

Technical Publication

Diesel Engine
12 V 2000 P62, P82
16 V 2000 P62, P82
Application group 3B

Operating Instructions
MS15009/00E



Printed in Germany

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Salvo alterações.

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

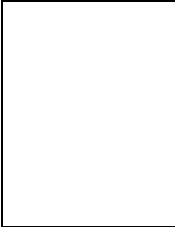
Ritagliare “Avviso di messa in servizio“ e rispedirlo debitamente compilato alla MTU Friedrichshafen GmbH.

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

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





Postcard

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Department SCSD
88040 Friedrichshafen
GERMANY

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



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

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

**Inbetriebnahme-
meldung**

**Commissioning
Note**

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

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

**Notice de mise
en service**

**Aviso de puesta
en servicio**

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

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

**Avviso di messa
in servizio**

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

**Participação da
colocação em
serviço**

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

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1 Safety

1.1 General conditions

General

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

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

Correct use

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

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

Modifications or Conversions

Modifications made by the customer to the engine may affect safety.

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

Spare parts

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

1.2 Personnel and organizational requirements

Personnel

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

The specified legal minimum age must be observed.

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

Organization

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

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

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

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

Working clothes and protective equipment

Wear proper work clothing for all work.

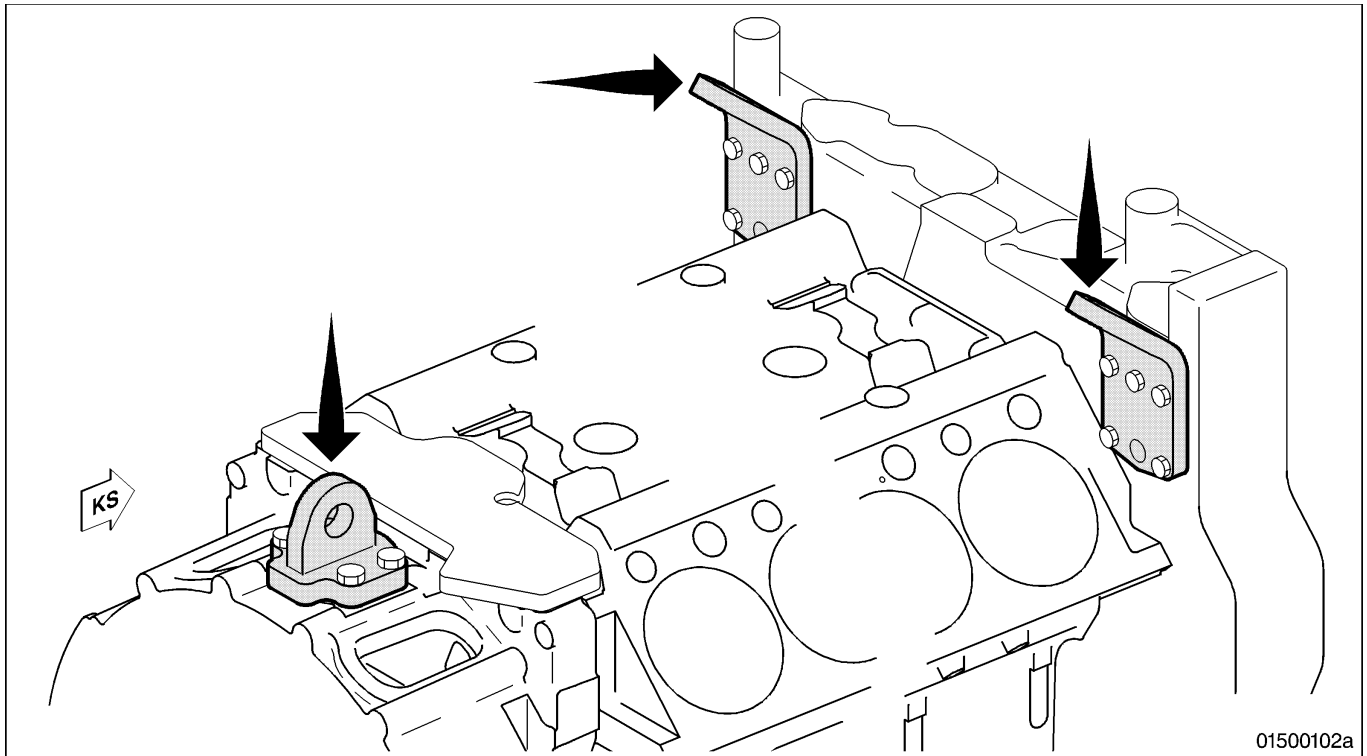
Depending on the kind of work, use additional protective equipment, e.g. protective goggles, gloves, helmet, apron.

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

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

1.3 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 transport. The engine must be especially secured against slipping or tilting when going up or down inclines and ramps.

Setting the engine down after transport

Place the engine only on an even, firm surface.

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

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

1.4 Safety precautions when working on the engine

Safety precautions when putting the equipment into operation

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

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

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

Immediately after putting the device or system into operation, make sure that all control and display instruments as well as the signaling and alarm systems work properly.

Safety requirements for operators

Procedures for cases of emergency must be practised regularly.

The operator must be familiar with the controls and displays.

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

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

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

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

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

Engine operation

When the engine is running, always wear ear protectors.

Ensure that the engine room is well ventilated.

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

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

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

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

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

Maintenance and repair

Strict adherence to the maintenance and repair schedule is an essential safety factor.

Never carry out maintenance and repair work with the engine running unless expressly instructed to do so.

Lock-out/tag-out the engine to preclude undesired starting. Disconnect the battery when electrical starters are fitted. Close the main valve on the compressed-air system and vent the compressed air line when air starters are fitted. Post the "Do Not Start" sign in the operating room or affix it to the controlling device! Persons not involved must keep clear.

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

Use only proper, calibrated tools.

Do not work on engines or components which are only held by lifting equipment or crane. Always support by suitable means which conform with the applicable regulations before commencing maintenance or repair work.

Before barring the engine, make sure that nobody is standing in the danger zone. After completing work on the engine, check that all protective devices/safety guards have been installed and that all tools and loose parts have been removed from the engine.

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

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

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

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

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

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

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

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

Never touch hot parts of the compressor and exhaust system ⇒ Risk of burning!

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

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

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

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

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

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

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

Welding work

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

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

Never route the welding lead over or near the wiring harnesses of MTU systems. The welding current may otherwise induce an interference voltage in the wiring harnesses which could conceivably damage the electrical system.

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

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

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

Hydraulic installation and removal

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

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

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

Do not attempt to bend or apply force to lines.

Before starting work, pay attention to the following:

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

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

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

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

Working on electrical/electronic assemblies

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

De-energize the appropriate areas prior to working on assemblies. Any measures requiring a power supply are expressly defined as such at the appropriate place in the manual.

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

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

Do not secure wiring to fluid-carrying lines.

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

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

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

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

Spare parts shall be properly stored prior to replacement, i.e. particularly protected against moisture. Defective electronic components and assemblies must be suitably packed when 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.

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

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

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

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

Operation of electrical equipment

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

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

1.5 Auxiliary materials, fire prevention and environmental protection

Fire prevention

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

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

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

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

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

Noise

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

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

Environmental protection

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

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

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

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

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

Auxiliary materials

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

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

Lead

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

Acids and alkaline solutions

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

Paints

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

Liquid nitrogen

- Store liquid nitrogen only in small quantities and always in regulation containers without fixed covers.
- Do not bring liquid nitrogen in contact with the body (eyes, hands), as this causes frostbite and loss of tissue.
- Wear protective clothing, including gloves, closed shoes and protective goggles!

- Ensure that the room is well ventilated. Nitrogen concentration exceeding 88% of breathing air leads to suffocation.
- Avoid all knocks and jars to the containers, fixtures or workpieces.

Compressed air

Compressed air is air compressed at excess pressure and is stored in vessels from which it can be extracted.

The pressure at which the air is kept can be read off at pressure gauges which must be connected to the compressed air vessels and the compressed air lines.

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

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




Used oil

Used oil may contain health-threatening combustion residues.

Rub barrier cream into hands!

Wash hands after contact with used oil.

1.6 Standards for warning notices in the publication

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

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

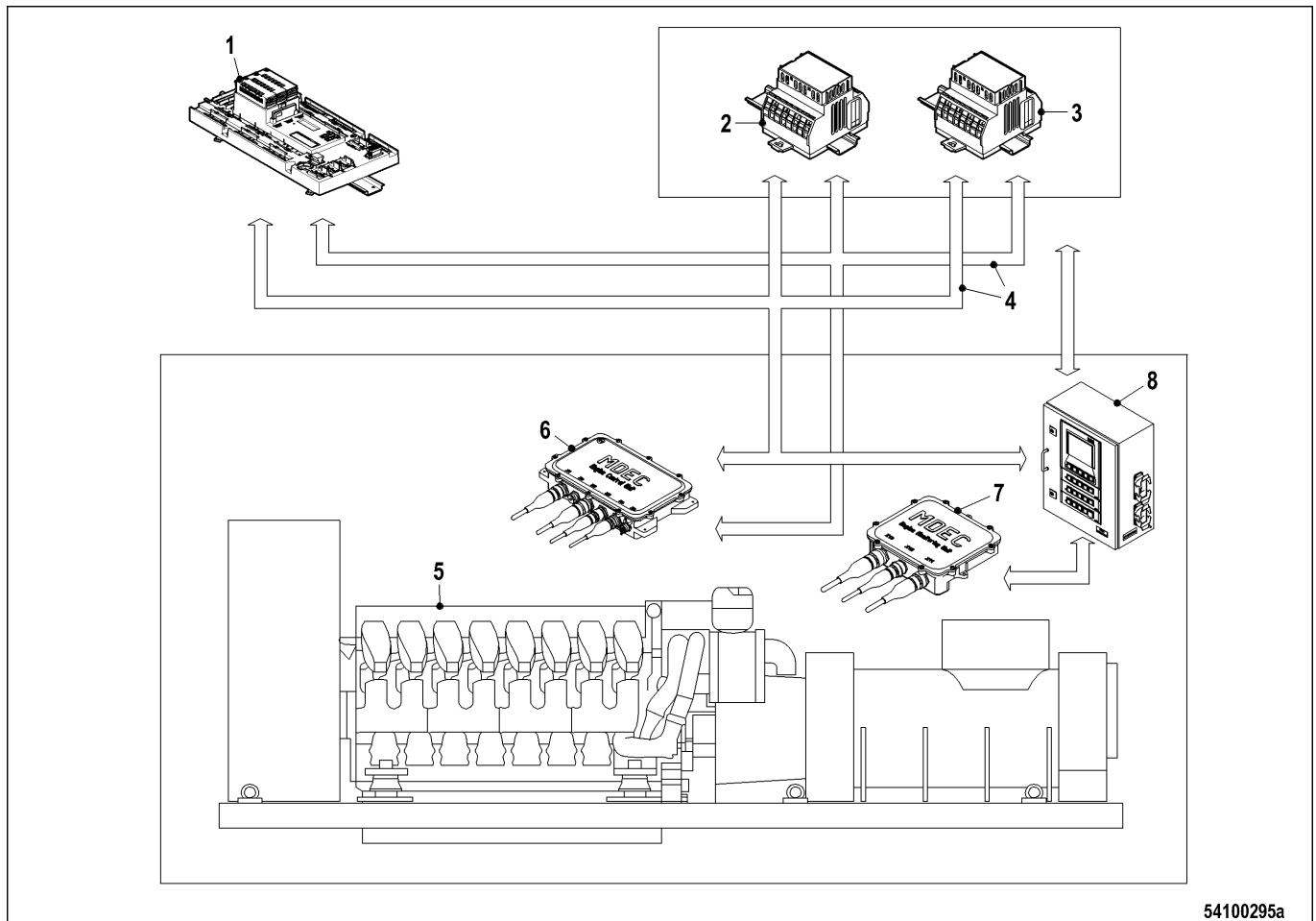
Warning notices

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

2 Product Summary

2.1 Plant Overview

2.1.1 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

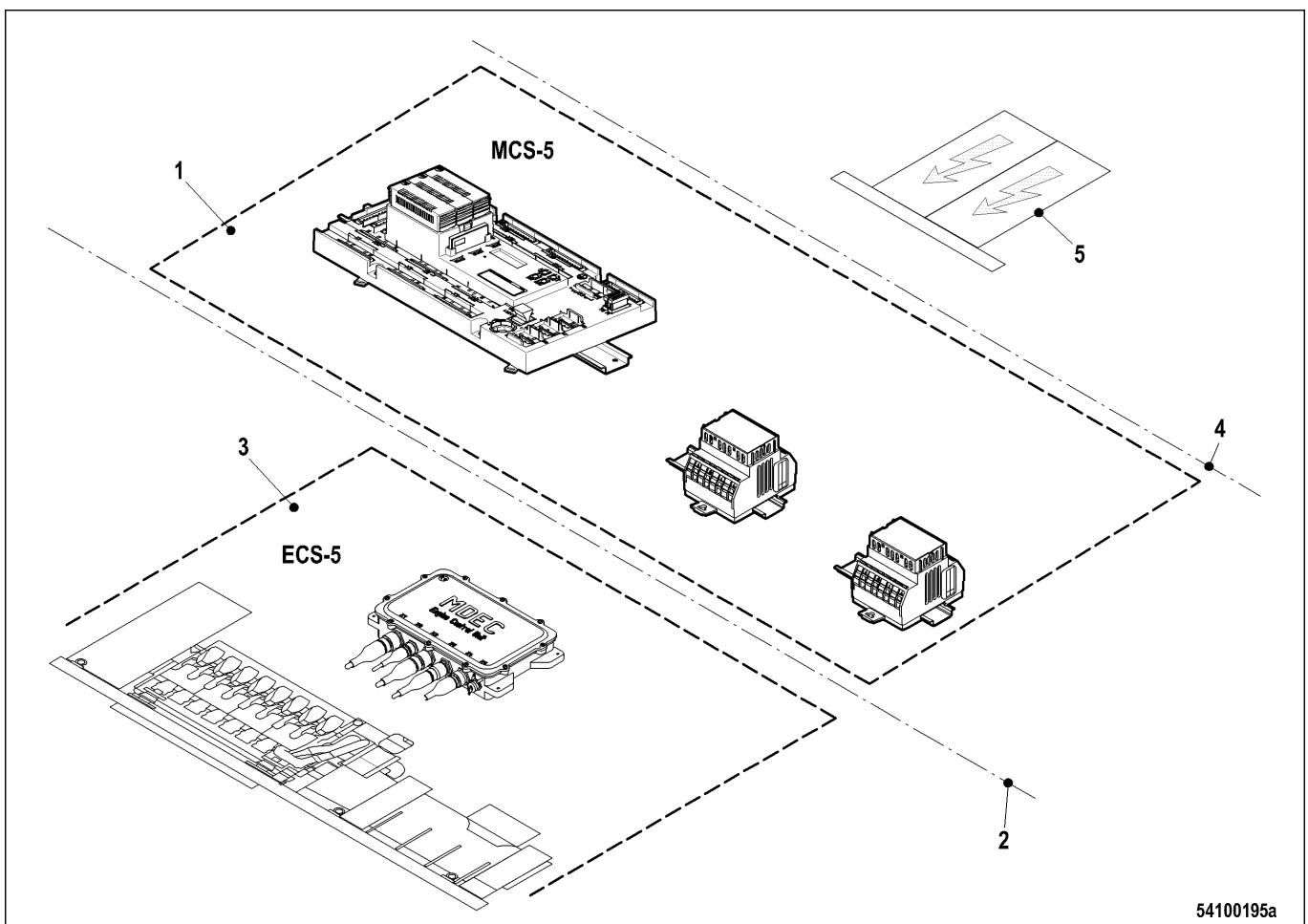
- Control of the engine.
- Monitoring of operating states.
- Closed-loop control of fuel injection and engine speed (depending on operating state).
- Indication of faulty operating states (display SAM (1)).

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

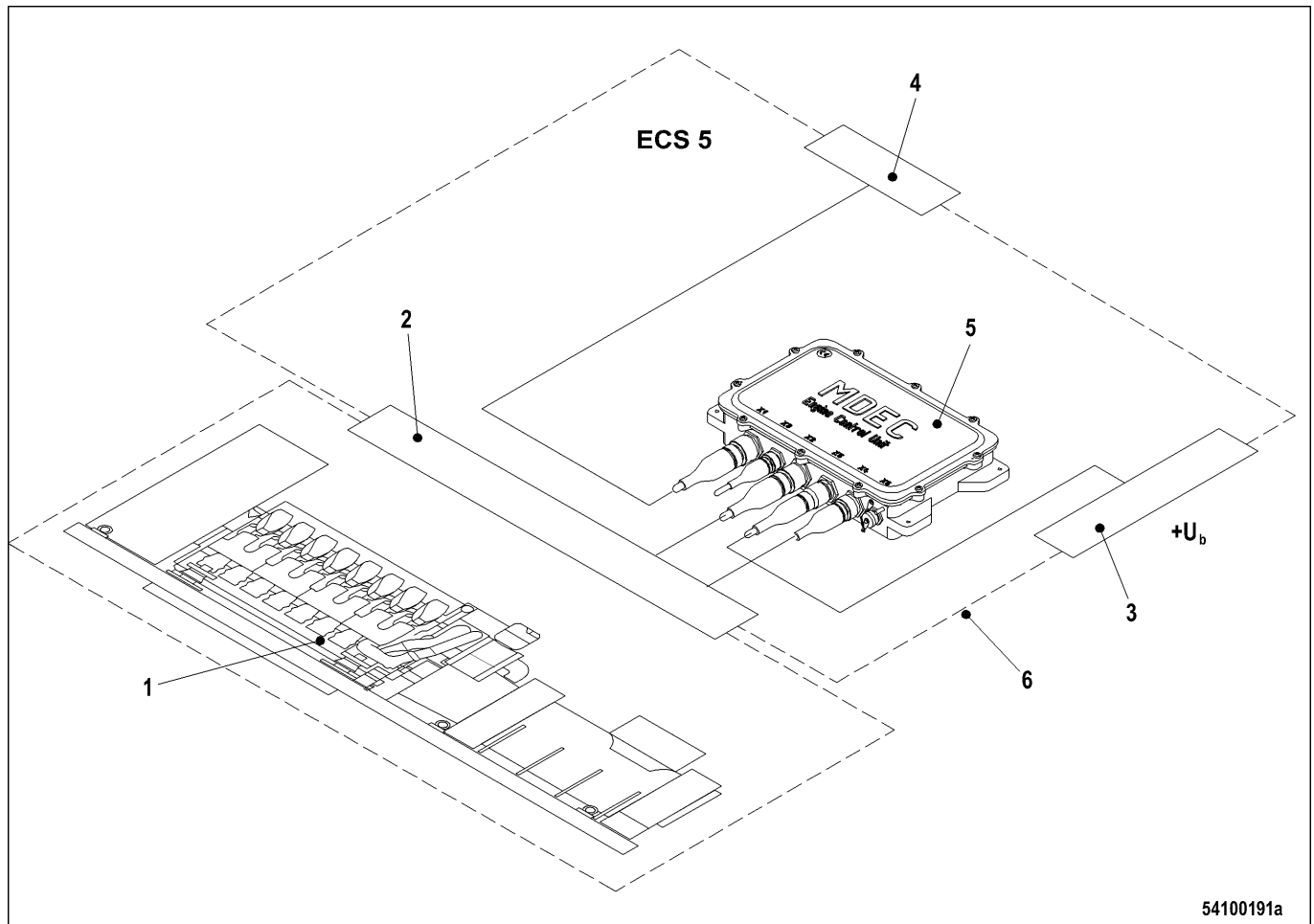


- | | |
|---|--|
| <p>1 Monitoring and Control System
MCS-5 (PIMs optional)</p> <p>2 CAN bus between ECS-5
and MCS-5</p> | <p>3 Engine Control System ECS-5</p> <p>4 RS422 interface and RS232
interface to an external controller</p> <p>5 External controller</p> |
|---|--|

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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



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1 Engine with generator
 2 Engine interface
 3 Power supply +U_b

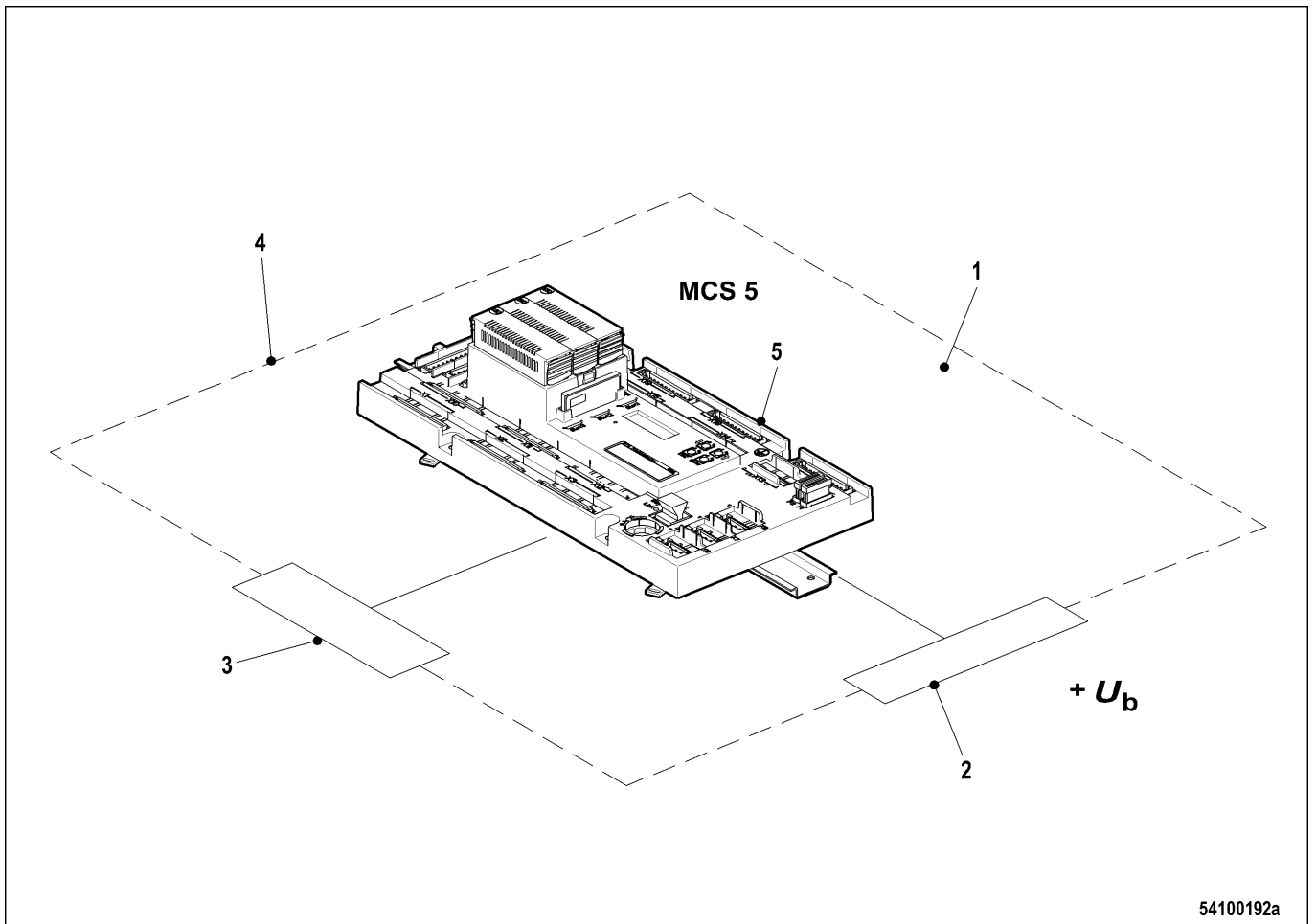
4 Signal connection to the MCS
 devices and the higher-level
 control systems

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

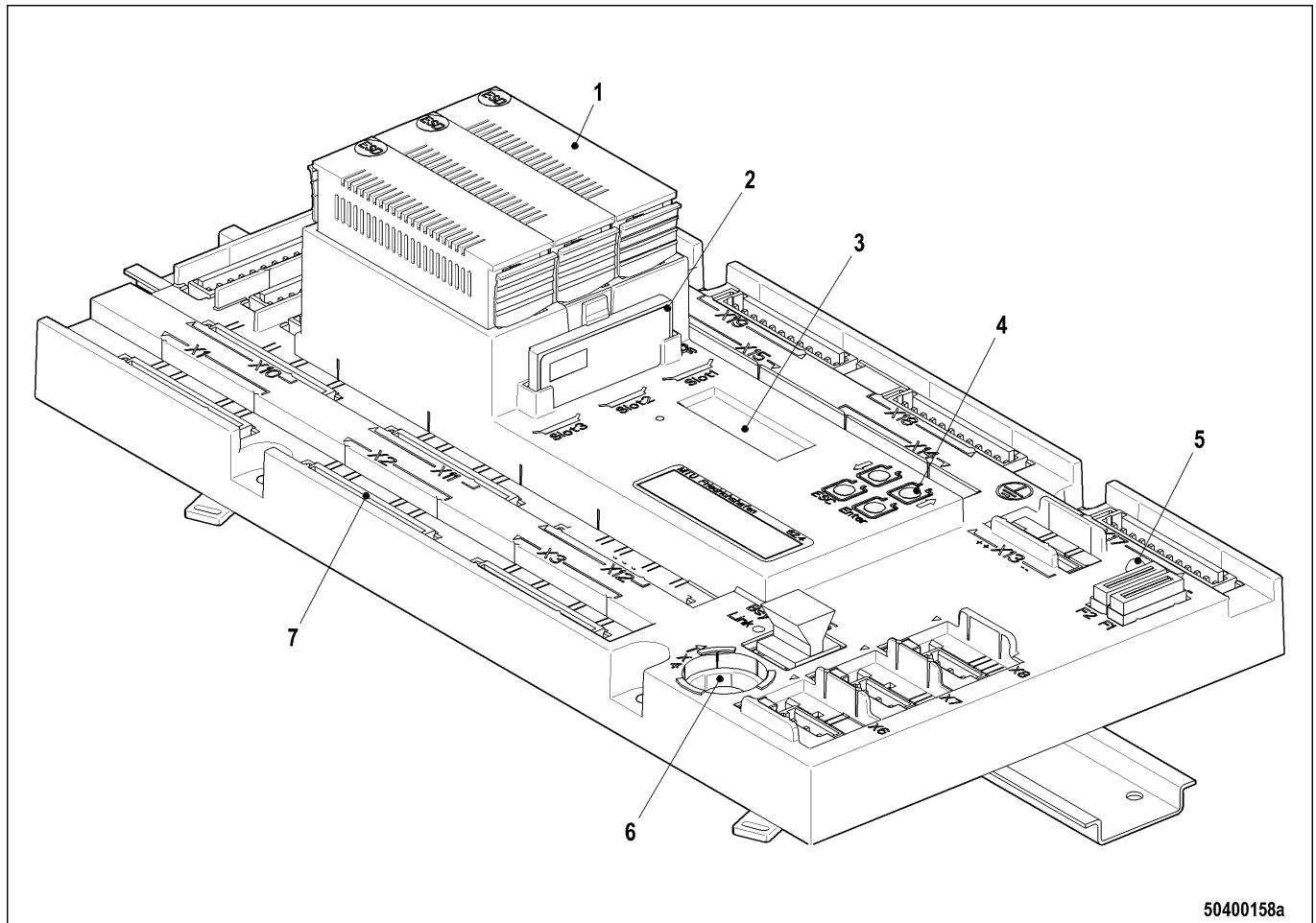


1 Monitoring and Control System
MCS-5

2 Power supply $+U_b$
3 Signal connection to ECS devices

4 System boundary MCS-5
5 SAM

Service and Automation Module (SAM)



50400158a

1 Module cassette, slots for additional I/O PIM cards
2 Compact flash memory card

3 Display for fault codes and minialog
4 Control keys for minialog

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

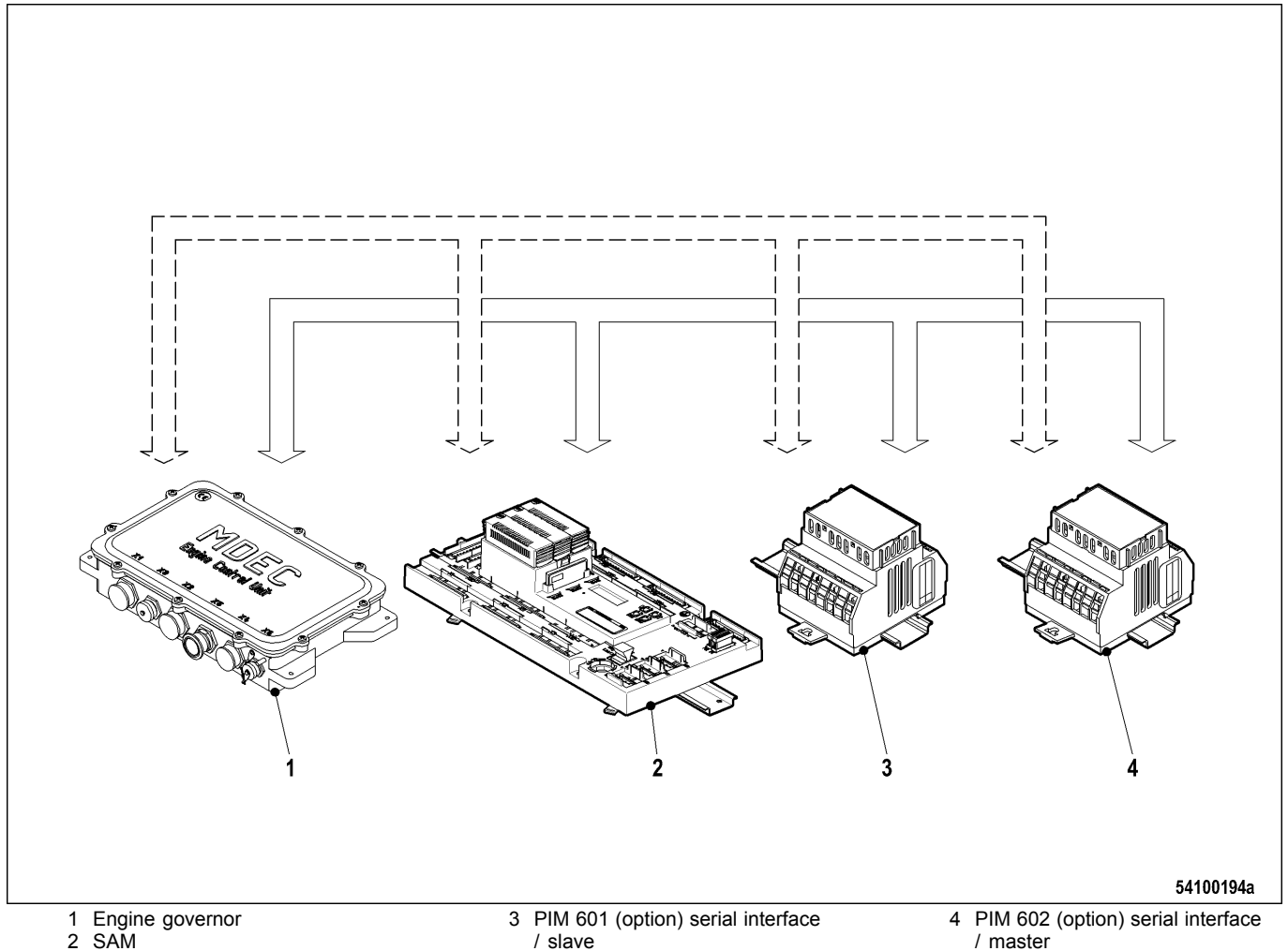
- Straightforward diagnosis by fault code display.
- Self-diagnosis by diagnostic lamp (5).
 - Steady = SAM is OK.
 - Flashing = SAM is faulty, contact Service.
 - Dark = Supply voltage missing.

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



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.

