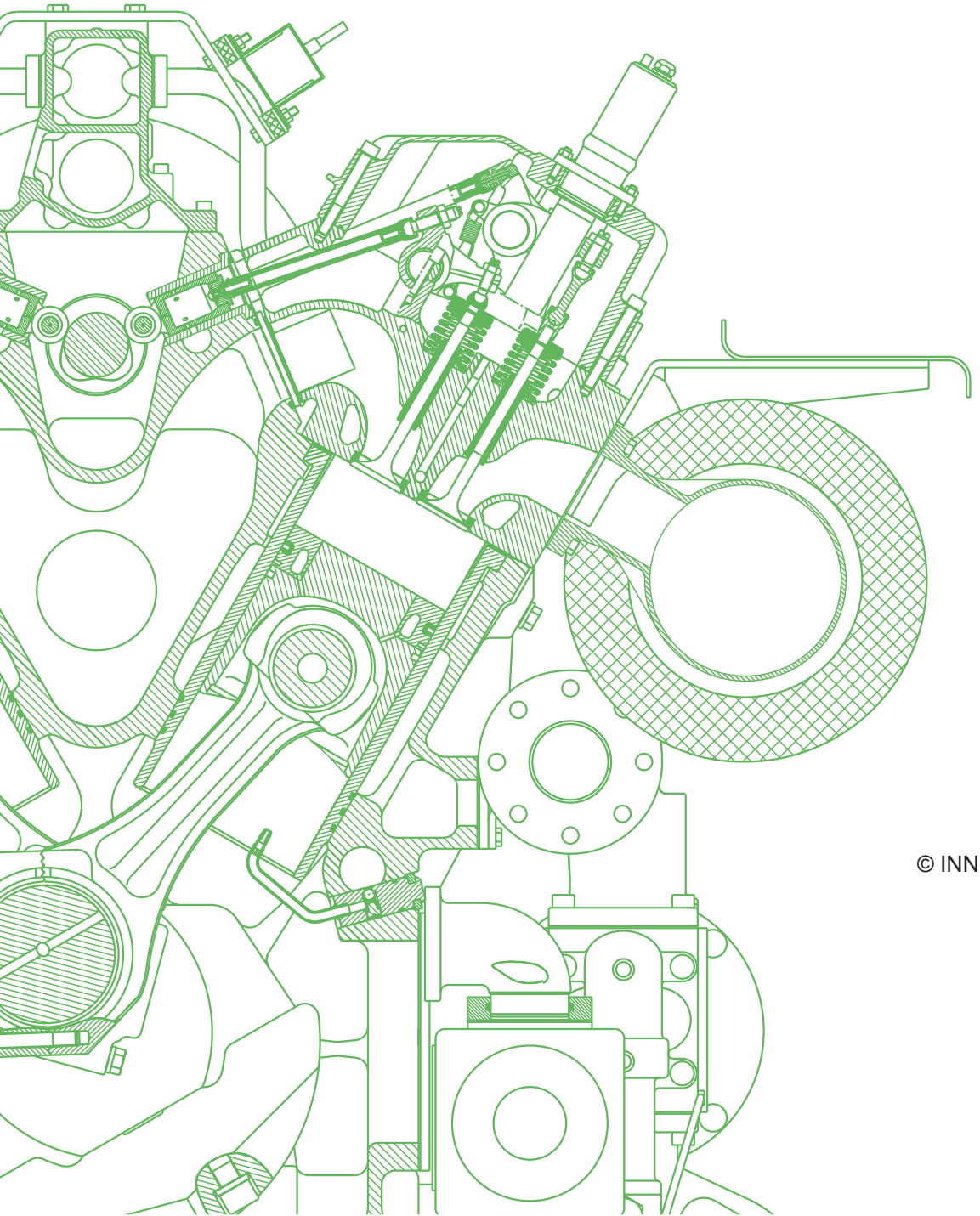
JENBACHER

TA 1502-0068

Technical Instruction

MORIS ignition



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1 Scope

This Technical Instruction (TA) applies to the following Jenbacher Gas Engines:

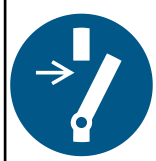
- Type 4 engines
- Type 6 engines
- Type 9 engines

2 Purpose

This Technical Instruction (TA) describes the design and operation of the MORIS ignition system.

3 Safety information

⚠ DANGER



Danger to life from high voltages

Extremely dangerous voltages can be produced during the self-test and engine operation (primary power supply of 185 V to the ignition coil and high voltage in excess of 40 kV on the secondary side). Currents of up to 100 A occur during operation. Improper use may result in a risk of injury or death due to electric shocks.

- ➢ Before assembly or repair work on the ignition system, shut down the engine in accordance with TA 1100-0105 and secure it against unauthorised restarting in accordance with TA 2300-0010.
- ➢ Before working on the ignition system, disconnect the power supply to **MORIS** and check to ensure that the system is dead.

⚠ WARNING

Personal injury

Failure to use personal protective equipment and comply with safety instructions or employee protection information may lead to personal injury.

- ➢ Wear the relevant personal protective equipment (PPE).
- ➢ Observe the safety instructions as per TA 2300-0005.
- ➢ Observe the employee protection information as per TA 2300-0001.

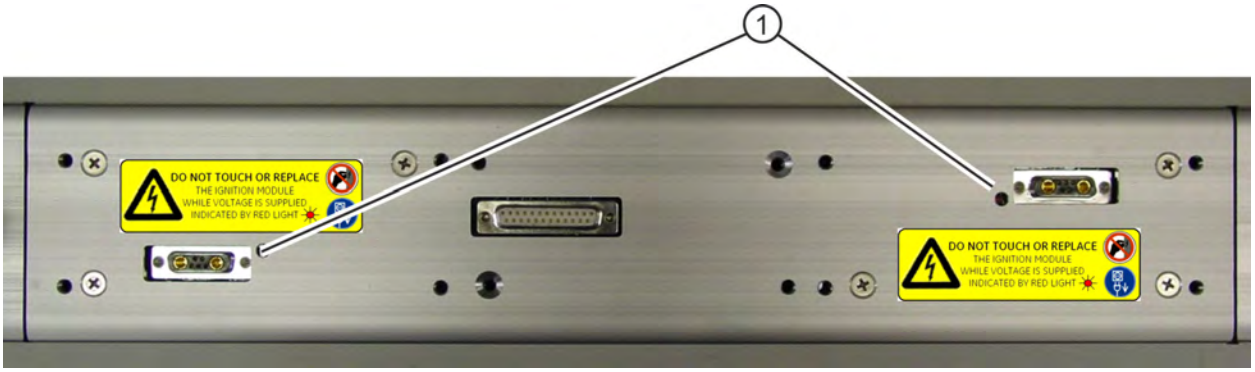
Ignition module

⚠ WARNING

High voltage

You are not permitted to touch the connection sockets or replace the ignition module while the 185 V power supply is live, as indicated by the red LEDs!

When working on the ignition rail system, read the instructions displayed there.



①	red LED

Before replacing **MORIS** components, disconnect the 24 V and 185 V power supplies to the rail and check to ensure that the system is dead! To do so, remove both connector plugs from the connection module for the power supply to the **MORIS** rail and check the LED located underneath an **M coil** to ensure that the 185 V voltage is dead.

The ignition modules are identical apart from the expansion of the port injection actuation.

4 Additional information

Relevant documents:

TA 1100-0105 – Engine shut-down

TA 1502-0068 – ⇨ MORIS ignition

TA 1502-0069 – MPM (MORIS Power Module)

TA 1502-0071 – SAFI (Sensor Actuator Function Interface)

TA 1502-0072 – SPA24 (SAFI pick-up amplifier)

TA 2300-0001 – Employee protection

TA 2300-0005 – Safety instruction

TA 2300-0010 – Guidelines for using the LOTO kit

5 Description

5.1 MORIS

The name **MORIS** is derived from the term "**Mo**dular **R**ail **I**gnition **S**ystem" and describes the design configuration of the ignition system. With this modular concept, every cylinder or engine configuration can be put together using individual modules. The output stage of the ignition system, the ignition module, has been integrated in the cabling rail. One ignition module contains the power electronics for two cylinders.

The **SAFI** (**S**ensor **A**ctor **F**unctional **I**nterface) is a further development of the **KLS98** (knock sensor system). The **SAFI** is a DSP-based device into which the ignition control and monitoring system have been integrated as well as comprehensive monitoring functions (knocking, exhaust-gas temperatures, etc.). The **SAFI** calculates the speed and crankshaft angle position for the ignition pulses from pickup signals from the camshaft and the crankshaft which are processed by the **SPA 24** (**S**AFI **P**ick-up **A**mplifier). The **SAFI** and the engine controller communicate via the CAN bus.

Power is supplied to the **MORIS** by the 24 V mains and the **MPM** (**M**ORIS **P**ower **M**odul).

5.2 MORIS2

MORIS2 is an expansion consisting of the addition of power electronics for controlling the PI (port injection) of the main chamber gas valve. This modular concept also means that any desired cylinder or engine configuration can be assembled from individual modules.

The second-generation SAFI (Sensor Actuator Functional Interface) (SAFI2) controls the port Injection control. A combination of a first-generation SAFI with MORIS2 is therefore not possible.

SAFI is available in the version for knock detection with knock sensors or for the PBC (pressure-controlled engine control) with inputs for cylinder pressure sensors.

The SAFI calculates the speed, combustion pressure curve and knocking intensity from pick-up signals from the camshaft and the crankshaft which are processed by the SPA (SAFI Pick-up Amplifier), and controls the ignition and port injection. The SAFI and the engine control unit communicate via the CAN bus.

Power is also supplied to the MORIS by the 24 V grid and the MPM (MORIS Power Module). The increased power output from the additional actuation of the gas valves means that four MPMs are needed for one J920, one to supply each closed MORIS rail.

The following Technical Instructions are referred to in this document:

- TA 1502-0069 - **MPM** (**M**ORIS **P**ower **M**odule)
- TA 1502-0071 - **SAFI** (**S**ensor **A**ctor **F**unctional **I**nterface)
- TA 1502-0072 - **SPA24** (**S**AFI **P**ick-up **A**mplifier)

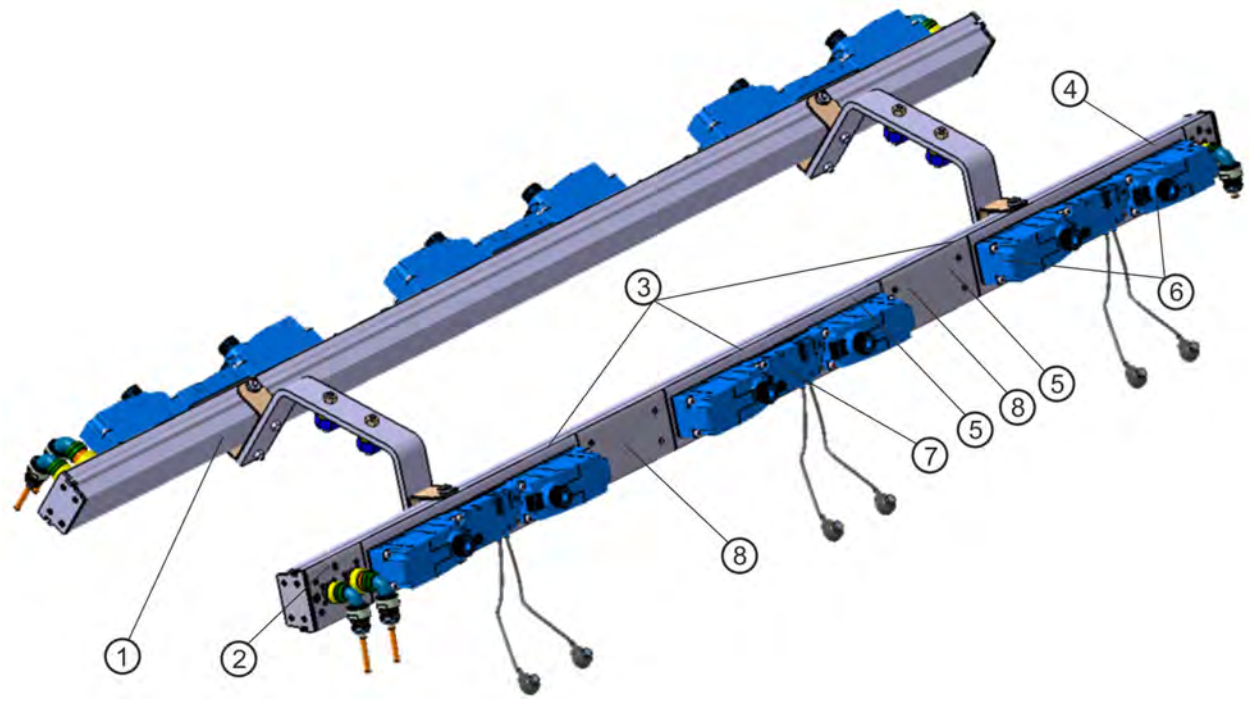
You will need these Technical Instructions to obtain a complete understanding of the **MORIS** functions.

