Operating Instructions

Diesel engine
12 V 2000 P12
16 V 2000 P12

MS150025/02E

Power. Passion. Partnership.

Printed in Germany

This handbook is provided for use by maintenance and operating personnel in order to avoid malfunctions or damage during operation.

Subject to alterations and amendments.

Table of Contents

1 Safety

1.1 Important provisions for all MTU engines or systems

Nameplate

Engine identification is provided by the engine serial number on the nameplate.

The nameplate is located on the engine.

General information

This engine or plant may present a risk of injury or damage in the following cases:
- Incorrect use
- Operation, maintenance and repair by unqualified personnel
- Modifications or conversions
- Noncompliance with the safety instructions

Correct use

The engine or plant is intended solely for use in accordance with contractual agreements and the purpose envisaged for it on delivery.

This means that the equipment must be operated:
- Within the permissible operating parameters in accordance with the (→ engine data)
- With fluids and lubricants approved by MTU in accordance with the (→ MTU Fluids and Lubricants Specifications)
- With spare parts approved by MTU in accordance with the associated (→ Spare Parts Catalog)
- In the original as-delivered configuration or in a configuration approved by MTU in writing (engine and engine control/parameters)
- In compliance with all safety instructions and in adherence to all warning notices in these Operating Instructions
- In compliance with the maintenance and repair instructions contained in these Operating Instructions, in particular with regard to the specified tightening torques
- Appointing only qualified personnel to carry out work related to initial startup, operation, maintenance and repair
- Contracting only workshops authorized by MTU to carry out repair and overhaul

Any other use is considered improper use and increases the risk of personnel injury or material damage in engine/plant operation.MTU will accept no liability for such damage.

Modifications or conversions

Unauthorized modifications to the engine or plant represent a safety risk.

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

Spare parts

Only genuine MTU spare parts must be used to replace components or assemblies.

MTU will accept no liability or warranty claims for any damage caused by the use of other spare parts.

1.2 Personnel and organizational requirements

Organizational measures of the operator

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

Keep it at hand at the operating site of the engine so that it is available to operating, maintenance, repair and transport personnel at all times.

Use the manual as a basis for instructing personnel on engine operation and repair with an emphasis on explaining safety-relevant instructions.

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

For the identification and layout of the spare parts during maintenance or repair work, take photos or use the spare parts catalog.

Personnel requirements

All work on the engine or plant shall be carried out by trained and qualified personnel only:
- Training at the MTU Training Center
- Qualified personnel specialized in mechanical and plant engineering

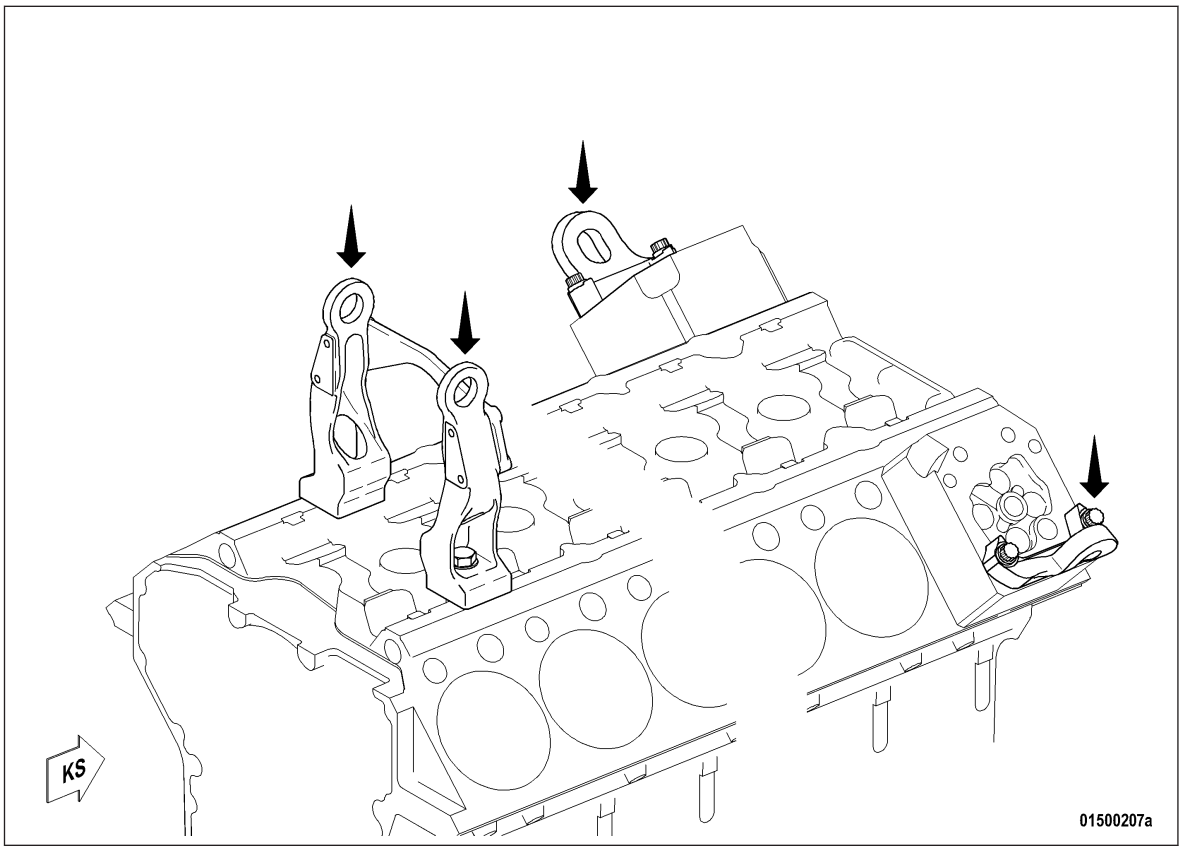
The operator must define the responsibilities of the personnel involved in operation, maintenance, repair and transport.

Working clothes and protective equipment

Wear proper protective clothing for all work.

1.3 Transport

Transport



Lift the engine only with the lifting eyes provided.

Use only the transport and lifting equipment approved by MTU.

Take note of the engine center of gravity.

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

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

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

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

Setting the engine down after transport

Place the engine only on an even, firm surface.

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

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

1.4 Safety regulations for maintenance and repair work

Safety regulations prior to maintenance and repair work

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

Allow the engine or plant to cool down to less than 50°C before starting maintenance work (risk of explosion of oil vapors, fluids and lubricants, risk of burning).

Before starting work, relieve pressure in systems and compressed-air lines which are to be opened. Use suitable containers of adequate capacity to catch fluids and lubricants.

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

Never carry out maintenance and repair work with the engine running.

Carry out function checks on a running engine only if expressly permitted to do so.

Secure the engine or plant against accidental starting.

Disconnect the battery. Lock circuit breakers.

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

Disconnect the control equipment from the engine or plant.

The following additional instructions apply to starters with beryllium copper pinion:

- Breathing protection of filter class P2 must be applied during maintenance work to avoid health hazards caused by the beryllium-containing pinion. Do not blow out the interior of the flywheel housing or the starter with compressed air. Clean the flywheel housing inside with a class H dust extraction device as an additional measure.

Safety regulations during maintenance and repair work

Take special care when removing ventilation or plug screws from the engine or plant. Cover the screw or plug with a rag to prevent fluids escaping under pressure.

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

Use only proper and, if applicable, calibrated tools. Observe the specified tightening torques during assembly/disassembly.

Carry out work only on assemblies or plants which are properly secured.

Never use lines for climbing.

Keep fuel injection lines and connections clean.

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

Take care not to damage lines, in particular fuel lines, during maintenance and repair work.

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. Do not place fuel or oil lines near hot components.

Do not touch elastomeric seals if they have carbonized or resinous appearance unless hands are properly protected.

Note cooling time for components which are heated for installation or removal (risk of burning).

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

Observe special cleanness when conducting maintenance and repair work on the engine or plant. After completion of maintenance and repair work, make sure that no loose objects are in/on the assembly or plant (e.g. cloths and cable ties)

Safety regulations after completion of maintenance and repair work

Before barring the engine, make sure that nobody is standing in the danger zone of the engine or plant.

Check that all guards have been reinstalled and that all tools and loose parts have been removed after working on the engine or plant (in particular, the barring tool).

Welding work

Never carry out welding work on the assembly or plant, or attached units. Cover the engine or plant when welding in its vicinity.

Before starting welding work:
- Switch off the power supply master switch.
- Disconnect the battery.
- Separate the electrical ground of electronic equipment from the ground of the unit.

No other maintenance or repair work must be carried out in the vicinity of the engine or plant while welding is going on. Risk of explosion or fire due to oil vapors and highly flammable fluids and lubricants.

Do not use the engine or plant as ground terminal.

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

Remove parts (e.g. exhaust pipes) which are to be welded from the engine beforehand.

Hydraulic installation and removal

Check the function and safe operating condition of tools and fixtures to be used. Use only the specified devices for hydraulic removal/installation procedures.

Observe the max. permissible push-on pressure specified for the equipment.

Do not attempt to bend or apply force to lines.

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

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

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

Working on electrical and electronic assemblies

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

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

Do not damage cabling during removal work. When reinstalling ensure that wiring is not damaged during operation by contact with sharp objects, by rubbing against other components or by a hot surface.

Do not secure cables on lines carrying fluids.

Do not use cable binders to secure cables.

Always use connector pliers to tighten connectors.

Subject the device or system to a function check on completion of all repair work. In particular, check the function of the engine emergency stop feature.

Store spare parts properly prior to replacement, i.e. protect them against moisture in particular. Pack defective electronic components and assemblies in a suitable manner when dispatched for repair, i.e. particularly protected against moisture and impact and wrapped in antistatic foil if necessary.

Working with laser equipment

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

1.5 Fire prevention and environmental protection, auxiliary materials, fluids and lubricants

Fire prevention

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

Do not weld 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 accident if acoustic signals, warning shouts or noises indicating danger are drowned.

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

Environmental protection and disposal

Modification or removal of mechanical or electronic components or the installation of additional components as well as the execution of calibration processes that might affect the emission characteristics of the engine 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 MTU or equivalent components. Noncompliance with these guidelines will lead to forfeiture of the operating permit issued by the emission monitoring authorities. MTU does not accept any liability for violations of the emission regulations. The Maintenance Schedules of MTU must be observed over the entire life cycle of the engine or plant.

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

Within the EU, batteries can be returned free of charge to MTU FN / MTU Onsite Energy where they are subjected to proper recycling procedures.

Auxiliary materials, fluids and lubricants

The Fluids and Lubricants Specifications will be amended or supplemented as necessary. Before using them, make sure you have the latest version. The latest version is also available at: http://www.mtu-online.com/mtu/mtu-valuecare/mtu-valueservice-Technische-Dokumentation.

Auxiliary materials, fluids and lubricants might be hazardous goods or toxic substances.When using fluids, lubricants and other chemical substances, follow the safety instructions that apply to the product. Take special care when using hot, chilled or caustic materials. When using flammable materials, avoid contact with ignition sources and do not smoke.

Used oil

Used oil contains harmful combustion residues.

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 lead-containing compounds, avoid direct contact to the skin and 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 (danger class AI, AII and B) out of containers, results in a risk of explosion.
- Wear goggles when blowing off components or blowing away chips.
- Forcing compressed air into thin-walled containers (e.g. containers made of tin, plastic and glass) for drying purposes or to check for leaks, results in a risk of bursting.
- Pay special attention to the pressure level in the compressed air network or pressure vessel.
- Assemblies or plants to be connected must either be designed for this pressure, or, if the permitted pressure for the connecting elements is lower than the pressure required, a pressure reducing valve and safety valve (set to permitted pressure) must form an intermediate connection.
- Hose 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 equipment is disconnected from the supply line, or before the equipment or tool is to be replaced.
- Carry out leak test in accordance with the specifications.

Paints and lacquers

- Observe the relevant safety data sheet for all materials.
- When carrying out painting work outside the spray stands provided with fume extraction systems, ensure that the area is well ventilated. Make sure that neighboring work areas are not impaired.
- Avoid open 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.
- Store liquid nitrogen only in small quantities and always in regulation containers without fixed covers.
- Avoid body contact (eyes, hands).
- Wear protective clothing, protective gloves, closed shoes and protective goggles / safety mask.
- Make sure that working area is well ventilated.
- Avoid all knocks and jars to the containers, fixtures or workpieces.

Acids and alkaline solutions

- Observe the relevant safety data sheet for all materials.
- When working with acids and alkaline solutions, wear protective goggles or face mask, gloves and protective clothing.
- If such solutions are spilled onto clothing, remove the affected clothing immediately.
- Rinse injured parts of the body thoroughly with clean water.
- Rinse eyes immediately with eyedrops or clean tap water. Seek medical attention as soon as possible.

1.6 Standards for safety messages in the text

DANGER 	In the event of immediate danger. **Consequences: Death or serious injury** • Remedial action
WARNING 	In the event of potentially dangerous situations. **Consequences: Death or serious injury** • Remedial action
CAUTION 	In the event of hazardous situations. **Consequences: Minor or moderate injuries** • Remedial action
NOTICE 	In the event of a situation involving potentially adverse effects on the product. **Consequences: Material damage.** • Remedial action • Additional product information

Note: This manual contains highlighted safety messages in accordance with the US ANSI Z535 standard which begin with one of the signal words listed above depending on the severity of the hazard.

Safety messages

1. Read and familiarize yourself with all safety message before starting up or repairing the product.
2. Pass on all safety messages to operating, maintenance, repair and transport personnel.

1.7 ATEX precautions (if applicable)

The following additional precautions must be taken to comply with the requirements of the ATEX explosion protection directives:

- Unoccupied connections for the wiring harness must be sealed with protective caps.
- The entire engine wiring harness must be covered with metal guards to protect it from mechanical impact and UV radiation.
- Continuous power supply to the engine must be ensured when the engine is in the hazardous zone.

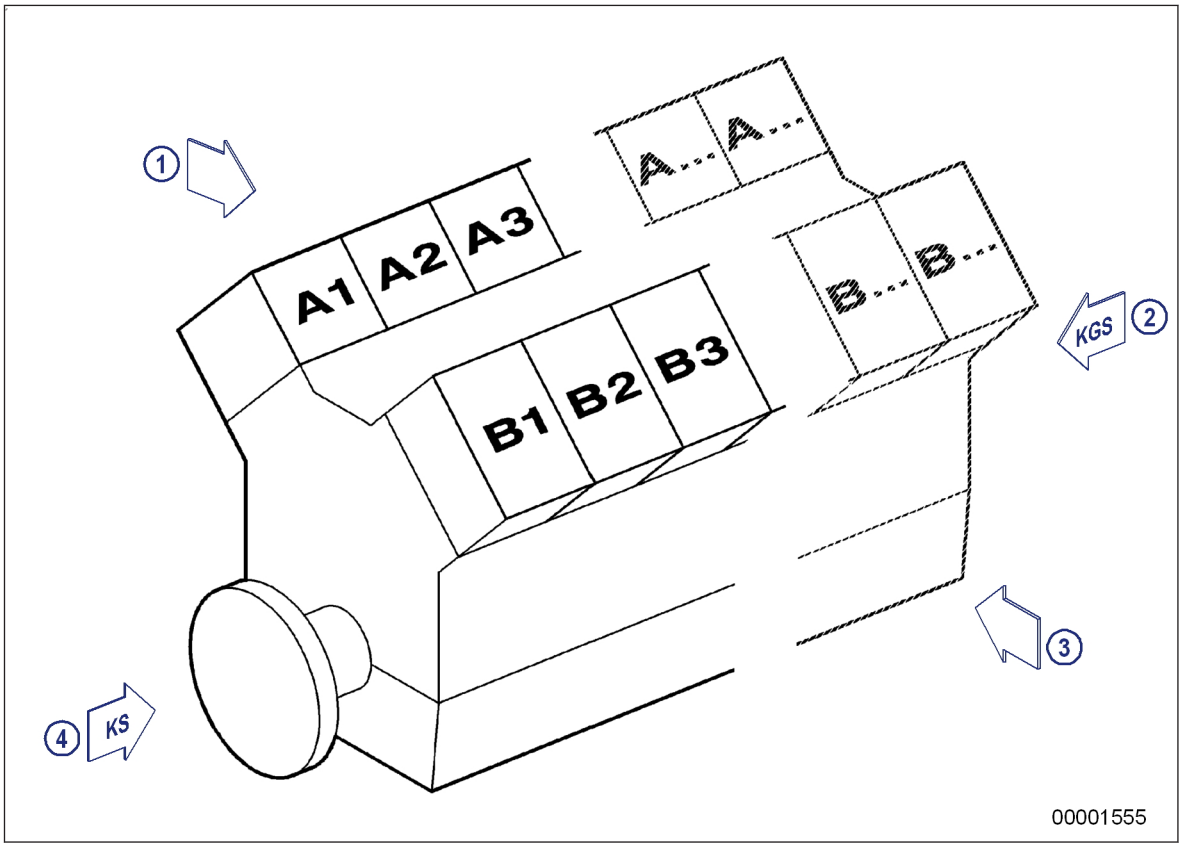
2 General Information

2.1 Engine side and cylinder designations

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

The cylinders of the left engine side are designated "A" and those of the right side "B" (as per DIN ISO 1204). The cylinders of each bank are numbered consecutively, starting with No. 1 at the driving end.

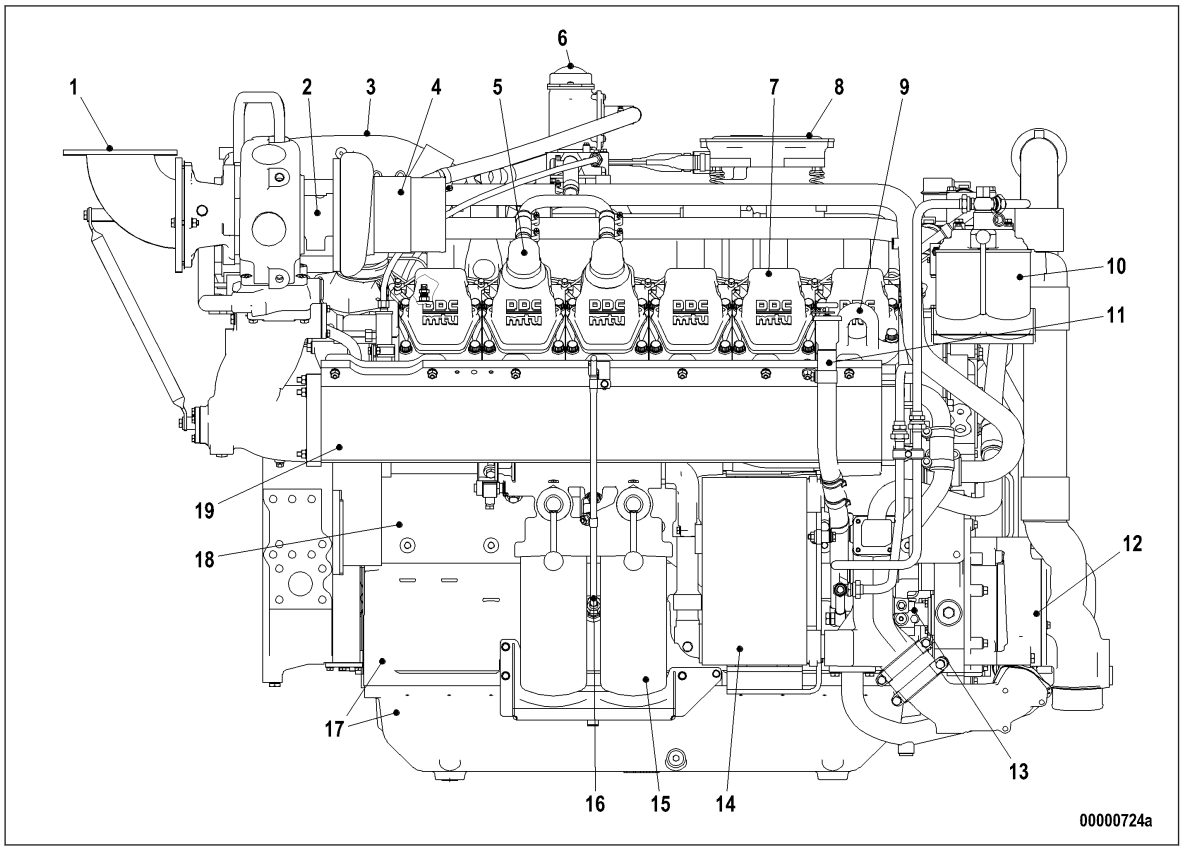
Other components are numbered in the same way, i.e. starting with No. 1 on driving end.



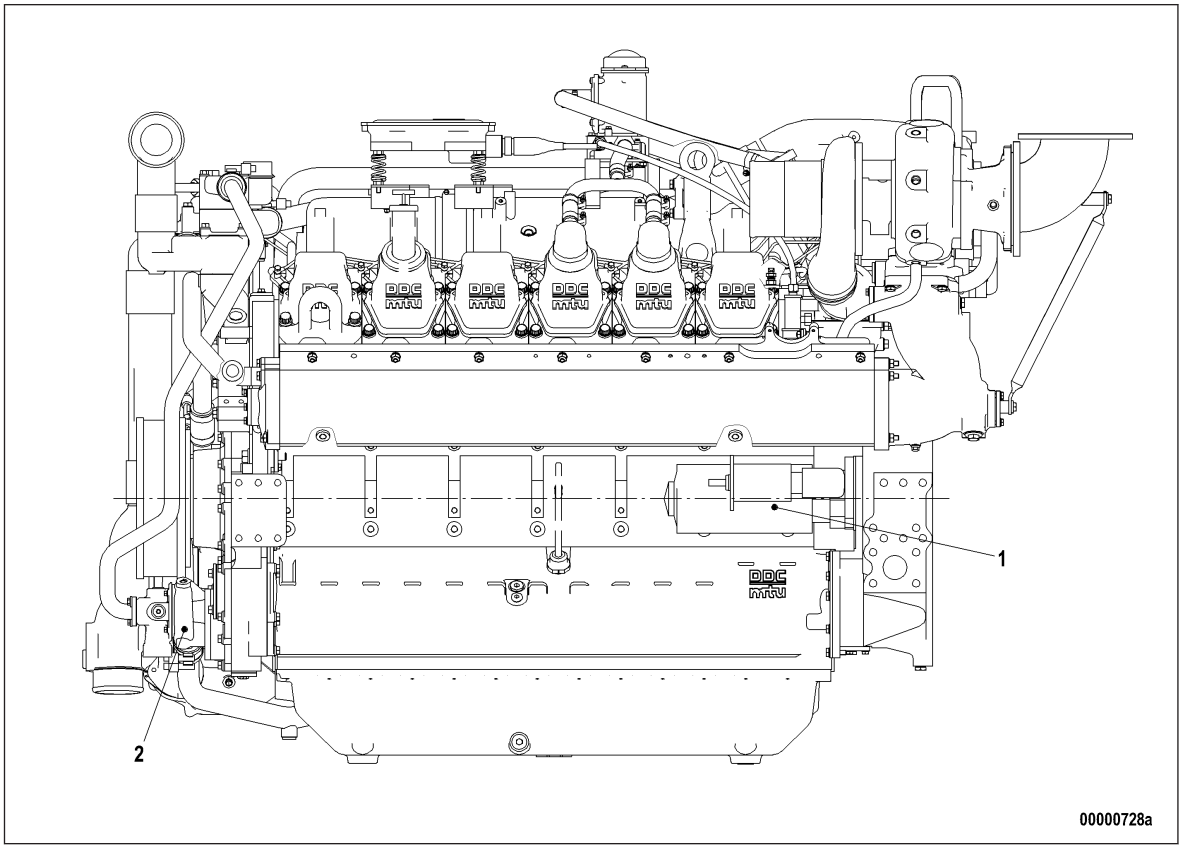
1 Left engine side
2 KGS = Free end
3 Right engine side
4 KS = Driving end

2.2 Engine layout

Illustrations are also applicable to 16 V



1 Exhaust outlet
2 Exhaust turbocharger
3 Intercooler
4 Air intake connection
5 Crankcase ventilation
6 Crankcase ventilation
7 Cylinder head cover
8 ECU
9 Engine lifting equipment
10 Fuel duplex filter
11 Oil filler neck
12 Engine coolant pump
13 Fuel pump
14 Oil cooler
15 Oil filter
16 Oil dipstick
17 Oil pan
18 Crankcase
19 Exhaust manifold



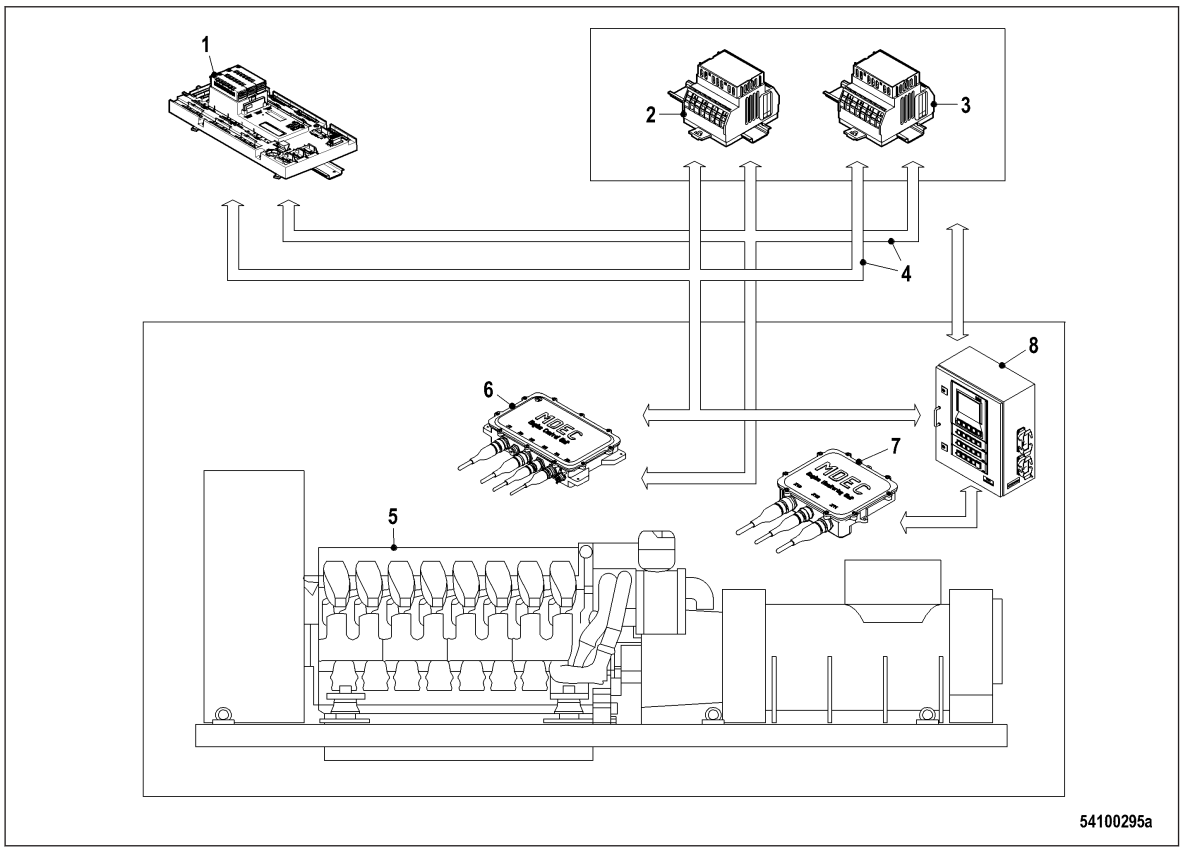
1 Starter 2 Charge-air coolant pump

Engine model designation

Key to the engine model designation 12/16V 2000 Px2

12/16	Number of cylinders
V	Cylinder arrangement: V engine
2000	Series
P	Application
X	Application segment (1, 6, 8, 9)
2	Design index

2.3 Use



1 Service and Automation Module (SAM)
2 Peripheral Interface Module 601 (option)
3 Peripheral Interface Module 602 (option)
4 CAN bus
5 Engine with generator
6 Engine governor
7 Engine monitoring (optional)
8 LOP (optional)

Up to 8 additional Peripheral Interface Modules can be connected for linking to higher-level systems.

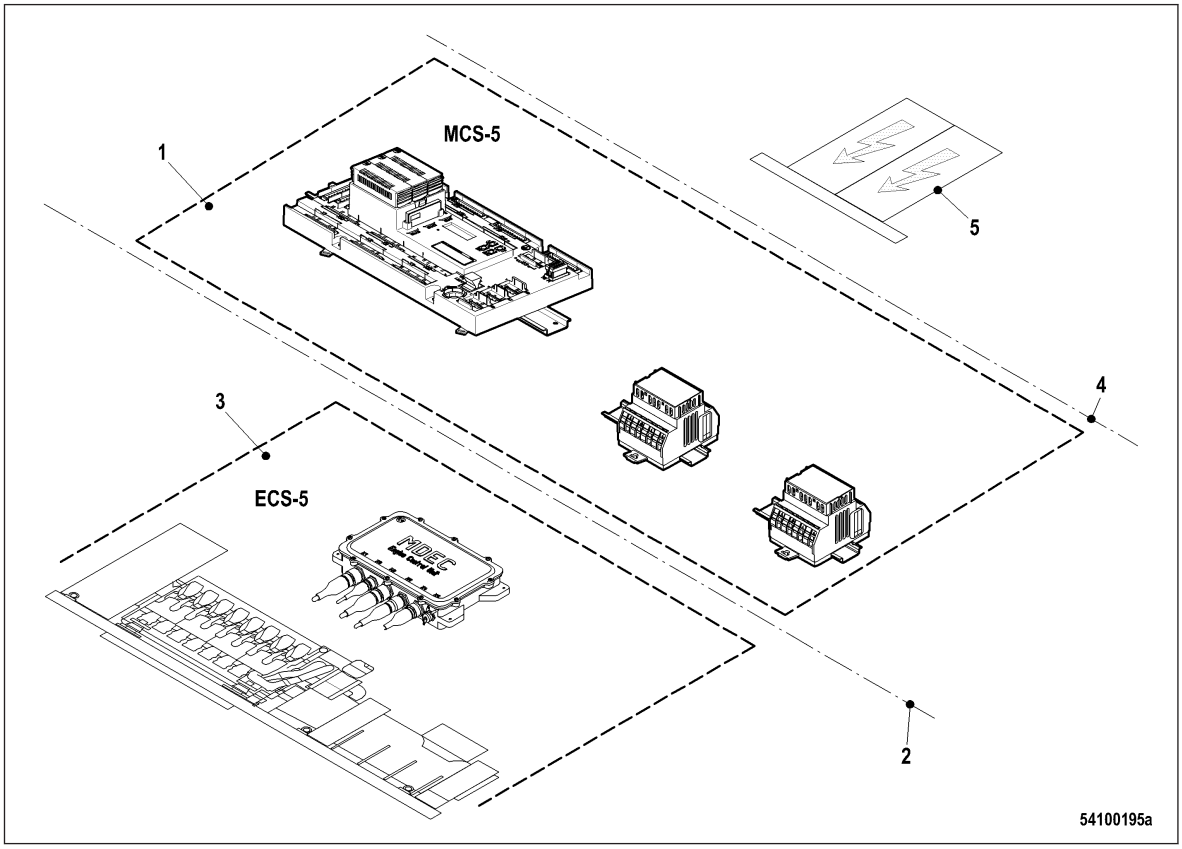
Functions

- Control of the engine.
- Monitoring of operating states.
- Closed-loop control of fuel injection and engine speed (depending on operating state).
- Indication of faulty operating states (display SAM (1)).

Features

- Electronic engine governing and control.
- Monitoring of inadmissible engine operating states.
- Display of fault messages and fault codes.
- Connecting cable for power supply to engine governor.
- Connecting cable for connection to a higher-level genset control system.
- Hardware interfaces to a higher-level control system (option).
- Inputs for plant sensors (option).
- Engine safety features including engine shutdown.
- Integral fault diagnosis system ITS.
- Integral load profile recorder.
- Speed droop switching possible with engine running.
- Straightforward engine governor replacement.
  - Engine and interface data stored in SAM.
  - Complete automatic software download following connection of a new, unprogrammed engine governor.

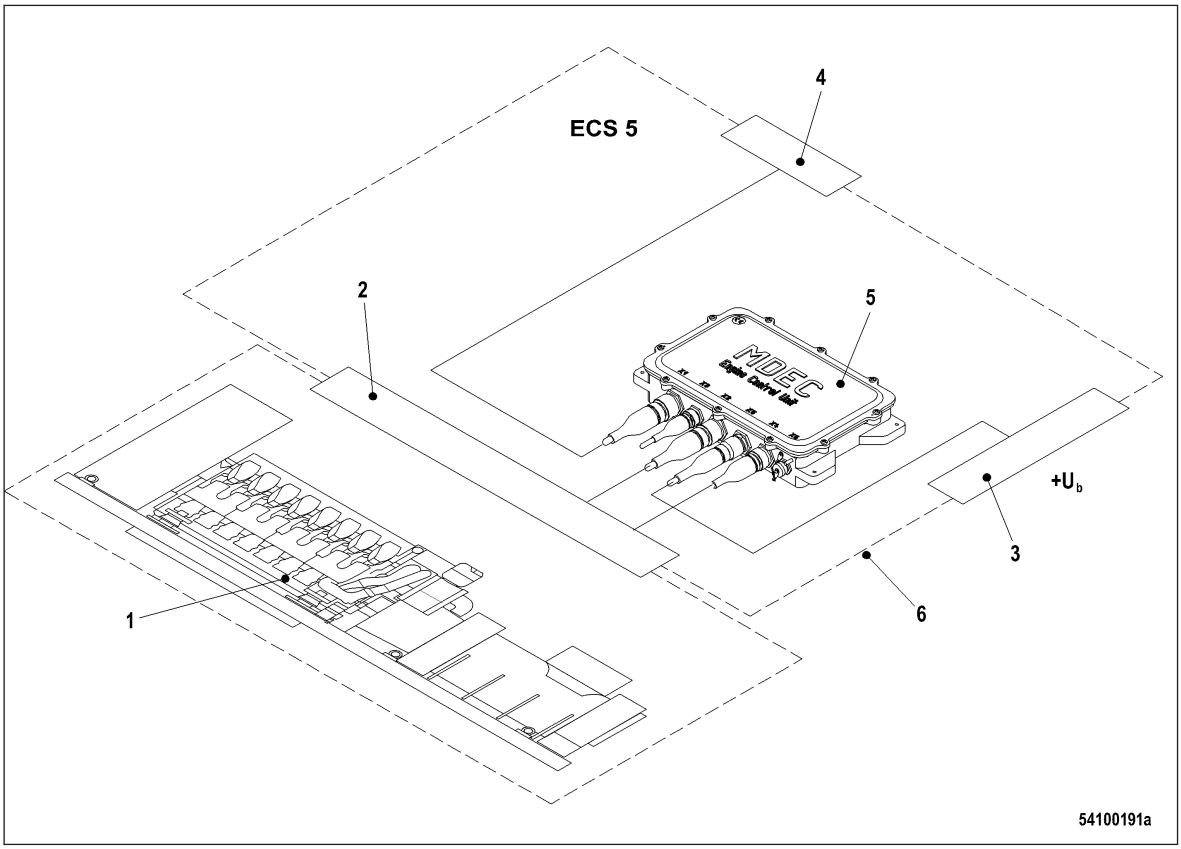
Design of the overall MDEC system



1 Monitoring and Control System MCS-5 (PIMs optional)
2 CAN bus between ECS-5 and MCS-5
3 Engine Control System ECS-5
4 RS422 interface and RS232 interface to an external controller
5 External controller

The design of the overall MDEC system comprising the ECS-5 and MCS-5 subsystems depends on customer requirements and the higher-level control system.

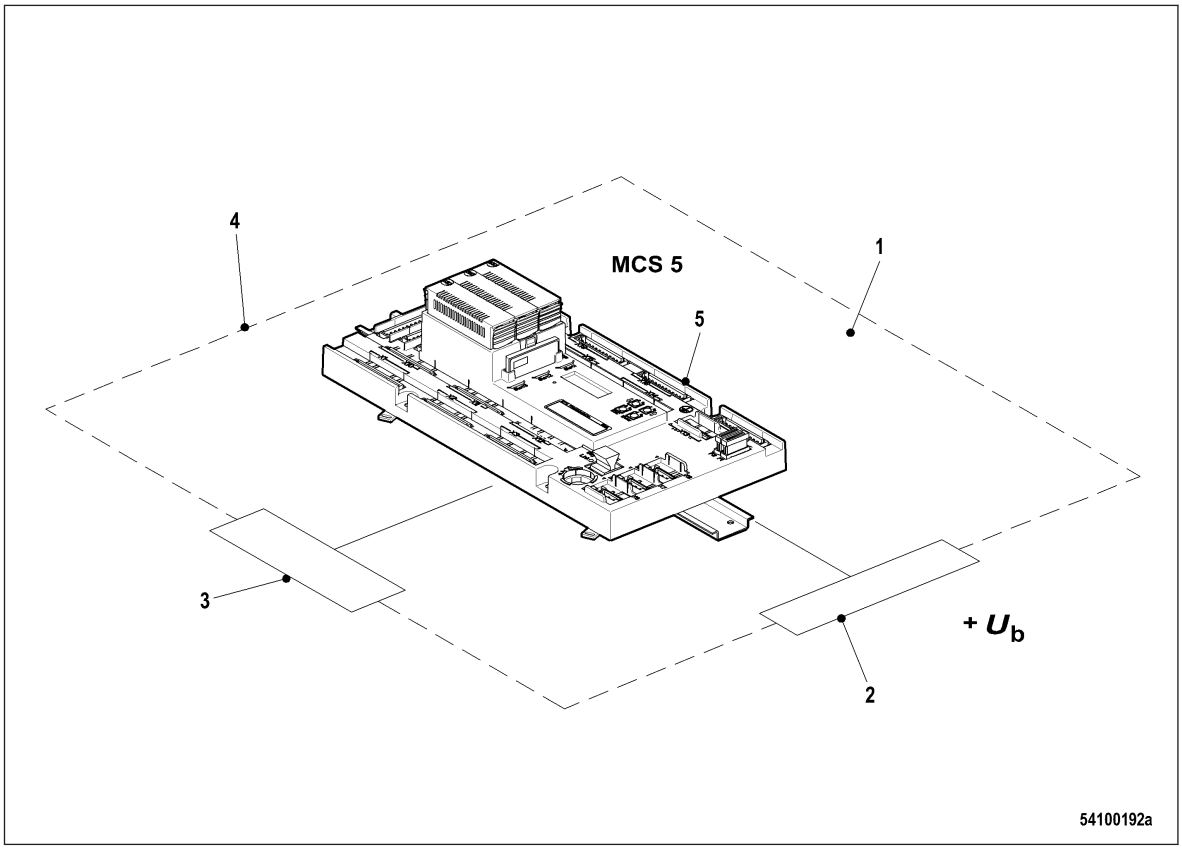
Design of Engine Control System ECS-5



1 Engine with generator
2 Engine interface
3 Power supply +U_b
4 Signal connection to the MCS devices and the higher-level control systems
5 Engine governor
6 System boundary ECS-5

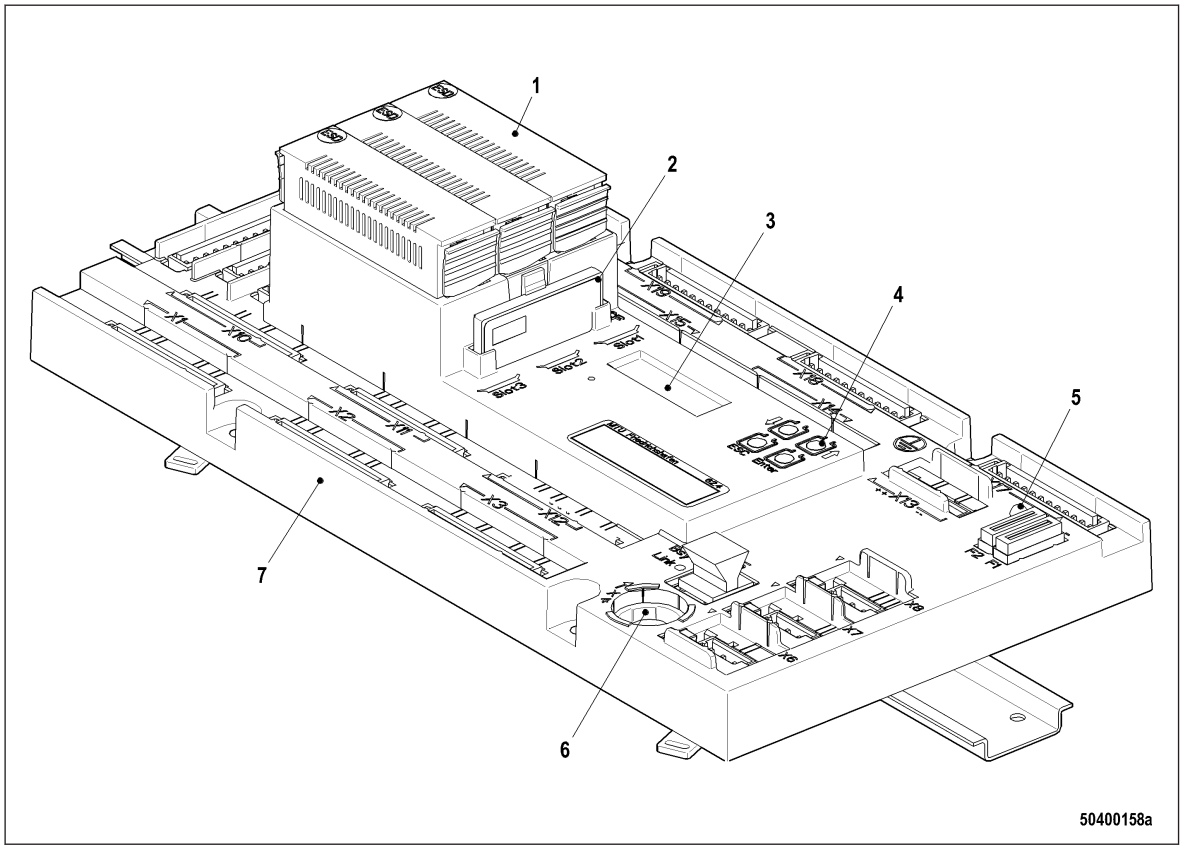
The Engine Control System comprises the following devices:
- Engine governor
- Sensors on engine
- Actuators on engine
- Injectors on engine
- Wiring harnesses on engine

Basic scope of Monitoring and Control System MCS-5



1 Monitoring and Control System MCS-5
2 Power supply +U_b
3 Signal connection to ECS devices
4 System boundary MCS-5
5 SAM

Service and Automation Module (SAM)



1 Module cassette, slots for additional I/O PIM cards
2 Compact flash memory card
3 Display for fault codes and minidialog
4 Control keys for minidialog
5 Diagnostic lamp
6 Interface for dialog unit
7 Connector with spring design

Functions

SAM functions

- Display of fault codes from engine governor and SAM (3).
- Backup function, engine life data are stored,
  - every hour,
  - after every engine stop
  - after every emergency engine stop.
- Interface for dialog unit.

