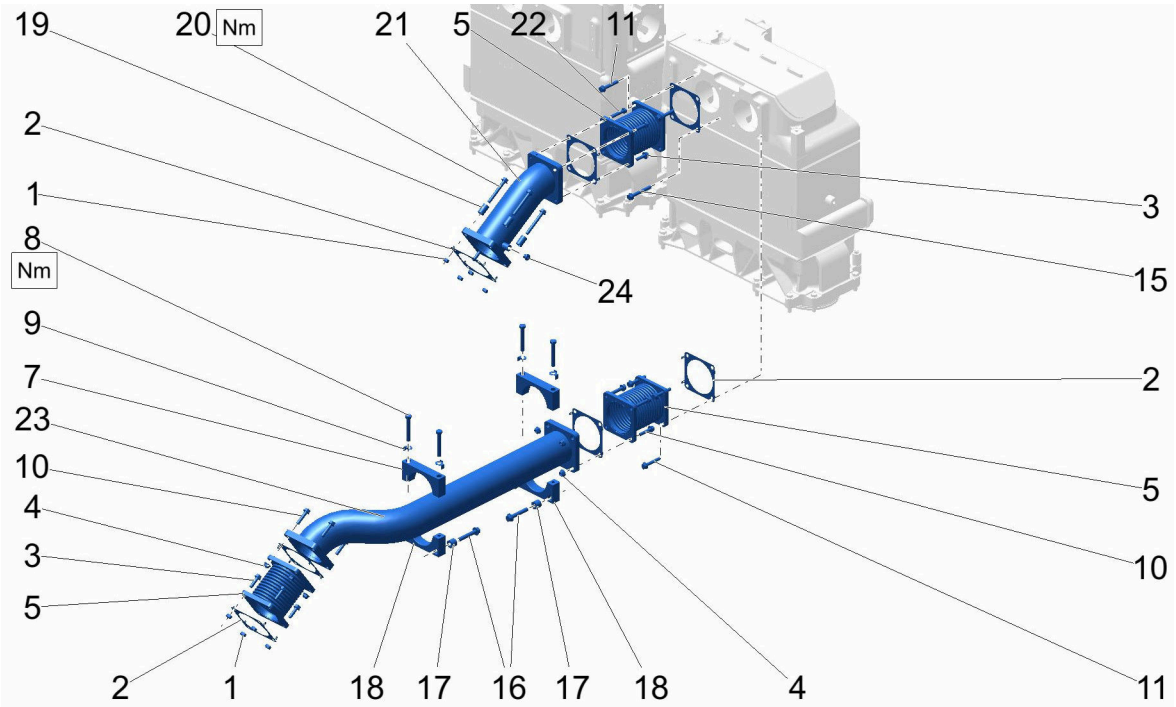


Fig. 167: Installing compensators and charge air lines

- ▶ Assemble pipe **21** with compensator **5** using screws **3, 22** and seal **2**.
- ▶ Screw assembly to charge air cooler with screws **11, 15** and seal **2**.
- ▶ Screw assembly to turbocharger with screws **20**, distance sleeves **19**, seal **2** and nuts **1**.
- ▶ Install screw plug **24**.
- ▶ Assemble pipe **23** with compensators **5** on both sides using screws **10**, seals **2** and nuts **4**.
- ▶ Screw assembly to charge air cooler with screws **11** and seal **2**.
- ▶ Screw assembly to turbocharger with screws **3**, seal **2** and nuts **1**.
- ▶ Screw clamps **7, 18** with screws **8, 16**, locking plates **9** and distance sleeves **17**.

Information

Bend locking plates **9** after assembly.

- ▶ Tighten screws **8** to torque.

Specific values

Not applicable.

Tightening specifications

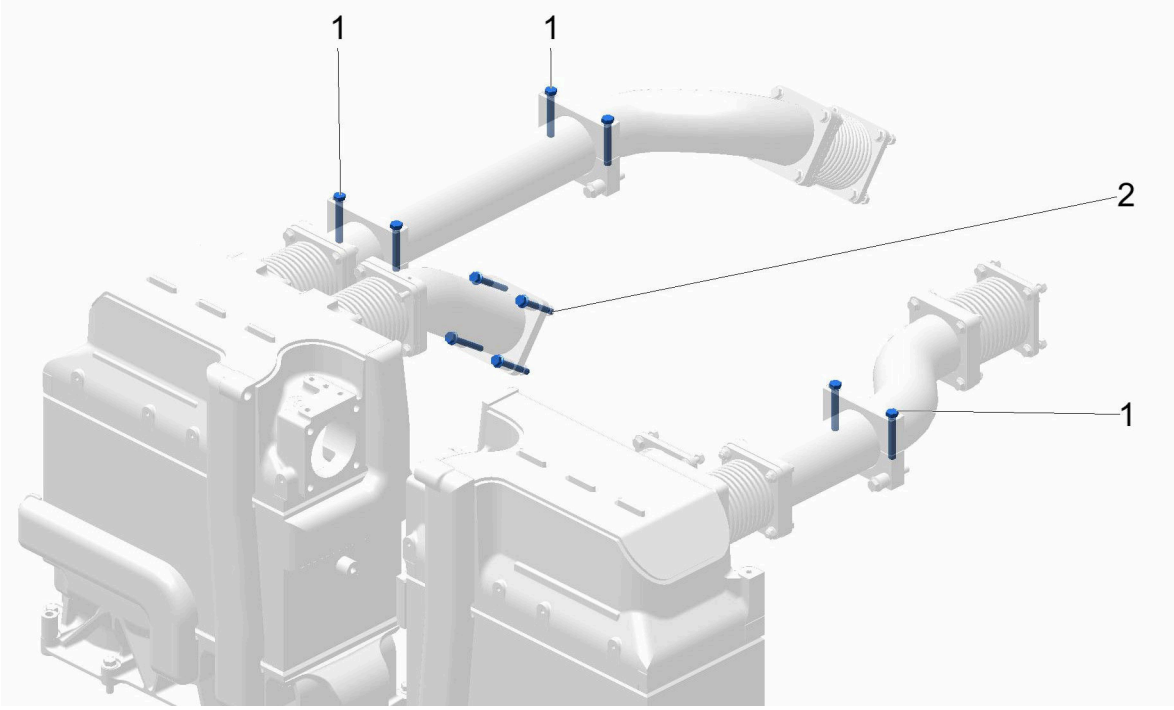


Fig. 168: Clamp screws

Reference	Key	Screw specifications	Lubricant *	Reuse**	Torque		Angle (°)	
					Step	± 5%	Step	± 5°
1	230AB	ISO 4014 M12x1.75x80-10.9-FLZN	-	Yes	1	40 Nm 30 ft-lb	-	-
2	230AH	EN 1665 M10x1.5x80-10.9-FLZN	-	Yes	1	43 Nm 32 ft-lb	-	-

Tab. 35: Tightening specifications table

*Lubricants:
MG = Molykote G-n-plus
MW = Castrol Optimol paste white T
MH = Molykote HSC
O = Engine oil
XX = Loctite 243
YY = Loctite 577

**Refer to screws reuse rules. (For more information see: 5.3.2 Screws pre-tightening, reuse and marking, page 274.)

Charge air line removal and installation (EATS configuration)

Previous tasks

Not applicable.

Specific safety instructions

NOTICE
Risk of property damage by reuse of sealing.
Leakage by faulty seal.

▶ Replace all sealings.

Special tools

Not applicable.

Consumables and equipment

– Rags
– Cleaner
– Grease (Optimol)

Overview

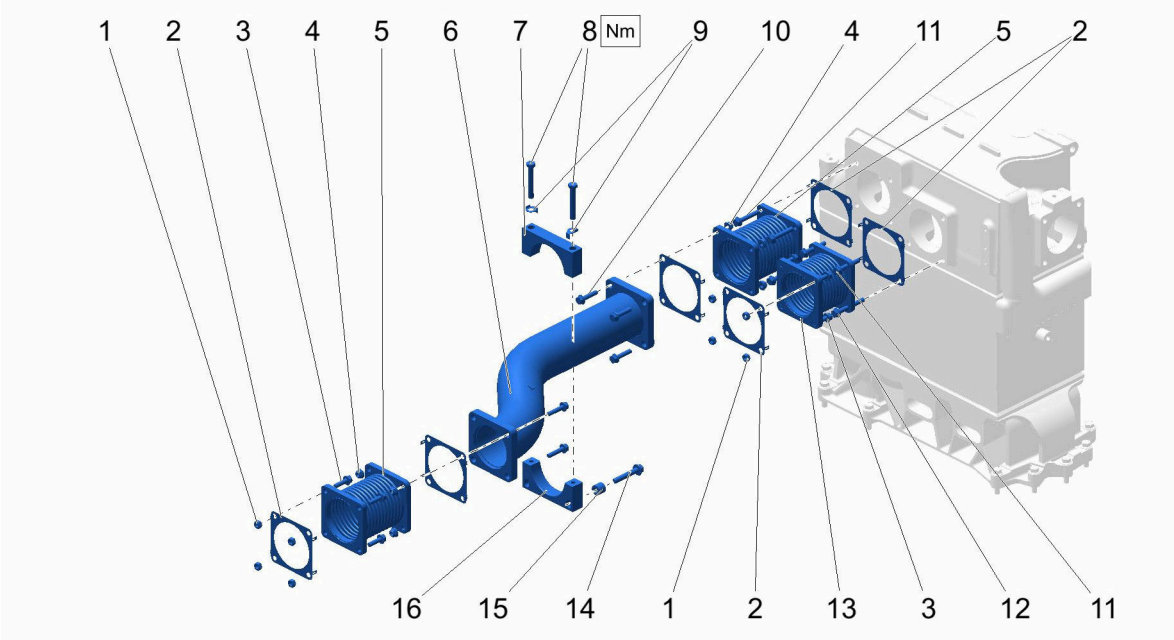


Fig. 169: Task overview

1 Nut (M10)
2 Seal
3 Screw (M10)
4 Nut (M10)
5 Compensator
6 Pipe
7 Clamp
9 Locking plate
10 Screw (M10)
11 Screw (M10)
12 Screw (M10)
13 Compensator
14 Screw (M10)
15 Distance sleeve

See next page for continuation of the image legend

8 Screw (M12)

16 Clamp

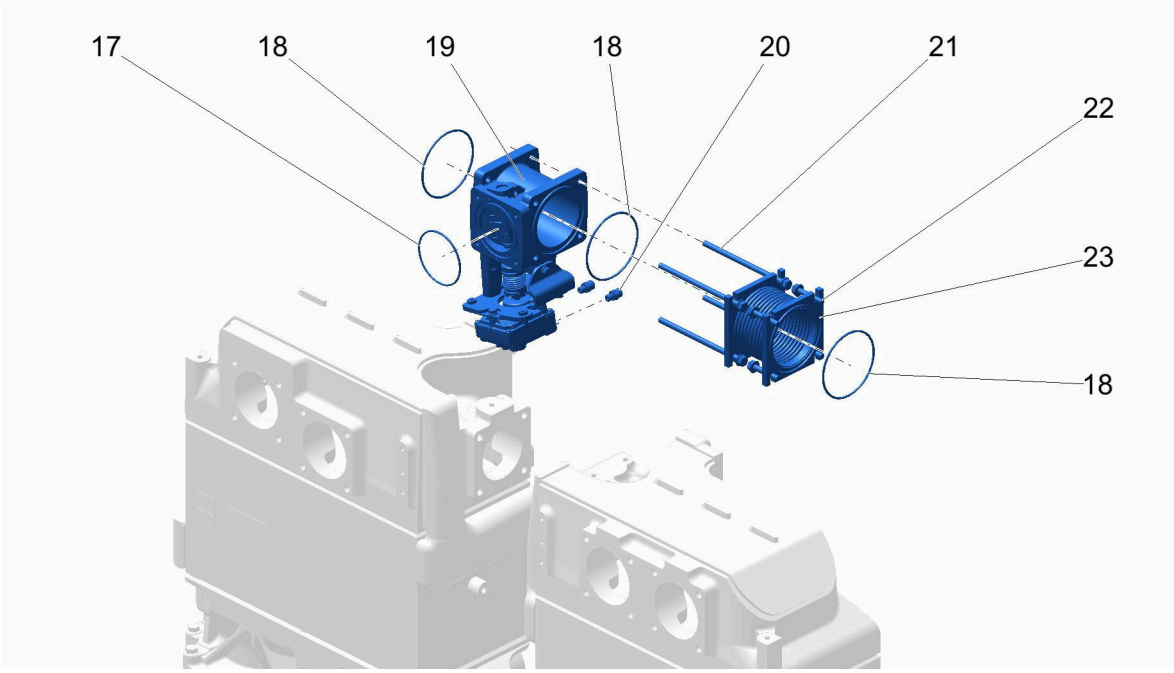


Fig. 170: Task overview

17 O-ring
18 O-ring
19 Flap with actuator
20 Flange joint
21 Screw (M10)
22 Screw (M10)
23 Compensator

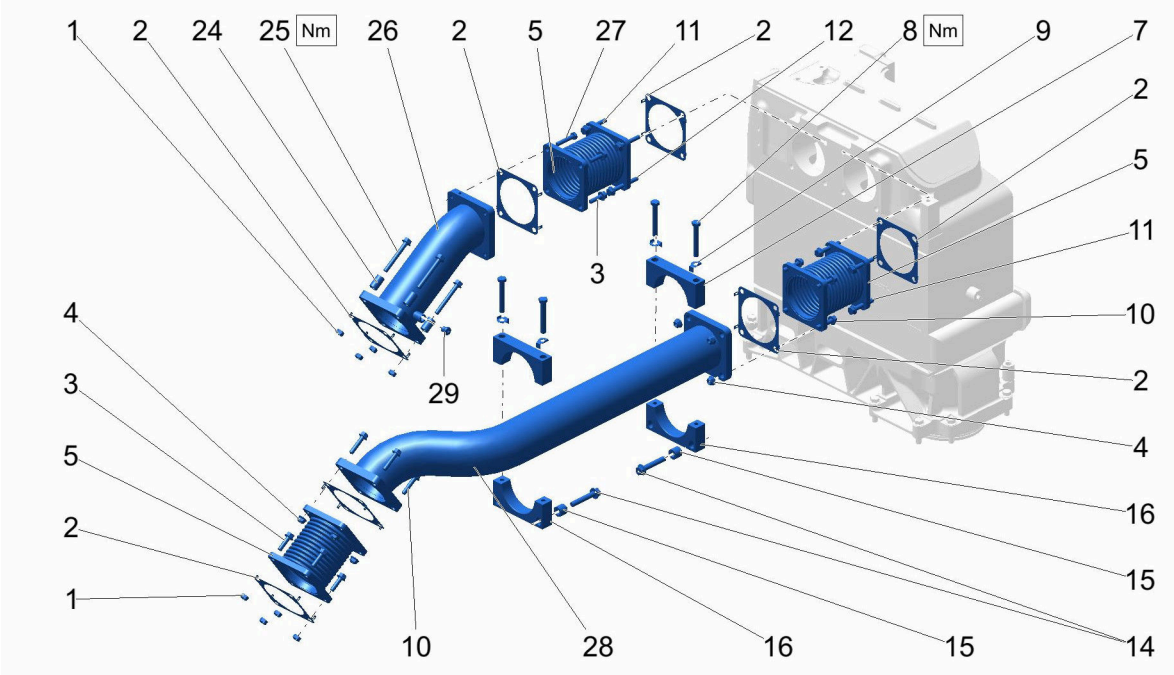


Fig. 171: Task overview

24 Distance sleeve
25 Screw (M10)
26 Pipe
27 Screw (M10)
28 Pipe
29 Screw plug

Removal

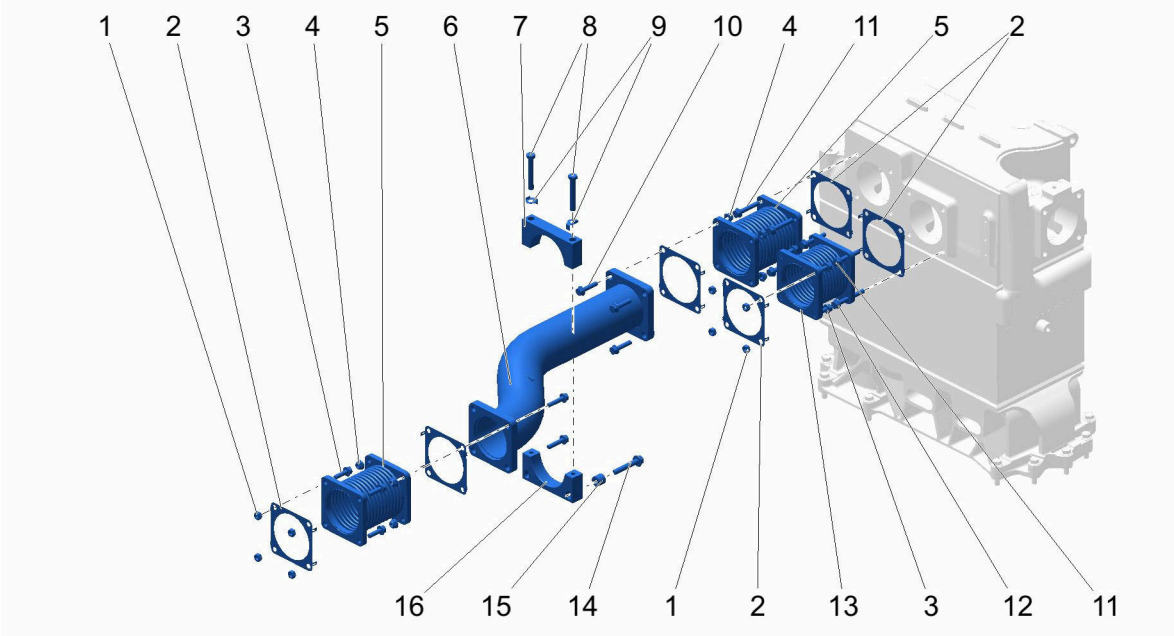


Fig. 172: Removing charge air lines

- ▶ Remove screws **3, 11, 12**, and nuts **1**.
- ▶ Remove compensator **13**, and seals **2**.
- ▶ Remove screw **14**, and distance sleeve **15**.
- ▶ Remove screws **8**, and locking plates **9**.
- ▶ Remove clamps **7, 16**.
- ▶ Remove screws **3, 10**, and nuts **1, 4**.
- ▶ Remove compensator **5**, and seals **2**.
- ▶ Remove screws **10**, and nuts **4**.
- ▶ Remove pipe **6**.
- ▶ Remove screws **11**.
- ▶ Remove compensator **5**, and seals **2**.

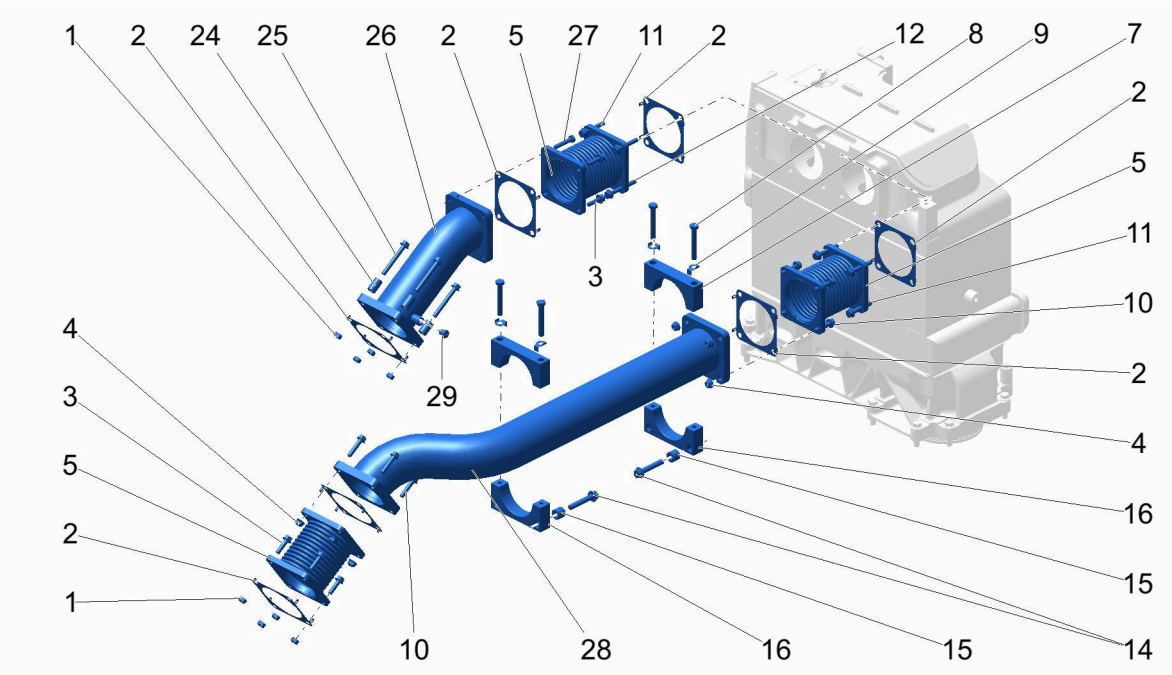


Fig. 173: Removing charge air lines

- ▶ Remove screws **25**, distance sleeves **24**, and nuts **1**.
- ▶ Remove screws **3, 27**.
- ▶ Remove pipe **26**.
- ▶ Remove screws **11, 12**.
- ▶ Remove compensator **5**, and seals **2**.
- ▶ Remove screws **14**, and distance sleeves **15**.
- ▶ Remove screws **8**, and locking plates **9**.
- ▶ Remove clamps **7, 16**.
- ▶ Remove screws **3, 10**, and nuts **1, 4**.
- ▶ Remove compensator **5**, and seals **2**.
- ▶ Remove screws **10**, and nuts **4**.
- ▶ Remove pipe **28**.
- ▶ Remove screws **11**.
- ▶ Remove compensator **5**, and seals **2**.

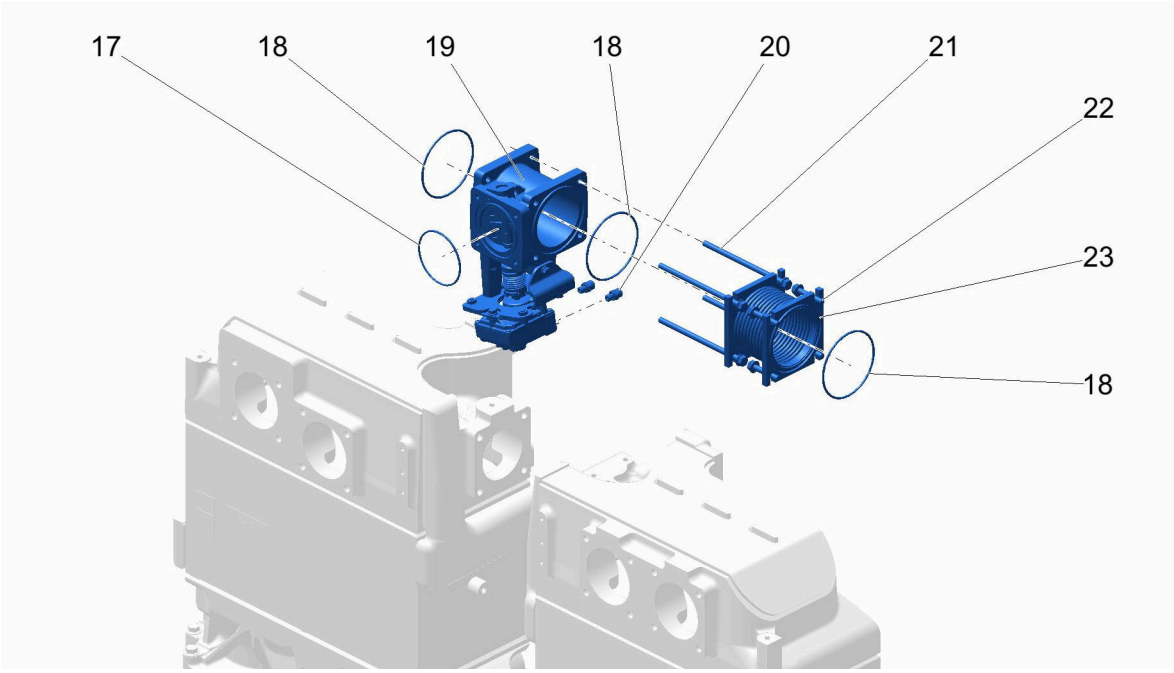


Fig. 174: Removing flap with actuator

- ▶ Disconnect connector of the flap with actuator **19**.
- ▶ Disconnect coolant lines from flange joints **20**.
- ▶ Remove screws **22**.
- ▶ Loosen screws **21**.
- ▶ Remove flap with actuator **19**, and compensator **23** as an assembly.
- ▶ Remove compensator **23** from flap with actuator **19**.

Installation

Information

Preassemble all seals on compensators.

Information

At first, install the whole line without tightening the screws.

Tighten all screws to torque at the end of installation, making sure that compensators are aligned evenly.

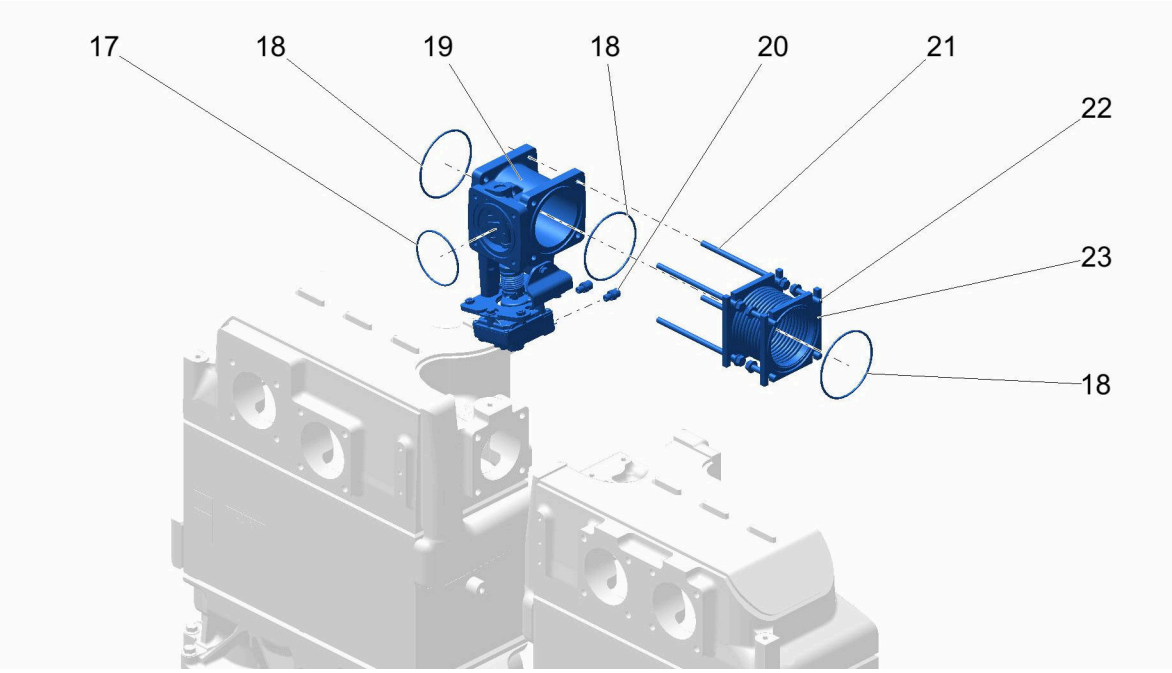


Fig. 175: Installing flap with actuator

- ▶ Assemble flap with actuator **19** and compensator **23** with screws **21**, and new o-rings **17, 18**.
- ▶ Install assembly with screws **21, 22**.
- ▶ Install flange joints **20**.

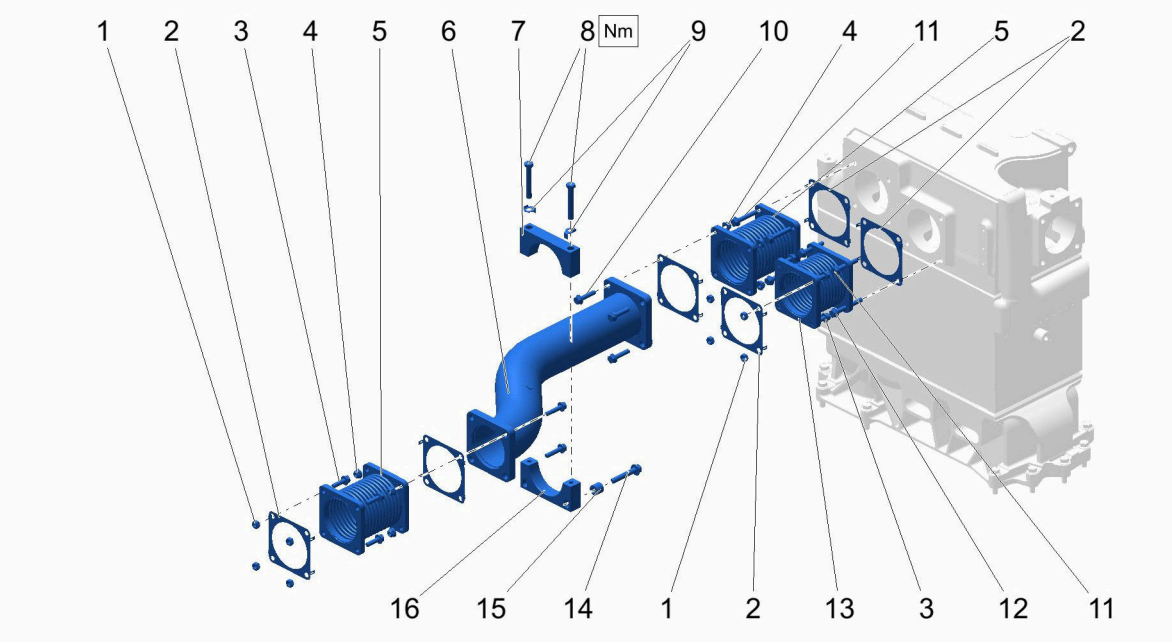


Fig. 176: Installing charge air lines

- ▶ Install compensator **13** with seals **2**, screws **3, 11, 12**, and nuts **1**.
- ▶ Assemble pipe **6** with compensators **5**, and seals **2** using screws **10**, and nuts **4**.
- ▶ Install assembly to charge air cooler with screws **11** and seal **2**.
- ▶ Install assembly to turbocharger with screws **3**, seal **2**, and nuts **1**.

▶ Install clamps **7, 16** with screws **8, 14**, distance sleeve **15**, and locking plates **9**.

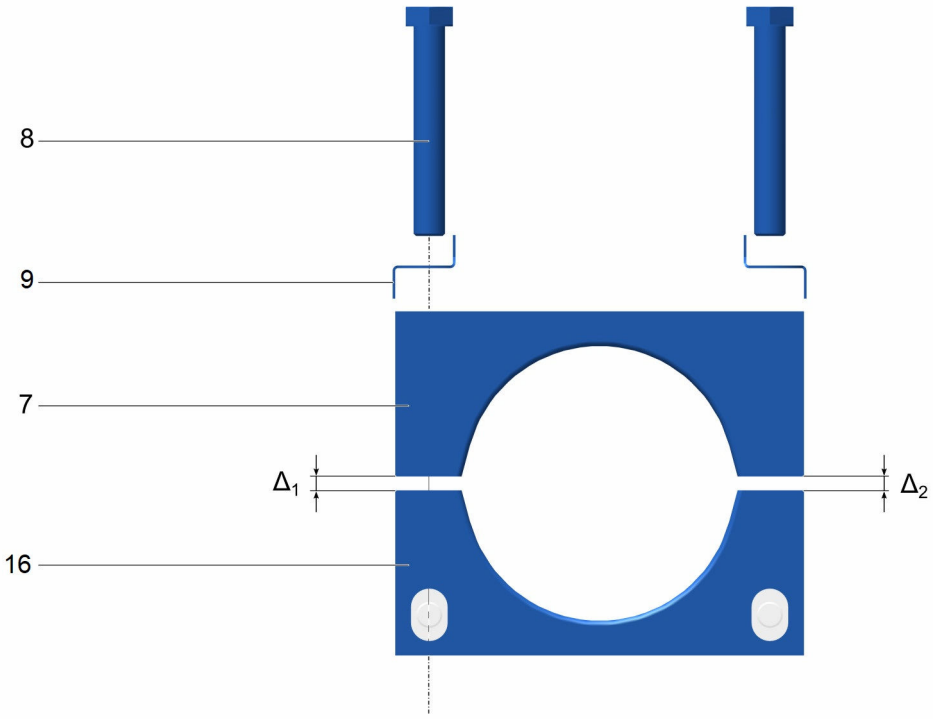


Fig. 177: Installing clamps

▶ Pretighten both screws **8** simultaneously to ensure $\Delta_1 = \Delta_2$ after tightening.

Information

Bend locking plates **9** after assembly.

▶ Tighten screws **8** to torque.

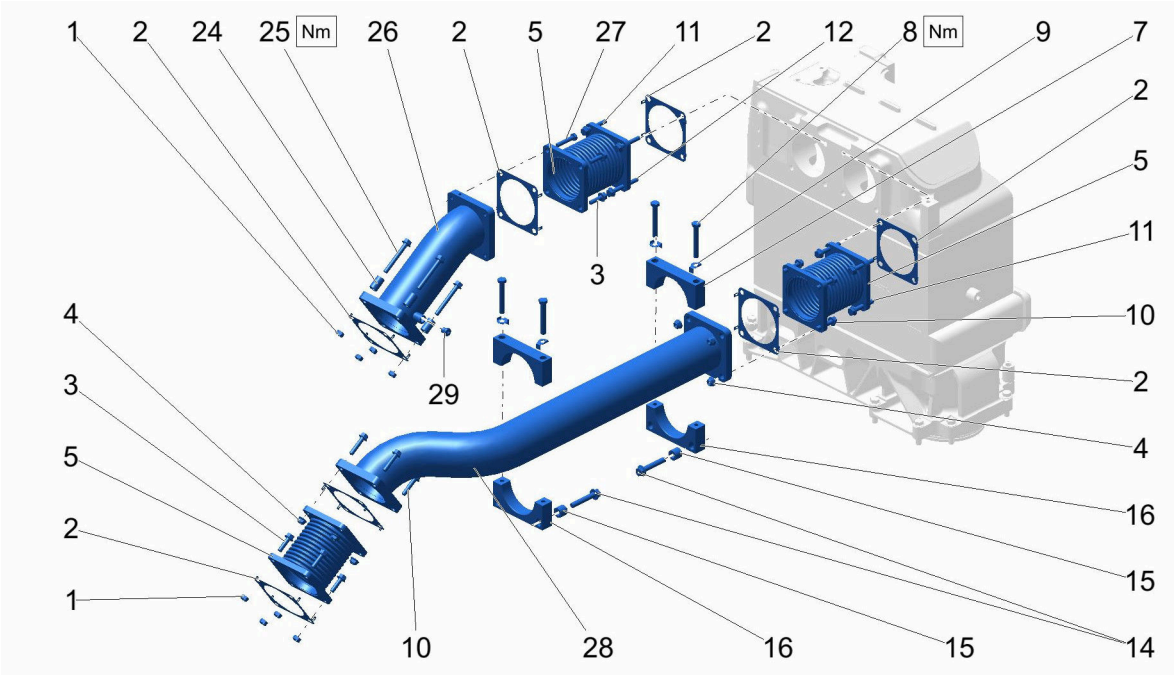


Fig. 178: Installing compensators and charge air lines

- ▶ Assemble pipe **26** with compensator **5**, and seal **2** using screws **3, 27**.
- ▶ Install assembly to charge air cooler with screws **11**, and seal **2**.
- ▶ Install assembly to turbocharger with screws **25**, distance sleeves **24**, seal **2**, and nuts **1**.
- ▶ Install screw plug **29**.
- ▶ Assemble pipe **28** with compensators **5** using screws **10**, seals **2**, and nuts **4**.
- ▶ Install assembly to charge air cooler with screws **11**, and seal **2**.
- ▶ Install assembly to turbocharger with screws **3**, seal **2**, and nuts **1**.
- ▶ Install clamps **7, 16** with screws **8, 14**, distance sleeves **15**, and locking plates **9**.

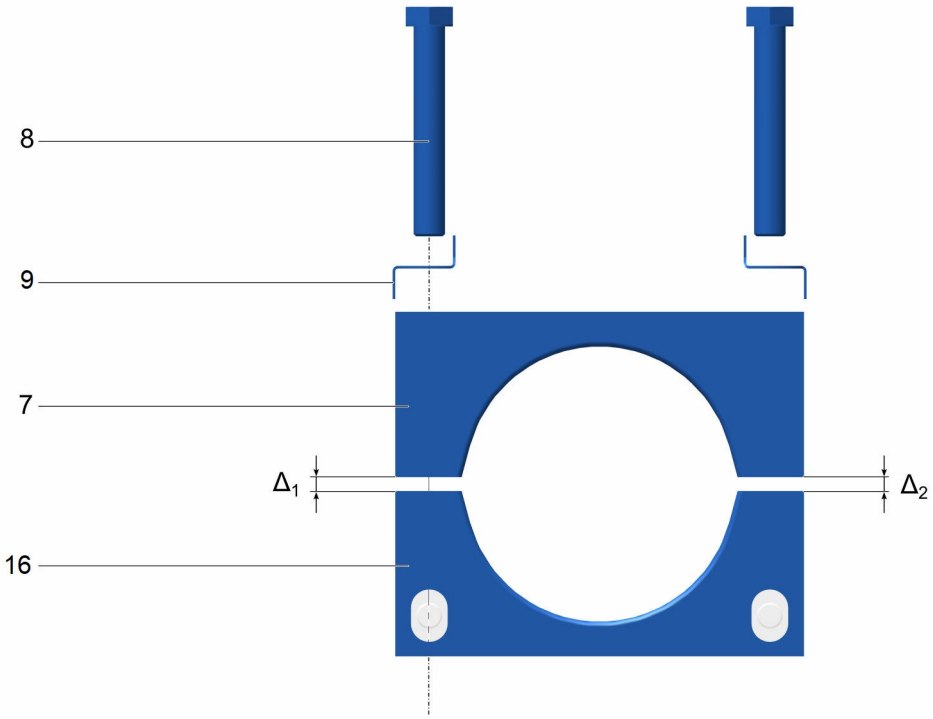


Fig. 179: Installing clamps

▶ Pretighten both screws **8** simultaneously to ensure $\Delta_1 = \Delta_2$ after tightening.

Information

Bend locking plates **9** after assembly.

▶ Tighten screws **8** to torque.

▶ Tighten all screws to torque, making sure that compensators are aligned evenly.

Specific values

Not applicable.

Tightening specifications

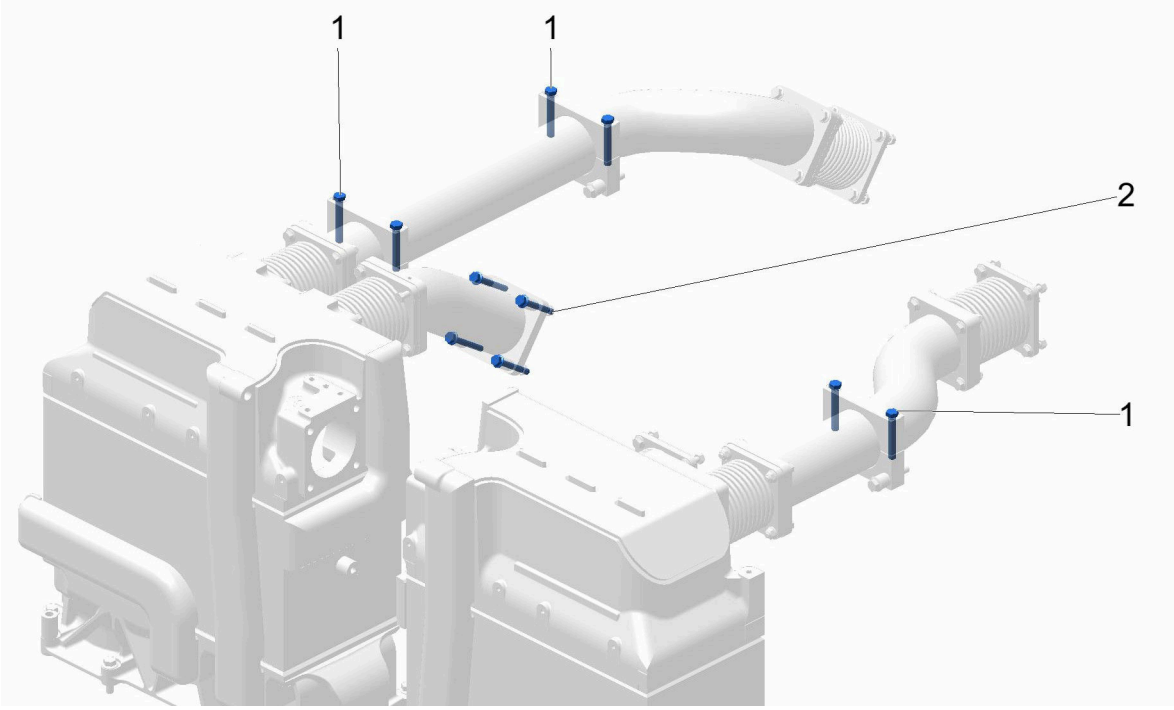


Fig. 180: Clamp screws

Reference	Key	Screw specifications	Lubricant *	Reuse**	Torque		Angle (°)	
					Step	± 5%	Step	± 5°
1	230AB	ISO 4014 M12x1.75x80-10.9-FLZN	-	Yes	1	40 Nm 30 ft-lb	-	-
2	230AH	EN 1665 M10x1.5x80-10.9-FLZN	-	Yes	1	43 Nm 32 ft-lb	-	-

Tab. 36: Tightening specifications table

*Lubricants:
MG = Molykote G-n-plus
MW = Castrol Optimol paste white T
MH = Molykote HSC
O = Engine oil
XX = Loctite 243
YY = Loctite 577

**Refer to screws reuse rules. (For more information see: 5.3.2 Screws pre-tightening, reuse and marking, page 274.)

3.8 Exhaust gas system

3.8.1 Admission pipes to turbocharger removal and installation

Previous tasks

❑ Disconnect admission connection of application set.

Specific safety instructions

NOTICE
Risk of property damage by reuse of sealing.
Leakage by faulty seal.

▶ Replace all sealings.

Special tools

Not applicable.

Consumables and equipment

– Rags
– Cleaner

Overview

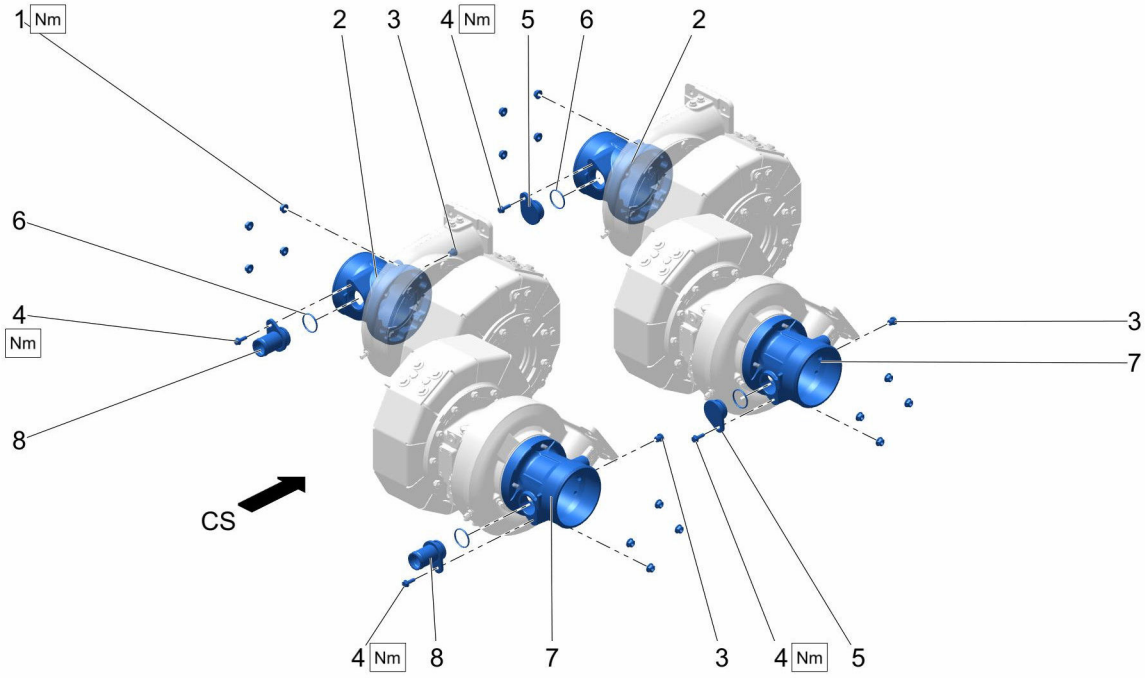


Fig. 181: Task overview

1 Nut
5 Terminal flange

See next page for continuation of the image legend

2 Straight air intake connection
3 Screw plug
4 Screw (M8)
6 O-ring
7 Straight air intake connection
8 Connection flange

Removal

▶ Remove nuts **1**.

▶ Remove straight air intake connections **2, 7**.

Installation

▶ Install straight air intake connections **2, 7** with nuts **1**.

▶ Install flanges **5, 8** with o-rings **6** and screws (M8) **4**.

▶ Install screw plugs **3** in straight air intake connections **2, 7**.

Specific values

Not applicable.

Tightening specifications

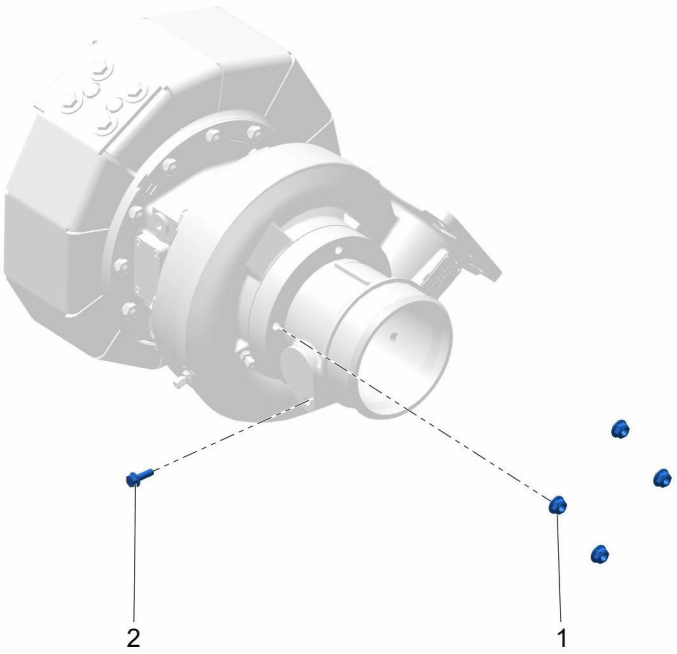


Fig. 182: Admission pipes

Reference	Key	Screw specifications	Lubricant *	Reuse**	Torque		Angle (°)	
					Step	± 5%	Step	± 5°
1	221AA	EN 1664 M10x1,5-10.9-FLZN	-	Yes	1	35 Nm 26 ft-lb	-	-

Reference	Key	Screw specifications	Lubricant *	Reuse**	Torque		Angle (°)	
					Step	± 5%	Step	± 5°
2	221AB	EN 1665 M8x1.25x25-8.8-FLZN	-	Yes	1	25 Nm 18 ft-lb	-	-

Tab. 37: Tightening specifications table

*Lubricants:
MG = Molykote G-n-plus
MW = Castrol Optimol paste white T
MH = Molykote HSC
O = Engine oil
XX = Loctite 243
YY = Loctite 577

**Refer to screws reuse rules. (For more information see: 5.3.2 Screws pre-tightening, reuse and marking, page 274.)

3.8.2 Exhaust pipes to turbocharger removal and installation

Previous tasks

❑ Disconnect application set exhaust system.

Specific safety instructions

WARNING
Risk of injuries by contact with hot surfaces!
Engine is hot near operating temperature.

▶ Avoid any contact with the engine, parts carrying hot coolant or oil, the exhaust system, the turbocharger, the heat protection, the battery and the covers.

▶ After the temperature has cooled down to a level it can be touched, proceed with the tasks on the engine.

NOTICE
Risk of property damage by reuse of sealing.
Leakage by faulty seal.

▶ Replace all sealings.

Special tools

Not applicable.