6 Layout

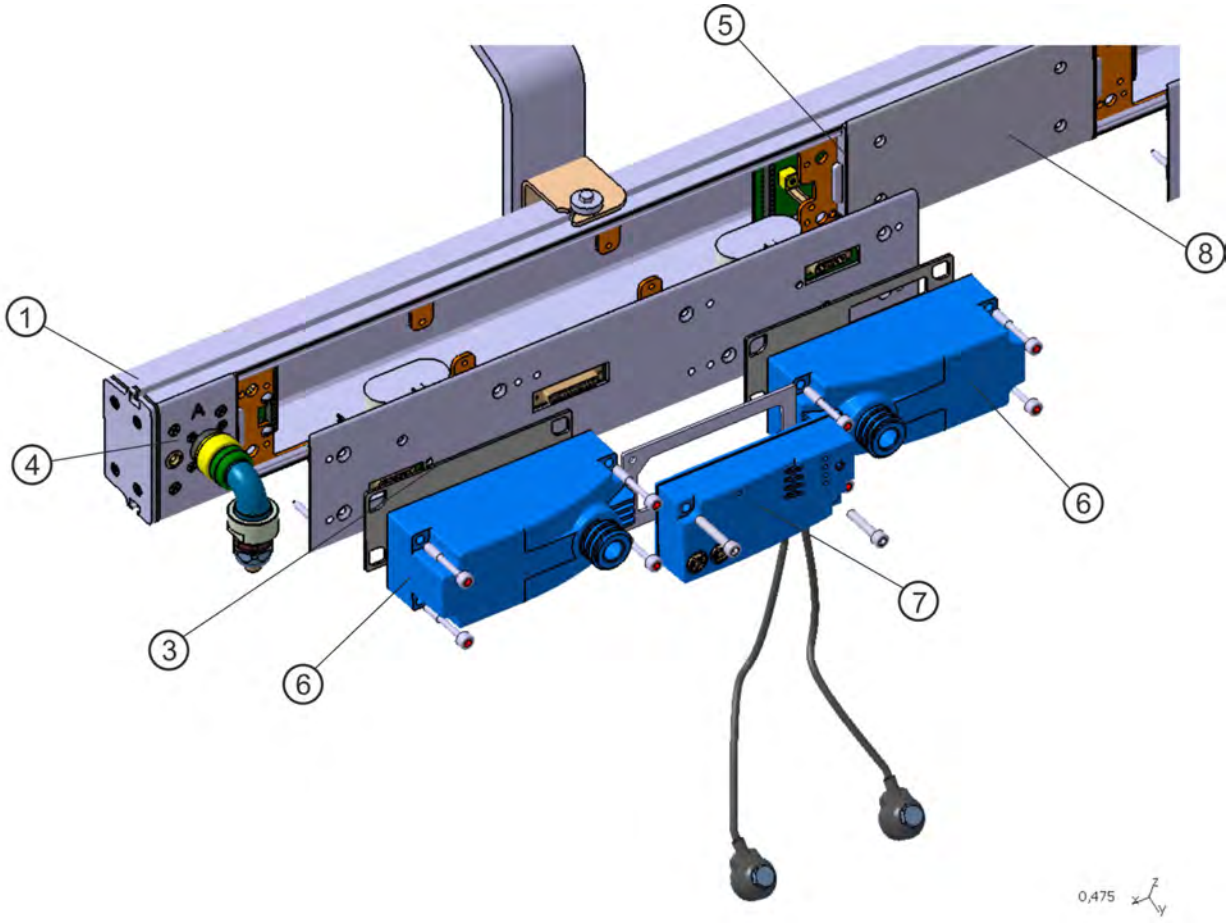
6.1 MORIS

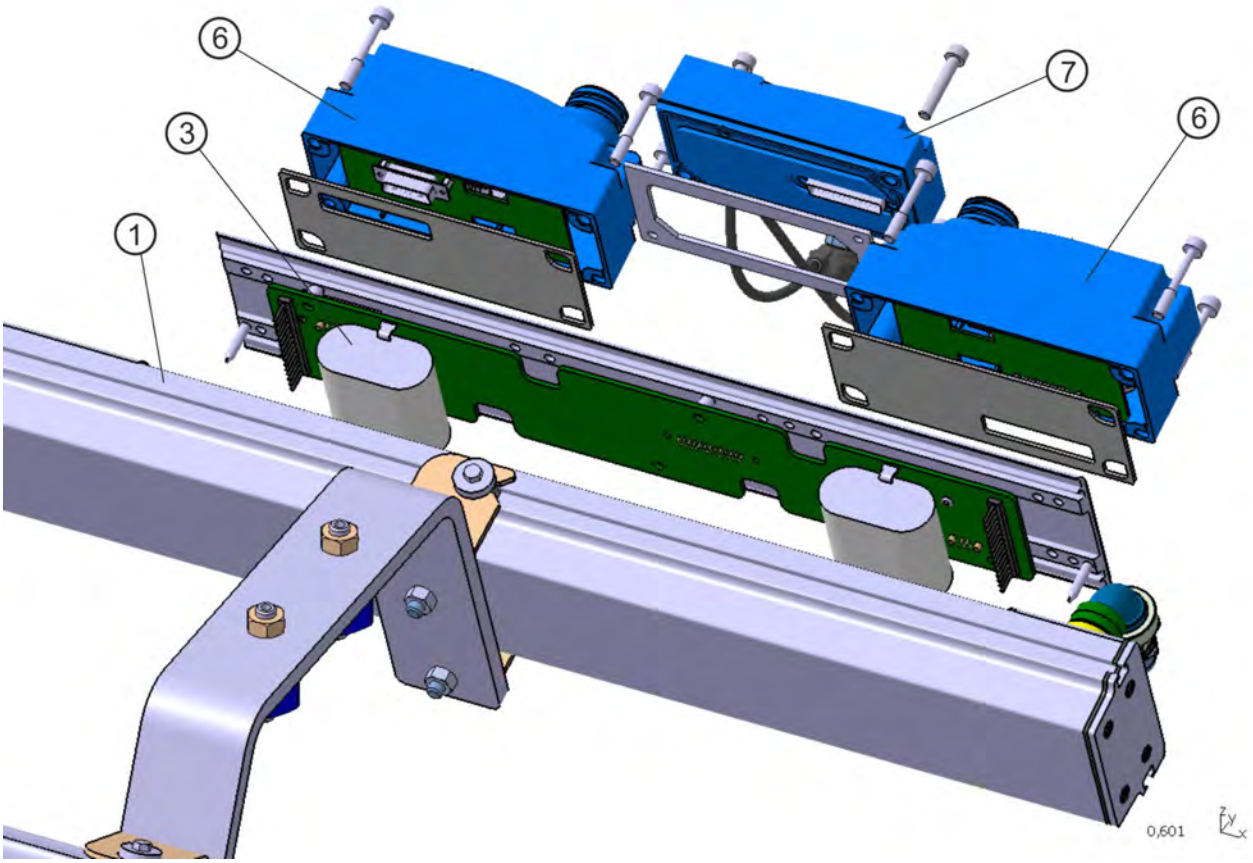
One aluminium mounting rail is used for each row of cylinders. The rail connected to cylinder 1 is designated as Bank A and the rail for the second row of cylinders as Bank B.

MORIS with holder, **M coils** and **SAFI** for J612 engine



①	Aluminium mounting rail
②	Connection module for power supplies, signal and CAN bus connections
③	Ignition module
④	End module
⑤	Gasket between the individual modules
⑥	**M coil**
⑦	**SAFI**
⑧	Link module





6.2 MORIS2

One aluminium mounting rail is used for each row of cylinders. The rail connected to cylinder 1 is designated as Bank A and the rail for the second row of cylinders as Bank B.

①	Aluminium mounting rail
②	Connection module for power supplies, signal and CAN bus connections
③	MORIS2 PI ignition module, rev. 7
④	End module
⑤	Gasket between the individual modules
⑥	M coil
⑦	SAFI2 Type 9 engines: PBC with raised cover and spring terminal strip Type 6 engines: normal with screw-type terminals
⑧	MORIS J920 link module

7 Technical data

7.1 Protection class

When assembled, the **MORIS** ignition system with all components mounted on it complies with Protection Class IP54.

7.2 Ambient conditions

Temperature limits	storage	-25 ... + 70 °C
	operation	-25 ... + 85 °C
Relative humidity	storage	90 %, no dew
	operation	85 %, no dew
Air pressure	up to 2,000 m above sea level	

7.3 Chemical resistance

MORIS has been developed to meet the specific INNIO Jenbacher GmbH & Co OG requirements for chemical resistance to the antifreeze (glycol) in the engine cooling water, sulphurous acid, engine oil and UV radiation.

In general, the following limit levels for atmospheric pollution apply:

Sulphur dioxide (SO2)	0.030 ppm
Hydrogen sulphide (H2S)	0.010 ppm
Nitrous oxide gases (NOx)	0.030 ppm
Chlorine (C12)	0.010 ppm
Hydrogen fluoride (HF)	0.010 ppm
Ammonia (NH2)	0.500 ppm
Ozone (O3)	0.005 ppm

7.4 Mechanical data

7.4.1 Vibration resistance

MORIS is designed for vibration loads to an effective value of max. 20 mm/s at 10 - 300 Hz.

7.4.2 Rail dimensions

The length of the rail depends on the engine type in use. Two J612 rails per cylinder row are used for the J624.

Part number	Engine type	Length
487209	Rail J412	1 557 mm
487210	Rail J416	2 017 mm
487211	Rail J420	2 477 mm
487804	Rail J612	1 933 mm
487805	Rail J616	2 581 mm
487806	Rail J620	3 229 mm

7.4.3 Tightening torques

Bolt type	Dimension	Position	Tightening torque
Hexagonal socket bolt	M6 x 35 mm	**SAFI** top left	3.4 Nm | 30 lb in
Hexagonal socket bolt	M6 x 30 mm	**SAFI** bottom right	3.4 Nm | 30 lb in
Special hexagonal socket bolt	M6 x 40 mm	**M coil**	3.4 Nm | 30 lb in
Countersunk bolt	M5 x 12 mm	Ignition module	2.3 Nm | 20 lb in
Countersunk bolt	M4 x 9 mm with 8-32 X 3/8 SEAL FT HD joint ring	Connecting module, Type 6 engine link and end modules	1.7 Nm | 15 lb in
Hexagonal head screw	M6 x 12 mm	Earthing bolt on connection and end modules	3.4 Nm | 30 lb in
Hexagonal head screw	M5 x 12 mm	Mounting	2.3 Nm | 20 lb in
Special hexagonal head bolt	M10 x 15 mm	Thermocouple	15 Nm | 133 lb in
Hexagonal head screw	M8 x 25 mm	Knock sensor	20 Nm | 177 lb in

7.5 Electrical data

The terminal designations of all **MORIS** components are listed in Section ⇨ Terminal designation.

7.5.1 24 V power supply

MORIS is powered by a battery with a nominal voltage of 24 V DC. The battery voltage may fluctuate within a range from 18 V to 32 V.

The battery voltage must not fall below 15 V during the start-up process, otherwise the **SAFI** and the **MPM** may fail.

The 24 V power supply for MORIS is protected by a 16.5 x 11 x 3.8 mm violet-coloured 3 A MINI automotive fuse in the connection module. Replacement of the fuse is described in ⇨ Connection and end modules.

7.5.2 185 V power supply

MPM (**M**ORIS **P**ower **M**odule) is a DC-DC converter and supplies the **MORIS** with a DC current at 185 V from the 24 V grid. The voltage output is activated via a digital input. A safety contact reports the output of the **MORIS** power supply to the control system.

The **MPM** supplies 2.5 A rms at a nominal input voltage of 24 V with an 80% efficiency.

Nominal input voltage	24 V DC
Maximum power consumption at rated voltage	24.1 A
Nominal output voltage	185 V DC
Maximum output current	2.5 A rms
Operating temperature range	-20 °C to + 75 °C

Number of MPMs:

Due to the power output of 462 W per MPM, it is necessary to fit more MPMs on some engine configurations in order have the required power available. On Type 4 and 6 engines with more than 20 cylinders, a second MPM must be fitted. Because the port Injection valves on the Type 9 are actuated from the 185 V circuit, the additional power required for all port injection applications must be ensured by means of the number of MPMs.

Further information on the **MPM** can be found in the relevant TA 1502-0069.

7.5.3 Pickup signal amplifier SPA24

SPA24 (**S**AFI **P**ick-up **A**mplifier **24**V), is a pickup amplifier which processes the camshaft, reset and ring gear signals into the form required for the **SAFI**.

A voltage of at least 3 V is required to identify passive pick-up signals.

Rated power consumption	170 mA
Nominal input voltage	DC 24 V
Operating temperature range	0 °C to + 70 °C
Max. power per output	100 mA

Further information on the **SPA24** can be found in the relevant TA 1502-0072.

7.5.4 SAFI

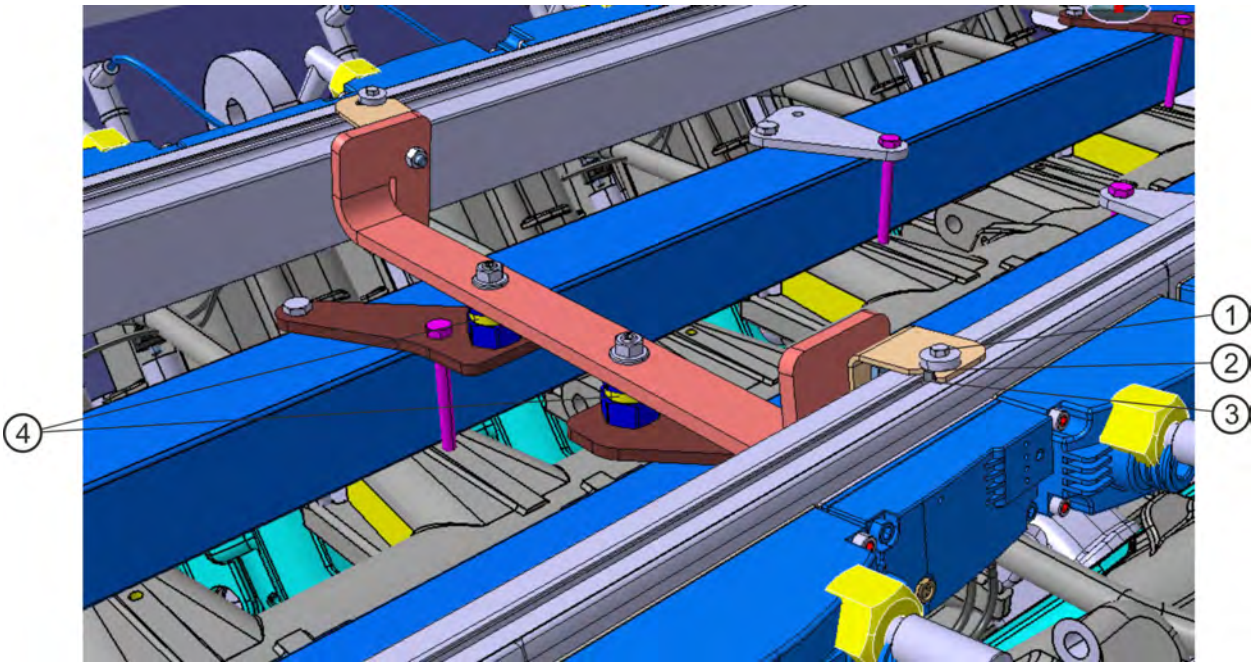
The **SAFI** power supply may fluctuate within a range from 18 V to 32 V with ± 10% residual ripple.

Rated power consumption	175 mA
Nominal input voltage	DC 24 V
Operating temperature range	-25 °C to 85 °C
Input voltage range for signals	15 – 32 V DC

Further information on the **SAFI** can be found in the relevant TA 1502-0071.

8 Installation

8.1 Mounting the ignition system on the engine



Example of a mounting on a Type 4 engine			
①	M5 x 20 bolt	③	T-groove slide nut M5 x 20
②	Washer	④	Metal cushion-type damper

Metal cushion-type dampers are used to protect the structure of the **MORIS** rails from vibration.

The rails are secured to the mounting on the engine by means of M5 x 20 mm T-groove slide nuts, M5 x 12 mm mounting bolts and dished washers.

8.2 Earthing the ignition system

Connect the **MORIS** rails to the engine earth using an earthing cable with a cross-section of least 6 mm².

One M6 x 12 mm bolt is provided at each connection and end module to connect the earthing cable to the rail.

Cables for equipotential bonding are fitted between the Safi front right mounting bolt and the rear left mounting bolt of the right port injection valve to minimise interference in the pressure measurement signals. The cable cross-section is 6 mm². No additional bolts/connection points are provided to connect these cables; instead, the cable is fastened to the Safi M6 bolt with a cable lug eyelet and to the thread of the PI valve mounting bolt with an extra M8 nut. (Retaining force for the PI valve therefore does not place a load on the eyelet.)

8.3 Mounting and adjusting the pickups on the engine

The mounting and adjustment of pick-ups is described in TA 1502-0072 – **SPA24**.

8.4 Replacing components

Please read the guidelines and safety instructions in the Section ⇨ Safety information before replacing any MORIS component.

Each time you fit or remove a MORIS component, inspect the gaskets for damage and replace if necessary. This is the only way to guarantee that the system as a whole remains permanently watertight (IP54).

8.4.1 Spark plug connector

To replace the spark plug connector, loosen the union nut on the coil terminal and the two M8 nuts of the double-end studs on the valve cover.

Each time you remove a spark plug connector, inspect the area of the adapter between the cylinder-head cover and the spark plug sleeve for oil leaks and if necessary replace defective O-rings.