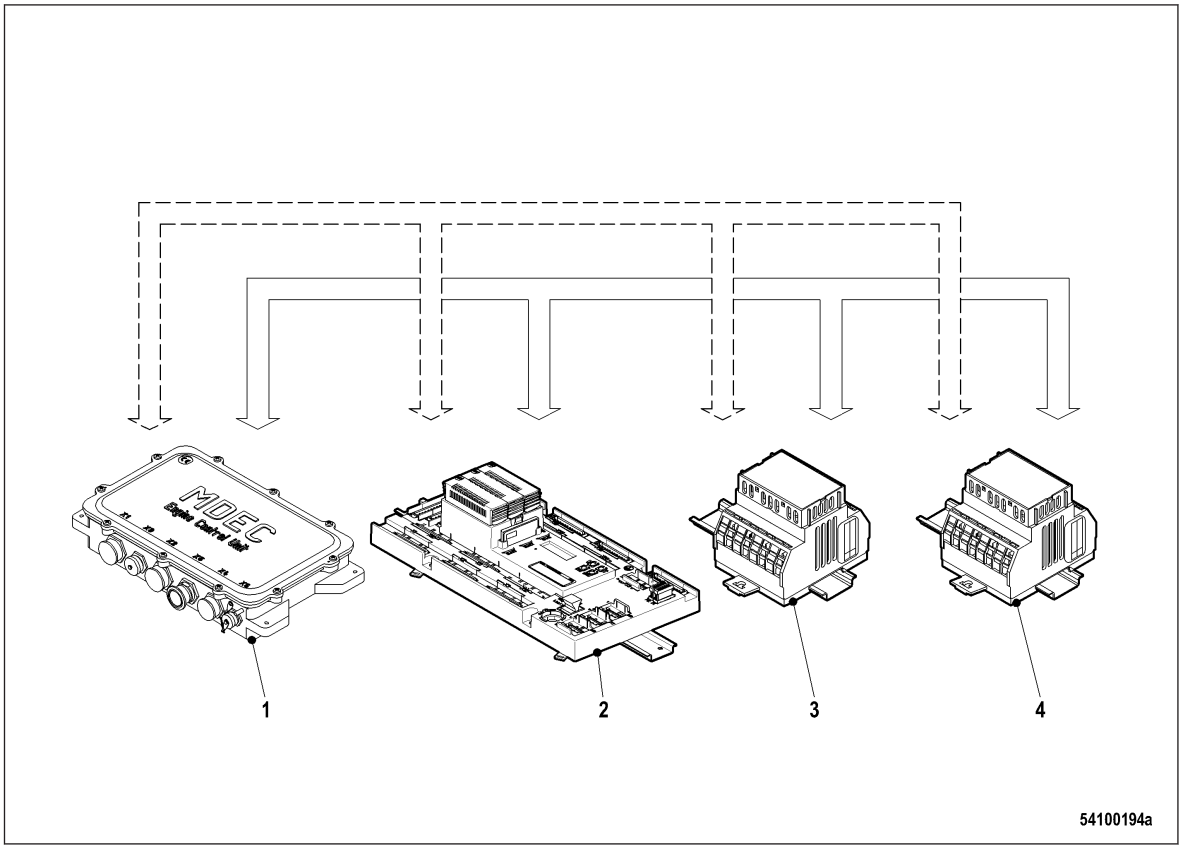
Diagnosis

- Straightforward diagnosis by fault code display.
- Self-diagnosis by diagnostic lamp (5).
  - Steady = SAM is OK.
  - Flashing = SAM is faulty, contact Service.
  - Dark = Supply voltage missing.

Customer interface

- 24 binary outputs
- 3 PWM outputs
- 8 display outputs
- 28 channel binary input
- 10 analog inputs (e.g. PT100, 4–20 mA, 0-10 V, etc.)
- 4 frequency inputs
- 1 dialog interface
- Extendable with MCS 5 PIM I/O cards

Data connections



1 Engine governor
2 SAM
3 PIM 601 (option) serial interface / slave
4 PIM 602 (option) serial interface / master

Data transmission

The devices are equipped with a CAN bus for transmitting data between the individual subsystems. This CAN bus is in redundant design.

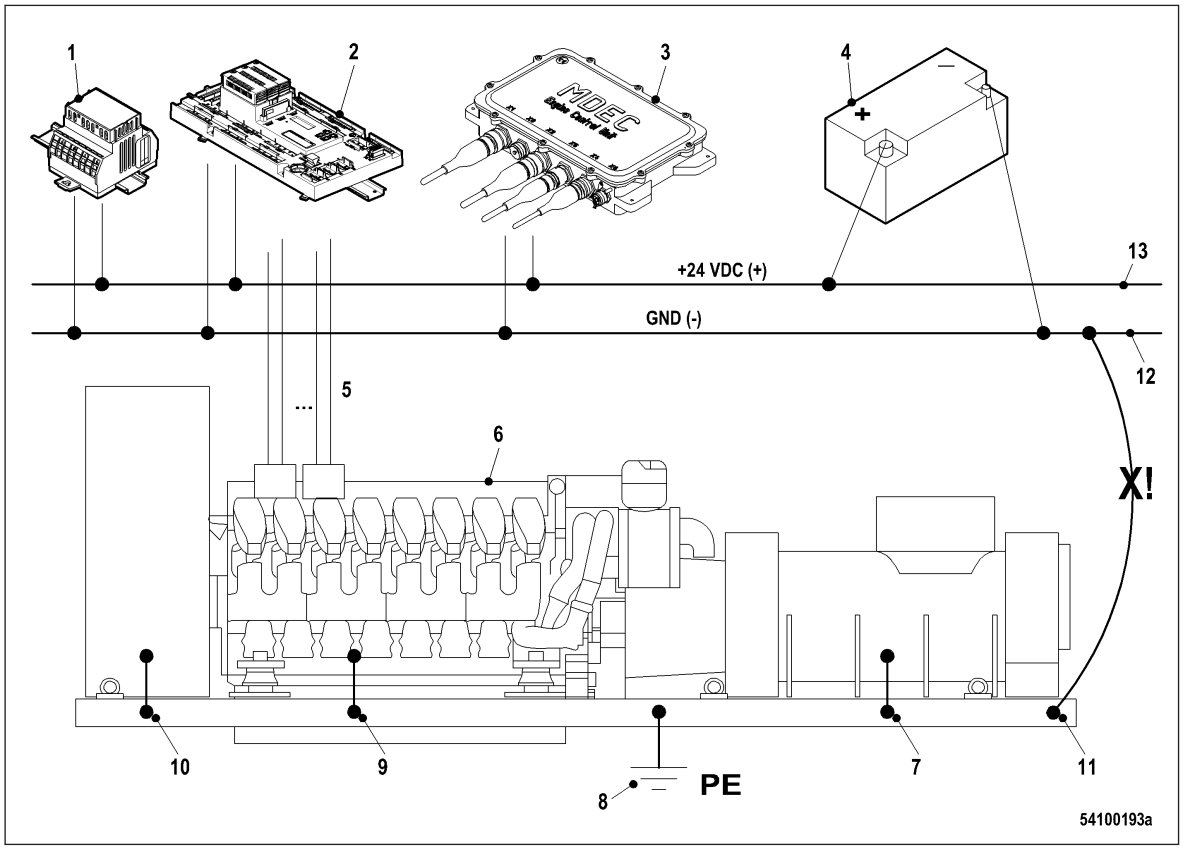
The CAN bus is a standardized automation technology field bus which allows various systems and devices to communicate with each other providing they are equipped with a CAN bus interface.

Tasks of the CAN bus:

CAN bus

Tasks:
- Receiving plant signals (desired speed) and commands from higher-level control systems.
- Outputting all measured values/limit values for the Monitoring and Control System.
- Outputting alarms for signaling and evaluation in the Monitoring and Control System.
- Outputting relevant signals for engine control.

Grounding



1 PIM
2 SAM
3 Engine governor
4 Battery
5 To engine sensors
6 Generating set
7 Equipotential bonding strip
8 Grounding
9 Equipotential bonding strip
10 Equipotential bonding strip
11 Mounting frame
12 GND (-)
13 +24 V VDC (+)
X! Inadmissible connection!

Grounding

Both the engine and the generator are connected to ground (8) via equipotential bonding strips (7, 9, 10) on the mounting frame (11).

EMC

EMC design of the overall system is based on a two-pole ungrounded power supply. This is particularly relevant to CE labeling as per EMC directive.

Ground connection

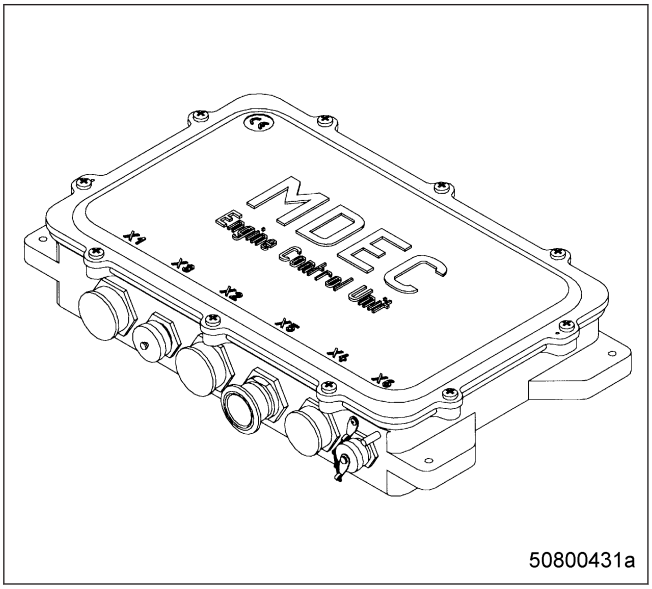
The ground of the power supply (battery negative) and all electronic devices (-) should not be connected to ground (8). The entire electronic system is electrically isolated from ground. This also applies to the sensors (5). All sensor signal lines and/or supply lines are not connected to the corresponding sensor housings.

Signal-to-noise ratio

Electrical isolation of the mechanical and electronic components significantly increases the signal-to-noise ratio. This high signal-to-noise ratio on all electrical lines is necessary for satisfactory transmission of all data on the CAN bus and also all analog and binary sensor signals.

2.4 ECS-5 – Use of devices

Engine governor



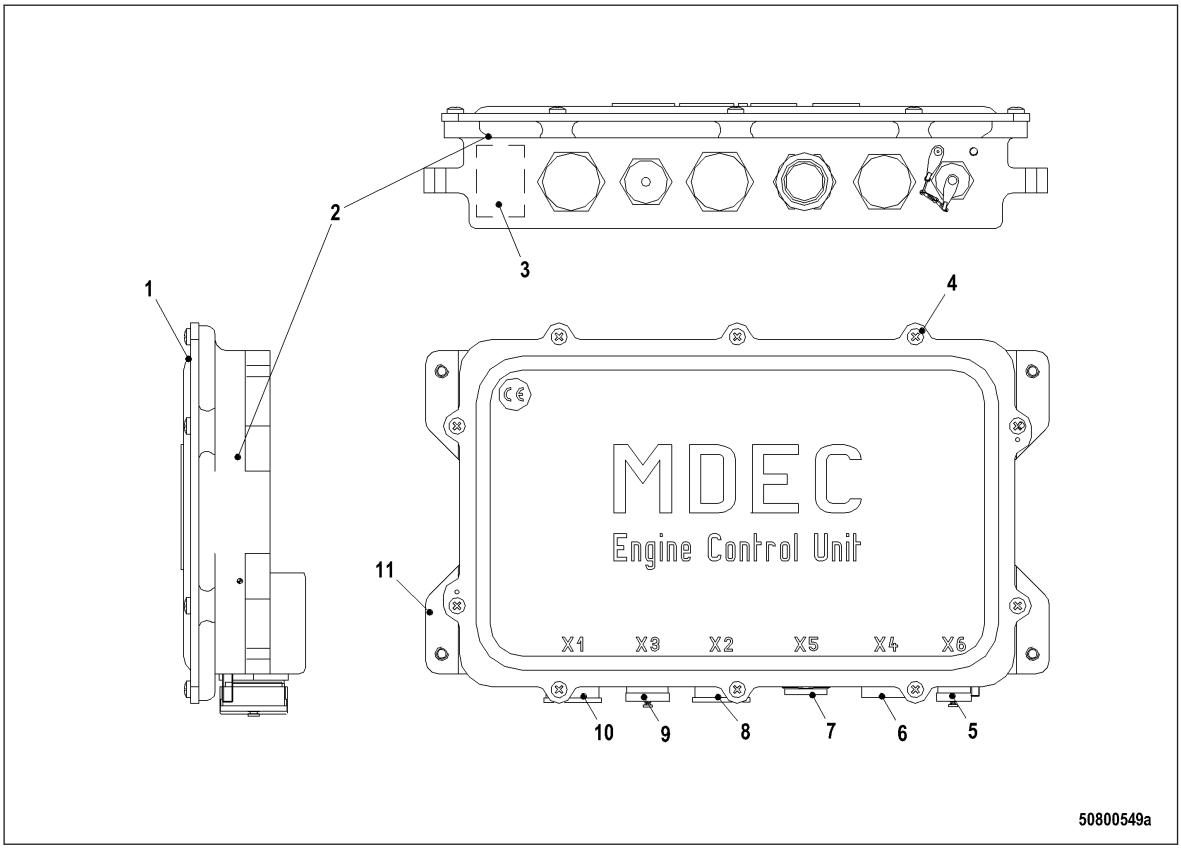
Central control and monitoring device for the engine

- Communication with other devices and higher-level systems via CAN bus.
- Control of injection system.
- Control of up to 20 injectors.
- Acquisition and evaluation of engine operating states.
- Monitoring of limit values.
- Self-monitoring and diagnosis,
  - integral status/fault display
  - fault memory
- Extensive I/O features:
  - Plant side 13 inputs, 10 outputs, 2 serial interfaces,
  - engine side 26 inputs, 26 outputs.
- Engine and plant-related setting variables in exchangeable memory modules.
- In case of inadmissible states and limit value violations: Initiation of power reduction, engine stop and emergency engine stop (configurable).
- Diagnosis via RS232 interface for dialog unit.

Software structure:

Name	Meaning
Download software	For downloading firmware and configuration data.
Dialog software	For the dialog with a PC or notebook.
Automation software for open-loop control.	E.g. to control injection quantity.
Automation software for monitoring.	E.g. for engine stop and emergency engine stop.
Communication software	For communication with other devices and via the CAN bus.

Hardware structure



Item.	Name	Meaning
1	Cover	–
2	Housing	–
3	Rating plate	Part and serial number Data record and engine number
4	Screws	–
5	Connector X6	Connection for dialog unit
6	Connector X4	Connection for injector wiring harness
7	Connector X5	Connection for power supply
8	Connector X2	Connection for sensor/actuator wiring harness
9	Connector X3	BR 2000: Not used BR 4000: HP controller
10	Connector X1	Connection for CAN bus
11	Mounting lugs	–

Technical data

Dimensions (width x height x depth)	455 mm x 277 mm x 91 mm Draw-out clearance: +230 mm
Weight	7 kg

Operating voltage	Rated voltage: 24 VDC Continuous voltage: 16.5 VDC to 32 VDC Temporarily restricted operation: 11 VDC to 36 VDC Residual ripple: Max. 8 V_{pp}
Power consumption	Max. 30 A
Heat loss	Max. 35 W
Operating temperature range	0 °C to +75 °C
Storage temperature range	–10 °C to +75 °C
Relative air humidity	0% to 95 % condensing
Degree of protection	IP 65 DIN 40 050
Shock	15 g/11 ms semi-sinusoidal shock
Vibration	2 Hz to 13 Hz: X_{pp}= ±1.6 mm 25 Hz to 100 Hz: a= ±4 g 100 Hz to 2000 Hz: Electrical noise 1.3 g rms
EMC	DIN EN 50081–2 DIN EN 50082–2 IEC 1000–4–2 IEC 1000–4–3 IEC 1000–4–4 IEC 1000–4–5 IEC 1000–4–6

2.5 MDEC – Functions

Control functions

Following engine functions are controlled:

- Engine start
- Engine stop
- Emergency start
- Restart response
- Sequences with activated “Override” function (safety system bypass).
- Nominal speed switching between two set values (optional operation as 50 Hz or 60 Hz genset).
- Injection quantity as a function of engine loading and speed.

Engine start

The starting sequence is controlled by the software integrated in the engine governor as follows.

1. Engine start
2. Start lockout time t>16 seconds.
   - Starting terminated if start lockout time is t<16.
3. Start interlock.
   - Start terminated if start interlock applied.
4. Emergency air-shutoff flaps open.
   - Start terminated if emergency air-shutoff flaps closed.

   .
5. Starter on.
6. Speed n>n1 (configurable) reached within t1 (configurable).
   - Start terminated if speed is n<n1 within t1. Start speed is too low “Start speed low”.

   .
7. Start injection quantity
8. Speed n>300 reached within t2 (configurable).
   - Start terminated if speed is n<300 within t2 (configurable). Start speed is too low “Run up speed low”.
9. Starter off.
10. Idling speed reached.
    - Start terminated if idling speed not reached, “Idle speed low”.
11. Engine running at idling speed.

Restart response

The response of the engine is determined by the following factors on receiving a start request when the engine is running down following a stop command:

- The engine immediately runs up to nominal speed if the engine speed is > 80 rpm;
- the engine is shut down if the engine speed is < 80 rpm. Restarting is only possible on expiry of the start lockout time.

Emergency start

The following start interlock criteria are bypassed when override is active on starting the engine:

- Low coolant temperature (configurable).
- High coolant temperature (configurable).
- Coolant level (configurable).

Engine stop

An engine stop is tripped by activation of binary input BE1 at the engine governor or by the engine protection system. Fuel is no longer injected as injector activation is disrupted.

Any starting procedure which has been initiated is interrupted.

Override (safety system bypass)

The “Override” feature is used to bypass safety functions tripped by limit value violations or sensor faults and to bypass start interlocks.

Operating states which would normally lead to engine shutdown are ignored when the “Override” function is activated. The following operating states can also be configured to shut the engine down in override mode:

- Coolant level
- Coolant temperature
- Coolant pressure
- Charge air coolant level
- Lube oil pressure
- Lube oil temperature

Monitoring functions

The engine management system for engines used in Oil&Gas applications fulfills the following monitoring tasks:

- Control of analog instruments;
  - engine speed (default)
  - engine lube oil pressure (default)
  - engine lube oil temperature (default)
  - engine coolant temperature (default)
- Transmission of all measurands, warnings and alarms to monitoring system via CAN bus.
- Automatic shutdown in case of limit value violations.

Refer to the measuring-point list for order-specific configuration data.

Engine monitoring can basically be divided into two different areas:

- Engine protection system, monitors the engine during operation,
- Safety system, generates automatic engine shutdown in case of limit value violation.

These two functional areas are constantly monitored by the internal “Integral Test System (ITS)” to ensure operational availability.

Engine protection system

The engine governor incorporates an integral engine protection system. It monitors the operational data of the engine.

Tasks of the engine protection system are:

- Safeguarding the engine from critical operating states.
- Signaling alarms to operating personnel.
- Restricting engine operation to remain within admissible operating values.

Action is taken such as warning, start interlock, power reduction or engine shutdown by reducing the quantity of fuel injected depending on the values measured.

Closed-loop control functions

Closed-loop engine control functions:

- Speed
- Injection control with mapped commencement of injection.
- Two adjustable speed droops.
- Desired speed via:
  - Analog or binary speed setting on the CAN bus.
  - Analog speed setting 0 V to 10 VDC / 0 V to 5 VDC / 4 mA to 20 mA.
  - Binary speed setting via Up/Down signal, frequency CAN bus.
  - Frequency speed setting.
- Acquisition of a load pulse signal (analog or CAN bus) in preparation for load application.
- HP fuel governor.

Speed - injection control

Functions of the closed-loop engine speed control integrated in the engine governor:
- Maintaining the desired engine speed under changing load conditions.
- Adjusting the engine speed when the setting is changed by the operator.

Additional tasks with an effect on closed-loop engine speed control:
- Setting a defined fuel injection quantity on starting the engine.
- Engine safety shutdown.
- Optimizing operation, exhaust emissions and fuel consumption.
- Protecting the engine against overloading.

Speed droop calculation

Speed droop influences the effective setpoint speed depending on engine power. Maximum, speed-dependent engine power is limited by the DBR curve. The setpoint speed is not influenced by speed droop at 100% power. The effective setpoint speed increases at lower power. This allows power to be balanced when operating a number of engines in a network.

Switchable speed droop

Two different speed droops may be selected at the engine governor for stationary genset engines. Which speed droop is active depends on whether the genset is running in isolated operation or in a parallel network with other gensets feeding a common busbar.

The speed droop is selected by a binary input (BE4) at the engine governor.

Speed droop is required to balance the load of coupled prime movers. Speed droop can be adjusted to meet plant requirements via the dialog unit.

Dynamic quantity limitation

Dynamic quantity limits protect the engine against overloading and optimize exhaust emission values. The engine governor determines the maximum injection quantity based on preset and stored engine performance maps.

Following limits are applied:
- Speed-sensitive fuel quantity limitation (DBR).
- Fuel quantity limitation as a function of fuel temperature.

Fixed quantity limitation

Fixed quantity limitations are used for power limitation and power reduction to protect the engine in case of:
- Electronic malfunctions.
- Supply voltage out of tolerance.

Fuel quantity control during engine start

The quantity of fuel injected during engine start increases along a time ramp from a set initial value to a specified value. This value is calculated by the function $q_{inject} = f_{(speed)}$. This limits the quantity of fuel injected as a function of speed. This fuel quantity limitation is effective until idling speed has been reached.

Cylinder cutout

Only half of the injectors are activated when cylinder cutout is active. The other half of the injectors are activated on expiry of a switchover time. This prevents white smoke being emitted when the engine is running.

Desired speed handling

The desired speed is the command variable for the engine speed control loop.

When the engine is started it runs up to an internally programmed desired speed (for 50 Hz network frequency: 1500 rpm, for 60 Hz network frequency: 1800 rpm).

Switching to an external speed setting takes place automatically once the nominal speed has been reached.

The following speed setting variants are possible:
- Desired speed setting via an analog input:
  The setpoint speed can be adjusted within a (configurable) range around the preset synchronous speed (depending on the set network frequency).
  In this case the voltage can either control the speed window only or cover the entire speed range.
  The internal setpoint speed follows the applied speed setting value along a configurable acceleration/ deceleration curve (speed ramp). The setting value last applied is maintained or the engine is throttled back to idling speed should the applied signal fail.
  The response can be configured as desired:
  - Speed setting via CAN bus.
  - Speed setting via an analog speed setting input (0 V to 10 V).
  - Speed setting via an analog speed setting input (4 mA to 20 mA).
  - Frequency input.
- Setpoint processing via binary inputs “Setpoint speed up” (BE5)/ “Setpoint speed down” (BE6):
  The setpoint speed can be adjusted within a (configurable) range around the preset synchronous speed (depending on the set network frequency). Briefly actuating the appropriate optocoupler input for less than 0.3 s increases or decreases the setpoint speed by 1 rpm.
  The setpoint speed is automatically adjusted at a configurable rate if the input is activated for longer than 0.3 seconds.

Safety functions

Safety shutdowns

Safety shutdowns are initiated by the engine protection system in case of:
- Limit value violations;
- Sensor faults (depending of specific configuration).

This applies to the following measuring points:
- Engine speed/overspeed (configurable)
- Engine lube oil pressure (configurable)
- Coolant level (configurable)
- Charge-air coolant temperature (configurable)
- Coolant temperature (configurable)
- Charge-air temperature (configurable)
- Engine lube oil temperature (configurable)

All safety shutdowns can be suppressed by activating the “Override” input (BE8, default).

The occurrence of safety-relevant alarms is still logged when the “Override” input has been activated.

Fault number 500 is added to the current fault number.

Integral Test System (ITS)

The ITS monitors all important functions of the engine governor and connected electrical components:
- Electronics inside the engine governor itself,
- sensors,
- actuators,
- bus communication,
- power supply.

The ITS detects any faults which occur, pinpoints them and signals accordingly by combined alarms. Furthermore, a fault message is output via the CAN bus to a higher-level monitoring system (if applicable) and can visualized there for the operator.

Fault messages are stored in two memories:

- Chronological memory
  The fault message numbers are stored in a ring memory in chronological order of their occurrence or cancellation together with the hour meter reading. The ring memory stores the last 80 setting and cancellation procedures.
- Statistical memory
  Fault message occurrences are counted in a statistical memory.
  A counter counting up to max. 10 000 is set up for each fault message number .

Monitoring of engine governor electronics

The hardware and software of the engine governor is designed to allow faults in the electronic system to be detected to enable the operator to respond accordingly to such faults. Fault signals are also forwarded.

The temperature inside the engine governor housing is monitored. Should it rise above a limit value, a fault signal is output via the combined alarm output and the CAN bus to a higher-level monitoring system (if applicable) where it can be visualized for the operator.

Monitoring of sensors and actuators

The various sensor and actuator channels of the engine governor system are designed to tolerate faults to a large extent (e.g. short-circuit withstandability).

Faults such as broken wires, short circuit etc. are detected by plausibility checking and are output to a higher-level monitoring system (if applicable) in the form of a combined alarm.

Monitoring of bus communication

Bus communication is monitored by plausibility checking and timeout monitoring. Detected faults are output in the form of a combined alarm and, if possible, to a higher-level monitoring system (if applicable) via the CAN bus.

Overspeed test

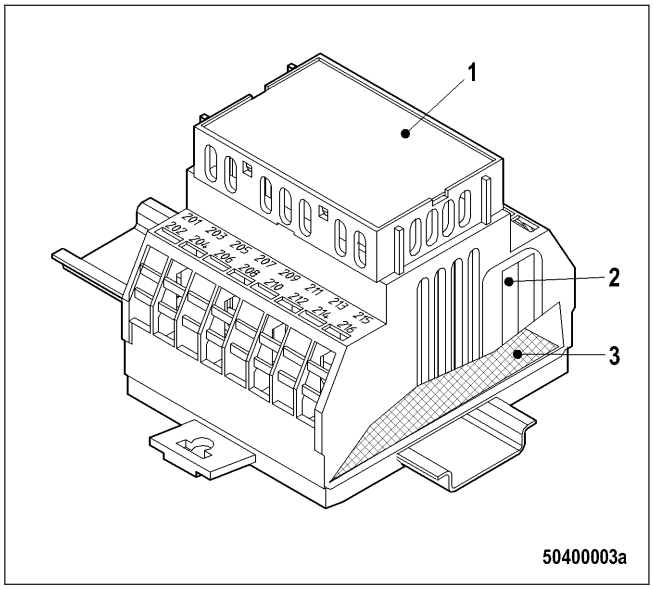
Activating this input lowers the overspeed threshold such that the engine shuts down at any speed. This makes it possible to check that the overspeed shutdown function operates correctly.

2.6 Peripheral Interface Modules (PIMs)

PIMs for use with processor printed circuit board MPU 23 and MPU 27

PIM design

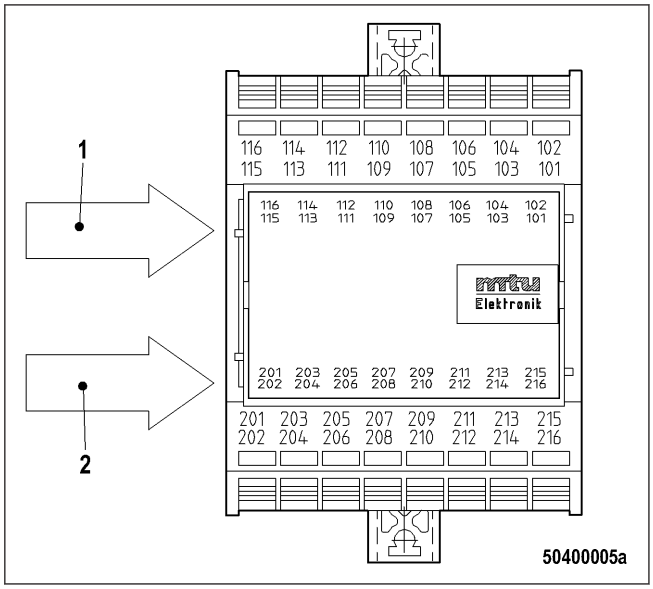
1 Module cassette 1
2 Basic module 1
3 Printed circuit board



PIM 601/602 comprises:
- Module cassette 1 (1) to accommodate one MPU 23, MPU 27 and one PIM printed circuit board.
- Basic module 1 (2) with printed circuit board COB 1-0X (3).
- Printed Circuit Board SCB 3

Slots and terminals

1 Slot 1
2 Slot 2



Slot 1 is reserved for the microprocessor card (MPU 23 and MPU 27). All other slots may be populated with PIM printed circuit boards.

Example: The "n" in "n09" stands for the slot and "09" designates the terminal. "209" means: Slot 2, terminal 9.

The following information is transmitted via the optional interface modules PIM 601 and PIM 602:
- Analog operational data
- Analog limit values
- Status messages
- Alarms
- Shutdowns

Function of PIM 601

Serial interface
- Computer coupling 512
- Procedure 3964 (R)
- RS232 or
- RS422
- MTU (SLAVE)

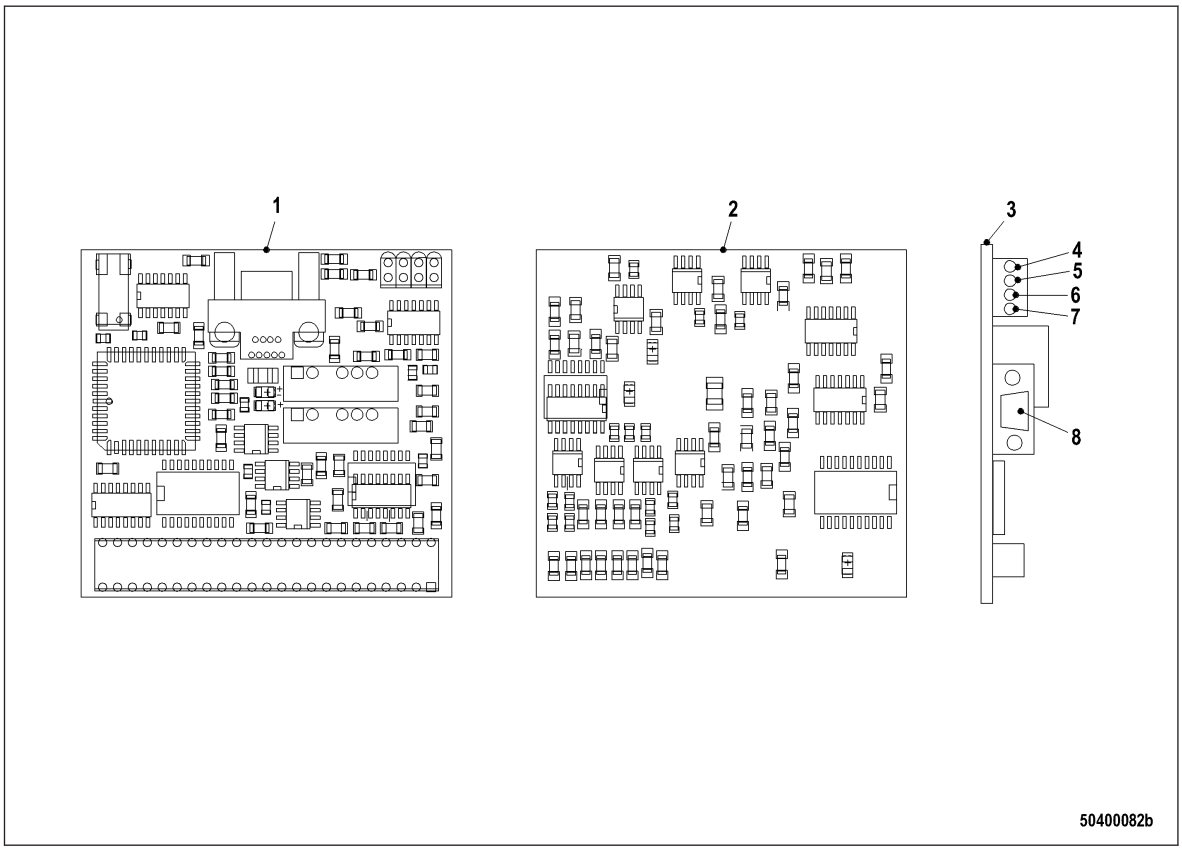
Function of PIM 602

Serial interface
- Computer coupling 512
- Procedure 3964 (R)
- RS232 or
- RS422
- MTU (MASTER)

2.7 Printed circuit board SCB 3

Purpose and design

Design



1 Component side
2 Soldering side
3 Top view
4 LED (red) “Printed circuit board RESET”
5 LED (green) “Ready”
6 LED (yellow) “Interface 1: Receiving and transmitting line active”
7 LED (yellow) “Interface 2: Receiving and transmitting line active”
8 Connector RS232 interface

A yellow LED lights (o flashes) only when data interchange is active at the relevant interface. When there is no communication at the (connected!) interface, the LED remains dark.

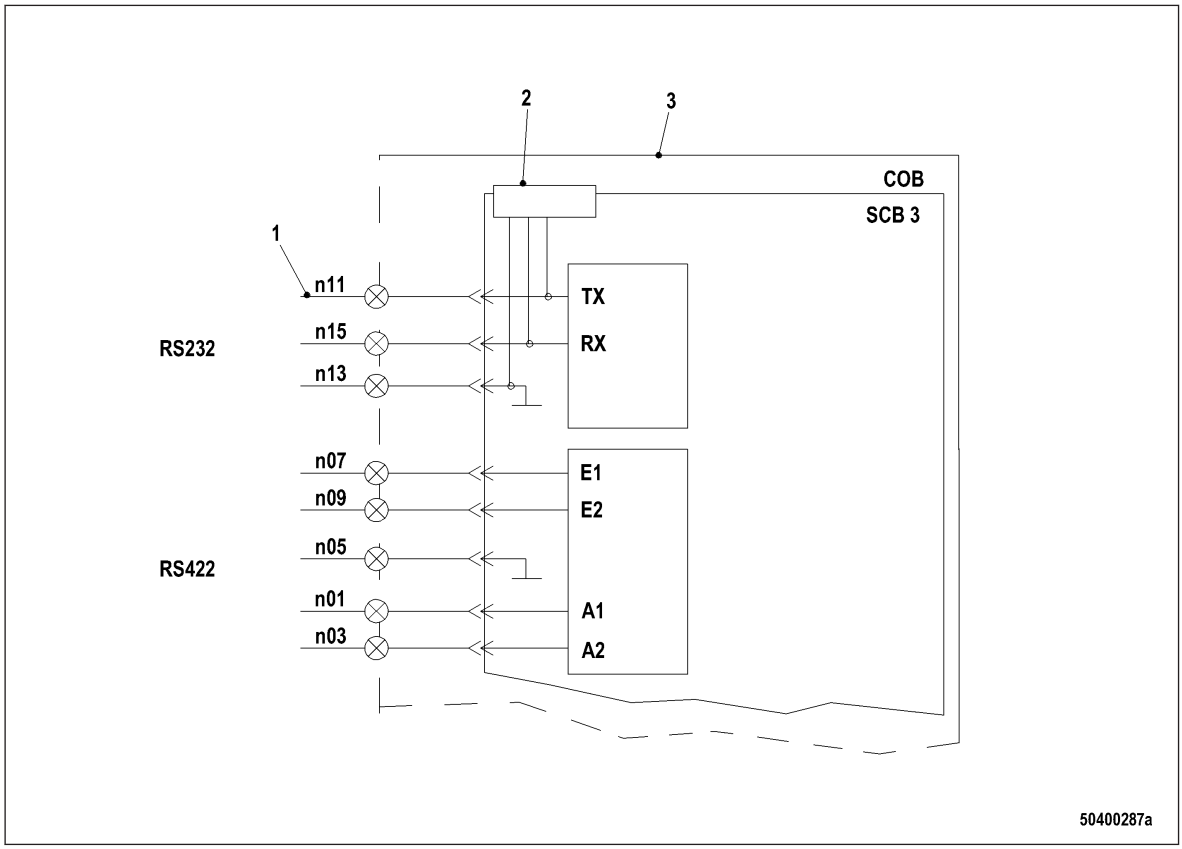
Features

- 2 interfaces as per RS422 or RS232 standard
- Interface are electrically isolated

Use

SCB 3 is used as an interface extension (additional serial interfaces), as an interface converter or as an amplifier.

Function



1 Transmission channel 1 2 Connector 3 Module housing with SCB 3

SCB 3 is equipped with two serial transmission channels routed to the terminal strip of the PIM.

The software of the relevant processor printed circuit board determines which interface is active on which transmission channel. Only one interface may be active for any one transmission channel.

- Transmission channel 1
  is equipped with a connection for a serial RS422 interface and a serial RS232 interface.
  The RS232 interface is connected via the terminals of the PIM or by a connector.
  When connected by the connector, the terminals of the RS232 interface are automatically switched off.
- Transmission channel 2
  is equipped with a connection for a serial RS422 interface and a serial RS232 interface.

Data processing and interface driver control (baud rate) depend on the processor printed circuit board used.

With processor printed circuit board MPU 23:

- Fixed 9600 kBd

With processor printed circuit board MPU 27 (project-dependent):

- 4800 kBd
- 9600 kBd
- 19200 kBd

Terminal assignment

Relationship between SCB 3 and the terminals of the PIM.

Connection terminal	Name
n01	Channel 1: O1 of RS422 interface
n02	Channel 2: O1 of RS422 interface

Connection terminal	Name
n03	Channel 1: O2 of RS422 interface
n04	Channel 2: O2 of RS422 interface
n05	Channel 1: Ground (GND) of RS422 interface
n06	Channel 2: Ground (GND) of RS422 interface
n07	Channel 1: I1 of RS422 interface
n08	Channel 2: I1 of RS422 interface
n09	Channel 1: I2 of RS422 interface
n10	Channel 2: I2 of RS422 interface
n11	Channel 1: TX of RS232 interface
n12	Channel 2: TX of RS232 interface
n13	Channel 1: Ground (GND) of RS232 interface
n14	Channel 2: Ground (GND) of RS232 interface
n15	Channel 1: RX of RS232 interface
n16	Channel 2: RX of RS232 interface

3 Technical Data

3.1 12/16 V 2000 P12 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 setting.
N Not yet defined value
- Not applicable
X Applicable

Engine model			12V2000 P12	16V2000 P12
Application group			4A	4A
Intake air temperature		°C	25	25
Charge air coolant temperature		°C	45	45
Barometric pressure		mbar	1000	1000
Site altitude above sea level		m	100	100

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

Number of cylinders			12	16
Nominal engine speed	A	rpm	1800	1800
Fuel stop power ISO 3046	A	kW	600	800

GENERAL CONDITIONS (for maximum power)

Number of cylinders			12	16
Intake air depression (new filter)	A	mbar	15	15
Intake air depression, max.	L	mbar	30	30
Exhaust overpressure	A	mbar	30	30
Exhaust gas overpressure, max.	L	mbar	50	50

MODEL-RELATED DATA (basic design)

Number of cylinders			12	16
Engine with exhaust turbocharging (ETC) and charge-air cooling (CAC)			X	X
Number of cylinders			12	16
Cylinder arrangement: V angle		Degrees	90	90
Bore		mm	130	130
Stroke		mm	150	150

Number of cylinders			12	16
Cylinder displacement		liter	1.99	1.99
Total displacement		liter	23.88	31.84
Compression ratio			16	16
Number of inlet valves per cylinder			2	2
Number of exhaust valves per cylinder			2	2
Standard flywheel housing flange (engine main PTO)		SAE	0	0

COOLANT SYSTEM (HT circuit)

Number of cylinders			12	16
Coolant temperature (at engine outlet: to cooling equipment)	A	°C	95	95
Coolant temperature after engine, warning	R	°C	97	97
Coolant temperature after engine, shutdown	L	°C	99	99
Coolant antifreeze content, max.	L	%	50	50
Pressure loss in off-engine cooling system, max.	L	bar	0.7	0.7

COOLANT SYSTEM (LT circuit)

Number of cylinders			12	16
Coolant temperature before intercooler (at engine connection: inlet from cooling equipment)	A	°C	N	N
Coolant antifreeze content, max.	L	%	50	50
Pressure loss in off-engine cooling system, max.	L	bar	0.7	0.7

LUBE OIL SYSTEM

Number of cylinders			12	16
Lube oil operating temperature before engine, from	R	°C	88	88
Lube oil operating temperature before engine, to	R	°C	98	98
Lube oil temperature before engine, warning	R	°C	99	99
Lube oil temperature before engine, shutdown	L	°C	102	102
Lube oil operating pressure before engine, from	R	bar	7.5	7.0
Lube oil operating pressure before engine, to	R	bar	8.5	8.0
Lube oil pressure before engine, warning	R	bar	5.5	5.5
Lube oil pressure before engine, shutdown	L	bar	5.0	5.0

FUEL SYSTEM

Number of cylinders			12	16
Fuel pressure at supply connection to engine, min. (during engine starting)	L	bar	-0.4	-0.4
Fuel pressure at supply connection on engine, max. (when engine is starting)	L	bar	0.5	0.5

GENERAL OPERATING DATA

Number of cylinders			12	16
Cold start capability: air temperature without starting aid, without preheating) - (case A)	R	°C	0**	0**
Coolant preheating: preheating temperature (min.)	R	°C	32	32
Firing speed, from	R	rpm	100	100
Firing speed, to	R	rpm	120	120

CAPACITIES

Number of cylinders			12	16
Engine coolant, engine-side (without cooling system)	R	liter	46	58
Charge-air coolant, engine side	R	liter	19	20
Engine oil capacity, initial filling (standard oil system) (Option: max. operating inclinations)	R	liter	95	123
Oil change quantity, max. (standard oil system) (Option: max. operating inclinations)	R	liter	90	120
Oil pan capacity, dipstick mark min. (standard oil system) (Option: max. operating inclinations)	L	liter	78	96
Oil pan capacity, dipstick mark max. (standard oil system) (Option: max. operating inclinations)	L	liter	85	103

ACOUSTICS

Number of cylinders			12	16
Exhaust noise, undamped - BL (sound power level LW, ISO 6798)	R	db(A)	123	128
Engine surface noise with damped intake noise (filter) - BL (sound-power level LW, ISO 6798)	R	db(A)	117	126

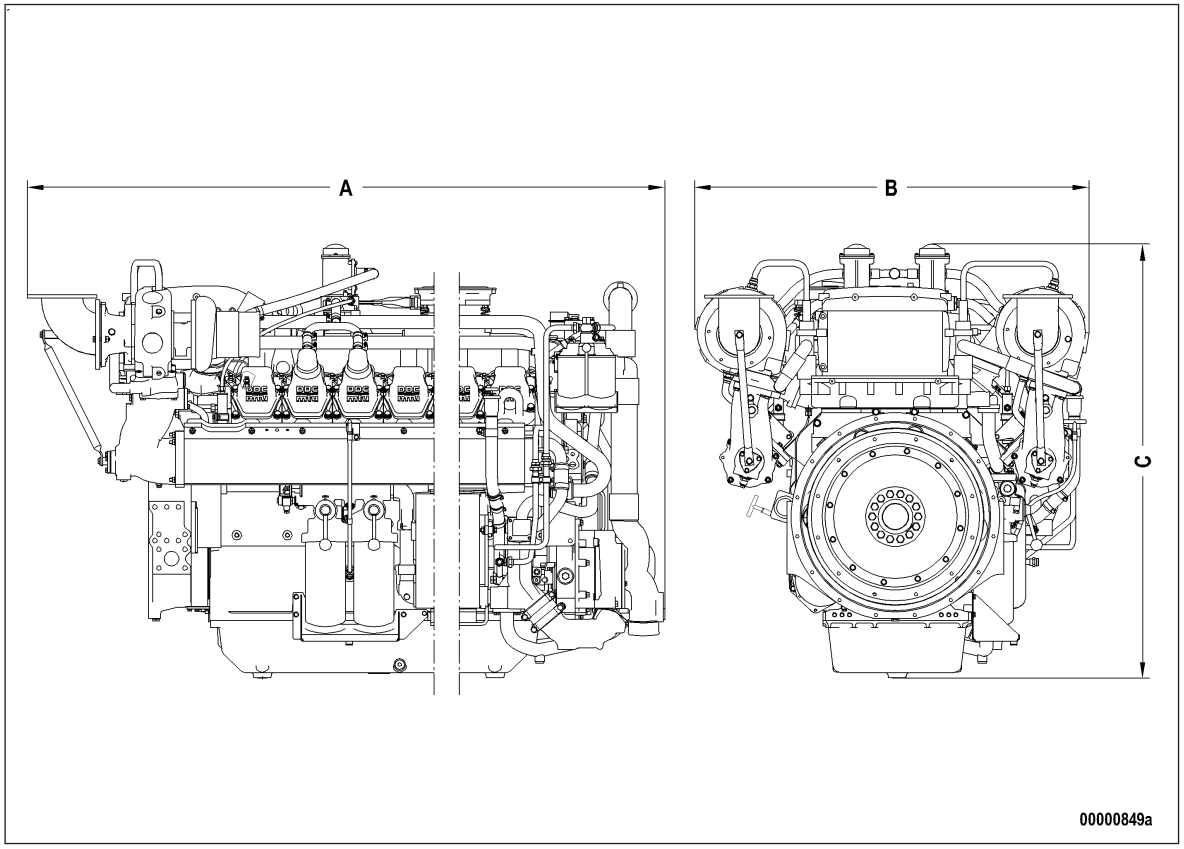
3.2 Firing order

Firing order

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

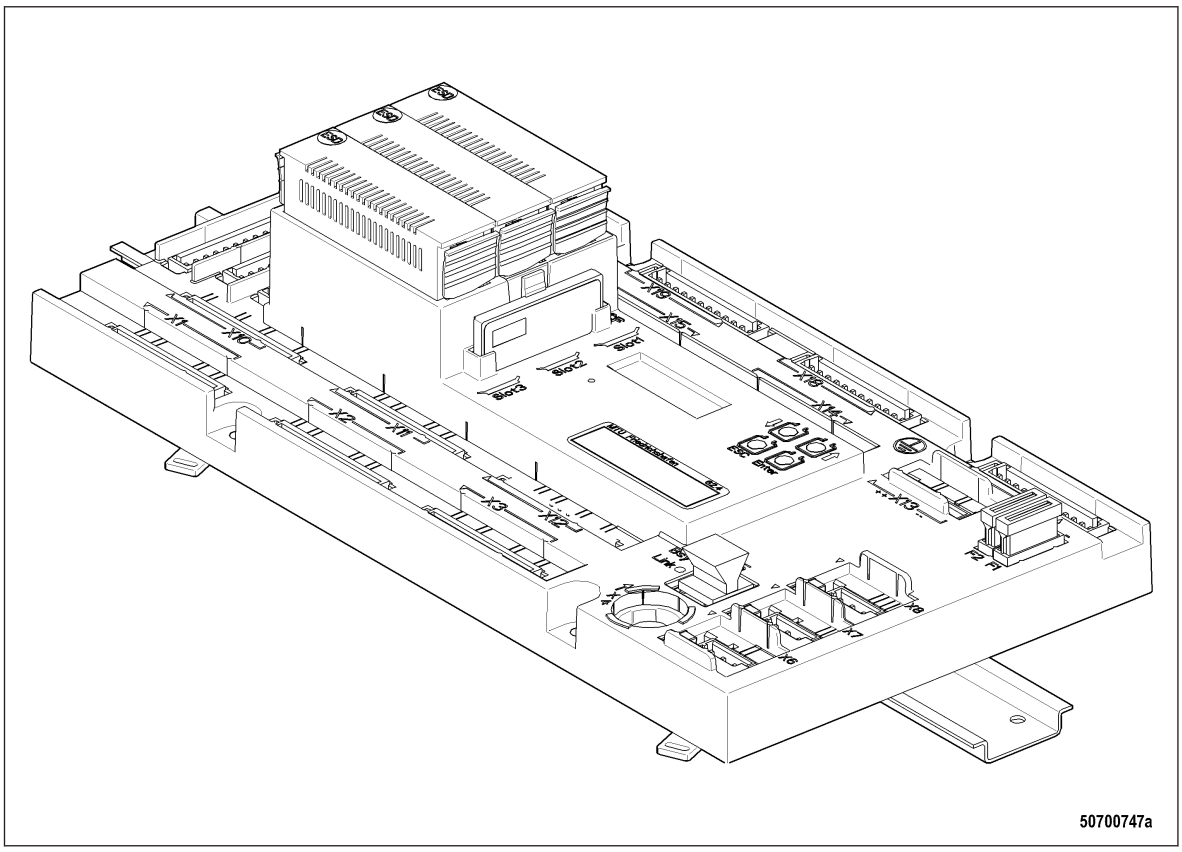
3.3 Engine – Main dimensions

Engine – Main dimensions



Engine model	12 V 2000 Px2	16 V 2000 Px2
Length (A)	approx. 2165 mm	approx. 2505 mm
Width (B)	approx. 1340 mm	approx. 1340 mm
Height (C)	approx. 1475 mm	approx. 1495 mm

3.4 SAM



Use/application

- Installation in enclosed control cabinets.
- Suitable for mounting on mounting rails (rail installation) or for installation with screws on the rear wall of the cabinet (fixed installation).
- Suitable for connection wires or leads up to AWG16 (US) (1.5 mm^2).