Consumables and equipment

– Hot temperature grease
– Rags
– Cleaner

Overview

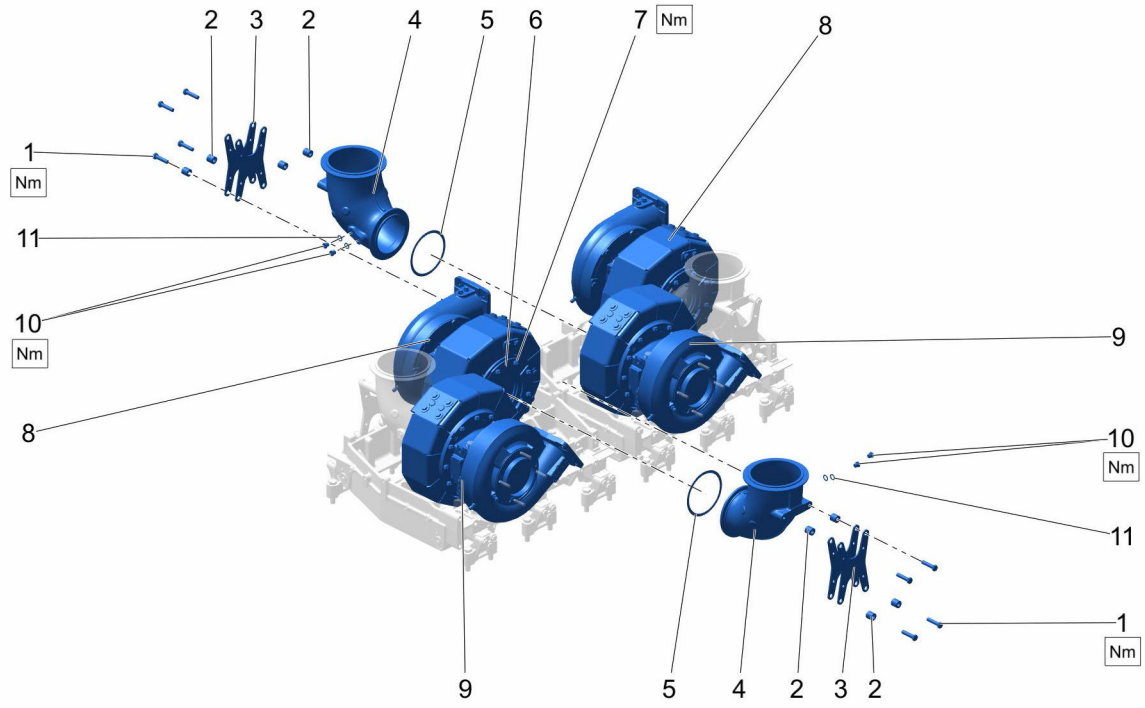


Fig. 183: Task overview

1 Screw (M12)
2 Distance sleeve
3 Support
4 Exhaust elbow
5 Seal
6 Clamp segment
7 Nut (M10)
8 Turbocharger
9 Turbocharger
10 Screw plug
11 Washer

Removal

- ▶ Remove screws **1** with distance sleeves **2**.
- ▶ Remove supports **3**.
- ▶ Remove nuts **7** with clamp segments **6**.
- ▶ Remove exhaust elbow **4**.

Installation

- ▶ Install screw plugs **10** with washers **11** into exhaust elbows **4**.
- ▶ Tighten screw plugs **10** to torque.
- ▶ Position exhaust elbow **4** with seal **5** in turbocharger outlet.
- ▶ Position clamp segments **6** and hand tighten nuts **7**.
- ▶ Position supports **3** with distance sleeves **2**.
- ▶ Tighten nuts **7** to torque.
- ▶ Tighten screws **1** to torque.

Specific values

Not applicable.

Tightening specifications

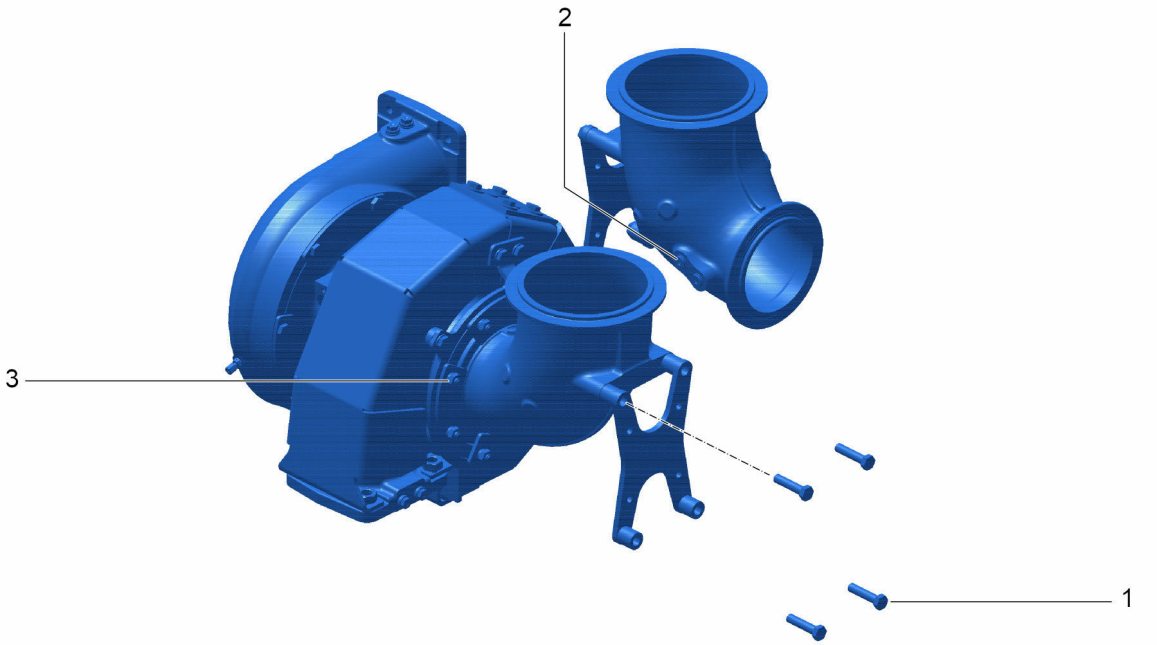


Fig. 184: Exhaust pipes

Reference	Key	Screw specifications	Lubricant *	Reuse**	Torque		Angle (°)	
					Step	± 5%	Step	± 5°
1	412AA	M12x1.75x50-C3J	-	Yes	1	67 Nm 49 ft-lb	-	-
2	412AB	DIN 908 G1/4 A	MH	No	1	30 Nm 22 ft-lb	-	-
3	430AA	DIN 939 M10x1.5x22	MH	Yes	1	24 Nm 18 ft-lb	-	-

Tab. 38: Tightening specifications table

*Lubricants:
MG = Molykote G-n-plus
MW = Castrol Optimol paste white T
MH = Molykote HSC
O = Engine oil
XX = Loctite 243
YY = Loctite 577

**Refer to screws reuse rules. (For more information see: 5.3.2 Screws pre-tightening, reuse and marking, page 274.)

Exhaust pipes to turbocharger removal and installation (EATS configuration)

Previous tasks

❑ Disconnect application set exhaust system.

Specific safety instructions

WARNING
Risk of injuries by contact with hot surfaces!
Engine is hot near operating temperature.

▶ Avoid any contact with the engine, parts carrying hot coolant or oil, the exhaust system, the turbocharger, the heat protection, the battery, and the covers.

▶ After the temperature has cooled down to a level it can be touched, proceed with the tasks on the engine.

NOTICE
Risk of property damage by reuse of sealing.
Leakage by faulty seal.

▶ Replace all sealings.

Special tools

Not applicable.

Consumables and equipment

– Hot temperature grease
– Rags
– Cleaner

Overview

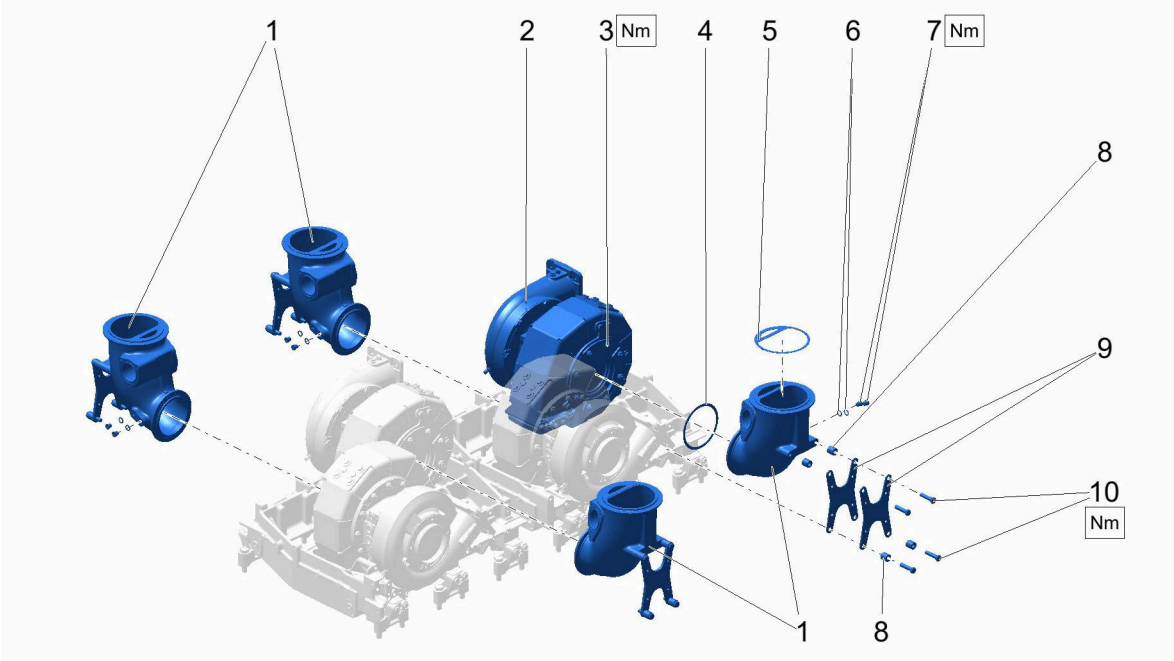


Fig. 185: Task overview

1 Exhaust elbow
2 Exhaust gas turbocharger
3 Nut (M10)
4 Seal
5 Orifice plate
6 Washer
7 Screw plug
8 Distance sleeve
9 Retaining plate
10 Screw (M12)

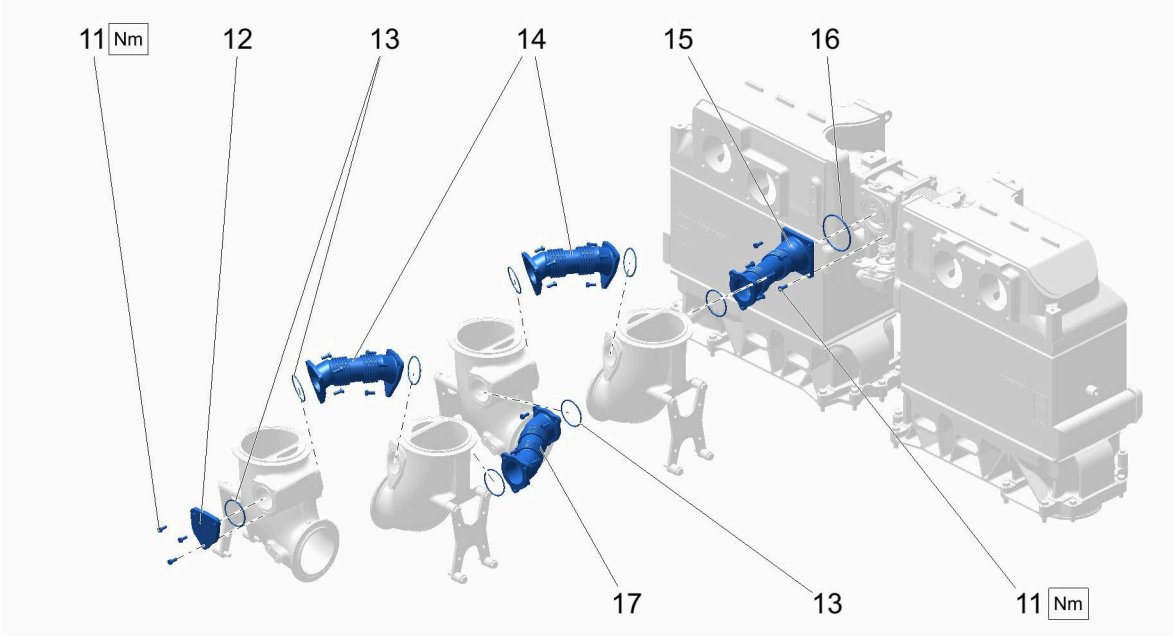


Fig. 186: Task overview

11 Screw (M8)
12 Cover
13 O-ring
14 Compensator
15 Compensator
16 O-ring
17 Compensator

Removal

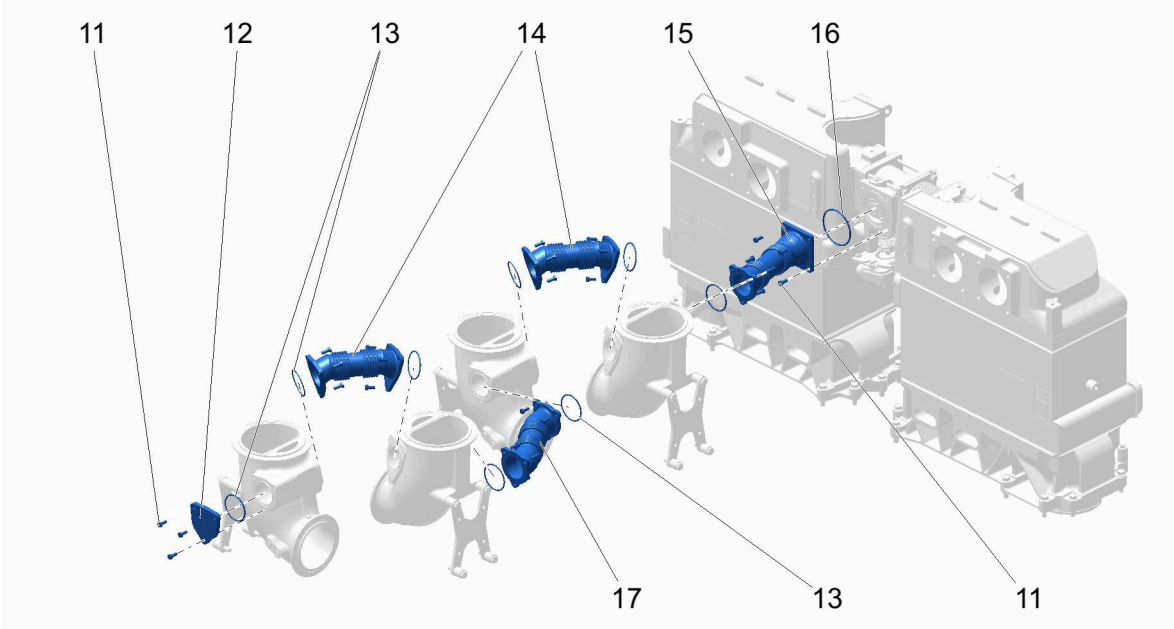


Fig. 187: Removing compensators

- ▶ Remove screws **11**.
- ▶ Remove compensators **14, 15, 17**.
- ▶ Remove cover **12**.

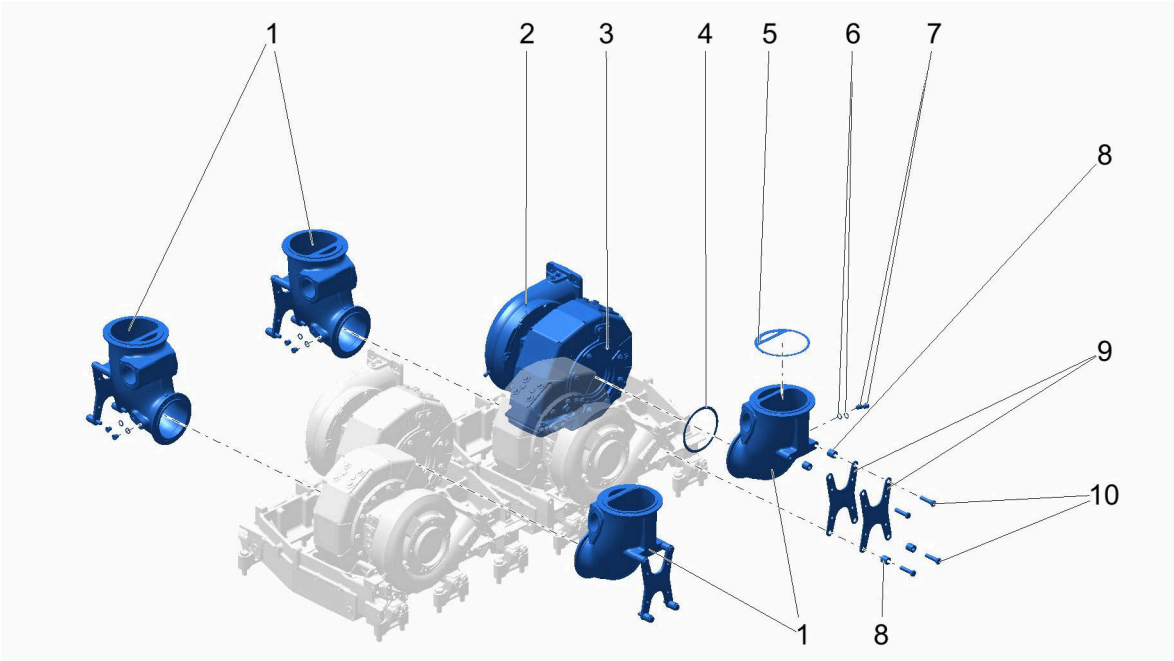


Fig. 188: Removing elbows

- ▶ Remove screws **10**, and distance sleeves **8**.
- ▶ Remove retaining plates **9**.
- ▶ Remove exhaust elbow **1**.

Installation

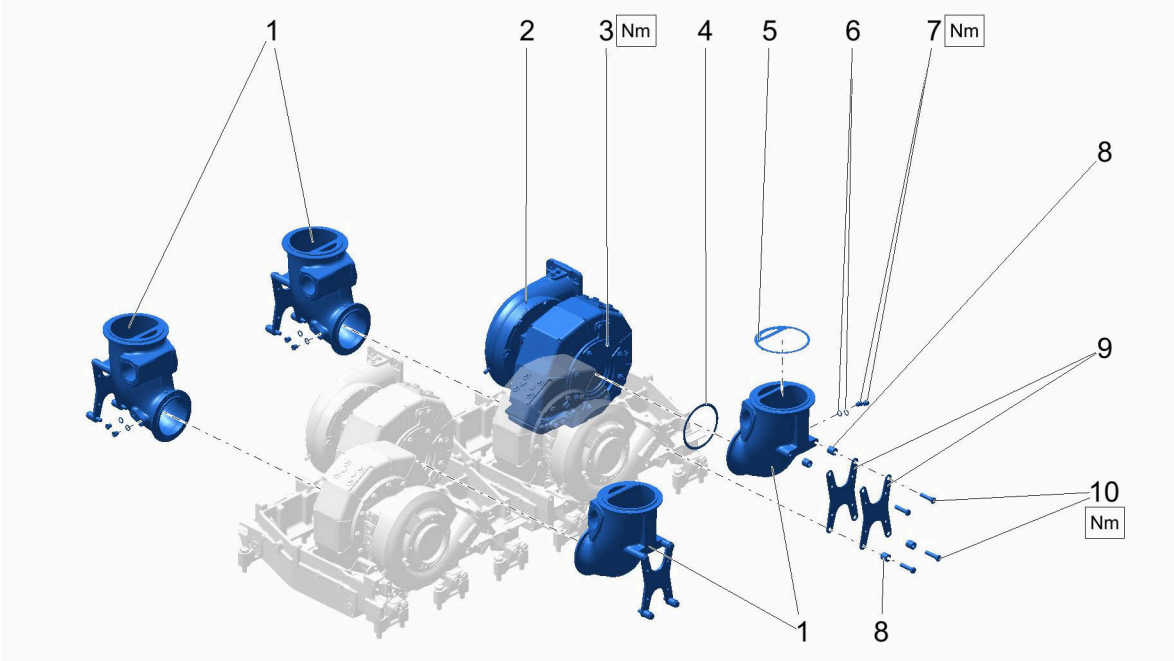


Fig. 189: Installing elbows

- ▶ Install orifice plate **5** on exhaust elbow **1**.
- ▶ Install screw plugs **7** with washers **6** into exhaust elbow **1**.
- ▶ Tighten screw plugs **7** to torque.
- ▶ Install exhaust elbow **1**, and seal **15** on turbocharger outlet.
- ▶ Install retaining plates **9** with screws **10**, and distance sleeves **8**.
- ▶ Tighten screws **10** to torque.
- ▶ Repeat procedure for each exhaust elbow.

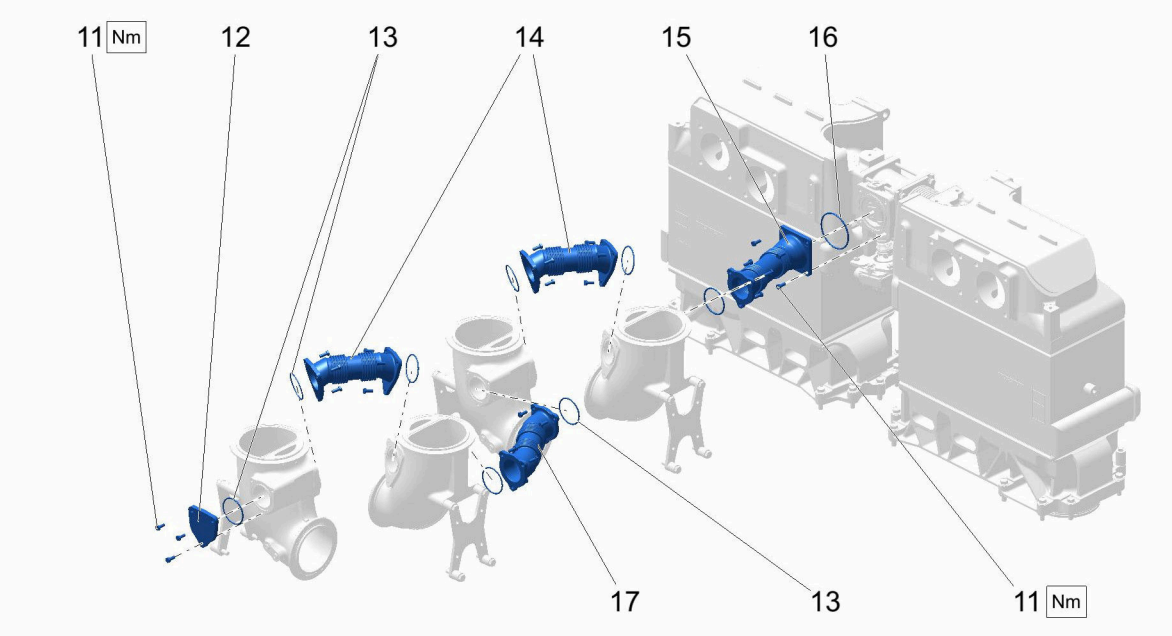


Fig. 190: Installing compensators

- ▶ Install cover **12** with screws **11**, and o-ring **13**.
- ▶ Install compensators **14, 17** with screws **11**, and o-rings **13**.
- ▶ Install compensator **15** with screws **11**, and o-rings **13, 16**.
- ▶ Tighten screws **11** to torque.

Specific values

Not applicable.

Tightening specifications

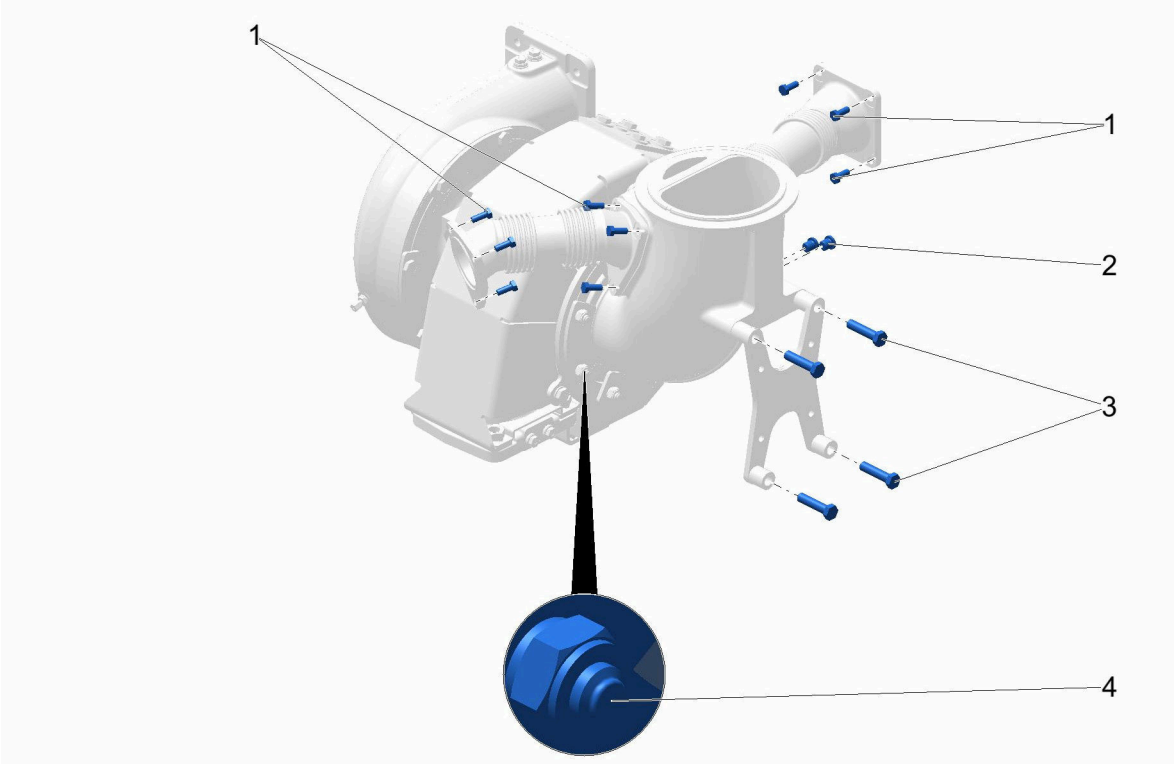


Fig. 191: Exhaust pipes

Reference	Key	Screw specifications	Lubricant *	Reuse**	Torque		Angle (°)	
					Step	± 5%	Step	± 5°
1	230AI	M8x1.25x20-C3J	MH	Yes	1	20 Nm 15 ft-lb	-	-
2	412AB	DIN 908 G1/4 A	MH	No	1	30 Nm 22 ft-lb	-	-
3	412AD	M12x1.75x50-C3J	-	Yes	1	56 Nm 41 ft-lb	-	-
4	430AA	DIN 939 M10x1.5x22	MH	Yes	1	24 Nm 18 ft-lb	-	-

Tab. 39: Tightening specifications table

*Lubricants:
MG = Molykote G-n-plus
MW = Castrol Optimol paste white T
MH = Molykote HSC
O = Engine oil
XX = Loctite 243
YY = Loctite 577

**Refer to screws reuse rules. (For more information see: 5.3.2 Screws pre-tightening, reuse and marking, page 274.)

3.8.3 Exhaust gas turbocharger removal and installation (SL 213)

Previous tasks

- ❑ Drain LT coolant water.
- ❑ Remove turbocharger cooling lines. (For more information see: 3.10.3 Turbocharger cooling lines removal and installation, page 211.)

Specific safety instructions

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.

NOTICE
Risk of property damage by reuse of sealing.
Leakage by faulty seal.

- ▶ Replace all sealings.

Special tools

Not applicable.

Consumables and equipment

- – Hot temperature grease
- – Rags
- – Cleaner

Overview

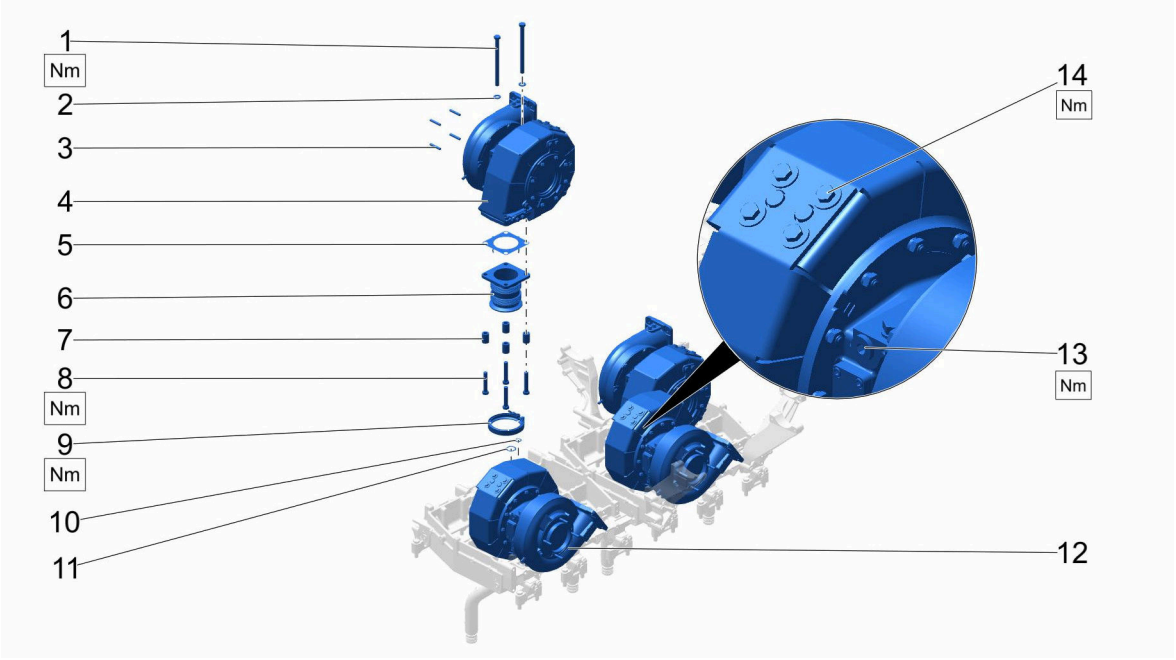


Fig. 192: Task overview

1 Screw (M16)
2 Washer
3 Stud
4 Turbocharger
5 Seal
6 Compensator
7 Distance sleeve
8 Screw (M16)
9 V-clamp
10 O-ring
11 O-ring
12 Turbocharger
13 Screw plug
14 Screw (M10)

Removal

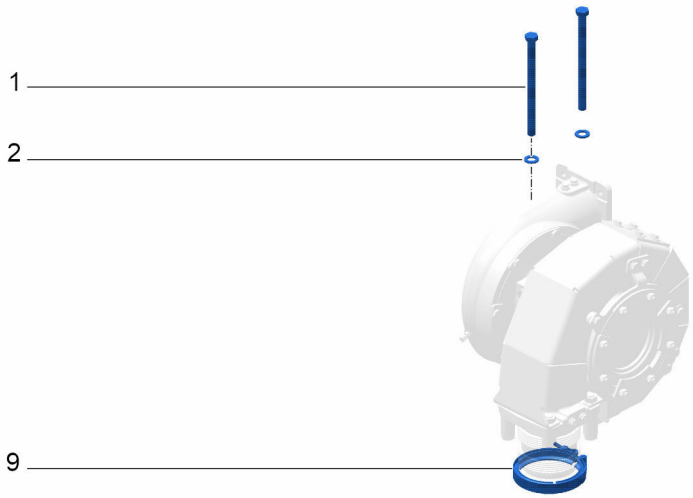


Fig. 193: Removing turbocharger

▶ Remove screws **1** and washers **2**.

▶ Open and loosen V-clamp **9**.

▶ Lift the turbocharger.

Information

During lifting, make sure the turbocharger does not tilt.

▶ Place the turbocharger on a workbench.

▶ Remove the straight air intake connection. (For more information see: 3.8.1 Admission pipes to turbocharger removal and installation, page 159.)

▶ Remove the exhaust elbow. (For more information see: 3.8.2 Exhaust pipes to turbocharger removal and installation, page 161.)

▶ Remove screws **8** and distance sleeves **7**.

▶ Remove compensator **6** and seal **5**.

▶ Repeat procedure for all turbochargers.

Installation

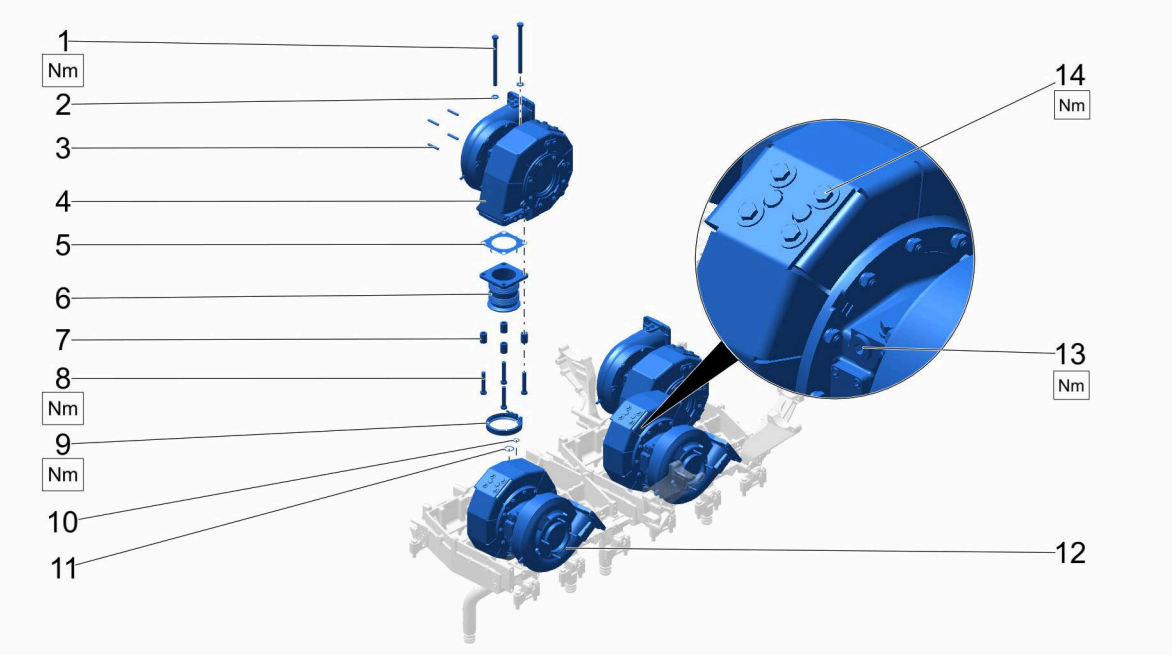


Fig. 194: Installing turbocharger

▶ Place the turbocharger on a workbench.

▶ Install the straight air intake connection. (For more information see: 3.8.1 Admission pipes to turbocharger removal and installation, page 159.)

▶ Install the exhaust elbow. (For more information see: 3.8.2 Exhaust pipes to turbocharger removal and installation, page 161.)

▶ Grease screws **1, 8** with Molykote HSC before installation.

▶ Install studs **3**.

▶ Mount compensator **6** with seal **5** on turbocharger **4, 12**.

▶ Tighten screws **8** with applied distance sleeves **7** to torque.

▶ Insert o-rings **10, 11** in turbocharger bracket.

- ▶ Position V-clamp **9** on exhaust pipe outlets.
- ▶ Lift the turbocharger.

Information

During lifting, make sure the turbocharger does not tilt.

Before installation, the turbocharger should be perfectly aligned with the exhaust pipe connection.

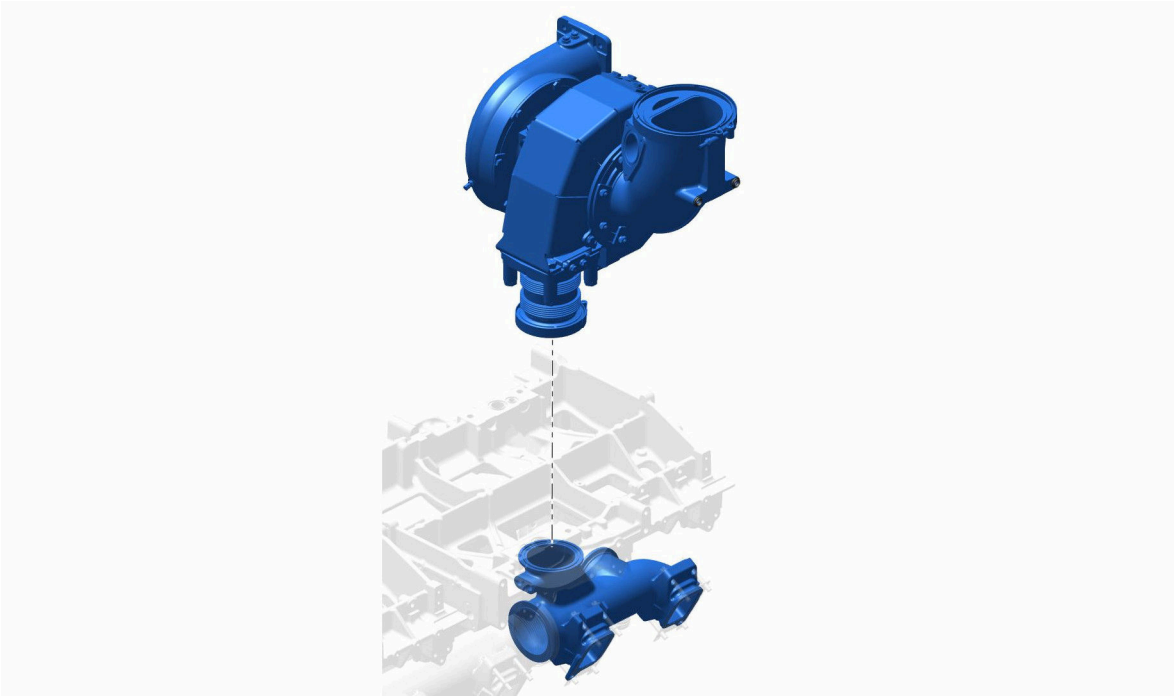


Fig. 195: Aligning turbocharger with exhaust pipe connection

- ▶ Position the turbocharger on the bracket so that the compensator is aligned with the exhaust pipe connection.
- ▶ Tighten screws **1** with washers **2** to torque.
- ▶ Install V-clamp **9** on exhaust pipe connection to compensator **6** and tighten to torque.
- ▶ Install turbocharger cooling lines. (For more information see: 3.10.3 Turbocharger cooling lines removal and installation, page 211.)

Information

Vent coolant circuit at the end of installation.

Specific values

Not applicable.

Tightening specifications

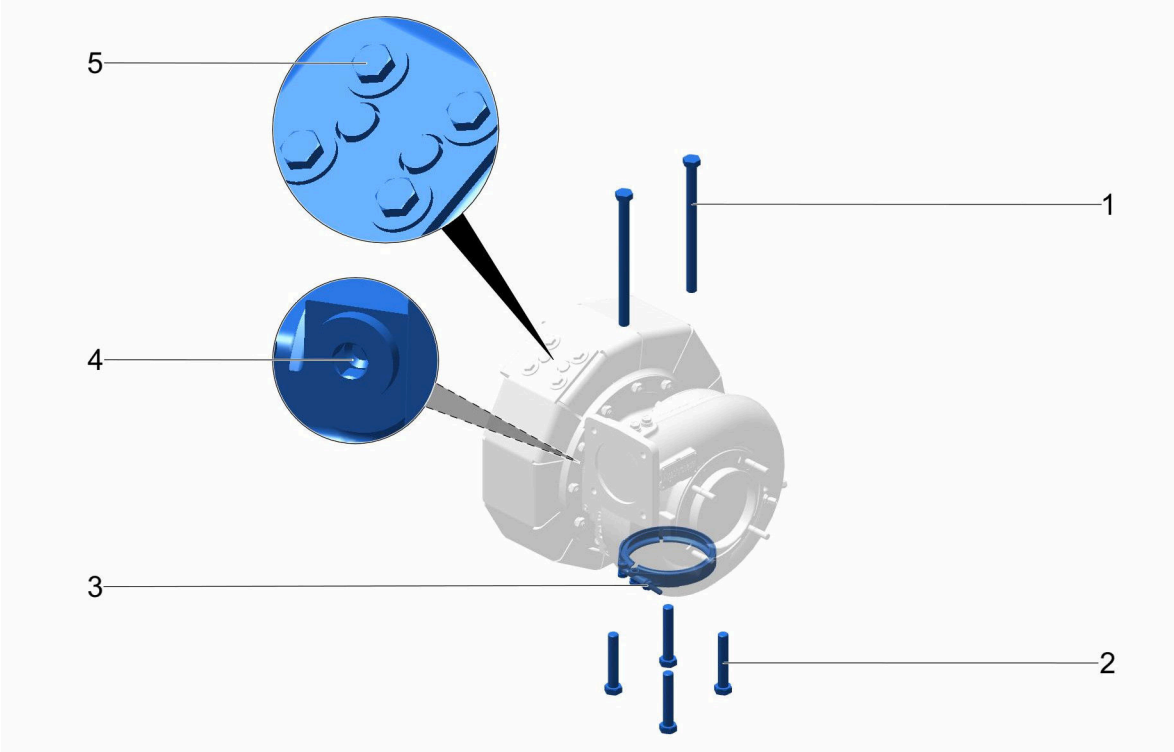


Fig. 196: Turbocharger screws

Reference	Key	Screw specifications	Lubricant *	Reuse**	Torque		Angle (°)	
					Step	± 5%	Step	± 5°
1	430AB	ISO 4014 M16x2x220-10.9-FLZN	MH	Yes	1	230 Nm 170 ft-lb	-	-
2	430AD	M16x2x90-C3J	MH	No	1	120 Nm 89 ft-lb	-	-
3	430AE	M8x1.25	MH	Yes	1	20 Nm 15 ft-lb	-	-
4	430AF	M22x1.5	O	Yes	1	90 Nm 66 ft-lb	-	-
4	430AG	M10x1.5	-	Yes	1	20 Nm 15 ft-lb	-	-

Tab. 40: Tightening specifications table

*Lubricants:
MG = Molykote G-n-plus
MW = Castrol Optimol paste white T
MH = Molykote HSC
O = Engine oil
XX = Loctite 243
YY = Loctite 577

**Refer to screws reuse rules. (For more information see: 5.3.2 Screws pre-tightening, reuse and marking, page 274.)

3.8.4 Oil supply – turbocharger removal and installation

Previous tasks

Not applicable.

Specific safety instructions

Not applicable.

Special tools

Not applicable.

Consumables and equipment

– Rags
– Cleaner

Overview

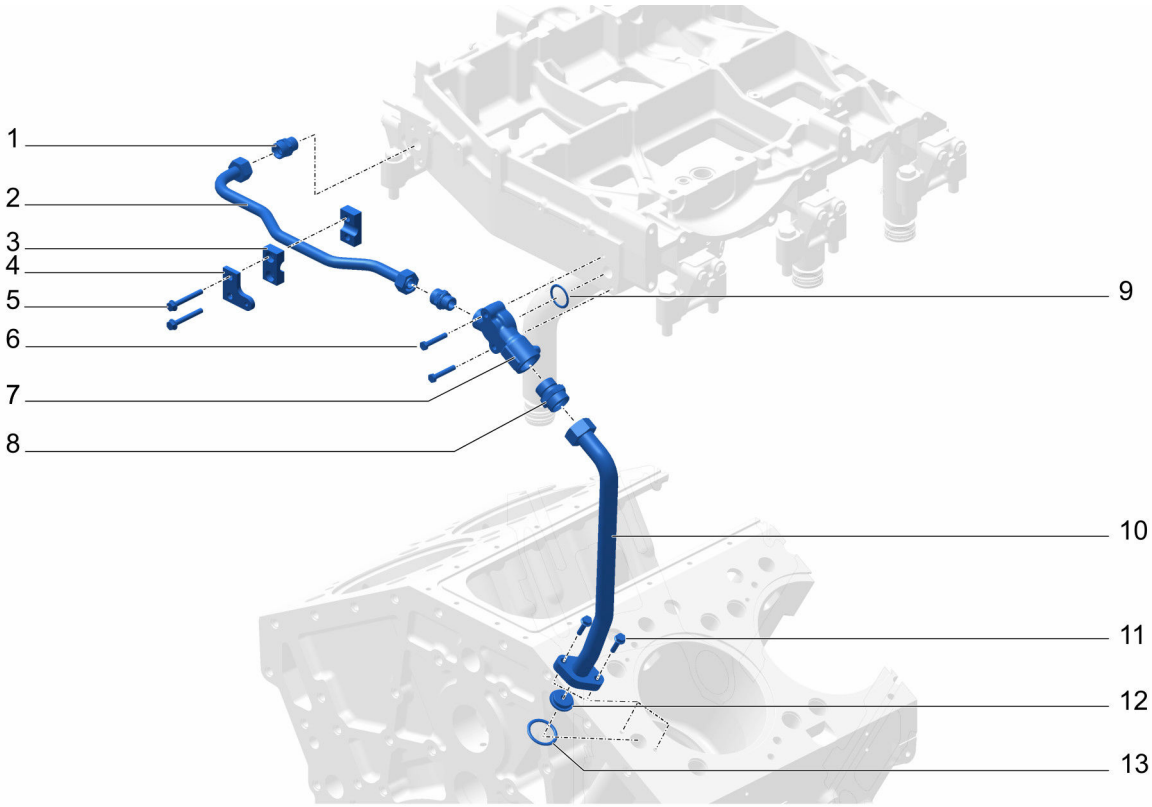


Fig. 197: Task overview

1 Flange joint
2 Pipe
3 Clamp
8 Flange joint
9 O-ring
10 Pipe

See next page for continuation of the image legend

4 Plate
5 Screw (M8)
6 Screw (M8)
7 Distribution block
11 Screw (M10)
12 Orifice
13 O-ring

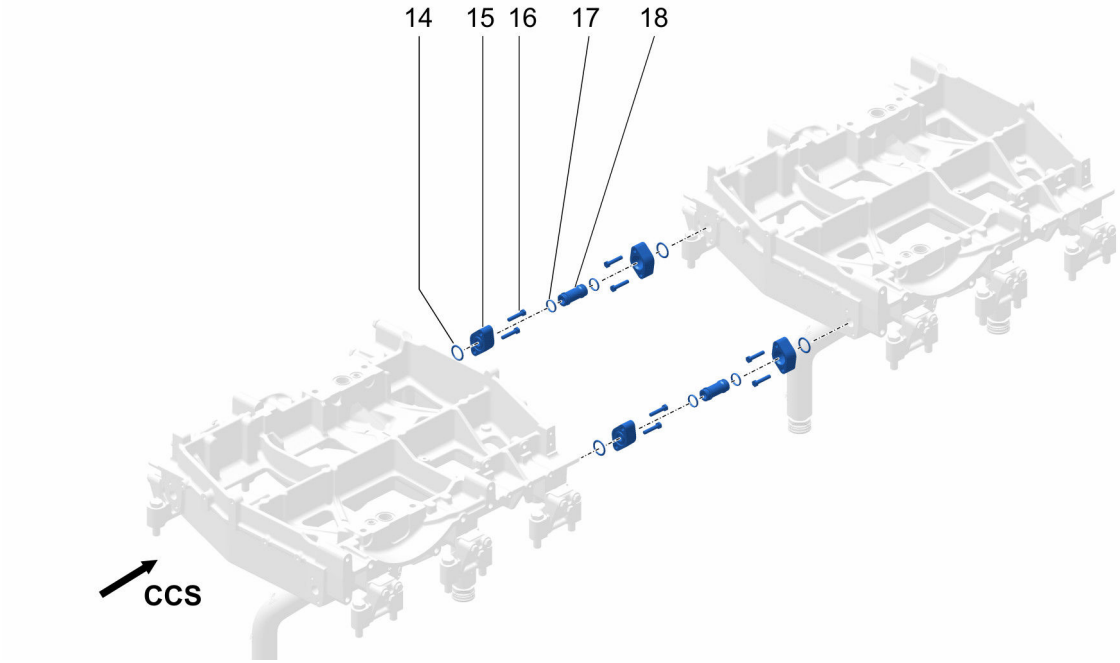


Fig. 198: Task overview

14 O-ring
15 Flange
16 Screw (M8)
17 O-ring
18 Pipe

Removal

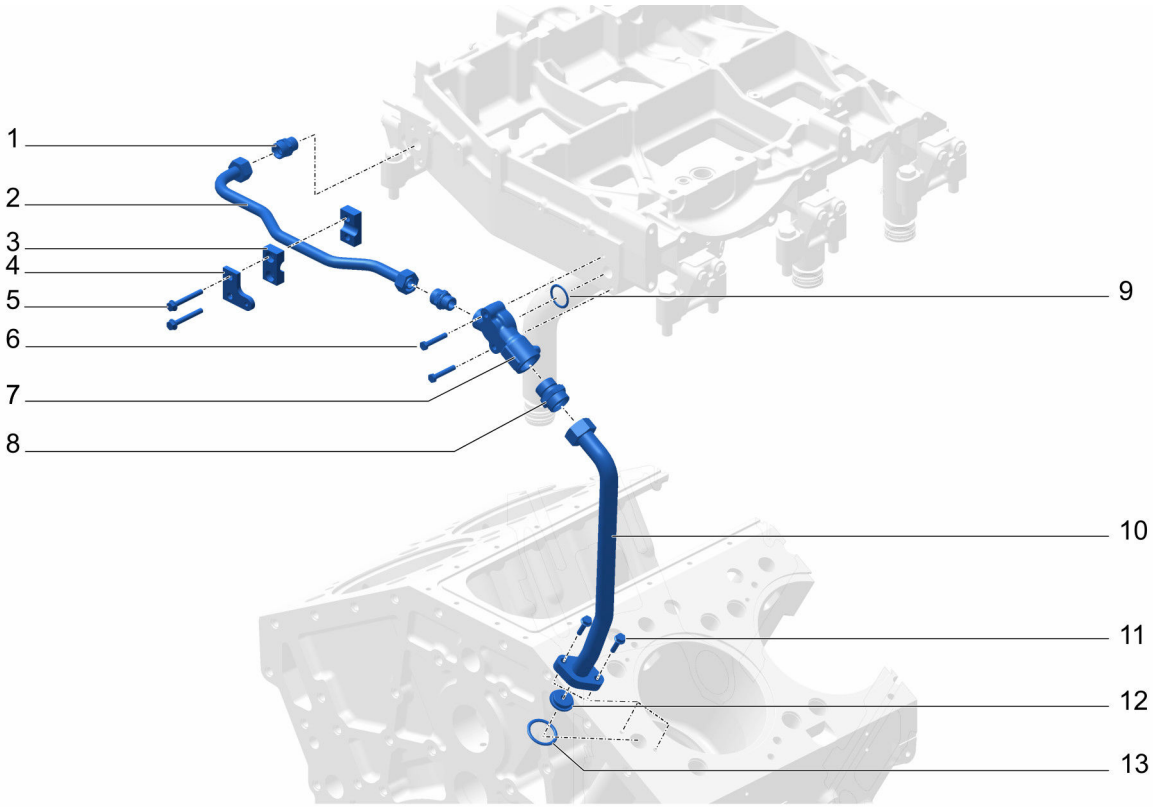


Fig. 199: Removing distribution block and pipes

- ▶ Remove screws **5** with plate **4** and clamps **3**.
- ▶ Remove pipe **2**.
- ▶ Remove screws **11**.
- ▶ Remove pipe **10**, orifice **12** and o-ring **13**.
- ▶ Remove screws **6**.
- ▶ Remove distribution block **7** and o-ring **9**.
- ▶ Remove flange joints **1, 8**.