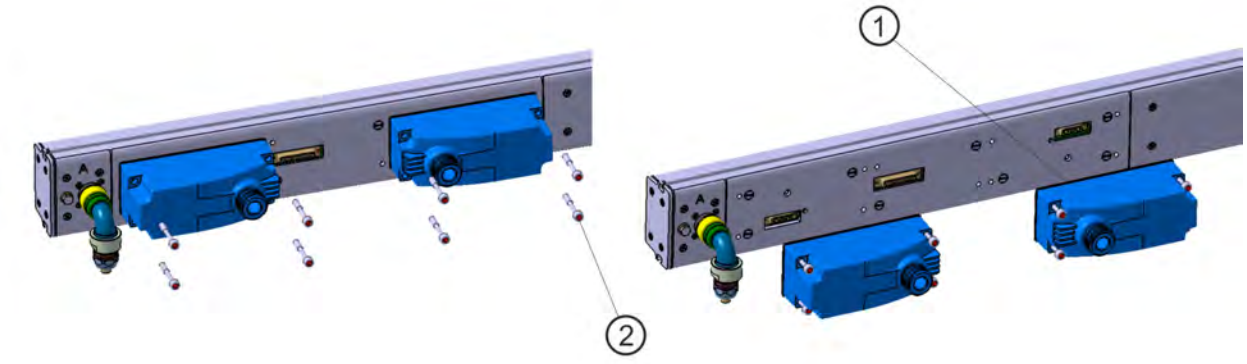
8.4.2 Thermocouple

Tighten the thermocouple sleeves to a torque of 30 Nm. The exhaust gas thermocouples must be manually tightened to the SAFI and the engine block to a torque of 15 Nm. Connect the thermocouple for the left cylinder to the left-hand connector, and the thermocouple for the right cylinder to the right-hand connector, of the **SAFI**.

8.4.3 M coil

The **M coil** is fastened to the ignition module with four special M6 x 40 hexagonal socket bolts (refer to Section ⇨ Tightening torques).

The first time a coil is fitted or replaced, the self-adhesive 3 mm NBR gasket supplied must be affixed to the **M coil**.



①	3 mm self-adhesive NBR gasket
②	M6 x 40 hexagon socket bolt

Before disassembling, loosen the coil terminal on the spark plug connector. After fitting the **M coil**, reconnect the coil terminal on the spark plug connector and hand-tighten.

8.4.4 SAFI

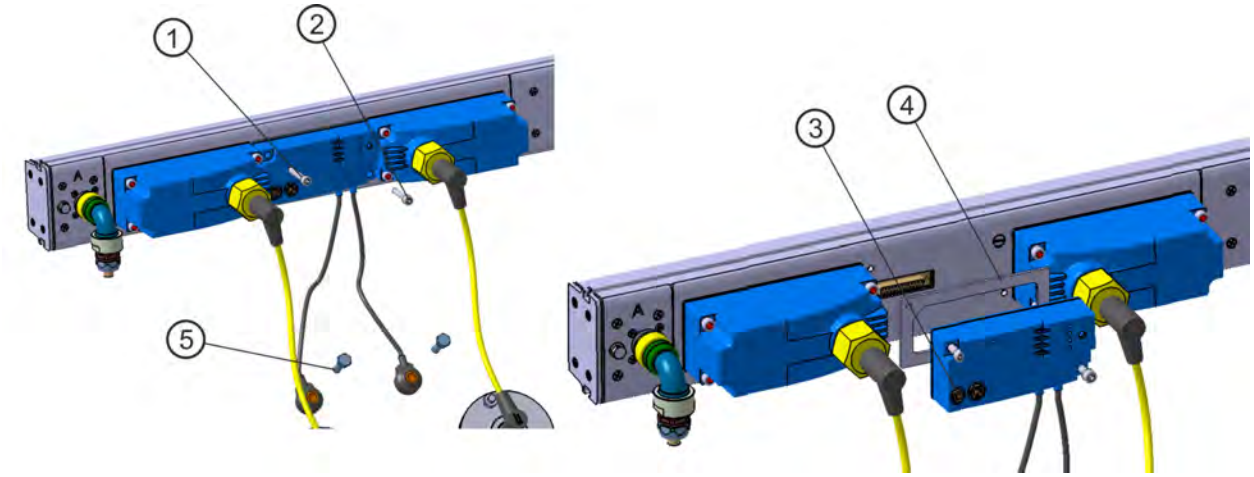
NOTE

Damage to SAFIs

SAFIs must never be removed from, or mounted on, the MORIS rail when energised. This can cause preliminary damage to the SAFIs and later result in their failure.

- ➢ Always switch off the 24 V supply and disconnect the supply plug from the MORIS before working on SAFIs or MORIS rails.

SAFI is fitted with two hexagonal socket bolts (M6 x 30 bottom right / M6 x 35 top left) (see Section ⇨ Tightening torques). The 3 mm thick NBR gasket supplied must be attached when fitting the SAFI.

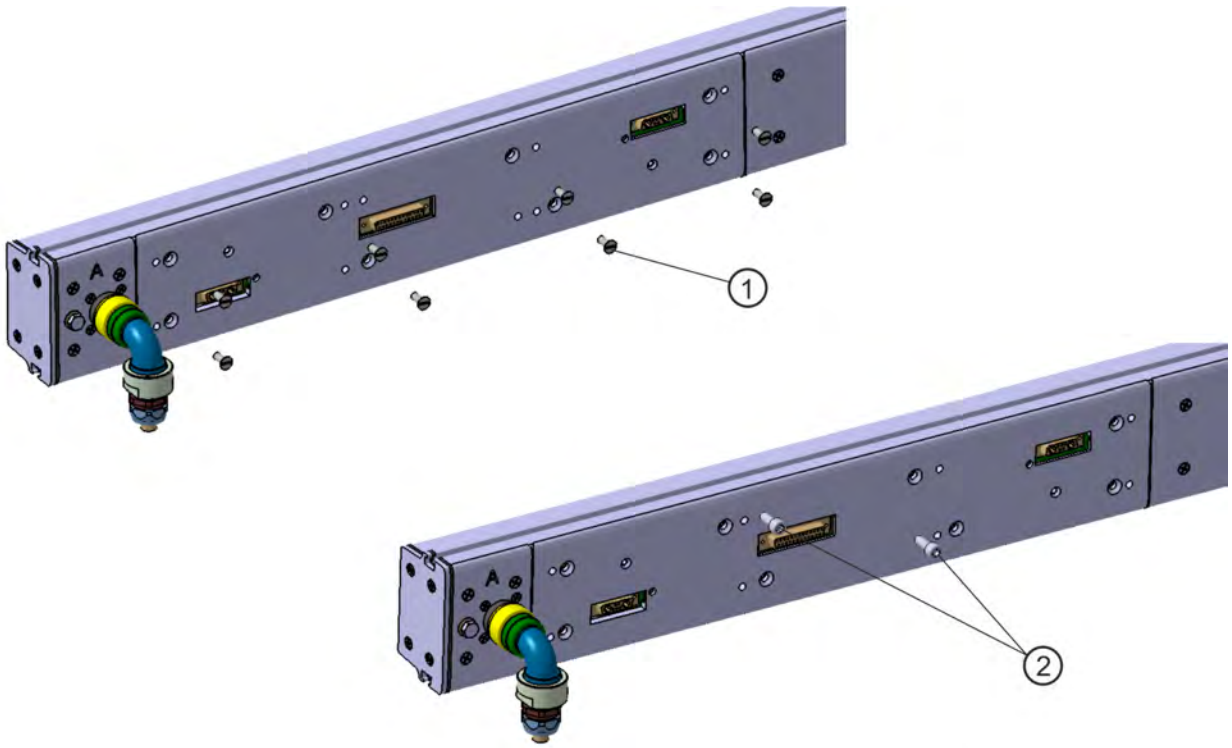


①	M6 x 35 hexagon socket bolt
②	M6 x 30 hexagon socket bolt
③	Connections for thermocouples
④	3 mm NBR gasket
⑤	M8 x 25 hexagon-head bolt

Loosen the thermocouples and the knock sensors before removing the **SAFI**. After fitting the **SAFI**, connect the thermocouples and tighten the knock sensors with the required tightening torque (see Section ⇨ Tightening torques).

8.4.5 Ignition modules

Remove the **M coils** and the **SAFI** before disassembling the ignition module. Next, loosen the eight M5 x 12 mm countersunk bolts and pull the ignition module off the rail using two M6 bolts.



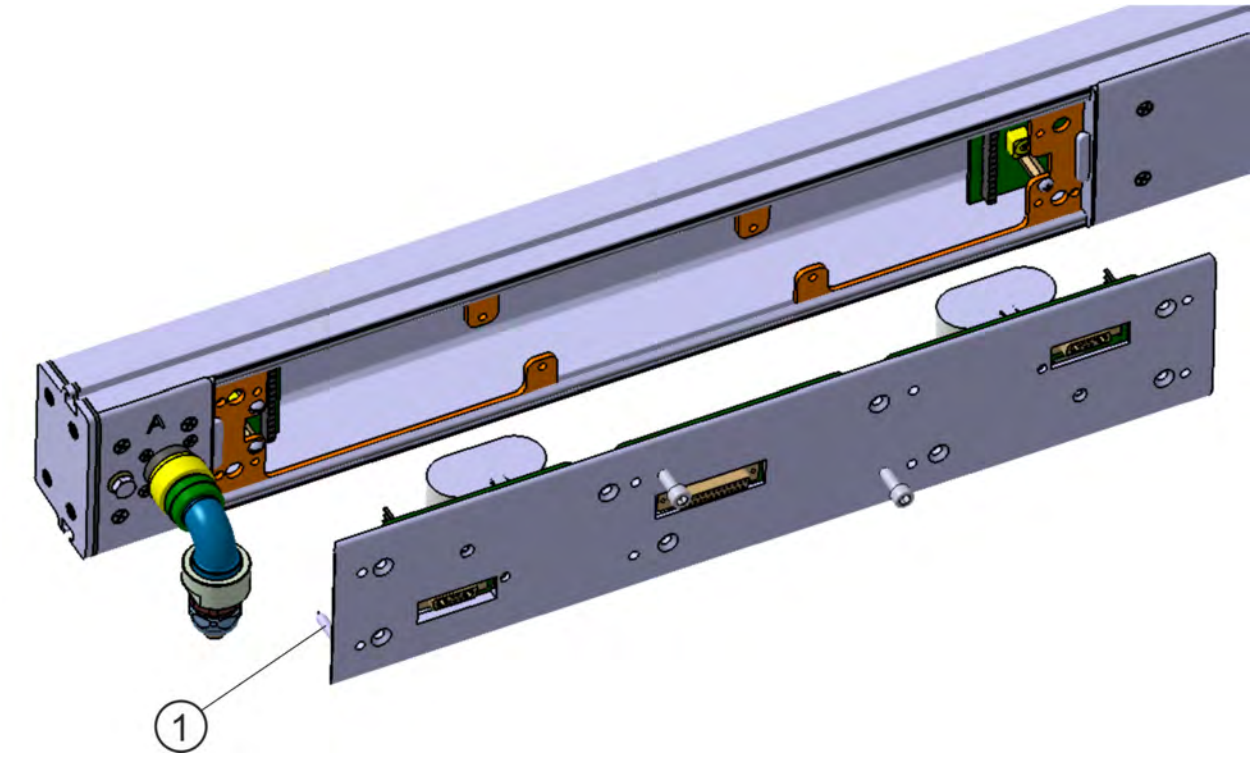
①	M5 x 12 countersunk bolt (8 off)
②	M6 bolts for the ignition module extension

NOTE

Damage to the O-ring cord

Never lever the ignition module out of the rail with a screwdriver. This can damage the O-ring cord so that it can no longer be guaranteed watertight.

➢ Before fitting, check all the gaskets on the ignition module again.



①	Guide pin

Using the guide pins to keep it as parallel as possible to the rail, push the ignition module carefully and without exerting excessive force into the rail. If excessive force is required, you should check for damage around the gaskets, around the plug-in connectors both on the ignition module (bent off pin in 15-pole ODU connector block) and on the sockets on the rail (15-pole socket terminal strip).

After fitting the ignition module, tighten the M5 x 12 mm mounting bolts with the appropriate tightening torque (refer to Section ⇨ Tightening torques).

8.4.6 Connection and end modules

To replace a connection or end module, detach the rail from the engine.

The next step is to remove the adjacent ignition module (see the instructions in Section ⇨ Ignition modules).

Then remove the end cover with the four M4 x 9 mm bolts, loosen the four M4 x 9 mm bolts on the cover of the connection or end module, remove the gasket and push the module out of the rail.

Mount the new module in reverse order. When installing the module, ensure that it is mounted exactly flush with the end of the rail. Incorrect positioning can cause problems when you come to plug in the ignition module.

NOTE

Before re-installing the ignition module, ensure that the coding switch is adjusted to the same setting as with the replaced module and secure it with sealing varnish. The coding switch setting is described in Sections "⇨ Setting the cylinder coding", "⇨ Identifying the cylinder arrangement in the engine" and "⇨ Cylinder coding".

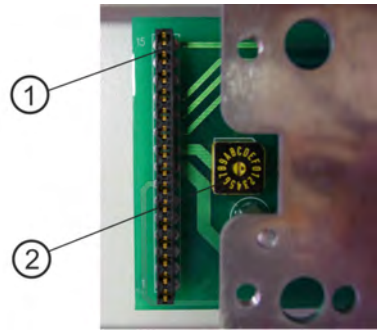
The 24 V power supply for MORIS is protected by a violet-coloured 3 A MINI automotive fuse 16.5 x 11 x 3.8 mm in size in the connection module. To replace the fuse, remove the front and side cover panels of the connection module and use flat-nose pliers to change the fuse. When reassembling, make sure the gaskets at the MIL plugs and the front and side cover panels are correctly positioned.

8.4.7 Link modules

1. To replace a link module, detach the rail from the engine.
2. Remove the adjacent ignition modules (see the instructions in Section "⇨ Ignition modules") either towards the connection module or towards the end module, depending on the number of modules to be removed.
3. Remove the connection or end module (see the Section ⇨ Connection and end modules).
   Before removing the link modules, you should note down the current position of the individual modules so that you don't have to change the coding of the modules during the subsequent re-assembly process.
4. Remove the gaskets and push the individual link modules out of the rail. In the case of Type 6 engine link modules, the M4 x 9 assembly bolts must be loosened beforehand.
5. Set the same coding on the replacement link module as on the original link module (see Sections "⇨ Setting the cylinder coding", "⇨ Identifying the cylinder arrangement in the engine" and "⇨ Cylinder coding")
6. To reassemble, push the link modules into the rail so that Pin 15 in the socket terminal strip is positioned level with the connection or end module.
7. Fit the link or end module.
   Insert the gasket before screwing down the link or end module (see Section "⇨ Connection and end modules").
8. Plug in the individual ignition modules and do not forget the gaskets!
9. Once all the modules have been positioned and mounted, tighten the M5 x 12 mm and M4 x 9 mm mounting bolts (with O-ring) on the ignition modules and link modules (Type 6 engine only).
10. Fit the end cover. Check the gasket and replace as necessary.

8.4.8 Setting the cylinder coding

The coding signal is required so that the **SAFI** can be allocated to the cylinder position. In the case of the **MORIS**, a hexadecimal rotary selector switch is used to set the coding. The SAFI receives two bits of code from the right side of the ignition module (2nd and 4th bits), and two from the left side (1st and 3rd bits).