Technical data

Term	Unit	Value
Installation position		As desired, ensuring that the installed fault display is legible.
Operating voltage	VDC	24 rated value (-30%; +30%, temporary -50%)
Power consumption	W	Below 7 (0.25A at 24V) without additional loads.
Degree of protection:		IP 40 according to DIN 40 050
Shock:		
Rail mounting		10 g, 11 ms
Fixed mounting		30 g, 11 ms
Vibrations:		
Rail mounting	Hz	2 - 12.8:Xpp < ± 3mm 12.8 - 1000:a < 1g [rms]
Fixed mounting	Hz	2 - 12.8: Xpp < ± 3 mm 12.8 - 100:a < 4g [rms]

Term	Unit	Value
Ambient temperature:	°C	-40 – +70 with circulating ambient air.
Storage temperature:	°C	-40 - +100
Relative humidity	%	5 – 97, no condensation.
Color:		Blue (RAL5015)
Material:	%	Polycarbonate, reinforced with 10 % fiberglass.
Dimensions:	mm	L x W x H (295 x 151 x 75)
Weight:	kg	Approx. 1.6

Note: Values stated above may be restricted when MCS 5 extension modules are used.

EMI/EMC – Electromagnetic interference (general)

The SAM has been tested according to the following standards and meets the relevant limit values:

Standard	Test
EN 55011	(Conducted emission) 10 kHz – 30 MHz, class A
EN 55011	(Radiated emission) 30 MHz – 1 GHz
IEC-60533:1999	(Conducted emission) 10 kHz – 30 MHz (type test)
EC-60533:1999	(Radiated emission) 150 kHz – 2 GHz (type test)
EN 61000-4-2	(ESD interference immunity) ±8 kV
EN 61000-4-3	(Radiated interference immunity) 80 MHz – 2 GHz
EN 61000-4-4	(Burst interference immunity) ±2 kV
EN 61000-4-5	(Surge interference immunity) ±1 kV/±2 kV
EN 50155	(Surge interference immunity) ±1.8 kV
EN 61000-4-17	(LF line-related interference) 0.03 – 10 kHz/3 Veff
EN 61000-4-29	(Line fluctuations/STANAG 1008)
IEC 60092-504	(Dielectric strength) 550 VAC/10 mA
EN 50155	(Isolation) 500 V/10 Mohm

Requirements for fulfillment of EMI/EMC limit values are as follows:

- If the housing is not grounded via the mounting plate, it must be connected to housing ground e.g. by means of a cable with a minimum cross-section of 2.5 mm^2. Cable length shall not exceed 10 cm.
- Only twisted-conductor cables may be used to connect sensors and actuators. The maximum length of unshielded cables is 5 m, of shielded cables 50 m (provided wiring harness resistance allows for this). Shielding shall be connected in the switchgear cabinet.

Electrical requirements

Term	Unit	Value
Operating voltage:	V	24, -30 % to +30 % (+16.8 – +32) Permissible residual ripple less than 5% acc. to STANAG 1008. Note: The processor is automatically reset if the voltage falls below 7 V.
Power supply:	W	Below 7 W. Without activated loads at SAM outputs Additional output power amperage of positive or negative line may not exceed 10 A DC.
Power connection terminals:	mm	5.08 terminals (spring-type terminals) • A wire diameter of AWG14 (US) or 2.5 mm^2 is recommended.
Electrical isolation:	V	• Supply ground is common reference potential (Common Ground) for all SAM electronics. This applies to the entire I/O range with the exception of certain electrically isolated channels. • SAM electronics ground is not connected to housing ground. • If signal cable shields are used, these must be connected to housing ground. • Unless specified otherwise, the maximum DC insulation voltage is 500.

Mechanical design

Term	Unit	Value
Installation position		• Horizontal (to ensure visibility of the fault display and labels on the SAM housing). • Note that space is required to connect cabling at the top and bottom when installing the SAM in control cabinets. • The device heats up as a result of power loss from the SAM. Heat from the SAM is dissipated through the rear panel. Ensure that heat can be conducted away from the rear panel of the SAM to the mounting frame. Avoid any additional heating of the SAM by neighboring devices.

Signal connections

The SAM module is easily replaced. The input and output signal cables are equipped with modular connectors. Common function channels are grouped together.

The wires are connected using spring terminals.

It is possible to connect two wires to one terminal if the wires are connected in a double core sleeve using crimp technology. For example, a Phoenix AL-TWIN 2* 0.75-10 may be used.

The connector modules are connected by clicking them in place. The connector modules have code pins to prevent polarity reversal.

Terminals

Term	Unit	Value
Terminal strip modules:		WAGO spring terminals
Current-carrying capacity (at 70 °C):	A	10 per contact
Rated voltage:	V	250
Rated surge voltage:	V	2500
Wire cross-sections:	mm^2	Up to 1.5 or AWG15
Clamping range:	mm^2	0.08 – 1.5 or AWG15

Other terminals (RM 5.08) are used for power supply and CAN bus connections.

Additional printed circuit boards in slots 1 to 3

Observe the relevant technical data applicable to the printed circuit boards concerned when additional boards are used in the SAM.

3.5 SCB 3 – Technical data

Term	Unit	Value
Dimensions (H x W x D)	mm	59 x 63 x 15
Weight	kg	0.036
Input voltage	VDC	+5 (±5 %) from processor printed circuit board used
Power consumption	mA	< 100
Power loss	mW	< 425

Table 1: General information

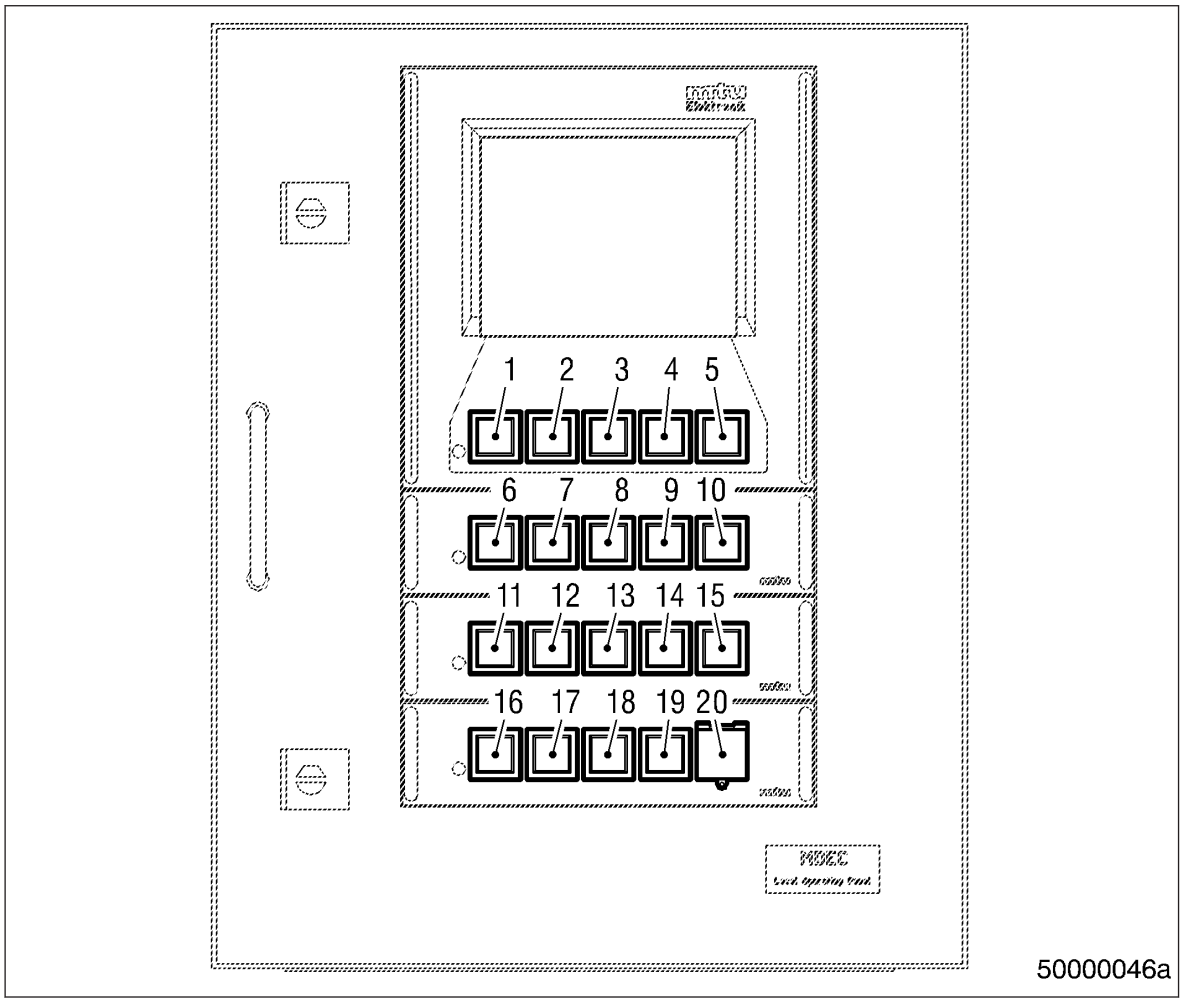
Term	Unit	Value
Bit-serial		In accordance with RS422 standard
Baud rate	kBd	• 9600 with MPU 23 • 4800, 9600, 19200 with MPU 27
Electrical isolation		By optocoupler.

Table 2: Data transmission

4 Operation

4.1 LOP – Controls

LOP – Controls



Item	Color	Inscription	Meaning / Function
1	White	F1	Function keys for operating the screen. Functions vary and are displayed on the LCD screen.
2	White	F2	
3	White	F3	
4	White	F4	
5	White	F5	
6	White	ALARM AC-KNOWLEDGE	Pressing the key the first time stops alarm signalization. Pressing the key a second time acknowledges an active alarm. LED (spot) lights up when an alarm is active.
7	White	DIMMER ↑	Holding down the key increases LCD background illumination.

Item	Color	Inscription	Meaning / Function
8	White	DIMMER ↓	Holding down the key decreases LCD background illumination.
9	White	LAMP TEST	Pressing the key initiates lamp test.
10	Red	TEST OVERSPEED	Pressing the key initiates overspeed test. LED (spot) lights up as long as the overspeed test is running.
11	Green	(none)	(none)
12	Green	(none)	(none)
13	Green	(none)	(none)
14	White	ENGINE SPEED INCREASE	Engine speed is increased as long as the key is held down.
15	White	ENGINE SPEED DECREASE	Engine speed is decreased as long as the key is held down.
16	Green	READY FOR OPERATION	Pressing the key causes changeover between “Not ready for operation” and “Ready for operation” status. LED (spot) lights up at "Ready for operation" switch position.
17	Green	LOCAL OPERATION	Pressing the key switches between local operation and remote control. LED (spot) lights up when local mode is active.
18	White	START	Pressing the key initiates automatic engine starting procedure. LED (spot) lights up as long as the starting procedure is running.
19	White	STOP	Pressing the key initiates automatic engine stopping procedure. Spot LED lit when stop signal is applied (also from remote control system).
20	Red	EMERGENCY STOP	Pressing the key initiates an immediate emergency engine stop. LED (spot) flashes once the emergency stop has been tripped and until the alarm has been acknowledged.

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

Preconditions

☑ Engine is stopped and starting disabled.

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

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

Item	Task
Engine	Depreserve (→ MTU Fluids and Lubricants Specifications A001061/..).
Lube oil system	Check engine oil level (→ Page 123).
Fuel prefilter	Prime (→ Page 115).
Fuel prefilter, pressure gauge	Align pointer with position of pressure indicator (→ Page 113).
Fuel system	Vent (→ Page 109).
Coolant circuit	If engine has been out of service for more than 1 year, change engine coolant (→ Page 132); Change charge-air coolant (→ Page 140).
Coolant circuit	Check engine coolant level (→ Page 131); Check charge-air coolant level (→ Page 141).
Coolant circuit	Preheat coolant with preheating unit.
ECU	Check plug connections (→ Page 147).
Monitoring equipment	Carry out lamp test (see manufacturer's documentation).
Engine/generator control system	Switch ON; Select operating mode, e.g. MANUAL OPERATION, AUTOMATIC OPERATION.

4.3 Putting the engine into operation after scheduled out-of-service-period

Preconditions

☑ Engine is stopped and starting disabled.

Putting the engine into operation

Item	Task
Lube oil system	Check oil level (→ Page 123);
Cooling system	Check engine coolant level (→ Page 131); Check charge-air coolant level (→ Page 141).
Cooling system	Preheat coolant with preheating unit.
Fuel prefilter	Drain (→ Page 114).
Monitoring equipment	Carry out lamp test (see manufacturer's documentation).
Engine/generator control system	Switch ON; Select operating mode, e.g. MANUAL OPERATION, AUTOMATIC OPERATION.

4.4 Start engine in manual mode (testing mode)

Preconditions

☑ Generator (if provided) not connected to network.

☑ External start interlock is not activated.

DANGER

Unguarded rotating and moving engine components.
Risk of serious injury – danger to life!
- Before barring or starting the engine, make sure that nobody is in the danger zone.

WARNING

Engine noise above 85 dB (A).
Risk of damage to hearing!
- Wear ear protectors.

Preparation

Item	Task
Operating mode selector switch (if provided)	Change to manual mode.
Preheating pump (if provided)	Switch ON.

Starting the engine

Item	Task
Switchgear cabinet, control panel etc. (depending on manufacturer)	If coolant temperature is • > 40 °C (with preheating equipment), or • > 5 °C (without preheating equipment): Press start button. • Automatic starting sequence is performed; • Engine speed display instrument indicates increasing crankshaft speed; • After the starting sequence is completed, engine is running at rated speed.

Connect generator to network (if provided), run engine to reach operating temperature)

Item	Task
Switchgear cabinet, control panel etc. (depending on manufacturer)	Close the generator circuit breaker.
Engine	Apply full load only after engine has reached operating temperature (coolant temperature approx. 75 °C).

4.5 Safety system – Override

CAUTION

Safety functions and engine shutdown alarms will be disregarded.
Serious damage to plant!
- Initiate emergency start only in emergency situations.

CAUTION

Inadmissible operational condition.
Major material damage!
- Use override function only in hazardous situations to ensure full capability in case of engine malfunctions.

Preparation

Note: This function is only available when a pushbutton is provided.

Bypassing the safety system (Override)

Item	Action
Switchgear cabinet, control panel etc. (depending on manufacturer)	Activate pushbutton for Override input of the ECU. • Certain shutdown criteria and/or starting prerequisites are ignored.
Switchgear cabinet, control panel etc. (depending on manufacturer)	Actuate start button, for further starting sequence, refer to engine start (→ Page 52).
Control and display panels	During operation, check the displayed operational data (speed, temperature, pressures). Constantly monitor plant limit values.

4.6 Operational checks

DANGER

Unguarded rotating and moving engine components.
Risk of serious injury – danger to life!
- Take special care when working on a running engine.

WARNING

Engine noise above 85 dB (A).
Risk of damage to hearing!
- Wear ear protectors.

Operational checks

Item	Task
Control and display panels	Check indicated operational data (speed, temperatures, pressures).
Engine under load, Engine at nominal speed	Check engine/plant and all pipework visually for leaks, rectify any leaks with the engine stopped; Check for abnormal running noises and vibrations.
Fuel prefilter	Check whether indicated differential pressure is within the limit (→ Page 113).
Exhaust system	Check exhaust color (→ Page 61).
Intercooler	Check condensate drain(s) for water discharge and obstruction (→ Page 119).
Air filter	Check signal ring position of service indicator (→ Page 121). Replace air filter (→ Page 120), if the signal ring is completely visible in the service indicator control window.
Coolant pump	Check relief bore (→ Page 136).
Compressed air system (if applicable to engine)	Check operating pressure on pressure gauge; Always fill compressed-air tank to max. pressure; Drain condensate from compressed-air tank, pressure drop must not exceed 1 bar.

TIM-ID: 0000010121 - 001

4.7 Stop engine in manual mode (testing mode)

Preconditions

☑ Generator (if provided) not connected to network.

☑ Engine is running in manual mode.

CAUTION

Stopping the engine when it is running at full load causes extreme stress to the engine.
Risk of overheating, damage to components!
- Before stopping the engine, operate it at idle speed until operating temperatures decrease and stable values are indicated.

Preparing the generator drive (only with generator breaker)

Item	Task
Engine	After opening the generator breaker (if provided), allow to cool down off-load for approx. 5 minutes.

Preparing the pump drive (diesel-mechanical/diesel-electric)

Item	Task
Engine	Allow to cool down for approx. 5 minutes at reduced engine speed. Observe natural resonance of engine (installation-dependent)!

Stopping the engine

Item	Task
Switchgear cabinet, control panel etc. (depending on manufacturer)	Press stop button. • Automatic stopping sequence is performed; • Engine is stopped.

After stopping the engine

Item	Task
Coolant pump	Allow to run on for sufficient time after stopping.

4.8 Emergency stop

CAUTION

An emergency stop causes extreme stress to the engine.
Risk of overheating, damage to components!
- Initiate emergency stop only in emergency situations.

Emergency stop from LOP

Item	Task
EMERGENCY STOP button	Press. • Engine is stopped by switching off power supply to ECU; • Signalization (e.g. by horn, flashing lamp) is released.

After emergency stop from LOP

Item	Task
Switching cabinet, control panel etc. (depending on manufacturer)	Press button for alarm acknowledgement. • Audible and visual signalization stops.

4.9 After stopping the engine – Engine remains ready for operation

After stopping the engine

Item	Action
Engine/generator/pump control	Select operating mode, e.g. MANUAL, AUTOMATIC OPERATION.

4.10 After stopping the engine – putting the engine out of service

Preconditions

☑ MTU-Preservation and Represervation Specifications (A001070/..) are available.

After stopping the engine

Item	Task
Cooling system	Drain engine coolant (→ Page 133); Drain charge-air coolant (→ Page 139) if: • freezing temperatures are expected and the engine is to remain out of service for an extended period and coolant has no antifreeze additive; • the engine room is not heated; • the coolant is not maintained at a suitable temperature; • the antifreeze concentration is insufficient for the engine-room temperature; • antifreeze concentration is 50 % and engine-room temperature is below -40°C.
Engine/generator/pump controller	Switch OFF.
Air intake and exhaust system	If the engine is to remain out of service for more than 1 week, seal the engine's air and exhaust sides. If the engine is to remain out of service for more than 1 month, preserve engine (→ MTU-Preservation and Represervation Specifications A001070/..).

4.11 Plant cleaning

Preconditions

☑ Engine is stopped and starting disabled.

☑ Operating voltage is not present.

Special tools, Material, Spare parts

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

WARNING

Compressed air
Risk of injury!
- Do not direct compressed-air jet at persons.
- Wear protective goggles / safety mask and ear protectors.

WARNING

Water jet.
Risk of injury and scalding!
- Do not direct water jet at persons.
- Wear protective clothing, gloves, and goggles / safety mask.

CAUTION

Excessive reaction time of cleaning agents on components.
Damage to component!
- Observe manufacturer's instructions.
- Wear protective clothing, gloves, and goggles / safety mask.

NOTICE

Dry with compressed air.
Damage to component!
- Never aim compressed air directly at electronic components.

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. During external cleaning of the plant with water/steam-jet units, 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.
5. Carry out external cleaning as follows:
   a) Seal all openings in a suitable fashion.
   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.

Note: Never aim compressed air directly at electronic components.
   e) Dry engine.

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	Maintenance tasks	
W0500	Check engine oil level.	(→ Page 54)
W0501	Visually inspect engine for leaks and general condition.	(→ Page 54)
W0503	Check signal ring position of service indicator on air filter.	(→ Page 54)
W0505	Check relief bores of water pump(s).	(→ Page 54)
W0506	Check engine for abnormal running noises, exhaust color and vibrations.	(→ Page 54)
W0507	Drain water and contaminants from fuel prefilter.	(→ Page 54)
W0508	Check reading on differential pressure gage of fuel prefilter.	(→ Page 54)
W1001	Replace fuel filter or fuel filter element.	(→ Page 110)
W1002	Check valve clearance.	(→ Page 95)
W1003	Check belt condition and tension, replace if necessary.	(→ Page 142)
W1005	Replace air filter.	(→ Page 120)
W1006	Replace fuel injectors.	(→ Page 102)
W1007	Replace fuel injection pump(s).	(→ Page 98)
W1008	Replace engine oil filter when changing engine oil, or when the interval (years) is reached, at the latest.	(→ Page 125)
W1010	Coolant cooler: Check exterior of cooler elements for dirt.	
W1011	Perform endoscopic examination of combustion chambers.	(→ Page 87)
W1056	Replace fuel pressure maintaining valve.	(→ Page 106)
W1140	Clean wire meshes of crankcase breather.	(→ Page 91)

6 Troubleshooting

6.1 Troubleshooting

Engine does not turn when starter is actuated

Component	Cause	Measure
Battery	Flat or defective	Charge or replace (see manufacturer's documentation).
	Cable connections faulty	Check if cable connections are properly secured (see manufacturer's documentation).
Starter (electric)	Engine wiring or starter faulty	Check if cable connections are properly secured, contact Service.
Starter (compressed air)	Starting-air pressure not available	Check firm seating of connections, check starting-air pressure and main valve of compressed-air system. Contact Service.
Engine wiring	Faulty	Check (→ Page 144).
Engine governor	Plug-in connections possibly loose	Check plug-in connections (→ Page 147).
Engine	Blocked (engine cannot be barred manually)	Contact Service.

Engine turns but does not fire

Component	Cause	Measure
Starter	Poor rotation by starter: Battery flat or defective	Charge or replace battery (see manufacturer's documentation).
Engine wiring	Faulty	Check (→ Page 144).
Fuel system	Air in fuel system	Vent fuel system (→ Page 109).
Engine governor	Faulty	Contact Service.

Engine fires unevenly

Component	Cause	Measure
Fuel injection equipment	Injector faulty	Replace (→ Page 102).
	Injection pump defective	Replace (→ Page 98).
Engine wiring	Faulty	Check (→ Page 144).
Fuel system	Air in fuel system	Vent fuel system (→ Page 109).
Engine governor	Faulty	Contact Service.

Engine does not reach rated speed

Component	Cause	Measure
Fuel supply	Fuel inlet blocked	Completely open shutoff valve upstream of fuel prefilter.
	Fuel prefilter clogged	Replace (→ Page 117).
	Easy-change fuel filter contaminated	Replace (→ Page 110).
Air supply	Air filter clogged	Check signal ring position of contamination indicator (→ Page 121).
Fuel injection equipment	Injector faulty	Replace (→ Page 102).
	Injection pump defective	Replace (→ Page 98).
Engine wiring	Faulty	Check (→ Page 144).
Engine	Overloaded	Contact Service.

Engine speed not steady

Component	Cause	Measure
Fuel injection equipment	Injector faulty	Replace (→ Page 102).
	Injection pump defective	Replace (→ Page 98).
Speed sensor	Faulty	Contact Service.
Fuel system	Air in fuel system	Vent fuel system (→ Page 109).
Engine governor	Faulty	Contact Service.

Charge-air temperature too high

Component	Cause	Measure
Engine coolant	Engine coolant treatment incorrect	Check (MTU test kit).
Intercooler	Contaminated	Contact Service.
Engine room	Air-intake temperature too high	Check fan; check air inlet/outlet ducts.

Charge-air pressure too low

Component	Cause	Measure
Air supply	Air filter clogged	Check signal ring position of contamination indicator (→ Page 121).
Intercooler	Contaminated	Contact Service.
Exhaust turbocharger	Faulty	Contact Service.

Coolant leaks at intercooler

Component	Cause	Measure
Intercooler	Leaking, major coolant discharge	Contact Service.

Black exhaust gas

Component	Cause	Measure
Air supply	Air filter clogged	Check signal ring position of contamination indicator (→ Page 121).
Fuel injection equipment	Injector faulty	Replace (→ Page 102).
	Injection pump defective	Replace (→ Page 98).
Engine	Overloaded	Contact Service.

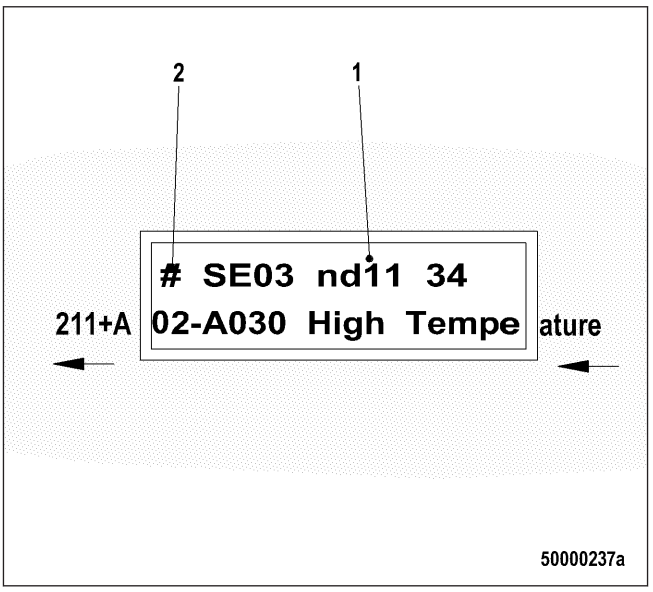
Blue exhaust gas

Component	Cause	Measure
Engine oil	Engine oil level too high	Drain engine oil (→ Page 124).
	Oil separator or oil-preseparator of crankcase breather clogged	Replace (→ Page 93).
Exhaust turbocharger	Faulty	Contact Service.
Cylinder head		
Piston rings		
Cylinder liner		

White exhaust gas

Component	Cause	Measure
Engine	Not at operating temperature	Run engine to reach operating temperature.
Fuel system	Water in fuel	Check fuel system at fuel prefilter Drain fuel prefilter (→ Page 114).
Intercooler	Leaking	Contact Service.

6.2 Fault indication on printed circuit board SAM



The structure of the display (1) is as follows:

- First line
  - Fault indication
    - # (2) = Alarm is no longer active, does not appear on next power-up,
      - A = Currently active alarms,
      - B = Alarm was active during the last hour,
      - C = Alarm was active during the last four hours,
      - C = Alarm was active during the last four to twelve hours,
      - E = Alarm was active more than twelve hours ago.

      .
    - Fault type (e.g. SE03).
    - Node number at which the fault occurred (e.g. nd11).
- Second line
  - Running text, providing more information about the fault currently displayed

Proceed to the next alarm by pressing key (↓ ↑).

Fault type – fault message text

SE No.	Fault message text
0	Sensor Temperature Defect
1	Temperature failure
2	Sensor Voltage Defect
3	Voltage failure
4	CAN Bus- 1 Error/Bus Defec
5	CAN Bus- 1 Overrun
6	CAN Bus- 2 Error/Bus Defec
7	CAN Bus- 2 Overrun
8	Temperature Compensation Error
9	I/O-Module Slot2 Defect
10	I/O-Module Slot3 Defect

SE No.	Fault message text
11	I/O-Module Slot4 Defect
12	Serial Connection Lost
13	CAN Bus- 3 Error/Bus Defec
14	CAN Bus- 3 Overrun
15	S/A Bus Faulty
16	PAN 1 Defect
17	PAN 2 Defect
18	PAN 3 Defect
19	PAN 4 Defect
20	PAN 5 Defect
21	PAN 6 Defect
22	I/O-Module Slot1 Defect
23	I/O-Module Slot5 Defect
24	I/O-Module Slot6 Defect
25	I/O-Module Slot7 Defect
26	I/O-Module Slot8 Defect
27	Download Server Collision
28	not projected node

Engine governor fault codes and fault messages

Fault code	Fault message	Meaning	Action
005	L1 T-CHARGE AIR	Charge air temperature too high (1st limit value)	Reduce power.
009	L1 T-INTERCOOLER	Charge-air coolant temperature too high (1st limit value)	Reduce power.
015	L1 P-LUBE OIL	Oil pressure too low (1st limit value)	Check oil level, top up as necessary (→ Engine operating instructions).
016	L2 P-LUBE OIL	Oil pressure too low (2nd limit value) automatic engine shutdown.	1. Check oil level, top up as necessary (→ Engine operating instructions). 2. Attempt to restart engine (→ Engine operating instructions).
019	L1 T-EXHAUST A	Exhaust temperature engine A side too high (1st limit value)	1. Check cabling (→ Engine operating instructions); 2. Contact Service.
020	L2 T-EXHAUST A	Exhaust temperature engine A side too high (2nd limit value)	1. Check cabling (→ Engine operating instructions); 2. Contact Service.
021	L1 T-EXHAUST B	Exhaust temperature engine B side too high (1st limit value)	1. Check cabling (→ Engine operating instructions); 2. Contact Service.
022	L2 T-EXHAUST B	Exhaust temperature engine B side too high (2nd limit value)	1. Check cabling (→ Engine operating instructions); 2. Contact Service.

Fault code	Fault message	Meaning	Action
023	L1 COOLANT LEVEL	Coolant level too low (1st limit value)	Check coolant level in expansion tank (→ Engine operating instructions).
024	L2 COOLANT LEVEL	Coolant level too low (2nd limit value)	Check coolant level in expansion tank (→ Engine operating instructions).
025	L1 P-OILFILTER DIFF	Oil filter differential pressure too high (1st limit value)	Check oil filter (→ Engine operating instructions).
027	L1 LEVEL LEAKAGE FUEL	Leak fuel (1st limit value).	Check fuel system (→ Engine operating instructions).
030	ENGINE OVERSPEED	Engine overspeed; automatic emergency engine stop.	1. Acknowledge alarm. 2. Attempt to restart engine.
031	CHARGER 1 OVERSPEED1	ETC 1 – speed violation (1st limit value).	• Engine management system automatically reduces power. • Check air filter (→ Engine operating instructions).
032	CHARGER 1 OVERSPEED2	ETC 1 – speed violation. (2nd limit value)	• Engine management system automatically reduces power. • Check air filter (→ Engine operating instructions).
044	L1 LEVEL INTERCOOLER	Charge air coolant level too high/low (1st limit value violated).	Check coolant level (→ Engine operating instructions).
045	L2 LEVEL INTERCOOLER	Charge air coolant level too high/low (2nd limit value violated).	Check coolant level (→ Engine operating instructions).
051	L1 T-LUBE OIL	Oil temperature too high (1st limit value)	Reduce power.
052	L2 T-LUBE OIL	Lube oil temperature too high (2nd limit value)	1. Reduce power. 2. Check oil level (→ Engine operating instructions).
057	L1 P-COOLANT	Coolant pressure too low (1st limit value) .	Check coolant circuit
058	L2 P-COOLANT	Coolant pressure too low (2nd limit value)	• Automatic engine shutdown. • Check coolant level (→ Engine operating instructions).
065	L1 P-FUEL	Fuel inlet pressure too low (1st limit value)	(→ Engine operating instructions) • Check fuel lines for leakage. • Clean fuel prefilter. • Rinse fuel prefilter. • Replace fuel prefilter element . • Replace fuel filter.
066	L2 P-FUEL	Fuel inlet pressure too low (2nd limit value)	(→ Engine operating instructions) • Check fuel lines for leakage. • Clean fuel prefilter. • Rinse fuel prefilter. • Replace fuel prefilter element . • Replace fuel filter.

Fault code	Fault message	Meaning	Action
067	L1 T-COOLANT	Coolant temperature too high (1st limit value);	Reduce power.
068	L2 T-COOLANT	Coolant temperature too high (2nd limit value); automatic engine shutdown	1. Allow engine to cool down. 2. Contact Service • Check engine coolant cooler, clean if dirty (→ Engine Workshop Manual). 3. Restart engine.
089	ENGINE SPEED LOW	Engine speed has failed to reach 200 rpm. Stop is activated.	Check for additional messages.
100	EDM NOT VALID	Checksum error in Engine Data Module EDM/EEPROM 1.	Redundant design of EDM allows engine management system to remain operational.
101	IDM NOT VALID	Checksum error in Interface Data Module IDM/EEPROM 2.	Redundant design of EDM allows engine management system to remain operational.
102	INVALID FUEL CONS. 1	Invalid fuel consumption display, checksum error in EDM/EEPROM 1 (redundant data record 1).	Contact Service.
103	INVALID FUEL CONS. 2	Invalid fuel consumption display, checksum error in IDM/EEPROM 2 (redundant data record 2).	Contact Service.
104	OP HOURS1 NOT VALID	Checksum error of hour meter in EDM/EEPROM 1	Hour meter remains operational.
105	OP HOURS2 NOT VALID	Checksum error of hour meter in IDM/EEPROM 2	Hour meter remains operational.
106	ERR REC1 NOT VALID	Checksum error of fault memory in EDM/EEPROM 1 (redundant data record 1).	Faults are still recorded.
107	ERR REC2 NOT VALID	Checksum error of fault memory in IDM/EEPROM 2 (redundant data record 2).	Faults are still recorded.
118	L1 SUPPLY VOLT. LOW	Supply voltage too low (1st limit value)	Contact Service. • Check engine governor supply voltage.
119	L2 SUPPLY VOLT. LOW	Supply voltage too low (2nd limit value)	Contact Service. • Check engine governor supply voltage.
120	L1 SUPPLY VOLT. HIGH	Supply voltage too high (1st limit value).	Contact Service. • Check engine governor supply voltage.
121	L2 SUPPLY VOLT. HIGH	Supply voltage too high (2nd limit value); automatic engine shutdown (configurable):	Contact Service. • Check engine governor supply voltage.

Fault code	Fault message	Meaning	Action
122	L1 T-ELECTRONIC	Temperature in ECU housing too high (1st limit value)	1. Improve engine room ventilation. 2. Reduce engine power.
134	15V POS ECU DEFECT	Internal voltage (-15 VDC) faulty; automatic engine shutdown.	Replace engine governor (→ Engine operating instructions).
136	15V NEG ECU DEFECT	Internal voltage (-15 VDC) missing; automatic engine shutdown	Contact Service.
139	L1 TE BUFFER TEST	Temperature sensor supply voltage faulty.	Contact Service. • Check sensors; • replace engine governor.
140	TE BUF. ECU DEFECT	Temperature sensor supply voltage faulty.	Contact Service. • Check sensors; • replace engine governor.
142	BANK1 ECU DEFECT	Power output stage for control of solenoid valves on bank 1 is faulty; engine does not start.	Replace engine governor (→ Engine operating instructions).
144	BANK2 ECU DEFECT	Power output stage for control of solenoid valves on bank 2 is faulty; engine does not start.	Replace engine governor (→ Engine operating instructions).
145	15V_GOOD ECU DEFECT	Power supply is faulty; automatic engine shutdown.	Replace engine governor (→ Engine operating instructions).
146	L1 AD-TEST1 SUPPLY	A/D converter supply voltage too low.	Replace engine governor (→ Engine operating instructions).
147	AD-TEST1 ECU DEFECT	Electronics faulty; automatic engine shutdown.	Replace engine governor (→ Engine operating instructions).
148	L1 AD-TEST2 SUPPLY	A/D converter supply voltage too low.	Replace engine governor (→ Engine operating instructions).
149	AD-TEST2 ECU DEFECT	Internal electronics faulty; automatic engine shutdown.	Replace engine governor (→ Engine operating instructions).
150	L1 AD-TEST3 SUPPLY	Internal electronics faulty; automatic engine shutdown.	Replace engine governor (→ Engine operating instructions).
151	AD-TEST3 ECU DEFECT	Internal electronics faulty; automatic engine shutdown.	Replace engine governor (→ Engine operating instructions).
186	CAN 1 BUS OFF	CAN 1 in Bus-Off state: • Either short circuit on bus. • Or strong magnetic fields disrupting bus.	Contact Service. • Check CAN bus for short circuit, rectify short circuit as necessary. • Check shielding, improve shielding as necessary.

Fault code	Fault message	Meaning	Action
187	CAN 1 ERROR PASSIVE	CAN 1 in Error-Passive state, minor bus disruption or missing CAN node .	Contact Service. • Check that at least one CAN node is present. Check cabling as necessary. • Check shielding, improve shielding as necessary.
188	CAN 2 BUS OFF	CAN 2 in Bus-Off state: • Either short circuit on bus. • Or strong magnetic fields disrupting bus.	Contact Service. • Check CAN bus for short circuit, rectify short circuit as necessary. • Check shielding, improve shielding as necessary.
189	CAN 2 ERROR PASSIVE	CAN 2 in Error-Passive state, minor bus disruption or missing CAN node .	Contact Service. • Check that at least one CAN node is present. Check cabling as necessary. • Check shielding, improve shielding as necessary.
201	SD T-COOLANT	Sensor B06 faulty (coolant temperature).	1. Check cabling (→ Engine operating instructions); 2. Contact Service • Check sensor.
202	SD T-FUEL	Sensor B33 faulty (fuel temperature).	1. Check cabling (→ Engine operating instructions); 2. Contact Service • Check sensor.
203	SD T-CHARGE AIR	Sensor B09 faulty (charge air temperature) A-side.	1. Check cabling (→ Engine operating instructions); 2. Contact Service • Check sensor.
205	SD T-COOLANT INTERC.	Sensor fault (charge-air coolant temperature).	1. Check cabling (→ Engine operating instructions); 2. Contact Service • Check sensor.
206	SD T-EXHAUST A	Sensor B4.21 faulty (exhaust temperature) engine side A.	1. Check cabling (→ Engine operating instructions); 2. Contact Service • Check sensor.
207	SD T-EXHAUST B	Sensor B4.22 faulty (exhaust temperature) engine side B.	1. Check cabling (→ Engine operating instructions); 2. Contact Service • Check sensor.
208	SD P-CHARGE AIR	Sensor B10 faulty (charge-air pressure) A-side.	1. Check cabling (→ Engine operating instructions); 2. Contact Service • Check sensor.
211	SD P-LUBE OIL	Sensor B05 faulty (lube oil pressure).	1. Check cabling (→ Engine operating instructions); 2. Contact Service • Check sensor.
212	SD P-COOLANT	Sensor B16 faulty (coolant pressure).	1. Check cabling (→ Engine operating instructions); 2. Contact Service • Check sensor.

Fault code	Fault message	Meaning	Action
216	SD T-LUBE OIL	Sensor B07 faulty (lube oil temperature).	1. Check cabling (→ Engine operating instructions); 2. Contact Service • Check sensor.
219	SD T-INTAKE AIR	Sensor B03 faulty (intake air temperature).	1. Check cabling (→ Engine operating instructions); 2. Contact Service • Check sensor.
220	SD COOLANT LEVEL	Sensor F33 faulty (engine coolant level 1).	1. Switch system off and back on; 2. check fault message; 3. check cabling (→ Engine operating instructions); 4. Contact Service • Check sensor.
222	SD LEVEL LEAKAGE FUEL	Sensor fault (leak fuel).	1. Check cabling (→ Engine operating instructions); 2. Contact Service • Check sensor.
223	SD LEVEL INTERCOOLER	Sensor fault (charge air coolant level).	1. Check cabling (→ Engine operating instructions); 2. Contact Service • Check sensor.
229	SD ENG. SPEED SENSORS	Sensor fault crankshaft speed and camshaft speed.	1. Check cabling (→ Engine operating instructions); 2. Contact Service • Check sensor.
230	SD CRANKSHAFT SPEED	Sensor B13 faulty (crankshaft speed).	1. Check cabling (→ Engine operating instructions); 2. Contact Service • Check sensor.
231	SD CAMSHAFT SPEED	Sensor B1 faulty (camshaft speed).	1. Check cabling (→ Engine operating instructions); 2. Contact Service • Check sensor.
232	SD CHARGER SPEED 1	Sensor B44 faulty (ETC speed 1).	1. Check cabling (→ Engine operating instructions); 2. Contact Service • Check sensor.
240	SD P-FUEL	Sensor B34 faulty (fuel pressure).	1. Check cabling (→ Engine operating instructions); 2. Contact Service • Check sensor.
245	SD POWER SUPPLY	Sensor fault (ECU operating voltage).	Replace engine governor (→ Engine operating instructions).
246	SD T-ELECTRONIC	Temperature sensor for measuring electronics temperature faulty.	Replace engine governor (→ Engine operating instructions).
250	SD CAN SPEED DEMAND	Sensor fault (CAN setpoint speed).	Contact Service. • Check CAN communication.
266	SD SPEED DEMAND AN.	External speed setting faulty.	(→ Engine operating instructions) 1. Check cabling 2. Check speed setting.