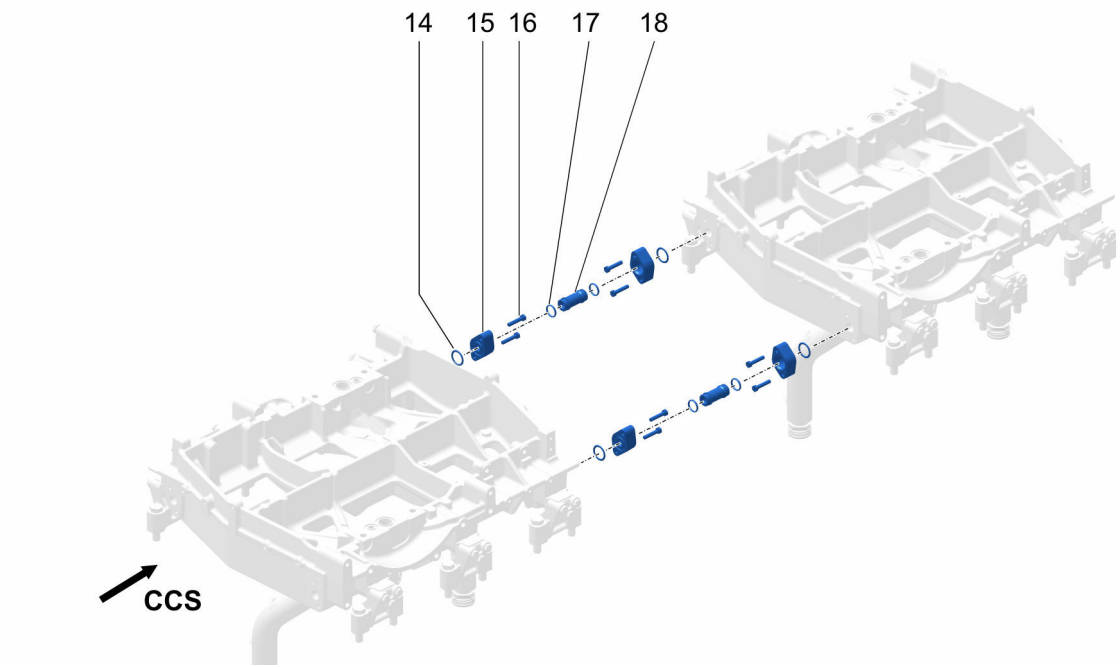


Fig. 200: Removing flanges and pipes

- ▶ Remove screws **16**.
- ▶ Remove flanges **15** with o-rings **14** and pipe **18**.

Installation

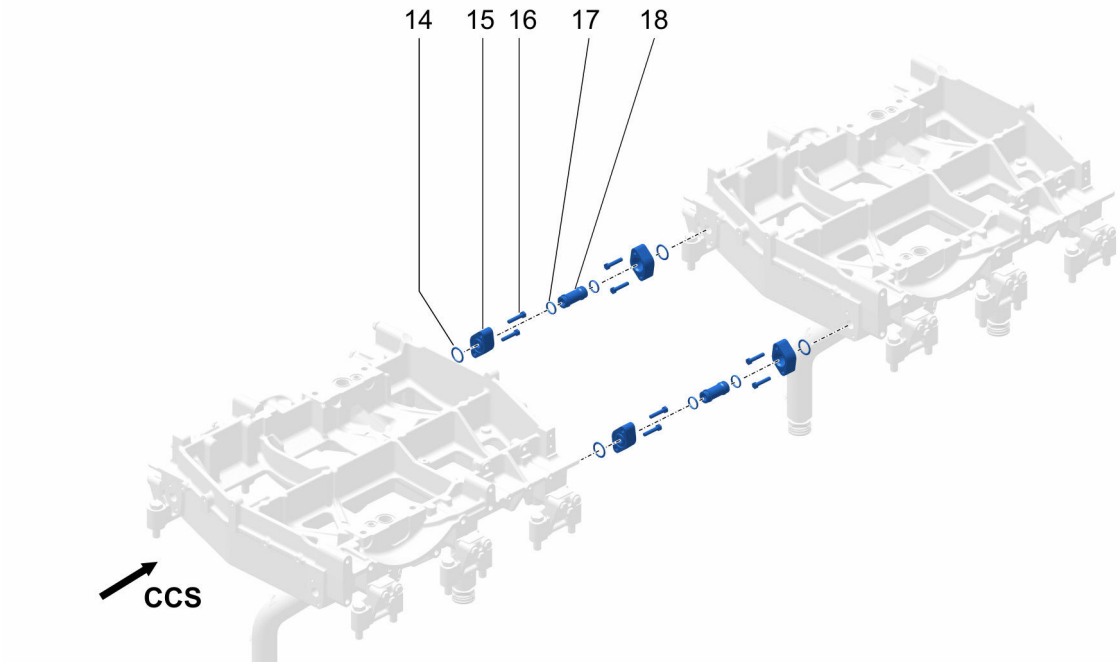


Fig. 201: Installing flanges and pipes

- ▶ Assemble o-rings **17** on pipe **18** and place both flanges **15**.
- ▶ Insert o-rings **14** in bothflanges **15**.
- ▶ Position assembly with screws **16** between both turbocharger brackets on oil supply connection.

▶ Tighten screws **16** to torque.

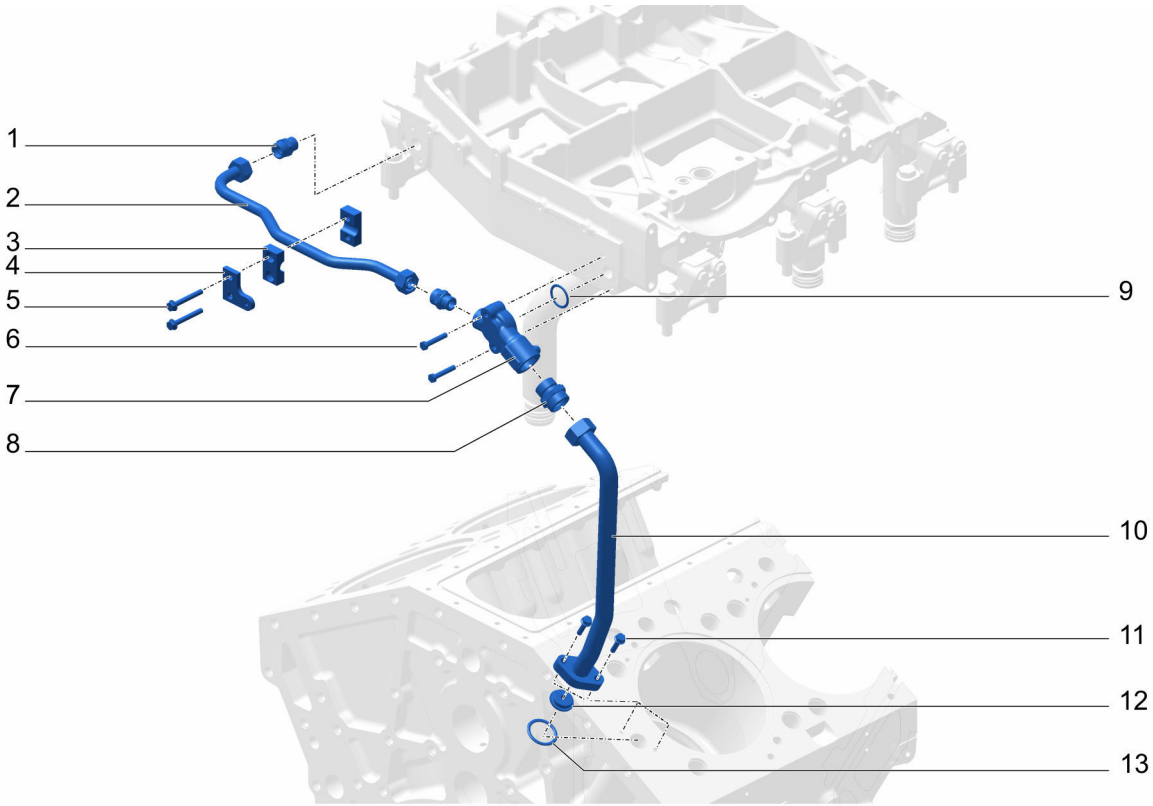


Fig. 202: Installing distribution block and pipes

▶ Insert o-ring **9** in distribution block **7**.
▶ Position distribution block **7** with screws **6** on oil entry of turbocharger bracket.
▶ Tighten screws **6** to torque.
▶ Install and tighten flange joints **1, 8** to torque.
▶ Grease orifice **12**.
▶ Install pipe **10** with orifice **12**, screws **11** and seal **13** between flange joint **8** and crankcase.
▶ Install pipe **2** with flange joints **1** on oil entry of turbocharger bracket.
▶ Tighten screws **11** to torque.
▶ Install plate **4** and clamps **3** with screws **5**.
▶ Tighten screws **5** to torque.

Specific values

Not applicable.

Tightening specifications

Refer to standard tightening torques. (For more information see: 5.3 Standard tightening torques, page 274.)

3.8.5 Turbocharger brackets removal and installation

Previous tasks

❑ Remove oil supply pipes. (For more information see: 3.8.4 Oil supply – turbocharger removal and installation, page 175.)

Specific safety instructions

Not applicable.

Special tools

Not applicable.

Consumables and equipment

– Rags
– Cleaner

Overview

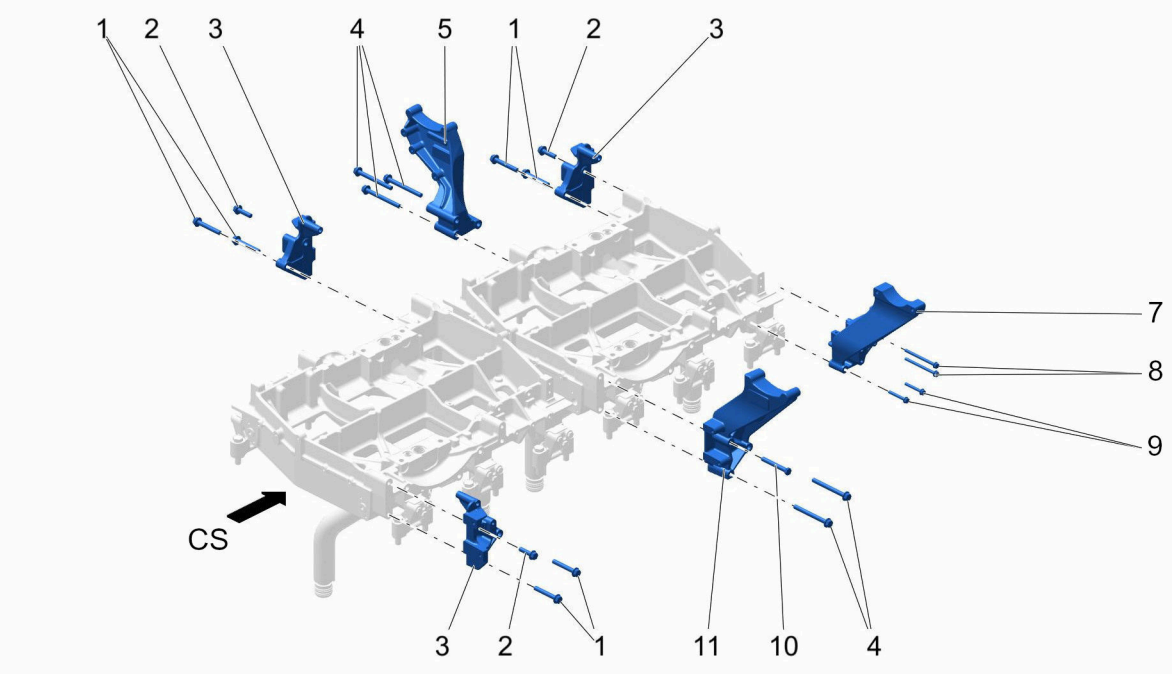


Fig. 203: Task overview - 60 Hz engine without EATS

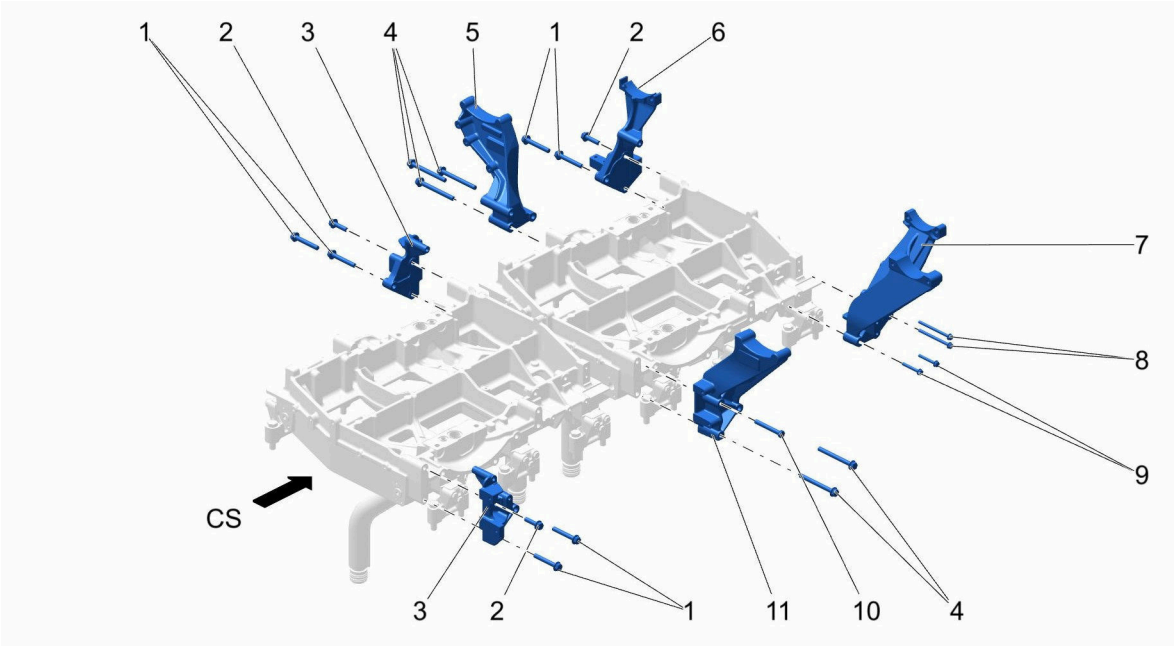


Fig. 204: Task overview - 60 Hz engine with EATS and 50 Hz engine

1 Screw (M12)
2 Screw (M12)
3 Holder
4 Screw (M12)
5 Holder
6 Holder
7 Holder
8 Screw (M8)
9 Screw (M8)
10 Screw (M12)
11 Holder

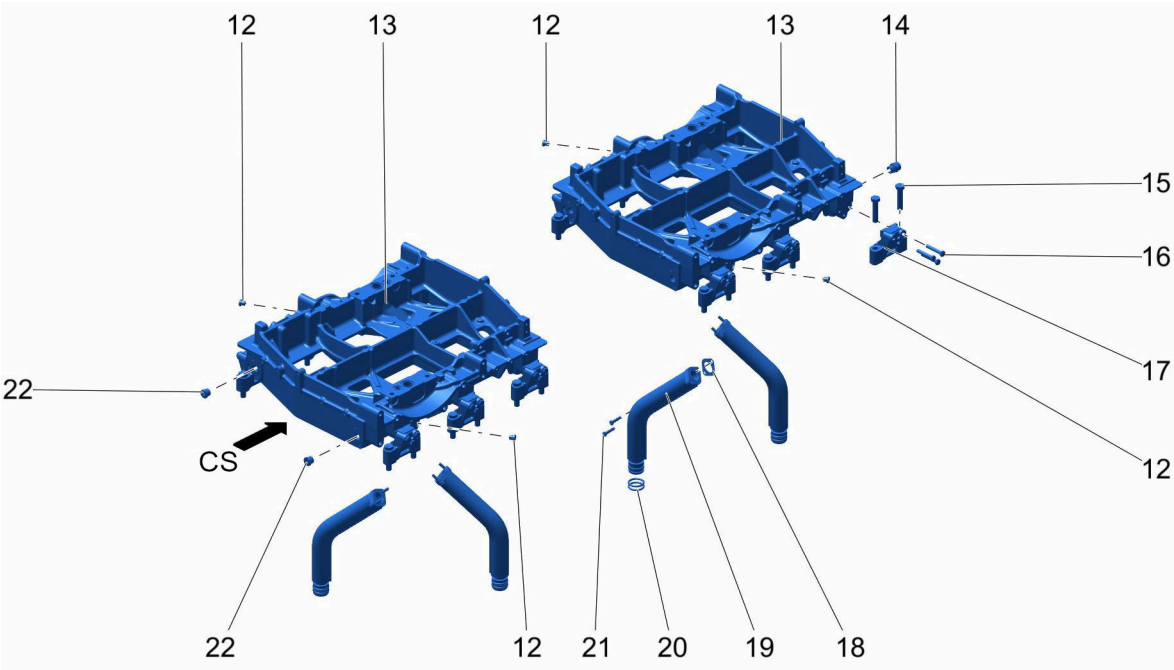


Fig. 205: Task overview

12 Screw plug
13 Turbocharger bracket
14 Fitting
15 Screw (M16)
18 Seal
19 Oil return pipe
20 O-ring
21 Screw (M8)

See next page for continuation of the image legend

16 Screw (M10)
17 Holder
22 Screw plug

Removal

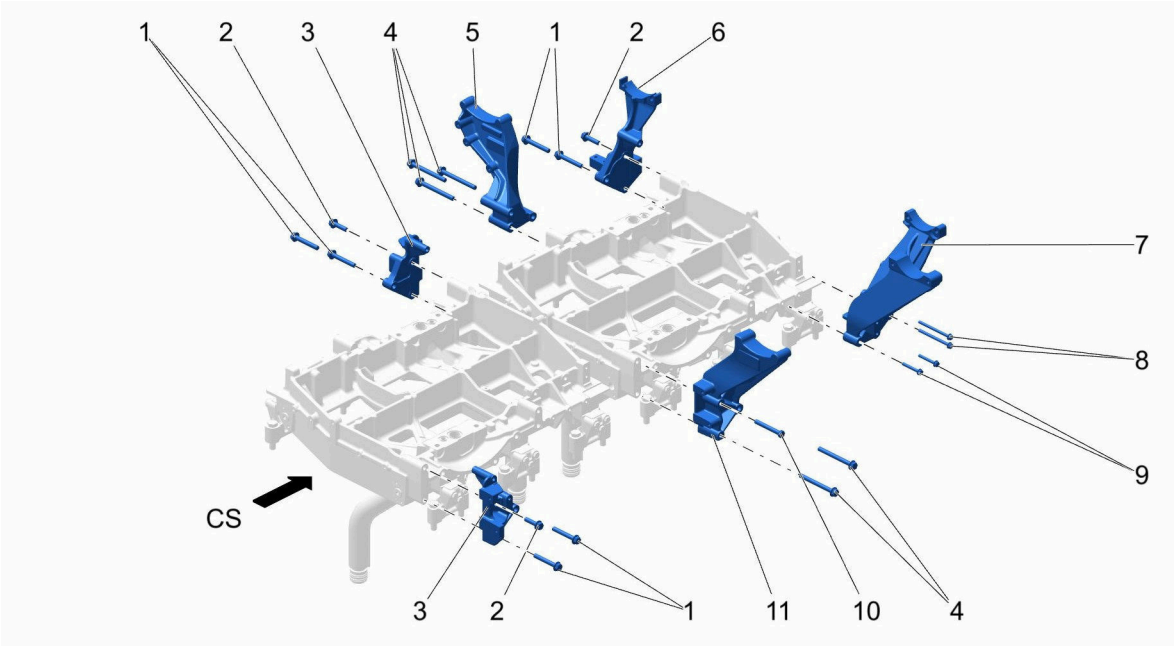


Fig. 206: Removing holders

- ▶ Remove screws **1, 2**.
- ▶ Remove holders **3, 6**.
- ▶ Remove screws **4**.
- ▶ Remove holder **5**.
- ▶ Remove screws **8, 9**.
- ▶ Remove holder **7**.
- ▶ Remove screws **4, 10**.
- ▶ Remove holder **11**.

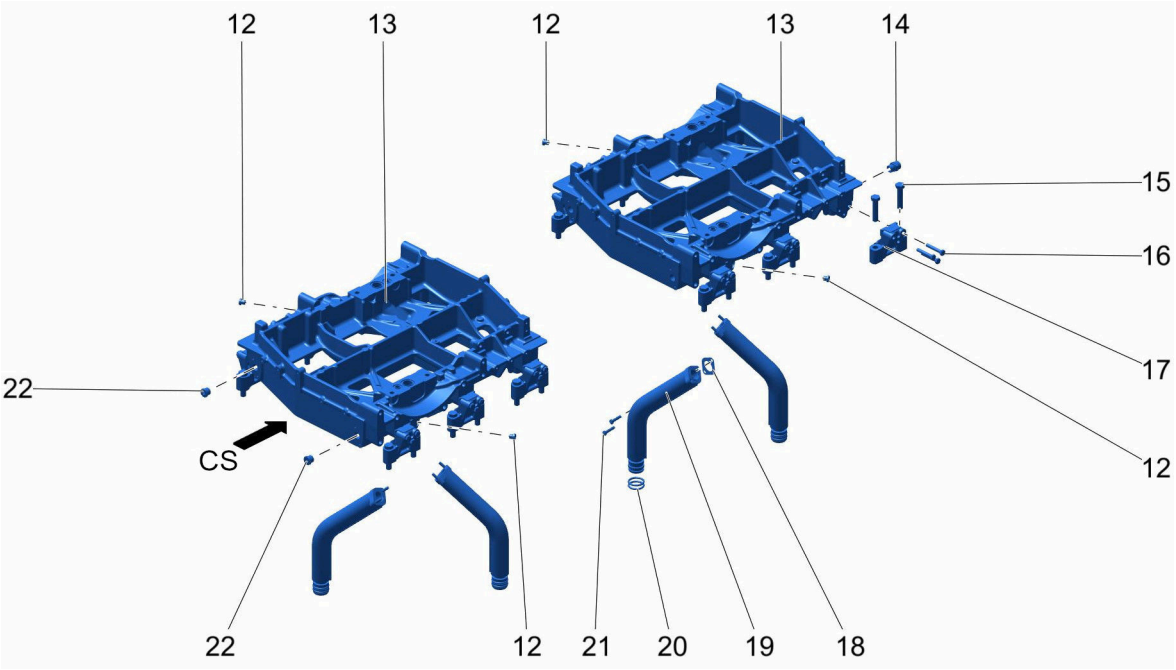


Fig. 207: Removing turbocharger brackets and oil return pipes

- Remove screws **15**.
- Lift off turbocharger brackets **13**.
- Remove screws **21**.
- Remove oil return pipe **19** with seal **18** and o-ring **20**.
- Repeat procedure for all oil return pipes **19**.
- Remove screws **16**.
- Remove bracket **17**.
- Repeat procedure for all brackets **17**.

Installation

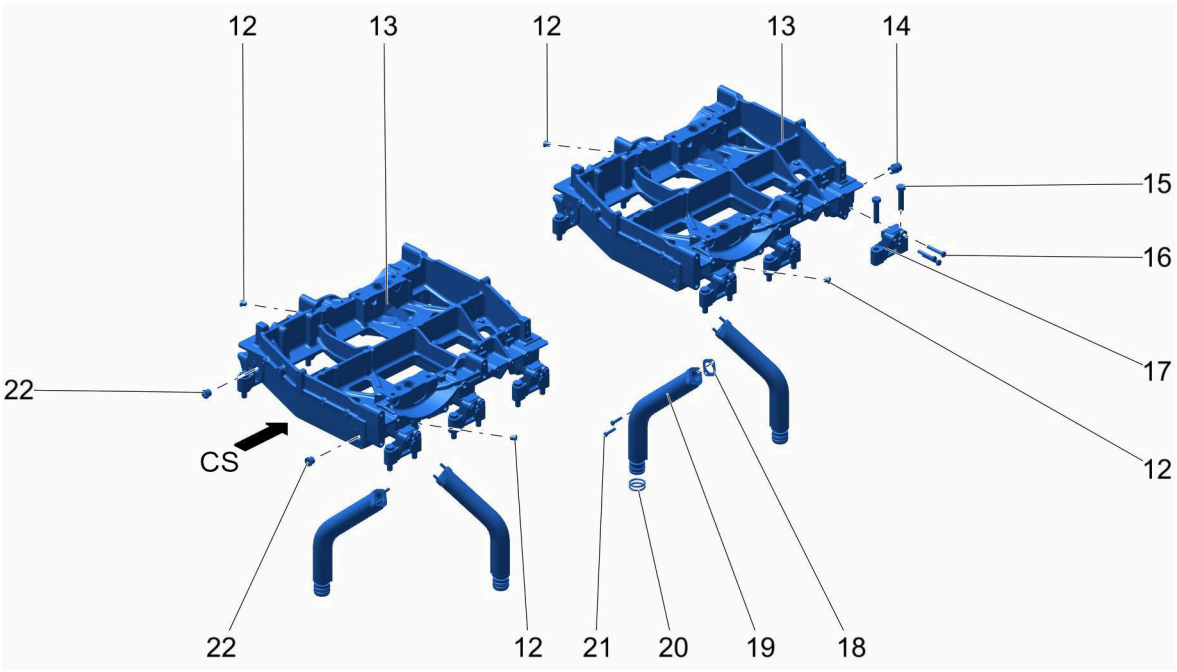


Fig. 208: Installing turbocharger brackets and oil return pipes

- ▶ Position brackets **17** on turbocharger brackets **13**.
- ▶ Tighten screws **16** to torque.
- ▶ Position oil return pipes **19** with seals **18** and screws **21**.

NOTICE
Misalignment.
Parts damage.

- ▶ Pay attention to align oil return pipes in camshaft cover plate properly.

- ▶ Tighten screws **21** to torque.
- ▶ Insert o-rings **20** on the oil return pipes **19**.
- ▶ Position turbocharger brackets **13** on the rocker arm housings with screws **15**.
- ▶ Tighten screws **15** to torque.
- ▶ Install screw plugs **12, 22**.

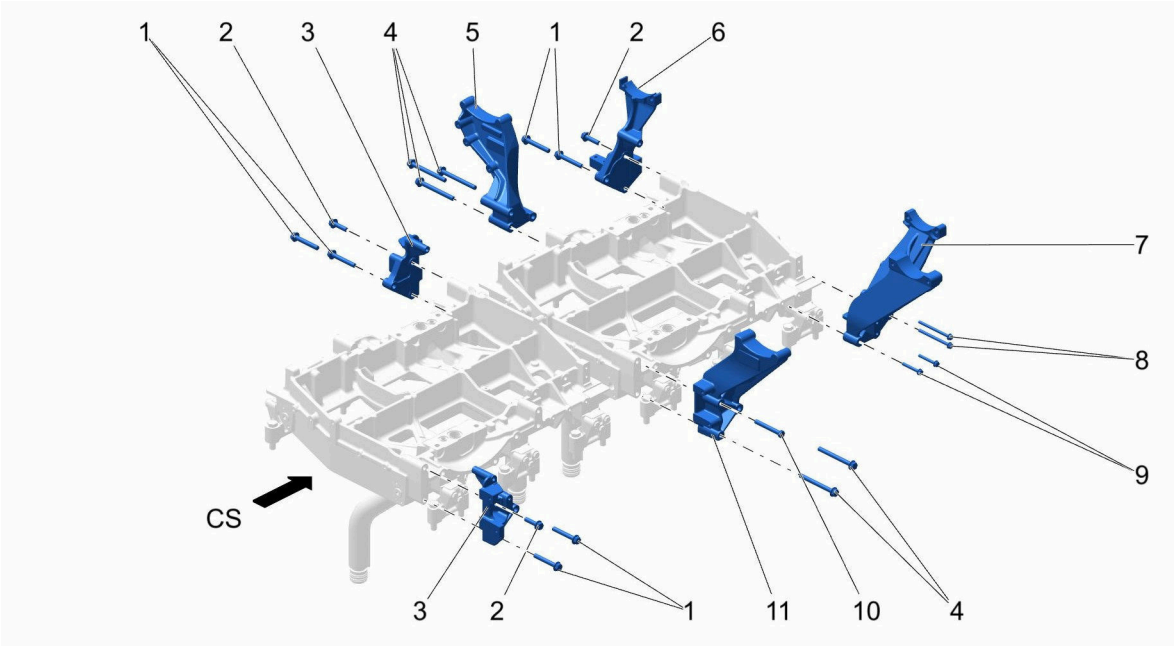


Fig. 209: Installing holders - 50Hz engine

- ▶ Install holders **3, 6** with screws **1, 2**.
- ▶ Install holder **5** with screws **4**.
- ▶ Install holder **7** with screws **8, 9**.

Information

At this stage, screw screws **1, 2, 8, 9** on charge air cooler side without tightening.

Tighten screws **1, 2, 8, 9** to standard torque when charge air cooler is correctly positioned.

- ▶ Install holder **11** with screws **4, 10**.

Specific values

Not applicable.

Tightening specifications

Refer to standard tightening torques. (For more information see: 5.3.2 Screws pre-tightening, reuse and marking, page 274.)

3.8.6 Exhaust pipes and compensators (SL 214)

Previous tasks

- ❑ Remove turbocharger. (For more information see: 3.8.3 Exhaust gas turbocharger removal and installation (SL 213), page 170.)
- ❑ Remove turbocharger bracket. (For more information see: 3.8.5 Turbocharger brackets removal and installation, page 180.)

Specific safety instructions

WARNING
Risk of injuries by contact with hot surfaces!
Engine is hot near operating temperature.

- ▶ Avoid any contact with the engine, parts carrying hot coolant or oil, the exhaust system, the turbocharger, the heat protection, the battery and the covers.
- ▶ After the temperature has cooled down to a level it can be touched, proceed with the tasks on the engine.

Special tools

Not applicable.

Consumables and equipment

– Hot temperature grease
– Rags

Overview

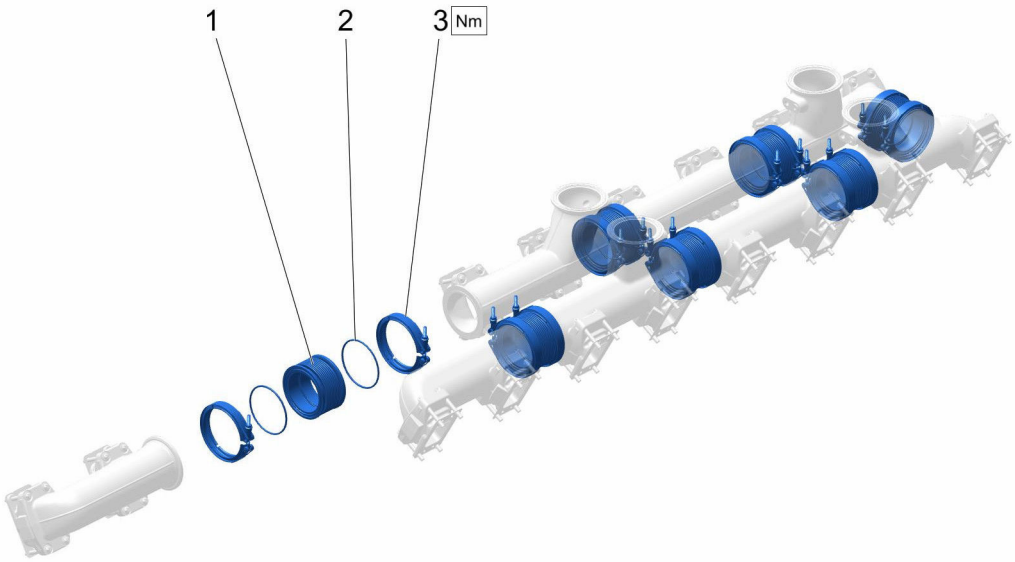


Fig. 210: Task overview

1 Compensator
2 Seal
3 V-clamp

Removal

- ▶ Loosen V-clamps **3**.
- ▶ Remove compensators **1** with seals **2**.

Installation

▶ Install compensators **1** with seals **2** and V-clamps **3**.

▶ Tighten V-clamps **3** to torque.

Specific values

Not applicable.

Tightening specifications

Fig. 211: V-clamps

Reference	Key	Screw specifications	Lubricant *	Reuse**	Torque		Angle (°)	
					Step	± 5%	Step	± 5°
1	410AF	M8x1.25	MH	Yes	1	20 Nm 15 ft-lb	-	-

Tab. 41: Tightening specifications table

*Lubricants:
MG = Molykote G-n-plus
MW = Castrol Optimol paste white T
MH = Molykote HSC
O = Engine oil
XX = Loctite 243
YY = Loctite 577

**Refer to screws reuse rules. (For more information see: 5.3.2 Screws pre-tightening, reuse and marking, page 274.)

Exhaust pipes removal and installation

Previous tasks

❑ Remove turbocharger. (For more information see: 3.8.3 Exhaust gas turbocharger removal and installation (SL 213), page 170.)

❑ Remove turbocharger bracket. (For more information see: 3.8.5 Turbocharger brackets removal and installation, page 180.)

Specific safety instructions

WARNING
Risk of injuries by contact with hot surfaces!
Engine is hot near operating temperature.

▶ Avoid any contact with the engine, parts carrying hot coolant or oil, the exhaust system, the turbocharger, the heat protection, the battery and the covers.

▶ After the temperature has cooled down to a level it can be touched, proceed with the tasks on the engine.

Special tools

Not applicable.

Consumables and equipment

– Hot temperature grease
– Rags

Overview

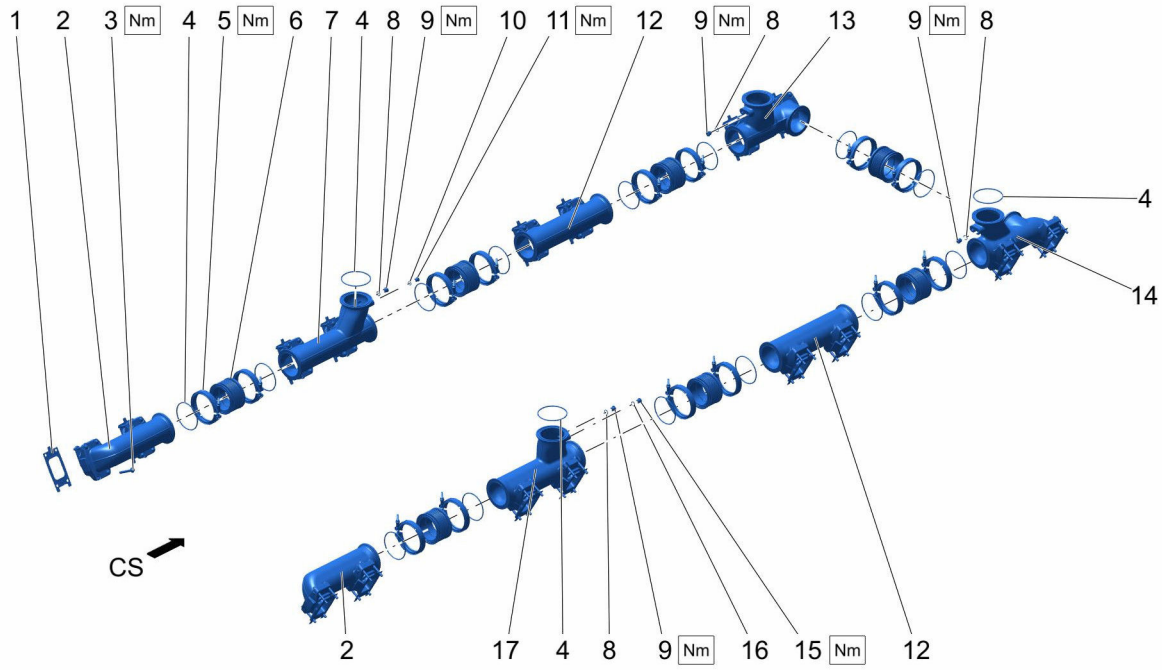


Fig. 212: Task overview

1 Seal
2 Outlet manifold
3 Screw (M10)
4 Seal
5 V-clamp
6 Compensator
7 Outlet manifold
10 Sealing ring
11 Plug
12 Outlet manifold
13 Outlet manifold
14 Outlet manifold
15 Plug
16 Sealing ring

See next page for continuation of the image legend

8 Sealing ring
9 Plug
17 Outlet manifold

Removal

- ▶ Loosen V-clamp **5**.
- ▶ Remove screws **3** from outlet manifolds **2, 7, 12, 13, 14, 17**.
- ▶ Remove outlet manifolds **2, 7, 12, 13, 14, 17**.

Installation

- ▶ Install plug **9** with sealing ring **8** in outlet manifolds **13, 14, 17**.
- ▶ Install plug **11** with sealing ring **10** in outlet manifold **7**.
- ▶ Install plug **15** with sealing ring **16** in outlet manifold **17**.
- ▶ Mount outlet manifolds **13, 14** together with seals **4**, V-clamps **5** and compensator **6**.
- ▶ Place outlet manifolds **13, 14** with seals **1** and screws **3**.
- ▶ Mount outlet manifolds **12** on outlet manifolds **13, 14** with seals **4**, V-clamps **5** and compensator **6**.
- ▶ Place outlet manifolds **12** with seals **1** and screws **3**.
- ▶ Mount outlet manifolds **7, 17** on outlet manifolds **12** with seals **4**, V-clamps **5** and compensator **6**.
- ▶ Place outlet manifolds **7, 17** with seals **1** and screws **3**.
- ▶ Mount outlet manifolds **2** on outlet manifolds **7, 17** with seals **4**, V-clamps **5** and compensator **6**.
- ▶ Place outlet manifolds **2** with seals **1** and screws **3**.
- ▶ Tighten plugs **9, 11, 15**, V-clamps **5** and screws **3** to torque.

Specific values

Not applicable.

Tightening specifications

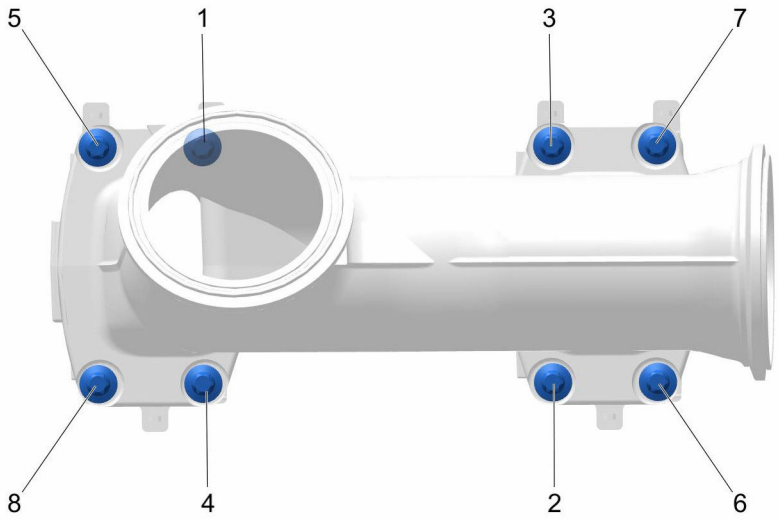


Fig. 213: Exhaust pipe screws tightening sequence

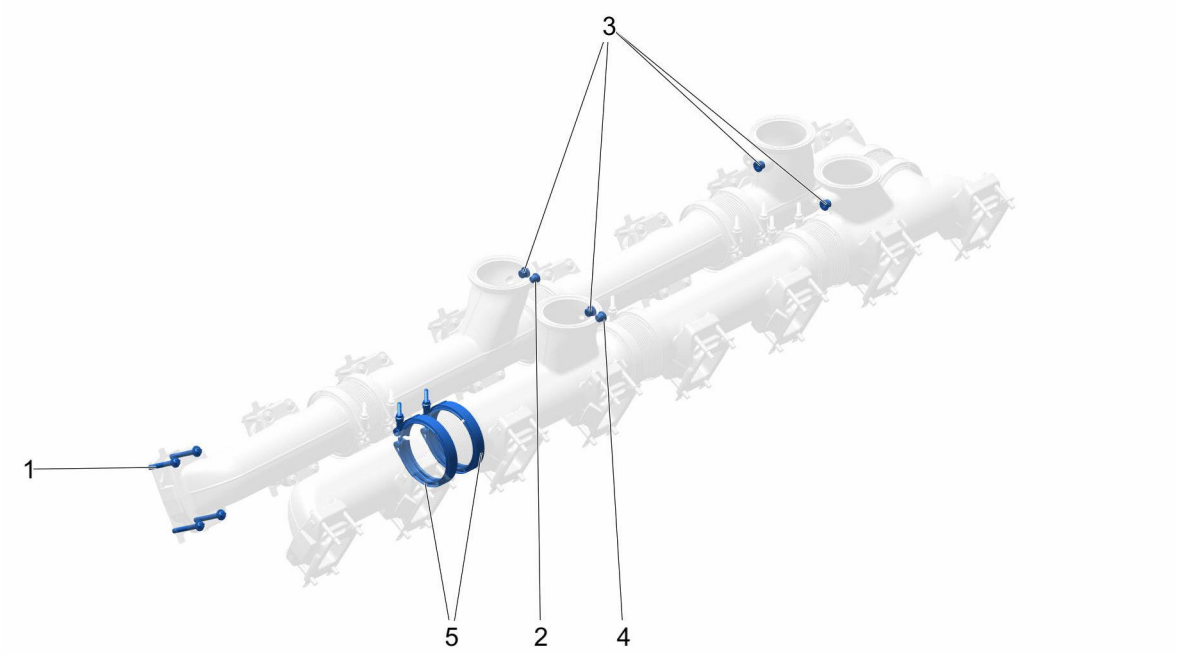


Fig. 214: Exhaust pipe screws and plugs

Reference	Key	Screw specifications	Lubricant *	Reuse**	Torque		Angle (°)	
					Step	± 5%	Step	± 5°
1	410AA	DRW 10123168 M10x1.5x80-C3J	MH	No	1	52 Nm 38 ft-lb	-	-
2	410AC	DIN 908 M14x1.5	MH	Yes	1	35 Nm 26 ft-lb	-	-
3	410AD	DIN 908 G3/8 A	MH	Yes	1	60 Nm 44 ft-lb	-	-
4	410AE	DIN 908 M16x1.5	MH	Yes	1	50 Nm 37 ft-lb	-	-
5	410AF	M8x1.25	MH	Yes	1	20 Nm 15 ft-lb	-	-

Tab. 42: Tightening specifications table

*Lubricants:
MG = Molykote G-n-plus
MW = Castrol Optimol paste white T
MH = Molykote HSC
O = Engine oil
XX = Loctite 243
YY = Loctite 577

**Refer to screws reuse rules. (For more information see: 5.3.2 Screws pre-tightening, reuse and marking, page 274.)

3.9 Lubricating system

3.9.1 Crankcase breather system rubber hoses (SL 219)

Previous tasks

❑ Not applicable.

Specific safety instructions

WARNING
Risks of burns

▶ Wait until the engine has cooled down.

Special tools

Not applicable.

Consumables and equipment

Not applicable.

Overview

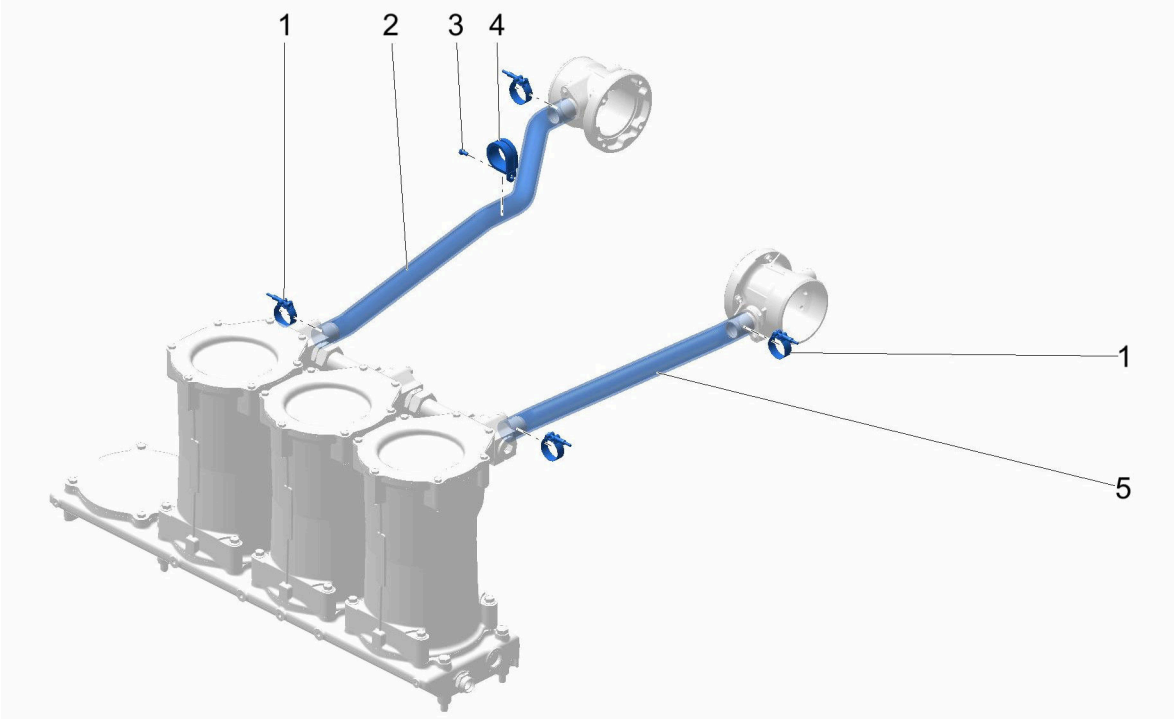


Fig. 215: Task overview

1 Clamp
2 Hose
3 Screw (M8)
4 Clamp
5 Hose

Removal

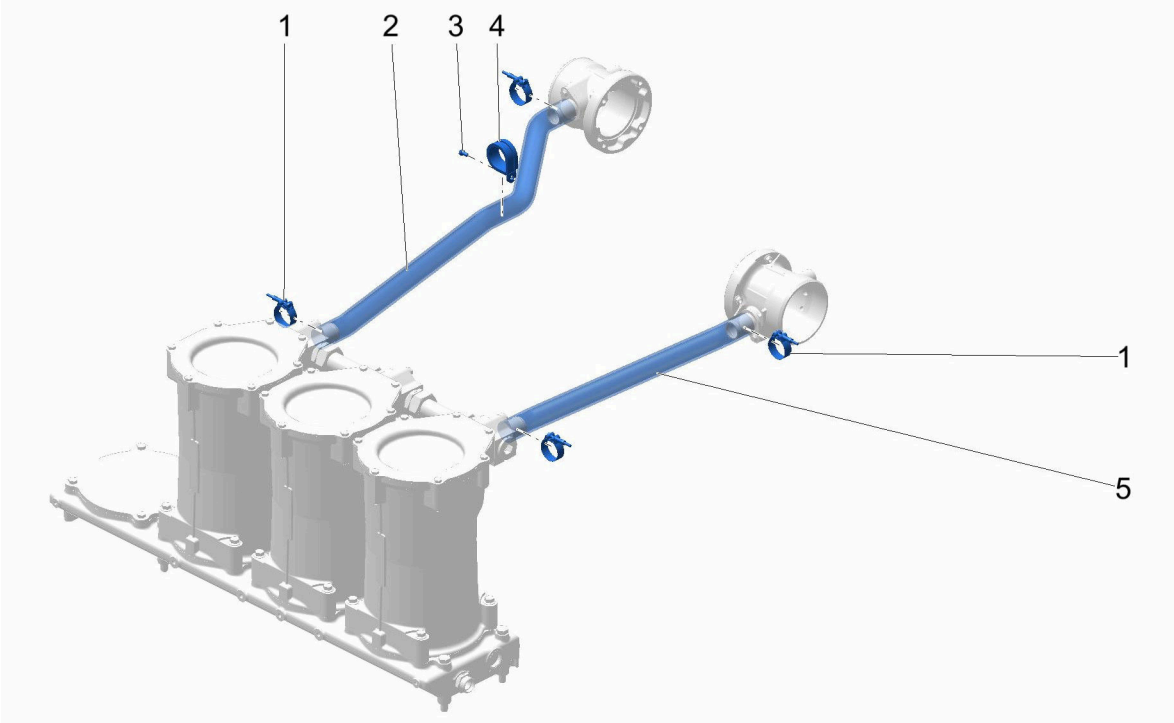


Fig. 216: Removing hoses

- ▶ Remove screw **3**.
- ▶ Remove clamp **4**.
- ▶ Loosen clamps **1**.
- ▶ Remove hoses **2, 5**.