Coding switch for Type 4 engine link module

①	Pin 15 of the socket terminal strip
②	Hexadecimal coding switch

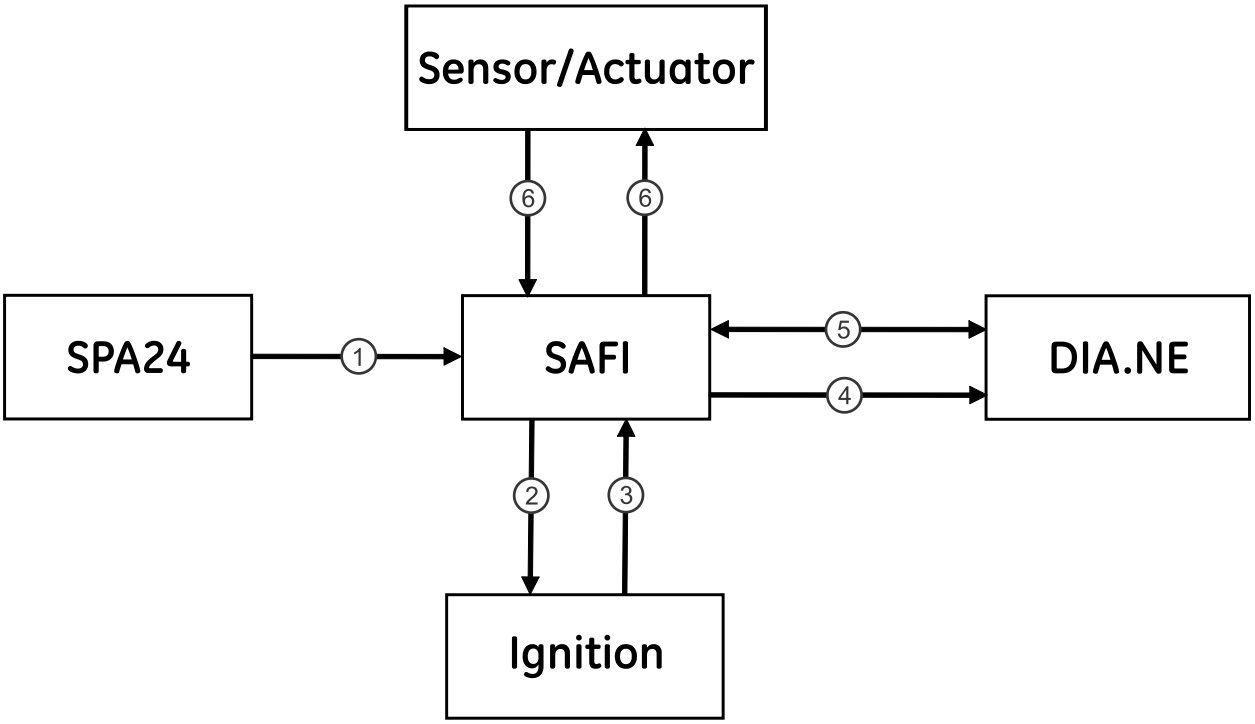
The coding on the connecting, link and end modules must be set as shown in the table in Section "⇨ Cylinder coding".

Check: The current coding is displayed on a flashing CAN LED while the **SAFI** is booting up. A precise description of this SAFI function can be found in Section "⇨ Identifying the cylinder arrangement in the engine".

9 Operation

The **MORIS** is operated and controlled via the **DIA.NE XT** visualisation system and regulated by means of the **SAFI** (see also TA 1502-0071).

The general diagram below shows in schematic form the structure of the control and regulation circuit of the **MORIS** ignition system.



①	Pick-up signals
②	Ignition control system
③	Ignition feedback Power supply Cylinder coding
④	MORIS fail-safe loop
⑤	CAN
⑥	Analogue signals

9.1 Ignition control system

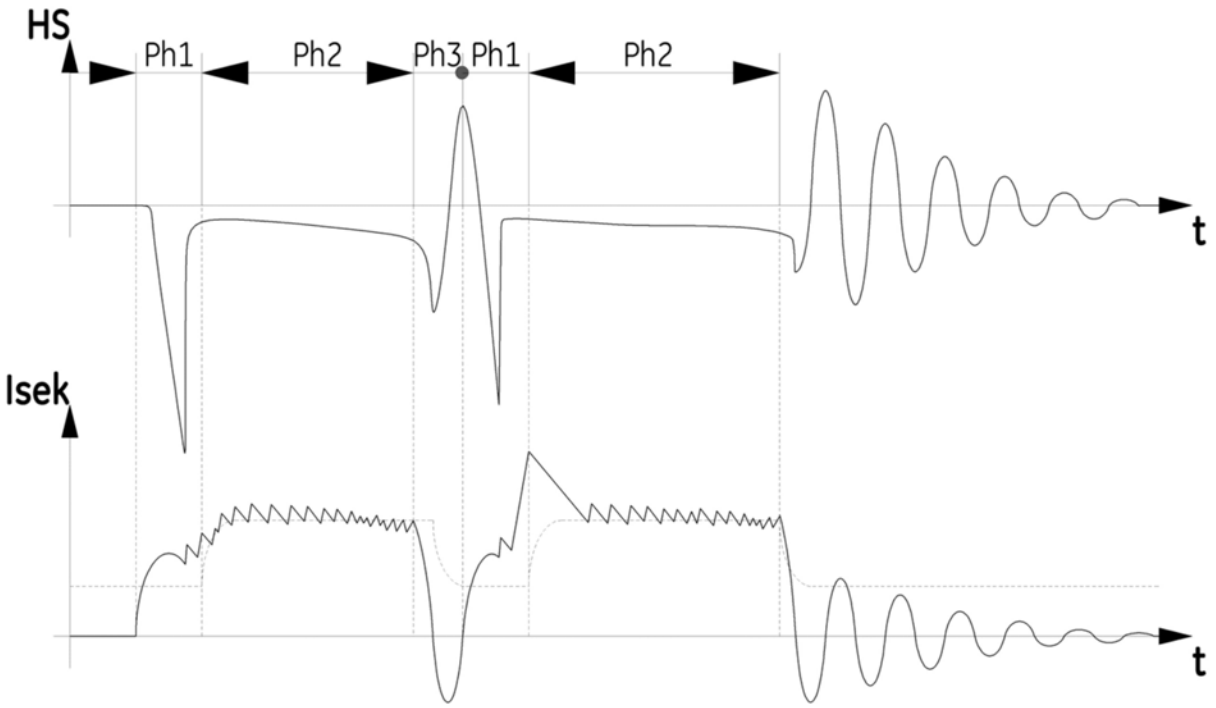
The ignition functions are enabled when **SAFI** is operated in combination with the **MORIS** ignition system. **SAFI** triggers the ignition, adjusts the ignition sparks in accordance with the set parameters and monitors the electrical ignition process.

MORIS operates in 3 phases.

Phase 1 – Producing the ignition spark

Phase 2 – Regulating the current in the ignition spark

Phase 3 – De-energising and synchronising for possible re-ignition after spark interruption



HV	Voltage at the spark plug	Ph1…3	Phases 1 to 3
Isec	Current in the high-voltage circuit	t	Time

9.1.1 Phase 1 – Producing the ignition spark

At the ignition point, **SAFI** switches the energy supplied by **MPM** and stored in the output stage to the ignition coil. The first pulse, which is determined by the characteristics of the ignition coil, produces the ignition spark. After a specified time, a response must be received from **MORIS** to indicate that the current flow has been established in the secondary circuit. If this response is not received, the error message "**MORIS** hardware error" is displayed and the ignition process aborted.

The ignition system also transmits a conditioned voltage signal to display the high voltage. **SAFI** analyses the peak value of this signal and transmits the ignition voltage value averaged over 10 cycles.

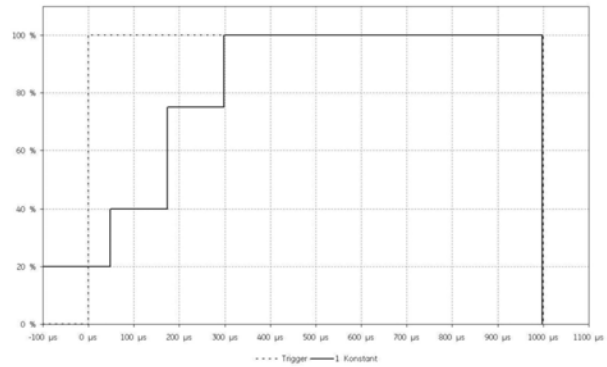
9.1.2 Phase 2 – Regulating the current in the ignition spark

Once the ignition spark has been produced, **MORIS** adjusts the current in the ignition spark to the specified set point value, which is determined by the ignition current curve. If the current in the ignition spark too low, more electrical energy is supplied to the ignition coil and when the set point value has been reached the energy supply to the ignition coil is disconnected.

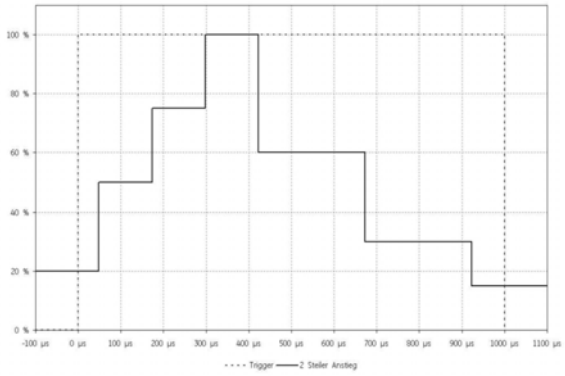
The following curves can be selected for the ignition current flow:

Ignition current flow - 0	Ignition current flow 1: Constant

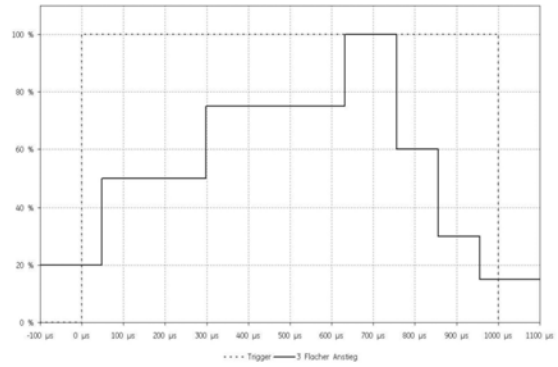
Parameters can be set for ignition current flow - 0, which is used for trial purposes.



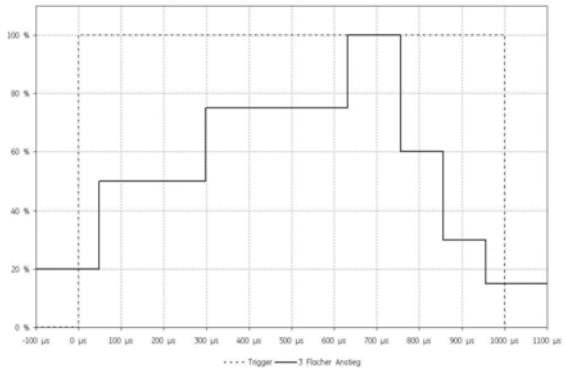
Ignition current flow 2: Steep rise



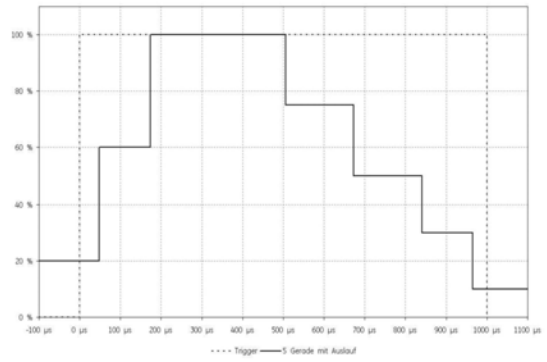
Ignition current flow 3: Flat rise



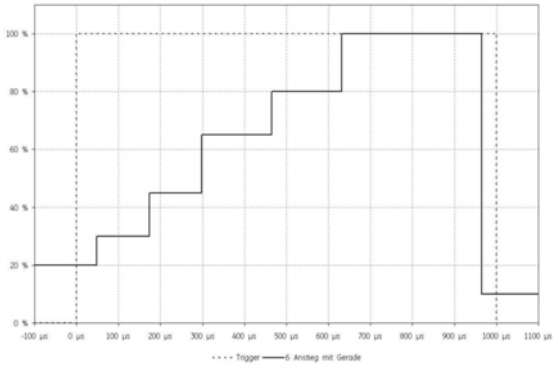
Ignition current flow 4: Rib



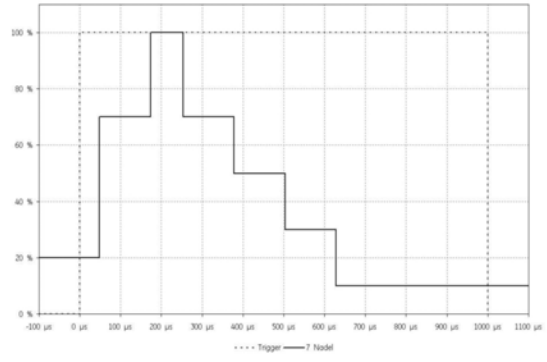
Ignition current flow 5: Straight line with tail



Ignition current flow 6: Rise with straight line



Ignition current flow 7: Needle



9.1.3 Phase 3 – De-energising and synchronising for possible re-ignition after spark interruption

If the system is overloaded, the **MORIS** is de-energised by disconnecting the energy supply to the ignition coil and prepared for re-ignition as soon as conditions in the ignition system permit. The time for the re-ignition is calculated by **SAFI** from the conditions in **MORIS** and Phase 1 - producing the spark - is initiated.

The ignition system issues a response. **SAFI** uses this response to check the function of the ignition system and generates messages accordingly.

9.1.4 Pickup signals

SAFI requires two digital signals to detect the engine running conditions. The three analogue pickup signals are converted to two digital signals by the **SPA24** (refer to TA 1502-0071 – **SAFI** and TA 1502-0072 **SPA24**).

9.1.5 Visual displays on the SAFI

The device has five LED displays, of which the "STATUS" LED is in three colours.

Designation	Colour	Meaning
POWER	Green	Power supply
STATUS	Green	Firing up
	Red	Error
	Yellow	Booting up
CAM	Yellow	Synthetic camshaft/reset pulse
TRIGGER	Yellow	Trigger pulse
CAN	Yellow	CAN bus activity

9.1.6 Identifying the cylinder arrangement in the engine

In each cabling rail, the position of **SAFI** on the engine is identified by the cylinder coding (see Section "⇨ Setting the cylinder coding"). The detection and verification by **SAFI** are described in TA 1502-0071.

9.1.7 Adjusting the reset position

After the engine has been started, an ignition timing strobe must be used to compare the ignition point on the flywheel with the ignition point value shown on the engine control system.

If the value displayed does not match the actual value on the flywheel, the engine must be shut down, the value for the reset signal corrected and the value rechecked (for the exact procedure, refer to TA 1502-0071 – **SAFI**).

The engine should not be put under load until the current ignition point matches the ignition point displayed on the DIA.NE XT!

9.1.8 High-voltage measurement

It is possible to use the high-voltage measurement system on the **M coil** to measure the **SAFI** ignition voltage and communicate this to the engine control system via the CAN bus.

In doing so, **SAFI** communicates the average value from 10 measurement cycles to the engine control system.

In the ignition self-test, the **DIA.NE XT** determines the maximum values of the individual cylinders in order to facilitate diagnosis of the high-voltage supply from the **M coils**.

The high-voltage measurement system does not generate trip error messages.

9.1.9 Port injection

The Port Injection function consists of selective cylinder control of the gas quantity by means of solenoid valves. Activation and monitoring of these solenoid valves, also referred to as Port Injection valves, is implemented in SAFI2 and MORIS2.

MORIS2 and SAFI2 are further developments of the MORIS/SAFI system, expanded by the addition of an activation and monitoring function for selective cylinder gas metering (Port Injection).

A feedback signal corresponding to the actual current signal through the PI valve is evaluated by SAFI2 to diagnose the function of the PI valve.

More detailed information about Port Injection can be found in TA 1502-0071 SAFI (Sensor-Actuator-Function-Interface).

9.2 Control and visualisation

9.2.1 Parameter setting

General ignition parameters

The following parameters have been saved in the **Ignition** parameter list.

- Ignition point for gas types 1 - 4

These settings lie between the value for the earliest and the latest ignition point:

- Earliest possible ignition point
- Latest possible ignition point
- Overspeed
- Misfire control

MORIS system parameters

The following parameters have been saved in the **Ignition – MORIS** parameter list.

- Settings
- combustion duration
- Maximum ignition current
- ignition current flow
- Coil type
- Power unit output for MORIS

- Monitoring functions
- Ignition error rates
- Tolerance for combustion time deviation

Parameters for MORIS hardware

The coil type determines the hardware design of the **MORIS** ignition coil. The necessary parameters are permanently stored in the Task.

