

# Operating Instructions

Diesel engine

12 V 2000 M86

12 V 2000 M96

12 V 2000 M96L

16 V 2000 M86

16 V 2000 M96

16 V 2000 M96L

MS150119/00E



*Power. Passion. Partnership.*

Engine model	kW/cyl.	Application group
12V2000M86	102 kW/cyl.	1D, Continuous operation, variable, medium load
12V2000M96	112 kW/cyl.	1DS, Continuous operation, variable, low load
12V2000M96L	119 kW/cyl.	1DS, Continuous operation, variable, low load
16V2000M86	102 kW/cyl.	1D, Continuous operation, variable, medium load
16V2000M96	112 kW/cyl.	1DS, Continuous operation, variable, low load
16V2000M96L	121 kW/cyl.	1DS, Continuous operation, variable, low load

*Table 1: Applicability*

# Table of Contents

1	Safety		7	Task Description	
1.1	Important requirements for all products	5	7.1	SOLAS	60
1.2	Personnel and organizational requirements	6	7.1.1	SOLAS shielding as per MTN 5233 - Installation	60
1.3	Transport	7	7.1.2	SOLAS shielding - Installation	61
1.4	Safety requirements for startup and operation	8	7.1.3	Installation locations for SOLAS shielding	62
1.5	Safety requirements for maintenance and repair work	9	7.2	Engine	67
1.6	Fire prevention and environmental protection, fluids and lubricants, auxiliary materials	12	7.2.1	Engine - Barring manually	67
1.7	Standards for safety notices in the text	14	7.2.2	Engine - Cranking on starting system	68
2	General Information		7.3	Cylinder Liner	69
2.1	Torque specifications for screws and nuts	15	7.3.1	Instructions and comments on endoscopic and visual examination of cylinder liners	69
2.2	Engine side and cylinder designations	26	7.3.2	Cylinder liner - Endoscopic examination	71
2.3	Product description	27	7.4	Crankcase Breather	73
2.4	Engine layout	33	7.4.1	Crankcase breather - Cleaning oil pre-separator element	73
2.5	Sensors and actuators - Overview	35	7.4.2	Crankcase breather - Oil separator element replacement, diaphragm check and replacement	74
3	Technical Data		7.5	Valve Drive	76
3.1	12V 2000 M86/M96/M96L engine data	40	7.5.1	Cylinder head cover - Removal and installation	76
3.2	16V 2000 M86/M86/M96L engine data	43	7.5.2	Valve clearance - Check and adjustment	77
3.3	Firing order	46	7.6	Injection Pump / HP Pump	79
3.4	Engine - Main dimensions	47	7.6.1	HP fuel pump - Filling with engine oil	79
4	Operation		7.7	Injector	80
4.1	Putting the engine into operation after extended out-of-service periods (>3 months)	48	7.7.1	Injector - Replacement	80
4.2	Engine - Putting into operation after scheduled out-of-service-period	49	7.7.2	Injector - Removal and installation	81
4.3	Operational checks	50	7.8	Fuel System	83
4.4	Starting the engine	51	7.8.1	Fuel system - Venting	83
4.5	Engine - Shutdown	52	7.9	Fuel Filter	84
4.6	Emergency engine stop	53	7.9.1	Fuel filter - Replacement	84
4.7	After stopping the engine	54	7.9.2	Fuel prefilter - Differential pressure check and adjustment of gauge	85
4.8	Plant - Cleaning	55	7.9.3	Fuel prefilter - Draining	86
5	Maintenance		7.9.4	Fuel prefilter - Flushing	88
5.1	Maintenance task reference table [QL1]	56	7.9.5	Fuel prefilter - Filter element replacement	90
6	Troubleshooting		7.10	Charge-Air Cooling	92
6.1	Troubleshooting	57	7.10.1	Intercooler - Checking condensate drain line for coolant discharge and obstruction	92
			7.11	Air Filter	93
			7.11.1	Air filter - Replacement	93
			7.11.2	Air filter - Removal and installation	94
			7.12	Air Intake	95
			7.12.1	Service indicator - Signal ring position check	95
			7.13	Starting Equipment	96
			7.13.1	Starter - Condition check	96

7.14	Lube Oil System, Lube Oil Circuit	97	7.22	Wiring (General) for Engine/Gearbox/Unit	115
7.14.1	Engine oil - Level check	97	7.22.1	Engine wiring - Check	115
7.14.2	Engine oil - Change	98			
7.15	Oil Filtration / Cooling	99	7.23	Accessories for (Electronic) Engine Governor / Control System	116
7.15.1	Engine oil filter - Replacement	99	7.23.1	Engine governor and connectors - Cleaning	116
7.16	Coolant Circuit, General, High-Temperature Circuit	100	7.23.2	EMU and connectors - Cleaning	117
7.16.1	Engine coolant drain and venting points	100	7.23.3	Engine governor plug connections - Check	118
7.16.2	Engine coolant - Level check	103	7.23.4	Engine Monitoring Unit EMU 8 - Plug connections check	119
7.16.3	Engine coolant - Change	104	7.23.5	Interface module EIM plug connections - Check	120
7.16.4	Engine coolant - Draining	105	7.23.6	Engine Control Unit - Self-test	121
7.16.5	Engine coolant - Filling	106	7.23.7	Engine governor ECU 9 - Removal and installation	122
7.16.6	HT coolant pump - Relief bore check	107	7.23.8	Engine Monitoring Unit - Removal and installation	123
7.16.7	Engine coolant - Sample extraction and analysis	108	7.23.9	Engine Interface Module EIM - Removal and installation	124
7.17	Low-Temperature Circuit	109	7.23.10	Diagnostic features of EIM	125
7.17.1	Charge-air coolant - Draining	109			
7.18	Raw Water Pump with Connections	110	8	Appendix A	
7.18.1	Raw water pump - Relief bore check	110	8.1	List of abbreviations	128
7.19	Engine Mounting / Support	111	8.2	MTU contact persons/service partners	130
7.19.1	Engine mounting - Checking securing screws for firm seating	111			
7.19.2	Engine mounting - Checking condition of resilient mounts	112	9	Appendix B	
7.20	Belt Drive	113	9.1	Special Tools	131
7.20.1	Drive belt - Condition check	113	9.2	Index	138
7.21	Battery-Charging Generator	114			
7.21.1	Battery-charging generator drive - Drive belt replacement	114			

# 1 Safety

## 1.1 Important requirements for all products

### **Nameplate**

The product is identified by a nameplate, model designation or serial number which must match the information on the title page of this manual.

Nameplate, model designation or serial number can be found on the product.

### **General information**

This product may pose a risk of injury or damage in the following cases:

- Improper use
- Operation, maintenance and repair by unqualified personnel
- Changes or modifications
- Noncompliance with the safety instructions and warning notices

### **Intended use**

The product is intended for use in accordance with its contractually-defined purpose as described in the relevant technical documents only.

Intended use entails operation:

- Within the permissible operating parameters in accordance with the (→ Technical data)
- With fluids and lubricants approved by the manufacturer in accordance with the (→ Fluids and Lubricants Specifications of the manufacturer)
- With spare parts approved by the manufacturer in accordance with the (→ Spare Parts Catalog/MTU contact/Service partner)
- In the original as-delivered configuration or in a configuration approved by the manufacturer in writing (including engine management/parameters)
- In compliance with all safety regulations and in accordance with all warning notices in this manual
- With maintenance work performed in accordance with the (→ Maintenance Schedule) throughout the useful life of the product
- In compliance with the maintenance and repair instructions contained in this manual, in particular with regard to the specified tightening torques
- With the exclusive use of technical personnel trained in commissioning, operation, maintenance and repair
- By contracting only workshops authorized by the manufacturer to carry out repair and overhaul

Any other use shall be considered non-intended. Such improper use increases the risk of injury and damage when working with the product. The manufacturer shall not be held liable for any damage resulting from improper, non-intended use.

### **Changes or modifications**

Unauthorized changes to the product represent a contravention of its intended use and compromise safety.

Changes or modifications shall only be considered to comply with the intended use when expressly authorized by the manufacturer. The manufacturer shall not be held liable for any damage resulting from unauthorized changes or modifications.

## 1.2 Personnel and organizational requirements

### **Organizational measures of the operator**

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

Keep this manual handy in the vicinity of the product such that it is accessible to operating, maintenance, repair and transport personnel at all times.

Use this manual as a basis for instructing personnel on product operation and repair, whereby the safety-relevant instructions, in particular, must be read and understood.

This is particularly important in the case of personnel who only occasionally perform work on or around the product. This personnel must be instructed repeatedly.

### **Personnel requirements**

All work on the product shall be carried out by trained and qualified personnel only.

- Training at the Training Center of the manufacturer
- Qualified personnel specialized in mechanical and plant engineering

The operator must define the responsibilities of the personnel involved in operation, maintenance, repair and transport.

### **Working clothes and personal protective equipment**

Wear proper protective clothing for all work.

When working, always wear the necessary personal protective equipment (e.g. ear protectors, protective gloves, goggles, breathing protection). Observe the information on personal protective equipment in the respective activity description.

## 1.3 Transport

### **Transport**

Use only the lifting eyes provided to lift the engine.

Only use transport and lifting devices approved by MTU.

Take the engine's center of gravity into account.

Transport the engine in the installation position only, max. permissible diagonal pull 10°.

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

Install the crankshaft locking device and the locking screws for the engine mounts prior to engine transportation.

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

### **Setting down the engine following transportation**

Set the engine down on a firm, level surface only.

Make sure that the consistency and load-bearing capacity of the ground or support surface is adequate.

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

## 1.4 Safety requirements for startup and operation

### Safety requirements for startup

The product must be installed and accepted in accordance with manufacturers' specifications prior to initial startup.

All the requisite regulatory approvals must have been granted and all startup requirements fulfilled prior to initial startup.

Whenever the product is started, always ensure that:

- All maintenance and repair work has been completed.
- All loose parts have been removed from rotating machine components.
- Wearers of cardiac pacemakers or other active medical implants are well clear.
- The operating room is adequately ventilated.
- Exhaust pipework is leak-tight and routed to atmosphere.
- Battery terminals, generator terminals and cables are guarded to preclude accidental contact.
- All personnel is clear of the danger zone represented by moving parts.

Immediately after putting the product into operation, make sure that all control and display instruments as well as the monitoring, signaling and alarm systems are working properly.

### Safety requirements for operation

The operator must be familiar with the controls and displays.

The operator must be aware of the consequences of any operations he/she performs.

During operation, the display instruments and monitoring units must be constantly observed in regard of present operating status, limit value violation and warning or alarm messages.

### Malfunctions and emergency stop

Emergency procedures, in particular emergency stop, must be practiced on a regular basis.

Take the following steps if a system malfunction is detected or signaled by the system:

- Inform the duty supervisor(s).
- Evaluate the message.
- Respond to the emergency appropriately, e.g. execute an emergency stop.

### Operation

Do not stay in the operating room when the product is running unless absolutely necessary and then as briefly as possible.

Keep a safe distance away from the product whenever possible. Do not touch the product unless expressly instructed to do so.

Do not inhale exhaust gases emitted by the product.

Ensure that the following requirements have been fulfilled before starting the product:

- Ear protectors are worn.
- Mop up any leaked or spilled fluids and lubricants immediately or soak up with a suitable binding agent.

### Operation of electrical equipment

Some components are live (high voltage) when electrical equipment is in operation.

Observe the safety instructions for these appliances.



## 1.5 Safety requirements for maintenance and repair work

### **Safety requirements before commencing maintenance and repair work**

Have maintenance or repair work carried out by qualified and authorized personnel only.

Allow the product to cool down to less than 50°C (risk of explosion for oil vapors, fluids and lubricants, risk of burning).

Relieve pressure in fluid and lubricant systems and compressed-air lines which are to be opened. Use suitable collection vessels with a sufficient filling volume.

Ensure that the operating room is adequately ventilated when changing the oil or working on the fuel system.

Do not perform maintenance or repair work when the product is running unless:

- expressly instructed to do so.
- the product is running in the low load range and only for as long as necessary to complete the task.

Lock-out the product to preclude undesired starting, e.g. start interlock.

Tag-out the product with a “Do Not Start” sign in the operation room or on the control facility.

Disconnect the battery. Lock the contactor.

Close the main valve on the compressed-air system and vent the compressed-air line when pneumatic starters are fitted.

Disconnect the control facility from the product.

For starters with pinions made of copper-beryllium alloy:

- Wear a respirator mask (filter class P3). Do not blow out the interior of the flywheel housing or the starter with compressed air. Clean the interior of the flywheel housing with a class H dust extractor.
- Observe the safety data sheet.

### **Safety requirements during maintenance and repair work**

Take special care when removing vent plugs or plug screws from the product. Hold a cloth over the screw or plug to prevent discharge of highly pressurized liquids.

Take care when draining hot fluids and lubricants (risk of burning).

Use suitable and calibrated tools only. Observe the specified tightening torques during assembly or disassembly.

Carry out work only on assemblies and/or installations which are properly secured.

Never climb up on the lines.

Keep fuel injection lines and connections clean.

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

Fit new seals when re-installing lines.

Avoid damaging lines, particularly the fuel lines.

Ensure that all retainers and dampers are installed correctly.

Ensure that all fuel injection and pressurized oil lines are installed with enough clearance to prevent contact with other components. Never route fuel or oil lines in the vicinity of hot components.

Do not touch elastomeric seals (e.g. Viton sealing rings) with your bare hands if they have a carbonized or resinous appearance.

Observe the cooling time for components which have been heated for installation or removal (risk of burning!).

Always use suitable ladders and work platforms when working above head-height. Ensure that components or assemblies are placed on stable surfaces.

Pay particular attention to cleanliness at all times.

## **Safety requirements after completing maintenance and repair work**

Ensure that all personnel is clear of danger zones before cranking.

Check that all access ports/apertures which have been opened to facilitate working are closed again.

Check that all safety equipment has been installed and that all tools and loose parts have been removed (especially the barring gear).

Ensure that no unattached parts have been left in/on the product (e.g. including rags and cable straps).

## **Welding work**

Do not perform welding on the product or its attachments. Cover the product when performing welding work in the vicinity.

Before commencing welding work:

- Switch off the master power supply switch.
- Disconnect the battery.
- Disconnect electronic and genset grounds.

Do not perform maintenance or repair work on the product when welding is in progress in its vicinity. Risk of explosion or fire due to oil vapors and highly flammable process materials.

Do not use the product as a grounding terminal.

Do not route the welding cable over or near the wiring harnesses of the product. The welding current may otherwise induce an interference voltage in the wiring harnesses which could conceivably damage the electrical system.

Remove components (e.g. exhaust pipe) from the product before performing necessary welding work .

## **Hydraulic installation and removal**

Check function and satisfactory condition of the jigs and fixtures to be used. Use only the specified jigs and fixtures for hydraulic removal/installation.

Observe the max. permissible force-on pressure specified for the installation/removal jig.

Do not attempt to bend or exert force on HP lines.

Before starting work, pay attention to the following:

- Vent the installation/removal jig, the pumps and the pipework at the relevant designated points.
- For hydraulic installation, screw on the jig with the piston retracted.
- For hydraulic removal, screw on the jig with the piston extended.

For hydraulic installation/removal jigs with central expansion pressure supply, screw the spindle into the shaft end until correct sealing has been established.

During hydraulic installation and removal, ensure that nobody is standing in the immediate vicinity of the component to be installed/removed.

## **Working with batteries**

Observe the safety requirements of the battery manufacturer when working with batteries.

Gases released from the battery are explosive. Avoid sparks and naked flames.

Do not allow electrolyte (battery acid) to come into contact with skin or clothing.

Wear goggles and protective gloves.

Do not place tools on the battery.

Check polarity before connecting the cable to the battery. Battery polarity reversal may lead to injury by the sudden discharge of acid or bursting of the battery unit.

## Working on electrical/electronic assemblies

Always obtain the permission of the duty supervisor before commencing maintenance or repair work or switching off any part of the electronic system required to do so.

De-energize the appropriate areas prior to working on assemblies.

Avoid damaging cabling during removal. When reconnecting, ensure that cabling cannot be damaged during operation by:

- Contact with sharp edges
- Chafing on components
- Contact with hot surfaces.

Do not secure cabling to lines bearing fluids.

Do not use cable ties to secure cabling.

Always use connector pliers to tighten union nuts on connectors.

Subject the device and also the product to appropriate function testing whenever repair work has been completed. In particular, check the function of the emergency stop feature.

Store spare parts properly prior to replacement, i.e. protect them against moisture in particular. Package faulty electronic components or assemblies properly before dispatching for repair:

- Moisture-proof
- Shock-proof
- Wrapped in antistatic foil if necessary.

## Working with laser equipment

Always wear special laser-protection goggles when working with laser equipment (danger due to intensely focused radiation).

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

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

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

## Measuring component deviations

Workpieces, components and measuring instruments are within specified tolerances at a reference temperature of 20°C.

## 1.6 Fire prevention and environmental protection, fluids and lubricants, auxiliary materials

### Fire prevention

Rectify any fuel or oil leaks immediately. Oil or fuel on hot components can cause fires – therefore always keep the product in a clean condition. Do not leave rags saturated with fluids and lubricants on the product. Do not store combustible materials near the product.

Do not carry out welding work on pipes and components carrying oil or fuel. Before welding, clean with a nonflammable fluid.

When starting the engine with an external power source, connect the ground lead last and remove it first. To avoid sparks in the vicinity of the battery, connect the ground lead from the external power source to the ground lead of the engine or to the ground terminal of the starter.

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

### Noise

Noise can lead to an increased risk of accidents if it makes it more difficult to hear audible signals, warning calls or noises indicating danger.

Wear ear protectors in workplaces with a sound pressure level in excess of 85dB (A).

### Environmental protection and disposal

Modification or removal of any mechanical/electronic components or the installation of additional components including the execution of calibration processes that might affect the emission characteristics of the product are prohibited by emission regulations. Emission control units/systems may only be maintained, exchanged or repaired if the components used for this purpose are approved by the manufacturer. Noncompliance with these guidelines will invalidate the design type approval issued by the emissions regulation authorities. The manufacturer does not accept any liability for violations of the emission regulations. The maintenance schedules of the manufacturer must be observed over the entire life cycle of the product.

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

Within the EU, batteries can be returned free of charge to the manufacturer where they will be properly recycled.

### Fluids and lubricants and auxiliary materials

The Fluids and Lubricants Specifications will be amended or supplemented as necessary. Prior to operation, make sure that the latest version is used. The latest version can be found on the website on the "Technical Info" or "Spare Parts and Service" tabs at <http://www.mtu-online.com>.

Consumable fluids and materials may also be hazardous or toxic. When using fluids, lubricants, consumables and other chemical substances, follow the safety regulations that apply to the product. Take special care when using hot, chilled or caustic substances. When using flammable materials, prevent them coming into contact with ignition sources and do not smoke.

### Used oil

Used oil contains combustion residues that are harmful to health.

Rub barrier cream into hands.

Wash hands after contact with used oil.

## Lead

- Adopt suitable measures to avoid the formation of lead dust.
- Switch on extraction system.
- When working with lead or pastes that contain lead, avoid direct contact with the skin. Do not inhale lead vapors.
- Wash hands after contact with lead or lead-containing substances.

## Compressed air

Observe special safety precautions when working with compressed air:

- Unauthorized use of compressed air, e.g. forcing flammable liquids (hazard class A1, A2 and B) out of containers, risks causing an explosion.
- Wear goggles when blowing dirt off workpieces or blowing away swarf.
- Blowing compressed air into thin-walled containers (e.g. containers made of sheet metal, plastic or glass) for drying purposes or to check for leaks risks bursting them.
- Pay special attention to the pressure in the compressed air system or pressure vessel.
- Assemblies or products to be connected must either be designed for that pressure, or, if the permissible pressure is lower than the system pressure, a pressure reducing valve and safety valve (set to the permissible pressure) must be connected between the assemblies/products and the system.
- Hose couplings and connections must be securely attached.
- Provide the snout of the air nozzle with a protective disk (e.g. rubber disk).
- First shut off compressed air lines before compressed air device is disconnected from the supply line, or before device or tool is to be replaced.
- Carry out leak test in accordance with the specifications.

## Paints and varnishes

- Observe the relevant safety data sheet for all materials.
- When painting in areas other than spray booths equipped with extractors, ensure good ventilation. Make sure that neighboring work areas are not adversely affected.
- There must be no naked flames in the vicinity.
- No smoking.
- Observe fire prevention regulations.
- Always wear a mask providing protection against paint and solvent vapors.





## Liquid nitrogen

- Observe the relevant safety data sheet for all materials.
- Work with liquid nitrogen may be carried out only by qualified personnel.
- Store liquid nitrogen only in small quantities and always in regulation containers (without gas-tight caps).
- Avoid body contact (eyes, hands).
- Wear protective clothing, protective gloves, closed shoes and safety goggles.
- Make sure that working area is well ventilated.
- Avoid knocking or jolting the containers, valves and fittings or workpieces in any way.

## Acids/alkaline solutions/urea (AdBlue<sup>®</sup>, DEF)

- Observe the relevant safety data sheet for all materials.
- When working with acids and alkaline solutions, wear goggles or face mask, gloves and protective clothing.
- Do not inhale vapors.
- If urea solution is swallowed, rinse out mouth and drink plenty of water.
- If spilled onto clothing, remove the affected clothing immediately.
- After contact with skin, rinse affected parts of the body with plenty of water.
- Rinse eyes immediately with eye drops or clean tap water. Seek medical attention as soon as possible.

## 1.7 Standards for safety notices in the text

<b>DANGER</b> 	In the event of immediate danger. <b>Consequences: Death, serious or permanent injury!</b> <ul style="list-style-type: none"><li>• Remedial action.</li></ul>
<b>WARNING</b> 	In the event of a situation involving potential danger. <b>Consequences: Death, serious or permanent injury!</b> <ul style="list-style-type: none"><li>• Remedial action.</li></ul>
<b>CAUTION</b> 	In the event of a situation involving potential danger. <b>Consequences: Minor or moderate injuries!</b> <ul style="list-style-type: none"><li>• Remedial action.</li></ul>
<b>NOTICE</b> 	In the event of a situation involving potentially adverse effects on the product. <b>Consequences: Material damage!</b> <ul style="list-style-type: none"><li>• Remedial action.</li><li>• Additional product information.</li></ul>

### Safety notices

1. This manual with all safety instructions and safety notices must be issued to all personnel involved in operation, maintenance, repair or transportation.
2. The higher level warning notice is used if several hazards apply at the same time. Warnings related to personal injury shall be considered to include a warning of potential damage.

## 2 General Information

### 2.1 Torque specifications for screws and nuts

#### Tightening torques for setscrew and connections as per MTN 5008 standard

The standard applies to setscrews and the associated nuts as specified in the following standards when not subjected to dynamic loading:

- MMN 384
- DIN 912
- ISO 4014 (DIN 931-1)
- ISO 4017 (DIN 933)
- EN 28765 (DIN 960)
- EN 28676 (DIN 961)
- DIN 6912

The standard applies to studs and the associated nuts as specified in the following standards:

- DIN 833
- DIN 835
- DIN 836
- DIN 938
- DIN 939

The standard does not apply to heat-resistant screws in the hot-component area.

Tightening torques  $M_A$  are specified for screws of strength class 8.8 (surface condition bare, phosphatized or galvanized) and 10.9 (surface condition bare or phosphatized).

The values in the table are based on a friction coefficient  $\mu_{tot} = 0.125$ .

Coat thread and mating faces of screws and nuts with engine oil prior to assembly.

An assembly tolerance of +10% of the table values is admissible when tightening manually (to specified torque).

The admissible assembly tolerance is  $\pm 15\%$  for machine tightening.

Thread	Hand-tightening		Machine-tightening	
	8.8 $M_A$ (Nm)	10.9 $M_A$ (Nm)	8.8 $M_A$ (Nm)	10.9 $M_A$ (Nm)
M6	9	12	8	11
M8	21	31	20	28
M8 x 1	23	32	21	30
M10	42	60	40	57
M10 x 1.25	45	63	42	60
M12	74	100	70	92
M12 x 1.25	80	110	75	105
M12 x 1.5	76	105	72	100
M14	115	160	110	150
M14 x 1.5	125	180	120	170
M16	180	250	170	235
M16 x 1.5	190	270	180	255
M18	250	350	240	330
M18 x 1.5	280	400	270	380
M20	350	500	330	475

Thread	Hand-tightening		Machine-tightening	
	8.8 M <sub>A</sub> (Nm)	10.9 M <sub>A</sub> (Nm)	8.8 M <sub>A</sub> (Nm)	10.9 M <sub>A</sub> (Nm)
M20 x 1.5	390	550	350	520
M22	480	680	450	650
M22 x 1.5	520	730	490	700
M24	600	850	570	810
M24 x 1.5	680	950	640	900
M24 x 2	660	900	620	850
M27	900	1250	850	1175
M27 x 2	960	1350	900	1275
M30	1200	1700	1100	1600
M30 x 2	1350	1900	1250	1800

M<sub>A</sub> = Tightening torques

### Tightening torque for stress bolt connections as per MTN 5007 standard

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

Shaft and transition dimensions as per MMN 209 standard and material and machining as per MMN 389 standard (bright surface or phosphatized).

The values in the table are based on a friction coefficient  $\mu_{tot} = 0.125$ .

Coat thread and mating faces of screws and nuts with engine oil prior to assembly.

An assembly tolerance of +10% of the table values is admissible for unavoidable deviations during the tightening process.

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

Thread	Not torsion-protected M <sub>A</sub> (Nm)	Torsion-protected M <sub>A</sub> (Nm)
M6	9	12
M8	21	28
M8 x 1	24	30
M10	42	55
M10 x 1.25	46	60
M12	75	93
M12 x 1.5	78	99
M14	120	150
M14 x 1.5	135	160
M16	180	225
M16 x 1.5	200	245
M18	250	315
M18 x 1.5	300	360
M20	350	450
M20 x 1.5	430	495
M22	500	620
M22 x 1.5	560	675
M24	640	790

TIM-ID: 0000002333 - 016



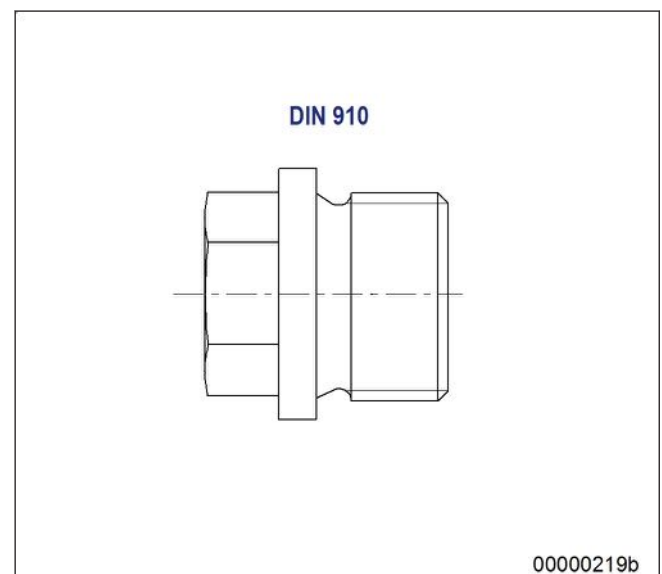
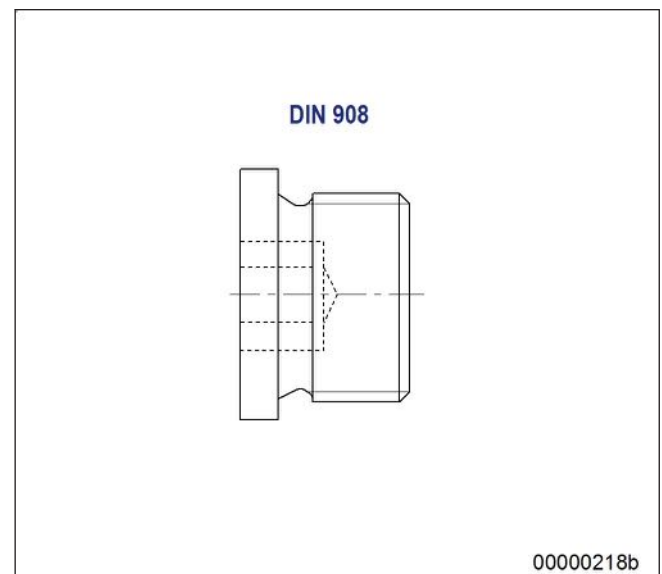
Thread	Not torsion-protected $M_A$ (Nm)	Torsion-protected $M_A$ (Nm)
M24 x 2	700	850
M27	900	1170
M27 x 2	1000	1230
M30	1250	1575

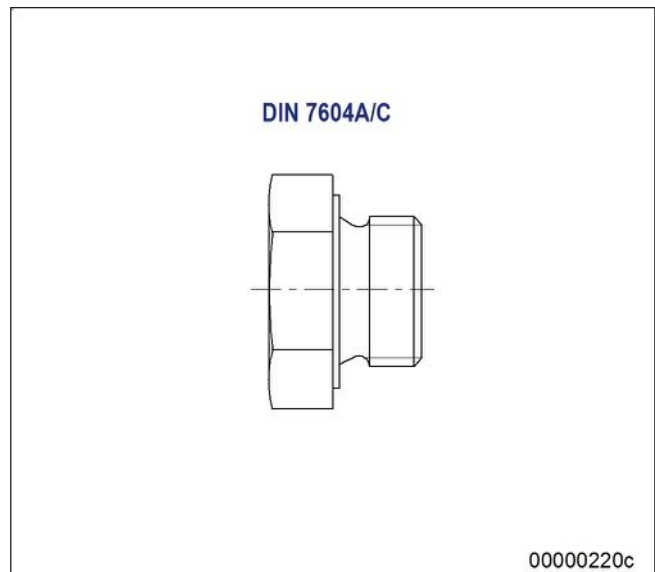
\*Protect screw shaft from torsion when tightening.

$M_A$  = Tightening torques.

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

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





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

Coat thread and mating faces beneath heads with engine oil prior to assembly.

An assembly tolerance of +10% of the table values is admissible for unavoidable deviations during the tightening process.

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

Thread	inserted in	
	Steel/gray cast iron $M_A$ (Nm)	Al alloy $M_A$ (Nm)
M10 x 1	15	15
M12 x 1.5	30	25
M14 x 1.5	35	30
M16 x 1.5	40	35
M18 x 1.5	50	40
M20 x 1.5	60	50
M22 x 1.5	70	70
M24 x 1.5	85	80
M26 x 1.5	100	100
M27 x 2	100	100
M30 x 1.5	110	110
M30 x 2	120	120
M33 x 2	160	160
M36 x 1.5	190	180
M38 x 1.5	220	200
M42 x 1.5	260	240
M45 x 1.5	290	270
M48 x 1.5	310	300
M52 x 1.5	325	320
M56 x 2	380	360
M64 x 2	400	400

$M_A$  = Tightening torques

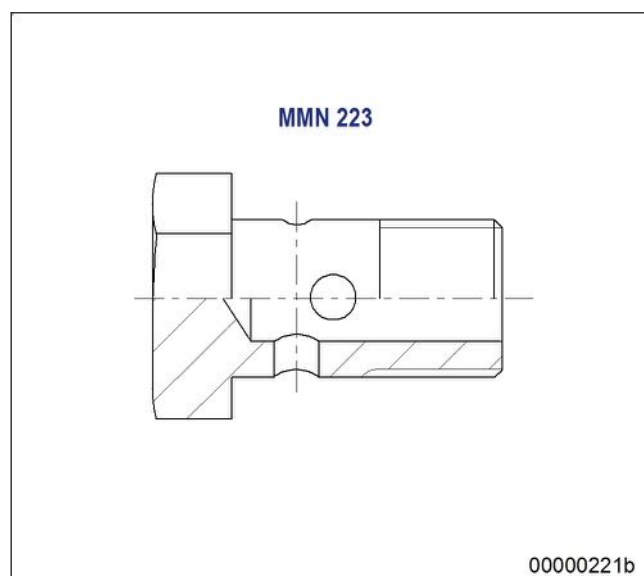
### Tightening torque for plug screws DIN 7604C (with long screwed end)

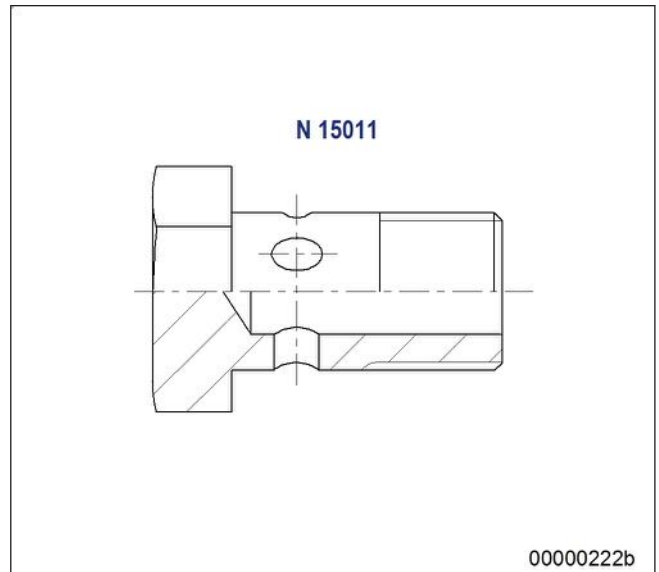
Thread	inserted in	
	Steel/gray cast iron $M_A$ (Nm)	Al alloy $M_A$ (Nm)
M8 x 1	10	10
M22 x 1.5	80	65
M26 x 1.5	105	90
M30 x 1.5	130	130
M38 x 1.5	140	120
M45 x 1.5	160	140

$M_A$  = Tightening torques

### Tightening torque for banjo screws as per MTN 5183-2 standard

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





The stated tightening torques  $M_A$  apply to steel (St) banjo screws with a phosphatized surface and oiled or galvanized and for copper-aluminum alloy.