Installation

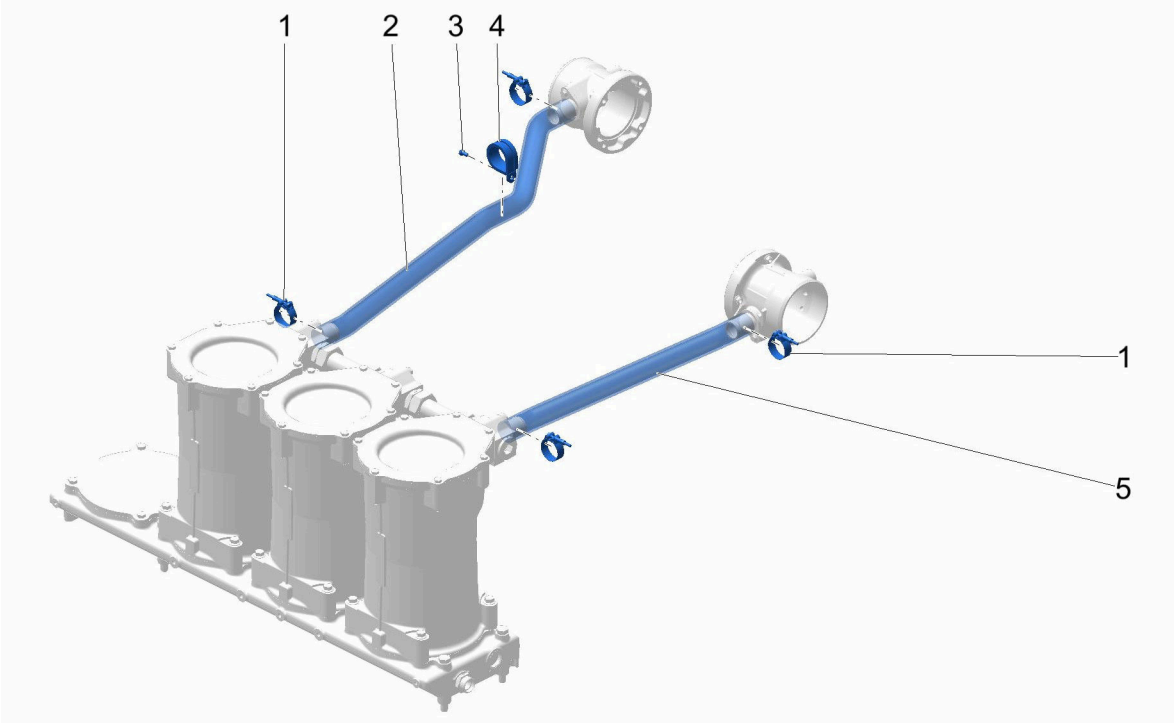


Fig. 217: Installing hoses

- ▶ Install hoses **2, 5** with clamps **1**.
- ▶ Install clamp **4** with screw **3** on hose **2**.
- ▶ Tighten clamps **1**.

Specific values

Not applicable.

Tightening specifications

**Refer to screws reuse rules. (For more information see: 5.3.2 Screws pre-tightening, reuse and marking, page 274.)

3.9.2 Oil centrifuge removal and installation (depending on application)

Previous tasks

- ❑ Drain engine oil.

Specific safety instructions

Not applicable.

Special tools

Not applicable.

Consumables and equipment

– Rags
– Cleaner

Overview

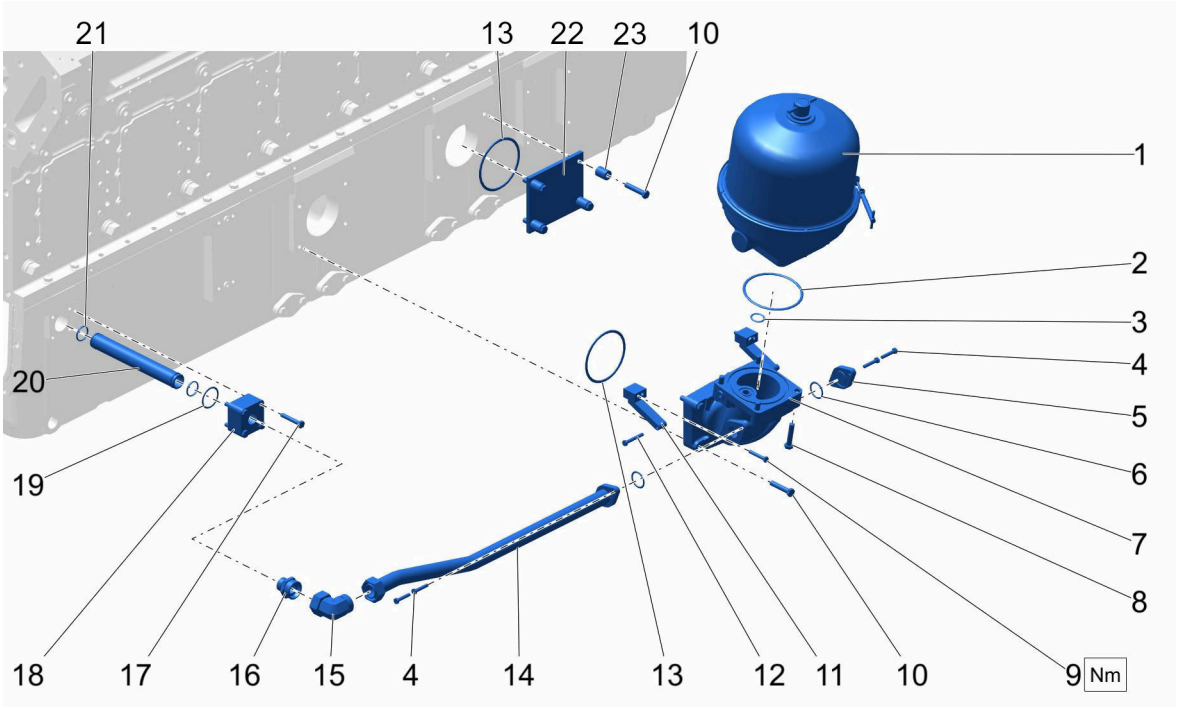


Fig. 218: Task overview

1 Oil centrifuge
2 O-ring
3 O-ring
4 Screw (M8)
5 Cover plate
6 O-ring
7 Oil centrifuge base
8 Screw (M12)
9 Screw (M8)
10 Screw (M12)
11 Holder
12 Screw (M8)
13 O-ring
14 Pipe
15 Flange joint
16 Flange joint
17 Screw (M10)
18 Flange
19 O-ring
20 Pipe
21 O-ring
22 Flange
23 Distance sleeve

Removal

▶ Remove screws **10** with distance sleeves **23**.
▶ Remove flange **22**.
▶ Remove screws **4** from pipe **14**.
▶ Disconnect pipe **14** with flange joints **15, 16**.
▶ Remove screws **9, 10**.
▶ Remove screws **12**.
▶ Remove holders **11**.

- ▶ Remove screws **8**.
- ▶ Remove oil centrifuge base **7** from oil centrifuge **1**.
- ▶ Remove screws **17**.
- ▶ Remove flange **18** with pipe **20**.

Installation

- ▶ Install o-rings **21** on pipe **20**.
- ▶ Install o-rings **19** on flange **18**.
- ▶ Assemble pipe **20** with flange **18**.
- ▶ Install flange **22** with o-ring **13**, screws **10** and distance sleeves **23**
- ▶ Assemble oil centrifuge base **7** and oil centrifuge **1** with screws **8** and o-rings **2, 3**.
- ▶ Install holders **11** with screws **12**.
- ▶ Install oil centrifuge assembly to oil pan with o-ring **13** and screws **9, 10**.
- ▶ Install pipe **14** to oil centrifuge base **7** with o-ring **6** and screws **4**.
- ▶ Connect flange joints **15, 16** to pipe **14**.
- ▶ Install cover plate **5** with o-ring **6** and screws **4**.

Specific values

Not applicable.

Tightening specifications

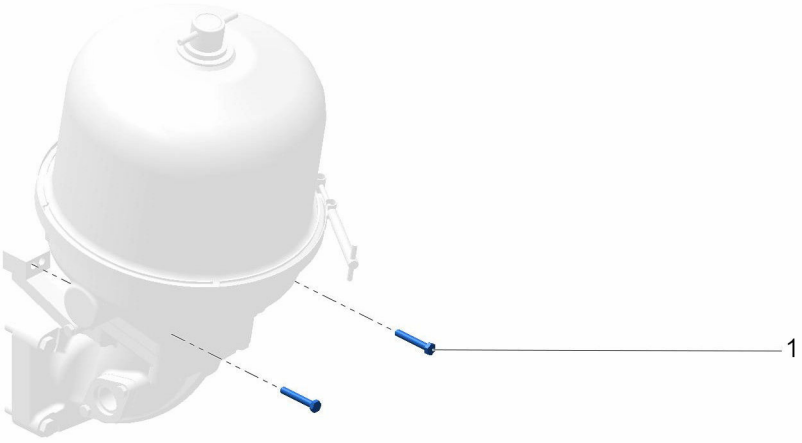


Fig. 219: Oil centrifuge screws

Reference	Key	Screw specifications	Lubricant *	Reuse**	Torque		Angle (°)	
					Step	± 5%	Step	± 5°
1	025AB	ISO 4017 M8x1.25x50-10.9-FLZN	-	Yes	1	27 Nm 20 ft-lb	-	-

Tab. 43: Tightening specifications table

*Lubricants:
MG = Molykote G-n-plus
MW = Castrol Optimol paste white T
MH = Molykote HSC
O = Engine oil
XX = Loctite 243
YY = Loctite 577

**Refer to screws reuse rules. (For more information see: 5.3.2 Screws pre-tightening, reuse and marking, page 274.)

3.9.3 Spin-on oil filters removal and installation

Previous tasks

Not applicable.

Specific safety instructions

Not applicable.

Special tools

Not applicable.

Consumables and equipment

– Cleaner
– Rags
– Optimol

Overview

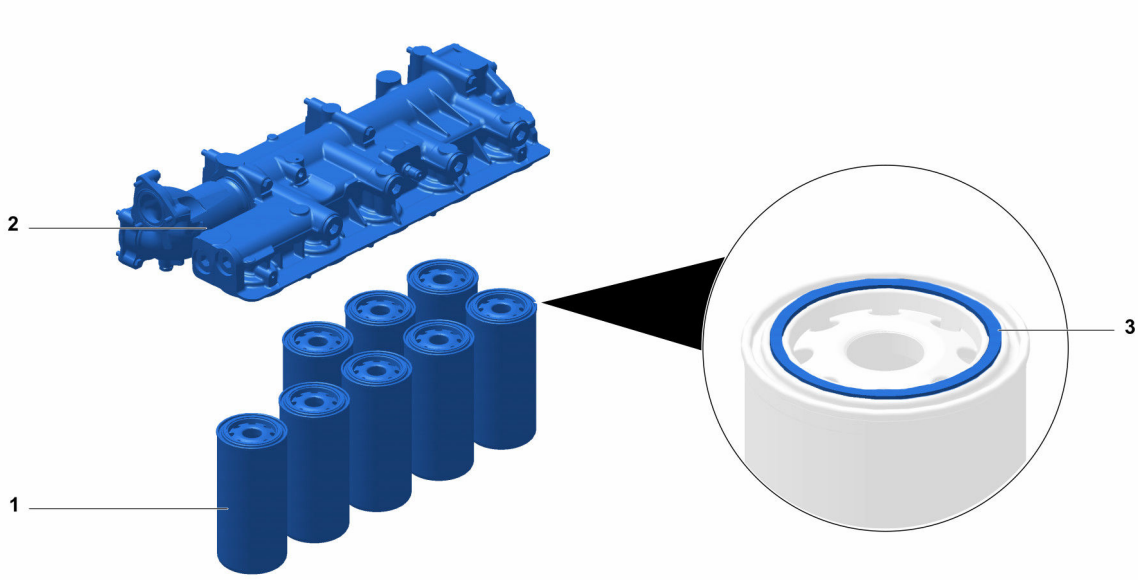


Fig. 220: Task overview

1 Spin-on oil filter
2 Filter head
3 Seal

Removal

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

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.

Specific values

Not applicable.

Tightening specifications

Refer to standard tightening torques. (For more information see: 5.3 Standard tightening torques, page 274.)

3.9.4 Prelubricating pump removal and installation (depending on application)

Previous tasks

❑ Drain engine oil.

Specific safety instructions

Not applicable.

Special tools

Not applicable.

Consumables and equipment

– Rags

Overview

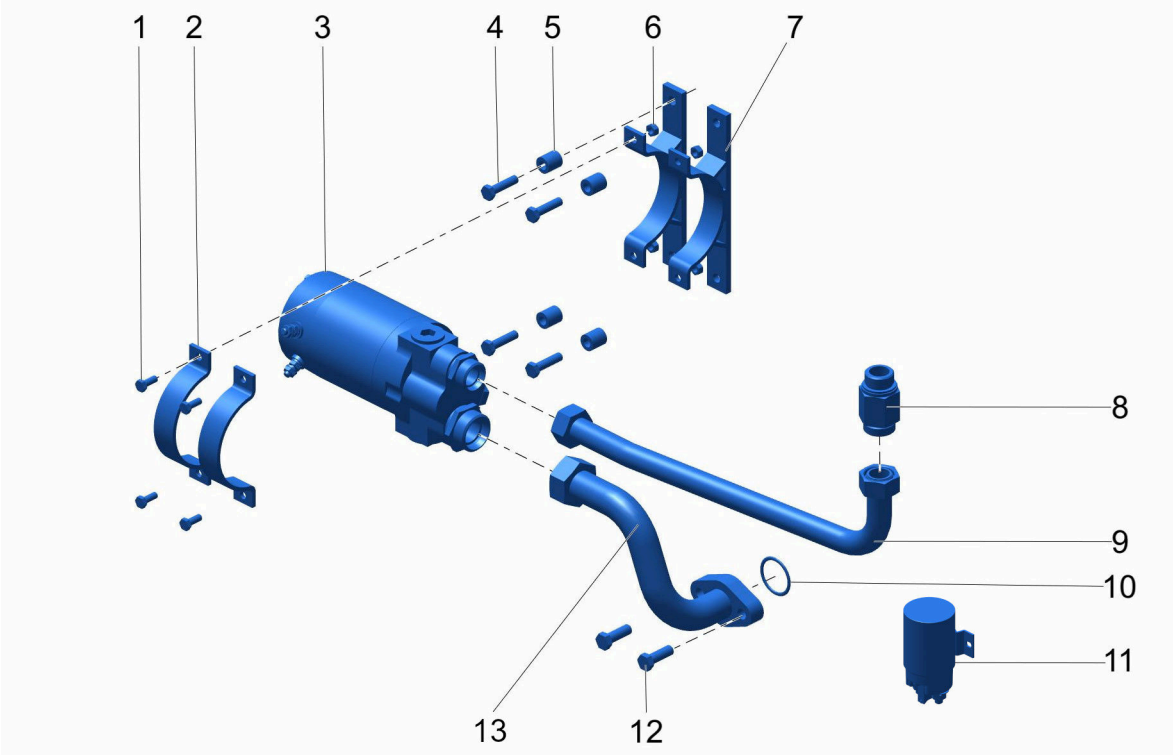


Fig. 221: Task overview

1 Screw (M8)
2 Clamp
3 Prelubricating pump
4 Screw (M10)
5 Distance sleeve
6 Nut
7 Holder
8 Return valve
9 Oil line
10 O-ring
11 Relay
12 Screw (M12)
13 Oil line

Removal

- ▶ Remove oil line **9**.
- ▶ Remove return valve **8**.
- ▶ Remove oil line **13** and screws **12**.
- ▶ Remove o-ring **10**.
- ▶ Remove screws **1**.
- ▶ Remove clamps **2**.
- ▶ Remove prelubricating pump **3**.
- ▶ Remove screws **4**, distance sleeves **5** and nuts **6**.
- ▶ Remove holders **7**.

Installation

Information

Do not install relay **11** on the engine.

- ▶ Install holders **7** with screws **4**, distance sleeves **5** and nuts **6**.
- ▶ Tighten screws **4**.
- ▶ Hand-tighten prelubricating pump **3** with clamps **2** and screws **1**.
- ▶ Hand-tighten oil line **13** with screws **12** and o-ring **10**.
- ▶ Install return valve **8**.
- ▶ Tighten return valve **8**.
- ▶ Hand-tighten oil line **9**.
- ▶ Tighten screws **1**.
- ▶ Tighten oil lines **9, 12** nuts.

Specific values

Not applicable.

Tightening specifications

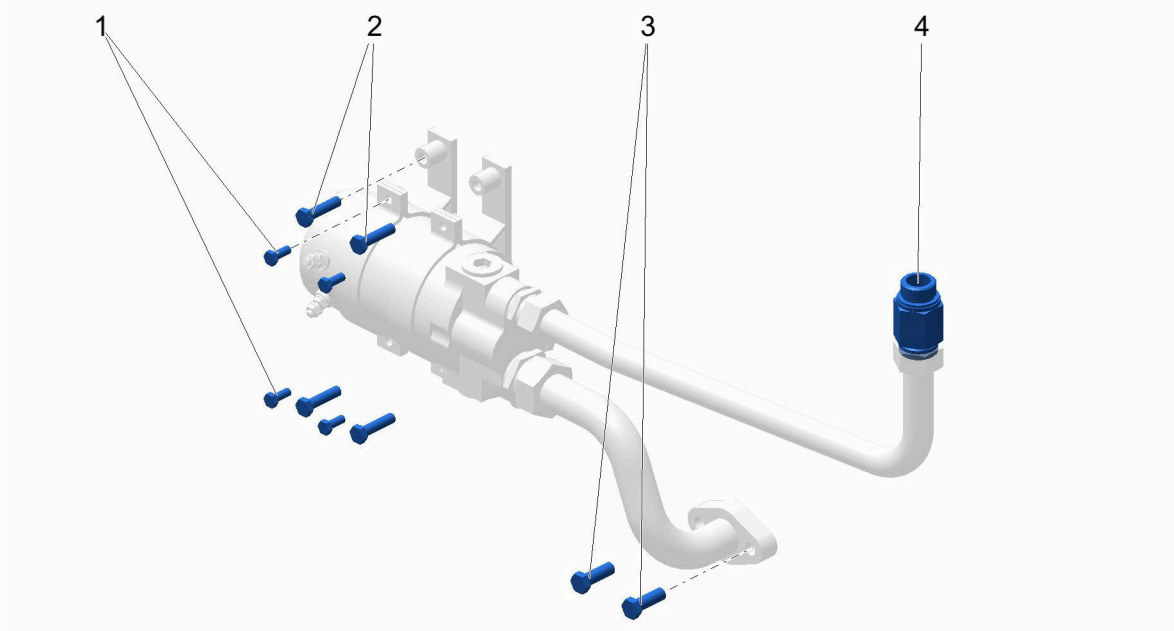


Fig. 222: Prelubricating pump screws and connections

Reference	Key	Screw specifications	Lubricant *	Reuse**	Torque		Angle (°)	
					Step	± 5%	Step	± 5°
1	-	M8 10.9 480H	-	Yes	1	34 Nm 25 ft-lb	-	-
2	-	M10 10.9 FLZN	-	Yes	1	66 Nm 49 ft-lb	-	-
3	-	M12 10.9 FLZN	-	Yes	1	113 Nm 83 ft-lb	-	-
4	-	M33x2	O	Yes	1	340 Nm 251 ft-lb	-	-

Tab. 44: Tightening specifications table

*Lubricants:
MG = Molykote G-n-plus
MW = Castrol Optimol paste white T
MH = Molykote HSC
O = Engine oil
XX = Loctite 243
YY = Loctite 577

**Refer to screws reuse rules. (For more information see: 5.3.2 Screws pre-tightening, reuse and marking, page 274.)

3.10 Cooling system

3.10.1 Water pipes (rocker arm housing) removal and installation

Previous tasks

❑ Dismount the water pipes on the rocker arm housing with the rocker arm housing. (For more information see: 3.3.3 Rocker arms housing removal and installation, page 82.)

Specific safety instructions

NOTICE
Risk of property damage by reuse of sealing.
Leakage by faulty seal.

▶ Replace all sealings.

Special tools

Not applicable.

Consumables and equipment

– Rags
– Cleaner

Overview

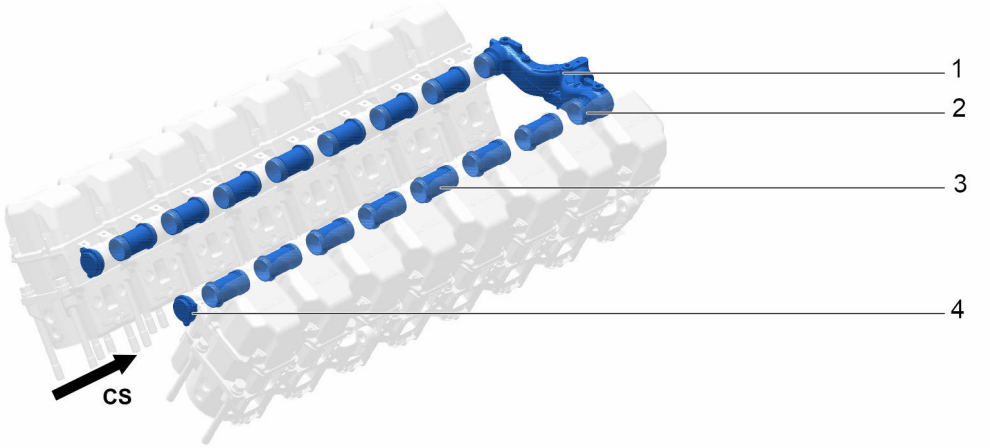


Fig. 223: Task overview

1 HT collector
2 Pipe
3 Pipe
4 Cover

Removal

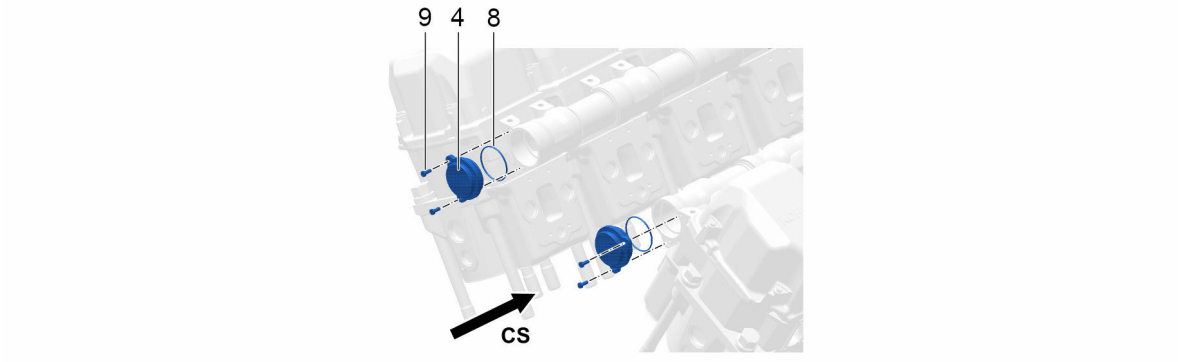


Fig. 224: Removing cover

- ▶ Remove screws **9**.
- ▶ Remove cover **4**.

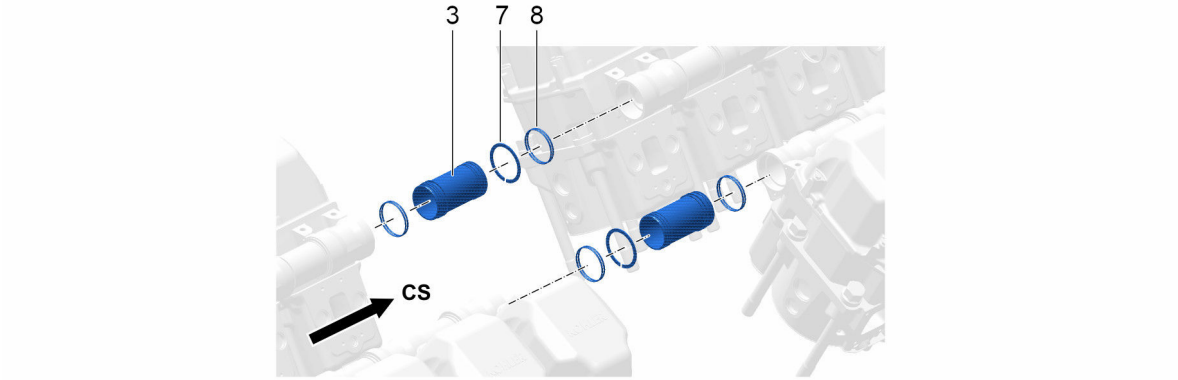


Fig. 225: Removing water pipe

- ▶ Move clamp **7** to the middle of the pipe **3**.
- ▶ Push pipe **3** towards the left housing.
- ▶ Remove rocker arm housing.
- ▶ Remove pipe **3**.

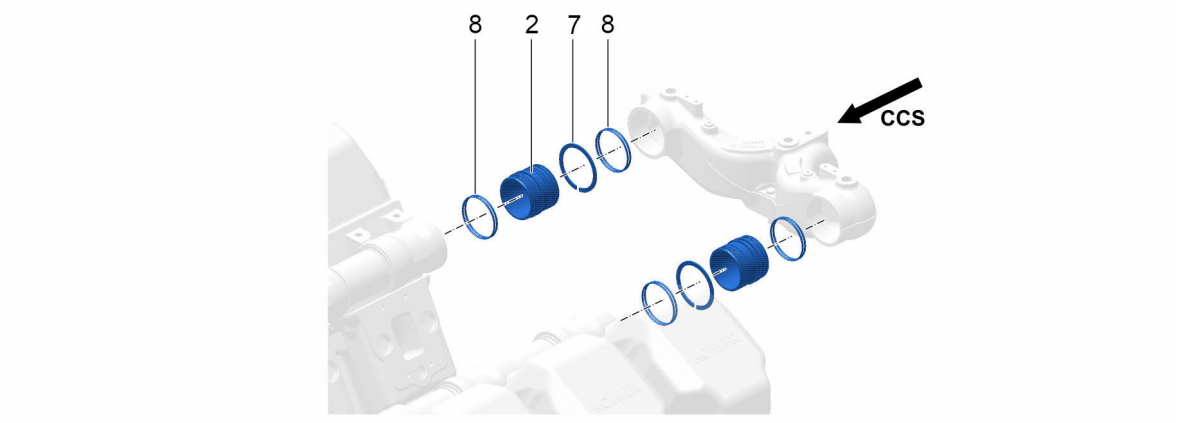


Fig. 226: Removing pipe

- ▶ Move clamp **7** to the middle of the pipe **2**.
- ▶ Push pipe **2** towards the left housing.
- ▶ Remove rocker arm housing.
- ▶ Remove pipe **2**.

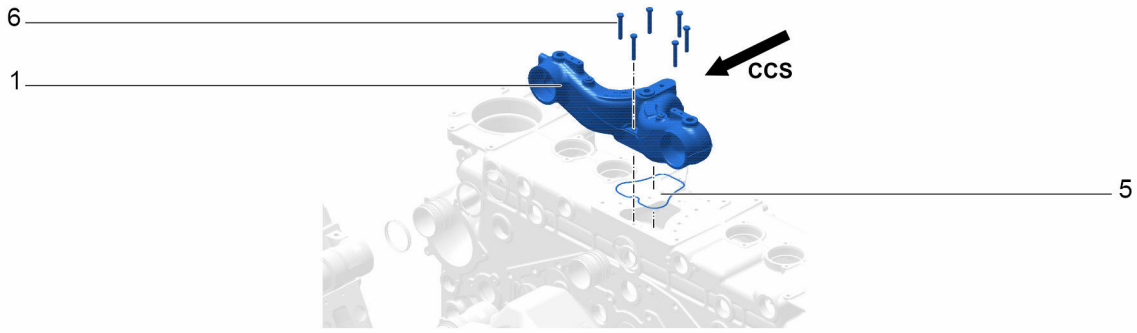


Fig. 227: Removing collector

- ▶ Remove screws **6**.
- ▶ Remove collector **1**.

Installation

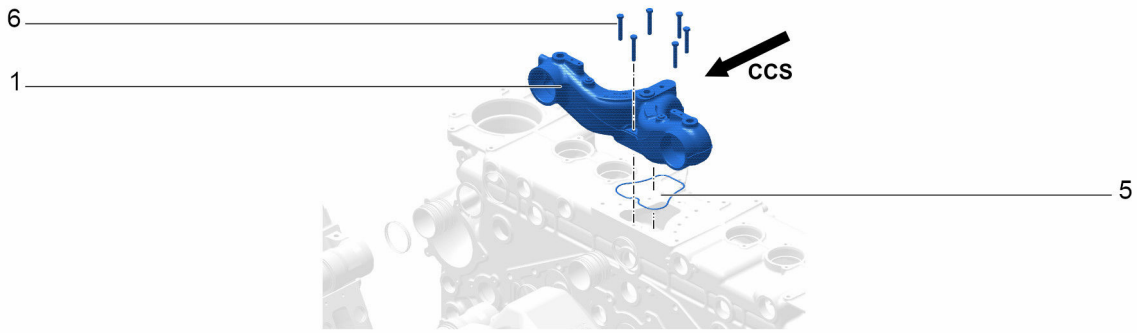


Fig. 228: Installing collector

- ▶ Insert o-ring **5** in HT collector **1**.

- ▶ Position HT collector **1** on aggregate support.
- ▶ Tighten screws **6** to torque.

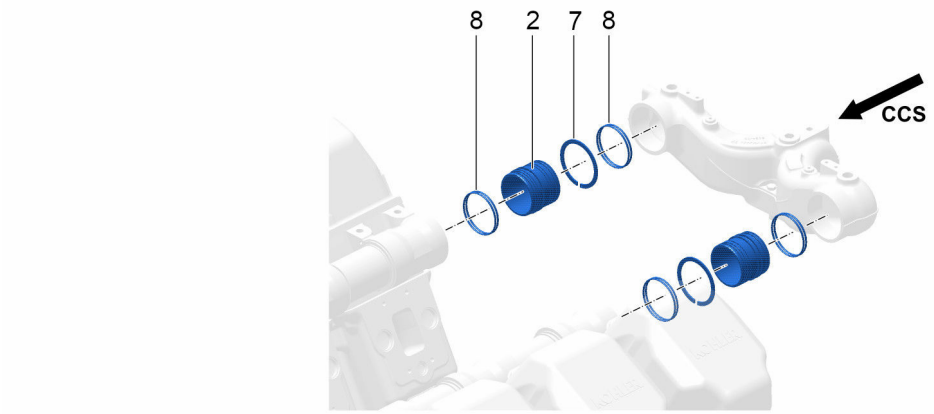


Fig. 229: Installing pipe

- ▶ Insert o-rings **8**.
- ▶ Position clamp **7** in the pipe middle.
- ▶ Insert A bank pipe **2** into collector.
- ▶ Insert B bank pipe **2** into rocker arm housing.
- ▶ After housing is installed, push pipes to the right until clamp **7** can be placed in its groove.

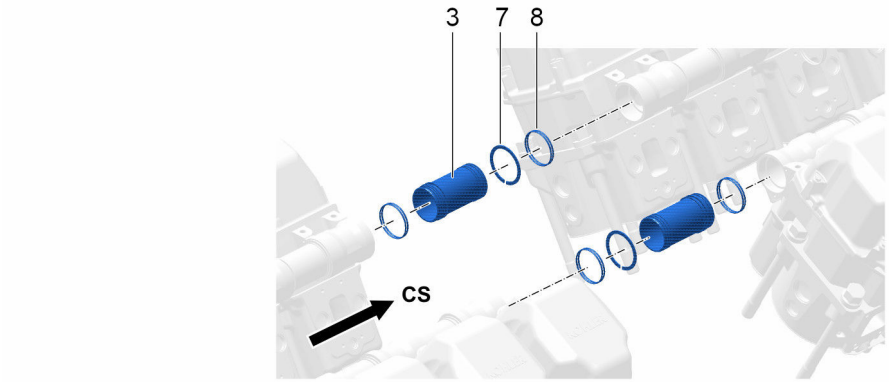


Fig. 230: Installing water pipe

- ▶ Insert o-rings **8**.
- ▶ Position clamp **7** in middle of pipe **3**.
- ▶ Insert pipe **3** from the left into the rocker arm housing.
- ▶ After housing is installed, push pipe to the right until clamp **7** can be placed in its groove.

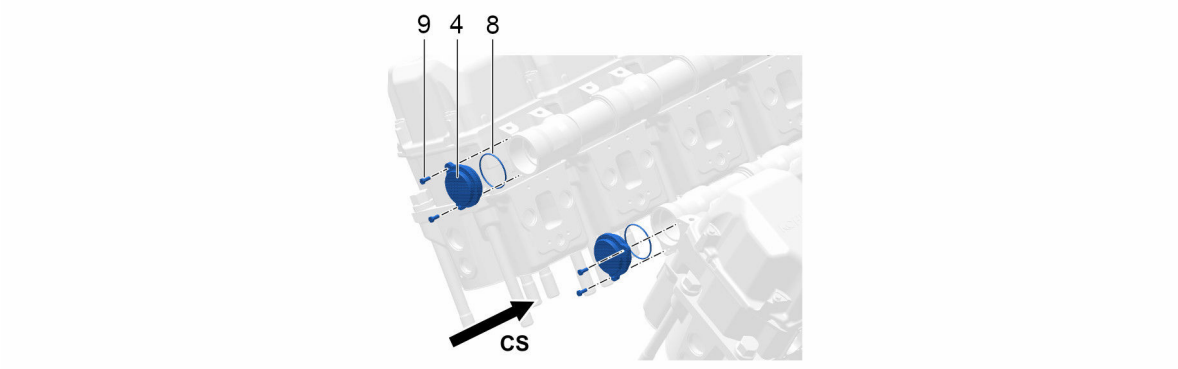


Fig. 231: Installing cover

- ▶ Insert o-ring **8**.
- ▶ Insert cover **4**.
- ▶ Tighten screws **9**.

Specific values

Not applicable.

Tightening specifications

Refer to standard tightening torques. (For more information see: 5.3 Standard tightening torques, page 274.)

3.10.2 Venting line removal and installation

Previous tasks

Not applicable.

Specific safety instructions

NOTICE
Risk of property damage by reuse of sealing.
Leakage by faulty seal.

- ▶ Replace all sealings.

Special tools

Not applicable.

Consumables and equipment

- – Rags
- – Cleaner
- – Loctite 243

Overview

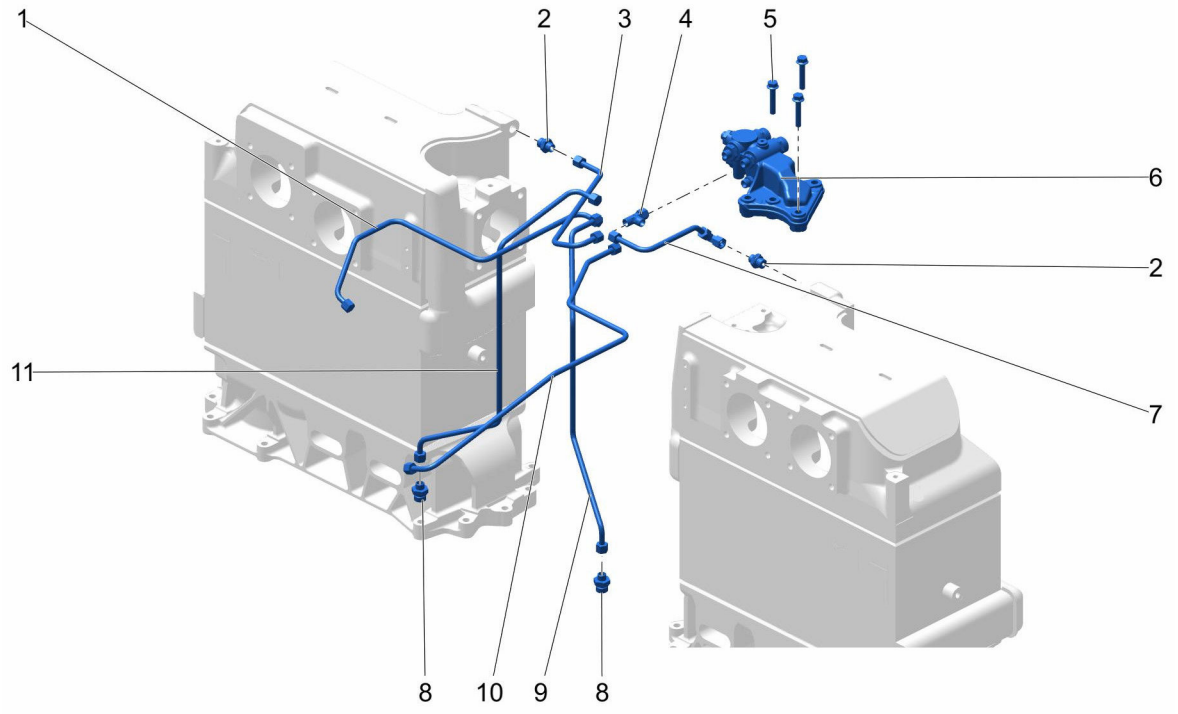


Fig. 232: Task overview

1 Venting LT turbocharger
2 Flange joint
3 Venting LT charge air cooler
4 T connector
5 Screw (M10)
6 Distribution block
7 Venting LT charge air cooler
8 Flange joint
9 Venting HT thermostat
10 Venting LT turbocharger
11 Venting HT collecting pipe

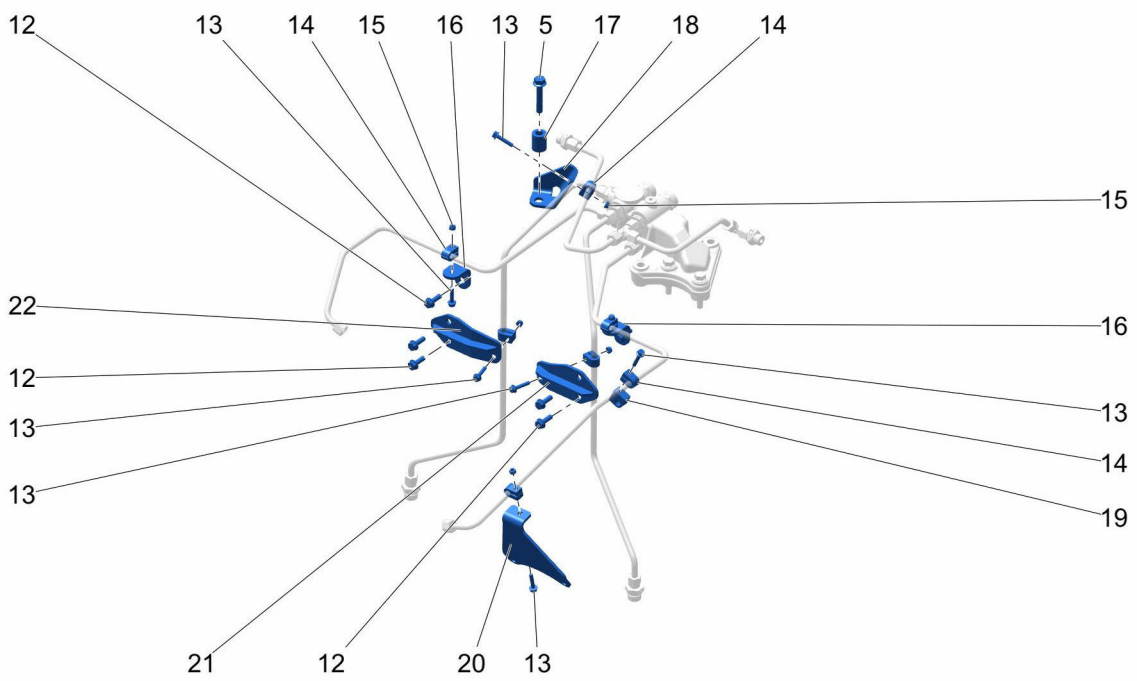


Fig. 233: Task overview

12 Screw (M8)
13 Screw (M6)
14 Clamp
15 Nut (M6)
16 Holder
17 Distance sleeve
18 Holder
19 Holder
20 Holder
21 Holder
22 Holder

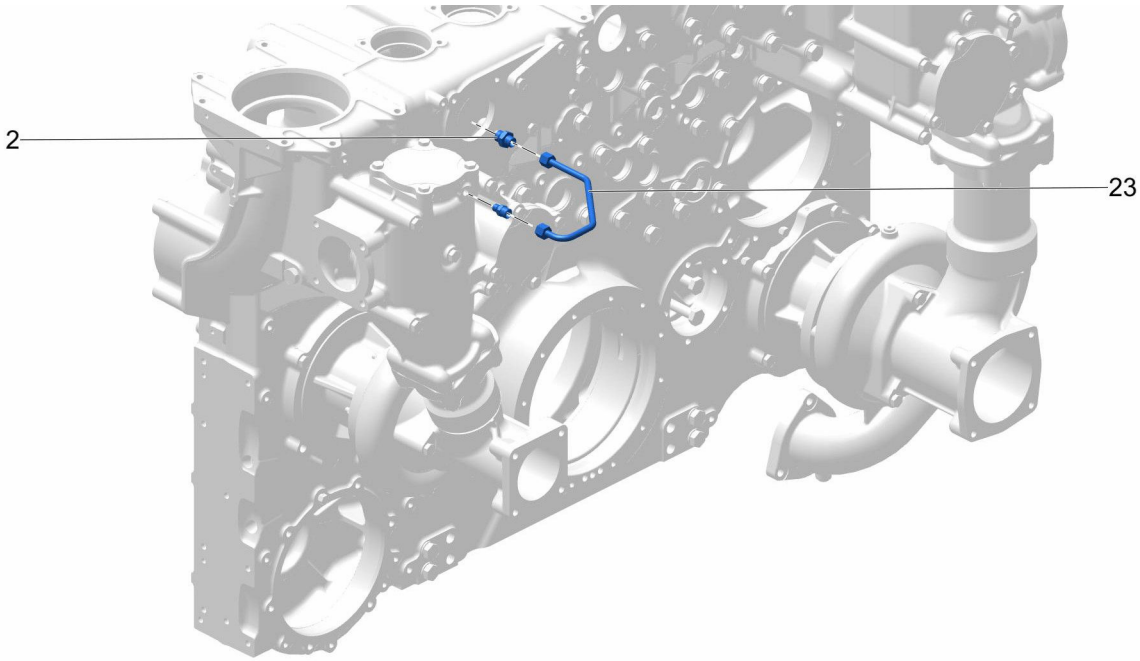


Fig. 234: Task overview

23 Venting line

Removal

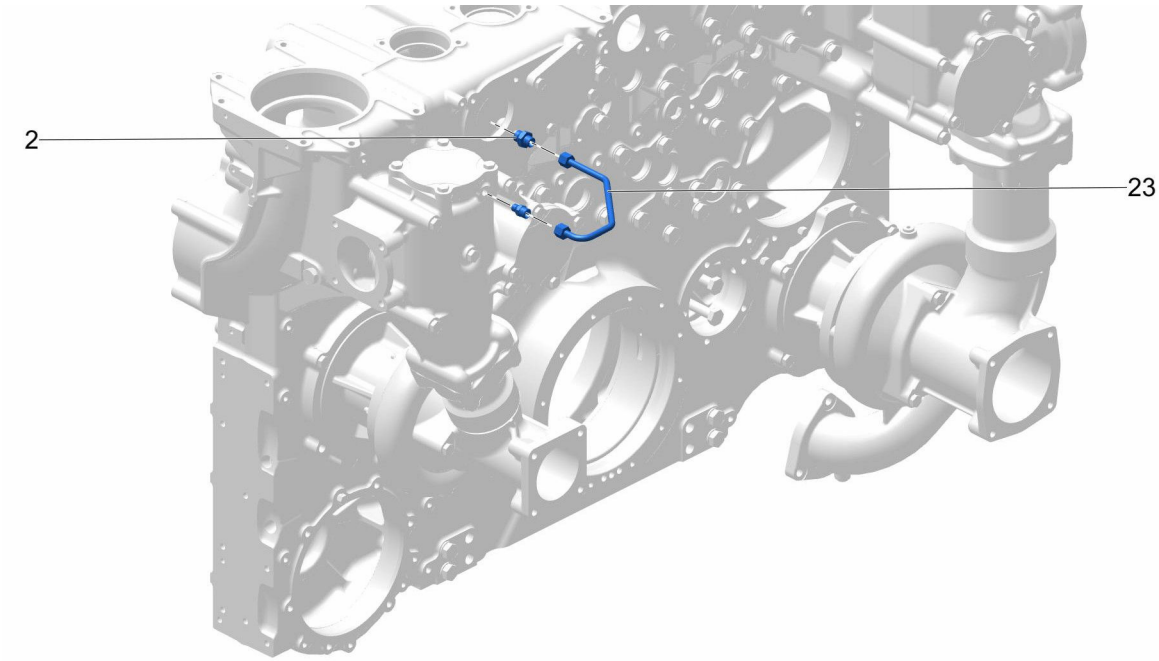


Fig. 235: Removing venting lines

▶ Remove venting line **23** with flange joints **2**.

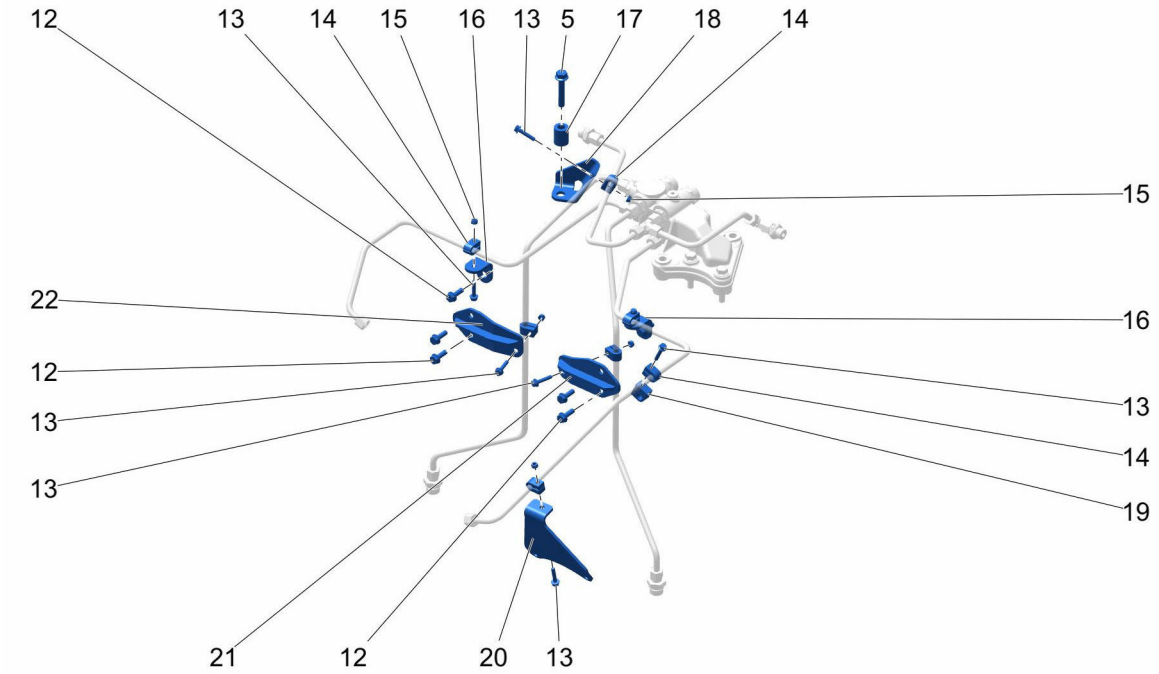


Fig. 236: Removing venting lines

▶ Remove clamps **14** with screws **13**, and nuts **15**.