The ignition current flow determines the spark characteristics. The necessary parameters are permanently stored in the Task.

Coil type 0 and ignition current flow 0 can be configured using the parameters in this menu and are used for testing new hardware designs. The parameters in this menu can be viewed and changed by User Level 45 and upwards.

9.2.2 MORIS2 port injection function parameters

The following parameters can be set in DIA.NE XT4 under Para / Cylinder / Port Injection:

The valve type can be set with "12147 Valve type".

If valve type 1 is set, preset parameters fixed in the code to Woodward Sogav 200 valves are used.

If valve type 2 is set, preset parameters fixed in the code to Woodward Hörbiger GV 400 valves are used.

If valve type 0 is selected, further subordinate parameters appear which can be freely changed. This allows other valve types to be validated or used.

The current curve, feedback current, pull-in current check, correct current control check, demagnetisation detection and closed detection can be set this way.

Caution! The Z code table for valve type 0 is fixed in the code for the Hörbiger GV 400. This must be modified in the DIA.NE code for other valves.

12146 Error rates for valve opening detection

Number of engine cycles with faulty valve-"open"-detection allowed over an observation period of 10 engine cycles. 0 deactivates the monitoring, 1 = highest sensitivity. 10 = lowest sensitivity.

13705 PI Correct current control check error rate

Number of engine cycles with faulty current control allowed over an observation period of 100 engine cycles. 0 deactivates the monitoring, 1 = highest sensitivity. 100 = lowest sensitivity.

13706 PI demagnetisation detection active

1 / 0 switches the demagnetisation on / off, and also the associated alarms and measurement functions.

12121 Valve closed detection active

Activates/deactivates the safety-relevant closed detection of the port injection valve.

13698 Number of allowed cycles with PI on and ignition off in the event of misfiring

Gas is aspirated into each cylinder for this many cycles after the start of Skipfire operation. After that, no more gas is aspirated until Skipfire is deactivated.

Current curve

These parameters describe the current curve. The currents are expressed as a % of maximum current, 100 % = 18 A.

13741 PI setpoint 1 current

First current stage in the port injection current curve.

13745 PI setpoint 1 duration

First current stage duration in the port injection current curve.

13742 PI setpoint 2 current

Second current stage in the port injection current curve.

13746 PI setpoint 2 duration

Second current stage duration in the port injection current curve.

13743 PI setpoint 3 current

Third current stage in the port injection current curve.

13747 PI setpoint 3 duration

Third current stage duration in the port injection current curve.

13744 PI setpoint 4 current

Fourth current stage in the port injection current curve. This is the holding current.

Feedback current

The feedback of the energy can be delayed, and the feedback current is defined by this.

13748 PI feedback delay

Feedback of the coil energy is delayed for this period, measured from the end of the pulse.

13749 PI feedback current

Feedback current preset value

13750 PI feedback duration

Length of the feedback pulse

9.2.3 Port injection function monitoring parameters

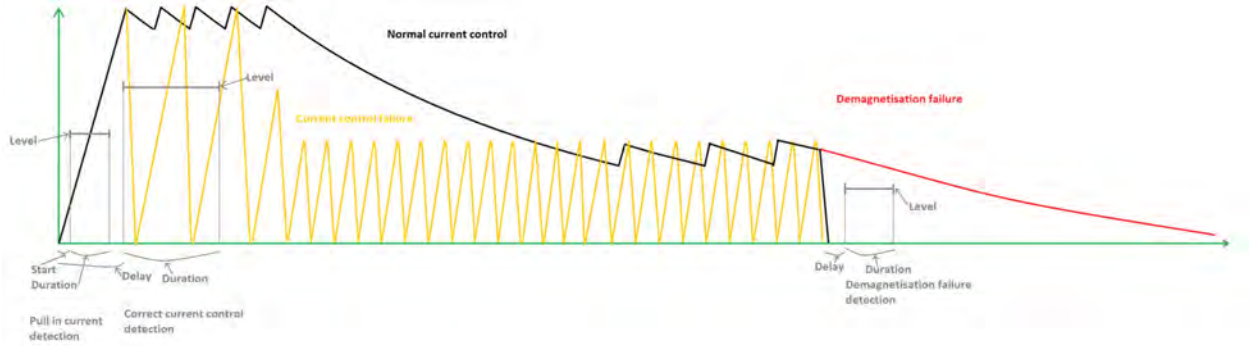


Fig. 1 Port Injection current curves

Black: good current pulse, valve opens and closes in a defined manner.

Yellow: a fault in the freewheeling circuit or current control prevents correct current control, and the current average does not reach the set level. Valve opens to late or not in a defined manner. Secondary faults in the Moris2 circuit can occur.

Red: a fault in the demagnetisation circuit allows the current to continue flowing. The current average remains above the set level. Valve closes in an undefined manner. Excess metering resulting in excess pressure in the cylinder can occur.

Pull-in current check

It detects whether a valve is connected (there is a current flow), and whether the wiring is correct (no cable breakage or short-circuit). A window is defined through which the leading edge of the valve current must pass. If the current is below the threshold before the window and above the threshold after the window, the test is OK. If not, the fault is added to the faulty events of this valve. If the number of faults in the last 10 cycles exceed the value defined in "12146 Error rates for valve opening detection", warning "2585 Error rates for valve opening detection" is output. If more than 1 cylinder has this warning, it is a "2254 Port injection hardware failure" and engine trips. This error is also output if no current flows at all, due to a lack of a power supply or a wiring fault.

13699 PI pull-in current check level

Level that has to be crossed by the feedback voltage value. Measured in V.

13700 PI pull-in current check starting point

Starting point of the pull-in current test window after the start of the PI pulse

13701 PI pull-in current check duration

Duration of the PI pull-in current check window.

Correct current control check

The level and measurement period above which the current value must lie are defined in order to be able for decide whether the current control is operating correctly. If the average current value is above this value, the test is OK. If not, the fault is added to the faulty events, and warning "2800 PI valve current too low on opening" is output. If the error rate in the last 100 cycles exceeds the value defined in "13705 PI Correct current control check error rate", error "2297 PI Value current too low on opening" is output and the engine will trip.

If this error occurs at several valves simultaneously, this is a fault in the MPM power supply or supply voltage. If this error occurs, the Safi must be restarted once the cause of the fault has been rectified, and at the moment there is a bug in the software that stops the fault from being reset.

13702 PI correct current control check delay

The time from when the pulse start is measured.

13703 PI correct current control check duration

The duration of the measurement. Average duration of the measurement.

13704 PI correct current control check level

This level, expressed as a percentage of the preset value, must be exceeded.

Demagnetisation detection

The level and measurement period below which the current value must lie are defined in order to be able for decide whether the demagnetisation is operating correctly. If the average current value is below this value, the test is OK. If not, ignition and further operation of the cylinder are prevented and the error "2298 PI electrical fault when closing" is output.

13707 PI demagnetisation delay

The time from when the pulse end is measured.

13708 PI demagnetisation length

The duration of the measurement. Average duration of the measurement.

13709 PI demagnetisation upper limit

This feedback voltage level, measured in V x 10, must be below this figure. 26 means: 2.6 V.

Closed detection

The closed detection measures the inductance of the coil in the valve. If a valve remains open mechanically due to dirt contamination, jammed particles or a return spring breakage, its inductance changes. This is measured using a measurement current pulse.

The angle position when the pulse should occur and the duration of this pulse are defined. The characteristics of this measurement pulse and the limits of the permissible measurement difference are also defined.

If the measured value is outside the tolerance relative to the average value, the error "2256 Port injection valve failure when closing" is reported, ignition and aspiration are prevented in this cylinder and the engine is tripped.

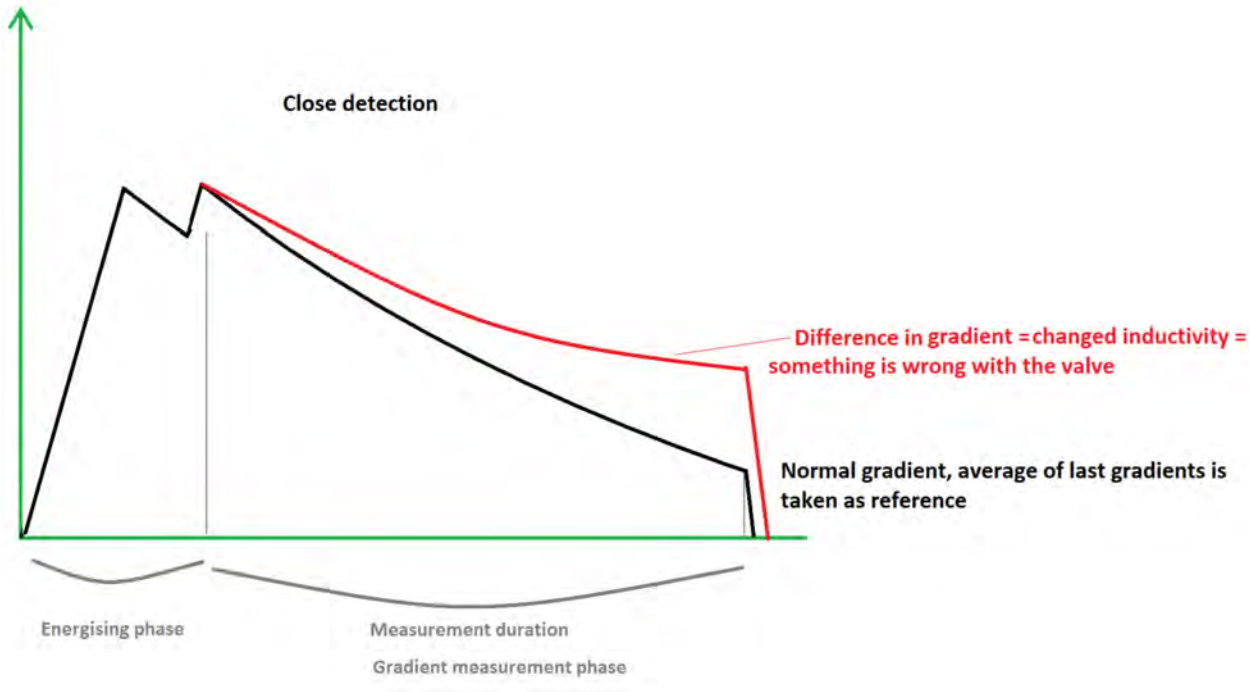


Figure 2 Closed Detection current curves

Red: mechanical fault causes a changed current pulse

Black: good current pulse

13710 PI closed detection set current value

The magnitude of the current pulse for the closed detection.

13711 PI closed detection set value duration

The length of the current pulse for closed detection.

13712 PI closed detection duration

This is the measurement duration after the current pulse, the measurement lasts this long.

13713 PI closed detection current gradient starting value

Starting value of the current gradient valid as from the engine start-up. Is replaced by cylinder-specific average values while the engine is working and actively followed up.

13714 PI closed detection current gradient tolerance start-up phase

Tolerance of the gradient. If the measured gradient deviates from the average value sent to the Safi by more than this tolerance, the engine is shut down immediately with alarm priority 1.

13715 PI closed detection current gradient tolerance idle phase

Tolerance of the gradient. If the measured gradient deviates from the average value sent to the Safi by more than this tolerance, the engine is shut down immediately with alarm priority 1.

13716 PI closed detection current gradient tolerance mains-parallel phase

Tolerance of the gradient. If the measured gradient deviates from the average value sent to the Safi by more than this tolerance, the engine is shut down immediately with alarm priority 1.

13717...13740 PI closed detection starting point cylinders 1 … 24

Timing point when the closed detection measurement pulse should be sent. Adjustable individually for each cylinder so as to avoid measurement inaccuracies due to interference from adjacent cylinders.

9.2.4 Displays

In the CYL menus of the DIA.NE XT you can switch between the screens for ignition point, ignition voltage, maximum ignition voltage and ignition output error.

The displays are always visible, irrespective of the user level.

Ignition point

The set point values of the ignition points of all the cylinders are displayed on this screen in bar and digital form.

Ignition voltage

The ignition voltages of all the cylinders are displayed in bar and digital form on this screen while the engine is running and during the self-test.

Maximum ignition voltage

The maximum values of the ignition voltages of all the cylinders are displayed in bar and digital form on this screen during the self-test. If the self-test is disabled, this screen is also disabled.

Ignition output errors

The bar indication shows the current output error rates, where the maximum value, 10, denotes a complete failure of the cylinder concerned.

The digital values represent the maximum values which have occurred for error rates, and the error rates can be reset to 0 on the click of a button by User Level 10 and upwards.

9.2.5 Monitoring functions

CAN communication

SAFI communication with the engine control system is monitored as follows:

- All **SAFIs** must be communicating with the control system before the engine is started.
- When at a standstill, the engine is prevented from starting after 25 seconds of interrupted communication with at least one **SAFI.**
- When in operation, the engine is shut down after 2 seconds of interrupted communication with at least one **SAFI**.

Voltage supply failure

The ignition end stages of **MORIS** are powered by the **MPM** power units. The 185 V power supply is switched with engine start preparation and in the self-test.

The output voltage of the **MPM** power units for the **MORIS** output stages is monitored and displays the status via digital outputs. If these digital outputs become inoperative while the engine is running or if the 185 V power supply is not activated within 10 seconds when requested by the power unit, the message Ignition power supply failed is displayed and the gas valves are closed during engine operation.

Ignition running and gas valves opening

The message "Ignition on" is generated when all the **SAFIs** display the message "Output firing". The gas valves must not be opened until it is certain that the state of all the **SAFIs** is 'Firing'.

The gas valves close if the message "Output firing" is not available for all the cylinders. In this case, the message "Ignition off" is generated (see also Section ⇨ Safety plan).

In the event of a shut-down, the ignition is deselected via the CAN bus and at the same time the 185 V power supply for the ignition is switched off and the gas valves closed.

Output error

The combustion time of the ignition spark is measured and compared with the preset set point value. If the measured combustion time is outside the tolerance, this is analysed by **SAFI** as an error.

If the number of errors over 10 ignition pulses exceeds the value for permissible error rates, **SAFI** issues the message "Error rates for ignition time exceeded" and from this generates a warning or the trip-producing error message Ignition output error.

The permissible deviation and the error rate over 10 ignition pulses are adjustable, where the value 0 disables the monitoring system.

Warning

If the **SAFI** error messages "Error rate for combustion time exceeded" is displayed on a maximum of one cylinder, the warning "Output error" is displayed with the operating notification for the cylinder.

Error message

The engine controller monitors all the cylinders and as soon as more than one cylinder is displaying the message "Error rate for combustion time exceeded" at the same time, the error message "Ignition output error" is generated with the operating notification for the cylinder concerned.

The error message with the operating notification for the cylinder is also displayed when the **SAFI** message "Output firing is missing" from any cylinder when the engine is running.

Ignition hardware error

If the ignition coil is defective or no spark plug connector is present at the ignition coil output or no spark plug is connected, the message "Ignition hardware error" is displayed.