Coat thread and mating faces beneath heads with engine oil prior to assembly.

An assembly tolerance of +10% of the table values is admissible for unavoidable deviations during the tightening process.

### Tightening torques for steel banjo screws

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

$M_A$  = Tightening torques

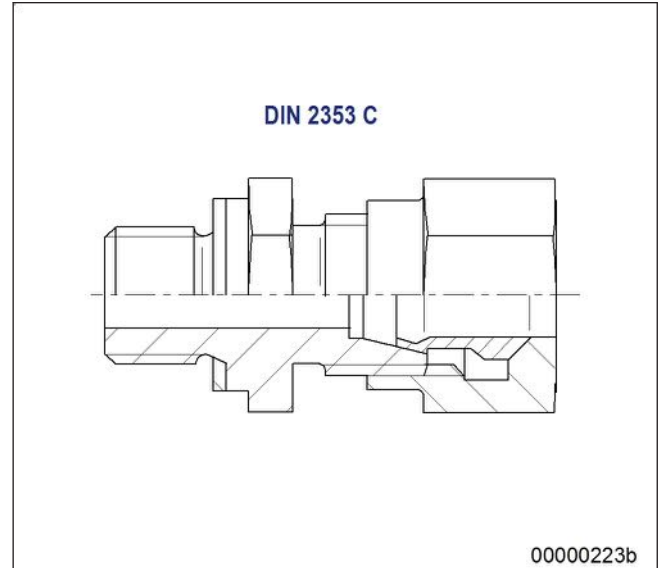
### Tightening torques for copper-aluminum alloy banjo screws

Thread	Screwed into steel/gray cast iron/Al alloy $M_A$ (Nm)
M10 x 1	15
M16 x 1.5	30

$M_A$  = Tightening torques

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

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



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

Coat thread and mating faces beneath heads with engine oil prior to assembly.

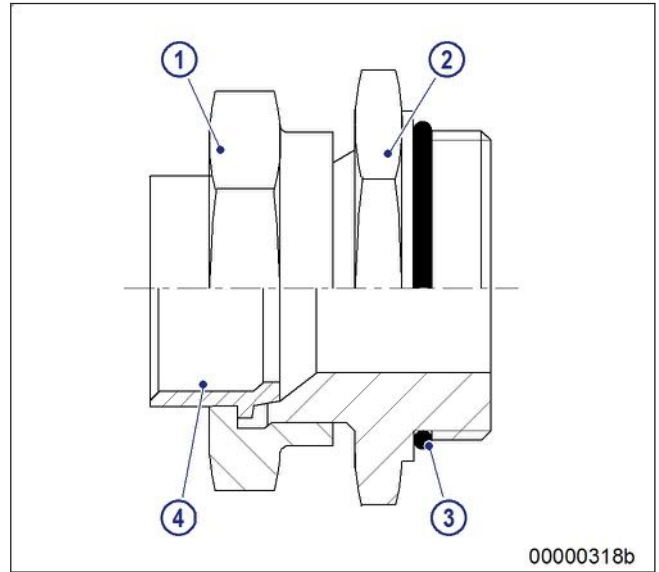
An assembly tolerance of +10% of the table values is admissible for unavoidable deviations during the tightening process.

Thread	Screwed into steel/gray cast iron $M_A$ (Nm)
M10 x 1	15
M12 x 1.5	20
M14 x 1.5	35
M16 x 1.5	50
M18 x 1.5	60
M22 x 1.5	70
M26 x 1.5	100
M32 x 2	160
M42 x 2	260
M48 x 2	320

$M_A$  = Tightening torques

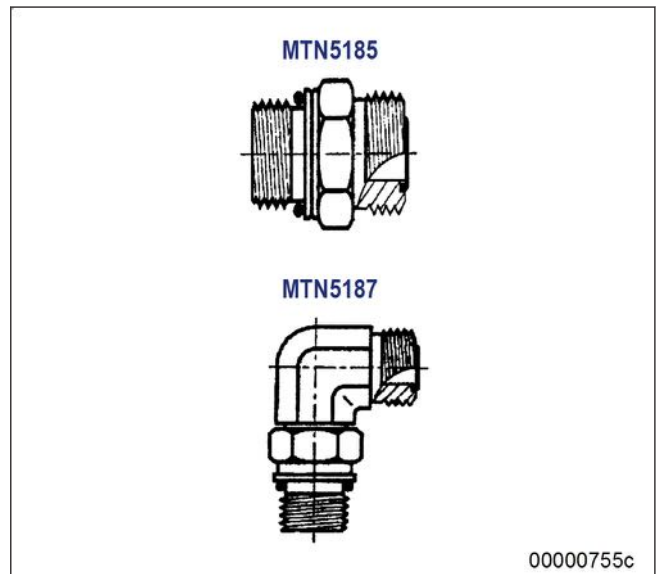
## Tightening torques for union nuts as per DIN 3859-2

- 1 Union nut
- 2 Screw fixture
- 3 O-ring
- 4 Ball-type union



Union nut: When installing the ball-type union, first tighten the union nut firmly by hand (noticeable increase in force), then tighten another 1/4 turn (90°) past this point.

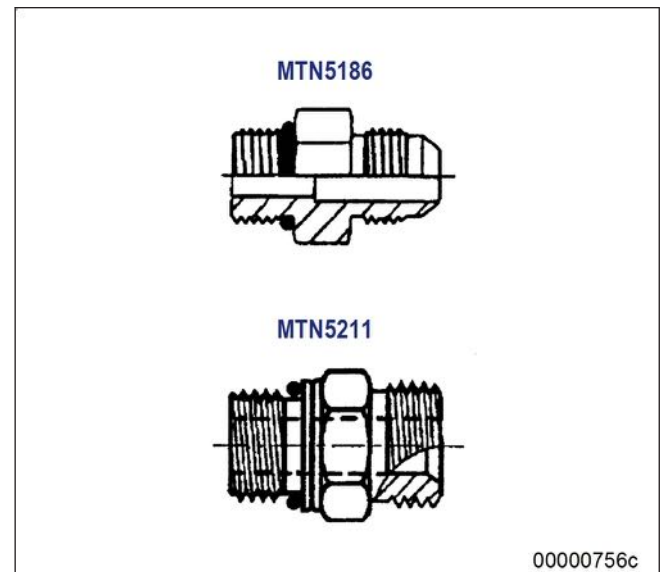
## Tightening torques for threaded journals with O-rings as per ISO 6149-2



Thread	Torque (Nm) +10%
M8 x 1	10
M10 x 1	20
M12 x 1.5	35
M14 x 1.5	45
M16 x 1.5	55
M18 x 1.5	70
M20 x 1.5 <sup>1)</sup>	80
M22 x 1.5	100
M27 x 2	170

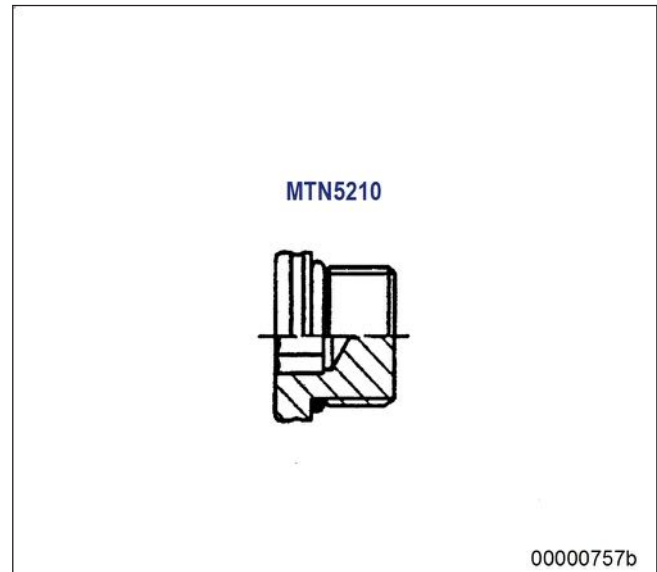
Thread	Torque (Nm) +10%
M33 x 2	310
M42 x 2	330
M48 x 2	420
M60 x 2	500
1) Only for closing off installation spaces for screw-in valves (see ISO 7789).	

### Tightening torques for threaded journals with O-rings as per ISO 6149-3



Thread	Torque (Nm) +10%
M8 x 1	8
M10 x 1	15
M12 x 1.5	25
M14 x 1.5	35
M16 x 1.5	40
M18 x 1.5	45
M22 x 1.5	60
M27 x 2	100
M33 x 2	160
M42 x 2	210
M48 x 2	260
M60 x 2	315

## Tightening torques for plug screw joints as per MTN 5183-6



Thread	inserted in	
	Steel/gray cast iron M <sub>A</sub> (Nm)	Al alloy M <sub>A</sub> (Nm)
M10 x 1	20	10+ 2
M12 x 1.5	35	14+ 2
M14 x 1.5	45	15+ 3
M16 x 1.5	55	18+ 3
M18 x 1.5	70	23+ 3
M22 x 1.5	100	33+ 4
M27 x 2	170	57+ 5
M33 x 2	310	103+ 10
M42 x 2	330	110+ 11
M48 x 2	420	140+ 14
M60 x 2	1)	200+ 20
1) Value still to be determined.		

## Assembly instructions and tightening torque for hose fittings with union nuts

These instructions do not apply to ORFS valves and fittings. When connecting hose fittings with sealing heads and the associated adapters proceed as follows contrary to the instructions for pipe unions.

Hose fitting, metallic sealing with union nut: Tighten union nut by hand then tighten max. 1/4 turn with wrench.

Hose fitting with O-ring and union nut: Tighten union nut by hand then tighten max. 1/2 turn with wrench.

Align hoselines appropriately before tightening the union nuts.

Sealing head/sealing cone with metric union nut		
Metric thread	Pipe outer Ø	Torque (Nm)
M12 x 1.5	6	20
M14 x 1.5	8	38

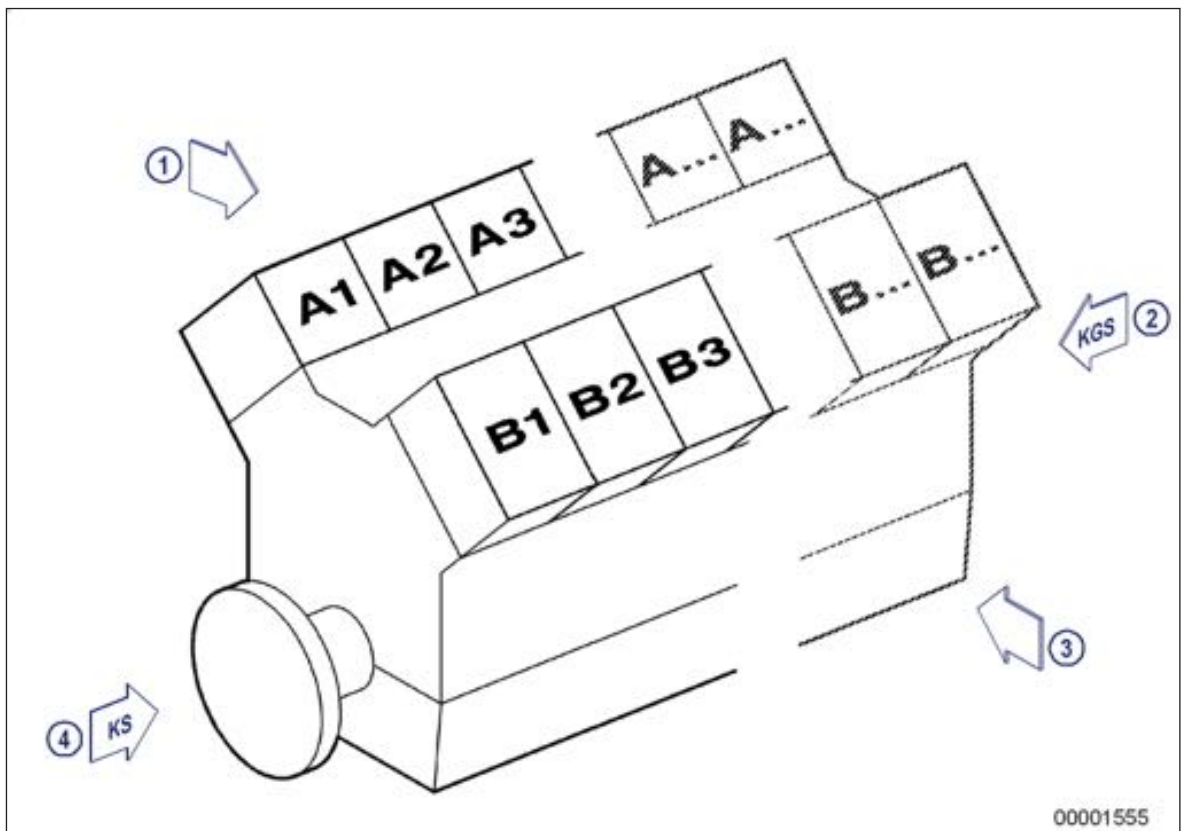


Sealing head/sealing cone with metric union nut		
Metric thread	Pipe outer Ø	Torque (Nm)
M16 x 1.5	8	45
	10	
M18 x 1.5	10	51
	12	
M20 x 1.5	12	58
M22 x 1.5	14	74
	15	
M24 x 1.5	16	74
M26 x 1.5	18	105
M30 x 2	20	135
	22	
M36 x 2	25	166
	28	
M42 x 2	30	240
M45 x 2	35	290
M52 x 2	38	330
	42	

Sealing head with BSP union nut	
BSP thread	Torque (Nm)
G1/4	20
G3/8	34
G1/2	60
G5/8	69
G3/4	115
G1	140
G1.1/4	210
G1.1/2	290
G2	400

## 2.2 Engine side and cylinder designations



- |  |  |
|--|--|
| 1 Left engine side (A-side)  | 3 Right engine side (B-side)   |
| 2 Engine free end in accordance with DIN ISO 1204 (KGS = Kupplungsgegen-seite) | 4 Engine driving end in accordance with DIN ISO 1204 (KS = Kupplungsseite) |

Engine sides are always designated (in accordance with DIN ISO 1204) as viewed from driving end (4).

For cylinder designation (in accordance with DIN ISO 1204), the letter "Ax" refers to the cylinders on the left-hand side of the engine (1) and letter "Bx" refers to the cylinders on the right-hand side (3). The cylinders of each bank are numbered consecutively, starting with x=1 at driving end (4).

The numbering of other engine components also starts with 1 at driving end (4).

## 2.3 Product description

### Description of the engine

#### Engine

The engine is a liquid-cooled four-stroke diesel engine with c.c.w. direction of rotation, direct injection, sequential turbocharging and charge-air cooling.

An electronic management system provides engine control and monitoring.

#### Fuel system with Common Rail injection

Controlled by the electronic engine management system, the common rail injection system determines injection pressure, injection timing and injection quantity independently of the engine speed.

Injection pressures up to 1800 bar ensure optimum fuel injection and combustion conditions.

#### Turbocharging system

The charging system comprises charge-air system, exhaust system and sequential turbocharging.

The exhaust system is equipped with triple-walled, water-cooled exhaust lines.

The triple-walled design permits

- low surface temperature,
- reduced thermal load,
- absolute gas-tightness.

#### Lube oil system

Wet-sump forced-feed lubrication system

Components supplied with oil:

- Bearings
- Piston cooling
- Control and actuating elements of the sequential turbocharging system

#### Cooling system

- Two separate cooling circuits:
  - Engine coolant
  - Raw water
- Coolant cooling by raw water-cooled plate-core heat exchanger
- Thermostat-controlled coolant system
- Coolant-cooled / preheated charge-air
- Coolant-cooled fuel return

#### Electronic system

Electronic control and monitoring system with integrated safety and test system with interfaces to the Remote Control System (RCS) and to the Monitoring and Control System (MCS).

#### Connection box EIM (Engine Interface Module)

The Engine Interface Module (EIM) is the central connection box on the engine. It covers the entire minimum scope of a Series marine engine. It has no controls or parts requiring maintenance.

Functions:

- Starter control (start repetition, tooth alignment, starter protection)
- Generator monitoring
- Open bus interface to the plant (SAE J1939)
- Emergency stop function with line break monitoring
- Redundant power supply
- Optional control of emergency air-shutoff flaps
- Key switch logic
- Interface to ECU and EMU
- MCS5 dialog interface
- Control of an MTU lube-oil priming pump (power components in separate MTU PPC Box)
- Connection facility for an MTU Local Operating Station (LOS)

### **Serial RS422 interface for diagnosis**

The engine interface is divided into two parts. The first part is integrated in the engine wiring harness via the 62-pole Tyco connector X52. The second part is formed by those signals involving a higher current. Such signals are routed out via M threaded pins and are also integrated in the engine wiring harness.

Functions

- ECU supply
- EMU supply
- Plant signals (ECU7 connector X1)
- Bus interface (2x MCS5 CAN)
- CAN dialog output (1x MCS5 CAN)
- ECU and EMU emergency stop
- Electric starter
- Terminal 45 starter A/B (engaged)
- Pneumatic starter
- Starting air pressure valve
- Starting air pressure sensor
- Barring gear (Barring Gear 1 and 2)
- Generator (with exciter control)
- Optional emergency air-shutoff flaps
- Activation of SDAF 1+2
- Feedback from SDAF 1+2

### **Electronic engine control unit (ECU)**

Closed-loop control:

- Engine speed
- Fuel HP

Open-loop control:

- Injection (fuel pressure, injection timing, injection duration, operating status)
- Sequential turbocharging (cutting-in and out) with secondary turbocharger
- Engine protection with multi-stage safety systems:
  - Power reduction
  - Power limitation
  - Emergency stop

#### Monitoring:

- Exhaust gas temperature, A side
- Exhaust temperature, B-side
- Engine speed
- Oil pressure
- Differential oil pressure
- Coolant temperature
- Coolant level
- Exhaust turbocharger speed
- Leak fuel level
- Oil temperature
- Coolant pressure
- Fuel pressure after filter

#### Monitoring in engine room

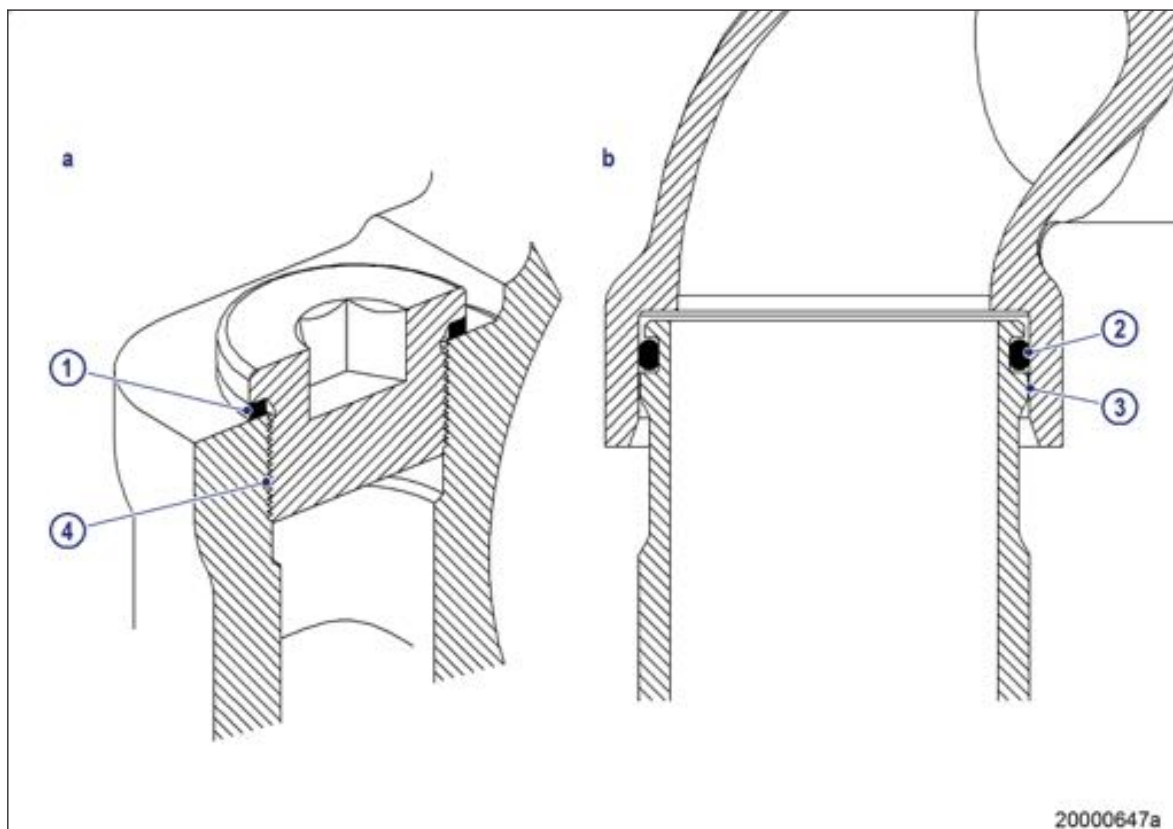
Engine control and monitoring unit (LOP)

#### Functions:

- Engine speed, oil pressure and coolant temperature are monitored and displayed
- Integrated safety system
- Integrated Test System
- Redundant CAN bus interface to governor and higher-level control and monitoring system
- 24 V DC supply

#### SOLAS – Fire protection specifications

#### Special connections



In case of leakage, the connection types shown above are spray-protected even without a cover and have been confirmed compliant with SOLAS by GL and DNV.

### Plug-in pipe union

The sleeve (3) covers the joint to prevent lateral spray.

Only leak-off along the line is possible, the pressure decreases significantly if an O-ring (2) fault occurs.

The connection is confirmed as compliant with SOLAS by DNV and GL.

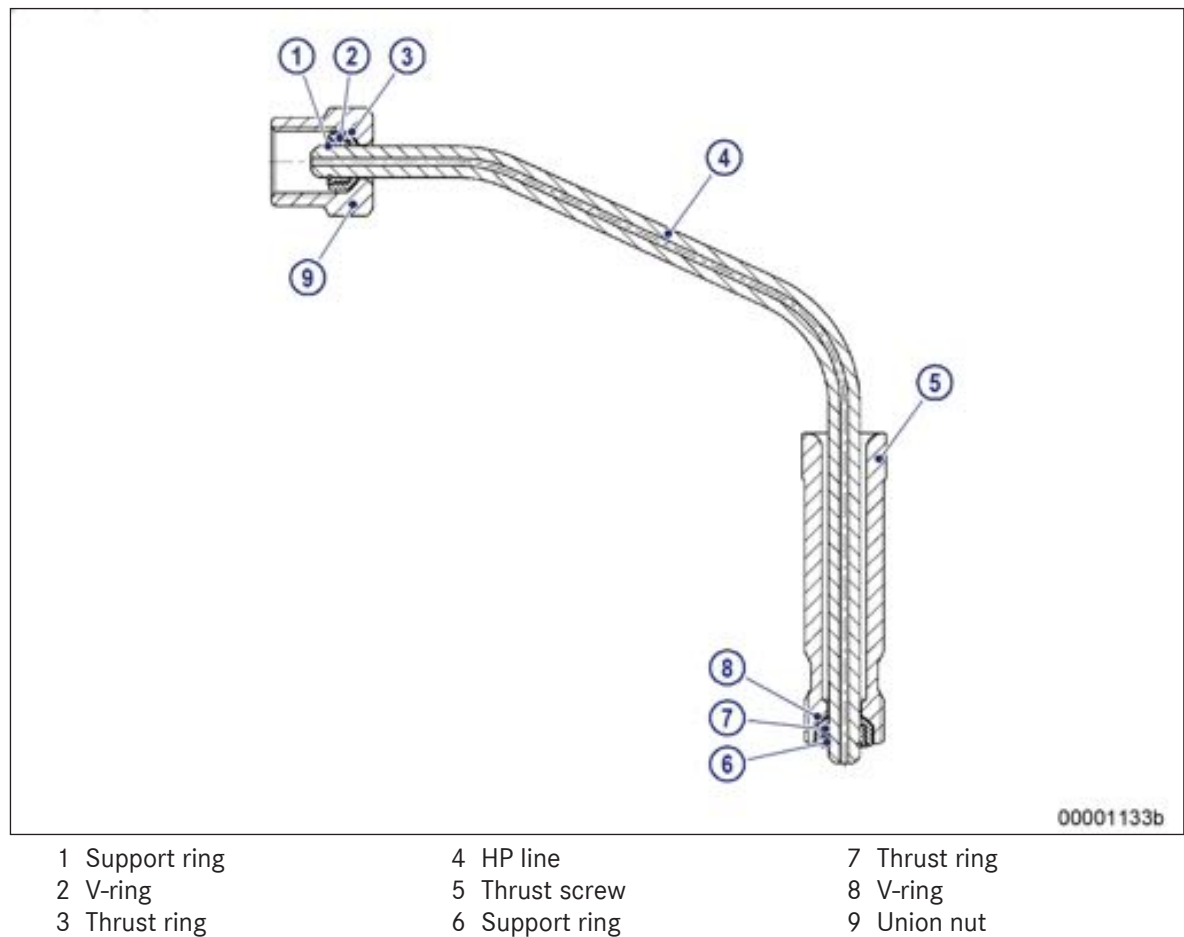
### Plugs and sensors

Screw-in plugs (4) are sealed toward the outside either with a copper sealing ring (1), according to DIN, or an O-ring (ISO).

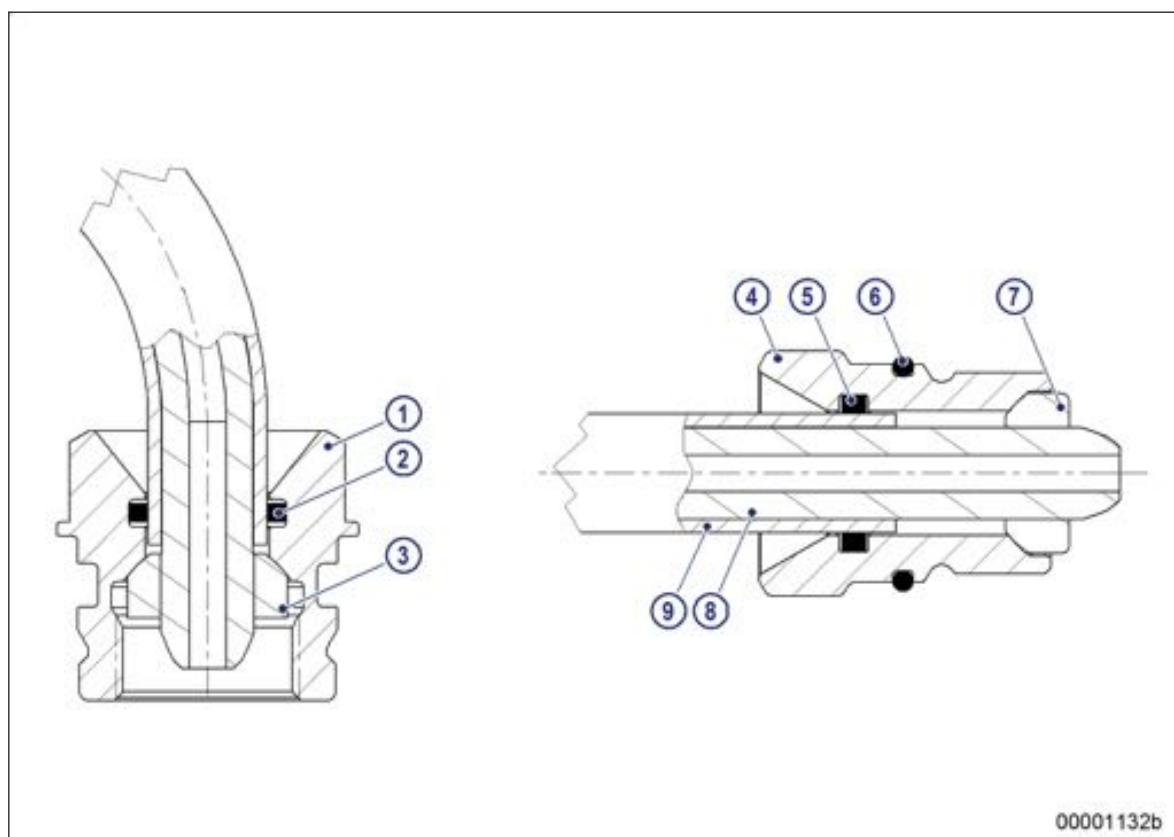
In case of a loose thread or a faulty sealing ring (1), the liquid first has to pass the thread.

The pressure is so greatly reduced by this and the faulty sealing ring (1) that any leakage is not under pressure.

### HP line between fuel injector and HP accumulator



## HP line between distributor and HP accumulator

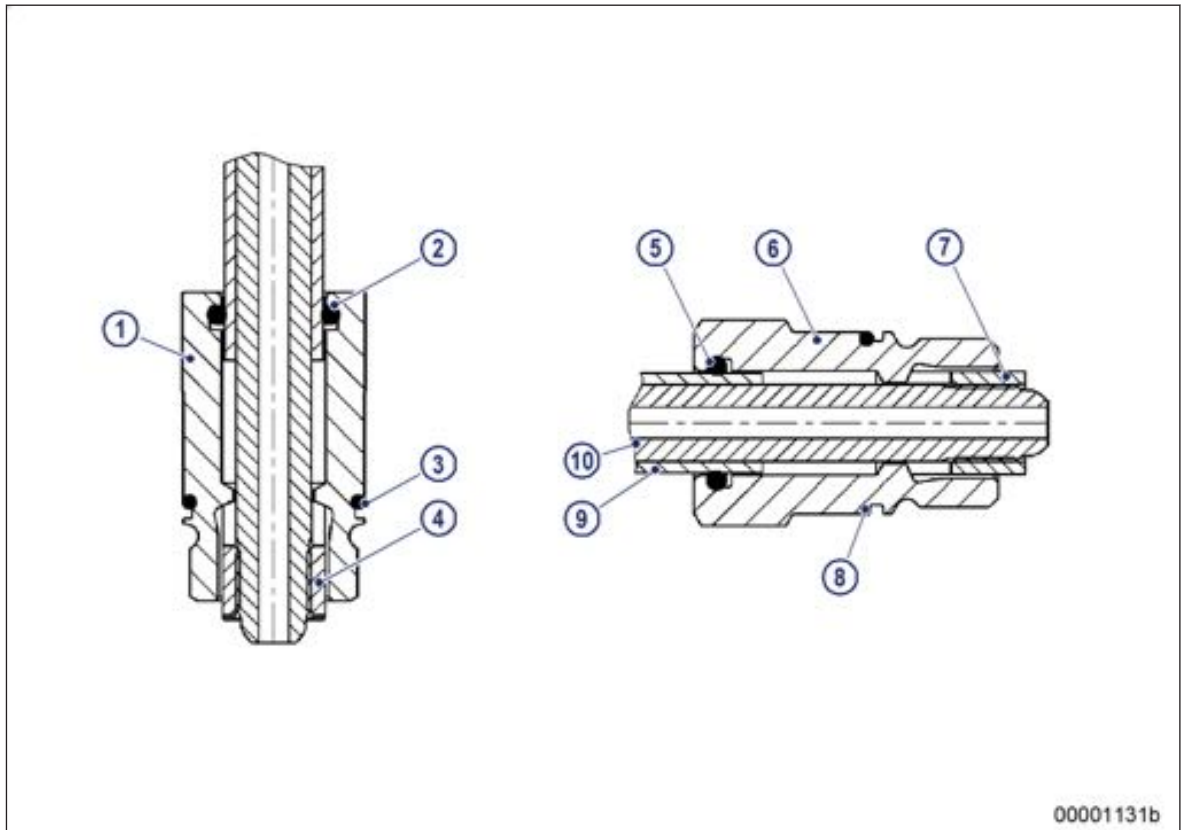


- 1 Union nut
- 2 O-ring
- 3 Thrust ring

- 4 Thrust screw
- 5 O-ring
- 6 O-ring

- 7 Thrust ring
- 8 Pressure pipe
- 9 Jacket pipe

## HP line between distributor and HP accumulator



- 1 Jacket pipe
- 2 O-ring
- 3 O-ring
- 4 Thrust ring

- 5 O-ring
- 6 Thrust screw
- 7 Thrust ring
- 8 O-ring

- 9 HP line
- 10 Pressure pipe

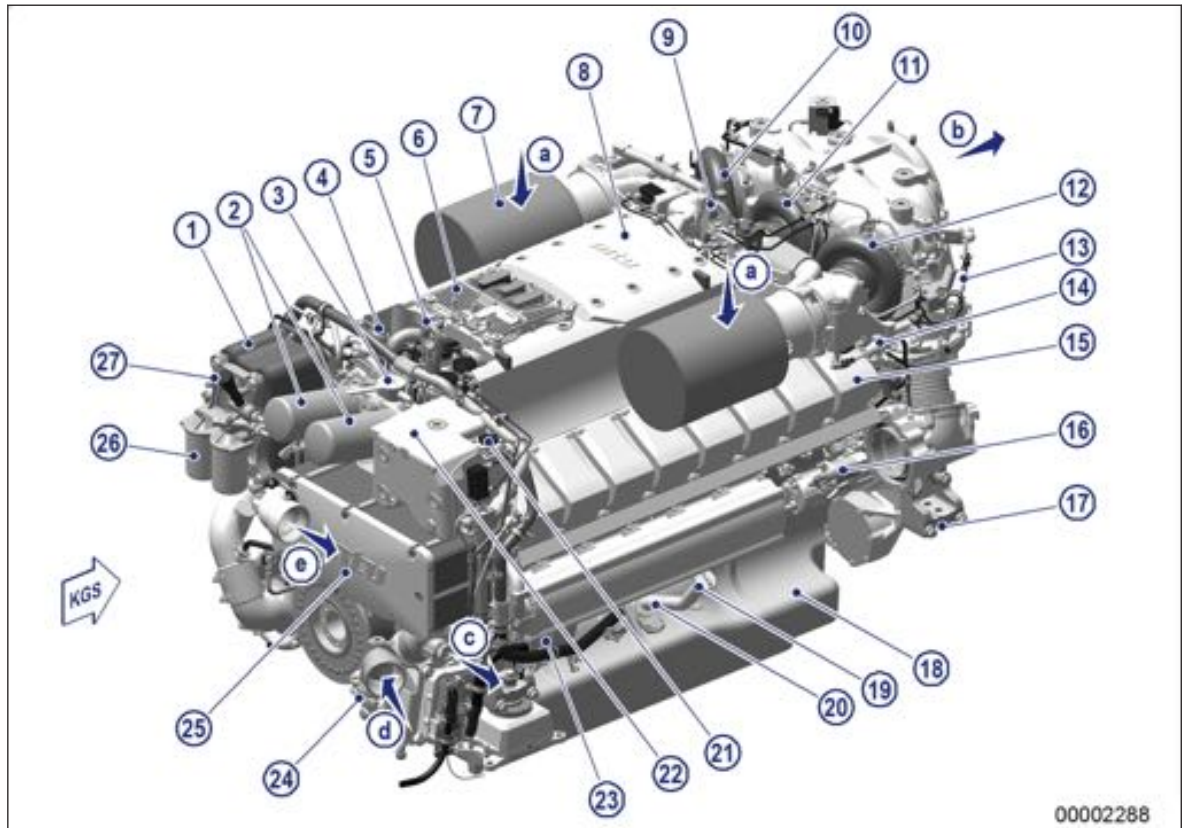
Leak-off fuel caused by leakages from the sealing cones or the HP lines is returned to the HP pump, from where it is routed at atmospheric pressure into a level-monitored leak-fuel tank.