▶ Remove holders **16, 18, 19, 20, 21, 22** with screws **5, 12**, and distance sleeve **17**.

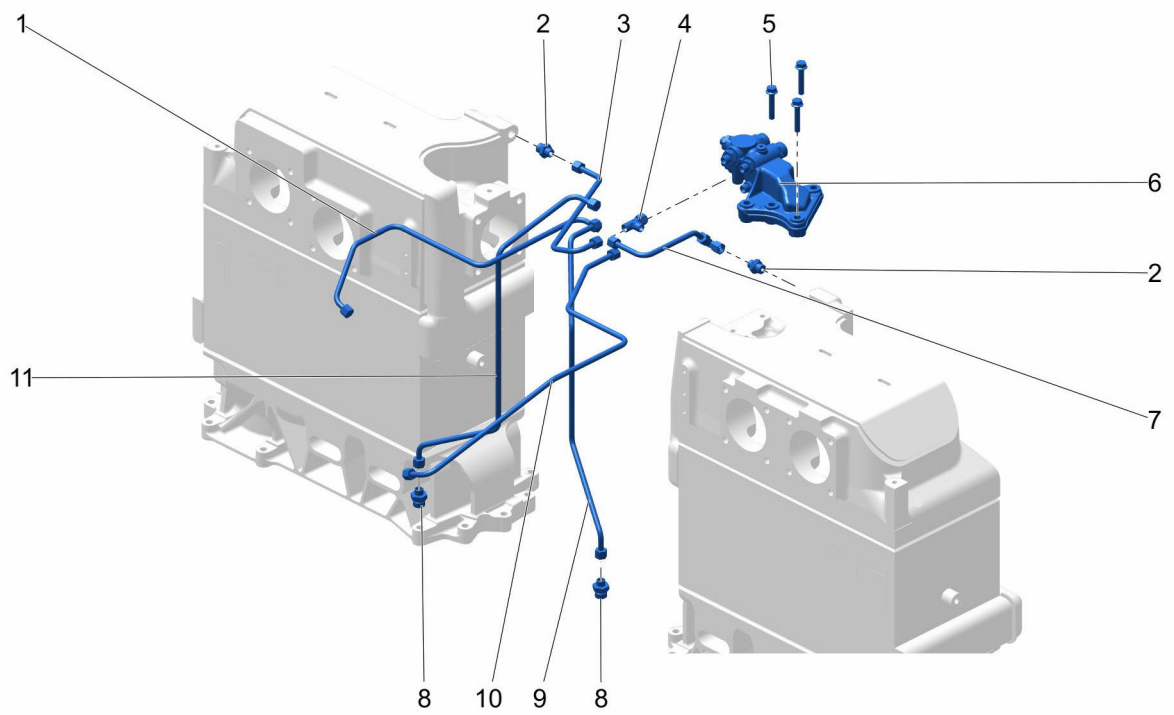


Fig. 237: Removing venting lines

- ▶ Remove venting pipes **1, 3, 7, 9, 10, 11**.
- ▶ Remove screws **5**.
- ▶ Remove distributor block **6**.

Installation

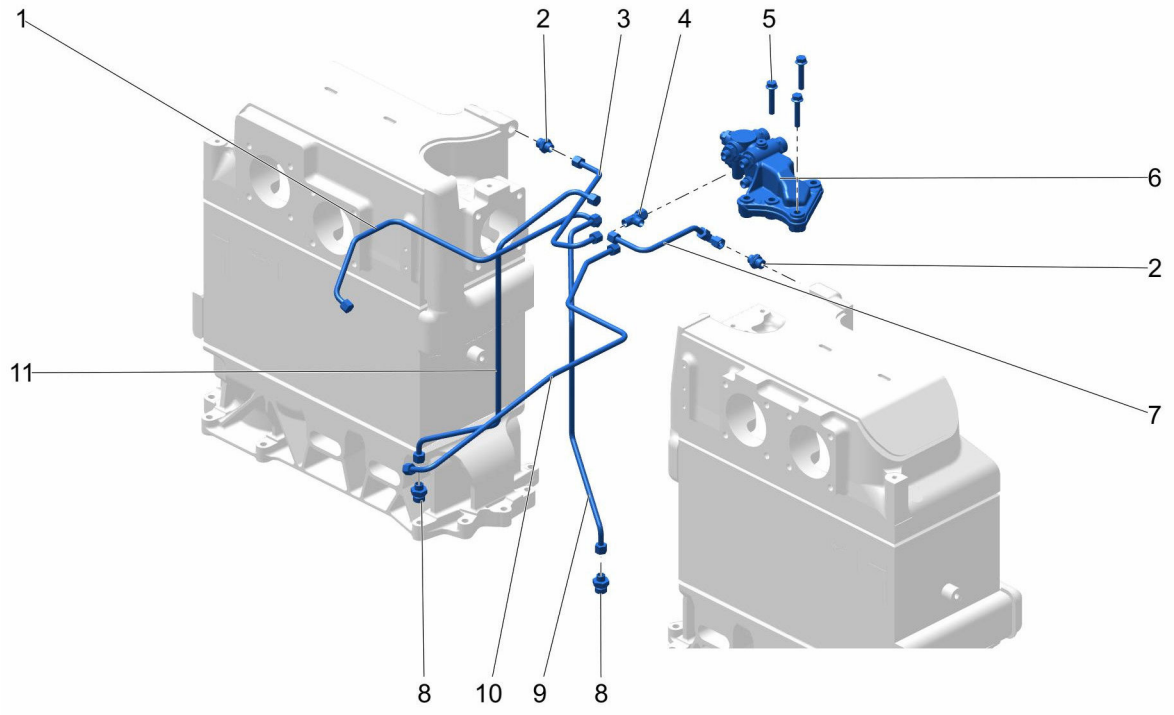


Fig. 238: Installing venting lines

▶ Screw distributor block **6** with screws **5**.

▶ Install venting pipes **1, 3, 7, 9, 10, 11** with T connector **4** and flange joints **2, 8**.

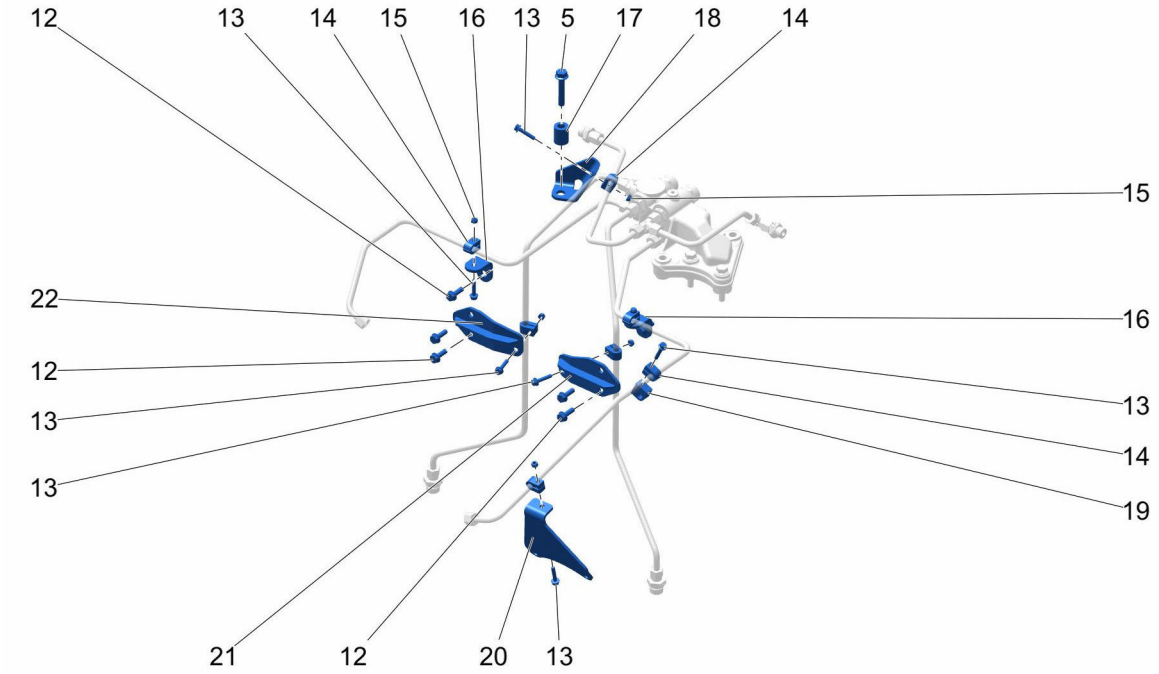


Fig. 239: Installing venting lines

▶ Install clamps **14** and holders **16, 18, 19, 20, 21, 22** with screws **5, 12, 13**, distance sleeve **17** and nuts **15**.

Information

Use Loctite 243 only for screw **13** in holder **19**.

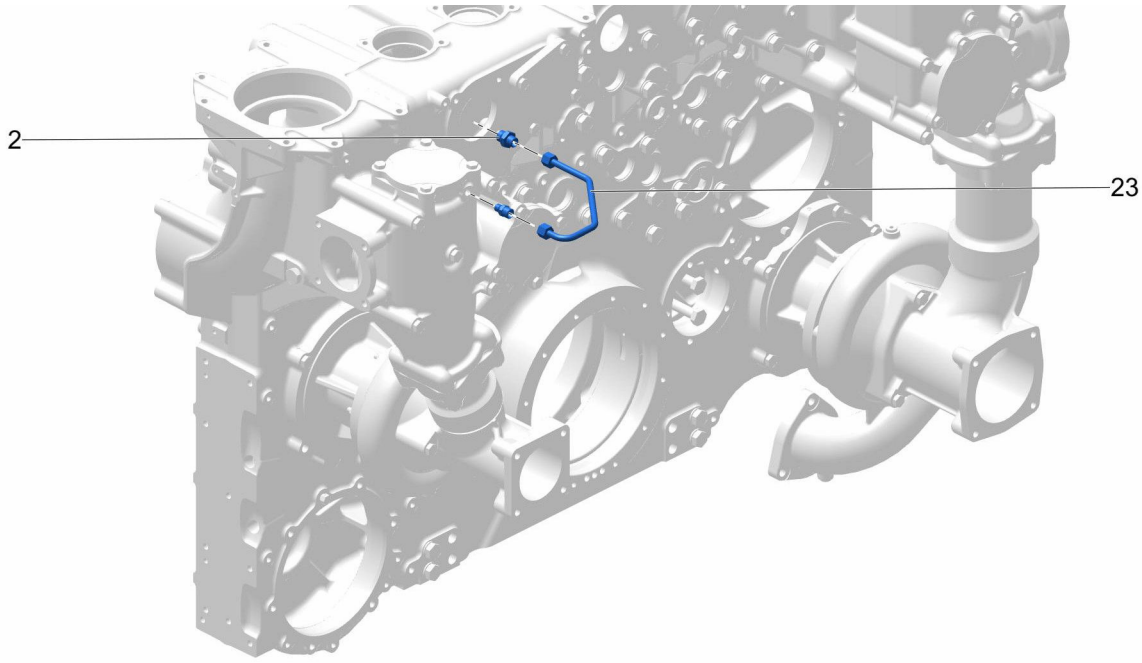


Fig. 240: Installing venting lines

▶ Install venting lines **23** with flange joints **2**.

Specific values

Not applicable.

Tightening specifications

Refer to standard tightening torques. (For more information see: 5.3 Standard tightening torques, page 274.)

3.10.3 Turbocharger cooling lines removal and installation

Previous tasks

❑ Remove venting lines. (For more information see: 3.10.2 Venting line removal and installation, page 205.)

Specific safety instructions

NOTICE
Risk of property damage by reuse of sealing.
Leakage by faulty seal.

▶ Replace all sealings.

Special tools

Not applicable.

Consumables and equipment

– Vaseline
– Rags
– Cleaner

Overview

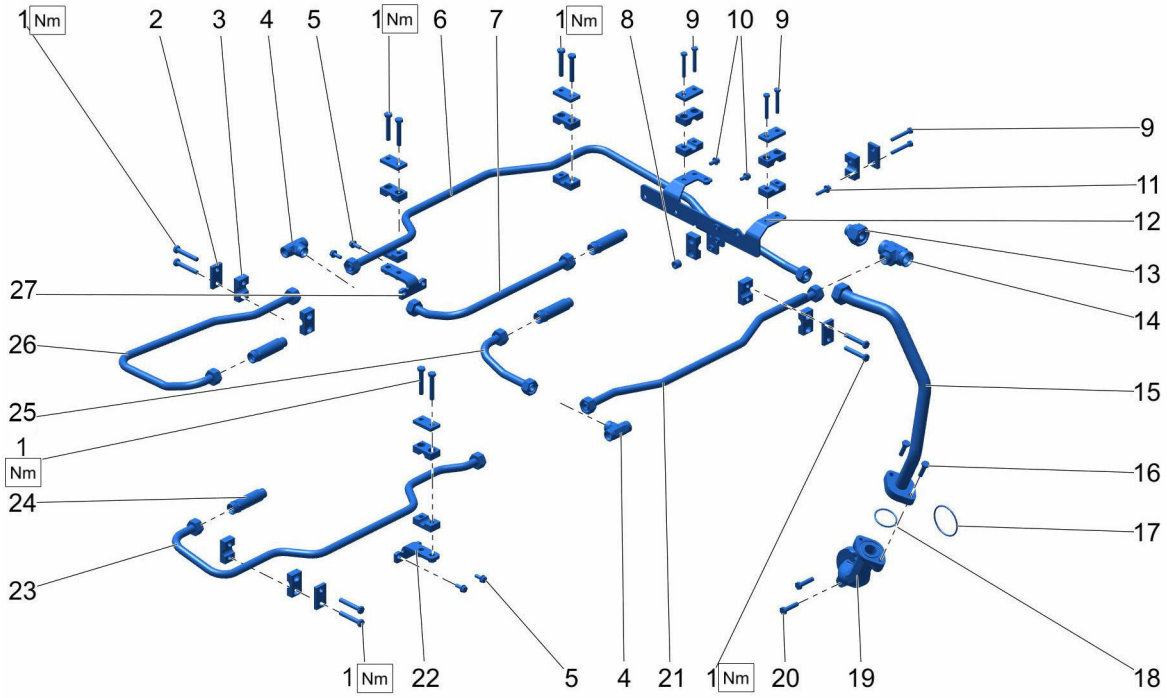


Fig. 241: Task overview

1 Screw (M10)
2 Plate
3 Clamp
4 T connector
5 Screw (M8)
6 Pipe
7 Pipe
8 Distance sleeve
9 Screw (M8)
10 Screw (M8)
11 Screw (M8)
12 Retaining plate
13 Flange joint
14 T connector
15 Pipe
16 Screw (M10)
17 O-ring
18 O-ring
19 Aggregate support connector
20 Screw (M10)
21 Pipe
22 Retaining plate
23 Pipe
24 Fitting
25 Pipe
26 Pipe
27 Retaining plate

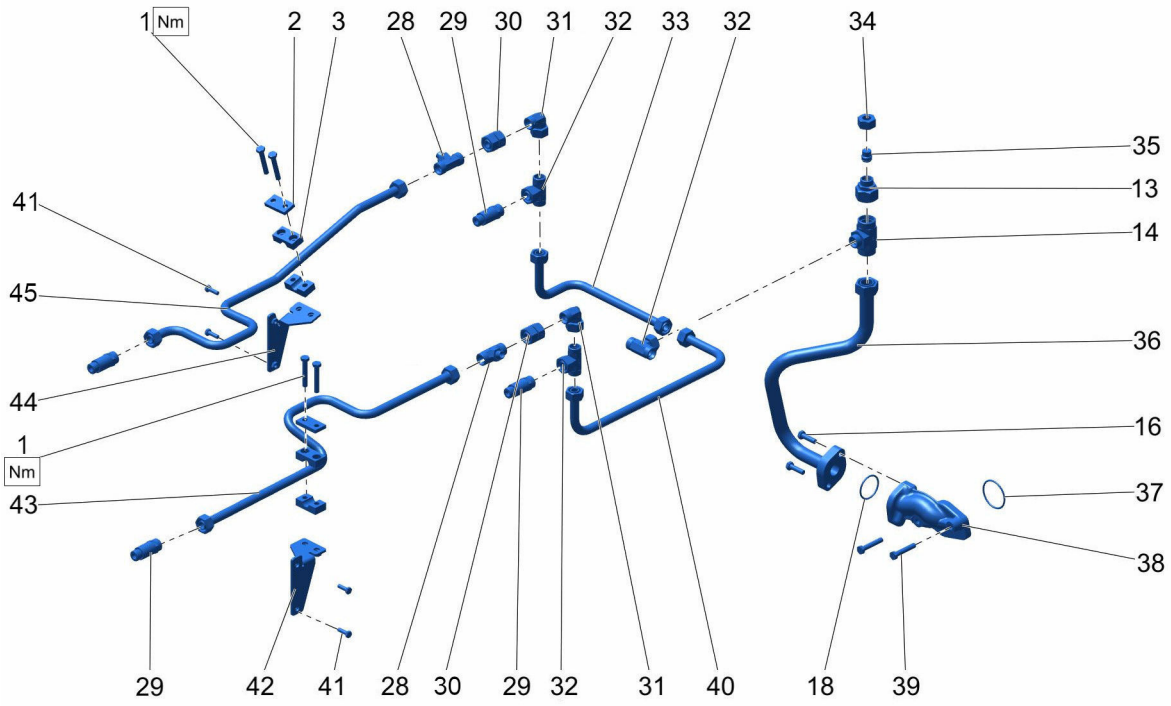


Fig. 242: Task overview

28 T connector
29 Fitting
30 Fitting
31 90° connector
32 T connector
33 Pipe
34 Flange joint
35 Adaptor
36 Pipe
37 O-ring
38 Aggregate support connector
39 Screw (M10)
40 Pipe
41 Screw (M8)
42 Retaining plate
43 Pipe
44 Retaining plate
45 Pipe

Removal

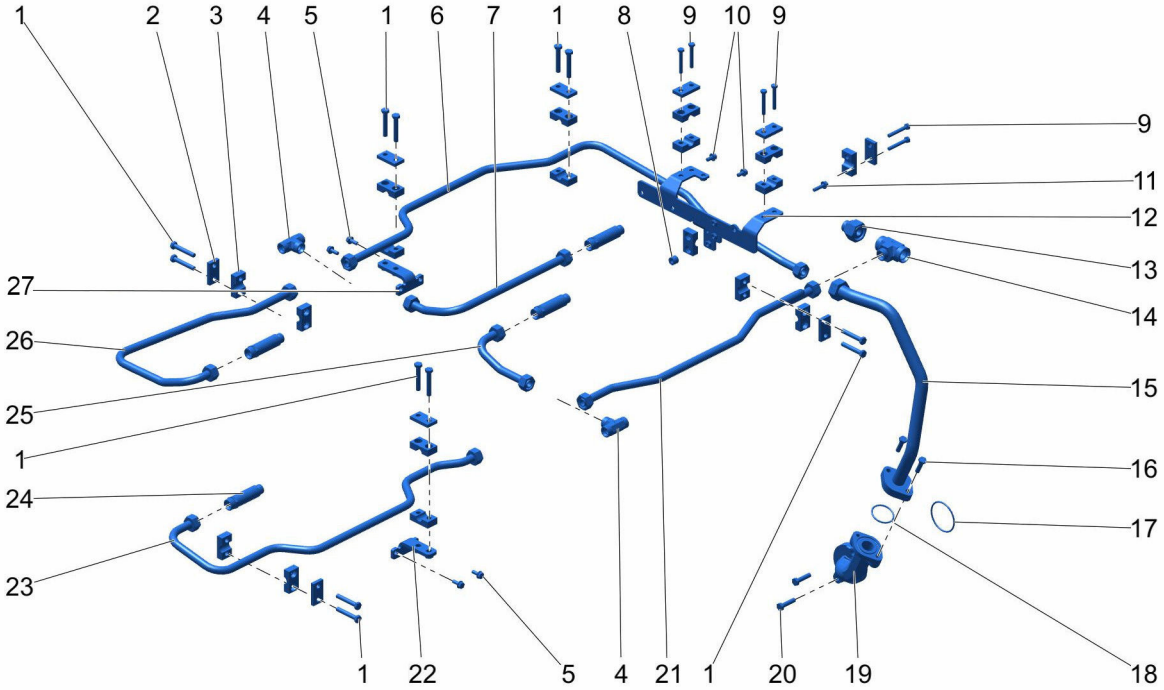


Fig. 243: Removing pipes

- ▶ Remove screws **1, 9**.
- ▶ Remove plates **2** and clamps **3**.
- ▶ Remove screws **9, 11** and distance sleeve **8**.
- ▶ Remove screws **16, 20**.
- ▶ Remove aggregate support connector **19**.
- ▶ Unscrew connection nuts of pipes **6, 7, 15, 21, 23, 25, 26**.
- ▶ Remove fittings **24**.
- ▶ Remove screws **10, 11** and distance sleeve **8**.
- ▶ Remove retaining plate **12**.

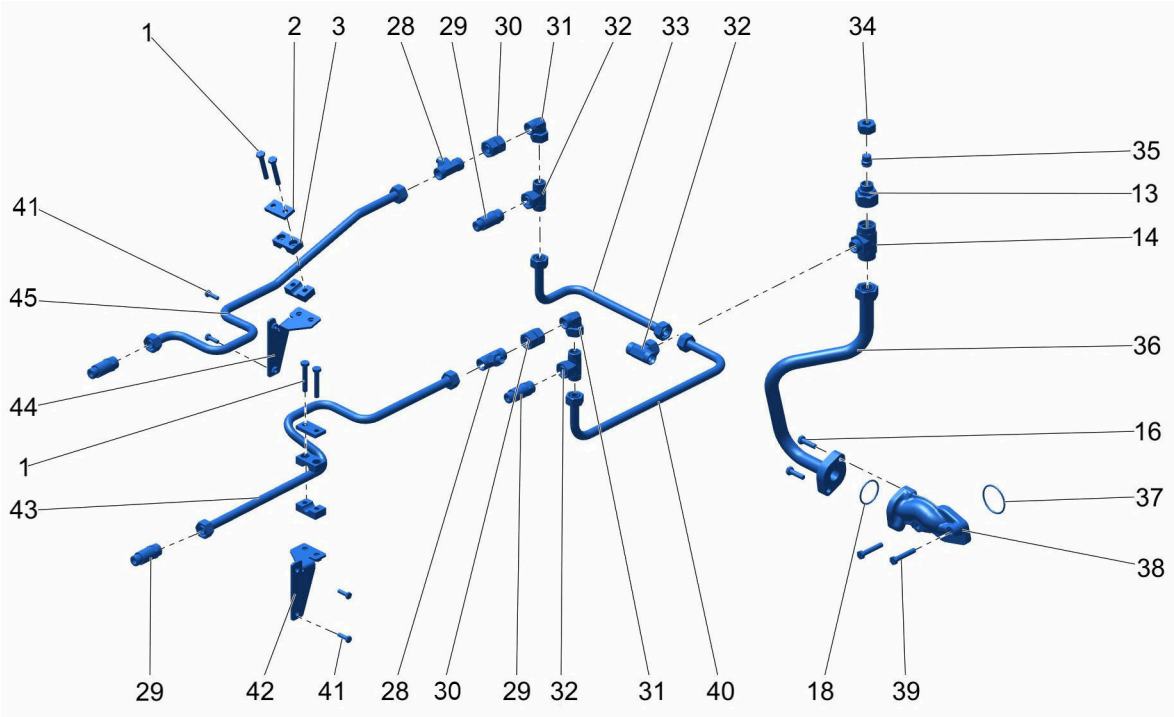


Fig. 244: Removing pipes

- ▶ Remove screws **1, 16, 39**.
- ▶ Unscrew connection nuts of pipes **33, 36, 40, 43, 45**.
- ▶ Remove pipes **33, 36, 40, 43, 45**.
- ▶ Remove aggregate support connector **38**.
- ▶ Disconnect fittings, flange joints, and connectors.

Installation

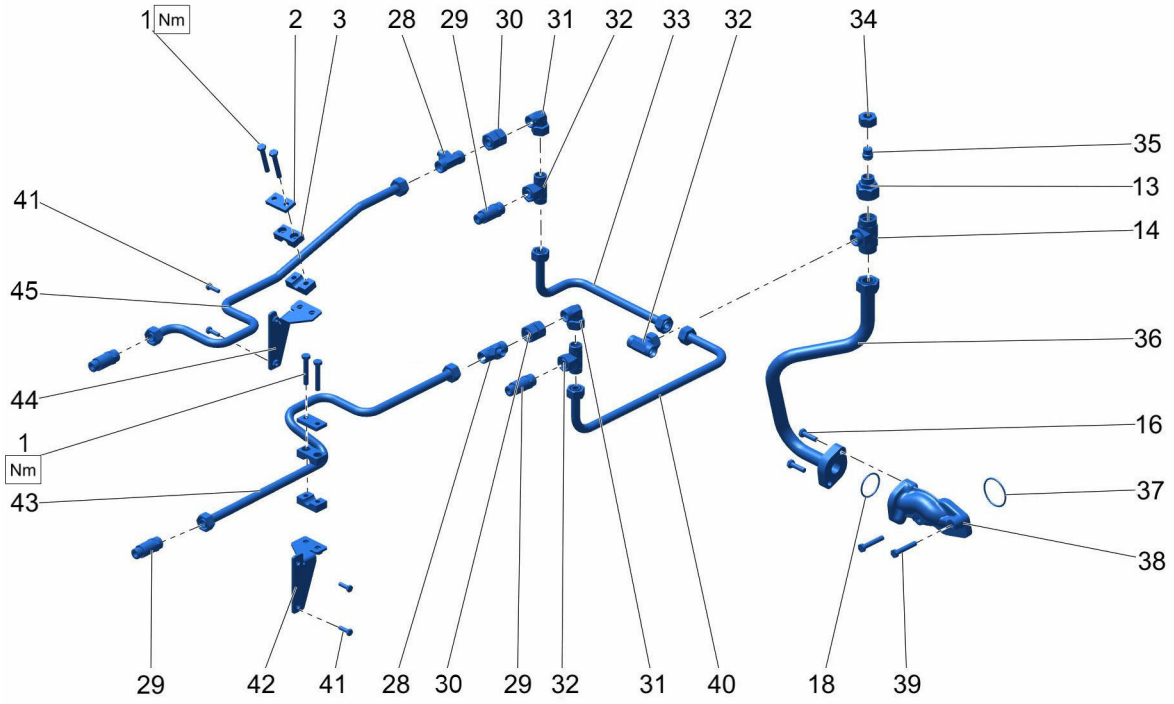


Fig. 245: Installing pipes

- ▶ Screw aggregate support connector **38** with screws **39** and o-ring **37**.
- ▶ Install pipe **36** on aggregate support connector **38** with screws **16** and o-ring **18**.
- ▶ Mount T connector **14** and flange joints **13, 34** with adaptor **35** on pipe **36**.
- ▶ Mount pipes **33, 40, 43, 45** with T connectors **14, 28, 32**.
- ▶ Install 90° connectors **31** and fittings **30** on pipe assembly **33, 40, 43, 45**.
- ▶ Install plates **2** and clamps **3** with screws **1**.

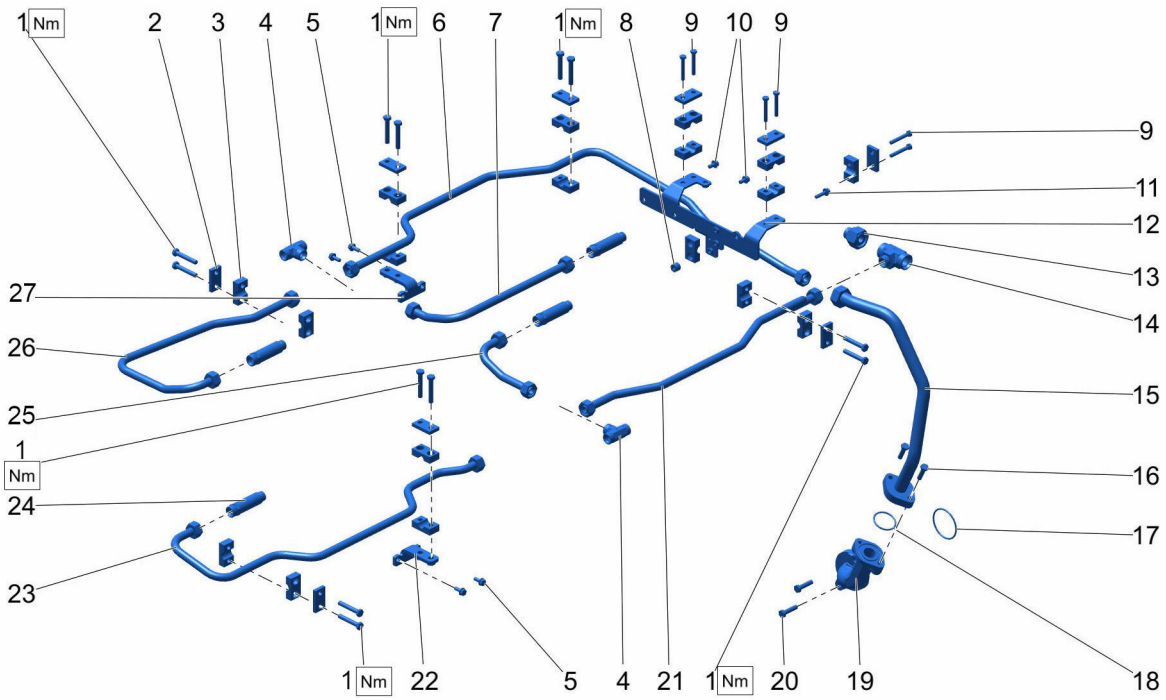


Fig. 246: Installing pipes

- ▶ Screw aggregate support connector **19** with screws **20** and o-ring **17**.
- ▶ Install pipe **15** with screws **16** and o-ring **18**.
- ▶ Mount pipes **6, 7, 15, 21, 23, 25, 26** with T connectors **4, 14** and flange joint **13**.
- ▶ Install fittings **24**.
- ▶ Screw retaining plate **12** with screws **10, 11** and distance sleeve **8**.
- ▶ Install retaining plate **27** with screws **1**, plate **2** and clamp **3**.
- ▶ Install plates **2** and clamps **3** with screws **1, 9**.

Specific values

Not applicable.

Tightening specifications

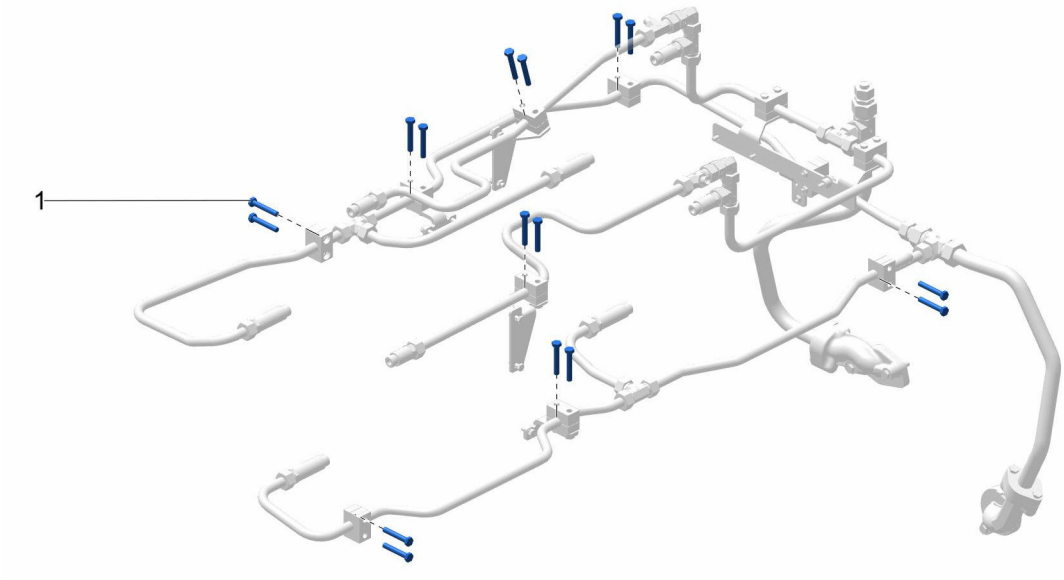


Fig. 247: Clamp screws

Reference	Key	Screw specifications	Lubricant *	Reuse**	Torque		Angle (°)	
					Step	± 5%	Step	± 5°
1	383AA	ISO 4014 M10x1.5x60-8.8-FLZN	-	Yes	1	30 Nm 22 ft-lb	-	-

Tab. 45: Tightening specifications table

*Lubricants:
MG = Molykote G-n-plus
MW = Castrol Optimol paste white T
MH = Molykote HSC
O = Engine oil
XX = Loctite 243
YY = Loctite 577

**Refer to screws reuse rules. (For more information see: 5.3.2 Screws pre-tightening, reuse and marking, page 274.)

Turbocharger cooling lines removal and installation (EATS configuration)

Previous tasks

- ❑ Remove venting lines. (For more information see: 3.10.2 Venting line removal and installation, page 205.)

Specific safety instructions

NOTICE
Risk of property damage by reuse of sealing.
Leakage by faulty seal.

▶ Replace all sealings.

Special tools

Not applicable.

Consumables and equipment

– Vaseline
– Rags
– Cleaner

Overview

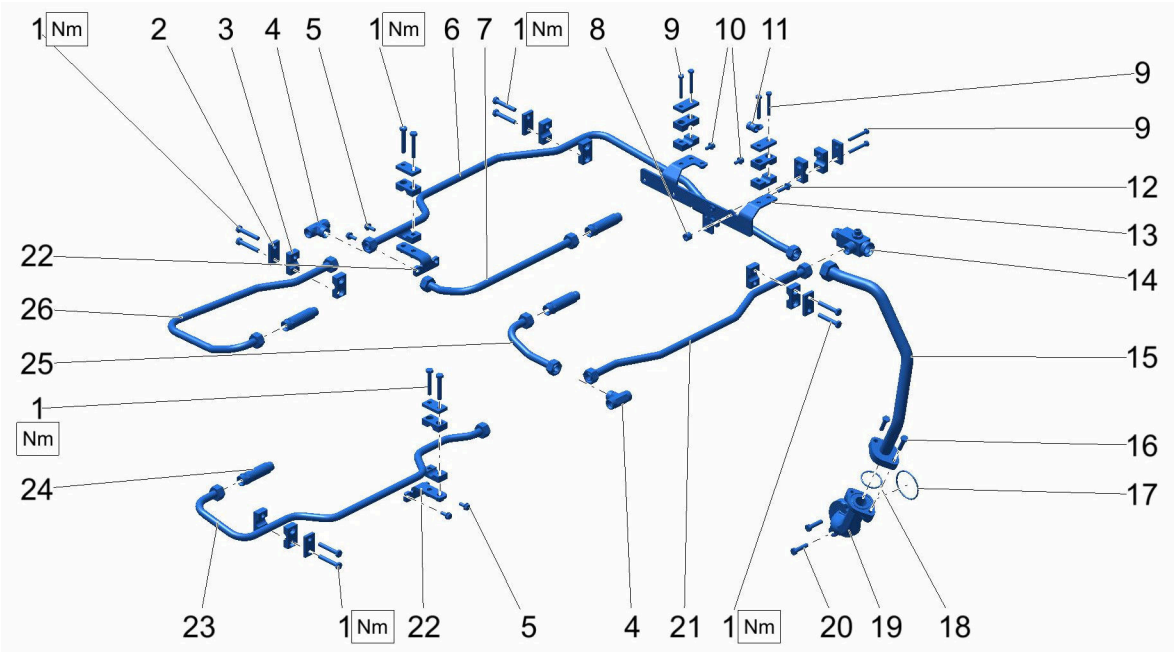


Fig. 248: Task overview

1 Screw (M10)
2 Plate
3 Clamp
4 T connector
5 Screw (M8)
6 Pipe
7 Pipe
8 Distance sleeve
9 Screw (M8)
10 Screw (M8)
11 Clamp
12 Screw (M8)
13 Retaining plate
14 Adaptor
15 Pipe
16 Screw (M10)
17 O-ring
18 O-ring
19 Aggregate support connector
20 Screw (M10)
21 Pipe
22 Retaining plate
23 Pipe
24 Fitting
25 Pipe
26 Pipe

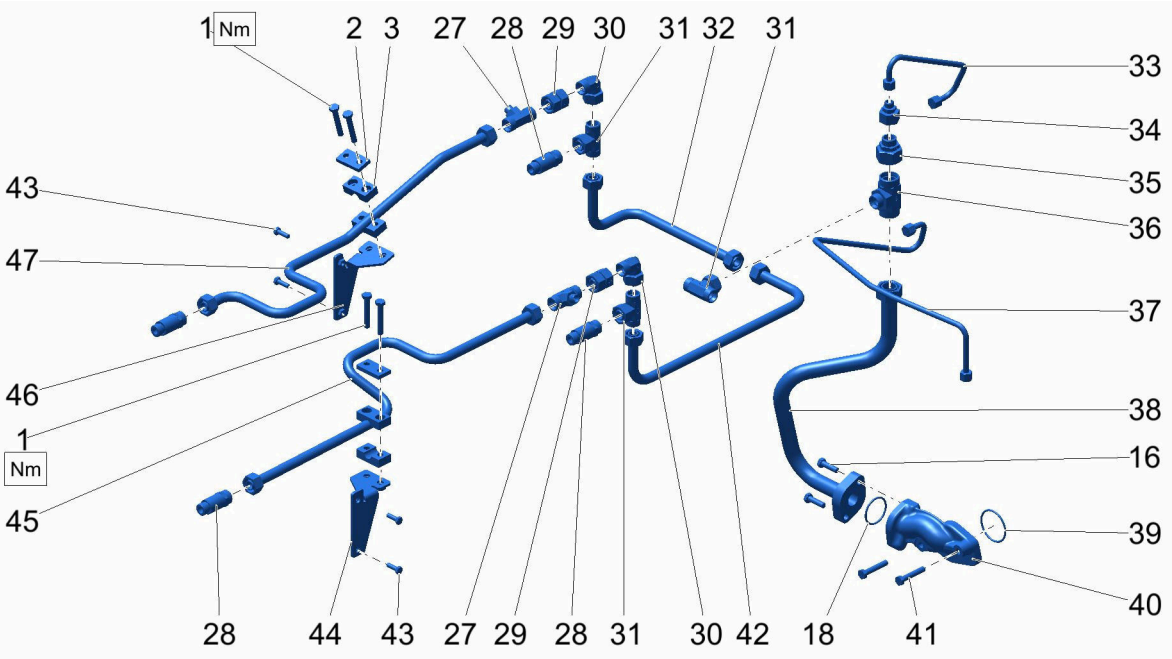


Fig. 249: Task overview

27 T connector
28 Fitting
29 Fitting
30 90° connector
31 T connector
32 Pipe
33 Pipe
34 Coupling
35 Flange joint
36 T connector
37 Pipe
38 Pipe
39 O-ring
40 Aggregate support connector
41 Screw (M10)
42 Pipe
43 Screw (M10)
44 Retaining plate
45 Pipe
46 Retaining plate
47 Pipe

Removal

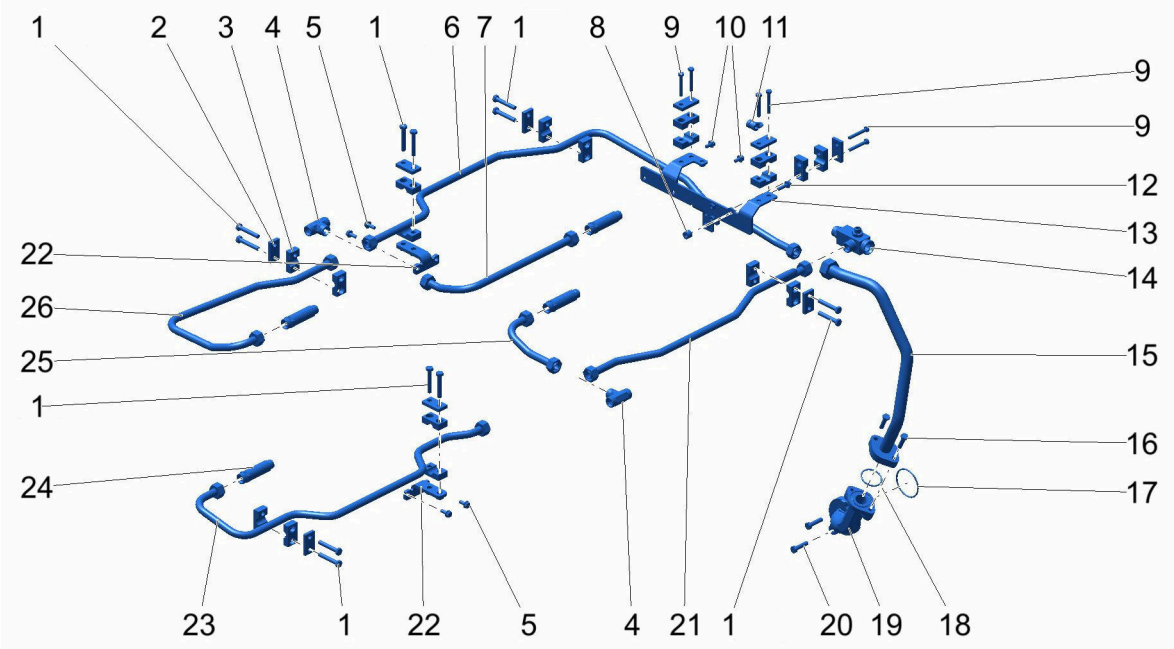


Fig. 250: Removing pipes

- ▶ Remove screws **1, 9**.
- ▶ Remove plates **2** and clamps **3**.
- ▶ Remove clamp **11**.
- ▶ Remove screws **16, 20**.
- ▶ Remove aggregate support connector **19**.
- ▶ Unscrew connection nuts of pipes **6, 7, 15, 21, 23, 25, 26**.
- ▶ Remove fittings **24**.
- ▶ Remove screws **10, 12** and distance sleeve **8**.
- ▶ Remove retaining plate **13**.

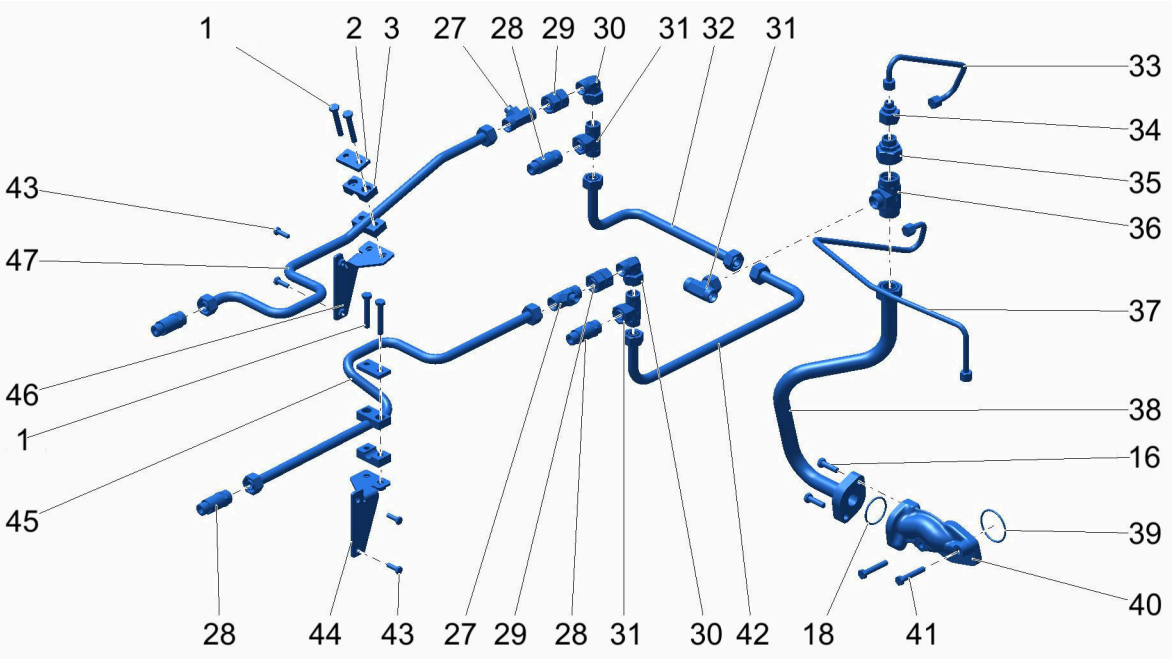


Fig. 251: Removing pipes

- ▶ Remove screws **1**.
- ▶ Remove plates **2** and clamps **3**.
- ▶ Remove screws **43**.
- ▶ Remove retaining plates **44, 46**.
- ▶ Remove screws **16, 41**
- ▶ Remove aggregate support connector **38**.
- ▶ Unscrew connection nuts of pipes **32, 33, 37, 38, 42 45, 47**.
- ▶ Remove pipes **32, 33, 37, 38, 42 45, 47**.
- ▶ Disconnect fittings, flange joints, and connectors.

Installation

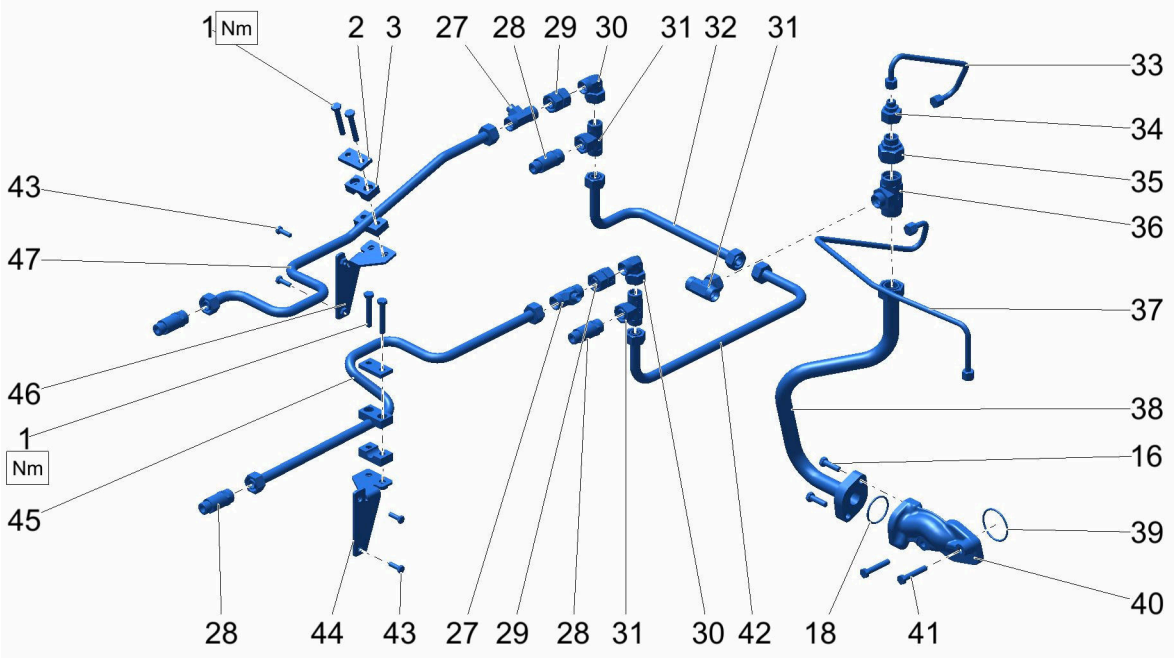


Fig. 252: Installing pipes

- ▶ Screw aggregate support connector **40** with screws **41** and o-ring **39**.
- ▶ Install pipe **38** on aggregate support connector **40** with screws **16** and o-ring **18**.
- ▶ Mount T connector **36** and flange joint **35** with coupling **34** between pipes **33, 38**.
- ▶ Mount pipes **32, 42, 45, 47** with T connectors **27, 31**.
- ▶ Install 90° connectors **30** and fittings **29** on pipe assemblies **32, 42, 45, 47**.
- ▶ Install fittings **28**.
- ▶ Install retaining plates **44, 46** with screws **43**.
- ▶ Install plates **2** and clamps **3** with screws **1**.