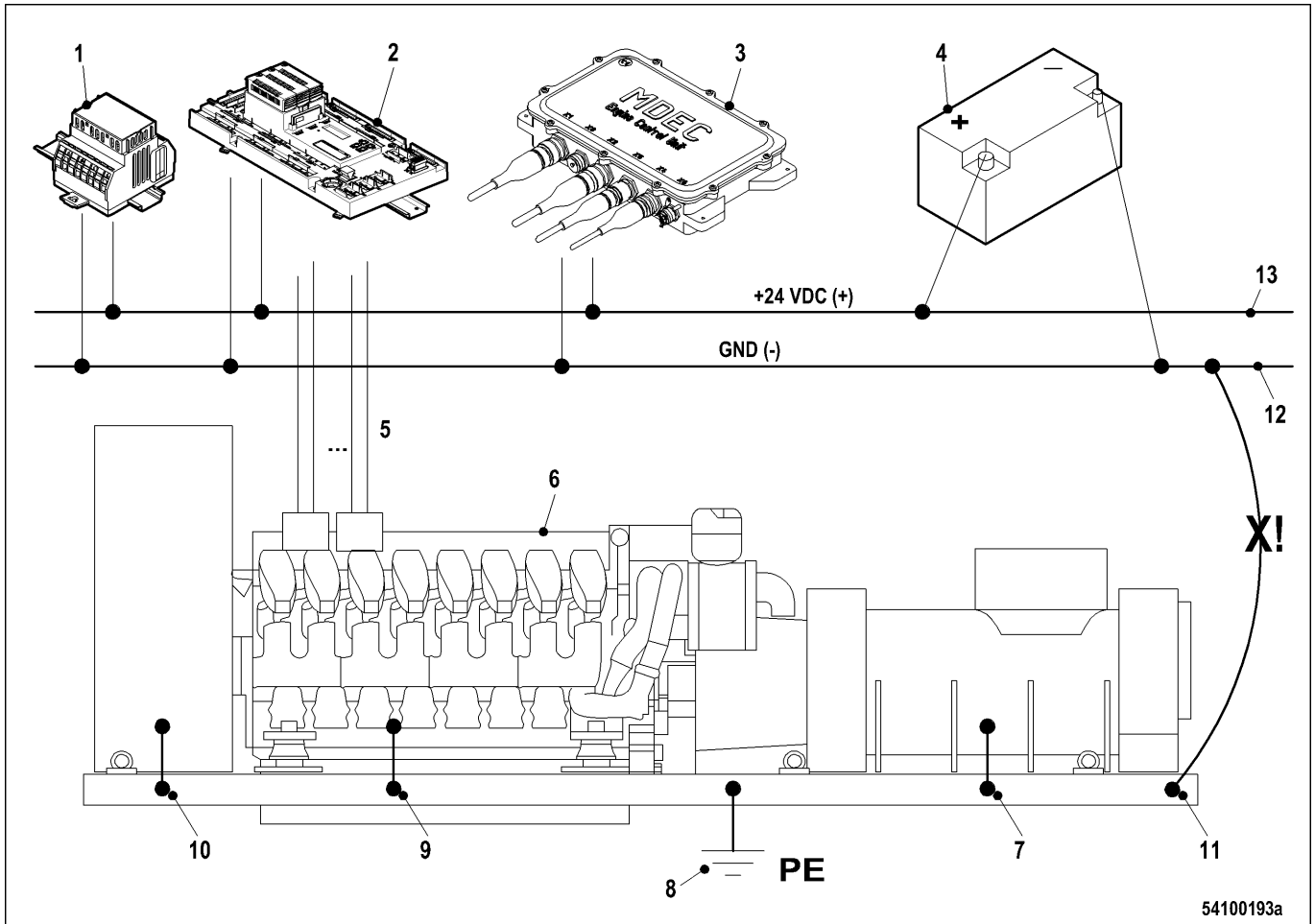
Tasks of the CAN bus:

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

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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

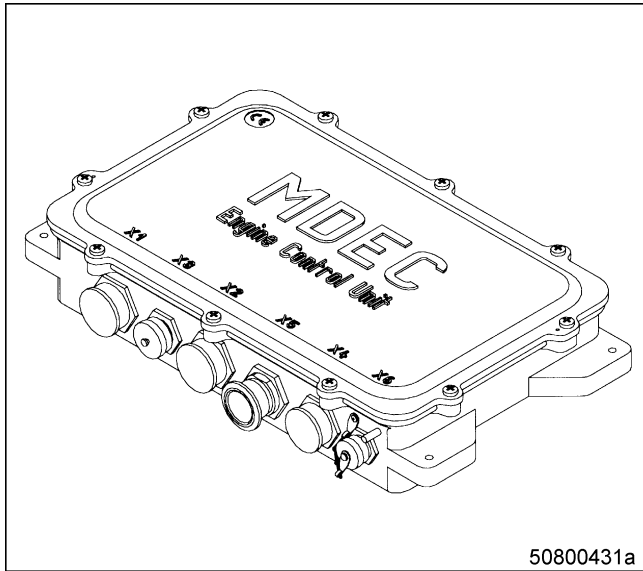
The ground of the power supply (battery negative) and all electronic devices (-) should not be connected to ground (8). The entire electronic system is electrically isolated from ground. This also applies to the sensors (5). All sensor signal lines and/or supply lines are not connected to the corresponding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

2.1.2 ECS-5 – Use of devices

Engine governor



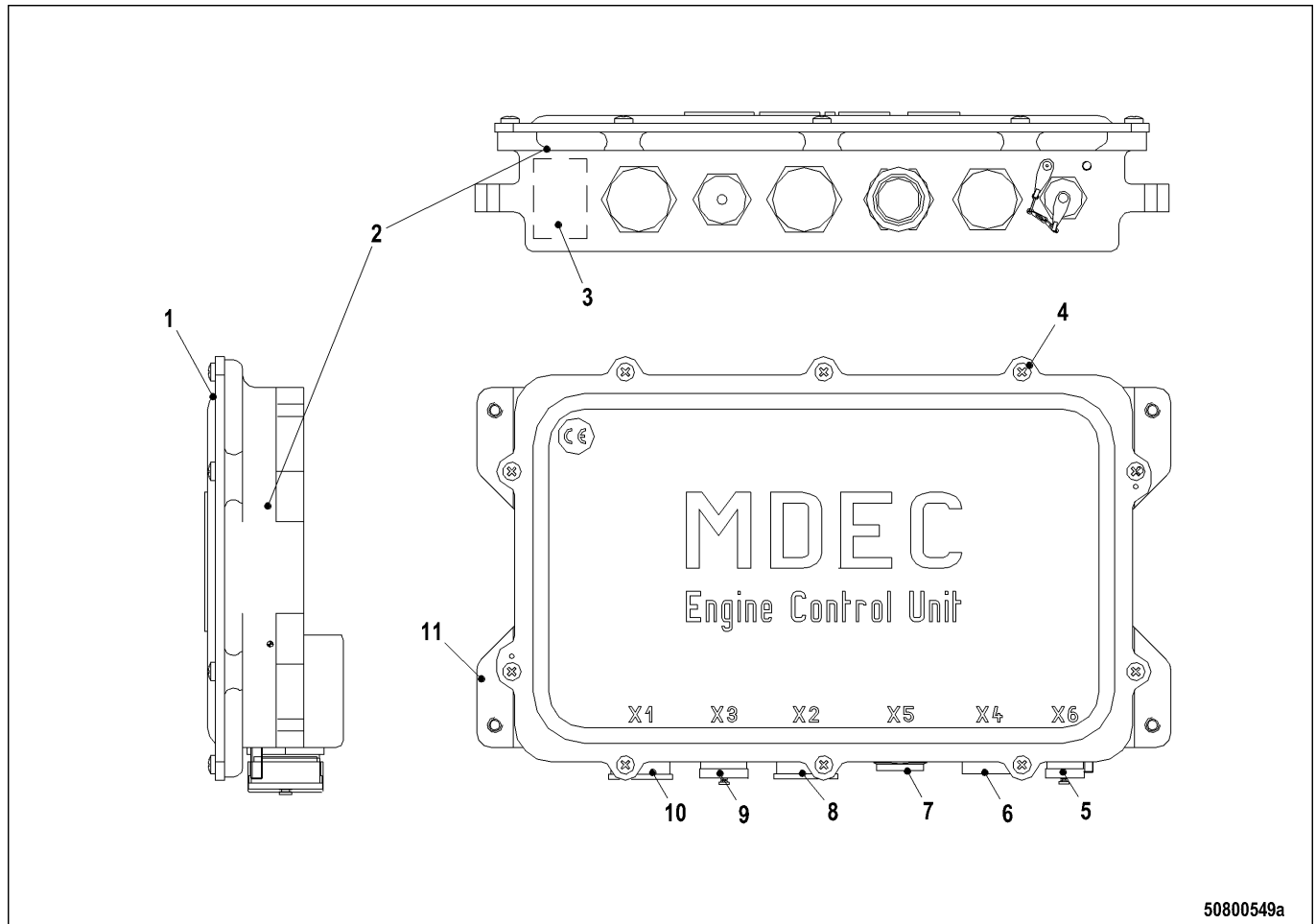
Central control and monitoring device for the engine

- 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



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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

Item.	Name	Meaning
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

2.1.3 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 $n > n_1$ (configurable) reached within t_1 (configurable).
 - Start terminated if speed is $n < n_1$ within t_1 . Start speed is too low “Start speed low”.
7. Start injection quantity
8. Speed $n > 300$ reached within t_2 (configurable).
 - Start terminated if speed is $n < 300$ within t_2 (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 $q_{\text{inject}} = f_{(\text{speed})}$. 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 be 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 settings 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.

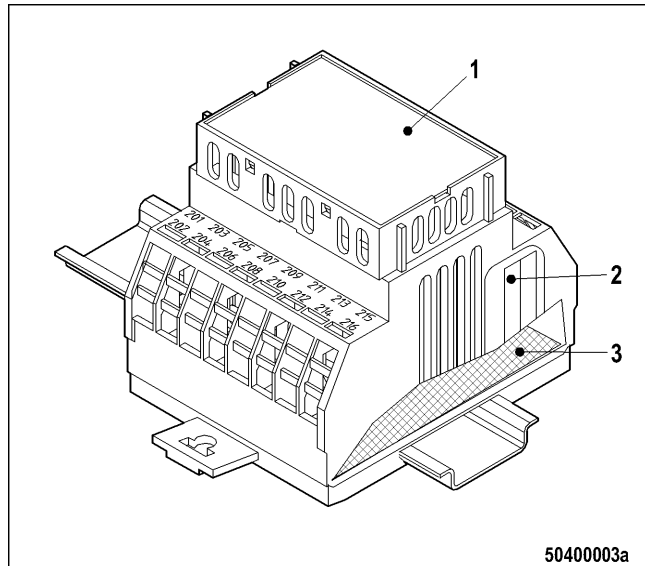
Overspeed test

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.

2.1.4 Peripheral Interface Modules (PIMs)

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

PIM design

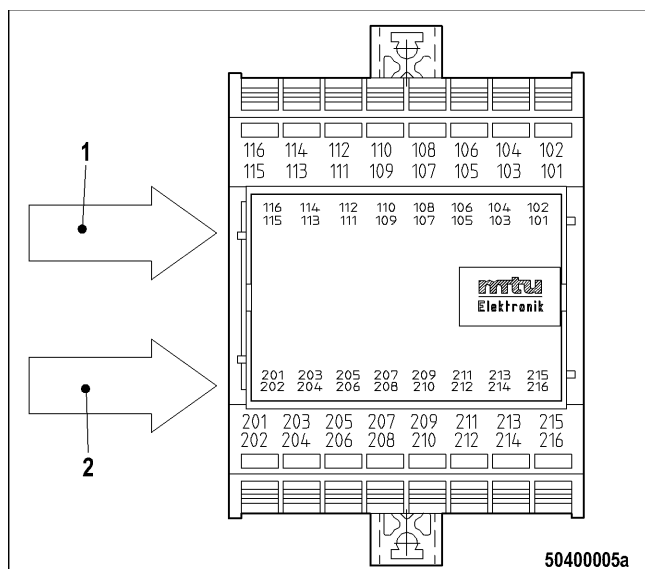


- 1 Module cassette 1
- 2 Basic module 1
- 3 Printed circuit board

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

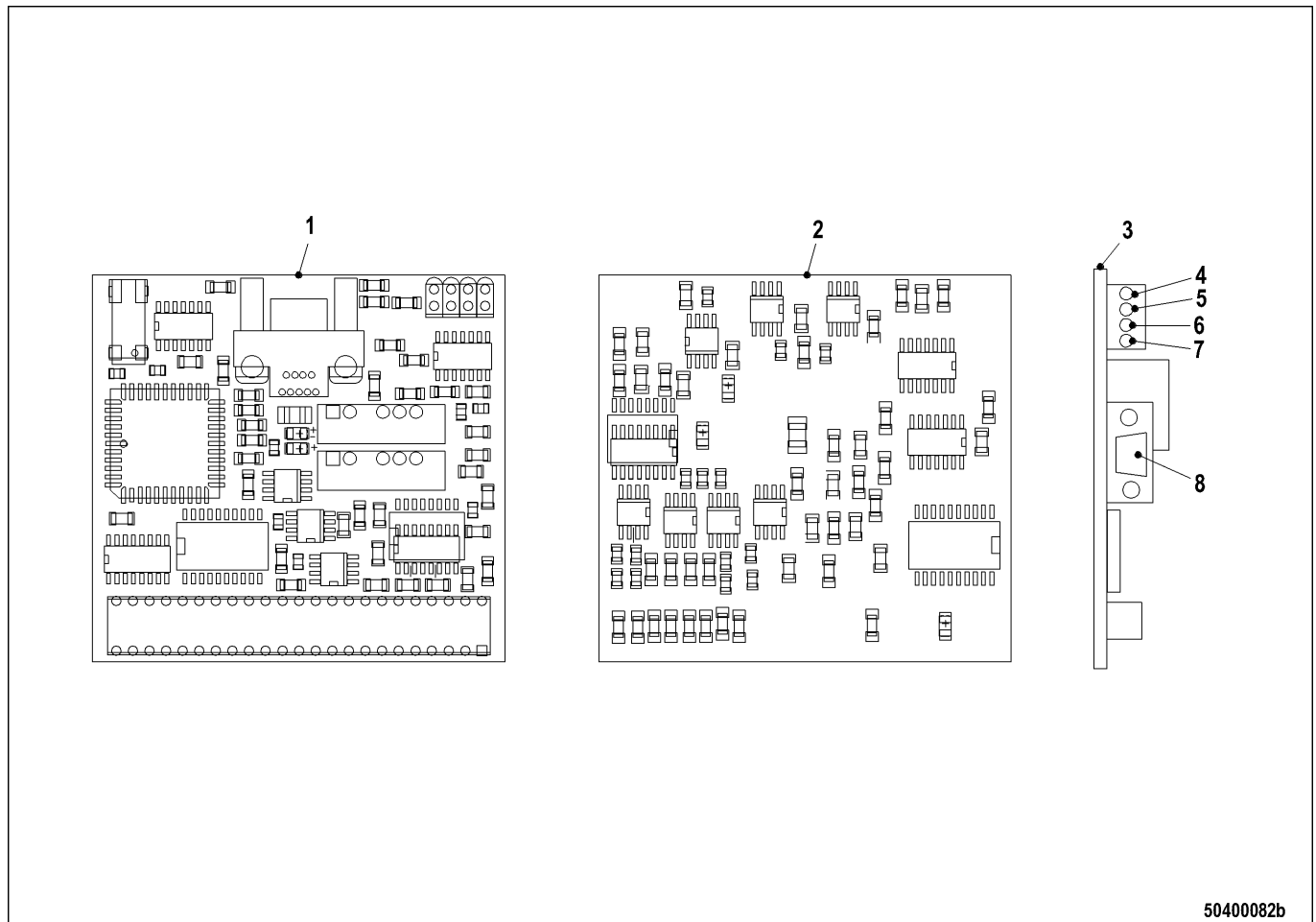
Serial interface

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

2.1.5 Printed circuit board SCB 3

Purpose and structure

Design



- 1 Component side
- 2 Conductor side
- 3 Plan 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

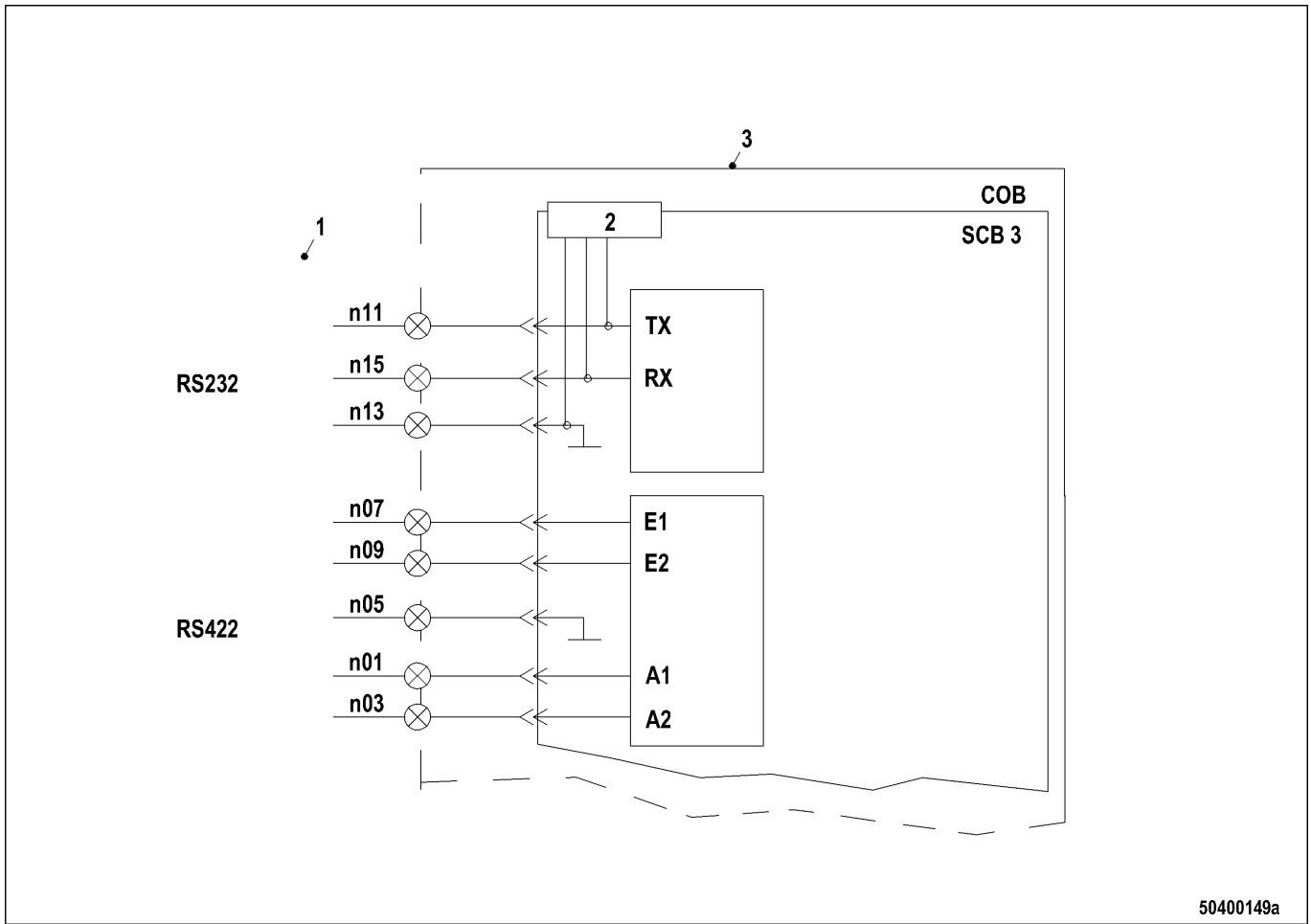
Features

- 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 MPU 23 or MPU 27 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.

MPU 23 or MPU 27 processes the data and controls the interface drivers.

Connection assignment

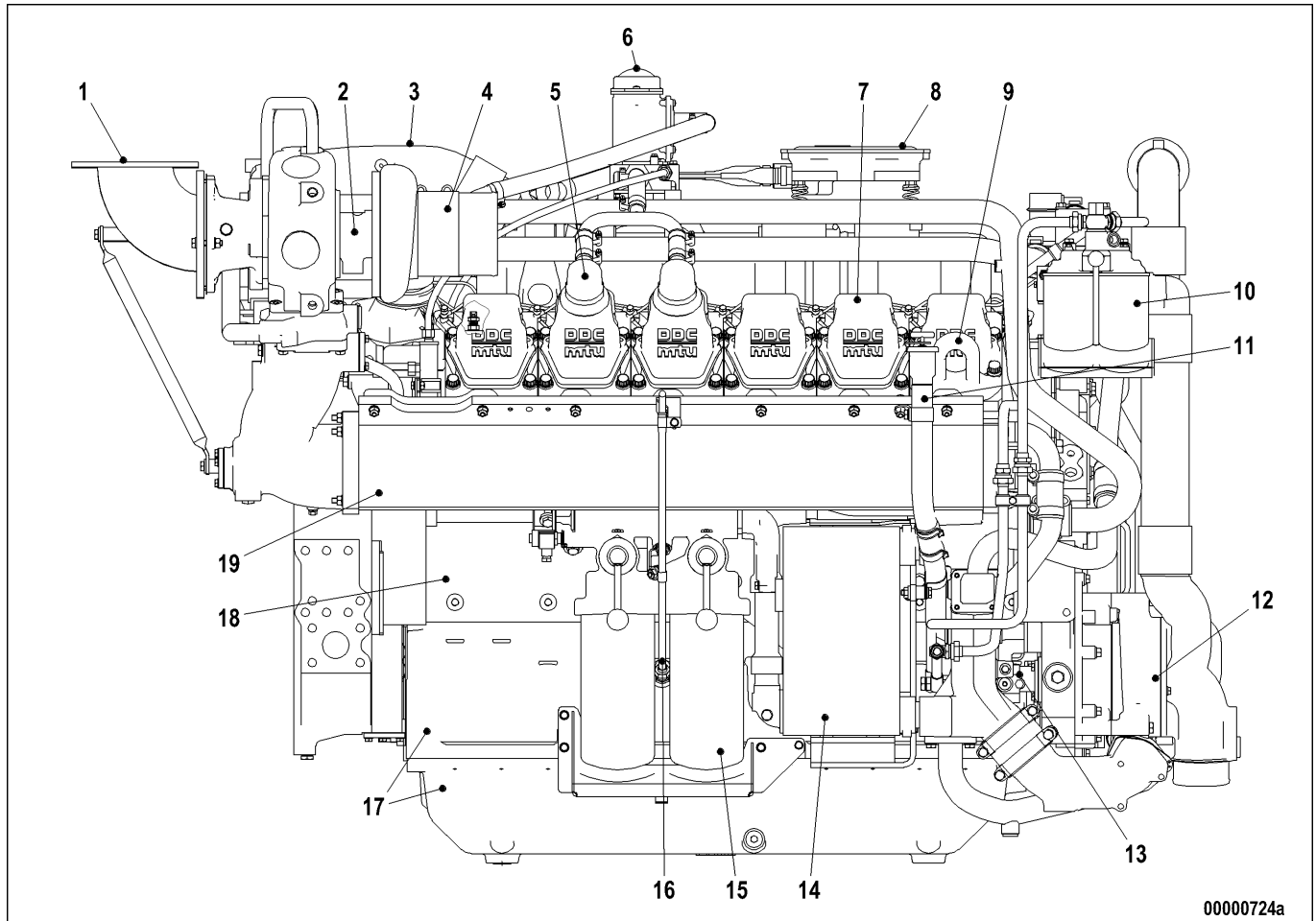
Relationship between SCB 3 and the terminals of the PIM.

Terminal	Designation
n01	Channel 1: O1 of RS422 interface
n02	Channel 2: O1 of RS422 interface
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

2.2 Engine Overview

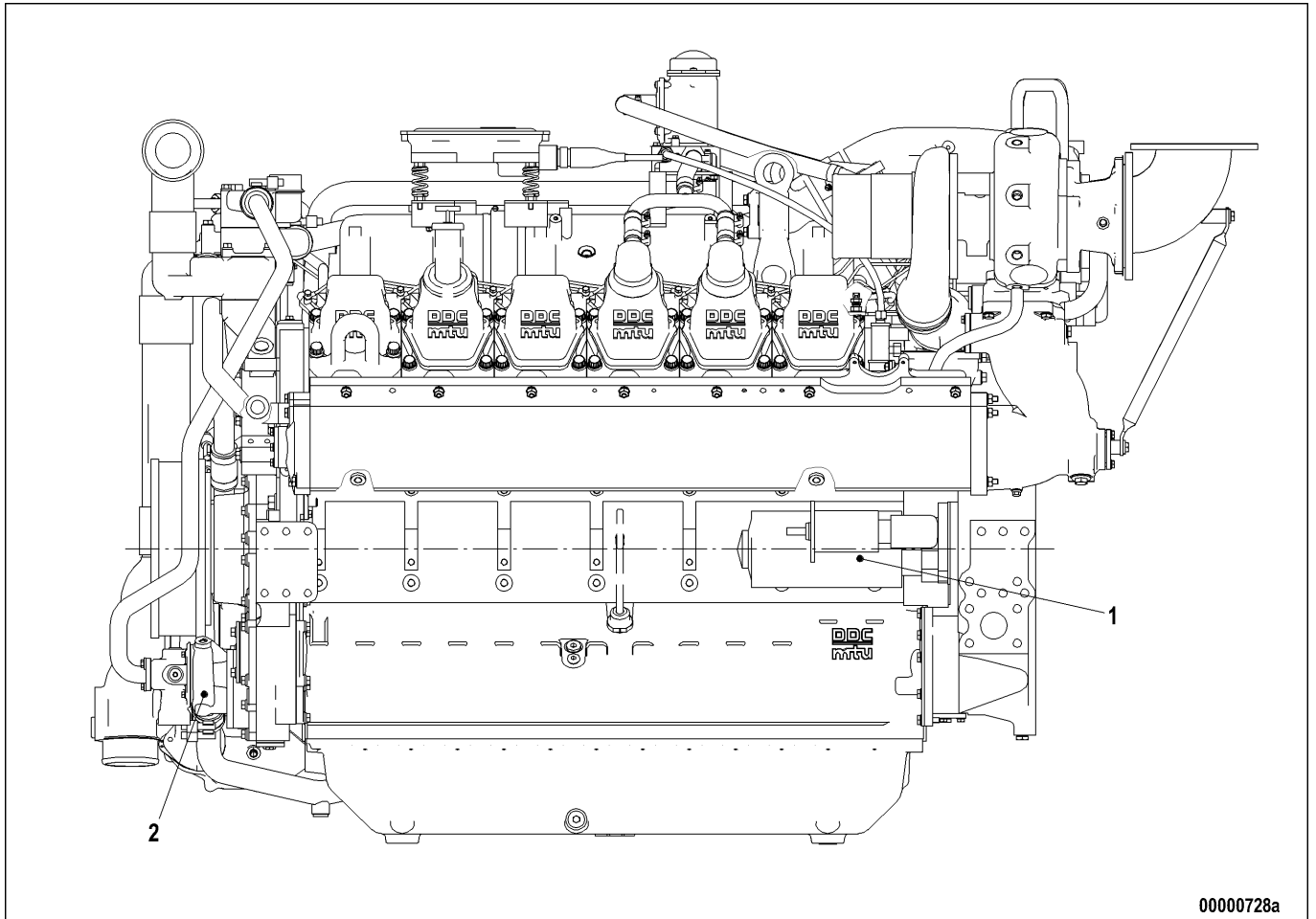
2.2.1 Engine layout

Illustrations are also applicable to 16 V



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



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1 Starter

2 Engine 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 (6, 8)
2	Design index

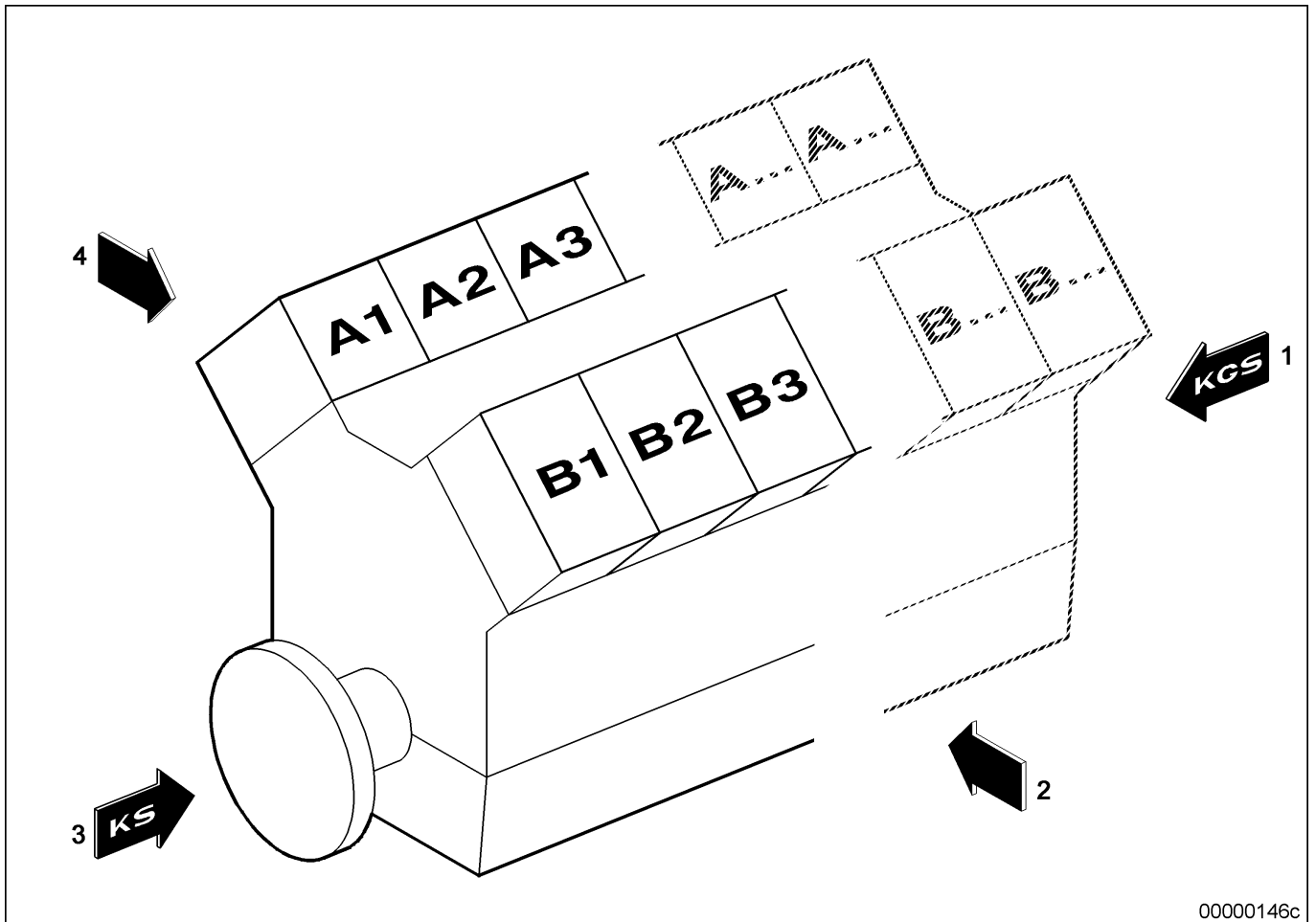
2.3 Engine Side and Cylinder Designations

2.3.1 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.

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



1 KGS = Free end
2 Right side

3 KS = Driving end
4 Left side

2.4 Final Compression Pressure

2.4.1 Final compression pressure

Final compression pressure

Final compression pressure at 120 rpm	30 bar to 36 bar
---------------------------------------	------------------

2.5 Technical Data

2.5.1 12/16V 2000 P62/82 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

REFERENCE CONDITIONS

Engine model			12V 2000 P62	12V 2000 P82	16V 2000 P62	16V 2000 P82
Application group			3B	3B	3B	3B
Intake air temperature		°C	25	25	25	25
Charge-air coolant temperature		°C	45	45	45	45
Barometric pressure		mbar	1000	1000	1000	1000
Site altitude above sea level		m	100	100	100	100

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

Number of cylinders			12	12	16	16
Engine rated speed	A	rpm	1500	1800	1500	1800
Continuous power as per ISO 3046 (10% overload capability) (rated power DIN 6280, ISO 8528)	A	kW	575	695	770	930

GENERAL CONDITIONS (for maximum power)

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

MODEL-RELATED DATA (basic design)

Number of cylinders			12	12	16	16
Engine with turbochargers (ETC) and charge-air cooling (CAC)			X	X	X	X
Working method: four-stroke diesel engine, single-acting			X	X	X	X
Combustion method: direct injection			X	X	X	X
Cooling method: treated water			X	X	X	X
Direction of rotation: c.c.w. (viewed on driving end)			X	X	X	X
Number of cylinders			12	12	16	16
Cylinder arrangement: V angle		degrees	90	90	90	90
Bore		mm	130	130	130	130
Stroke		mm	150	150	150	150
Cylinder displacement		liter	1.99	1.99	1.99	1.99
Total displacement		liter	23.88	23.88	31.84	31.84
Compression ratio			16	16	16	16
Cylinder heads: Single cylinder heads			X	X	X	X
Cylinder liners: wet, replaceable			X	X	X	X
Number of inlet valves, per cylinder			2	2	2	2
Number of exhaust valves, per cylinder			2	2	2	2
Standard flywheel housing flange (engine main PTO)		SAE	0	0	0	0
Flywheel connection		DISC	18"	18"	18"	18"

AIR / EXHAUST

Number of cylinders			12	12	16	16
Charge-air pressure before cylinder - DL	R	bar abs	2.4	3.2	2.5	3.6

COOLANT SYSTEM (HT circuit)

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

COOLANT SYSTEM (LT circuit)

Number of cylinders			12	12	16	16
Coolant temperature before intercooler (at engine connection: inlet from cooling equipment)	A	°C	45	45	45	45
Antifreeze percentage in coolant, max.	L	%	50	50	50	50
Pressure-loss in off-engine cooling system, max.	L	bar	0.7	0.7	0.7	0.7

LUBE OIL SYSTEM

Number of cylinders			12	12	16	16
Lube oil operating temperature before engine, from	R	°C	88	88	88	88
Lube-oil operating temperature before engine, to	R	°C	98	98	98	98
Lube-oil temperature before engine, warning	R	°C	102	102	102	102
Lube-oil temperature before engine, shutdown	L	°C	105	105	105	105
Lube oil operating pressure before engine, from	R	bar	7.5	7.5	6.5	7.0
Lube oil operating pressure before engine, to	R	bar	8.5	8.5	7.5	8.0
Lube-oil pressure before engine, warning	R	bar	4.9	5.5	5.5	5.5
Lube-oil pressure before engine, shutdown	L	bar	4.4	5.0	5.0	5.0

FUEL SYSTEM

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

GENERAL OPERATING DATA

Number of cylinders			12	12	16	16
Cold start capability: air temperature (w/o starting aid, w/o preheating) - (case A)	R	°C	0**	0**	0**	0**
Coolant preheating: preheating temperature (min.)	R	°C	32	32	32	32
Firing speed, from	R	rpm	100	100	100	100
Firing speed, to	R	rpm	120	120	120	120

CAPACITIES

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

ACOUSTICS

Number of cylinders			12	12	16	16
Exhaust noise, unsilenced - DL (sound power level LW, ISO 6798)	R	db(A)	123	117	122	128
Engine surface noise with attenuated intake noise (filter) - DL - (sound-power level LW, ISO 6798)	R	db(A)	117	117	125	125

2.5.2 SAM – Technical data

Use

- Installation in enclosed control cabinets.
- Suitable for installation on mounting rails or screw-mounting on cabinet rear wall (fixed installation).
- Suitable for connecting wires or litz wires up to AWG16 (US) (1.5 mm²).

Technical data

Term	Unit	Value
Installation position		As desired, however integral fault display should be legible.
Operating voltage	VDC	24 rated value (-30%; +30%, kurzzeitig -50%)
Power consumption	W	Under 7 (0.25A at 24V) without additional load.
Degree of protection:		IP 40 as per DIN 40 050
Shock:		
Rail mounting		10g, 11ms
Fixed installation		30g, 11ms
Vibration:		
Rail mounting	Hz	2 - 12.8: Xpp < ± 3mm 12.8 - 1000:a < 1g [rms]
Fixed installation	Hz	2 - 12.8: Xpp < ± 3mm 12.8 - 100:a < 4g [rms]
Ambient temperature:	°C	-40 - +70 in 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	Testing
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) $\pm 8\text{kV}$
EN 61000-4-3	(Radiated interference immunity) 80MHz - - 2GHz
EN 61000-4-4	(Burst interference immunity) $\pm 2\text{kV}$
EN 61000-4-5	(Surge interference immunity) $\pm 1\text{kV}/\pm 2\text{kV}$
EN 50155	(Surge interference immunity) $\pm 1.8\text{kV}$
EN 61000-4-17	(LF conducted interference) 0.03 – 10 kHz / $3V_{\text{eff}}$
EN 61000-4-29	(Mains fluctuation / STANAG 1008)
IEC 60092-504	(Dielectric strength) 550VAC / 10mA
EN 50155	(Isolation) 500V / 10M Ω

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

- The housing of the SAM must be connected to housing ground e.g. by a cable with a minimum cross-section of 2.5 mm². Cable length shall not exceed 10 cm.
- Twisted-conductor cables only shall be used to connect sensors and actuators. Maximum length of shall not exceed 5 m for unshielded cables and 50 m for shielded cables (providing that cable harness impedance allows).

Electrical requirements

Term	Unit	Value
Operating voltage:	V	24, -30% to +30% (+16.8 - +32) Admissible residual ripple less than 5% as per 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 current on positive or negative conductor shall not exceed 10 A DC in total.
Current terminals:	mm	5.08 terminals (spring-cage terminals) <ul style="list-style-type: none"> Wire diameter AWG14 (US) or 2.5 mm² recommended.
Electrical isolation:	V	<ul style="list-style-type: none"> 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. Signal cable shields must be connected to housing ground if applicable. Maximum direct current isolating voltage is 500 unless otherwise stated.

Mechanical design

Term	Unit	Value
Installation position:		<ul style="list-style-type: none"> Horizontal (to facilitate legibility of fault display and inscriptions on 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. Heat from the SAM dissipates through the back wall. Ensure that heat can be conducted away from the back wall of the SAM to the mounting frame. Do not allow neighboring devices to additionally heat up the SAM.

Signal connections

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

The wires are connected using spring-cage terminal technology.

Two wires may be connected to one terminal when the wires are crimped in a double-wire ferrule. For example, a Phoenix AL-TWIN 2* 0.75-10 may be used.

Connector modules are plugged together. The connector modules are equipped with coding pins to preclude polarity reversal.