Monitoring the port Injection valves

The diagnosis is divided into four main areas:

- Pull in Current Detection (see Figure 1 Port Injection current curves)
  The leading edge of the pull-in current is evaluated. It detects whether a valve is connected (there is a current flow), and whether the wiring is correct (no cable breakage or short-circuit).
  The current must pass through a parameterisable window and must be below the threshold value before the window, and above the threshold value after the window. If more errors are detected in the last 10 cycles than permitted, a warning is output.
  Parametrisable: delay, window duration, threshold value, number of errors per 10 cycles
  Warning and error message (A2254, W2585, B28185): Port Injection hardware error

- Correct Current Control Detection (see Figure 1 Port Injection current curves)
  This checks whether the PI drive is operating properly and the current is output correctly. This is done by evaluating the average value of the current.
  If this average value is under the threshold value, a warning is output.
  To prevent false warnings, the last 100 cycles are evaluated to determine the number of errors after which an error signal is output.
  Error, warning and operational message (A2297, W2800, B2906): PI valve current too low on opening
- Demagnetisation detection (see Figure 1 Port Injection current curves)
  This monitors whether the current can be dissipated quickly enough when closing the valve. If this is the case, an unwanted increase in the valve opening duration occurs. To avoid this damaging the cylinder, the following ignition in this cycle is prevented and the engine is shut down by the DIA.NE. This is done by checking whether the current value is below a defined value after a certain time and a certain duration.
  Error and operational message (A2298, B2907): PI valve electrical failure when closing
- Closed Detection (see Figure 2 Closed Detection current curve)
  After the mechanical closing of the valve and before the ignition process. this checks whether the valve has actually close mechanically. This is done by measuring in the inductance of the valve with a brief current pulse, without opening the valve. The measured current gradient is transmitted to the DIA.NE. DIA.NE forms a reference average value for each individual cylinder from the last 10 seconds of these measured values. DIA.NE sends this to SAFI, which is then compared with actual measurement. If the deviation is above the set limit value, an error message is sent, and the ignition and PI function at this cylinder stopped at once. DIA.NE then shuts down the engine.
  This detection reacts to rapid changes such as e.g. jammed particles or breakage of the return spring. If the measured value changes over an extended time, the average reference calculation balances this out. Creeping dirt contamination cannot therefore be detected.
  Error and operational message (A2256, B2820): PI valve mechanical failure when closing

9.2.6 Ignition self-test diagnosis capability

The self-test is best activated from the screen Detail – Ignition – Current ignition voltage and Ignition voltage.

If the engine starts to turn while the ignition system is in self-test mode, **SAFI** automatically switches off the self-test function.

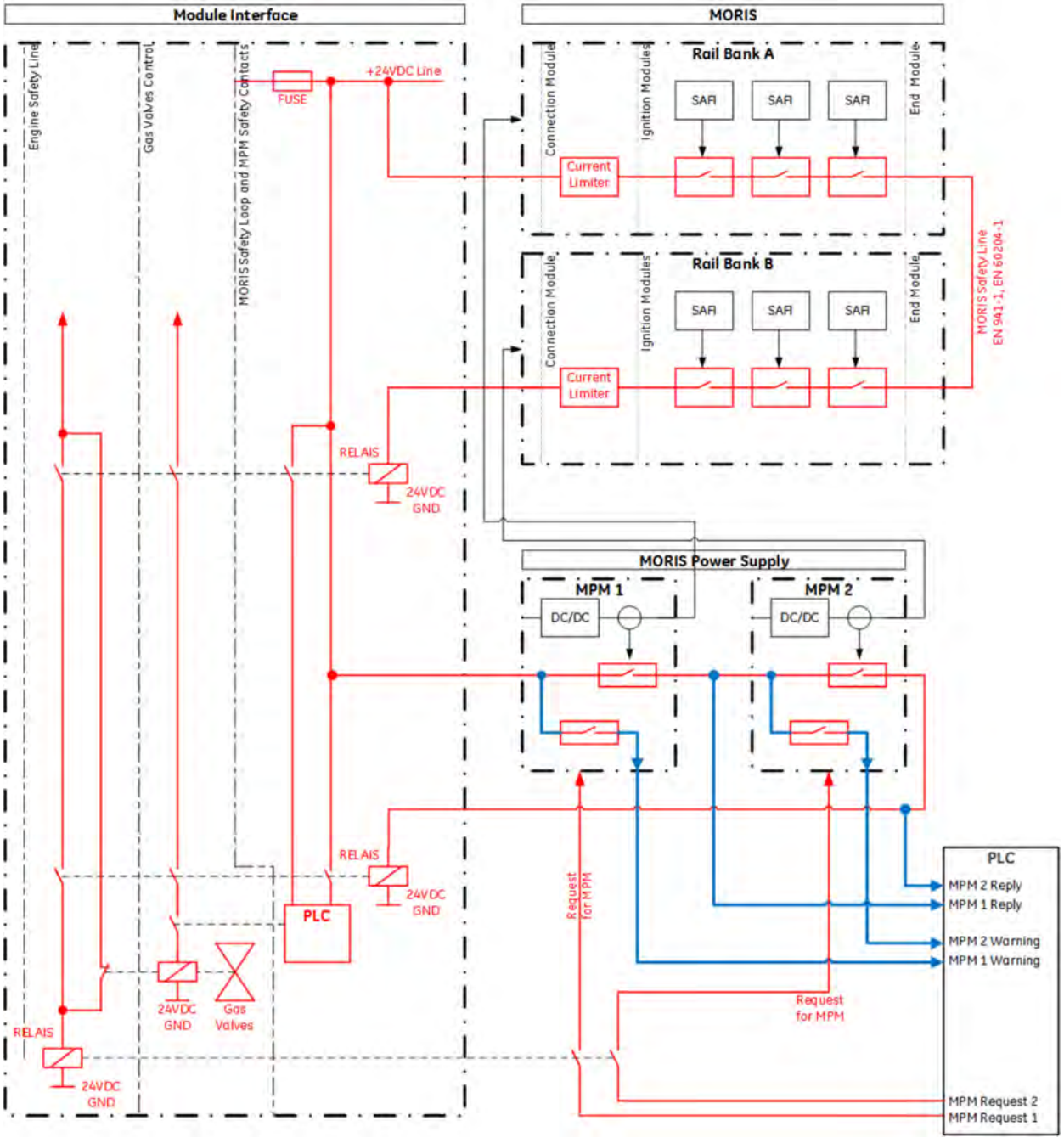
The self-test is automatically de-activated after 10 minutes.

The current ignition voltage values during the self-test are displayed on the screen Detail – Ignition – Current Ignition voltage and maximum values of the ignition voltages of all the cylinders are displayed in bar and digital form on this screen Detail – Ignition – Maximum ignition voltage (maximum value memory).

On Type 9 engines, the engine is briefly turned with the starter before the self test in order to remove any ignitable gas mixture present in the cylinder.

9.2.7 Safety plan

General view



MORIS fail-safe loop

The safety plan for **MORIS** is based on a fail-safe loop which covers the entire **MORIS**.

The **MORIS** fail-safe loop is supplied with 24 V DC and is based on the closed-circuit principle.

Each time the engine stops, the function of every contact integrated into the **MORIS** fail-safe loop is checked. If an error arises an alarm message is displayed and the engine is prevented from starting.

A self-resetting overload protection system (PTC) of 250 mA at an ambient temperature of 20°C is integrated into each connection module in the **MORIS** as overcurrent protection. The constant current of the **MORIS** fail-safe loop must not exceed 120 mA.

The **MORIS** fail-safe loop is closed when all the **SAFI**s switch to "Firing" mode and opened when a **SAFI** de-activates the "Firing" mode or reaches the set overspeed.

Optocouplers are used to integrate the **SAFI** safety contacts into the **MORIS** fail-safe loop.

MPM safety contact:

The ignition end stages only work at a voltage exceeding 125 V. The **MPM** power supply is activated during the start preparation phase and the **MPM** safety contact is closed 2 seconds after an output voltage of 130 V has been reached.

If the **MPM** output voltage falls below 130 V, the safety contact is opened without delay.

Emergency stop fail-safe loop:

If the emergency stop fail-safe loop in the engine control system, the **MORIS** fail-safe loop or an **MPM** safety contact is opened, the start-up process is stopped and the gas valves closed.

The **MORIS** fail-safe loop is integrated into the engine control system's emergency stop fail-safe loop in series with one or two **MPM** safety contacts depending on the ignition power required for the engine. The engine control system's emergency stop fail-safe loop must be closed so that the engine can be started and operated.

The **MORIS** fail-safe loop or the **MPM** safety contacts can only open the engine control system's emergency stop fail-safe loop if the gas valves have already been opened.

The engine control system's emergency stop fail-safe loop is opened by the **MORIS** emergency stop fail-safe loop when the gas valves have been activated and the following conditions apply:

- a **SAFI** de-activates the "Firing" mode (e.g. due to a faulty pick-up signal) or
- the pre-set overspeed point is reached
- **SAFI** loses its power supply or the processor freezes

The engine control system's emergency stop fail-safe loop is opened by an **MPM** safety contact when the gas valves have been activated and the following conditions apply:

- the output voltage falls below 130 V

Emergency shut-down of ignition system

The engine control system's emergency stop fail-safe loop shuts down the engine. In this case, not only are the gas valves closed when the emergency stop fail-safe loop is released, but the **MPM** is also de-activated and the energy supply to the ignition system interrupted within 80 ms.

The way the **MORIS** fail-safe loop and the **MPM** are integrated into the module control system is shown in the schematic diagram of the plant concerned.

Controlling the gas valves

The **MORIS** fail-safe loop and the **MPM** safety contacts are integrated directly into the control system for the gas valves. The gas valves are de-activated when the **MORIS** fail-safe loop or an **MPM** safety contact has been opened.

The gas valves are activated from the engine control system. The engine control system opens the gas valves when it has a response indicating that all the **SAFIs** are in "firing up" mode and the **MPMs** have an output voltage of over 130 V, no error is detected and the operating condition of the engine permits it (e.g. time-delayed in the event of a purge start).

9.3 PI self-test

The PI self test can be requested under Cyl. /PI in "Off" mode when the engine is at rest.

The PI self test activates the MPM and starts operation of the closed detection. The valves do not really open. The gradient measured values are displayed. If there is a fault, this can be read off on the displayed measured values, e.g. if a valve is not plugged in or the current flow is interrupted, the measured value will be between 2 and -30. Correct values are in the range between -80 and -210, and change slightly during measurement by up to ±10. Differences of up to ±30 can exist between the measured values for individual cylinders. This test is advisable after conversion work on the engine in which the Moris rails have been removed, or if the Moris2 / valve / Safi2 has been replaced.

10 Diagnosis and troubleshooting

Only ignition-related messages are dealt with below.

Detailed information and descriptions of monitoring functions, operational, warning and error messages and parameterisation of the **SAFI** and **DIA.NE XT** can be found in TA 1502-0071 – **SAFI**.

When replacing components, always read the instructions in Section ⇨ Replacing components or in the technical instruction for the device concerned.

10.1 Ignition

10.1.1 Operational message (Bxxxx)

Message number	Message	Description / troubleshooting
B2910	Ignition power supply overloaded MPM x	The ignition power supply is overloaded, and the MPM output voltage has dropped below 170 V. Operating notification for W3552. "MPM 1" to "MPM 4": The error is plausible and can be allocated to the respective MPM according to the respective MPM feedback contacts STATUS (WARNING OUT). "MPM 0": The error is not plausible and cannot be allocated to a MPM according to the respective MPM feedback contacts STATUS (WARNING OUT).
B3225	Ignition On	All the cylinders are firing
B3226	Ignition Off	At least one cylinder is not firing
B3294	Ignition power reduction active Cylinder xx	Display shows cylinder with power reduction
B3278	Ignition output error Cylinder xx	Display shows cylinder with output error
B3283	Ignition hardware error Cylinder xx	Display shows cylinder with hardware error

10.1.2 Warnings (Wxxxx)

Message number	Message	Description / troubleshooting
W3544	Ignition hardware error	No ignition current could be measured. Either no spark could be built up or no ignition coil has been fitted.

Message number	Message	Description / troubleshooting
		If the parameters set are OK, the problem may be caused by an excessive ignition-voltage requirement or a hardware defect in the coil, the ignition module or the SAFI. A self-test of the ignition system is useful for fault-finding. Corrective measures: Check the air gaps of the spark plugs. Replace the defective ignition coil, the ignition module or the SAFI.
W3545	Ignition output errors	A cylinder has an output error caused by exceeding the preset tolerance for combustion time deviation, which is assessed by means of an error rate. The error is displayed when no spark is produced or the spark combustion time deviates from the preset tolerance value. There may be a hardware defect in the spark plug, the spark plug connector, the ignition coil, the ignition module or the SAFI. A self-test of the ignition system is useful for fault-finding. Corrective measures: Check the air gaps of the spark plugs. Check that the spark plug connector and its forward resistance (< 2.5 kOhm) have been fitted correctly. Replace the defective spark plug, the spark plug connector, the ignition coil, the ignition module or the SAFI. Check that the parameters for the combustion time deviation and error rate have been set.
W3551	Ignition power reduction active	The ignition process had to be aborted before the set combustion time was reached as the power absorbed by the ignition system exceeded the maximum output of the power supply. If the parameters set are OK, the problem may be caused by an excessive ignition-voltage requirement or a defective coil. Corrective measures: Check the air gaps of the spark plugs. Replace the ignition coil.
W3552	Ignition power supply overloaded	When the engine is running, this error message is displayed immediately after the failure of the safety contact for the MPM power supply (WARNING OUT). If the MPM output voltage falls below 170 V for more than 2 seconds, the warning is displayed via the MPM STATUS (WARNING-OUT) contact. As soon as the nominal voltage of 185 V is restored the warning is automatically reset. The cause of the fault may be incorrectly set parameters for combustion time and ignition current setpoint. If the parameters set are OK, the problem may be caused by an excessive ignition voltage requirement due to excessive turbulence at the spark plug, or an incorrect type of spark plug has been installed or a defect has occurred in the MPM. Corrective measures:

Message number	Message	Description / troubleshooting
		Check the parameters set for ignition current, combustion time and the general power settings for the installed power units. Check the type of spark plug installed Check the MPM and cabling, measure the MPM output voltage. The faulty MPM or supplied MORIS can be narrowed down with the aid of the accompanying value of the associated operating notification "B2910 Ignition power supply overload MPM x". Replace the MPM.

10.1.3 Error messages (Axxxx)

Message number	Message	Description / troubleshooting
A3338	Ignition output errors	The error is displayed when no spark is produced in more than one cylinder or the spark combustion time deviates from the pre-set tolerance (for corrective measures, see W3545).
A3344	Ignition power supply failed	When the engine is running, this error message is displayed immediately after the failure of the safety contact for the MPM power supply (REPLY OUT) and the engine is shut down. The MPM power supply is activated during the start preparation. If the response from the MPM safety contact (REPLY OUT) is not successfully activated within 5 seconds, the error message is generated. If the MPM output voltage falls below 130 V, the 185V output voltage is switched off and the error with the MPM REPLY-OUT safety contact is reported to the control system. Corrective measures: The power unit output parameter for the power units must match the output of the installed power units. Check the LEDs on the MPM for 24V power supply (POWER), the request (REQUEST), the response (WARNING) and safety contact (REPLY). Check the cabling to the rail and the wiring to the control system including the relay function. The faulty MORIS can be narrowed down and found with the aid of the accompanying value MPM x. A wiring error may exist if the MPM reply signals do not give a combination that can be plausibly allocated. An error of this kind is then alarmed with the accompanying alarm text MPM 0. See also Section ⇨ PI valve fault or MPM power supply fault. Replace the MPM as described in TA 1502-0069.
A3343	Ignition hardware error	There is a hardware defect or the hardware components, e.g. SAFI, MORIS, M coil and the spark plug connector have not been fitted correctly. Corrective measures: Find the defective component and replace it as described in TA 1502-0069 for the MPM or in Section 4.4 Replacing components.

Message number	Message	Description / troubleshooting
A3345	Ignition fail-safe loop	SAFI opens the fail-safe loop (also called 'safety loop' or 'SFTY loop') in the event of overspeed, a SAFI hardware error, a pickup error or an "Ignition off" command from the control system. Corrective measures: If no additional message is displayed, check the cabling in the fail-safe loop including all installed switching elements and if necessary replace defective devices (see also Section 4.4 - Replacing components). Otherwise, depending on any additional error message, inspect the devices concerned and if necessary adjust or replace them.