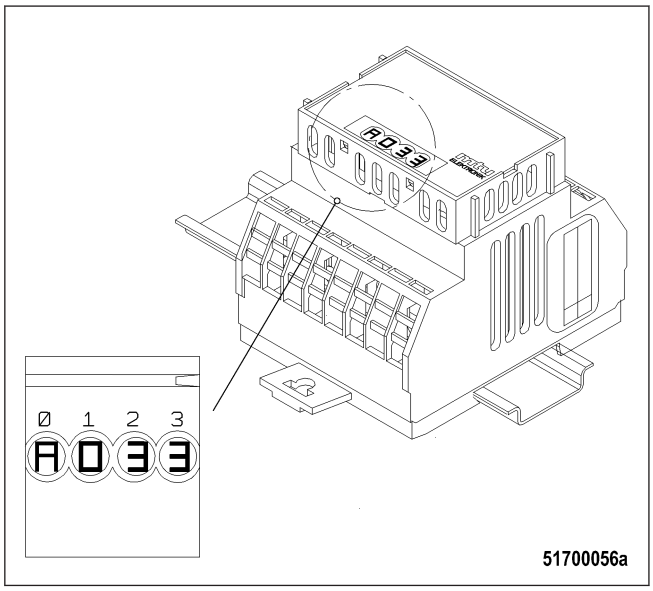
Fault code	Fault message	Meaning	Action
267	SD SP. DEM. TEST BENCH	External test bench speed setting faulty.	Check potentiometer and cabling (→ Engine operating instructions).
270	SD SPEED DEMAND	Sensor fault frequency setting.	1. Check cabling (→ Engine operating instructions); 2. Contact Service • Check setpoint speed sensor.
301...310	TIMING CYLINDER (A1- A10)	Timing bank 1 (solenoid valve 1) ... Timing bank 1 (solenoid valve 10)	Replace injector if fault message occurs frequently (→ Engine operating instructions).
311...320	TIMING CYLINDER (B1- B10)	Timing bank 2 (solenoid valve 1) ... Timing bank 2 (solenoid valve 10)	Replace injector if fault message occurs frequently (→ Engine operating instructions).
321...330	WIRING CYLINDER (A1- A10)	Wiring bank 1 (solenoid valve 1) ... Wiring bank 1 (solenoid valve 10)	Contact Service. • Check solenoid valve.
331...340	WIRING CYLINDER (B1- B10)	Wiring bank 2 (solenoid valve 1) ... Wiring bank 2 (solenoid valve 10)	Contact Service. • Check solenoid valve.
341...350	OPEN_LOAD CYL. (A1- A10)	Open load bank 1 (solenoid valve 1) ... Open load bank 1 (solenoid valve 10)	Contact Service. • Check solenoid valve.
351...360	OPEN_LOAD CYL. (B1- B10)	Open load bank 2 (solenoid valve 1) ... Open load bank 2 (solenoid valve 10)	Contact Service. • Check solenoid valve.
361	POWER STAGE FAIL 1	Fault in ECU (solenoid valve output stage bank 1).	(→ Engine operating instructions) 1. Check solenoid valve cabling. 2. Replace engine governor.
362	POWER STAGE FAIL 2	Fault in ECU (solenoid valve output stage bank 2).	(→ Engine operating instructions) 1. Check solenoid valve cabling. 2. replace engine governor.
363	STOP STAGE FAIL 1	Fault in solenoid valve, cabling or ECU; automatic engine shutdown.	1. Check cabling (→ Engine operating instructions). 2. Attempt to restart engine.
364	STOP STAGE FAIL 2	Fault in solenoid valve, cabling or in ECU; automatic engine shutdown.	1. Check cabling (→ Engine operating instructions). 2. Attempt to restart engine
365	STOP MV-WIRING	Fault in solenoid valve cabling; automatic engine shutdown.	1. Check cabling (→ Engine operating instructions). 2. Attempt to restart engine.
371	TRAN.OUT1 ENGINE DEF	Binary transistor output engine 1 faulty.	(→ Engine operating instructions) • Check charger valve/cabling repair as necessary • Replace engine governor.
372	TRAN.OUT2 ENGINE DEF	Binary transistor output engine 2 faulty.	(→ Engine operating instructions) • Check air recirculation valve/cabling repair as necessary. • Replace engine governor.

Fault code	Fault message	Meaning	Action
373	TRAN.OUT3 ENGINE DEF	Binary transistor output engine 3 faulty.	-
374	TRAN.OUT4 ENGINE DEF	Binary transistor output engine 4 faulty.	-
381	TRAN.OUT1 PLANT DEF	Binary transistor output TAA 1 faulty.	Check cabling to plant.
382	TRAN.OUT2 PLANT DEF	Binary transistor output TAA 2 faulty.	Check cabling to plant.
383	TRAN.OUT3 PLANT DEF	Binary transistor output TAA 3 faulty.	Check cabling to plant.
384	TRAN.OUT4 PLANT DEF	Binary transistor output TAA 4 faulty.	Check cabling to plant.
385	TRAN.OUT5 PLANT DEF	Binary transistor output TAA 5 faulty.	Check cabling to plant.
386	TRAN.OUT6 PLANT DEF	Binary transistor output TAA 6 faulty.	Check cabling to plant.
390	MCR EXCEEDED	MCR violation	1. No action necessary if alarm only signaled temporarily; 2. contact Service if alarm signaled permanently.
392	L1 T-COOLANT RED	Redundant coolant temperature (1st limit value).	1. Check cabling (→ Engine operating instructions). 2. Contact Service • Check sensor.
393	L2 T-COOLANT RED	Redundant coolant temperature (2nd limit value).	1. Check cabling (→ Engine operating instructions). 2. Contact Service • Check sensor.
394	L1 P-LUBE OIL RED	Redundant lube oil pressure (1st limit value).	1. Check cabling (→ Engine operating instructions). 2. Contact Service • Check sensor.
395	L2 P-LUBE OIL RED	Redundant lube oil pressure (2nd limit value).	1. Check cabling (→ Engine operating instructions). 2. Contact Service • Check sensor.
396	TD COOLANT	Transmitter deviation coolant temperature.	1. Check cabling (→ Engine operating instructions). 2. Contact Service • Check sensor.
397	TD OIL PRESSURE	Transmitter deviation engine oil pressure.	1. Check cabling (→ Engine operating instructions). 2. Contact Service • Check sensor.

6.3 ECU alarms

The ECU generates alarms which are indicated in different ways depending on the equipment configuration:

- as four-digit code on a PIM
- as alarm text on a display
- as four-digit code on a dialog PC



The four-digit code consists of one letter and three figures:

- The letter encodes when the fault occurred the last time:
  A = currently present
  B = within the last operating hour
  C = one to four operating hours ago
  D = four to twelve operating hours ago
  Alarms that occurred more than twelve hours ago are deleted automatically.
- The three figures encode the fault itself as listed in the table below.

Alarms can also be caused by defective sensors / actuators. If troubleshooting in accordance with the following table is not successful, contact Service to have the sensors / actuators checked and, if required, replaced.

Fault code	Alarm text	Meaning	Task
004	L2 T-FUEL	Fuel temperature too high (2nd limit)	Cool fuel tank.
005	L1 T-CHARGE AIR	Charge-air temperature too high (1st limit)	Reduce power.
006	L2 T-CHARGE AIR	Charge-air temperature too high (2nd limit)	Reduce power.
009	L1 T-INTER-COOLER	Charge-air coolant temperature too high (1st limit)	Reduce power.
015	L1 P-LUBE OIL	Lube-oil pressure too low (1st limit)	Check engine-oil level and top up, if required (→ Page 123);

Fault code	Alarm text	Meaning	Task
016	L2 P-LUBE OIL	Lube-oil pressure too low (2nd limit) automatic engine shutdown	1. Check engine-oil level and top up, if required (→ Page 123); 2. Try to re-start the engine (→ Page 52). 3. Contact Service.
023	L1 COOLANT LEVEL	Engine coolant level too low	Check coolant level and top up, if required (→ Page 131) .
024	L2 COOLANT LEVEL	Engine coolant level too low	Check coolant level and top up, if required (→ Page 131).
030	ENGINE OVERSPEED	Engine overspeed; automatic engine shutdown	1. Acknowledge alarm. 2. Try to re-start the engine (→ Page 52). 3. Contact Service.
033	L1 P-FUELFILTER DIFF	Differential pressure before/after fuel filter too high	Replace fuel filter (→ Page 110).
051	L1 T-LUBE OIL	Lube-oil temperature too high (1st limit)	Reduce power.
052	L2 T-LUBE OIL	Lube-oil temperature too high (2nd limit)	1. Reduce power. 2. If fault occurs repeatedly: Contact Service.
067	L1 T-COOLANT	Coolant temperature too high (1st limit) warning	Reduce power.
068	L2 T-COOLANT	Coolant temperature too high (2nd limit) automatic engine shutdown	1. Allow the engine to cool down. 2. Check coolant cooler (elements etc.) and clean contaminated parts (see manufacturer's documentation). 3. Re-start the engine (→ Page 52). 4. If fault occurs repeatedly: Contact Service.
069	L1 T-EXTERN 1	Violation of first limit for external temperature channel 1	(Depending on the corresponding measuring point, which is read via CAN bus)
070	L2 T-EXTERN 1	Violation of second limit for external temperature channel 1	(Depending on the corresponding measuring point, which is read via CAN bus)
071	L1 T-EXTERN 2	Violation of first limit for external temperature channel 2	(Depending on the corresponding measuring point, which is read via CAN bus)
072	L2 T-EXTERN 2	Violation of second limit for external temperature channel 2	(Depending on the corresponding measuring point, which is read via CAN bus)
073	L1 P-EXTERN 1	Violation of first limit for external pressure channel 1	(Depending on the corresponding measuring point, which is read via CAN bus)
074	L2 P-EXTERN 1	Violation of second limit for external pressure channel 1	(Depending on the corresponding measuring point, which is read via CAN bus)
075	L1 P-EXTERN 2	Violation of first limit for external pressure channel 2	(Depending on the corresponding measuring point, which is read via CAN bus)
076	L2 P-EXTERN 2	Violation of second limit for external pressure channel 2	(Depending on the corresponding measuring point, which is read via CAN bus)
077	LIM EXT.COOLANT LEV.	Alarm from external coolant level monitoring	(Depending on the corresponding measuring point, which is read via CAN bus)

Fault code	Alarm text	Meaning	Task
078	LIM INTER-COOLER LEV.	Alarm from external charge-air coolant level monitoring	(Depending on the corresponding measuring point, which is read via CAN bus)
079	L Bin-EXTERN 3	Alarm from external binary channel 3	(Depending on the corresponding measuring point, which is read via CAN bus)
080	L Bin-EXTERN 4	Alarm from external binary channel 4	(Depending on the corresponding measuring point, which is read via CAN bus)
089	ENGINE SPEED LOW	Engine speed lower than 200 rpm; automatic engine shutdown	Re-start the engine (→ Page 52).
090	IDLE SPEED LOW	Idle speed not reached within a specified period; Termination of starting procedure.	Note further alarms.
091	RUN UP SPEED LOW	Run-up speed not reached within a specified period; Termination of starting procedure.	Note further alarms.
092	START SPEED LOW	Starter speed not reached within a specified period; Termination of starting procedure.	Note further alarms.
093	PREHEAT TEMP. LIMIT2	Coolant preheating temperature too low during starting (2nd limit) Termination of starting procedure (depending on project design)	Check preheating pump / preheating system (see manufacturer's documentation).
094	PREHEAT TEMP. LIMIT1	Coolant preheating temperature too low during starting (1st limit)	Check preheating pump / preheating system (see manufacturer's documentation).
100	EDM NOT VALID	Check sum error of measuring-point data in EDM	If fault occurs repeatedly: Contact Service.
101	IDM NOT VALID	Check sum error of measuring-point data in IDM	If fault occurs repeatedly: Contact Service.
102	INVALID FUEL CONS. 1	Check sum error of accumulated fuel consumption data in EDM (redundant data record 1)	If fault occurs repeatedly: Contact Service.
103	INVALID FUEL CONS. 2	Check sum error of accumulated fuel consumption data in EDM (redundant data record 2)	If fault occurs repeatedly: Contact Service.
104	OP HOURS1 NOT VALID	Check sum error of hour meter data in EDM	If fault occurs repeatedly: Contact Service.
105	OP HOURS2 NOT VALID	Check sum error of hour meter data in IDM	If fault occurs repeatedly: Contact Service.

Fault code	Alarm text	Meaning	Task
106	ERR REC1 NOT VALID	Check sum error of fault memory in EDM (redundant data record 1)	If fault occurs repeatedly: Contact Service.
107	ERR REC2 NOT VALID	Check sum error of fault memory in EDM (redundant data record 2)	If fault occurs repeatedly: Contact Service.
118	L1 SUPPLY VOLT. LOW	Supply voltage too low (1st limit)	Check ECU supply voltage.
119	L2 SUPPLY VOLT. LOW	Supply voltage too low (2nd limit)	Check ECU supply voltage.
120	L1 SUPPLY VOLT. HIGH	Supply voltage too high (1st limit)	Check ECU supply voltage.
121	L2 SUPPLY VOLT. HIGH	Supply voltage too high (2nd limit) automatic engine shutdown (depending on project design)	Check ECU supply voltage. If engine was stopped: Start engine (→ Page 52).
122	L1 T-ELECTRONIC	Temperature in ECU housing too high (1st limit)	1. Improve engine room ventilation. 2. Reduce engine power.
134	15V POS ECU DEFECT	Electronic equipment defective; automatic engine shutdown	Contact Service.
136	15V NEG ECU DEFECT	Electronic equipment defective; automatic engine shutdown	Contact Service.
137	L1 5V BUFFER TEST	Power supply for pressure sensors defective.	1. Disconnect connectors X2 and X3 from ECU. If alarm does not disappear: Contact Service. 2. Check wiring (pressure sensors). 3. Contact Service.
138	SENSORPOWERDEFECT	Power supply for pressure sensors defective.	1. Disconnect connectors X2 and X3 from ECU. If alarm does not disappear: Contact Service. 2. Check wiring (pressure sensors). 3. Contact Service.
139	L1 TE BUFFER TEST	Internal electronic fault (temperature sensors)	Contact Service.
140	TE BUF. ECU DEFECT	Internal electronic fault (temperature sensors)	Contact Service.
142	BANK1 ECU DEFECT	Internal electronic fault; Engine does not start	Contact Service.
144	BANK2 ECU DEFECT	Internal electronic fault; Engine does not start	Contact Service.
145	15V_GOOD ECU DEFECT	Electronic equipment defective; automatic engine shutdown	Contact Service.

Fault code	Alarm text	Meaning	Task
146	L1 AD-TEST1 SUPPLY	A/D-converter supply voltage too low	Contact Service.
147	AD-TEST1 ECU DEFECT	Electronic equipment defective; automatic engine shutdown	Contact Service.
148	L1 AD-TEST2 SUPPLY	A/D-converter supply voltage too low	Contact Service.
149	AD-TEST2 ECU DEFECT	Electronic equipment defective; automatic engine shutdown	Contact Service.
150	L1 AD-TEST3 SUPPLY	A/D-converter supply voltage too low	Contact Service.
151	AD-TEST3 ECU DEFECT	Electronic equipment defective; automatic engine shutdown	Contact Service.
170	MI MODULE FAIL	Module in maintenance predictor either defective or missing	Contact Service.
171	MI NOT ACTIVE	Maintenance predictor no more activated	Contact Service.
173	MODULE WRITE LIMIT	EEPROM write limit reached	Contact Service.
180	CAN1 NODE LOST	At least one device not detected on Default CAN bus	1. Check wiring (CAN bus). 2. Contact Service.
181	CAN2 NODE LOST	At least one device not detected on Redundant CAN bus	1. Check wiring (CAN bus). 2. Contact Service.
182	CAN WRONG PARAMETERS	Consistency error in CAN parameters	Contact Service.
183	CAN NO PU-DATA	Error during loading of CAN project design data into ECU.	Contact Service.
184	CAN PU-DATA EE-FAIL	Error during project design data download in EEPROMs	Contact Service.
185	CAN LESS MAILBOXES	Error during CAN initialization.	Contact Service.
186	CAN1 BUS OFF	Severe fault on Default CAN bus; automatic change-over to Redundant CAN bus	Contact Service.
187	CAN1 ERROR PASSIVE	Light fault on Default CAN bus (e.g.shortage overload)	(none)
188	CAN2 BUS OFF	Severe fault on Redundant CAN bus; automatic change-over to Default CAN bus	Contact Service.
189	CAN2 ERROR PASSIVE	Light fault on Redundant CAN bus (e.g.short-time overload)	(none)

Fault code	Alarm text	Meaning	Task
201	SD T-COOLANT	Sensor defect (coolant temperature)	1. Check wiring. 2. Contact Service.
202	SD T-FUEL	Sensor defect (Fuel temperature)	1. Check wiring. 2. Contact Service.
203	SD T-CHARGE AIR	Sensor defect (charge-air temperature)	1. Check wiring. 2. Contact Service.
205	SD T-COOLANT INTERC.	Sensor defect (charge-air coolant temperature)	1. Check wiring. 2. Contact Service.
208	SD P-CHARGE AIR	Sensor defect (charge-air pressure)	1. Check wiring. 2. Contact Service.
211	SD P-LUBE OIL	Sensor defect (lube oil pressure)	1. Check wiring. 2. Contact Service.
216	SD T-LUBE OIL	Sensor defect (lube oil temperature)	1. Check wiring. 2. Contact Service.
220	SD COOLANT LEVEL	Sensor defect (coolant level)	1. Check wiring. 2. Contact Service.
229	SD ENG.SPEED SENSORS	Sensor defect (crankshaft speed) and sensor defect (camshaft speed)	1. Check wiring. 2. Contact Service.
230	SD CRANK-SHAFT SPEED	Sensor defect (crankshaft speed)	1. Check wiring. 2. Contact Service.
231	SD CAMSHAFT SPEED	Sensor defect (camshaft speed)	1. Check wiring. 2. Contact Service.
245	SD POWER SUPPLY	Sensor defect (ECU operating voltage)	Contact Service.
246	SD T-ELEC-TRONIC	Sensor defect (temperature in ECU)	Contact Service.
250	SD CAN SPEED DEMAND	Sensor defect (CAN nominal speed demand)	1. Check speed transmitter. 2. Check wiring (CAN bus). 3. Contact Service.
266	SD SPEED DE-MAND AN.	Sensor defect (analog nominal speed demand)	1. Check speed transmitter. 2. Check wiring. 3. Contact Service.
267	SD SP.DEM.TEST BENCH	Sensor defect (analog speed demand); NOTE: Only used in test-stand operation.	1. Check speed transmitter. 2. Check wiring. 3. Contact Service.
270	SD SPEED DE-MAND FI1	Sensor defect (frequency input for speed demand);	1. Check speed transmitter. 2. Check wiring. 3. Contact Service.
271	SD T-EXTERN 1	External device defective (CAN T-EXTERN 1)	Contact Service.
272	SD T-EXTERN 2	External device defective (CAN T-EXTERN 2)	Contact Service.
273	SD P-EXTERN 1	External device defective (CAN P-EXTERN 1)	Contact Service.

Fault code	Alarm text	Meaning	Task
274	SD P-EXTERN 2	External device defective (CAN P-EXTERN 2)	Contact Service.
275	SD EXT.COOLANT LEVEL	External coolant-level monitoring defective (CAN)	Contact Service.
276	SD INTERCOOLER LEVEL	External charge-air coolant-level monitoring defective (CAN)	Contact Service.
277	SD BIN-EXTERN 3	External device defective (CAN BIN-EXTERN 3)	Contact Service.
278	SD BIN-EXTERN 4	External device defective (CAN BIN-EXTERN 4)	Contact Service.
301	TIMING CYLINDER A1	Injection timing fault cylinder A1	If fault occurs repeatedly: Contact Service.
302	TIMING CYLINDER A2	Injection timing fault cylinder A2	If fault occurs repeatedly: Contact Service.
303	TIMING CYLINDER A3	Injection timing fault cylinder A3	If fault occurs repeatedly: Contact Service.
304	TIMING CYLINDER A4	Injection timing fault cylinder A4	If fault occurs repeatedly: Contact Service.
305	TIMING CYLINDER A5	Injection timing fault cylinder A5	If fault occurs repeatedly: Contact Service.
306	TIMING CYLINDER A6	Injection timing fault cylinder A6	If fault occurs repeatedly: Contact Service.
307	TIMING CYLINDER A7	Injection timing fault cylinder A7	If fault occurs repeatedly: Contact Service.
308	TIMING CYLINDER A8	Injection timing fault cylinder A8	If fault occurs repeatedly: Contact Service.
309	TIMING CYLINDER A9	Injection timing fault cylinder A9	If fault occurs repeatedly: Contact Service.
310	TIMING CYLINDER A10	Injection timing fault cylinder A10	If fault occurs repeatedly: Contact Service.
311	TIMING CYLINDER B1	Injection timing fault cylinder B1	If fault occurs repeatedly: Contact Service.
312	TIMING CYLINDER B2	Injection timing fault cylinder B2	If fault occurs repeatedly: Contact Service.
313	TIMING CYLINDER B3	Injection timing fault cylinder B3	If fault occurs repeatedly: Contact Service.
314	TIMING CYLINDER B4	Injection timing fault cylinder B4	If fault occurs repeatedly: Contact Service.
315	TIMING CYLINDER B5	Injection timing fault cylinder B5	If fault occurs repeatedly: Contact Service.
316	TIMING CYLINDER B6	Injection timing fault cylinder B6	If fault occurs repeatedly: Contact Service.
317	TIMING CYLINDER B7	Injection timing fault cylinder B7	If fault occurs repeatedly: Contact Service.
318	TIMING CYLINDER B8	Injection timing fault cylinder B8	If fault occurs repeatedly: Contact Service.

Fault code	Alarm text	Meaning	Task
319	TIMING CYLINDER B9	Injection timing fault cylinder B9	If fault occurs repeatedly: Contact Service.
320	TIMING CYLINDER B10	Injection timing fault cylinder B10	If fault occurs repeatedly: Contact Service.
321	WIRING CYLINDER A1	Faulty wiring to solenoid valve cylinder A1; Misfiring	1. Check wiring. 2. Contact Service.
322	WIRING CYLINDER A2	Faulty wiring to solenoid valve cylinder A2; Misfiring	1. Check wiring. 2. Contact Service.
323	WIRING CYLINDER A3	Faulty wiring to solenoid valve cylinder A3; Misfiring	1. Check wiring. 2. Contact Service.
324	WIRING CYLINDER A4	Faulty wiring to solenoid valve cylinder A4; Misfiring	1. Check wiring. 2. Contact Service.
325	WIRING CYLINDER A5	Faulty wiring to solenoid valve cylinder A5; Misfiring	1. Check wiring. 2. Contact Service.
326	WIRING CYLINDER A6	Faulty wiring to solenoid valve cylinder A6; Misfiring	1. Check wiring. 2. Contact Service.
327	WIRING CYLINDER A7	Faulty wiring to solenoid valve cylinder A7; Misfiring	1. Check wiring. 2. Contact Service.
328	WIRING CYLINDER A8	Faulty wiring to solenoid valve cylinder A8; Misfiring	1. Check wiring. 2. Contact Service.
329	WIRING CYLINDER A9	Faulty wiring to solenoid valve cylinder A9; Misfiring	1. Check wiring. 2. Contact Service.
330	WIRING CYLINDER A10	Faulty wiring to solenoid valve cylinder A10; Misfiring	1. Check wiring. 2. Contact Service.
331	WIRING CYLINDER B1	Faulty wiring to solenoid valve cylinder B1; Misfiring	1. Check wiring. 2. Contact Service.
332	WIRING CYLINDER B2	Faulty wiring to solenoid valve cylinder B2; Misfiring	1. Check wiring. 2. Contact Service.
333	WIRING CYLINDER B3	Faulty wiring to solenoid valve cylinder B3; Misfiring	1. Check wiring. 2. Contact Service.

Fault code	Alarm text	Meaning	Task
334	WIRING CYLINDER B4	Faulty wiring to solenoid valve cylinder B4; Misfiring	1. Check wiring. 2. Contact Service.
335	WIRING CYLINDER B5	Faulty wiring to solenoid valve cylinder B5; Misfiring	1. Check wiring. 2. Contact Service.
336	WIRING CYLINDER B6	Faulty wiring to solenoid valve cylinder B6; Misfiring	1. Check wiring. 2. Contact Service.
337	WIRING CYLINDER B7	Faulty wiring to solenoid valve cylinder B7; Misfiring	1. Check wiring. 2. Contact Service.
338	WIRING CYLINDER B8	Faulty wiring to solenoid valve cylinder B8; Misfiring	1. Check wiring. 2. Contact Service.
339	WIRING CYLINDER B9	Faulty wiring to solenoid valve cylinder B9; Misfiring	1. Check wiring. 2. Contact Service.
340	WIRING CYLINDER B10	Faulty wiring to solenoid valve cylinder B10; Misfiring	1. Check wiring. 2. Contact Service.
341	OPEN_LOAD CYL. A1	Disconnection in wiring to solenoid valve cylinder A1; Misfiring	1. Check wiring. 2. Contact Service.
342	OPEN_LOAD CYL. A2	Disconnection in wiring to solenoid valve cylinder A2; Misfiring	1. Check wiring. 2. Contact Service.
343	OPEN_LOAD CYL. A3	Disconnection in wiring to solenoid valve cylinder A3; Misfiring	1. Check wiring. 2. Contact Service.
344	OPEN_LOAD CYL. A4	Disconnection in wiring to solenoid valve cylinder A4; Misfiring	1. Check wiring. 2. Contact Service.
345	OPEN_LOAD CYL. A5	Disconnection in wiring to solenoid valve cylinder A5; Misfiring	1. Check wiring. 2. Contact Service.
346	OPEN_LOAD CYL. A6	Disconnection in wiring to solenoid valve cylinder A6; Misfiring	1. Check wiring. 2. Contact Service.
347	OPEN_LOAD CYL. A7	Disconnection in wiring to solenoid valve cylinder A7; Misfiring	1. Check wiring. 2. Contact Service.

Fault code	Alarm text	Meaning	Task
348	OPEN_LOAD CYL. A8	Disconnection in wiring to solenoid valve cylinder A8; Misfiring	1. Check wiring. 2. Contact Service.
349	OPEN_LOAD CYL. A9	Disconnection in wiring to solenoid valve cylinder A9; Misfiring	1. Check wiring. 2. Contact Service.
350	OPEN_LOAD CYL. A10	Disconnection in wiring to solenoid valve cylinder A10; Misfiring	1. Check wiring. 2. Contact Service.
351	OPEN_LOAD CYL. B1	Disconnection in wiring to solenoid valve cylinder B1; Misfiring	1. Check wiring. 2. Contact Service.
352	OPEN_LOAD CYL. B2	Disconnection in wiring to solenoid valve cylinder B2; Misfiring	1. Check wiring. 2. Contact Service.
353	OPEN_LOAD CYL. B3	Disconnection in wiring to solenoid valve cylinder B3; Misfiring	1. Check wiring. 2. Contact Service.
354	OPEN_LOAD CYL. B4	Disconnection in wiring to solenoid valve cylinder B4; Misfiring	1. Check wiring. 2. Contact Service.
355	OPEN_LOAD CYL. B5	Disconnection in wiring to solenoid valve cylinder B5; Misfiring	1. Check wiring. 2. Contact Service.
356	OPEN_LOAD CYL. B6	Disconnection in wiring to solenoid valve cylinder B6; Misfiring	1. Check wiring. 2. Contact Service.
357	OPEN_LOAD CYL. B7	Disconnection in wiring to solenoid valve cylinder B7; Misfiring	1. Check wiring. 2. Contact Service.
358	OPEN_LOAD CYL. B8	Disconnection in wiring to solenoid valve cylinder B8; Misfiring	1. Check wiring. 2. Contact Service.
359	OPEN_LOAD CYL. B9	Disconnection in wiring to solenoid valve cylinder B9; Misfiring	1. Check wiring. 2. Contact Service.
360	OPEN_LOAD CYL. B10	Disconnection in wiring to solenoid valve cylinder B10; Misfiring	1. Check wiring. 2. Contact Service.
361	POWER STAGE FAIL 1	Defect in ECU (solenoid valve power stage)	Contact Service.
362	POWER STAGE FAIL 2	Defect in ECU (solenoid valve power stage)	Contact Service.

Fault code	Alarm text	Meaning	Task
363	STOP POWER STAGE 1	Solenoid valve or wiring or ECU defective automatic engine shutdown	1. Check wiring. 2. Try to re-start the engine (→ Page 52). 3. Contact Service.
364	STOP POWER STAGE 2	Solenoid valve or wiring or ECU defective automatic engine shutdown	1. Check wiring. 2. Try to re-start the engine (→ Page 52). 3. Contact Service.
365	STOP MV-WIRING	Solenoid-valve wiring faulty; automatic engine shutdown	1. Check wiring. 2. Try to re-start the engine (→ Page 52). 3. Contact Service.
381	TRAN.OUT1 PLANT DEF	Binary transistor output plant 1 defective	Contact Service.
382	TRAN.OUT2 PLANT DEF	Binary transistor output plant 2 defective	Contact Service.
383	TRAN.OUT3 PLANT DEF	Binary transistor output plant 3 defective	Contact Service.
384	TRAN.OUT4 PLANT DEF	Binary transistor output plant 4 defective	Contact Service.
385	TRAN.OUT5 PLANT DEF	Binary transistor output plant 5 defective	Contact Service.
386	TRAN.OUT6 PLANT DEF	Binary transistor output plant 6 defective	Contact Service.

7 Task Description

7.1 Engine

7.1.1 Engine – Barring manually

Preconditions

☑ Engine is stopped and starting disabled.

Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Barring tool for 12V engines	F6558556	1
Barring tool for 16V engines	F6558557	1

DANGER

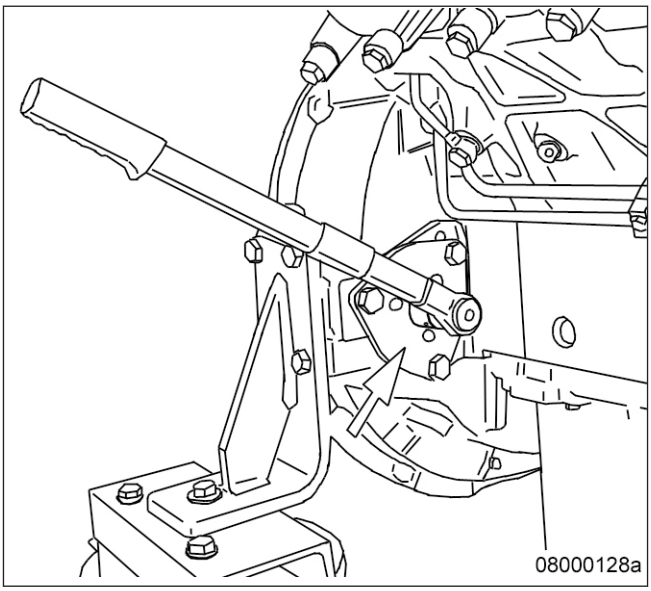
Unguarded rotating and moving engine components.
Risk of serious injury – danger to life!
- Before barring or starting the engine, ensure that nobody is in the danger zone.
- After working on the engine, check that all protective devices have been reinstalled and all tools removed from the engine.

Engine – Barring manually

1. Remove cover from flywheel housing.
2. Install barring tool (arrow) on flywheel housing.
3. Rotate crankshaft in engine direction of rotation. Apart from the normal compression resistance, there should be no abnormal resistance.

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

4. For barring-tool removal follow reverse sequence of working steps.



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7.1.2 Engine – Barring with starting system

Special tools, Material, Spare parts

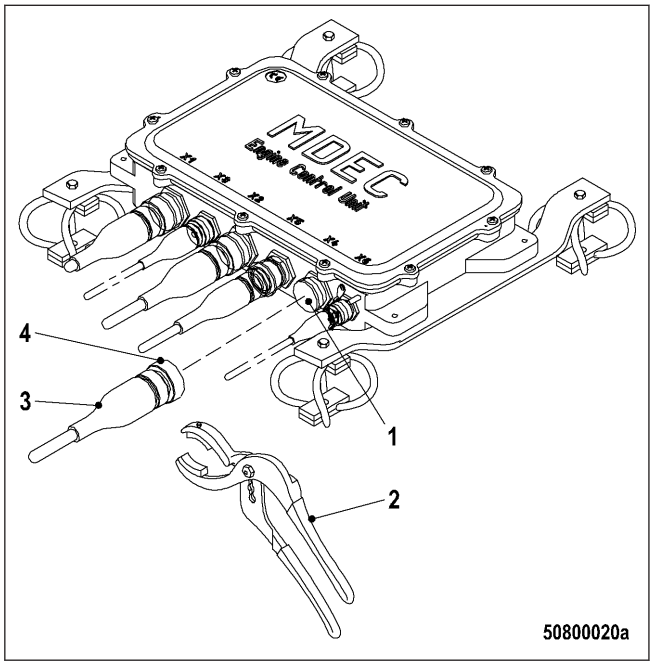
Designation / Use	Part No.	Qty.
Connector pliers	0135315483	1

DANGER

Unguarded rotating and moving engine components.
Risk of serious injury – danger to life!
- Before barring or starting the engine, ensure that nobody is in the danger zone.
- After working on the engine, check that all protective devices have been reinstalled and all tools removed from the engine.

Engine – Barring with starting system

1. Disengage the bayonet coupling (4) of connector X4 with connector pliers (2) and withdraw connector (3) from engine governor.
2. Bar engine in unloaded condition: Press START button.
3. Let the crankshaft rotate until oil pressure is indicated.
4. Engine start is automatically interrupted when specified starting period is expired. If necessary, re-start the engine after approx. 20 seconds.
5. Plug connector X4 (3) and use connector pliers (2) to secure the bayonet coupling (4) by turning it clockwise until it latches into place.



7.1.3 Engine – Test run

DANGER

Unguarded rotating and moving engine components.
Risk of serious injury – danger to life!
- Before barring or starting the engine, make sure that nobody is in the danger zone.

WARNING

Engine noise above 85 dB (A).
Risk of damage to hearing!
- Wear ear protectors.

Engine – Test run

1. Start engine (→ Page 52).
2. Perform test run not below 1/3 load and at least until steady-state temperature is reached.
3. Carry out operational checks (→ Page 54).
4. Stop engine (→ Page 55).

7.2 Cylinder Liner

7.2.1 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 97).
2. Remove injector (→ Page 103).

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	Action
• Thin carbon coating on circumference of carbon scraper ring • Slight localized additive deposits at top edge • Singular smooth areas at lower edge • Carbon deposits on circumference in clearance between top piston ring and bottom edge of carbon scraper ring • First signs of marks left by top piston ring • Bright mark on entire circumference • Consistent honing pattern without objections • First signs of marks left by lower cooling bores • Running pattern seems darker	No action required
• Dark areas with even or varying degrees of discoloration • Beginning and end of the discoloration are not sharply defined and do not cover the entire stroke area • Dark areas in the upper section of the cooling bore, remaining circumference without objections • Piston rings without objections	Further endoscopic examination required as part of maintenance work
• On the entire circumference, apart from light areas of discoloration (that do not impair operation) clearly darker stripes that start at the top piston ring • Heat discoloration in the direction of stroke and honing pattern damage • Heat discoloration of piston rings	Cylinder liner must be replaced; Service must be contacted

1. Compile endoscopy report using the table.
2. Use technical terms for description of the liner surface (→ Page 89).
3. Depending on findings:
   - do not take any action or
   - carry out a further endoscopic examination as part of maintenance work or
   - contact Service; cylinder liner must be replaced.

Final steps

1. Install injector (→ Page 103).
2. Install cylinder head cover (→ Page 97).

7.2.2 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	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.

Findings	Action
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 Crankcase Breather

7.3.1 Crankcase breather – Wire mesh cleaning

Preconditions

☑ Engine is stopped and starting disabled.

Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Cleaner		
Diesel fuel		
Grease (Kluthe Hakuform 30-10/Emulgier)	X00029933	1
Sealing ring	(→ Spare Parts Catalog)	
Screw	(→ Spare Parts Catalog)	

WARNING

Fuels are combustible.
Risk of fire and explosion!
- Avoid open flames, electrical sparks and ignition sources.
- Do not smoke.

WARNING

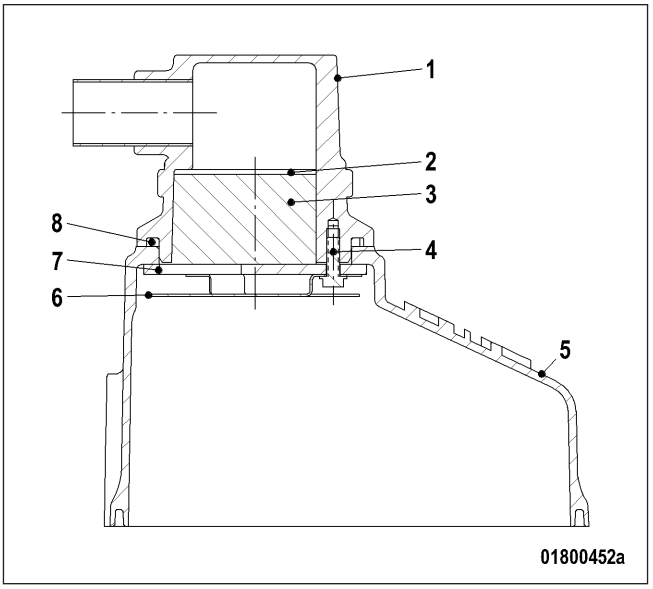
Compressed air
Risk of injury!
- Do not direct compressed-air jet at persons.
- Wear protective goggles / safety mask and ear protectors.

CAUTION

Excessive reaction time of cleaning agents on components.
Damage to component!
- Observe manufacturer's instructions.
- Wear protective clothing, gloves, and goggles / safety mask.

Crankcase breather – Wire mesh cleaning

1. Remove hose from oil separator housing (1).
2. Remove cylinder head cover (5).
3. Release screws (4), remove deflector plate (6) and retainer (7).
4. Take off oil separator housing (1).
5. Remove sealing ring (8) from oil separator housing (1).
6. Remove individual parts from oil separator housing (1).
7. Wash filter element (wire mesh) (3) with diesel fuel.
8. Blow out filter element (wire mesh) (3) with compressed air.
9. Clean residual parts with cleaner.
10. Remove cleaner.
11. Insert washer (2) and filter element (wire mesh) (3) in the correct sequence in the oil separator housing (1).
12. Coat sealing ring (8) with grease and insert in the groove of the oil separator housing (1).
13. Install oil separator housing (1), deflector plate (6) and retainer (7) with new screws (4) on the cylinder head cover (5).
14. Install cylinder head cover (5).
15. Install hose on oil separator housing (1), ensuring that it is not subjected to tension.



7.3.2 Crankcase breather – Oil separator element replacement, diaphragm check and replacement

Preconditions

☑ Engine is stopped and starting disabled.

Special tools, Material, Spare parts

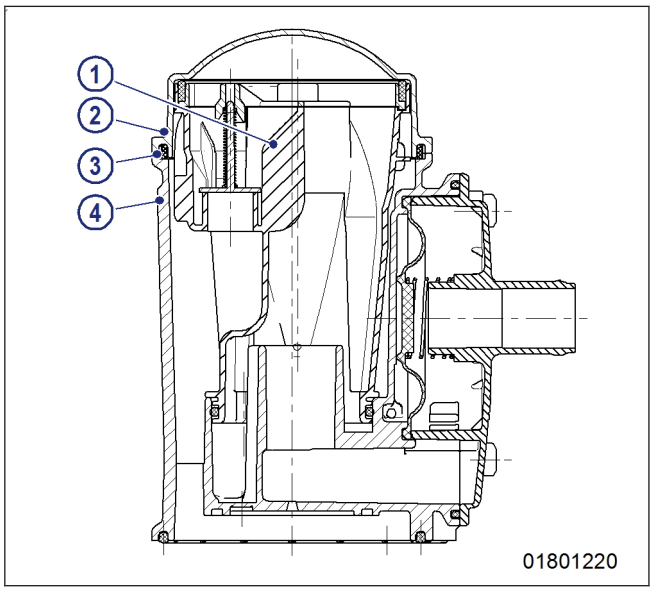
Designation / Use	Part No.	Qty.
Torque wrench, 6-50 Nm	F30027336	1
Ratchet adapter	F30027340	1
Engine oil		
Filter element	(→ Spare Parts Catalog)	
Diaphragm	(→ Spare Parts Catalog)	
Gasket	(→ Spare Parts Catalog)	

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.



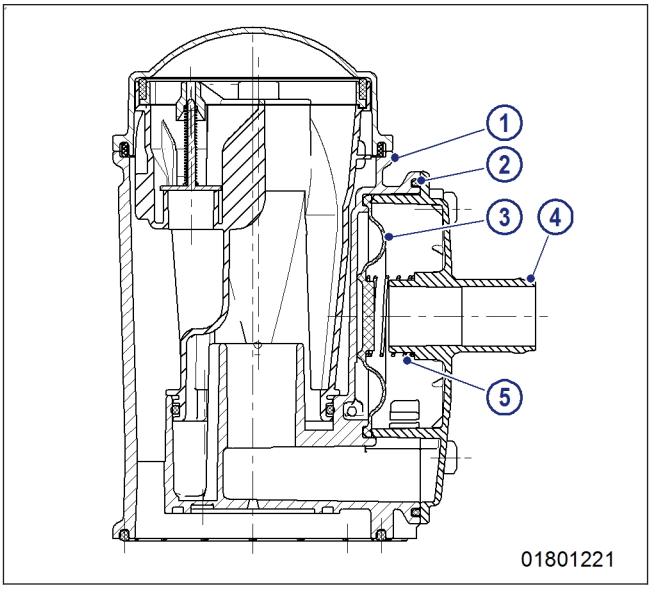
5. Use torque wrench to tighten the screws of cover (2) to the specified torque.

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.

7.4 Valve Drive

7.4.1 Valve clearance – Check and adjustment

Preconditions

☑ Engine is stopped and starting disabled.

☑ Engine coolant temperature is max. 40 °C.

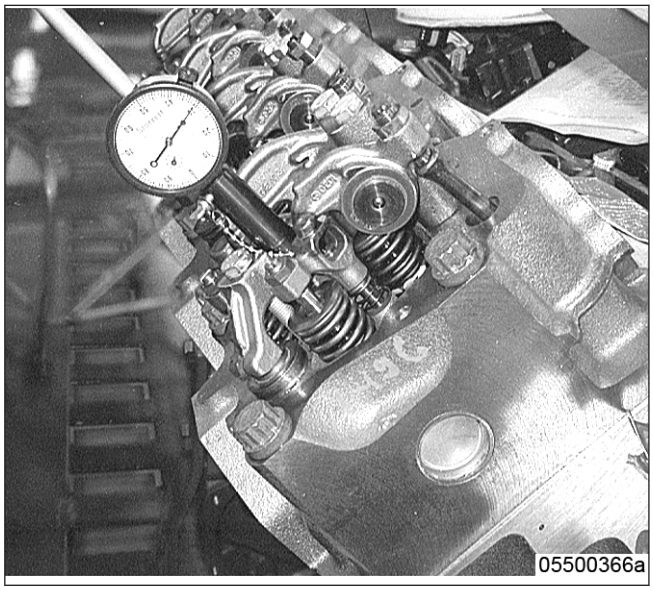
☑ Valves are closed.

Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Feeler gauge	Y20010128	1
Torque wrench, 20–100 Nm	F30026582	1
Ratchet adapter	F30027340	1
Measuring device	Y4341106	1

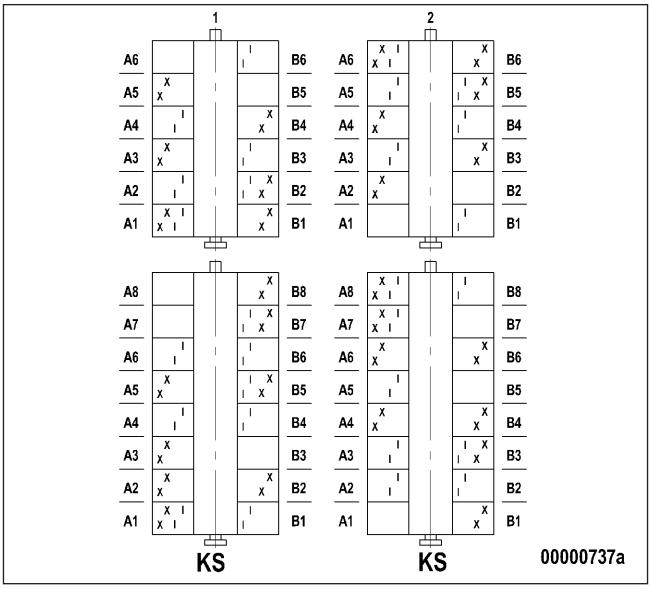
Preparatory steps

1. Remove cylinder head cover (→ Page 97).
2. Install barring tool (→ Page 84).
3. Disassemble fuel injector of cylinder A1 (→ Page 103).
4. Screw the measuring device into the fuel injector orifice.
5. Turn the crankshaft, checking the dial gauge, in the direction of engine rotation until the piston stands at the breakover point on the dial gauge display: Cylinder is in TDC position.



Checking valve clearance at two crankshaft positions

1 Cylinder A1 is in firing TDC
2 Cylinder A1 is in overlap TDC
I Inlet valve
X Exhaust valve

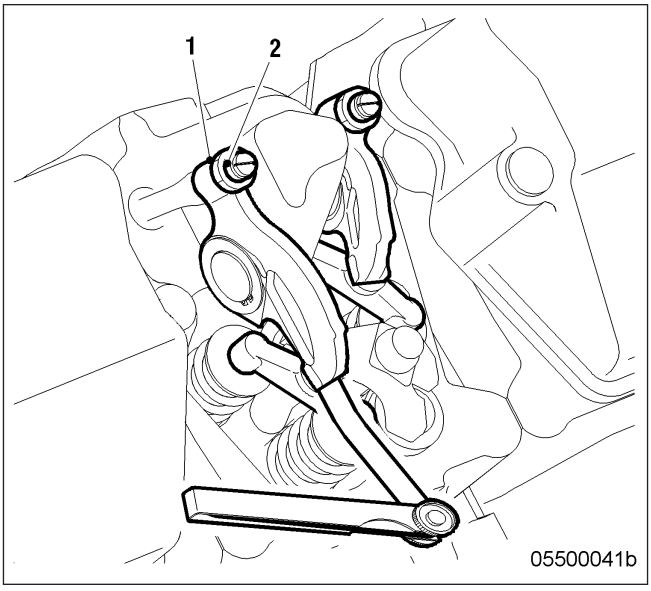


1. Check TDC position of piston in cylinder A1:
   - The piston is at firing TDC when the rockers are unloaded at cylinder A1.
   - The piston is at overlap TDC when the rockers are loaded at cylinder A1.
2. Check valve clearance with cold engine:
   - Inlet = 0.4 mm;
   - Exhaust = 0.6 mm;
3. Check all valve clearances in two crankshaft positions (firing TDC and overlap TDC of cylinder A1) as per diagram.
4. Use feeler gauge 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

1. Loosen locknut (1) and unscrew adjusting screw (2) slightly.
2. Insert feeler gauge between valve bridge and rocker arm.
3. Readjust adjusting screw (2) so that the feeler gauge just passes through the gap.
4. Tighten locknut (1) to 50 Nm, holding adjusting screw (2) firmly with screwdriver.
5. Check whether the feeler gauge just passes through between valve bridge and rocker arm.

Result: If not, adjust valve clearance.



Final steps

1. Remove barring tool.
2. Follow reverse sequence of working steps for installation.

7.4.2 Cylinder head cover – Removal and installation

Preconditions

☑ Engine is stopped and starting disabled.

Special tools, Material, Spare parts

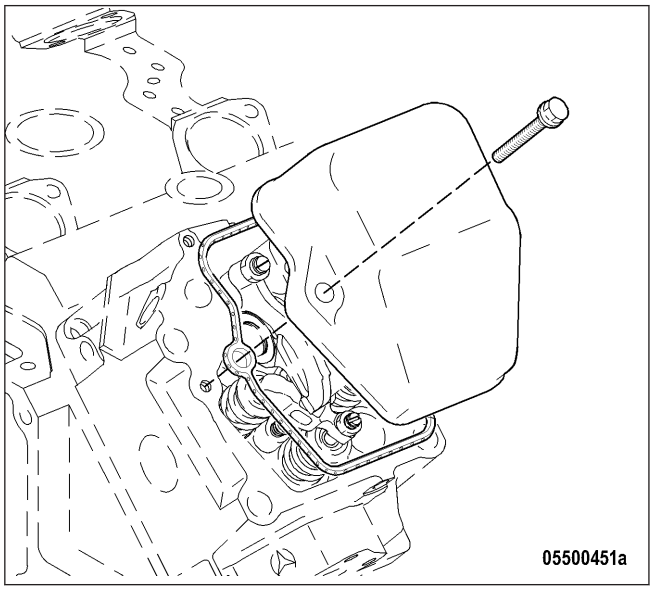
Designation / Use	Part No.	Qty.
Torque wrench, 8-40 Nm	F30043446	1
Ratchet	F30027340	1
Gasket	(→ Spare Parts Catalog)	

Preparatory steps

1. On cylinder head covers with crankcase breather: Loosen clamps.
2. Slide rubber sleeves onto the pipe.

Cylinder head cover – Removal and installation

1. Remove cylinder head cover with gasket from cylinder head.
2. Clean installation surface.
3. Check condition of gasket in cylinder head cover.
4. Replace damaged gasket(s).
5. Install cylinder head cover with screws.



Final steps

1. Slide rubber sleeves onto the relevant pipe connection.
2. Tighten all clamps.

7.5 Injection Pump / HP Pump

7.5.1 Injection pump – Replacement

Special tools, Material, Spare parts

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

Injection pump – Replacement

▶ Remove injection pump and install new one (→ Page 99).

7.5.2 Injection pump – Removal and installation

Preconditions

☑ Engine is stopped and starting disabled.

Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Crowfoot wrench, 19 mm	F30027424	1
Crowfoot wrench, 22 mm	F30027425	1
Torque wrench, 20–100 Nm	F30026582	1
Ratchet adapter	F30027340	1
Transition piece	F30006234	1
Torque wrench, 0.5–5 Nm	0015384230	1
Grease (Kluthe Hakuform 30–10/Emulgier)	X00029933	
Sealing ring	(→ Spare Parts Catalog)	
Sealing ring	(→ Spare Parts Catalog)	

DANGER

Unguarded rotating and moving engine components.
Risk of serious injury – Danger to life!
- Before barring the engine, ensure that nobody is in the danger zone.

WARNING

Fuels are combustible.
Risk of fire and explosion!
- Avoid open flames, electrical sparks and ignition sources.
- Do not smoke.

Preparatory steps

1. Shut off fuel supply line before fuel filter.
2. Remove engine control system (→ Page 149).
3. Drain fuel (→ Page 108).
4. Remove charge-air pipes and all seals.

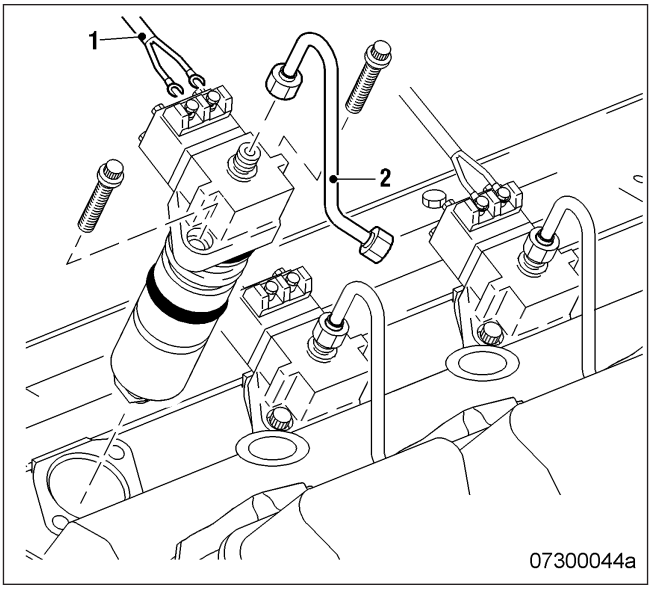
Removing injection pump

1. Mark installation position of injection pump.
2. Disconnect wiring (1) from injection pump.
3. Remove fuel line (2).
4. Unscrew securing screws of injection pump by approx. 6 mm.
   - The pretensioned compression spring will press the injection pump out of the crankcase, if this does not happen:

   a) Turn crankshaft with engine barring tool (→ Page 84)
      - The pump cam presses the injection pump out of the crankcase, if not:

      .

   b) Carefully press out injection pump at the recess in the injection pump head.
5. Remove injection pump securing screws.
6. Remove injection pump.
7. Remove sealing rigs from injection pump.
8. Seal all openings with appropriate covers after removal.



Installing injection pump

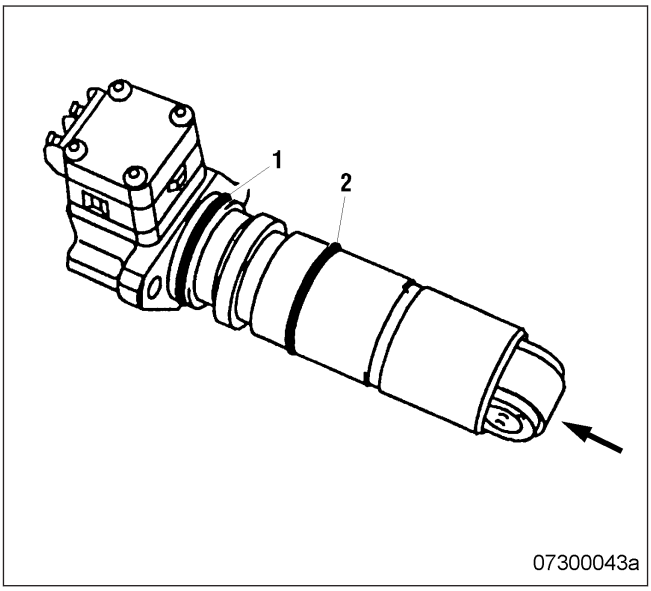
1. Remove all blanking plugs and covers.
2. Clean mating face of injection pump and roller.

Note: Sealing ring (1) Ø47 mm

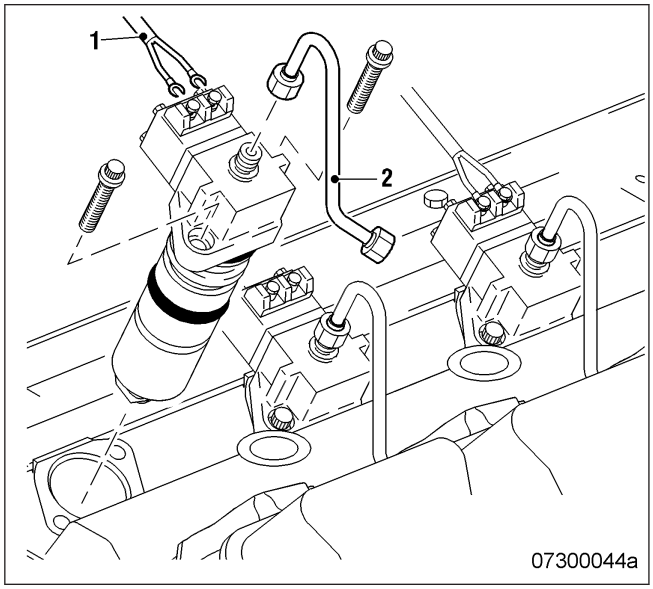
3. Coat sealing ring (1) with grease and fit onto injection pump.

Note: Sealing ring (2) Ø45 mm

4. Coat sealing ring (2) with grease and fit onto injection pump.
5. Coat roller (arrowed) with engine oil.
6. Clean sealing face and fuel bores in crankcase.
7. Use barring tool (→ Page 84) to position the pump cams on the camshaft at base circle.



8. Install injection pump, observing marked installation position.
9. Install securing screws of injection pump and tighten with torque wrench to specified torque 60 Nm + 12 Nm.
10. Install fuel line (2).
11. Use torque wrench to tighten union nut at injection pump to specified torque 20 Nm + 5 Nm.
    - Maximum permissible tightening torque: 35 Nm
12. Use torque wrench to tighten union nut on pressure pipe neck to specified torque 20 Nm + 5 Nm.
    - Maximum permissible tightening torque: 35 Nm
13. Install injection pump wiring (1).
14. Tighten screws to specified torque 1.0 Nm ± 0.2 Nm using torque wrench.



Final steps

1. Remove barring tool (→ Page 84).
2. Clean mating faces on cylinder head and charge-air pipe.
3. Check gaskets for damage and replace them, if required.
4. Coat gaskets with grease and place onto cylinder head.
5. Install charge-air pipes.
6. Install engine control system (→ Page 149).
7. Open fuel supply line before fuel filter.
8. Vent fuel system (→ Page 109).

7.6 Injection Valve / Injector

7.6.1 Injector – Replacement

Special tools, Material, Spare parts

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

Replacing injector

▶ Remove injector and install new injector (→ Page 103).

7.6.2 Injector – Removal and installation

Preconditions

☑ Engine is stopped and starting disabled.

Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Extractor	F30377999	1
Fuel suction device	F30378207	1
Torque wrench, 20-100 Nm	F30026582	1
Socket wrench	F30025897	1
Crowfoot wrench, 19 mm	F30027424	1
Crowfoot wrench, 22 mm	F30027425	1
Double box wrench	F30011450	1
Ratchet adapter	F30027340	1
Transition piece	F30006234	1
Grease (Kluthe Hakuform 30-10/Emulgier)	X00029933	
Sealing ring	(→ Spare Parts Catalog)	
Sealing ring	(→ Spare Parts Catalog)	

WARNING

Fuels are combustible.
Risk of fire and explosion!
- Avoid open flames, electrical sparks and ignition sources.
- Do not smoke.

WARNING

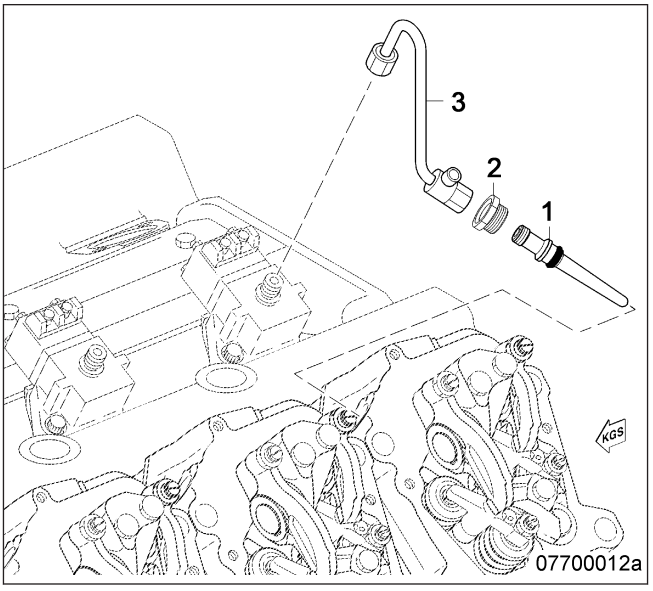
Compressed air
Risk of injury!
- Do not direct compressed-air jet at persons.
- Wear protective goggles / safety mask and ear protectors.

Preparatory steps

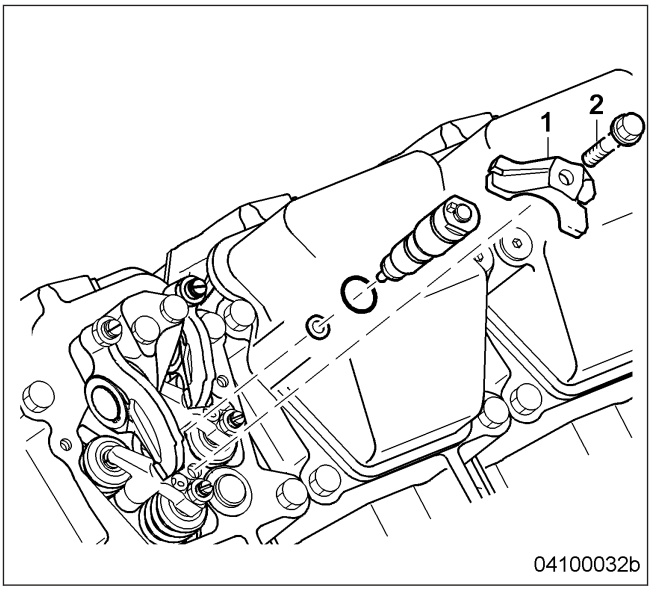
1. Remove cylinder head cover (→ Page 97).
2. Drain fuel (→ Page 108).

Removing fuel injector

1. Remove leak-off-fuel lines.
2. Remove fuel line (3).
3. Remove thrust screw (2).
4. Pull off pressure pipe neck (1).
5. Extract fuel from the exposed bores using the suction device.



6. Remove screw (2).
7. Take off clamp (1).
8. Screw extractor into injector.
9. Remove injector using the extractor.
10. Remove sealing ring using a self-made hook.
11. Seal all openings with appropriate covers after removal.



Installing fuel injector

1. Remove all covers before installation.
2. Clean sealing surface on cylinder head and protective sleeve.
3. Coat sealing ring (1) with grease and fit onto injector.
4. Coat sealing ring (2) with grease and fit onto injector.
5. Press injector into cylinder head by hand.

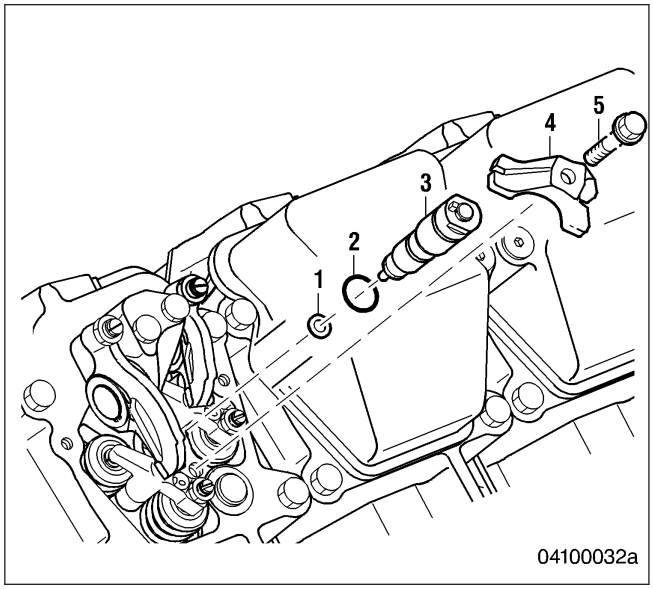
Result:
- The pin is at 11-o'clock position to the longitudinal axis of the engine.
- The pin is engaged in the groove of the clamp (4).

6. Install clamp (4) with screw (5), positioning it correctly.

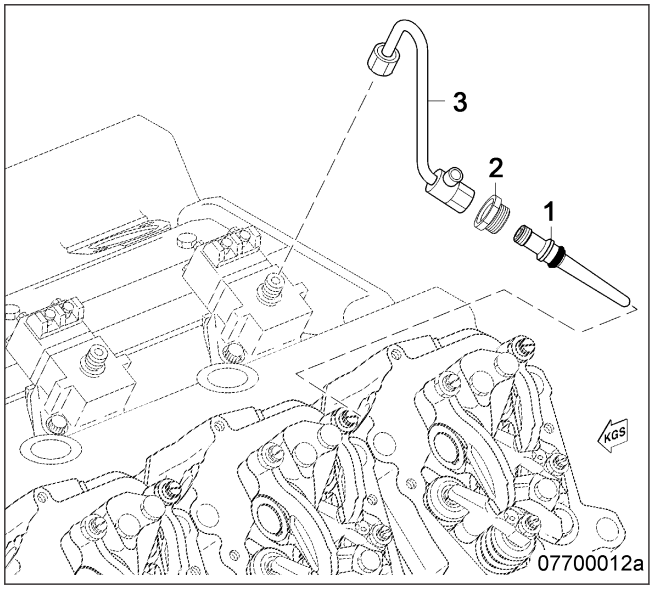
Result:
- Pin at injector is in the groove of the clamp.
- Forked clamp end is engaged in the cover recess.

7. Tighten screw (5) of the clamp by hand.

Result: Injector is still rotatable.



8. Blow out fuel line (3) and pressure pipe neck (1) with compressed air.
9. Coat sealing ring with grease and fit onto pressure pipe neck (1).
10. Coat sealing cone of pressure pipe neck with engine oil.
11. Insert pressure pipe neck into cylinder head until the sealing ring is in contact with cylinder head.
12. Fully press in pressure pipe neck (1) by hand.
13. Tighten thrust screw (2) to specified torque 40 Nm ± 5 Nm using torque wrench.
14. Install fuel line (3).
15. Use torque wrench to tighten union nut at injection pump to specified torque 20 Nm + 5 Nm.
16. Use torque wrench to tighten union nut on pressure pipe neck to specified torque 20 Nm + 5 Nm.
17. Use torque wrench to tighten screw for clamp at injector to specified torque 50 Nm.
18. Install leak-off-fuel lines.



Final steps

1. Install cylinder head cover (→ Page 97).
2. Vent fuel system (→ Page 109).

7.7 Fuel System

7.7.1 Fuel pressure relief valve – Replacement

Preconditions

☑ Engine is stopped and starting disabled.

Special tools, Material, Spare parts

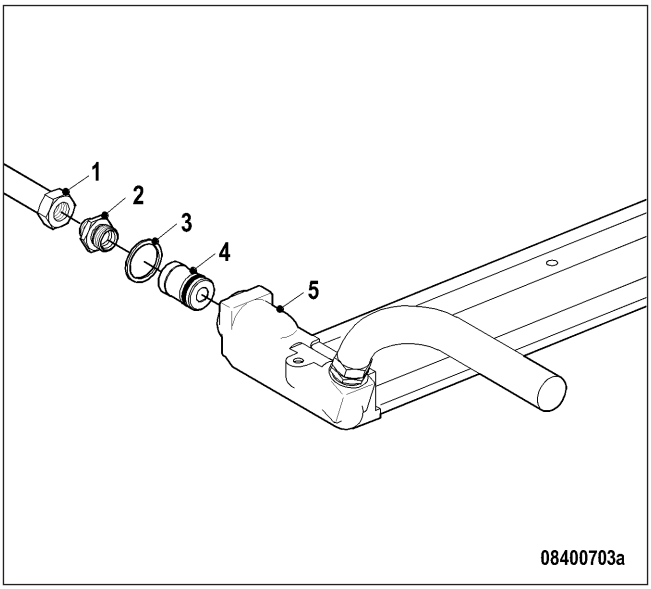
Designation / Use	Part No.	Qty.
Pressure relief valve	(→ Spare Parts Catalog)	
Sealing ring	(→ Spare Parts Catalog)	

WARNING

Fuels are combustible.
Risk of fire and explosion!
- Avoid open flames, electrical sparks and ignition sources.
- Do not smoke.

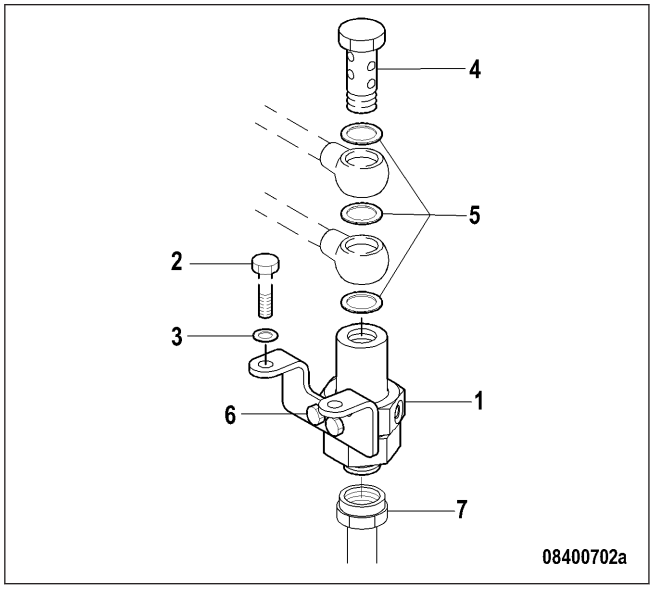
Fuel pressure relief valve – Replacement, variant A

1. Close fuel supply.
2. Remove fuel line (1).
3. Remove adapter (2).
4. Remove sealing ring (3).
5. Remove fuel pressure relief valve (4) from connecting piece (5).
6. Insert new fuel pressure relief valve (4) into connecting piece (5).
7. Screw in adapter (2) with sealing ring (3) and tighten.
8. Install fuel line (1).
9. Open fuel supply.



Fuel pressure relief valve – Replacement, variant B

1. Close fuel supply.
2. Remove fuel line (7).
3. Remove banjo screw (4).
4. Remove sealing rings (5).
5. Remove screws (2) with washer (3).
6. Remove screws (6) and take off bracket.
7. Install new pressure relief valve (1) with new sealing rings (5) in reverse sequence of operations.
8. Open fuel supply.



7.7.2 Fuel – 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.

Fuel – Draining

1. Provide a suitable container in which to collect the fuel.
2. Remove fuel filter (→ Page 110).
3. Catch fuel as it runs out.
4. Install fuel filter (→ Page 110).

7.7.3 Fuel system – Venting

Fuel system – Venting

1. Bar engine with starting system (→ Page 85).
2. Repeat procedure 2 to 3 times, the fuel system is automatically vented.

7.8 Fuel Filter

7.8.1 Fuel filter – Replacement

Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Filter wrench	F30379104	1
Diesel fuel		
Easy-change filter	(→ Spare Parts Catalog)	
Synthetic ring	(→ Spare Parts Catalog)	

DANGER

Unguarded rotating and moving engine components.
Risk of serious injury – danger to life!
- Take special care when working on a running engine.

WARNING

Fuels are combustible.
Risk of fire and explosion!
- Avoid open flames, electrical sparks and ignition sources.
- Do not smoke.

WARNING

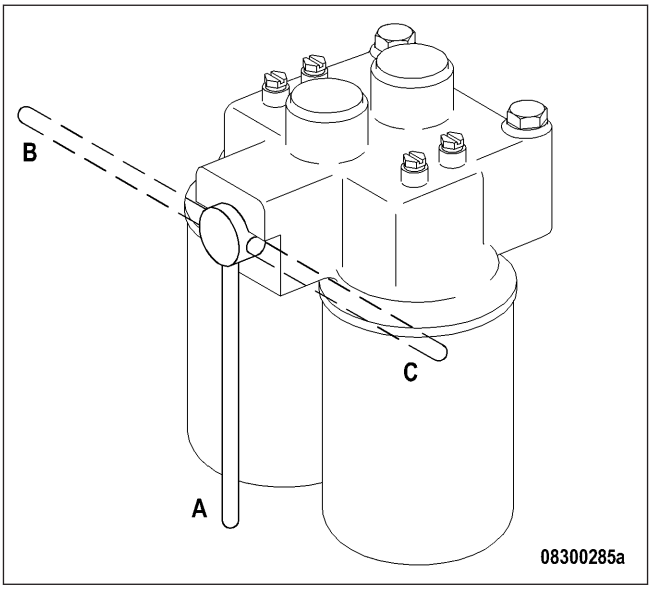
Engine noise above 85 dB (A).
Risk of damage to hearing!
- Wear ear protectors.

CAUTION

Damage to component.
Serious damage to plant!
- For filter replacement with the engine running, operate the engine at low engine load.
- The filter which is to be exchanged must be cut out for a brief period only.

Fuel filter replacement with the engine stopped

A Both filters cut in (operating position)
B Left filter cut out
C Right filter cut out



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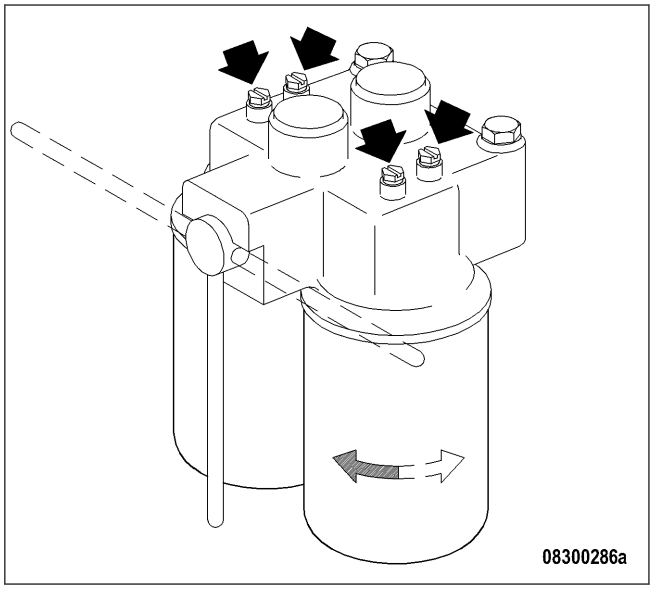
1. Stop engine (→ Page 55) and disable engine start.
2. Cut out the filter to be replaced.
3. Remove cut-out easy-change filter using the filter wrench.
4. Clean the sealing surface of the filter head.
5. Check sealing ring of the new easy-change filter and coat it with fuel.
6. Install and tighten new filter by hand.
7. Set three-way cock to operating position (both filters cut in).
8. Replace further fuel filters in the same way.
9. Vent fuel system.

Fuel filter replacement with the engine running

1. Cut out the filter to be replaced.
2. Open vent plug of the cut-out filter and make sure that the pressure is completely released from the filter.
3. Close vent plugs.
4. Remove cut-out easy-change filter using the filter wrench.
5. Clean the sealing surface of the filter head.
6. Check sealing ring of the new easy-change filter and coat it with fuel.
7. Install and tighten new filter by hand.
8. Set three-way cock to operating position (both filters cut in).
9. Replace further fuel filters in the same way.



7.8.2 Fuel prefilter cleaning

Preconditions

☑ Engine is stopped and starting disabled.

Special tools, Material, Spare parts

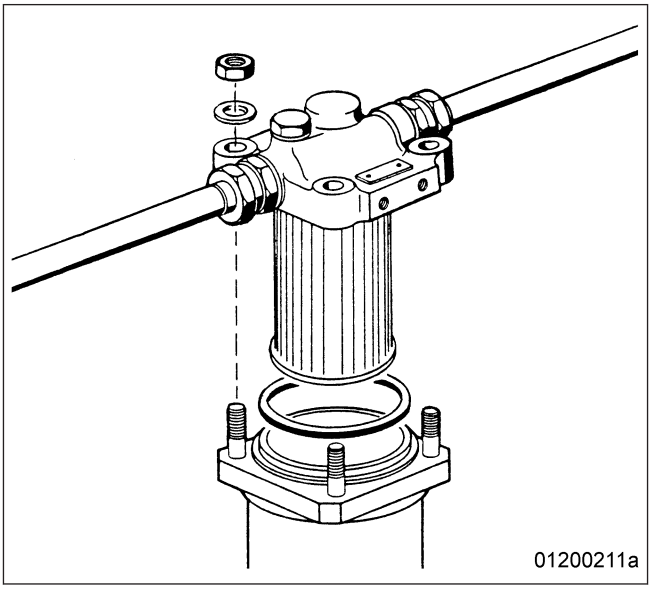
Designation / Use	Part No.	Qty.
Diesel fuel		
Sealing ring	(→ Spare Parts Catalog)	

WARNING

Fuels are combustible.
Risk of fire and explosion!
- Avoid open flames, electrical sparks and ignition sources.
- Do not smoke.

Fuel prefilter cleaning

1. Shut off fuel supply.
2. Remove nuts from filter head.
3. Take off filter housing and drain fuel into appropriate container.
4. Remove filter-element securing nut and remove filter element by pulling it downwards.
5. Wash filter element in clean fuel using a smooth brush.
6. Wash filter housing with clean fuel.
7. Insert filter element into filter housing and secure with nut.
8. Place new sealing ring into groove in filter head.
9. Fit cover with seal and secure it with nuts crosswise.
10. Open fuel supply.



7.8.3 Fuel prefilter – Differential pressure gauge check and adjustment

DANGER

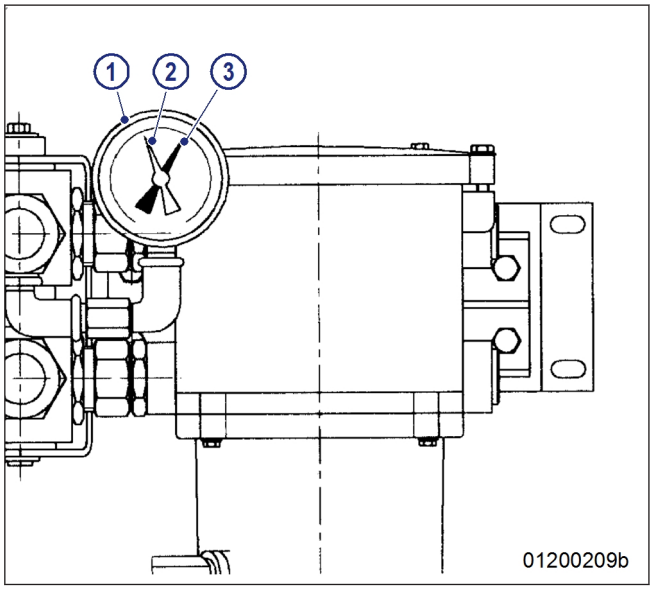
Unguarded rotating and moving engine components.
Risk of serious injury – danger to life!
- Take special care when working on a running engine.

WARNING

Engine noise above 85 dB (A).
Risk of damage to hearing!
- Wear ear protectors.

Adjusting differential pressure gauge

1. When installing the new filter element: align adjustable pointer (2) with pressure-indicating pointer (3) of pressure gauge (1).
2. Check differential pressure.



Checking differential pressure of fuel prefilter

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 ≥ 0.3 bar, flush filter element of the cut-in filter (→ Page 115).

7.8.4 Fuel prefilter – Draining

Preconditions

☑ Engine is stopped and starting disabled.

Special tools, Material, Spare parts

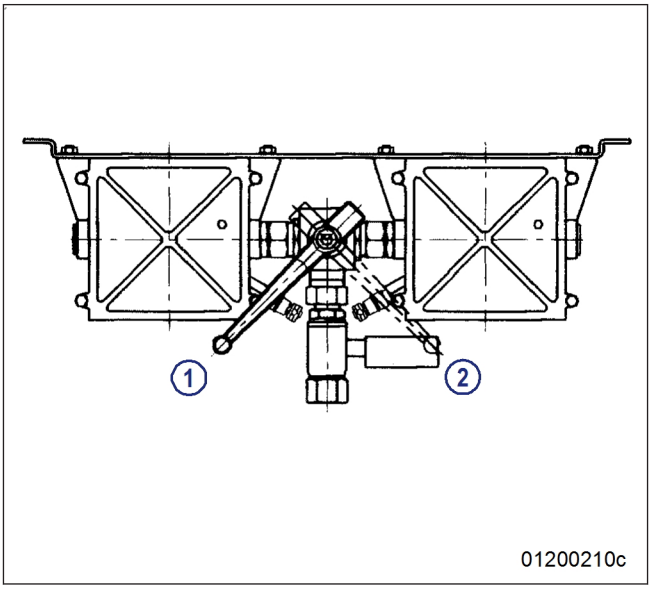
Designation / Use	Part No.	Qty.
Diesel fuel		
Gasket	(→ Spare Parts Catalog)	

WARNING

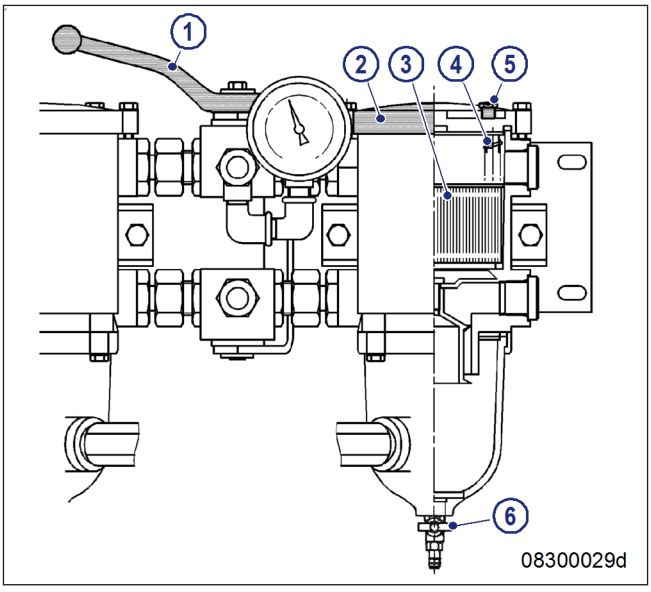
Fuels are combustible.
Risk of fire and explosion!
- Avoid open flames, electrical sparks and ignition sources.
- Do not smoke.

Fuel prefilter – Draining

1. Cut out filter to be drained.
   1 Left filter cut in
   2 Right filter cut in



2. Open threaded vent plug (5) of filter to be drained.
3. Unlock drain valve (6) by pressing toggle and open it.
4. Drain water and contaminants from filter until pure fuel emerges.
5. Close drain valve (6).
6. Remove screws for cover and take off cover (2).
7. Fill filter housing with clean fuel.
8. Place new gasket in cover (2).
9. Fit cover with gasket and secure it with screws.
10. Cut in the cut-out filter again.
11. Close threaded vent plug (5) when fuel emerges.



7.8.5 Fuel prefilter – Flushing

Special tools, Material, Spare parts

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

DANGER

Unguarded rotating and moving engine components.
Risk of serious injury – danger to life!
- Take special care when working on a running engine.

WARNING

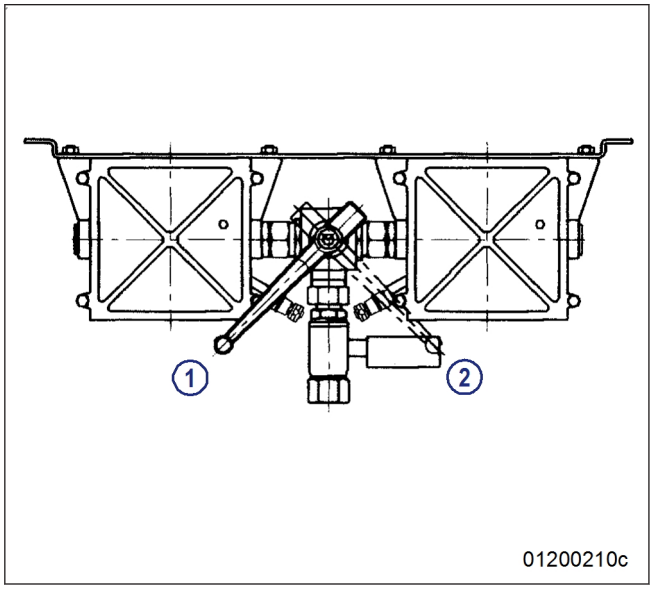
Fuels are combustible.
Risk of fire and explosion!
- Avoid open flames, electrical sparks and ignition sources.
- Do not smoke.

WARNING

Engine noise above 85 dB (A).
Risk of damage to hearing!
- Wear ear protectors.

Fuel prefilter – Flushing

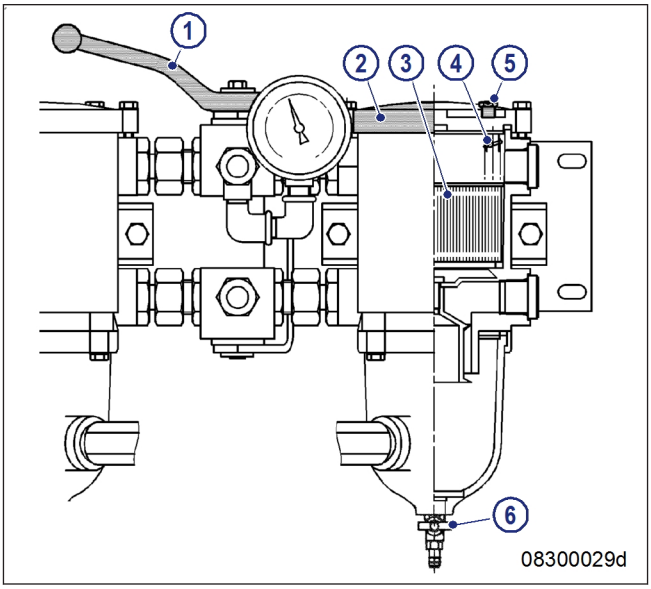
1. Cut out clogged filter.
   - I Left filter cut in
   - II Right filter cut in



2. Open threaded vent plug (5) of filter to be flushed.
3. Unlock drain valve (6) by pressing valve toggle, open it 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 (5) and drain valve (6).



Fuel prefilter – Topping up with fuel

1. Stop engine (→ Page 55) and disable engine start.
2. Remove screws for cover and take off cover (2).
3. Fill filter housing with clean fuel.
4. Place new gasket in cover (2).
5. Fit cover with gasket and secure it with screws.
6. Check differential pressure (→ Page 113).

Result: If flushing did not lead to an improvement of the differential pressure, replace filter element of fuel prefilter (→ Page 117).

7.8.6 Fuel prefilter – Filter element replacement

Preconditions

☑ Engine is stopped and starting disabled.

Special tools, Material, Spare parts

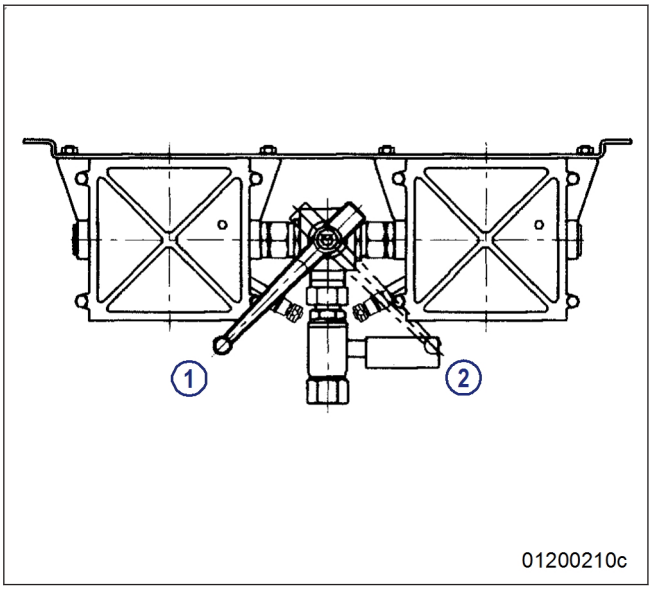
Designation / Use	Part No.	Qty.
Diesel fuel		
Filter element	(→ Spare Parts Catalog)	
Gasket	(→ Spare Parts Catalog)	

WARNING

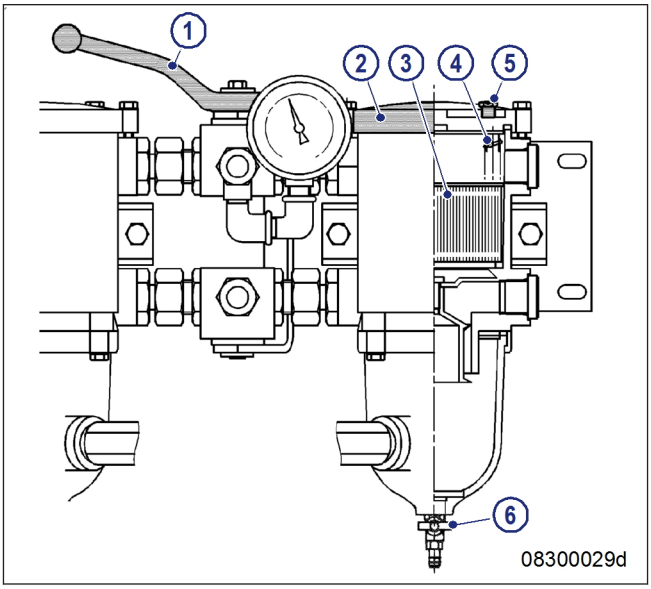
Fuels are combustible.
Risk of fire and explosion!
- Avoid open flames, electrical sparks and ignition sources.
- Do not smoke.