Terminals

Term	Unit	Value
Terminal strip modules:		WAGO spring-cage terminals
Current-carrying capacity (at 70 °C):	A	10 per contact
Measuring voltage:	V	250
Measuring 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 ... 3

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

2.5.3 SCB 3 – Technical data

General

Term	Unit	Value
Dimensions (H x W x D)	mm	59 x 63 x 15
Weight	kg	0.036
Input voltage	VDC	+5 ($\pm 5\%$) from MPU 23 or MPU 27
Power consumption	mA	Less than 100
Power loss	mW	Less than 425

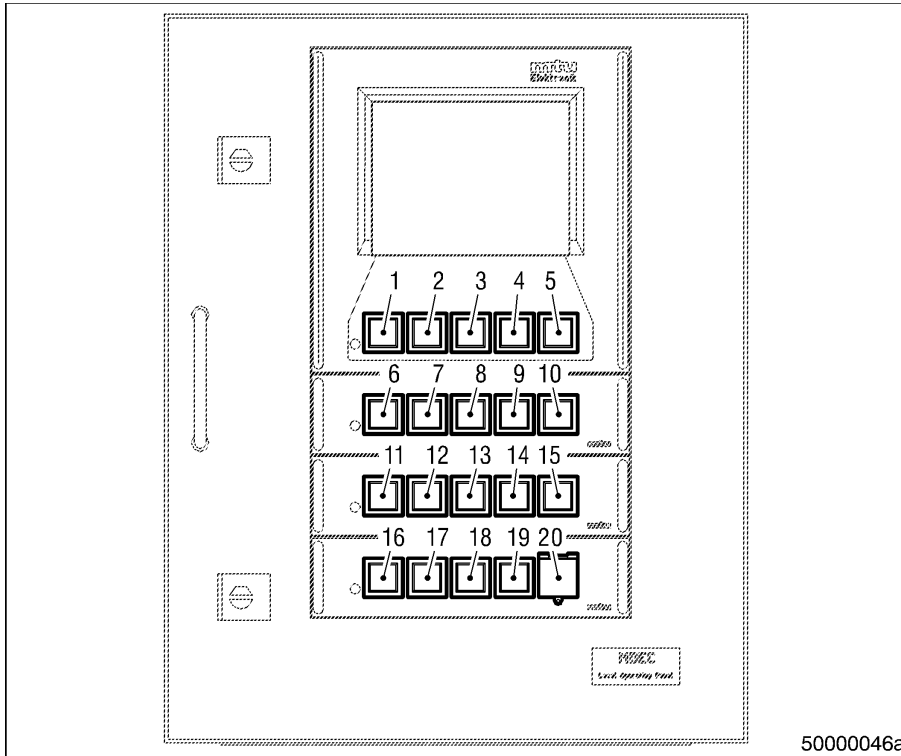
Data transmission

Term	Unit	Value
Bit serial		As per RS422 standard
Baud rate	kBd	1.2 to 19.2
Electrical isolation		With optocoupler.
Bit serial		As per RS232-Standard
Baud rate	kBd	1.2 to 19.2
Electrical isolation		With optocoupler.

3 Operation

3.1 LOP controls

LOP controls



Item	Color	Inscription	Meaning / Function
1	White	F1	Function keys for operating the screen. Functions change and are indicated on the display.
2	White	F2	
3	White	F3	
4	White	F4	
5	White	F5	
6	White	ALARM ACKNOWLEDGE	Pressing the button the first time stops alarm signalization. Pressing the button a second time acknowledges an active alarm. LED (spot) lights up when an alarm is active.
7	White	DIM ↑	Holding down the button increases LCD background illumination.
8	White	DIM ↓	Holding down the button decreases LCD background illumination.
9	White	LAMP TEST	Pressing the button initiates lamp test.
10	Red	TEST OVERSPEED	Pressing the button initiates overspeed test. LED (spot) lights up as long as the overspeed test is running.
11	Green	(none)	(none)

Item	Color	Inscription	Meaning / Function
12	Green	(none)	(none)
13	Green	(none)	(none)
14	White	ENGINE SPEED INCREASE	Engine speed is increased as long as the button is held down.
15	White	ENGINE SPEED DECREASE	Engine speed is decreased as long as the button is held down.
16	Green	READY FOR OPERATION	Pressing the switch 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 switch activates changeover between local and remote control mode. LED (spot) lights up when local mode is active.
18	White	START	Pressing the button initiates automatic engine starting procedure. LED (spot) lights up as long as the starting procedure is running.
19	White	STOP	Pressing the button initiates automatic engine stopping procedure. LED (spot) lights up as long as the STOP signal is available (also if transmitted from RCS).
20	Red	EMERGENCY STOP	Pressing the button initiates immediate emergency stop. LED (spot) flashes once the emergency stop has been tripped and until the alarm has been acknowledged.

3.2 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 129);
Fuel prefilter	Prime (→ Page 120).
Fuel prefilter, pressure gauge	Align adjustable pointer with position of pressure indicator (→ Page 115).
Fuel system	Vent
Coolant circuit	If engine is out of service for more than one year, change engine coolant (→ Page 137); Change charge-air coolant (→ Page 140).
Coolant circuit	Check engine coolant level (→ Page 138); Check charge-air coolant level (→ Page 143).
Coolant circuit	Preheat coolant with preheating unit.
ECU	Check plug-in connections (→ Page 152).
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.

3.3 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 129);
Cooling system	Check engine coolant level (→ Page 138); Check charge-air coolant level (→ Page 143).
Cooling system	Preheat coolant with preheating unit.
Fuel prefilter	Drain (→ Page 116).
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.

3.4 Starting the engine in manual mode

Preconditions

- Generator is not connected to network.
- External start interlock is not activated.

 DANGER	Unguarded rotating and moving engine components. Risk of serious injury — danger to life! <ul style="list-style-type: none"> • Before barring or starting the engine, ensure that nobody is in the danger zone.
--	--

 WARNING	Engine noise above 85 dB (A). Risk of damage to hearing! <ul style="list-style-type: none"> • 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
Switching cabinet, control panel etc. (depending on manufacturer)	If coolant temperature is <ul style="list-style-type: none"> • > 40 °C (with preheating pump), or • > 10 °C (60 Hz generator, without preheating pump), or • > 5 °C (50 Hz generator, without preheating pump): Press start button. <ul style="list-style-type: none"> • Automatic starting procedure is performed; • Tachometer indicates increasing crankshaft speed; • After the starting procedure is completed, engine is running at rated speed.

Connecting the generator to network, running the engine to reach operating temperature

Item	Task
Switching cabinet, control panel etc. (depending on manufacturer)	Close the generator circuit breaker.
Engine	Run engine at 10 to 15 % of rated power to reach operating temperature. Apply full load only after engine has reached operating temperature (coolant temperature approx. 75 °C).

3.5 Emergency start (override mode)



Safety functions and engine shutdown alarms will be disregarded.
Serious damage to plant!

- Initiate emergency start only in emergency situations.

Preparation

Item	Task
Operating mode selector switch (if provided)	Change to manual mode.



Emergency start

Item	Task
Switching cabinet, control panel etc. (depending on manufacturer)	Actuate switch/button for override input of ECU.
Switching cabinet, control panel etc. (depending on manufacturer)	Press start button. <ul style="list-style-type: none"> • Automatic starting procedure is performed; All safety functions are deactivated and engine shutdown alarms disregarded; • Tachometer indicates increasing crankshaft speed; • After the starting procedure is completed, engine is running at rated speed.

Connecting the generator to network

Item	Task
Switching cabinet, control panel etc. (depending on manufacturer)	If generator is not connected to network: Close the generator circuit breaker.
Engine	Run at rated power.

3.6 Operational checks

 DANGER	Unguarded rotating and moving engine components. Risk of serious injury – danger to life! <ul style="list-style-type: none"> • Take special care when working on a running engine.
 WARNING	Engine noise above 85 dB (A). Risk of damage to hearing! <ul style="list-style-type: none"> • Wear ear protectors.

Operational checks

Item	Task
Control and display panels	Check readings of operational data (speed, temperature, pressures).
Engine under load, Engine at nominal speed	Check engine/plant and pipework for leaks, rectify any leaks with the engine stopped; Check for abnormal running noises and vibration.
Fuel prefilter	Check whether indicated differential pressure is within the limit (→ Page 115).
Exhaust gas system	Check exhaust color (→ Page 65).
Intercooler	Check drain for coolant discharge and obstruction (→ Page 122).
Coolant pump	Check relief bore (→ Page 139).
Compressed-air system (if installed)	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.

3.7 Stopping the engine in manual mode

Preconditions

- Generator is not connected to network.
- Engine is running in manual mode.



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.

Preparation

Item	Task
Engine	After the generator circuit breaker has been opened, allow the engine to cool down by running it idle for approx. 5 minutes.

Stopping the engine

Item	Task
Switching cabinet, control panel etc. (depending on manufacturer)	Press stop button. <ul style="list-style-type: none"> • Automatic stopping procedure is performed; • Engine is stopped.

After stopping the engine

Item	Task
Cooling pump	Operate for approx. 5 minutes after engine stop.

3.8 Emergency stop



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. <ul style="list-style-type: none"> • 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. <ul style="list-style-type: none"> • Audible and visual signalization stops.

3.9 After stopping the engine – engine remains ready for operation

After stopping the engine

Item	Task
Engine/generator control system	Select operating mode, e.g. MANUAL OPERATION, AUTOMATIC OPERATION.

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

Preconditions

- MTU Fluids and Lubricants Specification (A001061/..) is available.

After stopping the engine

Item	Task
Cooling system	Drain engine coolant (→ Page 136); Drain charge-air coolant (→ Page 142) if: <ul style="list-style-type: none"> • 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 control system	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, carry out preservation (→MTU Fluids and Lubricants Specification A001061/..).

4 Maintenance

4.1 Preface

MTU maintenance concept

The maintenance system for MTU products is based on a preventive maintenance concept. Preventive maintenance facilitates advance planning and ensures a high degree of equipment availability.

The maintenance schedule is based on the load profile/load factor specified below. The time intervals at which the maintenance work is to be carried out and the relevant checks and tasks involved are average values based on operational experience and are therefore to be regarded as guidelines only. Specific operating conditions and technical requirements may require additional maintenance operations and/or modifications of the maintenance intervals. In order to be authorized to carry out the individual maintenance jobs, maintenance personnel must have achieved a level of training and qualification appropriate to the complexity of the task in hand. The various Qualification Levels QL1 to QL4 reflect the levels of training offered in MTU courses and the contents of the tool kits required:

QL1: Operational monitoring and maintenance which can be carried out during a break in operation without disassembling the engine.

QL3: Maintenance work which requires partial disassembly of the engine.

QL4: Maintenance work which requires complete disassembly of the engine.

The maintenance schedule matrix normally finishes with extended component maintenance. Following this, maintenance work must then be continued at the specified intervals.

The "task numbers" stated in the list identify the respective maintenance items. They provide a reference to the scope of parts required and appear on the labels of the appropriate replacement parts.

Preventive maintenance instructions

The specification of fluids and lubricants, guidelines for maintenance and change intervals as well as a list of approved fluids and lubricants are provided in the MTU Fluids and Lubricants Specifications A001061 and the component manufacturers' fluids and lubricants specifications. They are therefore not listed in the maintenance schedule (exception: deviations from the Fluids and Lubricants Specifications). Use only fluids and lubricants which comply with the MTU Fluids and Lubricants Specification / are approved by the relevant component manufacturer.

Amongst other items, the operator/customer must carry out the following additional maintenance work:

- Protect rubber and synthetic parts from oil and fuel, never treat with organic detergents, only wipe with a dry cloth.
- Fuel prefilter:

The maintenance interval depends on how dirty the fuel is. The filter elements of the fuel prefilter must be replaced every 2 years at the latest (Task 9998).

- Battery:

Battery maintenance depends on use and ambient conditions. The specifications of the battery manufacturer must be obeyed.

Manufacturer's specifications shall apply to the maintenance of all components not listed in this maintenance schedule.

Any maintenance items which are listed in this Maintenance Schedule but not included in the equipment of the engine concerned can be disregarded.

Out-of-service periods

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

Application group

3B Continuous operation, variable

Load factor

Load factor <75%

Load profile**Load-profile table**

Power	90%	75%	50%	20%
Corresponding operating time	5%	40%	50%	5%

4.2 Maintenance schedule matrix

0-10,500 operating hours

Item	Limit, years	Operating hours [h]																						
		Daily	500	1,000	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000	5,500	6,000	6,500	7,000	7,500	8,000	8,500	9,000	9,500	10,000	10,500	
Engine oil filter	2																							
Engine operation	-	X																						
Fuel filter	2		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Valve gear	-					X				X				X				X				X		
Fuel injectors	-									X								X						
Combustion chambers	-									X								X						
Fuel injection pump(s)	-													X										
Component maintenance	-																	X						
Cylinder head	-																	X						
Extended component maintenance	18																							
Fuel pressure maintaining valve	18																							

11,000-12,000 operating hours

Item	Limit, years	Operating hours [h]															
		11,000	11,500	12,000													
Engine oil filter	2																
Engine operation	-																
Fuel filter	2	X	X	X													
Valve gear	-			X													
Fuel injectors	-			X													
Combustion chambers	-			X													
Fuel injection pump(s)	-			X													
Component maintenance	-																
Cylinder head	-																
Extended component maintenance	18			X													
Fuel pressure maintaining valve	18			X													

4.3 Maintenance tasks

Qualification	Interval		Item	Maintenance tasks	Task
	[hours]	[years]			
QL1	-	2	Engine oil filter	Replace engine oil filter when changing the oil or when the interval/years is reached, at the latest (→ Page 130).	W1008
QL1	Daily	-	Engine operation	Check engine oil level (→ Page 53). Visually check engine for leaks and general condition (→ Page 53). Check intercooler drain (if fitted) (→ Page 53). Check signal-ring position of service indicator on air filter (→ Page 53). Check relief bores of water pump(s) (→ Page 53). Check engine for abnormal running noises, exhaust color and vibrations (→ Page 53). Drain water and contaminants from fuel prefilter (if fitted) (→ Page 53). Check reading on vacuum gauge of fuel prefilter (if fitted) (→ Page 53).	W0500 W0501 W0502 W0503 W0505 W0506 W0507 W0508
QL1	500	2	Fuel filter	Replace fuel filter or fuel filter element (→ Page 112).	W1001
QL1	2,000	-	Valve gear	Check valve clearance. ATTENTION! First adjustment after 1,000 operating hours! (→ Operating Instructions) (→ Page 98)	W1207
QL1	4,000	-	Fuel injectors	Replace injectors (→ Page 105).	W1006
QL1	4,000	-	Combustion chambers	Perform endoscopic examination (→ Page 92).	W1011
QL1	6,000	-	Fuel injection pump(s)	Replace fuel injection pump(s) (→ Page 101).	W1007
QL3	8,000	-	Component maintenance	Before starting maintenance work, drain coolant and flush coolant circuits. Clean air pipework (→ Workshop Manual). Clean intercooler and check for leaks (→ Workshop Manual). Check centrifugal oil filter for wear (if fitted) (→ Workshop Manual). Check vibration damper (→ Workshop Manual). Replace diaphragm of crankcase breather (→ Workshop Manual). Clean engine oil heat exchanger and check for leaks (→ Workshop Manual). Check engine alignment (→ Workshop Manual). Clean fuel cooler (→ Workshop Manual). Replace thermal actuator of coolant thermostat (→ Workshop Manual). Check rocker arms, valve bridge, pushrods and ball joints for wear (→ Workshop Manual). Overhaul exhaust turbochargers (→ Workshop Manual). Replace seals of all disassembled components (→ Workshop Manual). Overhaul engine coolant pump.	W2000 W2002 W2003 W2009 W2011 W2014 W2018 W2036 W2059 W2073 W2074 W2075 W2062 W2110
QL3	8,000	-	Cylinder head	Overhaul cylinder heads, inspect piston crowns and running pattern of cylinder liners (→ Workshop Manual).	W1063

Qualification	Interval		Item	Maintenance tasks	Task
	[hours]	[years]			
QL4	12,000	18	Extended component maintenance	Disassemble engine completely. Inspect engine components acc. to assembly instructions; repair or replace as necessary (→Workshop Manual).	W3000
				Replace all elastomer components and seals (→Workshop Manual).	W3001
				Replace piston rings (→Workshop Manual).	W3002
				Replace conrod bearings (→Workshop Manual).	W3003
				Replace crankshaft bearings (→Workshop Manual).	W3004
				Replace cylinder liners (→Workshop Manual).	W3005
				Replace antifriction bearing of auxiliary PTO (→Workshop Manual).	W3006
				Replace oil separator of crankcase breather (→Workshop Manual).	W3009
				Replace fuel delivery pump (→Workshop Manual).	W3010
				Overhaul starter (→Workshop Manual).	W3041
Overhaul battery-charging generator (→Workshop Manual).	W3042				
QL1	12,000	18	Fuel pressure maintaining valve	Replace fuel pressure maintaining valve (→Operating Instructions) (→ Page 109)	W1056

5 Troubleshooting

5.1 Troubleshooting

Engine does not turn when starter is actuated

Component	Probable Cause	Task
Battery	Low or defective	Charge or replace (see manufacturer's documentation).
	Cable connections defective	Check whether cable connections are properly secured (see manufacturer's documentation).
Starter (electric)	Engine wiring or starter defective	Check whether cable connections are properly secured, contact Service.
Engine wiring	Defective	Check (→ Page 144).
ECU	Plug-in connections are loose	Check plug-in connections (→ Page 152).
Engine	Running gear blocked (engine cannot be barred manually)	Contact Service.

Engine turns but does not fire

Component	Probable Cause	Task
Starter	Poor rotation by starter: Battery low or defective	Charge or replace battery (see manufacturer's documentation).
Engine wiring	Defective	Check (→ Page 144).
ECU	Defective	Contact Service.

Engine fires unevenly

Component	Probable Cause	Task
Fuel injection equipment	Injector defective	Replace (→ Page 105).
	Injection pump defective	Replace (→ Page 102).
Engine wiring	Defective	Check (→ Page 144).
ECU	Defective	Contact Service.

Engine does not reach nominal speed

Component	Probable Cause	Task
Fuel supply	Fuel supply shut off	Open shut-off valve before fuel prefilter completely.
	Fuel prefilter clogged	Replace (→ Page 120).
	Easy-change fuel filter clogged	Replace (→ Page 112).
Fuel injection equipment	Injector defective	Replace (→ Page 105).
	Injection pump defective	Replace (→ Page 102).
Engine wiring	Defective	Check (→ Page 144).
Engine	Overload	Contact Service.

Engine speed not steady

Component	Probable Cause	Task
Fuel injection equipment	Injector defective	Replace (→ Page 105).
	Injection pump defective	Replace (→ Page 101).
Speed sensor	Defective	Contact Service.
ECU	Defective	Contact Service.

Charge-air temperature too high

Component	Probable Cause	Task
Engine coolant	Incorrect coolant concentration	Check (MTU test kit)
Intercooler	Contaminated	Contact Service.
Engine room	Air-intake temperature too high	Check fans; Check air supply / ventilation ducts.

Charge-air pressure too low

Component	Probable Cause	Task
Intercooler	Contaminated	Contact Service.
Exhaust turbocharger	Defective	Contact Service.

Coolant leaks on intercooler

Component	Probable Cause	Task
Intercooler	Leaking, major coolant discharge	Contact Service.

Exhaust gas black

Component	Probable Cause	Task
Fuel injection equipment	Injector defective	Replace (→ Page 105).
	Injection pump defective	Replace (→ Page 101).
Engine	Overload	Contact Service.

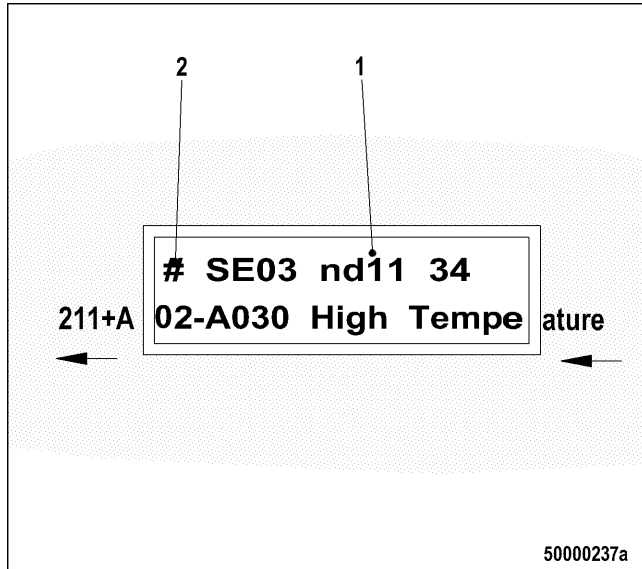
Exhaust gas blue

Component	Probable Cause	Task
Engine oil	Too much oil in engine	Drain engine oil (→ Page 127).
	Oil separator or oil preseparator of crankcase breather clogged	Replace (→ Page 96).
Exhaust turbocharger Cylinder head Piston rings Cylinder liner	Defective	Contact Service.

Exhaust gas white

Component	Probable Cause	Task
Engine	Not at operating temperature	Run engine to reach operating temperature.
Fuel system	Water in fuel	Check fuel system on fuel prefilter; Drain fuel prefilter (→ Page 116).
Intercooler	Leaking	Contact Service.

5.2 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
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.	<ol style="list-style-type: none"> 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)	<ol style="list-style-type: none"> 1. Check cabling (→ Engine operating instructions); 2. Contact Service.
020	L2 T-EXHAUST A	Exhaust temperature engine A side too high (2nd limit value)	<ol style="list-style-type: none"> 1. Check cabling (→ Engine operating instructions); 2. Contact Service.
021	L1 T-EXHAUST B	Exhaust temperature engine B side too high (1st limit value)	<ol style="list-style-type: none"> 1. Check cabling (→ Engine operating instructions); 2. Contact Service.
022	L2 T-EXHAUST B	Exhaust temperature engine B side too high (2nd limit value)	<ol style="list-style-type: none"> 1. Check cabling (→ Engine operating instructions); 2. Contact Service.
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.	<ol style="list-style-type: none"> 1. Acknowledge alarm. 2. Attempt to restart engine.
031	CHARGER 1 OVERSPEED1	ETC 1 – speed violation (1st limit value).	<ul style="list-style-type: none"> • Engine management system automatically reduces power. • Check air filter (→ Engine operating instructions).
032	CHARGER 1 OVERSPEED2	ETC 1 – speed violation. (2nd limit value)	<ul style="list-style-type: none"> • 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).

Fault code	Fault message	Meaning	Action
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)	<ol style="list-style-type: none"> 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)	<ul style="list-style-type: none"> • Automatic engine shutdown. • Check coolant level (→ Engine operating instructions).
065	L1 P-FUEL	Fuel inlet pressure too low (1st limit value)	(→ Engine operating instructions) <ul style="list-style-type: none"> • 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) <ul style="list-style-type: none"> • Check fuel lines for leakage. • Clean fuel prefilter. • Rinse fuel prefilter. • Replace fuel prefilter element . • Replace fuel filter.
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	<ol style="list-style-type: none"> 1. Allow engine to cool down. 2. Contact Service <ul style="list-style-type: none"> • 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.

Fault code	Fault message	Meaning	Action
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.
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).

Fault code	Fault message	Meaning	Action
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: <ul style="list-style-type: none"> • Either short circuit on bus. • Or strong magnetic fields disrupting bus. 	Contact Service. <ul style="list-style-type: none"> • Check CAN bus for short circuit, rectify short circuit as necessary. • Check shielding, improve shielding as necessary.
187	CAN 1 ERROR PASSIVE	CAN 1 in Error-Passive state, minor bus disruption or missing CAN node .	Contact Service. <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Either short circuit on bus. • Or strong magnetic fields disrupting bus. 	Contact Service. <ul style="list-style-type: none"> • 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. <ul style="list-style-type: none"> • 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).	<ol style="list-style-type: none"> 1. Check cabling (→ Engine operating instructions); 2. Contact Service <ul style="list-style-type: none"> • Check sensor.

Fault code	Fault message	Meaning	Action
202	SD T-FUEL	Sensor B33 faulty (fuel temperature).	<ol style="list-style-type: none"> 1. Check cabling (→ Engine operating instructions); 2. Contact Service <ul style="list-style-type: none"> • Check sensor.
203	SD T-CHARGE AIR	Sensor B09 faulty (charge air temperature) A-side.	<ol style="list-style-type: none"> 1. Check cabling (→ Engine operating instructions); 2. Contact Service <ul style="list-style-type: none"> • Check sensor.
205	SD T-COOLANT INTERC.	Sensor fault (charge-air coolant temperature).	<ol style="list-style-type: none"> 1. Check cabling (→ Engine operating instructions); 2. Contact Service <ul style="list-style-type: none"> • Check sensor.
206	SD T-EXHAUST A	Sensor B4.21 faulty (exhaust temperature) engine side A.	<ol style="list-style-type: none"> 1. Check cabling (→ Engine operating instructions); 2. Contact Service <ul style="list-style-type: none"> • Check sensor.
207	SD T-EXHAUST B	Sensor B4.22 faulty (exhaust temperature) engine side B.	<ol style="list-style-type: none"> 1. Check cabling (→ Engine operating instructions); 2. Contact Service <ul style="list-style-type: none"> • Check sensor.
208	SD P-CHARGE AIR	Sensor B10 faulty (charge-air pressure) A-side.	<ol style="list-style-type: none"> 1. Check cabling (→ Engine operating instructions); 2. Contact Service <ul style="list-style-type: none"> • Check sensor.
211	SD P-LUBE OIL	Sensor B05 faulty (lube oil pressure).	<ol style="list-style-type: none"> 1. Check cabling (→ Engine operating instructions); 2. Contact Service <ul style="list-style-type: none"> • Check sensor.
212	SD P-COOLANT	Sensor B16 faulty (coolant pressure).	<ol style="list-style-type: none"> 1. Check cabling (→ Engine operating instructions); 2. Contact Service <ul style="list-style-type: none"> • Check sensor.
216	SD T-LUBE OIL	Sensor B07 faulty (lube oil temperature).	<ol style="list-style-type: none"> 1. Check cabling (→ Engine operating instructions); 2. Contact Service <ul style="list-style-type: none"> • Check sensor.
219	SD T-INTAKE AIR	Sensor B03 faulty (intake air temperature).	<ol style="list-style-type: none"> 1. Check cabling (→ Engine operating instructions); 2. Contact Service <ul style="list-style-type: none"> • Check sensor.
220	SD COOLANT LEVEL	Sensor F33 faulty (engine coolant level 1).	<ol style="list-style-type: none"> 1. Switch system off and back on; 2. check fault message; 3. check cabling (→ Engine operating instructions); 4. Contact Service <ul style="list-style-type: none"> • Check sensor.
222	SD LEVEL LEAKAGE FUEL	Sensor fault (leak fuel).	<ol style="list-style-type: none"> 1. Check cabling (→ Engine operating instructions); 2. Contact Service <ul style="list-style-type: none"> • Check sensor.

Fault code	Fault message	Meaning	Action
223	SD LEVEL INTERCOOLER	Sensor fault (charge air coolant level).	<ol style="list-style-type: none"> 1. Check cabling (→ Engine operating instructions); 2. Contact Service <ul style="list-style-type: none"> • Check sensor.
229	SD ENG. SPEED SENSORS	Sensor fault crankshaft speed and camshaft speed.	<ol style="list-style-type: none"> 1. Check cabling (→ Engine operating instructions); 2. Contact Service <ul style="list-style-type: none"> • Check sensor.
230	SD CRANKSHAFT SPEED	Sensor B13 faulty (crankshaft speed).	<ol style="list-style-type: none"> 1. Check cabling (→ Engine operating instructions); 2. Contact Service <ul style="list-style-type: none"> • Check sensor.
231	SD CAMSHAFT SPEED	Sensor B1 faulty (camshaft speed).	<ol style="list-style-type: none"> 1. Check cabling (→ Engine operating instructions); 2. Contact Service <ul style="list-style-type: none"> • Check sensor.
232	SD CHARGER SPEED 1	Sensor B44 faulty (ETC speed 1).	<ol style="list-style-type: none"> 1. Check cabling (→ Engine operating instructions); 2. Contact Service <ul style="list-style-type: none"> • Check sensor.
240	SD P-FUEL	Sensor B34 faulty (fuel pressure).	<ol style="list-style-type: none"> 1. Check cabling (→ Engine operating instructions); 2. Contact Service <ul style="list-style-type: none"> • 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. <ul style="list-style-type: none"> • Check CAN communication.
266	SD SPEED DEMAND AN.	External speed setting faulty.	(→ Engine operating instructions) <ol style="list-style-type: none"> 1. Check cabling 2. Check speed setting.
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.	<ol style="list-style-type: none"> 1. Check cabling (→ Engine operating instructions); 2. Contact Service <ul style="list-style-type: none"> • 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).

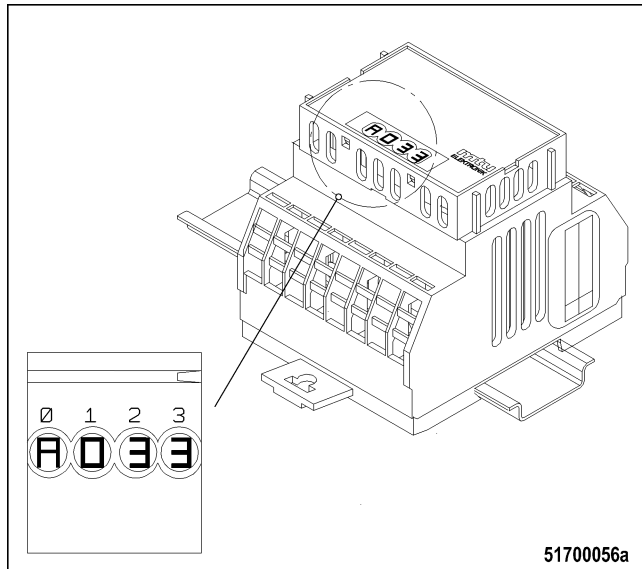
Fault code	Fault message	Meaning	Action
321...330	WIRING CYLINDER (A1- A10)	Wiring bank 1 (solenoid valve 1) ... Wiring bank 1 (solenoid valve 10)	Contact Service. • Check solenoid valve.
331...340	WIRING CYLINDER (B1- B10)	Wiring bank 2 (solenoid valve 1) ... Wiring bank 2 (solenoid valve 10)	Contact 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.
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.

Fault code	Fault message	Meaning	Action
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	<ol style="list-style-type: none"> 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).	<ol style="list-style-type: none"> 1. Check cabling (→ Engine operating instructions). 2. Contact Service <ul style="list-style-type: none"> • Check sensor.
393	L2 T-COOLANT RED	Redundant coolant temperature (2nd limit value).	<ol style="list-style-type: none"> 1. Check cabling (→ Engine operating instructions). 2. Contact Service <ul style="list-style-type: none"> • Check sensor.
394	L1 P-LUBE OIL RED	Redundant lube oil pressure (1st limit value).	<ol style="list-style-type: none"> 1. Check cabling (→ Engine operating instructions). 2. Contact Service <ul style="list-style-type: none"> • Check sensor.
395	L2 P-LUBE OIL RED	Redundant lube oil pressure (2nd limit value).	<ol style="list-style-type: none"> 1. Check cabling (→ Engine operating instructions). 2. Contact Service <ul style="list-style-type: none"> • Check sensor.
396	TD COOLANT	Transmitter deviation coolant temperature.	<ol style="list-style-type: none"> 1. Check cabling (→ Engine operating instructions). 2. Contact Service <ul style="list-style-type: none"> • Check sensor.
397	TD OIL PRESSURE	Transmitter deviation engine oil pressure.	<ol style="list-style-type: none"> 1. Check cabling (→ Engine operating instructions). 2. Contact Service <ul style="list-style-type: none"> • Check sensor.

5.3 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-INTERCOOLER	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 129);
016	L2 P-LUBE OIL	Lube-oil pressure too low (2nd limit) automatic engine shutdown	<ol style="list-style-type: none"> 1. Check engine-oil level and top up, if required (→ Page 129); 2. Try to re-start the engine (→ Page 51). 3. Contact Service.

Fault code	Alarm text	Meaning	Task
023	L1 COOLANT LEVEL	Engine coolant level too low	Check coolant level and top up, if required (→ Page 138) .
024	L2 COOLANT LEVEL	Engine coolant level too low	Check coolant level and top up, if required (→ Page 138).
030	ENGINE OVERSPEED	Engine overspeed; automatic engine shutdown	<ol style="list-style-type: none"> 1. Acknowledge alarm. 2. Try to re-start the engine (→ Page 51). 3. Contact Service.
033	L1 P-FUELFILTER DIFF	Differential pressure before/after fuel filter too high	Replace fuel filter (→ Page 112).
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)	<ol style="list-style-type: none"> 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	<ol style="list-style-type: none"> 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 51). 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 INTERCOOLER 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 51).
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.
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.

Fault code	Alarm text	Meaning	Task
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 51).
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	SENSORPOWER-DEFECT	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.
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.

Fault code	Alarm text	Meaning	Task
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)
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.

Fault code	Alarm text	Meaning	Task
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 CRANKSHAFT 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-ELECTRONIC	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 DEMAND 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 DEMAND 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.
274	SD P-EXTERN 2	External device defective (CAN P-EXTERN 2)	Contact Service.

Fault code	Alarm text	Meaning	Task
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.

Fault code	Alarm text	Meaning	Task
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.
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.

Fault code	Alarm text	Meaning	Task
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.
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.

Fault code	Alarm text	Meaning	Task
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.
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.

Fault code	Alarm text	Meaning	Task
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.
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 51). 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 51). 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 51). 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.

6 Task Description

6.1 Engine

6.1.1 Engine – Barring manually

Preconditions

- Engine is stopped and starting disabled.

Special tools

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



DANGER

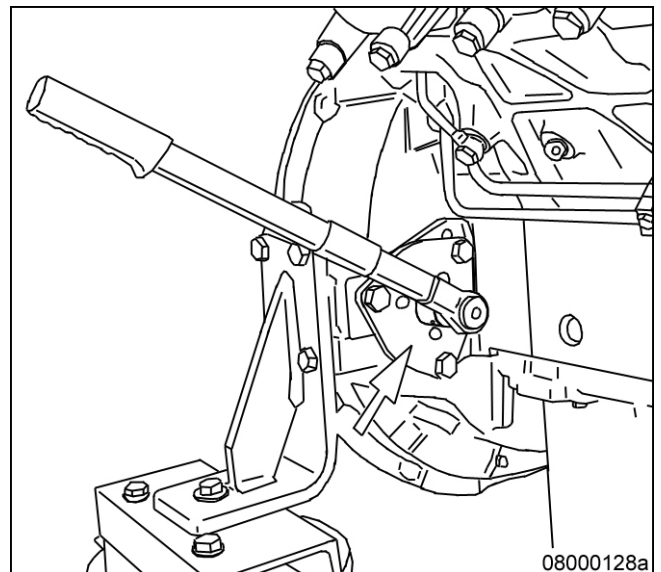
Unguarded rotating and moving engine components.

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.



6.1.2 Engine – Barring with starting system

Special tools

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



DANGER

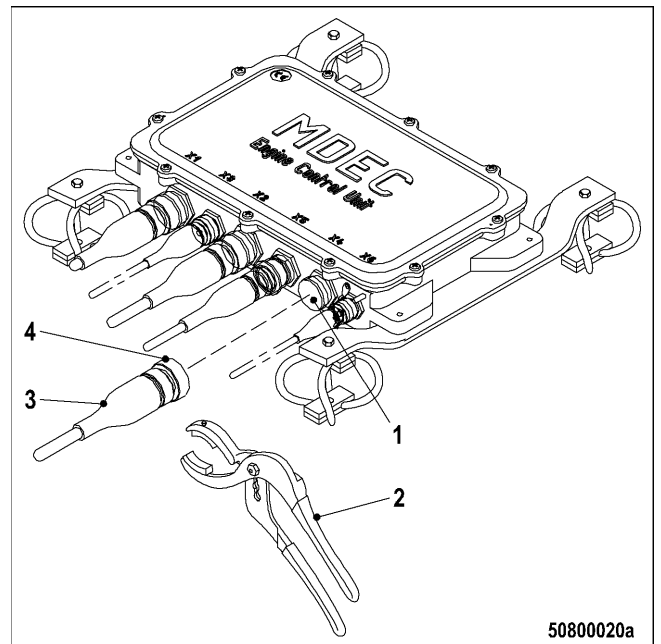
Unguarded rotating and moving engine components.