10.2 High-voltage measurement

10.2.1 Operational message (Bxxxx)

Message number	Message	Description / troubleshooting
B3286	Ignition coil offset error Cylinder xx	Display shows cylinder position of SAFI with offset error.
B3287	Ignition voltage too low Cylinder xx	Display shows cylinder position of SAFI with excessively low ignition voltage
B3288	Ignition voltage too high in cylinder xx	Display shows cylinder position of SAFI with excessive ignition voltage
B3289	Average ignition voltage too high Cylinder xx	Display of cylinder position of SAFI with excessive average ignition voltage.
B3290	Ignition voltage difference too high Cylinder xx	Display shows cylinder position of SAFI with excessive ignition voltage difference.

10.2.2 Warnings (Wxxxx)

Message number	Message	Description / troubleshooting
W3546	Ignition coil offset error	There is no offset voltage in the coil. If this error affects one cylinder, the line connecting the ignition coil and SAFI may be damaged or the measuring device on the ignition coil may be defective. Corrective measure: To effect a diagnosis, you can also measure the offset voltage on the relevant pin of the SAFI connector plug while the engine is at a standstill (see "terminal designation" in Section 8.1 – Ignition module). Replace the defective ignition coil, the SAFI or the ignition module.
W3547	Ignition voltage too low	The ignition voltage is too low, which can cause misfires. Possible causes are thread on the spark plug electrodes, the air gaps are too small, defect in the ignition coil or high-voltage sensor. Check the ignition system with the self-test function.

Message number	Message	Description / troubleshooting
		Corrective measure: Check the parameters in the section on SAFI – HV measurement. Check the air gaps of the spark plugs and look out for thread. Replace the ignition coil.
W3548	Ignition voltage too high	The ignition voltage is too high, which may result in damage to the high-voltage cables and the ignition coil. The ignition voltage could be so high that no spark is formed on the electrode, thereby causing misfires. Corrective measure: Check the parameters in the section on SAFI – HV measurement. The air gap in the spark plug electrodes may be too big and must be checked. An interruption in the high-voltage circuit between the ignition coil and the spark plug may also result in an excessive ignition voltage. Check the forward resistance of the spark plug connector (< 2.5 kOhm) and the spark plug. Defective high-voltage sensor in the ignition coil. Replace the ignition coil.
W3549	Average ignition voltage too high	The average value of all ignition voltages calculated in the DIA.NE is too high. Corrective measure: Check the parameters in the section on SAFI – HV measurement. Check the air gaps of the spark plugs.
W3550	Ignition voltage difference too high	The difference between the cylinders with the highest and lowest ignition voltage is too great. Corrective measure: Check the parameters in the section on SAFI – HV measurement. Check the air gaps of the spark plugs.

10.3 Port injection

10.3.1 Operational message (Bxxxx)

Message number	Message	Description
B2814	Maximum PI opening duration	Display of cylinder position with maximum opening duration Error message: A2252
B2815	Minimum PI opening duration	Display of cylinder position with maximum opening duration Error message: A2253
B2816	PI On	Shows activation of Port Injection valves
B2817	PI Off	Shows deactivation of Port Injection valves
B2818	PI valve failure when opening cylinder	Gives as feedback the number of the affected cylinder where the pull-in fault occurred when opening the PI valve.

Message number	Message	Description
		Warning: W2585 Error message: A2254
B2906	PI valve current too low on opening cylinder	The average current value is below the defined value in the opening phase. The current is therefore not being controlled correctly. Shows the cylinder position. Warning: W2800 Error message: A2297
B2907	PI valve electrical fault when closing cylinder	Demagnetisation of the valve is not taking place correctly. Shows the cylinder position. Error message: A2298
B2820	PI valve mechanical fault when closing cylinder	Shows cylinder position of SAFI with Closed Detection error. Error message: A2256

10.3.2 Warnings (Wxxxx)

Message number	Message	Description
W2800	PI valve current too low on opening	The measured average value of the current during opening is too low. Cylinder message: B2906 Error message: A2297
W2585	PI valve failure when opening	With "Pull-in current -check" more faulty current curves occur in the last 10 cycles than the "PI error rate for pull-in current" allows. The error occurs with only one cylinder, and is therefore only a warning. If the error occurs with more cylinders, it becomes a shutdown. Error message: A2254 Cylinder message: B2818

10.3.3 Error messages (Axxxx)

Message number	Message	Description / troubleshooting
A2252	Maximum PI opening duration	The calculated preset value for the opening duration has reached its maximum permissible value. Cylinder message: B2814
A2253	Minimum PI opening duration	The calculated preset value for the opening duration has reached its minimum permissible value.
A2254	PI valve failure when opening	With "Pull-in current -check" more faulty current curves occur in the last 10 cycles than the "PI error rate for pull-in current" allows. The main reason for this failure is a short circuit in the valve or cable, or a cable breakage between the Port Injection driver and valve, or a valve which is not connected. A faulty MORIS2 module can also be the cause. Cylinder message: B2818
A2297	PI valve current too low on opening	The measured average value of the current during opening is too low.

Message number	Message	Description / troubleshooting
		If the error occurs more often in the last 100 cycles than the "error rate", the engine is shut tripped with an error message. It is highly probable that the PI driver (MORIS module) is faulty. It could also be the valve. If several PI valves of a rail are affected, the fault is due not to the PI valve or MORIS2 but to the 24 V supply of the MPM. Can then also occur in conjunction with A2256. See also Section ⇨ PI valve fault or MPM power supply fault. Cylinder message: B2906, Warning: W2800
A2298	PI valve electrical failure when closing	Demagnetisation unsuccessful, valve closing takes too long. The demagnetisation of the PI valve was faulty and the valve therefore closes too late. Since an ignition would have resulted in too high a pressure, ignition was prevented and the valve function stopped. DIA.NE shuts down the engine. Cylinder message: 2907
A2256	PI valve mechanical failure when closing	The PI valve remains open when de-energised, which can allow an uncontrolled quantity of gas to be metered. Immediately after the error SAFI2 suppresses the ignition and deactivates the PI function at the cylinder in question. DIA.NE shuts down the engine. When troubleshooting check whether the valve is damaged, blocked mechanically, or prevented from closing by foreign bodies. If several PI valves of a rail are affected, the fault is due not to the PI valve or MORIS2 but to the 24 V supply of the MPM. Can then also occur in conjunction with A2297. See also Section ⇨ PI valve fault or MPM power supply fault. Cylinder message: B2820

11 Troubleshooting in the fail-safe loop

How, and in which direction, does the fail-safe loop run?

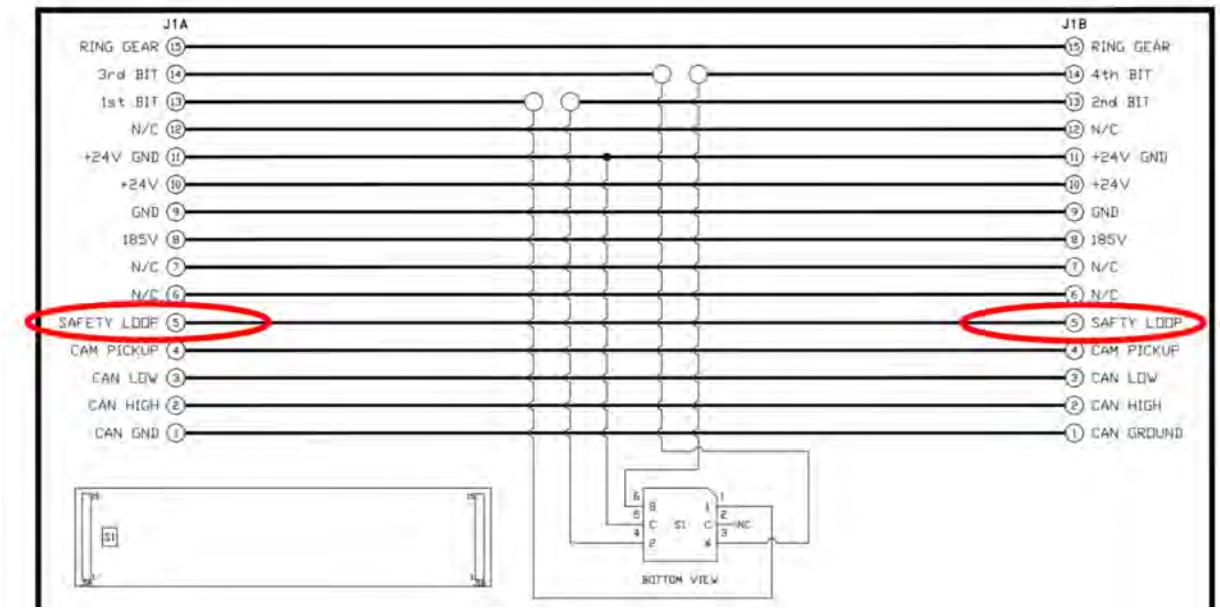
See also Section ⇨ Safety plan. The fail-safe loop starts in the module interface cabinet, and has a 24 V supply. It continues via pin I to the MORIS rail connection module on side A. There, it goes via pin 5 to the first MORIS module. The MORIS carries it onward via an optoswitch, which is activated by SAFI during engine operation (or fail-safe loop self-test). From the MORIS, the loop continues via pin 5 via the link module to the next MORIS, and so on. At the last MORIS module, the loop runs via pin 5 to the end module, to pin D. It now carries on via the CAN/fail-safe loop connection cable to the MORIS rail on side B, pin D, end module. Then again via pin 5 to the MORIS, etc., and on to the connection module, where it goes from pin I via cable into the control cabinet. There, diodes are also series-connected and switch the relay of the ignition fail-safe loop.

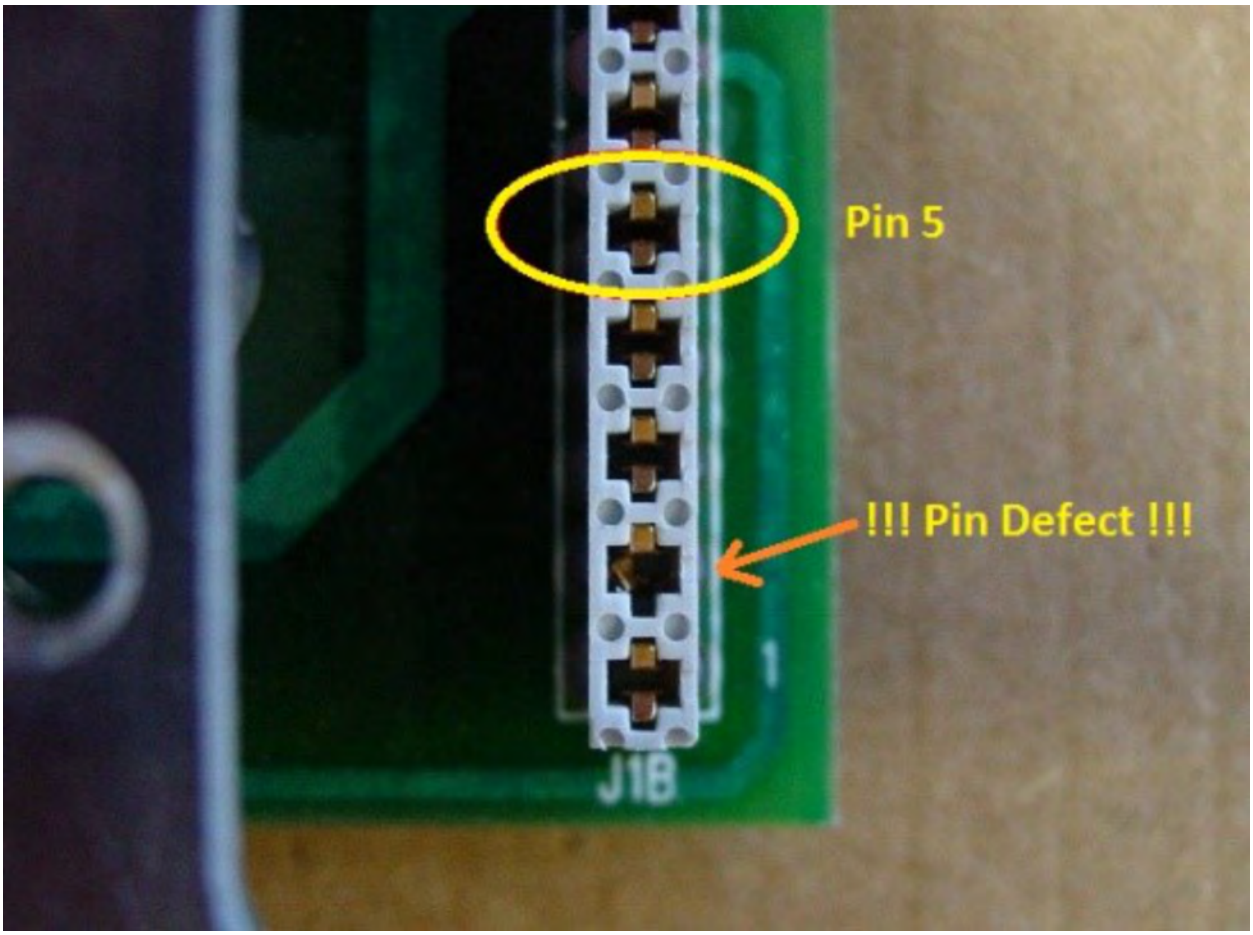
The exact routing must be taken from the plant wiring diagram. This applies in particular to the J624 and J920.

SAFIs are visible on the DIA.NE under SYS/Versions/SAFI, but the engine does not start and the fail-safe loop does not switch to active when starting. "Ignition faulty" or "Ignition power supply faulty" after short period of starting.

MORIS connection of the fail-safe loop is faulty, or MORIS optocoupler is broken, or pins for the coupler, connection module or end module are broken

- Localisation of the broken MORIS or MORIS connection:
  - First disconnect the 24 V power supply from the MORIS rail, and then remove all SAFIs and instead plug wire jumpers between pins 10 (SFTY Loop) and 13 (+24 V) into the Dsub-25 sockets.
  - Then reconnect the 24 V power supply and check whether the fail-safe loop relay becomes active. If it does, then one of the SAFIs is the cause.
    If not, then continue with the following step
  - Check the voltage at the connection module for Bank A and Bank B, and the end modules for Banks A and B, or at the connection cable between the end modules and at the terminals in the module interface cabinet. This enables the fault to be localised to the rail or the wiring (pin "I" on the 10-pole plug).
  - On the rail that has been thus identified as suspect, remove the middle MORIS module, and check the presence of 24 V at the pins of the fail-safe loop. Left or right, depending on where the 24 V should appear, and systematically determine the cause of the fault. See the schematic for the link modules:





If 24 V is present at pin 5, refit the module and continue with the next module towards the end of the fail-safe loop.

If 24 V is not present, continue with the next module towards the beginning of the fail-safe loop.

Note: It may be that the pin receptacles in the connection-, end- or coupling-modules are the cause of the fault, so please examine them carefully. See the example at pin 2 in the above picture. There, the lower part of the receptacle has been crushed to the left. Receptacles of this type are the cause of intermittent contacts that do not appear until later and are very difficult to locate. If a contact receptacle is defective, the relevant connection-, coupling- or end-module must be replaced.

Fail-safe loop output of a SAFI is destroyed and does not switch the fail-safe loop through. Localising the defective SAFI:

- If it is certain that the MORIS can switch the fail-safe loop through (see above), then reconnect the SAFIs one after the other. When re-connecting the SAFIs, make sure that the 24 V supply at the MORIS is switched off.
- Apply power to the MORIS rail again and start the fail-safe loop self-test. If the ignition fail-safe loop relay does not activate, i.e. indicator does not turn green or relay does not energise, then the faulty SAFI has been found.
- But if the fail-safe loop does activate, then fit the next SAFI and test it, and so on.