Replacing filter element

1. Cut out filter to be drained.
   - I Left filter cut in
   - II Right filter cut in



2. Open threaded vent plug (5) of contaminated filter.
3. Unlock drain valve (6) by pressing toggle and open it.
4. Drain water and dirt from filter.
5. Close drain valve (6).
6. Remove screws securing the cover and take off cover (2).
7. Remove spring housing (4) and filter element (3).
8. Insert new filter element (3) and spring housing (4).
9. Fill filter housing with clean fuel.
10. Place new gasket in cover (2).
11. Fit cover with gasket and secure it with screws.
12. Cut in the cut-out filter again.
13. Close threaded vent plug (5) when fuel emerges.
14. Adjust the differential pressure gauge (→ Page 113).



7.9 Charge-Air Cooling General, Left-Hand Side

7.9.1 Intercooler – Checking condensate drains for coolant discharge and obstructions

Preconditions

☑ Engine is stopped and starting disabled.

Special tools, Material, Spare parts

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

WARNING

Compressed air
Risk of injury!
- Do not direct compressed-air jet at persons.
- Wear protective goggles / safety mask and ear protectors.

Intercooler – Checking condensate drains for coolant discharge and obstructions

1. Remove plug screw(s) from charge-air manifold.
2. Check drain bore(s) for air discharge. If no air escapes:
3. Clean drain bore(s) and blow out with compressed air.
4. More significant coolant leakage indicates a leaking intercooler. Contact Service.
5. Install plug screw(s) with new sealing ring and tighten.

Emergency measures prior to engine start with a leaking intercooler

1. Remove injectors (→ Page 103).
2. Bar the engine manually (→ Page 84).
3. Bar the engine with the starting system to blow out cylinder chambers (→ Page 85).
4. Install injectors (→ Page 103).

7.10 Air Filter

7.10.1 Air filter – Replacement

Preconditions

☑ Engine is stopped and starting disabled.

Replace air filter, carry out work in accordance with the instructions of the manufacturer – scope of supply of the unit manufacturer.

7.11 Air Intake

7.11.1 Service indicator – Signal ring position check

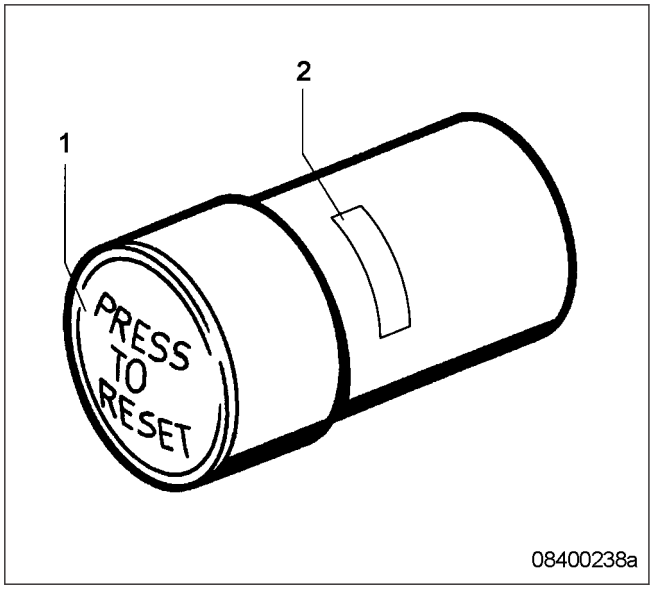
Preconditions

☑ Engine is stopped and starting disabled.

Checking signal ring position of service indicator (if fitted)

1. If the signal ring is completely visible in the control window (2), replace air filter (→ Page 120).
2. After installation of new filter, press reset button (1).

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



7.12 Starting Equipment

7.12.1 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 144).

7.13 Lube Oil System, Lube Oil Circuit

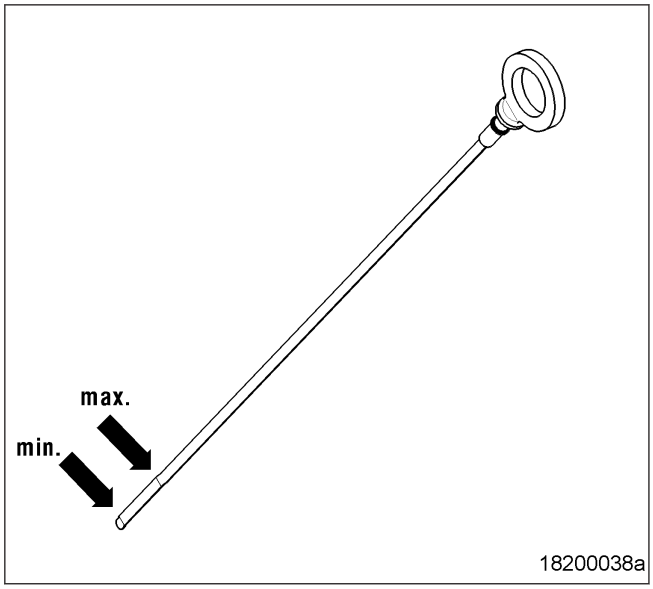
7.13.1 Engine oil – Level check

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." and "max." marks.
4. Top up to "max." if required (→ Page 124).
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 124).
5. Insert oil dipstick into guide tube up to the stop.

7.13.2 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		
Sealing ring	(→ 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.

Oil change without semirotary hand pump: Draining oil at drain plug on oil pan

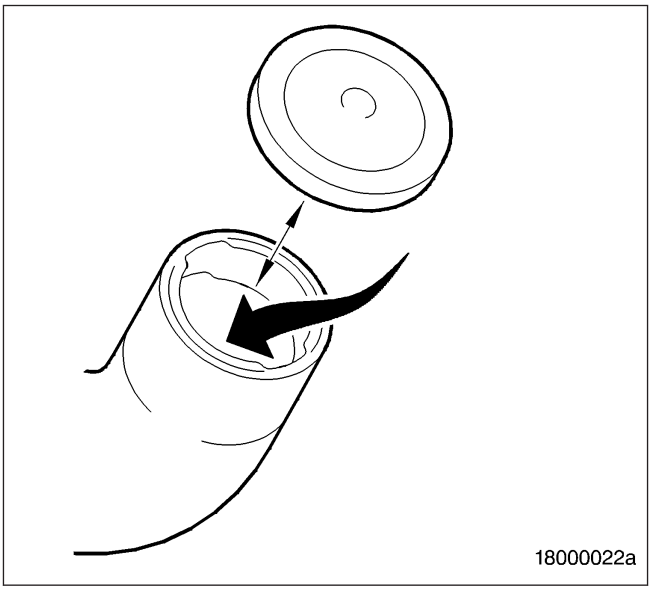
1. Provide a suitable container to collect the oil.
2. Remove drain plug and drain oil.
3. Install drain plug with new sealing ring.
4. Replace engine oil filter (→ Page 125).

Oil change with semirotary hand pump: Oil extraction

1. Provide a suitable container to collect the oil.
2. Extract all oil from oil pan using the semirotary hand pump.
3. Replace engine oil filter (→ Page 125).

Filling with new oil

1. Open cover on filler neck.
2. Pour oil in at filler neck up to "max." mark at oil dipstick.
3. Close cover on filler neck.
4. Check engine oil level (→ Page 123).
5. After oil change and filter replacement, bar engine with starting system (→ Page 85).



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7.14 Oil Filtration / Cooling

7.14.1 Engine oil filter – Replacement

Special tools, Material, Spare parts

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

DANGER

Unguarded rotating and moving engine components.
Risk of serious injury – danger to life!
- Take special care when working on a running engine.

WARNING

Engine noise above 85 dB (A).
Risk of damage to hearing!
- Wear ear protectors.

WARNING

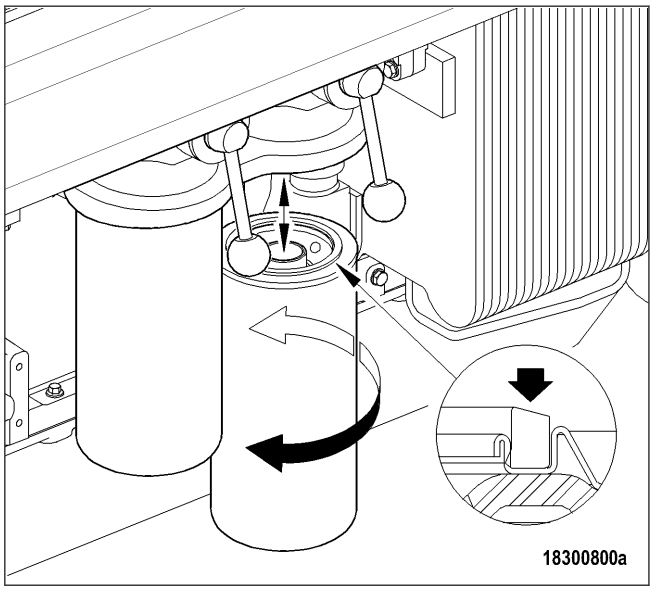
Hot oil.
Oil can contain combustion residues which are harmful to health.
Risk of injury and poisoning!
- Wear protective clothing, gloves, and goggles / safety mask.
- Avoid contact with skin.
- Do not inhale oil vapor.

CAUTION

Damage to component.
Serious damage to plant!
- For filter replacement with the engine running, operate the engine at low engine load.
- The filter which is to be exchanged must be cut out for a brief period only.

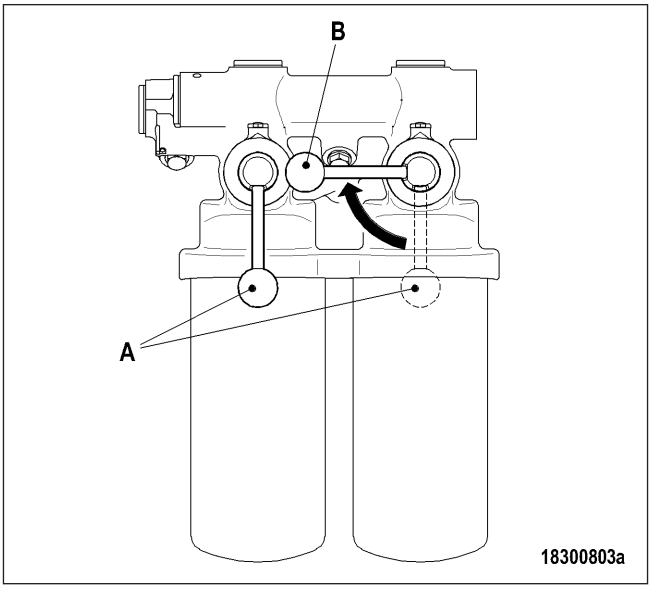
Oil filter replacement with the engine stopped

1. Stop engine (→ Page 55) and disable engine start.
2. Remove oil filter using the filter wrench.
3. Clean the sealing face of the connecting piece.
4. Check sealing ring of new oil filter and coat with oil.
5. Install and tighten new oil filter by hand.
6. Replace other oil filters in the same way.
7. After each oil change and filter replacement, bar engine with starting system (→ Page 85).
8. Check oil level (→ Page 123).



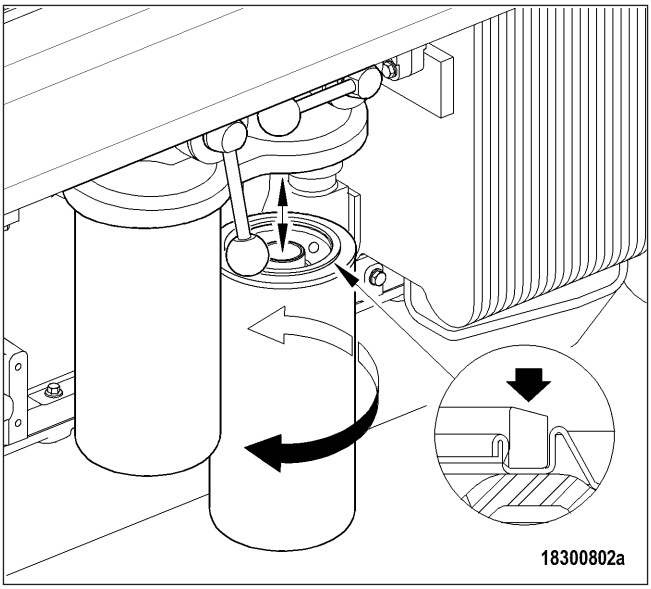
Oil filter replacement with the engine running

A Filter in operation (normal position)
B Filter switched off



Note: When changing filters during engine operation only 1 filter may ever be cut out.

1. Cut out the filter to be replaced: Turn switching lever to position B.
2. Remove oil filter using the filter wrench.
3. Clean the sealing face of the connecting piece.
4. Check sealing ring of new oil filter and moisten it with oil.
5. Install and tighten new oil filter by hand.
6. Cut in the cut-out filter: Turn switching lever to position A.
7. Replace other oil filters in the same way.
8. Check oil level (→ Page 123).



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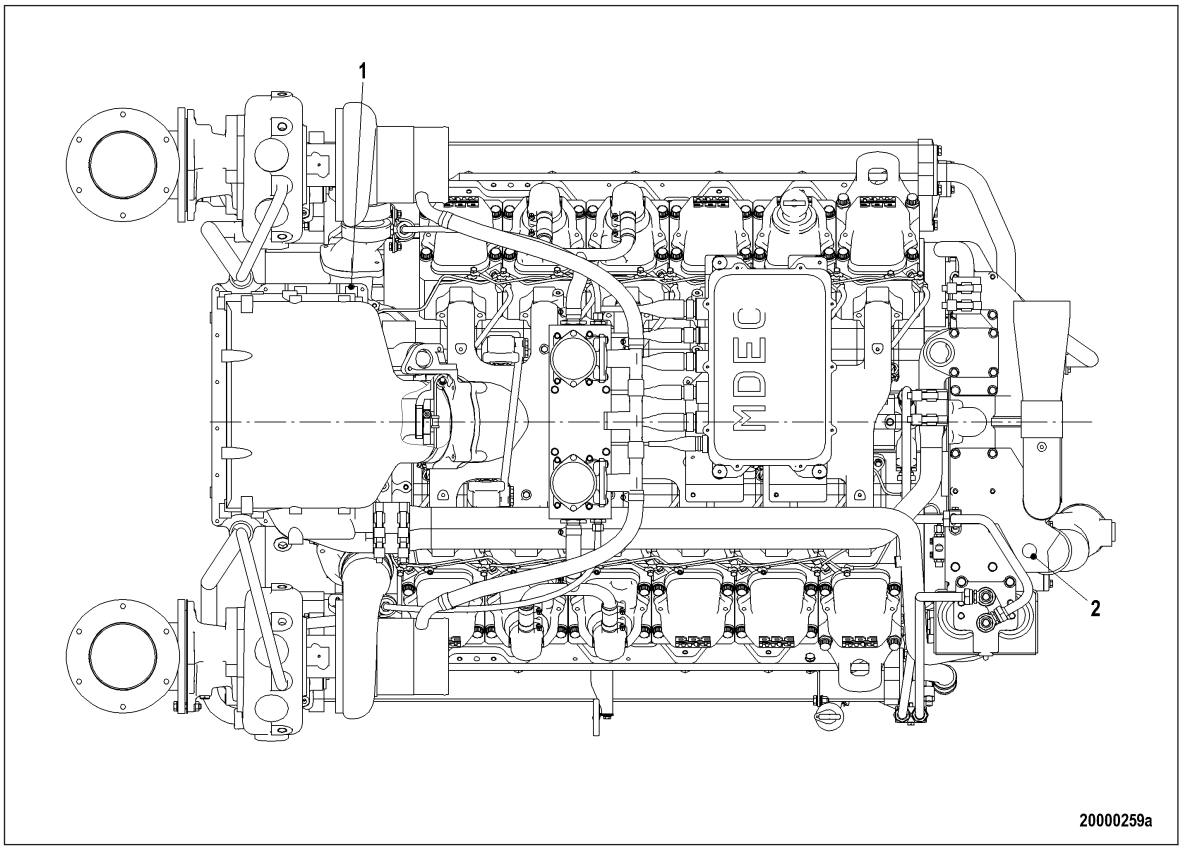
7.15 Coolant Circuit, General, High-Temperature Circuit

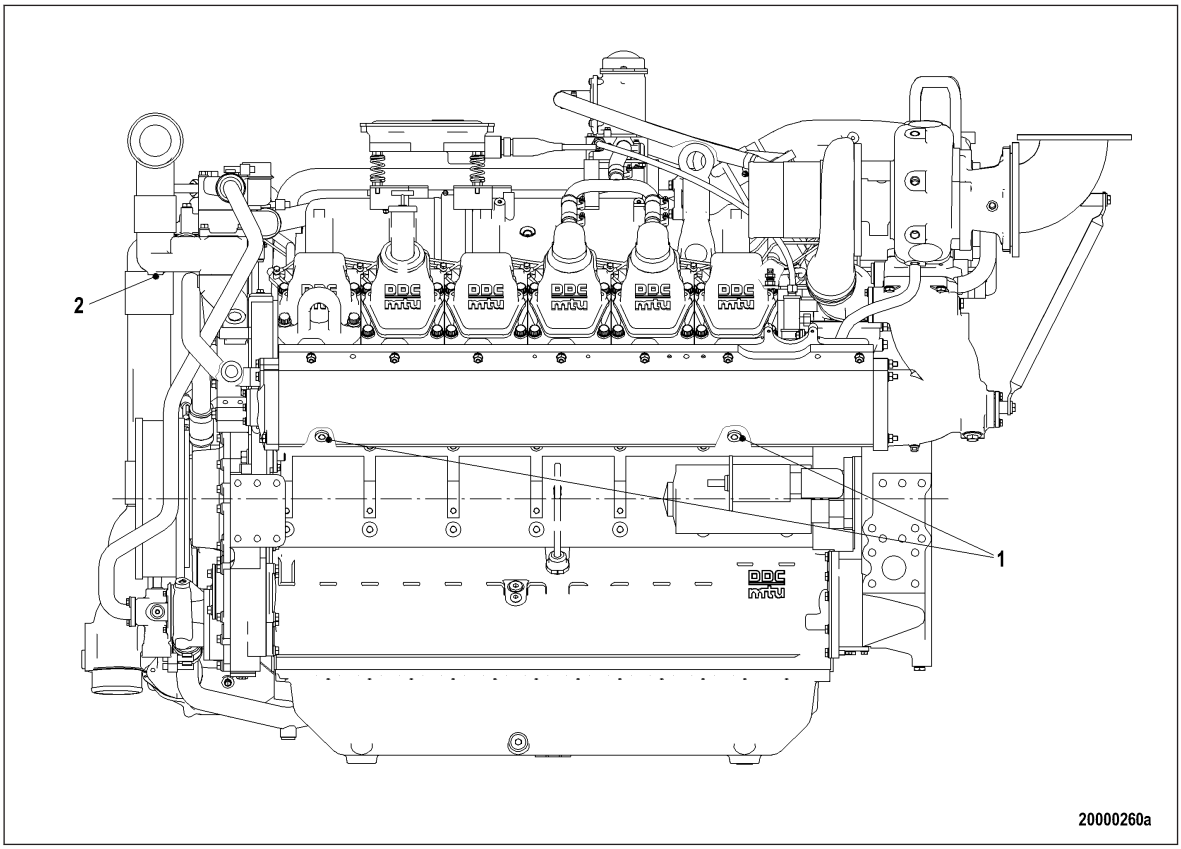
7.15.1 Drain and venting points

Top view



1 Engine coolant vent 2 Engine coolant vent

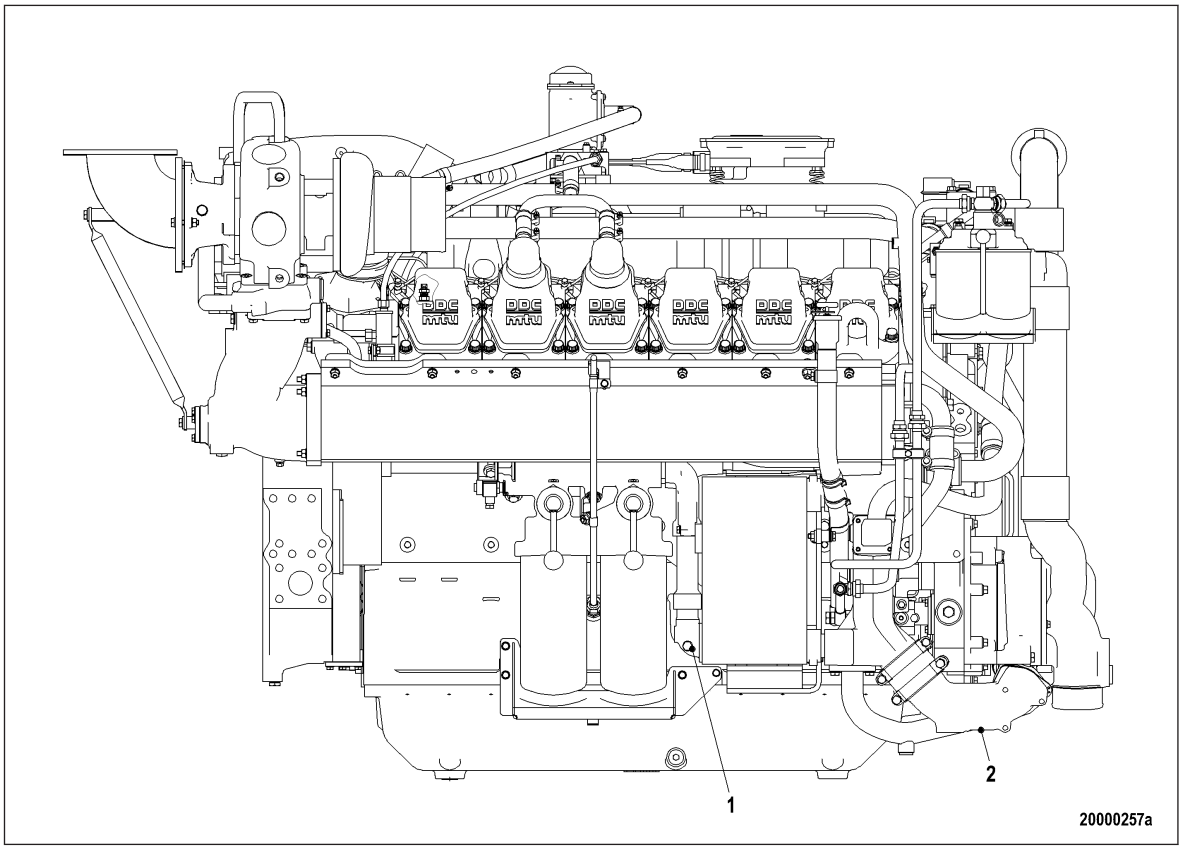
Left side



1 Engine coolant drain plug

2 Engine coolant drain plug

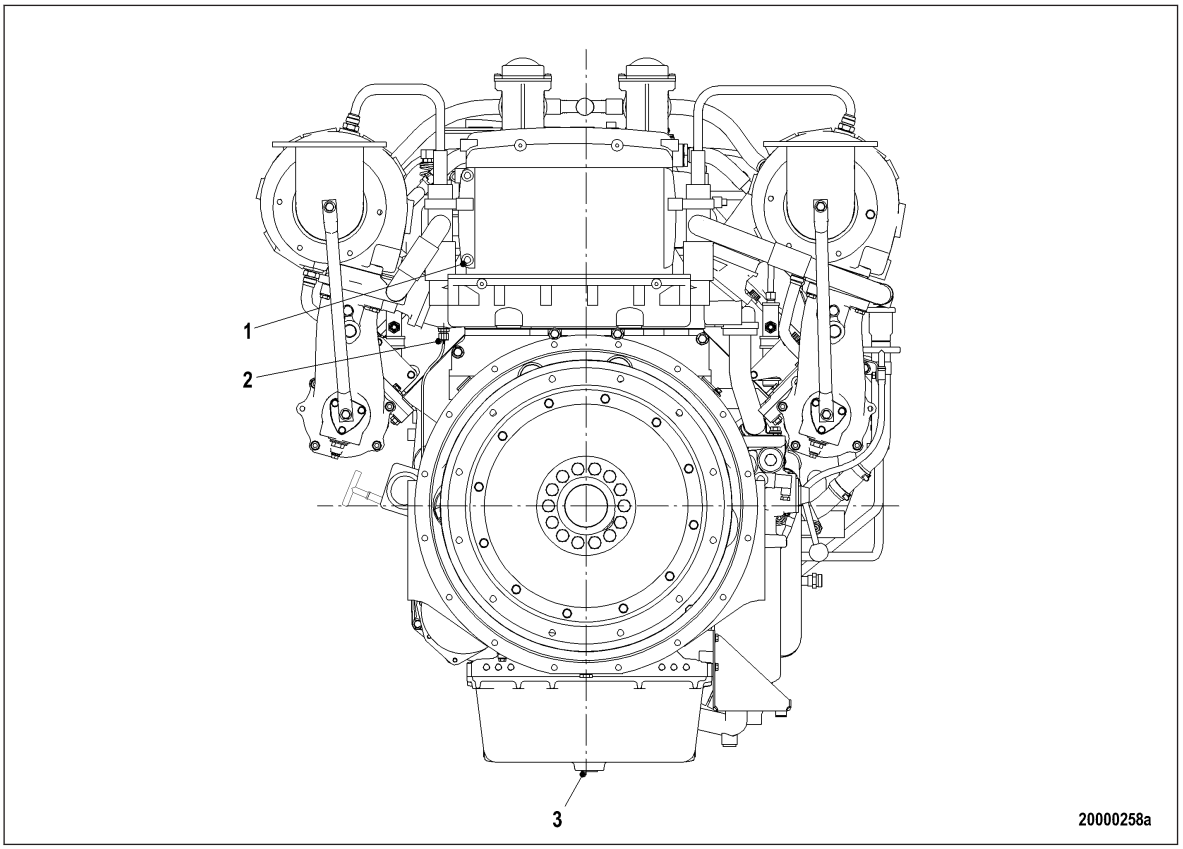
Right side



1 Engine oil drain plug (heat exchanger)

2 Engine coolant drain plug

Driving end (KS)



1 Engine coolant drain plug

2 Intercooler drain

3 Engine oil drain plug

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7.15.2 Engine coolant – Level check

Preconditions

☑ Engine is stopped and starting disabled.

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

WARNING

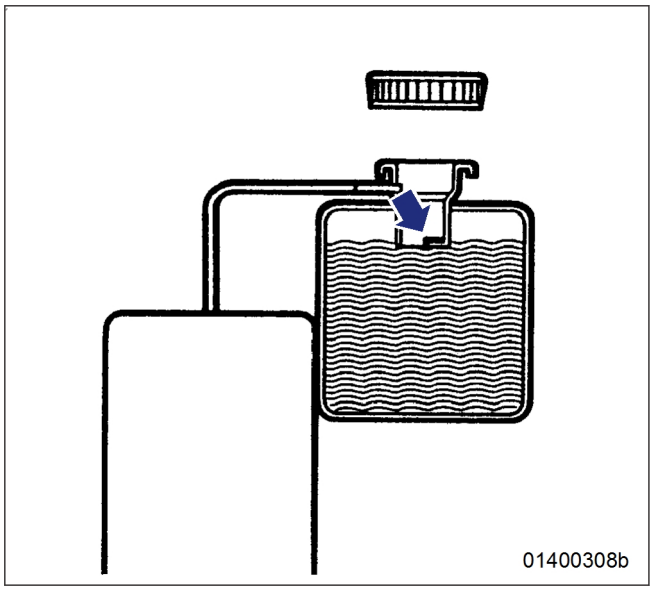
Coolant is hot and under pressure.
Risk of injury and scalding!
- Let the engine cool down.
- Wear protective clothing, gloves, and goggles / safety mask.

Checking engine coolant level at filler neck:

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

Checking engine coolant level at remote cooler:

1. Check engine coolant level (coolant must be visible at marker plate).
2. Top up engine coolant if necessary (→ Page 134).
3. Check and clean breather valve.
4. Place breather valve on filler neck and close.



Checking engine coolant level via level sensor:

1. Switch on engine control system and check readings on the display.
2. Top up engine coolant if necessary (→ Page 134).

7.15.3 Engine coolant – Change

Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Coolant		

Engine coolant – Change

1. Drain engine coolant (→ Page 133).
2. Fill with engine coolant (→ Page 134).

7.15.4 Engine coolant – Draining

Preconditions

☑ Engine is stopped and starting disabled.

Special tools, Material, Spare parts

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

WARNING

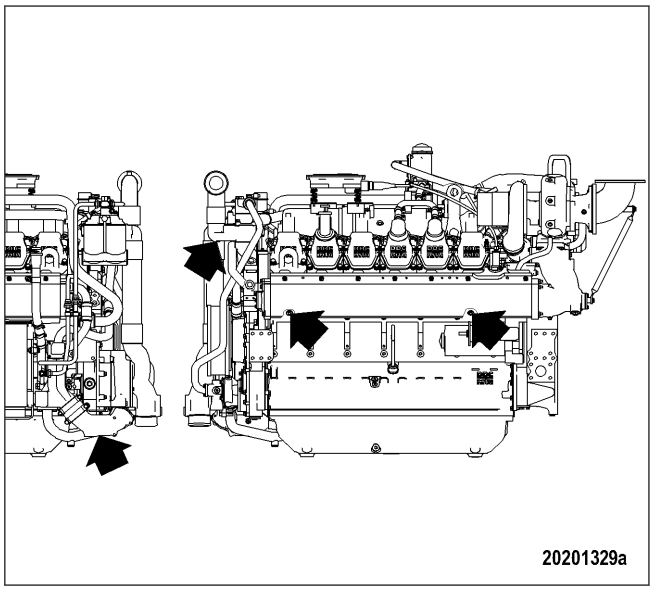
Coolant is hot and under pressure.
Risk of injury and scalding!
- Let the engine cool down.
- Wear protective clothing, gloves, and goggles / safety mask.

Preparatory steps

1. Provide an appropriate container to drain the coolant into.
2. Switch off preheating unit.

Draining engine coolant

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. Draw off precipitated corrosion inhibitor oil from the expansion tank through filler neck.
4. Open the drain valve at the drain point in the coolant pipe to the engine-coolant cooler and drain the coolant, (see unit manufacturer).
5. Draining of residual coolant:
   - At the preheating unit, if applicable.
6. Additional drain points:
   - At the engine coolant pump elbow;
   - At the crankcase, left and right sides.
   - At the thermostat housings.
7. Close all drain valves and install drain plugs with new sealing rings.
8. Set breather valve onto filler neck and close it.



7.15.5 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.
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.

WARNING

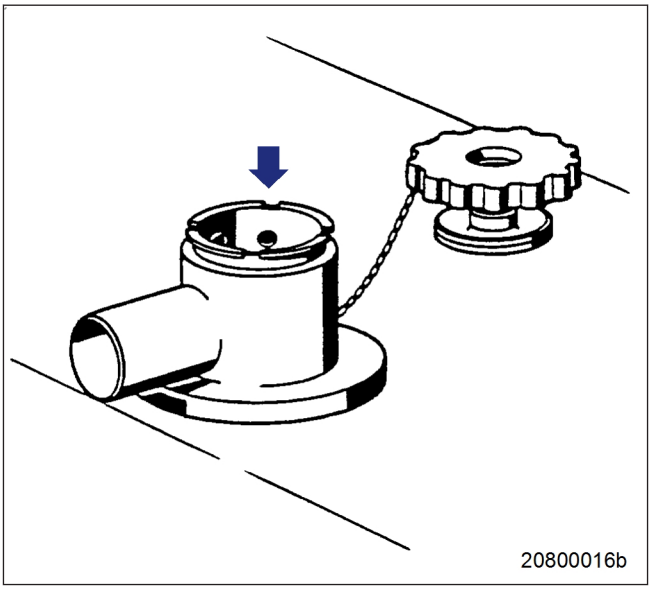
Engine noise above 85 dB (A).
Risk of damage to hearing!
- Wear ear protectors.

CAUTION

Cold coolant in hot engine can cause thermal stress.
Formation of cracks in components!
- Fill / top up coolant only into cold engine.

Preparatory steps

1. Turn breather valve on coolant expansion tank counterclockwise to the first stop and allow pressure to escape.
2. Continue to turn breather valve counter-clockwise and remove.



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Engine coolant – Filling

1. Fill coolant through filler neck on expansion tank or through filling line until coolant level reaches lower edge of cast-in eye or marking plate.
2. Check proper condition of breather valve, clean sealing faces if required.
3. Fit breather valve and close it.

Final steps

1. Start the engine and operate it at idle speed for some minutes.
2. Check coolant level (→ Page 131), top up with coolant if required.

7.15.6 Coolant pump – Relief bore check

DANGER

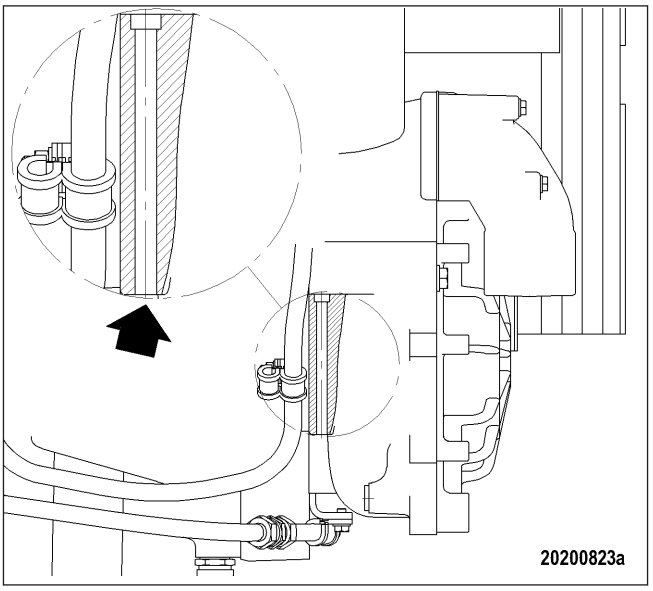
Unguarded rotating and moving engine components.
Risk of serious injury – danger to life!
- Take special care when working on a running engine.

WARNING

Engine noise above 85 dB (A).
Risk of damage to hearing!
- Wear ear protectors.

Coolant pump – Relief bore check

1. Check relief bore for oil and water discharge.
2. Permissible discharge:
   - Up to 10 drops of coolant per hour
   - Up to 5 drops of oil per hour
3. If discharge exceeds the specified limits, contact Service.
4. If relief bore is dirty:
   a) Stop engine (→ Page 55) and disable engine start.
   b) Clean relief bore with a wire.
   c) Start the engine (→ Page 52) and operate it at idle speed for some minutes.
   d) Check relief bore again for oil and coolant discharge.



7.16 Low-Temperature Circuit

7.16.1 Charge-air 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.
Coolant		
Sealing ring	(→ Spare Parts Catalog)	

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.

WARNING

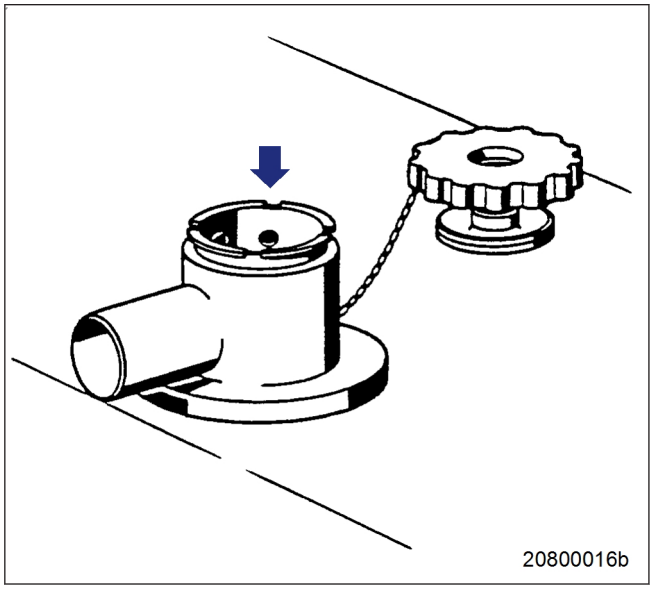
Engine noise above 85 dB (A).
Risk of damage to hearing!
- Wear ear protectors.

CAUTION

Cold coolant in hot engine can cause thermal stress.
Formation of cracks in components!
- Fill / top up coolant only into cold engine.

Preparatory steps

1. Turn breather valve on coolant expansion tank counterclockwise to the first stop and allow pressure to escape.
2. Continue to turn breather valve counter-clockwise and remove.
3. Remove plug screw from filling point on coolant line to intercooler.



Charge-air coolant – Filling

1. Fill treated coolant through filling line or through filler neck of coolant expansion tank until coolant level reaches marking plate.
2. Install plug screws of filling points with new sealing rings.
3. Check proper condition of breather valve, clean sealing faces if required.
4. Fit breather valve and close it.

Final steps

1. Start the engine and operate it at idle speed for some minutes.
2. Check coolant level (→ Page 141).

7.16.2 Charge-air coolant – Draining

Preconditions

☑ Engine is stopped and starting disabled.

Special tools, Material, Spare parts

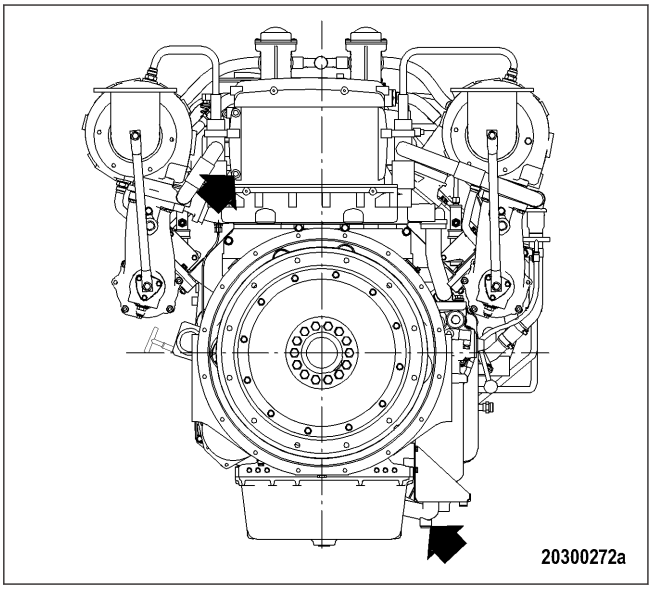
Designation / Use	Part No.	Qty.
Sealing rings	(→ Spare Parts Catalog)	

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.

Draining charge-air coolant

1. Provide an appropriate container to drain the coolant into.
2. Turn breather valve of coolant expansion tank counterclockwise until the first stop and allow pressure to escape.
3. Continue to turn breather valve counter-clockwise and remove.
4. Draw off precipitated corrosion inhibitor oil from the expansion tank through filler neck.
5. Open the drain valve at the drain point in the coolant pipe to the charge-air coolant cooler and drain the coolant, (see unit manufacturer).
6. Open drainage screw on the elbow of the charge-air coolant pump and drain the coolant.
7. Draining of residual coolant:
   - At the charge-air cooler.
8. Close all drain valves and install drain plugs with new sealing rings.
9. Set breather valve onto filler neck and close it.



7.16.3 Charge-air coolant – Change

Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Coolant		

Charge-air coolant – Change

1. Drain charge-air coolant (→ Page 139).
2. Fill with charge-air coolant (→ Page 137).

7.16.4 Charge-air coolant – Level check

Preconditions

☑ Engine is stopped and starting disabled.

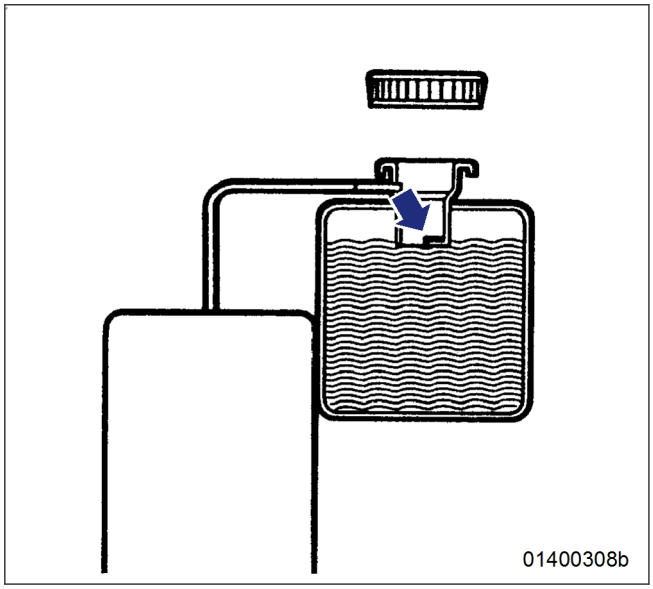
☑ MTU Fluids and Lubricants Specifications (A001061/..) are available.

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 charge-air coolant level at filler neck:

1. Turn breather valve on coolant expansion tank counterclockwise to the first stop and allow pressure to escape.
2. Continue to turn breather valve counter-clockwise and remove.
3. Check coolant level (coolant must be visible at marking plate).
4. Top up coolant if necessary (→ Page 137).
5. Check proper condition of breather valve, clean sealing faces if required.
6. Fit breather valve and close it.



Checking charge-air coolant level by means of level sensor:

1. Switch on engine control system and check display (coolant level is automatically monitored by engine control system).
2. Top up coolant if necessary (→ Page 137).

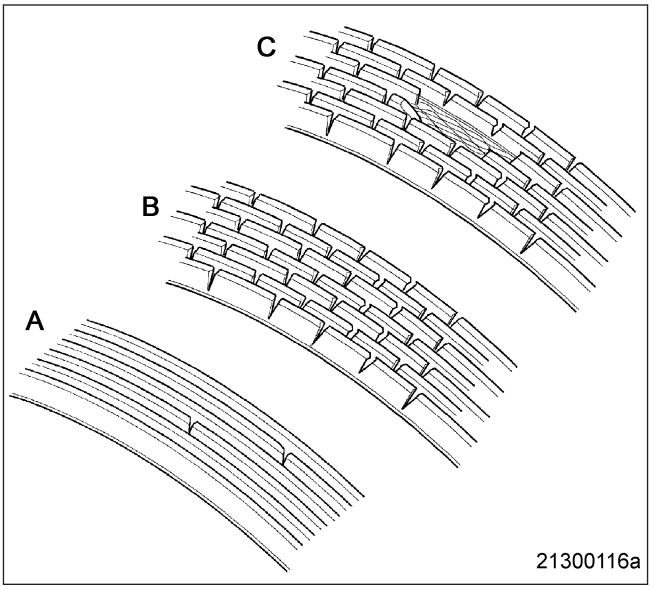
7.17 Belt Drive

7.17.1 Drive belt – Condition check

Preconditions

☑ Engine is stopped and starting disabled.

☑ Guard is removed.



Item	Findings	Task
Drive belt A	Breaks in a few individual places	None
Drive belt	Belt is oily, shows signs of overheating	Replace
Drive belt B	Breaks around the entire circumference	
Drive belt C	Areas of belt material missing	

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7.18 Engine Mounting / Support

7.18.1 Engine mounts – Resilient elements check

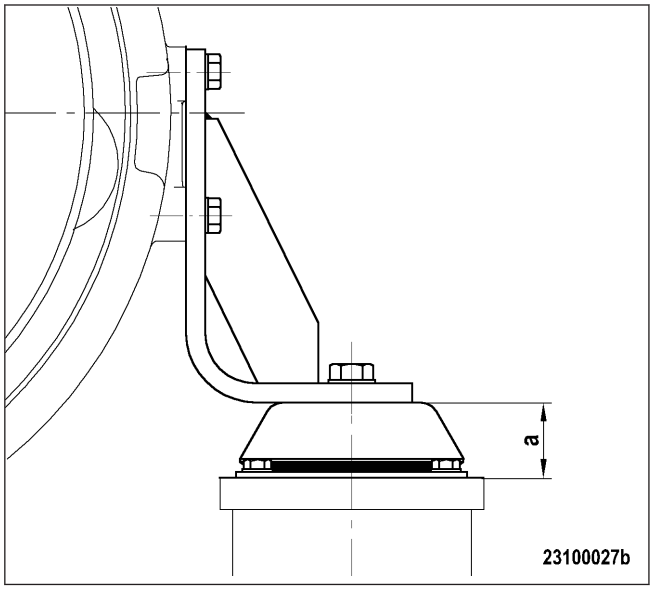
Preconditions

☑ Engine is stopped and starting disabled.