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 ring-nut (4) of connector X4 with connector pliers (2) and withdraw connector (3) from ECU.
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 ring (4) by turning it clockwise until it latches into place.



6.1.3 Engine test run



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.



Engine noise above 85 dB (A).

Risk of damage to hearing!

- Wear ear protectors.

Engine test run

1. Start engine (→ Page 51).
2. Perform test run at not below 1/3 load and at least until steady-state temperature is reached.
3. Carry out operational checks (→ Page 53).
4. Stop engine (→ Page 54).

6.2 Cylinder Liner

6.2.1 Cylinder liner – Endoscopic examination

Preconditions

- Engine is stopped and starting disabled.

Special tools

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

Preparatory steps

1. Remove cylinder-head cover (→ Page 100).
2. Remove injector (→ Page 106).

Positioning crankshaft at BDC

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

Cylinder liner - Endoscopic examination

Findings	Task
<ul style="list-style-type: none"> • Thin carbon coating on carbon scraper ring • Slight localized additive deposits at top edge • Localized smooth areas at lower edge • Carbon deposits on entire circumference between top piston ring and lower edge of carbon scraper ring • First signs of marks left by top piston ring • Bright mark on entire circumference • Faultless, even honing pattern • First signs of marks left by lower cooling bores • Running pattern seems darker 	No actions required
<ul style="list-style-type: none"> • Darker areas of even or varying color intensity • 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 cannot be faulted • Piston rings cannot be faulted 	Further endoscopic examination required as part of maintenance work
<ul style="list-style-type: none"> • On the entire circumference not only bright discoloration (not critical for operation) clearly visible darker stripes that begin 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 93).
3. Depending on findings:
 - Do not take any action or
 - carry out further endoscopic examination as part of maintenance work or
 - contact Service: cylinder liner must be replaced.

Final steps

1. Install injector (→ Page 106).
2. Install cylinder-head cover (→ Page 100).

6.2.2 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.

Minor dirt scores	Light scoring can take place 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 from 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.
Polished area	Polished 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 are corrosion pittings.
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. Cylinders with a number of black lines around the running surface have limited service life and should be replaced.
Discolorations (Heat)	These are caused by a disturbance 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 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 heat discoloration starting in the TDC-ring 1 have to be replaced.
Seizures, Seizure marks	Irregular circumference lengths and depths. Can be caused by either 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. Thorough investigation and compliance with the above evaluation criteria allows a definite evaluation. To avoid unnecessary disassembly work, it is recommended that another inspection be carried out after further operation of the engine.

6.3 Crankcase Ventilation

6.3.1 Crankcase breather – Wire mesh cleaning

Material

Designation / Use	Part No.	Qty.
Cleaner		
Diesel fuel		
Petroleum jelly		

Spare parts

Designation / Use	Part No.	Qty.
Sealing ring		



Fuels are combustible.

Risk of fire and explosion!

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



Compressed air.

Risk of injury!

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



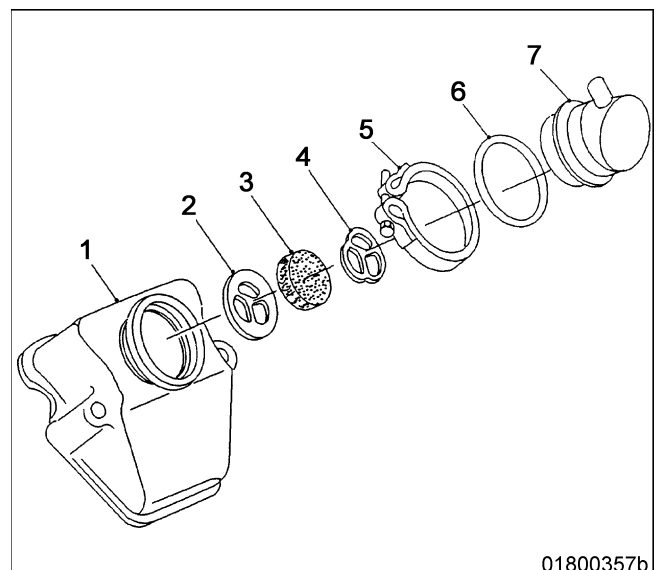
Excessive reaction time of cleaning agents on components.

Damage to component!

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

Crankcase breather – Wire mesh cleaning

1. Remove hose.
2. Loosen clamp (5).
3. Remove oil separator cover (7).
4. Remove individual parts from oil separator cover (7).
5. Wash filter element (wire mesh) (3) with diesel fuel.
6. Blow out filter element (wire mesh) (3) with compressed air.
7. Clean residual parts with cleaner.
8. Remove cleaner.
9. Coat sealing ring (6) with petroleum jelly and insert in groove in the oil separator cover (7).
10. Insert both holders (2, 4) and filter element (wire mesh) (3) into the oil separator cover (7), ensuring correct installation sequence.
11. Install oil separator cover (7) with clamp (5) on cylinder head cover (1).
12. Install hose, ensuring that it is not subjected to tension.



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6.3.2 Crankcase breather – Oil separator replacement, diaphragm check and replacement

Preconditions


- Engine is stopped and starting disabled.

Special tools

Designation / Use	Part No.	Qty.
Torque wrench 6-50 Nm	F30027336	1
Ratchet adapter	F30027340	1

Spare parts

Designation / Use	Part No.	Qty.
Filter element		
Diaphragm		
O-ring		

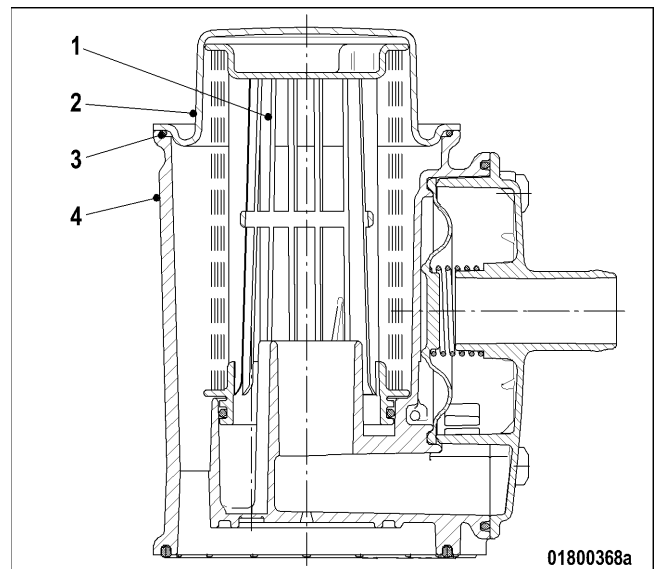


WARNING Hot oil.
Oil can contain combustion residues which are harmful to health.
Risk of injury and poisoning!

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

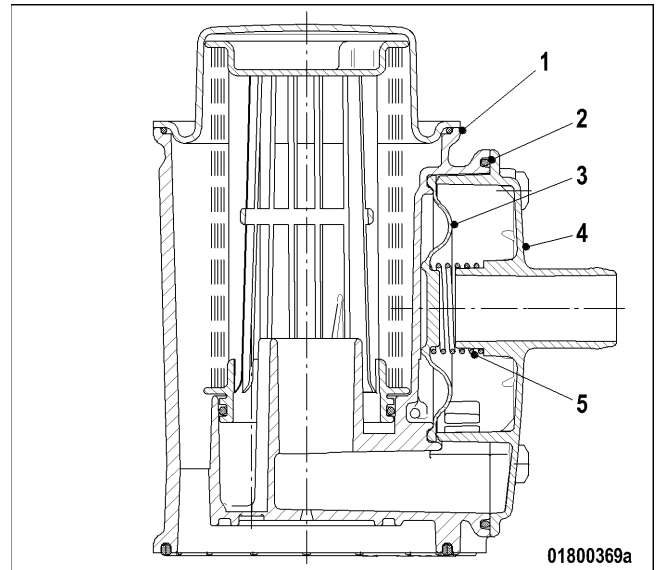
Replacing filter element of oil separator

1. Remove cover (2) with O-ring (3).
2. Remove filter element (1) from housing (4).
3. Insert new filter element into housing (4) ensuring correct installation position, and fit cover (2) with new O-ring.
4. Tighten screws of cover (2) to specified tightening torque of 6 Nm + 2 Nm.
5. Replace filter elements of further oil separators in the same way.



Checking diaphragm

1. Remove cover (4).
2. Take off spring (5), seal (2) and diaphragm (3).
3. Check diaphragm (3) for damage.
4. Fit new diaphragm if used one is damaged.
5. Mount diaphragm (3) on housing (1).
6. Install new seal (2) and spring (5) together with cover (4).
7. Tighten screws of cover (4) to specified tightening torque of 6 Nm + 2 Nm.
8. Check diaphragms in further oil separators in the same way.



6.4 Valve Drive

6.4.1 Valve clearance – Check and adjustment

Preconditions

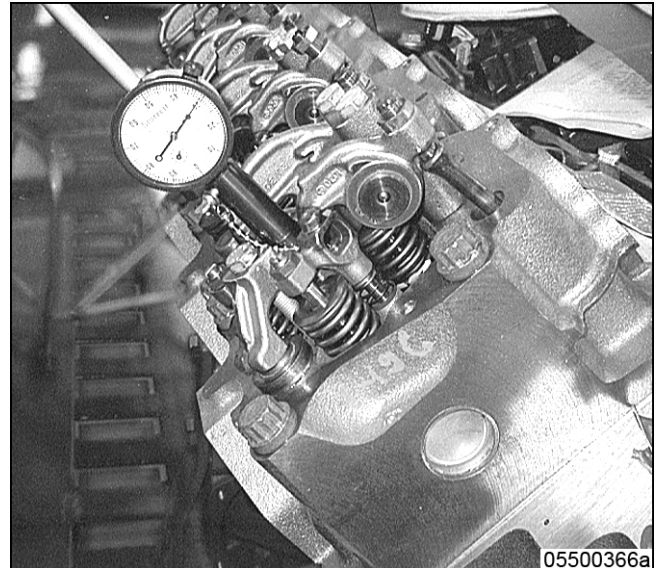
- Engine is stopped and starting disabled.
- Engine coolant temperature is max. 40 °C.
- Valves are closed.

Special tools

Designation / Use	Part No.	Qty.
Feeler gauge	Y20010128	1
Torque wrench 20-100 Nm	F30026582	1
Ratchet adapter	F30027340	1

Preparatory steps

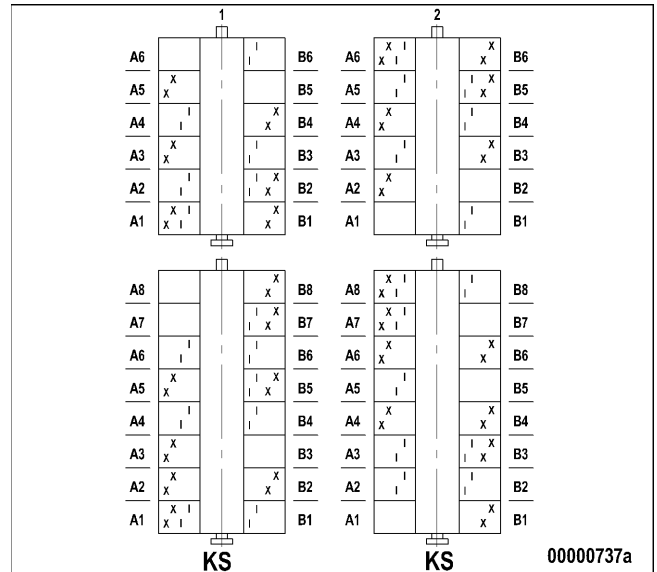
1. Remove cylinder-head cover (→ Page 100).
2. Using the barring tool, bar engine manually in engine direction of rotation (→ Page 89) until cylinders are at TDC.



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Checking valve clearance at two crankshaft positions

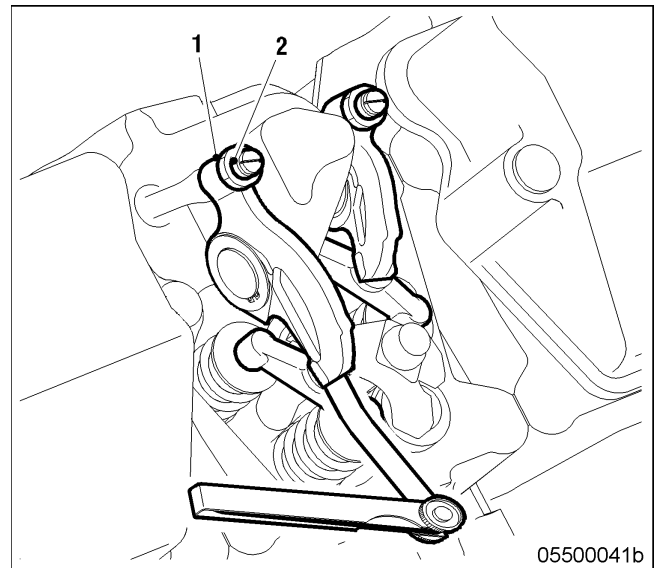
1. Check TDC position of piston in cylinder A1:
 - The piston is at firing TDC when the rockers are unloaded at cylinder A1.
 - The piston is at overlap TDC when the rockers are loaded at cylinder A1.
2. Check valve clearance with cold engine:
 - Inlet = 0.4 mm;
 - Exhaust = 0.6 mm;
3. Check all valve 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.



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

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.



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Final steps

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

6.4.2 Cylinder-head cover – Removal and installation

Preconditions

- Engine is stopped and starting disabled.

Special tools

Designation / Use	Part No.	Qty.
Torque wrench 8-40 Nm	F30043446	1
Ratchet adapter	F30027340	1

Spare parts

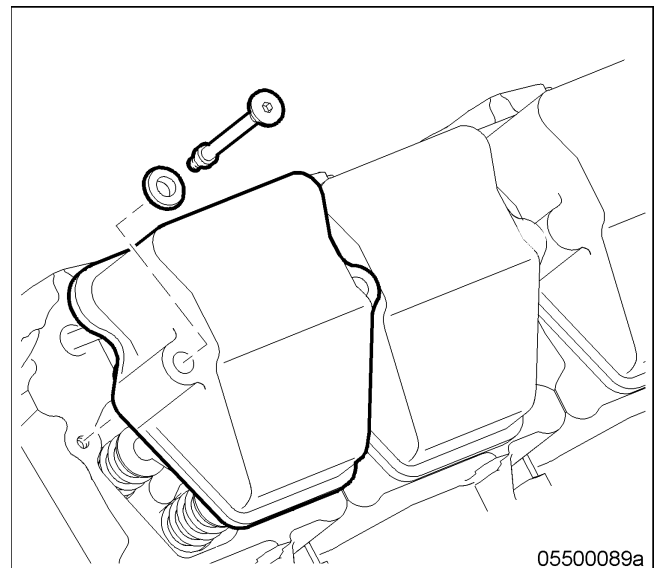
Designation / Use	Part No.	Qty.
Gasket		

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 screws.
2. Remove cylinder-head cover with gasket from cylinder head.
3. Clean mating faces.
4. Check condition of gasket in cylinder-head cover.
5. Replace damaged gasket(s).
6. Place cylinder-head covers onto crankcase and tighten screws to 20 Nm.



Final steps

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

6.5 Injection Pump/ HP Pump

6.5.1 Injection pump replacement

Spare parts

Designation / Use	Part No.	Qty.
Injection pump		

Remove injection pump and install new one (→ Page 102).

6.5.2 Injection pump – Removal and installation

Preconditions

- Engine is stopped and starting disabled.

Special tools

Designation / Use	Part No.	Qty.
Barring tool	F6557929	1
Spider patch spanner	F30027424	1
Spider patch spanner	F30027425	1

Material

Designation / Use	Part No.	Qty.
Petroleum jelly		

Spare parts

Designation / Use	Part No.	Qty.
Sealing ring		
Sealing ring		



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.



Fuels are combustible.

Risk of fire and explosion!

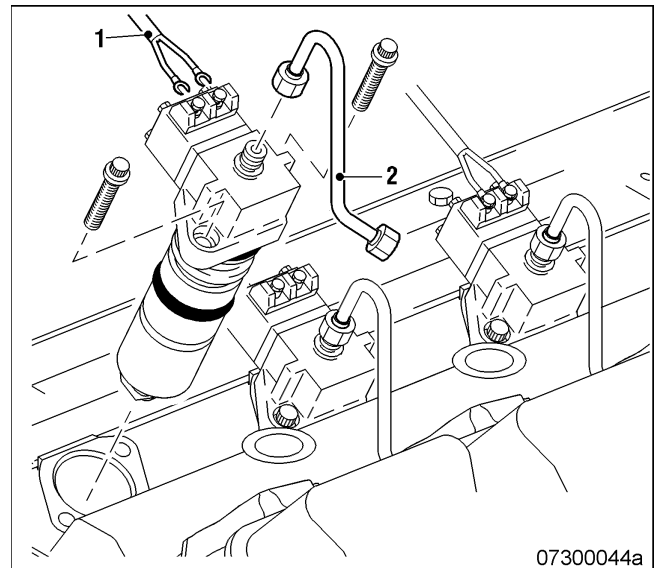
- Avoid naked flames, electrical sparks and ignition sources.
- Do not smoke.

Preparatory steps

1. Shut off fuel supply line before fuel filter.
2. Remove engine control system (→ Page 154).
3. Drain fuel (→ Page 111).
4. Remove charge-air pipes and all seals.

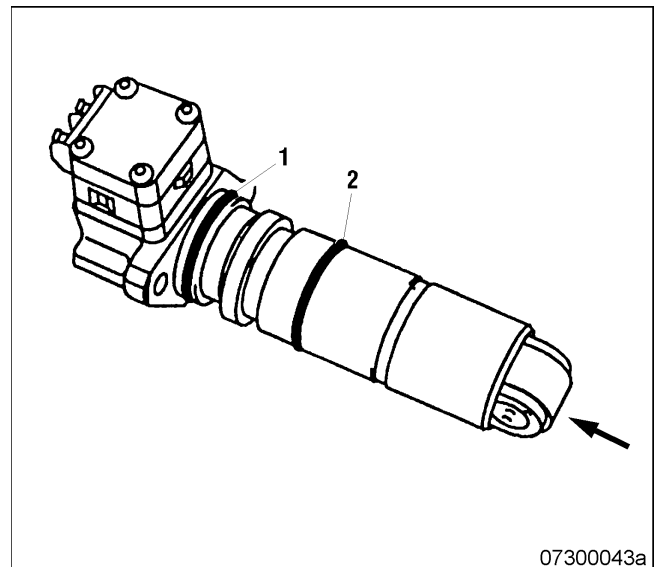
Removing injection pump

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:
 - 4.1. Rotate crankshaft with barring tool (→ Page 89)
 - The pump cam presses the injection pump out of the crankcase, if not:
 - 4.2. 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.

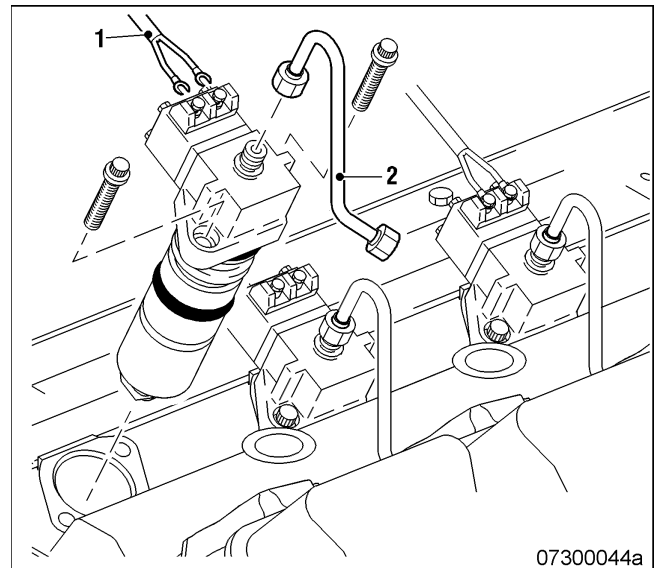


Installing injection pump

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 petroleum jelly and fit onto injection pump.
 - Note:** Sealing ring (2) Ø45 mm
4. Coat sealing ring (2) with petroleum jelly 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 89) to align camshaft pump cams with 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 \pm 0.2 Nm using torque wrench.



Final steps

1. Remove barring tool (\rightarrow Page 89).
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 petroleum jelly and place onto cylinder head.
5. Install charge-air pipes.
6. Install engine control system (\rightarrow Page 154).
7. Open fuel supply line before fuel filter.
8. Vent fuel system.

6.6 Injector

6.6.1 Injector replacement

Spare parts

Designation / Use	Part No.	Qty.
Injector		

Remove injector and install new one (→ Page 106).

6.6.2 Injector – Removal and installation

Preconditions

- Engine is stopped and starting disabled.

Special tools


Designation / Use	Part No.	Qty.
Extractor	F30377999	1
Fuel suction device	F30378207	1
Torque wrench 20-100 Nm	F30026582	1
Socket wrench	F30025897	1
Spider patch spanner	F30027425	1
Spider patch spanner	F30027424	1
Double box wrench	F30011450	1
Ratchet adapter	F30027340	1


Material

Designation / Use	Part No.	Qty.
Petroleum jelly		

Spare parts

Designation / Use	Part No.	Qty.
Sealing ring		
Sealing ring		

 WARNING	Fuels are combustible. Risk of fire and explosion! <ul style="list-style-type: none"> • Avoid naked flames, electrical sparks and ignition sources. • Do not smoke.
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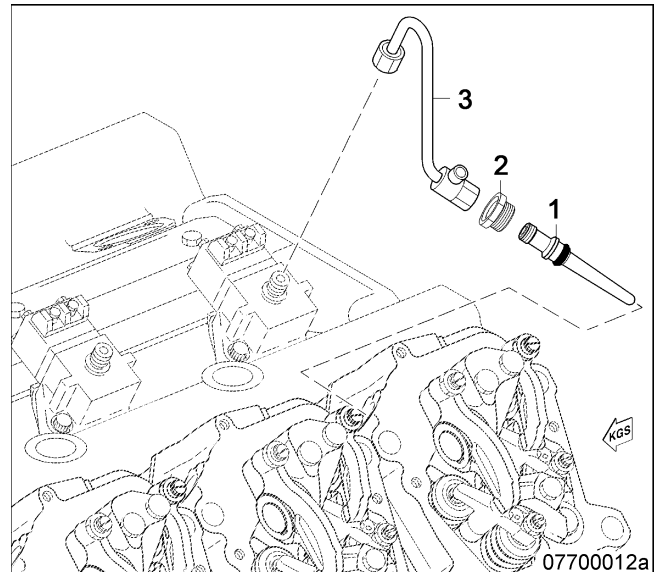
 WARNING	Compressed air. Risk of injury! <ul style="list-style-type: none"> • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors.
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Preparatory steps

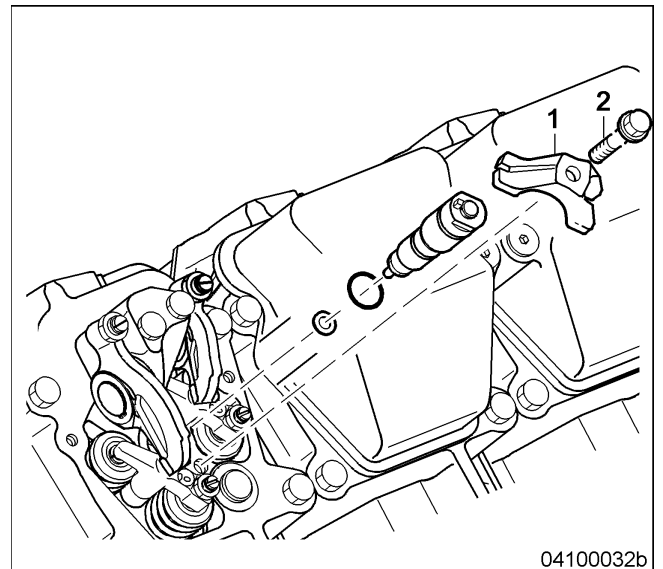
1. Remove cylinder-head cover (→ Page 100).
2. Drain fuel (→ Page 111).

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 petroleum jelly and fit onto injector.
4. Coat sealing ring (2) with petroleum jelly 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 petroleum jelly 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 $40 \text{ Nm} \pm 5 \text{ Nm}$ using torque wrench.

14. Install fuel line (3).

15. Use torque wrench to tighten union nut at injection pump to specified torque $20 \text{ Nm} + 5 \text{ Nm}$.

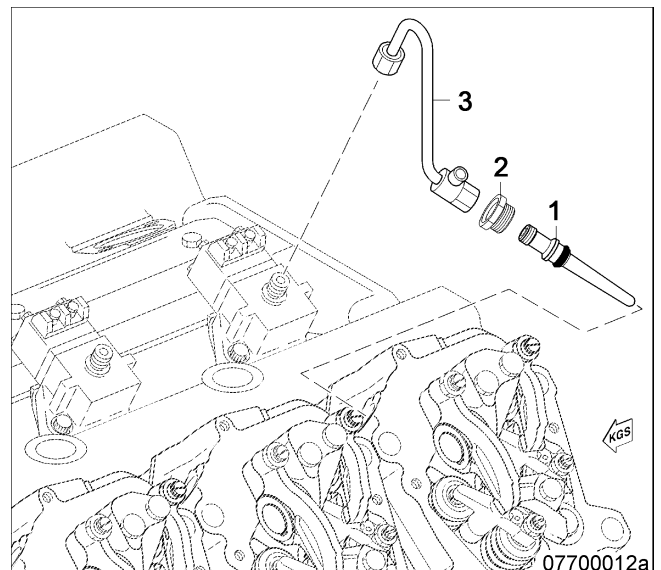
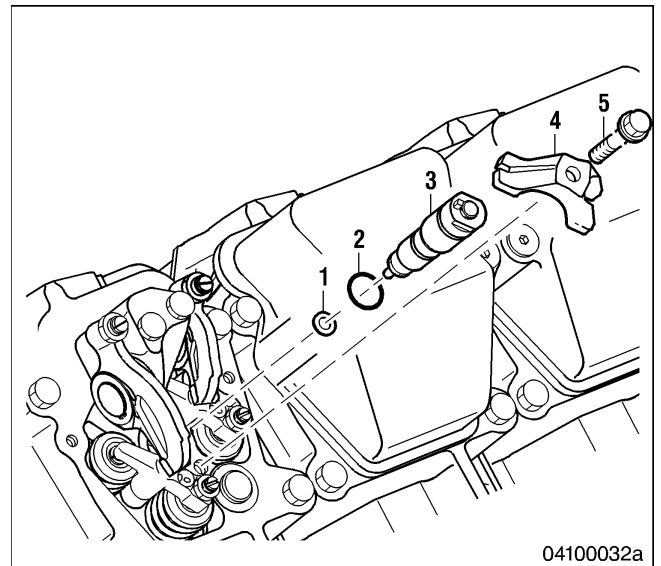
16. Use torque wrench to tighten union nut on pressure pipe neck to specified torque $20 \text{ Nm} + 5 \text{ Nm}$.

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 100).
2. Vent fuel system.



6.7 Fuel System

6.7.1 Fuel pressure relief valve – Replacement

Preconditions

- Engine is stopped and starting disabled.

Spare parts

Designation / Use	Part No.	Qty.
Pressure relief valve		
Sealing ring		



WARNING

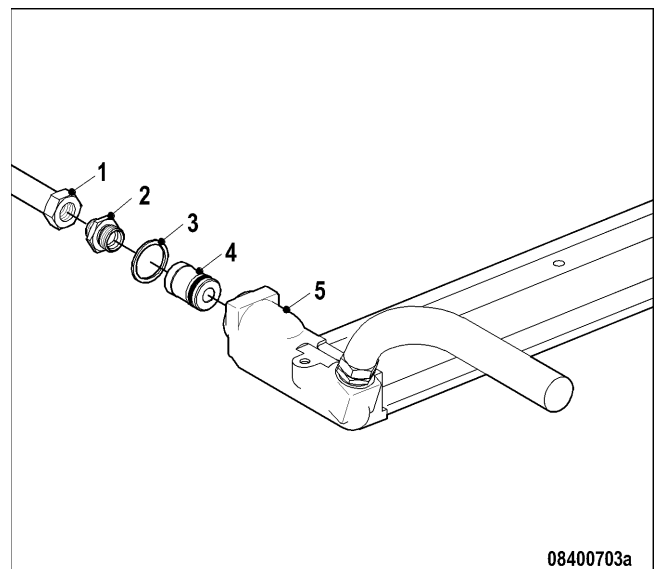
Fuels are combustible.

Risk of fire and explosion!

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

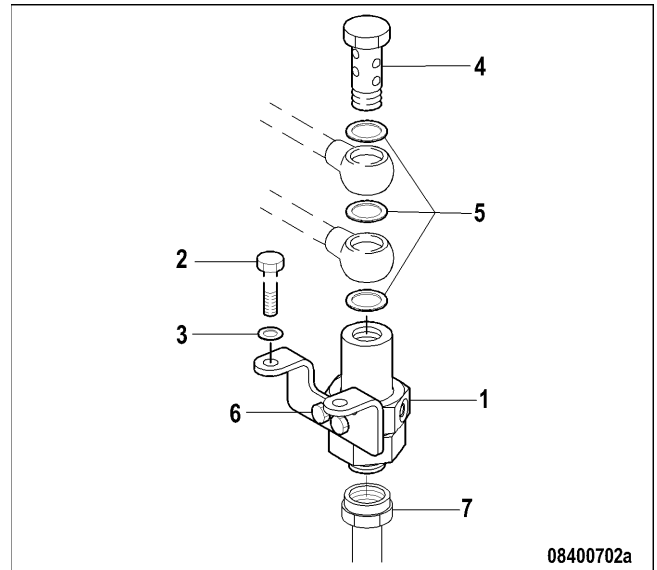
Fuel pressure relief valve – Replacement, variant A

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.



6.7.2 Fuel – Draining

Preconditions

- Engine is stopped and starting disabled.



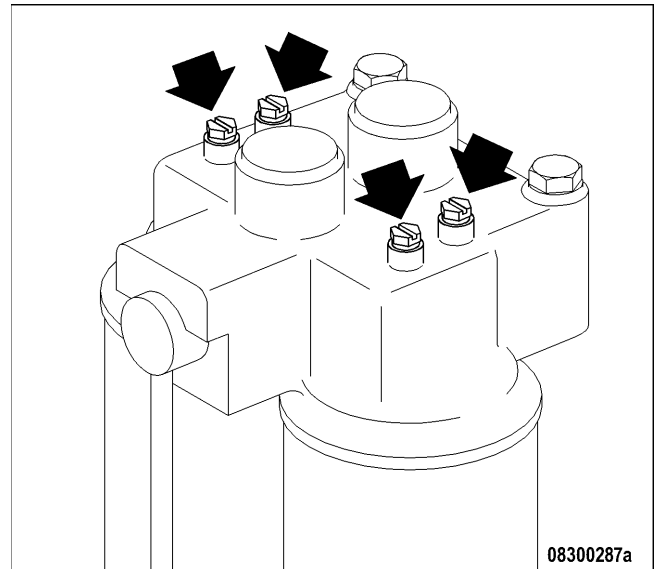
Fuels are combustible.

Risk of fire and explosion!

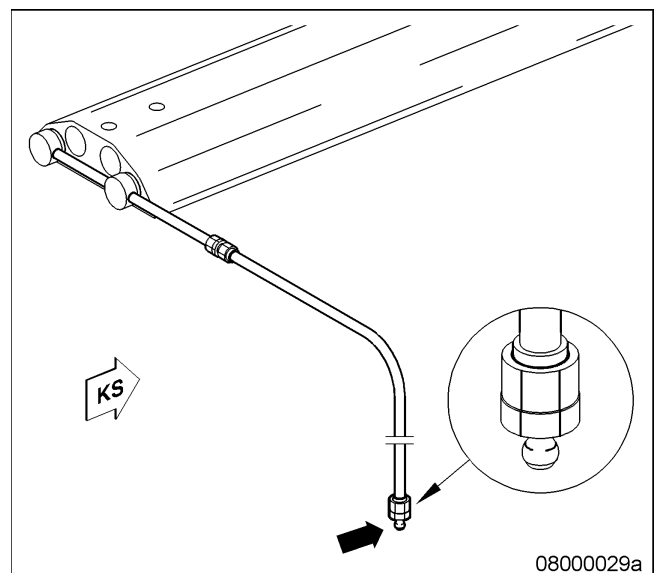
- Avoid naked flames, electrical sparks and ignition sources.
- Do not smoke.

Fuel – Draining

1. Release threaded vent plugs on filter head.



2. Open nipple on fuel line and drain fuel into appropriate container.
3. When fuel stops emerging from system, close nipple on fuel line.
4. Close vent plugs on filter head.



6.8 Fuel Filter

6.8.1 Fuel filter – Replacement

Special tools

Designation / Use	Part No.	Qty.
Filter wrench	F30379104	1

Material

Designation / Use	Part No.	Qty.
Diesel fuel		

Spare parts

Designation / Use	Part No.	Qty.
Easy-change filter		
Synthetic ring		



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



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



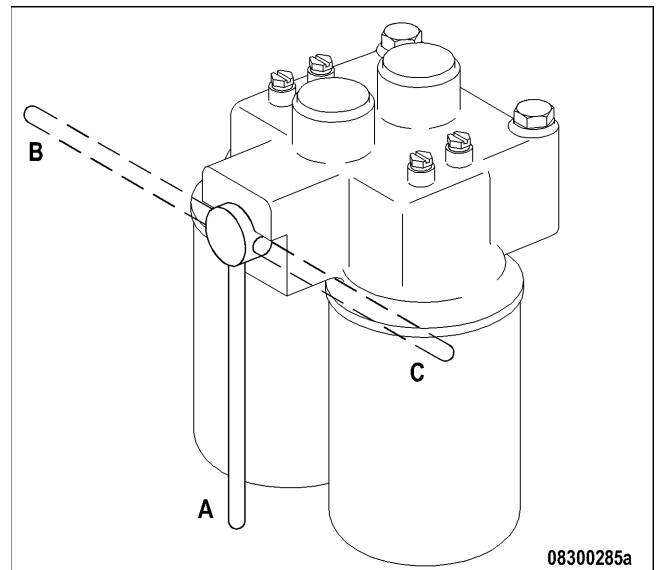
Engine noise above 85 dB (A).
Risk of damage to hearing!
 • Wear ear protectors.



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

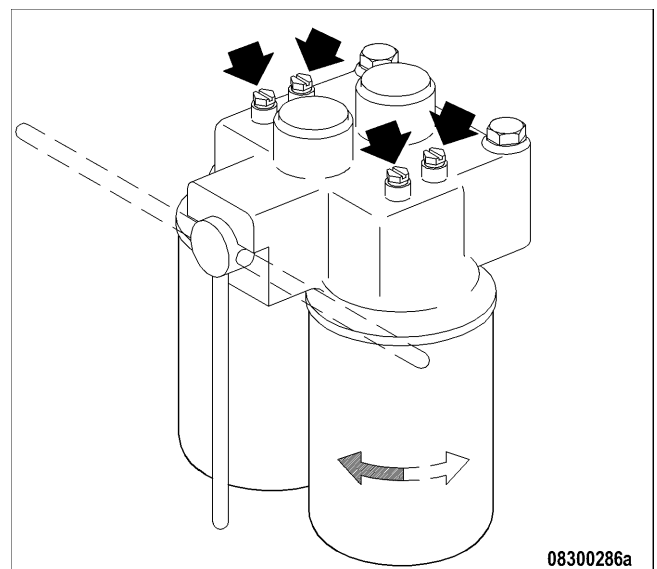
1. Stop engine (→ Page 54) and disable engine start.
2. Cut out the filter to be replaced.
3. Remove cut-out easy-change filter using the filter wrench.
4. Clean the sealing surface of the filter head.
5. Check sealing ring of the new easy-change filter and coat it with fuel.
6. Install and tighten new 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.