## 2.4 Engine layout

### Overview of free end

Also applies similarly to 12V.

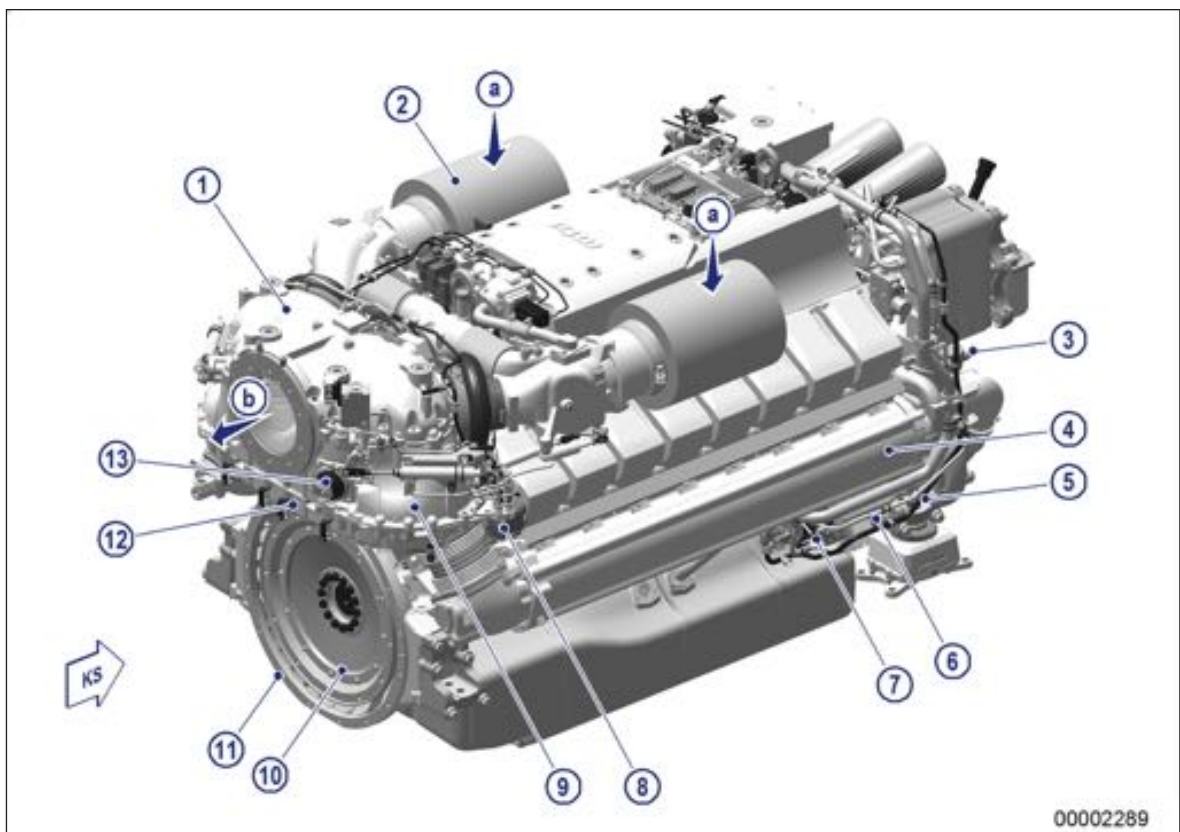


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- |   |  |  |
|---|--|--|
| 1 Engine oil heat exchanger                             | 12 Exhaust turbocharger, left (secondary turbocharger)         | 23 Battery-charging generator                    |
| 2 Engine oil filter                                     | 13 Actuating cylinder for exhaust flap                         | 24 Raw water pump                                |
| 3 Diverter lever for engine oil filter                  | 14 Actuating cylinder for air flap                             | 25 Plate-core heat exchanger                     |
| 4 Fuel cooler   | 15 Cylinder head cover   | 26 Fuel duplex filter (switchable)               |
| 5 Engine lifting eye (free end)                         | 16 Electric starter  | a Air intake                                     |
| 6 Engine governor                                       | 17 Engine mounting   | b Exhaust outlet (horizontal)                    |
| 7 Air filter (air intake)                               | 18 Exhaust housing   | c Raw water connection to gearbox cooling system |
| 8 Air collecting housing                                | 19 Oil filler neck   | d Raw water connection from sea                  |
| 9 Engine lifting eye (driving end)                      | 20 Oil dipstick  | e Raw water connection to sea                    |
| 10 Exhaust turbocharger, right (secondary turbocharger) | 21 Engine coolant filler neck                                  | KGS = Kupplungsgegenseite (free end)             |
| 11 Exhaust turbocharger (primary turbocharger)          | 22 Coolant distribution housing with integrated expansion tank |  |

### Overview of driving end

Also applies similarly to 12V.



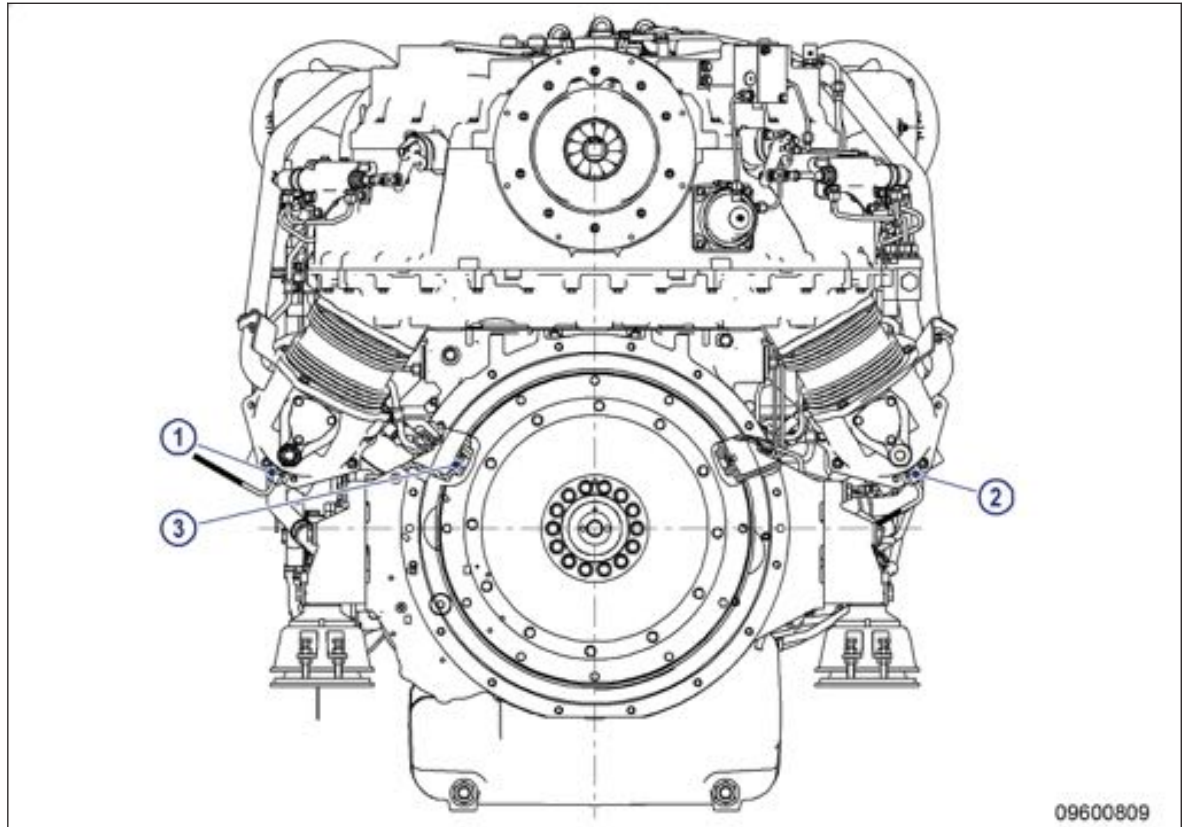
- |                                 |                                  |                                   |
|---------------------------------|----------------------------------|-----------------------------------|
| 1 Carrier housing upper section | 7 Fuel delivery pump             | 12 Carrier housing lower section  |
| 2 Air filter (air intake)       | 8 Exhaust turbocharger oil valve | 13 Bleeder valve                  |
| 3 Thermostat housing            | 9 Carrier housing middle section | a Air intake                      |
| 4 Exhaust housing               | 10 Drive flange                  | b Exhaust outlet                  |
| 5 Crankcase vent line           | 11 Flywheel housing              | KS = Kupplungsseite (driving end) |
| 6 HP fuel pump                  | 11 Fuel filter                   |                                   |

## Engine model designation

Key to the engine model designation 12V/16V 2000 Mxyz	
12/16	Number of cylinders
V	Cylinder arrangement: V engine
2000	Series
M	Application
x	Application segment (4, 5, 6, 7, 8, 9)
y	Design index (0, 1, 2, ...)
z	Special features

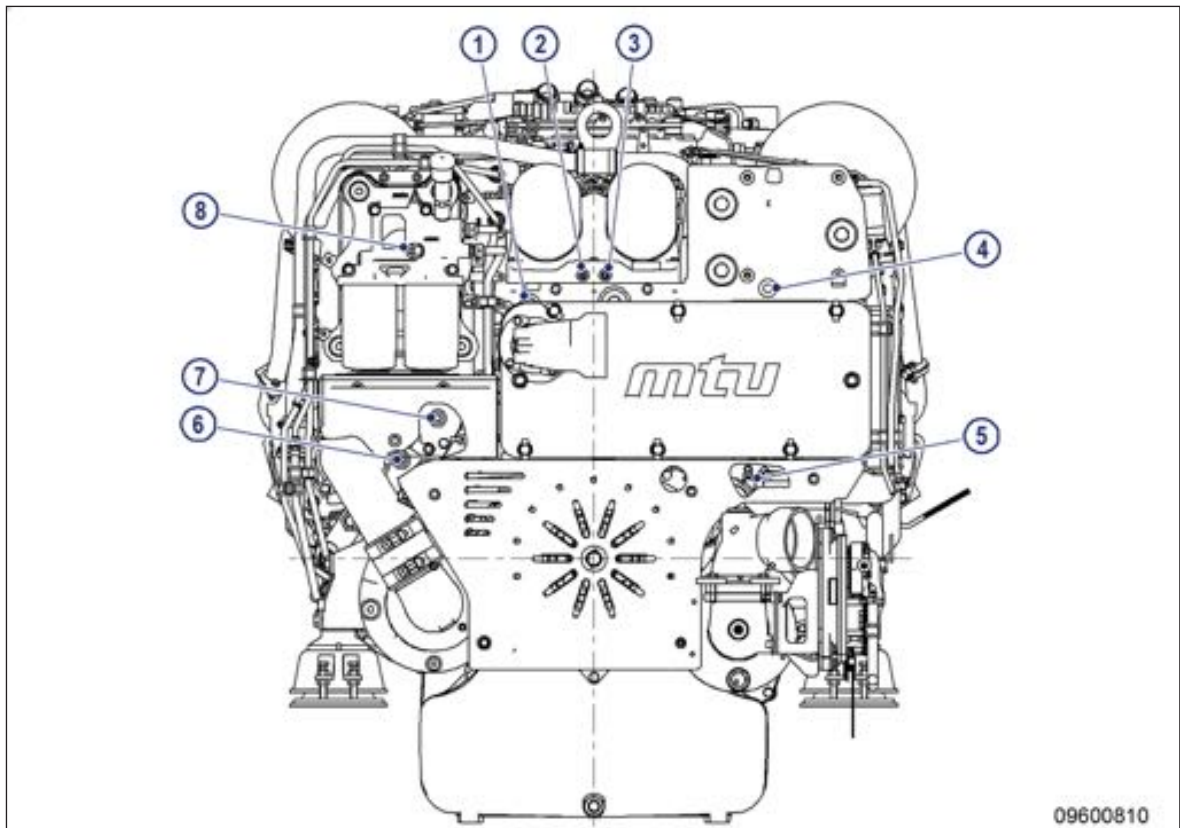
## 2.5 Sensors and actuators - Overview

### Sensors and actuators on engine driving end



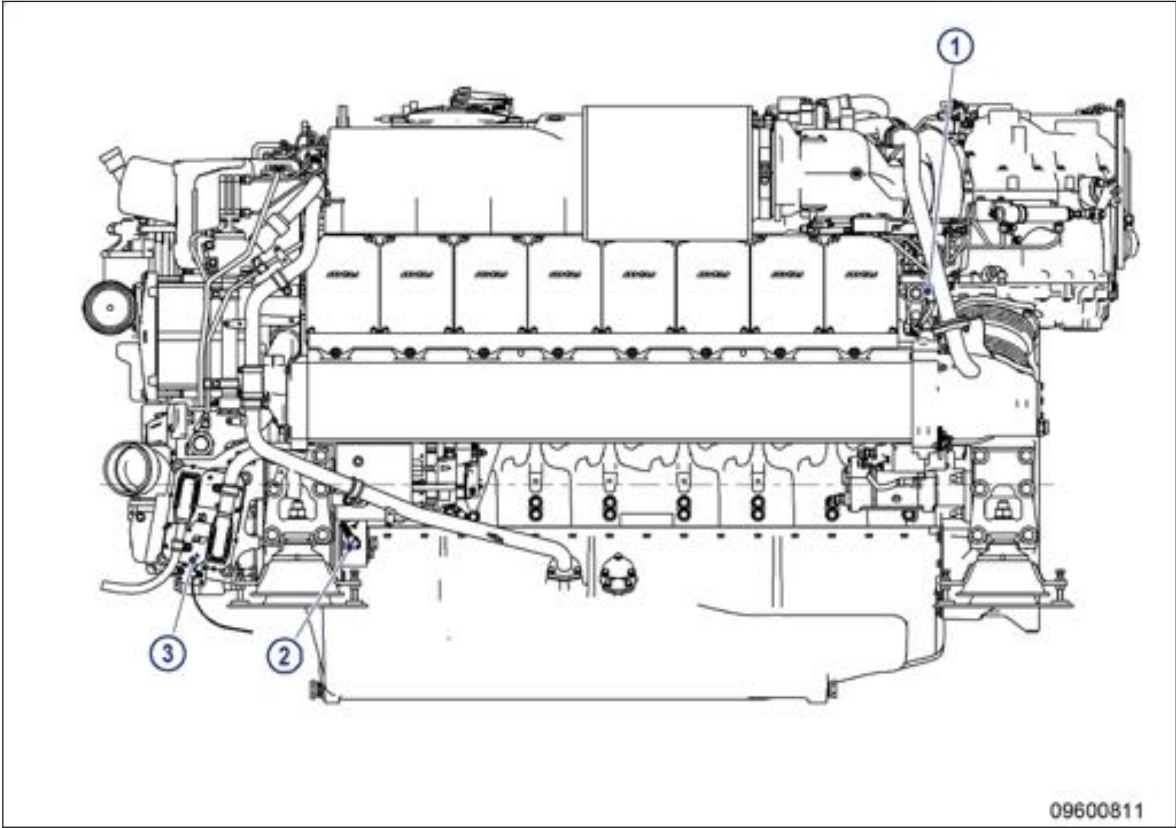
Item	Name	Monitoring of
1	B4.21	ETC temperature, A side
2	B4.22	ETC temperature, B side
3	B13.1	Crankshaft speed

## Sensors and actuators on engine free end



Item	Name	Monitoring of
1	B5.3	Lube oil pressure before filter
2	B5.2	Lube oil pressure after filter
3	B5.1	Lube oil pressure after filter
4	F33	Coolant level probe in expansion tank
5	B21	Raw water pressure
6	B6.2	Coolant temperature
7	B6.1	Coolant temperature
8	B34	Fuel pressure after filter

Sensors and actuators on left side

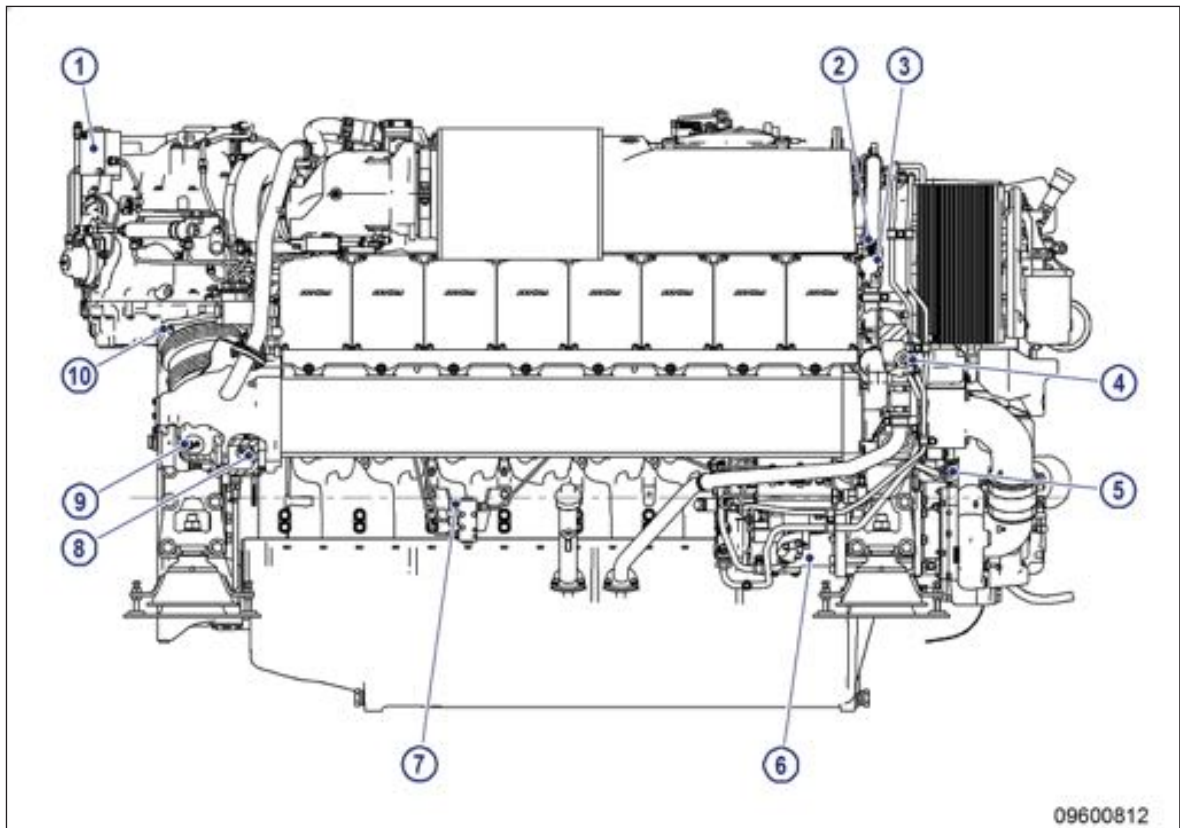


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Item	Name	Monitoring of
1	Y27.1	4/2 directional control valve, A side
2	B54	Oil replenishment pump pressure
3	A18	EIM Engine Interface Module



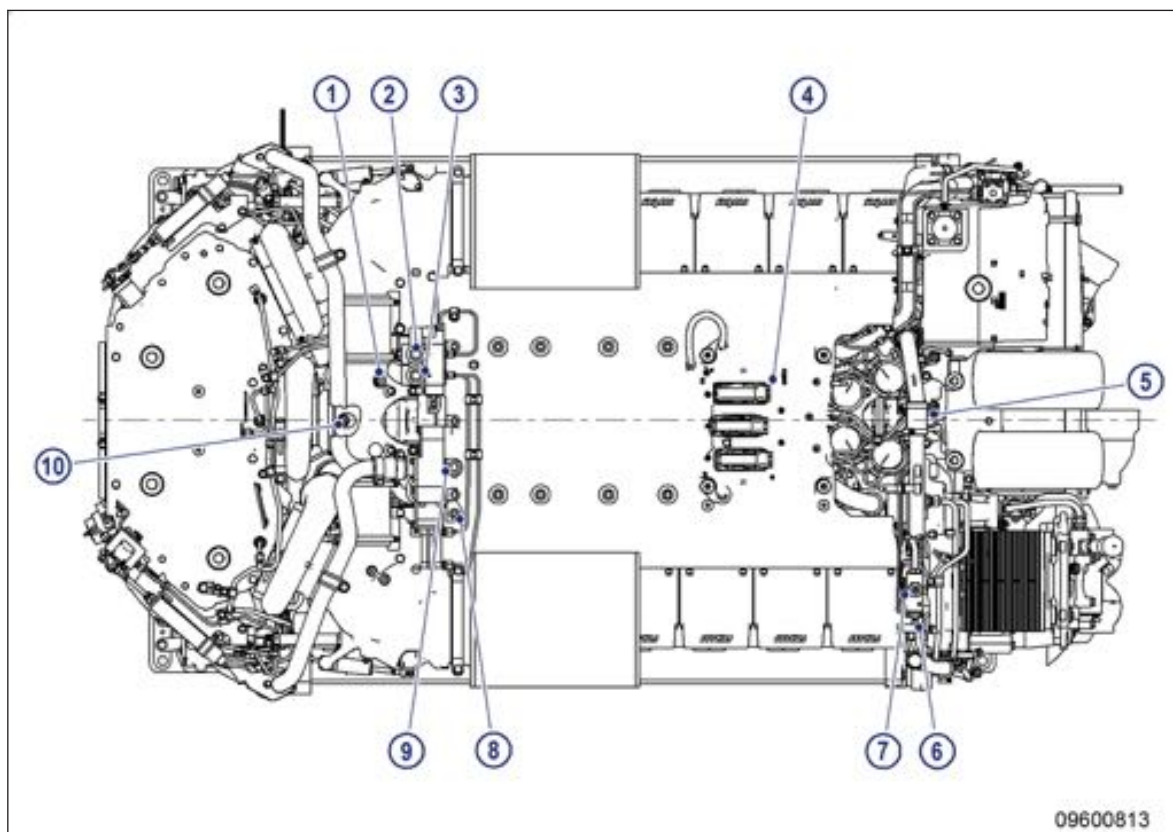
## Sensors and actuators on right side



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Item	Name	Monitoring of
1	M52	Exhaust gas recirculation (bypass at ETC)
2	B48	HP fuel pressure
3	Y45.1	Pressure regulating valve
4	A19	EIL electronic label
5	B16	Coolant pressure
6	M8	CR pump
7	F46	Leak fuel level
8	B1	Camshaft speed, B side
9	B13.2	Crankshaft speed
10	Y27.2	4/2 directional control valve, B side

## Sensors and actuators on engine top



Item	Name	Monitoring of
1	B3	Intake air temperature
2	Y35	4/2 mixing valve, intercooler
3	Y56	4/2 directional control valve, recirculation
4	A77	EMU Engine Monitoring Unit
5	B7	Lube oil temperature
6	B33	Fuel temperature
7	Y45.2	Pressure regulating valve
8	B9	Charge air temperature
9	B10	Charge air pressure
10	B44	ETC speed

## 3 Technical Data

### 3.1 12V 2000 M86/M96/M96L engine data

Explanation:

DL Ref. value: Continuous power

BL Ref. value: Fuel stop power

A Design value

G Guaranteed value

R Guideline value

L Limit value, up to which the engine can be operated, without change (e.g. of power settings).

N Not yet defined value

- Not applicable

X Applicable

#### REFERENCE CONDITIONS

Reference conditions	-	Unit	Value
Application group	-	-	1DS
Intake air temperature	-	°C	25
Raw water inlet temperature	-	°C	25
Barometric pressure	-	mbar	1000
Site altitude above sea level	-	m	100

#### POWER-RELATED DATA (power ratings are net brake power as per ISO 3046)

Power-related data		-	Unit	Value
Number of cylinders		-	-	12
Rated engine speed		A	rpm	2450
Fuel stop power ISO 3046:	12V 2000 M86	A	kW	1268
	12V 2000 M96	A	kW	1342
	12V 2000 M96L	A	kW	1432

#### GENERAL CONDITIONS (for maximum power)

General conditions	-	Unit	Value
Intake depression (new filter)	A	mbar	15
Intake depression, max.	L	mbar	30

#### MODEL-RELATED DATA (basic design)

Model-related data	-	Unit	Value
Cylinder arrangement: V-angle	-	Degrees (°)	90
Bore	-	mm	135
Stroke	-	mm	156
Displacement, cylinder	-	Liters	2.23
Displacement, total	-	Liters	26,76

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Model-related data	-	Unit	Value
Number of inlet valves per cylinder	-	-	2
Number of exhaust valves per cylinder	-	-	2

## RAW WATER CIRCUIT (open circuit)

Raw water circuit	-	Unit	Value
Raw water pump: Inlet pressure, min.	L	bar	-0.4
Raw water pump: Inlet pressure, max.	L	bar	+0.5
Pressure loss in engine-external raw water system, max.	L	bar	0.7

## LUBE OIL SYSTEM

Lube oil system	-	Unit	Value
Lube-oil operating temperature before engine, from	R	°C	-
Lube oil operating temperature before engine, to	R	°C	-
Lube oil operating pressure upstream of engine, from	R	bar	-
Lube-oil operating pressure before engine, to	R	bar	-
Lube oil operating pressure (low idle) (meas. point: before engine)	R	bar	-

## FUEL SYSTEM

Fuel system	-	Unit	Value
Fuel pressure at engine inlet connection, min. (when engine is starting)	L	bar	-0.3
Fuel pressure at supply connection to engine, min. (when engine is running)	L	bar	-0.3
Fuel pressure at engine inlet connection, max. (when engine is starting)	L	bar	+0.25
Fuel supply flow, max.	R	Liter/min	-

## GENERAL OPERATING DATA

Engine speed	-	Unit	Value
Firing speed, from	R	rpm	100
Firing speed. to	R	rpm	120

## STARTER (electric)

Starter	-	Unit	Value
Rated starter voltage (standard design)	R	V=	24

## INCLINATIONS, STANDARD OIL SYSTEM (reference: waterline)

Inclinations, standard oil system	-	Unit	Value
Longitudinal inclination, continuous max. driving end down (option: max. operating inclinations)	L	Degrees (°)	-
Longitudinal inclination, temporary max. driving end down (option: max. operating inclinations)	L	Degrees (°)	-
Longitudinal inclination, continuous max. driving end up (option: max. operating inclinations)	L	Degrees (°)	-
Longitudinal inclination, temporary max. driving end up (option: max. operating inclinations)	L	Degrees (°)	-

Inclinations, standard oil system	-	Unit	Value
Transverse inclination continuous max. (option: max. operating inclinations)	L	Degrees (°)	-
Transverse inclination, temporary max. (option: max. operating inclinations)	L	Degrees (°)	-

## CAPACITIES

Capacities	-	Unit	Value
Engine coolant capacity, engine side (with cooling equipment)	R	Liters	125
Engine oil capacity, initial filling (standard oil system) (design: max. operating inclinations)	R	Liters	123
Oil change quantity max. (standard oil system) (design: max. operating inclinations)	R	Liters	-
Oil pan capacity dipstick mark min. (standard oil system) (design: max. operating inclinations)	L	Liters	-
Oil pan capacity dipstick mark max. (standard oil system) (design: max. operating inclinations)	L	Liters	-

## WEIGHT

Weight	-	Unit	Value
Engine dry weight (with mounted standard accessories, w/o coupling)	R	kg	-

## NOISE

Noise	-	Unit	Value
Exhaust noise, unsilenced - BL (free-field sound-pressure level Lp, 1m distance, ISO 6798, +3dB(A) tolerance)	R	dB(A)	-
Engine surface noise with attenuated intake noise (filter) - BL (free-field sound-pressure level Lp, 1 m distance, ISO 6798, +2dB(A) tolerance)	R	dB(A)	-

## 3.2 16V 2000 M86/M86/M96L engine data

Explanation:

DL Ref. value: Continuous power

BL Ref. value: Fuel stop power

A Design value

G Guaranteed value

R Guideline value

L Limit value, up to which the engine can be operated, without change (e.g. of power settings).