☑ Engine is filled with coolant and engine oil.

Engine mounts – Resilient elements check

1. Wipe rubber surface with dry cloth, do not use organic detergents.
2. Check resilient elements for crack formation and deformation by visual inspection.
3. Have cracked elements replaced, contact Service.



Setting dimension check

1. Measure setting dimension:
   - Dimension (a) = 55 mm.
2. If dimension (a) is less than 55 mm, resilient elements must be replaced. Contact Service.

7.19 Wiring (General) for Engine/Gearbox/Unit

7.19.1 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 that cable ties are firm, tighten loose cable ties.
4. Replace faulty cable ties.
5. Visually inspect the following electrical line components for damage:
   - connector housings;
   - contacts;
   - sockets;
   - cables and terminals;
   - plug-in contacts.
6. (→ Contact Service) if cable conductors are damaged.

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

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

7.20 Accessories for (Electronic) Engine Governor / Control System

7.20.1 Engine governor and connectors – Cleaning

Preconditions

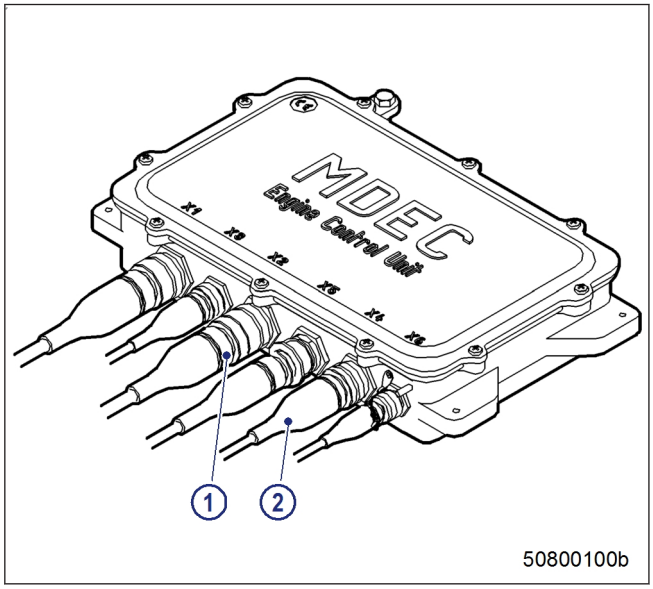
☑ Engine is stopped and starting disabled.

Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Connector pliers	0135315483	1
Isopropyl alcohol	X00058037	1

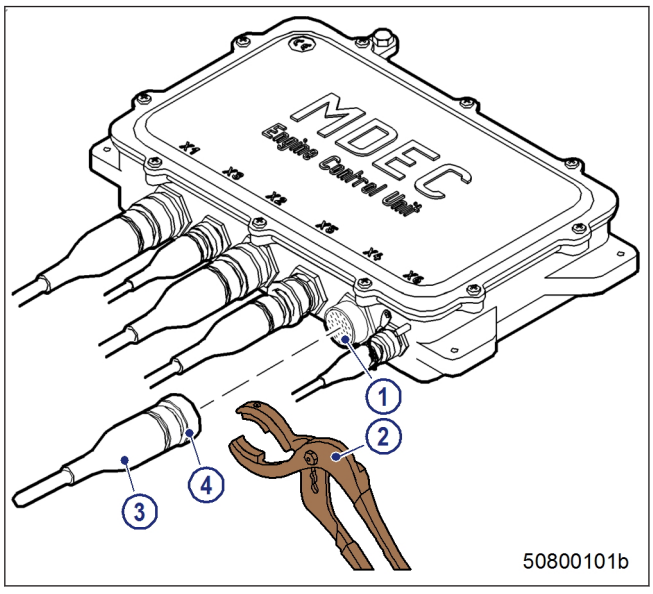
Engine governor and connectors - Cleaning

1. Remove coarse dirt from housing surface with isopropyl alcohol.
2. Remove dirt from surface of connectors (1), connector sockets and shrink sleeves (2) using a cloth moistened with isopropyl alcohol.
3. Check legibility of cable labels. Clean or replace illegible labels.



Cleaning severely contaminated connectors on engine governor

1. Use connector pliers (2) to disengage bayonet union nut (4) and withdraw connector (3).
2. Clean connector housings, connector socket housings (1) and all contacts with isopropyl alcohol.
3. When connectors, sockets and all contacts are dry: Fit connectors and check governor connections (→ Page 147).



7.20.2 Engine monitoring unit and connectors – Cleaning

Preconditions

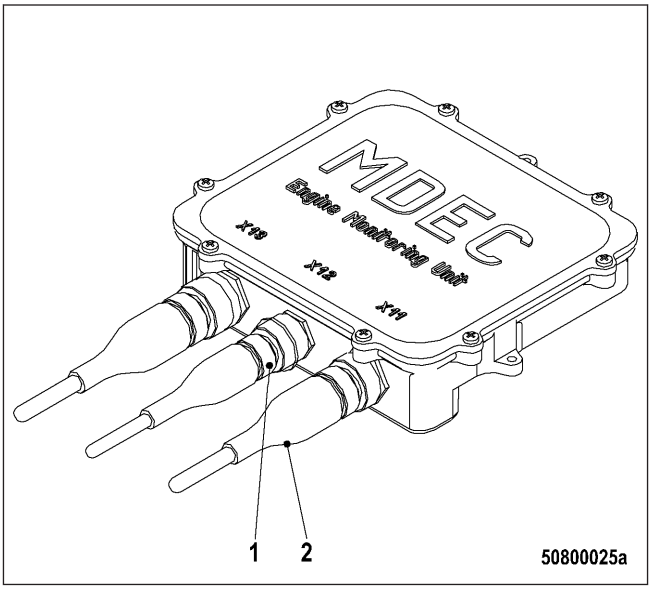
☑ Engine is stopped and starting disabled.

Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Connector pliers	0135315483	1
Isopropyl alcohol	X00058037	1

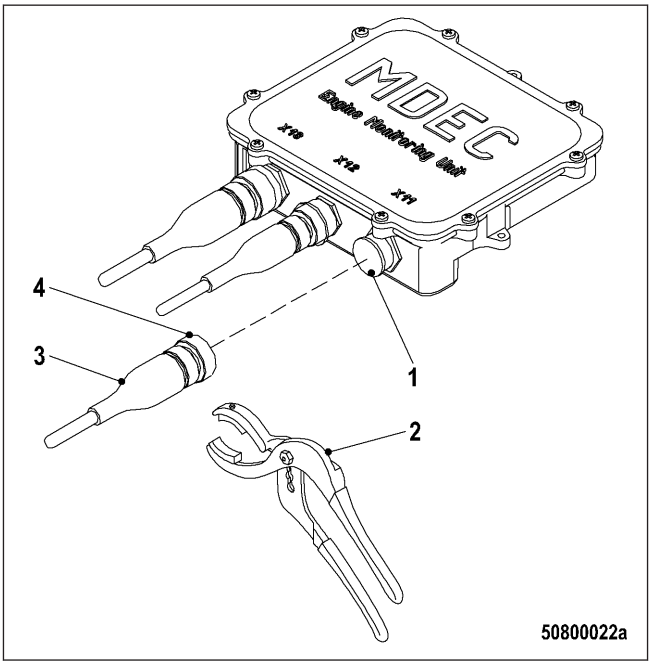
Engine monitoring unit and connectors – Cleaning

1. Remove coarse dirt from housing surface with isopropyl alcohol.
2. Remove dirt from surface of connectors (1), connector sockets and shrink sleeves (2) using a cloth moistened with isopropyl alcohol.
3. Check legibility of cable labels. Clean or replace illegible labels.



Cleaning severely contaminated EMU connectors

1. Use connector pliers (2) to disengage bayonet union nut (4) and withdraw connector (3).
2. Clean connector housings, connector socket housings (1) and all contacts with isopropyl alcohol.
3. When connectors, sockets and all contacts are dry: Fit connectors and check plug connections on EMU (→ Page 148).



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7.20.3 Checking engine control unit plug connections

Preconditions

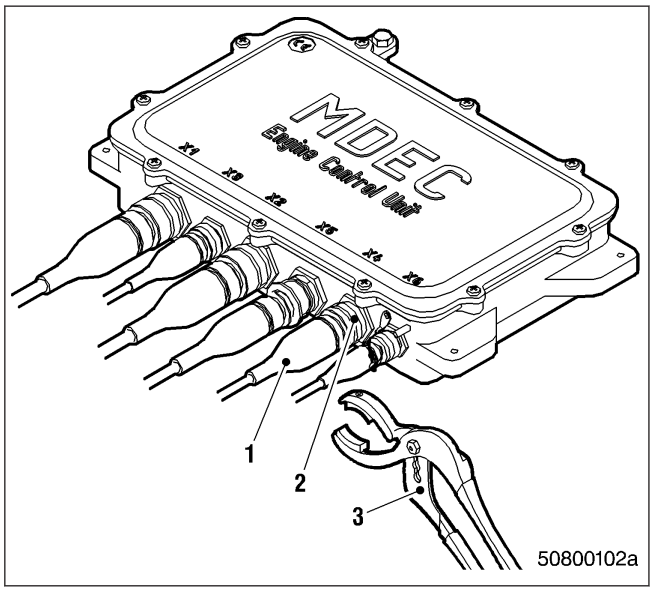
☑ Engine shut down and starting disabled.

Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Connector pliers	0135315483	1

Checking engine control unit plug connections

1. Use connector pliers (3) to make certain that all plug-in connections on engine control unit are securely seated.
2. Tighten loose bayonet couplings (2) with connector pliers (3) by turning them clockwise until they latch into place.
3. Make sure that unassigned sockets are closed off with cover caps.
4. Contact Service if bayonet union nut is defective.



7.20.4 Engine monitoring unit – Plug connection check

Preconditions

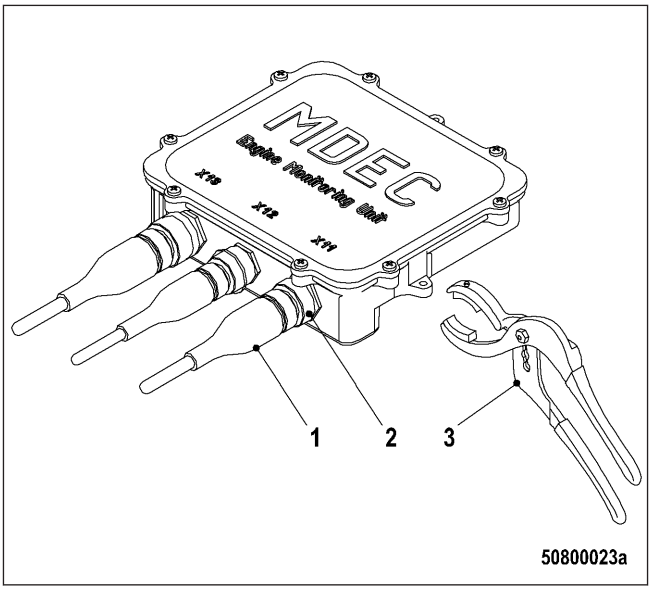
☑ Engine is stopped and starting disabled.

Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Connector pliers	0135315483	1

Checking engine monitoring unit plug connections

1. Use connector pliers (3) to make certain that all engine monitoring unit plug connections are securely seated.
2. Tighten loose bayonet union nuts (2) with connector pliers (3) by turning them clockwise until they lock into place.
3. Make sure that unassigned sockets are closed off with cover caps.
4. If bayonet couplings are defective, contact Service.



7.20.5 Engine control unit – Removal and installation

Preconditions

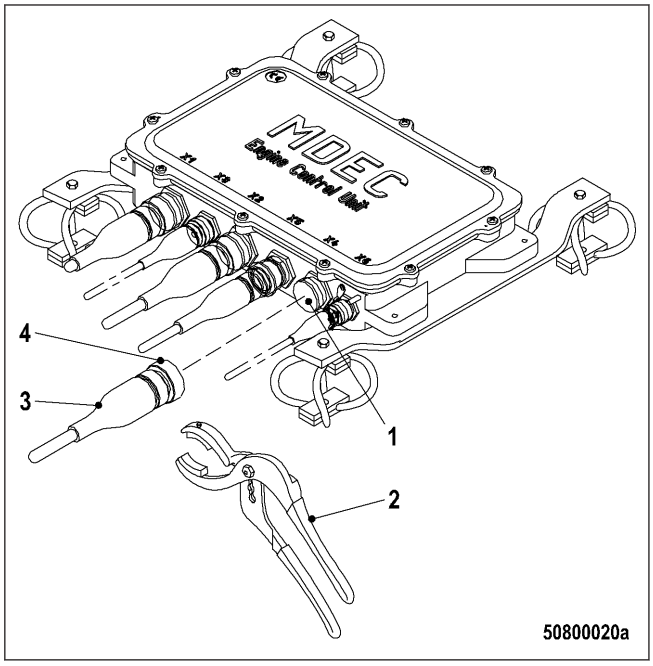
☑ Engine is stopped and starting disabled.

Special tools, Material, Spare parts

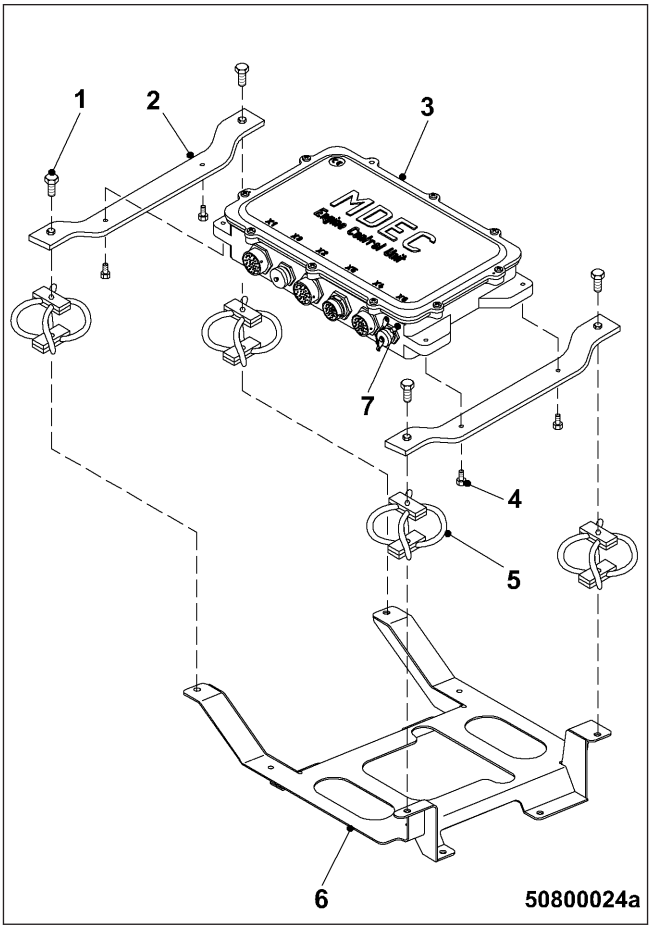
Designation / Use	Part No.	Qty.
Connector pliers	0135315483	1
Covering caps for Cannon sockets		

Removing control unit from engine

1. Note or mark assignment of cables to connector sockets.
2. Use connector pliers (2) to disengage the bayonet union nuts (4) of the connectors (3) by turning them counterclockwise.
3. Remove all connectors.
4. Close connector sockets with appropriate covering caps (1).



5. Disconnect ground strap from engine control unit grounding stud (7).
6. If the screws (4) are easily accessible:
   1. Remove screws (4).
   2. Remove engine control unit housing (3) from mounting plates (2).
   3. Unscrew mounting plates (2), cable shock absorbers (5) and further fastening parts (6) as one unit from engine.
7. If the screws (4) are not easily accessible:
   1. Unscrew screws (1).
   2. Remove engine control unit housing (3) together with mounting plates (2).
   3. Unscrew cable shock absorbers (5) and further fastening parts (6) as one unit from engine.



Installing engine control unit on engine

1. Install in reverse order. Ensure correct assignment of plugs and sockets.
2. Use connector pliers to turn the bayonet union nuts of the connectors clockwise until they lock into place.

7.21 Emergency Instrumentation (Local Operating Panel)

7.21.1 LOP – Visual inspection

Preconditions

☑ Engine is stopped and starting disabled.

Preparatory steps

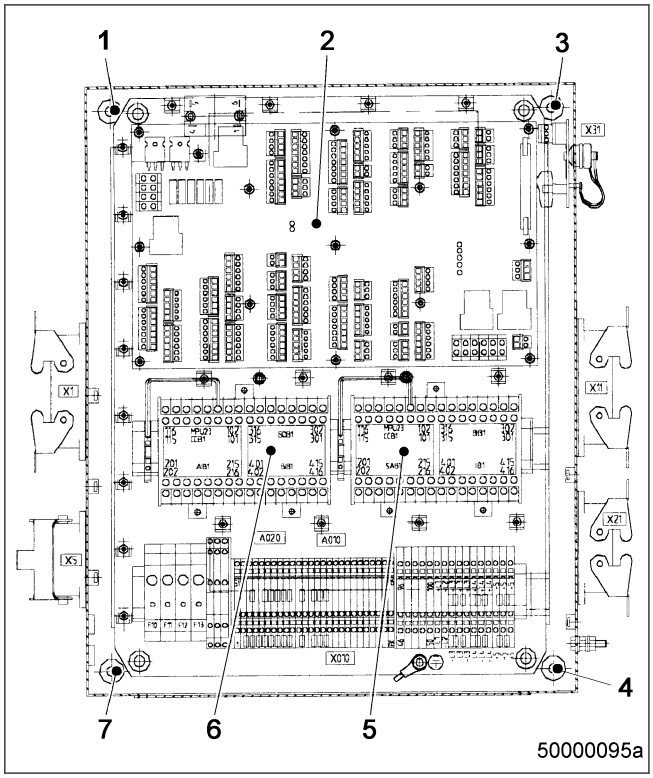
1. If READY FOR OPERATION pushbutton is illuminated brightly, press switch briefly.

Result: READY FOR OPERATION pushbutton returns to basic brightness.

2. Switch master power switch to OFF.
3. Disconnect battery in accordance with battery manufacturer's instructions.

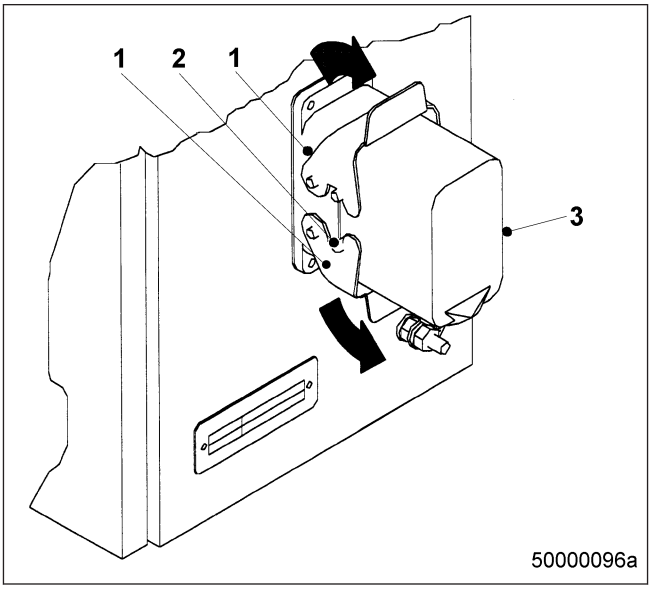
Checking housing and internal assemblies for secure seating

1. Open LOP front door.
2. Check securing screws (1, 3, 4, 7) for firm seating. Tighten loose threaded connections.
3. Check internal assemblies for firm seating, this applies in particular to printed circuit board (2) and PIMs (5, 6). Tighten loose threaded connections.
4. Close LOP front door.



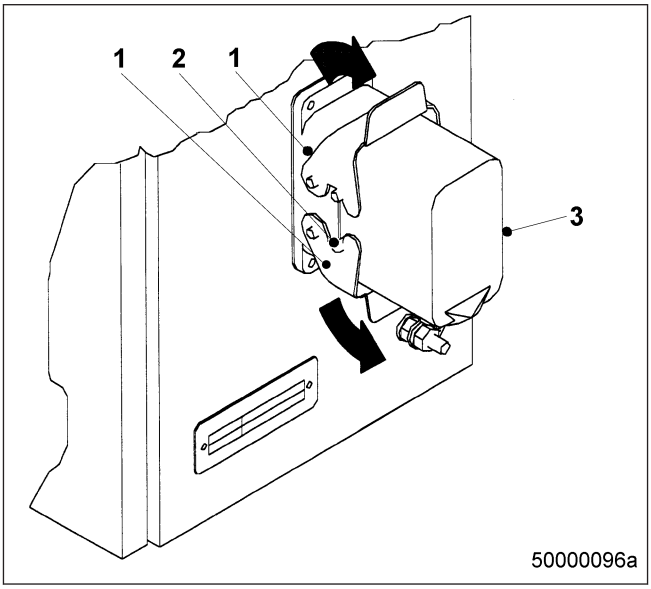
Checking threaded connections

1. Check all connected cables to verify that the two securing elements (1) are engaged on the lugs (2) so that the respective male connector (3) is held firmly in place in the socket.
2. If this is not the case, press the securing elements (1) concerned in the direction of the arrow until they engage noticeably.



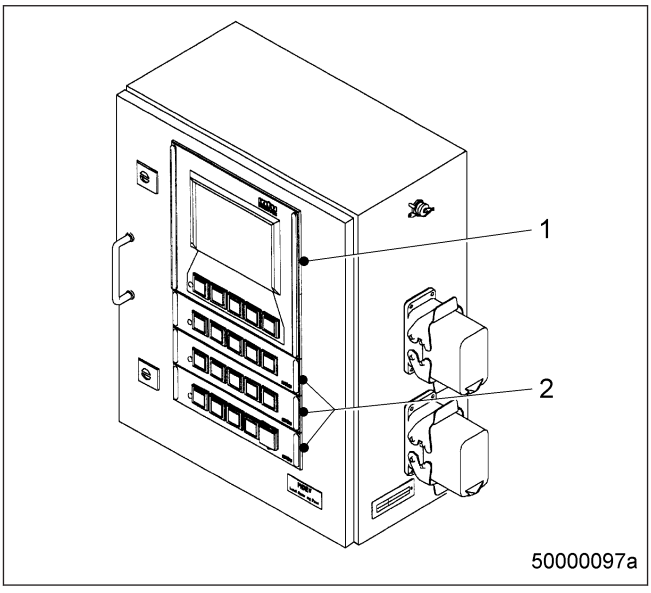
Checking unassigned connector sockets

1. Ensure that non-assigned connector sockets are protected with covering caps.
2. Make certain that the two securing elements (1) are engaged in the lugs (2) so that the covering cap (3) is held firmly in place in the socket.
3. If this is not the case, press the securing elements (1) concerned in the direction of the arrow until they engage noticeably.



Checking pushbuttons and display

1. Pushbuttons: Ensure that
   - Pushbutton caps are not damaged (cracks or similar damage)
   - Pushbuttons move easily
   - Pushbutton housings are seated securely
   - Seals (2) between PAN control panels and LOP housing are not damaged.
2. Display: Ensure that
   - Front glass is not damaged or pressed in
   - Seal (1) between display housing and LOP housing is not damaged.
3. Have damaged components replaced immediately by Service.



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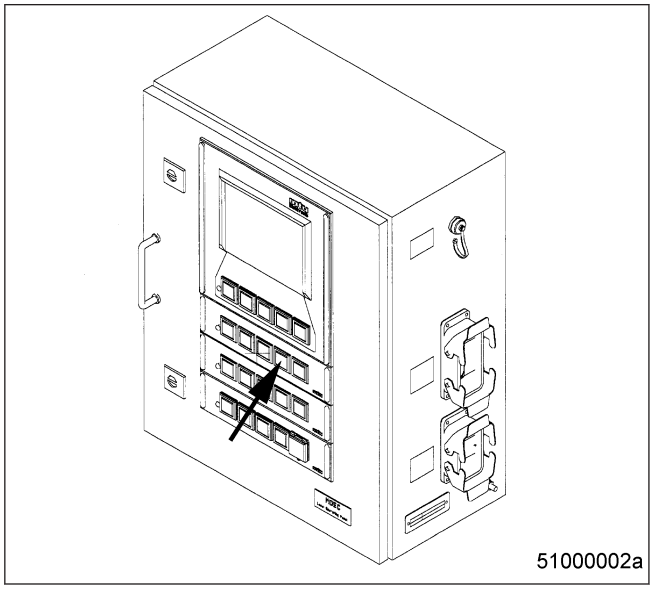
Performing lamp test

1. Connect battery in accordance with battery manufacturer's instructions.
2. Switch master power switch to ON.
3. Switch on engine control system.
4. Hold down LAMP TEST pushbutton:

Result: Indicators and controls light up.

5. Have damaged lamps immediately replaced by Service.



7.21.2 LOP – Test procedures

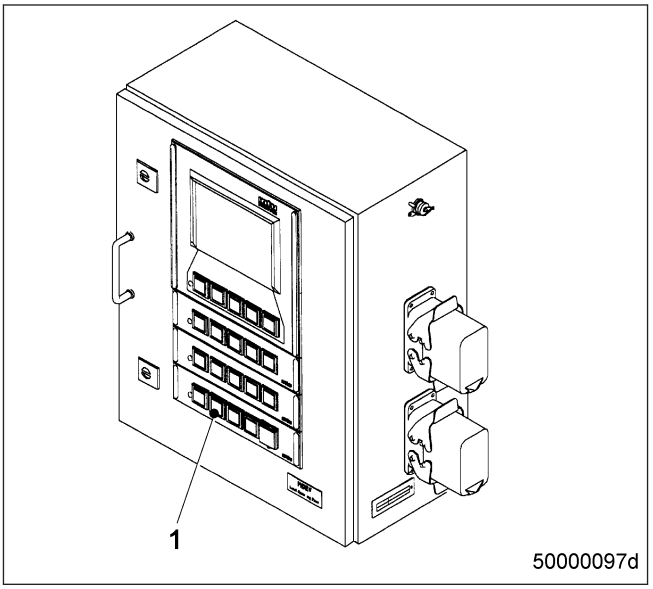
Preconditions

☑ Engine is stopped and starting disabled.

Preparatory steps

1. Connect battery in accordance with battery manufacturer's instructions.
2. Switch master power switch to ON.
3. Switch on engine management system ECS-5.

Result:
- LOCAL OPERATION pushbutton (1) is illuminated brightly (local control mode is active);.



Switching between Local and Remote mode (automatic on-board network)

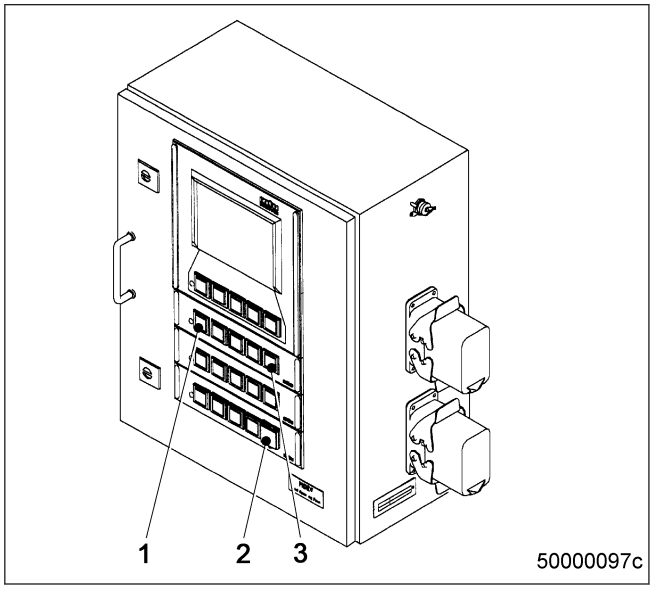
1. Press LOCAL OPERATION pushbutton (1).

Result:
- LOCAL OPERATION pushbutton (1) flashes: Setting does not correspond with feedback signal from Engine Control Unit.
- LOCAL OPERATION pushbutton (1) is illuminated at basic brightness: Remote mode active.

2. Press LOCAL OPERATION pushbutton (1) again.

Result: LOCAL OPERATION pushbutton (1) is illuminated brightly (Local mode is active);.

Overspeed test with the engine at standstill



Note: Overspeed test with the engine at standstill can only be carried out if the engine is equipped with Engine Monitoring Unit.

1. Press OVERSPEED TEST illuminated pushbutton (3). Observe speed limit and speed simulated by Engine Monitoring Unit on display.

Result:
- Engine Control Unit is de-energized by the safety system.
- Engine governing is completely deactivated.
- On engines with emergency air-shutoff flaps: Flaps close.
- EMERGENCY STOP illuminated pushbutton (2) flashes;. Alarm signalling by horn, flashing light etc. is initiated. ALARM ACKNOWLEDGE pushbutton (1) is illuminated brightly.

2. Press ALARM ACKNOWLEDGE pushbutton (1).

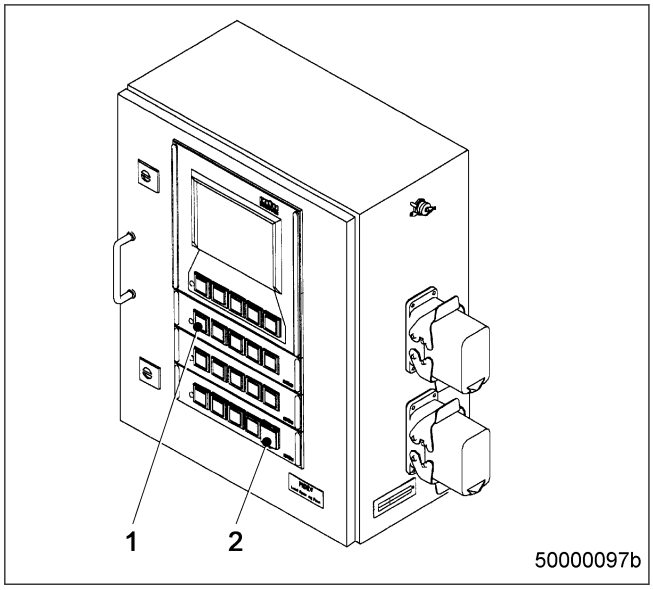
Result: Audible and visual alarm signaling stops.

3. Press ALARM ACKNOWLEDGE pushbutton (1) again.

Result: Power supply to Engine Control Unit is provided.

4. On engines with emergency air-shutoff flaps: Open flaps.

Emergency stop simulation with the engine at standstill



1. Open cap of EMERGENCY STOP pushbutton (2).
2. Press EMERGENCY STOP pushbutton (2).

Result:
- Engine Control Unit is deenergized by the safety system.
- Engine governing is completely deactivated.
- On engines with emergency air-shutoff flaps: Flaps close.
- EMERGENCY STOP pushbutton (2) flashes;. Alarm signalling by horn, flashing light etc. is initiated. ALARM ACKNOWLEDGE pushbutton (1) is illuminated brightly.

3. Press ALARM ACKNOWLEDGE pushbutton (1).

Result: Audible and visual alarm signaling stops.

4. Press ALARM ACKNOWLEDGE pushbutton (1) again.

Result: Power supply to Engine Control Unit is provided.

5. On engines with emergency air-shutoff flaps: Open flaps.

8 Engine Governor Assignment and Circuitry

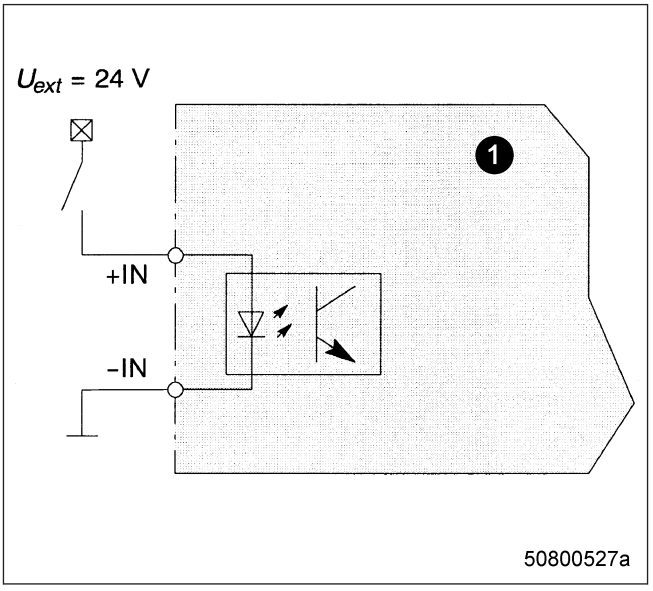
8.1 Engine Governor

8.1.1 Engine governor channel circuitry

Engine governor channel circuitry

Binary inputs BE1 to BE9

1 Engine Control Unit ECU 4



Function

Function	Source
Acquisition of binary signals.	Switches, pushbuttons, monitors, contacts.

Channel specification

Type	Isolated binary input, external supply.
Input signal	U_{In}(high) = 24 V (min. 8 V). U_{In}(low) = 0 V (max. 4 V).

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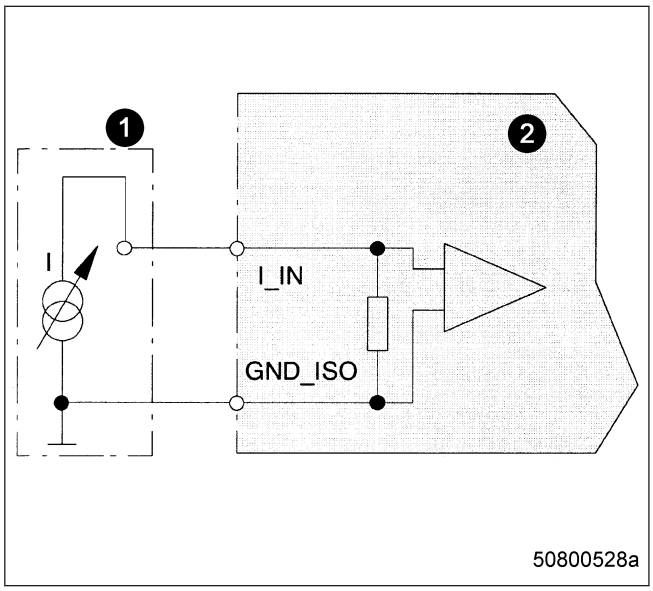
Current input IUE 1

1 Current source, voltage source
2 Engine Control Unit ECU 4



Function

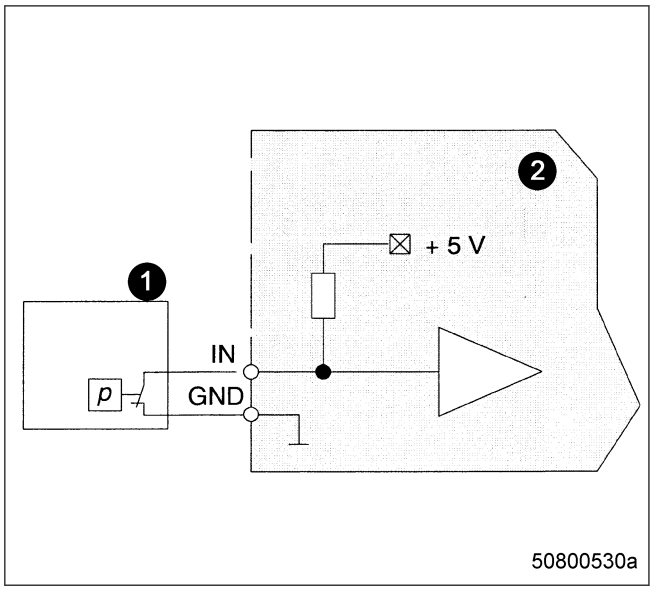
Function	Source
Acquisition of a current signal (4 to 20 mA).	-

Measuring channel specification

Measuring range	I_{In} = 4 to 20 mA; Load: At 20 mA approx. 4 V; isolated. Or: UIn = 0 to 10 V

Binary sensor input NSE 1

1 Monitor contact
2 Engine Control Unit ECU 4

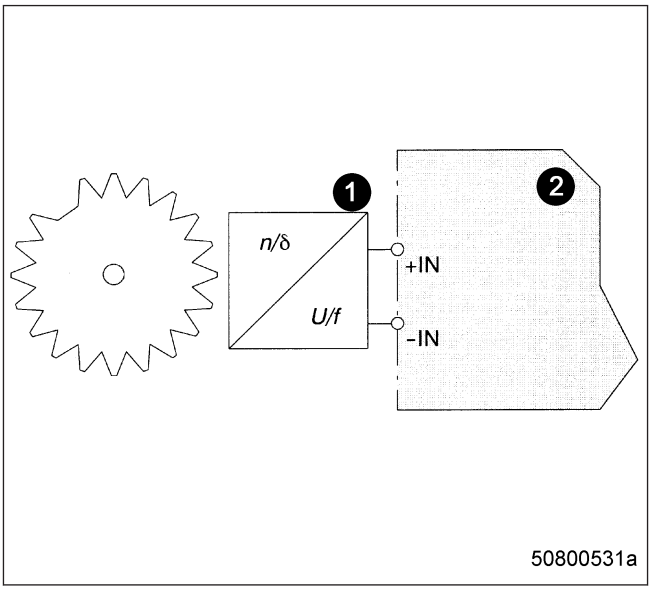


Function

Function	Source
Lube oil differential pressure monitoring.	Lube oil differential pressure monitor

Pulse measuring inputs KW 1 and NW 1

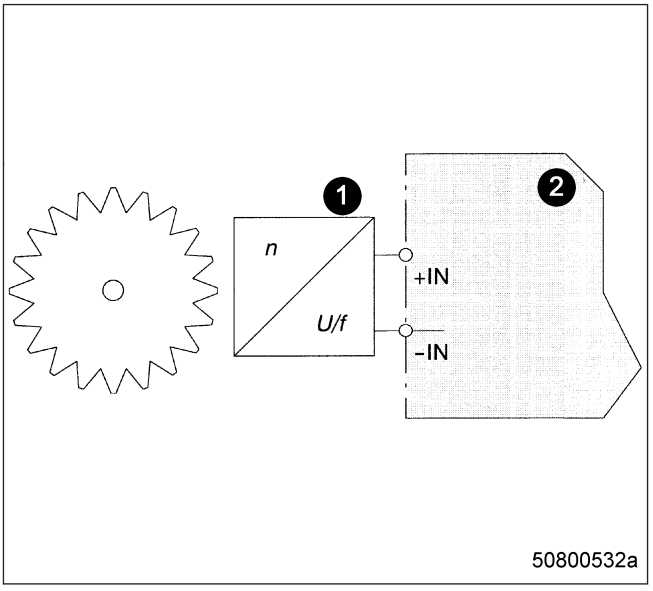
1 Inductive sensor
2 Engine Control Unit ECU 4



Channel	Function	Sensor
KW1	Measuring of crankshaft angle and crankshaft speed.	Inductive sensor
NW1	Measuring of camshaft angle and camshaft speed.	Inductive sensor

Speed measuring input DME 1, DME 2

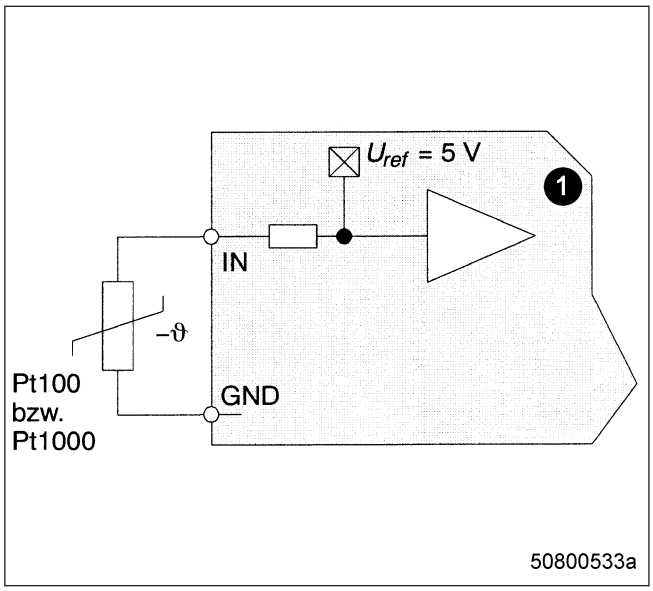
1 Inductive sensor
2 Engine Control Unit ECU 4



Function	Sensor
Measuring of speeds (e.g. ETC).	Inductive sensor

Temperature inputs TE 1 to TE 9

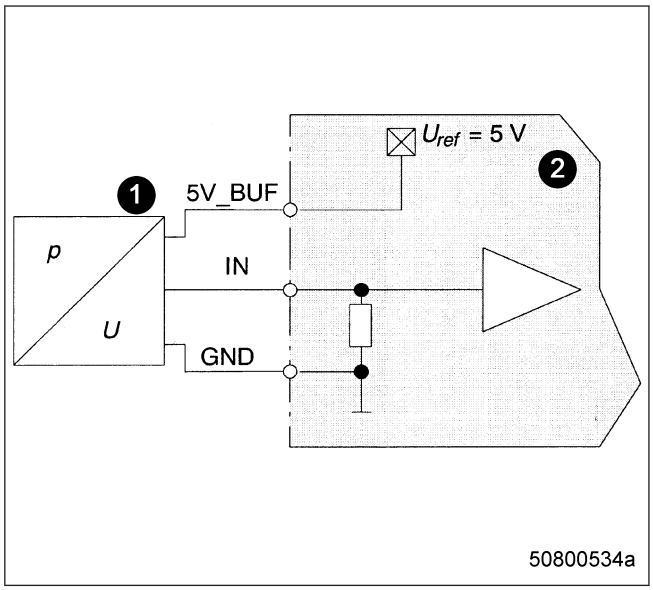
1 Engine Control Unit ECU 4



Function	Sensor
Temperature measuring	Temperature-dependent resistor Pt100/Pt1000 (exhaust gas temperatures are measured with Pt100).

Pressure inputs DE 1 to DE 7

1 Pressure sensor
2 Engine Control Unit ECU 4



Function

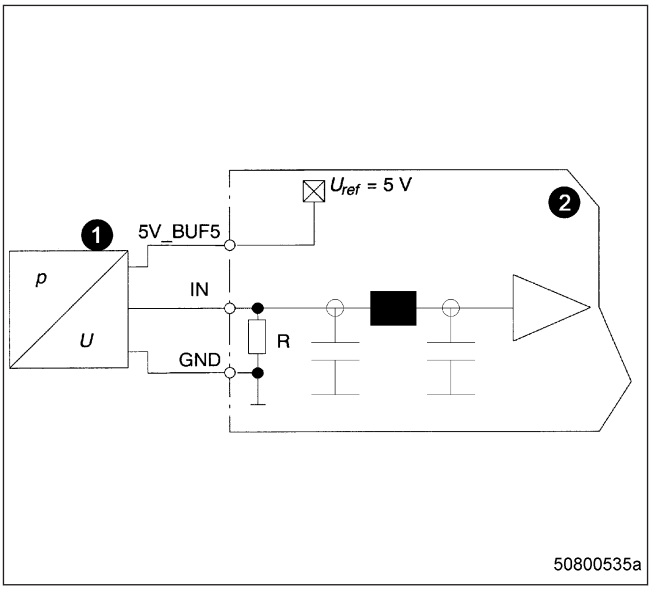
Function	Sensor
Pressure range measuring	Relative pressure sensors (exception: The charge-air pressure sensor is an absolute pressure sensor).