12 PI valve fault or MPM power supply fault

Engine stops with "Port injection valve fault when closing"

If this error occurs only once on a PI valve, and the measured values of the "PI valve closed detection" after the repeated start once again seem

- similar and plausible (max. deviations of ±15), and there are no sporadic peaks either upwards or downwards, then it was a one-off event of a jammed particle that freed itself again at starting.
- plausible, but with a different mean value, then something has changed in the PI valve or the MORIS PI driver electronics, and the valve and the measured values must continue to be monitored. It may be that the return spring is broken, or a particle has become jammed, or there is a fault in the PI driver electronics.

If this fault occurs more often at the same valve, but only at this valve, and the measured values show peaks greater than ±20 (with the Hoerbiger valve), then the cause is a fault in the MORIS2 PI driver electronics for this valve. The valve coil, or the valve cable, may also be the cause. These peaks can occur now and then and do not always immediately lead to shutdown, because they can also be smaller than the parametrised deviation limit. It is recommended to first replace the MORIS module and then, if the error persists, to replace the PI valve.

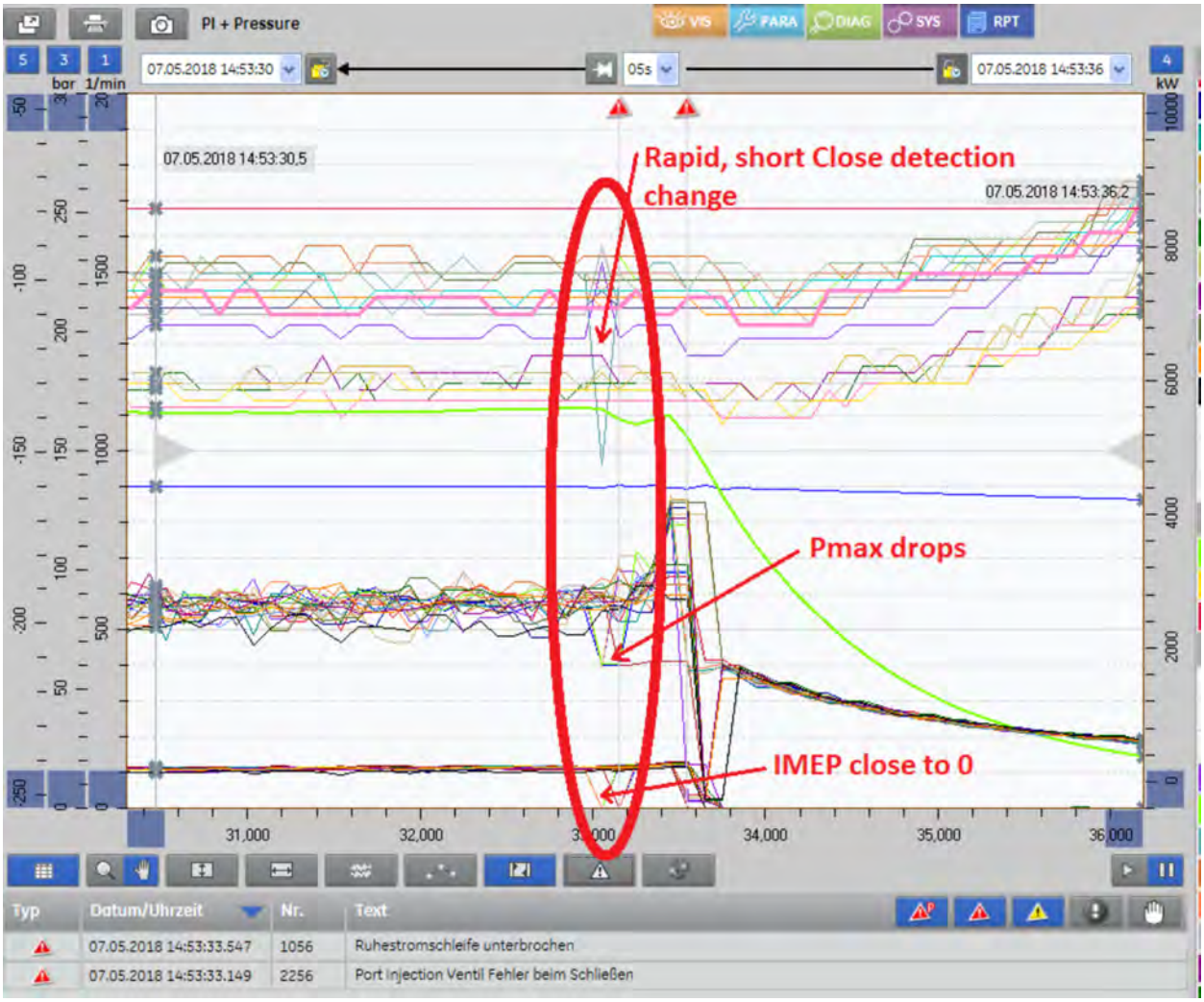
Checking the diagnostics trend "Closed detection I-degree" on the affected cylinder:

- In most cases, the values in normal operation have a noise of at most ±20. Only when starting or stopping the engine (Skipfire operation, changes in PI opening duration, etc.) will the value on some cylinders change by more than ±20.
- If there are sporadic peaks in the + and - direction that are larger than ±20, then a fault in the MORIS2 electronics or the PI valve is to be assumed, and it is recommended to replace the MORIS2. If that does not help, replace the PI valve.
- Contamination or jammed particles change the measured values in the + direction.
- In emergency shutdowns, all measured values move in the + direction, because the power supply is switched off and there is no longer sufficient voltage for Close Detection.

If the error occurs with different valves on the same MORIS rail, and the measured values of the "Closed detection I-degree" are otherwise plausible (max deviations of ±20):

- If, simultaneously with several valves on this rail, the measured values in the event of a fault exhibit a change or peaks greater than ±20, and at the same time the IMEP falls to 0 and Pmax drops, then the cause is a fault in the 185 V supply to the rail.
  - It is advisable to examine or replace the 24 V fuses supplying the MPM and the relays near the MPM.
  - The 24 V supply plug for the MPM can also be faulty. Please replace it. If burn marks are visible on the pins of the MPM, replace the MPM as well.
- In addition, "PI valve current too low when opening" may also occur on this rail. This is a side effect due to there not being enough current for the PI supply in the event of a fault.

Example illustration: Loose contact at 24 V fuse of MPM causes rise and fall of several PI measured values, and combustion stops in several cylinders on this rail.



If the fault occurs at various valves on the whole engine, a general problem / intermittent contact of the 24 V supply of the MPM should be assumed and localised.

Engine stops with "Ignition power supply fault"

If, at the same time, "Port Injection valve fault when closing" or "PI valve current too low when opening" also appears, see above, because the cause is a fault in the MPM power supply. If only "Ignition power supply fault", then see troubleshooting for the MPM.

SAFIs and ignition voltages are visible in DIA.NE, but engine will not start because the port injection valves never open

If all PI valves are affected, and ignition voltage is to be measured, but the PI valves do not open, and also, according to the diagnostic trend, the PI opening duration remains 0°, then it is a case of a missing requirement by DIA.NE. Please restart DIA.NE and SAFIs, and locate the cause in DIA.NE. The cause is usually a faulty SW update / module on the DIA.NE, or a fault in the gas line / gas pressure measurement.

2 valves on the same SAFI do not open for PI, but all other PI valves work normally

SAFI outputs destroyed (by hotswap, etc.) and do not control the PI valves. Please replace the SAFI.

13 CAN bus troubleshooting

There can also be errors on the CAN bus if various components of the MORIS rail have poor contact. The path of the CAN bus is similar to that of the fail-safe loop, and runs through the same cables and plug connectors. The same problems of intermittent contact may occur. If the temperatures are too high, a short-circuit may occur in the connection cable: either a short-circuit between the shielding and the CAN bus conductor, or a short-circuit between each other.

Terminating resistor correct?

- A terminating resistor of 120 Ω must be present at both ends of the CAN bus.
  - The terminating resistor must be switched on at the CAN node.
  - At the other end, a 120 Ω wire resistor must be connected between the CAN Low and CAN High terminals.
- Using resistance measurement in the switched-off state, a total resistance of 120 Ω x 120 Ω = 60 Ω must be measurable between CAN High and CAN Low.

Not all SAFIs are visible in the DIA.NE Sys screen

The fault location in the connection can be found using the visible SAFIs and the accompanying messages.

Does the oscilloscope image look healthy?

Using two measuring probes, contact CANH and CANL at the end of the bus at the terminating resistor. Check if CANH changes between 2.5 V and ~4 V, and if CANL changes between 2.5 V and ~1 V. For the measurement, connect the Gnd terminals of the oscilloscope with CAN Gnd.

14 Cylinder coding

	8 cylinders	**Coding**		**12 cylinders**	**Coding**	
Bank	**Module**	**DEC**	**HEX**	**Module**	**DEC**	**HEX**
Bank A	Connection module A	0	0	Connection module A	0	0
	Link module 1	0	0	Link module 1	0	0
	Link module 2	3	3	Link module 2	3	3
	Link module 3	2	2	End module A	0	0
	End module A	1	1			
Bank B				Connection module B	1	1
				Link module 1	6	6
				Link module 2	5	5
				End module B	0	0

	16 cylinders.	Coding		20 cylinders	Coding	
Bank	**Module**	**DEC**	**HEX**	**Module**	**DEC**	**HEX**
Bank A	Connection module A	0	0	Connection module A	0	0
	Link module 1	0	0	Link module 1	0	0
	Link module 2	3	3	Link module 2	3	3
	Link module 3	2	2	Link module 3	2	2
	End module A	1	1	Link module 4	1	1
				End module A	4	4
Bank B	Connection module B	4	4	Connection module B	5	5
	Link module 1	5	5	Link module 1	4	4
	Link module 2	4	4	Link module 2	7	7
	Link module 3	7	7	Link module 3	2	2
	End module B	2	2	Link module 4	9	9
				End module B	8	8

Type 6-MD 12-cylinder engine		Coding		Type 6-MD 16-cylinder engine	Coding	
Bank	**Module**	**DEC**	**HEX**	**Module**	**DEC**	**HEX**
Bank A	Connection module A	0	0	Connection module A	0	0
	Link module 1	0	0	Link module 1	0	0
	Link module 2	3	3	Link module 2	3	3
	End module A	0	0	Link module 3	2	2
				End module A	1	1
Bank B	Connection module B	1	1	Connection module B	4	4
	Link module 1	6	6	Link module 1	5	5
	Link module 2	5	5	Link module 2	4	4
	End module B	0	0	Link module 3	7	7
				End module B	2	2

24-cylinder bank A		Coding		24-cylinder bank B		Coding	
Bank	**Module**	**DEC**	**HEX**	**Bank**	**Module**	**DEC**	**HEX**
Bank A-A	Connection module A	0	0	Bank B-A	Connection module B	4	4
	Link module 1	0	0		Link module 1	7	7
	Link module 2	3	3		Link module 2	2	2
	End module A	0	0		End module B	8	8
Bank A-B	End module B	2	2	Bank B-B	End module A	1	1
	Link module 1	1	1		Link module 1	8	8
	Link module 2	4	4		Link module 2	11	B
	Connection module B	5	5		Connection module A	10	A

Type 9 20-cylinder engine, bank A	Coding	Type 9 20-cylinder engine, bank B	Coding

Bank	Module	DEC	HEX	Bank	Module	DEC	HEX
Bank A-A	Connection module A	0	0	Bank B-A	Connection module B	5	5
	Link module 1	0	0		Link module 1	4	4
	Link module 2	3	3		Link module 2	7	7
	End module A	0	0		End module B	2	2
Bank A-B	End module B	2	2	Bank B-B	End module A	0	0
	Link module 1	1	1		Link module 1	9	9
	Connection module B	4	4		Connection module A	8	8

15 Terminal designation

15.1 Ignition module

25-pole sub-D connection socket for **SAFI:**

Pin	Designation	Description
1	HS2	High-voltage measurement signal from right ignition coil
2	HS1	High-voltage measurement signal from left ignition coil
3	POWER	Ignition current setpoint for left and right ignition end stage
4	ZZP L (IP L)	Trigger signal for the left ignition end stage
5	CODE 4	Third bit of SAFI coding for position sensing
6	CODE 1	First bit of SAFI code for position sensing
7	CODE 2	Second bit of SAFI code for position sensing
8	CAN low	CAN low
9	CAN high	CAN high
10	OFF	Emergency shut-down / safety loop
11	CAM	Combined signal from the camshaft pickup
12	GND	Ground
13	+24 V	Power supply for SAFI
14	PI R	Port Injection control signal right
15	PCI R	Prechamber gas valve control signal right
16	ZZP R (IP R)	Trigger signal for the right ignition end stage
17	RM1	Ignition end stage current feedback
18	PCI L	Prechamber gas valve control signal left
19	CODE 8	Fourth bit of SAFI code for position sensing
20	RM2	Ignition end stage polarity feedback
21	CAN-GND	CAN-GND
22	PI RM R	Port injection / PCI feedback signal right
23	TRIGGER	Signal from ring gear
24	PI RM L	Port Injection / PCI feedback signal left
25	PI L	Port Injection control signal right

7W2 sub-D socket for **M coil:**

Pin	Designation	Description
A1	185 V	185 V power supply for **M coil**
A2	IGBT	Switch contact for end stage
1	HV Sensor out	Output for high-voltage sensor
2	Isec	Electrical response signal
3	GND	Ground
4	+24 V	Power supply for high-voltage sensor
5	n.c.	Unallocated

15.2 Connection module

5-pole MIL connector plug for 185 V power supply for **MORIS**:

Pin	Designation	Description
A	+185 V	185 V power supply for **MORIS** output stages
B	GND	GROUND for 185V power supply
C	SC-A, SC-B	Bank A or B safety contact for **MPM** (GND potential)
D	GND	GROUND for 185 V power supply
E	+185 V	185 V power supply for **MORIS** output stages

10-pole MIL connector plug for 24 V power supply, signal lines and CAN bus:

Pin	Designation	Description
A	+24 V	Power supply for output stage and **SAFI**
B	GND	24 V ground
C	n.c.	Unallocated
D	CAM	CAM/RESET signal from **SPA24**
E	TRIGGER	TRIGGER signal from **SPA24**
F	CAN-LOW	CAN BUS low-level line
G	CAN-HIGH	CAN BUS high-level line
H	CAN-GND	CAN bus GROUND line
I	SAFETY LOOP	**MORIS** fail-safe loop with **SAFI** safety contacts
J	n.c.	Unallocated

15.3 End module

4-pole MIL connector plug for CAN bus and fail-safe loop connection line:

Pin	Designation	Description
A	CAN-LOW	CAN BUS low-level line
B	CAN-HIGH	CAN BUS high-level line
C	CAN-GND	CAN bus GROUND line
D	SAFETY LOOP	**MORIS** fail-safe loop with **SAFI** safety contacts

16 Revision code

Revision history

Index	Date	Description / Revision summary	Expert *Auditor*
5	11.04.2019	GE durch INNIO ersetzt / GE replaced by INNIO	**Opoku** *Pichler R.*
4	28.09.2018	Fehlersuche bzgl. Zündung Sicherheitsschleife, PI, MPM und CAN Bus hinzugefügt / Troubleshooting regarding ignition safety loop, PI, MPM and CAN Bus added	**Gyurko M.** *Kopecek H.*
3	31.01.2018	Strukturelle Anpassungen / Structural adaptions Port Injection Informationen hinzugefügt / Port Injection informations added	**Gyurko M. / Kraus M.** *Kopecek H.*
2	27.06.2014	Überarbeitung / revision	**Boxleitner** *Fröhlich*
1	28.05.2010	Umstellung auf CMS / Change to **C**ontent **M**anagement **S**ystem ersetzt / replaced Index: **-**	**Schartner** *Pichler*