N Not yet defined value

- Not applicable

X Applicable

### REFERENCE CONDITIONS

Reference conditions	-	Unit	Value
Application group	-	-	1DS
Intake air temperature	-	°C	25
Raw water inlet temperature	-	°C	25
Barometric pressure	-	mbar	1000
Site altitude above sea level	-	m	100

### POWER-RELATED DATA (power ratings are net brake power as per ISO 3046)

Power-related data		-	Unit	Value
Number of cylinders		-	-	16
Rated engine speed		A	rpm	2450
Fuel stop power ISO 3046	16V 2000 M86	A	kW	1630
	16V 2000 M96	A	kW	1790
	16V 2000 M96L	A	kW	1939

### GENERAL CONDITIONS (for maximum power)

General conditions	-	Unit	Value
Intake depression (new filter)	A	mbar	15
Intake depression, max.	L	mbar	30

### MODEL-RELATED DATA (basic design)

Model-related data	-	Unit	Value
Cylinder arrangement: V-angle	-	Degrees (°)	90
Bore	-	mm	135
Stroke	-	mm	156
Displacement, cylinder	-	Liters	2.23
Displacement, total	-	Liters	35.68
Number of inlet valves per cylinder	-	-	2
Number of exhaust valves per cylinder	-	-	2

## RAW WATER CIRCUIT (open circuit)

Raw water circuit	-	Unit	Value
Raw water pump: Inlet pressure, min.	L	bar	-0.4
Raw water pump: Inlet pressure, max.	L	bar	+0.5
Pressure loss in engine-external raw water system, max.	L	bar	0.7

## LUBE OIL SYSTEM

Lube oil system	-	Unit	Value
Lube-oil operating temperature before engine, from	R	°C	-
Lube oil operating temperature before engine, to	R	°C	-
Lube oil operating pressure upstream of engine, from	R	bar	-
Lube-oil operating pressure before engine, to	R	bar	-
Lube oil operating pressure (low idle) (meas. point: before engine)	R	bar	-

## FUEL SYSTEM

Fuel system	-	Unit	Value
Fuel pressure at engine inlet connection, min. (when engine is starting)	L	bar	-0.3
Fuel pressure at supply connection to engine, min. (when engine is running)	L	bar	-0.3
Fuel pressure at engine inlet connection, max. (when engine is starting)	L	bar	+0.25
Fuel supply flow, max.	A	Liter/min	-

## GENERAL OPERATING DATA

Engine speed	-	Unit	Value
Firing speed, from	R	rpm	100
Firing speed, to	R	rpm	120

## STARTER (electric)

Starter	-	Unit	Value
Rated starter voltage (standard design)	R	V=	24

## INCLINATIONS, STANDARD OIL SYSTEM (reference: waterline)

Inclinations, standard oil system	-	Unit	Value
Longitudinal inclination, continuous max. driving end down (option: max. operating inclinations)	L	Degrees (°)	20
Longitudinal inclination, temporary max. driving end down (option: max. operating inclinations)	L	Degrees (°)	22.5
Longitudinal inclination, continuous max. driving end up (option: max. operating inclinations)	L	Degrees (°)	15
Longitudinal inclination, temporary max. driving end up (option: max. operating inclinations)	L	Degrees (°)	17.5
Transverse inclination continuous max. (Option: max. operating inclinations)	L	Degrees (°)	15
Transverse inclination, temporary max. (option: max. operating inclinations)	L	Degrees (°)	22.5

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## CAPACITIES

Capacities	-	Unit	Value
Engine coolant capacity, engine side (with cooling equipment)	R	Liters	135
Engine oil capacity, initial filling (standard oil system) (design: max. operating inclinations)	R	Liters	145
Oil change quantity max. (standard oil system) (design: max. operating inclinations)	R	Liters	134
Oil pan capacity dipstick mark min. (standard oil system) (design: max. operating inclinations)	L	Liters	106
Oil pan capacity dipstick mark max. (standard oil system) (design: max. operating inclinations)	L	Liters	134

## WEIGHT

Weight	-	Unit	Value
Engine dry weight (with mounted standard accessories, w/o coupling)	R	kg	3160

## NOISE

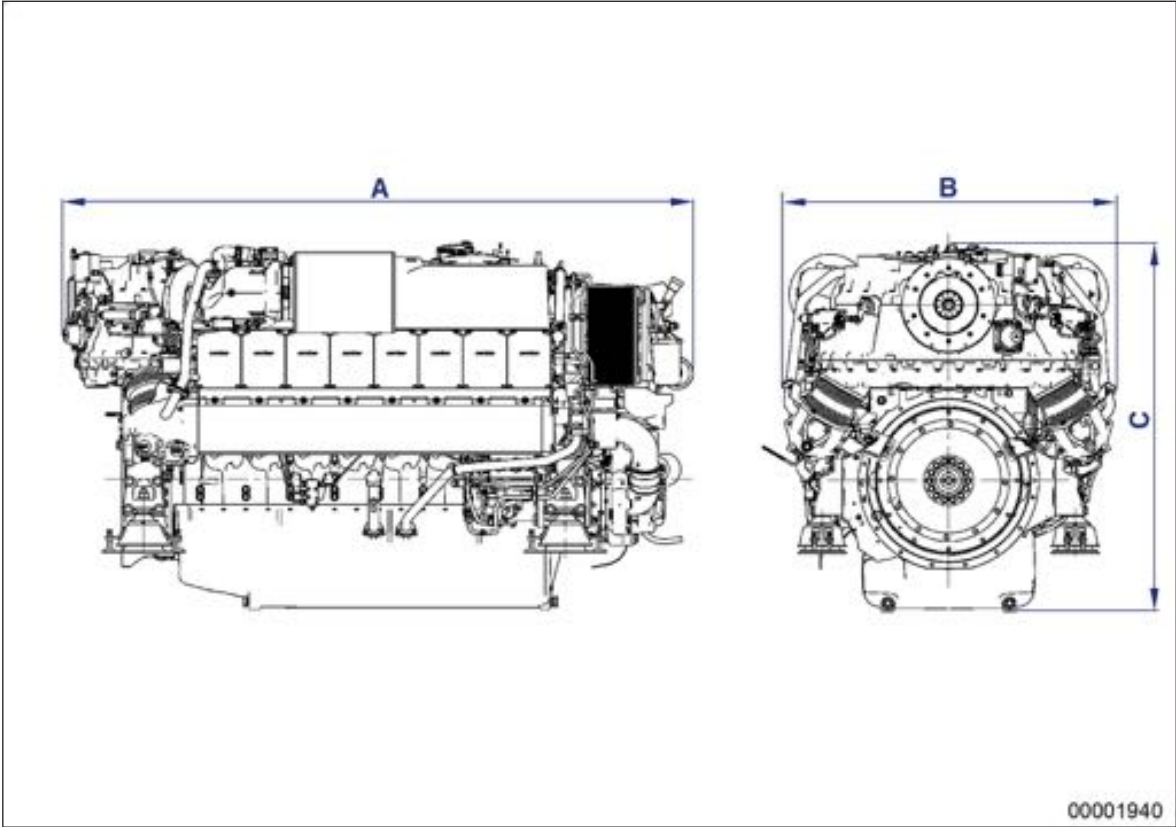
Noise	-	Unit	Value
Exhaust noise, unsilenced - BL (free-field sound-pressure level Lp, 1m distance, ISO 6798, +3dB(A) tolerance)	R	dB(A)	-
Engine surface noise with attenuated intake noise (filter) - BL (free-field sound-pressure level Lp, 1 m distance, ISO 6798, +2dB(A) tolerance)	R	dB(A)	-

### 3.3 Firing order

Firing order	
12 V	A1-B5-A5-B3-A3-B6-A6-B2-A2-B4-A4-B1
16 V	A1-B5-A3-A5-B2-B8-A2-A8-B3-A7-B4-B6-A4-A6-B1-B7

### 3.4 Engine - Main dimensions

#### Main dimensions



Engine model	Length (A)	Width (B)	Height (C)
16V 2000 M86 16V 2000 M96 16V 2000 M96L	2495 mm	1318 mm	1455 mm
12V 2000 M86 12V 2000 M96 12V 2000 M96L	2082 mm	1292 mm	1440 mm

## 4 Operation

### 4.1 Putting the engine into operation after extended out-of-service periods (>3 months)

#### Preconditions

- ☑ Engine is stopped and starting disabled.
- ☑ MTU Preservation and Represervation Instructions (A001070/..) available.

#### Putting the engine into operation (out-of-service period > 3 months)

Item	Action
Engine	Depreserve (→ MTU Preservation and Represervation Instructions A001070/..).
Lube oil system	Check engine oil level (→ Page 97).
Fuel prefilter	Fill with fuel (→ Page 90).
Fuel prefilter, pressure gage	Align adjustable pointer with position of pressure indicator (→ Page 85).
Fuel system	Vent (→ Page 83).
Raw water pump (if located above waterline)	Prime (approx. 3 to 4 liters). Filling point (→ Page 100).
Coolant circuit	If engine is out of service for more than one year, change engine coolant (→ Page 104).
Coolant circuit	Check coolant level (→ Page 103).
Coolant circuit	Heat engine coolant with coolant preheating unit.
Engine Control Unit ECU	Check plug connections (→ Page 118).
Engine Interface Module EIM	Check plug connections (→ Page 120).
Engine Monitoring Unit EMU	Check plug connections (→ Page 119).



## 4.2 Engine – Putting into operation after scheduled out-of-service-period

### Preconditions

☒ Engine is stopped and starting disabled.

### Putting into operation

Item	Action
Lube oil system	Check engine oil level (→ Page 97).
Coolant circuit	Check coolant level (→ Page 103).
Coolant circuit	Heat engine coolant with coolant preheating unit.
Fuel prefilter	Drain water and contaminants (→ Page 86).
Battery-charging generator drive	Check condition of drive belt (→ Page 113).
Engine Control Unit ECU	Check plug connections (→ Page 118).
Engine Interface Module EIM	Check plug connections (→ Page 120).
Engine Monitoring Unit EMU	Check plug connections (→ Page 119).

## 4.3 Operational checks

### DANGER



Rotating and moving engine parts.

**Risk of crushing, danger of parts of the body being caught or pulled in!**

- Only run the engine at low power. Keep away from the engine's danger zone.

### WARNING



High level of engine noise when the engine is running.

**Risk of damage to hearing!**

- Wear ear protectors.

### Operational checks

Item	Measure
Engine under load Engine at nominal speed	Visually inspect engine for leaks and general condition; Check for abnormal running noises and vibration; Check exhaust color (→ Page 57).
Fuel prefilter	Check if suction-side pressure indicated at the fuel prefilter is within the limit (→ Page 85). Drain water and contaminants (→ Page 86).
Air filter	Check signal ring position of contamination indicator (→ Page 95). Replace air filter (→ Page 93), if the signal ring is completely visible in the service indicator observation window.
HT coolant pump	Check relief bore for oil and coolant discharge and contamination (→ Page 107).
Raw water pump	Check relief bore for oil and water discharge and contamination (→ Page 110).
Intercooler	Check condensate drain (if applicable) (→ Page 92).
Engine oil	Check engine oil level (→ Page 97).

## 4.4 Starting the engine

### Preconditions

- ☑ External start interlock is not active.
- ☑ Emergency air shut-off flaps (if fitted) are open.

#### DANGER



Rotating and moving engine parts.

**Risk of crushing, danger of parts of the body being caught or pulled in!**

- Before cranking the engine with starter system, make sure that there are no persons in the engine's danger zone.

#### WARNING



High level of engine noise when the engine is running.

**Risk of damage to hearing!**

- Wear ear protectors.

### The engine can be started from the following points

Item	Action
Control stand	(→ Operating instructions for electronic system)
Local Operating Panel LOP	(→ Operating instructions for electronic system)
Local Operation Station LOS	(→ Operating instructions for electronic system)
CCU	(→ Operating instructions for electronic system)

## 4.5 Engine - Shutdown

### Preconditions

- ☑ Engine is running in Local mode

#### NOTICE



Stopping the engine when it is running at full load causes extreme stress to the engine.

#### **Risk of overheating, damage to components!**

- Before shutting down, disengage gear and run the engine at idle speed for at least 10 minutes until engine temperatures have dropped and constant values are displayed.

### The engine can be stopped from the following points

Item	Action
Control stand	(→ Operating instructions for electronic system)
Local Operating Panel LOP	(→ Operating instructions for electronic system)
Local Operation Station LOS	(→ Operating instructions for electronic system)
CCU	(→ Operating instructions for electronic system)

## 4.6 Emergency engine stop

### NOTICE



An emergency stop causes extreme stress to the engine plant.

**Risk of overheating, damage to components!**

- Initiate emergency stop only in emergency situations.

### An emergency engine stop can be initiated from the following points

Item	Action
Control stand	(→ Operating instructions for electronic system)
Local Operating Panel LOP	(→ Operating instructions for electronic system)
Local Operation Station LOS	(→ Operating instructions for electronic system)
CCU	(→ Operating instructions for electronic system)

## 4.7 After stopping the engine

### Preconditions

☑ MTU Fluids and Lubricants Specifications (A001061/..) are available.

### After stopping the engine

Item	Measure
Coolant circuit	Drain coolant (→ Page 105) if: <ul style="list-style-type: none"><li>• freezing temperatures are expected and the engine is to remain out of service for an extended period, but engine coolant has no antifreeze additive;</li><li>• the engine room is not heated;</li><li>• the coolant is not kept at a suitable temperature;</li><li>• the antifreeze concentration is insufficient for the engine-room temperature;</li><li>• antifreeze concentration is 50 % and engine-room temperature is below -40°C.</li></ul>
Raw water	Drain <ul style="list-style-type: none"><li>• if freezing temperatures are to be expected and the engine is to remain out of service for an extended period.</li></ul>
Engine control system	Switch off.
Air intake and exhaust system	Out-of-service-period > 1 week <ul style="list-style-type: none"><li>• Seal engine's air and exhaust sides.</li></ul>
Engine	Out-of-service-period > 1 month <ul style="list-style-type: none"><li>• Depreserve engine (→ MTU Preservation and Represervation Specifications A001070/..)</li></ul>

## 4.8 Plant – Cleaning

### Preconditions

- ☑ Engine is stopped and starting disabled.
- ☑ Operating voltage is not applied.

### Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Steam jet cleaner	-	1
Cleaner (Hakupur 312)	30390	1

#### WARNING



Compressed air gun ejects a jet of pressurized air.

**Risk of injury to eyes and damage to hearing, risk of rupturing internal organs!**

- Never direct air jet at people.
- Always wear safety goggles/face mask and ear defenders.

#### WARNING



Steam jet cleaner ejects jet of pressurized water.

**Risk of injury to eyes and scalding!**

- Never direct water jet at people.
- Wear protective clothing, protective gloves and safety goggles/face mask.

#### NOTICE



Cleaning agents should not be left to take effect for too long.

**Damage to components is possible!**

- Observe manufacturer's instructions.

#### NOTICE



Blowing down product with compressed air.

**Entry of dirt and damage to components is possible!**

- Do not aim compressed air gun directly at seals or electronic components such as connectors or ECUs.

### Plant – Cleaning

1. Carry out plant cleaning only in areas where an appropriate oil separator is provided (environmental protection).
  2. Prior to putting the cleaning unit into operation, read the operating instructions of the water/steam jet unit carefully and observe the safety precautions.
  3. For external cleaning of the plant with water or steam-jet cleaners:
    - The pressure of the high-pressure jet (cleaning jet) must not exceed 50 bar.
    - A minimum distance between spray nozzle and plant of 1 m must be observed.
    - The temperature of the cleaning medium must not exceed 80°C.
  4. For external cleaning with high-pressure jet, use a flat-mouth nozzle only.
- Note: Never aim compressed air directly at electronic components.
5. Carry out external cleaning as follows:
    - a) Seal all openings in a suitable way.
    - b) Remove coarse dirt.
    - c) Spray on cleaner sparingly and leave it for 1 to 5 minutes.
    - d) Use the high-pressure jet to remove the loosened dirt.
    - e) Dry engine with compressed air.

# 5 Maintenance

## 5.1 Maintenance task reference table [QL1]

The maintenance tasks and intervals for this product are defined in the Maintenance Schedule. The Maintenance Schedule is a stand-alone publication.

The task numbers in this table provide reference to the maintenance tasks specified in the Maintenance Schedule.

Task	Option	Maintenance tasks	
W0500		Check engine oil level.	(→ Page 97)
W0501		Visually inspect engine for leaks and general condition.	(→ Page 50)
W0502	X	Check intercooler drain(s).	(→ Page 92)
W0503		Check maintenance indicator of air filter.	(→ Page 95)
W0505		Check relief bores of water pump(s).	(→ Page 107) (→ Page 110)
W0506		Check engine for abnormal running noises, exhaust color and vibrations.	(→ Page 50)
W0507	X	Drain water and contaminants from fuel prefilter.	(→ Page 86)
W0508	X	Check reading on differential pressure gage of fuel prefilter.	(→ Page 85)
W1001		Replace fuel filter or fuel filter element.	(→ Page 84)
W1002		Check valve clearance and adjust as necessary.	(→ Page 77)
W1005		Replace air filter.	(→ Page 93)
W1006		Replace fuel injectors.	(→ Page 80)
W1008		Replace engine oil filter when changing engine oil, or when the interval (years) is reached, at the latest.	(→ Page 99)
W1009	X	Check layer thickness of oil residue, clean out and replace filter sleeve when engine oil is changed at the latest.	-
W1011		Perform endoscopic examination.	(→ Page 71)
W1244	X	Check function of rod electrode .	-
W1245	X	Check alarm function of differential pressure gage .	-
W1246	X	Check pump capacity.	-
W1675	X	Replace fuel prefilter or fuel prefilter element.	(→ Page 90)

Table 2: Maintenance task reference table [QL1]



## 6 Troubleshooting

### 6.1 Troubleshooting

#### Engine does not turn when starter is actuated

Cause	Corrective action
Battery flat or defective.	► Charge or replace (see manufacturer's documentation).
Cable connections on battery are defective.	► Check if cable connections are properly secured (see manufacturer's documentation).
Engine wiring or starter defective.	► Check if cable connections are properly secured, contact Service.
Engine wiring faulty.	► Check (→ Page 115).
Plug connections are loose at interface module EIM.	► Check plug connections (→ Page 120).

#### Engine turns but does not fire

Cause	Corrective action
Poor rotation by starter: Battery flat or defective.	► Charge or replace battery (see manufacturer's documentation).
Engine wiring faulty.	► Check (→ Page 115).
Air in fuel system.	► Vent fuel system (→ Page 83).
Engine governor ECU is defective.	► Contact Service.

#### Engine fires unevenly

Cause	Corrective action
Injector faulty.	► Replace (→ Page 80).
Injection pump faulty.	► Contact Service.
Engine wiring faulty.	► Check (→ Page 115).
Air in fuel system.	► Vent fuel system (→ Page 83).

#### Engine does not reach full load speed

Cause	Corrective action
Fuel supply blocked.	► Completely open shutoff valve upstream of fuel prefilter.
Fuel prefilter clogged.	► Replace filter element (→ Page 90).
Easy-change fuel filter clogged.	► Replace (→ Page 84).
Air filter clogged.	► Check signal ring position of contamination indicator (→ Page 95).
Injector faulty.	► Replace (→ Page 80).
Injection pump faulty.	► Contact Service.
Engine wiring faulty.	► Check (→ Page 115).
Overload.	► Contact Service.

## Engine speed not steady

Cause	Corrective action
Injector faulty.	► Replace (→ Page 80).
Injection pump faulty.	► Contact Service.
Speed sensor is faulty.	► Contact Service.
Air in fuel system.	► Vent fuel system (→ Page 83).

## Charge-air temperature too high

Cause	Corrective action
Incorrect engine coolant concentration.	► Check (MTU test kit).
Charge-air cooler is contaminated.	► Contact Service.
Air inlet temperature in engine room is too high.	► Check fan Check air inlet/outlet ducts.

## Charge-air pressure too low

Cause	Corrective action
Air filter clogged.	► Check signal ring position of contamination indicator (→ Page 95).
Charge-air cooler is contaminated.	► Contact Service.
Exhaust turbocharger faulty.	► Contact Service.

## Coolant leaks at intercooler

Cause	Corrective action
Major coolant discharge at charge-air cooler. Charge-air cooler leaky.	► Contact Service.

## Black exhaust gas

Cause	Corrective action
Air filter clogged.	► Check signal ring position of contamination indicator (→ Page 95).
Injector faulty.	► Replace (→ Page 80).
Injection pump faulty.	► Contact Service.
Overload.	► Contact Service.

## Blue exhaust gas

Cause	Corrective action
Too much oil in engine.	▶ Drain engine oil (→ Page 98).
Oil separator or oil preseparator of crankcase breather clogged.	▶ Replace (→ Page 74).
Exhaust turbocharger faulty.	▶ Contact Service.
Cylinder head is faulty.	▶ Contact Service.
Piston rings are defective.	▶ Contact Service.
Cylinder liner defective.	▶ Contact Service.

## White exhaust gas

Cause	Corrective action
Engine is not at operating temperature.	▶ Run engine to reach operating temperature.
Water in fuel.	▶ Check fuel system at fuel prefilter. Drain fuel prefilter (→ Page 86).
Charge-air cooler leaky.	▶ Contact Service.

## 7 Task Description

### 7.1 SOLAS

#### 7.1.1 SOLAS shielding as per MTN 5233 - Installation

##### Preconditions

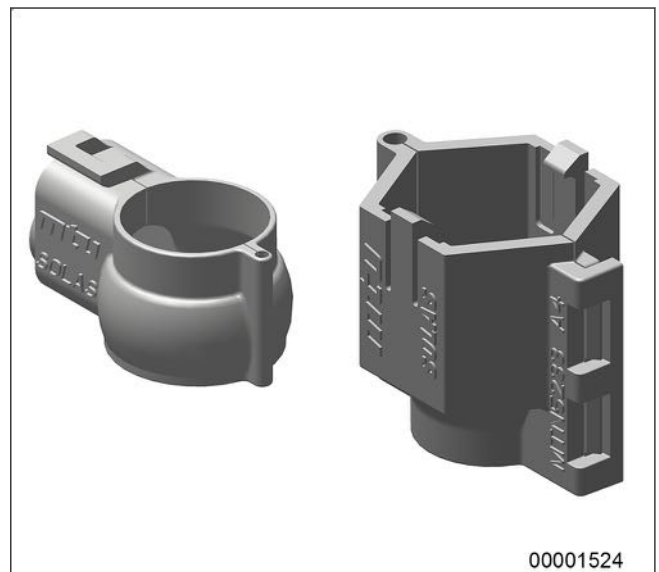
- ☒ Engine is stopped and starting disabled.

##### Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Shield A4	735233000100	10
Shield A5	735233000101	14
Shield A7	735233000103	6
Shield A8	735233000104	2

##### SOLAS shielding - Installation

1. Pinpoint installation location (→ Page 62).
2. Install suitable shielding.
3. Press shielding until locked.



## 7.1.2 SOLAS shielding – Installation

### Preconditions

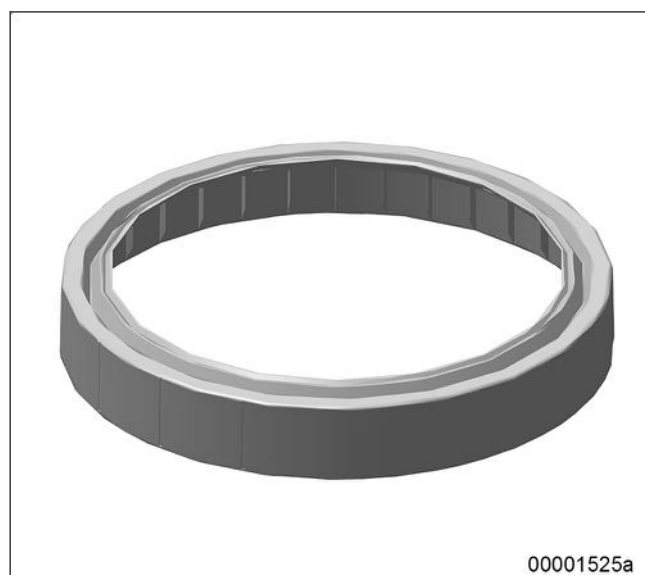
- ☒ Engine is stopped and starting disabled.
- ☒ Engine is cooled down to ambient temperature.

### Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Oil filter shield	X00009628	
Fuel filter shield	X00009654	

### Installing SOLAS shield on oil filter and fuel filter

1. Pinpoint installation location (→ Page 62).
2. Install suitable shielding.

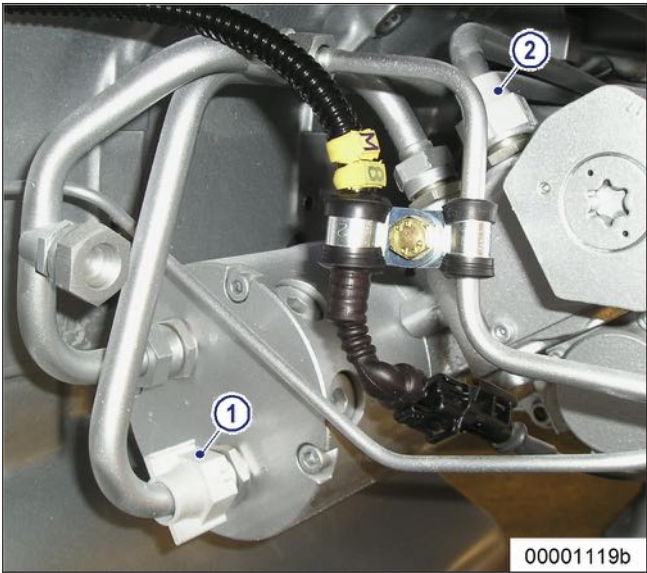


7.1.3 Installation locations for SOLAS shielding

General information

Primarily fit SOLAS shielding as per MTN 5233 (→ Page 60).

Free end B-side



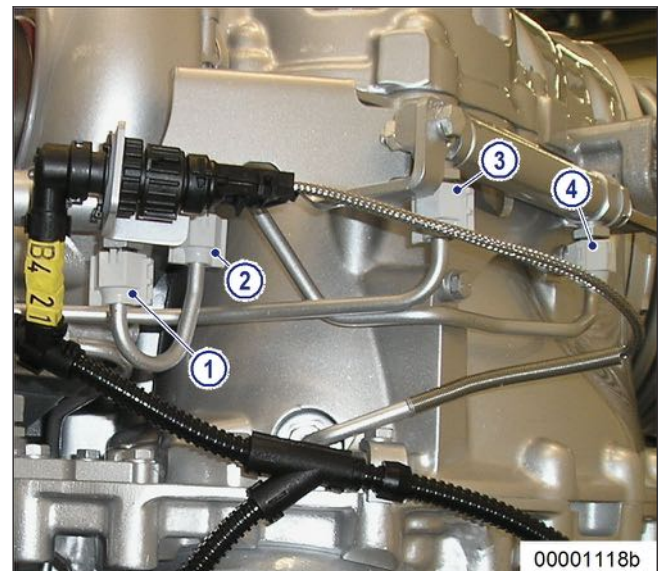
Item	Type of shielding	Comments
1 (free end, B-side)	Shield (A7)	On fuel delivery pump
2 (free end, B-side)	Shield (A7)	On HP fuel pump

Free end



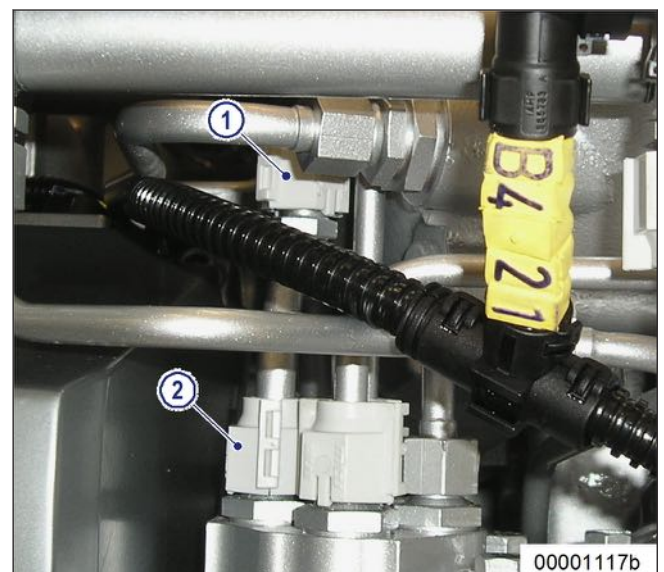
Item	Type of shielding	Comments
1 (free end)	Shield (A8)	On fuel filter
2 (free end)	Shield (A7)	Above fuel priming pump
3 (free end)	Shield (A7)	Below fuel priming pump

### Driving end A-side



Item	Type of shielding	Comments
1 (Driving end, A-side)	Shield (A5)	On air flap
2 (driving end, A-side)	Shield (A4)	On brazed-on union
3 (driving end, A-side)	Shield (A5)	On turbocharger flap
4 (driving end, A-side)	Shield (A5)	On turbocharger flap

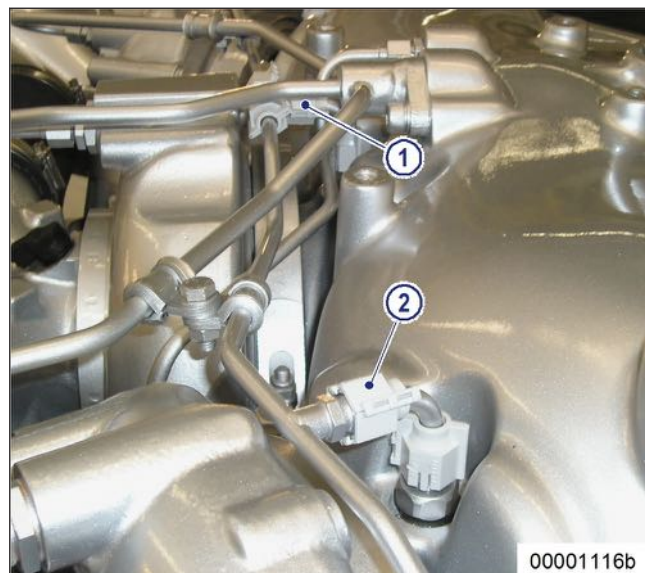
### Driving end A-side





Item	Type of shielding	Comments
1 (Driving end, A-side)	Shield (A5)	To turbocharger lubrication
2 (driving end, A-side)	Shield (A5)	On valve plate

## Driving end



Item	Type of shielding	Comments
1 (driving end)	Shield (A4)	Turbocharger lubrication, left side
2 (driving end)	Shield (A4)	Turbocharger lubrication, center

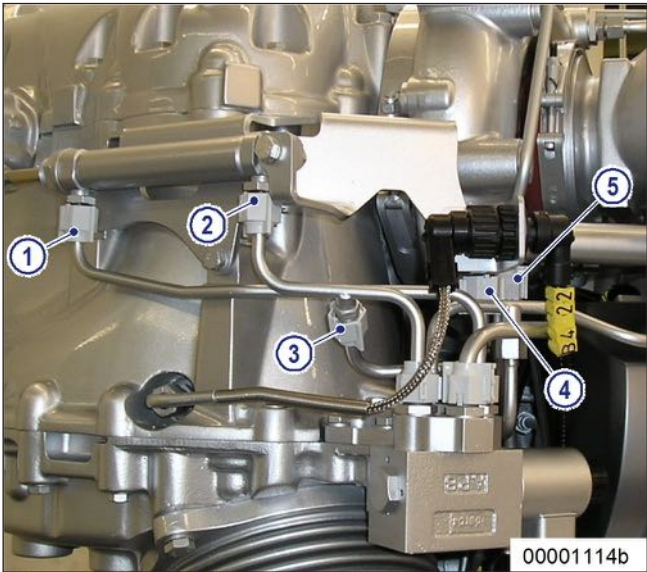
## Driving end



Item	Type of shielding	Comments
1 (driving end)	Shield (A4)	Turbocharger lubrication, right side

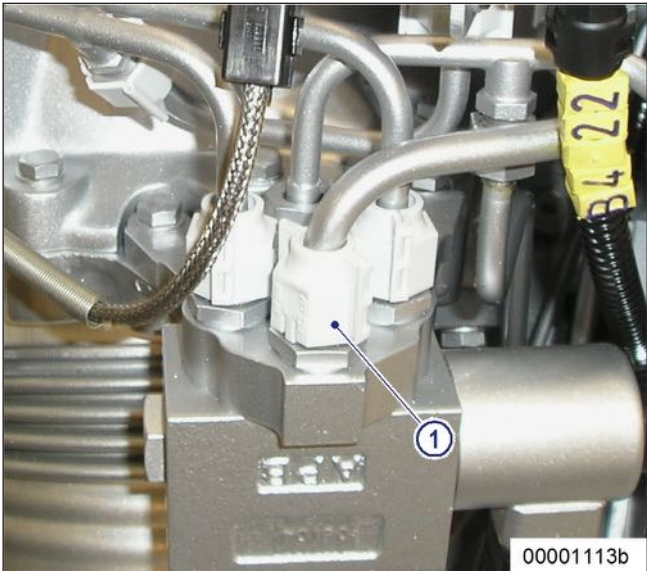


Driving end B-side



Item	Type of shielding	Comments
1 (driving end, B-side)	Shield (A5)	Turbocharger flap
2 (driving end, B-side)	Shield (A5)	Turbocharger flap
3 (driving end, B-side)	Shield (A4)	On brazed-on union
4 (driving end, B-side)	Shield (A5)	On air flap
5 (driving end, B-side)	Shield (A4)	To turbocharger lubrication

Driving end B-side



Item	Type of shielding	Comments
1 (driving end, B-side)	Shield (A5)	On valve plate

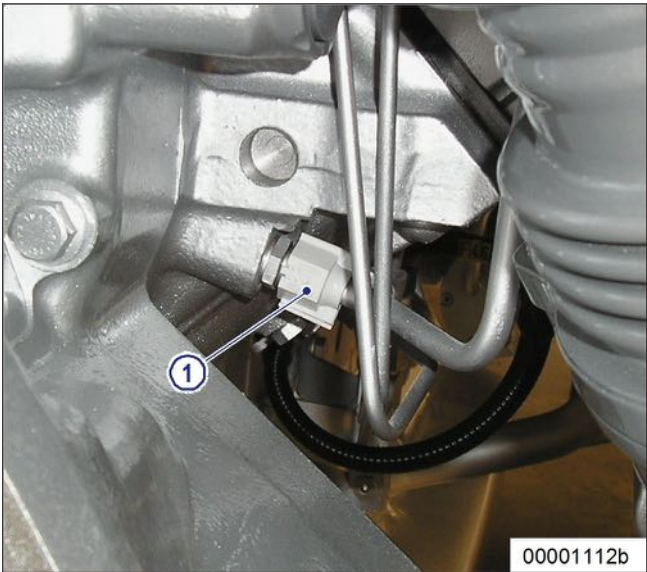
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Driving end A-side



Item	Type of shielding	Comments
1 (Driving end, A-side)	Shield (A5)	To flap control

Driving end B-side



Item	Type of shielding	Comments
1 (driving end, B-side)	Shield (A5)	To flap control

## 7.2 Engine

### 7.2.1 Engine - Barring manually

#### Preconditions

- ☑ Engine is stopped and starting disabled.

#### Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Engine barring gear	F6783914	1
Ratchet	F30006212	1

#### DANGER



Rotating and moving engine parts.

#### **Risk of crushing, danger of parts of the body being caught or pulled in!**

- Before barring the engine, make sure that there are no persons in the engine's danger zone.
- After finishing work on the engine, make sure that all safety devices are put back in place and all tools are removed from the engine.

#### Barring engine manually

1. Fit ratchet with barring gear on barring gear connection at the vibration damper on engine free end.
2. Rotate crankshaft in engine direction of rotation. Apart from the normal compression resistance, there should be no resistance.

Result: If the resistance exceeds the normal compression resistance, contact Service.

## 7.2.2 Engine - Cranking on starting system

### Preconditions

- ☑ Clutch is disengaged.
- ☑ Engine start is disabled.
- ☑ LOP is accessible and open.

DANGER



Rotating and moving engine parts.

#### **Risk of crushing, danger of parts of the body being caught or pulled in!**

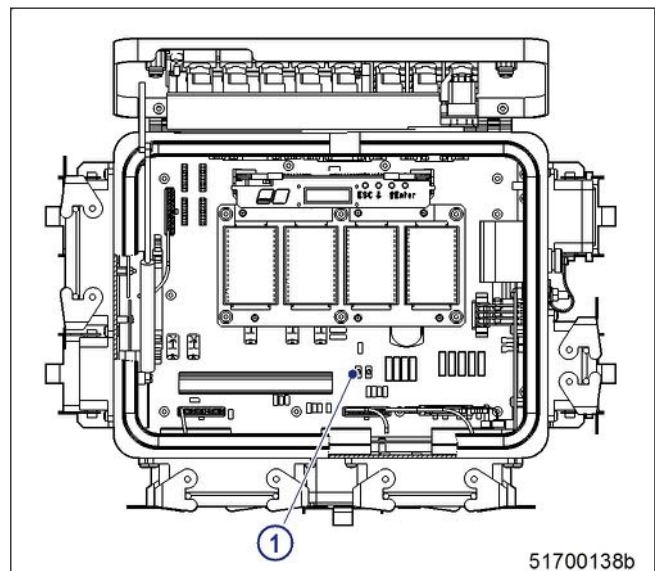
- Before barring the engine, make sure that there are no persons in the engine's danger zone.
- After finishing work on the engine, make sure that all safety devices are put back in place and all tools are removed from the engine.

### Turning

1. Press and hold down TURN pushbutton on LMB motherboard of LOP.

Result: Engine is cranked on starter for max. 20 seconds.

2. Release TURN button.



## 7.3 Cylinder Liner

### 7.3.1 Instructions and comments on endoscopic and visual examination of cylinder liners

#### Terms used for endoscopic examination

Use the terms listed below to describe the condition of the cylinder-liner surface in the endoscopic examination report.

Findings	Explanations/Action
Minor dirt scores	Minor dirt scores can occur during the assembly of a new engine (honing products, particles, broken-off burrs). Removed cylinders clearly show such scoring on the running surface under endoscope magnification. Cannot be felt with the fingernail. Findings not critical.
Single scores	Clearly visible scores caused by hard particles. They usually start in the TDC area and cross through the hone pattern in the direction of stroke. Findings not critical.
Scored area	These areas consist of scores of different length and depth next to one another. In most cases, they are found at the 6-o'clock and 12-o'clock positions (inlet/exhaust) along the transverse engine axis. Findings not critical.
Smoothened area	Smoothened areas are on the running surface but almost the whole honing pattern is still visible. Smoothened areas appear brighter and more brilliant than the surrounding running surface. Findings not critical.
Bright area	Bright areas are on the running surface and show local removal of the honing pattern. Grooves from honing process are not visible any more.
Discoloration	This is caused by oxidation (surface discoloration through oil or fuel) and temperature differences around the liner. It appears rather darker within the honed structure in contrast to the bright metallic running surface. The honing pattern is undisturbed. Discolorations extend in stroke direction and may be interrupted. Findings not critical.
Corrosion fields / spots	Corrosion fields / spots result from water (condensed water) with the valves in the overlap (open) position. They are clearly visible due to the dark color of the honing groove bottom. This corrosion is not critical unless there is corrosion pitting.
Black lines	Black lines are a step towards heat discoloration. They are visible as a clear discoloration from TDC to BDC in the running surface and the start of localized damage to the honing pattern. Cylinder liners with a large number of black lines around the running surface have limited service life and should be replaced.
Burn mark	This is caused by a malfunction in the liner / ring tribosystem. Usually they run over the whole ring-travel area (TDC/BDC), starting at the first TDC-ring and becoming more visible from the second TDC-ring 2 onwards and less pronounced from TDC-ring 1. The honing pattern is usually no longer visible and displays a clearly defined (straight) edge to the undisturbed surface. The damaged surface is usually discolored. The circumferential length varies. Liners with burn marks, or heat discoloration, starting in TDC-ring 1 have to be replaced.
Seizure marks, scuffing	Irregular circumference lengths and depths. Can be caused either by the piston skirt or the piston crown. Material deposits on the liner (smear), heavy discoloration. Severe, visible scoring. Replace liner.

## **Evaluation of findings and further measures**

The findings in the start phase of oxidation discoloration and heat discoloration are similar. A thorough investigation and compliance with the above evaluation criteria allow an unambiguous evaluation. To avoid unnecessary disassembly work, it is recommended that another inspection be carried out after further operation of the engine.

## 7.3.2 Cylinder liner – Endoscopic examination

### Preconditions

- ☑ Engine is stopped and starting disabled

### Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Rigid endoscope	Y20097353	1

### Preparatory steps

1. Remove cylinder head cover (→ Page 76).
2. Remove injector (→ Page 81).

### Positioning crankshaft at BDC

1. Using barring gear, turn crankshaft until crankshaft journal of the cylinder to be inspected has reached BDC.
2. Insert endoscope into cylinder liner through injector seat.

### Cylinder liner – Endoscopic examination

Findings	Task
<ul style="list-style-type: none"><li>• Thin carbon coating around circumference of carbon scraper ring</li><li>• Slight localized additive deposits at top edge</li><li>• Localized smooth areas at bottom edge</li><li>• Carbon deposits around circumference between top piston ring and bottom edge of carbon scraper ring</li><li>• First signs of marks left by top piston ring</li><li>• Bright mark around circumference</li><li>• Faultless, even honing pattern</li><li>• First signs of marks left by lower cooling bores</li><li>• Running pattern seems darker</li></ul>	No action required.
<ul style="list-style-type: none"><li>• Darker areas of even or varying color intensity</li><li>• Beginning and end of the discoloration are not sharply defined and do not cover the entire stroke area</li><li>• Dark areas in the upper section of the cooling bore, remaining circumference cannot be faulted</li><li>• Piston rings faultless</li></ul>	Further endoscopic examination required as part of maintenance work.
<ul style="list-style-type: none"><li>• On the entire circumference not only bright discoloration (not critical for operation) clearly visible darker stripes that begin at the top piston ring</li><li>• Heat discoloration in the direction of stroke and honing pattern damage</li><li>• Heat discoloration of piston rings</li></ul>	Cylinder liner must be replaced, contact Service.

1. Compile endoscopy report using the table.
2. Use technical terms for description of the liner surface (→ Page 69).
3. Depending on findings:
  - Do not take any action or
  - Carry out further endoscopic examination as part of maintenance work or
  - Contact Service; cylinder liner must be replaced.

### **Final steps**

1. Install injector (→ Page 81).
2. Install cylinder head cover (→ Page 76).



## 7.4 Crankcase Breather

### 7.4.1 Crankcase breather – Cleaning oil pre-separator element

#### Preconditions

- ☑ Engine is stopped and starting disabled.

#### WARNING



Fuels are combustible.

#### **Risk of fire and explosion!**

- Avoid open flames, electrical sparks and ignition sources.
- Do not smoke.

#### WARNING



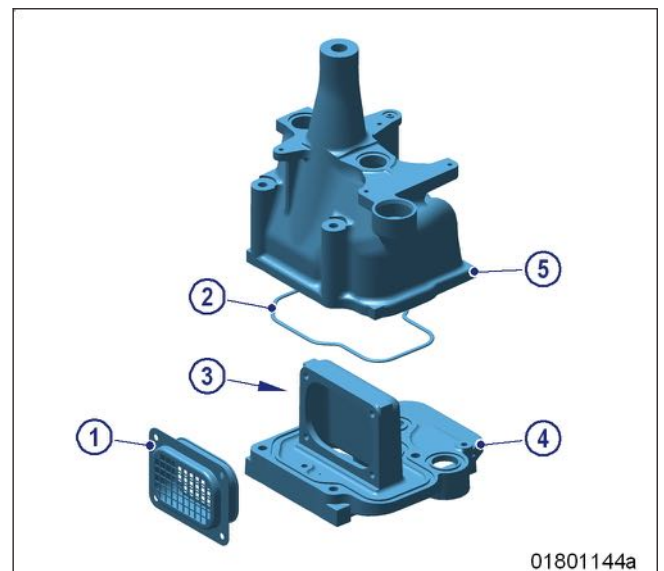
Compressed air gun ejects a jet of pressurized air.

#### **Risk of injury to eyes and damage to hearing, risk of rupturing internal organs!**

- Never direct air jet at people.
- Always wear safety goggles/face mask and ear defenders.

#### **Crankcase breather – Cleaning oil pre-separator element**

1. Remove cover (5) from housing (4).
2. Take off oil pre-separator element (1), gasket (3) and O-ring (2).
3. Wash oil pre-separator element (1) and housing (4) in fuel and blow out with compressed air.
4. Moisten oil pre-separator element (1) with engine oil.
5. Position oil pre-separator element (1) with new gasket (3) and O-ring (2) on housing (4) and install cover (5).
6. Clean other oil pre-separator elements in the same way.



## 7.4.2 Crankcase breather – Oil separator element replacement, diaphragm check and replacement

### Preconditions

- ☑ Engine is stopped and starting disabled.

### Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Torque wrench, 6-50 Nm	F30027336	1
Ratchet	F30027340	1
Engine oil		
Filter element	(→ Spare Parts Catalog)	
Diaphragm	(→ Spare Parts Catalog)	
Gasket	(→ Spare Parts Catalog)	

#### WARNING



Hot oil.

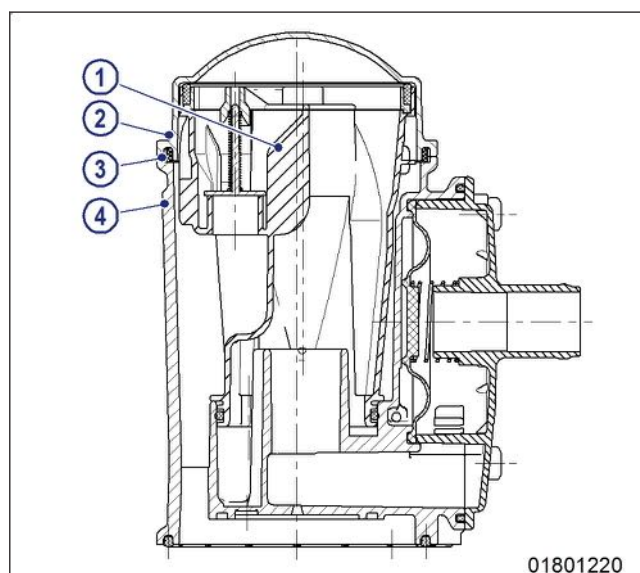
Oil can contain combustion residues which are harmful to health.

#### Risk of injury and poisoning!

- Wear protective clothing, gloves, and goggles / safety mask.
- Avoid contact with skin.
- Do not inhale oil vapor.

### Replacing oil separator element

1. Remove cover (2) with O-ring (3).
2. Remove filter element (1) from housing (4).
3. Insert new filter element in housing (4).
4. Install cover (2) with new O-ring.



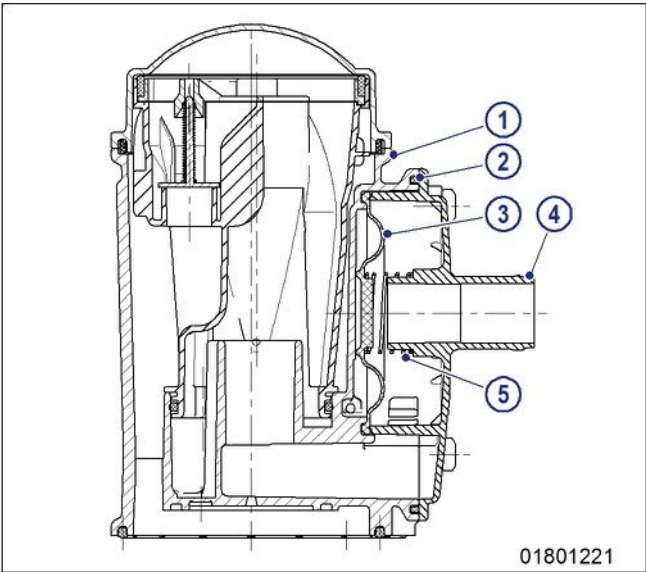
5. Use torque wrench to tighten the screws of cover (2) to the specified torque.

Name	Size	Type	Lubricant	Value/Standard
Screw		Tightening torque	(Engine oil)	10 Nm –2 Nm

6. Replace further oil separator elements in the same way.

Checking diaphragm

- 1. Remove cover (4).
- 2. Remove spring (5), gasket (2) and diaphragm (3).
- 3. Check diaphragm (3) for damage, fit new diaphragm if used one is damaged.
- 4. Install diaphragm (3) on housing (1).
- 5. Install new seal (2) and spring (5) together with cover (4).



- 6. Use torque wrench to tighten the screws of cover (4) to the specified torque.

Name	Size	Type	Lubricant	Value/Standard
Screw		Tightening torque	(Engine oil)	10 Nm –2 Nm

- 7. Check diaphragms in further oil separators in the same way.

## 7.5 Valve Drive

### 7.5.1 Cylinder head cover – Removal and installation

#### Preconditions

- ☑ Engine is stopped and starting disabled.

#### Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Centering jig	F6783025	1
Sealing	(→ Spare Parts Catalog)	

#### Preparatory steps

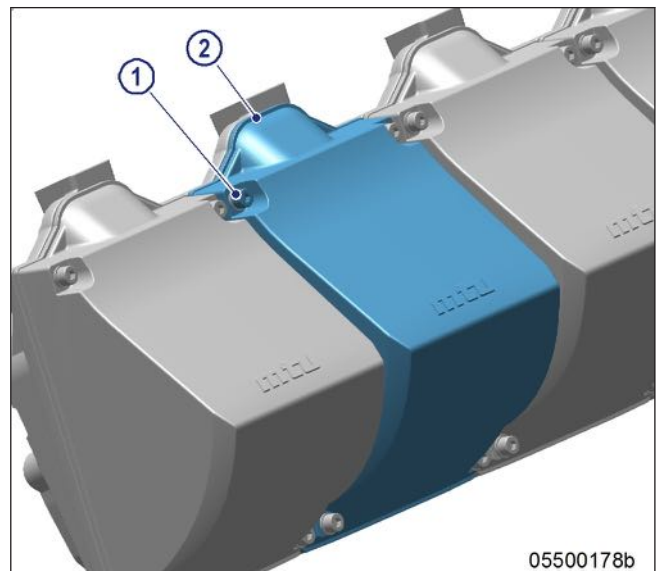
1. Remove air filter (→ Page 94).
2. Remove air guide housing.

#### Removing and installing cylinder head cover

1. Remove screws (1).
2. Remove cylinder head cover (2) with gasket from cylinder head.
3. Clean installation surface.
4. Check condition of gasket of cylinder head cover.

Result: Replace damaged seals.

5. Align cylinder head cover (2) with centering jig.
6. Tighten screws (1) to specified torque 20 Nm using a torque wrench.



#### Final steps

1. Install air filter (→ Page 94).
2. Install air guide housing.
3. Check cylinder head covers for leaks.

## 7.5.2 Valve clearance – Check and adjustment

### Preconditions

- ☒ Engine is stopped and starting disabled.
- ☒ Engine coolant temperature is max. 40 °C.
- ☒ Valves are closed.

### Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Feeler gage	Y4345893	1
Barring gear	F6783914	1
Ratchet	F30006212	1
Double-head box wrench	F30002800	1
Offset screwdriver	F30002816	1
Socket wrench	F30030450	1
Torque wrench, 10-60 Nm	F30510423	1
Measuring instrument	Y4345888	1

### Preparatory steps

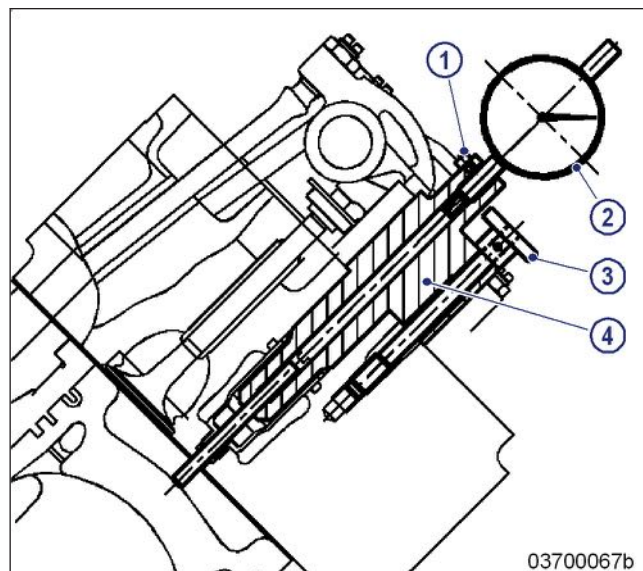
1. Remove air filter (→ Page 94).
2. Remove cylinder head cover (→ Page 76).

### Positioning A1 piston at TDC

Note: With cylinder head and valve gear installed.

1. Insert preloaded dial gage (2) into measuring device (4) and secure using screw (1).
2. Install measuring device (4) in cylinder head and secure using knurled-head screw (3).
3. Zero dial gage (2).
4. Turn engine using barring gear until piston A1 reaches firing TDC.

Result: The piston is at firing TDC when both rocker arms are unloaded, i.e. have clearance.



## Checking valve clearance at two crankshaft positions

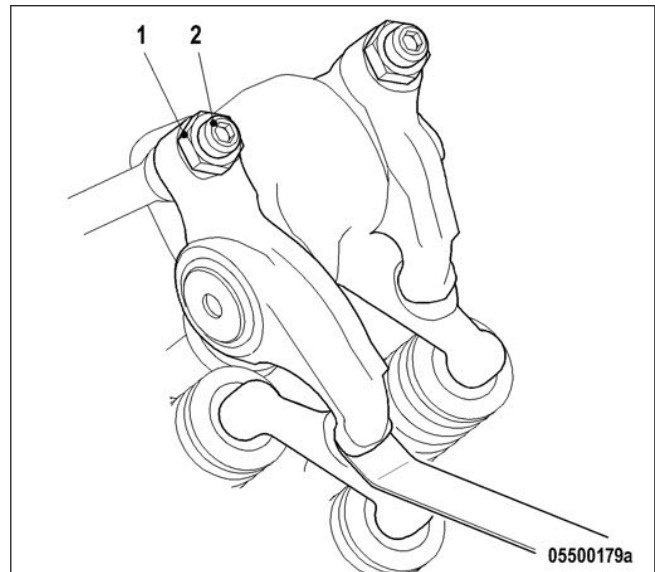
1. Check TDC position of piston in cylinder A1:
  - If the rocker arms are unloaded on cylinder A1, the piston is in firing TDC.
  - If the rocker arms are loaded on cylinder A1, the piston is in overlap TDC.
2. Check valve clearance with the engine cold:
  - Inlet (E) = 0.3 mm;
  - Exhaust (A) = 0.4 mm.
3. Check all valve clearances at two crankshaft positions (firing TDC and overlap TDC) according to the table below.
4. Use feeler gage to determine the distance between valve bridge and rocker arm.
5. If the deviation from the reference value exceeds 0.1 mm, adjust valve clearance.

## Adjusting valve clearance

Position	Cylinder	1	2	3	4	5	6	7	8
Firing TDC in cylinder A1	Bank A	"E", "A"	"A"	"A"	"E"	"A"	"E"	-	-
	Bank B	"E"	"A"	-	"E"	"E", "A"	"E"	"E", "A"	"A"
Overlap TDC in cylinder A1	Bank A	-	"E"	"E"	"A"	"E"	"A"	"E", "A"	"E", "A"
	Bank B	"A"	"E"	"E", "A"	"A"	-	"A"	-	"E"

1. Loosen locknut (1) and unscrew adjusting screw (2) by a few threads.
2. Insert feeler gage between valve bridge and rocker arm.
3. Readjust adjusting screw (2) so that the feeler gage just passes through the gap.
4. Tighten locknut (1) with torque wrench to the prescribed tightening torque of 50 Nm while holding the adjusting screw (2) with an Allen key.
5. Insert feeler gage between valve bridge and rocker arm to verify that the gage just passes through the gap.

Result: If not, adjust valve clearance.



## Final steps

1. Remove barring gear.
2. Install cylinder head cover (→ Page 76).
3. Install air filter (→ Page 94).

## 7.6 Injection Pump / HP Pump

### 7.6.1 HP fuel pump - Filling with engine oil

#### Preconditions

- ☑ Engine is stopped and starting disabled.

#### Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Engine oil		

#### WARNING



Fuels are combustible.

#### Risk of fire and explosion!

- Avoid open flames, electrical sparks and ignition sources.
- Do not smoke.

#### WARNING



Oils/oil vapors are combustible/explosive.

#### Risk of fire and explosion!

- Avoid open flames, electric sparks and ignition sources.
- Do not smoke.

#### NOTICE



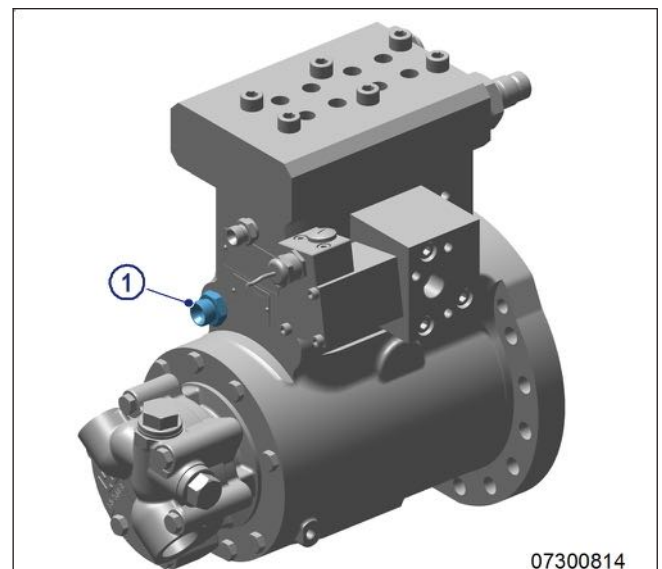
HP fuel pump not filled with engine oil.

#### Damage to components, major material damage!

- Ensure that th HP fuel pump is filled with engine oil before it is installed or put into operation.

#### Filling HP pump

1. Remove plug screw (1).
2. Fill HP pump with engine oil using pump oiler until engine oil emerges.
3. Install plug screw.



## 7.7 Injector

### 7.7.1 Injector – Replacement

#### Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Injector	(→ Spare Parts Catalog)	

#### Injector – Replacement

- ▶ Remove injector and install new one (→ Page 81).



## 7.7.2 Injector – Removal and installation

### Preconditions

- ☑ Engine is stopped and starting disabled.

### Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Screwdriver bit T45	F30454548	1
Assembly sleeve	F30454554	1
Puller	F6795554	1
Puller	F6790991	1
Puller	F6790992	1
Puller	F6795777	1
Torque wrench, 10-60 Nm	F30452769	1
Grease (Kluthe Hakuform 30-10/Emulgier)	X00029933	1
Engine oil		

#### WARNING



Fuels are combustible.

#### **Risk of fire and explosion!**

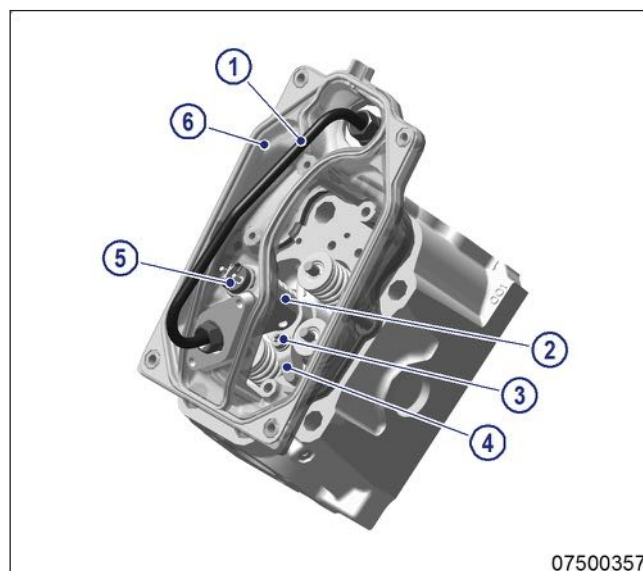
- Avoid open flames, electrical sparks and ignition sources.
- Do not smoke.

### Preparatory steps

1. Close off fuel supply to engine.
2. Remove upper part of cylinder head cover (→ Page 76).

### Removing injector

1. Remove HP line (1) using socket wrench.
2. Disconnect cable at control cable connection (5) of injector (2).
3. Remove lower part of cylinder head cover (6).
4. Remove retaining screw (3) from hold-down clamp (4).
5. Take off hold-down clamp (4).
6. Remove injector (2) with puller.
7. Remove O-rings from injector (2).
8. Mask all connections and bores or seal with suitable plugs.



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## Installing injector

1. Prior to installation, remove all blanking plugs.
2. Fit new O-rings on injector (2) and coat with grease.
3. Secure new sealing ring on injector (2) with grease observing installation position of sealing ring.
4. Clean sealing surface on cylinder head and protective sleeve.
5. Insert injector (2) in cylinder head, ensuring correct alignment with HP line connection.
6. Fit hold-down clamp (4) in correct position, coat hold-down clamp retaining screw (3) with engine oil.
7. Screw in retaining screw (3) of hold-down clamp (4) and tighten by hand.
8. Install lower part of cylinder head cover (6).
9. Coat thread and sealing cone of HP line (1) and injector (2) with engine oil.
10. Align injector (2) and HP line (1) with alignment device.
11. Connect HP line (1) to HP accumulator and tighten by hand.
12. Connect HP line (1) to injector (2) and tighten by hand.
13. Tighten retaining screw (3) of hold-down clamp (4) to specified torque using a box wrench adapter and a torque wrench.
14. Tighten HP line (1) to specified torque using socket wrench and torque wrench.

Name	Size	Type	Lubricant	Value/Standard
HP line		Tightening torque	(Engine oil)	37 Nm + 3 Nm

15. Connect cable.

## Final steps

1. Install upper part of cylinder head cover (→ Page 76).
2. Open up fuel supply to engine.

## 7.8 Fuel System

### 7.8.1 Fuel system – Venting

#### Preconditions

- ☑ Engine is stopped and starting disabled.

#### WARNING



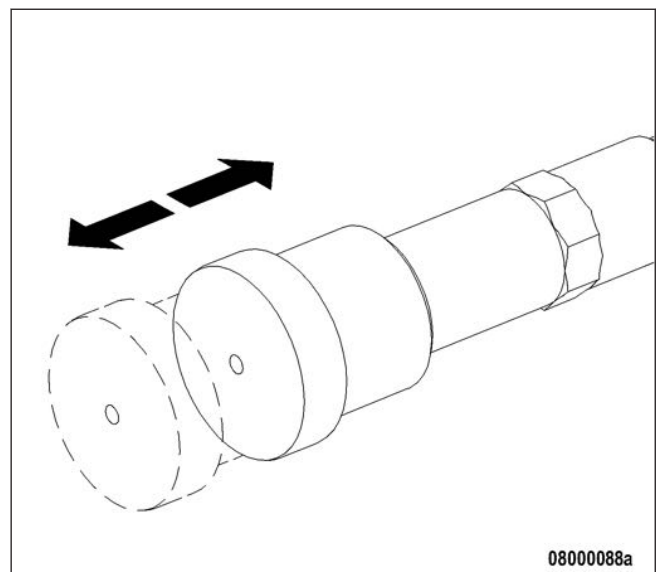
Fuels are combustible.

#### **Risk of fire and explosion!**

- Avoid open flames, electrical sparks and ignition sources.
- Do not smoke.

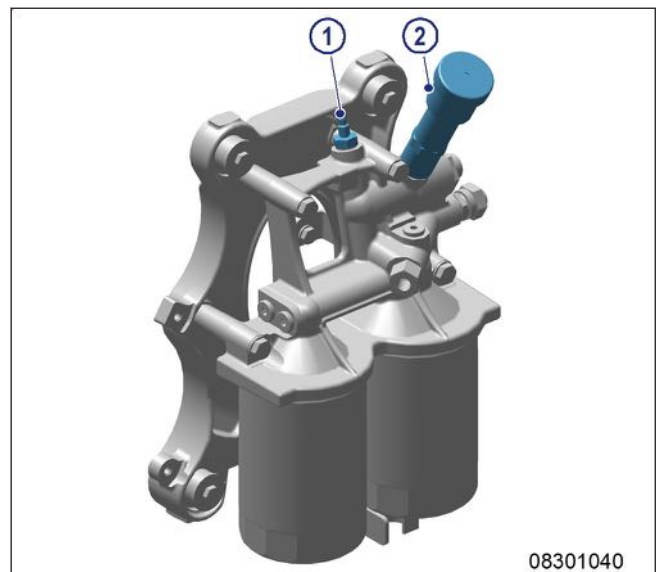
#### Fuel system – Venting

1. Unlock fuel priming pump, unscrew handle.



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2. Open threaded vent plug (1) on filter head.
3. Operate the pump (2) with the handle until bubble-free fuel emerges at the nipple.
4. Close vent plugs on filter head.
5. Lock fuel priming pump, screw in handle.



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## 7.9 Fuel Filter

### 7.9.1 Fuel filter – Replacement

#### Preconditions

- ☑ Engine is stopped and starting disabled
- ☑ Coolant temperature is below 40 °C

#### Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Oil filter wrench	F30379104	1
Fuel		
Easy-change filter	(→ Spare Parts Catalog)	

#### WARNING



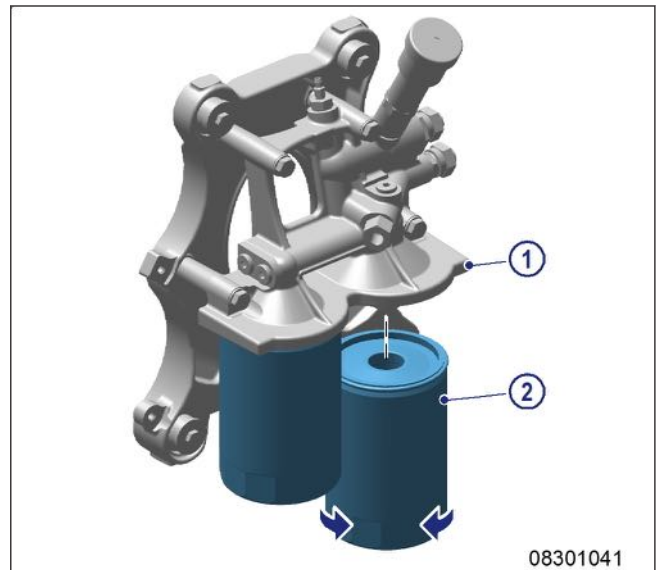
Fuels are combustible.

#### Risk of fire and explosion!

- Avoid open flames, electrical sparks and ignition sources.
- Do not smoke.

#### Replacing easy-change fuel filter with the engine stopped

1. Stop engine and disable engine start.
2. Unscrew easy-change filter (2) from filter base (1) using an oil filter wrench.
3. Clean sealing surface on filter head.
4. Check seal on new easy-change filter and moisten with fuel.
5. Fit SOLAS shield.
6. Screw on easy-change filter and tighten by hand.
7. Replace further fuel filters in the same way.
8. Vent fuel system (→ Page 83).



## 7.9.2 Fuel prefilter – Differential pressure check and adjustment of gauge

### DANGER



Rotating and moving engine parts.

**Risk of crushing, danger of parts of the body being caught or pulled in!**

- Only run the engine at low power. Keep away from the engine's danger zone.