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

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.



6.8.2 Fuel prefilter cleaning

Preconditions

- Engine is stopped and starting disabled.

Material

Designation / Use	Part No.	Qty.
Diesel fuel		

Spare parts

Designation / Use	Part No.	Qty.
Sealing ring		



WARNING

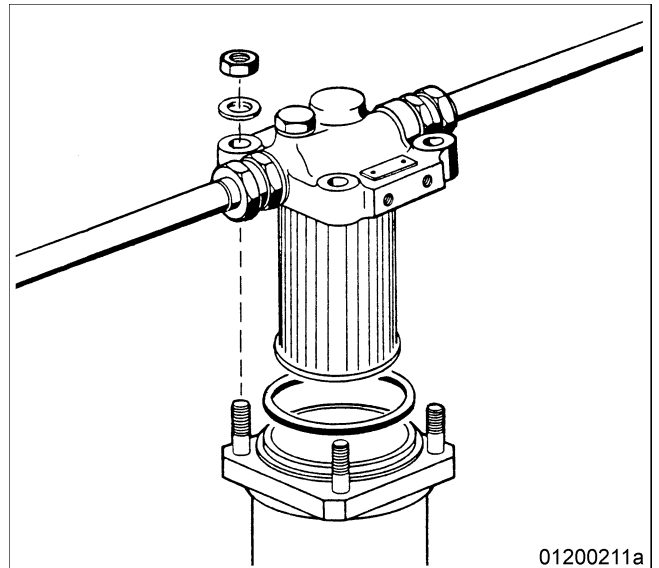
Fuels are combustible.

Risk of fire and explosion!

- Avoid naked 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.



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6.8.3 Fuel prefilter – differential pressure check and adjustment of gauge



Unguarded rotating and moving engine components.

Risk of serious injury – danger to life!

- Take special care when working on a running engine.



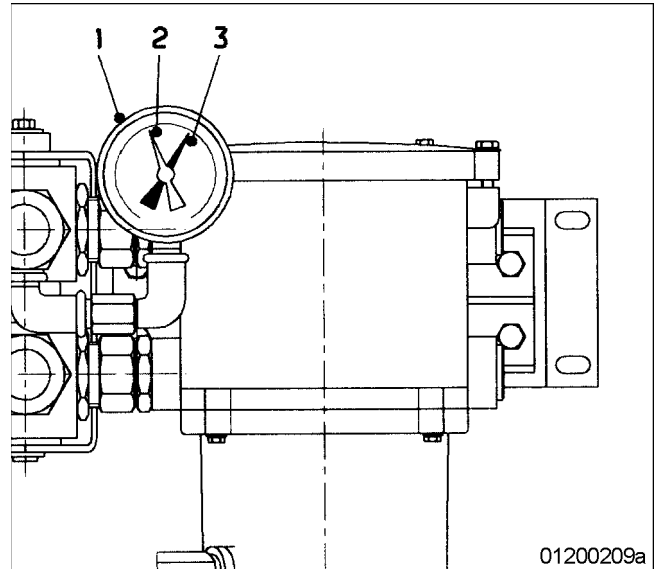
Engine noise above 85 dB (A).

Risk of damage to hearing!

- Wear ear protectors.

Setting adjustable pointer of differential pressure gauge

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



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Fuel prefilter – checking differential pressure

1. With the engine running at full load or rated power, read off pressure at gauge (1).
2. If differential pressure as indicated between position of adjustable pointer (2) and pressure-indicating pointer (3) of pressure gauge is ≥ 0.3 bar, flush filter element of the cut-in filter (→ Page 118).

6.8.4 Fuel prefilter – draining

Preconditions

- Engine is stopped and starting disabled.

Material

Designation / Use	Part No.	Qty.
Diesel fuel		

Spare parts

Designation / Use	Part No.	Qty.
Gasket		



WARNING

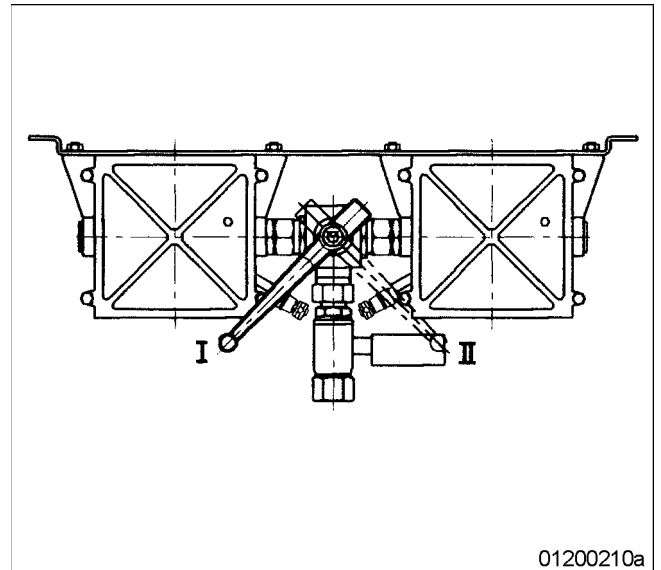
Fuels are combustible.

Risk of fire and explosion!

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

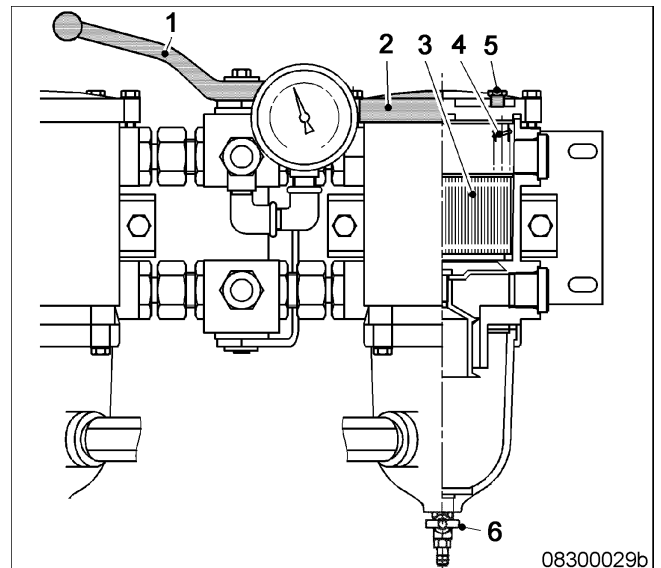
Fuel prefilter – draining

1. Cut out the filter to be drained.



I Left filter cut in
II Right filter cut in

2. Open vent plug (5) of the filter to be drained.
3. Unlock drain cock (6) by pressing toggle and open it.
4. Drain water and contaminants from the filter until pure fuel emerges.
5. Close drain cock (6).
6. Remove screws securing the 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 the cut-out filter in again.
11. When fuel emerges from system, close vent plug (5).



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6.8.5 Fuel prefilter – flushing

Material

Designation / Use	Part No.	Qty.
Diesel fuel		

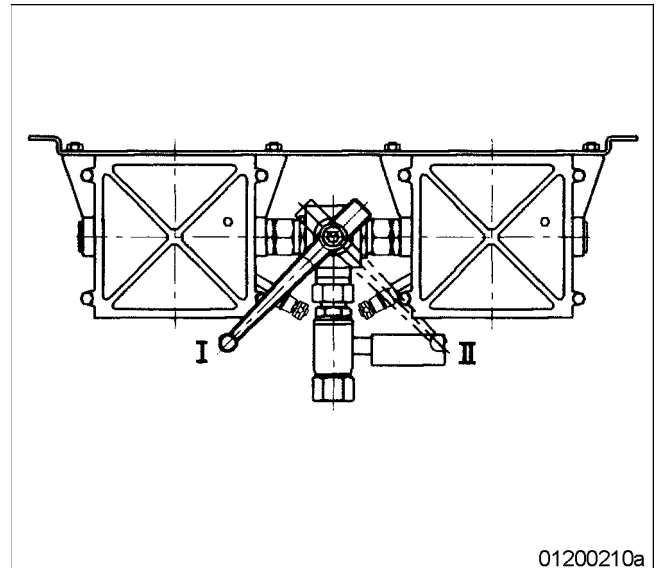
Spare parts

Designation / Use	Part No.	Qty.
Gasket		

 DANGER	Unguarded rotating and moving engine components. Risk of serious injury – danger to life! <ul style="list-style-type: none"> • Take special care when working on a running engine.
 WARNING	Fuels are combustible. Risk of fire and explosion! <ul style="list-style-type: none"> • Avoid naked flames, electrical sparks and ignition sources. • Do not smoke.
 WARNING	Engine noise above 85 dB (A). Risk of damage to hearing! <ul style="list-style-type: none"> • Wear ear protectors.

Fuel prefilter – flushing

1. Cut out the contaminated filter.

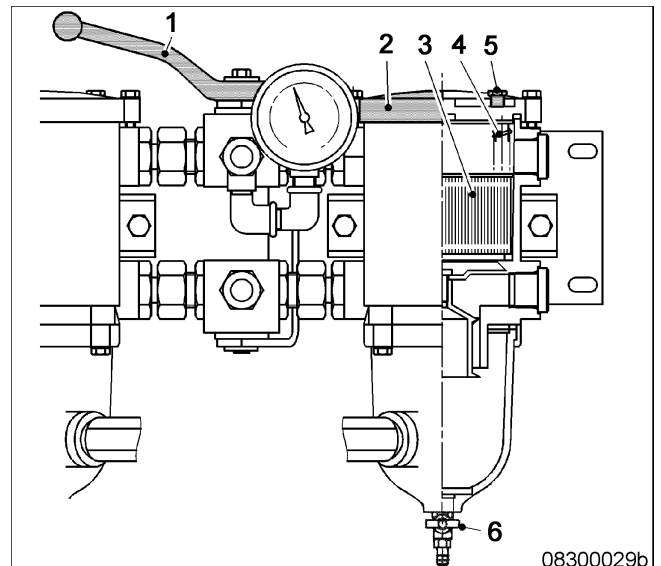


I Left filter cut in
II Right filter cut in

2. Open vent plug (5) of the filter to be flushed.
3. Unlock drain cock (6) by pressing 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 vent plug (5) and drain cock (6).



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Fuel prefilter – filling fuel

1. Stop engine (→ Page 54) and disable engine start.
2. Remove screws securing the 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 115).

Result: If flushing did not lead to an improvement of the differential pressure, replace filter element (→ Page 120).

6.8.6 Fuel prefilter – filter element replacement

Preconditions

- Engine is stopped and starting disabled.

Material

Designation / Use	Part No.	Qty.
Diesel fuel		

Spare parts

Designation / Use	Part No.	Qty.
Filter element		
Gasket		



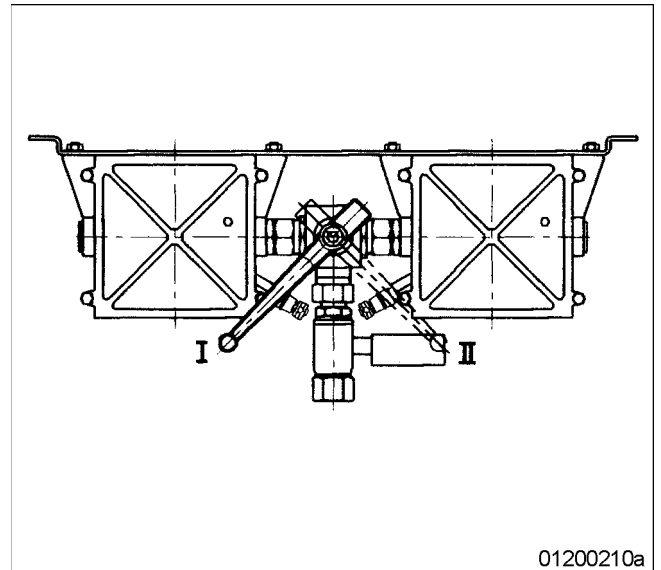
Fuels are combustible.

Risk of fire and explosion!

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

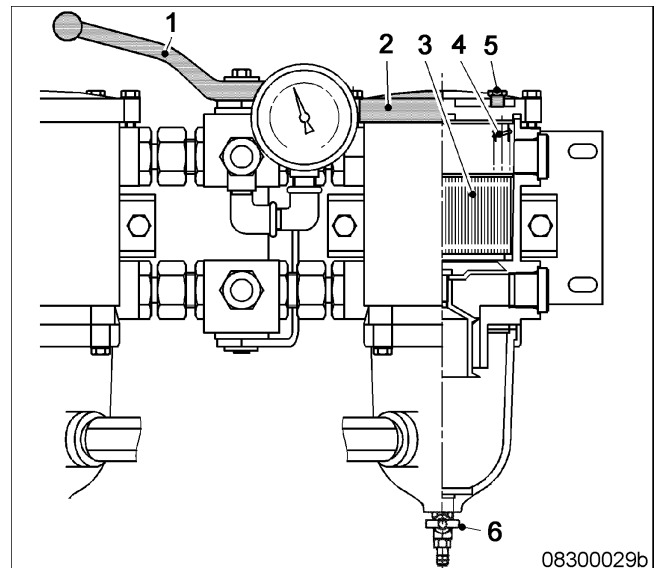
Fuel prefilter – filter element replacement

1. Cut out the contaminated filter.



I Left filter cut in
II Right filter cut in

2. Open vent plug (5) of the contaminated filter.
3. Unlock drain cock (6) by pressing toggle and open it.
4. Drain water and contaminants from the filter.
5. Close drain cock (6).
6. Remove screws securing the cover and take off cover (2).
7. Remove spring (4) and filter element (3).
8. Insert new filter element (3) and spring (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 the cut-out filter in again.
13. Close vent plug (5) when fuel emerges.
14. Align adjustable pointer of differential pressure gauge with pressure-indicating pointer.
(→ Page 115).



08300029b

6.9 Charge-air Cooling, General, Left Side

6.9.1 Intercooler – Checking condensate drains for coolant discharge and obstructions

Preconditions

- Engine is stopped and starting disabled.

Spare parts

Designation / Use	Part No.	Qty.
Sealing ring		



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 emerges:
3. Clean drain bore(s) and blow out with compressed air.
4. If a large amount of coolant is continuously discharged, the intercooler is leaking. 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 106).
2. Bar engine manually (→ Page 89).
3. Bar engine with starting system to blow out combustion chambers (→ Page 90).
4. Install injectors (→ Page 106).

6.10 Air Filter

6.10.1 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.

6.11 Air Intake

6.11.1 Service indicator – Signal ring position check

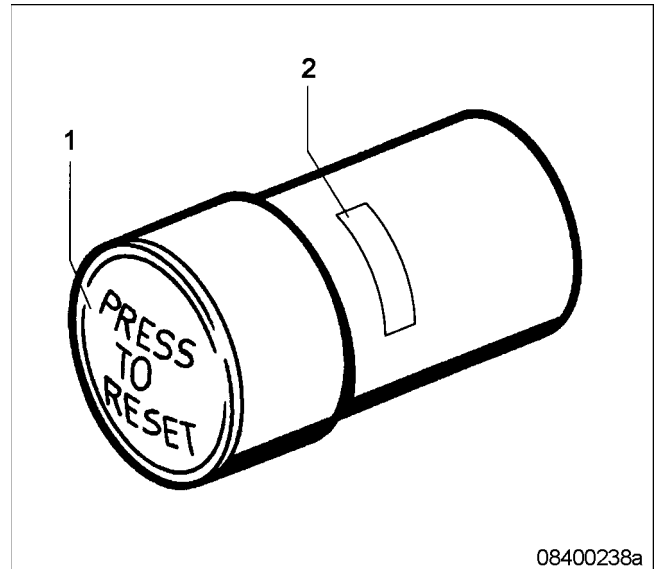
Preconditions

- 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 123).
2. After installation of new filter, press reset button (1).

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



6.12 Starting System

6.12.1 Air starter – manual operation



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.



WARNING

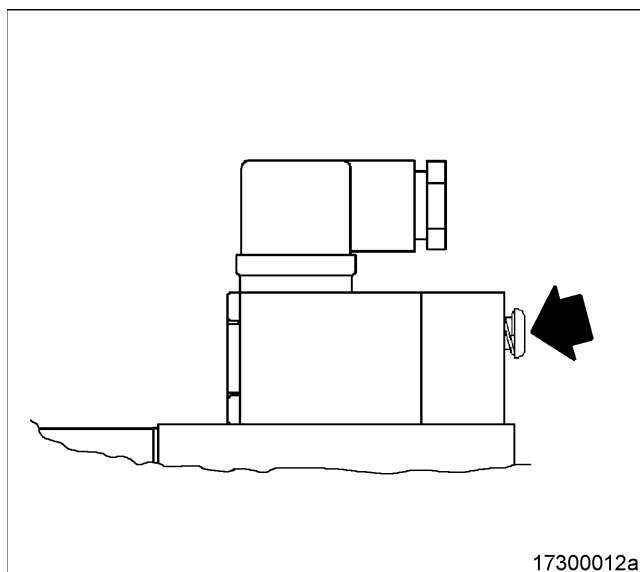
Engine noise above 85 dB (A).

Risk of damage to hearing!

- Wear ear protectors.

Air starter – manual operation

1. Press pushbutton for manual start and hold it.
2. Allow compressed air to enter the air starter until the engine fires evenly.
3. Release pushbutton.



6.12.2 Starter – Condition check

Preconditions

- Engine is stopped and starting disabled.

Starter – Condition check

1. Check starter securing screws for secure seating.
2. Tighten loose screw connections.
3. Check wiring (→ Page 144).

6.13 Lube Oil System / Lube Oil Circuit

6.13.1 Engine oil change

Preconditions

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

Material

Designation / Use	Part No.	Qty.
Engine oil		

Spare parts

Designation / Use	Part No.	Qty.
Sealing ring		



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

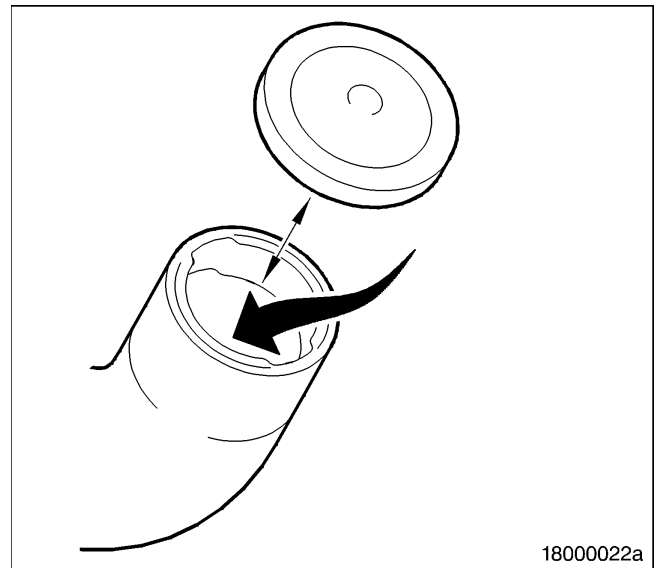
1. Provide a suitable container in which to collect the oil.
2. Remove drain plug and drain oil.
3. Install drain plug with new sealing ring.
4. Replace engine oil filter (→ Page 130).

Oil change using semirotary hand pump: Oil extraction

1. Provide a suitable container in which to collect the oil.
2. Extract all oil from oil pan using the hand pump.
3. Replace engine oil filter (→ Page 130).

Engine oil system filling

1. Open cover of filler neck.
2. Pour oil in at filler neck up to "max." mark at oil dipstick.
3. Close cover of filler neck.
4. Check oil level (→ Page 129).
5. After oil change and oil filter replacement, bar engine with starting system (→ Page 90).



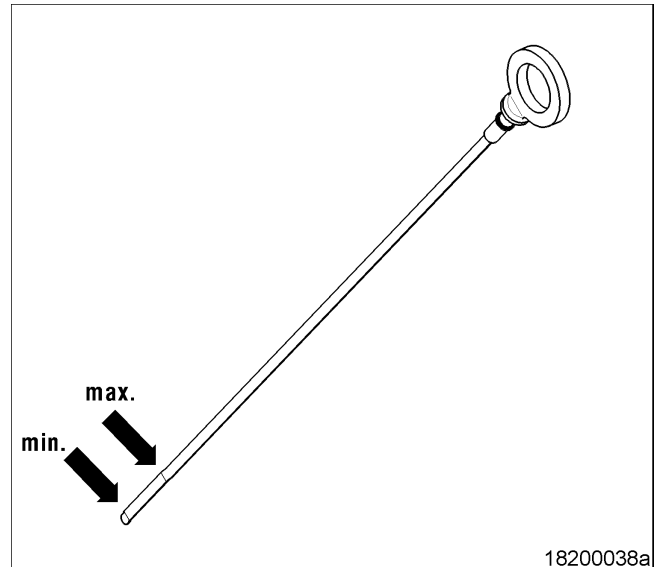
6.13.2 Engine oil – Level check

Preconditions

- Engine is stopped and starting disabled.

Oil level check prior to engine start

1. Withdraw dipstick from guide tube and wipe it.
2. Insert 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 127).
5. Insert 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 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 127).
5. Insert dipstick into guide tube up to the stop.

6.14 Oil Filtration / Cooling

6.14.1 Engine oil filter – Replacement

Preconditions

- Engine is stopped and starting disabled.

Special tools

Designation / Use	Part No.	Qty.
Filter wrench	F30379104	1

Material

Designation / Use	Part No.	Qty.
Engine oil		

Spare parts

Designation / Use	Part No.	Qty.
Oil filter		



WARNING

Hot oil.

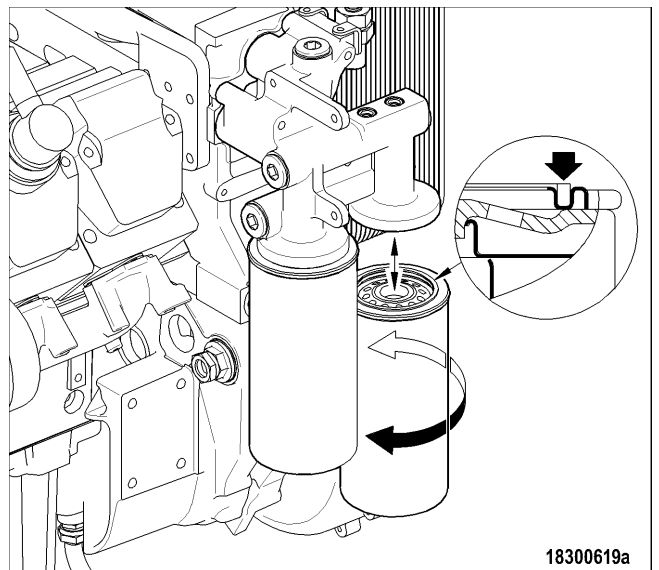
Oil can contain combustion residues which are harmful to health.

Risk of injury and poisoning!

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

Engine oil filter – Replacement

1. Remove oil filter using the filter wrench.
2. Clean the sealing surface of the filter head.
3. Check condition of the new sealing ring and coat it with oil.
4. Install and tighten new oil filter by hand.
5. Replace further oil filters in the same way.
6. After each oil change and filter replacement, bar the engine with starting system (→ Page 90).
7. Check oil level (→ Page 129).

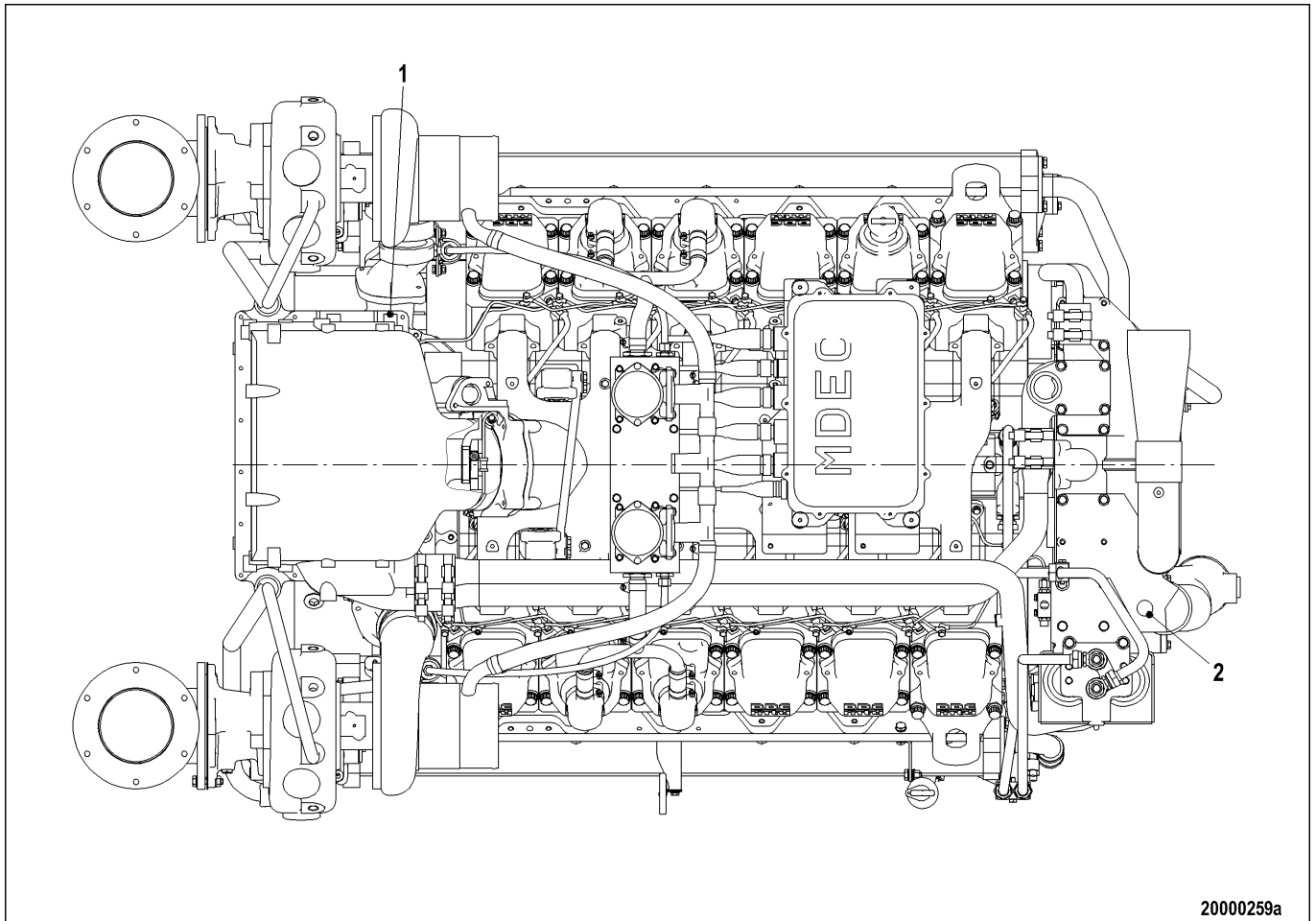


18300619a

6.15 Cooling Circuit, General, HT Circuit

6.15.1 Drain and venting points

Top view

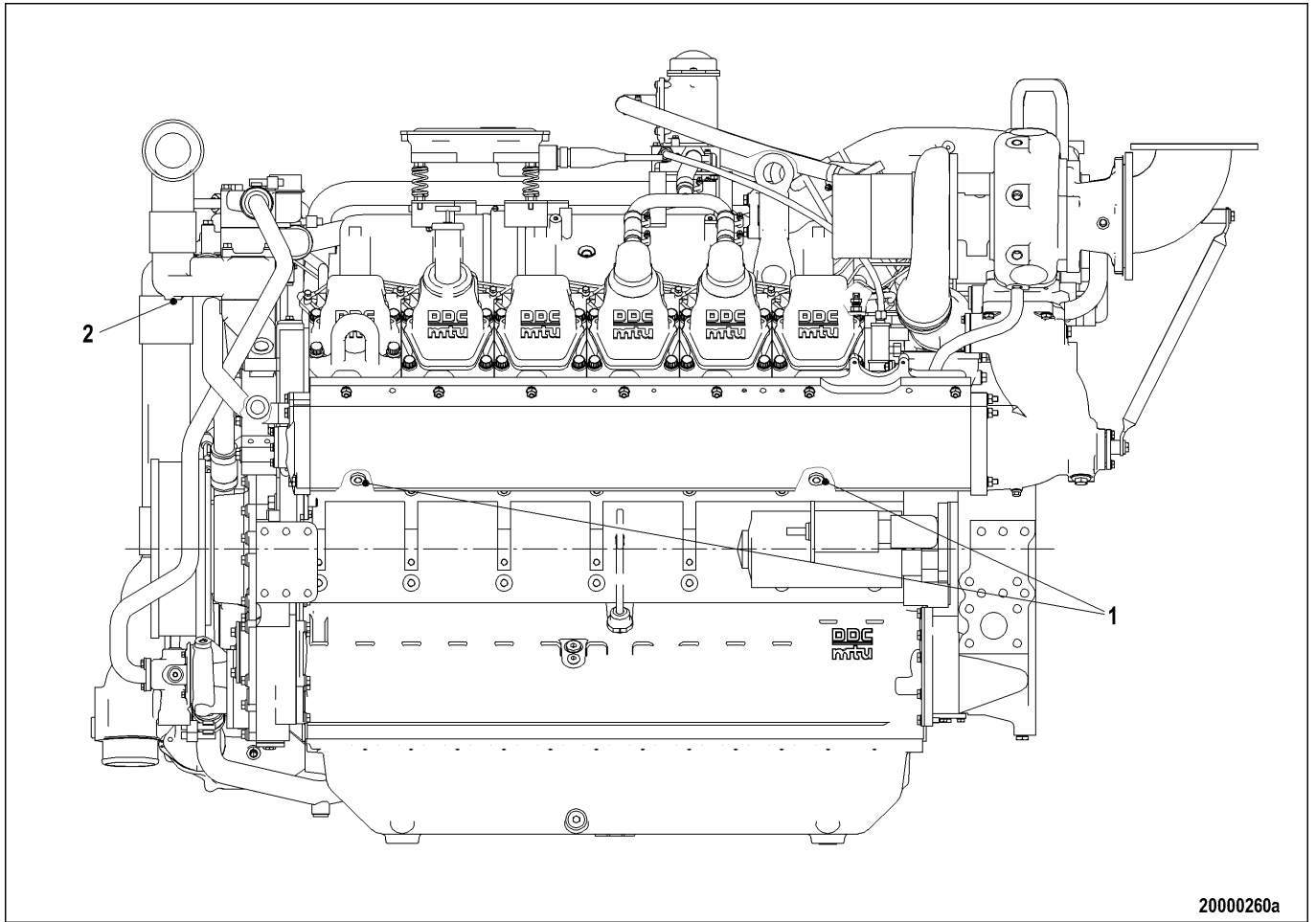


1 Engine coolant vent

2 Engine coolant vent

20000259a

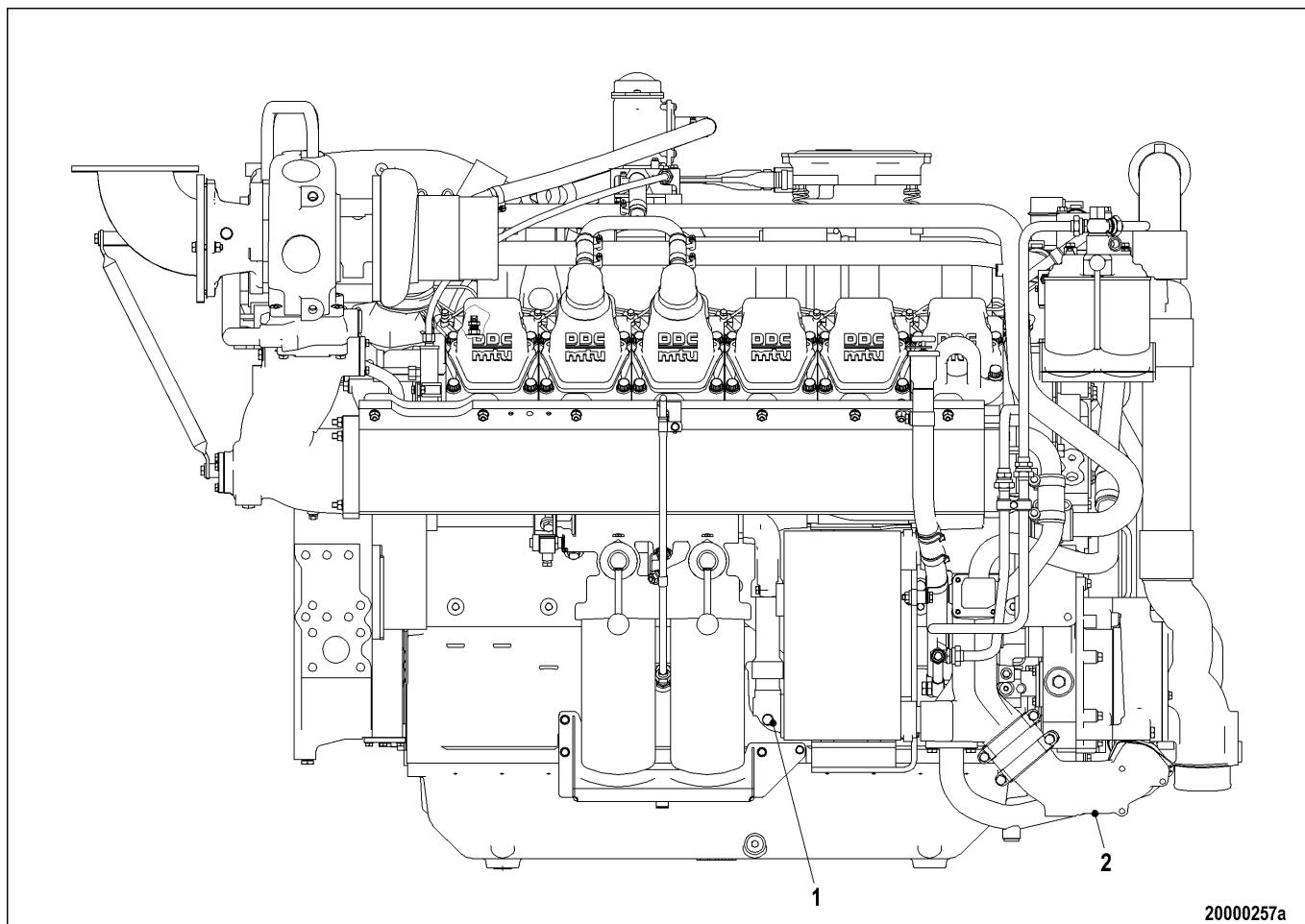
Left side



20000260a

1 Engine coolant drain plug

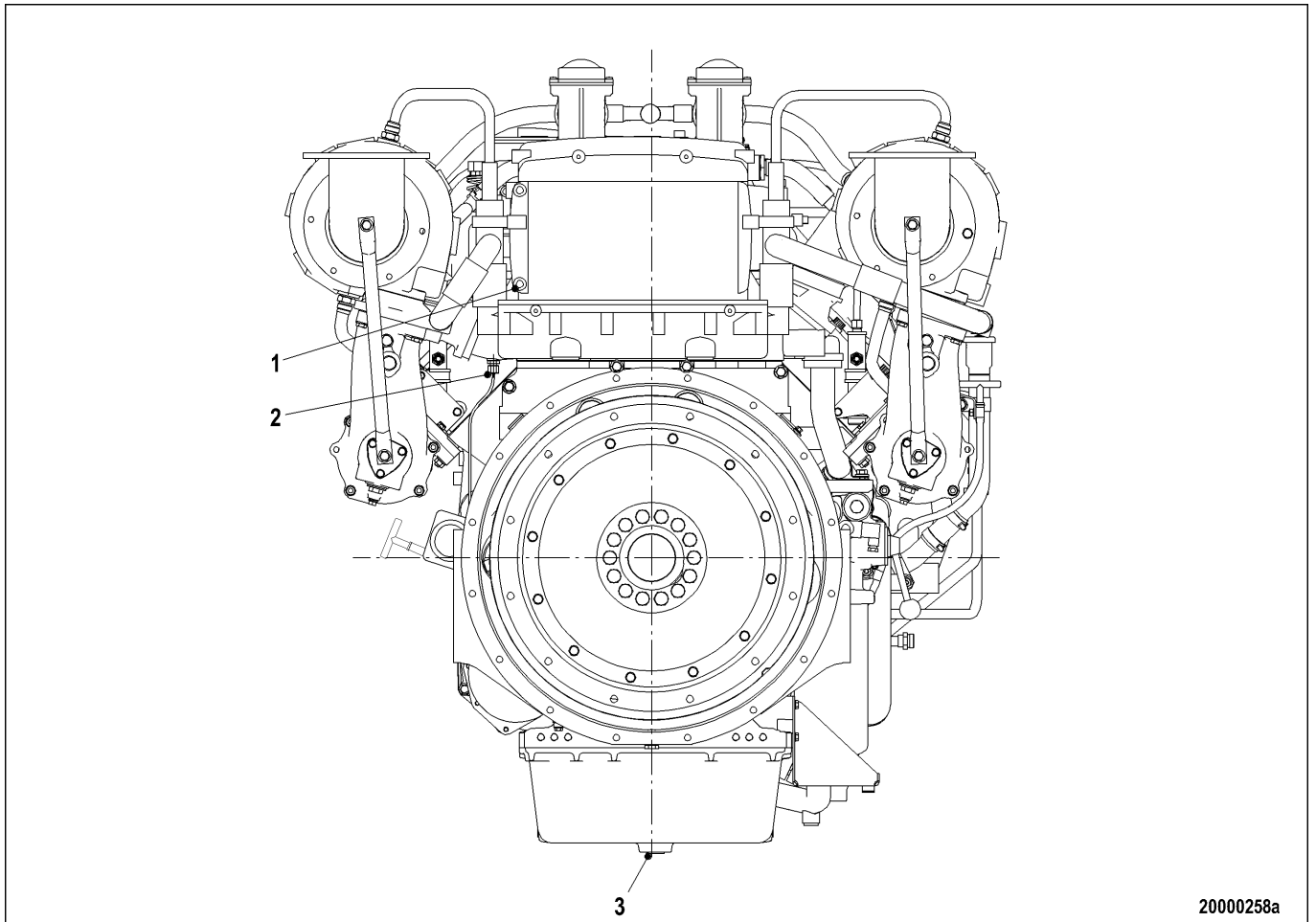
2 Engine coolant drain plug

Right side

- 1 Engine oil drain plug (heat exchanger)
- 2 Engine coolant drain plug

2000257a

Driving end (KS)



20000258a

1 Engine coolant drain plug

2 Intercooler drain

3 Engine oil drain plug

6.15.2 Engine coolant filling

Preconditions

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

Material

Designation / Use	Part No.	Qty.
Engine coolant		



Coolant is hot and under pressure.