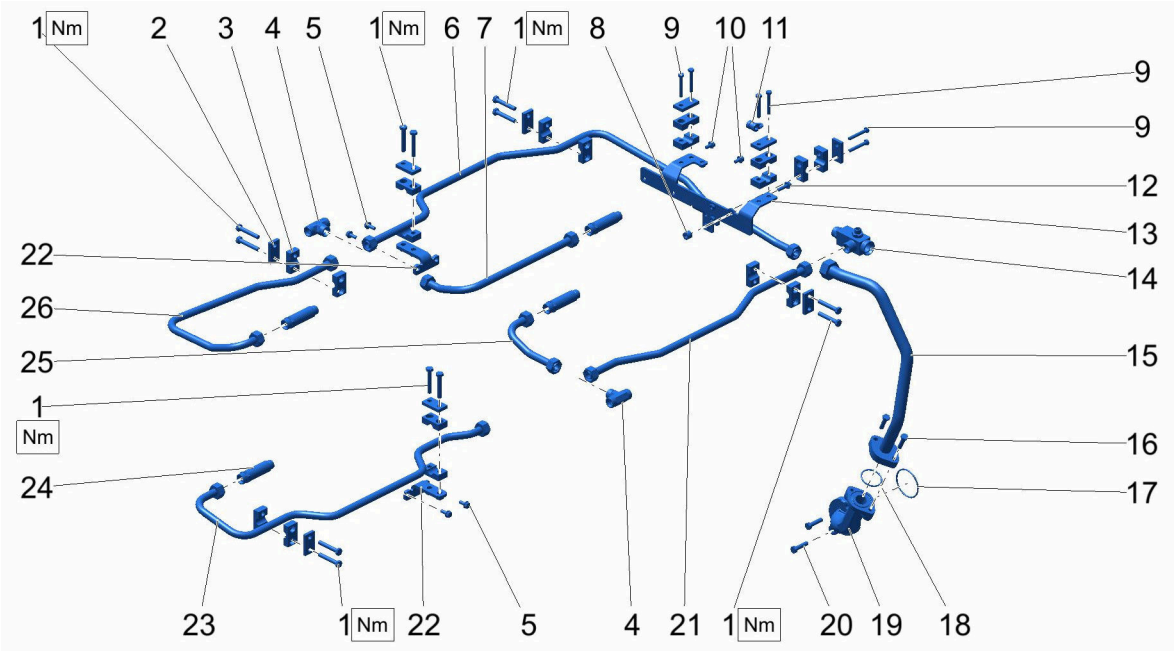


Fig. 253: Installing pipes

- ▶ Screw aggregate support connector **19** with screws **20** and o-ring **17**.
- ▶ Install pipe **15** with screws **16** and o-ring **18**.
- ▶ Mount pipes **6, 7, 15, 21, 23, 25, 26** with T connectors **4, 14** and adaptor **14**.
- ▶ Install pipe **37**.
- ▶ Install fittings **24**.
- ▶ Screw retaining plate **13** with screws **10, 12** and distance sleeve **8**.
- ▶ Install retaining plates **22** with screws **5**.
- ▶ Install plates **2**, clamps **3**, clamp **11** with screws **1, 9**.

Specific values

Not applicable.

Tightening specifications

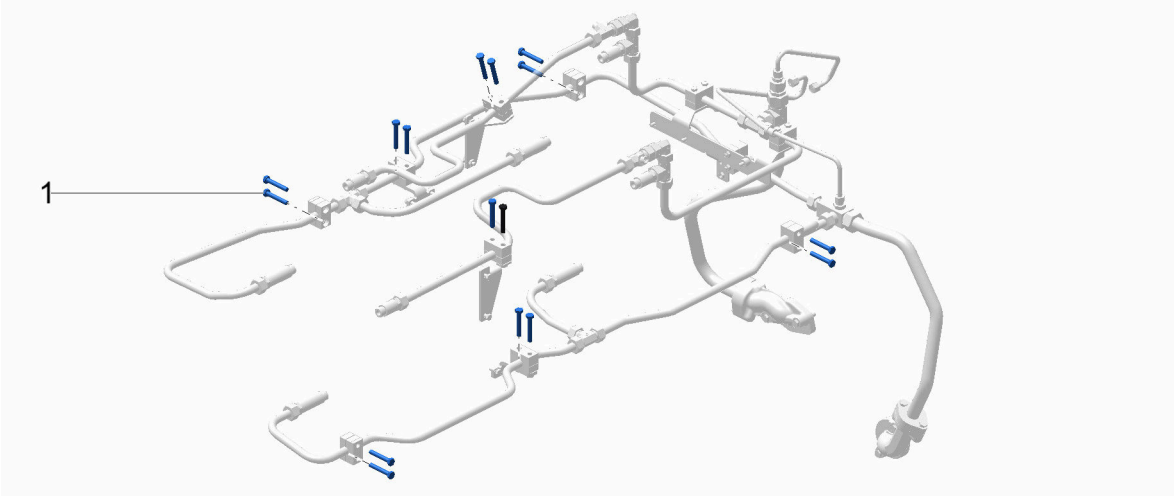


Fig. 254: Clamp screws

Reference	Key	Screw specifications	Lubricant *	Reuse**	Torque		Angle (°)	
					Step	± 5%	Step	± 5°
1	383AA	ISO 4014 M10x1.5x60-8.8-FLZN	-	Yes	1	30 Nm 22 ft-lb	-	-

Tab. 46: Tightening specifications table

*Lubricants:
MG = Molykote G-n-plus
MW = Castrol Optimol paste white T
MH = Molykote HSC
O = Engine oil
XX = Loctite 243
YY = Loctite 577

**Refer to screws reuse rules. (For more information see: 5.3.2 Screws pre-tightening, reuse and marking, page 274.)

3.10.4 Thermostat HT and housing removal and installation (SL 217)

Previous tasks

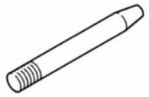
❑ Drain HT coolant circuit.

Specific safety instructions

NOTICE
Risk of property damage by reuse of sealing.
Leakage by faulty seal.

▶ Replace all sealings.

Special tools

Special tool	Designation
 12465862	Guiding rod M12x230 – Thermostat (x2)

Tab. 47: Special tools

Consumables and equipment

– Vaseline
– Rags
– Cleaner

Overview

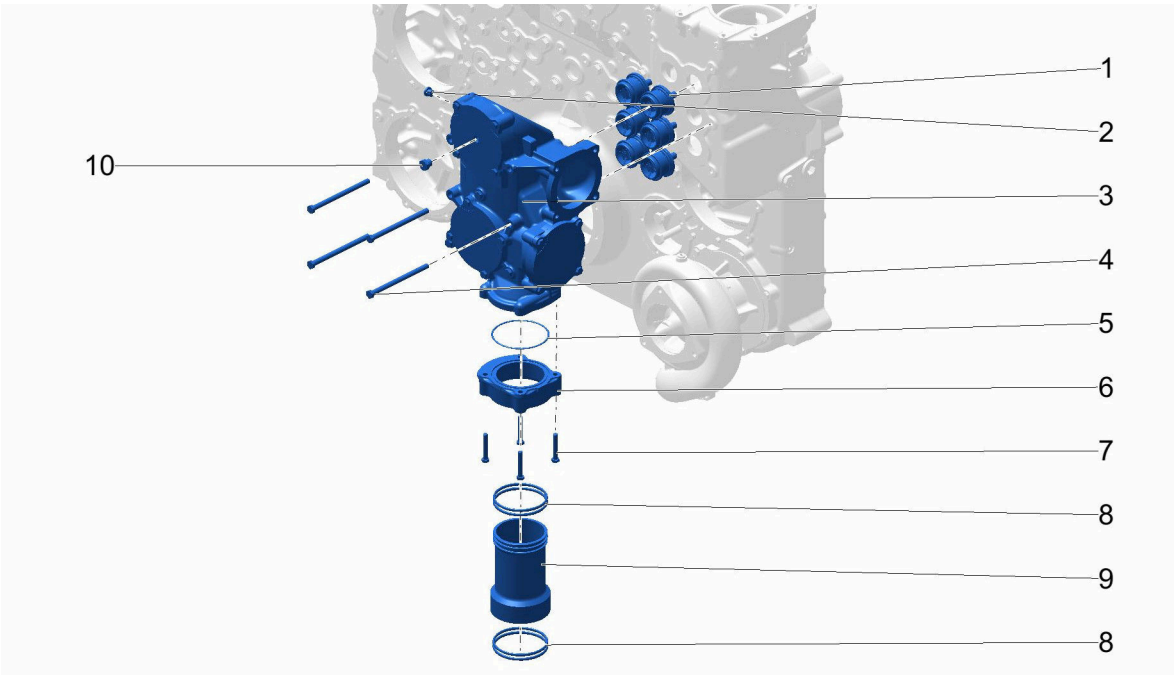


Fig. 256: Task overview

1 Thermostat
2 Screw plug
3 Thermostat housing
4 Screw (M12)
5 O-ring
6 Flange
7 Screw (M10)
8 O-ring
9 Pipe
10 Screw plug (depending on application)

Removal

▶ Remove two screws **4** diametrically opposed.

▶ Place guiding rods in place of the two screws **4**.

- ▶ Remove remaining screws **4** and screws **7**.
- ▶ Remove thermostat housing **3**.
- ▶ Remove guiding rods.
- ▶ Remove thermostats **1**.
- ▶ Remove pipe **9** with flange **6**.

Installation

- ▶ Assemble pipe **9**, and flange **6** with o-rings **5, 8**.
- ▶ Insert o-rings **8** on coolant pump inlet.
- ▶ Position pipe assembly on coolant pump inlet.
- ▶ Install thermostats **1** in thermostat housing **3**.
- ▶ Place guiding rods in place of two screws **4**.
- ▶ Install thermostat housing.
- ▶ Install screws **4**.
- ▶ Remove guiding rods.
- ▶ Install remaining screws.
- ▶ Install thermostat housing **3** with screws **4, 7**.
- ▶ Install new screw plugs **2, 10**.
- ▶ Tighten screws to torque.

Information

Vent coolant circuit at the end of installation.

Specific values

Thermostats HT start to open at 71 °C (160 °F) and are fully opened at 81 °C (178 °F).

Tightening specifications

Refer to standard tightening torques. (For more information see: 5.3 Standard tightening torques, page 274.)

3.10.5 Thermostat LT and housing removal and installation (SL 217)

Previous tasks

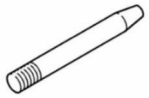
- ❑ Drain LT coolant circuit.
- ❑ Remove venting line LT charge air cooler. (For more information see: 3.10.2 Venting line removal and installation, page 205.)

Specific safety instructions

NOTICE
Risk of property damage by reuse of sealing.
Leakage by faulty seal.

▶ Replace all sealings.

Special tools

Special tool	Designation
 12465862	Guiding rod M12x230 – Thermostat (x2)

Tab. 48: Special tools

Consumables and equipment

– Vaseline
– Rags
– Cleaner

Overview

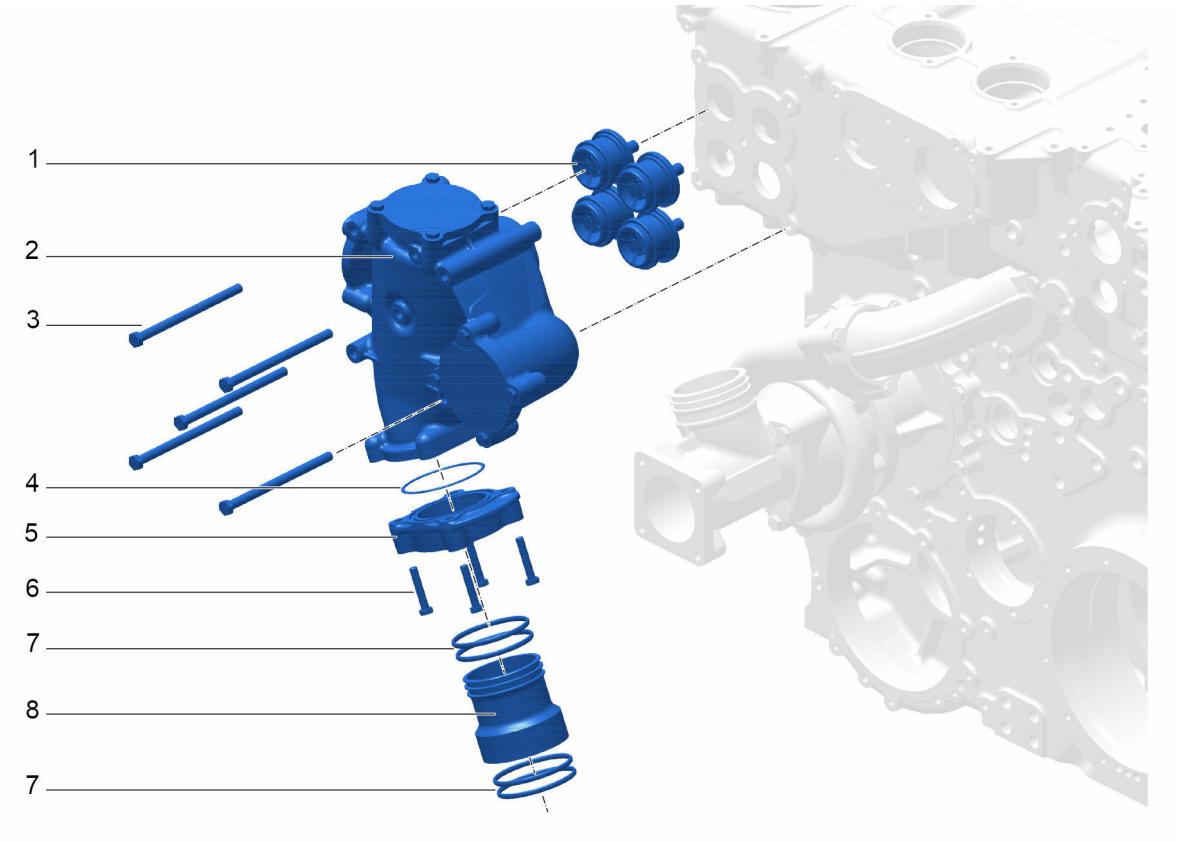


Fig. 258: Task overview

1 Thermostat
2 Thermostat housing
3 Screw (M12)
4 O-ring
5 Flange
6 Screw (M10)
7 O-ring
8 Pipe

Removal

- ▶ Remove two screws **3** diametrically opposed.
- ▶ Place guiding rods in place of the two screws **3**.
- ▶ Remove remaining screws **3** and screws **6**.
- ▶ Remove thermostat housing **2**.
- ▶ Remove guiding rods.
- ▶ Remove thermostats **1**.
- ▶ Remove pipe **8** with flange **5**.

Installation

- ▶ Assemble pipe **8** and flange **7** with o-rings **4, 7**.
- ▶ Insert o-rings **7** on coolant pump inlet.
- ▶ Position pipe assembly on coolant pump inlet.
- ▶ Position thermostats **1** in thermostats housing **2**.

- ▶ Place guiding rods in place of two screws **3**.
- ▶ Place thermostat housing.
- ▶ Place screws **3**.
- ▶ Remove guiding rods.
- ▶ Place remaining screws.
- ▶ Screw thermostat housing **2** with screws **3, 6**.
- ▶ Tighten screws to torque according to tightening specifications.

Information

Vent coolant circuit at the end of installation.

Specific values

Thermostats LT start to open at 45 °C (113 °F) and are fully opened at 57 °C (135 °F).

Tightening specifications

Refer to standard tightening torques. (For more information see: 5.3 Standard tightening torques, page 274.)

3.10.6 Coolant pump HT removal and installation (SL 216)

Previous tasks

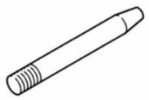
- ❑ Drain HT coolant circuit.
- ❑ Remove machinery HT cooling system piping.

Specific safety instructions

NOTICE
Risk of property damage by reuse of sealing.
Leakage by faulty seal.

- ▶ Replace all sealings.

Special tools

Special tool	Designation
 12427300	Guiding rod M12x100 - Coolant pump (x2)

Tab. 49: Special tools

Consumables and equipment

– Rags
– Cleaner
– Vaseline

Overview

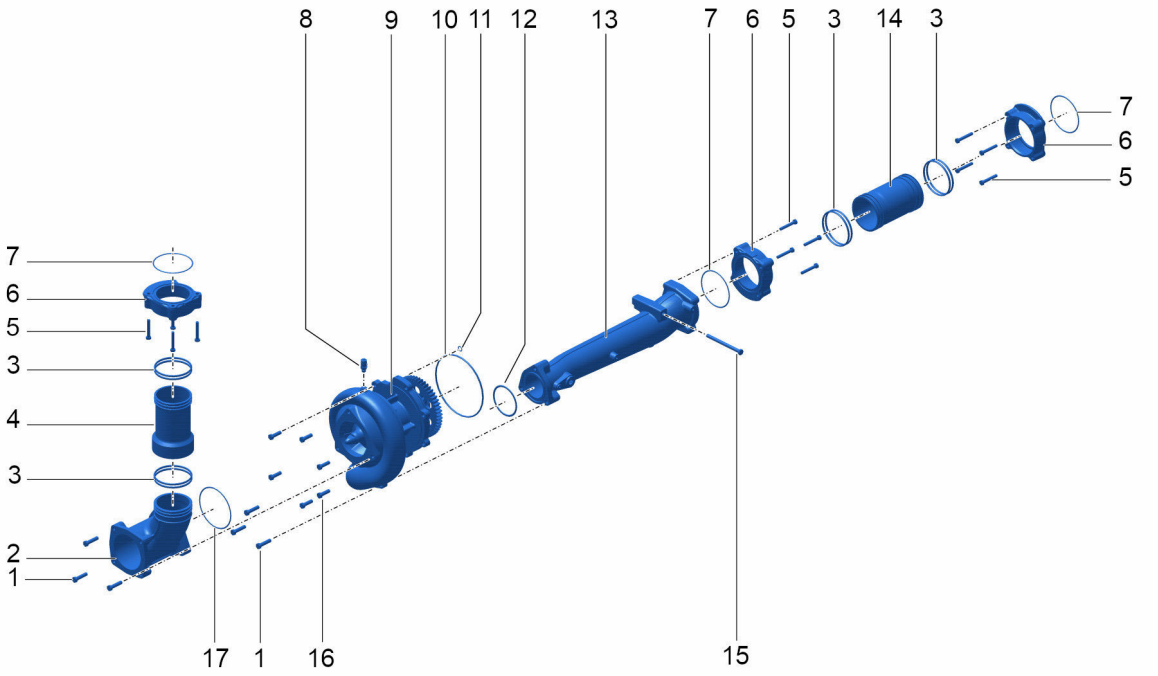


Fig. 260: Task overview

1 Screw (M12)
2 T-pipe
3 O-ring
4 Pipe
5 Screw (M10)
6 Flange
7 O-ring
8 Test point fitting
9 Coolant pump HT
10 O-ring
11 O-ring
12 O-ring
13 coolant pipeline
14 Pipe
15 Screw (M12)
16 Screw (M12)
17 O-ring

Removal

▶ Remove screws **1, 5**.
▶ Remove piping assemblies **2, 4, 6**.
▶ Remove two screws **16**.
▶ Install guiding rods.
▶ Remove remaining screws **16**.
▶ Remove coolant pump HT **9**.
▶ Remove screws **5, 15**.
▶ Remove coolant pipe **13** with flange **6**.
▶ Remove pipe **14** with flange **6**.

Installation

- ▶ Insert o-ring **7** and flange **6** on pipe from oil cooler casing.
- ▶ Mount pipe **14** with o-rings **3** on flange **6**.
- ▶ Mount coolant pipeline **13** with o-ring **7** on flange **6**.
- ▶ Insert guiding rods in coolant pump **9**.
- ▶ Insert o-rings **10, 11, 12**.
- ▶ Insert coolant pump HT **9**.
- ▶ Tighten screws **1, 16** according to tightening specifications.
- ▶ Remove guiding rods.
- ▶ Tighten remaining screws **16** to torque.
- ▶ Assemble t-pipe **2**, pipe **4** and flange **6** with o-rings **3, 7, 17**.
- ▶ Position assembly with screws **1, 5** and tighten according to tightening specifications.
- ▶ Install test point fitting **8** on coolant pump.

Information

Vent coolant circuit at the end of installation.

Specific values

Not applicable.

Tightening specifications

Refer to standard tightening torques. (For more information see: 5.3 Standard tightening torques, page 274.)

3.10.7 Coolant pump LT removal and installation (SL 215)

Previous tasks

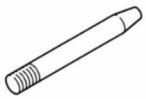
- ❑ Drain LT coolant circuit.
- ❑ Remove machinery LT cooling system piping.
- ❑ Remove vibration damper cover. (For more information see: 3.2.1 Vibration damper cover removal and installation, page 59.)
- ❑ Remove battery charging alternator cover. (For more information see: 3.2.2 Battery charging alternator & PTO cover removal and installation, page 61.)

Specific safety instructions

NOTICE
Risk of property damage by reuse of sealing.
Leakage by faulty seal.

- ▶ Replace all sealings.

Special tools

Special tool	Designation
 12427300	Guiding rod M12x100 - Coolant pump (x2)

Tab. 50: Special tools

Consumables and equipment

– Rags
– Cleaner
– Vaseline

Overview

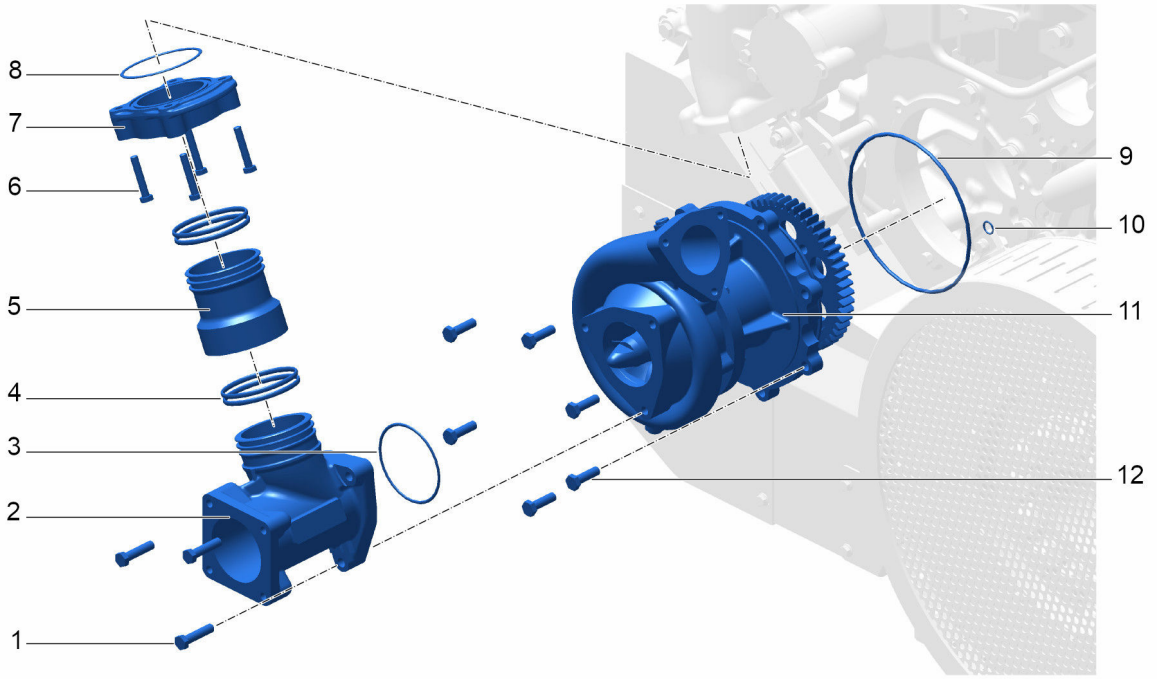


Fig. 262: Task overview

1 Screw (M12)
2 Branch pipe
3 O-ring
4 O-ring
5 Pipe
6 Screw (M10)
7 Flange
8 O-ring
9 O-ring
10 O-ring
11 Coolant pump LT
12 Screw

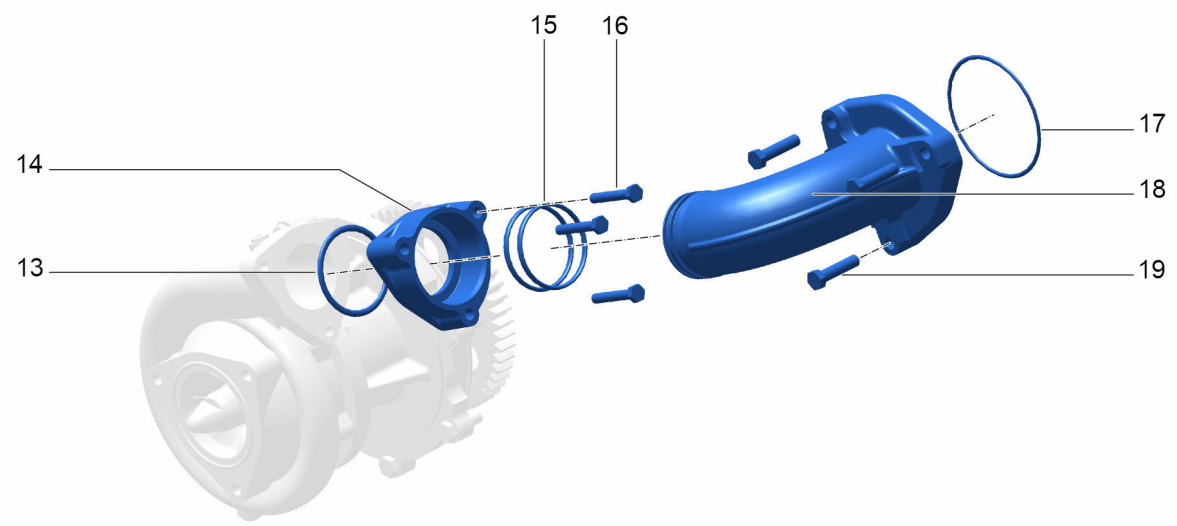


Fig. 263: Task overview

13 O-ring
14 Flange
15 O-ring
16 Screw (M10)
17 O-ring
18 Elbow pipe
19 Screw (M12)

Removal

- ▶ Remove screws **6, 1, 16, 19**.
- ▶ Remove piping assemblies **2, 5, 7, 14, 18**.
- ▶ Remove screws **12**.
- ▶ Remove coolant pump LT **11**.

Installation

- ▶ Install guiding rods.
- ▶ Insert o-rings **9, 10**.
- ▶ Insert coolant pump LT **11**.
- ▶ Place four screws **12**.
- ▶ Remove guiding rods.
- ▶ Place the remaining screws **12**.
- ▶ Assemble elbow pipe **18** with flange **14** and o-rings **13, 15, 17**.
- ▶ Tighten screws **16, 19** according to tightening specifications.
- ▶ Assemble branch pipe **2** with pipe **5** and flange **7** with o-rings **3, 4, 8**.
- ▶ Position assembly with screws **1, 6** and tighten according to tightening specifications.

Information

Vent coolant circuit at the end of installation.

Specific values

Not applicable.

Tightening specifications

Refer to standard tightening torques. (For more information see: 5.3 Standard tightening torques, page 274.)

3.10.8 Fan drive (option)

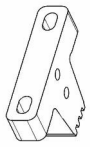
Previous tasks

- ❑ Remove vibration damper cover. (For more information see: 3.2.1 Vibration damper cover removal and installation, page 59.)

Specific safety instructions

Not applicable.

Special tools

Special tool	Designation
 11343230	Locking device

Tab. 51: Special tools

Consumables and equipment

– Rags
– Cleaner

Overview

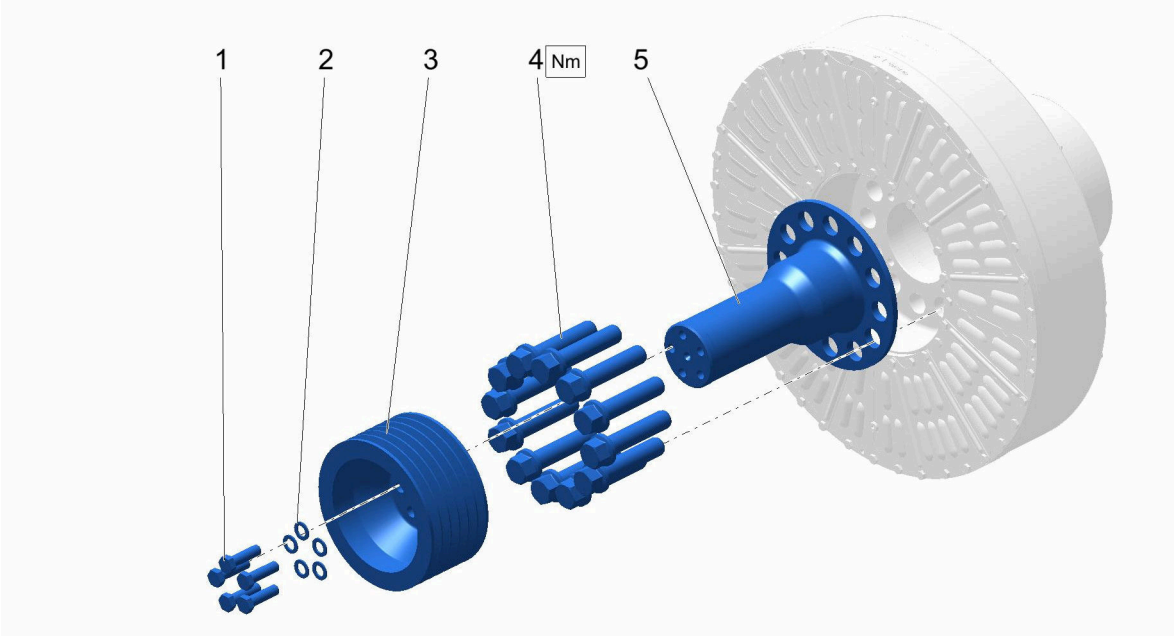


Fig. 265: Task overview

1 Screw (M16)
2 Washer
3 Pulley
4 Screw (M28)
5 Axle

Removal

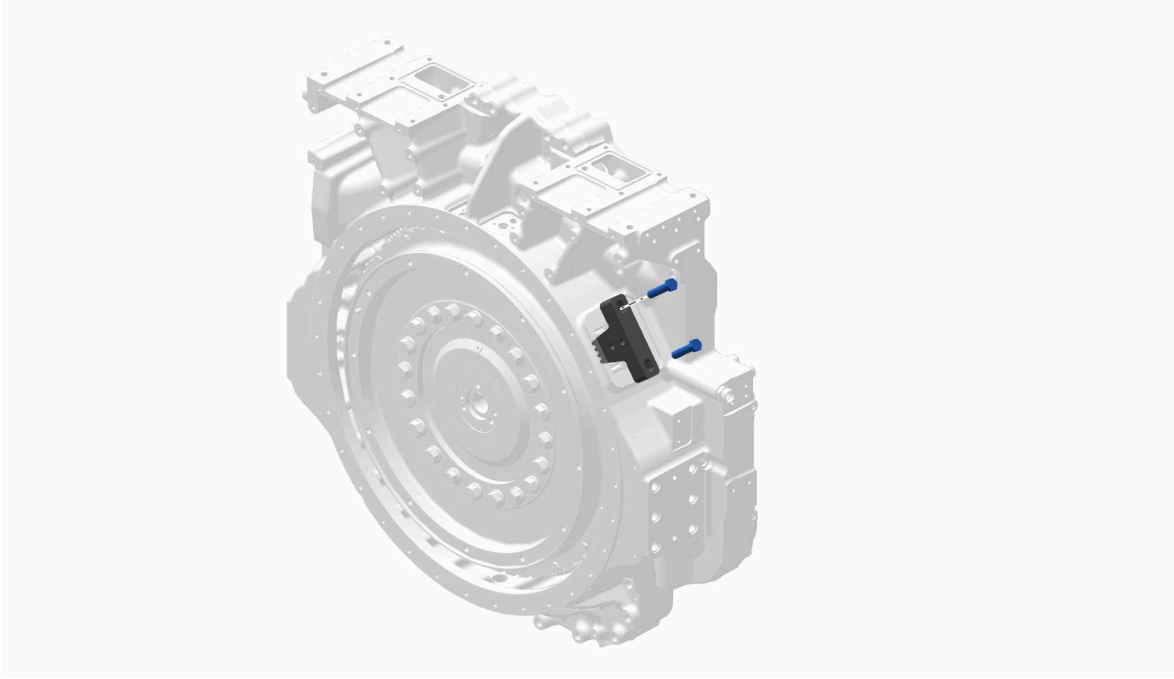


Fig. 266: Locking device

▶ Install locking device with screws (M16) to lock crankshaft.

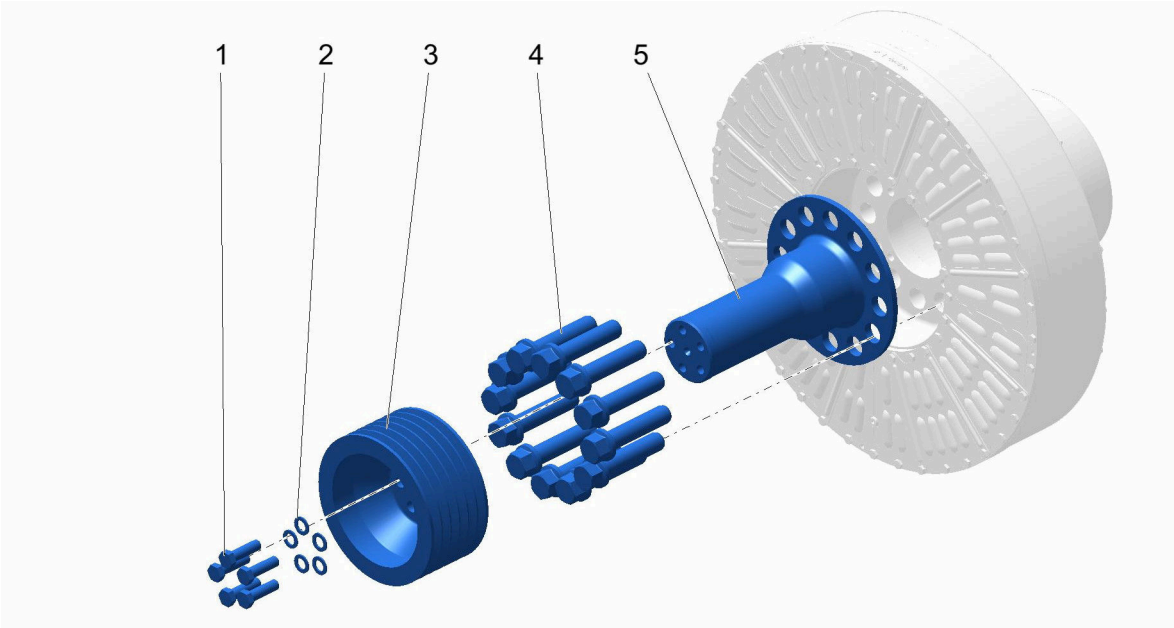


Fig. 267: Removal of fan drive pulley

- ▶ Remove screws **1**, and washers **2**.
- ▶ Remove pulley **3**.
- ▶ Remove screws **4**.
- ▶ Remove axle **5**.
- ▶ Remove locking device.

Installation

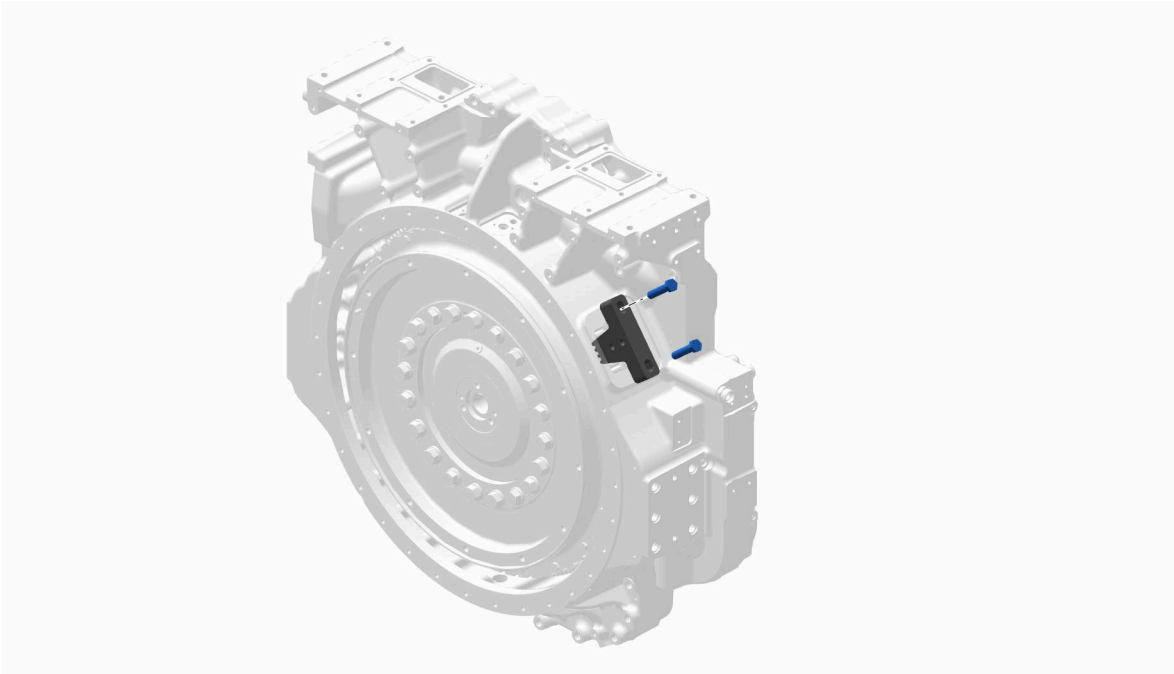


Fig. 268: Locking device

- ▶ Install locking device with screws (M16) to lock crankshaft.

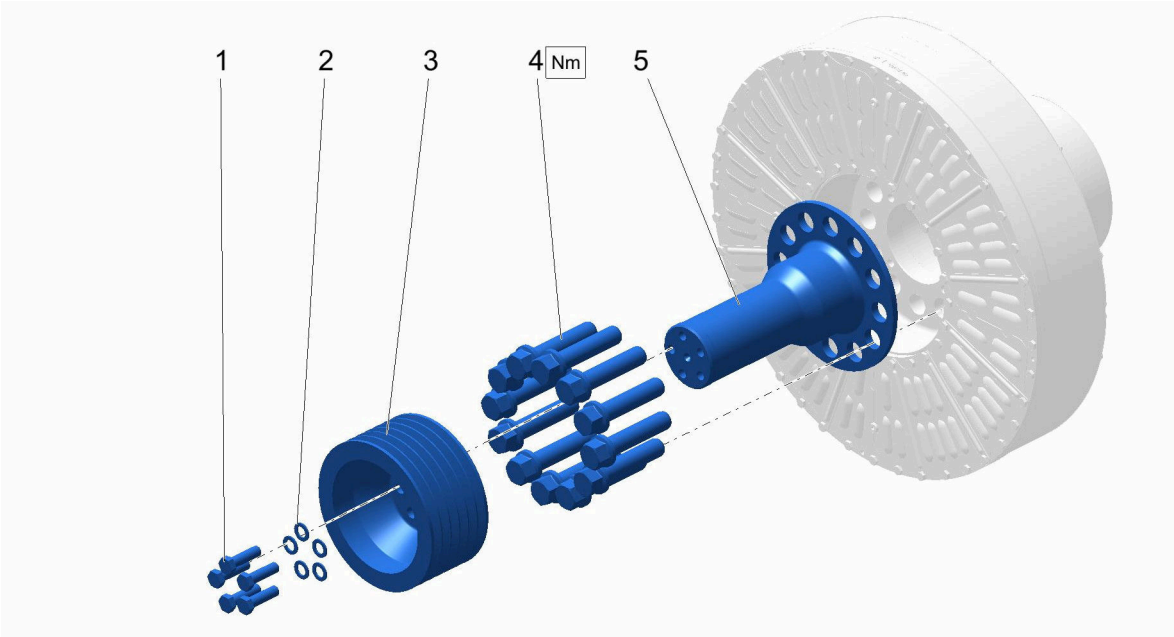


Fig. 269: Installation of fan drive pulley

▶ Install axle **5** with screws **4**.

Information

Observe screws **4** tightening sequence and tightening torque.

▶ Tighten screws **4** to torque.

▶ Install pulley **3** with screws **1**, and washers **2**.

▶ Tighten screws **1** to torque.

Specific values

Not applicable.

Tightening specifications

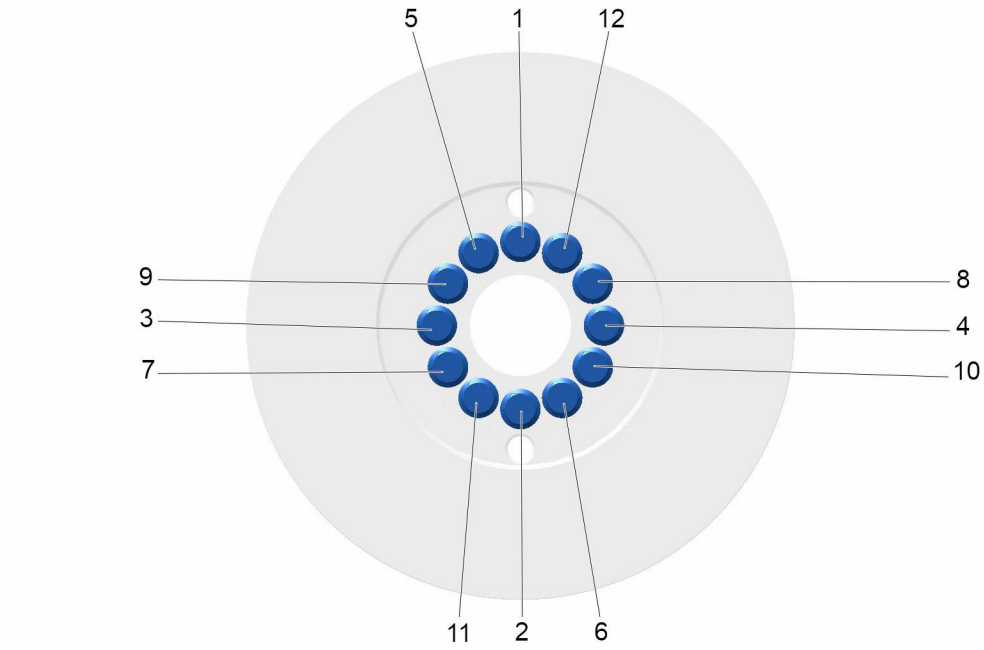


Fig. 270: Tightening sequence of pulley axle screws

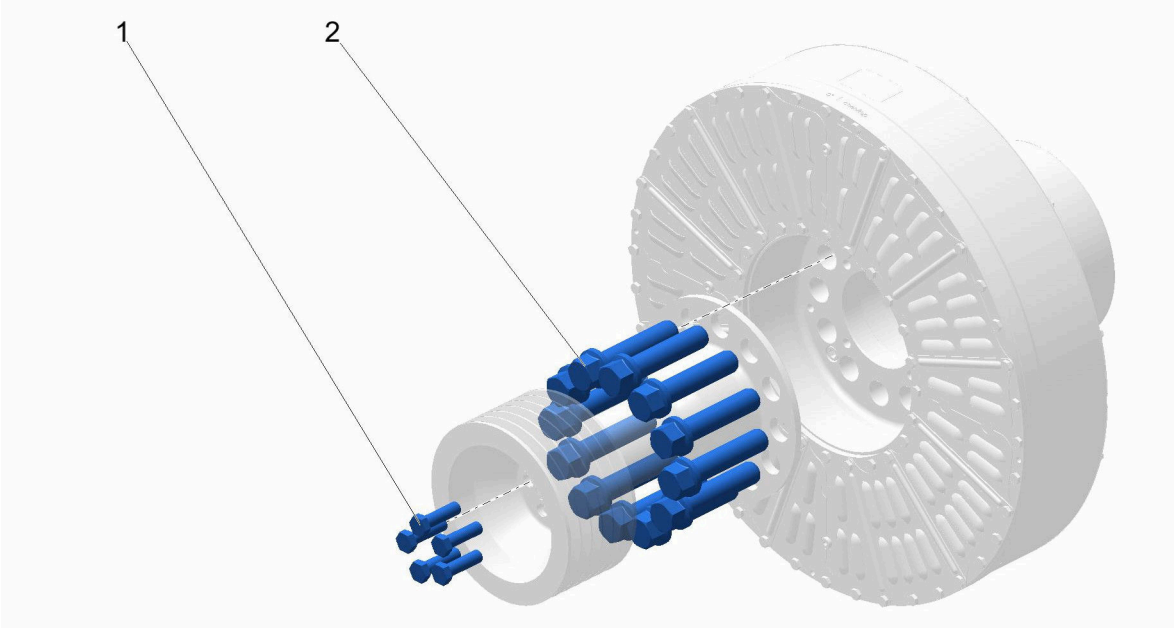


Fig. 271: Screws of fan drive pulley

Reference	Key	Screw specifications	Lubricant *	Reuse**	Torque		Angle (°)	
					Step	± 5%	Step	± 5°
1	-	M16x55 10.9 FLZN	-	No	1	275 Nm 203 ft-lb	-	-

Reference	Key	Screw specifications	Lubricant *	Reuse**	Torque		Angle (°)	
					Step	± 5%	Step	± 5°
2	056AC	M28x2x122	-	No	1	430 Nm 317 ft-lb	2	75°

Tab. 52: Tightening specifications table

*Lubricants:
MG = Molykote G-n-plus
MW = Castrol Optimol paste white T
MH = Molykote HSC
O = Engine oil
XX = Loctite 243
YY = Loctite 577

**Refer to screws reuse rules. (For more information see: 5.3.2 Screws pre-tightening, reuse and marking, page 274.)

3.11 Electrical system

3.11.1 Power take-off (PTO) and battery charging alternator removal and installation (SL 223)

Previous tasks

❑ Remove battery charging alternator cover. (For more information see: 3.2.2 Battery charging alternator & PTO cover removal and installation, page 61.)

Specific safety instructions

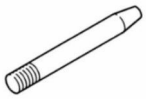
WARNING
Hazards by electrical shocks.
Contact with live conductor could result in death or serious injury.

- ▶ 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's technical data sheet.
- ▶ Check the grounding connection to avoid any risk of electrical arc.
- ▶ Observe the local safety regulations that apply to the machinery.

NOTICE
Risk of property damage by reuse of sealing.
Leakage by faulty seal.

- ▶ Replace all sealings.

Special tools

Special tool	Designation
 **12217125**	Pin for belt tensioner (x1)
	Frequency meter

Tab. 53: Special tools

Consumables and equipment

– Vaseline
– Rags
– Belt tension frequency meter

Overview

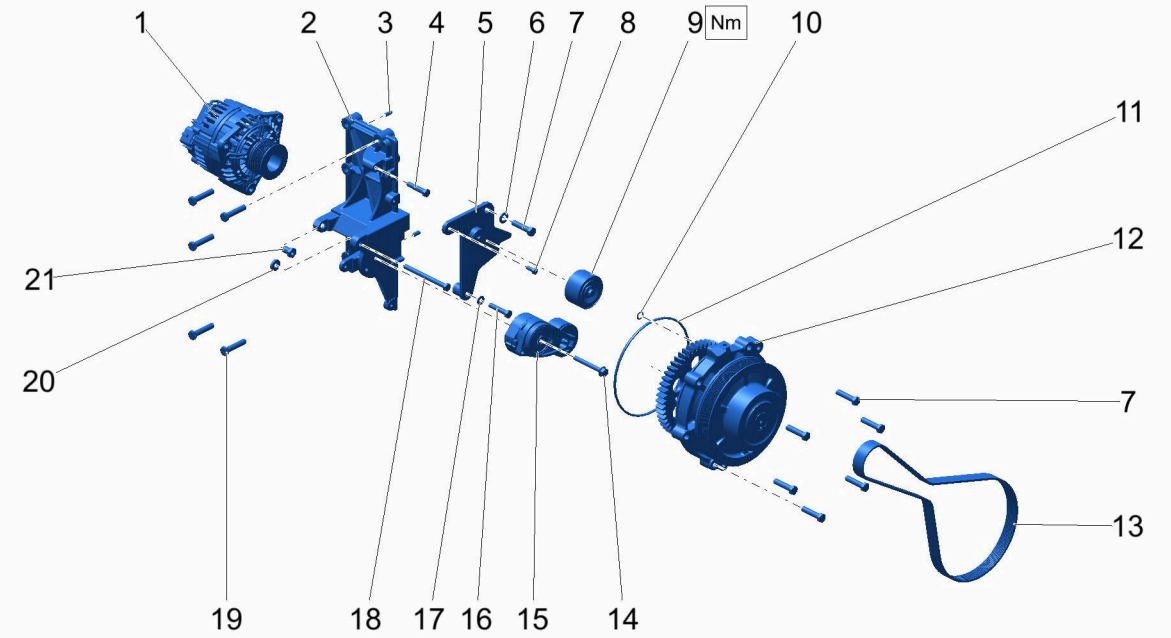


Fig. 273: Task overview

1 Battery charging alternator
2 Bracket
3 Pin
4 Screw (M10)
5 Retaining plate
6 Washer
7 Screw (M12)
8 Screw (M8)
9 Roller
10 O-ring
11 O-ring
12 Auxiliary PTO
13 Belt
14 Screw (M10)
15 Tensioning device
16 Screw (M10)
17 Washer
18 Screw (M10)
19 Screw (M12)
20 Distance sleeve (EATS only)
21 Sleeve

Removal

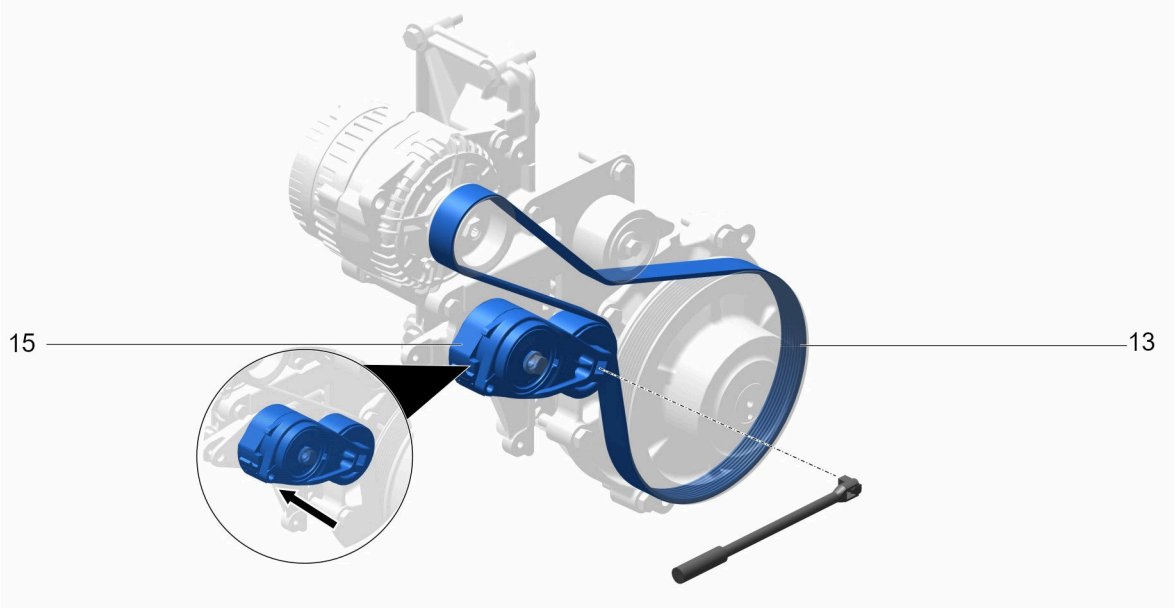


Fig. 274: Removing belt and pin location

- ▶ Use 1/2” toggle in tensioning device **15**.
- ▶ Pivot back the tensioning device against the spring force to the limit stop.
- ▶ Use a guiding rod in the specified location to lock the tensioning device.
- ▶ Remove belt **13**.
- ▶ Remove guiding rod.