### WARNING



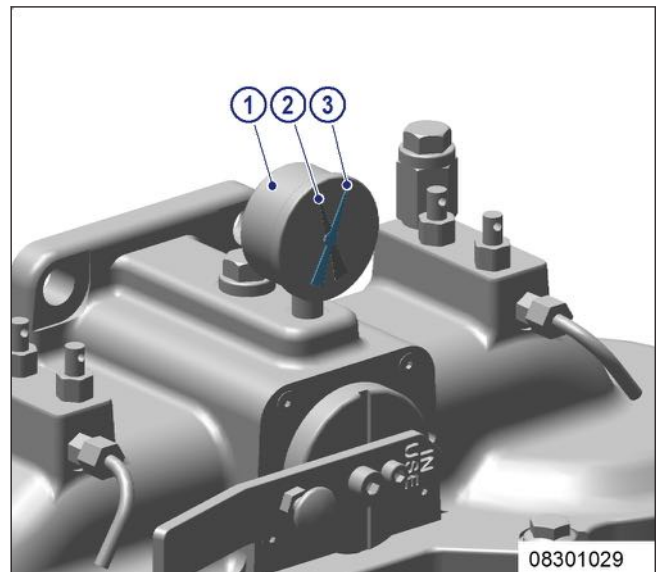
High level of engine noise when the engine is running.

**Risk of damage to hearing!**

- Wear ear protectors.

### Setting adjustable pointer of differential pressure gauge

1. After installation of a new filter element, align adjustable pointer (2) with pressure-indicating pointer (3) of pressure gauge (1).
2. Verify that differential pressure is within the limit.



### Fuel prefilter – checking differential pressure

1. With the engine running at full load or rated power, read off pressure at gauge (1).
2. If differential pressure as indicated between position of adjustable pointer (2) and pressure-indicating pointer (3) of pressure gauge is  $\geq 0.3$  bar, flush filter element of the cut-in filter (→ Page 88).

### 7.9.3 Fuel prefilter – Draining

#### Preconditions

- ☑ Engine is stopped and starting disabled.

#### WARNING



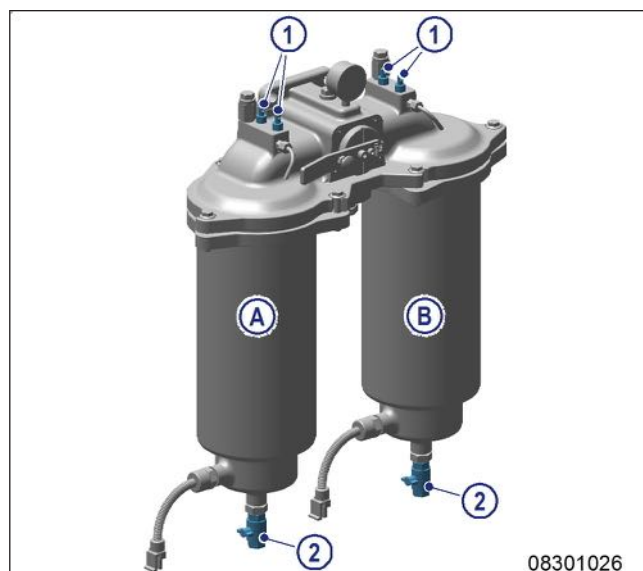
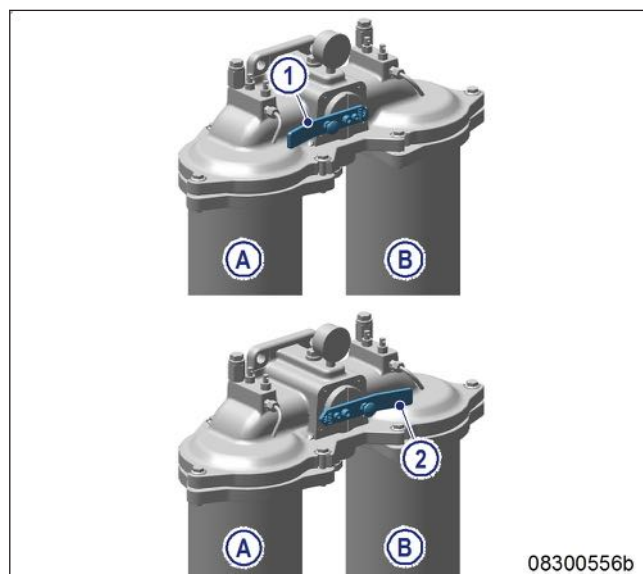
Fuels are combustible.

#### Risk of fire and explosion!

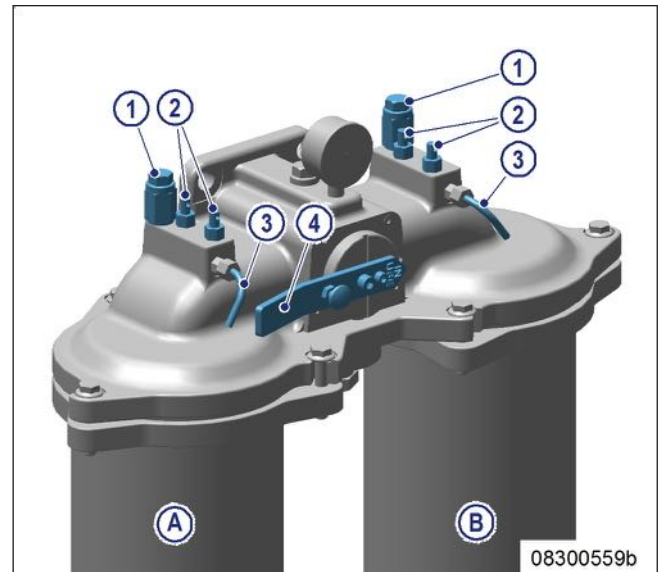
- Avoid open flames, electrical sparks and ignition sources.
- Do not smoke.

#### Draining fuel prefilter

1. Switch off filter which is to be drained (A or B):
  - 1 Filter A switched off
  - 2 Filter B switched off
2. Open threaded vent plug (1) of the filter to be drained.
3. Open drain valve (2).
4. Drain water and contaminants from the filter until pure fuel emerges.
5. Close drain valve (2).



6. Connect filling pump to filling connection (1) on suction side of filter.
7. Open vent valve (2) and fill with fuel until it emerges from the vent pipe (3).
8. Close vent valve (2).
9. Turn slide (4) a little (approx. 30°) and open vent valve(s) (2) until fuel emerges from the vent pipe (3).
10. Close vent valve(s) (2).
11. Turn slide (4) back to the locked position.



## 7.9.4 Fuel prefilter – Flushing

### Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Diesel fuel		

#### DANGER



Rotating and moving engine parts.

**Risk of crushing, danger of parts of the body being caught or pulled in!**

- Only run the engine at low power. Keep away from the engine's danger zone.

#### WARNING



Fuels are combustible.

**Risk of fire and explosion!**

- Avoid open flames, electrical sparks and ignition sources.
- Do not smoke.

#### WARNING



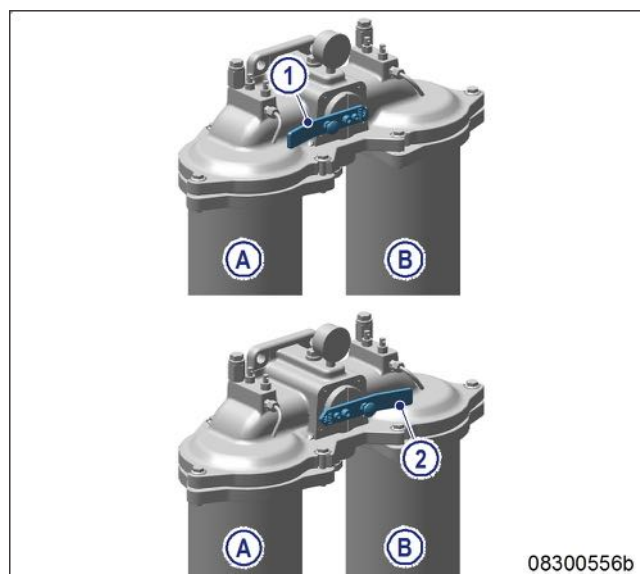
High level of engine noise when the engine is running.

**Risk of damage to hearing!**

- Wear ear protectors.

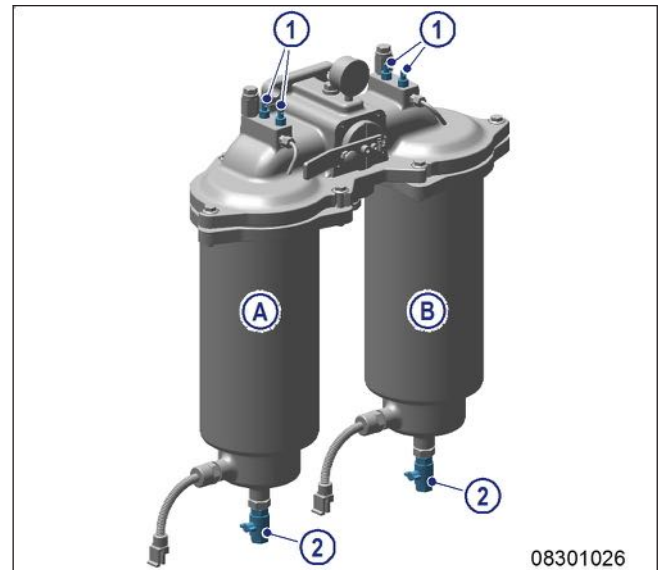
### Flushing fuel prefilter

1. Cut out contaminated filter (A or B):
  - 1 Filter A cut out
  - 2 Filter B cut out



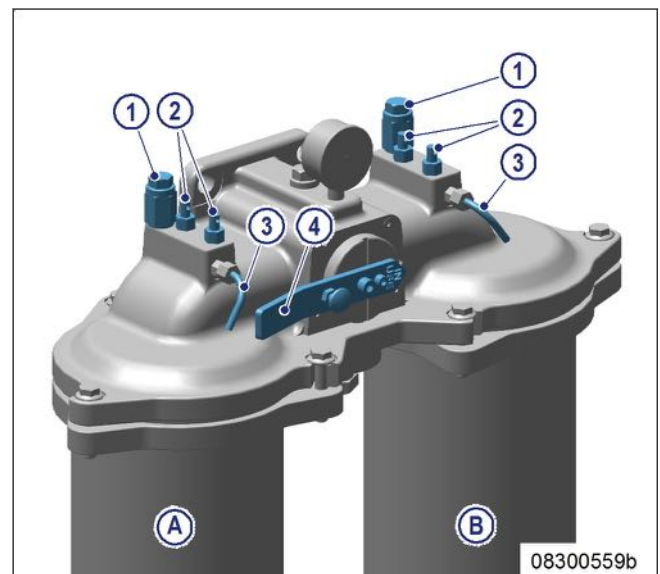


2. Open threaded vent plug (1) of filter to be flushed.
  3. Open drain valve (2) and drain fuel.
- Result: Fuel flows from filtered side back to the unfiltered side, flushing the filter deposits downwards out of the filter.
4. Close threaded vent plug (1) and drain valve (2).



### Filling fuel prefilter with fuel

1. Stop engine (→ Page 52) and disable engine start.
  2. Connect filling pump to filling connection (1) on the intake side of the filter.
  3. Open vent valve (2) and fill with fuel until fuel emerges from the vent pipe (3).
  4. Close vent valve (2).
  5. Open rotary slide valve (4) a little (by approx. 30°) and open vent valve(s) (2), until fuel emerges from the vent pipe (3).
  6. Close vent valve(s) (2).
  7. Turn rotary slide valve (4) back to locked position.
  8. Check differential pressure (→ Page 85).
- Result: If flushing did not improve differential pressure, replace filter element in fuel prefilter (→ Page 90).



## 7.9.5 Fuel prefilter – Filter element replacement

### Preconditions

- ☑ Engine is stopped and starting disabled.

### Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Diesel fuel		
Filter element	(→ Spare Parts Catalog)	
Sealing	(→ Spare Parts Catalog)	

#### WARNING



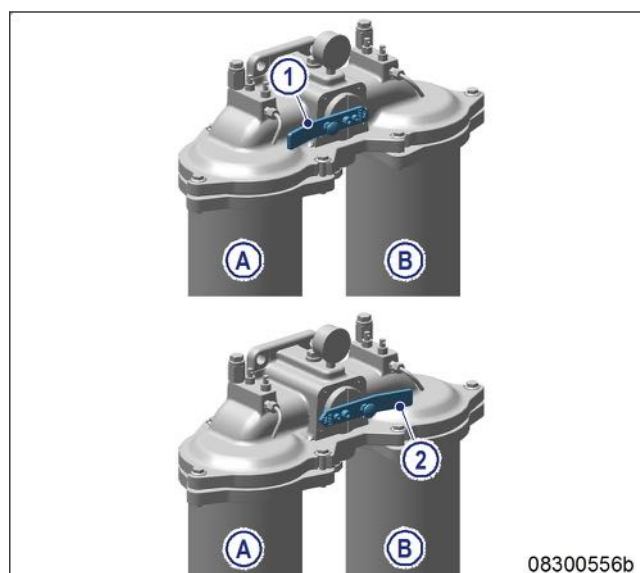
Fuels are combustible.

#### **Risk of fire and explosion!**

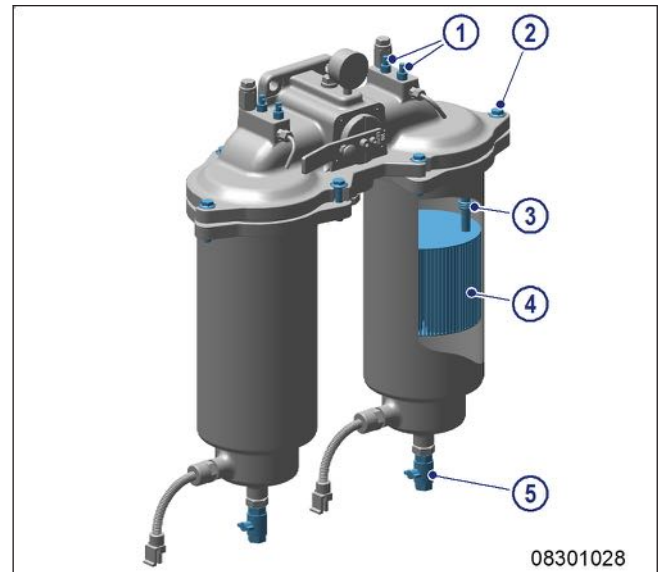
- Avoid open flames, electrical sparks and ignition sources.
- Do not smoke.

### Replacing filter element

1. Switch off filter which is to be changed (A or B):
  - 1 Filter A switched off
  - 2 Filter B switched off



2. Open threaded vent plug (1) of contaminated filter.
3. Unlock drain valve (5) by pressing toggle and open it.
4. Drain water and dirt from filter.
5. Close drain valve (5).
6. Remove screws securing cover (2) and take off cover.
7. Remove spring cartridge (3) and filter element (4).
8. Insert new filter element (4) and spring cartridge (3).
9. Fill filter housing with clean fuel.
10. Place new seal in cover.
11. Fit cover with gasket and secure it with screws (2).
12. Cut in the cut-out filter again.
13. Close threaded vent plug (1) when fuel emerges.
14. Set adjustable pointer of differential pressure gage (→ Page 85).



## 7.10 Charge-Air Cooling

### 7.10.1 Intercooler – Checking condensate drain line for coolant discharge and obstruction

#### DANGER



Rotating and moving engine parts.

**Risk of crushing, danger of parts of the body being caught or pulled in!**

- Only run the engine at low power. Keep away from the engine's danger zone.

#### WARNING



High level of engine noise when the engine is running.

**Risk of damage to hearing!**

- Wear ear protectors.

#### WARNING



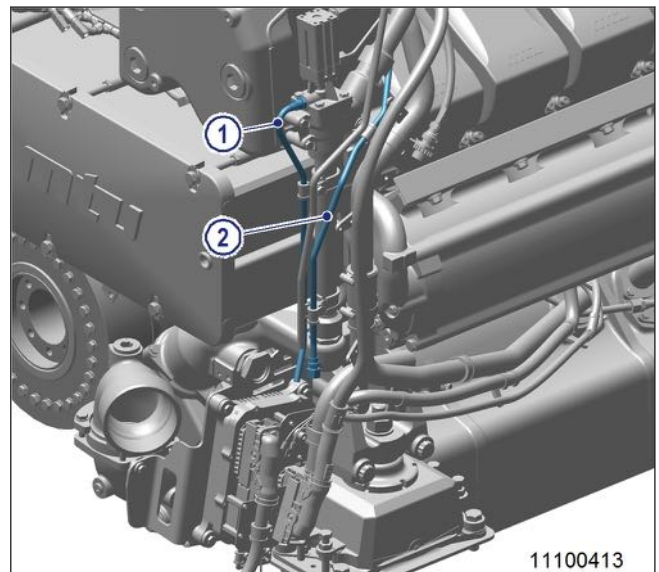
Compressed air gun ejects a jet of pressurized air.

**Risk of injury to eyes and damage to hearing, risk of rupturing internal organs!**

- Never direct air jet at people.
- Always wear safety goggles/face mask and ear defenders.

#### Intercooler – Checking condensate drain line for coolant discharge and obstruction

1. With the engine running, check the condensate drain line (1) on engine driving end and free end for air discharge.
2. If no air emerges, remove condensate drain line (1) and blow out with compressed air.
3. Replace obstructed drain line (1) by new one.
4. Install condensate drain line (1).
5. If a large amount of coolant is continuously discharged, the intercooler is leaking. Contact Service.



#### Emergency measures prior to engine start with a leaking intercooler

1. Remove injectors (→ Page 80).
2. Bar engine manually (→ Page 67).
3. Bar engine with starting equipment to blow out cylinder chambers (→ Page 68).
4. Install injectors (→ Page 81).

## 7.11 Air Filter

### 7.11.1 Air filter - Replacement

#### Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Air filter	(→ Spare Parts Catalog)	

#### Replacing the air filter

1. Remove old air filter and install new air filter (→ Page 94).
2. Reset signal ring of contamination indicator (→ Page 95).

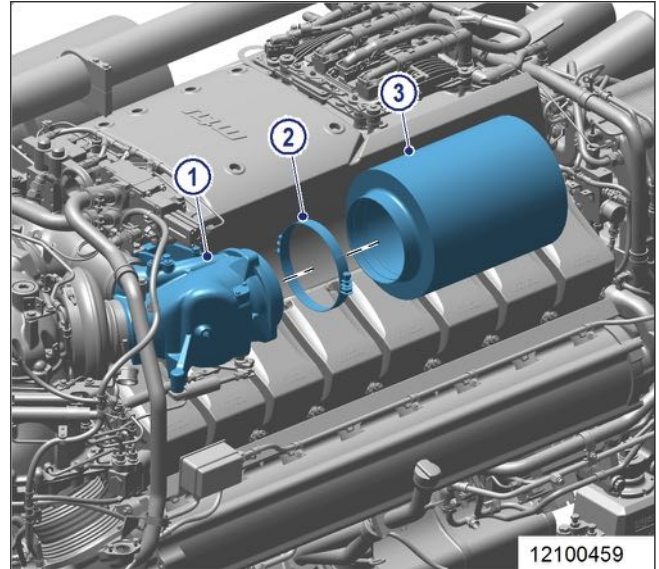
### 7.11.2 Air filter – Removal and installation

#### Preconditions

- ☑ Engine is stopped and starting disabled.

#### Air filter – Removal and installation

1. Loosen clamp (2).
2. Remove air filter (3) and clamp (2) from connecting flange of intake housing (1).
3. Clean connecting flange (1) of intake housing and check for obstruction.
4. Place new air filter (3) with clamp (2) onto intake housing (1).
5. Tighten screw on clamp (2) to specified torque using a torque wrench.



## 7.12 Air Intake

### 7.12.1 Service indicator – Signal ring position check

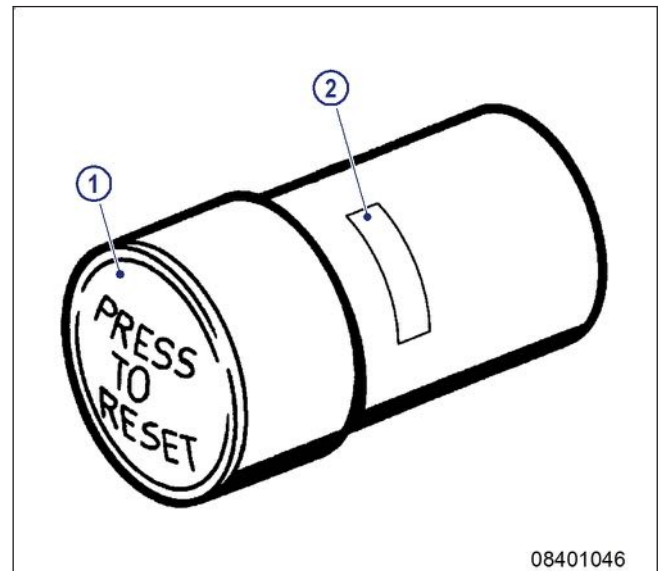
#### Preconditions

- ☑ Engine is stopped and starting disabled.

#### Checking signal ring position

1. If the signal ring is completely visible in the control window (2), replace air filter (→ Page 93).
2. After installation of new filter, press reset button (1).

Result: Engaged piston with signal ring moves back to initial position.



## 7.13 Starting Equipment

### 7.13.1 Starter - Condition check

#### **Preconditions**

- ☒ Engine is stopped and starting disabled.

#### **Checking starter condition**

1. Check securing screws of starter for secure seating and tighten if required.
2. Check wiring (→ Page 115).



## 7.14 Lube Oil System, Lube Oil Circuit

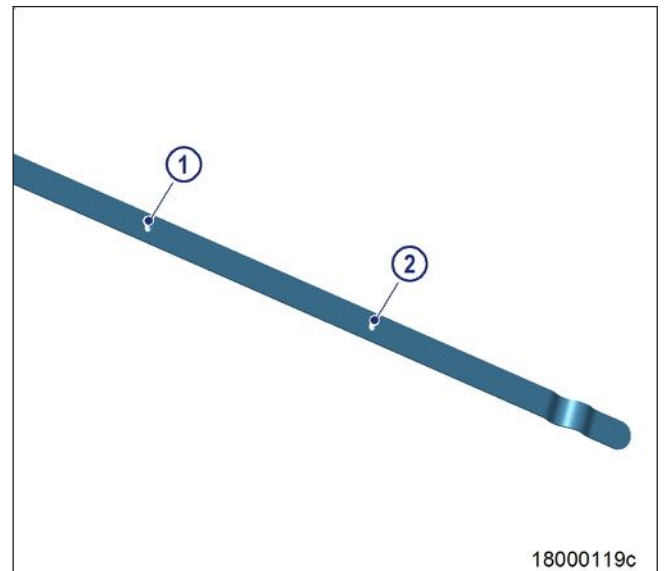
### 7.14.1 Engine oil - Level check

#### Preconditions

- ☑ Engine is stopped and starting disabled.

#### Oil level check prior to engine start

1. Withdraw oil dipstick from guide tube and wipe it.
2. Insert oil dipstick into guide tube up to the stop, withdraw after approx. 10 seconds and check oil level.
3. Oil level must be between "min." (2) and "max." (1) marks.
4. Top up with oil up to the "max" (1) mark (→ Page 98) if required.
5. Insert oil dipstick into guide tube up to the stop.



#### Oil level check after the engine is stopped

1. 5 minutes after stopping the engine, remove oil dipstick from the guide tube and wipe it.
2. Insert oil dipstick into guide tube up to the stop, withdraw after approx. 10 seconds and check oil level.
3. Oil level must be between "min." and "max." marks.
4. Top up to "max." if required (→ Page 98).
5. Insert oil dipstick into guide tube up to the stop.

## 7.14.2 Engine oil – Change

### Preconditions

- ☑ Engine is stopped and starting disabled.
- ☑ Engine is at operating temperature.
- ☑ MTU Fluids and Lubricants Specifications (A001061/..) are available.

### Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Engine oil		

#### WARNING



Hot oil.

Oil can contain combustion residues which are harmful to health.

#### Risk of injury and poisoning!

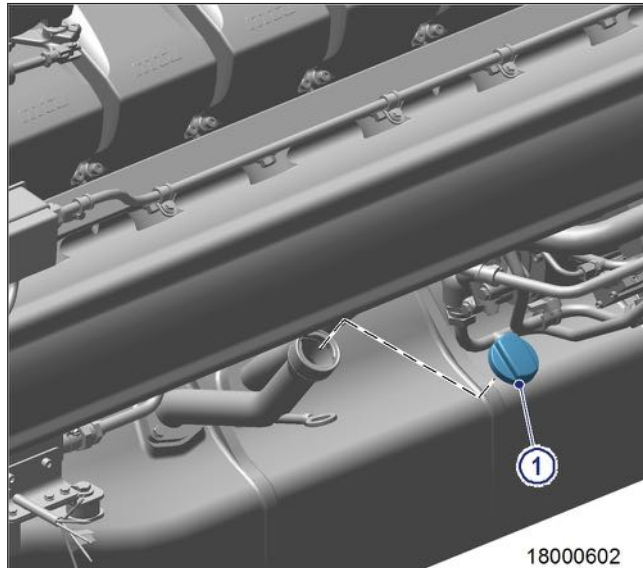
- Wear protective clothing, gloves, and goggles / safety mask.
- Avoid contact with skin.
- Do not inhale oil vapor.

### Version with extraction equipment: Engine oil extraction

1. Position a suitable container to drain the engine oil into.
2. Extract all engine oil from oil pan using the extraction equipment.

### Filling with new engine oil

1. Determine amount of engine oil required for oil change (→ Page 40).
2. Open cap (1) on filler neck.
3. Pour engine oil in at filler neck up to “max.” mark at oil dipstick.
4. Close cap (1) on filler neck.
5. Check engine oil level (→ Page 97).
6. After oil change, bar engine with starting system.



## 7.15 Oil Filtration / Cooling

### 7.15.1 Engine oil filter – Replacement

#### Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Oil filter wrench	F30379104	1
Engine oil		
Oil filter	(→ Spare Parts Catalog)	
Cover for SOLAS	(→ Spare Parts Catalog)	

#### DANGER



Rotating and moving engine parts.

**Risk of crushing, danger of parts of the body being caught or pulled in!**

- Only run the engine at low power. Keep away from the engine's danger zone.

#### WARNING



High level of engine noise when the engine is running.

**Risk of damage to hearing!**

- Wear ear protectors.

#### WARNING



Hot oil.

Oil can contain combustion residues which are harmful to health.

**Risk of injury and poisoning!**

- Wear protective clothing, gloves, and goggles / safety mask.
- Avoid contact with skin.
- Do not inhale oil vapor.

#### NOTICE



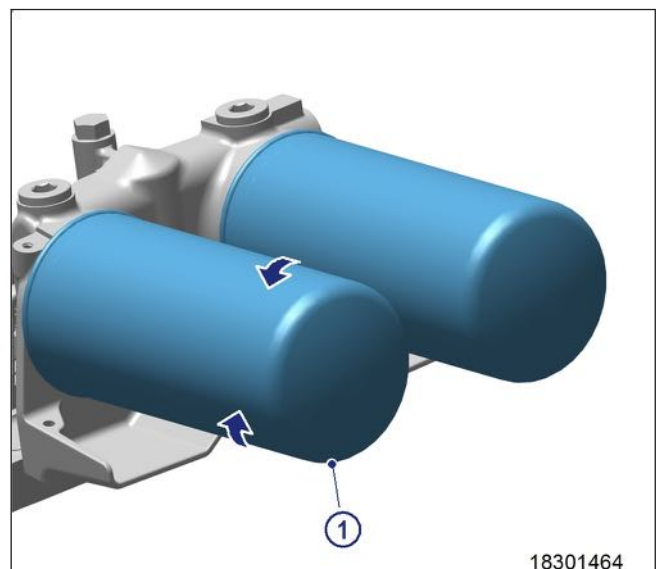
Damage to component!

**Severe material damage!**

- For filter replacement with the engine running, operate the engine at low engine load.
- The filter which is to be replaced must be cut out for a brief period only.

#### Replacing oil filter with the engine stopped

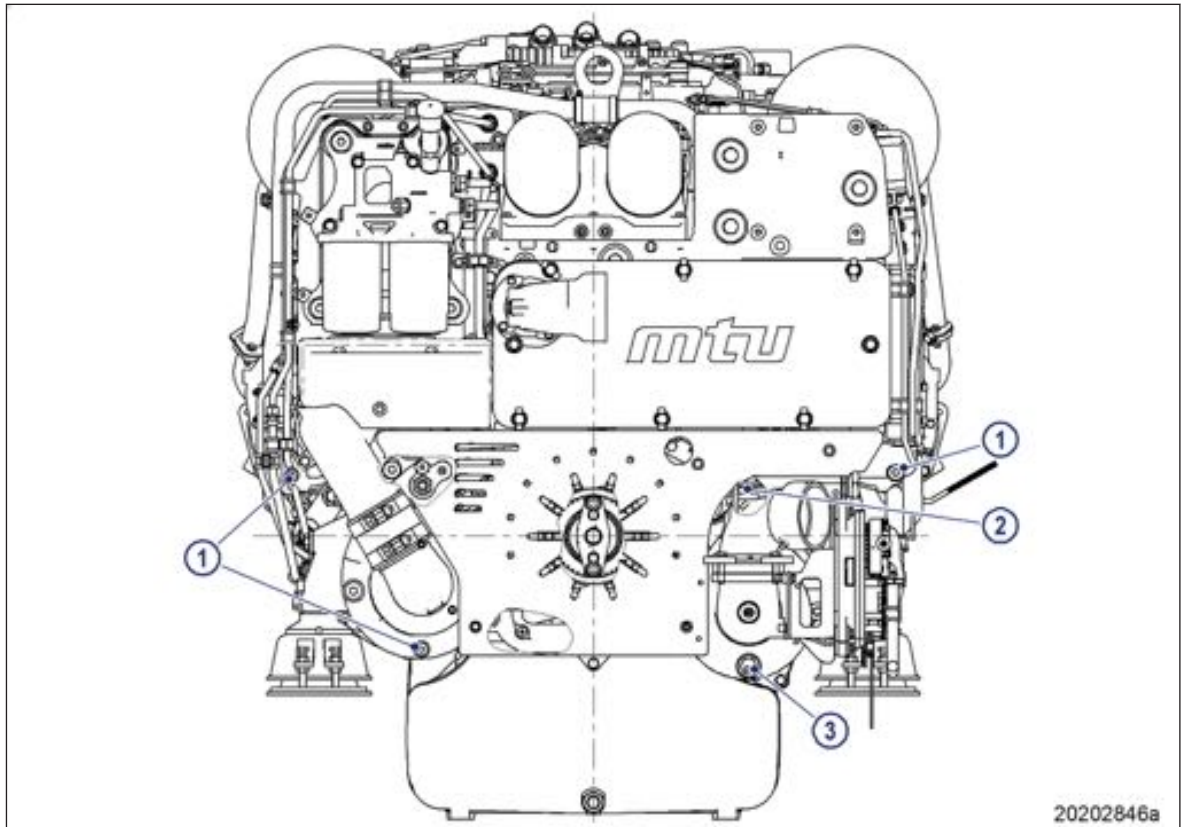
1. Stop engine (→ Page 52) and disable engine start.
2. Unscrew oil filter with oil filter wrench.
3. Clean sealing face on connecting piece.
4. Check condition of the new oil filter sealing ring and coat it with oil.
5. Fit SOLAS shield .
6. Screw on and tighten new engine oil filter by hand.
7. Replace other oil filters in the same way.
8. After each oil change and filter replacement, bar engine with starting system (→ Page 68).
9. Check oil level (→ Page 97).