Measuring channel specification

Measuring range	Sensor-dependent
Output signal U_O	0.5 to 4.5 VDC
Sensor supply	5 V ± 250 mV

Pressure measuring input HP pump DEH (rail pressure)

1 Pressure sensor
2 Engine Control Unit ECU 4



Function

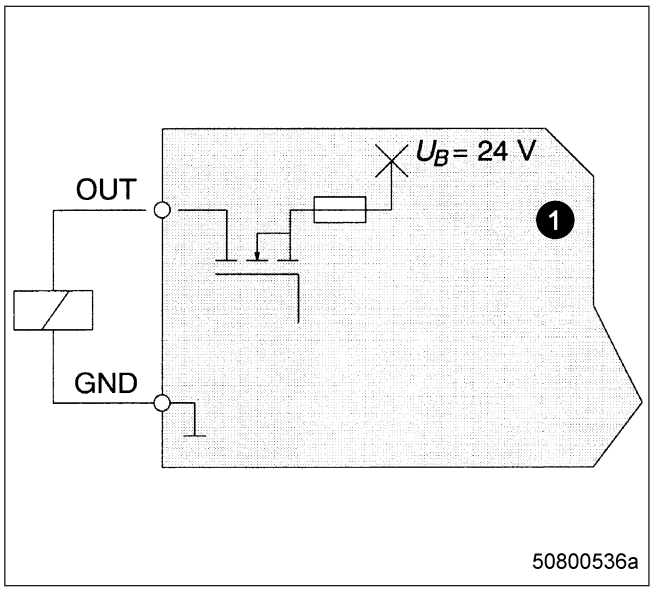
Function	Sensor
Pressure measuring	Relative pressure sensor

Measuring channel specification

Measuring range	Sensor-dependent
Output signal U_O	0.5 to 4.5 VDC
Sensor supply	5 V ± 250 mV

Transistor outputs TAA 1 to TAA 6

1 Engine Control Unit ECU 4



Function

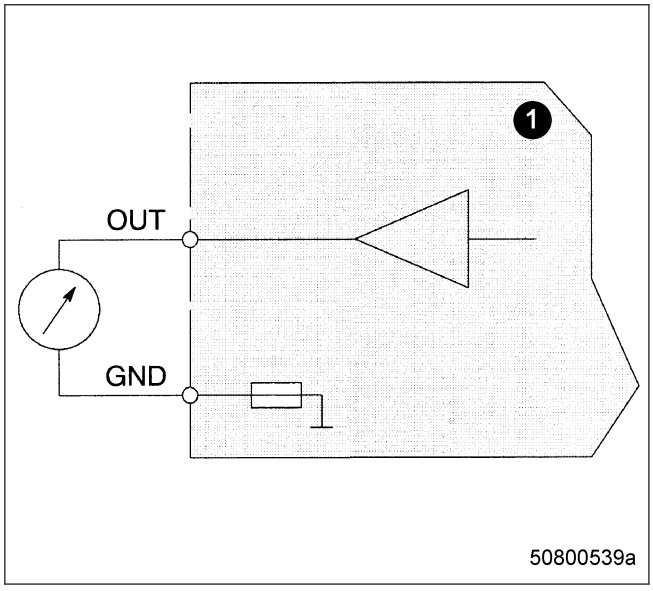
Function	Sensor
Switching output	Plant

Channel specification

Channel	TAA1 to TAA6 positive-switching 24 VDC.
Output current	TAA1 to TAA4: I_O = 150 mA max. TAA5: I_O = 300 mA max. TAA6: I_O = 1 A max.

Voltage outputs UA 1 to UA 4

1 Engine Control Unit ECU 4



Function

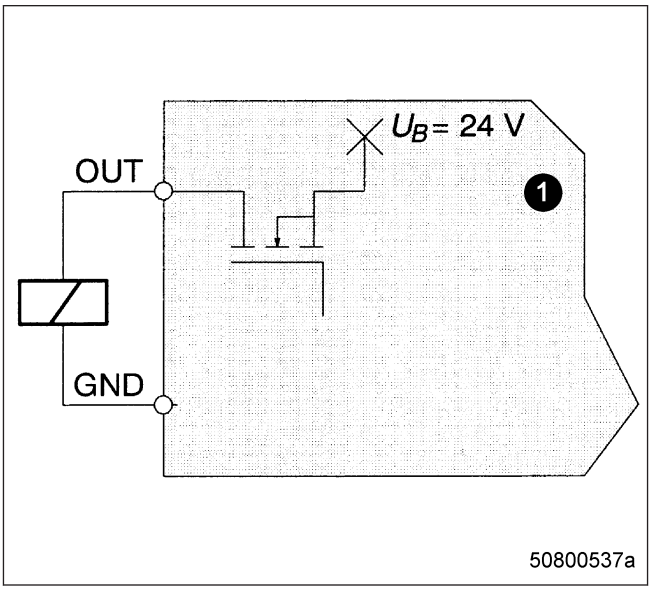
Function	Sensor
Output voltage 0 to 10 V, e.g. for display instruments	Plant

Channel specification

Output voltage	U_O = 0 to 10 V
Output current	I_O = 5 mA max.

Transistor outputs TAM 1 to TAM 4

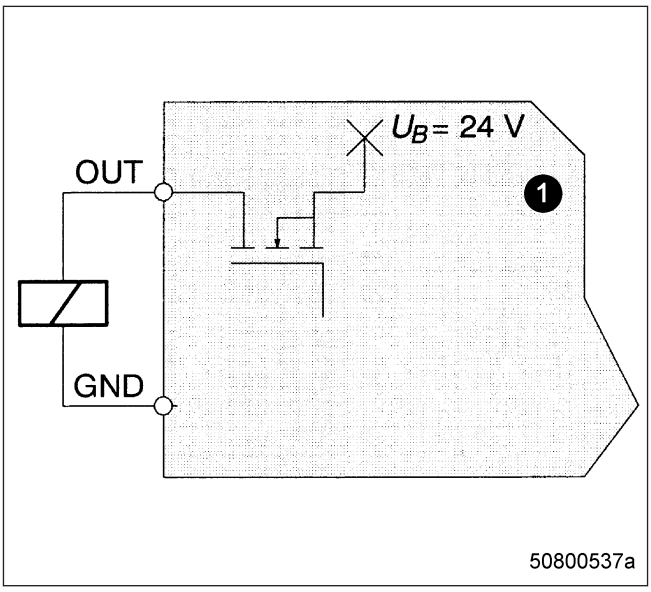
1 Engine Control Unit ECU 4



Function	Sensor
Switching output	Engine

PWM output PDM 2

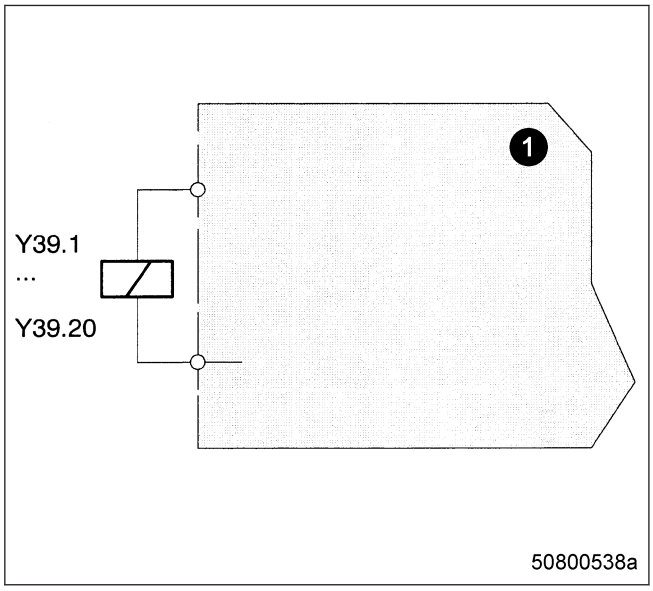
1 Engine Control Unit ECU 4



Function	Sensor
Switching output	Engine

Solenoid valve outputs MVA 1 to MVA 20

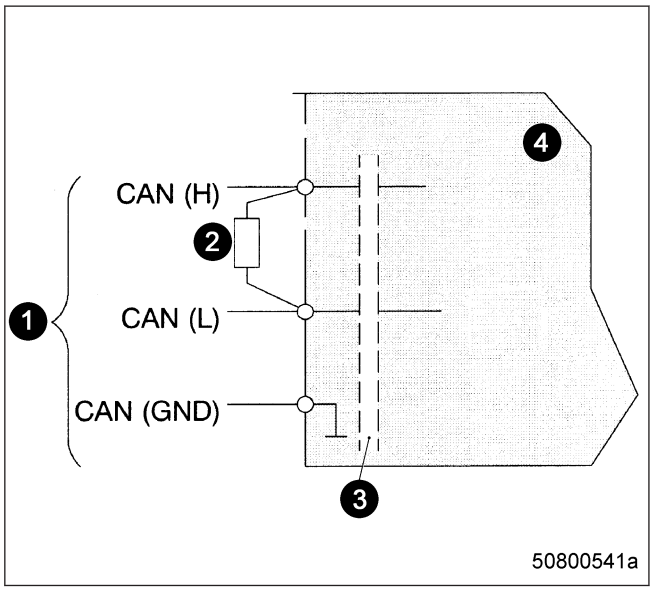
1 Engine Control Unit ECU 4



Function	Sensor
Injector control	Injection solenoid valve

CAN bus interface

1 CAN bus
2 Terminator
3 Electrical isolation
4 Engine Control Unit ECU 4



Function

Channel	Function	Target
CAN1 / CAN2	Bus connection to external systems.	MCS

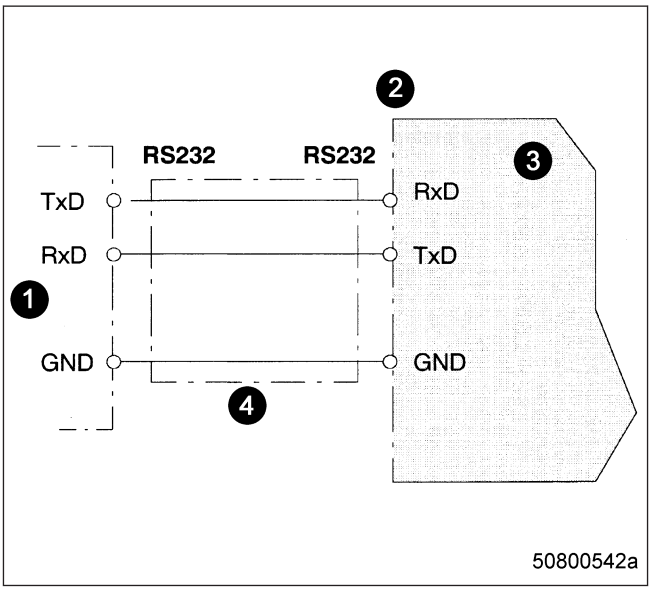
Channel specification

Physical level	ISO 11 898
CAN specification	Version 2.0 A
Data format	MTU-specific
Terminator	In connector (no bus disruption when connector disconnected)
Baud rate	125 kbaud
Electrical isolation	± 50 V

The CAN bus interfaces operate independently of each other.

Serial interface RS232

1 Dialog unit
2 Connector XC6
3 Engine Control Unit ECU 4
4 Dialog cable



Channel	Function	Target
RS232	Serial interface for data transmission between dialog unit and engine governor.	Dialog unit

8.1.2 MDEC governor assignment

Scope of delivery

Included in the scope of delivery are:
- SAM
- W004 MDEC connector X1 10 m long (15 m and 25 m available as an option).
- W003 (4x2.5 mm^2) MDEC connector X5 (15 m and 25 m available as an option).

The MDEC governor is protected by a 20 A automatic cutout via cable W003 connector X5.

The PIM modules are wired to a separate 10 A fuse (see MTU wiring diagram).

All control, display and communication signals are in interface cable W004 MDEC connector X1.

CAN 1 is transmitted to the PIM module(s) via conductors 48, 49, 50 and CAN 2 via conductors 51, 52, 53.

A 121 ohm CAN bus terminal resistor must be installed for CAN 1 and CAN 2 respectively at the last PIM module.

Terminal resistors for the MDEC governor are already fitted in cable W004 connector X1.

Digital MDEC inputs/outputs

Inputs

Observe input polarity.

BE1 Stop input	This input is inverted (line-break protected), i e 24 V DC must always be applied to BE1 for engine operation.
BE2 Cylinder cutout	The cylinder cutout function is deactivated via this input.
BE3 SISY override	Activating BE8 suppresses all VDS operation shut-down messages such as “Lube oil pressure too low”. The corresponding outputs such as Com-bined alarm red are still set.
BE4 Fixed speed	The fixed speed function is activated via this input.
BE5 Speed up	Binary input for speed up.
BE6 Speed down	Binary input for speed down.
BE7 Speed droop 2 / desired speed setting	Speed droop can be switched via this input with the engine running/at a standstill. Default speed droop setting in the governor: • 1 = 4% • 2 = 0%
BE8	Not used.
BE9	Not used.

Outputs

Observe max. output current-carrying capacity.

TAA1 Emergency stop	Transistor output for emergency stop.
TAA2 Automatic engine stop	Transistor output for automatic engine stop.

TAA3 Combined alarm	All warning messages (Limit1) are indicated here as a combined alarm.
TAA4 n > 300	Indication of engine speed > 300 rpm.
TAA5 SS T-coolant	Shutdown, coolant temperature too high.
TAA6 SS P-lube oil	Shutdown, lube oil pressure too low.

Analog MDEC inputs

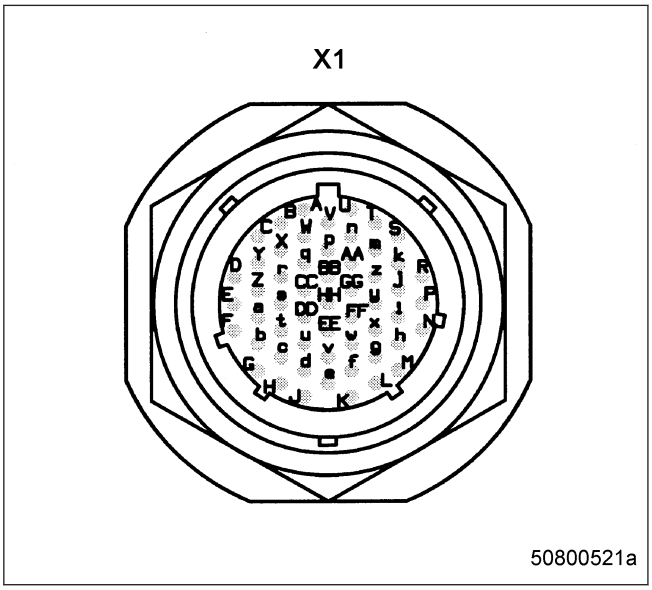
IEU1 = 0 to 10 V or 4 to 20 mA	It is possible to activate different analog desired speed settings for the MDEC governor. Default setting: • Characteristic curve 71 (50 Hz) in MDEC governor 0 to 10 V activated. Parameterized desired speed setting 4 to 20 mA must be changed if desired. Same applies to characteristic curve 72 (60 Hz).

8.2 Connector Assignment

8.2.1 Connector pin assignment

Connector pin assignment

Connector X1, view to socket



Connector X1

Connector type	VPT 06 GSE 22–55 P
Target	Plant wiring harness

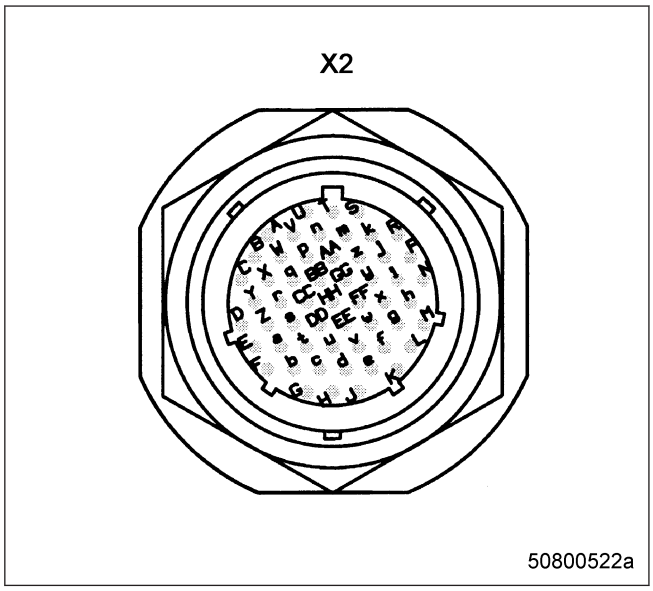
Pin assignment

Channel	Signal	Pin	Comments
IUE1	5V_ISO	BB	5 V / 20 mA electrically isolated
IUE1	U_IN	AA	0 V to 10 V
IUE1	I_IN	X	0 V to 23.7 mA
IUE1	GND_ISO	q	
IUE2	5V_ISO	b	5 V / 20 mA electrically isolated
IUE2	U_IN	r	0 V to 10 V
IUE2	I_IN	A	0 V to 23.7 mA
IUE2	GND_ISO	W	
UA1	OUT	HH	0 V to 10 V/ 8 mA
UA1	GND	GG	
UA2	OUT	DD	0 V to 10 V/ 8 mA
UA2	GND	CC	
UA3	OUT	t	0 V to 10 V/ 8 mA
UA3	GND	s	

Channel	Signal	Pin	Comments
UA4	OUT	Z	0 V to 10 V/ 8 mA
UA4	GND	Y	
BE1	+IN	h	U < 4 V = low / U > 8 V = high
BE1	-IN	g	Electrically isolated
BE2	+IN	x	U < 4 V = low / U > 8 V = high
BE2	-IN	w	Electrically isolated
BE3	+IN	R	U < 4 V = low / U > 8 V = high
BE3	-IN	P	Electrically isolated
BE4	+IN	j	U < 4 V = low / U > 8 V = high
BE4	-IN	i	Electrically isolated
BE5	+IN	FF	U < 4 V = low / U > 8 V = high
BE5	-IN	EE	Electrically isolated
BE6	+IN	v	U < 4 V = low / U > 8 V = high
BE6	-IN	u	Electrically isolated
BE7	+IN	f	U < 4 V = low / U > 8 V = high
BE7	-IN	e	Electrically isolated
BE8	+IN	d	U < 4 V = low / U > 8 V = high
BE8	-IN	c	Electrically isolated
BE9	+IN	N	U < 4 V = low / U > 8 V = high
BE9	-IN	M	Electrically isolated
FE1	GND	J	U < 1.5 V = low / U > 3.5 V = high
FE1	IN	H	Frequency input
TAA1	GND	V	24 V / 600 mA
TAA1	GND	U	
TAA2	OUT	p	24 V / 600 mA
TAA2	GND	n	
TAA3	OUT	T	24 V / 600 mA
TAA3	GND	S	
TAA4	OUT	z	24 V / 600 mA
TAA4	GND	y	
TAA5	OUT	m	24 V / 600 mA
TAA5	GND	k	
TAA6	OUT	L	24 V / 2 A

Channel	Signal	Pin	Comments
TAA6	GND	K	(Plant supply, coil instruments FZ)
CAN1	HIGH	G	Electrically isolated
CAN1	LOW	F	
CAN1	GND	E	
CAN2	HIGH	C	Electrically isolated
CAN2	LOW	B	
CAN2	GND	D	

Connector X2, view to socket



Connector X2

Connector type	VPT 06 GSE 22–55 PW
Target	Engine wiring harness

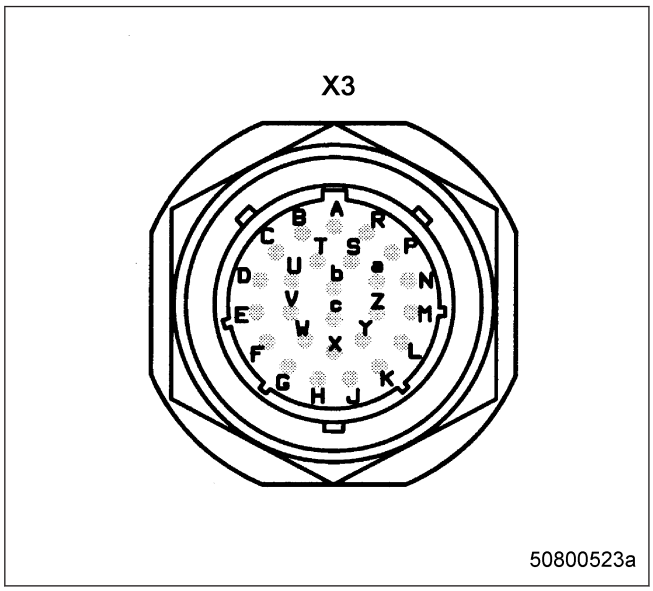
Pin assignment

Channel	Signal	Pin	Comments
TE1	IN	k	0 V to 5 V/ internal 2 k0 pullup to 5 V_TE_BUF
TE1	GND	z	
TE2	IN	N	0 V to 5 V/ internal 2 k0 pullup to 5 V_TE_BUF
TE2	GND	P	
TE5	IN	M	0 V to 5 V/ internal 2 k0 pullup to 5 V_TE_BUF
TE5	GND	g	
TE6	IN	y	0 V to 5 V/ internal 2 k0 pullup to 5 V_TE_BUF
TE6	GND	FF	

Channel	Signal	Pin	Comments
TE7	IN	w	0 V to 5 V/ internal 2 k0 pullup to 5 V_TE_BUF
TE7	GND	x	
TE8	IN	t	0 V to 5 V/ internal 2 k0 pullup to 5 V_TE_BUF
TE8	GND	a	
TE9	IN	E	0 V to 5 V/ internal 2 k0 pullup to 5 V_TE_BUF
TE9	GND	F	
DE1	5 V_BUF1	D	5 V / 20 mA
DE1	IN	Z	0 V to 5 V / internal 47k5 pulldown
DE1	GND	Y	
DE2	5 V_BUF1	r	5 V / 20 mA
DE2	IN	s	0 V to 5 V / internal 47k5 pulldown
DE2	GND	CC	
DE3	5 V_BUF2	BB	5 V / 20 mA
DE3	IN	GG	0 V to 5 V / internal 47k5 pulldown
DE3	GND	HH	
DE4	5 V_BUF2	d	5 V / 20 mA
DE4	IN	H	0 V to 5 V / internal 47k5 pulldown
DE4	GND	J	
DE5	5 V_BUF3	f	5 V / 20 mA
DE5	IN	v	0 V to 5 V / internal 47k5 pulldown
DE5	GND	e	
DE6	5 V_BUF3	EE	5 V / 20 mA
DE6	IN	DD	0 V to 5 V / internal 47k5 pulldown
DE6	GND	u	
DE7	5 V_BUF4	c	5 V / 20 mA
DE7	IN	G	0 V to 5 V / internal 47k5 pulldown
DE7	GND	b	
NSE1	24 V_NSE1	X	Sensor supply max. 300 mA
NSE1	IN	C	0 V to 5 V/ internal 47k5 pullup to 5 V_TE_BUF
NSE1	GND	B	
NSE2	24 V_NSE2	W	Sensor supply max. 300 mA

Channel	Signal	Pin	Comments
NSE2	IN	q	0 V to 5 V/ internal 47k5 pullup to 5 V_TE_BUF
NSE2	GND	V	
KW	+IN	m	U < 0 V = low / U > 400 mV = high
KW	-IN	S	
NW	+IN	T	U < 0 V = low / U > 400 mV = high
NW	-IN	n	
DME1	+IN	p	U < -400 mV = low / U > 400 mV = high
DME1	-IN	AA	
DME2	+IN	A	U < -400 mV = low / U > 400 mV = high
DME2	-IN	U	
PDM1	OUT	K	24 V / 3 A
PDM1	GND	L	
TAM1	OUT	R	24 V / 1.5 A
TAM1	GND	j	
TAM2	OUT	h	24 V / 1.5A
TAM2	GND	i	

Connector X3, view to socket



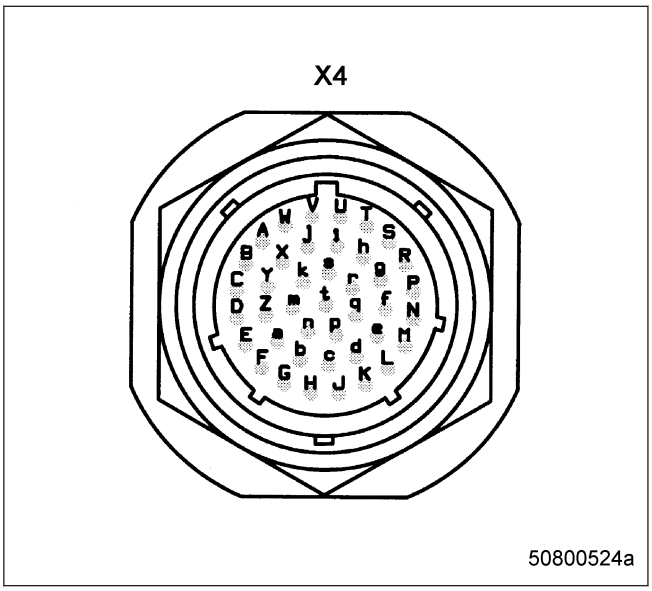
Connector X3

Connector type	VPT 06 GSE 16–26 P
Target	Engine wiring harness

Pin assignment

Channel	Signal	Pin	Comments
TE3	IN	b	0 V to 5 V/ internal 2 k0 pullup to 5 V_TE_BUF
TE3	GND	c	
TE4	IN	U	0 V to 5 V/ internal 2 k0 pullup to 5 V_TE_BUF
TE4	GND	V	
TE10	IN	E	0 V to 5 V/ internal 2 k0 pullup to 5 V_TE_BUF
TE10	GND	D	
DE8	5 V_BUF4	J	5 V / 20 mA
DE8	IN	Y	0 V to 5 V / internal 47k5 pulldown
DE8	GND	K	
DEH	5 V_BUF5	B	5 V / 20 mA
DEH	IN	T	0 V to 5 V / internal 47k5 pulldown/ TP2:20 Hz
DEH	GND	C	
NSE3	24 V_NSE3	A	Sensor supply max. 300 mA
NSE3	IN	R	0 V to 5 V/ internal 47k5 pullup to 5 V_TE_BUF
NSE3	GND	S	
PDM2	OUT	M	24 V / 3 A
PDM2	GND	N	
TAM3	OUT	L	24 V / 1.5 A
TAM3	GND	Z	
TAM4	OUT	P	24 V / 1.5 A
TAM4	GND	a	
EDM	TXD	X	RS232
EDM	RXD	H	RS232
EDM	GND	F	RS232
TA_EDM	24 V_OUT	G	EDM - supply / 2 A
TA_EDM	GND	W	

Connector X4, view to socket



Connector X4

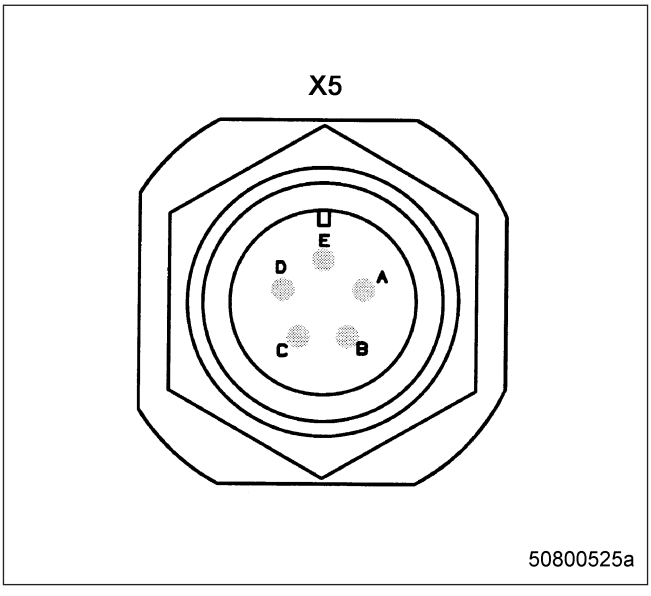
Connector type	VPT 06 GSE 21–41 PW
Target	Engine wiring harness (solenoid valves)

Pin assignment

Channel	Signal	Pin	Comments
MV1	HIGH	n	24 V / 20 A
MV1	LOW	m	Bank 1
MV2	HIGH	D	24 V / 20 A
MV2	LOW	C	Bank 1
MV3	HIGH	F	24 V / 20 A
MV3	LOW	E	Bank 1
MV4	HIGH	a	24 V / 20 A
MV4	LOW	Z	Bank 1
MV5	HIGH	H	24 V / 20 A
MV5	LOW	G	Bank 1
MV6	HIGH	s	24 V / 20 A
MV6	LOW	r	Bank 1
MV7	HIGH	Y	24 V / 20 A
MV7	LOW	X	Bank 1
MV8	HIGH	W	24 V / 20 A
MV8	LOW	V	Bank 1
MV9	HIGH	k	24 V / 20 A
MV9	LOW	j	Bank 1
MV10	HIGH	B	24 V / 20 A
MV10	LOW	A	Bank 1
MV11	HIGH	S	24 V / 20 A

Channel	Signal	Pin	Comments
MV11	LOW	R	Bank 2
MV12	HIGH	P	24 V / 20 A
MV12	LOW	N	Bank 2
MV13	HIGH	i	24 V / 20 A
MV13	LOW	h	Bank 2
MV14	HIGH	g	24 V / 20 A
MV14	LOW	f	Bank 2
MV15	HIGH	U	24 V / 20 A
MV15	LOW	T	Bank 2
MV16	HIGH	K	24 V / 20 A
MV16	LOW	J	Bank 2
MV17	HIGH	M	24 V / 20 A
MV17	LOW	L	Bank 2
MV18	HIGH	e	24 V / 20 A
MV18	LOW	d	Bank 2
MV19	HIGH	c	24 V / 20 A
MV19	LOW	b	Bank 2
MV20	HIGH	q	24 V / 20 A
MV20	LOW	p	Bank 2

Connector X5, view to socket



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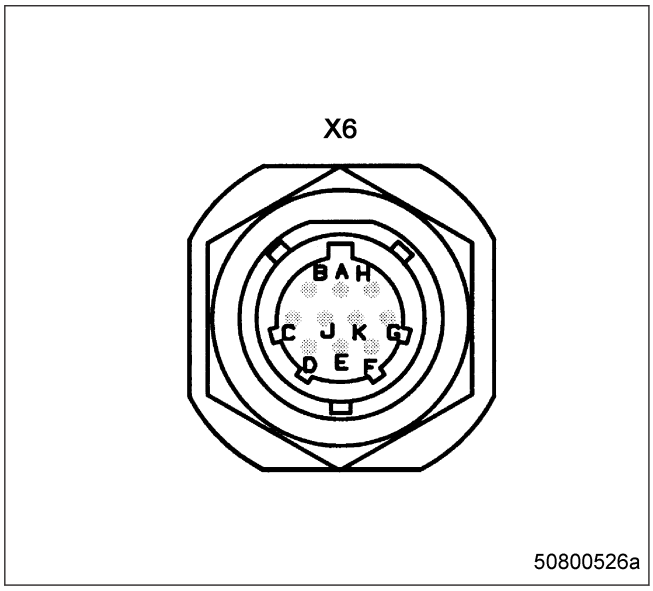
Connector X5

Connector type	CIR 06 G2 – 18 – 11 S
Target	Plant wiring harness (power supply)

Pin assignment

Channel	Signal	Pin	Comments
POWER	+24 V	A	U_{supp} = 24 V / 30 A
POWER	+24 V	D	
POWER	GND	B	
POWER	GND	C	
POWER	GND	E	

Connector X6, view to socket



Connector X6

Connector type	VPT 06 GSE 12-10 P
Target	Dialog unit

Pin assignment

Channel	Signal	Pin	Comments
POWER	+24 V	A	U_{supp} = 24 V / 30 A
POWER	+24 V	D	
POWER	GND	B	
POWER	GND	C	
POWER	GND	E	

9 Appendix A

9.1 Abbreviations

Abbreviation	Meaning	Explanation
A/D	Analog/Digital	Transformer: transforms sensor voltages into numeric values
ADEC	Advanced Diesel Engine Controller	Engine management system
AFRS	Air Filter Restriction Sensor	
ANSI	American National Standards Institute	Association of American standardization organizations
ATL	Abgasturbolader	Exhust turbocharger (ETC)
ATS	Air Temperature Sensor	
BR	Baureihe	Series
BV	Betriebsstoffvorschrift	MTU Fluids and Lubricants Specifications, publication No. A01061/..
CAN	Controller Area Network	Data bus system, bus standard
CDC	Calibration Drift Compensation	Setting of drift compensation in engine governor with DiaSys
CEL	Stop engine light	1st function: Warning lamp (rectify fault as soon as possible) 2nd function: Read out fault codes
CKT	Circuit	
CLS	Coolant level sensor	
CPS	Coolant pressure sensor	
CTS	Coolant temperature sensor	
DDEC	Detroit Diesel Electronic Controls	Engine control system made by Detroit Diesel
DDL	Diagnostic Data Link	
DDR	Diagnostic Data Reader	
DIN	Deutsches Institut für Normung e. V.	At the same time identifier of German standards (DIN = “Deutsche Industrie-Norm”)
DL	Default Lost	Alarm: Default CAN bus failure
DOC	Diesel Oxidation Catalyst	Oxidation catalyst upstream of the diesel particulate filter
DPF	Diesel particulate filter	
DT	Diagnostic Tool	
ECM	Electronic Control Module	Electronic control unit of the DDEC system
ECU	Engine Control Unit	Engine governor
EDM	Engine Data Module	Memory module for engine data
EEPROM	Electrically Erasable Programmable Read Only Memory	
EFPA	Electronic Foot Pedal Assembly	
EGR	Exhaust Gas Recirculation	

Abbre-viation	Meaning	Explanation
EMU	Engine Monitoring Unit	
ETK	Ersatzteilkatalog	Spare Parts Catalog (SPC)
EUI	Electronic Unit Injector	
FPS	Fuel Pressure Sensor	
FRS	Fuel Differential Pressure Sensor	
FTS	Fuel Temperature Sensor	
FWCP	Fire Water Control Panel	
GND	Ground	
HP	High pressure	
HI	High	Alarm: Measured value exceeds 1st maximum limit
HIHI	High High	Alarm: Measured value exceeds 2nd maximum limit value
HT	High Temperature	
IDM	Interface Data Module	Memory module for interface data
INJ	Injector	
ISO	International Organization for Standardi-zation	International umbrella organization for all national standardization institutes
KGS	Kraftgegenseite	Engine free end in accordance with DIN ISO 1204
KS	Kraftseite	Engine driving end in accordance with DIN ISO 1204
LED	Light Emitting Diode	
LO	Low	Alarm: Measured value lower than 1st minimum limit value
LOLO	Low Low	Alarm: Measured value lower than 2nd minimum limit value
LSG	Limiting Speed Governor	
N/A	Not Applicable	
LP	Low pressure	
OEM	Original Equipment Manufacturer	
OI	Optimized Idle	
OLS	Oil Level Sensor	
OPS	Oil pressure sensor	
OTS	Oil Temperature Sensor	
OT	Oberer Totpunkt	Top dead center (TDC)
PAN	Panel	Control panel
PIM	Peripheral Interface Module	
PWM	Modulated signal	
P-xyz	Pressure-xyz	Pressure measuring point, xyz specifies the meas-uring point designation
RL	Redundancy Lost	Alarm: Redundant CAN bus failure
SAE	Society of Automotive Engineers	U.S. standardization organization
SD	Sensor Defect	Alarm: Sensor failure

Abbre-viation	Meaning	Explanation
SEL	Stop engine light	1st function: Warning lamp (stop engine and rectify fault) 2nd function: Read out fault codes
SID	System Identifier	
SRS	Synchronous Reference Sensor	TDC cylinder 1
SS	Safety System	Safety system alarm
TBS	Turbocharger Boost Sensor	Monitors charge-air pressure
TCI	Turbo Compressor Inlet	
TCO	Turbo Compressor Outlet	
TD	Transmitter Deviation	Alarm: Deviation in transmitter values
TPS	Throttle Position Sensor	
TRS	Timing Reference Sensor	
T-xyz	Temperature-xyz	Temperature measuring point, xyz specifies the measuring point designation
UT	Unterer Totpunkt	Bottom dead center (BDC)
VNT	Variable nozzle turbine	
VSG	Variable-speed governor	
VSS	Vehicle Speed Sensor	
WZK	Werkzeugkatalog	Tool Catalog

9.2 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 at Headquarters: Service-support@mtu-online.com

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

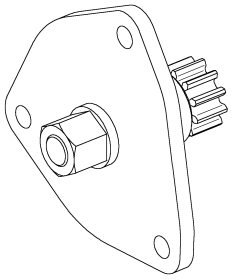
Phone: +49 7541 908555

Fax: +49 7541 908121

10 Appendix B

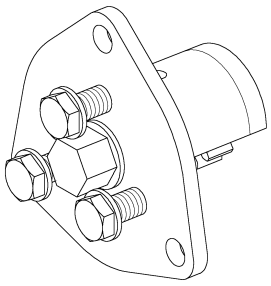
10.1 Special Tools

Barring tool for 12V engines



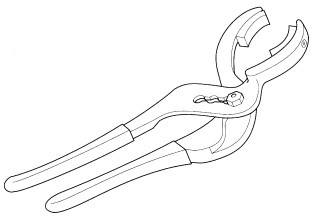
Part No.:	F6558556
Qty.: Used in:	1 7.1.1 Engine – Barring manually (→ Page 84)

Barring tool for 16V engines



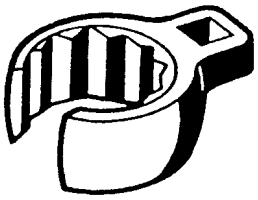
Part No.:	F6558557
Qty.: Used in:	1 7.1.1 Engine – Barring manually (→ Page 84)

Connector pliers



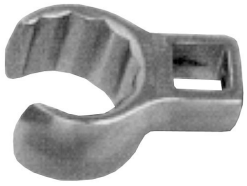
Part No.:	0135315483
Qty.: Used in:	1 7.1.2 Engine – Barring with starting system (→ Page 85)
Qty.: Used in:	1 7.20.1 Engine governor and connectors – Cleaning (→ Page 145)
Qty.: Used in:	1 7.20.2 Engine monitoring unit and connectors – Cleaning (→ Page 146)
Qty.: Used in:	1 7.20.3 Checking engine control unit plug connections (→ Page 147)
Qty.: Used in:	1 7.20.4 Engine monitoring unit – Plug connection check (→ Page 148)
Qty.: Used in:	1 7.20.5 Engine control unit – Removal and installation (→ Page 149)

Crowfoot wrench, 19 mm



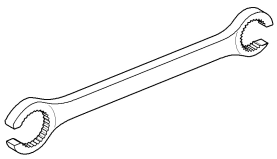
Part No.:	F30027424
Qty.: Used in:	1 7.5.2 Injection pump – Removal and installation (→ Page 99)
Qty.: Used in:	1 7.6.2 Injector – Removal and installation (→ Page 103)

Crowfoot wrench, 22 mm



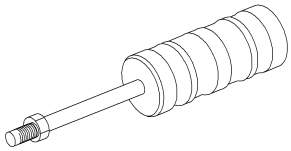
Part No.:	F30027425
Qty.: Used in:	1 7.5.2 Injection pump – Removal and installation (→ Page 99)
Qty.: Used in:	1 7.6.2 Injector – Removal and installation (→ Page 103)

Double box wrench



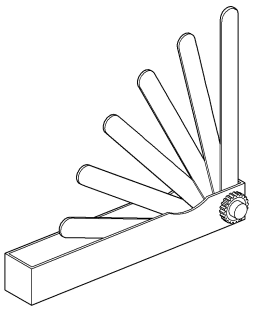
Part No.:	F30011450
Qty.: Used in:	1 7.6.2 Injector – Removal and installation (→ Page 103)

Extractor



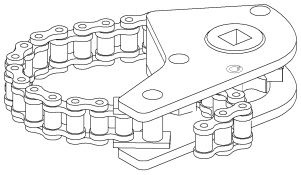
Part No.:	F30377999
Qty.: Used in:	1 7.6.2 Injector – Removal and installation (→ Page 103)

Feeler gauge



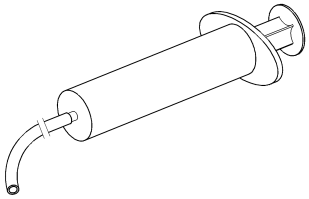
Part No.:	Y20010128
Qty.: Used in:	1 7.4.1 Valve clearance – Check and adjustment (→ Page 95)

Filter wrench



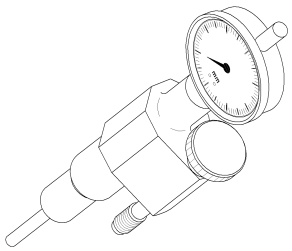
Part No.:	F30379104
Qty.: Used in:	1 7.8.1 Fuel filter – Replacement (→ Page 110)
Qty.: Used in:	1 7.14.1 Engine oil filter – Replacement (→ Page 125)

Fuel suction device



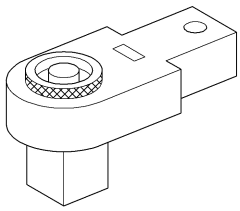
Part No.:	F30378207
Qty.: Used in:	1 7.6.2 Injector – Removal and installation (→ Page 103)

Measuring device



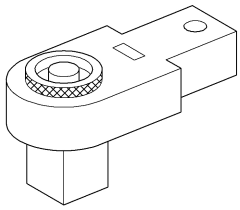
Part No.:	Y4341106
Qty.: Used in:	1 7.4.1 Valve clearance – Check and adjustment (→ Page 95)

Ratchet



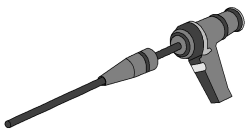
Part No.:	F30027340
Qty.: Used in:	1 7.4.2 Cylinder head cover – Removal and installation (→ Page 97)

Ratchet adapter



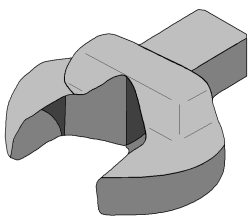
Part No.:	F30027340
Qty.: Used in:	1 7.3.2 Crankcase breather – Oil separator element replacement, diaphragm check and replacement (→ Page 93)
Qty.: Used in:	1 7.4.1 Valve clearance – Check and adjustment (→ Page 95)
Qty.: Used in:	1 7.5.2 Injection pump – Removal and installation (→ Page 99)
Qty.: Used in:	1 7.6.2 Injector – Removal and installation (→ Page 103)

Rigid endoscope



Part No.:	Y20097353
Qty.: Used in:	1 7.2.1 Cylinder liner – Endoscopic examination (→ Page 87)

Socket wrench



Part No.:	F30025897
Qty.: Used in:	1 7.6.2 Injector – Removal and installation (→ Page 103)

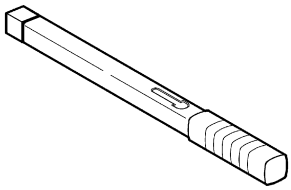
Steam jet cleaner

Part No.:	-
Qty.: Used in:	1 4.11 Plant cleaning (→ Page 59)

Torque wrench, 0.5–5 Nm

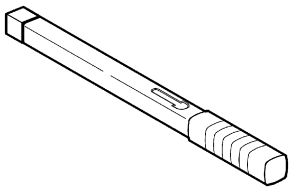
Part No.:	0015384230
Qty.: Used in:	1 7.5.2 Injection pump – Removal and installation (→ Page 99)

Torque wrench, 20-100 Nm



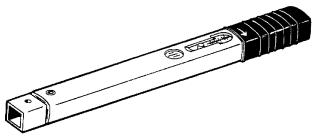
Part No.:	F30026582
Qty.: Used in:	1 7.6.2 Injector – Removal and installation (→ Page 103)

Torque wrench, 20–100 Nm



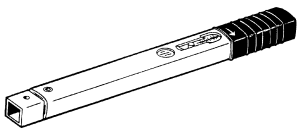
Part No.:	F30026582
Qty.: Used in:	1 7.4.1 Valve clearance – Check and adjustment (→ Page 95)
Qty.: Used in:	1 7.5.2 Injection pump – Removal and installation (→ Page 99)

Torque wrench, 6-50 Nm



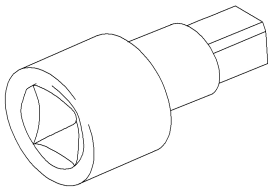
Part No.:	F30027336
Qty.: Used in:	1 7.3.2 Crankcase breather – Oil separator element replacement, diaphragm check and replacement (→ Page 93)

Torque wrench, 8-40 Nm



Part No.:	F30043446
Qty.: Used in:	1 7.4.2 Cylinder head cover – Removal and installation (→ Page 97)

Transition piece



Part No.:	F30006234
Qty.: Used in:	1 7.5.2 Injection pump – Removal and installation (→ Page 99)
Qty.: Used in:	1 7.6.2 Injector – Removal and installation (→ Page 103)

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