Risk of injury and scalding!

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



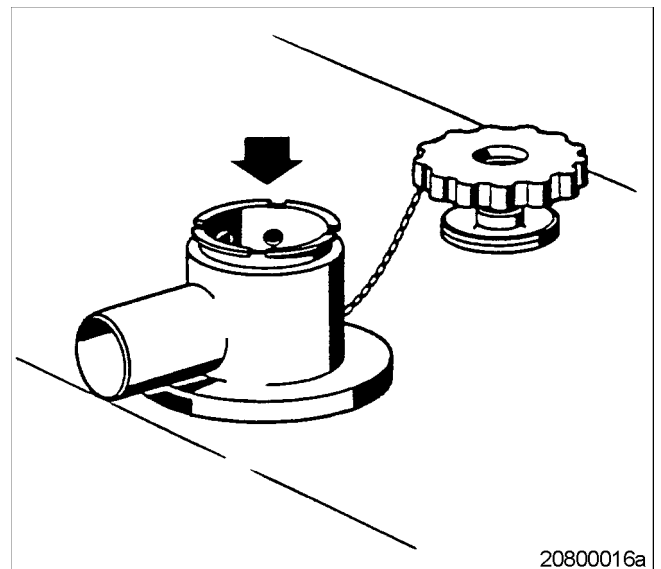
Cold coolant in hot engine can cause thermal stress.

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 first stop and allow pressure to escape.
2. Continue to turn breather valve counterclockwise and remove.



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 and clean sealing faces, if required.
3. Set breather valve onto filler neck and close it.

Final steps

1. Start the engine and operate it at idle speed for some minutes.
2. Check coolant level (→ Page 138) and top up, if required.

6.15.3 Engine coolant draining

Preconditions

- Engine is stopped and starting disabled.



Coolant is hot and under pressure.

Risk of injury and scalding!

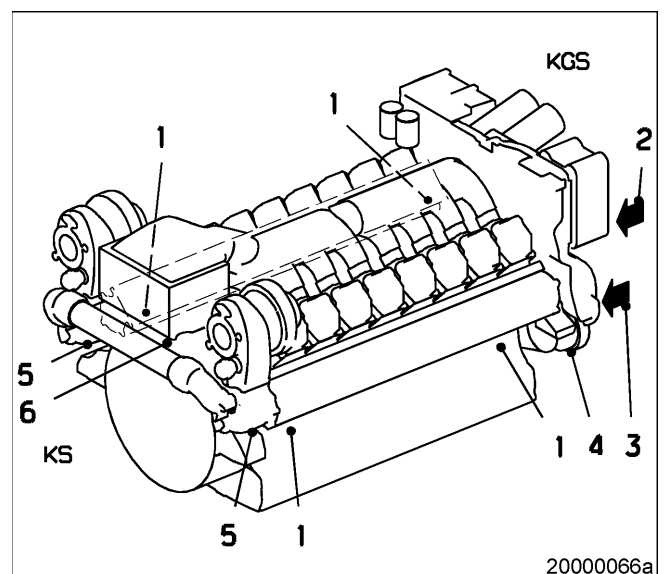
- Let the engine cool down.
- Wear protective clothing, gloves, and goggles / safety mask.

Preparatory steps

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

Draining engine coolant

1. Turn valve cover on coolant expansion tank counterclockwise to the first detent 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 drain cocks and drain plugs and drain coolant at the following points:
 - Drain plug (4)
 - Crankcase (1)
 - Intercooler (6)
 - Exhaust-pipe elbow (5)
 - Heating connection (3)
 - Engine-oil heat exchanger (2)
5. Close all open drain points.
6. Fit breather valve on filler neck and close it.



6.15.4 Engine coolant – Change

Material

Designation / Use	Part No.	Qty.
Engine coolant		

Drain engine coolant (→ Page 136).

Fill engine coolant system (→ Page 135).

6.15.5 Engine coolant level – Check

Preconditions

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



Coolant is hot and under pressure.

Risk of injury and scalding!

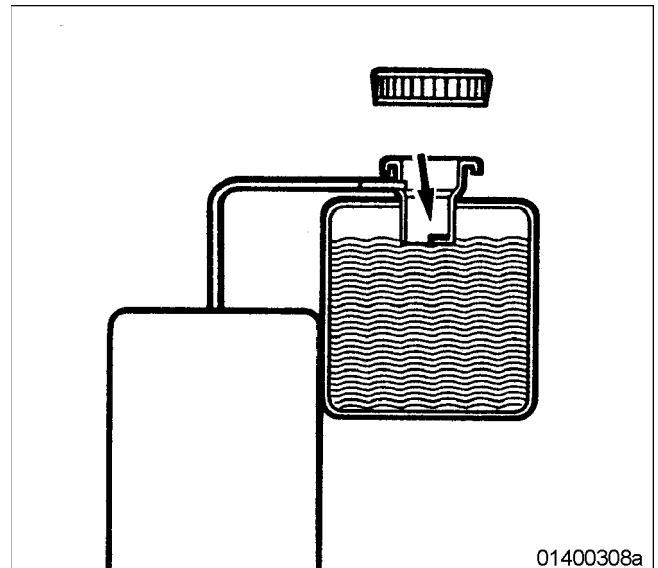
- Let the engine cool down.
- Wear protective clothing, gloves, and goggles / safety mask.

Coolant-level check at filler neck:

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

Coolant-level check at external cooler:

1. Check coolant level (coolant must be visible at marking plate).
2. If required, top up with treated coolant (→ Page 135).
3. Check and clean breather valve.
4. Set breather valve onto filler neck and close it.



Coolant-level check by means of level sensor:

1. Switch on engine control system and check readings on the display.
2. If required, top up with treated coolant (→ Page 135).

6.15.6 Coolant pump – Relief bore check



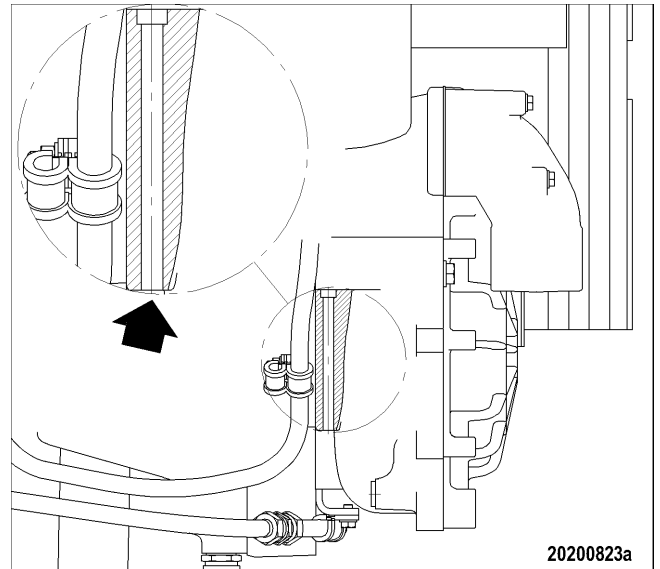
Unguarded rotating and moving engine components.
Risk of serious injury – danger to life!
• Take special care when working on a running engine.



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. Stop engine (→ Page 54) and disable engine start.
3. Clean the relief bore with a wire if it is dirty.
 - Permissible coolant discharge: Up to 10 drops/hour;
 - Permissible oil discharge: Up to 5 drops/hour;
4. If discharge exceeds the specified limits, contact Service.



6.16 LT Circuit

6.16.1 Charge-air coolant change

Material

Designation / Use	Part No.	Qty.
Coolant		

Drain charge-air coolant system (→ Page 142).

Fill charge-air coolant system (→ Page 141).

6.16.2 Charge-air coolant filling

Preconditions

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

Material

Designation / Use	Part No.	Qty.
Coolant		

Spare parts

Designation / Use	Part No.	Qty.
Sealing ring		



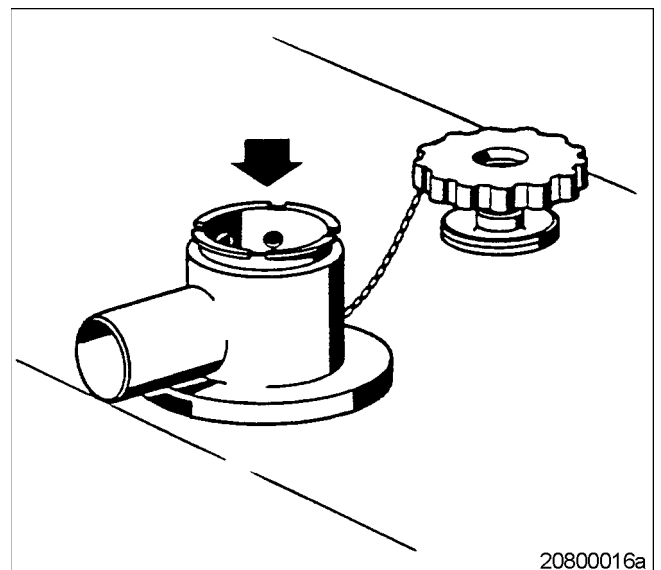
Engine noise above 85 dB (A).
Risk of damage to hearing!
 • Wear ear protectors.



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 first stop and allow pressure to escape.
2. Continue to turn breather valve counterclockwise and remove.
3. Remove plug screw from filling point on coolant line to intercooler.



20800016a

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 and clean sealing faces, if required.
4. Set breather valve onto filler neck and close it.

Final steps

1. Start the engine and operate it at idle speed for some minutes.
2. Check coolant level (→ Page 143).

6.16.3 Charge-air coolant – Draining

Preconditions

- Engine is stopped and starting disabled.

Spare parts

Designation / Use	Part No.	Qty.
Sealing ring		



WARNING

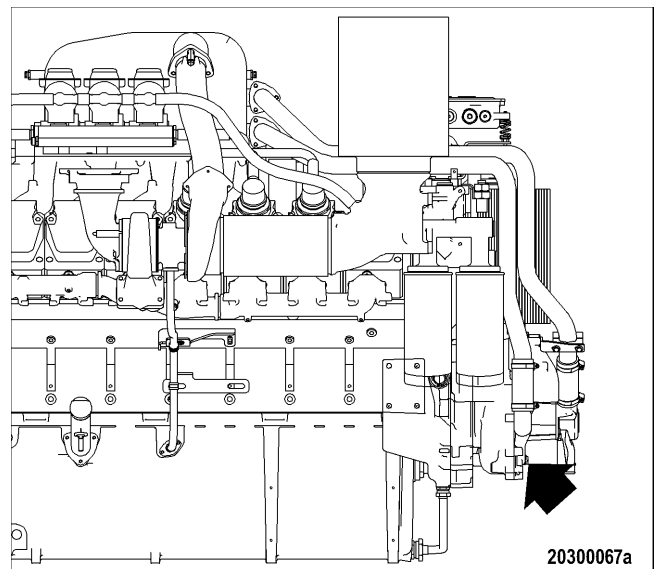
Coolant is hot and under pressure.

Risk of injury and scalding!

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

Charge-air coolant – Draining

1. Provide an appropriate container to drain the coolant into.
2. Turn breather valve of filler neck on coolant expansion tank counterclockwise to first stop and allow pressure to escape.
3. Continue to turn breather valve counterclockwise and remove.
4. Draw off precipitated corrosion inhibitor oil from the expansion tank through filler neck.
5. Open drain plugs and drain coolant at the following points:
 - at the LT cooling pump;
 - at the coolant line (customer's equipment).
6. Draining of residual coolant:
 - at charge-air cooler.
7. Screw in drain plugs with new sealing rings.
8. Fit breather valve onto filler neck and close it.



6.16.4 Charge-air coolant level check

Preconditions

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



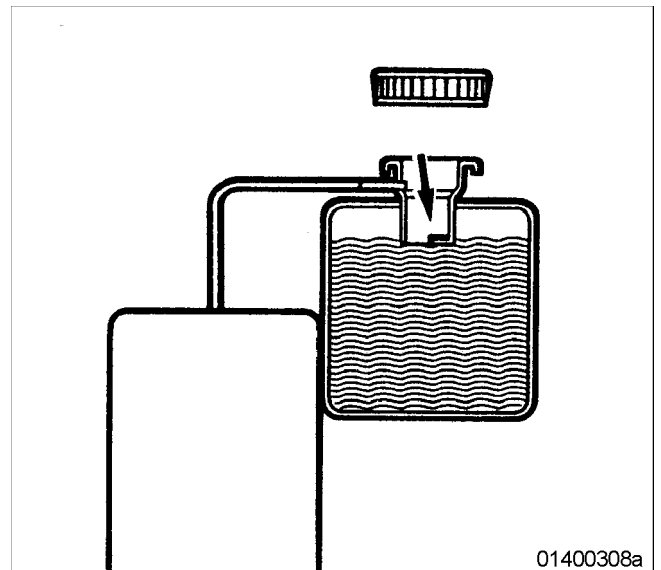
Coolant is hot and under pressure.

Risk of injury and scalding!

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

Charge-air coolant level check at filler neck:

1. Turn breather valve of filler neck on coolant expansion tank counterclockwise to first stop and allow pressure to escape.
2. Continue to turn breather valve counterclockwise and remove.
3. Check coolant level (coolant must be visible at marking plate).
4. If required, top up with treated coolant (→ Page 141).
5. Check proper condition of breather valve, clean sealing faces if required.
6. Fit breather valve onto filler neck and close it.



Charge-air coolant level check by means of level sensor:

1. Switch engine control system ON and check display (coolant level is automatically monitored by the engine control system).
2. If required, top up with treated coolant (→ Page 141).

6.17 General Cabling for Engine / Gearbox / Unit

6.17.1 Engine wiring check

Preconditions

- Engine is stopped and starting disabled.

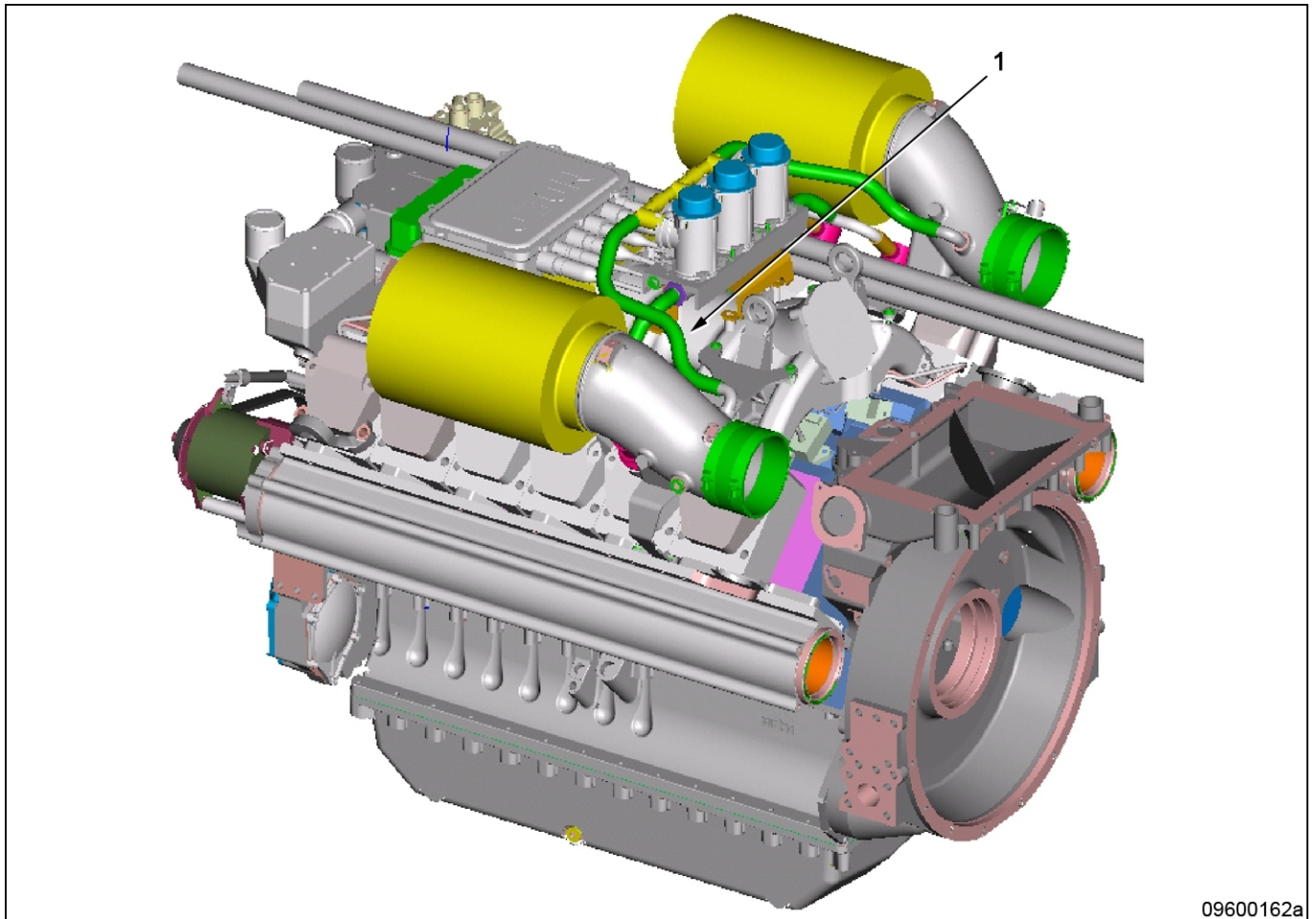
Material

Designation / Use	Part No.	Qty.
Isopropyl alcohol		

Engine wiring check

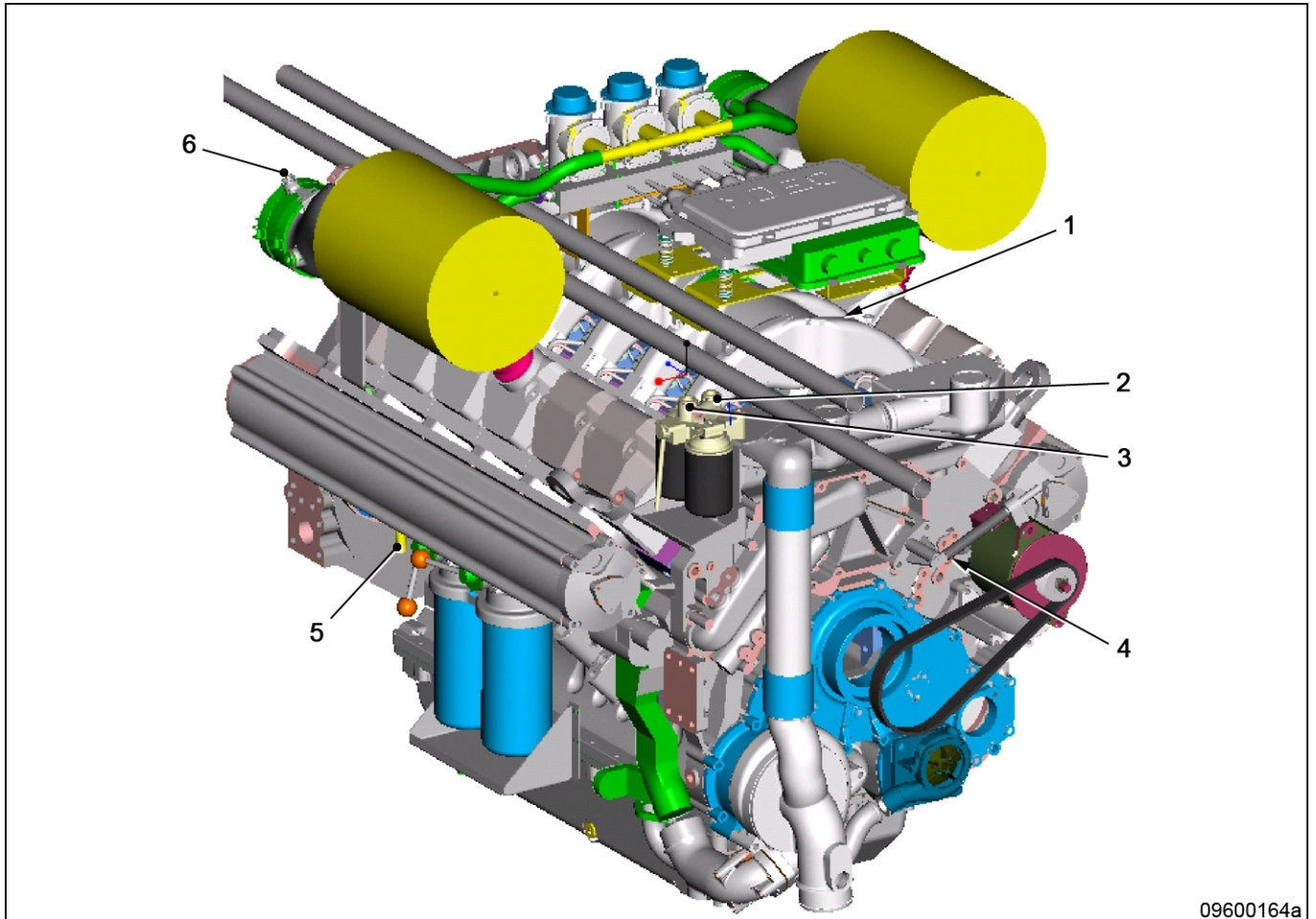
1. Check securing screws of cable clamps on the engine and tighten loose screw connections.
2. Make certain that cables are securely seated in clamps and cannot move freely.
3. Check cable binders for secure seating, tighten loose cable binders.
4. Replace defective cable binders.
5. Inspect electrical components visually for damage:
 - connector housings;
 - contacts;
 - connector sockets;
 - cables and terminals;
 - plug-in contacts.
6. If conductors are damaged, contact Service.
7. Clean dirty connector housings, sockets and contacts with isopropyl alcohol.

6.17.2 Sensors and actuators



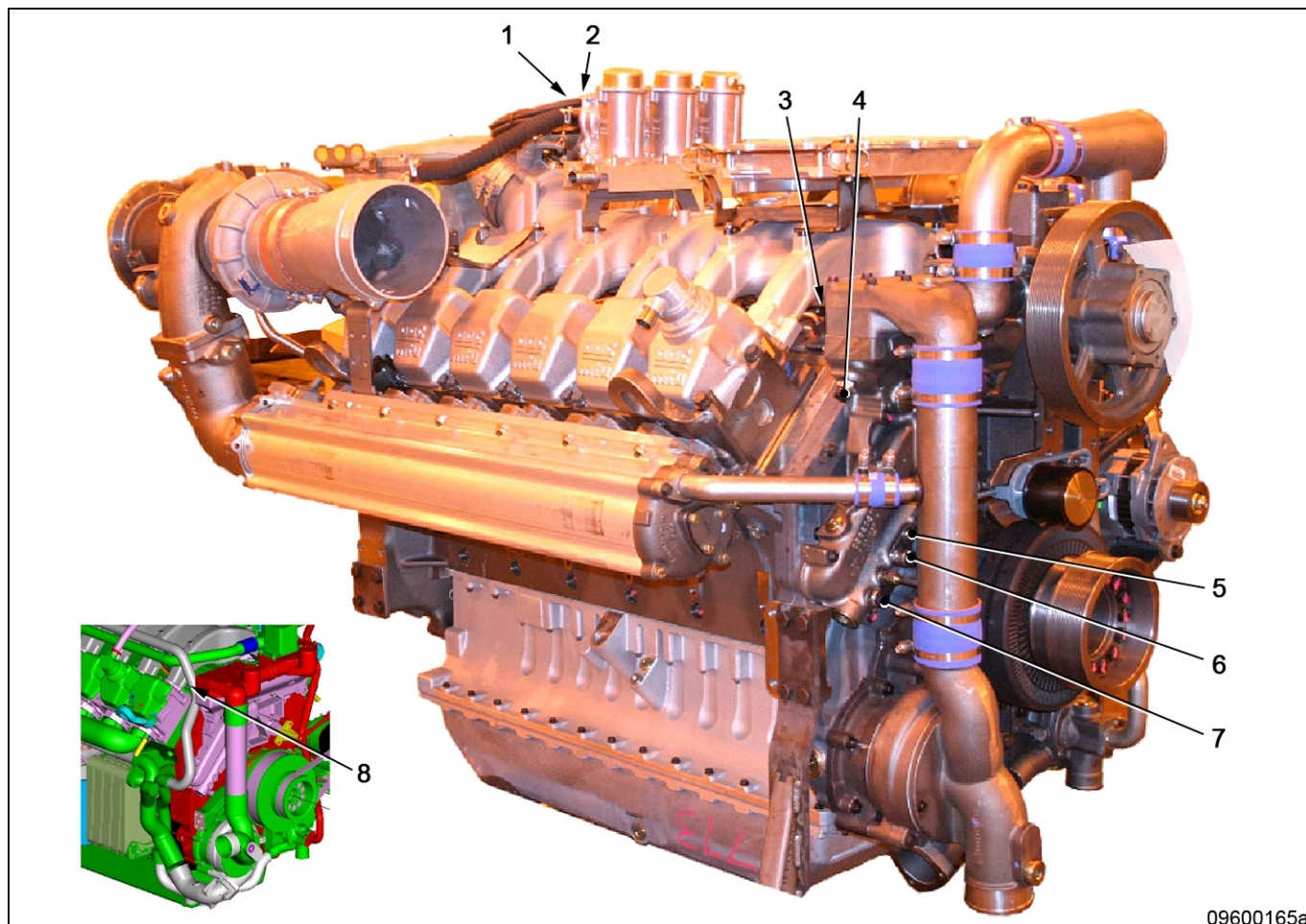
09600162a

No.	Designation	Monitoring of
1	B10	Charge-air pressure



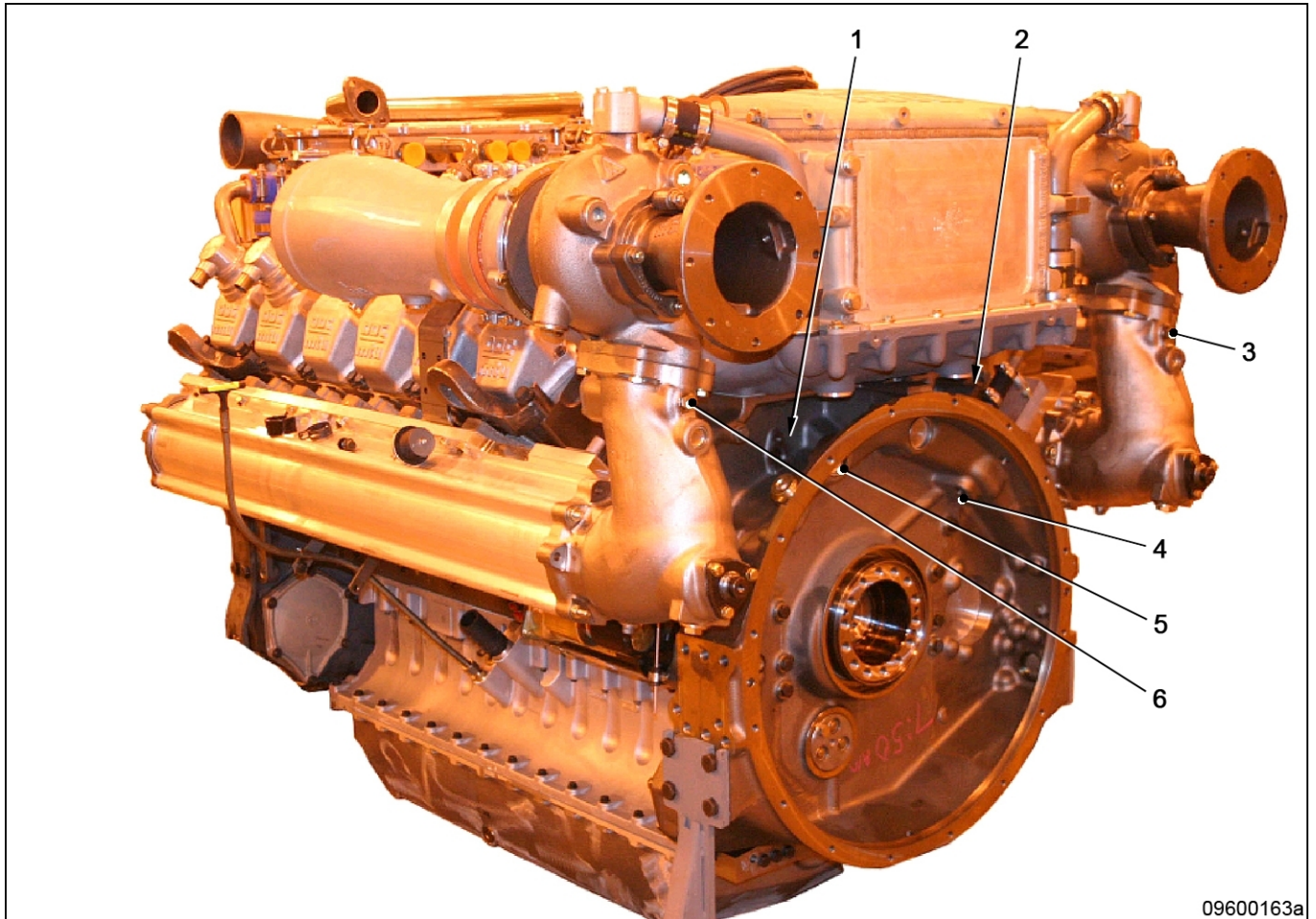
09600164a

No.	Designation	Monitoring of
1	B9	Charge-air temperature
2	B34	Fuel pressure after filter
3	B33	Fuel temperature
4	B6.2	Coolant temperature
5	F25	Lube oil differential pressure
6	B44.1	Turbocharger speed



09600165a

No.	Designation	Monitoring of
1	S12	Emergency air-shutoff flaps
2	Y12	Solenoid valve, emergency air shut-off flaps
3	F46	Leak-off fuel level
4	B6	Coolant temperature
5	B5.2	Lube-oil pressure
6	B5	Lube-oil pressure
7	B7	Lube oil temperature
8	B26	Coolant temperature, coolant cooler



No.	Designation	Monitoring of
1	—	—
2	B1	Camshaft speed
3	B4.22	Exhaust gas temperature
4	B13	Crankshaft speed
5	B13.2	Crankshaft speed
6	B4.21	Exhaust gas temperature

6.18 Accessories for Engine Governor (Electronic) / Control System

6.18.1 ECU and connectors – Cleaning

Preconditions

- Engine is stopped and starting disabled.

Special tools

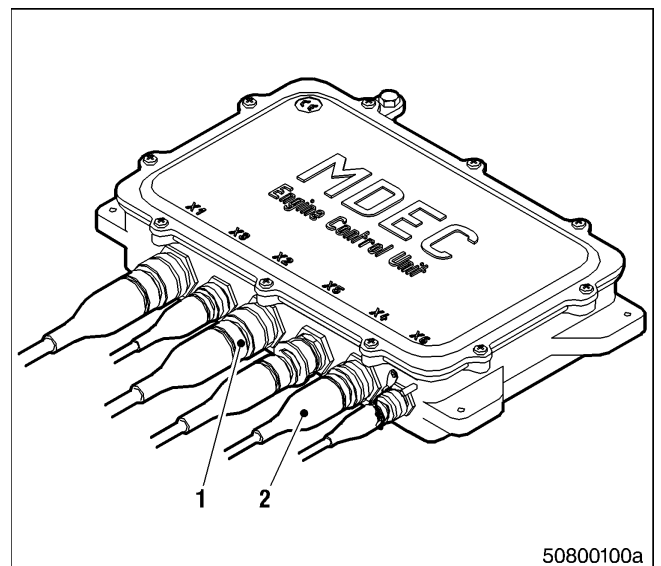
Designation / Use	Part No.	Qty.
Connector pliers	0135315483	1

Material

Designation / Use	Part No.	Qty.
Isopropyl alcohol		

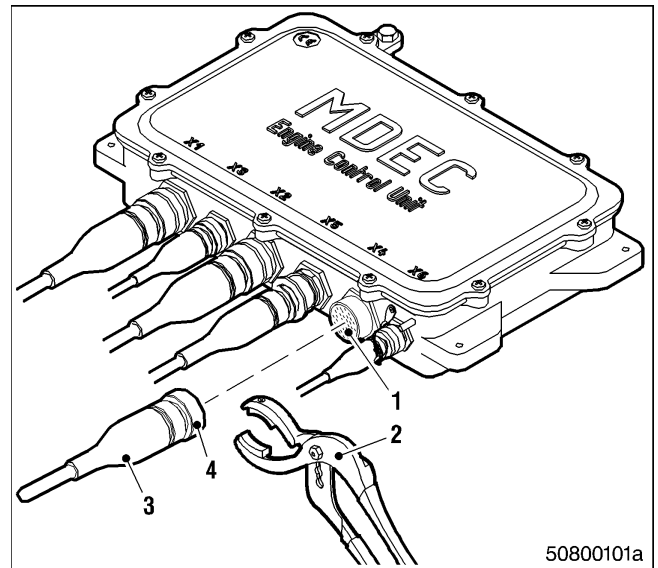
ECU and connectors – Cleaning

1. Remove coarse dirt from housing surface using a cloth moistened 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 ECU

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: Install connectors and check plug-in connection on ECU (→ Page 152).