## 7.16 Coolant Circuit, General, High-Temperature Circuit

### 7.16.1 Engine coolant drain and venting points

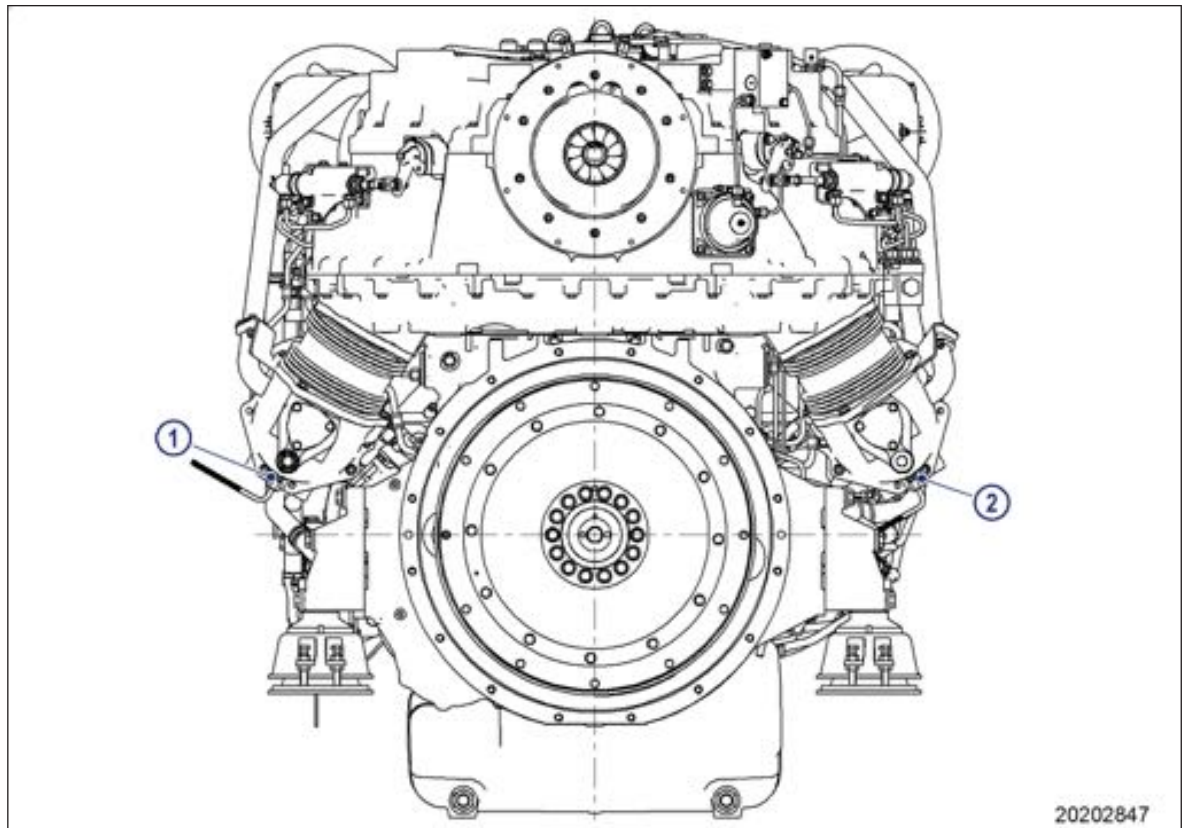
#### 16V 2000 M96L



1 Engine coolant drain screw

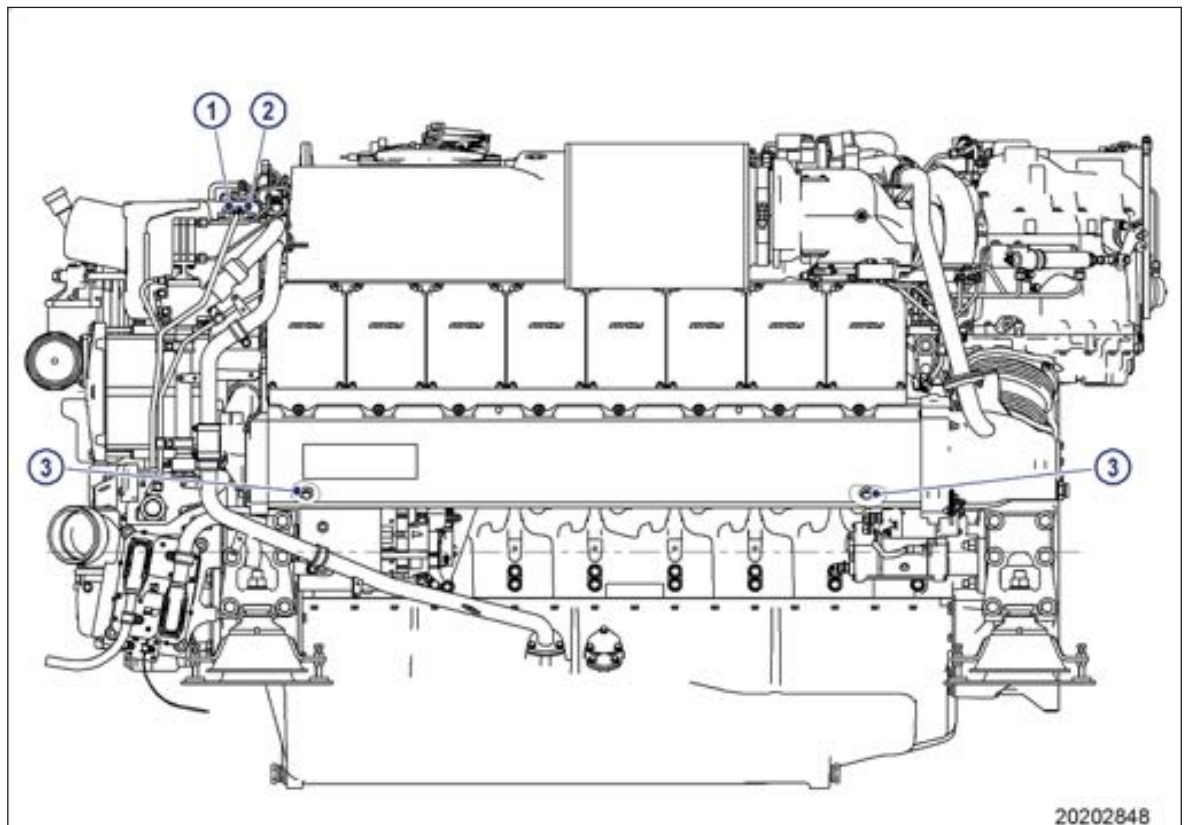
2 Filling screw on seawater  
pump

3 Seawater pump drain



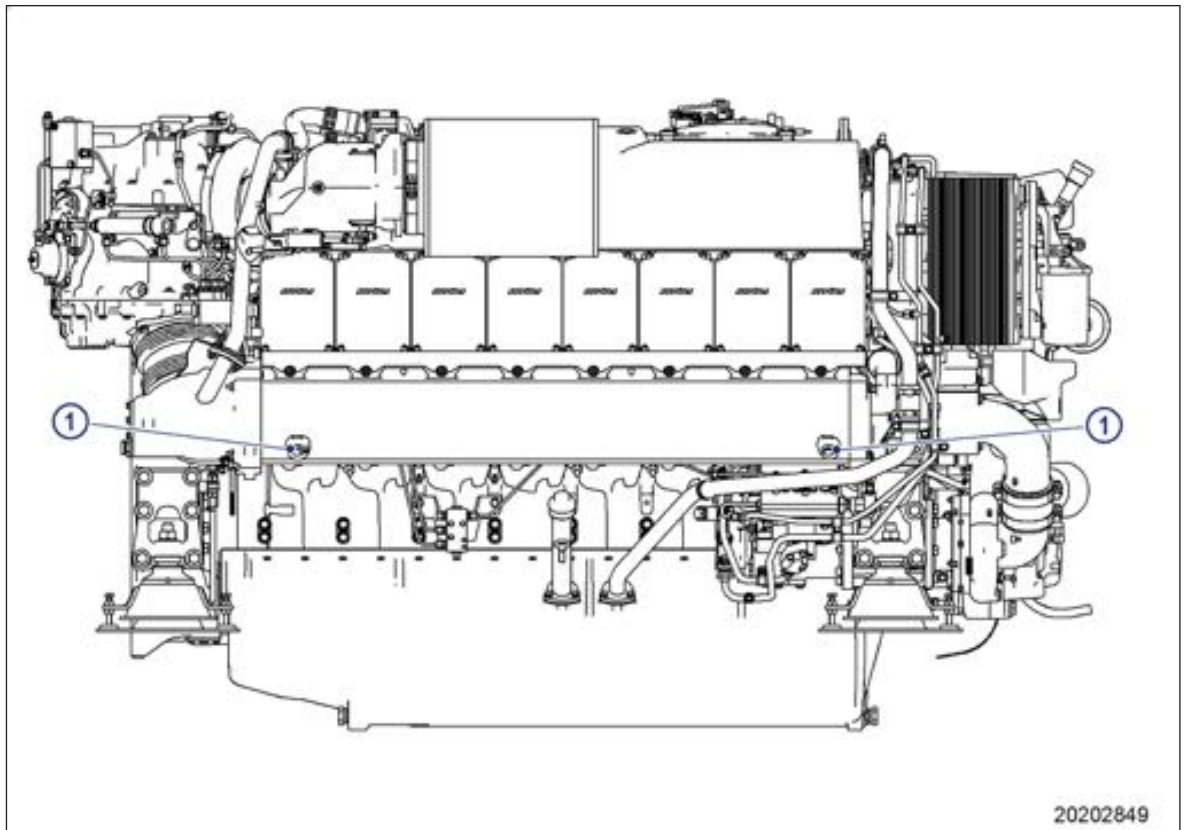
20202847

- |                              |   |
|------------------------------|---|
| 1 Engine coolant drain screw | 2 Engine coolant drain screw<br>Preheating line inlet con-<br>nection |
|------------------------------|---|



20202848

- |                                   |                              |                              |
|-----------------------------------|------------------------------|------------------------------|
| 1 Engine coolant overflow<br>line | 2 Engine coolant filler neck | 3 Engine coolant drain screw |
|-----------------------------------|------------------------------|------------------------------|



20202849

1 Engine coolant drain screw

## 7.16.2 Engine coolant – Level check

### Preconditions

- ☑ Engine is stopped and starting disabled.
- ☑ MTU Fluids and Lubricants Specifications (A001061/..) are available.

#### WARNING



Coolant is hot and under pressure.

#### **Risk of injury and scalding!**

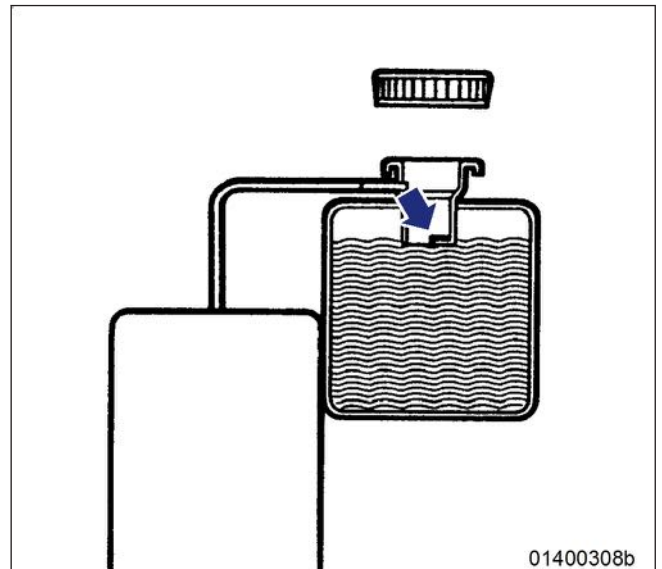
- Let the engine cool down.
- Wear protective clothing, gloves, and goggles / safety mask.

### Checking coolant level at filler neck:

1. Turn breather valve of coolant expansion tank counterclockwise until the first stop and allow pressure to escape.
2. Continue to turn breather valve counterclockwise and remove.
3. Check coolant level (coolant must be visible at the bottom edge of the cast-in eye of the filler neck).

### Checking coolant level at external cooler:

1. Check coolant level (coolant must be visible at marker plate).
2. Top up coolant if necessary (→ Page 106).
3. Check and clean breather valve.
4. Position breather valve on filler neck and close.



### Coolant-level check by means of level sensor:

1. Switch on engine control system and check readings on the display.
2. Top up coolant if necessary (→ Page 106).



### 7.16.3 Engine coolant - Change

#### Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Coolant		

#### Engine coolant change

1. Drain engine coolant (→ Page 105).
2. Fill with engine coolant (→ Page 106).



## 7.16.4 Engine coolant – Draining

### Preconditions

- ☑ Engine is stopped and starting disabled.

#### WARNING



Coolant is hot and under pressure.

#### **Risk of injury and scalding!**

- Let the engine cool down.
- Wear protective clothing, gloves, and goggles / safety mask.

### Preparatory steps

1. Provide an appropriate container to collect the coolant or
2. Switch on the extraction device.
3. Switch off preheating unit.

### Draining engine coolant

1. Turn breather valve of filler neck on coolant expansion tank (→ Page 100) counterclockwise to first stop and allow pressure to escape.
2. Continue to turn breather valve counterclockwise and remove.
3. Draw off separated corrosion inhibitor oil in expansion tank through the filler neck.
4. Open drain valves/plugs (→ Page 100) and drain or pump out engine coolant.
5. Close all open drain points.
6. Place breather valve on filler neck and close.

## 7.16.5 Engine coolant – Filling

### Preconditions

- ☑ Engine is stopped and starting disabled.
- ☑ MTU Fluids and Lubricants Specifications (A001061/..) are available.

### Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Engine coolant		

#### WARNING



Coolant is hot and under pressure.

#### **Risk of injury and scalding!**

- Let the engine cool down.
- Wear protective clothing, gloves, and goggles / safety mask.

#### NOTICE



Cold coolant in hot engine can cause thermal stress.

#### **Possible formation of cracks in the engine!**

- Fill / top up coolant only into cold engine.

### Filling with engine coolant

1. Turn breather valve of coolant expansion tank (→ Page 33) counterclockwise until the first stop and allow pressure to escape.
2. Continue to turn breather valve counterclockwise and remove.
3. Pour coolant into engine until coolant level reaches bottom edge of cast-in eye of filler neck.
4. Check satisfactory condition of breather valve and clean sealing faces.
5. Place breather valve on filler neck and close.
6. Start the engine and operate it at idle speed for some minutes.
7. Check coolant level (→ Page 103).

### 7.16.6 HT coolant pump – Relief bore check

#### DANGER



Rotating and moving engine parts.

**Risk of crushing, danger of parts of the body being caught or pulled in!**

- Only run the engine at low power. Keep away from the engine's danger zone.

#### WARNING



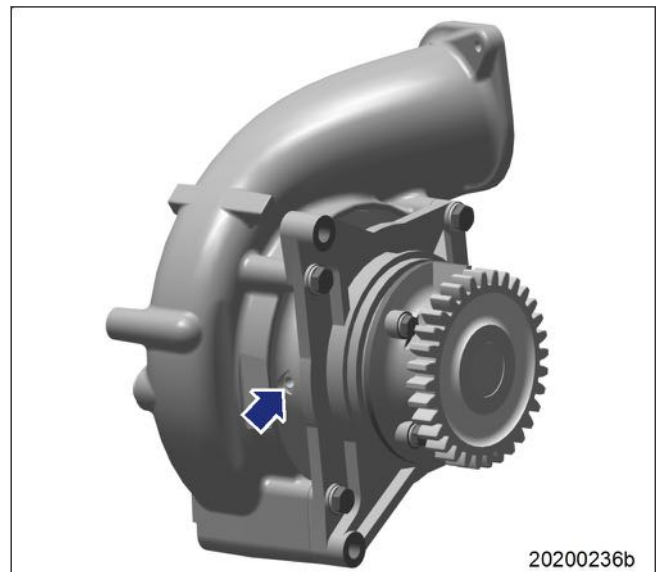
High level of engine noise when the engine is running.

**Risk of damage to hearing!**

- Wear ear protectors.

#### HT coolant pump – Relief bore check

1. Check relief bore for oil and coolant discharge.
2. Stop engine (→ Operating instructions electronic system) and disable engine start.
3. Clean the relief bore with a wire if it is dirty.
  - Permissible engine coolant discharge: up to 10 drops per hour;
  - Permissible oil discharge: up to 5 drops per hour.
4. If discharge exceeds the specified limits, contact Service.



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### 7.16.7 Engine coolant – Sample extraction and analysis

#### Preconditions

- ☑ Engine is stopped and starting disabled.
- ☑ MTU Fluids and Lubricants Specification (A001061/..) is available.

#### Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
MTU test kit	5605892099/00	1

#### WARNING



Coolant is hot and under pressure.

#### Risk of injury and scalding!

- Let the engine cool down.
- Wear protective clothing, gloves, and goggles / safety mask.

#### Engine coolant – Sample extraction and analysis

1. Turn breather valve on coolant expansion tank (→ Page 100) counterclockwise until first stop and allow pressure to escape.
2. Continue to turn breather valve counterclockwise and remove.
3. Draw off precipitated corrosion inhibitor oil from expansion tank and dispose of oil.
4. Draw off approx. 1 liter coolant and drain into a clean container.
5. Using the equipment and chemicals from the MTU test kit, examine coolant for:
  - antifreeze concentration;
  - corrosion inhibitor concentration;
  - pH value.
6. Fit breather valve and close it.
7. Change engine coolant according to the coolant operating times specified in the (→ MTU Fluids and Lubricants Specifications A001061/..) (→ Page 105).

## 7.17 Low-Temperature Circuit

### 7.17.1 Charge-air coolant - Draining

#### Preconditions

- ☑ Engine is stopped and starting disabled.

#### WARNING



Coolant is hot and under pressure.

#### **Risk of injury and scalding!**

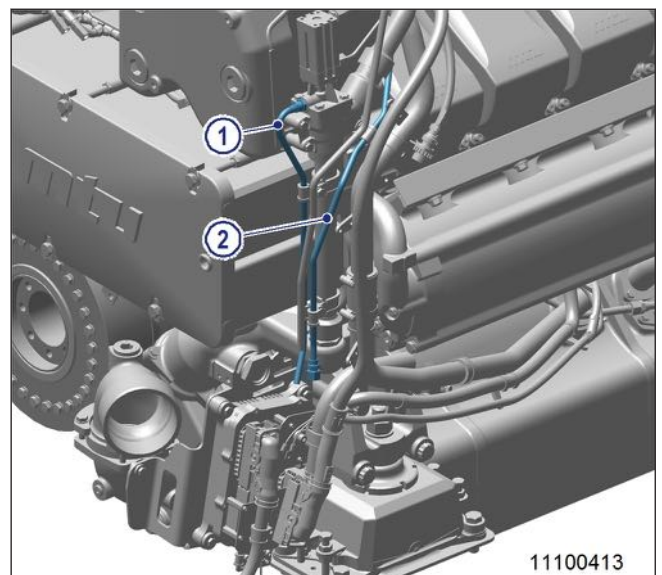
- Let the engine cool down.
- Wear protective clothing, gloves, and goggles / safety mask.

#### Charge-air coolant - Draining

1. Provide a suitable container to collect the raw water.
2. Open union nut on drain line (2) on driving end and free end.

Result: It may take a little time before raw water first emerges from the intercooler drain line.

3. Wait until the raw water has drained completely from the intercooler.
4. Close union nut on drain line (2).



## 7.18 Raw Water Pump with Connections

### 7.18.1 Raw water pump – Relief bore check

#### DANGER



Rotating and moving engine parts.

**Risk of crushing, danger of parts of the body being caught or pulled in!**

- Only run the engine at low power. Keep away from the engine's danger zone.

#### WARNING



High level of engine noise when the engine is running.

**Risk of damage to hearing!**

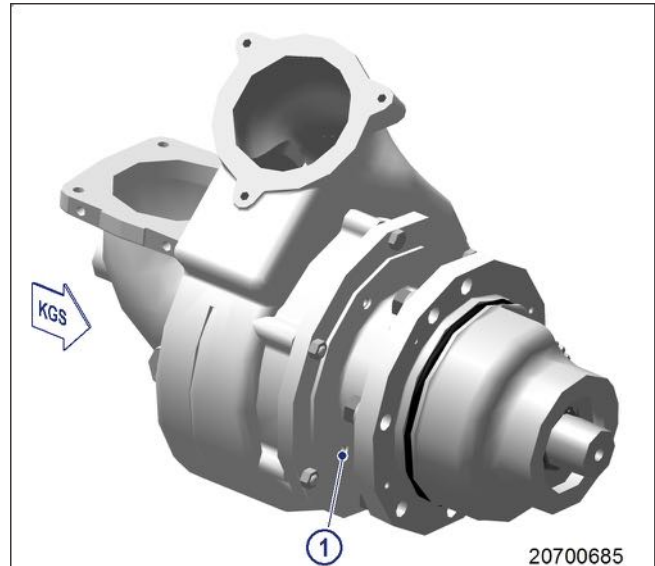
- Wear ear protectors.

#### Raw water pump – Relief bore check

1. Check relief bore (1) for oil and coolant discharge.

Result: No fluid should emerge.

2. If clogged:
  - Stop engine (→ Page 52) and disable engine start.
  - Clean the relief bore with a wire.
3. Contact Service if fluid emerges.



## 7.19 Engine Mounting / Support

### 7.19.1 Engine mounting - Checking securing screws for firm seating

#### **Preconditions**

- ☒ Engine is stopped and starting disabled.

#### **Engine mounting, checking securing screws for firm seating**

1. Check securing screws for firm seating.
2. Tighten loose threaded connections.

## 7.19.2 Engine mounting – Checking condition of resilient mounts

### **Preconditions**

- ☒ Engine is stopped and starting disabled.

### **Engine mounting – Checking the condition of resilient mounts**

1. Wipe rubber surface with dry cloth, do not use organic detergents.
2. Visually inspect resilient mounts for cracking and deformation.
3. Check rubber surfaces for swelling.
4. Have cracked or swollen mounts replaced, contact Service.



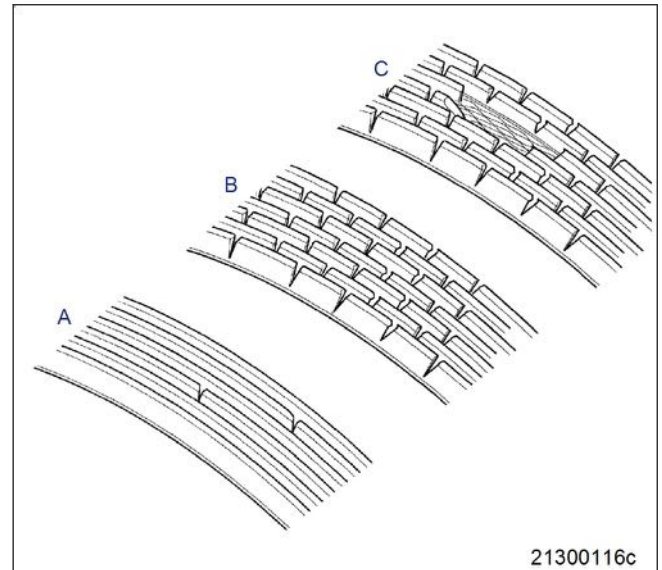
## 7.20 Belt Drive

### 7.20.1 Drive belt – Condition check

#### Preconditions

- ✓ Engine is stopped and starting disabled.
- ✓ Guard is removed.

#### Drive belt – Condition check



Item	Findings	Action
Drive belt A	Singular cracks	None
Drive belt B	Cracks on entire circumference	Replace (→ Page 114)
Drive belt C	Chunking	
Drive belt	Belt is oily, shows signs of over-heating	

## 7.21 Battery-Charging Generator

### 7.21.1 Battery-charging generator drive – Drive belt replacement

#### Preconditions

- ☒ Engine is stopped and starting disabled.

#### Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Mandrel	8205892861/08	1

#### Preparatory steps

1. Remove safety equipment (if fitted).
2. Remove screws of protective cover (engine free end).
3. Remove protective cover.

#### Replacing drive belt

1. Hold adjusting lever at square.
2. Rotate adjusting lever until drive belt is released.
3. Use mandrel to lock adjusting lever in position.
4. Remove drive belt.
5. Check cleanness of belt pulleys.
6. Fit new drive belt.
7. Remove mandrel.

#### Final steps

1. Install protective cover.
2. Install screws of protective cover.
3. Install safety equipment (if fitted).
4. Check function of safety equipment (if fitted).

## 7.22 Wiring (General) for Engine/Gearbox/Unit

### 7.22.1 Engine wiring - Check

#### Preconditions

- ☑ Engine is stopped and starting disabled.

#### Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Isopropyl alcohol	X00058037	1

#### Engine wiring – Check

1. Check securing screws of cable clamps on engine and tighten loose threaded connections.
2. Ensure that cables are fixed in their clamps and cannot swing freely.
3. Check if all cable clips are closed and intact.
4. Replace faulty cable clips.
5. Check that cable clamps are firm, tighten loose cable clamps.
6. Replace faulty cable clamps.
7. Visually inspect the following electrical line components for damage:
  - Connector housing
  - Contacts
  - Sockets
  - Cables and terminals
  - Plug-in contacts

Result: Contact Service if cable conductors are damaged.

Note: Close male connectors that are not plugged in with the protective cap supplied.

8. Clean dirty connector housings, sockets and contacts using isopropyl alcohol.
9. Ensure that all sensor connectors are securely engaged.

## 7.23 Accessories for (Electronic) Engine Governor / Control System

### 7.23.1 Engine governor and connectors – Cleaning

#### Preconditions

- ☒ Engine is stopped and starting disabled.

#### Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Isopropyl alcohol	X00058037	1

Note: Always use test connectors to enter the connectors. Never use test leads for this purpose. Otherwise the contacts could be bent.

#### Engine governor and connectors – Cleaning

1. Remove coarse dirt from housing surface using a cloth moistened with isopropyl alcohol.
2. Remove dirt from the connector and cable surfaces with isopropyl alcohol.
3. Check legibility of cable labels. Clean or replace illegible labels.

#### Cleaning severely contaminated connectors on the engine governor

Note: Seal unused connectors with the supplied protective cap.

1. Release the latch and pull off connectors.
2. Clean connector housings, connector socket housings and all contacts with isopropyl alcohol.
3. When connectors, sockets and all contacts are dry: Fit connectors and lock them.

## 7.23.2 EMU and connectors – Cleaning

### Preconditions

- ☒ Engine is stopped and starting disabled.

### Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Isopropyl alcohol	X00058037	1

### Cleaning EMU and connectors

1. Remove coarse dirt from housing surface using a cloth moistened with isopropyl alcohol.
2. Remove dirt from the connector and cable surfaces with isopropyl alcohol.
3. Check legibility of cable labels. Clean or replace illegible labels.

### Cleaning severely contaminated connectors on EMU

1. Release the latch and pull off connector.
2. Clean connector housings, connector socket housings and all contacts with isopropyl alcohol.
3. When connectors, sockets and all contacts are dry: Fit connectors and latch.

### 7.23.3 Engine governor plug connections – Check

#### Preconditions

- ☑ Engine stopped and starting disabled.

#### NOTICE



Insertion of unsuitable test probe, e.g. test prod.

**The contacts in the plug connection can be bent!**

- Carry out check of plug connection only with test connectors.

#### Checking plug connections at engine governor

1. Check all plug connections for secure seating.
2. Latch loose connectors.

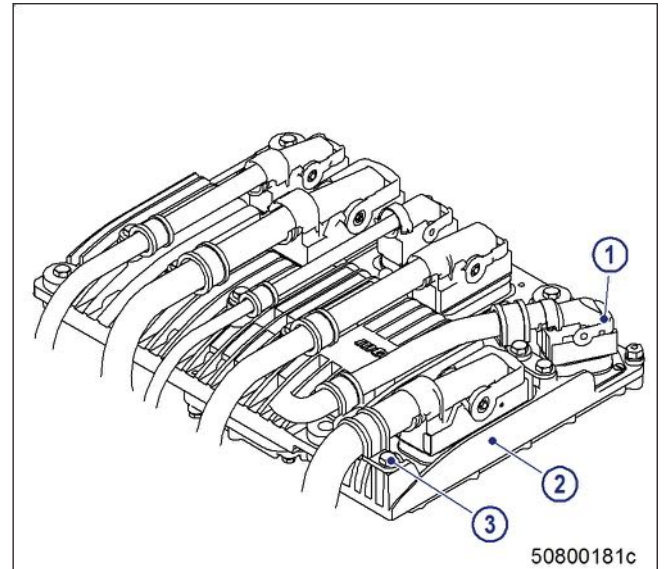
## 7.23.4 Engine Monitoring Unit EMU 8 - Plug connections check

### Preconditions

- ☑ Engine is stopped and starting disabled.

### Checking EMU plug connections

1. Check both connectors on EMU (2) for firm seating. Ensure that the clips (1) are engaged.
2. Check screws (3) of cable clamps on EMU (2) for firm seating. Ensure that cable clamps are not faulty.



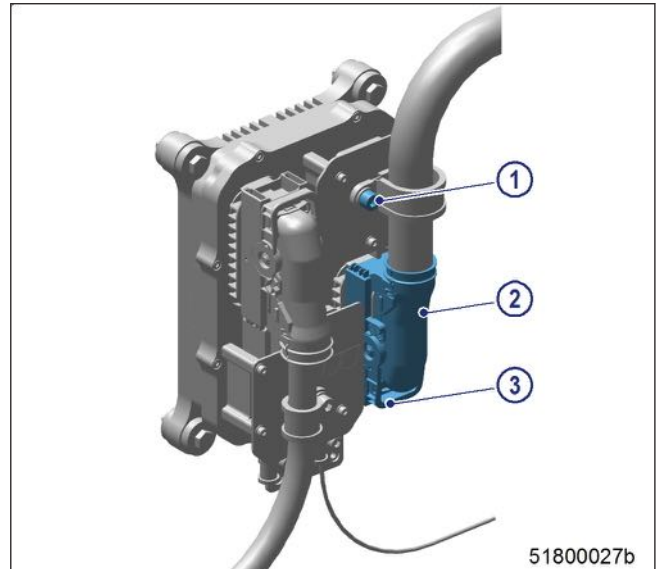
### 7.23.5 Interface module EIM plug connections - Check

#### Preconditions

- ☑ Engine is stopped and starting disabled.

#### Checking EIM plug connections

1. Check both Tyco plugs (62-pole) (2) on EIM for firm seating. Ensure that clips (3) are engaged.
2. Check screws (1) of cable clamps on EIM for firm seating. Ensure that cable clamps are not faulty.





## 7.23.6 Engine Control Unit – Self-test

DANGER



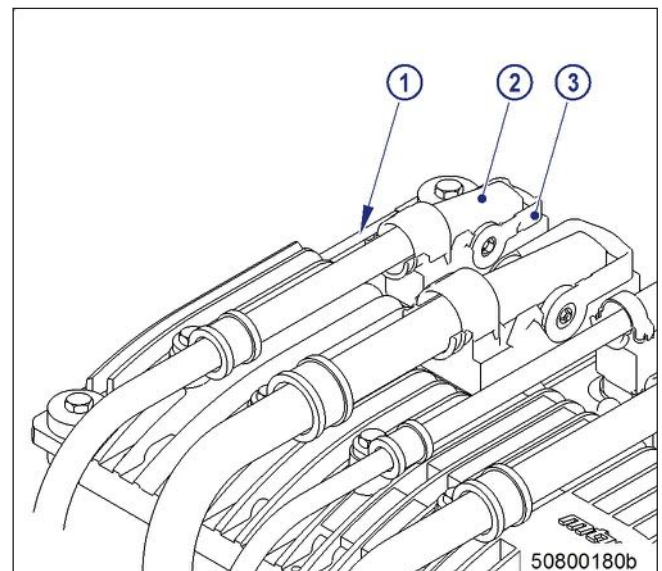
Electric voltage supply for operation.

### **Danger of burns and fatal electric shock!**

- Make certain that the power supply to the product is switched off before starting work. Secure against unintentional switching on!

### **ECU7 self-test**

1. Switch off power supply to system.
  2. Remove connectors X1, X2 and X4 from the Engine Control Unit.
    - a) Release lock (3) of connectors (2).
    - b) Unplug connector (2).
  3. Switch on power supply
- Result:
- The Engine Control Unit is operable if the diagnostic lamp (1) changes to continuous illumination within 30 seconds after power has been switched on.
  - If the diagnostic lamp (1) flashes after 30 seconds, replace Engine Control Unit and (→ contact Service).
  - Check the power supply if the diagnostic lamp remains dark.
4. Switch off power supply.
  5. Refit connectors X1, X2 and X4 on Engine Control Unit.
    - a) Plug in connector (2).
    - b) Lock connectors.



## 7.23.7 Engine governor ECU 9 – Removal and installation

### Preconditions

- ☑ Engine is stopped and starting disabled.

#### NOTICE



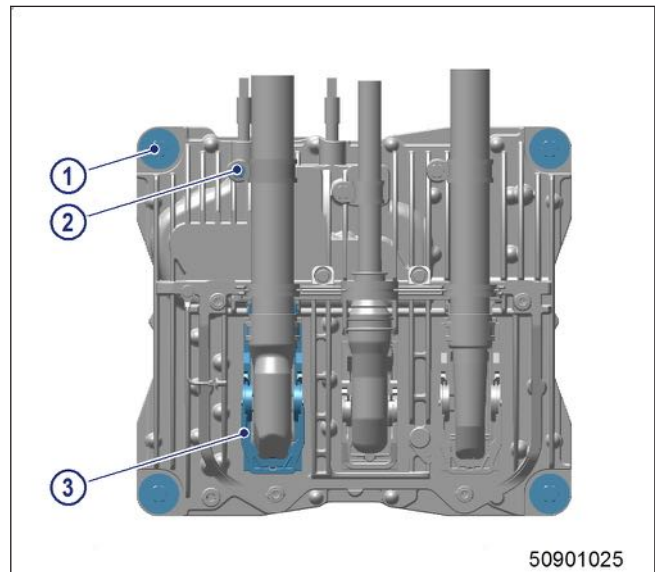
Wrong engine governor installed.

#### Engine damage!

- When reassembling an engine, make sure that the governor with the data record for the given engine is installed.

### Removing engine governor from engine

1. Note or mark assignment of cables and connectors.
2. Remove all screws (2).
3. Undo clips (3) on connectors.
4. Remove all male connectors.
5. Remove screws (1).
6. Take off engine governor.



### Installing engine governor on engine

1. Install in reverse order. Ensure correct assignment of connectors and sockets.
2. Check resilient mount before installing.

Result: If resilient mount is porous or defective then replace it.

## 7.23.8 Engine Monitoring Unit – Removal and installation

### Preconditions

- ☑ Engine is stopped and starting disabled.