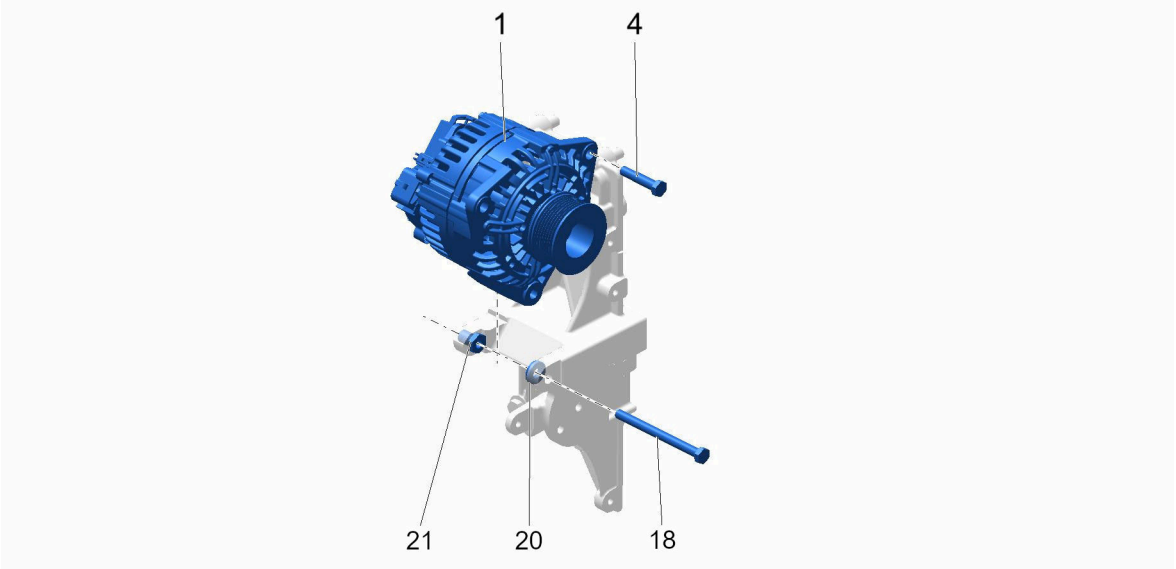


Fig. 275: Removing battery charging alternator

- ▶ Remove screws **4, 18**.
- ▶ Remove battery charging alternator **1**.
- ▶ Remove distance sleeve **20**.

▶ Remove sleeve **21**.

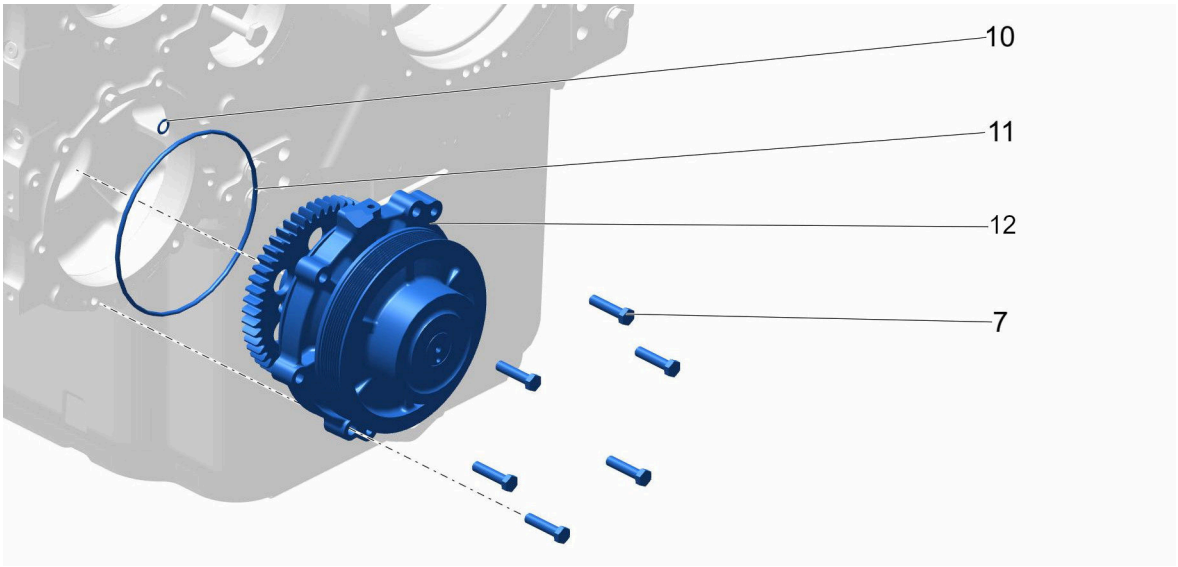


Fig. 276: Removing auxiliary PTO

▶ Remove screws **7**.

▶ Remove auxiliary PTO **12**.

▶ Remove o-rings **10, 11**.

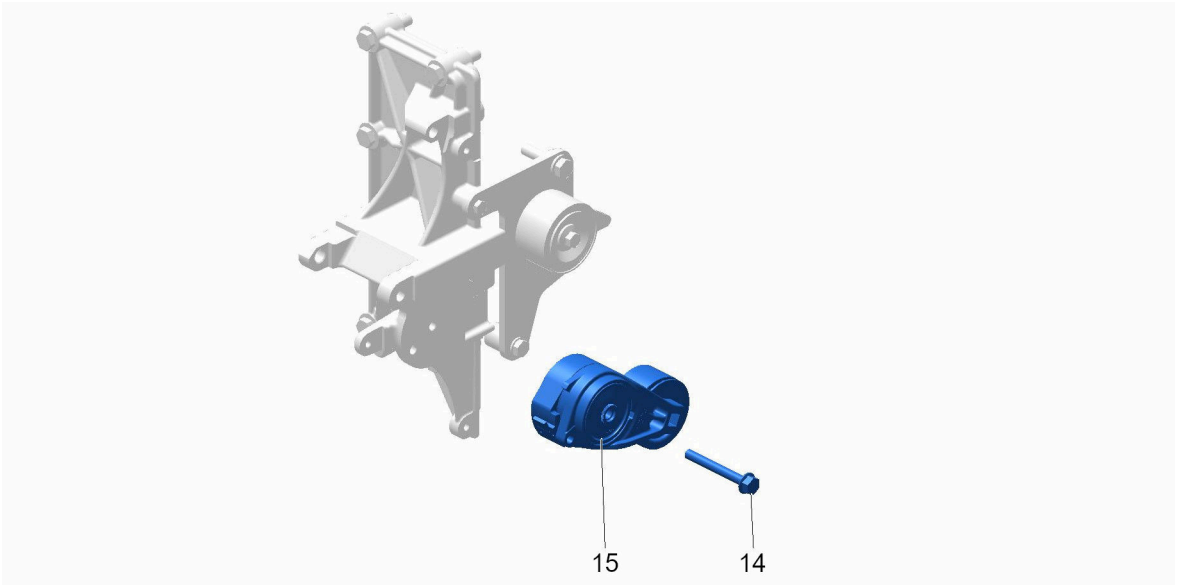


Fig. 277: Removing tensioning device

▶ Remove screw **14**.

▶ Remove tensioning device **15**.

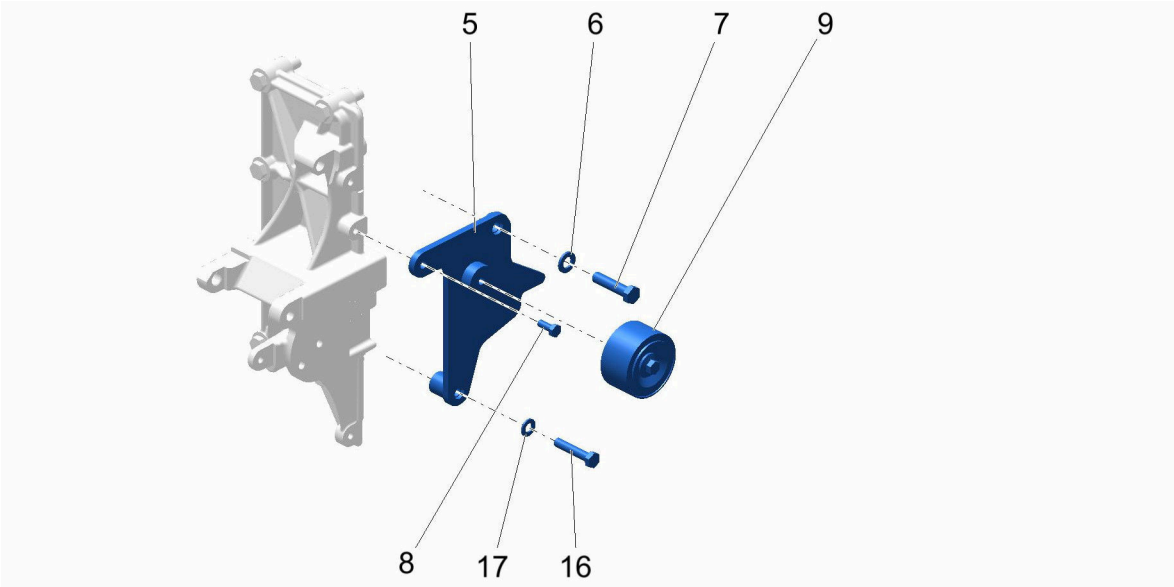


Fig. 278: Removing roller

- Loosen roller **9** fastening.
- Remove roller **9**.
- Remove screws **7, 8, 16** and washers **6, 17**.
- Remove plate **5**.

Installation

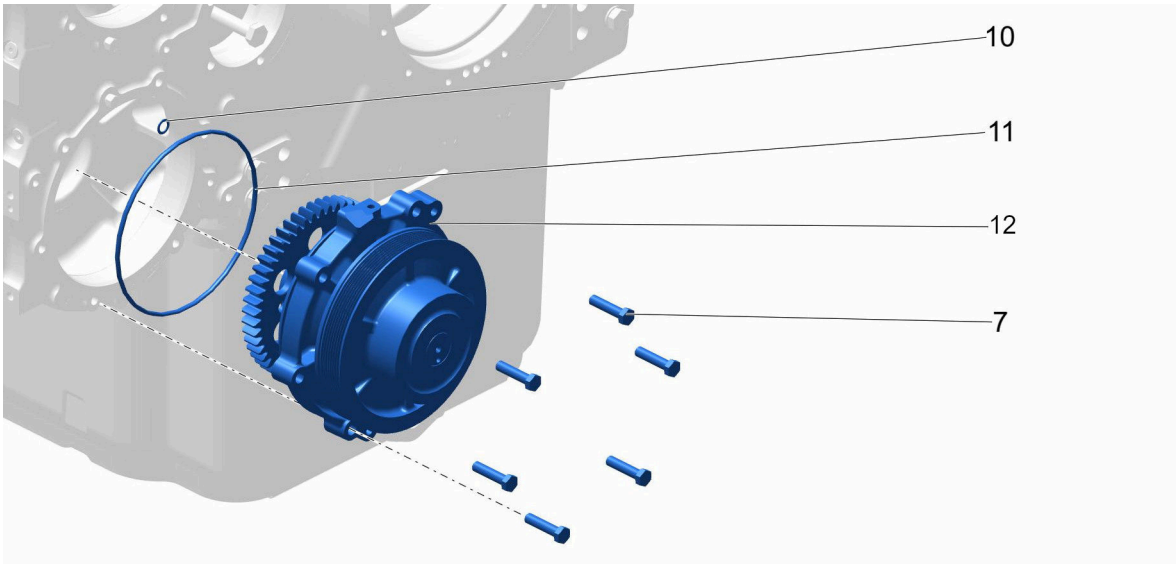


Fig. 279: Installing auxiliary PTO

- Grease o-rings **10, 11**.
- Insert o-rings **10, 11** in auxiliary PTO **12**.
- Install auxiliary PTO **12** with screws **7**.

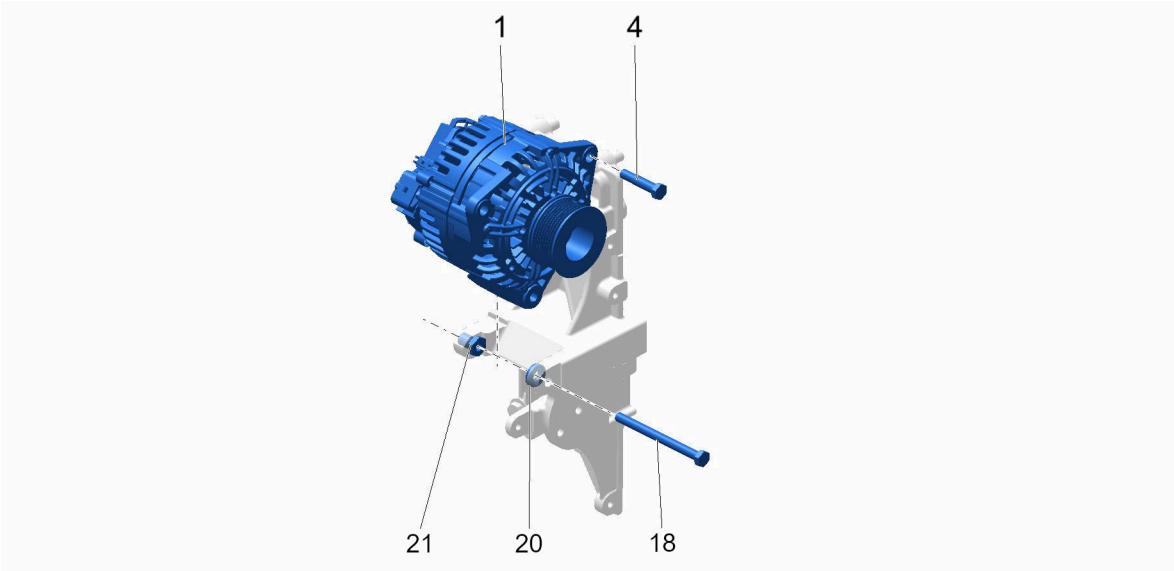


Fig. 280: Installing battery charging alternator

- ▶ Insert sleeve **21** into bracket.
- ▶ Position battery charging alternator **1** in bracket.
- ▶ Install battery charging alternator **1** with screw **4** and screw **18** with distance sleeve **20**.

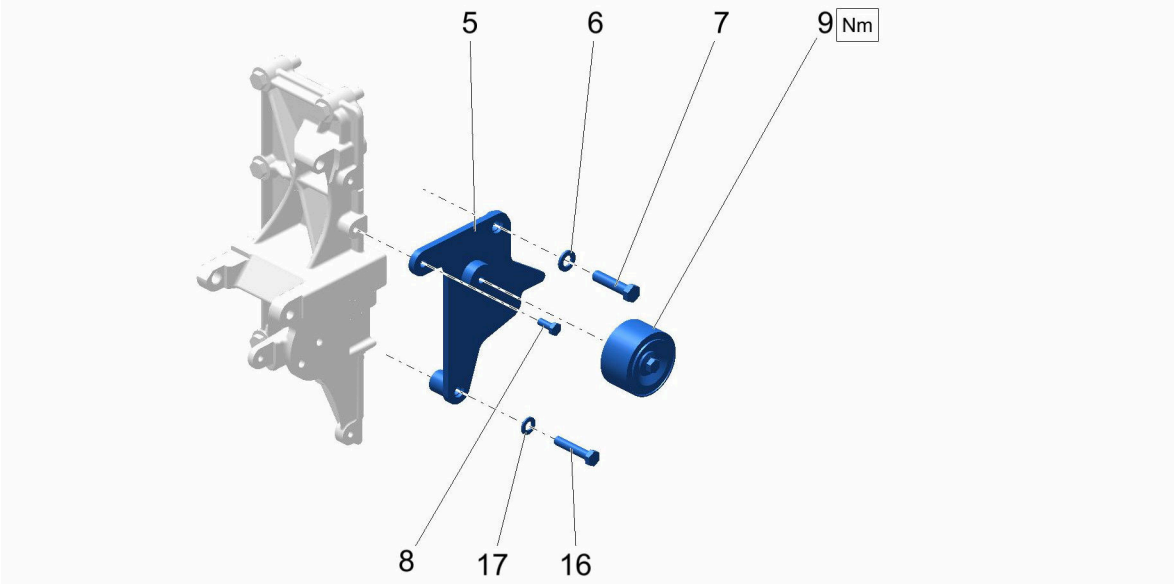


Fig. 281: Installing roller

- ▶ Install roller **9** on plate **5**.
- ▶ Install plate **5** with screws **7, 8, 16** and washers **6, 17**.
- ▶ Tighten roller **9** to torque.

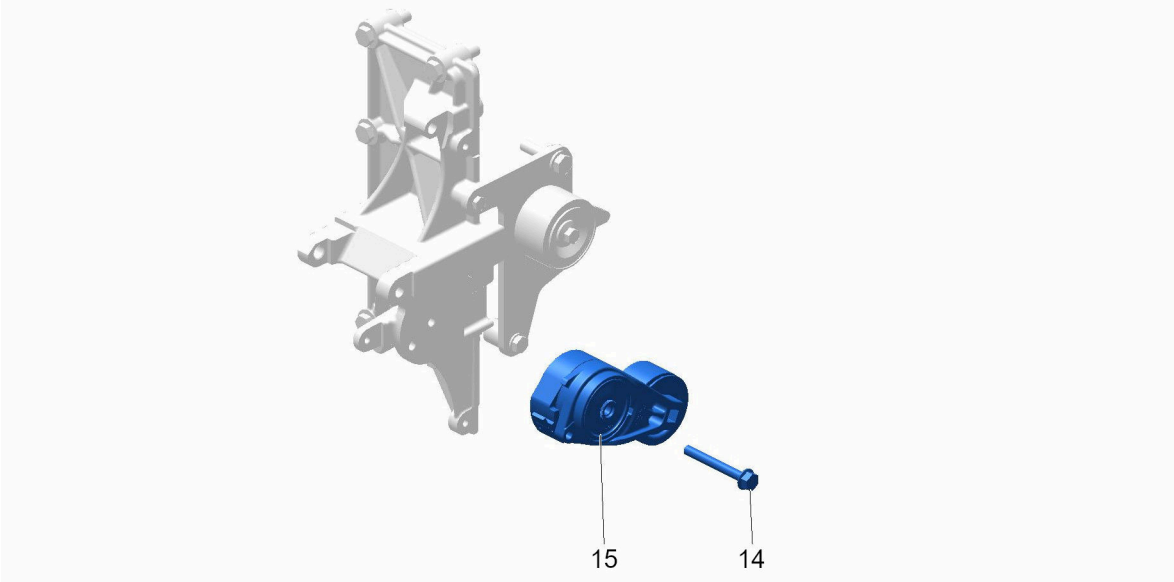


Fig. 282: Installing tensioning device

▶ Install tensioning device **15** on bracket with screw **14**.

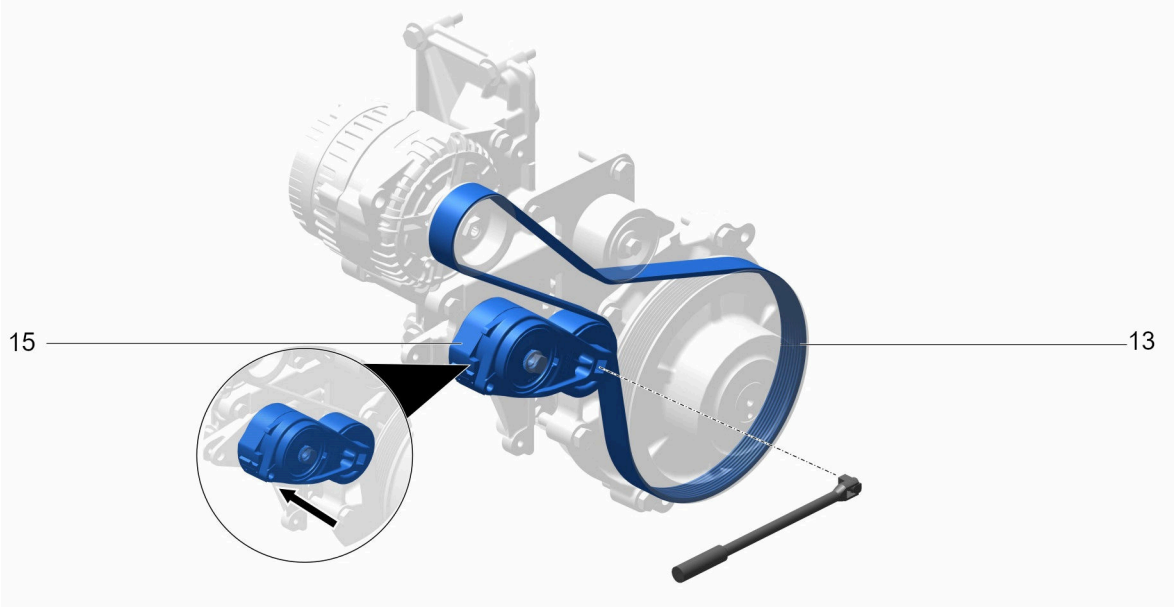


Fig. 283: Mounting belt

▶ Use 1/2” toggle in tensioning device **15**.

▶ Pivot back the tensioning device **15** against the spring force to the limit stop.

▶ Use a guiding rod in the specified location to lock the tensioning device **15**.

▶ Install belt **13** on the PTO pulley.

▶ Remove the guiding rod.

▶ Use 1/2” toggle in tensioning device **15** to tension belt **13**.

▶ Check belt **13** tension.

Specific values

Belt tension: 165 Hz (Min 149 Hz - Max 182 Hz).

Tightening specifications

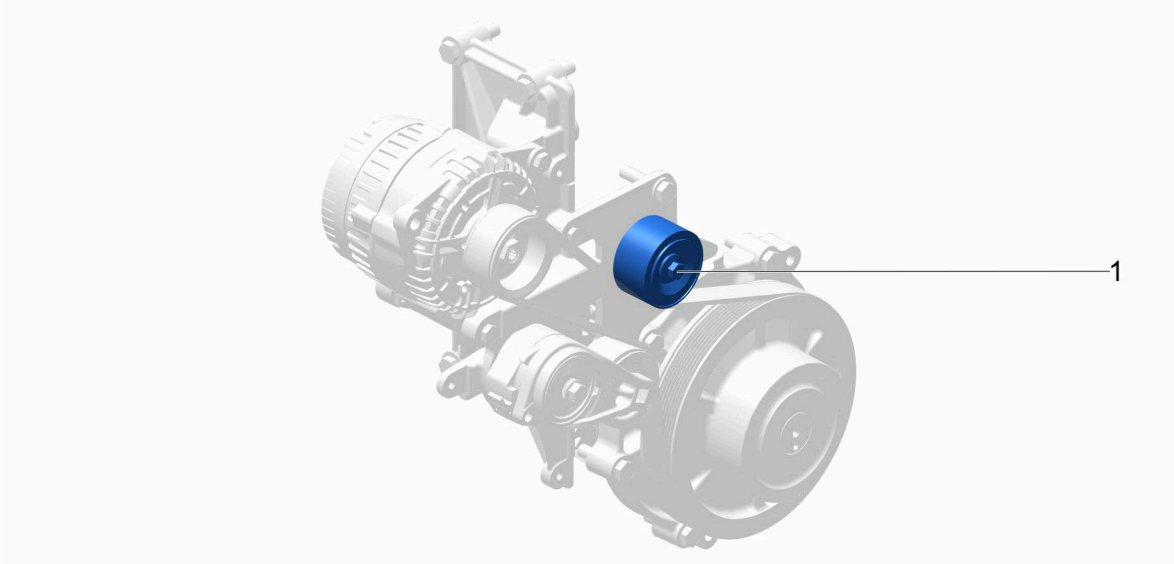


Fig. 284: Belt tensioner

Reference	Key	Screw specifications	Lubricant *	Reuse**	Torque		Angle (°)	
					Step	± 5%	Step	± 5°
1	441AD	M10x55-10.9-Zinc Coating	-	Yes	1	50 Nm 37 ft-lb	-	-

Tab. 54: Tightening specifications table

*Lubricants:
MG = Molykote G-n-plus
MW = Castrol Optimol paste white T
MH = Molykote HSC
O = Engine oil
XX = Loctite 243
YY = Loctite 577

**Refer to screws reuse rules. (For more information see: 5.3.2 Screws pre-tightening, reuse and marking, page 274.)

3.11.2 Starter removal and installation (SL 260)

Previous tasks

Not applicable.

Specific safety instructions

Not applicable.

Special tools

Not applicable.

Consumables and equipment

– Rags
– Cleaner

Overview

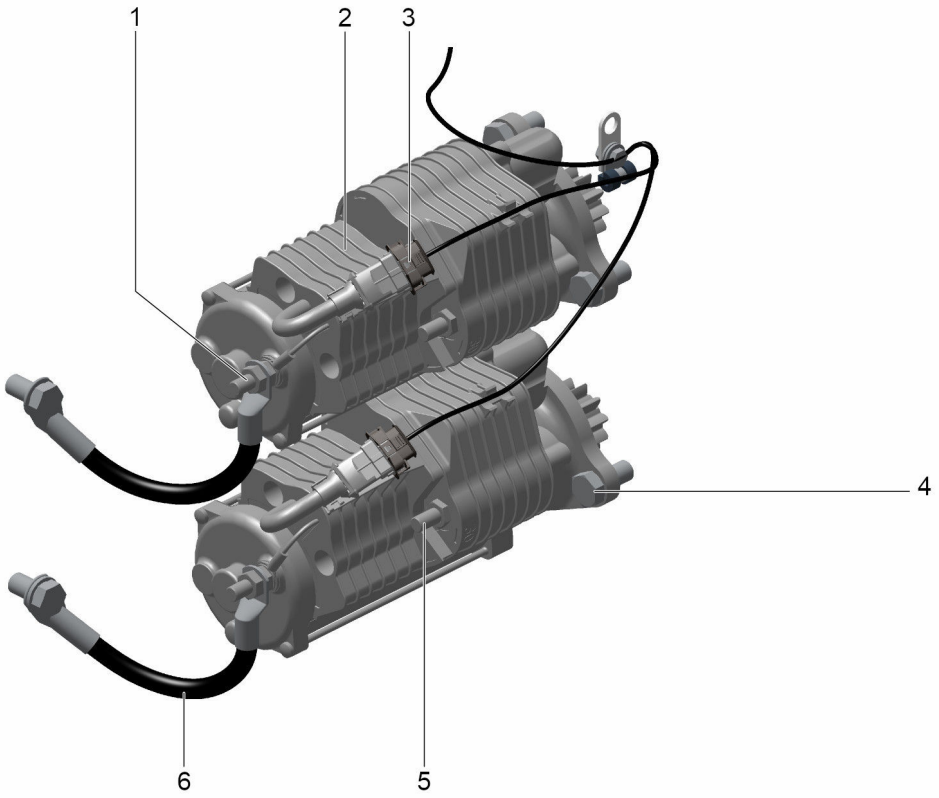


Fig. 285: Task overview

1 Ground connection -
2 Starter
3 Wiring harness connection
4 Screw (M16)
5 Power supply T30, battery +
6 Ground cable

Removal

▶ Unplug wiring harness connection **3**.
▶ Remove nut from ground connection **1**.
▶ Disconnect ground cable **6**.
▶ Remove nut from power supply **5**.
▶ Disconnect power supply cable.

- ▶ Remove screws **4**.
- ▶ Remove starter **2**.

Installation

- ▶ Position starter **2**.
- ▶ Tighten screws **4**.
- ▶ Connect plug **3**.
- ▶ Connect power supply **5** with nut.
- ▶ Tighten nut to torque.
- ▶ Connect ground cable **6** with nut and tighten according to tightening specifications.

Specific values

Not applicable.

Tightening specifications

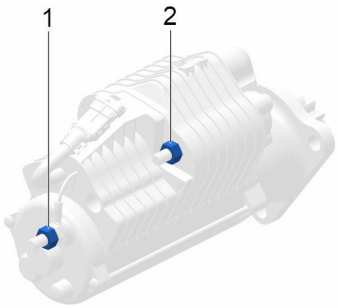


Fig. 286: Starter nuts

Reference	Key	Screw specifications	Lubricant *	Reuse**	Torque		Angle (°)	
					Step	± 5%	Step	± 5°
1	-	M12	-	Yes	1	22 Nm (16 ft-lb)-30 Nm (22 ft-lb)	-	-
2	-	M12	-	Yes	1	22 Nm (16 ft-lb)-30 Nm (22 ft-lb)	-	-

Tab. 55: Tightening specifications table

*Lubricants:
MG = Molykote G-n-plus
MW = Castrol Optimol paste white T
MH = Molykote HSC
O = Engine oil

XX = Loctite 243
YY = Loctite 577

**Refer to screws reuse rules. (For more information see: 5.3.2 Screws pre-tightening, reuse and marking, page 274.)

Prestolite starter removal and installation (option)

Previous tasks

❑ Disconnect the battery.

Specific safety instructions

– Not applicable.

Special tools

– Not applicable.

Consumables and equipment

– Not applicable.

Overview

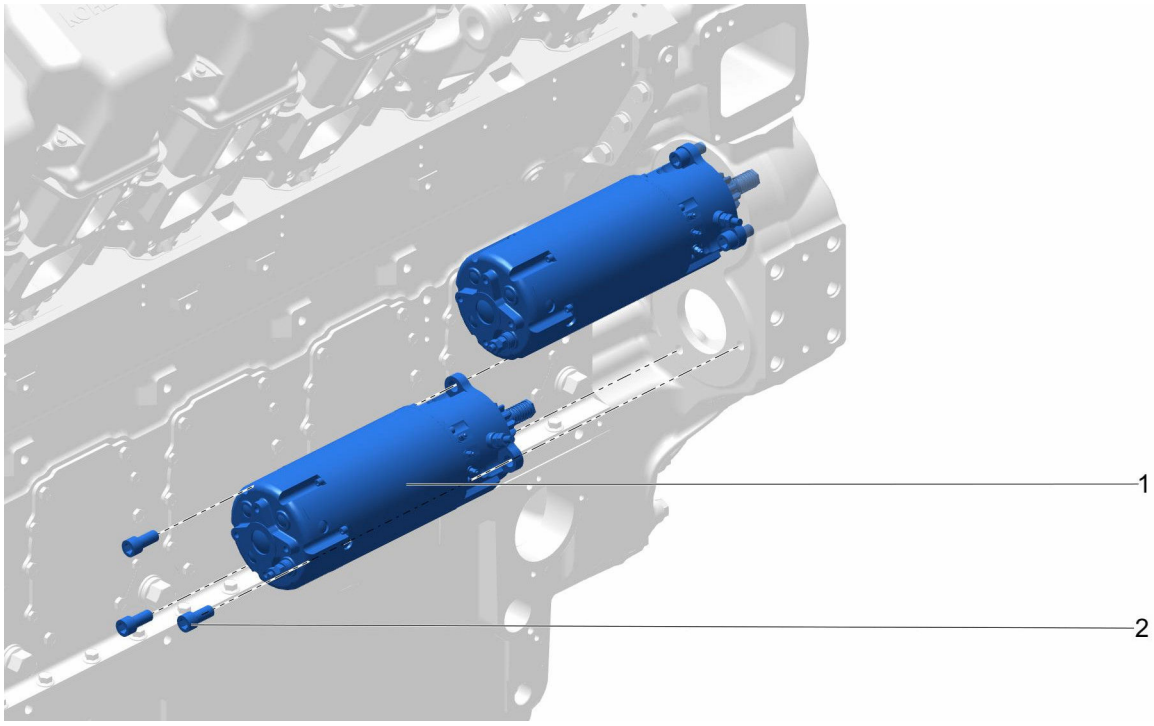


Fig. 287: Task overview

1 Starter

2 Screw (M16)

Removal

▶ Disconnect starter electrical connections.

▶ Remove screws **2**.

▶ Remove starter **1**.

Installation

▶ Install starter **1** with screws **2**.

▶ Tighten screws **2** to 180 $^{\pm 45}$ Nm (133 $^{\pm 33}$ ft-lb).

▶ Connect starter electrical connections

Specific values

Not applicable.

Tightening specifications

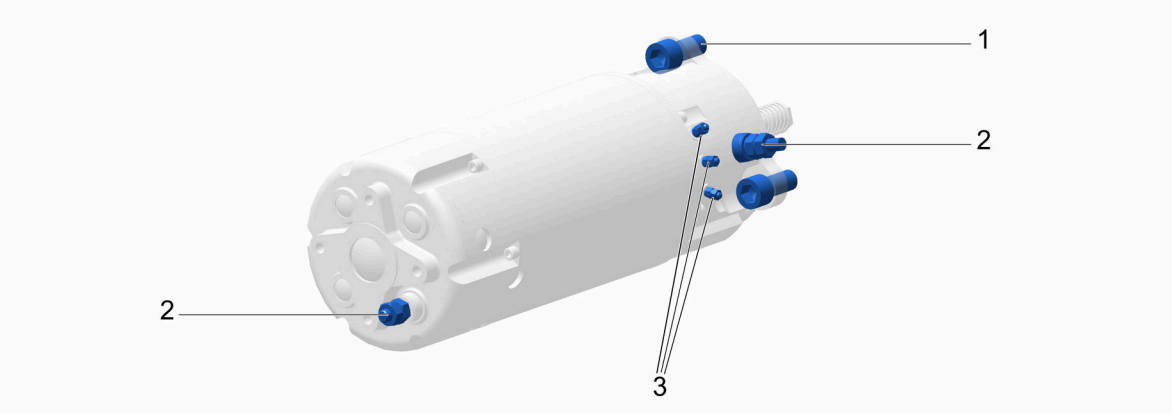


Fig. 288: Starter screws and connections

Reference	Key	Screw specifications	Lubricant *	Reuse**	Torque		Angle (°)	
					Step	± 5%	Step	± 5°
1	450AA	ISO 4762 M16x2x35-10.9-FLZN	-	Yes	1	180 Nm (133 ft-lb)***	-	-
2	-	Nut	-	-	1	9.5 Nm 7 ft-lb	-	-
3	-	Nut	-	-	1	1.6 Nm 1 ft-lb	-	-

Tab. 56: Tightening specifications table

*Lubricants:
MG = Molykote G-n-plus
MW = Castrol Optimol paste white T
MH = Molykote HSC
O = Engine oil
XX = Loctite 243
YY = Loctite 577

**Refer to screws reuse rules. (For more information see: 5.3.2 Screws pre-tightening, reuse and marking, page 274.)

***± 25% Accuracy is accepted.

3.12 Exhaust aftertreatment system

3.12.1 Diesel exhaust fluid injector removal and installation (SL2-5330)

Previous tasks

- ❑ The engine is switched off.
- ❑ The exhaust system has cooled down.
- ❑ The exhaust aftertreatment system is drained.

Specific safety instructions

WARNING
Risk of injuries by contact with hot surfaces!
Engine is hot near operating temperature.

- ▶ Avoid any contact with the engine, parts carrying hot coolant or oil, the exhaust system, the exhaust gas turbocharger, the heat protection, the battery, and the covers.
- ▶ After the temperature has cooled down to a level it can be touched, proceed with the tasks on the engine.

NOTICE
Risk of property damage by reuse of sealing.
Leakage by faulty seal.

- ▶ Replace all sealings.

Special tools

Not applicable.

Consumables and equipment

- – High temperature grease
- – Rags
- – Cleaner

Overview

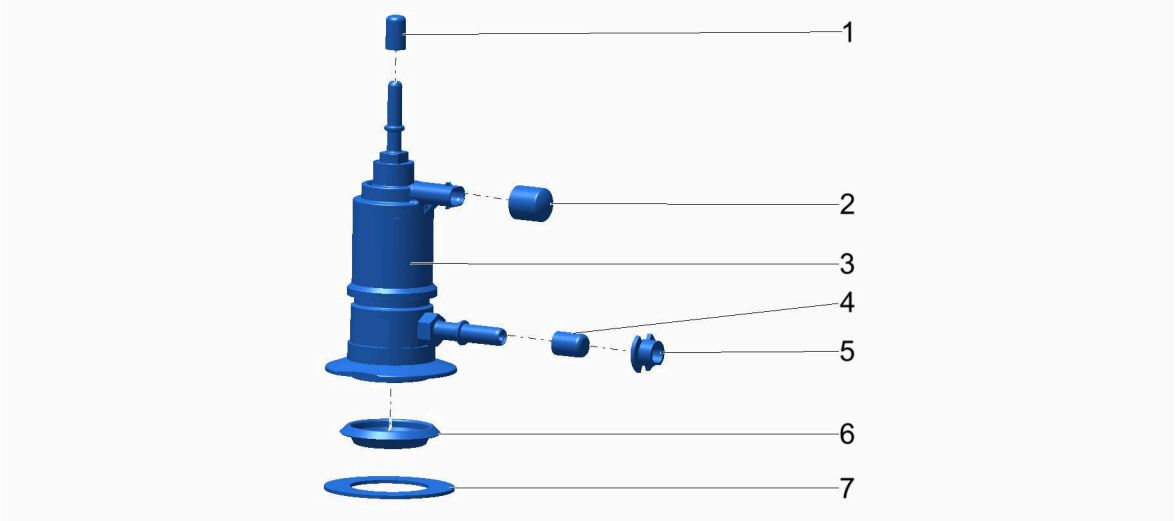


Fig. 289: Task overview

1 Shipping cap
2 Shipping cap
3 Diesel exhaust fluid injector
4 Shipping cap
5 Teflon ring
6 Shipping cap
7 Gasket

Removal

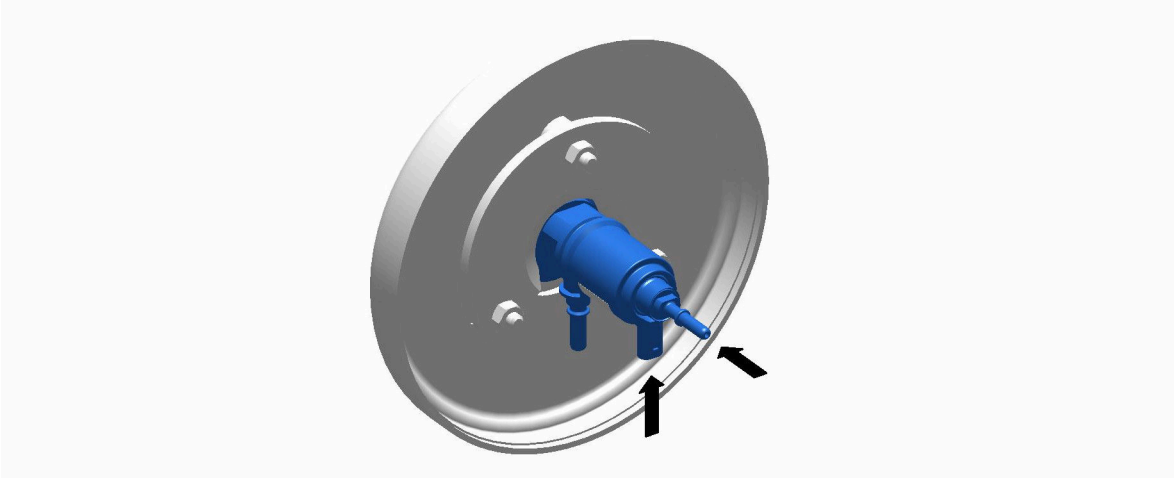


Fig. 290: Disconnecting return line and electrical connector

- ▶ Disconnect the diesel exhaust fluid return line from the injector.
- ▶ Disconnect the electrical connector from the injector.

Information

Make sure that dust cannot go into the system.

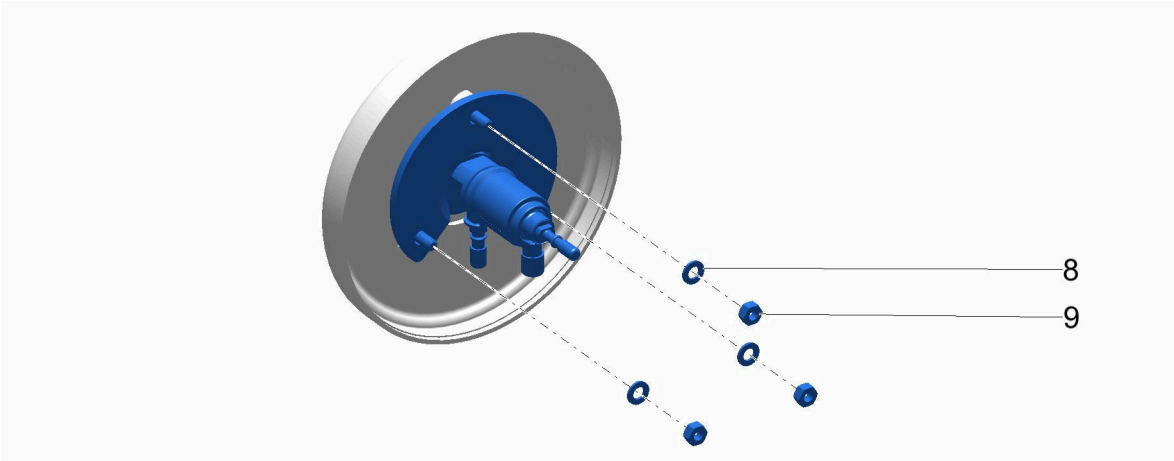


Fig. 291: Removing injector nuts

▶ Remove the injector fixing nuts **9**, and washers **8**.

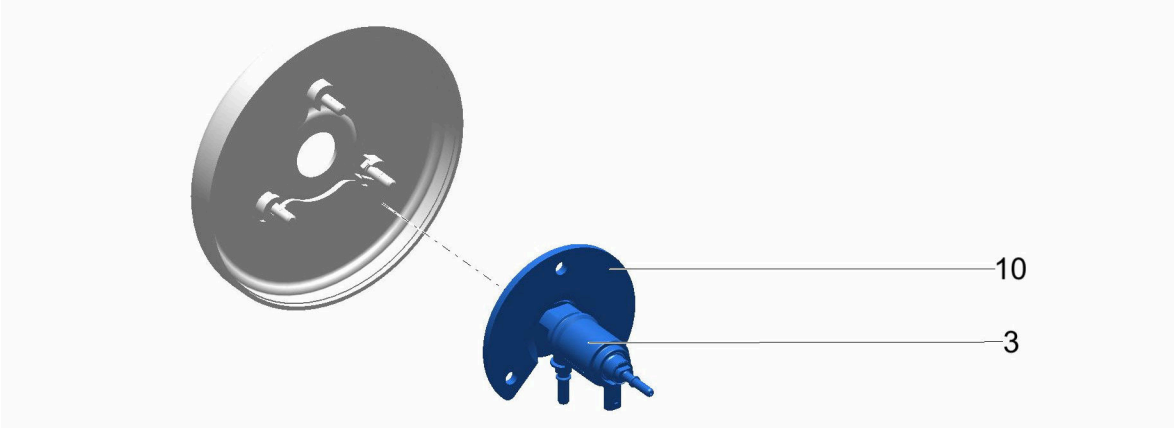


Fig. 292: Removing injector assembly

▶ Remove the injector **3**, and the retaining plate **10** together as an assembly.

Information

Make sure the screws remain in place on the reactor.

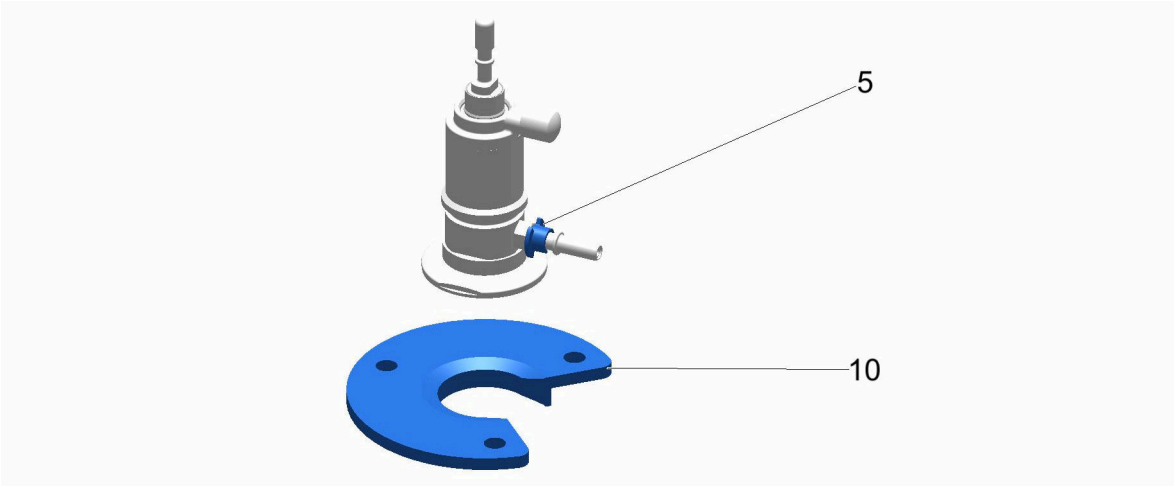


Fig. 293: Removing retaining plate

- ▶ Remove the retaining plate **10** from the injector.
- ▶ Push the teflon ring **5** outwards to disconnect the diesel exhaust fluid inlet line.

Information

Make sure that dust cannot go into the system.

- ▶ Discard the injector, and the injector gasket.

Installation

Fig. 294: Preparing reactor surface

- ▶ Clean the sealing surface on the reactor.

Information

The sealing surface between injector and reactor must be clean to avoid gas leakage.

- ▶ Apply high temperature grease on the screws.

Information

Make sure that dust cannot go into the system.

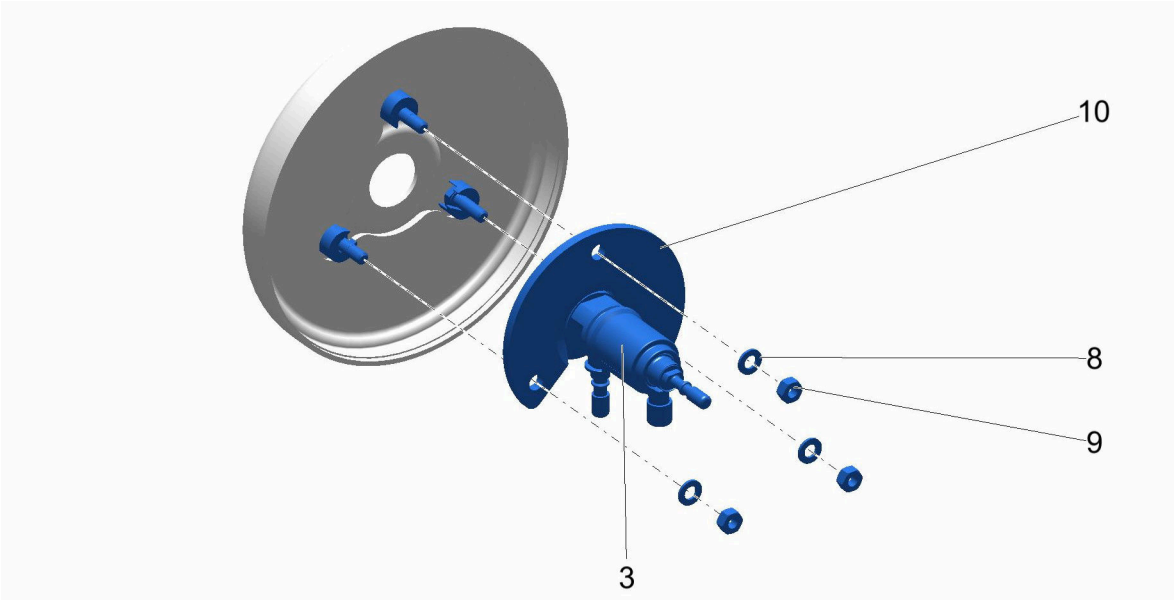


Fig. 295: Installing injector

▶ Install the retaining plate **10** on the reactor with nuts **9**, and washers **8**.