6.18.2 EMU and connectors – Cleaning

Preconditions

- Engine is stopped and starting disabled.

Special tools

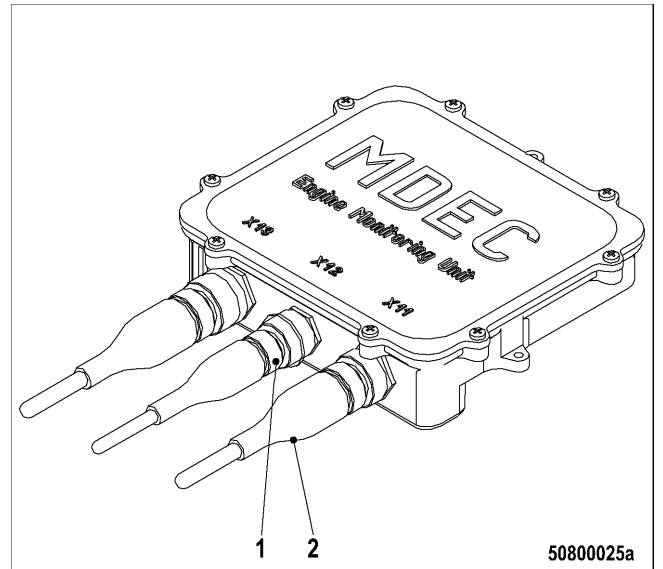
Designation / Use	Part No.	Qty.
Connector pliers	0135315483	1

Material

Designation / Use	Part No.	Qty.
Isopropyl alcohol		

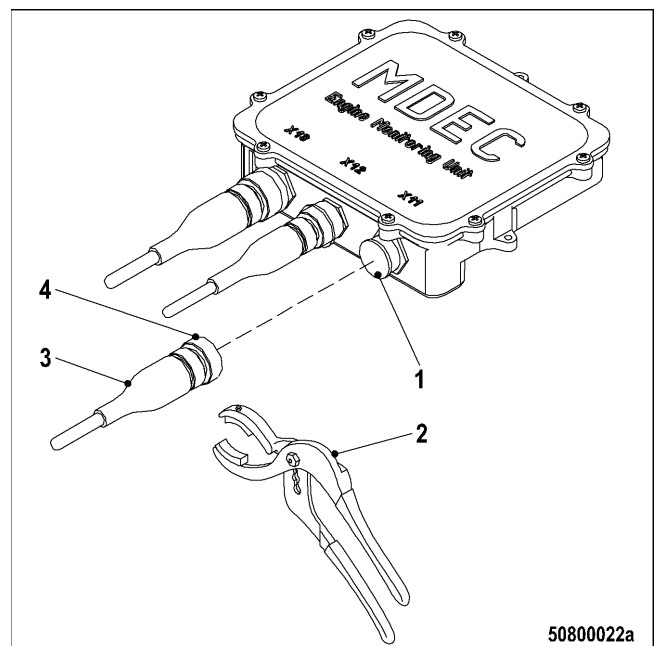
Cleaning EMU and connectors

1. Remove coarse dirt from housing surface using a cloth moistened 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: Install connectors and check plug-in connection on EMU (→ Page 153).



6.18.3 ECU – Checking plug-in connections

Preconditions

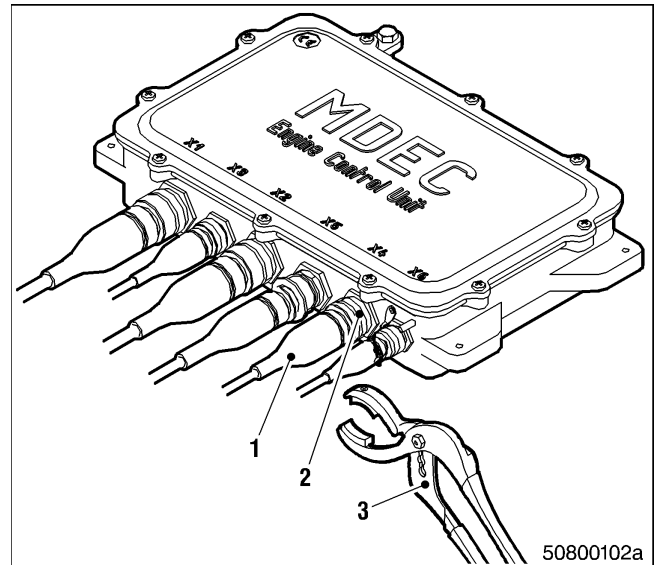
- Engine is stopped and starting disabled.

Special tools

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

ECU – Checking plug-in connections

1. Use connector pliers (3) to make certain that all plug-in connections of ECU are securely seated.
2. Tighten loose bayonet union nuts (2) with connector pliers (3) by turning them clockwise until they lock into place.
3. Ensure that unassigned connector sockets are protected with covering caps.
4. If bayonet union nut is defective, contact Service.



6.18.4 EMU – Checking plug-in connections

Preconditions

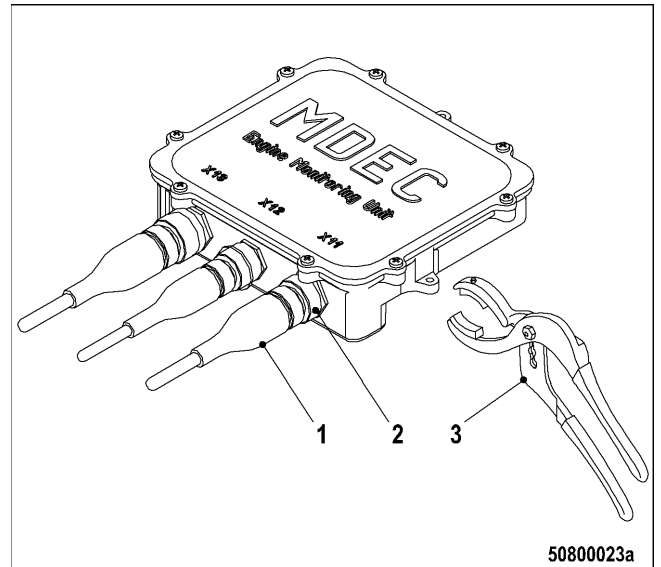
- Engine is stopped and starting disabled.

Special tools

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

EMU – Checking plug-in connections

1. Use connector pliers (3) to make certain that all EMU plug-in 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. Ensure that unassigned connector sockets are protected with covering caps.
4. Contact Service if bayonet union nut is defective.



6.18.5 ECU – Removal and installation

Preconditions

- Engine is stopped and starting disabled.

Special tools

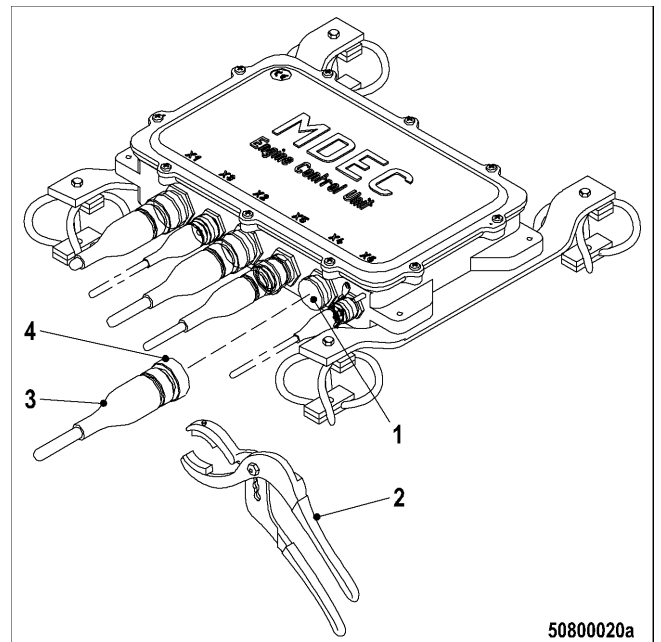
Designation / Use	Part No.	Qty.
Connector pliers	0135315483	1

Material

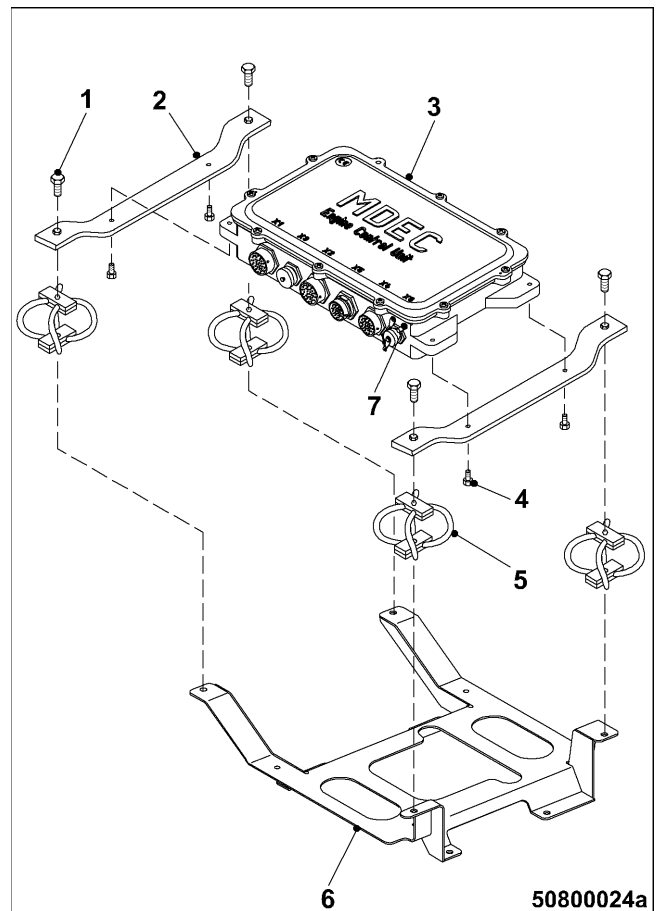
Designation / Use	Part No.	Qty.
Covering caps for Cannon sockets		

ECU – Removal

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. Withdraw all connectors.
4. Close connector sockets with appropriate covering caps (1).



5. Disconnect grounding strip from ECU grounding pin (7).
6. If the screws (4) are easily accessible:
 - 6.1. Remove screws (4).
 - 6.2. Take off ECU housing (3) from mounting brackets (2).
 - 6.3. Unscrew mounting brackets (2), cable shock absorbers (5) and further securing parts (6) as one unit from engine.
7. If the screws (4) are not easily accessible:
 - 7.1. Remove screws (1).
 - 7.2. Take off ECU housing (3) together with mounting brackets (2).
 - 7.3. Unscrew cable shock absorbers (5) and further securing parts (6) as one unit from engine.



ECU – Installation

1. For installation follow reverse sequence of working steps. Ensure that connectors are plugged in the correct socket.
2. Use connector pliers to turn the bayonet union nuts of the connectors clockwise until they lock into place.

6.19 Emergency Instrumentation (LOP)

6.19.1 LOP – visual inspection

Preconditions

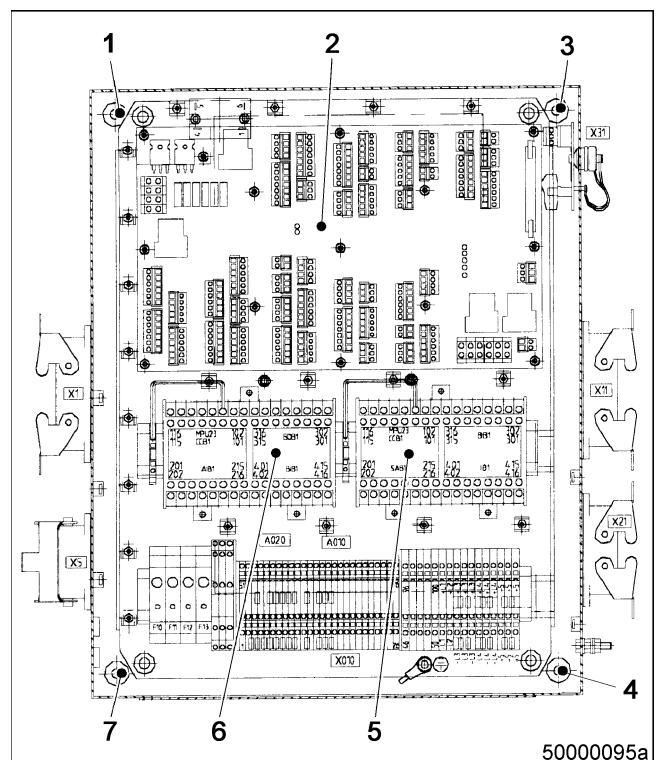
- Engine is stopped and starting disabled.

Preparatory steps

1. If READY FOR OPERATION button is illuminated brightly, press button briefly.
Result: READY FOR OPERATION button returns to basic brightness.
2. Switch master power switch to OFF.
3. Disconnect battery in accordance with battery manufacturer's instructions.

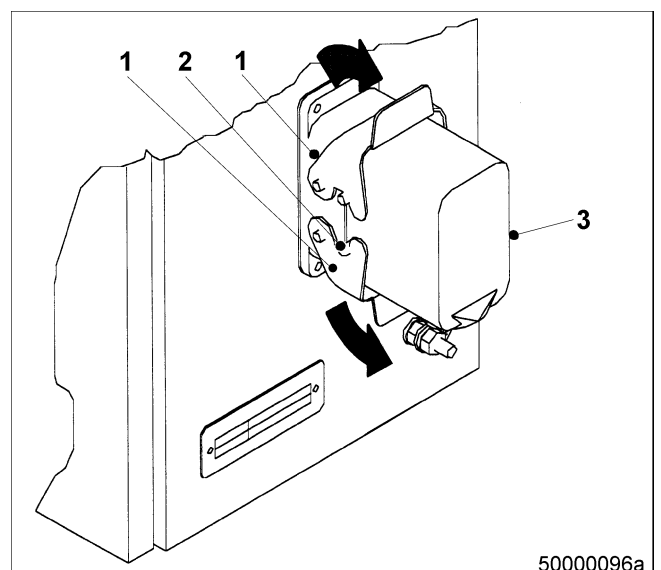
Housing and internal assemblies – check for secure seating

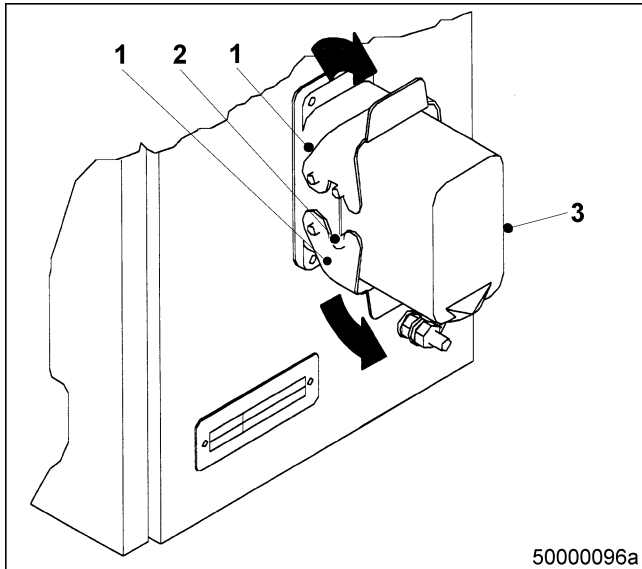
1. Open LOP front door.
2. Check securing screws (1, 3, 4, 7) for secure seating. Tighten loose screw connections.
3. Check internal assemblies for secure seating, this applies in particular to p.c.board (2) and PIMs (5, 6). Tighten loose screw connections.
4. Close LOP front door.



Plug-in connections – check for secure seating

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



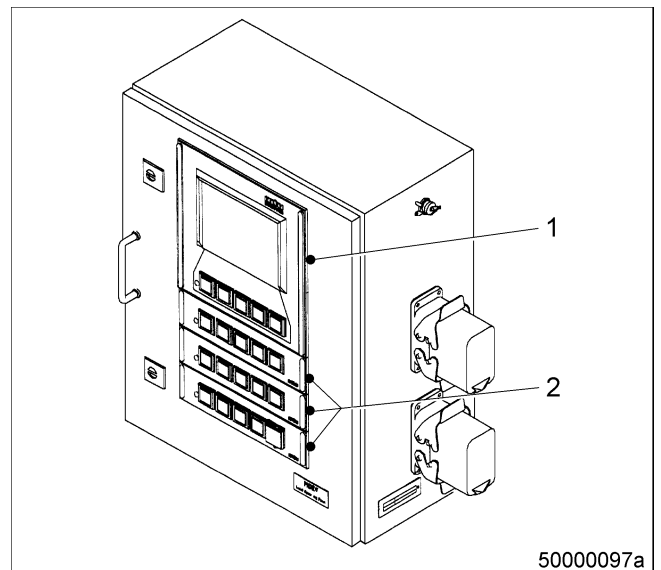


Non-assigned bases check

1. Ensure that non-assigned connector bases 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 base.
3. If this is not the case, press the securing elements (1) concerned in the direction of the arrows until they are felt to engage.

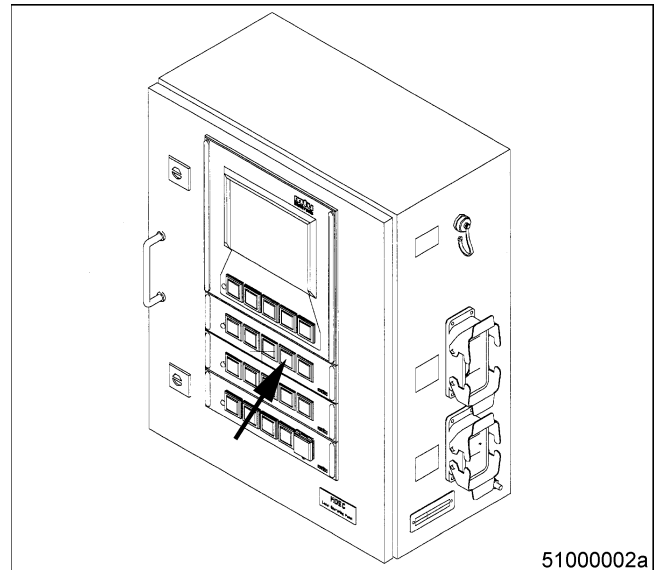
Keys and display check

1. Keys: Make certain that
 - Button caps are not damaged (cracks or similar damage);
 - Keys move easily;
 - Key housings are seated securely;
 - Gaskets (2) between PANs and LOP housing are not damaged.
2. Display: Make certain that
 - Front glass is not damaged or crushed;
 - Gasket (1) between display housing and LOP housing is not damaged.
3. Have damaged components immediately replaced by Service.



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. Keep LAMP TEST button pressed:
Result: Control and indication fields light up.
5. Have damaged lamps immediately replaced by Service.



6.19.2 LOP test procedures

Preconditions

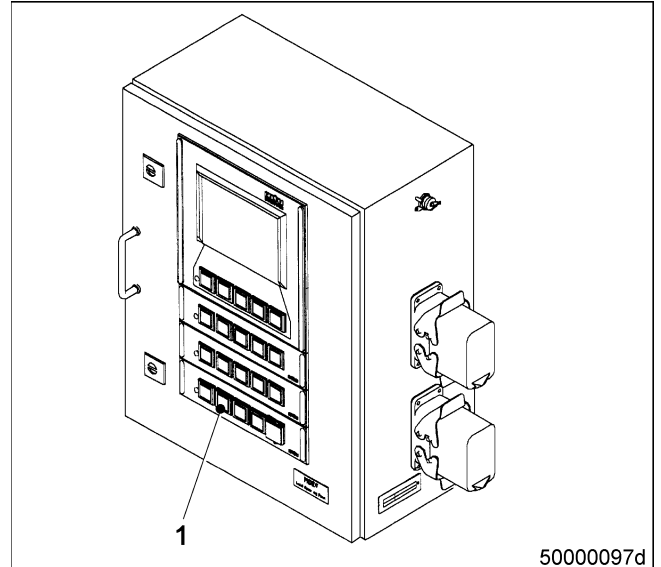
- Engine is stopped and starting disabled.

Preparatory steps

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

Result:

- LOCAL OPERATION button (1) is illuminated brightly (local control mode is active);



Switching between local and remote control mode (automatic on-board network)

1. Press LOCAL OPERATION button (1).

Result:

- LOCAL OPERATION button (1) flashes: Setting does not correspond with feedback signal from ECU.
- LOCAL OPERATION button (1) is illuminated at basic brightness: Remote control mode is active.

2. Press LOCAL OPERATION button (1) again.

Result: LOCAL OPERATION button (1) is illuminated brightly (local control 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 EMU.

1. Press TEST OVERSPEED button (3). Observe speed limit and speed simulated by EMU on display.

Result:

- ECU is deenergized by the safety system.
- Engine control is deactivated.
- Engines with emergency air-shut-off flaps: Flaps close;
- EMERGENCY STOP button (2) flashes; Signalization by horn, flash lamp etc. is released; ALARM ACKNOWLEDGE button (1) is illuminated brightly.

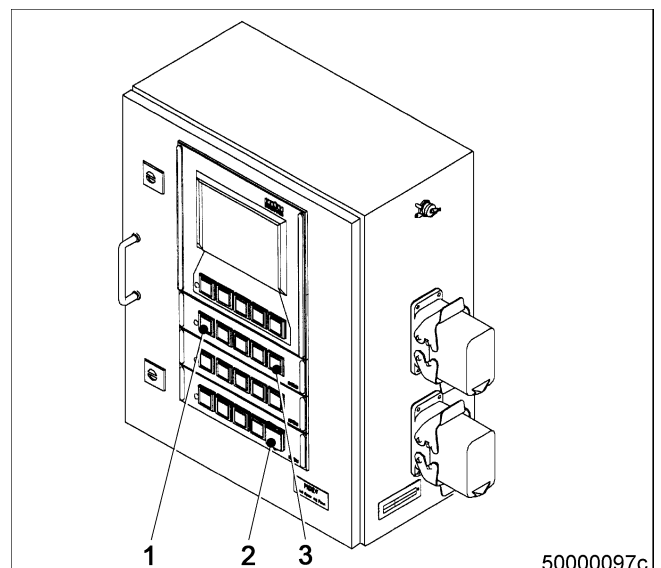
2. Press ALARM ACKNOWLEDGE button (1).

Result: Audible and visual signalization stops.

3. Press ALARM ACKNOWLEDGE button (1) again.

Result: Power supply to ECU is provided.

4. Engines with emergency air-shut-off flaps: Flaps open.

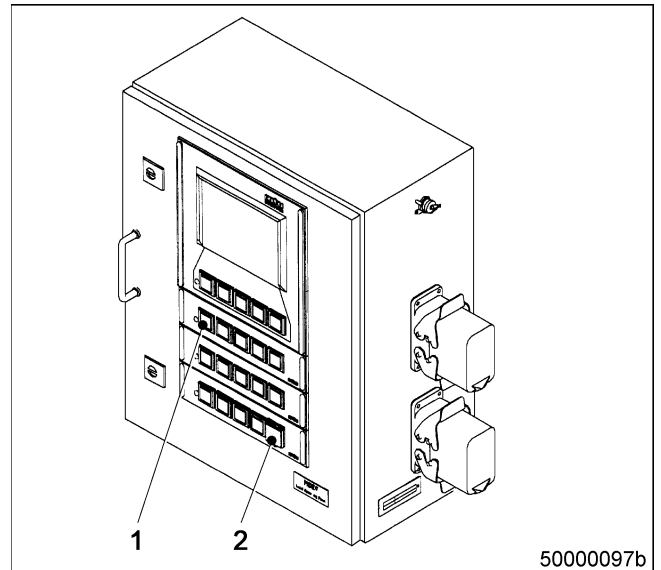


Emergency stop simulation with the engine at standstill

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

Result:

- ECU is deenergized by the safety system.
 - Engine control is deactivated.
 - Engines with emergency air-shut-off flaps: Flaps close;
 - EMERGENCY STOP button (2) flashes; Signalization by horn, flash lamp etc. is released; ALARM ACKNOWLEDGE button (1) is illuminated brightly.
3. Press ALARM ACKNOWLEDGE button (1).
Result: Audible and visual signalization stops.
 4. Press ALARM ACKNOWLEDGE button (1) again.
Result: Power supply to ECU is provided.
 5. Engines with emergency air-shut-off flaps: Flaps open.



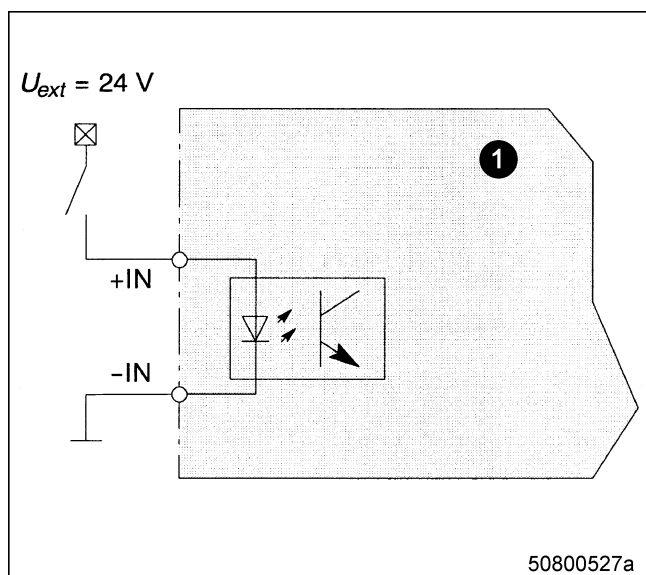
7 Engine Governor Assignment and Circuitry

7.1 Engine Governor

7.1.1 Engine governor channel circuitry

Engine governor channel circuitry

Binary inputs BE1 to BE9



1 Engine Control Unit ECU 4

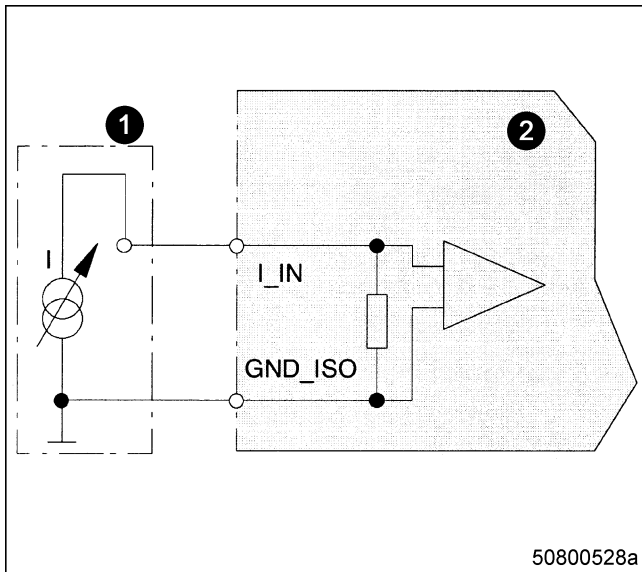
Function

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

Channel specification

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

Current input IUE 1



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

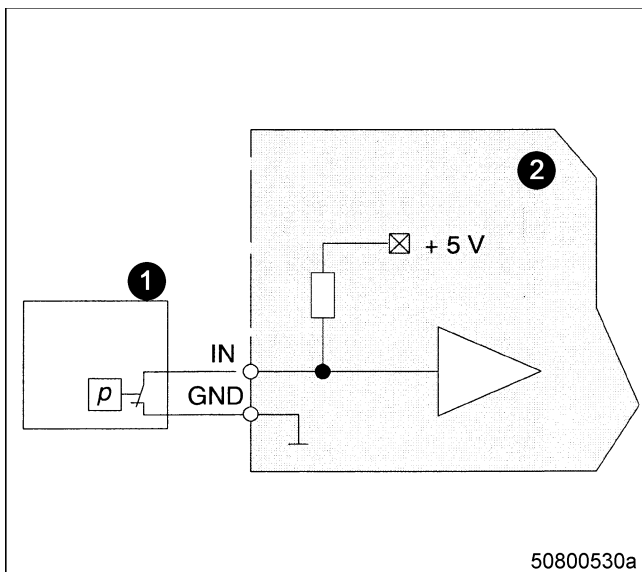
Function

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

Measuring channel specification

Measuring range	$I_{In} = 4 \text{ to } 20 \text{ mA}$; Load: At 20 mA approx. 4 V; isolated. Or: $U_{In} = 0 \text{ to } 10 \text{ V}$
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Binary sensor input NSE 1

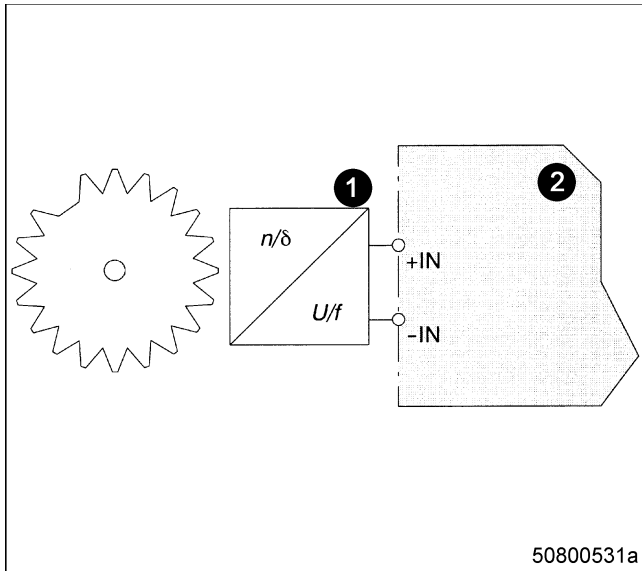


- 1 Monitor contact
- 2 Engine Control Unit ECU 4

Function

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

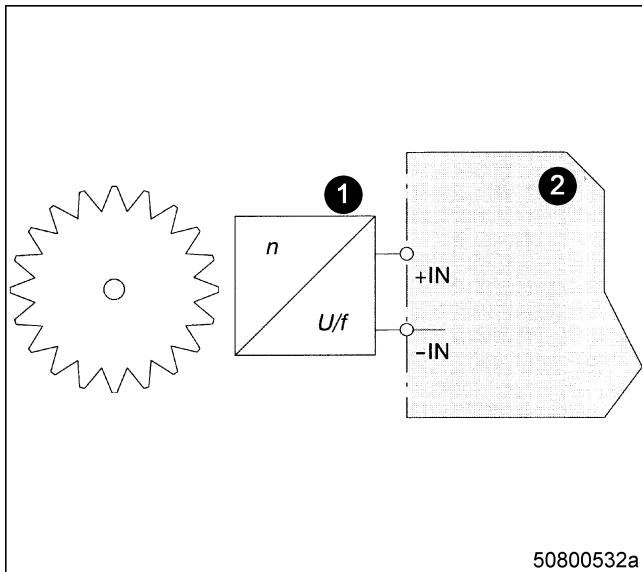
Pulse measuring inputs KW 1 and NW 1



- 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

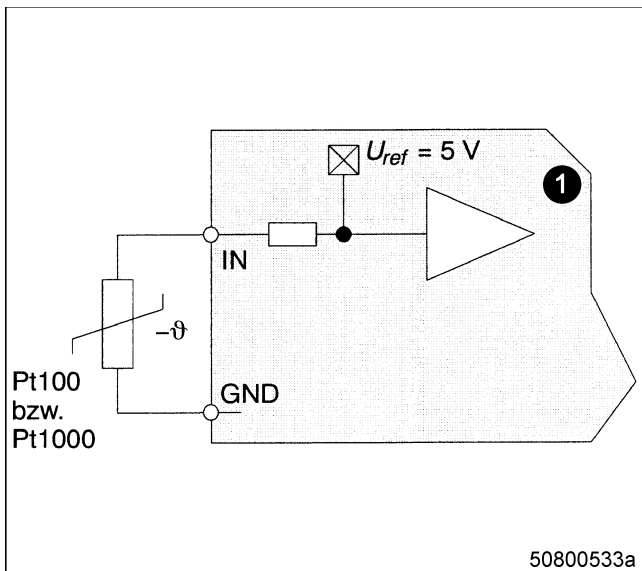
Speed measuring input DME 1, DME 2



- 1 Inductive sensor
- 2 Engine Control Unit ECU 4

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

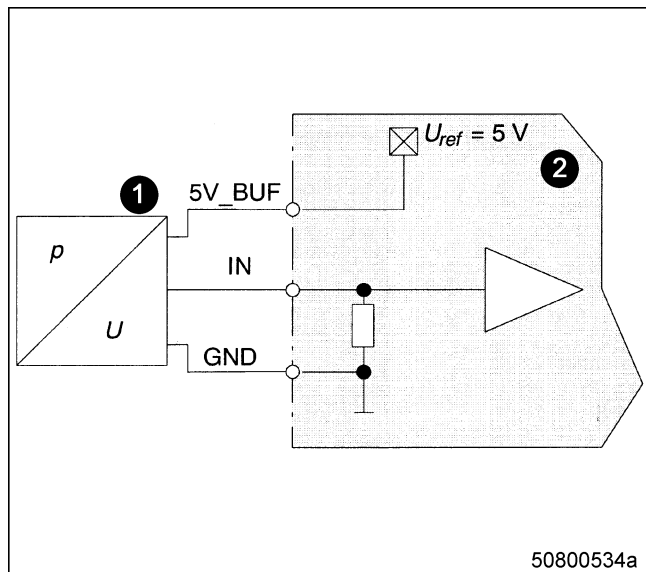
Temperature inputs TE 1 to TE 9



- 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

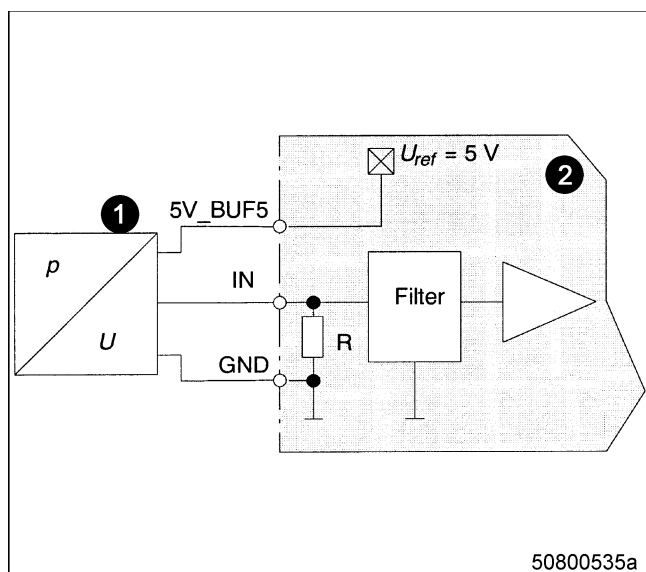
Function

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 \pm 250 mV

Pressure measuring input HP pump DEH (rail pressure)