#### NOTICE



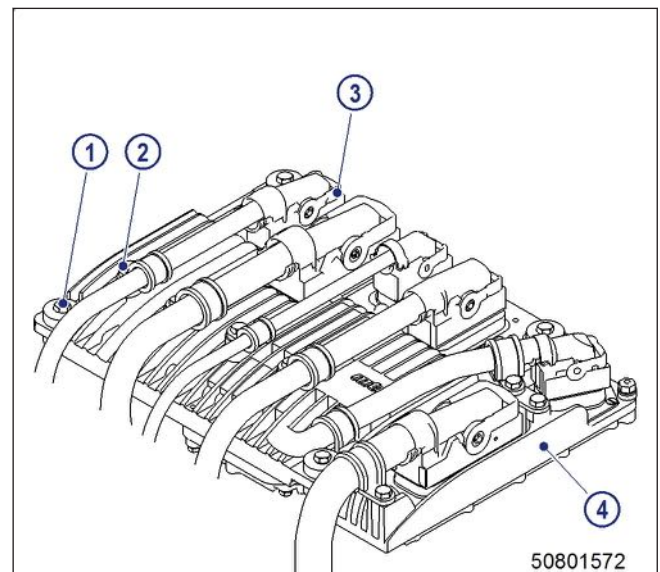
Wrong engine governor installed.

#### Engine damage!

- When reassembling an engine, make sure that the governor with the data record for the given engine is installed.

### Removing Engine Control Unit with Engine Monitoring Unit from engine

1. Note or mark assignment of cables and connectors.
2. Remove all screws (2).
3. Release lock (3) on connectors.
4. Remove all connectors.
5. Remove screws (1).
6. Remove Engine Control Unit (1) with Engine Monitoring Unit (4).



### Removing Engine Monitoring Unit

1. Unscrew screws on base of Engine Monitoring Unit (4).
2. Remove Engine Monitoring Unit (4) with Engine Control Unit (1).

### Installing Engine Monitoring Unit

1. Place Engine Monitoring Unit (4) in position on Engine Control Unit (1).
2. Screw in and tighten screws on base of Engine Monitoring Unit (4).

### Installing Engine Control Unit with Engine Monitoring Unit on engine

1. Install in reverse order. Ensure correct assignment of connectors and sockets.
2. Check resilient mount before installing.

Result: If resilient mount is porous or defective then replace it.

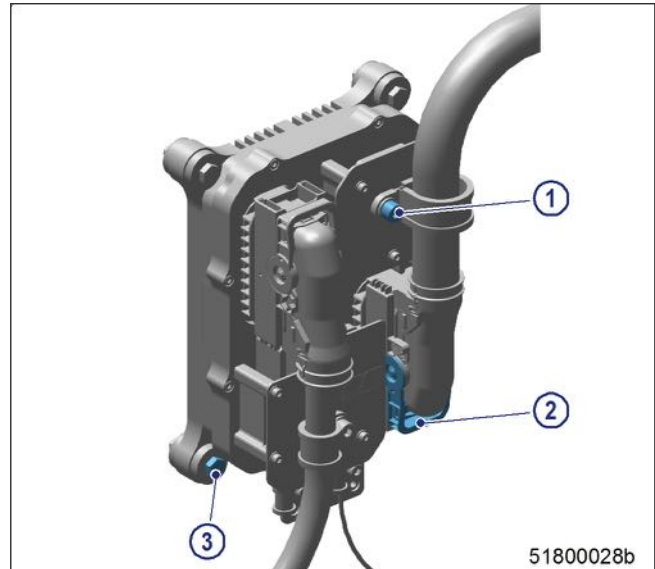
## 7.23.9 Engine Interface Module EIM - Removal and installation

### Preconditions

- ☑ Engine is stopped and starting disabled.

### Removing EIM from the engine

1. Note or mark assignment of cables and connectors.
2. Unscrew all screws (1).
3. Undo clips (2) on connectors.
4. Disconnect all connectors.
5. Unscrew power and starter cable.
6. Remove screws (3).
7. Take off EIM.



### Installing EIM on the engine

1. Install in reverse order. When doing so, observe correct assignment between cables and plugs.
2. Check seal before installing.

Result: Replace seal if porous or defective.

### Downloading software

1. The new EIM still does not have appropriate FSW and parameter/descriptor module (the diagnostic lamp (DILA) indicates flashing code 4 when the power supply is connected, (→ Page 125)).
2. The FSW and the parameter/descriptor module must first be downloaded from the central database (CDB) based on the relevant engine number using the DiaSys software tool, and then loaded in the EIM.

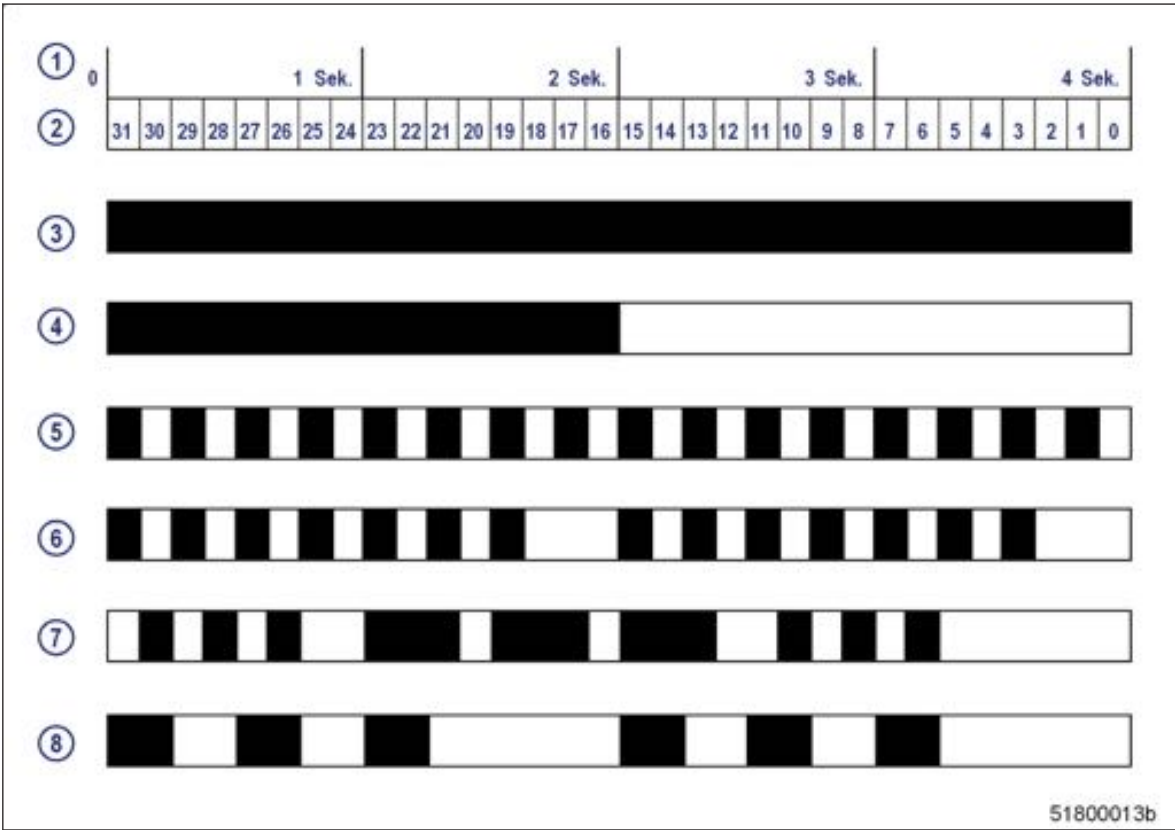
7.23.10 Diagnostic features of EIM

Diagnostic lamp (DILA)

A diagnostic lamp (LED, blue) is integrated in the housing of the Engine Interface Module (EIM). It indicates the operating status of the EIM.

Functions of diagnostic lamp DILA	
DILA lights	Engine Interface Module (EIM) is OK.
DILA dark	EIM supply voltage missing or diagnostic lamp activation is faulty.
DILA flashes	Hardware or software fault in the Engine Interface Module.

The diagnostic lamp (DILA) signals the following states:



- 1 Time in seconds

2 Timing: 1/8 s

3 Ready for operation
- 4 Application loader active

5 External RAM faulty

6 External FLASH faulty
- 7 No firmware

8 Application crashed

Fuse lamp (SILA)

A second indicator is the fuse lamp.

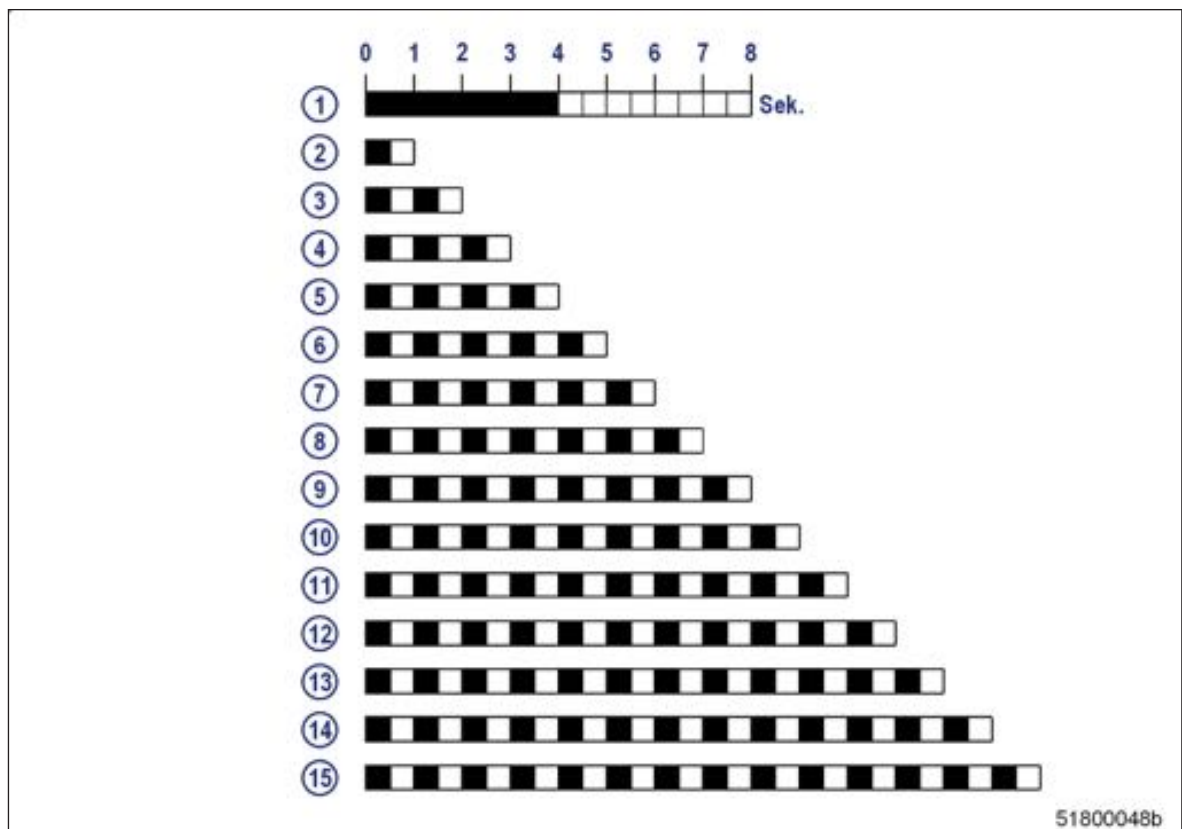
This is also integrated in the housing of the Engine Interface Module. It indicates the status of the fuses.

An orange LED is provided to allow diagnosis of a “tripped fuse” fault directly at the unit as it is often difficult to pinpoint a fault in the field without cabling diagrams.

This LED is activated by the controller.

Functions of fuse lamp SILA	
SILA dark	Normal operating state.
SILA flashes orange	One or more fuses have tripped.

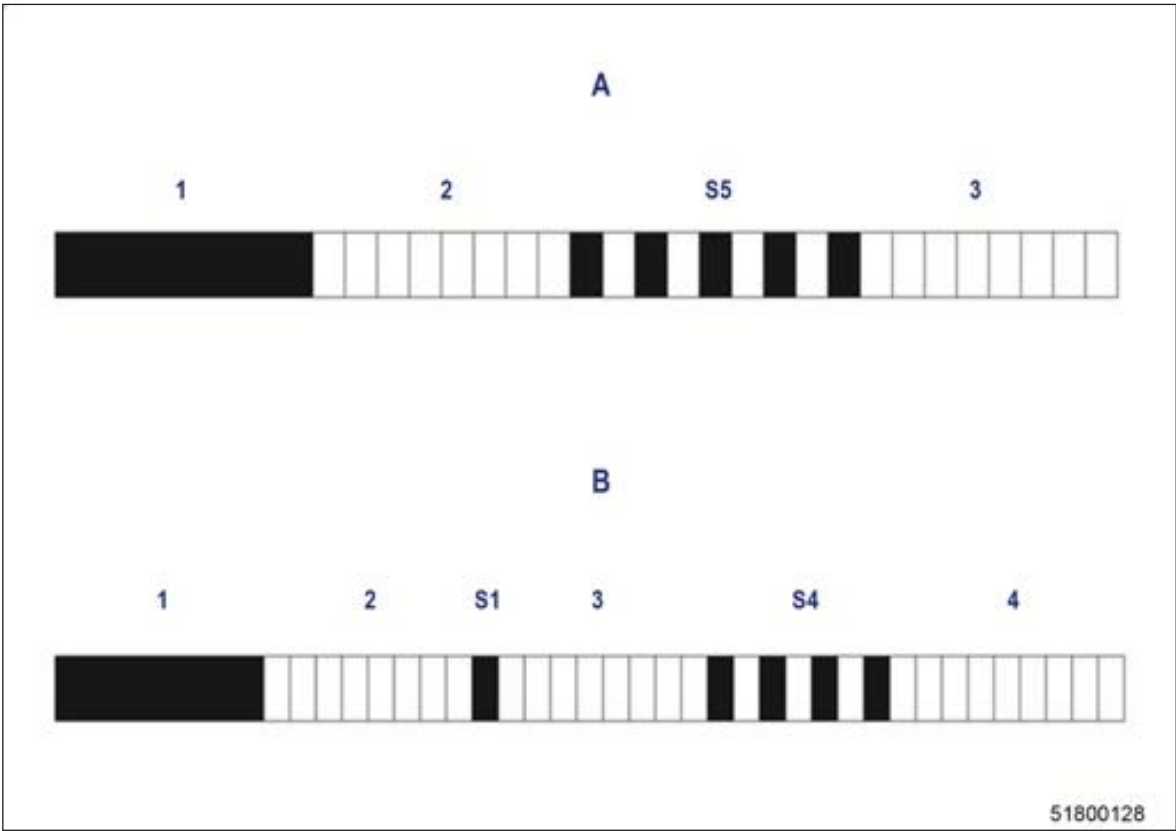
The fuse lamp (SILA) signals the following states:



- |   |   |   |
|---|---|---|
| 1 Preamble  | 6 VSP current path failed (S5)                            | 11 ES pushbutton current path failed - 24V external (S10) |
| 2 ECU current path failed (S1)  | 7 SLD current path failed (S6)                            | 12 Key switch current path failed (S11)                   |
| 3 MCS current path failed (S2)  | 8 DDV current path failed (S7)                            | 13 SDAF 1+2 current path failed (S12)                     |
| 4 EMU current path failed (S3)  | 9 Gear monitoring current path failed (S8)                | 14 PIM current path failed (S13)                          |
| 5 Starter voltage: Terminal 30, 31 not connected and PR 10.0600.001 has value 1 or 2 (S4) | 10 Emergency stop current path failed - 24V internal (S9) | 15 Spare current path failed (S14)                        |

The failed current paths are signaled consecutively following the preamble (LED on for 4 seconds (1)). There is a pause lasting 4 seconds in between.

Sample flashing sequences



A Fuse S5 failure (1/2 second steps)      B Fuse S1 and fuse S4 failure (1/2 second steps)

**Note:**

These bit sequences are transmitted constantly.

Information about the status of the current paths of the EIM is also provided in the CAN message “Status internal power supply”.

## 8 Appendix A

### 8.1 List of abbreviations

Abbreviation	Meaning	Explanation
ADEC	Advanced Diesel Engine Controller	Engine management system
AGR	Abgasrückführung	Exhaust Gas Recirculation (EGR)
AL	Alarm	General alarm
ANSI	American National Standards Institute	Umbrella organization administering and coordinating US standards
ATL	Abgasturbolader	Exhaust turbocharger (ETC)
BDM	Backup Data Module	
BR	Baureihe	Series
BV	Betriebsstoffvorschrift	Fluids and Lubricants Specifications, MTU Publication No. A001061/..
CAN	Controller Area Network	Data bus system, bus standard
CPP	Controllable Pitch Propeller	
CR	Common Rail	
DIN	Deutsches Institut für Normung e. V.	German Standardization Organization, at the same time identifier of German standards ("Deutsche Industrie-Norm")
DIS	Display Unit	Display panel
DL	Default Lost	Alarm: CAN bus missing
DOC	Diesel Oxidation Catalyst	
DPF	Diesel Particulate Filter	
ECS	Engine Control System	Engine management system
ECU	Engine Control Unit	Engine governor
EDM	Engine Data Module	
EIL	Engine Ident Label	
EMU	Engine Monitoring Unit	
ETK	Ersatzteilkatalog	Spare Parts Catalog
FPP	Fixed Pitch Propeller	
GCU	Gear Control Unit	
GMU	Gear Monitoring Unit	
HI	High	Alarm: Measured value exceeds 1st maximum limit value
HIHI	High High	Alarm: Measured value exceeds 2nd maximum limit value
HT	High Temperature	
ICFN	ISO – Continuous rating – Fuel stop power – Net	Power specification in accordance with DIN-ISO 3046-7
IDM	Interface Data Module	Memory module for interface data
IMO	International Maritime Organization	



Abbreviation	Meaning	Explanation
ISO	International Organization for Standardization	International umbrella organization of all standards institutes
KGS	Kupplungsgegenseite	Engine free end in accordance with DIN ISO 1204
KS	Kupplungsseite	Engine driving end in accordance with DIN ISO 1204
LCD	Liquid Crystal Display, Liquid Crystal Device	
LCU	Local Control Unit	LOP subassembly
LED	Light Emitting Diode	
LMU	Local Monitoring Unit	LOP subassembly
LO	Low	Alarm: Measured value below 1st minimum limit value
LOLO	Low Low	Alarm: Measured value below 2nd minimum limit value
LOP	Local Operating Panel	Control console, control panel
LOS	Local Operating Station	Local control unit
MCS	Monitoring and Control System	
MG	Message	
MPU	Microprocessor Unit, Microprocessing Unit	
OT	Oberer Totpunkt	Top Dead Center (TDC)
P-xyz	Pressure-xyz	Pressure measuring point, xyz specifies the measuring point designation
PAN	Panel	Control panel
PAU	Power Automation Unit	Module for monitoring, control and plant-related system integration of peripheral components
PCU	Propeller Control Unit	
PIM	Peripheral Interface Module	
PLD	Pumpe-Leitung-Düse	Unit-pump system
POM	Power Output Module	Module to control starter and battery-charging generator
RCS	Remote Control System	
RL	Redundancy Lost	Alarm: Redundant CAN bus failure
SAE	Society of Automotive Engineers	US standardization organization
SD	Sensor Defect	Alarm: Defective sensor
SDAF	Shut Down Air Flaps	
SS	Safety System	Safety system alarm
SSK	Schnellschlussklappen	Shut Down Air Flaps (SDAF)
T-xyz	Temperature-xyz	Temperature measuring point, xyz specifies the measuring point designation
TD	Transmitter Deviation	Alarm: Sensor/transmitter comparison fault
UT	Unterer Totpunkt	Bottom Dead Center (BDC)
VS	Voith Schneider	Voith-Schneider drive
WJ	Water Jet	Water jet drive
WZK	Werkzeugkatalog	Tool Catalog

## 8.2 MTU contact persons/service partners

Our worldwide sales network with its subsidiaries, sales offices, representatives and customer service centers ensures fast and direct support on site and the high availability of our products.

### **Local support**

Experienced and qualified specialists place their knowledge and expertise at your disposal.

For locally available support, go to the MTU Internet site: <http://www.mtu-online.com>

### **24h hotline**

With our 24h hotline and the outstanding flexibility of our service staff, we are always ready to assist you – either during operation, for preventive maintenance, corrective work in case of malfunction or changed operating conditions, or for spare parts supply.

Your contact person in our Customer Assistance Center:

E-mail: [info@mtu-online.com](mailto:info@mtu-online.com)

Tel.: +49 7541 9077777

Fax: +49 7541 9077778

Asia/Pacific: +65 6100 2688

North and Latin America: +1 248 560 8000

### **Spare parts service**

Fast, simple and correct identification of spare parts for your drive system or vehicle fleet. The right spare part at the right time at the right place.

With this aim in mind, we can call on a globally networked spares logistics system, a central warehouse at headquarters and on-site stores at our subsidiary companies, agencies and service workshops.

Your contact at Headquarters:

E-mail: [spare.parts@mtu-online.com](mailto:spare.parts@mtu-online.com)

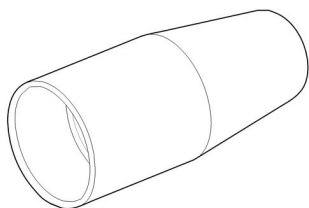
Tel.: +49 7541 908555

Fax: +49 7541 908121

## 9 Appendix B

### 9.1 Special Tools

#### Assembly sleeve

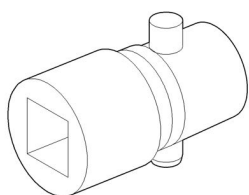


Part No.: F30454554

Qty.: 1

Used in: 7.7.2 Injector – Removal and installation (→ Page 81)

#### Barring gear



Part No.: F6783914

Qty.: 1

Used in: 7.5.2 Valve clearance – Check and adjustment (→ Page 77)

#### Centering jig

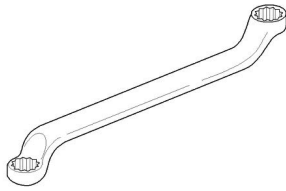


Part No.: F6783025

Qty.: 1

Used in: 7.5.1 Cylinder head cover – Removal and installation (→ Page 76)

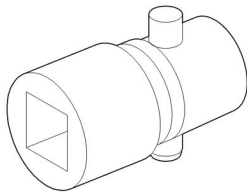
### Double-head box wrench



Part No.: F30002800

Qty.: 1  
Used in: 7.5.2 Valve clearance – Check and adjustment  
(→ Page 77)

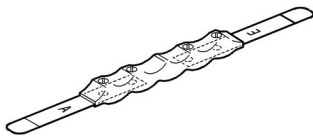
### Engine barring gear



Part No.: F6783914

Qty.: 1  
Used in: 7.2.1 Engine – Barring manually (→ Page 67)

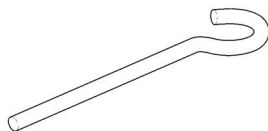
### Feeler gage



Part No.: Y4345893

Qty.: 1  
Used in: 7.5.2 Valve clearance – Check and adjustment  
(→ Page 77)

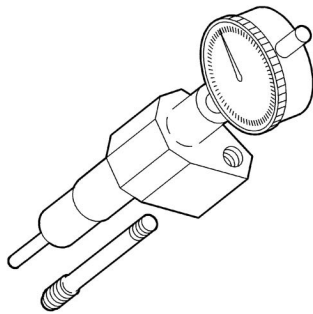
### Mandrel



Part No.: 8205892861/08

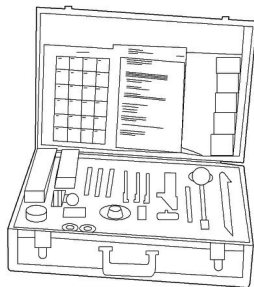
Qty.: 1  
Used in: 7.21.1 Battery-charging generator drive – Drive belt replacement (→ Page 114)

### Measuring instrument



Part No.:	Y4345888
Qty.:	1
Used in:	7.5.2 Valve clearance – Check and adjustment (→ Page 77)

### MTU test kit



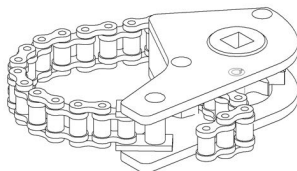
Part No.:	5605892099/00
Qty.:	1
Used in:	7.16.7 Engine coolant – Sample extraction and analysis (→ Page 108)

### Offset screwdriver



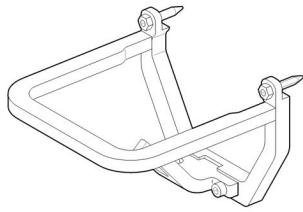
Part No.:	F30002816
Qty.:	1
Used in:	7.5.2 Valve clearance – Check and adjustment (→ Page 77)

### Oil filter wrench



Part No.:	F30379104
Qty.:	1
Used in:	7.9.1 Fuel filter – Replacement (→ Page 84)
Qty.:	1
Used in:	7.15.1 Engine oil filter – Replacement (→ Page 99)

## Puller



Part No.: F6795554

Qty.: 1

Used in: 7.7.2 Injector – Removal and installation (→ Page 81)

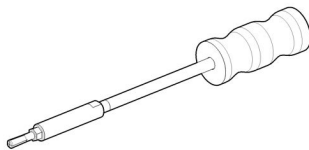
## Puller

Part No.: F6790991

Qty.: 1

Used in: 7.7.2 Injector – Removal and installation (→ Page 81)

## Puller

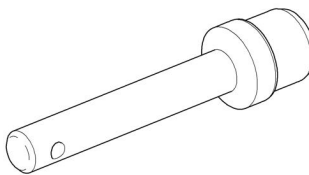


Part No.: F6790992

Qty.: 1

Used in: 7.7.2 Injector – Removal and installation (→ Page 81)

## Puller

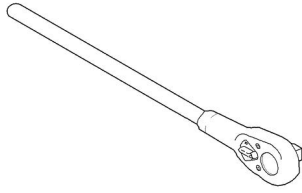


Part No.: F6795777

Qty.: 1

Used in: 7.7.2 Injector – Removal and installation (→ Page 81)

### Ratchet



Part No.: F30006212

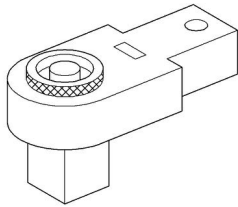
Qty.: 1

Used in: 7.2.1 Engine – Barring manually (→ Page 67)

Qty.: 1

Used in: 7.5.2 Valve clearance – Check and adjustment (→ Page 77)

### Ratchet

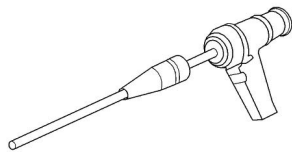


Part No.: F30027340

Qty.: 1

Used in: 7.4.2 Crankcase breather – Oil separator element replacement, diaphragm check and replacement (→ Page 74)

### Rigid endoscope

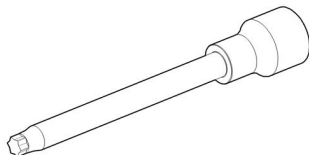


Part No.: Y20097353

Qty.: 1

Used in: 7.3.2 Cylinder liner – Endoscopic examination (→ Page 71)

### Screwdriver bit T45

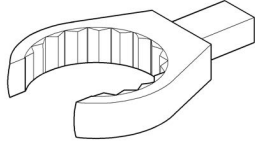


Part No.: F30454548

Qty.: 1

Used in: 7.7.2 Injector – Removal and installation (→ Page 81)

### Socket wrench



Part No.: F30030450

Qty.: 1

Used in: 7.5.2 Valve clearance – Check and adjustment  
(→ Page 77)

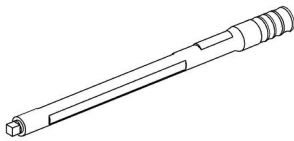
### Steam jet cleaner

Part No.: -

Qty.: 1

Used in: 4.8 Plant – Cleaning (→ Page 55)

### Torque wrench, 10-60 Nm

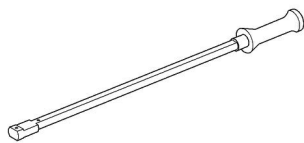


Part No.: F30510423

Qty.: 1

Used in: 7.5.2 Valve clearance – Check and adjustment  
(→ Page 77)

### Torque wrench, 10-60 Nm



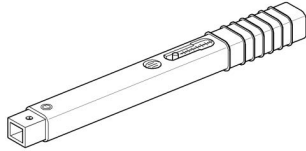
Part No.: F30452769

Qty.: 1

Used in: 7.7.2 Injector – Removal and installation (→ Page 81)



## Torque wrench, 6-50 Nm



Part No.: F30027336

Qty.: 1

Used in: 7.4.2 Crankcase breather – Oil separator element replacement, diaphragm check and replacement (→ Page 74)

## 9.2 Index

### A

- Actuators
  - Overview 35
- After stopping the engine 54
- Air filter
  - Installation 94
  - Removal 94
  - Replacement 93

### B

- Battery-charging generator drive
  - Drive belt
    - Replacement 114

### C

- Charge-air coolant
  - Draining 109
- Connectors
  - Cleaning 116, 117
- Contact persons 130
- Coolant
  - Change 104
- Crankcase breather
  - Diaphragm check 74
  - Oil pre-separator element
    - Cleaning 73
  - Oil separator element replacement 74
- Cylinder
  - Designation 26
- Cylinder head cover - Removal and installation 76
- Cylinder liner
  - Endoscopic examination 71
  - Instructions and comments on endoscopic and visual examination 69

### D

- Drain points 100
- Drive belt
  - Condition check 113

### E

- ECU 9
  - Installation 122
  - Removal 122
- EMU
  - Cleaning 117
- Engine
  - Barring
    - Manually 67
  - Cranking
    - On starting system 68
  - Emergency shutdown 53
  - Layout 33
  - Main dimensions 47
  - Shutdown 52
  - Start 51

- Engine Control Unit
  - Self-test 121
- Engine coolant
  - Change 104
  - Draining 105
  - Filling 106
  - Level check 103
- Engine coolant - Sample extraction and analysis 108

### Engine data

- 12V 2000 M86 40
- 12V 2000 M96 40
- 12V 2000 M96L 40
- 16V 2000 M86 43
- 16V 2000 M96 43
- 16V 2000 M96L 43

### Engine driving end

- Definition 26

### Engine free end

- Definition 26

### Engine governor

- Cleaning 116
- Plug connections
  - Check 118

### Engine governor ECU 9

- Installation 122
- Removal 122

### Engine Interface Module EIM

- Removal and installation 124

### Engine Monitoring Unit

- Removal and installation 123

### Engine Monitoring Unit EMU 8

- Plug connections check 119

### Engine mounting

- Checking condition of resilient mounts 112
- Checking securing screws for firm seating 111

### Engine oil

- Change 98

### Engine oil filter

- Replacement 99

### Engine oil level

- Check 97

### Engine sides

- Designation 26

### Engine wiring

- Check 115

### F

### Firing order 46

### Fuel filter

- Replacement 84

- Fuel prefilter
  - Differential pressure gauge
    - Adjustment 85
    - Check 85
  - Draining 86
  - Filter element
    - Replacement 90
  - Flushing 88
- Fuel system
  - Venting 83

## H

- Hotline 130
- HP fuel pump
  - Filling
    - with engine oil 79
- HT coolant pump
  - Relief bore check 107

## I

- Injector
  - Installation 81
  - Removal 81
  - Replacement 80
- Installation locations for SOLAS shielding 62
- Intercooler
  - Check
    - Coolant discharge 92
    - Drain 92
    - Obstruction 92
- Interface module EIM
  - Check 120

## L

- List of abbreviations 128

## M

- Maintenance schedule
  - Maintenance task reference table [QL1] 56
- MTU contact persons 130

## O

- Oil filter
  - Replacement 99
- Operational checks 50

## P

- Plant
  - Cleaning 55
- Plug connections
  - Check 120
- Product description 27

## R

- Raw water pump
  - Check
    - Relief bore 110

## S

- Safety notices, standards 14
- Safety regulations
  - Auxiliary materials 12
  - Environmental protection 12
  - Fire prevention 12
  - Fluids and lubricants 12
  - Organizational requirements 6
  - Personnel requirements 6
- Safety requirements
  - Important requirements 5
  - Maintenance work 9
  - Operation 8
  - Repair work 9
  - Safety notices, standards 14
  - Startup 8
- Sensors
  - Overview 35
- Service indicator
  - Signal ring position check 95
- Service partners 130
- SOLAS shielding
  - Installation 61
- SOLAS shielding as per MTN 5233 - Installation 60
- Spare parts service 130
- Starter
  - Condition check 96
- Startup
  - After extended out-of-service periods (>3 months) 48
  - Putting into operation after scheduled out-of-service-period 49

## T

- Torque specifications
  - Nuts 15
  - Screws 15
  - Screws and nuts 15
- Transport 7
- Troubleshooting 57

## V

- Valve clearance
  - Adjustment 77
  - Check 77
- Venting points 100

## W

- Wiring
  - Check
    - On engine 115