Information

The protruding side of the retaining plate **10** should face toward the reactor.

At this stage, do not tighten the nuts **9**, so that the injector **3** can be installed.

▶ Install a new gasket **7** to the new injector **3**.

▶ Slide the injector **3** and gasket **7** assembly between the reactor and the retaining plate.

Information

Make sure that the gasket **7** remains in place during installation.

Make sure that the injector inlet port faces **3** downwards and overlaps the slot in the retaining plate **10**.

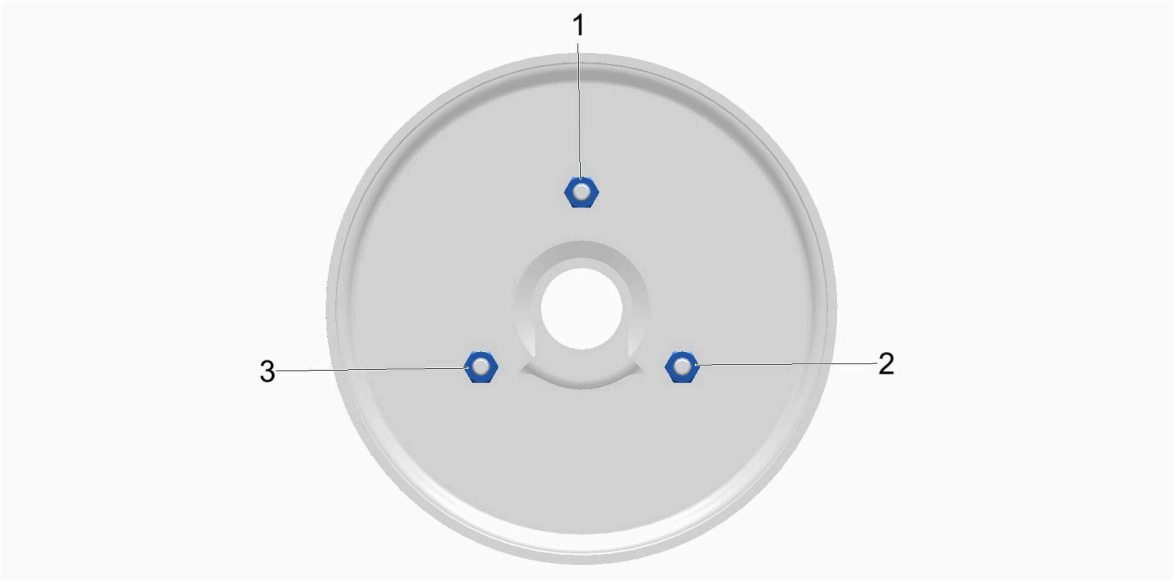


Fig. 296: Nuts tightening sequence

▶ Tighten the nuts to 18.5 $^{\pm 1.5}$ Nm (14 $^{\pm 1}$ ft-lb).

Information

Observe the nuts tightening sequence.

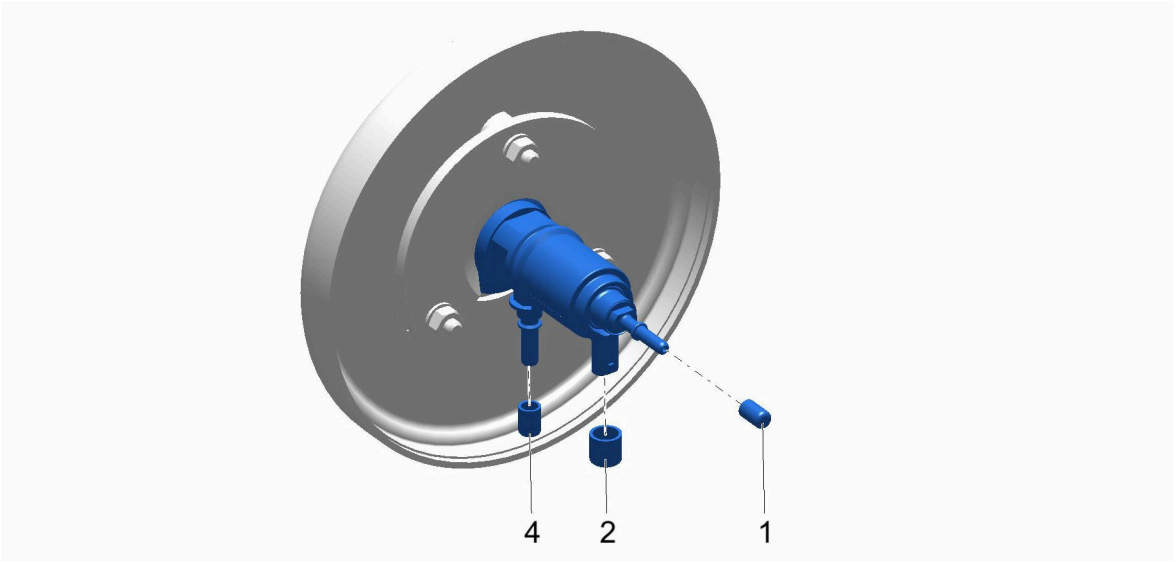


Fig. 297: Removing shipping caps

▶ Remove the shipping caps **1, 2, 4** from the injector.

▶ Connect the diesel exhaust fluid inlet line.

▶ Connect the diesel exhaust fluid return line.

▶ Connect the electrical connector.

▶ Run the system for 30 min to confirm leak-free operation.

Specific values

Not applicable.

Tightening specifications

Refer to standard tightening torques. (For more information see: 5.3 Standard tightening torques, page 274.)

3.12.2 Diesel exhaust fluid pump removal and installation (SL2-5340)

Previous tasks

- ❑ The engine is switched off.
- ❑ The exhaust aftertreatment system is drained.

Specific safety instructions

DANGER
Crushing, shearing or impact hazards by instable transportation conditions or losing control of the means of transport, load or loose part.
Loss of control of the load, of any loose part or means of transport will result in death or serious injury.

- ▶ Secure the means of transport.
- ▶ Use only adapted means of transport.
- ▶ Fix or remove any loose part on the load.
- ▶ Pay attention to the center of gravity and the total weight.
- ▶ Ensure the load against slipping and toppling.

Special tools

Not applicable.

Consumables and equipment

Not applicable.

Overview

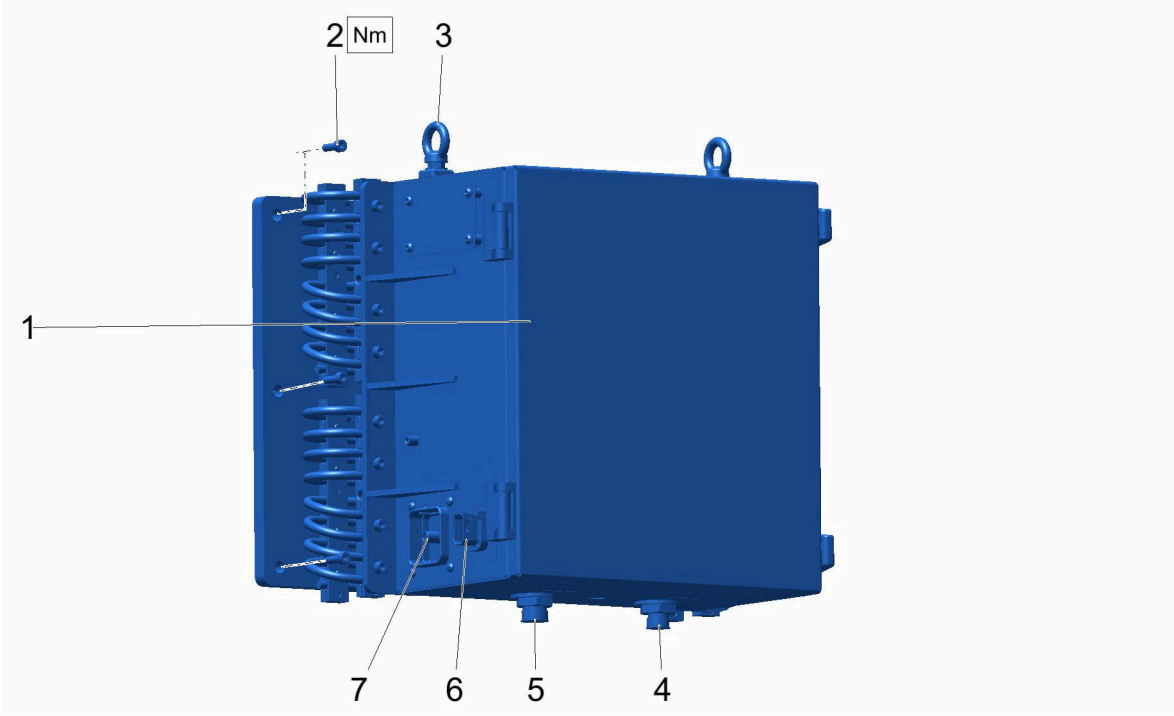


Fig. 298: Task overview

1 Diesel exhaust fluid pump
2 Screw (M10)
3 Lifting hook
4 Connection (M26/M22)
5 Connection (M26/M22)
6 10-pin connector
7 48-pin connector

Removal

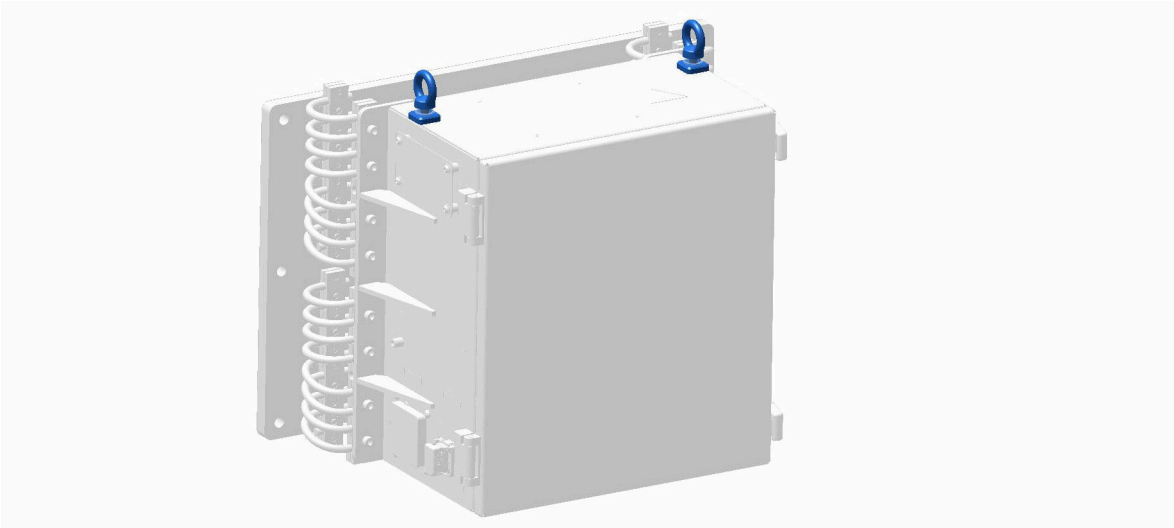


Fig. 299: Securing pump

▶ Using the lifting hooks **3**, secure the pump **1** to a crane.

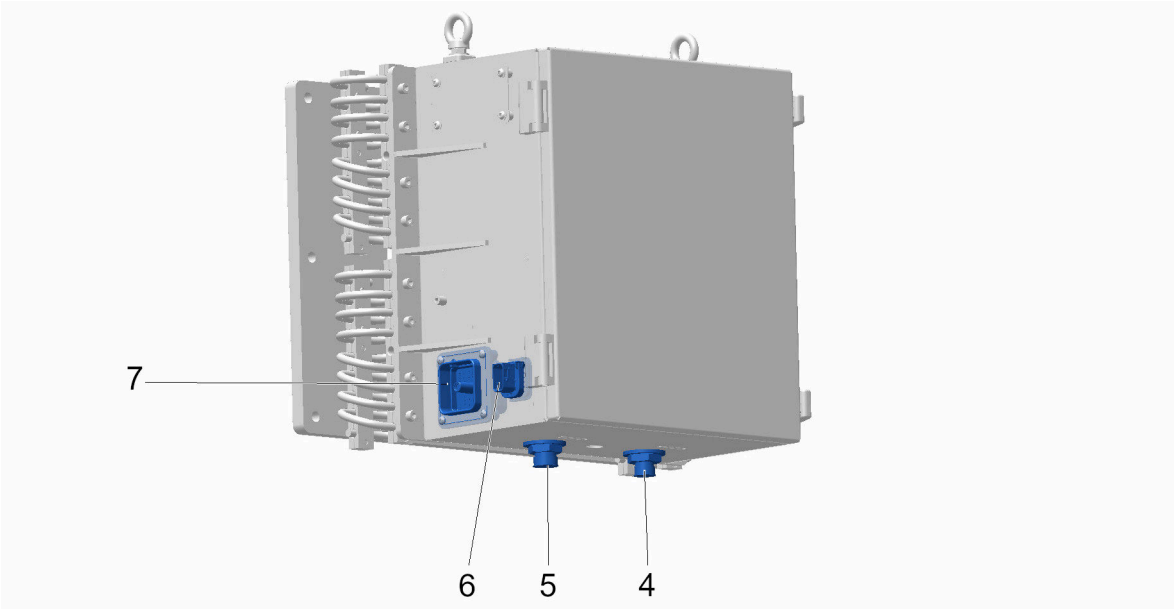


Fig. 300: Disconnecting connectors

▶ Remove the fastening screws of the 48-pin connector **7**.

▶ Disconnect the 48-pin connector **7**.

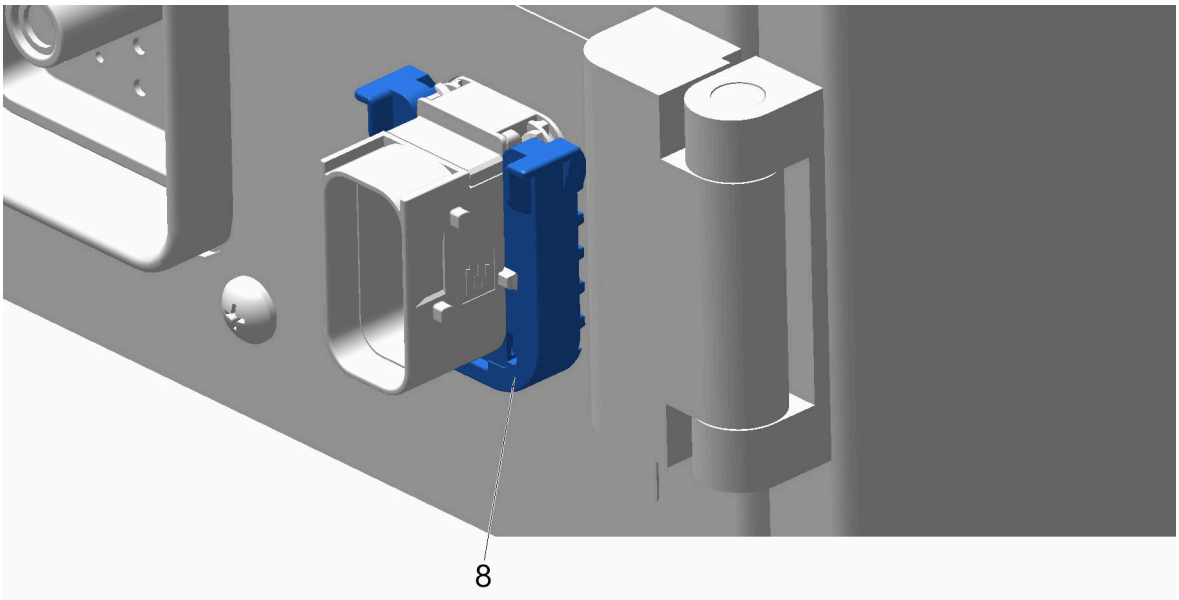


Fig. 301: Connector locking device - handling forbidden

▶ Disconnect the 10-pin connector **6**.

Information

It is forbidden to handle the connector locking device **8** on the pump side.

Only use the lock on the harness side to disconnect the 10-pin connector **6**.

▶ Disconnect the connectors **4, 5** of the diesel exhaust fluid lines.

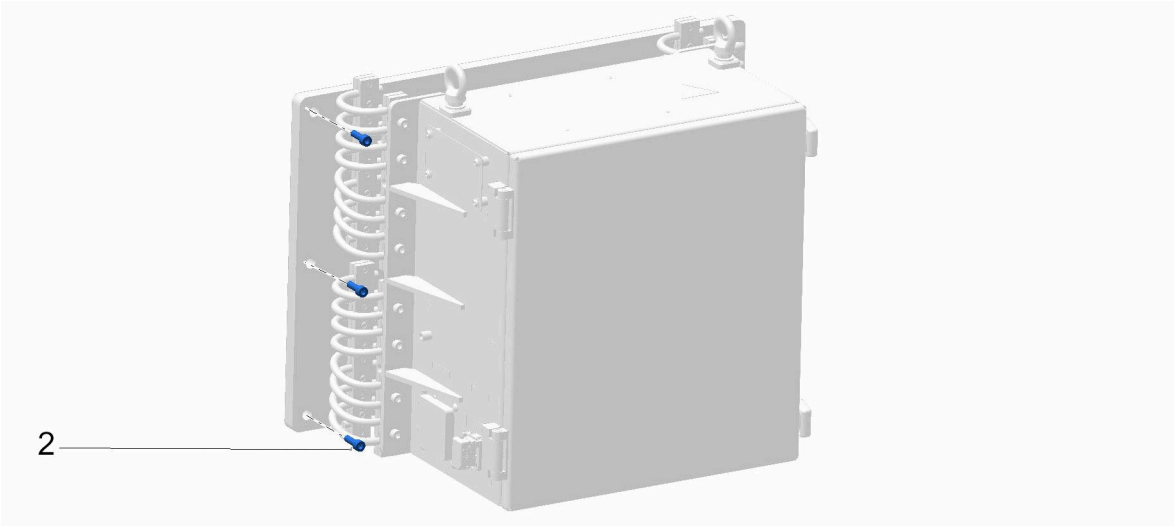


Fig. 302: Removing screws

- ▶ Remove the screws **2**.
- ▶ Remove the pump **1**.

Installation

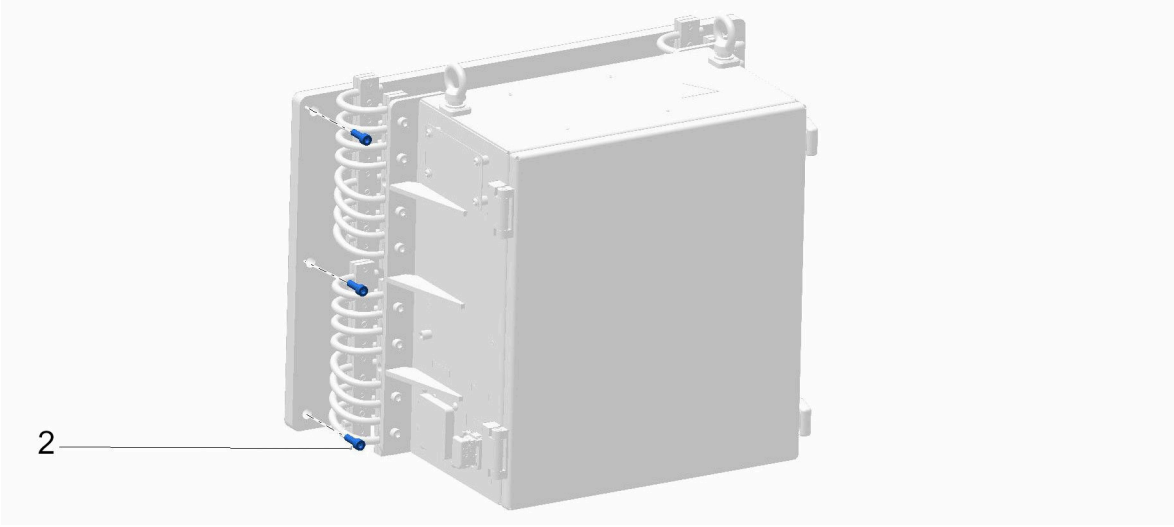


Fig. 303: Installing pump

- ▶ Install the pump **1** with screws **2**.
- ▶ Tighten the screws **2** to 33 $^{\pm 3}$ Nm (24 $^{\pm 2}$ ft-lb).

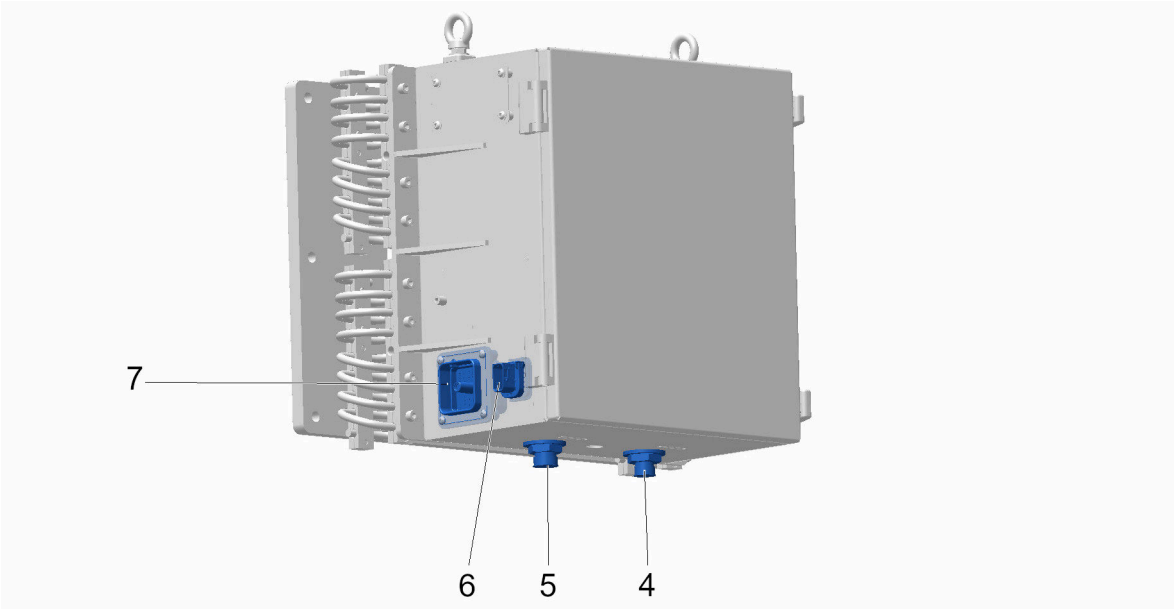


Fig. 304: Connecting connectors

- ▶ Connect the diesel exhaust fluid lines to the pump **1** with connectors **4, 5**.
- ▶ Tighten connectors **4, 5** to 35 $^{\pm 5}$ Nm (26 $^{\pm 4}$ ft-lb).
- ▶ Connect the 48-pin connector **7** to the pump **1**.
- ▶ Tighten the fastening screws of the 48-pin connector **7** to 4 $^{\pm 0.5}$ Nm (3 $^{\pm 0}$ ft-lb).

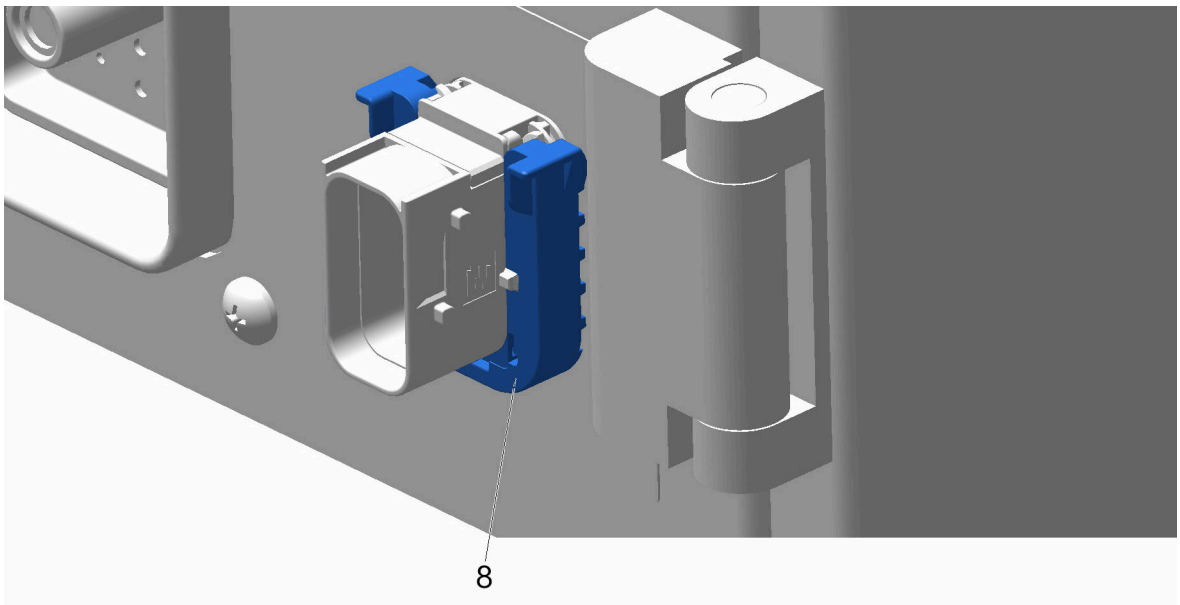


Fig. 305: Connector locking device - handling forbidden

- ▶ Connect the 10-pin connector **6** to the pump **1**.

Information

It is forbidden to handle the connector locking device on the pump side.

Only use the lock on the harness side to connect the 10-pin connector **6**.

▶ Run the system for 30 min to confirm successful priming and leak-free operation.

Specific values

Not applicable.

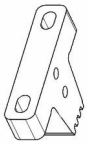
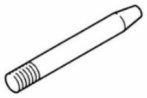
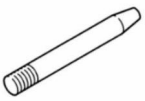
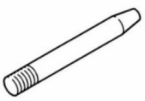
Tightening specifications

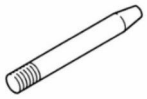
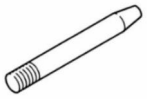
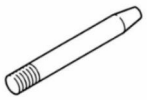
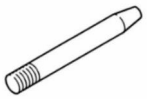
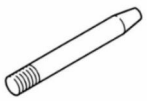
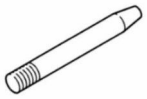
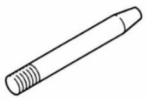
Refer to standard tightening torques. (For more information see: 5.3 Standard tightening torques, page 274.)

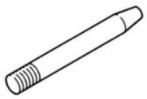
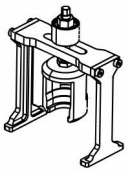
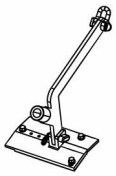
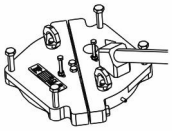
4 Tools and devices

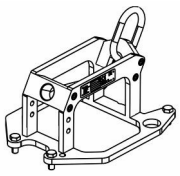
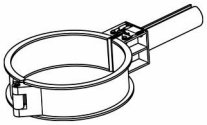
4.1 Tools

4.1.1 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. 57: Special tools

4.1.2 Turning device

Safe handling of the turning device

The turning device is used to turn a gearwheel which drives the flywheel gear rim, and is mounted on the engine on delivery.

NOTICE
Risk of engine main failure by forgotten turning device
Keeping the turning device screwed on the flywheel housing while operating the engine will lead to a break of the turning device and to an engine main failure!

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

WARNING
Risk of crushing, shearing, cutting or severing by use of the turning device
Using the turning device can lead to injuries to personnel working on the engine!

▶ Before using the turning device, prevent the personnel in the vicinity of the engine and get confirmed they stand in a secure area.

WARNING
Risk of injuries by ejected tools or turning devices parts
Keeping the turning device screwed on the flywheel housing or the wrench tool on the turning device while operating the engine can lead to injuries by tool ejection or break of turning device!

- ▶ Check for spring function of the turning device. If faulty, replace by new turning device.
- ▶ Always take away the wrench tool from the turning device, after the flywheel has been turned.
- ▶ 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.

Mount the turning device

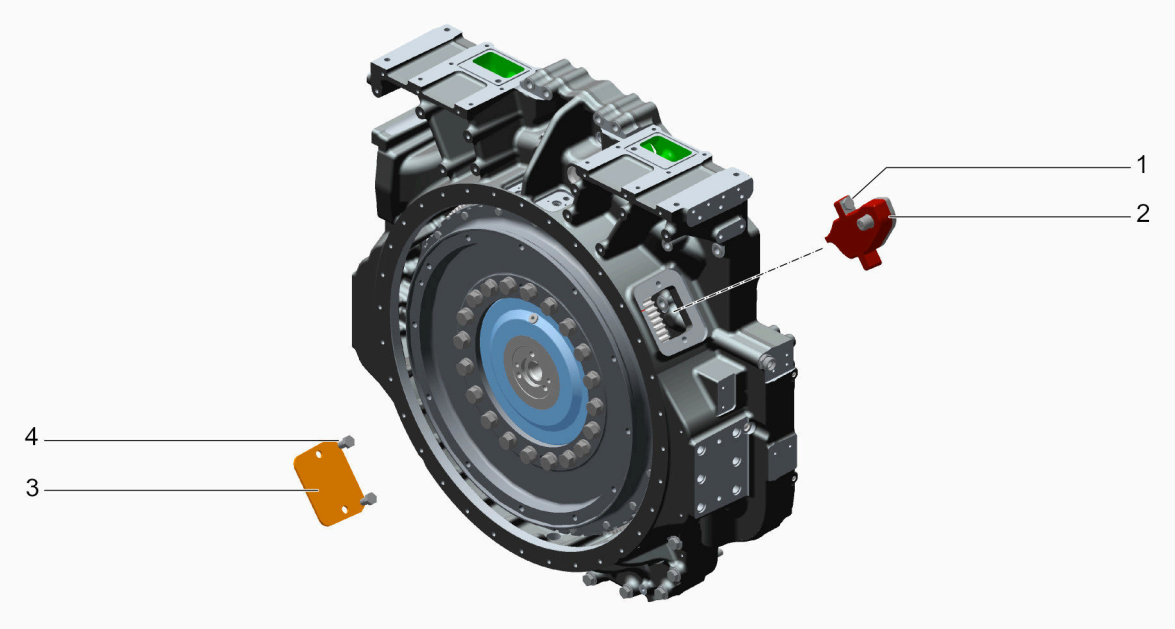


Fig. 325: Mounting the turning device

1 Screws (M16x35 -8.8)
2 Turning device
3 Cover
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 torques values.

Information

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

Use the turning device

❑ The 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 which 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.

Unmount the turning device

WARNING
Risk of injuries by ejected tools or turning devices parts.
Keeping the turning device screwed on the flywheel housing could result in death or serious injuries by tool ejection or break of turning device.

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

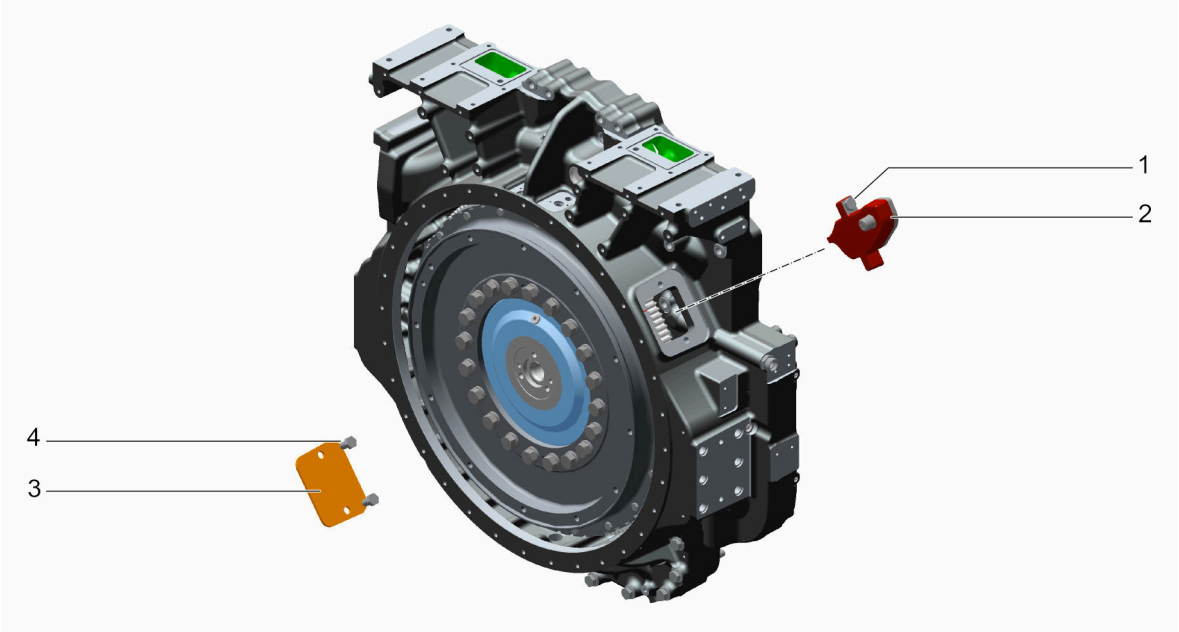


Fig. 326: Unmount the turning device

1 Screws (M16x35 -8.8)
2 Turning device
3 Cover
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.

5 Appendix

5.1 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.

5.2 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.

5.2.1 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. 58: 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. 59: Cleaning agents and thread-locking adhesives

5.2.2 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. 60: Greases

5.3 Standard tightening torques

5.3.1 Lubricant and threadlocker application rules

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

Tab. 61: Lubricant and threadlocker application rules

5.3.2 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 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

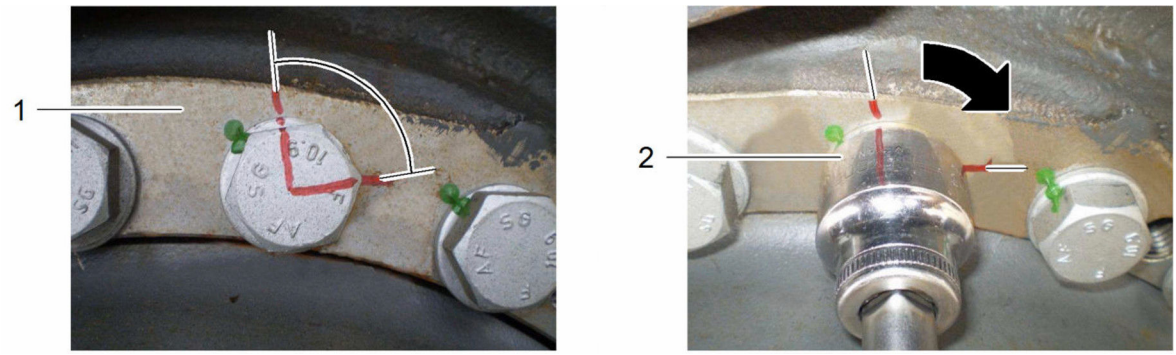


Fig. 329: Pre-tightening marking and angles

- ▶ 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.

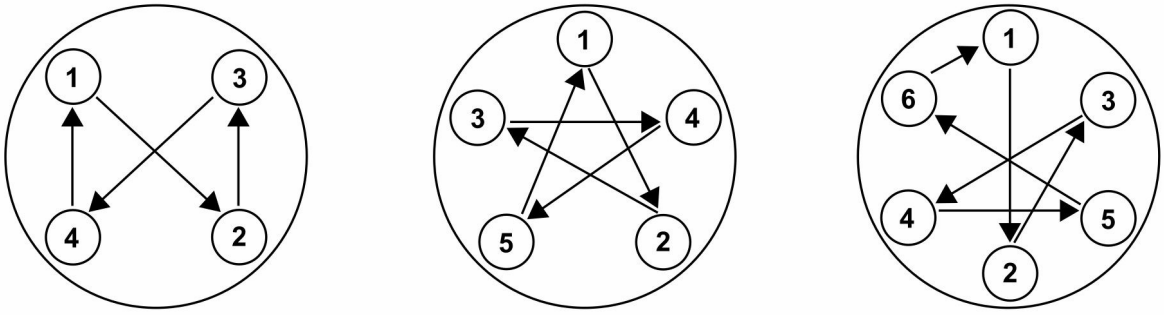


Fig. 330: Standard sequence for 4, 5 and six screws.

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 damage appears (thread, coating).

For screws on:

– **Main bearing**
– **Connecting rod**
– **Cylinder head**
– **Damper**
– **Flywheel**
– **Camshaft**
– **Trunnion mount**
– **Engine feets CS and CCS**
– **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 dismouting.

▶ Change connections after 3 tightenings.

For cutting rings:

▶ Replace connections after first dismouting.

▶ 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. 331: Examples of markings on screws and HP pipe nut.

Some nuts and screws are marked to track their reuse:
– **Fuel and HP injections pipes**
– **Cutting rings**

If 2 punchs appears,
▶ Replace pipe or system after each untightening.

If none or 1 punch appears,
▶ Add one punch after each untightening.

5.3.3 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:

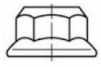
– EN 1665

For hexagonal nuts in accordance with:

– ISO 4032 / ISO 4034 / ISO 4035

For flange nuts in accordance with:

– EN 1664

Thread diam-eter	Quality class 8.8					Quality class 10.9				
	Hexag-onal screw	Socket screw	Hexag-onal nut	Flange screw	Flange nut	Hexag-onal screw	Socket screw	Hexag-onal 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 diam-eter	Quality class 8.8		Quality class 10.9	
M20	320 Nm 236 ft-lb	358 Nm 264 ft-lb	470 Nm 347 ft-lb	525 Nm 387 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. 62: Standard torques for hexagonal / socket / flange screws and hexagonal / flange nuts, with coating without lubricant

5.3.4 Standard torques for internal drive pipe plug with conical thread

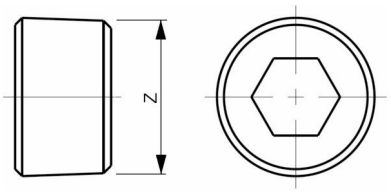


Fig. 342: Internal drive pipe plug with conical thread DIN 906

Information

Tolerances of the indicated tightening torques: 10 %.

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

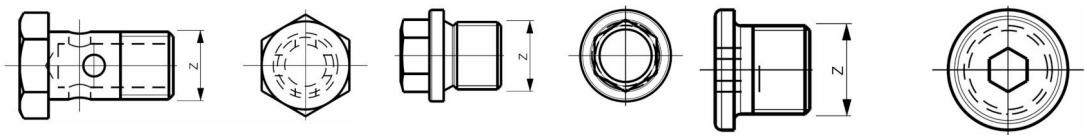
Thread	Tightening torque	Thread	Tightening torque	Thread	Tightening torque
M 6 x 1	5 Nm 4 ft-lb[1)]	**M 14 x 1.5**	57 Nm 42 ft-lb	**M 20 x 1.5**	98 Nm 72 ft-lb
M 8 x 1	12 Nm 9 ft-lb	**M 16 x 1.5**	68 Nm 50 ft-lb	**M 36 x 1.5**	280 Nm 207 ft-lb
M 10 x 1	18 Nm 13 ft-lb	**M 18 x 1.5**	87 Nm 64 ft-lb	**M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

Tab. 63: Standard torques for internal drive pipe plug with conical thread

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

5.3.5 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. 64: 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. 65: Tightening torques for screws according to DIN 7643, DIN 910, DIN 908

5.3.6 Standard torques for flange joints

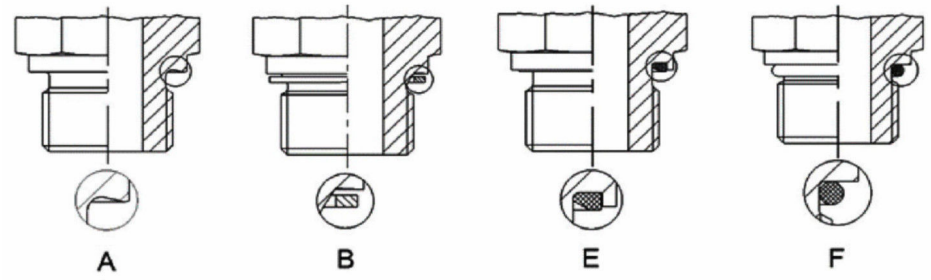


Fig. 346: Flange joints overview

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

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. 66: Standard torques for metric thread unions L series, for steel – see figure above

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

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. 67: Standard torques for metric thread union S series, for steel – see figure above

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

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. 68: Standard torques for imperial thread unions L series, for steel – see figure above

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

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. 69: Standard torques for imperial thread union S series, for steel – see figure above

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. 70: 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. 71: 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. 72: 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. 73: Standard torques for imperial thread union S series, for aluminium – see figure above

5.3.7 Assembling pipes with cutting rings

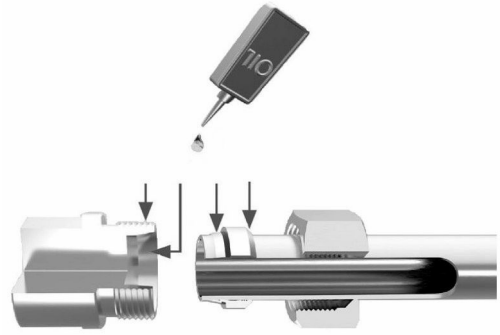


Fig. 347: Cutting ring lubrication

Information

Tolerances of the indicated tightening torques: 10 %.

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

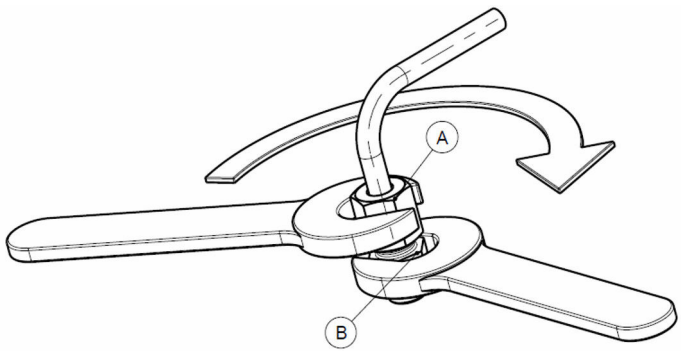


Fig. 348: Cutting ring tightening

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. 74: Alternative tightening torques for cutting ring flange joints

5.3.8 Standard torques for triple lock flange joints

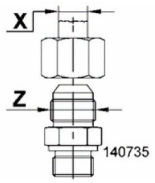


Fig. 349: Triple lock flange joints

Serie	Pipe diam. X		Thread Z	Tightening torque	
	mm	inch	UN/UNF	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	Tightening torque	
	mm	inch	UN/UNF	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. 75: Standard torques for triple lock flange joints

Information

To tighten the screwed socket, proceed like following:

▶ Hold screwed socket instead.

▶ Unscrew union nut until noticeable resistance (without wrench extension).

▶ Tighten union nut according to torque above.

5.3.9 Standard torques for VSTI screw plugs for steel

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).

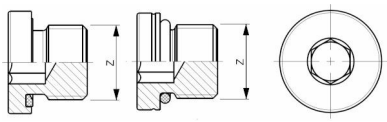


Fig. 350: VSTI screw plugs with ED seal (left), with o-ring (right)

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. 76: VSTI screw plug tightening torques for steel and iron cast parts

[1] Do not use hydropneumatic screwdriver.

5.3.10 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).

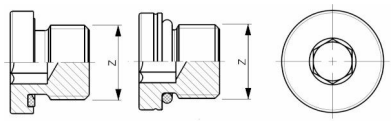


Fig. 351: VSTI screw plugs with ED seal (left), with o-ring (right)

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. 77: VSTI screw plug tightening torques for aluminium parts

[1] Do not use hydropneumatic screwdriver.

5.3.11 Assembling pipes with DKO connectors (EL, ET, EW, GZ, GZR, RED)

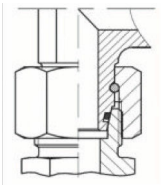


Fig. 352: DKO connector

Fig. 353: 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, observe the following steps:

- ▶ When tightening the nut, make sure 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

Size	Equivalent specification	Size	Equivalent specification
08L	30 Nm 22 ft-lb	08S	40 Nm 30 ft-lb
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. 78: Alternative tightening torques for DKO connectors

5.3.12 Standard torques for collar clamps

Fig. 354: 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. 79: Tightening torques for collar clamps according to DIN 3017-3

5.4 Abbreviations - Acronyms

Abbr.	Designation
AC	Alternating Current
BDC	Bottom Dead Center
CAN	Controller Area Network
CCS	Counter Coupling Side = Damper side
CR	Common Rail
CRS	Common Rail System
CS	Coupling Side = Flywheel side
DC	Diagnosis Code
EATS	Engine After Treatment System
ECU	Engine Control Unit
EMC	Electromagnetic Compatibility
ENG	Engine
EPDM	Ethylene-Propylene - Diene Monomer
HFRR	High Frequency Reciprocating Rig – Measured value for the lubricity of diesel fuels
HP	High Pressure
HT	High Temperature
JSA	Job Safety Analysis
LAN	Local Area Network
LED	Light Emitting Diode
LOTO	LockOut/TagOut
LP	Low Pressure
LT	Low Temperature
MMC	Multi-Media Card (used with digital cameras)
OMM	Operation and Maintenance Manual
PCV	Pressure Control Valve
PPE	Personal Protective Equipment
PTO	Power Take-Off
RSM	Repair and Service Manual
SAPS	Sulphated Ash, Phosphorus and Sulfur
SWP	Safe Work Procedure
TDC	Top Dead Center
VCV	Volume Control Valve

Tab. 80: Abbreviations table

Acronym	Designation
ANSI	American National Standards Institute
DIN	German standard
EN	European standard
EU	European Union
ILO	International Labor Organisation
ISCED	International Standard Classification of Education
SAE	Society of Automotive Engineers
WHO	World Health Organization

Tab. 81: Acronyms table

5.5 Unit conversion tables

Use the following tables to convert units used in this guideline. Suitable number of decimals are used for inaccurate conversion factor.

5.5.1 Length conversion factors

Convert from	To	Multiply by
mm	in	0.0394
mm	ft	0.00328
µm	th	0.0394

Tab. 82: Length conversion factors table

5.5.2 Mass conversion factors

Convert from	To	Multiply by
kg	lb	2.205
kg	oz	35.274

Tab. 83: Mass conversion factors table

5.5.3 Pressure conversion factors

Convert from	To	Multiply by
kPa	psi (lbf/in²)	0.145
kPa	lbf/ft²	20.885
kPa	inch H2O	4.015
kPa	foot H2O	0.335
kPa	mm H2O	101.972

Tab. 84: Pressure conversion factors table

5.5.4 Volume conversion factors

Convert from	To	Multiply by
m³	in³	61023.744
m³	ft³	35.315
m³	Imperial gallon	219.969
m³	US gallon	264.172
m³	l (liter)	1000

Tab. 85: Volume conversion factors table

5.5.5 Power conversion factors

Convert from	To	Multiply by
kW	hp (metric)	1.360
kW	US hp	1.341

Tab. 86: Power conversion factors table

5.5.6 Moment of inertia and torque conversion factors

Convert from	To	Multiply by
kgm^2	$lbft^2$	23.730
kNm	lbf ft	737.562

Tab. 87: Moment of inertia and torque conversion factors table

5.5.7 Fuel consumption conversion factors

Convert from	To	Multiply by
g/kWh	g/hph	0.736
g/kWh	lb/hph	0.00162

Tab. 88: Fuel consumption conversion factors table

5.5.8 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. 89: Flow conversion factors table

5.5.9 Temperature conversion factors

Convert from	To	Multiply by
°C	°F	F = 9/5*C + 32
°C	K	K = C + 273.15

Tab. 90: Temperature conversion factors table

5.5.10 Density conversion factors

Convert from	To	Multiply by
Kg/m^3	lb/US gallon	0.00834
Kg/m^3	lb/imperial gallon	0.01002

Convert from	To	Multiply by
Kg/m^3	lb/ft^3	0.0624

Tab. 91: Density conversion factors table

5.6 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. 92: Common prefix multipliers table

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