- 1 Pressure sensor
- 2 Engine Control Unit ECU 4

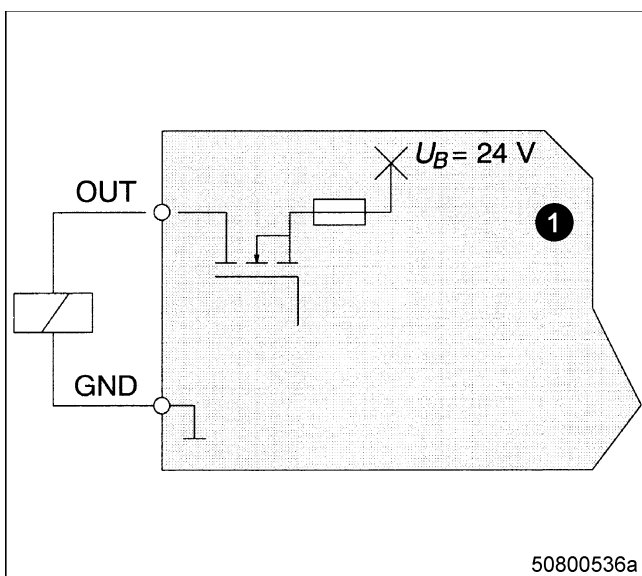
Function

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 \pm 250 mV

Transistor outputs TAA 1 to TAA 6



1 Engine Control Unit ECU 4

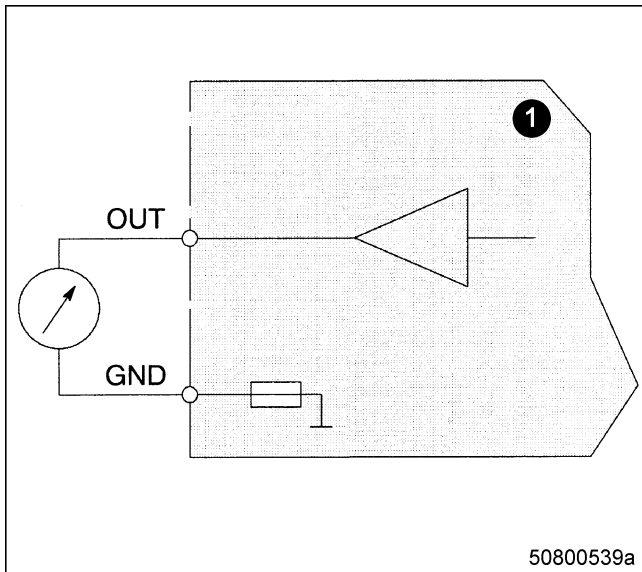
Function

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

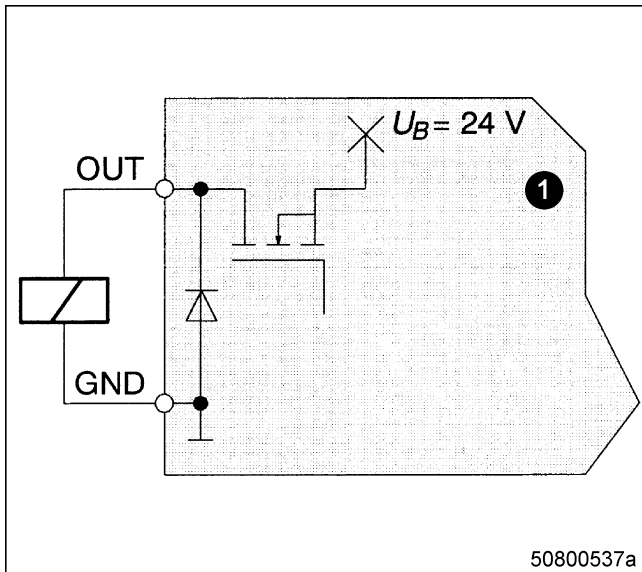
Function

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

Channel specification

Output voltage	$U_O = 0 \text{ to } 10 \text{ V}$
Output current	$I_O = 5 \text{ mA max.}$

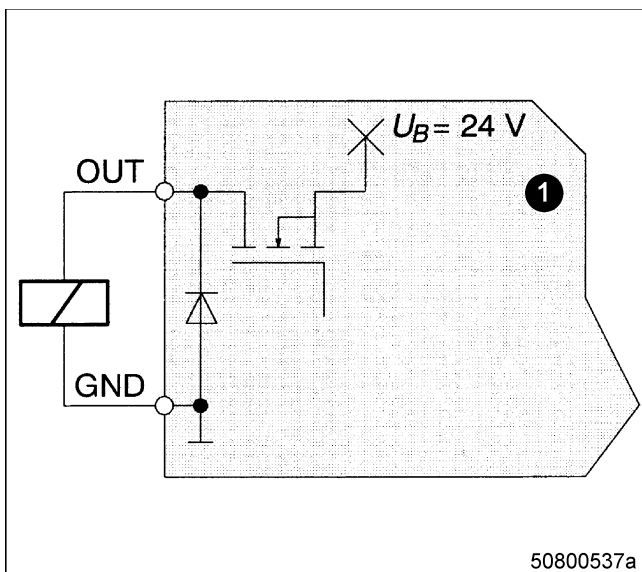
Transistor outputs TAM 1 to TAM 4



1 Engine Control Unit ECU 4

Function	Sensor
Switching output	Engine

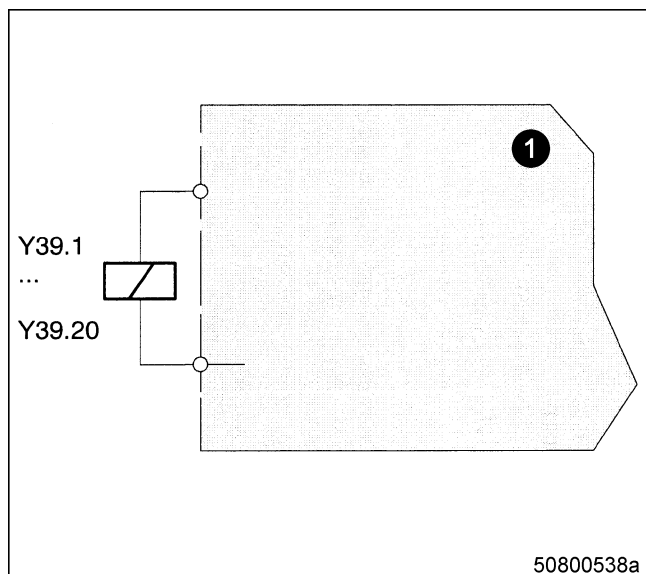
PWM output PDM 2



1 Engine Control Unit ECU 4

Function	Sensor
Switching output	Engine

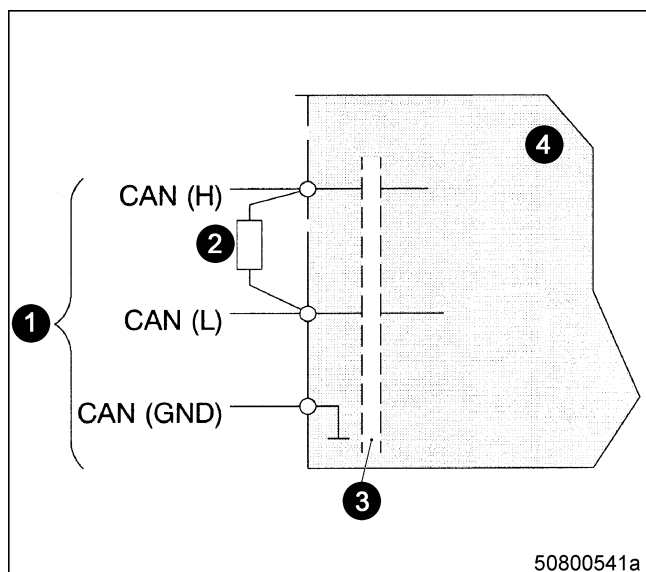
Solenoid valve outputs MVA 1 to MVA 20



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

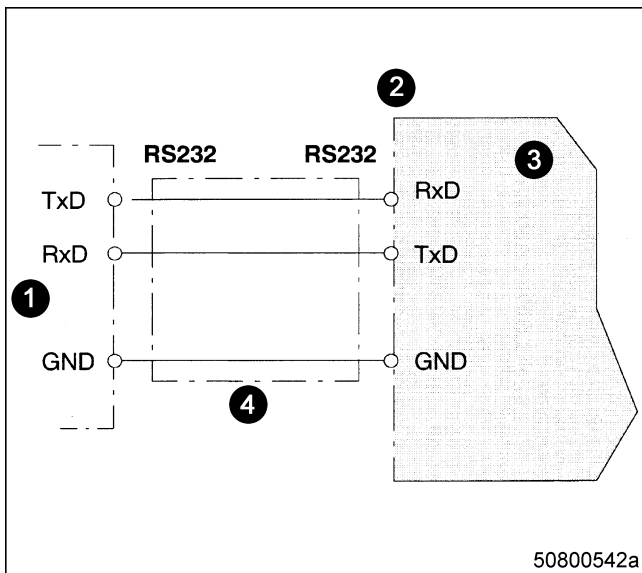
Channel	Function	Target
CAN1 / CAN2	Bus connection to external systems.	MCS

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 Dialog cable

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

7.1.2 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 mm²) 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 shutdown messages such as "Lube oil pressure too low". The corresponding outputs such as Combined 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: <ul style="list-style-type: none"> • 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

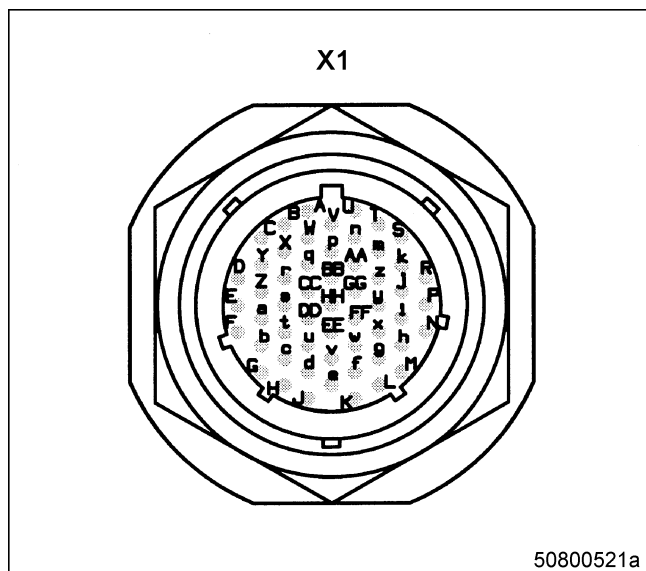
IEU1 = 0 to 10 V or 4 to 20 mA	<p>It is possible to activate different analog desired speed settings for the MDEC governor.</p> <p>Default setting:</p> <ul style="list-style-type: none"> • Characteristic curve 71 (50 Hz) in MDEC governor 0 to 10 V activated. <p>Parameterized desired speed setting 4 to 20 mA must be changed if desired.</p> <p>Same applies to characteristic curve 72 (60 Hz).</p>
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7.2 Connector Assignment

7.2.1 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

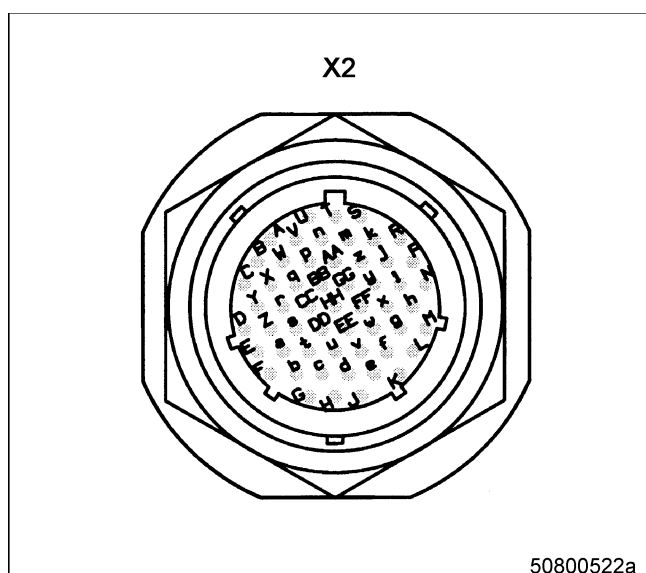
Pin assignment

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

Channel	Signal	Pin	Comments
UA2	GND	CC	
UA3	OUT	t	0 V to 10 V / 8 mA
UA3	GND	s	
UA4	OUT	Z	0 V to 10 V / 8 mA
UA4	GND	Y	
BE1	+IN	h	$U < 4 \text{ V} = \text{low} / U > 8 \text{ V} = \text{high}$
BE1	-IN	g	Electrically isolated
BE2	+IN	x	$U < 4 \text{ V} = \text{low} / U > 8 \text{ V} = \text{high}$
BE2	-IN	w	Electrically isolated
BE3	+IN	R	$U < 4 \text{ V} = \text{low} / U > 8 \text{ V} = \text{high}$
BE3	-IN	P	Electrically isolated
BE4	+IN	j	$U < 4 \text{ V} = \text{low} / U > 8 \text{ V} = \text{high}$
BE4	-IN	i	Electrically isolated
BE5	+IN	FF	$U < 4 \text{ V} = \text{low} / U > 8 \text{ V} = \text{high}$
BE5	-IN	EE	Electrically isolated
BE6	+IN	v	$U < 4 \text{ V} = \text{low} / U > 8 \text{ V} = \text{high}$
BE6	-IN	u	Electrically isolated
BE7	+IN	f	$U < 4 \text{ V} = \text{low} / U > 8 \text{ V} = \text{high}$
BE7	-IN	e	Electrically isolated
BE8	+IN	d	$U < 4 \text{ V} = \text{low} / U > 8 \text{ V} = \text{high}$
BE8	-IN	c	Electrically isolated
BE9	+IN	N	$U < 4 \text{ V} = \text{low} / U > 8 \text{ V} = \text{high}$
BE9	-IN	M	Electrically isolated
FE1	GND	J	$U < 1.5 \text{ V} = \text{low} / U > 3.5 \text{ V} = \text{high}$
FE1	IN	H	Frequency input
TAA1	GND	V	24 V / 600 mA
TAA1	GND	U	

Channel	Signal	Pin	Comments
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
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

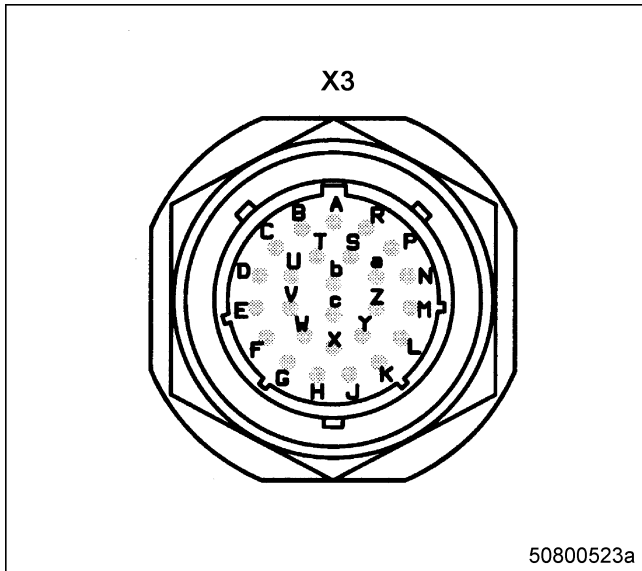
Pin assignment

Channel	Signal	Pin	Comments
TE1	IN	k	0 V to 5 V/ internal 2 k Ω pullup to 5 V_TE_BUF
TE1	GND	z	
TE2	IN	N	0 V to 5 V/ internal 2 k Ω pullup to 5 V_TE_BUF
TE2	GND	P	
TE5	IN	M	0 V to 5 V/ internal 2 k Ω pullup to 5 V_TE_BUF
TE5	GND	g	
TE6	IN	y	0 V to 5 V/ internal 2 k Ω pullup to 5 V_TE_BUF
TE6	GND	FF	
TE7	IN	w	0 V to 5 V/ internal 2 k Ω pullup to 5 V_TE_BUF
TE7	GND	x	
TE8	IN	t	0 V to 5 V/ internal 2 k Ω pullup to 5 V_TE_BUF
TE8	GND	a	
TE9	IN	E	0 V to 5 V/ internal 2 k Ω 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 47k Ω pulldown
DE1	GND	Y	
DE2	5 V_BUF1	r	5 V / 20 mA
DE2	IN	s	0 V to 5 V / internal 47k Ω pulldown
DE2	GND	CC	
DE3	5 V_BUF2	BB	5 V / 20 mA
DE3	IN	GG	0 V to 5 V / internal 47k Ω pulldown
DE3	GND	HH	
DE4	5 V_BUF2	d	5 V / 20 mA
DE4	IN	H	0 V to 5 V / internal 47k Ω pulldown
DE4	GND	J	

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

Channel	Signal	Pin	Comments
TAM2	OUT	h	24 V / 1.5A
TAM2	GND	i	

Connector X3, view to socket



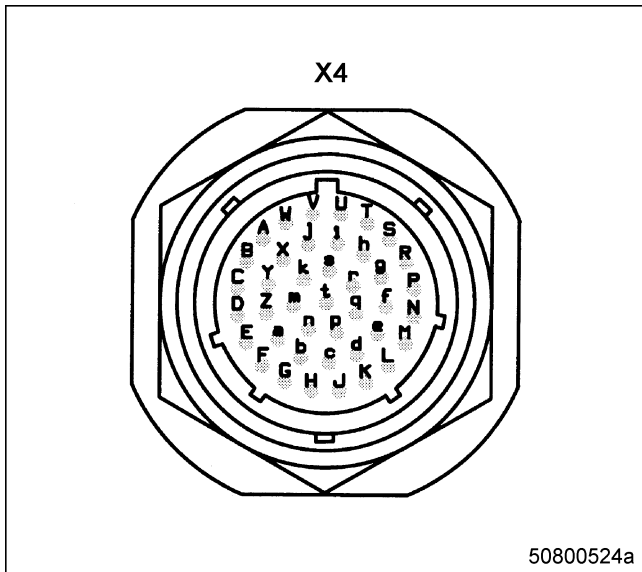
Connector X3

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

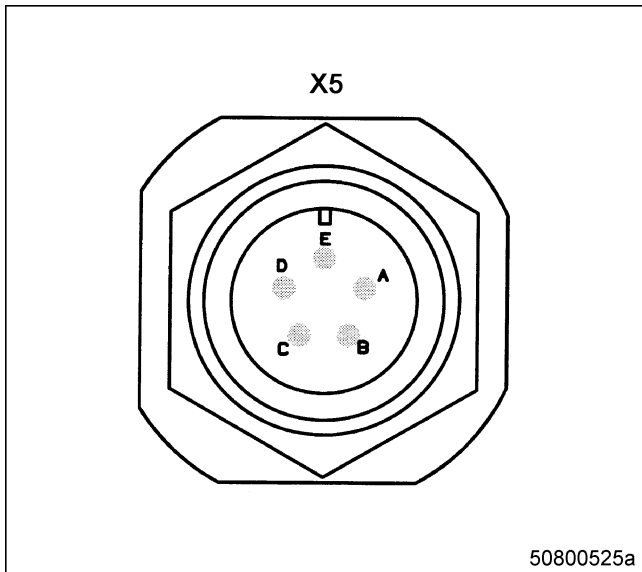
Connector type	VPT 06 GSE 21–41 PW
Target	Engine wiring harness (solenoid valves)

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

Channel	Signal	Pin	Comments
MV9	LOW	j	Bank 1
MV10	HIGH	B	24 V / 20 A
MV10	LOW	A	Bank 1
MV11	HIGH	S	24 V / 20 A
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



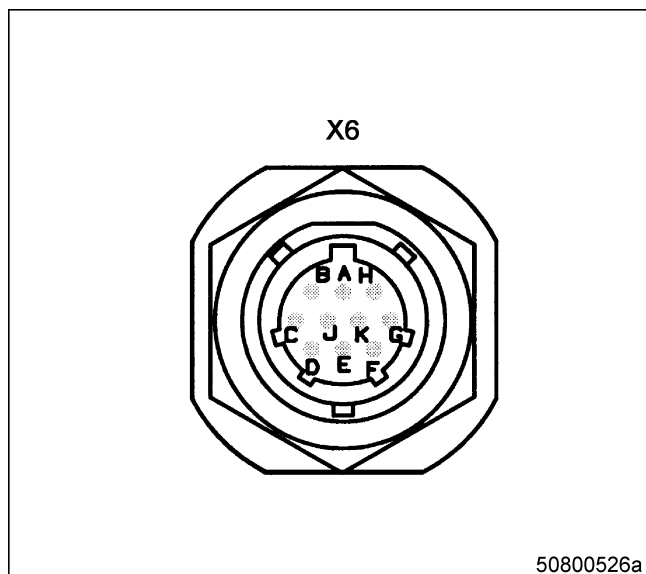
Connector X5

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

Pin assignment

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

Connector X6, view to socket



Connector X6

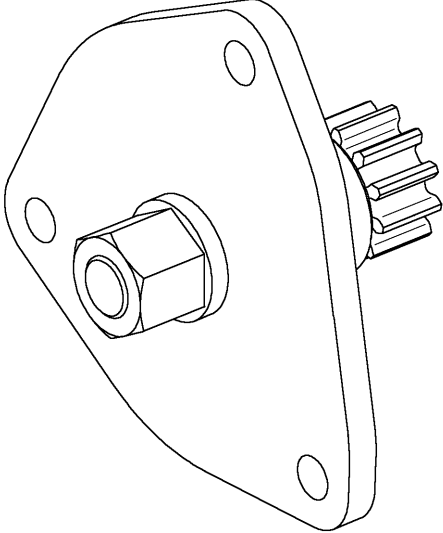
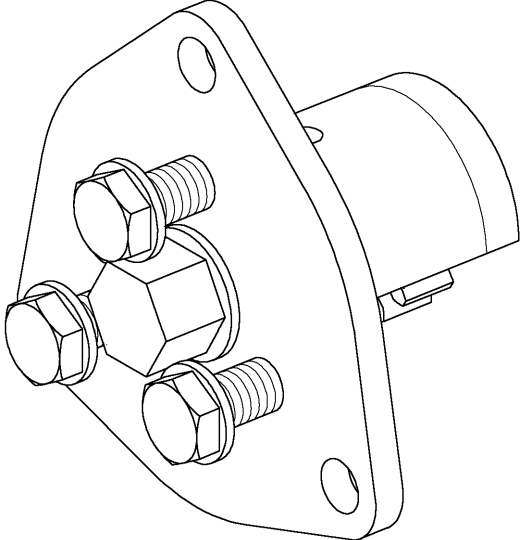
Connector type	VPT 06 GSE 12-10 P
Target	Dialog unit

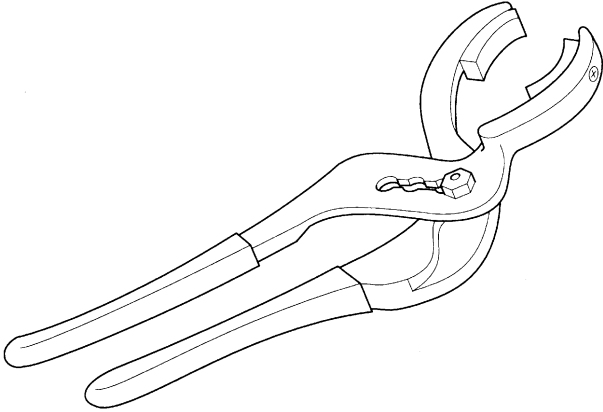

Pin assignment

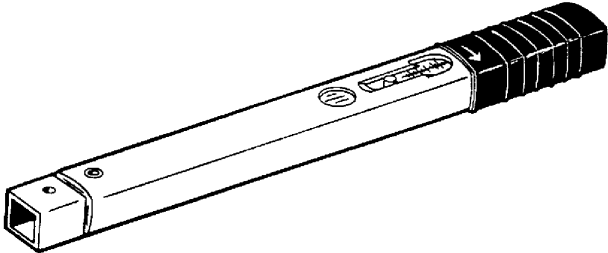
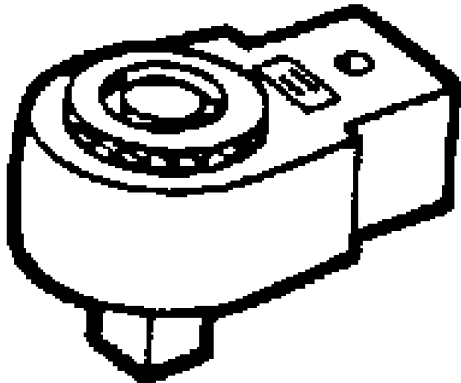
Channel	Signal	Pin	Comments
POWER	+24 V	A	$U_{\text{supp}} = 24 \text{ V} / 30 \text{ A}$
POWER	+24 V	D	
POWER	GND	B	
POWER	GND	C	
POWER	GND	E	

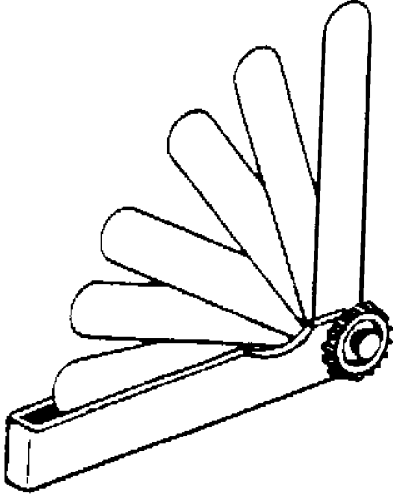
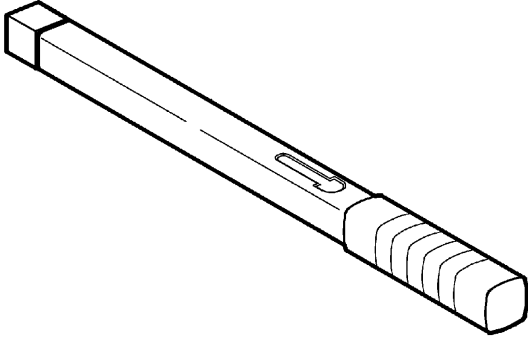
8 Special Tools

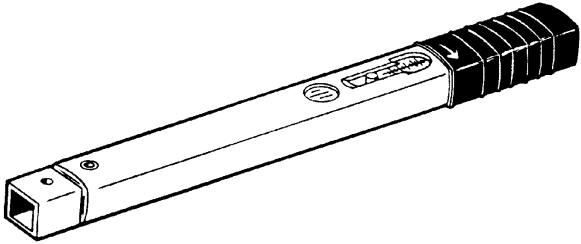
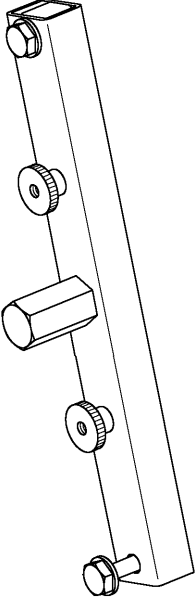
8.1 Special tools

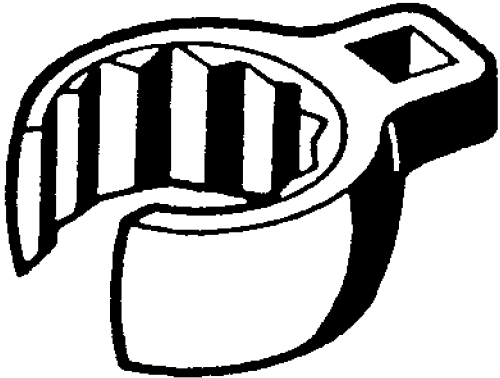
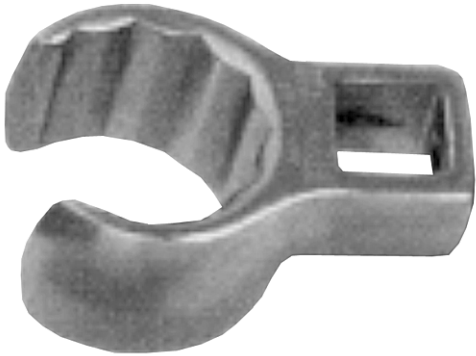
Part No.	Designation / Use	Qty.	
F6558556	Barring tool for 12V engines	1	
F6558557	Barring tool for 16V engines	1	

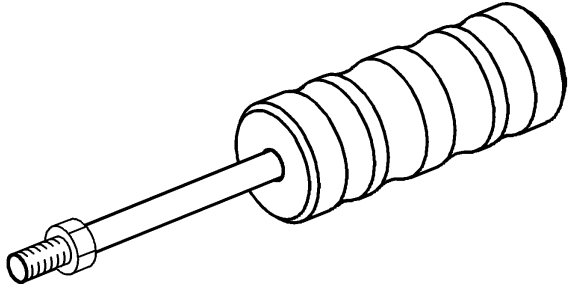
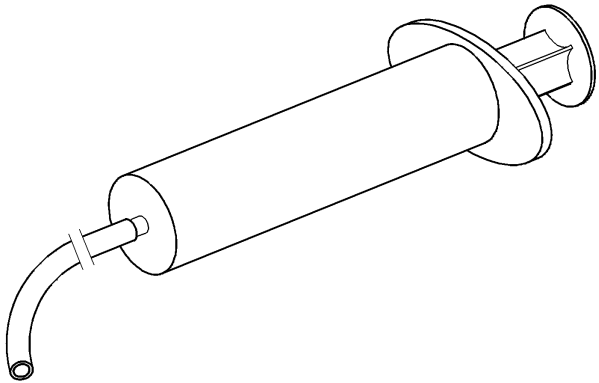
Part No.	Designation / Use	Qty.	
0135315483	Connector pliers	1	 A line drawing of a pair of connector pliers. The tool has two long, tapered handles. The heads are curved and feature a central locking mechanism with a small pin or screw. The jaws are designed to grip and manipulate electrical connectors.
Y20097353	Rigid endoscope	1	 A photograph of a rigid endoscope. It consists of a long, thin, cylindrical shaft with a lens at the tip. The handle is black and has a T-shaped grip. The shaft is connected to the handle via a series of joints.

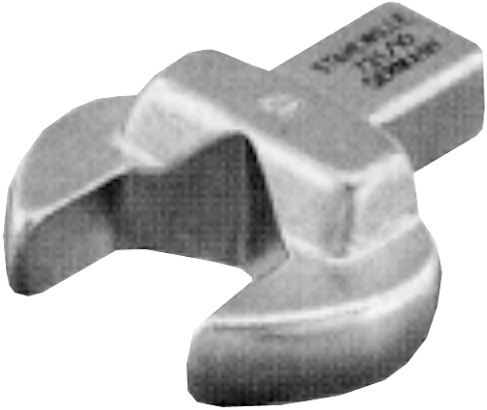
Part No.	Designation / Use	Qty.	
F30027336	Torque wrench 6-50 Nm	1	
F30027340	Ratchet adapter	1	


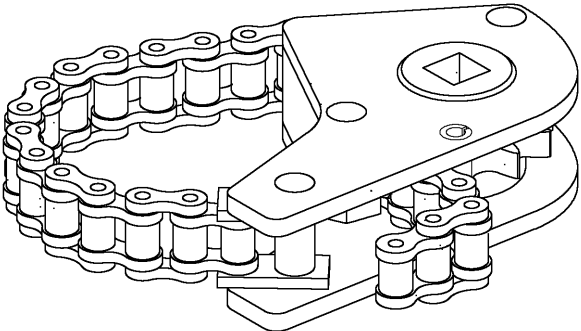
Part No.	Designation / Use	Qty.	
Y20010128	Feeler gauge	1	
F30026582	Torque wrench 20-100 Nm	1	

Part No.	Designation / Use	Qty.	
F30043446	Torque wrench 8-40 Nm	1	
F6557929	Barring tool	1	

Part No.	Designation / Use	Qty.	
F30027424	Spider patch spanner	1	 <p>A line drawing of a spider patch spanner. It features a C-shaped body with a handle on the right side that has a rectangular cutout. The inner surface of the C-shape is divided into several vertical segments, resembling a spider's legs, which are used to grip a patch.</p>
F30027425	Spider patch spanner	1	 <p>A 3D rendering of a spider patch spanner, showing its physical form and shading. It is a dark grey or black tool with a C-shaped body and a handle on the right side with a rectangular cutout. The inner surface of the C-shape is segmented into vertical ridges.</p>

Part No.	Designation / Use	Qty.	
F30377999	Extractor	1	
F30378207	Fuel suction device	1	

Part No.	Designation / Use	Qty.	
F30025897	Socket wrench	1	

Part No.	Designation / Use	Qty.	
F30011450	Double box wrench	1	
F30379104	Filter wrench	1	

9 Annex

9.1 Manufacturer's documentation

See Manufacturer's documentation.

9.2 MTU contact person/service partner

You will find the MTU contact person/service partner for your region at www.mtu-online.com, worldwide, in the left-hand navigation margin.

9.3 Abbreviations

Abbreviation	Meaning	Explanation
A/D	Analog/Digital	Transformer: transforms sensor voltages into numeric values
AFRS	Air Filter Restriction Sensor	
ANSI	American National Standards Institute	
ATL	Abgasturbolader	Exhaust turbocharger (ETC)
ATS	Air Temperature Sensor	
BR	Baureihe	Engine Series
CAN	Controller Area Network	
CEL	Check Engine Light	1st function: Warning lamp (rectify fault as soon as possible) 2nd function: Read out fault codes
CKT	Circuit	
CLS	Coolant level sensor	Monitors coolant level
CPS	Coolant pressure sensor	Monitors coolant pressure
CTS	Coolant temperature sensor	Monitors coolant temperature
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.	German Standardization Organization, at the same time identifier of German standards ("Deutsche Industrie-Norm")
DL	Default Lost	Alarm: Default CAN bus failure
DT	Diagnostic Tool	
ECM	Electronic Control Module	Electronic control unit of the DDEC system
ECU	Engine Control Unit	Engine governor
EDM	Engine Data Module	
EEPROM	Electrically Erasable Programmable Read Only Memory	
EFPA	Electronic Foot Pedal Assembly	
EGR	Exhaust Gas Recirculation	
EMU	Engine Monitoring Unit	
EUI	Electronic Unit Injector	
FLS	Fluids and Lubricants Specification	MTU Publication No. A01061/..
FPS	Fuel Pressure Sensor	Monitors fuel pressure

Abbreviation	Meaning	Explanation
FRS	Fuel Differential Pressure Sensor	
FTS	Fuel Temperature Sensor	Monitors fuel temperature
GND	Ground	
HI	High	Alarm: Measured value exceeds 1st maximum limit
HIHI	High High	Alarm: Measured value exceeds 2nd maximum limit
HT	High Temperature	
IDM	Interface Data Module	
INJ	Injector	
ISO	International Organization for Standardization	
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
LOLO	Low Low	Alarm: Measured value lower than 2nd minimum limit
LSG	Limiting Speed Governor	
N/A	Not Applicable	
OEM	Original Equipment Manufacturer	
OI	Optimized Idle	
OLS	Oil Level Sensor	Monitors oil level
OPS	Oil Pressure Sensor	Monitors oil pressure
OTS	Oil Temperature Sensor	Monitors oil temperature
OT	Oberer Totpunkt	Top dead center (TDC)
PAN	Panel	
PIM	Peripheral Interface Module	
PWM	Pulsewidth modulated	
P-xyz	Pressure-xyz	Pressure measuring point xyz
RL	Redundancy Lost	Alarm: Redundant CAN bus failure
SAE	Society of Automotive Engineers	U.S. standardization organization
SD	Sensor Defect	Alarm: Sensor failure

Abbreviation	Meaning	Explanation
SEL	Stop Engine Light	1st function: Warning lamp (stop engine and rectify fault) 2nd function: Read out fault codes
SID	System Identifier	
SPC	Spare Parts Catalog	
SRS	Synchronous Reference Sensor	TDC cylinder 1
SS	Safety System	Indicated alarm is initiated by the safety system
TBS	Turbocharger Boost Sensor	Monitors charge-air pressure
TC	Tools Catalog	
TCI	Turbo Compressor Inlet	
TCO	Turbo Compressor Outlet	
TD	Transmitter Deviation	Alarm: Sensor-comparison failure
TPS	Throttle Position Sensor	
TRS	Timing Reference Sensor	
T-xyz	Temperature-xyz	Temperature measuring point xyz
UT	Unterer Totpunkt	Bottom dead center (BDC)
VNT	Variable nozzle turbine	
VSG	Variable Speed Governor	
VSS	Vehicle Speed Sensor	

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